Detail response to Referee #1 (anonymous)

In the following letter, each comment by Referee #1 in black is followed by our replies in red.

This paper proposes an assessment of the risk of coastal flooding and submersion by waves in one of the Palau islands surrounded by a coral reef in 2100, in a context of climate change. The study is certainly of interest, the study is rather comprehensive, well conducted and the paper is concise, clear and well written. The objectives of the paper are clearly exposed and the conclusions correspond to these objectives.

We are grateful to you that you review.

I have however two main concerns, that in my opinion prevent the acceptance of the paper in its present state: 1- The authors state that their first objective is to assess the present-day efficiency of the Palau coral reef as wave breaker and natural barrier against water level rise during a tropical cyclone (TC). They give (from what I understand) the corresponding figures obtained from a numerical hydrodynamic modeling, using as forgings the outer wave significant height (SWHo), the outer significant wave period, and the outer water level. These forcings are taken from a GFS simulation and observations of SWH in similar conditions. The percent of reduction of wave height due to the reef is 85.7% (87.9%) with (without) storm surge. As these values are used as a reference in the projective part of the paper, it would be relevant to confirm them (at least at first order) using observations. Recent TCs (Bopha and Haiyan) hit Palau, and it is may be possible to find even crude observations of (outer) SWHo and (reef) SWHr to check either the value of SWHr or the percentage of reduction (Table1). The same applies to the flooding risk (Table2). Especially, the authors mention in the discussion that some of the values obtained in 2100 would result in a flooding of the coastal road: did such flooding occur in the recent years? in the historical period? Has the value of 2.10m for the present-day coastal flooding with storm surge already been observed? The authors did a rather good job in estimating the various contributions (even if it is first order) and their uncertainties but it would be more convincing if the accuracy (and not only uncertainty) was estimated (by comparing with observations).

We are glad to receive your constructive comments. Firstly, we attempted to find a recorded data of ocean wave and water level in Palau Islands. However, we could not found any *in situ* observation data for ocean wave and water level at offshore and onshore using underwater loggers and/or radar observational systems in Palau Islands. Therefore, we conducted the wave simulation using the wave height and wave period obtained by the Global Forecast System (GFS) model at the study site.

Secondly, we attempted to find a record of past typhoon around the study site, using Digital Typhoon (http://agora.ex.nii.ac.jp/digital-typhoon/index.html.en) based on the Japan Meteorological Agency (JMA) best track data. According to the record, 19 typhoons have passed within 150 km of Melekeok reef since 1951. Only 1 severe typhoon passed near the study reef in 1990 (Typhoon Mike), but the impact on Palau's reef was limited to the northern reef (Maragos and Cook, 1995 *Coral Reefs*).

Consequently, prior to Typhoon Bopha in 2012, it is supposed that no major typhoons had caused significant damage to coral reefs and coastal areas for over 60 years. We also talked with local peoples and confirm this expectation. These evidences imply that Typhoon Bopha in 2012 was the most severe typhoon around the study site for over 60 years.

Thirdly, since we could not found any record of wave height at the study site during Typhoon Bopha, we conducted interviews to the local peoples about the state of flooding at the study reef during Typhoon Bopha. As a result, local people mentioned that the road (+2.86 m above MSL) along the shore at the study site was flooded during the Typhoon Bopha and that this was never seen for a past ca. 70 years. Unfortunately, we could not obtain quantitative data, however, our simulation data (please see the following new Fig. 3) seems to match with the observation by the local peoples.

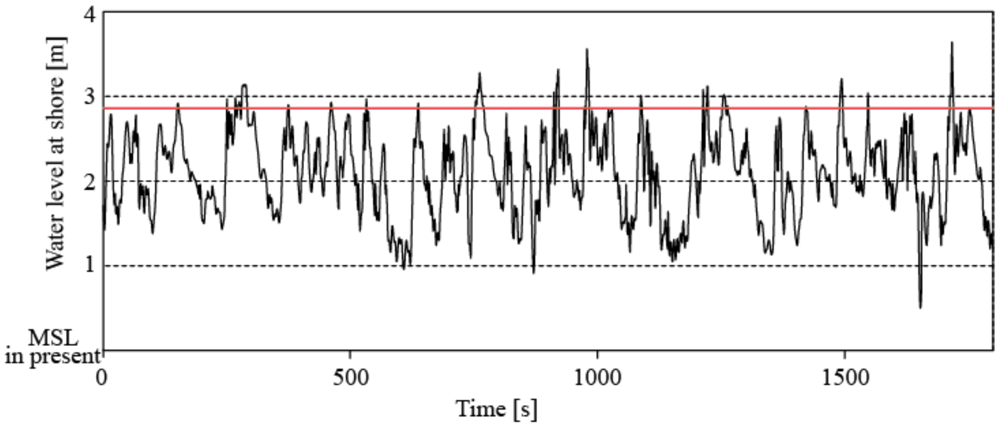

Figure 3: Calculated water level at the study site under the present-Day TC (Typhoon Bopha). The assumed SWHo and SWPo values were 8.70 m and 13.0 s, respectively. The assumed WLo was +1.80m above MSL (i.e., high tide and storm surge). The horizontal solid line in red shows the elevation of the road (+2.86 m above MSL) at the study site. The road was frequently flooded.

As pointed by the reviewer, taking into account that the lack of field observation system for ocean wave and water level around Palau limit accurate predictions for the wave and water level at coastal areas during TCs, we also added in the discussion awareness for the importance of establishing field observation system to predict potential coastal disaster in Palau.

To clarify these points, we added the following sentences into the revised manuscript:

In Section 2.1:

[Since 1951, 19 typhoons passed within 150 km of Melekeok reef in Palau, provided by the Digital Typhoon (http://agora.ex.nii.ac.jp/digital-typhoon/index.html.en) based on the Japan Meteorological Agency (JMA) best track data. Only 1 severe typhoon passed near this study reef in 1990 (Typhoon Mike), and the impact was limited to the northern reef of Palau (Maragos and Cook, 1995). Consequently, prior to Typhoon Bopha that passed south of Palau in December 2 2012, it is suspected that no major typhoons had caused significant damage to coral reefs and coastal areas of Palau for over 60 years. The minimum pressure of Typhoon Bopha center was 935 hPa and the maximum wind speed was 50 m/s (data obtained by Digital Typhoon). The average wind speed was 27 m/s around the study site (see http://www.windguru.cz) in December 2 2012 because the study site is 121 km distance from the pass of Typhoon Bopha. Destruction of piers and erosions occurred at the coast of present study site by the Typhoon Bopha, (Figure 1c, d). As a result, local people mentioned that the road (+2.86 m above MSL) along the shore at the study site was flooded during the Typhoon Bopha and that this was never seen for a past ca. 70 years.]

In Section 2.2:

[(1) SWH_o: Since there is no *in situ* observation systems for ocean wave and water level at offshore and onshore using underwater loggers and/or radar observational systems in Palau Islands, the present-day SWH_o value was simulated by using the Global Forecast System (GFS) model at 27 km resolution, provided by Windguru (see http://www.windguru.cz). In Palau Islands, the values for 4 sites (Melekeok, Koror, North beaches, and West Passage) are provided by the model. The largest SWH_o value during Typhoon Bopha at Melekeok was 8.70 m.]

In Section 3.1:

[The WL_s was 0.86 m for present-day TCs (case 30, Table2) and the WL_s increased to 2.10 m under storm surge conditions (case 44, Table 2). Moreover, the water level at the shore under present-day TCs reached the elevation of road (+2.86 m above MSL) at the study site (Figure 3).]

In Section 4.1:

[Our result of water level at the shore (WL_s) shows that the road (+2.86 m above MSL) at the study site was flooded during an assumed present TC (i.e., Typhoon Bopha). Our simulation data seems to correspond with the observation by the local peoples, although we could not obtain quantitative data.]

In Section 4.3:

[Furthermore, to evaluate the impact of hydrodynamic forces at coastal areas in the islands, establishment of *in situ* observation systems of wave height, wave period, and water level should be considered. For example, establishment of ultrasonic-wave-based wave gauges, observation buoys, and radar-based wave meters are recommended to predict accurately the ocean wave heights and periods to alert peoples for disasters such as flooding during TCs.]

2-The conclusion of the projective part of the study is twofold. Firstly, the healthy of the reef does not impact significantly the risk of flooding – in some cases, an healthy reef will result in higher water level at the shoreline than a damaged reef. Secondly, there is an impact of the state of the reef on SWHr, which varies according to the climatic scenarios (sea level rise), to the wave conditions, and to the presence of storm surge. Its maximum value (SWHr at degraded reef – SWHr at healthy reef) is 0.30m (0.44m with storm surge), corresponding to a change of the percentage of reduction from 88.2

to 85.2% (85.5 to 81.3%). I wonder whether this 3-4% change is significant and whether the corresponding change in SWHr will really have an impact at the shoreline. Providing such estimates is certainly interesting per se, but their significance justify the discussion about the use of coral reef to mitigate the future coastal risk (4.2,4.3). So, even though this study actually proves that an healthy reef slightly reduces the SWH at the shoreline with respect to a damaged reef, this reduction is may be not enough to provide an efficient protection against high waves at the shore. Is there any (observed) difference between a SWHr of 1.24m and 1.05m (present-day values with/without surge)? This point is not answered This could help to assess whether a 0.30m change in the 2100 scenarios would have an impact or not and justify the recommendation of using of coral reef as an efficient barrier.

Thank you for giving the comments. The original manuscript has insufficient explanations. If the future WL_s value shows below the road (+2.86 m above present MSL), the difference in SWH_r between healthy and degraded reefs (max. 0.44 m) will have not a significant impact on the coastal area. However, our results indicated that the WL_s will increase from max 2.10 m at present to max 3.45–3.51 m by 2100. This means that by year 2100, the WL_s will often reach the road (+2.86 m above present MSL) and then an increase in SWH_r of only 0.1 m will lead an increasing of coastal risks such as flooding, destruction of constructions, saltwater intrusion into groundwater and coastal erosion. Consequently, we add the following point in a revised manuscript:

In Section 4.2:

[If the future WL_s value shows below the road (+2.86 m above present MSL), the difference in SWH_r between healthy and degraded reefs (max. 0.44 m) will have not a significant impact on the coastal area. However, our results indicate that the future WL_s will almost reach the elevation of the road at the study site. The above result implies that an increase in wave height of only 0.1 m leads to an increase in risks of substantial coastal damages such as flooding, destructions of constructions (houses and buildings), saltwater intrusion into groundwater, and coastal erosion. Detail quantity of the damages was beyond the scope of the present study, but the difference in SWH_r by a maximum of 0.44 m will probably cause a significant coastal damages. For example, flooding mostly occurs within a 1-km wide coastal zone along the shoreline, and a 0.33 m of water level rise has little effect on inundation, but 0.66 m of water level rise, reveals widespread groundwater inundation of the land surface at Oahu Island in Hawaii (Rotzoll and Fletcher, 2013), although it is difficult to directly compare a coastal area between the Melekeok reef and the result of Oahu Island. Consequently, upward reef growth will be required for the reduction of risks of coastal damages.]

In this context, we clearly changes of wave height and water level between degraded reef and healthy reefs for Figures 4 and 5 (as Figure 3 in the original manuscript).

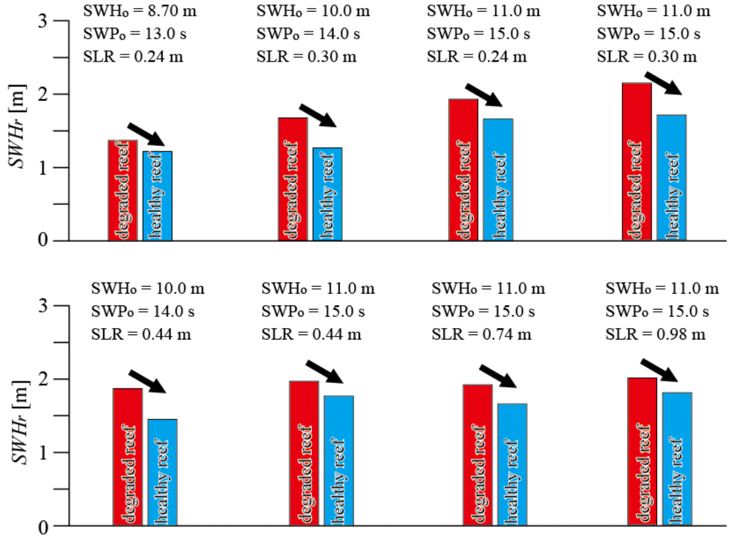

Figure 4: Effect of reef growth on change in the significant wave height at the reef flat for the TCs by 2100. Assumptions: 8.70–11.0 m SWH$_o$; 13.0–15.0 s SWP$_o$; SLR 0.24–0.98 m; 1.8 m above present MSL WL$_o$ (i.e., high tide and storm surge). The SLR values are based on the values for the RCP scenario in 2100 (Church et al., 2013). The examples show that healthy reefs will reduce wave height.

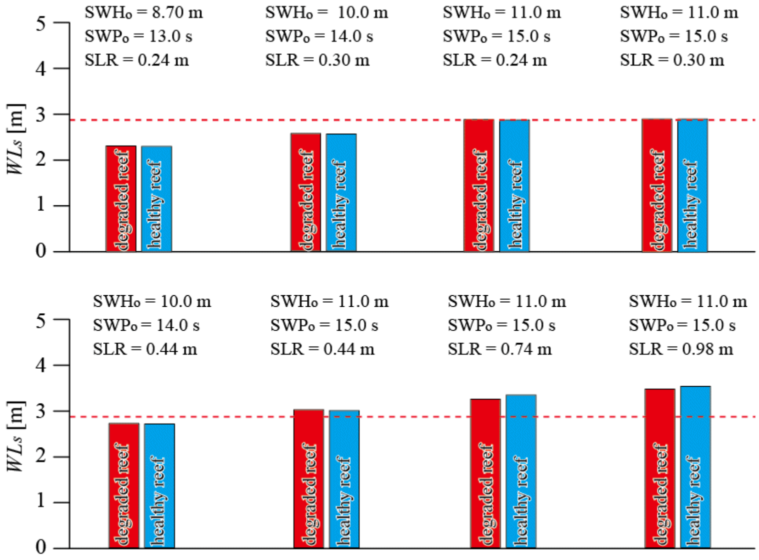

Figure 5: Effect of reef growth on change in the water level at the shore for the TCs by 2100. Assumptions: 8.70–11.0 m SWH$_o$; 13.0–15.0 s SWP$_o$; SLR 0.24–0.98 m; 1.8 m above present MSL WL$_o$ (i.e., high tide and storm surge). The SLR values are based on the values for the RCP scenario in 2100 (Church et al., 2013). The horizontal dashed line shows the elevation of the road (+2.86 m above present MSL) at the study site. The road will be frequently flooded even if the reef is healthy.

As pointed by the reviewer, we recognize the lack of evacuation information in the Palau Islands. We added an importance of evacuation information into discussion, as follows.

In Section 4.3:

[Additionally, we recognize that a ground elevation of construction varies from house to building. To evacuate the people from the flooding area, an investigation of ground elevation each construction and the signboard of elevation will be required.]

Minor comments:

p.1, l.21-24: the role of the reef crest/entire reef in reducing the wave height is not clear here (much clearer in part 3.1), please improve.

We clearly revised.

In Abstract:

[The present reef is currently highly effective in dissipating incoming waves. The SWH_o was found to rapidly decrease from the upper reef slope to the reef crest. Under present-day TCs (8.70 m SWH_o, 13.0 s SWP_o), the SWH at the reef crest was 2.15 m and the SWH_r was 1.05 m. The reef crest dissipated 75.3% of the SWH_o. The shallow lagoon dissipated 51% of the remaining wave height at the reef crest. The entire reef dissipated 87.9% of the SWH_o.]

p.4, l.8 to 31: the values and uncertainties of the forcings given here correspond to order of magnitude rather than precise values. This is not an issue, as the impact on the final results (SWHr and water level) is probably very weak, but this should be specified more clearly.

We clearly explained in a revised manuscript.

In Section 2.2

[The four input parameters are given as double figures below decimal point because the future SLR is given as double figures below decimal point (e.g., +0.24 m: Church et al., 2013). Therefore, the calculated values of SWH_r and WL_s are given as rounding at triple figures below decimal point.]

p.4, l.10: the values of SWHo and wind speed are model outputs? 27m/s seems rather "low" for cyclonic wind. I wonder whether this is due to the rather crude resolution of the (global) atmospheric model. Are the corresponding wind observations (possibly satellite products) available?

Yes, the values of SWH_o and wind speed are provided by by the Global Forecast System (GFS) model at a 27 km resolution. We attempted to find the values based on more high resolution model, but we could not find it. Typhoon Bopha passed south Palau in December 2 2012. The maximum wind speed of 50 m/s, provided by Digital Typhoon (http://agora.ex.nii.ac.jp/digital-typhoon/index.html.en) based on JMA best track data. But the study site is 121 km distance from the pass in December 2. Therefore, the wind speed was 27 m/s at the study site. Consequently, we clearly explained in a revised manuscript.

In Section 2.1:

[The average wind speed was 27 m/s around the study site (see http://www.windguru.cz) in December 2 2012 because the study site is 121 km distance from the pass of Typhoon Bopha.]

In Section 2.2:

[Since there is no *in situ* observation systems for ocean wave and water level at offshore and onshore using underwater loggers and/or radar observational systems in Palau Islands, the present-day SWH_o value was simulated by using the Global Forecast System (GFS) model at 27 km resolution, provided by Windguru (see http://www.windguru.cz).]

p.4, l.27: about the SLR, if the level of precision of the discussion is 0.1m or below, you should also take into account a possible effect of ElNino/LaNina. This could result regionally (tropical Pacific in 0.3m difference or more.

Thank you for the comment. We know that the sea level around the Palau Islands is not constant due to effects of El Niño/La Niña. During the El Niño of early 1998, mean sea level was ca. 0.20 m lower than normal in Palau Islands (Colin 2009 *Marine Environments of Palau*). This was quickly followed by the La Niña of late 1998, during which period the mean sea level was 0.35 m above normal (Colin 2009). In this study, we focused on predictable effects of sea level change such as long-term global sea-level rise and tropical cyclones. But, it is difficult to predict the timing and magnitude of El Niño/La Niña around the study site, thus the effect of El Niño/La Niña was beyond our research. However, to better understand the coastal risks by wave and water movements, we will take into account the effects of El Niño/La Niña. Consequently, we described the importance as one of further researches in Conclusion.

In Conclusion:

[The present study emphasizes that further research is required regarding a short-term variation in sea level. During the El Niño of early 1998, mean sea level was ca. 0.20 m lower than normal in Palau Islands (Colin, 2009). This was quickly followed by the La Niña of late 1998, during which period the mean sea level was 0.35 m above normal (Colin, 2009). This was a half-meter change in mean sea level over just a few months. Such information will allow us to better understand changes in wave height and water level in the Palau Islands by 2100.]

p.6, l.30-31: how comes that these cases show a decrease of SWHr with a degraded reef? In cases5, 11, 18, the reduction is comparable to the opposite reductions obtained with an healthy reef. Please elaborate.

The original manuscript is lacking in the explanation. Our results showed that 6 cases (cases 3, 6, 14, 17, 23, and 26) the SWH_r was increased to 0.02 m–0.18 m by upward reef growth by 2100. We think that the difference was explained by an effect of infragravity waves although its overall effect remains unclear. In the original manuscript, we have discussed a reduction of wave height for upward reef growth, affected by three processes: (1) Future coral growth in the reef crest–upper reef slope zone will increase the dissipation of waves breaking as the water depth decreases. (2) Upward reef growth will increase the reef angle in the wave breaking zone as a result of a rapid decrease in water depth in this zone. (3) With upward reef growth the wave breaking zone will probably migrate from its present location towards the ocean. Moreover, we discuss infragravity waves in a revised manuscript.

Due to the complex reef bathymetry and wave dynamics characters of reef conditions, waves propagating onto shallow reefs steepen and break, and while some of the breaking wave energy propagates shoreward as reformed high-frequency waves, the spectral wave energy shifts into lower frequencies and long-period (infragravity) waves often dominate (Cheriton et al., 2016). In extreme wave conditions such as tropical cyclones, infragravity waves cause increasing of wave height and water level (e.g., Nakaza et al., 1994; Shimozono et al., 2015). In the present study, the upward reef growth affects a reduction in water depth in the reef crest–upper reef slope zone and it probably enhances a resonant oscillation of water by infragravity waves. The process probably causes increase of $\mathrm{SWH_r}$ at the degraded reefs. However, the infragravity waves are known to be generated across the coral reef through nonlinear wave interactions and its overall effect remains unclear. Consequently, we add a detail explanation in a revised manuscript, as follows:

In Section 4.2:

[However, our results showed that 6 cases (cases 3, 6, 14, 17, 23, and 26) the $\mathrm{SWH_r}$ was increased to 0.02 m–0.18 m by upward reef growth by 2100. An increase in $\mathrm{SWH_r}$ is likely to be explained by a difference in magnitude of infragravity waves between the degraded reef and the healthy reef. Waves propagating onto shallow reefs steepen and break, and while some of the breaking wave energy propagates shoreward as reformed high-frequency waves, the spectral wave energy shifts into lower frequencies and long-period (infragravity) waves often dominate (Cheriton et al., 2016). Infragravity waves over shallow reef flats have established relationships between the offshore conditions and resulting reef flat characteristics (e.g., complex bathymetry). Increased of wave height and water level due to the infragravity waves have been observed for various coral reefs (Nakaza et al., 1994; Cheriton et al., 2016) and have also been demonstrated in laboratory and modelling studies (Nakaza et al., 1994; Roeber and Bricker, 2015; Shimozono et al., 2015). Under normal wave conditions, the effect is not remarkable phenomenon. In contrast, in extreme wave conditions such as tropical cyclones, extreme waves enhance the effect on coral reefs. For above 6 cases, the upward reef growth affects a reduction in water depth in the reef crest–upper reef slope zone and it probably enhances a resonant oscillation of water by infragravity waves. However, the infragravity waves are known to be generated across the coral reef through nonlinear wave interactions and its overall effect remains unclear.]

p.7, l.30-31: the cases leading to the road flooding give similar results with a degraded and healthy reef.

We clearly describe your comment in a revised manuscript.

In Section 3.3:

[We found that a road (+2.86 m above MSL) adjacent to the study site would be flooded both degraded and healthy reefs in 7 cases (cases 49, 50, 53, 55, 56, 57, and 58, Table 2) of intensified TCs, SLR, and storm surge.]

p.9, 4.2: I really appreciate the discussion on the effects of the reef growth on the wave dissipation.

Thank you for giving the comments. We believe that Figure 7 enhances an understanding of wave deformation by readers.

p.9,15: this sentence is not clear. You mean that there is no significant WLs change in response to upward reef growth? Please rephrase.

Thank you for giving the comments. We clearly describe it in a revised manuscript.

In Section 4.2:

[Our results indicate that there is no significant change in WL_s between a degraded reef and a healthy reef.]

Table1, also table2: the readability of the results would be improved if the forecasts were more clearly related to the present-day values. For instance, present-day value without storm surge and projected (2050 and 2100) values without storm surge and different scenarios, then present-day value with storm surge, and projected values with storm surge.

Thank you for giving the suggestions. We modify Tables 1 and 2, as follows:

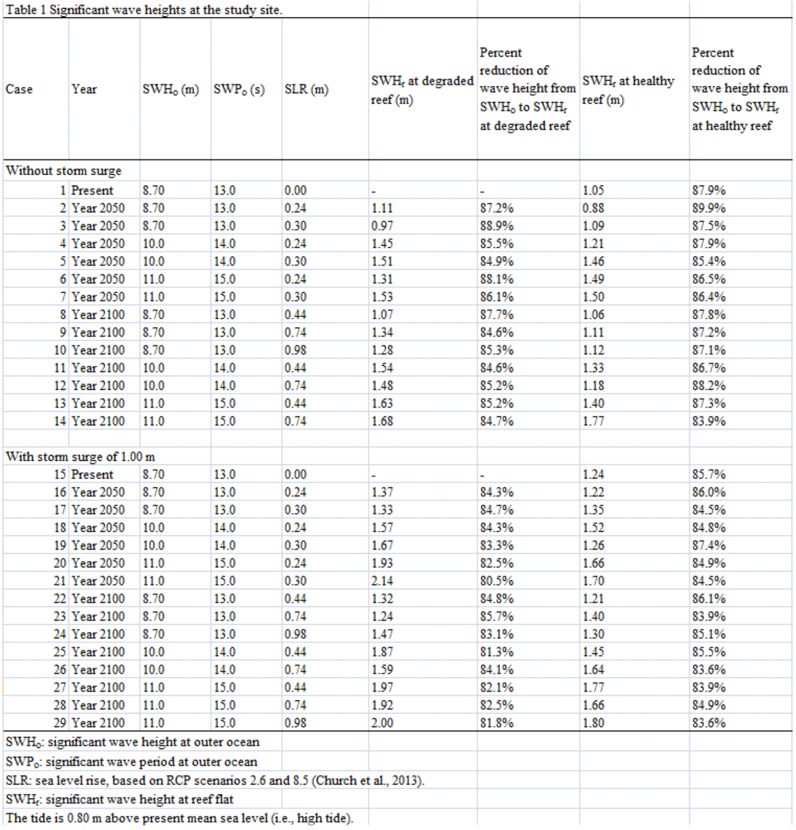

Table 1 Significant wave heights at the study site.

Case	Year	SWH_o (m)	SWP_o (s)	SLR (m)	SWH_r at degraded reef (m)	Percent reduction of wave height from SWH_o to SWH_r at degraded reef	SWH_r at healthy reef (m)	Percent reduction of wave height from SWH_o to SWH_r at healthy reef
Without storm surge								
1	Present	8.70	13.0	0.00	-	-	1.05	87.9%
2	Year 2050	8.70	13.0	0.24	1.11	87.2%	0.88	89.9%
3	Year 2050	8.70	13.0	0.30	0.97	88.9%	1.09	87.5%
4	Year 2050	10.0	14.0	0.24	1.45	85.5%	1.21	87.9%
5	Year 2050	10.0	14.0	0.30	1.51	84.9%	1.46	85.4%
6	Year 2050	11.0	15.0	0.24	1.31	88.1%	1.49	86.5%
7	Year 2050	11.0	15.0	0.30	1.53	86.1%	1.50	86.4%
8	Year 2100	8.70	13.0	0.44	1.07	87.7%	1.06	87.8%
9	Year 2100	8.70	13.0	0.74	1.34	84.6%	1.11	87.2%
10	Year 2100	8.70	13.0	0.98	1.28	85.3%	1.12	87.1%
11	Year 2100	10.0	14.0	0.44	1.54	84.6%	1.33	86.7%
12	Year 2100	10.0	14.0	0.74	1.48	85.2%	1.18	88.2%
13	Year 2100	11.0	15.0	0.44	1.63	85.2%	1.40	87.3%
14	Year 2100	11.0	15.0	0.74	1.68	84.7%	1.77	83.9%
With storm surge of 1.00 m								
15	Present	8.70	13.0	0.00	-	-	1.24	85.7%
16	Year 2050	8.70	13.0	0.24	1.37	84.3%	1.22	86.0%
17	Year 2050	8.70	13.0	0.30	1.33	84.7%	1.35	84.5%
18	Year 2050	10.0	14.0	0.24	1.57	84.3%	1.52	84.8%
19	Year 2050	10.0	14.0	0.30	1.67	83.3%	1.26	87.4%
20	Year 2050	11.0	15.0	0.24	1.93	82.5%	1.66	84.9%
21	Year 2050	11.0	15.0	0.30	2.14	80.5%	1.70	84.5%
22	Year 2100	8.70	13.0	0.44	1.32	84.8%	1.21	86.1%
23	Year 2100	8.70	13.0	0.74	1.24	85.7%	1.40	83.9%
24	Year 2100	8.70	13.0	0.98	1.47	83.1%	1.30	85.1%
25	Year 2100	10.0	14.0	0.44	1.87	81.3%	1.45	85.5%
26	Year 2100	10.0	14.0	0.74	1.59	84.1%	1.64	83.6%
27	Year 2100	11.0	15.0	0.44	1.97	82.1%	1.77	83.9%
28	Year 2100	11.0	15.0	0.74	1.92	82.5%	1.66	84.9%
29	Year 2100	11.0	15.0	0.98	2.00	81.8%	1.80	83.6%

SWH_o: significant wave height at outer ocean

SWP_o: significant wave period at outer ocean

SLR: sea level rise, based on RCP scenarios 2.6 and 8.5 (Church et al., 2013).

SWH_r: significant wave height at reef flat

The tide is 0.80 m above present mean sea level (i.e., high tide).

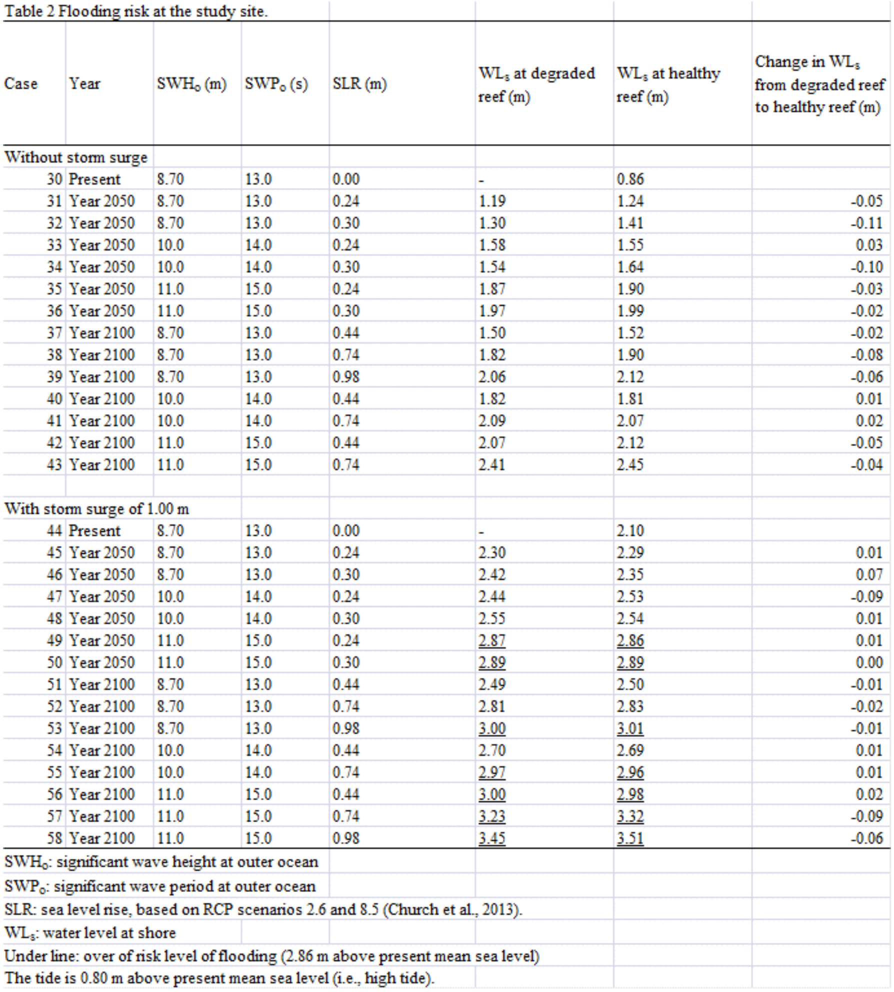

Table 2 Flooding risk at the study site.

Case	Year	$\mathrm{SWH_O}$ (m)	$\mathrm{SWP_O}$ (s)	SLR (m)	$\mathrm{WL_s}$ at degraded reef (m)	$\mathrm{WL_s}$ at healthy reef (m)	Change in $\mathrm{WL_s}$ from degraded reef to healthy reef (m)
Without storm surge							
30	Present	8.70	13.0	0.00	-	0.86	
31	Year 2050	8.70	13.0	0.24	1.19	1.24	-0.05
32	Year 2050	8.70	13.0	0.30	1.30	1.41	-0.11
33	Year 2050	10.0	14.0	0.24	1.58	1.55	0.03
34	Year 2050	10.0	14.0	0.30	1.54	1.64	-0.10
35	Year 2050	11.0	15.0	0.24	1.87	1.90	-0.03
36	Year 2050	11.0	15.0	0.30	1.97	1.99	-0.02
37	Year 2100	8.70	13.0	0.44	1.50	1.52	-0.02
38	Year 2100	8.70	13.0	0.74	1.82	1.90	-0.08
39	Year 2100	8.70	13.0	0.98	2.06	2.12	-0.06
40	Year 2100	10.0	14.0	0.44	1.82	1.81	0.01
41	Year 2100	10.0	14.0	0.74	2.09	2.07	0.02
42	Year 2100	11.0	15.0	0.44	2.07	2.12	-0.05
43	Year 2100	11.0	15.0	0.74	2.41	2.45	-0.04
With storm surge of 1.00 m							
44	Present	8.70	13.0	0.00	-	2.10	
45	Year 2050	8.70	13.0	0.24	2.30	2.29	0.01
46	Year 2050	8.70	13.0	0.30	2.42	2.35	0.07
47	Year 2050	10.0	14.0	0.24	2.44	2.53	-0.09
48	Year 2050	10.0	14.0	0.30	2.55	2.54	0.01
49	Year 2050	11.0	15.0	0.24	2.87	2.86	0.01
50	Year 2050	11.0	15.0	0.30	2.89	2.89	0.00
51	Year 2100	8.70	13.0	0.44	2.49	2.50	-0.01
52	Year 2100	8.70	13.0	0.74	2.81	2.83	-0.02
53	Year 2100	8.70	13.0	0.98	3.00	3.01	-0.01
54	Year 2100	10.0	14.0	0.44	2.70	2.69	0.01
55	Year 2100	10.0	14.0	0.74	2.97	2.96	0.01
56	Year 2100	11.0	15.0	0.44	3.00	2.98	0.02
57	Year 2100	11.0	15.0	0.74	3.23	3.32	-0.09
58	Year 2100	11.0	15.0	0.98	3.45	3.51	-0.06

$\mathrm{SWH_O}$: significant wave height at outer ocean

$\mathrm{SWP_O}$: significant wave period at outer ocean

SLR: sea level rise, based on RCP scenarios 2.6 and 8.5 (Church et al., 2013).

$\mathrm{WL_S}$: water level at shore

Under line: over of risk level of flooding (2.86 m above present mean sea level)

The tide is 0.80 m above present mean sea level (i.e., high tide).

In this context, we change all case number in the original manuscript into new one.