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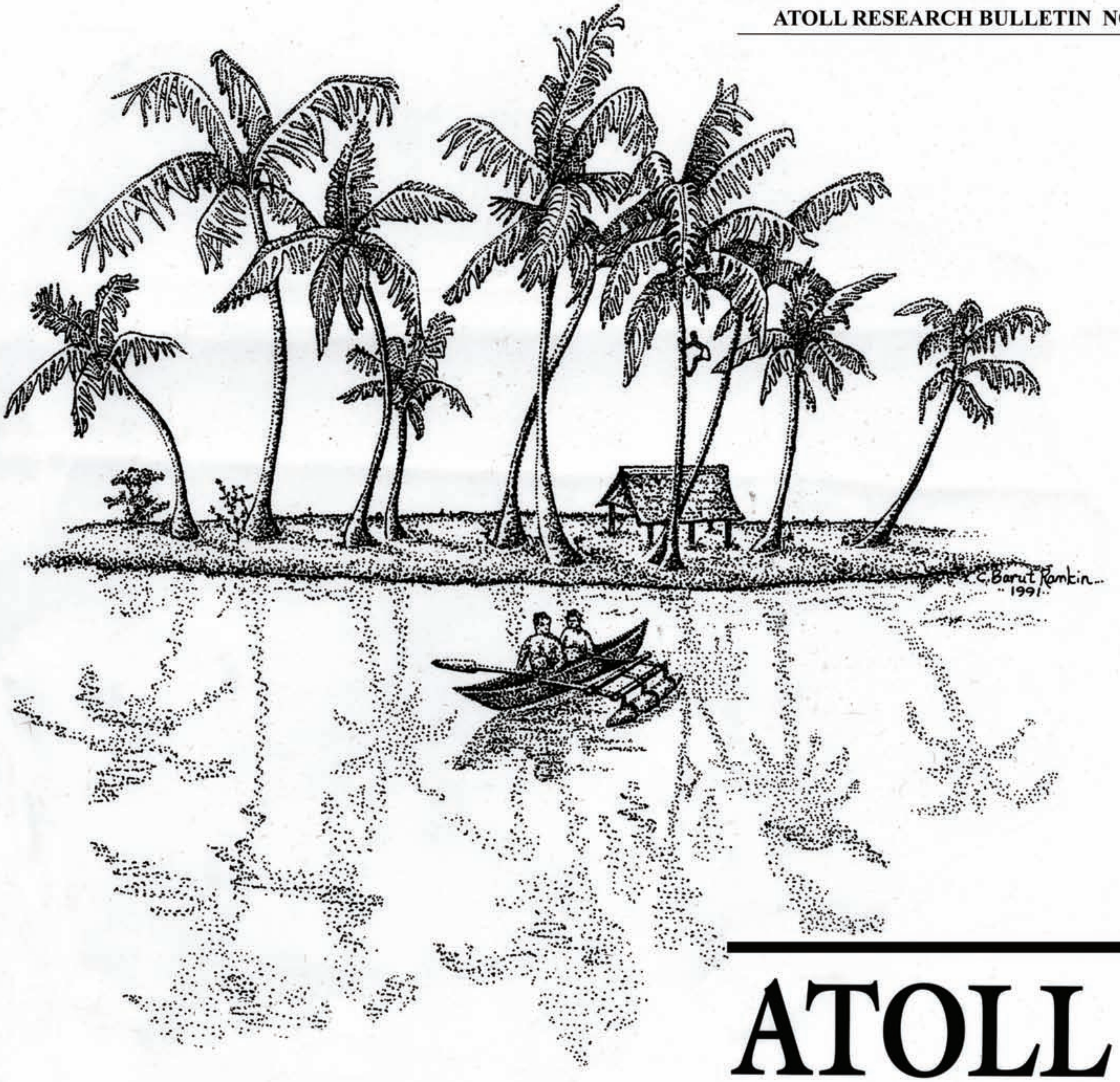

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TSUNAMIS AND CORAL REEFS

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TSUNAMI IMPACTS IN THE REPUBLIC OF SEYCHELLES, WESTERN INDIAN OCEAN

BY

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ABSTRACT

Temporal and spatial characteristics of the December 2004 tsunami in the Republic of Seychelles, Western Indian Ocean are described, with particular reference to the detailed water level record from the Pointe La Rue tide-gauge, Mahé, and tsunami run-up characteristics on Mahé and Praslin. Assessments of tsunami impacts on coastal and shallow marine environments in the granitic islands of the Northern Seychelles, and on the coral islands of selected locations in the Southern Seychelles, are reported. The lack of noticeable impacts within the southern islands compared to those further north appears to be related to both reduced tsunami wave heights to the south and to differences in regional bathymetry, the tsunami being accentuated by the shelf seas of the Seychelles Bank in the north and not amplified around the southern islands surrounded by deep water.

INTRODUCTION

At some 5000 km from Sumatra, the 115 islands of the Republic of the Seychelles were not in the front line of tsunami impacts. Only two tsunami-related fatalities were reported. Nevertheless, the tsunami did have a considerable infrastructural and economic impact, notably on the northern granitic islands. There was prolonged flooding of the capital, Victoria, as a result of the blocking of the storm drainage system by sediments mobilized by the tsunami, fissuring and failure of dock walls at Port Victoria from repeated inundation and drawdown cycles on unconsolidated fills (Plates 1, 2), washouts of key transport routes by the drainage of tsunami waters from coastal lagoons (Plates 3, 4), disruptions to water supply and sewerage networks (with in the case of the latter attendant pollution problems) and extensive structural damage to houses, hotels, restaurants and other beach-front infrastructure. Total estimates of damage have been assessed at US$30 million (UNEP, 2005) due to both structural damage and loss of earnings following the event. The tsunami was said to have damaged 94 fishing boats, a third of the entire fishing fleet, around Mahé and fish catches for January 2005 dropped

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by 30% compared to previous catches for this month (Payet, 2005, pers. comm.). Here we document the temporal and spatial characteristics of the tsunami in the Seychelles and review its impact on geomorphology and shallow marine ecosystems. We draw heavily on the Canadian United Nations Educational, Scientific and Cultural Organization (UNESCO) mission to the Seychelles (Jackson et al., 2005) and on the International Union for the Conservation for Nature and Natural Resources (IUCN) report (Obura and Abdulla, 2005), supplemented by our own observations in Mahé (Stoddart and Hagan, 1 and 4/2005) and the remote southern islands of the Amirantes, Alphonse/St. François and Providence Bank (Hagan, 1/2005), Aldabra and Assumption (Stoddart 4/2005).

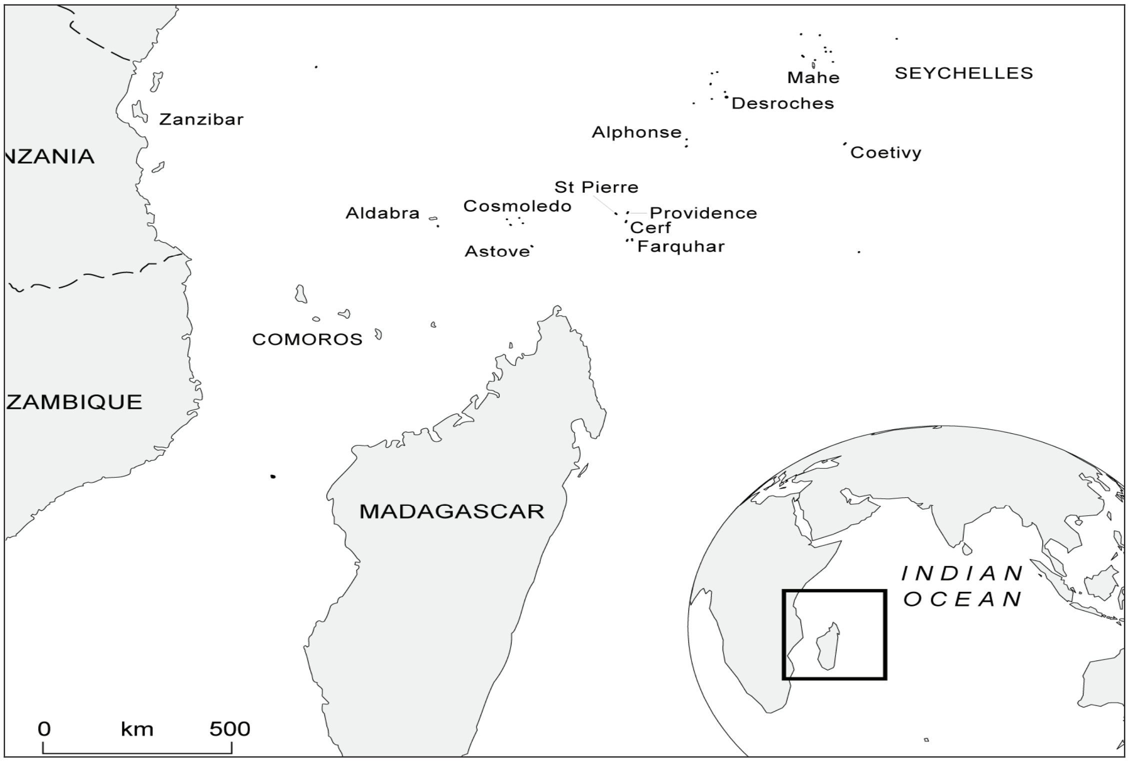
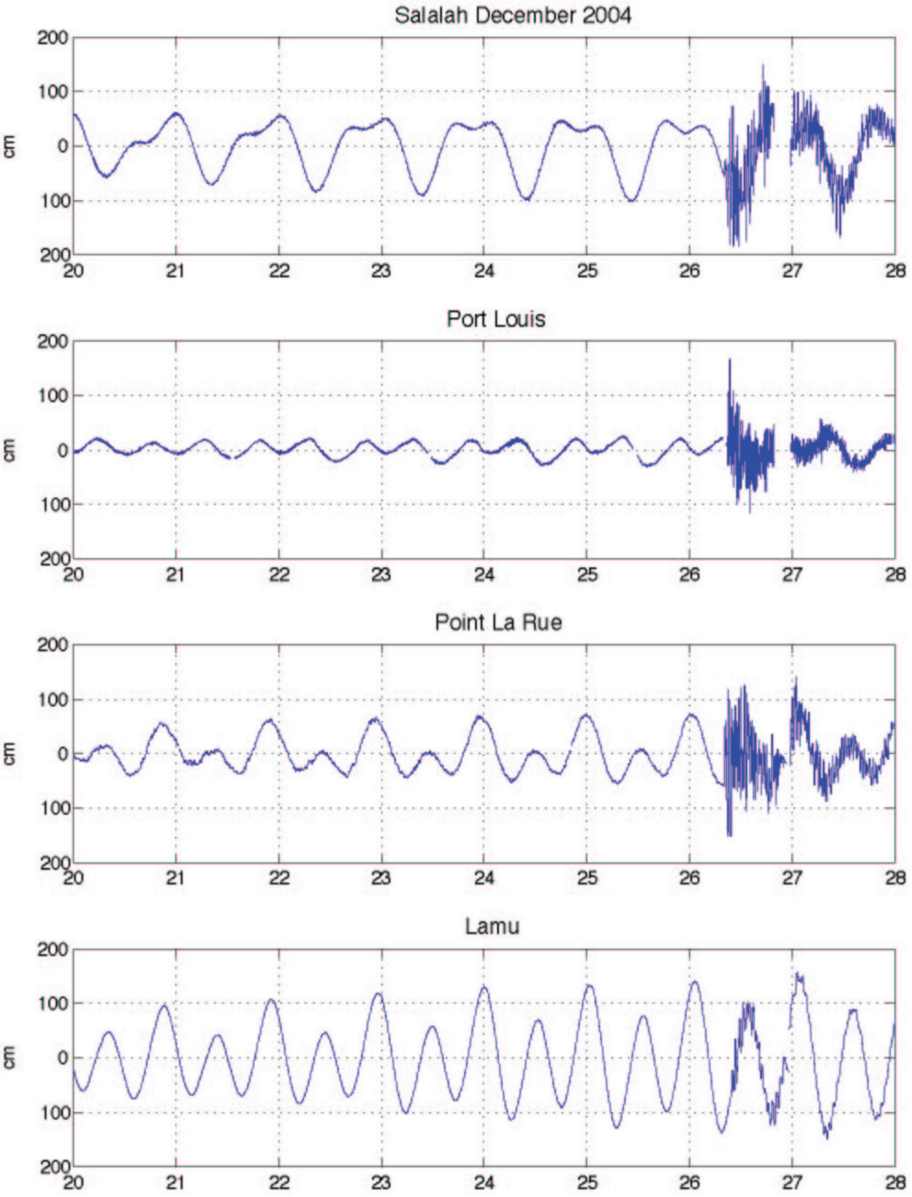


Figure 1. Islands of the Seychelles, western Indian Ocean (after Stoddart, 1970).

CHARACTERISTICS OF THE 26 DECEMBER 2004 TSUNAMI IN THE SEYCHELLES

Temporal Characteristics: Granitic Islands of the Northern Seychelles

Tsunami waves reached the Seychelles at about the same time they impacted Mauritius and Salalah, Oman, ca. 7 hours after the earthquake (Fig. 2; Merrifield et al., 2005).


Salalah December 2004

Port Louis

Point La Rue

Lamu

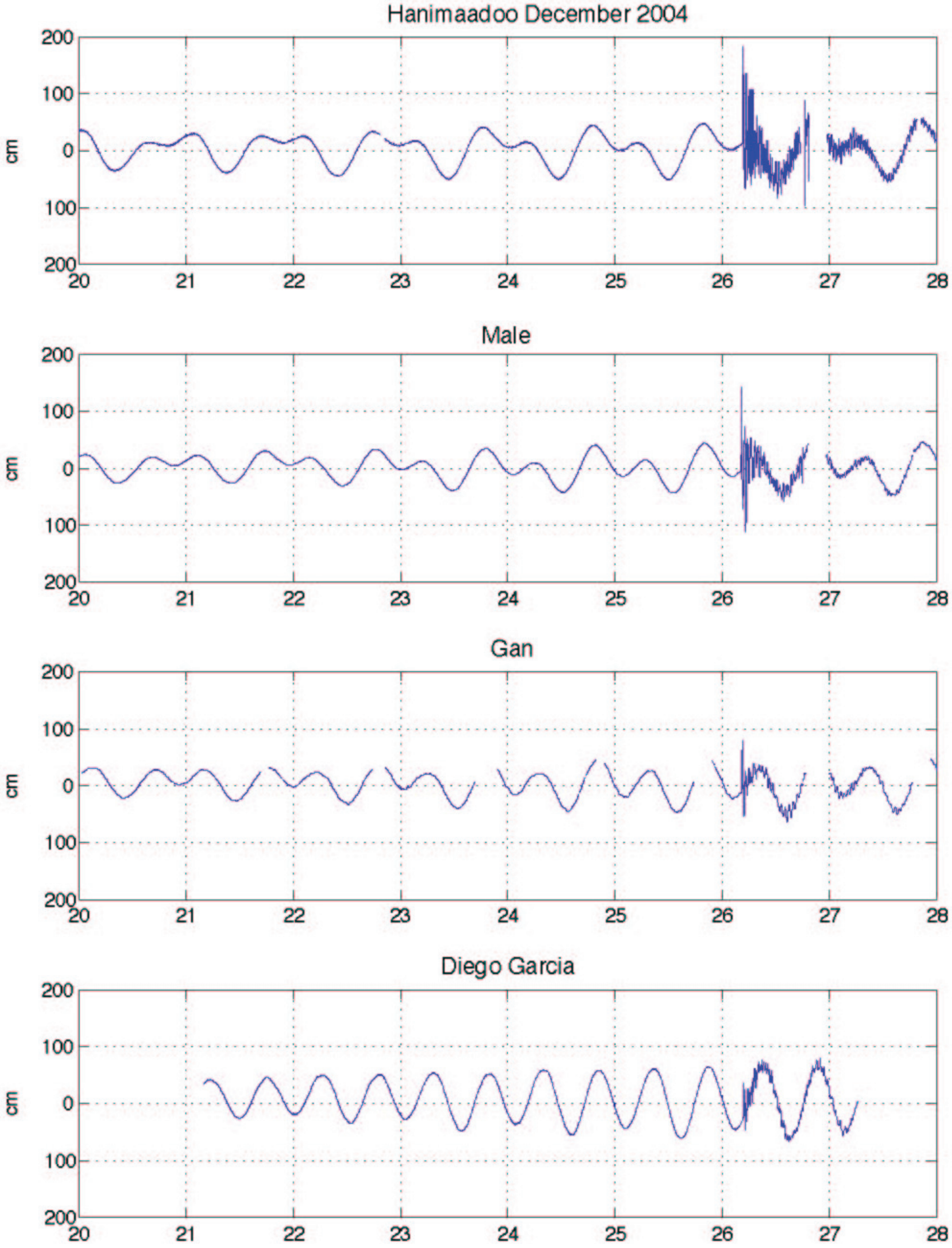
Figure 2. Water level records for Indian Ocean stations, showing the timing and magnitude of the 26 December, 2004 tsunami. Top-to-bottom: Salalah, Oman; Port Louis, Mauritius; Pointe La Rue, Seychelles; Lamu, Kenya. (Courtesy of J. Huthnance; available at http://www.pmel.noaa.gov/tsunami/indo20041226/tsunami2.pdf).

Tsunami amplitudes are greatest perpendicular to generating structures; thus the NNW–SSE orientation of the earthquake faultline between NW Sumatra and the Andaman Islands put the Seychelles Bank directly in line with the tsunami wave front as a simulation of wave heights 15 hours after the earthquake makes clear (Fig. 3; Yalciner et al., 2005).

Figure 3. Computer modelling of the 26 December, 2004 tsunami after 900 minutes (courtesy of A. Yalciner, U. Kuran, T. Taymaz) (available at: http://yalciner.ce.metu.edu.tr/sumatra/max-elev-sim-1.jpg).

Wave approach was, however, complicated by the large-scale refraction of the wave around southeastern Sri Lanka and southern India and by smaller-scale refraction effects across the Maldives chain and the Chagos Archipelago (NOAA 2005b) which were crossed by the tsunami ca. 4 hours and 2.5 hours earlier (Fig. 4; Merrifield et al., 2005).

All locations in the Indian Ocean to the west of the earthquake epicenter first experienced a wave crest (Merrifield et al., 2005). This first arrival was seen in the tide gauge at Pointe La Rue on Mahé at 08:08–08:12 Coordinated Universal Time (UTC) (12:08–12:12 local time) (Fig. 5). The level reached was 0.59 m above mean sea level datum (MSLD) (Fig. 6). The first arrival was on a rising tide, the predicted low tide having been at 07:26 UTC (11:26 local time); water levels were raised but only to typical high spring tide levels and not as high as the preceding high tide (which had peaked at 0.74 m MSLD). The first large wave arrived at 09:12 UTC (13:12 local time), registering a peak of 1.16 m MSLD. Both the first arrival and the first large wave were followed by significant drawdown events of –1.53 m MSLD at 08:56 and 09:36–09:40 respectively. However, these levels relate to the base of the tide-gauge stilling well and, therefore, most probably do not record the complete fall in water level. From eyewitness reports, Jackson et al. (2005) estimate that the true fall in water level may have been as low as –4.0 m below mean sea level. Thereafter a sequence of 8 waves was recorded by the tide-gauge in couplets of a larger wave of a magnitude similar to the first arrival followed by a smaller wave; superimposed on a rising tidal level the trend was for an increase in tsunami wave height peaking at 1.24 m at 12:52 UTC (16.52 local time) (Fig. 6). This wave was followed by a further noticeable drawdown event but after the next high wave, there was a lessening of activity after ca. 14:30 UTC (18:30 local time).



Hanimaadoo December 2004

Male

Gan

Diego Garcia

Figure 4. Water-level records for Indian Ocean stations, showing the timing and magnitude of the 26 December, 2004 tsunami. Top-to-bottom: Hanimaadoo, Maldives; Male, Maldives; Gan, Maldives; Diego Garcia, BIOT. (Courtesy of J. Huthnance; available at http://www.pmel.noaa.gov/tsunami/indo20041226/tsunami1.pdf).

However, activity continued into the next high-tide cycle. The predicted high-tide level (peak stage=75 cm) was considerably higher than the previous high-tide level (12 cm) and when the tsunami activity was superimposed on this high tide it resulted in a water level of 1.41 m at 00:56 UTC (04:56 local time) on 27 December, almost exactly 24 hours after the earthquake and 17 hours after the first arrival in the Seychelles (Figs. 5and 6).

Eyewitness accounts of tsunami impact on the east coast of Mahé broadly correspond to the timings extracted from the tide-gauge record. However, there are observations of significant drawdown events at 07:45–08:00 and 08:00 UTC (11:45–12:00 and 12:00 local time) at Anse Royale/Anse Forbans and Pointe aux Sel respectively which appear to lead the tide-gauge record (situated 14 km to the north of Anse Forbans and 7 km north of Pointe aux Sel) by almost one hour. However, the timings of the first large wave are broadly comparable to the tide-gauge record at these sites. At Anse a la Mouche, on the southwest coast, drawdown again appears to have occurred prior to that recorded in the tide-gauge record. The first large wave, however, appears to have been a later impact than on the east coast, timed at 09:25 UTC (13:25 local time), presumably reflecting the slowing of the tsunami wave front on refraction around the island. Victoria, Anse Royale and Anse Forbans on the east coast all experienced a second phase of flooding between 12:30 and 13:00 UTC (16:30–17:00 local time), as did Anse a la Mouche on the west coast half an hour later, a pattern consistent with the later arrival of the first large wave earlier in the day. In Victoria, it is clear that there was significant further flooding during the night of 26–27 December clearly associated with the wave peak timed at 01:00 UTC (05:00 local time) (Jackson et al., 2005). The tsunami struck Praslin, 40 km to the northeast of Mahé, in two separate surges, the first beginning at 08:10 UTC (12:10 local time). This was one hour before the first large wave was registered by the Mahé tide-gauge. There was a major drawdown event between this wave and the second larger wave which occurred at 08:24 (12:24 local time). Some locations registered large waves at ca. 09:30 and 10:00–11:00 UTC (13:30 and 14.30–15:00 local time) and the late afternoon wave of 26 December was seen at the northwestern end of the island at 12:45 UTC (16:45 local time) (Jackson et al., 2005).

The Pointe La Rue tide-gauge showed that activity continued throughout 27 December (Fig. 5), with an envelope of residuals around predicted tidal levels declining over a 24-hour period (Fig. 7). On 28 December residuals were still present but of the order of 10 cm or less; by 30 December the event was over (Fig. 7).

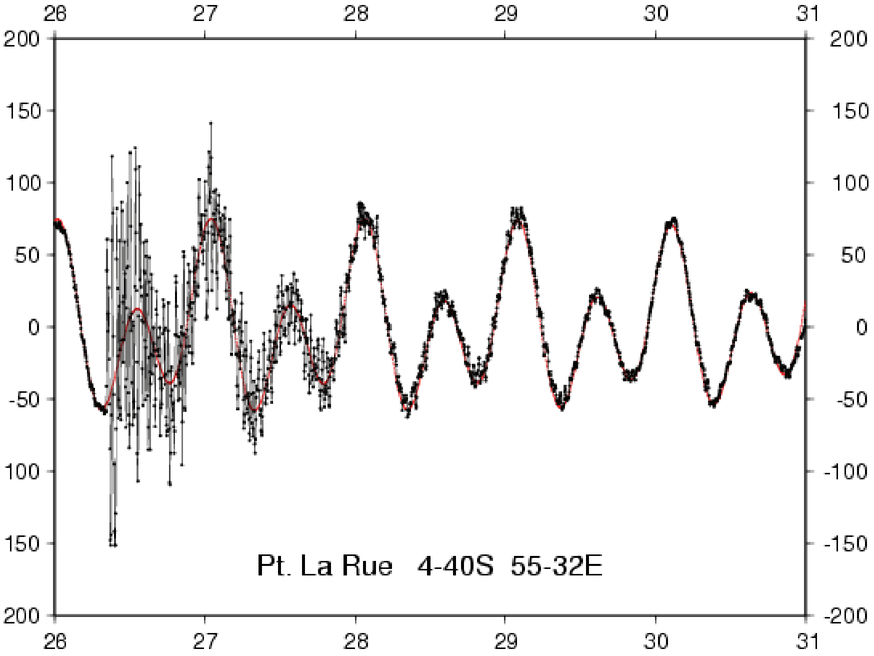


Figure 5. Predicted tidal-curve and water-level records, Pointe La Rue tide-gauge, Mahé, Seychelles, 26–30 December 2004. Heights in cm relative to Mean Sea Level Datum. (National Meteorological Service Seychelles / University of Hawaii Sea Level Center; available at: http://ilikai.soest.hawaii.edu/uhslc/iotd/plar1.html)

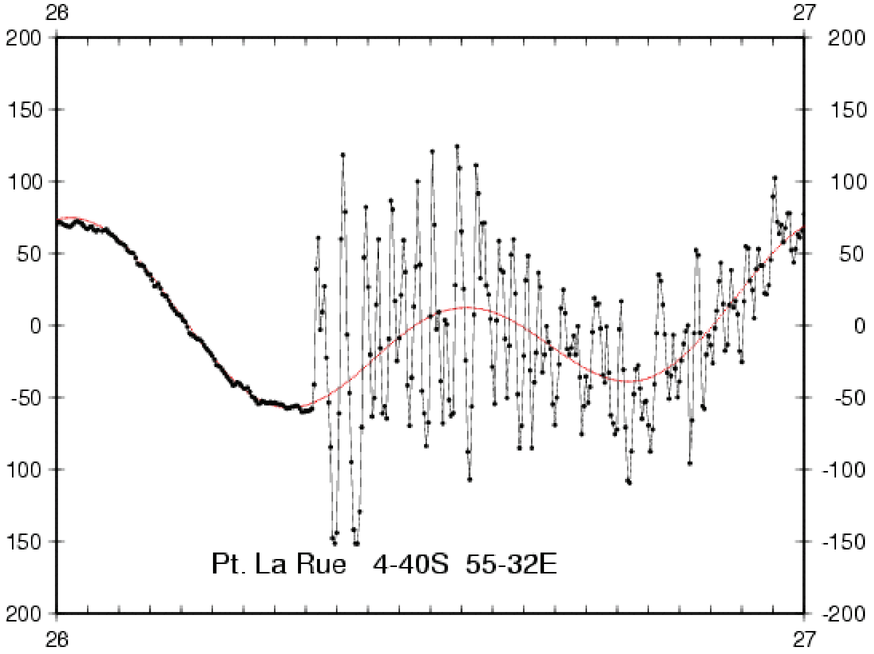


Figure 6. Detail of Figure 5 showing predicted tidal level and individual tsunami peaks and water-level drawdowns, 26 December, 2004. (National Meteorological Service Seychelles / University of Hawaii Sea Level Center; available at: http://ilikai.soest.hawaii.edu/uhslc/iotd/plar5.gif).

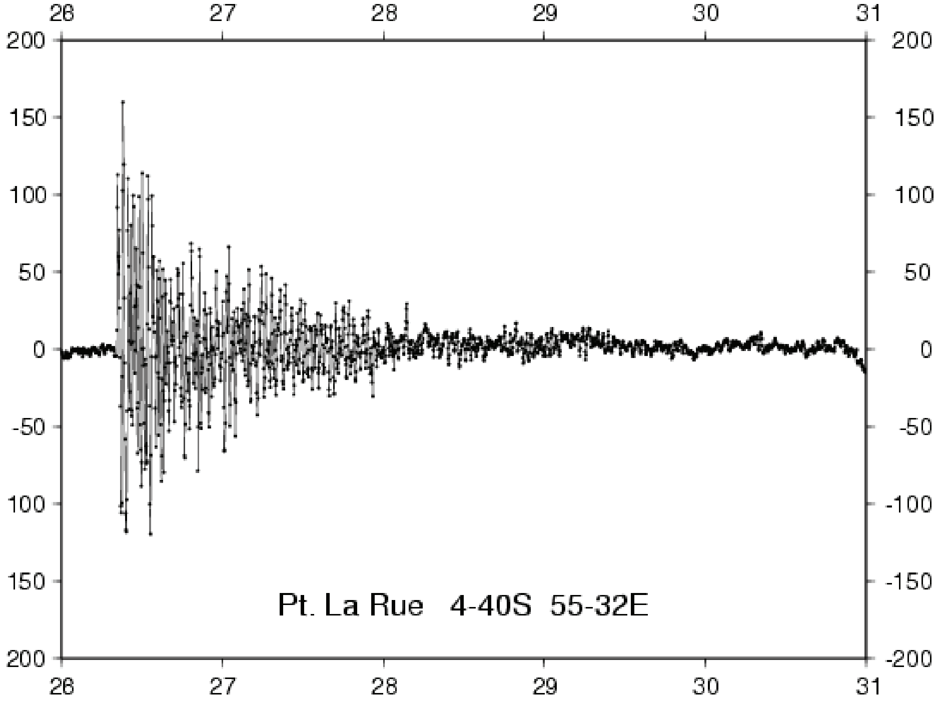


Figure 7. Water level residuals, Pointe La Rue tide-gauge, Mahé, Seychelles, 26–30 December, 2004. (National Meteorological Service Seychelles / University of Hawaii Sea Level Center; available at: http://ilikai.soest.hawaii.edu/uhslc/iotd/plarbr.html).

One of the striking features of the tsunami at an Indian Ocean basin scale was the differentiation between stations, associated with shelf areas, which showed a sustained tide-gauge signal over several days and those stations, predominantly in mid-ocean locations, which exhibited a strong initial signal but little subsequent “ringing” (Merrifield et al., 2005). The Seychelles clearly belonged to the first category. The implication is that the tsunami excited some form of seiche on the Seychelles Bank that both amplified and prolonged the tsunami signal; disentangling the two effects remains a major analytical challenge.

Spatial Characteristics: Granitic Islands of the Northern Seychelles

Statistics on tsunami wave heights at the shoreline, tsunami run-up (the tsunami’s height above mean sea level at its limit of penetration inland) and inundation distance are reported in Table 1. They show the considerable site-to-site variability over distances often of less than 10 km. Thus, for example, Anse Boileau on the west coast of Mahé recorded a run-up of 2.5 m whereas Grande Anse 5 km to the north experienced inundation to 4.3 m. While impacts in general were greatest on eastern shores facing the direction of wave arrival, the significant tsunami signals present on the leeward coasts of Mahé and Praslin are noteworthy and suggest the operation of a series of controls at a number of different spatial scales.

At the largest scale, ocean-basin scale modelling of the December event (e.g., NOAA, 2005b) shows divergence of the tsunami around the shallow shelf areas of the Mascarene Plateau, the streaming of the wave-front around bank margins and the convergence of the wave in the lee of the Plateau at several locations, including on the Seychelles Bank (NOAA, 2005b). Refraction at the Bank scale is supported by the observation from the northwest point of Praslin that the wave came from the northeast (Jackson et al., 2005). It can be imagined that on the Seychelles Bank there were further refraction effects around the larger individual islands. Thus, for example, eyewitness accounts of tsunami wave arrival at Anse a la Mouche on the leeward southwest coast of Mahé reported that wave trains approached the bay from both the north and south (Jackson et al., 2005). Similarly, maximum wave heights on Praslin were experienced on the lee shore (Table 1).

Table 1. Maximum water levels at the coast and wave run-up, relative to mean sea level, of the 26 December, 2004 tsunami in the Seychelles (from Jackson *et al.*, 2005).

Location		**Maximum Water Level Near Shoreline (m)**	**Wave Run-up (m)**	**Inundation Distance (m)**
North East Point	Mahé	2.2		100
Victoria	Mahé	>1.7	>1.4	>200
Seychelles International Airport	Mahé	3.0		200
Anse aux Pins	Mahé	>1.9		>50
Pointe au Sel	Mahé	2.8	2.3	>35
Anse Royale (N)	Mahé	>3.8	3	>100
Anse Royale (S)	Mahé	>4.4		>45
Anse Forbans	Mahé	2.8		20
Baie Lazare	Mahé	1.6		20
Anse a la Mouche	Mahé	3.0 (3.5)*	2.5	250
Anse Boileau	Mahé	2.5		53
Grand Anse	Mahé	4.3		nil
Beau Vallon	Mahé	1.7		10
Chevalier Bay	Praslin	3.1		140
Anse Possession	Praslin	3.0		35
Anse Petit Cour	Praslin	2.5		225
Anse Volbert (1)	Praslin	1.9		100
Anse Volbert (2)	Praslin	2.0		>100
Grande Anse	Praslin	3.6		>50
Baie Ste Anne	Praslin	1.8		nil

*Figure of 3.5 m at Anse a la Mouche records height of wave surge damage.

Within these island-wide patterns of incidence, tsunami impacts were sensitive to changes in shoreline orientation. Thus, for example, at Beau Vallon, Mahé, which faces north, the maximum run-up level was only 1.7 m, slightly above a normal high-tide. Similarly, the southeast-facing Baie Ste Anne on Praslin only suffered inundation to typical high-tide level (Jackson et al., 2005). In addition, waves were funnelled between rocky headlands into embayments and influenced by offshore fringing reef topography, particularly the presence or absence of deep-water passages through the reef system. In reef-fronted locations it appears that the tsunami waves broke on the reef and then propagated across the reef as a bore. These water flows were influenced by wave interactions (including wave refraction and reflection) and interactions with bottom topography. In particular, it appears that tsunami run-up was often greatest at the head of deep channels through fringing reefs. Finally, at the very local level it is clear that tourist development very close to, or even on, the beach made many buildings highly vulnerable to water levels even only slightly above normal high-tide levels and to surge velocities of 3.3–4.4 m s^{-1}, particularly where the natural energy dissipation afforded by the presence of upper beach berms and/or coastal vegetation had been removed to enhance beach access (Jackson et al., 2005).

Impacts on the Marine Environment: Granitic Islands of the Northern Seychelles

A series of rapid assessments of marine environments in the granitic islands between 30 December, 2004 and 13 February, 2005 (Obura and Abdulla, 2005) identified two major patterns of coral-reef damage related to location and substrate type. The most heavily impacted areas were carbonate reef substrates in the northern islands around Praslin (including Curieuse, La Digue, Felicite, Isle Coco and Ste. Pierre). Here levels of substrate damage (movement of rubble, erosion gullies within rubble deposits) exceeded 50%, and levels of direct coral damage (coral toppling and overturning) exceeded 25%. By comparison, around Mahé damage levels on carbonate substrates were less than 10%. Throughout the granitic islands of the Seychelles, levels of damage on granitic substrates were less than 1% (Obura and Abdulla, 2005). Cemented reef substrates showed little evidence of coral breakage or overturning; where damage was present it was restricted to water depths of less than 50 cm. However, many reef surfaces in the granitic Seychelles are currently characterized by poorly consolidated surfaces resulting from reef-framework degradation, following the coral-bleaching and mass-mortality event associated with the Indian Ocean warming of 1998 (e.g., Spencer et al., 2000). There was considerable movement of reef rubble in such settings under tsunami surge conditions, and the dislocation and damage of live coral colonies established on such surfaces (Obura and Abdulla, 2005).

It is important to realise that a substantial sector of the east coast reefs has been profoundly modified since the classical descriptions of them by Lewis (1968,1969), Taylor (1968) and the summaries by Braithwaite (1984) and Stoddart (1984). Starting with the construction of the airstrip in 1971, large-scale reclamation now extends for 11 km from north of Victoria to Pointe La Rue. The reclamation, used for housing, light industry, and rapid road access to the airport, typically is separated from the old island shoreline by open water. Surges in sea-level can thus be ponded behind them and can only drain back to sea via egress channels. This accounts for the destruction of the bridge shown in Plate 3. Drawdown and upsurge were also severely damped in the lee of the reclamations.

The tsunami resulted in beach cliffing of 2.5 m at Anse Kerlan, northwest Praslin and a calculated loss of 200 $x10^3$ m^3 of beach sand offshore (UNEP, 2005). The waves also mobilized marine sediments, both stripping sediments from coral-reef rubble beds and depositing sediments in new locations; back-drainage from run-up may have also deposited terrestrial sediments on fringing reefs. These processes were exacerbated by stormy weather in the days immediately following the tsunami which generated rough seas. Rainfall totals in excess of 250 mm triggered landslides on Mahé and led to high terrestrial runoff but it is not clear if fluvial sediments reached reef environments. Fringing reefs were exposed by the significant drawdown events (e.g., reported for Anse Royale, Anse Forbans and Anse a la Mouche, Mahé; exposure of massive corals at Anse Petit Cour, Praslin at 08:00 UTC, 26 December; Jackson et al., 2005) but it is unlikely that these events were of sufficient duration to cause coral death. Seagrasses at Baie Ternai, Mahe were smothered by carbonate sediments but general damage levels in seagrass beds were low. The causeway enclosing the mangrove parkland at Curieuse was toppled inwards by tsunami waves but no damage to the mangroves was noted (Obura and Abdulla, 2005).

Tsunami Impacts in the Southern Seychelles

A collaborative expedition between the Khaled bin Sultan Living Oceans Foundation, Cambridge Coastal Research Unit and SCMRT-MPA to the southern Seychelles was conducted onboard M.Y. Golden Shadow, 10–28 January 2005. Although the primary focus of this expedition was airborne mapping of the outer islands, due to the timely nature of this expedition, it was expected that impacts of the tsunami on the remote southern islands of the Seychelles could also be reported. The expedition visited the islands of Providence, St. Pierre, Alphonse and St. François and the southern islands of the Amirantes group (D'Arros, Desroches, Desnoeufs, Marie-Louise, Boudeuse, Etoile and Poivre) some previously described by Stoddart (1970). Stoddart also visited Aldabra and Assumption in April 2005.

On all the southern Seychelles islands visited no physical damage to either the terrestrial or marine environments was observed. The littoral hedge was intact in all cases and there was no evidence of beach sediment movement or water inundation in the littoral area. Underwater there was no evidence of reef damage; thus, for example, there was no physical damage to the branching corals (principally *Pocillopora* spp.) that dominate these reefs and no coral toppling. The islands of Providence, Alphonse, D'Arros, Desroches, Marie-Louise and Poivre are inhabited. In all cases, island personnel said that there had not been any impact caused by the tsunami and they hardly noticed the event. On Providence Island, the island manager was radioed from Mahé and warned of the tsunami waves approaching. The I.D.C. (Island Development Company) manager on Assumption and the manager of the S.I.F. (Seychelles Island Foundation) Research Station on Aldabra both state that in spite of radio warnings they did not detect any tsunami surges. It is fair to add that if there had been a substantial surge it would have impacted rocky coastlines in the east of each island, and that in both cases the settlements are in protected western locations. Providence Island is at the northern tip of the large (approximately 400 km^2) Providence Bank, and here the tsunami was observed as a sudden influx of water approximately 10 cm higher than normal that remained for a few minutes before dropping to a normal level. No accurate time could be given for this observation, but it was said to be “about lunch-time”. Unfortunately there are no reports of tsunami effects on Coetivy.

Computer modelling of the passage of the tsunami wave front indicates a regional scale refraction of the wave front towards the southwestern Indian Ocean (NOAA, 2005b). This would have led to an increase in the length of wave crest and hence lower wave heights to the south. In addition, there are considerable contrasts in bathymetric setting between the two areas. In contrast to the northern, granitic islands of the Seychelles, the southern islands are typically low-lying sand cays (islands of the Amirantes) and atolls (Alphonse, St. François; Desroches is a drowned atoll) with the exception of St. Pierre which is a raised platform reef island. The granitic islands protrude from the shallow Seychelles Bank (mean water-depth 44-65 m; Braithwaite, 1984), but the southern islands are situated in open ocean and exhibit steeply shelving fore-reef slopes or vertical reef wall drop-offs, surrounded by deep water (>5,000 m). Thus when the tsunami approached the region of the southern islands, the waves passed through the gaps between the islands and there was no increase in wave amplitude due to the continuity of deep water and lack of a shallow barrier in the flow path. This would explain the contrast between the lack of tsunami impacts observed on the southern Seychelles islands compared to the significant impacts observed on the granitic islands of the Seychelles Bank.

ACKNOWLEDGEMENTS

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REFERENCES

Braithwaite, C.J.R.
1984. Geology of the Seychelles. In: *Biogeography and Ecology of the Seychelles Islands* D.R. Stoddart (Ed.): The Hague: W. Junk, pp.17-38.

Jackson, L.E. Jr., J.V. Barrie, D.L. Forbes, J. Shaw, G.K. Manson, and M. Schmidt
2005. Effects of the 26 December 2004 Indian Ocean tsunami in the Republic of Seychelles/ Report of the Canada – UNESCO Indian Ocean Tsunami Expedition, 19 January–5 February, 2005. *Geological Survey of Canada, Open File* 4359, 73pp.

Lewis, M.S.
1968. The morphology of the fringing coral reefs along the east coast of Mahé, Seychelles. *Journal of Geology* 76:140-153.

Lewis, M.S.
1969. Sedimentary environments and unconsolidated carbonate sediments of the fringing coral reefs of Mahé, Seychelles. *Marine Geology* 7:95-127.

Merrifield, M.A., Y.L. Firing, T. Aarup, W. Agricole, G. Brundit, D. Chang-Seng, R. Farre, B. Kilonsky, W. Knight, L. Kong, C. Magori, P. Manurung, C. McCreery, W. Mitchell, S. Pillay, F. Schindele, F. Shillington, L. Testut, E.M.S. Wijeratne, P. Caldwell, J. Jardin, S. Nakahara, F.-Y. Porter, and N. Turetsky
2005. Tide gauge observations of the Indian Ocean tsunami, December 26, 2004. *Geophysical Research Letters* 32:L09603, doi: 10.1029/2005GL022610.

National Oceanic and Atmospheric Administration (NOAA)
2005. Tsunami Propagation in the Indian Ocean. http://www.pmel.noaa.gov/tsunami/Mov/TITOV-INDO2004.mov

Obura, D., and A. Abdulla
2005. Assessment of tsunami impacts on the marine environment of the Seychelles. http://www.iucn.org/info_and_news/press/seychelles-tsunami-22-02-05.pdf

Spencer, T., K. Teleki, C. Bradshaw and M.D. Spalding
2000. Coral bleaching in the southern Seychelles during the 1997-98 Indian Ocean warming event. *Marine Pollution Bulletin* 40:569-586.

Stoddart, D.R.
1970. Coral islands of the western Indian Ocean. *Atoll Research Bulletin* 136:1-224.

Stoddart, D.R.
1984. Coral reefs of the Seychelles and adjacent regions. In: *Biogeography and Ecology of the Seychelles Islands* Stoddart, D.R. (Ed.) Junk Publishers, The Hague, The Netherlands pp. 63-81.

Taylor, J.D.
1968. Coral reef and associated invertebrate communities (mainly molluscan) around Mahé, Seychelles. *Philosophical Transactions of the Royal Society of London,* Series B 254:129-206.

UNEP
2005. After the tsunami: Rapid environmental assessment. Chapter 6. Seychelles, 96-111.
http://www.unep.org/tsunami/tsunami_rpt.asp

Yalciner, A., U. Kuran and T. Taymaz
2005. Computer modeling of the December 26, 2004 North Sumatra tsunami.
http://yalciner.ce.metu.edu.tr/sumatra/max-elev-sim-1.jpg

Plate 1

Plate 2

Plate 1. Internal fissuring and collapse of dock quay, Port Victoria, Mahé.

Plate 2. Failure of quayside, Port Victoria, Mahé.

Plate 3. Road bridge washout from seaward drainage of tsunami waters from coastal lagoon, west coast of Mahé.

Plate 4. Road bridge washout following drainage of tsunami waters, southwest Mahé.