6. Assessing the vulnerability profile and interpretation of results

6.1. Impacts on socio-economic and ecological system

In Section 2 we demonstrated that much of Kiribati is enchanged in subsistence, some in subsistence supplemented by a minor cash income and outlay, and only a small portion of the country is engaged in a direct cash economy. On that basis rigourous benefit/cost analysis is inappropriate. In any case the costs of protective measures for the disproportionately large perimeter of the Kiribati islands would clearly exceed the funding that the Kiribati economy could afford, and such infrastructural support (of a much more modest nature) has been sought in the past as grant from donor countries.

In Section 5 we demonstrated that it is not possible to quantify the physical impact of accelerated sea-level rise simply because we do not have a good understanding of either the contemporary, quite marked physical changes which the coast undergoes, or the likely direction of change under sea-level rise. We note that reef scientists are divided on whether islands will get larger or will decrease in size.

Under these circumstances we can proceed no further with step 6 of the IPCC Common Methodology.

6.2. Institutional implications of response options

Concern about the changing environment in Kiribati, both as a result of global issues such as ASLR, and as a result of local deterioration of habitats and lagoon water quality have led to a strengthening of environmental arm of government, with the setting up of an Environmental Section within the Ministry of Environment and Natural Resources Development.

Table 6. Vulnerability related to implentation feasibility

	Low	Medium	High	Critical
Legislative/institutional /organisational		X		
Economical/financial			X	
Technical		X		
Cultural/social	X			

The Section contained the Secretary for Environment and an Environmental Officer at the time of the field visit, with at least one more position to be filled. The future growth of this section is considered in detail in the National Task Force (1992) report to UNCED.

On the basis of limited discussions with staff in that Section, only a very broad outline of problems likely to be experienced in the preparation and implementation of response options can be undertaken. There are legislative, institutional and organisational issues to be resolved, but these are recognised and are being addressed. There are shortcomings in technical knowledge and experience as would be expected for such a recently-formed and short-staffed section, but these too are being addressed, and there is good exchange of personnel and equipment between government departments. Cultural and social constraints on the implementation of environmental policies are not a major issue, but are discussed in detail in the UNCED report (National Task Force, 1992). Inevitably, however, the economic/financial constraints on implementation of protective measures are high to critical (Table 6).

Table 7. Socio-economic Summary for Case Studies (1990-1991)

	GDP (mil.$A)	Land Area (sq, km)	Population 1990	Population Density (persons/ sq. km)	Population Growth Rate (%)	Capital Value of Land ($A/ha)
Nation	$40.70	726.0	72,298	100.0	2.63	-
Betio	-	1.7	9,226	5,524.6	2.55	$10,500
Buota	-	0.9	591	671.6	12.47	$2,500-$10,500
Buariki	-	10.1	526	51.9	-2.32	$2,500
Maiana	-	17.0	2,184	128.5	0.40	$2,500
Kuria	-	15.0	985	65.7	-1.27	$2,500
Kiritimati	-	388.0	2,537	6.5	9.21	$2,500

7. Identification of needs and plan of action.

We believe that the threat of sea-level rise is not so immediate as to require precipitous action. Sea-level rise will be only one, and it may not be the major one, of the problems facing Pacific nations in the 21st century (Brookfield, 1989). We consider that there is time to put in place a detailed program of environmental monitoring to assess several environmental impacts including the effects of any sea-level change.

We make a series of recommendations which we feel can be achieved within the recently-formed Environmental Section, with only a minimum of assistance from overseas technical advisers, and organisations such as SPREP and SOPAC. These include:

a) There is a need to gather more basic environmental data, on vegetation, sediments, soils, water quality and land use. This might form part of a Natural Resources Survey of the entire country. The aerial photographic coverage already available in Tarawa would provide a good starting point, and mapping would require a minimum of technical expertise. Fieldwork, however, would also be essential.

b) Systematic cross-island surveying is needed (along the lines of the profiles presented in the case studies in this report). These surveys are important because they indicate elevations of features, and hence susceptibility both to inundation under present sea-level conditions (i.e. during storm surges), and in the face of accelerated sea-level rise. These surveys need to be undertaken by an environmental scientist, because they are essentially environmental surveys, not geodetic or cadastral surveys.

c) A program of research needs to be undertaken into sediment production, transport and deposition. Techniques should involve investigation of the geological and geomorphological history of several islands, and regular monitoring of beach/shoreline profiles (along the lines of the twice-yearly surveys of Betio and Bairiki, but including areas remote from human disturbance and causeways) to gauge natural processes of accretion and erosion.

d) Vulnerability analysis needs to be combined with coastal zone mapping. In view of the inevitable shortage of resources in the Environment Section of the Ministry of Environment and Natural Resources Development, coastal zone mapping should probably be undertaken as a part of the broader land resources study suggested above. Coastal types should be determined in a manner somewhat similar to that attempted for Buota in the case study below (see Figure 20). This should then allow determination of a vulnerability index as has been attempted for Buota (see Figure 21). This vulnerability indexing of the coast is intended as a planning and management tool for the present coast, to regulate building setback distances from the high watermark, or to demarcate certain beaches from which no sediment should be collected, or to protect a stretch of coastal vegetation. This would also then serve to indicate vulnerability to ASLR.

e) The collection of reef rock from areas of the reef flat is to be strongly discouraged, and in areas close to settlements it should be prohibited. Similarly collection of sand and shingle from beaches should be prevented, particularly from beaches whose protective role is especially needed.

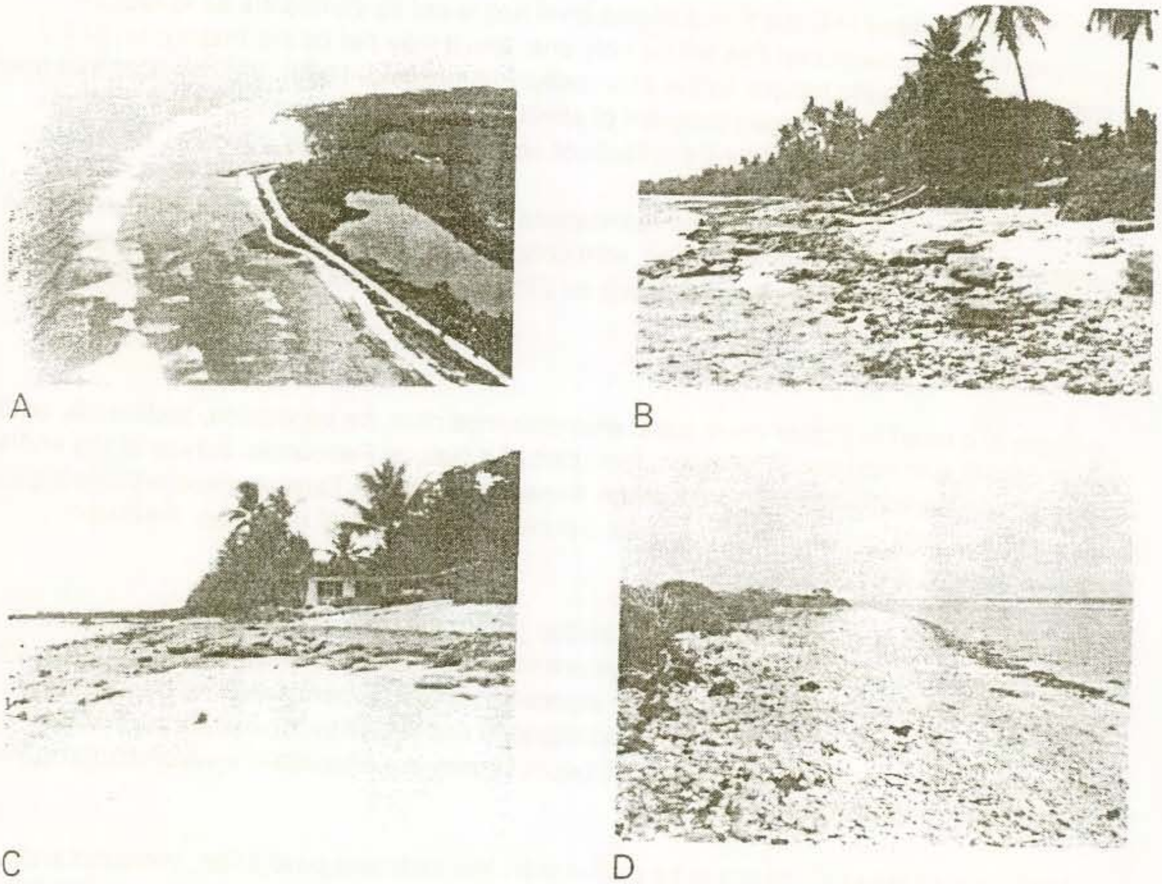


Plate 4 Some coastal types, Kiribati. A) Temaiku, south Tarawa. The outcrops of conglomerate platform can be clearly seen to be anchoring the more seaward parts of the island. B) Beachrock, Temaiku, Tarawa. The beachrock protects the foot of the beach but it easily breaks into blocks which can be removed. C) Beachrock on the oceanward side of Betio. D) A rubble beach at Cape Manning, Kiritimati.

8. Case Studies

8.1. Case Study 1: Betio

Case study 1 is the island of Betio, Tarawa. It is the westernmost island of South Tarawa and has the highest population density. There were 9226 persons on Betio in the 1990 census, giving a density of 5525 persons/km^2, and a population growth rate of 2.55%, similar to the national average (Table 7). The island can be regarded as one impact zone, although we believe that the vulnerability of the coast may vary substantially around the island, as the island has various natural coastal types, including conglomerate and beachrock which afford it some protection (see Plate 4c). Of the total perimeter of 8.1 km, 2.6 km are already protected by seawalls (see Plates 5a and 5b).

The reef flat and lagoon surface around Betio has been extensively modified, mined and reworked, leaving little natural habitat to be preserved (Zann, 1982). Coastal vegetation is still an important element of the natural protection of the shorelines.

There exists good mapping and survey data for the island (Figure 18), but a more detailed ground survey would be necessary before vulnerability indices could be calculated. Benchmarks reduced to mean sea level exist throughout Betio (and continue along South Tarawa). Betio has the University of Hawaii tide gauge installed on the wharf, so it should be possible to relate all survey data to tidal water levels. However there seems to be very little data on wave patterns and wave run-up, so that tide levels may not give a true indication of areas subject to wave incursion. Figure 18 shows a profile across the reef flat and island. It demonstrates the flat nature of the island topography, and its closeness to present high water mark.

Land values probably reach their highest in Kiribati on Betio ($10,500/ha), although as indicated above it remains difficult to put true values on the land. The island contains abundant coconut palms which contribute to the life of a large proportion of the population, and the combination of cash and subsistence economy renders extension of the IPCC Common Methodology to full vulnerability analysis inappropriate.

On Betio there exists the best set of data on physical changes for any of the islands of Kiribati. Coastal profiles have been surveyed and monitored (as often as twice a year) for over 10 years, largely to assess the impact of the causeway. Time did not permit the analysis of this data set, but it should be pointed out that both erosion and accretion are recorded around Betio over that period. The complexity of shoreline changes experienced at present, while possibly partly a function of the causeway and human modification of the reef flat and lagoonal environment, indicates the difficulty in predicting shoreline response to fluctuating mean sea levels would be premature to speculate on the amount of erosion or accretion that would be expected under accelerated sea-level rise.

The island of Betio represents the most urbanised and least natural of any of the islands of Kiribati. It already has one of the highest ratios of seawall to non-protected coastline. It would appear particularly vulnerable to accelerated sea-level rise, and indeed much of the island would be flooded by regular high tides under ASLR2 at the end of a 30 year period. Further protection is likely to be required. Using the costs for seawall construction from Table 5, we calculate that protecting the 5.5 km necessary for full protection under ASLR1 at $250/m would represent a capital cost of $1,375,000. Protecting against ASLR2, though the costs are more speculative (let us say $500/m), would appear to cost $4,050,000 for the entire island. We note that using the quoted land values, and assuming an erosion rate of 5m a year (which is probably excessive) the capital loss would be around $28875 / year. As we have emphasised there is also a considerable, but unmeasurable, subsistence loss.

We emphasise that the Kiribati economy is unable to meet such a capital cost for an infrastructural project such as protection of this order would represent, and has sought aid from a friendly donor country to meet such infrastructural needs in the past.

The tidal, and the coastal survey data exist for Betio for a far more detailed appraisal of erosional trends and their relationship to water level changes. Such an appraisal should be the next stage in the vulnerability assessment of Betio.

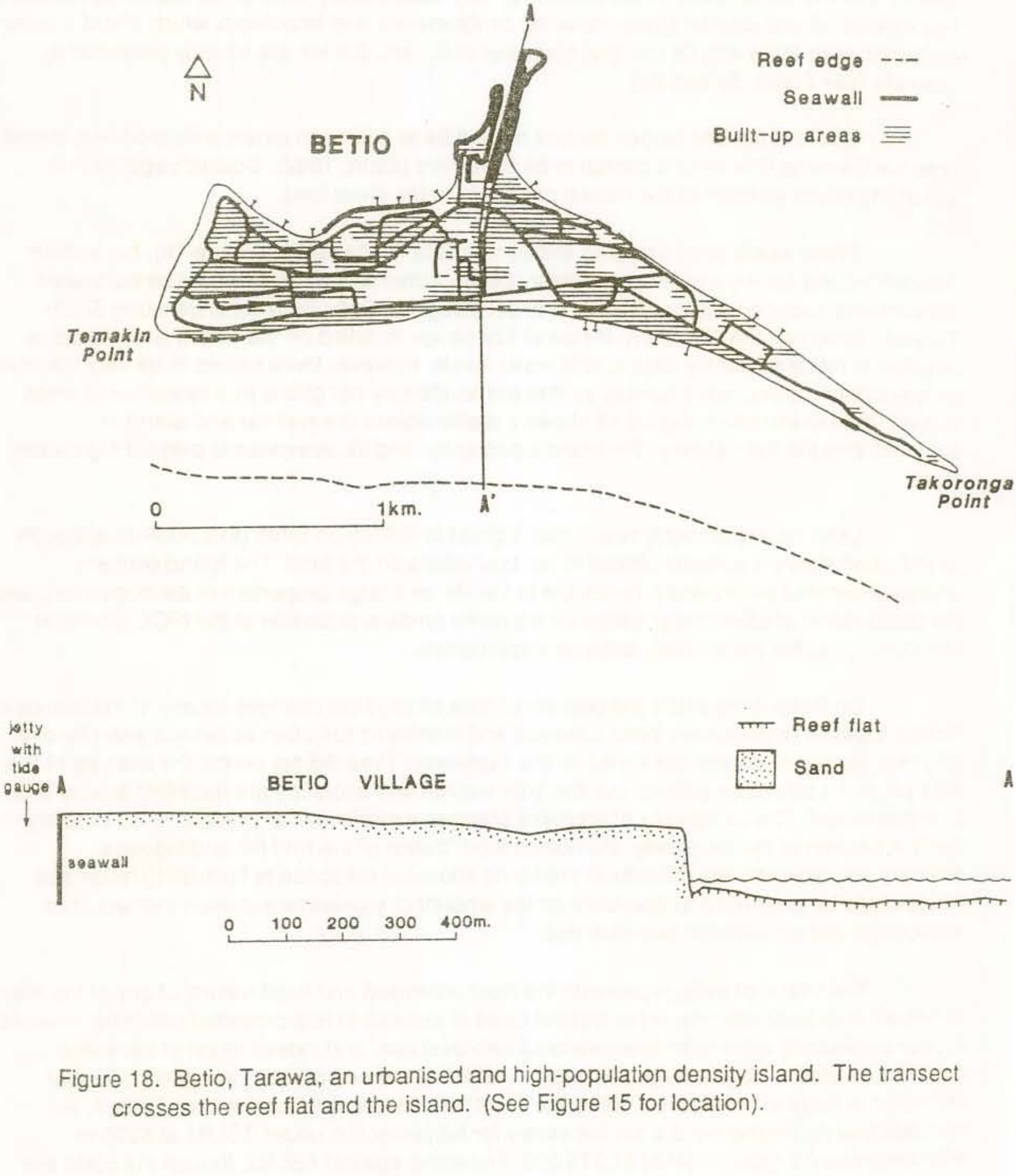


Figure 18. Betio, Tarawa, an urbanised and high-population density island. The transect crosses the reef flat and the island. (See Figure 15 for location).

8.2. Case Study 2: Buota

Case study 2 is the island of Buota, presently at the end of the South Tarawa road, and a small relatively undeveloped island that is presently undergoing rapid urbanisation. This is reflected in the very high rate of population increase (12.5%, see Table 7). Even this figure, however, is almost certainly an underestimate as there is a high incidence of squatters settling on land that they do not own in this part of Tarawa. The squatter problem only serves to compound the rational economic approach advocated in the IPCC Common Methodology.

The island, of area 0.88 km^2, was mapped in considerable detail during fieldwork in order to attempt to develop a vulnerability index that could be used more extensively in Kiribati. Figure 19 shows a typical topographic cross section across the island, surveyed in order to examine how much of the island lies above present high water mark. The island reaches an elevation more than 3.5 m above the reef flat, and the highest point is on the oceanward beach crest. Extreme high water mark is close to the ridge crest and complete overwash looks easy. Nevertheless the island does not appear to have been inundated, even during those periods when the mean sea level is uncharacteristically elevated.

Figure 19 maps several features which provide a natural protection for the shoreline. Conglomerate outcrops, as outlined above, provide protection for the oceanward beaches (and sometimes other parts of the island too). On Buota conglomerate occurs as broad platforms stretching towards the reef crest across the reef flat, and as conglomerate ramps, steep, scoured rocky beach fronts which reflect past erosion of the platform. There are outcrops of beachrock. In terms of the efficiency with which these rocky outcrops prevent erosion of sand or shingle islands behind them, the platforms exceed the ramps, which in turn exceed the beachrock outcrops. The small island of Naninimai to the north of Buota is composed mainly of shingle ridge and appears to be accreting.

On the lagoonward shore mangroves represent an important natural coastal protection. The mangroves fringing the lagoonward shore of Buota prevent waves generated by the westerlie winds from scouring the lagoon beach, and are hence important shoreline stabilisers, as well as promoting sedimentation in their own right.

Figure 20 represents an attempt to develop a coastal zone mapping procedure based on coastal types. The mapping of coastal types shown in Figure 20 can then be used to generate an index of vulnerability (see Figure 21) and will enable detailed tables of natural system data, as required by the Common Methodology (see Table 8). This index represents a measure of the stability of the coast assessed on a rapid survey, and can thus be used not only to plan for changes associated with ASLR, but also for more immediate coastal zone planning and management. In addition to fieldwork, the preliminary mapping was based upon a comparison of aerial photographs of the island from the 1960s and 1980s. Thus the high vulnerability index for the southern tip of the island, where there is a major village, is based upon the low gradient of the coast, the general absence through clearing of coastal vegetation, the presence of some minor seawall constructions, and the fact that there has been shoreline recession in this area between aerial photographic runs. Some of the recession along this shoreline may have been related to the building of the causeway and bridge linking this island with Bonriki.

The most likely development scenario for Buota is continued rapid population growth as more people attempt to join urban Tarawa. The 'ribbon' development along the road will presumably continue, either legally or by squatters. Presumably land values will increase, and agricultural production (i.e. babai production from pits) will decrease as more space is used for houses. Buota is at the transition from predominantly subsistence to cash/subsistence economy.

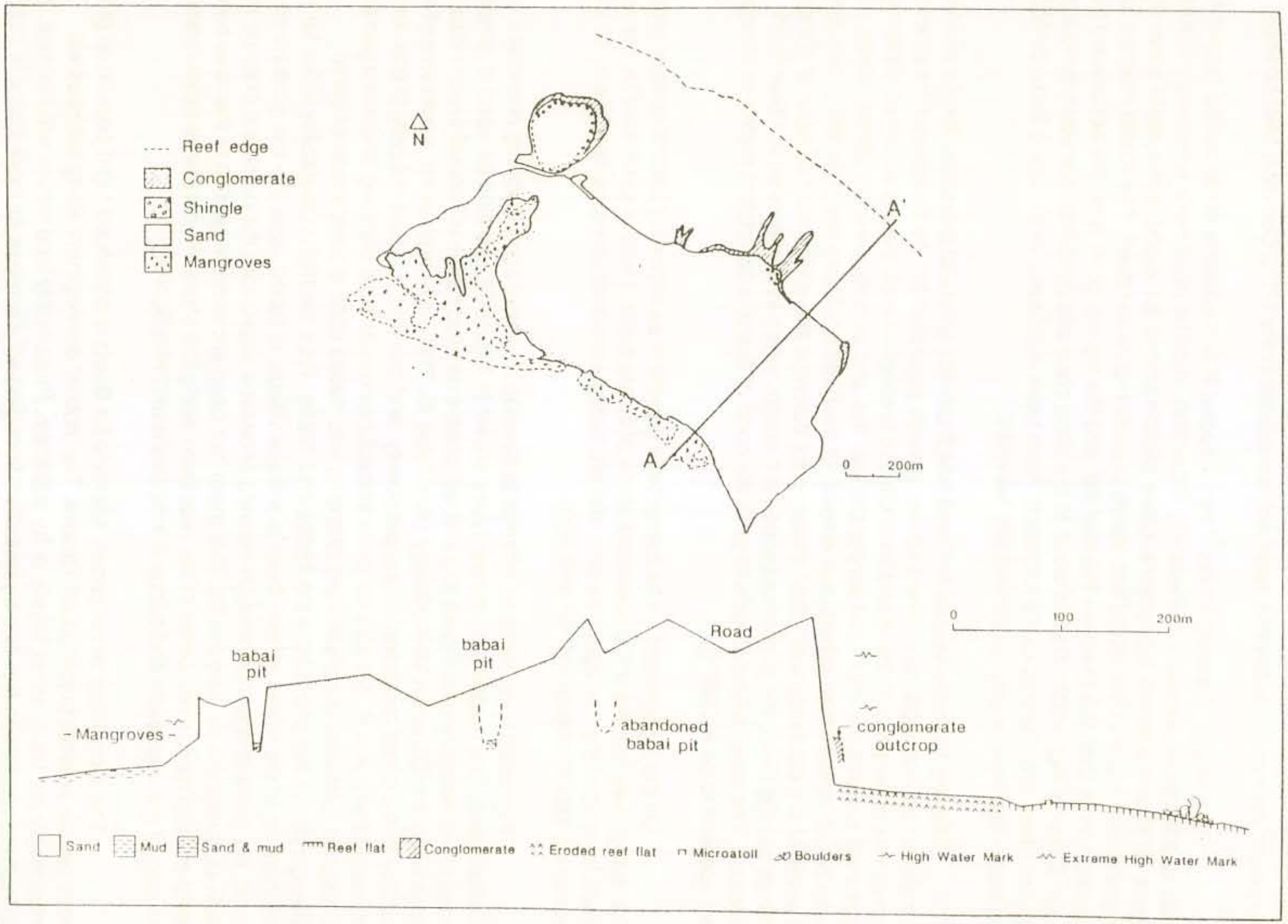


Figure 19. Buota, an island on Tarawa that is undergoing rapid population increase. Note that the oceanward shore contains outcrops of conglomerate, and the lagoonward shore is colonised by mangroves (see Figure 15 for location).

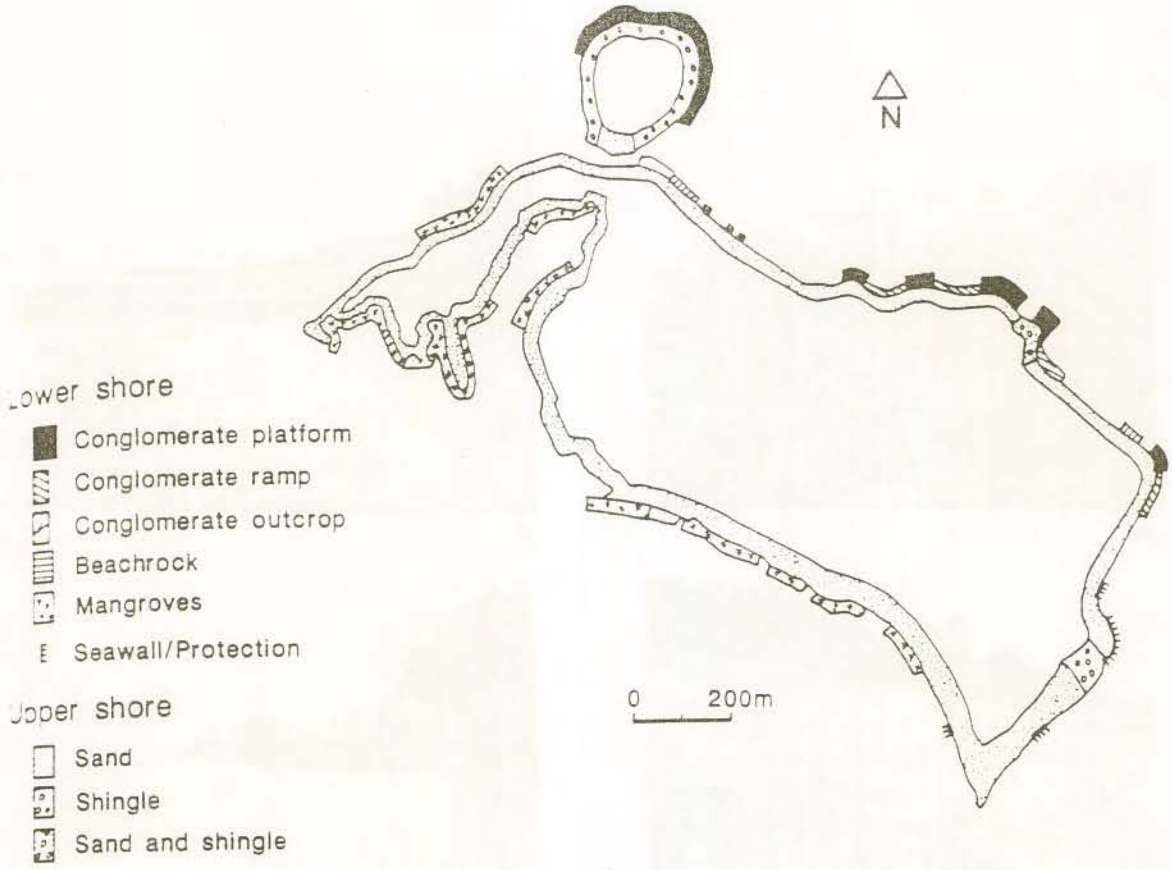


Figure 20. Coastal types: Buota.

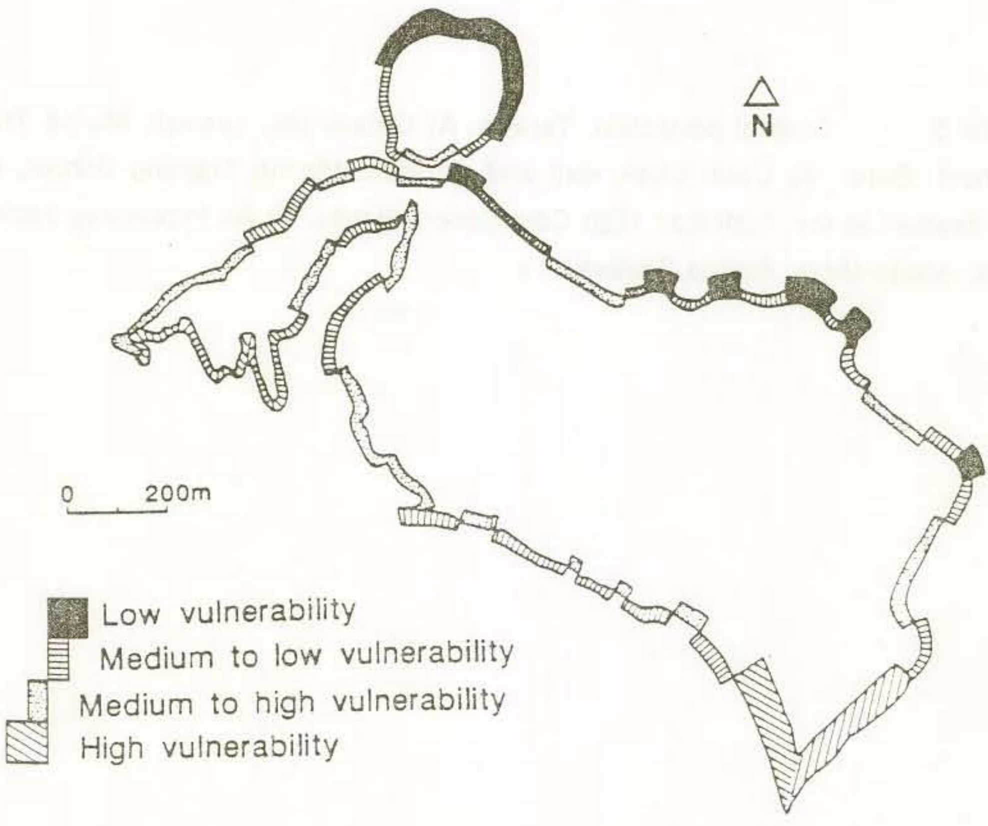


Figure 21. Vulnerability index: Buota.

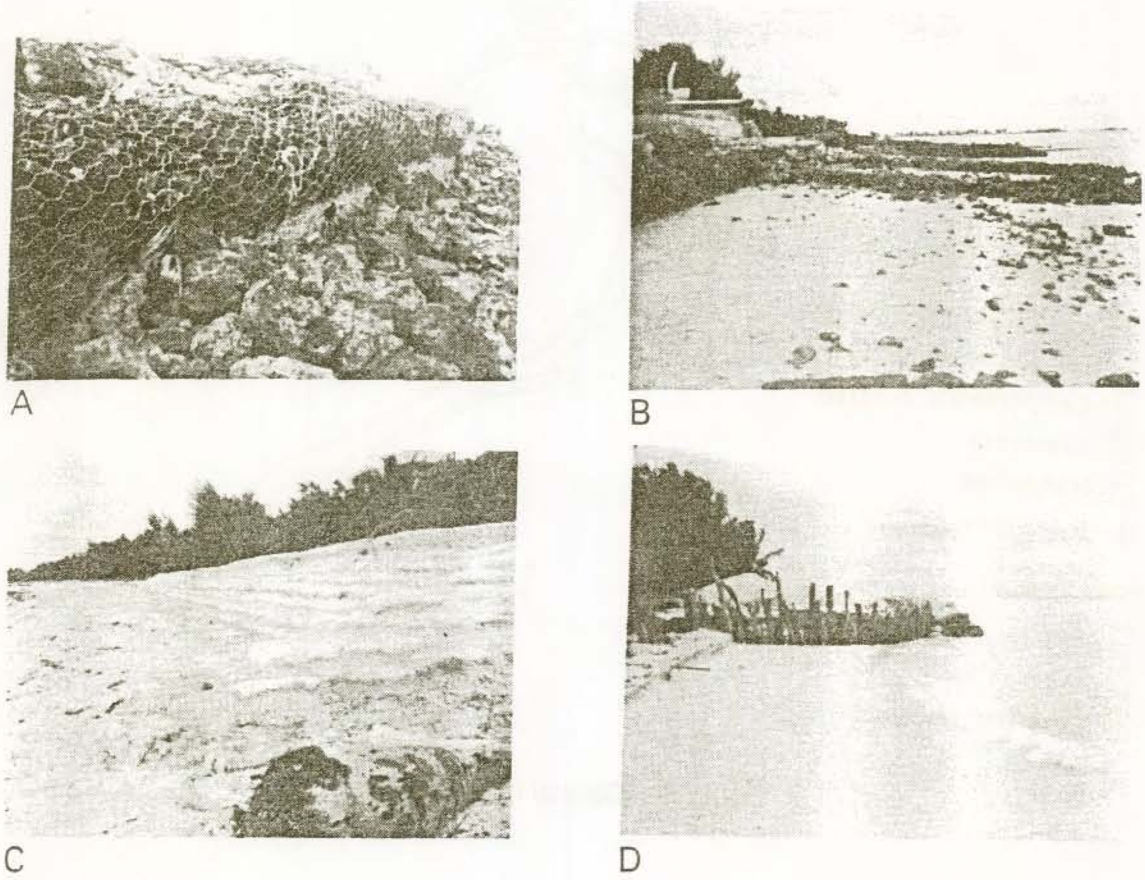


Plate 5 Coastal protection, Tarawa. A) Gabion bag seawall, Marine Training School, Betio. B) Coral block wall and groynes, Marine Training School, Betio. C) Seawall at the Australian High Commission, Bairiki. D) An improvised seawall of logs, lagoon shore, Abarao, Tarawa.

8.3. Case Study 3: Buariki

Buariki is the northernmost island in Tarawa. It was visited in order to assess the more rural part of Tarawa, and to determine whether island characteristics differed significantly from those of the islands to the south. The oceanward shoreline of Buariki shows clearly the alternation of outcrops of conglomerate and sandy beaches. This is shown in Figure 22, which shows a representative profile across each. The conglomerate platform forms broad natural groynes across the reef flat upon which shingle and rubble are preferentially deposited. The sandy beaches are almost always much further back from the reef crest, and their finer sediments suggest that they receive less wave energy.

The preliminary data in Figure 22 suggests that Buariki contains a similar range of coastal types, which will differ in their vulnerability as do those on Buota. The population on Buariki is less than that officially recorded on Buota, and is declining. Its far greater area and perimeter would make it a much more difficult island to protect from either ASLR1 or ASLR2, on the other hand, Buariki is a much wider island, with considerable natural sea defences of its own in the form of outcrops of conglomerate platform.

Table 8. Natural system data : physical characteristics, Buota.

	Buota	Naninimai	Total
Upper shore			
sand	5800 m	100 m	5900 m
shingle	100 m	700 m	800 m
sand and shingle	100 m	--	100 m
Lower shore			
conglomerate platform	600 m	500 m	1100 m
conglomerate ramp	500 m	--	500 m
conglomerate outcrop	60 m	--	60 m
beachrock	120 m	--	120 m
mangrove	2100 m	--	2100 m

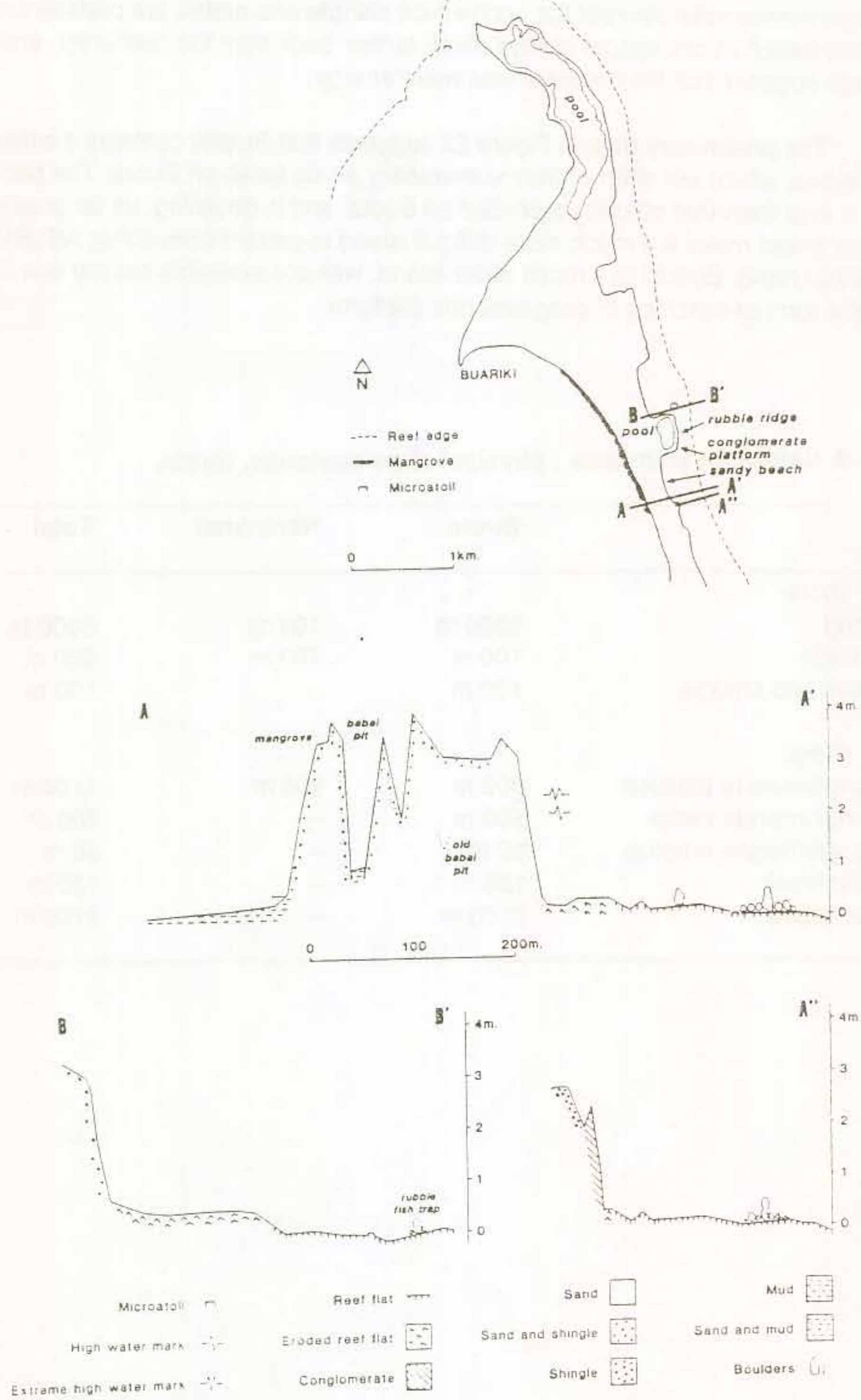


Figure 22. Buariki, Tarawa. Typical transects of reef flat and reef island showing conglomerate outcrops and sandy beach profiles on oceanward side, and mangroves on lagoonward side (see Figure 15 for location).

8.4. Case Study 4: Maiana

The atoll of Maiana lies directly southwest of Tarawa. It is one of the outer islands and contrasts with Tarawa in that it is not urbanised, and depends largely on subsistence. However, not only does it contrast with Tarawa economically, it is also physically different from its close neighbour. Maiana comprises one large island on the eastern margin of the atoll, and several small islands at the northern and southern ends (Figure 23). It has a total population of 2184, all but 80 of whom live on the main island (Table 7). Though its total land area is only 15 km^2, it has a perimeter of 80 km. At least 9 km of the lagoonal shore is lined with mangroves (see Appendix).

There seems to be no data on the physical characteristics of Maiana, except the topographic map and aerial photographs. Figure 24 shows a series of transects that were surveyed across the reef island as a part of this study in order to characterise the elevation and sediments. While the reef island has the broad form of islands as outlined in Figure 11, the majoirty of the transects demonstrate that there is a low swale along much of the island immediately landward of the ocean ridge crest. On several transects conglomerate, which forms an anchor under much of the island, is exposed in this swale. Numerous babai pits have been excavated across the southernmost transect.

The highest parts of Maiana are associated with the oceanward beach crest (on transect E, Figure 24), and with spoil banks from babai pit excavation. These are towards the lagoon, and they are dug into sediments dominated by mollusc fragments. Figure 25 summarises the sediment size data from a series of sediment samples collected during the visit to Maiana, and Figure 26 breaks down a subsample of these in terms of the major skeletal components. The domination of lagoonal sediments by molluscs can be seen. It is interesting that this contrasts with Tarawa where Halimeda is a important lagoonal component, and it illustrates that adjacent atolls may be dominated by different sedimentary processes. On Maiana sediment production in the lagoon is extremely important, and judging from the composition of sediment in the pits excavated for babai, much of the island has built up from lagoonward.

As on Tarawa, the oceanward shore consists of an alternation of conglomerate outcrops, and extensive sandy beaches built up from foraminifera which are growing on the reef flat. The conglomerate outcrops appear more numerous towards the north of the island and so play a more major part in reducing vulnerability to erosion there than to the south.

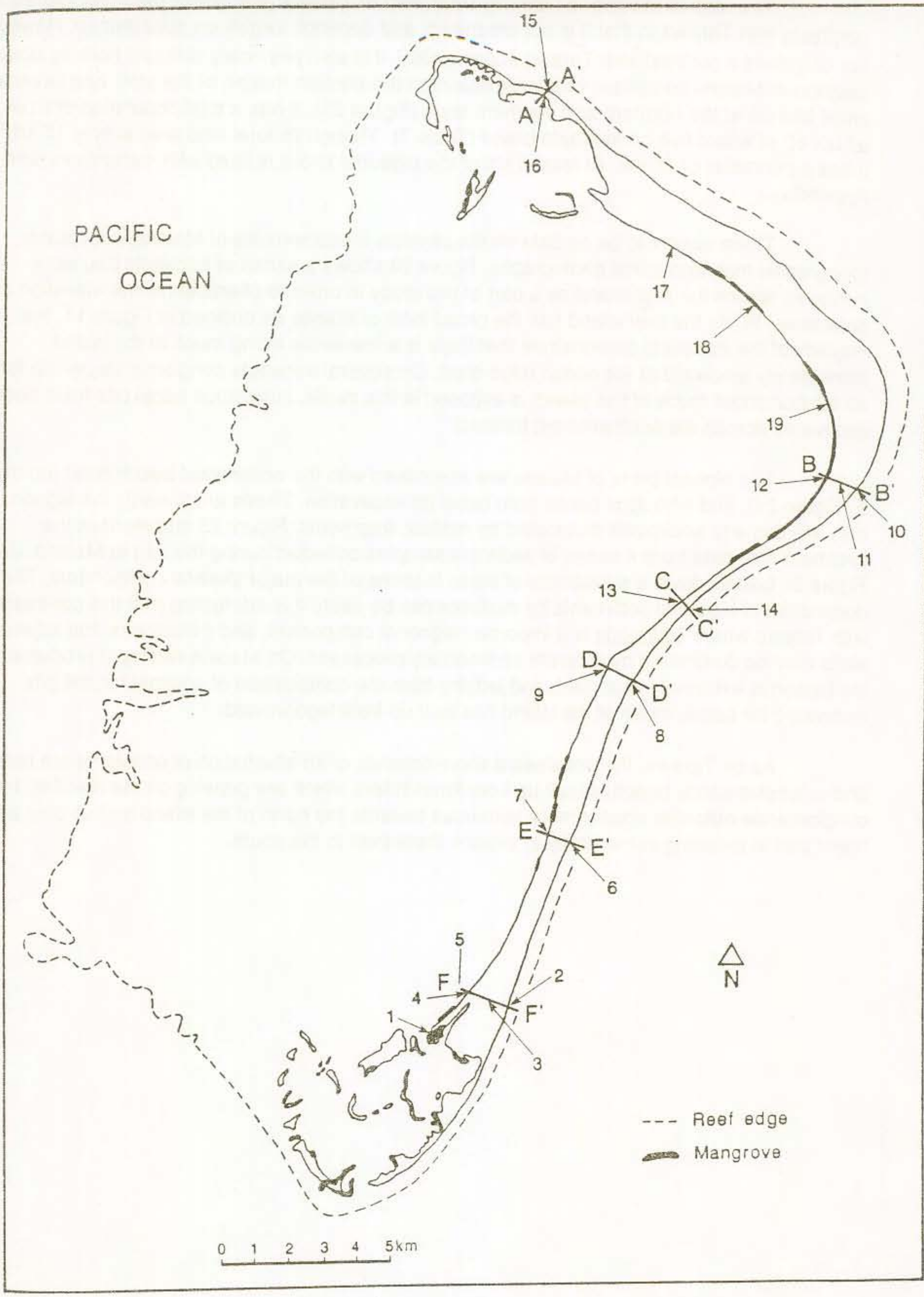


Figure 23. The atoll of Maiana, showing location of transects and sediment sample sites.

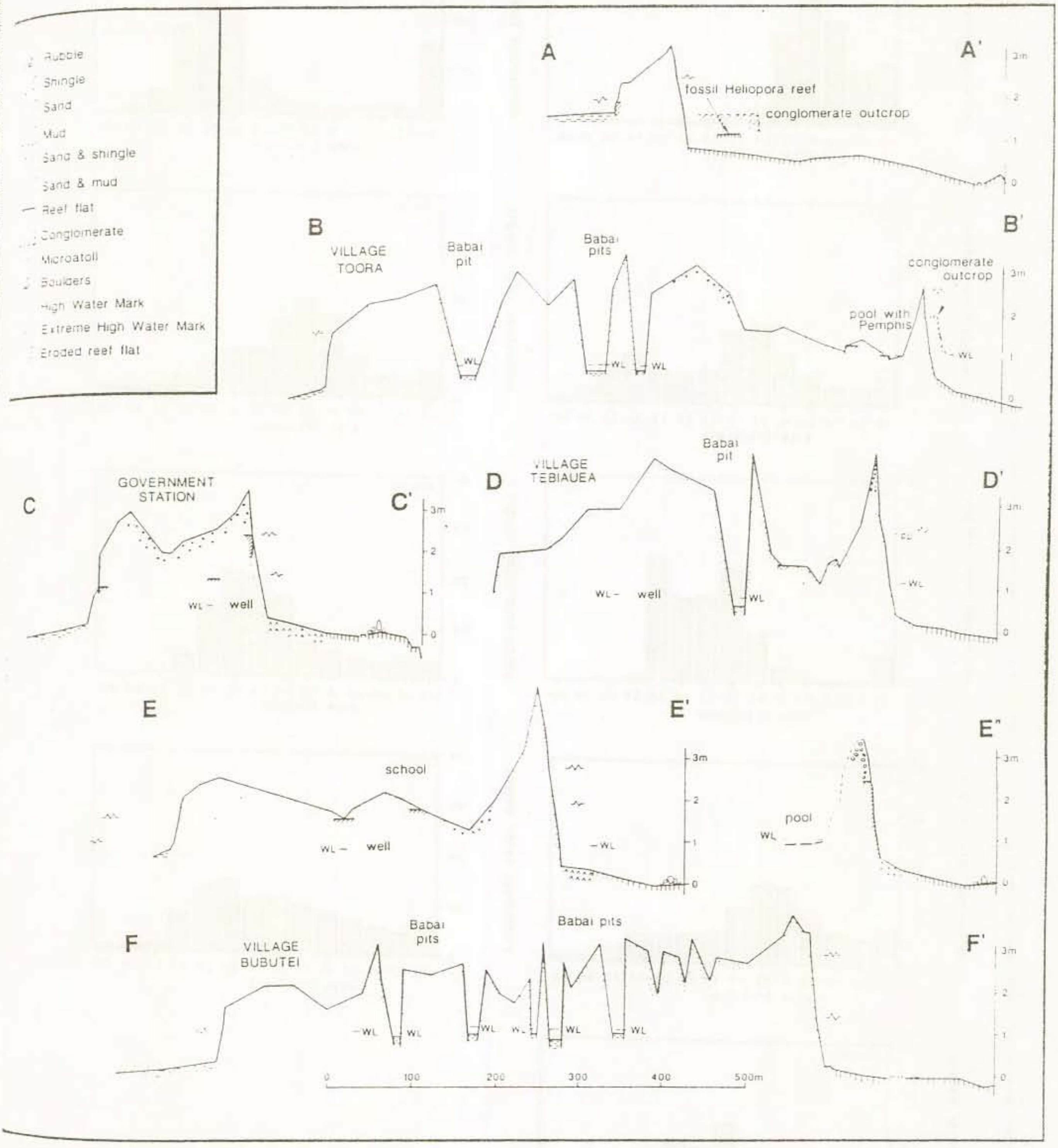


Figure 24. Transects on Maiana (see Figure 23 for location).

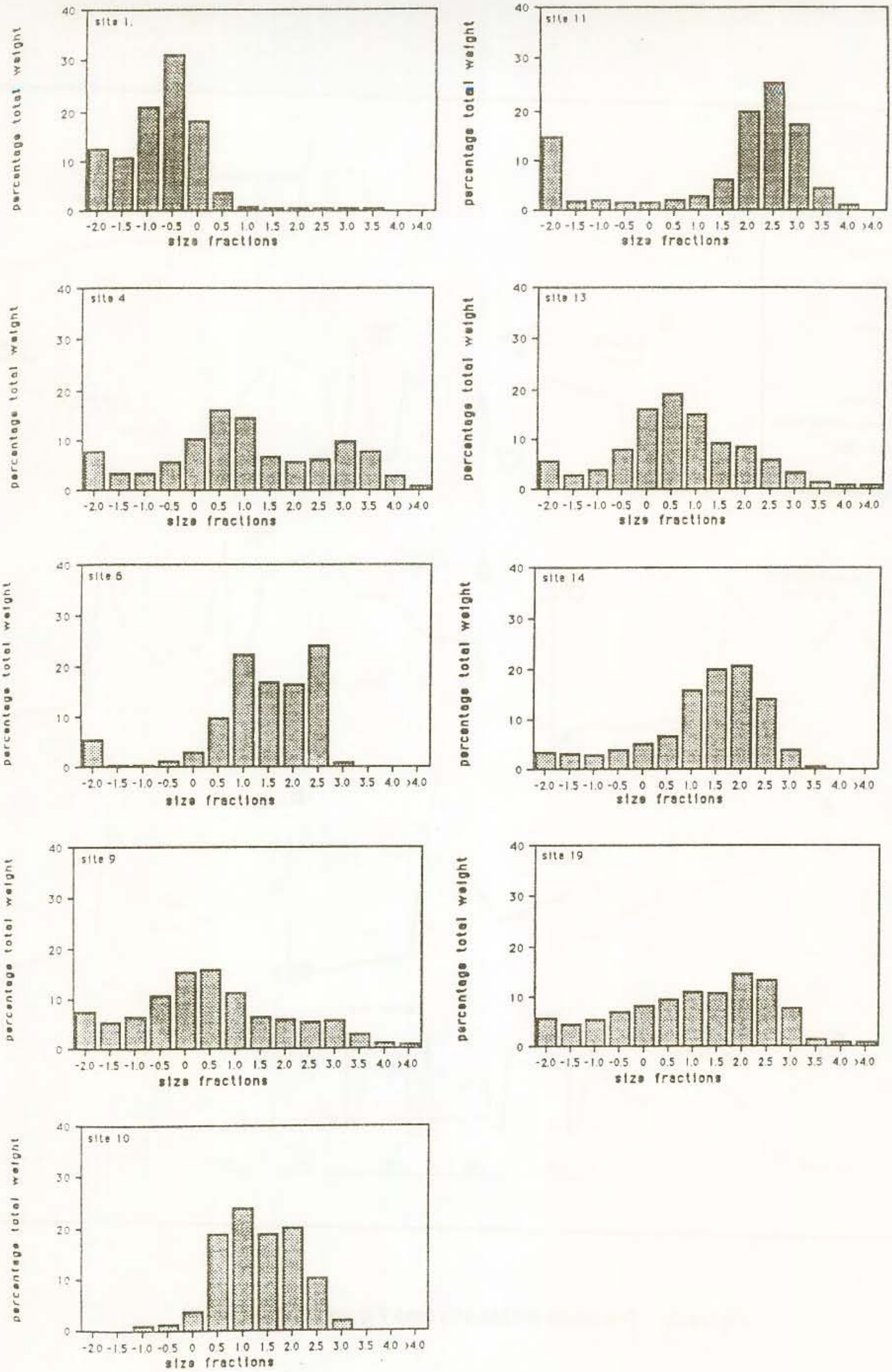


Figure 25.. Sediment size characteristics of samples from Maiana (see Figure 23 for locations).

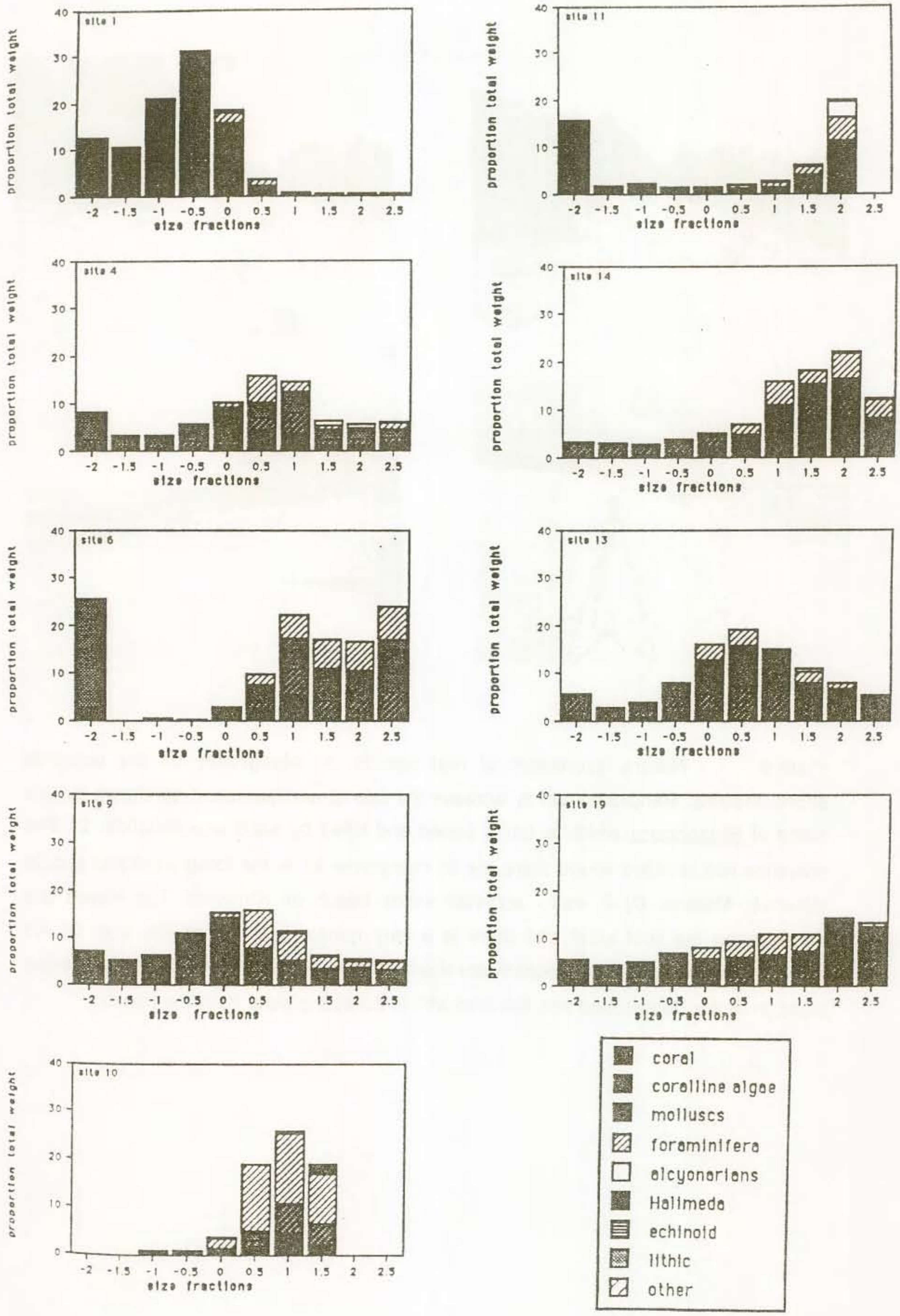


Figure 26. Components of sediment sample size fractions on Maiana (see Figure 23 for locations).

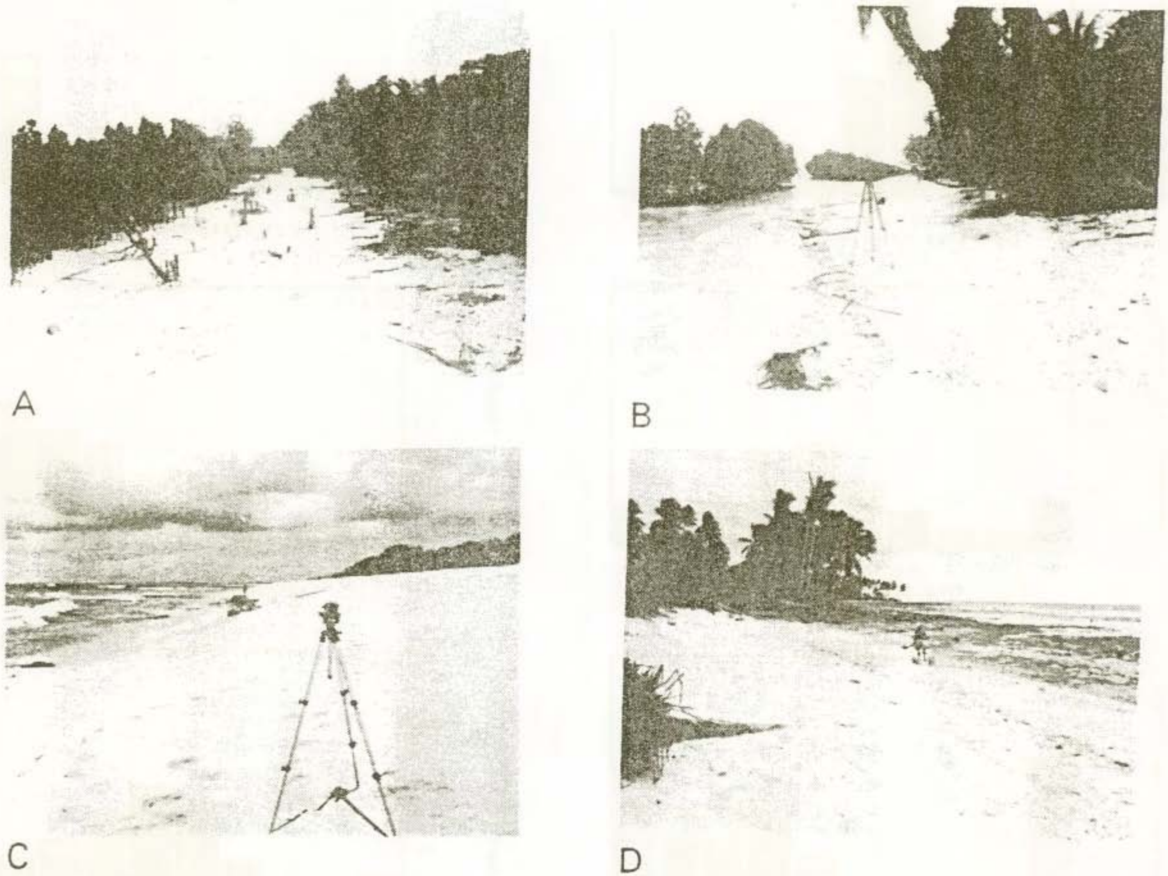


Plate 6 Natural protection of reef islands. A) Mangroves on the lagoonal shore, Maiana. Mangroves act to increase the rate of sedimentation as shown by this stand of <u>Rhizophora</u> which is being buried and killed by sand accumulation. B) The shoreline has receded where there are no mangroves as in the foreground and middle distance, Maiana. C) A well - accreted sandy beach on Kiritimati. The waves are breaking on the reef crest and there is a very narrow reef flat at this site. D) An accreted sandy beach on the oceanward shore of South Tarawa. Note the comglomerate platform in the background and the man who is collecting sand from the beach.

8.5. Case Study 5: Kuria

Kuria is a reef-top island, comprising two islands which almost completely fill the reef platform, and without a lagoon (see Figure 27). This island was not visited during this study, but Figure 27 summarises surveys undertaken by McLean (1989). The island to the north contains a series of prominent ridges and swales (profile A, Figure 27), indicating accretion of sediment.

Reef-top islands may be less vulnerable to sea-level rise because there is nowhere for sediment to go, unless the island is entirely overtopped and the sediment is washed entirely off the reef platform. Even under ASLR2 the sea will not entirely overwash the islands, and this does not appear to be likely within the timeframe considered by the IPCC Common Methodology.

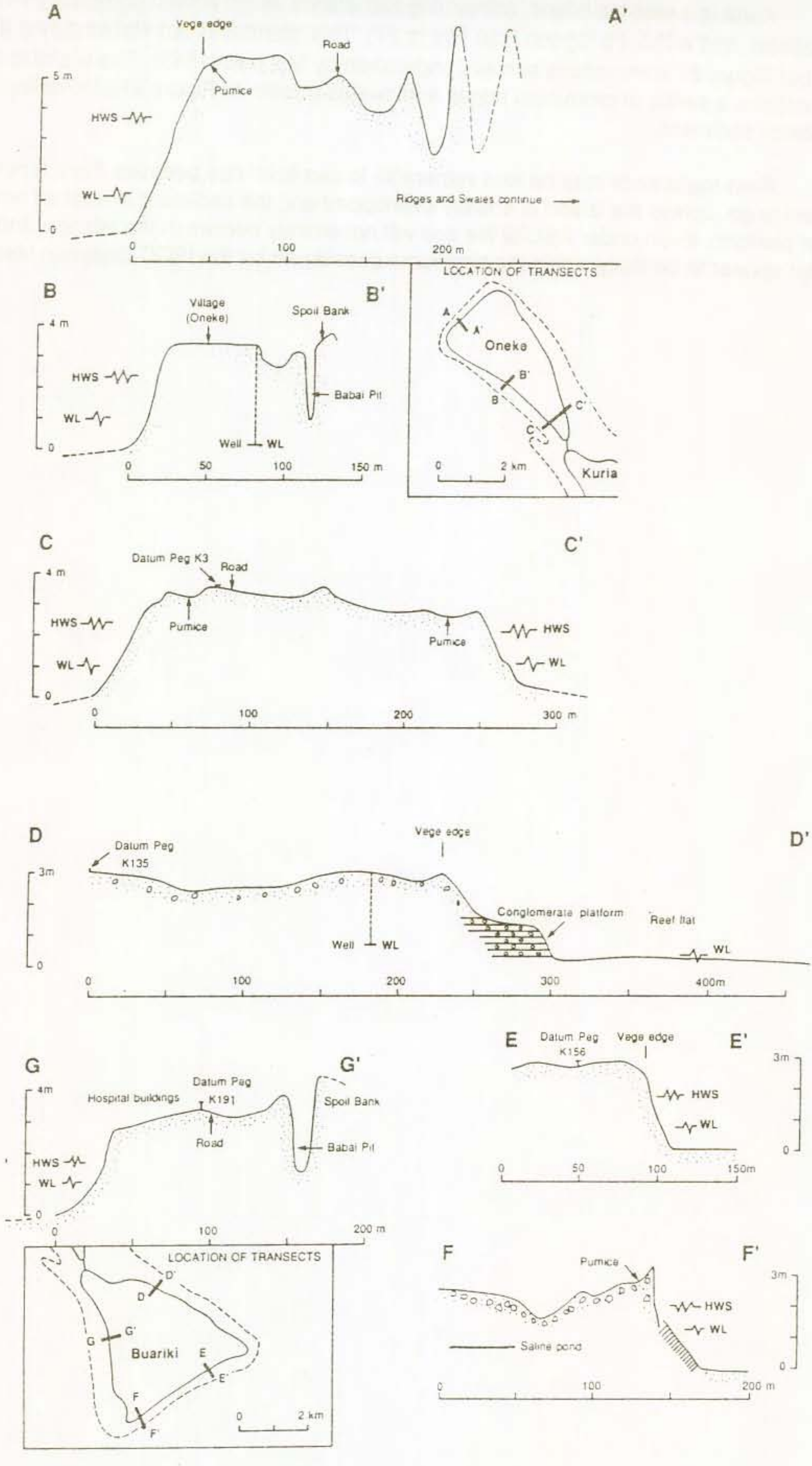


Figure 27. Transects on Kuria (from McLean, 1989).

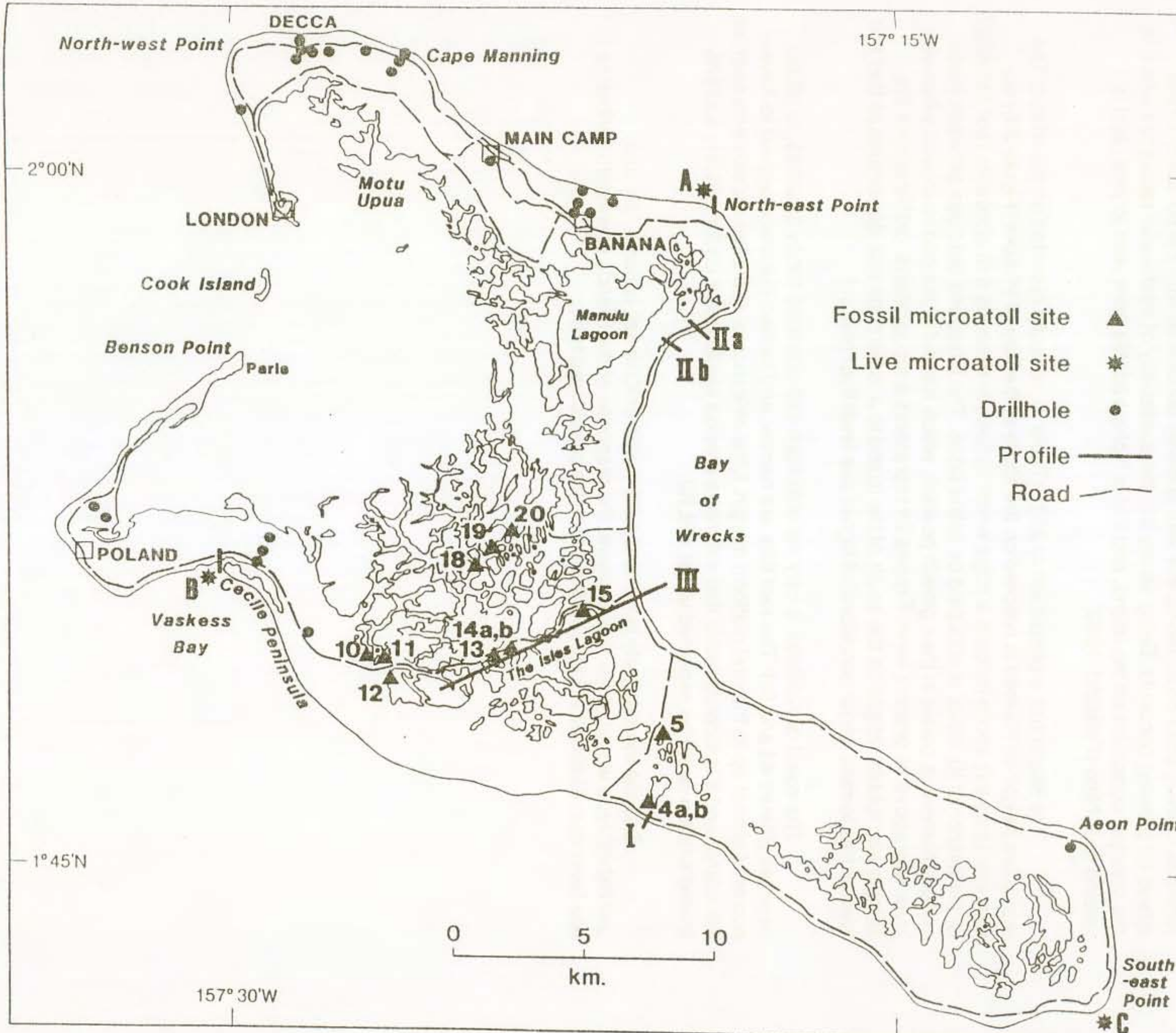
8.6. Case Study 6: Kiritimati

A vulnerability analysis of Kiribati would not be complete without an assessment of Kiritimati (Christmas Island). With a surface area of 388 km^2, this single island contains more than half the total land area in Kiribati. There has been a detailed land resources survey of Kiritimati (Jenkin and Foale, 1968), this was primarily concerned with the suitability of the island for growing coconuts. Being so dry it is the availablility of freshwater resources which is the principal constraint on the island, and this is highly variable from year to year, and is related to El Niño (Falkland, 1983).

The island has a population of 2537 (Table 7), recently resettled on the island. The maximum height on Kirimati is reached on the shore of the Bay of Wrecks (Figure 28); our surveys along this shore indicate a rdige which frequently exceeds 6 m abovethe reef flat. Much of the interior of Kiritimati is occupied by saline lakes. The limestone outcrops between these contain numerous corals in their growth position, which formed in the mid Holocene when sea level was above its present level. Figures 29 represents a topograsphic profile across the shingle and rubble ridfges on the south of the island to a fossil coral that demonstrates that this islands has formed under conditions of higher sea level than present.

The coast of Kiritimati is very variable from well-accreted sandy beaches, to rubble beaches (Plates 4d and 6c). The reef flats are narrow, and indeed the island appear to have accreted almost up to the reef platform margin. Little evidence of shoreline erosion was seen on the island, and it is inconceivable that extensive erosion would occur under ASLR1, and only limited erosion could be expected under ASLR2.

Despite the relatively large land area, much of Kiritimati is harsh, dry and uninhabitable. It would seem that whatever the response of the islands of western Kiribati to sea-level rise, Kiritimati will survive the scenarios considered here.



F... ure 2... he i... d of ...nati ...istmas.

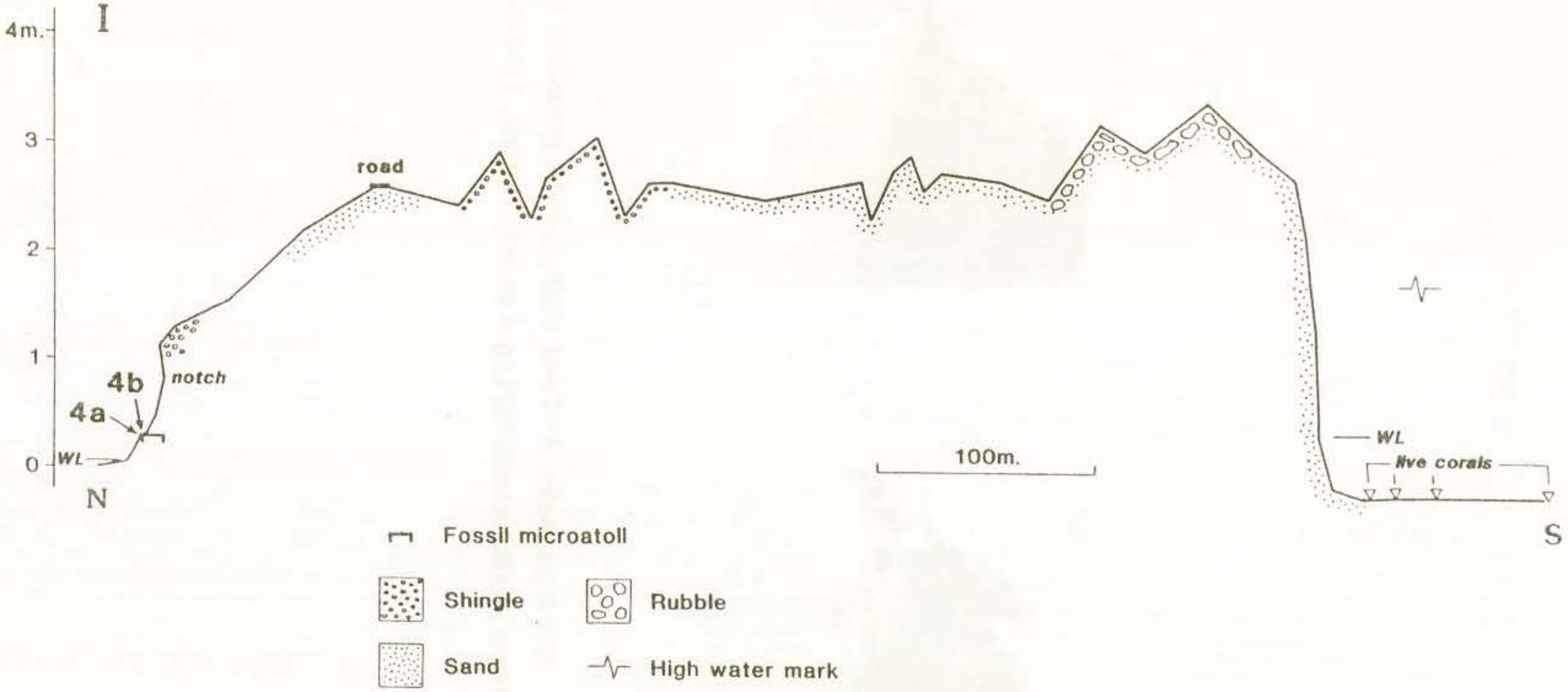
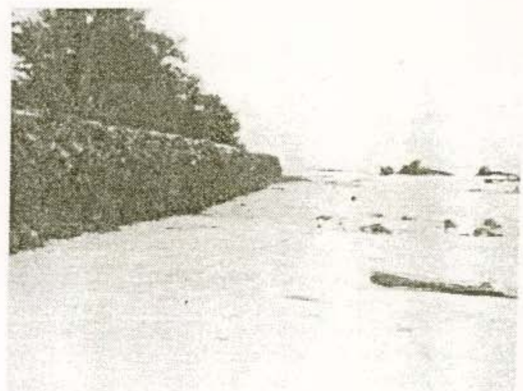


Figure 29. Transect 1, Kiritimati.

A



B

Plate 7 Coral seawalls. A) Coral block seawall protecting a house, Abarao, Tarawa. B) Hand - built seawall fronting a church, Nanikai, Tarawa.

9. References

Ayers, J.F. and Vacher, H.L. (1986) Hydrogeology of an atoll island: a conceptual model from detailed study of a Micronesian example. Ground Water 24: 185-198.

Baines, G.B.K., Beveridge, P.J. and Maragos J.E. (1974) Storms and island building at Funafuti Atoll, Ellice Islands. Proc. 2nd Int. Coral Reef Symp. 2: 485-496.

Baines, G.B.K. and McLean, R.F. (1976a) Resurveys of 1972 hurricane rampart on Funafuti atoll. Search 7: 36-37.

Baines, G.B.K. and McLean, R.F. (1976b) Sequential studies of hurricane bank evolution at Funafuti atoll. Marine Geology 21: M1-M8.

Barnett, T. (1983) Recent changes in sea level and their possible cause. Climatic Change 5: 15-30.

Barnett, T. (1984) The estimation of 'global' sea level change: a problem of uniqueness. J. Geophys. Res. 69: 7980-7986.

Barth, M.C. and Titus, J. G. (eds.) (1984) Greenhouse effect and sea level rise: a challenge for this generation. New York, van Nostrand Reinhold.

Bayliss-Smith, T.P. (1973) Ecosystem and economic system of Ontong Java atoll, Solomon Islands. Unpubl. PhD thesis, University of Cambridge.

Bayliss-Smith, T.P. (1982) The ecology of agricultural systems. Cambridge University Press.

Bayliss-Smith, T.P. (1988) The role of hurricanes in the development of reef islands, Ontong Java Atoll, Solomon Islands. Geogrl. J. 154: 377-391.

Belperio, A. (1989) The greenhouse debate and rising sea-levels. Search 20: 48-50

Braithwaite, C.J.R. (1982) Progress in understanding reef structure. Prog. Phys. Geogr. 6: 505-523.

Brookfield, H. (1989) Global change and the Pacific: problems for the coming half century. The Contemporary Pacific 1: 1-17.

Bruun, P. (1988) The Bruun rule of erosion: a discussion on large-scale two and three dimensional usage. J. Coastal Res. 4: 626-648.

Bryant, E. A. (1988) Sea-level variability and its impact within the greenhouse scenario, in Pearman, G. I. (ed.) Greenhouse: planning for climatic change, C.S.I.R.O. Melbourne, pp. 135-146.

Buddemeier, R.W. and Holladay, G.L. (1977) Atoll hydrology: island groundwater characteristics and their relationship to diagenesis. Proc. 3rd Int. Coral Reef Symp. 2: 167-174.

Buddemeier, R.W. and Oberdorfer, J.A. (1986) Internal hydrology and geochemistry of coral reefs and atoll islands: key to diagenetic variations. In: Schroeder, J.H. and Purser, B.H. (eds.) Reef Diagenesis, Springer-Verlag, pp. 91-111.

Buddemeier, R.W. and Oberdorfer, J.A. (1989) Climate change and island groundwater resources. In Pernetta, J.C. and Hughes, P.J. (ed.) Studies and reviews of greenhouse related climatic change impacts on the Pacific Islands, Association of South Pacific Environmental Institutions, Majuro. pp. 16-27.

Buddemeier, R.W., Smith, S.V. and Kinzie, R.A. (1975) Holocene windward reef-flat history, Enewetak Atoll. Geol. Soc. Am. Bull. 86: 1581-1584.

Buddemeier, R.W. and Smith, S.V. (1988) Coral reef growth in an era of rapidly rising sea level: predictions and suggestions for long term research. Coral Reefs 7: 51-56.

Burgess, S.M. (1987) The climate and weather of western Kiribati. New Zealand Met. Serv.. Misc. Publ. 188/7.

Burne, R.V. (1983) Origin and transportation of beach sand Betio-Bairiki, Tarawa, Kiribati - July 1983. CCOP/SOPAC Cruise Rept. 81.

Byrne, G. (1991) Sediment movement on Tarawa, Kiribati. Proceedings workshop on coastal processes in the South Pacific nations, Lae, 1987, CCOP/SOPAC Tech. Bull. 7, pp. 155-159.

Carter, R. (1983) Coastal erosion in Kiribati 10-13 Jan 1983. CCOP/SOPAC Tech. Rept. 76.

Catala, R.L.A. (1957) Report on the Gilbert Islands: some aspects of human ecology. Atoll Res. Bull. 59.

Chappell, J. and Shackleton, N.J. (1986) Oxygen isotopes and sea level. Nature 324: 137-140.

Chappell, J. and Polach, H. (1991) Post glacial sea level rsie from a coral record at Huon Peninsula, Papua New Guinea. Nature 349: 147-149.

Chivas, A., Chappell, J., Polach, H., Pillans, B. and Flood, P. (1986) Radiocarbon evidence for the timing and rate of island development, beach-rock formation and phosphatization at Lady Elliot Island, Queensland, Australia. Marine Geol. 69: 273-287.

Clapp, R.B. and Sibley, F.C. (1971) The vascular flora and terrestrial vertebrates of Vostok Island, South-central Pacific. Atoll Res. Bull. 144: 1-10.

Clark, J.A., Farrell, W.E. and Peltier, W.R. (1978) Global change in post glacial sea level: a numerical calculation. Quat. Res. 9: 265-287.

Cloud, P.E. (1952) Preliminary report on geology and marine environments of Onotoa Atoll, Gilbert Islands. Atoll Res. Bull. 12: 1-73.

Colman, R. (1989) The hydrodynamics and sediment transport of atoll lagoon channels: a pilot investigation into the effects of construction of road links between the islets of North Tarawa, Kiribati. Report prepared to AIDAB, Victoria Institute of Marine Sciences70pp.

Commonwealth Secretariat (1989) Climate Change: Meeting the Challenge: report of a Commonwealth group of experts, London, September 1989.

Connell, J. and Roy, P. (1989) The greenhouse effect: the impact of sea level rise on low coral islands in the South Pacific. In Pernetta, J.C. and Hughes, P.J. (ed.) Studies and reviews of greenhouse related climatic change impacts on the Pacific Islands, Association of South Pacific Environmental Institutions, Majuro. pp. 106-133.

Darwin, C. (1842) The structure and distribution of coral reefs. London, Smith, Elder and Co.

Degener, O. and Degener, I. (1959) Canton Atoll, South Pacific (resurvey of 1958) Atoll Res. Bull. 64:

Doran, E. (1960) Report on Tarawa Atoll, Gilbert Islands. Atoll Res. Bull. 72.

Falkland, A.C. (1983) Christmas Island (Kiritimati): Water Resources Study, prepared for Australian Development Assistance Bureau, Australia.

Falkland, A. and Brunel, J.P. (1989) Regional hydrology and water resources problems of humid tropical islands. International colloquium on the development of hydrologic and water management strategies in the humid tropics, Townsville, Australia.

Gauss, G.A. (1982) Nearshore surveys, Tarawa, Kiribati, 5 Nov-23 Dec 1981. CCOP/SOPAC Tech. Rept. 63.

Gillie, R.D. (1991) Beach profile surveys on Betio and Bairiki and along the Nippon Causeway, South Tarawa, Republic of Kiribati, January 1991. SOPAC Prelim Rept. 37.

Gornitz, V., Lebedeff, L. and Hansen, J. (1982) Global sea level trend in the past century. Science 215: 1611-1614.

Gornitz, V. and Lebedeff, S. (1987) Global sea level changes during the past century. In Sea-level fluctuation and costal evolution, SEPM Spec. Publ. 41: 3-16.

Gorntiz, V. (1990) Mean sea level changes in the resent past. In Warrick, R.A. and Wigley, T.M.L. (eds.) Climate and sea level change: observations, projections and implications. Cambirdge University Press.

Guinther, E.B. (1974) Groundwater and nearshore hyposaline conditions at Fanning Island during a period of higher than normal rainfall. Pacific Science 28: 319-337.

Guinther, E.B. (1978) Observations on terrestrial surface and subsurface water as related to island morphology at Canton atoll. Atoll Res. Bull. 221: 171-183.

Hanor, J.S. (1978) Precipitation of beachrock cements: mixing of marine and meteoric waters versus CO_2 degassing. J. Sedim. Petrol. 48: 489-501.

Harper, J.R. (1987) Initial survey of the Betio/Bairiki causeway, Tarawa, Republic of Kiribati. CCOP/SOPAC Tech. Rept. 82.

Harper, J.R. (1989a) Follow-up survey of the Betio-Bairiki causeway, Tarawa, Republic of Kiribati. CCOP/SOPAC Tech. Rept. 86.

Harper, J.R. (1989b) Reconnaissance survey of coastal erosion sites on Abaiang Atoll, Republic of Kiribati, 3-4 April 1989. CCOP/SOPAC Tech. Rept. 92.

Harper, J.R. (1989c) Evaluation of beach profile data from Betio and Bairiki, Republic of Kiribati. CCOP/SOPAC Tech Rept. 94.

Holmes, D.W. (1979) Gilbert islands: land reclamation and sea defences on Tarawa Atoll. Hydraulics Research Station Report OD18.

Holmes, D.W. (1983) Report on visits to Kiribati and BDDP Suva 7-16 Dec 1983. Hydraulics Research Station Report ODV162.

Hopley, D. (1982) The Geomorphology of the Great Barrier Reef. New York, Wiley Interscience.

Hopley, D. and Kinsey, D. W. (1988) The effect of a rapid short-term sea level rise on the Great Barrier Reef. in Pearman, G. I. (ed.) Greenhouse: planning for climatic change, C.S.I.R.O. Melbourne, pp. 189-201.

Howorth, R. (1982) Coastal erosion in Kiribati: visit to South Tarawa 22 Jan-10 Feb 1982. CCOP/SOPAC Tech Rept. 22.

Howorth, R. (1983a) Coastal erosion in Kiribati: second visit to South Tarawa 10-16 June 1982. CCOP/SOPAC Tech Rept. 25.

Howorth, R. (1983b) Coastal erosion in Kiribati: visit to South Tarawa 23 Aug - 8 Sept 1983. CCOP/SOPAC Tech Rept. 31.

Howorth, R., Cowan, H. and Carter, R. (1986) Coastal erosion potential South Tarawa, Kiribati. South Pacific Marine Geology Notes 3: 29-32.

Howorth, R. and Radke, B. (1991) Investigation of historical evidence of shoreline changes: Betio, Tarawa Atoll, Kiribati, and Fongafale, Funafuti Atoll, Tuvalu. Proceedings workshop on coastal processes in the South Pacific nations, Lae, 1987, CCOP/SOPAC Tech. Bull. 7, pp. 91-98.

Hydraulics Research Station (1976) Gilbert Islands, Land reclamation, causeway construction, and sea defences. Hydraulics Research Station, Wallingford, England. Report 44pp.

Jacobson, G. and Taylor, F.J. (1981) Hydrogeology of Tarawa atoll, Kiribati. B.M.R. Geol. Geophys. Record 1981/31.

Jenkin, R.N. and Foale, M.A. (1968) An investigation of the coconut-growing potential of Christmas Island. Land Resources Study no 4, Land Resources Division, Directorate of Overseas Surveys, England.

Jokiel, P.L. and Coles, S.L. (1990) Response of Hawaiian and other Indo-Pacific reef corals to elevated temperature. Coral Reefs 8: 155-162.

Lewis, J. (1988) Sea level rise - Tonga, Tuvalu, (Kiribati). Report of a rapid field reconnaissance mission. Commonwealth Secretariat. 97pp.

Lewis, J. (1990) The vulnerability of small island states to sea level rise: the need for holistic strategies. Disasters 14: 241-248.

Lloyd, J.W., Miles, J.C., Chessman, G.R. and Bugg, S.F. (1980) A ground-water resources study of a Pacific Ocean atoll - Tarawa, Glbert Islands. Water Res. Bull. 16: 646-653.

Luomala, K. (1953) Ethnobotany of the Gilbert Islands. Bull. B.P. Bishop Museum, 213. 129pp.

McLean, R.F. (1980) Spatial and temporal variability of external physical controls on small island ecosystems. in Brookfield, H.C. (ed.) Population-environment relations in tropical islands: the case of eastern Fiji, Paris, UNESCO, pp. 149-175.

McLean, R. F. (1989) Kiribati and sea level rise. Report to the Commonwealth Secretariat.

McLean, R.F. and Hosking, P.L. (1991a) Tuvalu Land Resources Survey: Country Report. A report prepared for the Food and Agriculture Organisation (UNDP).

McLean, R.F. and Hosking, P.L. (1991b) Geomorphology of reef islands and atoll motu in Tuvalu. South Pacific Journal of Natural Science 11: 167-189.

Maragos, J.E., Baines, G.B.K. and Beveridge, P.J. (1973) Tropical cyclone creates a new la formation on Funafuti atoll. Science 181: 1161-1164.

Marshall, J.F. and Jacobson, G. (1985) Holocene growth of a mid-plate atoll: Tarawa, Kiribat Coral Reefs 4: 11-17.

Mather, J.D. (1975) Development of the groundwater resources of small limestone islands. C Jl. Engng Geol. 8: 141-150.

Miller, D.L.R. and Mackenzie, F.T. (1988) Implications of climate change and associated sea-level rise for atolls. Proc. 6th Int. Coral Reef Congr. 3: 519-522.

Moul, E.T. (1957) Preliminary report on the flora of Onotoa Atoll, Gilbert Islands. Atoll Res. Bull. 57: 1-48.

Nakada, M. and Lambeck, K. (1988) The melting history of the late Pleistocene Antarctic ice sheet. Nature 333: 36-40.

National Planning Office (1988) Kiribati: 6th National Development Plan 1987-1991, Ministry of Finance, Kiribati.

National Task Force (1992) Republic of Kiribati, National Report for the United Nations Conference on Environment and Development (UNCED)

Neumann, A.C. and Macintyre, I. (1985) Reef response to sea level rise: keep-up, catch-up or give-up. Proc. 5th Int. Coral Reef Congr. 3: 105-110.

Newell, N.D. and Bloom, A.L. (1970) The reef flat and 'two-meter eustatic terrace' of some Pacific atolls. Geol. Soc Am. Bull. 81: 1881-1894.

Nunn, P. (1988) Potential impacts of projected sea level rise on Pacific Island States (Cook Islands, Fiji, Kiribati, Tonga and Western Samoa): a preliminary report. Potential impacts of greenhouse gas generated climatic change and projected sea-level rise on Pacific Isla states of the SPREP region, pp. 53-81.

Oberdorfer, J.A. and Buddemeier, R.W. (1988) Climate change: effects on reef island resource Proc. 6th Int Coral Reef Congr. 3: 523-527.

Oerlemans, J. (1989) A projection of future sea level. Climatic Change 15: 151-174.

Peltier, W.R. and Tushingham, A.M. (1989) Global sea level rise and the greenhouse effect: might they be connected? Science 244: 806-810.

Pernetta, J. C. (1988) Projected climate change and sea level rise: a relative impact rating for the countries of the Pacific basin. in Association of South Pacific Environmental Institutions, Potential impacts of greenhouse gas generated climatic change and projectec sea-level rise on Pacific Island states of the SPREP region, pp. 1-11.

Pirazzoli, P.A. (1986) Secular trends of relative sea-level (RSL) changes indicated by tide-gauge records. J. Coastal Res. SI 1: 1-26.

Pirazzoli, P.A. and Montaggioni, L.F. (1986) Late Holocene changes in trhe northwest Tuamotu Islands, French Polynesia. Quat. Res. 25: 350-368.

Pirazzoli, P.A. and Montaggioni, L. (1988) The 7000 yr sea-level curve in French Polynesia: Geodynamic implications for mid-plate volcanic islands. Proc. 6th Int. Coral Reef Congr. 3: 467-472.

Richmond, B.M. (1990) Nearshore sediment distribution, South Tarawa, Kiribati. CCOP/SOPAC Tech. Rept. 91.

Roy, P. and Connell, J. (1989a) Greenhouse: impact of sea level rise on low coral islands in the South Pacific. Research Institute for Asia and the Pacific Occasional Paper 6, 55pp.

Roy, P. and Connell, J. (1989b) The greenhouse effect: where have all the islands gone? Pacific Islands Monthly 59: 16-21.

Roy, P. and Connell, J. (1990) Greenhouse effects on atoll islands in the South Pacific. Geol. Soc. Aust. Symp. Proc. 1: 57-70.

Roy, P. and Connell, J. (1991) Climatic change and the future of atoll states. J. Coastal Res. 7: 1057-1075.

Russell, R.J. (1962) Origin of beachrock. Z. Geomorph. N.F.3: 227-236.

Schofield , J.C. (1977a) Late Holocene sea-level, Gilbert and Ellice Islands, west central Pacific Ocean. N.Z. J. Geol. Geophys. 20: 503-529.

Schofield, J.C. (1977b) Effect of Late Holocene sea-level fall on atoll development. N.Z. J. Geol. Geophys. 20: 531-536.

Scott, G.A.J. and Rotondo, G.M. (1983) A model to explain the differences between Pacific plate island atoll types. Coral Reefs 1: 139-150.

Small, C.A. (1972) Atoll Agriculture. Department of Agriculture, Tarawa.

Stoddart, D.R. (1971) Coral reefs and islands and catastrophic storms. in Steers, J.A. (ed.) Applied Coastal Geomorphology, pp. 155-197.

Stoddart, D.R., McLean, R.F. and Hopley, D. (1978) Geomorphology of reef islands, northern Great Barrier Reef. Phil. Trans. Roy. Soc. London B 284: 39-61.

Stoddart, D.R. and Steers, J.A. (1977) The nature and origin of coral reef islands. in Jones, O.A. and Endean, R. (eds.) Biology and Geology of Coral Reefs IV, Geology II, pp.59-105.

Sullivan, M. and Gibson, L. (1991) Environmental planning, climate change and potential sea level rise: report on a mission to Kiribati. South Pacific Regional Environment Programme Reports and Studies 50, 55 pp.

Sullivan, M. and Pernetta, J. (1989) The effect of sea level rise on atolls and motu. In Pernetta, J.C. and Hughes, P.J. (ed.) Studies and reviews of greenhouse related climatic change impacts on the Pacific Islands, Association of South Pacific Environmental Institutions, Majuro. pp. 1-15.

Szabo, B.J., Tracey, J.I. and Goter, E.R. (1985) Ages of subsurface stratigraphic intervals in the Quaternary of Eniwetak Atoll, Marshall Islands. Quat. Res. 23: 54-61.

Thaman, R.R. (1990) Kiribati agroforestry: trees, people and the atoll environment. Atoll Res. Bull. 333.

Thom, B.G. and Roy, P.S. (1988) Sea-level rise and climate: lessons from the Holocene. in Pearman, G. I. (ed.) Greenhouse: planning for climatic change, C.S.I.R.O. Melbourne, pp. 177-188.

Tofiga, M.P. (1985) Agricultural subsistence and development. In Kiribati: a changing atoll culture, Institute of Pacific Studies, pp.155-165.

Tracey, J.I. (1972) Holocene emergent reefs in the central Pacific. 2nd Conference, American Quaternary Association, Abstracts: 51-52.

Tracey, J.I. and Ladd, H.S. (1974) Quaternary history of Eniwetok and Bikini atolls, Marshall Islands. Proc. 2nd Int. Coral Reef Symp. 2: 537-550.

Tsyban, A., Everett, J. and Titus, J. (1990) World oceans and coastal zones. In Tegart, W.J.McG., Sheldon, G.W. and Griffiths, D.C. (eds.) Climate Change. The IPCC Impacts Assessment, Australian Goverrnment Publishing Service, Canberra. pp. 6-1 - 6-28.

Valencia, M.J. (1977) Christmas Island (Pacific Ocean): reconnaissance geologic observations. Atoll Res. Bull. 197.

Ward, M.W. and Monsell-Davis, M. (1990) Outer Islands Development Program: study of socio-economic impact of causeways. Report to the Australian International Development Assistance Bureau.

Warrick, R. and Oerlemans, J. (1990) Sea level rise. In Houghton, J.T., Jenkins, G.J. and Ephraums, J.J. (eds.) Climate Change: The IPCC Scientific Assessment, Cambridge University Press. pp. 257-281.

Weber, J.N. and Woodhead, P.M.J. (1972) Carbonate lagoon and beach sediments of Tarawa Atoll, Gilbert Islands. Atoll Res. Bull. 157: 1-21.

Wester, L. (1985) Checklist of the vascular plants of the Northern Line Islands. Atoll Res. Bull. 287: 1-38.

Wiens, H. (1962) Atoll environment and ecology. Yale Univ. Press.

Williams, E.H. Jr and Bunkley-Williams, L. (1990) The world-wide coral reef bleaching cycle and related sources of coral mortality. Atoll Res. Bull. 335.

Woodroffe, C.D. (1988) Pacific Island mangroves: distribution and environmental settings. Pacific Science 41: 166-185.

Woodroffe, C.D. (1989a) Maldives and sea-level rise: an environmental perspecive. Report to the Maldives Government.

Woodroffe, C.D. (1989b) Saltwater intrusion into groundwater: an assessment of effects on small island states due to rising sea level. Paper presented at the Small States Conference on Sea Level Rise, Malé, 1989.

Woodroffe, C.D. (1991) Vegetation of Tuvalu. South Pacific Journal of Natural Science 11: 82-128.

Woodroffe, C.D., Stoddart, D.R., Spencer, T., Scoffin, T.P. and Tudhope, A. (1990a) Holocene emergence in the Cook Islands, South Pacific. Coral Reefs 9: 31-39.

Woodroffe, C.D., McLean, R.F. and Wallensky, E. (1990b) Darwin's coral atoll: geomorphology and recent development of the Cocos (Keeling) Islands, Indian Ocean. National Geographic Research 6: 262-275.

Woodroffe, C.D. and McLean, R.F. (1990) Microatolls and recent sea level change on coral atolls. Nature 344: 531-534.

Woodroffe, C.D., Veeh, H. H., Falkland, A., McLean, R.F. and Wallensky, E. (1991) Last interglacial reef and subsidence of the Cocos (Keeling) Islands, Indian Ocean. Marine Geology 96: 137-143.

Wyrtki, K. (1974) Sea level and the seasonal fluctuations of the equatorial currents in the western Pacific Ocean. J. Phys. Oceanogr. 4: 91-103.

Wyrtki, K. (1990) Sea level rise: the facts and the future. Pacific Science 44: 1-16.

Yonekura, N., Ishii, T., Saito, Y., Maeda, Y., Matsushima, Y., Matsumoto, E. and Kayanne, H. (1988) Holocene fringing reefs and sea-level change in Mangaia Island, southern Cook Islands. Palaeogeog. Palaeoclim. Palaeoecol. 68: 177-188.

Zann, L. (1982) Marine ecology on Betio Island, Tarawa Atoll, Republic of Kiribati 5-18 Nov 1981. CCOP/SOPAC Tech. Rept. 23.

Appendix: Area, perimeter and population of outer Gilbert Islands.

Island	Area (km^2)	Peri-meter (km)	Length mangrove (km)	Maximum length (km)	Maximum width (km)	Population
LITTLE MAKIN						
Little Makin	5.56	17.4	2.0	6.50	1.50	1,359
Kiebu	0.93	5.00	--	2.37	0.62	403
Biki n 'Eitei	0.02	0.25	--	0.17	0.10	--
	0.04	1.00	--	0.45	0.08	--
Aonbike	0.12	2.00	--	0.87	0.27	--
Tebua Tarawa	0.04	0.75	--	0.25	0.10	--
Onne	0.52	3.75	--	1.62	0.45	--
TOTAL	7.23	30.12	2.0			1,762
BUTARITARI						
Bikati	0.52	5.00	--	2.00	0.60	172
Bikatieta	0.09	1.50	--	0.50	0.33	--
Teirio	0.01	0.25	--	0.05	0.05	--
Oteariki Sand	0.03	0.63	--	0.12	0.08	--
	0.01	0.38	--	0.12	0.08	--
	0.01	0.25	--	0.25	0.12	--
Nabuni	0.02	0.38	--	0.12	0.08	--
Butaritari	10.47	57.25	18.38	21.75	3.13	2,941
Tikurere	0.01	0.25	--	0.15	0.03	--
	0.01	0.25	--	0.05	0.05	--
	0.07	1.25	--	0.50	0.53	--
	0.03	0.63	--	0.25	0.23	--
	0.01	0.50	--	0.13	0.10	--
	0.02	0.50	--	0.13	0.10	--
	0.01	0.25	--	0.05	0.05	--
	0.01	0.25	--	0.05	0.03	--
Kotabu	0.02	0.75	--	0.25	0.08	--
Ubantakoto	0.001	0.25	--	0.13	0.03	--
Namoka	0.06	1.08	--	0.30	0.25	--
	0.03	2.00	--	0.75	0.05	--
Natata	0.16	1.75	--	0.68	0.45	--
Kaionobi	0.01	0.50	--	0.25	0.08	--
	0.03	1.00	--	0.25	0.23	--
	0.01	0.63	--	0.25	0.05	--
Keuea	3.12	25.38	--	11.25	0.75	673
	0.09	1.38	--	0.43	0.25	--
	0.01	0.25	--	0.08	0.05	--
	0.01	0.38	--	0.18	0.08	--
	0.02	0.25	--	0.13	0.05	--
	0.04	0.50	--	0.08	0.13	--
	0.03	0.38	--	0.20	0.05	--
TOTAL	14.97	106.00	18.38			3,786

Island	Area (km^2)	Perimeter (km)	Length mangrove (km)	Maximum length (km)	Maximum width (km)	Population
MARAKEI						
Tanimaiaki	5.07	33.75	--	10.38	0.75	701
Rawannawi	8.62	35.38	--	13.50	3.38	2,162
Aontereke	0.10	5.56	--	2.00	0.13	--
Bikentetao	0.01	0.75	--	0.25	0.06	--
	0.001	0.19	--	0.06	0.06	--
MRZ10	0.01	0.25	--	0.13	0.06	--
	0.01	0.25	--	0.19	0.13	--
Taborann-	0.02	0.5	--	0.25	0.13	--
amakaina	0.01	0.13	--	0.03	0.03	--
	0.001	0.19	--	0.38	0.03	--
	0.01	0.25	--	0.06	0.06	--
TOTAL	13.86	77.20				2,863
ABAIANG						
Teraereke	14.00	76.87	--	37.13	1.05	4,570
Iaia	0.02	0.75	--	0.31	0.20	--
Taete	0.30	2.25	--	0.70	0.45	--
Terinabanau	0.02	0.25	--	0.15	0.08	--
Rainabara	0.02	0.50	--	0.20	0.15	--
Rainaba	0.10	1.25	--	0.38	0.35	--
Ribono	0.73	4.75	--	1.88	0.58	--
Abanango	0.02	0.35	--	0.13	0.08	--
Bakatorotoro	0.02	0.25	--	0.15	0.03	--
Onabike	0.01	0.25	--	0.08	0.08	--
Nanikirata	0.06	1.50	--	0.38	0.25	--
Tepanonga	0.01	0.75	--	0.25	0.13	--
Kataraniti	0.02	0.50	--	0.23	0.05	--
Nuotea	1.00	11.25	--	5.38	0.38	458
Anaeai	0.02	0.50	--	0.15	0.10	--
Baititi	0.001	0.10	--	0.03	0.03	--
Nanteakoi	0.01	0.25	--	0.08	0.05	--
Anaua	0.02	0.50	--	0.20	0.08	--
Toukina	0.01	0.25	--	0.05	0.03	--
Bikentourakai	0.01	0.25	--	0.08	0.05	--
Taboniba	0.01	0.10	--	0.03	0.03	--
Tennia	0.03	0.50	--	0.10	0.08	--
Bike	0.01	0.25	--	0.08	0.05	--
Neiteba	0.001	0.10	--	0.03	0.03	--
Anariki	0.13	1.63	--	0.60	0.25	--
Nantorom	0.01	0.25	--	0.10	0.08	--
Manra	0.05	1.00	--	0.43	0.20	--
Ouba	0.03	0.35	--	0.13	0.10	--
Eke	0.06	0.50	--	0.25	0.08	--
Teirio	0.11	2.00	--	0.90	0.20	--
Iku	0.20	0.25	--	0.08	0.05	--
TOTAL		110.25				5,314

Island	Area (km^2)	Peri-meter (km)	Length mangrove (km)	Maximum length (km)	Maximum width (km)	Population
MAIANA						
Maiana	14.08	65.63	7.75	29.5	22.25	2,104
Tebikerai	0.25	3.25	0.50	1.00	0.63	80
Bikentiroi	0.05	0.70	--	0.20	0.08	--
Bikenmamara	0.05	1.25	--	0.50	0.15	--
Arinnanona	0.20	2.50	0.25	0.95	0.33	--
Bikenikau	0.05	1.08	0.50	0.38	0.20	--
Bikentiang	0.05	2.13	--	0.50	0.20	--
Bikenibuni	0.05	0.80	--	0.43	0.10	--
Bikeningako	0.04	0.68	--	0.25	0.18	--
Tekatoka	0.05	0.75	--	0.35	0.18	--
Nanuteute	0.04	0.63	--	0.33	0.05	--
Tuakiri	0.06	1.00	--	0.35	0.18	--
Abaokoro	0.01	0.50	--	0.20	0.06	--
Toiaki	0.37	5.00	--	1.63	0.58	--
TOTAL	14.97	80.40	9.00			2,184
ABEMAMA						
Bike	0.37	2.88	--	1.13	0.63	--
Abatiku	2.92	8.53	--	3.83	1.30	203
Tabaiang-Tabioaki	21.65	68.63	--	30.13	1.05	2,450
Manoku	1.53	5.63	0.63	2.25	0.75	216
Kabangaki	7.41	13.20	2.28	5.00	1.13	349
Kenna	0.80	4.68	--	1.38	0.70	--
TOTAL	34.68	103.55	2.91			3,218
KURIA						
Oneaka	5.05	11.50	--	4.75	1.50	139
Buariki	10.14	14.75	--	4.33	4.25	327
TOTAL	15.19	26.25	--	9.08	5.75	466
ARANUKA						
Takaeang	5.55	14.38	--	5.63	1.75	272
Bikentakenako	0.03	0.38	--	0.10	0.05	--
Bikentekai	0.11	0.88	--	0.20	0.08	--
	0.06	0.5	--	0.25	0.05	--
Naekai	0.06	1.00	--	0.55	0.05	--
Autiuka	0.04	0.63	--	0.18	0.13	--
Tekautu	0.41	5.88	--	1.75	0.63	--
Tetongo	0.26	4.50	0.18	1.50	0.33	--
Terawanimatang Kauake	6.78	23.8	2.00	10.25	1.25	830
TOTAL	13.30	51.90	2.18			1,102

Island	Area (km^2)	Perimeter (km)	Length mangrove (km)	Maximum length (km)	Maximum width (km)	Population
NONOUTI						
Numatong		1.25	--	0.50	0.20	--
Tabontena	0.09	1.25	--	0.63	0.13	--
Tewao	0.09	2.00	--	0.73	0.25	--
	0.03	0.75	--	0.20	0.05	--
	0.56	12.5	--	4.50	0.83	--
	0.04	1.00	--	0.40	0.08	--
Toroto	0.11	3.50	--	1.88	0.13	--
Abamakoro	0.19	2.50	--	1.00	0.38	--
Tabukaokao	0.24	2.50	--	0.93	0.33	--
Matannato	0.07	1.75	--	0.80	0.20	--
Tengani	0.33	2.75	--	1.00	0.70	--
Abauareke	0.27	7.50	--	3.00	0.25	--
	0.02	0.75	--	0.35	0.05	--
Matabou	0.31	2.88	--	1.00	0.45	--
Buariki	0.32	3.88	--	1.50	0.33	--
Tebuka	0.11	2.00	--	0.53	0.30	--
Teuabu	1.62	9.75	--	3.00	0.75	--
Temanoku	14.09	72.50	6.5	30.75	0.88	--
Temotu	1.34	24.38	8.38	8.23	0.68	--
TOTAL	19.83	155.39	14.88			2,766
TABITEUEA						
Anikai	20.91	44.75	--	18.50	2.20	2,703
Tauma	1.50	7.50	--	3.13	0.60	174
Biken Tevenei	0.01	0.25	--	0.10	0.08	--
Kabuna	1.06	10.88	--	4.75	0.60	155
Taekimoa	0.08	1.25	--	0.40	0.33	--
Tebuka	0.01	0.50	--	0.25	0.03	--
Tenatabani	0.04	0.75	--	0.28	0.08	--
Teabuaeroa	0.12	2.00	--	0.83	0.15	--
Bikenteinari	0.01	0.25	--	0.08	0.03	--
Aontena	0.22	5.25	--	2.13	0.18	--
Nukumatawaru	0.05	1.50	--	0.65	0.15	--
Tabai	0.09	2.75	--	1.08	0.15	--
Autoronga	0.05	4.38	--	0.70	0.20	--
Tengea	0.10	2.13	--	0.65	0.18	--
Maukawa	0.07	1.75	--	0.68	0.18	--
Tenatemakoi	0.03	0.75	--	0.38	0.05	--
Tenamweau	0.03	1.13	--	0.50	0.08	--
Tenatorua	0.20	2.63	--	1.25	0.43	89
Noutuaru	0.43	5.00	--	2.00	0.68	--
Tengabuka	0.24	1.25	--	1.00	0.38	--
Nautia	0.10	1.25	--	0.38	0.33	--
	0.03	0.50	--	0.20	0.08	--
Bangai	0.24	2.50	--	0.60	0.58	43
	0.01	0.38	--	0.15	0.05	--
Taura	0.11	2.13	--	0.93	0.30	--
Tebukautongo	0.17	2.00	--	0.63	0.43	--
Nakaitu	0.04	1.00	--	0.38	0.08	--
Auenene	0.28	5.63	--	0.93	0.68	--

Island	Area (km^2)	Perimeter (km)	Length mangrove (km)	Maximum length (km)	Maximum width (km)	Population
Barebatu	0.23	3.50	--	1.08	0.58	--
Aiwa	0.36	5.00	--	0.93	0.68	111
Nakaeariki	0.02	0.63	--	0.20	0.04	--
	0.16	2.50	--	0.88	0.28	--
Namauri	0.13	1.50	--	0.60	0.15	--
Tenon	0.10	1.50	--	0.70	0.23	--
Tenauea	0.13	3.00	--	1.24	0.25	--
Nantatae	0.05	0.63	--	0.20	0.08	--
Teruabine	0.19	2.00	--	0.70	0.58	--
Tenaumariki	0.22	2.50	--	0.85	0.58	--
Tengongo	0.11	1.63	--	0.55	0.25	--
Nanikika	0.08	1.38	--	0.60	0.27	--
Benuangongo	0.11	1.63	--	0.70	0.28	--
Takorongaieta	0.25	3.5	--	0.43	0.25	--
Teakaurongo	0.20	4.00	--	1.58	0.20	--
Abarie	0.32	4.25	--	1.88	0.43	--
Tetongo	0.13	3.75	--	1.38	0.30	--
Arakeaka	0.47	4.75	--	1.75	0.45	--
Tewai	0.06	4.25	--	0.75	0.18	295
	1.57	7.12	--	2.05	1.03	--
	0.03	0.75	--	0.25	0.15	--
Unitia	0.38	4.00	--	1.25	0.68	--
Taungaeaka	1.17	8.00	--	2.63	1.50	134
Nikitiri	0.38	3.00	--	1.00	0.45	--
Aranuka	0.03	0.63	--	0.18	0.10	--
	0.11	2.25	--	0.83	0.15	--
	0.01	0.50	--	0.25	0.03	--
Buariki	4.14	12.5	--	4.75	1.90	470
Katabanga	0.99	8.00	--	3.08	0.75	83
Taku	0.89	10.75	--	4.50	0.45	156
TOTAL	39.25	221.44				4,600
BERU						
Beru	17.00	52.25	4.25	20.50	1.85	2,909
NIKUNAU						
Nikunau	19.91	31.00	--	14.25	2.60	2,048
ONOTOA						
Temao	5.12	25.50	5.25	9.00	1.00	1,152
Apenekeneke	0.04	0.75	--	0.25	0.15	--
Nantaboariki	0.02	0.25	--	0.15	0.08	--
Abeiningan	0.06	1.25	--	0.48	0.15	--
Ngakena	0.01	0.50	--	0.25	0.08	--
Otowae	4.69	27.00	--	13.00	0.58	599
Tekaiti	1.28	12.5	--	4.50	0.70	361
Aoniebike	0.06	1.38	--	0.60	0.15	--
	0.21	3.13	--	0.90	0.53	--
Onteuma	0.01	0.50	--	0.20	0.08	--
TOTAL	11.50	72.76	5.25			2,112

Island	Area (km^2)	Peri-meter (km)	Length mangrove (km)	Maximum length (km)	Maximum width (km)	Population
TAMANA						
Tamana	4.73	11.00	--	5.00	1.08	1,396
ARORAE						
Arorae	7.64	19.03	--	9.50	1.00	1,440