

**Implications of Climate Change and
Sea Level Rise for the
Republic of Palau**

Report of a Preparatory Mission

By

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Foreword

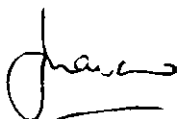
The first *Intergovernmental Meeting on Climate Change and Sea Level Rise for the South Pacific Region* was held in Majuro, Marshall Islands, in 1989. It was organised by the South Pacific Commission (SPC) and South Pacific Regional Environment Programme (SPREP) to create a public awareness on the future implications of these issues to the governments. Subsequently, necessary actions are being undertaken to address these issues in order to develop appropriate policies.

In this meeting, SPREP member governments gave the mandate to SPREP to coordinate and act as clearing house on all climate change and sea level activities for the region.

The *United Nation Environment Programme* (UNEP) then provided financial assistance through SPREP (use of SPREP Climate Change Task Team Group) to undertake preparatory missions to Tonga, Kiribati, Tuvalu, Cook Islands, Guam, Palau, Federated States of Micronesia, Western Samoa and Tokelau to discuss the study with the governments, and to prepare reports before undertaking in-depth studies on the impacts of climate change.

The main task of this mission to Palau was to prepare a report in close consultation with the government officials, identifying areas for in-depth study into the potential impacts of expected climate and sea level changes on the natural environment and the socio-economic structures and activities of Palau. In addition, it identified suitable and available response options to avoid or mitigate the impacts of climatic changes.

It is anticipated that the Palau government will have the opportunity to closely examine these recommendations in the report, and to advise SPREP and other organisations accordingly.



Vili A. Fuavao

Director

South Pacific Regional Environment Programme

Executive Summary

This report outlines the implications of the expected climate change and consequent sea-level rise for the Republic of Palau. The report is one of a series of reports produced for a number of Pacific Island countries which have been identified as being under threat of major environmental change due to the expected greenhouse-forced global warming and consequent sea-level rise. The report is a result of a seven-day consultation mission to the Republic of Palau between April 12 and 19, 1993, by a two-person team operating under the auspices of the South Pacific Regional Environment Programme. The objective of the mission was to prepare a report, in close consultation with national experts, and the government a proposal for a programme of assistance to undertake an in-depth study of the potential negative impacts of climatic changes due to global warming and consequent sea-level rise on the natural environment and socio-economic structures and activities of the Republic of Palau.

The Republic of Palau is fortunate to have a number of organisations responsible for developing, protecting and managing a wide-range of structures and activities pertaining to the natural, socio-economic and cultural environment. Unfortunately for the Republic of Palau, and for many of the other Pacific Island countries there is still a general lack of awareness about the potential negative impacts of climatic changes and consequent sea-level rise on the natural and the social (economic and cultural) environment. It is proposed that public awareness and education about the potential negative impacts in the Republic of Palau is essential for its integration into the mainstream longer term management and planning.

Seven sets of specific recommendations have been made from the mission to facilitate not only greater public awareness and education but also to develop and maintain Palau-specific data on the potential negative impacts of climatic changes and consequent sea-level rise. The importance for climate data development in relation to Palau's natural, socio-economic and socio-cultural environment cannot be overemphasized. Specific sets of recommendations have been outlined under each of the following:

- Research and monitoring of the ocean-atmosphere system;
- Marine and terrestrial resources assessment and monitoring;
- Strengthening of environmental legislation;
- Urban services development;
- Public awareness and education;
- The National Master Plan; and,
- Environmental perception of migrants in Palau.

Summary of Recommendations

1. Research and monitoring of ocean-atmosphere system

- a) that in-depth study of climate impacts and the long-term research and monitoring of climate change and sea level rise should be undertaken and include measurement of sea surface temperatures (SST), salinity, turbidity, air temperature and density of water masses in and around Palau.
- b) that a local person be trained and that office space and equipment be provided to allow development, handling, interpretation and application of Palau-specific data.

2. On-going marine and terrestrial resource surveys, monitoring and management

- a) that the populations of sea-turtles, dugongs, reef fishes, corals, trochus and giant clams be surveyed to develop management programmes.
- b) that the research and monitoring programme based on the 15 sites surveyed in 1990 be extended to cover terrestrial resources to provide information on changing demands and resource use arrangements. The Southwest Islands, Kayangel, Peleliu and Angaur, need to be included in such surveys.
- c) that the current resource management programmes such as the Historic Preservation Project and the Marine Resource Management Programme, currently under review by Marine Resources Division, be supported fully so that long-term monitoring and management can be realised. The support should involve allocation of funds to increase the number of people working on the project and for the costs of equipment, transport operation and maintenance.

- d) that an integrated coastal zone management program be developed within the Master Plan to ensure that minimal damage is done to the coastal zone through onshore development.

3. Strengthening and enforcing environmental legislation

- a) that enforcement of the by-laws governing the protection of endangered species, over-fishing and poaching, and marine pollution from fishing boats is enhanced through the employment of more staff.
- b) that dredging activities be made subject to environmental impact assessment and planning.

4. Urban services development

- a) that a study be undertaken to develop appropriate ways and means of dealing with the disposal of septic waste on Koror and on the outer islands.
- b) that frequently visited tourist sites are monitored regularly for effects of pollution or destruction.
- c) that further studies are carried out to assess the groundwater potential of the islands of Palau in order to establish water resource capacity.
- d) that the National Emergency Management Office strengthened to ensure that contingency plans such as evacuation and relocation plans are developed and implemented in the case of inundation of causeways, extended droughts, extremely high tides, etc. Particular attention should be given to resettlement options of people living on low-lying coastal areas, alternative water sources, and the resiting and protection of key public services.

5. Public awareness and education

- a) provide the necessary resources to extend the environmental awareness and education programs currently run by the Bureau of Resources and Development, EQPB and the local primary and secondary schools.
- b) that specific programmes be developed to prevent poaching and marine pollution from fisheries boats.

6. The National Master Plan process

- a) that greater consideration be given to the long-term effects of climate change and sea-level rise in the National Master Plan, in particular to the resiting of the main functions of the Republic of Palau away from the coastal area and onto Babeldaob. This would include consideration of land tenure arrangements as well as the physical and economic implications of such a major resettlement scheme.

7. Environmental perception of migrants in Palau

- a) that an environmental perception study be carried out among the migrant community in Palau leading to a programme which will raise their awareness about traditional conservation ethics and practices of the fragility and the need to protect Palau's natural environment.

Contents

Foreword	iii
Executive Summary	iv
Summary of Recommendations	v
1. Introduction	1
1.1 Background.....	1
1.2 Purpose of the mission.....	1
1.3 Programme of visit	2
2. Physical and Natural Environment of Palau	3
2.1 Location	3
2.2 Geology	3
2.3 Climate	7
2.4 Biology: flora and fauna	7
2.5 Oceanography.....	8
3. Social and Economic Environment	9
3.1 Historical antecedents.....	9
3.2 Discovery and foreign rule	9
3.3 Historical population trends.....	10
3.4 Recent population trends and health status	11
3.5 Settlement	12
3.6 Land use and resources.....	15
3.7 Historical and cultural sites.....	15
3.8 Economy and development.....	15
4. Climate Change and Sea-Level Rise: Relevance to Pacific Nations	18
5. Vulnerable Components of Natural and Socio-economic Environments 19	
6. Current Environmental Management Problems	20
6.1 Dredging.....	20
6.2 Solid waste disposal and sanitary landfill.....	20
6.3 Potable water shortage.....	20
6.4 Deterioration of coral reef and marine resources	20
6.5 Marine pollution from fisheries boats	21
6.6 Disposal of septic waste.....	21
6.7 Drought and storms.....	21
7. Institutional Arrangements	22
7.1 Legislative framework for environmental management	22
7.2 Bureau of Resources and Development.....	22
7.3 Environmental Quality Protection Board (EQPB).....	22
8. Recommendations	23
9. Conclusion	27
10. References	28
Annexes	30
Annex One: Schedule of Consultations April 12 - 19, 1993	30
Annex Two: Government Organisations and the Environment.....	32

1. Introduction

1.1 Background

At the nineteenth South Pacific Forum Meeting in 1988, the leaders of member countries expressed concern about climatic changes in the South Pacific and the potential for serious social and economic disruptions to their countries. The following activities were proposed at the "SPREP/UNEP/ASPEI Intergovernmental Meeting on Climate Change and Sea-Level Rise in the South Pacific" at Majuro, Republic of Marshall Islands in 1989 as a direct result of these concerns;

- (1) establishing of a network of accurate sea-level monitoring stations,
- (2) strengthening environmental programs within the *Forum* infrastructure, and
- (3) undertaking preliminary studies of countries of the region identified as being under threat of major environmental change due to the expected greenhouse-forced global warming and consequent sea-level rise.

Those countries identified as likely to experience profound environmental and social impacts include Tokelau, Kiribati, Tuvalu, Marshall Islands, Guam, Cook Islands, Palau, Western Samoa and the Federated States of Micronesia (FSM). All of these countries differ in physical characteristics such as area, relief, insularity, number of islands and atolls, socio-cultural attitudes and political systems. Therefore, the impacts of expected climatic changes due to global warming and the consequent sea level rise on the natural and human environment needed to be evaluated separately for each country.

As part of this evaluation and in preparation for further in-depth studies, a two-person team was sent by the South Pacific Regional Environment Programme (SPREP) to each country to prepare, in close consultation with national counterparts, a proposal for a program of assistance. To date reports have been completed for Tokelau, Cook Islands, Marshall Islands, Tuvalu, Kiribati, Guam and Western Samoa.

1.2 Purpose of the mission

The main objective of the mission was to prepare a report in close association with national experts and government officials, for a programme of assistance to undertake an in-depth study of the potential impact of expected negative impacts of climatic changes due to global warming and the consequent sea-level rise on the natural environment and the socio-economic structures and activities of the Republic of Palau. The proposal includes identifying response options suitable and available to avoid or mitigate the expected negative impacts of climatic change. Working closely with the national experts of the Republic of Palau the "SPREP Climate Change Task Team" had the following terms of reference:

- i) examine and evaluate the available information affecting the physical and biological environment of the islands and atolls comprising the Republic of Palau;
- ii) examine and carry out a preliminary assessment of available demographic, social (archaeological and cultural) and economic data of the Republic of Palau,
- iii) present the results of relevant studies as to their applicability to the case of the Republic of Palau;
- iv) discuss with the national authorities, organisations, institutions and experts their perceptions of the consequences of the potential impacts of climatic change and seek their views on suitable response options;
- v) identify national authorities, organisations, institutions and experts which may participate in the in-depth study to follow the mission, and determine the modalities of cooperation between the legal and administrative structures of the Republic of Palau with the team which will assist in the implementation of the in-depth study.

On the basis of the activities above, a report was to be prepared containing,

- i) a general overview of the climatological, oceanological, biological and socio-economic factors which may be relevant to or affected by the potential impact of expected climatic change;
- ii) a preliminary identification of the most vulnerable components and sites of the natural environment, as well as those socio-economic structures and activities which may be most critically affected by expected climatic change;
- iii) an overview of current environmental management problems in the Republic of Palau and an assessment of how such problems may be exacerbated by climatic change;
- iv) a detailed proposal for a joint program of assistance to the Republic of Palau for the in-depth evaluation of the potential impacts of expected climatic change on the natural environment and the socio-economic structures and activities of the Republic of Palau. This includes the identification of the policy or management options suitable to avoid or mitigate the impact of climatic changes; the proposal should identify the workplan, timetable and financial requirements of the in-depth evaluation as well as the possible institutional arrangements for carrying out the evaluation.
- v) Before leaving the Republic of Palau the mission will present to and discuss with the authorities, the outline of the proposed program as well as the major findings of the mission. The comments and suggestions of the authorities of Republic of Palau will be duly taken into account in preparing the final report of the mission.
- vi) The final report of the mission will be transmitted by SPREP to the government of the Republic of Palau through the Conservation and Entomolgy Division of the Bureau of Resources and Development within 30 days of the completion of the visit.

1.3 Programme of visit

The preparatory mission to the Republic of Palau took place between 12th and 19th April 1993. The consultants spent most of their time in formal interviews around Koror, the capital of the Republic of Palau and the seat of government. Informal visits were made to the Rock Islands and to Airai to see cultural sites and the environmental attractions which make these islands renowned worldwide.

The mission was organised by SPREP and the program of consultations, meetings and visits in Koror was planned in association with the Division of Conservation and Entomology of the Palau Bureau of Resources and Development. The outline of the program of consultations with relevant national experts and organisations is in Annex One.

2. Physical and Natural Environment of Palau

2.1 Location

The Republic of Palau is an archipelago of about 350 high and low islands located in the most western part of the Caroline Islands of the southwestern Pacific. Situated at a latitude 7° 20' N and longitude 134° 28' E (Fig. 1), the Palau islands are almost 800 kilometres (km) equidistant west of the Philippines, north of Irian Jaya and southeast of Guam (Fig. 2).

The islands in the main archipelago are strung in a northeast-southwest direction about 160km long and 25km at its widest. The main archipelago consists of the inhabited islands of Angaur, Peleliu, Babeldaob, Kayangel, Koror and the adjacent islands of Arakebesan, Malakal and Ngermalk. The Republic of Palau also includes the islands of Fanna, Sonsorol, Pula Ana, Merir, Helen and Tobi which lie about 480km southwest of the main archipelago.

2.2 Geology

The main archipelago of the Palau islands is a remnant of the highest peaks of the Kyushu range, an underwater chain of volcanic mountains stretching from Japan to the island of New Guinea. The mountains of the Kyushu range rise 8,000 metres (m) from the bottom of the ocean floor. The exposed mountain tops which form the islands on the Palau archipelago are a combination of limestone and coral, totalling a land area of 488 km².

The Palau islands consist of four major geologic formations, volcanic, reef and atoll, low platform and high limestone. Volcanic islands comprise about 80% of the land area in Palau. These volcanic islands are Babeldaob, Meiuns, Malakal and the western part of Koror. Babeldaob is the largest island and represents 75% of the land area in Palau. It contains the highest point, Mt. Ngerechelehuus at 213m above sea level, and the only perennial rivers and streams. Babeldaob also has the largest river, Ngeremeskag river which is 16km long, the largest freshwater lake, Ngardok with an area of five hectares, and one of the largest

estuaries in Micronesia, Ngeremeduu Bay (Cassell *et al* 1992).

The reef islands are located north and northeast of Peleliu and comprise Ngemelis Islands, Ngerkersil, Ngeruchubtang, Ngare-telin and Ngerechong Islands. Kayangel and Ngaruangel are situated at the northern most point of Palau's barrier reef which stretches about 105 km from Kossol in the north to Peleliu in the south. The low platform islands and atolls form the Southwest Islands, 483km southwest of the main archipelago. Peleliu and Angaur are also classified as low platform islands.

The volcanic islands of Palau developed during the Miocene and Pleistocene as a result of tectonic activity while platform and high limestone islands formed during relatively recent times in the shallow waters surrounding the volcanic islands. The 'Rock Islands' south of Koror have formed as a result of uplift of reef systems and lowering of sea-level during the Pleistocene (see Plate 1). All of these islands have been colonised by plants and animals, many of which are unique to Palau.

Subaerial weathering caused by freshwater solution on emergent limestone islands, has been particularly important in the formation of jagged pit, pinnacle topography, solution fissures, sink holes and caves notable on the Rock Islands (U.S. Army 1956), as seen in Plate 2. Marine solution and bio-erosion combine to create a sea-level notch on most limestone islands at 1-6m, causing the overhanging limestone to collapse. This process creates a vertical slope face which is eventually undercut in the same process.

Data on the geology of Palau is available from the United States Geological Survey of the Department of the Interior. Information concerning lithospheric plates, their boundaries and associated geological phenomena is available from the American Association of Petroleum Geologists and the Circum-Pacific Council for Energy and Mineral Resources.

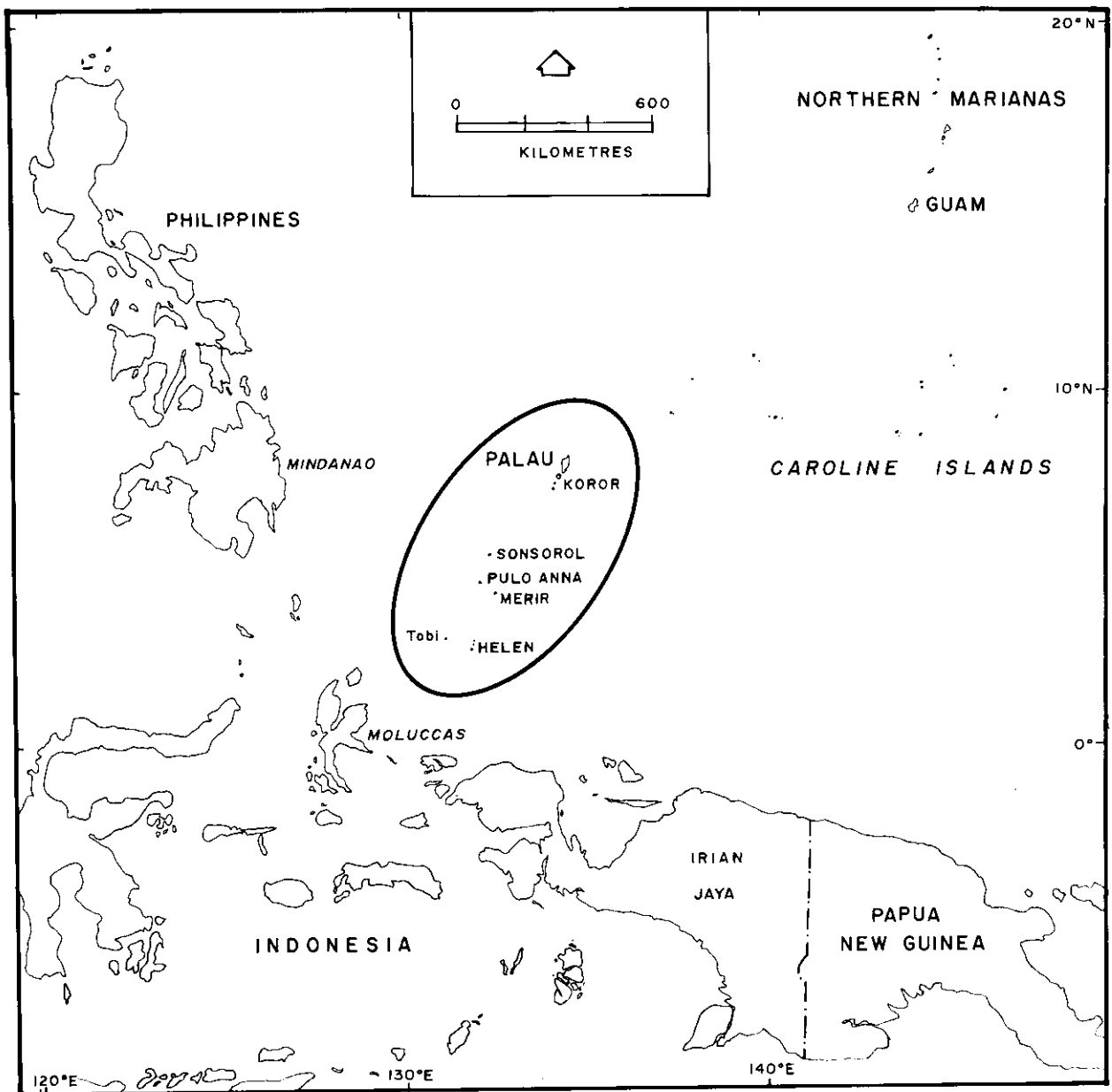


Fig. 1. Location of the Republic of Palau in the Pacific

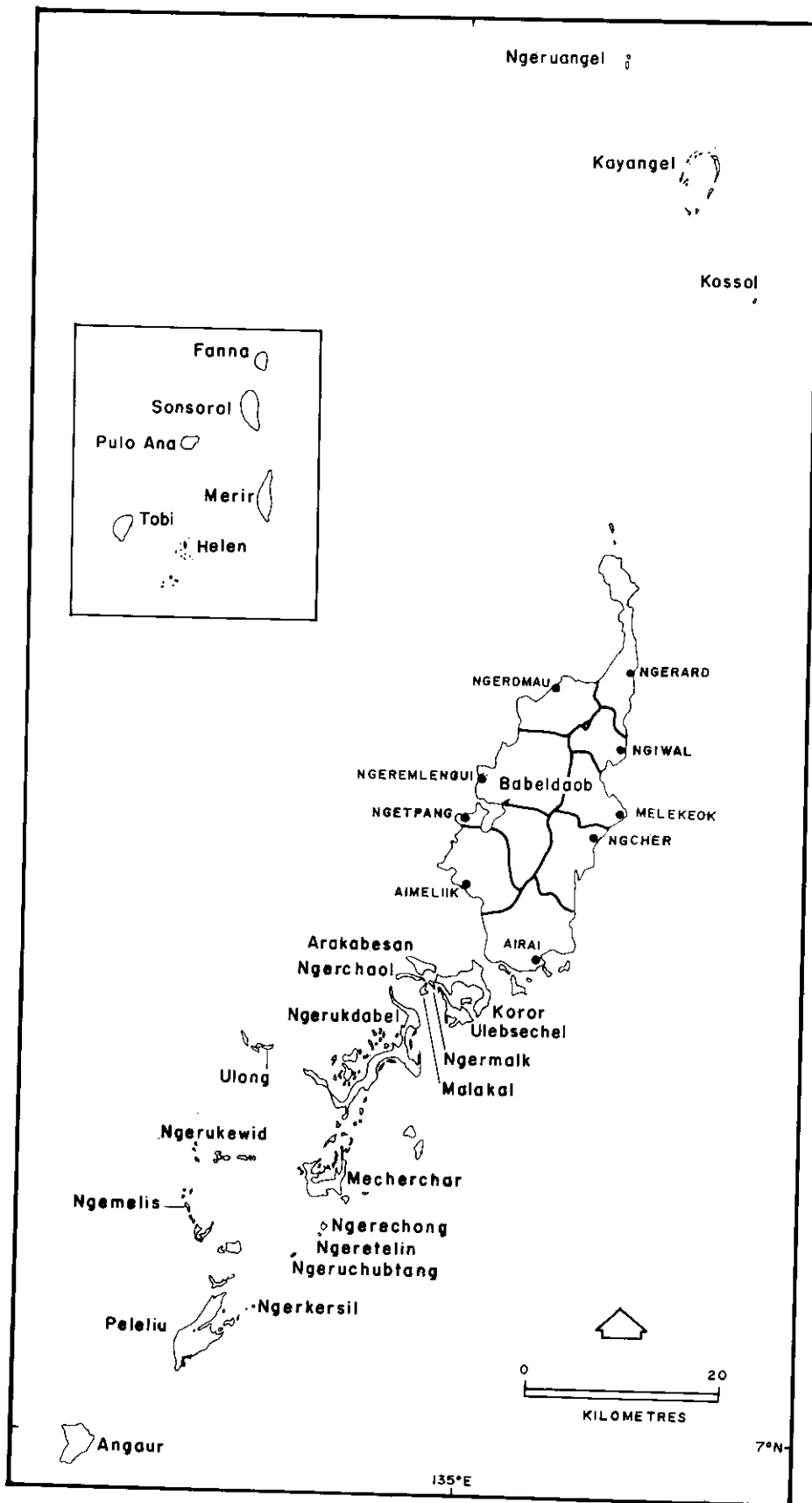


Fig. 2. Locality map of the islands and states of the Republic of Palau.



Plate 1: Uplifted reef forming part of the "Rock Islands" south of Koror.



Plate 2: West coast of Koror showing fringing reef and "T-dock" (foreground), and east coast showing jagged pit and pinnacle topography.

2.3 Climate

The Republic of Palau has a maritime tropical rainy climate. There is little seasonal variation in temperature and the annual mean daily temperature for all months is 27°C and a relative humidity of 82%. The average annual rainfall is 3,810mm, although rainfall is variable for each month and from year to year (NOAA 1991).

The prevailing northeast tradewinds and southwest tradewinds dominate throughout the year in Palau. The northeast trades dominate from November through to May and the southwest winds are predominant between July and October. Precipitation is heavy during the northeasterlies when the Inter-Tropical Convergence Zone (ITCZ) moves over the archipelago. The ITCZ remains in the vicinity of Koror which experiences heavy rainfall and thunderstorms during November and December. February, March and April are the driest months of the year (NOAA 1991).

The Palau islands lie outside the main tropical cyclone (typhoon) tracks. Thus, the occurrence of typhoons which affected the islands have been few and far between. In fact over a 21-year period of 1949 and 1969 only three typhoons were recorded within 100km of Palau compared to Federated States of Micronesia which experienced 42 typhoons during the same period.

The Republic of Palau has not experienced a severe typhoon since *Louise* in November 1964 and *Sally* in March 1966, although super-typhoon *Mike* badly damaged Kayangel in November of 1990 (Cassell *et al* 1990). Typhoon *Mike* caused extensive damage to crops, 1,000 homes and 20 businesses (FEMA 1992). The threat of severe typhoons to the Palauan chain of islands still exists but is not as great as it is for the central and eastern Caroline islands.

All climatic data such as precipitation, sunshine hours, and climatic extremes are recorded and sent to the Hawaii Office of the National Oceanic and Atmospheric Administration (NOAA) of the United States Department of Commerce.

2.4 Biology: flora and fauna

The geographic position of the Palau archipelago, with humid and favourable climate and close proximity to the Indo-Malay biogeographic province, is reflected in a very rich variety of flora and fauna which is by far the most diverse in Micronesia. Cassell *et al* (1992) provide an updated summary of a recent survey based on aerial photographic interpretation of vegetation types and habitats.

Fosberg *et al* (1980) provide a good account of the native flora of Palau which includes many endemic species, some of which are restricted to a few islands in the archipelago. For instance, the Ngerukewid Island Preserve contains at least 49 genera representing 113 species of plants, and 109 of these are endemic or indigenous to Palau. The endemic species in the preserve include *Gulubia palauensis* (*nipa* palm) while introduced species include *Artocarpus* sp. and *Eugenia malaccensis*.

Palau also has useful food plants which include wild figs, bamboo shoots, malay apple (*Syzygium* ?), *Derris* sp., *Barringtonia asiatica*, *Pandanus* sp., Palauan hibiscus *Abrome molle* and tropical hardwoods such as *Intsia bijuga* and *Eugenia reinwardtiana* (Osborne 1966). In disturbed / exposed sites *Dicranopteris linearis* is common and *Semecarpus venenosus* is common in the forest. The cultivated plants include taro, sweet potato, coconut, breadfruit, lime, orange, pineapple, bananas, melons, passionfruit, sugarcane, arrowroot, yams and areca palm (betel nut). Babeldaob and Koror also contain extensive mangrove ecosystems dominated by *Rhizophora*, *Sonneratia* and *Bruguiera* species.

Palau archipelago lies at the intersection of three ocean currents which bring nutrients that attract a variety of marine creatures. Palau supports more corals, fish and other invertebrates per unit area of marine habitat than any other on earth (Maragos 1992). An estimated 700 coral species and 1,400 species of reef fishes have been recorded from the waters of Palau. In 1992, 80 new records of reef fishes were reported. Over 400 stony corals and 200 soft corals are also recorded from Palau (Maragos 1992).

Apart from reef fishes and corals a number of important higher vertebrate fauna are present in Palau. These vertebrate fauna include breeding populations of dugong, saltwater crocodile, green sea turtles and hawksbill sea turtles. All of these vertebrates are listed as endangered or threatened by the United States Fish and Wildlife Service.

Palau has a rich avifauna which consists of 141 species of birds. Ninety-one of these are migratory and do not breed in Palau, while 50 species are considered to be resident, meaning they nest in Palau and are present year-round (Engbring 1988). Of the 50 resident birds, 14 are seabirds and 36 are land or wetland species.

The Micronesian megapode *Megapodius laperouse* is rare and has been listed on the United States Endangered Species List. Eight species of birds are endemic and include the Palau ground-dove *Gallicolumba canifrons*, the Palau fruit-dove *Ptilinopus peleuensis*, the Palau owl *Pyrroglaux podargina*, the Palau flycatcher *Myiagra erythroptera*, the Palau fantail *Rhipidura lepida* and the Palau greater white-eye *Megazosterops palauensis*.

2.5 Oceanography

Little information was available to the team members during the visit about the oceanographic conditions of the Palauan waters. However information from other sources suggest that the Republic of Palau experiences a semi-diurnal tidal regime and a mean tidal range of one meter (USGS 1984). The only documented sea-surface temperature of 25°C is available from Ngeremeduu estuary which was recorded on August 15 1989. Satellite data and ship reports routinely give sea-surface temperatures.

Salinity of water for seven locations within Ngeremeduu Bay recorded on the same date suggests a mean salinity of 31‰ at the surface and 33‰ at three meters below the surface (Birkeland *et al* 1990). High diversity of reef fishes and coral species indicates favourable oceanographic conditions but further systematic research is needed to support this hypothesis.

There is very little published information on the water quality and circulation patterns of the Palauan waters. Palau experiences a semi-diurnal tidal regime. Extreme low tides occur during the year and can expose the shallow coral on the fringing reef. Heavy rains and flooding are considered to be a threat to this fragile ecosystem as the rains may cause coral bleaching and die-back (Thomas and Holthus 1989). The possibility of serious water-borne pollution in and around the inhabited Palau islands is high due mostly to solid waste disposal and the increase in shipping.

3. Social and Economic Environment

3.1 Historical antecedents

The main islands of Palau were originally settled from the Philippines and western Indonesia between 2000 and 3000 BC (Hezel 1983), while most of the outer islands were settled from the east during the first millennium BC as part of a wave of colonisation from the Marshall Islands and Kiribati. The volcanic islands of Palau provided a natural setting for subsistence agriculture, based on wet-taro cultivation, which was supplemented with the richness of inshore marine resources. In contrast, the Southwest islands were limited in their agricultural productivity by the coralline nature of their environment. People relied on marine resources for their livelihood.

In pre-contact Palau, a complex village-oriented matrilineal system developed where social position, inheritance, residence and land was derived through the women, but power was yielded by the men. While a single chiefdom inhabited the smaller island units, the large island of Babeldaob was divided between several chiefs. Although Palau society has changed significantly over time, traditional customs continue to play important roles in both daily activities and the politics of modern-day Palau.

The transformation of Palau from a traditional subsistence economy to a modern cash economy is a result of inevitable changes which occurred throughout the world. However, the involvement of foreigners in Palau over the last century has been dramatic. The sheer size of the population and the destructiveness of particular activities associated with various administrations of Palau, provide an important context within which to review the contemporary environmental situation in Palau.

3.2 Discovery and foreign rule

In just under 100 years, Palau was ruled by the Spanish (1886-1899), the Germans (1899-1918), the Japanese (1918-1945) and finally the United States (1945-1981) as part of the Trust Territories of the Pacific Islands. Even since the adoption of its own constitution in 1981, the internally self-governing Republic of Palau has yet to resolve its future political status independent of the United States. The changes wrought by each different external administration over this last century as well as the effects of the World War II, have had wide-ranging effects on Palau's economic, social, cultural, demographic and political systems. These in turn have affected Palau's natural environment.

Brief contact was made by Spanish and British explorers in the sixteenth century. However extended contact did not begin until the eighteenth century with Spanish and British missionaries and traders (Peacock 1987). By mid-nineteenth century many of the marine resources of interest to Europeans were no longer as easy to collect or may have been completely depleted, so the trading emphasis shifted elsewhere in Micronesia. Despite having its authority recognised internationally, Spanish activity was minimal and its hold on the area tenuous (Force and Force 1972).

Germany took over the administration of Palau following Spain's defeat in the Spanish-American War in 1899. Under German rule commercial activities based on Palau's natural resources expanded; phosphate was mined on Angaur, bauxite on Babeldaob, pearlshell and trochus was collected and copra production grew. Although most daily administrative functions stayed in the hands of native chiefs, all decisions were made by the German administration. In addition, the Germans built roads, conducted studies and in general attempted to improve the lives of native residents.

When Japanese authority over the region was recognised by the League of Nations following WWI, a massive transformation was set for Palau. Koror became the administrative centre of Japan's efforts in Micronesia, and by the mid-1930's was a busy modern colonial town. In addition to the growth of administrative services, agricultural development on Babeldaob was supported, mining on Angaur continued and blacklip pearlshell was almost depleted (Cassell *et al* 1992).

Migration was actively promoted under Japanese rule so that by 1928, 88% of Palau was alienated state land leading to a contemporary crisis in land claims. Only six percent of the approximately 18,000 lots have been issued certificates of title which provide Palauans with secure legal title to their land (Nakamura 1993). By 1940 an estimated 20,000 Japanese were living in Palau, mostly in Koror. Throughout Micronesia, the Japanese outnumbered native Micronesians, growing in number from 220 in 1921 to 51,861 in 1935 whereas the number of Micronesians grew from 48,505 to 50,573 during the same period.

In their haste to establish a transplanted Japanese economy and society in Micronesia as a strategic stepping stone into the Pacific, the Japanese overlooked the Palauans. Traditional chiefs were ignored, having no part in the running of the country. Few Palauans worked in the sizable government bureaucracy or the small businesses that mushroomed during this period. Most people remained in villages as subsistence gardeners or making copra and were charitably permitted to acculturate or die out gradually as long as they did not interfere with more important affairs (Oliver 1961).

After the first decade in Micronesia, the Japanese administration shifted their interest from economic projects to military concerns and began fortifying several islands in the region, including Palau. Although the main military build-up occurred elsewhere in Micronesia, Koror was bombed throughout 1944 destroying the town and forcing the Japanese administration to shift to Babeldaob. By early 1945, Japanese forces had been defeated and survivors faced a period of hardship obtaining adequate food and health care.

At the end of World War II all Japanese settlers were repatriated to their homelands (Scarr 1990) and Palauans were left with all their life-savings gone (having invested in Japanese banks), depopulated reefs, slaughtered livestock, and no income sources (Oliver 1961).

The United States Navy administered Japan's former Micronesian possessions immediately following WWII and until 1947 when the United Nations placed them under the Trust Territory of the Pacific Islands (TTPI), with the United States as the administering authority. Until the 1960's, the TTPI did not see major aid funds, although health and education services were extended.

Established to promote the economic advancement and self-sufficiency of its inhabitants, the TTPI was also considered essential to the United States, for security reasons (Scarr 1990). As part of the TTPI, Palauans prospered. However, long-term dependence on the United States was inevitable, as beginning in the 1960s, massive sums of aid began pouring into the region. By the early 1960s, internally generated revenue, mostly copra and fish, comprised less than a third of the United States government aid, which had reached half a million dollars (Scarr 1990).

In the political quagmire which characterises the last two decades (for example see Cassell *et al* 1992), Palau seems imminently poised to agree on a *Compact of Free Association* with the United States, worth several million dollars in aid funds. In 1992 a provision in the constitution was made for a simple majority vote to change a clause which forbids nuclear arms in Palau to be overwritten in favour of a formalised economic relationship with the United States. Before the end of 1993 the Republic of Palau may well have taken another plebiscite towards becoming a sovereign country.

3.3 Historical population trends

Population trends in Palau have followed a general pattern seen elsewhere in the Pacific: an early period of depopulation up to the end of the last century following contact with foreigners; a period of population growth and recovery during the middle of the century supplemented by massive immigration of non-Palauans in the 1920s and 1930s; and finally a modest growth in the last three decades, due partly to low fertility but also to the emigration of young people.

When first "discovered" by the Spanish in the sixteenth century, Palauans were estimated to number somewhere between 25,000 and 50,000 (Scarr 1990). Incessant warfare between neighbouring chiefdoms during traditional times kept population levels stable, but it is likely that contact with diseases introduced by outsiders such as traders, sailors and missionaries decimated the population such that by the beginning of the twentieth century the population of native Palauans numbered less than 4,000.

By 1901, the population of native Palauans was 3,748, about 4,321 in 1908 and 4,543 in 1914 on the eve of Japanese rule (Office of Planning and Statistics 1993). By the 1920s the population of native Palauans appeared to have declined further to "about 3,000" (Department of State 1993).

During the years of active immigration under Japanese rule the resident population of Palau swelled, although historical census counts exclude foreigners (e.g., Office of Planning and Statistics 1993). Nevertheless, it is clear that population levels in the 1920s and 1930s were historically high due to immigration, were concentrated in Koror, and may well have exceeded current levels.

The direct impact of these historically high population densities on the urban environment in terms of solid and liquid waste disposal as well as the extra demand placed on terrestrial and marine resources is largely undocumented. However, it is likely to have attributed to the depletion of particular marine resources like pearl shell and trochus and may even have contributed to the expansion of grasslands now seen on Babeldaob, because of consumer demands for agricultural produce.

3.4 Recent population trends and health status

The long term growth rate for Palau, from 1970-1990, was just under one percent, although the average annual growth rate for the decade 1980-1990 was 2.2 percent (Table 1). However, the 1990 census recorded 15,122 people in Palau which is a 1.7 percent annual growth rate from the 1986 census Fig. of 13,873. These latest figures indicate that population growth may be stabilising which would be consistent with other countries in the Pacific such as American Samoa, Guam, Niue and the Cook Islands.

The total dependency ratio in Palau is 57 which is not high compared to other countries of a similar size in the Pacific such as Cook Islands (72), Wallis and Futuna (88), but it is higher than the Northern Marianas (32) and Guam (51).

Table 1. Population: size and growth, 1970-1990

Year	Size	Average Annual Growth Rates
1970	12,525	1970-80 -0.3
1973	12,673	1980-90 2.2
1980	12,116	1986-90 1.7
1986	13,873	1970-90 0.9
1990	15,122	

(Source: Office of Planning and Statistics 1993)

According to Taylor *et al* (1989), the population of Palau has almost completed its demographic transition from high mortality and fertility to low mortality and fertility. This means a relative stability in the size of the population, with migration being the major factor determining future population levels.

Currently there is some concern about the increase in number of Filipinos entering the country. This immigrant population is also thought to be having an impact on inshore marine resources, with a pattern of reef gleaning which is more exhaustive than the local pattern. Another population movement of concern in Palau is a "brain drain". The Government is actively trying to attract home those educated Palauans who are currently living abroad (Office of Planning and Statistics 1993, Nakamura 1993).

Compared to other Pacific Island countries, and especially in Micronesia, Palau has a relatively healthy population with low infant mortality rates, a key indicator of health status (Table 2). The Republic is well served with dispensaries dispersed through the country, community health centres providing primary care, two private medical clinics and a new national hospital in Koror, as well as an efficient referral service to Guam and Hawaii. Although there are no outlying aid posts, there is a generally accepted belief that people seek medical care at hospital.

Table 2. Comparative vital statistics and health indicators for Palau

Country	Crude Birth Rate ¹	Crude Death Rate ¹	Infant Mortality Rate ²	Life Expectancy	Year
Palau	25	7	26	69	1989
Cook Islands	24	5	25	67	1989
Marshall Islands	49	9	57	61	1988
Kiribati	29	9	65	60	1990

Notes: 1. Per 1000 population.

2. Per 1000 live births.

(Source: South Pacific Commission 1993, Department of State 1993.)

Currently about 96% of all births occur in hospital, resulting in low infant mortality and subsequently high life expectancy. Vital statistics appear to be of good quality and coverage and importantly have a useful time-depth. Major health problems are related to diseases of modern developing countries, with a current screening of diabetes and hypertension resulting in between 15% and 20% of Palauans being identified as requiring treatment (Nakamura 1993).

However, there is a high proportion of elderly people (Office of Planning and Statistics 1993) which is also reflected in the high incidence of health conditions suffered by older people, such as diseases of the genitourinary system (TTPI 1992).

3.5 Settlement

Palau's population is not evenly distributed (Figs. 3 and 4) with a concentration in Koror State. Koror State has been home to the greatest number of residents for most of this century, comprising 60% of the nation's total population in 1990.

However, in the last decade the growth of Koror seems to be stabilising (Office of Planning and Statistics 1993). Although the high population density of Koror makes the delivery of public services relatively efficient, there is now a shortage of land for a new sanitary waste disposal site and adjacent States are not willing for their land to be used for such purposes. In addition, overuse of the landfill site is affecting the foreshore, both through leaching of waste material and direct contamination.

Other informal waste disposal sites are also located on the coastal zone, with similar problems for marine resources, especially the mangrove ecosystem.

Since 1979, Koror has been connected to Babeldaob island by a 235m long cantilever bridge. A network of roads covers Koror and the southern part of Babeldaob and the current road construction programme is extending the road network rapidly. Causeways have been constructed linking Malakal, Ngermalk, Koror and Arakabesan as well as between other smaller settlements on Babeldaob. Access to other islands and most coastal villages on Babeldaob still is by boat.

By extending the main road further into Babeldaob, it is hoped that more Palauans living in Koror will rekindle links to their villages and perhaps even encourage some to live in villages and commute to work in Koror (Nakamura 1993). The low lying causeways which extend Koror's functions as the capital onto adjacent islands are subject to inundation and erosion and require on-going maintenance with, inevitably, detrimental effects on nearby mangroves and other coastal resources (see Plates 3 and 4).

Given the small land area of Koror (9.8km²), causeways are necessary but they are vulnerable to extreme climatic events and carry with them the risk that critical functions may be detached from most of the population at a time when links are most needed. For instance, the Belau National Hospital, the Office of the President and the Communications Centre are all located on Arakabesan Island, linked by one causeway to Koror. Further north, two causeways and the Koror-Babeldaob bridge link the three islands which connect Palau International Airport to Koror.

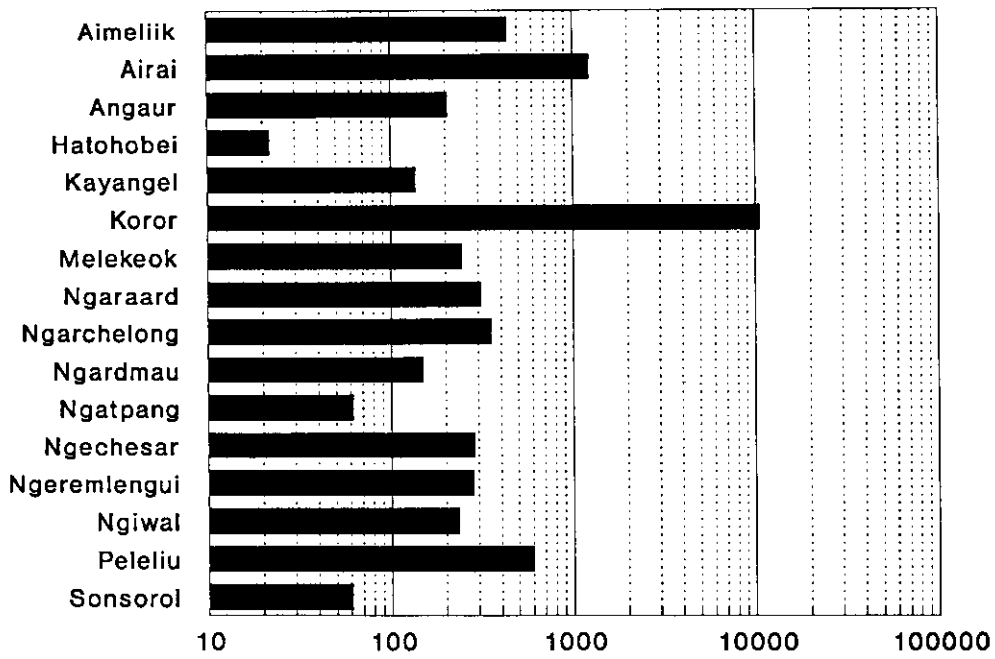


Fig. 3: Population by state in Palau, 1990.

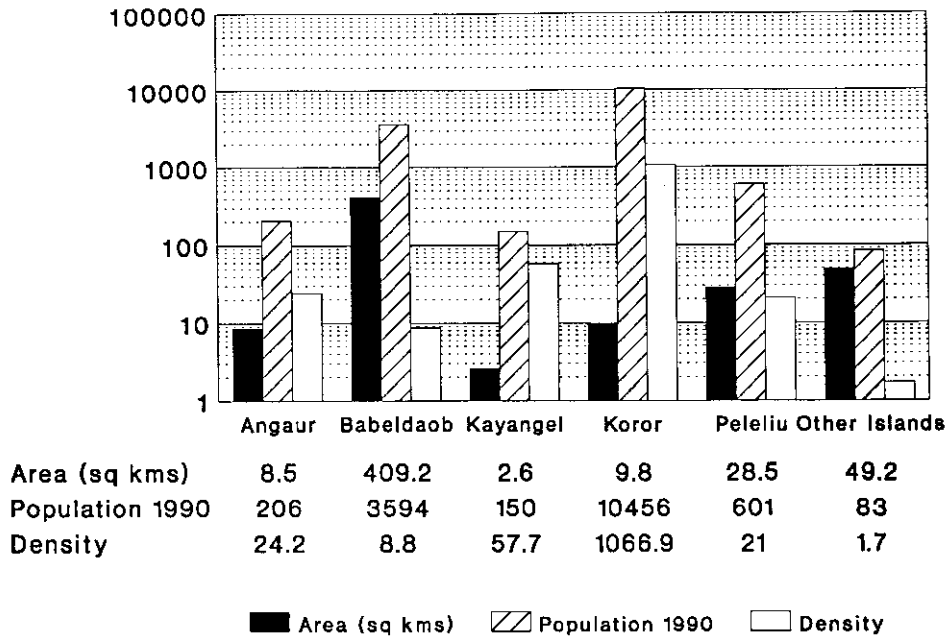


Fig 4.: Population and density by main islands.

(from Cassell 1992)

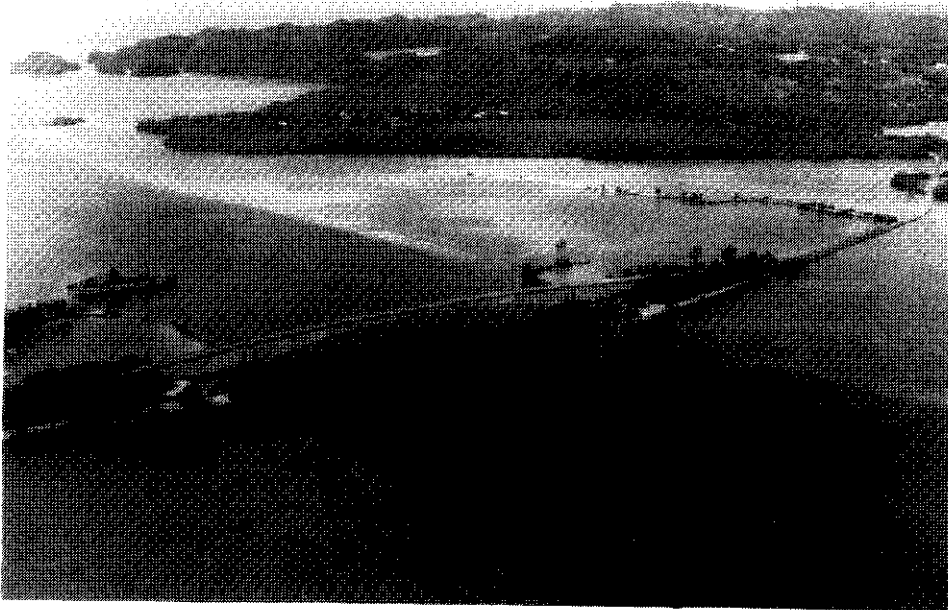


Plate 3: The 235 m-Koror-Babeldaob cantilever bridge.



Plate 4: A network of causeways connecting Koror to nearby islands. In the foreground (bottom right) is Arakebesan Island with Belau National Hospital, the Presidential residence and Palau Telecom. Ngermalk and Malakal wharf are top centre.

3.6 Land use and resources

More than 75% of the Republic of Palau is still in forest, much of it being upland forest and mangrove on the island of Balbeldaob. A further 20% is non-forest, most of which is grassland; the remaining land area consists of secondary vegetation and agroforestry (Cassell *et al* 1992), as seen in Table 3.

Table 3. Distribution of major land use types in Palau

Land Use	Area (km ²)	Percentage of total land area
Forest	312	75
Secondary Forest	7	2
Agro-forest	11	3
Non-forest	85	20
Total area	416	100

(Source: Cassell *et al*, 1992)

Cassell *et al* (1992) provides a comprehensive summary of the resources of the Republic of Palau. Their discussion includes a description of the cultural, historical, archaeological and natural resources of Palau, as well as an assessment of their value, status and management. Rather than attempt to summarise this excellent material, we suggest it should be read in its entirety. The following sections, however, focus on sectors which were highlighted in our discussions with national counterparts on Palau as requiring particular consideration.

3.7 Historical and cultural sites

The Republic of Palau is richly endowed with a valuable historical and cultural heritage spanning 4,500 years of settlement. Archaeological sites are found throughout the Republic and relatively recent relics from WWII are also abundant. There is an active attempt, under Palau Historic Preservation Programme to ensure that Palau's heritage is preserved in the face of the inevitable increasing contact with foreigners. Both cultural sites and knowledgeable elders are considered national treasures.

Naturally occurring environmental changes threaten the physical heritage, such as burial places, but also plants used in traditional medicines. This is especially so, since many cultural sites lie on the coastal fringes of the Palau islands or, in the case of WWII relics, in the sea itself.

The Division of Cultural Affairs is in the process of establishing an extensive database of registered cultural sites which developers, tourists and future generations will be obliged to protect. There is strong external support for this programme and more local States are passing legislation to preserve their cultural heritage.

3.8 Economy and development

Palau is now almost a full cash economy, displaying many signs of a modern society. Cars abound, domestic energy generation is growing, as is the incidence of social problems associated with modern societies, such as alcohol and drug abuse. Fisheries production for 1992 was valued at US\$857,000, most of which came through the sale of assorted reef fish (Department of State 1993). The export of tuna to sashimi markets in Japan was also sizable, while US\$37,000 was generated from fishing rights fees (Nakamura 1993).

Domestic agriculture production for 1992 was worth just over US\$500,000, most of which came from the production of eggs (Department of State 1993). Tourism sector attracted over 36,000 visitors in 1992 (Nakamura 1993).

Taro gardening, farming and fishing are now supplementary rather than a subsistence activity for most households. Only 11% of the economically active population is engaged in traditional or commercial agriculture and fisheries (SPC 1993). Despite its relative insignificance in the national statistics, farming and fishing are major activities which make an unknown contribution to the local consumption, and have cultural and social importance.

The economy of Palau is heavily dependent on budgetary aid from the United States of America. In 1990, 40% of the total government revenue was derived from US budgetary aid, which was an increase of 35% on the 1991 appropriation (SPC 1993). As a result, Palauans experience a comfortable standard of living as reflected in a relatively high GDP per capita of US\$3,564. This is higher than FSM (US\$1,717), but lower than Guam (US\$12,374) and the Commonwealth of the Northern Mariana Islands (US\$12,851). Sixty-four percent of the GDP is derived from the wholesale and retail trade sector with half of the economically active population absorbed in the service and the construction sector (SPC 1993).

Future economic development rests on three main platforms: tourism (see Plates 5 and 6), the exploitation of marine resources (see Plate 7) and the establishment of a sound physical infrastructure which would encourage private sector development and foreign investment (Nakamura 1993). Currently a National Master Plan is being developed for Palau. This is expected to provide the long-term strategies for the achievement of economic self-sufficiency built upon these three sectors and led by private sector investment.

The physical environment of Palau is critical to the success of future economic development. Thus, the success of tourism rests on preserving the pristine and unique features of Palau's environment while also making the islands accessible to and comfortable for foreign visitors.

Sustainable marine resource development, especially of inshore fisheries, is also directly dependent on a healthy physical environment, especially with the growing competition for these resources by different sectors of the population, ie local restaurants, exporters and recreational users.

Palau's Exclusive Economic Zone (EEZ) generates a sizable income, but faces a credibility problem because of local resentment over the lack of direct economic returns or benefits to Palau (Cassell *et al* 1992). The mariculture industry is a example of the ability of the marine resources sector to establish a viable, though small, foreign exchange earning activity. Revenue from the export of the giant clams reached US\$122,000 in 1990 (Cassell *et al* 1992).

The development of an efficient physical infrastructure including roads, water and sewage facilities also makes demands on the physical environment. Balancing the need for economic growth with the minimum of environmental destruction is an everpresent concern. Long-term climatic changes and expected sea-level rise add another dimension to such considerations, but have yet to be seriously addressed in this context.

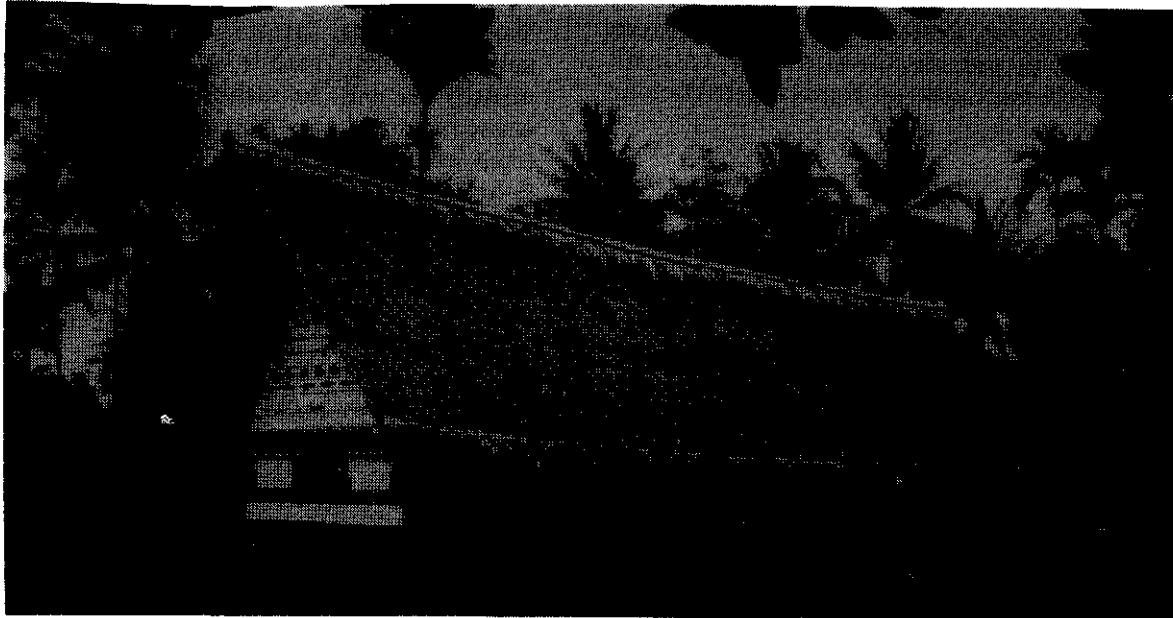


Plate 5: A traditional bai - a tourist attraction at Airai.



Plate 6: Palau Pacific Resort provides first class hotel accomodation for tourism.

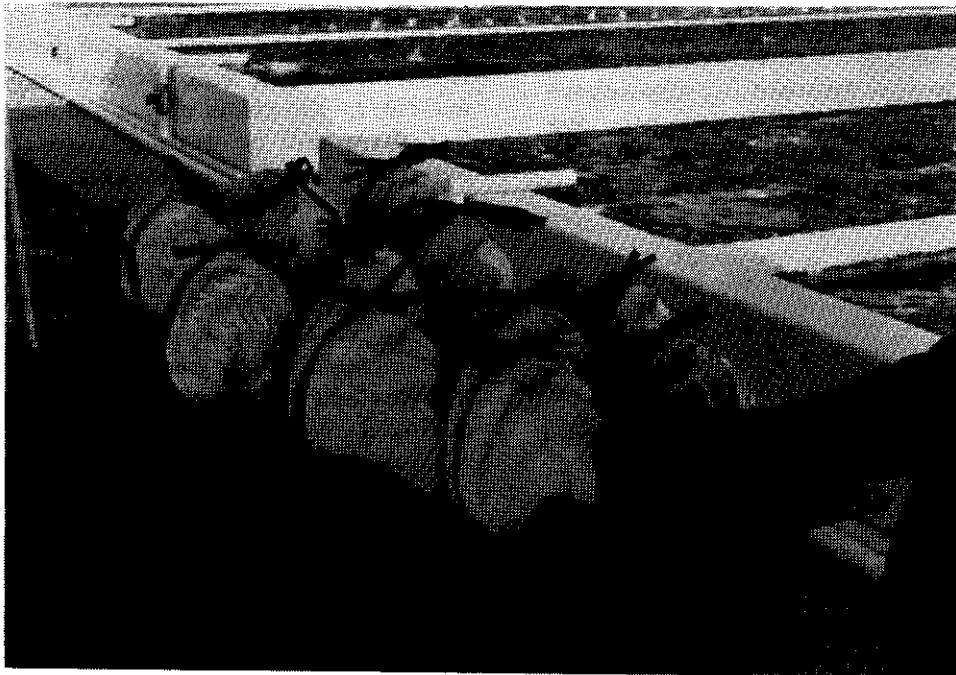


Plate 7: Giant clams and clam culture ponds at the Micronesian Mariculture Demonstration Centre, Malakal.

4. Climate Change and Sea-Level Rise: Relevance to Pacific Nations

Climate change is not a new phenomenon. However, the reason it has become a global concern now is because the climate is changing faster than in the past. This greater rate of change is hastened by human activities which involve the burning of fossil fuels and the production and use of chlorofluorocarbons (CFCs). When released into the atmosphere they destroy the ozone layer.

Ozone is partly responsible for protecting life systems on the earth's surface. Thus the depletion of the ozone layer will lead to increases in temperatures which in some situations will be constructive, and in others, they will be destructive.

Perhaps the most important "greenhouse gas" is carbon dioxide (CO₂). Carbon dioxide is emitted from the burning of fossil fuels and destruction of tropical rainforests by slash and burn agriculture, logging, construction and simply removal of forest cover, all of which contribute to global warming. It is estimated that CO₂ will contribute at least 50% to projected global warming. This will result in an increase in global mean temperature of 2°C above pre-industrial values by the year 2025. The increase in temperature will not only affect the energy exchanges between the atmosphere and ocean, but also will increase the temperature of the water column thereby affecting the level of the sea.

Current estimates by the Intergovernmental Panel on Climate Change (IPCC 1992) suggests that, on a global average, the sea-level will rise at a rate of six centimetres for every 10 years for the next 100 years. This means that by the year 2030 the sea level will have risen by 20cm or 0.6m by the end of the next century.

The projected rise in sea-level is not only a result of the greenhouse-forced climate change but also of other physical factors. Mclean (1993) gives a comprehensive summary of the relative sea-level changes which result from a complex interaction of climatic, oceanographic and lithospheric factors at global, regional and local scales. He argues that in the Pacific region variability in sea level is perhaps the most important consideration for the island populations, economies and environments, rather than secular change in sea level.

Sea level variability can be driven by glacio-eustatic, tectono-eustatic and geoidal-eustatic changes and therefore present, a complex array of interacting factors which need to be isolated if one is to understand the full impact of climate change and sea level rise.

The projected increase in sea level does not necessarily mean that the seas around Palau will rise by the global average of 20cm by 2030. But there will be some changes in weather patterns (rainfall, drought, temperature, cloudiness), sea level, tidal ranges and sea surface temperatures which will affect both natural and socio-economic structures, processes and activities. Thus climate change and the consequent sea level rise are long term phenomenon which need to be incorporated into strategic planning for both the natural and managed environment.

5. Vulnerable Components of Natural and Socio-economic Environments

Palau has few immediate signs of severe environmental damage. However, there is no room for complacency because many vulnerabilities are evident. Vegetation is changing with changing land use practices and new technologies. In particular, mangrove forests are damaged by the growing intensity of coastal developments such as roads, causeways, tourist resorts, and solid waste disposal sites. Because of the key role of the mangrove ecosystem to other marine species, the loss of mangrove habitat is a major environmental problem. Local fishermen are also noticing changes in the near shore fishing resource such as fish appearing out of season (Abel Zuzuki pers. comm. 1993). This could be caused by many factors and requires closer investigation.

Most of the threats are anthropogenic. Naturally induced changes are inevitable but on their own they are not likely to cause lasting damage. However, combined with human induced changes like the increasing silt load due to road construction or landfill activities and forest removal, major problems such as damage to coral reef systems and the shoreline are very likely to occur. If climatic change and accelerated sea-level rise are superimposed on this, the problems are magnified further. Because it is difficult to intervene in naturally occurring events, the focus must necessarily be on ensuring that social and economic developments cause the minimum damage.



Plate 8: Solid waste disposal near mangrove forest, Airai State, Babeldaob.

6. Current Environmental Management Problems

A number of environmental problems were identified in the course of our visit as posing major threats to the physical and natural environment and social and economic structures of Palau. None relate directly to the impact of impending climatic change and consequent sea-level rise but all would be exacerbated by such phenomenon.

6.1 Dredging

Dredging poses the biggest threat to benthic marine communities around the main Palauan islands of Koror and Babeldaob and is currently seen as the major environmental problem. It is carried out for two main purposes; for landfill activities especially on the island of Koror, and for road construction and maintenance. Dredging also threatens the historical and or cultural resources which include burial sites and sacred platforms on land, sacred fishing grounds and underwater relics from WWII.

Currently dredging is carried out in a number of sites on Babeldaob such as Ngermetengel, Ngaraard and Ngchesar, for national and state road materials with little regard for the impact such activities have on the immediate environment or for any downstream effects which may result. Birkeland *et al* (1990) suggested that little care was taken to reduce the effects of dredging at Ngchesar. Sediment screens or siltation curtains were not used. In addition a leakage of a gasoline drum lying on the nearby shore covered at least 2,000m² of the shoreline. Siltation of the reef substrate at the Ngaraard dredge site may be attributed to dredging activities.

6.2 Solid waste disposal and sanitary landfill

Solid waste disposal is the other major environmental problem, especially on Koror. Currently disposal has been by a process of landfill, but this is becoming environmentally unsafe as the quantity of material has grown.

Increasingly material is washed into the sea at high tides. The current landfill site in Koror is close to capacity and poses a potential health hazard if it continues to be used. Attempts have been made by the State Government to secure land on the island of Babeldaob, but the people of Babelodaob do not want to be recipients of garbage from Koror. The search for a new site for a sanitary landfill continues.

6.3 Potable water shortage

The shortage of potable water is an acute problem, not only in the northeast and southwest islands of Palau, but also in Koror. The freshwater lens occurs beneath the low coral islands of Angaur and Peleliu. It is estimated that these underground water reserves could hold about 1,000,000 gallons of water per day (US Army 1956).

Surface water is restricted to the islands of Babeldaob and Koror. Much of the freshwater reserves on low coral and high limestone islands are subject to sea water intrusion, which creates brackish conditions. The potable lens of freshwater in the northeast atoll of Kayangel is small and brackish because it is at sea-level (US Army 1956). Groundwater reserves on low lying islands depend on the tidal range, local geology and geomorphology. Extensive local assessments are required to establish groundwater potentials and their vulnerability.

6.4 Deterioration of coral reef and marine resources

Due to their small size, oceanic character and geographic position, the islands of Palau support more corals, reef fishes and other invertebrates per unit area of marine habitat than any other locality on earth (Maragos 1992). This biodiversity is under threat by a deteriorating marine environment and overfishing.

Over-harvesting of shell-fish and over-fishing of fin fish are reducing stocks rapidly and affecting other coastal resources. For example, the North Coast of Koror and Ngesaol, which is frequently used for fishing and collection of seafood by a growing number of residents of Koror who do not have boats or vehicles that would allow them to go to more distant areas, is highly vulnerable. Although no effects have yet been identified it is likely that continued uncontrolled harvesting and fishing in these areas will deplete its marine resources (Birkeland *et al* 1990).

The development of resorts, causeways, a commercial port and fisheries wharf in the coastal zone of Babeldaob will also have serious effects on the coral reef and mangrove ecosystems. The construction of a major road in Babeldaob and soil erosion associated with forest clearance will also increase the sedimentation of coastal waters. This will have detrimental effects on coral reefs and other marine resources.

Rare breeding populations of sea turtles, dugongs and crocodiles are under the greatest threat as a result of the deterioration of the coastal area but they are also threatened by over-fishing by local fishermen and commercial enterprises. The rare populations of hawksbill turtle and green turtle have been placed on the endangered species list and could be exterminated if over-fishing continues (Maragos 1992).

6.5 Marine pollution from fisheries boats

At present, there is no specific legislation in the Republic of Palau that controls the disposal of solid waste and oil spills from fishing boats in and around the waters under Palau's jurisdiction. Consequently marine pollution occurs unchecked. In addition, under the United States Environmental Protection Agency laws which are exercised through the Republic of Palau's Environmental Quality and Protection Board (EQPB), there is limited control over fish poaching by distant water fishing nations. Palau-specific legislation is required to fully assert the control of fishery-related environmental problems.

6.6 Disposal of septic waste

Septic waste from Koror goes directly into the sea south of Malakal. Sixty-five percent of septic waste is treated and 35% is untreated waste. Regular water quality tests are carried out in Malakal. A resurvey of septic waste disposal site in 1990 indicated no damage to coral reef substrate. This suggests that the natural dilution of the toxicity and turbidity of the septic waste by sea water has occurred (Birkeland *et al* 1990). No other islands have sewage treatment facilities and this is seen as a major problem on atolls and low coral islands where freshwater reserves in lens could be contaminated.

6.7 Drought and storms

Variability in weather patterns and climate extremes such as drought, tropical storms and typhoons due to ENSO events threaten all low lying oceanic islands like Palau. The unusually high tide which lasted several days in 1988 and the drought in 1983 had a marked affect on the taro patches on most islands and the potable water supply in Koror. Climatic variability, and the possible increased frequency and intensity of storms not only damage Palau's shoreline, shallow reefs, seagrass beds, beaches, mangroves, estuaries and rivers but also damage the physical infrastructure and socio-economic activities, causing major economic problems.

7. Institutional Arrangements

The Republic of Palau currently has an institutional structure in place for protecting the environment. However, this structure requires more support, particularly in terms of more people to enforce or monitor laws and for undertaking community awareness and education programmes. The favourable institutional context for environmental protection provides an implicit means by which the effects of global climate change and impending sea-level rise can also be managed.

7.1 Legislative framework for environmental management

Apart from the use of administration and enforcement of the mandates of the US Environmental Protection Agency in managing the environment, the Republic of Palau is in the process of developing its own laws for environmental management, conservation and to ensure maintenance of environmental quality.

The two organisations which are charged with the responsibility of ensuring and maintaining environmental quality and the conservation of natural, physical, socio-cultural and human resources are the Bureau of Resources and Development (within which are the Division of Conservation and Entomology, the Division of Marine Resources, the Division of Cultural Affairs) and the Environmental Quality Protection Board (EQPB). There is strong recognition of the need for clear regulatory measures to ensure that the environment is managed sustainably. However, legislative mechanism will fall short of these expectations without the necessary financial commitment.

7.2 Bureau of Resources and Development

The main programmes of the Bureau include developing rules and regulations for resource management, working with US Federal Agencies on Palau law and resource management issues which conflict with US law under which Palau is still bound, designing and implementing a conservation education programme and providing assistance to non-profit groups in Palau such as The Nature Conservancy. In the future, a major priority will be to enforce modern and traditional conservation laws.

7.3 Environmental Quality Protection Board (EQPB)

The EQPB is the major environmental protection and management agency charged to ensure that the quality of the human environment, the air, soil and water of the Republic of Palau are protected.

The major programmes of the EQPB, which are often undertaken in association with other relevant agencies, include developing regulations on activities which affect environmental quality, monitoring water quality throughout Palau, evaluating and monitoring permits for earth-moving and dredging, managing solid waste disposal, controlling and monitoring pesticide use, monitoring village environmental health, and reviewing building permits. Future priorities include establishing a public environmental education programme, coastal zone management planning, and input into the Palau Master Plan. Other organisations involved in the development and management of natural and socio-cultural resources are outlined in Annex Two.

8. Recommendations

Any in-depth study of climate change in Palau should be placed within the context of on-going environmental programmes and the National Environmental Management Strategy which has been developed with the support of SPREP and the University of Oregon Micronesia Programme. We found little support within the country for separate programmes that look specifically at impending climate change and sea-level rise. However, continued monitoring of the atmosphere-ocean interface, and more information on the science of climate change oriented to the lay-person would be welcomed in Palau. In particular, the latter could be easily fed into current environmental education programmes, which are very successful.

The following recommendations are based on the strategy of improving Palau-specific information on impending climate change and sea-level rise, continued surveying and monitoring of resources, supporting current environmental initiatives, especially environmental awareness programmes, and integrating longer-term environmental management into current social and economic planning. The recommendations aim not only to monitor current and potential environmental problems but to enable the development of minimum sets of data related to climate change and consequent sea-level rise.

8.1 Research and monitoring of ocean-atmosphere system

At present the Republic of Palau has no research and monitoring programme to examine the dynamics of the ocean-atmosphere system as it affects the Palauan archipelago. All climatic data recorded in Palau is sent to NOAA in Hawaii and is therefore controlled by NOAA. There is only one automatic weather station (AWS) located in Koror and four rain gauges, one in Peleliu, two in Koror and one in Babeldaob. Two tide gauges are currently in use as part of the TOGA-COARE project located at Malakal. Tide records are automatically transmitted to the University of Hawaii in Honolulu.

Palau has little capacity to analyse all the information relating to climate within the country. A local person with some scientific and technical background needs to be trained for this task so that total dependency on the US National Weather Service in Guam can be reduced. This will not only increase local application and interpretation capability, but will also increase climate data development and handling capability. The appointment of such a person will also remove periodic communication mishaps caused by failure of the communication system between Palau and Guam. This causes difficulties in maintaining continuity of information.

Any climate research and monitoring programme in Palau should include a training component so that skills in research and the handling of monitoring tools and machinery, as well as data handling, presentation and interpretation skills, can be developed.

Recommendation One:

- a) *that in-depth study of climate impacts and the long-term research and monitoring of climate change and sea level rise should be undertaken and include measurement of sea surface temperatures (SST), salinity, turbidity, air temperature and density of water masses in and around Palau.*
- b) *that a local person be trained and that office space and equipment be provided to allow development, interpretation and application of Palau-specific data.*

8.2 On-going marine and terrestrial resource surveys, monitoring and management

Palau is ahead of many other Pacific island nations, in terms of reconnaissance-level and fixed-time appraisals of selected marine resources. Since 1990 the Bureau of Resources and Development, National Marine Fisheries Service and SPREP have carried out surveys of sea turtles, corals, reef fishes, invertebrates, seabirds, crocodiles and dugongs. Over 150 marine sites were surveyed as part of a Rapid Ecological Assessment for Palau in 1992 and other baseline surveys at Ngerukewid Island Preserve (Maragos 1992). Such rapid surveys of selected marine resources are important because they provide baseline data for further monitoring work.

In 1990, the University of Guam Marine Laboratory, the EQPB, East-West Environment and Policy Institute and SPREP carried out coastal resource surveys of 15 different sites at the request of the government of Palau (Birkeland *et al* 1990). This study provided comprehensive baseline data for all the sites. These are frequently used for fishing and harvesting of seafood.

Recommendation Two:

- a) *that the populations of sea-turtles, dugongs, reef fishes, corals, trochus and giant clams be surveyed to develop management programmes.*
- b) *that the research and monitoring programme based on the 15 sites surveyed in 1990 be extended to cover terrestrial resources to provide information on changing demands and resource use arrangements. The Southwest Islands, Kayangel, Peleliu and Angaur need to be included in such surveys.*

c) *that the current resource management programmes such as the Historic Preservation Project and the Marine Resource Management Programme, currently under review by Marine Resources Division, be supported fully so that long-term monitoring and management can be realised. The support should involve allocation of funds to increase the number of people working on the project and for the costs of equipment and transport operation and maintenance.*

d) *that an integrated coastal zone management programme be developed within the Master Plan to ensure that minimal damage is done to the coastal zone through onshore development.*

8.3 Strengthening and enforcing environmental legislation

Although there is some progress being made on developing Palau legislation which will allow for sustainable development of natural resources, monitoring and enforcing such legislation will be difficult. More resources are needed to ensure that environmental impact assessment and planning are undertaken, especially with regard to protection of endangered species against dredging, fishing and road building activities.

Recommendation Three:

- a) *that enforcement of the by-laws governing the protection of endangered species, over-fishing and poaching, and marine pollution from fishing boats is enhanced through the employment of more staff.*
- b) *that dredging activities be made subject to environmental impact assessment planning.*

8.4 Urban services development

With its high population density, Koror State is now the first place to experience localised environmental problems. Furthermore, Koror plays a critical role in the functioning of the Republic of Palau. Consequently, measures need to be taken to ensure the smooth functioning of the country in the face of climatic variability, including high winds and seas destroying causeways and extended droughts exhausting water and food supplies. In addition, Koror is more likely to be the site of environmental pollution from visiting boats. Current environmental problems require concerted efforts to find long-term sustainable solutions.

Recommendation Four:

- a) that a study be undertaken to develop appropriate ways and means of dealing with the disposal of septic waste on Koror and on the outer islands.*
- b) that frequently visited tourist sites are monitored regularly for effects of pollution and destruction.*
- c) that further studies are carried out to assess the groundwater potential of the islands of Palau in order to establish water resource capacity.*
- d) that the National Emergency Management Office be strengthened to ensure that contingency plans such as evacuation and relocation plans are developed and implemented in the case of inundation of causeways, extended droughts, extremely high tides, etc. Particular attention should be given to resettlement options of people living on low-lying coastal areas, alternative water sources, and the resiting and protection of key public services.*

8.5 Public awareness and education

Although effective environmental education initiatives are currently available, there remains a general lack of awareness about the possible changes to the physical infrastructures and socio-economic activities as a result of the greenhouse-forced global warming and the consequent sea-level rise.

The general lack of awareness is due to the lack of climate/ocean-specific and Palau-specific information. Current programmes are well placed to incorporate global climate change concerns and their effects on Pacific island nations. Public awareness and education are just as important as any in-depth study of the ocean-atmosphere system and require continual financial support.

The public awareness and education programme should be aimed at three levels of the community. The programmes should be directed to inform;

- the general public through school programmes and the use of print media (local newspapers and magazines) and electronic media (radio and television),
- the planners of physical, socio-economic and socio-cultural infrastructure and activities, and,
- the business/private sector or most appropriate organisations such as the local Chamber of Commerce, Boat Owners and Divers Associations.

This approach will increase awareness about the likely impacts of climate change and consequent sea level rise and environmental degradation especially regarding marine pollution, dredging activities and poaching.

Recommendation Five:

- a) provide the resources necessary to extend the environmental awareness and education programmes currently run by the Bureau of Resources and Development, EQPB and the local primary and secondary schools,*
- b) that specific programmes be developed to prevent poaching and marine pollution from fisheries boats.*

8.6 The National Master Plan

The Palau National Master Development Planning process is set to provide an extensive review of the anticipated development options for the Republic as it works towards a Master Plan for sustainable economic, physical and social development. This process provides an opportunity to address the long-term implications of climate change and possible sea-level rise.

Climatic change should be viewed from the perspective of both the immediate mitigating measures necessary in the light of current and possibly increased climatic variability, as well as the longer term implications of sea-level rise, such as the possibilities of the resettlement of populations or the resiting of critical public services. Integrated coastal zone management should be a key aspect of the final Master Plan.

Recommendation Six:

a) that greater consideration be given to the long-term effects of climate change and sea-level rise in the National Master Plan, in particular to the resiting of main functions of the Republic of Palau away from the coastal area and onto Babeldaob. This would include consideration of land tenure arrangements as well as the physical and economic implications of such a major resettlement scheme.

8.7 Environmental perception of migrants in Palau

With the increasing number of migrants from the Phillipines in Palau, there is a growing concern that their marine resource use practise is more destructive than the way in which local use of resources is organised. It is generally believed that migrants are more likely to take all the fish and seafood from a particular reef environment, thus exhausting the reef system. Following similar trends in Guam and Saipan, where migrants appear to have hastened the depletion of marine resources, there is a concern that the same might occur in Palau.

Given the relatively small size of the migrant community currently in Palau, a survey of their environmental perception and use of Palau's marine resources by the migrants would be timely. Information gathered by such a survey could be used to design environmental awareness and education programmes for the migrants with respect to Palau's fragile reef ecosystems and about the local ethics of conservation.

Recommendation Seven:

a) that an environmental perception study be carried out among the migrant community in Palau leading to a programme which will raise their awareness about traditional conservation ethics and practices and of the fragility and the need to protect Palau's natural environment.

9. Conclusion

This mission found that more data on the likely impacts of climate change and the consequent sea-level rise in Palau is required for longer-term environmental planning and management. Climate data development is imperative and should be integrated into development projects and programmes that are both ongoing and planned for the future.

The conclusions drawn from consultations and meetings held with appropriate organisations and individuals in Palau suggest that unless a concerted effort is made to make the public and the private sector aware of the likely impacts of climate change and consequent sea-level rise, planning for climate change will receive little attention from development planners and policy-makers. Site and event specific information on climate change are needed for long term environmental planning and sustainable development.

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Annexes

Annex One: Schedule of Consultations April 12 - 19, 1993

- Day One** **Monday 12 April 1993**
- Morning** Arrived 10.30am from Papua New Guinea via Sydney and Guam.
- Afternoon** Introduction to conservation issues and arrangement of the week's schedule.
- Mr Demei Otobed Chief Conservationist, Division of Conservation/Entomology, Bureau of Resources and Development and SPREP Focal Point.
- Mr Haruo Adelbai Entomology Technician, Division of Conservation/Entomology, Bureau of Resources and Development.
- Mrs Roberta Louch Education Officer, Division of Conservation/Entomology, Bureau of Resources and Development.
- Ms Neva Wendt Team Leader, National Environmental Management Strategy, South Pacific Regional Environment Programme.
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- Day Two** **Tuesday 13 April 1993**
- Morning** Viewed video *Palau: our precious environment*
- Mr Demei Otobed Chief Conservationist, Division of Conservation/Entomology, Bureau of Resources and Development, and SPREP Focal Point.
- Attended hearing of President Kuniwo Nakamura's First State of the Republic Address at the Senate Chambers, Olbil Era Kelulau, Koror.
- Afternoon**
- Mr Gilbert Demei Executive Officer, Environment Quality Protection Board.
- Mr Noah Idechong Chief, Division of Marine Resources, Bureau of Resources and Development.
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- Day Three** **Wednesday 14 April 1993**
- Mr Rammon Rechebei Chief, Technical Assistance Division, Bureau of Foreign Affairs, and Palau Maritime Authority.
- Mr Issac Soalandaob Chief, Division of Foreign Affairs.
- Mrs Vicky Kanai Chief/HPO, Division of Cultural Affairs.
- Mr Hirao Kloulchad Officer-In-Charge, National Weather Service.
- Mr Harrison Mikel Sewerage Treatment Plant Technician, Public Utilities and Sewerage System, Malakal Treatment Plant.
- Mr Charles Cook The Nature Conservancy.

Day Four **Thursday 15 April**

Morning

Mr Luke Bekelukmad Economic Development.

Mr Abel Suzuki Co-ordinator, National Emergency Management Office.

Ms Mary A. Delemel Managing Director, Palau Visitors Authority.

Afternoon

Ms Julie Tellei Palau Resources Institute and former Health Planner.

Mrs Maura Gordon Palau Resources Institute.

Preparation of preliminary findings.

Day Five **Friday 16 April 1993**

Morning

Mr Koichi Wong Chief, Statistics and Planning.

Mr Herman Francisco Chief, Division of Agriculture.

Presentation of a lecture on *Climatic Change and Sea-level Rise* to SPREP and Bureau of Natural Resources and Development Environmental Awareness Workshop, Osiaol Catholic Mission Centre, Palau.

Afternoon

Mr David Idip Director, Bureau of Resources and Development.

Meeting at Mariculture Demonstration Centre to present preliminary findings of visit to the organisations and individuals consulted during the visit.

Day 6 **Saturday 17 April**

Morning

Ms Julie Tellei Palau Resources Institute and former Health Planner.

Afternoon Visit to Airai and environs

Day 7 **Sunday 18 April**

All day visit to Rock Islands: fishing, diving, and sightseeing.

Day 8 **Monday 19 April**

Morning

Ms Faustina Rehurer Director, Belau National Museum.

Departed Palau at 12.00 noon for Papua New Guinea via Guam and Brisbane

Annex Two: Government Organisations and the Environment

This is a summary of the major objectives of four government organisations responsible for protecting and managing Palau's natural environment, socio-economic and socio-cultural structures and activities.

A. The Environmental Quality Protection Board

The major policy initiatives of the EQPB include;

- to maintain for all Palauans and future generations a safe, healthy, productive and aesthetically pleasing environment.
- to preserve the ecological functioning of natural air, water, and soil systems which influence the quality of the human environment.
- to allow for the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable or unintentional consequences.

B. Division of Conservation and Entomology

Besides the EQPB, whose objective as manifested within its charter to maintain environmental quality, the Division of Conservation and Entomology is charged with the task "to develop and implement national policies to conserve the resources of Palau". The policy initiatives include;

- to plan, develop and implement strategies for sustained use and protection of the natural, cultural and historical resources of Palau.
- to promote, develop and implement conservation and entomology education for the general public, private and government sector representatives.
- to promote and maintain contacts with US and International conservation organisations.
- to plan and implement strategies for control of introduction and of existing insect pests and weeds.

C. Division of Marine Resources

The main objective of the Division of Marine Resources is to manage and develop the inshore marine resources of the Republic of Palau. The specific objectives are to;

- conduct a pilot programme on fishery development projects with the aim towards promoting and developing commercialization of fisheries and fishery products.
- maintain and operate the Micronesian Mariculture Demonstration Centre as a site for marine biological research, study, and experimentation of mariculture and aquaculture fisheries.
- conduct hatchery and rearing of certain species of fish, mollusks, crustaceans, and turtle to be placed back in the natural habitats at maturity as a means of preventing the depletion of important marine resources.
- Assess and evaluate commercial potential of reef and deep water fish, baitfish, mollusks, crustaceans, turtles, etc, from catch record, census, and quantitative field measurements.
- Formulate, establish and implement guidelines and conservation measures to safeguard against over-exploitation in harvesting of fish and other marine resources.
- Provide technical assistance and advisory services to local fishing cooperatives in the purchasing, handling, and marketing of fish and other marine products both locally and externally.
- Provide staff support and administrative assistance to the Board of Directors of Palau Fishing Authority upon request and on the basis of staff availability (Executive Order #9, 1982, Republic of Palau).

D. Division of Cultural Affairs

The Division of Cultural Affairs and the Palau Historic Preservation Programme, administers the Historical and Cultural Preservation Act which upholds the following;

- the historical and cultural heritage of the people of Palau constitutes a precious national resource which should be preserved and fostered for the benefit of all.
- a thorough and workable plan of historical and cultural preservation and education is to be developed because the history and culture of Palau are threatened with extinction.
- a strong regulatory framework is necessary to assure that historical sites and historical and cultural properties located in Palau are protected from destruction.
- a strong programme of support for intangible cultural properties is required to preserve Palauan cultural and tradition in the face of inevitably increasing foreign contact and interaction.