EU EDF 9 – SOPAC Project Report 34b

Reducing Vulnerability of Pacific ACP States

NIUE – TECHNICAL NOTE
An assessment of Cyclone Heta's impact on Niue's coastline

23rd April – 4th May 2004

"Welcome to the Rock"

Compilers:

Litea Biukoto and Michael Bonte-Grapentin
SOPAC Secretariat

July 2008

IMPORTANT NOTICE

This document has been produced with the financial assistance of the European Community; however, the views expressed herein must never be taken to reflect the official opinion of the European Community.

For more copies of this report, apply to the SOPAC Secretariat at the address below:

PACIFIC ISLANDS APPLIED GEOSCIENCE COMMISSION
c/o SOPAC Secretariat
Private Mail Bag
GPO, Suva
FIJI ISLANDS
http://www.sopac.org
Phone: +679 338 1377
Fax: +679 337 0040
director@sopac.org

SOPAC

SOPAC/EU EDF9 PROJECT

Niue Mission, 23 April – 4 May 2004

Pacific Island Paradise turned into barren rock – Namukulu Motel swimming pool (left) after Heta (right).[1]

BACKGROUND

On 5th January 2004, Heta, a Category 5 tropical cyclone, struck Niue and widely devastated its N to NW exposed coastlines from Uluvehi to Alofi. Buildings in Alofi and the villages of Makefu, Tuapa, Namukulu and Hikutavake, including the Niue Hotel and the hospital were destroyed by waves approaching unexpectedly over the Alofi terrace located some 20m above present sea level. As part of the TC Heta Recovery Plan and as the basis for building a "New Niue" there are strong considerations of relocating critical assets like the hospital and government ministries to higher ground, as well as encouraging the civil society and the private sector to follow this example. Furthermore, the Government of Niue is developing a policy to discourage future development in hazard-prone coastal areas. SOPAC was requested to assist the identification of coastal hazard zones, to assess and model impacts of TC Heta to Niue's coastline and to support the recovery of the Niue GIS database at the Ministry of Justice.

Technically, the mission was a little too late to allow a comprehensive scientific assessment of impacts of TC Heta and extent of wave action, since most of the areas worst affected had been cleaned up already and vegetation had started to recover. A similar concern was expressed by most stakeholders, who had expected SOPAC to provide assistance and advice for the benefit of recovery and rebuilding, immediately after TC Heta. The assessment of wave impacts had to rely on damage reports, photos taken immediately after Heta, reports of eye-witnesses and field observation of more remote areas. For future post-disaster missions, it is recommended SOPAC perform scientific analysis of impacts and lessons learnt as soon as feasible after the event.

[1] Photos taken by Robyn and Joe Wright of Namukulu Motel

OBJECTIVES

- To collect and assess required data sets for planned storm-wave impact modeling of TC Heta and assess extension of wave impacts.
- To assess cliff failures caused by TC Heta.

1: SURVEY OF WAVE IMPACTS

Observations

- Eye-witness reports on the time of wave peaks are contradictory and range from 13:00 hrs to 17:00 hrs Niue time. In South Alofi highest waves might have occurred between 14:30 hrs and 15:30 hrs, and according to Prime Añover, an eye-witness trapped in South Alofi till 03:00 hrs the next morning, there were only a limited number of big waves, 10 to 20 swashing over the terrace and destroying the buildings. He estimated the frequency of these waves to be over 1 minute. At least he had enough time to find shelter in Brendon Pasisi's water tank shed on the other side of the road after he was washed away together with his house by the second big wave approaching over the terrace.

Figure 1: Post TC Heta IKONOS Scene 12/01/04 – Areas affected (red) by waves marked in red.

- Highest wind speeds were recorded at Niue airport between 16:30 to 17:10 hrs [power cut after 17:10 hrs disabled further recording] with wind speeds around 130 km/h and gusts up to 200 km/h. Nevertheless, the Regional Specialised Meteorological Centre in Nadi, Fiji estimates maximum sustained winds of 210 km/h with gusts up to 300 km/h. The wind direction turned steadily from ENE at about 13:00 hrs to N at 17:00 hrs and according to witness reports further to NW. Unfortunately there are no additional records, since the monitoring station in Alofi broke down and data could not be recovered.

- Evidence for impacts of wave were found on sites up to +25 m above sea level and up to 200 m inland on the Alofi terrace. Areas affected by waves were delineated according to the post-Heta IKONOS scene (see Figure 1) and GPS mapping of coral rubble, several dm-m in size (see figures 2 & 3) and other debris thrown onshore by the waves. The accuracy of the latter is critical, since some areas have been cleaned up and location of debris might have been changed during the cleaning. The satellite image, taken 12 January 2004 one week after the cyclone struck, shows a clear indication of affected areas, where vegetation was wiped out, barren rock exposed and coral rubble deposited. All these areas show a high reflection and appear in white.

Figure 2: Deve Telagi, Director PWD, standing on the foundations of a destroyed building in Hikutavake and next to the biggest boulder picked up by the waves (~3-4 t). The boulder was thrown on the cliff edge during TC Ofa and during TC Heta transported some fifty metres further inland and smashed into this building.

- The highest impacts by waves occurred along N to NW exposed coastlines, in particular in Alofi (especially Alofi South) and Makefu to Hikutavake. A corridor of about 20-50 m from the cliff edge was de-vegetated, the soil washed away and only the barren rock left (see Figure 4).
- Beside the sea track at Uluvehi, which was severely damaged, the waves approaching far inland at the N coast did not cause major damage, because all settlements and infrastructure are located at the upper terrace.

Figure 3: Building in Makefu smashed by coral rubble and tree debris.

Figure 4: The former location of the Niue Hospital – barren rock is exposed where the waves washed over the cliff.

- At Tuapa and between Makefu and Alofi North waves did not approach far inland over the cliff. The Tuapa area seemed to be protected by Niue's widest fringing reef (about 130 m) and between Makefu and Alofi North wave direction was probably parallel to the coastline.

- Between Makefu and Hikutavake as well as at Alofi North major damage was observed behind channels/breaks in the cliff face, where waves were approaching further inland than elsewhere. Often houses on the landward side of the main road were affected. The waves (swash) might by concentrated in the channels, sea tracks and reached the Alofi terrace on the more gentle slopes with high energy. Neighbouring houses on the seaward side of the road, but on the ridges in-between two channels, were often not damaged.

- In Alofi South – the overall most severe affected area, both in terms of wave impacts (height/distance onshore) as well as property damage (hotel, hospital, houses and businesses) – the effects of channel/breaks in the cliff face are not obvious, since the whole terrace seemed similarly severely affected. But eye witnesses reported waves (swash) running parallel to the coastline and inundating the terrace around 1-2 m (see Figures 5 & 6).

Figure 5: Mary from Alofi Rentals indicates the height of the waves.

- Sea tracks: Wherever relatively loose sediments (e.g. breccia, conglomerate, beach sandstone) were exposed, e.g. after removal of concrete sealing, significant erosion took place. Erosional holes up to 2 m deep were observed at Numukulu and Uluvehi sea tracks (see Figure 8). Poorly cemented conglomerates and sandstones were noted at various locations forming a 1-2 m thick lithologic layer near the cliff base – some might be the remains of former pocket beaches and/or fillings of collapsed caves (see Figure 9). Whatever their origin, once removed these sediments (boulders/concrete blocks) act as "erosion weapons" and enforce further erosion and damage to infrastructure and buildings.

Figure 6: What's left? Only 3 buildings 'survived' the waves hitting Alofi South, the library, the restaurant of the Niue Hotel and one private home.

Figure 7: Crashed cars and iron debris collected after TC Heta, piled up in front of the remains of the Niue Hotel.

Figure 8: After the sealing was removed, waves dug huge holes in the weakly cemented fill: Uluvehi (above) and Namakulu (below) sea track.

Figure 9: Poorly consolidated conglomerates in Uluvehi (above) and Namakulu (below) enable wave energy to erode significantly.

Preliminary Recommendations

The recommendations by Forbes 1995 (SOPAC Technical Report 233) with regards to storm-wave hazards could be fully endorsed:

1. Future development along the Alofi terrace should be based on a thorough assessment of storm-wave hazards, including analysis of past cyclone tracks, cliff morphology and numerical modelling of storm-wave action at the coastline under different cyclone scenarios.
2. Development in Alofi South between the former Hospital and the Niue Hotel should be discouraged. This area was worst affected during TC Ofa in 1990 and TC Heta in 2004.
3. For the west coast from Alofi to Hikutavake, a general setback (restricting development) from the cliff edge of the Alofi terrace should be considered, at least landward of the coastal road, with special emphasis on areas behind channels and breaks in the cliff face.
4. *"A similar restriction might be appropriate along the southwest coast from Anaana to Avatale"* (Forbes 1995, SOPAC Technical Report 233). This area was not severely affected by wave action during TC Heta, because of the sheltering effects of Alofi South to the north-westerly waves. Future hazard assessment should analyse the risk and probability of different wave directions.
5. Some businesses rely on the proximity to the sea, like Tourism and Fisheries and may require exemptions of development restriction in the hazard zone. Nevertheless the risk of storm-wave damage has to be acknowledged and other forms of risk reduction (e.g. risk funds) should be considered.
6. Relocation of the fuel tanks to higher ground.
7. Sea tracks, coastal lookouts and picnic facilities which have been destroyed should be rebuilt either:–
    a. on a low-cost basis, considering replacement after each major cyclone, or
    b. sufficiently robust to withstand forces acting during a major cyclone; ensuring that any surface sealing will not break off and allow erosion of the underlying sediments.

2: SURVEY OF CLIFF FAILURES

Figure 1: Cliff failure at Makefu South – one of the biggest failures that occurred during TC Heta.

Several cliff failures occurred along the N-NW coast of Niue during TC Heta. They have been surveyed from the sea and on-shore. Most of them are in a range from several 10 to few 100 m^3, and two sites close to Makefu show a displacement of a few 1000 m^3. They are currently not posing any major threat, since there is no interaction with human activity, like settlements on the cliff top or fishing or tourist activities at the cliff base. Most of the displaced blocks are too big to be picked up by waves or currents. The cliff failures are most probably a product of the gradual undercutting by the sea and subsequent development of notches, and the ground tremor produced by the giant waves crashing into the cliff during TC Heta.

The only critical site is at Avaiki Cave, a scenic tourist site, where a failure at the open face of a double storey cave occurred, opposite the “King’s bathing pool” (see Figure 3). Pronounced tension cracks have been developed 2 m inside of the failure. The stability of the site should be assessed by a Geologist or Engineering Geologist and the probability of failure calculated before re-opening the site to the public. Further, the entrance cave shows a gap in the roof (an opened joint), where a 1 m thick coral boulder is lying on top. The possibility of stones or parts of the coral rubble disintegrating and falling through the gap should be investigated.

Figure 2: Cliff failures at Makefu.

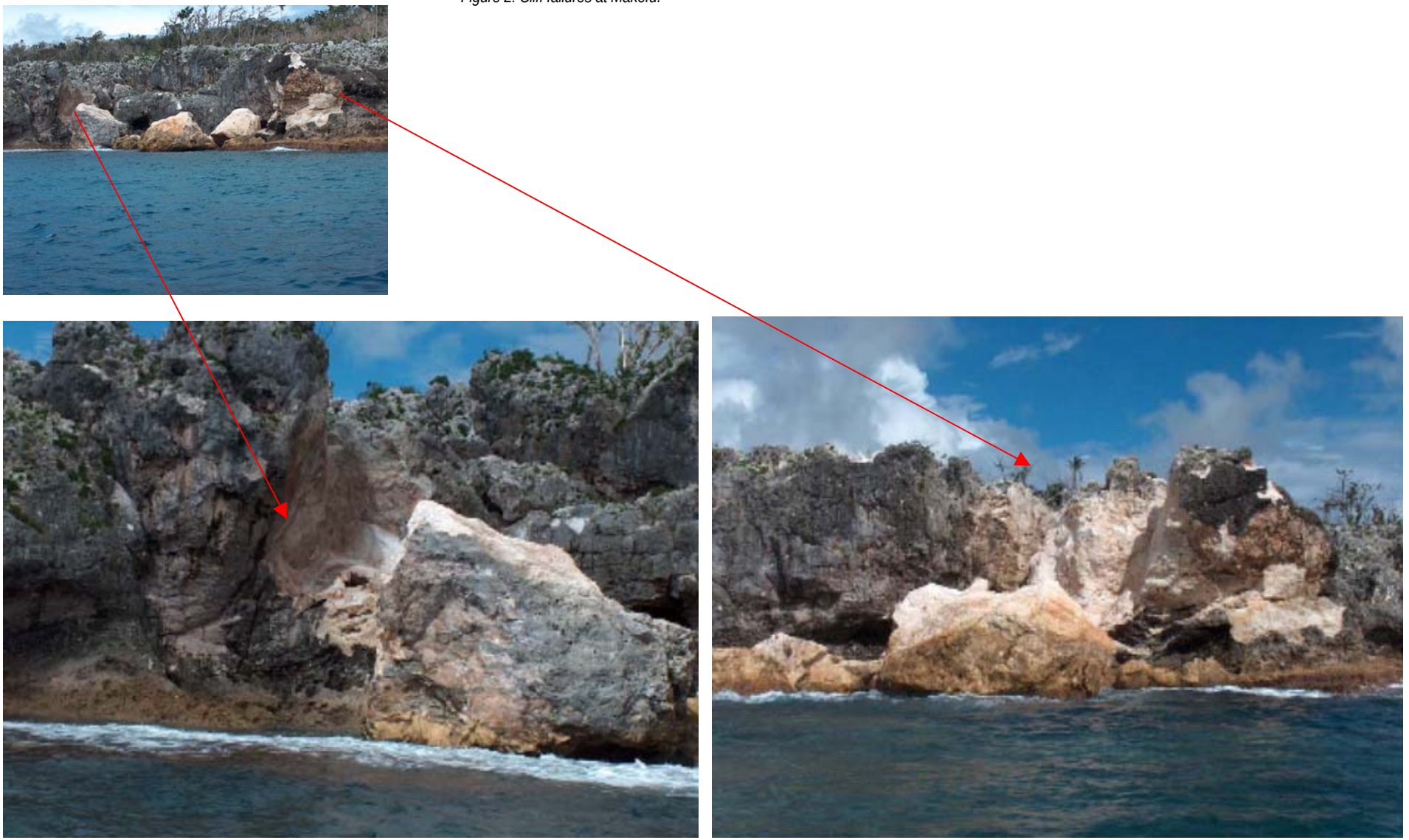
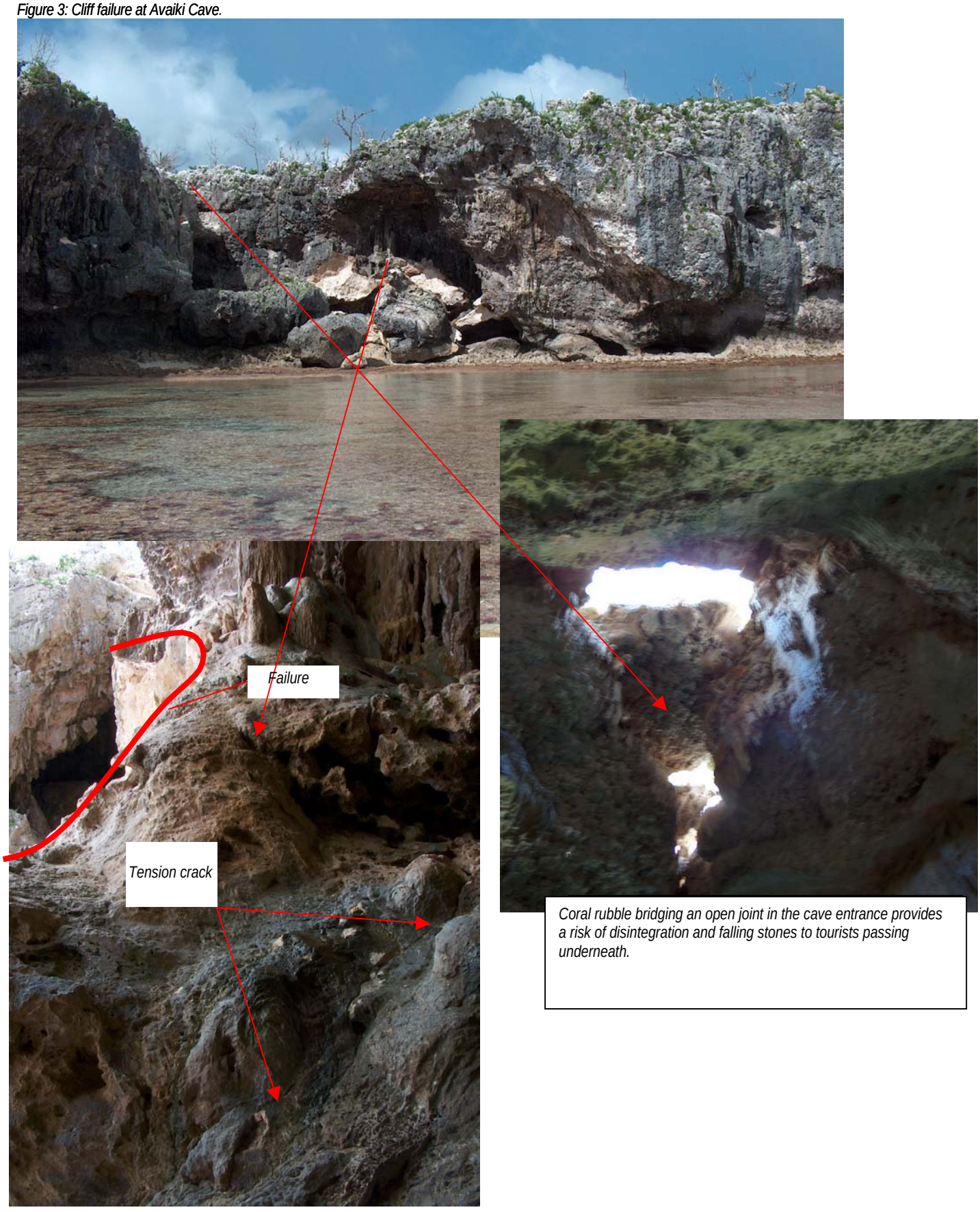


Figure 3: Cliff failure at Avaiki Cave.



Coral rubble bridging an open joint in the cave entrance provides a risk of disintegration and falling stones to tourists passing underneath.

NOTES