Intergovernmental Oceanographic Commission

Workshop Report No. 51

CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations

Lae, Papua-New Guinea, 1-8 October 1987

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IOC Workshop Reports

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No.	Title	Publishing Body	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand 24-29 September 1973 UNDP (CCOP), 138 pp.	Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand	English
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (Unesco Technical Paper in Marine Sciences, No. 20).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock)
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO Via delle Terme di Caracalla 00100 Rome, Italy	English (out of stock) Spanish (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock) Russian
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Russian
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
17 Suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
18	IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4)	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stoc French Spanish (out of sto Russian
19	IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian Arabic
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
21	Second IDOE Symposium on Turbulence in the Ocean, Liège, Belgium, 7-18 May 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
22	Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Russian
24	WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stoc
25	Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (superseded by IOC Technical Series No. 22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
29	WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
30	International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980.	IOC, Unesco Place de Fontenoy, 75700 Paris, France	English (out of stoc Spanish
31	Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32	UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish

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This Summary Report was jointly prepared by the CCOP/SOPAC Technical Secretariat and the IOC Secretariat. The Report is also issued as the CCOP/SOPAC Training Report Series No. 15

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1. OPENING

On behalf of the Director of CCOP/SOPAC and the Organizing Committee of the Workshop on Coastal Processes in the South Pacific Island Nations, Dr. Russell Howorth of the CCOP/SOPAC Technical Secretariat, welcomed all the participants at the Lae International Hotel on 1 October 1987.

Mr. Robin Moiana, the Deputy Chief Governmental Geologist of the Geological Survey of Papua New Guinea chaired the opening session. He welcomed participants and introduced Mr. Vari Fore, Provincial Secretary of the Morobe Province (Papua New Guinea), who officially opened the Workshop.

In his statement, Mr. Fore mentioned that, in the South Pacific region, people depend upon the sea and its related systems for their daily life. However, many parts of the sea still remain a mystery to them and they wish to get more acquainted with current knowledge through experts from all over the world. He stressed that the Workshop would indicate proper ways and means for the exploitation of the oceanic resources and other life support systems of the sea, and effective utilization of them.

Dr. Russell Howorth, Chairman of the Organizing Committee, introduced the basic idea of the Workshop: A workshop on mineral resources of the nearshore zones was first recommended at the CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-Scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific, held in Suva (Fiji), in October 1983; the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources (STAR) also recommended it at its First Session held in Apia (Western Samoa), in October 1984 and at the Second Session held in Honiara (Solomon Islands) in September 1985. At the following session held in Rarotonga (Cook Islands) in 1986, the STAR Study Group on Coastal Processes and Resources, a subsidiary body of the Joint Working Group, convened the first organizing committee meeting. The prime objective of the Workshop is to provide an opportunity whereby scientists and engineers with practical experience in the field of coastal processes can meet with governmental officials from the South Pacific island countries, particularly those of SOPAC Member Countries, who are actually engaged in coastal zone management, to enable them to exchange their views and opinions. At the same time, they could share information and experiences, discuss the problems of the region and initiate technology transfer so as to aid the long-term planning activities for CCOP/SOPAC Members countries.

Dr. Robert Burne, the Representative of the IOC, welcomed the participants on behalf of the IOC Secretary, Dr. Mario Ruivo, who sent his best wishes for the success of the Workshop. Dr. Burne introduced the Global Shallow Water Sub-programme of the OSNLR which includes:

(i) Study of natural and human effects on the coastal zone, including global sea level rise, regional subsidence, extraction of ground water and hydrocarbons, and river-estuarine-coastal dynamics and interactions.

(ii) Study of the dynamics of the coastal and shelf region (e.g. tidal monitoring, wave climate, storm surges, etc.).

(iii) Mapping of the distribution and composition of superficial shelf sediments; the strand-lines of the last low (18 000 years BP) and high (125 000 years BP) still-stands should be delineated world-wide.

The Workshop was attended by forty-two participants from eleven countries (Australia, Cook Islands, Fiji, France, Kiribati, New Zealand, Papua New Guinea, Solomon Islands, Tonga, USA and Western Samoa). The List of Participants in given in Annex III, hereto.

2. ADMINISTRATIVE ARRANGEMENTS

2.1 ELECTION OF THE CHAIRMAN AND RAPPORTEUR

Mr. Stephen Danitofea proposed Mr. Robin Moaina of the Geological Survey of Papua New Guinea, as Chairman of the Workshop because of his experience of practical works in the field of coastal geology. He was unanimously elected as Chairman.

Dr. Patrick Nunn, University of the South Pacific (Fiji), kindly agreed to serve as Rapporteur. Dr. Robert Buddemeier, University of California (USA), accepted to assist him.

2.2 SCHEDULE

Dr. Howorth introduced the time-table of the Workshop: the first four days (1, 2, 5 and 6 October) would be spent for a scientific session and the fifth day would be used to prepare the recommendations for consideration for future action of both sponsoring organizations.

The programme for the scientific session on the state-of-the-art review of coastal processes research and coastal-processes case studies is listed in Annex II.

3. ADOPTION OF THE AGENDA

The Agenda was amended by the Workshop and is given in Annex I.

4. STATE-OF-THE-ART REVIEW OF COASTAL PROCESSES RESEARCH

Eight papers were presented by invited key-note speakers.

Mr. Benjamin Talai (Geological Survey of Papua New Guinea) explained coastal changes in an active volcano, taking the example of the Rabaul Volcano.

There are just over 100 recognizable volcanoes in PNG; about 40 are active and 22 are believed dormant; the rest are extinct. Most of the active volcanoes lie along the Bismarck Volcanic Arc, associated with an active Benioff Zone.

A variety of coastal changes have been associated with past volcanic activity and an understanding of how these relate to magma chamber variations clearly has great diagnostic potential, especially the longer-term, subtle changes not associated directly with eruptions. Since 1971, there has been a general increase in seismicity and ground deformation at Rabaul. At least 2 m of uplift was measured on Matupit Island between 1973 and 1984. Direct measurements and monitoring since 1983 have shown the uplift rate at deformation loci to average 8 mm/month, but this conceals considerable variability. Annually repeated bathymetric surveys since 1983 have identified two uplift bulges a little southwest of Matupit Island.

Uplift is believed to be associated with magma chamber expansion heralding a major eruption in the future. It is clear that monitoring of coastal changes in the build-up to such an event is of widespread interest, especially to those interested in mechanisms of volcanism and hazard prediction.

Professor David Hopley (James Cook University of Australia) reported on coral-reef geology; particularly the structures and communities.

In the southwest Pacific are found the richest and most diverse coral-reef assemblages in the world. Much work has been done on the Great Barrier Reef, the understanding of which can be transferred to other areas. The diversity of Great Barrier Reef coral is a legacy of post-Tethyan plate movements.

Three tectonic settings cover the majority of Pacific reefs:

(i) mid-plate passive continental margins slowly subsiding and characterized by interdigitated marine and fluvial facies laid down as transgressive onlapping and regressive offlapping sequences and on which reef growth may be largely random and fortuitous; e.g. the Great Barrier Reef;

(ii) mid-plate volcanic island chains associated with sub-crustal hot spots or melting anomalies with definable vertical movements associated with crustal loading and producing the classic Darwinian sequences of fringing, barrier and atoll reefs; e.g., the Society Islands and Hawaiian chain;

(iii) the island areas of active subduction zones with violent vertical movements leading to the drowning and demise of reefs or, more obviously, extensive sequences of emerged reefs; e.g., northern Papua New Guinea, Vanautu, New Caledonia.

Although tectonic settings allow different reef types to be identified, reef morphology is more closely related to sea level changes. The average rise of Holocene sea-level was 10 mm/year, much faster than the sustained upward growth rate of most reef-building corals. As a result, most reefs were drowned during the Holocene and, in some places, as long as 2000 years elapsed following sea-level reaching its present level before coral growth resumed. Contrasts in reef structure in different areas are attributable to the nature of the Holocene sea-level rise in these areas.

Fringing reefs have been largely ignored by reef geologists, but most such reefs are structurally distinct from barrier reefs in that they build outward on their own detritus.

Coral reefs have a wide range of uses (e.g., tourism, pharmaceutical) but are under stress. While the easily visible and demonstrable problems can be legislated against, the less subtle ones are more difficult to identify and to counter.

Dr. Peter Flood (University of New England, Australia) spoke on coastal processes with particular attention to human impact on a coral cay on Heron Island, Great Barrier Reef.

As tourism pressure increases, development on coral cays must be carefully controlled. Coral cays develop on reef platforms, the cay itself grows around the nodal point of accretion relative to wave and wind direction. Fluctuations in the shapes of coral cays are linked to changes in these controls.

In the early 1960s, on Heron Island (300 x 100m), as the result of tourist interest, a gap was blasted in the reef for anchoring tourist boats, but sediment was lost through this gap and the cay began changing shape. Sea walls were subsequently erected to contain sediment loss.

In 1967, a deep water channel and boat harbour was blasted through the reef to the cay, involving 40-60 000 m^3 of sediment loss. The nodal point of accretion consequently shifted. In 1969 and 1972, cyclones filled this channel, which was re-dredged in 1973, the spoil being placed back on the island. This material eventually moved back to the channel and associated harbour, which was subsequently walled, to no avail. The problems can be explained by migration of the nodal point, which was caused by changes in directions (within 45^{o}) of the predominant wind.

Data suggest there is a 20-22 year cycle in wind direction which may be linked to sunspot activity cycles. Successful correlation will allow cogent predictions.

Professor Robert Buddemeier (University of California, USA) presented on sea-level changes.

The scientific definition of sea level includes tectonic and eustatic (water volume) effects, the latter being a focus for future concern. Climate-related effects on sea-level include the extent to which storm effects are felt, the El Nino phenomena, and changes in ocean/atmosphere circulation. Geomorphological effects refer to the type of coastline, such as barrier-reef or dune-protected coasts.

With reference to eustatic effects, the greenhouse effect is the warming of the Earth's surface owing to increases in atmospheric carbon dioxide. Temperature increases of 1.5° - 3°C in the next 100 years are likely. This warming will change the pattern of atmospheric and oceanic circulation. Existing models do not currently permit accurate local predictions. The increased temperature will cause sea level rise by (i) melting of polar ice and (ii) thermal expansion of ocean water. The effects on coastal ecosystems must also be considered.

Predictions in water level rise vary from about 0.2m to 3.5m by the year 2100, most falling within the range 0.5 - 1.5m. Although these changes will probably occur gradually, this is not certain.

We are entering an era of rising sea level. Detailed predictions of the timing and absolute magnitude of local effects are not, and may never be, possible, but we and our immediate descendants will clearly face an inevitable and progressively increasing threat to our nearshore territories and resources.

Dr. John Marshall (Bureau of Mineral Resources, Australia) reported on Holocene reef growth in the southwest Pacific with the aims of applying a growth model for the Great Barrier Reef to some reefs in the south-west Pacific. The critical factors in reef growth are substrate, sea level, energy and the types and rates of biological accumulation.

With reference to substrate, solution unconformities are found to separate periods of reef growth, which were similar during the Pleistocene and Holocene. The Holocene rise of sea level outstripped reef growth in many places, and the depth of drowning, linked to the substrate level, has influenced the time at which reefs reached around present sea level. The energy regime on reefs was different during the Holocene as implied by the composition of contemporary reefs found in cores through the Great Barrier Reef. The time at which the coral grows into the high energy surf zone clearly influences the construction of present barrier-reef morphology.

Comparisons between the Great Barrier Reef and Tarawa suggest that, although they occur in distinctly different settings and there are broad differences in scale, the growth of the Holocene reef in both examples is remarkably similar. These similarities can be attributed to four common components: (i) the depth of the substrate from which the Holocene reef has grown; (ii) the rate at which the reefs have accumulated vertically; (iii) the similar rise and stabilization of sea-level during the Holocene; and (iv) the surface hydrological energy, particularly once the reef reached sea level.

Dr. Robert Burne (Bureau of Mineral Resources, Australia) gave a paper on carbonate sediment budgets.

An understanding of carbonate sediment budgets is essential to the understanding of reef systems. There are three ways in which carbonate mineralization can occur, namely skeletal mineralization, biologically-mediated calcification, and organic precipitation, cementation and diagenesis. This carbonate sediment can be mechanically eroded, dissolved or subjected to biological erosion. Within coastal, nearshore and reefal systems, carbonate grains are continually moved. Many grains have a hydraulic equivalent size much less than their actual size. Thus apparently high-energy beach structures may result from quite low energy conditions in environments where carbonates are highly mobile.

Carbonate provinces are not confined to the tropics and the subtropics. The most common carbonate provinces are reefs, sea-grass banks, tidal shoals, skeletal deposits and lagoons. Within the coastal zone, coastal dynamics are important to understand because carbonates are effectively a non-renewable resource. On-land terrigenous carbonate deposits should not be regarded as permanent. It is also necessary to understand the recent history of most coasts, especially sea-level and tectonic history.

Many coastal engineering structures are ineffective because of a poor understanding of coastal dynamics. Some intended remedies actually exacerbate the problem, Dredging and sand mining must be carefully controlled if the consequences are not to be disastrous. All carbonate environments are highly sensitive systems.

Dr John Harper (CCOP/SOPAC Technical Secretariat), spoke on non-carbonate sediment deposits with special attention to the construction of non-carbonate sediment budgets, basically balancing sources and sinks. Sediment budgets are end members of sediment dispersal models. Once the system has been defined, sources and sinks need to be identified, then transport paths and transport mechanisms. Then you can construct a sediment budget by estimating the inputs and outputs to the system and quantifying its internal parameters.

One difficulty in constructing sediment budgets is the time taken to change. Changes during cyclones are clearly difficult to monitor, other processes are conversely very slow and similarly difficult to monitor effectively over relatively short time periods. A whole variety of techniques can be used to estimate elements in sediment budgets. It is also important to remember that few sediment budgets can be considered as closed.

Mr. Lionel Loubersac (IFREMER, France) introduced the application of the SPOT digital high-resolution imagery.

Satellite image analysis is now being employed widely in the understanding of coastal systems. There are many advantages in this, principally arising from the ability to view at high resolutions large areas very rapidly, and being able to see below the surface, especially in shallow offshore environments. For example, METEOSAT has a high temporal resolution

but a low spatial resolution to allow effective understanding of meteorological systems. SPOT-20m and SPOT-10m satellite imagery is most suitable for coastal systems although the temporal resolution is not as high as desired.

In Ecuador, where no good maps exist, satellite image (SPOT) interpretation has been used to help plan extensions of the shrimp farming industry. Maps with scales of 1:50 000 were produced from SPOT images for New Caledonia for the purpose of identifying barren salt flats. Selected part of these maps can be blown up by using SPOT. The use of artificial colouring to pick out particular vegetation/land-surface types is helpful. It is also possible to calculate areas of these types precisely.

Satellite mapping has also been used to map reefs in parts of French Polynesia. Mapping of patch reefs and their depths in atoll lagoons was also carried out. Coastal changes on Aitutaki (Cook Islands) following cyclones have also been mapped using satellite imagery. Information can also be gained about swells using SPOT images.

Processing can allow different elements of the image to be removed or enhanced, for example. In the case of swell, a mathematical relationship between swell wavelength and bathymetry can be input to image processing so that swell patterns can be directly transformed into bathymetry.

5. COASTAL-PROCESS CASE STUDIES

5.1 EVIDENCE OF COASTAL CHANGES

Dr. Russell Howorth (CCOP/SOPAC Technical Secretariat), reported work carried out as part of the Coastal Processes Work Programme on atolls in Kiribati and Tuvalu. When this work commenced in 1981, coastal erosion in Betio (Kiribati) was severe and threatening public and private buildings. Most existing coastal protection - gabion-basket walls were most common- was ineffective. Historical coastal changes since 1943 were examined. By comparing contemporary to modern maps and other details, it is clear that much of the north coast of Betio has extended by as much as 40m in places. Land tenure data since 1953 also indicate coastal extension on most of Betio in the last three decades.

On Fongafale on Funafuti in Tuvala, coastal erosion is a problem on the atoll's lagoon side. Coastal modifications, mainly in the form of channels cut across the atoll, have acted as sinks (sand traps) which have deprived the beaches on the lagoonal coasts of sand. Prior to the 1940s, typical sand atoll beaches existed here.

Professor Roger McLean, (University of New South Wales, Australia), explained the formation of platform reefs and atolls in Tuvalu.

Most surfaces under Tuvalu islands are 3-4 000 years old, although parts of the reef platform on Funafuti are less than 2 000 years old. This means probably that we are dealing with a catch-up situation in reef upgrowth following the earlier and more rapid sea-level rise.

Radio metric dates of in situ reefal materials (corals, reef flat) indicates that in Tuvalu the reef platform reached sea-level approximately 4 000 years ago on patch reefs and 3 000 years ago on atolls. Episodic sediment supply to the reef top, which was subsequently remoulded, constitute the bulk of the atoll islands.

Features such as natural causeways and hurricane banks are noticeably mobile, having been observed to migrate lagoonwards and this may be an important mechanism in island construction. Probably about 1 000 years elapsed between the formation of platform reef flats and atolls. Persistence of island forms has occurred despite insignificant changes in these over the last 100 years or so.

Dr. Patrick Nunn (University of South Pacific, Fiji) examined the evidence for Holocene sea-level changes in the Fiji, Tonga and Western Samoa areas, with emphasis on the question of the existence of a mid- to late-Holocene high stand and on changes within the last 50 to 100 years.

Although interpretation is hampered by sketchy knowledge of tectonic behaviour of the Fiji area, there is widespread evidence throughout the region of the occurrence of Holocene corals, molluscs, beachrock, peat and beach formation at elevations up to 2.1m above present sea level. Dating of samples suggests a gradual decline in sea-level from about 3 500 years BP. In view of the variety and geographic distribution of the evidence, it seems unlikely that uplift can be invoked to explain the data. Tonga and Western Samoa also provide observations in support of a mid-Holocene one-to two-metre-high stand.

Oral traditions, interviews with older inhabitants and archaeological evidence has been used to assemble qualitative evidence on the behaviour of sea level in Fiji over the last 50-100 years. Widespread reports of extensive shoreline retreat from a variety of locations appear to suggest a rate of sea level rise that is substantially greater than expected rates of subsidence alone. There is extensive evidence for these occurrences over the past century, with some suggestions that it may have been occurring for 300 years or more.

5.2 GEOLOGICAL EVIDENCE FOR RELATIVE COASTAL CHANGES

Professor John Chappel (Australian National University) reported on tectonic uplift of the Huon Peninsula in Papua New Guinea.

The late Cenozoic tectonic history of the Huon area was dominated by the uplift of the Sepik Ranges which became fringed by reef, presently at about 700m above sea-level, 400 000 years old. The energy used in uplift represents only about 1/10th of that generated by plate convergence. The 400 000-year-old reef marks the top of the terrace flight exposed on the Huon Peninsula. Each terrace is a separate coral reef; lagoon remnants are preserved in places, as are human occupation sites, indicated by shell middens.

This terrace flight is the result of sea-level and tectonic change, and coral growth. If sea-level rises faster than the land, then a reef will form. Each terrace (reef) is believed to indicate such an event. Each reef has been dated, which has allowed a sea-level curve for the last 250 000 years to be developed. Ground failure caused by earthquakes has rendered the record unintelligible in places.

An important question is whether the land is uplifted intermittently in a number of small events, smoothly (through creep), or in a number of large events. Recent work suggests the first option is most likely, but with the amount of uplift in single events being so small that a number of such events give the appearance of creep. In other places, small scale coastal morphology indicates that uplift is occurring in a series of small jumps. Elsewhere it seems that the land remains stable for a long time while a platform is cut and that this is then uplifted in a large earthquake event. During such events, landslides would have fed large amounts of coarse sediment into the rivers. This picture is broadly confirmed by the agreement between the ages of uplift and those of gravel terraces at the mouths of rivers. The recurrence interval of these large magnitude, local uplift-producing earthquakes is about 2 000 years.

Dr. Keith Crook (Australian National University) reported on Quaternary uplift rates at a plate boundary, taking Lae urban area as an example.

Offshore of Lae, coral pinnacles have been drowned several hundred metres indicating subsidence. The submarine Markham Canyon exhibits typical convergent boundary morphology. On land, if you go up the Markham Valley, there are exposures of the Laron Formation and Menah Beds, about 1 million years old, as uplifted fluvial terraces. The material is submarine with an alluvial cover, and indicative of uplift material formed in a trench. Long-term uplift rate is 4.3 - 6.8m/1 000 years, but more precise and shorter-term results can be obtained from Lae.

The water depth of dated Laron Formation facies in Lae was calculated and related to dated sea level giving uplift rates of 6.7-7.6m/1000 years (Stewart Park site). At Bumbu Park in Lae, sediments formed in a tidal swamp formed at sea level are now uplifted, the uplift rate implied is 2-3.5m/1 000 years. Another site in Stewart Park gives a similar rate. In both locations, tilting as well as uplift has occurred. The difference in uplift rate are broadly the result of the time period over which uplift was measured. The question as to how this uplift occurs-smoothly or intermittently - cannot yet be answered for this area. Future work should include laser-ranging distance measurements across the Lae Gulf, tilt measurements in the urban area, and measurements of microseismicity using a range of sea-floor seismometers.

Dr. Patrick Nunn (University of South Pacific, Fiji) reported on late-Cenozoic shoreline displacement in Fiji.

Fiji occupies a tectonically complex position, with different island groups variously reflecting the influences of adjacent spreading centres and subduction zones, as well as volcanic activity. Based on marine geology and limited data on shoreline changes, the region may be divided into seven sub-areas that appear to show distinct origins and tectonic characteristics. Neither field observations or geophysical interpretations of structural features are presently sufficiently comprehensive to characterize each area, but the data are consistent with a general pattern of subsidence punctuated by short bursts of earthquake-related uplift in many places. The attitude of reconstructed shorelines from the Lau islands of eastern Fiji suggests that uplift of the northern part of the Lau Ridge has considerably exceeded that in the central part. More field studies are needed, but for the present the most reasonable prediction is for continuation of past trends of coastal behaviour (stable in some regions, subsiding in others).

5.3. EFFECT OF TSUNAMI ON COASTAL GEOLOGY

Mr. Robin Moaina (Geological Survey of Papua New Guinea) reported on the effects of tsunamis in the Lae-Madang area of Papua New Guinea.

Submarine sediment turbidity currents appear to be common in the waters of the Madang-Lae region, and to have caused several breaks in the SEACOM submarine communications cable during its 21-year life. The region has also seen the most devastating tsunami in Papua New Guinea's history, that being caused by the 1888 cone collapse (rather than eruption) of the Ritter Island volcano.

Tsunamis have also been experienced from large earthquakes, but not from the magnitude 7.4 Vitiaz Strait earthquake of 9 February 1987, after which about 2 000 people fled their reef-island homes in fear on an impending tsunami.

Dr. Rajendra Singh (Mineral Resources Department, Fiji) reported on tsunamis in Fiji and their effects.

Although eleven tsunami have been catalogued for the period of 1877-1977, only one tsunami (1953) is known to have caused damage and loss of life. The areas affected by the 1877, 1881 and 1953 tsunamis have been mapped: the southeastern coast of Viti Levu from Rewa to Deuba; the southern and northern coasts of Vanua Levu, the northern coastal areas on Kadavu and the coastal areas of the smaller islands Beqa, Gau, Koro, Ovalau and Ono. The only damaging tsunami recorded in Fiji (1953) caused damage to wharf facilities and seawalls in Suva, and recreational facilities on two small atolls in Laucala Bay. Three people in Suva and two in Kadavu were drowned as a result of the tsunami.

Submarine landslides off the coast of southern Viti Levu caused the 1953 tsunami and a similar mechanism possible caused the 1881 and 1975 tsunamis. Bathymetric surveys soon after the 1953 tsunami showed substantial changes of the sea-floor. More recent bathymetric surveys

indicate that huge slumps and submarine canyons are predominant features along the entire southern coast of Viti Levu. Generally speaking, in many areas of Fiji the earthquake fault displacements are not large enough to generate a tsunami without slumping.

5.4 EFFECT OF CYCLONES AND FLOODS ON COASTAL GEOMORPHOLOGY

Dr. Russell Howorth (CCOP/SOPAC Technical Secretariat), reported on the effects of Cyclones Ursula (2-11 December 1971), Carlotta (13-20 January 1972) and Uma (4-11 February 1987) in the Port Vila - Mele Bay area on Efate Island in Vanuatu. Bedrock in the area is up-raised coral reef. Work was confined to three river valleys - the Tagabe, La Colle, and Tepukoa Rivers.

Cyclone Ursula produced high rainfall although winds were comparatively subdued. Carlotta did not produce so much rain but was accompanied by destructive westerly winds.

A spit developed at the mouth of the Tagabe following Carlotta but this had been redistributed by August 1972. A bridge was washed away on the La Colle during Ursula and much vegetation stripped away. A shallow delta at the mouth of this river developed after Carlotta but had gone by August 1972. The cyclones in 1971 and 1972 caused the Tepukoa River mouth to reoccupy its old (1929/30) channel.

Mr. Stephen Danitofea (Ministry of Natural Resources, Solomon Islands) reported on Cyclone Namu and Guadalcanal coast (Solomon Islands) particularly its implications for economic developments.

Cyclone Namu hit the Solomon Islands in 1986. It was accompanied by particularly heavy rainfall and was very slow moving; both factors combined to cause widespread flooding, especially on the Guadalcanal plains. The visible effects on the landscape were serious but have not yet been properly reported. Further, there has been no opportunity to make a proper assessment of the damage in economic terms.

Some information gathered on delta growth, offshore sedimentation patterns, and areas of high flood risk in Guadalcanal have proved of benefit to future economic planning.

Dr. George Cowan (Secretary of Works, Cook Islands), spoke on the effects of cyclone Sally on Rarotonga (Cook Islands).

Cyclone Sally (December 1986 - January 1987) passed from Pukapuka to Mangaia in the Cook Islands. The first effects were experienced on Palmerston; by New Year's Day, the centre had passed to Rarotonga, taking about four days to pass. The central business area of the capital was inundated to a depth of about 0.5m. Many buildings were completely demolished. Fortunately, no serious injuries occurred. In some places, the foreshore retreated 30m as the result of sea damage associated with the cyclone. Some of the fronts of stream valleys and storm-water outlets were

eroded back by as much as 50m - a serious problem on a small island. Rehabilitation of the capital's foreshore and its subsequent protection is clearly a priority for the future.

5.5 SEDIMENT BUDGET STUDIES

Mr. David Tappin (Ministry of Lands, Survey and Natural Resources, Tonga), presented a paper on a Tongatapu coastal morphology and sediment budget study.

Tongatapu is in the south of the island kingdom. It is a low-lying limestone island, the basement of which is Eocene volcanic epiclastics. Modern morphology is attributable to palaeoreef growth around a central lagoonal core with fossil patch reefs. Sand cays exist in the northwest. Last interglacial reefs now form cliffs mainly on the south, southwest and southeast facing coasts. The main beaches are in the north, west and south, their occurrence correlated with wide reefs. Variations in profiles of these beaches are largely attributable to sand mining. Longshore sediment movement is northwards in response to the southeast trade winds. Sediment production is about 3 500 tons per year, sand mining uses about 15-20 000 tons per year.

Mr. Paul Holthus (SPREP), reported on effects of increased sedimentation on coral reef ecosystems.

The most serious problem affecting coral reefs in the Pacific is sedimentation resulting from human activities. Logging, mining, earthworks and road building are among several causes of man-made sedimentation. The paper indicated the ways in which sediment can adversely affect living reef. The reef system cannot be treated in isolation from associated ecosystems such as sea grasses and mangroves.

Different types of coral differ in their susceptibility to impact from sedimentation, but broadly, as sediment levels increase, coral growth is reduced for a number of reasons. Different impacts can be recognized at the colony, community and individual level.

Mr. Gerry Byrne (Reidel and Byrne, Australia), reported on the effect of man-made structures on coastal sediment movements on Tarawa (Kiribati).

At Bikenibeu, lagoonal sediment is moving eastward alongshore and accumulation is occurring; at Abarao and Ambo, lagoonal sediment is moving west. Erosion in the form of coastal retreat characterizes most of the ocean-facing coasts. Much of this pattern of sediment movement is explained by the closure of gaps which once existed between islands in southern Tarawa. This explanation is preferred to one involving a recent sea-level rise.

The causeway linking Betio to Bairiki has a channel cut through it which will probably infill. Sedimentation on Betio is continuing, recent beachrock is plentiful, but this may change with causeway construction. It

would be beneficial for further study if air photo material was available. Further, an archive for prospective investigators and a systematic recording of oral history information about the coastline would be worth considering.

5.6 COASTLINE MONITORING

Dr. Richard Randall (University of Guam, USA), explained a reconstruction of palaeogeography with respect to sea level at an archaeological site on the northern coast of Guam.

The primary features of Holocene sea-level history are a submarine bench (-96m) representing the most recent low stand, a high stand (+2m) dated at about 6 000 years BP and present sea-level, reached by regression from the high stand by 3 400 years BP. Evidence for the high stand consists of relict algal ridge features, extensive wave cut notches, and eroding supratidal reef platforms. Dating is supported by 42 radiocarbon dates. The sequence of transgressions and regressions correlates well with a model of reef development and erosion.

Dr. Jeremy Gibbs (Ministry of Conservation, New Zealand), drew attention to the relationships between erosion-accretion and emergence-submergence processes, and to the fluctuating and dynamic nature of shoreline movements.

The study site, Hokitika (West Coast Borough in the South Island of New Zealand), is a town sited at the mouth of a river and developed all the way to the shoreline. Concerns about coastal erosion led to a study that demonstrated a 10-30 year cycle of accretion and erosion. Sediment transport is controlled by the varying direction of discharge of the river mouth and the prevailing wave set.

Erosion and accretion can be rapid (10m/month) at their peaks, and problems have been caused by past practices of developing into newly accreted land without recognizing the probability of future erosion.

The message to be stressed is that short-term studies or comparisons of two isolated data points may show fluctuations in a coastal system rather than long-term trends.

5.7 HAZARD MAPPING

Dr. John Harper (CCOP/SOPAC Technical Secretariat), described the technique of using aerial video recording to assess post-cyclone coastal hazards. Such a technique provides hard data in an easily retrievable form, data which are otherwise difficult to gather and which are rarely gathered systematically in such situations.

The mechanics of this system are described in the paper provided. Dr. Harper recommended that, following equipment acquisition and manual preparation, on-the-job training should be given and a mapping method developed for the countries of the SOPAC region.

Mr. Jon King (Geological Survey of Papua New Guinea), reported on coastal zone evacuation following large landslides and lake formation after the New Britain earthquake in May 1985.

This paper describes a large debris flow that destroyed the costal village of Bairaman. The debris flow occurred in the Bairaman River valley on the Island of New Britain, Papua New Guinea, on the 12 September 1986 and was the result of the artificial breaching of a large landslide dam in the headwaters of the river. The filling of the dam had been monitored since its formation in May 1985 and its overtopping and failure was predicted. Evacuation of Bairaman Village was advised but in practice it was found to be impossible to maintain a complete evacuation. The dam was artificially breached while a short term evacuation of the village was enforced thus, although the village was swept away, no lives were lost.

Mr. Graham Shorten (CSIRO, Australia),reported on hazard zonation study of the Suva Harbour area.

The morphostructure, tectonic processes, and sedimentary infill are considered together in assessing the potential for earthquake-related ground failure in Suva Harbour. Three major generations of extensional deformation have been recognized in the Mio-Pliocene marl which forms the bedrock of the harbour. The morphology of the harbour is primarily dictated by geologic structure, but has been modified by erosion and sedimentation resulting from Quaternary sea-level fluctuations. Up to a 100 m thickness of sediments has been deposited in the Pliocene graben of Suva Harbour. The lowermost deposit consists of weakly lithified Plio-Pleistocene sediments. This deposit, and the bedrock formation, has been deeply dissected during the latest glacial low-stand of sea level. Palaeo channels, which are continuous with present-day streams and sediment-filled coastal inlets, can be traced seaward to deeper than 90 m below mean sea-level. Channel fill and bay mud deposits up to 60 m thick were formed during the late Pleistocene-Holocene marine transgression. Coral/algal biotherms have developed on high erosional remnants.

In general, the bay mud consists of high-plasticity marine calcarious silt and clay. The sediments are typically soft to firm, moderately sensitive to remoulding, and have high void ratios.

Earthquake focal mechanisms for SE Viti Levu suggest that current faulting might be occurring along NW-trending faults. Earthquake energy release appears to have a 30-year periodic maximum, and intensity/frequency characteristics are comparable to Zone B of the New Zealand code. Historically, the magnitudes of regional earthquakes have been limited to below 7.1 in Richter Scale.

During earthquake shaking, ground failure is likely to occur in a number of situations within the harbour sediments, the weathered soil profile, and the rock mass. Seven distinct modes of failure are considered likely on the basis of the geology outlines earlier. Each of these modes is assigned a multiplying factor on the basis of its potential to inflict damage. A four-level scale of probability is applied to each mode to describe its likelihood of occurrence. The weighted capability, the product

of the two, allows a comparison of the likelihood and severity of each failure mode. The study area is divided into unit areas, and the total weighted capability for all modes is totalled in each unit square. The final map provides a comparative assessment of risk from ground-failure within the study area.

5.8 COASTAL DEVELOPMENT/ENGINEERING

Mr. Saimone Helu (Ministry of Lands, Surveys and Natural Resources, Tonga), reported on seawall construction and coastal development at Nuku'alofa foreshore to replace old and largely ineffective foreshore protection structures. The nature and cost of these structures - old and new - are described comprehensively in the paper provided.

Mr. Gerry Byrne (Reidel and Byrne, Australia), spoke on three port projects in the Kingdom of Tonga, on Tongatapu and 'Eua, focusing on the problems of coral from an engineering standpoint. Work on Nuku'alofa Port Development Project, Faua Harbour Project and Nafanua Harbour Project on 'Eua is described in detail in the paper provided. One common problem was shifting some of the in situ coral masses, especially the living patch reefs and their foundations. The most appropriate way to excavate coral is by use of a large hydraulic excavator, principally on account of its flexibility.

Dr. Russell Howorth (CCOP/SOPAC Technical Secretariat), reported the results of repeated beach profile monitoring on Kiribati and Tuvalu. For Betio and Bairiki (Kiribati), a comparison of data from the two beach profile surveys indicates the following: a vertical shift of less than 10cm between corresponding points on a beach profile is probably not reproducible; whilst this figure might appear excessive it includes not only levelling imprecision but also an allowance for irregularities in the beach. Irregularities resulting from the activity of crabs, activity of man, stranded logs and intertidal ripples are considered unimportant. A change is considered to have taken place when 10cm or more shift has occurred along at least 10m of a profile. Changes of less than 10cm on profiles were ignored as not being ambiguous indicators of natural change. More than 10cm of shift was interpreted as significant change.

Problems include relocation and loss of survey pegs, use of a common vertical datum, finding and resurveying profiles.

Several beaches on Bairiki experienced considerable profile changes with up to 26 m of erosion. Most of these changes appear to be cyclical, perhaps linked to El Nino the Southern Oscillation.

5.9 PUBLIC AWARENESS

Mr. Paul Holthus (SPREP), reported on coastal management planning in the Pacific.

A training course has been run by SPREP twice in different countries; i.e., at an in-country level. Within each two-week course, emphasis is on field study. Other than training, SPREP runs planning activities - in Pohnpei and French Polynesia.

Mr. Jeremy Gibb (Ministry of Conservation, New Zealand) explained about coastal hazard mapping, a technique based on the maxim that "prevention is better than cure", particularly in the context of coastal-zone construction. The principal challenge is to decide whether present shoreline trends will continue.

In New Zealand, sea level reached its present level about 6 500 years BP since which time sea level has oscillated gently. It is clear that this situation will not continue, and that sea level will rise. The consequences of this are: (i) an increase in coastal erosion especially in tidal inlets; (ii) an increase in flooding because of wave overtopping; (iii) an increase in flooding from tidal rivers; (iv) a rise in the groundwater level; (v) salt intrusion into freshwater aquifers; (vi) an increase in frequency of onshore storms and (vii) disruption of ocean outfalls, reclamation and coastal protection works.

The effects could clearly be quite damaging. It is essential to decide what sea level us doing at present. We clearly need better ways of predicting the effects of the sea level rise. Hazard zoning is a useful way of presenting this information.

Dr. Russell Howorth (CCOP/SOPAC Technical Secretariat), described on the history of the annual CCOP/SOPAC Coastal Mapping Workshops 1983-1987, the primary objective of which has been to provide training in carrying out simple coastal zone surveys.

The secondary objective is to collect information to be used in the work programme of SOPAC member countries. The United States Geological Survey has provided the instructors to the workshops. The content of the workshops has changed as the expertise of those participating has changed.

Professor David Hopley (James Cook University, Australia), reported on the application of near infra-red photography to coral reef monitoring. Wherever coral is healthy, it shows up red, the result of the symbiotic plants. We use a camera mounted in the floor of the plane. His group uses a 70mm aerial infra-red film with yellow filter. They take true colour and infra-red (false colour) photographs simultaneously.

Coral heads reflect more strongly than algae. Water depths also show up well. The uses of this are many, including tourist damage, eutrophication study, and the response of reefs to sea-level rise.

5.10 TECHNOLOGY FOR COASTAL STUDY

Dr. John Harper (CCOP/SOPAC Technical Secretariat), described and enumerated the CCOP/SOPAC equipment available for nearshore and coastal surveys. Equipment is available in the categories of navigation,

geophysical measurements, sampling, computers, software, oceanographic and others. Also presented is a summary of past applications and of the CCOP/SOPAC technical support operation.

Mr. Lionel Loubersac (IFREMER, France), described the CCOP/SOPAC-IFREMER pilot project to assess the utility of SPOT satellite imagery. Images were obtained in June 1986 and in February 1987 after the occurrence of Cyclone Sally. A field survey including echosounding, seismic profiling and sediment sampling was also conducted in June 1986.

One project was to develop a seafloor map from SPOT imagery and to calibrate it against in situ measurements to determine the accuracy and utility of SPOT measurements. The second application was assessment of cyclone damage by comparison of images before and after the event.

Mr. Loubersac introduced a paper prepared by Mr. Serge Berne and Mr. Gilles Lericolais (IFREMER, France), on improvements of geophysical methods for detailed cartography of the coastal zones.

The paper describes the applications of ADOP, a data logging system that permits simultaneous control and integration of positioning equipment, high resolution digital bathymetry, seafloor mapping systems (side-scan sonar), and high resolution seismic equipment. Bathymetric maps can be contoured automatically, and data can be filtered, merged and cross-checked to produce a final mosaic that can be completed into three dimensional geological cartography by use of coring and/or seafloor TV scans.

6. ROUND-TABLE DISCUSSION

Many participants expressed their appreciation of the Workshop, particularly the efforts made by the Organizing Committee and they suggested that the Proceedings of the Workshop should be published with full texts of the submitted papers rather than only with abstracts. It was announced that the Summary Report of the Workshop will be published by the IOC under its Workshop Report Series with a clear indication of the co-sponsoring organizations. CCOP/SOPAC will do their utmost to publish the full text as requested, within an appropriate time.

Several participants stated that they found this Workshop useful as a forum to exchange current problems concerning their coastlines with government officials responsible for coastal affairs from neighbouring island countries and to receive practical advice from experienced experts. However, it was pointed out that a clear direction is necessary for establishing a country's coastal management plan and that additional field works are required by professional staff.

Recognizing the strong priority set up by the member countries to study coastal and nearshore areas, the Workshop hoped that STAR would

increase its involvement in research in these areas to a level at least equal to research committed to deep-sea geology/geophysics projects. Every effort should be made to expand the membership of STAR to encompass scientists and institutions with expertise in the coastal and nearshore zones.

The Workshop recognized the lack of basic information, e.g., sea-level changes, meteorological and coastal oceanographic records, and hazard potential, and felt it necessary to compile such data on historical and on-going basis as coastal zone inventory which would benefit not only for planning/management of coastal affairs but also for increasing scientific understanding of a coastal nature. It also recognized the importance of coastal hazard assessment and its presentation in the form of hazard maps.

The Workshop stressed that application of available new technology, e.g., aerial photography and satellite imagery, for coastal zone monitoring must be used. This should be applied particularly to damaged areas immediately after natural hazards, for reconnaissance and reconstruction.

Some participants pointed out the lack of local expertise to solve technical problems in coastal protection. The Workshop felt the necessity of on-the-job training for local staff on monitoring methods and techniques of coastal processes and on practical engineering techniques to protect coastal lines. It was proposed to have a manual for coastal survey with consideration of local conditions in the South Pacific for benefit of local staff.

The Workshop pointed out that active participation in the implementation of the OSNLR Programme would be beneficial to the recommended scientific research since the OSNLR's Global shallow water sub-programme includes common interests such as Cenozoic reef evolution, palaeo-geographic mapping, coastal zone as a resource, mapping of strand-lines and modification of the coastal environment. It also pointed out that exchange of experiences and knowledge with scientists in other regions would be possible through the framework of OSNLR.

The Workshop felt the importance of public awareness on hazardous coastal processes and on conservation of coastal environments.

7. RECOMMENDATIONS

Following the presentation of formal papers, workshop participants were invited to make recommendations and suggestions for future coastal and nearshore studies in the SOPAC region. A Drafting Group consisting of Drs. Buddemeier, Flood and Hopley collated these suggestions and synthesized them into seven overall recommendations for consideration by the Workshop participants.

These Recommendations included suggestions for practical studies at both a regional and local level and suggestions for establishing scientific research programmes designed to provide the necessary academic framework for the practical studies.

The Workshop made the following Recommendations to the sponsoring organizations.

Recommendation 1

IMPLICATION OF PAST, PRESENT AND FUTURE SEA-LEVEL FLUCTUATIONS

The Workshop expressed its concern about the likely implications to the Pacific island nations of an accelerated rise in eustatic sea-level, expected to occur during the next century, and recommended that the CCOP/SOPAC and the IOC undertake an assessment of the probable impacts of sea-level fluctuations on the land and its coastal resources, and assemble information to enable the production of Sea Level Hazard Assessment Maps and Contingency Plans, with a view to preventing and/or mitigating the effect of an accelerated rise in eustatic sea level, and, in due course, the development of a public awareness programme.

Recommendation 2

INFLUENCE OF OCEAN CLIMATE AND WEATHER PATTERNS
OF THE COASTAL ZONES

The Workshop recommended that the CCOP/SOPAC Technical Secretariat, with the collaboration of the IOC, consider collecting and co-ordinating appropriate meteorological data from all available sources with a view to developing a regional climatic data base useful in coastal studies and, from this, commission a series of reports on the implications and effects of any climatic changes on the coasts of Pacific island countries and, in collaboration with the Australian Institute of Marine Science (AIMS), establish a systematic Porites coral coring programme in selected areas for the determination of environmental history.

Recommendation 3

COASTAL ZONE INVENTORY AND MAPPING

Recognizing the concerns expressed by CCOP/SOPAC member countries relating to such matters as environmental hazards (hurricanes, volcanic eruptions, earthquakes, landslides, etc.), development and conservation issues in the coastal zone, and acknowledging that there is inadequate baseline information for planning/management purposes, the Workshop recommended that: (i) CCOP/SOPAC and IOC use or develop appropriate methods

and procedures for compiling coastal-zone inventories and for coastal-zone mapping; and (ii) CCOP/SOPAC and IOC encourage their members to initiate coastal inventory programmes and identify priority areas relating to specific themes (e.g. hazard maps).

Recommendation 4

ASSESSMENT OF VOLCANIC, SEISMIC AND RELATED EVENTS RELEVANT TO COASTAL ZONE UTILIZATION

The Workshop recommended that a tectonic framework be established for the understanding of geological hazards, such as earthquakes, volcanic eruptions, tsunamis and landslides as they are likely to affect the coastal zone. It also requested that detailed ocean-bottom maps of submarine slopes be prepared to identify potential areas of slumping and mass wasting.

Recommendation 5

DETAILED STUDIES OF COASTAL AND SHALLOW WATER SYSTEMS

The Workshop recommended that detailed shallow-water investigation with particular attention to coastal and shallow water environmental systems, typical of various island settings, be established in co-operation with the Global Shallow Water Sub-programme of OSNLR.

Recommendation 6

DESIGN CRITERIA, ENGINEERING PRACTICES, GEOTECHNICAL CHARACTERIZATION AND ENVIRONMENTAL IMPACT ASSESSMENT

The Workshop felt that there was a need for the control of engineering works proposed in the coastal zone. The Workshop recommended that CCOP/SOPAC, in collaboration with IOC, prepare Guidelines on Environmental Impact Assessment of Coastal Construction.

Recommendation 7

DEVELOPMENT OF CAPABILITY AND INFRASTRUCTURE OF CCOP/SOPAC FOR COASTAL ZONE INVENTORIES AND INFORMATION DISSEMINATION AND DISASTER RESPONSE; AND TRAINING OF MEMBER COUNTRY NATIONALS

The Workshop recommended that the CCOP/SOPAC, in collaboration with IOC and/or other appropriate international/intergovernmental organizations, establish a set of data related to the coastal zone, including natural hazard data, to provide services for the needs of Member countries on coastal zone management and to provide training for member governmental personnel in marine information management.

8. ADOPTION OF THE REPORT

The Workshop adopted the Summary Report and the Recommendations therein.

9. CLOSURE

On behalf of the participants, the Chairman thanked the Organizing Committee for its efforts to convene the Workshop and bring together experienced experts. The Chairman of the Organizing Committee also thanked the participants for their valuable inputs and the Geological Survey of Papua New Guinea, for the local arrangements.

The Chairman closed the Workshop at 11.30 on 8 October 1987.

ANNEX I

AGENDA

1. OPENING

2. ADMINISTRATIVE ARRANGEMENTS

   2.1 DESIGNATION OF THE CHAIRMAN AND RAPPORTEUR
   2.2 SCHEDULE OF THE WORKSHOP

3. ADOPTION OF THE AGENDA

4. STATE-OF-THE-ART REVIEW ON COASTAL PROCESSES RESEARCH

5. COASTAL PROCESSES CASE STUDIES

   5.1 EVIDENCE OF COASTAL CHANGES
   5.2 GEOLOGICAL EVIDENCE FOR RELATIVE COASTAL CHANGES
   5.3 EFFECT OF TSUNAMI ON COASTAL GEOLOGY
   5.4 EFFECT OF CYCLONES AND FLOODS ON COASTAL GEOMORPHOLOGY
   5.5 SEDIMENT BUDGET STUDIES
   5.6 COASTLINE MONITORING
   5.7 HAZARD MAPPING
   5.8 COASTAL DEVELOPMENT/ENGINEERING
   5.9 PUBLIC AWARENESS
   5.10 TECHNOLOGY FOR COASTAL STUDIES

6. ROUND-TABLE DISCUSSION

7. RECOMMENDATIONS

8. ADOPTION OF THE REPORT

9. CLOSURE

ANNEX II

PROGRAMME FOR THE SCIENTIFIC SESSION

1. STATE-OF-THE-ART REVIEW ON COASTAL RESEARCH

Coastal Changes at an Active Volcano, Example of Rabaul Caldera, Papua New Guinea,
Ben Talai, P. de Saint Ours, J. J. Mori, C. O. McKee, (Geological Survey of Papua New Guinea), and I. Itikarai, (Rabaul Volcano Observatory).

Coral Reef Geology: Structures and Communities,
David Hopley, (Centre for Tropical Marine Studies, James Cook University, Australia).

Coastal Processes,
Peter Flood, (Department of Geology and Geophysics, University of New England, Australia).

Sea-level Changes,
Robert Buddemeier, (Lawrence Livermore National Laboratory, University of California, USA).

Models of Holocene Reef Growth in the Southwest Pacific,
John Marshall,(Bureau of Mineral Resources, Canberra, Australia).

Carbonate Sediment Budgets,
Robert Burne, (Bureau of Mineral Resources, Australia).

Non-Carbonate Sediment Budgets,
John Harper, (CCOP/SOPAC Technical Secretariat, Fiji).

The SPOT Digital High Resolution Imagery; a New Technology for Coastal Processes Studies,
Lionel Loubersac, (IFREMER, France).

2. COASTAL PROCESSES CASE STUDIES

2.1 EVIDENCE FOR COASTAL CHANGES

Investigation of Historical Evidence for Shoreline Changes : Betio, Tarawa Atoll, Kiribati; and Fongafale, Funafuti Atoll, Tuvalu,
Russell Howorth, (CCOP/SOPAC Technical Secretariat, Fiji).

Reef Islands and Atoll Motu in Tuvalu: Formation Persistence and Change,
Roger McLean, (University of New South Wales, Australia).

Evidence for Relative Sea-Level Change in the last 6000 years from Fiji, Tonga and Western Samoa,
Patrick Nunn, (Department of Geography, University of the South Pacific, Suva, Fiji).

2.2. GEOLOGICAL EVIDENCE FOR RELATIVE COASTAL CHANGES

Tectonic uplift Huon Peninsula, Papua New Guinea,
John Chappell, (Australian National University, Australia).

Quaternary Uplift Rates at a Plate Boundary: Implications for Seismic Risk, Lae Urban Area, Papua New Guinea,
Keith Crook, (Australian National University, Australia).

Late Cenozoic Shoreline Displacements in Fiji: Effects and Predicted Trends,
Patrick Nunn, (Department of Geography, University of the South Pacific, Fiji).

2.3 EFFECTS OF TSUNAMI ON COASTAL GEOMORPHOLOGY

Tsunamis in Papua New Guinea,
I. I. Ripper and R. Moaina (Geological Survey of Papua New Guinea).

Tsunamis in Fiji and Their Effects,
Rajendra Singh, (Mineral Resources Department, Fiji).

2.4 EFFECTS OF CYCLONES AND FLOODS ON COASTAL GEOMORPHOLOGY

Effects of Cyclones Ursula, Carlotta and Uma in the Port Vila-Mele Bay area, Vanuatu,
Russell Howorth, (CCOP/SOPAC Technical Secretariat, Fiji and Gary Greene, USGS, USA).

Cyclone Namu and the North Guadalcanal Coast, Solomon Islands, Implications for economic development,
Stephen Danitofea, (Ministry of Natural Resources, Solomon Islands) and Graham Baines, (South Pacific Regional Coastal Zone Management Programme, Solomon Islands).

The Effect of Cyclone Sally on Ravotonga
G. Cowan, (Secretary of Works, Cook Islands) and A. Utanga (Secretary of Internal Affairs, Cook Island).

2.5 SEDIMENT BUDGET STUDIES

Tongatapu: Coastal Morphology and Sediment Budget Study,
David Tappin, (Ministry of Lands, Survey and Natural Resources, Tonga).

Effects of Increased Sedimentation on Coral Reef Ecosystems,
Paul Holthus, (SPREP, New Caledonia).

Sediment Movements on Tarawa, Kiribati,
Gerry Byrne, (Reidel and Byrne, Consulting Engineering Pty Ltd., Australia).

2.6 COASTLINE MONITORING

Palaeo-geography of the Taragne Archaeological Site Area,
Dick Randall, (University of Guam, USA).

Impacts of Rising Sea-Level and Coastal Erosion Processes on a West Coast Borough, New Zealand,
Jeremy Gibb, (Ministry of Conservation, New Zealand).

2.7 HAZARD MAPPING

Post Cyclone Coastal Hazard Assessment and Mapping Using a Simple Aerial and Video Recording System,
John Harper, (CCOP/SOPAC Technical Secretariat, Fiji and Edward Owens.

Coastal Zone Evacuation Following Large Landslides and Lake Formation, Papua New Guinea,
Jon King, (Geological Survey of Papua New Guinea).

Geotechnical Study and Hazard Zonation of Suva City and Harbour,
Graham Shorten, (CSIRO, Australia), Frank Whippy and Satish Prasad, (Mineral Resources Department, Fiji).

2.8 COASTAL DEVELOPING/ENGINEERING

Seawall Construction and Coastal Development at Nuku'alofa, Tonga,
Saimone Helu, (Ministry of Lands, Surveys and Natural Resources, Tonga).

Implications of Excavations in Coral Reefs, Some Examples From Tonga,
Gerry Byrne, (Reidel and Byrne, Australia).

Beach Profile Monitoring Programmes in Tuvalu and Kiribati,
Russell Howorth, (CCOP/SOPAC Technical Secretariat, Fiji).

2.9 PUBLIC AWARENESS AND TRAINING

SPREP Coastal Management Planning and Awareness in the South Pacific region,
Paul Holthus, (SPREP, New Caledonia).

Coastal Hazard Mapping as a Technique for Coastal Management,
Jeremy Gibb, (Ministry of Conservation, New Zealand).

CCOP/SOPAC Coastal Mapping Workshops 1983-1987,
Russell Howorth, (CCOP/SOPAC Technical Secretariat, Fiji).

Application or Near Infra-Red Air Photography to Coral Reef Problems,
David Hopley, (James Cook University, Australia).

2.10 TECHNOLOGY FOR COASTAL STUDIES

CCOP/SOPAC Equipment for Use in Nearshore and Coastal Surveys,
John Harper, (CCOP/SOPAC Technical Secretariat, Fiji).

SPOT Image Work - Aitutaki, Cook Islands,
Olivier Lemaire, (CCOP/SOPAC Technical Secretariat, Fiji); Lionel Loubersac,(IFREMER, France); Bruce Richmond, and Pascal Colotte,(CCOP/SOPAC Technical Secretariat, Fiji.

Improvements of Geophysical Methods for Detailed Cartography of the Coastal Zones,
Serge Berne, Gilles Lericolais, (IFREMER, France)

Betio-Bairiki Causeway: A Proposal for a Case Study of the Effect of a Causeway on a Coral Atoll,
John Harper, (CCOP/SOPAC Technical Secretariat, Fiji).

ANNEX III

LIST OF PARTICIPANTS

I. FROM MEMBER COUNTRIES

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ANNEX IV

LIST OF ACRONYMS

AIMS	Australian Institute of Marine Sciences
ANU	Australian National University
BMR	Bureau of Mineral Resources (Australia)
BP	Before Present (Years)
CCOP/SOPAC	Committee for Co-ordination of Joint Prospecting for Mineral Resources in the South Pacific Areas
CSIRO	Commonwealth Scientific and Industrial Research Organzation (Australia)
IFREMER	Institut Francaise de Recherche pour l'Exploitation de la Mer
IOC	Intergovernmental Oceanographic Commission
OSNLR	IOC-UN(OETB) Programme of Ocean Science in Relation to Non-Living Resources
PNG	Papua-New Guinea
SPOT	Satellite pour l'Observation de la Terre (French Satellite)
SPREP	South Pacific Regional Environment Programme
STAR	Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
UN(OETB)	United Nations, Ocean Economics and Technology Branch
UNU	United Nations University
USA	United States of America
USGS	United States Geology Survey
USP	University of the South Pacific (Fiji)

No.	Title	Publishing Body	Languages
32 Suppl.	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife 12-17 December 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific Suva, Fiji, 3-7 October 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36	IOC/FAO Workshop on the Improved Uses of Research Vessels *Lisbon, 28 May - 2 June 1984*	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36 Suppl.	Papers submitted to the IOC-FAO Workshop on Inproved Uses of Research Vessels Lisbon, 28 May-2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37	IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region Basrah, Iraq, 8-12 January 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific Suva, Fiji, 24-29 September 1985	IOC, Unesco Place de Fontenoy *75700 Paris, France*	English
40	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications Sidney, B.C., Canada, 29-31 July 1985 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2) Dakar, Senegal, 28 October - 1 November 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
42	IOC/UNEP Intercalibration Workshop on Dissolved/Dispersed Hydrocarbons in Seawater Bermuda, USA, 3-14 December 1984 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean Venice, Italy, 23-25 October 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
44	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
45	IOCARIBE Workshop on Physical Oceanography and Climate Cartagena, Colombia, 19-22 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
46	Reunión de Trabajo para Desarrollo del Programa «Ciencia Oceanica en Relación a los Recursos No vivos en la Región del Atlantico Sudoccidental Porto Alegre, Brazil 7-11 de Abril de 1986 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	Spanish
47	IOC Symposium on Marine Science *in the Western Pacific: The Indo-Pacific* Convergence Townsville, 1-6 December 1986 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on "Ocean Science in Relation to Non-Living Resources (OSNLR)"	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on "El Niño" Guyaquil, Ecuador, 27-31 October 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
50	CCAMLR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR) Paris, France, 2-6 June 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations, Lae, Papua-New Guinea, 1-8 October 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English