MALACCA STRAITS

ENVIRONMENTAL PROFILE

Edited by Chua Thia-Eng, S. Adrian Ross and Huming Yu



GEF/UNDP/IMO Regional Programme for the Prevention
and Management of Marine Pollution in the East Asian Seas

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MISSION STATEMENT

The primary objective of the Global Environment Facility/United Nations Development Programme/International Maritime Organization Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas is to support the efforts of the eleven (11) participating governments in the East Asian region to prevent and manage marine pollution at the national and subregional levels on a long-term and self-reliant basis. The 11 participating countries are: Brunei Darussalam, Cambodia, Democratic People's Republic of Korea, Indonesia, Malaysia, People's Republic of China, Republic of the Philippines, Republic of Korea, Singapore, Thailand and Vietnam. It is the Programme's vision that, through the concerted efforts of stakeholders to collectively address marine pollution arising from both land- and sea-based sources, adverse impacts of marine pollution can be prevented or minimized without compromising desired economic development.

The Programme framework is built upon innovative and effective schemes for marine pollution management, technical assistance in strategic maritime sectors of the region, and the identification and promotion of capability-building and investment opportunities for public agencies and the private sector. Specific Programme strategies are:

- Develop and demonstrate workable models on marine pollution reduction/prevention and risk management;
- Assist countries in developing the necessary legislation and technical capability to implement international conventions related to marine pollution;
- Strengthen institutional capacity to manage marine and coastal areas;
- Develop a regional network of stations for marine pollution monitoring;
- Promote public awareness on and participation in the prevention and abatement of marine pollution;
- Facilitate standardization and intercalibration of sampling and analytical techniques and environment impact assessment procedures; and
- Promote sustainable financing mechanisms for activities requiring long-term commitments.

The implementation of these strategies and activities will result in appropriate and effective policy, management and technological interventions at local, national and regional levels, contributing to the ultimate goal of reducing marine pollution in both coastal and international waters, over the longer term.

Dr. Chua Thia-Eng
Regional Programme Manager
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for the Prevention and Management
of Marine Pollution in the East Asian Seas

CONTENTS

Mission Statement iii

List of Tables vii

List of Figures xiii

Abbreviations xvi

Summary xix

Acknowledgment xxviii

Chapter 1. Introduction 1

Geographical Coverage 1
Significance of the Malacca Straits 2
Purpose of This Environmental Profile 2
Definitions 3

Chapter 2. Physical, Ecological and Demographic Characteristics 6

Hydrometeorological Characteristics 6
Physical Characteristics 9
River Systems 11
Coastal Erosion and Sedimentation 12
Land and Sea-bottom Features 17
Ecological and Biological Characteristics 17
Land Uses and Development 30
Demographic Characteristics 33

Chapter 3. Natural Resources Exploitation, Utilization and Conflicts 51

Capture Fisheries and Coastal Aquaculture: Status and Socioeconomic Contributions 51
Exploitation and Use of Mangrove Resources 70
Exploitation and Use of Coral and Seagrass Resources 82
Oil and Mineral Resources: Status of Development 83
Coastal Tourism Resources: Status of Development, Potential and Socioeconomic Contributions 85
Growth Triangles 92

Chapter 4. Maritime Trade and Development 95

Importance of the Straits to the Shipping, Petroleum and Cargo Industries 97
Use of the Straits as a Transport Channel by the Littoral States 106
Development and Exploitation of Oil and Gas Resources in the Straits 109
Port and Harbor Development 115

Chapter 5. Pollution from Land-based Sources 138

Waste Sources and Loadings 139
Waste Management Facilities and Services 152

Chapter 6. Sea-based Sources of Marine Pollution 157

Ships 157
Offshore Activities 162
Prevention and Management of Sea-based Sources of Pollution 163

Chapter 7. Impact of Human Activities on the Marine and Coastal Environment 189

Physical, Chemical and Biological Conditions 189
Major Environmental Concerns in the Malacca Straits 201
Conclusion 206

Chapter 8. Policies and Management Practices 207

Policies, Legislation and Enforcement Activities 207
Financial Mechanisms and Investments in the Management of the Malacca Straits 223

References 226

Annexes
1. *Traffic Separation Scheme* 240
2. *Rules for Vessels Navigating through the Straits of Malacca and Singapore* 255
3. *East Asia Response Private Limited (EARL) Equipment List* 257

LIST OF TABLES

2.1. Major river drainage systems in the East Coast of Sumatra bordering the Malacca Straits 11
2.2. Average volumes of annual river discharge of the provinces bordering the Malacca Straits 11
2.3. Discharge of principal rivers in West Peninsular Malaysia 12
2.4. Distribution of eroding coastline in Malaysia 14
2.5. Major land reclamation schemes in Singapore 16
2.6. Straits of Malacca: distribution of major mangroves and peat swamp forests along the coastal areas of Peninsular Malaysia 19
2.7. Straits of Malacca: distribution of major mangroves and peat swamp forests along the East Coast of Sumatra, Indonesia 20
2.8. Summary of the "health" status of Malaysian coral reefs 23
2.9. Rating the causes of coral reef degradation and destruction in Malaysia 23
2.10. Species of seagrasses found in littoral States bordering the Malacca Straits 25
2.11. Habitat coverage for Sumatra 30
2.12. List of protected and threatened marine species and mangrove associated species along the East Coast of Sumatra adjacent to the Malacca Straits 31
2.13. Land area, as well as general land use, physical features, vegetation and climate of the three littoral States of the Malacca Straits 32
2.14. Areas of land used for agriculture in the eastern lowland of Sumatra bordering the Malacca Straits 32
2.15. Land uses in the West Coast States of Peninsular Malaysia bordering the Malacca Straits 33
2.16. Land use and development in Singapore 33
2.17. Indonesia: estimated population change, sex ratio, age distribution, median age and population density, 1975 to 2020 36
2.18. Indonesia: annual population change, growth rate, infant mortality rate, and life expectancy, 1970 to 2020 36
2.19. Malaysia: estimated population change, sex ratio, age distribution, median age and population density, 1975 to 2020 38
2.20. Malaysia: annual population change, growth rate, infant mortality rate and life expectancy, 1970 to 2020 39
2.21. Population of coastal States and districts bordering the West Coast of Peninsular Malaysia 40
2.22. Singapore: estimated population change, sex ratio, age distribution, median age, and population density, 1975 to 2020 41
2.23. Singapore: annual population change, growth rate, infant mortality rate and life expectancy, 1970 yo 2020 42
2.24. Singapore: distribution of religions according to the male and female resident population from the 1990 census 43
2.25. Number of schools of Sumatra by regency bordering the Malacca Straits 44
2.26. Tertiary level education in Aceh, North Sumatra, and Riau Provinces 45
2.27. Number of workers by main group of economic activites in Aceh, North Sumatra and Riau Provinces, 1993 45
2.28. Development of labor force and employment in Indonesia 46

2.29. Number of job opportunities in various economic sectors in 1995 and projection for 1999 46
2.30. Number of assisted primary and secondary schools in Peninsular Malaysia 46
2.31. Number of pupils in assisted primary and secondary schools in Peninsular Malaysia 47
2.32. Number of teachers in assisted primary and secondary schools in Peninsular Malaysia 47
2.33. Employment in Malaysia 47
2.34. Percentage distribution of employed persons by occupation 48
2.35. Education in Singapore: enrollment in educational institutions in 1994 and the average ratio of pupils to teacher 48
2.36. Education in Singapore: major tertiary education centers 49
2.37. Employment in Singapore: employed persons by industry, 1994 50
2.38. Employment in Singapore: occupations of employed persons, 1994 50
3.1. Marine fishery resources in the Malacca Straits 51
3.2. Data on fisheries in the East Coast Provinces of Aceh, North Sumatra, and Riau, 1990-1993 54
3.3. Total fish landings, numbers of fishermen and fishing boats from the West Coast of Peninsular Malaysia compared to other States, 1990 56
3.4. Landings, imports and exports of fishery products in Singapore, 1990-1995 58
3.5. Brackishwater pond fisheries in the provinces of Sumatra bordering the Malacca Straits, 1991-1993 60
3.6. Potential land for development and potential production of brackishwater ponds in the Provinces of Sumatra bordering the Malacca Straits 60
3.7. List of potential species for brackishwater ponds in North Sumatra 61
3.8. Biota with mariculture potential 61
3.9. Potential area for development and potential production of mariculture along the East Coast of Sumatra in the Malacca Straits 62
3.10. Malaysia: aquaculture production by freshwater and brackishwater species, 1990-1993 64
3.11. Economically important species by province bordering the Malacca Straits, 1990-1993 65
3.12. Quantities and values of fishery products exported by Malaysia to other countries 67
3.13. Quantities and values of fishery products imported by Malaysia from other countries 67
3.14. Estimated standing stocks and maximum sustainable yield for fishery stocks in the Indonesian portion of the Malacca Straits, 1980 68
3.15. CPUE of pelagic fish in the Malacca Straits (Indonesian portion), 1969-1990 68
3.16. Comparison of potential yields, maximum sustainable yields and average catches between the West and East Coasts of Peninsular Malaysia 69
3.17. Extent of mangrove forests in the Straits of Malacca 70
3.18. Commercial and subsistence uses of mangrove forest resources in North Sumatra, Indonesia 72
3.19. Financial profile of a typical charcoal factory in North Sumatra, Indonesia 73
3.20. Matang Mangrove Forest Reserve: main ecological and production features 74
3.21. Landings of mangrove-dependent fishes of economic importance for the West Coast of Peninsular Malaysia 77
3.22. Development in the utilization and management of mangrove forests by Indonesia 79
3.23. Development in the utilization and management of mangrove forests by Malaysia 80

3.24. Development in the utilization and management of mangrove forests by Singapore 80
3.25. Classification, characteristics and management considerations of seagrass beds in the ASEAN Region 84
3.26. Summary of values and negative environmental impacts resulting from detrimental uses of the coastal ecosystems (mangroves, coral reefs and seagrass beds) 85
3.27. Potential recoverable oil and gas reserves along the East Coast of Sumatra bordering the Malacca Straits 86
3.28. Production of tin in four locations in Riau Province, 1986-1989 86
3.29. Inventory of important coastal tourist spots along the Malacca Straits 87
3.30. List of tourist and recreational areas in the East Coast of Sumatra in the Malacca Straits 88
4.1. Values of imports and exports by East Asian countries 95
4.2. Volume of marine transported goods unloaded and loaded 95
4.3. Indonesian exports to Malaysia and Singapore, their change, growth and contribution to the total national export value, 1993-1994 96
4.4. Values and growth of Indonesia's imports from Malaysia and Singapore, 1993-1994 97
4.5. Shift in contributions by major economic activities to the gross domestic product, 1985-1995 97
4.6. Total shipping traffic passing through the Malacca Straits 98
4.7. Additional costs of oil tankers using the Lombok-Makassar Straits as an alternative route to the Malacca Straits 100
4.8. Estimated number of oil tankers passing through the Malacca Straits, 1987-1993 100
4.9. Tankers belonging to the ASEAN and other Asian countries in 1992 100
4.10. Quantities of petroleum oil imported by Japan from the Middle East, African continent and Southeast Asian countries 101
4.11. Outlook for oil demands in the Asia-Pacific region 101
4.12. Global movement of oil in 1995 102
4.13. Quantities of petroleum trade passing through the Malacca Straits compared to other alternative routes in Asia 102
4.14. General cargo and container vessels transiting the Malacca Straits 104
4.15. Container throughputs for Asian and Pacific Rim ports, 1991-1992 104
4.16. Commodity composition handled by Port Klang of Malaysia 105
4.17. Number of container vessel movements in the highest trafficked port-to-port links in the East Asian region, April-June 1992 106
4.18. Number of vessels using the Malacca Straits and number of vessels calling at Malaysian Ports and their percentage to vessels using the Malacca Straits, 1982-1990 107
4.19. National economic indicators of Malaysia, 1982-1992 107
4.20. Malaysia: volumes of exports and imports with major trading countries 108
4.21. Malaysia: comparison of economic performance in the West Coast and East Coast of Peninsular Malaysia, and Sabah/Sarawak of East Malaysia 108
4.22. Estimated numbers of vessels using the Malacca Straits and vessels calling at Singapore Port 109
4.23. Volume and value of export of oil, natural gas and their derivatives from Indonesia, 1990-1994 111
4.24. Crude oil production by company in Riau Province, 1989-1993 112

4.25. Location of oil refineries along the Malacca Straits and their operators, production capacities and percentage of production in the Malacca Straits to national production capacity for each littoral State 114
4.26. Trade statistics for petroleum products in Singapore 115
4.27. Percentage share of Singapore's main sources of petroleum imports 115
4.28. Percentage share of major exports of Singapore's petroleum products 116
4.29a. List of major sea ports of the East Coast of Sumatra along the Malacca Straits showing export and import activities in 1994 116
4.29b. Activities of Malahayati sea port, Aceh Province, 1990-1994 118
4.30. Berth length, depth, transit shed, yard area and main functions of the base ports of Belawan, Indonesia 119
4.31. Ferry schedules in the Port of Belawan, Indonesia 119
4.32. Facilities in the Lhokseumawe Port, Aceh, Indonesia 119
4.33. Facilities in the Port of Dumai, Riau Province, Indonesia 120
4.34. Facilities in the Port of Blang Lancang, Aceh Province, Indonesia 120
4.35. Facilities in the Port of Pekan Baru, Riau Province, Indonesia 121
4.36. Facilities in the Port of Pulau Sambu, Riau Archipelago, Indonesia 121
4.37. Facilities in the Port of Lhok Nga, Aceh Province, Indonesia 121
4.38. Facilities in the Port of Sabang, Aceh Province, Indonesia 121
4.39. Facilities in the Port of Asahan, North Sumatra, Indonesia 121
4.40. Private ports in Northern Sumatra, Indonesia 122
4.41. Development of sea transport facilities in North Sumatra Province, 1989-1995 122
4.42. Facilities in the important sea ports in Riau Province, Indonesia 122
4.43. Existing conditions and planned sea port facilities in Batam Island 123
4.44. Facilities provided by container terminals in Port Klang 125
4.45. Facilities of dry bulk cargo terminals in Port Klang, Malaysia 125
4.46. Facilities provided by liquid bulk cargo terminals in Port Klang, Malaysia 126
4.47. Facilities provided by the breakbulk cargo terminals in Port Klang, Malaysia 126
4.48. Number of ships visiting Port Klang, types of cargo carried, and tonnages 127
4.49. Scheduled development of West Port facilities in Port Klang 129
4.50. Facilities in the base ports of Penang Port, Malaysia 130
4.51a. Facilities and commodities handled in various terminals in Port Dickson—LPG Terminals 131
4.51b. Facilities and Commodities handled in the various terminals in Port Dickson—Tanker Terminals 132
4.52. Number of ships calling at the Port of Singapore 136
4.53. Cargoes handled by the Port of Singapore 136
4.54. Dry dock capacity in Singapore as of 30 June 1983 137
5.1. Origin and characteristics of major marine pollutants from land-based sources 138
5.2. Estimated BOD loading from sewage discharges in coastal areas of the littoral States bordering the Malacca Straits 139
5.3 Pollutants discharged to the Malacca Straits from Peninsular Malaysia in domestic sewage 140
5.4 Water consumption breakdown, 1989 140
5.5. Potential pollutants discharged from Singapore, 1989 141
5.6. Major industries of Indonesia and their potential impact 141
5.7. Industrial waste discharges to rivers in Aceh, North Sumatra, and Riau Provinces 142
5.8. Total pollutant loads generated by domestic and industrial activities discharged from rivers along the West Coast of Peninsular Malaysia 144

5.9. Distribution of industrial plants along the coastal rivers basins of the West Coast of Peninsular Malaysia, 1987 145
5.10. Pollutants discharged to the Malacca Straits from Peninsular Malaysia by the agro-based industries 146
5.11. Pollutants discharged to the Malacca Straits from Peninsular Malaysia by the manufacturing sector 148
5.12. Pesticide use in agricultural activities on the East Coast of Aceh, North Sumatra, and Riau Provinces 149
5.13. Number of farms and populations of pigs on the West Coast of Peninsular Malaysia, 1990-1991 149
5.14. Pollutants discharged to the Malacca Straits from Peninsular Malaysia by the agriculture industry 149
5.15. Organochlorine consumption in the Malaysian coastal areas bordering the Malacca Straits 150
5.16. Composition of solid wastes in Java and Sumatra 150
5.17. Solid wastes generated by Malaysian coastal States bordering the Malacca Straits 151
5.18. Composition of refuse in Singapore 151
5.19. Solid waste generation in Singapore, 1990 to 1994 151
5.20. History of sewage management in Singapore 153
6.1. Shipping accidents in the Malacca Straits, 1977-1993 158
6.2. Types of shipping casualties in the Malacca Straits, 1977-1993 158
6.3. Breakdown of shipping casualties in the Malacca Straits according to type of ship 158
6.4. Number and percentage of accidents according to the type of vessel passing through the Malacca Straits 159
6.5. Maritime casualties in the Malacca Straits, 1978-1994 159
6.6. Principal types of oceanic minerals 162
6.7. International conventions on marine pollution 163
6.8. Status of ratification of IMO conventions on navigational safety 164
6.9. VHF radio stations in the Malacca Straits 169
6.10. Malacca Strait Council projects and financial commitments 173
6.11. Global estimates of the causes of oil spills 175
6.12. Major oil spills in the Malacca Straits, 1975-1993 175
6.13. State of oil pollution preparedness and response in the Malacca Straits 176
6.14. Oil pollution control equipment held by PERTAMINA, 1993 179
7.1. Demographic and socioeconomic features of the Straits of Malacca and Singapore 189
7.2. Total suspended solids exceeding standard (50 mg/l) for Malaysian states bordering the Straits of Malacca 191
7.3 Water quality data of the marine environment along the West Coast of Peninsular Malaysia 192
7.4. Water quality values and national environmental standards for the Straits of Malacca 193
7.5. Heavy metal concentrations in sediments around Sungai Pakning, Riau 193
7.6. Heavy metal concentrations in Sediments from locations around the Straits of Malacca and Singapore 193
7.7. Mean concentrations of trace metals in seawater samples 194
7.8. Elemental concentrations in sediment samples from Singapore coastal waters 194
7.9. Levels of heavy metals in fish and shellfish from the West Coast of Peninsular Malaysia 194
7.10. Levels of organochlorine in West Coast Malaysian Rivers 195

7.11. Chlorinated pesticide water quality criterion for Malaysia 195
7.12. Range of organochlorine in sediment of Siak Estuary, Riau, Indonesia 195
7.13. Oil and grease in coastal waters and petroleum hydrocarbons in coastal waters and surfacial sediments off the West Coast of Peninsular Malaysia 196
7.14. Hydrocarbon contamination along the East Coast of Sumatra 196
7.15. Oil content around Riau Archipelago 196
7.16. Total hydrocarbon content in waters and sediments of selected sites in the Malacca Straits and other marine bodies 197
7.17. Malaysia: tar ball survey 197
7.18. Marine water quality — *Escherichia coli*, 1985-1991 198
7.19. Microbial water quality at aquaculture sites on the West Coast of Peninsular Malaysia 198
7.20. Microbial water quality at recreational sites on the West Coast of Peninsular Malaysia 198
7.21. Record of red tide occurrences in Malaysia 199
7.22 Modified version of sensitivity ranking for coastal ecosystems and habitats 202
7.23. Sensitivity of cultivated species to stranded or drifting oil 202
7.24. Fish kills in coastal waters of the West Coast of Peninsular Malaysia 204
7.25. Concentration of TBT in water samples from the West Coast of Peninsular Malaysia 205
7.26. Concentration of TBT in sediment 205
7.27. Concentration of TBT in bivalves 205
7.28. Imposex among gastropods in the Straits of Malacca 206
8.1. Long-term strategy and step by step approaches for environment management and pollution control in Indonesia 208
8.2. Legislation and regulations pertinent to the management of coastal pollution by Indonesia 209
8.3. Partial list of existing rules and regulations on environmental and natural resources management in Indonesia 214
8.4. Protected marine areas in the East Coast of Sumatra 216
8.5. Legislation and regulations pertinent to the management of coastal pollution in Malaysia 217
8.6. Environmental pollution control regulations gazetted under Environmental Quality Act (EQA) 1974 and EQA (amendment) 1985 of Malaysia 218
8.7. List of prescribed activities in the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 of Malaysia 220
8.8. Legislation and enforcement pertinent to the management of coastal pollution by Singapore 222
8.9 Programs of action to control land-based sources of pollution as proposed by COBSEA Project EAS-97, UNEP 224

LIST OF FIGURES

1.1a. Geographical coverage of the Malacca Straits—Indonesian and Malayan portions of the Malacca Straits 1
1.1b. Geographical coverage of the Malacca Straits—Singaporean portion of the Malacca Straits 1
2.1. Surface water currents of Southeast Asian seas in April 7
2.2. Surface water currents of Southeast Asian seas in August 7
2.3. Surface water currents of Southeast Asian seas in October 8
2.4. Surface water currents of Southeast Asian seas in December 8
2.5. Major river basins along West Peninsular Malaysia 11
2.6. Reservoirs and drainage systems in Singapore 12
2.7. Critical coastal erosion areas in Peninsular Malaysia 14
2.8. Reclamation along the coast of the main island and the offshore islands in Singapore 16
2.9. Distribution of mangroves and peat swamps along the coastal zones of the Malacca Straits: Indonesia, Malaysia and Singapore 18
2.10. Mangroves and nature parks in Singapore 19
2.11. Distribution of coral reefs in the ASEAN countries 21
2.12. Location map of observation of soft corals in Batam 22
2.13. Location map of observation of scleractinian corals in Batam 22
2.14. Distribution of coral reefs in Singapore 24
2.15. Distribution of seagrass beds in the ASEAN region 25
2.16. Distribution of seagrass, their substrate types and species composition in Peninsular Malaysia 26
2.17. Distribution of seagrass beds in Singapore 26
2.18. Distribution of soft-bottom habitats in the ASEAN region 28
2.19. Critical intertidal habitats off the East Coast of Sumatra 28
2.20. Mudflats in and around the mouth of Rokan river in Riau 29
2.21. Distribution of vegetation types in Sumatra 30
2.22. The revised concept plan for long-term land uses and development in Singapore 33
2.23. Land use and development in Singapore: existing and planned public housing estates, private residences and off-island settlements 34
2.24. Land uses and development in Singapore: industrial estates and power plants 34
2.25. Jurong town, Singapore: waterfront industries and residential housing 35
2.26. Indonesia: age distribution in the resident population, 1975-2050 35
2.27. Indonesian regencies bordering the Malacca Straits in Sumatra 37
2.28. Population of provinces along the East Coast of Sumatra 37
2.29. Malaysia: age distribution in the resident population, 1975-2050 38
2.30. Peninsular Malaysia: population of coastal states and districts along the West Coast of Peninsular Malaysia 39
2.31. Singapore: age distribution in the resident population, 1975-2050 41
3.1. Demersal and pelagic fish production from the Indonesian portion of the Malacca Straits 52
3.2. Number of full-time fishermen from Aceh, North Sumatra and Riau, Indonesia 53
3.3. Fish production from Aceh, North Sumatra and Riau, Indonesia 53

3.4. Transport and road networks in Peninsular Malaysia 55
3.5. Capture fisheries in the Malacca Straits: total fish landings from the West Coast States vs. East Coast States of Peninsular Malaysia, 1993 56
3.6. Capture fisheries in the Malacca Straits: fish landings by State along the West Coast of Peninsular Malaysia, 1993 56
3.7. Capture fisheries in the Malacca Straits: type and quantity of fishing gear operated by fishermen from the West Coast of Peninsular Malaysia, 1993 57
3.8. Demersal and pelagic fish resources in the Malacca Straits 57
3.9. Level of fishing intensity of coastal pelagic fish and cephalopods 58
3.10. Level of fishing intensity of demersal fish and crustaceans 59
3.11. Potential areas for collection of milkfish and shrimp fry in the waters along the East Coast of Sumatra 62
3.12. Aquaculture in the coastal zone of the Malacca Straits: types of aquaculture and area by State along the West Coast of Peninsular Malaysia, 1993 63
3.13. Aquaculture in the coastal zone of the Malacca Straits: total per State along the West Coast of Peninsular Malaysia, 1993 63
3.14. Aquaculture in the coastal zone of the Malacca Straits: distribution of cockle bed area per State along the West Coast of Peninsular Malaysia, 1993 63
3.15. Foreign exchange earnings from import and export of fish in Peninsular Malaysia 66
3.16. Distribution of mangroves in Indonesia 70
3.17. Cost structure of the charcoal industry in North Sumatra, Indonesia 73
3.18. Employment potential for different mangrove use options in Sumatra, Indonesia 74
3.19 Relationship of fisheries landings and aerial cover of mangroves in the ASEAN region 75
3.20. Major prawn fishing grounds and mangrove areas in ASEAN countries 76
3.21. Relationship between maximum yield of prawns from offshore fisheries and the area of adjacent mangrove and wetlands in the Philippines and Indonesia 77
3.22. Tin ore reserves along the eastern coastal region of Sumatra 84
3.23. Visitor arrivals to Indonesia, 1980-1991 and predictions to year 2000 87
3.24. The two growth triangles in the Malacca Straits 92
3.25. Map of Batam Island in relation to Singapore, Johor and Bintan 93
3.26. Number of overseas tourists to Batam, 1985-1995 93
3.27. Population growth in Batam, 1973-1995 94
4.1. Average daily shipping traffic through the Malacca Straits 97
4.2. Shipping traffic generated by Peninsular Malaysia 98
4.3. Percentage of shipping traffic in the Straits of Malacca by type of vessel 98
4.4. Alternative routes for ships transiting the Indian Ocean and South China Sea 99
4.5. Shipping routes for the transport of crude oil in Southeast Asia 102
4.6. Distribution of petroleum products in Sumatra, Indonesia 103
4.7. Container concentrations in East and South Asian ports 103
4.8. Hub/mainline/feeder networks in the region 105
4.9. Oil and gas fields and refineries along the Malacca Straits 110
4.10. Map of producing and explored tertiary age basins around Sumatra Island 111
4.11. Commercial ports along the Malacca Straits 117
4.12. Major sea ports along the East Coast of Sumatra 118
4.13. Location and approaches of the three base ports of Port Klang 124
4.14. Road networks in Peninsular Malaysia and Port Klang 124
4.15. Number of ships visiting Port Klang and their tonnages 126
4.16. Types and volumes of cargo handled in Port Klang, 1990-1994 127

ABBREVIATIONS

ADB	Asian Development Bank
AEGE	ASEAN Expert Group on Environment
AMDAL	Analisis Mengenai Dampak Lingkungan (Environmental Impact Assessment), Indonesia
APCMMP	ASCOPE Plan for the Control and Mitigation of Marine Pollution
APEC	Asia-Pacific Economic Cooperation
ASCOPE	ASEAN Council on Petroleum
ASEAN	Association of South East Asian Nations
ASOEN	ASEAN Senior Officers on Environment
BAPEDAL	Badan Pengendalian Dampak Lingkungan (Environmental Impact Control Agency), Indonesia
BAPPENAS	Badan Perencanaan dan Pembangunan Nasional (National Planning and Development Agency), Indonesia
BARELANG	Batam-Rempang-Galang
BIDA	Batam Industrial Development Authority
BIOTROP	Center for Studies on Tropical Biology
BOD	Biochemical Oxygen Demand
BOPD	Barrel of Oil Per Day
BSCF	Billion Standard Cubic Feet
CA	Cagar Alam Laut (Strict Marine Reserve), Indonesia
CAM	Coastal Area Management
CCOP	Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia
CECU	Coastal Erosion Control Unit
CEL	Commission on Environmental Law
CETC	Coastal Engineering Technical Center
CIDA	Canadian International Development Agency
CLC	Civil Liability Convention
COBSEA	Coordinating Body for the Seas of East Asia
COD	Chemical Oxygen Demand
COREMAP	Coral Reefs Rehabilitation and Management Programme, Indonesia
COST	ASEAN Committee on Science and Technology
CRC	Coastal Resources Committee
CRM	Coastal Resources Management
CRMP	Coastal Resources Management Project
CSC	Convention on Safe Containers
CZM	Coastal Zone Management
DAS	Daerah Aliran Sungai (Watershed Area), Indonesia
dbh	diameter at breast height
DESIPA	Department for Economic and Social Information and Policy Analysis of the United Nations
DGS	Department of Geological Survey
DID	Drainage and Irrigation Department, Singapore
Ditjen PHPA	Direktorat Jenderal Pengawetan Hutan dan Perlindungan Alam (Directorate General of Forest Protection and Nature Conservation), Indonesia
DO	Dissolved Oxygen
DOA	Department of Agriculture
DOE	Department of Environment
DOM	Department of Mapping
DOWW	Department of Waterworks
DPW	Department of Public Works
DRN	Dewan Riset Nasional (National Research Council), Indonesia
DSM	Department of Survey and Mapping
DTCP	Department of Town and Country Planning
DVC	Department of Veterinary Services
EARL	East Asia Response Pte Ltd
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Niño Southern Oscillation
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization
FRI	Fisheries Research Institute
FRIM	Forest Research Institute of Malaysia
GBHN	Garis-Garis Besar Haluan Negara (Guidelines of the State Policy), Indonesia
GEF	Global Environment Facility
GESAMP	Group of Experts on the Scientific Aspects of Marine Pollution

GIS	Geographical Information Systems
GRT	Gross Registered Tonnage
HDB	Housing and Development Board, Singapore
IAEA	International Atomic Energy Agency
IAIN	Institut Agama Islam Negeri (Islamic Religion State Institute), Indonesia
IKIP	Institut Keguruan Ilmu Pendidikan (Teachers Education Institute), Indonesia
IMO	International Maritime Organization
IMTGT	Indonesia-Malaysia-Thailand Growth Triangle
INPRES	Instruksi Presiden (Presidential Instruction Programme), Indonesia
IOPP	International Oil Pollution Prevention
IPB	Institut Pertanian Bogor (now Bogor Agricultural University)
IPFC/FAO	Indo-Pacific Fishery Council of FAO
ISME	International Society of Mangrove Ecosystem
ITOPF	International Oil Tanker Owners' Pollution Federation
IUCN	International Union for the Conservation of Nature (World Conservation Union)
J-F MPMC	Johore-Federal Marine Park Management Committee
JICA	Japan International Cooperation Agency
JPA	Johore Port Authority
KEJORA	Lembaga Kemajuan Johor Tenggara (South Johore Development Authority)
Kg.	Kampong (village)
KPTS; Kpts	Keputusan (Decree), Indonesia
LIPI	Lembaga Ilmu Pengetahuan Indonesia (Indonesian Institute of Sciences)
LKIM	Lembaga Kemajuan Ikan Malaysia (Fisheries Development Authority of Malaysia)
LNG	Liquefied Natural Gas
LOP	Load on Top
LPG	Liquefied Petroleum Gas
LWS	Lowest Water Spring-tide
MAB	Man and Biosphere Coastal and Marine Programme of UNESCO
MABSD	Million Barrels Stream Day
MARPOL	International Convention for the Prevention of Pollution from Ships
MCRST	Malaysian Coastal Resources Study Team
MENKLH	Menteri Negara Kependudukan dan Lingkungan Hidup (State Minister on Population and Environment), Indonesia
MENLH	Menteri Negara Lingkungan Hidup (State Minister on Environment), Indonesia
MEPC	Marine Environment Protection Committee
MIMA	Maritime Institute of Malaysia
MITA	Ministry of Information and the Arts, Singapore
MOA	Ministry of Agriculture
MOD	Ministry of Defense
MOSTE	Ministry of Science, Technology and the Environment
MPE	Menteri Pertambangan dan Energi (Minister on Mining and Energy), Indonesia
mpn	most probable number
MSC	Malacca Strait Council
MSY	Maximum Sustainable Yield
NATMANCOM	Malaysian National Mangrove Committee
NCECC	National Coastal Erosion Control Council
NCEP	National Committee on Environment Protection, Indonesia
NESP	National Environment Standard Procedure
NGO	Nongovernment Organization
NIE	Newly Industrializing Economies
NSRC	National Scientific Research Council
NUS	National University of Singapore
OCIMF	Oil Companies International Marine Forum
ODA	Ocean Development Agency
OISCA	Organization for Industrial, Spiritual and Cultural Advancement
OPA 90	US Oil Pollution Act of 1990
OPRC	International Convention on Oil Pollution Preparedness, Response and Cooperation
OSPAR	ASEAN Oil Spill Preparedness, Action and Response
OSRAP	ASEAN Oil Spill Response Action Plan
P.	Pulau (Island)
PIL	Penyajian Informasi Lingkungan (Initial Environmental Assessment), Indonesia

PJP	Pembangunan Jangka Panjang (Long Term Development Plan), Indonesia
PSA	Port Authority of Singapore
PSP	Paralytic Shellfish Poisoning
PUB	Public Utilities Board
REPELITA	Rencana Pembangunan Lima Tahun (Five Year Development Plan), Indonesia
RePPProT	Regional Physical Planning Programme for Transmigration
RESTEK	Riset dan Teknologi (Research and Technology), Indonesia
SASAR	Singapore Association of Shipbuilders and Repairers
SEAPOL	Southeast Asian Programme in Ocean Law Policy and Management
SIJORI	Singapore-Johor-Riau Growth Triangle
SM	Suaka Margasatwa Laut (Managed Marine Reserve/Marine Sanctuary), Indonesia
SOLAS	International Convention on Safety of Life at Sea
STCW	Standards of Training, Certification and Watchkeeping for Seafarers International Convention
TARC	Tiered Area Response Capability
TEUs	Ten-foot Equivalent Units
TOL	Temporary Occupation License
TOR	Terms of Reference
TSS	Traffic Separation Scheme; Total Suspended Solids
TTEG	Tripartite Technical Experts Group
TW	Taman Wisata Laut (Protected Seascape), Indonesia
UKC	Underkeel Clearance
ULCC	Ultra Large Crude Carrier
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
VLCC	Very Large Crude Carrier
VTIS	Vessel Traffic Information System
VTMS	Vessel Traffic Management System
WESTPAC	Western Pacific
WMO	World Meteorological Organization
WWF	World Wildlife Fund

SUMMARY

Purpose of This Document

This document is intended to:

(i) provide an environmental profile of the Malacca Straits with special reference to marine pollution;
(ii) compile the existing policies, strategies, practices and initiatives taken by the littoral States, regional and international organizations with regard to the management of marine pollution, arising from both land- and sea-based sources and activities; and
(iii) prepare an information reference for use in a risk assessment appraisal of the Malacca Straits.

The profile forms part of the activities of the Malacca Straits Demonstration Project executed by the GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas.

Physical setting of the Malacca Straits

Geographical location, land and sea-bottom features

The Strait of Malacca is situated between the East Coast of Sumatra Island and the West Coast of Peninsular Malaysia. It is contiguous with the Strait of Singapore at its southeast end forming an international shipping route linking the Indian Ocean (via the Andaman Sea) with the South China Sea to the Pacific Ocean. (In this report, **"Straits of Malacca"** or **"Malacca Straits"** is used to include collectively the two straits.) The length of the Straits is around 600 nautical miles (nm), with the widest section (220 nm) near the northwest entrance, narrowing gradually to around 8 nm at the southeast entrance near the Riau Archipelago.

The onshore topography of the West Coast of Peninsular Malaysia bordering the Malacca Straits is characterized by poorly drained coastal plains, basins, terraces, headlands and ridges of different geological origin, composition and age with coastal plains and basins dominating the landscapes. The eastern lowlands and eastern islands (excluding the provinces of Jambi and Lampung) of the Sumatra Island together form the land component of the coastal zone of the Malacca Straits. Much of the lowlands consist of swamps and flat terrains with an elevation of no more than 5 to 6 m above sea level and are dominated by alluvial soils with marine deposits overlaid by peat in most areas.

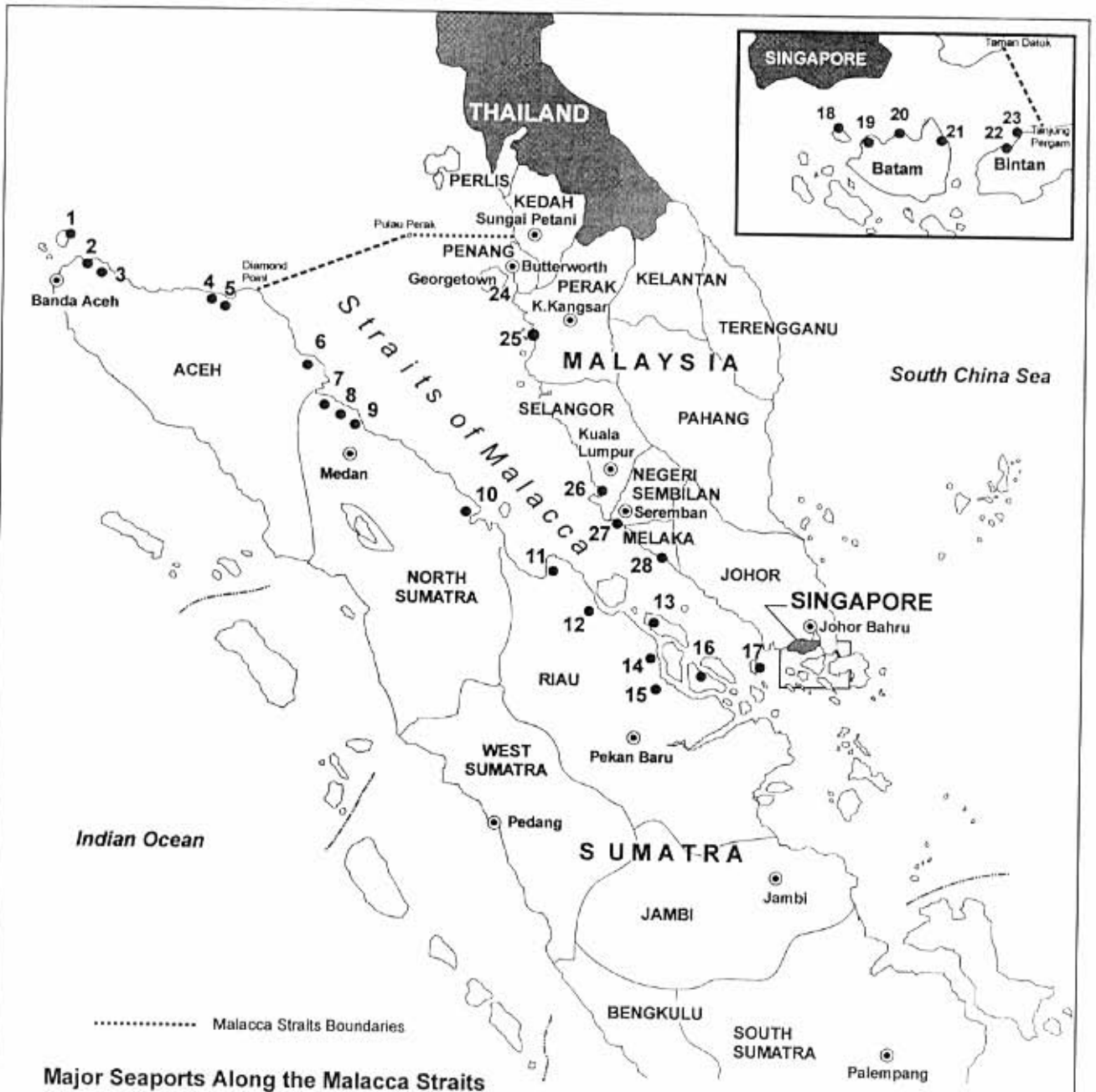
The dominant group of the eastern Sumatran islands that borders the Malacca Straits is the Riau Archipelago. The offshore coastal zone of the Malacca Straits consists of many islands (241 islands), coral reefs, estuaries, deltas and lagoons, apart from being an important international waterway and rich fishing ground.

The Straits of Malacca, Java Sea, southern part of South China Sea and Gulf of Thailand together form the extensive Sunda Shelf which joins the western part of Southeast Asia to the continental shelf of Asia at depths of less than 200 m. The depth of the Straits increases from 30 m at its most narrow part to more than 100 m towards the continental slope of the Andaman Sea. The strong undercurrent that enters the Straits at its northeast entrance forms large ripples in the sediments of the sea floor.

Climate and weather

The tropical climate of the Malacca Straits is strongly influenced by monsoons. The northeast monsoon, which generally brings in more rains, lasts from December to February and the southwest monsoon, which is generally dry, from June to August. The rest of the year is dominated by two intermonsoon periods (March-May and September-November, respectively), when the weather conditions are rather unstable.

The Malacca Straits



Major Seaports Along the Malacca Straits

ACEH PROVINCE	NORTH SUMATRA PROVINCE	RIAU PROVINCE		MALAYSIA PENINSULA
1. Sabang	7. Pangkalan Susu	11. Bagan Siapi-api	18. Pulau Sambu	24. Penang
2. Uleelheue	8. Tanjung Beringin	12. Dumai	19. Sekupang	25. Kuala Sepetang (Port Weld)
3. Malahayati	9. Belawan	13. Bengkalis	20. Batuampar	26. Port Kelang
4. Blang Lancang	10. Tanjung Balai	14. Sungai Pakning	21. Kabil	27. Port Dickson
5. Lhokseumawe		15. Siak Sri Indrapura	22. Tanjung Uban	28. Melaka
6. Kuala Langsa		16. Selat Panjang	23. Tanjung Pinang	
		17. Tanjung Balai Karimun		

The direction of wind changes with the onset of monsoon seasons. Infrequent but strong squalls known as the "Sumatras" may occur in any month of the year. They are usually associated with thunderstorms and occur mostly in the evening or during the early part of the night, giving rise to winds gusting up to 50 knots.

Rainfall is abundant in the Malacca Straits. Torrential rains of short duration but with high intensities can occur any time of the year. Visibility in the Straits used to be good except during showers. Haze has been a regular occurrence during the past few years.

Tides, waves and currents

Tides in the Malacca Straits are mainly semi-diurnal, with two high and two low tides each lunar day. Tidal range varies from 1.6 to 3.7 meters depending on localities. In certain localities along the East Coast of Sumatra, the tidal range may rise to 4 to 5 meters due to the influence of local sea-bottom conditions.

Current flows predominantly in a northwesterly direction at 1.00 to 1.25 knots in all monsoon periods. Wave conditions are closely influenced by monsoonal winds. Stronger waves occur during the northeast monsoon (and its following intermonsoon season) than the southwest monsoon (and its following intermonsoon season).

Water temperature, salinity, turbidity and dissolved oxygen

Surface water temperatures range from 28 to 30°C during the southwest monsoon, while lower ranges of 26 to 27°C occur during the northeast monsoon. Salinity changes are strongly influenced by the run-off from large rivers on the East Coast of Sumatra and West Coast of Peninsular Malaysia, around 30.80 to 31.38 ppt at the surface and 31.33 to 31.48 ppt near the bottom of the Straits. In the open water, turbidity or water transparency may vary from 10 to 30 meters deep while in areas around the river mouths the reading is usually less than 10 meters. In the open water, surface dissolved oxygen seldom shows strong seasonal variation, with average annual variation of around 4.03 to 4.61 mg/l and 3.5 to 3.88 mg/l in the deeper water near the bottom.

Nutrients, pH and productivity

The average values of inorganic phosphate, nitrate and silicate are normally higher in water near the bottom than at the surface. The open water of the Malacca Straits is relatively alkaline, with pH values of around 7.43 to 8.13 in water near the surface, compared to 7.38 to 8.25 near the bottom. Primary productivity of the water in the southern part of the Malacca Straits is higher than in the northern part.

Coastal erosion/sedimentation and drainage system

Coastal erosion affects almost every state in Malaysia, being particularly alarming for several of the West Coast states of Peninsular Malaysia fronting the Malacca Straits. Erosion brings about siltation and sedimentation. As a result of the siltation, the river mouths or ports and harbors suffer inadequate draft for navigation, restricting the passage of large vessels and causing heavy investments in dredging work.

Coastal erosion is much more serious in the northern portion than in the central portion of the East Coast of Sumatra. The acceleration of this coastal erosion is largely attributed to the uncontrolled conversion of naturally vegetated upland areas to agricultural use.

In Singapore, large-scale land reclamation schemes were carried out over the last two decades, which have created lands used for residential housing, industrial estates, recreational facilities, parks, expressways and extending airport facilities. The reclamation has contributed to the social and economic development of the country but some negative impacts on the coastal environment were experienced. These impacts include the loss of natural coastline, threat to marine life and burial of corals due to siltation.

The extent and causes of coastal erosion, siltation and sedimentation around the coastal zone of the Malacca Straits are described in detail in the profile. Control strategies to solve the problems of coastal erosion and siltation taken by the littoral States are stated.

Importance of the Malacca Straits

The Malacca Straits is:

- Historically an important sea route for local and international trade and shipping traffic. It is also one of the world's busiest sea lanes vital to the economic development of the littoral States and East Asian countries;
- A major shipping route for petroleum oil tankers. In 1993, on average, around 98 to 100 oil tankers carrying about 7.0 million barrels of oil cruised the Straits daily;
- A unique, tropical estuarine environment rich in renewable and nonrenewable natural resources; and
- One of the international straits highly vulnerable to pollution risks, high incidence of marine casualties and oil spills.

Demographic Characteristics

The present population of the three littoral States of the Malacca Straits is as follows: 197.6, 20.1 and 2.8 million for Indonesia, Malaysia and Singapore, respectively, with the corresponding growth rates for the last two decades at around 1.77 to 2.41, 2.32 to 2.60 and 1.03 to 1.74%, respectively. Singapore has maintained the lowest growth rate among the three countries. A significant characteristic of Singapore is the gradual increase in the "greying population". After the year 2030, more than half of the population in Singapore will be over 60 years old. Such a characteristic is not so significant with either the Indonesian or Malaysian population. Lower percentages of the population will be over 60 years old after the year 2030 (around 24%) for both Malaysia and Indonesia. The eight States along the West Coast of Peninsular Malaysia that border the Malacca Straits are highly populated, with a total population of around 13.78 million in 1994, accounting for more than 65% the national population of Malaysia. Other relevant demographic features for the three littoral States are presented.

Coastal and Marine Living Resources: Exploitation and Utilization

Fisheries and aquaculture

Capture fisheries are extensive along the Malacca Straits with a variety of demersal, pelagic and shrimp species being harvested. In 1993, the fish landings, number of fishermen and boats for both the Indonesian and Malaysian portions of the Malacca Straits stood at 884,159 metric tonnes, 245,161 and 66,723, respectively. Even though Indonesia employs a greater number of fishermen and boats, the fish landings for Indonesia and Malaysia are about the same along the Malacca Straits. The local landings from Singapore-based fishermen are minor and the nation is dependent on imports of fish from Malaysia and Indonesia.

Aquaculture is practiced widely along the Indonesian and Malaysian portions of the Malacca Straits. The extent of aquaculture growth in Malaysia is apparent if one considers that the total aquaculture production increased from 52,303 metric tons (MT) valued at RM132.8 million in 1990, to 103,723 MT valued at RM298.4 million in 1993. Brackishwater ponds also dominate the coastal areas of eastern Sumatra that border the Malacca Straits. Prawns and milkfish are cultivated. In 1991, some 41,494 ha of brackishwater ponds were in existence. It has been estimated that a further 114,000 ha of potential land are suitable for brackishwater pond cultivation. Brackishwater pond culture predominates in Aceh followed to a lesser extent in North Sumatra and Riau Provinces. Aquaculture activities in Singapore are quite limited compared to those in Indonesia and Malaysia.

Mangrove resources

The mangrove reserves of Indonesia, Malaysia and Singapore comprise some 386,100 ha, 111,409 ha and 600 ha, respectively. The mangroves in the region are used for a variety of purposes such as charcoal, fuelwood, poles for construction, dyes, etc. In addition, mangrove areas serve as breeding and nursery grounds for a variety of species and help support the local fisheries. They also have value in terms of recreational and tourism related uses. Therefore, mangrove forests play a crucial role in the welfare of the local inhabitants either directly or indirectly. Data are presented on the economic benefits generated from the different types of mangrove utilization. The case of the Matang forest reserve in Malaysia is highlighted with regard to the benefits derived from a well-managed mangrove forest reserve. However, mangroves are fast disappearing as a result of conversion into aquaculture ponds and industrial, urban and other non-sustainable purposes. Policies and management issues related to conservation and sustainable exploitation of mangrove forests are discussed.

Coral reef resources

As a whole, coral reef resources in the Straits of Malacca and Singapore are not highly developed because of the relatively turbid conditions and fluctuating salinity. Along the West Coast of Peninsular Malaysia, the coral reefs are mostly found around the islands of Pulau Sembilan, Pulau Pangkor and Pulau Langkawi and off the coast of Port Dickson. Along the East Coast of Sumatra, coral reefs are concentrated mostly around the Riau Archipelago and with small patches occurring at the northeastern tip of Sumatra. Coral reefs also occur along the southern islands of Singapore.

The economic value of coral reefs stems from their use as building material, supply of marine and ornamental fishes, support for commercial fish species and tourism. In addition, they serve as natural breakwater to protect low-lying coastal areas from erosion and the destructive actions of the sea.

Seagrass resources

Several species of seagrass are found along the Malacca Straits. Their distribution is less extensive compared to other ASEAN locations. Seagrasses can be found in the Riau Archipelago, Cape Rochado, Port Dickson, locations around Langkawi Island and at several sites around Singapore.

Seagrasses can be used as material for household construction purposes, fiber for insulation, upholstery and packing, fertilizer and fodder, food and medicine and chemicals. In addition, seagrasses can serve as habitats for a variety of species, i.e., sea cow (*Dugong dugong*), green turtles (*Chelonia midas*), molluscs, shrimps, etc. Recently it has been noted by researchers that seagrasses are a much neglected resource and are under severe threat from human impacts.

Biodiversity

The Malacca Straits is located within a zone of high biodiversity and rich habitats characteristic of estuarine environments. They support a number of flora and fauna. The region also has important turtle nesting sites for species such as *Chelonia midas* and *Eretmochelys imbricata* and for a number of sea bird breeding colonies such as brown booby, brown noddy, black-naped, birdled and roseate terns and milky terns and also for waterfowls. A number of protected areas have been delineated for conserving biodiversity.

Non-Living Coastal and Marine Resources: Exploitation and Utilization

Mineral and oil resources

Oil is being exploited along the East Coast of Sumatra Island. Potential recoverable reserves of oil and gas from three major basins in the region are believed to be of the order of 8 billion barrels. The major offshore regions include the Arun fields in Aceh and the basins around the Riau islands. The oil and gas fields support a number of refineries in the region. So far, no oil has been produced along the Malaysian section of the

Malacca Straits but contract areas have been assigned for exploration purposes. Some of the other minerals that are exploited in the region include tin, bauxite, granite, kaolin and sand.

Coastal tourism resources

The Malacca Straits is located in one of the most rapid tourist growth areas in the Asia-Pacific region. Several major tourist resorts and beaches are found in the Malacca Straits region. These have contributed to the socioeconomic development of the localities where they are located. They have however also brought about some negative impacts to the region.

The location and facilities of several of the major resorts along the Malaysian portion of the Straits are discussed. Likewise Indonesia also has a great many marine tourist spots along the Malacca Straits. One of the main gateways for tourists coming to Indonesia used to be Medan but in recent years the development of the resort islands of Bintan and Batam have become the major tourist focus in the region. Several major resort areas have been developed along the coast of Singapore, including the East Coast, Changi, Pasir Ris-Loyang and Sentosa Island.

Growth triangles

The ASEAN member nations believe that their economies would benefit considerably if there was greater economic complementarity instead of competition. This has been put into practice with the development of the growth triangles in the southern and the northern entrances of the Malacca Straits.

The growth triangle at the southeastern entrance links Singapore, State of Johor (Malaysia) and Riau Province and has the acronym SIJORI. The activities of this growth triangle have been focused mainly on Bintan and Batam Islands. The second growth triangle has the acronym IMT (Indonesia-Malaysia-Thailand). This has been developed along the northern entrance and links North Sumatra and Aceh of Indonesia, five provinces of southern Thailand and four northern states of Malaysia.

Maritime Trade and Development

Shipping industry and national economies

The development of the industrialization programs by the Newly Industrializing Economies (NIEs) of Singapore, Hong Kong, Taiwan and South Korea, as well as other Asian countries during the last two decades has resulted in:

- an increased demand for oil;
- an increase in shipping traffic in response to increased trade between East Asian countries and the rest of the world; and
- a change in the composition of traffic through the Malacca Straits.

Thus, besides an increase in the traditional tanker traffic that brings oil produced in the Middle East, there was also an increased volume of reciprocal traffic bringing manufactured goods from East Asian countries to West Asia and beyond. During the past two decades, shipping traffic in the Malacca Straits rose from an average of 119 vessels transiting the Straits daily in 1982 to around 274 vessels daily in 1993. Shipping traffic in the Malacca Straits is projected to increase further to around 598 vessels daily by the year 2000. Maritime accidents in this congested waterway also showed an increasing trend.

The Malacca Straits is vital to the economies of the bordering States in that it serves as transport link among the littoral States and their trading partners. It provides the shortest and less costly shipping route compared to other alternative Asian straits.

Detailed descriptions of the shipping traffic and maritime trade development in the Malacca Straits and how these contribute to the national economies of the littoral States are provided.

The oil industry and national economies

The oil production/refining enterprises along the Malacca Straits have developed into centers of economic activities. New ports have developed and existing ports expanded in the vicinity of these companies; industrial complexes associated with seaborne transport and raw material sources have been set up and in many cases, changes have occurred in the urban population.

Almost all the oil fields in the Malacca Straits are located off and along the East Coast of Sumatra Island, Indonesia. Offshore and onshore oil production in Sumatra contributes greatly to the total oil production in Indonesia. Offshore oil production from the Malacca Straits amounts to 55,000 bpd and represents 0.04% of the national component and 0.11% of the offshore. A major natural gas field (Arun field) is located northeast of the Sumatra Island, near the northwest entrance of the Malacca Straits. Arun gas field contributes around 47% of Indonesia's total gas production, with an output of around 12 trillion cubic feet (tcf) annually. In this document, the status of petroleum oil and natural gas production around the Malacca Straits is described. Their contributions to the national economies of the littoral States are assessed.

The total oil refining capacity by the refineries located along the Malacca Straits as of 1 January 1995 was estimated to be around 1.54 million bpd. Among the three littoral States, Singapore has the highest refining capacity which constitutes about 72.43% of the total; Malaysia, 16.72%; and Indonesia, 11.30%. The demand for refined petroleum products in the Asia-Pacific region is expected to increase by around 14.25% in 1993-1997 and the supply from the region's refineries is predicted to increase by around 15.07% over the same period. There are numerous plans for increasing the refining capacity in the region and if these plans were to materialize, it would add another 6 million bpd to Asia's refining capacity by the year 2000. Detailed narrations of the oil refineries located along the Malacca Straits are provided and their contribution to the national economic development of the littoral States is assessed.

Port and Harbor Development

The major commercial ports/harbors located along the Malacca Straits include the following:

- Port of Singapore at the southern tip of Peninsular Malaysia;
- Pasir Gudang, Malacca Port, Port Dickson, Port Klang, Lumut and Penang along the West Coast of Peninsular Malaysia; and
- Tanjung Uban, Sambu, Bengkalis, Sungai Pakning, Dumai, Belawan, Pangkalan Susu and Lhokseumawe along the East Coast of Sumatra Island, Indonesia.

Among them, the Port of Singapore is the largest and the busiest port in this region. The port has invested heavily in modern cargo handling facilities. In 1993, the total amount of cargo handled by the Port of Singapore amounted to around 273.7 million freight tons (FWT), of which the mineral oil constituted 123.5 million FWT and general/dry cargo, 150.2 million FWT. Besides being the busiest commercial port, Singapore is also one of the major shipbuilding, rigbuilding and ship repair centers of the world.

Port Klang is the largest port in Malaysia. It handles about 30% of Malaysia's total shipborne cargo. All the port's operational services have been privatized in line with the Government's privatization policy. Cargo traffic in Port Klang reached 943,846 TEUs (Ten-foot Equivalent Units) in 1994. Belawan Port is the largest among all the Indonesian ports located along the East Coast of Sumatra Island, while Dumai and Lhokseumawe also have well-developed oil terminals serving the oil industry on the island.

Detailed descriptions are provided with regard to the cargo/shipping traffic and other maritime activities, as well as the present and future developments of all the major ports located along the Malacca Straits.

Marine Pollution

Pollution from land-based sources

Land-based sources are thought to contribute as much as 70% of the pollution in the marine environment. The pollutants originate from urban, agricultural and industrial activities. Wastes generated from these activities are discharged either directly into the Straits or into the coastal rivers emptying into the Straits. The wastes discharged include organic material, suspended solids, heavy metals, petroleum hydrocarbons, synthetic organic compounds and sewage.

Pollution loads and waste management facilities and services are examined. Attention is focused upon the control strategies, actions plans, legislation and management measures for dealing with land-based pollutants.

Pollution from sea-based sources

With regard to sea-based sources of pollution, accidental oil spills and oily discharges attributable to regular shipping activities and the operation of offshore oil and gas platforms are recognized. Other sea-based sources of pollution include leaching of anti-fouling paints from vessels and offshore platforms and the introduction of unwanted aquatic species through ballast water exchange. The deliberate dumping of wastes from vessels, platforms and other man-made structures and discharges from aquaculture installations and harbor dredging are also identified.

Even though oil spills are low frequency events, the threats that they pose are quite considerable. As the economies of the region grow, the risk increases and a large oil spill could have devastating effects on the fishing, tourism and aquaculture industries in the Straits. The three littoral States have undertaken several initiatives, legislations and management plans over the years to address the issue.

Marine pollution impacts

Major causes of concern for marine pollution in the Straits are heavy metal contamination, nutrient loading leading to harmful algal blooms, fecal coliform contamination, tributyl tin contamination, oil and chemical spills and erosion/sedimentation. The level of contamination and the impact of these pollutants on human and ecosystem health are examined. Fish kills, recent incidents of algal blooms and paralytic shellfish poisoning and pollution hot spots of heavy metals and hydrocarbons are testimony to the degradation of the marine environment in the Malacca Straits.

Policies and Management Practices

Indonesia

In Indonesia, the agency responsible for environmental management is the Office of the State Minister on Environment. The agency is responsible for coordinating national efforts on environmental matters including the drafting of laws and regulations and the establishment of environmental standards. The National Committee on Marine and Coastal Environment is involved in the preparation of rules and regulations of the development and management of marine and coastal areas. Another important agency in Indonesia is BAPEDAL, the Environmental Impact Control Agency.

Malaysia

The department responsible for the management of environmental affairs in Malaysia is the Department of Environment. The legislations and regulations related to the management of marine environment can be broken into three major classes:

- Industrial Waste and Wastewater Pollution Control
- Sea Pollution Control
- Control of Hazardous Wastes

Malaysia has also made it a requirement to carry out environmental impact assessment reports for some 19 classes of "prescribed activities" within the Environmental Quality Order of 1987.

Singapore

Singapore's Ministry of Environment is the agency responsible for the management of the marine environment. As Singapore has grown economically, the government has made sure that the environment is protected adequately from economic development. As in Malaysia and Indonesia, Singapore has legislations to deal with the control of industrial waste, sea pollution and hazardous waste. Singapore's licensing system is based on a polluter pays principle and it has strict pollution control regulations and enforcement.

In addition to strengthening national efforts towards marine pollution, all three of the Malacca Straits littoral States participate in several regional and international cooperation arrangements such as ASEAN-COST, ASOEN, CCOP, ASCOPE, COBSEA, UNEP, etc. This reflects the serious intention of these States to work together to protect the marine environment.

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Malaysia

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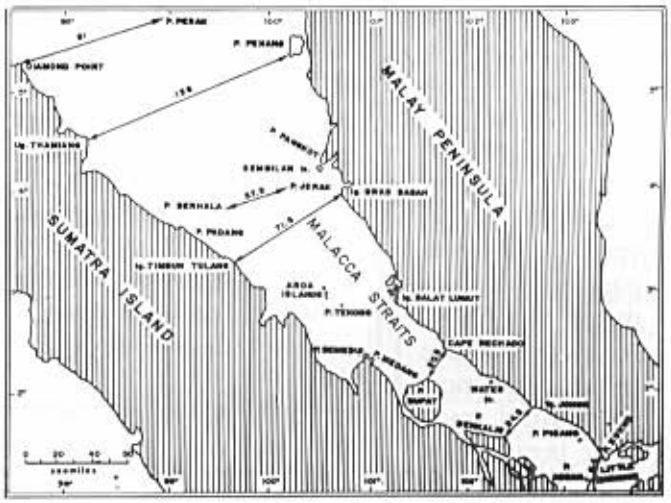
Chapter 1

INTRODUCTION

Geographical Coverage

The Strait of Malacca is situated between the East Coast of Sumatra island and West Coast of Peninsular Malaysia. It is contiguous with the Strait of Singapore at its southeast end, forming an international shipping route linking the Indian Ocean (via the Andaman Sea) with the South China Sea to the Pacific Ocean. Along this waterway, there are at least another three smaller straits: between the islands of Bengkali and Sumatra (Bengkali Strait), Rupat and Sumatra (Rupat Strait), as well as between the southern tip of Peninsular Malaysia and the north coast of Singapore (Johor Strait). Together, the straits form a significant ecosystem. In this report, reference to the **Straits of Malacca** or the **Malacca Straits** includes all straits within the international waterway.

Figure 1.1. Geographical Coverage of the Malacca Straits (Chin, 1993).



(a). Indonesian and Malaysian Portions of the Malacca Straits.

The Malacca Straits is about 600 nautical miles (nm) or 1,000 km long (Chin, 1993; Forbes, 1995). The northwest entrance of the Straits, which links to the Indian Ocean via the Andaman Sea, is either between Pulau Perak (Malaysia) and Diamond Point (Indonesia), with a width of around 91 nm, or between Penang (Malaysia) and Ujung Thamiang (Indonesia), which is around 126 nm wide. The southeast entrance, which links the Straits to the Pacific Ocean via the South China Sea, is between Tahan Datok (Malaysia) and Tanjung Pergam (Indonesia). This southeast entrance is only around 11.1 nm wide (*Figure 1.1*). The widest section of the Straits is found at its northwest entrance, narrowing gradually to 8 to 9 nm near the southeast entrance, around the Riau Archipelago. The occurrence of numerous sand banks, shoals and rocks in this southeast portion of the Straits further restricts the shipping channel between Pulau Senang (Singapore) and Pulau Takong Besar (Indonesia) to about 3.2 nm or 5 km wide (Jaafar and Valencia, 1985a, 1985b; Burbridge, 1988;

Figure 1.1. Geographical Coverage of the Malacca Straits (Chin, 1993).



(b). Singaporean Portion of the Malacca Straits.

Danusaputro, 1988; Schoolman, 1991; Lee, 1994; Forbes, 1995; Ibrahim, R., 1995). The water depth in the Straits varies from 9.5 to 30 fathoms (17 to 55 m).

Significance of the Malacca Straits

- *Historically an important sea route for local and international trade and shipping traffic.* The Straits is of vital importance to both the littoral States and major trading countries in the world. It is the world's second busiest waterway after the English Channel, with an estimated 274 vessels of all types passing through daily (Chin, 1993). It provides the shortest and most economical trade route between the Indian Ocean and the South China Sea. It is an important international sea lane that plays a key role to the traffic of more than 29 million "ten-foot equivalent units" (TEUs) or standard shipping containers of cargo by the nine (out of the world's 20) largest container ports which are clustered within the shipping corridor between Singapore and Japan. Rapid economic development in the East Asian region during the last two decades has resulted in a substantial increase in shipping traffic which will likely continue at an even greater pace in the future (Ross et al., 1995).

Box 1.1.

MALACCA STRAITS: IMPORTANT MARITIME, ENVIRONMENTAL AND RESOURCE MANAGEMENT ACTIVITIES

- One of the world's busiest sea lanes for international navigation vital to economic development of both the littoral States and East Asian countries.
- An important sea route for oil tankers. On average, 98-100 tankers carrying around 7.0 million barrels of oil cruise the Straits daily.
- High incidence of marine casualties and oil spills.
- A unique tropical estuarine environment rich in renewable and non-renewable natural resources.
- An international strait highly vulnerable to pollution risks.

- *A major international shipping route for petroleum oil tankers.* Between 1987 and 1993, on average, 201 ships were reported to traverse the Straits each day and 35.8% of them were oil tankers (Naidu, 1994). About 3.23 million barrels of crude oil are shipped daily via the Straits to the East Asian region, while 3.81 million barrels of crude oil and refined products are transported from the region en route to Japan through the South China Sea (Cheevaporn, 1995).

The Straits is also the shortest route for oil tankers plying between the oil-rich and oil-exporting Middle East and industrialized Japan; about 90% of Japan's required oil passes through the Straits from the Middle East (Lee, 1994).

- *Unique, tropical estuarine environment (salinity less than 35 ppt) rich in renewable and non-renewable natural resources.* The Malacca Straits is rich in renewable and non-renewable natural resources, e.g., fishery products, oil, gas, tin, etc. Economies of the three littoral States (Indonesia, Malaysia and Singapore) rely greatly either on the production of these rich natural resources or on trade/shipping businesses associated with the Straits (Burbridge, 1988; Naidu, 1994).

- *One of the international straits that is highly vulnerable to pollution risks.* The increased maritime activities and rapid industrial developments along the coastal areas of the littoral States generate high levels of harmful pollutants, causing deterioration of the Straits' marine and coastal ecosystems. Maritime activities have substantially increased the incidence of oil spills, posing pollution threat to the Straits. The historically important shipping industry, particularly oil tankers, pose a serious threat to living coastal resources (Paw and Diamante, 1995).

With the dynamic economic development occurring in the Asia-Pacific region, the Malacca Straits will be utilized even more by ships.

Purpose of This Environmental Profile

This document is intended to:

- provide an inventory of resources in the Malacca

Straits, with special reference to pollution risks;
- compile the existing management policies, strategies, practices and initiatives taken by littoral States, regional and international organizations in the management of the Straits' pollution risks arising from the land- and sea-based sources; and
- identify information sources which will serve as a basis for the preparation of a management atlas, i.e., an information reference for management decision-making.

This document forms part of the Malacca Straits Demonstration Project which is a component of the GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas.

BOX 1.2.

MALACCA STRAITS DEMONSTRATION PROJECT PRIORITIES

- Environmental profile of the Malacca Straits.
- Marine pollution risk assessment.
- Marine pollution prevention measures in the Malacca Straits.
- Implementation of marine pollution-related international conventions.
- The need and feasibility of designating the Malacca Straits as a special area under MARPOL 73/78.
- Preparedness and response strategies to combat oil pollution in the Malacca Straits.
- Capacity building.

Definitions

The following definitions and terminologies have been adopted in the profile.

Archipelago and archipelagic state

UNCLOS III: PART IV (ARCHIPELAGIC STATES) Article 46 provides the following definitions for *Archipelagic State* and *Archipelago*:

Archipelagic State: A State constituted wholly by one or more archipelagos and may include other islands.

Archipelago: A group of islands including parts of islands, interconnecting waters and other natural features which are so closely inter-related that such islands, waters and other natural features form an intrinsic geographic, economic and political entity, or which historically have been regarded as such.

Coastal zone

Several definitions of *coastal zone* have been adopted by various sources. Johnston and Pross (1975) suggested that, for intellectual purposes, the definition should be sufficiently broad to include functional, ecological and geographical considerations. They cited the working definition adopted by the Coastal Zone Workshop at Woods Hole in May-June 1972 as the most appropriate. The definition reads as follows:

> *The coastal zone is the band of dry land and adjacent ocean space (water and submerged land) in which ecology and use directly affect ocean space and vice versa. The coastal zone is a band of variable width which borders the continents, the inland seas and the Great Lakes. Functionally, it is the broad interface between land and water where production, consumption and exchange processes occur at high rates of intensity. Ecologically, it is an area of dynamic biogeochemical activity, but with limited capacity for supporting various forms of human use. Geographically, the landward boundary of the coastal zone is necessarily vague. The oceans may affect climate far inland from the sea. Ocean salt penetrates estuaries to various extents, depending largely upon the geometry of the estuary and river flow and ocean tides may extend even further upstream than salt penetration. Pollutants added even to the freshwater part of a river ultimately reach the sea after passing through the estuary. The seaward boundary is easier to define scientifically, but it has been the cause of extensive political argument and disagreement. Coastal waters differ chemically from those of the open sea, even in areas where man's impact is minimal. Generally, the coastal water can be identified at least to the edge of the continental shelf (depth of 200 m), but the influence of major rivers may extend many miles beyond this boundary. For the purpose of the Coastal Zone Workshop, the seaward boundary has been defined as the extent to which man's land-based activities have a measurable influence on the chemistry of the water or on the ecology of marine life.*

Hail (1980) further defined *coastal zone* as "*an area of variable width which extends seaward to the edge of the*

continental shelf, but which has no distinct landward demarcation. It is within this zone that man's activities can interrupt or destroy natural systems (ecosystems) and natural processes whether they are biological, chemical or physical". Mastura (1992) argued that although there exist many definitions of *coastal zone*, it is important that delimitation of the zone should be flexible, taking into consideration the area where influences from the land are significant and its uses are constantly in conflict. Danusaputro (1988) suggested that if we were to adopt the Woods Hole's working definition to apply to the Straits of Malacca, the Straits itself plus the coastal areas of the West Coast of Peninsular Malaysia, East Coast of Sumatra and Singapore would thus constitute one coastal zone. The total area of the Malacca Straits also lies within the Sunda continental shelf (Burbridge, 1988).

In 1992, the Malaysian Government commissioned three Technical Working Groups (TWGs) to investigate the problems of erosion along the country's coastal areas and to draw up recommendations to combat the erosion. The first group of TWGs (TWG-I) which is responsible for the compilation of an inventory of the coastal resources and their utilization has made a relatively specific definition of *coastal zone* as follows (Ibrahim, E.I., 1993):

Onshore (limit)

- *The inner landward limit is 5 km from the coastline (shoreline);*
- *If the coastal zone is lined with mangrove/nipah swamps, then the coastal zone extends 5 km from the inner boundary (landward side) of the swamp;*
- *If the coastal zone is covered by peat swamps, then the coastal zone starts from the shoreline to the inner limit (landward side) of the swamp that could be more than 5 km in width.*

Offshore (limit)

The seaward limit is the Exclusive Economic Zone (EEZ) i.e. 200 nautical miles from the coastline (shoreline).

The rationale for choosing a 5-km landward boundary and the EEZ to define the coastal zone, as given by the TWG-I, is that the former encompasses areas which are facing immediate danger from coastal erosion while the latter represents the outermost limit for Malaysia's offshore economic activities.

Marine pollution

GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution) has defined *marine pollution* as:

The introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water and reduction of amenities (GESAMP, 1990b, 1991).

A similarly worded definition was adopted by the Third United Nations Convention on the Law of the Sea (UNCLOS III) (Chua, 1994):

Pollution of marine environment means the introduction by man, directly, or indirectly, of substances or energy into the marine environment, including estuaries, which results or is ***likely to result*** *in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.*

Sea lane

Sea lane is simply defined as a standard navigational route for ships traversing an ocean or sea. It is also known as a shipping lane. The definition of shipping lanes can be clarified by examining Article 41 of UNCLOS III, which concerns both shipping lanes and traffic separation schemes:

1. *In conformity with this Part, States bordering straits may designate sea lanes and prescribe traffic separation schemes for navigation in straits where necessary to promote the safe passage of ships.*
2. *Such States may, when circumstances require and after giving due publicity thereto, substitute other sea traffic separation schemes for any sea lanes or traffic separation schemes previously designated or prescribed by them.*

3. *Such sea lanes and traffic separation schemes shall conform to generally accepted international regulations.*
4. *Before designating or substituting sea lanes or prescribing or substituting traffic separation schemes, States bordering straits shall refer proposals to the competent international organization with a view to their adoption. The organization may adopt only such sea lanes and traffic separation schemes as may be agreed with the states bordering the straits, after which the states may designate, prescribe or substitute them.*
5. *In respect of a strait where sea lanes or traffic separation schemes through the waters of two or more States bordering the strait are being proposed, the States concerned shall co-operate in formulating proposals in consultation with the competent international organization.*
6. *States bordering straits shall clearly indicate all sea lanes and traffic separation schemes designated or prescribed by them on charts to which due publicity shall be given.*
7. *Ships in transit passage shall respect applicable sea lanes and traffic separation schemes established in accordance with this article.*

Strait

A *strait,* in simple terms, is a narrow passage of water connecting two large bodies of water. Chia and Leng (1987) in their paper **The Strategic Strait with special reference to the Malacca Straits** provided rather strict *geographical* or *legal* definitions regarding the Straits. The definitions provided by them are summarized below.

Geographical definition: A strait is a narrow sea channel separating two land areas and connecting two water bodies. In order to qualify as a strait four criteria should be met:

1. *A strait should not be artificially created. For example a canal can perform similar functions but because it is not a natural arm of the sea it is not a strait.*
2. *A strait must have a certain limited width. Thus a strait is also referred to as a contraction of the sea, implying a degree of narrowness. However, although a strait is a narrow sea channel, it is not possible to state any definitive measure.*
3. *A strait must connect two areas of the sea.*
4. *A strait must separate two areas of land. It is irrelevant whether the land masses are two continents, one continent and an island or two islands.*

Chia and Leng (1987) also added that instead of stressing the importance of topographical and physical features, a geographical definition of a strait could emphasize the functional aspect, the function being place of transfer. It is a medium of transfer through which flows of personnel, goods and services connect two territories or traverse two seas. From a purely physical perspective, straits separate territories of land. But from a functional perspective, a strait, as a place of transfer, connects both land and sea masses by traffic.

Legal definition: The legal definition provided by Chia and Leng (1987), quoted from Smith (1973), is more exact:

> *A strait is any passage whose minimum breadth is equal to or less than the combined territorial sea claim of the bordering state or states. If the passage were wider than the combined territorial sea claims, the feature would not be a legal strait because passage could be accomplished without entering the territorial sea of the littoral States.*

Chapter 2

PHYSICAL, ECOLOGICAL AND DEMOGRAPHIC CHARACTERISTICS

Hydrometeorological Characteristics

Monsoons, winds and rainfall

The tropical climate of the Malacca Straits is strongly influenced by monsoons that affect the water circulation and seasonal distribution of its physical, chemical and biological characteristics. The northeast (NE) monsoon generally brings along more rain and lasts from December to February. The southwest (SW) monsoon is generally dry, from June to August (Uktolseya, 1988). The rest of the year is dominated by two intermonsoon periods (March-May and September-November), when the weather conditions are rather unstable. The onset of monsoons is largely influenced by the movement of an intertropical convergence zone (ITCZ). The ITCZ is a zone of unstable air and heavy rainfall which migrates north and south over Indonesia, crossing the equator in May and November each year and reaching approximately 15° south in January (Uktolseya, 1988). During the NE monsoon, ITCZ generally migrates to the south and westerly winds prevail, which bring in abundant rainfall resulting in a more pronounced wet season. During the dry monsoonal season, the ITCZ migrates to the north and the winds move around to the southeast (Uktolseya, 1988).

In April, the winds are variable. With the onset of the SW monsoon, winds change from variable directions into a more stable south-southeast direction. In October, winds begin to blow in a westerly direction, changing to a predominantly north-northwest direction in November and December. In January and February, north winds prevail while by March, northeast winds become about as frequent as north winds. A unique feature of this region which may occur in any month of the year is the so-called "Sumatras", the infrequent but very strong squalls coming from the west; they are associated with thunderstorms and occur mostly in the evening or during the early part of the night (Uktolseya, 1988). These occasional thunderstorm squalls can give rise to winds gusting up to 50 knots (Kamaruzaman, 1995).

Rainfall is abundant in the Malacca Straits and torrential rain of short duration but with high intensities can occur any time of the year. The Barisan mountain range on Sumatra Island influences the usual pattern of rainfall in the Malacca Straits (Uktolseya, 1988). Westerly winds with moist air are forced upwards as they move east across the Barisan mountain range; thus, more rainfall is found in the coastal areas west of the Barisan mountain range than to its east.

Visibility in the Malacca Straits is good except during showers. Haze has been a regular occurrence during the past few years. In 1992, there was a prolonged period of thick haze reducing visibility to less than 1 kilometer (Kamaruzaman, 1995), due largely to forest fires on the Sumatra Island for several months.

Tides, waves and currents

For the sake of clarity, Uktolseya (1988) had adopted the following definitions for *tide* and *tidal current*: *"A tide is the vertical rise and fall of the water, while the tidal current is the horizontal flow of the water; thus, the tide rises and falls, but the tidal current floods and ebbs".*

Tides in the Malacca Straits are mainly semi-diurnal, with two high and two low tides each lunar day; the tidal range varies from 1.6 to 3.7 m depending on locality. For instance, at some localities in Port Kelang at the West Coast of Peninsular Malaysia, high water at spring tide could reach 5 m (Kamaruzaman, 1995). Along the East Coast of Sumatra, the mean tidal range is about 2 to 3 m except in the areas of Asahan, Indragiri and Bagan Siapi-api, the range may rise to 4 to 5 m due to the influence of local sea-bottom conditions (Uktolseya, 1988).

The surface current in the Malacca Straits flows mainly in two directions at all monsoon seasons (***Figures 2.1, 2.2, 2.3*** and ***2.4***). The dominant direction is westward from the southeast entrance (from South China Sea) to the northwest entrance (to Andaman Sea).

Figure 2.1. Surface Water Currents of Southeast Asian Seas in April (Wyrtki, 1961).

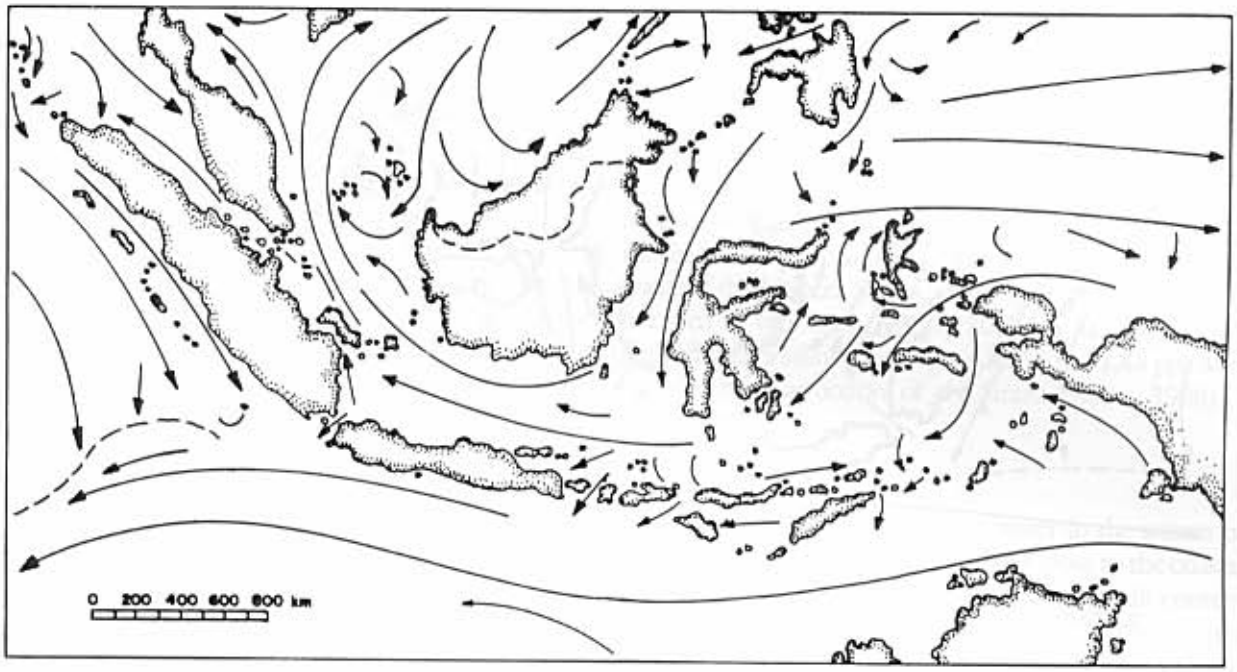


Figure 2.2. Surface Water Currents of Southeast Asian Seas in August (Wyrtki, 1961).

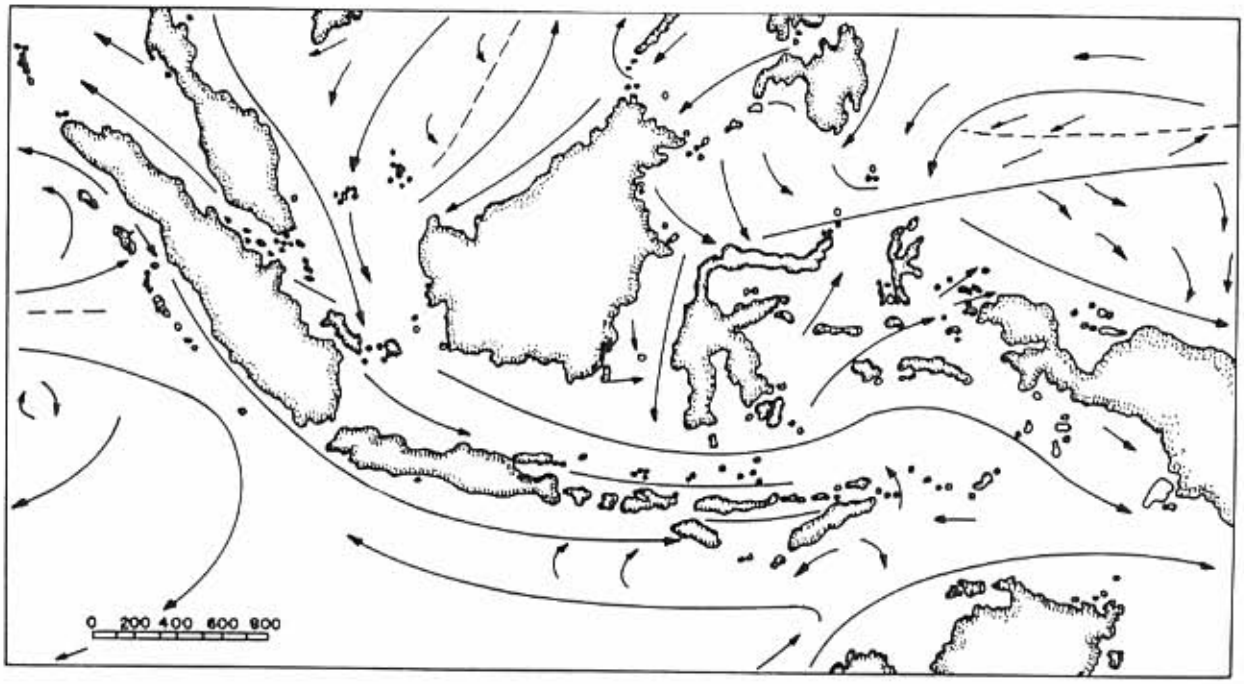


Figure 2.3. Surface Water Currents of Southeast Asian Seas in October (Wyrtki, 1961).

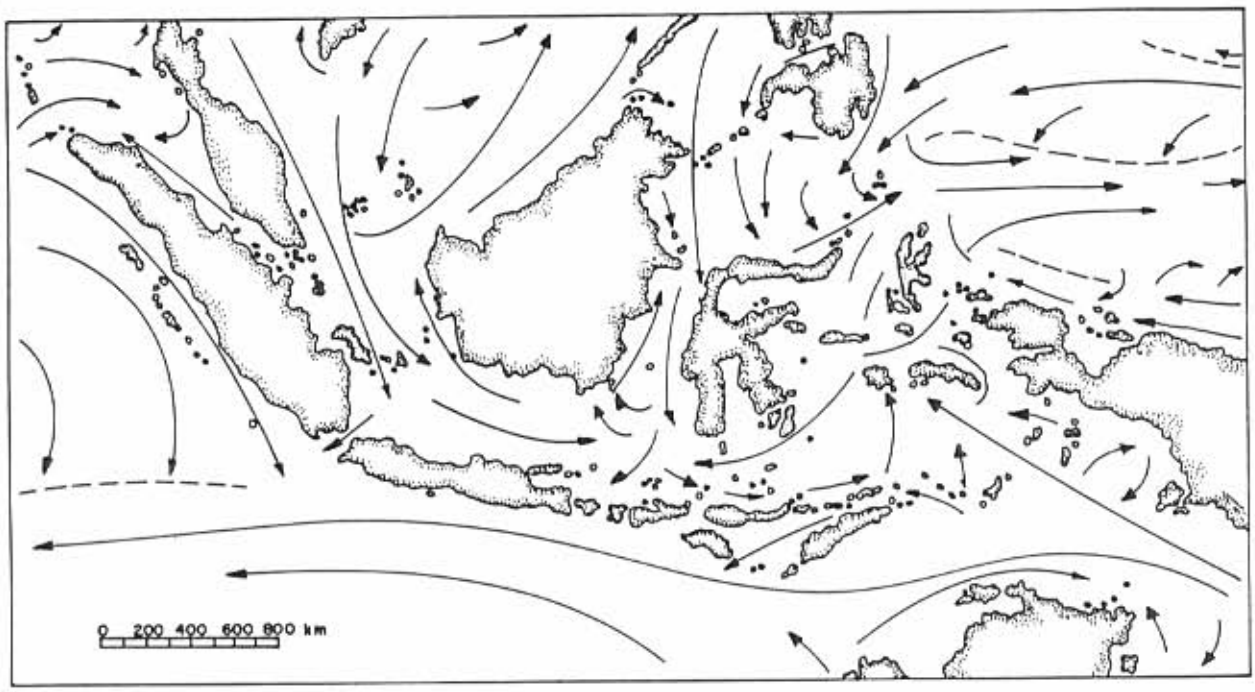
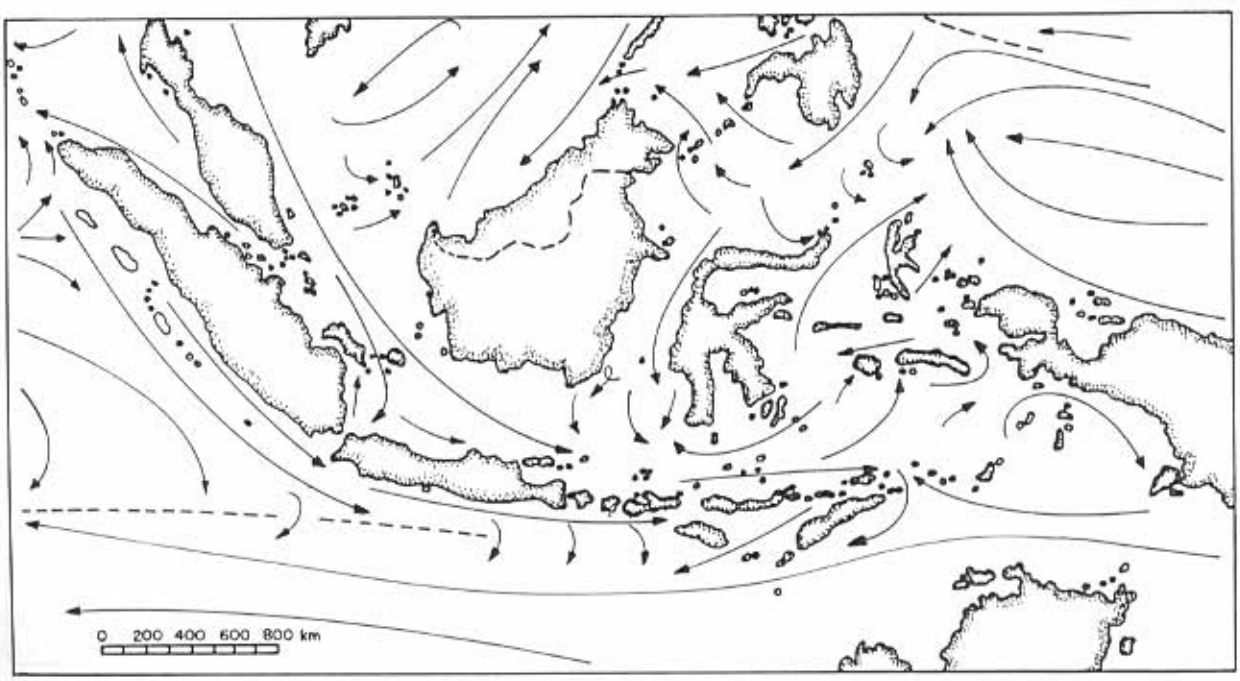


Figure 2.4. Surface Water Currents of Southeast Asian Seas in December (Wyrtki, 1961).



Another surface current enters the Straits of Malacca from its northeast entrance (coming from the Andaman Sea), but reverses itself to the northwest direction in the waters off Penang island and along the coast of Perak, Peninsular Malaysia (*Figure 2.4*; Wyrtki, 1961; Uktolseya, 1990). Although the change in monsoons does not appear to influence the direction of flow, it influences the amplitude and velocity of the surface current. Thus, the flow of the surface current is stronger during the NE monsoon, when stronger winds prevail, than during the SW monsoon (Uktolseya, 1988).

During the monsoon periods, there is an undercurrent flowing from the Andaman Sea into the western part of the Straits, which causes a light upwelling near One Fathom Bank, the water west of Port Kelang on the Malaysian coast (Wyrtki, 1961; Uktolseya, 1988). Stronger tidal currents of 3 to 4 knots were observed in narrow straits and passages around Pulau Iyu Kecil during ebb tides. At some localities in Port Kelang, strong tidal currents of over 4 knots were observed (Kamaruzaman, 1995). However, in the Dumai port area at the Sumatra coast, tidal currents were unaffected by water masses or fronts caused by coastal configuration. In the open water of the Malacca Straits, tidal currents are generally weak, flowing mainly northwesterly at 1.00 to 1.25 knots (Kamaruzaman, 1995). They merely strengthen or weaken the surface currents generated mostly by monsoonal winds.

Wave conditions in the Malacca Straits are closely influenced by monsoonal winds. Generally, winds during the NE monsoon (December-February) and its following intermonsoon period (March-May) are stronger than those during the SW monsoon (June-August) and its following intermonsoon period (September-November). Stronger waves generally occur during the former than the latter monsoon period. Thus, during the NE monsoon and its following intermonsoon period (December-May), about 27% of the waves were recorded to be lower than 1 m high, 43% lower than 1.5 m and 60% lower than 2 m while the frequencies of wave heights recorded during the SW monsoon and its following intermonsoon period (June-November) were 52%, 72% and 82% for 1, 1.5 and 2 m, respectively (Uktolseya, 1988).

Physical Characteristics

Water temperature and salinity

In the Straits of Malacca, surface water temperatures range from 28 to 30°C during the SW monsoon, while lower temperatures of 26 to 27°C are recorded during the NE monsoon (Soegiarto, 1985). The average annual range, like in other tropical waters, is less than 2°C.

In contrast to the temperature regimes which show relatively uniform changes, the salinity is highly variable due to the influence of high rainfall and freshwater run-offs from large rivers on the East Coast of Sumatra and the West Coast of Peninsular Malaysia (Uktolseya, 1988, 1990). The run-offs from rivers are largely responsible for lowering the surface salinity regime, while the monsoons that cause rainy and dry seasons play a key role in affecting the annual salinity variation. In the open water of the Malacca Straits, average surface salinities were recorded to vary from (UCD) 30.80 to 31.83 ppt while higher average salinity readings of 31.33 to 31.48 ppt were recorded near the bottom of the Straits (Moosa, 1988).

Turbidity

Turbidity or transparency of water in the waters of the Malacca Straits, particularly those close to the coastal areas, is influenced by several factors such as silt content and abundance of plankton or other particulate matter in the water. Low transparency (less than 10 m) was found in areas around the river mouths and in waters around the coasts of Sumatra and Malaysia (Soegiarto, 1985; Gomez et al., 1990). In the open water of the Malacca Straits, water transparency varies from 10 to 30 m.

Dissolved oxygen

Generally, the surface dissolved oxygen (DO) contents seldom show a strong seasonal variation in the open water of the Malacca Straits. The average annual variation was 4.03 to 4.61 mg/l near the surface and 3.51 to 3.88 mg/l in deeper water near the bottom (Simanjuntak et al., 1984). The minimum value for surface water, observed in January 1980, was 3.76 mg/l and, in January 1979, the maximum value was 5.50 mg/l. The minimum value near the bottom, observed in January 1979 was 2.03 mg/l.

DO contents in the nearshore coastal waters may show high variations from one locality to another due to the influence of land drainage and freshwater run-off from the large rivers on the coasts of Sumatra and Malaysia.

Nutrients

In the open water of the Malacca Straits, the average annual inorganic phosphate concentrations varied from 0.17 to 0.42 mg PO_4-P/l near the surface and 0.27 to 0.85 mg PO_4-P/l near the bottom. The minimum value (almost zero) was recorded in January 1980, while

the maximum value (6.60 mg PO_4-P/l) was observed near the bottom in July-August 1978. The average value of inorganic phosphate is normally higher near the bottom than near the surface (Simanjuntak et al., 1984).

The average annual nitrate concentrations varied from 0.12 to 0.98 mg NO_3-N/l near the surface and 0.21 to 3.76 mg NO_3-N/l near the bottom. Higher average nitrate values were observed in the bottom water than in the surface. Minimum value of nitrate content (0.04 mg NO_3-N/l) was observed in the surface in August-September 1980 and the maximum value (5.27 mg NO_3-N/l) was observed near the bottom in January 1980 (Simanjuntak et al., 1984).

The average annual silicate contents near the surface of the Malacca Straits varied from 1.15 to 11.13 mg SIO_3-Si/l compared to 8.41 to 11.98 mg SIO_3-Si/l near the bottom (Simanjuntak et al., 1984). Minimum value of almost zero was recorded near the surface in January 1980 and the maximum value of 27.72 mg SIO_3-Si/l was observed near the bottom in January 1979. The average silicate contents near the bottom is normally higher than near the surface.

pH values

The open water of the Malacca Straits is relatively alkaline. Average annual pH values near the surface varied from 7.43 to 8.13 compared to 7.38 to 8.25 near the bottom (Simanjuntak et al., 1984).

BOX 2.1

GENERAL HYDROMETEOROLOGICAL CHARACTERISTICS OF THE MALACCA STRAITS
(Praseno, 1984; Uktoseya, 1988, 1990; Kamaruzaman, 1995)

- Current flows predominantly in a northwesterly direction at 1.00-1.25 knots at all monsoon periods.
- Tidal range varies according to locality from 1.6 to 3.7 m; high water at spring tide in some localities of Port Kelang may reach over 5 m with a tidal current of over 4 knots.
- Tropical climate with sea conditions is generally calm. However, during the southwest monsoon (June-August) and the two intermonsoon periods (March-May and September-November), occasional thunderstorms may occur with winds gusting up to 50 knots.
- Rainfall is abundant with torrential showers of high intensities occuring at any time of the year.
- Visibility is good except during showers but haze regularly occurred in the past few years.
- Primary productivity of the water in the southern part of the Straits is higher than its northern part.

Productivity

The primary productivity and plankton counts in the open water of the Malacca Straits are summarized as follows:

- Near the surface chlorophyll content varied from 0.51 to 0.95 mg/m^3. There appeared no significant seasonal variation. Average chlorophyll content of 0.54 mg/m^3 was recorded at the northern part of the Straits where the water was deeper and more open, while higher values of 0.79 to 0.80 mg/m^3 were observed in the southern part of the Straits where the water was shallower and narrower (Setiapermana et al., 1984).
- During the NE monsoon, the zooplankton counts varied from 0.38 x 10^3/m^3 to 0.50 x 10^3/m^3 while higher zooplankton counts of 0.67 x 10^3 to 0.84 x 10^3/m^3 were recorded during the SW monsoon (Arinardi et al., 1984).
- There appeared relatively constant phytoplankton counts during both the NE and SW monsoons. The southern part of the Straits, where the water was shallower with vertical mixing and high nutrient input from rivers of the Sumatra island, showed a higher phytoplankton count (0.157 x 10^6 cells/m^3) than those (0.08 x 10^6 to 4.16 x 10^6 cells/m^3) recorded in the northern part of the Straits (Praseno, 1984).

River Systems

Indonesia

Based on the Department of Public Works record, there are 5,886 rivers distributed throughout the Indonesian archipelago. For management purposes, based on their physical and socioeconomic features, the rivers are grouped into 90 drainage systems (Hehanusa et al., 1994). There are 30 river drainage systems covering the island of Sumatra. ***Table 2.1*** lists the drainage systems located along the East Coast of Sumatra bordering the Straits of Malacca.

Table 2.1. Major River Drainage Systems in the East Coast of Sumatra Bordering the Malacca Straits.

Province	Name of the River Drainage System
Aceh	Krueng Aceh Krueng Meureudu Krueng Peusangan Krueng Jambuaye Krueng Tamiang
North Sumatra	Sungai Wampu Sungai Belawan Bahbolon Sungai Asahan Sungai Barumun
Riau	Sungai Rokan Sungai Siak Batang Kampar Batang Indragiri

The Center for R&D on Water Resources is responsible for monitoring all the major river systems in Indonesia. However, their monitoring stations are few. For example, as of 1990, the Center had only 2,900 stations for rainfall measurement (75% in Java and 25% in the rest of the archipelago) and only 1,325 gauging stations (with only 20% working properly) out of the 2,217 needed for measuring the water debit of the rivers. ***Table 2.2*** represents only approximations of river discharge and should be treated accordingly.

Based on these generalized data, the Center for R&D on Water Resources computed the per capita water availability at 71 m^3/cap/day for Aceh, 29 m^3/cap/day for North Sumatra and 109 m^3/cap/day for Riau Province.

Malaysia

There are several major rivers that empty into the Straits of Malacca, including the Perak river which is the second largest river in Malaysia, extending for about 322 km (200 miles). Other major rivers flowing into the Malacca Straits are the Muar and Muda. Most of the western rivers have relatively short courses. In the upper reaches they may drop more than 1,219 m (4,000 ft) in less than 24 km (15 miles) before reaching the flat coastal plain. ***Figure 2.5*** shows the major rivers flowing into the Malacca Straits. ***Table 2.3*** provides values of the discharge for a few of the major rivers.

Figure 2.5. Major River Basins Along West Peninsular Malaysia (Tan et al., 1994).

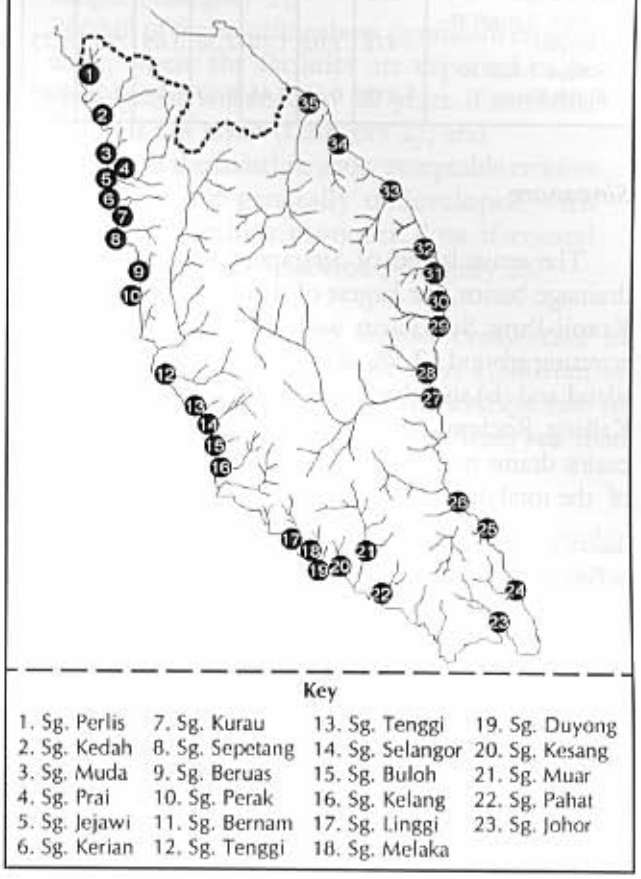


Table 2.2. Average Volumes of Annual River Discharge of the Provinces Bordering the Malacca Straits (Hehanusa et al., 1994).

Province	Area (km^2)	Rainfall (mm)	Average Discharge (m^3/sec)	Annual Discharge (million m^3)
Aceh	57,037	2,708	1,061.39	33,513
North Sumatra	72,561	2,633	1,132.63	23,994
Riau	96,346	2,509	1,889.83	36,602

Table 2.3. Discharge of Principal Rivers in West Peninsular Malaysia (Van der Leeden, 1975).
(Monthly discharge in cubic feet per second per square mile of basin area)

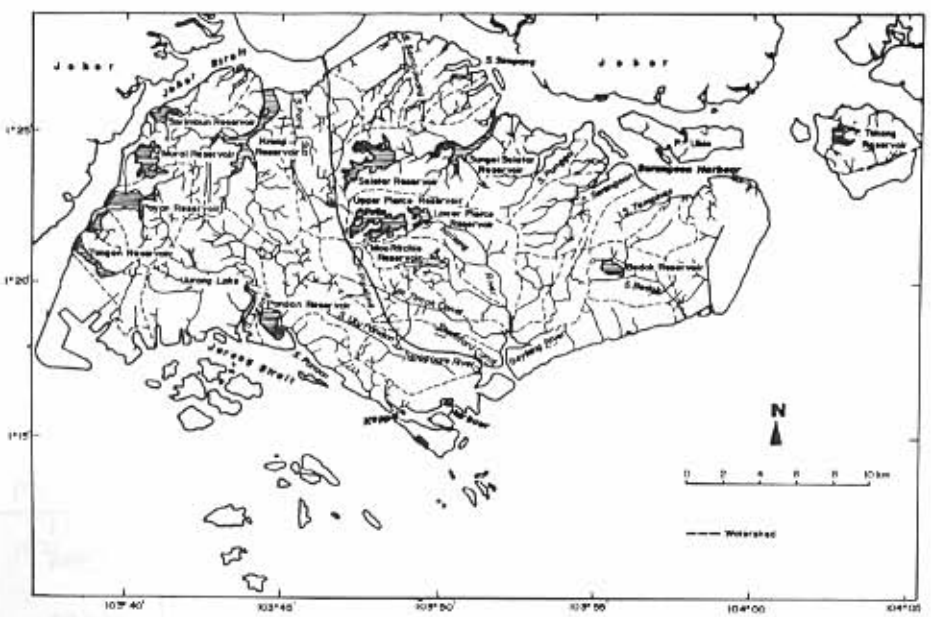
River and Basin	Area (mi²)	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Max flow	Date	Min flow	Date	Record period
Sungai Pandang Terap at Lengkuas	492	1.42	1.85	2.77	5.15	5.92	2.37	0.73	0.38	0.35	0.97	2.02	1.32	17.68	Nov. '55	0.06	Mar. '55	1946-60
Sungai Muda at Batu Pekaka	1,290	2.51	2.48	3.60	5.76	6.21	3.45	1.69	1.25	1.35	2.22	2.86	2.51	15.16	Sep. '47	0.05	Feb .'49	1947-60
Sungai Perak at Iskandar Bridge	3,000	1.93	1.83	2.29	3.91	4.81	4.17	3.80	2.57	2.11	2.40	2.96	2.18	13.30	Dec. '26	0.27	Aug. '23	1948-60
Sungai Sungkai at 8th Mile Telok Anson-Kampar	189	5.66	5.72	6.25	7.98	9.40	8.75	6.96	5.16	7.02	8.19	8.56	5.21	17.09	Dec. '55	1.43	Jul. '58	1954-60
Sungai Bernam at Lima Blas Estate	422	3.43	2.92	4.76	5.62	7.11	5.66	5.59	4.87	5.75	5.62	6.51	4.31	24.17	Jan. '51	0.73	Mar. '40	1949-55
Sungai Selangor at Rantau Pajang	560	2.28	1.85	2.76	4.80	7.55	5.83	4.72	3.22	3.89	6.42	5.82	3.27	25.15	Jan. '27	0.26	Jul. '38	1950-60
Sungai Klang at Puchong	275	2.12	2.18	2.60	4.49	4.75	4.20	3.20	2.96	3.38	4.99	4.25	2.75	20.90	Oct. '57	0.15	Sep. '49	1948-60
Sungai Langat at Dengkil	478	2.02	1.70	2.38	3.69	5.64	5.75	3.47	3.12	3.35	5.07	4.60	2.86	14.45	Jun. '54	0.32	Aug. '51	1949-60
Sungai Muar at Buloh Kasap	1,210	0.58	0.44	0.53	1.02	2.26	2.49	1.98	1.43	0.88	1.44	1.57	0.80	15.00	Dec. '54	0.05	Mar. '59	1952-60

Singapore

The main island of Singapore is divided into 40 drainage basins, the largest of them include: (a) Sungai Kranji-Pang Sua Basin with an area of 68.12 km², covering around 12.5% of the total drainage area on the island and (b) six other basins of Sungai Seletar, Jurong, Kallang, Rochore, Serangoon and Geylang; each of these basins drains more than 16 km², covering around 27% of the total drainage area on the island (*Figure 2.6*).

More than a quarter of the drains on the island flow southwards to the city area via the Kallang, Geyland and Singapore rivers (Chia et al., 1988). The concentration resulted in floods among the low-lying areas during the 1970s to 1980s. However, sustained efforts to upgrade the drainage infrastructure by the Singapore Government have significantly reduced the flood-prone areas from 3,178 ha in the 1970s to 297 ha in 1994 (MOE/ Singapore, 1995a).

Figure 2.6. Reservoirs and Drainage Systems in Singapore (Chia, 1992).



Coastal Erosion and Sedimentation

Indonesia

Coastal erosion is much more serious in the northern portion than in the central portion of the East Coast of Sumatra. The acceleration of the coastal erosion process is largely attributed to the uncontrolled conversion of naturally vegetated upland areas to agricultural use (Burbridge, 1988). The indiscriminate clearing of coastal forests has

caused downstream flooding and increased rates of siltation, as well as erosion of river banks. The river systems which are most seriously affected include the Asahan, Bilah, Kuala, Padang, Barumun, Silau, Perchut and the Bahbolon rivers in the North Sumatra Province and Arakundo, Pase and Baro rivers in Aceh (Burbridge, 1988). In Riau Province, flooding was reported in the four major rivers: the Siak, Indragiri, Kampar and Rokan rivers.

Coastal accretion. Sedimentation is believed to be the primary cause for the accretion of coastline along the eastern coastal plains of Sumatra (Vestappen, 1964, 1973). The Barisan mountain range, which stretches from the central to the southern parts of Sumatra, contains materials that can be more easily weathered and eroded compared to other mountain ranges in northern Sumatra (e.g., Pusa Gayo Range). The large rivers, such as the Rokan, Siak, Kampar and Indragiri rivers, which originate from the Barisan range and flow into the central Sumatran plain and subsequently to the Malacca Straits, yield large amounts of sedimentary materials that contribute to the accretion of coastal lands. Thus, the alluvial plain along the East Coast of Sumatra is gradually becoming narrower towards the north where sedimentation has not kept pace with the retreat of the coastline. This partially explains the greater width of the Malacca Straits at the north end of Sumatra than towards its southern portion (Vestappen, 1964, 1973). Although coastal accretion creates new land for agriculture and aquaculture, the accompanying rapid siltation could influence public and private investment. For instance, rapid siltation of the navigational channels of Bagan Siapi-api, one of Indonesia's largest fishing ports, has pushed the port hinterland some distance from the coast and access is becoming difficult; large investments have to be made for dredging and improvement of port facilities (Vestappen, 1964).

Malaysia

Malaysia has a total coastline of 4,810 km distributed as follows (Abdullah, 1992):

East Coast of Peninsular Malaysia	860 km
West Coast of Peninsular Malaysia (bordering the Malacca Straits)	1,110 km
Sabah	1,800 km
Sarawak	1,040 km

Agricultural development comprises about 48% of the total coastline while housing, transport and recreational facilities comprise another 16%. The remaining 36% is undeveloped, consisting of pristine natural environment. With the rapid land development activities in recent years, coastal erosion has become a serious problem resulting in widespread damage including loss of agricultural lands, mangrove forests, housing, road communication links and recreational beaches.

Extent of coastal erosion. Findings from the National Coastal Erosion Study on the severities of coastal erosion along the Malaysian coastlines may be summarized as follows (EPU/Malaysia, 1985; Abdullah, 1992):

- 145 km of the coastline show serious erosion, such that shore-based facilities are in imminent danger (Category 1);
- 246 km of the coastline show significant erosion areas, where the facilities are expected to be endangered within 5 to 10 years if remedial action is not taken (Category 2); and
- 975 km of the coastline show acceptable erosion areas that are generally undeveloped with consequent minor economic loss if coastal erosion continues unabated (Category 3).

Coastal erosion affects almost every state in Malaysia. It occurs along more than 1,300 km of Malaysia's 4,810 km coastline. The average rate of shoreline retreat due to erosion ranges from less than 1 m to more than 10 m per year.

More areas along the coastline of Peninsular Malaysia were badly eroded compared to those along the coastline of Sabah and Sarawak (***Table 2.4***). Of the 145 km coastline that show serious erosion (Category 1), about 131 km occur at 43 locations found along the coastline of Peninsular Malaysia; 36 locations of these critical erosion areas occur along the West Coast of Peninsular Malaysia (***Figure 2.7***).

Along the West Coast of Peninsular Malaysia, many agricultural lands are threatened by erosion. Bunds that were originally built to protect the lands have been breached by wave attacks; tidal flooding that follows the bund breach can penetrate as far as 2 km inland (Abdullah, 1992). Many existing crops of coconut, cocoa, oil palm and paddy have been damaged and soil fertility reduced. In some areas, permanent structures such as residential and commercial housing, hotels, schools and other public establishments have been or soon will be damaged as a result of the coastal erosion. Areas that show serious coastal erosion conditions are found along the coastline from Kuala

Table 2.4. Distribution of Eroding Coastline in Malaysia (Abdullah, 1992).

Area	Total Length of Coastline (km)	Category 1 (km)	Category 2 (km)	Category 3 (km)	Total Length of Eroding Coastline	
					(km)	(%)
Peninsular	1,972	131 (43)[1]	213 (57)[1]	651 (58)[1]	995 (156)[1]	73
Sabah	1,802	6 (3)	10 (7)	310 (14)	326 (24)	24
Sarawak	1,035	8 (3)	23 (11)	14 (7)	45 (21)	3
Total	**4,809**	**145**	**246 (49)**	**97 (75)**	**1,366 (79)**	**100 (203)**

[1] Number of locations along the coastline.

Perlis to Kuala Sungai Udang, western Johor and northern Kuala Selangor coasts (Mastura, 1995a).

The Director of the State Drainage and Irrigation Department (DID), Mr. Che Amran Mohd. Yusoff, told the newspaper (*New Straits Times*, 26 December 1995) that about 30 km of the northern coast of Malacca is facing serious erosion due to the natural movement of beach soil. The soil movement, as Mr. Che Amran indicated, might be due to strong undercurrents. The affected areas stretched along the coast of Malacca facing the Straits, from Pantai Klebang to Kuala Linggi up north to the Negeri Sembilan border. Studies are needed to explain this rapid movement of beach soil as in 1996 alone, four areas along the coast were severely affected (classified under Category 1) needing immediate action. These areas were not listed as serious in the 1986 national coastal erosion study. Mr. Che Amran pointed out that the last national study on coastal erosion was done in 1986 and since then the soil movement might have changed. A new and extensive study is needed especially for the West Coast of Peninsular Malaysia.

Extent of coastal siltation/sedimentation. The problem of coastal siltation or sedimentation affects a large number of river mouths and ports/harbors along the West Coast of Peninsular Malaysia. As a result of siltation, the river mouths or ports/harbors suffer inadequate draft for navigation restricting the passage of large-size vessels, as well as incur heavy investments in dred-ging (Cho, 1995). A total of 35 river mouths have been identified by the National River Mouths Improvement Study (JICA, 1994 cited by Cho, 1995) to be in critical condition, i.e., they have inadequate water depth for navigation, resulting in serious economic losses to the local fishing communities. The commercial and fishing ports along the West Coast of Peninsular Malaysia that suffered serious siltation include: Port Klang, Kuatan, Kuala Perlis and Kuala Kedah. Heavy siltation resulted in increased dredging requirements, subsequently inflating the annual maintenance cost of the ports. For instance, the annual maintenance dredging requirement for Port Klang was estimated to be 226,000 m^3 soil, while as much as 50,000 m^3 of maintenance dredging is required for the fishing ports at Kuala Perlis and Kuala Kedah (Cho, 1995).

Figure 2.7. Critical Coastal Erosion Areas in Peninsular Malaysia (Abdullah, 1992).



Causes of coastal erosion. The main causes of coastline erosion in Malaysia as cited by Zamali and Lee, 1991; Kamaludin, 1992; Mastura, 1995a, 1995b include:

- ***Storm, wave or current actions.*** Storms that frequent the monsoon periods result in wave actions causing increased offshore sediment loss. Although some materials might be brought back to the shore by the succeeding longer-period swells after the monsoons, the quantity is lesser and hence, a net erosion results.
- ***Loss of mangroves or other coastal vegetation.*** Loss of mangroves or other coastal vegetation decreases stability and exposes the shoreline to damaging wave or current actions, accelerating the coastal erosion.
- ***Human activities.*** The building of dams for irrigation, hydro-electricity and water supply, coupled with sand mining for construction along many major rivers in Peninsular Malaysia, drastically cut down the amount of sediment discharged by the rivers. The damming of rivers also resulted in a reduction of freshwater supply to the mangroves, which may result in the loss of mangroves as the availability of freshwater is important for sustenance of the mangrove ecosystem. Other human activities such as the clearance of coastal lands for agriculture and exploitation of forest products up to the peripheral limit of the mangrove lining the shore could disrupt shoreline structures causing coastal erosion. Seawalls and similar shoreline structures, if poorly sited, could concentrate and deflect wave energy at their bases, thereby accelerating erosion of the beach in front of them.

Erosion control strategy. A two-pronged strategy to solve the coastal erosion problems has been adopted by the Malaysian government since 1987 (Abdullah, 1992). This includes: (a) the short-term plan that requires structural solutions, such as the construction of seawalls, revetments and beach restoration and (b) the long-term plan, which aims to control erosion consequences by instituting non-structural measures, such as land use control. In January 1987, a National Erosion Control Council and a Coastal Engineering Technical Center were established to implement the erosion control strategy. The National Erosion Control Council decides on the priority areas to be protected and apportions development funds accordingly, while the Coastal Engineering Technical Center executes and oversees the physical implementation of the erosion control programs.

The existing legislation that controls the problem of coastal erosion is included in the "Environmental Quality Act (Prescribed Activities) (Environmental Impact Assessment) 1987". The legislation requires all developers who propose to initiate any of the prescribed activities listed under the Schedule of the Act to carry out the environmental impact assessment (EIA) study. The Schedule covers not only activities in the coastal zone but also includes any upstream development that influences the coastal environment and coastal morphology. For smaller-scale coastal development that does not fall within the ambit of the above legislation, the government has issued General Circular No. 5/1987, which empowers the Coastal Engineering Technical Center of the Drainage and Irrigation Department to control the development plan.

Technical guidelines for the development and management of the coastal zone to prevent coastal erosion in Malaysia have been drawn by the Drainage and Irrigation Department. They include the following (Ibrahim, E.I., 1995):

a) Establishment of a setback limit for coastal development from the mean high water spring mark: 60 m for sandy coastline and 400 m for a mangrove coast;
b) Provision of protective structures against erosion for any development that requires a coastal frontage (e.g., wharves or jetties);
c) Prohibition of sand mining/extraction in shallow waters and ensuring proper disposal of sand; and
d) Locating proposed development or relocating existing facilities further inland.

Singapore

Large-scale land reclamation schemes were carried out during the last two decades in order to solve the problem of land shortage for massive housing development and rapid industrialization (Chia et al., 1988; Yong et al., 1991).

From 1966 to 1992, the total area of accreted coastal lands was estimated to be around 8,316 ha or around 83 km² (***Table 2.5***). The reclaimed areas stretch to almost all the coastline of Singapore island except the northeast coast (***Figure 2.8***).

Impact of reclamation. The massive reclamation projects have created lands that could be used for constructing residential houses, industrial estates,

recreational facilities, parks, expressways and for extending airport and seaport facilities. The reclamation has contributed positively to the social and economic development of the country.

In order to mitigate these negative environmental impacts, the Department of Civil Engineering (DCE) at the National University of Singapore (NUS) in collaboration with the Port of Singapore Authority

Table 2.5. Major Land Reclamation Schemes in Singapore (Chia et al., 1988; Yong et al., 1991).

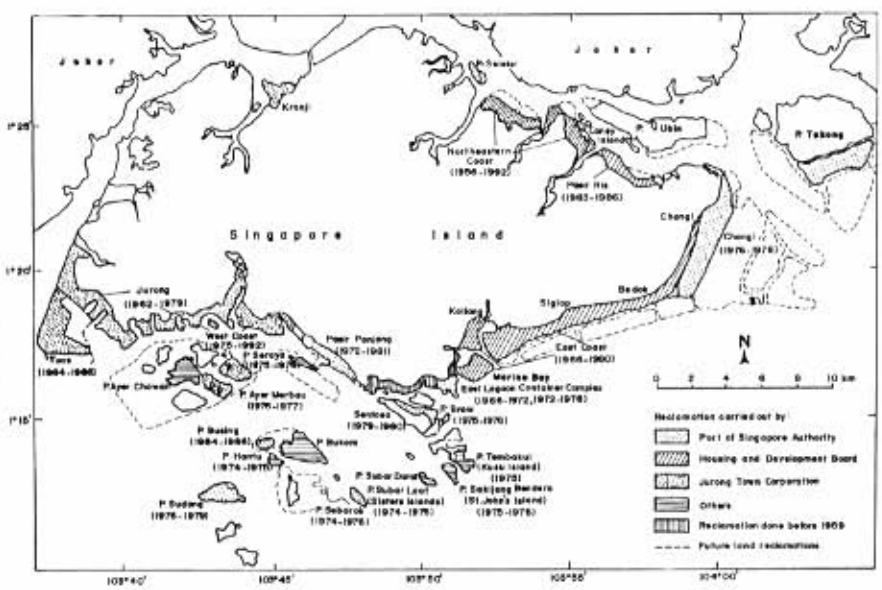
Reclamation Scheme	Period	Area[1] Reclaimed (ha)	Utilization
East Coast (seven phases)	1966-1985	1,525	Housing, parks, expressway.
Changi Airport Reclamation Project	1976-1978	663	For extension of airport facilities.
East Lagoon Container Complex Reclamation Scheme	1967-1976	23	For extension of port facilities.
Pasir Panjang Reclamation Scheme	1972-1973	61	For extension of port facilities.
West Coast Reclamation Scheme	1975-1977	89	For residential and industrial uses.
Jurong Reclamation Scheme	1984-1988	1,416	For industrial uses.
Tuas Reclamation Scheme	1984-1988	1,359	For industrial uses.
Northeastern Coast Reclamation Scheme (four phases)	1985-1992	685	For residential, recreational and industrial uses.
Offshore Island Reclamation Schemes	1975-1984	1,695	Mainly for industrial uses.
Southern Islands	Planned	800	
Total		8,316	

[1] Areas include land areas already reclaimed plus planned or undergoing projects.

However, some negative impacts on the coastal environment were inevitably experienced (Yong et al., 1991). These include the loss of natural coastline, the threat to marine life and the burial of coral reefs due to siltation. The nearshore reclamation could alter the coastal water and current flow regimes and cause high turbidity to water, as well as reduction in light penetration, which could affect the natural marine ecosystem. Low and Chou (1994c) studied the effects of sedimentation on coral reefs around the southern islands and found that over the past 20 years, the extensive reclamation work had resulted in the loss of coral reefs and other coastal habitats, as well as increased the sedimentation rates in Singapore waters.

(PSA) developed a mathematical model of the coastal region of Singapore. The model can be used to predict

Figure 2.8. Reclamation Along the Coast of the Main Island and the Offshore Islands in Singapore (Chia, 1992).


Johor
Singapore Island
Kranji
Jurong
West Coast
Pasir Panjang
Tuas
Pulau Ayer Merbau
Pulau Seraya
Pulau Bukom
Pulau Hantu
Pulau Sudong
Pulau Seboroh
Pulau Subar Darat
Pulau Subar Laut
Pulau Senang
Pulau Tekukor
Pulau Tekong
Pulau Ubin
Northeastern Coast
Pasir Ris
Changi
Changi Airport
Seletar
Sembawang
Yishun
Sungei Kadut
Kranji
Woodlands
Admiralty
Sembawang
Yishun
Ang Mo Kio
Bedok
Tampines
Pasir Ris
Serangoon
Hougang
Punggol
Sengkang
Seletar

the hydraulic effects of reclamation. To further control the reclamation works and to minimize the environmental impact, contractors carrying out the reclamation work are required to submit detailed measures to prevent siltation/pollution of surrounding sea/seabed areas (Yong et al., 1991).

Land and Sea-bottom Features

The offshore coastal zone of the Malacca Straits consists of many islands (241 islands), coral reefs, estuaries, deltas and lagoons.

The onshore topography of the West Coast of Peninsular Malaysia bordering the Malacca Straits is characterized by poorly drained coastal plains, basins, terraces, headlands and ridges of different geological origins, composition and age with coastal plains and basins dominating the landscapes (Ibrahim, E.I., 1995). The coastal plains and basins are generally formed by alluvial deposits consisting of clay, silt and organic materials belonging to the Quaternary period (Tjia, 1992). Sandy beaches are found in the form of pocket beaches hemmed in between rocky headlands in a few areas along the coastline (Abdullah, 1992).

The eastern lowlands and eastern islands (excluding the provinces of Jambi and Lampung) of the Sumatra Island together form the land component of the coastal zone of the Malacca Straits. The strip of the eastern lowlands which stretches from Aceh to the southern part of the island is approximately 88,000 km^2 or about 18% of Sumatra's total area (Burbridge, 1988). The strip narrows at both the northern and southern reaches, but forms a wide belt of 900 km long and 70-80 km wide at the central portion (Provinces of Riau and Jambi). Much of the lowlands consist of swamps and flat terrains with an elevation of no more than 5-6 m above sea level and dominated by alluvial soils with marine deposits overlaid by peat in most areas.

The dominant group of the eastern Sumatran islands that borders the Malacca Straits is the Riau Archipelago. Islands in this archipelago are made up of granitic and old sedimentary materials which are rich sources of tin and bauxite, respectively. In islands like Bintan, bauxite forms the major soil component of the landscape. The broad alluvial coastal plain of central Sumatra consists largely of thick deposits of sediments where Indonesia's main deposits of oil and natural gas are located.

The Straits of Malacca, Java Sea, southern part of South China Sea and Gulf of Thailand together form the extensive Sunda Shelf, which joins the western part of Southeast Asia to the continental shelf of Asia at depths of less than 200 m (Moosa, 1988). The depth of the Straits increases from 30 m at its most narrow part to more than 100 m towards the continental slope of the Andaman Sea. The strong undercurrent that enters the Straits at its northeast entrance forms large ripples in the sediments of the sea floor (Moosa, 1988; Uktolseya, 1988).

Ecological and Biological Characteristics

Coastal forests: mangroves and peat swamps

The coastal forests found along the Malacca Straits mainly consist of mangroves and peat swamps. Mangroves thrive best in coastal areas where the tidal regime is normal, with a significant amplitude of one to two meters or more and where seawater mixes with freshwater from land run-off, with a temperature that does not drop below 20°C (Fortes, 1988). Extensive mangrove areas are found mainly in tropical and, to a certain extent, in subtropical areas. Peat swamps occur hinterland to mangroves and are more influenced by a freshwater environment than are mangroves (Paw and Diamante, 1995).

Spatial distribution. More than a quarter of the world's total mangrove area (20,774,000 ha) is found in the ASEAN countries (Paw and Chua, 1991). The total area of mangroves found along the coastal zones of the Malacca Straits was estimated to be more than 498,109 ha, of which 111,409 ha are distributed along the West Coast of Peninsular Malaysia and more than 386,100 ha along the coast of the three eastern provinces (Aceh, North Sumatra and Riau) of the Sumatra Island of Indonesia (RePPProT, 1990; Japar, 1994; Ibrahim, E.I., 1995). It is worth noting that there are wide discrepancies in the literature concerning areas covered by mangroves for East Sumatra. This is partly due to the question of whether the author used "old" or "new" data and whether it is "mangrove area" in legal terms or mangrove forested area, where only areas with mangrove forest exist. Most of these data are outdated, since the rate of conversion of mangrove area to other uses, in particular for brackishwater shrimp and fishponds, has been very rapid in recent years.

Peat is a soil type with high organic content ranging from 30 to 65% of its mass. An aggregate area of 299,145 ha of peat swamps was found along the West Coast of Peninsular Malaysia, of which 68,095 ha are virgin swamps and 231,050 ha are disturbed and

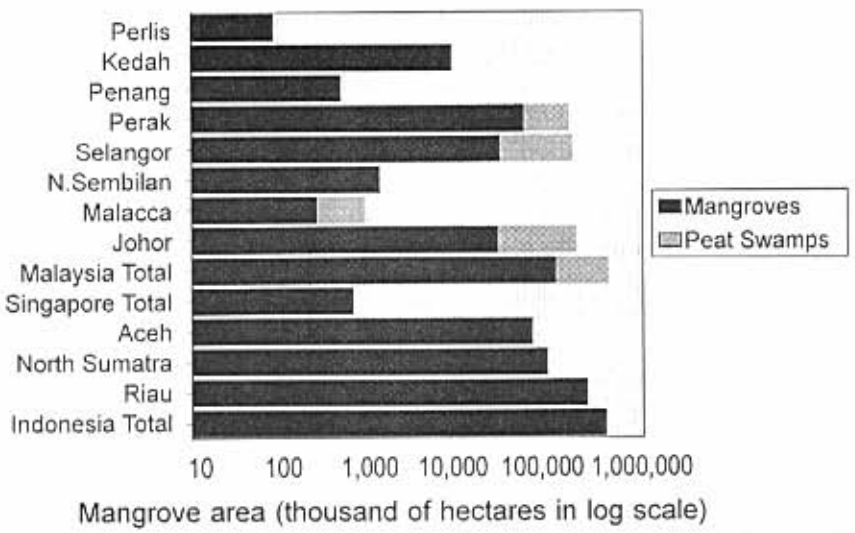
logged-over areas (Ibrahim, E.I., 1995; Paw and Diamante, 1995). The natural area of peat soils in Sumatra was estimated to be more between 7.3 and 9.7 million ha (Andriesse, 1974) or about 25% of all tropical peat lands (Driessen, 1977). Unfortunately due to rapid conversion to agricultural land and other uses, at present probably less than 50% of the peat swamps in Sumatra are left. The Directorate General of Forest Protection and Nature Conservation has established some 71 km² and currently another 2,490 km² are being proposed for conservation area (BAPPENAS, 1993). The area of peat swamps found along the coast of the three eastern provinces of Sumatra island could be more than 400,000 ha (Burbridge, 1982; WCMC, 1994).

Varying areas of mangroves and peat swamps occur along the eight coastal states of Peninsular Malaysia that border the Malacca Straits. More than 80% of the total area of mangroves and peat swamps are located along the coastal areas of Johor, Selangor and Perak (***Figure 2.9***).

Around 3,200 ha of mangrove forests were recorded in Singapore two decades ago. The area has diminished to around 600 ha in recent years due to increased land reclamation and urbanization activities (Ng and Low, 1994). Chia (1992) indicated that the decline of the mangrove forest in Singapore was due to reclamation of the coasts which removed much of the remaining mangroves. Mangroves will not regenerate on the foreshore areas of reclaimed land because ecological conditions have been unsuitable for their growth. The distribution of the remaining mangroves on the main and offshore islands of Singapore is shown in ***Figure 2.10***.

The location, area and site conditions including disturbances and threats to the existence of the major coastal forests for Malaysia are shown in ***Table 2.6*** and for Indonesia in ***Table 2.7***.

Figure 2.9. Distribution of Mangroves and Peat Swamps Along the Coastal Zones of the Malacca Straits: Indonesia, Malaysia and Singapore (RePPProT, 1990; Japar, 1994; Ibrahim, E.I., 1995).



Ecological significance. Mangroves and peat swamps comprise one of the most productive ecosystems found along the coastal zones and around islands. Their ecological significance to the coastal environment may be summarized as follows:

- ***They provide important spawning and nursery grounds for many economically important species of finfish, crustaceans and molluscs.*** Many species of finfish, such as gobies (*Eleotridae* and *Gobiidae*), mudskippers (*Blenniidae*) and sea catfish (*Ariidae*), are resident to the mangrove aquatic environment during all their life cycles, while mullets (*Mugilidae*), croakers (*Sciaenidae*) and rabbitfish (*Siganidae*) spend at least their larval and/or juvenile stages in the mangrove areas. Mangroves are the essential nursery ground for penaeid shrimp larvae and juveniles (Paw and Chua, 1991). Some species of oysters (*Cassostrea* spp.) and cockles (*Anadara granosa*) are associated with mangroves (Gomez, 1980; Jothy, 1984; Rao, 1986). An analysis of the 1981 fish landings in Malaysia shows that 32% of the species of fish caught may be associated with mangroves (Jothy, 1984) while recent data from TWG-I of Malaysia show that about 42% of captured species of fish are mangrove-related species (Ibrahim, E.I., 1995). Paw and Chua (1991) showed that both finfish and penaeid shrimp landings are positively and significantly

Figure 2.10. Mangroves and Nature Parks in Singapore (Chia, 1992).

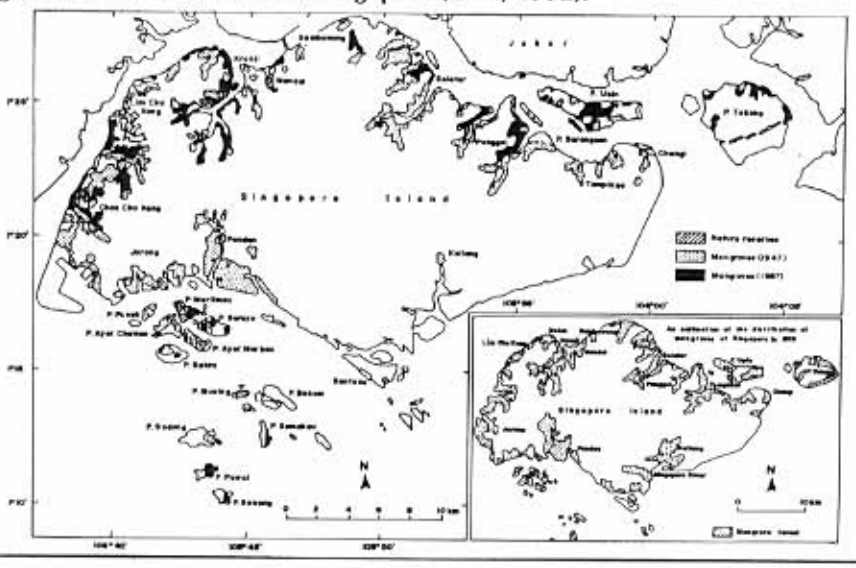


Table 2.6. Straits of Malacca: Distribution of Major Mangroves and Peat Swamp Forests Along the Coastal Areas of Peninsular Malaysia (WCMC, 1994).

Mangrove/Peat Swamp Forest	Location/Altitude	Area (ha)	Description of Site	Disturbance and Threats
1. Sungai Burung Mangrove, Perak	4°59' - 5°02' N, 100°22' - 100°25' E; sea level. Located adjacent to Sungei Burung, north of Kuala Kurau, Perak.	250	An area of mangrove forest and mudflats with a small river (Sungei Burung) and a few creeks. The water is brackish, and the median tidal range at Bagan Dato is 4.3 m; the entire swamp is inundated at spring tides.	The use of pesticides in adjacent ricefields may be affecting the breeding success of the black-owned night herons. Virtually the whole area has been mapped as land alienated for agricultural purposes.
2. Matang Forest Reserve, Perak	4°40'-4°55' N, 100°34'-100°40' E; sea level. Located in the district of Matang, Perak.	40,711	A large expanse of mangrove forest stretching 51 km along the coastline and up to 13 km wide. It includes 34,769 ha of productive forest and 5,942 ha of unproductive forest. The water is brackish and at low tide is less than 6 m deep.	Major threats include: reclamation for agriculture, depletion of pristine mangrove habitats, oil pollution disturbance from construction of infrastructure associated with timber extraction.
3. Kuala Selangor Mangrove Forest, Selangor	3°15'-3°27' N, 101°08'-101°18' E; sea level. Located at the mouth of Selangor river	5,760	A coastal belt of mangrove forest with extensive intertidal mudflats on the north to south of Kuala Selangor; the median tidal range is 3.8 m. One of the most productive prawn fishing grounds and second largest cockle bed in Peninsular Malaysia.	Major threats: the proposed development of Sungei Selangor for water supply; the proposed large-scale cattle feedlot scheme in the Rasa area; use of pesticides in plantations, discharge of untreated sewage; and industrial discharges.
4. Klang Islands, Selangor	2°53'-3°04' N, 101°13'-101°24' E; sea level. Located at the mouth of Klang river.	23,000	A group of mangrove-covered islands and associated intertidal mudflats in the estuaries of Sungei Klang and Sungei Langat, on the West Coast of Peninsular Malaysia.	Major threats: uncontrolled logging, oil pollution from discharges or traffic accidents in the Malacca Straits.

Table 2.7. Straits of Malacca: Distribution of Major Mangroves and Peat Swamp Forests Along the East Coast of Sumatra, Indonesia (WCMC, 1994).

Mangrove/Peat Swamp Forest	Location/Altitude	Area (ha)	Description of Site	Disturbance and Threats
1. Belawan, North Sumatra	3°45'N, 98°45' E, north of Medan; sea level.	15,765	A large area of mangrove forest with adjacent sandy beach and remnants of dry beach forest	Major threats: clearance of mangroves for agriculture.
2. Bakau Selat Dumai, Riau Province	1°35'N, 101°25' E, near Rupat, Kabupaten Bengkalis; sea level.	60,000	A large area of rich and almost undisturbed mangrove forest (20,000 ha) and peat swamps (40,000) on the mainland coast of Sumatra, opposite Rupat Island.	There are some new coastal settlements in the area and plans have been made to exploit the forest resources. The area has been proposed as a Wildlife Reserve (Suaka Margasatwa)
3. Bakau Muara Kapuas, Riau Province	0°3'N, 102°50' E, north of Sungai Kampar, Kabupaten Bengkalis and Kampar; sea level.	70,000	An excellent complex of mangrove formation backed by peat swamps. The forests are still in relatively undisturbed condition.	There are plans to log the area.
4. Tanjung Datuk, Riau Province	0°0'N/S, 103°45' E, on the equator, 15 km east of Desa Bekawan; altitude, 0-0.5 m.	25,000	A rich mangrove area consisting of almost untouched *Rhizophora* forest, extensive mudflats and several unspoiled tidal creeks. There are several brackishwater lakes in the interior of the mangrove forest; tidal range is 2.0-2.5 m.	Major threats: illegal logging and spontaneous reclamation projects.
5. Tanjung Bakung, Riau Province	0°13'-0°24'S, 103°35'-103°48' E, on Pulau Baso; altitude, 0-0.5 m.	40,000	Extensive mudflats and primary mangrove forests; several small lakes are present. The outermost tip of the mangrove forest is accreting extremely rapidly. The tidal mudflats comprise very ripe clay sediments over 15-m deep in places.	Major threats: small-scale logging and reclamation.
6. Pulau Burung, Riau Province	0°25'N, 103°34' E, east of the mouth of Kampar River; sea level.	200	A small mangrove island, surrounded by intertidal mudflats and with a shallow brackish lake (more than 50 m deep) in the center. It is separated from mainland by a channel several hundred meters wide. Average tidal variation is 2 m.	Major threats: some illegal logging of mangrove poles was reported in April 1994.

correlated to the areas of mangroves in the premises of the water where they have been caught.

- ***They provide control on water quality by trapping sediments and other particulate matter before moving into nearshore water (Ibrahim, E.I., 1995). They also contribute to coastal accretion by filtering land run-off and removing terrestrial organic matter (Fortes, 1988).*** The trapping and filtering help to prevent siltation which could cause damage to coral reefs and seagrass beds in the premises. Seedlings of mangrove species are known to effectively absorb certain heavy metals (e.g., mercury) that may be found in the water.
- ***Mangroves serve as a buffer zone against surges of storms, heavy waves and strong winds (Paw and Chua, 1991).*** Thus, mangroves help to protect the coastal land against erosion resulting from actions of waves and currents.
- ***Mangroves are the major producer of the detritus that contributes to the productivity of offshore waters.*** Leaf litters from mangroves provide a

nutrient pool that enriches the coastal or offshore waters which also supports fisheries resources. Such contribution, however, remains to be quantified (Paw and Diamante, 1995).

- ***High biodiversity is found in peat swamps.*** In Malaysia, for instance, as much as 4,300 plants belonging to 100 to 200 species are found in one hectare area of peat swamp.

Coral reefs

ASEAN countries are rich in coral reefs. About 30% of the world's coral reefs are located in this region (Chou et al., 1994b). The largest extent of coral reefs occurs in the archipelagos of Indonesia and the Philippines although smaller patches of coral reefs are also found in other ASEAN countries. Results of a survey of coral reefs in the ASEAN region conducted by Chou et al. (1994b) indicated that most of the reefs are in poor condition. In the Andaman Sea, pollution and overfishing had damaged the reefs around Phuket. On the West Coast of Malaysia, coral reefs are also severely impacted by sediments flowing off the land as a result of land clearing and industrialization. The reefs in Singapore, while small in area, are also being degraded by the extensive land reclamation (Chou et al., 1994c). The distribution of the coral reefs in the ASEAN region is shown in *Figure 2.11*. Compared to other areas in the ASEAN region, coral reefs are found in much smaller patches along the coasts of the Malacca Straits.

Indonesia. Coral reefs are distributed widely in Indonesia, in particular along the eastern part. The majority of the reefs are in the form of fringing reefs. However, there are also barrier reefs as well as atolls.

There is no satisfactory estimate of aerial coverage of coral reefs in Indonesia. Two rough estimates were from very low 750,000 ha (Meneg KLH, 1992) to very high 60,000 km^2 (BAPPENAS, 1993), based on a calculation that approximately 30% of the 81,000 km Indonesian coastline is covered with coral reefs with average width of 2 km. Earlier reviews of Indonesian coral reefs were made by Molengraaff (1929) and Umbgrove (1947). More recent and comprehensive reviews have been made by Soegiarto and Polunin (1981), Sukarno et al. (1983, 1986).

Along the Malacca Straits, coral reefs are concentrated mostly around the islands of the Riau Archipelago with small patches around the northeastern tip of Sumatra and Riau Archipelago (and Weh Island, which is located on the northern part of Aceh Special Regency, outside the Malacca Straits proper). Coral reef research along these parts of Indonesia is still limited. The only record of coral reefs on soft and scleractinian corals around Batam Island (*Figures 2.12* and *2.13*) is based on a two-week survey by Manuputty (1990a, 1990b) of the Center for R&D in Oceanology, LIPI, Jakarta, in 1985. The same Center has carried out a nationwide assessment on the extent of coral reefs destruction in Indonesia. The result indicated that on

Figure 2.11. Distribution of Coral Reefs in the ASEAN Countries (White, 1987).

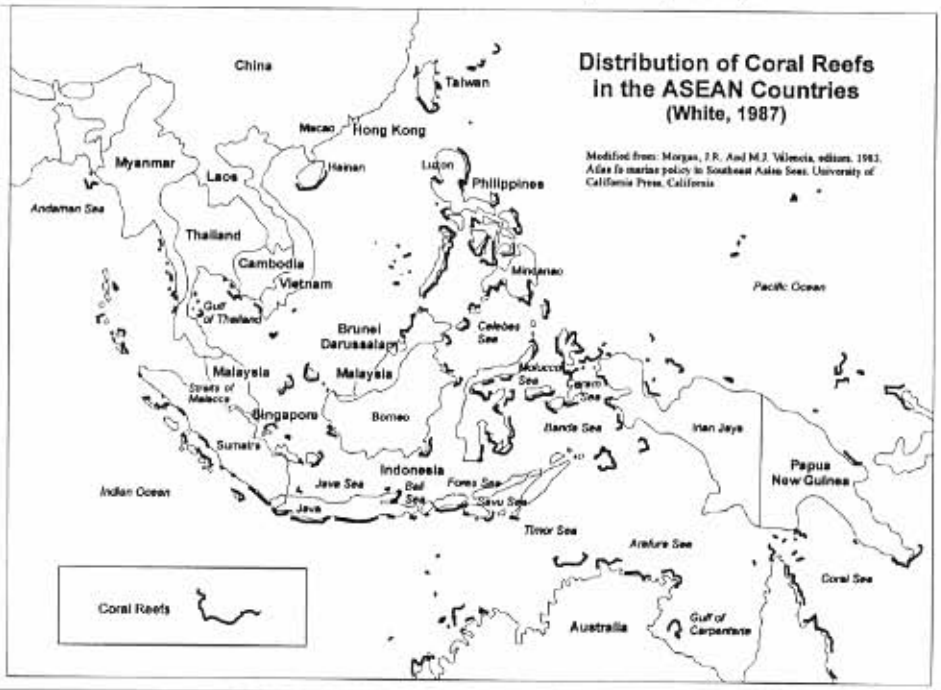
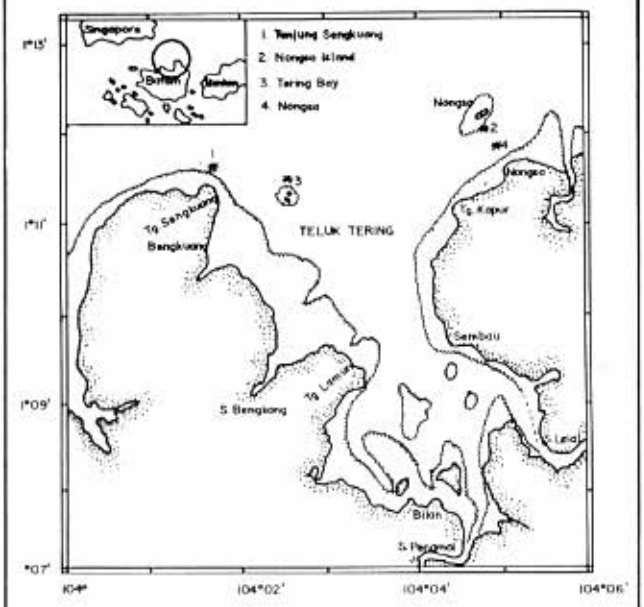


Figure 2.12. Location Map of Observation of Soft Corals in Batam (Manuputty, 1990a).



the average 42.4% of the assessed reefs are in poor condition, 28.6% are fair, 24.4% are still good and only 4.6% are in excellent condition (Soegiarto, 1996). In general, the coral reefs in the eastern part of Indonesia are in better condition than those in the central and western parts of Indonesia. Unfortunately, none of the coral reefs in the Riau Archipelago was included in the nationwide assessment.

Malaysia. As a group, coral reefs around the offshore islands along the East Coast of Peninsular Malaysia are in good condition, supporting an average range of 56 to 69% live coral cover (***Table 2.8***). Compared to the East Coast, the fringing coral reefs on the West Coast of Peninsular Malaysia are in fair condition with respect to live coral cover, exhibiting a range of 25 to 46% composition (Ridzwan, 1994). ***Table 2.9*** rates the causes of coral reef degradation and destruction in Malaysia. The condition was better than expected for the West Coast reefs as waters at the study sites were relatively turbid compared to those on the East Coast. The turbid waters are due to the high sediment load brought down by rivers and surface run-off from coastal areas experiencing rapid industrialization, urbanization, housing and tourism development (Ridzwan, 1994). Along the West Coast of Peninsular Malaysia, coral reefs are mostly found around the islands of Pulau Sembilan, Pulau Pangkor and Pulau Langkawi and off the coast of Port Dickson.

Singapore. Singapore's coral reefs are amongst the most stressed in Asia (Chou et al., 1994c). Singapore is a major port and massive land reclamation had taken place during the last two decades. This caused considerable deterioration in water quality, damaging the coral reefs, which once grew below 10 m depth and now only in the upper 5 m. However, recent government activities have significantly reduced pollution from shipping and all sewage is now treated before discharge to the sea (Chou et al., 1994c). Small patches of coral reefs are mostly found around the southern islands (***Figure 2.14***).

Seagrass beds

Seagrasses are a group of submerged flowering plants that grow in the marine environment. Unlike other marine plants (e.g., seaweeds and algae), they flower and produce fruits and seeds. Seagrasses possess true roots and an internal system for transport of gases and nutrients. They are adapted to thrive in mostly

Figure 2.13. Location Map of Observation of Scleractinian Corals in Batam (Manuputty, 1990a).

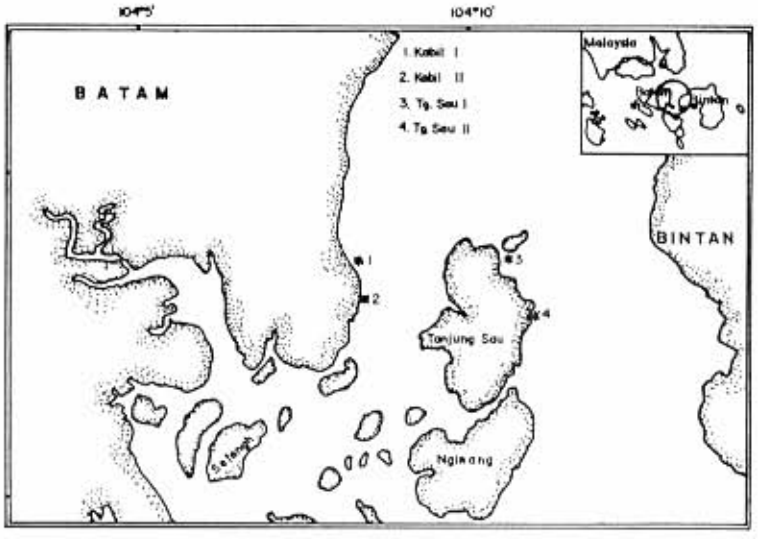


Table 2.8. Summary of the "Health" Status of Malaysian Coral Reefs (Ridzwan, 1994).

Island	No. of Stations	Reef Condition in Terms of % Coral Cover			
		Excellent 75-100	Good 50-74.9	Fair 24-49.9	Poor 0-24.9
Perhentian	6		56		
Redang	9		63		
Kapas	4			42	
Tenggol	6		69		
Tioman	15			27	
Renggis	4				13
Langkawi[1]	4			46	
Sembilan[1]	4			26	
P. Dickson[1]	4			44	
Sabah	13			43	
L.-Layang	18			29	

[1]Sites along the Malacca Straits.

shallow, saline, coastal habitats with an anchoring system that withstands wave action. They are capable of hydrophilous (through water medium) pollination (Fortes, 1995).

The seagrass ecosystem has important biological, as well as physical functions. It serves as a nursery ground, providing shelter and a wide range of food sources to fish, crustaceans and invertebrates. Many of them are commercially important. The ecosystem supports fisheries in the surrounding waters. About 300 species of fishes have been reported from Indonesian seagrass beds (Hutomo, 1985), most of them in juvenile stages. Juvenile groupers (*Epinephelus* spp.) and rabbitfish (*Siganus* spp.) are collected from this habitat to be raised in net cages until they attain suitable market size. In addition, the seagrass beds also provide harvestable stocks of molluscs, sea urchins, sea cucumbers and macro-algae by traditional fishermen for their own consumption. Some species of seagrass have been harvested for various traditional uses, such as fodder, fertilizers, substitute for paper, biomass fuel, stuffing materials for mattresses and furniture. The fruit of *Enhalus acoroides* and the rhizome of *Cymodocea* have been known to be collected for food by coastal communities (Hutomo, 1985).

The distribution of seagrass beds off the East Coast of Sumatra bordering the Malacca Straits is probably limited to the Riau Archipelago. The seagrasses form mixed species meadows, dominated in particular by *Enhalus acoroides* and *Thalassia hemprecii* or pure stands depending on the substrate (Hartog, 1958). In some cases, even distinct zonation can also be observed (Whitten et al., 1984).

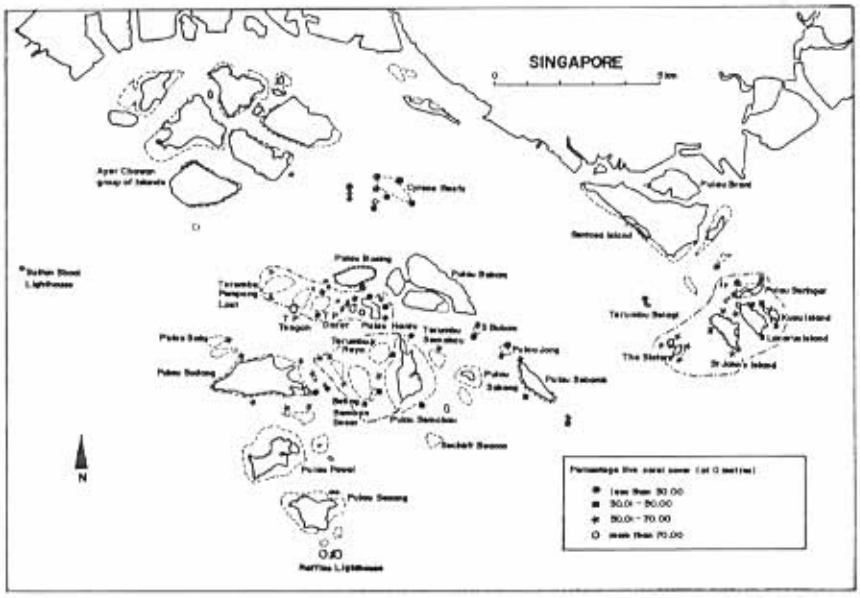
Seagrass meadows have high standing crop, high productivity and are able to concentrate nutrients. Therefore they are important in the food chains. The detritus is consumed by crabs and molluscs, which in turn are eaten by fishes. Seagrasses are grazed upon directly by green turtles and sea cows or dugong (*Dugong dugong*). However, dugongs are now extremely rare and it is doubtful whether a viable population exists anywhere in Sumatra, in particular

Table 2.9. Rating the Causes of Coral Reef Degradation and Destruction in Malaysia (Ridzwan, 1994).

Threats	West Coast of Peninsular Malaysia	East Coast of Peninsular Malaysia	East Malaysia
Fishing intensity	4	3	5
Fishing damage	3	3	5
Fish blasting	2	2	4
Gleaning	2	1	3
Boat scouring	2	3	4
Population pressure	4	3	4
Sedimentation	5	3	3
Domestic and agri-culture pollution	3	2	4
Industrial pollution	3	1	1
Oil spill	2	1	2
Disease and predation	2	4	3
Dredging	2	1	2
Coral mining	1	1	3
Tourist activities	1	2	2
Coral bleaching	1	1	1

Key to Scale of Values: 1 – None to Rare; 2 – Very Low Concentration; 3 – Some Damage, Some Stress; 4 – Medium to High Damaging; 5 – Very High, High Stress, Very Damaging.

Figure 2.14. Distribution of Coral Reefs in Singapore (Chua and Chou, 1991b).



in the Straits of Malacca. In addition, because seagrasses thrive best in shallow water habitats, they become most vulnerable to environmental pressures due to anthropogenic activities.

Species composition and distribution. Fourteen species of seagrasses were recorded in seagrass beds in Indonesia, nine species in Malaysia and eleven species in Singapore (***Table 2.10***).

Along the coastal zones of the Malacca Straits, dense beds of tropical seagrass are found in association with estuaries in Riau Archipelago of Indonesia (Hutomo et al., 1989), in Cape Rachado, Port Dickson, Kuah (Langkawi Island) and Tanjung Rhu (Langkawi Island) of Peninsular Malaysia (Phang and Pubalan, 1989) and in Pulau Semaku, Pulau Tekong, Terembu Jarat, Labrador Beach and Cyrene Reefs of Singapore (Hsu and Chou, 1989). The distribution of seagrass beds in the coastal zones of the Malacca Straits is less extensive compared to other waters in the ASEAN region, notably the Philippines (***Figure 2.15***).

Seagrass resources in Indonesia. Seagrass ecosystems are probably the least appreciated among all the coastal ecosystems in Indonesia. Seagrass beds are widely distributed in the Indonesian archipelago (Hartog, 1958; Soegiarto and Polunin, 1981). Unfortunately, there is only a limited amount of information on the seagrasses from various parts of Indonesia, such as from Kalimantan, North Sulawesi, part of the Molluccas, Irian Jaya and also Sumatra. Also, according to a recent report (Dahuri and Pahlevi, 1994), the Fisheries Department at the provincial level in Aceh and North Sumatra have neither the interest nor the capability to collect such data (due to constraints in budget and human resources).

Of the 50 or so known seagrass species worldwide, it was so far recorded that 14 of them have been found in Indonesian seas. The species of *Enhalus acoroides* forms dense beds and usually grows in estuaries or on reef flats. Other species found on reef flats are *Cymodocea rotundata, Halodule pinifolia, Thalassia hempricii* and *Syringodium isoetifolium*.

Seagrass resources in Malaysia. Seagrass beds along the West Coast of Peninsular Malaysia fronting the Malacca Straits mostly occur on substrates from sandy-muddy to sand-covered corals in the extreme north along the coast of Langkawi Island, Kedah to the south as far as Teluk Kemang in Negeri Sembilan (***Figure 2.16***). In the southern part of Peninsular Malaysia, seagrass beds occur on sandy-muddy banks of the mangrove estuary at Sungai Pulai where the water is shallow, around 2 to 3 m deep. Another seagrass bed in sandy-muddy area at the Merambong Shoal was discovered recently (1992) near the Sungai Pulai estuary. The bed exists under 2 to 3.2 m deep water and measures 1.2 km long and 80 to 100 m wide, which is probably the largest in Peninsular Malaysia (Japar, 1994b). There are nine species of seagrasses occurring in the West Coast of Peninsular Malaysia.

Table 2.10. Species of Seagrasses Found in Littoral States Bordering the Malacca Straits (Hartog, 1958; Fortes, 1990).

Species	Indonesia	Malaysia	Singapore
Round-tipped seagrass (*Cymodocea rotundata*)	x	x	x
Toothed seagrass (*C. serrulata*)	x	x	x
Tropical eelgrass (*Enhalus acoroides*)	x	x	x
Fiber-strand grass (*Halodule pinifolia*)	x	—	x
Fiber-strand grass (*H. uninervis*)	x	—	x
Estuarine spoon-grass (*Halophila beccarii*)	X[1]	x	x
Veinless spoon-grass (*H. decipiens*)	x	—	—
Small spoon-grass (*H. minor*)	x	x	x
Spoon-grass (*H. ovalis*)	x	x	x
Curled-base spoon-grass (*H. spinulosa*)	x	x	x
Syringe grass (*Syringodium isoetifolium*)	x	x	x
Dugong grass (*Thalassia hempricii*)	x	x	x
Ruppia maritima	X[1]	—	—
Woody seagrass (*Thalassodendron ciliatum*)	x	—	—
Total	**12**	**9**	**11**

[1] Limited record.

Seagrass resources in Singapore. Seagrass beds in Singapore are mostly found around the southern islands (*Figure 2.17*). They never form extensive beds but occur in isolated patches and their distribution is limited to the reef-flat and upper reef crest zones (Loo et al., 1994).

Ecological significance. Ecologically, seagrass beds function to: (a) reduce wave action in the coastal waters, preventing erosion of sandy shores; (b) regulate the chemical composition of coastal waters through filtering the suspended sediments and removing nutrients in the water; (c) regulate run-off, trap and stabilize bottom sediments; (d) maintain fertility of coastal water, through efficient fixation of solar energy and high biomass production; (e) maintain migration and nursery habitats for fish and shrimp; and (f) enhance the ecosystem and genetic diversity (Fortes et al., 1994; Fortes, 1995).

Threats to seagrass resources. The threats could be categorized as follows: (a) natural disasters; (b) mining activities; (c) coastal aquaculture; (d) deforestation; and (e) blast fishing (Fortes 1990, 1995; Kiswara, 1994).

Natural Disasters: Cyclones, typhoons, tidal waves, volcanic activities, pests and diseases constitute the natural threats that

Figure 2.15. Distribution of Seagrass Beds in the ASEAN Region (Fortes, 1990).

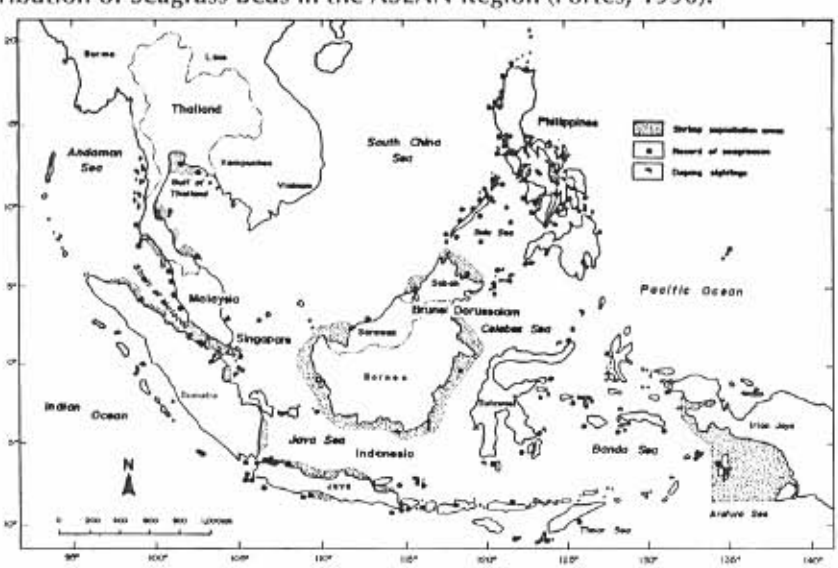
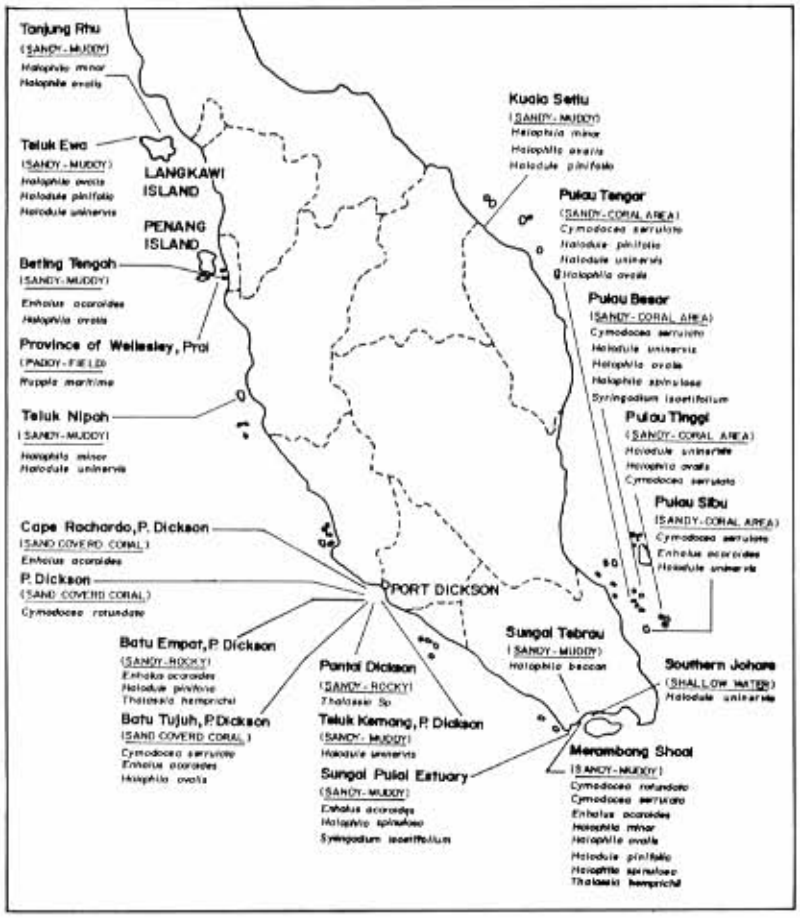


Figure 2.16. Distribution of Seagrass, Their Substrate Types and Species Composition in Peninsular Malaysia (Japar, 1994b).



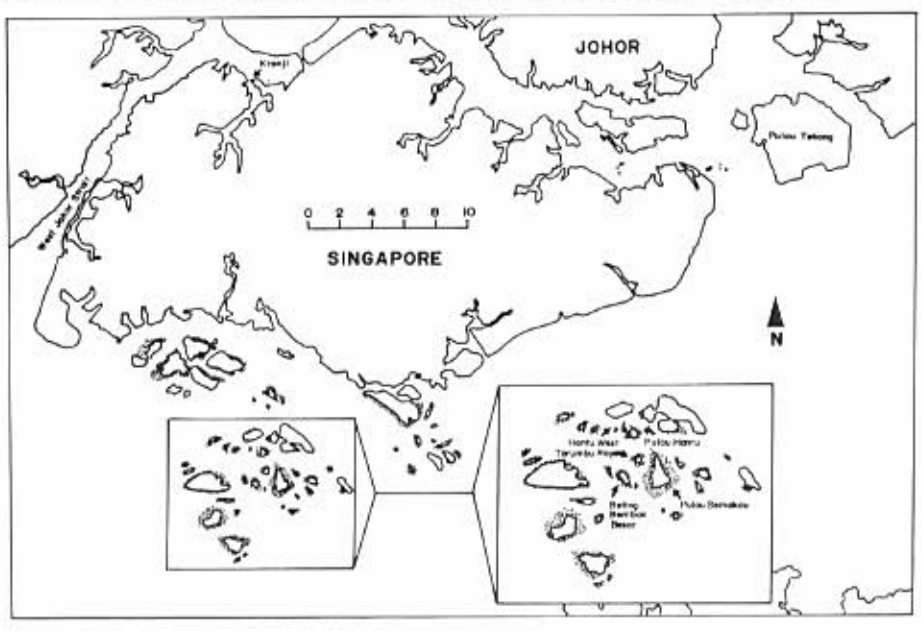
Coastal Aquaculture: Conversion of mangroves and other coastal forests into ponds for cultivating shrimps was the major cause of the loss of coastal vegetation in the ASEAN region. Brackishwater aquaculture in Thailand, Malaysia, Indonesia and the Philippines is being developed at the expense of clearing vast tracts of coastal land and of coastal resources.

Deforestation: In the ASEAN region, including the coastal zones of the Malacca Straits, run-offs from the exposed slopes resulting from deforestation cause heavy accumulations of silt on seagrasses, depressing their growth and threatening their survival. Logging and slash-and-burn agriculture resulted in loss of more than 60% of the coastal forests in Southeast Asia.

Blast Fishing: Blast fishing is the most destructive fishing method commonly practiced in the premises of coral reefs and could result in the loss of seagrass beds. Sand movements may also smother and push the seagrass beds into depths beyond their ability to survive.

Mining Activities: Mining of industrial minerals such as tin, coal, copper, etc., results in heavy deposits of spoil materials or tailings discharged into the nearby seagrass beds, threatening their survival.

Figure 2.17. Distribution of Seagrass Beds in Singapore (Loo et al., 1994).



seagrass beds in Southeast Asia. It can significantly destroy the structures of coral reefs and seagrass beds, resulting in the depletion of fishery production in adjacent coastal waters.

Interactions of mangrove-seagrass-coral reef ecosystems

Mangrove forests, seagrass beds and coral reefs are the major ecosystems that support a sustainable production of living resources in the tropical, marine and coastal environment. They are functionally and ecologically interconnected, as indicated by the high similarity indices between their associated fish, algal and epiphytic communities (Fortes, 1995). These interconnections, as identified by UNESCO (1983) and SPC/SPEC/ESCAP/UNEP (1985), are: physical, nutrients (dissolved and particulate organic matter), animal migrations and human impact.

Physical interaction. Seagrass beds are often found between the coral reefs and coastal mangrove forests. They act as dynamic barriers which dissipate waves, creating a low-energy zone favorable for the growth of mangroves (SPC/SPEC/ESCAP/UNEP, 1985). Seagrass beds also trap and stabilize suspended silt particles, which otherwise would be transported to coral reefs and cause unfavorable coral growth. On the other hand, mangroves regulate coastal freshwater flow and buffer changes in salinity which help to provide a favorable environment for the growth of seagrasses.

Contribution to fertility of coastal waters. Mangroves and seagrass beds tend to "leak" or export nutrients that contribute greatly to the primary productivity or fertility of coastal waters (Wood et al., 1969; Rao, 1986). Run-off of dissolved and particulate organic matter from mangroves into seagrass beds and vice versa also help to enrich nutrient pools of these two ecosystems (Fortes, 1988). Additionally, birds which feed on epiphyton in seagrass beds and return to mangroves for resting may defecate, providing nutrients for the growth of mangroves.

Animal migration and feeding. Animals migrate amongst seagrass beds, mangroves and coral reefs to feed and seek sheltering habitats (UNESCO, 1983). For instance, the spiny lobster and pink shrimp, as well as various grunts and snappers, may spend a part of their earlier life in the mangroves or seagrass beds and later migrate to coral reefs to feed or breed. The planktonic larvae produced by the epiphytic biota on mangroves may be carried by water movements to seagrass beds, serving as food for animals (Fortes, 1988).

Human impact. Clearing of coastal forests for human settlements or industrial development produces massive run-offs which may cause smothering, shading and eutrophication that could lead to destruction of seagrass beds or coral reefs as well as reduction in both the primary and secondary productivities of coastal waters (UNESCO, 1983; Fortes, 1988). Indiscriminate removal or destruction of seagrass beds, on the other hand, can render sediments unstable. Such sediments can be easily carried by currents or storms to mangroves or coral reefs causing detrimental effects, such as destruction of the nursery and feeding grounds or alteration of food-web patterns, thereby reducing fishery productivity.

Critical habitats

Soft-bottom habitats. Soft-bottom habitats refer to the relatively shallow, gently sloping continental shelves, such as the Sunda Shelf, which consist of all the muddy and sandy coastal or marine floor areas supporting the major fisheries of Southeast Asia (Chou, 1994a). The distribution of the soft-bottom habitats in Southeast Asia is shown in ***Figure 2.18***. The habitats are resources in themselves which support a high biodiversity of different animals, which include the cockles and clams. Soft-bottom habitats are highly vulnerable to destruction by excessive trawling.

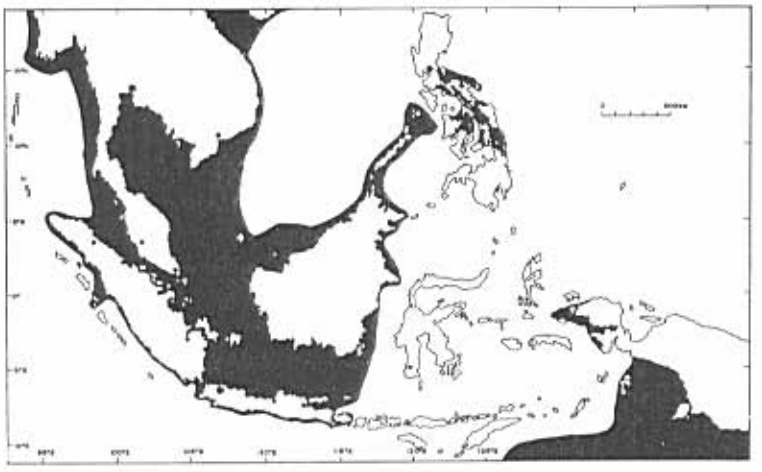
Soft-bottom habitats in the Southeast Asian region, including the Malacca Straits, are extensive. Sandy bottoms are found more in the offshore areas or in nearshore areas away from the river run-offs (Chou, 1994a). Muddy bottoms are common along the coasts near the major rivers and river mouths.

Resources from the soft-bottom habitats have numerous economic applications throughout the region (Chou, 1994a). Commercial species harvested from the soft-bottom habitats include: fishes, seaweeds, horseshoe crabs, shrimps, bivalves, gastropods, sea cucumbers and sea urchins. The multi-million dollar cockle industry along the West Coast of Peninsular Malaysia is a notable example of the valuable soft-bottom resources.

Estuaries

Indonesia. Almost the entire East Coast of Sumatra bordering the Malacca Straits can be considered as estuaries. There are a number of rivers in Sumatra with their mouths in the Straits of Malacca forming estuarine ecosystems. Along these coastal areas, there are numerous intertidal habitats that are vulnerable to environmental changes, such as siltation, pollution, oil

Figure 2.18. Distribution of Soft-Bottom Habitats in the ASEAN Region (Chou, 1994).



spills and other anthropogenic activities. Examples of these habitats are mangroves, seagrass beds, mudflats and reef flats. In addition, there are also species habitats which span the land-sea interface. These habitats include seabird colonies, nursery grounds for commercial species of fishes and shrimps, turtle nesting beaches, protected and other conserved coastal ecosystems and even areas of tourist development. *Figure 2.19* shows such intertidal habitats identified so far, which are considered in the contingency plan on spills or other hazardous materials (Salm and Halim, 1984).

Mudflats

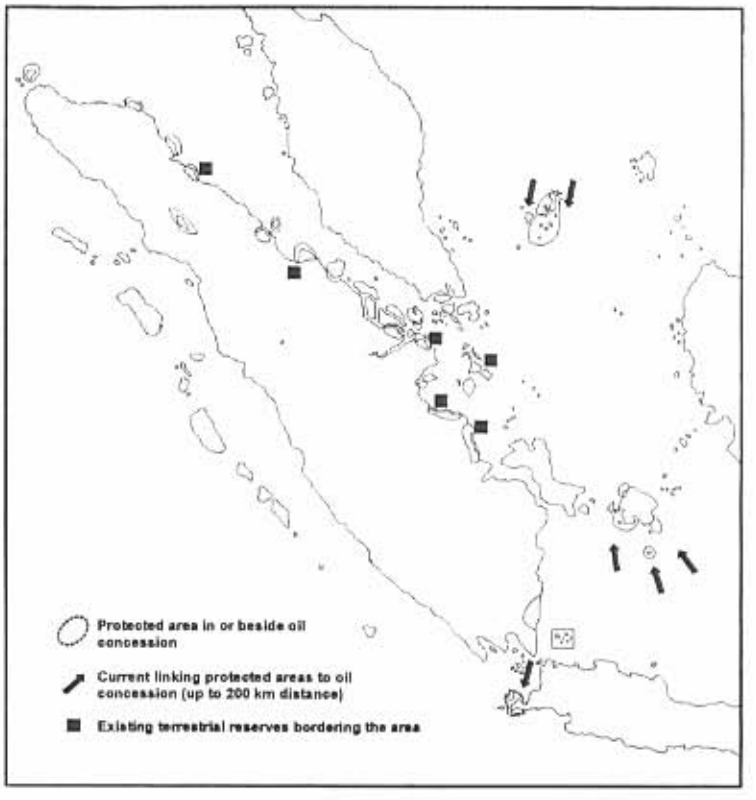
Indonesia. The numerous Sumatra rivers discharge their water with heavy sediment loads to the Straits of Malacca. As a result, deep and broad mudflats are formed along the coasts and islands. Mangroves and prevailing intertidal current systems also have a role in the formation of such mudflats. Examples are the rapid deposition rate and broad mudflats in front of and around the mouth of Rokan river in Riau, near the fishing town of Bagan Siapi-api (*Figure 2.20*, Kasry, 1984). Eventually these mudflats slowly develop into coastal land. It has been pointed out by Chambers (1980) that the entire alluvial plain of the East Coast of Sumatra and many adjacent coastal islands were developed through this process.

Beaches

Indonesia. The entire East Coast of Sumatra bordering the Malacca Straits has natural beaches. In general they are intertidal beaches with broad mudflats. Naturally, there are exceptions, for example, beaches that have been developed into ports, industrial estates, housing, tourist resorts, etc., e.g., Belawan, Batam and Bintan Islands. Percentage-wise, the developments represent only a small portion of the beach area.

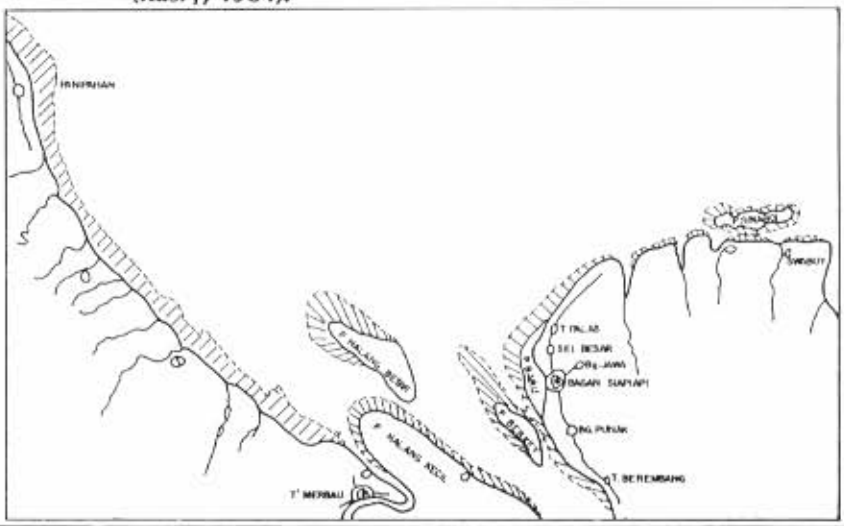
Singapore. Singapore has both natural and artificial beaches. Natural beaches are generally intertidal and narrow; artificial beaches are created from coastal land reclamation (Chia et al., 1988).

Figure 2.19. Critical Intertidal Habitats off the East Coast of Sumatra (Salm and Halim, 1984).



Natural beaches are found on the north-northeastern coast and the western coast of the main island and on the offshore island of Ubin, Tekong, Semakau, Pawai and Senang. Artificial beaches are mainly found along the East Coast of the main island (Chia et al.,1988).

Figure 2.20. Mudflats In and Around the Mouth of Rokan River in Riau (Kasry, 1984).



Biodiversity

Indonesia. Indonesia has been recognized as one of the mega-centers for biodiversity. Although Indonesia covers only 1.3% of the earth's surface, it harbors (BAPPENAS, 1993):

10% of the world's flowering plant species;
12% of the world's mammal species;
16% of all reptiles and amphibian species; and
17% of the world's bird species.

This richness in biodiversity can be attributed to the fact that Indonesia spans two major biogeographical realms: Indo-Malaya and Australia. The 17,508 islands of the archipelago support a wide range and variety of habitats, from lowland rain forest and mangrove to savanna grassland, swamp forests and limestone hills to montana forests, alpine meadows and snow topped mountains. These varied habitats support a rich flora and fauna.

Indonesia's great expanse of territorial waters and the richness of the Indo-West Pacific seas further add to the country's biodiversity. Indonesia supports a rich variety of coastal and marine habitats. This expanse of biogeographical area is divided into seven major regions. One of them is the island of Sumatra and its many offshore islands (*Table 2.11*). Sumatra, an island with an area of 471,000 km², has over 10,000 species of higher plants. Most of them are found in the lowland forest. The richness in biodiversity, both plant and animal species, is typical of the warm humid tropical areas of the Indo-Malaya region.

The broad alluvial plain in the East Coast of Sumatra is dominated by the lowland forest, freshwater swamp forest, peat swamp forest and mangrove forest (*Figure 2.21*). MacKinnon (1982) listed the average number of tree species found in 0.5-ha plots in different habitat types as follows:

Habitat type	Number of Tree Species
Fertile lowland forest	80
Infertile lowland forest	51
Heath forest	50
Beach forest	21
Complex mangrove	14
Simple mangrove	6
Peat/freshwater swamp forest	46

Faunistically, Sumatra is the richest island. It has most mammals (196 species) and birds. Out of the 580 species, 465 are resident, but only 14 are endemic. Due to its geological link with the Asian continent, there is a strong affinity of total plant species (49%), bird species (74%) and mammal species (63%) shared between Sumatra and Peninsular Malaysia (MacKinnon, 1982). However, no extensive and long-term research has been carried out on coastal habitats in Sumatra. The only available data and information are limited to one or two piecemeal observations and records. Those limited data and observations have been compiled by Silvius (1987) for wetland and BAPPENAS (1993) for biodiversity.

The Directorate General of Forest Protection and Nature Conservation (Ditjen PHPA, 1991) listed a number of protected, threatened and endangered biota in Indonesia from terrestrial and marine environments, as well as from coral reef and mangrove ecosystems. Some protected species of reptiles, sea birds and mammals listed in *Table 2.12* are found in the coastal areas of East Coast of North Sumatra and Riau Islands,

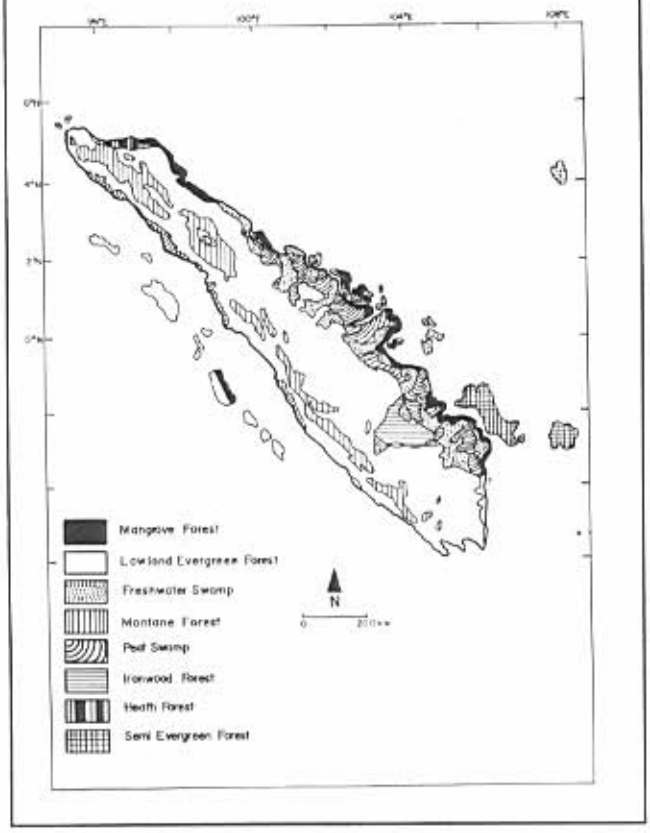
Table 2.11. Habitat Coverage for Sumatra (BAPPENAS, 1993).

Habitat	Original Area (km²)	Percent Remaining	Protected Area (km²)	Percent Protected	Proposed Area (km²)	Percent Proposed
Forest or limestone	31,079	59.0	3,280	10.5	0	0.0
Freshwater swamp	36,943	18.0	560	1.5	478	1.2
Heath forest	10,900	18.0	0	0.0	0	0.0
Ironwood forest	1,320	33.0	80	6.0	20	1.5
Lowland evergreen rainforest	229,218	31.0	8,075	3.5	10,388	4.5
Montane rainforest	54,500	68.0	9,345	17.1	1,630	2.9
Mangrove forest	13,529	29.0	365	2.6	870	6.4
Peat swamp	84,952	50.0	71	3.4	2,490	2.9
Semi-evergreen rainforest	5,280	17.0	50	0.9	60	1.1
Tropical pine forest	3,215	60.0	500	15.5	220	6.8
Total	470,941	41	25,266	5.3	16,156	3.4

The area of remaining habitats is based on forest cover figures from the early 1980s. Habitat loss has continued in the last decade. These figures will be revised as part of the National Conservation Plan in Forestry 2.

as recorded by Silvius (1987), Ditjen PHPA (1990) and Direktorat Bina Sumber Hayati (1993a, 1993b). In all probability, the protected molluscs and other biota can also be found in Riau Archipelago coral reefs.

Figure 2.21. Distribution of Vegetation Types in Sumatra (BAPPENAS, 1993).



Land Uses and Development

Indonesia

Indonesia is a country consisting of 17,508 islands, slightly less than half of which (6,000 islands) are inhabited; total land area of the country is around 1.9 million km², about 31% of the land have been cultivated and another 31% are covered with forest (***Table 2.13***).

Agricultural activities dominate the economy in Indonesia, particularly for the Sumatra island (Scholz et al., 1983; Burbridge et al., 1988). Agriculture provides the most important source of employment for the population in Sumatra, with 72% of all households and 84% of rural households being engaged fully or part-time in agricultural activities (Scholz et al., 1983). The areas of cultivated land along the East Coast of Sumatra are listed in ***Table 2.14***. Agricultural production is confined mainly to the eastern lowlands. On the average, the total cultivated area constitutes around 20% of the total lowland area. Wet rice and coconut dominate the agricultural production. Wet rice comprises around 40% of the lowland under cultivation and is produced largely from tidally irrigated sawah (wet rice fields) in the Indragiri-Batanghari tidal area and in the lowlands of the Riau Province (around 60,207 ha). Coconut production is important in the strip of eastern lowland area stretching from East Aceh to North Sumatra, dominating the 58,000 ha of perennial crops (Burbridge et al., 1988).

Table 2.12. List of Protected and Threatened Marine Species and Mangrove Associated Species Along the East Coast of Sumatra Adjacent to the Malacca Straits (Silvius, 1987; Ditjen PHPA, 1990, 1991; Direktorat Bina Sumber Hayati, 1993).

Indonesian Name	Scientific Name	English Name
Corals		
Akar bahar	*Anthipates* spp.	Black coral
Crustaceae		
Mimi	*Tachlypleus tridentatus*	King crab
Molluscs		
Kepala kambing	*Cassis cornuta*	Horned helmet
Triton	*Charonia tritonis*	Triton trumpet
Nautilus berongga	*Nautilus compilius*	Chambered nautilus
Batu laga	*Turbo mamoratus*	Green mussel
Susu bundar	*Trochus niloticus*	Top shell
Kima pasir	*Hippopus hippopus*	Bear's paw clam
Kima besar	*Tridacna maxima*	Small giant clam
Kima lubang	*Tridacna crocea*	Boring clam
Kima selatan	*Tridacna derasa*	Southern giant clam
Kima raksasa	*Tridacna gigas*	Giant clam
Kima sisik	*Tridacna squamosa*	Scaly clam
Reptiles		
Buaya	*Crocodylus porosus*	Estuarine crocodile
Penyu hijau	*Chelonia mydas*	Green turtles
Penyu sisik	*Eretmochelys imbricata*	Hawkbill turtles
Aves/Birds		
Kuntul besar	*Egretta alba*	Greater egret
Kuntul karang	*Egretta sacra*	Pacific reef egret
Raja udang	*Halcyon chloris*	White-collared kingfisher
Elang laut perut putih	*Haliaetus leucogaster*	White-bellied sea-eagle
Bangau tongtong	*Leptoptilos javanicus*	Lesser adjutant
Bangau putih	*Mycteria cinerea*	Milky stork
Dara laut	*Sterna* sp.	Tern
Mammalia		
Kera abu-abu	*Macaca fascicularis*	Macaque monkey
Beruang madu	*Helarctos malayanus*	Malayan sun bear
Duyung	*Dugong dugong*	Dugong
Kijang	*Munticus muntjak*	Barking deer

Malaysia

The total land area of Malaysia is around 0.33 million km^2, with 80% of it covered by forest and only 15% of the land being cultivated (***Table 2.13***).

The total land area of the eight Malaysian coastal states bordering the Malacca Straits is around 0.67 million ha; around 0.52 million ha are covered by forest, around 5,380 ha are grassland and 2,000 ha, unused land (***Table 2.15***). For the developed land, agriculture is the most dominant land use accounting for 0.32 million ha or around 48% of the coastal land area (Ibrahim, E.I., 1995). The area of land that was used for urban development, i.e., for the development of housing and industrial estates, accounts for 0.023 million ha or about 3.5% of the coastal land area.

Eight major urban settlements are located along the Malaysian coastline of the Malacca Straits. They include Georgetown (Penang), Seberang Prai (Penang), Port Klang (Selangor), Port Dickson (Negeri Sembilan), Muar (Johor) and Pontian Kecil (Johor). The population of these urban settlements ranges from 10,000 to 300,000. Apart from these urban settlements, there are rural settlements located along the coastal zone of the Malacca Straits. The population in rural settlements consist predominantly of farmers or fishermen. Around 139 fishing villages and 20 industrial estates are located along and within the coastal zone of the Malacca Straits (Ibrahim, E.I., 1995).

Singapore

Singapore is highly urbanized. Its cultivated land area constitutes only 3 to 5%; forest and wasteland, 4 to 6% of the total land area (main island plus offshore islands) (***Tables 2.13 and 2.16***). Development of housing and industrial estates dominates the land use covering almost 49% of the total land area (***Table 2.16***).

A comprehensive review of land use and development is given by Chia (1992). According to the revised Concept Plan provided by the Urban Redevelopment Authority (URA) in 1989, encouragement will be focused on the development of waterfront housing and communities (Chia, 1992; ***Figure 2.22***).

Table 2.13. Land Area, as well as General Land Use, Physical Features, Vegetation and Climate of the Three Littoral States of the Malacca Straits (Lee and Troxler, 1992; Koe and Aziz, 1995).

Country/Land Area (km^2)	Land Use (%)	Physical Features	Vegetation	Climate
INDONESIA/ 1,904,569	Cultivated: 31 Forest: 31 Pasture: 6	• Consists of 17,608 islands • Inhabited islands: 6,000 • Pronounced mountain ranges and extensive lowlands on larger islands • Little coastal plains on smaller islands that rise steeply from the sea • Volcanic eruptions common	• Variable dense tropical forests and tidal swamps, normal lowlands and savannah • Forests thinner towards the east	• Heavy rainfall all year-round with peak periods in the west and greater amounts from December to March • Little variation in high temperatures (26-27°C) • Dry season in the south (June-October) • Maritime equatorial climate
MALAYSIA/ 329,758	Cultivated: 15 Forest: 80 Pasture: 2	• Mountain ranges reach 2,100 m and run north to south, swampy forests and lowlands to the east of Peninsular Malaysia, Sabah and Sarawak • Wider lowlands and longer rivers in Sabah and Sarawak; outstanding feature is Mt. Kinabalu at 4,101 m	• Equatorial forest cover • More dense and continuous on Sabah and Sarawak than in the peninsula	• Variable rainfall in Sabah and Sarawak • Rainfall average 2,540 mm/ year in the peninsula • Average temperature is 21-32°C • Equatorial climate
SINGAPORE/ 626	Cultivated: 3.2 Forest: 4.6 Pasture: -	• Island's granite cores reach heights of 100 m • Surrounded by marshy lowland • Height rarely exceeds 15 m	• Remaining rainforests being reserved	• Hot and humid • No defined seasons • Average temperature is 27°C

Development of new towns and public housing estates. The Housing and Development Board (HDB), URA and Jurong Town Corporation (JTC) are jointly responsible for the housing developments. *Figure 2.23* shows the location of the various new towns and housing estates that have been developed. HDB's public housing program has been very successful. It has created over 200,000 residents for the housing estates in Toa Payoh and Ang Mo Kio (Chia, 1992). To date, more than 70% of Singapore's resident population stay in the HDB's housing estates established all over the main island.

Land use for urban and industrial development. Singapore is one of the Newly Industrializing Economies (NIEs) in the East Asian region. Rapid

Table 2.14. Areas of Land Used for Agriculture in the Eastern Lowland of Sumatra Bordering the Malacca Straits (Scholz et al., 1983).

District	Area (km^2)	Area in Cultivation (%)	Rice Field ($x10^3$ ha)	Other Crops ($x10^3$ ha)	Botanical Garden ($x10^3$ ha)	Total Cultivated ($x10^3$ ha)
East Aceh to North Sumatra	5,600	21	61	0/0	58	119
Indragiri-Batanghari Tidal Area	9,400	35	117	0/12	202	331
Musi-Bayuasin Delta	3,000	23	58	0/5	6	69
Central and South Sumatra	70,000	2	38	6/3	112	159
Total	**88,000**	**20.3 (ave.)**	**274**	**26**	**378**	**678**

Table 2.15. Land Uses in the West Coast States of Peninsular Malaysia Bordering the Malacca Straits (Ibrahim, E.I., 1995).

Coastal State	Land Use (ha)					Total
	Urban	Agriculture	Grassland	Forest Land	Unused Land	
Perlis	191	8,015	24	1,358	91	9,685
Kedah	664	44,281	481	42,544	821	88,791
Penang	7,687	24,746	991	10,726	97	44,247
Perak	2,426	44,764	1,576	74,410	650	123,826
Selangor	3,653	70,232	450	153,774	138	228,247
Negeri Sembilan	2,015	13,698	661	6,616	-	22,990
Malacca	3,976	23,999	394	5,373	-	33,742
Johor	2,632	89,725	807	20,874	218	114,256
Total	**23,244**	**319,460**	**5,384**	**315,675**	**2,021**	**665,784**

urbanization and development of new industrial estates to accommodate the increasing needs by the manufacturing industries have taken place during the past two decades. Most of the industrial estates are located in Jurong, Sembawang, Sungei Kadut, Kallang Basin and Loyang (***Figure 2.24***). Among these industrial estates, Jurong is the largest and earliest planned industrial estates (***Figure 2.25***). The major industries found in these industrial estates include: 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; wood working; flourmilling and feedmilling; cement making; and others (***Figure 2.25***; Chia, 1992).

Figure 2.22. The Revised Concept Plan for Long-Term Land Uses and Development in Singapore (Chia, 1992).

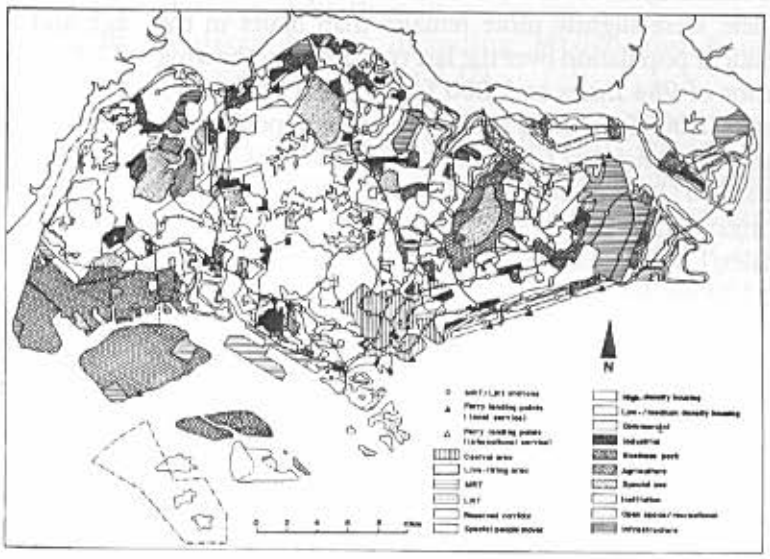


Table 2.16. Land Use and Development in Singapore (MOE/ Singapore, 1989).

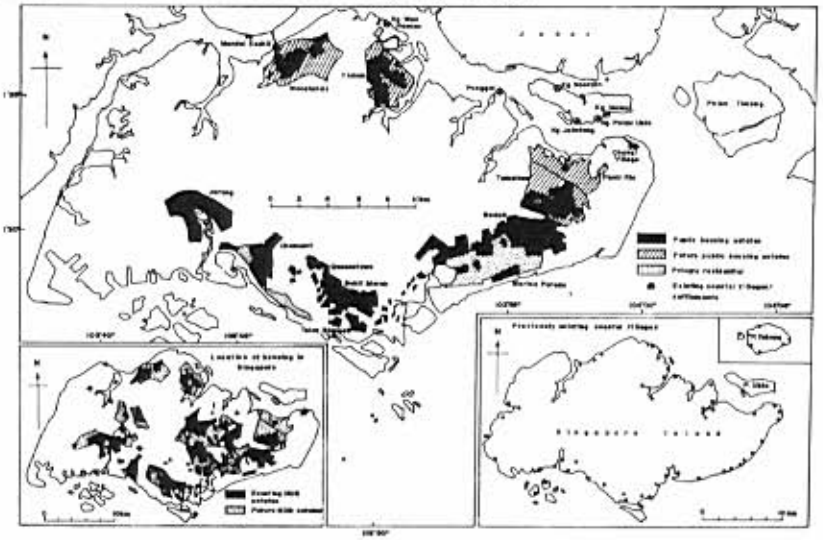
Land Use and Development	Area (km^2)	% Total Land Area
Built-up area: housing and industrial estates	302.9	48.7
Farm holding area	32.6	5.2
Forest	28.6	4.6
Marsh and tidal wasteland area	15.7	2.5
Others (inland waters, open spaces, public gardens, quarries, cemeteries, rubber and coconut plantations and unused land)	242.8	39.0
Total Land Area (main island and offshore islets)	**622.6**	**100**

Demographic Characteristics

National and coastal population

National population of Indonesia. The population change, sex ratio, age distribution, median age and population density from 1975 to 2020 for Indonesia, as estimated by the Population Division, Department for Economic and Social Information and Policy Analysis of the United Nations (DESIPA/UN, 1995), are shown in ***Table 2.17*** and their respective annual population change, growth rate, infant mortality rate and life expectancy are presented in ***Table 2.18***. The resident population in 1995 was estimated at 197,588,000 showing annual growth rates of 1.55 to 2.41% during the last two decades. Population density rose from

Figure 2.23. Land Use and Development in Singapore: Existing and Planned Public Housing Estates, Private Residences and Off-Island Settlements (Chia, 1992).



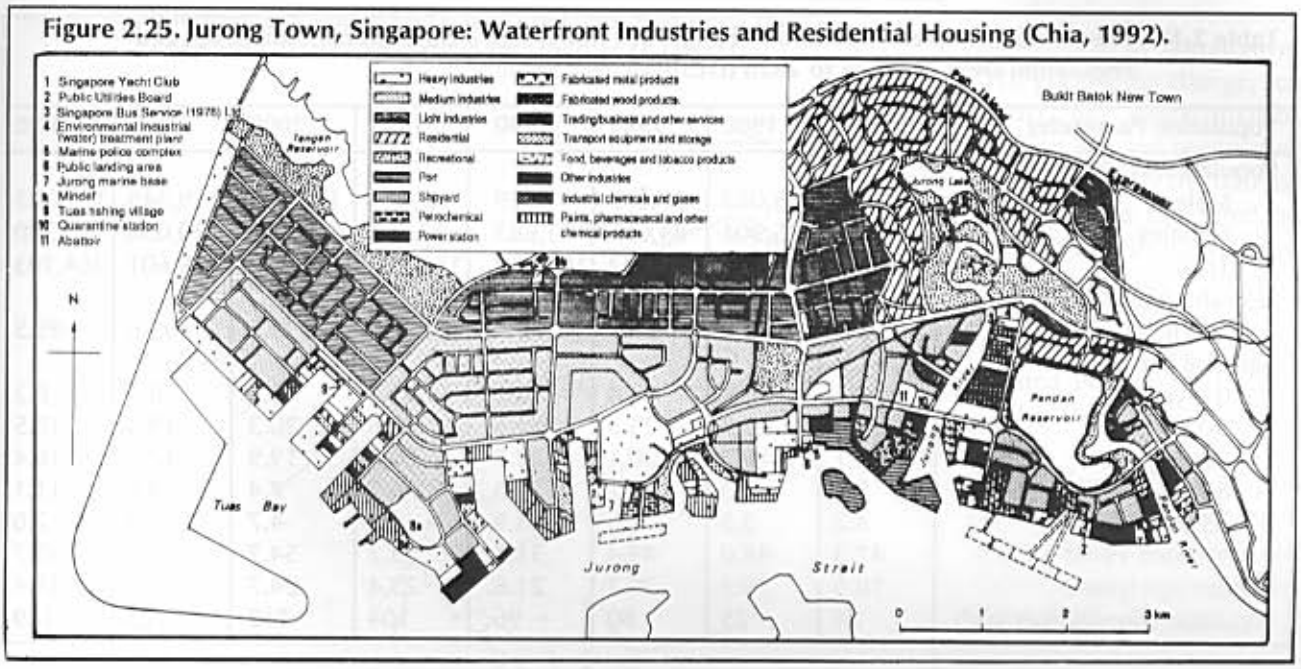
71 residents/km² in 1975 to 104 residents/km² in 1995. There were slightly more females than males in the resident population over the last two decades, showing ratios of 984 males to 1,000 females in 1975 to 996 males/1,000 females in 1995. The resident population has been estimated to increase to 239,601,000 in the year 2010 and 264,103,000 in 2020 with the corresponding sex ratios estimated to be 995 to 996 males/1,000 females and population densities at 126 to 139 residents/ km².

Over the last two decades, residents 15 years of age and below decreased from 42.0% in 1975 to 33.2% in 1995 and it is estimated to further decrease to 26.8% in 2020 and 23.6% in 2050. There were gradual increases in the "greying population", i.e., the number of residents over 60 years old, from 8.3% in 1975 to 11.0% in 1995 and 18.1% in 2020. From 2030 to 2050, around 24 to 37% of the resident population in Indonesia will be over 60 years old (***Figure 2.26***). This increased the median age from

Figure 2.24. Land Uses and Development in Singapore: Industrial Estates and Power Plants (Chia, 1992).



Figure 2.25. Jurong Town, Singapore: Waterfront Industries and Residential Housing (Chia, 1992).

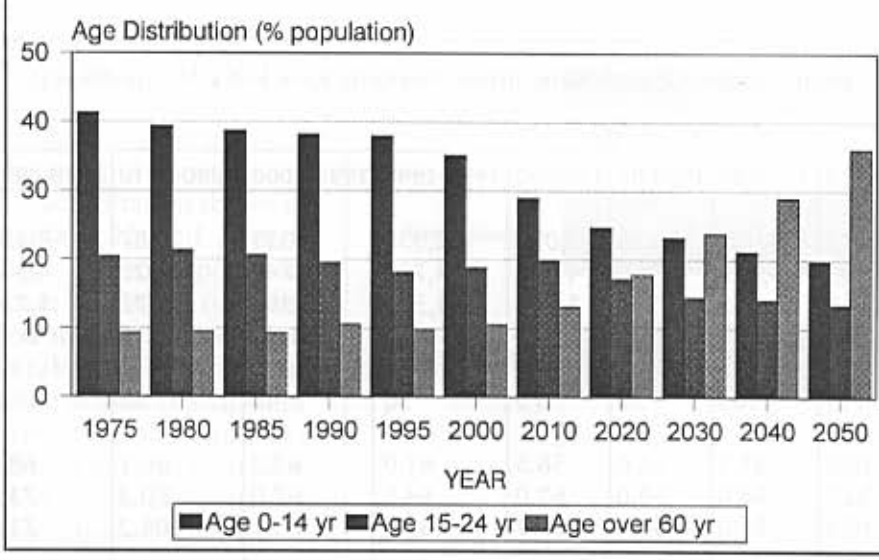


18.5 years in 1975 to 23.1 years in 1995 and to 25-31 years 10-20 years later (***Table 2.17***). Infant mortality and life expectancy significantly improved over the last two decades and are expected to improve further in the next decades (***Table 2.18***).

Coastal population of Indonesia along the Malacca Straits. Administratively, the island of Sumatra and its surrounding islands are divided into seven provinces with 51 "Kabupaten" or regencies. However, only three provinces directly border the Straits of Malacca. They are Aceh, North Sumatra and Riau. In these three provinces, there are twelve regencies fronting the Malacca Straits including Medan and Batam municipalities (***Figure 2.27***).

The total population in the three provinces is 10,930,408 (1993-1994) with a population density of 7,709.6/km². The population of the provinces along the East Coast of Sumatra is shown in ***Figure 2.28***. Medan municipality has the highest population density and the Kampar regency has the lowest (20.3 km²). On the average, the East Coast of North Sumatra has the highest and Riau Province has the lowest population density. It is anticipated that Batam Island soon will have a higher population due to migration of job seekers from other parts of Sumatra or even from other parts of Indonesia ("Growth Triangles").

Figure 2.26. Indonesia: Age Distribution in the Resident Population, 1975-2050 (DESIPA/UN, 1995).



National population of Malaysia. The population chang, sex ratio, age distribution, median age and population density from 1975 to 2020 for Malaysia, as estimated by the Population

Table 2.17. Indonesia: Estimated Population Change, Sex Ratio, Age Distribution, Median Age and Population Density, 1975 to 2020 (DESIPA/UN, 1995).

Population Parameter	1975	1980	1985	1990	1995	2000	2010	2020
Population ($x10^3$):								
Males	67,302	75,063	83,275	91,129	99,025	105,155	119,545	131,733
Females	68,365	75,904	84,057	91,683	99,563	106,576	120,056	132,370
Total	135,667	150,958	167,332	182,812	197,588	212,731	239,601	264,103
Sex ratio (males per 100 females)	98.4	98.9	99.1	99.4	99.6	99.6	99.6	99.5
Age distribution (%):								
0-4 years	16.4	14.8	13.4	12.2	11.1	10.6	8.5	8.2
5-14 years	25.6	26.2	25.3	23.5	21.9	20.3	19.3	15.5
15-24 years	19.1	19.7	20.1	20.9	20.8	19.9	17.7	16.4
60 years or over	5.3	5.3	5.7	6.3	6.7	7.4	9.6	11.1
65 years or over	3.2	3.3	3.6	3.9	4.3	4.7	5.9	7.0
Women 15-49 years	47.3	48.0	49.4	51.4	53.2	54.7	55.2	53.7
Median age (years)	18.5	19.3	20.2	21.6	23.4	24.7	28.2	31.4
Population density (per km^2)	71	75	80	96	104	112	125	139

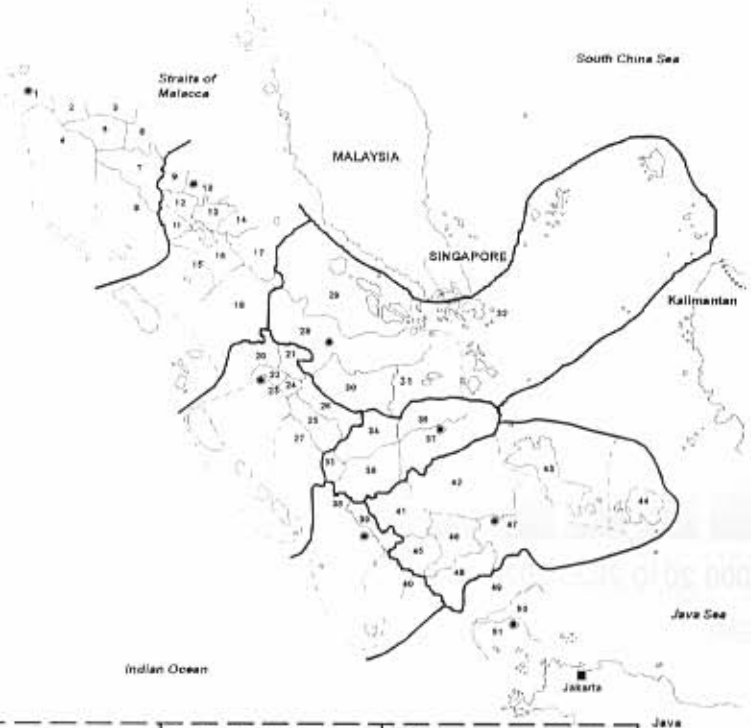
Division, Department for Economic and Social Information and Policy Analysis of the United Nations (DESIPA/UN, 1995) are shown in ***Table 2.19*** and their respective annual population change, growth rate, infant mortality rate and life expectancy are presented in ***Table 2.20***. The resident population in 1995 was estimated at 20,140,000 showing annual growth rates of 2.32 to 2.64% during the last two decades. Population density rose from 37 residents/km^2 in 1975 to 61 residents/km^2 in 1995. There were slightly more males than females in the resident population over the last two decades, showing ratios around 1,013 males/1,000 females in 1975 to 1,018 males/1,000 females in 1995. During the next two decades, the resident population is estimated to increase to 26,239,000 in the year 2010 and 29,787,000 in 2020 with the corresponding sex ratios estimated to be 1,020 to 1,020 males/1,000 females and population densities at 80 to 90 residents/km^2 .

Over the last two decades, residents 15 years of age and below decreased from 42.2% in 1975 to 38.0% in 1995 but is estimated to decrease further to 24.7% in 2020. There were gradual increases in the "greying population", i.e., the number of residents over 60 years old, from 9.3% in 1975 to 9.8% in 1995 and is estimated to be 17.8% in 2020. From 2030 to 2050, around 24 to 36% of the resident population in Malaysia will be over 60 years old (***Figure 2.29***). This increased the median age from 18.6 years in 1975 to 21.7 years in 1995 and is estimated to be 26 to 30 years old 10 to 20 years later (***Table 2.19***). Infant

Table 2.18. Indonesia: Annual Population Change, Growth Rate, Infant Mortality Rate and Life Expectancy, 1970 to 2020 (DESIPA/UN, 1995).

Population Parameter	1970-75	1975-80	1980-85	1985-90	1990-1995	1995-2000	2000-2010	2010-2020
Average annual change ($x10^3$):								
Population	3,077	3,058	3,275	3,096	2,955	3,029	2,687	2,450
Births	4,889	5,073	5,155	4,974	4,707	4,749	4,425	4,344
Deaths	2,217	2,163	1,787	1,651	1,591	1,561	1,575	1,734
Population growth rate (%)	2.41	2.14	2.06	1.77	1.55	1.46	1.19	0.97
Infant mortality rate (per 1,000 births)	114	105	90	75	58	48	36	25
Life expectancy								
Males	48.0	51.5	52.6	58.5	61.0	63.3	66.1	68.9
Females	50.5	54.0	59.0	62.0	64.5	67.0	70.3	73.4
Both sexes combined	49.3	52.0	56.2	60.2	62.7	65.1	68.2	71.1

Figure 2.27. Indonesian Regencies (With Thin Lines) Bordering the Malacca Straits in Sumatra (Whitten et al., 1984).



Aceh Capital: Banda Aceh	North Sumatra Capital: Medan	Riau Capital: Pekan Baru
1. Aceh Besar	9. Langkat	28. Kampar
2. Pidie	10. Deli Serdang	29. Bengkalis
3. North Aceh	14. Asahan	31. Indragiri Hilir
6. East Aceh	17. Labuhan Batu	32. Riau Islands

mortality and life expectancy were significantly improved over the last two decades and are expected to improve further in the next decades (*Table 2.20*).

Malaysia: Coastal population along the Malacca Straits. The coastal population distributed according to the states bordering the Malacca Straits is shown in *Table 2.21* and *Figure 2.30*. The most populous states are Johor (western Johor), Selangor and Perak. The total population of these coastal states (around 13 million) constitutes more than 65% of the total national population of Malaysia.

National (coastal) population of Singapore. The population change, sex ratio, age distribution, median age and population density in 1975 to 2020 for Singapore as estimated by the Population Division, Department for Economic and Social Information and Policy Analysis of the United Nations (DESIPA/UN, 1995) are shown in *Table 2.22* and their respective annual population change, growth rate, infant mortality rate and life expectancy are presented in *Table 2.23.*

The resident population in 1995 was estimated at 2,848,000 with annual growth rates of 1.03 to 1.74% during the last two decades. Population density rose from 3,661 residents/km² in 1975 to 4,608 residents/km² in 1995. There were slightly more males than females in the

Figure 2.28. Population of Provinces Along the East Coast of Sumatra (Statistical Offices of Aceh, North Sumatra and Riau 1995).

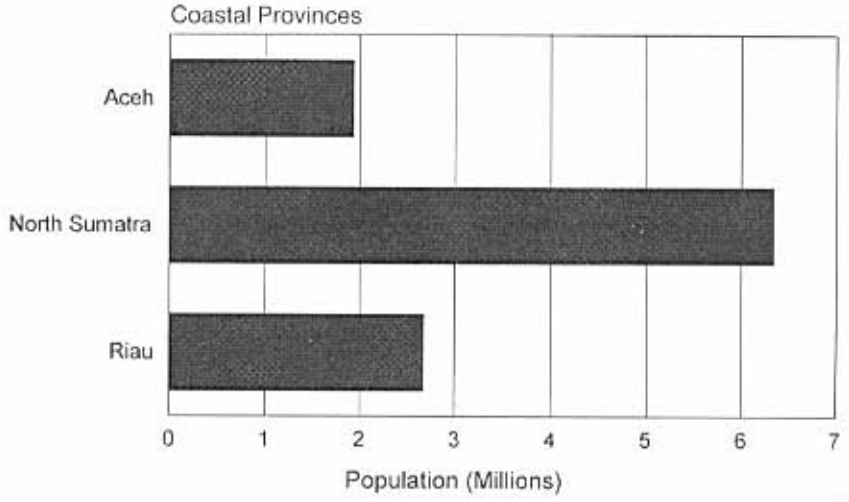
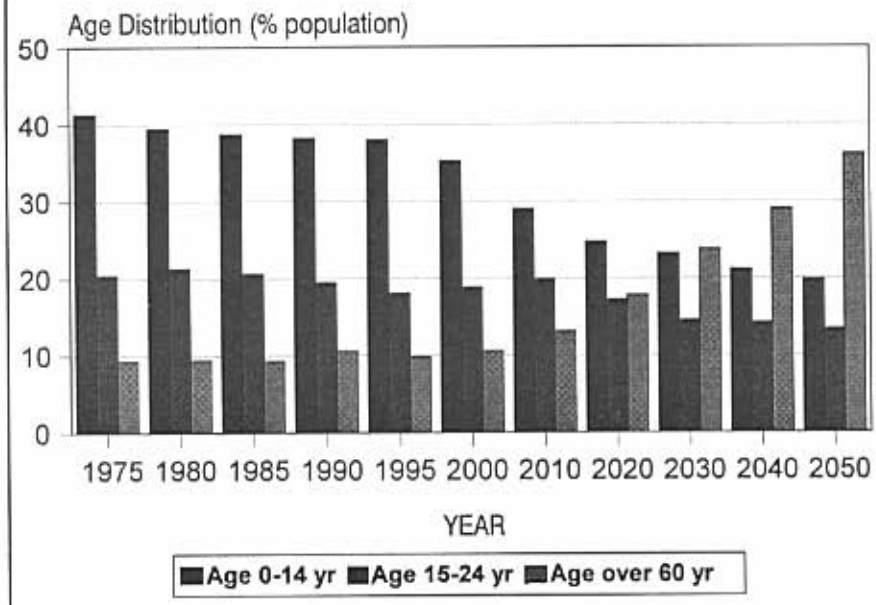


Figure 2.29. Malaysia: Age Distribution in the Resident Population, 1975-2050 (DESIPA/UN, 1995).



resident population over the last two decades, with ratios around 1,045 males/1,000 females in 1975 to 1,025 males/1,000 females in 1995. During the next two decades, the resident population is estimated to increase to 3,144,000 in 2010 and 3,295,000 in 2020 with the corresponding sex ratios estimated to be 1,017 to 1,009 males/1,000 females and population densities at 5,087 to 5,331 residents/ km².

Over the last two decades, residents 15 years of age and below decreased from 32.8% in 1975 to 23.8% in 1995 but further decreased to around 17.2% in 2020 and 17.5% in 2050. There were gradual increases in the "greying population", i.e., the number of residents over 60 years old, from 10.8% in 1975 to 16.7% in 1995 and 40.1% in 2020. After the year 2030, more than 50% of the resident population in Singapore will be over 60 years old (***Figure 2.31***). This increased the median age from 21.9 years old in 1975 to 32.2 years old in 1995 and is estimated to be 39 to 41 years old 10 to 20 years later (***Table 2.22***). Infant mortality and life expectancy were significantly improved over the last two decades and are expected to improve further in the next decades (***Table 2.23***).

The Ministry of Information and the Arts (MITA), Singapore reported an estimated resident population of 2,930,200 in June 1994, showing a 2.0% increase

Table 2.19. Malaysia: Estimated Population Change, Sex Ratio, Age Distribution, Median Age and Population Density, 1975 to 2020 (DESIPA/UN, 1995).

Population Parameter	1975	1980	1985	1990	1995	2000	2010	2020
Population (x 10^3)								
Males	6,169	6,923	7,898	9,021	10,161	11,256	13,252	15,038
Females	6,069	6,835	7,780	8,871	9,979	11,043	12,987	14,749
Total	12,258	13,768	15,678	17,892	20,140	22,299	26,239	29,787
Sex ratio (males per 100 females)	101.3	101.4	101.5	101.7	101.8	101.9	102.0	102.0
Age distribution (%)								
0-4 years	15.3	13.6	15.3	14.6	13.3	11.7	9.4	8.5
5-14 years	26.9	25.8	23.4	23.6	24.7	23.5	19.6	16.2
15-24 years	20.4	21.3	20.6	19.5	18.1	18.5	19.9	17.2
60-64 years	5.6	5.7	5.6	5.9	5.9	6.5	8.0	10.8
65 years or over	3.7	3.7	3.7	3.7	3.9	4.1	5.1	7.0
Women 15-49 years	47.1	49.6	50.4	50.5	15.2	14.3	11.7	9.6
Median age (years)	18.6	19.7	20.3	20.9	21.7	22.6	25.6	29.6
Population density (per km²)	37	42	48	54	61	68	80	90

Table 2.20. Malaysia: Annual Population Change, Growth Rate, Infant Mortality Rate and Life Expectancy, 1970 to 2020 (DESIPA/UN, 1995).

Population Parameter	1970-75	1975 -80	1980-85	1985-90	1990-1995	1995-2000	2000-2010	2010-2020
Average annual change (x 10^3)								
Population	281	301	383	443	450	432	394	355
Births	401	396	471	536	547	534	508	495
Deaths	102	94	88	93	97	102	114	140
Population growth rate (%)	2.44	2.32	2.60	2.64	2.37	2.04	1.63	1.27
Infant mortality rate								
(per 1,000 births)	42	34	28	17	13	11	9	6
Life expectancy								
Males	61.4	63.5	66.0	67.5	68.7	69.9	71.6	73.5
Females	64.7	67.1	70.0	71.6	73.0	74.3	76.0	78.0
Both sexes combined	63.0	65.3	68.0	69.5	70.0	72.0	73.7	75.7

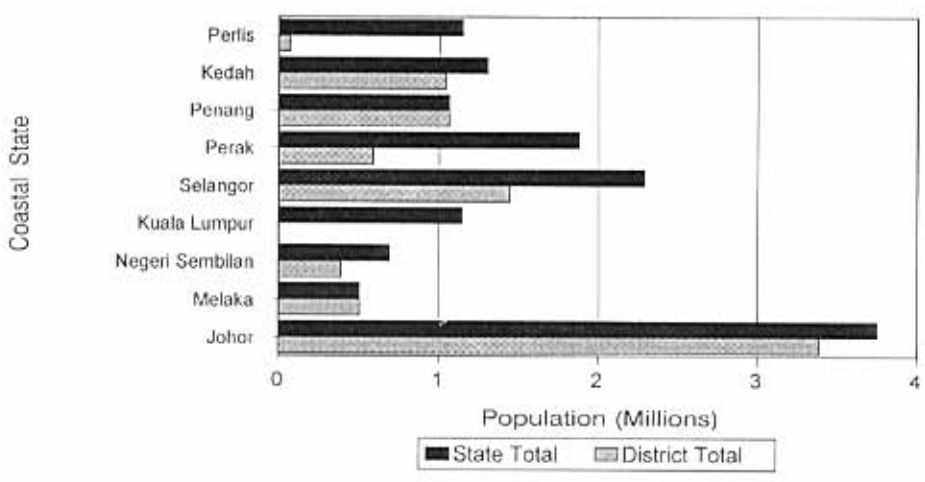
over the population in 1993; population density rose from 3,940 residents/km² in 1984 to 4,535 residents/km² in 1994 which showed slightly higher estimates as reported by the United Nations mentioned above (MITA/Singapore, 1995).

Ethnic composition, religion and culture

Indonesia. The majority of the Indonesian population is of the Malay ethnic group, distributed in particular in the western parts of the Indonesian Archipelago, such as Sumatra and its surrounding islands, Java, Kalimantan, even Sulawesi, Bali and the Nusa Tenggara Islands. The eastern parts, such as the Molluccas and in particular Irian Jaya and Timor, are inhabited by darker skin Melanesian ethnic groups. The Chinese ethnic group is only 2% of the total population. The Arab and Indian ethnic groups are an even small minority.

Culturally, Indonesia is extremely diverse. Each community has its own culture and follows its own customary adat. Some 250 different languages are spoken and over 300 distinctive ethnic groups have been recognized. Yet there are also remarkable similarities between cultures across the Archipelago. Common culture elements appear to be ancient, with differences in geography, economy, religion and history producing the present cultural variations.

Figure 2.30. Peninsular Malaysia: Population of Coastal States and Districts Along the West Coast of Peninsular Malaysia (MIFA/Malaysia, 1994).



Sumatra probably was first inhabited by food gatherers and hunters. But then fishing and horticulture developed, followed by agriculture and animal husbandry. Rice became the staple food for the most fertile areas. Trade developed in various goods. Ports and cities were built. Large-scale plantations were promoted and mining and logging activities increased. These various economic activities serve as a demarcation between cultures. For example, coastal communities are

Table 2.21. Population of Coastal States and Districts Bordering the West Coast of Peninsular Malaysia (MIFA/Malaysia, 1994).

Coastal State	District Bordering Closely to Malacca Straits	Living Quarters	Household	1991 Population
Perlis	Sanglang	3,535	3,316	15,131
	Kayang	2,329	2,188	9,970
	Kuala Perlis	3,442	2,873	13,483
	Utan Aji	3,204	3,020	13,824
	Seriap	1,366	1,269	5,834
	Wang Bintang	7,435	1,663	7,435
District Total		213,11	143,29	65,677
State Total		445,44	401,16	1,145,075
Kedah	Bandar Baharu	7,585	6,891	32,957
	Kuala Muda	67,100	53,817	255,091
	Yan	13,462	12,283	60,823
	Pendang	19,470	17,501	83,135
	Kota Setar	78,268	66,955	323,580
	Kubang Pasu	38,581	33,269	158,189
	Kulim	33,491	26,423	128,394
District Total		257,957	213,139	1,042,169
State Total		321,439	272,783	1,304,800
Penang	Seberang Prai Selatan	19,336	16,393	84,568
	Seberang Prai Tengah	55,609	47,885	236,319
	Seberang Prai Utara	47,914	44,382	225,769
	Penang Island	105,852	104,618	518,419
District Total		228,711	213,278	1,065,075
State Total		228,711	213,278	1,065,075
Perak	Hilir Perak Manjung	42,486	35,317	168,457
	Larut & Matang	67,906	56,631	272,006
	Kerian	34,764	30,499	148,575
District Total		145,156	122,447	589,038
State Total		471,370	339,692	1,880,016
Selangor	Sepang	12,307	10,593	54,653
	Kuala Langat	28,307	24,415	129,696
	Klang	84,913	78,181	406,832
	Petaling	148,006	132,969	633,144
	Kuala Selangor	27,818	23,662	123,095
	Sabak Bernam	23,975	20,196	100,053
District Total		325,326	290,016	1,447,473
State Total		537,422	467,586	2,289,236
Federal Territory	Kuala Lumpur	265,487	246,024	1,145,075
Negeri Sembilan	Port Dickson	22,217	18,098	92,077
	Rembau	10,633	7,988	34,817
	Seremban	69,516	54,913	390,181
District Total		102,366	80,999	390,181
State Total		179,596	144,654	691,150
Melaka State and Coastal District Total		102,470	246,898	504,502
Johor	Batu Pahat	503,222	425,981	2,074,297
	Johor Bahru	185,364	152,489	705,432
	Muar	68,415	59,713	302,947
	Pontian	28,427	25,443	129,702
	Segamat	42,321	35,293	178,266
District Total		827,429	698,919	3,390,644
State Total		877,118	801,219	3,753,120
Grand Total for All States		**3,028,157**	**2,772,250**	**13,778,049**

Table 2.23. Singapore: Annual Population Change, Growth Rate, Infant Mortality Rate and Life Expectancy (DESIPA/UN, 1995).

Population Parameter	1970-75	1975 -80	1980-85	1985-90	1990-1995	1995-2000	2000-2010	2010-2020
Average annual change (x 10^3)								
Population	38	30	29	29	29	24	18	15
Births	48	40	42	45	44	40	37	39
Deaths	11	12	12	13	16	17	19	24
Population growth rate (%)	1.74	1.30	1.16	1.12	1.03	0.82	0.58	0.47
Infant mortality rate								
(per 1,000 births)	19	13	10	8	6	5	5	5
Life expectancy								
Males	57.4	68.6	69.2	71.1	72.4	73.5	75.0	76.7
Females	71.8	73.1	74.6	76.2	77.4	78.6	80.1	81.8
Both sexes combined	59.5	70.8	71.8	73.6	74.8	76.0	77.5	75.2

a multi-racial society. Such varied multi-ethnic character in the Malaysian population has come into being over the course of the last 150 years. The ethnic groups could be generally classified into two main groups, namely the bumiputera and the non-bumiputera (MIFA/Malaysia, 1994).

The bumiputera groups consist of three broad categories: (1) the aborigines (*orang asli*); (2) the Malays; and (3) the Malay-related. The aborigines are few, residing in scattered groups mainly in the mountainous areas of Peninsular Malaysia. The Malays form the predominant group in the Malaysian population (around 50%), residing mainly in Peninsular Malaysia, with smaller groups in Sabah and Sarawak. Since 1850, Javanese and Sumatrans have crossed the Straits of Malacca and have settled in considerable numbers in the West Coast states (e.g., Johor, Selangor and lower Perak) of Peninsular Malaysia. They are regarded for practical purposes as Malays. The Malay community has common cultural traits and, above all, the bond of Islam (MIFA/Malaysia, 1994).

The non-bumiputera group consists mainly of Chinese and Indians with small groups of Arabs, Sinhalese, Eurasians and Europeans. The Chinese came largely from the provinces in the southern part of China, with the Cantonese and Hokkien forming the largest dialect groups. Among the Indians, the largest groups are the Tamils from South India and Sri Lanka, with small groups of Sikh and Malayalee. The non-bumiputera groups constitute around 30 to 40% of the population in Peninsular Malaysia.

Singapore. The 1994 estimates showed that Chinese residents numbered 2,269,600 (77.5%), Malays 415,900 (14.2%), Indians 209,400 (7.1%) and persons of other ethnic groups 35,300 representing 1.2% of the total population (MITA/Singapore, 1995). The people enjoy freedom of worship. The main religions are Buddhism, Christianity, Islam, Hinduism, Taoism and Sikhism. Buddhism and Taoism are traditional Chinese beliefs practiced by about 30.9 and 22.5%, of the total population, respectively. Hinduism and Sikhism are practiced mainly by the Indians (about 3.7 and 0.4%, respectively) and Christianity (Catholics and other Christians) by Chinese, Indians and other minor ethnic groups, comprising 12.6% of the total population. Islam is mainly practiced by the Malays consisting of around 15.5% of the total population, while a relatively large proportion of the population in Singapore (14.4%) are agnostics, i.e., without any religion (***Table 2.24***).

Education and employment

Indonesia

Primary and secondary education. After proclaiming its independence in 1945, the Indonesian government started to provide education for all. Unfortunately, economic conditions were poor. When the New Order (Orde Baru) government came to power in 1966, the earlier commitment to educate the people was reemphasized, with the support of an improving economy.

The education system consists of a six-year primary education (Sekolah Dasar: SD), three-year Junior High School (Sekolah Menengah Pertama: SMP), followed by a three-year Senior High School (Sekolah Menengah Atas: SMA). At the secondary level, it was decided to develop vocational schools, such as mechanics, economics, paramedics, forestry, agriculture and fisheries. ***Table 2.25*** shows the number of primary and secondary education school of the regencies of Sumatra

Table 2.24. Singapore: Distribution of Religions According to the Male and Female Resident Population from the 1990 Census.

Religion	Male	Female	Total	% to Total Resident Population
No religion	175,845	150,591	326,436	14.4
Buddhist	345,858	353,027	698,885	30.9
Taoist/Traditional	256,797	253,585	510,382	22.5
Muslim	182,183	168,337	350,520	15.5
Hindu	44,893	38,811	83,704	3.7
Sikh	4,838	4,707	9,545	0.4
Christian				
Catholic	49,048	58,374	107,422	4.7
Other Christians	78,155	99,705	177,860	7.9
Total	1,137,617	1,127,137	2,264,754	100.0

bordering the Malacca Straits. The tertiary or university level education has also developed throughout Indonesia. All schools and universities, public or private, are managed and regulated by the Department of Education and Culture. Other sectoral groups can establish their own specialized schools with the approval and consent of the Department of Education and Culture. Indonesian language is used as the primary language for instruction, although regional or local languages are employed during the first three years of instruction.

The demand for education has increased steadily since independence. In some cases, the annual increase in number of pupils and students far exceeds the population growth. From the start of Indonesia's first Five Year Development Plan (REPELITA I) in 1969, growth accelerated substantially in the primary education as a result of the Presidential Instruction Program (INPRES) and the introduction of compulsory primary education (for ages 7 to 12) in 1984. The strong and sustained growth in the six-year primary education led to the introduction of a compulsory nine-year primary education, which was launched by President Suharto in 1994. Girls are relatively well represented in both primary and secondary schools (about 40% of students). As a result of government efforts, enrolment rates in most of the outer island provinces, including those in Sumatra, are above those in Java.

Tertiary education. University level education has also expanded markedly since independence. In 1993, there were 51 state or government and 1,035 private universities listed by the Department of Education and Culture distributed all over Indonesia. *Table 2.26* lists universities and colleges in Aceh Special Region, North Sumatra Province and Riau Province

In addition, in recent years the Indonesian government has devoted attention to developing post-secondary education. There is a very large network of public and private specialized and vocational schools and training colleges. There is also special education in the fields of marine science, fisheries, natural resources and environmental studies. There are six universities in Indonesia with a primary program in marine science. One of them is the University of Riau. Similarly, all state universities in Aceh, North Sumatra and Riau have developed programs in the field of fisheries, natural resources and environment programs. The Faculty of Natural Sciences and Mathematics of the University of North Sumatra has developed a special program on the Straits of Malacca. According to 1995 data, there are fifteen state (with about 8,000 students) and twenty private universities (with more than 5,000 students) in Indonesia with fisheries-related faculty or departments.

Employment. The first 25-year Long Term Development Plan (PJP I: 1969 to 1994) was successful in creating job opportunities in Indonesia. Between 1980 and 1990, for example, employment increased by 21.5 million.

The structure of employment has been shifting from the agrarian sector to the non-agrarian production and service sectors. In 1980, about 56% of the labor force was employed in the agricultural sector. The remainder was employed in the industrial and other sectors. In 1990, the agricultural labor force decreased to 49.9% and the industrial and service sectors increased to 50.1%. A similar trend can also be noted in the shift from informal1 to formal2 employment, i.e., decreasing from 69.9% in 1980 to 63.6% in 1990 in the informal sectors.

The number of women employed in various sectors has increased steadily. In 1980, the 25 to 39 age group entering the job market in the urban cities was 40.5% and increased to 44.7% in 1990. The total number of women employed has also increased from 32.2% in 1980 to 39.1% in 1990. Urbanization has

Table 2.25. Number of Schools of Sumatra by Regency Bordering Malacca Straits (Statistical Offices of Aceh, North Sumatra and Riau, 1995).

Level of Type of School (State and Private)	Aceh 1993/1994				North Sumatra 1994/1995						Riau 1993/1994				
	Aceh Besar	Pidie	North Aceh	East Aceh	Lang-sa	Deli Serdang	Med-an	Asa-han	Tg. Balai	Labu-han Batu	Beng-kalis	Indra-giri	Kam-par	Riau Hilir	Batam Is.
Elementary School	212	378	660	452	651	1,203	817	706	77	693	803	456	789	485	79
Elementary special School	-	-	-	-	-	-	-	-	-	-	1	1	1	1	2,033
Special School	-	-	-	-	-	-	-	-	-	-	2	1	-	1	1
Junior High School	33	45	98	61	125	271	324	99	14	111	113	34	77	56	15
Junior Technical High School	-	1	2	1	-	-	-	-	-	-	-	1	-	-	-
Junior Home Economic High School	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Senior High School	16	22	42	28	43	88	175	37	7	36	30	11	14	21	4
Senior Economic High School	-	3	5	4	}						6	1	1	6	2
Senior Technical High School	-	-	-	-	}						3	-	-	1	1
					} 36	89	147	28	3	23					
Senior Home Economic High School	-	-	1	1	}						-	-	-	1	-
Agriculture Technical High School	1	1	3	2	}						-	-	1	1	-

caused a decrease in the labor force in the agricultural sector (Republik Indonesia, 1995).

Table 2.27 shows the number of workers by the main groups of economic activities in Aceh, North Sumatra and Riau Provinces. *Table 2.28* shows the development of labor force between 1980 and 1990 nationally in Indonesia. *Table 2.29* shows the number of job opportunities from various economic sectors at the end of the Fifth Five Year Development Plan (REPELITA V) in 1995 and the projected figures by the end of the Sixth Five Year Development Plan (REPELITA VI) in 1999.

Malaysia

Education and employment. The employment and education statistics have all been obtained from the 1993 Yearbook of Malaysian Statistics. Data presented in the tables below are for the whole of Malaysia or at best pertaining to Peninsular Malaysia, i.e, both the East and West Coast. The number employed in education, etc. can be approximated by taking into account that approximately 65% of the people of Malaysia reside along the West Coast States.

Primary and secondary education. Primary education starts at about 6 years old and is for a period of 6 years. The secondary level age-group is between 12 and 19 years old. Education at this level provides general and specialized learning or both. The Sixth Form is also included in this category. In *Table 2.32* the teachers include trained and untrained, as well as permanent and temporary teachers.

With regard to higher education, the minimum qualification required for the entry into higher education is the successful completion of the Malaysian Certification of Education (MCE) or the Sijil Pelajaran Malaysia (SPM) or the Higher School Certificate (HSC) or the Sijil Tinggi Persekolahan Malaysia (STPM). Education at this level provides specialized training in various fields of study. *Tables 2.30, 2.31* and *2.32* provide information on the number of government-assisted primary and secondary schools, pupils being educated and the number of teachers in Peninsular Malaysia.

Employment. Information presented on employment takes into account all persons who at any time during the reference week did any work for pay, profit

Table 2.26. Tertiary Level Education in Aceh, North Sumatra and Riau Provinces (Statistical Offices of Aceh, North Sumatra and Riau, 1995).

Province	Name of University/College	Status	No. of Students	Year
Aceh	Syiah Kuala University - Darussalam	State	13,330	1994/1995
	Jami'ah Ar-Raniry Islamic Religion Institute	State	5,013	1993/1994
	Samudra Langsa University	Private	1,213	1992/1993
	Serambi Mekkah University	Private	940	1993/1994
	Sabang Economic University	Private	155	1994/1995
	Iskandarmuda University	Private	3,775	1994/1995
	Jabal Chafur University	Private	1,813	1992/1993
	Abulyatama Aceh University	Private	*	*
North Sumatra	University of North Sumatra	State	17,582	1994/1995
	Teachers Education Institute (IKIP) Medan	State	8,768	1994/1995
	Medan Islamic Religion Institute (IAIN)	State	4,754	1994/1995
	There are more than 30 private colleges and academies in various fields	Private	91,279	1994
Riau	University of Riau	State	14,066	1993/1994
	Sultan Syarif Qasim Islamic Religion Institute (IAIN)	State	3,686	1993/1994
	Riau Islamic University	Private	2,692	1993/1994
	Lacang Kuning University	Private	1,454	1993/1994
	There are 8 academies and colleges in various fields: tourism, banking, technology, etc.	Private	1,321	1993/1994

*Data not available.

Table 2.27. Number of Workers by Main Group of Economic Activities in Aceh, North Sumatra and Riau Provinces, 1993 (Biro Pusat Statistik, 1993).

Economic Activities	Province		
	Aceh	N. Sumatra	Riau
Agriculture, Forestry, Hunting and Fishery	49,945	305,207	40,213
Mining and Quarrying	4,455	6,763	20,162
Manufacturing Industry	21,207	200,921	43,030
Electricity, Gas and Water	2,850	11,691	2,289
Construction	25,535	79,450	28,587
Wholesale Trade, Retail Trade, Restaurants and Hotels	10,883	60,506	15,586
Transportation, Storage, and Communication	18,082	97,849	20,468
Financing, Insurance, Real Estate, and Business Service	6,353	26,146	6,172
Community, Social and Personal Services	154,076	444,238	124,497
Others	2,402	2,723	1,036
Total	**295,788**	**1,235,545**	**302,040**

Table 2.28. Development of Labor Force and Employment in Indonesia (Republik Indonesia, 1995).

Explanation	1980	1986	1990
Total of Labor Force (in thousands)	5,242	63,826	73,914
Average Annual Growth Rate (%)	2.7	4.0	3.0
Percentage of Job Seekers from the Labor Force	1.7	2.1	3.2
Percentage of Workers with Less than 35 hours/week Working Hours	36.5	38.3	36.6
Percentage of Employed in Agriculture	55.9	54.7	49.9
Percentage of Women Workers	32.8	35.3	35.6
Percentage of Employees in Java	64.0	62.4	61.2

or family gain. Also included in the statistics are people who could not work during the reference week due to illness, injury, disability, bad whether, vacation, etc., as well as individuals who are temporarily laid off with pay as they will be called off to work. The labor force takes into account all persons in the age group 15 to 64. *Table 2.33* shows the number of people employed in the various sectors in Malaysia from 1988 to 1992.

Between 1986 and 1990 the percentage of people being employed in the agricultural sector (including animal husbandry, forestry workers, fishermen, etc.) fell and the percentage distribution within the production and related work increased. This is shown in *Table 2.34.*

Singapore

Primary and secondary education. The education system in Singapore aims to harness the best in each child and instill moral values. The system provides an average of ten years of primary and secondary education (six years in primary school and 4 to 5 years in secondary school). At the age of 6, a child enters the primary school where three core subjects: English, mathematics and the mother tongue, are taught. After successful completion of the Primary School Leaving Examination (PSLE), a child then enters the secondary school where he continues for another four to five years. Based on their PSLE results, the pupils have a choice of three courses, namely the four-year Special and Express course to prepare for the Cambridge-Singapore General Certificate of Education 'Ordinary' (GCE 'O') level examination and the four-year Academic and Technical courses preparing for the GCE 'Normal' (N) level; pupils who do well in the Academic and Technical courses may continue for a fifth year and sit for the GCE 'O' level (MITA/Singapore, 1995).

Table 2.29. Number of Job Opportunities in Various Economic Sectors in 1995 and Projection for 1999 (Republik Indonesia, 1995).

Sector	1995* ($x10^3$)	1999** ($x10^3$)	Percent Increase
Agriculture, Forestry, and Fisheries	37,956	39,882	5.1
Mining	842	989	17.5
Processing Industries	9,939	12,956	30.4
Electricity, Gas, and Water Resources	187	237	26.7
Construction	3,655	5,008	37.0
Retail, Hotels, Restaurants	11,721	13,917	18.7
Transportation and Communications	3,138	3,888	23.9
Commercial, Banking, and Insurance	793	1,007	27.0
General Services	10,582	12,842	21.4
Total	**78,813**	**90,726**	

* end of REPELITA V
** end of REPELITA VI

Table 2.30. Number of Assisted Primary and Secondary Schools in Peninsular Malaysia (Yearbook of Statistics Malaysia, 1993).

Year	Primary School	Secondary School				
		Academic	Vocational	Technical	Mara Junior Science College	Total
1988	4,549	963	35	9	11	1,1018
1989	4,574	979	45	9	14	1,047
1990	4,600	1,1007	45	9	14	1,075
1991	4,626	1,028	45	9	14	1,096
1992	4,652	1,037	53	9	16	1,115

Depending on results of the GCE 'N' or 'O' level and their choice, pupils may continue their post-secondary education in a technical or commercial

Table 2.31. Number of Pupils in Assisted Primary and Secondary Schools in Peninsular Malaysia (Yearbook of Statistics Malaysia, 1993).

Year	Primary School	Academic	Vocational	Technical	Mara Junior Science College	Total
1988	1,898,245	1,100,009	15,606	5,510	7,793	1,128,918
1989	1,942,105	1,012,274	18,139	5,700	8,475	1,134,588
1990	1,987,239	1,110,208	21,205	5,846	8,419	1,145,678
1991	2,059,275	1,115,119	22,363	5,739	8,693	1,151,914
1992	2,140,623	1,153,069	22,097	5,464	8,893	1,190,333

Table 2.32. Number of Teachers in Assisted Primary and Secondary Schools in Peninsular Malaysia (Yearbook of Statistics Malaysia, 1993).

Year	Primary School	Academic	Vocational	Technical	Mara Junior Science College	Total
1988	86,845	52,910	1,590	366	774	55,640
1989	88,647	54,027	1,889	377	842	57,135
1990	95,331	58,414	2,128	391	850	61,783
1991	98,705	61,133	2,221	412	853	64,619
1992	101,875	63,752	2,556	411	951	67,670

institute under the Institute of Technical Education (ITE); a polytechnic college to pursue diploma courses; or a junior college or a centralized institute to prepare themselves for the Singapore-Cambridge General Certificate of Education 'Advanced' (GCE 'A') level examination. The eligibility for tertiary education thus depends on the results of the GCE 'A' level examination.

The education system adopts a bilingual policy, i.e., pupils learn at least two languages in school: English and their mother tongue. English is the medium of instruction and the language of administration, commerce and technology in Singapore while the mother tongue which could be Chinese (Mandarin), Tamil or Malay can also be used whenever it is appropriate.

There are 192 primary schools; six full schools (boarding schools); 137 secondary schools, including 12 autonomous schools; eight independent schools; four centralized institutes; and 14 junior colleges in Singapore (MITA/ Singapore, 1995). Apart from the independent schools which are run by the private sector, the rest are either fully or partially Government-aided schools and are under the direct control of the Ministry of Education. However, since 1993, 12 Government-

Table 2.33. Employment in Malaysia (Yearbook of Statistics Malaysia, 1993).

Industry (in thousands)	1988	1989[1]	1990[1]	1991[1]	1992[2]
Agriculture, Forestry, Hunting and Fishing	1,908.3	1,851.0	1,837.6	1,834.8	1,832.1
Mining and Quarrying	37.2	38.3	39.1	39.4	40.2
Manufacturing	1,012.6	1,171.2	1,290.2	1,374.1	1,448.1
Construction	356.4	386.3	426.9	455.9	481.4
Electricity, Gas and Water	45.0	45.4	45.9	46.3	46.7
Transport, Storage and Communication	261.1	269.3	285.4	297.0	308.6
Wholesale and Retail Trade, Hotels and Restaurants	1,070.3	1,157.0	1,239.4	1,313.8	1,382.3
Finance Insurance, Real Estate and Business Services	211.6	221.7	231.3	240.3	248.2
Government Services	844.3	846.6	850.2	853.9	858.5
Other Services	340.7	364.0	375.0	393.4	414.0
Total	6,087.5	6,350.8	6,621.0	6,848.9	7,060.1

[1] Estimates by the Employment and Wage Estimation Group comprising the Economic Planning Unit, the Department of Statistics Malaysia and the Ministry of Human Resources.
[2] 1992 estimates by the Economic Planning Unit.

Table 2.34. Percentage Distribution of Employed Persons by Occupation (Yearbook of Statistics Malaysia, 1993).

Occupation	1986	1987	1988	1989	1990
Professional, Technical and Related Workers	7.8	7.6	7.4	7.5	7.8
Administrative and Managerial Workers	2.4	2.0	2.1	2.1	2.2
Clerical and Related Workers	9.5	9.5	9.4	9.5	9.8
Sales and Related Workers	11.1	11.9	11.9	11.4	11.3
Service Workers	11.9	11.8	11.7	11.4	11.4
Agricultural, Animal Husbandry and Forestry Workers, Fishermen and Hunters	30.5	30.8	30.6	28.9	26.2
Production and Related Workers, Transport Equipment Operators and Laborers	26.8	26.5	26.9	29.3	31.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

aided schools were given additional resources and greater autonomy to function more like private independent schools; they are known as autonomous schools.

In 1994, 447,796 pupils enrolled in the various primary and secondary schools as well as junior colleges and centralized institutes; on average, the ratio of pupils per teacher is 22.2:1 (*Table 2.35*).

Tertiary education. Tertiary education in Singapore is relatively advanced. There are various well-established tertiary educational centers such as universities, technical colleges, research centers, etc., offering a wide range of professional education and training (*Table 2.36*). Apart from those mentioned in *Table 2.36*, there are also some international schools and colleges offering courses for expatriate students, making Singapore the well-known center for professional and technical training and education in the region.

Employment. There were 1,649,300 employed persons 15 years of age and over in June 1994 (MITA/Singapore 1995). As shown in *Table 2.37*, majority of them were employed in the manufacturing (422,500), commerce (376,900), community/social/personal services (353,600), financial/business services (198,600), transport/communications (174,800) and construction (108,800).

A breakdown of the labor force in June 1994 is given as follows (MITA/Singapore 1995):

Total labor force	1,693,100
Employed persons	1,649,300
Unemployed persons	43,800
Labor participation rate	64.9%
Unemployment rate (average for the year 1994)	2.0%

A relatively low unemployment rate (2.0%) was recorded in 1994. Occupations of the employed persons in Singapore in 1994 are shown in *Table 2.38*. More than 50% of the employed persons were engaged in blue-collar jobs, including production and machine operators, laborers and service workers. Professionals and technicians comprised 30% of employed persons.

Table 2.35. Education in Singapore: Enrollment in Educational Institutions in 1994 and the Average Ratio of Pupils to Teacher (MITA/Singapore, 1995).

Institute/School	Enrollment of Pupils	Number of Teachers	Ratio of Pupils to Teacher
Primary Schools	251,005	10,553	23.8
Secondary Schools	174,508	7,990	21.8
Junior Colleges and Centralized Institutes	22,283	1,629	13.7
Total/Average	**447,796**	**20,172**	**22.2**

Table 2.36. Education in Singapore: Major Tertiary Education Centers (MITA/Singapore, 1995).

University/Institute	Enrollment of Students (1994/95)	Education Activities	Remarks
National University of Singapore (NUS)	Undergraduates: 16,137 Post-graduates: 3,298	• Eight faculties comprising 53 teaching departments. • Six national research institutes and more than 20 other research centers in various faculties. • A fully-computerized library holding over 1.89 million books and journals, and 18,123 current periodical titles.	NUS was established in August 1980, through the merger of the University of Singapore and Nanyang University.
Nanyang Technological University (NTU)	Undergraduates: 11,052 Post-graduates: 2,062	• Six schools: Accountancy and Business, Applied Sciences, Communication Studies, Civil and Structural Engineering, Electrical and Electronic Engineering and Mechanical and Production Engineering. • Six research institutes and centers.	The National Institute of Education (NIE) is part of NTU, which offers professional training for teachers.
Institute of Southeast Asian Studies (ISEAS)	32 visiting fellows and 26 visiting associates from 17 countries	• A regional research center for scholars and specialists concerned with modern Southeast Asia and its wider strategic environment. • Major research programs: ASEAN Economic Research Unit, Regional Strategic and Political Studies, Social Issues in Southeast Asia, Southeast Asia Cultural Programme and the Indochina Unit.	The institute has issued over 700 titles from both the ISEAS researchers and scholars in Southeast Asia and the Asia-Pacific; there were 28 publications in 1994-95.
Southeast Asian Ministers of Education Organization (SEAMEO), Regional Language Center (RELC)	Not available	• Conducts advanced courses in language teaching. • Undertakes and promotes research. • Disseminates information through seminars and publications. • Provides library and information services.	Apart from language courses, library and information services, the Center also offers post-graduate courses in applied linguistics to scholars from Southeast Asian countries.
Singapore Polytechnic (SP), Ngee Ann Polytechnic (NAP), Nanyang Polytechnic (NP) and Temasek Polytechnic (TP)	SP: 6,563 (4,857 full-time students); NAP: 13,637 (full-time), 1,229 (part-time) NP: 7,300 TP: 3,763	• SP offers diploma and certificate courses in business, computer studies, engineering, maritime studies and technology. • NAP offers 17 full-time courses including accountancy, commerce, biotechnology, information technology, engineering, computer science, etc. • NP: four Schools including Engineering, Business Management, Health Science and Information Technology. Offers 15 full-time diploma courses. • TP: offers 21 full-time courses in business, design, engineering, information technology and applied science.	

continued

Table 2.36. (continued)

University/ Institute	Enrollment of Students (1994/95)	Education Activities	Remarks
Institute of Technical Education (ITE)	Continuous Education and Training Programs: 64,630; Modular Skill Training: 13,980; Training Initiative for Mature Employees: 1,290; Adult Cooperative Training Scheme: 570.	• Provides technical training for secondary school leavers and working adults. • School leavers are trained in automation, electrical, electronics, precision engineering, business studies and mechanical servicing. • Full-time training in engineering and business courses is offered at its 11 technical institutes.	
Singapore Institute of Management (SIM)	Degree and Diploma courses: 8,000 company executives; Seminars/Workshops/ Conferences: 7,000.	• Offers two doctoral, nine master's, ten bachelor's and over 20 diploma and certificate programs. • Was selected by the Ministry of Education in 1992 to run Open University Degree Program in Singapore.	An independent, non-profit professional organization with a collective membership of over12,000 comprising both corporations and individuals.
National Maritime Academy	In 1994, 6,183 trainees graduated from the pre-sea course, 287 from the watchkeeping engineer course and 1,514 from the deck and engineer retraining course.	• Offers a three-year Diploma in Maritime Studies (Marine Power Plant) course. • Conducts a 16-week pre-sea general purpose course to train new seamen for the merchant navy.	

Table 2.37. Employment in Singapore: Employed Persons by Industry, 1994 (MITA/ Singapore, 1995).

Industry	Employed Persons	% to Total Employed Persons
Manufacturing	422,500	25.6
Commerce	376,900	22.9
Community/Social/ Personal Services	353,600	21.4
Financial/Business Services	198,600	12.0
Transport/Communications	174,800	10.6
Construction	108,800	6.6
Others	14,100	0.9
Total	1,649,300	100.0

The classification of industries for 1994 is based on the Singapore Standard Industrial Classification (SSIC), 1990.

Table 2.38. Employment in Singapore: Occupations of Employed Persons, 1994 (MITA/ Singapore, 1995).

Occupation	Employed Persons	% to Total Employed Persons
Production Craftsmen, Plant and Machine Operators, Cleaners and Laborers	583,100	35.4
Technicians and Associated Professionals	250,000	15.2
Clerical Workers	243,300	14.8
Service Workers, Shop/Market and Related Sales Workers	221,100	13.4
Legislators, Administrators and Managers	178,800	10.8
Professionals	106,400	6.4
Agricultural and Fishery Workers	2,900	0.2
Others	63,700	3.9
Total	**1,649,300**	**100.0**

[1] People in the "informal" sector are self-employed or in small family run business. Their income is based on what they can generate or that part they can generate that particular day or week, which is not a fixed income.

[2] People employed in the "formal" sector receive fixed monthly or weekly salaries with all the social fringe benefits from their employers such as government offices, banks, factories, crop estates, etc.

Chapter 3

NATURAL RESOURCES EXPLOITATION, UTILIZATION AND CONFLICTS

Capture Fisheries and Coastal Aquaculture: Status and Socioeconomic Contributions

Capture fisheries

Indonesia. The fishing grounds along the Indonesian portion of the Malacca Straits occupy approximately 5,500 km² (Burbridge, 1988). Pelagic fish, demersal fish and shrimp are all harvested by the capture fishery (***Table 3.1***). The pelagic stock consists of *Rastrelliger* spp., *Megalaspis cordyla, Decapterus* spp. and sardines, while the demersal stock consists of species belonging to the families of Ariidae, Carangidae (excluding *Megalaspis* spp. and *Decapterus* spp.), Leiognathidae, Lutjanidae, Polynemidae, Serranidae, shark ray, squid and cuttlefish (Martosubroto and Naamin, 1988). Based on statistical records, there are more than 45 species of fishes, crustaceans and shellfishes caught in the Malacca Straits. The total sustainable potential of fish in the Indonesian portion of the Straits of Malacca has been estimated at more than 270,000 tonnes/year. This value represents approximately 5.9% of the fishery potential for the whole of Indonesia.

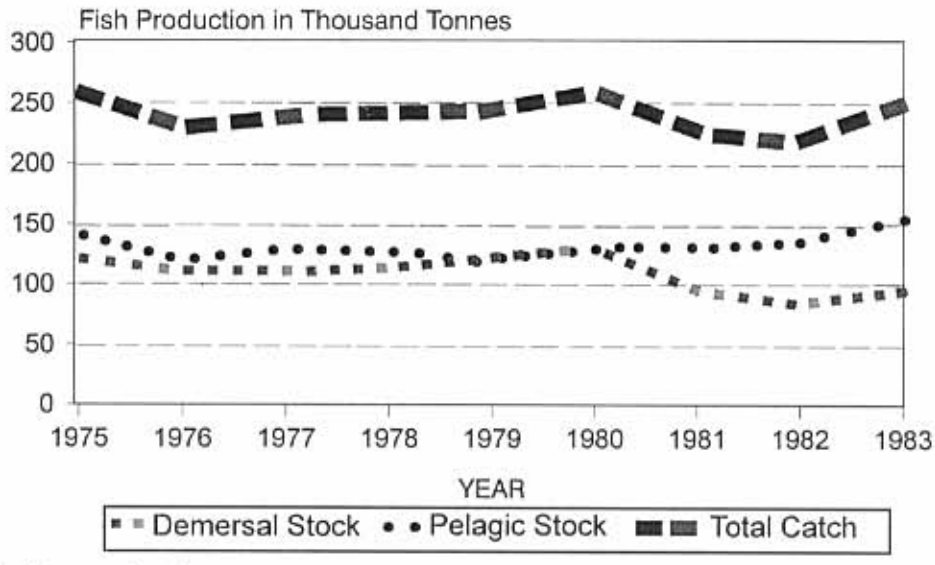
Table 3.1. Marine Fishery Resources in the Malacca Straits (Martosubroto et al., 1992).

Type of Marine Fishery	Malacca Straits (tonnes/year)	National (tonnes/year)
Demersal	116,900	1,033,800
Pelagic	108,000	2,580,00
Tuna	—	91,245
Skipjack tuna (shrimp)	—	18,470
Penaeid shrimp (shrimp)	22,900	89,700
Spiny lobster	428	4,128
Squid (molluscs)	8,250	315,150
Cuttle fish (molluscs)	1,080	41,010
Coral fish (molluscs)	80,841	66,036
Eucheuma (seaweed)	2,250	115,950
Gracilaria (seaweed)	2,000	28,300
Gelidium (seaweed)	150	4,500
Total	**270,799**	**4,554,569**

Traditional gear such as the bottom gill nets, lift nets, push nets and tidal traps are used to catch shrimps along the coasts of Aceh, North Sumatra and Riau. These traditional nets operate mainly in shallow waters (less than 12 m deep) and account for some 7,000 tonnes of penaeid shrimp catch per year in the 1950s. Shrimp trawling was introduced in the 1960s and developed rapidly in all the three provinces. Around 1975, shrimp production in the Straits of Malacca reached a level of 22,000 tonnes. Following the ban of trawling in waters around Sumatra on 1 January 1981 (Presidential Decision No. 39/1980), shrimp production fell to 18,000 tonnes. In 1983, the production again increased to 21,106 tonnes probably due to an increase in fishing units (Burbridge, 1988).

Pelagic fish species dominate the total catch from the Malacca Straits, accounting for some 62% of the total catch. The demersal stock, which also includes shrimps and squids, provides the rest of the total catch. During 1975 to 1983, catches showed slight increases over the years but a decline in the demersal catches was obvious starting from 1981 after the introduction of the Presidential decree for the ban of trawling (***Figure 3.1***). The fishing industry has provided jobs for many people. In 1983, the number of full-time fishermen for all three provinces was 97,000 or about 16% of the 602,000 full-time fishermen in Indonesia and by 1993 the number of fishermen along the East Coast provinces had more than doubled and stood at 212,779 (Direktorat Jenderal Perikanan, 1995). North Sumatra supplies the highest number of fishermen, approximately 50% of the total number of Indonesian fishermen operating in the Malacca Straits in 1993 (***Figure 3.2***). As can be seen from ***Figure 3.3***, North Sumatra and Riau over the years have contributed the highest in terms of fish landings, whereas Aceh has only had a minor share (between 8% and 16% of the total contribution). From 1975 to 1983, North Sumatra recorded the highest catches compared to the other two provinces. However, more recently (1989 to 1991), the fish production from Riau has been greater than North Sumatra. Overall, catches followed the distribution pattern of fishermen. This is because

Figure 3.1. Demersal and Pelagic Fish Production from Indonesian Portion of the Malacca Straits (Martosubroto et al., 1992).



*Includes the shrimps and squids.

the dominant fishing methods operating in this Indonesian portion of the Malacca Straits are the inshore fishing gear, the operation of which depends more on human skill than advancement in fishing technology (Martosubroto and Naamin, 1988).

For the provinces bordering the Malacca Straits, the statistics could be misleading because the catches may not necessarily be from the Malacca Straits but may also include catches from Natuna Sea, Bangka coastal waters, or from the Indian Ocean or other parts of Indonesia. Therefore, the annual catches from the three provincies bordering the Malacca Straits should be treated with care.

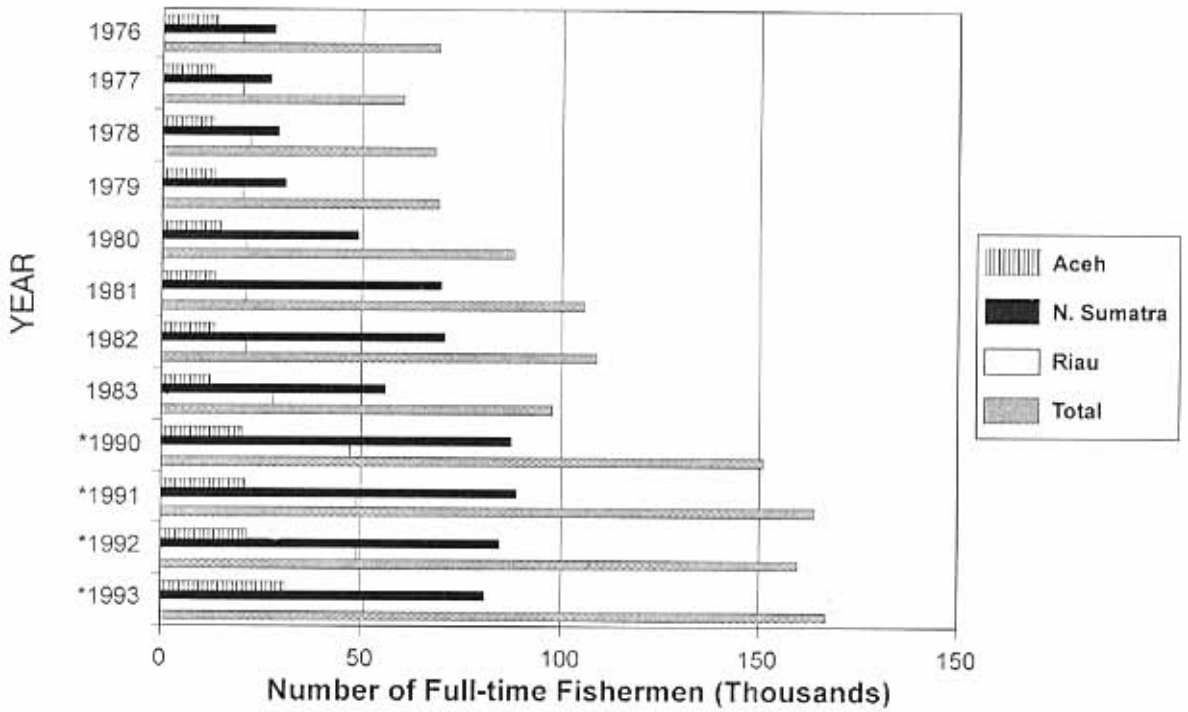
Table 3.2 provides data (1990 to 1993) on the number of fishing boats, fishery establishments, marine fishing units by gear and number of fishermen (part- and full-time) in the East Coast provinces of Aceh, North Sumatra and Riau.

Although nationally the fishery sector has grown annually at the rate of 5% by volume of catch and almost 15% by export value, fisheries in Indonesia are far from efficient and well-managed. Indonesia is still facing a number of problems, including, among others (Soegiarto, 1996):

- Stock assessments are not yet completely done for all waters and species. There are more than 40 major commercial species which have to be assessed and managed individually;
- Fishery statistics are generally incomplete and can generate misleading information and conclusion;
- Post-catch losses are still very high; some experts indicate about 20%;
- Exports are still dominated by two commodities: shrimp (60%) and tuna (14%). Both are facing high competition from other countries, such as Taiwan, Thailand, China, Mexico, etc. and a rather narrow market, mostly Japan. Thus, prices fluctuate from time to time;
- Exports are in fresh or raw condition. There is only limited effort for processing and giving an added value;
- Almost 80% of the fisheries in Indonesia are artisanal (traditional). There is a strong conflict between artisanal and commercial fisheries. Artisanal fisheries have a low productivity, low capital investments, low S&T inputs and are thus slow in responding to modernization and new ideas;
- The Central Government has almost unlimited authority to manage and regulate the marine fisheries; however, enforcement and management are weak.

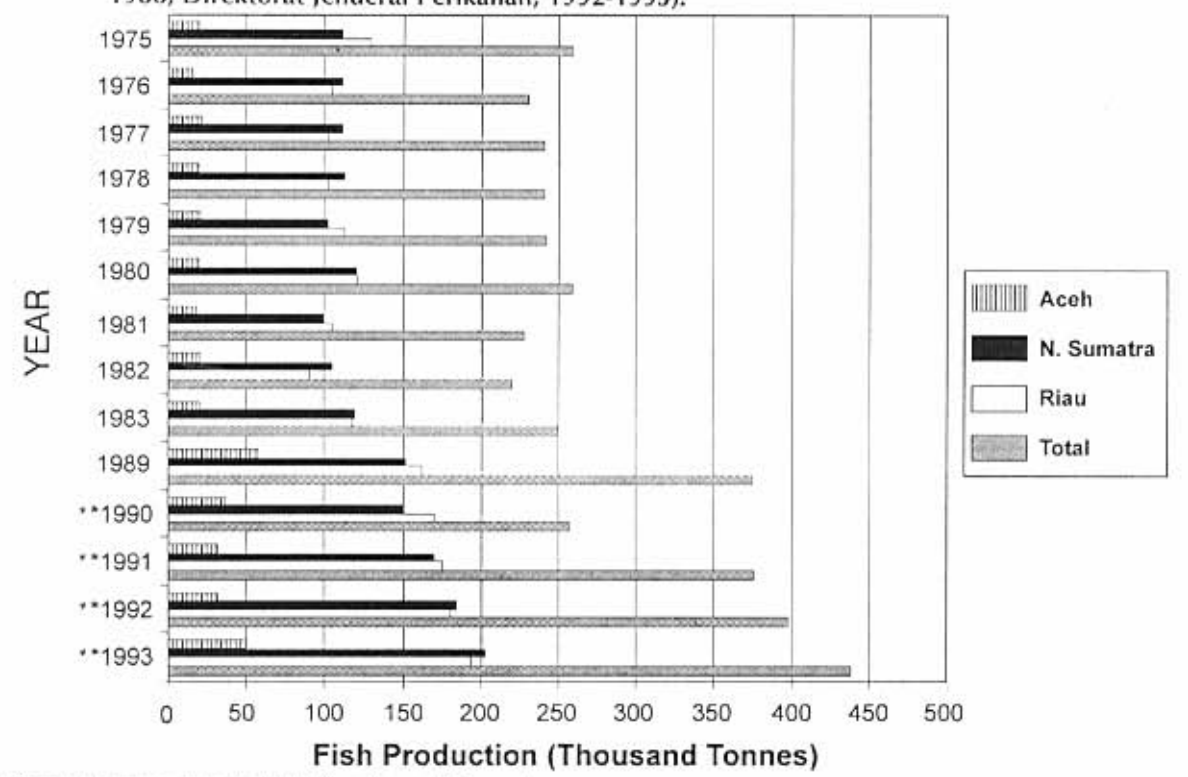
In order to collect statistical records of fish catch, the central government through the Directorate General of Fisheries has constructed fish auction facilities in various fishing regions. The local

Figure 3.2. Number of Full-Time Fishermen from Aceh, North Sumatra and Riau, Indonesia (Martosubroto and Naamin, 1988; Direktorat Jenderal Perikanan, 1992-1995).



*East Coast Provinces of Aceh, North Sumatra, and Riau only

Figure 3.3. Fish Production from Aceh, North Sumatra and Riau, Indonesia (Martosubroto and Naamin, 1988; Direktorat Jenderal Perikanan, 1992-1995).

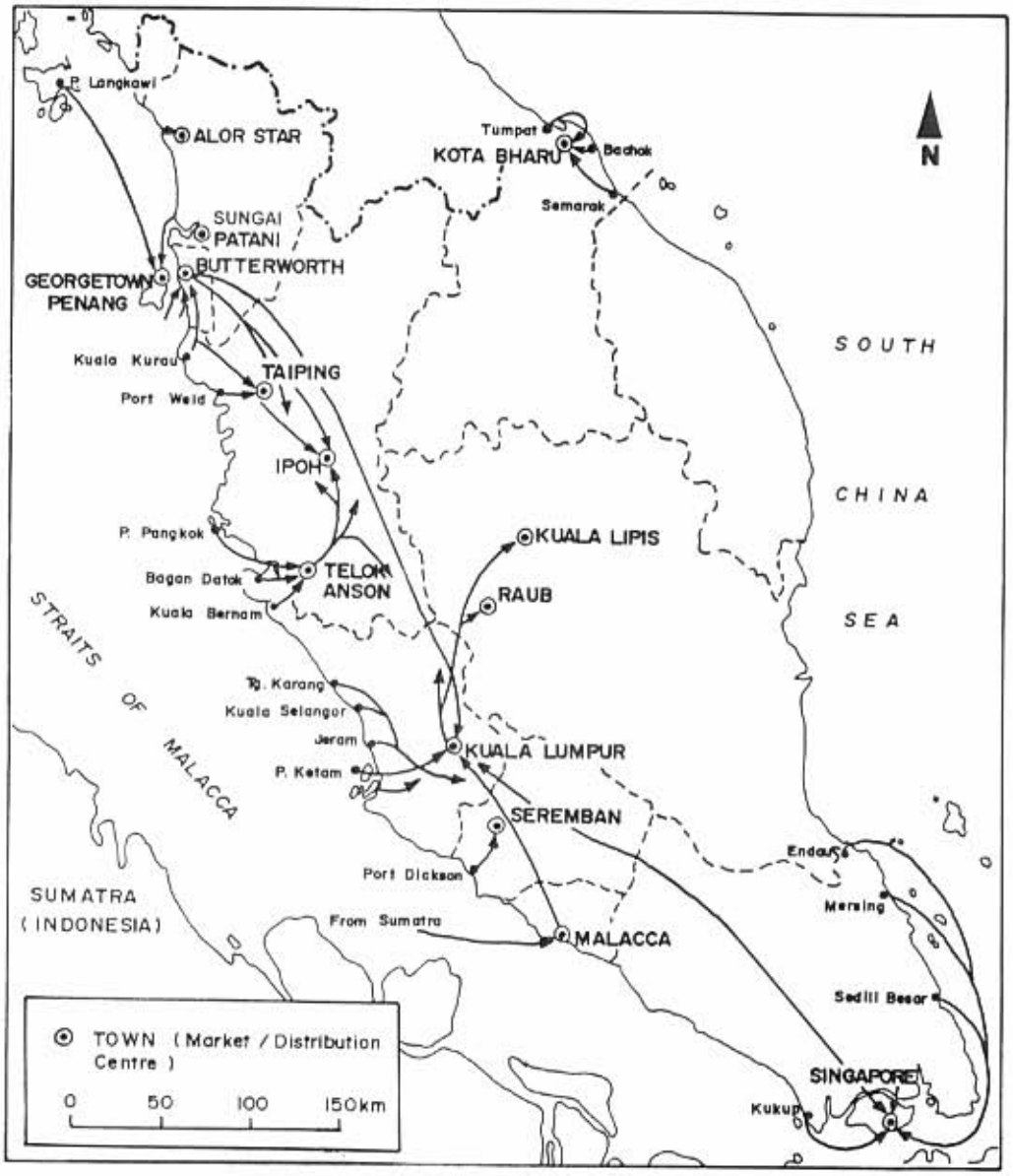


*East Coast Provinces of Aceh, North Sumatra, and Riau only

Table 3.2. Data on Fisheries in the East Coast of Provinces of Aceh, North Sumatra and Riau, 1990-1993. (Direktorat Jenderal Perikanan, 1992-1995).

Explanation	Aceh				North Sumatra				Riau			
	1990	1991	1992	1993	1990	1991	1992	1993	1990	1991	1992	1993
Fishery establishment by size of fishery management												
Without boat	293	165	183	92	401	1,273	3,806	1,969	2,643	1,952	1,958	2,033
With non-powered boat	1,654	1,707	1,657	2,273	8,057	8,596	9,527	8,998	10,918	10,632	10,673	11,078
With outboard boat	1,405	1,517	1,536	2,566	—	28	35	—	968	1,329	1,334	1,383
With inboard boat	883	1,176	1,227	2,553	10,414	10,791	10,127	11,139	8,174	9,549	9,596	9,976
Number of fishermen by fisherman category												
Full time	20,140	22,908	23,473	33,065	85,898	90,420	86,299	81,193	45,320	49,237	49,336	51,241
Part time (major)	3,220	3,662	3,753	5,287	22,382	23,696	22,487	21,157	10,376	11,220	11,528	11,973
Part time (minor)	2,589	669	686	866	2,589	2,741	2,601	2,447	5,045	5,457	5,344	5,550
Number of marine fishing boat												
Non-powered boat	1,682	1,925	1,862	2,832	8,210	9,246	9,814	9,694	11,278	11,025	11,051	11,363
Outboard motor	1,664	1,726	1,693	2,590	—	28	35	—	977	1,142	1,378	1,417
Inboard motor	994	1,213	1,234	1,583	11,569	11,863	12,840	12,746	8,239	9,873	9,910	10,192
Number of Marine Fishing Unit- by Type of Gear:												
Purse seine	95	288	212	288	857	494	1,389	1,026	63	59	56	56
Seine nets (payang, Danish seine, beach seine)	493	304	449	1,884	1,568	2,181	2,148	2,215	682	733	795	803
Gill nets (drift, encircling, shrimp, set and trammel)	2,500	2,030	1,939	2,447	6,899	7,590	8,919	9,039	6,844	7,061	7,097	7,849
Lift nets (raft, bagan, scoop, others)	2,665	157	223	296	2,732	2,500	2,749	2,842	2,141	1,786	1,772	2,146
Hook and lines (tuna longline, drift long-line other than tuna longline, set long-line, troll line, other poles and lines)	5,772	1,662	1,524	1,603	3,610	2,427	3,874	3,020	7,808	10,423	9,153	9,856
Traps (guiding barrier, stow net, portable net, etc.)	12	38	249	175	2,434	4,815	3,691	3,665	3,666	4,682	4,665	3,870
Shellfish collecting equipment	–	–	–	–	2,784	2,940	2,607	2,802	3,067	2,017	2,199	2,429
Others (harpoon, cast nets, etc.)	21	476	–	–	181	42	63	338	30	–	–	194

Figure 3.4. Transport and Road Networks in Peninsular Malaysia (Ooi, 1990).



government in turn receives about 5% of the revenue generated from these auctions. Fish auction facilities are also sometimes operated by an arm of the Directorate General of Fisheries (Unit Pelaksana Teknis).

Malaysia. Fish trading and transport are much more extensive along the West Coast States fronting the Malacca Straits than along the East Coast States (*Figure 3.4*). The introduction of synthetic-fiber fishing nets, mechanization of the fishing boats and trawler fishing in the 1960s has enhanced the development of the fishery sector in Peninsular Malaysia, particularly along its West Coast.

The most important fishery in the Malacca Straits, which engages about four-fifths of the fishing vessels, is the inshore fishery with fishing activities mainly confined to 12 miles off the coast (Ooi, 1990; Ibrahim, E.I., 1995). The estimated yield potential of total fishery resources in the inshore areas and up to 12 miles off the coast is around 588,200 tonnes, of which 321,800 tonnes are contributed by the West Coast and 266,400 tonnes by the East Coast of Peninsular Malaysia. The estimated potential fishery resources for the offshore areas (12-mile territorial water limit to 200 nautical mile limit) yield another 136,400 tonnes, of which 108,000 tonnes are demersal species and 28,400 tonnes are pelagic species (Ibrahim, E.I., 1995).

The recorded fish landings from the Malacca Straits by fishermen along the West Coast of Peninsular Malaysia in 1990 were 510,471 tonnes compared to 309,432 and 131,404 tonnes for the East Coast of Peninsular Malaysia and Sabah/Sarawak, respectively. The amount of fish caught from the Malacca Straits accounted for 54% of the national total (***Table 3.3***). In 1990, about 39,897 fishermen were recorded in the West Coast compared to 32,382 recorded in 1993; the number of licensed fishing boats increased from 10,283 in 1990 to 14,306 in 1993 (Kamaruzaman,

Table 3.3. Total Fish Landings, Numbers of Fishermen and Fishing Boats from the West Coast of Peninsular Malaysia Compared to Other States, 1990 (Naidu, 1997).

Parameter	West Coast of Peninsular Malaysia	East Coast of Peninsular Malaysia	Sabah and Sarawak	Total
Total Fish Landings				
Tonnes	510,471	309,432	131,404	951,307
% Total	53.6	32.5	13.9	100
Number of Fishermen				
Number	39,897	19,904	28,693	88,494
% Total	45.1	22.5	32.4	100
Number of Fishing Boats				
Number	10,283	5,043	8,689	24,015
% Total	42.8	21.0	36.2	100

Figure 3.5. Capture Fisheries in the Malacca Straits: Total Fish Landings from the West Coast States *vs.* the East Coast States of Peninsular Malaysia, 1993 (Kamaruzaman, 1995).

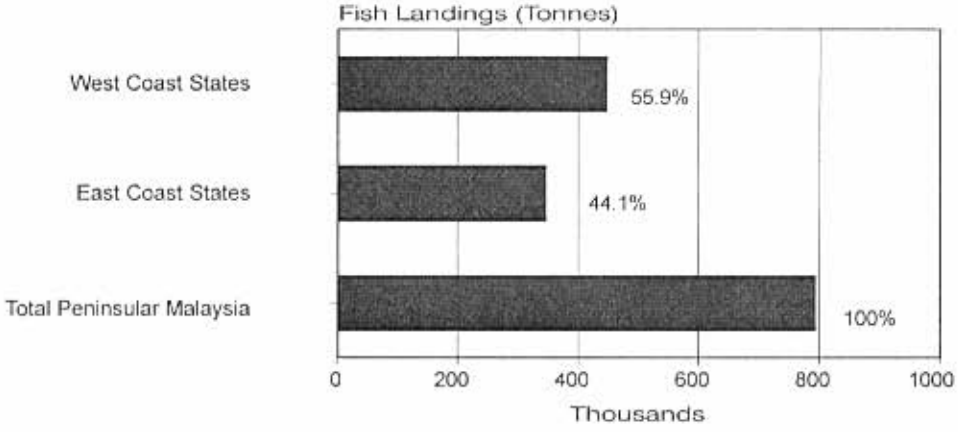


Figure 3.6. Capture Fisheries in the Malacca Straits: Fish Landings by State Along the West Coast of Peninsular Malaysia, 1993 (Kamaruzaman, 1995).

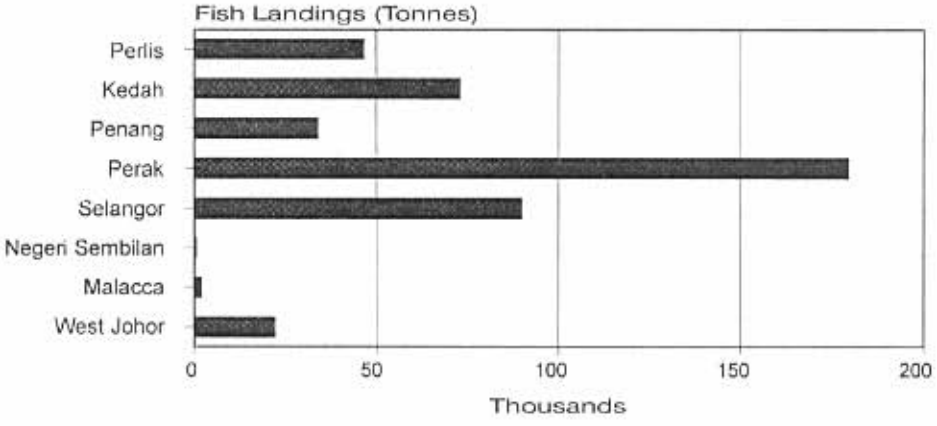
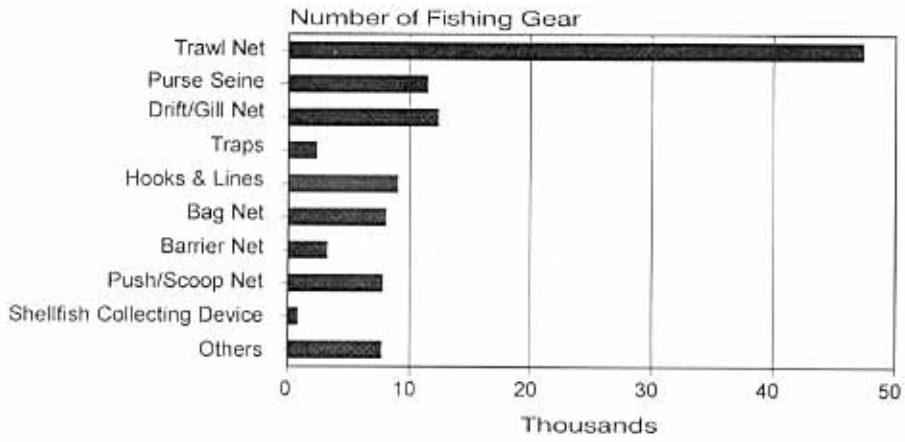


Figure 3.7. Capture Fisheries in the Malacca Straits: Type and Quantity of Fishing Gear Operated by Fishermen from the West Coast of Peninsular Malaysia, 1993 (Kamaruzaman, 1995).



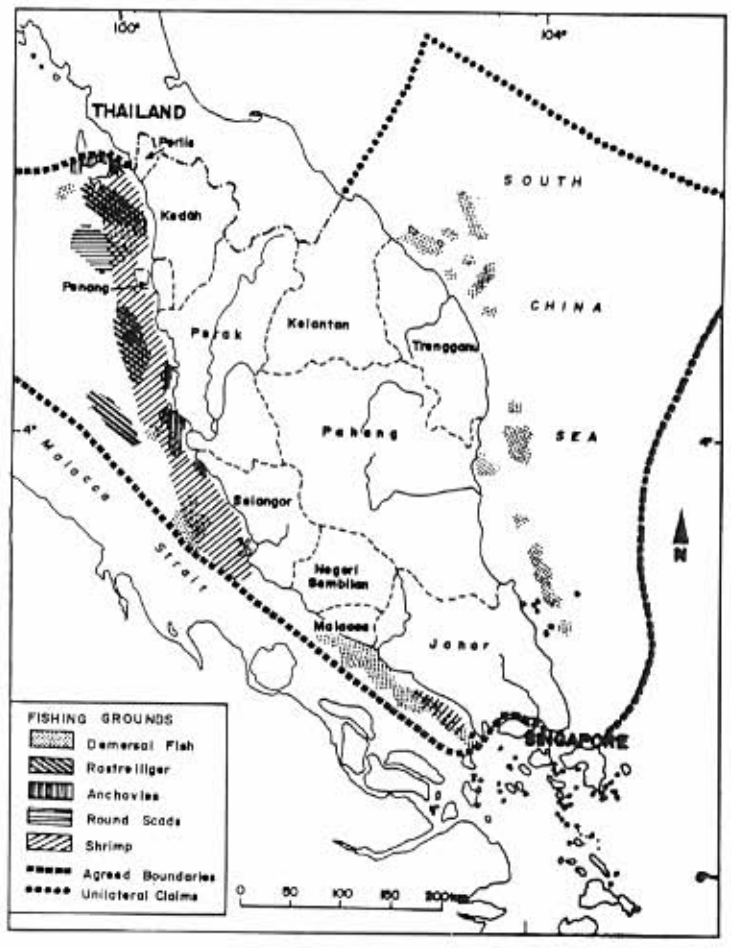
1995). There are around 139 fishing villages located along the West Coast of Peninsular Malaysia within the coastal zone of the Malacca Straits (Ibrahim, E.I., 1995).

Compared to the landings in 1990 (510,471 tonnes), total fish landings from the West Coast of Peninsular Malaysia in 1993 (446,515 tonnes) declined, although they accounted for more than 55% of the total landings in Peninsular Malaysia (*Figure 3.5*). Among the West Coast States, fish landings from Perak, Selangor and Kedah together account for more than 75% of the total catch from all the West Coast States of Peninsular Malaysia (*Figure 3.6*).

The trawl net is the most common fishing gear operating in the Malacca Straits followed by the drift/gill net and purse seine. Total numbers of trawl net, drift/gill net and purse seine for all the West Coast States recorded in 1993 were 47,273, 12,279 and 11,376, respectively, accounting for more than 70% of the total number of licensed fishing gears operating in the Malacca Straits (*Figure 3.7*). Other inshore fishing gears, such as hook-and-line, barrier net and push/scoop net are also relatively abundant (*Figure 3.7*).

The shallow waters of the Malacca Straits support a relatively abundant demersal and pelagic fish species, as well as shrimp species, compared to waters along the East Coast of Peninsular Malaysia (*Figure 3.8*). The West Coast of Peninsular Malaysia is

Figure 3.8. Demersal and Pelagic Fish Resources in the Malacca Straits (Ooi, 1990).



generally muddy with fertile water while the East Coast is predominantly sandy with deeper waters and rough seas during the NE monsoon (Ooi, 1990). Large areas of coral beds are irregularly distributed along the East Coast of Peninsular Malaysia making the fishing ground difficult for trawl fishing, particularly for operating the shrimp trawls. High exploitation of both fishing grounds has been reported (*Figures 3.9* and *3.10*).

Table 3.4. Landings, Imports and Exports of Fishery Products in Singapore, 1990-1995 (DOS/ Singapore, 1995).

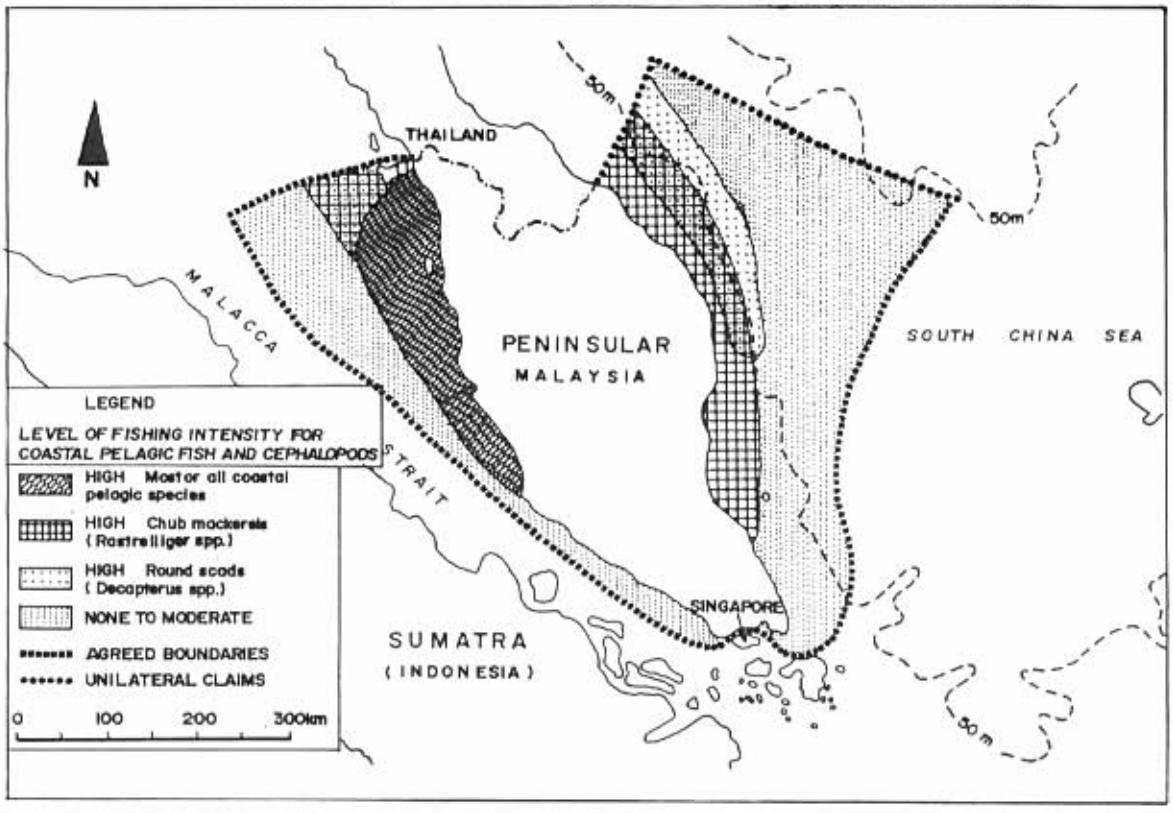
Year	Local Landing (Tonnes)	Import (Tonnes)	Export (Tonnes)	Fish Auction (Tonnes)
1990	11,400	161,719	116,213	106,829
1991	11,022	171,551	133,809	106,537
1992	9,198	180,403	121,941	108,589
1993	9,278	167,077	109,966	103,109
1994	11,280	178,537	136,518	92,550
1995 (up to November)	9,167	167,578	126,576	86,566

Excluding dried, salted, and fish in brine.

Singapore. Singapore is heavily dependent upon imports from Thailand, Malaysia and Indonesia to meet her annual fish supply of approximately 126,000 tonnes (Chia et al., 1988). Local production contributes around 12% of the total supply. The heavy dependence is shown in *Table 3.4,* which indicates that during 1990 to 1995, local landings constituted only 8.5 to 12.2% of the amount of fish auctioned in local markets, i.e., the local demand for fresh fish.

During the 1940s and early 1950s, fish production from local waters reached a maximum of around 40,000 tonnes annually. However, the catch declined to around 15,000 to 20,000 tonnes in the 1970s and 1980s. The catch further declined to 9,278 to 11,400 tonnes during 1990 to 1994 (*Table 3.4*). Similarly, the numbers of fishing boats also decreased significantly from 737 (499 powered) in 1975 to 446 (415 powered) in 1985. The palisade traps (*kelongs*) which operate along the nearshore waters used to contribute a relatively large proportion of local fish catches in the 1950s and 1960s. Their numbers decreased remarkably from around 300 in 1952 to only a few in the 1980s. In 1980, there were 2,025 fishermen while in 1985, there were only 1,321, a decrease of almost 35%.

Figure 3.9. Level of Fishing Intensity of Coastal Pelagic Fish and Cephalopods (Ooi, 1990).



A number of factors that limit the coastal fish production have been identified by Chia et al. (1988):

- Increased siltation of coastal waters (which may affect fish production) resulting from extensive coastal reclamation since the 1960s;
- Removal of coastal (mangrove) vegetation (during the reclamation);
- Canalizing of river courses which reduces the amount of fine sediments and nutrients;
- Increased shipping activities;
- Increased land-based activities and the resulting deliberate or inadvertent discharge of oil and other pollutants into coastal waters;
- Restrictions in giving licenses to operate traps; and
- Availability of more lucrative alternative employment opportunities resulting in fewer fishermen.

Coastal aquaculture

Indonesia. Brackishwater pond culture dominates the coastal areas of eastern Sumatra that border the Malacca Straits. Mainly prawns and milkfish are cultivated in these brackishwater ponds, locally known as *tambak*. There has been a steady increase in the areas of *tambak* in the provinces of Aceh, North Sumatra and Riau. For instance, in 1979, *tambak* covered an area of 22,793 ha, but by 1983, the area increased to 30,248 ha (Burbridge et al., 1988) and as can be seen from ***Table 3.5*** in 1993 it amounted to roughly 39,840 ha. Low productivity from *tambak* of 590 kg/ha/yr in Aceh, 410 kg/ha/yr in North Sumatra and 300 kg/ha/yr was recorded in 1983 (Burbridge et al., 1988).

The extension of the *tambak* area was made at the expense of the mangrove forest. It has been projected that the *tambak* area in North Sumatra will be extended to 4,900 ha under REPELITA V of the Indonesian economic development plan. ***Table 3.6*** shows the potential area for developing brackishwater ponds that have been studied and allocated by three provinces in the East Coast of Sumatra. The majority of ponds were directed toward the rearing of shrimp, although some of the ponds may also be suitable for other species. ***Table 3.7*** is a list of potential species, with their local names.

In order to stock these brackishwater ponds, substantial amounts of fry (both shrimp and milkfish) have to be collected from nature or produced annually. The Indonesian waters have a high potential for producing shrimp and milkfish fry. The Direktorat Bina

Figure 3.10. Level of Fishing Intensity of Demersal Fish and Crustaceans (Ooi, 1990).

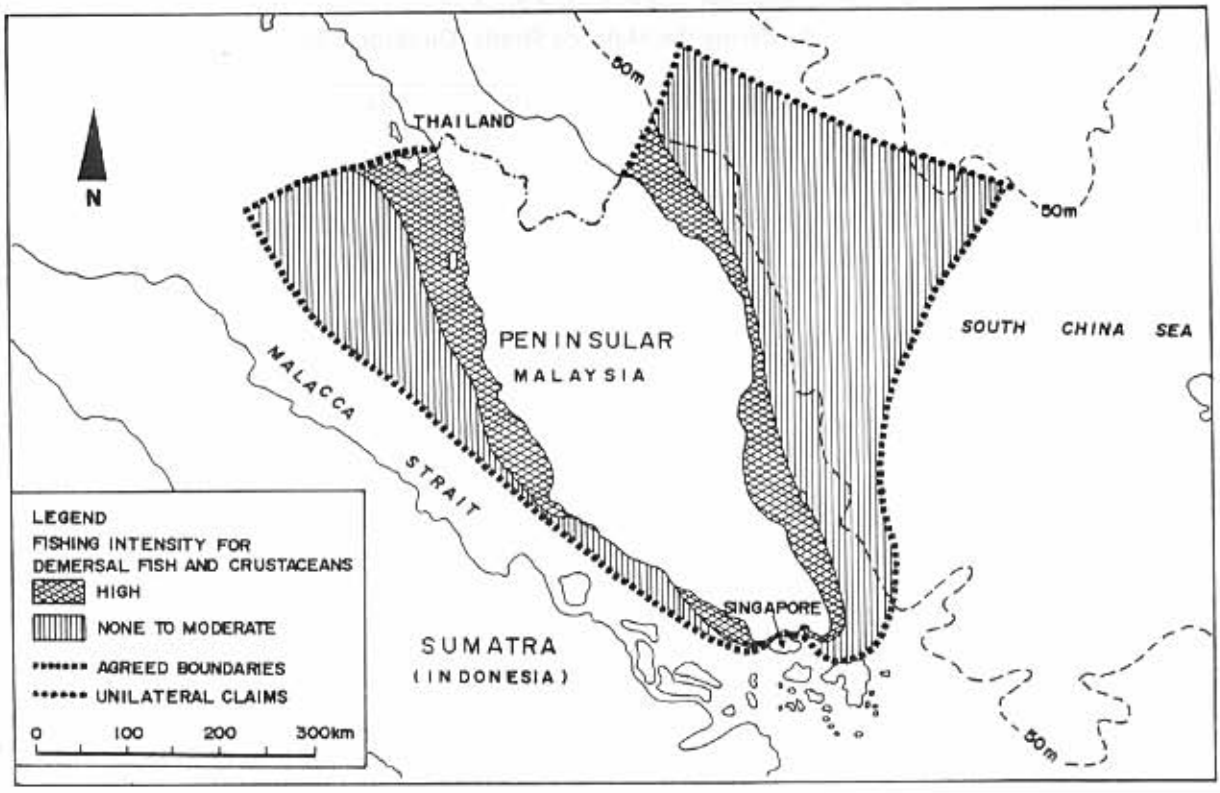


Table 3.5. Brackishwater Pond Fisheries in the Provinces of Sumatra Bordering the Malacca Straits, 1991-1993 (Direktorat Jenderal Perikanan, 1993-1995).

	Aceh Province			N. Sumatra Province			Riau Province		
	1991	1992	1993	1991	1992	1993	1991	1992	1993
Area :									
Gross Area (ha)	40,402	42,604	42,604	3,369	6,373	11,701	249	315	339
Net Area (ha)	36,323	37,851	38,428	1,910	4,671	1,147	186	246	265
Households by size of fisheries management:									
2 ha	6,414	6,414	6,361	364	259	168	93	93	133
2 - 5 ha	7,318	7,318	8,869	312	312	167	46	46	65
5 - 10 ha	1,140	1,140	2,019	944	454	318	11	21	31
10 ha	684	684	2,481	287	298	96	—	—	—
Total	15,556	15,556	19,730	1,907	1,323	749	150	160	229
Production by species (metric ton)									
Fish: Milkfish	3,937	3,638	5,693	2	1	7	14	10	6
Mullets	670	129	564	312	879	703	34	24	18
Barramundi	21	12	69	9		—	—	—	—
Tilapia	1,010	569	736	788	2,779	2	—	—	—
Others	1,178	952	1,090	36	23	2,566	98	44	22
Shrimp:									
Giant tiger prawn	12,500	15,820	12,785	2,757	8,323	5,093	30	22	62
Banana prawn	2,058	2,820	3,837	1,924	3,012	1,689	48	14	21
Metapenaeus shrimp	3,237	4,101	3,031	136	176	6	—	—	—
Crustacean: Mud crab	87	235	554	194	742	158	—	12	13

Table 3.6. Potential Land for Development and Potential Production of Brackishwater Ponds in the Provinces of Sumatra Bordering the Malacca Straits (Direktorat Bina Sumber Hayati, 1992).

Province		Aceh	North Sumatra	Riau	Total	Total Indonesia
Area of Mangrove Forest (ha)		54,335	60,000	276,000	390,335	4,290,292
Potential Land (ha)						
	10%	5,000	6,000	27,000	38,000	415,000
	20%	10,000	12,000	54,000	76,000	830,200
Existing Brackishwater Production (kg/ha/year)		39,476	1,826	192	41,194	268,743
	Monoculture shrimp	5,000	1,500	1,000	7,500	—
	Monoculture milkfish	4,000	2,000	800	6,800	—
	Polyculture milkfish	300	200	200	700	—
	Polyculture shrimp	750	500	500	1,750	—
Potential Production (ton/year)						
	10% Development	38,400	2,400	6,100	46,900	287,300
		37,000	3,400	5,200	46,200	334,800
	20% Development	42,700	4,200	12,200	59,100	368,000
		41,800	6,000	10,300	58,100	452,000
Total	10%	76,000	5,800	11,300	93,100	622,100
	20%	84,500	10,200	22,500	117,200	810,000

Table 3.7. List of Potential Species for Brackishwater Ponds in North Sumatra (Direktorat Bina Sumber Hayati, 1992).

Biota	Local name	Scientific name
Shrimp	Udang windu	*Penaeus monodon*
	Udang putih/jerbung	*P. indicus/merguiensis*
	Udang api-api	*Metapenaeus monoceros*
	Udang cendana	*M. brevicornis*
Fish	Bandeng	*Chanos chanos*
	Beronang	*Siganus* spp.
	Belanak	*Mugil* sp.
	Kakap	*Lates calcarifer*
	Nila	*Oreochromis niloticus*

Sumber Hayati (Directorate of Living Resources Development, 1992) estimated the production of fry from the natural environment of Indonesia to be 800 million shrimp fry and 1.5 million milkfish fry per year. For the Indonesian part of the Straits of Malacca, the potential production of shrimp fry is about 190 million/year and for milkfish fry about 530 million/year. The concentration of areas for harvesting shrimp fry are in the coastal waters of East Sumatra.

The East Coast of Aceh Province is known as an area of high concentration of milkfish fry (***Figure 3.11***). The best season for harvesting is from February to October, with the peak season being between April and June.

Mariculture. Aside from brackishwater ponds, Indonesia has also a developed mariculture industry. Mariculture requires a clean but productive and relatively calm coastal water environment, free from industrial pollution and human wastes. Although the general technical requirements to develop marine culture or marine farming may be common, each species requires a special environment. For example, the shellfish *Anadara* blood cockle requires muddy bottom waters. ***Table 3.8*** lists biota with potential for mariculture. As a rule, it will be easier if the species that is to be cultured is also available in the area naturally.

The potential areas for developing mariculture in Indonesia are estimated to be 80,925 ha with the potential production of 46 million tons/year consisting of :

Fishes	1,080,000 tons/year
Shellfish	45,171,900 tons/year
Seaweed	482,400 tons/year

Mariculture programs are currently being developed in Riau Archipelago, in particular around Batam and Bintan Islands. The estimated potential area and production of mariculture for the provinces of Sumatra bordering the Malacca Straits are shown in ***Table 3.9***.

Malaysia. Aquaculture is a fast growing industry in Malaysia. The Malacca Straits and its associated coastal zone together constitute a main center of many coastal aquaculture activities. Coastal aquaculture practices found along the West Coast of Peninsular Malaysia (***Figures 3.12, 3.13*** and ***3.14***) mainly include the following:

- Semi-intensive brackishwater pond culture of prawns, mainly the tiger prawn (*Penaeus monodon*), in the States of Johor (670 ha), Selangor (233 ha), Perak (160 ha) and Kedah (127 ha);
- Floating net-cage culture of groupers (*Epinephelus* spp.), seabass (*Lates calcalifer*) and snappers (*Lutjanus* spp.) in the coastal waters off the States of Penang (25 ha), Perak (13 ha), Selangor (13 ha) and Johore (11 ha);
- Cockle (*Anadara granosa*) culture in coastal mudflats in the States of Perak (2,679 ha), Penang (1,048 ha) and Selangor (654 ha);
- Mussels in the coastal waters off the States of Johor (4 ha), Malacca (0.5 ha), Negeri Sembilan (0.3 ha), Kedah (0.2 ha) and

Table 3.8. Biota with Mariculture Potential (Direktorat Bina Sumber Hayati, 1991).

Biota	Local name	Scientific name
Fishes	siganus/samandars	*Siganus javus*
		S. punctatus
		S. canaliculatus
		S. vermiculatus
	grouper	*Plextropoma maculata*
		Epinephelus spp.
	others	*Lutjanus johni*
		Lates calcarifer
Shellfish	tiram	*Crassostrea culculata*
	kerang darah	*Anadara granosa*
	kerang hijau	*Perna viridis*
Seaweeds	ramukasang	*Eucheuma spinosum*
	agar-agar mayang	*Gracillaria conformoides*
	ganggang coklat	*Sargassum* spp.

Selangor (0.1 ha); and
- Smaller scale culture of oysters in rafts in the coastal waters of the States of Kedah (0.1 ha), Penang (0.02 ha) and Selangor (0.01 ha).

Total aquaculture production increased from 52,303 metric tonnes (MT) valued at RM (Ringgit Malaysia) 132.8 million in 1990 to 103,723 MT valued at RM298.4 million in 1993 (*Table 3.10*). The major portion of aquaculture production and income came from the brackishwater culture (*Table 3.10*), while the rest were from freshwater culture. Production of cockle culture was the highest, contributing some 84 to 87% of the total production from brackishwater culture. Cockle culture, which utilizes more than 4,000 hectares of coastal mudflats, is largely managed by family-sized holdings.

Singapore. Some shrimp ponds operate in an offshore island, Pulau Ubin, mainly to produce tiger prawn (*Penaeus monodon*) for the local live prawn market. In 1987, there were 240 ha of shrimp ponds in Pulau Ubin producing around 76 tonnes of shrimps. There are also some floating net-cages for culturing mainly the marine fishes which are found occupying a sea space of around 100 ha in East and West Johore Strait (Chia et al., 1988). Total aquaculture production in 1987 was 1,880 tonnes of which 410 tonnes were finfish; 450 tonnes, crustaceans; and 1,020 tonnes, green mussels.

Figure 3.11. Potential Areas for Collection of Milkfish and Shrimp Fry in the Waters Along the East Coast of Sumatra (Direktorat Bina Sumber Hayati, 1992).

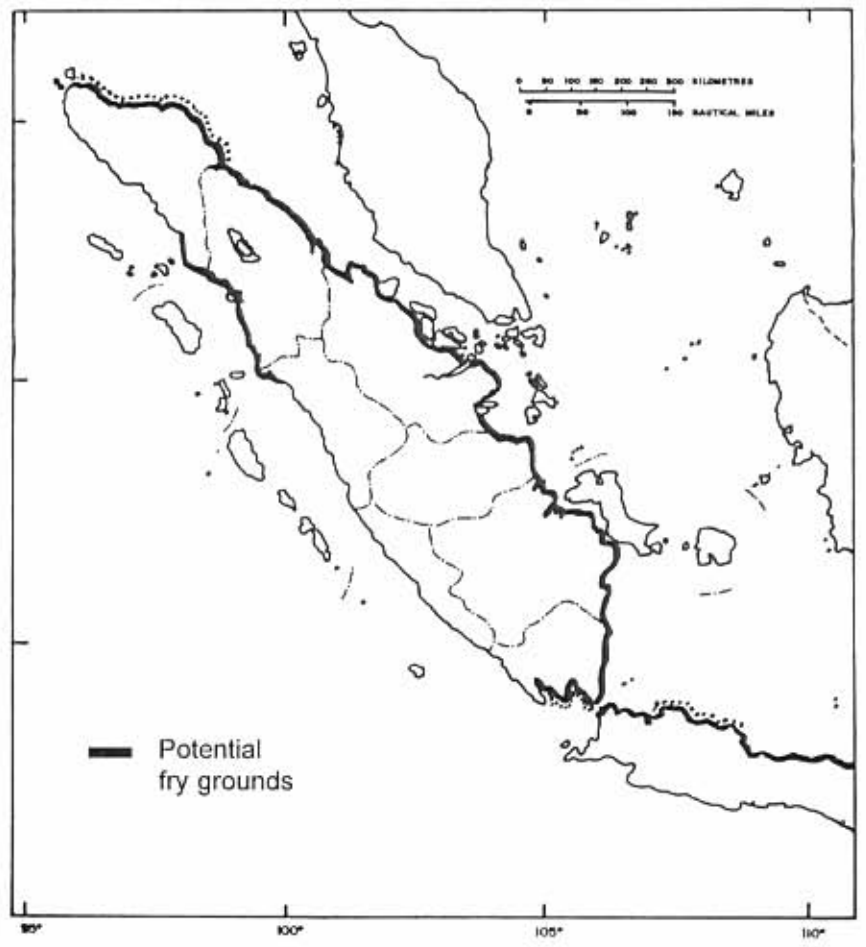


Table 3.9. Potential Area for Development and Potential Production of Mariculture Along the East Coast of Sumatra in Malacca Straits (Direktorat Bina Sumber Hayati, 1991).

Province	Potential Area (ha)			Potential Production (ton/year)		
	Fish	Shellfish	Seaweed	Fish	Shellfish	Seaweed
Aceh	200	0	250	60,000	0	4,700
North Sumatra	0	4,000	150	0	3,500,000	2,800
Riau	350	13,000	1,500	105,000	11,375,000	28,100
Total	550	17,000	1,900	165,000	14,875,000	35,600
Total Indonesia	36,000	53,625	25,700	1,080,000	45,171,900	482,400

Socioeconomic contributions

Indonesia. The Indonesian marine areas covering more than 6 million km² consist of 3.1 million km² of territorial and archipelagic waters and 2.7 million km² of 200 miles of exclusive economic zone (EEZ).

Figure 3.12. **Aquaculture in the Coastal Zone of the Malacca Straits: Types of Aquaculture and Area by State Along the West Coast of Peninsular Malaysia, 1993 (Kamaruzaman, 1995).**

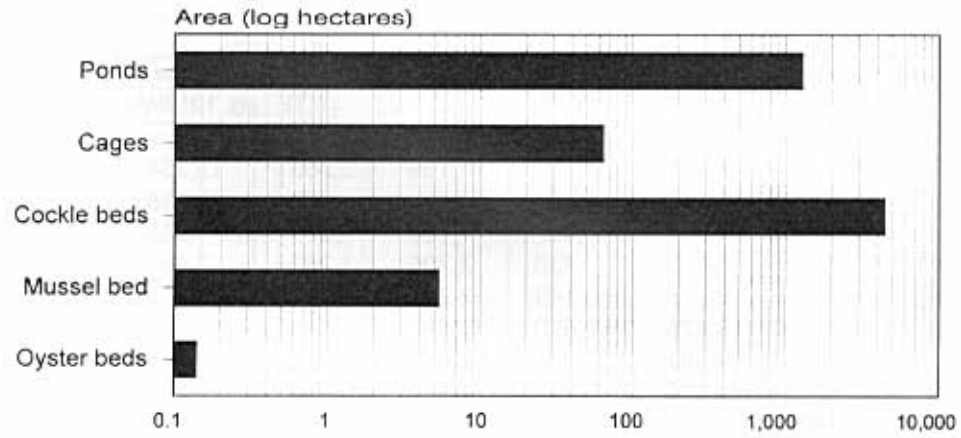


Figure 3.13. **Aquaculture in the Coastal Zone of the Malacca Straits: Total per State Along the West Coast of Peninsular Malaysia, 1993 (Kamaruzaman, 1995).**

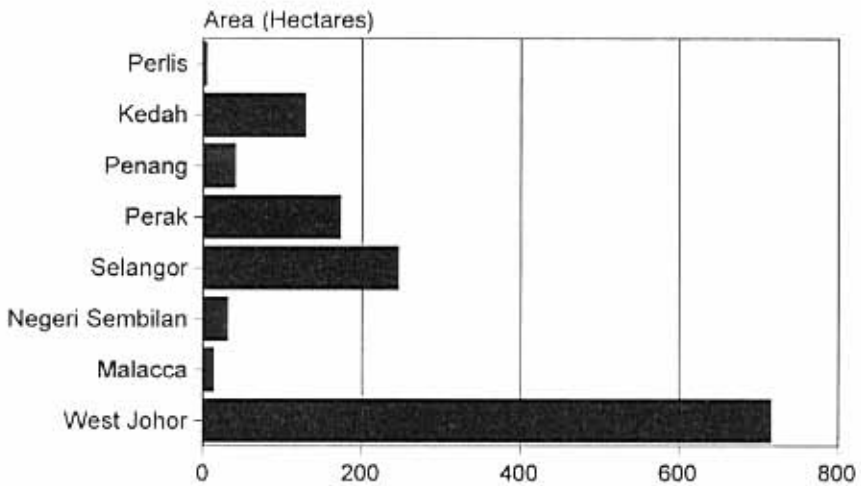


Figure 3.14. Aquaculture in the Coastal Zone of the Malacca Straits: Distribution of Cockle Bed Area per State Along the West Coast of Peninsular Malaysia, 1993 (Kamaruzaman, 1995).

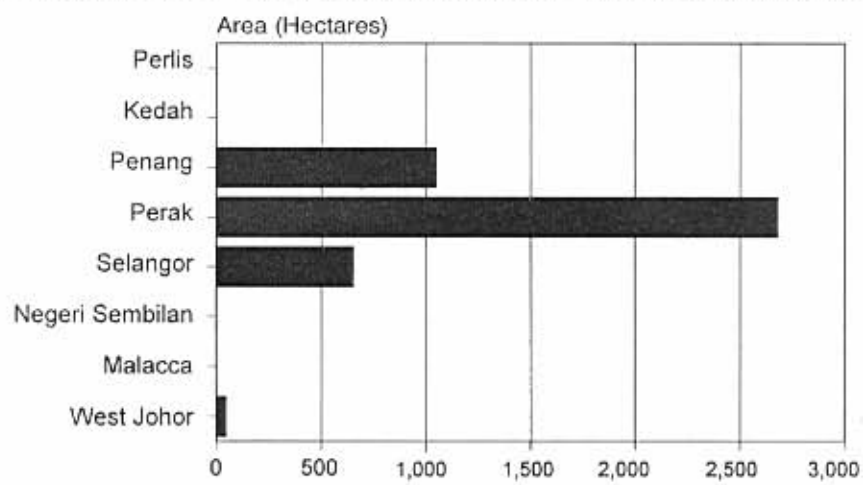


Table 3.10. Malaysia: Aquaculture Production by Freshwater and Brackishwater Species, 1990-1993 (Ferdouse, 1995).

Species	1990		1991		1992		1993	
	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)
Freshwater Species								
Javanese Carp	1,790	9,809	2,064	11,186	2,505	13,258	1,400	7,850
Common Carp	1,282	9,426	1,499	13,404	1,703	15,118	972	6,739
Grass Carp	1,108	4,855	1,089	4,686	913	4,085	726	3,085
Bighead Carp	763	2,095	730	2,706	1,221	2,793	169	788
Freshwater Prawn	137	6,050	145	2,218	94	1,720	56	758
Black Tilapia	200	13,476	2,690	17,997	3,146	20,814	3,774	25,264
Red Tilapia	944	3,481	709	3,059	1,486	5,885	1,564	7,874
River Carp	56	4,154	348	2,566	480	3,710	467	5,680
Freshwater Catfish	197	54	912	1,704	904	4,676	722	2,655
Goby	419	3,531	14	300	39	769	36	767
Eel	-	-	443	6,195	1,572	22,008	2,824	39,536
Others	2,792	2,312	1,436	5,685	1,852	9,100	178	2,836
Total (Freshwater)	**9,689**	**58,281**	**11,089**	**71,707**	**15,992**	**104,248**	**13,323**	**103,831**
Brackishwater Species								
Seabass	1,953	16,969	2,030	18,562	2,784	25,571	3,865	37,967
Grouper	144	1,991	154	2,987	288	7,648	1,056	26,441
Mangrove Snapper	414	2,462	98	921	281	2,857	841	9,461
Red Snapper	7	-	7	66	6	57	126	1,276
Red Tilapia	-	-	-	-	-	-	30	-
Banana Shrimp	155	2,784	162	3,741	141	2,917	57	1,342
Black Tiger Shrimp	2,184	40,982	2,895	50,032	2,821	46,260	3,937	66,060
Mud Crab	190	1,236	95	806	70	586	294	1,411
Cockles	35,932	14,755	46,625	14,116	55,587	14,540	77,755	40,848
Mussels	1,582	722	1,563	875	1,493	629	1,812	993
Oysters	-	-	63	833	33	324	37	405
Others	52	-	69	477	201	1,725	639	8,178
Total (Brackishwater)	**42,614**	**74,477**	**53,761**	**93,446**	**63,707**	**103,114**	**90,400**	**194,535**
Grand Total	**52,303**	**132,758**	**64,850**	**165,153**	**79,699**	**207,362**	**103,723**	**298,366**
Fresh. Sp./ Grand Total (%)	**18.5**	**43.9**	**17.1**	**43.4**	**20.1**	**50.3**	**12.8**	**34.8**
Brack. Sp./ Grand Total (%)	**81.5**	**56.1**	**82.9**	**56.6**	**79.9**	**49.7**	**87.2**	**65.2**

The Indonesian land area is only 1.94 million km². Therefore, fisheries and other marine activities are important parts of its economy. In 1992, the fishery sector employed almost 1.8 million people, 60% full time and the rest part time, either as major or minor occupation. Fisheries has become a source of foreign revenue for Indonesia. In 1992, for example, the value of export reached over one billion US$, consisting of US$757 million from shrimps and US$326 million from tuna and skipjack, the two main marine export commodities. In addition, fish has been an important source of inexpensive protein for the Indonesian people. In 1995, it was reported that, on the average, per capita consumption of fish was 16.0 kg/year (Soegiarto, 1995).

In 1990, the Directorate General of Fisheries defined fish species as economically important, if they met the following criteria:

- High market value;
- Broad and high macro production; and
- High yield.

Species of economic importance and their landings along the provinces bordering the Malacca Straits are listed in *Table 3.11*. The potential for the Malacca Straits

Table 3.11. Economically Important Species (in tons) by Province Bordering the Malacca Straits, 1990-1993 (Direktorat Jenderal Perikanan, 1990-1993).

Common Name/	Aceh				North Sumatra				Riau			
Indonesian/English	1990	1991	1992	1993	1990	1991	1992	1993	1990	1991	1992	1993
Kerapu/Groupers	240	292	1,072	1,531	290	1,548	1,464	1,574	980	1,371	3,099	5,309
Kakap/Baramundi	445	326	867	1,595	1,659	1,399	1,799	2,287	2,937	896	266	42
Ikan Merah/Red snapper	242	192	604	1,133	1,208	1,323	952	1,470	7,021	7,973	9,338	8,811
Gulamh/Croaker	536	390	589	973	2,645	3,409	4,026	4,285	1,811	3,014	4,668	4,876
Tengiri/Narrow barred king mackerel	645	1,690	869	1,320	992	1,238	1,300	2,845	2,746	2,874	1,738	1,808
Tuna/Tuna	1,836	1,241	1,129	1,922	-	-	-	-	-	-	-	-
Cakalang/ Skipjack tuna	1,450	1,225	1,626	2,028	-	-	-	-	-	-	-	-
Tongkol/Eastern little tuna	2,862	2,363	329	3,465	7,957	10,349	10,792	14,514	7,764	6,575	6,717	5,730
Kembung/ Indian mackerel	2,944	2,348	1,719	2,762	20,825	19,897	24,104	30,371	971	1,306	925	903
Bawal putih/ Silver pomfret	272	553	442	696	1,126	1,817	2,503	2,303	880	810	923	937
Rajungan/ Swimming crab	46	57	128	-	438	430	643	520	6.00	11	86	47.
Kepiting/Mud crab	28	18	21	10	985	1,256	1,845	1,733	24	16	914	793
Udang Baraong/ spiny lobster	-	-	11	22	-	251	220	-	168	173	-	-
Udang Windu/ Giant tiger prawn	1,071	1,010	1,918	1,136	1,003	1,011	1,638	1,689	-	-	-	-
Udang putih/ Banana prawn	1,274	1,098	947	1,207	2,848	3,076	3,689	3,606	5,393	5,732	8,864	8,963
Udang Dogol/ *Metapenaeus*	657	479	306	435	2,165	2,168	2,873	2,724	-	-	-	-
Kerang darah/ Blood cockle	-	-	-	21,325	18,378	29,006	20,642	6,039	6,760	7,512	10,544	-
Cumi-cumi/ Common squid	-	115	427	247	433	485	709	929	104	316	335	270
Sotong/Cuttlefish	-	31	92	-	613	771	1,444	1,404	136	124	227	217

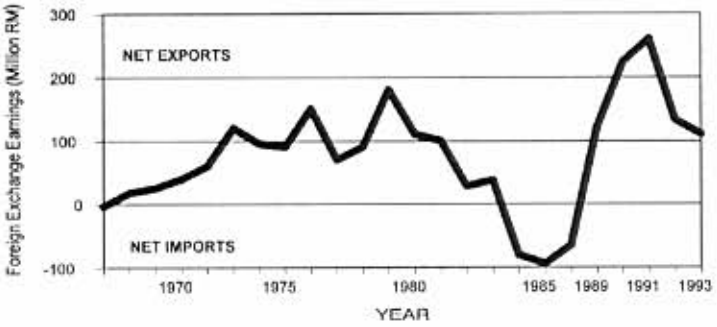
with regard to marine fishery resources amounts to about 5.9% of the combined total for the major fishery regions of Indonesia. Therefore, it is not surprising that a large number of people are employed in the fishing sector. It is noted that there are people employed in industries that are dependent (or indirectly involved) on the fisheries sector, i.e., canning, shipping, etc.

Malaysia. Vertzberger (1984) indicated that the Malacca Straits is of particular significance for Malaysia since a large proportion of the population resides along the Straits and many fishing harbors are situated in the 'rice bowl' for fishermen in the country. As indicated previously, in terms of fish landings and the number of people engaged in fishing activities and aquaculture production, the Malacca Straits is relatively more productive compared to other parts of the country.

Entry to the industry is easy, with only a minimum level of skill and capital needed and fish being an open-access resource. Employment in the industry climbed to an all-time high in 1980 with 89,000 people (2.1% of the labor force) in Peninsular Malaysia. It dropped to 69,500 (1.4% of the labor force) in 1985 and to 59,400 in 1986 (Ooi, 1990). More than 60% of these fisherfolk are directly involved in fishing activities in the Malacca Straits. Since 1986, unemployment has been high, as much as 30% on the West Coast and 24% on the East Coast of Peninsular Malaysia. These rates of unemployment are likely to remain as fisheries

development, in recent years, has become more capital-intensive than labor-intensive (Ooi, 1990).

Figure 3.15. Foreign Exchange Earnings from Import and Export of Fish in Peninsular Malaysia (Modified from Ooi, 1990 and Ferdouse, 1995).



Following the introduction and expansion of trawl fishing in the Malacca Straits in the mid-1960s and the export of high-value prawns and top-grade fish, Peninsular Malaysia has become a net exporter of fish in terms of both quantity and value. Between 1968 and 1983, substantial foreign exchange earnings from the export of fish were obtained, the best year being 1979 (***Figure 3.15***). However, in 1983, fish ceased to be an important foreign exchange earner due to a fall in fish landings, coupled with an increasing demand of fish for domestic consumption. The downward trend remained until 1985. Thereafter, the earnings climbed to a peak in 1991. Since 1991, a downward trend has been evident (***Figure 3.15***).

Exports of fishery products increased steadily both in volume and value, from RM577 million in 1989 to RM800 million in 1993 (Ferdouse, 1995). Aquarium fish, grouper, seabass, tilapia and eel were the main species exported live in 1993 and they accounted for 10% of the total export value. Shrimp was the main item of the fresh/frozen export products, accounting for only 6.3% in volume but 26.3% in value. Cultured seabass, grouper, red snapper and cockles were mainly consumed in the domestic market, as well as in oriental markets such as Singapore, Hong Kong, China, Taiwan and Japan (Ferdouse, 1995). Thailand also imported large volumes of fresh cockles from Malaysia for processing into canned products. In terms of value, Japan has long been the leading market outlet for fishery products, mainly the high-value shrimps and sashimi grade tuna. In terms of volume, Singapore was the top export market for the Malaysian fishery products. Other major markets included the USA, Australia, Hong Kong and the Netherlands (***Table 3.12***). Imports of fishery products for Malaysia increased during 1989 to 1993 with costs increasing from RM455.8 million in 1989 to RM690.7 million in 1993 (***Table 3.13***). No import duties on fishery products, particularly fresh and frozen fish and prawns, were imposed during the 5-year period as Malaysia had to depend on imports to meet local demands. The major suppliers of fishery products to Malaysia are Thailand and Indonesia (***Table 3.13***).

Overfishing

Indonesia. Burbridge et al. (1988) estimated the standing stock and maximum sustainable yield for fishery stock in the Indonesian portion of the Malacca Straits (***Table 3.14***). On the basis of the production figures from capture fisheries, they concluded the following:

- Between 1975 and 1983, shrimp catches were above the maximum sustainable yield (MSY) of 20,000 tonnes per year;
- The catch from demersal fish stocks reached 50,000 tonnes in 1977 and 114,00 tonnes in 1983, which exceeded the estimated MSY; and
- In 1977, the pelagic fish stocks were 112,500 tonnes but declined steadily after 1977 to around 77,000 tonnes in 1983, which is well below the estimated MSY of 126,500 tonnes per year .

According to Burbridge (1988), it is apparent that overfishing is occurring in the Indonesian portion of the Malacca Straits. A clear indication of overfishing is provided by examining the falling catch-per-unit-of-effort (CPUE) and the increasing fishing effort in the Malacca Straits for pelagic fish (***Table 3.15***). Also the majority of the fishermen from Bagan Siapi-api are no longer fishing in the Malacca Straits and have moved their activities, but not the official address of their vessels, to other waters, such as Bangka, Natuna, even as far as the Indian Ocean, south of Java, Bali and Nusa Tenggara.

Malaysia. Up to the 1960s, overfishing has not been experienced in Peninsular Malaysia. Since then, the situation has changed considerably due to the following factors (Ooi, 1990):

Table 3.12. Quantities and Values of Fishery Products Exported by Malaysia to Other Countries (Ferdouse, 1995).

Country	1989		1990		1991		1992		1993	
	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)
Brunei Darussalam	1,588	5,196	2,102	6,150	1,928	5,756	2,612	8,916	2,514	9,645
Indonesia	2,011	1,895	3,126	2,392	3,448	3,394	1,891	2,821	2,810	4,300
Philippines	479	1,632	1,846	1,826	2,366	2,728	4,600	4,722	3,385	3,795
Singapore	64,799	91,147	60,823	112,124	57,580	119,097	61,450	136,588	71,085	132,150
Thailand	47,426	17,315	47,670	21,044	57,669	27,048	65,025	32,151	63,751	22,797
Australia	5,108	66,613	4,659	68,581	6,663	75,855	5,243	57,605	7,204	59,014
Germany	1,713	14,869	2,324	22,520	1,775	20,993	1,507	15,810	1,010	12,693
Hong Kong	5,635	18,055	4,331	24,280	4,152	27,674	6,702	43,107	3,883	50,657
Italy	385	2,507	388	4,189	1,379	14,206	1,775	17,203	2,177	27,652
Japan	9,470	120,625	12,743	134,015	14,717	181,542	29,820	210,854	26,340	264,897
Korea PR	1,174	5,718	1,705	10,824	878	9,069	972	9,060	2,464	11,563
Netherlands	3,419	34,887	2,770	31,002	3,351	43,778	3,817	45,123	2,680	30,686
Spain	1,195	15,375	1,990	27,042	2,064	28,710	2,940	35,239	2,042	27,038
Taiwan	687	2,327	1,997	3,639	1,686	6,103	1,724	9,432	1,719	14,245
UK	1,808	18,391	1,566	18,002	2,460	27,592	2,299	22,732	2,351	22,131
USA	10,992	98,869	8,581	93,185	8,125	97,155	9,397	71,975	5,944	61,629
Grand Total	**164,477**	**577,253**	**163,709**	**630,002**	**175,216**	**739,651**	**205,979**	**765,510**	**206,189**	**800,734**

Table 3.13. Quantities and Values of Fishery Products Imported by Malaysia from Other Countries (Ferdouse, 1995).

Country	1989		1990		1991		1992		1993	
	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)	Quantity (MT)	Value (x 10^3 RM)
Indonesia	12,533	55,277	21,271	73,543	24,963	85,824	30,492	104,868	31,527	127,281
Philippines	149	500	213	454	332	1,521	467	1,602	1,347	4,801
Singapore	3,546	10,824	3,390	12,131	3,795	12,850	4,427	14,551	4,303	16,492
Thailand	219,715	246,352	161,090	171,494	171,665	202,992	176,748	295,555	165,164	306,245
Australia	463	3,012	369	2,102	418	2,661	614	10,542	1,586	11,304
Bangladesh	1,032	4,740	1,106	4,631	825	5,429	778	6,379	1,073	9,762
Chile	11,149	20,076	4,944	12,368	3,413	11,307	2,863	6,634	6,331	11,928
China	1,541	5,778	1,757	7,148	1,616	5,183	1,621	5,192	2,085	8,883
Hong Kong	687	4,275	1,127	11,043	580	13,498	1,165	18,109	294	2,024
India	2,694	15,722	2,016	14,064	3,440	21,024	4,168	22,484	4,406	23,024
Japan	10,596	31,842	9,082	28,056	11,731	39,983	12,250	45,323	12,175	48,247
New Zealand	2,558	9,391	2,887	12,449	2,325	16,745	2,437	17,283	4,909	19,586
Taiwan	8,558	13,137	11,895	19,009	13,142	25,224	11,754	47,401	11,980	48,088
UK	189	2,154	221	2,917	240	2,950	1,277	4,997	2,892	10,939
USA	1,366	12,463	768	5,847	526	2,315	1,417	4,437	1,748	6,056
Vietnam	205	748	558	2,285	2,223	6,806	4,091	9,343	1,062	7,817
Grand Total	**276,981**	**455,850**	**228,549**	**405,467**	**226,256**	**479,973**	**259,881**	**633,428**	**261,630**	**690,782**

Table 3.14. Estimated Standing Stocks and Maximum Sustainable Yield (MSY) for Fishery Stocks in the Indonesian Portion of the Malacca Straits, 1980 (Burbridge et al., 1988).

Fish and Shrimp Stocks	Standing Stock (x 10^3 t/yr)	MSY (x 10^3 t/yr)
Shrimp Stocks	44	20
Demersal Fish Stocks	220	110
Pelagic Fish Stocks	253	126.5

Table 3.15. CPUE of Pelagic Fish in the Malacca Straits (Indonesian Portion), 1969-1990 (Science Systems Consultants, 1994).

Year	Total Catch (ton)	Fishing effort (days)	CPUE (kg/day)
1969	40,102	151,248	265
1970	44,831	163,153	275
1971	49,632	174,001	285
1972	57,473	203,005	283
1973	59,750	213,371	280
1974	66,027	317,804	208
1975	32,597	(285,868)	(114)
1976	47,671	116,000	411
1977	47,758	153,900	310
1978	42,193	166,400	254
1979	41,343	212,700	194
1980	47,277	485,000	98
1981	38,598	585,200	66
1982	45,521	873,400	52
1983	-	-	-
1984	42,466	309,900	137
1985	67,875	407,000	162
1986	79,993	416,900	192
1987	88,668	672,700	132
1988	78,227	932,400	84
1989	87,315	636,000	137
1990-	97,274	543,700	179

Figures in brackets are estimates.

- Introduction and rapid spread of trawling, initially in the northwest, later to cover both coasts. In 1986, 19% of the fishermen worked on trawlers; 18% of the fishing gear were trawl nets and 51% of the fish landings were caught by trawling;
- The wide use of trawl nets has led to a more complete (and indiscriminate) harvesting of the fish resources;
- During the last 30 years, emphasis of the fishery development has focused on meeting the demand for fish as a source of protein and as a source of foreign exchange;
- A marked increase in the number of fishermen since the 1960s; and
- The participation of the government in commercial fishing through Majuikan.[1]

There is evidence that some sectors of the waters around Peninsular Malaysia, including the Malacca Straits, are being fished at or near their maximum and others overfished. The gross indicators are as follows (Ooi, 1990):

- ***A fall in the total catch and catch rates.*** Since 1981, the trend in fish landings has been downward. Surveys carried out by the Fisheries Research Institute, Penang, in 1971, 1972, 1974 and 1978 showed a reduction in the catch rate from 92 kg/hr in 1974 to 69 kg/hr in 1978 in the north part of the Straits of Malacca. For the West Coast, in 1970 to 1980, the catch rate declined from 132 kg/hr to 59 kg/hr, while for the East Coast of Peninsular Malaysia, it fell from 516 kg/hr in 1970 to 144 kg/hr in 1981.

- ***A fall in the catch per unit effort.*** The steepest fall in catch per unit effort were for the West Coast trawl fisheries, which fell from 1,492 pikuls[2]/trawler/year in 1967 to 269 pikuls/trawler/year as early as in 1972 or to 18% of the 1967 catch.

- ***A fall in the ratio of commercial fish to trash fish.*** Before 1968, trash fish constituted only 16% of the total landings but increased to 31 to 33% in the early 1970s.

As shown in ***Table 3.16***, the average catch for all categories of fish (demersal and pelagic fish species, prawns and others) in 1981 to 1986 from the West Coast approached or exceeded the potential yields and maximum sustainable yields (MSYs) for each category of the fishery resource. Although the demersal fish production along the East Coast is still about half the estimated MSY (***Table 3.16***), the following environmental and economic factors may inhibit its expansion (Ooi, 1990):

- The severity of the northeast monsoon;
- Deeper water and rougher seas than in the Malacca Straits;

[1]This authority was established as a public commercial fish cooperative responsible to the Ministry of Agriculture and Fisheries. Among its many functions was that of increasing fish production by engaging directly in fishing.

[2]Pikul was the traditional Malay weighing system. One pikul is equivalent to 60 kg. The traditional Malay weighing system has been replaced by the metric system.

- Larger areas of coral beds which can snag and destroy trawl nets; and
- The absence of the large prawn resources which sustain the trawl fishery of the West Coast.

Conflicts between the capture fisheries sector and coastal aquaculture

Many types of fishing activity take place along the shores and waters in the Malacca Straits. These include commercial fishing, subsistence fishing and aquaculture.

Many of the commercial operations are often fishing for luxury products such as shrimps and tuna for export in large quantities. Small-scale subsistence or artisanal fishing is normally aimed at local markets, providing local employment. Aquaculture operations can range from the small-scale village fishpond operation to large capital-intensive commercial farming. All three types of fishery resource exploitation are likely to create conflicts, such as the successful expansion of one will interfere with the yield of at least one of the other two.

Seafood is important to the economic and physical health of the population. The littoral States of the Malacca Straits have been active in promoting various fishery practices. However, conflicts often occurred because well-intentioned government efforts to develop or promote one fishery sector inadvertently harmed others. The large number of clashes which have occurred among traditional fishermen indicates the existence of the problem. In Indonesia, shrimp trawling was banned under Presidential Decree 39/1980 in waters around Sumatra after 1 January 1981. The ban, intended to protect artisanal interest, actually stimulated the conversion of mangrove areas to fishponds as a means of replacing the loss of shrimp exports (Schoolman, 1991).

Making matters even more complicated is the shared stock of fishery resources. Even if a reasonable national management plan is developed for fishery exploitation, well intentioned efforts could be hampered by the acts of a neighboring country. Biologically, the entire Malacca Straits fishery resources could be considered a single entity (Schoolman, 1991). Valencia (1981) indicated that :

- Marine resources are often transnational in distribution;
- The ocean, as a continuous fluid system, transmits environmental pollutants and impacts; and
- Maritime activities transcend projected national marine jurisdictional boundaries.

Thus, for the Malacca Straits, it is evident that there is a need for a regional or multilateral fishery management plan.

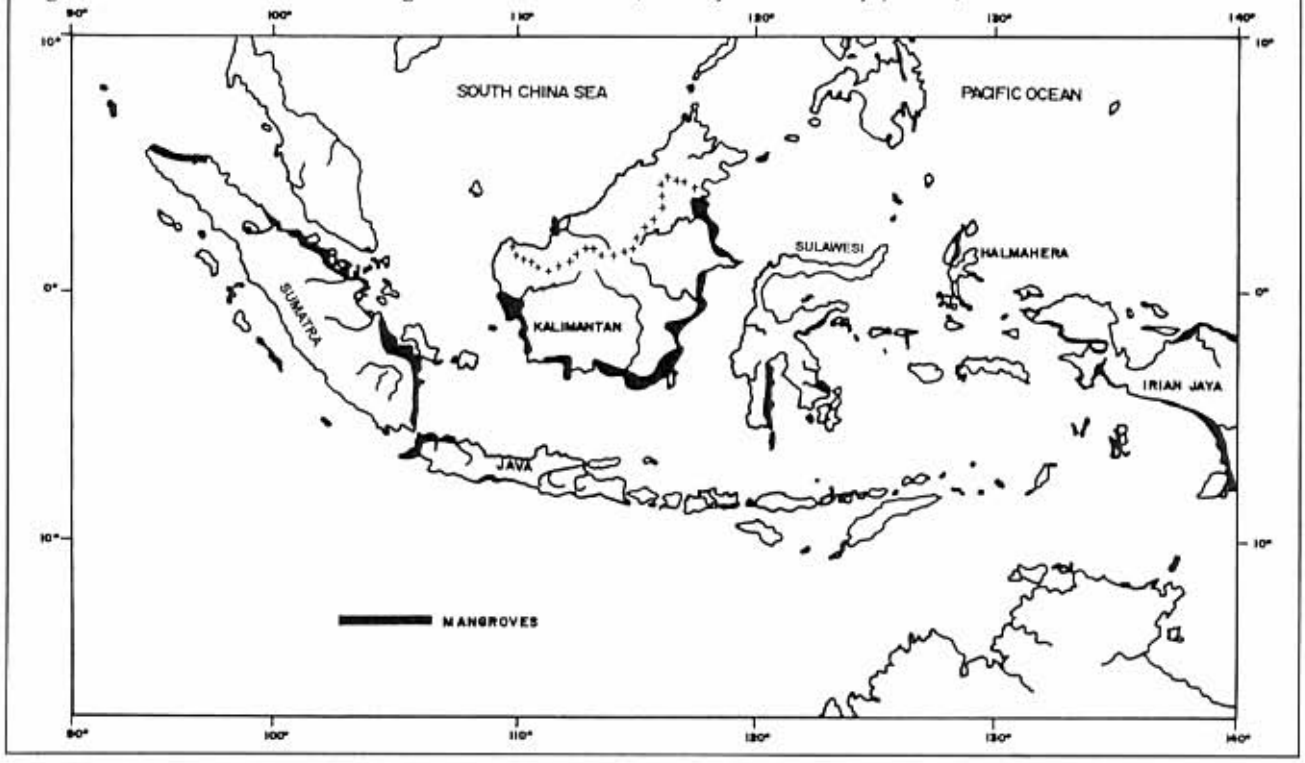
Expansion of the brackishwater ponds along the coast implies more clearing of mangroves, thus reducing the feeding and nursery grounds for fish and shrimps. When aquaculture production is compared with the productivity of mangroves on a hectare by hectare basis, the former was found to be less productive than the latter (Schoolman, 1991). This led to the question of the wisdom of "..... usefulness of a single system of resource development created by destroying a complex and highly productive ecosystem" (P.B.L. Srivatsava cited by Schoolman,

Table 3.16. Comparison of Potential Yields, Maximum Sustainable Yields (MSYs), and Average Catches Between the West and East Coasts of Peninsular Malaysia (Ooi, 1990).

Location/Species	Potential Yield	MSY per Year	Average Catch[1]
West Coast			
Demersal Species (x 10^3 tonnes)	90-94	110	152
Pelagic Species (x 10^3 tonnes)	81-91	53	133
Prawns & Other Crustaceans (x 10^3 tonnes)	35	40	59
Other Species (x 10^3 tonnes)	40-45	20	41
Total (x 10^3 tonnes)	**246-265**	**223**	**385**
East Coast			
Demersal Species (x 10^3 tonnes)	81	80	43
Pelagic Species (x 10^3 tonnes)	56-75	75	98
Prawns & Other Crustaceans (x 10^3 tonnes)	6	4	6
Other Species (x 10^3 tonnes)	—	5	5
Total (x 10^3 tonnes)	**143-162**	**164**	**152**

MSYs are for the coastal fish resources, i.e., those located within 60 nautical miles off the coastline.
[1] Annual Fisheries Statistics, 1981-1986, Ministry of Agriculture and Fisheries, Malaysia.

Figure 3.16. Distribution of Mangroves in Indonesia (Atmadja and Soerojo, 1994).



1991). However, aquaculture is not unilaterally a bad or destructive practice. Its ecological impact can range from almost none to extreme when large areas of mangrove are cleared for commercial production of prawns. Even large-scale production of prawns in coastal ponds can be ecologically sustainable if it is controlled and not extended over too large an area (Schoolman, 1991).

Exploitation and Use of Mangrove Resources

Status of resource exploitation

Indonesian mangrove resources. The total mangrove area in Indonesia was estimated to be around 3.80 to 4.25 million ha, of which around 0.38 million ha (RePPProT, 1990) are located along the East Coast of Sumatra (*Figure 3.16, Table 3.17*).

The mangrove area has, however, been fast disappearing. It was indicated by Silvius in 1987 that out of the 1,365,000 ha of original mangrove areas in Sumatra only 748,000 ha were remaining, or approximately 54.8%. BAPPENAS (1993) pointed out that by 1993 only 29% or about 395,850 ha of mangrove area would remain in Sumatra. Thus, the rate of loss for the whole Sumatra was very high. The extensive conversion of mangrove into *tambak* (brackishwater ponds) that has taken place in Sumatra

Table 3.17. Extent of Mangrove Forests in the Straits of Malacca (RePPProT, 1990; Japar, 1994; Ibrahim, R., 1995).

Country/State	Mangroves (hectares)
Indonesia	
Aceh	59,400
North Sumatra	86,800
Riau	239,900
Indonesia Total	**386,100**
Malaysia	
Perlis	81
Kedah	7,664
Penang	451
Perak	49,271
Selangor	27,023
N. Sembilan	1,202
Malacca	249
Johor	25,468
Malaysia Total	**111,409**
Singapore	
Southern islands	84
Mainland	333
Northern Island	183
Total	600
Total for the Malacca Straits	**498,109**

in recent years is one reason for the reduction in mangrove coverage. For example, almost 70% (36,000 ha) of the total area of mangroves in the East Coast of Aceh Special Province had been converted into *tambak* by 1990. Similarly in the East Coast of North Sumatra, in 1979, the *tambak* was only 839 ha (Burbridge et al., 1988); by 1990, it became 7,600 ha (Dahuri and Pahlevi, 1994).

Other major causes of losses of the mangrove ecosystems in Sumatra are :

- Overexploitation of their wood resources for export or domestic consumption, such as for wood chips, mangrove logs, poles, timber and charcoal, in particular in Aceh, North Sumatra and Riau Provinces;
- Conversion into industrial sites, port facilities, human habitation and other infrastructure and facilities, e.g., around the ports of Belawan and Dumai, as well as in Batam, South Sumatra, Lampung, etc.;
- Pollution from domestic, petrochemical and industrial wastes; and
- Sedimentation due to poor upland management.

Peat swamps are also extensive on the East Coast of Sumatra island. Peat swamps form important watershed areas that help to mitigate flooding in adjacent areas by absorbing and storing excess water. Many commercially valuable timber products are harvested from peat swamp forests. These include the valuable ramin wood species (*Gonystylus bancanus, Shorea* spp. and *Cratoxylum* spp.), rattans and resins.

The loss in peat swamp area for the whole of Sumatra can be estimated indirectly as follows:

Original Area (1,000 ha)	Remaining Area (1,000 ha)	(%)	Sources
7,282	4,613	63.35	Silvius (1987)
	3,641	50.00	BAPPENAS (1993)
Total Loss in Six Years	**972**	**13.35**	

Thus, for the whole Sumatra, the average loss was 162,000 ha/year in 1987 to 1993. The major loss of peat swamps in Sumatra apparently happened before 1987, when approximately 2.7 million ha, or about 36.6% from the original area was lost most probably due to logging, transmigration programs, large crop estates, or conversion to ricefields. For example, during the first 25-year Long Term Development Plan (1969 to 1994), Indonesia converted about 5.0 million ha of peat swamps; 2.36 million ha from Riau Province (Mardjono, personal communication, 1996) for oil palm or coconut estate crops, transmigration programs, opening new ricefields and for other purposes.

Malaysian mangrove resources. Among the states of Peninsular Malaysia fronting the Malacca Straits, the most extensive groups of mangroves occur in the States of Perak, Selangor and Johor, primarily along estuaries of larger rivers (***Table 3.17***). Peat swamp forests are mainly found along the coast of Selangor and Perak. They are valuable as sustainable timber resources, for flood mitigation and water catchment areas. A variety of endangered species of wildlife such as the proboscis monkey (*Nasalis larvatus*), estuarine crocodile (*Crocodylus porosus*), milky stork (*Mycteria cinerea*) and lesser adjutant stork (*Leptoptilos javanicus*) depend greatly on the mangrove ecosystem for their survival (WCMC, 1994). Mangrove resources, including peat swamps, are managed by the State Forest Department for timber production on a sustained yield basis.

In recent years, there has been severe pressure to use the mangrove lands for agriculture, urbanization, coastal aquaculture and building of industrial estates. Records from the Forest Department have shown that the total area of mangroves declined from 1,184 km^2 to 983 km^2 over a 20-year period from 1965 to 1985; in Selangor alone, about 86 km^2 were cleared for development of residential housing and industrial estates in just one year in 1988 to 1989 (WCMC, 1994).

Matang Forest Reserve, Malaysia. Since 1950, the Matang mangrove forest in Peninsular Malaysia has been partly or wholly managed on a sustainable-yield basis for the production of fuel wood or poles (Darus and Haron, 1989). The Matang mangrove forests are located on the northwest coast of Peninsular Malaysia, lying in the latitude 4°45' N and longitude 100°35' E. The forest comprises 17 reserves, divided into 108 compartments. The total area has been estimated to be around 41,000 ha, 93% of which is productive (Darus and Haron, 1989). Each compartment is leased to contractors for felling, extraction and replanting (if natural regeneration fails). As of 1993, there were 55 contractors operating 336 kilns in Matang (Gan, 1993; Sasekumar and Lim, 1994). The management objectives were to produce wood for the charcoal industry, fuelwood and poles for the

construction industry and to maintain the environment as a breeding ground for marine life (Gan, 1993). The mangrove forest has been managed for over 80 years, on a 30-year crop rotation period basis and the management has been a successful example of the sustainable use of mangroves.

Extensive areas of mangroves along the East Coast of Sumatra Island were cleared for building shrimp ponds (*tambak*) during the last two decades. Relatively large areas of the shallower peat swamp forests along the Malacca Straits were also drained to provide farmland for new transmigrants (WCMC, 1994).

Mangrove resources in Singapore. During the last two decades, there has seen a serious decline in mangrove resources in Singapore. In 1819, around 10 to 13% of Singapore's coastline were covered with mangrove forest (Corlett, 1986; Rao, 1986). As of 1993, only 0.5% or 600 hectares (***Table 3.17***) of mangrove forest remained, including small areas in the northern part of the main island and in the offshore island (Ng and Low, 1994). The decline was attributed largely to the extensive redevelopment of industries and housing starting in the 1970s.

Ng and Low (1994) stated that in Singapore the value of mangroves for fishery or forestry is virtually negligible. The reasons for the conservation of mangrove forest in Singapore are largely for aesthetic, heritage and educational purposes.

Economic and ecological value of mangrove resources

Properly managed mangrove forests provide many long-term and direct economic benefits (Low et al., 1994). The benefits are as follows:

- As a protection of the coastline from erosion;
- As a flood and typhoon buffer zone;
- As a support for the yield of inshore fisheries as feeding or nursery ground for juvenile or larval fish or shrimps;
- As a field habitat for education and research in resource management; and
- As a resource for conserving biodiversity.

Many species of birds (e.g., purple heron, *Ardea purpurea*; milky stork, *Mycteria cinerea*), amphibians (e.g., crab-eating frog, *Rana cancrivora*), reptiles (e.g., saltwater crocodile, *Crocodylus porosus*) and mammals (e.g., long-tailed macaque, *Macaca fascicularis*; Malaysian flying fox, *Pteropus vampyrus*) are currently endangered due to habitat loss and overexploitation by humans. These animals are wholly or partially dependent on mangroves for food, shelter and for many aquatic species as spawning and nursery grounds (Low et al., 1994).

A recent survey by the World Conservation Union (IUCN) identified 106 marine protected areas (MPAs) in Southeast Asia, with 35 in mangrove forests and

Table 3.18. Commercial and Subsistence Uses of Mangrove Forest Resources in North Sumatra, Indonesia (Sukardjo, 1982).

Species	Commercial Uses	Species	Subsistence Uses
Ceriops tagal and *Xylocarpus*	Batik dyes	*Avicennia* spp.	Fuelwood, firewood, rough walling, livestock grazing and bark for tannin.
Excoecaria agallocha and *Sommeratla alba*	Packing cases	*Bruguiera* spp.	Poles for construction, charcoal, firewood and fuelwood
Rhizophora apiculata, R. mucronata, Bruguiera gymmorhiza, B. parviflora, B. sexangula and *B. cylindrica*	Poles for construction, piling and timber	*Exocoecaria agallocha*	Boxes and firewood
Rhizophora spp. and *Bruguiera* spp. (bark)	Tannins, adhesives and dyes	*Ceriops* spp.	Tannin and dyes (bark) and fuelwood
Rhizophora spp. and *Bruguiera* spp.	Charcoal	*Avicennia corniculatum*	Fuelwood for charcoal production and fodder for goat
		Rhizophora spp.	Tannin (bark), poles, fuelwood, planking and boxes
		Sonneratia spp.	Walling board and firewood
		Derris trifoliata	Fodder for goat

another 48 being a combination of mangroves and coral reefs. Reportedly, only 3 mangrove reserves and 4 combined MPAs have effective resource management, whereas 69 reserves have ineffective or no management whatsoever (Low et al., 1994). Moreover, the MPAs cover only a very small portion of the coastal resources of the region. Vast areas of mangroves are still being disturbed and exploited, giving endangered species with little or no protection.

A four-pronged approach was suggested by Low et al. (1994) to ensure the survival of the endangered species and to conserve the biodiversity of mangrove areas:

- Political support;
- Establishment of nature parks, reserves and managed areas;
- Monitoring of management techniques; and
- Public education.

Timber extraction. For centuries the Indonesians have utilized mangroves for firewood, charcoal, tanning dyes, timber and for the construction of boats. The following genera are frequently used for those purposes: *Rhizophora, Bruguiera, Ceriops, Avicennia, Nypa* and *Oncosperma*. Nypa leaves can be used for various things, such as thatched roofs, baskets and cigarette "paper". The stalks of the flower are cut off and the sap is tapped for making brown sugar or the fermented palm wine or "arak". These traditional uses of mangrove resources go hand in hand with larger-scale exploitation using higher capital investments and technologies.

A number of mangrove species are harvested for charcoal production, fuelwood, etc. (***Table 3.18***). For example, Riau Province in Sumatra has long been a center for charcoal production from mangrove trees. The product is exported to Singapore, Malaysia and Hong Kong. In 1984, 836 kilns operated in Riau (Soemodihardjo, 1984). Exports of charcoal in 1989 amounted to over 22,000 tons at a total price of US$1.8 million (Pemerintah Daerah Tingkat I Riau, 1991). In North Sumatra, mangroves were used for charcoal production on a subsistence basis. The financial profile for a charcoal factory in North Sumatra is shown in ***Table 3.19***. ***Figure 3.17*** shows the cost structure and profit of the charcoal industry in North Sumatra. The operation of a charcoal factory compared to other land use options in mangrove in North Sumatra (***Figure 3.18***) provides only limited employment.

Table 3.19. Financial Profile of a Typical Charcoal Factory in North Sumatra, Indonesia (Output of Charcoal per Year: 300 t; Hambrey, 1993).

Cost and Profit Items	Cost or Profit (in million Indonesian Rupiahs)
Capital Charge	24
Cutters Labor Charge	8
Factory Labor Charge	11
Concession Fee	6
Maintenance/ Miscellaneous	3
Total Cost	52
Revenue	74
Profit	22

Export of mangrove logs is also a lucrative business. These logs originating from Sumatra, Sulawesi and Kalimantan are exported to Japan and Taiwan for conversion to wood chips. In 1978, the export of logs amounted to 382,737 tons. In 1981, West Kalimantan alone exported 25,409 tons. Some Japanese-Indonesian joint enterprises on a chip mill have started operation in Indonesia (e.g., Chipdeco in East Kalimantan).

Mangrove wood is also used as raw material for a large paper mill in Gowa, South Sulawesi. At the Gowa plant, bamboo is used as basic raw material, supplemented by mangrove wood and eucalyptus.

Figure 3.17. Cost Structure of the Charcoal Industry in North Sumatra, Indonesia (Hambrey, 1993).

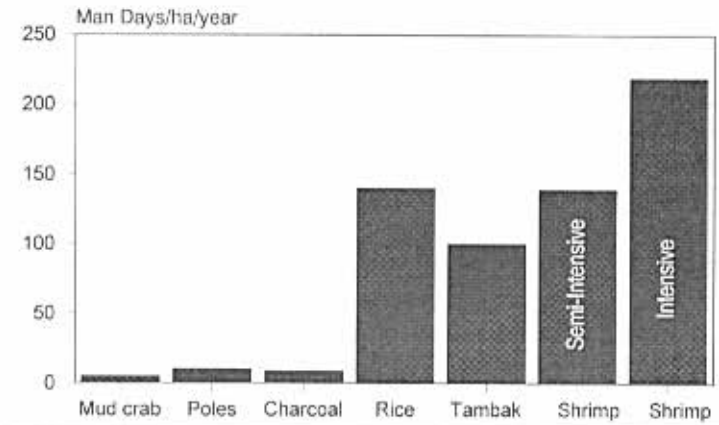
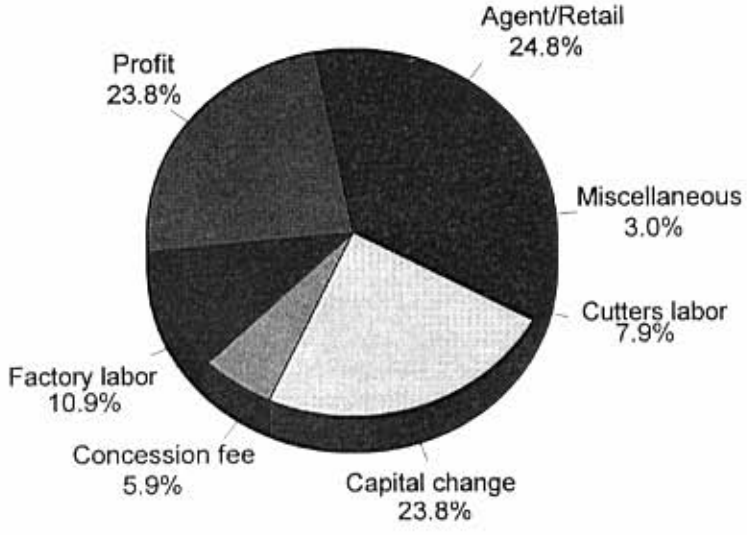


Figure 3.18. Employment Potential for Different Mangrove Use Options in Sumatra, Indonesia (Wage per Worker: Rp. 3,000-5,000/day) (Hambrey, 1993).



Experience has shown that a process with a ratio of 80% bamboo and 20% mangrove wood produces a very good quality paper (Rachmat, 1975). A paper mill using mangrove chips has been established in West Irian as part of a joint US and Indonesian venture.

Nursery and feeding grounds for fish and prawns. There is a close, positive correlation between nearshore or coastal prawn and/or fish catches and mangrove aerial cover, as demonstrated by Singh et al. (1994) in *Figure 3.19*. Mangroves help to enhance yields of nearshore or coastal fisheries by:

- Enhancement of food availability in coastal waters through the export of nutrients and detritus; and
- Providing feeding and/or nursery grounds for larval or juvenile fish or prawns.

Mangroves are highly effective in both primary and secondary production. The primary production comes from three sources, namely, the phytoplankton, plant and benthic algal production. Much of the primary production is not utilized but remains in the forest as litter or becomes available to the surrounding waters as dissolved nutrients (Singh et al., 1994). The secondary production is also significant. Waters in the mangrove forest have high densities of zooplankton, which are important food sources for newly recruited fish. The mangrove habitat is also rich in crab zoeae on which the fish larvae feed.

Fish and fishing. The shallow waters around the mangrove forests range from hypersaline to fresh and from moving to stagnant (Japar et al., 1994). Drainage channels, such as gullies, creeks, rivers of varying widths, lengths and depths intersect with mangroves forming a unique ecosystem which supports a variety of aquatic life. Traditional fishing gears, such as gill net, bag net and barrier net, are used to catch fish and prawns in shallow waters around the mangrove forests (Sasekumar and Lim, 1994). About 79 families of fish are associated with mangroves in the ASEAN region. The families of fish species of commercial importance found in the three littoral States of the Malacca Straits include the following (Japar et al., 1994):

- Indonesia: About one-tenth of the species found are the families of Carangidae, Leiognathidae and Lutjanidae;
- Malaysia: About one-tenth of the species found are the families of Sciaenidae, Engraulidae and Gobiidae; and
- Singapore: Almost a quarter of the species found in the mangroves are from the family Gobiidae. Higher species numbers are also found in the family Mugilidae.

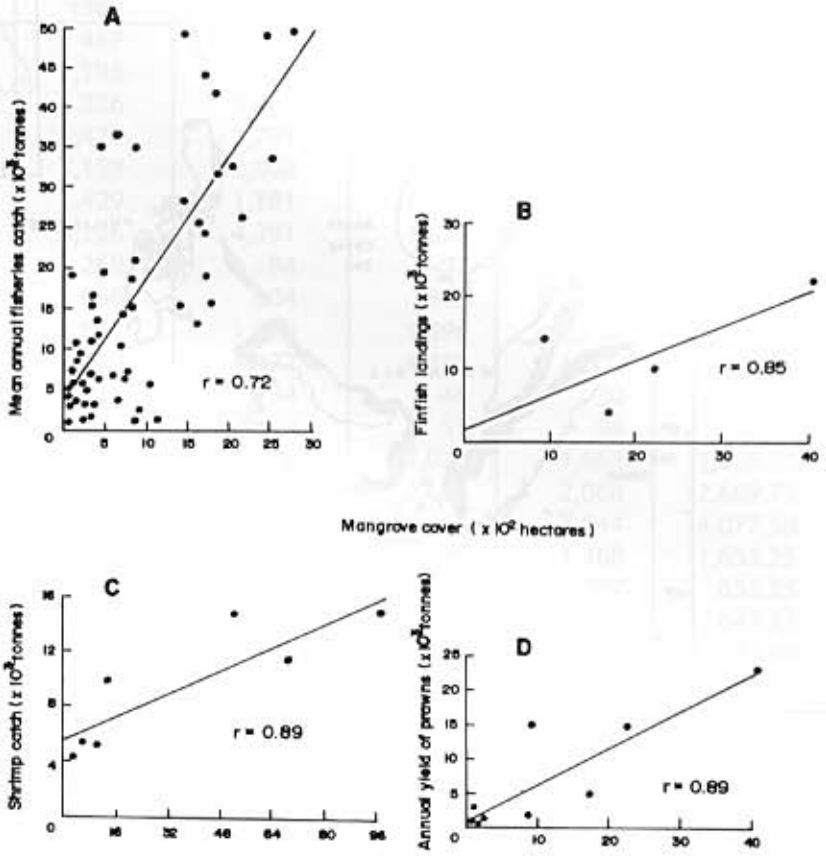
Table 3.20. Matang Mangrove Forest Reserve: Main Ecological and Production Features (Gong et al., 1994).

Total Forest Area (ha)	40,711
Area of Productive Forest (ha)	34,769
Year of Establishment	1,902
Rotation Cycle (years)	30
Area of Mudflats (ha)	5,043
Area of Waterways (ha)	8,653
Estimated Value of Capture Fisheries in	1990
Finfish (million US$)	26.0
Prawns (million US$)	45.0
Estimated Value of Aquaculture in 1990	
Cockles (million US$)	2.1
Cage Culture (million US$)	0.9

Results from research studies carried out in mangroves in the coastal areas of Klang (Selangor) and Matang (Perak) of Malaysia clearly indicate that a large number of marine fishes and prawns are dependent on mangrove forests as a habitat for juveniles and adults (Gong et al., 1994). The studies indicated that:

- The Matang mangrove system is mesotidal (tidal range, 2 meters) while the Klang system is macrotidal with a tidal range of 4 meters;
- Fish and prawns are more abundant in the channels and inlets of Matang system than in the Klang system; and
- The Matang mangrove channels contain a higher biomass of fish (37 kg/ha) and prawns (7 kg/ha) than in the Klang mangrove channels (18 kg/ha and 3 kg/ha, respectively).

Figure 3.19. Relationship of Fisheries Landings and Aerial Cover of Mangroves in the ASEAN Region (Singh et al., 1994).



A. Philippines: Annual fisheries catches by province.
B. Malaysia: Mangrove-dependent finfish landings on the West Coast of Peninsular Malaysia.
C. Indonesia: Shrimp landings.
D. Malaysia: Annual yield of prawns.

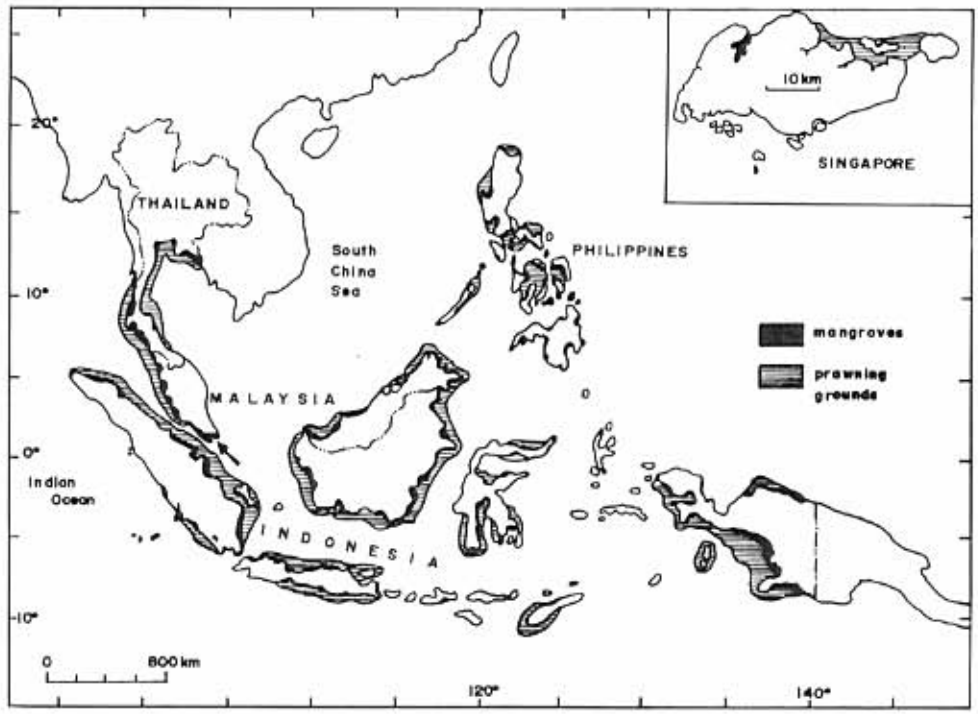
The main features of the Matang mangrove forest reserve are presented in ***Table 3.20***.

Landings of mangrove-dependent fishes from the West Coast of Peninsular Malaysia are recorded to be around 87,806 tonnes per year (***Table 3.21***). As shown in the table, several species of abundant catches such as the anchovies (*Stolephorus* spp.), sciaenids, trevallies (*Selar* spp.) and shads (*Ilisha elongata*) are of high commercial value. On the average, total landings from coastal waters along the West Coast of Peninsular Malaysia amounted to around 339,368 tonnes and 17,4557 tonnes, excluding trash fish. Catches of mangrove-dependent fish species, on the average, amounted to 87,805 tonnes, about 26% the total fish landings from the West Coast of Peninsular Malaysia, including trash fish and 50.4% without trash fish (***Table 3.2***).

Gong et al. (1994) indicated that the biomass values of fish and prawns in Malaysian mangroves were much lower than those recorded in Australia (e.g., 300 kg/ha) or USA (150 kg/ha) indicating that the Malaysian mangrove waterways may be overexploited. In 1990, the State of Perak recorded 39,000 tonnes of mangrove-associated fish and 29,000 tonnes of penaeid prawns and sergestid shrimps (*Acetes*) valued at US$31 and US$52 million, respectively (Gong et al., 1994).

Prawns and Acetes shrimps. The ASEAN region has the richest prawn resources in the world in terms of both species and annual production (about 370,000 tonnes). The major prawn fishing grounds occur predominantly in shallow waters of less than 40 m deep, which are adjacent to coastal mangrove forests (***Figure 3.20***).

Figure 3.20. Major Prawn Fishing Grounds and Mangrove Areas in ASEAN Countries (Chong et al., 1994).



Species caught are mostly penaeid prawns, such as the white prawn (*Penaeus merguiensis* and *P. indicus*), tiger prawn (*P. monodon*) and greasyback prawn (*Metapenaeus affinis* and *M. ensis*). There is a close relationship between the coastal prawn catches and the aerial coverage of mangroves (***Figure 3.21***). Prawn catches are higher in waters near the mangroves and prawn catches increase correspondingly with the increase of mangrove areas (Paw and Chua, 1991; Chong and Sasekumar, 1994).

Prawn resources in the Malacca Straits appear to be overfished (Chong et al., 1994b). Annual fisheries statistics (1990) indicated approximately 60,000 tonnes of prawns have been caught from waters in the Malacca Straits. The figure exceeds the potential yield of 57,000 tonnes (with an additional 13,000 tonnes if the deeper offshore waters are fished) as estimated by Chong (1984) for coastal waters of the Malacca Straits. Trends in overexploitation of prawn stock along the Indonesian coast of the Malacca Straits have been reported (Chong et al., 1994a).

Sergestid shrimp (*Acetes*) live near mudflats adjoining mangroves and mangrove creeks. The shrimp are caught by the traditional push net operated by an individual. The annual catch for Malaysia amounted to around 14,000 tonnes (Sasekumar and Lim, 1994).

Crabs. About 8,000 tonnes of mangrove crabs (*Scylla serrata*) are landed from the mangrove areas in Malaysia (Sasekumar and Lim, 1994). The crabs are probably overfished; the size of crabs landed are usually small.

Coastal aquaculture

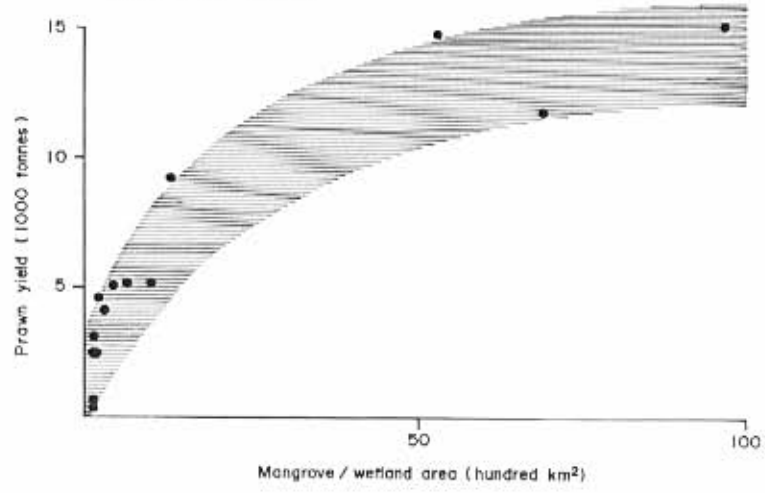
Cockle culture. Along the West Coast of Peninsular Malaysia, particularly off the coasts of Selangor and Perak, there are extensive areas of mudflats located in the vicinity of the mangrove forest. These mudflats are utilized for semi-intensive culture of cockles (*Anadara granosa*). The *Anadara* cockle is a bivalve that is indigenous to the intertidal mudflats in Southeast Asia. It is a filter feeder that has short siphons to suck food from the layer of water close to the surface of the bottom sediment (Broom, 1985; Sasekumar and Lim, 1994). Cockles are an inexpensive source of protein.

The culture of cockles depends on the natural spat, which are found near the large river mouths. It takes 8 months for the young cockles of 4 to 10 mm size to grow to a market size of around 32 mm in length, at a culture density of 1,000 young cockles per m^2 of mudflat. As the cockles grow, they are re-sown at densities of 100 to 200 per m^2 (Sasekumar and Lim, 1994). Annual cockle production in Malaysia has

Table 3.21. Landings (in tonnes) of Mangrove-Dependent Fishes of Economic Importance for the West Coast of Peninsular Malaysia (Sasekumar et al., 1994).

Species of Fish	1988	1989	1990	1991	Mean
Alectis/Caranx sp.	467	520	202	277	366.50
Anadontostoma chacunda	2,195	2,364	3,140	3,171	2,717.50
Arius sp.	3,326	3,749	3,656	3,404	3,533.75
Carangoides spp.	2,426	1,791	1,998	1,552	1,941.75
Chirocentrus dorab	3,159	2,802	2,326	2,557	2,711.00
Cynoglossus spp.	1,429	1,181	1,903	1,673	1,546.50
Gymnural/Dasyatis spp.	6,126	4,391	4,672	4,601	4,947.50
Drepene punctata	269	94	92	158	153.25
Eleutheronema tetradactylum	866	804	857	954	870.25
Epinephelus spp.	2,811	1,829	1,996	2,154	2,197.50
Ilisha elongata	4,620	4,432	4,950	4,802	4,701.00
Lates calcarifer	50	34	48	30	40.50
Leiognathus spp.	570	347	51	96	266.00
Liza/Mugil spp.	1,830	1,675	2,070	1,663	1,809.50
Lutjanus spp.	3,499	2,428	2,684	2,068	2,669.75
Megalaspis cordyla	4,764	3,841	3,061	4,644	4,077.50
Muraenesox cinereus	2,027	1,612	1506	1,468	1,653.25
Plotosus canius	582	826	1294	707	852.25
Pomadasys hasta	790	734	560	489	643.25
Sciaenids	9,111	1,084	8,257	8,072	8,131.00
Selar spp.	9,436	7,581	7,446	5,617	7,520.00
Signaus spp.	212	107	193	203	178.75
Silago spp.	215	349	773	781	529.50
Sphyraena spp.	1,488	1,460	1,504	1,249	1,425.25
Stolephorus spp.	25,325	26,223	25,469	14,891	22,977.00
Stromatids	4,897	3,868	5,138	4,071	4,493.50
Trichiurus spp.	5,066	2,087	1,598	1,961	2,678.00
Upeneus spp.	1,345	2,570	2,633	2,148	2,174.00
Total	**98,901**	**86,783**	**90,077**	**75,461**	**87,805.50**
Total Catch of All Fishes	**326,921**	**349,244**	**387,392**	**293,917**	**339,368.50**

Figure 3.21. Relationship between Maximum Yield of Prawns from Offshore Fisheries and the Area of Adjacent Mangrove and Wetlands in the Philippines and Indonesia (Sasekumar and Wilkinson, 1994).



varied from a high of 63,412 tonnes in 1979 to a low of 34,867 tonnes in 1988.

Coastal prawn/fish culture. Large areas of mangrove forests along the coastal zone of the Malacca Straits have been cleared and converted into coastal ponds for prawn (mainly the tiger prawn, *Penaeus monodon*) or fish (mainly the milkfish, *Chanos chanos*) cultures. Many of the prawn culture projects failed primarily due to the following (Sasekumar and Wilkinson, 1994):

- Ponds were located on sites with poor soil quality;

- Rising acidity and iron sulfides were released from mangrove soils, harming the prawns;
- Many ponds were sited together in one area, with insufficient coastal water flushing;
- Overstocking, overfeeding and inadequate flushing of organic rich pond bottom mud between crops;
- Indiscriminate use of antibiotics and other chemicals that disrupted the natural ecological balance in ponds; and
- Inexperience or improper training of the farm operators.

The life expectancy of a coastal prawn culture pond built from cleared mangroves is about 5 years. Ponds built behind mangroves should have an indefinite life, if management is good. This is due to the fact that the mangrove forest can be used to soak up nutrients and sediments from prawn ponds. On the other hand, mangrove tree growth is stimulated by the availability of nutrients. The addition of organic waste matter from the ponds will have little effect as the mangrove trees grow in anaerobic soils. It requires, respectively, 2 to 20 hectares of mangrove forest to absorb nutrients from one hectare of low intensive to high intensive ponds (Sasekumar and Wilkinson, 1994). Thus, well-placed and well-managed coastal prawn ponds sited behind mangroves can achieve high economic returns (Sasekumar and Wilkinson, 1994).

Cage culture. The culture of high market value finfish, such as seabass (*Lates calcarifer*), groupers (*Epinephelus* spp.) and snappers (*Lutjanus* spp.), in floating net-cages anchored in sheltered mangrove waterways is common in Penang, Perak (Matang), Selangor (Pulau Ketam) and Johore (Kukup). Although production is high, constraints, including shortage of fry for stocking and frequent disease outbreaks, limit the expansion of this culture method.

Tourism and educational studies. As an ecosystem linking land to sea, mangroves offer immense value for education and research. The unusual adaptations of mangrove flora and the role of mangrove ecosystems in the shallow water marine food chain are worthy of study and public education (Sasekumar and Lim, 1994).

The mangrove forest has a variety of habitats which offer a range of recreational opportunities, such as fishing, bird-watching, wildlife observation, photography and nature education. Coastal mangrove forests which are near settlements may be declared as nature-cum-recreational parks where destructive activities are prohibited to meet the requirements of tourists, as well as local recreational needs (Sasekumar and Lim, 1994).

Mangrove management practices, policies and strategies

Policies for mangrove management in the ASEAN region are primarily aimed at sustaining their ecological functions and benefits for national interest. Efforts to manage mangroves have been principally directed to reduce conflicts between environmental degradation and economic development (Atmadja et al., 1994). ***Tables 3.22, 3.23*** and ***3.24*** review the history of mangrove management practices, policies and strategies in the three littoral States of the Malacca Straits.

Indonesia

The Department of Forestry and Local Government is responsible in implementing the policies and strategies regarding conservation and management of the mangrove systems. The fundamental principles are:

- To maintain the essential ecological processes and life support systems; and
- To preserve genetic diversity and ensure the sustained utilization of the species and the ecosystem (Atmadja et al., 1994).

Management and conservation. The Indonesian government encourages the development of the forestry sector and, through the Department of Agriculture and Department of Forestry, has regulated the cutting of mangrove forests. A 50 to 200 m green belt of mangrove is required along the coast and 10 to 20 m along river banks.[1] The green belt serves not only to preserve the ecological functioning of mangrove ecosystems, but also to ensure the natural regeneration process of the mangroves in the region. A formula for determination of width of the mangrove green belt in the coastal area has been developed.[2] The proposed formula takes into account the width of mangrove ecosystem in the area, the slope of the coastline and the tidal range. The formula has been put into effect as an integral part of Presidential Decree

[1] This regulation was first announced in 1975 by the Directorate General of Fisheries and was soon followed by the Directorate General of Forestry. These two regulations were combined in 1984 and signed and announced by the Ministry of Agriculture and the Ministry of Forestry.

[2] The green belt should be equal to the width of the mangrove area and divided by 130x the average local tidal range in meters.

No. 32 (July 1990), on the Management of Protected Forest Areas. This formula now is applied throughout Indonesia.

Other efforts at conserving mangroves in Indonesia involve the establishment of protected and conservation areas. A number of nature reserves, wildlife sanctuaries, nature parks, natural recreation parks and grand forest parks have been developed in parts of Indonesia to conserve and protect mangrove areas. Currently, there are 13 reserves with the principal aim to protect mangroves (Soegiarto et al., 1982). Mangroves are also found bordering 14 other protected areas where they are of secondary interest. In addition, nine new proposals for mangrove reserves have been approved by provincial governors and a great number of proposals are currently being processed at the Directorate General of Forest Protection and Nature Conservation. Surveys and studies on those proposed sites are now underway, carried out jointly by the Directorate of Nature Conservation, Center for Research and Development in Oceanology, Center for Research and Development in Biology, various universities and the World Wildlife Fund of Indonesia. The protected areas will be 30% of the total Indonesian mangrove forest area by the year 2000.

Presently there are only 522,070 ha of mangrove area under conservation and 614,120 ha are assigned as protection forest or in total about 28.5%. However, in Sumatra, only 2.6% (365,000 ha) of mangrove area is protected and an additional 6.4% (870,000 ha) is being proposed to be protected (BAPPENAS, 1993). Generally speaking the protected areas are not effective; poaching and encroaching in the mangrove areas are quite high.

Indonesia has policies on fisheries and settlement, industry and transport, related to mangroves. Environmental impact studies are required to be carried out prior to establishing new settlements and industry, following guidelines provided by the government. Every development in the coastal zone, including mangrove areas, which may result in damage to the environment, must be approved by the government.

Organization and cooperation. While the principal responsibility for managing mangrove forests is in the hands of the Department of Forestry, research programs and other relevant activities on mangrove ecosystems are also carried out by a number of government agencies, research institutions and universities. In order to coordinate the activities and efforts of these bodies,

Table 3.22. Development in the Utilization and Management of Mangrove Forests by Indonesia (Paw and Chua, 1991).

Year	Utilization and Management Development
1933	Enacted a regulation for prohibiting the cutting of mangroves within 3 km from a village mainly to control mosquito population/incidences of malaria.
1937	Started the Transmigration Program in tidal swamplands in South Kalimantan.
1938	Enacted the regulation of basic silviculture practice known as the "seed tree method".
Prior to 1942	Mangroves were exploited for charcoal (Riau Province) and sugar industries and for the railway system.
1945 - 1950	Uncontrolled destruction of mangroves in Java island at the time of the War of Independence.
After 1950	Enforced a forestry regulation to halt rapid denudation of mangrove forests.
1969	Ministry of Public Works and Electric Power launched a pilot project to open mangrove areas in Sumatra and Kalimantan. About 200,000 ha of tidal swamp forests were converted to agricultural lands during the first Five-Year Development Plan.
1975	Enacted a regulation that enforced the establishment of a 400-m wide mangrove greenbelt along the Indonesian coast.
1978	The 1938 Act was amended to cover the requirements for the maintenance and replacement of cut-over areas by concessionaires.
1980	The Indonesian Mangrove Committee was created.
1982	Lease permits were issued to timber corporations to exploit mangroves in Irian Jaya, Kalimantan, Sulawesi, Sumatra and Riau.
1984	Enacted a regulation that enforced the establishment of a 200-m wide mangrove greenbelt along the Indonesian coast.

Table 3.23. Development in the Utilization and Management of Mangrove Forests by Malaysia (Paw and Chua, 1991).

Year	Utilization and Management Development
1904	The Forestry Department established a 20,000-ha Matang mangrove reserve in Perak.
1933 and 1982	Diverted 4,000 ha of agricultural lands as the mangrove reserve in the First Division of Sarawak.
1955	10,500 ha mangroves converted into a plantation for cash crops (up to 1980); 1,300 ha for urban and residential purposes.
1960s	There was a gradual transitional change from traditional to conventional uses of the mangrove ecosystem for coastal development.
1968 and 1970	Wood chipping plants in Peninsular Malaysia, Sarawak and Sabah were established to use mangroves for their production.
1970	Some 123,000 ha in Sabah and 6,200 ha in Sarawak were allocated for wood chip production for export to Japan.
1972	The Forestry Management Policy and Strategy of the National Forestry Policy that aimed at ensuring conservation, management, utilization and development of forest resources, was approved by the National Forestry Council and endorsed by the National Land Council.
1977	The shrimp culture project in Tawau, Sabah (80 ha) was established.
1978	An *ad hoc* Mangrove Research Coordinating Committee was formed.
1983	A research and management strategy for the mangrove ecosystem was drawn up.

a National Mangrove Committee (NATMANCOM) was established in 1980. The committee has some twenty members, representing government agencies and development programs pertaining to mangrove ecosystems. The membership is reviewed and updated every two years. The following are some of the committee's activities:

- To coordinate research programs on mangroves;
- To prepare lists of institutions and agencies dealing with mangrove programs;
- To prepare a directory of mangrove scientists;
- To compile and update a bibliography on mangrove research in Indonesia;
- To organize every four years a scientific seminar on mangrove ecosystem. The purpose of the seminars is to review the state of knowledge, to evaluate research results and to plan and give directions for future research programs. So far, five national seminars on mangrove ecosystem have been organized.

Rehabilitation. One of the positive management activities of the "Perum Perhutani" is the replanting of damaged mangrove forests in Java. More than 5,000 hectares of damaged mangrove forest have been rehabilitated in Cilacap in the last three years (1993). Over 10,000 hectares of disturbed mangrove areas on the North Coast of West Java have also been replanted since 1976. The *Rhizophora* and *Avicennia* seedlings were used in the North Coast of West Java rehabilitation programs, whereas *Rhizophora* and *Bruguiera* spp. were used in the Cilacap mangrove areas. The survival rate of replanting was between 60 and 75%.

A new approach to fish culture, called *tambak empang parit* (channel fishponds), has been initiated along the North Coast of West Java. The approach allows residents of the surrounding areas to catch or culture fish in the broad channels around the rehabilitated mangrove forest areas (Soegiarto, 1984; Tim Ekosistem Mangrove, 1984). A similar approach is now being developed along the East Coast of Aceh

Table 3.24. Development in the Utilization and Management of Mangrove Forests by Singapore (Paw and Chua, 1991).

Year	Utilization and Management Development
1819	Some 7,500 ha or 13% of the total land area was covered with mangroves.
1822	Reclamation work began at the south bank of the Singapore River.
1885	A forest reserve was established to conserve mangroves.
1900s	Started prawn farming.
1938	Abolished mangrove reserves.
1951	Pandan and Kranji were developed as national botanical reserves but such reserves ceased in 1968 and 1975, respectively.
1960s	The Jurong Industrial Estate was established with large areas of mangrove forests denuded.
1970	All major non-urban estuaries were barraged to create freshwater reservoirs, resulting in extensive destruction of mangrove areas.

and North Sumatra Provinces. Through the *tambak empang parit* pattern, the community (in particular the fishing community), has started to realize and observe the opportunities of mangroves in enhancing their livelihoods.

Developing community-based management. The urgency of developing community-based management of mangrove ecosystems in Indonesia has also been realized as a consequence of a number of internal and external factors, namely:

Internal factors

- Conflicting policies on development and conservation;
- In some cases, conflicting policies between the central government and the provincial/ local authorities;
- Weak enforcement of existing rules and regulations;
- Inadequate skills, education and motivation, especially locally; and
- Increasing population pressure on land and its resources.

External factors

- Increasing global awareness of the environment and the importance of community-based and NGO participation; and
- Open market and free exploitation and conversion of mangrove lands into prawn and fish culture areas, as well as other uses.

Indonesia is developing community-based management on biosphere reserves (e.g., in Gunung Leuser, Aceh Province), national parks and coral reefs (Coral Reefs Rehabilitation and Management Programme-COREMAP). Community residents are being trained to increase their awareness of relevant environmental issues and the sustainability of resources. At the same time, they are being provided with alternative skills to generate income. The community will be given the opportunity to participate in protecting the environment, as well as sustaining the resources of the area.

Constraints in mangrove management. The present constraints in the management of mangroves in Indonesia are as follows (Atmadja et al., 1994):

- Inadequate enforcement of existing laws, regulations, decrees;
- Insufficient resources (equipment, personnel, training);
- A lack of coordination and integration programs; and
- Unfavorable socioeconomic and customary law recognition.

Malaysia

Policy on managed mangrove forest. Mangrove forests are managed on the policy of sustainable yields in accordance with the Forest Management Policy and Strategy of the National Forest Policy approved by the National Forestry Council in 1977 and later endorsed by the National Land Council in 1978 (Atmadja et al., 1994).

The best example of mangrove forest management for sustainable yields is the Larut Matang forest. The forest is managed on the basis of the following strategies:

- **Rotation age**: Harvest of the trees is done 30 years after replanting. This is to ensure that there will be ample time for the mangrove trees to grow to mature size.
- **Silvicultural system:** Only trees greater than 8 cm in width are harvested, to ensure that there are adequate seed trees throughout the logged area. For the concession blocks which border main river channels and the sea, there is always a 3-meter buffer of trees left untouched to prevent or reduce erosion, as well as to propagate seedlings. Contractors are required to girdle or fell all non-useful species to ensure that only commercially valuable species remain.
- **Conservation and protection**: Stands of mature seed trees are retained to ensure a sufficient supply of quality seeds for planting.

The Larut Matang mangrove forest is regarded as the best managed mangrove forest in the region and possibly the world (Atmadja et al., 1994).

Fishery policy and threat to mangrove forests. Several regulations were issued by the Department of Fisheries to protect and conserve mangrove forests. There is a regulation allowing only traditional fishing gear to operate in waters less than 5 miles from shore, including the estuarine system. The regulation also serves as a strategy to ensure sufficient supply of mature fish, prawns and other fishery resources.

Because of market demands, the general policy of the Department of Fisheries is to encourage people to

venture into cockle culture, brackishwater finfish and prawns. The policy conflicts with conservation efforts in mangrove areas, because these aquaculture industry culture activities will be concentrated on mangroves. Many mangrove forests are expected to be converted to accommodate aquaculture activities (Atmadja et al., 1994).

Singapore

The Singapore Government has given little attention to mangrove forest management. About 99% of the original mangrove area has been converted into other uses, such as the development of residential and industrial estates. One small national park, Sungei Buloh, has been established to protect a remaining mangrove forest.

Exploitation and Use of Coral and Seagrass Resources

Economic values and uses

Coral reefs. Coral reef resources have been exploited by humans for a long time. Economic values of the coral reefs (White, 1987) include:

- A supply of marine ornamental fishes;
- Supporting catches of commercial fish species such as groupers, jellyfish, etc.;
- A source of building materials; and
- Diving site for coastal tourism.

Seagrass beds. Seagrasses have been used traditionally (Sudara et al., 1994) for various purposes including :

- Harvested and woven into baskets;
- Burned for salt, soda and warmth;
- Stuffing of mattresses;
- Thatching of roofs;
- Upholstery and packing materials;
- Insulation for sound and temperature;
- Fiber substitute for making nitrocellulose;
- Piled to build dikes; and
- Manufacturing of cigars and children's toys.

Seagrasses can also be used as:

- Sewage filters;
- Coastal stabilizers;
- In paper manufacture;
- A source of useful chemicals;
- Fertilizer and fodder; and
- Food and medicine.

Ecological value of coral and seagrass resources

Coral reefs

Function and valuation. Coral reefs are a unique, complex tropical shallow water ecosystem. From various sources, e.g., Odum (1971), Johannes et al. (1972), Soegiarto and Polunin (1981) and many others, it has been noted that coral reefs serve many functions:

- As living environments;
- As physical protection ecosystems;
- As sources of living resources; and
- As natural beauty.

As a living environment, coral reefs function as a habitat for many organisms. Many of them are of economic importance. The interdependencies of living organisms with their environment, as well as with other organisms, make the web of life in coral reef ecosystems one of the most complex on earth.

Because of its massive structure, coral reefs function as physical protectors of coastal and island ecosystems from the direct incoming wave actions. Extracting the coral structure weakens the protective function, resulting in coastal abrasion. For centuries, coastal communities have mined the coral heads, coral gravels and coral sands for construction materials or as material for producing lime. The genera of Porites, Goniopore and Goniastrea are commonly used for this purpose. The more exotic and colorful species of *Tubipora musica*, *Acropora* sp., *Pocillopora* sp. and *Montipora* sp. are used as decorations for aquariums, gardens and walls. Many species of corals are also cleaned, bleached and dried to be sold to tourists.

Other resources that have been extracted from coral reefs are seashells. Three species have dominated the trade. They are: *Trochus niloticus* shell, used as material for button making; *Pinctada* spp., better known as pearl oyster for making various shell handicrafts; and *Tridacna* spp. or the giant clams, used as material for exotic tile making. There are also a number of species of molluscs that are edible and consumed locally, or exported, such as *Tridacna* spp., *Trochus* spp. and *Heliotis* spp. (Sukarno et al., 1983).

However, the most valued living resources extracted from coral reefs are the varieties of fish for local consumption and export. Coral reefs support a high density and a high diversity of fishes and other biota. Fish species, such as *Caesio* spp., *Siganus* spp., *Lutjanus* spp., *Epinephelus* spp., *Caranx* spp., are among the most

valued reef fishes in Indonesia. In addition, Indonesia has been known internationally as an exporter of ornamental fishes. The volume and value of export of fishes are continuously increasing. It has been recorded that Indonesia exported 281 species of aquarium fishes and 99 other marine organisms (Kvalvagnaes, 1980).

Other export commodities from coral reefs include seaweeds, crustaceans, pearls and dried sea cucumbers. In recent years, the export of dried seaweed has been substantial. They are mostly *Eucheuma* spp. for carageenans and *Gracillaria* spp., *Gelidium* spp. and *Hypnea* spp. for "agar-agar". *Eucheuma* spp. is now cultured in many parts of Indonesia, such as Bali, Southeast Sulawesi, Nusa Tenggara, Molluccas and Riau Archipelago. The export value of seaweed is about US$3 million annually (Soegiarto et al., 1978).

Due to their natural beauty, coral reefs are now becoming a tourist attraction. Many parts of Indonesia have developed marine tourism resorts based on coral reefs (e.g., the Seribu Archipelago in Jakarta Bay; Bali Islands; Bunaken in North Sulawesi; Maumere in Flores; Biak in Irian; Banda Islands in the Molluccas; and Bintan Resort in Riau Archipelago). The development of marine tourism also generates other businesses, such as diving and boat operations, guides and handicrafts.

Seagrass beds. Seagrass beds provide important habitats as nursery areas for many fish and invertebrates. The nursery role appears to be associated with the ability of the seagrass beds to provide protection for small fishes from predators and an abundant food supply, particularly in the form of small epibenthic crustaceans, which in turn depend on the seagrass detritus cycle for their food (Poovachiranon et al., 1994). Seagrass beds also serve as feeding grounds for the juvenile and adult fish and shrimps. For example, rabbitfish (*Siganus canaliculatus*), green turtle (*Chelonia midas*) and sea cow (*Dugong dugong*) feed directly on seagrass leaves throughout all or part of their life cycles. Other species including shrimps, molluscs, polychaetes, sea urchins and sea cucumbers derive their nutrients indirectly from seagrasses. Fry or juveniles of groupers and snappers are found among seagrass beds in Thailand and the West Coast of Peninsular Malaysia. Four species of commercial penaeid prawns and two species of swimming crabs are commonly found in ASEAN seagrass beds.

Management practices, policies and strategies

Coral reefs. A variety of reef management systems exist in the ASEAN region. Marine protected areas (MPAs) have been established throughout the region, but many occur only in paper without any commitment to staffing and operational funding. Only a few MPAs have been effectively managed.

Seagrass beds. The management considerations as suggested by Fortes (1990) are given in ***Table 3.25.***

The overall values and negative environmental impacts resulting from detrimental uses of these important coastal ecosystems (mangroves, coral reefs and seagrass beds) are summarized in ***Table 3.26.***

Oil and Mineral Resources: Status of Development

Oil and gas resources

Oil reserves and production are mostly found along the coastal area of Sumatra Island. So far, no oil is produced along the West Coast of Peninsular Malaysia but the Strait has been divided into "contract areas" for the purposes of exploration. The potential recoverable oil and gas reserves along the East Coast of Sumatra bordering the Malacca Straits are presented in ***Table 3.27.*** Details of oil production, location and operation of refineries along the Malacca Straits and their importance to national economies are described in Chapter 4.

Metal resources

Non-fuel minerals in the Malacca Straits are mainly tin ore and bauxite. These are mined along the Indonesian coast of the Malacca Straits.

Tin. The production in 1981 totaled 35,238 tonnes. Production sites are shown in ***Figure 3.22.*** Extensive mining of tin ore has occurred on the islands of Bangka and Belitung, which are located in South Sumatra, outside the Malacca Straits (Burbridge et al., 1988). However, the tin placer deposits extend to the Riau Archipelago. ***Table 3.28*** presents data on tin production in Riau Archipelago between 1986 and 1989.

Sujitno (1974) estimated the tin reserve to be around 1.64 million tonnes, about 43% of which is located offshore. More optimistic estimates were given by Harris (1978) and MacDonald (1981), including 2.40 million tonnes of known reserve and 1.08 million tonnes of potential, totaling 3.48 million tonnes. Indonesia and Malaysia have been undertaking joint studies to explore the tin resources in the Malacca Straits (Burbridge et al., 1988).

Table 3.25. Classification, Characteristics and Management Considerations of Seagrass Beds in the ASEAN Region (Fortes, 1990).

Classification	Characteristics	Management Considerations
Pristine Seagrass Beds	• Virgin beds disturbed only by the normal intensity of natural elements • They form thick assemblages in shallow waters, usually dominated by tropical eelgrass, dugong grass and round-tipped seagrass	• They should be preserved and protected from any form of alteration or indiscriminate exploitation to be available for scientific and educational purposes
Disturbed Seagrass Beds	• They usually occupy bays, coves or other coastal waters near human habitation • They are the constant victims of human activities, suffering effects from domestic and industrial effluents • Due to ready availability of nutrients, they may yield high biomass and production rates under more favorable conditions	• Effective control measures are needed
Altered Seagrass Beds	• Low species diversity may be partially or completely converted to salt ponds or fish/shrimp ponds • They have the potential to be converted back into seagrass beds through rehabilitation or massive transplantation	• Should be considered for proper multiple use programs

Bauxite. Bauxite production ranks second for non-fuel minerals in the East Coast of Sumatra. Production is mainly in the Riau Archipelago, notably the Bintan island. In 1981, production totaled 1.2 million tonnes (Burbridge et al., 1988) and in 1993, it totaled 1.32 million tonnes (Statistical Office of Riau Province, 1995).

Non-metal resources

Urea. Urea production is based upon natural gas production in Lhokseumawe, Indonesia. In 1983, production was estimated to be more than 1.6 million tonnes (Burbridge et al., 1988).

Kaolin. Kaolin is produced on the islands of Bangka and Belitung off the south Sumatra coast. Production totaled 161,478 m^3 in 1980 (Burbridge et al., 1988).

Granite. Granite is produced from quarries located on the Pulau Karimum Besar, off the coast of Riau Province of Sumatra. Production was estimated to be around 3,581 tonnes in 1982 (Burbridge et al., 1988). In 1993, granite production from Riau had increased at a staggering rate and stood at 2.68 million tonnes (Statistical Office of Riau Province, 1995). Granite rocks are exported to Singapore for coastal land reclamation.

Figure 3.22. Tin Ore Reserves Along the Eastern Coastal Region of Sumatra (Burbridge et al. 1988).

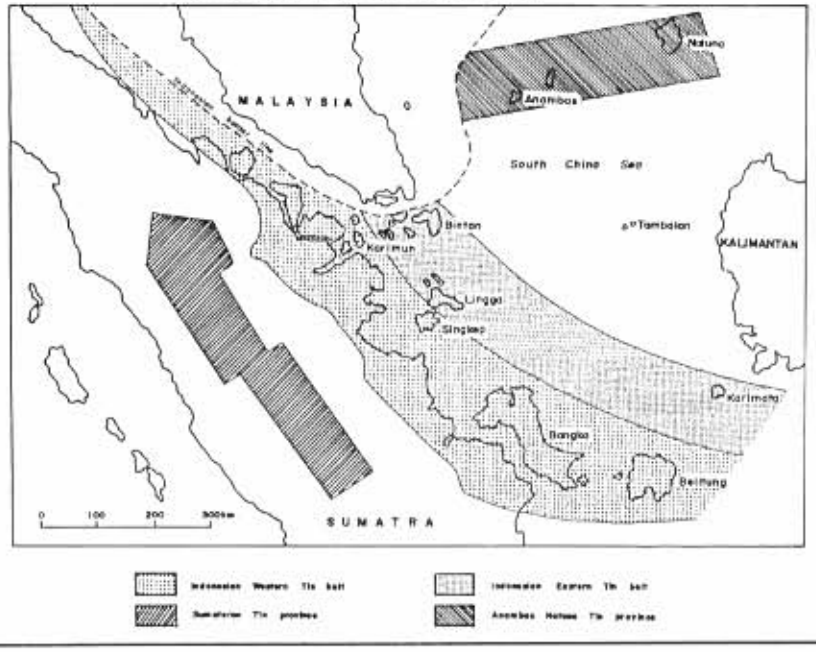


Table 3.26. Summary of Values and Negative Environmental Impacts Resulting from Detrimental Uses of Coastal Ecosystems (Mangroves, Coral Reefs and Seagrass Beds) (Fortes, 1988, 1990,1995; Paw and Diamante, 1995).

Coastal Ecosystem	Functions/ Potential Values	Detrimental Uses/ Practices	Negative Environmental Impacts
Coastal Forests	• Shoreline protection • Source of timber and fuelwood • Trapping of or filter for sediment and nutrients • Spawning, nursery, feeding grounds for fish and shrimps • Fishery catches • Source of tannin and other chemicals	• Overexploitation for timber, fuelwood and fishery resources • Indiscriminate conversion for shrimp ponds or human settlements • Reclamation and coastal mining • Discharges of domestic sewage and industrial wastes • Discharge of oil from ships or of land-based sources	• Deterioration of water quality • Degradation or loss of habitat • Reduced fish or shrimp fry production • Reduced overall fishery production • Coastal erosion and siltation • Secondary adverse impacts to adjacent coral reefs, seagrass beds, estuaries and other habitats
Coral Reefs	• Shoreline protection • Beach sand replenishment and beach protection • Spawning and nursery grounds for many fish species • Fishery catches • Source of aquarium fishes and other ornamental items • Mariculture • Tourism	• Coral mining • Discharge of domestic sewage or industrial waste • Unregulated tourism activities • Destructive fishing methods • Overfishing	• Degradation or loss of habitat • Reduced fishery production • Reduced tourism potential • Coastal erosion
Seagrass Beds	• Raw materials for making baskets, mattress stuffing, roof thatch, upholstery and insulation of sound and temperature, and piles to build dikes • Compost for fertilizer • Fiber substitute in making nitrocellulose • Sewage filters and coastal stabilizers • Maintenance of fertility of coastal waters and alternative feeding grounds for fish and shrimps • Fertilizer and fodder • Source of useful chemicals, food and medicine for man	• Discharge from coastal mining activities • Conversion of coastal areas for aquaculture • Run-offs from deforestation or slash-and-burn agriculture • Blast fishing or other destructive fishing methods • Discharge from domestic sewage or industrial wastes	• Degradation or loss of habitat • Reduced fishery production • Adverse effects on adjacent coral reefs and mangroves • Coastal erosion

Sand mining. Sand mining is also carried out at locations along the Malacca Straits in places such as Johor and Riau. The sand production from Riau in 1993 stood at 1.45 million tonnes. Sand is also exported to Singapore for reclamation of coastal areas (Statistical Office of Riau Province, 1995).

Coastal Tourism Resources: Status of Development, Potential and Socioeconomic Contributions

The coastal areas with potential for tourism development (Wong 1995) include the following:

Table 3.27. Potential Recoverable Oil and Gas Reserves Along the East Coast of Sumatra Bordering the Malacca Straits (Burbridge et al., 1988).

Basin	Oil and Gas Reserves (billion barrels of oil equivalent)	Percent of National Total
North Sumatra Basin	3.501	3.9
Sibolga Basin	1.825	2.0
Central Sumatra Basin	2.741	3.0
Total	**8.067**	**8.9**
National Total (Indonesia)	**89.5534**	

Table 3.28. Production of Tin (in tonnes) in Four Locations in Riau Province, 1986-1989 (Statistical Office of Riau Province, 1995).

Location	Regency	1986	1987	1988	1989
Singkep[1]	Riau Islands	988.5	728.0	810.5	787.0
Karimun	Riau Islands	990.0	1,446.5	812.0	1,033.0
Kundur	Riau Islands	893.5	1,116.0	1,662.0	1,285.0
Bangkinang	Kampar	—	15.5	22.5	4.5
Total		**2,877.0**	**3,306.0**	**3,307.0**	**3,109.5**

[1]Not in the Malacca Straits proper.

- Coastal habitats between land and sea including transitional features, e.g., beaches, cliffs, mangroves and barrier islands;
- Nearshore waters where currents, sedimentation and biota are influenced by adjoining land forms; and
- Small islands, coral reefs and atolls.

The Asia-Pacific region is a rapid tourist growth region. The share of world tourist arrivals in the region grew from 0.75% in 1950 to 11.4% in 1991. Revenues increased from 1.43% to 14.7% in the same period (Hall, 1994). The flourishing coastal tourism development in the Asia-Pacific region is largely attributed to its extensive coastal resources which are ideal for tourism, including the beaches, coral reefs, clear water and other natural attractions. In many countries, the rich cultural heritage adds to the tourist attraction (Wong, 1995).

There are several coastal tourist resorts and beaches found along the Malacca Straits (*Table 3.29*). Present status of development for these tourist resorts, their socio-economic contributions, impacts to the environment and the coastal areas of the Malacca Straits potential for tourism development are described in the following sections.

Indonesia

In 1969, the first year of REPELITA I, the number of foreign visitors entering Indonesia was few, accounting for only 90,000. By 1994, at the end of REPELITA V, Indonesia had welcomed over 4 million visitors, who collectively spent an estimated US$4.6 billion during their travels in the archipelago. On average, overseas tourists stay almost four days in Indonesia and spend approximately US$900. Most of the spending was on accommodation, travel, tours, food and beverages, entertainment, purchase of goods and souvenirs and other services.

Indonesia has seen its position as a tourist destination grow from the eleventh most important in Asia to the sixth from 1985 to 1994. The growth rate for tourism in Indonesia was an impressive 17.8% (Nuryanti, 1995). Tourism is currently Indonesia's third most important non-oil based source of foreign revenue, after timber and textile industries. It is projected that tourism will overtake oil as the principal source of revenue in Indonesia within the next decade.

Indonesia has abundant resources for the development of coastal tourism including white sandy beaches, coral reefs, islands, etc. A number of beach and island resorts can be reached relatively easily from the main gateway cities of Jakarta, Surabaya, Denpasar, Medan and more recently also Batam (the last two being located in the Malacca Straits region). As a result of the dedication and promotion since the 1990s as the "Visit Indonesia Decade", Indonesia has enjoyed a growing number of tourism arrivals from overseas (*Figure 3.23*). Medan has been the western main gate for tourist flow into Indonesia. The overseas tourist arrivals have increased from 84,864 in 1984 to 264,515 in 1994. In the same period, the domestic tourists also increased from 372,500 to 1,236,000 visitors. Hotel rooms have increased from 10,531 in 1990 to 17,430 in 1994, distributed among 19 star-rated hotels and 114 non-star-rated hotels (Sekretariat Wilayah/Daerah Propinsi Sumatra Utara, 1995). Recently, tourist arrivals in

Table 3.29. Inventory of Important Coastal Tourist Spots Along the Malacca Straits (DOE/Malaysia, 1989; TDC/ Malaysia, 1995; Wong, 1991b, 1995).

Country/State	Coastal Tourist Spots
Peninsular Malaysia	
Kedah	Langkawi Island: Tanjung Rhu, Pantai Cenang, Pasir Hitam, and Kuah
	Pantai Merdeka
	Payar, Segantang, Kala, and Lembu Islands
Penang	Penang Island: Batu Feringgi, Teluk Bahang, Gurney Drive, and Padang Kota
	Seberang Perai: Pantai Bersih
Perak	Pangkor Island: Pasir Bogak
	Pulau Pangkor Laut (neighboring Pangkor Island)
	Lumut: Pantai Teluk Batu
Selangor	Pantai Morib
Negeri Sembilan	Port Dickson
Malacca	Tanjung Bidara
	Pantai Kundor
	Pantai Klebang
	Pulau Besar
Indonesia	
Riau Province, Sumatra	Batam Island: Nongsa Beach
	Bintan Island: Trikora Beach
Singapore	Sentosa Island
	East Coast Resort Area
	Changi Resort Area
	Pasir Ris-Loyang Resort Area

Medan have been surpassed by Batam and Bintan Islands, partly due to their vicinity to Singapore and Johor.

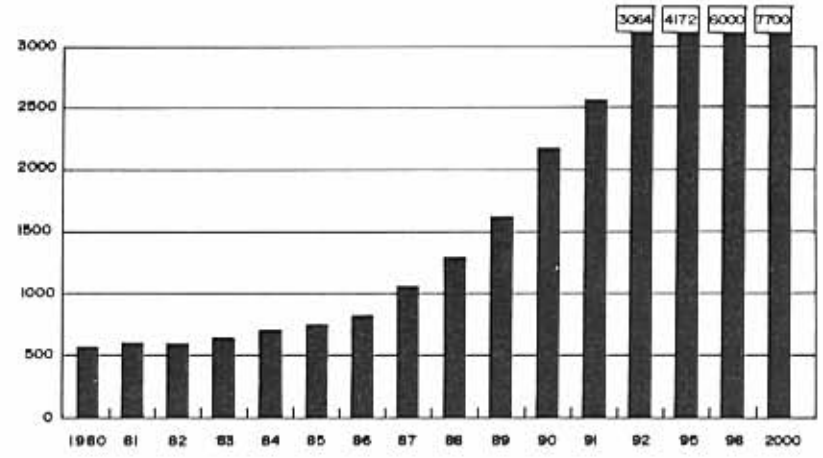
Although visiting the coastal recreation areas is a common practice, the concept of coastal tourism is still relatively new to Indonesia. There are a variety of resorts that have been developed in many parts of Indonesia. Originally, they catered especially to the domestic market, but gradually were improved in quality in order to attract overseas tourists as well.

Due to its high socio-economic potential for tourism, almost all provinces and regencies in Indonesia are now developing or establishing coastal tourism.

The new areas being planned and developed for coastal tourism are based on the concept of an integrated resort. Many of these projects are joint ventures between the government and private sectors; some are fully private and a few are purely government-supported. In addition to distributing the flow of tourists and spreading the economic benefits to other parts of the country, these new resorts are also a means of strengthening infrastructure and encouraging investments. ***Table 3.30*** shows the tourist, recreation and resort areas in the East Coast of Sumatra. They are at varying degrees of development and quality.

Riau Province: Bintan Island. The development of an integrated resort, the Bintan Beach International Resort, is ongoing on a 23,000 hectare coastal area. The resort is the most complex one in Southeast Asia, consisting of 20 hotels, 300 or more villas, one or more marinas, an agro-tourism park, an amusement park and a natural reserve for eco- and adventure tourism (Wong, 1995). The project is a joint venture investment by the Singapore and Indonesian governments, as well as private developers. The first phase of the project involved construction of requisite infrastructure, such as telephone lines, sewage treatment plants and a ferry terminal. The second phase, which includes

Figure 3.23. Visitor Arrivals (in thousands) to Indonesia, 1980-1991 and Predictions to Year 2000 (Jay, 1996).



construction of a golf course, has begun. It is estimated that it will take 20 years to complete half of the project (Wong, 1995). A regular ferry service between Singapore's Tanah Merah Ferry Terminal and Bintan Island has been launched in mid-October 1995 which will help to further enhance tourism development in Bintan Island.

Riau Province: Batam Island. Batam Island was gazetted as a free trade zone for industrial development. Coastal tourism development started in the 1980s when several hotels and holiday resorts of international standard were built to receive tourists mainly from Singapore. Most of the hotels and resorts are located around the Nongsa Beach area, the most popular tourist spot in the island. With the improvement of the ferry service between Singapore and Batam Island in the late 1980s, increased numbers of tourists from Singapore arrived in Batam Island to spend their leisure time particularly during weekends and public holidays. Coastal tourism development in Batam Island, however, has slowed down in recent years due to the change of destination to Bintan Island by increasing numbers of tourists from Singapore.

Malaysia

State of Kedah: Pulau Langkawi. Development of tourism started in the 1980s with support from both the federal and state governments. To date, Pulau

Table 3.30. List of Tourist and Recreational Areas in the East Coast of Sumatra in the Malacca Straits (Direktorat Bina Perjalanan Wisata, 1992-1993; Direktorat Jenderal Pariwisata, 1995-1996).

Province	Object	Location	Mode of Transportation	Type of Activity	Provided Facilities
Aceh	1. Weh/Rubiah Isl. Marine Park	23 km from Sabang	Motor boat, ferry, plane from B. Aceh	2,4,5,6,7	b,c,d,e
	2. Sabang Bay Mar. Park	Sabang , Weh Isl.	Motor boat, ferry, plane from B. Aceh	2,3,6	a,g
	3. Lhok Nga and Lampuk Beach	17 km from Banda Aceh	All kinds of motor vehicles	1,2,3,9	b.g
	4. Ujung Batee Beach	40 km from Banda Aceh	Ferry	3,6,7	-
	5. Ujung Blang Beach	10 km from Lhokseumawe	All kinds of motor vehicles	2,3,7,8,10	b,c,g
	6. Ujung Bade Beach	17 km from Banda Aceh	All kinds of motor vehicles	1,7,8,10	c
	7. Cermin Beach	5 km from Banda Aceh	All kinds of motor vehicles	1,2,7,8	b
	8. Kasih Beach	North of Sabang	Ferry from B. Aceh	1,7	b,c,g
North	9. Berhala Isl. Mar. Park	Deli Serdang	Motor boat	3,6,7	
Sumatra	10. Cermin Beach	55 km southeast of Medan	All kinds of motor vehicles	2,7,9	b,g
Riau	11. Sengarang Peninsular Marine Park	6 km from Tanjung Pinang	Motor boat, canoe	3,7,9	b,c
	12. Mapor Isl. and Abang Isl. Marine Park	Mapor Isl. and Abang Isl.	Motor boat	3,7	c,d
	13. Bayan Isl. Marine Park	West of Tanjung Pinang	Motor boat	2,3,7,9	c.g
	14. Terkulai Isl. and Soreh Isl. Marine Park	40 km from Tanjung Pinang	Motor boat, speed boat	2, 7,8,10	b,c
	15. Trikora Beach	Bintan, 48 km from Tanjung Pinang	Land	2,3,7,9	b,c
	16. Tanjung Pinang Beach	South of Bintan Isl.	Boat, ferry, plane from Pekan Baru	2,3,7,9	b,c,f
	17. Pasir Panjang Beach	North of Bintan Isl.	Motor boat	2,3,7,11	g
	18. Dendeng Isl.	Batam	Motor boat from Tanjung Pinang	2,3,6,7,10	b,c
	19. Nongsa Beach	Batam	Ferry from Tanjung Pinang	1,2,7,8,10	f,g

Type of Activity: 1. Beach recreation; 2. Swimming; 3. Diving; 4. Snorkeling; 5. Scuba diving; 6. Water skiing; 7. Fishing; 8. Canoeing; 9. Sailing; 10. Boating; 11. Surfing

Provided Facilities: a. Swimming equipment; b. Canoes; c. Motor boats; d. Diving equipment; e. Water skiing equipment; f. Hotel and restaurant; g. Other

Langkawi is the fastest developing island resort in Peninsular Malaysia, having 12 holiday resorts and 13 hotels with 4,749 rooms (TDC/Malaysia, 1995a, 1995b). These resorts and hotels were built near the coastal beaches around the island.

The positive and negative socioeconomic impacts from tourism development in Pulau Langkawi have been assessed (Bird, 1989; Wong, 1990, 1993):

Positive impacts

- A free port status was granted to the island in 1987 to attract more foreign tourists and Malaysians;
- Improvement of infrastructures in the island were made, particularly in roads and communications. The island is now served by air links to the major tourist generating centers in Malaysia and Singapore; and
- Increased employment opportunities for residents of the island.

Negative impacts

- Instead of cheaper prices from duty-free status, prices of basic necessities have risen since 1987;
- Ferry prices have become more expensive;
- There were various cases of displacement of the local residents from their land without adequate compensation; and
- Except for a few entrepreneurs, the majority of the locals gained little economic benefit except for those in the local chalet development projects.

Several other negative effects on the coastal environment resulting from the unplanned tourism development activities were also evident (Wong, 1990). For instance, the many chalets at Pantai Cenang, Pantai Kok and Pantai Tengah were built without proper sewage treatment and waste disposal facilities. Untreated sewage discharges to the coastal water causing pollution problems. Beach erosion occurred at the Pelangi Resort because the resort was built on a cuspate foreland.

A master plan for the island's tourist development up to the year 2005 was drawn up with the assistance of French experts (Wong, 1990). Proposals and suggestions for improving transportation, accommodation and other tourist facilities were included in the development plan. The introduction of zonation guidelines, the implementation of a setback line and the reservation of public areas and access for certain coastal stretches were also considered in the development plan in order to reduce adverse impacts on the coastal environment.

State of Kedah: Pantai Merdeka (Merdeka Beach). Pantai Merdeka is situated about 60 km south of Alor Setar, the capital of Kedah State. It is a white sandy beach about 1 km long, shaded by tall swaying palms. Water skiing and sailing are the popular tourist activities along the stretch of the coastal water outside the beach (TDC/Malaysia, 1995). There are only three chalets providing basic accommodation facilities.

State of Kedah: Payar, Segantang, Kala and Lembu Islands. This cluster of four islands is located at the northern end of the Malacca Straits, off the Kedah coast. They have been gazetted as marine parks since 1985 (TDC/Malaysia, 1995a, 1995b). The islands, particularly the Payar Island, are noted for their sandy bays, white sandy beaches and colorful coral reefs. The most breathtakingly beautiful coral reefs are found infringing the southern tip of the Payar Island. Waters around the island are so clear that it is possible to see to a depth of 100 feet (TDC/Malaysia, 1995a, 1995b).

Although the islands have high potential for water and reef tourism, the development to date is still preliminary. There are no accommodation facilities for visitors. Tourists can either camp on Payar Island or find accommodation in Langkawi Island in the north or Penang in the south.

State of Penang: Penang Island. Coastal tourism in Penang Island developed much earlier compared to other areas in Peninsular Malaysia. The island is a major tourist destination in Malaysia. The development has been concentrated on the 2.5-km coastal strip called Batu Feringgi, located on the island's northeast coast. Along the coast is a white sand beach, which lies between headland. A short distance inland from the beach, steep, jungle-clad hills rise, leaving limited low-sloping land for development (Smith, 1992). In the early 1960s, there were only fishing villages in Batu Feringgi and a number of second homes of the wealthy and influential residents of Penang and surrounding districts. Tourism expanded in the latter half of 1960s with the arrival of explorer tourists, increasing in numbers through the 1970s. Several hotels of international standard were built to accommodate the increasing numbers of tourists in the mid-1970s. Construction of hotels and other tourist facilities continued through the 1980s and early 1990s. The successive waves of construction

have increased the scale of tourism and transformed Batu Ferringgi physically, environmentally and socially (Smith, 1992).

Today, the Batu Feringgi resort is a major tourism destination in Malaysia, with nearly 3,000 hotel rooms which are mostly first class in quality (TDC/Malaysia, 1995a, 1995b). Yet, many proposals for condominiums and other resort accommodations have been approved by the government and construction of a few of these projects started in 1991. Almost all these projects are sited away from the beach, on the inland side of Batu Feringgi Road.

Environmental aspects

- Marine pollution has increased as resorts have grown. A sewage treatment plant for the resort was constructed in 1990 with funding from the federal government.
- Increased construction of new resorts and commercial facilities destroyed the previously excellent resort ambiance. While the hotels are typically contained within large and well landscaped sites, the expansion of other areas of commerce has resulted in the removal of trees, extension of areas with hard surfaces and the creation of a contrasting mix of architectural forms and colors.
- The quality of the beach has been degraded by activities, such as motorized boat rides, sea pollution and the surface drain of the wastewater treatment plant transecting the beach, severely detracting from its previously natural quality.

Economic aspects

- The construction of hotels and increased tourist activities have created many jobs for both local residents and Malaysians from other parts of the country. By 1989, there were 1,450 hotel jobs at Batu Feringgi, an increase from 50 hotel jobs in 1966.
- Resort expansion has promoted growth of business establishments oriented toward tourism. By 1989, business growth had considerably expanded the original commercial center and established a clearly identifiable center in the north of Batu Feringgi.

Social aspects

- The explorer tourists, locally known as hippies, had a negative impact on the resident community. Some of these visitors used drugs and went naked on the beach (Hong, 1985). While some residents may welcome these visitors for the income, others objected to their presence and the government used late-night raids to deport the visitors.
- The construction of the many hotels along the beachfront has resulted in the demolition and displacement of previously-built structures and resettlement of the predominantly Malay fishing villages away from the beach.
- As the scale of the tourism industry increased, the resident community shifted from dependence on income from fishing to dependence on tourism. By 1991, 49% of the residents of Kampong Batu Feringgi were in the work force and of these, 60.2% were hotel-related occupations, with others being employed in tourism-related jobs.
- The income of the residents has generally increased because of the growth of tourism. The increase in income has also resulted in increased social status for residents.
- The availability of tourism jobs, particularly hotel jobs, has increased the opportunity for women to enter into formal employment as an alternative to their traditional role as housekeepers. Approximately 40% of the full-time hotel staff are women (Smith, 1992).

State of Perak: Pangkor Island. The island is a popular weekend recreational retreat for visitors from mainland Peninsular Malaysia, particularly from the Ipoh area and nearby naval base at Lumut. With the improved ferry services and promotional efforts by hotels, the influx of visitors to Pulau Pangkor has increased in recent years.

Pasir Bogok (Bogok beach) is the main tourist spot on the island, where a number of resorts, hotels and low-cost accommodations were established and frequented by visitors. There are two large hotels and two holiday resorts located along this beach, with a total of 318 rooms (TDC/Malaysia, 1995a). As the beach is narrow and has virtually no backshore, the question of carrying capacity for more hotels or resorts has to be carefully addressed and the development properly planned (Wong, 1990).

The East Coast of Pangkor Island is occupied with several fishing villages, fish processing industries, etc.

Severe littering of solid waste to the coastal water from fishing and fish processing activities on this part of the island not only causes pollution but also affects the aesthetics of the beaches and the surrounding environment. The problem has to be solved if the island is to be developed into a major tourist center.

Pulau Pangkor Laut, a small island neighboring the Pangkor Island, also has potential for tourism development. Resorts exist on its South Coast (Pangkor Laut Resort, 125 rooms) and one each on the South and West Coasts, respectively. There is inadequate water supply on the island and water for the resorts is transported by boat from the main island (Pangkor Island). There is need for a proper water supply, a sewage treatment plant and a garbage disposal system if negative environmental effects are to be avoided (Wong, 1990).

State of Selangor: Pantai Morib (Morib Beach). Located along the coast of Selangor, about 70 to 80 km southeast of Kuala Lumpur, Pantai Morib consists of a long stretch of fine sandy beach, peaceful and tranquil in its relative isolation (TDC/Malaysia, 1995a). Near the beach, there is a 9-hole golf course with a golf club offering a swimming pool, a bar, sauna, jacuzzi and dining facilities. There is a one 20-room hotel offering accommodation to tourists.

Negeri Sembilan: Port Dickson. The 17 km of fine sandy beach stretching from south of the Port Dickson town to Cape Rachado offers a popular recreational retreat for both local and foreign visitors. Rapid tourism development has been evident in recent years. Today, the coastline is fronted by hotels, recreational centers, holiday bungalows, condominiums and other residences (Wong, 1990). There are at least 7 hotels with 122 rooms, three beach resorts with 542 rooms and one resort consisting of 200 holiday bungalows located along the 17-km coastline (TDC/Malaysia, 1995a).

State of Malacca: Tanjung Bidara, Tanjung Kling and Klebang Beach. Tanjung Bidara is located 35 km north of the Malacca town, endowed with beaches of fine white sands on the edge of sparkling blue seas. The blue waters of the cove are ideal for swimming, water skiing and canoeing. There are also several shady spots cozy for picnics. A number of resorts have emerged along the coast, making it a popular seaside haven for foreign and local tourists. Tanjung Kling is situated around 10 km away from the Malacca town. The white sandy beach is set within a coconut palm grove, making it another favorite beach for swimming and picnicking. Klebang Beach is a picturesque stretch of white sands on the edge of blue water ideal for swimming. Along the beach, foodstalls sell a variety of local fare (TDC/Malaysia, 1995a).

State of Malacca: Pulau Besar. Pulau Besar or Big Island is located around 3 nautical miles off the coast of Pengkalan Pernu at Umbai, 10 km south of the Malacca town. The island offers fresh air, sandy beaches, tranquility and unspoiled natural beauty for relaxation. It is believed that the island is the location of Malaysia's earliest civilization and abounds with intriguing legends and sacred graves and shrines (TDC/Malaysia, 1995a). There is an island with beach chalets, a yacht club and a host of sea-based sporting facilities. The island is ideal for swimming, sport fishing, snorkeling, camping and picnicking.

Singapore

Several holiday resort areas were developed along the coast of the Singapore Island and on a nearshore island (Sentosa Island) for locals and foreign tourists. These include the East Coast, Changi, Pasir Ris-Loyang and Sentosa Island resort areas.

East Coast resort area. This resort area was built on reclaimed land along the southeast coast of the Singapore island. A series of breakwaters were constructed at the seafront to protect the reclaimed land (Wong, 1991). The breakwaters acted as headlands between which sandy bays were formed; holiday chalets were built on three such bays within the East Coast Park. A typical transect from the chalets to the beach shows the following main components: chalets, bicycle path, footpath, barbecue pits, seawall, backshore and foreshore.

Changi resort area. This resort area stretches from the mouth of Sungei Selarang to the mouth of Sungei Changi and is dominated by four low hills (Wong, 1991b). Seawalls were built to protect the coast and the beaches are restricted mainly by the bays and a low straight stretch at the Changi Sailing Club. A hotel and several holiday accommodations were built within this resort area.

Pasir Ris-Loyang resort area. This resort area was built on reclaimed land protected by a series of riprap breakwaters which have given rise to three bays west of Sungei Tampines and five bays between Sungei Tampines and Sungei Loyang (Wong, 1991b). Holiday chalets were built within this resort area mainly for local residents.

Sentosa Island. Sentosa Island or "Island of Peace and Tranquillity" is the best developed tourist resort area popularly visited by locals and foreign tourists. In 1983, the number of visitors was recorded to be 1.9 million, of which 75% were local visitors and 25%, foreigners (Chia et al., 1988). The island lies about half a kilometer to the south of the Singapore Island, measures 4.15 km long and 1 km wide and covers 335 ha in area. Recently, a beach hotel of international standard was added to the many other tourist facilities on the island.

Growth Triangles

The potential strength of ASEAN's economy in the future will be enhanced if the economies of its member states can be made complementary instead of being competitive. The idea has been put into practice in the development of growth triangles in the southern and northern entrances of the Straits of Malacca (*Figures 3.24* and *3.25*). It is recognized that Singapore and Malaysia are relatively advanced in financial, technological communication and marketing infrastructure and expertise, while Indonesia and Thailand can provide abundant work force, with lower wage rates, ample land areas and rich natural resources. The growth triangle offers a unique mix of resources and infrastructures, labor and skills and product marketing opportunities.

SIJORI growth triangle

The growth triangles in the southeastern entrance of the Straits of Malacca links Singapore, the State of Johor and the Riau Province. It has the acronym SIJORI. Originally, activities within the first growth triangle were concentrated on Batam Island, in Riau Province, a group of islands located 20 km southeast of Singapore. Batam is being developed as an industrial estate. Foreign investments have risen from US$65 million in 1988 to US$300 million in 1990. In the same period, exports rose from US$44 million to US$150 million.

There are two side effects of the development. The positive one in the increasing number of domestic and foreign tourists visiting Batam *(Figure 3.26)*. In terms of numbers, Batam has surpassed Medan as tourists destination and is second only to Bali. The foreign tourist mostly Singaporean and Malaysian, are lured to Batam for tax free shopping, cheaper eating places and good recreation beaches. Due to this unexpected increase of tourism in Batam, the Riau Provincial government now is embarking on a major tourist resort development in other islands around Batam, including Bintan. The latest records show that Batam has earned US$3.7 billion per year from tourism and exports. Out of the total investment of US$3.8 billion in Batam up to 1993, US$3.1 billion (82.08%) came from the private sector and US$681.4 million (17.2%) was from the government. The private sector investments were 34.8% foreign and 65.2% domestic. From the activities, the investments consisted of 49.47% in industries, 16.76% in tourism, 17.76% in real estate, 12.13% in services, 2.86% in agro-business and 0.86% in commercial sectors (Habibie, 1993).

The negative side effect of the Batam development is the rapid population growth. In the 1970s, the population was only about 6,000 people; it rose to 95,000 in 1990 and in mid-1995 the official number was more than 198,000 people (*Figure 3.27*). Batam

Figure 3.24. The Two Growth Triangles in the Malacca Straits (Bakrie, 1995).



Figure 3.25. Map of Batam Island in Relation to Singapore, Johor and Bintan (BIDA, 1996).

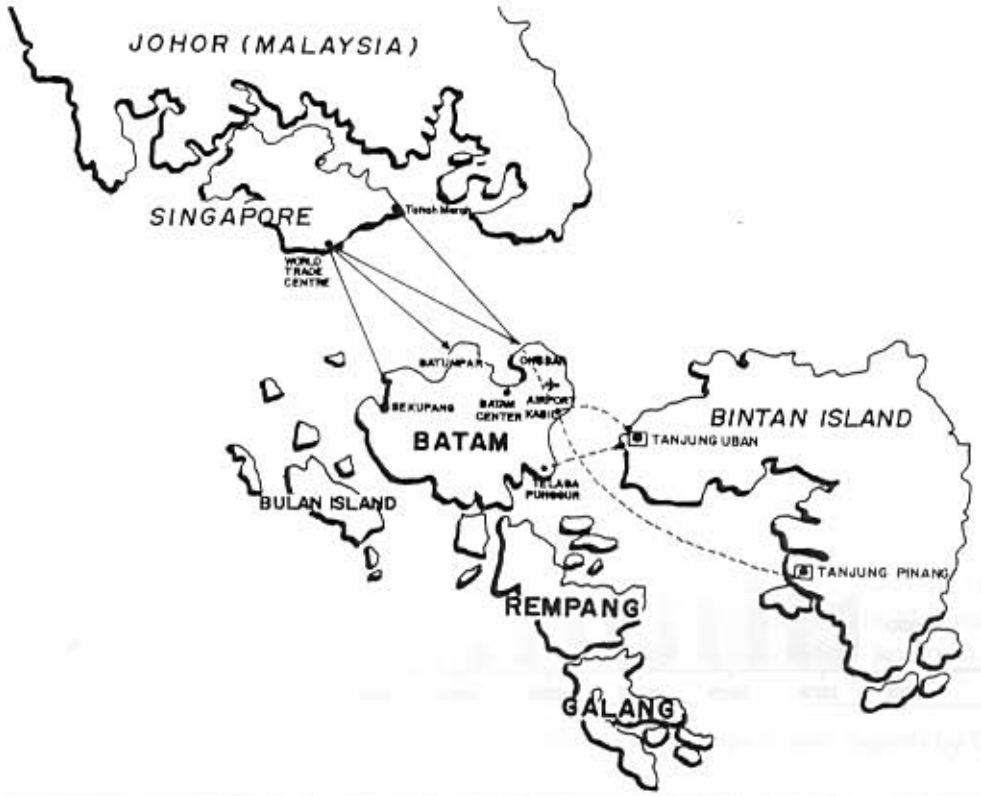


Figure 3.26. Number of Overseas Tourists to Batam, 1985-1995 (BARELANG, 1995).

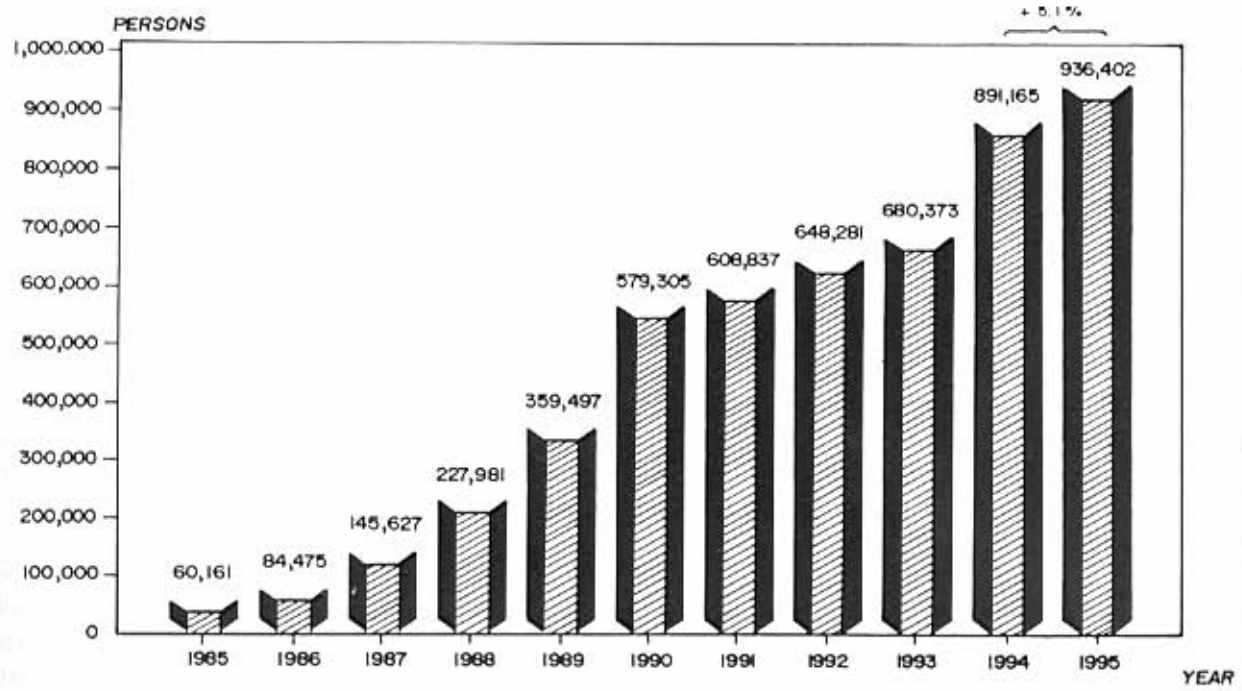
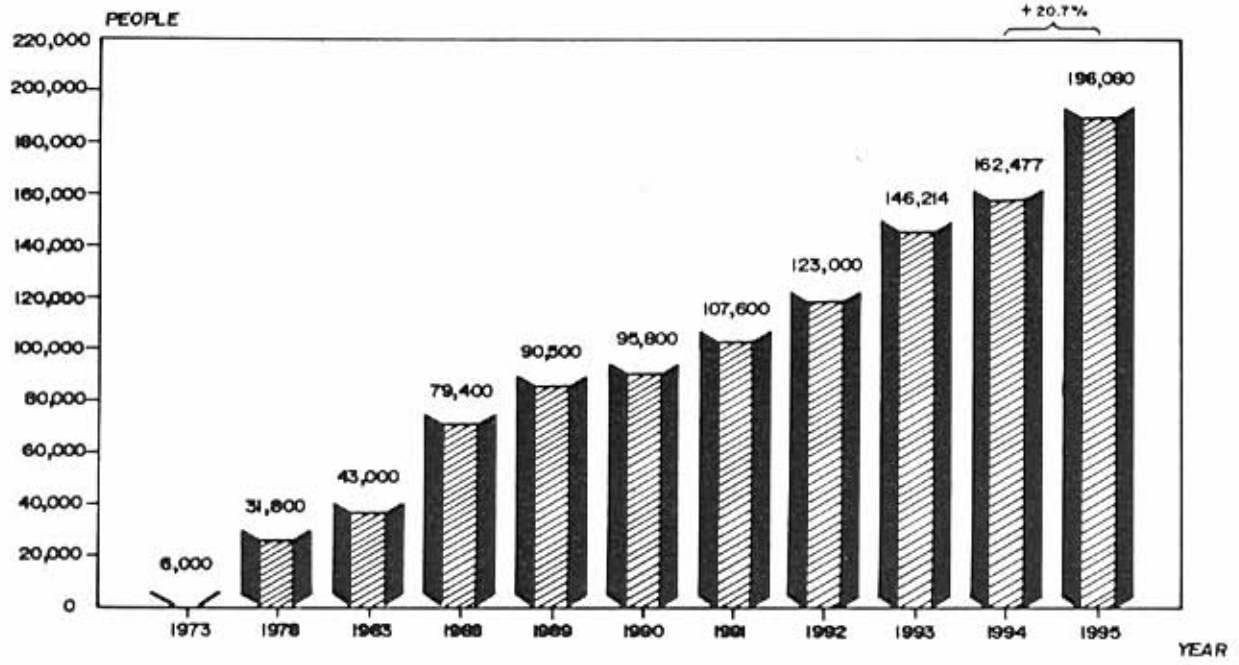


Figure 3.27. Population Growth in Batam, 1973-1995.



is growing at the rate of 19% yearly. The actual numbers are much higher, probably almost double the official records due to high numbers of illegal job seeking migrants from other parts of Indonesia. The official projected population is 700,000 by the year 2006. Housing, water supply, schools hospitals, public transportation, roads and communications are some of the challenges confronting the Batam Authority.

Apart from settling new migrant workers and catering to the needs of overseas and Indonesian companies to set up factories or tourism projects, the Batam Island Development Authority is working on various multi-million dollar development projects, such as a second runway and new terminal at the Hang Nadin Airport; a new cargo terminal; a 16,000 TEU-capacity container port terminal at Kabil; additional water supply dams; and six BARELANG bridges, connecting Batam Island with its neighboring islands of Setokoh, Rempang, Galang and Galang Baru.

IMT growth triangle

The second growth triangle is being developed in the northern entrance of the Malacca Strait, linking Aceh and North Sumatra Provinces of Indonesia with the five provinces of southern Thailand and four northern states of Malaysia. It is called the IMT (Indonesia-Malaysia-Thailand Growth Triangle) Development Cooperation. The combined population of the area exceeds 20 million, with economic output in 1988 of US$12.4 billion (Bakrie, 1995). The growth triangle originally was planned to link the tourist resort areas in the southwest of Thailand (e.g., Phuket and Suratani), northwest coast of Malaysia (Penang and Langkawi Island) and those in North Sumatra (Toba Lake and surroundings). However, in the latest development plan, it was officially agreed to expand the cooperation into a truly regional growth center, including agro-industries, industrial estates, tourist resorts, expanding port facilities for cargo, ferries and fisheries. The new development has assisted the Medan municipality to be the center of Development Area III in North Sumatra and the main Development Area A nationally (Sekretariat Wilayah/Daerah Propinsi Sumatra Utara, 1995).

The development of the growth triangles at both entrances of the Malacca Straits will generate heavier shipping traffic, both for cargo and trade and ferries, among the ports of the cooperating coastal states. Economically, they are very beneficial, but at the same time they will create more congestion and, in turn, increase the pollution risk.

Chapter 4

MARITIME TRADE AND DEVELOPMENT

The economies of the East Asian countries are growing rapidly. The combined value of gross domestic products (GDPs)/gross national products (GNPs) of the East Asian region is already around 70% of the European total (Swinnerton, 1994). The imports into East Asia have a combined value 20% greater than those in North America (Swinnerton, 1994). Volumes and values of cargo traded in the East Asian Region have grown as well, as shown in ***Tables 4.1*** and ***4.2***.

It is evident that the total volume of cargo loaded in the region is significantly lower than the volume unloaded. The values of the imports and exports are similar, reflecting the raw materials that are being shipped into the region.

For centuries, the Malacca Straits has been an important route for local and international maritime trade and traffic. It has been the center of international trade in the region since the 15th century when it was controlled by the Port Kingdom of Malacca. During the 17th and 18th centuries, the trade in the Malacca Straits was under the control of the Dutch East India Company (Ross et al., 1995). The importance of the Straits as a major trade route was further increased with the opening of the Suez Canal in 1869 when the dominant trade route between Europe and the Far East shifted from the Cape Town-Sunda Strait route to the Suez-Malacca Strait route (Naidu, 1994).

The Straits is the main sea route connecting the Indian Ocean with the South China Sea and the Pacific Ocean and it is also the shortest route for tankers trading between the Persian Gulf and the East Asian countries. This makes it a key trade route to the world's trading nations, providing a channel for the flow of global economy. The Straits is vital to the trade and economy of the bordering states. For instance, Naidu (1993) showed that about 75% of Malaysia's national trade volume passes through the Malacca Straits. The trade along the Straits has led to the development of ports and urban areas. The major Indonesian oil exporting port of Dumai, the trade port of Belawan and the main ports of Malaysia are located on the Straits. Singapore's position as a major

Table 4.1. Values (in million US$) of Imports and Exports by East Asian Countries (Swinnerton, 1994).

Country	Imports			Exports		
	1970	1980	1990	1970	1980	1990
China	2,330	20,020	45,586	2,260	18,120	62,091
Hong Kong	2,905	22,438	82,496	2,514	19,743	82,160
Indonesia	1,002	10,834	21,837	1,108	23,950	25,675
Japan	18,883	140,524	234,800	19,319	129,812	286,949
Korea (South)	1,984	22,292	69,844	835	17,505	65,016
Malaysia	1,412	10,779	29,261	1,686	12,945	29,419
Philippines	1,286	8,295	13,042	1,142	5,788	8,186
Singapore	2,584	24,769	63,826	1,554	19,379	52,729
Thailand	1,299	9,213	33,379	710	6,505	23,068
Total	**33,685**	**269,164**	**594,071**	**31,128**	**253,744**	**635,293**

Table 4.2. Volume (in thousand tonnes) of Marine Transported Goods Unloaded and Loaded (Swinnerton, 1994).

Country	Loaded		Unloaded	
	1986	1989	1986	1989
China	69,564	85,350	71,136	76,184
Hong Kong	17,000	17,436	42,984	45,486
Indonesia	91,581	90,000	16,741	16,510
Japan	87,600	81,600	597,936	703,174
Korea (South)	34,263	59,369	109,516	140,369
Malaysia	50,434	62,217	24,227	29,122
Philippines	11,796	15,820	16,011	23,673
Singapore	46,708	61,870	67,116	93,316
Thailand	17,937	28,437	18,007	29,059
Total	**426,883**	**502,099**	**963,674**	**1,156,893**

bunkering and transshipment port depends on traffic through the Straits.

This rapid increase in economic growth has resulted in a substantial increase in maritime trade. Although the ASEAN countries have experienced high export growth rates over the past decade, the majority of trade has been outside the ASEAN region. Intra-ASEAN trade, which is dominated by Singapore, increased from 12.8% of total world trade in 1970 to 19.3% in 1991 and the trend towards increasing trade within the region is likely to continue.

In 1994, Japan, the USA, Singapore, the Republic of Korea, Germany, Taiwan and the People's Republic of China were the seven major trading partners of Indonesia. Singapore was the third largest buyer of Indonesia's exports after Japan and the USA. Indonesia's trade with Singapore reached a little over US$6 billion in 1994.

Indonesia

Nationally, the trend in exports and imports during the past eleven years showed that Indonesian exports steadily increased from nearly US$21.9 billion in 1984 to US$40 billion in 1994, with an average 8.3% annual growth. National imports also increased from US$13.9 billion in 1984 to US$19.9 billion in 1994, a 13% annual growth. The increase was mainly due to the import of raw materials (Biro Pusat Statistik, 1994a).

Exports from Indonesia to other ASEAN countries generally show a positive trend with an increase of 20.2% or US$0.96 billion in 1994. This is mostly due to increased demands from Singapore, which rose from nearly US$3.4 billion to US$4.15 billion or 23.1%. Exports to Malaysia increased 26.0% for fixed vegetable fat and oil and iron and steel products with a value of US$1.4 million and US$24.5 million, respectively (Biro Pusat Statistik, 1994a). ***Table 4.3*** shows the Indonesian exports to Malaysia and Singapore in 1993 and 1994.

Among the ASEAN countries, imports from Singapore were the largest (64.11%) with a value of almost US$1.88 billion, Malaysia was the second with a share of 19.77% (Biro Pusat Statistik, 1994b). The value of imports from Malaysia and Singapore is presented in ***Table 4.4***. Data for exports to and imports from Malaysia are not readily available.

In general, for Indonesia the trend of the interregional trades is on the increase. It is projected that the increase will be enhanced further, when the two economic "growth triangles" have been fully developed. Also, with regard to future maritime trade and development it is important to note that since the 1980s Indonesia's economic structure has been changing from agriculture to industrial based (***Table 4.5***). This change will continue further in the 21st century. By the first part of the 21st century, Indonesia will shift from being a net exporter to a net importer of oils. Indonesia will still export natural gases, in particular from the Natuna natural gas fields.

The major economic sectors that contribute to the GDP in 1995 were the industrial sector (US$41 billion), commerce and trade (US$29 billion), agriculture, forestry and fisheries (US$28 billion) and oil, gas and mining (US$16 billion). These sectors are the main users of sea transportation services. Currently, about 90% of export-import cargoes are transported by ships (Soentoro, 1996).

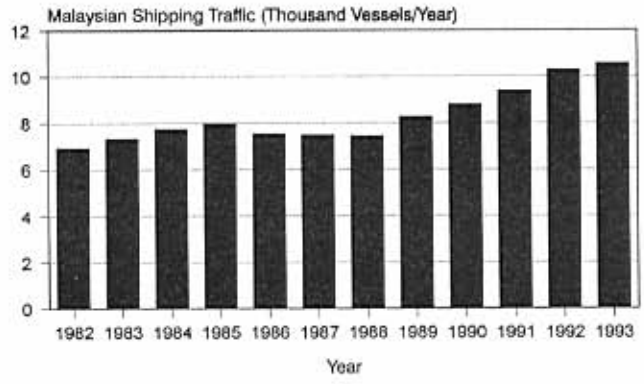
Although the time frame may be different, these changes will also be experienced in Sumatra. For example, in 1990, the value of Batam exports (mostly industrial and manufactured products) was only 30% of Riau Province exports (dominated by agriculture and forestry products). By 1995, the situation had reversed. The export from Batam was over 70% of the overall Riau Province exports. This trend will

Table 4.3. Indonesian Exports to Malaysia and Singapore, Their Change, Growth and Contribution to Total National Export Value, 1993-1994 (Biro Pusat Statistik, 1994a.)

Destination	1993		1994		Value Change (US$ million)	Growth (%)	Contribution (%)
	Volume (000 tonnes)	Value (US$ million)	Volume (000 tonnes)	Value (US$ million)			
Malaysia	2,566.4	586.0	2,494.1	738.5	152.5	26.0	1.8
Singapore	61,258.6	3,372.0	94,764.1	4,149.7	777.7	23.1	10.4
Total National Export	—	36,823.0	—	40,053.4	3,230.4	8.8	100.0

Sumatra-Southern Thailand) and the Southern Growth Triangle (Singapore-Johore-Riau) has generated and will continue to generate more cross-Straits traffic. The cross-Straits traffic between Riau and Singapore increased to about 28% of the total traffic in 1992, from less than 10% five years earlier (Lee, 1993 cited by Lee, 1994). The increasing cross-Straits traffic makes the shipping traffic in the Straits more complex and more difficult to manage, contributing to maritime casualties (Lee, 1994; Kamaruzaman, 1995).

Figure 4.2. Shipping Traffic Generated by Peninsular Malaysia (Lee, 1994; Naidu, 1997).



The realization of the ASEAN Free Trade Area (AFTA) by the year 2008 is expected to further enhance the growth of trade in this region. The increased trade flow has several implications. First, it will add traffic to the already busy Straits. Second, this will increase the probability of mishaps and pollution of the marine environment. Third, there is an urgent need for the littoral States to take appropriate measures to prevent and minimize accidents and also to design appropriate compensation schemes (Chin, 1993).

The shipping traffic generated by Peninsular Malaysia has also risen from 6,916 vessels in 1982 to 10,540 vessels in 1993 (*Figure 4.2*) constituting nearly 11% the total traffic passing through the Straits (*Table 4.6*).

Figure 4.3 shows the proportions of the types of vessels passing through the Malacca Straits during 1987-1993. About 70% of the total traffic is generated by general cargo vessels and tankers and approximately 16% of the traffic is generated by container ships.

Alternative shipping routes

Ships passing through the Malacca Straits have the option of taking alternative routes through the Lombok-Makassar and through the Sunda Straits (see *Figure 4.4*).

Fully-laden eastbound tankers over 200,000 dwt are compelled to use the Lombok-Makassar Straits because they cannot fulfill the 3.5 m underkeel clearance (UKC) requirement for the Malacca Straits; the return voyage of even the largest ultra large crude carriers (ULCCs) in ballast can be done through the Malacca Straits. It has been estimated that 72% of

Table 4.6. Total Shipping Traffic Passing Through the Malacca Straits (Naidu, 1997).

Year	Number of Ships
1982	43,633
1983	43,748
1984	41,982
1985	43,837
1986	48,866
1987	51,072
1988	53,826
1989	58,924
1990	72,416
1991	84,414
1992	91,826
1993	99,888

Figure 4.3. Percentage of Shipping Traffic in the Straits of Malacca by Type of Vessel (Naidu, 1994).

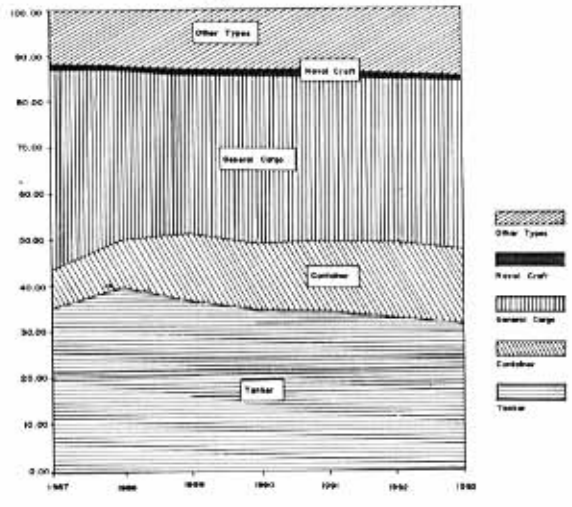


Figure 4.4. Alternative Routes for Ships Transiting the Indian Ocean and South China Sea (Chia, 1995).



eastbound loaded tankers use the Malacca Straits, whilst 21% of the tankers use the Lombok-Makassar Straits. In terms of tonnage, the volume of oil transported through the two Straits is similar, i.e., 52% of the total volume of oil transported eastwards is via the Malacca Straits and 48% of volume of oil is transported via the Lombok Straits. This route is also used by ore carriers from western Australia.

Both the Lombok-Makassar and the Sunda Straits are longer routes than the Malacca Straits route. A typical voyage of a vessel from an Arabian Gulf port (Rastanurah) to Japan (Yokohama) is 6,590 nautical miles via the Malacca Straits and 7,580 nautical miles via the Lombok-Makassar Straits. Assuming that the vessel is moving at 15 knots, then via the Lombok-Makassar Straits is three days longer than the route via the Malacca Straits. The Sunda Strait route is approximately 500 nautical miles or 1.5 days longer than the route through the Malacca Straits.

Various analyses have been done on the economic feasibility of using these alternative routes. In general, for most vessels plying between the Indian and Pacific Oceans, the Straits of Malacca are the least costly and the most preferred route. An analysis by the shipping industry has examined the additional costs/benefits of using Lombok-Makassar Straits as opposed to the use of the Malacca Straits for different vessel sizes. This calculation is based on the assumption that it takes an additional 3.5 days at a speed of 14 to 16 knots to transit the Lombok-Makassar Straits than the Malacca Straits (*Table 4.7*).

Poor tanker markets have plagued operators since the beginning of 1980s, therefore, it is unlikely that tankers currently using the Malacca Straits will use the alternative Straits routes. The option of transporting goods over land appears to be uneconomical at this time. The Malacca Straits is preferred over the alternative routes not only because it is a shorter and thus more economical route. Another determining factor is that it offers good support facilities as well as cheap bunker rates in Singapore.

Petroleum industry use of the Straits

On the average, about 35% of the vessels passing through the Malacca Straits are oil tankers. The number of tankers estimated to have used the Straits from 1987 to 1993 is shown in *Table 4.8*.

The age of tankers started with the building of the first modern tanker, the 2,704-ton *Gluckauf*, in 1886. By the end of the 19th century, the average size of a tanker was 8,000 dwt and by the mid-1940s the largest tanker was 23,815 dwt. The use of very large crude carriers (VLCCs) started, following the closure of the Suez Canal in 1956, when the sea voyage from the Persian Gulf was increased due to ships being required to

Table 4.7. Additional Costs (in thousand US$) of Oil Tankers Using the Lombok-Makassar Straits as an Alternative Route to the Malacca Straits (Naidu, 1993, 1994).

Parameters	Vessel Size (dwt)			
	80,000	150,000	250,000	300,000
3.5 days vessel cost[1]	60	84	104	125
3.5 days additional fuel cost	20	30	56	60
Total additional operating cost[2]	80	114	160	185
Deadfreight gained[3]	0	0	76	235
Net additional cost	80	114	84	50

These figures are indicative figures only since large fluctuations in the parameters occur.
[1] Based on demurrage value which represents the additional expenditure incurred as a result of the extra days taken to sail via the Lombok-Makassar Straits as opposed to the shorter route via the Malacca Straits.
[2] Total additional operating cost minus additional fuel cost.
[3] Tankers transiting the Malacca Straits are limited by the maximum depth. Tankers > 220,000 dwt (approximate) are able to gain additional deadfreight (capacity) when using the Lombok-Makassar Straits.

Table 4.8. Estimated Number of Oil Tankers Passing through the Malacca Straits, 1987-1993 (Naidu, 1993).

Year	No. of Tankers Passing Through the Straits
1987	18,130
1988	21,530
1989	21,979
1990	25,780
1991	29,798
1992	31,496
1993	32,863

pass around the Cape of Good Hope. The era of cheap oil came to a halt with the first oil crisis in 1973 to 1974, followed by a second crisis in 1979 to 1980. A significant development was the widening in the ownership of the tankers, from being solely owned by the oil companies to ownership by the oil producing and consumer countries. The trend toward increasing the size to ultra large crude carrier (ULCC)-class tankers also came to a halt. ***Table 4.9*** shows the tankers and their sizes and ages that belong to the ASEAN and other Asian countries in 1992.

Today the preferred VLCCs are around 280,000 dwt in size. Combination carriers account for about 10% of the oil carrying fleet. Product tankers are typically 10 to 50,000 dwt carrying refined oil products over shorter distances. The most complex tankers are the chemical parcel tankers. These can be highly sophisticated and expensive with sizes between 20,000 and 80,000 dwt, typically double-hulled and with as many as 60 separate cargo tanks, each with its own pumping system.

The rapid industrial and economic development of Japan, the People's Republic of China and the newly developing economies of South Korea, Taiwan and Hong Kong means that these countries are highly dependent on oil as their major source of energy. The pattern of distribution of the world's deposits of petroleum and economic development is such that much of the oil consumed in the Southeast Asian region comes from the Middle East.

Information from the Asia-Pacific Economic Cooperation (APEC) revealed that China's external oil requirements will rise

Table 4.9. Tankers Belonging to the ASEAN and Other Asian Countries in 1992 (Lloyds Registry of Shipping, Statistical Tables, 1992).

Flag State	Number	Size ($x10^3$ gross tonnes)	Age (years)
ASEAN Countries			
Brunei	1	0.2	2
Indonesia[2]	205	594.0	19
Malaysia [2,3]	71	256.2	16
Philippines [2,3]	103	387.6	20
Singapore [3]	294	4,821.0	14
Thailand	100	172.3	22
Subtotal	**774**	**5,592.3**	-
China, PR	258	1,720.3	15
China (Taiwan)	23	969.3	9
Japan	1,062	7,166.6	10
Hong Kong[1]	43	880.1	16
Korea, South	90	612.4	19
Vietnam	13	15.2	18
World	6,342	138,148.8	16
ASEAN as % of world total	12.20	4.05	

[1] The territory of Hong Kong's fleet has been largely flagged out to other national registries
[2] Own substantial tonnage primarily to meet domestic shipping needs
[3] Engaged in carriage of third-party crude oil cargo.

from 600,000 bbl per day to over one million by the year 2000, nearly three million by 2010 and seven million by 2015.

Japan, South Korea and Taiwan are major oil refiners which rely on the import of crude oil for their refineries, mainly from the Middle East. On the other hand, Vietnam and Hong Kong have no refining capability and they, therefore, depend entirely on imported products to meet their needs. ***Table 4.10*** shows the total volume of oil imported to Japan.

Table 4.10. Quantities of Petroleum Oil Imported by Japan from the Middle East, African Continent and Southeast Asian Countries (Robinson, 1994; Chia, 1995).

Year	Oil Imported from the Middle East and the African Continent (million tonnes)	Oil Imported from Southeast Asian Countries (million tonnes)
1988	129.0	-
1989	143.1	-
1990	157.7	-
1991	168.3	44.7

Although Japan has increased her share of energy from nuclear power, the total quantity of oil imported continues to increase. As long as crude oil remains relatively cheap, Japan will continue to rely heavily on this source of energy and her dependence on the Straits of Malacca as a transport route will continue. The pattern for South Korea and Taiwan is expected to be similar to that of Japan. Approximately 80 to 90% of all the oil imported by Japan passes through the Straits (i.e., nearly 200 million tonnes) (Ouchi, 1994). Most of the oil imports by South Korea and Taiwan also move through the Straits.

Demands for oil by countries in the Asia-Pacific region for the next decade is expected to further increase from 14.2 million barrels per day (bpd) to 21.6 million bpd in the year 2005 (***Table 4.11***). Japan, China and South Korea will be leading in the oil demands to the year 2005.

Figure 4.5 shows the transport of crude oil in the Southeast Asian Seas region. ***Table 4.12*** shows the global movement of oil in 1995. It has been estimated that about 7 million barrels of oil is transported daily from the Northern Indian Ocean through the Malacca Straits to the South China Sea and the Pacific Ocean. ***Table 4.13*** provides the petroleum trade along the Malacca Straits as compared with alternative shipping routes in Asia. The Malacca Straits still assumes an important role in the petroleum trade in this region.

The bordering States also contribute to the movement of oil along the Malacca Straits. Petroleum products including oil are shipped from the fields or

Table 4.11. Outlook for Oil Demands in the Asia-Pacific Region (thousand barrels per day) (Skrebowski, 1995).

Country	1993	2000	2005	Average Annual Growth Rate (%) 2000/1993	Average Annual Growth Rate (%) 2005/2000	Average Annual Growth Rate (%) 2005/1993
Japan	4,822	5,086	5,188	0.8	0.4	0.6
South Korea	1,552	2,217	2,740	5.2	4.3	4.8
Taiwan	570	701	814	3.0	3.0	3.0
China	2,743	4,031	5,001	5.7	4.4	5.1
Hong Kong	174	213	236	2.9	2.1	2.6
Singapore	472	640	699	4.4	1.8	3.3
Indonesia	756	1,170	1,556	6.4	5.9	6.2
Malaysia	290	414	522	5.2	4.7	5.0
Thailand	517	839	1,096	7.2	5.5	6.5
Philippines	253	367	466	5.4	4.9	5.2
Australia	672	776	845	2.1	1.7	1.9
New Zealand	102	115	122	1.7	1.1	1.5
India	1,273	1,902	2,346	5.9	4.3	5.2
Asia-Pacific	14,197	18,469	21,630	3.8	3.2	3.6

Figure 4.5. Shipping Routes for the Transport of Crude Oil in Southeast Asia (Morgan and Valencia, 1983).

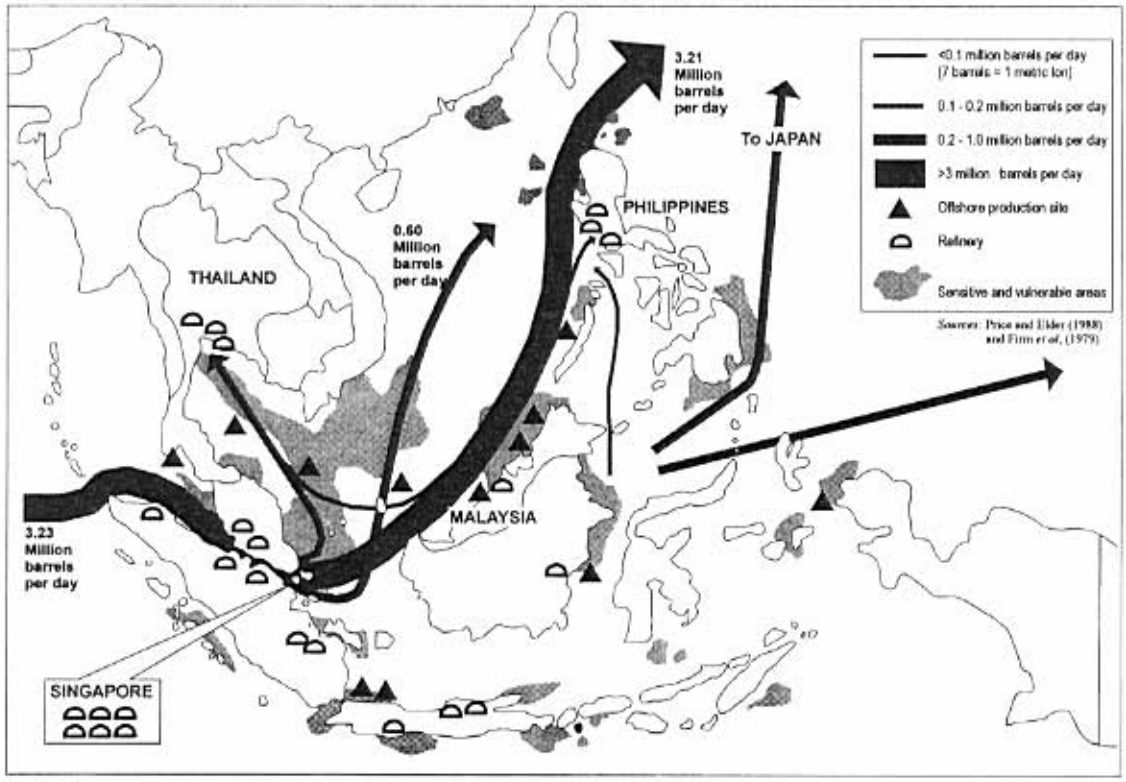


Table 4.12. Global Movement of Oil in 1995 (International Petroleum Encyclopedia, 1995).

Tanker Route	Amount of Oil Moved (barrels/day)	Percentage of Global Oil Consumption
Straits of Hormuz	14,000,000	21.21
Malacca Straits	7,000,000	10.61
Bosporus Strait	1,600,000	2.42
Suez Canal	900,000	1.36
Rotterdam Harbour	600,000	0.91
Panama Canal	500,000	0.76
Other routes	41,400,000	62.73
Global Total	66,000,000	100.00

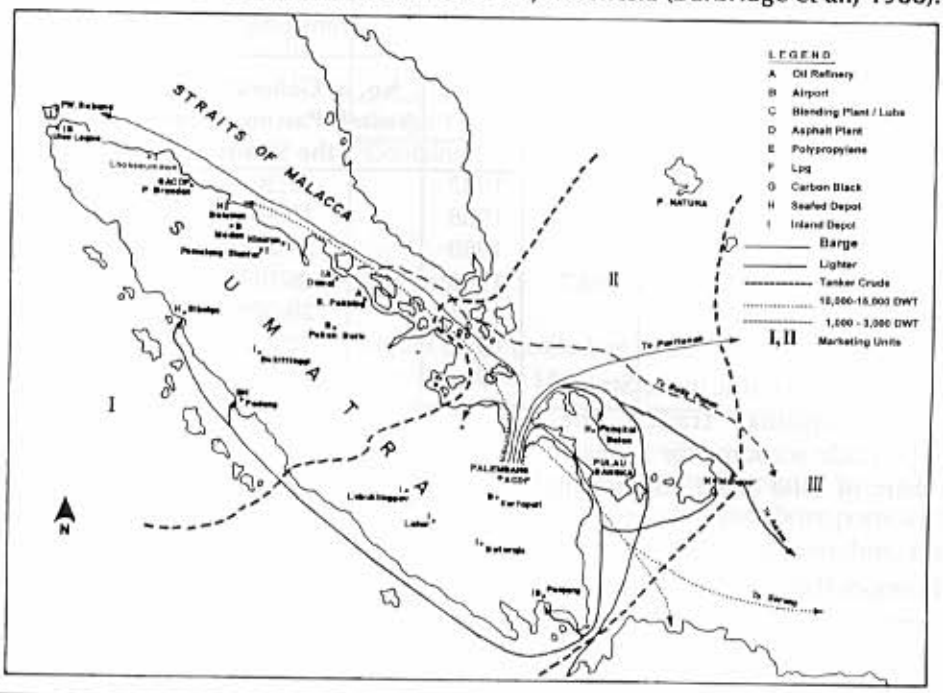
refineries in Northern Sumatra, mainly to Japan and the Republic of Korea. The two countries account for over 90% of export earnings (*Figure 4.6*). Exports from Northern Sumatra of Indonesia are dominated by oil and gas products from the Province of Aceh. Oil and gas exports account for over 94% of exports from Aceh.

Trade of liquefied natural gas (LNG). Reports by the Institute of

Table 4.13. Quantities (in million tonnes) of Petroleum Trade Passing through the Malacca Straits Compared to Other Alternative Routes in Asia (Chia, 1995).

Region	All Asian Straits		Malacca Straits		Lombok-Makassar Straits	
	Exports	Imports	Exports	Imports	Exports	Imports
Pacific US	0.044	138.2	0.023	71.9	0.021	66.3
Eastern Asia	61.0	4,375.6	31.7	2,275.3	29.3	2,100.3
Indian Ocean	4,309.4	2.3	2,240.9	1.2	2,068.5	1.1
Africa	29.4	5.6	15.3	2.9	14.1	2.7
Mediterranean	37.0	6.3	19.2	3.3	17.8	3.0
Atlantic Europe	0.035	6.3	0.028	3.3	0.016	3.0
Atlantic America	0	40.5	0	21.1	0	19.4
Total	4,436.88	4,574.8	2,307.15	2,379.0	2,129.74	2,195.8

Figure 4.6. Distribution of Petroleum Products in Sumatra, Indonesia (Burbridge et al., 1988).

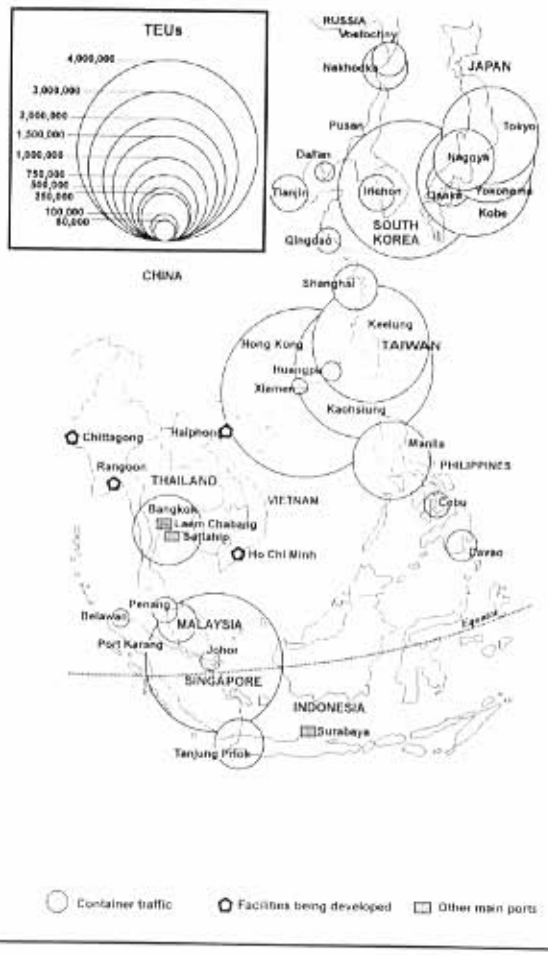


Energy Economics, Japan indicated that Indonesia is the world's leader in the export of liquefied natural gas (LNG). In 1993, Indonesia had a 38.4% share of the LNG traded internationally and exported more than 23.1 million tonnes of LNG, compared with 22.9 million tonnes in the previous year. Majority of LNG produced in the fields in the Malacca Straits is shipped to Japan. LNG is transported in a highly compressed state in specialized tankers. The transportability of LNG is the key to its growing use. Rapidly developing economies in the Pacific rim (Taiwan, Hong Kong, China and South Korea) rely on the transport of LNG in tankers. The traffic of LNG tankers in the Malacca Straits can be expected to increase in the future as an increasing number of countries favor the use of LNG as a source of energy. The Middle East has 30% of the world gas reserves (1.3 quadrillion cubic feet) and it is expected that this region will, in the future, become a center for LNG production.

Shipping of cargo through the Straits

In 1993, the world's twenty largest container ports handled an estimated 58 million ten-foot equivalent units (TEUS). Of this figure, 58% or 34 million TEUs (or 370 to 520 million tons) were handled by nine ports, all of which were clustered within the shipping corridor between Singapore and Japan (*Figure 4.7*). This demonstrates the high concentration of cargo traffic in the Southeast Asian region. Majority of cargo

Figure 4.7. Container Concentrations in East and South Asian Ports (Robinson, 1997).



handled in the region's ports result from imports and exports outside the region, a substantial part of which passes through the Straits.

It has been estimated that, on the average, about 36.75% of the vessels passing through the Straits are general cargo vessels and 13.61% are container vessels. ***Table 4.14*** shows the number of general cargo vessels and container vessels estimated to have used the Straits in 1987 to 1993.

Table 4.14. General Cargo and Container Vessels Transiting the Malacca Straits (Naidu, 1993).

Year	No. of General Cargo Vessels Passing through the Straits	No. of Container Vessels Passing through the Straits
1987	22,267	4,188
1988	19,808	5,544
1989	20,211	8,544
1990	26287	10,283
1991	29,629	12,915
1992	32,231	15,059
1993	36,060	16,382

A vast majority of cargo traffic in the Straits results from extraregional trade. The intraregional cargo trade accounts for a small, but increasing share of total cargo flow through the Straits.

There are no exact data on the amount of cargo transported through the Straits. However, data on the cargo handled by the major ports in the region and the origin and destination of the cargo give some indication of the amount and type of cargo trade through the Straits.

In 1993, the Port of Singapore handled 150.2 million tonnes of general and dry bulk cargo of which 126.2 million tonnes or 84% was containerized cargo. It has been estimated that 40% of container vessels arriving in the Port of Singapore transit the Straits eastbound (Robinson, 1994). Assuming that all the container vessels transported the same amount of cargo, it can be said that roughly 50.48 million tonnes of containerized cargo handled by the Port of Singapore passed through the Straits in 1993. In 1992, the Port of Singapore handled 7.56 million TEUs at an annual growth rate of around 10% (Swinnerton, 1994). Hong Kong handled 7.97 million TEUs in 1992 and the projected annual growth rate is 1 million TEUs (Swinnerton, 1994; ***Table 4.15***). Average growth of the container throughputs for the ports along the Malacca Straits was around 19.2% compared to around 23.5% for all the Asia-Pacific ports. Ports along the Malacca Straits handled around 7,411 TEUs in 1991 and 8,784 TEUs in 1992

Table 4.15. Container Throughputs (in thousand TEUs) for Asian and Pacific Rim Ports, 1991-1992 (Maritime Asia, June 1993).

Ports	1991	1992	% Change
Ports along the Malacca Straits			
Singapore	6,354.0	7,560.0	18.9
Johor	97.0	120.01	23.8
Klang	603.3	672.7	11.5
Penang	251.8	303.4	20.4
Belawan	105.6	128.2	21.4
Total for Ports in the Malacca Straits	7,411.7	8,784.3	19.2 (ave.)
Other Asia-Pacific Ports			
Hong Kong	6,161.9	7,972.0	29.4
Kaohsiung	3,913.1	3,960.5	1.2
Pusan	2,694.1	2,859.91	6.1
Kobe	2,635.4	2,595.0	-1.5
Los Angeles	2,038.4	2,289.0	12.3
Keelung	1,395.9	1,950.01	39.6
Yokohama	1,796.4	1,886.8	5.0
Long Beach	1,767.8	1,829.5	3.5
Tokyo	1,783.9	1,467.9	-17.7
Bangkok	1,170.7	1,303.3	11.3
Oakland	1.139.8	1,232.1	8.0
Seattle	1,154.9	1,151.0	-0.3
Nagoya	1,001.1	1,098.0	9.6
Manila	1,070.0	1,075.11	0.5
Tacoma	1,020.7	1,054.5	3.3
Tanjung Priok	621.6	815.7	31.0
Shanghai	576.01	760.01	32.0
Shekou	50.01	110.01	120.0
Ho Chi Minh City	40.01	110.01	175.0
Haiphong	N/A	34.01	-
Total for Asia-Pacific Ports	**39,443.4**	**44,338.6**	**23.5 (ave.)**

[1]Estimates; N/A = not available; TEUs = Ten-foot Equivalent Units.

(*Table 4.15*). These constitute around 18.8% and 19.8% of all the container throughputs handled by all Asia-Pacific ports in 1991 and 1992, respectively (*Table 4.15*).

Many of the Indonesian and Malaysian ports along the Straits have good cargo handling and storage facilities which means that much of the bordering States' exports and imports move through the Straits. In 1994, Port Klang handled 26.55 million tonnes of conventional dry and containerized cargo. Of this, 78% or 17.98 million tonnes were containerized cargo, 6.05 million tonnes were breakbulk cargo and 5.42 million tonnes were dry bulk cargo. The Port also handled 4.41 million tonnes of liquid bulk cargo, a major part of which consisted of petroleum (Annual Report of the Authority of Port Klang, 1995). The majority of the cargo (67.7%) handled by the port originated from or was destined to ports outside the region, whereas 32.3% of the port's cargo trade was with other ports in the Southeast Asian region. *Table 4.16* shows the main types of liquid, dry and containerized cargo handled by the port.

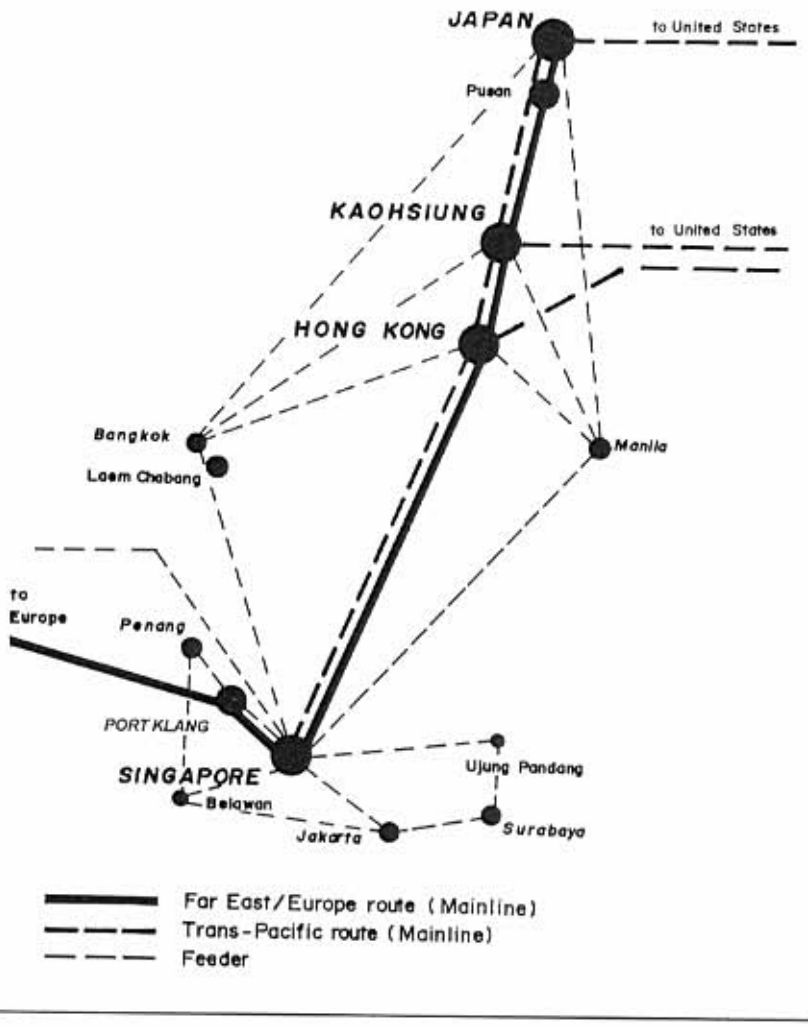
Table 4.16. Commodity Composition Handled by Port Klang of Malaysia (Annual Report of the Authority of Port Klang, 1994).

Cargo Type	Main Commodities Handled
Containerized cargo	Chemicals; Electronic goods; Rubber; Processed timber; Machinery; Plastic goods; Paper products; Electrical equipment; Textiles and apparel.
Dry cargo	Iron and steel; Coal; Cement; Timber; Cars; Wheat; Sugar; Maize
Liquid cargo (excluding petroleum and LNG)	Palm oil

Figure 4.8 shows the hub/feeder operations in the region. Both feeder and regional container traffic provide the basis for intra-Asian shipping networks. It is possible to recognize four subsystems, namely (Robinson, 1997) :

- *The Japan-Korea-Taiwan-Hong Kong-Singapore Corridor.* These services tend to be longer haul using larger vessels averaging from 500 to 1,500 TEUs (these include for example, MOL, K-Line NYK, TSK, Uniglory, Cheng Lie and PIL).
- *East Asia-Southeast Asia Services.* Centered on Hong Kong and Kaohsiung or Keelung or Taichung, these services link the above ports with places such as Ganbkok and Sattahip, Ho Chi Minh City, Manila, Port Kelang, Penang and Johor, China ports and others (these include

Figure 4.8. Hub/Mainline/Feeder Networks in the Region (Robinson, 1997).



services operated by Uniglory, Wan Hai, OOCL, RCL, APL, NOL, PIL, COSCO and others).

- ***East Asia Short Sea Services: Taiwan-Hong Kong-The Philippines-China.*** These services tend to be two or three port 'shuttle' services—Kaohsiung-Manila; Kaohsiung-Hong Kong-Manila; Hong Kong-Manila; Hong Kong-China-Tianjin, Xingang (operators include MOL, Uniglory, Sea-Land, APL, NOL, Maersk, COSCO and others).
- ***East Asia-Northeast Asia Services.*** These services may be more complex than the short sea services and include Taiwan-Japan; Hong Kong-Japan/Taiwan-Korea, for example (operators such as MOL, WAN, HAI, OOCL, PIL operate on these routes).

Table 4.17 shows the container vessel movements in the most heavily trafficked ports in the region. Container vessel movements from the ports along the Malacca Straits to other East Asian ports were relatively heavy.

Use of the Straits as a Transport Channel by the Littoral States

The Straits is vital to the economies of the bordering States in that it serves as a transport link between the States and their trading partners.

Indonesia

Ninety percent of the Indonesian exports and imports are transported by sea. Although the Straits of Malacca is an important waterway for international navigation, from the Indonesian economic and trade point of view, the Malacca Straits is not that important, except for the distribution and transportation of oils and natural gases. The reason is simple, Indonesia has other waterways and routes to transport its products for export and import, whether they are from European countries, the Middle East or Asia-Pacific rim countries. As an illustration (Soentoro, 1996), out of the total 656 general ports, a number handle substantial bulk cargoes. Over 50% of general cargoes in Indonesia are loaded and unloaded in 25 strategic ports. These strategic ports consist of four full container ports (only Belawan is located in the Straits of Malacca), eight semi-container ports (Dumai and Batam are located in the Straits of Malacca) and 13 conventional ports (Lhokseumawe, Pekan Baru and Tanjung Pinang are located in or are close to the Straits of Malacca).

The total cargo handled in 1994 was 366.12 million tonnes and consisted of 137 million tonnes of domestic cargo and 229.12 million tonnes of foreign cargo. Approximately 65% of the cargo was oil and gas. Probably over 60% of these oil and gas were transported through the Straits of Malacca, either for domestic use or for exports. In 1995, the total volume of containers was 2.75 million TEUs, 98% of those containers were transported from four main container ports. One of these, Belawan in the Straits of Malacca, transported 0.21 million TEUs or just over 7%.

There has been an increase in both the traffic in the Straits and the number of vessels calling at the Indonesian ports on the Straits. Between 1983 and 1991, the share of the gross domestic product of the three provinces bordering the Malacca Straits decreased by 2.34% even though the national gross domestic product figure increased by 8.31%. One conclusion is,

Table 4.17. Number of Container Vessel Movements in the Highest Trafficked Port-to-Port Links in the East Asian Region, April-June 1992 (Robinson, 1997).

Port-to-Port Link	Vessel Movements (Number of Vessels)	Average No. Vessels/Day
(A) Ports along the Malacca Straits to Other Ports		
Hong Kong - Singapore	472	5.2
Singapore - Hong Kong	393	4.3
Port Klang - Singapore	259	2.8
Singapore - Port Klang	243	2.7
Jakarta - Singapore	153	1.7
Singapore - Bangkok	151	1.7
Bangkok - Singapore	150	1.6
(B) Other Port Links		
Kaohsiung - Hong Kong	330	3.6
Hong Kong - Kaohsiung	278	3.1
Hong Kong - Keelung	240	2.6
Keelung - Hong Kong	301	3.3
Kobe - Nagoya	243	2.7
Nagoya - Kobe	212	2.3
Pusan - Kobe	176	1.9
Kobe - Pusan	152	1.7
Nagoya - Yokohama	166	1.8
Yokohama - Nagoya	146	1.6

in this sector, the increase in shipping traffic in the Straits does not necessarily support the increase in economic activity (Kamaruzaman, 1995).

Table 4.18. Number of Vessels Using the Malacca Straits and Number of Vessels Calling at Malaysian Ports and Their Percentage to Vessels Using the Malacca Straits, 1982-1990 (Modified from Naidu, 1997).

Year	Vessels Using the Straits	Vessels Calling at Malaysian Ports	Percent of Vessels Calling at Malaysian Ports
	(A)	(B)	(B/A x 100)
1982	43,633	6,916	15.85
1983	43,748	7,321	16.73
1984	41,982	7,731	18.45
1985	43,837	7,971	18.23
1986	48,866	7,527	15.44
1987	51,072	7,468	14.65
1988	53,826	7,427	13.83
1989	58,924	8,259	14.04
1990	72,416	8,785	12.15
1991	84,414	9,371	11.10
1992	91,826	10,268	11.18
1993	99,888	19,540	19.56

Malaysia

Of the total vessels using the Straits, 12% called at the four Malaysian ports located in the Straits in 1990. There has been an increase in both the traffic in the Straits and the number of vessels calling at the Malaysian ports in the Straits. However, the percentage of the Malacca Straits traffic calling at Malaysian ports may possibly be on a decline, as shown in ***Table 4.18***, indicating that the Malaysian economy may not be profiting as much as other States from the increased traffic.

The Malacca Straits is crucial to Malaysia's economy, with an estimated 75% of Malaysia's trade passing through the Straits. The reliance of the country's trade on the Malacca Straits can be explained by:

- The economy being highly dependent on trade;
- The external trade being dependent on maritime transport; and
- The economic activity of the country being concentrated on the West Coast of Peninsular Malaysia.

Table 4.19 provides an indication of the contribution of the trade sector to the national economy. Both the export and import sectors clearly contribute a very significant portion of the country's gross domestic product (GDP) and have grown significantly since 1980.

The Malaysian economy is highly dependent on export markets for the sale of much of its national output and heavily dependent on imports of consumer as well as capital goods. Therefore, it is essential for Malaysia to have an efficient export and import system in order to ensure economic survival (Kamaruzaman, 1995).

Nearly all of Malaysia's exports and imports are transported by ships, except for the high-valued electronics and electrical appliances, which are carried as air cargo. Although exact figures are not available, it is estimated that about 90% of the total value and 98% of the volume of the country's foreign trade are shipped by sea. Trade over land is ruled out by virtue of geography. The reason for the trade being maritime dependent is due to the commodity composition and the direction of the trade. ***Table 4.20*** shows Malaysia's major trading partners in 1992.

Table 4.19. National Economic Indicators of Malaysia, 1982-1992 (Naidu, 1997).

Year	Exports[1] (million RM)	Imports[1] (million RM)	GDP	Export/ GDP (%)	Import/ GDP (%)	Foreign Trade Index
1980	30,676	29,342	53,308	57.5	55.0	1.12
1985	42,537	38,561	77,561	54.9	49.8	1.04
1986	40,305	35,941	71,594	56.3	50.2	1.06
1987	50,838	39,592	79,625	63.8	49.7	1.14
1988	61,435	52,011	90,861	67.6	57.2	1.25
1989	75,151	68,792	102,587	73.3	67.1	1.40
1990	88,740	86,442	115,828	76.6	74.6	1.50
1991	105,468	113,108	129,559	81.4	87.3	1.68
1992	115,231	112,681	147,784	77.9	76.2	1.54

[1] RM – Ringgit Malaysia (Malaysian dollar).

As shown in *Table 4.21*, the eight Malaysian States bordering the Malacca Straits constitute the most important economic region of the country, about 70% of the national output. Of the 165 industrial estates existing in Malaysia in 1992, nearly two-thirds (i.e., 112) were located in these eight states. The region also receives most of the imports since the average per capita income in these states is well above the total per capita income of the other Malaysian states.

Table 4.20. Malaysia: Volumes of Exports and Exports with Major Trading Countries (Naidu, 1997).

Trading Countries	Exports[1]		Imports[1]	
	Million RM	% Share	Million RM	% Share
Japan	13,748.6	13.3	26,400.1	26.0
United States	19,272.7	18.6	16,090.3	15.9
European Community (EC)	15,392.8	14.8	12,671.9	12.5
Singapore	23,883.1	23.0	15,968.8	15.7
Australia	1,731.2	1.7	2,699.0	2.7
Others	29,628.3	28.6	27,610.4	27.2
Total	103,656.7	100.0	101,440.5	100.0

RM – Ringgit Malaysia (Malaysian dollar).

The traffic in the Straits generated by Malaysian import and export activities has grown over the years together with the robust growth of the Malaysian economy. Naidu (1993) reports that, according to the Malaysian Government, the Straits of Malacca will continue to be the principal throughfare for trade between Malaysia and the rest of the world. Support for this prediction comes from the fact that the Government is convinced that the States bordering the Straits will continue to dominate the economy of the country. With the increase in external trade, the role of the Malacca Straits as a transport link will be further

Table 4.21. Malaysia: Comparison of Economic Performance in the West Coast and East Coast of Peninsular Malaysia, and Sabah/Sarawak of East Malaysia (Modified from Naidu, 1997).

Parameter	West Coast of Peninsular Malaysia (Malacca Straits)		East Coast of Peninsular Malaysia		Sabah/Sarawak		Total for Malaysia (TM)
	Total	% of TM	Total	% of TM	Total	% of TM	
Land area (km^2)	75,504	49.5	63,863	41.9	13,076	8.6	152,443
Population (thousands) in 1990	11,655.8	64.7	3,053.1	16.9	3,301.3	18.4	18,010.2
GDP at purchaser's value (RM million)[1]							
1980	32,468	69.9	5,900	12.7	8,032	17.4	46.400
1990	54,209	68.5	11,121	14.1	13,768	17.4	79,098
2000	108,634	69.7	20,697	13.3	26,445	17.0	155,776
Per capita GDP (RM)[1]							
1980	3,519		2,630		3,338		3,343
1990	4,651		3,643		4,170		4,392
2000	7,562		5,238		6,092		6,874
Ratio to Malaysian average							
1980	1.05		0.79		0.99		1.0
1990	1.06		0.83		0.95		1.0
2000	1.10		0.76		0.89		1.0

[1] RM – Ringgit Malaysia (Malaysian dollar)

enhanced. There is also a likelihood that intranational cargo flows in Peninsular Malaysia may shift from land transport modes to the Straits of Malacca, due to land transport being highly congested and for environmental reasons. The chances of this taking place are increased since Port Klang aims to become a national cargo center and the vast majority of the country's port and marine park developments are planned for this area.

Singapore

Of the total vessels transiting the Straits, more than 80% called at the Port of Singapore in 1984 to 1990 (*Table 4.22*).

Development and Exploitation of Oil and Gas Resources in the Straits

Oil and gas deposits in Southeast Asia are found mainly in the deep sedimentary basins of the region (Burbridge et al., 1988). The main hydrocarbon-rich basin in the Malacca Straits is located in Sumatra Island of Indonesia and extends eastward under the floor of the Straits. *Figure 4.9* shows the location of the oil fields, gas fields and oil refineries in the Malacca Straits. Most of the oil and gas production in the Straits occur along the East Coast of Sumatra Island, whereas the majority of oil refineries are in Singapore.

The oil production/refining enterprises along the Straits have developed into centers of economic activity. New ports have developed and existing ports have expanded, industrial complexes associated with seaborne transport and raw material sources have been set up in many cases; and changes have occurred in the urban population.

Table 4.22. Estimated Numbers of Vessels Using the Malacca Straits and Vessels Calling at Singapore Port (PSA, 1994; Naidu, 1997).

Year	Estimated Vessels Using the Malacca Straits	Vessels that Called at the Port of Singapore
1982	43,633	36,361
1983	43,748	36,457
1984	41,982	34,985
1985	43,837	36,531
1986	48,866	40,722
1987	51,072	42,560
1988	53,826	44,855
1989	58,924	49,107
1990	72,416	60,347

Crude oil production

Indonesia. Indonesia is one of Asia's major oil producers, ranking second after China and fourteenth globally. Indonesia is also Asia's biggest oil exporter. Oil and gas production provide almost two-thirds of Indonesia's tax revenues and are a major source of foreign exchange (Burbridge et al., 1988).

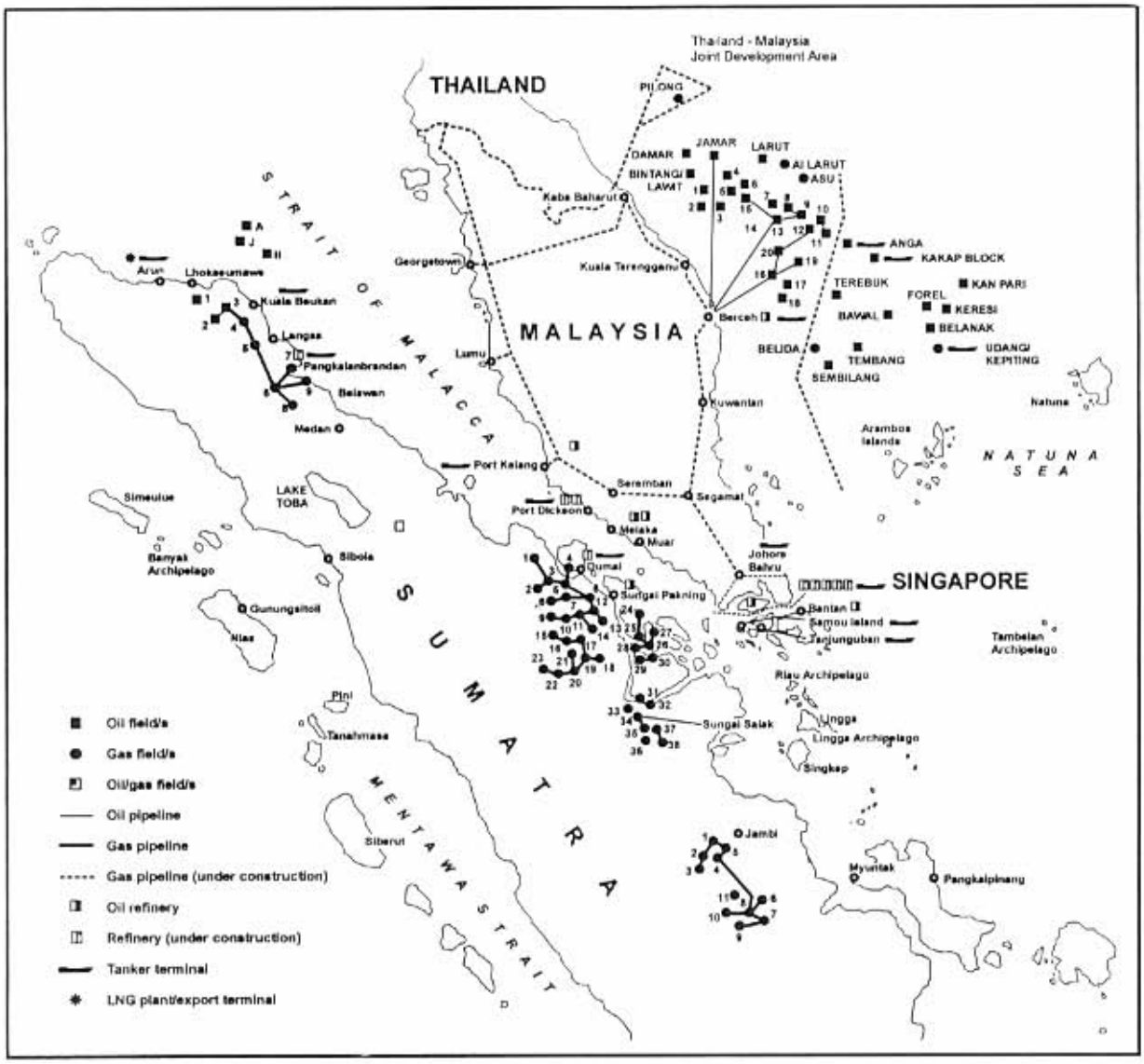
Indonesia is endowed with petroleum hydrocarbon resources, onshore as well offshore, spread widely throughout the archipelago. At present, 60 petroleum basins have been recognized in Indonesia. Among them, 14 are already producing, 7 have been drilled and proven productive, 15 are in an explorative drilling process and 24 are still undrilled. Seventy-three percent of the basins are located offshore. Many of them are still untouched until now due to their location in deep water. Most of these basins also produce natural gas. *Figure 4.10* shows the basin locations in and around Sumatra.

Over one-third of the oil produced in Indonesia comes from offshore fields, in particular the Java Sea and Makassar Strait and another large portion comes from coastal areas. Indonesian oil fields tend to be small in size, requiring continuous development of new fields to maintain the country's production levels. Offshore oil exploration activities in the Straits of Malacca commenced in 1980. However, so far only HUDBAY oil company has succeeded in producing oil in the Riau Archipelago (Wisaksono and Bilal, 1988). Offshore exploration areas include the southern part of the Java Sea, the Straits of Malacca, South China Sea around Natuna Island, West Kalimantan, Makassar Strait and South Sulawesi.

In the critical period of 1970 to 1990, oil financed and fueled Indonesia's economic development. Oil revenue contributed over 80% of the national revenue. With the growth of the non-oil sectors, the oil industry now contributes a substantial, but much lower, 25% of the national revenue (Rasyid, 1995). The current OPEC quota for Indonesia is 1.33 million barrels of crude oil per day for export, with prices ranging from US$15.0 to US$19.0 per barrel, depending on the international market price and the types of oil.

Table 4.23 shows the level of Indonesian oil exports between 1990 and 1994.

Figure 4.9. Oil and Gas Fields and Refineries Located Along the Malacca Straits (Burbridge et al., 1988).



INDONESIA

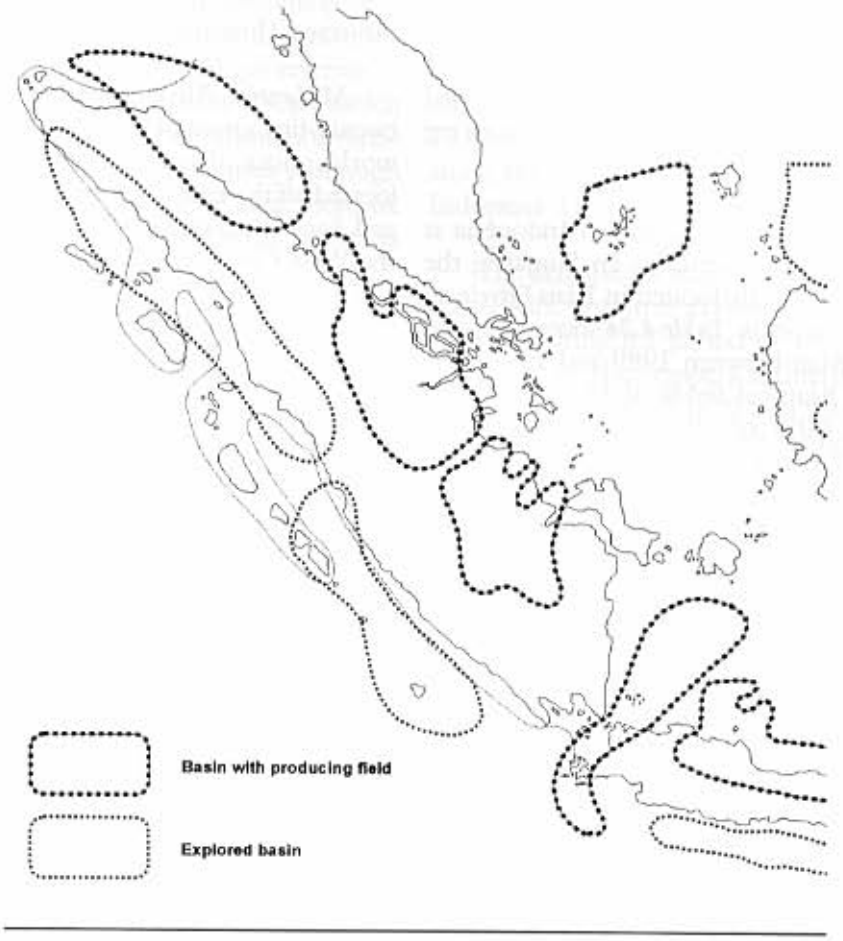
North Sumatra:

1. ARUN
2. LHO SUKON SOUTH A&B
3. ALUR SIWAH/LUULU RAJEU
(4-5: Partak fields)
4. ALUR JIMON/EE TABEUEA MEURANTIPERLAK/TUALANG
5. PEUTOUW
(5-9: Pantau fields
6. PALI/TABUHAN E&W
7. KUALA DALAM/ KUALA SIMPUNG E&W/RANTAU/ SERANG JAYA/SUNGAI/ SUNGAI BULUH
8. DARAT/TELAGA SAIO
9. GEBANG/SECURAI

Central Sumatra:

1. DAMAR/PINANG
(2-8: Bangko fields)
2. BALAM S&SE/TANJUNG MEDAN
3. BANGGKO/BEHAR/HELLA
4. GENTING/PERKEBUNAN/SINGA
5. KERANG/MUTIARA/SERUNI/ SINTONG/TUNAS
6. MENGGALA/MENGGALA N
7. PAGER/SIKLADI/TELINGA/UBI
8. BATANG
(9-12: Duri fields)
9. KOPLANG/PELITA/OBOR/RAKIRI
10. CUCIT/HIU/PUKAT/RANGAU
11. AMAK/AMPUH/BEKASAP/BEKASAP S
CEBAKAN/KOPAX/PEMATANG/ PEMATANG BOW/PETANI/PINGGIR/ PUOU
12. DURI/KUUM/LINCAX/PUNCAX
(13-23: Beruk fields)
13. ATUANTAN/SEBANGA BOW
14. PUNGUT
15. HITAM/JINGGA/RENTIS/WADUX
16. LIBO/LIBO SE
17. TALAS
18. MINAS
19. KOTA BATAK
21. LINOAI
22. KASIXAN/TERATUM
23. LANGGAK/PAITAN
(24-27: Sungai Pakning area)
24. PEDADA/SABAK
25. BENUA/OUSUN
26. BUTAN/LALANG/MANGKAPAN
27. KURAU/MELIBUR\
(28-30: Beruk area)
28. PUSAKA
29. BERUX/BERUX N&NE/ BUNGSU/ORIS
30. ZAMARUD/ZAMARUD S
(31-38: Brik fields)
31. MERBAU N/PANDAK/ KERUMUTAN/MERBAU/ MUTARA
32. GEMURUH/KAYAURA/ KAYUARA E
33. PULAJ N&S
34. LIRIX
35. MOLAK/SAGO
36. BINIO
37. PINLON
38. PEKAN
(1-8: Jambi fields)
1. SETITI
2. BAJUBANG
3. BETUNG JAMBI
4. TEMPINO
5. KENALI ASAM
6. BENTAYAN
(7-9: Pamol-Rame fields)
7. RAMBA SUNGAI/LILIN
8. KERANG/LANGKAP/TABUAN TANJIAN LABAN
9. RAWA N/RAWA S/SUPAT
10. KLUANG
11. REBONJARO
12. SUBAN BURUNG
13. KEBAN
14. MANGIDUAYA
(15-22: Raja fields)
15. SUKARAJA/TANIM
16. ABAB
17. BULU/DEWA/IBUL/RAJA/ BETUN SW/
18. BENEKAT/BENEKAT E/JIRIK/ KAJA/TALANG AKAR
19. JENE/PLAN
20. MUSI
21. TERAS
22. LAGAN
(23-32: Limau fields)
23. BETUNG
24. BENUANG/GUNG KEMALA
25. BELIMBING/LIMAU C, E&W/ TALANG JIMAR
26. TANJUNG MARING
27. TANJUNG TIGA
28. OGAN
29. TANJUNG MARING E
30. AIR SERDANG/BERINGAN
31. PAGER DEWA/PRABUMENJUNG
32. KUANG
(33-35: - fields)
33. LINGGA/SUBAN JERIGI
34. KUAMPONG MINYAK
35. SEMBING TANJUNG/LONTAR

Figure 4.10. Map of Producing and Explored Tertiary Age Basins around Sumatra Island (Salm and Halim, 1984).



The existing oil and gas operations are sources of employment and local business opportunities for Indonesians in engineering, rig work, supply boat operation, shore-based and warehouse work, oil field supply and contingency planning. They also serve as a leading sector for technology, data processing, sensitivity mapping and oil spill countermeasures. The development of support base facilities and service industries is a major stimulus to coastal community development and to the development of ports and industrial facilities, including refineries and petrochemical plants.

Table 4.23. Volume and Value of Export of Oil, Natural Gas, and Their Derivatives from Indonesia, 1990-1994 (Direktorat Jenderal Minyak dan Gas Bumi, 1995).

Year	Crude Oil	LNG (MMBTU)	Refined Products	Conden-sate	Total
A. Volume (millions of barrels)					
1990	248.4	1,064.9	56.1	40.0	1,373.4
1991	295.5	1,161.2	56.5	35.0	1,548.2
1992	258.6	1,218.6	64.6	34.4	1,576.2
1993	248.8	1,246.8	58.6	34.5	1,588.7
1994	289.3	1,368.2	63.2	34.7	1,755.4
B. Value (billion US$)					
1990	5.43	4.02	1.26	0.89	11.60
1991	5.68	4.05	0.99	0.70	11.49
1992	4.73	4.10	1.06	0.68	10.57
1993	4.18	3.94	0.90	0.61	9.63
1994	4.50	3.85	0.90	0.59	9.84

Offshore petroleum operations lead to many related support activities in marine and coastal areas, including shipping (supplying drill rigs and offshore installations), onshore infrastructure and support services. Most of the crude oil produced from offshore wells is transported through submerged pipelines to storage barges or land terminals. Oil is then pumped from these facilities to offshore single buoy mooring terminals where it is loaded onto tankers.

The current national production in Indonesia is about 1.5 million barrels per day. In Sumatra, the production fields are mostly located in Riau Province, including its offshore fields. *Table 4.24* shows the level of production in Riau between 1989 and 1993. The production from Riau oil fields of Mina and Duri represent about 60% of all the Indonesian oil production. Oil companies in other provinces bordering the Malacca Straits are ASAMERA in Aceh and PERTAMINA in North Sumatra. They produce much smaller volumes of oil than those located in Riau Province.

The offshore oil production from the Malacca Straits amounts to 55,000 barrels per day and represents 0.04% of the national component and 0.11% of the offshore component. The assessment of recoverable reserves is difficult because many of the offshore tertiary basins have not been fully re-explored, experimentally drilled for their production potential, and some have not even been touched due to their deep sea location. Percentage-wise, the overall offshore contribution from the Malacca Straits will still be low. However, in the longer term, the offshore production will increase as the land-based oil fields get depleted.

Indonesia has experienced a small steady decline in oil production after the boom in drilling during 1989 to 1991. The decline can be explained by a reduction in the discovery rate of oil reserves and the low world oil prices. The decline in oil reserves, coupled with an estimated 6% annual growth rate in domestic oil consumption, will probably cause Indonesia to become a net importer of oil by the year 2000. A ten-year reserve life for Indonesia's oil production has been projected (International Petroleum Encyclopedia).

Malaysia. Although Malaysia has been ranked twenty-first among the oil-producing countries in the world, most of her crude oil production fields are located off the East Coast of Peninsular Malaysia, Sabah and Sarawak (*Figure 4.9*). Only a few are located off the West Coast of Peninsular Malaysia bordering the Malacca Straits.

Liquefied natural gas production

The energy policies of both Indonesia and Malaysia focus on the development of gas production facilities and the conservation of oil reserves. As can be seen from *Figure 4.9*, the major gas field (Arun field of Indonesia) is located northeast of Sumatra Island, near the northwest entrance of the Malacca Straits. Other smaller fields are in the area around Dumai of Central Sumatra, whereas in Peninsular Malaysia, gas fields are mostly found off its East Coast.

Indonesia. Indonesia is the world's fourteenth largest gas producer with an annual production capacity of 24.4 million tonnes in 1994. Indonesia is also the world's leader in the export of LNG. Gas is second only to oil as Indonesia's leading generator of foreign exchange earnings and tax revenue. LNG has therefore been playing an increasing important role as a catalyst for national development. Indonesia's share of the international market for LNG has grown spectacularly. Its first LNG shipment for export was made in 1977. By 1987, Indonesia ranked as the world's leading LNG exporter, holding over 40% of the global market.

The total Indonesian natural gas reserves, both developed and undeveloped, amount to 94 trillion cubic feet (tcf). Of this, 45 tcf are in the Natuna area, 25.4 tcf are in East Kalimantan and 18 tcf in Northern Sumatra. Smaller reserves are scattered in Java, Sulawesi and Irian Jaya. It has been estimated that there remains a 40-year reserve life for Indonesia's gas production.

Forty-seven percent of Indonesia's gas is produced in

Table 4.24. Crude Oil Production (millions of barrels) by Company in Riau Province, 1989-1993 (Statistical Office of Riau Province, 1995).

Company	1989	1990	1991	1992	1993
PT. CALTEX	202.07	204.50	197.38	208.83	295.75
C & T (CPP + MFK)	1.43	1.46	1.42	1.52	1.02
C & T (C. Sumatra-KK)	24.70	4.71	23.57	24.65	233.61
HUDBAY OIL					
Malacca St)	20.14	25.11	29.84	38.88	21.27
CONOCO (Natuna)	3.07	2.82	2.46	2.35	11.03
MARATHON (Kakap)	4.70	5.85	6.93	9.03	28.46
PT STANVAC	8.01	9.97	11.82	15.38	0.53
Total	**264.12**	**274.50**	**273.42**	**300.64**	**581.67**

the Mobil-operated Arun gas field with an output of around 12 tcf annually. The remaining 32.4% of the country's gas output is produced in the fields in East Kalimantan which are operated by the oil companies of Total, ARCO and VICO and have a combined reserve of around 23.4 tcf. The current gas reserves in the fields nearby Arun are estimated at 14 tcf which should give it a 24-year life at current production rates. In reality, its production life is much shorter. Although new discoveries have been made in the area, these are not large enough to support new 20-year contracts (Burbridge et al., 1988).

The first LNG plant in Indonesia was constructed in Bontang, East Kalimantan and came on stream in 1977. A year later, in 1978, it was followed by the Arun plant in Lhokseumawe, East Aceh. Since that time, both facilities expanded and their production rose to about 18 million tons by 1987.

The Arun LNG plant, owned and constructed by PERTAMINA, the Indonesian state oil company, is located at Blang Lancang, Lhokseumawe, Aceh Special Region. It is located about 30 km from the Arun gas field. The Arun LNG plant has six LNG trains. Each train has the capacity of 300 million standard cubic feet of gas per day. Together with Bontang, the Arun plant also added facilities for producing LPG (liquefied petroleum gas) in 1988. By 1989, the LPG production from Arun plant was 1.6 million tons (P.T. Arun, 1989).

Most of Arun LNG is shipped to Japan whose contract for the gas field is set to expire in 2010. The remainder of the LNG production is shipped to South Korea and Taiwan. A small portion of Arun LNG also provides the raw material for urea and ammonia production at Lhokseumawe of North Sumatra.

Japan is a major LNG importer, consuming almost two-thirds of the world volume. In 1993, however, the Japanese LNG purchases decreased by 5%, whereas the South Korean imports increased by 29.5% (700,000 tonnes from Brunei) and the US imports increased by 82.5%. According to one projection, Japan will remain the number one importer of LNG during the next 15 years and the demand for LNG will grow at 3% per year. One estimate is that Japan's demand will increase from its 52.7 billion cubic meters (1.75 tcf) in 1992 to 65 billion cubic meters (2.16 tcf) in 2000, reaching 125 billion cubic meters (4.16 tcf) by the year 2010.

Oil refineries

The total oil refining capacity by the refineries located along the Malacca Straits as of 1 January 1995 was estimated to be 1.54 million barrels per day (***Table 4.25***). Among the three littoral States, Singapore has the highest refining capacity which constitutes about 72.43% of the total refining capacity by the refineries along the Malacca Straits. Malaysia has 16.72% and Indonesia 11.30%.

The demand for refined petroleum products in the Asia-Pacific region is expected to increase by around 14.25% during the period of 1993 to 1997 and the supply from the region's refineries is predicted to increase by around 15.07% over the same period. This will probably lead to the import requirements increasing by around 7.41% during the period (Bamber, 1995). Assuming that the oil imports from areas outside Asia remain at the current level, the refining capacity must be increased either by expansion of old facilities or by building new refineries. There are numerous plans for increasing the refining capacity in the region and, if these plans were to materialize, it would add another 6 million barrels per day to Asia's refining capacity by the year 2000. However, the lack of financing could limit expansion of the refining capacity in the region, especially in those countries where the refineries are operated by the private sector. In the next four to five years, half of the world's new oil refining capacity could be built in Asia (Bamber, 1995).

Indonesia. Indonesia's total refining capacity is currently estimated at around 985,200 barrels per day (bpd), of which about 13% or 127,300 bpd are produced by Indonesian refineries bordering the Malacca Straits (***Table 4.25***). This capacity is well in excess of the domestic demand for refined petroleum products. However, the domestic consumption of petroleum products is currently rising at a rate of about 6% a year and although the rate of growth is estimated to be slower in the later half of the 1990s, the consumption is projected to increase to around 1.0 million bpd by 1998 and 1.4 million bpd by 2005. By the end of 1998, refining capacity is expected to increase to about 1.10 million bpd. Almost all the oil refineries are owned by the state-owned oil company, PERTAMINA. In November 1994, PERTAMINA provided details of its refinery expansion plans for the next five years. However, none of these plans were for the refineries located along the Malacca Straits.

Table 4.25. Location of Oil Refineries Along the Malacca Straits and Their Operators, Production Capacities and Percentage of the Production in the Malacca Straits to National Production Capacity for Each Littoral State (Bamber, 1995).

Country	Location	Operator	Capacity (bpd) as of 1 January 1995	Malacca Straits/ National Total (%)	Source of Crude Oil
INDONESIA	Sungai Pakning	Pertamina	46,100	4.67	
	Dumai	Pertamina	122,500	12.43	
	Pangakalan Brandan	Pertamina	4,800	4.87	
	Bintan Island[1]	(BP/C Itoh)	(120,000)	(10.86)	
	Total for Malacca Straits		173,400 (293,400)	17.60 (26.55)	
	National Total		985,200 (1,105,200)	100.00	
MALAYSIA	Port Dickson[2]	Esso Malaysia Berhad	59,800 (75,000 by 1995)	16.17 (17.87)	
	Port Dickson	Shell Refining Co. Berhad	90,000	24.34	
	Malacca	Petronas Conoco	100,000 (200,000 by 1997)	27.04 (47.64)	
	Total for Malacca Straits		249,800 (365,000	67.55 (86.95)	
	National Total		369,800 (419,800)	100.00	
SINGAPORE	Pulau Bukom[2]	Shell Eastern Petroleum	415,000	37.32	70% Middle East 30% Far East
	Pulau Merlimau	Singapore Petroleum/ Caltex/BP	213,000 (280,000 by 1995)	19.15	Nearly 100% Middle East
	Jurong	Mobil Oil Singapore	235,000	21.13	90% Middle East 10% Far East
	Pasir Panjang	BP Refinery Singapore	29,000	2.61	50% Middle East; 30% Indonesia, 20% Malaysia
	Pulau Ayer Chawan	Esso Singapore	220,000	19.78	Nearly 100% Middle East
	National Total		1,112,000 (1,179,000)	100.00	

[1] Planned, start-up date not certain
[2] Expansion programme

Local private investors have put up proposals for new refineries to supply the domestic market. Foreign investors also provided proposals for export-oriented refineries. There is little incentive for private investors in a tightly regulated domestic market and PERTAMINA is not prepared to guarantee supplies of crude to either domestic or export-oriented refineries (Bamber, 1995).

Malaysia. Malaysia's refining capacity more than doubled from 230,000 bpd in 1988 to 470,000 bpd in 1994. A further 250,000 bpd of crude distillation capacity is due to come on stream during the next three years, although as much as 150,000 bpd of that capability may not get built. With the domestic consumption of the petroleum products not expected to increase to more than 400,000 bpd by 1998, Malaysia will have a substantial volume of products available for export for the rest of the decade (Bamber, 1995). About 67.55% of the total refining capacity in Malaysia (249,800 bpd) originate from the three refineries located along the West Coast of Peninsular Malaysia. Expansions have been planned for the refineries in Port Dickson and Malacca. These will increase the refining capacity to 365,000 bpd by 1997 The oil companies, Petronas and Conoco, which

collaborated in the Malacca refinery, signed an agreement in late 1994 for a second 100,000 bpd refinery in Malacca, with start-up scheduled for late 1997. To date, the Malacca refinery processes local Tapis crude to cater to the domestic market. However, with the expansion program being realized, the refinery will be upgraded to include facilities for refining the imported Middle Eastern sour crude oils (Bamber, 1995).

Singapore. There are five oil refineries located in the coastal areas of Singapore and their total refining capacity is around 1.11 million barrels per day (bpd). This makes Singapore the second largest oil refining area in the world, after Houston, Texas. The crude distillation capacity in Singapore is expected to rise from 1.16 million bpd in 1993 to 1.30 million bpd in 1998, mainly with the upgrading of existing facilities. Over the same period, the country's consumption of refined petroleum products is also expected to rise from an average of 420,000 bpd to 450,000 bpd. In theory, Singapore's export capacity should rise from 740,000 bpd to 850,000 bpd, but the demand for feedstock from the growing petrochemical sector could alter the projection (Bamber, 1995).

The petroleum industry plays a very important role in the country's foreign trade. In 1985, the export of petroleum and petroleum products accounted for 27% of the total exports and the percentage share of the commodity in total imports was 29% (*Table 4.26*).

Tables 4.27 and *4.28* show the main sources of petroleum imports and the main export destinations for Singapore.

Table 4.26. Trade Statistics (S$ million) for Petroleum Products in Singapore (Chia et al., 1988).

Year	Export	% of Total Exports	Imports	% of Total Imports
1974	3,654.1	26	4,891.3	24
1975	3,407.6	27	4,730.5	25
1976	3,743.7	23	6,136.6	27
1977	4,834.6	24	6,519.5	26
1978	5,279.1	23	7,074.5	24
1979	7,337.2	24	9,668.0	25
1980	11,828.0	29	14,879.5	29
1981	13,980.6	32	19,819.2	34
1982	14,437.3	33	20,471.4	34
1983	12,761.9	28	18,601.4	31
1984	12,992.3	25	16,949.4	28
1985	13,456.1	27	17,019.9	29

Table 4.27. Percentage Share of Singapore's Main Sources of Petroleum Imports (Chia et al., 1988).

Country	1980	1981	1982	1983	1984	1985
Saudi Arabia	43	54	46	35	33	11.5
Kuwait	19	10	5	8	11	5.7
Peninsular Malaysia	8	9	11	11	10	8.6
Bahrain	4	-	4	—	—	—
Iran	3	4	9	6	4	14.5
UAE	3	4		8	8	9.0
Sabah	—	—	4	4	—	2.9
Oman	—	—	—	4	—	—
Sarawak			—	4	4	3.0
China	—	—	—	—	9	22.7
USA	—	—	—	—	—	3.3
Brunei	—	—	—	—	—	3.0

Port and Harbor Development

The commercial ports located along the Malacca Straits are shown in *Figure 4.11*.

Indonesia

Indonesia has about 300 registered ports scattered throughout the archipelago. Most of Indonesia's ports serve international transportation needs. Four major ports for export and import that have been turned into full container ports, namely, Tanjung Priok in Jakarta, Tanjung Perak in Surabaya, Ujung Pandang in South Sulawesi, Belawan in North Sumatra, Dumai in Riau and Lhokseumawe in Aceh, located in the vicinity of large oil fields, also handle large volumes of exports, in addition to their main function as the center of crude oil and refined oil distribution. Another port, Kabil in Batam Island, Riau Archipelago, is also being expanded to serve as a major cargo port. *Table 4.29a* is a list of the major ports along the Malacca Straits including the total volume and value of goods handled. The activities of Malahayati sea port, Aceh Province are presented in *Table 4.29b*. The location of those sea ports is shown in *Figure 4.12*.

The following describes the development and activities of some of the major Indonesian ports along the Malacca Straits:

Belawan Port. Belawan is the third largest port in Indonesia (after Tanjung Priok-Jakarta

Table 4.28. Percentage Share of Major Exports of Singapore's Petroleum Products (Chia et al., 1988).

Country	1980	1981	1982	1983	1984	1985
Japan	18	22	22	20	22	21
Hong Kong	18	19	17	14	13	12
Peninsular Malaysia	10	12	16	17	15	16
Australia	8	7	7	5	6	5
Thailand	8	7	6	8	10	8
New Zealand	6	3	4			3
India	4	5	5	—	6	3
Bangladesh	3	3	—	—	—	—
Sabah	2	—	—	—	—	—
Taiwan	2	—	—	—	—	—
USA	—	2	—	3	5	8
Phillippines	—	—	—	4	—	—
Iran	—	—	3	5	4	6
S. Korea	—	—	—	3	—	—

- Bunkers: obtainable from PERTAMINA at the wharves or by barges;
- Water supplies (300 tonnes/day) and which are delivered alongside wharves or by barges of 200-tonne capacity;
- Waste reception facilities are not available;
- Ship repairs: minor repairs only. Drydocks are available for coasters only;
- Pilotage service is compulsory. The pilots on service are provided with five pilot boats and usually join vessels at the pilot station two miles from the harbor.

and Tanjung Perak-Surabaya) and the largest Indonesian port on the Malacca Straits. In 1993, the port handled a total of 12.3 million tons of cargo.

Belawan Port has four base ports. ***Table 4.30*** provides sizes, depth and main functions of these base ports.

The controlling depths at Belawan Port are from 6 to 10 m which limit the size of the ships visiting the port to less than 15,000 dwt. This means that cargo bound for Europe and North America needs to be transshipped via Singapore. The port currently has a capacity to handle 3,000 TEUs. It has the following facilities:

- Container facilities: PERTAMINA oil jetty, 60 m long with a width alongside of 10 m. There are also mooring buoys for tankers at a depth of 8.5 m;
- Bulk cargo facilities are available;

Table 4.29a. List of Major Sea Ports of the East Coast of Sumatra Along the Malacca Straits Showing Export and Import Activities in 1994 (Biro Pusat Statistik, 1994a, 1994b).

Sea Port	Export		Import	
	Net Weight (million kg)	Value (million US$)	Net Weight (million kg)	Value (million US$)
Aceh				
1. Sabang	0.9	0.1	x	x
2. Uleelheue	156.5	6.3	x	x
3. Malahayati[1]	-	-	-	-
4. Blang Lancang (Arun)	19,015.9	2,328.3	7.0	24.8
5. Lhokseumawe	749.5	104.5	49.5	187.4
6. Kuala Langsa	56.6	37.4	x	x
North Sumatra				
7. Pangkalansusu	77.6	9.9	43.9	29.5
8. Tanjung Beringin	0.8	1.9	x	x
9. Belawan	3,689.2	2,378.3	1,445.0	863.3
10. Tanjung Balai	247.2	238.3	22.4	5.7
Riau				
11. Bagan Siapi-api	9.0	5.8	x	x
12. Dumai	21,742.0	2.685.2	197.9	230.5
13. Bengkalis	1.4	0.7	x	x
14. Sungai Pakning	1,503.4	228.9	54.8	18.2
15. Siak Sri Indrapura	308.6	200.7	4.4	6.9
16. Selat Panjang	7.4	9.3	0.6	1.1
17. Tanjung Balai Karimun	5,228.6	24.7	52.8	7.5
18. Pulau Sambu	5,387.0	378.1	106.4	15.7
19. Sekupang	951.4	115.8	-	-
20. Batuampar	74,288.1	1,307.3	-	-
21. Kabil	21.5	20.0	-	
22. Tanjung Uban	1,191.3	4.5	160.0	51.
23. Tanjung Pinang	179.7	36.8	1.0	2.0

x = less than 0.1 million; — no data;
[1] see Table 4.29b.

Figure 4.11. Commercial Ports Along the Malacca Straits (Morgan and Valencia, 1983).

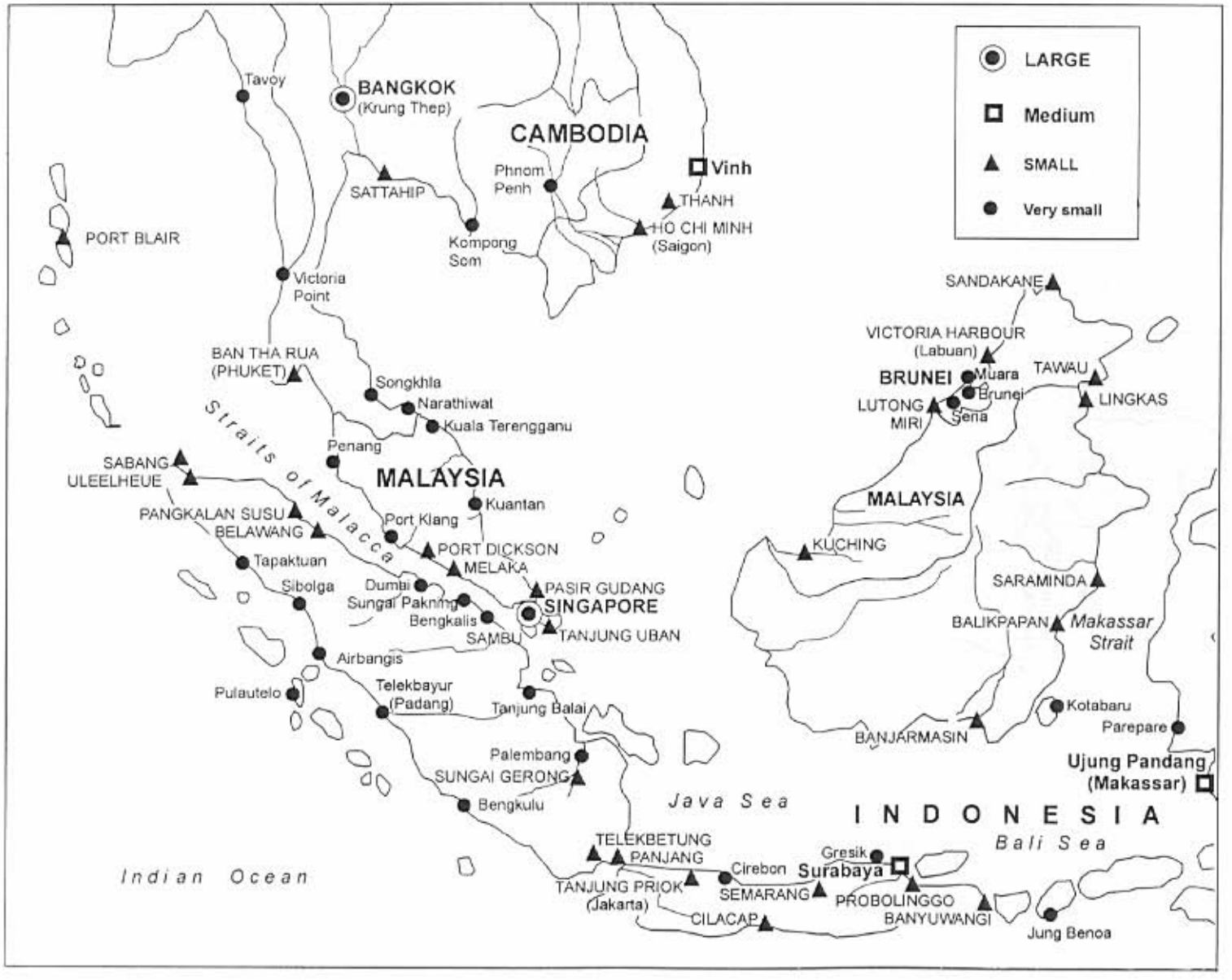
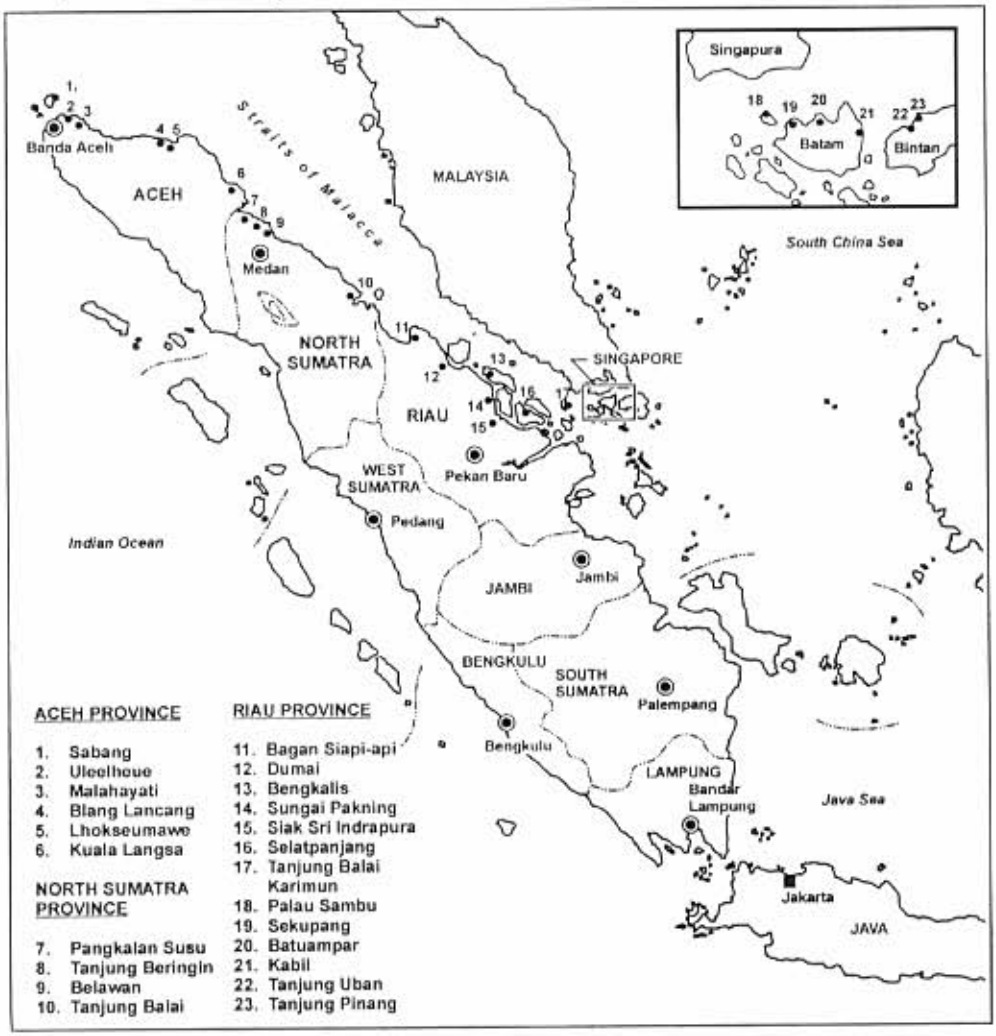


Figure 4.12. Major Sea Ports Along the East Coast of Sumatra.



The ferry schedules in 1994 in the Port of Belawan are shown in *Table 4.31*. The main passenger service is between Belawan and Penang. The service is provided by three Malaysian-owned ferries and one ferry owned by an Indonesian Government Corporation. The average running time between the two ports is about eight hours.

A surge of container traffic has led Belawan Port to plan for expansion of facilities and equipment. It has been estimated that by the year 2018, Belawan Port will be handling 1.1 million TEUs per year (approxmately the same as being currently handled by the major port in Indonesia, Tanjung Priok-Jakarta). If the container cargo continues its increase, Belawan Port will require by 1996, two more container cranes capable of handling 80,000 to 90,000 containers per year. In addition to equipment, Belawan Port will also need additional container berths and an expansion of the container storage yard. The available container

Table 4.29b. Activities of Malahayati Sea Port, Aceh Province, 1990-1994 (Statistical Office of Aceh Province, 1995).

Year	Number of Vessel Visits	Vessel Weight (dwt)	Cargo		Passengers	
			Unload (ton)	Load (ton)	onboard	offboard
1994	748	1,666,065.20	631,090.57	1,021,924.02	50,548	48,889
1993	691	2,802,867.71	696,115.87	159,464.16	45,530	45,965
1992	669	1,298,550.00	299,935.00	815,153.00	47,306	60,986
1991	612	863,353.00	300,432.00	638,004.00	52,074	55,459
1990	650	1,069,247.00	321,290.00	462,056.00	47,853	56,604

Table 4.30. Berth Length, Depth, Transit Shed, Yard Area and Main Functions of the Base Ports of Belawan, Indonesia.

Name of Base Port	Berth Length (m)	Depth (MLWS)	Transit Shed (m^2)	Yard Area (m^2)	Main Functions
Belawan Lama	602	-6	5,372	23,325	Shipping lines and inter-island shipping
Ujung Baru	1,660	-7/-9	31,508	15,885	Ocean ships and export-import
Citra	625	-6/-7	16,800	28,730	Inter-island shipping
Gabion	1,000	-10	11,800	35,000	Container/dangerous cargo
Total	**3,887**		**65,472**	**102,940**	

Table 4.31. Ferry Schedules in the Port of Belawan, Indonesia.

Ferry	No. of Seats	Destination	Weekly Departure(s)
K.M. Maharani	400	Port Klang	Monday, Wednesday
Mv. Perdana Express	350	Lumut,Penang	Tuesday, Saturday
			Wednesday, Friday, Saturday
Mv. Express Bahagia	190	Penang	Tuesday, Thursday, Saturday
Ms. Langkawi Star	1,500	Singapore, Pulau	Sunday
		Langkawi, Phuket	Thursday

Table 4.32. Facilities in the Lhokseumawe Port, Aceh, Indonesia.

Berth	Length (m)	Depth (m)	Cargo	Storage	Equip-ment	Supplies
Public berth	80 x 2	10	General cargo	Warehouse and open storage available; No refrigerated space	Cranes with 25 t capacity	Bunkers: not available Fresh water: available 20 t/h
AAF-A	195	10	Fertilizer in bulk			
AAF-B	300	10	Fertilizer in bag			
	195	10	Fertilizer in bulk			
	25	5	Fuel oil			

berths will need to be increased by 500 m and the current container yard capacity of 3,000 TEUs will need to be expanded to at least 6,000 TEUs.

Lhokseumawe. The port has both adequate berthing facilities and sufficient depths to attract larger ships. The port already handles large volumes of liquefied natural gas for export, as well as fertilizers and other high-volume commodities. It has transport advantages that could make it a focal point for additional industrial development in Aceh.

The port can accommodate vessels of up to 10,000 dwt. ***Table 4.32*** shows details of the port.

There are no navigational hazards in the approaches. Channel depth in Lhokseumawe Old Harbour (for general cargo and tugs/barges) is 11 m and in Kreung Geukeh fertilizer and public harbor is 10 m. Pilotage is compulsory and berthing and unberthing can only be done during daytime.

Dumai. Dumai is a major oil loading and unloading port in Indonesia. The port has well-developed facilities for use by oil tankers related to oil transport and storage. ***Table 4.33*** provides details.

The tanker terminals are owned by CALTEX Pacific Oil Co., Jakarta. Ship repair services are not available; however, CALTEX Pacific Oil Company can assist with minor repairs.

Blang Lancang. In 1992, 436 vessels of a total of 29,587,985 GRT visited the port. During the same year the port handled 32,430,070 tonnes of cargo. The facilities provided by the port are shown in ***Table 4.34***.

Anchorage is available for LNG and LPG carriers in position 5°15'15"N, 97° 07'45"E in 60 m depth; and for crude oil carriers in position 5°15'15"N, 97°05'25"E in 60 m depth. Pilotage service is compulsory. The pilots board vessels at the anchorage or in the vicinity of the sea buoy. For oil tankers, mooring is during daytime only and unmooring is both day and night. For LNG and LPG tankers, berthing and unberthing are allowed both day and night.

Table 4.33. Facilities in the Port of Dumai, Riau Province, Indonesia.

	Length between Dolphins (m)	Length (m)	Depth (m)	Maximum Size of Vessel (dwt)	Storage	Equipment	Supplies
Mercantile Wharf	228	78	11	23,000	12,000 m^2 space	3 mobile cranes (capacity 5 and 6 t)	Bunkers: available; drinking water: not available
Tanker Terminals for Crude Oil							
Wharf No.1	356		15.5 MLWS	100,000			
Wharf No.2	369		17.4	150,000			
Wharf No.3	207		11	23,000			

Bengkalis. Anchorage is available 200 to 300 m off the pier in 9 to 11 m of water. The pier is 163 m long and has a depth alongside 4.5 m and it has a mud bottom. No cargo handling facilities are available. Bunkers are not available. However, diesel oil is available in emergency. Freshwater is available but in limited supply. Pilotage is not available.

Pekan Baru. This is an inland port located in Sungai Siak about 80 km from Siak Sri Indrapura. Facilities provided by the port are shown in ***Table 4.35.***

Minor ship repair services are available. A new port area is to be constructed at Perawang, 25.6 km from Pekan Baru. There is a pilot station at Siak Sri Indrapura.

Pulau Sambu. This port is owned and operated by PERTAMINA. The port can accommodate vessels up to 225 m long and 10.5 m wide. Facilities of the port are shown in ***Table 4.36.*** The port has a depth at the entrance of 14 to 16 m. Pilotage is compulsory.

Lhok Nga. The largest vessel which this port can accommodate is 150 m long and 9.10 m wide. Facilities of the port are shown in ***Table 4.37.*** Pilot service is compulsory.

Sabang. In 1992, 182 vessels of a total 94,682 GRT visited the port. The port can accommodate vessels up to 5,000 dwt, 150 m long and 8.0 m wide. Anchorage is available in Sabang Bay in depth of 9.0 m lowest water spring-tide (LWS). Facilities in the port are shown in ***Table 4.38.***

The port also provides facilities for ship repairs, which include one floating dock with a lifting capacity

Table 4.34. Facilities in the Port of Blang Lancang, Aceh Province, Indonesia.

	Length (m)	Depth (m)	Maximum Size of Vessel (dwt)	Cargo	Storage	Equipment	Supplies	Main Function
LNG North	760	14	70,000 (13 m d., loa 300 m)	LNG	Only available for PERTAMINA materials	Cranes: maximum capacity 150 t	Bunkers: not available; water: available	
LNG South	760	14	70,000 (13 m d., loa 300 m)	LNG				
LPG	260	14	65,000 (13 m d., loa 255 m)	LPG				
Cargo Dock	300	6	loa 150 m, 6 m d.	Materials for PERTAMINA				
MBM	275	30	100,000 dwt (loa 275 m)	Condensates (light crude oil)				Tanker terminal
SBM	-	30	280,000 dwt	Condensate				Tanker terminal

Table 4.35. Facilities in the Port of Pekan Baru, Riau Province, Indonesia.

	Length (m)	Depth Alongside (m)	Storage	Equipment
Iron jetty	55	5	Warehouse 1,900 m^3 and other storage of 2,700 m^3	Cranes: one 7.5 t capacity; two 5 t capacity; and two 2.5 t capacity
Concrete jetty	40	5		

Table 4.36. Facilities in the Port of Pulau Sambu, Riau Archipelago, Indonesia.

	Length (m)	Depth Alongside (m)	Activity	Storage	Equipment	Supplies
No. 5 cargo wharf	19	2.6	Cargo	None	10 t mobile cranes	Bunkers: all grades available from shore tanks; water: available only for terminal users
No. 6 cargo wharf	27	3.0	Cargo			
No. 1 oil wharf	110	9.0	Tanker terminal			
No.3 oil wharf	105	8.5	Tanker terminal			

Table 4.37. Facilities in the Port of Lhok Nga, Aceh Province, Indonesia.

	Length (m)	Depth Alongside (m)	Equipment	Supplies
Concrete quay	125	10	One mobile crane of 10 t capacity	Bunkers: available; freshwater: available

Table 4.38. Facilities in the Port of Sabang, Aceh Province, Indonesia.

Berth	Length (m)	Depth LWS (m)	Storage	Supplies
Passenger berth	48	9.0	6 transit sheds each with a capacity of 2,500 t; No refrigeration space	Freshwater available at about 45 t/day.

Table 4.39. Facilities in the Port of Asahan, North Sumatra, Indonesia.

	Length (m)	Depth Alongside (m)	Largest Vessel	Storage	Equipment	Supplies
Teluk Nibung Terminal (iron jetty)	200	2 at LWT	4,000 dwt, 50 m loa, 4.0 m d.	3,100 m^2	No cargo handling equipment	Bunkers: not available; water: available, but should be chlorinated or boiled before drinking

of 1,500 t, owned and operated by the Indonesian navy.

Entrance to the port is from the northerly direction of the Sabang Bay. The Pulau Klah light buoy acts as a guide to vessels berthing at the port. The channel depth varies from 15 to 30 m. Pilotage service is not available.

Cargo worked is 160 t/day. It has been developed as a free port and already has adequate berthing capacity for tourist ships, but may need additional facilities for passenger terminals depending on the volume of tourism.

Asahan. The approach to the port is through a channel which is about 18 m wide and has a depth of 2.5 m at the lowest water spring-tide (LWS). Facilities of the port are shown in ***Table 4.39***. There are no ship repair facilities in the port.

Private Ports. There are a number of private ports in Northern Sumatra, Indonesia. Each handles special type of bulk cargo, mainly industrial products or raw materials. ***Table 4.40*** lists the locations of these ports and the companies that own the ports, including goods or cargo the ports handle.

Other ports that are located in the Straits of Malacca are Tanjung Balai/ Teluk Nibung, Pangkalan Brandan, Pangkalan Susu and Kuala Tanjung. Their overall facilities are shown in *Table 4.41*.

Table 4.40. Private Ports in Northern Sumatra, Indonesia (Ministry of Transport and Communications, Indonesia, 1994).

Name of Company	Location of Port	Goods Handled
P.T. Semen Andales	Lhok Nga	Bulk and bagged cement
P.T. Arun	Lhokseumawe	Liquefied natural gas
P.T. Asean Aceh Fertilizer	Kreung Guekeh	Fertilizer
P.T. Pupuk Iskandar Muda	Kreung Guekeh	Fertilizer
Mobil Oil Indonesia	Blang Langcang	Liquefied natural gas
Mobil Oil Indonesia	Lhok Sukon	Heavy equipment and capital goods

Table 4.41. Development of Sea Transport Facilities in North Sumatra Province, 1989-1995 (Humas Sekwilda Propinsi Sumatra Utara, 1995).

Facilities	1989/1990	1990/1992	1992/1993	1993/1994	1994/1995
Ports (units)	21	21	21	21	21
Quays (m^2)	75,335	77,013	77,788	82,263	83,975
Terminal (m^2)	1,500	1,500	1,500	1,820	1,985
Warehouses (m^2)	71,576	100,576	100,576	100,976	102,876
Lighthouses (number of units)	40	40	41	42	44

Riau Province has some 40 sea ports, although most of them are small. Eight among them have important positions as export-import harbors. *Table 4.42* shows their facilities.

In recent years, as a result of the SIJORI growth triangle concerted development efforts, the volume and value of exports from Batam have increased substantially. If in 1990 the volume of Batam exports was only less than 30% of the Riau Province exports, in 1995 the situation was reversed. The value of exports from Batam was than 70% of the overall Riau Province export. Similarly, there was also an impressive increase in the number of tourists and visitors to Batam was by air, as well as by sea, in particular from Singapore and Malaysia. Therefore, in the overall development plan, the Batam port facilities have been expanded and improved. *Table 4.43* shows the existing port facilities (1995).

Indonesian port development plans. The Government of Indonesia has a port development plan for Northern Sumatra to be carried out in REPELITA VI, Indonesia's sixth five-year plan. Included in the plan are improvements to Lhokseumawe Port's container handling facilities. The private ports listed in *Table 4.40* will serve the proposed development around Lhokseumawe. They would be served by a proposed rail reconstruction project and an upgraded road system.

Shipping services from Belawan (Indonesia) to Malaysian ports. Shipping services from Belawan to Malaysian ports are limited. Services to Aceh are non-existent. The existing cargo service between Belawan and Penang consists of wooden vessels that take about 14 hours to reach their destination. These provide the only transport services for fresh produce to Penang. Because the boats have no refrigeration and there are no refrigeration facilities at Belawan, the combination of lengthy transport times, poor packaging,

Table 4.42. Facilities in the Important Sea Ports in Riau Province, Indonesia (Regional Investment Coordinating Board of Riau Province, 1989).

Name of Sea Port	Facilities Available						
	Pier (m)	Warehouse (m^2)	Stack (m^2)	Crane (unit)	Fork-lift (unit)	Boat Type (unit)	
						Tow	Pilot
Pekan Baru	1,920	3,375	3	10	-	9	1
Dumai	9,554	4,803	3	6	-	6	1
Tanjung Pinang	2,854	2,450	1	2	1	2	-
Selat Panjang	1,120	-	-	-	-	-	-
Tembilahan	-	300	-	-	-	2	-
Rengat	600	375	-	-	-	-	-
Bengkalis	600	-	-	-	-	-	-
Bagan Siapi-api	-	-	-	-	-	-	-

Table 4.43. Existing Conditions and Planned Sea Port Facilities in Batam Island (BIDA, 1995).

Data	Condition	Sekupang	Batu Ampar	Kabil
Berth Capacity (dwt)	Existing Condition	10,000	35,000	35,000
	Final Condition	15,000	35,500	150,000
Berth Length (m)	Existing condition	177	1,100	400
	Final design	1,200	3,600	5,500
Basin Depth (m)	Existing condition	11	14	14
	Final design	12	14	18
Open Storage (m^2)	Existing condition	116,100	214,000	100,000
	Final design	143,600	230,950	-
Warehouse (m^2)	Existing condition	42,200	19,500	1,890
	Final design	92,950	208,950	-

inadequate storage and poor handling affects the quality and the price of perishable cargo. If transport of perishable goods from Aceh to Malaysia is to take place, Lhokseumawe will need cold storage facilities. Weh Island (Sabang Port) has potential as a tourist attraction. While most port facilities in place are adequate for the present demand, if tourism is to be developed further, passenger terminals will be needed.

Constraints to regional cooperation in the shipping sector. Indonesia bans the import of new, used or reconditioned vessels which means that the use of modern fishing vessels and ferry vessels is prevented. This ban was originally introduced to encourage a domestic boat-building industry which never materialized due to the absence of required forward and backward linkages. The ban has made Indonesia uncompetitive in the provision of ferry services between Malaysia and Indonesia. The fact is that three of the four companies providing services on the route are Malaysian companies and the fourth is an Indonesian government-owned corporation.

Northern Sumatra's trade with Malaysia accounted for about 16% of Indonesia's total trade with Malaysia in 1992. Excluding gas and oil exports, Malaysia received 1.6% of Aceh's and 4.7% of Northern Sumatra's exports. Exports of fresh vegetables are expanding more rapidly than exports of other commodities. Northern Sumatra exports about 200,000 tons of fresh vegetables yearly to Malaysia and Singapore, which accounts for at least 75% of the total fresh vegetable sales.

Malaysia

The Straits of Malacca forms a main transport channel for Malaysia. About 75% of the total foreign trade of Malaysia is shipped through the Malacca Straits and the economic activity of the country is concentrated mainly in the West Coast states of Peninsular Malaysia that border the Straits. It is not surprising that the major ports of Malaysia are also found along the Malacca Straits together with other infrastructure such as roads, railways, airports, shipyards and facilities associated with import/export activities. The location of major commercial ports along the West Coast of Peninsular Malaysia is shown in ***Figure 4.11***. The following describe the activities and development of these Malaysian ports.

Port Klang. Port Klang is the largest port in Malaysia, handling about 30% of Malaysia's total shipborne cargo. The port has three gateways: South Port, North Port and West Port (***Figure 4.13***). The South and North Ports together encompass a total area of 296 hectares (South Port, 48 ha; North Port, 248 ha) and have a total berth length of 5 km. The West Port is undergoing development which when completed will increase the total berth length of Port Klang to 16 km. The port is well-located and connected to road networks in Peninsular Malaysia (***Figure 4.14***).

All of the port's operational services have been privatized in line with the Government's privatization policy. The Klang Container Terminal Bhd. in the North Port is the first privatized container terminal in the country. Klang Port Management Sdn. Bhd. operates 22 berths at South and North Ports, as well as the dockyard and the pilotage service Klang Multi Terminal Sdn. Bhd. operates at the West Port. Port Klang has a free commercial zone status to further aid its development into a regional distribution center. The Cabotage Policy has been amended to encourage foreign shipping lines to consolidate cargo traffic in Port Klang and the equity participation of foreign ships has been increased to 70% to make it attractive for foreign shipping lines to set up regional offices. Freight forwarders are encouraged to play a more enhanced role to encourage CIF (cost, insurance and freight) exports.

Port Klang has facilities for catering to a diverse range of cargo, including containerized, breakbulk, liquid bulk, dry bulk, hazardous cargo and LPG. Within

the port there are many marine services such as bunkering, ship chandlers and supplies, ship repairs and seamen's facilities.

Port Klang has two container terminals located at the North Port, with a third one being planned at the West Port. Facilities provided by these container terminals are listed in *Table 4.44*.

There are two dry bulk cargo terminals, one at the North Port and the other at the South Port that can handle a variety of dry cargoes. Facilities provided by these terminals are presented in *Table 4.45*.

There are liquid bulk terminals both at the North Port and the South Port. Facilities provided by these liquid bulk cargo terminals are indicated in *Table 4.46*.

There are two breakbulk cargo terminals, one in the North Port and the other in the South Port. Facilities found in these breakbulk cargo terminals are shown in *Table 4.47*.

Figure 4.13. Location and Approaches of the Three Base Ports of Port Klang (Annual Report of the Authority of Port Klang, 1995).

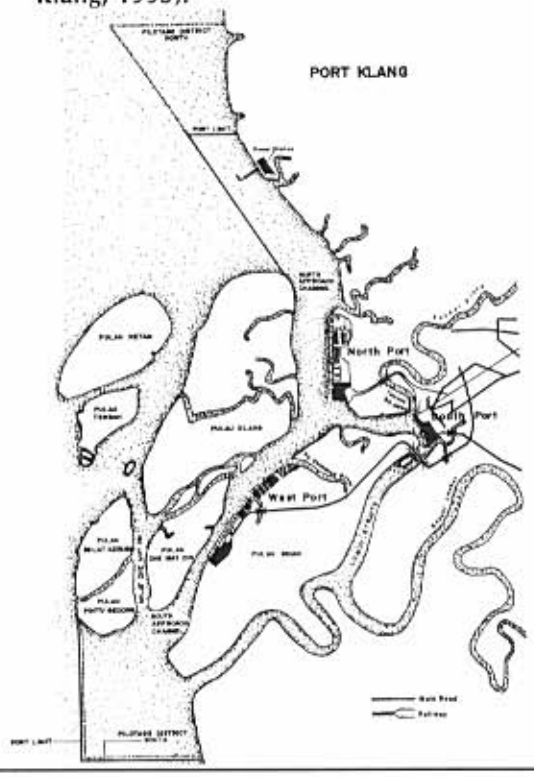


Figure 4.14. Road Networks in Peninsular Malaysia and Port Klang (Annual Report of the Authority of Port Klang, 1995).



The number of ships visiting Port Klang increased steadily from around 5,440 ships per year in 1990 to 7,286 ships annually in 1994 (*Figure 4.15*). *Table 4.48* provides a breakdown of the ships according to the cargoes they carried and their tonnages. Most of the ships visiting Port Klang are foreign-going liners while a sizable portion of them engaged in local trades.

The total cargo throughput in 1994 was 33.858 million tonnes, showing a 10% increase from the previous year. The greatest increase has been in the container throughput which reached 943,846 TEUs in 1994, increasing by 22.3% over the previous year. *Figure 4.16* shows the increases in the different types of cargo throughput from 1990 to 1994.

The major container throughput consisted of manufactured goods, electrical equipment and textiles. Non-containerized

Table 4.44. Facilities Provided by Container Terminals in Port Klang (Annual Report of the Authority of Port Klang, 1995).

Container Terminal	Berth Number	Length (m)	Depth Alongside (m)	Max. Vessel Size (displacement tonnes)	Berthing Facilities	Storage Facilities	Facilities/ Equipment
Klang Container Terminal Bhd (KCT)	8	213	10.5	40,000	Container berth; roll-on-roll-off berth for stern ramp vessels[1]	Stacking area of 30.5 ha with a total ground slot for 7,305 TEUs. Additional ground slots for 1,541 TEUs are available at the wharf area, CFS and open yard. Reefer points for 212 TEUs are also provided. Total warehouse space is 24,000 m².	8 quay cranes of up to 40.6 tonnes lifting capacity (additional 2 post-Panamax crane are on order) RTGs and straddle carries to handle up to 1.05 million TEUs.
	9	320	13.2	60,000			
	10	320	13.2	60,000			
	11	226	13.2	60,000			
Klang Port Container Terminal (KPCT)	19	213	13	60,000		Container yard of 24 ha, with 3,668 ground slots 90 reefer points and CFS of 6,445 m²	
	20	213	13	60,000			
	21	213	13	60,000			

[1] The roll-on-roll-off berth is used for handling vehicles, timber packs and other uncontainerized cargo. The ramp is 45 m long and 8 m wide, with a maximum gradient of 1:10 at tides between +0.3 and +5 m.

categories included iron and steel, timber, palm oil and bulk commodities, such as wheat, sugar, fertilizer and coke. The number of motor vehicles going through Port Klang has also increased significantly with the success of the national cars overseas (Annual Report of the Authority of Port Klang, 1995). The manufactured cargoes handled by Port Klang from 1990 to 1994 are shown in *Figure 4.17*. There is a steady increase in the total amount of manufactured cargoes handled by the Port, from 6.234 million FWT

Table 4.45. Facilities of Dry Bulk Cargo Terminals in Port Klang, Malaysia (Annual Report of the Authority of Port Klang, 1995).

Dry Bulk Cargo Terminal	Berth Number	Length (m)	Depth Alongside (m)	Maximum Vessel Size (displacement tonnes)	Major Commodities Handled	Facilities/ Equipment
North Port - Dry Bulk Terminal	24	213.0	11.0	45,000	Export: palm kernel expellers Import: sugar, maize, feedmeal, cement	Two bulk handling cranes; conveyor system running the length of the berths to 4 bulk warehouses onshore
	25	213.0	11.0	45,000		
South Port - Dry Bulk Terminal	4	148.3	10.3	20,000	Import: wheat,[1] maize, feedmeal	Suction units for discharge of wheat

[1] The wheat is transferred from terminal to a private flour mill at rear of berths 3 and 4. The average discharge rate is 1,800 tonnes/day.

Table 4.46. Facilities Provided by Liquid Bulk Cargo Terminals in Port Klang, Malaysia (Annual Report of the Authority of Port Klang, 1995).

Liquid Bulk Cargo Terminal	Berth Number	Length (m)	Depth Alongside (m)	Maximum Vessel Size (displacement tonnes)	Major Commodities Handled	Equipment Available	Major Companies within Terminal
North Port - Liquid Bulk Terminal	22	213	11.5	60,000	Refined vegetable oil, chemical, petroleum products, diesel oil, industrial fuel, and unleaded gasoline		Petronas; B.P. Products; FIMALY BULKING SERVICES (operates a common-user facility for edible oils, oleochemicals and industrial chemicals); FIMA-DEB BULKING (provides a common-user facility for bulk latex)
	23	213	11.5	60,000			
South Port - Liquid Bulk Terminal	1	176.7	11.3	40,000	Exports: palm oil, coconut oil, and latex	Pipelines for export loading of palm oil, coconut oil and latex	
	2	176.7	11.3	40,000			
	3	176.7	11.3	40,000			
	4	146.3	10.1	20,000			

Table 4.47. Facilities Provided by the Breakbulk Cargo Terminals in Port Klang, Malaysia (Annual Report of the Authority of Port Klang, 1995).

Breakbulk Cargo Terminal	Berth Number	Length (m)	Depth Alongside (m)	Ship Size (displacement tonnes)	Main Commodities Handled
North Port - Conventional Breakbulk Cargo	12	176.7	9.5	30,000	CKDs, iron and terminal steel, newsprint, primary commodities such as rubber
	13	176.7	9.0	30,000	
	14	176.7	9.0	30,000	
	15	244.0	11.5	60,000	
	16	213	11.5	60,000	
	17	213	11.5	60,000	
	18	213	11.5	60,000	
South Port - Conventional Breakbulk Cargo Terminal	3	176.7	10.1	20,000	Conventional cargo and palm oil
	5 (coastal berths)	106.6	6.0	6,000	
	6 (coastal berths)	106.6	5.5	6,000	
	7 (coastal berths)	94	5.5	6,000	
	7A (coastal berths)	94	5.5	6,000	

Figure 4.15. Number of Ships Visiting Port Klang and Their Tonnages (Annual Report of the Authority of Port Klang, 1995).

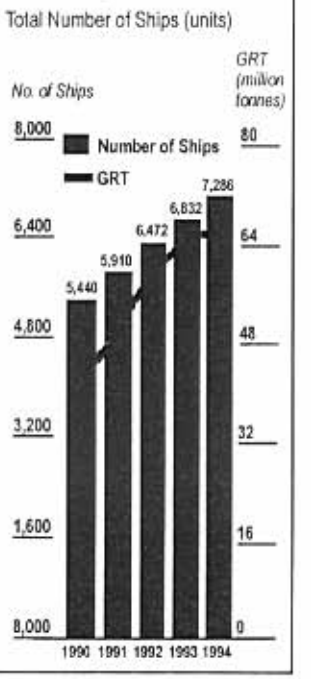


Table 4.48. Number of Ships Visiting Port Klang, Types of Cargo Carried and Tonnages (Annual Report of the Authority of Port Klang, 1995).

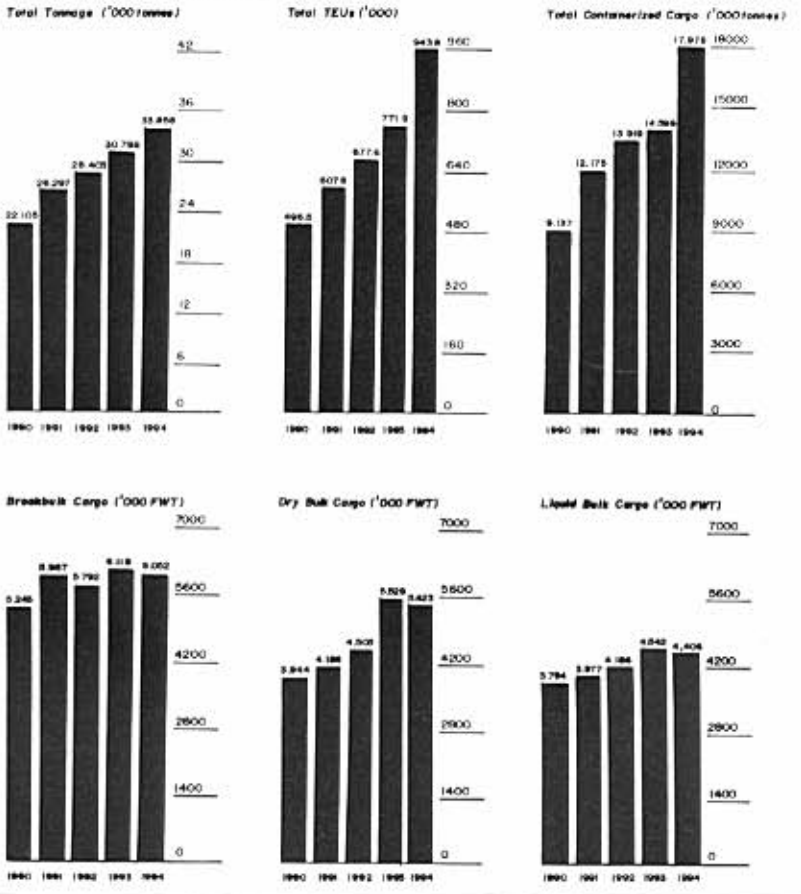
Types of Cargoes/ Trades	Number of Ships			GRT (tonnes)		NRT (tonnes)	
	1993	1994	% Change	1993	1994	1993	1994
(A) Types of Cargoes							
Container	2,556	2,393	-6.4	35,709,197	34,259,849	17,639,824	17,297,676
Liquid bulk	1,228	1,230	0.2	8,100,436	7,216,302	5,274,518	4,155,127
Dry bulk	513	510	-0.6	5,229,076	5,424,399	3,199,651	3,336,532
General breakbulk	2,031	2,121	4.4	13,213,367	14,810,653	7,305,687	8,210,978
Others	504	1,032	104.8	3,966,255	6,883,454	1,840,537	3,231,460
Total	6,832	7,286		66,218,331	68,594,657	35,260,217	36,231,773
(B) Types of Trades							
Foreign going	5,171	5,474	5.9	61,138,266	64,482,697	32,788,066	33,942,864
Local trade	1,661	1,812	9.1	5,080,065	4,111,960	2,472,151	2,288,909
Total	6,832	7,286		66,218,331	68,594,657	35,260,217	36,231,773

in 1990 to 14.817 million FWT in 1994. Export cargoes also showed increases over the period of 1990 to 1994, slightly higher than imported cargoes in 1994 (*Figure 4.17*).

Southeast Asian countries are the major trading partners of Malaysia; the proportion of cargoes handled in Port Klang to these countries was about 32.6% of the total amount of cargoes handled in 1994, followed by countries in the Far East (28.7%) and European countries (14.9%) (*Figure 4.18*).

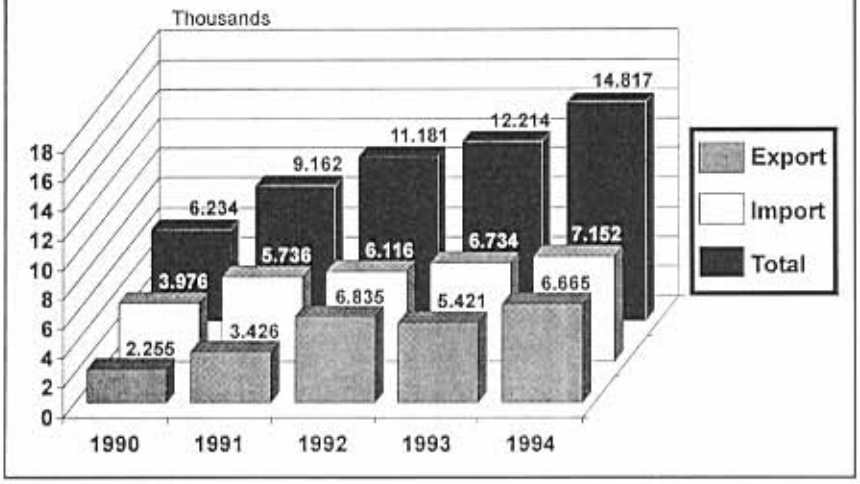
The long-term development of port facilities is aimed at facilitating the country's trade. The

Figure 4.16. Types and Volumes of Cargo Handled in Port Klang, 1990-1994 (Annual Report of the Authority of Port Klang, 1995).



development of the port facilities is supply-driven and the long-term port implementation projects are specifically designed to meet the 88 million tonnes of cargo traffic projected to be handled by the year 2010. Cargo traffic through the port is predicted to be 59 million tonnes by the year 2000, increasing to 73 million by 2005 and 90 million by 2010. Containerized cargo is predicted to be the fastest growing sector of the port's cargo traffic. In 1992, 70% of the port's containerizable cargo were brought in by containers. The percentage is projected to increase to 77% by the year 2000 and 84% by 2010. Container throughput is forecasted to reach 1.2 million TEUs by the turn of the century and manufactured products are expected to become the major export commodity. Currently 35% of the port's total traffic consists of manufactured goods; this should increase to 50% by the year 2000. The dry bulk cargo is projected to be over 7.3 million tonnes by the year 2010; the bulk liquid cargo handled will increase to 8.117 million tonnes by 2010; and breakbulk cargo is projected to increase to 7.55 million tonnes by the year 2000.

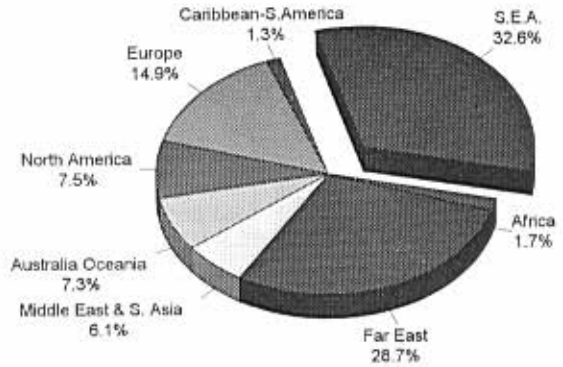
Figure 4.17. Imports and Exports of Manufactured Cargo in Port Klang (Annual Report of the Authority of Port Klang, 1995).



West Port, Port Klang. The development of port facilities is concentrated on West Port, where the development is ongoing *(Table 4.49)*. The port's main focus is on container operations, however, it will also have facilities for dry bulk, liquid bulk, LPG, cement, as well as general cargo. When fully developed, West Port will have 30 berths stretching along 11 km and back-up facilities on 510 ha of land. All berths will be able to accommodate ships of up to 80,000 tonnes displacement and the depth alongside will be between 14 and 17 m. West Port will have terminals for container, dry bulk and liquid bulk cargo and general cargo.

According to the Annual Report 1995 published by the Authority of Port Klang, three container/general cargo berths and two petrochemical berths were scheduled to be operational. Another four container/general cargo berths, two dry bulk berths and one LPG jetty will be operational in stages between July 1995 and December 1995. Further development will provide additional berthing facilities for container, dry bulk, liquid bulk and general cargoes. To allow for this throughput, four additional dry cargo berths will be provided, two of which will be operational in 1995 and the other two by 1996/1997. To meet this increase, five additional liquid bulk berths will be provided in West Port.

Figure 4.18. Origin and Destination of Cargoes Handled in Port Klang (Annual Report of the Authority of Port Klang, 1995).



The following terminals are planned for development in the West Port of Port Klang:

West Port - LPG Terminal: The single berth LPG Terminal will be built on 6 ha of land and will be operated on a common-user basis. Facilities will include 6 LPG spheres of 1,200 MT capacity, LPG filling sheds and loading bays. Safety standards will be in accordance to MS830 and the National Fire Prevention Association (NFPA).

Table 4.49. Scheduled Development of West Port Facilities in Port Klang (Annual Report of the Authority of Port Klang, 1995).

West Port Project Phase I and Phase II	Completion Date
3 general cargo/container berths	October 1994
2 warehouses	December 1994
2 general cargo/container berths	
Main Fire Station, Gate Complex, other buildings	April 1995
3 dry bulk berths	
3 transit sheds	June 1995
3 container/general cargo berths	November 1995

The LPG terminal will commence operations by December 1995. Projected volume is 120,000 tonnes, increasing to 245,000 tonnes by 2000.

West Port - Liquid Bulk Terminal: This terminal is developed for petroleum and petrochemical installations. The land area is 76 ha. Two berths will be commissioned by October 1994 to meet the projected volume of 1.8 million tonnes by the year 2000. Another two berths will be provided under the next phase of development.

West Port - Dry Bulk Terminal: This is being developed with four berths on 40.5 ha of land. The main dry bulk commodities handled will be cereals, fertilizers, feedmeal and scrap iron. The first two berths will be operational by July 1995. Conveyor belt systems and high speed bulk cranes will be on a common-user basis. Capacity of the cranes will be 1,000 tons/hour for fertilizer and 750 tons/hour for scrap iron. Operators will be permitted to build their own dry bulk warehouses.

West Port - Container/General Cargo Terminal: Initially seven container/general cargo berths will be constructed to meet the projected general cargo traffic of 13 million tonnes up to 2010. Three berths will be operational by October 1994 and another four, in stages by December 1995. The first 7 berths will be developed on 60 ha of land. Other planned facilities include transit sheds, warehouses and open yards.

A 1,600 hectare marine industrial park, located just north of the North Port, is being planned by HICOM (Heavy Industries Corporation of Malaysia) and the Selangor State Development Corporation. This will offer facilities, such as ship building, ship repair, building of oil rigs and other marine engineering services. Another industrial park adjacent to the West Port will be developed by a consortium of companies. Port Klang is not limiting its development to cargo traffic but is also developing a specialized passenger terminal, the first phase of which is scheduled to be completed in 1996. The Government will encourage private enterprises in the operation of the cruise center.

Entry to Port Klang is via two channels—North Channel and South Channel. Both channels allow for two-way traffic and for night navigation. Berthing and unberthing of ships are unrestricted. The Klang Port Authority maintains a dredged depth of 11.6 m and a width of 153 m in the North Channel; and a depth of 12.5 m and width of 366 m in the South Channel. Pilotage within the port's pilotage district is compulsory. For vessels entering via the North Channel, the pilot boarding ground is abeam of Pulau Angsa and for the South Channel it is south of Pintu Gedong. The ship's arrival at Port Klang should be notified at least 72 hours prior to arrival. Once the ship's estimated time of arrival is confirmed, the ship's agent is required to book the pilot through the control office at least four hours prior to the vessel's arrival. The ship master then needs to cable "Pilot Port Klang" giving the estimated time of arrival at the pilot boarding ground. For ships departing from the port, the pilot service needs to be booked two hours prior to departure. VHF radio communication with the port can be established on VHF Channels 12, 14 and 20.

For increased navigational safety in the harbor area, a vessel traffic management system (VTMS) is being set up by the Port Authority which will be operational in 1997. This will tie up with the Malaysian Government's Straits surveillance system of tracking movements of vessels along the Straits of Malacca. The VTMS will monitor shipping within the port's pilotage district, detect pollution and assist in navigation at times when the visibility is restricted. The port operators are obliged to provide dedicated warehouses for the storage of dangerous cargo. A new computerized system for the declaration of hazardous cargo has been set up. In line with the Government's policy of centralizing handling of petrochemicals away from built-up residential areas, petroleum companies are in the process of moving to the West Port.

Penang Port. About 6,043 vessels totalling 14,362,271 tonnes visited the Penang Port in 1993. In the same year, the port handled 330,922 TEUs of cargo. The principal imports arriving at the port included: petroleum products, fuel oil, fertilizers, paper

products, manufactured goods, grains and raw sugar. Exports from the port included: palm oil, rubber, manufactured goods and electrical equipment. Penang Port has three base ports. The facilities provided in these base ports are shown in ***Table 4.50***.

Penang Port has three container berths with a total quay length of 497 m. Equipment include 4 gantry cranes of 30 to 40 t lifting capacity each, 12 transfer cranes, 8 two trailers, 29 prime movers and 122 reefer points. The container marshalling yard covers an area of 15.8 ha (10,800 TEUs at any one time). There are also two container freight stations covering an area of 11,892 m^2.

Three privately owned oil jetties are operated by Shell and Esso at Butterworth and Caltex at Prai. Petronas operates at the Bulk Cargo Terminal facilities.

LPG is handled at the Bulk Cargo Terminal via pipelines to private tank farms located outside the terminal.

Bunker services are available from jetties of Shell, Esso and Caltex. Limited quantities of fuel can be supplied by barges to vessels in the Port.

The North Butterworth Container Terminal (NBCT), which is now under construction, is expected to be operational by April 1995. Under the Port Master Plan, the NBCT Phase 2 Plan is expected to be operational after 1997 and will increase the total capacity to 754,000 TEUs. Under Phase 3 of the Plan, capacity will be increased to more than 1 million TEUs per year. By Phase 2, all container operations will be handled at the NBCT and Butterworth Wharves will be expected to handle breakbulk cargo. A new dangerous cargo complex is also being proposed at a site in North Butterworth. Penang Port may face increasingly serious congestion, especially for container and bulk cargo if the current port expansion plans are not implemented as scheduled. The port may have difficulty in handling traffic beyond 500,000 tons. The port is also hampered by the absence of a rail link to the NBCT as well as a direct road link to the North-South Expressway (NSE) in Peninsular Malaysia.

Malacca Port. Malacca Port was privatized in November 1992. Activities in Malacca Port are centered in two areas, Tanjung Bruas Port and Malacca River lighterage port. Tanjung Bruas Port is a T-shaped jetty for ships of up to 124 m long and 10,000 dwt. The River lighterage port is located at the mouth of

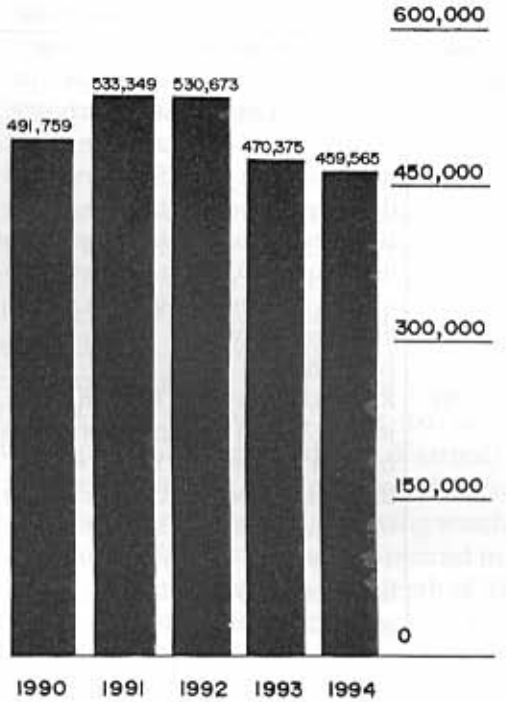
Table 4.50. Facilities in the Base Ports of Penang Port, Malaysia.

Base Port	No. of Berths	Berth Length (m)	Depth (m)	Max. Vessel Size (displacement tonnes)
Butterworth Wharves	3 transit sheds totalling 8,581 m^2, 5 storage go-downs totalling 19,510 m^2, one timber shed of 4,738 m^2 and open storage for timber of 5,092 m^2, and 122 reefer points for reefer containers	Four gantry cranes of 30-40 t capacity, 12 transfer cranes, 2 reach stackers, and 5 front-end loaders		
Container Berth	3	497	9	35,000
Breakbulk Berth	3	542	9	33,000
Vegetable Oil Tanker Pier	1 (dolphin berth)			39,000
Swettenham Pier	Two transit sheds totalling 4,464 m^2 and storage go-downs (including cold room facilities) of 10,661 m^2	Cranes can be hired from private operators. Forklifts are provided by private operators		
Breakbulk Berth	2	366	10	20,000
Prai Bulk Cargo Terminal	10 storage go-downs totalling 66,100 m^2 and 5 privately owned storage go-downs of 33,969 m^2 Open stockpile area of 4.7 ha	1 luffing crane of 12.5 t capacity and one gantry crane of 300 t/h		
Dry and Liquid Berths 1 & 2	1	140	10	33,000
	1	198	10	66,000
Inner Berth	1	154	7	13,000

the Malacca River. Ships are anchored 2 km offshore with the assistance of private junks for entering the port.

The cargo throughput in the Malacca Port decreased since 1992 (***Figure 4.19***). About 97% of the total cargo throughput are for export. The major commodities handled in the port include maize (45%), gas and lubricating oil (4%), soyabean meal (3%), salt (10%) and steel (17%).

Figure 4.19. Cargo Throughputs (tonnes) in the Malacca Port, 1990-1994.



Port Dickson. Port Dickson has relatively well-developed oil tanker terminals and LPG terminals for handling the petroleum products produced by the nearby refineries. ***Table 4.51*** lists the facilities and major commodities handled in these terminals.

The deepwater channel from NW is marked by 5 IALA system buoys. Pilotage is compulsory for vessels berthing and unberthing at the Railway Jetty and at the Tanker Mooring Buoys. Private pilotage service arrangements need to be made. Vessels making use of the Shell or Esso facilities can make private pilotage arrangements with these companies that operate such services. A mooring master boards tankers at Banbeck Scoal Buoy. All vessels are required to report their arrival and departure to the Marine Department via VHF Channel 16. Vessels must inform their expected time of arrival 96 and 24 hours in advance. Shell Oil Terminal can be reached on VHF Channels 9 and 16; cargo operations are communicated on VHF Channel 9. Towage is by local tug boats, no lighterage is available.

Ipoh Cargo Terminal (ICT). The Ipoh Cargo Terminal (ICT) is an inland port or "dry" port with all necessary facilities and logistical services as provided by any seaport. The port was developed by the Klang Port Authority to provide traders based in the northern Peninsular Malaysian state of Perak an alternative in the choice of ports for doing business. The services available at the ICT include cargo handling, warehousing, open storage, port services, documentation and clearance, shipping arrangements such as freight arrangements, customs brokerage, insurance coverage and cargo consolidation. The container yard space at ICT includes 1.6 ha for heavy stacking, 2 ha for emptiers and 0.4 ha of open storage area. Existing equipment in the ICT include forklifts, cranes and container trailers. The ICT can handle 1,000 laden and 500 empty containers, as well as 10,000 tons of breakbulk cargo per month.

The ICT has maintained a strong growth since its opening in November 1989. The amount of cargoes handled by the ICT increased phenomenally since 1990, from 10,127 tonnes in 1990 to 30,438 tonnes in 1994 (***Figure 4.20***).

Table 4.51(a). Facilities and Commodities Handled in Various Terminals in Port Dickson—LPG Terminals.

Terminals	Description	Major Commodities Handled	Storage Facilities	Equipment
(a) LPG Terminals Railway Jetty	Stone pier, 182.9 m long and 45.71 m wide with 'T'-shaped head which is 7.92 m alongside	- Discharge of empty LPG cylinders and loading of full ones for export to Sabah - General cargo imports - Livestock exports to East Malaysia - At high water used by lighters	Customs warehouse; no refrigeration space	Privately owned cranes can be hired

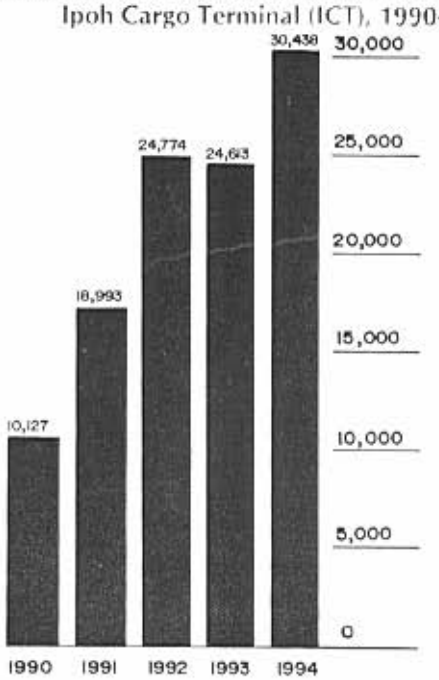
Table 4.51(b). Facilities and Commodities Handled in the Various Terminals in Port Dickson—Tanker Terminals.

Terminals	Description	Depth Alongside	Maximum Vessel Size	Storage Tanks	Equip-ment	Supplies	Berthing
(b) Tanker Terminals Shell Jetty	213.4 m long concrete jetty, with head 51.81 m by 10.97 m with 4 dolphins. The distance between between the inner dolphins is 182.9 m, and between the outer dolphins is 304.8 m	7.92 m (the depth on approach is also the same). Sand and mud bottom. Underkeel clearance requirement is 0.91 m	152.4 m length. Unrestricted beam. Depth 6.40 m About 18,000 dwt.	1,000 t fuel oil 1,400 t diesel 700 t mogas 600 t kero 1,000 t slop tank 1,700 t dirty ballast tank	Spill boom	Freshwater supplied at approximately 20 t/hr. Bunkering at 150 t/hr (can supply fuel oil and petrol but no marine diesel)	Berthing normally during daylight hours. Vessels up to 121.9 m can be handled at any tide state, vessels above this size requiring to swing are handled only on flood tide
Esso Jetty	Reinforced island jetty, 67.05 m by 7.31 m. The distance between inner buoys is 106.7 m and between buoys is 190.2 m	10.67 m (depth on approach is 12 m). Rocky bottom. Underkeel clearance requirement is 0.61 m	109.7 m length. Unrestricted beam. Depth 10.38 m. About 19, 500 dwt	33,000 t white oil; 43,000 t black oil; 100,000 t crude oil; 500 t dirty ballast tank.	Spill boom	Bunkering at 600 t/hr	Berthing during day and night and at any tide state
Esso/Shell Single Mooring Buoy	10.67 m length	27.43 m (minimum depth on approach 17.37 m). Mud and rock bottom	260.3 m length, unrestricted beam, depth 14.9 m 100,000 dwt underkeel clearance requirement	De-ballasting facilities available up to 35,000 bbls cap	Crude oil discharge rate 4,500 t/hour	No facilities for water or bunkering	Berthing at daylight only. Vessels 45,000 dwt can berth at any tide state. Vessels above this can only berth on ebbtide.

There is a 6-day per week rail service between the ICT and Port Klang, as well as a daily train service to Penang Port which takes 14 hours. Bonded warehouse facilities will be made available by mid-1994 for traffic from the two free trade zones in Perak State on the West Coast of Peninsular Malaysia.

Teluk Ewa Port. Teluk Ewa Port is located on the Langkawi Island at the northern entrance of the Malacca Straits. Teluk Ewa Port, which began full operation in September 1984 is designed primarily as a specialized port to handle clinker for a cement plant in the Langkawi Island. The port was granted free-port status in 1987 and is now handling cargoes and petroleum products for vessels below 10,000 dwt. The total amount of cargoes handled at Teluk Ewa Port in 1992 was around 1.6 million tonnes, of which a significant portion was ferried from Kuala Kedah. There is also trade with Kuala Perlis, Penang and Singapore. Existing facilities consist of two bulk cargo berths of 144 m long with a depth alongside of 9 m

Figure 4.20. Cargo Throughputs (tonnes) Handled by Ipoh Cargo Terminal (ICT), 1990-1994.



a significant portion was ferried from Kuala Kedah. There is also trade with Kuala Perlis, Penang and Singapore. Existing facilities consist of two bulk cargo berths of 144 m long with a depth alongside of 9 m and a general cargo berth and oil tanker berth with a combined berth length of 124 m and a depth alongside of 8 m. There is also a subjetty of 150 m for coasters and an open storage area of 15,328 m². The port can handle ships up to 10,000 dwt. There are plans to build a T-jetty out to deeper water to accommodate ships up to 15,000 dwt. This will eventually be expanded to accommodate ships up to 30,000 dwt. The T-jetty will cater primarily to the needs of Kedah Cement, which is expected to double production to 3.0 million tons per year. A feasibility study is underway to develop roll-on roll-off facilities for reefer container traffic, as well as additional facilities for barges. The Langkawi Development Authority is planning to establish a barter trade facility beside the Teluk Ewa Jetty to attract trade with Thailand, Myanmar and possibly Indonesia.

Kuah Jetty. Kuah Jetty is located on the Langkawi Island. The Kuah Jetty passenger terminal is being expanded with a new pontoon to accommodate the increasing number of arriving vessels. It is currently capable of accommodating four passenger vessels at any one time.

A number of proposals for a new port at Langkawi are in various stages of planning. A private company has proposed a new general-purpose port at Bukit Malut, fronting the Kuah Jetty by about 15 km, mainly for breakbulk shipments to Kuah. There is also a proposal for a new deep-sea port at Kubang Badak, west of Teluk Ewa, which provides a depth of 8 to 13 m. Another proposal is to develop a new port at Tanjung Gerak to handle liquid bulk and general cargo. It is understood that dredging will be required because of draft limitations.

Lumut Marine Terminal. The Lumut Marine Terminal has facilities to handle both dry and liquid bulk cargoes. It is essentially a privately-owned port in the process of development. The Phase I of the port development will offer a 350 m berth with a depth alongside of 10 m, which will allow berthing of vessels up to 15,000 dwt. The port is expected to serve the needs of 400 ha Lumut Port Industrial Park presently in operation. The Port Sdn Bhd. (a privately-owned company) is involved in a joint venture to develop a port facility in the nearby Satun area.

Presently, the port has two privately-owned terminals in operation with facilities as follows:

- Tanker Terminal (Tasek Cement Bhd.)—Length: 97 m; depth alongside: 10 m; maximum vessel size to berth: 30,00 dwt of 175.26 m and 9.30 m deep.
- Malaysian Flour Mill Wharf—Length: 167 m; depth alongside: 9.3 m. The wharf has two grain discharging units and conveyor belts.

At the entrance of the Port, the water depth can be as shallow as 7.3 m due to the occurrence of sand bars at the river mouth entrance. The depth of the channel to the wharf is around 7.6 m at lowest water spring-tide (LWST); the width of the channel is 70 m. The estimated time of vessel arrival needs to be sent 72, 24 and 12 hours prior to arrival. Communication of ETA (expected time of arrival) can be sent through Penang or Singapore by VHF radio. Royal Malaysian Navy maintains a listening watch on the VHF Channels. Anchorage can be obtained in the vicinity of the pilot boarding area in a depth of 18 m and also along the river at depths ranging from 9 m to 14.5 m. The pilot boards the vessel in position 4°11'N, 100°35'E. The pilot service can be contacted on VHF Channels 16 and 12.

Kuala Kedah. Kuala Kedah is a small riverine port with a passenger terminal. There are plans to build a new passenger terminal, as well as expand the cargo terminal by building a ro-ro facility.

Kuala Perlis. Kuala Perlis is a passenger terminal, as well as a fishing port. Eleven passenger ferries operate daily between Kuala Perlis-Langkawi and Kuala Kedah-Langkawi, providing a total daily passenger capacity of 10,700 persons. Coastal trade between Kuala Perlis and Satun is carried out by around 50 Thai long boats, each capable of carrying 30 to 40 passengers including cargo. Of the total trade between Kuala Perlis and Satun, approximately 90% is import trade consisting of agriculture and fisheries products, forest products and machinery. Export trade is primarily in chemicals and light industry products. Kuala Perlis Port faces congestion because siltation has compromised the draft depth at the Sungai Perlis estuary, causing navigational constraints. No plans currently exist to develop specialized container facilities at any of the minor ports. However, there are proposals to develop a bulk cargo handling facility at Kuala Sanglang as a component of the development at Tanjung Gerak on Langkawi.

Future development of ports in Malaysia. Malaysian ports have been experiencing a rather

long-term planning of port development in Malaysia. The need for proper port planning spurred the MIMA (Maritime Institute of Malaysia) Roundtable Meeting on Port Industry on 18 August 1994. The meeting reached the following conclusions:

- An increase in both cargo volume and competitiveness has exerted pressure on Malaysian ports to improve efficiency and provide more cost-effective services; and
- The development and expansion of ports should be "supply-driven". Ports should be geared to compete for business and also to market their services as efficiently as possible and not act merely as transit points for cargo shipment.

The construction of the Lumut Marine Terminal, the possibility of a new port in Langkawi and the proposed fourth phase of Klang Port's expansion, south of the existing port facilities, constitute part of the future development plans for ports along the Malacca Straits.

Most of Malaysia's major ports, i.e., Penang, Johor and Bintulu, have been privatized. Those ports which have not been privatized, have been incorporated in preparation for their eventual privatization. However, since the government still holds the controlling share in the corporation, there have been few changes at the decision-making level. In spite of privatization, the government still has a valid intervention role in certain areas, especially in relation to the environment, the use of coastal land and the impact on other users. Furthermore, the government regulates the privatized ports.

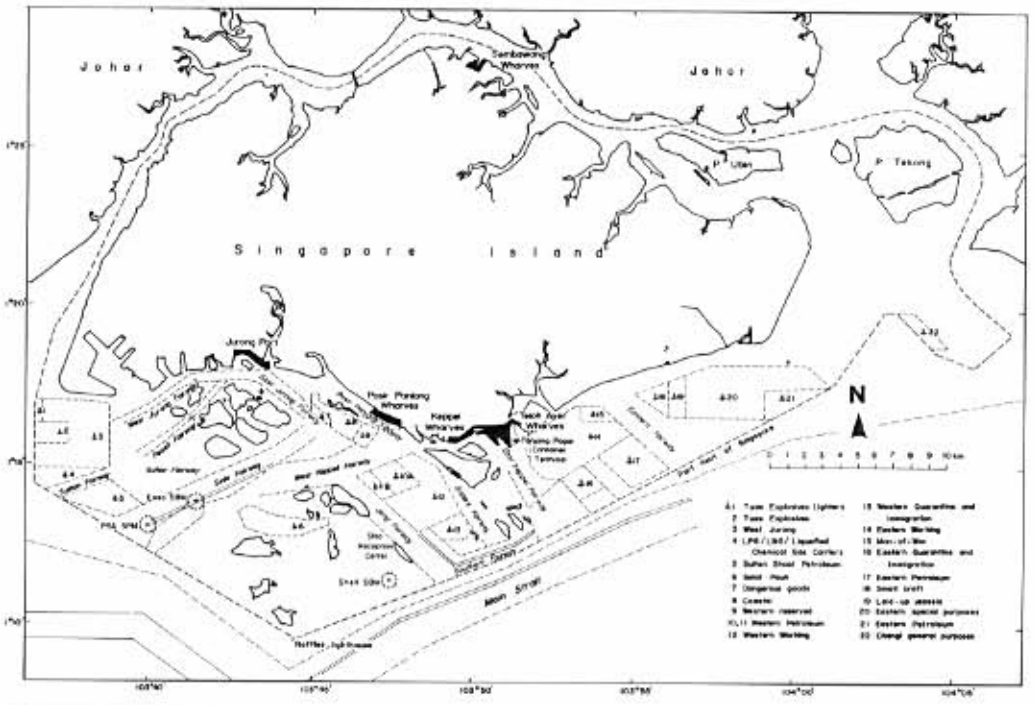
Although there seems to be great potential in Klang Port, internal competition between the various facilities might prevent its emergence as a hub port. It has also been suggested that Johor could also be developed as a transshipment point for specific routes (e.g., vessels en route to and from the Far East). Port Klang could serve other routes, such as to and from Europe.

Singapore

The facilities of the Port of Singapore are shown in ***Figure 4.21***. Singapore Port has five gateways—Keppel Terminal, Tanjong Pagar Container Terminal, Pasir Panjang, Sembawang Terminals and Jurong Port. The port has invested heavily in modern cargo handling facilities. The Pulau Brani Container Terminal will add 10 more quay cranes to the 13 existing ones (Chia, 1992). It began operation in late 1991. The island will be linked to the mainland via a recently completed causeway. There are similar plans 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 mainland by a causeway. Other new facilities will be the passenger terminal at the World Trade Centre (WTC). The Port of Singapore Authority (PSA) has designated all of its port areas as Free Trade Zones (FTZ) with extensive warehouse facilities for storing, stuffing and unstuffing, sorting, grading and repacking goods for re-export. It also provides direct waterfront access to the manufacturing plants, such as flour and grain milling, sawmilling, cement making, fertilizer bagging, iron and steel milling 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 (Chia,1992).

Oil terminals of major international oil companies are located on the coast and on the offshore islands comprising another important part of the activities on the Port of Singapore. Two of the major oil and liquid chemical storage companies are Van Ommeren and Paktank. The former is located on Pulau Sebarok and the latter, which is currently using an ultra large crude carrier (ULCC), will be permanently located on Pulau Busing when the facility is completed. The Petrochemical Corporation of Singapore Pte. Ltd. (PCS) has terminals on Pulau Ayer Merbau to handle the loading and unloading of its feedstocks and other products. Shell operates a storage terminal at Woodlands. Changi Airport has a jetty to serve fuel storage facilities and, unlike most other landing points with bunkering facilities, provides for the ship-to-ship transfer of bunkers and engine oil. The Port of Singapore Authority also operates barges which carry and remove bilge oil from the ships before bringing it to the oil and sludge treatment center (OSTC) on Pulau 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 (Chia, 1992). Singapore is a major center for oil distribution and a bunkering port. 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 (Chia, 1992).

Figure 4.21. Port of Singapore: Fairways, Terminals, Wharves and Navigational Channels in the Vicinity of the Port (Chia et al., 1988).



The port waters have been divided into navigational channels (fairways) and anchorages for various purposes. 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 flying the flag of almost all the maritime nations in the world in the port which means one vessel arriving or departing every 8 minutes. 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 destroy the sea bed. The sea space used for anchorage thus effectively preempts all other users (Chia, 1992). There are about 500 shipping lines linked to nearly all parts of the world (Chia et al., 1988).

Of the total 583 km^2 of port waters, their various uses are distributed as: 18.8% anchorages, 45% fairways, vessel maneuvering areas and unrestricted areas; 5% undersea cables and pipelines; 5% military training grounds; 26.2% other uses (Chia, 1992).

Keppel Terminal (incorporating the Telok Ayer Basin). It has been continually upgraded and transformed to augment the modern container port, the Tanjong Pagar Container Terminal. There are other sea terminals: Pasir Panjang, Sembawang and Jurong. These developments 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 (Chia, 1992). Jurong town is the largest planned industrial area deliberately set up to take advantage of the Port of Jurong which will conveniently serve the industries there.

Since 1986, the Port of Singapore has been rated as the world's busiest port in terms of shipping tonnage and, 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 sea port in Asia (Chia, 1992).

The PSA is a statutory board under the Ministry of Communications and Information (MOCI). The PSA is responsible for administering the port; managing some 583 km^2 of waters within the port limits which cover the major portion of the territorial waters of Singapore, providing and maintaining port facilities and services, regulating traffic and navigation in port; supplying pilotage and promoting the use and development of the port (Chia et al., 1988). The PSA at present operates five main gateways (***Figure 4.20***). These provide berthing facilities to accommodate container ships, bulk carriers, cargo freighters, coasters, lighters and passenger lines with the capacity to handle over 80 million freight tons per year (Chia et al., 1988).

In 1980, the total shipping tonnage of vessels arriving at and departing from the port was 528.8 million GRT (Chia et al., 1988). In 1990 alone, the port recorded a total of 44,600 ship arrivals with a total tonnage of 483 million GRT and a total cargo throughput of 187.8 million freight tons (ft), including 5.22 million ten-foot equivalent units (TEUs) of containers (Chia, 1992). In 1993, the total shipping tonnage of vessels arriving and departing from the port was 623.8 million GRT (Singapore, Department of Statistics, Yearbook of Statistics, 1992; Chia, 1995; Robinson, 1995).

The numbers of ships arriving and departing the Port of Singapore are shown in *Table 4.52*.

The amount of cargoes handled by the port increased over the years as demonstrated in *Table 4.53*.

In 1993, the total amount of cargoes handled by the Port of Singapore increased significantly to 273.7 million freight tons compared to around 105.8 million freight tons in 1985. A breakdown of the cargoes handled in 1993 included: mineral oil—123.5 million freight tons and general/dry bulk cargoes—150.2 million freight tons (PSA, 1994). In 1993, 84% (or 126.2 million tonnes) of the general and dry bulk cargo was containerized cargo; whereas in 1982 only 35% of the cargo was containerized (Robinson, 1994).

It has been estimated that 39 to 40% of the container vessels arriving at the Port of Singapore transit the Straits eastbound and 42 to 43% of the container ships departing the Port of Singapore move westbound through the Straits (Robinson, 1994).

The functions of the Port of Singapore are not only confined to cargo handling. It also has a comprehensive range of marine services, such as providing bunker fuel and ship supplies; oil refining; pilotage and tug; freshwater services; gas-free inspection and fumigation; and slop reception for oil tankers. Environmental control services, such as the cleaning of oil and debris from the sea and fire fighting services are also provided.

There are a total of 70 large and small shipyards, making Singapore one of the major shipbuilding, rigbuilding and ship repair centers of the world (Chia et al., 1988; Chia, 1992). The Singapore Association of Shipbuilders and Repairers (SASAR) which was formed in 1968 has the overall responsibility of developing the marine industry (Chia et al., 1988). 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. The ship repairing sector is the largest in the industry in terms of investment and revenue. Up to June 1983, the ship repairers operated 21 dry docks, two of which were 400,000 dwt in size (*Table 4.54*). The aggregate capacity of 2.8 million dwt represented the heaviest concentration of repair facilities in any major port.

Table 4.52. Number of Ships Calling at the Port of Singapore (PSA, 1986; Chia et al., 1988; Chia, 1995; Robinson, 1995).

Year	No. of Vessels (> 75 GRT)	Volume (million GRT)
1975	41,866	317.0
1976	43,367	351.6
1977	44,018	393.9
1978	44,403	386.0
1979	51,163	456.5
1980	54,061	474.1
1981	56,634	521.0
1982	60,973	554.0
1983	60,515	562.3
1984	57,442	527.5
1985	60,512	528.8
1991	70,345	283.0
1993	92,655	623.8

Figures for 1975-1985 by PSA (1986) and Chia et al. (1988); others by Singapore, Department of Statistics, Yearbook of Statistics (1992), Chia (1995), Robinson (1995).

Table 4.53. Cargoes Handled by the Port of Singapore (Chia et al., 1988).

Year	General and Bulk Cargo by PSA Wharves (freight tons)	Mineral Oil in Bulk (freight tons)	Total (freight tons)
1975	17,900,400	37,317,900	55,218,300
1976	19,335,100	40, 594,800	59,929,900
1977	20,503,600	45,314,200	65,817,800
1978	25,139,000	51,019,400	76,158,400
1979	29,832,000	53,305,500	83,137,500
1980	33,807,700	52,419,800	86,299,500
1981	35,759,300	56,803,700	92,563,000
1982	39,527,200	61,962,100	101,489,300
1983	42,787,900	63,560,500	106,348,400
1984	48,721,700	63,175,600	111,897,300
1985	42,225,200	63,610,600	105,835,800

PSA Wharves include Tanjong Pagar Container Terminal, Keppel Wharves, Pasir Panjang Wharves, Sembawang Wharves, and Jurong Port.

Most of the shipyards in Singapore 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 enviornment since shipyards cause water pollution as a result of bilge cleaning and the use of antifouling paints.

The Port of Singapore has the best facilities in the region for the reception and treatment of slop, sludge, dirty ballast and tank washings in Pulau Sebarok. Located 6 km from Keppel Wharves, the Slop and Sludge Treatment Centre was established in 1972. Facilities at the center include four piers which can accommodate vessels up to 264 m long and 45,800 t displacement and six deslopping barges with capacities ranging from 1,200 to 2,000 m^3 (Chia et al., 1988).

Table 4.54. Dry Dock Capacity in Singapore as of 30 June 1983 (Chia et al., 1988)

Capacity dwt (tonnes)	No.	Total (dwt) Capacity	Remarks
< 5,000	1	4,000	
5,000 - <30,000	6	43,000	One 10,000 dwt floating dock One 10,000 dwt Syncrolift
30,000 - <50,000	4	140,000	One 30,000 dwt floating dock One 40,000 dwt floating dock
50,000 - <100,000	1	90,000	
100,000 - <150,000	1	100,000	
150,000 - <200,000	3	470,000	One 150,000 dwt floating dock
200,000 - < 400,000	4	1,180,000	
400,000 and above	2	800,000	
Total	22	2,827,000	

Storage facilities for all types of import, export and transshipment cargo are provided both within and outside the Free Trade Zone by PSA and private companies. In the zone there are nearly 475,000 m^2 of covered storage space, while the open storage is about twice that. Outside the zone, there are some 400,000 m^2 of covered warehouse space at the Multi-Storey Complex and Pasir Panjang Complex. There is also a sophisticated multistorey cold storage complex at Keppel Wharves with a storage area of 12,000 m^2 for frozen and chilled meat, fish, fruit and vegetables. PSA is the largest warehouse owner in Singapore with a total of 486,000 m^2 of warehouse space.

Singapore is the salvage and towage center in the region due to its location astride the Europe-Asia shipping lines. The largest salvage companies operating out of Singapore are Smit International, Fukuda Salvage, Singapore Salvage Engineers and Sembawang Salvage. All companies keep tugs permanently at sea in the region. These tugs are equipped with the latest surveillance equipment and are in constant radio contact with their home bases. The companies compete for contractual salvage work, such as cargo retrieval and wreck removal and for towage work, with extensive services being offered to shipowners, rig owners and the offshore industry as a whole. PSA has a fleet of 17 tugs equipped with firefighting and anti-oil pollution capabilities (Chia et al., 1988).

Port of Singapore: Future port development. The new port developments are the responsibility of powerful national agencies and guided by the Master Plan and the Long-range Comprehensive Concept Plan. Available sea space 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 pro-tection. But current PSA practices allow their coexistence with other users (Chia, 1992). The large land reclamations are of concern to the 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 premier port (Chia, 1992).

Chapter 5

POLLUTION FROM LAND-BASED SOURCES

Globally speaking, pollutants from land-based sources contribute 60 to 70% of marine pollution (Koe and Aziz, 1995a, 1995b). Major sources are domestic sewage, agricultural and industrial waste, solid waste and chemical and hazardous waste. The polluting substances and materials that pose the greatest threat to the marine environment include: organics, nutrients, sediments, litter and plastics, metals, radionuclides, oil/hydrocarbons and polyaromatic hydrocarbons (PAH) (Koe and Aziz, 1995a, 1995b). The characteristic effects of land-based pollutants and the manner in which they are discharged into the marine environment are identified in ***Table 5.1***. Most of the large cities and rural settlements in East Asia are located along a coastline or river bank (Jaafar and Valencia, 1995b). Wastes, mostly untreated, are discharged directly to receiving waters. Organic components of domestic sewage create oxygen demand and increase nutrient levels, turbidity and concentrations of pathogenic microorganisms. Many

Table 5.1. Origin and Characteristics of Major Marine Pollutants from Land-based Sources (Koe and Aziz, 1995).

Type of Pollutant	Origin	Main Characteristics
Domestic Sewage	River discharges or direct outfall.	High bacterial count, high biochemical oxygen demand, high nutrient concentrations with eutrophication potential
Municipal Solid Waste	Direct dumping or river discharge	Interference with fishing operations, causes damage to marine life, unsightly and causes beach pollution
Industrial Wastes		
• Organic industrial waste (sulfite, phenols, polycyclic, aromatics, benzene, alpha-naphthylamine, oil products, etc.)	River discharges, coastal pipelines, marine dumping by chemical factories, refineries, pulp and paper mills and atmospheric fall-out of gaseous emissions	Many are toxic to marine life and cause oxygen depletion; affects higher forms of marine flora and fauna
• Inorganic industrial waste (acids and alkalis, nitrates and phosphates, mercury, lead, zinc, chromium, cadmium, arsenic, bismuth, antimony, selenium, etc.)	River discharges, coastal pipelines, marine dumping by chemical factories, refineries, metal finishing and atmospheric fall-out of gaseous emissions	Most metals are toxic to marine life Some heavy metals (e.g., mercury, lead and arsenic) are toxic to human beings Nitrates and phosphates are nutrients with eutrophication potential
• Pesticides (herbicides, organochlorine compounds, carbamate compounds, insecticides, fungicides, germicides, rodenticides, etc.). Most common forms are DDT, BHC, Dieldrin, Endrin, Aldrin and Endosulfan	Agriculture and forestry, marine absorption of atmopheric sprays, runoff from agricultural uses, floods, dumping, burning and drainage	Some are toxic to marine life, especially in the upper level of the food chain, causing chronic mammalian toxicity and adverse effects on sea birds. High concentrations may result in damage to fish
Mining, Dredging and Quarrying	Dredging operations, disposal of mining and quarrying spoils into the marine environment	Heavy concentrations of suspended materials cause serious changes in marine life and danger to fish population in spawning and nursery grounds. Can kill marine plant and animal life; often interfere with spawning operations

of the organic and inorganic industrial wastes are discharged into coastal waters, either by direct dumping or indirectly through rivers, are toxic and can have acute and long-term impacts on the living resources in the marine environment.

Waste Sources and Loadings

Domestic sewage

Sewage consists of human feces and household washwaters. The rapid growth in and around the coastal zones of the Malacca Straits is resulting in a steady increase in sewage discharges to the marine and coastal environment.

Table 5.2 identifies the biochemical oxygen demand (BOD) from sewage discharges to the Malacca Straits. The amount of sewage generated by the States is considerable, resulting in high BOD loadings to the coastal waters. In 1989, the estimated BOD loading from domestic sewage discharge in the coastal areas of Indonesia, Malaysia and Singapore was 5,014 tonnes per day. BOD loadings are expected to increase to over 6,000 tonnes per day by the year 2000.

Indonesia. About 75% of the Indonesian cities with populations of more than 100,000 are located in coastal areas, including those along the Malacca Straits (Soegiarto, 1987). In the Jakarta greater metropolitan area, almost 40% or about 3.75 million people discharge their wastewater to the river system, resulting in a BOD load of about 120 tonnes per day. Although there is a requirement to install wastewater treatment in large cities in Indonesia, the response is still very limited.

If one applies the estimates of Mahbub et al. (1990) to the East Coast of Sumatra, with a population of almost 11.0 million people (1994) and assuming that 60% of the sewage generated reaches river systems flowing into the Malacca Straits, total loadings of BOD, chemical oxygen demand (COD), total nitrogen and total phosphorus are 167,292 tonnes, 381,425 tonnes, 74,278 tonnes and 7,361 tonnes per year, respectively.

Malaysia. Along the West Coast of Peninsular Malaysia, there are twelve river basins. The total population situated along the rivers was estimated to be 7.141 million in 1989, generating sewage with an estimated BOD loading of 100,540 tonnes per year. The BOD discharge to the rivers and subsequently to the Malacca Straits was estimated to be 64,180 tonnes per year. The corresponding loading of COD, total nitrogen, total phosphorus, total suspended solids (TSS) to the rivers were 101,300, 4,256, 532 and 74,844 tonnes per year, respectively (***Table 5.3***). Among the river basins, the Kelang and Perak river basins are the most problematic due to the large populations and corresponding industrial activities.

Singapore. Domestic wastewater consists mainly of sewage and sullage water generated by human activities such as cooking and washing (MOE Singapore, 1989). The majority of Singapore's resident population (about 86% of the population) lives in flats built by the Housing and Development Board (HDB) and are served by public sewers.

Population growth and rapid industrialization have increased the amount of wastewater generated in Singapore (Tan, 1992). In 1989, water consumption

Table 5.2. Estimated BOD Loading from Sewage Discharges in Coastal Areas of the Littoral States bordering the Malacca Straits (Koe and Aziz, 1995b).

Year	Parameter	Indonesia	Malaysia	Singapore
1989	National population (million)	184.6	20.14	2.7
	Total BOD load (tonne)	9,230	870	324
	Coastal population (million)	110.76	12.8	2.7
	% national population	65	60	100
	Daily BOD load in coastal area			
	Generated (tonne)	5,538	565	324
	Primary treatment (%)	60	70	10
	Secondary treatment (%)	0	5	90
	Daily BOD removal (tonne)	997	144	272
	Residual daily BOD disposal (tonne)	4,541	421	52
2000	National population (million)	222	20.9	2.9
	Total BOD load (tonne)	11,100	1,045	348
	Coastal population (million)	133.2	13.58	2.9
	% national population	60	65	100
	Daily BOD load in coastal area			
	Generated (tonne)	6,600	679	348
	Daily BOD removal (tonne)	1,199	173	313
	Residual daily BOD disposal (tonne)	5,461	506	35

Table 5.3. Pollutants Discharged to the Malacca Straits from Peninsular Malaysia in Domestic Sewage (DOE/ Malaysia, 1989).

Domestic Sewage/ Wastewater	Kedah	Perai & Juru	Sepe-tang	Perak	Kelang	Langat	Linggi	Melaka	Muar	Batu Pahat	P/S/T*	Johor	Total
Population													
(thousand)	504	444	225	1,276	1,964	408	335	332	568	330	480	275	7,141
Waste load													
BOD (ton/yr)	6,081	5,950	2,952	17,166	31,094	5,661	4,285	4,624	7,754	4,350	6,847	3,778	100,542
COD (ton/yr)	9,590	11,260	5,480	32,650	68,210	11,110	7,710	9,110	14,990	9,350	13,770	7,340	200,570
Total nitrogen (ton/yr)	256	491	222	1,441	4,336	538	276	447	696	339	717	347	10,106
Total phospho-rus (ton/yr)	31	60	27	175	257	65	34	54	84	42	87	42	958
TSS (ton/yr)	7,917	7,570	3,377	21,823	38,263	7,150	5,507	5,836	9,829	5,569	9	4,781	117,631
Mass to river													
BOD (ton/yr)	5,230	4,015	2,216	12,384	14,600	3,872	3,306	3,142	5,446	3,241	4,468	2,260	64,180
COD (ton/yr)	7,060	6,410	3,280	18,370	25,240	5,760	4,970	4,680	8,090	6,870	6,660	3,910	101,300
Total nitrogen (ton/yr)	12	60	101	755	1,971	245	126	203	317	154	154	158	4,256
Total phospho-rus (ton/yr)	14	27	12	79	237	29	15	24	38	19	19	19	532
TSS (ton/yr)	6,902	4,854	2,890	16,086	15,943	5,007	4,409	4,058	7,055	4,233	6	3,401	74,844

BOD = Biochemical Oxygen Demand; COD = Chemical Oxygen Demand; TSS = Total Suspended Solids.
* P/S/T = Pontian/Sekudai/Terbau rivers.

was approximately 305 million m^3. The breakdown across sectors is shown in *Table 5.4.*

Table 5.4. Water Consumption Breakdown, 1989 (Tan, 1992).

Sector	Water Consumption (million m^3)	Percent
Residential	160	52.5
Industrial	115	37.7
Others	30	9.8

In 1990, the total volume of wastewater that was treated amounted to some 320 million m^3. The total volume of wastewater generated is expected to reach 620 million m^3 by the year 2025 (Tan, 1992). An indication of the wastewater composition and amount discharged into the marine environment is presented in *Table 5.5.*

Industrial waste

Industrial waste is mostly generated from agro-based and manufacturing industries including food and beverage processing, palm oil and rubber processing, tapioca starch processing and other manufacturing industries for fertilizers, textiles, pulp and paper, tanneries and sugar.

More than 50% of these industries in the ASEAN countries are located along river banks or in coastal areas. Aggregates of industries are found predominantly in the Manila Bay area, the inner Gulf of Thailand, along the Straits of Malacca and on the North Coast of Java Island, particularly in Jakarta Bay and off Surabaya (Koe and Aziz, 1995a, 1995b). Agro-based industries constitute a significant portion of all industries and they are normally distributed in remote rural areas. Waste treatment facilities are inadequate or lacking in most agro-based industrial plants (Koe and Aziz, 1994).

Pollution loads from industry are significant (*Table 5.1*). Industrial sources of hazardous waste are the mining, energy production, oil refining and pharmaceutical sectors, as well as hospital and health-care facilities and research laboratories. Heavy metals, such as lead, mercury, cadmium and silver, from the manufacturing sector are discharged into rivers and coastal waters, mostly untreated.

Table 5.5. Potential Pollutants Discharged from Singapore, 1989 (Tan, 1992).

	Volume of Sewage Treated (m^3/yr)	BOD	SS	Total N	Total P	Detergent	Oil and Grease
Domestic/Industry	283.42×10^6						
Waste Load (tonne/yr)		14,800	99,100	14,800	1,800	1,500	12,300
Mass to Sea (tonne/yr)		5,385	5,668	8,219	567	130	850
Agricultural Waste	—	—	—	—	—	—	—
Piggery Waste Load (tonne/yr)		18,429	50,261	—	—	—	—
Mass to Sea (tonne/yr		6,634	20,104	—	—	—	—
Zoo	0.32×10^6						
Waste Load (tonne/yr)		—	—	—	—	—	—
Mass to Sea (tonne/yr)		12	23	—	—	—	—
Oil Refinery							
O&G Load (tonne/yr)	—	—	—	—	—	—	257

Indonesia. On the West Coast of Sumatra, a number of industries may be found, including oil and gas, metal processing, fertilizer plants, paper mills and factories involved in the processing of palm oil, sago and tapioca. Some of the important industrial centers include Lhokseumawe and Batam. There are 96 industries located in Batam alone. *Table 5.6* lists some of the important types of industries found along the Malacca Straits.

Industrial wastes have increased steadily and rapidly in the last ten years. In 1987, Soegiarto noted that industrial wastes in Indonesia were limited and localized, compared to other sources of pollutants. However, the situation is changing.

Over the past 15 years many industries have been developed in Sumatra and particularly on the East Coast. They are mostly natural resource-based industries, such as oil and natural gases, fertilizers, paper mill, palm oil, crumb rubber and other agro-industries. Most of the industries are located in coastal areas or along a major river

Table 5.6. Major Industries of Indonesia and Their Potential Impact (Dahuri and Pahlevi, 1994; Science Systems Consultants, 1994).

Type of Industry	Location	Potential Pollutants
Aceh		
Palm Oil	East Aceh	Organic
Lhokseumawe Industrial Zone (LNG, Fertilizer, LPG, Paper Kraft and Olefin)	Lhokseumawe, North Aceh	Mercury, ammonia and sulfur
Oil and Gas (Drilling and Processing)	Lhokseumawe, North Aceh	Oil, organic, heavy metals
Forestry (Sawmill, Plywood)	Spread throughout lowland areas	Organic, chlorinated hydrocarbons
North Sumatra		
Power Generation	Belawan	Thermal, oil
Oil and Gas	P. Brandan	Oil, sulfur
Aluminium	Kuala Tanjun	Heavy metals
Mining of Sand Quartz	Tanjung Tiram	Coastal erosion, sedimentation
Palm Oil	Lowlands	Organic
Forestry (Pulp Mills)	Spread throughout lowlands	Organic
Riau		
Plastics, Electronics, Glass, Ashes and Porcelain, Chemicals, Textile, Tannery, Iron and Metal Works, Food and Organic Material, Shipping and Shipyard Construction	Batam	Organic, heavy metals, chlorinated hydrocarbons, thermal
Oil Refinery	Dumai	Oil
Palm Oil	Sungai Pakning (north of Siak River)	Organic
Palm Oil	Kampungcina	Organic
Pulp, Rubber, Palm Oil and Sago	100 km from Pekan Baru to downstream along Siak River	Organic

system. Although all industries are required to have wastewater treatment plants, most discharge their effluents directly to receiving waters. *Table 5.7* shows examples of selected rivers monitored under the PROKASIH in Aceh, North Sumatra and Riau provinces and the levels of industrial loading.

Due to the limited water supply, the Batam Development Authority has set criteria for developing industries in Batam, one of which is that the industries should not require excessive water for their operations and nor generate water-borne pollution.

As a result of industrial discharges into the river systems, many rivers in Sumatra are considered to be moderately to heavily polluted. The Aceh river (Krueng Aceh) in Aceh, the Deli, Belawan and Asahan rivers in North Sumatra and the Siak River in Riau

Table 5.7. Industrial Waste Discharges to Rivers in Aceh, North Sumatra, and Riau Provinces (PROKASIH [Clean River Program] BAPEDAL, 1994a).

Province	Industries		Total BOD (ton/year)			Total COD (ton/year)		
River	Type	No.	1991/1992	1992/1993	% Change	1991/1992	1992/1993	% Change
Aceh								
Langsa	Plywood	3						
	Cold Storage	1						
	Crumb Rubber	2						
	Glue	1						
		7	341.34	448.18	+31.30	729.43	771.31	+ 5.74
Tamiang	Palm Oil	6						
	Oil Refinery	1						
		7	2,290.00	651.43	-71.55	4,109.65	1,227.54	-70.13
N. Sumatra								
Deli	Rubber	1						
	Metal	1						
	Steel	2						
	Tanning	1						
	Paper	1						
	Formaldehyde	1						
	Cooking Oil/Soap	2						
	Wood Processing	1						
	Textile	2						
	Beer	1						
		13	160.84	119.76	-25.54	242.35	198.85	-17.95
Semayang/	Sugar	1						
Belawan	Battery	1						
	Aluminium	1						
	Rubber	2						
		5	271.94	151.63	-44.24	276.72	256.02	-7.48
Asahan	Rubber	3						
	Palm Oil	5						
	Pulp & Paper	1						
	Plant Oil	1						
		10	1,645.86	1,266.92	-23.02	2,348.62	1,728.80	-26.39
Merbau	Palm Oil	3	609.06	113.66	-81.33	579.59	195.25	-66.31
Riau								
Siak	Palm Oil	5						
	Crumb Rubber	3						
	Plywood	9						
	Pulp & Paper	1						
	Glue	1						
		19	10,802.34	3,699.81	-65.75	19,260.39	8,257.09	-57.13
Total Load from Seven Rivers		**64**	**16,121.39**	**6,451.39**	**-59.98**	**27,546.75**	**12,634.86**	**-54.13**

(Mahbub et al., 1990) are in this category. In order to alleviate the increasing pollution problems nationwide, the Office of the State Minister on Environment developed a PROKASIH or "Clean River Program" in 1989. The project was started in eight provinces, which had major pollution problems, including Aceh, North Sumatra and Riau Provinces. At a later stage, implementation will be expanded to other provinces.

According to Dahuri and Pahlevi (1994), the most polluted area on the East Coast of Sumatra is the Lhokseumawe Industrial Zone. Apparently, the Arun LNG plant has problems of disposing mercury (Hg) contaminated solid waste, which is extracted during the gas liquification process. In 1983, mercury waste at Lhokseumawe was stored in oil drums in an open, exposed location, 2 km from the nearest well and 1 km from the beach. A concrete bunker was built to store the drums, which were found to be rusting and leaking. The dump contained 175 tons of mercury waste, of which 10.5 tons were mercury sulfite. In 1992, the production of mercury waste was about 85 tonnes per year. There is no analysis of mercury residues in the surrounding waters or in fish, shellfish and other organisms in the water (Dahuri and Pahlevi, 1994).

Other potential sources of pollution from Lhokseumawe Industrial Zone, are:

- Gas flaring at the Arun LNG Plant;
- Various chlorinated organic substances, such as dioxins and furans, from the KRAFT paper mill;
- Urea dust from two fertilizer plants; and
- Mercury and ethylene from the olefin plant, which generates 7 tonnes of mercury-contaminated wastes daily.

Malaysia. Along the West Coast of Peninsular Malaysia, there are 171 rubber processing factories, 97 marine products processing factories and 81 palm oil mills. The total agro-based industries, including tapioca processing and pineapple canning factories, amounted to 375 in 1987 to 1988. The most common manufacturing industries are metal processing (339), followed by food processing (222) and chemical products (175). The total number of plants in the manufacturing sector is 1,218 (1987). Industrial wastewater loadings to rivers along Peninsular Malaysia are shown in ***Table 5.8***. The distribution of industry along the coastal river basins is identified in ***Table 5.9***.

Palm oil. Untreated palm oil effluent has a high BOD in the range of 22,000 to 61,000 mg/l. On the average, an effluent volume of 3.07 m^3 per tonne of fresh fruit bunches (FFB) of oil palm seeds processed will be generated. The BOD, COD, TSS, TN, TP and O&G are in the order of 31.3, 65.9, 25.5, 0.7, 0.4 and 20.8 kg, respectively. Pollution loading from the palm oil industry is significant. Sixty tonnes of fresh palm oil fruits processed in one hour will generate a daily BOD load equivalent to 900,000 persons.

With current treatment technologies, waste loadings from the palm oil industry can be reduced (***Table 5.10***). The disposal of effluents to estate lands as irrigation water/soil conditioner further reduces pollution loads to the coastal waters (DOE/Malaysia, 1989).

Rubber. The effluents from natural rubber processing plants is a major source of industrial pollution in Malaysia. For one tonne of SMR (Standard Malaysian Rubber) block produced, there is 20.5 m^3 effluent containing 21.3, 44.7, 7.0, 3.1 and 1.7 kg of BOD, COD, TSS, TN and AN (ammoniacal nitrogen), respectively (DOE/Malaysia, 1989). With treatment, pollutant load can be reduced before discharge to rivers (***Table 5.10***). Rubber processing factories are located mostly along the West Coast of Peninsular Malaysia. The most affected river basins are the Perak, Linggi and Muar rivers.

Tapioca/sago. Processing tapioca or sago requires large volumes of water and generates high organic loading in the wastewater. Effluent BODs may reach 5,000 to 7,000 mg/l and TSS greater that 13,000 mg/l (DOE/Malaysia, 1989). Among the river basins along the West Coast of Peninsular Malaysia, the Perak river receives the highest volume of effluent and highest pollution loads from tapioca/sago processing (***Table 5.10***).

Manufacturing. The Kelang river basin experienced rapid industrial development during the last two decades. In terms of BOD load, about 81% of the effluent loads from manufacturing industries along the West Coast of Peninsular Malaysia come from the Kelang river basin area, known as the Kelang Valley (***Table 5.11***). Apart from high BOD, high levels of COD, TP, TSS and heavy metals such as copper and lead, depending on the types of industries, are discharged to the river basin.

Food processing plants generate the highest BOD among the manufacturing sector. The contribution

Table 5.8. Total Pollutant Loads (in ton/yr) Generated by Domestic and Industrial Activities Discharged from Rivers Along the West Coast of Peninsular Malaysia (DOE, Malaysia, 1989).

Pollutant	BOD	COD	Total Nitrogen	Total P	TSS	Grease and Oil	Hg	Lead	Total Cr	Copper	Zinc
1. Domestic Wastewater/Sewage											
Waste generated	100,542	200,542	10,106	958	117,631	—	—	—	—	—	—
Waste discharged after treatment	64,180	101,300	4,256	532	74,844						
2. Livestock											
Waste generated	57,734	144,446	9,900	84,055	115,370						
Waste discharged after treatment	17,282	44,259	3,285	25,220	34,864						
3.1 Palm Oil Mill											
Waste generated	178,502	373,507	4,160	10,225	141,744	104,479					
Waste discharged after treatment	3,724	9,740	1,120	70	1,402	2,668					
3.2 Rubber Mill											
Waste generated	11,783	24,723	1,793	—	3,665	—					
Waste generated after treatment	819	3,786	578	—	1,119	—					
3.3 Others											
Waste generated	117,976	296,502	42	—	51,101	2,197					
Waste generaled after treatment	2,767	6,797	29	—	2,276	56					
4.1 Food and Beverage											
Waste discharged after treatment	2,558	11,114	—	—	48,144	373	—	—	—	—	
4.2 Chemical and Rubber											
Waste discharged after treatment	1,352	2,200	8	—	261	17	7	312	—	—	334
4.3 Textiles and semi-conductor											
Waste discharged after treatment	722	2,588	128	—	99,872	41	—	92	—	26,450	—
TOTAL (Waste discharged after treatment)	93,404	181,784	9,404	25,822	262,782	3,155	7	404	—	26,450	334
National Total	164,952	265,594	13,655	26,160	329,250	3,577	7	404	—	26,450	334
% of National Total	56.7	68.4	68.9	98.7	79.8	88.2	100	100	—	100	100

BOD = Biochemical oxygen demand; COD = Chemical oxygen demand; TSS = Total suspended solids.

of O&G and COD is mainly from the palm oil refining factories. Wastes from the chemical factories contain heavy metals, such as zinc and mercury. As shown in *Table 5.11*, high amounts of TP were generated by textile factories. High total chromium loadings were generated by the semi-conductor sectors.

Tin Mining. The Kinta river basin, a sub-catchment of the Perak River is the center for tin mining, with 85 tin mines in operation in 1987. This was followed by the Langat river basin (14 tin mines) and the Klang river basin (7 tin mines) (DOE/Malaysia, 1989). Effluents from tin mining contain high amounts of inorganic suspended solids that do not settle readily. Under the Malaysian Mining Enactment, the effluent discharge levels to rivers for TSS are 5,650 mg/l.

Singapore. Singapore embarked on an ambitious industrialization program beginning from the early 1960s. The manufacturing sector in 1988 accounted

Table 5.10. Pollutants Discharged to the Malacca Straits from Peninsular Malysia by Agro-based Industries (DOE Malaysia 1989).

Type of Waste	Kedah	Perai & Juru	Sepetang	Perak	Kelang	Langat	Linggi	Melaka	Muar	Batu Pahat	P/S/T*	Johor	Total
1. Agro-industry													
1.1 Palm oil production (x 10^3 ton/yr)	Nil	34	103	294	136	140	160	—	425	246	105	4,032	5,675
Waste generation													
BOD (ton/yr)	—	602	3,239	9,202	4,235	4,391	6,139	—	13,332	7,709	3,281	126,372	178,502
COD (ton/yr)	—	1,266	6,817	19,355	6,951	9,235	12,914	—	28,042	16,216	6,902	265,809	373,507
Total nitrogen (ton/yr)	—	14	74	211	98	161	141	—	306	177	75	2,903	4,160
Total phosphorus (ton/yr)	—	7,900	42	120	56	57	80	—	174	101	42	1,653	10,225
TSS (ton/yr)	—	489	2,637	7,489	3,464	3,574	4,097	—	10,852	6,275	3	102,864	141,744
Grease and oil (ton/yr)	—	398	2,145	6,092	1,017	2,907	148	—	825	5,105	2,172	83,670	104,479
Mass to river													
BOD (ton/yr)	—	1	2	139	14	69	13	—	17	7	3,281	181	3,724
COD (ton/yr)	—	0	19	412	79	379	143	—	235	90	6,902	1,481	9,740
Total nitrogen (ton/yr)	—	11	23	183	10	134	40	—	152	56	75	436	1,120
Total phosphorus (ton/yr)	—	28	0	0	0	0	0	—	0	0	42	0	70
TSS (ton/yr) (ton/yr)	—	3	7	288	36	117	15	—	65	26	3	842	1,402
Grease and oil (ton/yr)	—	6	3	127	22	133	4	—	68	31	2,172	91	2,668
1.2 Rubber production (x 10^3 ton/yr)	—	62	12	87	67	33	34	26	115	43	34	40	553
Waste generation													
BOD (ton/yr)	—	1,293	254	1,854	1,420	713	726	559	2,458	926	726	854	11,783
COD (ton/yr)	—	2,713	533	3,889	2,979	1,496	1,523	1,174	5,156	1,943	1,526	1,791	24,723
Total nitrogen (ton/yr)	—	187	37	268	205	103	195	81	355	134	105	123	1,793
Total phosphorus (ton/yr)	—	—	—	—	—	—	—	—	—	—	—	—	—
TSS (ton/yr)	—	423	83	607	465	233	238	183	804	303	237	299	3,665
Mass to river													
BOD (ton/yr)	—	14	4	285	46	37	265	82	155	21	95	75	819
COD (ton/yr)	—	44	24	786	162	124	908	348	610	74	399	307	3,786
Total nitrogen (ton/yr)	—	7	2	69	41	16	61	49	109	15	86	123	578
Total phosphorus (ton/yr)	—	—	—	—	—	—	—	—	—	—	—	—	—
TSS (ton/yr) (ton/yr)	—	23	16	231	87	55	35	83	233	34	186	136	1,119

BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids. * P/S/T = Pontian/Sekudai/Terbau rivers.

continued

North Sumatra and Riau Provinces have the largest areas of palm oil plantations in the country. The use of fertilizers as well as herbicides, pesticides, rodenticides and fungicides in agricultural activities has increased substantially.

Until 1985, Indonesia was the largest rice importer, as much as three million metric tons/year. Due to the concerted efforts since 1985, Indonesia has enjoyed self sufficiency in rice production. In order to reach self sufficiency in rice production, Indonesia has utilized

Table 5.10. (continued)

Type of Waste	Kedah	Perai & Juru	Sepe-tang	Perak	Kelang	Langat	Linggi	Melaka	Muar	Batu Pahat	P/S/T*	Johor	Total
1. Agro-industry													
1.3. Sago/tapioca production (x 10^3 ton/yr)	—	16	—	114	—	—	—	—	1	7	—	—	138
Dess. Coconut prod. (x 10^3 ton/yr)	—	—	—	7	—	—	—	—	—	1	—	—	8
Marine prod. canning (x 10^3 ton/yr)	—	—	—	—	151.25	—	—	—	—	—	—	—	151.25
Waste generation													
BOD (ton/yr)	—	683	—	5,019	111,926	—	—	—	30	318	—	—	117,976
COD (ton/yr)	—	1,212	—	8,813	285,866	—	—	—	53	558	—	—	296,502
Total nitrogen (ton/yr)	—	4	—	36	—	—	—	—	—	2	—	—	42
Total phospho-rus (ton/yr)	—	—	—	—	—	—	—	—	—	—	—	—	—
TSS (ton/yr)	—	472	—	3,458	46,886	—	—	—	21	264	—	—	51,101
Grease and oil (ton/yr)	—	8	—	152	2,025	—	—	—	—	12	—	—	2,197
Mass to river													
BOD (ton/yr)	—	207	—	2,495	30	—	—	—	14	21	—	—	2,767
COD (ton/yr)	—	587	—	5,901	210	—	—	—	25	74	—	—	6,797
Total nitrogen (ton/yr)	—	0	—	14	—	—	—	—	—	15	—	—	29
Total phospho-rus (ton/yr)	—	—	—	—	—	—	—	—	—	—	—	—	—
TSS (ton/yr) (ton/yr)	—	61	—	1,750	420	—	—	—	11	34	—	—	2,276
Grease and oil (ton/yr)	—	6	—	50	0	—	—	—	—	—	—	—	56

BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids. * P/S/T = Pontian/Sekudai/Terbau rivers.

Figure 5.1. Location of Industries in Singapore (Chia, 1992).

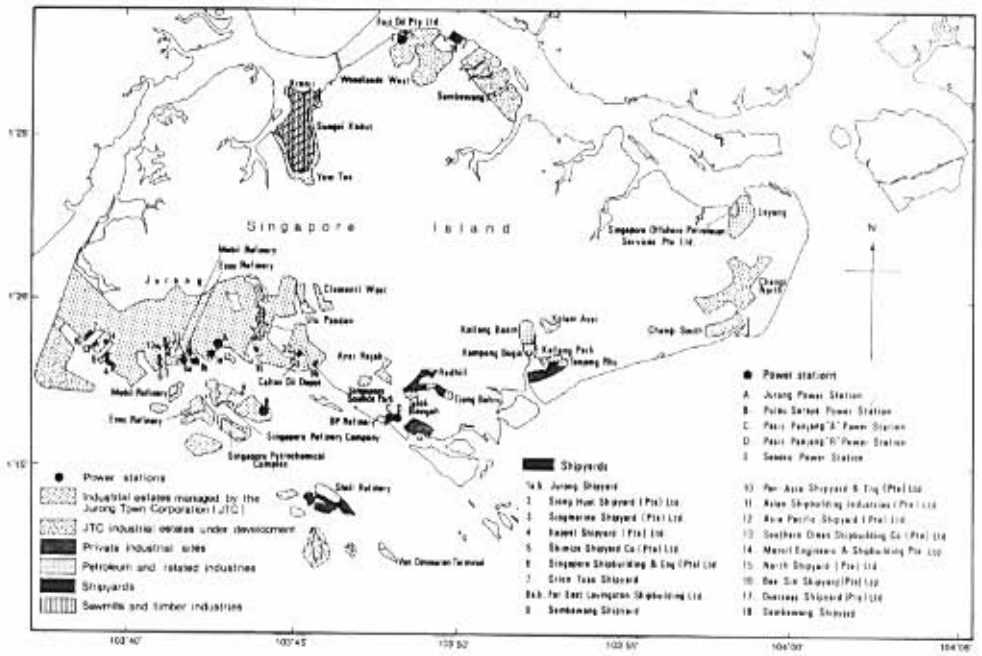


Table 5.11. Pollutants Discharged to the Malacca Straits from Peninsular Malysia by the Manufacturing Sector (DOE/ Malaysia, 1989).

Type of Waste	Kedah	Perai & Juru	Sepe-tang	Perak	Kelang	Langat	Linggi	Melaka	Muar	Batu Pahat	P/S/T*	Johor	Total
2. Manufacturing Industry													
2.1 Food/Beverage													
Mass waste to rivers													
BOD (ton/yr)	—	58	2	43	768	19	—	2	—	—	1	1,665	2,558
COD (ton/yr)	—	41	3	52	1,762	69	1	1	2	1	13	9,169	11,114
Total nitrogen (ton/yr)	—	—	—	—	24	—	—	—	—	—	—	—	24
TSS (ton/yr)	—	49	—	88	47,772	12	—	3	—	—	86	134	48,144
Grease and oil (ton/yr)	—	7	1	8	98	1	—	1	—	—	—	257	373
2.2 Chemical and Rubber													
Mass waste to rivers													
BOD (ton/yr)	—	176	—	96	579	4	—	53	—	—	1	443	1,352
COD (ton/yr)	—	255	—	55	1,264	9	—	11	—	—	1	605	2,200
Total nitrogen (ton/yr)	—	—	—	—	4	—	—	4	—	—	—	—	8
TSS (ton/yr)	—	72	—	47	25	1	—	15	—	—	—	101	261
Grease and oil (ton/yr)	—	3	—	—	14	—		—	—	—	—	—	17
Mercury (kg/yr)	—	—	—	—	7	—	—	—	—	—	—	—	7
Lead (kg/yr)	—	—	—	—	—	15	—	297	—	—	—	—	312
Zinc (kg/yr)	—	—	—	—	334	—	—	—	—	—	—	—	334
2.3 Textiles and Semi-conductor													
Mass waste to rivers													
BOD (ton/yr)	—	551	5	—	115	—	10	16	—	25	—	—	722
COD (ton/yr)	—	2,121	15	—	207	—	122	47	1	74	1	—	2,588
Total nitrogen (ton/yr)	—	10	—	—	114	—	—	—	—	4	—	—	128
TSS (ton/yr)	—	221	10	—	99,620	—	—	10	—	11	—	—	99,872
Grease and oil (ton/yr)	—	12	12	—	17	—	—	—	—	—	—	—	41
Lead (kg/yr)	—	—	—	—	89	—	—	—	3	—	—	—	92
Copper (kg/yr)	—	—	—	—	25,799	—	310	341	—	—	—	—	26,450

BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids. * P/S/T = Pontian/Sekudai/Terbau rivers.

a number of high yielding rice varieties and applied large amounts of fertilizers and pesticide. Similarly, substantial amounts of chemicals are also applied in plantations and crop estates. ***Table 5.12*** shows the approximate amounts of chemicals used in Aceh, North Sumatra and Riau Provinces.

It is suspected that a certain percentage of fertilizers as well as the applied pesticides are leached to rivers and to the coastal and estuarine environments. There is no research information on the presence or impact of these chemicals on the coastal waters of the East Coast of Sumatra.

Malaysia

One of the major sources of agricultural waste in Malaysia are the pig farms, many of which are located along river banks. Between 1990 and 1991, 3,226 pig farms with some 2.3 million pigs were recorded ***(Table 5.13)***. By the year 2000, it is projected that the pig population will be around 3 million

Table 5.12. Pesticide Use in Agricultural Activities on the East Coast of Aceh, North Sumatra, and Riau Provinces (Soegiarto, 1987; Dahuri and Pahlevi, 1994).

Coastal Area Regency	Insecticide	Fungicide	Rodenticide	Herbicide
Aceh				
Pidie	2,600,295	100,200	-	-
North Aceh	585,704	142	-	1,100
East Aceh	239	6,100	-	2,305
North Sumatra				
Langkat	129,050	632	3,329	3,770
Deli Serdang and Medan	856,461	3,183	283,813	7,712
Labuan batu	67,502	37	3,076	4,928
Asahan	140,453	175	1,138	6,450
Riau*	85,000[1]	-	4,000	-

*Regencial data of Riau Province on the use of pesticides are not available
[1] Including small amounts of fungicide

Table 5.13. Number of Farms and Populations of Pigs on the West Coast of Peninsular Malaysia, 1990 to1991 (Choo et al., 1994).

State	No. of Farms	Pig Population
Melaka	162	192,290
Kedah	19	5,116
Perak	559	407,688
N.Sembilan	654	618,326
Selangor	481	487,011
Penang	1,187	300,179
Johor	164	302,470
Total	**3,226**	**2,313,080**

Pig farming has given rise to many water pollution problems in Malaysia. The pollution load generated by pig farms was estimated to be 218 tonnes/day or about 46% of the total load generated in the whole of Malaysia in Linggi and Langat rivers, where many pig farms are operating (*Table 5.14*, DOE/Malaysia, 1989).

There are 319,460 hectares of agricultural land along the states bordering the Malacca Straits. Both pesticides and fertilizers are used for their cultivation. According to Lee and Troxler (1992), fertilizer use is around 154 kg/ha. The principal pesticides reported to be used in Malaysia are paraquat, dalapon, diuron, 2,4 D, methamidophos, permethrin, cypermethrin, malathion and carbaryl (Lee and Troxler, 1992). Three crops (i.e., rubber, oil palm and rice) account for 90% of the annual pesticide use. Seventy-five percent of the pesticides are herbicides for rubber and oil palm

Table 5.14. Pollutants Discharged to the Malacca Straits from Peninsular Malaysia by the Agriculture Industry (DOE/ Malaysia, 1989).

Type of Waste	Kedah	Perai & Juru	Sepetang	Perak	Klang	Langat	Linggi	Melaka	Muar	Batu Pahat	P/S/T*	Johor	Total
Agriculture													
Pig production													
(head/yr)	3,631	47,650	13,680	55,146	34,455	121,762	130,381	6,420	29,870	16,350	71,300	35,000	565,555
Waste generation													
BOD (ton/yr)	371	4,861	1,398	5,636	3,521	12,444	13,325	656	3,053	1,625	7,267	3,577	57,734
COD (ton/yr)	941	12,325	3,545	14,291	6,929	31,555	33,788	1,664	7,741	4,120	18,477	9,070	144,446
Total nitrogen (ton/yr)	64	833	240	966	604	2,133	2,284	112	523	279	1,249	613	9,900
Total phosphorus (ton/yr)	19	243	70	282	176	622	666	33	152	81,249	364	179	84,055
TSS (ton/yr)	848	11,110	3,196	12,882	8,049	28,444	30,457	1,499	6,978	3,714	17	8,176	115,370
Mass to river													
BOD (ton/yr)	111	1,458	419	1,691	1,056	3,733	3,953	197	916	488	2,187	1,073	17,282
COD (ton/yr)	282	3,698	1,064	4,287	2,679	9,466	10,461	500	2,322	1,236	5,543	2,721	44,259
Total nitrogen (ton/yr)	19	250	72	290	189	940	691	34	157	84	375	184	3,285
Total phosphorus (ton/yr)	6	73	21	85	53	187	201	10	46	24,375	109	54	25,220
TSS (ton/yr) (ton/yr)	254	3,333	959	3,865	2,415	8,533	9,390	450	2,093	1,114	5	2,453	34,864

BOD = biochemical oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids. * P/S/T = Pontian/Sekudai/Terbau rivers.

plantations. Insecticides are more commonly used on vegetable, rice and tobacco crops. The pesticides are applied 4 or 5 times during a season and the preferred mode of application is as an emulsion (i.e., spray), although granules and wettable powders are also used (Alabaster, 1986).

There are two types of organochlorine pesticides used in the agriculture industry in Malaysia. They are liquid DDT (25% EC) and powder DDT (75% WDP) (DOE/Malaysia, 1989). The national consumption of these two pesticides amounted to 386,900 liters of DDT and 85,500 kg of powder DDT. The consumption of DDT in river basins along the West Coast of Peninsular Malaysia constituted around 47% the national total (*Table 5.15*).

Table 5.15. Organochlorine Consumption in the Malaysian Coastal Areas Bordering the Malacca Straits (DOE/ Malaysia, 1989).

State	Total DDT and Related Compound Consumption			
	DDT 25% EC (liter)	% to National Total	DDT 75 % WDP (kg)	% to National Total
Perlis	4,200	1.1	20	0.02
Kedah	84,900	21.9	—	—
Penang	3,700	0.9	—	—
Perak	78,600	20.3	—	—
Selangor	4,500	1.2	—	—
Melaka	800	0.2	—	—
Negeri Sembilan	3,700	0.9	100	0.10
Johor	2,500	0.6	200	0.20
National Total	**386,900**	**100.0**	**85,500**	**100.00**

EC – Emulsion concentration (liquid DDT); WDP – Powder DDT.

Singapore

The major source of agricultural waste used to be pig farms. However, the continued pollution of the water courses prompted the government to phase out pig farming (1985). This was successfully achieved in 1990 (Gee, 1992). However, poultry farms are still in operation. According to MOE Singapore (1989), there are 2,000 poultry farms with a total of 3 million layers, 3.5 million broilers, 371,000 breeders and 918,000 ducks. The poultry are kept in cages within covered sheds and the wastes are collected in solid form. The waste from poultry rearing is believed to be insignificant as there is proper waste disposal.

Farmlands occupy only about 3% of the total land area. In 1988, there were some 2,076 licensed farms occupying 2,306 ha, which produced an estimated S$261 million worth of farm produce (Tan, 1992). The major cultivated crops include vegetables, orchids and ornamental plants. These are small-scale operations and the use of toxic and persistent chemicals are not allowed. Most of the agricultural practices are found in the northern portion of the main island and on P. Ubin. Even though fertilizers and pesticides are used, farmers are educated on methods of pesticide and fertilizer application. Also, many farms have drainage systems which collect the run-off in storage ponds, from which the water is pumped back to the fields as irrigation water.

Solid waste

Indonesia

Surveys carried out in various cities in Java indicate that 60 to 80% of solid waste is collected and either recycled or transported to dump sites or incinerators. The management of solid wastes in cities outside Java is less controlled because of a lack of facilities and infrastructure.

Table 5.16 shows the composition of solid waste from Jakarta, Bandung, Semarang and Pekan Baru (Riau).

Table 5.16. Composition of Solid Wastes in Java and Sumatra (Biro Pusat Statistik, 1995).

Type of Waste	Jakarta 1994/1995	Bandung, Capital of West Java, 1994/1995	Semarang, Capital of Central Java, 1993/1994	Pekan Baru, Capital of Riau, 1992/1993
Organic/ Plant origin	73.92	63.56	68.14	79.93
Papers	10.18	10.42	5.95	5.98
Plastics	7.86	9.76	14.15	5.00
Metals	2.04	0.95	5.07	3.00
Rubber/Imitation Leather	0.55	0.14	-	0.50
Woods	0.98	3.60	0.56	2.00
Fabrics	1.57	1.70	2.97	0.50
Glass	1.75	1.45	0.16	1.20
Others	1.15	8.16	-	1.89

Malaysia

A survey conducted by the Department of Environment (DOE), Malaysia, indicates that the municipal waste generation rate is 0.5 kg/capita/day (DOE/Malaysia, 1989). The West Coast of Peninsular Malaysia is the most developed area having a large population equivalent to 90% total urban population in Malaysia. About 4.1 million tonnes of solid waste were generated mostly from the Klang Valley area (2.6 million tonnes/year) (DOE/Malaysia, 1989). The amount of solid waste generated by the West Coast states of Peninsular Malaysia are shown in ***Table 5.17***. The average per capita waste generation rate in the coastal states is calculated to be 1.12 kg/day.

Table 5.17. Solid Wastes Generated by Malaysian Coastal States Bordering the Malacca Straits (DOE/Malaysia, 1989).

State/Province	Quantity of Solid Waste (x 10^3 ton/yr)		
	Collected	Uncollected	Generated
Perlis	6.0	3.0	9.0
Kedah	15.0	0.6	15.6
Penang	75.0	—	—
Perak	—	—	—
Selangor	2,892.7	30.0	2,922.7
Negeri Sembilan	600.0	—	600.0
Federal Territory	—	—	—
Malacca	—	—	—
Johor	489.6	11.4	501.0
Sub-total	4,078.3	42.3	4,120.6
Total State Population (million)			3.74
Per Capita Daily Rate (kg)			1.12

Singapore

Tan (1992) divided Singapore's solid waste into three categories: (1) domestic and trade refuse; (2) industrial refuse; and (3) institutional refuse. The bulk of the refuse comes from domestic and trade refuse, i.e., households, markets, food centers, hotels, restaurants, shops etc. Refuse from industrial sources are also significant having grown by 4.7 times from 1980 to 1990 as a result of the rapid industrial and economic growth (Low, 1991). Institutional refuse is the output from government installations, hospitals, schools and public parks.

Solid waste generation in 1970 amounted to 1,278 t/day, doubling to approximately 2,572 t/day in 1980 and, in 1990, the load was an estimated 5,696 t/day (Tan, 1992). In 1990, contributions from domestic, industrial and institutional waste amounted to 2,824 t/day, 2,554 ton/day and 318 t/day respectively. It is estimated that by the year 2010, refuse volume will stand at approximately 7,500 t/day. The composition of the refuse from Singapore is shown in ***Table 5.18***.

Table 5.19 shows the amount of refuse collected during 1990 to 1994 and the per capita refuse generated. The large amounts of solid waste generated in Singapore are due to the high population densities and the increased industrialization over the past few years. About 52% of the refuse collected are from residences, food centers, markets and commercial premises. Refuse collected from industrial premises accounts for 47% of the total, while the remaining 1% comes from institutions.

Table 5.18. Composition of Refuse in Singapore (Low, 1991).

Constituents	Percentage by Weight
Fruits, Vegetables, Garden Waste	44.4
Paper, Cardboard and Wood	28.3
Plastics	11.8
Textiles, Leather and Rubber	3.0
Metals	4.8
Glass	4.1
Ceramics	1.6
Residue	2.0

Table 5.19. Solid Waste Generation in Singapore 1990 to 1994 (Modified from MOE Singapore, 1995a and DOS Singapore, 1995).

Year	Amount of Solid Waste or Refuse Generated		
	Total Amount (million tonnes)	Population (million)	Generation Rate (kg per capita)
1990	2.08	2.74	0.76
1991	2.15	2.79	0.77
1992	2.26	2.85	0.79
1993	2.23	2.90	0.77
1994	2.24	2.96	0.76

Waste Management Facilities and Services

Domestic sewage treatment

Indonesia

There is no written record concerning the start-up of waste treatment in Indonesia. Up to the 1970s, cities had no waste treatment. Almost all wastes were discharged directly to the rivers. Therefore, water pollution problems built up rapidly, particularly in rivers passing through human settlements. At present, only a few cities have sewage treatment facilities, including Jakarta, Surabaya, Semarang and Bandung in Java and Medan and Batam in Sumatra. The sixth Five Year Development Plan (1994 to 1999) proposes that most cities be provided with wastewater treatment facilities.

Malaysia

From the 1980 census, only 4.0% of the total population of Malaysia was served by a central sewerage system, while 44% of the population were still employing unacceptable methods of sanitation (DOE/ Malaysia, 1989). Up to 1988, there were five sewerage systems located in major cities along the West Coast of Peninsular Malaysia, namely: Georgetown; Butterworth; Bukit Mertajam; Shah Alam; Kuala Lumpur and Bangi, serving a population of about one million (6% of the total population of 16.6 million). Under the 5th Malaysia Plan (MP), 19 feasibility studies for sewage treatment systems were conducted, but only nine of them were implemented due to financial constraints. Estimated cost for the new sewage treatment systems was RM64.5 million. Funding for sewage treatment systems under the 6th MP has increased substantially to RM550.9 million. Throughout the period of the 6th MP, efforts were focused to provide centralized sewage treatment systems in state capitals, major urban areas and tourist resorts such as Langkawi, Pangkor and Desaru (Dow, 1993).

To date, communal sewage treatment systems are mostly comprised of stabilization/oxidation ponds commonly found in the new residential areas, industrial estates and townships. These sewage systems are constructed in accordance with the guidelines issued by the Ministry of Health and Ministry of Housing and Local Government.

According to the Department of Services, Ministry of Housing and Local Government of Malaysia, about RM6 billion will be spent by a local consortium, Indah Water Konsortium (IWK), to improve the country's sewerage system over the coming years. The project, which is to be carried out in six phases, will benefit all 143 local authorities in the country. Eleven local councils, mainly in Peninsular Malaysia, have been identified as priority areas for implementation of the first phase of the project. They are Penang, Labuan, Langkawi, Port Dickson, Johor Bahru, Kuala Lumpur, Ipoh, Seremban, Malacca, Kangar and Kuching Utara (*New Straits Times*, 7 November 1995). IWK is the sole concession holder of Malaysia's sewerage services.

Sewerage facilities will continue to be upgraded and expanded to progressively control pollution of ground and surface waters. Apart from expanding sewerage facilities for major cities, sewerage systems will be constructed in designated tourist resorts in order to sustain these resorts as principal destinations for tourists (Koe and Aziz, 1995).

Singapore

The Singapore Government has invested heavily in the building and maintenance of a comprehensive sewerage system. The pan-island sewerage system also serves the trade and industrial premises. Singapore has a long history of development of domestic sewage/ wastewater management, which dated back to 1890. A chronicle of the history of development is shown in ***Table 5.20***.

Presently, there are six major sewage treatment works (STWs) in Singapore (MOE/Singapore, 1989). Their treatment capacities are:

Sewage Treatment Works	Treatment Capacity (m^3/day)
Ulu Pandan	286,000
Kim Chuan	256,000
Jurong	164,000
Bedok	116,000
Seletar	57,000
Kranji	38,000

All six STWs are activated sludge treatment facilities, with final discharges to the sea. Part of the effluent is recycled for non-potable uses, including industrial cooling and irrigation of golf courses.

In August 1995, expansion work on the Seletar Sewage Treatment Works was completed, increasing the plant's treatment capacity to 114,000 m^3 per day. According to the Ministry of Environment (MOE), almost 100% of the population in Singapore is serviced

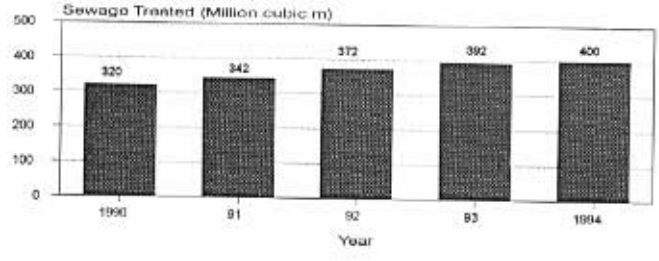
Table 5.20. History of Sewage Management in Singapore (*The Straits Times*, 17 August 1995).

Year	Description of the Development
1890	First report on disposal of sewage in Singapore compiled by municipal engineer, Mr. James MacRitchie. However, his proposal to collect and dispose night soil into the sea was not implemented.
1911	Municipal engineer, Mr. R. Pierce, submitted a report outlining his proposal for water-borne sewage disposal system. The scheme comprised the laying of a sewer network, construction of sewage pumping stations, and a treatment work at Alexandra Road.
1915	Singapore's first water-borne sewage disposal system was implemented. The first pumping station, Park Road Pumping Station and Alexandra Sewage Disposal Works, were completed.
1941	The Kim Chuan Sewage Treatment Works and the Serangoon Sludge Disposal Works were constructed and began operations, serving 150,000 people.
1955	The City Council demolished the Alexandra Sewage Disposal Works and built a new facility at Ulu Pandan to cope with the increased population.
1961	The Ulu Pandan Sewage Treatment Works was commissioned with an initial capacity to serve 400,000 people.
1970s	A sewerage master plan was formulated, dividing Singapore into seven sewerage catchments: Kim Chuan, Ulu Pandan, Bedok, Kranji, Seletar, Jurong, and Lim Chu Kang. In 1970, 51% of Singapore enjoyed modern sanitation.
1973	Planning began for the Bedok Sewage Treatment Works which had a treatment capacity of 58,000 cubic meters per day.
1974	Design of Kranji and Seletar Sewage Treatment Works commenced.
1979	Construction of Bedok Sewage Treatment Works completed.
1980	The Kranji Sewage Treatment Works, with a capacity of 38,000 cubic meters per day, was completed. The system now serves 75% of Singapore's population.
1981	Seletar Sewage Treatment Works, with a treatment capacity of 57,000 cubic meters per day, was completed. The number of sewage treatment works in Singapore increased to six.
1987	The practice of collecting night soil buckets from unsewered premises was phased out.
1993	From 1989 to 1993, a total of $390 million was invested in sewerage development.
1994	Wastewater from 134 pumping stations located all over the island was directed to the six central sewage treatment works. The Sewerage Department maintained 2,450 km of public sewers. Development expenditure for sewerage amounted to $80 million in 1994, excluding the cost of constructing sewers within housing estates by the Housing and Development Board.
1995	Expansion works in progress at Kranji, Seletar, and Ulu Pandan Sewage Treatment Works. For these and other sewerage projects involving the laying of new sewers and pumping mains, the government will spend more than $1 billion in the next few years.

by modern sanitation facilities. The Singapore Government spent about S$390 million between 1989 and 1993 to ensure that sewage is properly treated. In order to cope with the increasing amount of wastewater resulting from a larger population and increased industrial development, MOE of Singapore plans to spend more than S$1 billion in the next few years to expand the capacities of the treatment works (*The Straits Times*, 17 August 1995).

Wastewater from domestic and industrial sources are channeled to the six sewage treatment works through a system of sewers, sewage pumping stations and pressure mains. Remote residential areas which are not served by the sewerage system are provided with small supplemental sewage treatment plants. Under the Water Pollution Control and Drainage Act of 1957, factories and industrial operations are required to treat their wastewaters in pretreatment plants in order to comply with effluent standards. The pretreated

Figure 5.2. Singapore: Volumes of Sewage Treated During 1990-1994 (MOE/Singapore, 1995a).



effluents are discharged into the sewers and transported to the sewage treatment works for further treatment, along with the domestic wastewater, before being discharged to the surrounding canals, rivers and coastal waters (*The Straits Times*, 17 August 1995).

In 1994, a total of 400 million m^3 of sewage was treated in the six STWs operated by the Ministry of the Environment (***Figure 5.2***).

Industrial waste

Indonesia

Indonesian industry, in general, has limited wastewater treatment facilities. Wastewater effluents are discharged directly to water bodies. It was only in the early 1980s that industry was required to treat their waste discharges. However, in practice many industries are still discharging untreated effluents directly to water bodies or are using undersized or inferior wastewater treatment processes which produce effluents of poor quality.

The first integrated industrial effluent treatment plant was built by the Jakarta Industrial Estate in Pulo Gadung, Jakarta in the mid-1980s. This is followed by Surabaya Industrial Estate in Waru, Surabaya and on a smaller scale by Medan and Batam Industrial Estates.

There are a number of steps that have been taken to control industrial wastewater, including environmental impact assessment (AMDAL) of new industry, technological interventions to reduce or avoid harmful emissions and discharges and regulatory controls on effluent discharges to bodies of water. The local government has the responsibility to monitor effluents, but is hampered by lack of resources and know-how.

The Office of the State Minister on Environment has implemented a more comprehensive pollution monitoring program on the river system, called the PROKASIH (Program Kali Bersih or Clean River Program). The program was first started with eight provinces having major pollution problems, including Aceh, North Sumatra and Riau Provinces in 1991/1992. Selected rivers and the types of industries discharging their effluents are presented in ***Table 5.7***. The preliminary results of a two-year monitoring exercise (1991/1992 to 1992/1993) for BOD and COD were also included in ***Table 5.7***. In the Langsa River segment, the total BOD and COD increased substantially, 31% and 6%, respectively, whereas the Tamiang river segment BOD and COD decreased substantially, 72% and 70%, respectively. It seems that the PROKASIH initiative had no effect on the industrial effluents discharged to the Langsa River. On the other hand, industries located along the Tamiang River followed the PROKASIH direction relatively well.

Malaysia

Biological purification systems, mainly anaerobic and facultative ponds are used by the palm oil mills and rubber processing factories to treat their wastewater effluents. The systems, although requiring larger land areas than mechanical systems, are effective in reducing high strength organic wastewaters. In the case of rubber plant wastewater, existing systems do not appear to effectively remove total nitrogen and ammonia nitrogen loads (DOE/Malaysia, 1989).

Palm oil effluent can be applied to the land as fertilizer. The palm oil sludge also contains significant quantities of protein and carbohydrates for processing into animal feed (DOE/Malaysia, 1989).

Most of the manufacturing industries in Malaysia treat their wastewaters in on-site primary or secondary treatment systems.

Singapore

Singapore operates on a licensing system based on a "polluter pays" principle and has strict pollution control regulations specifying discharge limits. As a result of these measures, a large number of medium and large industries have installed pollution control and waste treatment facilities. Industrial parks have also been established and cost-shared waste treatment facilities are encouraged (Lee and Troxler, 1992).

Singapore has discouraged hazardous waste-producing establishments by imposing stringent waste disposal requirements and hazardous waste transportation manifests. The Pollution Control Department (PCD) is responsible for maintaining stringent control and disposal of hazardous substances. The PCD conducts spot checks and audits to ensure that materials are safely being used and disposed. Singapore has an incinerator and two landfill sites for hazardous waste processing and final disposal. Also, a number of chemical waste disposal contractors process and treat hazardous wastes (Lee and Troxler, 1992).

In October 1989, a program was implemented whereby private hospitals were required to use color

coded disposal bags to segregate waste for the purposes of collection and disposal (Yau, 1991). All hospitals have qualified management staff who serve as waste managers and who are responsible for the proper implementation of the hospital management programs. In addition, each hospital has a waste management manual with directives on waste handling, collection and disposal. According to Yau (1991), there are two licensed waste disposal contractors operating a fleet of six enclosed trucks for collection and disposal of biohazardous waste. All biohazardous and cytotoxic wastes are incinerated.

Agricultural waste

Indonesia

There is no information on agricultural waste management facilities and practices in Indonesia.

Malaysia

Proper animal waste management remains a problem in Malaysia because of land tenure issue (i.e., inadequate land allocation for modernizing agricultural activities) and the lack of political will. According to Law (1992), the problem of animal waste management could be overcome if society would change its attitude of animal husbandry from a backyard industry to that of a modern industry.

The most problematic waste is the manure from pig farms. The manure is usually discharged directly to rivers without treatment (DOE/Malaysia, 1989). Pig farmers in Malaysia have been advised to treat the waste before discharging into rivers. Waste treatment systems, such as aerobic and facultative lagoons and anaerobic digesters, are used with varying degrees of success. The issue is the apparent lack of knowledge in the management and operation of waste treatment systems on the part of pig farmers.

Pesticide use is reported to be extensive, as are the number of pesticides that are being sold in the market. The Pesticide Act of 1974 regulates pesticide sales. It also provides for investigation and reporting of pesticide related accidents, deaths and personal injuries. Restrictions on pesticides sale and education programs for people working with pesticides have also been implemented.

Singapore

To control wastes from poultry farms, farmers are required to rear poultry in covered sheds and remove dung in solid form. Poultry rearing in batteries makes for simple and effective collection and disposal of pollution. The amount of waste that finds its way into the drain is insignificant.

Solid waste

Indonesia

In order to alleviate the garbage problem in the cities, in 1986 the Indonesian Government implemented the "ADIPURA" (Beautiful City) award for the most beautiful and clean city in the country. The award is presented by the President every year in the framework of the Environmental Day celebration on 5 June. Cities are divided into three groups: metropolitan cities with populations of more than one million people; medium-sized cities with 0.5 to 1.0 million people and small-sized cities with 100,000 to 500,000 people. Through this approach, all cities in Indonesia are competing to receive the most prestigious award. As a result, many cities in Indonesia are cleaner, at least from the garbage point of view and more beautiful. There are still many cities, small towns and villages facing a garbage problem (Soegiarto, 1987).

Another program that has been put in place to reduce uncontrolled dumping of domestic wastes is the City Development Program. The program includes *kampong* improvement, which consists of enhancing the environmental infrastructure, such as walkways, drainage systems, garbage container and garbage collecting systems and public sanitation facilities.

Malaysia

In Malaysia, solid waste management is a local government function under the Ministry of Housing and Local Government. In Kuala Lumpur, Klang valley and Johor Baharu, collection frequency is daily for commercial areas and alternate days for residential areas (Lokman and Othman, 1991). Premises that generate large volumes of waste are serviced more frequently depending on the need. In most cases, collection is the responsibility of the local authority. There are a few contracted private companies assigned to collect refuse from areas under contract to the local government.

Landfill is the most common method of waste disposal in Malaysia and there is a Recommended Code of Practice for Landfill Development and Management. However, very few operating landfills meet the engineering standards for sanitary landfilling and, in most cases, open dumping of waste is practiced.

In Kuala Lumpur, two landfill sites are in operation (Lokman and Othman, 1991). However, the sites are in need of upgrading. The availability of new landfill sites around Kuala Lumpur is limited and alternative methods of solid waste disposal need to be considered. One such alternative is incineration.

In Johor Bahru, the Municipal Council has resorted to dumping most of the wastes into Pasir Pelangi, a swampy area located at the estuary of the Tebrau River (Lokman and Othman, 1991). It was suspected that this practice is resulting in pollution of the seashore.

It appears that new landfill sites are increasingly difficult to find, due in part to the high cost and scarcity of land in urban areas and the "not in my backyard" (NIMBY) syndrome which, according to Law (1992), prevails among the majority of the local residents.

Singapore

MSW is disposed in sanitary landfills or at incineration plants in Singapore. The three incineration plants, located at Ulu Pandan, Tuas and Senoko process a combined load of 1.76 million tonnes or 73% of the total refuse generated in Singapore (MOE Singapore, 1995a). The balance is disposed to the Lorong Halus Dumping Ground.

In 1994, construction of a leachate treatment plant at Tampines (S$ 9 million) was completed. In August 1994, the Singapore Parliament approved the reclamation of the foreshore area off Pulau Semakau for an offshore landfill site. Construction of the facility was started in early 1995.

SEA-BASED SOURCES OF MARINE POLLUTION

Marine pollution from sea-based sources is attributable to a number of activities.

The most significant pollutant entering marine waters from sea-based sources is oil. Tanker accidents, although much publicized, contribute a comparatively small percentage of the total oil entering the sea. However, the consequences of such accidents can be disastrous, particularly where the coastline is affected and where a large tanker is involved. A much larger quantity of oil enters the marine environment as a result of normal tanker operations (either accidentally or intentionally), much of which is associated with the cleaning of tank residues. The most common oil pollution occurs during terminal operations when oil is being loaded or unloaded. According to figures published by the International Tanker Owners Pollution Federation, globally speaking, as much as 92% of oil spills occur during these types of operations. Other sources of oil pollution include tank cleaning in connection with dry docking, the release of bilge and fuel oil, as well as accidents involving non-tanker vessels.

Although oil spills have serious effects on the marine environment, many of the chemicals carried by ships and handled in ports are potentially more hazardous to the marine environment and can have devastating effects when they enter the marine environment, even if only in small quantities.

Other sea-based sources of pollution include the leaching of anti-fouling paints from vessels and offshore platforms/other man-made structures and the introduction of unwanted aquatic species through ballast water exchange. Ocean dumping of wastes and other matter from vessels, platforms and other man-made structures is another source of pollution.

Ships

Operational discharges

Finn et al. (1979) reported on oil pollution from tankers in the Straits of Malacca, referring to all discharges which occur as a result of normal ship operations. They further subdivided operational discharges into functional and consequential types. Functional type discharges are discharges integrally connected with the peculiar characteristics of the transportation of petroleum and include deballasting and tank cleaning. Consequential type discharges are discharges integrally related to the nature of the carriage of the oil in tankers, but they may be greater than in non-tanker vessels. Among the consequential sources of discharges are bilge, bunkering and cargo loading and unloading.

Deballasting. An oil tanker on its return journey after having delivered its cargo of crude or refined oil needs to pick up water to give the vessel stability. This is called ballasting. When the ship arrives at its pickup point, the ballast water is discharged (called deballasting). The deballast water contains oil that was originally carried by the ship. According to Finn et al. (1979) significant deballasting occurs either during transit through the Straits or shortly before the vessels enter the Straits. It was noted by the same authors that the most significant deballasting occurs in the South China Sea prior to entry into the Straits by tankers on the return leg of their trip between Japan (and other destinations) and the Middle East. It was pointed out that deballasting in the South China Sea, at the eastern end of the Straits, will have pollution effects owing to the water circulation patterns.

Tank cleaning. The walls of the tank vessel contain oil. The amount of residual varies between 1% and 0.1% of the total cargo carried. The walls must be cleaned regularly; otherwise, there would be problems of co-mingling cargo and impediments to drainage. The most economical solution is to clean the tank with seawater and discharge the waste directly into the sea.

Bilge water and sludge. For cargo and container vessels, routine operational discharges, such as the disposal of oily bilge water and sludge (from the purification of heavy duty fuel oil), as well as ballast water, add to the marine oil pollution problem. It is estimated that 0.5% of all oil transported over the sea

ends up in the sea and almost three-quarters of that comes from the routine operation of ships (Ramayah, 1994).

In a recent paper by Tahir (1996), it was cited that one to two tonnes per day of oily waste, mainly via tanker deballasting, gets discharged into the Malacca Straits. There have also been incidences of illegal operational discharge. In 1994, the Department of Environment (DOE), Malaysia, reported 14 oil spill incidents due to oil sludge discharges, leakages during transfer and tanker cleaning activities. Seven of the incidents occurred in the Straits of Malacca (DOE/Malaysia, 1995). A major incident occurred on 15 January 1994. The Department of Environment of Malaysia detained a Liberian registered tanker (*Arabian Sea*) for alleged pollution in the Straits of Malacca. About 900 tonnes of oily sludges were found on board the tanker. The tanker was released on 2 February 1994 with a banker's guarantee of RM500,000 as security to compensate the Malaysian Government for all expenses incurred in mitigating the pollution caused by the tanker. On 25 February 1994, the tanker was given approval by the Ministry of Environment, Singapore, to sail into port for repair and proper disposal of the sludges (DOE/Malaysia, 1995). Tahir (1996) also pointed out that of the 28 cases of oil slick observed in the Straits of Malacca in 1995/1996, 14 cases were intentional dumping.

Discharges from small vessels. Discharges from small fishing boats, although low in volume individually, collectively represent a large input. According to Tahir (1996), the 10,000 fishing boats operating in the Malaysian side of the Straits contribute about 2 tonnes of oil pollution daily. It can be presumed that a similar or larger amount of operational discharge is contributed from the 50,000 fishing vessels which are operating along the Indonesian side of the Malacca Straits. In addition, discharges from other cargo and transport vessels that are operating along the Malacca Straits add to the pollution loading of the Straits.

Accidents

Number of shipping accidents. There has been an increasing number of maritime accidents in the Straits since 1985 (*Table 6.1*). The common type of accidents involved collisions and groundings (*Table 6.2*). Large vessels were more prone to groundings due to their draught in relation to the available water depth for navigation. Both groundings and collisions are mainly the result of navigational hazards, topography, currents and tides in the Straits and human error. Collisions have been found to account for more than 35% of the total number of accidents and this could be attributed to the large number of vessels using the Malacca Straits (Lee, 1994).

The most common types of vessels involved in accidents are the general cargo ships and oil tankers (*Table 6.3*). Of these, accidents involving loaded oil tankers accounted for 17% of shipping casualties in the Straits (Lee, 1994).

Accident statistics for the Straits are by no means complete or comprehensive, ranging from an average of 3 accidents per year to 30 depending on the source. Figures supplied by the Singapore authorities for the area covered by the Singapore VTIS (Vessel Traffic Information System) show an average of 4.7 marine

Table 6.1. Shipping Accidents in the Malacca Straits, 1977-1993 (Naidu, 1993; Lee, 1994).

Year	Number of Accidents	Year	Number of Accidents
1977	1	1986	5
1978	0	1987	4
1979	4	1988	9
1980	1	1989	1
1981	0	1990	21
1982	0	1991	2
1983	1	1992	5
1984	2	1993	9
1985	6	**Total**	**71**

Table 6.2. Types of Shipping Casualties in the Malacca Straits, 1977-1993 (Lee, 1994).

Type of Casualty	Number of Ships	Percentage
Collision	25	35.2
Grounding/Stranding	13	18.2
Explosion/Fire	5	7.0
Foundering	7	9.9
Others	21	29.6
Total	**71**	**100.0**

Table 6.3. Breakdown of Shipping Casualties in the Malacca Straits According to Type of Ship (Lee, 1994).

Type of Ship	Number of Casualties	Percentage
Container Carrier	3	4
Fishing Boat	11	15
General Cargo Carrier	23	32
Govt. Cargo Carrier	4	6
Passenger Liner	6	8
Oil Tanker	12	17
Tug Boat	5	7
Others	7	10
Total	**71**	**100**

incidents per year during 1985 or 1990, increasing to 10 in 1991 and 9 in 1992.

Casualty statistics from Lloyds Maritime Information Service (LMIS), as cited by Kamaruzaman (1995), show that of the total 476 maritime casualties which occurred in the Straits from 1978 to 1994, all types of vessels were involved at varying frequencies (***Table 6.4***). Vessels carrying general cargo top the accident figures (253) followed by oil tankers (98) and bulk cargo carriers (32).

Table 6.5 and ***Figure 6.1*** identify annual maritime casualties according to the type of vessel navigating through the Straits from 1978 to 1994. The following is derived from analysis of the data:

- The general cargo carriers, oil tankers and bulk cargo carriers had high incidences of maritime accidents compared to other types of vessels;
- Maritime casualties for both the general cargo ships and oil tankers occurred every year in varying frequencies from 1978 to 1994 and they were higher than any other type of vessel (***Figure 6.2***);
- If the casualties for both the general cargo ships and oil tankers are combined, they represent more than 60% the total marine accidents occurring annually from 1978 to 1994; and
- Since 1989, there was an increase in accidents by all types of vessels, particularly the fishing boats and other small cargo ships. This indicates that the cross-Straits traffic is probably increasing, adding to maritime casualties (***Table 6.5***).

The high incidence of marine casualties for general cargo carriers and oil tankers is not surprising, as they constitute more than 70% of the total shipping traffic in the Malacca Straits.

Table 6.4. Number and Percentage of Accidents According to the Type of Vessel Passing through the Malacca Straits (Kamaruzaman, 1995).

Type of Vessel	Number of Accidents	Percentage of Total Accidents
General cargo	253	53.15
Tanker	98	20.59
Bulk carrier	32	6.72
Fishing	21	4.41
Container ship	14	2.94
Liquefied Gas	8	1.68
Tug 7	1.47	
Ore carrier	6	1.26
Unknown type of vessel	4	0.84
Ferry	3	0.63
Landing craft	3	0.63
Passenger	3	0.63
Roro cargo	3	0.63
Supply ship	3	0.63
Tug/supply ship	3	0.63
Vehicle carrier	3	0.63
Livestock carrier	2	0.42
Aggregate carrier	1	0.21
Barge carrier	1	0.21
Cable layer	1	0.21
Crane pontoon	1	0.21
Destroyer	1	0.21
Drilling ship	1	0.21
Hopper/Dredges	1	0.21
Processing tanker	1	0.21
Refrigerated cargo	1	0.21
Utility vessel	1	0.21
Total	**476**	**100.00**

Causes of shipping accidents. There appears to be a close correlation between maritime accidents and the age or size of the vessels. Over the period of 1978 to 1994, about 456 accidents occurred, which have

Table 6.5. Maritime Casualties in the Malacca Straits, 1978-1994 (Kamaruzaman, 1995).

Year / Vessel	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
Bulk carrier	-	1	-	-	2	3	2	4	3	1	-	2	5	3	4	2	1	**33**
Container	-	-	-	1	-	-	-	1	2	2	-	1	1	1	2	1	3	**15**
General cargo	16	11	17	24	24	19	19	15	14	7	9	18	12	12	10	17	8	**252**
Liquefied gas carrier	-	-	-	-	-	-	-	1	-	1	1	1	2	1	1	-	-	**8**
Tanker	10	11	7	1	3	2	7	1	7	3	10	3	9	2	10	9	4	**99**
Fishing boat	1	-	1	-	1	-	1	-	-	2	2	2	3	1	3	1	3	**21**
Other	2	4	-	7	5	3	2	2	-	-	1	5	4	1	7	2	3	**48**
Total	29	27	25	33	35	27	31	24	26	16	23	32	36	21	37	32	22	**476**

Figure 6.1. Maritime Casualties by Type of Vessel in the Malacca Straits, 1978-1994 (Kamaruzaman, 1995).

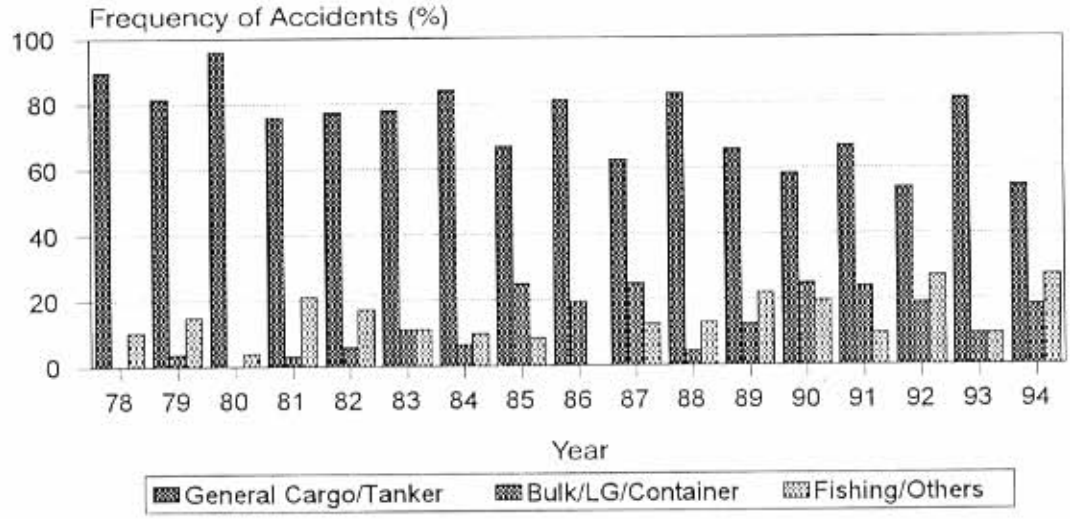
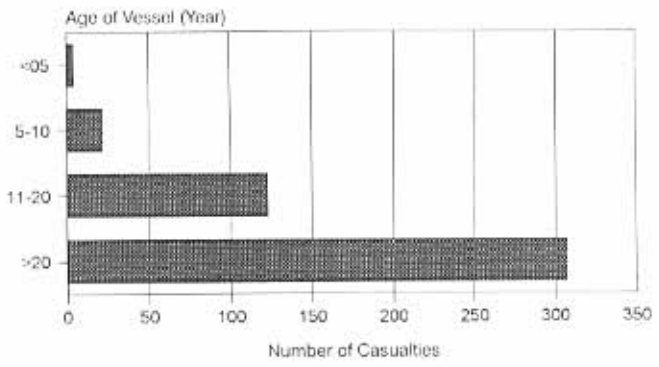


Figure 6.2. Maritime Casualties by Age of Vessel in the Malacca Straits, 1978-1994 (Kamaruzaman, 1995).

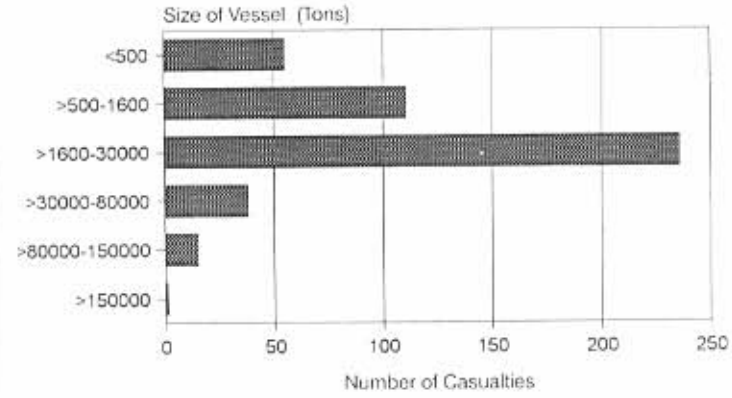


Notes: Total casualties over 1978-1994: 456

records of the size and age of vessels involved. As shown in *Figures 6.2* and *6.3*, the highest maritime casualties occurred among vessels that were older than 20 years and in the size category of 160,000 to 300,00 tons. The data indicate that the age factor, among others, is an important element to be considered when dealing with shipping safety issues in the Malacca Straits.

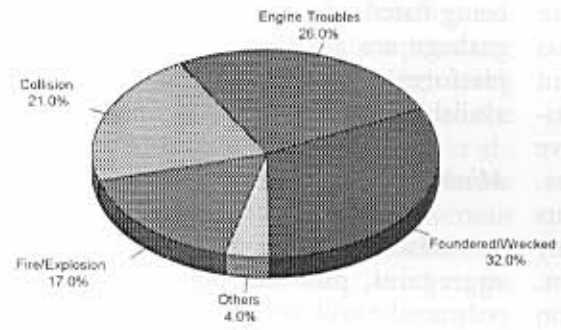
Maritime accidents in the Malacca Straits occur principally as a result of ships being wrecked/foundered/stranded, followed by ships developing engine trouble and colliding (*Figure 6.4*). R. Kamaruzaman (personal communication, November 1995) pointed out that in a traffic congested Malacca Straits, the potential for ship accidents caused by engine trouble or springing leaks should be viewed seriously. The potential threat to the safety of navigation and pollution, particularly in view of the increasing number of older vessels plying the Straits, is evident. Such incidents, although not drawing media attention, are occurring frequently and could develop into catastrophic proportions in the Malacca Straits (Kamaruzaman, 1995).

Figure 6.3. Maritime Casualties by Size of Vessel in the Malacca Straits, 1978-1994 (Kamaruzaman, 1995).



Notes: Total casualties over 1978-1994: 456

Figure 6.4. Causes of Maritime Casualties in the Malacca Straits, 1978-1994 (Kamaruzaman, 1995).



Total number of casualties over 1978-1994: 476

Ships, especially the deep-draught vessels that navigate in the Malacca Straits, require high vigilance because of the following (Ramayah, 1994):

- Heavy shipping traffic passing through the Straits, including a high proportion of very large crude carriers (VLCCs), oil tankers and container ships;
- Frequent cross-Straits traffic by small cargo and fishing vessels;
- Restricted navigational channels, strong tidal streams and rain squalls; and
- Unreliable navigational aids and numerous unconfirmed wrecks and shoal patches.

The relatively high frequency of attacks by pirates or armed robbers, when the vessels are often left unattended to sail through the Straits, further increases the risk of shipping in the Straits. It is no surprise that more than 80% of VLCC masters when interviewed expressed that they are duly worried when navigating through the Straits (Ouchi, 1994).

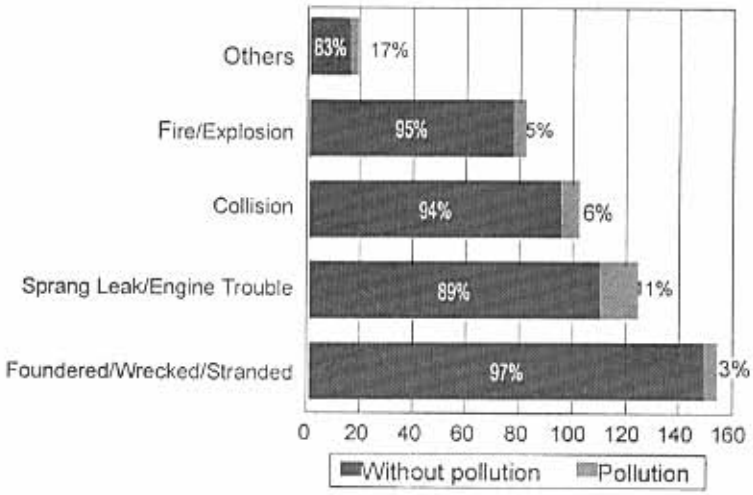
There are certain areas in the Malacca Straits where the navigation of deep-draught vessels is particularly difficult and further assistance to shipmasters is needed. These are at the areas off Medan (along the East Coast of Sumatra) and Cape Rachado (along the West Coast of Peninsular Malaysia) where large vessels are required to make major course alterations in relatively narrow waters. Another area where navigation is particularly difficult is the area around the Fair Bank Channel. Deep-draught vessels bound for Singapore from the West are required to cross the westbound lane of the Singapore Traffic Separation Scheme (TSS), requiring difficult and critical navigational maneuvers.

Although past records show that of the total ship accidents only a small proportion are associated with pollution of the environment (***Figure 6.5***), the fact remains that the total number of shipping accidents is high and many of the pollution incidences have had serious environmental and economic consequences. The presence of numerous ships carrying large amounts of potential pollutants in this ever-increasingly congested waterway gives rise for concern. Improving the safety of navigation in the Straits will help to reduce loss of lives and accidental pollution resulting from incidents of shipping mishaps.

Anti-fouling paints

Over the years, anti-fouling paints containing active compounds, such as lead, bitume, arsenic and mercurial compounds and DDT, have been used on ships. Many of these products have, however, been withdrawn from use due to their high toxicity. Today, anti-fouling paints are mainly based on tributyltin (TBT) and to a lesser extent on copper systems. These paints come in two basic types, namely: TBT Free

Figure 6.5. Maritime Causualties and Incidences of Pollution in the Malacca Straits, 1978-1994 (Kamaruzaman, 1995).



Association Paints and Copolymer Paints. In the former type, the biocide (TBT/copper) leaches freely from the resinous matrix. The initial biocide release rate is rapid and declines over time. In the copolymer type of paints, the biocide is released slowly at a controlled rate and uniform anti-fouling performance is achieved throughout the life of the paint. It has been reported that TBT copolymer paints represent 70% of the worldwide commercial usage of anti-fouling paints. Studies carried out worldwide have shown TBT to have adverse environmental effects. Since TBT is exclusively anthropogenic in origin, its occurrence in the marine environment has been directly attributed to its application as an anti-fouling agent. In light of these facts and taking into consideration the number of large shipping vessels that are traversing the Straits and calling at the different ports, it can be assumed that anti-fouling paints also represent a serious threat to the region.

In 1992, studies of TBT contamination on the West Coast of Peninsular Malaysia showed high levels (281.8 ng/l) in the seawater at Port Klang and in the sediments (27.6 ng/g wet weight) of Port Dickson (Tong et al., 1996). The levels of TBT in the tissues of mussels and cockles were between 0.5 and 23.5 ng/g-wet weight (Tong et al., 1996).

Offshore Activities

Oil and gas exploration and production

On the East Coast of Sumatra, the only company producing oil offshore is Hudbay Oil Malacca Straits Ltd. (HOMSL), where production has reached 40,000 barrels per day. The Hudbay concession, called the Lalang Field, is situated in the Lalang Strait, which lies between mainland Sumatra and Pulau Rupat. The field consists of several offshore wells. To serve the field, five platforms have been constructed, of which three are well-head platforms, one is a production platform and another is a platform for living quarters. In addition to these platforms, the field has a mooring tower to which a storage barge or tanker is moored. Submarine pipelines connect the relevant wells and the production and storage sites. Other offshore areas are still in the exploration phase (Coutrier, 1988).

The potential of pollution discharge from such offshore operation is primarily from the drilling effluents, such as enormous volumes of high concentration saltwater. These fluids may also contain traces of heavy metals and gases which are normally being flared. In addition, domestic wastewater and garbage are also generated. Information on the platform discharges to the Straits is not readily available.

Mining

Offshore mining is carried out for construction aggregates, precious metals, ferrous metals and polymetalic nodules and crusts (***Table 6.6***).

All three nations are involved to some extent in offshore mining, especially sand and gravel. Offshore mining of tin is occurring in Malaysia and Indonesia, as well as several other metals and non-metals (Chansang, 1984; Burbridge et al., 1988). The extent of mining activities and their precise impact in the marine environment requires further assessment.

Apart from the obvious problem of direct destruction of habitat, a major problem concern is turbidity. Turbid plumes are created when mechanical and hydraulic dredges are used. The turbid plumes can extend up to 1,500 to 2,000 feet from the dredging site. Smothering of fish habitat, coral and bottom dwelling organisms can occur.

Aquaculture

Aquaculture is a valuable and fast growing marine industry within the Malacca Straits. The industry is not only sensitive to the problems of pollution, but is

Table 6.6. Principal Types of Oceanic Minerals.

Type of Deposit	Materials or Elements	Main Geological Setting
Construction aggregates	Pebbles and quartz	Coast and continental shelf
Industrial materials	Phosphorite, sulfur, aragonite, shells, and silica sand	Coast and nearshore submarine plateau
Precious metals/ minerals	Gold, platinum, tin, diamond, rare earth elements, zirconium, titanium, chromium, scheelite, and others.	Coast and nearshore
Ferrous and non-ferrous metals	Iron, copper, manganese, lead, zinc, and others	Fracture zones and spreading centers
Polymetallic nodules and crusts	Manganese, iron, cobalt, nickel, titanium, molybdenum, and others	Deep sea

also a polluter of the marine environment (Chua et al., 1989). The extent of pollution impact depends on the nature of aquaculture, its precise location and upon the technologies that are being applied.

In general, the biggest pollution problem is the effluent which is generated as a result of the aquaculture operation. The effluents tend to contain high levels of nutrient and organic materials, which reduce the water quality of the surrounding waters (Chua et al., 1989; Pillai, 1993). Other potential problems occur as a result of the use of chemicals and the inadvertent discharge of chemical residuals. The chemicals used in aquaculture farms include antibiotics, disinfectants and biocides. Recent data (1995) from the Direktorat Jenderal Perikanan show that 81,695 kg of fertilizer and 816 kg of pesticides were used in the brackishwater ponds for the provinces of Aceh and North Sumatra, Indonesia (1993).

Dredging

High sediment loads can result from both land- and marine-based activities. As a result of the high silt loadings, harbors and ports need to be periodically dredged to ensure the safe passage of the larger vessels. Dredging leads to the resuspension of sediments which can have deleterious effects on the benthic organisms and consequently reduce the primary production capacities in the area.

Prevention and Management of Sea-based Sources of Pollution

Pollution prevention

International conventions

IMO Conventions on Marine Pollution. The main IMO convention on marine pollution is the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78). MARPOL covers all the technical aspects of pollution from ships, except the disposal of waste and other matter by dumping which is regulated under the London Convention. MARPOL applies to all types of ships, but not to pollution arising from the exploration and exploitation of seabed mineral resources. Indonesia, Malaysia and Singapore have ratified Annex I and II of MARPOL 73/78. ***Table 6.7*** lists the international conventions relating to marine pollution by Indonesia, Malaysia and Singapore.

International Conventions on Liability and Compensation for Oil Pollution from Tankers. At present, there are two international regimes through which compensation for clean-up costs and damage are available for persistent oil (crude oil, fuel oil, heavy diesel oil and lubricating oil) namely, the:

- International Convention on Civil Liability for Oil Pollution Damage, 1969 (CLC) with its 1976 and 1992 protocols; and
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (Fund) with its 1976 and 1992 protocols.

The CLC and Fund are international conventions adopted under the auspices of the International Maritime Organization (IMO) and they apply only in those countries which have ratified the conventions.

United Nations Convention on the Law of the Sea (UNCLOS) contains various articles dealing with the prevention of pollution from ships and platforms,

Table 6.7. International Conventions on Marine Pollution.

Conventions	Indonesia	Malaysia	Singapore
UNCLOS 82	■	■	■
MARPOL			
Annex I/II	■	■	■
Annex III			■
Annex IV			
Annex V		■	
London Convention			
Convention 72			
Amend 78			
Intervention			
Convention 69			
Protocol 76			
CLC			
Convention 69	■	■	■
Protocol 76			■
Protocol 92			
FUND			
Convention 71	■	■	
Protocol 76			
Protocol 92			
COLREG 72	■	■	■
SALVAGE 89			
OPRC 90		■	
BASEL 89	■	■	■

■ – Ratified

under which new regulatory measures may be established. All three littoral States are parties to UNCLOS. Part XII of the Convention deals with the protection and preservation of the marine environment. Article 211 deals with international rules and national legislation to prevent, reduce and control pollution of the marine environment from vessels.

Tokyo Memorandum of Understanding on Port State Control. All three littoral States are parties to the Tokyo Memorandum of Understanding on Port State Control for the Asia-Pacific Region. Under the MOU, ship inspections are required to ensure that vessels comply with MARPOL 73/78, as well as with relevant international safety conventions. Under MARPOL 73/78, the inspection should be limited to verifying that there is a valid International Oil Pollution Prevention (IOPP) Certificate on board[1]. If the Port State doubts the condition of the ship/equipment or if it does not carry a valid certificate, the ship can be prevented from sailing until the Port State is satisfied that it presents no threat to the marine environment. The Governments are responsible for issuing certificates and for providing reception facilities. In the case of countries which are members of the MOU, but which have not yet ratified MARPOL 73/78, classification societies are responsible for issuing IOPP Certificates and the Governments are not obliged to provide reception facilities. This could lead to discrepancies in the implementation of the MOU.

Navigational safety

International conventions

IMO Conventions on Safety of Navigation focus on international standards for design, construction, equipping and maintenance of ships. In addition, IMO conventions provide standards for ensuring that vessels are operated by adequately trained crews. The status of ratification of these conventions by the littoral States of the Malacca Straits is shown in ***Table 6.8.***

Ensuring that the IMO conventions are implemented is the responsibility of the Contracting Parties to the conventions. Contracting Parties are obliged to enforce the provisions set forth in the conventions on all vessels flying their flag. Safety of lives and the marine environment are put at risk when ships using the Straits fly the flag of a country which is

Table 6.8. Status of Ratification of IMO Conventions on Navigational Safety.

Conventions	Ratified by Indonesia	Ratified by Malaysia	Ratified by Singapore
International Convention for the Safety of Life at Sea, 1969 (SOLAS Convention 69)	Yes	Yes	Yes
International Convention on the Safety of Life at Sea, 1974 (SOLAS Convention 74)	Yes	Yes	Yes
Protocol Relating to the Safety of Life at Sea, 1978 (SOLAS Protocol 78)	Yes	Yes	Yes
Protocol Relating to the Safety of Life at Sea, 1988 (SOLAS Protocol 88)	Yes	Yes	Yes
International Convention on Load Lines, 1966 (LOAD LINES Convention 66)	Yes	Yes	Yes
Protocol on Load Lines, 1988 (LOAD LINES Protocol 88)	No	No	No
International Convention on Tonnage Measurement of Ships, 1969 (TONNAGE Convention 69)	Yes	Yes	Yes
Special Trade Passenger Ships Agreement, 1971 (STP Agreement 71)	Yes	No	No
Protocol on Space Requirements for Special Trade Passenger Ships, 1973 (STP Protocol 73)	Yes	No	No
Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material, 1971	No	No	No

[1]The International Oil Pollution Prevention (IOPP) Certificate is required for oil tankers of 150 tons gross tonnage and above involved in international trade and for ships other than tankers of 400 gross tonnage and above trading internationally.

not a party to the IMO maritime safety conventions or when the Flag State has ratified the conventions but is not implementing adequate safety measures.

Records of inspections by various Port States around the world have revealed that a large number of ships carrying certificates as required by IMO conventions lack the necessary provisions set forth in the conventions. This indicates irresponsible conduct by the ship owners, operators and the authorities issuing certificates, as well as poor control and monitoring by the Flag States. In order to alleviate the problem, IMO has developed and promotes Port State Control on a global basis to ensure the phasing out of substandard ships through the active implementation of ship inspections.

The *UNCLOS* provides an international legal umbrella beneath which a variety of new regulatory measures relating to the control of navigation, standards of ship construction and operation, as well as prevention of marine pollution may be established.

UNCLOS contains various articles dealing with the safety of passage. Article 94 clearly defines the jurisdiction, control and responsibility of Flag States to ensure safety at sea. Paragraph 3 of this Article requires every State to take measures for ships flying its flag as are necessary to ensure safety at sea with regard, *inter alia*, to:

- the construction, equipment and seaworthiness of ships;
- the manning of ships, labor conditions and the training of crew, taking into account the applicable international instruments;
- the use of signals, the maintenance of communications and the prevention of collisions.

Paragraph 4 of the same Article specifies that the measures taken should include those necessary to ensure:

- that each ship, before registration and thereafter at appropriate intervals, is surveyed by a qualified surveyor of ships and has on board such charts, nautical publications and navigational equipment and instruments as are appropriate for the safe navigation of the ship;
- that each ship is in the charge of a master and officers who possess appropriate qualifications, in particular in seamanship, navigation, communications and marine engineering and that the crew is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship;
- that the master, officers and, to the extent appropriate, the crew are fully conversant with and required to observe the applicable international regulations concerning the safety of life at sea, the prevention of collisions, the prevention, reduction and control of marine pollution and the maintenance of communications by radio.

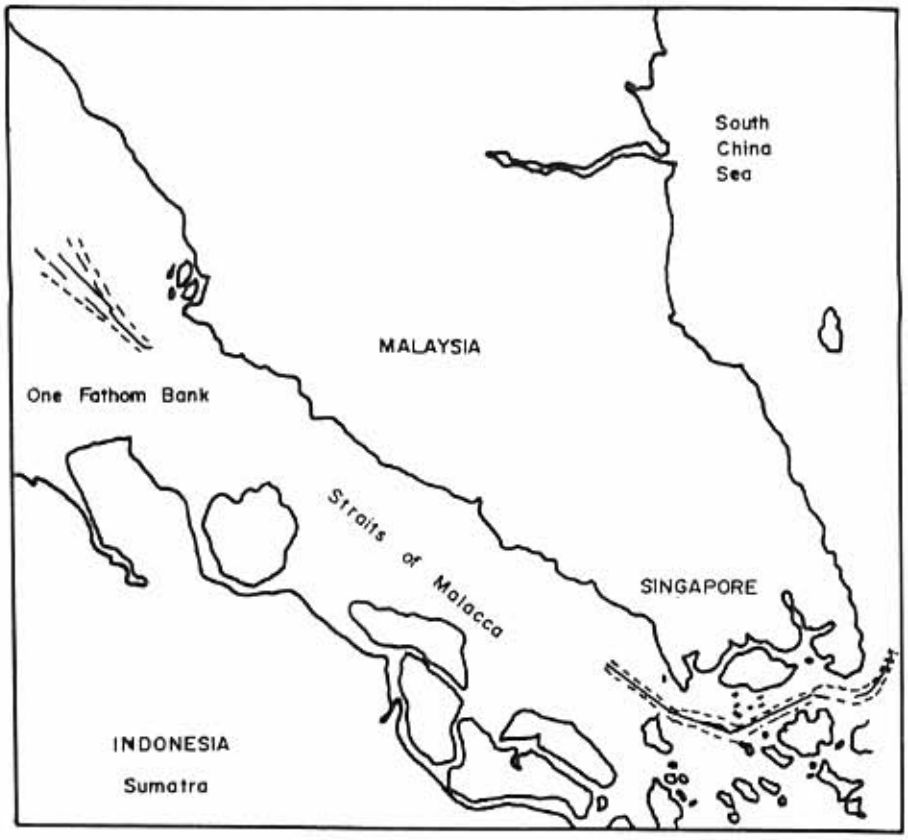
Paragraph 5 of Article 94 further enforces that the above paragraphs are implemented, whereas paragraphs 6 and 7 include measures which should be taken by the Flag State if proper jurisdiction and control have not been taken by the ship.

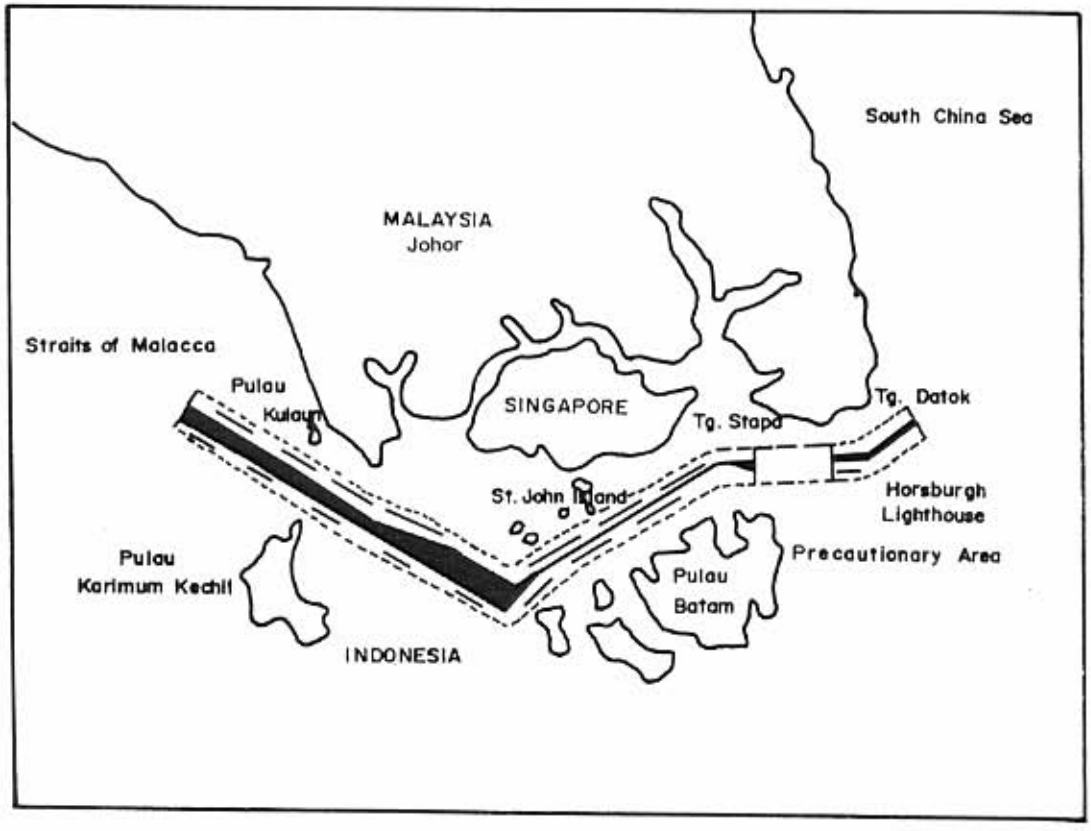
Article 41 provides for the designation of sea lanes and traffic separation schemes in straits used for international navigation, while Article 42 provides for regulations of maritime traffic.

Routing measures. IMO has adopted routing measures in the Malacca Straits which consist of: Traffic Separation Schemes; Deep-Water Routes; and Rules for Vessels Navigating through the Straits of Malacca and Singapore.

Traffic separation schemes. Two traffic separation schemes have been developed which cover the main areas of traffic congestion and restricted fairways within the Straits. These are at One Fathom Bank and in the Singapore Strait in the vicinity of Horsburgh Lighthouse (***Figure 6.6***). There is no routing scheme between the two traffic separation schemes; however, a joint proposal by the International Chamber of Shipping and Oil Companies International Marine Forum considers joining these two schemes. All three littoral States have agreed in principle to review the present traffic separation schemes. A proposed scheme is currently under consideration among the three littoral States and will be presented to the Navigation Sub-Committee of the IMO for approval. The establishment of traffic separation schemes through the Straits will mean that the littoral States will have the responsibility of ensuring that ships are able to position themselves with reasonable ease and that the route is safe from navigational hazards, unobstructed and with ample maneuvering width. This will require additional navigational aids, verification of charted depths, hydrographic surveys, marking and removal of wrecks and establishment of monitoring and communication capability to issue navigational warnings.

Figure 6.6. Traffic Separation Schemes (TSSs) along the Malacca Straits (Dow, 1993).





Rule 10 of the International Regulations for Preventing Collisions at Sea, 1972 (COLREG 1972), as amended, applies to traffic separation schemes and is attached as Annex 1.

Deep-water routes. There is a deep-water route within the eastbound lane of the Traffic Separation Scheme in the Singapore Strait (***Figure 6.6***).

IMO rules for vessels navigating through the Straits of Malacca and Singapore are presented in Annex 2.

Pilot service. An arrangement exists whereby ships can take on board a Singapore "Port Captain" or make private arrangements with Singapore-based master mariners who are experienced in the area and who can advise the master during transit through the Straits. Although some VLCC operators use pilot services on a regular basis, others feel that the "advisors" have the disadvantage of not being fully aware of the handling characteristics or limitations of the vessel. Malaysia has indicated that she also has experienced and fully trained "advisors" available for this service (IMO, 1993).

Aids to navigation. From 1968 to 1988, the Malacca Strait Council donated and installed 29 aids to navigation in the Straits. These consisted of 4 lighthouses, 10 light beacons, 7 resilient light beacons and 8 light buoys (currently 11 of these navigational aids are equipped with racons). ***Figure 6.7*** shows the location of aids to navigation in the Malacca Straits.

The navigational aids are checked each year by a joint team comprised by the Malacca Strait Council, Indonesia and Malaysia and repairs are carried out as necessary. Conflicting viewpoints exist regarding the adequacy of navigational aids (buoys/beacons) in the Malacca Straits. The littoral States feel that the existing navigational aids are adequate. For example, Malaysia is maintaining a 99% availability (reliability) of offshore aids to navigation and this is planned to be upgraded to a 99.9% availability through the implementation of several lighthouse modernization schemes. On the other hand, ships report that the availability of aids to navigation in the Malacca Straits cannot be relied upon fully. Notices to mariners, pilot publications and lists of radio signals all contain warnings regarding the reliability of aids to navigation in the Malacca Straits (IMO, 1993).

The littoral States report that there is a problem with unidentified vessels colliding with navigational buoys and causing them to be dragged out of position and/or damaged. They feel that an unfair burden is being placed upon their resources requiring them to maintain aids to navigation for ships, which in the main part, do not call at their ports (IMO, 1993).

A safety study by the Oil Companies International Marine Forum (OCIMF) concluded that safety improvements would result if selected navigational buoys were replaced with fixed light beacons or fixed radar transponder beacons. Indonesia has acknowledged that to enhance the safety of navigation, it is more important to improve the performance of existing navigational aids than to provide additional facilities (IMO, 1993).

Vessel traffic systems (VTSs) and radar facilities. There is at present no VTS to cover the whole of the Malacca Straits. However, parts of the Malacca Straits are covered by the Singapore Vessel Traffic Information Service and by the Indonesia Customs Coastal Radar System. ***Figure 6.8*** shows the areas of the Straits currently covered by the vessel traffic systems.

A report of the IMO Working Group on the Malacca Straits Area concluded that, at the time of the study, there was no particular need for a sophisticated VTS for the Malacca Straits (IMO, 1993). It should be recalled that any proposal for the establishment of a vessel traffic system in the Malacca Straits must fully comply with IMO resolution A.578(14).

Singapore's Vessel Traffic Information Service (VTIS) has been in operation since October 1990. This is a comprehensive radar and computer-based vessel traffic system covering the Singapore Strait Traffic Separation Scheme. The objectives of the VTIS are to improve safety of navigation in the Singapore Strait; to facilitate the safe flow of shipping in and out of the Port of Singapore; and to provide navigational information to vessels using the Singapore Strait.

The VTIS is operated by the Port of Singapore Authority. There are two operators designated to communicate with ships within the Singapore Traffic Separation Scheme area and an additional console can be utilized if required. The center has five multi-tracking radars, VHF-DF facilities to identify targets and a database of vessel particulars. The VTIS operates on VHF Channels 10 (Primary Channel), 73 (Secondary) and 12, 21 and 22 for port operations.

All vessels and tows of 300 gross tons or more and all passenger vessels intending to enter or depart from the Port of Singapore are required to participate in the VTIS. Vessels transiting the Singapore Strait

Figure 6.7. Location of the Various Navigation Aids in the Malacca Straits (Lee, 1994).

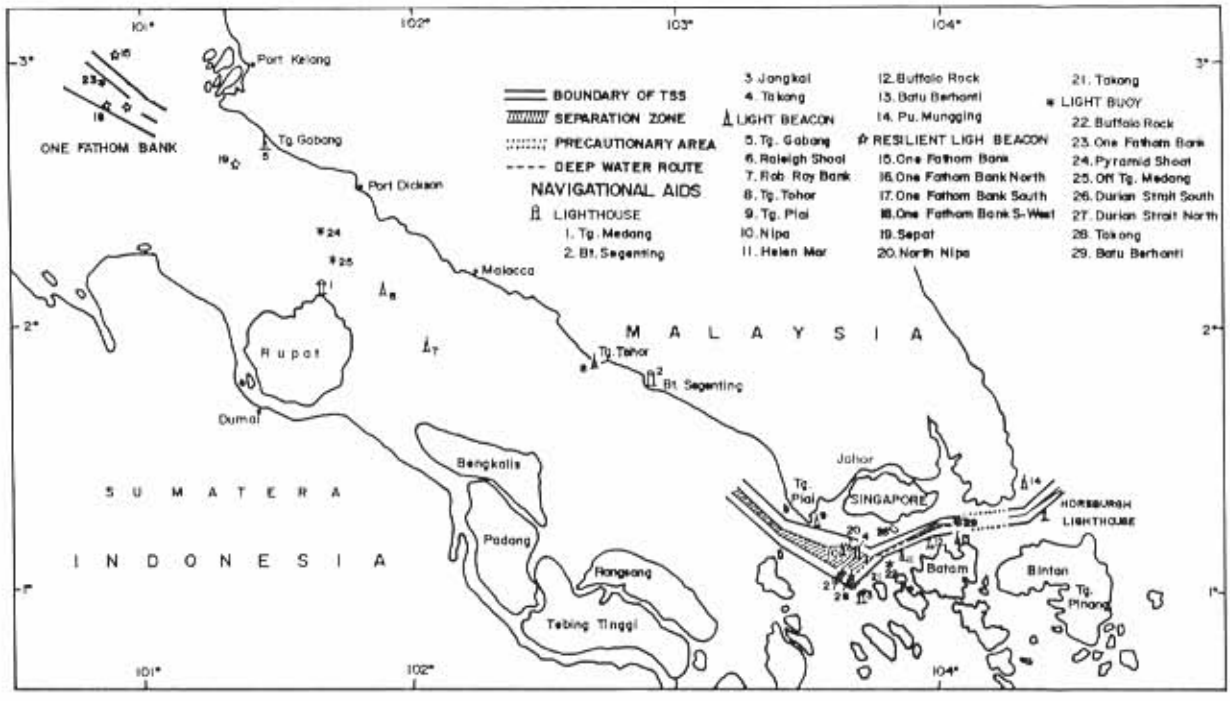
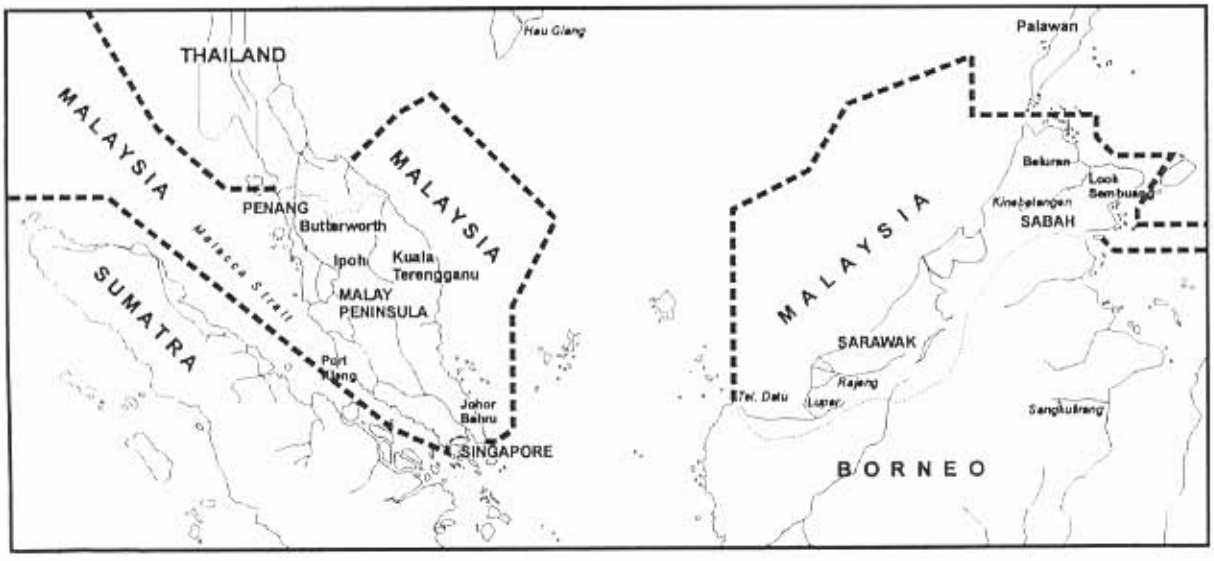


Figure 6.8. Vessel Traffic System (VTS) Coverage of the Malacca Straits (Hamzah, 1994).



are encouraged to do so. However, it has been reliably estimated that only 20-30% of through traffic in the Singapore Strait participate in the VTIS (IMO, 1993). The safety of navigation in the Straits could be improved further if more through traffic participated in the VTIS. It must be noted that with over 200 vessels arriving in the Port of Singapore each day and each vessel being required to transmit a lengthy confirmation of arrival on VHF Channel 10, both operators are fully utilized and VHF Channel 10 is congested with various messages. The fact that the system is fully utilized could be part of the reason for the low compliance rate (IMO, 1993).

Singapore installed a new traffic monitoring and control system in 1993, but its range and jurisdiction are limited to the island's immediate locality.

Customs authorities in Indonesia have established a shore-based high resolution radar system for anti-smuggling purposes, called the Customs Coastal Radar System. The system consists of radar scanners located in Jantan Hill on Great Karimun Island and in Dangas Hill on Batam Island, with a coverage of 32 nautical miles. The system provides radar coverage of the extreme southern end of the Malacca Strait and Singapore Strait. The control center is situated on Great Karimun Island and has direct radio contact with customs patrol boats. The facility is dedicated to anti-smuggling operations and is fully controlled by customs. Communications between the control center and other outside organizations, such as the Maritime Rescue Coordination Centres, Singapore VTIS, Coast Guard and ships in the Straits, are not provided.

Indonesia has come up with a proposal for the establishment of three new VTS, with four surveillance radars and the three patrol vessels operating around each radar site. Funds are currently lacking for this proposal.

Malaysia is looking at the feasibility of establishing a sea surveillance system which would initially consist of radar coverage at One Fathom Bank, South of Kelang, Port Dickson and Melaka.

Radiocommunications

Ship to shore communication. The three littoral States operate a number of coast (earth) stations for different radiocommunication systems/frequencies. The systems include: MF telephony/telegraphy, HF telephony/telex/telegraphy, VHF telephony, INMARSAT telephony/telex/EGC, as well as transmission of NAVTEX warnings and reception of COSPAS-SARSAT EPIRB alerting. Although many different radio systems may be used to inform shore authorities of an emergency situation, experience indicates that ships generally prefer to use either VHF or INMARSAT.

Coast stations. There are approximately 25 VHF coast stations around the Malacca/Singapore Straits area; however, the majority of these do not operate on a 24-hour basis.

Table 6.9 shows the VHF radio stations in the Malacca Straits which are operational on a 24-hour basis and indicates the channels which keep a continuous listening watch.

The total number of coastal stations in the Straits should be able to cover the whole area reasonably well with respect to MF radiotelephony and radiotelegraphy. However, the atmospheric noise levels in the area are sometimes extremely high in the MF band and this may periodically disturb or prevent communications, in particular radiotelephony communications. The HF coastal stations in the area should, however, adequately cover the short wave bands and some of the stations are reputed to provide very efficient services. The communication range on VHF bands mainly depends on the height above sea level of the coast station antennas. The Singapore coast station has a range of approximately 50 nm, however this is longer than normal due to the high antenna positions. The VHF coast stations in the area being operational on a 24-hour basis are, however, not sufficient to give continuous coverage on VHF of the whole area.

Table 6.9. VHF Radio Stations in the Malacca Straits.

Country	Radio Station	Channel
Indonesia	Dumai Radio[1] and Belawan Radio	VHF Channel 162,182 kHz (radio telephony) 500 kHz (morse telegraphy)
Malaysia	Klang Radio and Penang Radio	VHF Channel 162,182 kHz (radio telephony) 500 kHz (morse telegraphy)
Singapore	Singapore Radio	VHF Channel 162,182 kHz (radio telephony) 500 kHz (morse telegraphy)

[1] According to the ITU List of Coastal Stations, Dumai Radio is not continuously operational on 500 kHz.

INMARSAT Coast Earth Station. Singapore has established an INMARSAT Coast Earth Station (CES), which provides both INMARSAT-A and -C services, including EGC. The Singapore INMARSAT Coast Earth Station operates into the Pacific Ocean satellite and thus only marginally covers the Singapore Strait and also the eastern part of the Malacca Strait. The disadvantage of this is that ships sending messages using this INMARSAT system will normally send the messages to one of the stations operating in the Indian Ocean area which means that the messages may be diverted through coastal stations far away before they reach the Singapore Coast Earth Station.

Mission Control Centre and Local User Terminals. Indonesia has established a Mission Control Centre and two Local User Terminals (LUT) for the COSPAS-SARSAT system. These installations provide a complete real time coverage of all areas under consideration and will ensure minimum alerting delays when ships in these areas are using COSPAS-SARSAT EPIRBs for distress alerting. Both of the LUTs cover all relevant frequencies (i.e., 406, 121.5 and 243 Mhz).

Communication between the various shore authorities The three littoral States have established fixed point-to-point communication lines (telephone, telefax and telex communications) between their national Maritime Resource Coordination Centres. Experience has shown the communications between the three States to be very good.

The following systems are used for communicating between the various shore authorities (i.e., between coastal stations, Maritime Rescue Coordination Centers, maritime authorities, the law enforcement agencies, etc.) within one country and between the three countries: partly dedicated (leased) point-to-point lines; ordinary switched telecommunication networks; and radio links.

In general, dedicated point-to-point lines will be the most reliable and will also permit the use of the ordinary switched telecommunication networks as backups. The reliability of the ordinary switched networks seems to be adequate. The dedicated point-to-point mode of communication is generally recommended in cases of distress which do not involve piracy/armed robbery attacks.

IMO recommends (MSC/Circ.597) that the Maritime Rescue Coordination Center (RCC) in each country be the contact point for ships when in distress. It should also be pointed out that, in case of piracy/armed robbery attacks, the RCC only acts as a contact point between the ship and the law enforcement agency. In these cases, reporting to RCC may only cause unnecessary delays, especially in cases where the Maritime RCC is not manned on a 24-hour basis.

Singapore does not have its Maritime RCC manned on a 24-hour basis and it will not be manned until an accident requiring its involvement is actually reported. The aeronautical RCC, which is manned on a continuous basis and is located together with the maritime RCC, ensures appropriate response to any call reaching the Maritime RCC, until its own personnel arrive (this is normally within 10 to 15 minutes). When a coastal station receives a message from a ship which necessitates the involvement of the Maritime RCC, the coast station also ensures that appropriate personnel are summoned. In Singapore, each coastal radio station which may receive messages from ships regarding piracy and armed robbery is instructed to contact the appropriate law enforcement agency directly.

In Peninsular Malaysia, there is one RCC located at Kelang and two Rescue Subcenters (RSC) servicing the Malacca Straits at Penang and Johor Bahru. All of these Rescue Coordination Centers are manned on a 24-hour basis. However, in the case of a piracy/armed robbery attack the RCC is not the focal point for reporting incidents since it would only forward the message to the appropriate law enforcement agency for their response.

Indonesia has four RCCs and fifteen RSCs. The RCC in Jakarta and RSCs in Medan, Pekan Baru and Tanjung Pinong cover the Malacca Straits and vicinity. The RCCs and RSCs are manned on a 24-hour basis and Indonesia has also installed two Local User Terminals (LUTs) for the COSPAS/SARSAT system which provide real time coverage of the Malacca Straits area and minimize alerting delays for vessels fitted with COSPAS/SARSAT EPIRBs. Both LUTs cover all relevant frequencies. By 1994, Indonesia expects to install VSAT at fourteen RCCs and RSCs.

Facilities for transmission of warning messages to ships. When a ship is in distress it is important that other ships are warned so that they can take extra precaution. Different systems/frequencies can be used for passing on such messages: Verbal warnings can be given, for example, through VHF Channel 16 or 2,182 kHz. Written messages, although taking time, ensure correct reception of messages.

All vessels flying the flag of a nation which has ratified the SOLAS Convention are required as of 1 August 1993 to carry a NAVTEX receiver. There is a NAVTEX transmission station in Singapore which is normally capable of covering all areas within a range of 400 nm of the transmitter, sometimes farther. Normal NAVTEX messages (routine messages) are transmitted every 4 hours. These mainly comprise navigational and meteorological information. NAVTEX Important messages can be sent when the NAVTEX frequency is not in use. NAVTEX Vital messages can be sent at any time and these will interrupt any messages being sent out.

Certain areas of the Straits are not covered by the NAVTEX station. In general, these areas will be covered by the INMARSAT EGC (SafetyNET) system. It is, however, not mandatory under SOLAS for ships to be fitted with EGC receivers and, therefore, some ships may not be able to receive INMARSAT EGC messages.

Patrol boats. The three littoral States have together a large number of patrol boats on continuous patrol assignments in the Straits area. In general, the patrol boats will keep a listening watch on VHF Channel 16. Thus, even if an emergency message is transmitted by a ship outside the coverage of VHF coast stations, there is a possibility that such a message will be received by one or more of the patrol boats in the area.

Navigation guides. Various guides have been published to assist shipmasters to navigate through the Straits. Among the existing publications are the International Chamber of Shipping/Oil Companies International Marine Forum "Straits of Malacca and Singapore - A Guide to Planned Transits by Deep Draught Vessels" (Third Edition, 1990). This publication contains general information and guidance and concentrates on explaining methods of planning transit in order to achieve a safe passage through the Straits.

Search and rescue. None of the three littoral States has ratified the International Convention on Maritime Search and Rescue, 1979 (SAR).

Search and rescue in Indonesia is carried out under the auspices of Basarnas, which is part of the Transport Ministry. Basarnas provides SAR assistance for both aircraft and vessels in distress. With the exception of two helicopters, Basarnas has no dedicated response units. The Indonesian Armed Forces have the authority to deploy vessels and aircraft on an as-needed-basis. Private vessels are also expected to respond to requests for assistance to the extent that they can be of assistance.

In Malaysia, the national search and rescue is the responsibility of the Marine Department, Ministry of Transport. There are no dedicated SAR resources; however, units from the Royal Malaysian Navy, Royal Malaysian Air Force, Marine Police, Marine Department and other Government agencies are available for use, as required. There is apparently good cooperation among the various organizations to employ the appropriate vessels/aircraft in response to each SAR incident.

Search and rescue in Singapore is the responsibility of the Singapore Marine Department. There are no resources specifically designed for SAR response. However resources for SAR response are provided by the following: Police Coast Guard and Republic of Singapore Naval vessels, aircraft and salvage tugs, plus vessels of opportunity such as merchant vessels in the area and civil aviation authority aircraft.

Organizations. The following organizations have worked and continue to work towards ensuring safety of navigation in the Straits.

International Maritime Organization (IMO). The main actions/discussions which have taken place in IMO regarding the improvement of safety of navigation in the Malacca Straits include:

Adoption of Assembly Resolutions

Resolution A.375(X) Navigation through the Straits of Malacca and Singapore (November 1977) describes a new routing system for the Malacca and Singapore Straits, including traffic separation schemes, deep-water routes and special rules for deep-draught vessels and VLCCs.

Resolution A.476(XII) Navigation through the Straits of Malacca and Singapore (November 1981) adopts the amendment to the special rule on deep-draught ships (effectively amending the rules which had been adopted by resolution A.375(X)).

Resolution A.545(13) Measures to prevent acts of piracy and armed robbery against ships (November 1983) urges governments to take, as a matter of highest priority, all measures necessary to prevent and suppress acts of piracy and armed robbery against ships in or adjacent to their waters.

Maritime Safety Committee (MSC). In April 1978, the thirty-eighth session of MSC noted that the three littoral States had in principle reached agreement to amend the Traffic Separation Scheme in the Singapore Strait.

In April 1981, the forty-fourth session of MSC considered a proposal by the three littoral States to amend one of the special rules concerning the problem of a loaded VLCC crossing the westbound lane when approaching the Sultan Shoal pilot boarding area, to ensure it was consistent with the Collision Regulations which apply to vessels in TSSs. The change to the rule was approved.

In April 1984, the forty-ninth session of MSC established "Piracy and armed robbery against ships" as a separate and fixed item in its work program.

In December 1992, the sixty-first session of the MSC considered recommendations by the Oil Companies International Marine Forum that safety of navigation would improve in certain parts of the Malacca Straits if selected navigational buoys were replaced with fixed light beacons or fixed radar transponder beacons (racons).

IMO Sub-Committee on Safety of Navigation. In January 1981, the twenty-fifth session of the Sub-Committee considered suggestions by the Oil Companies International Marine Forum that lighted navigational marks and radar reflectors should be established at suitable positions on both sides of the channel to the northeast of Fair Channel Bank in the Singapore Strait. The Sub-Committee has also considered the feasibility of introducing additional Traffic Separation Schemes in selected areas within the Straits.

IMO Working Group on the Malacca Strait Area was set up following a proposal by the Secretary-General of the IMO to establish a Working Group on piracy and armed robbery composed of Member Government experts, which included experts from the three littoral States. The proposal was endorsed by the IMO Council in November 1992 and the MSC in December 1992. In addition to looking at the piracy/armed robbery situation, the group also considered the enhancement of safety of navigation and the protection of the marine environment in the area. The Group came up with a number of recommendations which are published in the "Report of the IMO Working Group on the Malacca Straits Area" (IMO, 1993). A summary of the recommendations given by the Group can be found in the section "Proposals for Improving Safety".

Tripartite Technical Experts Group on Safety of Navigation in the Straits of Malacca and Singapore (TTEG) comprises technical officials from the three littoral States. The discussions at the TTEG meetings are aimed at exchanging information and seeking means to enhance safety of navigation in the Straits. Matters discussed include: routing of ships; aids to navigation; surveys of the Straits; production of up-to-date navigational and tidal charts; and verification of wrecks and shoals and their removal or marking as necessary. The TTEG does not have a fixed schedule of meetings but meets as and when necessary, with the three countries taking turns in hosting the meetings. Significant achievements of the TTEG include: drawing up routing measures for the Straits which were put to the IMO for adoption; undertaking of hydrographic surveys of the Straits; and producing common datum charts.

Malacca Strait Council (MSC). Japan, as a major user of the Straits, formed the Japan MSC in 1968. The objective of the MSC is to promote the improvement of safety of navigation in the Straits of Malacca and Singapore. The Council has also undertaken a number of cooperative projects for combating oil spills resulting from maritime accidents.

Since its start, the Council has undertaken several projects as listed in ***Table 6.10***.

Recently, an agreement has been reached on a cooperative effort to conduct bathymetric mapping of the Straits. The Straits will be resurveyed and mapped commencing September 1996. The remapping will be focused on selected critical areas only and assigned individually to each coastal State (Elo, personal communication, July 1996).

Oil Companies International Marine Forum (OCIMF). As users of the Straits, the Oil Companies International Marine Forum (OCIMF) has conducted a study of navigational risks in the Straits. It has also been involved in the publication of the joint OCIMF/ICS (International Chamber of Shipping) Publication "Straits of Malacca and Singapore - A Guide to Planned Transits by Deep Draught Vessels" (Third Edition, 1990), which advises a recommended track off Tanjung Medang.

Malaysian Institute of Maritime Affairs (MIMA) is a policy research institute set up by the Malaysian Government to deal specifically with national and regional maritime issues. In the past, MIMA has undertaken a number of projects, published papers/books and organized conferences relating to the Malacca Straits.

Table 6.10. Malacca Strait Council Projects and Financial Commitments.

Project	Description	Amount (in million yen)
Improvement of navigational conditions		
Hydrographic surveys and production of marine charts	Between 1968 and 1978, the MSC together with the three littoral States conducted hydrographic surveys. From 1976 to 1982, Common Datum Charts were produced based on the results of the surveys which replaced the previously used marine charts	Hydrographic surveys : 1,424 Common Datum Charts : 359
Tidal and current studies	In 1976 and 1979, tidal and current studies were done jointly with the three littoral States which produced data necessary for forecasts.	646
Clearance of navigational fairways	From 1972 to 1978, four shipwrecks were removed from the navigational route, and from 1979 to 1981, some shoals off the Port of Singapore were also cleared.	1,435
Installation and maintenance of navigational aids	From 1968 to 1988, a total of 29 navigational aids were installed and donated to Indonesia and Malaysia. These included 4 lighthouses, 10 light beacons,-7 resilient light beacons, and 8 light buoys. Currently, 11 of these aids are equipped with racons.	Installation of navigational aids (1968-1994) : 2,272
	Since 1989, the Council has replaced many of the non-functioning navigational aids. The MSC, jointly with Indonesia and Malaysia, is also conducting annual checking of the navigational aids and necessary repairs are done.	Maintenance of navigational aids (1970-1994) :1,433
Donation of a buoy tender vessel	A buoy tender vessel was donated to the Government of Malaysia in 1976 to be used for installing and maintaining aids to navigation.	502
Dredging works in the Strait of Singapore	Between 1979 and 1981, the Council undertook dredging works in Singapore Strait	1,001
Cooperative projects for combating oil spills		
Donation of an oil skimming vessel	An oil skimming vessel was donated to the Government of Singapore in 1973.	52
Donation of fund for the Straits of Malacca Revolving Fund	In 1980, a capital worth 400 million yen was donated to the three littoral States towards the setting up of the revolving fund to combat oil pollution from ships.	400
Other International Cooperation by MSC		(1968-1994) 424
Total		9,948[1]

[1]This does not include the running costs of the Malacca Strait Council and the salaries of project personnel.

Proposals for improving the safety of navigation in the Malacca Straits. The IMO Working Group on the Malacca Straits Area (IMO, 1993) made the following recommendations for improving safety of navigation in the Straits:

- the addition of a new rule to the IMO Rules for Vessels Navigating through the Straits of Malacca and Singapore (see Annex 2). The present Rule 8 be renumbered as Rule 8(a) and a new Rule 8(b) be added as follows:

"All vessels and tows of 300 gross tons or more and all passenger vessels transiting the Singapore Strait are strongly recommended to participate in the Singapore Vessel Traffic Information Service (VTIS)".

- Singapore be requested to review the VTIS to ensure that additional traffic be catered and to ensure that the training of operators complies with the IMO Guidelines for Vessel Traffic Services (Resolution A.578(14));

- Shoal patches be urgently resurveyed to effectively ensure the safe navigation of deep-draught vessels in the Malacca and Singapore Straits;
- Selected navigational buoys be replaced by fixed light beacons or fixed radar transponder beacons (Oil Companies International Marine Forum proposal);
- Consideration be given to the need for additional Traffic Separation Schemes and/or other routing measures in the Strait;
- The need for proper training of both shipboard and shore-based personnel making use of the Straits in their respective areas of activity (e.g., VTS operators and staff manning radio stations, search and rescue units, pilot stations, etc.), be re-emphasized.

Kamaruzaman (1995) suggests that to improve the safety of navigation in the Straits, the following safety measures should be considered:

- Review and extend existing Traffic Separation Schemes;
- Develop routing measures to reduce ship encounters with end-on situations;
- Provide designated crossing points along the Strait;
- Introduce precautionary areas where traffic converges;
- Separate through traffic from port traffic by providing inshore traffic zones;
- Introduce mandatory ship reporting especially where Traffic Separation Schemes are established;
- Apply additional control mechanisms (such as requirement of escorts, regular position reporting, requirement of pilots, etc.) for unwieldy tows, deep-draught vessels, ships carrying ultra hazardous cargo, damaged or hampered vessels or even apply a prohibition on ultra hazardous ships without acceptable contingency plans, liability for compensation regimes, etc.;
- Review the existing IMO Rules for Vessels Navigating Through the Straits of Malacca and Singapore, including the current underkeel clearance limit of 3.5 m.

Financing safety activities. Substantial financial inputs are required to maintain the existing level of safety in the Straits and if additional safety measures are to be taken, funding is required to support both the capital and maintenance costs. The Malacca Strait Council has contributed nearly 10 billion Yen in project services and finances between 1968 and 1993. One estimate has put per capita expenditure by Malaysia for the Straits of Malacca up to the end of 1993 at over 100 million Malaysian Ringgit. In addition, operating expenses have averaged about 25 million Ringgit a year. The income from fees paid by vessels calling at Malaysian ports falls far short of these costs.

According to Article 43 of the UNCLOS, User States and States bordering a strait should by agreement cooperate:

- in the establishment and maintenance in a strait of necessary navigational and safety aids or other improvements in aid of international navigation; and

- for the prevention, reduction and control of pollution from ships.

In May 1994, the Government of Malaysia requested IMO to consider how Governments and international organizations could assist, both technically and financially, the littoral States of the Malacca Strait in implementing additional safety measures in the region. The request is under consideration by the IMO.

Oil spills and preparedness and response

Risk of oil pollution. On a global scale, about 84% of accidental oil spills are small (under 50 barrels). These normally result from routine operations, such as loading, discharging and bunkering in ports or at oil terminals. Intermediate spills (50 to 5,000 barrels) are most likely to occur in ports/terminals during routine oil transfer operations, such as loading, discharging and bunkering. Typical causes of such operational spills are hose/valve failures and overfilling of tanks. A significant number of intermediate spills also result from less severe casualties, such as low energy collisions, groundings and berthing accidents also within port limits. Major oil spills (>5,000 barrels) are typically caused by serious casualties such as collisions, groundings, structural failures and fires and explosions and they usually occur offshore or outside ports (ITOPF, 1995). *Table 6.11* shows the causes of oil spills on a global scale in 1974 to 1994.

It has been estimated that 3.7 million barrels per day of crude oil (14% of the world's seaborne oil) transit the Malacca Straits. Of this, about 20% is destined for Singapore, the remainder passing through the South China Sea to Japan and South Korea (ITOPF, 1995).

The large volume of oil transported, combined with heavy shipping traffic and poor navigation conditions make the Straits a high risk area. It has been estimated that between 1978 and 1994, about 20% of the accidents in the Straits involved tankers. Many of these tanker accidents resulted in severe oil pollution of the Straits and were mostly due to collisions and groundings. ***Table 6.12*** shows the major oil spills (over 1,500 tonnes) which have occurred from tankers in the Malacca Straits from 1975 to 1993 together with the cause of the accident and the size of the oil spill. The combined spill from the accidents involving the *Showa Maru*, the *Diego Silang* and *Nagasaki Spirit* resulted in 26,000 tonnes of oil being released.

The location of oil spills which have occurred in the Malacca Straits is shown in ***Figure 6.9.***

There are also a significant number of groundings and collisions of non-tankers/tankers in the Straits which result in relatively small amounts of oil being released.

The risk of oil spills in the Straits is likely to increase in the future for the following reasons:

- The rapid economic growth rate in Asia (currently three times the rate of the OECD) is coupled with an increase in the demand for energy. Japan's Institute of Energy Economics has estimated that oil demand for the Asia-Pacific region will increase from its 1993 figure of 14.2 million barrels per day to 18.5 million barrels per day in the year 2000 and 21.6

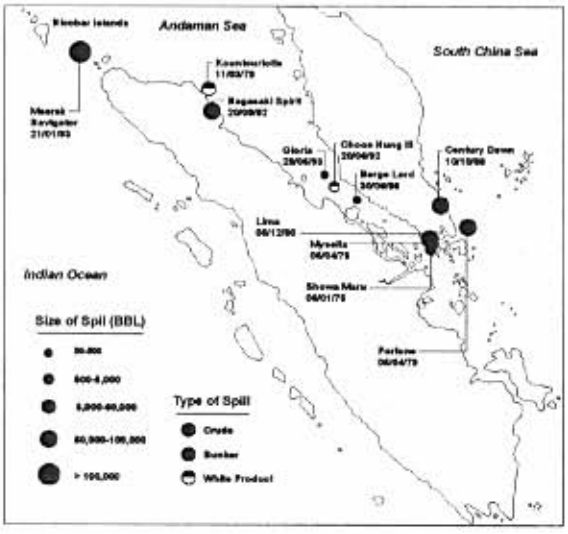
Table 6.11. Global Estimates of the Causes of Oil Spills (ITOPF, 1995).

Cause of Spill (% occurance)	Size of Spill (barrels)		
	< 500	500-5,000	>5,000
Operations			
Loading/discharging	34.9	27.7	4.7
Bunkering	6.7	2.3	0.0
Other operations	14.8	4.1	0.0
Accidents			
Collision	2.0	22.5	28.7
Groundings	3.0	17.9	33.5
Hull failures	7.0	6.8	11.4
Fires and explosions	1.8	1.5	13.4
Others	29.8	17.2	13.4

Table 6.12. Major Oil Spills in the Malacca Straits, 1975-1993 (WCMC, 1994).

Year	Tanker Name	Cause
1975	*Heiwa Maru*	Grounding
1975	*Showa Maru*	Grounding
1976	*Mysella*	Grounding
1976	*Diego Silang*	Collision
1976	*Sealift Pacific*	Grounding
1978	*Sealift Mediterranean*	Grounding
1978	*Kountouriotis*	Fire/Explosion
1979	*Fortune*	Collision
1980	*Lima*	Collision
1983	*Monemvasia*	Grounding
1987	*El Hani*	Grounding
1988	*Century Dawn*	Collision
1992	*Nagasaki Spirit*	Collision
1993	*Maersk Navigator*	Collision

Figure 6.9. Oil Spills in the Malacca Straits.



million barrels per day in 2005. With oil demand growing sharply and sluggish oil production in Asia, imports from outside the region are projected to increase. Asia imported 59% of its oil from outside the region in 1993. It will need to import 64% of its oil demand from outside the region by 2000 and 70% in 2005. Most of the imports will still be from the Middle East oil fields which will mean an increase in oil and tanker traffic flowing through the Straits.

- There are several plans for the littoral States to increase their refining capacity along the Straits. Singapore, which is the second largest refining area in the world, is expected to increase its capacity from 1.16 million barrels per day in 1993 to 1.30 barrels per day in 1998. Malaysia has expansion plans for the refineries in Port Dickson and Melaka which will increase the refining capacity to 365,000 barrels per day by 1997. The increased refining capacity will mean an increase in the movement of oil in coastal waters to/from the refineries.
- The port expansion plans along the Straits, especially for the development of oil terminals, will increase the risk of oil being released into the marine environment.
- The increasing shipping traffic through the Malacca Straits (estimated current annual rate of increase of 7.6%) will mean an increase in the risk of oil being released both through shipping accidents and discharges (accidental/deliberate).

Oil pollution preparedness and response measures. Despite the safety measures taken and the national/international legislation, to prevent pollution of the marine environment, oil spills will continue. To compensate for the high risk of oil spills in the Straits, the littoral States, together with the users of the Straits and the oil industry, have taken measures at the national/regional/international levels which ensure that they are generally well prepared to respond to spills. *Table 6.13* provides a summary of the preparedness and response measures in place.

Table 6.13. State of Oil Polution Preparedness and Response in the Malacca Straits.

Measures	Indonesia	Malaysia	Singapore
OPRC (1990)	No	Yes	No
National Contingency Plans	Yes	Yes	Yes
Subregional Plan (SOP)	Yes	Yes	Yes
Regional Plan (ASEAN OSRAP)	Yes	Yes	Yes
Oil Compensation Schemes			
CLC 69	Yes	Yes	Yes
Fund 71	Yes	Yes	No
Revolving Fund	Yes	Yes	Yes

International conventions

International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC). Of the three littoral States, only Malaysia has ratified the OPRC Convention which is designed to help Governments respond to major oil pollution incidents involving ships, offshore units, sea ports and oil handling facilities. The Convention aims to facilitate international cooperation and mutual assistance in preparing for and responding to a major oil pollution incident and it encourages states to develop and maintain an adequate capability to deal with oil pollution emergencies. The Convention includes the following topics: preparation of oil pollution emergency plans by operators; oil pollution reporting procedures and actions to be taken on receipt of such a report; the establishment of national and regional systems for preparedness and response; international cooperation in pollution response; research and development; and technical cooperation.

National level

Indonesia. When the *Showa Maru* oil spill accident occurred in the Strait of Singapore in 1975, Indonesia was not prepared. A series of emergency crisis meetings were held under the leadership of the Minister of Justice, Prof. Dr. Mochtar Kusumaatmadja, with the expertise provide by the LEMIGAS Study Group on Pollution, established in 1970. Subsequently, a Standard Operating Procedure (SOP) was developed to monitor, control and assess the *Showa Maru* oil spill. A compensation negotiation team, headed by Prof. Dr. Mochtar Kusumaatmadja, was organized. The coordination of the SOP was the responsibility of the Director General of Sea Communications and the Director General of Oil and Gas. The 1975 SOP was intended as a forerunner to a National Contingency Plan (NCP) (Soegiarto, 1982).

In 1978, the State Minister for Population and Environment (KLH) was established by the President. Among its immediate functions was the preparation of environmental legislation and the NCP Act No. 4 of 1982 on Basic Provisions for Environment Management, the key umbrella legislation for environmental protection, provided the legislative framework for marine pollution concerns. In 1984, KLH, with the assistance of CIDA (Canadian International Development Agency), completed an oil spill contingency pre-feasibility study for Indonesia.

In 1992, the KLH released a draft decree of the President regarding the emergency control of oil pollution at sea. The objective of the decree was to coordinate local, regional and national resources in the rapid response to emergencies at sea due to oil pollution. The decree outlines control procedures, tasks and obligations of responsible parties, costs of control and compensation claims.

The primary lead agencies designated under Chapter I, Article 2 of the decree are the Directorate General of Sea Communications and BAPEDAL. The Director General of Sea Communications is responsible for physical control of the oil spill situation and the Head of BAPEDAL is responsible for the control of the environmental impact and rehabilitation of the marine environment. Both are authorized to request assistance from government and private parties and both are authorized to seek international assistance if deemed necessary. Within Indonesia, government and private parties may not refuse to give support when so requested.

At the regional level, the Head of the Regional Office of the Ministry of Communications is responsible for operational control of an oil spill emergency. At the local level, either the Port Administrator (ADPEL or the Head of the Port Office) is responsible for the operational control. The On Scene Coordinator (OSC) may function at either the regional or local level, depending on the spill situation.

Although not specifically designated in the decree, the assumption is made that the equipment and expertise to mount response operations will be provided by PERTAMINA. The historical precedence for this is the Joint Decree between the Director General of Sea Communications and the Director General of Oil and Gas signed in 1981. According to this decree, the Directorate General of Sea Communications has the role of Coordinator and PERTAMINA, the state-owned oil company, has the role of oil pollution equipment operator. The cooperation of PERTAMINA, as the sole possessor of government oil spill response equipment, is absolutely essential for the successful operation of the national plan.

A large marine oil spill concerns many agencies and disciplines. The groups with an interest in the marine environment in Indonesia consist of:

- Coordinating Ministries
  - National Planning and Development Agency Board (BAPPENAS)
  - State Ministry for Environment (LH)
- Central Line Ministries/Departments
  - Department of Communications, Directorate General of Sea Communications
  - Department of Public Works
  - Department of Mining and Energy, Directorate General of Oil and Gas
  - Department of Home Affairs
  - Department of Forestry, Directorate General of Forest Protection and Nature Conservation
  - Department of Agriculture, Directorate General of Fisheries
  - Department of Defense and Security
- Non-departmental Government Agencies (LPND)
  - The Environmental Impact Control Agency (BAPEDAL)
  - Scientific Information Agencies
  - Hydro-Oceanography Service of the Indonesian Navy (DISHIDROS)
  - Indonesian Institute of Sciences (LIPI)
  - Agency for Assessment and Application of Technology (BPPT)
- Universities
- Nongovernment Organizations
- Private Sector/Company, such as PERTAMINA

Oil spill contingency plan

Background. The Government of Indonesia established on 12 June 1981 a Standard Operating Procedure (SOP) for oil spill response in the Malacca Straits. The SOP is a joint Decree between the Director General of Sea Communications and the Director General of Oil and Gas. The SOP is the forerunner of a national contingency plan for oil spill response in Indonesian waters. The National Oil Spill Contingency Plan is in draft form, although its concept

has been applied for regular exercises including exercises with its neighboring states. It was also activated successfully in combating the *Nagasaki Spirit* and *Maersk Navigator* oil spill incidents.

Structure and organization of the plan. In the SOP for oil spill response in the Malacca Straits, the Directorate General of Sea Communications has the responsibility of coordination and PERTAMINA (the state-owned oil company) has the role of oil pollution equipment operator. At the central, regional and port levels, the SOP provides for the establishment of a Joint Standard Operation Procedure (JSOP) with each of the supporting agencies to ensure quick response to oil spill incidents.

The primary responsibility in the draft National Oil Spill Contingency Plan is with the Directorate General of Sea Communications and the Environment Impact Control Agency (BAPEDAL). At the head office of the Directorate General of Sea Communications there is the National Operation Center for Combating Oil Pollution (NOCOP), which is linked to various provinces in the country and has the capability to communicate with the Lead Agencies of other ASEAN countries and serves as a contact point for international cooperation for oil spill, response. The NOCOP reports directly to the Minister of Communications and the Head of the Environmental Impact Control Agency. In the event of an oil spill, the NOCOP uses the command, control, communication and information system of the Command and Control Post for Maritime Safety Guard and Rescue System which operates on a 24-hour basis. The Guard and Rescue Communication System comprises a central command post. Nine other Regional Command Posts and three Subregional command posts are located at strategic points spread across the Indonesian waters. BAPEDAL is responsible for the assessment of damage to the natural environment and socioeconomic losses and costs of rehabilitation. ***Figure 6.10*** shows the organization structure of the draft material oil spill contingency plan.

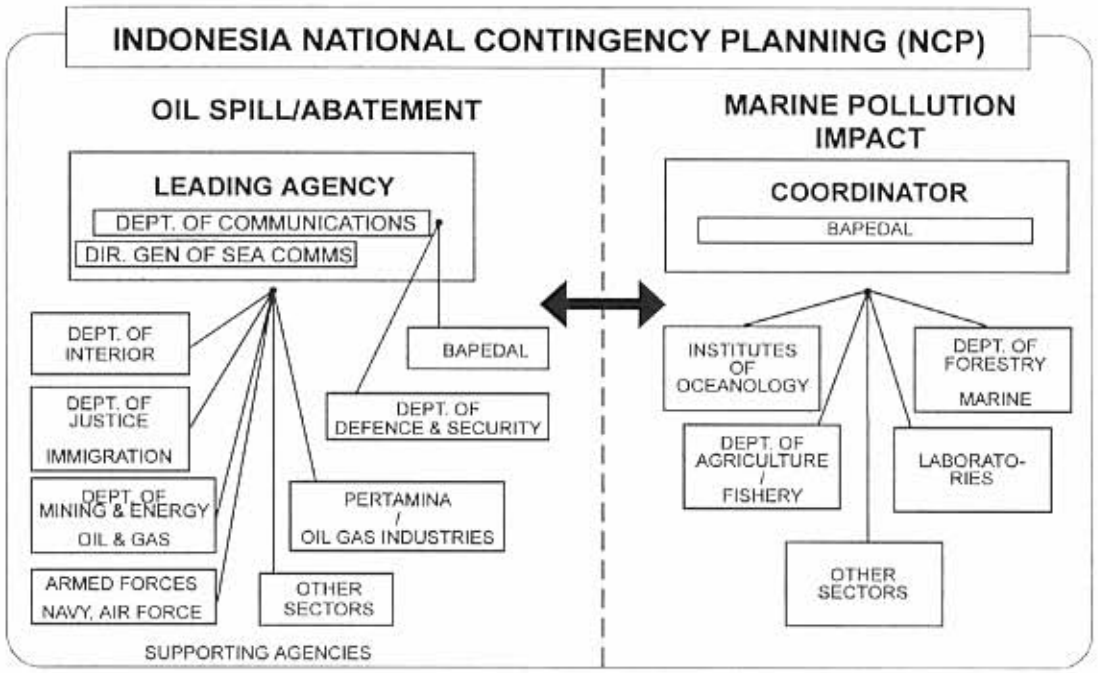
Response equipment/personnel. Studies have been conducted on the establishment of monitoring stations on major tanker routes and equipment for oil spill response has been purchased. PERTAMINA has the role of providing and operating the equipment.

PERTAMINA

Background and objectives. PERTAMINA, established as Indonesia's enterprise for state oil and gas mining and geothermal industries, has the responsibility to manage and coordinate the various oil and gas industries operating in Indonesia.

Spill response. PERTAMINA has developed its own oil spill response plan. If the spill derives from or involves the industry's interest then the industry will initiate the response. If, on the other hand, the incident

Figure 6.10. Organization Chart of the Indonesian National Oil Spill Contingency Plan.



does not involve the interest of the industry, then the government will take the initiative and the industry will act as a supporting agency as drafted in the National Contingency Plan (NCP).

The preparedness and response strategies of the oil, gas and geothermal industries are to:

- Establish equipment stockpile bases;
- Establish and maintain cooperation among industries and partake in national, regional and international cooperation schemes; and
- Maintain and improve preparedness and response capabilities including facilities and human resources.

Equipment. Table 6.14 shows the oil pollution control equipment owned by PERTAMINA (1993). Each holding site carries out regular practice training of personnel for maintaining and operating the equipment. The basic components of a comprehensive oil spill contingency plan include procedures for alerting, response, containment, cleaning, disposal and rehabilitation. The support of these components requires equipment, the means to deliver the equipment and trained personnel. All of these operational components must be in place and all components must be coordinated. Response activities must be practiced, personnel must be prepared and the entire system must be in a state of readiness 24 hours/day, seven days/week to insure a response which is prompt and precise. Indonesia appears to have most of the above components in place to varying degrees but improvements are possible and needed to control the risk of oil pollution by operational means (Astuti et al., 1994).

Malaysia

Oil spill contingency plan

Background. Malaysia formulated its first oil spill response plan in 1975[2] known as the National Oil Spill Contingency Plan for the Straits of Malacca (SOMCP). This plan was revised and updated during subsequent years and components such as search and rescue and information on environmentally sensitive areas were incorporated into it. In 1989, the Government formulated another contingency plan to cover the South China Sea, called the Oil Spill Contingency Plan for South China Sea (SCSCP). The two plans (SOMCP and SCSCP) have since been integrated to

Table 6.14. Oil Pollution Control Equipment held by PERTAMINA, 1993 (Astuti et al., 1994).

Location	Oil Boom	Oil Skimmers	Dispersant Equipment	Pumps	Oil Bags
Pangkalan Susu, North Sumatra	315 m Troil	1 Komara 12K	Pump and Spray Arm	1 Megator and Sprayers	1 Fikoma FR 4.5 m^3
Dumai, Riau	300 m Slick Bar 700 m Troil	2 Kamara 12K 1 GRT 185 Pharos Marine	1 Sea Spray w/ 2 Arms	2 Megators and Sprayers	--
Pulau Sambu, Riau	450 Vikoma Seapack 450 m Troil	2 Vikoma 100 1 Komara 12K	--	2 Megators	1 Diodon 40 35 m^3
Tanjung Priok, Jakarta	300 m Slick Bar (24 inch)	1 Vikoma 50 1 Komara 12K	1 Sea Spray	2 Megators and Sprayers	2 Diodon 40 each 35 m^3
Cilacap, Central Java	500 m Slick Bar (24 inch)	1 Komara 12K	1 Sea Spray	2 Megators	1 Diodon 40 35 m^3
Bitung, N. Sulawesi	400 m Troil	2 Komara 12K	1 Sea Spray w/ 2 Arms	1 Megator	--
Ujung Pandang, South Sulawesi	300 m Globe 24 300 m Slick Bar	2 Komara 12K	1 Sea Spray w/ 2 Arms	1 Megators and Sprayers	1 Vikoma FR 4.5 m^3
Balikpapan East, Kalimantan	300 m Slick Bar 400 m Roulund	2 Komara 12K 2 GRT 185 Pharos Marine	1 Sea Spray w/ 2 Arms	2 Megators and Sprayers	--
Balongan, West Java	200 m Slick Bar	1 Komara 12K	--	Megator	--
Surabaya, East Java	200 m Slick Bar Harbour Boom MK7	1 Komara 12K 1 Komara 30K 1 GRT 185 Pharos Marine	--	Megator	--

[2]Chia L. S. 1995. Protecting the marine environment of ASEAN from ship-generated oil pollution and Japan's contribution to the Region. Institute of Developing Economies, V.R.F. Series No. 245, March 1995.

form the National Oil Spill Contingency Plan (NOSCP). *Figure 6.11* shows the components of the NOSCP.

Scope and objective. The NOSCP caters to oil spills occurring in Malaysian waters, including the 200 nauticalmile Exclusive Economic Zone. It aims to meet the following objectives:

- To provide a mechanism for coordinating response systems for effective containment and recovery of oil;
- To enhance capability with the existing resources with respect to equipment and manpower, as well as training in combating oil spills; and
- To alleviate or minimize potential adverse impacts to the marine environment arising from the spill.

Response arrangements. The NOSCP is activated on a three tiered response basis (*Figure 6.12*).

- The tier one response is activated in the event of a small spill. In this case, a local oil spill contingency plan is activated utilizing existing manpower and equipment. This tier response is coordinated by the local authority or local oil industry in the event of a spill arising either within port limits, oil terminal/depots or oil exploration and production platforms.
- The tier two response is activated when the spill is beyond the local area response capability, both in terms of resources and mobilization time. In this case, one or more of the three operation committees of the SOMCP or the SCSCP is activated depending on the response requirements for the spill. The three Area Operation Committees under the SOMCP cover: Penang (operation center in Penang), Selangor (operation center in Kelang) and Johor (operation center in Johor Bahru).
- The tier three response is activated when a major oil spill occurs, where all available government and industry resources are exhausted and when the assistance of neighboring countries is required, as well as when the spill spreads out to neighboring countries. In this case, the regional contingency plan (ASEAN OSRAP) will be activated through the national oil spill control committee

Figure 6.11. National Oil Spill Contingency Plan (NOSCP) of Malaysia.

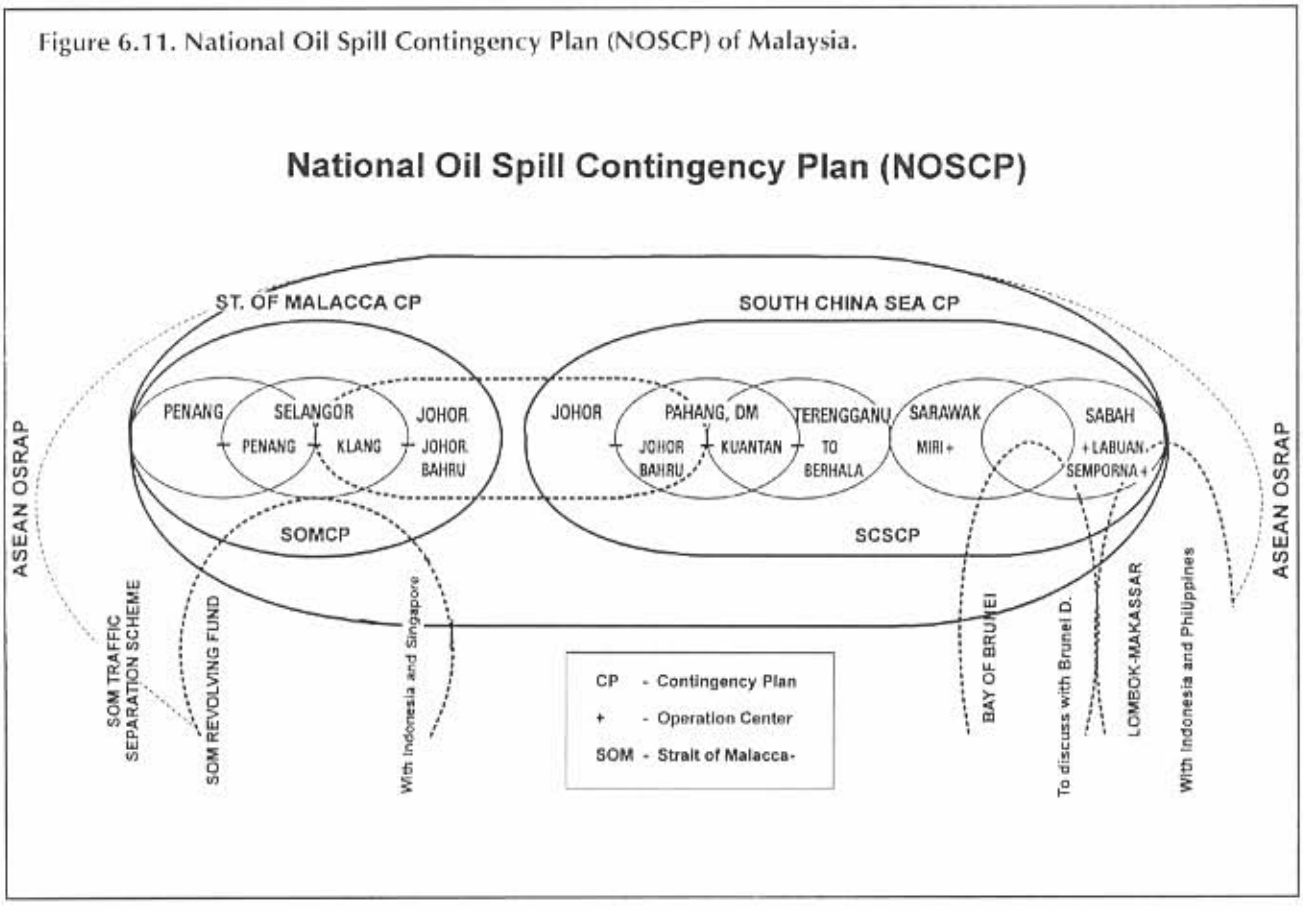
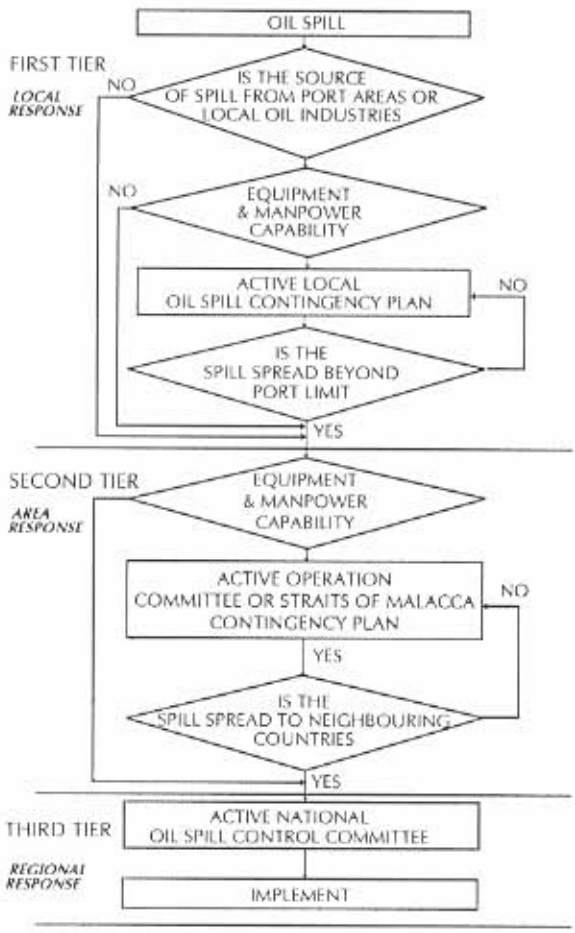


Figure 6.12. The Tiered Response Procedures of the Malaysian National Oil Spill Contingency Plan.



Response equipment. The oil industries operating in Malaysian waters hold tier one response equipment. The government holds response equipment which are located along the Malacca Straits in the three operation centers, namely: Penang, Kelang and Johor Bahru. PIMMAG (see below) can provide tier two response equipment on request. In the case of tier three spills, response equipment is obtained from neighboring countries or from EARL.

Coordination of the plan. The NOSCP is coordinated by the National Oil Spill Committee. The Committee is chaired by the Director-General of Department of Environment (DOE) and includes related government agencies and the oil industry, namely: the Marine Department, Fisheries Department, Meteorological Services Department, Custom and Excise Department, Immigration Department, Royal Malaysian Navy, Royal Malaysian Air Force, Marine and Air Wing Police, Foreign Affairs Ministry, the National Security Council, Maritime Enforcement and Coordination Centre, PETRONAS (the state-owned oil company) and the Petroleum Industry of Malaysia Mutual Aid Group (PIMMAG). The Committee has the mandate to advise the Area Coordinator and to coordinate the various agencies involved in clean-up operations, air surveillance, procurement and deployment of equipment, movement of personnel and communication. The Committee, through the Foreign Ministry, also coordinates with other neighboring countries for assistance to expedite action with minimum delays.

Elements included in the NOSCP. The NOSCP includes elements, such as notification and reporting, spill investigation, security against liability, communication, sample collection, safety, public relations, claims, environmental and property damages, use of dispersants, salvage and transfer of cargo, temporary disposal of oily waste and training.

Funds for response. The government has established a National Fund for Oil Spill Clean-up which has been allocated 2 million Ringgit. The funds can be used during an emergency response. The SOMCP receives significant funding and it is linked to the ASEAN Regional Oil Spill Contingency Plan.

The Petroleum Industry of Malaysia Mutual Aid Group (PIMMAG)

Background. The oil companies led by PETRONAS (Malaysia's state-owned oil company) established a private, non-profit making joint service company called the Petroleum Industry of Malaysia Mutual Aid Group (PIMMAG). The organization was in established on 1 July 1994.

Scope and objective. The main aim of PIMMAG is to provide its members with a tier two response capability for potential oil spill emergencies arising from their activities in Malaysian waters, including the EEZ. The company facilitates the sharing of industry oil spill response resources among members. From time to time, it will undertake a review of existing oil spill resources and it will acquire, lease, maintain and operate oil spill response resources. To strengthen the response capability, PIMMAG provides training assistance. PIMMAG will also support non-members' response to oil spills upon request. The company augments the government's oil spill response efforts and it will, without liability to its members, provide

the necessary oil spill response resources to the National Oil Spill Control Committee (NOSCC) to enable them to combat oil spills. The joint effort of sharing stockpiled equipment by PIMMAG greatly enhances the country's oil spill response capability.

Membership. PIMMAG comprises of members from a whole spectrum of petroleum industry activities including exploration, production, pipeline operation, terminal and storage operation, refining and bulk transportation. It is pointed out that membership is not open to tanker operators. ***Figure 6.13*** shows the different oil spill exposure categories. There are two categories of memberships: Ordinary Membership and Associate Membership. Companies which undertake activities on a temporary basis, such as those conducting oil exploration activities, fall into the Associate Membership category. All PIMMAG members are required to have in place an appropriate tier one Oil Spill Response Capability. The cost contribution of members is based on the total yearly barrels of persistent oil produced and/or handled through marine terminals.

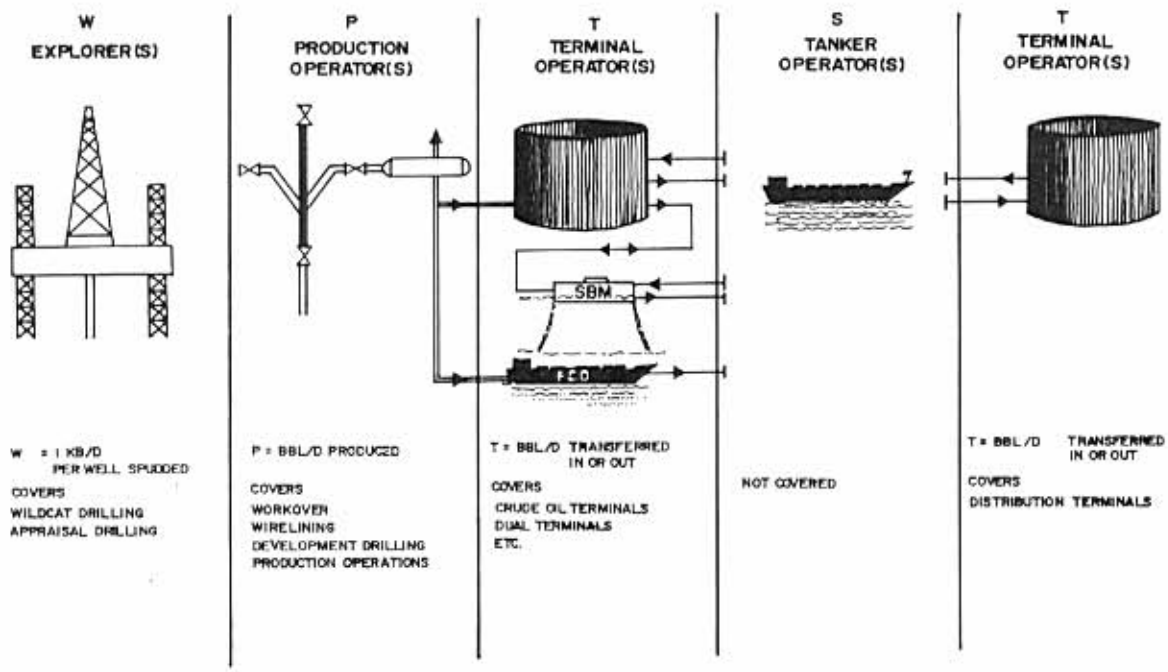
The following companies are current members:
Ordinary Members—Petronas, Esso, Shell, Caltex, BP and Mobil;
Associate Members—Occidental, Overseas Petroleum Investment Corporation (OPIC), Texaco and Nippon Oil

PIMMAG cost is classified under administration cost, capital cost and ongoing cost for maintenance and deployment of shared oil spill capability. The administrative cost is shared equally among all members (up to a limit of 10% of the total operating cost). The capital and ongoing costs are paid by the Ordinary Members based on their oil exposure value. The Ordinary Members' capital contribution (less depreciation) is paid into their membership interests account. Associate Members pay a fee consisting of administration cost element and operating and capital depreciation cost element, according to their oil spill exposure volume percentage. However, they do not contribute to the capital requirements and consequently do not acquire "membership interests".

Structure and organization. PIMMAG is governed by a Board of Directors comprising of Ordinary Members with the overall responsibility for ensuring that PIMMAG objectives are met. The Board of Directors appoints one or more service contractors who act in a service capacity only. The service contractor provides maintenance and a small core of trained manpower, as well as specified logistical support to ensure that PIMMAG equipment is readily available where and when required. The service contractors also provide training for PIMMAG members.

Existing and planned oil spill response capability. In order to effectively respond to tier two oil spills at any location throughout Malaysia, PIMMAG has a total

Figure 6.13. PIMMAG Oil Spill Exposure Categories.



Oil Spill Response Capability of 131,000 bbls and it is planned that this will be increased to 199,000 bbls. The response capability is acquired through pooling of existing resources of members, as well as procuring additional resources where necessary. These resources are mobilized at three stockpile areas, namely in Port Dickson, Kertih and Labuan (the latter two being in Eastern Malaysia). Each stockpile area will enable PIMMAG to mobilize the area resources within 12 to 24 hours. For larger spills which are beyond the capacity of the stockpile area, mobilization of resources from the other stockpile areas will be made possible within 24 to 48 hours (in these cases up to 50% of the resources from each of the two stockpile areas can be mobilized). In the case of large spills, PIMMAG will also liaise with other oil spill response organizations.

Spill response, liability and indemnity. Each member of PIMMAG has equal access to PIMMAG equipment in the event of an oil spill and for training. In the event of an oil spill, the spiller shall request PIMMAG oil spill response assistance directly from the contractor, under the call-out procedures.

A spiller is responsible for the management and control of the oil spill response required to combat such a spill. PIMMAG operates on a "spiller-pays" principle. The actual cost of call-out and deployment of shared PIMMAG resources in response to oil spills or training of members will be paid for by the specific member requesting the service. Non-members are requested to pay higher call-out costs compared to members. PIMMAG rules include comprehensive liability and indemnity clauses protecting PIMMAG and its members against any and all liabilities that may arise from the actual provision of oil spill response services.

Singapore

Oil spill contingency plan

Background. Singapore has developed an oil spill contingency plan called the Marine Emergency Action Procedure (MEAP).

Response arrangements. The MEAP is a two tiered response system. The tier one response will be activated in case of minor and isolated spills. For spills occurring within port waters, the Port of Singapore Authority will deploy its anti-pollution equipment and personnel to tackle the spill. For spills occurring within the premises of the oil companies, the companies will be responsible for the clean-up.

Tier two response will be activated when large spills occur within the territorial waters which are beyond the response capabilities of the Port of Singapore Authority or the oil companies. For these spills, the combined resources of the Port Authority, the oil companies and other agencies, such as the Ministry of Environment, Ministry of Defence, Police Coast Guard, Civil Defense Force and the Republic of Singapore Navy will be called upon.

Response equipment/personnel. Singapore has the added advantage in that the tier three response center—EARL—is based there and that there are also a number of salvage companies operating out of Singapore (which include Smit International Singapore, Semco Salvage and Marine Pte Ltd. and Salvindo Towage and Salvage Pte Ltd.).

Preparedness and response plans on a subregional level

Standard Operating Procedure for Joint Oil Spill Combat in the Straits of Malacca and Singapore (SOP) is an agreement between Malaysia, Indonesia and Singapore which aims to enable the littoral States to take prompt measures, either individually or together, to tackle oil spills from ships. The SOP has communicaiton centers in Kuala Lumpur, Jakarta and Singapore.

Three joint oil spill combat exercises have been conducted to test the SOP:

- The first exercise, hosted by Indonesia, was carried out in 1986 off Pulau Sambu in the Singapore Strait. It was organized by the Department of Communication of Indonesia. The exercise was attended by representatives from the Government of Indonesia, Malaysia and Singapore as well as the oil industry PERTAMINA. Ten vessels and approximately 200 men were involved in the exercise which was held over two days.
- The second test was held off Pulau Kukup at the southern end of the Malacca Strait. This was hosted by Malaysia in 1990 and organized jointly by the Department of Environment and the Marine Department of Malaysia. Eighteen vessels and approximately 120 men participated. The exercise also involved aircraft spraying (simulated) dispersants. The exercise was attended by representatives from the Governments of Indonesia, Malaysia and Singapore and the major oil companies (Esso, Shell, Caltex,

Mobil, Petronas) from Malaysia and Singapore. The Regional Programme Officer for Asia and the Pacific of IMO also participated in the exercise as a resource person.

- Singapore hosted an exercise in 1993 at the southern fringe of the Singapore limits. The three-day exercise was jointly organized by the Port of Singapore Authority and the Marine Department, attended by delegates from the littoral States, a technical adviser from the Japanese Malacca Strait Council, TARC Committee which represented the local oil industry (BP, Caltex, Esso, Mobil, Shell), TARC's operating agent, East Asia Response Private Ltd. (EARL) and the Petroleum Association of Japan. Of particular significance was the participation of resources from EARL and the Petroleum Association of Japan.

Preparedness and response arrangements at the regional level

ASEAN Council on Petroleum (ASCOPE). In 1976, the ASEAN Council on Petroleum (ASCOPE) was formed by the state-owned oil companies of the ASEAN member countries and soon initiated programs relating to the control and mitigation of marine pollution. By 1980, an ASCOPE Plan for the Control and Mitigation of Marine Pollution (ASPCMMP) was initiated to enhance the individual national plans.

ASEAN Oil Spill Response Plan (ASEAN-OSRAP). In 1993, the six ASEAN countries agreed to establish the ASEAN Oil Spill Response Action Plan (ASEAN-OSRAP). The memorandum of understanding was signed on 20 May 1993 for Brunei Darussalam, Indonesia, the Philippines, Singapore and the Kingdom of Thailand; and on January 1994 for Malaysia.

Scope and objective. The objective of the Plan is to enhance the ability of a country to respond to oil spills which exceed the response capability of the individual country. It provides a cooperative plan for mutual assistance from member states and organizations for oil spill response. The individual country's National Contingency Plan continues to be the guiding doctrine and its importance is in no way diminished by the formation of ASEAN-OSRAP.

The area of responsibility for the ASEAN-OSRAP includes all waters within the exclusive economic zone of the ASEAN countries and the territorial waters surrounding Singapore. The area of interest applies to all waters outside the area of responsibility in which an oil spill could affect one or more ASEAN countries. ***Figure 6.14*** shows the area of responsibility of the ASEAN-OSRAP.

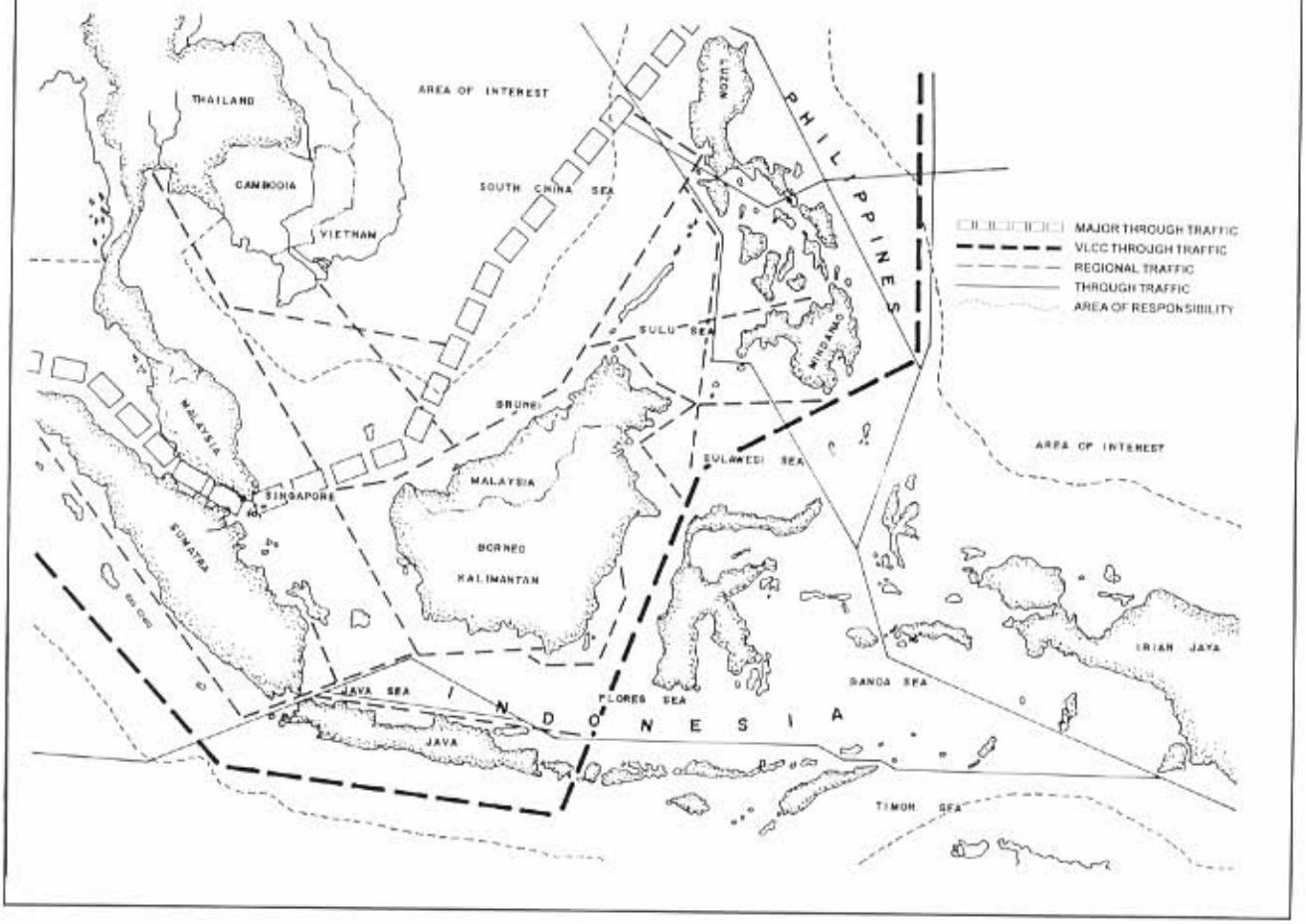
Administration. The ASEAN action plan is administered by the ASEAN Focal Point Agency. The Focal Point Agency, however, does not have an operational role during an oil spill when the ASEAN-OSRAP is activated.

Response action. In the ASEAN-OSRAP, the National Lead Agency is responsible for notifying the Lead Agencies of other member countries in the event of a major oil spill. The Lead Agency in each country is specified in the National Contingency Plan of the country in question. The National Lead Agency is responsible for the internal dissemination of information within the country. A National Lead Agency may receive a report of a spill from a variety of sources and it may need to confirm the information received. After confirmation, the National Lead Agency will initiate the Pollution Reporting System (POLREP) within the ASEAN countries.

The Lead Agency of the country whose waters are affected is responsible for initiating any action within the area of responsibility in accordance with the country's National Oil Spill Contingency Plan. When an oil spill occurs near the boundary of two countries and spreads to the territorial waters of a neighboring country, then each country will have an On-Scene Commander (OSC) responsible for clean-up activities in their own area of responsibility. In certain spill cases, it may be advisable to have one OSC in charge, who will require the approval of all interested Lead Agencies. In the case of a large spill occurring near a common territorial border, one country may be in a better position to respond to the spill due to geographical location than the country actually affected. The ASEAN-OSRAP includes a Protocol for the Equal Right of Access between Member Countries which outlines the procedures for doing this.

If assistance from other ASEAN countries is required, the National Lead Agency of the affected country shall request assistance from the other Lead Agencies during the mobilization phase through direct contact with the Lead Agency of the assisting country/countries. Spills that occur in the area of interest are monitored by the country whose area of responsibility is most likely to be affected.

Figure 6.14. Area of Responsibility of ASEAN-OSRAP.



Response resources. Throughout the ASEAN countries, a variety of pollution abatement equipment is stockpiled and maintained at numerous locations. Some of the equipment is owned by the National Lead Agencies; however, the majority is owned by the oil industry. The ASEAN Council on Petroleum (ASCOPE) has a catalog of all the equipment owned by government and private oil companies in the region.

Within the ASEAN countries, there are two equipment stockpiles that are not dedicated to an individual facility or location, namely:

- EARL has tier three response equipment (for further details refer to the section below).
- The Sulawesi Sea Oil Spill Response Equipment which is stored in Davao, Republic of the Philippines. It is primarily for use in the Lombok/Sulawesi Sea Straits, however, the equipment is also available for use within the ASEAN region and access to the Davao Center's equipment can be obtained through the Lead Agency for the Philippines.

East Asia Response Private Ltd. (EARL) aims to provide a rapid and effective response to oil spills in the Asia-Pacific region. It is the only tier three response center in the region. Its other aims include: to act as a premier center of expertise in oil spill response for East Asia and the Pacific; to encourage the participation of industry and to integrate industry with national oil spill response plans; as well as to promote the tiered response concept.

EARL was established in Singapore on 18 May 1992 as a nonprofit company. The founding shareholders are: British Petroleum Singapore, CALTEX Services Ltd., Esso Eastern, Mobil Spill Response Inc. and Shell Response Ltd. In 1994, BHP Petroleum became a shareholder. Participation in EARL is offered to any oil-related company operating in the Asia-Pacific region and the participants are

shareholders in the company. Each participant member pays a retainer fee to EARL.

EARL has its Regional Center in Jurong, Singapore, where it stores and maintains a wide range tier three oil spill response equipment. The center has sufficient equipment available to provide a credible response to a major tanker incident estimated to result in an oil spill of some 20,000 to 30,000 tons. EARL has a team of specialist staff who are able to provide technical support to companies requiring assistance and if required, it can call upon additional trained contractors. The staff of the Center are also able to provide training to delegates both in Singapore or on location and also offer consultancy services on oil spill related matters to the industry.

Annex 3 provides an inventory of the EARL equipment. The equipment is owned by the joint venture company Oil Spill Holdings (OSH), which consists of the five founder companies of EARL. The equipment is leased to EARL, which operates it on behalf of its member participants. Equipment is also available for non-EARL members in accordance to the companies Operational Plan. To enable the equipment to be quickly airlifted to the spill site, EARL has a Lockheed C-130 transport aircraft continuously on standby. To offset the lease costs, the aircraft is subchartered for flights not exceeding 4 hours from Singapore which is the maximum time it would take to activate EARL and mobilize the team and equipment to Changi Airport where the equipment would be loaded. EARL also provides a waterborne response to incidents in the Malacca Straits. It has three dedicated fast response vessels on standby, two of these are located in Singapore and the third one is located in Port Dickson.

EARL is at present developing plans to establish a quick response marine base in Port Dickson on the West Coast of Malaysia mid-way along the Malacca Strait. EARL is discussing joint occupation of the old Shell Distribution Depot at Port Headland P.D. with the Petroleum Industry of Malaysia Mutual Aid Group (PIMMAG) who wish to set up a tier two facility on the West Coast of Peninsular Malaysia (Pyburn, 1994).

Preparedness and response arrangements made by Japan

Petroleum Association of Japan (PAJ)

Background. The Petroleum Association of Japan (PAJ) is a nonprofit and nongovernment trade association comprising of 25 companies engaged in refining and/or marketing of oil in Japan. It was established in November 1955 to promote and encourage the sound development of the Japanese petroleum industry.

In January 1973, PAJ established the PAJ Oil Spill Cooperative which is annexed to PAJ as a voluntary mutual aid organization. To further strengthen its capability, the Ministry of International Trade and Industry (MITI) of Japan arranged a government subsidy for the Major Oil Spill Response Programme which started implementation in 1991 (it is implemented through PAJ).

Oil spill response program. The main objectives of the Oil Spill Response Programme are to promote the oil spill response capability, to conserve the global marine environment and to ensure the stable supply of oil to Japan. The Programme has two areas of activities:

- Stockpiling and lending of oil spill response equipment; and
- Research and development related to oil spill and response techniques.

Stockpiles of oil spill response equipment. PAJ maintains a stockpile of oil spill response equipment and is involved in the selecting and purchasing of additional equipment. There are currently eight equipment stockpile bases, two of which are in the Malacca Straits, namely in Singapore in the facilities of Nippon Express Singapore Pte. and in Malaysia in Port Kelang. ***Figure 6.15*** provides an inventory of PAJ's equipment.

Lending of oil spill response equipment. PAJ will lend its equipment on request to parties involved in an oil spill, including government agencies, in accordance with PAJ's "Agreement of Lending of Oil Spill Response Equipment". To simplify the lending procedures, PAJ will also provide a "Special Contract of the Agreement of Lending of Oil Spill Response Equipment" for member companies and for others, including government agencies.

The basic lending conditions are:

- Use of equipment is free of charge;
- The lender is responsible for making the necessary arrangements for transporting the equipment from the base and for returning it to the base after use, for deploying the equipment and for bearing all expenses incurred;

- After using the equipment, the lender is responsible for cleaning, checking and repairing the equipment. The lender is responsible for bearing any expenses incurred;
- In principle, the equipment must be returned within 3 months after release.

Contingency support and training. PAJ organizes training courses on the operation of the equipment and together with the PAJ Oil Spill Cooperative, holds training courses on oil spill response for the staff of member companies.

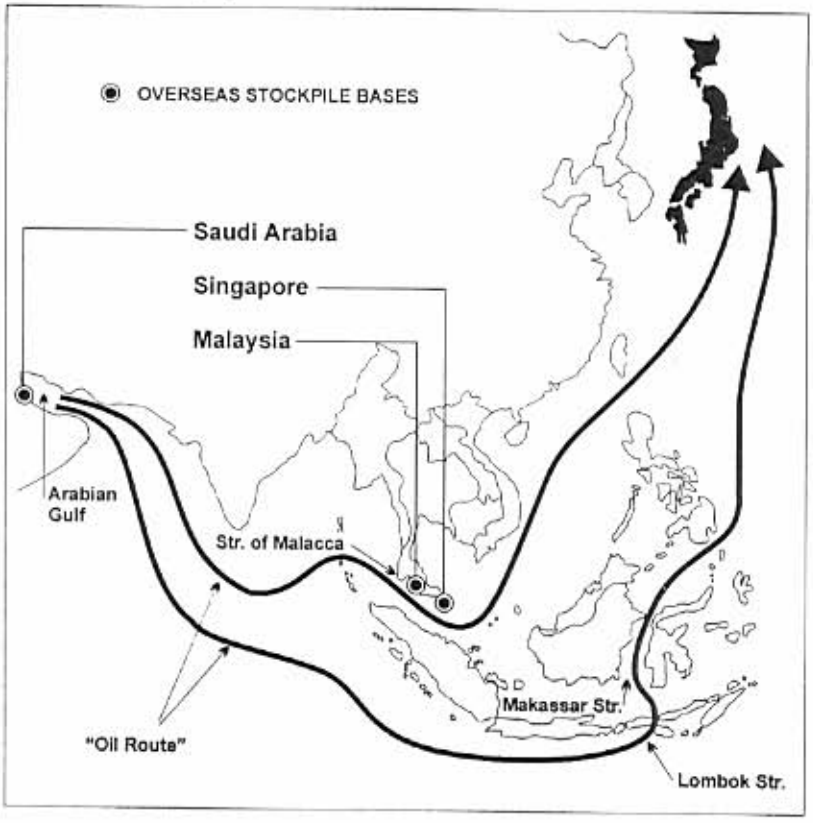
Research and development plan. Research and development is undertaken in fields such as diffusion-drift modelling of spilled oil; changes of properties of oil through weathering processes; and self-clean-up mechanism of the ocean for spilled oil.

ASEAN-Japan Oil Spill Preparedness and Response (OSRAP) Project. Japan, in its efforts to positively meet the expectations of OPRC 1990, promoted a cooperative project on oil spill preparedness and response with the acronym OSRAP. The aim of OSRAP is to promote cooperation between Japan and the ASEAN to combat oil spills in the ASEAN sea area. The OSRAP project was sponsored by the Japanese Ministry of International Trade and Industry (MITI) and it is executed by the Japan Association for Preventing Marine Accidents which is a private organization. Financial backing is through the Sasakawa Foundation and the Japanese Ship Owners Association of Japan.

The OSRAP project for ASEAN waters has contributed in the following:

- Development of an ASEAN Oil Spill Information Network System;
- Enhancement of equipment stockpile bases in: Muara (Brunei Darussalam), Balikpapan (Indonesia); Port Kelang, Pengang, Johor, Penang and Labuan (Malaysia); Manila, Cebu and Davao (Philippines); southern part of Thailand; and Singapore.
- Establishment of the regional oil spill contingency plan.

Figure 6.15. PAJ Equipment Stockpile Bases.



The Straits of Malacca Revolving Fund

Background. Japan, as the major user of the Straits, set up the Revolving Fund in 1981. A Memorandum of Understanding (MOU) was signed by Indonesia, Malaysia and Singapore and the Malacca Strait Council, the latter representing a Japanese nongovernment association to combat oil pollution from ships in the Straits of Malacca and Singapore. Under the MOU, 400 million yen were donated by Japan to the Fund.

Scope and objective. The fund is used for the specific purpose of facilitating immediate clean-up operations in the event of an oil spill incident caused by a ship, whether accidental or intentional. The Revolving Fund allows any of the three littoral States to take an advance

for use in combating an oil spill from a ship. When compensation is received, the amount is paid back into the Fund.

Management. The Revolving Fund is controlled by a Revolving Fund Committee, which is made up of one representative from each littoral State. The Committee meets at least once a year to deliberate on various matters, including approving the annual budget. The littoral States take turns to manage the Fund, each for five years. Indonesia first managed the Fund in 1981. Malaysia took over in 1986 and Singapore in April 1991.

Use of the Fund. The first occasion when the Fund was used was in the incidence involving the *Nagasaki Spirit* when claims were made against the Fund by both Indonesia and Malaysia. Malaysia sought an advance of US$580,000 and Indonesia sought another US$660,000 from the Fund to combat the spill.

During the last Revolving Fund Committee meeting, it was decided that the Committee would request the Malacca Straits Council to make a further contribution to the Fund since it has been noted that when advances are paid, the sum left in the Fund is small.

The weakness of the current oil spill response capability. The main weaknesses in the response capability in the region are (Soentoro, 1994)

Equipment. Most of the oil pollution equipment available along the Straits of Malacca belongs to the oil companies and they are specifically selected to meet the needs of the company concerned. They are mainly designed for use in sheltered or nearshore waters and not to meet the risk of oil spills occurring in wider areas outside the companies location. EARL equipment, on the other hand, is suitable for offshore spills. PERTAMINA Oil Port in Sambu Island (near Batam Island) also has offshore type response equipment, as do Malaysia and Singapore.

Personnel. A better training system is required for the training of response equipment operators, while personnel at the coordinator level are still limited.

Mobilization of equipment. A joint Standard Operation Procedure between the Lead Agency and each of the equipment owners is required in order to ensure efficient mobilization of equipment.

Communication. Large ships prefer to use the satellite emergency system in emergencies. This could cause a delay in receiving the message since not all of the coastal radio stations have satellite communication facilities. Application of the Global Maritime Distress and Safety System Convention would improve the speed of transfer of emergency messages from ships.

Chapter 7

IMPACT OF HUMAN ACTIVITIES ON THE MARINE AND COASTAL ENVIRONMENT

The strategic locations of the Straits of Malacca and Singapore make them important international waterways linking the Andaman Sea and the South China Sea. The Straits is about 500 miles long and varies in width from 11 to 200 miles and in depth from 10 to 70 meters (Kamaruzaman, 1995). After World War II, the establishment of good port facilities, the availability of ship repair and maintenance services, the high demand for crude and refined oil from the growing economies of East Asia and the development of export oriented manufacturing industries in the region made the Straits of Malacca and Singapore among the busiest shipping lanes in the world. The Straits of Malacca is also the lifeline for hundreds of thousands of fishermen and coastal inhabitants whose livelihoods depend on the availability of fisheries and other goods and services provided by the coastal and marine ecosystems.

A number of large rivers discharge directly into the Straits of Malacca, giving it characteristics similar to an estuarine environment, including relatively low salinity, high spatial and temporal variation in many physical and chemical elements and rich primary productivity and biodiversity. For these reasons, the Straits is far more complex in terms of physical, chemical and biological properties compared to that of the open sea.

During the last five decades, the three littoral States have experienced rapid economic development. Significant increases in population growth and economic development have occurred along the coastal areas. It is recognized, however, that the three littoral States are at different stages of economic development and are marked by different political and sociocultural characteristics (*Table 7.1*)

This section reviews available information on the physical, chemical and biological characteristics of the Straits of Malacca, identifies the types and levels of human activities that contribute to the changing environmental conditions and suggests major environmental concerns which require immediate management intervention.

Physical, Chemical and Biological Conditions

An analysis of the state of the marine environment involves the assessment of the physical, chemical and biological conditions as affected by both natural forces and human activities. The marine environment is in a natural state of change which, in the absence of human interference, maintains the dynamics of the ecosystem in a state of ecological equilibrium. However, with human interference, the marine ecosystem may not be able to maintain its ecological balance if its functional integrity is impaired. The ecosystem then falls into a state of degradation.

Physical conditions

Shoreline retreats and accretion. The general geomorphological features of the Straits of Malacca and Singapore do not appear to have varied significantly

Table 7.1. Demographic and Socioeconomic Features of the Straits of Malacca and Singapore.

Features	Indonesia	Malaysia	Singapore
National population in 1994 (million)	192.2	19.5	2.9
Population along the Malacca Straits (million)	10.91	9.62	2.9
% of population along the Malacca Straits	5.67	49.23	100
National population growth, 1990-1994 (%)	1.7	2.6	1.4
GDP (billion US$) in 1994	163.8	70.0	70.2
Average GDP growth, 1990-1994 (%)	6.9	8.7	8.2
GNP per capita in 1994 (US$)	795	3,406	24,425
Inflation (%) 1990-1994	8.9	3.8	3.0

[1] Data on population along the Malacca Straits for Indonesia were obtained from the Statistical Offices of Aceh, North Sumatra, and Riau Provinces (1995).
[2] Data on population along the Malacca Straits for Malaysia were obtained from MIFA (1994).

from those displayed in the map of the Straits prepared for the United Company of Merchants of England in 1799 (*Figure 7.1*). Some physical changes have been observed however, specifically with respect to the modification of the coastlines.

Coastal erosion and land accretion are the main attributes to coastline change. A National Coastal Erosion Study conducted in 1985 showed that more than 1,972 km of coastline in Peninsular Malaysia had been affected by erosion, some of which were in a critical or significant stage of degradation, specifically along the West Coast. The critical areas include the coastline from Kuala Perlis to Sungai Udang, the West Johor coast and Northern Kuala Selangor coast (Abdullah, 1992).

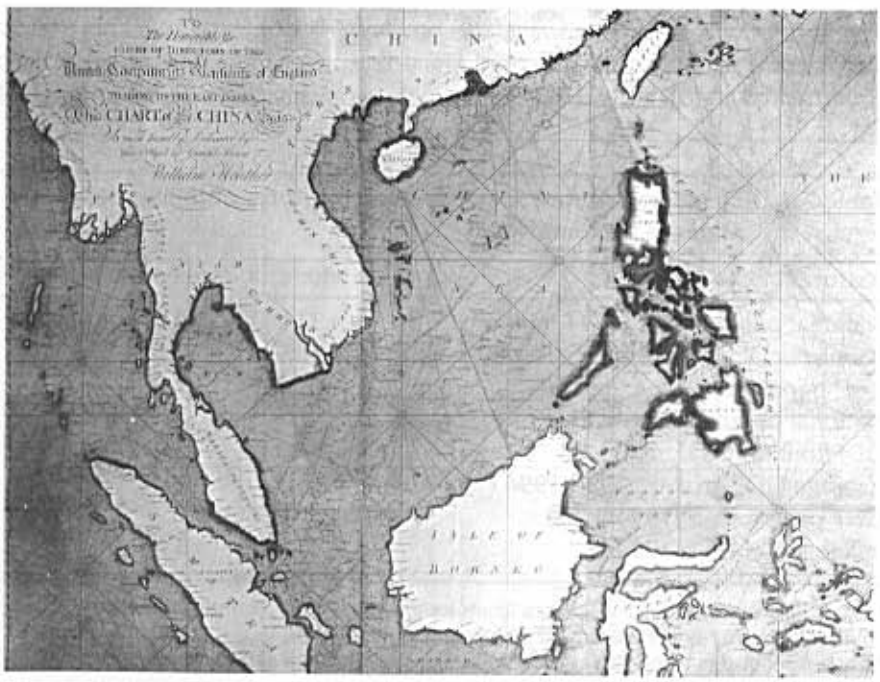
In the Kuala Kurau region, it is estimated that 0.5 km^2 of coastal mangroves were lost to the sea between 1969 and 1986 (Kamaludin, 1992). In addition, 85% of the 39.3 km of shoreline from Sungai Kerian to Sungai Gula was retreating, while only a 5.9 km stretch from Sungai Aceh to Sungai Megat Aris and Sungai Baharu was accreting (Stanley Consultants, 1995). Indications of negative coastal growth along the West Coast have been related to the construction of dams along the major rivers and the reduction in sediment transport into the Straits (Kamaludin, 1992).

On the Indonesian side of the Straits of Malacca, coastal erosion has also been reported. The shoreline at the west end of the Bengkalis Island is diminishing at a rate of about 10 meters per year, while at Anak Setahan, north of Rangsang island, the shoreline is eroding by as much as 20 meters per year (Science Systems Consultants, 1994). High rates of shoreline erosion are attributed to mangrove felling and the clearing of land for agricultural development (Burbridge et al., 1988).

In addition to erosion of coastal areas, large quantities of sediments are transported into the Straits of Malacca by many rivers on the West Coast of Peninsular Malaysia and the East Coast of Sumatra. The result is the formation of deltas and mudflats and the accretion of coastal mangrove swamps (Vestappen 1964, 1973; Bird, 1985). About 100 meters of coastal accretion were reported near the coast of Perak between 1961 and 1981 (Tjia 1973, as cited by Bird, 1985). Some mudflats extend far into the sea with large areas exposed during low tides. Mudflats may be a few meters deep. Mangroves and prevailing intertidal current systems also contribute to the formation of mudflats. The extent of land accretion can be noted in the case of Palembang (located near the southern end of Sumatra) which, during the visit of Marco Polo in 1292, was at the edge of the river mouth. Now Palembang is some 50 km upstream from the river mouth behind a swampy coastal plain (Bird, 1985).

It is also evident that the alluvial plains along the southern end of Sumatra have become narrower. However, towards the northern end of Sumatra, where sedimentation has not kept pace with the retreat of the coastline, the Straits of Malacca is wider. The southeastern coastline of Sumatra is subjected to land accretion due to heavy sediment influx. Because of this sedimentation rate, periodic dredging is necessary to ensure the safe passage of larger vessels. Serious siltation problems in some river mouths and harbors along the West Coast

Figure 7.1. Map of the Malacca Straits Prepared for the United Company of Merchants of England in 1799. Courtesy of the National Maritime Museum, London.



of Malaysia, especially around the ports and harbors at Klang, Kuala Perlis and Kuala Kedah have also been reported (Cho, 1995).

While sediments from river discharges are brought about by natural processes, human activities such as deforestation, land reclamation, onshore mining and dredging, increase the amount of sediment loads brought into the Straits of Malacca. Results of several studies (Yahya and Leong, 1987; USM, 1995; Din, 1996) and those from routine surveys conducted by the Department of Environment (DOE) in Malaysia, show that total suspended solids (TSS) values in the Straits range between 100 and 200 mg/l (TSS levels define the amount of suspended particles in the water column). In other words, the higher the TSS, the greater amount of suspended particles in the water. These values are high compared to the interim standard of 50 mg/l which has been adopted by the DOE in Malaysia. In some stations, values greater than 500 mg/l were reported, such as the Tengi estuary in Selangor (671 mg/l), the Tanjung Pandang estuary in Perak (925 mg/l) and Pantai Sungai Lurus in Johor (1,395 mg/l). However, TSS values reported in most stations are close to the interim standard (Dow, 1995).

In the case of the southwestern and southeastern coast of Singapore, coastline modification is primarily the result of land reclamation and port development. Since the 1970s, the dumping of dredged material has enlarged several of the offshore islands creating new islands such as Pulau Ular and Terumbu Retan Laut (Chia, 1979). Between 1965 and 1985, Singapore's 131.5 km coastline was altered with the total land area increasing by some 6.71% as a result of land reclamation (Chia et al., 1988). Intensive land reclamation schemes in Singapore resulted in temporary increase in TSS in the surrounding coastal waters, especially near the reclamation sites.

The amount of sediment loads in the Straits could increase considerably through the continued activities of deforestation, land clearing and construction for human settlement, coastal land reclamation, unsound agricultural and forest practices, onshore mining activities, dumping of terrestrial mining spoils and effluents and submarine dredging (Dow, 1995). High TSS is reported on both sides of the Straits of Malacca, with levels exceeding the standards in a number of areas (***Table 7.2***). The monitoring results of the DOE Malaysia, as quoted by Dow (1995), show no improvement from the status reported in 1992.

The impact of sea level rise on the shoreline has not been fully investigated. However, it is expected that the sea level rise will seriously affect shoreline retreat, increase flooding and increase saline intrusion inland. Unprotected low-lying coastal and riverine areas will be permanently inundated, while sandy beaches and muddy coastlines will be eroded (Abdullah, 1992).

Hydrographic conditions. The hydrographic conditions of the Straits of Malacca and Singapore are dominated by the diurnal tides and by the northeast and southwest monsoons. General climate patterns (e.g., rainfall, temperature and wind currents) have remained somewhat consistent over the years, although some limited variations have occurred.

Chemical conditions

In addition to natural intrusions, the Straits of Malacca and Singapore are receptacles of waste discharged from both land- and sea-based sources. Many of the wastes contain hazardous substances harmful to human health, as well as to the health of the ecosystem. Pollutant sources include discharges from agriculture activities (pesticides organic wastes, and fertilizers), human settlements (sewage and garbage), industry (heavy metals, hydrocarbons, phenols, etc.), and shipping (sewage, garbage, oil, chemicals). These pollutants have greatly affected the water quality of the Straits.

Freshwater dilution. The Strait of Malacca is a euryhaline environment as the water therein is greatly diluted by river discharges. A recent survey along the West Coast of Peninsular Malaysia showed that salinity varied from 6.8 ppt to 31.6 ppt (Din et al., 1996). Salinity variation is less along the Strait of Singapore, fluctuating between 29 and 32 ppt. River water dilution also affects the pH, ranging from 6.2 to 8.4 in the Malaysian coastal waters and from 8.0 to 8.1 in

Table 7.2. Total Suspended Solids (TSS) Exceeding Standard (50 mg/l) for Malaysian States Bordering the Straits of Malacca (Modified from Ibrahim, E.I., 1995).

State	Percent of Samples Exceeding Standard	Mean (mg/l)
Penang	60.2	100
Johor	7	16
Kedah	58.9	103
Melaka	63.2	130
Selangor	47.6	82
N. Sembilan	29.6	52
Perak	70	265

the Singapore coastal waters. Both salinity and pH values recorded in the Straits of Malacca and Singapore are generally lower than values recorded in the open sea.

Organic loads. The Straits of Malacca receives large organic waste loadings from municipal, industrial, agricultural and shipping discharges. These discharges include sewage, piggery and other animal wastes and wastewater effluents from palm oil, rubber and other processing plants. High organic content in water usually leads to oxygen consumption (i.e., biochemical oxygen demand-BOD) resulting in low levels of dissolved oxygen (DO) in the water column.

Table 7.3 presents a range of mean values for the samples collected from DOE monitoring stations between 1985 and 1991 (Ibrahim, E.I., 1995). It is noted that a significant percentage of the results for lead, mercury, copper and cadmium are above the interim standard for marine water quality. A recent survey by Din et al. (1996) found that concentrations of heavy metals were higher than those determined in 1991, indicating an increase in heavy metal contamination. Choo et al. (1994) identified the coastal waters of Perak and Penang to have high concentrations of cadmium, copper, lead, mercury and nickel. It was also reported that most of the rivers along the West Coast of Peninsular Malaysia contained high concentrations of heavy metals which exceeded the interim standards.

Table 7.3. Water Quality Data of the Marine Environment Along the West Coast of Peninsular Malaysia, 1985 to 1991 (Ibrahim, E.I, 1995).

Parameter (mg/l)	Mean Values	Interim Standard for Marine Quality	Percent Samples Exceeding Standard
Mercury	0.00 - 0.068	0.001	0.9 - 15.4
Lead	0.014 - 0.108	0.1	3.0 - 36.9
Copper	0.034 - 0.0146	0.100	3.90 - 5.0
Cadmium	0.049 - 0.114	0.010	11.50 - 39.8
Arsenic	0.001 - 0.008	0.100	0.00 - 0.8
Chromium	0.002 - 0.062	0.500	0.00 - 0.3

Din et al. (1996) found that the levels of dissolved oxygen at 43 stations along the Straits of Malacca varied from 0.78 to 6.93 mg/l. Most of the stations recorded low DO levels, especially those in the Juru estuary of Penang, the Kerian estuary, the Teluk Nibong and Larut estuaries of Perak and Kota Kuala Linggi and Tanjung Keling of Melaka. Similarly, low dissolved oxygen levels were reported during routine surveys by DOE Malaysia from 1989 to 1994. In some areas, the DO content ranged from 1 to 2 mg/l. It is recognized that the level of DO in coastal waters can be affected by a number of factors, such as high primary productivity, high water temperature (27.4 to 32.8°C), high salinity levels and organic loading.

BOD measurements in the coastal waters of the West Coast of Peninsular Malaysia vary from 1.33 mg/l to 9.95 mg/l. However, most other stations show levels between 3 and 4 mg/l (Din et al., 1996). On the East Coast of North Sumatra, the BOD values range from 3.3 to 56.6 mg/l and chemical oxygen demand (COD) from 10.8 to 766.1 mg/l. The BOD levels at four sampling stations in the Bengkalis Straits of Riau range from 8.14 to 13.64 mg/l and CODs range from 20.16 to 32.64 (Abdullah et al., 1995). The high levels of BOD were usually found close to industries or sewage outfalls, such as in the Juru estuary, Chuah (Negeri Sembilan) and the Penang and Johor Straits.

Heavy metals. DOE Malaysia reports high concentrations of heavy metals in the waters off the West Coast of Peninsular Malaysia (Choo et al., 1994). Some water samples were found to contain lead, copper and cadmium at levels above the interim standards.

On the Sumatra coast facing the Strait of Malacca, Dahuri and Pahlevi (1994) reported heavy metal contamination in some locations, such as Lhokseumawe in North Aceh and Asahan and Deli Serdang in North Sumatra. The heavy metals (mercury, lead, cadmium and copper) were found to exceed national water quality standards for bathing, swimming and mariculture (*Table 7.4*). Heavy metal contents were high in sediments of the Pakning River, Bengkalis district, Riau Province (*Table 7.5*) where oil refining, offshore oil exploitation and transportation activities occur (Abdullah et al., 1996). *Table 7.6* identifies heavy metal content in the sediments of rivers and coastal areas in the Straits of Malacca and Singapore.

According to Grace et al. (1987), high concentrations of copper, cadmium, cobalt, nickel, lead and zinc were found in the waters off the southern coast of Singapore. No detectable levels of mercury were recorded. The report indicated high copper and zinc levels in Keppel harbor and main port areas. Also, high concentrations of lead, nickel and

Table 7.4. Water Quality Values and National Environmental Standards for the Straits of Malacca (Rozak et al., 1984, as cited by Dahuri and Pahlevi, 1994).

Parameters	Lowest (mg/l)	Highest (mg/l)	Environmental Standard (mg/l)[1]	
			Required	Allowable
Hg	ud	0.013	< 0.0001	≤0.0003
Pb	0.035	0.060	< 0.0002	≤0.01
Cd	0.009	0.014	< 0.0002	≤0.01
Cu	0.071	0.107	< 0.001	≤0.06

[1] Based upon standard for fisheries uses of marine waters (Environmental Ministerial Decree No. 02/MENKLH/1988).
ud = undetected

Table 7.5. Heavy Metal Concentrations in Sediments Around Sungai Pakning, Riau (Abdullah et al., 1995).

Metal (µg/gm)	Station			
	Kuala Siak Besar	Kuala Siak Kecil	Dompas	Sungai Pakning
Cd	ud	5.49	0.005	ud
Cu	5.49	6.79	7.49	7.49
Ni	27.27	67.12	48.94	88.80
Pb	68.42	134.55	107.38	48.94
Zn	58.03	163.62	67.72	220.85

ud = undetected

Table 7.6. Heavy Metal Concentrations in Sediments from Locations Around the Straits of Malacca and Singapore.

Heavy Metal (µg/gm)	Siak Estuary[1]	Penang Island[2]	Strait of Malacca[2]	Port of Singapore[3]	Johor Strait[3]
Pb	29.1 - 47.4 (42 ± 9.4)	14.2-34.7	30 ± 0.7	85	16
Cd	0.40-0.75 (0.6 ± 0.1)	0.04-0.07	0.11 ± 0.06	nd	nd
Cu	4.2-8.1 (5.9 ± 1.5)	8.4-13.2	10.8 ± 4.3	138.5	19
Cr	14.9 - 28.7 (23 ± 7.0)	37.5-76.5	45.2 ± 21.1	nd	nd
Ni	12.3 - 24.6 (19 ± 5.4)	18.0-37.7	16.3 ± 7.4	19.6	19
Zn	40.0 - 73.1 (57 ± 16)	20.5-42.3	65.9 ± 24.5	275	112
Mn	81 - 524 (327 ± 127)	71.9-108.0	384 ± 160	213.3	233

nd = no data available

(1) Hutagalung et al., 1996; (2) Din and Jamaliah, 1996, as cited by Hutagalung et al., 1996; (3) Orlic et al., 1995.

cobalt were reported in waters near petroleum refineries. Heavy metal contents in rivers were not significantly higher than those detected in coastal waters. It was noted, however, that higher concentrations of heavy metals were present at the downstream area of a canal in the Jurong Industrial Estate. A recent study by Tang et al. (1996) reported that the concentration of heavy metal levels in the Singapore coastal waters (*Table 7.7*) were about the same levels determined by Chai (1975) twenty years ago. The study further confirmed the earlier report by Orlic et al. (1995) that waters around the Port of Singapore have the highest concentration of metallic pollutants, followed by Johor Strait, while the West and East Coast of Singapore were the least polluted.

Heavy metals were also detected in bottom sediments (*Table 7.8*). Din et al. (1996) concluded that heavy metal concentrations in sediments were relatively high compared to those detected in the suspended solids in the water column. Higher concentrations of heavy metals (copper, zinc and lead) were found in bottom sediments in areas experiencing heavy shipping traffic, probably due to antifouling paints used extensively by ships (Goh and Chou, in press).

Heavy metals are known to accumulate in fish and shellfish. In Malaysia, heavy metals (lead, mercury and arsenic) were found in fish tissues (Jothy et al., 1983; Shahunthala, 1986; Law and Singh, 1991) (*Table 7.9*) and seaweed (Ramachandran et al., 1995). However, a recent survey by Din et al. (1996) showed that, in general, heavy metal contamination in coastal waters was limited to certain areas close to industrial sites and estuaries.

Pesticides. Pesticide residues are found in the riverine systems along the West Coast of Peninsular Malaysia. Some of these organochlorines end up in the coastal waters though in a much diluted form. According to the survey by Tan et al. (1991), high concentrations of aldrin (0.005 to 0.061 ng/l), endosulfan (0.009 to 0.256 ng/l) and heptachlor (0.039 to 1.742 ng/l) were detected in Kelang River. A subsequent study by Tan

and Vijayaletchumy (1994) reported that endosulfan, heptachlor, DDT, dieldrin, lindane and γ-HCH were detected in all river samples on the West Coast (*Table 7.10*). As DDT and endosulfan are widely used in rice growing areas, their levels were found to be higher in rivers which pass through these areas. There is evidence in Sg. Selangor and Sg. Bernam, which are the two most polluted rivers along the West Coast, that DDT and endosulfan levels exceed the Malaysian interim standards. However, Tan et al. (1991) pointed out that the levels of other organochlorine pesticides found in the rivers were still below the standard values set for Malaysian aquatic life (*Table 7.11*).

Table 7.7. Mean Concentrations of Trace Metals in Seawater Samples (Tang et al., 1996).

Trace Metal (mg/l)	Port of Singapore (9 samples)	Sentosa and Marina Bay (5 samples)	East Coast (7 samples)	Johor Strait East (16 samples)	Johor Strait West (3 samples)
Mn	5	0.6	2	4	3
Fe	241	3	9.2	50	23
Ni	0.9	0.2	0.3	1.4	0.1
Cu	3.9	0.4	0.4	2.3	2
Zn	2.4	0.8	1.4	2.1	0.8
Pb	-	0.3	0.8	0.4	0.3

Table 7.8. Elemental Concentrations in Sediment Samples from Singapore Coastal Waters (Modified from Tang et al., 1996).

Trace Metal (μg/gm)	Port of Singapore	Sentosa and Marina Bay	East Coast	Changi Point	Johor Strait East	Johor Strait West	West Island Tip
Cr	63	66	67	62	58	69	53
Mn	233	297	277	428	303	507	21
Ni	23	16	25	21	20	16	11
Cu	229	42	14	15	67	38	17
Zn	428	132	80	96	212	183	88
As	26	19	13	18	19	24	25
Sb (Tin)	54	32	13	22	27	22	15
Pb	88	45	24	33	47	32	21

Table 7.9. Levels of Heavy Metals in Fish and Shellfish from the West Coast of Peninsular Malaysia (μg/gm wet weight)

	Cu	Zn	Cd	Pb	Hg	References
Fish	min: 0.05-	1.7	<0.001	<0.005	0.01	Jothy et al.
	max: 0.75	10.8	0.10	1.2	0.58	(1983)
Shellfish	min: 0.21-	7.70	0.01	0.25-	9.2-	
	max: 7.70	0.77	0.07	0.74	25.2	
Fish	1.05±0.19	10.45±0.19		0.29±0.02	0.33±0.23	Law and Singh (1991)
Shellfish	0.4 - 3.3	10.9-	0.12	0.01	0.006	Shahunthala
		33.7	1.11	1.63	0.049	(1986)

On the East Coast of Sumatra, insecticides, fungicides, rodenticides and herbicides are used heavily to control pests in rice fields, oil palm and crop plantations. About 3,780 tons of insecticides, 110 tons of fungicides, 291 tons of rodenticides and 22 tons of herbicides are used along the East Coast of Sumatra (Dahuri and Pahlevi, 1994). Although there are no comprehensive estimates on pesticide residues in the coastal waters, available information on pesticide residues in water samples from the Siak River shows that the concentration of p,p'-DDT is between <0.03 μg/g and 0.71 μg/g; endrin, 0.03 and 11.17 μg/g; dieldrin 0.03 and 1.40 μg/g; aldrin, 0.04 and 8.17 μg/g; heptachlor, <0.002 and 0.36; endosulfan-I, 0.09 and 3.15 μg/g; and γ-HCH, 0.02 and 2.14 μg/g. Pesticide residue levels were higher in the sediments than those in the water column (Hutagalung et al., 1996) (*Table 7.12*).

Within Singapore, a limited number of crops are cultivated. These crops include vegetables, orchids and ornamental plants. The use of toxic and persistent chemicals, such as chlorinated hydrocarbon compounds are not allowed (MOE/Singapore, 1989). The only chlorinated pesticide allowed is chlordane. In 1987, some 47 tons of chlordane were used (MOE/Singapore, 1989).

Oil, grease and petroleum hydrocarbons. It is expected that the oil and grease content in the waters of the Straits is high in areas near ports, refineries, oil terminals, industrial sites and shipping lanes. In addition to accidental and chronic discharges from ships and powered fishing crafts, the processing of palm oils, latex, sago (tapioca), desiccated coconut, textile

Table 7.10. Levels of Organochlorine in West Coast Malaysian Rivers (Modified from Tan and Vijayaletchumy, 1994).

River	Residue level (ng/l)					
	t-HCH	t-Endo	Heptachlor	t-DDT	Dieldrin	Total OCPs
Sg. Perlis	30	159	11	33	nd	233
Sg. Kedah	50	25	16	42	11	144
Sg. Merbok	32	111	15	35	15	207
Sg. Muda	60	145	16	69	nd	290
Sg. Perai	65	110	26	48	15	264
Sg. Juru	54	47	18	52	nd	171
Sg. Bernam	320	62	120	190	39	731
Sg. Selangor	280	310	100	110	47	847
Sg. Klang	1.1	0.4	nd	9.5	4.0	15
Sg. Liggi	2.7	nd	0.1	7.8	1.3	12
Sg. Melaka	3.9	33	16	74	3.0	130
Sg. Muar	nd	9.3	22	122	2.5	154
Sg. Batu Pahat	nd	10	10	100	1.6	122
Sg. Tebrau	1.4	1.0	29	59	14	104
Sg. Johor	nd	13	11	65	34	123

nd = not detected (i.e., below detection limit); t-HCH = α-HCH + β-HCH + γ-HCH; t-Endo = endosulfan I + endosulfan II; t-DDT = p,p'-DDE + p,p'-DDT.

and other manufacturing industries also contributes to the oil and grease loading. DOE Malaysia has conducted regular monitoring activities of the coastal waters in the West Coast of Peninsular Malaysia. It was reported that high levels of oil and grease were detected in Negeri Sembilan, Melaka and to a lesser extent in Selangor (1992), all consistently above standards. A summary of the levels of these pollutants in the water column, as prepared by Tahir (1996), is presented in ***Table 7.13***. As can be seen from the table, the oil and grease in the water column and the petroleum hydrocarbons from the coastal waters and sediments give range of data. The highest levels of oil and grease and hydrocarbons were recorded in the vicinity of Kukup in Johor. The samples collected were within the vicinity of the shipping lanes. The elevated levels were attributed to sea-based activities, in particular those from illegal dumping activities (Abdullah, 1996, as cited by Tahir, 1996). High levels of hydrocarbons were also observed in the vicinity of Port Klang, the largest port in Malaysia.

Table 7.11. Chlorinated Pesticide Water Quality Criterion for Malaysia (Tan et al., 1991).

Pesticides	Criterion (ng/l)		
	Livestock	Aquatic Life	Human Health
Aldrin/Dieldrin	90	8	20
BHC	600	130	2,000
DDT/DDE	300	4	100
Endosulfan	12,000	10	10,000
Endrin	90	14	60
Heptachlor	60	60	50
Lindane	600	380	2,000

Table 7.12. Range of Organochlorine in Sediment of Siak Estuary, Riau, Indonesia (Hutagalung et al., 1996).

Pesticide	Range (μg/g dry wt)
p,p'-DDT	<14 to 5,392
Endrin	<7 to 143
Dieldrin	<8 to 4,374
Aldrin	52 to 4,374
Heptachlor	<1 to 243
Endosulfan-I	66 to 1,448
γ-HCH	<2 to 1,378

Data from 1979 show that the oil concentrations in the water column along the East Coast of Sumatra ranged from 100 to 6,300 μg/l (Soegiarto 1982, as cited by Dahuri and Pahlevi, 1994). Hydrocarbon contamination shown in studies carried out by LEMIGAS in waters surrounding the offshore oil fields and refineries, specifically those around Riau Islands, is found in the ***Table 7.14***.

More recently, Hutagalung et al. (1996) presented data (***Table 7.15***) on the hydrocarbon content in the waters around Riau. The data clearly indicate levels higher than in Jakarta and Java.

In Singapore, recent studies carried out by Tang et. al. (1996) indicated that waters and sediments were contaminated by hydrocarbons. They noted high levels of petroleum hydrocarbons in sediments from Johor Strait West and along Changi Point.

A comparison of the total hydrocarbon levels in the Straits of Malacca and Singapore with other areas indicate that both Straits are heavily contaminated with oil. As can be seen from ***Table 7.16***, the levels of hydrocarbon determined are well above FAO's 0.0025 mg/l water column standard and marginally

Table 7.13. Oil and Grease in Coastal Waters and Petroleum Hydrocarbons in Coastal Waters and Surfacial Sediments off the West Coast of Peninsular Malaysia (Tahir, 1996).

Location	Water Concentration[1] (µg/l)		Sediment (µg/g dry wt)	# of Sampling Stations		Year of Survey	References
	Oil/Grease	Hydrocarbon		Water	Sediment		
Perlis							
K. Perlis	600 - 900	2.1 - 2.8	94 - 125	3	2	1995	Abdullah (1995)
	-	1.5 - 1.9	139 - 148	4	2	1992	Abdullah et al. (1994)
Penang							
B. Feringgi	600 - 1,400	2.1 - 2.7	29 - 47	3	2		
K. Perai	400 - 800	1.5 - 1.9	36 - 44	3	2	1995	Abdullah (1995)
Juru	1,000 - 1,400	1.9 - 3.3	16 - 144	3	2		
Penang	-	5 - 31	53 - 125	9	2	1992	Abdullah et al. (1994)
Penang	-	60 ± 30[2]	-	-	-	-	Phang et al. (1984)
Perak							
K. Kurau	400 - 700	13 - 43	25 - 46	5	3	1995	Abdullah (1995)
Lumut	100 - 900	21 - 186	9.1- 54	6	5		
Lumut	-	314 - 386	87 - 180	4	2	1992	Abdullah et al. (1994)
Selangor							
K. Selangor	700 - 1,000	16 - 22	33 - 162	4	3		
Port Klang	300 - 600	6.3 - 63	83 - 704	6	3	1995	Abdullah (1995)
Morib	400 - 1,000	13 - 45	5.6 - 26	4	3	-	
Port Klang	-	18 - 129	146 - 734	9	3	1992	Abdullah et al. (1994)
Morib	-	9 - 43	76 - 83	6	2		
N. Sembilan							
K. Lukut	100 - 600	21 - 30	6.4 - 31	6	4	1995	Abdullah (1995)
Port Dickson	400 - 500	17 - 101	8.2 - 45	6	4		
Port Dickson	-	8 - 112	62 - 115	10	2	1992	Abdullah et al. (1994)
Port Dickson	-	69 ± 46[3]	22 - 75[3]	31	23	-	Law et al. (1990)
Malacca							
Rembang	500 - 600	20 - 140	28 - 89	4	4	1995	Abdullah (1995)
Malacca	-	8 - 15	94 - 151	6	2	1992	Abdullah et al. (1994)
Johor							
Muar	-	18 - 48	199	3	1	1992	Abdullah et al. (1994)
Batu Pahat	-	26 - 81	82 - 108	3	2		
Tg. Piai	-	115[4]	-	2	-	-	Md. Pauzi (1994)
Kukup	2,100 - 3,500	2,000 - 2,700	92 - 175	5	3	1995	Abdullah (1995)

[1] Unless otherwise stated, concentration is in Esso Selingi Crude Equivalent.
[2] Hydrocarbon standard mixture equivalent; 37.5 iso-octane; 37.55 hexadecane; 25% benzene.
[3] ESSO Tapis A crude oil equivalent.
[4] Dual ng whole crude oil equivalent.

Table 7.14. Hydrocarbon Contamination Along the East Coast of Sumatra (Bilal, 1980).

Region	Average (µg/l)		Year
	Surface	Subsurface	
Rangsang Island	0 - 1,500	3,500 - 11,150	1975
Bengkalis Island	0 - 1,500	1,600 - 1,800	1975
Rupat Island	3,100 - 4,500	1,200 - 1,500	1975
Pangkalan Brandan	3,100 - 4,500	400 - 1,200	1975
Pangkalan Susu	0 - 1,500	600 - 800	1975

Table 7.15. Oil Content Around Riau Archipelago (Hutagalung et al., 1996).

Area	Oil and Grease (µg/l)
Siak Estuary, Riau	1,200 to 9,600 (dry season); 450 to 3,850 (rainy season)
Mapor	1,170 to 2,700
Batam	2,440 to 4,270
Jakarta Bay	100 to 200
Jatibarang, West Java	640 to 870
Cilacap, Central Java	370 to 100

consistent with the 100 mg/kg sediment standard (Marchand et al., 1982, as cited by Abdullah et al., 1994) set for aquatic life.

Tar balls. Beaches are considered to be adversely polluted when tar levels reach 10 grams per meter. At levels of 100 gram per meter, they are considered virtually unusable (UNEP, 1990).

Table 7.16. Total Hydrocarbon Content in Waters and Sediments of Selected Sites in the Malacca Straits and Other Marine Bodies.

Locations	THC (mg/l) (water)	THC (mg/kg) (sediments)	Reference
West Coast, P. Malaysia	0.005 - 0.386	52.81 - 733.74	Abdullah et al. (1994)
Port Dickson, Malaysia	0.015 - 0.15	21.7 - 74.5	Law et al. (1991)
Bengkalis Island, Indonesia	0 - 1.5	nd	Bilal (1980)
Siak Estuary, Riau, Indonesia	1.2 - 9.6	nd	Hutagalung et al. (1996)
Hong Kong	0.004 - 0.012	nd	Cheung (1979)
English Channel	0.0003 - 0.014	0.3 - 560	Fileman and Law (1988)
Western Mediterranean	0.001 - 0.012	nd	Faraco and Ros (1979)
Omani water	0.0016 - 0.033	3.1 - 40.35	Badawy and Al-Harthy (1991)
Manila Bay	1.25 - 6.98	nd	Bilal (1980)

All data other than Hutagalung et al. (1996) have been cited in Abdullah et al. (1994).
nd = no data available

Tar balls have long been reported along the beaches lining both sides of the Straits (Bilal, 1980). The DOE Malaysia conducts tar sampling along selected beaches designated for recreational purposes. The results of the DOE 1991 tar ball survey are shown in *Table 7.17*. As can be seen from the table, the UNEP standards of adverse tar pollution have been exceeded at beaches located in Pantai Pasir Panjang (Perak State) and Tanjung Rhu (Kedah State).

Table 7.17. Malaysia: Tar Ball Survey, 1991.

State	Beach	Max. Value Recorded (gram per meter strip)
Johor	Kuala Sungai Johor	1.5
Negeri	Port Dickson, Bt. 5	1.0
Sembilan	Port Dickson, Bt. 7	3.7
	Port Dickson, Bt. 8	4.3
	Kuala Sungai Lukut	0.8
Perak	Pantai Pasir Panjang	16.0
Selangor	Pantai Morib	3.8
Kedah	Tanjung Rhu	13.58

Between 1982 and 1984, LEMIGAS and CENEXO examined the levels of tar pollution in the Kepulan Riau islands. These are located some 16 km south of Singapore. The beach tar contamination values were shown to be 15.4 g per meter strip (± 5.4) (Bilal 1990). The tar samples were analyzed by gas liquid chromatography to determine the source of hydrocarbons. It was found that of the 675 weathered crude oils, 20% came from tanker oil sludge and 13% were fuel oil residues.

Biological conditions

The biological environment in the Straits has undergone significant change as a result of human interventions. The changes in biological conditions may be examined in relation to the distribution and level of coliform bacteria in the water column, the occurrence of harmful algae, the condition of various habitats and ecosystems and biodiversity.

Coliform bacteria. The discharge of organic wastes into the Straits of Malacca and Singapore has resulted in an increase in bacterial population in the coastal waters, specifically fecal coliform bacteria. Surveys along the West Coast of Peninsular Malaysia show that fecal coliform levels in most of the water samples have values exceeding the interim standard of 100 MPN/100 ml for recreational purposes (DOE/Malaysia, 1990). In 1988, *Escherichia coli* levels in Penang and Selangor reached 100,000 MPN/100 ml. A survey conducted in 1992 (Dow, 1995) showed that the *E. coli* level was about 25,000 MPN/100 ml in the Penang area.

In many areas, coliform levels are many times higher than the interim standards set by the national authority (*Table 7.18*). The lack of adequate sewage treatment and disposal facilities has resulted in the direct discharge of untreated or primary treated sewage and other organic wastes into the waterways.

Table 7.19 presents water quality data at selected aquaculture sites in the west coast of Peninsular Malaysia. High concentrations of coliform have also been found in recreational waters (*Table 7.20*).

Table 7.18. Marine Water Qulaity—*E. coli*, 1985-1991 (Ibrahim, E.I., 1995).

State	Samples Exceeding Standard (%)	Mean (MPN/100 ml)
Penang	76.1	16,823
Johor	44.5	24,452
Kedah	43.6	9,524
Melaka	43.4	14,721
Selangor	42.3	1,719
N. Sembilan	41.7	4,360
Perak	36.4	599

Harmful algal blooms. The enriched waters of the Straits of Malacca and Singapore support high primary productivity and sustain relatively high levels of aquatic standing crops. However, hypernutrification could cause a gradual change of species composition in the Straits. One change that is evident is the occurrence and increased frequency of harmful algal blooms, commonly known as red tides, as noted during the monitoring of phytoplankton composition in Singapore and Johor Strait (Khoo and Wee, 1996).

The rich coastal water of the Straits of Malacca and Singapore favor the growth of a variety of red tide causing dinoflagellates. The most predominant species causing the red tide phenomenon are *Noctiluca scintillans* and *Hornellia marina* (Choo et al., 1994). The occasional blooms of these organisms are reported to cause fish and shrimp mortality as a result of oxygen depletion. Red tides have been reported in the coastal waters on both sides of the Straits (***Table 7.21***) and in Singapore waters (Khoo and Wee, 1996).

Mangrove habitats. It is estimated that about 498,000 hectares of mangroves border the Straits of Malacca and Singapore. This number constitutes approximately 10% of the total mangrove forests in the three

Table 7.19. Microbial Water Quality at Aquaculture Sites on the West Coast of Peninsular Malaysia (Modified from Wang, 1996).

State	Location	Activity	Total Coliform (MPN/100 ml) (Geom. mean)	Fecal Coliform (MPN/100 ml) (Geom. mean)
Penang	Kuala Sungai Kerian	Aquaculture	170 (1989-93)	75 (1989-93)
	Kuala Sungai Juru	Aquaculture	360 (1989-93)	300 (1989-93)
	Telok Bahang	Fishing villages	1,000 (1989-93)	410 (1989-93)
	Batu Maung	Fish landing	2,000 (1989-93)	1,100 (1989-93)
Perak	Kuala Sungai Gual	Aquaculture	250 (1991)	190 (1989-91)
	Kuala Sungai Kurau	Aquaculture	93 (1989-91)	80 (1989-91)
	Kuala Sungai Perak	Aquaculture	27 (1989-91)	27 (1989-91)
	Kuala Sungai Sepetang	Aquaculture	285 (1989-91)	253 (1989-91)
Selangor	Kuala Sungai Sepang	Aquaculture	210 (1989-93)	95 (1989-93)
	Kuala Sungai Bernum	Aquaculture/ Fishing villages	105 (1989-93)	46 (1989-93)
	Kuala Sungai Selangor	Aquaculture/ Fishing villages	316 (1989-93)	115 (1989-93)

Table 7.20. Microbial Water Quality at Recreational Sites on the West Coast of Peninsular Malaysia (Modified from Wang, 1996).

State	Location	Total Coliform (MPN/100 ml) (Geom. mean)	Fecal Coliform (MPN/100 ml) (Geom. mean)
Melaka	Rembang beach	70 (1989-91)	18 (1989 - 91)
	Kundor beach	105 (1989-91)	21(1989 - 91)
	Tanjung Bidara beach	55 (1989-91)	22 (1989-91)
Negeri	Port Dickson beach, 5th mile	90 (1989-93)	30(1989-93)
Sembilan	Port Dickson, 7th mile	380 (1989-93)	190 (1989-93)
	Port Dickson, 8th mile	110 (1989-93)	100 (1989-93)
	Port Dickson, 10th mile	90 (1989-93)	50 (1989-93)
Penang	Telok Bahang beach	105 (1989-93)	70 (1989-93)
	Telok Bahang beach, near Mutiara hotel	450 (1989-93)	200 (1989-93)
	Batu Ferringgi beach	430 (1989-93)	265 (1989-93)
	Batu Ferringgi beach, near Casuarina hotel	1,000 (1989-93)	450 (1989-93)
	Batu Ferringgi beach, near Bayview hotel	1,000 (1989-93)	400 (1989-93)
	Batu Ferringgi beach, near Rasa Sayang	860 (1989-93)	380 (1989-93)
Perak	Pantai Telok Batik	48 (1989-91)	38 (1989-91)
	Pantai Pasir Panjang	13 (1989-91)	6 (1989-91)
Selangor	Pantai Morib	74 (1989-93)	38 (1989-91)
	Pantai Bangan Lalang	54 (1989-93)	34 (1989-93)

littoral States (4.9 million hectares) or 6 to 8% of the total world mangroves (6 to 8 million hectares). The mangroves are important coastal habitats and nursery grounds which support a significant level of the inshore fisheries (i.e., commercial species of fish, shrimps and crabs) in the Straits of Malacca. Mangroves also play a significant role in shoreline protection and the supply of fuelwood and other products.

Table 7.21. Record of Red Tide Occurrences in Malaysia (Modified from Choo et al., 1994).

Date	Site	Organism	Impact
Aug 78	T. Kumbar, Penang	*Noctiluca*	Fish kills
Nov 78	P. Betong/K. Sg. Penang, Penang	*Noctiluca*	Fish asphyxiation
Oct 79	T. Kumbar, Penang	*Noctiluca*	Fish asphyxiation
Mar, May-Jul, Sep, Nov 83	Johor Strait	*Hornellia*	Fish, shrimp, crab mortality
Jan-Feb 85	Johor Strait	*Hornellia*	Shrimp mortality
Jun 90	Sg. Dindings, Perak	unidentified	Sores in fish, mussel mortality

The West Coast of Peninsular Malaysia contains some 110,00 hectares of mangroves, which represent about 17% of the total mangrove swamps in Malaysia. About 80% of the mangroves are concentrated in four states, namely Johor, Selangor, Perak and Kedah. According to Gong et al. (1994), mangrove forests decreased by about 35%, mostly along the West Coast as a result of land conversion for human settlement, agriculture (including shrimp farming) and industrial development.

The large part (77.5%) of the mangrove forest in the Straits is located on the East Coast of Sumatra. The most serious threat to the mangrove ecosystem in Indonesia is their conversion into milkfish ponds (locally known as *tambak*). The total area of *tambak* in North Sumatra increased from the 839 hectares in 1979 to over 7,581 in 1990 (Dahuri and Pahlevi, 1994). More than 99% of the *tambak* are found on the East Coast. Other activities that threaten the existence of mangroves include excessive harvesting for fuel, poles, timber and chip production, human settlements, operation of petrochemical plants, refineries and oil terminals and upland deforestation (Dahuri and Pahlevi, 1994).

In Singapore, mangroves covered 10 to 13% of the coastline in 1819. These have been dramatically reduced to about 1% (600 hectares) according to recent estimates (Ng and Low 1994). Existing mangroves are found mainly along the northern part of the island fringing the southern shore of the Tebrau Strait of Johor. Many of the mangrove areas according to Ng and Low (1994) are fragmented or degraded to a certain extent.

Seagrass beds. Seagrasses are the only submerged flowering plants in the marine environment (Fortes, 1990). Seagrass beds thrive in shallow coastal waters and exist in enormous quantities often forming large, dense meadows at the bottom. They form an important coastal submerged ecosystem playing a significant role, such as a breeding, feeding and nursery ground for fish, shrimps and dugongs. They have high standing crops, high productivity and are able to concentrate nutrients in their mass, thus playing an important role in marine food chains.

About 20% of the 50 species of seagrasses in the world are found in the Straits of Malacca and Singapore. Seagrasses are mostly found on the Malaysian side of the Straits of Malacca. Most occur on substrates ranging from sandy-muddy bottoms to sand covered corals.

Seagrass beds are found along the coast of Langkawi Island, Kedah, Penang, Perak, Negeri Sembilan and the Pulai estuary in Johor. The largest seagrass bed in Malaysia is located at the Merambong Shoal measuring 1.2 km in length and 80 to 100 meters in width (Japar, 1994a). The more common genera include *Enhalus*, *Halophila* and *Thalassia* found in sandy-muddy bottoms, while *Cymodocea* is found in sand-covered corals near Port Dickson.

Most of the seagrasses reported in Sumatra are found on the West Coast. In Singapore, only 7 of the 11 species of seagrasses still remain (Fortes, 1992; Loo et al., 1994). They no longer form extensive beds but occur in isolated patches in reef flats and upper reef-crest zones (Loo et al., 1994). Although as many as 300 species of fauna are associated with seagrass beds in Indonesia (Hutomo, 1985), Loo et al. (1994) found a total of only 46 species of fish and mollusks associated with seagrass in Singapore.

The loss of seagrass beds in Singapore was predominantly due to increased sedimentation as a

The loss of seagrass beds in Singapore was predominantly due to increased sedimentation as a result of land reclamation and destruction of fringing reefs.

Coral reefs. As a whole, coral reef resources in the Straits of Malacca and Singapore are not highly developed because of the relatively turbid conditions and fluctuating salinity. Some fringing and patch reefs are present. Along the West Coast of Peninsular Malaysia, the coral reefs are mostly found around the islands of Pulau Sembilan, Pulau Pangkor and Pulau Langkawi and off the coast of Port Dickson. According to Ridzwan (1994), the fringing reefs are still in fair condition with 25% to 46% of live coral cover.

Along the East Coast of Sumatra, coral reefs are concentrated mostly around the island of Riau Archipelago and small patches occurring at the northeastern tip of Sumatra (WCMC, 1994). Coral reef research along parts of Indonesia is still limited. The Center for Research and Development in Oceanology carried out a nationwide assessment on the extent of coral reef destruction in Indonesia. The results indicated that, on the average, 42.4% of the assessed reefs were in poor condition, 28.6% were fair, 24.4% were good and only 4.6 % were in excellent condition (Soegiarto, 1996). In general, the coral reefs in the eastern part of Indonesia are in better condition than those in the central or the central and western parts of Indonesia. The coral reefs in the Riau Archipelago were not included in the nationwide assessment.

The coral reefs of Singapore are reported to occur in the southern islands, specifically Pulau Hantu, Pulau Sudong, Pulau Salu, Pulau Samakau, Sudong, Pawai, Senang, St. John's and Raffles Lighthouse. Because of the deterioration in water quality, coral reefs which once grew below a 10 m depth, now only grow in the upper 5 m (Chou et al., 1994).

A variety of factors contribute to the degradation of the coral reefs, the majority of which are human related. These include heavy sedimentation caused by deforestation, land reclamation and dredging, intensive fishing and other human activities in the reef area and pollution caused by industry, shipping and domestic discharges.

Mudflat and soft-bottom ecosystems. One major characteristic of the Straits of Malacca is the extensive mudflats along the coastline. These mudflats contain rich organic substances and fine silt particles which support rich benthic communities. They form excellent culture beds for the commercially important blood cockles (*Anadara granosa*). Most of the mudflats in the Malaysian coast are used for the farming of blood cockles, the production of which is the highest in the world.

As part of the Sunda Shelf, the Straits of Malacca and Singapore are also characterized by their muddy sand bottom, forming extensive habitats for soft bottom communities, specifically bivalves and gastropods. Sandy bottoms are found more in the offshore areas or in nearshore areas away from the mouths of rivers (Chou, 1994a). These soft-bottom habitats support major demersal fisheries in the Straits. Commercial species harvested from the soft-bottom habitats include fishes, seaweeds, horseshoe crabs, shrimps, crabs, bivalves, gastropods, sea cucumbers and sea urchins.

Soft-bottom habitats are highly vulnerable to physical destruction by excessive trawling. However, it is the heavy coastal pollution that has caused serious harm through contamination of marine food products.

Productivity. High standing crops of fisheries and other commercially important marine products in the Straits are attributed to the euryhaline conditions, rich nutrient levels, shelter from strong currents and wave actions, high but rather uniform temperatures and adequate tidal flushing. These attributes enable a rich mix of marine flora and fauna from both the Indian and the Pacific Oceans.

Fish production in the Straits of Malacca was about 865,000 tons in 1990 and 884,000 tons in 1993. The two littoral States contributed equally to the total fish catch. However, the number of fishermen in Malaysia constitute less than one-seventh of the total fishermen population and employ about 21% of the total number of fishing boats. Almost all the Malaysian fishing vessels are powered and highly mechanized.

Despite the fact that the total landings are increasing, available data on catch per unit effort (CPUE) for the pelagic fisheries in the Indonesian waters of the Straits of Malacca indicate sharp declines from 275 kg/hr in 1970 to 194 kg/hr in 1979 and finally, to 52 kg/hr in 1982. In the case of demersal fisheries, Saharuddin (1995) reported that the CPUE in Malaysian waters decreased from 131.1 kg/hr in 1970 to 55 kg/hr in 1981. Obviously, both pelagic and demersal fisheries in the Straits of Malacca have long been overexploited.

resulted in changes of species composition, the disappearance of other species and the increasing numbers of endangered species.

In the early 1950s, both the herring-like fish, locally known as *ikan terobok* (*Alosa toli*) and another species of clupeids, *Lactarius lactarius*, were abundant in the Straits of Malacca. Today, the former is rarely caught in either of the Straits and the latter have completely disappeared. The disappearance of the *Lactarius lactarius* was reported in the late seventies. Similarly, the population of sting rays has also decreased. The dugongs (*Dugong dugong*), which feed on seagrasses and were once a common sight in the Straits of Malacca, are now scarce. This scarcity is attributed to the disturbance and destruction of seagrass beds by trawling operations and industrial pollution.

The *Red List* of Singapore identifies species declared extinct or at the verge of extinction (Ng and Wee, 1994). The great numbers include 52 species of fish, 13 species of corals and sea anemones and 12 species of crustaceans declared extinct. More than 50 other species are considered threatened.

Major Environmental Concerns in the Malacca Straits

Major causes of environmental concern in the Malacca Straits include:

- oil and chemical spills;
- harmful algal blooms and fish kills;
- fecal coliform contamination
- tributyl tin (TBT) contamination;
- heavy metal pollution;
- sedimentation; and
- degradation of critical habitats.

Oil and chemical spills

There are over 100,000 oil tankers, container vessels and other cargo vessels transiting the Straits of Malacca and Singapore each year. Oil tankers carry about 3.23 million barrels of crude oil through the Straits each day. With such heavy traffic, incidents of oil spillage are not uncommon. Most of the spills are caused by collision or grounding of ships, others are due to accidental operational discharges during loading, production, refining and other shipping activities (e.g., tank cleaning; overflows during oil transfer; leaks and oil spills). The number of incidences of major oil spills has increased in recent years, from less than 2 per year in 1976 to 9 in 1993.

The impacts of oil spills in the Straits are summarized in a number of recent reports (Cheevaporn, 1995; Dow, 1995). Of particular concern is the impact on the intertidal zone where a number of fragile ecosystems exist. The slow recovery of mangroves affected by major oil spills was presented by Soegiarto (1980b) and Bilal and Kuhnhold (1980). Because of the limited coral reefs in the Straits, the stress caused by oil spills on the fringing reefs is a serious concern. Oil spills also affect fisheries, mariculture, coastal tourism, biodiversity and standing crops (Paw and Diamante, 1995).

In 1984, the Indonesian Office of the State Minister on Environment established a modified version of sensitivity ranking for coastal ecosystems and habitats for oil spills (Sloan, 1993) as shown in *Table 7.22*.

Mangroves. Even though a large number of oil spills have occurred in the Straits of Malacca, very few studies have documented the extent of the impact. One of the few studies was that following the *Showa Maru* incident in 1975, which impacted hundreds of mangrove forest with stranding of slicks in the intertidal zone (Bilal and Kuhnhold, 1980; Soegiarto, 1980b). After two and a half years, the mangroves showed little sign of recovery. Even though there is a lack of information on the environmental impacts of oil spills in the Straits, other studies (Sloan, 1993; Cheevaporn, 1995) confirm adverse impacts upon the fragile intertidal ecosystems and the slow recovery following an oil spill.

Marine fisheries. Some of the impacts of oil spills on marine fisheries include:

- Following an oil spill, for reasons of health safety, a fisheries exclusion zone is often implemented. This will entail lost revenues to fishermen;
- The impacts of the oil spill will be felt for a long time if the spawning grounds and juveniles are affected, which would translate to reduction in the fish stocks;
- Fish tissue may become tainted and remain tainted for an extended period;
- A final problem is that of perception, with consumers refusal to purchase fish products originating from affected areas.

Losses to fisheries, as evident from the *Torrey Canyon* and the more recent *Braer* oil spill, can be in the millions. Yahaya (1995, as cited by Tahir, 1996)

Table 7.22. Modified Version of Sensitivity Ranking for Coastal Ecosystems and Habitats (Office of the State Minister on Environment, Indonesia, 1984).

Sensitivity Ranking	Habitat	Oil Spill Sensitivity Characteristics
1	Coral Reef	Delicate coral-algal symbiosis and diverse associated reef flora and fauna; recovery of coral from severe oiling may take up to 5-10 years or 20-50 years for reestablishment of complete reef ecosystem; sensitive to dispersants.
2	Mangrove	Important nursery areas for commercial fish and shrimp species and supports detritus-based food chain; protects shoreline from erosion; oil may persist in mangrove habitat, especially where tidal flushing is reduced; recovery may take several years; sensitive to dispersants.
3	Estuaries	Important productive habitat for aquatic organisms; high socioeconomic importance for large estuaries; difficult to adequately mitigate oil spills in estuaries.
4	Tidal Flats	Productive biological habitat; high organic matter content of sediment will increase persistence; natural clean-up recommended.
5	Seagrass Beds	Productive habitat and diverse associated flora and fauna; usually located in subtidal and not affected directly; contaminated bottom sediments may cause most damage; recovery may take several years; sensitive to dispersants.
6	Upwelling Zones	Upwelling zones nutrient-rich water support concentrations of pelagic and benthic organisms; sensitive to dispersants.
7	Sandy Shores	Shores impacts vary according to substrate type, etc.
8	Rocky Shores	Shores wave action and tidal flushing reduce the impacts associated with oil spills.

1 is the most sensitve, 8 the least sensitive; this is a qualitative order and not based on quantitative criteria.

estimated lost revenues could total as much as RM98.8 million should a large oil spill occur around Johor.

Aquaculture. The aqua-culture industry in the Malacca Straits is fast expanding. The potential damage from oil spills to the aquaculture industry is particularly severe. ***Table 7.23*** provides information on the sensitivity of cultivated species to floating and drifting oil. It is clear from this table that cockles, oysters and mussels, which are the most common types of aqua-culture in the region, are also the most vulnerable to oil spills. Yahaya (1995, as cited by Tahir, 1996) estimated that in the event of an oil spill around Johor some RM66.5 million would be lost by the aquaculture enterprises.

Tourism. The fouling of beaches, coastlines and visitor facilities can have a profound effect on tourism. Within the Malacca Straits, islands such as Pangkor, Penang and Langkawi, the sandy beaches of Port Dickson and Lumut in Malaysia and Batam and Bintan in Indonesia are at risk to oil spills. Oil spills within or near these areas could affect the livelihood of many thousands of people. A good example of economic losses suffered following an oil spill was the collision between the Singapore registered oil tanker *Slimy* with LPG carrier *Explode* during February 1993. *Slimy* lost 50,000 tonnes of oil valued at US$7.5 million and all its bunker oil. The spill occurred about one mile south of Sentosa island, a popular tourist resort with beach. The owner of the hotel suffered business losses estimated at US$1.5 million. Yahaya (1995, as cited by Tahir, 1996)

Table 7.23. Sensitivity of Cultivated Species to Stranded or Drifting Oil (Moller et al., 1989).

Cultivation Method	Species (Example)	Level of Impact
Onshore tanks	Fish, crustacea, molluscs, seaweed	Moderate
Sea impoundments and ponds	Prawns, fish	Moderate/low
Intertidal zone	Clam, razorshell, oyster, cockle, mussel	High
Seabed	Sea cucumber, abalone, arkshell	Low
Ropework suspended at sea surface by floats or poles	Sea laver, sea mustard	High
Vertical ropes/cages supported below sea by floats	Kelp, mussel, scallops, oyster, sea squirt, yellowtail, sea bream, bass, salmon	Moderate/low
Seabed enclosure	Crab, lobster	Low

estimated that if an oil spill occurred near a coastal resort such as *Desaru* at the southeast of Johor, lost revenues from tourism following a major oil spill would amount to some RM20 to 264 million.

Clean-up costs. Oil spills need to be cleaned up and high clean-up costs may have a serious dent on the budget of local authorities following a large oil spill. A good example of the costs to national authorities was that following the *Showa Maru* incident in 1975. Malaysia claimed US$10 million for the clean-up costs and damage to marine life. Indonesia and Singapore claimed US$51 million and US$1.6 million, respectively (Logaraj, 1978). In the previously mentioned *Slimy* incident, the clean-up costs for Singapore authorities amounted to US$25 million.

The damage from many of the chronic low level hydrocarbon pollution sources appears to be minimal and localized in comparison to the acute oil spills (GESAMP, 1990). But one should exercise caution over these; damage may in fact be occurring but it may be at a very slow pace and therefore, go unrecognized and when the problem is made apparent, it may be too late. As was discussed in one of the earlier sections, within regions of the Malacca Straits, hydrocarbon is reaching levels as high as 1,000 or even 11,500 µg/l, i.e, in Riau Archipelago. Mesocosm studies have shown that sublethal effects can be observed at concentrations as low as 20 µg/l in *Mytilus edulis*. Also, reductions in diversity and changes in size structure of phytoplankton and zooplankton were observed in concentrations down to 75 µg/l (GESAMP, 1989).

However, according to a GESAMP 1989 report on long-term consequences of low-level marine contamination, "the evidence for and significance of long term changes associated with the effects on marine biota of low-level contamination is frequently challenged by policy-makers, industry and scientists". The report also implied that one of the challenges for scientists is to identify and predict the threat from these low-level long-term pollutants to give an early indication and warning of potential changes.

Chemical spills

There are no published records of dangerous goods being shipped through the Straits. Thus, it is not possible to assess the potential significance of chemical spills due to shipping accidents. Analyses of maritime casualties in the Straits show a consistently high rate of accidents for cargo vessels. According to Kamaruzaman (1995), about 252 casualties (52%) were recorded for general cargo vessels from 1978 to 1994.

According to IMO (1996), more than 50% of packaged goods and bulk cargoes transported by sea are regarded as dangerous, hazardous or harmful to the environment. The cargoes include products which are transported in bulk and packaged form, such as solid or liquid chemicals, gases and products related to the petroleum industry and waste materials and substances. Based on these statistics, the potential incidence of dumping or accidental spillages of hazardous substances into the Straits is cause for concern.

Harmful algal blooms and fish kills

The occurrence of red tide causing dinoflagellates, especially those that cause PSP, is a matter of growing concern. In Sabah, Brunei and later in the Philippines, red tide outbreaks became common occurrences, causing numerous deaths and thousands of victims suffering from PSP. Parallel to this, the loss of millions of dollars in fisheries revenue was experienced. The presence of PSP causing dinoflagellates in the Straits could mean the beginning of the invasion of harmful algae. Although PSP monitoring in shellfish from the Straits of Malacca (Norhana and Nahar, 1996) indicate that shellfish are safe for human consumption, there is no assurance that red tides will not occur again.

Harmful algal blooms that cause paralytic shellfish poisoning (PSP) were not known to occur in the Straits until very recently. For instance, in 1993, six persons from Malaysia were hospitalized with PSP-like symptoms (Anton et al., 1995). A second incident was reported in April 1994 in Sg. Sebatu and Sg. Rambai, two mussel growing areas on the West Coast of Peninsular Malaysia. The dinoflagellates which caused PSP were identified as *Alexandrium tamiyavanicii* (Norhana and Nahar, 1996). The occurrence of the marine blue-green algae, *Trichodesmium erythraeum* in Singapore coastal waters was reported as early as 1974 (Khoo and Wee, 1996). In the later years, two other dinoflagellates (*Cochlodinium* sp. and *Gymnodinium catenatum* and *Chattonella* sp.) which may cause PSP were also reported.

Fish mortality caused by organic pollution, oil spills, sedimentation and factory discharges have been reported since 1975 throughout the West Coast of Peninsular Malaysia (***Table 7.24***) (Choo et al., 1994). Fish kills usually occurred in heavily polluted estuaries and coastal waters in Penang and Johor.

Coliform contamination

Discharges of untreated or partially treated domestic sewage to coastal waters is the main cause of cholera, typhoid and other gastrointestinal disorders, usually associated with the consumption of raw or inadequately cooked contaminated seafood. High concentrations of coliform have been found in recreational waters and associated incidences of skin disease and eye irritation have been documented. Although most of the blood cockles are reported safe for eating (Choo et al., 1994), there are warnings of caution to refrain from eating shellfish because of the rising incidences of hepatitis and gastrointestinal diseases.

Littoral governments have taken active measures to provide sewage treatment in Singapore and Malaysia. Some of these same efforts may also be taking place in the Indonesian coasts in the years to come. However, in view of the increasing population and economic activities, it is envisaged that the problem of sewage contamination will remain for some time to come.

Tributyl tin contamination

Tributyl tin (TBT) is a biocide used in antifouling paints and largely used for ships. In recent years, it has been employed for the prevention of fouling organisms in net cages (Lee et al., 1985). TBT has been found to cause imposex (i.e., male genitalia imposed on females) in Neogastropods, such as whelks. Imposex is brought about by a toxin, causing growth and reproductive deformities. The presence of imposex is therefore used as an indicator of TBT contamination.

Imposex was found in muricid snails and Neogastropods in Singapore and Port Dickson in 1989 (Ellis and Pattisina, 1990). In 1992, studies of TBT contamination on the West Coast of Peninsular Malaysia showed high levels (281.8 ng/l) in the seawater at Port Klang and in the sediments (27.6 ng/g wet weight) of Port Dickson (Tong et al., 1996) (*Tables 7.25* and *7.26*). The levels of TBT in the tissues of mussels and cockles were between 0.5 and 23.5 ng/g-wet weight (Tong et al., 1996) (*Table 7.27*).

Recent surveys in the Straits of Malacca and Singapore indicate an increasing frequency of imposex in areas with shipping traffic. Findings show that TBT stays active far outside the target area and influences non-target animals (*Table 7.28*). The effects of TBT are even found within shellfish culture plots and in human food in the market areas (Swennen et al., in press). Research has shown that TBT can be accumulated in salmon (Ellis and Pattisina, 1990). Thus, the presence of TBT in the Straits may have a serious implication with respect to accumulation in food fishes and shellfish, which are staple foods. In view of its possible serious human health and economic implication, the use of TBT requires special control.

Heavy metal pollution

Heavy metals are known to accumulate in fish and shellfish. In Malaysia, heavy metals (lead, mercury and arsenic) were found in fish tissues (Shahunthala, 1986; Law and Singh, 1991) and seaweed (Ramachandran et al., 1995). The report of Choo et al. (1994), citing the works of Jothy and Ibrahim (1987) and Shahuntala (1989), stated that shellfish were relatively safe for human consumption. However, there is a common perception among the more educated sector in the littoral States to avoid shellfish, particularly the blood cockles, as a precautionary measure against heavy metal poisoning. Economically, this has considerable impact on the sustainability of the multi-million dollar cockle industry in Malaysia.

Table 7.24. Fish Kills in Coastal Waters of the West Coast of Peninsular Malaysia (Choo et al., 1994).

Date	Location	Outcome	Reported Cause
Jun 75	B. Feringgi, Penang	Fish mortality	Severe organic pollution; piggery waste
Oct 77	Juru Estuary, Penang	Mass cockle mortality	Effluent pollution; heavy rain with salinity drop
Nov 79	Tebrau Bay, Johor	Mass mortality of fish fingerlings	Piggery wastes
Nov 80	Prai estuary, Penang	Fish mortality	Factory effluents
Jan 81	Puala Aman, Penang	Cage-cultured fish mortality	Oil spill
Apr 84	Batu Maung, Penang	Mass cockle mortality	Piggery wastes and soil erosion
Apr 85	Muar estuary, Johor	Oyster mortality	Factory effluent
Sep 85	Tebrau Bay, Johor	Mussel mortality	Low oxygen
Jun 89	Kuala Kurau, Perai	Fish kills	High sediment
Apr 90	Sg. Sepetang and estuary, Perak	Fish kills	Factory effluent

Table 7.25. Concentration of TBT in Water Samples from the West Coast of Peninsular Malaysia (Modified from Tong et al., 1996).

Location	Type of Site	TBT (ng liter^{-1})
Sg. Buloh	Mudflats	< 3.4
Pulau Jenor	Open water	100.4 ± 15.2
Pulau Jemor	Open water	10.8 ± 4.2
Kapar Power Station	Open water	26.6 ± 4.4
Port Klang (North Port)	Coastal water	23.0 ± 6.1
Port Klang (North Port)	Channel entrance	49.6 ± 23.9
Port Klang (North Port)	Port area	39.6 ± 22.5
Port Klang (North Port)	Port area	24.2 ± 12.5
Port Klang (North Port)	Port area	20.5 ± 5.4
Port Klang (North Port)	Port area	25.4 ± 8.8
Straits of Klang	Port area	61.3 ± 27.9
Sg. Klang mouth (Yatch Club)	Estuarine water	48.6 ± 27.4
Port Klang (Jetty)	Jetty area	96.0 ± 56.7
Port Klang (South Port)	Port area	281.8 ± 23.9
Port Klang (West Port) under construction	Narrow channel	53.0 ± 11.0
500 m downstream of Kota Bridge	Estuarine water	57.9 ± 3.2
Kota Bridge (Klang Town)	Estuarine water	33.5 ± 4.2
Off 13th mile Puchong Road	River mouth	23.5 ± 9.3
Kuala Lumpur	River mouth	22.2 ± 6.1
Port Dickson	Jetty area	24.2 ± 8.1
Teluk Kemang	Public beaches	48.4 ± 3.2
Tanjung Tuan	Resort beaches	24.2 ± 3.9

Table 7.26. Concentration of TBT in Sediment (Modified from Tong et al., 1996).

Location	Type of Site	TBT Concentration (ng/g wet weight)
Sungai Buloh, Selangor	Mudflats	29.3 ± 10.3
Port Dickson, Negeri Sembilan	Jetty area	27.6 ± 5.1
Tanjung Tuan, Port Dickson, Negeri Sembilan	Recreational beach area	< 0.7

Table 7.27. Concentration of TBT in Bivalves (Modified from Tong et al., 1996).

Sample Site	Species (common name)	TBT Concentrations (ng/g wet weight)
Markets in Kuala Lumpur and Petaling Jaya	*Anadara granosa* (cockles)	< 0.5
Markets in Kuala Lumpur and Petaling Jaya	*Anadara granosa* (cockles)	3.7 ± 1.5
Markets in Kuala Lumpur and Petaling Jaya	*Paphia* sp. (soft shell clams)	3.7 ± 2.0
Markets in Kuala Lumpur and Petaling Jaya	*Perna viridis* (green mussels)	23.5 ± 5.6
Sg. Buloh mudflats	*Anadara granosa* (cockles)	5.6 ± 1.0
Pulau Jemor	*Perna* sp. (green mussels)	14.2 ± 4.9

Although the effects of heavy metals on human health are not very clear, the Minamata incident in Japan is considered to be the best testimony of the possible effects of heavy metal pollution. Thus, it is very important for the littoral States of the Straits to regularly monitor heavy metals in the waters and in edible fish and shellfish. As long as chemicals are being released into the water body, there will be a risk to human health. Both Malaysia and Singapore have made significant progress in this direction.

Sedimentation

Increased turbidity of the water reduces light penetration and affects photosynthesis and primary productivity. It also affects the growth and propagation of seagrasses and benthic communities. Silt particles in the water column trap heavy metals, chlorinated organic pesticides and bacteria which could pose serious threat to human and ecosystem health. Bioaccumulation may occur and could affect the species composition, causing the disappearance of some species and the appearance of undesirable ones.

Degradation of critical habitats in the Straits

The Straits of Malacca is one of the biggest estuarine environments in the region, characterized by soft-bottom habitats, fringing coral reefs, seagrass beds and mangrove swamps lining the coastlines. As part of the larger Southeast Asian tropical ecosystem, it is critical not only to ensure the high level of water quality but also to maintain the functional integrity of the ecosystems therein. Southeast Asia is the center of marine diversity, with the Straits of Malacca and Singapore being significant components of the regional ecosystem. Most coastal ecosystems that once lined the southern coast of Singapore have been obliterated by foreshore reclamation (Tun and Chou, 1995). The situation in the Straits of Malacca is not any better, as most ecosystems therein are also under stress.

Table 7.28. Imposex among Gastropods in the Straits of Malacca (Modified from Swennen et al., in press)

Sample Site	Depth (m)	Distance to Nearest Shipping Route (miles)	Gastropod Species	No. of Females in Sample/No. of Imposex Females	Female Imposex (%)
Kuala Selangor	4	20	*Murex occa*	44/2	5
			Thais lacera	3/2	67
			Volema conchlidium	34/2	6
			Total	**81/6**	**7**
Sungai Buloh "t"	4	27	*Murex occa*	40/0	0
			Thais lacera	56/2	4
			Total	**96/2**	**2**
Pantai Jeram "u"	0	28	*Thais gradata*	92/1	1
Bagan Lalang "v"	0	14	*Thais lacera*	58/8	14
			Volema conchlidium	10/0	0
			Total	**68/8**	**12**
S. of Melaka "w"	0	11	*Thais gradata*	60/0	0
Kuala Sebatu "x"	15	3	*Murex occa*	17/12	71
Pontian Kechil "y"	25-30	1	*Distortio reticulata*	2/2	100
			Bursa rana	2/2	100
			Murex occa	3/3	100
			Total	**9/9**	**100**
S. Buloh Nature Park "z"	0	18	*Chicoreus capucinus*	65/57	88

Conclusion

The deterioration of the marine environment in the Straits will get worse with expanding human activities if no management actions are taken to reduce pollution. With expected increases in shipping traffic, expanding activities in the growth triangles, increased urbanization and burgeoning population growth in the coastal zones of the littoral States, increasing degradation is not just a threat, it is becoming a fact.

Maintaining the integrity of the Straits of Malacca and Singapore as safe and clean international waterways can only be achieved if management measures are taken to regulate and reduce the pollutants in the Straits. Management measures should include: (1) effective integrated coastal management programs, applied at the local government level, to address marine pollution from land-based sources; and (2) sustainable, subregional marine pollution prevention and management policies, strategies and action plans to address marine pollution arising from sea-based activities. The latter action plans need to include the ratification and implementation of marine pollution conventions, especially those of IMO and UNCLOS

The existing environmental issues and potential environmental threats demand serious consideration. Furthermore, the three littoral States must establish an effective marine pollution monitoring mechanism and appropriate protocols so that the monitoring results from the three littoral States can be compared and used for management interventions.

The users of the coastal resources, international sea lanes and the littoral States have the responsibility to ensure safe passage and a clean marine environment in the Straits. This requires the improvement and sharing of the shipping and navigational information for vessels cruising the Straits. There may also be a need to improve navigational services and surveillance. Finally, there should be more effective port state control of all vessels. There will be requirements for the littoral States to provide the necessary waste reception facilities at their ports.

Information about the state of the marine environment of the Straits of Malacca and Singapore is far from complete. Despite hundreds of reports and publications on the Straits, relevant information on environmental conditions and shipping traffic is not adequate and readily available to enable detailed management planning and interventions. A concerted effort amongst the littoral States is necessary to pool available information for the design and development of an effective subregional program of management actions to be participated in by both the littoral and user States.

POLICIES AND MANAGEMENT PRACTICES

Policies, Legislation and Enforcement Activities

Indonesia

In Indonesia, the principal agency responsible for resolving environment and development issues is the Office of the State Minister for Environment. The Office was first established in 1978, originating from the National Committee on Environment Protection (NCEP), an inter-departmental committee established in 1971.

The function of NCEP was to formulate national policies and to establish guidelines and priorities for conserving the quality of environment without hindering economic growth. Three priority areas were identified (Soegiarto, 1987):

- Problems related to forest utilization;
- Problems related to human settlement; and
- Problems related to marine pollution.

The present function of the Minister of Environment is now much broader in scope. The Office of the Minister coordinates national efforts on environmental matters, including drafting of laws and regulations and establishing environmental standards. The Environment Ministry has received strong support from many government agencies, research institutions, universities and many national committees dealing with environment. One such committee is the National Committee on Marine and Coastal Environment. The function of this National Committee is, among others, to prepare rules and regulations on the development and management of marine and coastal areas, monitoring of pollution and advising the Office of the State Minister for Environment.

A significant development concerning waste management in Indonesia was the creation of the enforcement agency, BAPEDAL (Environmental Impact Control Agency). BAPEDAL is involved virtually in all aspects of environmental regulation, from the design and formulation of regulations and standards, to the investigation of potentially harmful polluting activities, mediation of disputes between factory and communities claiming damages from effluents and the negotiation of contracts defining standards for unregulated activities.

It is realized that pollution and environmental degradation can hinder economic development, give a bad image of the country and create social tensions and problems. The Indonesian government, through the Office of the State Minister for Environment, has carried out programs and concerted efforts on pollution and rehabilitation on the environment. The following basic strategy and approach have been adopted:

- Education and information;
- Consultation and cooperation;
- Persuasion;
- Rewards and punishment;
- Implementation and enforcement; and
- Enforcement of the polluter pays principle

More details on the step by step strategies and action plans can be seen in ***Table 8.1.***

Industrial waste and wastewater pollution control. Indonesian legislation concerning industrial waste and wastewater control is listed in ***Table 8.2.*** In addition, numerous regulations on water quality and effluent have been issued at the provincial level, primarily for major centers of population, e.g., Jakarta, Bandung, Surabaya and Yogyakarta on the island of Java.

The Petroleum and the Law Act of 1960 and Decree 476 of 1961 are the primary regulations for the petroleum industry in Indonesia. The terms under which most companies operate are contained in production-sharing contracts (PSCs) and Decree 476, which outlines the basic tenets of the PSC. The recent PSC forms contain provisions specifically requiring operators and contractors to comply with environmental requirements.

Table 8.1. Long-Term Strategy and Step by Step Approaches for Environment Management and Pollution Control in Indonesia.

Third Five Year Development Plan (1978 -1983)	- to enhance awareness of the public, government officials, private sector and industry on environmental issues, criteria, and priorities; - to generate coordination on environmental issues and problems among sectoral departments; - to introduce environmental issues into the curriculum of grade school, secondary, and high schools, and to create Centers for Study on Environment and Natural Resources Management at the post-secondary level; - to formulate and pass the Basic Provision Law on Environment; - to collect and collate environmental data and information as a base to formulate more detailed and specific regulations; and - to encourage the establishment of NGOs specializing in environmental issues as working partners with government.
Fourth Five Year Development Plan (1984 - 1989)	- to strengthen the existing cooperation and coordination among the sectoral departments; - to strengthen regional cooperation on environment, in particular with the ASEAN countries; - to request support for national capacity building to international and regional donor agencies and through bilateral cooperation; - to prepare government and sectoral rules and regulations on specific environment problems; - to create an Environmental Impact Control Agency (BAPEDAL) as an arm of the Office of the State Ministry to manage impact assessment and pollution control, and branches at the regional level (BAPEDALWIL), at the provincial level (BAPEDALDA), as well as environment units in various sectors and provinces; and - to prepare a status report on the environment in Indonesia.
Fifth Five Year Development Plan (1989 - 1994)	- to prepare various Action Plans, e.g., on biodiversity, coral reef, mangroves etc.; - to strengthen BAPEDAL and BAPEDALDA (Provincial); - to educate, inform, and consult industries, government officials, and judges on the existing rules and regulations; - to launch PROKASIH (Clean River Program) in a number of provinces; - to monitor and evaluate PROKASIH; and - to enforce rules and regulations.
Sixth Five Year Development Plan (1993 - 1998)	- to enhance the effectiveness of water pollution control and give more authority to BAPEDALDA; - to establish major treatment plants for industrial wastewaters, such as Jakarta Greater Metropolitan, Surabaya, East Kalimantan, and Lhokseumawe; - to establish wastewater treatment plants in various cities, such as Medan, Batam, and Bandung; - to establish more facilities for solid waste disposal and incineration; - to acquire environment friendly technologies; - to offer economic incentives for cleaner industries; - to enforce environmental quality and pollution control standards; - to green and beautify cities and river systems; and - to establish and strengthen infrastructure and facilities for marine pollution abatement, with special emphasis on oil pollution in major tanker routes and seaports (Medan and Batam in the East Coast of Sumatra).

Act No. 4 or the Basic Provisions on Environment Management was enacted in 1982, but detailed regulations on water pollution and wastewater treatment were only issued in 1990 through Government Regulation No. 20/1990. Rules on industrial wastewater treatment are now being enforced more. The PROKASIH scheme is being developed further to reduce the pollution levels to allowable standards. Industries which show serious effort in the treatment and processing of their effluents are given tax incentives. In addition, industries planning to build waste treatment plants are offered low-interest financial loans and duty free considerations for the import of equipment

Table 8.2. Legislation and Regulations Pertinent to the Management of Coastal Pollution by Indonesia (Chua et al., 1992; IBC, 1993; Chua, 1994; Chia, 1995; Koe and Aziz, 1995a).

Legislation	Provision
(A) Industrial Waste and Wastewater Pollution Control	
Public Water Law (1936)	Disposal of industrial wastes into public streams
Nuisance Ordinance (1926) (Amended 1940)	Industrial control standards and disposal of harmful wastes
Presidential Decree No. 7 (1973)	Regulation of pesticide distribution; storage and use of pesticides
Ministry of Agriculture Directives (1973-1975)	Registration, handling, and use of pesticides
Ministry of Health Regulation No. 173/Men. Kes/1977	Provisions to control water pollution in various water use situations in relation to public health
Environmental Management Act (1982)	Basic provisions for the management of the living environment
PROKASIH (1989)	Clean-up of rivers in various provinces
Government Regulation No. 20/1990 - Control of Water Pollution	Introduces national quality standards; authorizes Governors to set local standards; provides for licensing and regulation of liquid waste generators; and specifies administrative and other sanctions
Regulation of Public Works 45/1990 - Control of Water Quality at its Source State Minister of Population and Environment No. KEP-03/MENKLH/1991 - Liquid Waste Quality Standards for Activities Already in Operation	Prescribes measures designed to monitor water quality, control the disposal of wastes into water sources and waste treatment, sets standards for liquid waste effluents in some 14 industries
(B) Sea Pollution Control	
Continental Shelf Act (1973)	Provisions for prevention of and combating pollution from exploration and exploitation, as well as scientific research on the country's continental shelf
Exclusive Economic Zone (EEZ) Act (1983)	Provisions for the prevention and combating marine environmental pollution from any activities in the EEZ of Indonesia
Act 17: Ratification of the UNCLOS 82, Part XII (1985)	Apart from provisions dealing with the protection and preservation of the marine environment, it also contains provisions for establishing oil spill contingency plans
Presidential Decree No. 46: Ratification of MARPOL Convention, Annexes I and II (1986)	Issues regulations to implement MARPOL 73/78, Annexes I and II
Decree of the Directorate General of Sea Communication No. PY. 69/1/11-86 (31/10/86)	Deals with the supply of facilities for the prevention of pollution from ships
Decree of the Minister of Communication No. KM 215/AL/506/PHB-87 (19/09/87)	Deals with the "International Certificate for the Prevention of Waste from Petroleum and Poisonous Liquids"
(C) Control of Hazardous Waste	
Decree of the Minister of Industry No. 148/1985 - The Safeguarding of Toxic and Dangerous Materials in Industrial Undertakings	Imposes requirements for handling specified hazardous products in industrial establishments with offenses and sanctions (fines and imprisonment) prescribed
Government Regulation No. 7/1973 - Control of the Circulation, Storage, and Use of Pesticides	Applies to matters as described in the heading
Decree of the Minister of Agriculture No. 147/1990 - The Registration and Licensing of Pesticides	Applies to matters as described in the heading
Government Regulation No. 13/1975 - Transportation of Radioactive Materials	Applies to matters as described in the heading

Table 8.2. (continued)

Legislation	Provision
Regulation of the Minister of Health No. 453/MEN.KES/PER/XI/1983 - Re Hazardous Materials	Licenses or controls by registration of the production, import, and distribution of certain hazardous materials; prescribes standards for the transport of hazardous materials; and requires a license-holder to record and report "cases" caused by hazardous materials under his management
Decree of the Minister of Communications No. KM. 167/1986 - International Certificate on the Prevention of Oil Pollution and on the Prevention of Pollution from Liquid Toxic Materials	Applies to matters as described in the heading
(D) Other Legislations of Environmental Concerns	
Act No. 5 (1984)	Relates to pollution caused by industrial activities
Act No. 9 (1985)	Relates to pollution caused by fisheries and aquaculture activities
Government Regulation No. 51 (1993) - Environmental Impact Analysis	Applies to matters as described in the heading

Sea pollution control. By Presidential Decree No. 46 (1986) the Government of the Republic of Indonesia ratified MARPOL 73/78. Indonesia has also issued legislation to implement MARPOL 73/78. However, at the time, the Government declared that it did not accept the provisions of Annexes III and IV of the Convention.

National legislation. Indonesia ratified MARPOL 73/78 by Presidential Decision No. 46 in September 1986. The ratification marks a significant event in an attempt to reduce oil pollution in Indonesian waters. But at the same time, it places obligations on Indonesia to provide facilities to comply with the regulations embodied in the Convention. Diraputra (1990) cited six regulations directly related to the ratification of the Convention. They are:

- Minister of Transport Decision No. 167/ Hm.207/Phb-86 on International Oil Prevention Certificate and International Certificate for the Prevention of Pollution from Noxious Liquid Substances;
- Decision of the Director General of Sea Transport No. Py.69/i/11-86 on the implementation of Minister of Transport Decision No. 167;
- Circular Note of the Director General of Sea Transport No. UM.48/27/20-85 on Technical Directives on the Implementation of Decision No. Py.69/i/11-86;
- Minister of Transport Decision No. KM.215/AL/-506/Phb-87 on Reception Facilities at Port and Offshore Terminals;
- Decision of Director General of Sea Transport No. DN 5/15 dated 14 July 1980 and Decision No. 18 of 1988 on Organizational Units in Charge of Combating Marine Pollution.

One example of implementation concern is the requirement that ports and oil loading terminals have oily waste reception facilities with a capacity of 1,000 metric tons per day. Currently, Indonesia has such reception facilities at four major ports, one of them is Belawan in North Sumatra and at eight oil loading terminals, five of which are located in Sumatra (Blang Lancang, Dumai, Sambu Island, Plaju and Sungai Gerong) the last two are in nearby Palembang, the capital of South Sumatra Province.

Continental Shelf Act (1973) - Act No.1 contains provisions for the prevention of and combating pollution from exploration and exploitation, as well as scientific research on Indonesia's continental shelf.

Act No. 4, 1982, concerning Basic Provisions for the Management of the Living Environment, deals directly with environmental issues. The legislation is a broad statement of principles with little detail specific to vessel-source pollution. Regulations pursuant to the Act are anticipated to cover specific issues and

sectors. The Department of Sea Communications has been assigned the task of drafting regulations regarding vessel-source pollution. At an earlier point, a bill had been proposed regarding the regulation, preservation and abatement of marine pollution with emphasis on the Straits of Malacca and Singapore.

Exclusive Economic Zone Act (1983) Act No. 5 contains provisions for the prevention and combating of marine pollution from all activities in Indonesia's EEZ. A key provision of the legislation states: "Within the Indonesian EEZ, the freedom of international navigation....shall be respected in accordance with the principles of the international Law of the Sea. The Act, in a few sections, establishes the general framework of rights and duties regarding the EEZ. Article 11 of the Act proclaims strict liability for polluters, which includes liability for damages caused by the pollution and rehabilitation costs. This concurs with the provisions set forth in IMO's 1969 CLC Convention, to which Indonesia has acceded. However, the legislation foresees a maximum amount of liability that is to be fixed by a regulation.

Act No. 17 (1985) ratifies the 1982 United Nations Convention on the Law of the Sea. Part XII of this Convention deals with the protection and preservation of the marine environment.

Presidential Decree No. 18 (1978) is the decree which allowed Indonesia to accede to the 1969 CLC Convention and the 1971 Fund Convention. Although Indonesia acceded to the conventions, it has not enacted its domestic legislation to implement the provisions set forth in the two conventions.

Environmental Management Act (1982) imposes a strict liability for polluters which is consistent with the 1969 CLC Convention. Strict liability for polluters is also specifically proclaimed in Article 11 of the 1983 Exclusive Economic Zone Act.

Presidential Decree No. 46 (1986) is responsible for the ratification of Annex I (regulations for the prevention of pollution by oil) and Annex II (regulations for the control of pollution by noxious liquid substances in bulk) of MARPOL 73/78.

Decree of the Directorate General of Sea Communications No. PY. 69/1/11-86 (31/10/86) deals with the provision of facilities for the prevention of pollution from ships.

Decree of the Minister of Communication No. KM 215/AL/506/PHB-87 (19/9/87) deals with the International Certificate for the Prevention of Waste from Petroleum and Poisonous Liquid.

Government Regulation No. 13/1975 deals with the transportation of radioactive materials.

Regulation of the Minister of Health No. 453/MEN.KES/PER/XI/1983-Re Hazardous Materials licenses or controls through the registration of the production, import and distribution of certain hazardous materials. It prescribes standards for the transportation of hazardous materials and it requires a license-holder to record and report cases caused by hazardous materials under his/her management.

Decree of the Minister of Communications No. KM.167/1986 deals with the International Certificate on the Prevention of Oil Pollution and on the Prevention of Pollution from Liquid Toxic Materials.

Indonesia has no legislated standards for pollution from its own flag vessels and the legislation noted above is not very detailed. This has led to the view that a great deal of legislative development is still needed to give Indonesia a full-scale system of preventive and remedial measures to deal effectively with the various forms of ship-generated pollution threatening its national waters and adjacent areas.

Enforcement. There is no record of enforcement regarding vessel-source pollution incidents, mainly due to the vagueness of the relevant legislation. Under the 1983 Exclusive Economic Zone Act, the Navy has the responsibility for investigation and law enforcement. The legislation provides that a vessel presumed to have committed an offense within the EEZ can be detained up to seven days and released when appropriate security is provided. Penalties for international pollution, may involve imprisonment for ten years and/or a fine of Rp100 million. For unintentional pollution, the prison term may be up to a year and the fine Rp1 million. These penalties are in addition to the payment of damages for compensation and rehabilitation.

The Office of the State Minister for Population and Environment is coordinating studies on developing a marine environmental sensitivity index to oil pollution. The information gathered will include habitat inventories with shoreline sensitivity mapping.

According to one report, the Directorate General of Sea Communications is enforcing the IMO requirement for oil separation on ships by refusing to

issue operating licenses to companies which own vessels not equipped with oil separators.

Hazardous waste control. Hazardous waste regulations are listed in ***Table 8.2***.

Environmental impact assessment reports. Any major development project industry is required to undergo an environmental impact assessment or AMDAL (Analisa Mengenai Dampak Lingkungan) before commencing construction (Government Regulation No. 29/1986). In order to determine whether indeed AMDAL is necessary, a preliminary PIL (Penyajian Informasi Lingkungan-Initial Environmental Assessment) must be completed by the proponent. The PIL is a standard document requiring a brief assessment of the proposed activity to be conducted, the location of the project site and potential negative and positive consequences. It is submitted to the Central AMDAL Commission or Regional AMDAL Commission.

The AMDAL analyzes the positive and negative impacts of a project and identifies and evaluates appropriate remedial actions. The Environmental Management Plan (PKL) and Environmental Monitoring Plan (RPL) prescribe design and operating requirements for mitigating environmentally harmful impacts and methods for measuring compliance.

The implementation and enforcement of the AMDAL process is still very weak. In 1990, BAPEDAL was established by Presidential Decree No. 23, as an integral part of the State Ministry for Environment. To strengthen the existing institutional capacity, BAPEDAL was expanded and regionalized as a result of the Presidential Decree No. 77, 1994. BAPEDALDAs, the BAPEDAL at the regional level were then established. BAPEDAL is chaired by the State Minister for Environment. As a non-departmental government body, BAPEDAL is directly responsible to the President. Its main role is to assist the President in environmental impact control, which includes the prevention and control of environmental pollution, environmental deterioration and the rehabilitation of environment quality, in accordance with the prevailing statutes and regulations. With the establishment of BAPEDAL, it is expected that the enforcement of AMDAL can be carried out more effectively. A series of regulations have been prepared to strengthen the enforcement of AMDAL and this includes:

- Government Regulation No. 5/1993 on environmental impact assessment;
- Decision No. KEP.11/MENLH/3/94 on activities requiring AMDAL; and
- Decision No. KEP.14/MENLH/3/94 on guidelines for the preparation of AMDAL.

Policies and legislation concerning coastal development and natural resource management. Laws, regulations, decrees and decisions on environmental management and development in Indonesia have their primary source in the 1945 Constitution (Undang-Undang Dasar 1945). One of the paragraphs in the Preamble states that "the Government of Indonesia shall protect the whole of the Indonesian people and their entire land". This statement may be referred to as the principle of the responsibility and obligation of the Indonesian State to protect "the Indonesian human resources and their environment" (Hardjasoemantri, 1985). This provision is further defined in Article 33 Paragraph (3) of the 1945 constitution, establishing the principle of the management of its environment and natural resources. It reads :

> *"Land and water and the natural resources therein shall be controlled by the State and shall be utilized for the greatest welfare of the people".*

The main source of environment and natural resource management legislation in Indonesia is Law No. 4 entitled "Basic Provisions for the Management of the Living Environment", which was enacted by the Parliament in March 1982. From the "Basic Provision", environmental legislation, rules and regulations were derived. They are in the form of "Law", "Government Regulation", "Presidential Decree", "Ministerial Decree/Decision", "Governor Decree", "Provincial Regulation" or even more detailed technical guidelines.

Table 8.3 lists various controls concerning the environment and management of natural resources, grouped into various development sectors. Indonesia has signed and, in most cases, ratified international conventions, such as the UN Convention on the Law of the Sea (UNCLOS), Biodiversity Convention, Climate Change Convention, IMO Shipping and Marine Pollution Conventions, etc.

The development of nature conservation and protected areas is another important program in Indonesia that safeguards the ecosystem, critical habitats and species for future generations. Indonesia has developed categories of nature conservation and protected areas, ranging from very strict protection to more flexible approaches. These categories include (Salm and Halim, 1984):

Scientific Reserve/Strict Marine Reserve (Cagar Alam Laut). To protect nature and maintain natural processes in an undisturbed state in order to have an ecologically representative example of the natural environment available for scientific study, environmental monitoring, education and for the maintenance of genetic resources in a dynamic and evolutionary state.

Marine National Park (Taman Nasional Laut). To protect natural and scenic areas of national or international significance for scientific, educational and recreation uses.

Natural Monument Marine Park (Taman Laut). To protect and preserve nationally significant natural features because of their special interest or unique characteristics, while enabling controlled use for recreation, interpretation and education.

Managed Marine Reserve/Marine Sanctuary (Suaka Margasatwa Laut). To assure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities or physical features of the environment, where these may require specific human manipulation for their perpetuation.

Protected Seascape (Taman Wisata Laut). To maintain nationally or provincially significant natural areas which are characteristic of the harmonious interaction of man with islands, coasts and sea, while providing opportunities for public enjoyment through recreation and tourism within the normal life-style and economic activity of these areas.

Resources Reserve (Suaka Sumberdaya Laut). To protect the natural resources of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives which are based upon appropriate knowledge and planning.

Multiple Use Management Area/Managed Resources Area (Kawasan Sumberdaya Laut). To provide for the sustained production of timber, wildlife, fisheries and outdoor recreation, with the conservation of nature primarily oriented to the support of the economic activities (although specific zones may also be designed within these areas to achieve specific conservation objectives).

World Heritage Site. To protect the natural features for which the area was considered to be of world heritage quality and to provide information for worldwide public enlightenment

The Department of Forestry, in particular the Director General of Forest Protection and Nature Conservation (Ditjen PHPA), is the management authority for those nature and conservation areas. The Office of the State Minister for Environment in cooperation with the Minister of the Department of Forestry is the policy-making body and the Indonesian Institute of Sciences (LIPI) has been assigned as the scientific authority. The Ditjen PHPA has formulated the objectives, criteria for identification and selection, guidelines for development of short-term, medium-term, as well as long-term plans and order of priorities on the establishment of nature and conservation areas in Indonesia. For example, included in the first order of priority to be developed, among others, are: Cenderawasih Bay in Irian and Aru Island in the Molluccas. The second order of priority includes Taka Bonerate, south of South Sulawesi and Komodo in Nusatenggara. The Riau Archipelago and East Coast of Sumatra are included in the long-term or third order of priority to be developed (Djohani, 1989).

At present, there are 23 established marine reserves in Indonesia covering approximately 2.6 million ha. It is far below the targeted area of 10 million ha by the end of REPELITA V and 30 million ha by the year 2,000. Until 1994, the end of REPELITA V, about 5.4 million ha of marine conservation area had been studied. Activities are planned in REPELITA VI (1995-1999), so that 6.2 million ha will be properly studied before being officially declared as marine reserves. Even that still represents only 62% of the medium-term target. One of the serious problems facing the Ditjen PHPA is the inadequately trained and motivated personnel to carry out this highly commendable but ambitious undertaking.

Figure 8.1 and ***Table 8.4*** show the list of protected or proposed marine conservation areas on the East Coast of Sumatra, bordering the Straits of Malacca.

In addition, in order to strengthen the national efforts to prevent marine pollution, Indonesia also participates in several regional and international cooperation arrangements to protect the marine environment, such as ASEAN-COST, ASOEN, CCOP, ASCOPE, WESTPAC, COBSEA and UNEP. This cooperation reflects the serious intention of Indonesia and other coastal states in the ASEAN and Asia-Pacific regions to work together to protect the marine environment (Soegiarto, 1987).

Table 8.3. Partial List of Existing Rules and Regulations on Environmental and Natural Resources Management in Indonesia[1]

National Legislations

Act No. 5 of 1967 on Forestry Principles
Act No. 1 of 1973 on Indonesia's Continental Shelf
Act No. 11 of 1974 on Water Resources Management
Act No. 4 of 1982 on the Basic Provisions of Environmental Management
Act No. 9 of 1985 on Fisheries
Act No. 17 of 1985 on Ratification of UN Law of the Sea
Act No. 5 of 1990 on Conservation of Wild Natural Living Resources and Ecosystems
Act No. 12 of 1992 on Cultivated Plants System
Act No. 24 of 1992 on Spatial Planning
Act No. 5 of 1994 on Ratification of UN Convention on Biodiversity
Act No. 11 of 1994 on Navigation
Government Regulation No. 28 of 1985 on Forest Protection
Government Regulation No. 13 of 1994 on Hunting of Game Animal
Government Regulation No. 20 of 1994 which was updated by Government Regulation No. 12 of 1995, on the Management of Hazardous Wastes
Presidential Decree No. 43 of 1978 on Ratification of CITES
Presidential Decree No. 26 of 1989 on World Cultural and Natural Heritage
Presidential Decree No. 23 of 1990 on the Establishment of the Agency on Environmental Impact Control (BAPEDAL)
Presidential Decree No. 32 of 1990 on Management of Protected Area
Presidential Decree No. 48 of 1991 on Ratification of Convention on Wetlands

Protection of Flora and Fauna

Ministerial Decree No. 421 of 1970 on Protected Animals
Ministerial Decree No. 54 of 1972 on Protected Tree Species
Ministerial Decree No. 251 of 1975 on Protection of Certain Tree Species and Seeds
Ministerial Decree No. 903 of 1988 on Protected Forest
Ministerial Decree No. 23 of 1994 on Monkey Species and Arowana Fish for Export Purposes

Water Resources Management and Development

Act No. 11 of 1974 on Water Resources Development
Government Regulation No. 22 of 1982 on Water Management Procedure
Mutual Decision of Ministry of Public Works with Ministry of Mining and Energy No. 076/K/101/MPE & No. 04/KPTS/1991 on the Use of Ground Water for Mining Activities
Decision of the Director General of Geology and Mineral Resources No. 392/526/060000/85, on Manual for Ground Water Management

Environmental Impact Assessment

Government Regulation No. 5 of 1993 on Environmental Impact Assessment
No. Kep-12/MENKLH/3/94, State Minister for Environment on General Guidelines on Environment Management and Monitoring Programmes
Decision No. Kep-14/MENKLH/3/94, State Minister for Environment on General Guidelines on Preparation of Environmental Impact Assessment
Decision No. 103 K/008/MPE/1988, Minister of Mining and Energy on the Technical Guidelines on the Preparation of Initial Environmental Assessment and Environmental Impact Assessment on General Mining, Oil and Natural Gas, and on Geothermal Energy
Decision No. 1158/008/NPE/1989, Minister of Mining and Energy on Environmental Impact Assessment on Activities Related to Mining and Energy
Decision No. 390/K/008/MPE/1995, Minister of Mining and Energy on Technical Guidelines on Report Preparation of Environment Management and Environmental Monitoring Activities of Ground Water Extraction
Decision No. 75/1994, Minister of Transportation on Technical Guidelines on Preparation of Environmental Impact Assessment on Ports
Decision No. KEP-056/1994, Head of the Environmental Impact Management Agency on Criteria of Important Impacts

Hazardous Waste Management

Decision No. 68/BAPEDAL/05/1995, Head of the Agency, Environmental Impact Management Agency on Procedure in Obtaining Permit on Transporting, Collecting, Operation of Processing Plant, Processing and Final Disposal of Hazardous and Toxic Wastes
Decision No. 01/BAPEDAL/09/1995, *ibid* on Procedure and Technical Requirements on the Storage and Collection of Hazardous and Toxic Wastes
Decision No. 02/BAPEDAL/09/1995, *ibid* on Document of Hazardous and Toxic Wastes
Decision No. 03/BAPEDAL/09/1995, *ibid* on Technical Requirements on the Processing of Hazardous and Toxic Wastes
Decision No. 04/BAPEDAL/09/1995, *ibid* on Procedure and Requirements on the Dumping Grounds for Processed Hazardous and Toxic Wastes

Table 8.3. (continued)

Decision No. 05/BAPEDAL/09/1995, *ibid* on Symbol and Label of Hazardous and Toxic Materials Indonesia's efforts to protect the marine environment has been strengthened by the ratification of many international conventions, among others (Purwaka, in press) International Convention for the Safety of Life at Sea (SOLAS), 1960 (ratified in 1966) International Agreement for Facilitation of Search Ships in Distress and Rescue of Survivors of Ship Accident (ratified in 1976) International Convention on Civil Liability for Oil Pollution Damage, 1969 (ratified in 1978) International Convention on the Establishment of an International Fund for Convention for Oil Pollution Damage, 1971 (ratified in 1978)	Convention on the International Regulation for Preventing Collisions at Sea (CORLEG), 1972 (ratified in 1979) International Convention for the Safety of Life at Sea (SOLAS), 1972 (ratified in 1980) International Convention for Prevention of Pollution from Ship (MARPOL, Annexes I and II), 1973 and MARPOL Protocol 1978 (ratified in 1986) International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978 (ratified in 1986) SOLAS Protocol, 1978 (ratified in 1988) Convention for Safe Containers (CSC), 1972 (ratified in 1989) International Convention on Load Lines (LL), 1996 (ratified in 1976)

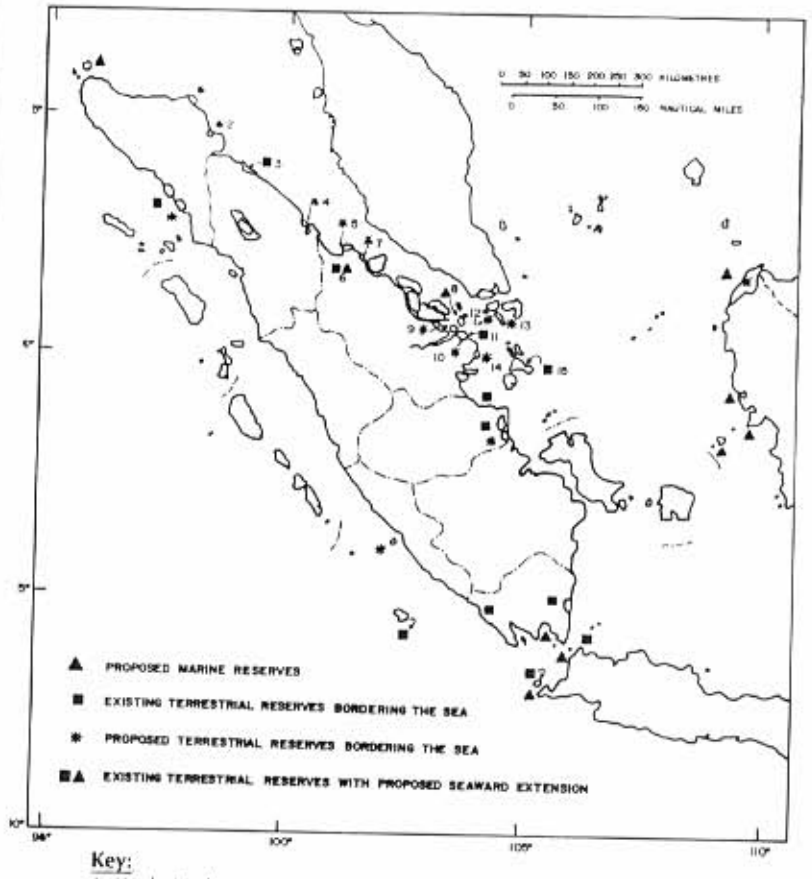
Malaysia

Legislation and regulations pertinent to the management of coastal pollution for Malaysia are summarized in ***Table 8.5***.

Industrial waste and wastewater pollution control. The Environmental Quality Act 1974 (EQA) and its amendment, EQA 1985, are the primary regulators of all the facets of pollution-causing activity that applies throughout Malaysia. The EQA has regulations to control air, water and land-based pollution. The main features of EQA and its regulations are that no person, unless licensed, may emit, discharge or deposit, waste including oil or mixtures containing oil, into any inland waters or Malaysian waters in the contravention of established conditions. Licenses to permit contravention of acceptance conditions of effluent discharge may be granted in limited circumstances.

The environmental pollution control regulations gazetted under EQA are listed in ***Table 8.6***.

Figure 8.1. Protected and Proposed Marine Conservation Areas in the East Coast of Sumatra bordering the Straits of Malacca (Salm and Halim, 1984).



Key:

1. Kuala Jambu Air
2. Kuala Langsa
3. SM. Karang Gading
4. Sei Prapat
5. Tg. Sinebu - P. Alang Besar
6. Berekeh
7. Bakau Selat Dumai
8. P. Pasir Panjang
9. Bakau Muara Kaupas
10. Muara Gunting
11. P. Burung
12. P. Bulan
13. P. Penyengat
14. Tg. Datuk
15. P. Laut

Table 8.4. Protected Marine Areas in the East Coast of Sumatra (Salm and Halim, 1984).

No.	Name	Status	Major interest
Aceh			
1	Kuala Jambu Air	p.CA	Mangrove
2	Kuala Langsa	p.CA	Mangrove
N. Sumatra			
3	SM. Karang Gading	Ministerial Decree of the Dept. of Forestry 11/Kpts/ Um/11/80	Mangrove nesting turtles
4	Sei Prapat	p.CA	Mangrove
Riau			
5	Tg. Sinebu - P. Alang Besar	p.SM	Mangrove, mangrove island
6	CA P. Berekeh	Ministerial Decree of the Dept. of Forestry 13/Kpts/ Um/3/68	Mangrove nesting water birds
7	Bakau Selat Dumai	p.SM	Mangrove crocodiles
8	P. Pasir Panjang	p.TW	Mangrove islet
9	Bakau Muara Kaupas	p.CA	Fringing mangrove, swamp forest
10	Muara Gunting	p.CA	Fringing mangrove, swamp
11	CA P. Burung	Ministerial Decree of the Dept. of Forestry 13/Kpts/ Um/3/68	Mangrove, nesting water birds
12	P. Bulan	p.SM	—
13	P. Penyengat	p.TW	mangrove island
14	Tg. Datuk	p.CA	Mangrove
15	CA P. Laut	Ministerial Decree of the Dept. of Forestry 13/Kpts/ UM/3/68	Mangrove island, nesting water birds and turtles

p = Proposed
CA = Cagar Alam Laut = Strict Marine Reserve
SM = Suaka Margasarwa Laut = Managed Marine Reserve/Marine Sanctuary
TW = Taman Wisata Laut = managed Marine Reserve / Marine Sanctuary

Control of domestic sewage/wastewater. Management of domestic sewage or industrial wastewater is controlled by the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979. Previously, management of the sewerage systems was the responsibility of various local authorities throughout the country. Little attention was given to the operation and maintenance of these facilities resulting in many constructed systems not performing adequately to meet health and environmental standards. Realizing the urgent need to accelerate the development program for upgrading and extending the sewerage service, the Malaysian Government has given a concession to a private consortium to undertake a nationwide sewerage development program for the next 18 years for 145 population centers.

Control of industrial and agricultural waste. In order to enforce compliance of all significant sources of pollution with various standards of discharges either directly into watercourses or onto land, the DOE Malaysia adopted several enforcement mechanisms as its strategy, mainly through the application of licenses (Koe and Aziz, 1995a). Several types of licenses are issued by the DOE. A typical example is the annual license for prescribed premises, provided for under Section 18(1) of the Environmental Quality Act (EQA). Palm oil and natural rubber processing mills are required to comply with the standards of discharges specified under the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 (Amended 1982) and the Environmental Quality (Prescribed Premises - Raw Natural Rubber) Regulations 1978 (Amended 1980), respectively. Another type of license which is issued under Section 25(1) of the EQA concerns the manufacturing sector. The licenses are issued for the purpose of enforcing discharge standards provided in the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979.

Sea pollution control. Malaysia ratified MARPOL 73/78 in January 1997. Legislation dealing with sea pollution control in Malaysia (IBC 1993) includes:

- *Merchant Shipping Ordinance 1952 (Amended 1991).* The Act gives wide power

Table 8.5. Legislation and Regulations Pertinent to the Management of Coastal Pollution in Malaysia (Chua et al., 1992; IBC, 1993; Chua, 1994; Chia, 1995; Koe and Aziz, 1995).

Legislation	Provision
A) Industrial Waste and Wastewater Pollution Control	
Mining Enactment 146/147 (1929)	Control of effluent waters from mining
Land Conservation Act (1960)	Control of silt and erosion resulting from land use activities
Water Enactment Act (1920) (Amended 1970)	Control of river and water pollution
Street, Drainage, and Building Act (1974) and domestic wastes into rivers; control of	Regulations to control discharges of trade effluent earthworks
Local Government Act (1974)	Regulations to prohibit stream pollution and to provide sanitary services
Rearing of Pigs Enactments: Province of Wellesley Piggery By-Laws (1956) Johor (1975) Terengganu (1976) Malacca and Negeri Sembilan (1980) Selangor (1984)	Requires treatment of pig wastes before discharge
Environmental Quality (Licensing) Regulations (1977)	Provides licensing regulations for environmental and pollution controls
Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations (1977)	Provides regulations to control environment in the premises of palm oil factories
Environmental Quality (Prescribed Premises) (Crude Natural Rubber) Regulations (1978)	Provides regulations to control environment in the premises of natural rubber processing areas
Environmental Quality (Sewage and Industrial Effluents) Regulations (1979)	Provides regulations to control discharges of sewage and industrial effluents
Environmental Quality Act (1974) (Amended 1985)	Environmental impact assessment, licenses for polluting activities (land, air, and noise) with regulations for crude palm oil, raw natural rubber, sewage, and industrial effluents
B) Sea Pollution Control	
Fisheries Act (1963)	Regulations to protect fishery and fish farming activities in marine and estuarine waters and the environment
National Forestry Act (1984)	Regulations to prohibit water pollution in forest reserves including coastal forests
Exclusive Economic Zone Act (EEZ Act) (1984)	Part IV of the Act covers the protection and preservation of the marine environment for the zone beyond the territorial sea out to 200 nautical miles
Merchant Shipping Ordinance (1952) (Amended 1991)	Provides wide powers to the Director of Marine to take action to prevent or reduce the extent of pollution through the escape of oil and other harmful substances
Merchant Shipping Act (Oil Pollution) 1993	Provides regulations to enforce the provisions in the IMO's CLC and Fund Conventions
C) Control of Hazardous Waste	
Atomic Energy Licensing Act (1984)	Prohibition of unauthorized disposal of radioactive waste
Environmental Quality (Scheduled Wastes) Regulations (1989)	Regulations to control handling of scheduled wastes
Environmental Quality (Prescribed Premises) Scheduled Waste Treatment and Disposal Facilities Order (1989)	Regulations for the treatment and disposal of scheduled wastes
Environmental Quality (Prescribed Premises - Scheduled Waste Treatment and Disposal Facilities) Regulations (1989)	Provides facility requirements for the treatment and disposal of scheduled wastes

Table 8.6. Environmental Pollution Control Regulations Gazetted under Environmental Quality Act (EQA) 1974 and EQA (amendment) 1985 of Malaysia (Sani, 1993).

Regulation/Order	Effective Enforcement Date
1. Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order 1977, P.U.(A) 199	1 July 1978
2. Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977 Amendment (1982), P.U.(A) 342	4 November 1977
3. Environmental Quality (Licensing) Regulations 1977 P.U.(A) 198	1 October 1977
4. Motor Vehicle (Control of Smoke and Gas Emissions) Rules 1977 (made under the Road Traffic Ordinance, 1958), P.U.(A) 414	22 December 1977
5. Environmental Quality (Prescribed Premises) (Raw Natural Rubber) (Amendment) Order 1974, P.U.(A) 337	1 April 1979
6. Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978 Amendment (1980), P.U.(A) 338	1 December 1978
7. Environmental Quality (Clean Air) Regulations 1978, P.U.(A) 280	1 October 1978
8. Environmental Quality (Compounding of Offenses) Regulations 1978, P.U.(A) 281	1 October 1978
9. Environmental Quality (Sewage and Industrial Effluents) Regulations 1979, P.U.(A) 12	1 January 1979
10. Environmental Quality (Control of Lead Concentration in Motor Gasoline) Regulations 1985, P.U.(A) 296	11 July 1979
11. Environmental Quality (Motor Vehicle Noise) Regulations 1987, P.U.(A) 244	16 July 1987
12. Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987, P.U.(A) 362	1 April 1988
13. Environmental Quality (Scheduled Wastes) Regulations 1989, P.U.(A) 139	1 May 1989
14. Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Order 1989, P.U.(A) 140	1 May 1989
15. Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Order 1989, P.U.(A) 141	1 May 1989

for the Director of Marine to take action to prevent or reduce the extent of pollution though the escape of oil and other harmful substances (IBC, 1993).

- *Exclusive Economic Zone Act (EEZ Act) 1984.* The main features of the Act include the following (IBC, 1993):

1) If any oil, mixture containing oil or pollutant is discharged or escapes into the EEZ from any vessel, land-based source, installation or other device, the relevant person commits an offense (subject to limited defenses) and is liable to a fine of up to RM1,000,000.
2) The authority may issue directions as "necessary" to remove, disperse, destroy or mitigate damage or threat of damage as a result of the discharge of a pollutant. The persons responsible for the relevant discharge (owner and master of the vessel, the owner or occupier of the place on land or owner and person in charge of the installation or device) are jointly and severally liable for the cost of work to remove, disperse or mitigate pollution. That cost constitutes a charge on the property or interest held by the relevant person.
3) An owner or occupier of land, a shipowner and master of a vessel or an owner and person in charge of an installation or device (as applicable), is liable for damage to the environment within the EEZ or Continental Shelf caused by the discharge or escape of oil, mixture containing oil or other pollutant. The authority may detain any vessel from which the pollutant escaped.

Environmental Quality Act (1974, Amended 1985) is the main environmental legislation in Malaysia. The Act has been described as being 'control orientated' since it prescribes the need for licenses for activities in order to be exempt from pollution liability. The Environmental Quality Act deals with vessel-source pollution, among other pollution sources. It prohibits any vessel passing through or entering Malaysian

territorial waters from discharging or spilling any oil or oily mixture unless they are licensed to do so. The Act also provides for the recovery costs with respect to clean-up operations. The Act includes provisions for the detention of vessels and fines and imprisonment for contravention. The Act has been used on several occasions against vessels to recover the cost of clean-up and more recently to impose fines. Most of these cases involved pollution incidents within Malaysian ports.

Environmental Quality (Scheduled Wastes) Regulations (1989) were made under the Environmental Quality Act to control the management of hazardous wastes, which under the Malaysian national regulation include oily wastes and sludges. The regulations control the generation, transport and disposal of wastes through a notification and licensing system for facilities. The regulations require the ship owners or their agents engaged in tanker desludging activities in Malaysian waters to notify the Department of Environment; to treat and dispose of waste at prescribed/licensed premises only; to ensure proper storage and labeling of wastes; to keep a complete inventory of wastes; and to complete the consignment notes when wastes are delivered to a transporter/ contractor and to treatment and disposal facilities.

Exclusive Economic Zone Act (1985) Part IV covers the protection and preservation of the marine environment for the zone beyond the territorial sea out to 200 nautical miles. An owner or master of any vessel from which oil, a mixture containing oil or pollutant (which is given a broad meaning) is discharged either intentionally or accidentally is liable to a fine unless a license has been issued to permit dumping or that the discharge was necessary to save the vessel/lives. Failure to report a discharge of any pollutant, whether deliberate or accidental, will give rise to a fine. A vessel owner, a master or a person responsible for pollution incidents are liable for costs incurred in the clean-up of the pollution or in the prevention of a pollution incident.

Merchant Shipping Ordinance (1952, Amended 1991) provides wide powers to the Director of Marine to take action to prevent or reduce the extent of pollution through the escape of oil and other harmful substances.

Merchant Shipping Act (Oil Pollution 1993) is expected to be enforced in 1996. The Act provides regulations which enable Malaysia to enforce IMO's Civil Liability Convention and Fund Convention (both of which have been ratified by Malaysia).

The Department of Environment is currently drafting regulations to deal with vessel-source pollution that are to take into consideration the various IMO and other international pollution conventions. Malaysia ratified MARPOL 73/78 in January 1997.

Enforcement. Not one department has been charged with the responsibility for enforcement of the marine environmental legislation. Responsibility is expected to come within the jurisdiction of the Maritime Rescue and Coordination Center (MRCC), in which the major enforcement agency is the Royal Malaysian Navy, with the Royal Malaysian Police having jurisdiction in the 12-nautical mile territorial sea.

The Director-General of Environmental Quality (Department of Environment - Ministry of Science, Technology and the Environment) has extensive powers under the 1985 Exclusive Economic Zone Act and authorized officers (which include fishery, port, armed forces, police and customs officials) have a broad mandate to enforce the legislation. The Director-General of Environmental Quality is given extensive discretion to deal with vessels which as a result of the discharge of pollutant (whether deliberate or accidental) damage or threaten to damage Malaysia's coastline or any segment or element of the environment or related interests, including fishing, in the EEZ. The Director-General is permitted to issue directions or take the necessary response to mitigate the damage or threat of damage. Moreover, if a vessel discharges a pollutant which damages or threatens to damage the marine environment and escapes from the scene, then the vessel may be detained until sufficient security is obtained to meet the cost of clean-up and/or any other incurred costs. Any authorized officer can stop, board and search any vessel in the EEZ when there exists reason to believe that an offense under this Act has been committed. An authorized official can also detain the vessel and in certain cases the Court can order the vessel to be forfeited. In the event of a maritime casualty which is expected to result in major harmful consequences, the government can take action necessary to protect the environment. However these actions need to be proportionate to the damage incurred or to the threat of damage.

Control of hazardous waste. Malaysia started to examine hazardous waste management in 1981. Feasibility studies were conducted by Australian, Danish and US consultants. Guidelines for the handling, storage, transport and disposal of hazardous waste were drawn up by a Task Force on Toxic and Hazardous Waste following the study recommen-

dations by DOE Malaysia (1993). A survey conducted by the DOE Malaysia in 1984 found that about 280,000 m^3 of hazardous waste were being generated by various industries in the country. The major producers of these wastes were the metal finishing and electroplating, chemical, electronic and electrical, printing and packaging industries. Following a Danish consultant's study in 1984, the DOE drafted a set of regulation's dealing with the hazardous waste management, based on the "cradle-to-grave" management concept. The regulations, gazetted in April 1989, were as follows:

- Environmental Quality (Scheduled Wastes) Regulations, 1989;
- Environmental Quality (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facilities) Regulations, 1989; and
- Environmental Quality (Scheduled Wastes) (Treatment and Disposal Facilities) Order, 1989.

About 107 categories of toxic and hazardous wastes were defined as "scheduled wastes" under the Environmental Quality (Scheduled Wastes) Regulation 1989. Under the Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Order 1989, six types of premises are described for which their occupation and use requires written permission and a license from the DOE. The premises are as follows:

(i) Land treatment facilities, such as sludge farms;
(ii) Off-site recovery facilities;
(iii) Off-site treatment facilities, such as centralized physical/chemical wastewater treatment plants;
(iv) Scheduled waste incinerators;
(v) Off-site storage facilities, including transport vehicles; and
(vi) Secure landfills designated for the disposal of scheduled wastes.

The above premises (except land farming facilities) must also comply with the requirements of the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987, which requires an Environmental Impact Assessment (EIA) to be conducted. The EIA report must be submitted to the Director-General of Environmental Quality before construction activities are carried out. Procedures for license applications, renewals and ownership transfers, requirements for record-keeping and submissions to the DOE are specified under the Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Regulations 1989. Offenders can be prosecuted in court and, if found guilty, the maximum penalty is RM10,000, 2 years imprisonment or both. A fine of RM1,000 per day for every day the offense is committed is also prescribed.

Currently there are no comprehensive hazardous waste treatment and disposal facilities in Malaysia. There are many garbage disposal sites all over the country which also cater to industrial wastes. But none of these sites are suitable for the disposal of toxic and hazardous wastes because of poor siting, unsuitable geological characteristics of the soil and poor management.

Environmental impact assessment (EIA). A person who intends to carry out a prescribed development must submit a report to the Director-General of the Department of Environment. The report must contain an assessment of the impact that the activity will have or is likely to have on the environment and proposed measures to prevent, reduce or control the adverse impact on the environment. The Government is taking steps to standardize and simplify the procedures for preparing EIA reports to "minimize delays in approving the reports for new projects". The objective will be accomplished in part by introducing mandatory formats for EIA reports. Standard formats will be developed for each type of economic activity, such as petroleum-related industries.

The prescribed activities requiring EIA reports under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 are listed in *Table 8.7*.

Table 8.7. List of Prescribed Activities in the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 of Malaysia (Sani, 1993).

1. Agriculture	11. Mining
2. Airport	12. Petroleum
3. Drainage and irrigation	13. Power generation and transmission
4. Land reclamation	14. Quarries
5. Fisheries	15. Railways
6. Forestry	16. Transportation
7. Housing	17. Resort and recreational development
8. Industry	18. Waste treatment and disposal
9. Infrastructure	
10. Ports	19. Water supply

Singapore

Legislation and enforcement pertinent to the management of coastal pollution for Singapore are summarized in ***Table 8.8***.

The Ministry of the Environment is planning to enact a new environmental law that will contain new guidelines for companies in the oil and petrochemical sector. The new legislation will 'merge' Singapore's pollution laws into a single statute and introduce provisions requiring all oil and petrochemical companies to have standardized safety and audit systems in processing facilities and warehouses.

Singapore has the most extensive legislation concerning vessel-source pollution of all the ASEAN countries. Singapore has the requisite legislation to deal with the prohibition of marine pollution, as well as the prevention and remedial measures and measures for strict liability for compensation. Sufficient enforcement powers have also been given in the form of detention, denial of entry and sale of offending ships.

Civil Liability (Oil Pollution) Act (1973) was passed to give effect to the 1969 CLC Convention.

Merchant Shipping (Oil Pollution) Act (1981) (MSOPA) supersedes the 1973 Civil Liability (Oil Pollution) Act. Section 13 of the MSOPA contains the provision that ships carrying oil cargo of more than 2,000 tons are not to enter or leave any port in Singapore (or enter the territorial waters of Singapore) without a certificate of insurance indicating the capability to pay for potential oil pollution damages. Vessels flying the Singaporean flag are likely to carry such insurance certificates.

Prevention of Pollution of the Seas Act (1971, Amended 1981) was enacted to give effect to the 1954 OILPOL Convention. The Act makes it an offense for a Singaporean flag-vessel to discharge oil outside the territorial limits of Singapore. Section 9(1) of the Act allows for the making of regulations requiring all ships in Singapore's waters to be fitted with equipment to prevent pollution. Thus far, this has been narrowly interpreted to mean that ships are to carry certain dispersants but it does not provide the Singapore authorities with legislative capability to require equipment standards and perhaps design, construction and manning standards, which are required under MARPOL 73/78.

Prevention of Pollution of the Sea Act 1990 (Sea Act of 1990) together with six sets of subsidiary regulations* came into force on 1 February 1991. They gave effect to MARPOL 73/78 Convention, which Singapore acceded to on 1 November 1990.

Both the MSOPA and the Prevention of Pollution of the Sea Act impose strict liability on the ship owner and responsible party for any discharge of oil or a mixture containing oil into Singapore waters. The legislation establishes that it is a criminal offense to discharge oil from any vessel within Singapore territorial waters and, as well, imposes extensive civil liability on a polluter and allows for the recovery of damages and costs of removing the oil. Exceptions are provided within the Acts to strict liability. For example, pollution within the territorial sea is an exception to strict liability if the discharge of oil was necessary to save the vessel or lives or was a result of an act of war, act of God, a willful act of damage to the vessel and that all reasonable steps were taken to prevent the escape of oil.

Enforcement. The Port of Singapore Authority (PSA) has the responsibility to enforce legislation respecting vessel-source pollution. The PSA has the power to detain a vessel if there exist reasonable grounds to believe that oil has been discharged. This ability to detain vessels does not extend to vessels which have the required insurance certificate and is only available if the pollution damage affects the area of Singapore.

The biggest contribution of Singapore towards enforcing the prevention of vessel-source pollution is the reception facility on Pulau (island) Sebarok for the deposit of oil residues, refuse and other waste matter. Every vessel in Singapore is required to avail itself of these facilities. The facility has an annual capacity of 300,000 m^3 for slops/tank cleaning water/ dirty ballast, 25,000 m^3 for contaminated slops and 10,000 tonnes for sludge.

In April 1993, the Environment Ministry issued strict new regulations to control tank cleaning contractors working on vessels within the country's waters. In order to obtain permits to undertake such

*Regulations under the Prevention of the Pollution of the Sea, Act, 1990 are: Prevention of Pollution of the Sea (Oil) Regulations; Prevention of Pollution of the Sea (Noxious Liquid Substances) Regulations; Prevention of Pollution of the Sea (Reporting of Pollution Incidents) Regulations; Prevention of Pollution of the Sea (Reception Facilities) Regulations; Prevention of Pollution of the Sea (Detergent and Equipment) Regulations; and Prevention of Pollution of the Sea (Composition of Offenses) Regulations.

Table 8.8. Legislation and Enforcement Pertinent to the Management of Coastal Pollution by Singapore (Chua et al., 1992; IBC, 1993; Chua, 1994; Chia, 1995; Koe and Aziz, 1995).

Legislation	Provision
(A) Industrial Waste and Wastewater Pollution Control	
Water Pollution Control and Drainage Act (1975)	Control of effluent discharges from industrial, commercial, domestic, and agricultural sources
Trade Effluent Regulations (1976) (Amended 1977)	Control of trade effluent discharges into sewers and watercourses
Environmental Public Health Act (1978)	Control of solid waste dumping
(B) Sea Pollution Control	
Prevention of Pollution of the Sea Act (1971) (Amended 1981)	Control of oil pollution and other contaminants discharged into rivers and seas
Civil Liability (Oil Pollution) Act (1973)	The Act was passed to give effect to IMO's Civil Liability Convention 1969 which Singapore acceded to in 1981
Singapore Port Regulations (1977)	Protection of the harbor environment
Prevention of Pollution of the Sea Act (1990)	The Act was enacted and came into force on 1 February 1991 in order to give effect to implementing provisions of MARPOL 73/78 which Singapore acceded to on 1 November 1990. The Act consists of six sets of subsidiary regulations to cover the following: oil, noxious liquid substances, reporting of pollution incidents, reception facilities, dispersants and equipment, and composition of offenses
(C) Control of Hazardous Waste	
Poisons (Hazardous Substances) Rules (1986)	Regulations to control the possession, storage, handling, and disposal of poisonous substances
Environmental Public Health Act (Toxic Industrial Waste Regulations) (1988)	Specifies in detail the regulations for storage, handling, transport, reporting, and notification obligations in relation to toxic wastes

work, contractors are required to dispose of sludge and waste oil at approved sites, i.e., Pulau Sebarok slop and sludge disposal facility. A ship docking in Singapore must inform the PSA the name of the contractor which last cleaned the tanks and show proof that the sludge has been disposed of correctly. The new rules were ready for some time, but the government was intending to coordinate its policy with Indonesia and Malaysia. The new rules were implemented following an incident when a VLCC allegedly dumped sludge into the waters.

Industrial waste and wastewater pollution control. Industrial pollution control regulations include:

- The Water Pollution Control and Drainage Act (WPA) 1985; and
- The Environmental Public Health Act (EPA) 1988.

The Trade Effluent Regulations 1976 under the WPA regulate the manner and the locations of effluent discharges, including discharges into public sewers. The Regulations require industrial wastewaters to be treated to prescribed standards prior to discharge.

Sea pollution control. The Prevention of Pollution of the Sea Act (PPA) 1990 gives effect to MARPOL 73/78. It provides (among other matters) that if refuse, garbage, waste, marine pollutant, trade effluent, oil or an oily mixture is discharged into areas or circumstances to which the PPA applies, the owner of the ship or facility (as applicable) is liable for the cost of measures taken to eliminate or reduce the damage. Penalties for unauthorized discharge of waste and oil range from S$500 to S$500,000 and/or 2 years imprisonment of the master, owner and agent. Additional remedies apply to a vessel from which pollutants have been discharged, including detention.

Control of hazardous waste. Both the Environmental Public Health Act (EPA) and Water Pollution Act (WPA) regulate hazardous waste. The Environmental Public Health (Toxic Industrial Waste Regulations) 1988 require a toxic waste generator to comply with specified storage, handling, transport,

reporting and notification obligations in relation to that waste.

The Petroleum Act regulates the impact, storage and transport of petroleum substances on land, Singapore's territorial sea and inland waters. It requires licenses to be obtained for specified quantities of petroleum and in specified locations. It imposes conditions on the import, transport and storage of petroleum on land and areas of sea within Singapore jurisdiction including its inland waters.

Financial Mechanisms and Investments in the Management of the Malacca Straits

Global trend in privatizing waste management

Privatization of waste management is gaining popularity in European countries, as well as in Canada and the USA (Smith, 1992). Smith (1992) stated that private refuse collection contractors serve 80% of the cities in Canada, 70% in West Germany (including 50% of the cities) and almost 50% of the French population. Hong Kong is also in the process of privatizing its waste collection, transport, treatment and disposal services. In the littoral States of the Malacca Straits, such a trend is being pursued by the government authorities. For instance, the water quality monitoring work for the twelve river basins along the West Coast of Peninsular Malaysia, which is presently being carried out by the Department of Environment, Malaysia, is to be privatized to enhance work efficiency (Ms. Hajah Rosnani Ibarahim, DDG/DOE, Kuala Lumpur, January 1996, personal communication). The development of waste management centers by private companies to treat hazardous waste in Indonesia and Malaysia is another example of awareness of the benefits of privatization in the region.

Current development and future potential

In December 1995, a local company (Kualiti Alam Sdn Bhd) in joint venture with foreign partners (Arab Malaysian Development Bhd and Danish Waste Treatment Services) started an ambitious project to set up a huge waste management center at Bukit Nanas of Peninsular Malaysia's West Coast state, Negeri Sembilan (*New Straits Times*, 26 December 1995). Construction of the facility has started and is scheduled to be completed in the next 2 to 3 years. On completion, the center will have an initial treatment capacity of 70,000 tonnes of hazardous waste per year. Charges for the treatment (i.e., incineration) of the wastes will be RM900 per tonne to incinerate mineral oil and up to RM 7,000 per tonne for pesticides and mercury waste. The center will have, in one complex, an incineration plant, solidifier, landfill and physical/chemical treatment facilities. Types of wastes that can be treated and the capacity of the facilities will be as follows:

- Incinerator Plant: Type of waste - mineral oil, organic chemicals, solvents and pesticides; Capacity - 30,000 t/yr;
- Solidifier: Type of waste - metal hydroxide sludge, spent catalysts, lead/zinc dross; Capacity 30,000 t/yr;
- Landfill: Type of waste direct to landfill - asbestos, mineral sludge; Capacity - 10,000 t/yr;
- Physical/Chemical Facilities: Type of waste - Acid/alkaline, chromate, cyanide, mercury; Capacity - 10,000 t/yr.

According to the DOE, the manufacturing industries in Malaysia generated 417,000 tonnes of scheduled wastes (toxic and hazardous wastes) in 1994 (*New Straits Times*, 26 December 1995).

Control strategies, action plans, legislation, and management

Control strategies and program activities for controlling land-based sources of pollution in Malaysia, Singapore and Indonesia, as proposed in a recent UNEP/COBSEA project, are listed in ***Table 8.9.***

Table 8.9. Programs of Action to Control Land-Based Sources of Pollution as Proposed by COBSEA Project EAS-97, UNEP (Koe and Aziz, 1995).

Country	Priority Area of Concern	Program/Activity	Time Schedule (Year)
INDONESIA	• Establishment of water quality objectives, standards, management and monitoring programs. • Waste discharges from settlements, industries, and agriculture. • Silt from land clearance and other development activities. • Capacity building. • National/provincial jurisdiction on pollution control.	• **Water Quality Assessment and Monitoring** **Activity 1:** Establishment/assessment of existing water quality (rivers, estuaries, coastal waters, and ground water) and continued monitoring to observe potential trends. **Activity 2:** Establishment of water quality objectives and corresponding standards based on present and potential use of water resources. **Activity 3:** Communication of information established under Activities 1 & 2 shall be regularly transmitted to appropriate government agencies, private sectors, and the general public. • **Control of Waste Discharge** **Activity 1:** Development/updating of the Master Plan for Sewerage Infrastructure. **Activity 2:** Prioritization of waste management plan with emphasis on major urban centers. **Activity 3:** Implementation of waste treatment systems for agricultural wastes. • **Siltation** **Activity 1:** Upgrading of erosion control measures in public and private development. **Activity 2:** Establishment of soil erosion control guidelines and verification procedures for public and private development. • **Capacity Building** **Activity 1:** Education and training attachments at selected institutions on waste management. **Activity 2:** Supporting attachments for regional and provincial level officials to the related activities including training in information networking. • **Public Education and Community Participation** **Activity 1:** Continuing with public awareness campaigns, newsletters, and public forums.	1995-1998 by 1996 1995-1998 by 1996/97 by 1996/97 by 1997 by 1996 by 1996/97 1995-2000 1995-2000 1995-2000
MALAYSIA	• Waste discharges from industries and agriculture. • Silt from land clearance and other development sites. • Capacity building. • Federal/State jurisdiction on pollution control.	• **Water Quality Assessment and Monitoring** **Activity 1:** Expansion of water quality assessment and monitoring programs, and the incorporation of water quality criteria and standards according to classification of rivers in accordance with beneficial uses for river basin management. **Activity 2:** Improvement of communication of information established under Activity 1. Information shall be regularly transmitted to appropriate government agencies, industry, and the general public.	1997-2002 ongoing

Table 8.9. (continued)

Country	Priority Area of Concern	Program/Activity	Time Schedule
MALAYSIA		**Activity 3:** Improvement of enforcement/implementation of EIA procedures particularly to coastal development to ensure appropriate adoption of pollution control technologies in planned development.	ongoing
		• **Control of Waste Discharge**	
		Activity 1: Extension and updating of the Sewerage Master Plan to cover all urban centers in the country.	ongoing
		Activity 2: Early implementation of national solid waste management plan.	ongoing
		Activity 3: Development of coordinated approach to address water pollution.	by 1997
		• **Siltation**	
		Activity 1: Review of soil erosion and siltation guidelines.	by 1995
		Activity 2: Development of guidelines for the control of soil erosion and siltation by specific development projects.	by 1996/97
		• **Capacity Building**	
		Activity 1: Training attachments at selected institutions on waste management.	1996-2001
		Activity 2: Establishment of environment training institute to train Department of Environment officers.	by 2000
		• **Legal Strengthening**	
		Activity 1: Review and amendment of the Environment Quality Act, 1974.	by 1996/97
		Activity 2: Review and amendment of the Environment Quality (Sewage and Industrial Effluents) Regulations, 1978 with respect to discharge limits.	by 1996/97
		Activity 3: Review of the Environment Quality (Prescribed Activities) (Environment Effluents) Order, 1987.	by 1996/97
		Activity 4: Formulation of Marine Pollution Control regulations.	by 1997
		Activity 5: Formulation of regulations to control tanker cleaning activities.	by 1997/98
		Activity 6: Formulation of regulations to control electroplating industry.	by 1997/98
SINGAPORE	• Building environmental consciousness. • Upgrading environmental management and infrastructure. • Adoption of clean technologies by industries.	• **Building Environmental Consciousness**	
		Activity 1: Introduction of environmental education in schools and tertiary institutions.	ongoing
		• **Unpgrading Environmental Management and Infrastructure**	
		Activity 1: Encourage waste minimization/recycling and inhouse treatment of waste by industries.	ongoing
		Activity 2: Upgrading of sewage treatment and sewerage systems.	ongoing

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ANNEXES

Annex 1

TRAFFIC SEPARATION SCHEMES

Rule 10 of COLREG 1972

Rule 10 of the International Regulations for Preventing Collisions at Sea, 1972, as amended on 19 November 1981 by Assembly resolution A.464(XII), on 19 November 1987 by Assembly resolution A.626(15) and on 19 October 1989 by Assembly resolution A.678(16), is applicable to all the traffic separation schemes contained in this Part. The text is given below.

Traffic Separation Scheme

(a) This rule applies to traffic separation schemes adopted by the Organization and does not relieve any vessel of her obligation under any other rule.

(b) A vessel using a traffic separation scheme shall:
  (i) proceed in the appropriate traffic lane in the general direction of the traffic flow for that lane;
  (ii) so far as practicable keep clear of a traffic separation line or separation zone;
  (iii) normally join or leave a traffic lane at the termination of the lane, but when joining or leaving from either side shall do so at as small an angle to the general direction of traffic flow as practicable.

(c) A vessel shall, so far as practicable, avoid crossing traffic lanes but if obliged to do so shall cross on a heading as nearly as practicable at right angles to the general direction of traffic flow.

(d) (i) A vessel shall not use an inshore traffic zone when she can safely use the appropriate traffic lane within the adjacent traffic separation scheme. However, vessels of less than 20 metres in length, sailing vessels and vessels engaged in fishing may use the inshore traffic zone.
  (ii) Notwithstanding subparagraph (d)(i), a vessel may use an inshore traffic zone when *en route* to or from a port, offshore installation or structure, pilot station or any other place situated within the inshore traffic zone, or to avoid immediate danger.

(e) A vessel other than a crossing vessel or a vessel joining or leaving a lane shall not normally enter a separation zone or cross a separation line except:
  (i) in cases of emergency to avoid immediate danger;
  (ii) to engage in fishing within a separation zone.

(f) A vessel navigating in areas near the terminations of traffic separation schemes shall do so with particular caution.

(g) A vessel shall so far as practicable avoid anchoring in a traffic separation scheme or in areas near its terminations.

(h) A vessel not using a traffic separation scheme shall avoid it by as wide a margin as is practicable.

(i) A vessel engaged in fishing shall not impede the passage of any vessel following a traffic lane.

(j) A vessel of less than 20 metres in length or a sailing vessel shall not impede the safe passage of a power-driven vessel following a traffic lane.

(k) A vessel restricted in her ability to maneuver when engaged in an operation for the maintenance of safety of navigation in a traffic separation scheme is exempted from complying with this Rule to the extent necessary to carry out the operation.

(l) A vessel restricted in her ability to maneuver when engaged in an operation for the laying, servicing, or picking up of a submarine cable, within a traffic separation scheme, is exempted from complying with this Rule to the extent necessary to carry out the operation.

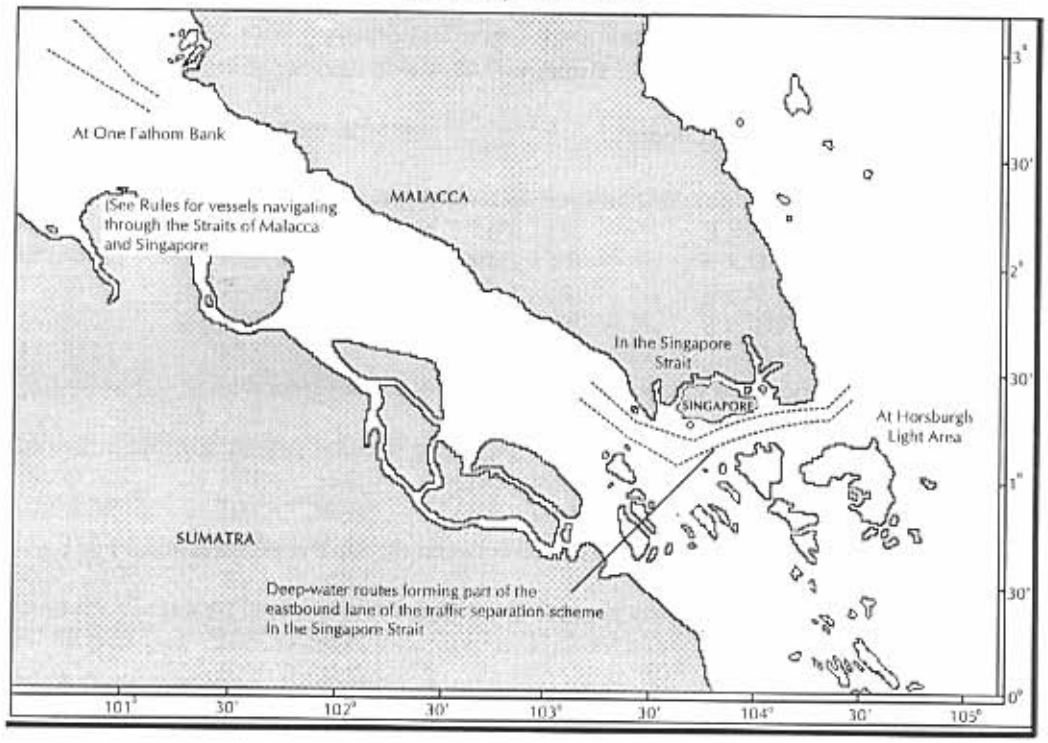
Caution:

The chartlets are for illustrative purposes only and must not be used for navigation. Mariners should consult the appropriate nautical publications and charts for up-to-date details on aids to navigation and other relevant information.

Warning:

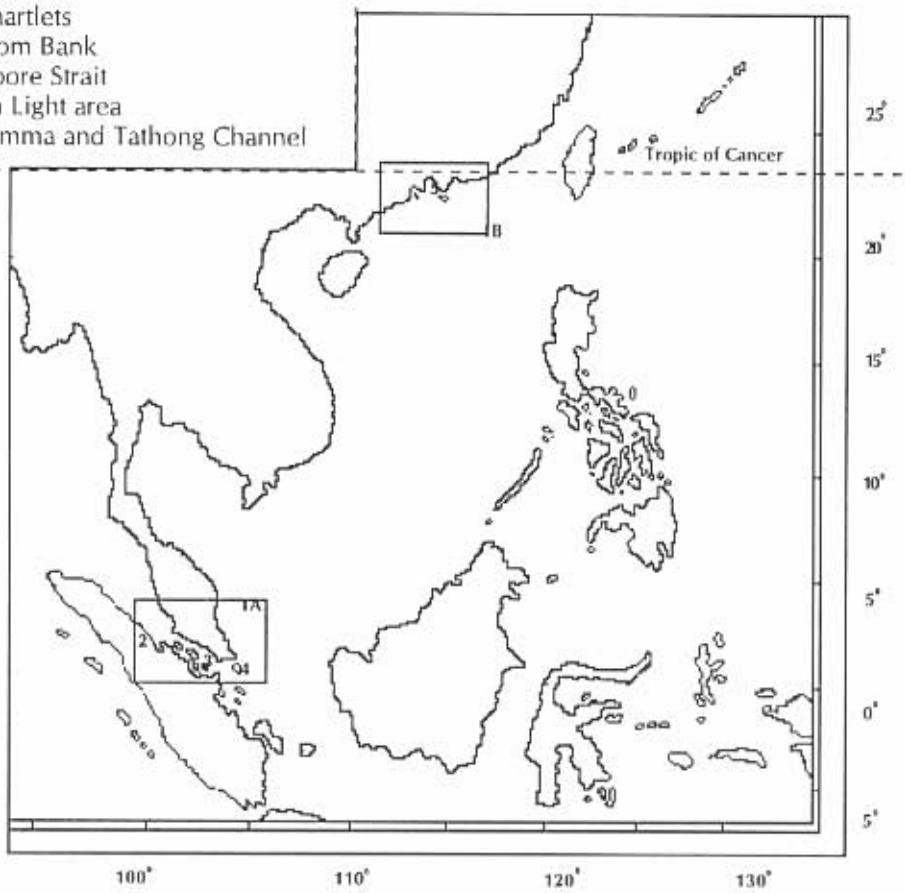
The geographical positions given in the descriptions of the routing systems are only correct for charts using the same geodetic datum as the reference charts indicated under each scheme. Charts published by other hydrographic offices may use a different geodetic datum, as may new editions of the reference charts published after the adoption of the routing system.

Summary Chartlet A



Index: Southeast Asia

1. Summary Chartlets
2. At One Fathom Bank
3. In the Singapore Strait
4. At Horsburgh Light area
5. In the East Lamma and Tathong Channel



At One Fathom Bank

(Reference chart: Japanese 622B, 1982 edition.
Note: This chart is based on World Geodetic System 72 Datum.)

Description of the traffic separation scheme

(a) Separation zone is bounded by a line connecting the following geographical positions:

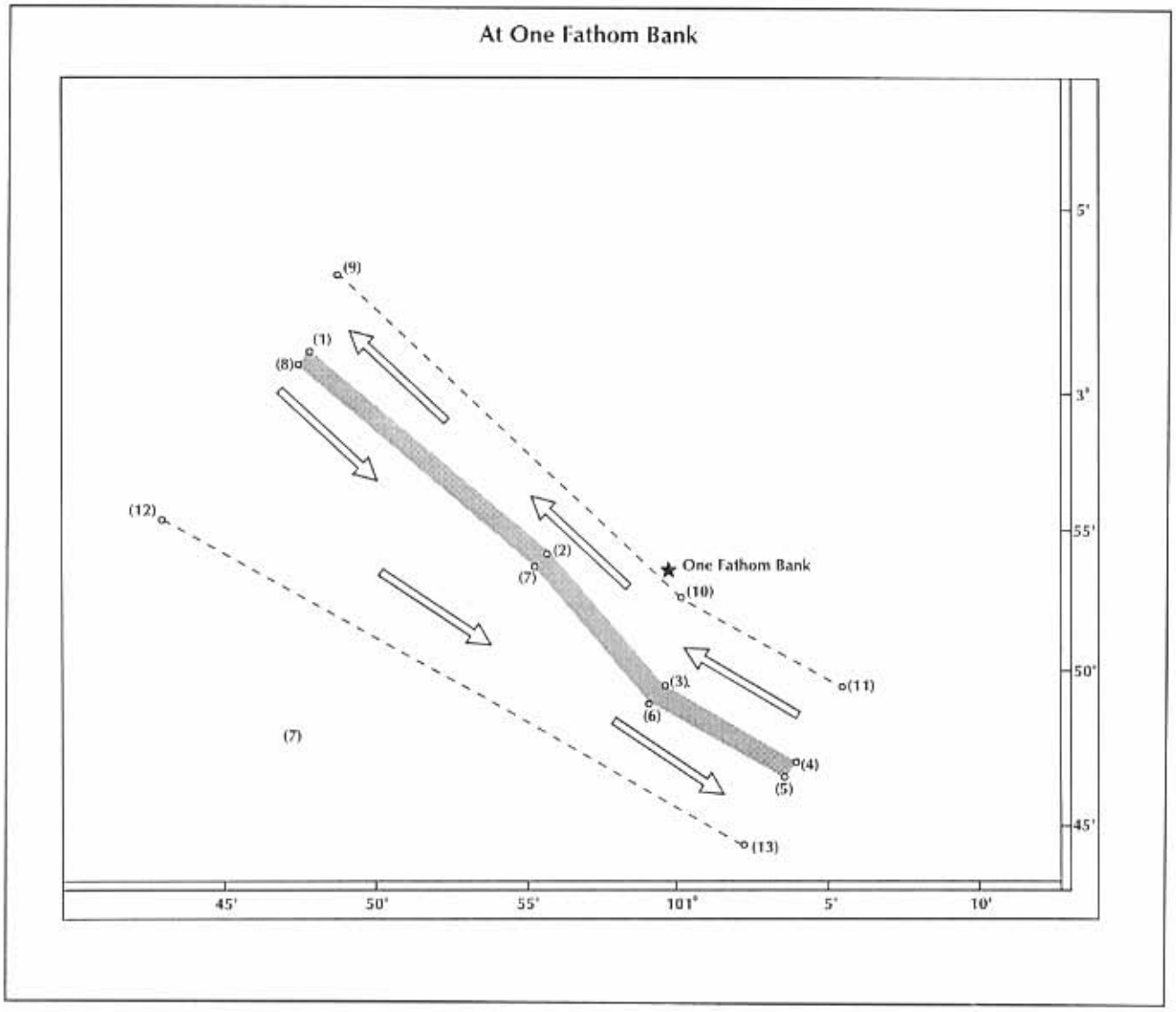
(1)	3°00'.7 N,	100°47'.3 E	(5)	2°46'.7 N,	101°03'.6 E
(2)	2°53'.7 N,	100°55'.7 E	(6)	2°49'.0 N,	100°59'.4 E
(3)	2°49'.5 N,	100°59'.4 E	(7)	2°53'.4 N,	100°55'.3 E
(4)	2°47'.1 N,	101°03'.9 E	(8)	3°00'.3 N,	100°47'.0 E

(b) A traffic lane for north-westbound traffic is established between the separation zone and a line connecting the following geographical positions:

(9)	3°02'.7 N,	100°48'.7 E	(11)	2°49'.4 N,	101°05'.3 E
(10)	2°52'.5 N,	100°59'.9 E			

(c) A traffic lane for south-eastbound traffic is established between the separation zone and a line connecting the following geographical positions:

(12)	2°54'.7 N,	100°43'.0 E	(13)	2°44'.4 N,	101°02'.1 E



In the Singapore Strait

(Reference charts. Japanese 621 and 622A, 1982 edition, 747 and 750, 1985 edition, 749 and 751, 1981 edition. *Note*: These charts are based on World Geodetic System 72 Datum.)

Description of the traffic separation scheme

(a) A separation zone is bounded by a line connecting the following geographical positions:

(1)	1°23'.20 N,	102°12'.30 E	(7)	1°07'.50 N,	103°43'.62 E
(2)	1°13'.20 N,	103°23'.30 E	(8)	1°10'.35 N,	103°39'.75 E
(3)	1°07'.80 N,	103°31'.60 E	(9)	1°10'.35 N,	103°33'.70 E
(4)	1°03'.60 N,	103°38'.85 E	(10)	1°13'.80 N,	103°23'.90 E
(5)	1°05'.90 N,	103°43'.28 E	(11)	1°24'.20 N,	103°13'.50 E
(6)	1°08'.60 N,	103°45'.33 E			

(b) A separation line connects the following geographical positions:

(12)	1°08'.60 N,	103°45'.33 E	(15)	1°13'.43 N,	103°54'.90 E
(13)	1°10'.25 N,	103°47'.80 E	(16)	1°14'.88 N,	103°58'.90 E
(14)	1°11'.30 N,	103°50'.40 E			

(c) A separation zone is bound by a line connecting the following geographical positions:

(17)	1°14'.88 N,	103°58'.90 E	(19)	1°15'.42 N,	104°03'.35 E
(18)	1°15'.67 N,	104°03'.30 E			

(d) A traffic lane for westbound traffic is established between the separation zones line and a line connecting the following geographical positions:

(20)	1°25'.50 N,	103°14'.90 E	(25)	1°10'.45 N,	103°47'.40 E
(21)	1°15'.20 N,	103°25'.20 E	(26)	1°11'.95 N,	103°51'.10 E
(22)	1°14'.22 N,	103°29'.90 E	(27)	1°14'.00 N,	103°54'.90 E
(23)	1°11'.50 N,	103°40'.45 E	(28)	1°16'.02 N,	103°59'.90 E
(24)	1°08'.65 N,	103°44'.30 E	(29)	1°16'.60 N,	104°03'.22 E

(e) A traffic lane for eastbound traffic is established between the separation zones/line and a line connecting the following geographical positions:

(30)	1°22'.00 N,	103°11'.00 E	(35)	1°09'.47 N,	103°48'.60 E
(31)	1°11'.55 N,	103°22'.70 E	(36)	1°11'.45 N,	103°52'.75 E
(32)	1°01'.60 N,	103°39'.55 E	(37)	1°13'.50 N,	103°57'.57 E
(33)	1°05'.00 N,	103°43'.57 E	(38)	1°14'.05 N,	104°03'.48 E
(34)	1°07'.80 N,	103°46'.15 E			

(f) A deep-water route is established within the eastbound lane described in paragraph (e). The deep-water route is bounded by a line connecting the following geographical positions:

(i)	1°03.60 N,	103°38'.85 E	(v)	1°09.95 N,	103°48'.18 E
(ii)	1°05'.90 N,	103°43'.28 E	(vi)	1°08'.90 N,	103°46'.72 E
(iii)	1°08'.60 N,	103°45'.33 E	(vii)	1°04'.95 N,	103°42'.77 E
(iv)	1°10'.25 N,	103°47'.80 E	(viii)	1°02'.97 N,	103°39'.00 E

Note: Reference is made in Rule 1 of the Rules for vessels navigating through the Straits of Malacca and Singapore.

(g) A deep-water route is established within the eastbound lane described in paragraph (e). The deep-water route is bounded by a line connecting the following geographical positions:

(ix)	1°10'.25 N,	103°47'.80 E	(xii)	1°11'.80 N,	103°52'.53 E
(x)	1°11'.30 N,	103°50'.40 E	(xiii)	1°09'.95 N,	103°48'.13 E
(xi)	1°12'.12 N,	103°52'.10 E			

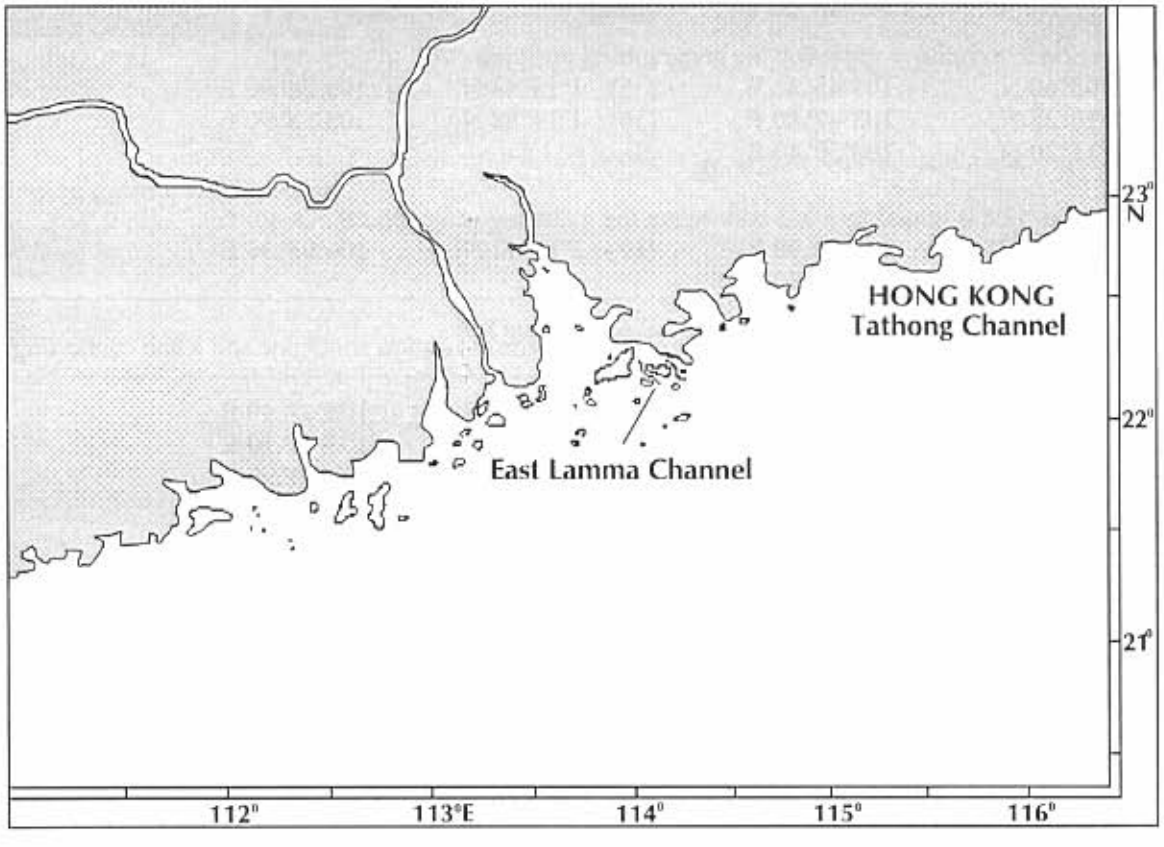
(h) A precautionary area is established in the Singapore Strait south of Tanjong Stapa bounded by a line connecting the following geographical positions:

(38) 1°14'.05 N, 104°03'.48 E
(29) 1°16'.60 N, 104°03'.22 E

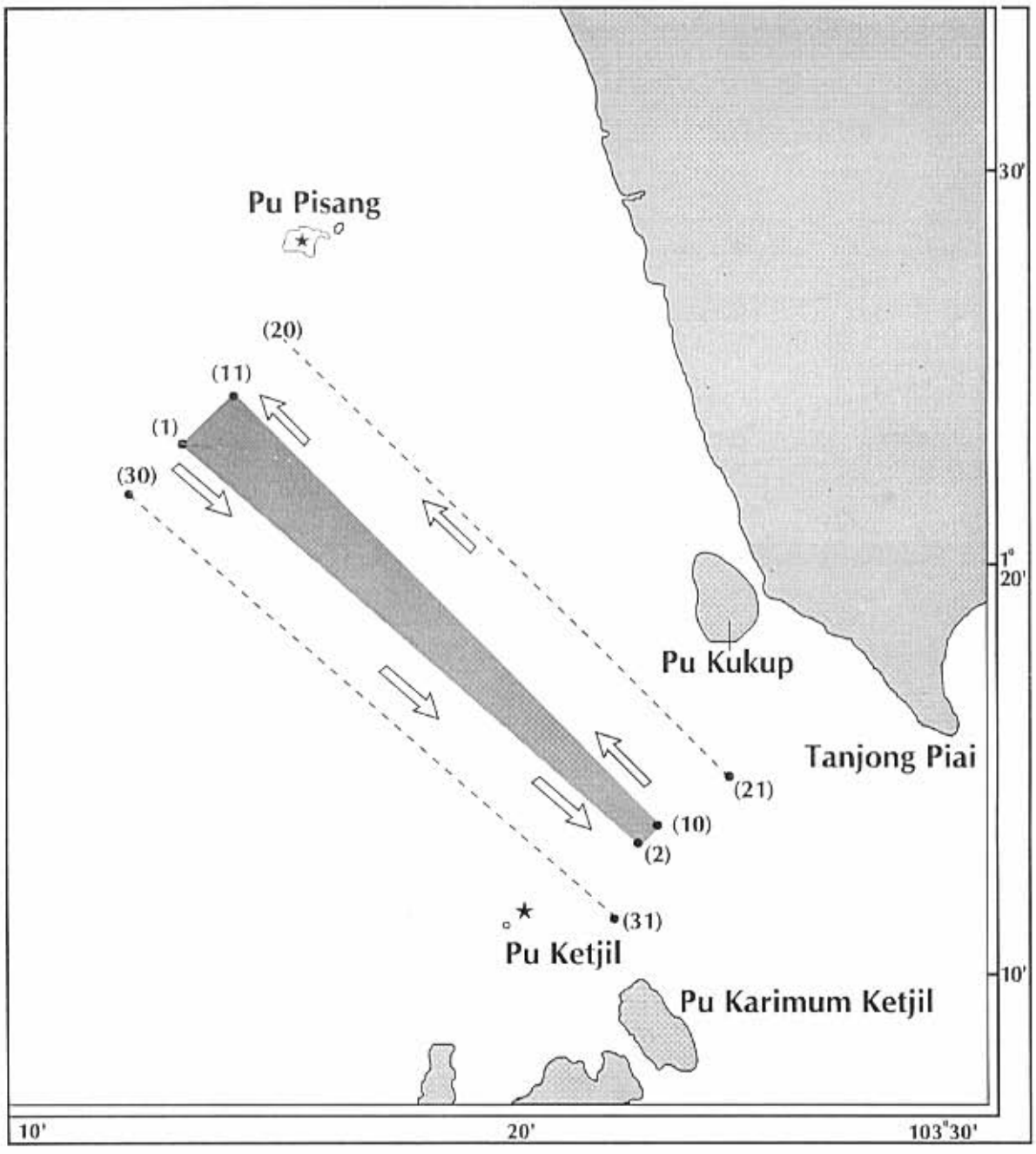
and the following geographical positions of the traffic separation scheme "At Horsburgh Light area".

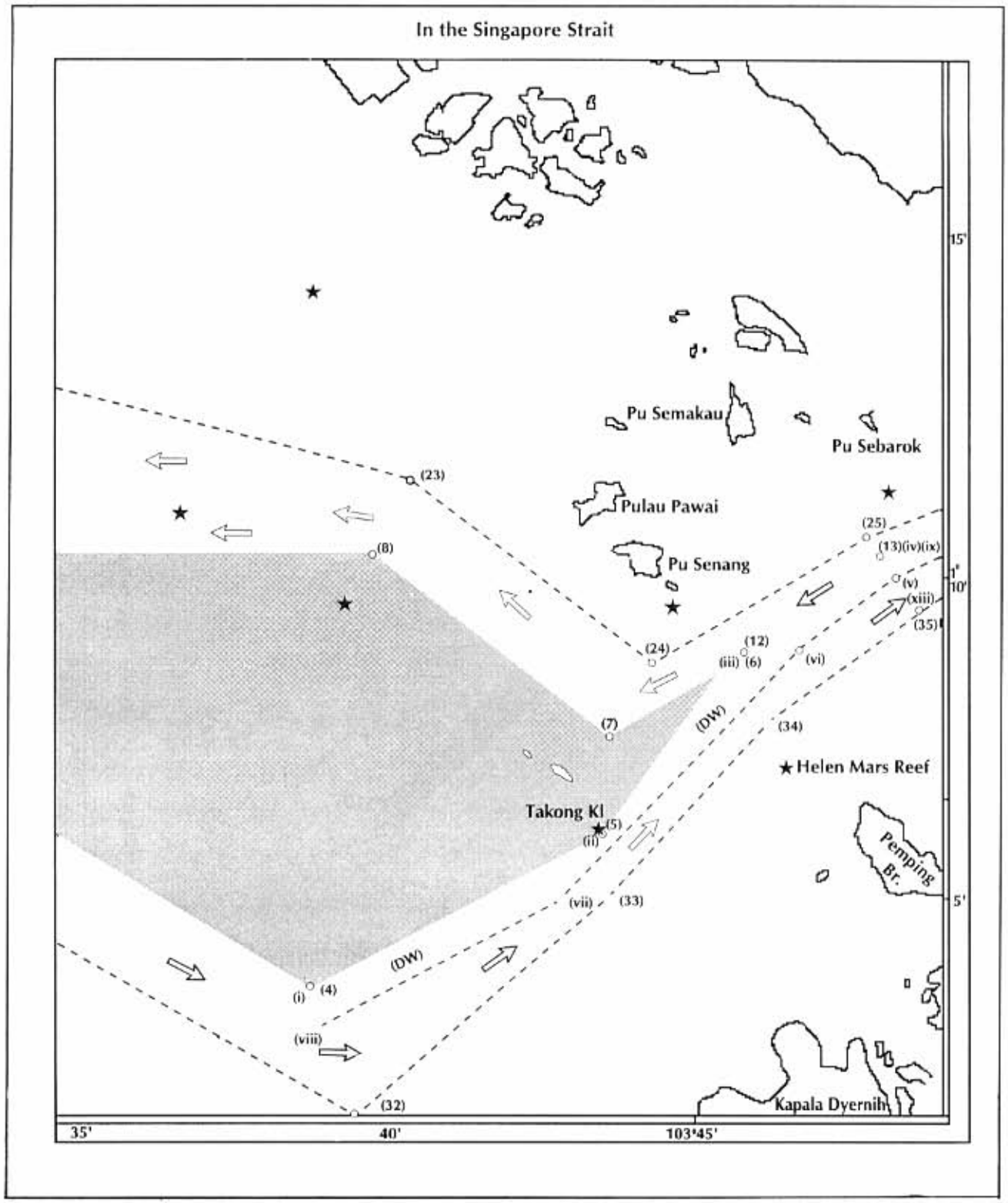
(9) 1°18'.63 N, 104°14'.90 E (see page V/4)
(10) 1°15'40 N, 104°14'.90 E (see page V/4)

Summary Chartlet B

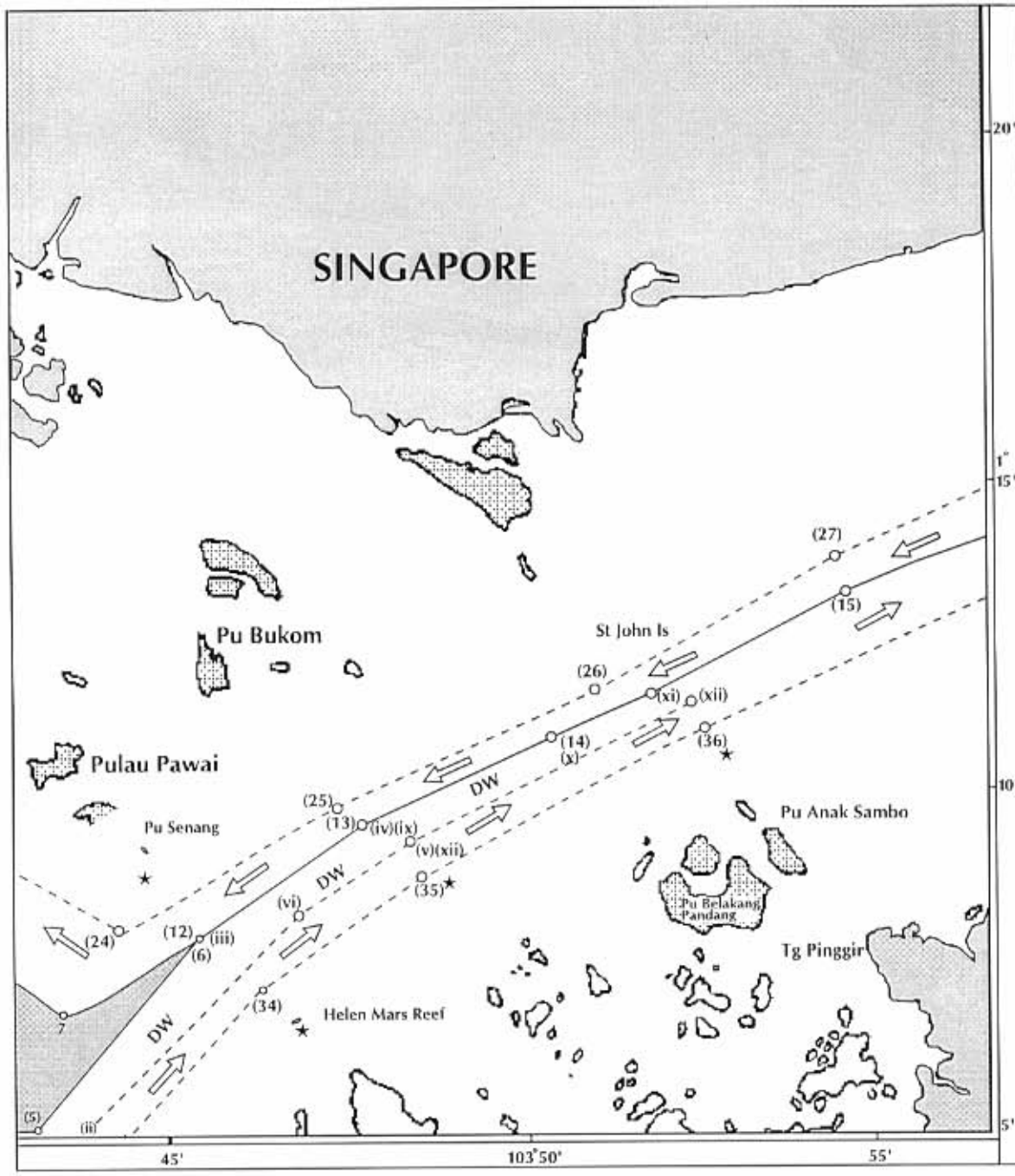


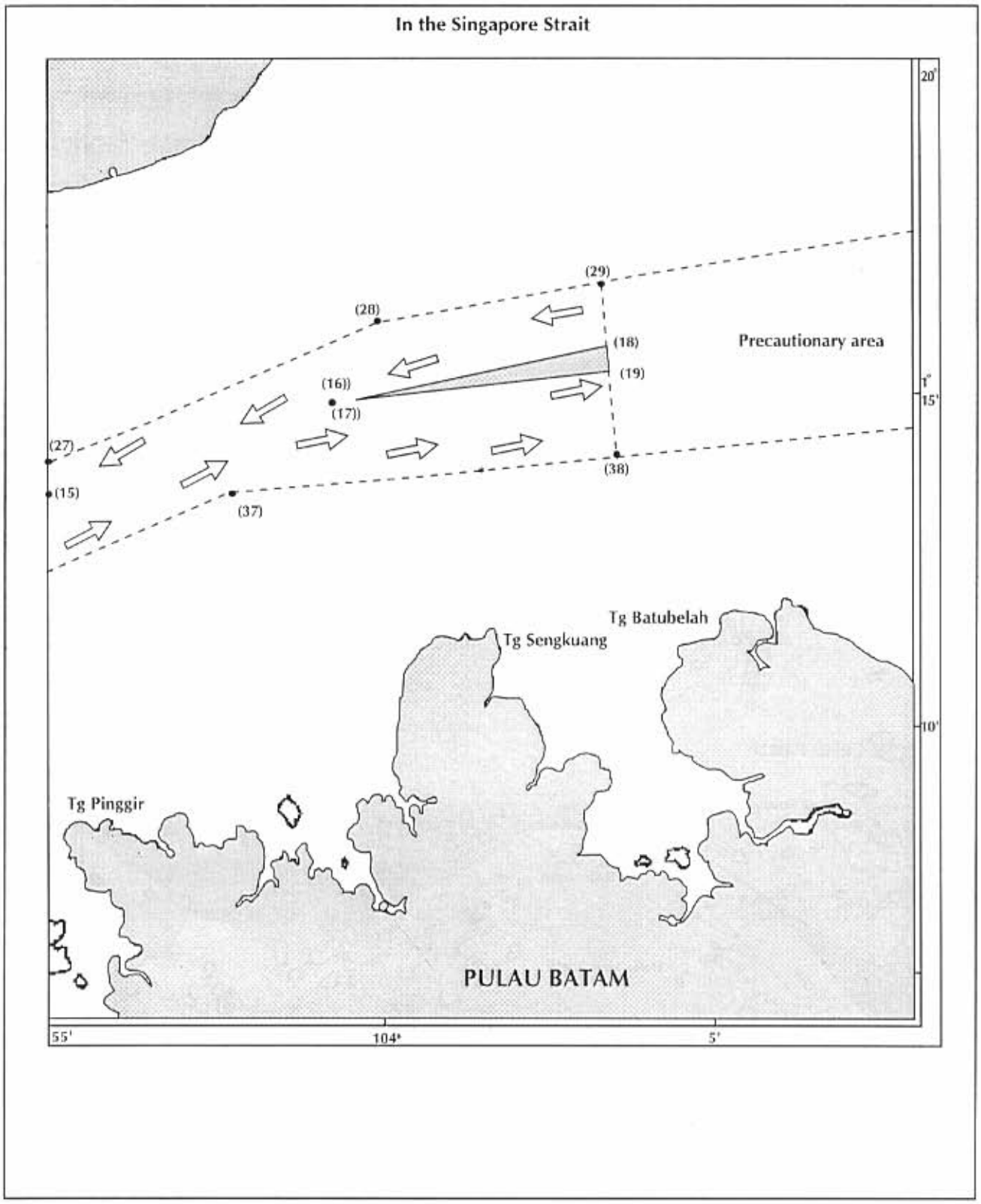
In the Singapore Strait



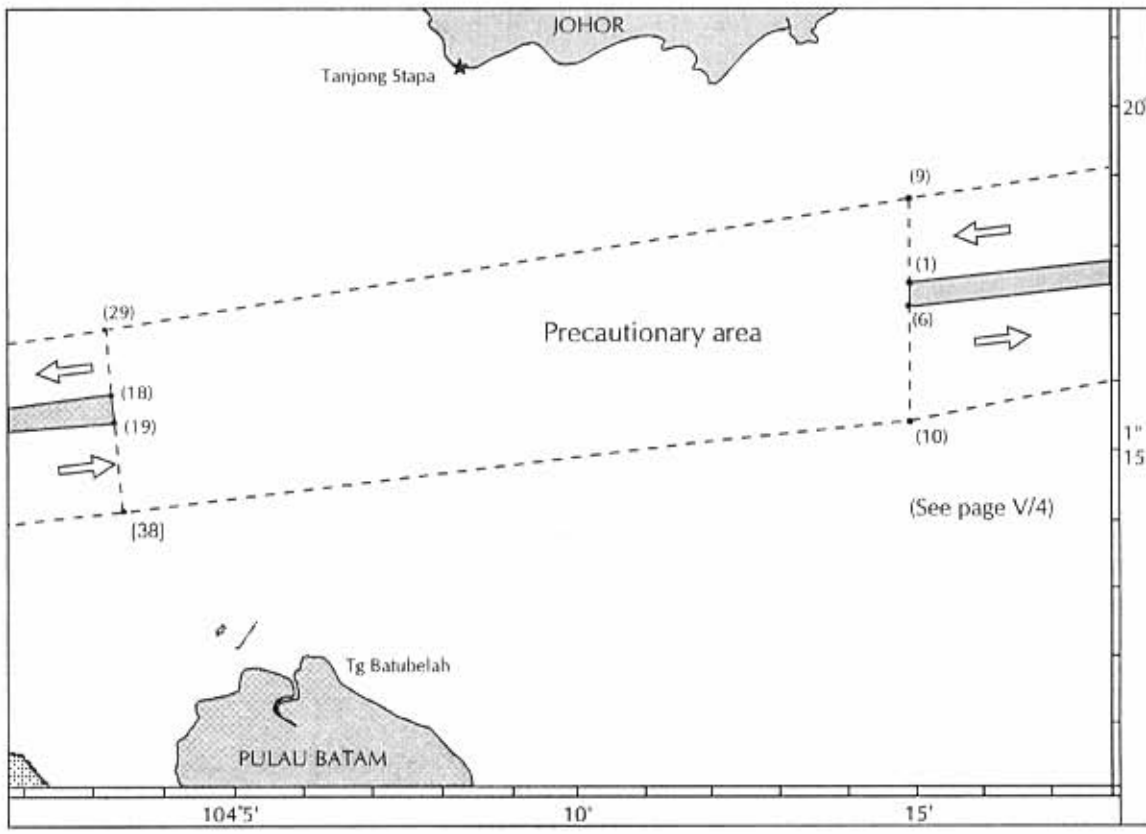

In the Singapore Strait
Pu Semakau
Pu Sebarok
Pulau Pawai
Pu Senang
Takong Kl
★Helen Mars Reef
Pemping Br.
Kapala Dyernih
(23)
(8)
(24)
(25)
(13)(iv)(ix)
(v)
(xiii)
(35)
(12)
(iii) (6)
(vi)
(7)
(34)
(5)
(ii)
(vii)
(33)
(i)
(4)
(viii)
(32)
(DW)
15'
1° 10'
5'
35'
40'
103°45'

In the Singapore Strait




In the Singapore Strait
(29)
(28)
(18)
Precautionary area
(19)
(16))
(17))
(27)
(15)
(37)
(38)
Tg Batubelah
Tg Sengkuang
Tg Pinggir
PULAU BATAM
20'
1°
15'
10'
55'
104°
5'

In the Singapore Strait



In the East Lamma and Tathong Channels

(Reference charts: British Admiralty 1917, 1988 edition, 1918, 1988 edition.
Note: These charts are based on Hong Kong 1963 Datum.)

Description of the Traffic Separation Scheme

The traffic separation schemes in the approaches to Hong Kong consist of two parts:

Part 1: Eastern approaches to Victoria Port (Tathong Channel)

(a) A separation zone is bounded by lines connecting the following geographical positions:

(1)	22°13'.42 N,	114°20'.00 E	(3)	22°13'.25 N,	114°17'.47 E
(2)	22°13'.07 N,	114°20'.00 E	(4)	22°13'.42 N,	114°20'.00 E

(b) A separation line connects the following geographical positions:

(5)	22°13'.25 N,	114°17'.47 E	(7)	22°16'.33 N,	114°15'.50 E
(6)	22°14'.12 N,	114°16'.42 E	(8)	22°17'.05 N,	114°14'.33 E

(c) A traffic lane for inbound traffic is established between the separation zone/line and a line connecting the following geographical positions:

(9)	22°14'.08 N,	114°20'.00 E	(12)	22°16'.38 N,	114°15'.78 E
(10)	22°13'.93 N,	114°17'.27 E	(13)	22°17'.15 N,	114°14'.40 E
(11)	22°14'.23 N,	114°16'.67 E			

(d) A traffic lane for outbound traffic is established between the separation zone/line and a line connecting the following geographical positions.

(14)	22°12'.30 N,	114°20'.00 E	(17)	22°16'.30 N,	114°15'.22 E
(15)	22°12'.47 N,	114°17'.67 E	(18)	22°16'.97 N,	114°14'.27 E
(16)	22°14'.02 N,	114°16'.13 E			

Inshore traffic zones

The area enclosed by the outer limit of the inbound traffic lane and the adjacent coast, and a line drawn from position (13) 22°17'.15 N, 114°14'.40 E, in the direction 034° true to the shore, and a line drawn from position 22°13'.95 N, 114°17'.75 E in the direction 360° true to the shore, is designated as an inshore traffic zone.

The area enclosed by the outer limit of the outbound traffic lane and the adjacent coast, and a line drawn from position (18) 22°16'.97 N, 114°14'.27 E in the direction 214° true to the shore, and a line drawn from position (15) 22°12'.47 N, 114°17'.67 E in the direction 270° true to the shore, is designated as an inshore traffic zone.

Part II: Western approaches to Victoria Port (East Lamma Channel)

(a) A separation line connects the following geographical positions:

(1)	22°12'.65 N,	114°10'.23 E	(3)	22°16'.37 N,	114°06'.40 E
(2)	22°14'.92 N,	114°07'.18 E			

(b) A traffic lane for inbound traffic is established between the separation line and a line connecting the following geographical positions:

(4)	22°12'.87 N,	114°10'.42 E	(6)	22°16'.47 N,	114°06'.67 E
(5)	22°15'.10 N,	114°07'.43 E			

(c) A traffic lane for outbound traffic is established between the separation line and a line connecting the following geographical positions:

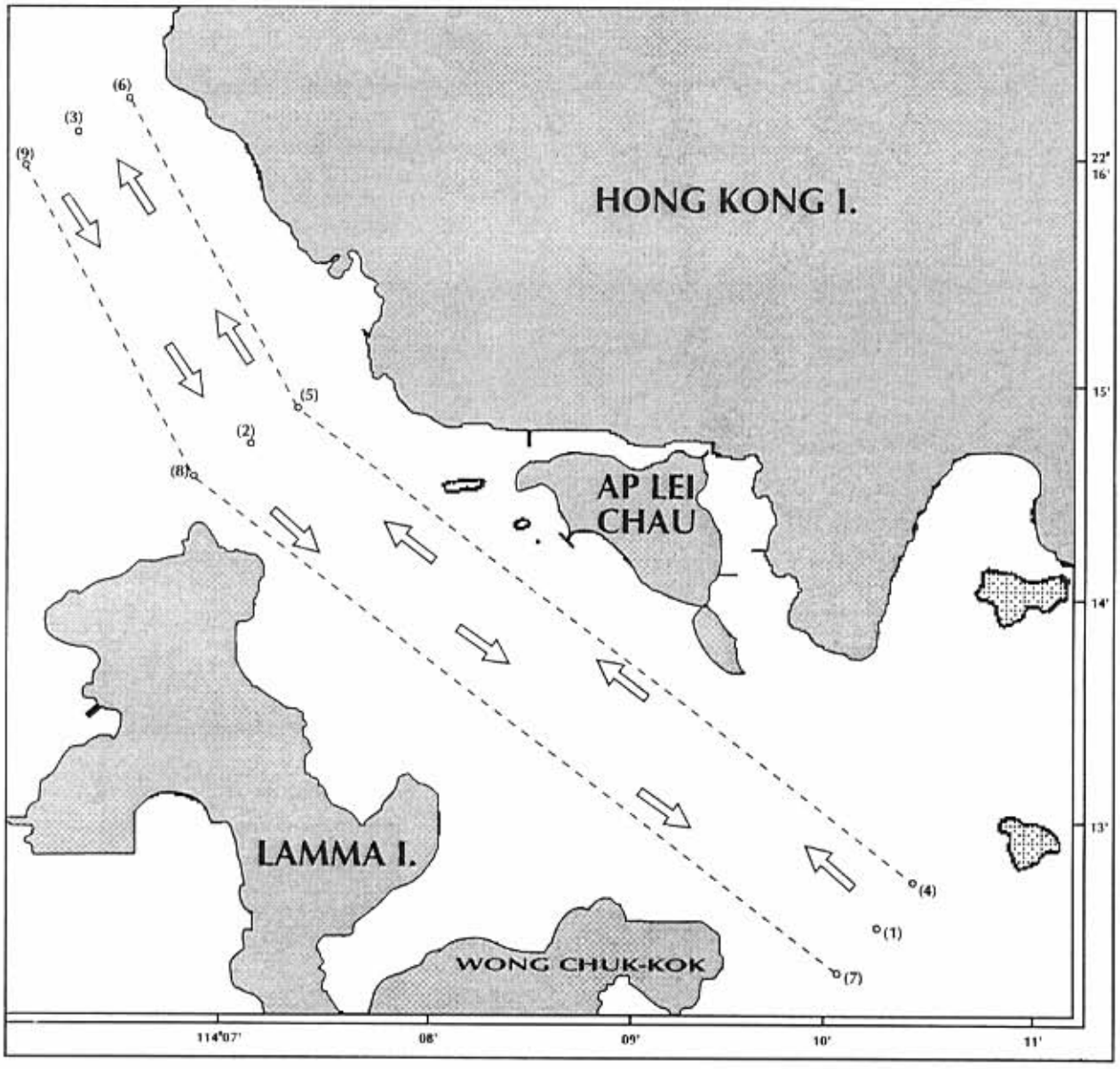
(7)	22°12'.45 N,	114°10'.07 E	(9)	22°16'.23 N,	114°06'.13 E
(8)	22°14'.73 N,	114°06'.97 E			

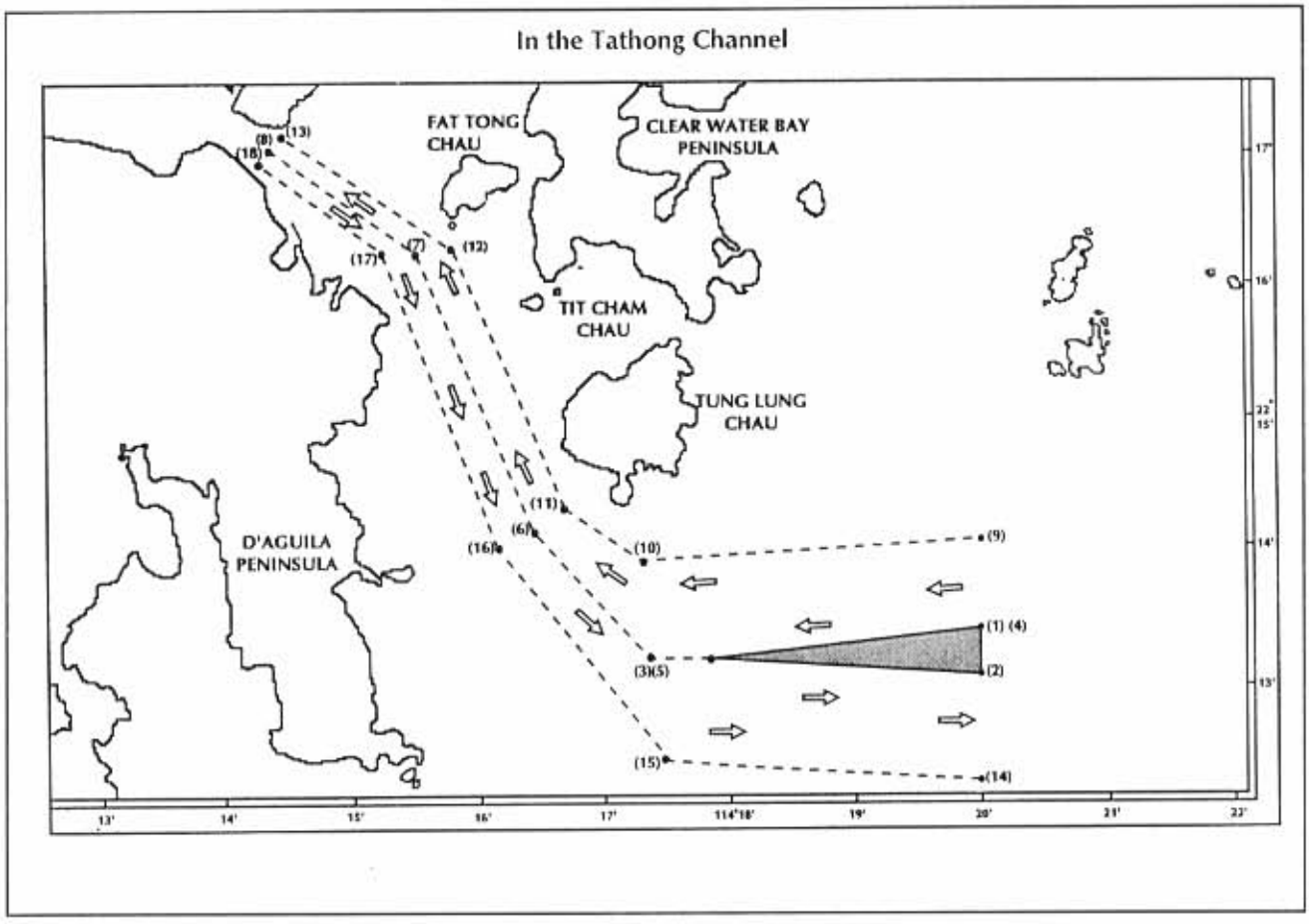
Inshore traffic zones

The area enclosed by the outer limit of the inbound traffic lane and the adjacent coast, and a line drawn from position (4) 22°12'.87 N, 114°10'.42 E, in the direction 038.5° true to the shore, and a line drawn from position (6) 22°16'.47 N, 114°06'.67 E, in the direction 063° true to the shore, is designated as an inshore traffic zone.

The area enclosed by the outer limit of the outbound traffic lane and the adjacent coast, and a line drawn from position (7) 22°12'.45 N, 114°10'.07 E, in the direction 218.5° true to the shore, and a line drawn from position (8) 22°14'.73 N, 114°06'.97 E, in the direction 231° true to the shore, is designated as an inshore traffic zone.

In the East Lamma Channel




In the Tathong Channel
FAT TONG CHAU
CLEAR WATER BAY PENINSULA
TIT CHAM CHAU
TUNG LUNG CHAU
D'AGUILA PENINSULA
(1) (4)
(2)
(3)(5)
(6)
(8)
(9)
(10)
(11)
(12)
(13)
(14)
(15)
(16)
(17)
(18)
13'
14'
15'
16'
17'
114°18'
19'
20'
21'
22'
17'
16'
22° 15'
14'
13'

At Horsburgh Light Area

(Reference charts: Japanese 621, 1982 edition; 749, 1981 edition.
Note: These charts are based on World Geodetic System 72 Datum.)

Description of the Traffic Separation Scheme

(a) A separation zone is bounded by a line connecting the following geographical positions:

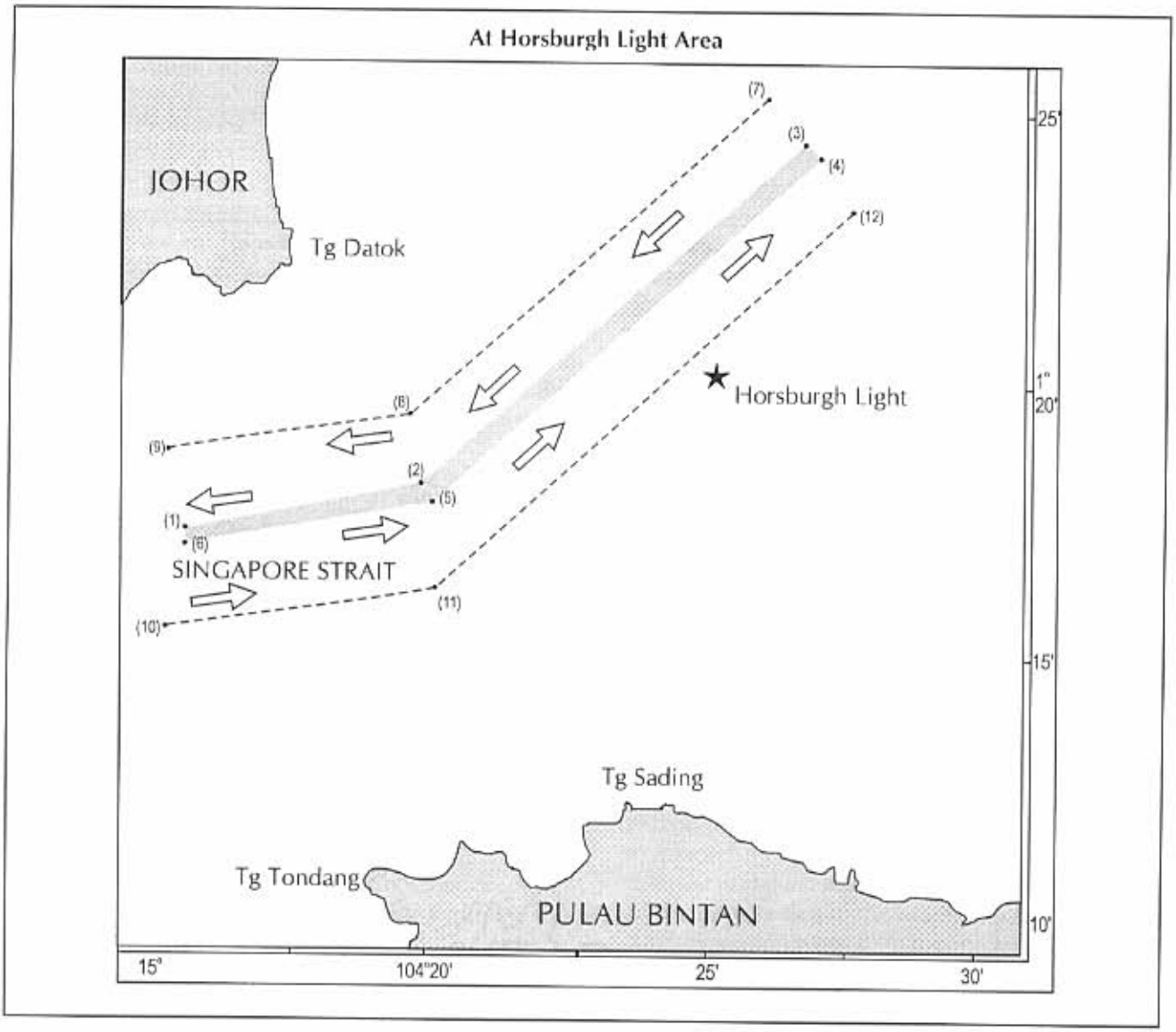
(1)	1°17'.32 N,	104°14'.90 E	(4)	1°24'.30 N,	104°27'.15 E
(2)	1°18'.00 N,	104°19'.60 E	(5)	1°17'.80 N,	104°19'.75 E
(3)	1°24'.55 N,	104°26'.95 E	(6)	1°17'.10 N,	104°14'.90 E

(b) A traffic lane for south-westbound traffic is established between the separation zone and a line connecting the following geographical positions:

(7)	1°25'.40 N,	104°26'.22 E	(9)	1°18'.63 N,	104°14'.90 E
(8)	1°19'.40 N,	104°19'.40 E			

(c) A traffic lane for north-eastbound traffic is established between the separation zone and a line connecting the following geographical positions:

(10)	1°15'.40 N,	104°14'.90 E	(12)	1°23'.40 N,	104°27'.85 E
(11)	1°16'.30 N,	104°19'.75 E			



Deep-water Routes Forming Part of the Eastbound Traffic Lane of the Traffic Separation Scheme in the Singapore Strait

(Reference charts: Japanese 747 and 750, both 1985 edition; 751, 1981 edition.
Note: These charts are based on World Geodetic System 72.)

Description of the Deep-Water Routes

(a) The deep-water route is established within the eastbound lane described in paragraph (e) of the traffic separation scheme "In the Singapore Strait". The deep-water route is bounded by a line connecting the following geographical positions:

(i)	1°03'.60 N,	103°38'.85 E	(v)	1°09'.95 N,	103°48'.18 E
(ii)	1°05'.90 N,	103°43'.28 E	(vi)	1°08'.90 N,	103°46'.72 E
(iii)	1°08'.60 N,	103°45'.33 E	(vii)	1°04'.95 N,	103°42'.77 E
(iv)	1°10'.25 N,	103°47'.80 E	(viii)	1°02'.97 N,	103°39'.00 E

Note: Reference is made to Rule 1 of the Rules for vessels navigating through the Straits of Malacca and Singapoore (see Part F).

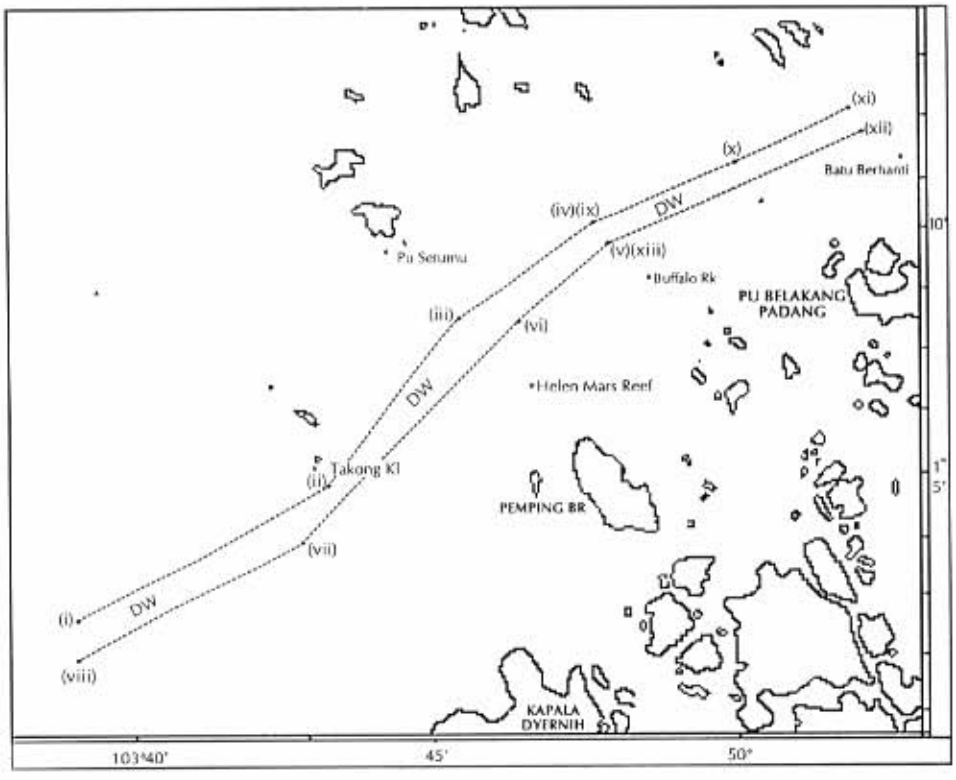
(b)The deep-water route is established within the eastbound lane described in paragraph (e) of the traffic separation scheme "In the Singapore Strait". The deep-water route is bounded by a line connecting the following geographical positions:

(ix)	1°10'.25 N,	103°47'.80 E	(xii)	1°11'.80 N,	103°52'.53 E
(x)	1°11'.30 N,	103°50'.40 E	(xiii)	1°09'.95 N,	103°48'.18 E
(xi)	1°12'.12 N,	103°52'.10 E			

Note: Attention is drawn to the Rules for vessels navigating through the Straits of Malacca and Singapore (See Part F).

I. Definitions

Deep–water Routes Forming Part of the Eastbound Traffic Lane of the Traffic Separation Scheme in the Singapore Strait



Annex 2

RULES FOR VESSELS NAVIGATING THROUGH THE STRAITS OF MALACCA AND SINGAPORE

I. Definitions

For the purpose of these Rules the following definitions should apply.

(1) A vessel having a draught of 15 metres or more shall be deemed to be a deep-draught vessel.
(2) A tanker of 150,000 dwt and above shall be deemed to be a very large crude carrier (VLCC).

Note: The above definitions do not prejudice the definition of "vessel constrained by her draught" described in Rule 3(h) of the International Regulations for Preventing Collisions at Sea, 1972

II. General Provisions

(1) Deep draught vessels and VLCCs shall allow for an underkeel clearance (UKC) of at least 3.5 metres at all times during the entire passage through the Straits of Malacca and Singapore and shall also take all necessary safety precautions, especially when navigating through the traffic separation schemes.

(2) Masters of deep-draught vessels and VLCCs shall have particular regard to navigational constraints when planning their passage through the Straits.

(3) All deep-draught vessels and VLCCs navigating within the traffic separation schemes are recommended to use the pilotage service of the respective countries when they become available.

Rules

Rule 1.

(a) Deep-draught vessels shall use the designated deep-water route (DWR) between position 01°09'.95 N, 103°48'.28 E and 01°02'.97 N, 103°39'.10 E. Other vessels should, as far as practicable, avoid the deep-water route.
(b) Deep-draught vessels are advised to use the deep-water route between Buffalo Rock and Batu Berhanti.

Rule 2: Deep-draught vessels navigating in the deep-water route shall, as far as practicable, avoid overtaking.

Rule 3: All vessels navigating within the traffic separation scheme shall proceed in the appropriate traffic lane in the general direction of traffic flow for that lane and maintain as steady a course as possible consistent with safe navigation.

Rule 4: In the event of an emergency or breakdown of a vessel in the traffic lane it shall, as far as practicable and safe, leave the lane by pulling out to the starboard side.

Rule 5:

(a) Vessels proceeding in the westbound lane of the traffic separation scheme "In the Singapore Strait" when approaching Raffles Lighthouse shall proceed with caution, taking note of the local warning system, and in compliance with Rule 18(d) of the International Regulations for Preventing Collisions at Sea, 1972, avoid impeding the safe passage of a vessel constrained by her draught which is exhibiting the signals required by Rule 28, and which is obliged to cross the westbound lane of the scheme in order to approach the single point mooring facility (in approximate position 01°11'.42 N, 103°47'.50 E from Phillip Channel.
(b) Vessels proceeding in the westbound lane of the traffic separation scheme "In the Singapore Strait" when approaching the Western Light Beacon in position 01°12'.72 N, 103°35'. 88 E shall proceed with caution, taking note of the local warning system, and, in compliance with Rule 18(d) of the International Regulations for Preventing Collisions at Sea, 1972, avoid impeding the safe passage of a vessel constrained by her draught which is exhibiting the signals required by Rule 28 and which is obliged to cross the westbound lane of the scheme in order to approach the Sultan Shoal pilot boarding ground from the eastbound lane of the scheme.
(c) A vessel proceeding in the westbound lane of the traffic separation scheme "In the Singapore Strait"

which is required to avoid impeding the safe passage of a vessel constrained by her draught shall so far as practicable navigate in such a way as to avoid the development of risk of collision.

(d) Information relating to the movement of ships constrained by their draught as referred to in paragraphs (a) and (b) above will be given by radio broadcasts. The particulars of such broadcasts are promulgated by Notices to Mariners. All vessels navigating in the area of the traffic separation scheme "In the Singapore Strait" should monitor these radio broadcasts and take account of the information received.

Rule 6: VLCCs and deep-draught vessels are advised to navigate at a speed of not more 12 knots over the ground.

Rule 7: All vessels navigating in the traffic separation scheme shall maintain at all times a safe speed consistent with safe navigation, shall proceed with caution, and shall be in a maximum state of manoeuvring readiness.

Rule 8: VLCCS and deep-draught vessels navigating in the Straits of Malacca and Singapore are advised to participate in the existing voluntary ships' reporting system. Under this system, such vessels broadcast eight hours before entering the Straits/traffic separation schemes navigational warnings giving names, deadweight tonnage, draught, speed and times of passing One Fathom Bank Lighthouse, Raffles Lighthouse and Horsburgh Lighthouse. Difficult and unwieldy tows also broadcast similar warnings giving the type, length, speed of tows and times of passing the three above-mentioned areas.

Rule 9: All vessels navigating the Straits of Malacca and Singapore are requested to report by radio to the nearest shore authority any damage to or malfunction of the aids to navigation in the Straits, or any aids out of position in the Straits.

Rule 10: Flag States, owners and operators should ensure that their vessels are adequately equipped in accordance with the appropriate international conventions/recommendations.

Warning

Mariners are warned that local traffic could be unaware of the internationally agreed regulations and practices of seafarer and may be encountered in or near the traffic separation schemes, and should take any precautions which may be required by the ordinary practice of seamen or by the special circumstances of the case.

Annex 3

EAST ASIA RESPONSE PRIVATE LIMITED EQUIPMENT LIST

	Quantity
Containment Boom	
Ro-Boom 1500 Boom System 200 m containment boom on powered winders complete with towing equipment and inflation unit	12
Hi Sprint 950 Rapid Boom System Length - 300 m	3
Troil Boom Concave 1500HD boom system (in 60 m sections	16
Coastal Boom (Foam filled) (in 50 m sections)	40
Seasentinel Inshore Boom Air inflatable boom on powered reels-section length 100 m. Total length per reel 200 m	8
Seasentinel Inshore Boom Air inflatable curtain boom for inshore waters	
- Section length 20 m	60
- Section length 10 m	40
Shoreguardian Beach Sealing Boom Air and water tube boom for use in intertidal area	
- Section length 25 m	20
- Section length 20 m	5
- Section length 10 m	20
Boom Ancillary Equipment	
Boom Deployment Boxes Comprising air fans, connector pumps, etc.	9
Troil Boom Recovery Machine	1
15 m Outrigger Arm for Ro-Boom	2
Heavy Oil Net System for Ro-Boom *(Nets to be replaced at cost)	2
Anchors, Chains, Moorings (per set)	60
Oil Recovery Devices	
Ro-skim Unit for use with Ro-Boom capacity 100 t/hr	2
Marflex Sweep Arms	2
Seaskimmer 50 Oleophilic Disc Skimmer Capacity 50 t/hr	2
GT185 Weir Skimmer Complete with discharge and hydraulic hoses	5
T18 Oleophilic Disc Skimmer Capacity 19 t/hr complete with power pack	4
T12 Oleophilic Disc Skimmer Complete with power pack	9
Delta Skimmer Complete with pump system	6
Power Vac Vacuum Unit Complete with power pack and hopper unit	10
Oil Mop Unit Trailer mounted rope mop unit capacity approx. 10 t/hr	2
Vikoma Seawoolf Unit Heavy oil skimmer	2
Vikoma Seadevil Skimmer Complete with hydraulic and discharge hose capacity 70 t/hr	1

	Quantity
ORS AB WP 1-30 Heavy oil skimmer complete with hydraulic and discharge hose capacity 30 t/hr	1
Dispersant Delivery Systems	
Airborne Dispersant Delivery System (ADDS Pack)	1
Simplex Helicopter Spray System	7
Transland Helicopter Spray System	3
Frank Ayles Spillspray Vessel mounted dispersant application system	6
Storage Systems	
Unitor Oil Bag (capacity 500 m^3)	1
Unitor Oil Bag (capacity 200 m^3)	2
Unitor Oil Bag (capacity 100 m^3)	3
Ro-Tank Storage System (capacity 10 m^3)	6
Fastanks 2,000 gall (portable storage system)	12
Porta Berm Containment System	3
Pillow Tanks (capacity 500 gall)	12
Pumps	
Framo Offloading Systems Complete with pump, power pack hose systems	2
Desmi DOP250 screw Pump unit complete with hoses	2
Peristaltic Pump Units Complete with hose systems	6
Spate Pump 75C Complete with hose systems	2
Ancillary Equipment	
High Pressure Washers (Skid mounted)	3
High Pressure Washers (Wheel mounted)	1
Vessels	
20 m Oil Spill Response Vessels Equipment - 300 m Hi Sprint Boom - GT185 Skimmer - Dispersant System - 8 tons Dispersant - 100 m^3 Storage System - 7.5 m Tender - GPS Navigator - Speed 25 knots - 6 crew	3
Inflatable with Outboard (25 HP)	1
Absorbents (Consumables)	
Lori Brooms and Containers	20
Sorbent Pads	100
Sorbent Booms	100
Pompom Oil Snare	200
Mops with Wringers	20
Sorbent Rolls	150
Communications Equipment	
Satellite Communications system	1
RT 2048 Base Station (25 w Transceiver with scanning monitor)	3
VHF Repeater Station	1
Mx1000 Handsets (set of 5) Complete with batteries and chargers	15
HT220s Standard Handsets	3
Bosch 100 Channel Portable VHF radios	22
Hilomast Telescopic Aerial	3
Photophone Unit	1

	Quantity
Jottron Surface-to-air radios	2
Power Packs	
Pharos Marine 35 kw Hydraulic power packs	6
Desmi Diesel Hydraulic Multi Purpose Power pack - 50 kw	4
Miscellaneous Items	
Low Bed Trailer	1

	Quantity
Emulsion Break Metering Pump	4
Life Jackets	30
Bulk Storage Tanker (contains 24,600 litres Shell VDC)	1
Dispersant	
Bulk Storage Tank (110 BBLS)	1
Drum (209 litres) Storage	150
EARL Vessels (each 48 BBLS)	3

PUBLICATIONS OF THE MPP-EAS

- Integrated Coastal Management in Tropical Developing Countries: Lessons Learned from Successes and Failure
- Enhancing the Success of Integrated Coastal Management: Good Practices in the Formulation, Design and Implementation of Integrated Coastal Management Initiatives (*Available in English, Vietnamese, Bahasa Indonesia, French, Portuguese, Swahili, Korean, Chinese and Thai)*
- Strategic Environmental Management Plan for the Batangas Bay Region
- Coastal Environmental Profile of the Batangas Bay Region
- Integrated Waste Management Action Plan for the Batangas Bay Region
- Strategic Management Plan for Marine Pollution Prevention and Management in Xiamen
- Coastal Environmental Profile of Xiamen
- Sustainable Financing Mechanisms: Public Sector-Private Sector Partnership
- Oil Spill Modelling in the East Asian Region *with Special Reference to the Malacca Straits*
- Marine Pollution Updates *(quarterly publication)*
- Tropical Coasts *(bi-annual newsletter)*
- Annual Report

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GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas

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