# In situ Temperature Profile of Shallow Reef Communities in Negros and Apo Island: 2013-2014

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Coral reefs provide a wide variety of ecosystem services and goods that benefit humankind. However, the survival and health of reefs are threatened by natural and anthropogenic factors such as climate change and pollution. Increased seawater temperature often results in bleaching of certain coral species. This study aimed at profiling in situ temperature of shallow reef communities in Apo I. and Sibulan, Negros I. using data loggers programmed to record hourly. Results for Apo showed temperature peaked in the months of May, June, and July. For Sibulan site, peaks were observed in May, June, and September. The lowest temperature for both sites was observed in February. Comparison with satellite-derived sea surface temperatures (SST) for the Bohol Sea indicated Apo Island recorded lower temperatures (>0.5°C) except for the months of October, November, and December whereas in Sibulan site, logger-derived temperature recordings were mostly higher by <0.5 °C in the months of March, May, October, November, December, and February. Between sites, variation may be explained by differences in coastal profiles, depths of reefs, and influences of different water current systems. Variation from satellite-derived data may be due to depth differences since the latter were taken only from the surface. Continuous in situ temperature monitoring is recommended to provide a more localized profile especially in this period of changing climate.

**Keywords:** in situ temperature, Negros I., Apo I., Sibulan, PHERNet, coral bleaching

## INTRODUCTION

Coral reefs are one of the most productive marine ecosystems providing a variety of services and goods benefitting human population (Moberg & Folke, 1999, Barbier, *et al.*, 2011). However, coral reefs are continuously threatened or destroyed by natural and/or anthropogenic causes (Veron *et al.*, 2009; Pandolfi, Connolly, Marshall, & Cohen, 2011; Hoegh-Guldberg, 2011). Coral bleaching is one of the results triggered by a coral's exposure to at least 1 to 2°C increase in temperature based on summer monthly mean temperature (Berkelmans & Willis, 1999 in NOAA-Coral Reef Watch [CRW], 2000) above its tolerance level.

During the 1997-1998 El Niño (NOAA, 2000), coral bleaching events were observed in most reefs of the Philippines (Chou, 2000) including in the Bohol Sea (Divinagracia, 2000). It becomes increasingly important therefore to profile localized temperature in coral communities because it provides valuable information regarding its seasonal temperature fluctuations. The objective of this study was to profile in situ temperatures of shallow reef communities in Sibulan, Negros Island and Apo Island, and to compare the results with available data in the Bohol Sea.

## METHODS

Seawater temperatures of shallow coral reef communities in two sites were monitored by deploying replicate HOBO Pendant Temperature/Light Data Loggers. For Apo Island site, reef communities include Rock Pt. (9.071923°N; 123.268002°E) on the southwestern tip of the island, and inside the Apo Marine Sanctuary (9.07489°N; 123.27197°E) on the eastern side of the island about 500 m apart. Data logger was fixed at approximately 6 m deep for both reefs. Approximately 30 kilometers north of Apo Island, in Sibulan site, one logger was deployed for each reserve namely Cangmating and Agan-an Marine Reserves which are about 2.5 km apart. These loggers were fixed at approximately 3-4m deep for both reserves.

For Sibulan site, temperature-logging period was from March 5, 2013 to February 28, 2014 while for Apo, the period was from March 26, 2013 to February 28, 2014. Daily composite temperature (mean of 24 hrs. from 19:00 to 18:00) and daily nighttime temperature (mean of 10 hrs. from 19:00-05:00) were computed for each station, and both stations were averaged to represent each site

(N=2). A non-parametric Mann-Whitney U Test was employed to determine significant difference between sites. Daily nighttime in situ temperature was used to compare sites with satellite-derived SST data for the Bohol Sea for the period March 4, 2013 to February 27, 2014 (NOAA CRW, 2000).

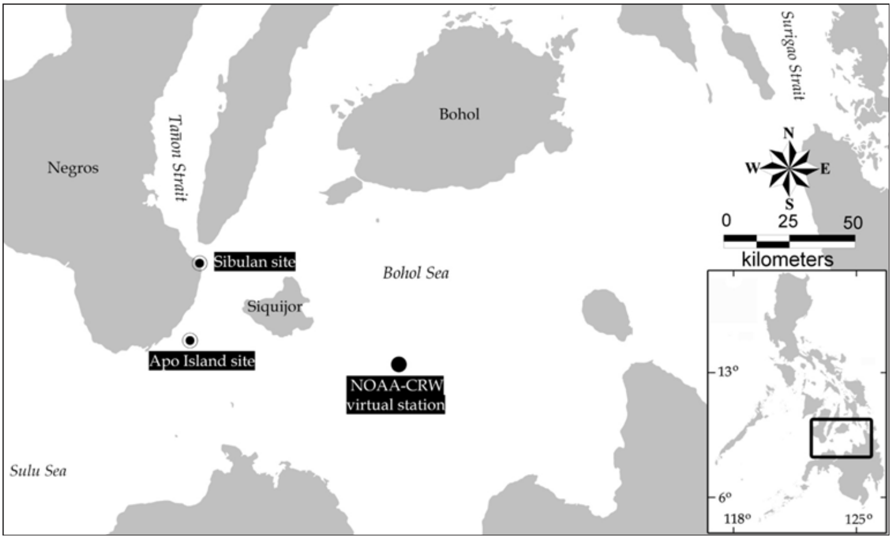


**Figure 1.** In situ temperature sampling sites. Two data loggers were deployed for each site in different coral reef communities. Also shown is the NOAA Coral Reef Watch virtual station in the Bohol Sea (9°N; 124°E) taken from http://coralreefwatch.noaa.gov/satellite/vs/index.php.

## RESULTS

Daily composite mean temperature for Apo was 28.71 °C ± 0.85 with a range of 26.48-30.01 °C for a total logging period of 340 days from March 26, 2013 to February 28, 2014. For Sibulan, mean temperature was 28.93 °C ± 0.86 with a range of 26.61-30.44 °C for a total logging period of 361 days from March 5, 2013 to February 28, 2014. Using Mann-Whitney U Test, a significant difference ($U = 49987.5$, $p = 0.000022$) was determined in the daily composite mean temperatures between the two sites during the logging period. For daily nighttime mean temperature comparison, Apo I. had a mean of 28.58 °C ± 0.83 (range 26.35-29.83 °C) while Sibulan, was slightly higher at 28.82 °C (range 26.33-30.29 °C) for the same logging period mentioned above. The daily nighttime mean temperature between two sites indicated to be significantly different using the Mann-Whitney U Test ($U = 48934.5$, $p = 0.000003$).

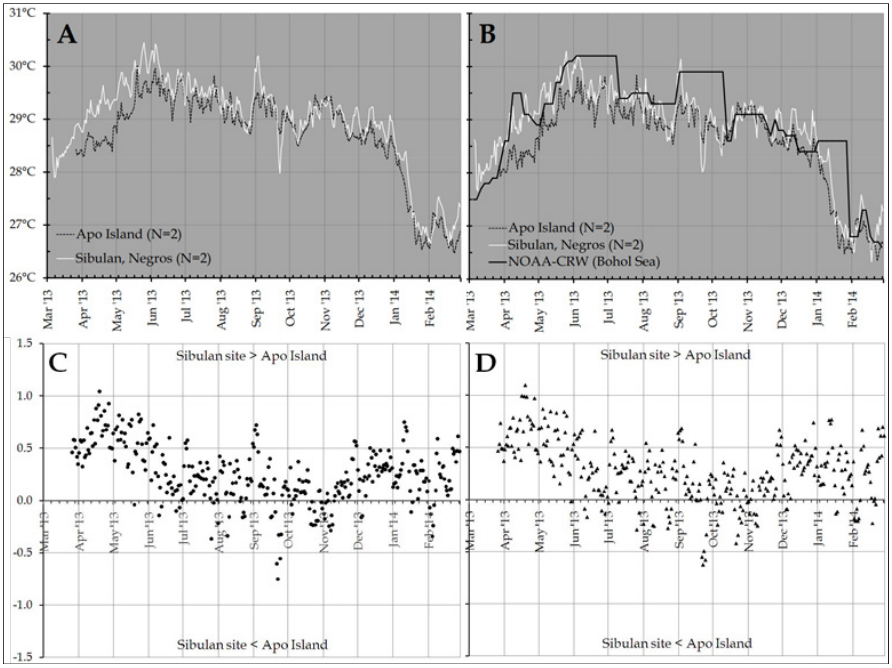


**Figure 2.** Temperature comparison between sites during the temperature-logging period: (A) Daily composite; (B) Daily nighttimeoverlayed with satellite-derived SST data from the Bohol Sea (NOAA-CRW, 2000); (C) Temperature difference for daily composite; and (D) daily nighttime. For C & D, values above the x-axis denotes higher temperature recording for Sibulan site than Apo Island, and below the x-axis indicates the opposite. Values below the x-axis are absolute values.

Seasonal fluctuations for daily composite mean temperature in Apo I. indicated peaks in the months of May (30.0 °C ± 0.05), June (29.96 °C ± 0.04 & 29.96 °C ± 0.04), and July 2013 (29.82 °C ± 0.08), while lowest recordings in January (26.53 °C ± 0.13) and February 2014 (26.56 °C ± 0.06 & 26.48 °C ± 0.11)(Fig. 2 A&B). For Sibulan, peaks were recorded in May (30.44 °C ± 0.14), June (30.42 °C ± 0.12) and September 2013 (30.19 °C ± 0.07) with an abrupt decrease to 27.98 °C ± 0.06 observed in the same month. Lowest temperatures were recorded in February 2014 (26.65 °C ± 0.06 & 26.61 °C ± 0.07). Likewise, for daily nighttime mean temperature, peaks in Apo I. were recorded in the months of June (29.80 °C ± 0.07), July 2013(29.83 °C ± 0.19), and the lowest temperatures were in January (26.48 °C ± 0.11) and February 2014 (26.49 °C ± 0.08 & 26.35 °C ± 0.08). Sibulan records showed the following: May (30.29 °C ± 0.06); June (30.19 °C ±

0.05); September 2013 (30.13 °C ± 0.08) with an abrupt decrease to 28.02 °C ± 0.04. The lowest temperature was in February 2014 (26.50 °C ± 0.03 & 26.33 °C ± 0.05).

The temperature difference between the two sites was less than 0.5 °C, with Apo I. recording mostly lower temperatures relative to Sibulan for both composite and nighttime periods (Fig. 2 C&D). However, marked in situ temperature differences greater than 0.5 °C but less 1 °C were observed in the months of April, May, to early June, further increasing temperature differences between the two sites.

Comparison with satellite-derived sea-surface temperature (SST) in the Bohol Sea (NOAA-CRW, 2000) indicated a similar pattern in temporal fluctuations for both sites with late May, June, and early July having the highest temperature recordings and February having the lowest during the comparative period (Fig. 2B). It should be noted that during an ocular survey in Apo in July 2013, it was observed that there were dead coral recruits and juveniles due to bleaching inside the Apo Marine Sanctuary (Reboton, unpublished data). Apparently, this period was also categorized as "Bleaching Watch" level by the NOAA-CRW (2000).

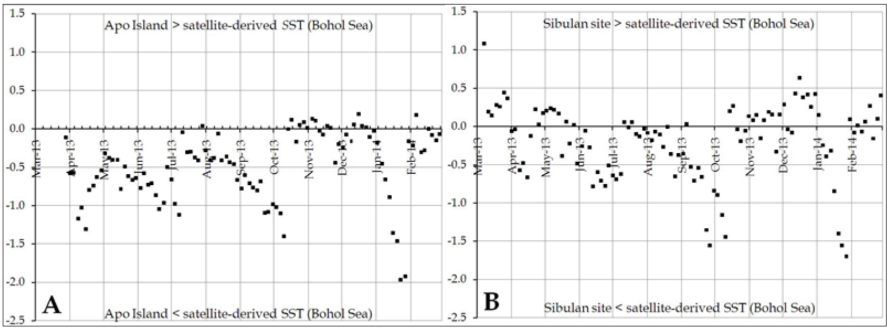


**Figure 3.** Temperature difference between data logger-derived and satellite-derived SST (NOAA-CRW - Bohol Sea) for (A) Apo Island, and (B) Sibulan site. Dots above the x-axis denote higher temperature recording for logger-derived than satellite-derived temperatures, and dots below the x-axis indicate the opposite. Values below the x-axis should be taken as absolute value.

Temperature differences between the two sites against satellite-derived SST for the Bohol Sea (NOAA-CRW, 2000) indicates that Apo had lower temperature recordings except for October, November, and December (Fig. 3A). For Sibulan, March, May, and February recorded high temperatures in addition to October, November, and December (Fig. 3B). Maximum temperature difference was less than 2 °C during the later part of January for both sites.

## DISCUSSION

Observed temperature variations between sites may have been due to the varying depths where these data loggers were deployed, different coastal profiles of these sites as well as influences of the different water current systems affecting these areas. Apo is an offshore coastal island while Sibulan is a coastal area of a channel (Serate & Maypa, 1997). Moreover, there may be different water current systems affecting each site. For example, Tañon Strait may have significant influence on the coastal waters of Sibulan site compared to Apo I. In the Bohol Sea, two different water current patterns were observed: the Bohol Jet which brings water from the Pacific Ocean to Sulu Sea through Surigao Strait passing by north of Siquijor and entraining it with deeper and colder waters; and the Iligan Bay Eddy located in the southwestern basin of the Bohol Sea (Cabrera, Villanoy, David, & Gordon, 2011). The Bohol Jet may have had major influence on the waters of Apo Island while the Iligan Bay Eddy may have had influence on the satellite-derived SST recordings.

## CONCLUSIONS

Seasonal temperature fluctuations in coral reefs monitored in Apo Island and Sibulan showed similar patterns with highest recordings in late May, June, and early July, and low recordings in February, except in September where a temperature spike was recorded for the Sibulan site. Temperature differences in Apo and Sibulan reefs showed the latter having higher recordings with temperature differences reaching more than 0.5 °C but less than 1 °C, particularly during the months of April, May, and early June. Comparison with satellite-derived SST for the Bohol Sea indicated Apo Island having lower temperature recordings than Sibulan site. Highest difference (<2 °C) was observed during the month of January. It is recommended that in situ temperature monitoring of these reefs be continued as this will provide a more localized profile especially during this period of changing climate.

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## REFERENCES

Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C., & Silliman, B.R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs, 81*(2), 169-193.

Berkelmans, R., & Willis, B.L. (1999). Seasonal and local spatial patterns in the upper thermal limits of corals on the inshore Central Great Barrier Reef. *Coral Reefs, 18*, 219-228. (Abstract only)

Cabrera, O.C., Villanoy, C.L., David, L.T., & Gordon, A.L. (2011). Barrier layer control of entrainment and upwelling in the Bohol Sea, Philippines. *Oceanography, 24*(1), 130-141.

Chou, L.M. (2000). Southeast Asian reefs – status update: Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. *In* C. Wilkinson (Ed.), *Status of coral reefs of the world: 2000* (pp. 117-129). Australia: Australian Institute of Marine Science.

Divinagracia, M.F.B. (2000). *Extent and degree of coral bleaching in selected reefs in Central Visayas* (master's thesis). Silliman University, Dumaguete City, Philippines.

Hoegh-Guldberg, O. (2011). Coral reef ecosystems and anthropogenic climate change. *Regional Environmental Change*, 11(Suppl. 1), S215-S227.

Moberg, F., & Folke, C. (1999). Ecological goods and services of coral reef ecosystems. *Ecological Economics, 29,* 215-233.

NOAA Coral Reef Watch. (2000). *NOAA Coral Reef Watch 50-km Satellite Virtual Station Time Series Data for Bohol Sea, Mar. 4, 2013-Feb. 27, 2014*. Silver Spring, Maryland, USA: NOAA Coral Reef Watch. Retrieved from http://coralreefwatch.noaa.gov/satellite/vs/index.php

Pandolfi, J.M., Connolly, S.R., Marshall, D.J., & Cohen, A.L. (2011). Projecting coral reef futures under global warming and ocean acidification. *Science, 333*, 418-422.

Serate, E.B., & J.L.P. Maypa. (1997). Bathymetry and Hydrography. *In* H.P. Calumpong, J.S. Estacion, M.V. Lepiten, & C.E. Acedo (Eds.), *Status of the coastal resources of the Negros Learning Site (Manjuyod to Dauin)* (pp. 29-36). Dumaguete City: Silliman University Marine Laboratory and the Center of Excellence in Coastal Resource Management, Silliman University.

Veron, J.E.N, Hoegh-Guldberg, O., Lenton, T.M., Lough, J.M., Obura, D.O., Pearce-Kelly, P., Sheppard, C.R.C., Spalding, M., Stafford-Smith, M.G., & Rogers, A.D. (2009). The coral reef crisis: The critical importance of <350 ppm $CO_2$. *Marine Pollution Bulletin, 58*, 1428-1436.