SPC
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Rapid Assessment of Shoreline Erosion in Kemur Beab, Ngermeaus and Ngkesill Islands, Rock Islands, Southern Lagoon, Palau

July 2012

Omekang beach area – July 2012

SOPAC Technical Assessment Report PR112

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Ocean and Islands Programme

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Rapid assessment of shoreline erosion in Kemur Beab, Ngermeaus and Ngkesill Islands, Rock Islands, Southern Lagoon, Palau

Assessment undertaken
under the auspices of the

SPC/GIZ *Coping with Climate Change in the Pacific Island Region* (CCCPIR)

In collaboration with

Koror State Government

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Rapid Assessment Report

SPC/GIZ Coping with Climate Change in the Pacific Island Region (CCCPIR)

Rapid assessment of shoreline erosion in Kemur Beab, Ngermeaus and Ngkesill Beaches, Rock Islands Southern Lagoon. Palau.

Arthur Webb, July 2012

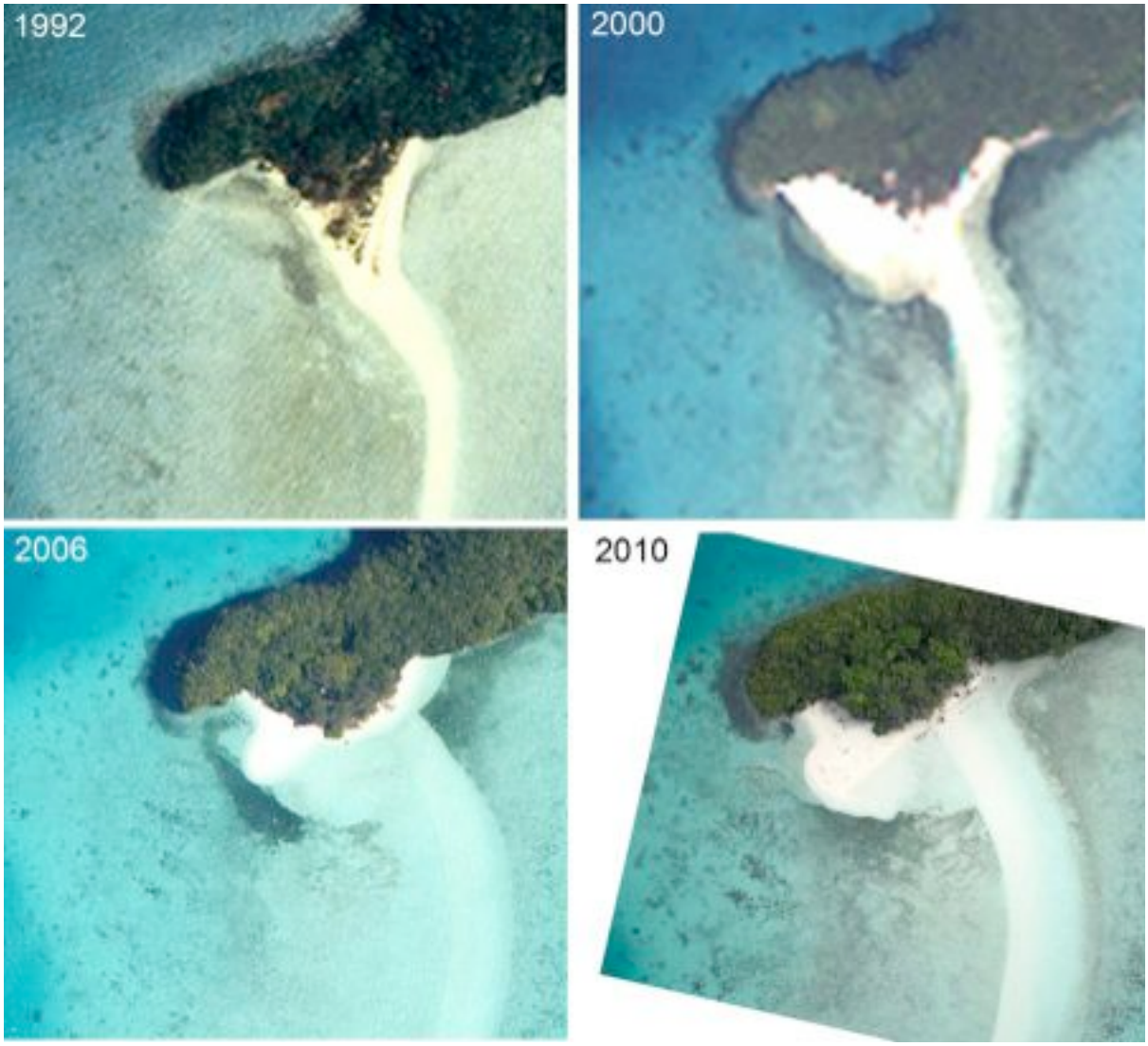
Introduction

Shoreline erosion has occurred in several important recreational and tourist beach areas in the Rock Islands Southern Lagoon, Palau and Koror State Government as well as the National Government have expressed concern over the instability of these beach areas given their importance as day visits for large numbers of tourists who visit the Rock Islands each year (up to 100 visitors / site / day). Tourism and particularly beach and water activities in the Rock Islands are a major attraction and source of revenue to Palau and thus there is significant urgency to address the shoreline instability issues in those key tourist beach areas.

On the 13th July 2012 Arthur Webb (Coastal Processes Advisor, Ocean & Islands Programme. SOPAC Division), Mr. Isaias Oiterong, Director, Department of Public Works and Mr King M. Sam, Rock Islands Development Officer, Dept. of Conservation & Law Enforcement, both of the Koror State Government, undertook site visits to Kemur Beab, Ngermeaus and Ngkesill Beaches, in the Southern Lagoon of the Rock Islands. Several additional beach sites were also viewed. The sites named are also the subject of an additional recent study by Patrick Colin of the Coral Reef Research Foundation, Palau "*Report to Koror State Government on Status and Restoration of Rock Island Beaches 11 April 2011*" (note that *Kemur Beab* is equivalent to *Omekang* in Colin's report). This follow up assessment was funded by the GIZ CCCPIR Project at the request of the Government of Palau and is intended to assist to set priorities and recommendations to address shore erosion. This current rapid assessment also builds on the earlier report by Colin (2011) and is largely complementary to that report.

Kemur Beab Beach – Shoreline Processes

Kemur Beab beach is composed entirely of marine biogenic (once living) sediment which appears to be predominantly coral derived with some shell and other marine organism content (foraminifera and halimeda were notably absent). It is possibly unhelpful to term the area of interest an "island" but rather like most sandy beach environments in the Rock Islands it is a natural accumulation of unconsolidated sand on the shallow intertidal reef flat immediately adjacent to the island proper. The main island, typical of the geology in the Rock Islands is a raised limestone block with steep vertical cliffs and under cutting at water level. Because that islands are so inaccessible these beach areas have great value to the tourism industry. The southern extremity of the island provides a confluence point for sand accumulation particularly from along the eastern shore due to predominant easterly trade winds. The persistent southerly sand spit extension of the beach suggests significant volumes of sand are being continually mobilised and oscillating wind / wave conditions between predominate trade winds and less frequent westerly wind maintains the spit. Currents may also play a role and are likely complex in the Rock Islands, they could not be meaningfully assessed during this study however they could be an important factor.



Time series vertical images of Kemur Beab beach produced by Colin (2011) from 1946 to 2000 highlights the persistence but also the mobile nature of the beach and southern sand spit feature.

In order to develop appropriate plans to address the present erosion issues on Kemur Beab Beach there must first be an understanding that these features are highly dynamic and susceptible to seasonal wind and wave effects. There is no starting point or "steady state" position for the shoreline, at any given time it is simply a reflection of the current seasonal conditions. Whilst significant erosion has occurred on the eastern shore of the beach and caused damage to infrastructure (compost toilet facility and picnic tables) there has also been significant accretion on the western shore. The present pattern of redistribution of sand on the beach (from the east-side to west-side) appears consistent with the recent 2010/2011 intense La Nina event (the strongest on measured record). La Nina conditions tend to intensify the duration and strength of easterly trade wind conditions (see also in Colin, 2011) and the pattern of erosion on the eastern side of the beach and rapid accretion on the western shore fits well with such seasonal patterns. Anecdotal observations in other locations in the equatorial Pacific Islands show similar patterns of erosion and accretion or redistribution of sand consistent with stronger than normal trade winds.

ENSO (El Nino Southern Oscillation) conditions have now returned to neutral and may switch towards El Nino in the coming months / year(s). If El Nino forms these conditions tend to break down the strength and persistence of the easterly trade winds and may result in a greater incidence of westerly winds. It is possible that some recovery in the eroded areas could gradually occur under

such conditions, i.e. sand could be redistributed again from the western shoreline areas to the eastern. Some evidence of this is already apparent as a small raised sand spit has started to extend again from Kemur Beab Beach towards the south (see Annex 1).

It is important to note however, the current rapid changes experienced appear to have (at least in part) been influenced by a very strong La Nina event and we may not see such a strong ENSO signal again for many years. As such, it is unlikely that the old beach shape will fully re-establish in the short term (say next 5 years). However, if strong westerly winds do occur these may again redistribute sands from the west back towards the east. It is highly advisable that managers of these beach areas become familiar with the potential for such cyclic shifts in the position of the shores. It is a part of the natural flexing of such features all over the Pacific Islands region and if this is understood it is possible to manage human use of these environments far more effectively and harmoniously.

Kemur Beab Beach – Damage to infrastructure and response

The eastern shore of Kemur Beab Beach has eroded significantly and a compost toilet facility has been undermined and lost (see images below). Likewise, picnic tables and shade facilities nearer the southern shoreline of the beach have also been lost. These losses are not trivial for the Rock Islands Authorities who are now working to ensure adequate facilities continue to be provided for visitor's needs and thus maintain tourism revenues. Also due to the costs and logistic challenges of transporting and building facilities in the Rock Islands it is not surprising that Koror State Government has taken the decision to armour the eastern shore with rock filled gabion baskets. The alignment of the wall is thought to be roughly equivalent to the position of the shore as perceived at the time of building the toilet facilities. The wall is intended to protect the remaining compost toilet and presumably provide confidence to reinstate the second unit.

Protective gabion basket wall and remains of one of two compost toilet facilities to the left. The wall approximates the former berm position.

Footings from the former shade and picnic table facilities. Note the reforming raised southern sand spit and larger sub-tidal feature stretching towards the west (right).

To back fill the gabion basket wall the Koror State Government indicates it may consider using sand which has accreted on the western side of the island. Given the knowledge that this sand will at some stage again be re-mobilised perhaps to move back to the southern or eastern shore it would be very unwise to disturb those volumes. The author is aware that Koror State has an established carbonate sand dredge operation. An initial assessment of those dredged lagoon sands suggests it would be fairly consistent with the sands at Kemur Beab Beach and more appropriate as a back fill material and certainly its use would be far more advisable than mining from the western shores of the island.

The gabion wall design is simply two vertical steps each about 2ft high with the upper set back about 2ft. This more or less vertical hard surface replaces what was a very shallow sloped soft beach and it follows that the ability of sand to establish and deposit at the foot of the new wall may be prevented as vertical structures tend to reflect wave energy pushing sand away. If the wall remains the preferred option by the local authorities, it is recommended that is be constructed with a slope approximating that of the natural shore as this will have far higher chance of allowing sand to naturally accrete and bury the wall over time. A correctly sloped wall is also less likely to disturb nearby beach areas, where as vertical walls can cause downstream erosion.

When faced with erosion, walls are a common response because it is often mistakenly thought that it is a permanent one off solution. However, engineering and seawalls frequently have significant on-going maintenance costs and they often disturb the surrounding shoreline possesses leading to more erosion and the need for additional walls and structures. There is also an important visual consideration at this location. It is apparent that visitors are attracted to the Rock Islands and its beach areas because of their unspoilt natural beauty, clean white sandy beaches are a major part of

the visitor experience. If the beach area becomes ringed by an entirely engineered hard shore structure (seawall) this natural beauty and value will be partly lost. From a practical perspective it is also more difficult to land tourists and their equipment alongside a vertical hard wall than it is to beach vessels on a sandy shore and likewise soft shores provide easy safe all tide access to the water for swimmers and divers, additionally children can safely play in sandy beach shallows in full view of parents, unlike the situation with seawalls.

The main justification for the present protective wall appears to be to protect the compost toilet facility. The toilets are placed inadvisably close to the shore but it appears a design criteria for these facilities that they must have good exposure to sunlight to work effectively. This is why the nearshore locations have been selected for these facilities as locations further inland are heavily shaded. It would be worth investigating the possibility of retrofitting this compost toilet design with for example solar 12v operated fans for ventilation, allowing these facilities to be relocated much further inland and placing the associated solar panel in an exposed sunny location. In addition, picnic tables and shelters which have been damaged by erosion were also placed near the shore for visitors to enjoy the proximity to the sea. If picnic table and shade structures were built to be portable (rather than concreted into the ground) these could be more easily moved if necessary. E.g. structures could be fastened to the ground will steel stakes or bolted to sacrificial footings and easily disconnected and moved if necessary. During this field trip it was noted that shoreline tourist activities had naturally migrated to the newly accreted western shore which offered space and a clean white beach environment. Had the picnic shelters and tables been easily removable, these could have already been in place to support this shift in location of tourist activities.

If at the broader level there was the intension to protect tourist interests by building the rock seawall it is important to note the fact that the tourists have already naturally gravitated away from the eroded areas and now use the newly accreted western shore. Thus the only remaining justification for the seawall is to protect the present site of the compost toilet, this hardly seems a priority if options for retrofitting and moving the existing structure have not been exhausted. Thus it is recommended that Koror State Government consider converting effort and resources being used to build the rock wall into effort to move and retrofit the compost toilet facilities and picnic facilities. It is also recommended that hard shoreline stabilisation methods being used are not continued as they may likely destabilise the remaining sandy shoreline and from the perspective of tourist activity could inadvertently impact the very features which the State wishes to capitalise on – the natural unspoilt beauty on Kemur Beab Beach. If a rock seawall is continued then the design should at least be changed to incorporate a shallow seaward slope to be more compatible with beach recovery.

There are other arguments for the adoption of a more harmonious strategy for the design of facilities on Kemur Beab and the other beach areas such as moving facilities to the most stable and protected locations. It is guaranteed that the shorelines of beach areas like this will continue to shift and move and relocating facilities to areas of least possible risk will have significant benefits in the long term. Also in the specific case of Kemur Beab, moving the toilet facility to the more densely vegetated inner beach areas presents less of an aesthetic eyesore and relocation would free up additional higher value nearshore space for other activities. Finally, protection measures such as gabion baskets will eventually fail as the baskets break down in the marine environment, replacement will be costly and unsightly, again disturb the visual amenity of the beach area for tourist use.

The newly accreted western shore area at Kemur Beab Beach, tourist activities have already naturally followed this shoreline trend away from the eroded areas. This suggests the natural seasonal and event driven cycling of the shoreline position does not necessary impact tourist perceptions and needs, they are happy to use this new beach area.

Kemur Beab Beach – Recommendations

1. As per Colin's (2011) recommendations improved monitoring and understanding of how these beaches respond to ocean events and season is key to managing the risks and maintaining the viability of these important beach areas. Simple regular beach monitoring using established profiling techniques would provide invaluable information.
    a. This is a simple exercise and once appropriate bench marks are installed and local rangers are trained this can be continuously and easily implemented.
    b. Given these beach areas are small semi-circular features a radial arrangement from 1 or 2 bench marks set back near the limestone cliff face would provide excellent data.
2. Toilet amenities; investigate the potential to retrofit these with active ventilation (possibly solar) this would provide greater options in terms of their location. Re-location to safer inner areas of the beach being preferable.
3. Near-shore picnic table and shade facilities could be designed to be easily re-locatable. This would allow rangers to move these if seasonal shoreline shifts start to threaten the position of the structures. It will be important to ensure appropriately designed fastenings and footings are devised to avoid wind damage etc.
4. Consider adjusting the present plan for shoreline armouring. This structure has only been partially constructed and could still easily be removed to allow natural shoreline process to reinstate the beach. Obviously this would be contingent on relocation of the compost toilet and picnic facilities.
    a. If the decision is to keep the gabion wall, consider the use of dredged lagoon sands for back filling. Mining the newly accreted western beach in not recommended and

could damage tourist use of the area as well as destabilise this new beach environment.

5. Develop a location-specific adaptive plan for how facilities will be designed and placed on Kemur Beab Beach (and others).
    a. Over time this adaptive plan could be informed by the beach monitoring work also recommended above.
    b. It is understood that Koror State Government wishes to develop a plan which alternates tourist use of favoured Rock Island beach areas. This sounds an excellent strategy however in order to understand if this is beneficial, monitoring of these environments should be undertaken, including beach profiling.
    c. It would also be very advantageous to start to keep tourist number and activity statistics for each beach area.
6. Develop training sessions with local stakeholders and rangers on monitoring techniques as well as back ground introduction to shoreline processes and dynamics. This will support improved adaptive management and decision making.

Ngermeaus Beach – Shoreline Processes

Ngermeaus Beach shares many similarities to Kemur Beab Beach. Its situation and proximity to the actual Ngermeaus raised limestone island is also very similar to Kemur Beab and the end result, is a familiar, roughly semi-circular, low-lying accumulation of unconsolidated sand which is situated at the terminal protected southern edge of the Island and appears to be the point at which sediment transport on either side of the island meets before leaking off southwards towards deeper water. Given the similar settings and orientation, it is not surprising that the pattern of recent change in Kemur Beab Beach is very similar to that seen in Ngermeaus, i.e. net erosion in the eastern shore and accretion on the western shore of the beach area. The rate or extent of this westward redistribution of sand and subsequent erosion on the eastern shore does not appear quite as extensive and has not (yet) resulted in damage to facilities such as the composting toilets. It was thus not afforded quite such high priority by the Koror State Government but they do correctly perceive threat to facilities such as the toilet block and picnic tables and shade areas if the present erosive trend on the eastern shore does not abate.

The composition of the sands at Ngermeaus was on casual inspection indistinguishable from Kemur Beab Beach, appearing to be mostly coral and shell fragments. A trend of finer, very well sorted sediment size was observed on the newly accreted western beach and courser more mixed material on the eastern shores. Possibly also supporting the premise of on-going redistribution of material from the east to the west as finer material is more mobile and it is assumed higher energy is reaching the eastern shore removing the smaller sizes and leaving a larger mixed material behind. In essence, this is all supportive of the observation that easterly trade winds have been acting on these shores redistributing sand to the west.

Sand from the accreting western shore (left) and erosive eastern shore (right). Note grain size of the newly accreted beach was fine <0.25mm and generally very well sorted, grain size on the erosive shore was generally larger >1.5mm and not so well sorted.

Unlike Kemur Beab Beach, Ngermeaus Beach does not have a raised sand spit trailing to the south as evidence of sand "leaking" from the system but does have a clear pattern of on-going deposition into the deeper water south of the beach (note clean white south-western depositional area in the image below). Colin (2011) also draws attention to a shallow sandy area on the north-western coast of Ngermeaus Island but this is hard to assess from the imagery (overexposure has erased details) and this location was not visited during this rapid assessment.

Two images of Ngermeaus Island and tourist beach area in the south. The change it the position of the toe of the beach in the east is easily seen (its moved landward in 2010) and the western beach (left hand side) has clearly accreted westwards (images sourced from Colin, 2011).

Ngermeaus Beach – Damage to infrastructure and response

Fortunately at the time of writing infrastructure at Ngermeaus Beach had not been damaged however a number of fairly large trees have been lost and the photo below shows the close proximity of the compost toilet and picnic facilities to the erosive shore. At this stage no engineering response has been implemented but it was understood that depending on the success or otherwise of the hard structures being built in Kemur Beab such measures may also be implemented in Ngermeaus Beach as well to prevent what is perceived as loss of land and possible risk to infrastructure. The consideration of alternative management and response action on Ngermeaus Beach is recommended before any hard engineering or more structures such as toilets are considered. The reservations shared already about placement of buildings and use of hard shoreline protection in Kemur Beab Beach are identical on Ngermeaus Beach.

Eastern end of Ngermeaus Beach showing undercut tree roots and proximity of the composting toilet block and in the background a picnic shelter which is within a few feet of the shoreline. Again, the design of the toilet block necessitates a sunny position and any retrofitting techniques applied in Kemur Beab could equally assist to develop a strategy to move these facilities well inland.

The situation and opportunities at Ngermeaus Beach are identical to Kemur Beab however since the situation is not quite as urgent it is perhaps easier to consider a more strategic plan to manage this area. The fundamentals will be the same as Kemur Beab and the alternative approaches recommended start first with the recognition that Ngermeaus Beach is somewhat of an ephemeral feature, we must expect that is will continue to shift over time and that it too has been influenced by the recent strong La Nina event. It follows that with a return to ENSO neutral conditions it is possible that a degree of natural recovery may occur. However, it is unlikely that the beach will return to its former shape and it is fundamentally wrong to have that expectation. There is no one starting point for the shape or size of Ngermeaus Beach, it is simply a reflection of the ocean / atmosphere conditions at this time and it is natural for it to continue to flex and move as different seasons and conditions come and go.

Like Kemur Beab Beach, it was noted even during this short visit that tourists were unperturbed by the redistribution of sand to the west and erosion on the eastern shore. They had simply adjusted and were using the new western shore for their beach activities. This again underlines the importance of the natural environment to these tourist activities. If hard shoreline protection was implemented to retain the erosive area, it is highly likely tourists would choose to use different locations which still have sandy beaches intact.

Ngermeaus Beach – Recommendations

1. As per Colin's (2011) recommendations improved monitoring and understanding of how these beaches respond to ocean events and season is key to managing the risks and maintaining the viability of these important beach areas. Simple regular beach monitoring using established profiling techniques would provide valuable information.
    a. This is a simple exercise and once appropriate bench marks are installed and local rangers are trained this can be quickly and easily implemented.
    b. Given these beach areas are small semi-circular features a radial arrangement from 1 or 2 bench marks set well back near the limestone cliff face would provide excellent data.
2. Toilet amenities; investigate the potential to retrofit these with active ventilation (possibly solar) this would provide greater options in terms of their location.
    a. Re-location to safer inner areas of the beach being preferable.
3. Near-shore picnic table and shade facilities could be designed to be easily re-locatable. This would allow rangers to move these if seasonal shoreline shifts start to threaten the position of the structures. It will be important to ensure appropriately designed fastenings and footings are devised to avoid wind damage, etc.
4. Reconsider any plan to implement shoreline armouring with rock filled gabions, this approach is likely to cause more damage and is not compatible with present tourist use.
5. Develop a location-specific adaptive plan for how facilities will be designed and placed on Ngermeaus Beach.
    a. Over time this adaptive plan could be informed by the beach monitoring work also recommended.
    b. It is understood that Koror State Government wishes to develop a plan which alternates tourist use of favoured Rock Island beach areas. This sounds an excellent strategy however in order to understand if this is beneficial, monitoring of these environments should be undertaken, including beach profiling.
    c. It would also be very advantageous to start to keep tourist number and activity statistics for each beach area.
6. Implement training sessions with local stakeholders and rangers on monitoring techniques as well as back ground introduction to shoreline processes and dynamics. This will support improved adaptive management and decision making.

Ngkesill Beach – Shoreline Processes

The composition, site and orientation of Ngkesill Beach is again very similar to the circumstances at both Ngermeaus and Kemur Beab Beach and the factors which have led to the accumulation of sand at this southern island extremity again appears consistent with predominant easterly trade winds and sand transport dynamics around the island towards the south-western extremity. Likewise the pattern of redistribution and shoreline position change at Ngkesill Beach is consistent with the patterns seen at Ngermeaus and Kemur Beab Beach sites where strong easterly trade winds have stripped sand from the eastern shore and pushed it around to accumulate on the western shore. The scenes of erosion on the eastern shore are dramatic given the small size of the beach area but the same can be said of the very rapid accretion on the western shore, obviously the way these two processes are viewed by those with close emotional / cultural ties with the area is significantly different, one being feared the other being welcomed. In many ways this perception of the processes at work in all three locations is the problem, not the actual physical processes at work, the beaches are simply doing what they will always do – respond to seasonal climate events.

Two images of Ngkesill Island (red circle) from 1992 and 2011 (sourced from Colin, 2011). The Ngkesill Beach area appears to be fed from sand which moves from around the northern shore as well as via a narrow low-laying gap between the islands. The shift or redistribution of sand between 1992 and 2011 shows clearly the removal of sand from the south-eastern shore and accumulation on the north-western shore (see also July 2012 photos below).


Contrasting views of Ngakesill Beach area, to the left this area at the south-eastern end of the beach is now composed of exposed rubble and was several years earlier a sandy beach, note also fallen trees and proximity of the picnic shelter in the background. On the right is the north-western end of Ngakesill Beach and it clearly shows rapid accretion. The green picnic tables to the right in the background of the image were formally situated just behind the beach berm (top of the beach) they are now many yards behind the berm.

Ngakesill Beach – Damage to infrastructure and response

Again at the time of writing infrastructure at Ngakesill Beach had not been damaged however a number of fairly large trees have been lost at the south eastern end and picnic facilities are close to the erosive shore. Like Ngermeaus Beach no engineering has been implemented to protect or stabilise the shore but again it was reported that gabion baskets may be used depending on the success or otherwise of the hard structures being built in Kemur Beab Beach. Unlike either Kemur Beab and Ngermeaus Beach there is a natural rubble layer now being exposed on the erosive shore of Ngakesill (see photo above) this is a natural protective barrier which will slow erosion and in time will likely allow the re-establishment of sand in these areas. Again, it is strongly recommended that managers of the areas work with these natural processes and not against them. Avoid the temptation to implement hard stabilisation measures and consider alternative management and response strategies instead. Such strategies will match closely those already discussed for Kemur Beab and Ngermeaus Beach.

Ngakesill Beach – Recommendations

1. As per Colin's (2011) recommendations improved monitoring and understanding of how these beaches respond to ocean events and season is key to managing the risks and maintaining the viability of these important beach areas. Simple regular beach monitoring using established profiling techniques would provide valuable information.
    a. This is a simple exercise and once appropriate bench marks are installed and local rangers are trained this can be quickly and easily implemented.
    b. Given these beach areas are small semi-circular features a radial arrangement from 1 or 2 bench marks set well back near the limestone cliff face would provide excellent data.
2. Near-shore picnic table and shade facilities could be designed to be easily re-locatable. This would allow rangers to move these if seasonal shoreline shifts start to threaten the position of the structures. It will be important to ensure appropriately designed fastenings and footings are devised to avoid wind damage etc.
3. Reconsider any plan to implement shoreline armouring with rock filled gabions, this approach is likely to cause more damage and is not compatible with present tourist use.
4. Develop a location-specific adaptive plan for how facilities will be designed and placed on Ngakesill Beach.
    a. Over time this adaptive plan could be informed by the beach monitoring work recommended.
    b. It is understood that Koror State Government wishes to develop a plan which alternates tourist use of favoured Rock Island beach areas. This sounds an excellent strategy however in order to understand if this is beneficial, monitoring of these environments should be undertaken, including beach profiling.
    c. It would also be very advantageous to start to keep tourist number and activity statistics for each beach area.
5. Implement training session with local stakeholders and rangers on monitoring techniques as well as back ground introduction to shoreline processes and dynamics. This will support improved adaptive management and decision making.

Other Beach Areas

Several other beach areas in the Rock Islands were also viewed from the water during the field trip. Of these some showed surprising stability and appeared at least during a "drive-by" assessment, largely unperturbed by the ocean conditions which have caused significant change in the three study sites discussed above. Others showed significant erosion, likewise it was obvious that some sites were frequented by tourists and others infrequently visited. No specific patterns new to this discussion could really be assessed but it is worth sharing the limited information gleaned during these brief visits as it provides further context in addressing the broader issues of beach erosion in the Rock Islands.

Site 4. Located near Ngermeaus Beach with an easterly aspect this north / south running beach has been subject to hard vertical seawall construction. There was low sand accumulation in front of the wall and exposed beach rock can be seen to the left. Vertical walls tend to reflect wave energy and frequently push sand away rather than allowing it to deposit on the shore.

Site 5. Small pocket beach near Ngakesill has lost elevation and sand appears to have been redistributed into deeper water towards the west (right in the picture). Whilst this is a similar pattern to the study sites it must also be recognised that such a small “two-tree” islet simply cannot sustain a large amount of human traffic. These are very fragile environments and foot traffic alone could easily critically destabilise such a beach. This highlights the importance of the strategic closure and reopening of such beach areas to allow time for recovery.

Site 6. This beach area closer to Koror is several hundred yards long and faces east and is orientated approximately north / south. The beach is closed to tourists but is a favourite picnic location for local families, however it has become so eroded that only coral rubble and beach rock remains over much of its length. At the southern end some experimental nourishment has been undertaken using lagoon basin dredged sand. Interestingly this was seen as a failure by the State Authorities because the sand has migrated southwards into inaccessible sub-tidal areas. Nonetheless, a soft beach still exists at the southern end of the beach and it seems that the concept of nourishment has perhaps been misunderstood. Nourishment generally requires a continual effort and sustained strategic replenishment in order to retain a sandy beach.

Site 7. This beach lays directly north of the previous location and shares the same orientation and exposure, however it is clearly a far more stable system in comparison and remains sand covered. The precise reason these two locations are so different is unknown but it does appear that the second beach is not so heavily used for recreation as a private dwelling is located here. It is possible that heavy use has played some part in the erosion of the previous beach but such questions deserve more thorough investigation.

Discussion

Beach Erosion

Erosion elicits strong emotive reactions all over the world but especially so in small island settings where dry land area can be a scarce resource. The messages in this report which are aligned also with those of Colin (2011) centre around the need to learn to understand and live with these dynamic shoreline systems rather than fighting against the processes which have caused erosion. There appears some good opportunities for practical capacity building to enhance local understanding of how such shorelines function and continually respond to on-going season change and extreme events. With improved understanding it is possible to design more appropriate plans for facilities and use of these fragile beach environments. The current expectation that these beach systems should somehow be stopped from changing or that they are static features is incorrect. Likewise, working to ensure they are returned to a former position or shape underlines the disparity between the very genuine wish to manage and protect these areas and methods/approaches currently being employed to do this.

In the equatorial Pacific long shore transport often occurs in a net westerly direction and depending on the orientation of the island shoreline, transport may be north westerly and south westerly due to the predominant trade wind conditions. It follows that shores especially sandy shores are often a reflection of those "normal" conditions, they may be more stable whilst those normal trade wind conditions prevail. However, any shift from those average weather conditions such as the recent strong and persistent La Nina, or large storms, etc. will alter sand delivery to the shore and its movement along and loss from the shore. In the case of the beaches visited during this study the past strong La Nina conditions appear to explain the redistribution of sand witnessed in these beach systems. Assuming these rapid observations are correct, this is good news because now that ENSO neutral conditions have returned (neither El Nino or La Nina) it is likely the beach processes may become more stable once again. Stability does not necessarily mean the beaches will return to their former positions. In fact this is unlikely, because the changes seen appear to have been caused by a relatively strong event which has move a large volume of sand, but it does mean the rapid westerly redistribution of sand should slow down and it follows we can expect eastern shore erosion to also slow (Annex 1 has a simplified schematic showing these cyclic processes, common in the Pacific Islands).

Most important for the manager of these locations is to understand that the changes should not be viewed as good or bad. Such processes are simply part of the natural flexing of these sorts of shorelines. It has occurred before and it will continue to occur and it is better to understand how recovery or continued redistribution or erosion / accretion occurs in these beach areas than to fight these processes. Good management will include the design and the implementation of strategies to live with the changing environment and a well-designed but simple monitoring system to build understanding of change and warn of worrying signs where net loss of sand is becoming a dominant process, etc.

Beach Nourishment

Even though it is not recommended, if the Koror Authorities are adamant that shoreline protection must be implemented on these beaches, hard wall measures are not seen as the best approach. Nonetheless, if hard wall structures are used it is recommended the design and placement needs to be the subject of specialist and site specific assessment to maximise effectiveness and minimise environmental and tourist amenity impacts.

In the case of Kemur Beab Beach the gabions already in place do not appear to be designed in a manner which is more appropriate to the environment or tourism uses of the beach. It is

recommended that rather than hard engineering, beach sand nourishment (importing sand from elsewhere in Palau and placing it on the erosive beach areas) could be used as an alternative. Sand from Koror's existing lagoon basin dredge system may be appropriate but it would be advantageous to seek a resource which has a courser grain size e.g. 1.5 – 2mm. It must be understood however that nourishment will not likely be a permanent solution as continuing long shore transport will continue to carry the sand away (probably to deposit on the south / south-western shores). Nourishment is recommended however because it presents a less invasive, soft option and can reinstate the beach environments in a way which is compatible with the tourist use of the areas. A reinstated beach can also provide protection for infrastructure.

The greatest difficulty with nourishment is predicting how long the imported sand will remain in place at these sites. If nourishment is used, managers in these areas need to be prepared to replace the sand when needed (this might be several times a year if necessary, it may only be once) and subsequent shoreline processes need to be closely monitored to gauge the effectiveness (beach profiling discussed above). Assessment of the impacts of nourishment would also need to be monitored on near-shore shallow habitats, especially if nourishment is repeated at rapid intervals and / or if the finer dredged sands are used. Overall, since we are aware that seasonal ENSO conditions have changed from being strongly La Nina to neutral, nourishment stands a good chance of being effective in the immediate term and even if unsuccessful is a low risk action.

Overall Assessment Recommendations

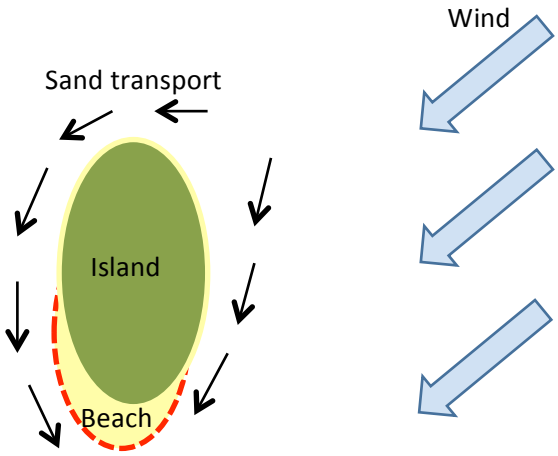
The overall assessment recommendations are;

- Avoid implementing hard engineering in these beach locations and capitalise on the newly accreted western shores of the beach areas rather than trying to artificially reinstate the former beaches.
- If protection must be considered pursue the possibility of nourishment regimes.
- Carry out collaborative field visits and capacity building in shoreline management and processes with the Rock Islands Management Authorities to build understanding of these shoreline systems.
- In partnership with the relevant authorities, develop site specific adaptive management plan for each location / beach area (nourishment, infrastructure placement, facility improvements, directing tourist "traffic" away from more sensitive areas, etc).
- Implement the management plan (possibly including relocation and retrofitting of existing facilities).
- Design and implement monitoring schedule at each site prior to any remedial action.
- Develop appropriate control sites away from tourist activities which are also monitored.
- Improve statistics collection for each site and integrate site specific plans into the broader Rock Islands Management Plan.

References:

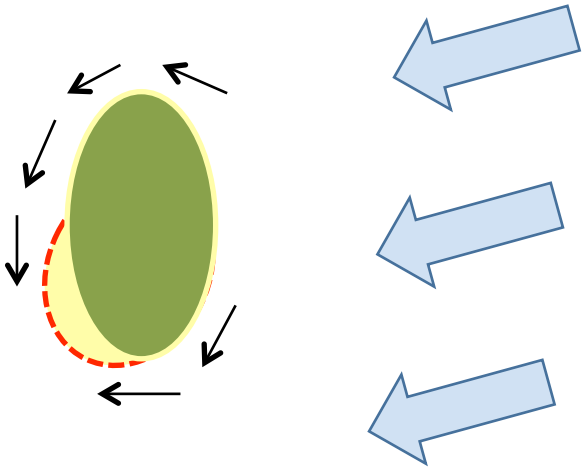
Colin, P. (2011) *Report to Koror State Government on status and restoration of Rock Island beaches*. Coral Reef Research Foundation.

Annex 1. These schematics are derived from work undertaken in the equatorial Pacific Islands but may also assist to explain what are thought to be the sediment processes on the Rock Island beaches as well. It does not account for the possibility of complex currents which may be active in the Rock Islands.



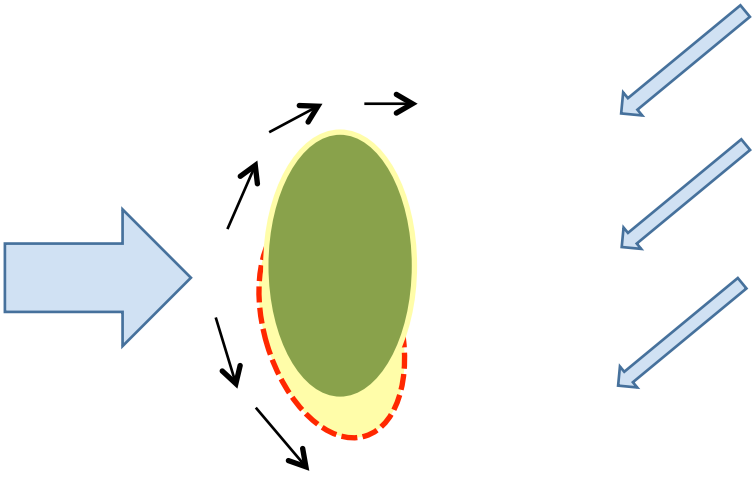
3. ENSO neutral; normal easterly trade winds prevail.

In this scenario soft beach sand moves gradually around the island and accumulates in the south.



2. La Nina; easterly trade winds stronger and more persistent.

In this scenario soft beach sand is pushed towards the west (left) of the island and erosion occurs in the south east. This appears to be the pattern of erosion seen during this study.



1. El Nino; easterly trade winds weaken and westerly wind can occur.

In this scenario soft beach sand movement can slow down due to calmer weather. However, the possibility of westerly winds (often associated with stormy weather) can push sand back towards the east (right) of the island, causing erosion in the west.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