Solomon Islands – Fisheries Livelihoods Recovery Project

# Preliminary Assessment of the Impacts of Reef Uplift on the Aquatic Environment in the Rarumana Lagoon.

Prepared for NZAID
By
The WorldFish Center
Solomon Islands


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**Executive Summary**

In April, 2007, a major earthquake resulted in uplifting of the southern shore of Parara Island in the Western Province of Solomon Islands. One of the areas most affected was the lagoon to the south of the island, upon which villagers from Rarumana depend. The uplift of the fringing reef meant that channels were no longer navigable and water exchange, between the lagoon and the open sea, reduced.

In a May 2007 rapid assessment of the impact of the earthquake and tsunami on fisheries-related livelihoods, conducted by the WorldFish Center, the Rarumana community identified that "not only had their shallow reef habitat been lost but that water exchange between the lagoon and open sea was now reduced with the potential to create water quality problems". At that early stage there was much discussion about the need to "blast" or clear channels to mitigate these effects. Accordingly, these ideas formed part of wider discussions around rehabilitation of fisheries related livelihoods between donors and partners. It became clear that to open channels would be a significant engineering operation and that before extensive and expensive works were undertaken to "fix" the water quality problems associated with the uplift, it was prudent to determine whether they were necessary and would be effective. On 27 August 2007, the WorldFish team returned to Rarumana as part of a tour to present the results of the post-disaster rapid assessment back to the communities in the region. At that presentation a request was made by Rarumana leaders, for advice from WorldFish on the need to create a channel to ensure the maintenance of a healthy lagoon. A preliminary study was designed by WorldFish scientists and incorporated by NZAID into a fisheries livelihood recovery package of work for Western and Choiseul Provinces. The overall goal was aligned with the community request and aimed to assess the ecological risk to the lagoon associated with not conducting excavation works.

Water quality measurements were made in Rarumana lagoon by WorldFish staff, and two experts from the Ministry of Mines and Energy visited Rarumana to advise the WorldFish Center team on issues associated with channel clearance. The water quality data suggested that while minor changes to water circulation within the lagoon are likely to have occurred, there were no substantial adverse impacts on water quality overall. It was therefore recommended that a watching brief be maintained on the lagoon water quality rather than immediately launching into a full environmental assessment. Mines and Energy staff considered that there was a significant risk of fracturing the porous coral rock forming the foundation of the southern boundary of the lagoon and, as the risk of environmental damage was assessed as low, recommended that no blasting or excavation works go ahead unless there was an urgent need by the community for canoe passage. In that case it was recommended that one small channel only be made by machinery and that it be deep enough only for use by canoes at high tide.

On the 16 April 2008, the findings were relayed by WorldFish and Mines and Energy staff to a public meeting in the village. Community leaders stated that they would not be pursuing a channel just for the sake of transport given that other navigable options remain. The leaders felt that the study had taken a weight off their minds and supported their wish to allow nature to take its course. They expressed thanks to the project team for listening to their concerns, carrying out the work needed to answer their

questions and feeding back the findings to the leaders. They expressed satisfaction with the process and requested that a copy of this report be lodged in the community for future reference.

**Introduction**

In April 2007, a major earthquake resulted in uplifting of the southern shore of Parara Island in the Western Province of Solomon Islands (Fig. 1). One of the areas most affected was the lagoon to the south of the island (cover picture), upon which villagers from the large Rarumana community on the shore of the lagoon are more or less dependent. The immediate effect of this uplift was that channels through the fringing reef on the southern side, that had previously been open at all states of tide, were no longer navigable even at very high tides (Figs. 2 and 3) and that water exchange between the lagoon and the open sea was reduced. This change compromised the ability of villagers living inside the fringing reef to access the open sea, and created concern amongst the community about the effect of reduced water flow on the "ecology" of the inner lagoon. These concerns led to initial discussion in the aftermath of the April 2007 earthquake of the practicality and affordability of clearing one or more of these passages.

**Figure 1.** Uplifted fringing reef viewed from Rarumana Village, May 2007

In a rapid assessment of the impact of the earthquake and tsunami on fisheries-related livelihoods, conducted in 2007 by WorldFish Center (Schwarz et al 2007), the Rarumana community specifically identified that "not only has their shallow reef habitat (previously used for seaweed farming) been lost but that water exchange between the lagoon and open sea is now reduced with the potential to create water quality problems in the lagoon owing to restricted flushing".

Six months after the disaster, on 27 August 2007, the WorldFish Center assessment team returned to Rarumana as part of a tour to present the results of the rapid assessment back to the communities in the region. In the interim, discussions had been held with NZAID regarding options for channel clearance and it had become clear that to open either or both channels would be a significant engineering excavation operation. In August 2007 the focus of community concerns was primarily around water quality issues, as people had begun to adjust to the changed access options. A request was made at that meeting for WorldFish to advise on the need to create a channel to ensure a healthy lagoon would be maintained. WorldFish returned to NZAID following that meeting with a proposal, aligned with the community request, that a determination of the risk of ecological impacts owing to inadequate flushing was needed to help assess the urgency of the need for excavation work. A study was designed and incorporated by NZAID into a post earthquake and tsunami fisheries livelihood recovery package of work for Western and Choiseul Provinces.

## Study outline

*Potential effects of reduced flushing by the uplifted reef*

The most likely impact, if any, of the reduced flushing is an anoxic event triggered by stagnation of a stratified water column. It would only require one such event to induce a kill of benthic organisms in the lagoon. However, understanding whether and how uplifting has affected circulation and water quality within the lagoon is difficult in the absence of any pre-disaster information. Before extensive and expensive works were undertaken to "fix" the water quality problems associated with the uplift, it was prudent to determine whether they were necessary and would be effective. The purpose of this brief study was to examine water quality in the lagoon after the earthquake to provide a basis on which to assess the probability of substantial impacts on its life supporting capacity and hence the need for either further more intensive study or remedial action, according to Table 1.

**Table 1.** Proposed plan of action according to Preliminary Environmental Risk Assessment.

| Risk assessment | Further environmental assessment | Excavation |
|---|---|---|
| Low | Keep a watching brief | Do not pursue further unless access is still major concern for the community |
| Medium | Get a second opinion (may require engagement of consultants) | Pursue on basis of second opinion |
| High | Get a second opinion (may require engagement of consultants) | Pursue with a view to completing |

The work was carried out by WorldFish Center staff, based in Gizo, with expertise in water quality and ecological risk assessment. In the aftermath of the 2007 disaster much of the attention of physical scientists was understandably focused on the spectacular uplifted reefs on Ranonga Island (e.g. McAdoo et al 2007) and the Rarumana uplift did not receive the same attention. Nevertheless Rarumana had been visited soon after the disaster by a marine geologist from the Solomon Islands Ministry of Mines and Energy and we sought his opinion along with that of a geological engineer to put the potential scale of excavation works into perspective, should the risk (Table 1) be determined to be medium or high.

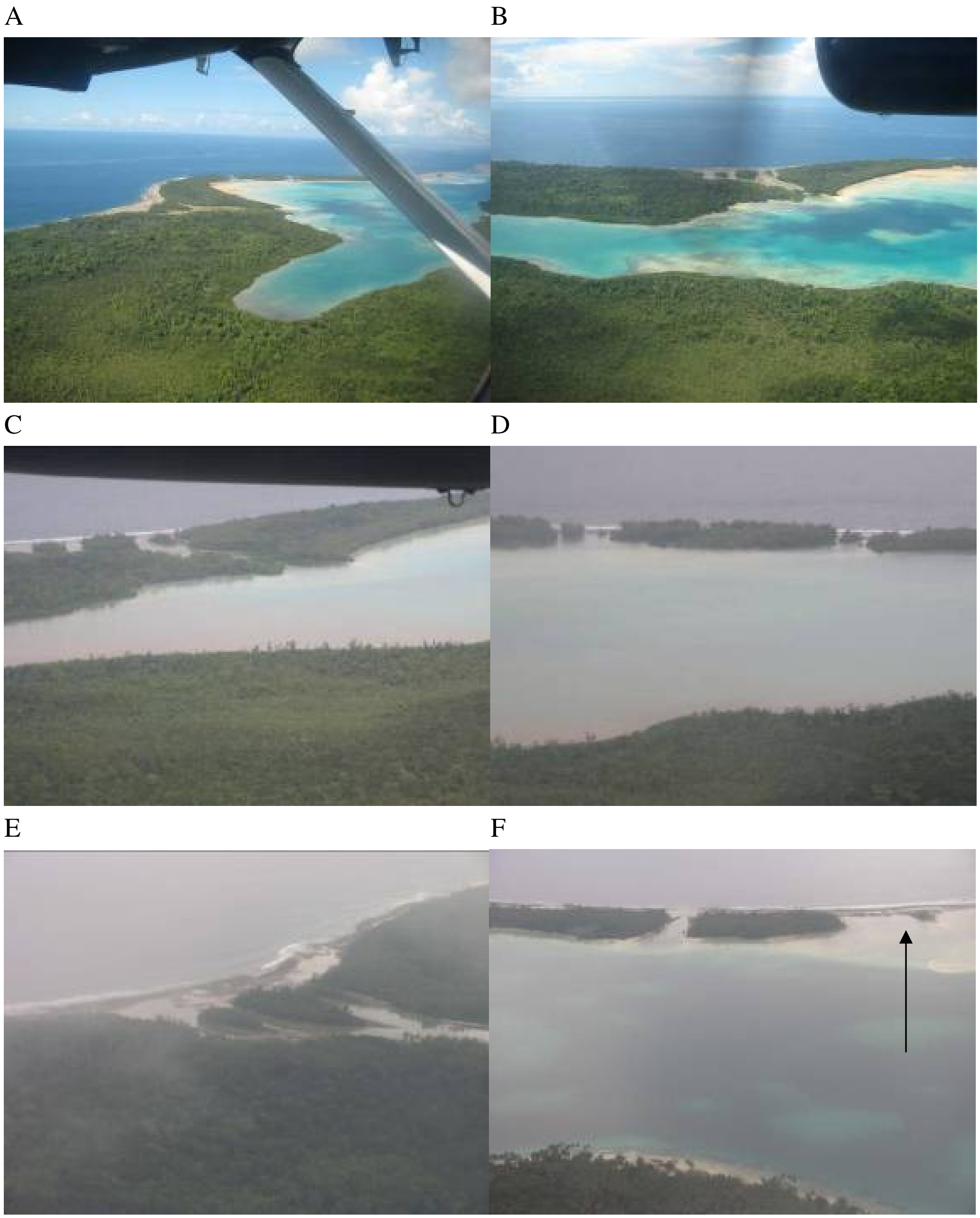



**Figure 2.** Aerial images of channels through the reef that were previously navigable at all states of the tide, but which are now: A and B, November 2007, dry during neap and low tides; C and D, December 2007, and E and F, February 2008, wet at high spring tides. Note that in the December photos (C and D) water is in the channels, but appears to be barely flowing through them, if at all. In the February 2008 photo E, the main channel remains cut off from the open sea on the seaward side.

**Figure 3.** Left: Dead branching corals on uplifted fringing reef opposite Rarumana Village, August 2007 and Right: channel indicated by black arrow in Figure 2F, August 2007.

*Definitions and names*

The partially enclosed water body of concern here (see cover image) falls between a *lagoon* (a body of water isolated from the open sea by shallow or tidally-exposed sandbanks or reefs) and an *embayment* (a body of water surrounded by land on three of four sides). A significant difference between the two categories of water body concerns the degree of continuity with the open sea; continuity is greater and less constrained by tidal height in the case of a bay which tends to have a deep opening to the sea. On its southern shore, the Rarumana water body is "lagoonal" in that it is delimited by a shallow reef/sand bank structure, over-topped in places by the tide. However, its western side has a higher degree of continuity with the open sea, albeit punctuated by reef structures, suggesting that that part of the water body acts more as a bay. Through this report we will refer to the water body as the Rarumana Lagoon, in deference to common local usage. We will also term the western margin of the lagoon the "entrance" even though photographs (Fig. 4) show that water still enters and leaves the lagoon over and through the southern reef during particularly high tides.

**Figure 4.** Fringing reef opposite Rarumana village, November 2007.

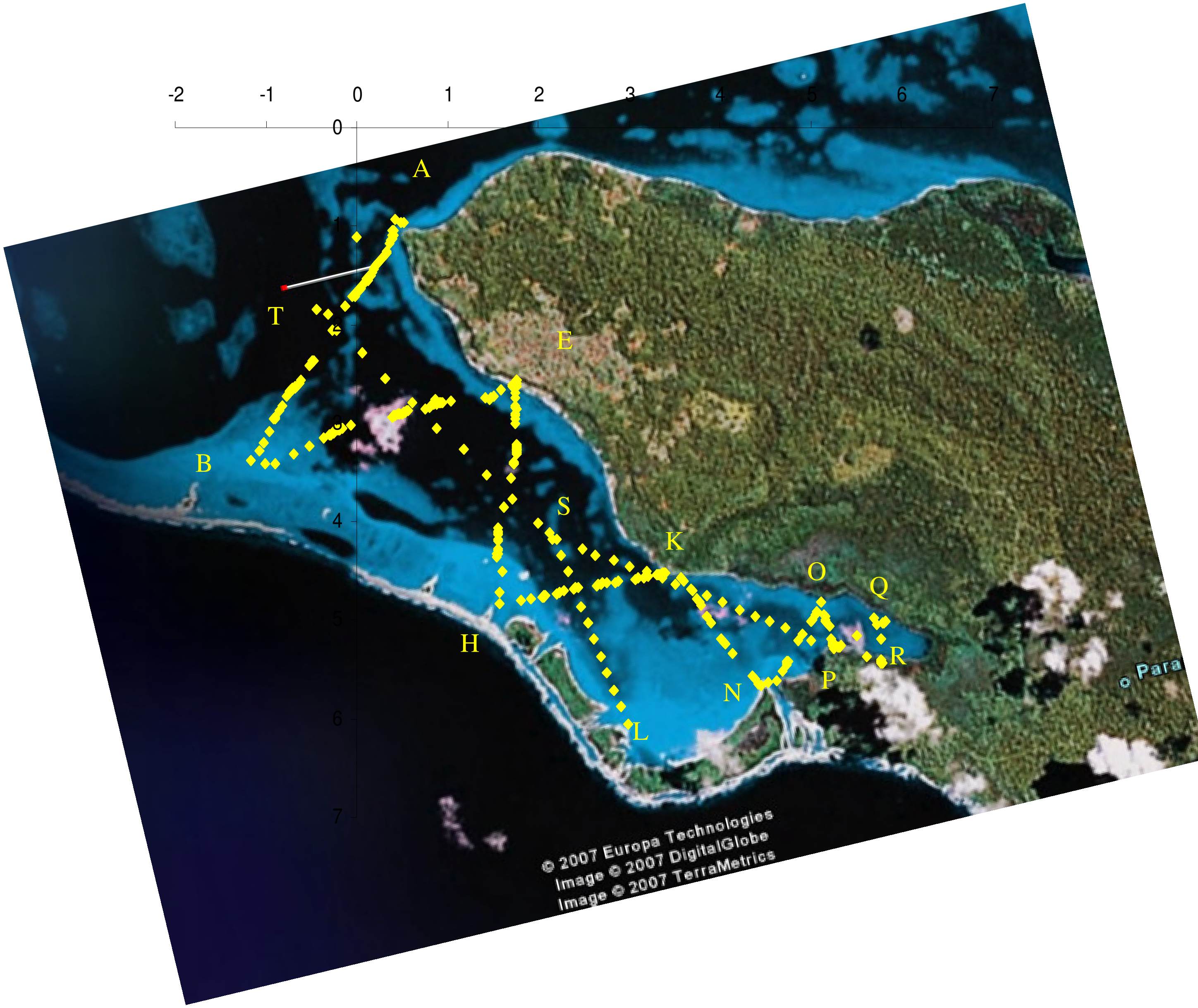
Restricted water exchange between lagoons and the adjacent open water can have a variety of undesirable impacts on their ecology. Primarily these relate to the lack of water exchange or mixing within the lagoon allowing the consequences of in-lagoon processes to accumulate over time. An example is the depletion of oxygen in deeper water resulting in damage to, or death of, the benthic community.

*Water quality and risk assessment approach*

This preliminary environmental investigation is constrained by the absence of any pertinent information on the lagoon prior to the earthquake and limited local resources. Within these constraints we have set out to determine whether, under current conditions, there is evidence of compromised water quality, as evidenced by reduced dissolved oxygen concentration or stagnant, stratified water masses within the lagoon. Given that in Solomon Islands air temperature and sea temperature vary little over the annual cycle, and tend to be similar to one another, thermal stratification of shallow water is likely to be a short-lived, diel phenomenon. This is because surface heating of shallow seawater during the day is likely to be offset by surface cooling at night – when sea temperature exceeds air temperature. The most likely form of persistent stratification for the Rarumana Lagoon is salinity stratification, which could, for example, develop if weak circulation allowed rainwater or inflowing stream water to form a low-salinity surface layer, isolating a full-strength seawater layer below. In either case oxygen depletion or waste accumulation could occur, though for short-term stratification this would require a rapid rate of depletion/accumulation while for longer term stratification adverse conditions could develop more slowly. For this reason we identified temperature, salinity and dissolved oxygen as critical indicators of system function. Temperature is an index of short-term physical processes that promote stratification on short term time scales, salinity an index of longer term stability-enhancing processes, and dissolved oxygen an index of the response of the ecosystem to these effects.

To assess the current status of the Rarumana Lagoon we have therefore determined the approximate bathymetry of the Rarumana Lagoon and undertaken water column profiling for dissolved oxygen concentration, temperature and salinity. In order to sample a worst case scenario, all sampling was carried out on calm, sunny days, when high oxygen demand and stratification are most likely to have occurred.

*A priori* we considered that an absence of oxygen depletion and/or water column stratification would suggest the existing conditions were not indicative of imminent catastrophe in the Rarumana Lagoon ecosystem, hence drastic remedial action would not be required, though it might be prudent to maintain a watch on the lagoon over a longer time frame. If, on the other hand, evidence of actual environmental deterioration were to be found, then this should at least trigger more intensive investigations of underlying causes.




White line = 1 km

**Figure 5.** Google Earth image of the Rarumana Lagoon, overlain with bathymetry transects. Way points (turn-points) used in the bathymetry survey are labelled with letters.

## Methods

*Bathymetry*

Bathymetry was estimated using a boat fitted with a Hummingbird 737 combined GPS and echo sounder. Waypoints were set up for the edges of the lagoon (Fig. 5) and transects run between these. GPS position and water depth were noted at intervals (data points) along these transects. The boat was not able to reach the shore in all cases due to the low water level. After data collation, the GPS positions (lat/long) were converted to a distance from a fixed point to allow map grids to be reconciled with other images (such as the Google Earth image used in Fig. 5). Distances between data points were computed enabling profiles (cross-sections) of distance from the north-east shoreline (Rarumana village shoreline) vs depth to be plotted for each transect. The exception was the long transect from point R, through S, to T which was plotted as distance along this transect from R.

All profiles are corrected to a constant (though undefined) sea level, using relative tide level observations made at Nusa Tupe at half hourly intervals throughout the survey period. In practice the range of correction varied up to 0.21 m. Profiles were then used to develop a sketch chart of the lagoon, at 5 m depth resolution, which was digitised and used to estimate the volume of various lagoon compartments. Key dimensions of the lagoon were derived from the Google Earth image, using the image processing package Image-J.

*Water Quality*

Water samples were taken at 2 m depth intervals to a maximum of 30 m, from 7 sites more or less evenly spread along the central axis of the lagoon. We measured water temperature and dissolved oxygen (DO) concentration using a Hach digital meter, and salinity using a refractometer. Water samples were pumped from the required depth, using a 12V electric diaphragm pump attached to a 15 mm internal diameter hose, which discharged through a flow-through chamber into which the measuring electrodes could be placed and water samples removed for salinity estimation. Care was taken to ensure that the tube was well flushed each time the depth was changed.

Water quality data were collated and converted to contour plots.

## Results.

### Bathymetry

*Longitudinal profile*

The single longitudinal profile (R through S to T (Fig. 5)) showed a gradual increase in overall depth from the head of the lagoon to around 30 m at the mouth (Fig. 6). At intervals this general profile was interrupted by reefs and sand banks. The longitudinal profile thus shows a number of potential “sumps” where, if any degree of stratification occurred, water could stagnate.  Examination of transverse profiles (across the width of the lagoon) allowed us to more fully interpret these apparent sumps to determine whether these are true sumps or actually convoluted channels.

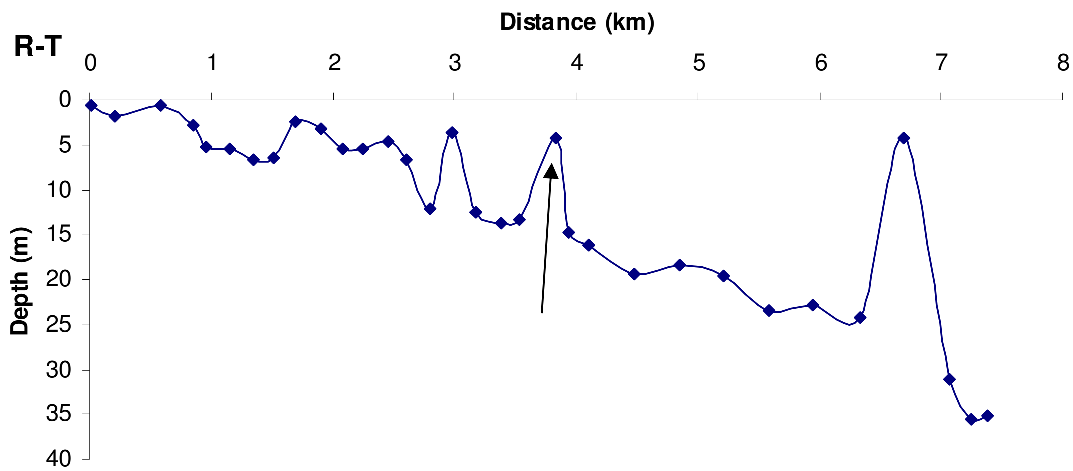



**Figure 6.** Longitudinal section from the shallow inside of the Lagoon (point R) to the deeper open sea (point T). The transect bends through Point S, marked on the figure with an arrow.

*Transverse profiles*

For ease of visualisation. transverse profiles are divided into two groups, with the K-H transect (Fig. 5) making a convenient break point between the deep and shallow sections.  The deeper end of the lagoon includes K-H and all parts the west of this line.

The shallow sections (K – N, Fig 6) show a steep-sided central channel, gradually deepening from 4.5 m on Q – R (Fig. 6) to almost 9 m depth by the end of the section.  At O-P this channel is slightly over-deepened to form a sump which is at least 1 m deeper than surrounding bottom.  By K-N the deep central portion has been divided into two sections by a central rise.

Within the deeper section (Fig. 7) the same basic topography continues.  Wide sandy banks descend rapidly to a central channel which is mostly divided into sub-channels by reefs, which rise steeply from the lagoon floor. The deep section shows no evidence for interruption of continuity between and within these sub-channels and there appear to be no barriers to deeper water circulation.

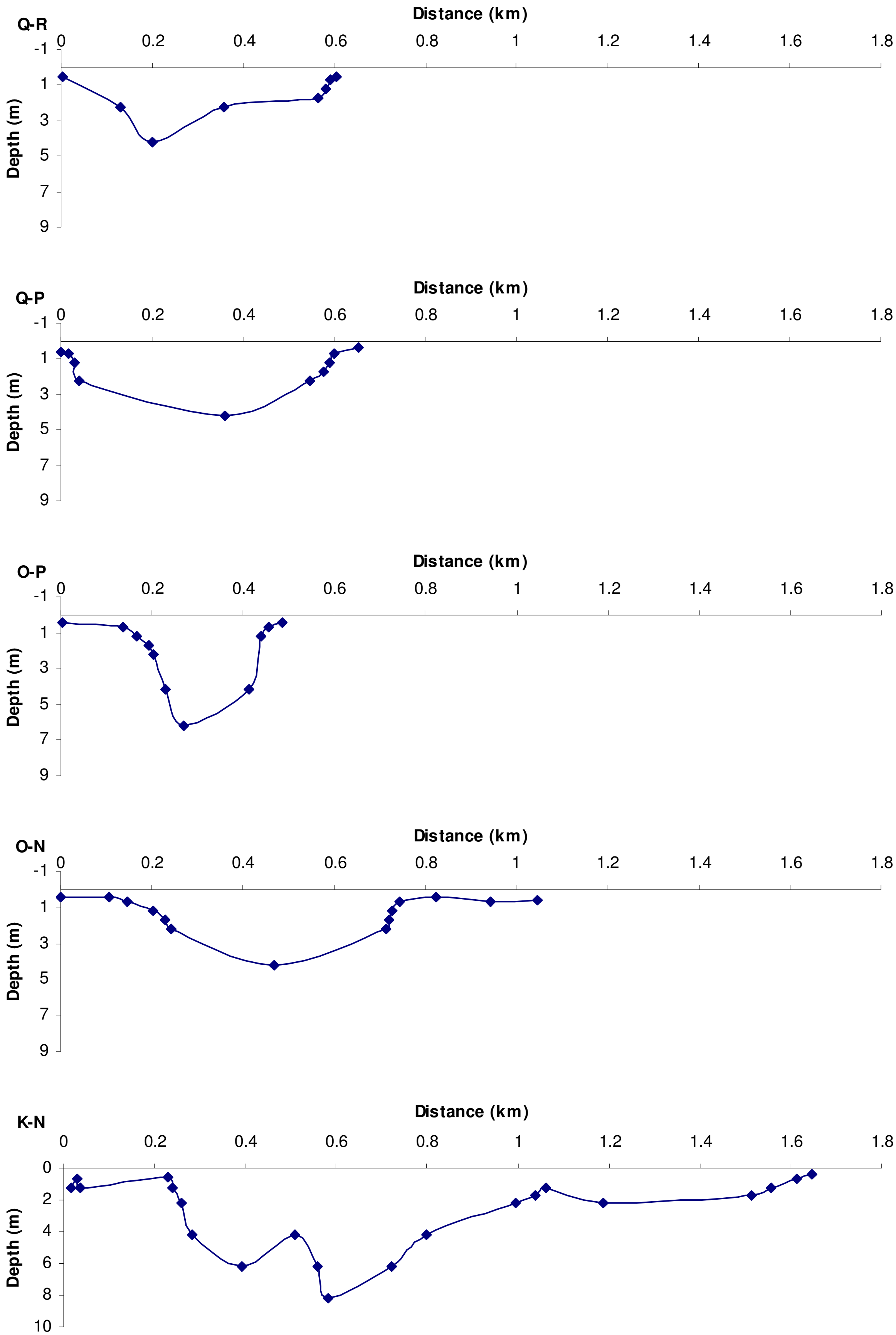



**Figure 6.** Profiles across the inner end of the Rarumana Lagoon.

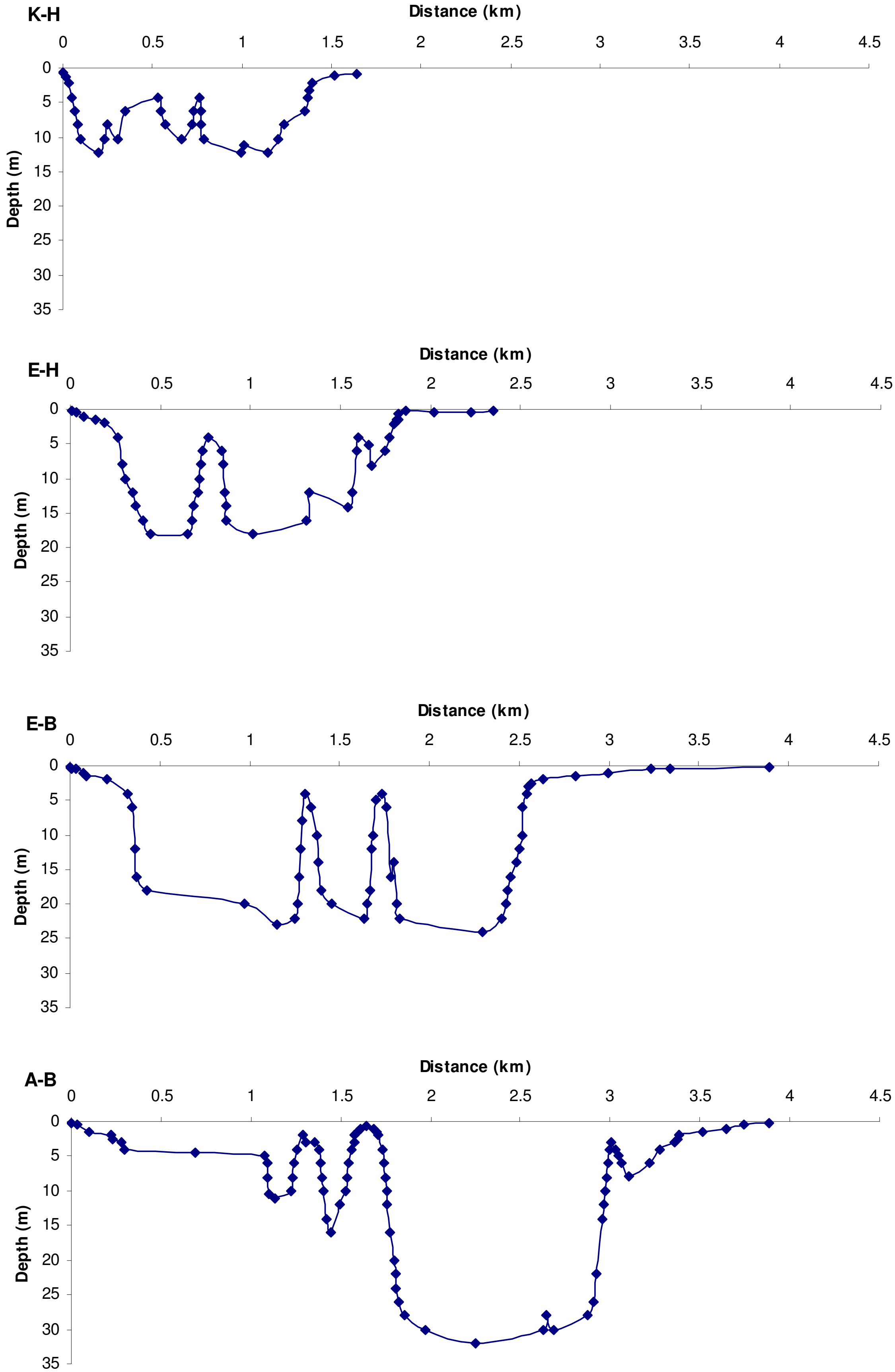



**Figure 7.** Profiles across the outer part of the Rarumana Lagoon

*Lagoon dimensions and volumes.*

The Rarumana Lagoon is 7.4 km long and 3.9 km wide at the entrance. Lagoon area is 15.43 $km^2$, with the area deeper than 5 m, estimated as 5.51 $km^2$. Approximate depth contours based on the bathymetric survey, existing maps and images are shown below (Fig. 8). The picture that emerges is of a steep sided basin, 15-20 m deep, filling the centre of the western half of the lagoon, with extensive shallow shelves on both north and (especially) south shores. The outer section of the lagoon has deep (to 20 m) channels constricted by series of submerged coral outcrops at the entrance. The inner half of the lagoon is by contrast shallow, with a few deeper pockets of water.

Integration of contours in Figure 8 yields an estimation for the volume of the lagoon as 100 x $10^6$ $m^3$.

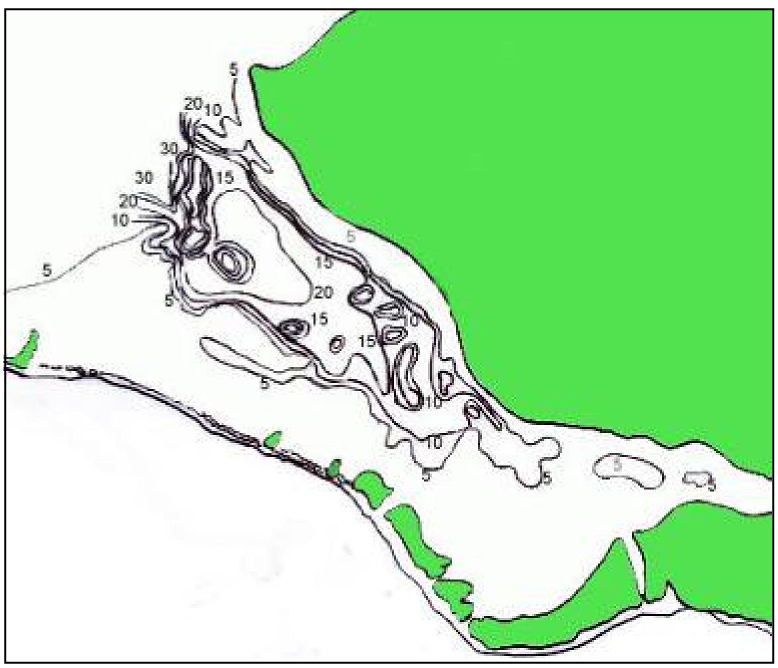



**Figure 8.** Approximate bathymetry of Rarumana Lagoon based on survey data and images. Contours are at 5 m intervals

In the absence of tidal height and tidal current data from around the lagoon, tidal range and lagoon dimensions were used to estimate tidal water flux. In December 2007 the tidal range at nearby Blackett Strait (http://www.mobilegeographics.com:81/locations/596.html) varied from 0.45 – 1.07m. If water level in the lagoon is assumed to follow a similar tidal pattern, this will require an exchange of up to 14.4 x $10^6$ $m^3$ per cycle, of which there is typically only one per day in this region. If this entire volume of water passed through the cross section A-B at the entrance (estimated at 2500 $m^2$), in 8 hours, tidal flux alone would generate an average flow of approximately 500 $m^3 s^{-1}$, at an average velocity through the entrance of 0.2 $m s^{-1}$, equivalent to 0.7 $km h^{-1}$ or ~0.4 kn. This calculation is based on assumptions that the tidal range throughout the lagoon follows that of the open sea outside, and that all of the water exchange passes through the entrance. Neither of these assumptions will be strictly true, and the calculated value thus represents an upper limit to water flow through the entrance. During neap tides it will be substantially less than this.

During spring tides, the tidal flux calculated above suggests that up to 15% of the water within the lagoon is exchanged; at neap tides less than half of that volume will be exchanged. While much of the exchange may be through the entrance, at high tides there will also be some exchange of water over the southern reef boundary (Fig. 9, also see Figs 2 and 4). We note that prior to the earthquake, exchange over the reef and through the now uplifted channels would have been greater. This equates to an average water residence time of 6-7 days, which provides adequate time for in-lagoon processes to affect water quality.

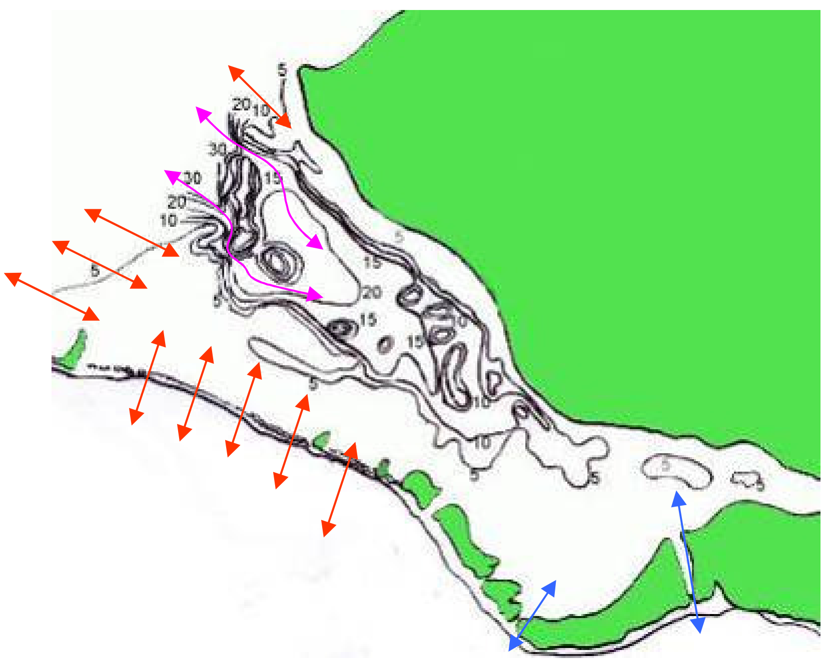


**Figure 9.** Probable exchange of shallow (red) and deep (purple) water in and out of Rarumana Lagoon under existing conditions. Prior to the uplift, more water may have been expected to exchange through the routes indicated by blue arrows.

*Water Quality*

The three water quality variables measured in this survey show little horizontal or vertical change (Fig. 10). Temperature was highest at the inward end of the transect, where it reached

34$^{o}$C, but at the mouth of the lagoon was only 2$^{o}$ cooler. Over the 30 m of water column sampled at the outer sites temperature varied only by 1$^{o}$C. Within the lagoon there was no evidence of strong diel or longer term temperature stratification. Salinity also indicated no strong gradients within the lagoon and there was no evidence of pooling of lower salinity run-off water within the sites occupied. Warming of water would be expected in the shallow, sheltered part of the inner lagoon under the calm, sunny sampling conditions.

When combined with temperature, salinity shows evidence of discreet water masses at the entrance. A well oxygenated, warm and slightly lower salinity water mass was found floating just inside the lagoon and in the lagoon entrance passages, while outside the lagoon there was a shift to slightly cooler, more saline water at the surface. However, none of the water inside or immediately outside of the deep western part of the lagoon, in either water mass showed any major oxygen deficit.

In summary, neither temperature nor salinity indicated any strong stratification within the lagoon, rather gradual gradients along its length but with a more complex pattern close to the lagoon entrance.

Oxygen concentration was lowest at the head of the lagoon and tended to increase towards the entrance. However, the lowest oxygen concentration was still 80% of saturation, and this was in the narrowest, warmest and most sheltered part of the lagoon, close to the highly reducing sediments of the fringing mangrove forest, and is not indicative of a severe water quality problem. Nowhere in the deeper western part of the lagoon was there any evidence for an alarming oxygen deficit.

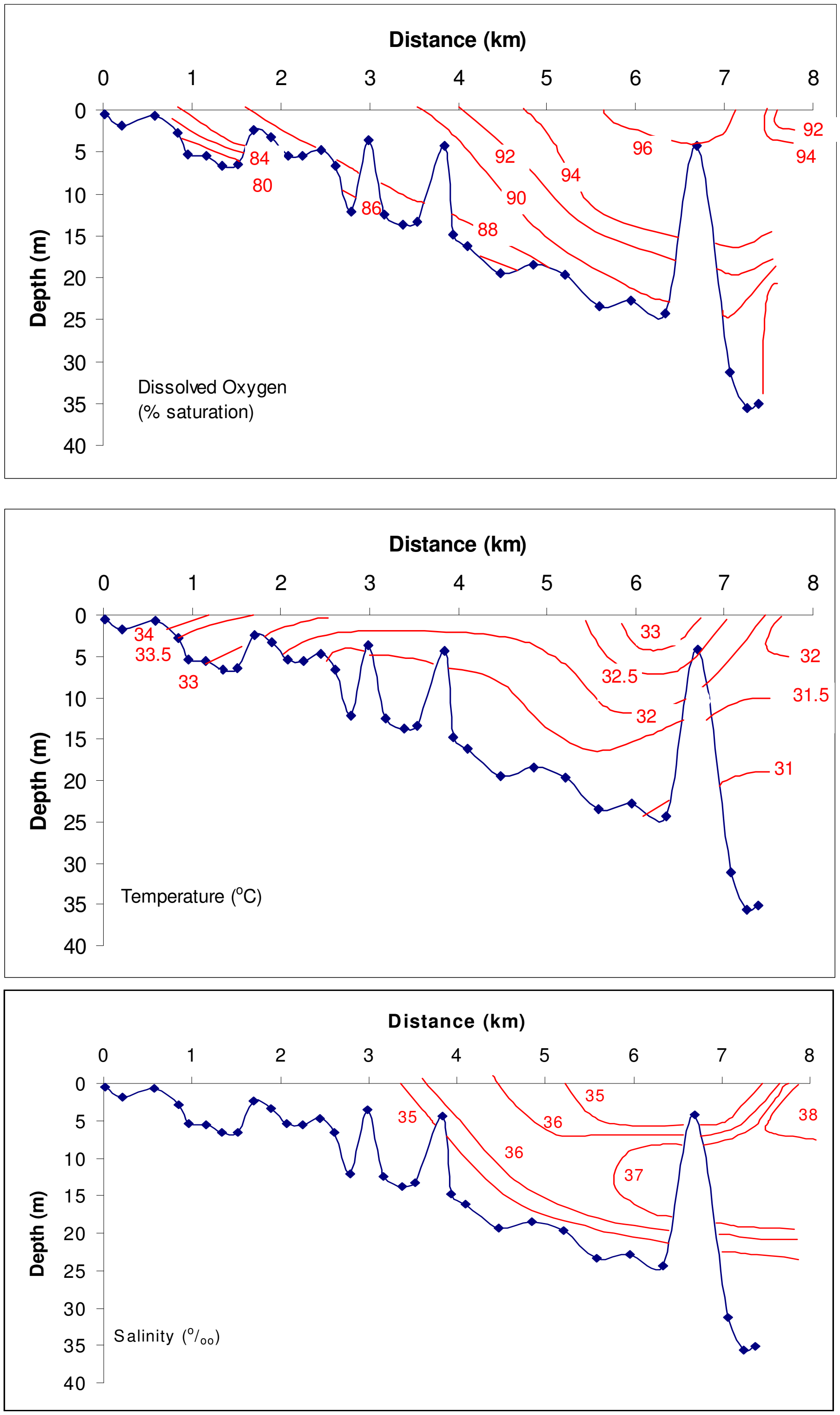



**Figure 10.** Aspects of water quality in the Rarumana Lagoon along the longitudinal section R-T (inner to outer lagoon). The top figure shows dissolved oxygen concentration as % saturation, middle panel water temperature and lower salinity.

*Water quality synthesis*

The bathymetric mapping of Rarumana Lagoon, while basic, is sufficient to divide it into two sections, an inner part, characteristically shallow (less than 5 m deep) with a few slightly deeper pools, and an outer, western half, some 15-20 m deep, connecting to the outer ocean via two deep channels. The outer section is punctuated by coral upcrops, but is otherwise rather flat bottomed.

Within the sheltered, shallow, inner section, we found no evidence of salinity stratification, though some warming of water, especially at the surface. Surface heating is to be expected under strong sunlight at low latitude, and this will tend to stabilise the water column during the day and exacerbate any effects of oxygen consumption by bottom sediments. At night the temperature gradient can be expected to disappear or diminish as heat is lost to the atmosphere. The absence of substantial oxygen depletion on our sampling days, however, suggests that currently sediment oxygen demand is only moderate, and unlikely to lead to ecosystem degradation under the prevailing regime.

The water column characteristics of the outer, deep part of the lagoon appear to be largely driven by water advecting in and out of the entrance with tidal and wind-driven flow. The constriction at the entrance appears to have little effect on this, with temperature, oxygen and salinity contours passing straight through the "island" in the entrance visible in Fig. 10. In the absence of tidal height and tidal current data from around the lagoon, it is impossible to determine precisely the volumes of water moving through the entrance passages, but it seems from the continuity of the water characteristics that it is substantial and unlikely that this picture has been compromised by the reduction in shallow water exchange across the southern reef. In general, our conclusion is then that at present there is no evidence of sufficiently low water quality in any part of the Rarumana Lagoon to raise environmental concerns.

Answering the question of "To what extent has closure of the southern channels affected water exchange in the lagoon?" is beyond this simple preliminary investigation, but, if we assume that tidal rise and fall is similar on the western and southern sides of the lagoon, and that under the pre-earthquake regime more water entered via the southern shore than at present, the following water exchange scenario can be suggested.

*Wind- and tide-induced surface currents.*

Prevailing SE and NW winds would both be expected to set up a general clockwise rotation within the lagoon (Fig. 11). Surface tidal currents entering the lagoon over the southern reef prior to uplift would have tended to drift to the left under Coriolis Effect and join the NW flowing current along that shore, while outflowing currents at ebbing tide would have tended to drain water from that current. Shallow water flowing in and out over the reef prior to the uplift event would therefore likely have been largely confined to interacting with the extensive shallow, gently sloping sandy shores of that part of the lagoon rather than the deeper sections or the extreme inner part that currently experiences most (though not dangerous) oxygen depletion. Surface water entering via the western entrance would tend to favour the northern side and to force the outgoing water to the south; thus water likely to end up in the extreme inner part of the lagoon is likely to include a high proportion that has drifted along the northern and central parts.

It is significant that the southern sand flats were previously used for farming seaweeds. Under the new regime, reduced water exchange across the reef itself will mean that this area will have less ocean water and more lagoon water. If there is any degree of enrichment of lagoon water during passage past the shore of the island, including from settlements, it may have more impact now on seaweed growth than before (i.e. through encouraging growth of epiphytes, a previous problem voiced by Rarumana seaweed growers). However at the time of writing, seaweed farming has not resumed in Rarumana since the 2007 disaster, largely because the extent of suitable areas has been markedly reduced by the uplift. Previous shallow water seaweed flats are now often exposed to the air for prolonged periods of time on low tides.

Deeper water influx is more constrained and prior to the uplift would have entered only via the entrance. This situation is unlikely to have changed substantially. However, the proportion of water entering through the entrance rather than over the southern reef may have increased, thus creating stronger currents through the entrance than prior to the uplift.


**Figure 11**. Likely general wind-induced surface currents within the lagoon under current conditions. These would be modified by tidally induced currents (see text).

*Geology*

During the site visit key points identified by the Ministry of Mines and Energy staff were that it is important to recognise that the uplifted reef provides physical protection to the lagoon and to Rarumana village from the open sea. The uplifted reef is characteristically porous, being comprised of old coral reef, therefore any attempts to blast the reef run the risk of creating weaknesses in areas other than the immediate channel environment. They recommended that any attempt to open the channels should be done using earthworks rather than blasting to minimise this risk. However, after discussing the low risk of water quality deterioration with the community, the recommendation of the Mines and Energy staff was that no blasting or excavation works go ahead unless there was an urgent need by the community for canoe passage.

## Summary and conclusions

*Water quality*

Over the year since the uplift we have, during regular visits to the site, noted dramatic changes to the flora and fauna of the channels themselves. Naturally, immediately following the uplift there was an almost complete die-off of corals and animals when they became exposed to the air. Subsequently the area has become colonised by different organisms, notably extensive mats of algae and cyanobacteria in those parts only occasionaly inundated, and this may change again in the future as the system stablises to a new equilibrium. This is worth noting as it is likely that in localised areas close to the channels productivity of the lagoon will have, and may continue to change as a result of the uplift.

Nevertheless, overall, our data suggest that while minor changes to water circulation within the lagoon are likely to have occurred, at the moment there are no substantial adverse impacts on bulk water quality in the lagoon. Our assessment of risk, according to Table 1 is therefore low. Our recommendation according to Table 1 is that a watching brief should be maintained on the lagoon water quality rather than immediately launching into a full environmental assessment. While this might ordinarily involve regular water quality sampling, this is beyond the scope of the Fisheries Livelihood Recovery Project and in this case the watching brief has comprised the Rarumana community being fully briefed on the study findings, and being advised to alert WorldFish staff should they see any sign of dead marine animals especially during long hot periods.

*Geology*

Ministry of Mines and Energy staff identified the risk that blasting could compromise the integrity of the porous coral rock formations forming the southern boundary of the lagoon that provides physical protection to the lagoon and to Rarumana village from the open sea. Mines and Energy staff recommended that no blasting or excavation works go ahead unless there was an urgent need by the community for canoe passage.

*Feedback of results to the community*

On the 16 April 2008, the findings from the environmental assessment and the geologists opinions were relayed by WorldFish and Mines and Energy staff to a public meeting in the village. The meeting was called with only 24 hours notice to take advantage of the presence of the Mines and Energy staff; nevertheless 10 community leaders attended including the chief and the community organiser. At the meeting the following key points were presented.

1. Although things have changed, there is still enough water exchange at the Gizo end of the lagoon to keep it healthy.
2. On the basis of the work so far, it does not appear to be necessary to clear the channels for the health of the lagoon
3. If no channel excavation occurs, the risk of an "anoxic" event is low.
4. The recommendation is that the Rarumana community are advised to alert WorldFish staff should they see any sign of dead marine animals during long hot periods.
5. The uplifted reef provides protection to the village of Rarumana from big seas.
6. The type of rock that the uplifted reef is made of is old dead corals with many holes and spaces in it. This means that if blasting was to happen there is a risk that damage could be done to parts of the reef much further away from the blasting area. This could make other parts of the reef weak.
7. If a channel is necessary the recommendation is that one small channel only is made at the shortest route to the sea in the old main channel closest to Munda and that it be made by machinery (bulldozer or scraper). The resultant channel could be used by canoes only at high tide.

*Feedback from community leaders*

The leaders expressed their relief at the findings of the environmental assessment, and took advantage of the presence of the Mines and Energy staff to ask many questions about the April 2007 event and related observations they had made since. The leaders stated that they would not be pursuing a channel just for the sake of transport given that other options to Gizo and via the VonaVona lagoon to Munda remain. The leaders felt that the study had taken a weight off their minds and supported their wish to allow nature to take its course. They expressed thanks to the project team for listening to their concerns, carrying out the work needed to answer their questions and feeding back the findings to the leaders. They expressed satisfaction with the process and requested that a copy of this report be lodged in the community for future reference.

**Acknowledgements**
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