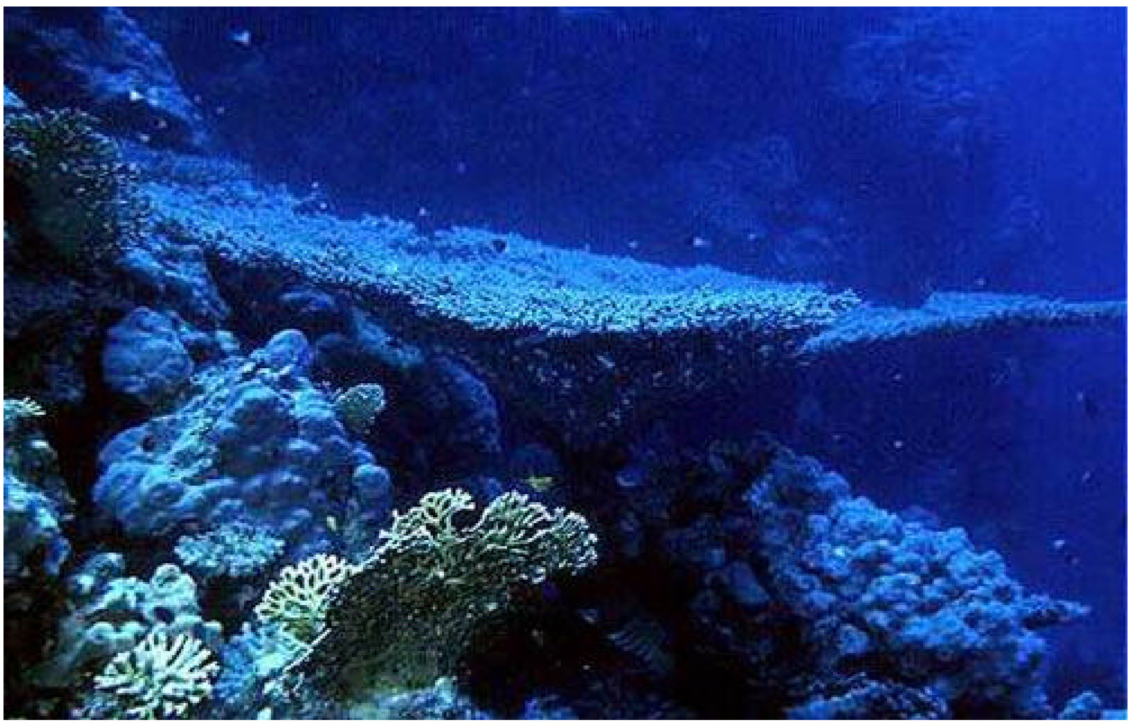
"Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand"

CORAL REEFS IN THE SOUTH CHINA SEA



UNEP/GEF
Regional Working Group on Coral Reefs

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FOREWORD

Covering three million square kilometres of sea surface, the South China Sea forms a major large marine ecosystem bordered by nine coastal states. Located within the global centre of marine biodiversity, the South China Sea supports immensely rich species diversity. Coastlines of the states bordering the sea are liberally endowed with coral reefs, a unique and certainly the most colourful of all marine ecosystems. In the deeper part of the South China Sea, numerous island groups also support coral reefs. Fringing reefs and atolls occur throughout this marine basin forming an effective network for larval connectivity and migratory species.

The reef ecosystem is known to provide ecological goods and services. Numerous studies and reports repeatedly emphasise the important benefits that societies obtain from coral reefs. Reefs support *in-situ* and *ex-situ* fisheries, are extremely productive, and protect shores against strong wave action. Reefs of the South China Sea contribute to the economic livelihood of many coastal communities. Reef-related fisheries form a significant part of fish landings, particularly in the South China Sea where more than 70% of the population live in the coastal area, and where fish is the major protein source.

The rich biodiversity makes the reefs here valuable in terms of ecotourism and in the potential for natural bioactive compounds. The great variety of reef species provides a great source for research into natural product chemistry. Novel bioactive compounds with biomedical and agricultural applications can generate huge economic benefits. The high degree of endemism makes it imperative to maintain this resource.

While the economic benefits of coral reefs are known, little is done to protect this ecosystem. Again, there are numerous reports pointing to reef degradation and destruction in the South China Sea. The ecosystem deserves better protection so that its full economic value can be realized. Coastal development and economic expansion together with population growth place extreme pressure on reef systems particularly along coastlines. Much of the degradation can be minimized with effective integrated coastal management. It is therefore important to implement action-oriented programmes to halt such degradation and help reefs to recover so that society can continue to reap the benefits of coral reefs in a more sustainable fashion.

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Bangkok, Thailand
January 2004

Reversing Environmental Degradation in the South China Sea and Gulf of Thailand.

Cambodia, China, Indonesia, Malaysia, Philippines, Thailand, Viet Nam

In 1996, the countries bordering the South China Sea requested assistance from UNEP and the GEF in addressing the issues and problems facing them in the sustainable management of their shared marine environment. From 1996 to 1998 initial country reports were prepared that formed the basis for the development of a Transboundary Diagnostic Analysis, which identified the major water related environmental issues and problems of the South China Sea. Of the wide range of issues identified the loss and degradation of coastal habitats, including mangrove, coral reefs, seagrass and coastal wetlands were seen as the most immediate problem. Over-exploitation of fisheries resources and land-based sources of pollution were also considered significant issues requiring action.

In 1999 the governments, through the Co-ordinating Body for the Seas of East Asia endorsed a framework Strategic Action Programme that established targets and timeframes for action. In December 2000, the GEF Council approved this project with UNEP as the sole Implementing Agency operating through the Environmental Ministries in the seven participating countries and with over forty specialised Executing Agencies at national level directly engaged in the project activities.

INTRODUCTION

Global Distribution. Coral reefs thrive best in warm tropical waters but extend beyond the tropics in situations where warm currents push through the tropical belt into the higher latitudes. Southeast Asia is recognized as the global centre of coral reefs, both in terms of extent and species diversity. An estimated 34% of the earth's coral reefs are located in the seas of Southeast Asia (Burke *et al*., 2002) which occupies only 2.5% of the total sea surface.

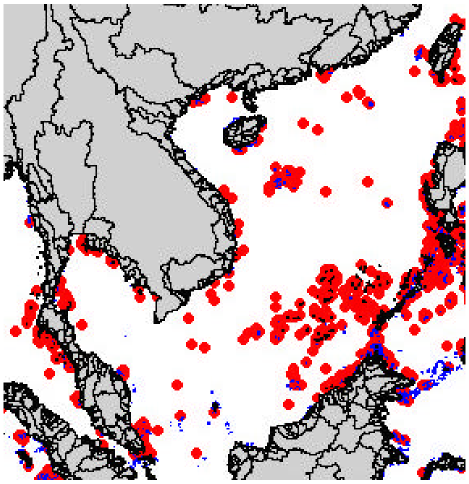


Figure 1 Coral reef distribution in the South China Sea.
(Sources: UNEP/GEF SCS & Reef at Risk in Southeast Asia)

The South China Sea is the largest sea in Southeast Asia. Bordered by Cambodia, the People's Republic of China, Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam, it forms a semi-enclosed large marine ecosystem. Circulation in the South China Sea is influenced by the twice-annual monsoons. The northeast monsoon towards the end of the year forces surface currents north to south, while the southwest monsoon that occurs mid year, drives currents in the reverse direction. There is also a flow of Pacific water into the basin interacting with water from the Indian Ocean.

The southwestern half of the South China Sea lies over the Sunda shelf at less than 200 m depth, while the northeastern sector drops to oceanic depths of more than 5,000 m. Coral reefs are liberally distributed along most of the coastlines bordering this large marine ecosystem particularly below the Tropic of Cancer (Figure 1.). Major island groups dot the South China Sea and support extensive oceanic reef systems. Approximately 20% of Southeast Asia's reefs occur in the South China Sea. Fringing reefs dominate the near shore waters, while atoll formations are common in the deeper areas. Talaue-McManus (2000) highlighted the ecological and economic importance of the coral reefs of the South China Sea in the Transboundary Diagnostic Analysis completed during the preparatory phase of this project.

Biological Diversity. The Indo-West Pacific marine biogeographic province has long been recognized as the global center of marine tropical biodiversity. Fifty of a global total of seventy coral genera occur in this marine basin (Tomascik *et al*., 1997) and 7 of the 9 giant clam species are found in the nearshore areas of the South China Sea.

Compared to the Atlantic, the tropical Indo-West Pacific is very diverse (Figure 2). Only some 35 coral species are found in the Atlantic compared with over 450 coral species recorded from the Philippines, 200 from the Red Sea, 117 from South East India and 57 from the Persian Gulf. The location of the South China Sea at the junction between the Pacific and Indian Ocean basins, has resulted in it becoming a centre of aggregation of species from both Oceans.

Coral species. More than half of Southeast Asia's hard coral species diversity is found in the South China Sea. Current information available for sites around the South China Sea (Table 1) indicates a wide variation in coral species diversity at different sites, ranging from between 12 and 351, reflecting the influence of physical parameters and human activity.

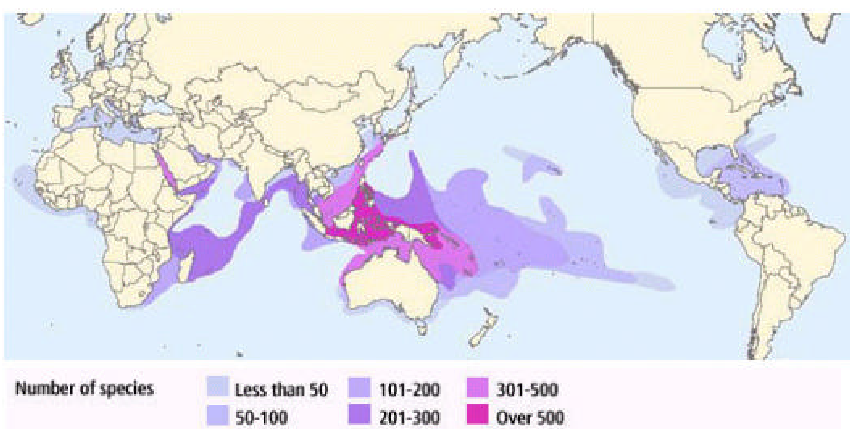


Figure 2 Distribution and diversity of coral reef species world-wide.
Source: J.E.N. Veron and Mary Stafford-Smith Corals of the World (Cape Ferguson: AIMS, 2000)

Hotspots of Biological Diversity. Hotspots of coral species diversity occur at Nha Trang (Vietnam) with 351 species and El Nido (Palawan, Philippines) with 305 species. Records of more than 200 coral species occur for a number of sites in Vietnam, Indonesia and the Philippines. In general, the data indicate higher species diversity at the deeper offshore reefs.

Diversity of other marine organisms. The marine biological diversity of the South China Sea is immensely rich. A preliminary assessment of the sea's biological diversity, which is not confined to coral reefs, indicates more than 8,600 species of plants and animals (Ng & Tan, 2000). Fish alone contribute 3,365 species (Randall & Lim, 2000). This preliminary listing however, excludes many important groups, which are less well studied. Even for those groups, which have been assessed, it was noted that many more species remain to be documented.

It is important to note that the South China Sea supports a significant number of endemic species. For example, only 5% of the 1,500 species of sponges in the South China Sea are distributed throughout the Indo-West Pacific (Hooper *et al*., 2000), and 12% of the 982 species of echinoderms in the South China Sea are endemic (Lane *et al*., 2000).

Global significance of Coral Reefs in the South China Sea. If coral reefs are the most diverse tropical marine ecosystems on earth, then the Indo-west Pacific in general and the South China Sea in particular are home to the most diverse coral reef systems. Marine endemism makes this system all the more valuable as species loss in this region translates into total extinction for many of the species concerned. The high species richness of corals and reef-associated fauna and flora in the South China Sea also makes this region a valuable source of genetic and biochemical material.

Pharmaceutical products. Coral reefs are a treasure house of many important biochemical compounds contained within the rich diversity of reef organisms. Some of these compounds have anti-cancer, anti-biotic, anti-viral and anti-oxidation properties. These compounds have great potential in the development of new pharmaceutical, cosmetic, and health products.

One species of cone shell for example that is found in coral reefs has been reported to produce a potentially important drug that can replace morphine. The market value of such a drug is several billions of dollars and the same species has over a hundred neuro-active compounds. With over 50 species of cone shells present in coral reefs, the economic potential of this rich biodiversity is enormous. Considering the potential new drugs for other biomedical applications, the economic spin-offs are indeed staggering.

Coral reefs as nursery areas. Ecologically, coral reefs of the South China Sea are sources of brood stock for many commercially important reef fish and invertebrate species. In addition, coral reefs are important breeding and nursery grounds for many pelagic and demersal fish species found in the open sea. These reefs provide the source of larvae and juveniles of fish and invertebrates that support the capture fisheries in the surrounding ocean. In fact, the future of the coral live-fish trade in the region is still dependent on wild brood stock from the reefs.

Table 1 Numbers of coral genera and species at coral reef locations in the South China Sea.

Site Name	Genera	Species	Site Name	Genera	Species	Site Name	Genera	Species
Cu Lao Cham	39	131	Mu Koh Ang Thong	38	110	Natuna	63	182
Nha Trang bay	64	351	Mu Koh Samui	45	140	Senayang Lingga	64	217
Con Dao	55	250	Mu Koh Samet	20	41	Batu Malang, Pulau Tioman	41	96
Phu Quoc	37	89	Sichang Group	38	90	Batu Tikus, Pulau Tinggi	41	79
Ninh Hai	49	197	Sattaheep Group	38	90	Pulau Lang Tengah	39	86
Ca Na bay	48	134	Lan and Phai Group	20	72	Pulau Lima, Pulau Redang	50	96
Ha Long - Cat Ba	48	170	Chao Lao	41	80	Teluk Jawa, Palau Dayang	35	80
Hai Van - Son Tra	49	129	Prachuab	35	74	Silam,Pulau Baik, Sabah	67	n/a
Bach Long Vi	31	99	Koh Tao Group	41	79	Pulau Linggisan, Pulau Banggi, Sabah	50	96
Batanes, Basco	16	n/a	Song Khla	8	12	Koh Kong	n/a	67
Bolinao/Lingayen Gulf	57	199	Koh Kra	35	80	Koh Sdach group	n/a	67
Masinloc, Zambales	24	n/a	Losin	40	90	Koh Rong group	n/a	34
Batangas bay/Maricaban	74	290	Anambas	62	206	Koh Takiev Group	n/a	23
Puerto Galera, Mindoro	62	267	Bangka	37	126	Koh Tang Group	33	70
El Nido, Palawan	74	305	Barelagn-Bintan	62	169	Kompot	n/a	67
Mu Koh Chumporn	31	120	Belitung	55	164	Koh Tunsay Group	n/a	67
Mu Koh Chang	42	130	Karimata	42	192			

Coral Reef Productivity. A coral reefs' very high productivity is derived from its structural complexity; its efficient turnover of nutrients; and the high primary production from unicellular symbiotic algal in the coral tissues. The evolutionary and ecological development of this complex system results in a series of synergistic and symbiotic processes manifested at different spatial and time scales in the ecosystem. These processes are the key to the reef systems' transboundary significance, and its resilience in the face of natural and human induced stress. The evolution of the reef community is reflected in the trophic relationships among reef organisms and their complex inter-related life history strategies. Social and economic benefits are dependent upon these processes, which provide essential goods and services to the majority of the human population in the region.

Importance of reefs to pelagic species. Food derived from reef fisheries remains one of the most basic and essential commodities to the impoverished but growing coastal populations. In addition, about a quarter of the diet of pelagic and transboundary migratory fish like the yellowfin tuna comes from reef-associated organisms (Grandperrin *et al.* 1978). In addition to trophic dependence on reef-associated organisms, other pelagic species are dependent on the reef habitat to complete their life cycle, visiting and using coral reefs as spawning, breeding and nursery grounds.

Threats and Rates of loss of coral reefs. The South China Sea has one of the largest areas of coral reefs of any tropical sea. While natural disturbances such as storms and El Nino related bleaching events (exacerbated by global changes brought about by human activities) have an impact on reef systems, human activities are currently resulting in widespread loss of reef habitats (*Arceo et al. 2001*).

Over the last century, many countries in the region have undergone rapid economic development and population growth, particularly in coastal areas. Consequently, human pressures on coral reefs have increased. Coastal Infrastructure development to support economic growth and the accompanying pollution of the marine environment associated with growing human activities have caused degradation of reefs close to major population centres. Resource exploitation has led to extensive coastal degradation and watershed deforestation and erosion have resulted in increased sedimentation on coral reefs. All these stresses affect the overall health of the reef systems.

The rates of loss of coral reefs are not precisely known due to a lack of detailed data and information on the status of coral reefs over the last few decades. Threats to coral reefs in Southeast Asia, have been estimated by Burke *et al* (2002) (Table 2), who consider that over 80% of Southeast Asia's coral reefs are under threat.

Table 2 List of Major Threats identified at sites bordering the South China Sea.

Country	Major Threats
Cambodia	Over fishing, blast fishing, poison fishing.
Indonesia	Over fishing, blast fishing, sand mining.
Malaysia	Over fishing, blast fishing, poison fishing, trawling.
Philippines	Over fishing, blast fishing, poison fishing, siltation.
Thailand	Over fishing, coastal tourism, siltation
Vietnam	Over fishing, poison fishing.

Although the impacts of human use, both direct and indirect, are generally more severe than impacts resulting from natural events, this is not the case with switches in the El Nino pattern of ocean circulation, which result in warming of the sea surface within the Indo-west Pacific in general and the South China Sea in particular.

Global warming of the sea surface could cause widespread coral mortality at alarming levels as illustrated by the consequences of the 1998 El Nino event when mean sea surface temperature was the highest ever recorded.

Thermal tolerance of corals. Corals in a particular area are known to tolerate quite narrow ranges of temperature although on a global scale different populations are able to withstand different temperature ranges. Those in the Red Sea for example, occur normally in waters that would cause bleaching of corals in colder water areas. A slight shift in temperature of 1-2^{o}C above or below the normal threshold level for a period of a few weeks may cause corals to bleach. When such temperature anomalies are prolonged, corals may die. The sea surface temperature rise experienced during the El Nino Southern Oscillation (ENSO) event between 1997 and 1998 caused mass coral bleaching worldwide, including in the South China Sea.

Coral Bleaching. Starting in late 1997 and continuing through to late 1998, sea temperature increased sequentially around the world. Sea surface temperature in most parts of the South China Sea was raised 2 – 3^{0} Celsius above the normal seasonal maximum (*Wilkinson, C.R. 1998).* By April 1998, anomalous hot water temperatures appeared in the South China Sea. Heating intensified in May and July, and coral bleaching was reported from Philippines, Vietnam, Thailand, Malaysia, Singapore and Indonesia. This coral bleaching was followed by mass mortality of scleractinian coral and other zooxanthellae-bearing reef organisms. Coral mortality reached 70 – 90 % extending from the reef flat down to a depth of 15 meters. Recovery rates varied throughout the region, from full and fast recovery in some reefs of Vietnam located in upwelling areas, to slow, partial recovery in other countries (Chou, 2000).

CORAL REEFS: A DEGRADING HABITAT

Coral reef degradation. Over the past 10 - 15 years, progressive degradation of coral reefs in several locations of the South China Sea has been noted. Many reefs, which used to be rich and pristine now have less live coral cover, and smaller-sized fish in response particularly to anthropogenic activities. Rapid population growth, land-based pollution, and over-fishing all contribute to this decline. In general, coastal resources located near large human population centres have suffered the most serious degradation.

This decline in the health of coral reefs has grave detrimental consequences to the social and economic well-being of the coastal communities that are directly dependent on reef resources and to the countries concerned through loss of tourism and other reef dependent sources of revenue.

Causes of reef degradation. Rapid population growth along the coast of most countries has resulted in increasing stress on coral reef resources, particularly for food. Many coastal communities are poor and have no means to fish in the open sea or offshore areas, hence, fishing and collecting of marine organisms from the coral reefs take place close to their villages or homes.

Hill cutting and construction activities degraded the coral reefs near this site

Coastal development. Coastal development is recognized as a growing threat throughout the South China Sea. In most countries, decline in live coral cover is closely associated with coastal development that involve activities such as land reclamation, land-clearing, dredging, and sand-mining, which very often, result in terrestrial soil and nutrient run-off at the development sites and sedimentation on adjacent coral reefs. Many of the coastal communities and high population density urban centres have inadequate sewage treatment systems resulting in the release of high levels of nutrients onto reefs that subsequently trigger shifts in reef community structure.

Overfishing. Overfishing and unmanaged exploitation of natural resources have resulted in widespread damage to coral reefs in the South China Sea. The use of destructive fishing techniques such as blast fishing and poisons, to capture fish on reefs further adds to the loss of coral habitat in many countries surrounding the South China Sea.

It has been suggested that despite the long history of over fishing in the South China Sea, the lag time in ecosystem response, such as the phase shifts seen in the early 1990's in the Caribbean, may be due to the greater resilience of the reefs in this region as a consequence of their high species diversity *(Jackson et al. 2001).* Based on recent simulation models *(Alino and Dantis 1999)* it is believed that the most immediate threats of ecological disaster stem from human actions including pollution and sedimentation.

Most reefs in the South China Sea appear to have reached maximum harvestable potentials around the mid-1970's, (Alino *et al.,* 1996) although in the case of turtles this level may have been reached even earlier. Recent observations in the Turtle Islands fringing reefs, suggest that mass slaughter of turtles during World War II caused a reduction of turtle nesting incidence near these areas that is still observable today.

DESTRUCTIVE FISHING.

As exploitation level increases and fish resources become depleted, some fishermen choose destructive techniques to catch fish. The use of explosives and poisons for fishing is widespread in many parts of the South China Sea. Burke *et al.* (2002) indicated that 50-60% of Southeast Asia's reefs are threatened by destructive fishing. The prevalence of destructive fishing such as blast and poison fishing will exacerbate Malthusian over fishing *(Pauly et al. 1989; Russ 1991)* under the present situation of increased human population and reduced resource productivity.

Use of Poison. Poison fishing, commonly using cyanide, to capture food fish live, targets high value species, which are among the top predators. These include the Napoleon wrasse, barramundi cod, coral trout and large groupers. The poison is squirted from plastic bottles by divers commonly into reef crevices where the fish take refuge. The effects of poison fishing are multiple. Corals are broken to retrieve the stunned fish and a wide range of larvae and small fish are killed by the low concentrations. Corals are also bleached by the poison at concentrations far below those used by the fishers.

Accurate figures for the live food fish trade are difficult to obtain as official records are for gross weights, which include the water in which the fish are transported. Poison fishing will continue in the future since the incentives are high. Prices in Hong Kong for live Napoleon wrasse reach US$ 60-80 per kg. The economic loss to the region from reef damage is high, estimated at US$ 46 million with the industry collapsing within 4 years at current catch levels. Alternatively, a sustainable hook and line fisheries option could create net benefit of US$ 321.8 million (Llewellyn, G. 1999).

Bomb fishing. Away from major population centres, destructive fishing practices are the greatest threats. Explosives are easily made from artificial fertilizer. Schooling reef fish such as, groupers, fusiliers, surgeon fish, rabbit fish and snappers are targeted and the explosives are thrown from only 5 meters distance. Dead and stunned fish are collected by, divers using "hookah" equipment.

Damage to the reef is catastrophic as a single beer bottle bomb can destroy a reef area of 5 m^2, while a larger gallon container destroys up to 20 m^2. On regular bombed reefs, coral mortality may be 50-80%. The economic loss over the next 20 years is conservatively estimated at US$ 3 billion in remote areas and US$ 60,800 per km^2 in reefs within areas of high tourism potential (Caesar, 1996).

Bomb fishing

USE AND VALUE

About 75% of the population in the nine countries bordering the South China Sea is resident in the coastal zone. The sea and coastal habitats including coral reefs, provide the main source of livelihood for most of these communities. Reefs support coastal fisheries and provide a variety of harvestable marine products. For example, coastal fisheries contributed 1,079,953 tonnes to the total fish production in Malaysia in 1998, (Dept of Fisheries Malaysia, 1999). In the Philippines alone, around 10-30% of total fisheries production is derived directly from reef fisheries. Fishery products from reef areas provide the major source of dietary protein and a substantial proportion is utilised directly through local consumption. This is particularly significant for island populations living in remote areas such as the Palawan islands (Philippines), islands of Sabah (Malaysia), Koh Samui (Thailand). Coastal communities also benefit from the collection of ornamental items such as mollusc shells to be sold as souvenirs.

The health of the coral reef ecosystem of the South China Sea is clearly related to fisheries production since coral reefs provide habitats for about 80% of the fish caught by coastal subsistence and small-scale fishers. The health of the reef system is therefore crucial to the welfare of these communities and degradation and loss can have severe social and economic consequences.

Coral reefs also provide services such as beach and coastal protection and their aesthetic appeal provides the basis for the international tourism market. In areas where storms abound, reefs provide the first buffer protection to the coastal habitats against the destructive effects of storm surges, and against the normal erosion effects of tidal and long-shore current movements during the monsoon periods.

Aquarium Trade. The aquarium fish trade continues to fuel demand for marine ornamentals with significant exports from the Philippines, Malaysia, Indonesia and Vietnam to North America and Europe. Live corals are also exported mainly to Oriental and European markets. Living "rocks" and dead corals are also exported as part of the marine ornamental trade.

Aquaculture. Marine aquaculture of coral reef fish and shellfish is a growing activity in the region as an increasing number of farms are established to culture spiny lobsters and groupers in particular. Juveniles are caught from the reefs and kept in such farms, while reef benthic invertebrates such as sea urchins and mollusks are collected to feed the cultured species. Overharvesting of wild individuals to stock such "farms" not only results in changes to the wild population and community of food species but also reduces the long-term economic viability of the farms themselves.

Table 3 Aquarium Trade in coral reef organisms. (Wabnitz, *et al*., 2003)

Origin	No. of invertebrates imported (exporters/ data)	% of total no. traded	Origin	No. of invertebrates imported (importers/ data)	% of total no. traded
Indonesia	561,506	44	Unknown	2,441,742	80
Philippines	460,817	36	Mexico	246,458	8
Sri Lanka	100,309	8	Indonesia	104,282	3
Solomon Islands	75,305	6	Singapore	68,190	2
Fiji	53,823	4	Fiji	48,358	2
Palau	10,315	1	Sri Lanka	33,782	1
			Philippines	29,440	1
			Vanuatu	15,904	1
Total	1,262,075	99	Total	2,988,183	98

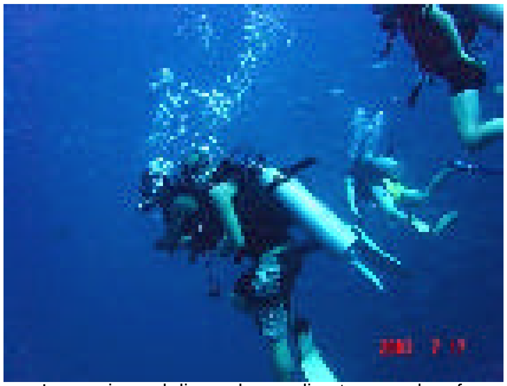
Coral mining Coral mining for lime production is a traditional activity, still practiced in some coastal villages of Vietnam. Some cement factories use coral rock as a limestone source, and coral rock is also used for shrimp pond construction in Vietnam.

Coastal Tourism. Many of the South China Sea countries have developed marine tourism based on coral reefs. The reefs support the scuba diving industry and attract divers world-wide. Marine tourism supports other economic activities such as the production of handicrafts, food, beverage and other local cultural products that provide extra income to local communities and contribute significantly to the hard currency earnings of the countries concerned.

The high species diversity of coral reefs, their easy accessibility and low cost of living make the South China Sea an attractive destination for marine tourism. The coral reefs of the countries bordering the South China Sea should be considered an important resource for economic development as they attract divers and fishing enthusiasts.

Reef-based Tourism. The importance of reefs in affecting tourist arrivals is illustrated by the experience of Peninsular Malaysia. The East coast islands have more extensive and more diverse reefs than on the west coast (Wells, 1988). The reefs of the east coast have 55 – 70% live coral cover (Wilkinson, 1998) and this has contributed to the high number of tourist arrivals on this side of the peninsula. Destinations growing in popularity include El Nido (Philippines), Mu Koh Chang (Thailand), Nha Trang (Vietnam), Pulau (Philippines), Layang-Layang (Malaysia) and Sanya (China). Coastal tourism in the region has increased remarkably in the last 15 years but popular destinations suffer from an over-burdening of the ecological carrying capacity.

Tourism Impacts. The tourism industry contributes to degradation of coral reefs both during the development of resorts and from their subsequent operation. The early construction phase may involve damaging practices of land clearance and even quarrying of the reef for materials used in resort construction. When the resort is operational, damage may result from improper sewage disposal, anchor dropping at dive sites (as mooring facilities are not normally installed), breakage of live corals by inexperienced divers, and from trampling on the reef flat or gleaning of reefs.


Inexperienced divers descending to a coral reef.

Reefs are also significant for recreational photography and many universities and research institutes in the region focus on reefs for education and research, contributing to a growing awareness of their ecological and economic value.

Coastal Protection. Coral reefs are important in terms of coastal protection in many locations exposed to strong conditions such as in central Vietnam, Sabah and Palawan. Reefs are used as natural harbours for small fishing boats.

Economic Value. Assessments of the economic value of coral reefs take into account both, the direct and indirect values, and also non-use values. Preliminary data from the Apo Islands (Philippines) indicate the total economic benefit at US$ 400,000 in 2000, when the reefs are well protected. Degradation of reefs results in loss of benefits. Cesar *et al.,* (2001) estimated the economic impact of coral bleaching to fisheries and tourism at El Nido, Palawan (Philippines), where a large percentage of corals bleached during the second half of 1998. Significant economic losses to tourism due to the coral bleaching event at El Nido was estimated at US$ 30 million based on the assumption that these losses were permanent at a 9% discount rate.

Table 4 Total Number of Visitors to the Malaysian Marine Park Islands.

Year	East Coast (Pulau Payar)		West Coast (Tioman, Redang, Mersing)		Total	
	Local	Foreign	Local	Foreign	Local	Foreign
1999	16,557	66,689	157,289	136,935	173,846	203,624
2000	19,944	68,836	189,914	169,164	209,858	238,000
2001	38,027	89,514	221,256	135,436	259,283	224,950
2002	56,259	77,516	118,864	34,392	175,123	111,908
Total	130,787	302,555	687,323	475,927	818,110	778,482

PURPOSE OF THE DEMONSTRATION SITES

The primary purpose of the demonstration sites selected under this project is to demonstrate actions, which either "reverse" environmental degradation or will demonstrate methods of reducing degradation trends if adopted and applied at a wider scale. In the case of coral reefs in the South China Sea marine basin, the major cause of the degradation is destructive use of coral reef resources. Therefore the demonstration activities will focus on proper management of coral reef resources at specific sites, with the aim of transfering successful practices and experiences to other, similar sites.

The types of demonstration sites selected within the coral reef sub-component of the project will be designed to illustrate sustainable use of coral reefs in the region, in particular in the priority areas identified during the preparatory phase (first 2 years) of the project. To date seventeen demonstration site proposals have been prepared by the national coral reef committees (or working groups) encompassing a wide range of different demonstration activities, including:

- *Enhancing capacity for monitoring and research*, at Phu Quoc islands, Nihn Hai, and Koh Tunsay;
- *Community-based management*, at Belitung, Mu Koh Samui, Mu Koh Angthong;
- *Establishing marine protected areas or sanctuaries*, at Batangas Bay, Calamianes Island Group;
- *Sustainable tourism*, at Mu Koh Angthong, Mu Koh Chang,
- *Sustainable financing/alternative livelihood*, at Masinloc, Zambales, Anda-Bolinao-Bani-Alaminos,
- *Legal instrument and law enforcement*, at Belitung, Mu Koh Angthong,
- *Pilot activities on restoration of coral reefs*, at Koh Tunsay, Mu Koh Samui

The proposed demonstration activities involve different organisations and different groups of people, including government agencies, local governments and organisations, non-governmental organisations, local communities, media, and civil society, in designing and executing the proposed activities.

Building on the networks of individuals and institutions developed during the preparatory phase of the project (2002 - 2003) regional mechanisms will be established to ensure sharing of experiences and exchange of knowledge regarding "good practices" between sites and between countries. The Regional Working Group on Coral Reefs will continue to provide advice and guidance regarding the establishment and operation of the demonstration sites once selected and to manage the regional co-ordination and exchange between sites in different countries.

CHARACTERISING POTENTIAL DEMONSTRATION SITES

At its first meeting the Regional Working Group on Coral Reefs (RWG-CR) discussed and agreed upon an ideal list of data and information, which should be assembled for all potential demonstration sites (UNEP, 2002a). National Committees or sub-committees working under the direction of the national focal point then proceeded to identify potential sites, and to assemble the required data and information. It soon became apparent that an ideal listing of data that could be used as the basis for criteria and indicators to prioritise sites could not be assembled for all potential demonstration sites due to the unavailability of data sets from certain locations or for certain parameters. The finally agreed set of data and information which the regional working group agreed to use in the subsequent selection procedures represent a compromise between available data sets and the ideal set (UNEP, 2002b).

A first step in comparing data and information on a regional basis involved the use of a cluster analysis to determine the relationships, in terms of the similarity and difference between all sites. Whilst all countries have determined national priorities for conservation and sustainable use of their coral reef systems these priorities have been, determined independently, within each country resulting in priorities, which do not necessarily reflect regional priorities, nor do they necessarily include consideration of transboundary issues, nor regional and global significance. By conducting a cluster analysis using an identical set of data and information from all countries (Table 5) regional comparability in the subsequent prioritisation process is assured.

COMPARING SIMILARITY AND DIFFERENCE.

The Regional Scientific and Technical Committee considered the process of determining regional priorities for action and recommended a three step process (UNEP, 2002c) as follows:

- Data and information for the site to be assembled by the national committees, (or working groups) from the participating countries, based on the regionally agreed format;
- Conduct a cluster analysis to determine similarity and difference between all potential sites;
- Determine regional priority on the basis of a rank score according to a prior agreed, sets of criteria and indicators.

In deciding upon the use of a cluster analysis to group similar sites the RSTC recognised that the available funds were unlikely to be sufficient to support interventions at all sites identified by the National Committees and Sub-committees. By grouping sites with similar characteristics and selecting sites from the groups the interventions could be chosen to maximise the range of biological diversity represented around the margins of the South China Sea.

Table 5 Uniform data set for coral reef potential demonstration sites used in determining similarity and difference between sites.

Site Name	Hard coral species	live coral cover (%)	No. of algae spp.	No. of crustacean species	No. of echinoderm species	No. of coral reef fish species	Other ecosystem	No. of endangered and threatened species
Viet Nam								
Cu Lao Cham	131	33.9	122	84	4	178	1	4
Nha Trang bay	351	26.4	55	69	27	222	2	3
Con Dao	250	23.3	84	110	44	202	2	4
Phu Quoc	89	42.2	98	9	32	135	2	3
Ninh Hai	197	36.9	190	24	13	147	1	4
Ca Na bay	134	40.5	163	46	26	211	1	3
Ha Long - Cat Ba	170	43	94	25	7	34	2	4
Hai Van - Son Tra	129	50.5	103	60	12	132	1	4
Bach Long Vi	99	21.7	46	16	8	46	M	2
Philippines								
Batanes, Basco	M	55.00	41	M	M	86	1	3
Bolinao/Lingayen Gulf	199	40.00	224	M	M	328	2	4
Masinloc, Zambales	M	33.00	57	M	M	249	2	4
Batangas bay/Maricaban	290	48.00	141	M	M	155	2	4
Puerto Galera, Mindoro	267	33.00	75	M	M	333	2	5
El Nido, Palawan	305	40.00	129	M	M	480	2	5
Thailand								
Mu Koh Chumporn	120	55	M	304	21	106	4	5
Mu Koh Chang	130	40	43	250	20	113	4	6
Mu Koh Ang Thong	110	55	7	136	21	106	4	1
Mu Koh Samui	140	40	7	136	21	106	4	5
Mu Koh Samet	41	35	38	134	11	74	4	5
Sichang Group	90	20	40	304	11	86	4	2
Sattaheep Group	90	33	40	304	15	75	4	2
Lan and Phai Group	72	18	40	304	15	75	2	2
Chao Lao	80	30	33	123	12	105	2	3
Prachuab	74	40	18	106	16	162	2	4
Koh Tao Group	79	45	7	136	21	106	2	4
Song Khla	12	20	2	M	M	30	2	2
Koh Kra	80	40	M	M	M	80	1	2
Losin	90	40	M	M	M	90	1	2
Indonesia								
Anambas	206	M	26	24	25	128	3	2
Bangka	126	M	M	25	23	169	3	2
Belitung	164	38.46	M	10	35	170	3	2
Karimata	192	M	M	15	15	200	3	2
Malaysia								
Batu Malang, Pulau Tioman	96	62.6	3.8	M	M	123	1	4
Pulau Lang Tengah	86	41.3	3.1	M	M	117	2	4
Pulau Lima, Pulau Redang	96	46.3	10	M	M	113	1	4
Teluk Jawa, Palau Dayang	80	38.4	11.9	M	M	156	1	4
Tun Mustapha, Sabah	252	M	69	M	45	375	4	4
Cambodia								
KKCR2	67	29.3	M	M	1	51	2	M
SHVCR1	34	23.1	M	M	14	6	3	M
SHVCR2	23	58.1	3	M	M	51	3	M
SHVCR3	70	M	M	M	14	42	3	M
KEPCR1	67	41	M	M	14	51	3	M

Clustering sites. Figure 3 presents the dendrogram resulting from a cluster analysis of the data presented in Table 5 using the Clustan6 software. Four clusters of sites are apparent, the lower cluster consisting of a grouping of outlying sites that for various reasons are somewhat distinct from the remainder of the set. The proposed demonstrations sites were divided by the RWG-CR into 3 groups.

Figure 3 Graphic result of cluster analysis.

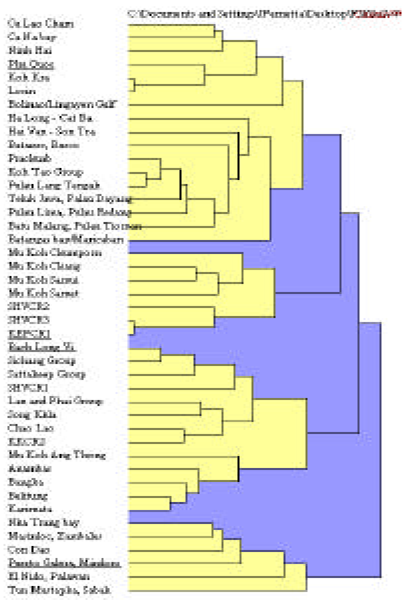


Table 6 Rank scores of coral reef potential demonstration sites based on agreed environmental and biological diversity criteria and indicators.

Site Name	Rank scores	Site Name	Rank scores
First Group		**Second Group**	
Ninh Hai	80	Mu Koh Ang Thong	64
Mu Koh Chang	76		
Mu Koh Chumporn	71	Belitung	55.5
Mu Koh Samui	71	Anambas	52.5
Ca Na bay	61	Karimata	51.5
Batangas	59	Chao Lao	50
Cu Lao Cham	57.5	Sichang Group	48
Koh Tao Group	57	SHVCR1	46.5
Mu Koh Samet	56	Sattaheep Group	45
Phu Quoc	55.5	KKCR2	45
Prachuab	55	Bangka	43.5
Ha Long - Cat Ba	54	Lan and Phai Group	40
Bolinao/Lingayan	52		
Hai Van - Son Tra	51.5	Song Khla	28
Batu Malang, Pulau Tioman	51.5	Bach Long Vi	27
Pulau Lang Tengah	47		
Teluk Jawa, Palau Dayang	46.5	**Third Group**	
SHVCR2	46.5	El Nido, Palawan	80.5
Pulau Lima, Pulau Redang	43.5	Tun Mustapha Sabah	69.5
Losin	41.5	Nha Trang bay	67.5
Batanes, Basco	40.5	Con Dao	66
Koh Kra	39.5	Puerto Galera	61.5
KEPCR1	35.5	Macinloc	50
SHVCR3	28.5		

FINALISATION OF RANK SCORES AND INDICATORS

Biological Indicators. At the same time that the group agreed on the data and information required to characterise the sites an initial discussion regarding the criteria and indicators that could be used as a mechanism for scaling transboundary, national, regional, and global significance was undertaken. Criteria and indicators were initially identified for the criteria covering indicators of environmental and biological diversity and agreement reached regarding the application of rank scores that could be applied objectively to the data from each site. The outcome of this process is presented in Table 6 in which the original 43 potential demonstration sites have been aggregated into groups and ranked in descending order of priority based on the rank score for environmental and biological diversity indicators.

Rank Scores. Social and economic criteria and indicators were also reviewed and discussed, and the rank scores agreed, covering such elements as the reversibility of current threats, national priority, level of direct stakeholder involvement in the current management regime, soco-economic values, and potential for co-financing support. The RGW-CR recognised that many of these parameters could not be measured objectively without the detailed investigations and consultations required to prepare a full proposal hence scoring based on this set of parameters was only conducted for those sites for which demonstration site proposals had been prepared and discussed with local stakeholders. In deciding upon the proportion of the final score that should be assigned to an individual proposal the RWG-CR agreed that since the environmental and biological parameters were more objective and easily verifiable, greater weight should be assigned to this category of criteria and indicators than to the social and economic criteria. It was agreed that the two groups of scores should be combined in the ratio 70:30 respectively and the final rank score is presented in Table 7.

Table 7 Rank scores for demonstration site proposals.

Site Name	Environ. rank Score	Socio-econ. Score	Total score
First Group			
Ninh Hai	80	55	72.5
Mu Koh Chang	76	69	73.9
Mu Koh Chumporn	71	52	65.3
Mu Koh Samui	71	50	64.7
Batangas	59	44	54.5
Phu Quoc	55.5	57	55.95
Bolinao/Lingayan	52	48	50.8
Batu Malang, Pulau Tioman	51.5	39	47.75
Pulau Lang Tengah	47	50	47.9
KEPCR1	35.5	57	41.95
Second Cluster			
Mu Koh Ang Thong	64	48	59.2
Belitung	55.5	47	52.95
KKCR2	45	52	47.1
Third Cluster			
Tun Mustapha, Sabah	69.5	70	69.65
Macinloc	50	57	52.1

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