COASTAL BIODIVERSITY AND POLLUTION

A Continuous Conflict

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Contents

ABSTRACT

Looking at the trend of the country's development and international concern on biodiversity in Malaysia, the government has developed a policy on conservation, biodiversity and many other policies related to the environment and biodiversity. Despite many policies, laws and regulations and commitment of many agencies on environmental protection and conservation, issues on biodiversity, conservation and protection are continuously highlighted. The demands for agriculture, industries, urbanisation and road networking have sacrificed the habitats for wildlife. The lack of expertise and public awareness on wildlife ecology and conservation caused the local authorities and developers to neglect planning for wildlife and habitat protection when designing the developments of the urban, industrial and residential areas. Many examples of habitat loss, habitat fragmentation, migration routes obstruction, poaching and habitat contamination have occurred. Great pressures can be observed on coastal wildlife. Hazardous chemicals in coastal environment in Malaysia have shown some elevation especially in specific areas. Realising that continuous developments and human activities can cause the elevation of hazardous chemicals in the coastal environment, a monitoring system is needed. In order to do this, bio-monitoring agents need to be identified and tested. From the long studies that I have conducted, many bio-monitoring agents have been proposed. Many of them are intertidal molluscs. However, more detailed studies on their biology and ecology are required. From these long term monitoring activities that were carried out, the Department of Biology, UPM has produced the most data with similar sampling methods, analysis and procedures in the literature on level and ecotoxicology of heavy metals in Malaysia. Perhaps the data produced can become guidelines for heavy metal levels in coastal marine ecosystems in Malaysia. Since heavy metals

are important hazardous chemicals that can cause toxic effects, monitoring and research related to establishing bio-indicators, bio-monitors and testing organisms need to be continuously enhanced. The results of understanding the biology, ecology and ecotoxicology of heavy metals on the potential bio-indicators will enable a specific bio-indicator to be suggested for a specific micro-habitat. Establishing a specific bio-indicator for a specific micro-habitat could support the idea of conservation of organisms at all levels from chemical contamination. This innovation can later aid hazardous chemical management in coastal environment and help to reduce the conflict between coastal wildlife conservation and pollution.

INTRODUCTION

Biodiversity and pollution have always been in conflict. Less developed countries usually have high biodiversity of flora and fauna. Countries such as Indonesia, Brazil, and Malaysia are considered as developing countries which are in dilemma between the conservation and development for poverty eradication and comfortable space for life. Malaysia as one of the top mega-biodiversity countries in the world is not excluded from facing a dilemma between conserving wildlife and promoting industrial development. Space needed for living, jobs and income generation will compete with wildlife if they are not managed carefully. Coastal environments are more sensitive because historically human colonisation mostly concentrated near the shore.

Over sixty percents of human population and urbanisation are concentrated in the coastal areas. These put a stress on the coastal ecosystem and many coastal habitats for wildlife were destroyed. The pressures do not only originate from inland but from the coastal and sea based activities as well. The Straits of Malacca for example serves as one of the busiest shipping routes in the world and a large number of aquaculture farms are located along the coastline. Beside physical disturbance to wildlife and their habitats, these activities plus industry, modern agriculture and urbanisation contribute to chemical pollution. The issues of atmospheric pollution, acid rain and greenhouse gaseous have been extensively discussed since 1970s. Later, the concerns are on hazardous chemicals such as pesticides, heavy metals, hydrocarbon, dioxin, tributyltin, endocrine disrupting chemicals and others. These chemicals are known to have either acute or chronic effect on wildlife which caused population decline and finally extinction. In Malaysia, there is no report on hazardous chemicals that cause population decline in specific organisms. This is not because there are no significant toxicological effects of hazardous chemicals but it is due to no detailed studies carried out. In general, the effects of hazardous chemicals on wildlife are reported in many events and well discussed in the literature. Malaysia is concerned about wildlife protection, forest reserve, environmental quality and conservation. Coastal wildlife is part of the conservation strategies, therefore it is important to consider both wildlife conservation and coastal pollution. Budget allocations for research will encourage researches and capacity building, provides more scientists in the fields to gather more information on biodiversity and pollution, promote public awareness, and finally create sustainability in developments.

Pressures on habitat loss and fragmentation, and hazardous chemical contamination on coastal wildlife have attracted many scientists in the fields of environmental biology, wildlife conservation and ecotoxicology. This report will discuss about the important coastal biodiversity especially birds that are pressured by habitat loss, fragmented habitat and chemical pollution and it will also analyse the potential bio-indicators to monitor hazardous contamination especially by heavy metals.

MALAYSIA AS A MEGA BIODIVERSITY COUNTRY IN THE WORLD

In 1998, Conservation International identified 17 mega-biodiversity countries in the world, and they were Australia, Brazil, China, Columbia, Democratic Republic of the Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, United States, and Venezuela. Biodiversity is not equally distributed all over the globe. There are many factors which can influence the distribution of flora and fauna such as temperature, humidity, water and land, food supply and other ecological factors. Certain countries are characterized by high species richness and more number of endemic species. Despite having many more unknown species of flora and fauna, Malaysia is ranked among the top twelve mega-biodiversity countries in the world. Together, these countries accommodate 60-70% of the world's recorded biodiversity.

In many literatures, it is reported that Malaysia recorded about 290-300 species of wild mammals, 700-750 species of birds, 350-380 species of reptiles, 160-205 species of amphibians and more than 300 species of freshwater fish. Insects represent a huge number of faunal species. Amongst them about 1,000-1,200 species of butterflies and 5,000-10,000 species of moths have been identified, but there are still a lot of insects that are yet to be studied. Freshwater habitats such as the lowland slow-flowing streams and upland rivers with fast-moving water support a diverse aquatic invertebrates and a variety of fish. More than 250 species of fresh water fishes have been recorded but there are many more that need investigation. Marine fauna include fish, cuttlefish, squids, eels, sea urchins, giant clams, sea cucumbers, copepods, shrimps, arrow worms and many other large and small organisms need to be documented. Little is known about their biology and ecology. According to MNRE (2010) more than 4,000 marine fishes have been reported in Malaysia. The ranges of estimated number of animal species in Malaysia show that more researches are needed to establish an accurate number of animal species in the country. Babjee (2010) commented that we do not have accurate answers on our biodiversity's wealth that is present in the heart of the jungle, in the black waters of the lakes, in the mud of the swamps and mudflats, and in the depth of the seas of Malaysia. There are hundreds and thousands of species that we have never seen or sighted are waiting to be identified. In case of birds, The Malaysian Nature Society commented that the checklists of birds are not permanent (MNS, 2005). These lists are constantly changing as more people are involved in bird watching and they keep updating the current status of birds in many localities in Malaysia. Furthermore, constant changes in developments that disturb these birds' habitats, fragment them or cause pollution and as a result, the bird's mobility may change and thus altering the lists. Therefore, monitoring the birds and compiling their list in specific localities such as bird sanctuaries and protected forests are important.

In general, we can say that information on biodiversity in Malaysia is not well documented. The rapid development in industries, agriculture, urbanisation and highways networking, reduction and fragmentation of inland forest and coastal areas will continuously raise conflicts between human and wildlife, pollution and political pressures. Thus, documentation on the biodiversity becomes more crucial. If the documentation of all flora and fauna that make up Malaysian biodiversity is complete, Malaysian ranking among the world mega-biodiversity countries may change. In order to realise this mission, all parties must participate. We already have the policy and active participation on biodiversity issues on the world stage. Perhaps, what we need more are encouragement, motivation, participation from the young generation and enough facilities to continuously research and document on biodiversity. This suggestion is in line with the National Policy on Biodiversity.

MALAYSIAN POLICY ON BIODIVERSITY

Malaysia's National Policy on Biological Diversity was officially declared on 16 April 1998. The vision of the policy is to transform Malaysia into a world centre of excellence in conservation, research and utilisation of tropical biological diversity by year 2020. This aim is certainly very high, thus, a lot of efforts are needed. Not only do we need the spirit of the people, but also the planning, skilled man power, funding, action and monitoring of the achievement which involve government officers and political power. The component of biodiversity will be utilised in a sustainable manner for the continued progress and socio-economic development of the nation.

As listed in Malaysia's National Policy on Biological Diversity, the objectives of the policy are:

i. To optimize economic benefits from sustainable utilisation of the components of biological diversity;

ii. To ensure long-term food security for the nation;

iii. To maintain and improve environmental stability for proper functioning of ecological systems;

iv. To ensure preservation of the unique biological heritage of the nation for the benefit of present and future generations;

v. To enhance scientific and technological knowledge, and educational, social, cultural and aesthetic values of biological diversity;

vi. To emphasize bio-safety considerations in the development and application of biotechnology;

In the Malaysian biodiversity policy, three levels of biodiversity are considered. They are genetic diversity which looks at the diversity within species and variation within genes of individual plants, animals and microorganisms; species diversity which refers to the variety of living organisms on earth and ecosystem diversity that refers to the variety of habitats, biotic communities and ecological processes in the terrestrial, marine and other aquatic environments.

Malaysia realised that information on the nation's biological diversity is still inadequate. It urgently needs to be investigated and documented. The lack of data slows down efforts to better utilise the nation's biological resources which are significant in economic benefits, food security, environmental stability, national biological heritage, scientific, educational and recreational values and bio-safety.

In order to achieve the objectives of Malaysia's National Policy on Biological Diversity, a strategy and plan of actions have been designed. Among them are improving the scientific knowledge base and enhancing sustainable utilisation of the components of biological diversity. The implementation of the policy can be successful if run together with other legislations such as; Fisheries Act 1985, Pesticides Act 1974, Plant Quarantine Act 1976, Customs (Prohibition of Exports)(Amendment) (No.4) Order 1993 Peninsular Malaysia, Waters Act 1920, Taman Negara (Kelantan) Enactment 1938, Taman Negara (Pahang) Enactment 1939, Taman Negara (Terengganu) Enactment 1939, (The State Parks from the above three Enactments constitute Taman Negara), Aboriginal Peoples Act 1954, Land Conservation Act 1960, National Land Code 1965, Protection of Wildlife Act 1972, National Parks Act 1980, National Forestry Act 1984, Sabah Parks Enactment 1984, Forest Enactment 1968, Fauna Conservation Ordinance 1963, Sarawak National Parks Ordinance 1956, Wildlife Protection Ordinance 1958, Forests Ordinance 1954, Natural Resources Ordinance 1949 as amended by Natural Resources and Environment (Amendment) Ordinance 1993, Public Parks and Greens Ordinance 1993 and Water Ordinance 1994. All agencies involved must know the part of each legislative related to biodiversity and conservation, understand clearly how to apply, integrate and enforce all available laws and regulations.

The implementation of strategic plans together with the enforcement of all the laws and regulations above are needed in order to fulfil the objectives of Malaysia's National Policy on Biological Diversity. Mega-biodiversity in Malaysia can be maintained and the lack of documented information can be improved when all parties understand and participate in the search of knowledge on biodiversity and conservation. Interested parties and funding are among the important requirements. As discussed elsewhere, lack of knowledge, expertise and poor planning, and absence of public awareness lead to illegal poaching and poor conservation strategies and government enforcement. These threaten biodiversity. Since Malaysia is a signatory for many international treaties, having a national policy on biodiversity and various legislations related to biodiversity and the support for the conservation of biodiversity, there is no reason why the implementation of the strategies cannot be accomplished. More grants and incentive are required to support the ideas and strategies.

COASTAL WILDLIFE

Malaysia is a maritime country. We have about 4675 kilometres (2068 in Peninsular Malaysia and 2607 in Sabah and Sarawak) of coastlines that face important seas such as the South China Sea, Andaman Sea and Straits of Malacca. Continuous development inland of the Peninsular and Borneo and active human activities in the sea and coastal areas will affect the coastal environment. Anthropogenic activities not only disrupt coastal habitat but also reduce the space and cause pollution.

Along the coastal area especially that of the west coast of Peninsular Malaysia, there are about 600,000 ha of mangrove forest (FAO, 2002) which are mainly protected. Figure 1 shows the estimated mangrove areas estimated from 1970-2000 by FAO (2002). The importance of mangrove forest is that it does not only protect and border human habitation but also serves as marine life's nursery ground. Besides that, mangrove, too, serves as a source for fisheries' products for local fishermen and a habitat for coastal wildlife.

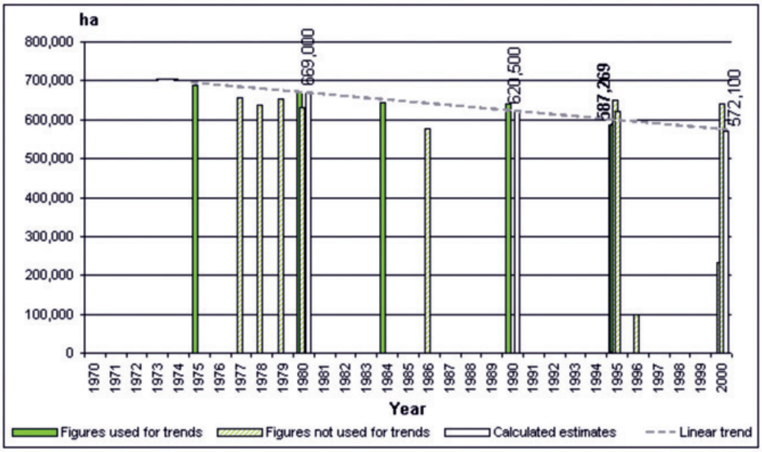


Figure 1 FAO's database on mangrove area estimates.
(Source: FAO, 2002)

Table 1 lists important species of coastal wildlife in Peninsular Malaysia. Among the important wildlife in coastal environment are migratory shorebirds. They depend on the intertidal mudflat where they feed and roost. These birds migrate from the northern hemisphere during cold winter season towards the south from August to April every year. The west coast of Peninsular Malaysia is one of their important stop-over for feeding and roosting activities. Some of them continue to fly to the south as far as Australia and New Zealand but some would remain in the west coast of Peninsular Malaysia during the whole period of the migration season. Muddy intertidal areas and healthy mangrove forests in the west coast of Peninsular Malaysia are some of the qualities that attract these annual visitors.

Table 1 List of some important coastal wildlife of Peninsular Malaysia (Source: Bailie et al., 2005 & Robson, 2005)

No	Family	Common Name	Scientific Name	Status	Range
	Waterbirds				
1	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	LC	WV
2	Procellariidae	Bulwer's Petrel	*Bulweria bulwerii*	LC	V
3		Streaked Shearwater	*Calonectris leucomelas*	LC	V
4		Wedge-tailed Shearwater	*Puffinus pacificus*	LC	V
5	Hydrobatidae	Swinhoe's Storm-petrel	*Oceanodroma monorhis*	LC	V
6		Wilson's Storm-petrel	*Oceanites oceanicus*	LC	V
7	Pelecanidae	Great White Pelican	*Pelecanus onocrotalus*	LC	WV
8		Spot-billed Pelican	*Pelecanus philippensis*	NT	WV
9	Sulidae	Masked Booby	*Sula dactylatra*	LC	WV
10		Red-footed Booby	*Sula sula*	LC	V
11		Brown Booby	*Sula leucogaster*	LC	V
12	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	LC	WV
13		Little Cormorant	*Phalacrocorax niger*	LC	V
14	Anhingidae	Oriental Darter	*Anhinga melanogaster*	NT	V
15	Fregatidae	Christmas Island Frigatebird	*Fregata andrewsi*	CR	WV
16		Greater Frigatebird	*Fregata minor*	LC	WV
17		Lesser Frigatebird	*Fregata ariel*	LC	WV
18	Ardeidae	Great-billed Heron	*Ardea sumatrana*	LC	R
19		Grey Heron	*Ardea cinerea*	LC	R
20		Purple Heron	*Ardea purpurea*	LC	R
21		Little Heron	*Butorides striatus*	LC	R
22		Indian Pond Heron	*Ardeola grayii*	LC	V

Table 1 (cont.).

No	Family	Common Name	Scientific Name	Status	Range
23		Chinese Pond Heron	*Ardeola bacchus*	LC	WV
24		Javan Pond Heron	*Ardeola speciosa*	LC	V
25		Cattle Egret	*Bubulcus ibis*	LC	R
26		Pacific Reef Egret	*Egretta sacra*	LC	R
27		Chinese Egret	*Egretta eulophotes*	VU	WV
28		Great Egret	*Casmerodius albus*	LC	R
29		Intermediate Egret	*Mesophoyx intermedia*	LC	R
30		Little Egret	*Egretta garzetta*	LC	R
31		Black-crowned Night Heron	*Nycticorax nycticorax*	LC	R
32		Malayan Night Heron	*Gorsachius melanolophus*	LC	R
33		Yellow Bittern	*Ixobrychus sinensis*	LC	R
34		Schrenck's Bittern	*Ixobrychus eurhythmus*	LC	R
35		Cinnamon Bittern	*Ixobrychus cinnamomeus*	LC	R
36		Black Bittern	*Dupetor flavicollis*	LC	R
37		Great Bittern	*Botaurus stellaris*	LC	V
38	Ciconiidae	Milky Stork	*Mycteria cinerea*	VU	R
39		Painted Stork	*Mycteria leucocephala*	NT	R
40		Woolly-necked Stork	*Ciconia episcopus*	LC	R
41		Storm's Stork	*Ciconia stormi*	EN	R
42		Lesser Adjutant	*Leptoptilos javanicus*	VU	R
43	Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus*	NT	V
44	Anatidae	Northern Pintail	*Anas acuta*	LC	WV
45		Common Teal	*Anas crecca*	LC	V
46		Eurasian Wigeon	*Anas Penelope*	LC	V
47		Garganey	*Anas querquedula*	LC	WV
48		Northern Shoveler	*Anas clypeata*	LC	WV

Table 1 (cont.).

No	Family	Common Name	Scientific Name	Status	Range
49		Tufted Duck	*Aythya fuligula*	LC	V
50		Cotton Pygmy-Goose	*Nettapus coromandelianus*	LC	WV
51		White-winged Duck	*Cairina scutulata*	EN	R
52	Gruidae	Sarus Crane	*Grus antigone*	VU	R
53	Rallidae	Slaty-breasted Rail	*Gallirallus striatus*	LC	R
54		Red-legged Crake	*Rallina fasciata*	LC	WV
55		Slaty-legged Crake	*Rallina eurizonoides*	LC	WV
56		Baillon's Crake	*Porzana pusilla*	LC	WV
57		Ruddy-breasted Crake	*Porzana fusca*	LC	WV
58		Band-bellied Crake	*Porzana paykullii*	NT	WV
59		White-browed Crake	*Porzana cinerea*	LC	R
60		White-breasted Waterhen	*Amaurornis phoenicurus*	LC	R
61		Watercock	*Gallicrex cinerea*	LC	R
62		Common Moorhen	*Gallinula chloropus*	LC	R
63		Common Coot	*Fulica atra*	LC	V
64		Purple Swamphen	*Porphyrio porphyrio*	LC	R
65	Heliornithidae	Masked Finfoot	*Heliopais personata*	EN	WV
66	Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	LC	WV
67		Bronze-winged Jacana	*Metopidius indicus*	LC	R
68	Rostratulidae	Greater Painted-Snipe	*Rostratula benghalensis*	LC	R
69	Haematopodidae	Eurasian Oystercatcher	*Haematopus ostralegus*	LC	V
70	Charadriidae	Grey-headed Lapwing	*Vanellus cinereus*	LC	WV
71		Red-wattled Lapwing	*Vanellus indicus*	LC	R

Table 1 (cont.).

No	Family	Common Name	Scientific Name	Status	Range
72		Yellow-wattled Lapwing	*Vanellus malabaricus*	LC	V
73		Grey Plover	*Pluvialis squatarola*	LC	V
74		Pacific Golden Plover	*Pluvialis fulva*	LC	WV
75		Common Ringed Plover	*Charadrius hiaticula*	LC	V
76		Little-ringed Plover	*Charadrius dubius*	LC	WV
77		Kentish Plover	*Charadrius alexandrinus*	LC	WV
78		Malaysian Plover	*Charadrius peronii*	NT	R
79		Mongolian/ Lesser Sand Plover	*Charadrius mongolus*	LC	WV
80		Greater Sand Plover	*Charadrius leschenaultii*	LC	WV
81		Oriental Plover	*Charadrius veredus*	LC	V
82	Scolopacidae	Wood Snipe	*Gallinago nemoricola*	VU	WV
83		Pintail Snipe	*Gallinago stenura*	LC	WV
84		Swinhoe's Snipe	*Gallinago megala*	LC	WV
85		Common Snipe	*Gallinago gallinago*	LC	WV
86		Eurasian Woodcock	*Scolopax rusticola*	LC	V
87		Eurasian Curlew	*Numenius arquata*	NT	WV
88		Whimbrel	*Numenius phaeopus*	LC	WV
89		Eastern Curlew	*Numenius madagascariensis*	VU	WV
90		Black-tailed Godwit	*Limosa limosa*	NT	WV
91		Bar-tailed Godwit	*Limosa lapponica*	LC	WV
92		Spotted Redshank	*Tringa erythropus*	LC	WV
93		Common Redshank	*Tringa tetanus*	LC	WV
94		Marsh Sandpiper	*Tringa stagnatilis*	LC	WV
95		Common Greenshank	*Tringa nebularia*	LC	WV

Table 1 (cont.).

No	Family	Common Name	Scientific Name	Status	Range
96		Spotted Greenshank	*Tringa guttifer*	EN	WV
97		Green Sandpiper	*Tringa ochropus*	LC	WV
98		Wood Sandpiper	*Tringa glareola*	LC	WV
99		Terek Sandpiper	*Xenus cinereus*	LC	WV
100		Common Sandpiper	*Actitis hypoleucos*	LC	WV
101		Grey-tailed Tattler	*Heteroscelus brevipes*	LC	WV
102		Ruddy Turnstone	*Arenaria interpres*	LC	WV
103		Asian Dowitcher	*Limnodromus semipalmatus*	NT	WV
104		Long-billed Dowitcher	*Limnodromus scolopaceus*	LC	V
105		Red Knot	*Calidris canutus*	LC	WV
106		Great Knot	*Calidris tenuirostris*	VU	WV
107		Red-necked Stint	*Calidris ruficollis*	LC	WV
108		Little Stint	*Calidris minuta*	LC	WV
109		Temminck's Stint	*Calidris temminckii*	LC	WV
110		Long-toed Stint	*Calidris subminuta*	LC	WV
111		Sharp-tailed Sandpiper	*Calidris acuminate*	LC	V
112		Dunlin	*Calidris alpine*	LC	WV
113		Curlew Sandpiper	*Calidris ferruginea*	LC	WV
114		Sanderling	*Calidris alba*	LC	WV
115		Spoon-billed Sandpiper	*Calidris pygmeus*	CR	WV
116		Pectoral Sandpiper	*Calidris melanotos*	LC	V
117		Broad-billed Sandpiper	*Limicola falcinellus*	LC	WV
118		Ruff	*Philomachus pugnax*	LC	WV
119		Red-necked Phalarope	*Phalaropus lobatus*	LC	WV

Table 1 (cont.).

No	Family	Common Name	Scientific Name	Status	Range
120		Red Phalarope	*Phalaropus fulicarius*	LC	WV
121	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	LC	WV
122	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	LC	WV
123		Little Cormorant	*Phalacrocorax niger*	LC	V
124	Dromadidae	Crab Plover	*Dromas ardeola*	LC	V
125	Glareolidae	Oriental Pratincole	*Glareola maldivarum*	LC	WV
126	Burhinidae	Beach Thick-knee	*Esacus giganteus*	NT	R
127	Laridae	Black-headed Gull	*Larus ridibundus*	LC	WV
128		Brown-headed Gull	*Larus brunnicephalus*	LC	WV
129		Whiskered Tern	*Chlidonias hybrida*	LC	WV
130		White-winged Tern	*Chlidonias leucopterus*	LC	WV
131		Gull-billed Tern	*Sterna nilotica*	LC	WV
132		Caspian Tern	*Sterna caspia*	LC	WV
133		Common Tern	*Sterna hirundo*	LC	WV
134		Roseate Tern	*Sterna dougallii*	LC	R
135		Black-naped Tern	*Sterna sumatrana*	LC	R
136		Bridled Tern	*Sterna anaethetus*	LC	WV
137		Sooty Tern	*Sterna fuscata*	LC	V
138		Great Crested Tern	*Sterna bergii*	LC	WV
139		Lesser Crested Tern	*Sterna bengalensis*	LC	WV
140		Chinese Crested Tern	*Sterna bernsteini*	CR	V
141		Little Tern	*Sterna albifrons*	LC	R
142		Brown Noddy	*Anous stolidus*	LC	WV
	Mammals				
143	Mustelidae	Common Otter	*Lutra lutra*	NT	R
144		Hairy-nosed Otter	*Lutra sumatrana*	EN	R

Table 1 (cont.).

No	Family	Common Name	Scientific Name	Status	Range
145	Rhinocerotidae	Javan Rhinoceros	*Rhinoceros sondaicus*	EN	R
146	Suidae	Wild Pig	*Sus scrofa*	LC	R
147		Bearded Pig	*Sus barbatus*	NT	R
148	Cercopithecidae	Long-tailed Macaque	*Macaca fascicularis*	LC	R
149		Silvered Leaf-monkey	*Trachypithecus cristatus*	NT	R
	Reptiles				
150	Cheloniidae	Green Turtle	*Chelonia mydas*	EN	R
151		Hawksbill Turtle	*Eretmochelys imbricata*	CR	R
152		Olive Ridley Turtle	*Lepidochelys olivacea*	VU	R
153	Dermochelyidae	Leatherback Turtle	*Dermochelys coriacea*	CR	R
154	Hydrophiidae	Spine-tailed Sea Snake	*Aepyurus eydoxi*	-	R
155		Stoke's Sea Snake	*Astrotia stokesii*	-	R
156		Beaked Sea Snake	*Enhydrina schistose*	-	R
157		Brook's Sea Snake	*Hydrophis brookei*	-	R
158		Blue-grey Sea Snake	*Hydrophis caerulescens*	-	R
159		Blue-banded Sea Snake	*Hydrophis cynaocinctus*	-	R
160		Banded Sea Snake	*Hydrophis fasciatus*	-	R
161		Narrow-headed Sea Snake	*Hydrophis gracilis*	-	R
162		Kloss's Sea Snake	*Hydrophis klossi*	-	R
163		Lesser Dusky Sea Snake	*Hydrophis melanosoma*	-	R
164		Ornate Sea Snake	*Hydrophis ornatus*	-	R
165		Yellow Sea Snake	*Hydrophis spiralis*	-	R
166		Garland Sea Snake	*Hydrophis torquatus*	-	R

Table 1 (cont.).

No	Family	Common Name	Scientific Name	Status	Range
167		Saddle-backed	*Kerilia jerdoni*	-	R
168		Annandale's Sea Snake	*Kolpophis annandalei*	-	R
169		Short Sea Snake	*Lapemis curtus*	-	R
170		Yellow-lipped Sea Krait	*Lapemis curtus*	-	R
171		Yellow-bellied Sea Snake	*Pelamis platurus*	-	R
172		Grey Sea Snake	*Praescutata viperina*	-	R
173		Anamalous Sea Snake	*Thalassophis anomalus*	-	R
174	Crocodylidae	Estuarine Crocodile	*Crocodylus porosus*	LC	R

Status: LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered
Range: R = Resident; WV = Winter Visitor; V = Vagrant

Since Malaysia is adopting many international treaties on biodiversity and related agreements, this annual visitors need to be given more attention. The Malaysian government is concern about the migratory birds by protecting the mangrove forest, monitoring and managing mudflats area without compromising other human benefits (such as managing cockles farming and other aquaculture activities) and enforcing the laws. In return, these acts have made these birds safer and this is important in supporting their world population. But if we look at closer details, the government efforts alone are insufficient. More researches and public education program are needed to achieve the country's vision on biodiversity. So far the Malaysian government has gazetted few places as important shore birds sanctuary. Kuala Gula in Perak is one of the valuable sites to the migratory shorebirds (Siti Hawa and Ismail, 1994). The list of migratory shorebirds regularly reported in Kuala Gula is listed in Table 2. In general, Kuala Gula Bird Sanctuary is a unique site which has been identified as one of the important stopovers for migratory shore birds in East Asian-Australasian Flyway.

Table 2 List of migratory shorebirds commonly found in Kuala Gula (Source: Jasmi Abdul, 1983)

	Malay Name	English Name	Scientific Name	Status
	CHARADRIIDAE			
1	Rapang Kelabu	Grey Plover	*Pluvialis squatarola*	LC
2	Rapang Kerinyut	Pacific Golden Plover	*Pluvialis fulva*	LC
3	Rapang Biji Nangka	Little-Ringed Plover	*Charadrius dubius*	LC
4	Rapang Mongolia	Mongolian Plover	*Charadrius mongolus*	LC
5	Rapang Besar	Greater Sand Plover	*Charadrius leschenaultii*	LC
	SCOLOPACIDAE			
6	Kedidi Kendi	Eurasian Curlew	*Numenius arquata*	NT
7	Kedidi Pisau Raut	Whimbrel	*Numenius phaeopus*	LC
8	Kedidi Ekor Hitam	Black-Tailed Godwit	*Limosa limosa*	NT
9	Kedidi Berjalur	Bar-Tailed Godwit	*Limosa lapponica*	LC
10	Kedidi Kaki Merah	Common Redshank	*Tringa tetanus*	LC
11	Kedidi Paya	Marsh Sandpiper	*Tringa stagnatilis*	LC
12	Kedidi Kaki Hijau	Common Greenshank	*Tringa nebularia*	LC
13	Kedidi Kayu	Wood Sandpiper	*Tringa glareola*	LC
14	Kedidi Sereng	Terek Sandpiper	*Xenus cinereus*	LC
15	Kedidi Pasir	Common Sandpiper	*Actitis hypoleucos*	LC
16	Kedidi Kerikil	Ruddy Turnstone	*Arenaria interpres*	LC
17	Kedidi Dada Merah	Asian Dowitcher	*Limnodromus semipalmatus*	NT
18	Kedidi Dian Kecil	Red Knot	*Calidris canutus*	LC
19	Kedidi Dian Besar	Great Knot	*Calidris tenuirostris*	VU

Table 2 (cont.).

No	Malay Name	English Name	Scientific Name	Status
20	Kedidi Luris Leher	Rufous-Necked Stint	*Calidris ruficollis*	LC
21	Kedidi Jari Panjang	Long-Toed Stint	*Calidris subminuta*	LC
22	Kedidi Pasir Kendi	Curlew Sandpiper	*Calidris ferruginea*	LC
23	Kedidi Paruh Lebar	Broad-Billed Sandpiper	*Limicola falcinellus*	LC
	RECURVIROSTRIDAE			
24	Stilt Kepak Hitam	Black-Winged Stilt	*Himantopus himantopus*	LC
	LARIDAE			
25	Camar Kepala Hitam	Black-Headed Gull	*Larus ridibundus*	LC
26	Camar Kepala Coklat	Brown-Headed Gull	*Larus brunnicephalus*	LC
27	Camar Batu Berumbai	Whiskered Tern	*Chlidonias hybridus*	LC
28	Camar Kepak Putih	White-Winged Tern	*Chlidonias leucopterus*	LC
29	Camar Tiram	Gull-Billed Tern	*Gelochelidon nilotica*	LC
30	Camar Siput	Common Tern	*Sterna hirundo*	LC
31	Camar Topi Hitam	Black-Naped Tern	*Sterna sumatrana*	LC
32	Camar Kecil	Little Tern	*Sterna albifrons*	LC
33	Camar Besar Berjambul	Greater Crested Tern	*Sterna bergii*	LC
34	Camar Kecil Berjambul	Lesser Crested Tern	*Sterna bengalensis*	LC

Status: LC = Least Concern; NT = Near Threatened; VU = Vulnerable

MATANG MANGROVE FORESTS AND KUALA GULA BIRD SANCTUARY

Matang Mangrove Forest Reserve, south of Kuala Gula, is located in Perak State in Peninsular Malaysia. Its location at 4°40'- 4°55'N, 100°34'-100°40'E with 51 kilometres long and 13 kilometres wide make the area in total about 40,7011 hectares. The Matang Mangrove Forest Reserve was designated as a Permanent Forest Reserve in 1906, and it has been intensively managed by the Forestry Department since 1908. Approximately 80% of the area is one of the best examples of a sustainably managed mangrove forest in the world. A 30-year rotation cycle practice is carried out to produce charcoal and poles from the mangrove trees. In 1999, with an area of about 40,000 hectares (about 154 square miles), it is the largest mangrove forest reserve in Peninsular Malaysia. About 95% of the mangrove areas are tidal swamp dominated by Rhizophoracea, with seven major estuaries and streams flowing through making the intertidal areas very productive and serve as feeding sites for migratory shore birds, including storks and herons. The Matang Mangrove Forest Reserve serves as one of the important wetlands for water birds, which come from as far away as Siberia and also an important tourist attraction site in the region. Out of the 22 types of wetlands found in Asia (Scott, 1989) (Table 3), The Matang Mangrove Forest Reserve includes the types of wetlands such as shallow sea bays and straits (under six meters at low tide), estuaries, deltas, mangrove swamps and mangrove forest.

Table 3 Asian wetland classification and types.
(Source: Scott, 1989)

Classification	Type
01	**Shallow sea bays and straits (under six meters at low tide)**
02	**Estuaries, deltas**
03:	Small offshore islands, islets
04:	Rocky sea coasts, sea cliffs
05:	Sea beaches (sand, pebbles)
06:	Inter-tidal mudflats, sand flats
07:	**Mangrove swamps, mangrove forest**
08:	Coastal brackish and saline lagoons and marshes
09:	Salt pans (artificial)
10:	Shrimp ponds, fish ponds
11:	**Rivers, streams - slow-flowing (lower perennial)**
12:	Rivers, streams - fast-flowing (upper perennial)
13:	Ox bow lakes, riverine marshes
14:	Freshwater lakes and associated marshes (lacustrine)
15:	Freshwater ponds (under 8 hectares), marshes, swamps (palustrine)
16:	Salt lakes, saline marshes (inland drainage systems)
17:	Water storage reservoirs, dams
18:	Seasonally flooded grassland, savanna, palm savanna
19:	Rice/paddy fields
20:	Flooded arable land, irrigated land
21:	Swamp forest, temporarily flooded forest
22:	Peat bogs

The Matang Mangrove Forest Reserve at the south of Kuala Gula and its adjacent coastline are among the major important stop-over and foraging areas for migratory shorebirds. This area is also known as the major remaining site of suitable habitat for the Milky Stork, *Mycteria cinerea,* and Lesser Adjutant, *Leptoptilos javanicus,* in Malaysia. Currently, there are no other areas in Malaysia inhabited by Milky Stork aside from an individual Milky Stork recently observed in the Malacca coast (MNS, 2011). Therefore, The Matang Mangrove Forest Reserve is very important to this globally threatened species. The Malaysian Government realises this status and takes drastic actions by exercising a releasing programme. Milky Storks bread in captivity had been released into the wild habitat in the Kuala Gula Bird Sanctuary with the assistance from Universiti Putra Malaysia and Zoo Negara Malaysia. To date, the programme which started in 2007 has shown success. A couple of birds had successfully nested and hatched, and now they are actively living in the wild. Among the factors that encourage breeding success are public support and suitability of the environment. A detail discussion on the adaptability of Milky Storks in the Kuala Gula Bird Sanctuary can be referred to a study by Ismail et al. (2010). Based on a review made by Li et al. (2006) and the recent study of Ismail et al. (2010), the Kuala Gula Birds Sanctuary and the Matang Mangrove Forest Reserve are viewed as good habitats for the Milky Storks. In fact, the Milky Stork can be listed as a key species for assessing the habitat quality of the Matang Mangrove Forest Reserve, as well as, being an iconic species for tourist attraction in Kuala Gula.

The Matang Mangrove Forest Reserve is also known for its importance to nearly a hundred thousand shorebirds such as *Tringa tetanus*, *Limosa limosa*, *Calidris ferruginea, Charadrius mongolus, Numenius phaeopus, Tringa stagnatilis*, *Xerus cinereus* and *Limnodromus semipalmatus* and many more as listed in Table 2. In a one year observation by Lomoljo et al. (2010a), the northern migrating group possesses higher number of individuals compared to the southern migrating group. This finding agrees with another observation reported by Riak et al. (2003b) in the central areas of west coast Peninsular Malaysia. This phenomenon may be due to longer period of stay during northwards migration.

MILKY STORK

In Malaysia, scientists and birds lovers claim that the Matang Mangrove Forest Reserve is the last remaining area in Peninsular Malaysia that is capable of supporting possible breeding population of the Milky Stork, *Mycteria cinerea*. Being one of the most systematic and sustainably managed forest reserves in Malaysia, the area is almost fully protected and well managed particularly for timber production (Malaysian Timber Council, 2009). Good understanding and cooperation between the Forestry Department, Department of Wildlife and National Parks would promise the continuity and survival of the last Milky Stork generation in the country. Nevertheless, more studies are needed to ensure the success of Milky Stork conservation program in the future.

The Milky Stork population in Malaysia is seriously endangered, having decreased drastically to about 100 birds in the last 10 years. The bird's population keeps decreasing and no sign of breeding is observed in the last 20 years (Li et al., 2006) (Figure 2). There are many theories behind the failure of this bird to breed successfully. Among them are the absence of suitable place for the species to build their nest, the lack of proper ratio of male and female that encourages the birds to breed, and threats from chemical pollution that may disturb the birds' biology and physiology. Since male and female morphology is in striking resemblance, the birds are difficult to distinguish without sex surgical determination. Therefore, well-planned reintroduction programmes that address the need of the process to overcome these issues have to be carried out.

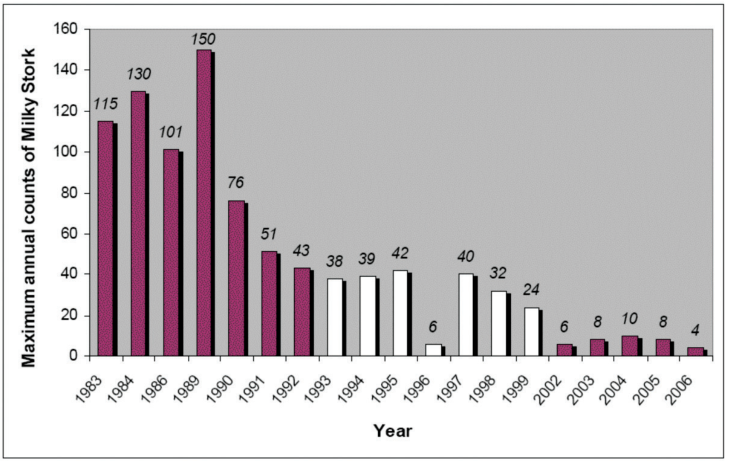


Figure 2 Maximum annual counts of Milky Stork from 1983 to 2005. (Source: Li et al., 2006)

Milky Storks issues in Malaysia have received nationwide attention through local prime media since 2007. The issues are widely discussed in each aspect of biology, ecology and conservation. This shows that the status of Milky Stork in Malaysia is very critical and needs urgent public and government attention and support. More research towards its conservation is extremely required.

Zoo Negara has successfully bred the Milky Stork in captivity. The number of captive reared Milky Storks increased from 10 birds in 1987 to more than 100 birds in 2005 alone (Ismail et al., 2011). To date, the Milky Stork is one of the iconic symbols of successful wildlife protection and conservation in the Zoo Negara itself. Figure 3 shows the success of breeding milky stork in Zoo Negara captivity. The limitation of this success is inbreeding. Further attempts to conserve the species include exchanging them with other zoos such as the Taiping Zoo and releasing them in Kuala

Selangor Nature Parks under the supervision and management of the Malaysian Nature Society for breeding and releasing programme. Unfortunately, the programme with MNS failed and some of the birds escaped from captivity.

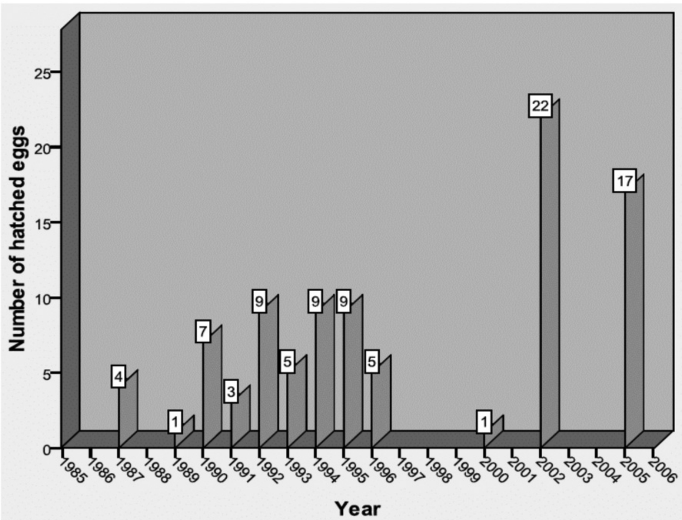


Figure 3 Number of Milky Storks hatched in Zoo Negara captivity from 1987 to 2005.
(Source: Ismail et al., 2011)

In the case of the Matang Mangrove Forest Reserve, only ten Milky Storks were recorded in 2005 (Li et al., 2006) and recently in 2010 less than five individuals were observed in the area (Ismail et al., 2010). Among other reasons that reduced the number of birds were human disturbance on nesting colonies, mangrove habitat loss, poaching, over predation and probably chemical contamination. According to Birdlife International (2010), the Milky Stork population in the world is estimated at about 5,550 individuals and the species is listed as vulnerable (VU) in the IUCN

Red List. The majority of these storks are available in Indonesia, with about 5,000 individuals in Sumatra and 400 in West Java. A number of Milky Storks is also reported in Medan near the north east of Sumatera, Indonesia (Iqbal et. al., 2010). A maximum of 150-200 were reported elsewhere, and may be less. The number is probably shared between Malaysia and Tonle Sap Lake, Cambodia and Thailand. There is no updated data to estimate the current status of Milky Stork in the wild. Milky Stork population is not only reducing in Malaysia but the birds are indeed globally threatened.

There are only four Milky Storks in the wild now in Malaysia. Nearly 30 individual Milky Storks were released in several stages into their natural habitat in Kuala Gula since March 2007. Now there are twelve of them flying around in Kuala Gula. With them are two newly hatched juveniles from one of the released couples. This is the first record of successful Milky Stork breeding since last observed in 1986 in Pulau Kalumpang, Pulau Terong, and the Matang Mangrove Forest Reserve as reported by Rahmah et al. (2007). As mentioned earlier, their survival depends on public support, enforcement, monitoring, continuous public awareness programmes and publicity besides protecting their habitat and continuous research. A systematic programme is needed if we want to conserve these birds for future generations. Participation from all agencies especially those related to coastal mangrove ecosystem near Kuala Gula is needed. The Perak State Government, Matang and Kerian District Office, Department of Wildlife and National Parks, Forestry Department, Sime Darby Corporation and others should consult the right experts to assist them. Universiti Putra Malaysia and Zoo Negara are seriously working together on the Milky Stork Release Programme. The effort is coordinated by the Department of Wildlife and National Parks Malaysia since 2009. Since the Matang Mangrove Forest Reserve is claimed to be the best managed mangrove forest in the world, it has regular monitoring and maintenance systems. This in turn, will help to monitor and conserve the Milky Storks in the area too. Even though the mangrove forest is well maintained and produces high population of marine life such as prawns, crabs, blood cockles and fish, this does not promise a long lasting and high quality habitat for the Milky Storks. From past experiences in handling and working with this bird, Milky Stork prefers suitable tall tress above 30 meters height for nesting. Sound cooperation between the two important agencies, the Department of Wildlife and the National Parks and Forestry Department should be established to undertake the missing actions for the conservation of Milky Storks.

Other colonial waterbirds like the herons also require attention. Similar to Milky Stork, the herons are mainly piscivorous, fish-eating birds that are often found foraging near the coastal area. Previous studies conducted in Putrajaya, Rawang and Kuala Selangor Nature Park showed that these birds may establish their colony in a short period of time, given that the area is abundant with food and is a suitable nesting area. If the Matang Mangrove Forest Reserve and other areas mentioned are protected, the unwanted colony establishment and immigration, often found near human settlements can be monitored and controlled.

MIGRATORY SHOREBIRDS, IMPORTANT BIRD AREA AND INTERNATIONAL NETWORKING

The migration of waders and other water birds between northern and southern hemisphere through East Asian-Australasian Flyway is well documented in the report on waterbirds in Kapar Power Station, Malaysia (Bakewell, 2009). Biologically rich mudflats in the north-central Selangor coastal areas are supporting tens of thousands out of a million birds passing through the Straits of Malacca every year. During high tide, when the mudflats are covered by water up to two to four metres, the birds will move towards nearby areas for roosting or feeding. Ash pond at Kapar Power Station is also one of the important areas for feeding and roosting during high tide. This unique site with biologically productive mangrove and intertidal mudflats in vicinity support great numbers of migratory water birds and waders. Every year ash pond of Kapar Power Station becomes one of the attration places for birds to gather during high tide. Bird watchers too take the opportunities to watch and count birds as a regular activity organised by the Malaysian Nature Society (MNS).

Table 4 shows important bird areas in west coast of Peninsular Malaysia as listed by Malaysian Wetland Directory (1987). There are other areas in the north, central and southern parts of the Peninsular that need to be identified. We have areas such as Kuala Gula, in Perak, Kuala Selangor to Kelang Islands in Selangor and Parit Jawa and Tanjung Piai in Johore that are in need of protection and to be seriously studied in order to protect and conserve the coastal wildlife. If at least three to four of these main areas are gazetted and protected (besides mudflats in between the suggested areas), the issues of threats to coastal wildlife including world's concerned migratory shorebirds can be greatly reduced. All important bird areas identified by Malaysian Wetland Directory (1987) need to be revisited to assess their function for future bird conservation move. This is very important because a recent report by Yeap et al. (2007) indicated that there is a reduction of important bird area (IBA) in the west coast of Peninsular Malaysia. Only those in Matang, Kuala Selangor and Tanjung Piai remain active.

Babjee (2010) recommended that an international collaboration and networking need to be developed to strengthen research and active participation on biodiversity. He stressed that migratory shorebirds make the biodiversity cuts across artificial man-made boundaries that had been recognized for a long time. Collaboration with developed nation could build up an effective network within local and regional agencies. Recent networking established between Universiti Putra Malaysia, the Department of Wildlife and National Park, Malaysian Zoological Society (Zoo Negara), the University of Tokyo and the National Polar Research Institute Japan is another avenue for collaboration. The collaboration has introduced new ideas, techniques and approaches of understanding the behaviour of Milky Storks in the wild. The results are published in journals and presented in conferences (Ismail et al*.,* 2011; Miyazaki et al., 2011).

Table 4 Important bird area in west coast of Peninsular Malaysia. (Source: Malaysian Wetland Directory, 1987)

	Name	Location	Area (ha)	Importance
1	Pantai Acheh	Penang	100	Supports a number of waders and migratory birds
2	Balik Pulau	Penang	166	Supports a number of waders and migratory birds
3	Telok Intan Swamp Forest	Perak	4050	Supports variety of waterbirds including the endangered *Leptoptilos javanicus*.
4	Krian Rice-fields	Perak	23000	A major feeding area for large numbers of migratory waterfowl and a breeding and feeding area for many resident water birds.
5	Sungei Burung Mangroves	Perak	250	Supports one of the largest breeding colonies of Black-crowned Night-Herons *Nycticorax nycticorax* in the world. Also an important area for other shorebirds.
6	Matang Mangrove Forest Reserve	Perak	40000	Important staging area for migratory shorebirds, and are the major remaining area of suitable habitat in Malaysia for the Milky Stork *Mycteria cinerea* and Lesser Adjutant *Leptoptilos javanicus*.
7	Pulau Ketam	Selangor	4000	Supports large numbers of migratory shorebirds including the endangered *Leptoptilos javanicus*.
8	Pulau Tengah	Selangor	2000	One of the most important staging and wintering areas for shorebirds, particularly *Limosa lapponica* and *Charadrius leschenaultii.*

Table 4 (cont.).

No	Name	Location	Area (ha)	Importance
9	Pulau Lumut	Selangor	4559	A staging and wintering area for a wide variety of shorebirds typical of the west coast of Peninsular Malaysia.
10	Pulau Klang	Selangor	8785	Supports a considerable number of shorebirds typical of the west coast of Peninsular Malaysia.
11	Pulau Selat Kering	Selangor	1220	Supports a considerable number of shorebirds during the migration seasons and northern winter.
12	Pulau Pintu Gedong	Selangor	1115	A staging and wintering area for a variety of shorebirds typical of the west coast of Peninsular Malaysia.
13	Pulau Che Mat Zin	Selangor	1338	A staging and wintering area for species of shorebirds typical of the west coast of Peninsular Malaysia.
14	Kapar Forest Reserve	Selangor	3800	Supports a diverse avifauna; 62 species of water birds are known to occur including 41 species listed under Schedule 3 of the Protection of Wildlife Act 1972.
15	Kuala Selangor Mangrove Forest	Selangor	5760	Supports a considerable number of birds typical of the west coast of Peninsular Malaysia.

Table 4 (cont.).

No	Name	Location	Area (ha)	Importance
16	Kuala Selangor Nature Park	Selangor	260	The Nature Park has been designed to provide an alternative high-tide roosting site for some 5,000-10,000 shorebirds.
17	North Selangor Swamp Forest	Selangor	74000	Supports a considerable variety of bird species, including migratory raptors.
18	Batu Berendam	Malacca	600	Supports at least 30 waterbirds species including migratory shorebirds
19	Benut Mangrove	Johor	1800	The third most important sites on the west coast of Johor for shorebirds
20	Sungai Suloh Kecil	Johor	1400	Supports up to thousands of migratory shorebirds from different species
21	Muar River-Tg. Johor	Johor	4000	Very important site for migratory shorebirds and breeding area

One aspect of collaboration with The University of Tokyo and the National Polar Research Institute Japan is bio-logging science. The result of this collaboration was presented in The Fourth International Science Symposium on Bio-logging, Hobart, Tasmania, Australia, on 14-18 March 2011 recently and will be published in the Journal of Tropical Ecology in 2011.

Bio-logging science that uses advanced digital technology has brought new insights into animal behaviour *in-situ* by providing sophisticated information on animal behaviour measured by the miniaturized acceleration loggers in fine scale. This technique has been broadly used to investigate diving behaviour of aquatic animals and flying behaviours of avian by measuring stroking and fluttering movements and/or body angles in fine scale time resolution. These sophisticated measurements are enabled by high speed sampling of the multi-axes accelerations of animal movement, and consequently this high speed sampling (i.e. 32Hz) limits the observation period of animal behaviour within a few days. In conservation study of wild animals, which often requires long term monitoring of behaviour including feeding, resting, habitat use and etc, and activities change in weekly, monthly, seasonally or yearly scales usually faces difficulties. In order to overcome the difficulties, experiments were carried out to establish a new long term monitoring logger system on animal behaviour using acceleration logger. Animals conduct specific movements related with particular behaviours that are usually discernible to each other. These specific movements appear in the acceleration signals in different forms in terms of signal frequency and amplitude, which would allow us to transform acceleration data into simple and compressed data form, and therefore extension of recording period of monitoring logger will be enabled. Preliminary experiments were carried out to test the idea to discern several behaviours using acceleration data obtained from the semi-wild Milky Storks in the Zoo Negara (Figure 4). The preliminary test distinguished some behaviours such as flying, walking and feeding in surge acceleration signals. This allows us to develop an algorism for data compression and expected to be used in the conservation strategies of Milky Storks in the wild.

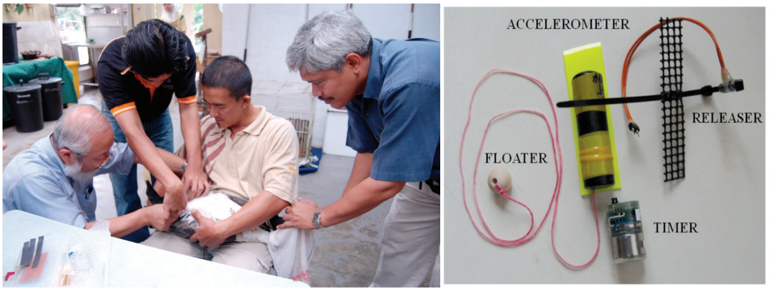


Figure 4 An example of bio-logging project activity in Zoo Negara. The project is in collaboration with Japanese scientists from the University of Tokyo and National Polar Research Institute Japan

Malaysia is considered young in the field of biology which is historically championed by the British, European, American and Japanese. The time has come for us to collaborate with developed nation's field biologists to study wildlife ecology and biology in the wild. New approaches of studies, technologies and current systematic practices by these scientists can be shared and documented to narrow the gap in knowledge and the lack of information on our biodiversity in order to support our wildlife conservation initiatives.

HABITAT QUALITY OF MIGRATORY SHORE BIRDS AND COASTAL WILDLIFE

The habitat quality for migratory shorebirds and other wildlife that are searching for food in the intertidal environment is a great concern in coastal wildlife conservation and protection. Two important aspects are food availability and chemical contamination. Coastal mudflats around protected mangrove areas are very productive. High density and diversity of macrobenthos serve as an important diet for migratory shorebirds. During migration, migratory shorebirds spend their time feeding and resting to refuel their energy and preparing to fly back to the northern hemisphere for breeding. Since coastal areas are exposed to open sea and receive continuously flowing water from inland, they may face a potential threat of chemical pollution. Chemical pollutants may accumulate in the benthic organisms and may transfer to the birds. Hazardous chemicals toxicity in birds has been discussed elsewhere. Heavy metals are among significant hazardous chemicals in coastal environment that attract many scientists to study.

Most of the shorebirds utilised intertidal mudflat habitat that is characterized by moist mud, wet mud, shallow edge and moderate water depth (Riak et al., 2003a). Table 5 shows the example of habitat availability and use by shorebirds in Mudflat of Kapar, west coast of Peninsular Malaysia. The landscape of mudflats such as wet mudflats and shallow water habitat are important for the management and conservation of shore birds. Those important characteristics of habitat quality are needed to maintain and continuously attract migratory shore birds. Similar phenomenon is observed in Kuala Gula, another important bird area. The habitat is very important for birds to feed and rest, and for their body maintenance. These activities are the most frequently observed behaviours and more than 40% of daily activities is resting (Riak et al., 2003b). Resting, sleeping and feeding are common activities during non breeding season. Most species of migratory shorebirds prey in the intertidal habitats during the non-breeding season for their energy reserves which will be used during migration. Migratory shorebirds usually increase their body weight at a rate of 3–5% per day to obtain sufficient energy to enable them to reach the breeding grounds for reproductive success.

Table 5 Availability and use of habitat by six common bird species on Kapar mudflats during migration period. (BSG= Bar-tailed Godwit, BLGD= Black-tailed Godwit, CR= Common Redshank, EC= Eurasian Curlew, LSP= Lesser Sandplover, W= Wimbrel.

Habitat	% use					
	BAG	**BLGD**	**CR**	**EC**	**LSP**	**W**
Dry mud	0.0	0.0	6.3	0.0	63.5	0.0
Moist mud	15.9	14.3	28.5	16.1	52.5	15.8
Wet mud	44.5	48.8	38.9	29.3	0.0	28.8
Shallow (<4cm)	39.6	36.9	26.3	42.6	0.0	42.7
Moderate (5-15 cm)	0.0	0.0	0.0	12.1	0.0	12.7
Number of Flocks	221	258	260	324	202	330

Intertidal mudflats are unique features of the western coastline of Peninsular Malaysia. This area of soft muddy substrate is the habitat for many species of invertebrate mainly infaunal and epifaunal communities. These invertebrates are important as prey for varieties of avian and other aquatic consumers such as shorebirds, crabs, fishes and ducks. At Kapar mudflats alone, over 100,000 migrant shorebirds visit these mudflats annually between late July and mid April on their way to southern hemisphere and back to their breeding grounds in Siberia and Alaska (Riak et al., 2002). By using quadrate techniques along with line transects methods, invertebrates that are potential diet for migratory shorebirds were analysed in Kapar-Kuala Selangor mudflats. The result showed that the diversity and density of invertebrates varied between areas along the coastal region. There are many factors that influence the density and diversity of invertebrates. Among them are the texture of the surface sediments, organic matters and optimum levels of nutrient. Among the common potential diet are crustaceans (15 species, 7 families), polychaetes (14 species, 6 families), and bivalves (10 species, 6 families) (Riak et al., 2003c). The high density and diversity of invertebrates in intertidal mudflats support the annual migration of birds for years. Continuous developments in coastal areas may cause chemical pollution including heavy metals and nutrient pollution which can threaten the benthic organisms and their predators.

Nitrate and phosphate are very important to aquatic life including the organisms in the coastal environment. When the concentrations of nitrate and phosphate exceed the accepted levels for the aquatic organisms, many changes will occur in the affected area. This can increase primary production (for example enhancement of algal biomass), fasten decay of organic materials, reduce dissolved oxygen and redistribute the species within the aquatic ecosystems. Elevated levels of nitrate, ammonia and phosphate in surface water in both marine and freshwater environments can affect invertebrate density in the feeding ground of migratory shorebirds. Short term studies in Kuala Gula Bird's Sanctuary showed that there are low levels of nitrate, ammonia and phosphate compared to earlier studies by Yap et al. (2005) in coastal areas of Selangor and Negeri Sembilan. However, the levels of nitrates and phosphate are fluctuating due to rice cultivation activities in the nearby paddy fields (Lomoljo et al., 2009).

Heavy metals are among the chemicals that may threaten the health of birds. Heavy metals are known to accumulate in the benthic organisms and may transfer to the birds if they feed on these contaminated benthic organisms. Heavy metals have been shown to affect birds. Several physiological and biological processes, such as feeding habits, growth, age, reproduction, moulting, and migration may influence metal concentration and distribution in birds. Very few studies on the accumulation of heavy metals in migratory shorebirds have been carried out. Many countries along the East Asian–Australian migration flyways enforce strict laws to protect these birds. In Malaysia, Wildlife Act 1972 and Wildlife Conservation Act 2010 are among the laws that protect these birds. Kim et al. (2007) reported that essential trace elements, zinc concentrations in kidneys, and copper concentrations in muscles significantly differed among shorebirds, but manganese concentrations did not differ in each tissue. They suggested that essential elements are within normal range and are maintained there by normal homeostatic mechanism. Another study by Yasunaga et al. (2000), showed concentrations of V, Cr, Mn, Co, Cu, Zn, Se, Rb, Sr, Mo, Ag, Cd, Sb, Cs, Ba, Hg, Tl, and Pb in the liver of 9 species of waders including migratory and resident collected from north Vietnam, south India, and the Philippines have no significant differences between genders and among localities. Toxic element levels in waders are dependent on the migration distance. Studies on heavy metals levels in intertidal mudflats of the west coast of Peninsular Malaysia showed that in general, metal concentrations are low except in several localities such as Juru in Penang, and a few locations in south of Johore (Zulkifli et al., 2010). Many locations of migratory shorebirds stopover are found to pose less threats of heavy metals contamination. Lomoljo et al. (2010b) reported on the distributions of Cd, Cu, Pb, and Zn in the surface sediments from two sites of the Kuala Gula Bird Sanctuary, Malaysia. Geochemical fraction of heavy metals in surface sediment collected from foraging sites in Kuala Gula Birds Sanctuary showed low levels of heavy metals input. About 51% to 96% of resistant fractions were observed for all four metals studied. These results indicate low contributions from anthropogenic sources. The findings constitute a baseline data archive for future reference. Even though the report from Lomoljo et al. (2010b) showed low levels of heavy metals in Kuala Gula, continuous input of heavy metals from inland human activities may elevate heavy metals levels in the coastal mudflats that are important to shorebirds. Studies by Shahrizad et al. (2005), Ismail et al. (2003) and Naji and Ismail (2011) showed there are potential inputs of heavy metals from rivers into the coastal environment. Sivalingam et al. (1980), Seng et al. (1987) and Lim and Kiu (1995) reported elevated levels of heavy metals in Juru and Prai areas north of Kuala Gula due to industrialisation, urbanisation, and agricultural activities. Since Kuala Gula Bird Sanctuary is close to urbanisation, industrial and agriculture areas, in the north and inland, continuous input of hazardous chemicals is expected through atmospheric deposition, sea based contamination and inland input via rivers flowing through those areas. Therefore, monitoring of hazardous chemicals including heavy metals in the surface sediments and benthic organisms is necessary.

MONITORING HEAVY METALS CONTAMINATION IN SEDIMENT IN MALAYSIA

Sediments are the ultimate sink for numerous anthropogenic chemical contaminants that may be contained in effluents originating from agricultural, industrial, urban and recreational activities. Trace elements occur naturally and are ubiquitous contaminants in the aquatic sediments. These elements become toxic if they occur above certain threshold bio-available levels (Rainbow, 1995). Concentrations of certain trace elements such as Cd, Cu, Ni, Pb, Zn and other metals are often elevated above the background levels in sediments that have been affected by human activities such as industrial, agricultural, mining, transportation, construction, and habitation (Ismail et al., 1993; Lim and Kiu, 1995; Shazili et al., 2007). Earlier studies have correlated elevated concentrations of certain inorganic elements in sediments of rivers, estuaries, and coastal regions with increased industrial growth, agricultural operations, land use etc. (Cuong et al., 2008; Naji et al., 2010). Contaminated sediments in rivers, lakes, and coastal regions have the potential to pose ecological- and human health risks. Depending on the hydrodynamics, biogeochemical processes, and environmental conditions (redox, pH, salinity and temperature) of the aquatic environment, sediments are recognised as an important sink for many pollutants in aquatic systems, as well as potential non-point sources of pollutants that might directly affect the overlying water (Ngiam et al., 2001). This process commonly occurs in intertidal sediment flats in estuaries. Moreover, trophic transfer of pollutants is identified as an important pathway for pollutants in sediments to accumulate in marine invertebrates and fishes (Rainbow, 1995).

In Malaysia, the coastal areas are likely to receive impacts from sea-based and land-based activities. Contamination accelerates due to intensifying rate of industrialisation and urbanisation, the advancement of agriculture and other activities. The Department of Environment, Ministry of Natural Resources and Environment Malaysia, stated in every annual report about the activities that can be the sources of anthropogenic pollutants, and potentially contaminate the coastal environment. Until recently, there are several reports on the status of heavy metals contamination in the aquatic environment in Malaysia, particularly in relation to intertidal sediments. Table 6 lists earlier studies on trace elements, including heavy metals contamination in sediment in Malaysia. Figure 5 shows some of the sampling locations for surface sediments in Malaysia. Continuous assessments on heavy metals since early 1980 demonstrated that there is an elevating trend of heavy metals contamination in sediments, especially from those located in the vicinity of pollutant sources.

After more than two decades of heavy metals studies, our laboratory members have published articles in CIJ and non-CIJ journals, chapters in books, and proceedings of national and international seminar and conferences. Some of the articles remain among the top ten articles published on the same topic since they were published. Further details can be seen at www.BioMedLib.com. Our studies stipulated trace elements concentration in intertidal sediments around Peninsular Malaysia could range between 0.1-340 $\mu g \cdot g^{-1}$ (As); 2-330 $\mu g \cdot g^{-1}$ (Cr); 1-670 $\mu g \cdot g^{-1}$ (Cu); 0.2-610 $\mu g \cdot g^{-1}$ (Zn); n.d.-45 $\mu g \cdot g^{-1}$ (Cd); 0.5-250 $\mu g \cdot g^{-1}$ (Pb); n.d.-50 $\mu g \cdot g^{-1}$ (Ni), respectively. Figure 6 and 7 show more levels of metals in the surface sediments from Peninsular Malaysia coastline in detail. In general, heavy metals concentration in intertidal sediments around Peninsular Malaysia is still low, with exception for several locations. Trace elements were found contaminating the areas close to the pollutant sources and were not evenly distributed throughout the coastal area. This is in line with other reports by Ismail et al. (1989, 1993) and Naji et al. (2010). Nevertheless, continuous monitoring and proper actions should be taken to prevent the deterioration of environmental quality in the coastal environment.

Based on a rough survey, we can briefly say that the Ecotoxicology & Wildlife Ecology Laboratory of UPM publishes the most publications on heavy metals studies in Malaysia, focusing mainly along the coastal area of Peninsular Malaysia. We developed and used similar established method throughout sampling and analytical procedures (e.g. Ismail and Roberts, 1992; Ismail et al., 1993; Ismail and Ramli, 1997). Consistent identical procedures are important to produce reliable data. In the near future, based on the obtained data, we will propose a background level of heavy metals in Peninsular Malaysia as guidance for extension and related studies.

Table 6 Concentration of trace elements ($\mu g \cdot g^{-1}$ dry wt.) in sediments from selected studies in Malaysia

Metal ($\mu g \cdot g^{-1}$)							Reference
As	Cr	Cu	Zn	Cd	Pb	Ni	
-	-	1.-26	8-76	<1.3	6-35	-	Sivalingam et al. (1980)
-	-	9.3-13.8	73.5-109.8	n.d.-6.8	20.8-33.0	24.8-46.7	Seng et al. (1987)
-	-	<9.0	11-66	<6.0	2.-6	-	Ismail et al. (1989)
-	-	10-80	100-550	0.2-0.8	40-250	-	Sin et al. (1991)
-	-	5-100	5.-14	0-16	1-45	-	Ismail et al. (1993)
-	-	7.0-13.0	39.0-91.0	1.0-5.0	11.0-36.0	-	Ismail (1993)
<14.4	<324	<185	-	<45.3	<42.8	-	Yusof and Wood (1993)
-	-	6-64	35-173	-	19-32	-	Lim and Kiu (1995)
-	-	n.d.-114	2.8-426	-	1.3-10.3	n.d.-8.4	Seng et al. (1995)
-	-	4-670	4-550	0.1-2.1	3.4-46.5	-	Ismail and Ramli (1997)
54-334	13-66	11.-93	54-334	0.08-0.34	19-160	21-34	Wood et al. (1997)
1.17-83.67	-	1.13-4.40	3.23-21.17	n.d.-0.67	0.52-3.50	-	Lau et al. (1998)
	-	15-31	303-365	n.d.-0.69	24-63	-	Ngiam and Lim (2001)
-	-	17.29	70.9	0.89	21.87	-	Yap et al. (2002)
-	-	-	4.00-79.05	0.1-1.42	-	-	Yap et al. (2003a)
-	-	-	3.12-306.20	0.03-1.98	-	-	Yap et al. (2003a)
-	-	-	-	-	-	-	Yap et al. (2003b)
9.89-46.50	2.81-112.0	8.48-53.40	85.03-230.01	0.10-4.03	1.70-23.50	-	Yusof et al. (2004)
-	18.44	4.28	0.29-50.22	0.28	14.74	-	Shazili et al. (2007)
-	37.48-50.52	6.30-21.01	48.20-62.36	0.054-0.217	24.14-37.28	13.27-26.59	Cuong et al. (2008)
0.11-311.84	11.16-207.04	1.63-150.81	23.70-609.20	n.d.-1.06	7.97-93.11	2.41-36.29	Zulkifli et al. (2010)

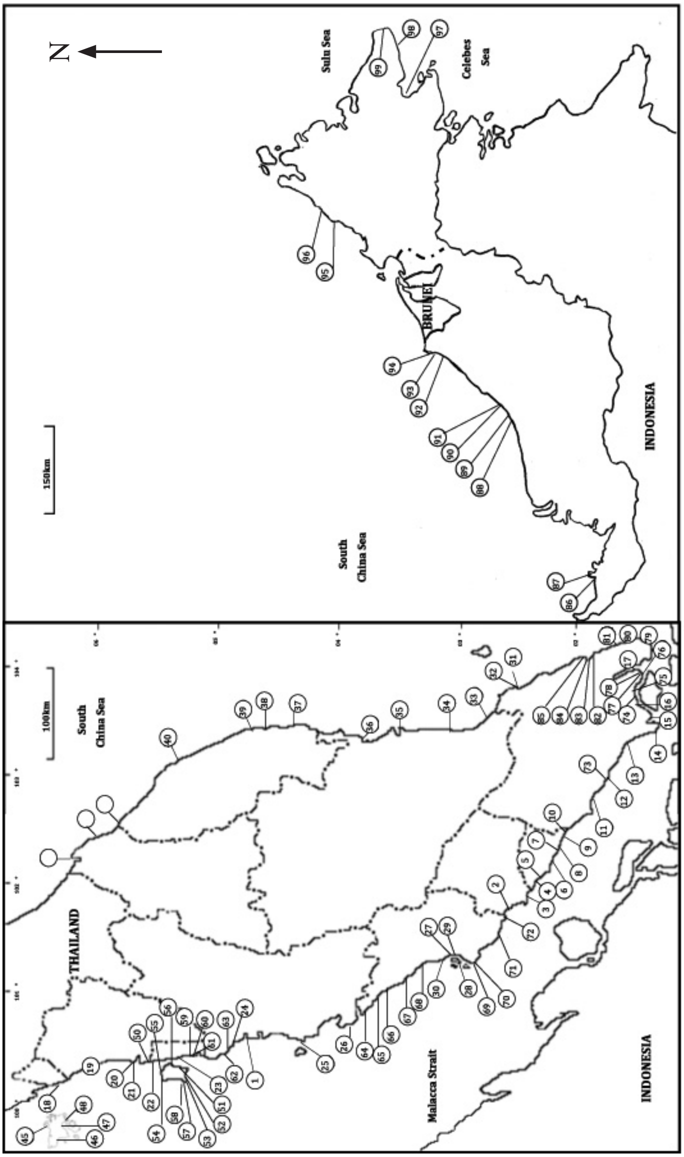


Figure 5 Some of the sampling locations for sediments around Peninsular Malaysia, Sabah and Sarawak

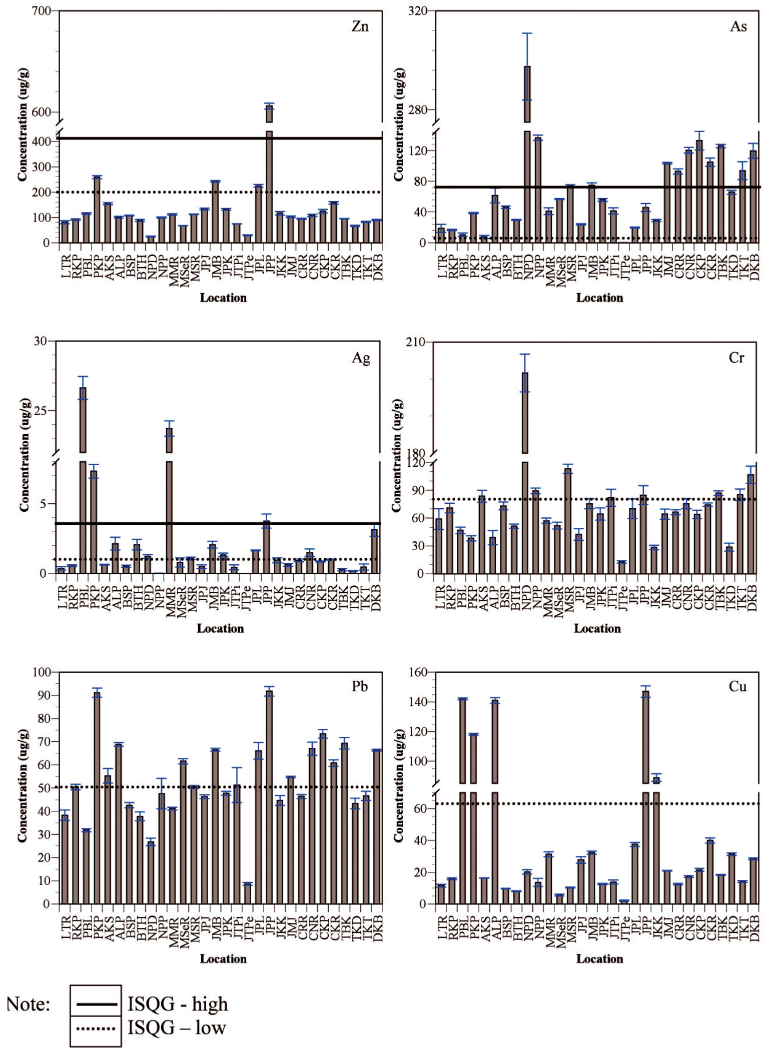
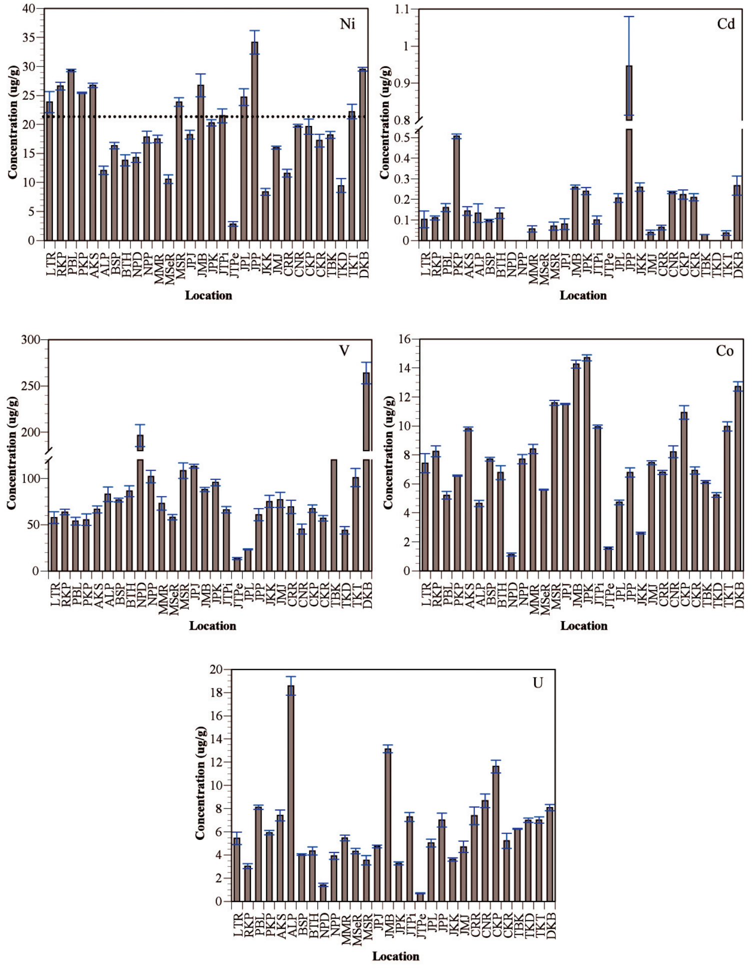


Figure 6 Concentrations of Zn, As, Ag, Cr, Pb and Cu in sampling locations along the Peninsular Malaysia coastline (Zulkifli et al. 2010). (ISQG = Interim Sediment Quality Guideline)



Note: .... ISQG – low

Figure 7 Concentrations of Ni, Cd, V, Co and U in sampling locations along the Peninsular Malaysia coastline (Zulkifli et al., 2010). (ISQG = Interim Sediment Quality Guideline)

STUDIES ON BIO-MONITORING AGENTS FOR HEAVY METALS CONTAMINATION IN COASTAL MARINE ENVIRONMENT OF PENINSULAR MALAYSIA

As previously discussed, hazardous chemicals that might cause toxicological effects to the coastal wildlife are pesticides, polycyclic aromatic hydrocarbon, tributyltin (TBT), heavy metals, estrogen and other endocrine disruptors. These hazardous chemicals could cause abnormalities and physiological effects in wildlife including birds. Historically, many incidents were reported in the literatures which include thinning of eggshell, premature hatching, deformed legs and other morphological and physiological abnormalities (Honda et al., 1986; Kim et al., 1996; Lam et al., 2005; Kim et al., 2007). These destructive deviations in wildlife may disturb their population and ecological balance in specific habitat. The studies on pollution effects on wildlife are important as they can help to establish indicators for environmental and human health.

One way to assess the presence of the hazardous chemicals is by monitoring their levels and patterns in the coastal environment. Many samples are used in the assessment of hazardous chemicals in the coastal environment. The samples are surface sediment, water, benthic organisms, fish and others, depending on the purpose of the study or assessment. Many monitoring activities of pesticides, Polycyclic Aromatic Hydrocarbons (PAHs), heavy metals, Polybrominated Diphenyl Ethers (PBDEs) and TBT were carried out in Peninsular Malaysia and Asian region (Ismail et al., 1991; Zakaria et al., 2000; Sudaryanto et al., 2002; Monirith et al., 2003; Agusa et al., 2007; Harino et al., 2008). The results from these monitoring reports revealed that the west coast of Peninsular Malaysia in particular is contaminated by these chemicals at certain degrees and locations. This contamination also shows that in Peninsular Malaysia, human activities, land and sea based activities had contributed to the elevated levels of hazardous chemicals in the coastal environment. Ultimately, the elevated levels may affect environmental health, wildlife and probably us, the human being.

Continuous developments and human activities in industries, agriculture and urbanisation are some of the well-known contributors of hazardous chemicals in the environment including heavy metals. Heavy metals toxicity has been reported elsewhere as important aspects of environmental issues. In the coastal environment, heavy metals may be deposited in surface sediment, accumulated in suspended particulate matter, dissolved in water column and taken up by intertidal organisms. High levels of heavy metals in the coastal environment may be toxic to organisms and affect the health of the ecosystem and its many components.

Since toxicity of heavy metals is hazardous and could cause direct impact on environmental health, wildlife conservation, food safety and human health, continuous physical developments and human activities that contribute to heavy metals pollution will also need to be monitored. Therefore continuous and systematic monitoring is one of the many important aspects being emphasised here. In the process of monitoring, effective monitoring agents, established sampling methods and analytical methodologies are significant points to consider to gain good results. Among important agents for monitoring heavy metals are biological samples. The organisms used to monitor the availability of heavy metals and other pollutants are called bio-monitors or bio-indicators.

Bio-monitoring is the science of inferring the ecological condition of an area by examining the status of the organisms that live there. Bio-monitoring is a method of observing the impact of external factors on ecosystems and their development over a long period, or of ascertaining differences between one location and another. Although bio-monitoring can be done in any ecosystem, it is most often used to assess the water quality of rivers, lakes, streams and wetlands.

In the case of monitoring heavy metals contamination, bio-monitor is a species which accumulates heavy metals in its tissues, and may therefore be analysed as a measure of bioavailability of metals in the ambient habitat. Suitable organisms must be chosen to ensure they fulfil the criteria for bio-indicators and bio-monitors. The use of bio-indicator for monitoring heavy metals status of the environment had been discussed by Markert et al. (1999). Further attention should be given to factors that may affect element concentrations which may lead to incorrect statements if ignored.

Bio-monitoring of heavy metals contamination and bio-monitors are well described (Goldberg et al., 1978; Phillips and Rainbow, 1993; Rainbow, 1995). Rainbow (1995) emphasised that understanding of the fundamental knowledge on biology, ecology and physiology is essential as a prerequisite before the organism is chosen as bio-monitor. The knowledge on kinetics of accumulation of metals in each species provides information on how much metal is accumulated. He stressed that correct species is important and species robustness alone is insufficient for the organisms to be used as bio-monitor and to be compared with the data of other studies in the world.

The idea of bio-monitoring was promoted at global level by Golberg (1975), and followed up by U.S. Mussel Watch Program (Golberg et al. 1983) and further discussed by Tripp et al. (1992) and Golberg and Bertine (2000). The U.S. Mussel Watch Program was implemented at several phases as listed by Golberg (1975). At the initial implementation phase, the programme utilised *Mytilus edulis* with the intention to:

1. generate high quality data on chlorinated pesticides and estimate PCB concentrations in the Central-South America-Caribbean coastal region
2. serve as a "field-test" of a large-scale international marine monitoring program for chemical contaminant
3. create an international network of coastal environmental scientists
4. provide a forum for training and for discussion of analytical results
5. create the institutional structure for a global scale coastal monitoring program.

Global Mussel Watch Program promoted by the late Prof Edward Golberg was later implemented in Asia-Pacific region. Edward D. Goldberg (1921–2008) was a marine chemist known for his studies of pollution in the oceans. A significant innovation in Goldberg's research implemented in Mussel Watch was the utilisation of mussels to measure pollutant levels that has become common in marine chemistry. Subsequently, green lipped mussels, *Perna viridis*, were used as bio-indicator for PCB isomers and congeners in coastal waters of Hong Kong by Tanabe et al. (1987) and followed by Fung et al. (2004). Tanabe (1994) then proposed to use *Perna viridis* for the intertidal mussel watch in Asia Pacific phase.

GREEN LIPPED MUSSELS, *PERNA VIRIDIS* AS BIO-MONITORING AGENT

The *Asia-Pacific Mussel Watch* Program (APMW) started in 1994, under the umbrella of the International Mussel Watch-Asia Pacific Phase. This special programme headed by Professor Shinsuke Tanabe from Ehime University, Japan was established in Asia Pacific to implement the concept of monitoring suggested by Golberg.

The programme was collaborated with many Asian countries such as Vietnam, Thailand, Malaysia, Indonesia, Philippines and India. Unlike the Global Mussel Watch initiated by Golberg 1975 which used blue mussels *Mytilus edulis*, the Asia-Pacific Mussel Watch Programme uses green mussels, *Perna viridis* (Figure 8). *Perna viridis* is suitable as a bio-monitoring agent as it fulfils the criteria for bio-monitoring agent such as widely distributed in the coastal waters, live a sedentary life style, long-lived and available at all periods of the year, large enough to provide sufficient tissue for metal analysis, low variability and easy to identify morphologically, can be easily maintained in laboratory conditions for experimental studies, have strong ability to accumulate heavy metals from ambient environment, a good suspension-feeder with a high filtration rate, tolerant and sensitive to heavy metal stresses and last but not least a significant relationship can be found between heavy metal levels in the mussel and its environment.

Figure 8 *Perna viridis*

Perna viridis is native and widely distributed in the coastal areas of Indo-pacific region either in the wild or cultured for human consumption. The mussels are also easily distributed through ballast water. Thus, they are easy to sample, widely available (in its native range), represent local environment and is significant to human consumption. Figure 9 shows suitable habitats for *Perna viridis* in the world, its native distribution (Figure 10) and its expected distribution by the year 2050 (Poutiers et al., 1998) (Figure 11). The culture of *Perna viridis* becomes more active in the Asia Pacific region due to its ease of culturing, suitability of habitat and to the high demand for protein resources. In Malaysia, *Perna viridis* culture has been reported earlier and well studied on their biology and ecology (Sivalinggam 1977; Al-Barwani et al., 2007). The environmental quality in the west coast of Peninsular Malaysia is extremely suitable for green mussel culture which can easily attain marketable size within 7 to 8 months. Oxygen saturation of approximately 6 ml/L, primary productivity of 5.2 mg chlorophyl/L, water current of 0.17-0.35 m/sec, high water temperatures throughout the year ($\approx$ 29.5^{o}C) and high salinity ($\approx$ 32 ppt) provide a favourable condition for the mussels to live and grow. According to FAO (2005), the production trends of green mussels in Malaysia increased from 1986 to 1998 for about 2000 tons per year and reaching 10,000 tons in year 2000. In 2003 the production of green mussels increased again and expected to increase in the future. According to FAO (2007), *Perna viridis* is highly prized as food in Malaysia and other countries with a range of yearly aquaculture production from around 69,153 mt in 1995 to 68,509 mt in 1999 (India, Malaysia, Philippines, Singapore, Thailand). Due to the importance of the species in its native range, priority should be given in assessing the population status and health. The importance of doing research and monitoring programme using *Perna viridis* is again being amphasised.

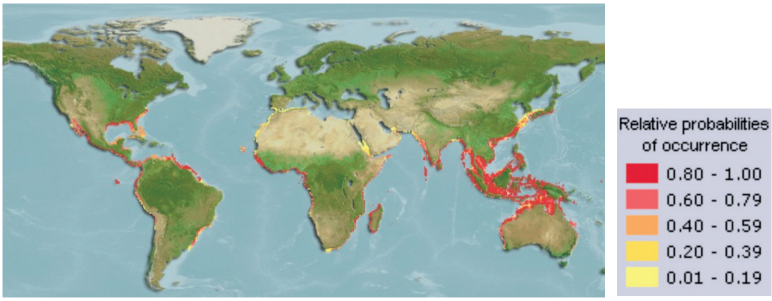


Figure 9 Suitable habitat of *Perna viridis* around the world

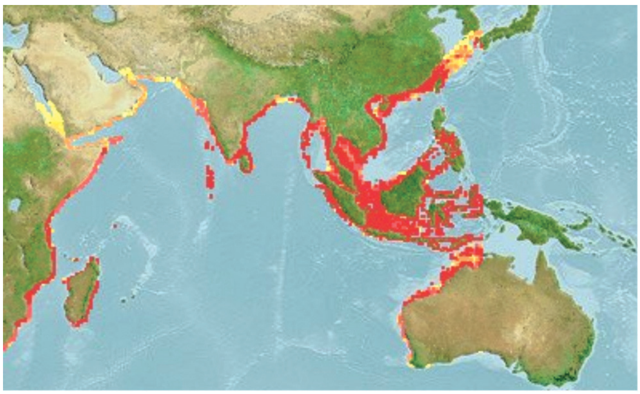


Figure 10 *Perna viridis* native range around the world

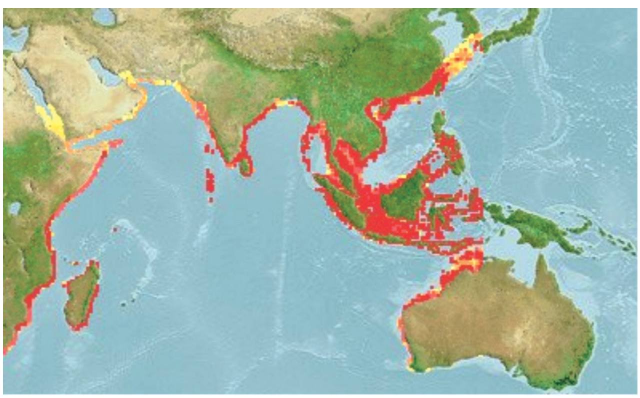


Figure 11 *Perna viridis* range by the year 2050
(Source: Poutiers et al., 1998)

In Malaysia, assessments of heavy metals contamination in *Perna viridis* were reported since 1980s by Sivalingam and Bhaskaran (1980) and Sivalingam (1985). Later in late 1980s and 1990s more assessments of heavy metals in green mussels, *Perna viridis* were carried out comprehensively in the coastal environment of the west coast of Peninsular Malaysia (Ismail, 1990, 1993b). The results of studies based on soft tissues analysis, showed good correlations and favourable agreement that *Perna viridis* can be a good bio-monitoring agent for heavy metals contamination including other hazardous chemicals such as pesticides and tributyltin. More aggressive studies are subsequently carried out on heavy metals accumulation in *Perna viridis* focusing on the best organ or tissues that are easy, effective and reliable to be a bio-monitoring agent and their ecotoxicological effects. This idea continues for more than ten years and significant publications are published in local and international journals. Most scientific publications related to this work can be seen in Yap et al. (2004) where a detailed discussion on the use of *Perna viridis* in monitoring heavy metals in Peninsular Malaysia was presented. All important criteria were discussed. *Perna viridis* are well distributed in Peninsular Malaysia except for some small areas in the east coast. It is easy to sample, available all year around at all sizes, sufficient samples for analyses are always available with moderate degree of genetic differences. Good correlation of most heavy metals levels in tissues and sediments can be observed including in different geochemical fractions of metals in sediments. The analyses showed that *Perna viridis* have good capacity of accumulating heavy metals in the tissues and good eco-toxicological response. Based on LC_{50} testing, the green mussels showed more sensitivity to copper compared to cadmium, zinc and lead, and smaller sized ones are more sensitive compared to the larger ones. In general, we can conclude that, *Perna viridis* is suitable for bio-monitoring agents in Peninsular Malaysia and Asia Pacific region and they have public health values since they are one of the protein sources for Asians. Even though metal levels in some samples are above the permissible limits set by Malaysian Food Regulation (1985), the green mussels in the coastal waters of Peninsular Malaysia are generally safe for consumption.

Studies on levels of heavy metals in *Perna viridis*, correlations with different geochemical fractions of heavy metals in sediment, distribution in the tissues and some basic ecotoxicological studies, can guide us on the use of *Perna viridis* as bio-monitoring agents for heavy metals, and perhaps for other hazardous chemicals such as pesticide, PAHs and tributyltin. More ecotoxicological studies are required especially to understand the regulation of the toxic chemicals in the whole tissues in detail. This may help to identify the best tissues for bio-indicator and for public health concerns.

In Malaysia, Asia Pacific Mussel Watch Programme involves analysis of three important groups of hazardous chemicals; pesticides, tributyltin and polycyclic aromatic hydrocarbons (PAHs) (Sudaryanto et al., 2002; Monirith et al., 2003; Sudaryanto et al., 2004; Ramu et al., 2007; Shahbazi et al., 2010). Main heavy metals studies for the programme were carried out in the Department of Biology, Universiti Putra Malaysia and the analyses some of the samples were carried out at the Centre for Marine Environmental Studies (CMES) in Ehime University, Japan. For the PAHs study, analysis of soft tissues for PAHs indicated a significantly higher concentration of the lower molecular weight (LMW) PAHs compared to that of the higher molecular weight (HMW) PAHs (Shahbazi et al., 2010). The results also suggested that the differences found in the contents of PAHs in various soft tissues of *Perna viridis* were mainly due to differences between individual PAHs mobility, volatility and solubility in water, as well as the mechanism of PAH accumulation by mussels. Whole homogenous mussel tissues analysis for TBT showed that higher concentrations of BTs were found in mussels collected at locations with intensive maritime activities (Sudaryanto et al., 2002). This implies that the usage of TBT as a biocide in antifouling paints was a major source of TBT measured. In addition, relatively high concentrations of TBT were observed in mussels from aquaculture areas in Malaysia, and as reported in Hong Kong and Thailand. Although contamination levels were generally low in mussel samples from most of the Asian developing countries, some of those from polluted areas in Hong Kong, India, Malaysia, the Philippines, and Thailand revealed levels comparable to those in developed nations. Furthermore, the concentrations of TBT in some mussels from polluted areas exceeded the threshold for toxic effects on organisms and estimated tolerable average residue levels as seafoods for human consumption. Sudaryanto et al. (2002) reported a significant correlation was observed between the concentrations of ΣBTs and ΣSn in mussels, and ΣBTs were made up mostly 100% of ΣSn in mussels taken from locations having intensive maritime/human activities. This suggests that anthropogenic BTs represent the major source of tin accumulation in mussels. Contamination of persistent organochlorines (OCs) such as PCBs (polychlorinated biphenyls), DDT and their metabolites (DDTs), HCH (hexachlorocyclohexane) isomers (HCHs), chlordane compounds (CHLs), and HCB (hexachlorobenzene) were examined in mussels under APMW and were discussed in detail by Monirith et al. (2003). Considerable residue levels of *p,p*′-DDT and ΣHCH were found in mussels, and the concentrations of DDTs and HCHs found in mussels from Asian developing countries were higher than those in developed nations. The studies conducted by Tanabe et al. (2000) and Monirith et al. (2003) suggested present usage of DDTs and HCHs along the coastal waters of Asian developing countries.

Lower concentrations of PCBs were detected in mussels from Asian developing countries than those in developed countries and this indicates that PCBs contamination in mussels is strongly related to industrial activities. This is the first comprehensive report on butyltin and organochlorines compounds pollution monitoring in developing countries in the Asia-Pacific region under the APMW. Tanabe (2000) suggested that APMW should be continued as there are continuous inputs of hazardous chemicals into the coastal marine environment. Prior to this Sivalingam et al. (1982) only analyzed PCB and pesticides in mussels from the specific areas in Peninsular Malaysia.

Based on ten years of collaboration with Japanese scientists under APMW, Japan Society for the Promotion of Science (JSPS) and Japan International Cooperation Agency (JICA), mussel watch programmes should be continued to monitor hazardous chemicals contamination in coastal environment. As discussed in detail earlier, monitoring is important not only for human health but for environmental health and wildlife conservation as well. Existing laboratories and expertise in Malaysia need to be supported by adequate laboratory facilities and maintenance, capacity building and sufficient budget to provide constant monitoring of hazardous chemicals that are inevitably being contributed by human activities. This is crucial for sensitive areas such as protected coastal environment for nature conservation, breeding and nursery ground for marine life, recreational beaches and polluted areas with active human activities.

OTHER MOLLUSCS AS BIO-MONITORS FOR HEAVY HETALS IN INTERTIDAL ENVIRONMENT

As commented by Rainbow (1995) on the availability of heavy metals in benthic organisms and the importance of bio-monitoring agents for chemical pollution, specific environment may have specific organism to be its bio-monitor. For example, *Perna viridis* live as filter feeders, filtering particles in the water column. In case of heavy metals, green mussels mainly filter heavy metals in suspended particulate matters or those dissolved in the water. However, other molluscs such as blood cockles may function differently in their habitat. The differences in micro-habitat, behaviour and food preference may vary their mode of chemicals accumulation. This phenomenon granted special attention on the biology, behaviour, ecology and correlation analysis between chemicals accumulation in soft tissues and the environment such as surface sediment and water column. To answer this, series of analyses has been carried out on the level of heavy metals in different species of intertidal molluscs and their environment.

Telescopium telescopium is among the intertidal mollusc that is dominant and easy to sample. The species can be seen grazing on the mudflat surface. Studies on heavy metals accumulation in *Telescopium telescopium* were carried out by Ismail and Safahieh (2005) in Lukut River, Negeri Sembilan and Amin et al. (2005) in intertidal mudflat of Dumai, Indonesia. The results showed that the *Telescopium telescopium* can also be used as bio-monitoring agent for heavy metals in intertidal mudflats close to mangrove areas and river mouths. Their existence in the areas can assess the input of heavy metals from inland through river system into the mangrove ecosystems. The findings of the studies gave important information on heavy metals concentrations on both sides of the Straits of Malacca. The coastal environments are not threatened by high levels of heavy metals. The ranges of heavy metals concentration measured in *Telescopium telescopium* are 0.33 - 0.69 µg/g; 9.38 - 52.29 µg/g; 1.73 - 10.78 µg/g; 14.69 - 69.87 µg/g dry weight for Cd, Cu, Pb and Zn, respectively. Another studies by

Yap et al. (2009) provided information on metal distributions in different soft tissues of *Telescopium telescopium* and on the wide distribution and abundance of *Telescopium telescopium* in the southwestern intertidal area of Peninsular Malaysia. The studies on detailed metal levels in the tissues indicated that it is more useful and accurate to monitor particular metals in the intertidal area using particular organ. In addition, the use of particular organ may be more effective than using the whole soft tissue to monitor metals in the intertidal zone. In general, the above studies suggested that the soft tissues of *Telescopium telescopium* can be considered as a potential indicator of Cu, Zn, and Pb.

Intertidal gastropod *Nerita lineata* is another mollusc that can be suggested as a good bio-monitoring agent for heavy metals. Unlike other gastropods, *Nerita lineata* (Family: Neritidae) is usually found grazing on mangrove trees, rocky shores and intertidal mud and sandy beaches. Sometimes this species is found aggregated on the intertidal rocky shores and near the roots of mangrove. Heavy metals levels in this snail which sampled along the coastal areas of Selangor and intertidal Sepang River were reported by Ismail and Ramli (1997) and Ismail and Jazlina (2003). After statistical analysis and comparison between the accumulation of heavy metals in snails and sediment, it has been revealed that the snail to be a potential bio-monitoring agent for their specific habitat. Later, Yap and Cheng (2009) and Amin et al. (2009b) carried our more detailed studies on heavy metals in *Nerita lineata* to assess the ability of this snail to be a good indicator for heavy metals. The studies were conducted on both sides of the Straits of Malacca: coastal areas of Dumai, Indonesia and the west coast of Peninsular Malaysia. The findings of these studies showed similar patterns of those earlier findings by Ismail and Ramli (1997) and Ismail and Jazlina (2003) where the accumulation of heavy metals are consistently elevated in the areas close to high anthropogenic activities compared to other areas.

Another interesting species to be a bio-monitoring agent for heavy metals is blood cockles, *Anadara granosa*. Like other clams, this bivalve may filter organic matter from the sediment. They are different from other gastropods such as *Cherithedia* that grazes on the surface of intertidal mudflats and *Nerita* that grazes on the surface of rocky areas or roots of *Rhizophora* mangroves. Due to these differences in habitat and feeding behaviour, there is a potential exposure of heavy metals to this source of food for humans. Thus, scientists are attracted to assess heavy metals accumulation in *Anadara granosa* and sediments. As we know, cockles are sessile, living in the mud, easy to collect, widely distributed in tropical intertidal muddy sediment and filter both phytoplankton and zooplankton. These characteristics establish them as potential bio-indicators or bio-monitoring agents. As heavy metals accumulate in sediments, and sediments are filtered into the cockles, the accumulations of heavy metals in the cockles are expected. Many studies on heavy metals in *Anadara granosa* in the west coast of Peninsular Malaysia are reported in the literature (Mat and Maah, 1994; Mat et al., 1994; Din and Ahmad, 1995; Chan et al., 2002; Yusof et al., 2004; Yap et al., 2007; Abbas-Alkarkhi et al., 2008).

Flat-tree oysters *Isognomon alatus* inhabit the mangrove areas near estuaries. This species is another good bio-indicator based on its habitat, sessile lifestyle and, it is easy to sample. They attach themselves to mangrove roots, filtering particles in water and can be a strategic bio-monitoring agent for assessing pollutants input to the coastal areas from river systems and sea based sources. Furthermore, mangrove areas are important breeding and nursing places for marine life. Bioaccumulation, depuration and physiological responses of heavy metals in tree oyster were studied in detail by Saed et al. (2001; 2004). Their metals bioaccumulation and kinetic responses suggested their abilities to be bio-monitoring agents for heavy metals contamination. Studies were conducted in both Sepang Besar and Sepang Kecil which were known to receive pig farm effluent containing high Cu and Zn (Ismail and Ramli, 1997).

Since these molluscs are available along the coastal areas of the west coast of Peninsular Malaysia and easily collected, it can therefore be suggested to be good monitoring agents for chemical pollution. The intertidal molluscs identified above represent different habitats and behaviours. These differences may reflect the behaviours of heavy metals intake by molluscs from their environment. The use of intertidal molluscs in the monitoring of heavy metals and organotin in the west coast of Peninsular Malaysia was discussed in detail by Ismail (2006) and Amin et al. (2009a). The above discussion may help to guide researchers to choose the right bio-monitor when assessing heavy metals pollution in a specific environment. *Isognomon alatus* and *Perna viridis* for examples are both filter feeders, but they may live in different locations. *Perna viridis* can be cultured far from the coastal areas and *Isognomon alatus* inhabit coastal and estuarine areas. Similarly *Nerita* sp. and *Telescopium* sp., inhabit different niches. Therefore their functions as bio-monitoring agents can be determined.

OTHER POTENTIAL BIO-MONITORS FOR HEAVY METALS

As discussed above, intertidal areas can be mudflats, sandy or rocky substrates. These different types of substrates house different types of organisms. In the protected areas of mangrove for example both sandy and muddy substrates can be found. Two important animals that can easily be seen are crabs and mudskippers. On the surface of intertidal areas, two common crabs that are filtering the surface sediment are fiddler crabs and soldier crabs. These fiddler crab, *Uca annulipes* and soldier crab, *Dotilla myctiroides* prefer different micro-habitats. Fiddler crabs concentrate more at the muddy area whereas soldier crabs prefer the sandy area. These differences may support them as a good bio-monitoring agent in the locality near mangroves. Previous studies conducted by Ismail et al. (1991) on fiddler crabs (*Uca annulipes*) suggested that these crabs may be important bio-monitors of metals pollution due to their potentials for accumulating metals. Furthermore, these two crabs fulfill the requisites of an ideal bio-monitor because they have sedentary lifestyle with limited mobility, widely distributed, abundant in the study area and easy to collect. The results of the studies conducted by Ikram et al. (2009) at Selangor coastline on these two crabs revealed that the concentrations of Zn and Cu were significantly ($P<0.05$) higher in *Uca annulipes* compared to *Dotilla myctiroides*. This difference is related to the percentage of organic matter in the crabs' microhabitat sediments since metals can be associated with the organic matter of sediments which they might ingest. Significantly ($P <0.05$) higher organic matter content was shown in *Uca annulipes* sediments compared to *Dotilla myctiroides* sediments for all stations. This finding reconfirmed that a specific bio-monitor is needed for a different type of microhabitat due to the behaviour of heavy metals and animals.

Mudskippers are another interesting creatures that inhabit muddy areas near mangroves. They fed on small fish, crabs, shrimps and other invertebrates that are trapped on the mudflats during low tides. Mudskippers are gobioid teleosts (order: Perciformes; family: Gobiidae, subfamily: Oxudercine), euryhaline, amphibious, and their degree of terrestrial activity varies widely among species.

The giant mudskipper species *Periophthalmodon schlosseri* (Pallas 1770) adapats well on land and can be found dwelling, burrowing, and foraging for food on muddy shores in estuaries and tidal zones of rivers in Southeast Asia (Lim et al., 2001; Khaironizam and Norma-Rashid, 2002). As a carnivore which dwells in muddy shore, it is necessary to evaluate the metal levels in this fish species which can be representative of the intertidal coastal mudflats for pollution monitoring purposes. Studies by Ikram et al. (2010) revealed that their study provides new information on the levels of heavy metal concentrations in different tissues of mudskipper species *P. schlosseri* collected from west coast of Peninsular Malaysia. Results showed that the bioaccumulative ability of the mudskippers in the different tissues for Cu, Cd, and Pb, in particular, did follow the higher concentrations of these metals found in the environmental surface sediment. This finding suggests mudskippers as potential bio-monitors of Cu, Cd, and Pb pollution in the ambient environment. Different tissues of the mudskipper showed different capacities for accumulating heavy metals.

Another creature available in the coastal areas or the west coast of Peninsular Malaysia is horseshoe crabs. *Tachypleus gigas* and *Carcinoscorpius rotundicauda* can be found in Malaysia, where they spawn throughout the year. Adult horseshoe crabs migrate from the offshore continental shelf to spawn on intertidal sandy (*T. gigas*) and mud sandy beaches and mangrove area (*C. rotundicauda*) at every full and new moon (Hajeb et al., 2005a). They inhabit shallow marine waters, generally on sandy bottoms where they move about or burrow just beneath the surface, preying on other animals (Hajeb et al., 2005b). Chemical pollutants are reported to accumulate in these fossil animals. Analyses of heavy metals Pb, Zn, Cu and Cd in horseshoe crabs showed that the level of these metals are considered to be high (Hajeb et al., 2009) when compared to permissible limits set by Malaysian Food Regulation (1985) for Cu (30.0 mg/kg ww), Cd (1.00 mg/kg ww), Zn (100 mg/kg ww), and Pb (2.00 mg/kg ww). This report is very important not only for human consumption but for the organism position in the food webs systems. These animals have different micro-habitat and behaviour compared to mudskippers. Their ability to accumulate heavy metals suggest that they can be another bio-indicators for heavy metals.

Coastal biodiversity with diversity of micro-habitat which continuously exposed to hazardous chemical pollution is very important to the ecology and management of habitat quality. The choice of right bio-indicator species and its microhabitat is important to support the monitoring programme for the sustainability of coastal environment.

JAVA MEDAKA *(ORYZIAS JAVANICUS)*: A POTENTIAL BIO-MONITORING AGENT AND TEST ORGANISM FOR COASTAL ENVIRONMENTAL POLLUTION

Java medaka has been surveyed along the coastline of Negeri Sembilan and Selangor since 2000. The species is later collected and analysed for heavy metal content. Table 7 shows the preliminary studies of heavy metals concentrations in Java medaka collected from Linggi and Kapar estuaries. Positive bioaccumulation of heavy metals in the fish tissues from its surrounding water was recorded. More detailed studies are in progress now.

Table 7 Comparison of zinc and copper concentrations in surface sediment, surface water and Java medaka from Kapar, Selangor and Kuala Linggi, Negeri Sembilan

Location and subjects measured	Zinc (Zn)	Copper (Cu)
Kapar		
Surface sediment	64.6 ± 2.9 µg/g Resistant: 75% Non resistant: 25%	20.4 ± 4.0 µg/g Resistant: 90% Non resistant: 10%
Surface water	0.086 ± 0.03	0.073 ± 0.006
Java medaka*	59.0 ± 3.0	6.0 ± 0.1
Kuala Linggi		
Surface sediment	15.3 ± 4.0 µg/g Resistant: 51% Non resistant: 49%	42.2 ± 2.9 µg/g Resistant: 86% Non resistant: 14%
Surface water	0.108 ± 0.01 µg/ml	0.093 ± 0.003 µg/ml
Java medaka*	63.0 ± 5.0 µg/g	4.0 ± 0.2 µg/g

* Concentrations of metals exclude those found in the stomach and head.

One of the criteria of a good bio-indicator or bio-monitoring agent is its wide dispersal and availability. Further short investigation on the availability of Java medaka showed that various life stages of the fish are available at any time for all ages (Table 8). Then, an extensive survey on Java medaka in Peninsular Malaysia was conducted in 2006. The survey showed that this fish is abundant all year round in the estuaries of the west and south coast of Peninsular Malaysia (Figure 12). Their tolerance to wide ranges of environmental conditions allows them to be extensively distributed in the coastal area. They occupy the brackish waters with pH of 5.3 – 9.5, temperature of 26 – 32 °C, salinity of 3.0 – 29.0 ppt, and DO of as low as 2.7 mgL^{-1} (Table 9). In the laboratory, Java medaka was shown to have a wide range of salinity tolerance (Inoue and Takei, 2002). This phenomenon is also shown in their wild habitat. Thus, this both seawater and freshwater-adaptable species can be used to assess the toxicity of aquatic systems in freshwater, estuarine, and marine environments.

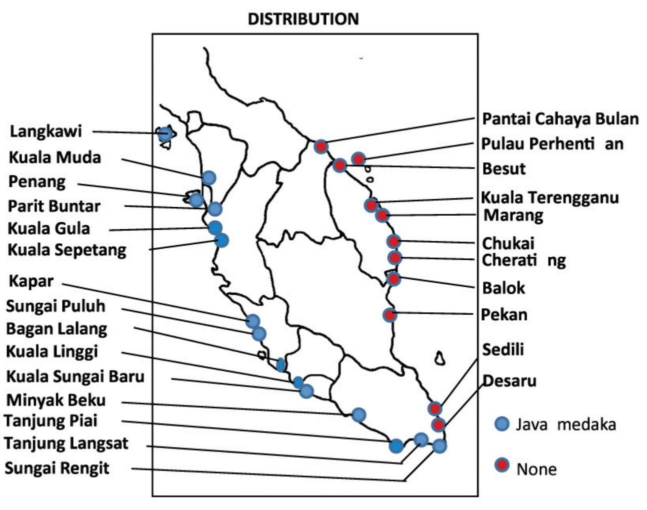


Figure 12 Distribution of Java medaka in Peninsular Malaysia as recorded in 2006

Table 8 Frequency (%) of Java medaka body length collected from Kuala Linggi, Negeri Sembilan and Kapar, Selangor in three months

Length Class	September 2001 Linggi/Kapar	October 2001 Linggi/Kapar	November 2001 Linggi/Kapar
<20mm	34/34	42/41	34/38
20-30mm	43/43	40/42	33/37
30-40mm	23/23	18/17	33/25
Total number	150/150	120/150	120/160

Table 9 Localities of Java medaka and their environmental parameters.

Locality	GPS	Temperature (°C)	Salinity (ppt)	pH	DO mgL^{-1}
Kuala Muda, Kedah	5° 35' 10" N 100°20' 32"E	29.6	3.0	5.7	4.2
Kilim, Langkawi	6° 24' 20" N 99° 51' 34" E	29.0	24.5	6.2	8.2
Tanjung Rhu, Langkawi	6° 27' 17" N 99° 49' 30" E	27.5	28.7	6.8	7.1
Kuala Triang, Langkawi	6° 21' 14" N 99° 43' 06" E	27.9	16.6	5.6	5.4
Kuala Juru, Penang	5° 20'25" N 100° 24' 30"E	27.8	21.2	6.7	6.2
Sungai Semilang, Penang	5° 18'35" N 100⁰ 24' 50"E	32.1	26.4	6.4	6.8
Jelutong, Penang	5° 23'17" N 100⁰ 19' 8"E	30.4	28.0	5.9	7.0
Pulau Betong, Penang	5° 18'23" N 100° 11' 37"E	29.5	16.8	6.0	6.6
Parit Buntar, Perak	5° 7' 56" N 100⁰ 29' 30"E	28.4	14.1	5.8	6.9
Kuala Gula, Perak	4° 56'15" N 100° 18' 22"E	30.5	28.3	8.4	7.8
Kuala Sepetang, Perak	4° 50'29" N 1000 39' 15"E	27.6	10.5	6.1	6.4
Kapar, Selangor	3° 6' 57" N 101° 19' 35"E	29.5	21.0	6.0	7.1
Sungai Puluh, Selangor	3o 4' 47" N 101023' 54"E	29.4	7.9	6.2	2.7
Bagan Lalang, Selangor	2° 36'36" N 101° 41'08" E	27.6	18.9	6.3	7.2

Table 9 (cont.).

Locality	GPS	Temperature (°C)	Salinity (ppt)	pH	DO mgL^{-1}
Batu Melintang, N. Sembilan	2° 24'01" N 100° 57'56"E	28.5	16.2	6.0	6.2
Kuala Linggi, N. Sembilan	2° 23'01" N 101° 38'12"E	28.9	20.0	6.0	6.9
Kuala Sungai Baru, Melaka	2° 21'37" N 102° 2' 23"E	29.1	23.6	6.9	6.8
Minyak Beku, Melaka	1° 47' 45" N 102° 53'24"E	28.2	17.2	6.0	3.5
Tanjung Piai, Johor	1° 16' 55" N 103° 30'38"E	29.1	30.0	7.8	5.9
Tanjung Langsat, Johor	1° 28' 40" N 104°0' 0" E	29.2	21.1	5.9	3.4
Rengit, Johor	1° 21' 03" N 104° 13'14"E	29.0	3.6	5.4	3.6

The results of our survey in Peninsular Malaysia showed that Java medaka is not distributed in the east coast which is facing the open sea. This phenomenon may indicate that Java medaka distribution is influenced by the geomorphology of the coastal areas. The distribution of the fish has never been reported in detail before. Java medaka is found to be an important component of the estuarine ecosystem in the tropical region. Since Java medaka is native to Malaysia, we establish this fish to be used in various fields of scientific studies particularly in ecotoxicology as bio-monitoring agent and bio-testing organism.

So far there is no aggressive utilisation of Java medaka in studies related to bio-indicators or bio-testing experiments. Its relative, the Japanese medaka (*Oryzias latipes*), has been utilised as research tools more than a century ago and has become the most important model organism among bony fish (Jordan and Snyder, 1906; Aida, 1921; Kamito, 1928).

The medaka fish is a diverse group of small fish distributed in large areas in Asia. They occupy fresh water, brackish water and salt water. The Nagoya University Medaka fish Group listed 24 species of *Oryzias*. The most popular among the genus is the Japanese medaka which is distributed in the freshwater of Japan, Korea and China (Naruse et al., 1993, Naruse, 1996). The Java medaka (*O. javanicus* (Bleeker, 1854) (Figure 13) is distributed in the brackish waters of Peninsular Malaysia, Singapore, Indonesia, Thailand and Western Borneo (Iwamatsu et al., 1982; Magtoon and Termvidchakorn, 2009; Roberts, 1998). This fish has the potential to be developed as test organism as discussed by Imai et al. (2005; 2007).

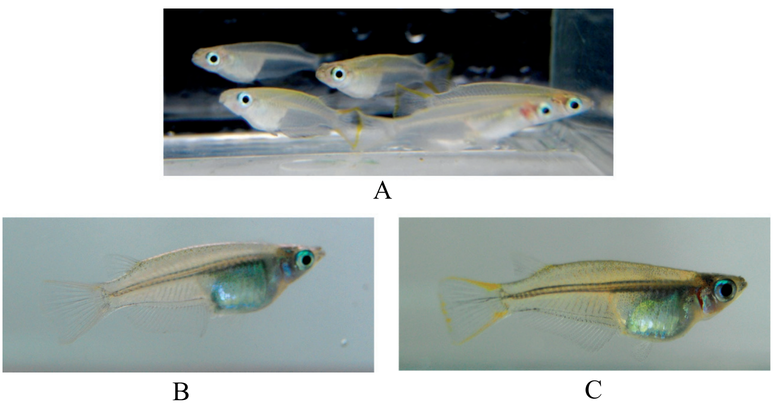


Figure 13 Java medaka (A) female (B) and male (C). The male individual is easily identified by the presence of yellow sub-marginal band of the caudal fin

In utilizing an organism as test organism, information on the biology and ecology of the organism including their behaviour is very important in order to understand their responses to any tests or treatments. Beside the knowledge of the dynamics in natural fish behaviour, it is essential to understand changes in fish abundance, their vulnerability to anthropogenic disturbances and natural changes of ecological parameters such as the interaction of tidal movements and anthropogenic input. Such information may also help in the improvement of the aquatic resources management (Krumme, 2004). Migration is one of the phenomena that occurs is many types of fish. They migrate regularly, from daily to annual or seasonal, and with distances ranging from a few meters to thousands of kilometres. The purpose of migration is for their survival which usually relates to ecological changes, feeding or breeding. In most cases migration is resulted from the influence of abiotic gradients (i.e salinity, temperature, dissolved oxygen, tide, water current, etc) (Katselis et al. (2007).

The information on the fish behaviour can be used to assess impacts in specific environments and also in a wider context. As brackish water species which are subjected to tidal change, Java medaka have their own salinity preference. In our study on tidal migration of Java medaka, it was found that the fish moved upstream during rising tide and followed the tide to small streams and into the inner part of the mangrove area. During receding tide they moved seaward to a certain extend but some may be trapped in the pools of brackish water in the mangrove or at the end of river tributaries. The fish were observed to be much localised and migrated in shore distances. This characteristic made these fish a good monitoring agent for ecological changes.

Another important characteristic of Java medaka is their large, transparent eggs that allow ease of observation on the developmental stages (Figure 14). The early life stages of fish have long been recognised as very sensitive biological material (Marchetti, 1965). The sensitivities of embryo-larval and early juvenile stages are, in most cases, comparable with those of full life-cycle tests (McKim, 1977). A number of researchers have reported the relevance of utilising early life stages of fish for assessing the ecological risk posed by pollutants in the aquatic environments (Eaton et al., 1978; Ward et al., 1982; Shazili and Pascoe, 1986; Strmac et al., 2002; Wedekind et al., 2007). Moreover, fish embryo tests are neither better nor worse than acute fish toxicity tests and provide strong scientific support for the embryo to surrogate the acute fish toxicity test which is not compatible with most current animal welfare legislation (Lammer et al., 2009).

Figure 14 The large and transparent medaka eggs

We utilised the early life stages of Java medaka in order to assess their sensitivity to several environmental pollutants. Developmental disorders such as teratogenecity, delayed development, premature hatching and developmental arrest occurred when the embryos were exposed to low levels of cadmium and mercury (Ismail and Yusof, 2011). Abnormal swimming behaviours, micronuclei induction and physiological impairments were observed when the embryos and juveniles were treated with heavy metals and endocrine disruptors such as estradiol and tributyltin. These impairments manifested by Java medaka could be good biomarkers for environmental pollutants.

In order to obtain consistent results, laboratory cultured Java medaka is required. Fish freshly sampled from the environment may not give uniform and comparable results due to their differences in age, size, and the salinity of water where they are taken from. Reproducible laboratory culture of Java medaka has successfully been carried out at ambient temperature in our laboratory and thus it can support continuous testing activities. This reliable laboratory culture provides fish of uniform quality and known age for use in testing and for the continuation of the culture itself. It provides readily available fish at desired life stages.

Based on the above discussion, this local laboratory-cultured fish is a suitable candidate to be established as test organism for ecotoxicological studies in the tropical region. Java medaka is a small tropical fish which has many characteristics similar to the laboratory fish. The adult fish is about 3 cm in length and possesses the basic vertebrate plan for organogenesis. It's secondary sexual characteristics are readily observable 60 days after hatching. It has a short life cycle, fast growth rate, hardy, easily identified and easy to culture. The successful laboratory culture of Java medaka could supply the required life stages of the fish for testing purposes. Since Java medaka is native to the tropical region, results of testing using Java medaka will reflect the natural environment of the region.

IMPOSEX IN *THAIS GRADATA*: AN INDICATOR FOR ORGANOTIN CONTAMINATION IN THE STRAITS OF MALACCA

Organotin (OT) contamination, especially from tributyltin (TBT), was reported in the Straits of Malacca and Johor Strait (Sudaryanto et al., 2004; Harino et al., 2008; 2009). These waterways are known to have the highest maritime activities in Southeast Asia. The Straits of Malacca is reported to be used by more than 140,000 sea vessels annually, including 50,000 super tankers carrying about one quarter of the entire traffic in traded goods worldwide (Freeman, 2003; Ismail et al., 2004). These busy shipping activities in both straits, have led to OT contamination, specifically TBT, as OT is used in TBT-based antifouling paints for coating the ship hulls. TBT is mainly released into the environment by hydro blasting wastes from the dockyard instead of via direct leaching.

TBT is documented to affect non-target organisms, causing, for example, organ deformation, endocrine disruption, and the formation of unnecessary organs. The most widely reported effect of TBT contamination was imposex in female gonochoristic gastropods. The term "imposex" is used to describe the "superimposition of male characters on to females". According to Smith (1971), "imposex" usually refers to the formation of male genital organs, such as penis and vas deferent duct in females of dioecious snails (Smith, 1971). In specific, one or both of male genital organs (penis or deferent duct) are formed and developed, causing lower function of ovary (incomplete oogenesis) or transformation of ovary into testis, or transforming oviduct into prostate gland (swollen deferent duct, an organ found in male) in some cases (Smith, 1971; Gibbs et al., 1987; Gibbs et al., 1988). Imposex is irreversible (Bryan et al., 1987). The occurrence of imposex is found to be an effect of TBT, whereas in some species it is found to occur due to triphenyltin

(TPT) contamination. Horiguchi et al. (1994) estimated that 10 to 20 ng TBT/ g wet tissue could cause imposex in *Thais clavigera* and *Thais bronni*. Shim et al. (2000) reported TBT concentration from 23 to 508 ng TBT dw/g in *Thais clavigera* with 100% imposex.

Imposex in *Thais gradata* is caused by TBT contamination. A detail description on the imposex in *Thais gradata* is reported in Mohamat-Yusuff et al. (2010). Studies on imposex cases in *Thais gradata* were conducted along the coastal areas of the west coast of Peninsular Malaysia. The results showed that 94% of the samples were showing imposex symptoms from stage 1 to stage 5. More than 30% of the imposex affected samples showed symptoms of imposex at stage 4, and a similar percentage was also found for stage 1. The remaining affected samples were of imposex stage 3 (<20%) and stage 2 (<20%). The highest imposex recorded in this study was at stage 5, which was found in a few samples (<4%). The detailed discussion on the imposex stages were reported in Mohamat-Yusuff et al. (2010). These findings showed that a coastal area of the Straits of Malacca is contaminated by TBT. If suggestion by Horiguchi et al. (1994) and Shim et al. (2000) can be accepted the level of TBT in Malaysian coastline is above 10 ng, which is the level that causes imposex. In fact Sudaryanto et al (2002; 2004) and Harino et al., (2008) reported that TBT levels in some localities in the west coast of Peninsular Malaysia were at contaminated levels. They reported that TBT in surface sediments were from 0.3-450ng/g, 1.4-115ng/g in surface water, 0.5-299ng/g in green mussels and 2.4-190ng/g in fish. As discussed above the main source of TBT is from the shipping activities in the Straits of Malacca and the coastal water of Peninsular Malaysia is contaminated by TBT. The examples of imposex cases in Peninsular Malaysia are displayed in Table 10. TBT contamination is expected from heavy shipping activity in the Straits of Malacca.

By understanding the distribution of *Thais gradata* and the imposex cases in the species, *Thais* can be a good indicator for TBT contamination. Further studies are needed in order to assess the degree of organotin based on the imposex stages in *Thais*.

Table 10 *Thais gradata* sample size, densities (D), number of females, percentages of imposex stages, value of vas deferens sequence index (VDSI), mean shell height in six sampling sites at the Southern coast of Peninsular Malaysia

No.	Location	Site	N	No. of ♀	% Imposex						VDSI	Shell height (mm)
					Stage 0	Stage1	Stage2	Stage3	Stage4	Stage 5		
1	Kong Kong	JKK	45	14	-	-	-	21.43	50.00	28.46	4.21	28.8393 ± 3.37
2	Laut Stulang	JS	71	37	-	-	15.79	10.53	73.68	-	3.67	32.8543 ± 2.16
3	Minyak Beku	JMB	49	33	-	48.57	45.71	-	5.71	-	1.67	21.3982 ± 2.99
4	Parit Jawa	JPJ	75	44	-	-	-	47.62	52.38	-	3.52	25.9657 ± 1.97
5	Sungai Sebatu	MSS	80	43	37.21	60.47	2.33	-	-	-	0.64	24.6727 ± 5.48
6	Malacca River	MRM	53	28	58.33	37.5	2.08	-	-	2.08	1.25	23.4128 ± 3.82

CONCLUSION

As an important mega biodiversity country in the world, Malaysia needs to conduct research on biodiversity and related issues aggressively. Biodiversity conservation should be managed in tandem with chemical pollution because habitat protection alone cannot guarantee the success of wildlife conservation. The coastal ecosystem, particularly the mangrove, is the richest ecosystem that should be protected. Daily inputs of chemicals into coastal wildlife habitats and their food web systems through inland river flows, surface run-offs, tidal movements, sea-based pollutant, and atmospheric depositions need to be continuously assessed. In order to know the levels of hazardous chemical input in the coastal marine ecosystems that can affect the organisms, long term monitorings have been carried out. This report suggests a few bio-indicators that can be used for monitoring heavy metals contamination in specific micro-habitats. Based on Mussel Watch Programme initiated by Golberg in U.S.A. followed by Global Mussel Watch Programme and Asia Pacific Mussel Watch Programme, intertidal molluscs have been found to be better bio-monitors in our coastal environment for their abilities to reflect real contamination levels in specific area.

Climate change and global warming issues that have been discussed at length should be handled not only by maintaining the percentage of green areas, and reducing green house gases but also by understanding the biology and ecology of local biodiversity and the ecosystem as well as by exercising continuous protection and conservation of gazetted coastal forest reserves. The role of local communities in the conservation, management and utilisation of biological diversity must be recognised and their rightful share of benefits should be ensured. Public awareness and education are essential to ensure effective conservation of biological diversity and the sustainable utilisation of its components.

In our attempt to lessen the conflict between pollution and conservation, bio-monitoring of the pollutants plays a significant role. Intertidal organisms have been suggested as good bio-indicators for heavy metals and similarly they can also be used for other chemicals such as tributyltin, PAH and endocrine disrupting chemicals. In order to ensure the suggestion is applicable for better management of the protected ecosystem and biodiversity, continuous monitoring, research on key organisms in the specific habitat, funding, capacity building and good management system are urgently required.

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BIOGRAPHY

Professor Dr. Ahmad Ismail was born in Bruas, Perak on 8 November, 1956. He received his primary and secondary education in Kedah. He obtained his Bachelor of Science degree in zoology from Universiti Kebangsaan Malaysia, in 1980. After graduating, he worked as a Superintendent at the Royal Custom and Excise, Ministry of Finance before becoming a tutor at Universiti Pertanian Malaysia Sarawak Branch in Kuching, Sarawak. In 1986, he completed his Doctor of Philosophy thesis in ecotoxicology at University of Essex, England. In July 1987, he was appointed as a lecturer in Universiti Pertanian Malaysia. He is now a Professor at the Department of Biology, Universiti Putra Malaysia (formerly known as Universiti Pertanian Malaysia).

Professor Dr. Ahmad Ismail teaches courses related to zoology (biodiversity, histology and anatomy) and ecology (wildlife ecology, ecotoxicology and tropical ecology). More than 1000 students have followed the courses. He has supervised more than 150 local and international students at undergraduate and postgraduate levels (M.Sc and Ph.D) in environmental toxicology, ecotoxicology and wildlife ecology. Many of his international students are from Indonesia, Iran, Sudan, Nigeria, Pakistan and Philippines, and a number of those who had graduated are now serving their nations in the fields of wildlife and ecotoxicology.

Professor Dr. Ahmad Ismail's main focus in research is on heavy metals such as copper, lead, cadmium, zinc, mercury, arsenic and tributyltin in the coastal environments particularly in the west coast of Peninsular Malaysia. He focuses mainly on developing bioindicators or biomonitoring agents for monitoring heavy metals in the coastal environment and studying their biochemical response, ecology and toxicology on coastal wildlife. His researches are funded by the Malaysian Government through UPM (short term and research university grants), Ministry of Higher Education, Ministry of Science Technology and Innovation and Ministry of Natural Resources and Environment (through the Wildlife Department), and in collaboration with other agencies such as ESSO, PETRONAS, TENAGA NASIONAL, NISSAN Japan, JICA (Japanese International Cooperation Agencies) and JSPS (Japanese Society for Promotion of Science). To date, over 300 scientific papers have been published and presented in local and international refereed journals, seminars, workshops, symposiums and conferences. Prof. Dr Ahmad Ismail is regarded as a leading scientist in his field in Malaysia. His involvements have extended to Japan (including The University of Tokyo, Kyoto University, Ehime University, National Institute of Basic Biology Japan and Kagoshima University), Europe and Asean countries through collaborative work with their scientists. His long and numerous collaborations in research with scientists abroad have benefited the university and country through the establishment of memorandums of understanding (MOUs) with The University of Tokyo, Kagoshima University, Indonesian Institute of Sciences and Reading University, United Kingdom. Through the MOUs, many young scientists and students can be trained and be involved in his field of study.

Prof. Dr Ahmad Ismail has also been a consultant to several government departments such as the Department of Environment, the Department of Education, Department of Domestic Tourism, Department of Wildlife and National Parks, Department of Civil Aviation, Department of Public Work, Forestry Department and Drainage and Irrigation Department Perak, Selangor State Secretary, Education Department of Negeri Sembilan and to government agencies such as PETRONAS, Tenaga Nasional Berhad, Universiti of Technology MARA (UiTM), local authorities (MBPJ/MPSJ/Putrajaya) and some private sectors on environmental issues and wildlife. He was also an advisor for the National Sports Council and Bukit Jalil Sport School on Special Matriculation Programme (1987-2004), several training activities organised by PETROSAINS Petronas (2008-2010) and a permanent judge (2002-2004) for young scientist competition organised for all MARA Juniour Colleges in Malaysia.

Prof. Ahmad Ismail strongly believes that a lecturer's duty is not only to disseminate knowledge to students, but also to nurture and develop students' personality and character. In view of this, Prof Ahmad involves himself actively in numerous students' activities such as student clubs at faculty and university level. He was a residential college fellow at Kolej Tun Perak in 1989 -1996 and the Principal for the Thirteenth College in 2001-2004. He also served as a Deputy Director for Matriculation Centre UPM in 1997-2000 and the Deputy Dean of Faculty of Agriculture and Food Sciences UPM Campus Bintulu (2005). He still continues to be involved in students' activities at faculty level to develop their sense of self-belonging to the faculty and establish strong bonds through faculty alumni.

Prof. Dr. Ahmad is also actively involved in public services especially in motivating school children to appreciate the field of science and technology, training science teachers for effective teaching and learning of science, and conducting environmental awareness programmes for school and university students at national and regional levels. He has appeared on television, radio and newspapers several times for the purpose of disseminating the importance of inculcating knowledge in environmental issues, science and technology to the public.

In order to have more effective involvement with the public, and promoting knowledge on nature and conservation, Dr Ahmad had also formed and helped to develop three NGOs: Ecological

Society of Malaysia (Founder and First Honourary Secretary), Benthology Society of Malaysia (Deputy President) and Society of Ecotoxicology for Malaysia (President). He is also a council member for Malaysian Zoological Society 2003/2007, Vice President of Malaysian Zoological Society 2006-2008, Advisory Committee for Environmental Education of Malayan Nature Society 2009-2010, and Council Member of Malaysian Nature Society 2010-2012. Prof. Dr. Ahmad is currently the President of Academic Officers Association UPM 2011-2013.

He received several awards such as the British High Commission Award, Japanese Society for Promotion in Science (JSPS), UNESCO, UNIDO, JICA, and National Institute of Environmental Studies (NIES), Japan for research attachments and collaborations.

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LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
   The Challenge to Communication Research in Extension
   22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
   Indigenous Materials and Technology for Low Cost Housing
   30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
   Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
   30 January 1993

4. Prof. Dr. Mohamed Suleiman
   Numerical Solution of Ordinary Differential Equations: A Historical Perspective
   11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
   Changing Roles of Agricultural Economics
   5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
   Marketing Management: Prospects and Challenges for Agriculture
   6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
   The Changing Demand for Livestock Products
   20 April 1994

8. Prof. Dr. Ruth Kiew
   Plant Taxonomy, Biodiversity and Conservation
   11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
   Engineering Technological Developments Propelling Agriculture into the 21st Century
   28 May 1994

10. Prof. Dr. Shamsuddin Jusop
    Rock, Mineral and Soil
    18 June 1994

11. Prof. Dr. Abdul Salam Abdullah
Natural Toxicants Affecting Animal Health and Production
29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
Pest Control: A Challenge in Applied Ecology
9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
Managing Challenges in Fisheries Development through Science and Technology
23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
Sejarah Keagungan Bahasa Melayu
6 Ogos 1994

15. Prof. Dr. Law Ah Theem
Oil Pollution in the Malaysian Seas
24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
Fine Chemicals from Biological Resources: The Wealth from Nature
21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
Health, Disease and Death in Creatures Great and Small
25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
Fish Health: An Odyssey through the Asia - Pacific Region
25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
Chromosome Distribution and Production Performance of Water Buffaloes
6 May 1995

20. Prof. Dr. Abdul Hamid Mahmood
Bahasa Melayu sebagai Bahasa Ilmu- Cabaran dan Harapan
10 Jun 1995

21. Prof. Dr. Rahim Md. Sail
Extension Education for Industrialising Malaysia: Trends, Priorities and Emerging Issues
22 July 1995

22. Prof. Dr. Nik Muhammad Nik Abd. Majid
The Diminishing Tropical Rain Forest: Causes, Symptoms and Cure
19 August 1995

23. Prof. Dr. Ang Kok Jee
The Evolution of an Environmentally Friendly Hatchery Technology for Udang Galah, the King of Freshwater Prawns and a Glimpse into the Future of Aquaculture in the 21st Century
14 October 1995

24. Prof. Dr. Sharifuddin Haji Abdul Hamid
Management of Highly Weathered Acid Soils for Sustainable Crop Production
28 October 1995

25. Prof. Dr. Yu Swee Yean
Fish Processing and Preservation: Recent Advances and Future Directions
9 December 1995

26. Prof. Dr. Rosli Mohamad
Pesticide Usage: Concern and Options
10 February 1996

27. Prof. Dr. Mohamed Ismail Abdul Karim
Microbial Fermentation and Utilization of Agricultural Bioresources and Wastes in Malaysia
2 March 1996

28. Prof. Dr. Wan Sulaiman Wan Harun
Soil Physics: From Glass Beads to Precision Agriculture
16 March 1996

29. Prof. Dr. Abdul Aziz Abdul Rahman
Sustained Growth and Sustainable Development: Is there a Trade-Off 1 or Malaysia
13 April 1996

30. Prof. Dr. Chew Tek Ann
Sharecropping in Perfectly Competitive Markets: A Contradiction in Terms
27 April 1996

31. Prof. Dr. Mohd. Yusuf Sulaiman
Back to the Future with the Sun
18 May 1996

32. Prof. Dr. Abu Bakar Salleh
Enzyme Technology: The Basis for Biotechnological Development
8 June 1996

33. Prof. Dr. Kamel Ariffin Mohd. Atan
The Fascinating Numbers
29 June 1996

34. Prof. Dr. Ho Yin Wan
Fungi: Friends or Foes
27 July 1996

35. Prof. Dr. Tan Soon Guan
Genetic Diversity of Some Southeast Asian Animals: Of Buffaloes and Goats and Fishes Too
10 August 1996

36. Prof. Dr. Nazaruddin Mohd. Jali
Will Rural Sociology Remain Relevant in the 21st Century?
21 September 1996

37. Prof. Dr. Abdul Rani Bahaman
Leptospirosis-A Model for Epidemiology, Diagnosis and Control of Infectious Diseases
16 November 1996

38. Prof. Dr. Marziah Mahmood
Plant Biotechnology - Strategies for Commercialization
21 December 1996

39. Prof. Dr. Ishak Hj. Omar
Market Relationships in the Malaysian Fish Trade: Theory and Application
22 March 1997

40. Prof. Dr. Suhaila Mohamad
Food and Its Healing Power
12 April 1997

41. Prof. Dr. Malay Raj Mukerjee
A Distributed Collaborative Environment for Distance Learning Applications
17 June 1998

42. Prof. Dr. Wong Kai Choo
Advancing the Fruit Industry in Malaysia: A Need to Shift Research Emphasis
15 May 1999

43. Prof. Dr. Aini Ideris
Avian Respiratory and Immunosuppressive Diseases- A Fatal Attraction
10 July 1999

44. Prof. Dr. Sariah Meon
Biological Control of Plant Pathogens: Harnessing the Richness of Microbial Diversity
14 August 1999

45. Prof. Dr. Azizah Hashim
The Endomycorrhiza: A Futile Investment?
23 Oktober 1999

46. Prof. Dr. Noraini Abdul Samad
Molecular Plant Virology: The Way Forward
2 February 2000

47. Prof. Dr. Muhamad Awang
Do We Have Enough Clean Air to Breathe?
7 April 2000

48. Prof. Dr. Lee Chnoong Kheng
Green Environment, Clean Power
24 June 2000

49. Prof. Dr. Mohd. Ghazali Mohayidin
Managing Change in the Agriculture Sector: The Need for Innovative Educational Initiatives
12 January 2002

50. Prof. Dr. Fatimah Mohd. Arshad
Analisis Pemasaran Pertanian di Malaysia: Keperluan Agenda Pembaharuan
26 Januari 2002

51. Prof. Dr. Nik Mustapha R. Abdullah
Fisheries Co-Management: An Institutional Innovation Towards Sustainable Fisheries Industry
28 February 2002

52. Prof. Dr. Gulam Rusul Rahmat Ali
Food Safety: Perspectives and Challenges
23 March 2002

53. Prof. Dr. Zaharah A. Rahman
Nutrient Management Strategies for Sustainable Crop Production in Acid Soils: The Role of Research Using Isotopes
13 April 2002

54. Prof. Dr. Maisom Abdullah
Productivity Driven Growth: Problems & Possibilities
27 April 2002

55. Prof. Dr. Wan Omar Abdullah
Immunodiagnosis and Vaccination for Brugian Filariasis: Direct Rewards from Research Investments
6 June 2002

56. Prof. Dr. Syed Tajuddin Syed Hassan
Agro-ento Bioinformation: Towards the Edge of Reality
22 June 2002

57. Prof. Dr. Dahlan Ismail
Sustainability of Tropical Animal-Agricultural Production Systems: Integration of Dynamic Complex Systems
27 June 2002

58. Prof. Dr. Ahmad Zubaidi Baharumshah
The Economics of Exchange Rates in the East Asian Countries
26 October 2002

59. Prof. Dr. Shaik Md. Noor Alam S.M. Hussain
Contractual Justice in Asean: A Comparative View of Coercion
31 October 2002

60. Prof. Dr. Wan Md. Zin Wan Yunus
Chemical Modification of Polymers: Current and Future Routes for Synthesizing New Polymeric Compounds
9 November 2002

61. Prof. Dr. Annuar Md. Nassir
Is the KLSE Efficient? Efficient Market Hypothesis vs Behavioural Finance
23 November 2002

62. Prof. Ir. Dr. Radin Umar Radin Sohadi
Road Safety Interventions in Malaysia: How Effective Are They?
21 February 2003

63. Prof. Dr. Shamsher Mohamad
The New Shares Market: Regulatory Intervention, Forecast Errors and Challenges
26 April 2003

64. Prof. Dr. Han Chun Kwong
Blueprint for Transformation or Business as Usual? A Structurational Perspective of the Knowledge-Based Economy in Malaysia
31 May 2003

65. Prof. Dr. Mawardi Rahmani
Chemical Diversity of Malaysian Flora: Potential Source of Rich Therapeutic Chemicals
26 July 2003

66. Prof. Dr. Fatimah Md. Yusoff
An Ecological Approach: A Viable Option for Aquaculture Industry in Malaysia
9 August 2003

67. Prof. Dr. Mohamed Ali Rajion
The Essential Fatty Acids-Revisited
23 August 2003

68. Prof. Dr. Azhar Md. Zain
Psychotheraphy for Rural Malays - Does it Work?
13 September 2003

69. Prof. Dr. Mohd. Zamri Saad
Respiratory Tract Infection: Establishment and Control
27 September 2003

70. Prof. Dr. Jinap Selamat
Cocoa-Wonders for Chocolate Lovers
14 February 2004

71. Prof. Dr. Abdul Halim Shaari
High Temperature Superconductivity: Puzzle & Promises
13 March 2004

72. Prof. Dr. Yaakob Che Man
Oils and Fats Analysis - Recent Advances and Future Prospects
27 March 2004

73. Prof. Dr. Kaida Khalid
Microwave Aquametry: A Growing Technology
24 April 2004

74. Prof. Dr. Hasanah Mohd. Ghazali
Tapping the Power of Enzymes- Greening the Food Industry
11 May 2004

75. Prof. Dr. Yusof Ibrahim
The Spider Mite Saga: Quest for Biorational Management Strategies
22 May 2004

76. Prof. Datin Dr. Sharifah Md. Nor
The Education of At-Risk Children: The Challenges Ahead
26 June 2004

77. Prof. Dr. Ir. Wan Ishak Wan Ismail
Agricultural Robot: A New Technology Development for Agro-Based Industry
14 August 2004

78. Prof. Dr. Ahmad Said Sajap
Insect Diseases: Resources for Biopesticide Development
28 August 2004

79. Prof. Dr. Aminah Ahmad
The Interface of Work and Family Roles: A Quest for Balanced Lives
11 March 2005

80. Prof. Dr. Abdul Razak Alimon
Challenges in Feeding Livestock: From Wastes to Feed
23 April 2005

81. Prof. Dr. Haji Azimi Hj. Hamzah
Helping Malaysian Youth Move Forward: Unleashing the Prime Enablers
29 April 2005

82. Prof. Dr. Rasedee Abdullah
In Search of An Early Indicator of Kidney Disease
27 May 2005

83. Prof. Dr. Zulkifli Hj. Shamsuddin
Smart Partnership: Plant-Rhizobacteria Associations
17 June 2005

84. Prof. Dr. Mohd Khanif Yusop
From the Soil to the Table
1 July 2005

85. Prof. Dr. Annuar Kassim
Materials Science and Technology: Past, Present and the Future
8 July 2005

86. Prof. Dr. Othman Mohamed
Enhancing Career Development Counselling and the Beauty of Career Games
12 August 2005

87. Prof. Ir. Dr. Mohd Amin Mohd Soom
Engineering Agricultural Water Management Towards Precision Framing
26 August 2005

88. Prof. Dr. Mohd Arif Syed
Bioremediation-A Hope Yet for the Environment?
9 September 2005

89. Prof. Dr. Abdul Hamid Abdul Rashid
The Wonder of Our Neuromotor System and the Technological Challenges They Pose
23 December 2005

90. Prof. Dr. Norhani Abdullah
Rumen Microbes and Some of Their Biotechnological Applications
27 January 2006

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