Malaysian Journal of Science **24**: 219 – 235 (2005)

The Scientific, Social, Environmental and Economic Value of N.E. Langkawi: An Overview of the Present Status

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ABSTRACT The area of North-east Langkawi is described, and the findings of the two scientific expeditions to Langkawi, where relevant to the north-east, are summarised. Threats to the environment and the potential of ecotourism in the area are discussed and the value of the conservation of this region of the Langkawi Islands is considered. Conclusions are that N.E. Langkawi has a physical landscape worthy of preservation, as well as a diverse and often unique biodiversity with interconnected ecosystems in a combination that has considerable commercial, scientific, social and educational value.

ABSTRAK Kawasan Langkawi Timur Laut adalah diterangkan, dan keputusan dari dua ekspedisi Langkawi yang relevan kepada kawasan timur laut di ringkaskan. Ancaman kepada persekitaran dan potensi ekopelancongan dalam kawasan ini dibincangkan dan nilai konservasi kawasan Kepulauan Langkawi ini dipertimbangkan. Kesimpulannya ialah Langkawi Timur Laut mempunyai lanskap fizikal yang penting/terkenal/.termashyur untuk pemerliharaan, serta satu kepelbagaian yang bercorak dan unik dengan beberapa ekosistem berpautan yang mempunyai nilai kommersil, saintifik, social dan pendidikan.

(ecotourism, Northeast Langkawi, Scientific, Social, Environmental and Economic Value)

INTRODUCTION

The Langkawi archipelago consists of a group of 104 islands off the north-west coast of Malaysia and has a land area of 47,848ha. The archipelago is part of Kedah State and administratively, Langkawi Island - the largest of the island group - is divided into 6 *mukim*.

In recent years, Langkawi Island has experienced a development boom, international tourism is being emphasized and urban areas have expanded rapidly, with resulting environmental problems. Some of these problems could well threaten the success of the tourism.

Background information

Calls for the upgrading of the protection of N.E.Langkawi, or for its sustainable management, have been made [1]. These growing concerns led to the Scientific and Heritage Expedition Langkawi 10-19th April 2003, jointly organised by Jabatan Perhutanan Semenanjung Malaysia (JPSM), Langkawi Development Authority (LADA) and the Malaysian Nature Society (MNS). 150 scientists and students from six universities, two non-government organisations and officers from various government departments and a local hotel participated in the expedition.

The main objective was to investigate the biodiversity and natural heritage of the islands as a whole, with the aim of ensuring environmental and economic sustainability for the tourist industry. Secondary aims included public awareness and education programmes. Scientific papers based on findings in various fields are being published in a forthcoming issue of the Malayan Nature Journal.

A seminar in October 2003 on these findings found that an unsuitable and unmanaged

tourism industry on Langkawi could be disastrous for biodiversity and the beauty of the landscape, and that there is some evidence of this already happening.

Recommendations made at the seminar included the following:

- The formulation of a Sustainable Ecotourism Master Plan to ensure the long term conservation of nature side by side with economic and social development.
- The formulation of a conservation blueprint, outlining sites and strategies, to guide planning.
- That part of the archipelago should be converted or protected as national park(s). The areas of N.E. Langkawi were mentioned as possible sites.
- Niche tourist (e.g. ecotourism) should be promoted for such areas.
- That the plan to relocate the huge number of foreign workers—now in the anchovies industry at Kuala Mulut—to Kilim mangroves would damage the pristine mangroves there, as well as degrade the spawning grounds for marine wildlife. This will in turn affect the fishing industry of Langkawi and mainland states.
- That there is a need to instil in all local stakeholder groups a sense of stewardship and love towards protecting Langkawi's natural heritage through nature education and awareness at all levels.

Recognition of the special significance of N.E. Langkawi as a unique area of biodiversity and geological formations is further exemplified by generous fundamental research funds granted to more than 20 scientists from the University of Malaya, leading to the Second Scientific Langkawi Expedition in April 2004, organized by the University of Malaya Marine Research Centre (UMMReC), in collaboration with Jabatan Perhutanan, Kedah.

The Second Scientific Langkawi Expedition culminates in this special issue of the Malaysian Journal of Science.

N.E.Langkawi: the area under consideration

The area termed N.E.Langkawi is in the largely undeveloped north eastern portion of Langkawi Island. It involves a part of 3 *mukim*: Kuah, Ayer Hangat and Ulu Melaka. The area, covering 5,698 ha (land), 12,550 ha (sea) and 148 ha (estuary), is an entity, interconnected by river systems and ocean.

The land boundaries of the area coincide with the boundaries of several reserves:

- Sg. Kilim-Kisap Permanent Forest Reserve
- Ayer Hangat Permanent Forest Reserve
- Pulau Langgun Permanent Forest Reserve (which includes P.Tj. Dendang)
- P. Dangli, P. Pasir, P.Gasing Permanent Forest Reserve
- Gua Cherita Recreational Forest Reserve

Part of three river basins on Langkawi Island are included within these forest reserves: Sg. Ayer Hangat, Sg. Kilim and Sg. Kisap. The three river systems are interconnected by man-made canals—if one system is not protected and the others are, the protected areas will suffer from development in the unprotected river basin. All of these rivers have their catchments in the Gunung Raya area. Sg. Kisap also draws form Hutan Rizab Selat.

N.E. Langkawi includes 13 other small Islands or islets beside those named above: P.Anak Tikus, P. Anak Berangan, P.Kapal, P.Peluru, P.Anak Kilim, P.Tanggok, P.Chempulin, P.Tk.Jong, P.Anak Gua Cerita, P.Gua, P.Belibis, P.Kelam Baya, P.Cabang. Islands are separated from each other and the main island of Langkawi by Selat Pulau Peluru, Selat Tikus and Selat Tanjung Dendang.

During the two Langkawi Expeditions, coral reefs were identified near Pulau Tanjung Dendang, Pulau Langgun and Tanjung Gua Cerita.

In summary, the N.E.Langkawi area includes:

- Gua Cerita Headland (523 ha) 5.23 km^2
- Sg. Ayer Hangat Basin (1252 ha) 12.52 km^2
- Sg. Kilim Basin (1533 ha) 15.33 km^2
- Sg. Kisap Basin (1584 ha) 15.84 km^2
- Pulau Langgun (674 ha) 6.74 km^2
- Pulau Tj Dendang (132 ha) 1.32 km^2

- Sg. Ayer Hangat Estuary (148 ha) 1.48 km^2
- Marine /coral reef area (12,550 ha) 125.5 km^2

Land area	56.98 km^2	(5,698 ha)
Sea area	125.50 km^2	(12,550 ha)
Estuary area	1.48 km^2	(148 ha)

Total area (land and sea) : 183.96 km^2 (18,396ha)

General description and access

Most of this land area is now under forest, either lowland rainforest (especially that adapted to limestone and that of coastal margins) or mangroves. The mangroves are mostly regenerating production forest.

The whole area is a unique conjoining of marine and riverine habitats (mangroves, seaweed beds, coral/rocky reefs, beaches, rivers and estuaries) that are ecologically linked.

On Langkawi Island, the area is mostly wetland forest laced with interlinked waterways, or limestone outcrops presenting spectacular scenery of cliffs plunging into fringing mangroves and blue waters. There are a number of caves in the limestone. Several of the offshore islands are still pristine unlogged forest with a rugged limestone landscape, sheltered idyllic beaches and fringing corals reefs. There is a sinkhole lake on Pulau Langgun.

There are no roads offering direct access into the coastal areas, only to the landward side of the mangroves e.g. the Kilim and Ayer Hangat Jetties. Access elsewhere is therefore by boat – a big draw for tourists wanting holidays "away from it all".

Present status of N.E. Langkawi: the stakeholders

Forestry

As can be seen from the figures given above, most of N.E.Langkawi is contained within reserves under the contol of Jabatan Perhutanan Semenanjung and Jabatan Perhutanan Negeri Kedah. However, it should be noted that the forest reserves are no longer being harvested as production forests, or have never been harvested because of unsuitable terrain/timber.

Tourism

Langkawi Development Authority (LADA) has an interest in all the development projects of the Langkawi Islands and a corresponding interest in conserving the environment for the health and well-being of island residents, as well as preserving Langkawi's image as a major tourist destination. Much of N.E.Langkawi has tourist potential, or is already being used by tour operators and their clients. The Langkawi Tourism Development Council and members of other tourist organisations, such as LADA Eco-Tourism Sdn Bhd and Persatuan Agensi Pelangcongan dan Pengembaraan Malaysia (MATTA) Kedah Chapter, hotels and tour companies and tour guides, all therefore have an interest in any project involving the area. The hotels around Tanjung Rhu in particular already have a stake in the continued wilderness of the area, as they already make substantial use of it for tourist outings for guests.

Fisheries

The Persatuan Nelayan Tg Rhu and, in fact, all fishermen of Langkawi, obviously wish to maintain or improve their catches. It is therefore in their interest to maintain water quality and the nursery and spawning areas of the commercial species of fish and other sea produce. Even the off-shore fishermen of the Kedah and Perlis coasts may be catching fish that live part of their life cycle in North-east Langkawi mangrove forests and coral reefs. Any increase in tourist numbers also benefits fishermen and associated industries, as tourists on an island expect and request seafood.

Residents and commercial enterprises

There are already N.E. Langkawi residents making a living from the area. 558 fishermen fish in the N.E. area [2]. There are fish cages, fish restaurants, and boatmen who take tourists around. There are people who maintain the jetties of the Sg. Kilim and the Sg. Ayer Hangat and tour guides taking tourists to the caves and other scenic spots. Enterprises such as the restaurant "Barn Thai" in the mangroves, the "Galleria Perdana" at the edge of the reserve and "Langkawii Crystaal" nearby would benefit from increased tourism to N.E. Langkawi.

It should be noted that, according to a survey done during the course of the Second Scientific Expedition [2], N.E. Langkawi is the most

undeveloped area in Langkawi. 84% of people polled there during surveys earned less than $ RM 1,500 a month. Only 25% of the respondents said they are now employed in the tourism industry. More than 88% of these polled residents perceive that tourism development is the most appropriate development strategy for the area; 93% agreed the effects of tourism development would produce more job opportunities, and increased business opportunities such as the sale of souvenir items, food, traditional herbs and medicine and opening up car rental companies and travel agencies.

Other stakeholders of the area are the cement factories and Langkawi Marble quarries, which have had land excised from the forest reserves in the past.

Summary of scientific data pertaining to N.E.Langkawi

The following is summarised from data obtained during the course of the two expeditions to the Langkawi islands in 2003 and 2004. Further scientific detail and analysis can be found in the papers published within this issue of the Malaysian Journal of Science, or in the *Malayan Nature Journal* (Vol. **57** and others).

Geology / paleontology / geomorphology

General
The Langkawi islands are a geologist's paradise, containing almost the complete range of Peninsular Malaysia's geological formations – including the oldest. The North-east Langkawi area has unique and ancient rock formations of international interest, worthy of preservation on aesthetic, geomorphic and palaeontological grounds.

Important formations (see [3])
The Setul Limestone Formation (which also runs through Perlis into Thailand) underlies the Northeast Langkawi area. Fossils showing the most complete cross-section of the Setul Formation are found here, in N.E.Langkawi. The presence of two detrital bands provides an important tool for the palaeogeographic and palaeoclimatic interpretation for the region. The best exposed sequence showing the relationships between these is at Telok Mempelam on Pulau Langgun and is of international importance because it is recognised as the international type-section for the Ordovician-Silurian-Devonian boundaries.

Exposed limestone hills in the Kisap, Kilim, Air Hangat, southern Pulau Langgun and the southern Pulau Tanjung Dendang areas contain fossils. The thick-bedded, grey limestone of the Lower Setul Formation contains a rich Ordovician fossil fauna, mainly silicified remains of nautiloids and sponges. Also abundant are gastropods and brachiopods. The Upper Setul Limestone contains other fossils of interest to scientists.

Caves of the area have not been fully explored. However, the formation of limestone caves often gives rise to the many spectacular odd-shaped cave deposits like stalactites, stalagmites, curtains, pillars and gaur pools.
Most of the known caves known in this north-eastern part of Langkawi are small and shallow ones in the Setul Limestone. The most accessible ones are Gua Buaya, Gua Cerita, Gua Teluk Dedap and Gua Kelawar. The others are not so accessible and require bashing through thick mangrove swamp (Gua Siam) or climbing up steep to overhanging cliff faces (Gua Tanjung Dendang).

Flora of North-east Langkawi

General vegetation types
The North-east Langkawi region has three principal vegetation types of note: the mangroves, the vegetation specially adapted to the limestone hills and islands, and the beach flora.

Importance of the area for biodiversity
The limestone vegetation and beach flora have special significance. This is firstly because—in the unique cluster of islands that form the Langkawi group—the limestone of the north-east does have differences in detail to that if the south-eastern portion. Secondly, outside of the Langkawi group, there are now very few sites along the Peninsular Malaysian west coast with any intact beach flora left; samples of this are therefore worthy of preservation.

Limestone flora

During the Langkawi Expedition, Sg. Kilim, Sg. Kisap, Teluk Mempelam and Pulau Langgun were surveyed [4] along with other areas. Seventy-two plant specimens were collected from limestone, showing them to have a rich diversity of species. This is partly the result of the many different microhabitats. The flora of limestone soil is of great conservation importance because of high species endemism; many of their components are restricted to the habitat and are rare or have very localized distribution. Limestone vegetation is fragile and particularly sensitive to habitat disturbance.

Mangrove flora

Mangrove forest plays an important ecological role in coastal and estuarine areas. Their dense timber stands and extensive root systems reduce coastal and river bank erosion, offer protection from tsunamis and prevent flooding. Moreover, mangroves are the spawning and nursery grounds for approximately 70% species of Malaysia's marine fish, prawns and other seafood products (MPP-EAS, 1999).

Preliminary investigations of N.E. Langkawi [5] indicate that the mangroves grow in sandy reef and peat substrates trapped amongst limestone karsts, instead of mud. Island mangroves normally show distinctive features in terms of tree diversity and structure anyway, as well as fish diversity and ecology, since salinity is comparatively higher than in most mainland estuaries. More research is needed to elucidate these unique features of Langkawi's mangroves in order that appropriate management strategies can be formulated.

The Expeditions' surveys of North-east Langkawi [5] also revealed that the mangrove vegetation here includes many important vulnerable species (e.g. *Xylocarpus*, *Acanthus*, *Aegicerus, Derris, Scyphiphora, Lumnitzera* etc) that are fast disappearing from Malaysian mangroves elsewhere. In addition, some of these species have recently been reported to have important medicinal properties (e.g. *Plucea, Acanthus* etc) with potential commercial implications. While the *Rhizophora* stands at Sg. Pinang Katong are about 10-12 years old, those at other locations are exceptionally young (e.g. along Sungai Itau the *Rhizophora* stands are about 3-4 years old) indicating continuous destruction /harvesting of these forests that would certainly threaten the continued diversity of the flora, as well as its fauna.

Bryophytes

Limestone topography always holds interesting bryophyte flora but Langkawi is especially interesting. The monsoon, the "island effect" and the influence of northern flora elements have combined to produce flora which cannot be found elsewhere in Peninsular Malaysia. A total of 83 species of bryophyte were collected from the north eastern part of Langkawi Island [6]. The high diversity of bryophtes in this area is indicated by the high percentage (64.3%) of species out of the total of 129 taxa reported for Langkawi Islands to date.

The Northeast Langkawi area is also home to some rare species such as *Weissia edentula* and *Neckeropsis fimbriata*, with a distribution restricted to the northern tip of Peninsular Malaysia, and only reported from Langkawi and the state of Perlis. Other rare species found in this area are *Calymperes aeruginosum*, *Pinnatella alopecuroides* and *Racopilum cuspidigerum*. The conservation of this area is crucial in order to preserve the bryophyte diversity.

Lichens

The lichens in Pulau Langgun [7] are unique because of the island's location and its pristine, environmentally pure condition, being remote from the other islands. (Lichens grow best in a non-polluted environment.) On the island, most of the lichen habitat is near the shore, where there is plenty of sunlight. The foliose lichen, *Heterodermia* species and *Colemma* species, are abundant, in addition to the usual crustose-type lichens.

Macrofungi

North-East Langkawi is unique in having different ecosystems and highly diverse forest types which are relatively undisturbed, making this area a most favourable habitat for macrofungi [8]. A total of 158 specimens were collected from eight localities in the north-east during the Langkawi Expedition, and also from Gunung Raya and Sungai Sireh Forest Reserve. A high diversity of Basidiomycotina, 61 genera belonging to 17 orders and 29 families were among the identified specimens. Many species belonging to *Anthracophyllum*, *Poromycena*,

Leotia and *Hericeum* have not been encountered before and represent new records or perhaps new species for Malaysia.

Fauna: Bats

Gua Kelawar within the Sungai Kisap mangrove forest is one of the famous tourist attractions in Langkawi. The cave is about 60 m long, named because it is the roosting site of hundreds of fruit bats. Three species were found roosting here during the Expedition: the roundleaf bat, *Hipposideros armiger*, the intermediate roundleaf bat, *Hipposideros larvatus*, and the Southeast Asian bent-winged bat, *Miniopterus medius*. The population of each species was estimated at 150, 860, and 60 individuals respectively [9].

Several studies have suggested that roosting conditions may influence bat distributions and abundance. This has strong implication for conservation: without protection of roosting areas, populations could decline, which may have implications for pollination of fruit and forest trees, or insect infestations.

Avifauna

Little has been done to produce an avifaunal list specifically of North-east of Langkawi, but 221 species have been recorded from the Langkawi Archipelago, of which about 45 species have already been identified from the N.E. [10]. Doubtless this number will grow substantially as more surveys are carried out. About ten migratory species have been found here, showing that the area is used by birds either over-wintering or on passage. Several Malaysian species are found only in Langkawi and one of these has been found in North-east Langkawi, the Brown-winged Kingfisher *Halcyon amauroptera.*

Birds known to nest in the area [11] include the Red-rumped Swallow *Hirundo daurica.* The nest of this species has been found in the caves at water level along the Sg. Kilim. Other species do well on limestone cliffs such as the Blue Rock Thrush *Monticola solitarius*, which also nests along the Sg. Kilim.

The White-bellied Sea-eagle *Haliaeetus leucogaster* and the Brahminy Kite *Haliastur indus* are two common raptor species found along the sea coast and the rivers of N.E. Langkawi. The sea-eagle is a large and spectacular species. Tour guides have been feeding the two species for some years, and it is not uncommon to have sixty or more birds circling and diving to eat the scraps thrown to them along the rivers. This has become popular with tourists and offers an unrivalled photographic opportunity.

At the moment, tourism in the area is relatively unregulated. There are concerns that birds nesting in the caves could be disturbed, and that the unregulated feeding of birds, using offal that is not part of their usual diet (e.g. mostly fat, non-fish products containing antibiotics used in poultry rearing) can be detrimental, especially if they are feeding young, or should be teaching juveniles to fish by themselves.

The fragmentation of the forest reserves on Langkawi, already occurring, will negatively impact forest bird populations. Coastal development which directly or indirectly involves mangrove and beach habitats will inadvertently threaten endangered mangrove specialists and waterbirds, e.g. rare waders such as the Malaysian Plover *Charadrius peronii* which requires pristine and quiet stretches of beach.

The protection of the cliffs, forests, mangroves, island beaches and coastlines of N.E.Langkawi would help sustain avifaunal habitat on Langkawi.

Fauna: Beetles

A total of 631 beetles of 135 species from 30 families were collected from North-east Langkawi, namely from the limestone forests of Dendang Island, Langgun Island and Gua Cerita; and the mangrove swamps of Tanjung Rhu and Teluk Apau. 54 species from 18 families were collected from Langgun Island. 50 species from 21 families were collected from Dendang Island. 35 species from 14 families were from the limestone forests of Gua Cerita [12].

The limestone forests on Dendang Island and Langgun Island thus contain an abundance of beetles with good diversity. Both islands are uninhabited, although some parts of Langgun Island are sometimes used for picnics by visitors.

The smallest beetle in the world, belonging to the family Ptiliidae, was found on Dendang Island. These are very rare and usually not assembled in many samplings by scientists in other parts of the world. A number of other beetles collected were found to be of uncommon species. 72 beetles were collected that are as yet unidentified. Some could be new undescribed species, or even of new families. Protecting the area a would preserve such biodiversity for the benefit of future generations of Malaysia, and be a rich source of study for entomologists.

Marine biodiversity: Mammals

Populations of the Indo-Pacific Humpback Dolphin *Sousa chinensis,* a threatened marine mammal, uses both the marine and freshwater as its habitat [1]. These dolphins are found in Langkawi and forage in river mouths and estuaries where mangrove forests are present.

Marine biodiversity: Fungi

Mangrove ecosystems are one of the world's most productive ecosystems in terms of gross primary production and production of leaf litter. Both bacteria and fungi play vital roles in the release of nutrients from organic matter in this ecosystem. Enzymes produced by a number of fungal taxa have subsequently been exploited in the biotechnology industries.

There was no information on marine fungi in Malaysian Islands until the first Langkawi Expedition. Seventy-one species were recorded from 350 wood samples examined from decaying material, which included 21 unidentified species, which may be new to science [13].

Marine biodiversity: Benthic macroinvertebrates

Benthic macroinvertebrates were investigated as water quality indicators of fresh waters of Langkawi Island during the second Expedition. Findings suggest that the fresh waters vary from marginally good quality to only fair, i.e. the water quality of Langkawi Island is assessed quantitatively as disturbed. This has implications for tourism and health and future domestic/industrial water supply [14].

The mangrove forests are colonized by a large variety of benthic invertebrates living on the surface, within the sediment and on the lower trunks of trees. A preliminary study indicates these include 16 species of crustaceans (largely crabs from the Ocypodidae and Grapsidae) and 12 species of gastropods (Ellobiidae, Cerithididae and Littorinidae). These invertebrates play an important role in the ecology of the mangrove forests, by consuming organic matter and recycling nutrients [15, 16].

Marine biodiversity: Fish

A total number of 4908 fishermen were found to be engaged in fishing related activities in Langkawi [17]. For N.E. Langkawi, based on Fisheries Dept statistics, the number of fishermen found from Ayer Hangat to Teluk Apau is 558.

In 1990, total commercial fisheries landings in Langkawi were only 1,678 metric tonnes but this has dramatically risen. In 2002, the total catches were 14,726 MT [17]. The pronounced increase in commercial fishery landings in Langkawi over these 12 years can be attributed to the increase in the number of licensed fishing boats and artisanal fishing boats.

At the same time, more than half of the Langkawi coastal areas have been developed into tourism-related industries and more are being reclaimed for various commercial activities. As many studies show that the mangrove forest and seaweed meadows play pivotal roles as the major nursery ground for many species of marine prawn and fishes, the removal of such ecologically important breeding and nursery grounds will result in habitat loss of most of the ecologically and commercially important marine species.

To counteract this, it is essential to conserve as much as possible of the natural mangrove, coral reefs and seaweed meadow ecosystem. This is one of the cheapest ways to ensure future sustainability of Langkawi fisheries. (It should be noted that fresh fish consumption is not only of importance to the local population, it is also an important part of island tourism—tourists expect the seafood to be plentiful and good.)

Fish and invertebrate diversity in the mangrove-fringed estuaries of Sg. Ayer Hangat, Sg. Kilim and Sg. Kisap in north-eastern Langkawi Island were investigated during the Expeditions. 91 species of fish from 42 families were recorded

for all three rivers, which are interconnected, and several coastal inlets. The number of fish species recorded for Sg. Ayer Hangat, Sg. Kilim, Sg. Kisap and coastal inlets were 39, 34, 32 and 26 species, respectively. The total number of fish species recorded from open nearshore waters (<1 km) was 50, of which 20 species were exclusively marine species not recorded from the mangroves [18].

Fish species not characteristic of mangrove waters or normally found in rocky and coral reefs, apparently also make use of mangrove-fringed rivers as habitats and feeding areas. The star snapper *Lutjanus stellatus* is a new record for Malaysia and the Indian Ocean, being previously recorded from southern Japan to Hong Kong. Catches of invertebrates included 31 species of crabs, prawns, molluscs and echinoderms, some of which have never been recorded in the mainland mangroves [19]. The box crab (*Calappa bilineata*) is the first record for Malaysia, being only recently described as a new species.

Present studies [18] seem to lend support to the idea of fish movements between the various habitats. Thus, the high-salinity mangroves here are extensively utilised as habitat and possibly feeding areas for various species of reef fish. Snappers and groupers are known to utilise mangrove areas as nursery areas before migrating back to off shore reef areas to spawn. In addition it is possible that mangrove detritus helps to support reef life. It should be noted, therefore, that damage to the mangrove areas could result in the decline of species on the reefs and shores – and vice versa.

This interconnectedness of habitat is one reason that joint management, within the context of coastal development planning for Langkawi, should be given serious consideration.

Marine biodiversity: Mudskippers

A survey of mudskippers was conducted in the mangrove areas of Kisap Mangrove Reserve Forest as well as areas outside N.E.Langkawi [20]. A total of 7 species were collected. *Periophthalmus walailakae* was reported for the first time in Langkawi and has only been reported for the Klang Strait.

An array of habitat structures were fully utilized by these fishes and one interesting observation as an outcome of this study is the vast exploitation of even the sandy beaches. Mudskippers have important ecological significance as well as the potential for utilization as food and medicine.

Marine biodiversity: Diversity of Seaweed Flora

The tally of Malaysian marine algae stands at 377 specific and infraspecific taxa. About 84 taxa of seaweeds (1 Cyanophyta, 25 Chlorophyta, 62 Rhodophyta and 14 Phaeophyta) have been identified from the Langkawi Islands - a relatively high diversity. Biomass is low except for some green seaweeds like the *Calaurpa* species, that grow abundantly on the nets of the fish cages in the estuaries [21].

Several seaweeds of commercial as well as bioprospecting potential were collected. *Caulerpa* species are valued as salad seaweeds, while *Gracilaria*, *Hypnea* and *Acanthophora* produce phycocolloids like agar. Other species like *Halymenia* harbour bioactive compounds that could lead to discovery of new drugs.

Seaweeds form an important component of the marine ecosystem, providing feeding, breeding and nursery grounds for the diverse marine and fishery life, even assisting in the reduction of global warming. Aesthetically they form beautiful beds of colourful marine plants, within which swim and live a diversity of marine life. Seaweeds form an important component of coral reefs, estuaries, mangroves and rocky shores. Dugongs and turtles feed on them. Seaweeds and seagrass beds can help to reduce wave action and protect shores from erosion. Seaweeds also help to remove toxic compounds from the water.

The seaweed flora of Langkawi is quite distinct from that of Peninsular Malaysia and East Malaysia. It may have elements common to the Andaman Sea flora. An unidentified species, which was collected some years ago in Sg. Kisap, was found to grow abundantly in Sungai Kilim, Kisap, Air Hangat, and especially on the nets of the cage cultures. It is either a new variety or a new species of *Caulerpa*. The biodiversity and biogeography of the Langkawi Seaweed Flora will make an interesting study and will contribute significantly to tropical seaweed studies.

Marine biodiversity: Aquatic Microbiology

In NE Langkawi, three rivers (Sg. Kisap, Sg. Kilim and Sg. Ayer Hangat) and their tributaries, and the coastal waters off Pulau Langgun were sampled [22]. The bacterial abundance for NE Langkawi was found to be low, one to half order lower than the bacterial abundance isolated at Port Dickson or Port Klang. Therefore the waters in Northeast Langkawi are relatively unpolluted in terms of bacteria. The water should, however, be protected by proper management of both the terrestrial and aquatic ecosystems through planning and surveillance programmes. A survey to determine the occurrence of waterborne diseases was conducted at 15 sites along Sg. Kilim, Sg. Ayer Hangat, Sg. Kisap, Sg. Batu Asah, Sg. Korok, Sg. Ulu Melaka, Sg. Telaga Tujuh, Sg. Temurun and well water in Langgun Island [22].

Total coliforms (TC), faecal coliforms (FC) and faecal streptococci (FS) were detected in only 22%, 11% and 22% of the marine samples, respectively. On the other hand, all the 100% of the samples from the freshwater sites had TC, FC and FS. *Salmonella* was detected in one marine water (Sg. Kisap) and 4 freshwater sites (Sg. Ulu Melaka, Sg. Telaga, Sg. Temurun, and the well water in Langgun Island). All the freshwater rivers pass through human habitations. Hence, it is not surprising that the indicator organisms were detected in the fresh water.

Overall, the microbiological quality of the natural, marine pristine waters of NE Langkawi is good. However, with the increased interest in ecotourism to our pristine Malaysian habitats, appropriate measures should be considered to reduce the human sources of organisms that can cause intestinal illness.

Marine biodiversity: Diversity of Phytoplankton

Northeast Langkawi has been relatively little disturbed. Sustainable management of this area will ensure protection of the diversity of phytoplankton in its waters. Phytoplankton serve as an important primary producer in the ecosystem, as well as the basis of all aquatic food chains. A variety of useful products for the food, pharmaceutical, feed and other industries come from microalgae.

A total of 129 species of marine phytoplankton from 33 genera, and a total of 55 species of freshwater phytoplankton from 33 genera were identified in Northeast Langkawi [23].

Marine biodiversity: Coral Reefs

Coral reefs signatures interpreted from enhanced Landsat 5 satellite imagery and aerial photographs were investigated on site. Field investigations were carried out mainly along the coastlines around Pulau Tanjung Dendang, Pulau Langgun, Tanjung Gua Cerita in the NE Langkawi, and outside the north-east area [24].

Pulau Tanjung Dendang

Coral reefs, about 50 meters wide, line the eastern coast of this island but turn north-westerly at the island's north-eastern tip. Here the reef structure is almost triangular. On the western coast of Pulau Tanjung Dendang no fringing reef is seen except at Telok Cina, where there is a broad reef structure both to the east and west. To the south of Tj Dendang, small patches of reef occur but are largely covered by sediment.

Pulau Langgun

Mud, up to 10cm thick, covers much of the reefs on the western coast of Pulau Langgun. This mud cover thins towards the north-east where reefs are found rimming the headlands and bays. The largest reef is located at Telok Mempelam but is already in poor condition, with a large population of sea urchins in the eastern side and sediment cover in the western side. Hard corals make up most of the coral cover in both Pulau Tanjung Dendang and Pulau Langgun.

Gua Cerita

On this promontory, narrow reefs rim the headlands and patch reefs of soft corals, sea anemones and seaweeds dominate the bays of Telok Jong, Gua Cerita and Pasir Panjang and Telok Dedap. On the western side of the promontory, in a large bay in which Pulau Gua is located, the shallow floor supports the growth of coral knobs. However, the proximity to the Air Hangat estuary inhibits coral growth with the high deposition of muddy sediment.

Overview

It is clear from the problems of sedimentation that coral reef degradation is already taking place in North-east Langkawi, and much that was once a thriving reef is already under threat. Further development of the coastal areas could result in the death of the reefs with devastating consequences for the local fishing industry.

Coral diversity is lower when compared to the east coast of the Peninsula. The study sites are significantly dominated by massive hard corals from the Faviid and Porites group. Other notable organisms found at some study sites were *Tridacna* sp. (giant clams) and, surprisingly, branching *Acropora* sp. corals.

Pulau Langkawi is one of the only islands on the West Coast of Peninsular Malaysia that still has a significant coral reef community, even with the high turbidity and sedimentation rates. Some study sites have up to 35% hard coral cover [24]. The density of corals is fair, compared to the Coral Cay Conservation survey done on the east coast islands of Peninsular Malaysia in 2000, where the mean coral cover was 42.2%. Using criteria set by the ASEAN-Australia Living Coastal Resources project (>75% = excellent, 75-50% = good, 50-25% = fair and <25% = poor) then the coral reefs studied are in poor to fair condition.

Protected, and with sustainable management of coastal areas, these reefs may yet be able to flourish again. It is well known that coral reefs are an important part of adjacent fisheries, as well as the ecotourism industry. Juvenile fish and invertebrates use the reef as their breeding ground and nursery and are an excellent tourist attraction. According to a University of Malaya consultancy study for IMO/GEF (1999), the economical value of Langkawi reefs has been estimated to be as follows:

Total Use Value of Langkawi coral reefs
$RM 20.8 million per year, divided as follows:

- fisheries $ 2.65 m
- tourism $14.0 m
- shoreline protection $ 3.98 m
- carbon sequestration $ 0.16 m
- biodiversity value total: $ 13.5 m

When figures like these are considered, it is obvious that the reefs of N.E. Langkawi must be gazetted and protected and monitored.

Other important facts are that coral reefs of the world maintain 25% of all marine species. Reefs have been estimated to have 1-9 million species of organisms. The value of reefs in Langkawi per hectare per year has also been estimated at $USD 23,175 or $RM 88,068 [25]. Fisheries from reefs account for 12.7% of Langkawi's total commercial catch. If the reefs were to disappear, then the financial loss to Langkawi will be substantial!

The biodiversity importance of reefs cannot be ignored. In addition, if reefs are destroyed, then the rate of coastal erosion will be higher and there will be a need to strengthen the coastline with man-made barriers or relocate infrastructure and people. Conservation of the coral reefs, and reaping the benefits in a sustainable manner, makes more sense.

Education and the environment
A study, conducted during the Expeditions to identify the level of environmental awareness among secondary school students [26], concluded that students either in primary and secondary schools still have insufficient environmental education and values. If environmental values are inculcated during the early stage of childhood, the majority of Malaysians will be environmentally concerned citizens and they will contribute toward conserving our natural heritage.
The study recommended that educators at all levels should play a greater role to increase environmental awareness among students, which would in turn ensure less environmental degradation in our country.

The habitat of N.E. Langkawi offers school children and university students the possibility of an outdoor living "laboratory" for the study of subjects as diverse as palaeontology, geology, botany, zoology, marine biology, limestone ecology, fisheries, pollution and environmental studies.

THREATS TO N.E. LANGKAWI

Water Quality

The Future
Langkawi Island is currently experiencing extensive development and thus the demand for

water also increases. This demand may result in water shortages to the island. Judging by the population/ tourism growth, it will be a serious problem of the future. Urgent action is necessary to balance this development with the conservation of the natural environment, including water bodies and catchment areas.

Present pollution outside N.E.Langkawi

Most Langkawi rivers are facing a serious pollution problem due to rapid development and poor environmental awareness. During the Langkawi Expeditions, the most polluted river location was found to be the river mouth of Sg. Melaka, pollutants coming from upstream agricultural and residential areas and land development projects within the catchment. Other polluted water was found in the mangrove swamp next to the landfill site along Kuah-Air Hangat Road (polluted by leachate from the nearby landfill), and sea water within the Mutiara Burau Bay (sewage from the Mutiara Burau Bay Resort which flows continuously into the sea through a buried sewer pipe) [27].

According to the Environmental Quality Report [28], Langkawi's coastal waters is contaminated by oil and grease (exceeding 100% of the Interim Marine Standard or IMS) and heavy metals, especially mercury (exceeding 33% of IMS) and copper (exceeding 53% IMS).

N.E. Langkawi

The examples above of pollution elsewhere in Langkawi show that if the north-east is to maintain its present state, some effective control measures need to be installed by potential polluters within the catchment areas, coupled with effective enforcement by the related authorities in order to preserve the water resources.

All upstream stations in the three river systems were found to have comparatively turbid waters that were slightly acidic (pH < 7) [19]. This may have to do with the upstream activities that occurred during the time of study. The upstream mangrove muds were extensively dug to create connecting channels between the three river systems. In addition, at the jetty point in Sg. Kilim and its connection with Sg. Kisap, rubbish and solid wastes were strewn in the waterway and its banks, especially plastic waste. Upstream from the confluence of Sg. Belanga Pecah with Sg. Kisap, on-going land reclamation work was observed. The north-east area can easily have its water quality threatened by these and similar projects, especially as development continue along Jalan Air Hangat.

From a field study carried out by a group of University of Malaya's Master students in Langkawi [29], where water samples were taken from Sg. Kilim, from offshore fish cages, and from Sg. Kisap (upstream and downstream), and chemically analysed, the concentrations of cadmium, nickel, lead and mercury at all sites were found to exceed the Interim Marine Standard by 2-4 times. It is believed that heavy metal contamination results from the landfill leachates. Independent reporting by the Fisheries Department for Halim Mazmin Company further substantiates the high levels of these metals. The short- and long-term effects of these heavy metal contaminants to Langkawi's marine life are unknown, nevertheless the high contamination needs to be further studied and quickly addressed to protect human health. Should this not be addressed, it could also have a detrimental effect on the tourism industry.

Plans to build an artificial island of 174 ha with connecting bridge, for the establishment of an air recreation centre and runway, commercial complexes, housing and industry – all of which could be built on the mainland – has raised some concerns.

Fish cages in the river systems can affect water quality by adding nutrients to the water. With proper management, this is not necessarily a problem, and authorities could monitor such activities, thus benefiting both the environment, tourism and the owners of the fish cages.

Other Threats

To Limestone

Limestone outcrops are generally under threat because of the need for cement. Langkawi marble is much sought after as well. Some of the original forest reserve has already been excised for mining purposes.

To Mangroves

Elsewhere in Langkawi, mangroves have been converted to prawn ponds e.g. Bukit Malut

mangroves (11 ha) is now entirely converted. There are plans to relocate the huge foreign workers' settlement at Kuala Malut (itself an environmentally degraded area without sewage or waste disposal) to the pristine Kilim area. Leachate from landfill already pollutes the waters of the mangroves along Jalan Air Hangat-Kuah and produced some of the most polluted waters in the Langkawi Expedition studies [27].

The mangrove area has been extensively harvested in the past; e.g. the Sg. Itau stands are only 2-3 years old, indicating continuous harvesting/ destruction that will have altered the forest composition and biodiversity. There is now evidence of the constant pilfering of mangrove timber for local use.

To waterways

Other possible problems are that speeding boats may cause erosion through the waterways if there is no enforcement of regulations, and that the anchorage of sailing yachts in the waterways may result in problems of waste disposal. Once again, it is the lack of regulation and supervision which may be a problem, rather than the activities themselves.

To flora

Over-collection of rare and endangered plant life such as slipper orchids and cycads is a possibility. The tragic sight of roadside shops selling ancient cycads that took hundreds of years to grow is common in northern Malaysian states. The Langkawi cycad *Cycas clivicala* is a Langkawi endemic and no more than one or two plants are to be found at any locale. Further reckless harvesting may result in its extinction in the wild. In addition, much of the flora in this area is on a limestone base, which is of value for the making of cement.

To avifauna

Uncontrolled feeding of marine birdlife may result in young sea eagles never learning to fish, and may endanger their health. The natural diet of the species is exclusively fish and sea snakes. Feeding of chicken offal can include concentrations of antibiotics used in poultry rearing, and include a much higher fat ratio in their diet than is normal for the birds. All this may destroy the reproductive ability of the species.

To corals

The following could all have a detrimental effect on coral reefs:

- Destruction and degradation of corals by siltation caused by coastal development.
- Plans to resettle foreign workers in the fragile ecosystem of the Sg. Kilim-Kisap area.
- Floating seafood restaurants and associated fish-farms without adequate rubbish disposal and pollution control.
- Possible continuation of coastal development into this area in the future (as evidenced elsewhere in Langkawi), affecting the siltation and pollution of offshore reefs.
- Potential for damage caused by unregulated tourism, e.g. exceeding the carrying capacity of reefs with diving groups, or by unguided groups.
- Potential damage by unrestricted anchorage of diving/fishing boats on the reefs.

To fisheries

Apart from the threat posed to fish by diminishing water quality, and by damage or destruction to coral reefs and mangroves in the area, there is also the danger of overfishing in sensitive areas. At the moment, fishing which occurs inside the mangroves is largely low-key, by gill netting and fish-pots. However, this is also the nursery, feeding and spawning grounds for the various marine species. Large spawners, e.g. barramundi, are generally more vulnerable. These activities need to be monitored for impact.

THE JUSTIFICATION FOR CONSERVATION OF N.E.LANGKAWI

Conservation of the unique ecosystems and biodiversity

As has been shown in the scientific papers written after the two Expeditions, there is much to indicate there is a need for the ecosystems of the area be protected in order to preserve part of our unique Malaysian biodiversity. If the area is damaged or destroyed, there is no way of ever regaining what is lost.

The rareties – both in flora and fauna, as well as in the geological stuctures and fossils – are abundant and wondrous, worthy of preservation for themselves.

If, however, their innate value is considered insufficient to warrant their protection, then

certainly their other contributions to wealth and health cannot be ignored: the biodiversity and the ecosystems play an essential part in tourism, fisheries, water quality, recreation, science and education, research and potential commercial products, and air quality.

Tourism benefits from conservation of the area

The area is one of stunning beauty, combining limestone cliffs, islands, mangroves and beaches and sea in a visual feast. The romance of "desert isles", isolated beaches, and lack of roads (access is by boat) and no buildings is always a drawcard for international visitors and local city dwellers "wanting to get away from it all". Nowadays there are few such wilderness areas, and yet here hotels, roads and other infrastucture are all close by, with easy access.

Tourism to N.E. Langkawi has already commenced. Tourists are charmed by the natural beauty of the area, by the stunning boat ride; they are drawn by the sea-food restaurants and the artificial feeding of the eagles. At present, activities taking place in N.E. Langkawi are unregulated, and with increased tourism to the area, the very things which attract could be destroyed. Carefully planned development with a strong bias towards conservation may prevent problems before they become too large to cure.

Fish farms, floating restaurants, boat trips, fishing, even feeding the birds, are all activities which – if conducted in a responsible manner – can be compatible with ecotourism. Promoting ecotourism can benefit those who are already involved in these tourist-related activities by increasing tourist numbers, but only monitoring coupled with regulation will ensure the sustainability of ecosystems and biodiversity.

The Malaysian government has identified tourism as a potential growth sector, and Langkawi, which was elevated to *"Tourism City"* status two years ago, is among the places targeted for tourism development. The number of tourists in Langkawi increased dramatically from just 200,000 in 1986 to 1.9 million in 2004, about half being foreign tourists [30]. With the estimated maximum carrying capacity of Langkawi being 4.9 million tourists (Lee, 2005), there is still room for expansion.

Tourism has transformed the socio-economic conditions of the island. In 1987, 63% of the population were employed in the agricultural and fisheries sector but by 1999 this percentage had declined to only 19% as the tourism industry increasingly dominated the economy. People in N.E. Langkawi are keen to see more tourism in their area; those people polled believe it will improve their economic lot and improve infrastructure without serious negative social consequences [31].

However, the number of tourists visiting Langkawi has stagnated or declined since the mid 1990s. This is partly due to external factors: tsunami fears, terrorism etc, but the lack of new attractions in Langkawi and the rise of a more discerning breed of tourists may also be part of the reason. To compete with similar places (Thai islands, Sri Lanka etc), Langkawi needs to emphasize what makes it different: and it is here that N.E. Langkawi can come into its own. It has so many different activities and sights to offer, yet is so close to an international airport.

Unfortunately tourism also brings social costs, ignored by market forces, which will be paid by future generations. These social costs include destruction and degradation of the natural environment (flora and fauna; soil, water, air, noise); reduced biodiversity; erosion of cultural heritage and way of life of local populations; higher sewerage costs, imported inflation. Some of these problems have already been seen in parts of Langkawi.

Unfortunately, too, these kind of problems often result in the death of the tourism they were intended to service. Local tourists may keep coming because they cannot afford to go elsewhere, but the high spending foreign tourist expects a clean and beautiful environment and will simply go elsewhere if they don't find it.

One way to curb such problems in natural areas is to adhere to the principles of ecotourism which has been defined by the Ecotourism Society as: "*the purposeful or responsible travel to natural areas to understand the culture and natural history of the environment, taking care not to alter the integrity of the ecosystem while producing economic opportunities that make the conservation of natural resources beneficial to local people.*"

People who enjoy natural areas will also stop coming as soon as they notice degradation to the environment at the site (for example, corals being damaged by divers, plastic trash being thrown everywhere etc). Therefore, ecotourism can also self-destruct if not properly handled.

Ecotourists tend to be people who are prepared to stay longer and spend more money than the present tourist. Tourists from Singapore, Thailand and Indonesia made up 70.6 per cent of the total number of tourist arrivals to Malaysia in 2002. The average spending per person for all visitors was only $RM1,880 - compared to RM4,300, RM2,800, and RM3,115 in Indonesia, Thailand and Singapore respectively [30]. It is evident from these figures that Malaysia is losing out to its neighbours.

Ecotourism may help reverse this trend, however, as it requires longer trips because it involves other things besides relaxation – hiking, diving, climbing, birdwatching etc. Moreover, ecotourists tend to be people from higher income countries, willing to spend more.

Polls taken of departing tourists at Langkawi airport during the second Expedition in 2004, showed that most had not come for ecotourism, but to "relax" [30]. The ecotourism market is therefore still untapped. Ironically, though, for 56 per cent of the polled visitors to Langkawi, the most memorable event or experience was linked to nature of one kind or another. More than three quarters of the tourists were of the opinion that Langkawi had not lost its pristine nature and is still very authentic. This augers well for ecotourism in Langkawi.

Ecotourism is an ingenious way of conserving the natural environment while obtaining an income and benefiting from the peripherals (clean air and water, maintaining safe areas for fish to spawn and grow, maintaining biodiversity, preserving our geological heritage, etc.) It does not necessitate building hotels or expensive infrastructure – in fact, ecotourists prefer minimal infrastructure and untouched wilderness. Their emphasis is on maximum information (brochures, well run visitor / interpretive centres, competent, well-informed guides, well-marked trails, proper signages).

With increased ecotourism comes more jobs for locals working as boatmen, guides, restaurant workers, on fish farms, renting out sports equipment, teachers of sailing, diving, climbing, etc. The north-east, one of the poorer areas of Langkawi, will be able to prosper from an increase in this niche tourism.

It should be stressed that ecotourism can be hard to sell if you cannot offer the enticement of a National Park, or similar, because this is the label that serves as a guarantee of an unspoilt, pristine environment providing authentic experiences. The label itself is a drawcard for overseas tourists.

The conservation in the north-east of coral sites, of water quality and a pristine sea-side will not only preserve fisheries, but ensure the possibility of tourism activities such as snorkelling and diving; sailing and wind-surfing; and swimming, canoeing or kayaking in the sheltered estuaries, waterways and canals. Conservation of wildlife is pivotal for ecotouristic activities such as birdwatching and photography. Conservation of landscape will preserve caves of interest (e.g. Gua Cerita, Langkawi's most famous cave with ancient inscriptions) and ancient fossils.

Few places in Malaysia can offer so much variety of recreational possibilities in such a small area. In addition to those activities mentioned above, other possibilities include hiking, climbing, rainforest education trails; guided tours to cage fish culture/oyster culture with fish feeding; recreational fishing and off-shore sport fishing. Floating fish restaurants are already in place, as is dining in the mangroves. Old charcoal kilns of Ayer Hangat and Kisap could be reopened as a tourist attraction and possibly brought into production once more. Combined with tourist revenue, this could be a viable economic venture for the local population on a sustainable basis. Most of these activities are dependent for success on the maintenance of a natural, sustainable environment.

Research, development and education

The scientific papers produced by those participating in the two Langkawi Expeditions show that the area contains so much of interest and value. There are species as yet unnamed and unstudied. For students and scientists, the

area is fascinating. Several of the scientific papers pointed out the possibilities of commercial products being developed (e.g. edible seaweeds; medicinal mangrove plants; marine fungi of use in biotechnology industries; microalgae in the food, pharmaceutical and feed industries).

There is also always the potential for money to be made from hosting overseas scientists whose biodiversity is less diverse and overstudied and who are willing to pay to work in pristine tropical areas. This is still a relatively untapped source of income, but it is a sector that can only grow as long as Malaysia maintains its biodiversity.

The area offers an unparalleled opportunity for public education on the flora, fauna, geology and the connectivity of ecosystems, as well as a study site for local students of all ages.

Other economic benefits

Protection of reefs and mangroves offers financial and economic rewards related to fisheries. The Langkawi fishing industry benefits twofold: from the preservation of nursery and spawning areas, and from the increased sale of fish.

CONCLUSION

In summary, it is clear that N.E.Langkawi possesses:

- unique and ancient rock formations of international interest, worthy of preservation on aesthetic, geological and palæontological grounds;
- unique conjoint marine habitats (mangroves, seaweed beds, coral/rocky reefs) that are ecologically linked.
- a fragile mangrove ecosystem uniquely formed over a limestone base, rather than over tidal mudflats, and of value to Malaysia's fishing industry;
- a rich plant biodiversity that includes vulnerable limestone flora, increasingly rare beach vegetation and endemics such as the endangered Langkawi cycad;
- a rich faunal biodiversity from coastal sea-eagles to a rare beetle, the world's smallest;
- a spectacular combination of cliff, riverine, ocean, island and rainforest scenery not found elsewhere;
- coral reefs essential to the sustainability of marine life, of value to Malaysia's fishing industry, and with potential for tourism;
- cave systems that include roosting bats and nesting birds;
- still relatively pristine environments rich in rare plants and fauna on the two offshore islands and 16 smaller islets of the area.

The area has considerable potential as an ecotourist site for the following reasons:

- The area is one of stunning beauty.
- Coral reefs offer snorkelling and diving.
- A variety of other activities is possible: swimming, sailing and wind-surfing, canoeing, kayaking, birdwatching, cave exploration, hiking, climbing, rainforest education trails, recreational fishing within the estuaries and rivers, and sport fishing offshore.
- The bird and animal life, and the unique plant life, are all of fascination to tourists.
- The area is of geological interest and rich in fossils.
- The romance of "desert isles" and isolated beaches and lack of roads, a drawcard for international visitors "wanting to get away from it all".
- Excellent floating fish restaurants.
- The area offers an unparalleled opportunity for public education on the flora, fauna, geology and the connectivity of ecosystems, and for students and scientists to study a unique ecosystem.

A number of threats to N.E. Langkawi have been identified, such as:

- plans to resettle foreign workers in the fragile ecosystem of the Sg. Kilim-Kisap area;
- upstream pollution and degradation of the rivers feeding the ecosystems;
- downstream and coastal water contamination by heavy metals;
- pollution with solid wastes such as plastics;
- over-collection of rare and endangered plant life such as slipper orchids and cycads;
- destruction and degradation of corals by siltation;
- destruction of ancient limestone for use in cement;
- quarrying for Langkawi marble;
- pilfering of mangrove timber with consequences for the fishing industry;

- continuation of coastal development as evidenced elsewhere in Langkawi, and reclamation for an artificial island devoted to air recreation and other complexes;
- unregulated fisheries in sensitive areas, particularly mangroves;
- potential for damage caused by present unregulated tourism, e.g.
  - speeding boats causing erosion,
  - floating seafood restaurants and associated fish-farms without adequate rubbish disposal and pollution control,
  - uncontrolled feeding of marine birdlife;
  - disturbance of roosting bats;
  - uncontrolled mooring of large sail boats and their activity within the Kilim estuary.

Conservation of the area would be beneficial for the following reasons:

- part of Malaysia's unique landforms, cave systems, coral reefs and scenic beauty would be preserved for future generations.
- the spectacular biodiversity of this area has intrinsic value.
- Langkawi Islands as a domestic and international tourist destination could be enhanced by emphasising ecotourism, offering a new dimension to the tourist industry and thus reviving stagnant arrival figures.
- conservation of the coral reefs and mangroves would help maintain commercial fisheries and preserve coastline from erosion, tsunami damage etc.
- traditional lifestyles of those earning their living around the area could be protected and their incomes enhanced.

It is evident that N.E.Langkawi has a physical beauty worthy of protection, as well as a diverse and often unique biodiversity and interconnected ecosystems in a combination not found elsewhere in the world. The area can be of estimable use as a stimulus to public awareness, a tool for the teaching of our children, a laboratory for our scientists, a recreational area for residents.

There are few areas of the world that offer so much, in such variety, in such a small area: Kedah is indeed fortunate to possess such a gem. It is hoped that future generations can also delight in it because our generation was generous enough to pass it on intact.

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