Indian Journal of Marine Sciences
Vol. 34(1), March 2005, pp. 76-87

On the current status of coastal marine biodiversity in Malaysia

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Received 1 April 2004; revised 13 July 2004

The seas surrounding Malaysia is one of the largest continental shelf areas in the world contain very productive and diverse habitat and should therefore be the centre for marine biological research and data collection. Though there have been some studies on marine biodiversity dated back to mid 30's, the data collection and information gathered are however far from satisfaction. The process of data collection is in progress by time and though the process of mega-biodiversity recording is somehow jeopardized by inadequacy of taxonomists in the country. Nevertheless, the status of marine biodiversity studies around Malaysian waters is examined towards a better approach for future prospects in research and management of this valuable yet fragile ecosystem.

[**Key words:** Marine flora, fauna, coastal diversity, Malaysia]

1.0 Introduction

Malaysia (1-8^{o}N; 100-119^{o}E), comprising Peninsular Malaysia, Sabah and Sarawak, is located in the Indo-Pacific region that is also includes sea areas surrounding Indonesia and the Philippines. Peninsular Malaysia is bounded by seas on all sides except in the north where it is connected to the Asian mainland via Thailand (Fig. 1). Sabah and Sarawak are located on the northern part of Borneo Island. The two land masses are about 1200 km apart, separated by southwestern portion of the South China Sea, while the west coast of Peninsular Malaysia is bordered by Strait of Malacca with Andaman Sea to the north and Java Sea to the south. Malaysia has one of the largest continental shelf areas within the tropical world. In comparison with other areas, this region is very rich in biodiversity, and considered to contain the greatest species diversity of marine life in the world[2]. The total coastline for Malaysia is 4,800 km, with 2,100 km for Peninsular Malaysia and 2,700 km for East Malaysia[1]. This manuscript was prepared in conjunction with the Censor of Marine Life (CoML) initiative and its associated organization in an effort to make the unknown to become known with respect to marine biological diversity in Malaysia waters.

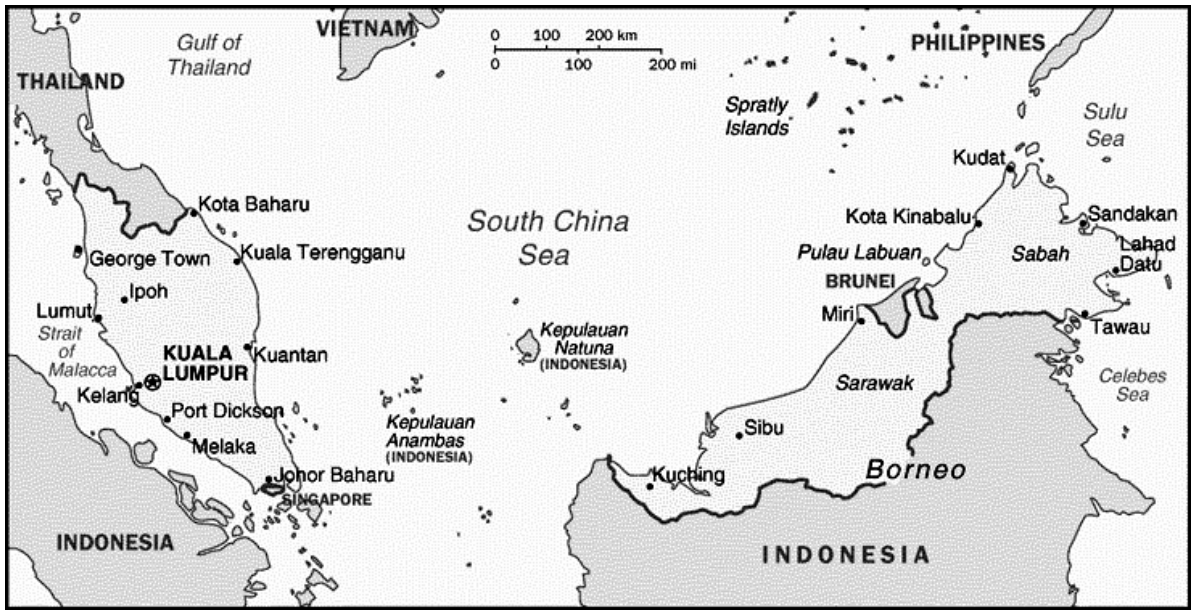
2.0. General Overview of Peninsula Malaysia and Sabah Coastal Marine Habitats

2.1. Coral reefs

The reefs of the East Asian seas support a rich assemblage of marine life making them second only to rainforest in species richness. This mega diversity is a result of careful sharing of a reef by all its inhabitants. They provide the fish, mollusks and crustaceans on which many coastal communities depend on and, with other coastal habitats, provide nutrients and breeding grounds for many commercial species[3]. Study on the association of organisms in the marine habitats is very scarce and is one of the areas that should be exploited. Reef organisms display extraordinary specialization, intensive predator-prey evolutionary pathways, and competitive interactions within and among species. It is also believed that about 90% of all reef species are small invertebrates yet to be discovered. A single reef may have over 3000 different kinds of plants and animals. Reefs and non-reef communities within 15 kilometers of shore are generally over fished, while offshore subsurface atolls and pinnacle reefs are often beyond the reach of small-scale fishermen. Major destructive forces include excessive sedimentation and nutrients related to deforestation and agricultural activities, and various forms of destructive fishing, especially blast fishing.

2.2. The mangrove forest

In comparison with the mangrove flora of equivalent latitudes on the Atlantic shores of Africa and the Americas the mangroves of the Indo-Pacific region and Southeast Asia in particular, are extremely diverse. Mangrove is the dominant coastal community in tropical Asia, with the Malay-Indonesian region as its centre of distribution. Malaysia has 650,000 ha of



mangrove forest comprising 104 species and ranked second after Indonesia with 4.25 million ha[4]. The mangroves in most parts of Malaysian coastal waters have suffered heavily from human impacts which include illegal cutting, conversion to other uses (such as mariculture and other forms of coastal development) and possible landbased industrial pollution[5]. The mangroves in Sabah, however, are less affected but signs of degradation have been recorded in some locations[6] (e.g. West and Northern Coast of Sabah).

2.3. The seagrass, sandy beaches and the rocky shores

2.3.1. Seagrass beds

Malaysia has about 14 species of seagrasses from a total recorded of 20 species in the Southeast Asia[7]. There are about 7 dominant genera and considered as the most highly diverse seagrass flora in the world. Both mangroves and seagrasses show a similar global pattern of generic richness, characterized by a maximum variety in the Indo-West Pacific and secondary centers of diversity usually in the Caribbean. Although the number of seagrass species is relatively small in comparison to other groups their numbers are by no means proportional to their ecological and economic importance. They form dense beds which cover large areas of coastal waters and perform a wide spectrum of biological and physical functions, serving as habitat and nursery areas for fish, invertebrates, turtles and dugongs.

2.3.2. Sandy beaches

Sandy beaches and surf zones occur extensively on the shores of coral islands and are interspersed among other shore formations throughout continental Asia. Only a restricted fauna tolerate the surf forces and instability of an exposed sandy shore. Tropical organisms are further inhibited by high temperatures and desiccation. The middle and lower beach animals are absent from shores with severe wave action. The fauna of sheltered sandy beaches is much richer by comparison[8]. On sand flats containing a proportion of silt, burrowing polychaetes, echinoderms, and coelenterates become important components of the fauna and a seaward zone of the marine herb *Enhalus* is developed. Marine turtles nest on the many sandy beaches along Malaysian coasts.

2.3.3. Rocky shores

Rocky shores occur on the coasts of many Malaysian islands. Smaller rocky outcrops and boulder formations are common above coral reef flats and on headlands bordering sandy bays. The zonation of organisms on rocky shores in the region follows the typical pattern with three major zones (supra-, mid-, and sub-littoral), characterized by key organisms (littorinid snails, barnacles, and algae, respectively). A rich assemblage of organisms occurs at the lowest tidal level and in crevices[8,9], where the environment is less extreme. Tropical rock pools are subject to extreme heating and wide fluctuations in salinity and consequently support a minimal biota.

3.0. The Known and Past Studies

Studies on marine biodiversity in this region were initiated by European and American scientists through many expeditions. The earliest work on diversity of marine species in Malaysia was perhaps by Cantor[10] who finally presented a catalog of fish species of Peninsula Malaysia. This was then followed by other significant studies on fisheries and other taxonomic groups. Table 1 shows group of organisms that have been recorded, with number of species discovered and selected references. The phyla Chordata, Cnidaria, Arthropoda and Mollusca appeared to have high numbers of species recorded, but still very small when compared with the known number of species of the world. There are still many areas to be explored, especially the study of smaller invertebrates that made up the reefs and the benthos, as both communities contain high numbers of organism. Considering that this region is the center of diversity, more efforts should be made in inventorying the marine species in Malaysian waters. However, a major obstacle in achieving this objective is nonavailability of taxonomists of various marine taxa.

To date, most detailed account on biological diversity studies could be derived from the freshwater and marine fishes[11-13], marine reptiles such as turtles and sea snakes[14-17], the marine mammal[18], the invertebrates sea cucumber (Holothuroid)[19], and seagrasses[7]. Detailed accounts on other marine organisms are still lacking especially on the microscopic and smaller organisms.

3.1. Coastal marine fishes

In general, a total of 1500 species of fishes were estimated to occur in Malaysian waters. The published reference material by Mohsin & Ambak[11], described detailed account on marine fishes and fisheries of Malaysia and neighbouring countries (Table 2). They reported a total number of 710 species (Elasmobranchii + Teleostei). Later Mansor, *et al.*[13], listed a total number of 358 commercially important marine fishes in the South China Sea. Those numbers of species were recorded based on systematic identification of the specimens collected from fish landing port and central market sampling from the various coastal towns or city centres and research cruise in the South China Sea. Later in the same year, Chin[12] has published a secluded book on the marine food fishes and fisheries of Sabah. In this book, he listed 376 species of marine fishes representing the major groups of food fishes (excluding the elasmobrachii) that commonly found in Sabah Malaysia.

Table 1—Estimates of numbers of known species of marine organisms in Malaysia and the world (in parenthesis)

Phylum/Major Categories	Group of organisms	No. of known species*
Chordata	Fish	1,500 (45,000)
	Commercial	710
	Marine Mammals	29 (78)
	Reptiles	40 (200)
	Sea turtles, sea snake and crocodile	
Cnidaria	Anthozoans	500 (6,500)
	Scleractinian coral	346 (?)
Arthropoda (Crustacea)	Decapods	1,100 (10,000)
	Cirripedians	10 (1000)
	Ostracods	5 (5,700)
	Copepods	100 (11,500)
	Isopods	10 (4,000)
	Amphipods	20 (6,000)
	Tanaids	5 (500)
	Cumaceans	5 (800)
	Mysids	10 (780)
Mollusca	Gastropods	300 (39,000)
	Bivalves	100(7500)
	Scaphopods	20 (350)
	Cephalopods	10 (1,000)
Annelida & other marine worms	Polychaetes	50 (10,000)
	Sipunculans	5 (320)
	Nemertians	2 (800)
	Tubellarians	2 (6,000)
	Nemathods	20 (5,000)
	Chaetognatha	10 (65)
Echinodermata	Asteroids	20 (1,800)
	Holothuroids	23 (1,100)
	Echinoids	20 (1,000)
	Ophiuroids	15 (2,000)
	Crinoids	10 (800)
Porifera	Sponges	10 (5,000)
Phytoplankton	Dinoflagellates	30 (1,200)
	Diatoms	70 (4,200)
Seaweed & other algae	Chlorophytes	78 (800)
	Rhodophytes	69 (4,000)
	Phaeophytes	49 (1,500)
	Cyanophytes	13 (1,500)
Mangroves		104(114)
Seagrass & angiosperms	Spermatophyta	14(20)

*Note: Number in parentheses is world estimates of number of species.

Table 2—The coastal marine fishes as reported by Mohsin & Ambak[11]

	Class / Order	Number of families	Number of species	Number of commercially important species
A	**Elasmobranchii**			
1	Carcharhiniformes	4	14	11
2	Heterodontiformes	1	1	0
3	Orectolobiformes	3	4	0
4	Squaliformes	1	1	0
5	Rajiformes	9	18	17
6	Torpediniformes	1	2	0
	Sub total (Elasmobranchii)	19	40	28
B	**Teleostei**			
7	Clupeiformes	8	42	42
8	Cetomimiformes	1	1	0
9	Siluriformes	2	7	7
10	Mytophiformes	2	8	8
11	Gadiformes	1	1	0
12	Beloniformes	3	12	8
13	Anguilliformes	5	9	2
14	Mugilliformes	2	12	12
15	Atheriniformes	1	1	0
16	Pegasiformes	1	1	0
17	Syngnathiformes	3	5	0
18	Beryciformes	2	12	0
19	Zeiformes	1	2	0
20	Polynemiformes	1	5	4
21	Perciformes	60	449	327
22	Pleuronectiformes	6	27	14
23	Lophiiformes	4	5	0
24	Batrachoidiformes	1	1	0
25	Echeneiformes	1	1	0
26	Tetraodontiformes	8	42	6
27	Scorpaeniformes	5	25	0
28	Dactyloteriformes	1	2	0
	Sub total (Teleostei)	119	670	430
	Total (A + B)	138	710	458

3.2. Marine reptiles

The marine reptiles of Malaysian coastal waters received uneven and less attention from the researchers. Sea turtles received the most attention due facing a serious threat and listed in IUCN endangered species book. Four major species of sea turtles inhabit the coastal water of Malaysia[14-16]. These are the most endangered leatherback turtle (*Dermochelys coriacea*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*) and olive ridley turtle (*Lepidochelys olivacea*).

Studies of sea snakes however are very scarce[17]. The most common species of sea snake is from the family Hydrophiidae contains some 14 genera and 47 species. Of these, about 30 species are found in the Malaysian waters. Other common family is sea kraits (Laticaudidae) also occur throughout the region. This family contains only six species in a single genus (Laticauda; some taxonomists recognize a second genus, *Pseudolaticauda*). Three of the six species are found in the Malaysian waters. One of them is the commonly found *Laticauda colubrina*. Sea kraits are also exploited for their skins and food.

3.3. Marine mammals

Studies on marine mammals in Malaysia are currently centered in Universiti Malaysia Sabah. The current studies are mainly based on the *in situ* survey and distribution of questionnaires to the coastal people in an effort to gather information on marine mammals in Malaysian waters. Recent literature surveyed by Saifullah *et al.*[18], reported a total number of 29 species of marine mammals in Malaysian waters and at least 13 species of whales, dolphins, porpoises and dugongs are common in the Malaysian waters. The dugong (*Dugong dugon*) at present is endangered because of hunting and by destruction of its natural habitat (i.e. seagrasses). A further 16 species of cetaceans such as *Orcinus orca*, *Physeter catodon*, *Kogia breviceps* occasionally stray or pass through the Peninsular Malaysian EEZ in the Straits of Malacca or South China Sea. These are based on the recorded observations in South China Sea of Peninsular Malaysia, Sabah and Sarawak and Brunei Darussalam.

Balaenoptera edeni (Bryde's whale) is the most common cetacean in the region. Other species recorded are *Balaenoptera acutirostrata* (minke whale), *Balaenoptera borealis* (sei whale), *Balaenoptera musculus* (blue whale), *Balaenoptera physalus* (fin whale), and *Megaptera novaeangliae* (humpback whale). Dolphin and porpoise species include *Sousa chinensis* (Indo-Pacific humpbacked dolphin), *Orcaella brevirostris* (Irrawady dolphin), *Neophocaena phocaenoides* (finless porpoise), *Tursiops truncatus* (bottlenose dolphin), *Delphinus delphis* (common dolphin) and possibly also *Sousa borneensis* (white dolphin), *Sousa plumbea* (plumbeous dolphin) and *Stenella malayana* (Malayan dolphin).

Besides the work on specific taxonomic groups, there is also the need to study the ecosystem as a whole, the association between organisms and the interaction within and between ecosystems. There have been studies on biodiversity from surveys confined to particular locations[8,9,20-25], which of course leaves lot more areas yet to be exploited.

3.4. Coral reefs around the coastal islands

The earlier coral reef biodiversity survey in Malaysia was conducted by Elizabeth Wood in the early 70's in the west coast of Sabah[26]. In Peninsular Malaysia, intensive surveys of coral reef surrounding the selected coastal island was done through ASEAN-AUSTRALIAN Project in collaboration of the locals and foreign marine biologists and have been reviewed extensively by Ridzwan[27].

The recent 2000 coral survey by the Malaysian Marine Park Authority with the help of Coral Cay foundation, UK and local Universities expertise have produced a significant finding on coral reefs associated faunal biodiversity in the Marine Park areas[42]. In this survey a total number of 330 coral species with an additional eight undescribed species (unknown) have been listed (Tables 3 and 4).

4.0. Current Threats

4.1. Development of coastal mangrove ecosystem

Malaysia is a developing country that underwent rapid development in every inch of its coastal water-land interfaces. The wide ranges of development include conversions of the mangrove forest into aquaculture pond and tourism related industries, reclamation of mangrove forest and coastal mudflats into commercial industrial complex and for extension of the commercial ports which lead to total or critical habitat losses. Coastal habitat degradation such as removal of the mangrove forest systems denied the role of mangrove ecosystem in coastal protection and as integral areas of spawning and nursery ground for fresh water, brackish and marine fauna[22,28].

4.2. Captured fisheries

The continuing pressures on the marine ecosystems are sometime inevitable due to rapid development and increase in population density. Increased commercial fisheries can lead to overexploitation of certain commercially important marine species and habitat loss due to uncontrolled trawling activities (Table 5). Continued exploitation at levels above Maximum Sustainable Yield (MSY) can result in disruption of species composition by increased of by-catch yield (trash fish landing) and recruitment failure of the commercially important marine species.

4.3. Invasiveness of the introduced species

Other salient biodiversity threatening factor that required is to protect the local coastal marine species from the invasiveness of the introduced marine organism in the natural environment. For example, a single fish family such as cichlidae, such as *Tilapia mozambica* and *Etroplus suratensis* although freshwater origin in their native countries, are found to survive and adapt well in brackish water environment, that affect the ecology of the local residence species.

4.4. Coral reefs ecosystem and its associated biota

The coral reefs ecosystem and its associated biota in Malaysia have long been under threat due a combination of natural hazards and fast track developments in the coastal areas. According to the results of the previous survey in the surrounding reefs much of the dead coral may be attributable to the natural hazard such as the 1998 bleaching event, which obviously had a significant effect on the marine parks[42]. Further coral mortality has been caused, and continues to be caused, by the corallivores species like *Acanthaster planci* and *Drupella* spp. However, assuming there is no population outbreak of *A. planci*; this mortality is relatively minor and will not inhibit either coral recovery or general reef integrity.

For the coastal islands that relatively closed to the mainland a higher sedimentation regime was expected than for sites further offshore, partly for natural reasons but also because of coastal development. For example, the development on the island around Pulau Payar, Kedah as well as increase in number of vessels transiting the Straits of Melaka have been shown to have an impact on the coral reefs and fishes of Pulau Payar marine park[29]. High sediment loads also appeared to be related to anthropogenic influences such as forest removal and land development.

There were several past and current issues of coastal development threats on the Marine Park Islands such as development of golf course in Pulau Redang and Pulau Tioman within last decade. It was reported that sedimentation due to development projects in Pulau Redang caused depletion in the coral abundance[30]. The independent studies on the impacts of such development on the coral reefs and its associated biota have currently been engaged by several local researchers.

Local fishermen have been given permission to fish within the marine parks via traditional techniques but fishing pressure appears low to moderate. However, snagged lines were seen at many sites, along with some traps and nets. Although abandoned gear is not

Table 3—Species list of coral reef species occurred in the coastal waters of Malaysia[42]

1	*Acanthastrea echinata*	48	*Blastomussa wellsi*	95	*Gala ea fascicularis*
2	*Acanthastrea hemprichii*	49	*Catalaphyllia jardini*	96	*Galaea sp. 1*
3	*Acanthastrea lordhowensis*	50	*Caulastrea tumida*	97	*Gardineroseris planulata*
4	*Acanthastrea* sp. 1	51	*Coscinaraea collumna*	98	*Goniastrea edwardsi*
5	*Acropora aspera*	52	*Coscinaraea exesa*	99	*Goniastrea favulus*
6	*Acropora austera?*	53	*Coscinaraea hahazimaensis*	100	*Goniastrea pectinata*
7	*Acropora bruggemanni*	54	*Ctenactis albitentaculata*	101	*Goniastrea retiformis*
8	*Acropora cerealis?*	55	*Ctenactis crassa*	102	*Goniastrea* sp. 1
9	*Acropora cytherea*	56	*Ctenactis echinata*	103	*Goniopora planulata?*
10	*Acropora digitifera*	57	*Cycloseris erosa*	104	*Heliofungia actiniformis*
11	*Acropora divaricata*	58	*Cycloseris patelliformis?*	105	*Heliopora coerulea*
12	*Acropora elseyi (cf Wallace)*	59	*Cynarina lacrimalis*	106	*Herpolitha lima*
13	*Acropora florida*	60	*Diaseris distorta*	107	*Herpolitha weberi*
14	*Acropora formosa*	61	*Diaseris fragilis*	108	*Hydnophora e esa*
15	*Acropora gemmifera*	62	*Diploastrea heliopora*	109	*Hydnophora grandis*
16	*Acropora hoeksemai?*	63	*Distichopora violacea*	110	*Hydnophora microconos*
17	*Acropora horrida*	64	*Echinophyllia aspera*	111	*Leptastrea pruinosa*
18	*Acropora humilis*	65	*Echinophyllia echinata*	112	*Leptastrea purpurea*
19	*Acropora hyacinthus*	66	*Echinophyllia orpheensis*	113	*Leptoria phrygia*
20	*Acropora latistella*	67	*Echinopora gemmacea*	114	*Leptoseris e planata*
21	*Acropora loripes*	68	*Echinopora horrida*	115	*Leptoseris incrustans?*
22	*Acropora microphthalma*	69	*Echinopora lamellosa*	116	*Leptoseris mycetoseroides*
23	*Acropora millepora*	70	*Echinopora pacificus*	117	*Leptoseris papyracea*
24	*Acropora monticulosa*	71	*Euphyllia ancora*	118	*Leptoseris scabra?*
25	*Acropora nasuta*	72	*Euphyllia divisa*	119	*Lithophyllon undulatum*
26	*Acropora nobilis*	73	*Euphyllia glabrescens*	120	*Lobophyllia corymbosa*
27	*Acropora palifera*	74	*Euphyllia yaeyamensis*	121	*Lobophyllia hataii*
28	*Acropora pinguis*	75	*Favia ma ima*	122	*Lobophyllia hemprichii*
29	*Acropora prostrata*	76	*Favia maritima*	123	*Lobophyllia robusta*
30	*Acropora robusta*	77	*Favia pallida*	124	*Lobophyllia* sp. 1
31	*Acropora rosaria*	78	*Favia* sp. 1	125	*Lobophyllia* sp. 2
32	*Acropora samoensis*	79	*Favia stelligera*	126	*Lobophyllia* undescribed
33	*Acropora secale*	80	*Favia veroni*	127	*Merulina ampliata*
34	*Acropora selago?*	81	*Favites abdita*	128	*Merulina scabricula*
35	*Acropora solitaryensis?*	82	*Favites acuticollis*	129	*Millepora dichotoma*
36	*Acropora stoddarti?*	83	*Favites halicora*	130	*Millepora e aesa*
37	*Acropora tenuis*	84	*Favites pentagona?*	131	*Millepora platyphylla*
38	*Acropora valenciennesi*	85	Favites sp. 1	132	*Millepora tenera?*
39	*Acropora valida*	86	*Fungia concinna*	133	*Monitpora millepora*
40	*Acropora vermiculata*	87	*Fungia fungites*	134	*Montastrea curta*
41	*Acropora yongei*	88	*Fungia granulosa*	135	*Montastrea magnistellata*
42	*Anacropora matthai*	89	*Fungia klunzingeri*	136	*Montastrea* sp. 1
43	*Astreopora gracilis*	90	*Fungia moluccensis*	137	*Montipora aequituberculata*
44	*Astreopora myriopthalma*	91	*Fungia paumotensis*	138	*Montipora altisepta*
45	*Astreopora ocellata*	92	*Fungia repanda*	139	*Montipora cebuensis*
46	*Balanophyllia* sp.	93	*Fungia scruposa*	140	*Montipora confusa*
47	*Barabattoia amicorum*	94	*Gala ea astreata*	141	*Montipora foliosa*

Contd..

Table 3—Species list of coral reef species occurred in the coastal waters of Malaysia[42]—*Contd.*

142	*Montipora gaimardi*	169	*Pectinia ma ima*	196	*Psammocora haimeana?*
143	*Montipora hispida*	170	*Pectinia paeonia*	197	*Psammocora nierstraszi*
144	*Montipora informis*	171	*Platygyra daedalea*	198	*Psammocora profundacella*
145	*Montipora malampaya?*	172	*Platygyra lamellina*	199	*Psammocora superficialis*
146	*Montipora mollis*	173	*Platygyra sinensis*	200	*Pseudosiderastrea tayami*
147	*Montipora* sp. 1	174	*Platygyra* sp. 1?	201	*Rhizopsammia verrilli*
148	*Montipora* sp. 2	175	*Platygyra verweyi*	202	*Sandalolitha robusta*
149	*Montipora* sp. 3	176	*Plerogyra sinuosa*	203	*Scapophyllia cylindrica*
150	*Montipora tuberculosa*	177	*Plesiastrea versipora*	204	*Scolymia australensis*
151	*Mycedium elephantotus*	178	*Pocillopora damicornis*	205	*Scolymia vitiensis*
152	*O ypora crassispinosa*	179	*Pocillopora danae*	206	*Stylocoeniella guentheri*
153	*O ypora lacera*	180	*Pocillopora eydou i*	207	*Stylophora pistillata*
154	*Oulastrea crispata*	181	*Pocillopora meandrina*	208	*Stylophora subseriata*
155	*Oulophyllia bennettae*	182	*Pocillopora verrucosa*	209	*Symphyllia agaricia*
156	*Oulophyllia crispa*	183	*Podabacia crustacea*	210	*Symphyllia radians*
157	*Pachyseris foliosa*	184	*Polyphyllia talpina*	211	*Symphyllia recta*
158	*Pachyseris rugosa*	185	*Porites annae*	212	*Symphyllia valenciennesi*
159	*Pachyseris speciosa*	186	*Porites cylindrica*	213	*Trachyphyllia geoffroyi*
160	*Pavona bipartita*	187	*Porites evermanni*	214	*Tubastraea coccinea*
161	*Pavona cactus*	188	*Porites horizontalata*	215	*Tubastraea diaphana*
162	*Pavona clavus*	189	*Porites monticulosa*	216	*Tubastraea micranthus*
163	*Pavona decussata*	190	*Porites nigrescens*	217	*Turbinaria frondens*
164	*Pavona e planulata*	191	*Porites rus*	218	*Turbinaria irregularis*
165	*Pavona frondifera*	192	*Porites solida?*	219	*Turbinaria mesenterina*
166	*Pavona varians*	193	*Psammocora contigua*	220	*Turbinaria peltata*
167	*Pectinia alcicornis*	194	*Psammocora digitata*	221	*Turbinaria stellulata*
168	*Pectinia lactuca*	195	*Psammocora e planulata*		

a major threat to coral health, nets can smother relatively large areas and there was some evidence of net dragging in the park areas. Fishing itself can have major economic and ecological impacts, including the reduction of herbivorous fish which can affect the ability of reefs to regenerate. Finally, there are numerous dive and snorkeling sites within the marine parks and coral damage may be a significant threat in many areas.

4.5. Sea turtles

Sea turtles of the Malaysian waters have long being seriously under threat although efforts to protect them were among the earliest conservation activities adopted by various governmental and non-government agencies in Malaysia. The most popular turtle species in the earlier time was the cosmopolitan Giant Leatherback turtle *Dermochelys coriacea*. Other three species of sea turtles commonly and abundantly found in the Malaysian coastal waters were the Green turtle, *Chelonia mydas*, the Hawksbill turtle *Eretmochelys imbricata* and the Olive Ridley turtle, *Lepidochelys olivacea*.

In the early 70's, the beaches of Rantau Abang Terengganu, east coast of Peninsular Malaysia used to be the major nesting site for the Giant Leatherback turtle. The major threat to the sea turtles have been well documented. These include the incidental capture in the fishermen fishing gears[14], natural rhythmic predators as soon as the newly hatched turtle hatchlings were released to the sea and due to other illegal human activities such as turtle hunting for food by illegal fishermen and curios industries[16].

4.6. Marine mammal

The population of marine mammal particularly the sea cow (*Dugong dugon*) is currently under threat due to its natural habitat loss to the coastal developments.

Table 4—New record of coral species in Peninsular Malaysia[42]

1. Pocillopora danae	*41. Porites monticulosa*	*80. Cynarina lacrimalis*
2. Pocillopora meandrina	*42. Goniopora planulata?*	*81. Scolymia australis*
3. Stylophora subseriata	*43. Psammocora explanulata*	*82. Scolymia vitiensis*
4. Montipora aequituberculata	*44. Psammocora nierstraszi*	*83. Acanthastrea hemprichii*
5. Montipora altisepta	*45. Psammocora profundacella*	*84. Acanthastrea lordhowensis*
6. Montipora cebuensis	*46. Psammocora superficialis*	*85. Acanthastrea* sp. 1
7. Montipora confusa	*47. Coscinaraea collumna*	*86. Lobophyllia corymbosa*
8. Montipora sp. 1	*48. Coscinaraea exesa*	*87. Lobophyllia* sp. 1
9. Montipora gaimardi	*49. Coscinaraea hahazimaensis*	*88. Lobophyllia* sp. 2
10. Montipora malampaya?	*50. Pavona bipartite*	*89. Lobophyllia* sp. 3
11. Montipora millepora	*51. Leptoseris explanata*	*90. Hydnophora grandis*
12. Montipora sp. 2	*52. Leptoseris incrustans?*	*91. Merulina scabricula*
13. Montipora sp. 3	*53. Leptoseris mycetoseroides*	*92. Caulastrea tumida*
14. Anacropora matthai	*54. Leptoseris papyracea*	*93. Favia maritima*
15. Acropora austera?	*55. Leptoseris scabra?*	*94. Favia* sp. 1
16. Acropora bruggemani	*56. Pachyseris foliosa*	*95. Favia veroni*
17. Acropora cerealis	*57. Cycloseris erosa*	*96. Favites acuticollis*
18. Acropora cytherea	*58. Cycloseris patelliformis?*	*97. Favites* sp. 1
19. Acropora digitifera	*59. Diaseris distorta*	*98. Goniastrea favulus*
20. Acropora gemmifera	*60. Diaseris fragilis*	*99. Goniastrea* sp. 1
21. Acropora hoeksemai?	*61. Fungia concinna*	*100. Platytyra contorta*
22. Acropora horrida	*62. Fungia granulosa*	*101. Platygyra verweyi*
23. Acropora loripes	*63. Fungia klunzingeri*	*102. Montastrea curta*
24. Acropora monticulosa	*64. Fungia moluccensis*	*103. Montastrea* sp. 1
25. Acropora nobilis	*65. Fungia paumotensis*	*104. Montastrea magnistellata*
26. Acropora prostrata	*66. Fungia scruposa*	*105. Plesiastrea versipora*
27. Acropora rosaria	*67. Ctenactis albitentaculata*	*106. Leptastrea pruinosa*
28. Acropora samoensis	*68. Ctenactis crassa*	*107. Echinopora gemmacea*
29. Acropora secale	*69. Herpolitha weberi*	*108. Echinopora pacificus*
30. Acropora selago	*70. Lithophyllon undulatum*	*109. Trachyphyllia geoffroyi*
31. Acropora solitaryensis	*71. Podabacia motuporensis*	*110. Euphyllia ancora*
32. Acropora stoddarti?	*72. Galaxea* sp. 1	*111. Euphyllia divisa*
33. Acropora valenciennesi	*68. Echinophyllia echinata*	*112. Euphyllia yaeyamensis*
34. Acropora valida	*73. Echinophyllia orpheensis*	*113. Catalaphyllia jardini*
35. Acropora vermiculata?	*74. Oxypora crassispinosa*	*114. Turbinaria irregularis*
36. Acropora yongei	*75. Mycedium elephantotus*	*115. Turbinaria mesenterina*
37. Astreopora gracilis	*76. Pectinia alcicornis*	*116. Turbinaria stellulata*
38. Astreopora ocellata	*77. Pectinia maxima*	*117. Balanophyllia* sp.
39. Porites annae	*78. Pectinia paeonia*	*118. Rhizopsammia verrilli*
40. Porites evermanni	*79. Blastomussa wellsi*	*119. Tubastraea coccinea*

The conversion of seagrass bed into the commercial cargo terminal port such as Tanjung Pelepas in South Johore is currently exerted serious impacts on the seagrass communities that have long being important feeding habitat for sea cow. The permanent loss of seagrasses bed resulted in decline of sea cow in the Malaysian coastal waters. Other marine mammal species such as whales, dolphin and porpoise are not so seriously under threat due to their nature of cosmopolitan swimming habit. The development of the coastal areas is localized in nature that depends on the state developmental status as summarized in

Table 5—The current status of exploitation level of commercial fishery resources in South China Sea

Fishing zone	Resource category	East coast Peninsular Malaysia	Sarawak	West coast of Sabah
	Prawn	OE	OE	OE
	Coral fishes	?	UE	OE
12 nm from	Pelagic fishes	OE	OE	OE
coastline	Demersal fishes	OE	OE	UE
	Small pelagic fishes	UE	UE	UE
Exclusive Economic	Demersal fishes	UE	UE	UE
Zone (EEZ)	Tuna	UE	UE	UE

Note: OE = Over-exploitation; UE = Under exploitation; ? = Status not available

Table 6. Other potential threats are related to localized activities as well as global environmental changes, and the factors are summarized below:

Reefs and marine resources

- Overharvesting of fish and shellfish
- Degradation of coral reefs due to use of explosives for fishing (Sabah)
- Degradation of reefs from cyanide and other harvesting methods (Sabah)
- Mortality of corals due to increased water temperature (coral beaching)
- Damage caused by large populations of coral-feeding starfish, *Acanthaster planci*
- Damage caused by 'black sponge' infestation
- Loss of biodiversity due to these factors

Dealing with shoreline and land use

- Land claims, customary rights and ownership issues
- Illegal settlements and immigration
- Unregulated use of mangrove and forest resources
- Unregulated land clearance and agricultural development
- Loss of biodiversity

Water quality and wastes

- Threats from river-borne pollution and run-off from mainland
- Vulnerability of reef lagoons to sediment run-off from island slopes
- Limited fresh water supply
- Lack of proper disposal of sewage and rubbish

Recreation and tourism

- No environmental guidelines for visitors
- Lack of a plan for tourism development

Aquaculture

- Established seaweed farming operations are not part of integrated plan
- Lack of a plan for potential aquaculture projects

Gaps in information and education

- Lack of awareness of the need for - - and benefits of - - conservation and management
- Incomplete understanding of natural systems and processes

5.0. Biodiversity Conservation and Management Programmes

Continuous efforts have been made by various governmental research bodies, non-governmental and higher institution agencies to explore and collate latest information and the biodiversity status of the coastal marine faunas through organized joint scientific expeditions, independent research and conferences. The Malaysian government through its various agencies has embarked active responses in challenging various environmental and biodiversity issues. The development of various policies and policy corresponds with different threats posed to the environment and its inhabitant with the specific ultimatum of balancing between the social demands on biodiversity resources and sustainable exploitation, social, environmental and biodiversity health. The requirement of an Environmental Impact Assessment for every prescribed coastal development activity is mandatory for any coastal development projects. The government also for example, has developed three policy documents to address problems of pollution, deterioration of biological diversity and uneven exploitation of fisheries resources. In addition, a draft national coastal zone policy has also been prepared to

address crosscutting issues in coastal zone management (i.e. Integrated Coastal Zone Management or ICZM). It therefore appears that these areas are the priority areas for policy development where the government of Malaysia is concerned.

However, the development of a number of policies was in isolation of one another. These have led to a situation where there are possibilities for conflict between the different objectives and strategies adopted by these policies. This conflicting policies are so clear for example, the National Agricultural Policy 3 (NAP3) espouse the need to increase the exploitation of fisheries resources by increasing the amount of capture fisheries and aquaculture production. This could have repercussions on marine biological diversity if carried out without consideration given to objectives and strategies outlined in the National Policy on Biological Diversity and draft National Coastal Zone Policy. There are several constraints of regional environmental governance. Those are the ability of the countries to arrest the deterioration of the coastal and marine environment, despite ongoing efforts taken by various levels of government agencies is recognized. Ten years after Rio and despite national efforts in development of Agenda 21 programs, there is little evidence of attaining the sustainable development goals. Despite the existence of clear provisions in domestic and international law (e.g. Several articles in UNCLOS such as Articles 43, 122-125 and 192-197), which provide direction to countries to address the situation through cooperation with one another, there is no substantive commitment to regional environmental governance. Lack of a comprehensive regional environment management framework, interagency conflicts, sectoral approaches addressing economic development and environmental management issues, inappropriate policies, limited experience with successful working model and financial constraints are among the most frequently addressed reasons.

A new approach to regional environmental governance is seen as an essential strategy to minimize the standing problems in biodiversity and its management. Chua & Ross[31] recommend that the existing regional environmental governance can be strengthened in three major areas:

1. A functional framework for cooperation and collaboration
2. An integrated approach to implement

Table 6—List of major coastal development activities that currently threatening the flora and fauna of the Malaysia coastal marine waters (unpublished observation)

	Locality	Threatening items	Activities
1	South Johore	Mangrove / seagrasses - benthic invertebrates - marine, brackish water fishes	Reclamation activities for extension of commercial Port and water front
2	West Coast Selangor	Mangroves, - benthic invertebrates - fishes species and other fauna and floral.	Excavation for conversion into aquaculture ponds
3	Negeri Sembilan and Melaka	Beaches and Mangroves - benthic invertebrates - fishes and flora	Reclamation conversion into commercial centres and tourism
4	Northeastern Langkawi	Surf Zone, seagrasses - coastal marine faunas and floras	Reclamation for tourism development industries
5	Tioman Island	Coral reef's - benthic invertebrates + corals - fishes - seaweeds	Reclamation for establishments of the Free Duties Port
6	Sabah	Coral reef's - reefs fishes - fishes - seaweeds Mangrove forest	Dynamite fishing, and overexploitation of certain commercially important species Excavation for conversion into aquaculture pond and coastal development

international environmental instruments at the regional level.

3. Documentation and assessment of changes, through integrated environmental monitoring and reporting, scientific research and intergovernmental cooperation.

6.0. Conclusion

Considering the mega biodiversity of the Malaysian coastal marine waters, more extensive studies on biodiversity should be carried out to explore the unknown of this world's most diverse region. The primary problems are mostly due to the country's lack of taxonomists and paucity in published information on the basic biology and ecology of the common marine organisms. With all the information, biology and ecology, it was every Malaysian's hope to see better management for conservation for future generations.

7.0. Acknowledgement

We are indebted to all our colleagues for providing the updated information and documentation during the course of preparing the manuscript. Our sincere thanks to Dr. Wafar of his initiative of calling the first author to Goa for IOC meeting. Our special gratitudes to Census of Marine Life (CoML) and other associated bodies for their financial supports during the course of the meeting. Last but not least, our special gratitudes are also due to the Dean of the Faculty, Prof. Dato' Dr. Abdul Latiff Mohamad and the Head of School, Prof. Dr. Mahani Mansor Clyde for their advices and encouragements toward completing the manuscript.

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