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South China Sea: Present and Potential Coastal Area Resource Use Conflicts

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ABSTRACT

Coastal areas of the South China Sea exhibit broad geomorphological, climatic, biological and physical oceanographic similarities. Conflicts between coastal area resource uses in this physical marine region are becoming apparent. These conflicts result from a combination of increasing coastal area population concentration and traditional dependence on the coastal area for livelihood, food, trade and waste disposal, recently supplemented by recreational, industrial and non-renewable resource extraction activities.

This paper reviews the general present status of major competing coastal area resource uses and their conflicts, and delineates present and potential geographic areas of concern. Extractive industries, industrial water use, and estuarine discharge conflict with fisheries, tourism/recreation, and human health. Geographic areas of concern include the region's major coastal urban concentrations, the Malacca Straits, the Bight of Bangkok and the greater Gulf of Tailand. To ameliorate conflict resolution, governmental philosophies geared to Western models of growth development should also incorporate the concept of planned growth, i.e., optimum allocation of coastal area resource use designed to minimize conflict, so recently, and thus painfully, adopted in the West.

INTRODUCTION

More than a quarter of humanity resides in the political entities bordering the South China Sea and 75% of Southeast Asia's population lives on islands. Due to infertile or rugged, forested hinterlands, much of the population is crowded into river valleys and available coastal plains. The average national rate of population increase of 2.7% per year (Marr, 1976) greatly diminishes per-capita benefits derived from annual percentage increases in gross national product. To meet the increased expectations of their expanding populations, to board original copy in sup. file

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the developing nations of the region are struggling to increase their agricultural production for export and internal consumption while simultaneously encouraging industrial development. Although the South China Sea has been

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His involvement with the problems of marine science and resource development in Southeast Asia includes service as a Lecturer/Researcher with the Universiti Sains Malaysia, Penang (1973–1975), as a Technical Expert with UNDP Technical Support for the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) (1975–1976) and as an intercountry Fulbright–Hays Program Lecturer at Mindanao State University in the Philippines. During his assignment in Malaysia, Dr. Valencia was a member of an international, interdisciplinary team funded to determine the potential impact of an oil spill on the coastal resources of western Sabah. His duties with UNDP included responsibility for all Project interests and undertakings in marine pollution and coastal area development planning and management. He also represented the Economic and Social Commission for Asia and the Pacific and the Project at the UNEP/FAO/IOC-sponsored International Workshop on Marine Pollution in East Asian Waters.

used by man for eons for commerce and its natural resources, particularly protein, recent rapid acceleration of marine transport and non-renewable resource extraction activities together with agricultural, industrial and human waste disposal is producing increasing conflict with the traditional harvesting of marine protein, human health and the recent demand for coastal recreation. The conflicts identified in the South China Sea coastal area * are not unique to this region but are indicative of similar problems that must eventually be faced by other developing coastal regions of the world. To be sure, compatible multiple use is feasible and ongoing; however, this paper concentrates on a general survey of present and potential coastal area resource use conflicts in the South China Sea region with a view to delineating geographic areas of concern.

ENVIRONMENTAL SETTING

Geography and climate

The South China Sea extends from a southwestern boundary along the 3°00'S parallel between Kalimantan and Sumatra northeast to a line drawn from the northern tip of Taiwan to the coast of Fukien, China. This semi-enclosed, $3.5 \cdot 10^6$ km^2 marine area (Marr, 1976) is bordered by China, Taiwan, Hong Kong, Macau, Vietnam, Kampuchea (the former Cambodia), Thailand, Malaysia, Singapore, Indonesia, Brunei and the Philippines (Fig. 1).

The South China Sea itself is bathymetrically divided into the deep China Sea Basin in the northeastern portion extending over $1.745 \cdot 10^6$ km^2 or 52% of the total area, and extensive continental shelf areas comprising $1.755 \cdot 10^6$ km^2 or 48% of the total area. The China Sea Basin has a maximum depth of 5,016 m off Palawan and a central abyssal plain at about 4,300 m (Wyrtki, 1961). Within the deep basin area are submerged banks, e.g., Macclesfield (Chungsha) and island groups, e.g., the Paracels (Hsisha) and the Dangerous Ground, including Spratly (Nansha) Island. The continental shelf areas include the Mainland Shelf extending from the Taiwan Strait through the Gulf of Tonkin, the great shallow Sunda Shelf underlying the south-

* The coastal area as used here, includes the coastal waters and the continental shelf, as well as the adjacent shorelands and water bodies strongly influenced by each other and in proximity to the shoreline. For management purposes, the area can be considered as extending seaward to the limits of the exclusive economic zone (200 nm or 357 km) and landward to the extent necessary to control the shorelands, the use of which have a direct impact on coastal waters.

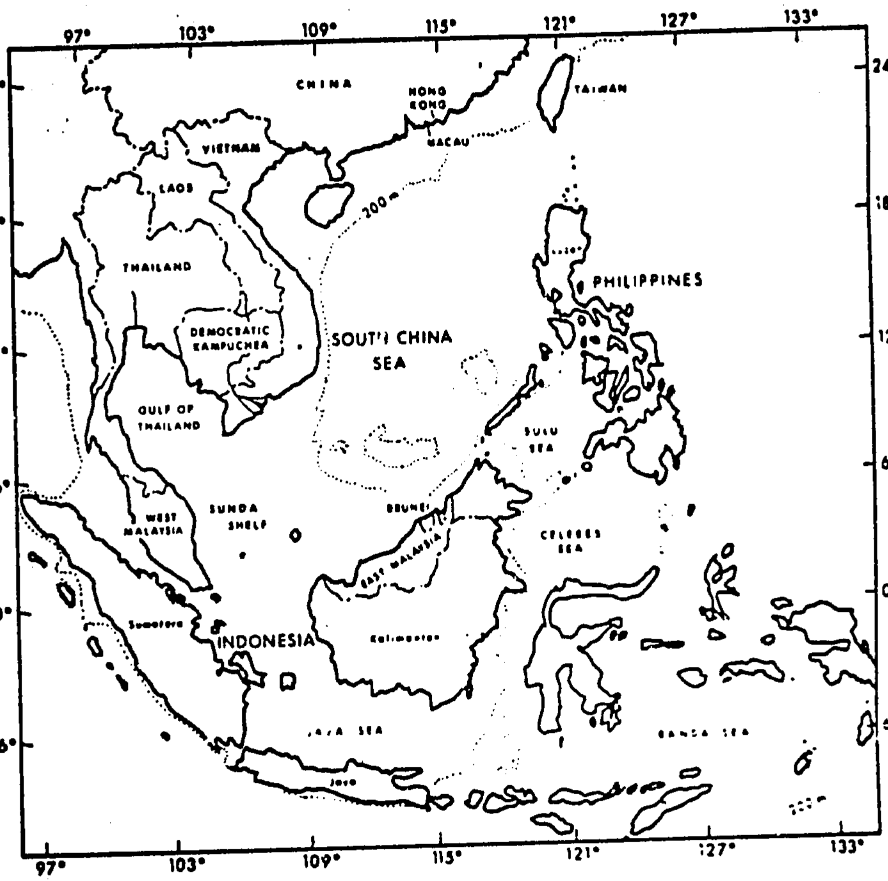


Fig. 1. Southeast Asia and the South China Sea (from Marr, 1976).

western South China Sea including the Gulf of Thailand, and the narrow shelves off western Palawan and Luzon. Two major petroliferous Tertiary basins underlie a portion of the Gulf of Thailand and the outer edge of the Sunda Shelf from northwest Borneo to Indochina. Smaller petroliferous basins are scattered along the Mainland Shelf and the coastal areas of the Indonesian, and possibly, the Philippine archipelagoes (CCOP-IOC, 1974). The Southeast Asian "tinbelt" extends southward from the Malay Peninsula to the "tin islands" of Indonesia (Singkep, Bangka and Billiton) and to the west and possibly the east of the Peninsula (Hosking, 1971).

The South China Sea region is situated almost entirely between the

Equator and the Tropic of Cancer and is under the influence of a monsoonal climatic regime. North of the Equator, the dry monsoon with northeasterly winds extends from October to April and the wet monsoon with southwesterly winds lasts from May to September (Marr, 1976). Precipitation in the region varies with the distribution of land and sea and mountain chains but 2,500 mm a year is common in the coastal area (Wyrtki, 1961, plate 15). The coastal climates and hence the coastal landforms, biological systems, and the very way of life of the inhabitants are thus monsoonal tropical throughout most of the region. Tropical ecosystems have evolved and flourished under relatively stable environmental conditions as compared to temperate regions and are thus possibly more vulnerable to geologically abrupt, man-induced impacts. The rate of environmental degeneration due to human impact appears to be greater than the rate of natural recovery or readjustment.

Fig. 2 illustrates the general morphology and significant features of the region's coastal area. Coastal plains are not a predominant coastal land type as compared to mountains and hills. However, extensive coastal plains are found along the western coast of Taiwan, on the Chinese mainland opposite Hainan and on northern Hainan itself, in central and extreme southern Vietnam, the southern Malay Peninsula, the entire northeast coast of Sumatra and north Java, the southern Celebes and almost all of Borneo. Deltas with mud flats and adjacent nutrient-rich, turbid coastal waters are generally located where the region's major rivers discharge into the sea, e.g., China's Si, Vietnam's Red and Mekong, Thailand's Mae Klong-Chao Phya, Burma's Irrawaddy, and Indonesian Borneo's Kapuas. Mangrove forests are a predominent coastal feature in northern and extreme southern Vietnam, Kampuchea, Thailand, Burma, the Malay Peninsula, Sumatra, north Java, Borneo and the Phillippines. Although patches of fringing coral occur along the land—water interface of virtually all the political entities of the region, extensive fringing reefs are limited to the eastern Indonesian Archipelago and the Philippines. Coral fringed islands, atolls and isolated reefs abound in the Gulf of Thailand, the eastern central South China Sea and throughout the Indonesian and Phillippine archipelagoes wherever sufficiently clear waters and geological development permit growth. Sandy beach is not a common coastal type in Southeast Asia. Extensive stretches of beach do occur in southwest and northeast Taiwan, central Vietnam, and along the east coast of the Thai Isthmus and the Malay Peninsula; smaller stretches of sandy beach are scattered throughout the region.

Earthquakes and volcanic eruptions are common throughout the Indonesian and Philippine island arcs and have generated destructive tsunamis; typhoons spawned in the Western Pacific frequently pass through the northeastern sector of the region.

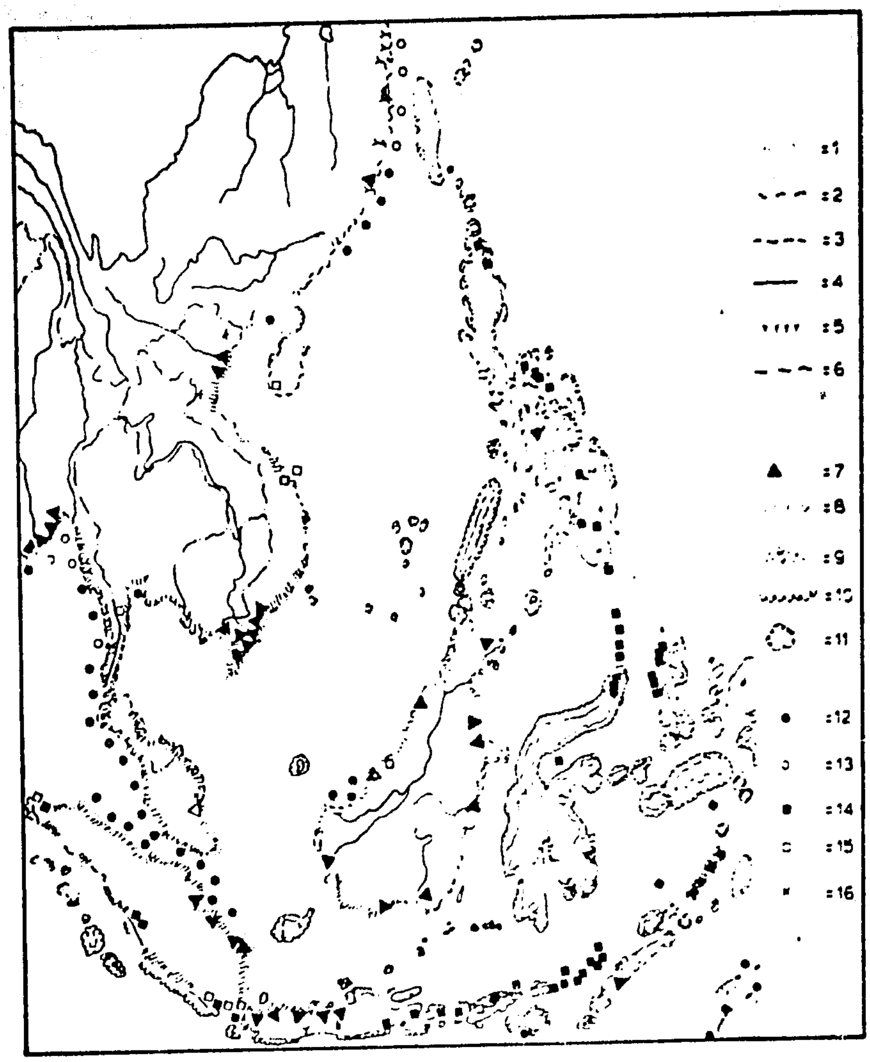


Fig. 2. Significant coastal features in Southeast Asia (after McGill, 1958): *1* = plain; *2* = plain <5 miles wide; *3* = hills; *4* = mountains; *5* = embayments; *6* = political boundary; *7* = delta; *8* = mangrove (extensive); *9* = dunes and beaches (extensive); *10* = fringing or barrier reef; *11* = isolated reef; *12* = tidal range ≥10 ft.; *13* = tidal range ≥20 ft.; *14* = active volcano; *15* = inactive volcano; *16* = karst topography.

Oceanography

Surface currents in the South China Sea are greatly influenced by the monsoon regime (Fig. 3). During the southwest monsoon, northeasterly currents, intensified in the western portion of the sea, dominate the surface flow. However, a weaker southwesterly return flow develops in the central eastern portion off Borneo, producing an anticyclonic circulation pattern. The main inflow at this time is Pacific Ocean water from the Java Sea via the Flores and Celebes seas, and the main outflow is through the Java Sea. During both monsoons, smaller amounts of water flow into the South China Sea through the Philippines from the Pacific and out to the Indian Ocean through the Malacca Straits (Wyrtki, 1961). Since the surface flow reverses direction twice each year and there is a counter current producing a circulatory gyre even at the peak of each monsoon, it is possible that flushing rates of surface layer pollutants deposited in the South China Sea are quite low. Water movement in the Gulf of Thailand is weakly anticyclonic during the southwest monsoon and weakly cyclonic during the northeast monsoon; here surface flushing rates are certainly low and deeper horizontal circulation is retarded by a shallow sill across the mouth of the Gulf. In the Philippine and Indonesian archipelagoes, deep circulation is inhibited by sills dividing the numerous separate deep basins, thus retarding replenishment and ventilation.

Maximum tidal ranges are greater than 3 m along the coasts of the Adaman Sea and Malacca Straits, as well as the head of the Gulf of Thailand, along southern Sarawak, the head of the Gulf of Tonkin and further east along the China coasts. Tidal ranges reach more than 6 m in the Taiwan Straits and at the head of the Gulf of Martaban (Fig. 2). Salinities are generally less than oceanic (35‰) throughout the region due to an excess of precipitation and runoff over evaporation, and nearshore or restricted areas can become brackish at times.

Nutrient enrichment of the surface layers is through vertical mixing over the shelf, river discharge and upwelling. Upwelling occurs during the southwest monsoon in the South China Sea and along the edge of the shelf southeast of Vietnam, and locally and temporarily during the northeast monsoon along the coast of China near Hong Kong and off Sarawak. Production is relatively high (>1.0 g C m^{-2} day^{-1}) over the Sunda Shelf such as in the Gulf of Thailand, along the east coast of the Malay Peninsula and between Sumatra and Borneo, and low (<0.5 g C m^{-2} day^{-1}) over the deep ocean areas (Wyrtki, 1961). Production of fish, crustaceans and molluscs is thus high in the shelf areas. Tropical marine ecosystems generally consist of large numbers of species with fewer individuals of shorter life cycles, as compared to higher latitude ecosystems. Fisheries in the South China sea are based on

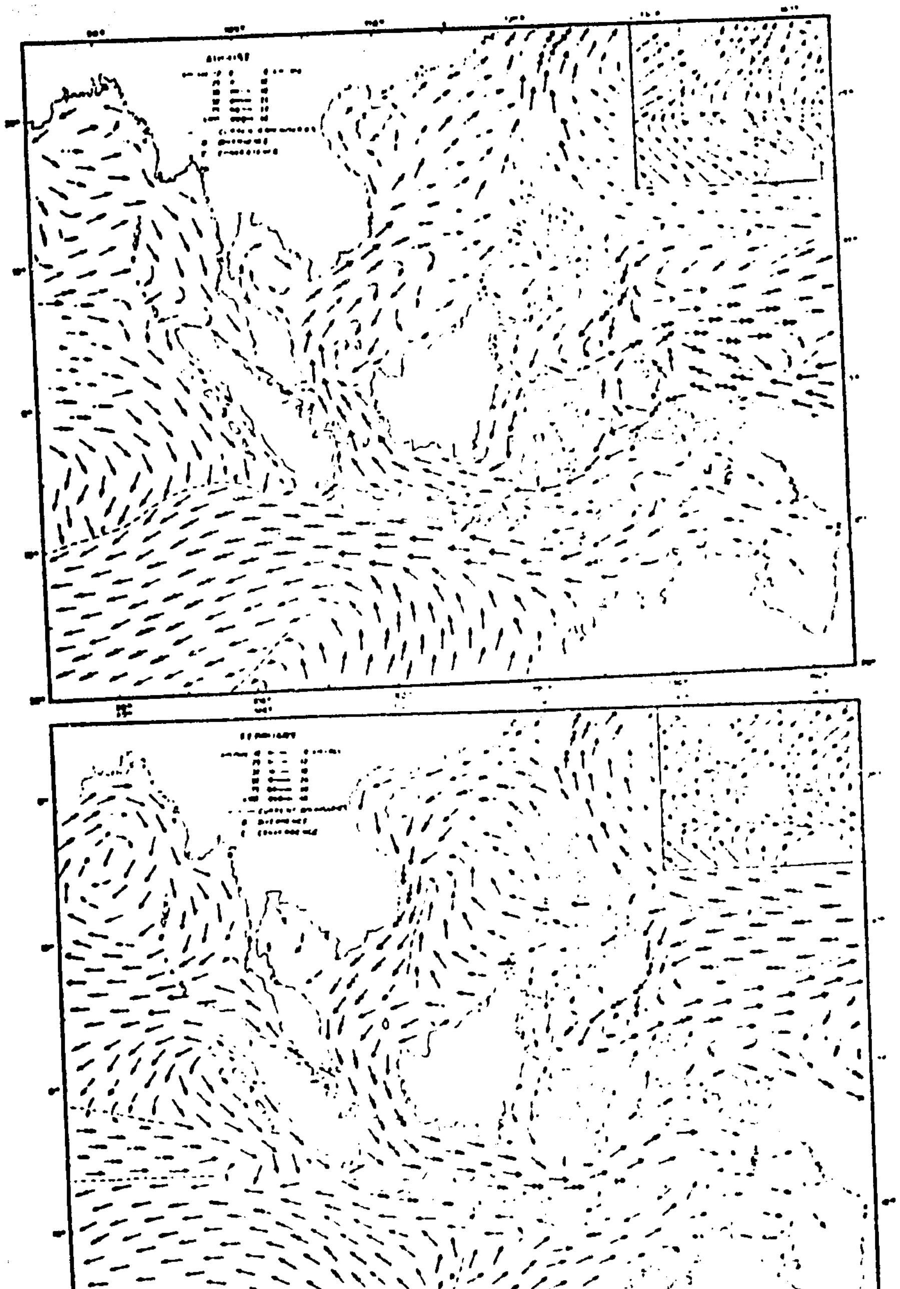


Fig. 5. Surface circulation in the South China Sea (from Wyrtki, 1961).

large numbers of short-lived species containing fewer individuals, and catches are thus "mixed" (Marr, 1976).

PRESENT AND POTENTIAL COASTAL AREA RESOURCE USES AND CONFLICTS

There are basically four categories of coastal area resource use conflicts: competition for coastal space itself, synchronic competing uses of the same resource, present dedicated use versus future use of the same resource, and uses at some distance away affected by uses that modify the coastal environment (Wenk, 1972). Table I provides a general categorization of compatibility among coastal area resource uses in Southeast Asia and serves as a guide to the following discussion.

Urbanization

The population in the coastal area of Southeast Asia is concentrated around coastal capital cities such as Taipei, Manila, Djakarta, Singapore, Bangkok, Ho Chi Minh, Hanoi-Haiphong and Hong Kong (Fig. 4). Densities are greater than 200/km^2 and increasing as rural inhabitants migrate to these areas, placing severe strains upon facilities, services and living space itself. This increased demand for scarce living space and the attendant strain on life-support systems often conflict with one another and with other uses of coastal space. With an increasing population and the lack of success, so far, in attempts to stem urban immigration from rural areas, this demand upon coastal space, as well as attendant conflicts, will be intensified.

Commercial/Industrial Activities

Urbanization in the region is also often accompanied by commercial/industrial growth, which serves as an attractant for the employment-seeking populace. Since most of the political entities of Southeast Asia are in a "developing" economic status, industrial activity is not as advanced or widespread as in the "developed" world, and is predominantly confined to primary processing of indigenous raw materials prior to export. However, because of few, if any, restrictions on industrial effluent, and lax enforcement, the damage to water quality by waste discharge and ensuing conflicts in coastal resource use may be as great, for a given length of shoreline, as that in a developed country with a higher concentration of industries, but

TABLE I

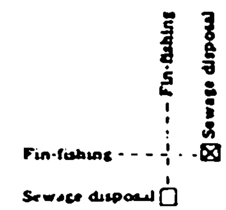
Southeast Asia: general functional compatibility categories for significant coastal area uses (after Wenk, 1972, Fig. 14)

		Introduced activities												
		Desalination	Transporation		Commercial fisheries					Extractive industries				
			Vessels	Port-side facilities	Off-shore	Artisanal (coastal)	Fin fish	Shell fish	Aqua-culture	Char-coal/fire-wood	Logging (defolia-tion)	Terres-trial mining	Petro-leum	Bottom mining
Existing activities														
Research/education	Space and facilities	X	X	X	2	2	2	2	2	X	X	X	X	X
Tourism/recreation	Aesthetics/conservation	X	X	X	X	X	X	X	X	X	X	X	X	X
	Swimming and diving	2	2	X	3	X	2	3	2	2	X	X	X	X
	Highway, airport, etc.										3	3	3	
Urbanization	Commercial-Industrial			3					3	3	3	3	3	3
	Habitation/Human health			X						3	2	2	2	3
	Land reclamation			2						2		2		2
Water use and	Sewage disposal									3	3	3		3
estuarine discharges	Power facilities	3					3		3	3	3	3	3	3
	Disease control							2	2		2	2		
	Agriculture wastes etc.										3	3		
Extractive industries	Bottom mining		3		3	3	3						3	3
	Petroleum		3		3	3	3						3	3
	Terrestrial mining											3		
	Logging/(defoliation)										2	3		
	Charcoal/firewood					3			2	3	2	X		X
Commercial fisheries	Aquaculture	X		2		2	3			3	X	X	X	X
	Shellfish	X	3	2				3	2	2	X	X	3	X
	Fin fish	3	3	2		2	3		3	2	X	X	2	X
	Artisanal (coastal)	X		X	2	2	2		2	2	X	X	X	X
	Offshore	3	3	2		2	3		2	2	X	X	2	X
Water transportation	Portside facilities					3				3	3	3	2	3
	Vessels		3		3	3	3		2	3	3	3	3	2
	Desalination	3					3						3	

TABLE I (continued)

	Introduced activities										
	Water use and estuarine discharges				Urbanization				Tourism/recreation		Research/Education
	Agri-culture: wastes etc.	Disease control	Power facilities	Sewage disposal	Land recla-mation	Habita-tion/Human health	Commer-cial-Indus-trial	Highway-airport etc.	Swim-ming and diving	Aesthe-tics/conser-vation	Space and facili-ties
Space and facilities	X	X	X	X	X	X	X	X	X		
Aesthetics/conservation	X	X	X	X	X	X	X	X	3		
Swimming and diving	X	3	2	X	X	2	X	3	2	3	
Highway, airport etc.										X	
Commercial-Industrial	3	3		2	3	3	3	3		X	
Habitation/Human health	2	3	3	X	3	2	X	3		X	
Land reclamation		3								X	
Sewage disposal	3	2		2	3	2	2			X	
Power facilities	3			2	3		3	3		X	
Disease control	2	3		2	2	3	3			X	
Agriculture: wastes etc.	3	2								X	
Bottom mining					X		3			X	
Petroleum										X	
Terrestrial mining		3								X	
Logging/(defoliation)		3								X	
Charcoal/firewood					3	2				X	
Aquaculture	X	X	X	X	X	2	X	2	3	X	
Shellfish	X	X	X	X	X		X	3	2	X	3
Fin fish	X	X	X	3	X		X		2	X	3
Artisanal (coastal)	X	X	X	2	X		X		2	X	3
Offshore	X	X	X	3	X		X		3	X	3
Portside facilities	3			3	3		3	3	3	X	
Vessels	3			3	3				3	X	
– Desalination	3	3	3	3	3		2			X	

Example 4



Introduction of commercial fin-fishing activities, will not have adverse effects on existing sewage disposal activities; however, introduction of sewage disposal could have highly adverse effects on existing commercial fin-fishing activities.

Potential degree of compatibility:

High
3 Medium
2 Low
X Very low

Assumes functional, not locational conflict; activity will not be introduced into an area where a suitable location is unavailable.

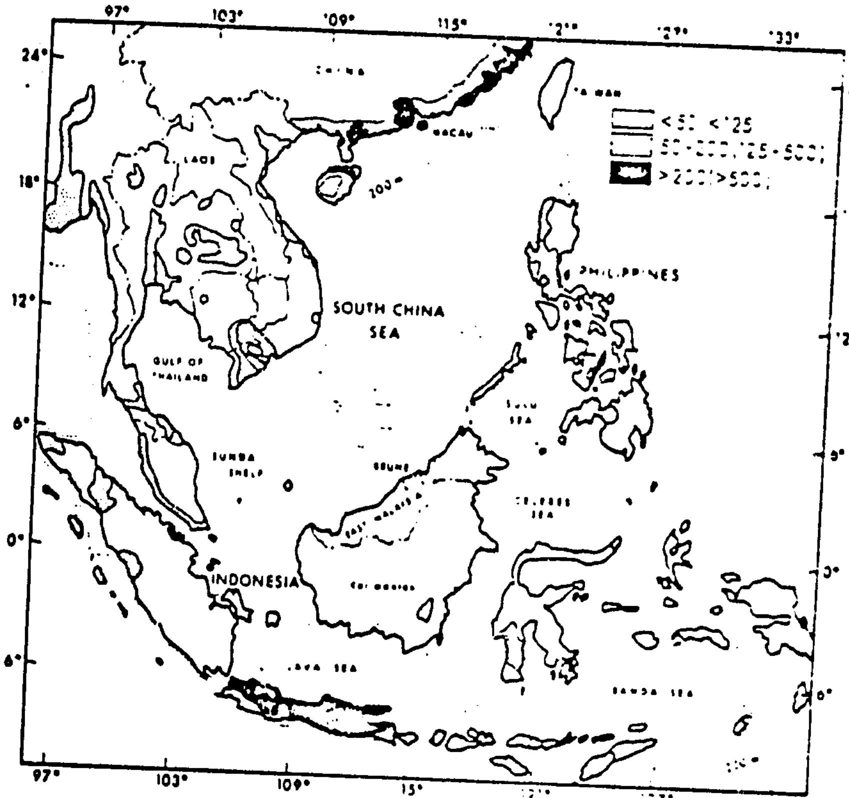


Fig. 4. Southeast Asia: population concentrations (after Anonymous, 1964) (inhabitants km^2).

with stringent environmental regulations and enforcement procedures. Primary processing industries in the region are normally established on the coast or adjacent to rivers and estuaries due to the need for a ready water supply and a ready waste-disposal system: in any event, the waste eventually reaches the sea. Common agriculturally based industries, which produce significant amounts of organic wastes, include tapioca, soyabean, pineapple canneries, sugar mills, fish and shellfish processing, fish meal, rubber, palm oil, wood processing and livestock. Significant contributors of chemical and heavy metal waste include such industries as pulp and paper, metallurgical (smelting), electrical, chemical, plastics, petrochemical, refining, textiles and monosodium glutamate (FAO/IPFC, 1976).

Industrial/commercial activities compete for space with, and degrade the environment for, healthy human habitation; effluents may also adversely impact commercial fisheries and the fishery resource. The situation along the west coast of West Malaysia is indicative of similar, but undocumented, present or potential conflicts elsewhere in the region. Agricultural products comprise a third of Malaysia's exports, and Malaysia is the world's leading producer of rubber and palm oil. The processing of rubber and palm oil contributes great amounts of oxygen-consuming organic wastes, although effluents from tapioca, sugar cane, pineapple and soyabean processing add to the man-induced biochemical oxygen demand in Malaysian water bodies. Only half of Malaysia's palm oil mills have effluent-treatment facilities and the majority of waste is sludge. Nearly $30 \cdot 10^6$ litres of rubber wastes and $2 \cdot 10^6$ metric tons of oil palm effluents are discharged annually into Malaysia's water courses. The biochemical oxygen demand of oil palm wastes alone in 1975 was equivalent to the total wastes from a community of $11.8 \cdot 10^6$ people, a little more than the present population of West Malaysia.

The decline of river and paddy field fish due to a combination of agricultural processing wastes, industrial effluents and extensive pesticide and herbicide use in paddy fields has significant socioeconomic implications, as much of the poorer rural Malay population use river and paddy field fish to supplement their diet and income. Also, three quarters of the protein intake of west coast Malaysians is derived from fish taken in the Malacca Straits and coastal rivers, and half ($45 \cdot 10^3$) of the country's full-time fishermen ply their trade in these waters. However, west-coast fisheries production has declined significantly in recent years due to biological overfishing and possibly to pollution of coastal spawning and nursery habitats. This production decline has intensified intra- and international competition for the available fish, resulting in an increasing frequency of violent intra- and international incidents. The quality of living adjacent to effected water bodies is also a potential socioeconomic concern in this tropical region, where much of the rural population is already unable to function at full capacity due to persistent debilitating maladies such as parasites.

The conflicts, which are most acute in Johore, Selangor and Perak, are relatively recent, as oil palm cultivation was introduced on a large scale only in 1966, and rubber was traditionally processed in Singapore. However, a 20% increase over the 1975 palm oil production was projected for 1976 and by 1978, 2000 km^2 will be added to 1976 cultivation, comprising a total of 7000 km^2 (Ho Kwon Ping, 1976a).

Specific Malaysian examples of deleterious effects of agricultural industrial wastes on fisheries include the destruction of oyster beds in estuaries of the Sungai Muar and Sungai Perak by effluents from sawmills, boatyards and iron foundaries (Jothy, 1976), and the termination of the Kuala Juru fishery. The latter event was a result of waste discharge into a tributary of the Sungai Juru from 39 factories in the Prai Industrial Estate and Free

Trade Zone. These factories produce synthetic textiles, industrial chemicals and gases, palm oil, insecticides, fertilizers, light metals, plastics and drugs. There are 34 industrial estates on the west coast concentrated around Penang, Kuala Lumpur, Johore and Malacca; 18 more are planned including 8 for the undeveloped east coast (Ho Kwon Ping, 1976b).

In the Philippines, 31 rivers are reported as polluted by discharge from sugar-mill distilleries, textile factories, pulp and paper mills and food-processing plants, engendering complaints from fishermen, fishpond operators, farmers and housewives (Lesaca, 1974). During the dry season, 80% of the flow of the Mae Klong river in central Thailand is used by 12 sugar mills for a once-through coolant and cleanser. These mills discharge a total of 136 metric tons of waste per day exceeding the river's dry-season carrying capacity of 45 metric tons per day and rendering the river water unfit for irrigation or domestic use (Michaels, 1976). In Hong Kong, destruction of fish in 30 floating fattening cages was caused by effluents from a nearby film-processing studio (Thompson, 1976). In this manner, tourism recreational amenities can be degraded and the water may become unfit even for other industrial uses, such as coolant in power facilities, without pre-treatment; downstream silting of harbor facilities may also result.

Although primary processing of indigenous resources will continue to grow with economic development, resulting eventually in manufacturing industries based on indigenous resources, environmental awareness appears to be increasing in, e.g., Singapore, Malaysia and Thailand, and may result in a reduction of incompatibilities when implementation *and* enforcement of stringent discharge restrictions become politically and economically feasible.

Highways and airports

Highways and airports are also generally concentrated in the areas of highest population densities and can be expected to expand as development proceeds. The decision to construct a major highway or airport in a particular coastal area usually precludes the conservation of the site for aesthetic purposes. Attendant land-clearing and construction may increase coastal accretion rates and suspended-sediment content of nearshore waters, thus contributing to the silting-up of deepwater berths, shellfish beds, aquaculture ponds, and necessary pre-treatment of cooling water in power facilities.

Land reclamation

Because of the relative scarcity of permanently dry, level land in the Southeast Asian coastal region, and the ensuing conflicts over use of that resource, land reclamation is widely practiced as a short-term solution. It is usually achieved by infilling of mangrove-dominated intertidal regions with sanitary and, occasionally, unsanitary fill. Siltation from dredging and filling operations and seepage from unsanitary fill can be inimical to all aspects of nearshore commercial fisheries and aquaculture, tourism/recreation, and "control areas" for environmental monitoring, and reduces the quality of water that may be used for domestic or commercial/industrial purposes. Potential bottom mining and shell fisheries would be precluded as an option in a reclamation area. Reclamation projects have been completed or are underway in many coastal urban areas, including Hong Kong, Singapore, Java, Penang, Kota Kinabalu and Manila; a large land reclamation project for agriculture is also ongoing in southeast Sumatra. With increasing pressure for suitable land for industrial development, land reclamation will become an even more attractive option.

Water use and estuarine discharge

Sewage disposal

Domestic effluent from the region's coastal urban concentration is generally discharged untreated into the nearshore area, often exceeding the dispersal, dilution and decomposition capacity of that environment. In addition, sewage in rural areas is both a point and a non-point source pollutant. Sewage can contaminate water, aquaculture products and natural shellfish beds with viral and bacterial pathogens (hepatitis, typhoid, dysentery, cholera) deleterious to human health, and through decomposition, competes for oxygen with finfish larvae being nurtured in the estuarine environment. For example, in the Philippines, mussel and oyster beds around Manila Bay and brackish-water fishponds just north of Manila have experienced reduced production supposedly due to effects of sewage discharge (Garcia, 1976). In Hong Kong, oysters in Deep Bay are reported to contain faecal bacteria (Thompson, 1976) and dysentery is thought to have been transmitted from consumption of cockles in Malaysia (Jothy, 1976). Even epidemics of typhoid and hepatitis have been linked to consumption of sewage-contaminated water and shellfish in Vietnam (Tran-ngoc Loi, 1976).

Unrestricted, untreated sewage and garbage disposal are also proving incompatible with tourism/recreation in Southeast Asian coastal areas. In the Philippines, beach resorts near Manila have been abandoned, (Garcia, 1976) whereas garbage is an aesthetic nuisance and even a navigation hazard in Hong Kong Harbor (Thompson, 1976), eventually stranding on beaches. Coastal waters off Johore Bahru and the tourist mecca of Penang are unfit for swimming by developed country standards (Jothy, 1976) whereas beaches of Nha Trang, Da Nang, Vung Tau and Rach Gia in Vietnam are littered with sewage and garbage (Tran-ngoc Loi, 1976). Domestic, power-facility and industrial/commercial users of sewage-laden water may find pre-treatment necessary or desirable. Increased siltation rates from sewage discharge can block natural and artificial drainage systems causing floods and inhibiting such diverse activities as mangrove harvesting and coastal vessel transport. For example, infilling of the ancient drainage systems of Bangkok (klongs) and Manila (esteros) with domestic waste has been linked to flooding in those cities. Due to limited space available for settling ponds, the cost of more complex treatment methods and population increases, waste disposal will continue to be a coastal resource use incompatible with many others.

Power facilities

Fossil fuel power facilities require large amounts of cooling water. Adverse interaction with other coastal uses such as fisheries, stems from impingement, entrainment, and thermal and chemical (defoulant) effluent. Radioactive waste from proposed nuclear power plants is a future consideration. Coastal fisheries resources might be adversely affected by either type of power plant, and human health might be endangered by unsafe operation of, or waste discharge/disposal from, nuclear plants. Since most of the region's nations are not industrialized, fossil fuel power facilities tend to be few, and are concentrated in or near the major population centers; further development of fossil fuel power facilities will accompany development. Nuclear power is envisioned by several of the region's entities; Thailand and the Philippines plan to implement two stations in the near future; Indonesia plans 15 to 25 such plants by the year 2000; one nuclear power plant is already operational in Taiwan and another is planned (FAO/IPFC Secretariat, 1976).

Disease control

Measures to control potential mosquito vectors of malaria, filiriasis and dengue fever include filling of potential breeding areas and widespread use of insecticides such as DDT. These insecticides can adversely impact fisheries/aquaculture through direct kills in confined areas or through decreased marketability of contaminated products; tourism/recreational activities may be similarly restricted. Mosquito control measures may also demand modification of other activities which create breeding places for mosquitoes, e.g., logging, terrestrial mining and land reclamation. Although use of the less persistent organophosphates has increased in recent years, total use of insecticides for disease control has also increased markedly and the predominant types of insecticides imported into the region are still organochlorines (FAO/IPFC Secretariat, 1976); the trend away from organochlorines, but toward increased insecticide use, is expected to continue.

Agriculture

Agriculture involves land clearing, dam construction for irrigation and flood control, tide-forced irrigation, and the use of herbicides, pesticides and fertilizers. Dam construction retards river flow, reducing the water body's

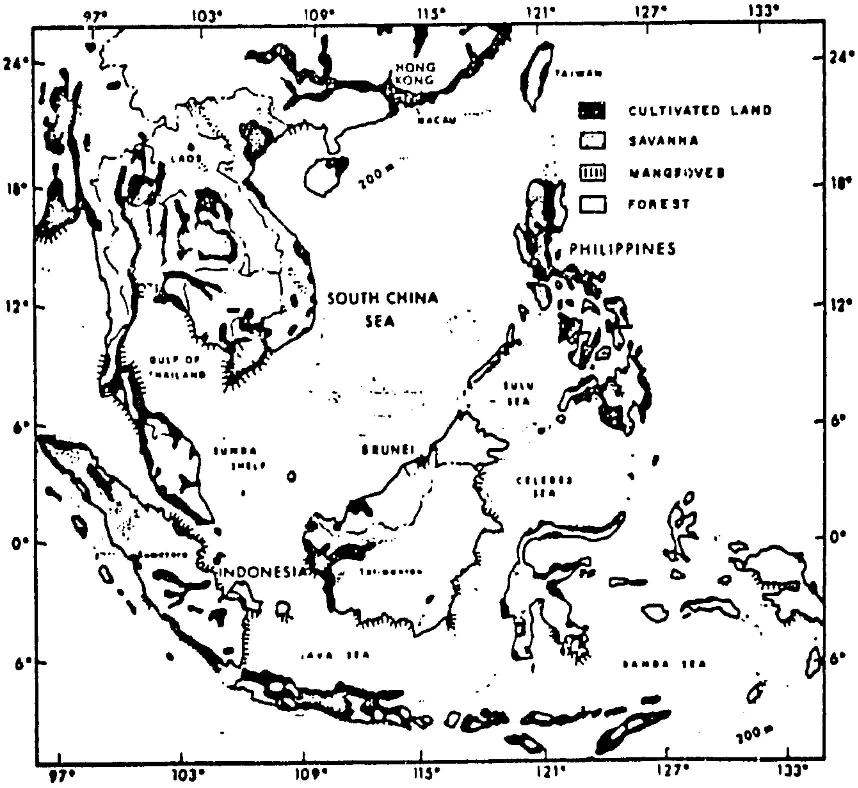


Fig. 5. Southeast Asia: cultivated land (after Anonymous, 19[illegible]4).

downstream capacity to decompose, transport and/or dilute wastes, and increasing sedimentation rates which can contribute to flooding during the rainy season. Commercial fisheries and aquaculture can be adversely affected by dam construction through a reduction in nutrient supply, and by runoff of herbicides, pesticides, fertilizer and sediment from agricultural lands, overloading the coastal strip and nearshore waters. In this manner, the suitability of water for domestic, industrial and power plant use may also be adversely affected, and channel and harbor silting may be accelerated.

For example, in Malaysia, Indonesia and Vietnam, a linkage between the decline in rice-field fish production and increased use of pesticides has been observed, and in the Philippines, artisanal fishermen along the coast have complained that agricultural pesticide runoff has depleted fishery resources and contaminated river water so that it is unusable for domestic purposes (Garcia, 1976). The distribution of cultivated land (Fig. 5) generally coincides with that of high population density (Fig. 4), i.e., cultivated land and population are concentrated in coastal plains and river valleys. Although much of the arable land in the region is already in use, more land will be cleared and fertilizer and herbicide/pesticide use will be intensified on existing and newer, less arable land, as demand for land, and food, increases.

Water transportation

Many of Southeast Asia's ports are highly congested, have antiquated facilities, and are shallow and subject to heavy siltation. Severely congested and/or silted ports include Bangkok, Penang-Butterworth, Port Swettenham, Port Klang, Hong Kong, Manila and many smaller ports on the South China Sea. Moreover, those nations bordering on the shallow Sunda Shelf have few naturally suitable areas available for port construction. Expansion of existing ports and construction of deep-water facilities are planned by many nations of the region. For example, deep-water commercial and/or naval ports are planned by Thailand for Sattahip and Songkla on the Gulf of Thailand and at Phangna and Phuket on the Andaman Sea. Port expansion and maintenance entails almost constant construction and dredging of channels and berths to meet the demands of increased, and deeper draft traffic, while new port establishment is inevitably accompanied by a concentration of coastal commercial and industrial activity, human habitation, and pollution. Port construction inhibits many other coastal resource uses at or adjacent to the selected site, such as water-oriented tourism recreation, fisheries, conservation, and bottom mining for tin such as in, e.g., Penang Harbor (Malaysia), an area of mining interest.

Any sediment-generating activity in the vicinity of the port would contribute to increased maintenance costs. In some of the shallow straits, e.g., the Malacca Strait, and nearshore areas of Southeast Asia, siltation combined with changing bottom configuration introduces hazards to shipping. Other coastal activities such as static artisanal fisheries using traps and nets, as well as active fisheries, water-contact recreation, and petroleum exploration/exploitation and bottom-mining operations could interfere with vessel traffic.

Extractive industries

Hydrocarbons

Hydrocarbon exploration, exploitation and transport can physically interfere with fisheries operations and general shipping, and through deliberate discharges and spills from these activities, or during oil use, storage and refining, endangers the aesthetic aspect of tourism/recreational facilities, nature preserves, and edible and/or integral components of the ecosystem, including commercial fisheries and aquaculture products. Oil in the coastal environment also decreases water quality for desalination, power plant cooling, and commercial/industrial and domestic use.

Present status

Fig. 6 is an oil and gas map summarizing current offshore hydrocarbon exploration activities in Southeast Asia. Probably all of the continental shelf has been explored by the oil and gas industry; and most of it has been leased, with the present exception of areas claimed by Kampuchea and Vietnam. * Important non-Indonesian producing fields or discoveries include Bintang, Tapis, Bekok, Pulai, Seligi, Sotong and Anding oil fields, and Duyong gas field off the east coast of West Malaysia; South Furious, Tembungo, Erb West, and Samarang oil fields off west Sabah (East Malaysia); Champoint, Fairley, Seria and Swampa oil fields off Brunei; and Fairley-Baram, Baram, Baronia, Betty, Bokor, Bakau, Tukau and Temana oil fields and Central

* Areas originally offered under concession agreements by Thailand are disputed by Kampuchea and Vietnam. In the interim, the industry has agreed not to drill in the disputed area although it appears to be one of the more promising from a geological viewpoint. One oil company had reportedly made a discovery in Kampuchean waters, but has since abandoned the well for non-technical reasons. Similarly, considerable interest has been shown by the industry in southern Vietnamese waters and Elf-Aquitaine of France has recently signed an offshore exploration and exploitation agreement with Hanoi.(Nayan Chanda, 1977).

Fig. 6. Southeast Asia: present and potential offshore hydrocarbon exploitation and lease history (UNDP/CCOP, 1974; CCOP–IOC, 1974, Rowley, 1977).

Laconia and West Lutong gas fields in adjacent Sarawak waters (Rowley, 1977). Two recent offshore discoveries in the Phillippines are Nido No. 1 off northwest Palawan and Sampaguita on the Reed Bank near the disputed Spratly Islands (Gonzaga, 1976). Important offshore Indonesian producers include Gita, Rama and Arjuna oil fields in the Java Sea, and Attaka oil field off east Kalimantan. No confirmed reports of pollution-causing blowouts in the area are known to this author.

Potential development areas

Under general arrangements between foreign oil companies and governments, large offshore areas are leased for exploration for limited durations. At the expiration of the time limit, the company must relinquish the initial lease area, except for a small portion where it will concentrate its detailed exploration and perhaps its exploitation effort. Thus, on the basis of lease history, areas of the shelf can be classified as having unknown, low, moderate and high potential for hydrocarbons (Fig. 6). If an area has been leased and relinquished twice, e.g., south, west and east of Natuna Island, between Sumatra and Kalimantan, off west-central Sumatra, the central Java Sea, off south-central Java, off southeast Kalimantan, and north and southwest of Irian Jaya, the prospects of significant hydrocarbon potential and thus activity in that area are less than if the area has only been leased and relinquished once. Such areas include that immediately offshore of the east coast of West Malaysia and around and northwest of Natuna Island, the central-western Malacca Straits, between Singapore and Kalimantan, north from Kuching and the coastal strip along Sarawak and west and northeast Sabah, several areas at the mouth of Darvel Bay, off southwest Kalimantan, the northwest and central Java Sea, off extreme southwestern Sumatra, off south-central Java, the western Flores Sea, and off Sulawesi, Halmahera and Morotai, and the Moluccas.

Excluding those areas which are presently productive, the remaining areas have either never been leased, or have been leased and explored, have potential, and have been retained, it is these latter areas such as the Gulf of Thailand, * the Andaman Sea, the western Malacca Straits, the southwestern and southeastern Sulu Sea, and off western Palawan, the Visayan Sea, the Makassar Straits and the Western Vogelkop, that are the sites of the most intense interest and exploration activity and that offer the most potential for discovery on the shelf.

* However, the gas/oil well ratio increases markedly as exploitation proceeds northward from the Indonesian island arc, possibly due to post-depositional heating of petroleum deposits by granitic intrusions.

Deeper water, i.e., the continental slope (including inter-arc troughs and sediment-filled trenches), the continental rise and small ocean basins are also receiving exploration and lease attention although the exploitation technology is not yet available for water depths beyond 200 m. However, exploratory drilling has been conducted in over 800 m of water on the Thai portion of the Andaman Sea (a world record), and full-scale exploration programs are being initiated in many areas under 610 to 915 m of water extending at the extreme to 2,750 m water depth (United Nations, 1973). It is noteworthy that while some concessions on the shelf near Phuket have been relinquished, there have been widespread rumors of a significant discovery in the deep-water wells drilled by Esso and Union: the discovery of particularly favorable geologic structures there has been acknowledged. In fact, more deep-water area has been leased in the Southeast Asian region than in any other region, because the geologic regime and ocean environment are particularly favorable and therefore more attractive to deep water exploration and exploitation. However, exploitation technology for these depths is not expected to be available before the 1980's (United Nations, 1973), and extreme technical difficulties and concomitant expense encountered by Esso in drilling its world record water depth well, combined with recent Indonesian and Malaysian alterations of their profit-sharing agreements, and the reduction in depletion allowances and allowable tax deductions on overseas earnings for U.S. companies may retard development of deep-water deposits in Southeast Asia (Business Information and Research, 1977).

In addition to the southeastern Andaman Sea continental slope and rise, examples of deep-water leases in Southeast Asia include the southeast Sumatra inter-arc trough and trench, Makassar Straits continental slope and rise, and the east Timor trench. Although the geology of the seaward provinces beyond the upper continental slopes has been little investigated with respect to petroleum potential, in general, the small ocean basins such as the Andaman, South China, Sulu, Celebes, and Banda Seas appear to be promising (United Nations, 1973). In any event, long-range coastal area development planning must consider the probability of deeper water hydrocarbon exploitation in the next decade.

Transportation, storage and refining

Transportation routes and refineries together with a general geographic categorization of potential oil pollution are illustrated in Fig. 7. The major transportation route for oil imported into the region is from the Middle East and Africa through the Straits of Malacca to Japan (Soegiarto, 1976) with offshoots to Thailand, Taiwan and the Phillippines (Anonymous, 1977b;

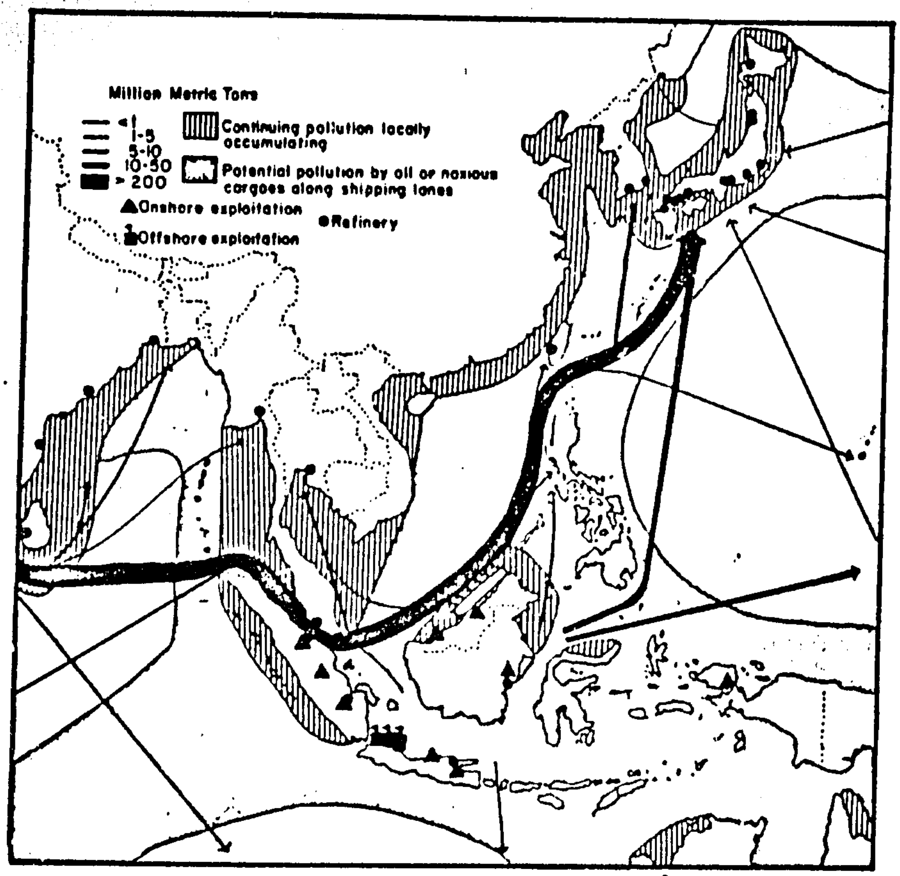


Fig. 7. The South China Sea: major sources of oil pollution — transportation routes, present exploitation and refineries; potential areas of concern (FAO/IPFC Secretariat, 1976; McGwire and Broeren, 1975).

Das, 1977) including transshipment in Singapore. The 920 km long, 15 to 232 km wide Straits of Malacca is the world's second most busy seaway; over 100 vessels transit the Straits every day, including six greater than $30 \cdot 10^3$ dwt ($27.2 \cdot 10^3$ metric tons) and 10 VLCC's per day are expected in 1980 (Moberg, 1976). Within the region, Indonesian production is exported to Japan, the United States, the Philippines, Thailand and Australia, whereas Brunei's production is exported to Japan and Thailand. Thailand and the Phillippines (and Japan) import oil from China (not shown). Numerous spills and discharges during transport have occurred (Table II) and the expected

TABLE II

South China Sea region: some oil transport accidents

Immediate waters affected	Date	Vessel name	Cause	Amount (metric tons); type spilled
Hong Kong (FAO/IPFC Secretariat, 1976)	11/68	Columbia Trader	Grounding	172; heavy marine diesel oil
Hong Kong (Thompson, 1976)	1/73	Eastgate/ Circea	Collision	181; aviation fuel
Hong Kong (FAO/IPFC Secretariat, 1976)	4/74	Korea Hope	Grounding	145; aviation fuel
Indonesia, Malaysia, Singapore (FAO/IPFC Secretariat, 1976)	1/75	Showa Maru	Grounding	6,350; crude oil
Malaysia (Penang) (FAO/IPFC Secretariat, 1976)	8/75	Tolo Sea	Grounding	36
Malaysia (Tg. Kling) (New Straits Times, 1977)	5/77	Asian Guardian	Pipeline burst	54
Taiwan (Anonymous, 1977a)	3/77	Borag	Grounding	9,000
Vietnam (Tran-ngoc Loi, 1976)	1974	?	Mined	?
Singapore/Indonesia (Soegiarto, 1976)	4/75	Tosa Maru/ Cactus Queen	Collison	?
South China Sea (Haslam, 1977)	3/74	Sir Winston Churchill	Grounding	?
North of Sunda Sea (Haslam, 1977)	3/73	Igara	Grounding	?

increase of vessel traffic in the region raises the probability of accidental transport-related spills in this semi-enclosed sea. However, a recent tanker-safety scheme introduced by Malaysia, Indonesia and Singapore to regulate tanker traffic in the congested Malacca and Singapore Straits will eventually encourage a detour by VLCC's over $250 \cdot 10^3$ dwt ($227 \cdot 10^3$ metric tons) through the deeper Lombok and Makassar Straits and the Sulu or Celebes Seas (Das, 1977).

Petroleum discharge during tank cleaning and from transfer operations at wells, terminals, storage tanks and refineries, as well as from non-point sources, also contributes significant petroleum to the region's coastal environment. Tanker terminals and/or refineries illustrated in Fig. 7 include three in Ban si Racha, Thailand, two in Port Dickson, Malaysia, five in Singapore, and those at Cilicap, Bali, Merak, Wonokromo, Pladju, Sungai Gerong, and Balikpapan in Indonesia, two at Tambangai in the Philippines, and at Keelung, Taiwan. Refineries/terminals are planned for Tg. Gelang, P. Tioman and Labuan in Malaysia and P. Batam in Indonesia. Dispersants used to combat the visual aesthetic damage caused by a slick were in the past often more immediately toxic than the oil itself; $15 \cdot 10^3$ litres/year of BW Concentrate were used routinely in Hong Kong harbor and $60.5 \cdot 10^3$ litres of BW Concentrate and $11.4 \cdot 10^4$ litres of a Shell "low toxicity" dispersant were used after a tank farm spillage there. Large amounts of dispersant were used on the Showa Maru spill in the Malacca Straits (Thompson, 1976).

A few complaints from Malaysian fishermen have been registered concerning tar balls in their nets while fishing in the Straits of Malacca (Jothy, 1976) and the catch of 100 fisherman was adversely affected by oil spilled from a burst pipeline during tanker offloading operations at Tg. Kling (New Straits Times, 1977). In Vietnam, cultured fish and lobsters were tainted for two weeks from an oil spill, and corals exposed at low tide were adversely affected. Vietnamese fishermen attributed the scarcity of milkfish fry sought for culture seed from Cam Ranh Bay to the thick oil film present there, and fishermen at Binh Cang asserted that mullets and green mussels were often tainted (Tran-ngoc Loi, 1976). In Hong Kong, failure of the foundations at Ap Lei Chau tank farm on 8 November, 1973 released $3.6 \cdot 10^3$ metric tons of heavy marine diesel oil into Picnic Bay and Aberdeen Harbor, killing outright many fish being kept in floating cages for fattening, and rendering the remainder unmarketable due to skin blemishes and tainting. A total of US $1,200,000 was paid in compensation for the market value of the fish and loss of earnings. Wild fish were also destroyed by the spill (Thompson, 1976). Oil lumps have washed up on tourist resort beaches from Port Dickson to Malacca in Malaysia, several locations in Indonesia (Soegiarto, 1976) and at Pattya and Bang Saen (Michaels, 1976) in Thailand.

Bottom mining

Bottom mining for, e.g., tin or sand and gravel involves dredging and disposal of tailings. Offshore mineral exploration and dredging can thus inter-

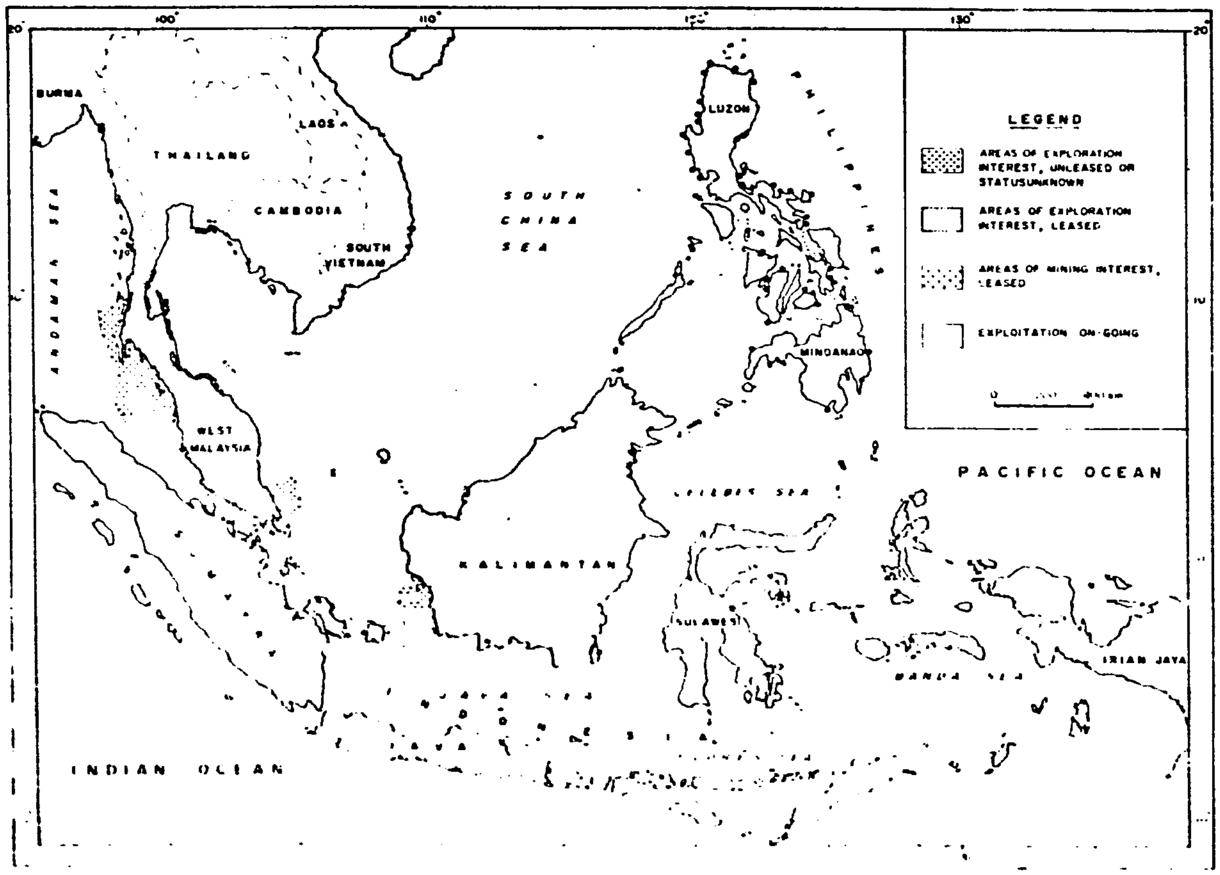


Fig. 8. Southeast Asia: bottom and coastal mining areas of interest, exploration and exploitation (compiled from various personal communications).

fere with marine transportation and fisheries operations, and through increased turbidity and siltation, as well as through alteration of the bottom and/or shore sediment regime, can directly or indirectly endanger or adversely influence aquaculture and the harvest of pelagic and benthic fish by direct removal and smothering of benthic organisms and alteration of bottom character. Increased turbidity may decrease primary productivity or force pelagic fish to migrate or de-school. Other coastal area resource uses affected by bottom mining include tourism/recreation and even human settlements through alteration of the coastlines, when current and/or wave regimes and the sediment budget are changed. High sediment content may also render water unsuitable for agricultural, commercial/industrial and domestic use, power plant cooling or desalination. With bottom dredges operating in the vicinity, port facilities may become silted, sewage sludge or other benthic waste may be resuspended, harvesting of mangrove may be inhibited, and aquaculture ponds silted-up.

Fig. 8 summarizes the principal areas of current detrital mineral interest, exploration and exploitation in the coastal area of Southeast Asia. Tin exploitation in Indonesian waters is concentrated in several localities around the "tin islands", Banka and Belitung, whereas an entire envelope enclosing these islands and extending to the northwest to the international boundaries with Singapore and Malaysia and including the islands of Singkep, Lingga, Karimun, Kundur and Riau, is considered of good potential. Although no systematic exploitation of tin is being undertaken in Malaysian waters, small areas of Lumut and Malacca are being systematically test-drilled and the entire west, south and southeast West Malaysian state and federal territorial waters are considered as having potential, especially the Johore estuary (Hosking, 1971; 1973). In Thai waters, mining is ongoing off southeast Phuket and in portions of a coastal strip extending from southwest of Phuket to the Tahi–Burma border. Some tin is being won from beach deposits near Rayong in southeast Thailand and there is good potential in Phang-nga Bay and some offshore exploration interest north and south of Songkla and west and east of Rayong. The southeast appendage of Burma, on the basis of geology and occasional independent operators, has long been considered to harbor significant tin resources (Hosking, 1971), but no organized exploration or exploitation in the coastal area is known to this writer.

Potential tin-mining areas

Maximum sub-sea mining depth of detrital minerals feasible with present conventional technology is approximately 50 m, although skin deposits might be mineable to depths of 65 m (A.L. Scholtens, personal communication, 1974). Although the 50 m isobath includes a large portion of the continental shelf in Southeast Asia, geologic considerations such as a 2–8 km maximum transport distance from source for economic deposits of placer tin (Hosking, 1971), presence or absence of coastal, or offshore granitic exposures, or shallowly buried granites or ultra-basic rocks, and the presence or absence of a large coastal plain, significantly narrow the prospecting area. The occurrence of basins containing hydrocarbons is also a general indication of low potential for tin and other detrital mineral deposits.

Other detrital materials

Silica sand prospects and/or exploitation are known at a few localities along the coast in Rayong Province (southeast) and southwest Chumpon Province, Thailand, and at some ten sites scattered throughout the Philippines. In Indonesia, iron sands are being mined at Cilicap and are to be developed immediately south of Jogjakarta. Numerous mining leases for iron sands have been awarded throughout the Philippines, especially in northern, western and southeastern Luzon. Dredging of live and dead coral heads for construction use has severely damaged the reefs of west Sabah, particularly in the Palau Gaya National Park off Kota Kinabalu (Mathias and Valencia, 1975), and is also practiced in Indonesia and the Philippines (FAO IPFC Secretariat, 1976). Coral reefs provide nursery and adult habitat to harvestable fish, protect the shoreline from erosion, and contribute to tourism recreational amenities. In a well-documented incidence of incompatibilities associated with offshore tin mining, silt from this activity was found to contribute to decreased water clarity and to have been deposited on corals and beaches in Phuket, Thailand, thus competing with the incipient tourist recreational industry there. In addition, the potential for pearl oyster culture has been diminished, harvesting of mangrove inhibited, and fish catch has declined, reportedly due to migration of fish and fishermen away from turbid areas (Ludwig, 1976).

Terrestrial mining

Terrestrial mining of tin placers is accomplished by dredging, or more commonly, the cheaper gravel pump method used by smaller and generally less regulated and environmentally aware operators. A pond, often artificial, is necessary with dredging, and the tailings tend to be trapped in the pond. Gravel pump mining often involves the discharge of tailings directly into available streams which supply the water for the operation. Placer tin deposits are generally located on the sides of, or in river valleys which often still serve as active drainage basins. Mining of other mineral deposits also requires a disposal of the tailings, often into streams or directly into the sea, if accessible.

Even where tailings are not deliberately dumped into water bodies, frequent heavy rains transfer the gangue sediment to streams. These sediments are eventually deposited in the coastal marine environment where the increased sediment load interferes with other coastal area resource uses as described under "Bottom mining". Placer tin mining, as well as surface mining of other mineral deposits can also leave open water-filled pits and defoliated areas impairing the aesthetic quality of the landscape and increasing erosion rates. Land is often left in this condition for years owing to the economic feasibility of reprocessing tailings as market prices fluctuate.

Terrestrial mining of tin placers is scattered throughout the coastal area and river basins of southern Thailand, the Malay Peninsula, and the tin islands of Indonesia. Extraction of other metal ores which could be significant because of the extent of the deposit or because of the potential harm of the extraction to the coastal environment, includes that focused on nickel and coal in Indonesia, and on copper, gold, silver, mercury (cinnabar), iron and chromite in the Philippines (FAO/IPFC Secretariat, 1976). The negative impact of offshore tin dredging on other coastal resource uses in Phuket has been mentioned; actually sediment derived from onshore tin mining contributes much of the observed effects here (Ludwig, 1976). In the Philippines excessive suspended sediments derived from the tailings of 18 active mines have adversely affected the water quality of the 7 rivers into which they are discharged; agriculture and fishery resources along and in these rivers have also been adversely impacted. Two copper mines discharge $63.5 \cdot 10^3$ and $22.7 \cdot 10^3$ metric tons of tailings, respectively, into Tanon Strait between Negros and Cebu, and Tayabas Bay in southwestern Luzon, and artisanal fishing has ceased in those coastal areas (Garcia, 1976). The easy-to-find terrestrial tin deposits have already been discovered, particularly in Malaysia and Indonesia, and offshore possibilities and prospects are receiving increased interest. However, other terrestrial mineral deposits, particularly porphyry copper, lead, zinc, nickel and chromite will be the focus of intense exploration and development in eastern Indonesia, East Malaysia and the Philippines.

Logging

Unregulated defoliation through clear-cutting of large areas in the process of logging, often without replanting or other means of stabilization is perhaps the most important single cause of artificially increased sedimentation in the region's coastal area. In tropical areas of high rainfall, topsoil is quickly washed downslope into rivers and eventually to sea, and flooding of coastal inhabited and cultivated land becomes more frequent. In addition to the potential conflicts associated with this increased sediment load, which

TABLE III

Southeast Asia: forest area and deforestation (FAO/IPFC Secretariat, 1976)

Country	Initial percent forested	Percentage change in forested area	Year interval
Brunei	96	−21	1960–1971
China	12	−4	1971–19[illegible]
Hong Kong	11	−1	1973–1976
Indonesia	64	−?	?
Kampuchea	74	0	1964–1974
Malaysia			
West	67	−7	1962–1970
Sabah	99.6	−18	1963–1970
Sarawak	74	+2	1962–1970
Philippines	56	−10	1965–1973
Singapore	4	0	1961–1972
Thailand	55	−6	1962–1965
Vietnam (southern)			
upland	60	−35 (sprayed)	1962–1975
mangrove (Westing, 1971)		−20+	1962–1975

are noted under "Bottom Mining", land clearing may leave breeding grounds for mosquitoes, and lumber trucks are a significant agent of erosion for poorly constructed and maintained rural roadways, occasionally causing slumping from associated vibrations. Logging operations also discharge saw-dust and bark, which, e.g., have polluted fish ponds in Tayabas Bay, Philippines (Lesaca, 1974).

Although logging is not the only cause, or purpose of, land-clearing, this industry has contributed significantly to the recent acceleration of deforestation depicted in Table III. Entities exhibiting the highest recent rates of deforestation include Sabah (3%/yr.), the Philippines (2%/yr.), Thailand (2%/yr.) and Brunei (2%/yr.). Although rates are not available for Sumatra, Java and Kalimantan, they are thought to be comparable. Southern Vietnam's defoliation has resulted from herbicidal spraying during the hostilities there. With the exception of Vietnam, the current logging intensity and practices are expected to continue and eventually spread to unharvested areas as the demand and thus the price for Asia's timber grows with increasing environmental regulations on harvesting of scarce timber resources in the west.

Mangrove harvesting

Mangrove areas can serve as habitats for juvenile fish and shrimp and as nutrient sources to estuarine organisms, and enhance shoreline stabilization and extension. Harvesting of mangrove for firewood and charcoal cooking fuel is a significant organized and unorganized practice throughout the rural Southeast Asian coastal area. As long as the rate of harvest does not exceed the natural regeneration rate, mangrove is a naturally renewable resource. However, the demand of the increasing population, in combination with other uses of mangrove area such as aquaculture and agriculture, may put pressure on, and eventually deplete, the resource. An example of the degree of mangrove harvesting activity is found in the estimated annual value of charcoal produced in Phangna and Phuket, Thailand — about U.S.$ $6 \cdot 10^6$. Commercial mangrove forest concessions include 24 km^2 in Phuket and 384 km^2 in Phangna. The industry involves approximately 110 charcoal factories with 330 ovens, employs 1,300 persons and exports $9 \cdot 10^3$ metric tons/yr of charcoal to Malaysia. Other uses of mangrove in the Phuket—Phangna area include firewood and construction piles (Ludwig, 1976).

Research, tourism/recreation, commercial fisheries

Table I demonstrated that the major intercategory conflicts are between extractive industries, water use and estuarine discharge, and fisheries, tourism/recreation and human health. The following section describes the extent and requirements of fisheries, tourism/recreation and research activities, as well as some aspects of their competitive use of coastal resources.

Research

Monitoring of environmental degradation requires pristine "control" areas for comparative analysis. Introduction of other human activities including fisheries and tourism/recreation will alter the environment and diminish the value of the site as a control area. Marine research stations in the region are few, the most important being in Nha Trang (Vietnam), Hong Kong, Phuket (Thailand), Penang (Malaysia), Singapore, Ambon (Indonesia) and Iloilo (Philippines). Of course, outstations occasionally undertake environmental monitoring and intermittent field expeditions contribute data; but with the exception of Ambon, the major research facilities are situated in areas of conflicting coastal activity.

Tourism/recreation

Tourism/recreation has two main components relevant to coastal resource use conflicts: aesthetics and water contact activities. The perception of aesthetic beauty is a relative concept: local, intra- and extraregional tourists flock to such coastal resorts as Pattaya in Thailand and Penang in Malaysia; others consider these turbid and polluted waters and debris-laden beaches unattractive. Tourism/recreation is a rapidly growing industry and source of foreign exchange in the region, but extensive beach areas suitable for tourism/recreation, especially those politically secure and readily accessible but not adversely impacted by man, are rare commodities. Initial effects have been made to establish preserves, such as Palau Gaya National Park in Sabah, Muka Head State Park in Penang and several small areas in the Philippines. Other coastal areas in the region have been nominated for conservation status by indigenous environmental organizations (Table IV).

However, blast fishing, as well as coral specimen and aquarium fish removal from reef areas has significantly diminished the aesthetic experience for snorkelers and divers in Pulau Gaya National Park (Mathias and

TABLE IV

Coastal areas suggested for preservation/conservation status in Thailand and Malaysia

Thailand (Michaels, 1976):
Preservation areas
(1) Entire northern coastal arc of the upper Gulf from Petchaburi around to Chon Buri
(2) Areas of coral habitat off the coast at Bang Lamung
(3) Important coastal and estuarine sections and corals between Rayong and Trat
(4) Reefs off Phuket Island
(5) Northern section of Songkhla Lake

Conservation areas
(1) The sea area from Laem Chabang, out to Kho Pai, and back into Leam Kham above Sattahip
(2) The sea and islands off Sattahip
(3) The channel and coasts around Kho Samet in Rayong Provine
(4) The area of Trat and the offshore islands including Kho Chang
(5) The coastal strip of Hua Hin as far south as Khao Krat Lat
(6) Most of the coast and minor islands at Phuket
(7) Almost all of Songkhla Lake

Malaysia (Wycherley, 1969):
Marine nature reserves
(1) Four islands off Kuala Kedah
(2) Pulau Lallang in the Sembilan Islands
(3) Pulau Lang Tengah
(4) Tanjong Genting
(5) Tanjong Tokong, Penang (Ong Jin Eong, personal communication, 1973)

Valencia, 1975) and on reefs off Phuket (Ludwig, 1976) and the Malay Peninsula (Wycherley, 1969). Of course, a major problem for tourism/ recreation in this region of scarce facilities is overcrowding by tourists/recreators themselves; coral and shell collectors have been the principal destroyers of reefs off the west coast of Malaysia (Wycherley, 1969) and Phuket (Ludwig, 1976). It would appear that this conflict between the tourist industry, including the demand for coastal recreational facilities and preserves by incipient middle classes, and the national drive for development will soon provide a test of governmental philosophy and resolve in the area of coastal resource use conflicts.

Commercial fisheries

Fisheries resources, both nearshore and offshore, are vulnerable to other coastal activities which affect the productivity/catch or marketability of the resource. The adverse effects of extractive industries, urbanization and water use/estuarine discharge have been mentioned. However, perhaps the most severe conflicts for fisheries is within and between the fisheries sectors themselves. These conflicts include biological overfishing and defoliation of mangrove nursery and nutrient supply areas in preparation for aquaculture. For example, artisanal fishermen throughout the region often employ the method of blast or poison fishing which indiscriminately kills adults and larvae alike and destroys the coral habitat as well. Tourism/recreation and even marine biological research collections can, in turn, contribute to predation on local artisanal fisheries and coral habitats.

Demersal and pelagic fish catch in the Southeast Asian region is illustrated in Fig. 9. It is interesting to note the correspondence of some major fishing grounds with areas of high petroleum exploration interest and/or recent discoveries (Fig. 6). Such areas of potential conflict include northwest Palawan, the Gulf of Thailand, the northern Malacca Straits, and possibly the area off southern Vietnam. Some of these fishing grounds also straddle major and minor petroleum tanker routes. Spatial interference of rigs with trawling runs, fouling of nets, and tainting of the catch are the major potential short-term problems for the fishing industry.

Aquaculture, an ancient practice in the region, is being modernized and expanded through intensive national and international efforts with the hope of providing protein to Asia's expanding and increasingly undernourished population. However, expansion and modernization of aquaculture implies clearing of large areas of mangrove and use of fertilizers, lime and pesticides, which may, in turn, diminish offshore and artisanal fish catch. Sediment-generating activities in the hinterland require constant dredging of aquacul-

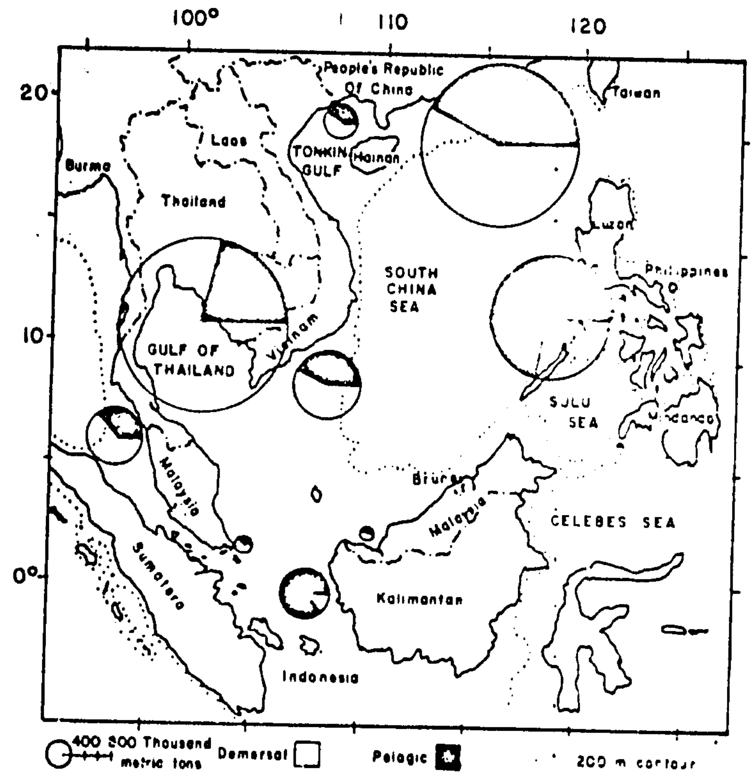


Fig. 9. South China Sea: pelagic and demersal fishing grounds and catch (from Marr, 1976).

TABLE V

Southeast Asia: area under coastal aquaculture and potential area for aquaculture development (Pillay, 1970)

Country	Area developement (km^2)	Potential area (km^2)
Indonesia	1,650	>4,000
Kampuchea	—	500
Malaysia	32	>500
Philippines	1,660	5,000
Singapore	6	60
Taiwan	276	100
Thailand	>200	>5,000
Vietnam	26	1,500

ture ponds, which have replaced the mangroves' role in retaining sediment at the coast. In Malaysia and Thailand, aquaculture expansion has been inhibited by classification of some mangrove tracts as forest preserves (Ludwig, 1976). Table V lists the developed and potential aquaculture areas in the region, which generally coincides with the extensive stretches of mangrove fringed coasts. Areas of expected major expansion include northwest Sumatra, both the Andaman and Gulf of Thailand coasts of Thailand, and Luzon, Visayas, Palawan and Mindanao in the Philippines.

AREAS OF CONCERN

Based on the foregoing survey of coastal-area activities and resource-use conflicts in Southeast Asia, priority areas of concern may be delineated as urgently requiring coastal area planning for the most efficient utilization of the available resources. Certainly, the coastal areas enveloping the region's major cities are of concern due to the concentration of many resource uses in a small area: dense human habitation, commerce and industry, highways, airports, ports, land reclamation, unrestricted domestic and industrial waste disposal, power facilities, disease control, and logging, terrestrial mining and agriculture in the hinterland. Priority urban areas would include Manila, Djakarta and all of north Java, and Bangkok. Although controls on existing coastal resource uses may be difficult to implement due mainly to non-technical reasons, new or additional uses might be regulated or at least planned for, especially in new "development" areas. The upper Gulf of Thailand, particularly the Bight of Bankok, is a case in point. Circulation is extremely weak, and Sattahip may be converted to a civilian deep-water port, with attendant domestic and industrial/commercial activity, adding further stress to the coastal resources in this area. Areas of potential conflict in coastal resource use include northwest Palawan, where aquaculture, petroleum exploitation and offshore fisheries may coincide, and the greater Gulf of Thailand.

The constricted, shallow Malacca Straits is a priority area for a coordinated international approach by the four bordering nations: Thailand, Malaysia, Indonesia and Singapore. This area is a microcosm of the coastal activities and conflicts of the region. The Straits are a major transport route for petroleum tankers. Coastal petroleum exploitation is ongoing in north Sumatra, with exploration off southwest Thailand, and coastal depots and refineries are situated in Port Dickson and Singapore. Bottom mining is ongoing from Phuket northwards and exploration is underway off Malacca and Penang. Terrestial tin mining is scattered throughout the Thai Isthmus and the Malay Peninsula. Logging activity is significant on Sumatra, generating much sediment and contributing to coastal accretion. In addition to Singapore, the west coast of the Malay Peninsula is rapidly becoming urbanized and much of Malaysia's population and industrial agricultural processing activity is concentrated there, discharging wastes into the Straits, including those from disease control. The ports of Penang, Port Swettenham, Port Dickson and Singapore are situated on the Straits. Aquaculture is being expanded in north Sumatra and may be expanded in suitable locations along Malaysia's west coast, and mangrove harvesting is locally significant throughout the coastal area of the Straits. Much of the West Malaysian coastal plain above the high-tide mark is under cultivation, and an agricultural scheme utilizing reclaimed land is planned for southeast Sumatra. Artisanal fishing including shellfish harvesting is widespread in the nearshore areas and significant offshore fishing is conducted in the northern Straits. Tourism recreation centers bordering the Straits include Phuket, Penang, and Pangkor: marine research stations are located at Phuket, Penang and Singapore.

From a realistic politico-economic perspective, it is clear that certain activities in the region will have priority, such as extraction of hydrocarbons and minerals. However, such activities should be planned so as to minimize adverse impacts on other coastal resources and uses; also other uses, such as tourism/recreation may be geographically situated in areas less likely to be exploited for other purposes. However, it remains to be seen whether and when governmental philosophies, so geared to growth development on the Western model, will also incorporate the concept of planned growth and optimum allocation of coastal resources, so recently, and thus painfully, adopted by the West.

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