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REGIONAL COOPERATION IN PREVENTION AND RESPONSE TO MARINE POLLUTION IN THE SOUTH CHINA SEA

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ABSTRACT

The South China Sea region contains valuable habitats which are rich in terms of diversity and productivity. The nations whose coastlines border the South China Sea are rapidly growing economies with increasing populations. Fast increasing populations, coupled with rapid industrialization and development has resulted in increased stress on the coastal and marine environment. Improper or inadequate pollution prevention, control and management constantly threatens the health of the coastal and marine habitats that the populations in this region heavily depend upon. The growing concern for the degradation of the marine environment has lead the United Nations to formulate the United Nations Convention on the Law of the Sea (UNCLOS). More recently, the 1992 United Nations Conference on Environment and Development (UNCED) also addressed the problem of marine pollution, endorsing an integrated and developmentally sustainable approach to the problem. In addition to national programmes, bilateral and regional cooperation (e.g. among ASEAN nations) also exist in this region to deal with marine pollution. Indeed, regional and international initiatives are required to help stem the growing tide of pollution, in particular the implementation of regulations and standards on discharge levels, and the enforcement of legislation. There remains much to be done, however, as many countries are constrained by the lack of either financial or technical resources to implement regulations on marine pollution. Funding and technical expertise from international and regional counterparts are thus needed if the tide is to be turned in the battle against pollution of the marine environment is to be won.

INTRODUCTION

The South China Sea region is bordered by the six ASEAN nations (Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore and Thailand), Vietnam, Cambodia, China and Taiwan (Fig. 1). Of the total of 89,391 km of coastline in the Southeast Asian region, more than 80% belongs to Indonesia and the Philippines (Chou, 1994). Indonesia comprises more than 13,600 islands which cover only one third of the country (Thayib & Thayib, 1987), while the Philippines has a marine water area 5 times the land area of its 7,000 islands.

The States that share the waters of the South China Sea are rapidly growing economies with increasing populations. The Southeast Asian region's current population of 444 million is projected to grow by 63% to 724 million by the year 2025 (Chou, 1994). An estimated 70% of the population live in the urbanised centres along the coast. In addition, this region contains shipping activity which is amongst the world's busiest, and is also a centre for the production and transport of oil and gas.

The rising population and increasing development of the coastal areas have placed a heavy strain on the coastal and marine environment in the region. Improper waste management has lead to the increased outflow of sewage and industrial effluent to the surrounding waters, increasing the health risks to the population. Elevated pathogenic bacteria levels, high heavy metal concentrations in seafood, occurrences of red tides and oil spills from vessels, oil platforms and underwater pipelines, and land-based petrochemical plants are some of the many pollution concerns of this region.

This paper is intended to be a working document briefly reviewing the marine pollution problems, and international and regional collaborative initiatives relevant to the prevention, control and management of marine pollution in the South China Sea region.

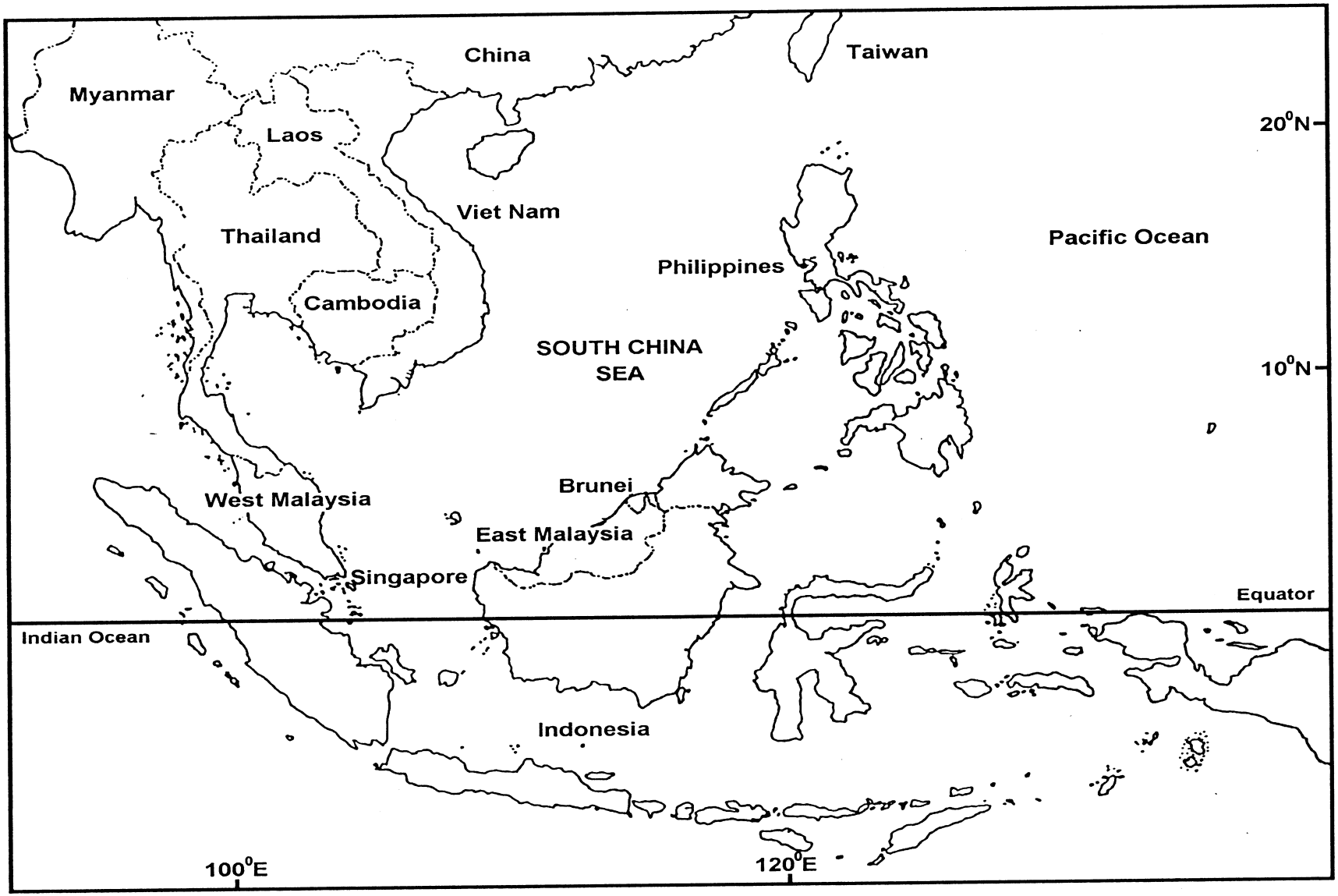

Figure 1. The South China Sea region.

LIVING RESOURCES

The semi-enclosed South China Sea is a very rich resource, with fisheries being a prominent activity. Eleven percent of the world's marine catch comes from this region, with almost 5 million people directly dependent upon fishing for their livelihood (Anon., 1992). A large proportion of the populations in this region depend on the approximately 2,500 species of fish, and many more invertebrates as the major source of protein (Anon., 1992). In Brunei Darussalam, the fish consumption rate per capita is in excess of 40 kg/person/annum, half of which are caught in local waters (Matdanan *et al.*, 1987). Similar consumption rates were reported in the Philippines, with fisheries providing more than half the animal protein intake (Guerrero *et al.*, 1987; Hammond *et al.*, 1994), and employing over one million people. The annual marine catch for the six ASEAN countries alone increased from 1.5 million tons (in 1960s) to 5.5 million tons in the early 1980s.

Thirty percent of the world's coral reefs are found in Southeast Asia (Smith, 1978). Diversity is very high, with coral reef fisheries supplying 12% of the world's total fish catch (Munro & Williams, 1985). In Sabah, East Malaysia, reef fisheries were estimated to contribute more than 30% of East Malaysia's total catch (Langham & Mathias, 1977), while in the Philippines it was estimated to be 25% (Gomez, 1988). Other reef organisms including seaweeds, molluscs, crustaceans and echinoderms, are also harvested for food (McManus, 1988). In addition, reef organisms are collected for the marine curio and aquarium trade, with the bulk of this harvest exported to countries outside Southeast Asia. Reefs have also traditionally been mined for coral or limestone blocks for use as building material in some countries.

The coral reef is a carbon sink (deposited as calcium carbonate), similar in many ways to the tropical rainforests. Productivity rates for reefs are high due to an efficient and complex recycling system, and the ability of many reef organisms to fix nitrogen. The coral reef provides a visual display of colour and form unmatched anywhere on earth, and is a natural avenue for income from tourism that has been exploited by many nations in this region.

Mangroves cover more than 50,000 km^2 of coastal areas in the region, accounting for more than 30% of the world's mangrove forests (Chou, 1994). About 20 species of mangrove trees are commercially important, being harvested for use as fuel, as building materials and for the production of chipboard. Tannins are also extracted from the bark, and edible fruits and leaves are collected from others (Chou, 1994). The mangroves support a highly productive fisheries. In Malaysia for example, the value of mangrove dependent fisheries in 1990 was reported to be US$28.6 million. Prawn production from mangrove forests are also important in some of the countries in the region, with up to 145,000 tons harvested in 1990 (Chong *et al.*, 1994). The mangrove forests act as nursery and feeding grounds for many species of fish and prawns (Chong *et al.*, 1990). Indonesia produced an estimated US$26 million of mangrove forest products in 1978, and US$194 million in mangrove-linked fisheries (Salm & Halim, 1984).

In addition to fisheries, coral reefs and mangroves, the South China Sea region also contains many other valuable habitats, namely, estuarine river systems, seagrass beds and other nursery and spawning grounds, all of which are tremendously rich resources.

SOURCES OF MARINE POLLUTION

Marine pollution can be described as anthropogenic inputs into the marine environment resulting in harm to living resources and marine life, danger to human health, hindrances to marine activities, and a reduction in the quality and usefulness of sea water (GESAMP, 1969). The most widely distributed pollutants of the oceans may be classified into radionuclides, organochlorine toxicants, metals, petroleum and petroleum products and detergents (Patin, 1982). These pollutants may originate from land (land-based) or the sea (sea-based).

Rapid industrialization and burgeoning populations in the countries of this region have resulted in increased levels of sewage and pollutant discharge into the surrounding seas. Land-based activities, such as agriculture, mine tailing disposal, logging and reclamation, contribute to the elevated levels of organic waste, heavy metal concentrations and sediment loads of the waters. The increased organic waste poses

an immediate threat to public health, stimulating the growth of pathogenic bacteria (Thayib & Thayib, 1987) and causing blooms of toxic dinoflagellates (red tides). Manila Bay, for example, was found to be "unsafe" for recreational activities, and red tide occurrence in mid-1983 affected one of the country's major fisheries areas, resulting in the deaths of 21 people, and a loss of US$ 5 million (Guerrero *et al.*, 1987). In 1988, red tides resulted in the loss of 4 lives (Anon., 1992). In Indonesia, the river of Citarum showed a doubling of its faecal coliform concentrations between 1987 and 1990 (UNEP, 1993).

Heavy metal contamination from improper waste disposal is also a major problem. Studies on the Bay of Jakarta indicated that its waters and sediment contained concentrations of mercury, lead and cadmium that were four times higher than normal levels (Thayib & Thayib, 1987). In Malaysia, cadmium and mercury concentrations up to 28 times have been observed at disposal sites of mine tailings (Anon., 1992).

The impact of pesticide residues in the estuaries and other coastal environments is a major cause for concern to the fisheries industry. Studies conducted by the Indonesian Department of Agriculture show that the pesticide residue thiodan has toxic effects even after seven days, and that 3 ppm is lethal to juveniles of the freshwater fishes *Punctius javanicus*, *Cyprinus carpio* and *Tilapia mossambica* (Thayib & Thayib, 1987).

Accelerated erosion from improper land management, reclamation of coastal areas for industrial development and mining in coastal waters have resulted in heavy sediment loads, destroying coral reefs and other benthic communities, and resulting in a decline in fish yields. An estimated 13.5×10^3 Mt of sediment reaches the ocean annually, and it has been reported that approximately 215 million tons of dredged material were dumped annually between 1980 and 1985 (GESAMP, 1990). The Huanghe (Yellow River) of China has seen a 4-fold increase in its suspended solids content since 1987 (UNEP, 1993), while sedimentation rates in Singapore have been observed to reach 45 mg/cm^2/day (Lane, 1991; Low & Chou, 1994). Changes in the physical and chemical make-up of the environment have also been observed in areas where dredge-mining occur (Chansang, 1988).

Oil pollution from shipping and offshore oil rigs is a major concern for all countries in the region. The proximity of the countries to one another means that any spillage in one country could affect the coastal waters of others. Tankers carried an estimated 117 million barrels of crude oil through the Straits of Malacca (Chua, 1994), and several accidents have been reported (Anon., 1992). In addition, sludge and waste discharged directly into the sea from petroleum industries has resulted in high concentrations of hydrocarbons in waters around busy ports (e.g. up to 30 ppm in some Indonesian waters; Thayib & Thayib, 1987).

Various forms of marine pollution are thus not only a threat to human health, they may also cause detrimental and irreversible impacts on sensitive habitats and ecosystems, and eventually affect the livelihoods of populations.

INTERNATIONAL INITIATIVES IN MARINE POLLUTION CONTROL

A number of international treaties and conventions have taken place that deal directly with the management and prevention of marine pollution. Some of the conventions and treaties of direct relevance to marine pollution, are the Stockholm Declaration, 1972, the Third United Nations Convention on the Law of the Sea (UNCLOS), 1982, the "Montreal Guidelines", 1985, and more recently, the Convention on Biological Diversity (or Agenda 21, Chapter 17), 1992. An overview of these initiatives has been presented (Koh & Lim, unpublished).

The Stockholm Declaration resulting from a conference held in Stockholm between 5-16 June 1972 contains principles laid down by the United Nations Conference on Human Environment. Two principles (6 and 7) in particular, relate to the prevention of pollution of the seas by substances that are liable to be deleterious to humans, living resources and marine life.

The Third United Nations Convention on the Law of the Sea (UNCLOS), 1982, dealt with the protection and preservation of the marine environment. The Convention contains articles that range from specifying that States are obligated to protect and preserve the marine environment, to calling for regional and global

cooperation in preventing marine pollution, to specifications requiring States to adopt national legislation to deal with land-based pollution, sea-bed activities and activities by sea vessels, e.g. programmes to prevent accidents at sea. In the South China Sea region, UNCLOS has already been ratified by the countries Indonesia, Philippines and Thailand.

The 1985 Montreal Guidelines for the Protection of the Marine Environment against Pollution from Land-Based Sources, endorsed by the United Nations Environment Programme (UNEP), were drafted to specifically aid Governments to deal with land-based sources of marine pollution. The guidelines, adopted by the United Nations Conference on Environment and Development (UNCED) are not only intended to help Governments draft appropriate national legislation, they also encourage bilateral, regional and multilateral collaborations in preventing marine pollution. In these guidelines, a holistic approach to environmental pollution control is taken, and programmes on environmental and data management, assessment, monitoring and control are encouraged.

The Convention on Biological Diversity (or Chapter 17 of Agenda 21) was adopted by UNCED in Rio de Janeiro in 1992. It contains seven programme areas of which one specifically addresses marine environmental protection. Whereas UNCLOS dealt with the prevention, reduction and control of marine pollution, the marine environmental protection programme in Chapter 17 of Agenda 21 acts to implement the UNCLOS provisions. The approaches used in this programme are to initiate preventive, precautionary and anticipatory measures, and emphasis is placed on using economic incentives, and pegging costs to environmental degradation. Again, a holistic approach to the management of marine pollution is taken, endorsing methods which are integrated and sustainable, strongly encouraging the participation of local and national agencies to build up activities that involve collaboration regionally and internationally.

In addition to these main international initiatives, other conventions that have taken place also complement the objective of preventing and managing marine pollution. Among them are the 1969 International Convention on Civil Liability for Oil Pollution Damage (CLC), the 1972 London Dumping Convention (LDC), the 1973 International Convention for the Prevention of Pollution and the Protocol of 1978 (MARPOL 1973/78), and the 1990 International Convention for Oil Pollution Preparedness, Response and Cooperation (OPRC).

REGIONAL PROGRAMMES

Apart from the international initiatives that aim to address the problem of marine pollution, there have also been regional programmes that deal with similar issues. The following are examples of such programmes within the South China Sea region:

In Southeast Asia, the Association of Southeast Asian Nations (ASEAN) comprising the countries Brunei, Indonesia, Malaysia, Philippines, Singapore and Thailand, has emerged as an important economic and political entity. The countries of ASEAN have successfully collaborated to implement many regional programmes, some of which directly address issues of marine pollution. For example, the ASEAN Committee on Science and Technology (COST) together with its dialogue partners from Australia, Canada, USA, the European Economic Commission and Japan have developed relevant programmes to better manage marine pollution in the ASEAN region, including improving pollution monitoring techniques and resource assessment. To further secure environmental health, an ASEAN Expert Group on Environment (AEGE) was established under COST in 1978, with specific objectives to deal with environmental issues in ASEAN. Some of the projects of the AEGE directly deal with marine pollution matters, in particular oil pollution.

Other collaborative projects between ASEAN and countries like Australia, Canada and the USA have been reported in Chua (1994). These projects include the ASEAN-Australia Marine Science Project that deals with regional ocean dynamics and living resources assessment, the ASEAN-Canada Marine Pollution Project with the objective of determining environmental criteria for the protection of marine resources, and the ASEAN-US Coastal Resources Management Project that was aimed at developing a multidisciplinary and environmentally sustainable coastal area management plan for ASEAN.

In addition, many projects in the region have been initiated by the various agencies of the United Nations, for example, UNEP and the United Nations Development Programme (UNDP). The Coordinating Body

of the Seas of East Asia (COBSEA) has developed many programmes dealing the marine pollution. Some of them address oil pollution problems, while others deal with various other forms of pollution. COBSEA was set up by UNEP under its Regional Seas Programme, and has as its agenda for action, an East Asian Seas Action Plan. A new programme initiated by the Global Environmental Facility (GEF) with the collaboration of UNDP and the International Maritime Organization (IMO), began in 1994. This programme, the Prevention and Management of Marine Pollution in the East Asian Seas specifically looks at effective prevention, control and mitigation of marine pollution, and risk management in coastal and international waters of East Asia.

Shipping is one of the most important activities in the South China Sea Region, and understandably, initiatives from the region, and also the private sector, have developed to ensure that pollution from this activity, mainly oil pollution, is prevented and controlled. In ASEAN, a regional oil spill contingency plan was initiated by AEGE in 1970, and has developed to include the participation of IMO and UNEP. The ASEAN Council on Petroleum (ASCOPE) was formed to address environmental issues related to oil and natural gas exploration, while the ASEAN Senior Officials on the Environment (ASOEN) formed in 1990 is expected to ensure that the regional oil spill contingency plan is implemented successfully. In addition, another Oil Spill Preparedness and Response Plan (OSPAR) has been initiated, with Japan providing financial support to ASEAN for equipment to combat oil spills, and also the operation of an information network to document oil spills.

Private sector involvement in addressing oil pollution in the region has also been substantial, with the formation of action groups such as the Petroleum Industries Malaysia Mutual Aid Group (PIMMAG) in Malaysia and the Oil Industry Environmental Safety Group (OIESG) in Thailand. The Tiered Area Response Capability (TARC) and more recently, the East Asia Response Ltd. (EARL), formed by British Petroleum, Caltex, Exxon, Mobil and Shell, stocks equipment capable of handling oil spills of between 10,000 and 30,000 tons (Chua, 1994). Also, the Petroleum Association of Japan and the Japanese Ministry of International Trade and Industry have set up a supply base for oil spill response equipment in Singapore (Koh & Lim, unpublished).

In addition, various regional programmes ensure that international protocols and conventions that have already taken place are effectively implemented. For example, the Asia-Pacific Memorandum of Understanding on Port State Control in the Asia-Pacific Region signed by 18 port states in 1993, undertook to establish and maintain a system to ensure that all foreign ships visiting ports complied with the regulations set by the international conventions of MARPOL 73/78, the International Convention on Standards for Training, Certification and Watchkeeping for Seafarers (1978), the Convention on the International Regulations for Preventing Collisions at Sea (1972) and the IMO Convention No 147 Concerning Minimum Standards in Merchant Ships (1976) (Koh & Lim, unpublished).

Bilateral and sub-regional agreements also exist between countries of the South China Sea region to manage and control activities that carry the risk of marine pollution. For example, to reduce the number of accidents along the heavily used Straits of Malacca and Straits of Singapore, Indonesia, Malaysia and Singapore adopted and implemented the Traffic Separation Scheme (TSS), developed by the Tripartite Technical Experts Group (TTEG), which deals exclusively with technical matters pertaining to the prevention of pollution in the two straits. The TSS has been in operation since 1981, and a Vessel Traffic Information Scheme was set up in Singapore to ensure compliance with the TSS. Programmes such as the TSS are directly in line with the UNCLOS agenda of prevention of marine pollution by vessels at sea.

NATIONAL PRIORITIES

On a national level, individual countries in the region have specific laws to control pollution, as well as various monitoring programmes for the environment. However, countries differ in their approach to pollution control. In the control of solid wastes from land-based sources, for example, the countries of ASEAN have different national priorities (Chua *et al.*, 1992; Table 1). The following are some examples of pollution control programmes in individual countries:

Table 1. Summary of legislation concerning waste management in the ASEAN countries.

NATION	LEGISLATION
Brunei Darussalam	Solid Waste Management Plan (1987) National Water Quality Standards Study (1987)
Indonesia	Public Water Law (1936) Nuisance Ordinance (1926) (Amended 1940) PD 7 (1973) Ministry of Agriculture Directives (1973-1975) Environmental Management Act (1982) Act 4, 1982, Basic Provisions for Environmental Management PROKASIH (1989) Act 24, 1992, Spatial Planning Regulations Government Regulation 20, Hazardous Waste Management (1993) Government Regulation 51, Analysis of Impacts upon the Environment (1993) Ministerial Decree, 1992, River Cleaning Programme Act 5, 1994, Ratification of Biological Diversity Convention Act 6, 1994, Ratification of Climate Change Convention
Malaysia	Land Conservation Act (1960) Waters Enactment Act (Amended 1970) Mining Enactments 146/147 Street Drainage and Building Act (1974) Local Government Act (1976) Rearing of Pigs Enactments (1975, 1980) Environmental Quality Act (1974) (Amended 1985)
Philippines	Republic Act 3931 (Amended by Presidential Degree (PD) 984 (1964) PD 600 (1967) PD 463 (1974) PD 1151 (1977) PD 1152 (1977) PD 1586 (June 1978/June 1982) PD 1121 (1977) Several other PDs
Singapore	Prevention of Pollution of the Sea Act (1971) Water Pollution Control and Drainage Act (1975) Trade Effluents Regulations (1976) (Amended 1977) Singapore Port Regulations (1977) Environmental Public Health Act (1978)
Thailand	Fishery Act (1947) Toxic Substance Act (1967) Environment Quality Act (1975) Sec. 17 National Environment Promotion Bill of 1976 (Amended 1978) Public Health Act 1041) and Factories Act (1969) (Amended 1975 and 1979)

In Brunei, red tides, directly related to the quality of water, have been a concern of the Government since its reported occurrence in 1976. Matdanan & Selvanathan (1984) documented red tide occurrences and their monitoring in detail. Regular checks on water samples are conducted, with toxic assays conducted on the mussel *Perna viridis*, by the Fisheries Department. A National Water Quality Standards Study was launched to address this problem, in 1987.

In the Philippines, many Presidential Decrees and Acts have been issued to tackle the problem of pollution. They include the Republic Act 3931, PD 600 (1967), PD 463 (1974), PD 1121 (1977) and PD 1151 and 1152 (1977). The National Pollution Control Commission (NPCC) spearheaded three programs to monitor water quality, discharge zones and to study physical oceanography in the southern outfall area of Manila Bay, and provided a good opportunity for inter-agency linkages. The NPCC is also monitoring 5 rivers in the Metro Manila area, and 6 rivers outside Metro Manila, to determine long term and seasonal changes in the physical and chemical characteristics of the river water. In addition, baseline studies of over 200 other major rivers and water bodies have been conducted.

There is also a significant contribution from various universities in the Philippines in the area of pollution research, with up to 30% of total pollution research conducted by the universities. Major fishing grounds are monitored by the College of Fisheries, University of the Philippines in the Visayas, while the Marine *Science Institute of the University of the Philippines has collaborated with the Bureau of Fisheries and* Aquatic Resources, the Natural Resources Management Centre and Silliman University to monitor coral reefs and its organisms.

In Singapore, a central agency coordinates and implements controls on pollution. The Pollution Control Department (PCD) of the Ministry of the Environment is responsible for environmental planning and building development control, air and water pollution control, hazardous substances and toxic wastes management. Industries may be required to conduct environmental impact assessments, including measures to reduce and control discharges of waste water and cooling water, and the disposal of wastes. Industrial effluent must meet the standards set by the PCD, which is backed by several Acts and Regulations, for example, the Trade Effluent Regulations, 1976 and the Poisons Act (Hazardous Substances Rules, 1986). The collection and disposal of toxic industrial waste is also controlled through licensing. Recently, a comprehensive "environment" law covering all aspects of the environment was drafted, and is expected to be presented to Parliament within the next two years (Anon., 1994).

Tolentino (1988) provides a good review on the legislation in the ASEAN countries dealing with marine pollution.

PROBLEMS AND CONSTRAINTS

A major constraint in the implementation of pollution prevention and management measures is the high costs involved, and the time required for the programme to be effective. For example, the programme to clean up the Singapore River totalled S$ 300 million over 10 years. Rehabilitation programmes for larger water bodies, such as Pasig River in Manila and Chao Praya River in Bangkok would certainly require more funds and time.

Coupled with the high costs of the management of pollution, the lack of financial support and technical expertise for implementing pollution programmes also exacerbates the problem in this region. Although countries may be signatories of a particular treaty or convention, and legislation may already exist in the constitution, many nations are unable to ratify the conventions, and implement the regulations effectively. To date only Brunei Darussalam, Singapore, Indonesia and Vietnam have ratified the MARPOL Convention. The lack of technical capability and financial resources have hindered its implementation in other countries (Chua, 1994). Also, although UNCLOS will enter into force on 16 November 1994, only Indonesia, the Philippines and Thailand have ratified this convention.

To compound the problem of lacking financial support, policy makers generally view pollution prevention programmes as an irrecoverable investment, and these projects are therefore not considered a high priority for funding. The monitoring programme by the NPCC in the Philippines for example, could be extended to other areas if adequate funding, facilities, equipment and technical manpower, were made available.

Present day pollution management initiatives call for integrated planning, and protocols that allow for sustainable development. However, countries in this region often lack the experience of implementing practical approaches to integrated and sustainable management measures for the marine environment. Because of the lack of expertise in this region, temperate-zone models and regulations are often ineffectively modified for the tropics. In addition to building up expertise in integrated and sustainable management of pollution, there is a need to convince policy makers that environmental protection and economic development are compatible.

The problem of a lack of experience is also evident in the much researched field of oil pollution. The Exxon-Valdiz incident is one such example. The response to the spill, while admirably swift, was ineffective in preventing the spill from spreading. The disaster has so far cost Exxon US$2.9 billion on the environmental cleanup alone, and billions more in lawsuits (Yoder, 1994). The capabilities of the various oil spill response groups set up in the region have not been tested (Chua, 1994).

In most countries, development plans are based on single-purpose, exclusive assessments of land and water-use. Various agencies take specific measures to manage specific habitats and areas, and often no Ministry or Department coordinates the implementation and enforcement of anti-pollution laws. In Brunei for example, 9 departments from 4 Ministries (Matdanan *et al.*, 1987) are each responsible for implementation of legislation and in the development and study of coastal areas. On the regional level, data management and methodologies used by various countries differ, making comparisons and inter-calibrations difficult. Clearly, more coordination within each country and collaboration within the region are essential if marine pollution management is to be successfully implemented.

PROPOSALS FOR FUTURE PROGRAMMES

One of the first measures essential for a marine pollution control programme to be effective is a regular monitoring programme for the environment. In the past, pollution monitoring protocols only involved the chemical analyses of pollutants in the environment. Presently, the monitoring of changes in genetic, biochemical, physiological and ecological parameters caused by contaminants in the biota has seen widespread applications. The advantage of this method over straight contaminant measurement is that it demonstrates changes taking place in the environment, with changes in parameters measured taken as a basis for further investigation (UNEP, 1993). However, since results are sometimes difficult to interpret, biological monitoring should be used in conjunction with existing chemical contaminant level studies.

Integrated monitoring is defined as the repeated measurement of a range of related environmental variables or indicators in the living and non-living components of the environment, and the investigation of the transfer of substances or energy from one ecosystem to another. The success of this holistic approach requires the use of a set of standard methodologies and failure to do so has hindered international cooperation in the past (UNEP, 1993). Among the networks that exemplify international integrated monitoring are the Global Ocean Observing System (GOOS) and the UNEP Global Environment Monitoring System (GEMS), which monitors priority pollutants at remote sites, in marine and fresh water, the atmosphere and in the biota. With proper training and financial support, countries in this region may utilise these existing integrated monitoring systems effectively.

Due to the transboundary nature of marine pollution, a practical approach would be to deal with pollution at the source. At the local level, strict enforcement is necessary at all sources to combat marine pollution. UNCLOS and UNCED (Agenda 21) not only provide legislative support for implementing and enforcing regulations within the boundaries of each country, they also require member states to cooperate on a global or regional basis in formulating international rules, standards and practices to handle pollution problems (Koh & Lim, unpublished). In Singapore the "polluter pays" principle can be illustrated in its pollution laws. In cases of unlawful discharges from ships for example, the master, the owner and the agent of the ship are individually liable to a fine not exceeding S$10,000 or imprisonment (not exceeding 2 years) or both.

In addition, more regional initiatives should be made to promote UN conventions like UNCLOS and Agenda 21, so that decision makers may be convinced to ratify and implement the regulations in their countries.

This region urgently requires practical marine pollution models to be developed. Effective models can then be used for integrated coastal zone management strategies, which should also involve local governments and industries (Chua, 1994). The development of such models require the collaboration of experts from the various countries. Chua (1994) recommended the development of regional networks for the purpose of exchange of expertise, or the expansion of existing networks for the region. For example, the Association of Southeast Asian Marine Scientists (ASEAMS) links scientists from various fields of marine science in the Southeast Asian region. Clearly, there is also a need for a regional network of experts on marine pollution monitoring and management of databases. Regional networks may also be linked to global networks so that scientists may seek inputs from international experts in the area of pollution management, and vice versa.

Increased bilateral and regional collaboration to deal with specific pollution prevention measures should be actively encouraged. The success of the TTEG in implementing the TSS is one example of how countries sharing the same water-bodies could develop strategies to minimise accidents at sea.

Since financial support is essential for any programme to be sustained, sources of funding should be actively sought, in particular to fund regional initiatives on pollution prevention and control. Koh & Lim (unpublished) have suggested that some form of tax or fee be levied for the users of coastal waters, e.g. the Strait of Malacca. A large source of funds may be obtained from such a scheme as more than 117 million barrels of crude oil pass through the Strait bound for countries like USA, Japan and Australia . Support from these countries both financially and technically could ensure that safety measures are implemented. In addition, private companies can also play an important part in the prevention of pollution from industry, for example, oil spills.

In conclusion, the South China Sea contains valuable resources that the populations in the region depend upon for their livelihood and economic development. Rapidly expanding populations and development has increased the threat of marine pollution in the region. Although many international initiatives to prevent and control marine pollution exist, countries in this region still require financial and technical support to fully implement these initiatives. There is also much potential in the development of regional cooperation in this area. Apart from seeking sustainable sources of financial support for increased regional programmes, integrated monitoring programmes, regional and global networking and technical support are just some other ways that regional cooperation may be fostered in the prevention and response to marine pollution in the South China Sea.

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