PULAU GAYA I

A Reef Survey of Pulau Gaya and Associated Islands Part I

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Pulau Gaya viewed from the twin Platform Reefs
A REEF SURVEY OF PULAU GAYA AND ASSOCIATED ISLANDS
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TERMS OF REFERENCE

To ascertain the extent of damage caused by sand and coral mining to certain coral reefs adjacent to Kota Kinabalu, and advise whether these areas would be worth perpetuating as Protected Areas and inclusion within the boundaries of a National Park.

CONCLUSION

Although some reefs have been extensively damaged, generally the reefs are viable and considerable regrowth is evident. Large sections of reef are in excellent condition. The areas designated are as a whole well worth preserving and provide unique opportunities for urban recreation and tourism.

TERMINOLOGY

Three reef forms were examined; the profiles of these are illustrated and described below for easy reference.

Off Reef Floor. In the area examined this is the bottom beyond the reef slope consisting of sand and mud at a depth of 60 feet or more and either flat or gently sloping to greater depths.

Reef Slope. This consists of coral rubble and sand generally fairly well consolidated rising from the reef floor at an angle of 35° to 40°.

Reef Front. The region of commencement of coral growth ranging from a depth of 25 to 30 feet and rising to the highest part of the reef.

Reef Rim. This is the most active part of the reef, rising at this point closest to the surface, and usually consisting of dense masses of highly diversified coral, or sometimes deep banks of a single variety.

There is usually a deep vertical development in this very active zone.

Coral Zone. Fully develops under conditions which allow an unimpeded flow of water across the whole reef flat. Such areas are generally fairly limited in size but form a dense, rich, and varied platform of viable coral with, normally, a low vertical development.

Boulder, or Shingle and Boulder Zone. Where the reef rim is associated with an island shore or exposed sand/shingle banks, the water flow across the coral zone is impeded. In such reefs the coral grades into a zone of predominantly dead coral resulting in shallow areas of coral boulders and broken coral. Sheltered boulder zones are often colonised with sea weed.

Weed and Sand Flats. Beyond the boulder zone the shallows degrade into areas of sand which are sometimes colonised with sea grass and weed.

Tide Channels. These are shallow gullies or channels with sand or rubble bottoms running at right angles to the prevailing wave front.

Coral Heads. These are large dense masses of slow growing corals, usually brain coral, with high vertical development in old structures. Found primarily along the reef rim, it is generally the material being mined.

Boulders. These refer to smaller blocks of dead coral and not of stone in the geological sense.

Shingles. Reef destruction, either natural or by man, produces large quantities of coral stick gravel and is often referred to as shingle, not to be confused with stone shingles in the geological sense.

Carbide Bombs. These are bottles, either plain or bound with cloth and fishing line to give added strength, charged with carbide and used as an explosive device to kill fish in reef areas.
Pulau Dinawan

Pulau Dinawan Kampong and beach from Everett Reef

Mouth of Pulau Dinawan Lagoon
EVERETT REEF

Full grown undamaged reef rim and front.

Mined area colonised by Fungia spp.

Broken area regrowing

Rejuvenation in damaged area.
Basic Equipment. This term refers to the basic mask, snorkel and flippers used by snorkel divers.

Snorkel Divers. These are swimmers who dive with basic equipment and without the aid of any breathing apparatus. Normally used in reasonably shallow water.

Aqua Lungs. Underwater breathing apparatus employing compressed air and used for aqua lung diving.

Scuba. Self Contained Underwater Breathing apparatus; an American term for the Aqua Lung.

DESCRIPTION OF REEFS.

This may perhaps be over detailed but is given with the consideration that it may prove useful later when details are required for tourist promotion.

Pulau Dinawan. Everett Reef.

Site 1. A bank reef running parallel to the Eastern face of Pulau Dinawan, separated from the island by a deep channel. The bank consists basically of a distinct reef slope with the reef front commencing at 20 feet below the surface and a reef rim circling the whole bank. Inside this is a shingle and boulder zone terminating in the middle at an exposed shingle bank following the longitudinal axis.

This reef has been extensively damaged by both mining and carbide bombs.

Two thirds of the western side of the reef rim is in good shape with some coral heads remaining, but considerably scarred by the removal of coral heads.

The north western section of the reef rim is extensively broken up by mining and probably blasting. Amid this area, however, there is considerable evidence of regrowth.

The north point, and north eastern edge are dead and now consist largely of shingles and boulders. The area is barren with little evidence of regrowth. To cause this type of damage both mining for coral heads and fish blasting must have taken place, for this end of the reef is the leading edge to the prevailing current and would normally be rich in both fish and coral. In this area the remains of one carbide bomb was found.

Southward along the eastern edge, undamaged patches of coral increase steadily until it becomes a complete and normal coral bank. The reason that this area has escaped destruction is perhaps because there are no coral heads, and consequently no mining.

Pulau Dinawan. Two sites were visited, the eastern edge of the southern reef, and the western reef opposite the mouth of the lagoon.

Site 2. The southern reef is extensive in area; the shallow sand flats with isolated small clusters of coral gradually develop with distance from the island into an excellent reef rim of actively growing coral; this is prolific in quantity and variety, extending down the reef front to a depth of 25 feet before shelving into a sandy reef slope. Behind the reef rim the coral, while remaining very active, develops in clusters separated by patches of clean sand. The coral in this back reef apron changes from hard to the soft types of coral.

None of this reef appears damaged in any way and it is generally an excellent bed of coral.

Site 3. Opposite the outlet to the small lagoon there is a wide shelf of bedrock covered with an excellent bank of coral in about 12 feet of water. This coral is completely undamaged, a dense and varied population with little vertical development. The full extent of the reef is unknown and no reef rim was seen.
Pulau Sulug

Pulau Manukan from Platform Reef visible at bottom of photograph

Pulau Mamutik
The lagoon is a shallow basin of shingles and sand, colonised by patches of sea grass.

**General Observations.** All areas examined exhibited a general poverty of reef fish both in number and variety although clouds of small fingerlings were observed in two separate areas. This dearth of fish on the Everett reef is undoubtedly due to the effects of blasting and mining. It is difficult to say why other areas should be as barren.

The area is notable for a particular type of coral, *Fungia spp.*, which appears to densely colonise any damaged areas.

**Conclusion.** Despite the severe damage which the Everett reef has suffered, the condition of the remaining coral provides excellent proof of what the reef has been and could become again. The amount of regeneration seen would indicate that in a matter of a few years much of the present damage could be repaired. With adequate protection not only would the undamaged reefs be kept in good condition but the damaged areas would be allowed to regrow undisturbed.

**Pulau Manukan and Pulau Mamutik**

Sites 1 and 2. Only the Eastern and South eastern fringing reefs facing Pulau Gaya were examined. That examined on Pulau Manukan had degenerated into algae covered small boulders and dead coral rubble. A little, poorly developed coral, was seen growing on the reef front facing Pulau Mamutik. The corresponding reef front to Pulau Mamutik was in better condition with some isolated coral growth in a generally bouldery terrain. Much of this debris was weed covered. The reef front along the South east shore gradually changed to sand flats and slopes with isolated small clumps of good coral.

**Conclusion.** A proper examination of this group of three islands needs to be done. What was seen can hardly be regarded as representative and good coral may very well exist. If the isolated patches of good coral are an indication of what can grow, protection could result in a rejuvenation of these reefs.

**Pulau Sapangar**

Two sites were examined.

Site 1. South east shore: generally the reef rim is dead with a fair scattering of broken boulders but there is evidence that new coral is re-establishing. The back reef apron is primarily a boulder zone colonised by weed.

Three *Crown-of Thorns, Acanthaster planci*, the star fish which eats coral polyps and has caused so much damage in Australia and Guam, were seen in this area.

Much of the damage examined has been caused by mining.

Site 2. This is a long spit of sand and shingle extending out at right angles from the island. The reef slopes on both sides are steep with a gradient of approximately 45°. The reef front is in two zones, the first ending at 15 feet, the second occurring between 25 and 35 feet and separated by sand.

The reef rim encompassing the total perimeter of the spit contained areas of very good coral, again with considerable diversity of population. Mining along this reef rim has been fairly extensive and where coral heads have been removed the destruction of the coral is severe. Nevertheless an estimated 70% of the reef remains in good condition.

The back reef apron, that is the area running along the top of the spit, is mostly strewn with weed covered boulders interspersed with areas of sand. From the evidence it would seem that mining of these small boulders is a fairly constant business and as a result very little stability or rehabilitation can be maintained. Although new coral growth is constantly evident, much of this rejuvenation has been overturned.
Fulau Sapangar
Site I

Badly mined area

Blue sponges
on the reef slope

Acanthaster planci
Crown-of-thorns
on coral
FULAU SAPANGAR
SITE II

Overturned rejuvenating coral on the reef back apron

Rejuvenating coral on the reef rim

Large sponge on the reef front
PULAU SAPANGAR
SITE II

Coral head of a species of brain coral

Destruction caused by mining

Shoal of fingerlings on reef front destroyed by mining

Fingerlings in weed colonised reef back apron
Particularly healthy coral

View of coral zone from the surface

Typical views of the coral zone
Conclusion. Generally an interesting island which with protection could develop good coral reefs.

Pulau Udar

Site 1. The South and South eastern edges of the island were examined. The reef complex along this part of the island contains three parallel ridges of concreted dead coral with a fourth, representing the present reef rim, containing healthy growing coral. This growing coral has good vertical development but shows considerable evidence of coral head mining.

Each of the old ridges in the back reef apron are separated by channels of sand and debris. The reef immediately behind the reef rim is covered in individual clusters of newly developing coral. The other two ridges are dead and without new growth. Beyond this the inshore shallows are coral rubble and weed.

Conclusion. Again there is plenty of evidence that, if left alone, good coral will develop.

Pulau Udar Kechil and Pulau Udar Priok

Site 1. The site chosen to be inspected lay between the two islands and although Pulau Udar Priok is not included in the areas originally intended for protection, the reef between these two islands is of such excellence that this small island and the sea surrounding it should be protected.

The area between the two islands is a wide shallow saddle covered in a flourishing bed of coral with little vertical development but densely packed with a remarkably varied population. The depth ranges from 6 to 12 feet.

The fact that there is little vertical development of coral – and therefore no coral heads – possibly has saved this reef from damage. There is however some evidence of bombing.

Conclusion. A first class area that should be fully protected and is possibly one of the best beds of coral in the area.

Pulau Gaya

In all 13 sites were examined, which represented all the major variations likely to be found around the island and reefs included within the boundary marked for the National Park.

Sites 1 and 2. These are the two platform reefs to be found to the South of Pulau Gaya and adjacent to Pulau Manukan and Pulau Mamutik.

Both are in fact small sea mounts rising from a floor 60 to 70 feet deep. The reef slope is typical of the other reefs, falling off at an angle of 40°. The reef front commences at 25 to 30 feet terminating at the usual reef rim. Behind this is an extensive coral zone continuing without interruption across the whole platform top.

Both reefs are actively growing and have excellent stands of coral. The reef rim has a considerable amount of vertical growth and contains a few coral heads. The coral varieties along the reef rim exhibit interesting changes from a diverse population to banks of a single species. On the northern edge tide channels are an interesting feature.

The platform is a densely packed colony of immensely varied coral and sea anemones; the whole platform has a low vertical development. The depth of water over the reef top is 6 to 8 feet and offers excellent possibilities for viewing from the surface. Both these reefs offer a tremendous amount of interest scientifically as well as aesthetically, and could be equally enjoyed by the professional and the layman.
Reef rim

Hydroids

Blasted area heavily colonised with Pungia spp.

Large sponge on reef rim
Coral type in reef rim

General view along reef rim

Reversed plate of coral regrowing along its edge (bottom right)

Tide channel
Deep vertical development on reef rim

Blue sponge in coral zone

Single coral type reef rim and front showing reef slope

Bank of single coral type in coral zone
The blast area of a carbide bomb

Reef rim with normal fish population

Vigorous stag coral

Blasted stag coral covered with algae. Undamaged coral on edge of blast zone. (Upper left)
Excellent example of blue sponge a special feature of this area

Blue sponges on coral head and plate coral left

Recently blasted stag coral
Old blasted area sealed with algae

General view of the coral zone

Coral types of the coral zone
Rejuvenating coral on mined area

Typical growth on coral zone as would be seen from a glass bottomed boat

Blue algae on coral zone peculiar to this platform reef
Two particularly interesting features are the vivid blue calcareous, or hard, algae which are found on the reef platform and the excellent formations of light blue tubular sponges.

Although both reefs are in particularly good condition, some damage has occurred. A little mining has taken place but a fair amount of blasting has been done. This is evident from the isolated round patches of dead and broken coral found mostly on the reef rim. Two misfired bottle bombs were found on the reef.

These reefs give the impression of being far more extensive than indicated on the charts.

Conclusion. Both these reefs are excellent, fully deserve protecting and would be valuable assets to the National Park.

Pulau Gaya

Sites 2 to 6. These are situated along the Southern shore of the island.

A high percentage of the reef along this area has been damaged, but very little of this mining is of recent origin as much of the bottom is now covered with boulders well cemented in place by calcareous algae.

Site 4 was an exception, having a certain amount of good varied coral on the reef rim but recent attempts at mining have caused some damage.

Generally speaking patches of fair coral do exist and some regrowth can be seen. It would seem, however, that general rejuvenation will be slow. Nevertheless, as part of the National Park strict protection should be introduced.

Site 7. Pulau Sapi-Si. The reef area is extensively damaged by recent mining which would indicate that a reef with good vertical development once existed here. The bottom is now littered with coral rubble and boulders. There are occasional patches of good coral of both the hard and soft varieties.

One particularly interesting feature is the unusually large colonies of a fern-like hydroid.

Protected, the fringing reef of this islet could come back fairly rapidly.

Sites 8 and 9. These were on the open sea side of Sapi-Si and Gaya. Both exhibited typical exposed shore bottoms; exposed bed rock and fine sand patches; scattered rock boulders with individual brackets of coral. No damage was seen in this area.

Sites 10 to 13. These are all along the Northern shore and proved to be totally different to the Southern area. All corals seen are in excellent condition. The sites visited will be described individually.

Site 10. A gently sloping reef bed in 15 to 20 feet of water, part of a wide coral zone extending from the reef rim to the shore. No actual reef rim was seen at this site although a considerable drop off into the 100 foot deep bay must exist.

Some blast damage was noted but regeneration is good. Coral tended to be large patches of single types with staghorn predominant.

Site 11. A pronounced reef rim of good coral with a narrow shelving coral zone grading into a clean, sandy back reef apron to the rocky shore. The reef front extends down to 30 feet and has considerable vertical development with some massive coral heads. No damage seen.

An excellent bay with a good beach and clean water in addition to the fine coral.
Pulau Gaya

Rejuvenating coral on the south side

Alcyonarians - a soft coral - on the rocky point: North side
Site 12. An underwater extension of the rocky point of massive boulders resulting in 30 foot high submarine cliff faces. An interesting diving area and, although coral is very limited on this type of site, it does have good examples of Alcyonarians, a type of soft coral.

A pleasing diving area.

Site 13. Good low coral in two shelving platforms, one at 20 feet, the second between 25 and 30 feet divided by a belt of sand. Part of this area has rock and coral boulders mingling with patches of coral and sand.

Some damage from blasting was observed.

Conclusion. The whole area marked for inclusion within the proposed Gaya National Park is well worth being declared a marine National Park, particularly Gaya’s North coast and the Southern platform reefs. The marine area as a whole would add an important and valuable dimension to the National Park.

Sapangar Bay beyond Melanim Point

Three reef sites were inspected within this deeply recessed bay; all three were, for the most part, dead and not worth protecting. In fact, if areas for mining sand and shingle are required, this bay could be mined without causing much more damage. It is even possible that by removing some of these sand bars, shoals and spits the coral may commence regrowing.

General Water Conditions.

Generally the water clarity averaged 25 feet with increases to 40 feet in some areas. The water has a faint milky quality which may vary with the seasons. Although the water clarity does not match that of the Pacific islands it would be, nevertheless, very acceptable to the average tourist.

DESCRIPTION OF DAMAGE OBSERVED

Coral mining. This basically takes two forms; the extraction of large blocks of coral in the form of coral heads, or the gathering of coral boulders from shallow water.

Coral heads are almost all formed by brain coral of the Goniopora species, and being a slow growing variety may take scores of years to reach the massive proportions of those selected to be mined.

The method of mining these coral heads is to loop a cable around the base of the column and winch until it breaks off. The coral block is then dragged down the reef front and reef slope until it is directly below the vessel from whence it is winched aboard.

Discussing this subject with a local contractor revealed that on a good day 450 tons of coral heads could be mined. As each coral head is said to weigh 5 to 7 tons (and this must be taken as a maximum figure) between 64 and 90 coral heads a day can be assumed to be removed by a single boat.

Because coral heads form on the reef rim and the reef front the amount of wreckage caused by dragging a block down the reef slope is impressive. A swath is cut through the coral as if by a bulldozer and the coral in this area is completely destroyed.

From the evidence examined each coral head destroys, on average, an area 10 feet wide and 25 feet long – 250 square feet per extraction. At the tonnage quoted above the area destroyed per day would amount to between 1/3 and 1/2 an acre per vessel per day. Extractions at this rate would, fortunately, require a fairly large boat and these would, presumably, be fairly restricted. Nevertheless, it can be seen that mining of this kind is extremely destructive and very wasteful; the area of reef destroyed by a dragged coral head is about 9 times the area it normally occupies in the reef rim.
Mined coral heads at Kota Kinabalu. Note the size of individual blocks.
Boulder Mining. This would appear to be the occupation of the small boat owners and mining is done by diving onto the shallow reef tops or back reef aprons. The boulders collected are usually the debris of already destroyed reef and would at first glance appear to be harmless. It does however continue the damage already caused by not allowing new growth to form. This constant setback to rejuvenation appears to have resulted on many reefs in the colonization of the affected area with weeds. Once this has happened it appears difficult for corals to re-establish.

Furthermore, the constant turning over of coral slabs and boulders results in extensive ecological disturbances. Beneath each slab of coral or rock is always a whole collection of marine life entirely dependent upon the protection of that coral slab etc. Once turned over they are immediately killed off by fish. This type of environmental destruction causes a break in the reef ecosystem which may eventually result in desert conditions.

Blasting. This is one of the most destructive forms of fishing presently in practice. It is both unsatisfactory and inefficient. Probably only 10% of the fish killed are collected. But perhaps the most serious aspect of blasting is the extent of damage caused within the area of explosion. The coral is totally shattered; fish are indiscriminately killed, including those of no commercial value; and a whole spectrum of marine organisms upon which the health and vigour of the reef depends is completely destroyed, resulting in a massive disturbance in the biological balance. It is often found that following an explosion, algae invade the debris to form a sealed mat of rubble on which very little coral appears able to re-establish.

Over and above being a complicated and delicately balanced ecosystem the reef acts as a place of refuge and nursery to a large variety of juvenile fish including many of commercial value. As these juveniles always swarm in tight formation (and several such swarms were seen on the reefs) they are particularly susceptible to the shock waves caused by a blast.

Apart from the three bomb remains found, the writer heard and felt the concussion of a bomb blast at 10.45 am on Sunday the 10th of June while inspecting the platform reefs in the Gaya National Park.

GENERAL CONCLUSIONS

Despite the damage observed on many of the reefs, the general impression was of sufficient good reef areas, plus evidence of active rejuvenation, to justify the protection of all these islands which are eminently suitable for tourism.

Pulau Gaya National Park. It is suggested that prior to marking the final boundaries, aerial photographs be examined to determine the actual extent of the south west platform reefs to make sure that the reef slope is well within the protected area. This will ensure the full protection of the reefs concerned.

Pulau Dinawan. It is suggested that the Eastern boundary be extended well beyond the Eastern edge of Everett Reef and should include the double reef to the South east of Everett Reef and the full extension of the Southern reef of Pulau Dinawan itself.

The three islands of the Pulau Manukan Group. Although very little was seen of this group, and that seen was not good, protection of these three islands would be wise as they are so closely associated with the excellent twin reefs of the Gaya National Park. Protection here would make for easier policing of the waters of the National Park and act as a buffer zone to an important reef.

Furthermore these three islands are picturesque and have good beaches, and being so close to Kota Kinabalu offer a considerable tourist attraction.

Notwithstanding that good reefs may exist on both Pulau Sulug and Manukan, protection would result in a rejuvenation of their fringing reefs whatever their condition may now be.
The Island chain of the Pulau Sapangar Group. It is suggested that the boundary of the area to be protected on Pulau Sapangar be extended eastward from the middle section of the island to include the coral lined sand spit mentioned in the site report above. (Site 2).

The boundary of Pulau Udar Kechil should be extended to include Pulau Udar Priok and sufficient area of the adjacent water to include all of the coral platform between the two islands. This would need fairly careful examination and eventual demarcation to ensure that a good margin of deeper water borders the actual reef.

TOURIST UTILIZATION

Kota Kinabalu is perhaps unique in South East Asia in being able to provide a variety of attractions to the traveller at such close proximity to an international airport. Other than the magnificent attraction offered by Mount Kinabalu and its National Park, the islands and reefs offer a range of activities that would meet most demands.

Tourists might be classified into three rough categories:

1) those who have a limited amount of time in any one place;
2) those who insist upon full international standards of accommodation;
3) and those who have come prepared for an extended vacation and desire simple but exotic accommodation.

The National Park and the three island groups offer a marine environment that caters for all three types of tourist.

For the tourist in category one and two, even for those who have only a day, and for the non-swimmer, viewing the reefs through glass bottomed boats is an obvious and an attractive solution.

For tourists with very limited time the twin platform reefs in the National Park would be ideal and could be reached within an hour.

For those who have a day to spare the reefs around Pulau Dinawan and particularly the Pulau Udar Priok reefs are excellent. Both islands also have beaches for added recreation.

For tourists who want to snorkel only suggested areas are:

- Pulau Dinawan area
  - The National Park twin platform reefs
  - The North shore bays of Pulau Gaya
  - The Pulau Sapangar island group, particularly Pulau Udar Priok.

- For aqua lung divers, all the areas mentioned above plus;
  - Bulijong Point on Pulau Paya
  - Marangis Point.

CLASSIFICATION OF MARINE AREAS

Although the following sections may not strictly be within the terms of reference as stated above, the information given below may be of interest and some value.

The growing acceptance of the principles of conservation and the consequent establishment of Reservations, has brought with it a rash of names for these protected areas which are often confusing and occasionally conflicting with the intended purpose of the reserves. There is an urgent need for a standard nomenclature.

The most important initial step is to define the purpose in establishing any particular reservation. Such reasons can include;
1) Perpetuating an outstanding natural feature of great beauty or interest, protecting it from the impact of detrimental usage;
2) the restoration and rejuvenation of an area that has been degraded;
3) the establishment of areas specifically for recreation and tourism with restricted urban development or none at all;
4) the protection, restoration, and perpetuation of the habitat of specific, rare, or unusual species;
5) the protection of areas which are recognised as breeding zones;
6) the seasonal restriction of commercially important species to prevent over exploitation;
7) buffer zones between protected and open areas;
8) areas established specifically for scientific research and education.

Classifications such as these can be broken down into ever decreasing segments of specialisation and this has been one of the basic problems of establishing a suitable nomenclature.

To simplify the choice of departments of authority under whose jurisdiction such reservations must be allocated and to ease the problems of managing such areas, a division of reserve types with broad application is desirable.

It is very important that the nomenclature selected be clearly and simply stated and that the functions of each be precisely described and easily understood.

Three names are suggested below which have wide meaning and which can be subdivided into specialised areas if required for specific reasons. In order of increasing severity of protection these are:

 Protected Areas
     National Parks
     Marine Reserves.

Protected Areas.

These are established with basically recreational and commercial motivation and selected on the following criteria:

1) as marine areas with scenic and aesthetic value;
2) to biologically stabilize areas which have tourist and recreational values;
3) for the rejuvenation of degraded areas;
4) as a buffer zone to more protected areas;
5) to protect areas where damage may result in the deterioration of commercial or urban regions - such as public beaches, harbour fronts, etc.

These areas can, and often would be, inhabited. Construction could be allowed within the area provided such building was not out of sympathy with the aims of the Protected Area.

These areas allow maximum public usage for recreation and relaxation.

The restrictions imposed would be against the damage, killing, capture or removal of any marine organism or sea floor material. The exception would be hand line fishing which would be allowed, as well as specified forms of inshore fishing by those who traditionally earned their living thus prior to the establishment of the Protected Area, provided the reef and marine ecology are not unduly disturbed by such actions.
National Parks

This term has an established and accepted meaning and would, in the marine sense, cover those areas of outstanding beauty or rarity which in themselves deserve protection as a National asset.

Such Parks allow full public participation for recreation and aesthetic enjoyment, all forms of aquatic sports being allowed except those which are liable to result in damage of the reef or any of its associated marine organisms.

No fishing of any kind would be permitted nor the collection of any marine organisms, whether alive or dead, except by the issue of special permit.

Usually restricted but well planned building is allowed on the land section of a National Park, and to a limited extent into the sea - jetties etc., if specifically for maintenance or public facilities. Such planning should, however, ensure that construction causes a minimum of biological disturbance and that effluents from such buildings do not result in pollution of the marine environment.

Marine Reserves.

These are strictly protected areas established for scientific study; as undisturbed breeding areas or fish habitats; areas where all natural processes are allowed to take place in the absence of any direct human interference, to become an index against which the rate of pollution and degeneration of open areas may be gauged.

These areas allow for little or no public participation depending on the severity of protection involved, and the only buildings permitted are those necessary for marine biological stations, or posts, for research and education.

Marine Reserves would be strictly uninhabited areas.

HARZARDS WHICH ARE LIKELY TO EFFECT MARINE PRESERVATIONS

The marine ecosystem is perhaps one of the most delicate in nature. A reef consists of a whole chain of interdependent organisms which, if seriously disrupted, can cause a biological breakdown in the normal functions of the reef.

There are three basic agents which can severely damage a reef. Direct interference and destruction by man; pollution, especially from oil spills and chemicals; and silting caused by the alteration of the sea bottom (dredging etc.) resulting in a movement of bottom sediments, or erosion resulting from large agricultural projects adjacent to major river systems.

The result of mining and blasting has been adequately illustrated by the damage reported above. There are, however, some side effects to this damage.

The Acanthaster, or Crown-of-Thorns, has one major controlling factor: the coral polyps upon which it feeds. In its larval stage the Acanthaster is eaten by coral polyps and so the number of larvae which reach maturity is very limited. It has been suggested however that the existence of major breaks in the reef resulting from dredging, mining and/or blasting, provides areas without predators in which the juvenile Crown-of-thorns can develop to maturity. This eventually causes a population explosion from the bare areas into the living reef. Already the Acanthaster has destroyed 20% of the Australian Barrier Reef and 90% of the coral in Guam was destroyed in two and one half years.

No control has yet been discovered against the Acanthaster. In Samoa and other Pacific Islands, not badly affected, a bounty is given for all that are caught. Although only a few were seen, and those in the Sape group of islands, this action may be worth considering as a preventive measure, or if nothing else, as an index of its spread.
By his direct interference man can, and has, caused severe disruptions in the reef ecology. The effects of many of his actions are only now being fully recognised. Two recorded cases illustrate the type of changes that can occur.

On the Great Barrier Reef of Australia a large size static fish trap was used by research people for 5 years continually. This either fished-out a local population which fed largely on algae, or, more likely, the fish learnt to avoid the area. When, later on, the trap was removed, the reef flat appeared overgrown with sizeable algae, and the corals were less obvious. This type of environmental change could result from over fishing an area or from blasting.

Two permanent members of the reef community are the cleaning prawn (Stenopus hispidus) and the cleaning fish (Labroides scen.); These fish establish what are termed ‘cleaning stations’ and under careful observation it has been determined that somewhere in the region of 600 fish will visit each cleaning station during the 12 hours of daylight. On the specific reef under examination it was estimated that 60,000 fish were cleaned each day.

To determine the importance of these cleaning fish to the reef ecosystem as a whole, two scientists removed all cleaning fish and prawns from an isolated reef in the Bahamas. Within two weeks, a previously richly populated reef became largely denuded of fish life. There remained only a few conspicuously damaged and diseased fish; the rest had drifted away to more accommodating areas.

Normally such small fish and prawns would be only interesting curiosities to people visiting the reefs. But a problem arises as soon as dealers in tropical marine aquarium fish begin working a specific area. These cleaning fish are colourful and in constant demand. They are also easily caught and are very adaptable to aquarium tanks.

So too are the colourful clown or anemone fish (Amphiprion spp.) who live in close relationship with anemones; a very popular aquarium fish which is one of the first to be eliminated by collectors. This type of listing can be extended to half of the small reef fish.

Even private collecting can cause damage, but the effects become serious and even catastrophic when done commercially.

This effect upon the reef is also true of shell collectors. Although the population density of shells along the East coast reefs of Malaya was greatly reduced by diving collectors, the irreversible damage was caused as soon as money was offered for shells in Singapore. As a result, many of the excellent reefs about the offshore islands along the East coast of Malaya are now dead areas of algae covered rubble. Club diving shell collectors overturned so many coral slabs in their search for shells that the ecology was totally disrupted. The result is now a dead reef and a complete loss to tourism.

It is therefore very important to ensure that, while legislating for protected marine areas, these particular matters are kept in view.

Water, by its very nature, is a remarkably efficient vehicle to carry and disperse fine particles in suspension as well as chemical pollutants. This makes the problems of detecting pollution and controlling it very difficult.

A phrase that is often quoted is that pollution is many things to many people and the definition of what are pollutants is often dependent upon the standpoint and involvement of the person concerned.

Generally, however, pollution can be referred to as a contamination of the environment that lowers its ecological efficiency.

As a State Capital, Kota Kinabalu occupies a unique position having both mountains and sea, coral reefs and islands, so close to the urban centre; all the ingredients of an excellent tourist trade.

However, urban development at such close proximity to reef areas can result in serious problems in maintaining an unpolluted environment.
In the first instance the harbour is encompassed by islands intended to be declared Protected Areas and a National Park. With Sabah’s normal volume of shipping (and this is bound to increase) and the anchorages point specially designated for oil tankers, the possibility of oil pollution will be a constant hazard.

Other countries have reduced this problem to some extent by insisting that no ship garbage be dumped within a specific mileage of the harbour and that no bilges are pumped within territorial waters. The Japanese have contained oil spillages with narrow floating plastic curtains which could also be used to surround the oil tanker zones in case of accidental oil spillages.

Pollution from sewage, industrial waste and pesticides can be a serious problem and sometimes almost impossible to overcome in established urban and industrial complexes. In developing zones, safe guards can still be built into urban expansion to ensure adequately processed sewage, while in planning newly expanding industrial zones part of the capital cost of establishing an industry should be the installation of adequate effluent treatment.

The effects of pesticides are far reaching and therefore do not influence the reef ecology alone but a wide spectrum of sea life including species of commercial value.

Most of this form of pollution is carried by rivers which drain agricultural regions and so the net accumulation of residual pesticides may be found at these river mouths. It is here that the monitoring of chemical pollution, which is carried out by concerned countries to ascertain the extent of contamination, takes place.

The reduction of this problem is largely dependent upon the agricultural policies and the type of pesticides in use. Some have far longer residual effects than others.

THE TOURIST ASPECT

The present requirements of those who travel for a holiday have not yet been appreciated by the international tourist concerns. Since World War II the distribution of individual wealth is wider than ever before and as a result the age and interests of those who travel have changed drastically. With the speed and relative cheapness of modern transport, areas previously accessible only to a few are now on the normal tourist routes. Furthermore the high cost of living in the developed countries makes it often more expensive to spend a holiday in a local resort than fly to Asia for the same period.

There are generally two types of tourists; those who must have all the conveniences of modern living, and those who travel to get away from them.

Kota Kinabalu is ideally situated to accommodate both these types. The town providing the modern hotels, while the islands can provide something very different.

At present there is an increasing number of Europeans who, with the aid of charter flights, want to spend their winter holidays by the sea in a tropical climate. Many of these are Scuba divers. In fact there are now special Clubs which set up resort centres all over the world specifically to cater for the sport diver.

A good example of this is Club Mediterranee who build accommodation at their resorts strictly in accordance with local architecture: so that in Morocco it is an Algerian house; in Tahiti a Tahitian hut.

One form of pollution not usually taken into consideration is that caused by human structures totally out of sympathy with the surrounding environment.
From personal experience in various parts of the world and from discussions on the subject with fellow travellers, the following suggestions and observations may be of interest.

On each of the protected islands might be constructed small well-built chalets of native design, well spaced to provide privacy for those who want it but within easy reach of a neighbour if the need arises. Two concessions might be made to international standards: a comfortable bed and good bathroom facilities. Each chalet could be self-sufficient with gas cooking and kerosene lighting and refrigeration.

If tourists could be offered a chalet on an island of their own to cater for themselves, with a private beach, clear water, and good coral — it would provide the type of holiday that most tourists only dream of.

As is done in Kashmir and other parts of the world, such out-of-the-way chalets could be serviced by small delivery boats doing a daily run from island to island with mail, papers and provisions. This type of service spreads the tourist business among the local inhabitants and distributes the income from the tourist trade.

To exploit the full range of the underwater environment, diving gear and air compressors should be made readily available at Kota Kinabalu and basic equipment, such as mask, snorkel and flippers, might even be made part of the normal equipment supplied with a chalet.

For the National Park, perhaps a series of individual chalets with a central restaurant and lounge, again of native design, could be designed to intrude as little as possible on the natural vegetation. Here, normal facilities such as lighting and air conditioning would provide a compromise between the island chalet and the international hotel. In both cases, the emphasis should be on traditional local design and materials, without any attempt to reproduce the concrete jungles that the majority of tourists are trying to escape.

It is obvious that the many aspects of park management would require a team of experts. For this reason, conservationists have suggested that the Board of Management of National Park, Protected Areas, etc., should include biologists, marine biologists, park wardens, and architects.

THE CONFLICT BETWEEN CONSERVATION AND LIVELIHOOD

In proclaiming marine reserves of any form there will inevitably be some clash of interests between those wishing to preserve the natural environment and those whose livelihood is directly affected by the restrictions necessarily imposed.

This has been perhaps the most difficult problem confronting those wishing to introduce conservation. It was a particularly pressing problem in Japan when an appreciable section of coastline was declared a National Park. It was only finally overcome when the local fishermen were shown that they could earn as much, or more, by utilizing their expert local knowledge as guides and their boats to provide various essential services.

This method of absorbing the island inhabitants and local fishermen could be usefully adopted here. They could be employed as crew for glass-bottomed boats; delivery services to island chalets; caretakers of tourist bungalows; and wardens of Protected Areas and National Park reefs.

LEGISLATION FOR CONSERVING MARINE AREAS

Although the details of any ordinance specifically promulgated for the protection of nature reserves are all basically similar it may be of interest to review some provisions selected from different parts of the world, but principally from the ordinance establishing The John Pennekamp Coral Reef State Park of the U.S.A.
(1) The National Park (Protected Area) has been established for the protection of the coral reef formation and its associated marine life. The provisions of this section are intended to provide maximum public use of the area consistent with the preservation of its scenic and scientific values.

(Legislation for Marine Reserves would clearly state the purpose for their establishment, i.e. scientific investigation, controls for obtaining comparative indices; for protection of rare or commercial species during breeding and immaturity; etc).

(2) Removal or destruction of Natural Features and Marine Life.

No person shall destroy, injure, deface, mar, move, dig, harmfully disturb or remove from this Park (Protected Area) any beach sand, gravel, or minerals, coral, sea feathers or other marine invertebrates, sea weeds, grasses whether dead or alive, or any soil, rock, artifacts, stones or other materials.

No person shall cut, carve, injure, mutilate, move, displace or break off any bottom formation or growth. Nor shall any person dig in, or in any way injure or impair the natural beauty or usefulness of this Park (Protected Area).

No rope, wire or other contrivance shall be attached to any coral, rock or other formation, whether temporary or permanent in character or use.

(3) Dredging, Filling, Excavating and Building.

No dredging, excavating or filling operations of any kind are permitted in the Park (Protected Area), and no materials of any sort may be deposited in or on the water thereof.

(Regulations concerning the construction of buildings should be subject to the requirements of Park management and policy).

(4) Refuse and Polluting Substances.

No person shall dump or deposit in or on the waters of the Park (Protected Area) any oily liquids or wastes, acids or other deleterious chemicals, bottles, broken glass, paper, boxes, dirt, rubbish, waste, garbage, refuse or other debris or polluting substance.

(5) Markers.

No person shall wilfully mark, deface, or injure in any way, displace, remove or tamper with any park signs, notices or placards, whether temporary or permanent, or with any monument, stakes, posts, or other boundary markers.

(6) a/ Spear Fishing.

Spear fishing or possession of spear fishing equipment within the Park (Protected Area) is prohibited.

b/ The use of organic or inorganic poisons, electric charges, carbide bombs, and any similar method for the taking or killing of fish or other marine organisms is prohibited.

(7) Fishing, (Protected Areas only)

a/ Fishing is permitted with hook and line for the purpose of taking surface fish provided no more than two (2) hooks per line are employed.

b/ Where, prior to the establishment of the Protected Area, traditional indigenous fishing has been a means of livelihood, fishing by means of non static traps may be permitted provided that all non commercial fish are returned to the sea without harm.
Such persons will receive a licence to fish from the Protected Area director (manager). All licences are subject to cancellation without notice at the discretion of the Protected Area director (manager).

b/ No person shall tamper in any way with the traps set by authorised persons or licenced indigenous fishermen.

(8) Aqua lungs and Skin Diving.
Sport diving for photography, for observation and for pleasure is permitted and encouraged.

(9) Collecting of Scientific Specimens.
Collecting of natural objects and marine life for educational purposes and for scientific and industrial research shall be done only in accordance with the terms of written permits granted by the Park (Protected Area) director (manager). Such permits shall be issued only to persons representing reputable scientific, research, or educational institutions. No permit will be granted for specimens the removal of which would disturb the remaining natural features or mar their appearance. All permits are subject to cancellation without notice at the discretion of the Park (Protected Area) director (manager). Permits shall be for a limited term and may be renewed at the discretion of the Park (Protected Area) director (manager).

(10) Operation of Watercraft.

a/ No watercraft shall be operated in such a manner as to strike or otherwise cause damage to the natural features of the Park (Protected Areas).

b/ Except in case of emergency endangering life or property, no anchor shall be cast or dragged in such a way as to damage any reef structures. Watercraft wishing to remain stationary over a reef area may secure themselves to buoys provided specifically for this purpose by the Park (Protected Area) authorities.

c/ No watercraft shall operate at a speed of greater than four (4) miles per hour when in the vicinity of divers, sightseeing boats, or fishermen.

d/ All watercraft from which diving operations are being conducted shall fly in a conspicuous manner the International Code of Signals Flag 'A' it being recognised as the International Diving Flag. No boat under power shall approach closer than 100 yards to such a boat displaying the Diving Flag except at idling speed and with great caution.

e/ Boats anchored or proceeding at slow speed for fishing or observation shall be approached or passed at such slow speed that the wake of the approaching or passing boat does not disturb the fishing or observation boats.

(11) Advertising or Publicity.

No person shall erect or cause to be displayed within the Park (Protected Area) any signs, slogans or markings containing any advertising or other kind of message.

(12) No person shall carry, use, or possess within the Park (Protected Area) spring guns, spear guns operated by any method of discharge, harpoons, suction guns, or any other kind of weapon potentially harmful to fish or wild life or to the reef structure and dangerous to human safety. The use of such weapons from beyond the boundaries of the Park (Protected Area) and aimed or directed into the Park (Protected Area) is forbidden.
A number of other legislations, although not specifically applicable to areas of conservation, have been introduced by a number of countries who have had to face the problems of the new and rapidly developing underwater sport. Underwater Guns. In some areas, to protect the interests of the fishermen, in others to protect specific fish, certain restrictions have been introduced to control the use of underwater guns.

In some countries an underwater gun may not be used in company with an aqua lung or any other form of breathing apparatus. In these countries it is usual that to carry an underwater gun in the same boat with diving equipment is prohibited.

In other countries, as is the case in Malaysia, gun licences are required to purchase and possess an underwater gun.

There is a general world wide movement now to totally ban the use of underwater guns under any circumstances. Countries who adopt this form of approach will, in the long run, eliminate a lot of problems and damage to fish, particularly certain commercial types which have limited territorial movement.

Lobsters and Crabs. Many countries now forbid by law the shooting of lobsters and crabs with guns and harpoons of any kind, as this form of killing is totally indiscriminate.

These countries usually allow the taking of lobsters and crabs by hand provided that any crustacean which carries eggs is released, and that the catch is above the minimum size allowed by law.

General. I would like to thank the Sabah Government for giving me the opportunity of inspecting the reefs off Kota Kinabalu and the Fisheries Department for their co-operation in providing a boat.

I would also like to take this opportunity of thanking Mr. and Mrs. Jenkins for their generous hospitality during my visit.

R.B. Lulofs