Panel Data Regression Model for Coral Cover in Lian, Batangas

Regine C. Robles[1*], Jose Lorenzo M. Javid[1], Rechel G. Arcilla[1], and Wilfredo Y. Licuanan[2]
[1] *Mathematics Department, De La Salle University*
[2] *Biology Department and the Br. Alfred Shields Ocean Research Center, De La Salle University*
**Corresponding Author: roblesreginec@gmail.com*

Abstract: Incidence of mass coral bleaching has been linked to fluctuations in water temperatures. To examine this link, average coral cover and temperature data of the seven sites monitored in Lian, Batangas from 2008 to 2011 was analyzed using Panel Regression. Panel Regression, mostly used in the social sciences, is applied to data that are both time series and cross-sectional. It was found that sea surface temperature (SST) has a significant relationship with the average coral cover. The resulting random effects model, with minimum SST as independent variable, for predicting average coral cover showed an overall coefficient of determination, R^2, of 0.1649. The Breusch-Pagan LM test performed rejected the null hypothesis and verified that there is panel effect present in the data (p-value≈0). Despite the low coefficient of determination, panel regression model was of better fit to the data due to the significant differences across sites (i.e. panel effect).

Key Words: Panel Regression; Coral cover; Water temperature

1. INTRODUCTION

The Philippine reef is home to the second richest reef in the Coral Triangle. However, for the past several decades, the country's reefs are being threatened by intensified natural and anthropogenic stresses that often lead to coral bleaching.

Corals thrive in water temperatures no more than 29 degrees Celsius and are highly sensitive to slight changes in sea surface temperature (SST) (Winter et al., 2000). An increase of more than 1 degrees Celsius in average SST over summer averages for a few weeks induces bleaching (Walther et al., 2002).

Coral bleaching is a common stress response by corals. Bleaching happens when the symbiotic algae called Zooxanthellae loses their chloroplasts and eventually, detaches themselves from the coral, making the coral's white skeleton visible. The coral could usually recover within several weeks up to a few months if the mild stress decreased in time. However, this leads to coral mortality if the stress remained and/or intensified (Buccheim, 1998).

Most of the studies involving coral cover focused on its differences across areas and over time. To achieve this, a two-way fixed factor analysis of variance was applied in the study done by Arceo et al. (2001). Thermal anomalies from satellite-derived temperatures starting early June to late November coincided with the mass coral bleaching observed throughout the Philippines. Results showed that live hard coral cover from Bolinao, North Palawan Shelf, Kalayaan Island Group and Tubbataha reefs differed across areas and over time (before and after bleaching). A decrease of up to 46% in live coral cover was detected over the four locations. In particular, Bolinao had the highest average decrease in live coral cover of 27.9%.

Linear repeated measures regression analysis was also used to examine the relationship of coral cover in the Indo-Pacific region and time period from 1968 to 2004 (Bruno and Selig, 2007). In comparison to early 1980s coral cover of 42.5%, the current region-wide coral cover was lower with an average of 22.1% for the year 2003. The linear repeated measures analysis for the 1997 to 2004 monitoring sites showed an average yearly decline of 0.72% and an R^2 of 0.01.

The objective of this study is to examine the relationship of average live coral cover and water temperature using Panel data regression models.

2. METHODOLOGY

2.1 Data

Three primary data sets were gathered from the seven sites monitored by the SHORE Center in Lian, Batangas. The three data sets are percent coral cover, in situ water temperature and daily satellite-derived SST. The coral cover data of December 2008 to April 2011 were collected from each site. Thermistor temperature loggers deployed in the sites recorded in situ water temperature data in 15-30 minute intervals from July 2009 to April 2011. Satellite-derived SST data of July 2009 to April 2011 was retrieved from the National Oceanic and Atmospheric Administration – National Operational Model Archive & Distribution System (NOAA-NOMADS) Live Access Server (LAS).

2.2 Data Processing

The monthly mean live coral cover was computed for the dependent variable, AverageCor. NOAA and THERM variable names were assigned to satellite-derived SST and in situ water temperature, respectively. The monthly mean, median, minimum, and maximum values of each of the NOAA and THERM independent variables were computed to match with the interval of the coral cover data collection. Missing THERM and NOAA values for periods earlier than July 2009 were imputed using a linear regression model. Dummy variables corresponding to the sites and periods were also created.

2.3 Analysis

Data sets that are both time series and cross-sectional are known as panel or longitudinal data sets. Thus, panel data could have group effects, time effects, or both which are analyzed by Fixed Effects (FE) and Random Effects (RE) model. Individual heterogeneity is accounted in panel data for unobservable or immeasurable variables are controlled.

Both FE and RE models for AverageCor were generated for all possible combinations of the variables NOAA and THERM. Variables were omitted from the model if found to be multi-collinear. The Hausman Specification test was performed to determine whether an FE or RE model should be applied. The best model between the FE model with the highest adjusted R^2 and RE model with the highest overall R^2 was taken and subjected to diagnostic checks. Breusch-Pagan Lagrange Multiplier (LM) test and Wooldridge test was performed to check for the presence of panel effect and first order correlation in the best model, respectively. All statistical tests were applied with a 5% level of significance using STATA 12 (StataCorp, 2011)

3. RESULTS AND DISCUSSION

The final data set contained a total of 40 observations with 15 variables. It appears that coral cover across sites decreases in time (Figure 1). Differences test for trend was applied to confirm this. AverageCor from all sites showed negative mean differences. However, only sites Galvez, Talim Inner, and Talim outer showed a significant decline in coral cover (p-values=0.0210, 0.0006 and 0.0315, respectively).

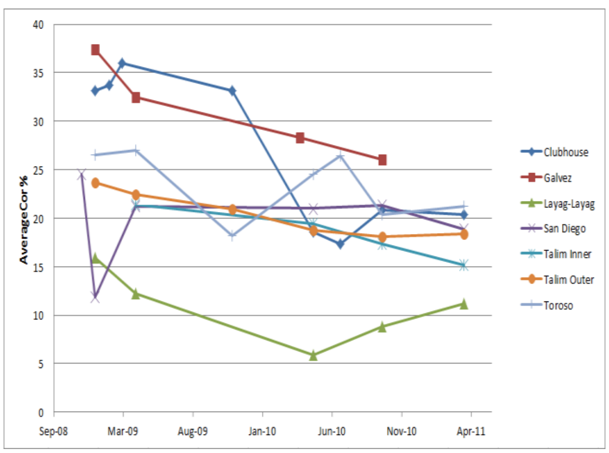

Fig. 1. AverageCor graphed through time.

Of the seven sites, Galvez has the highest mean average coral cover with a value of 31% and a standard deviation of 5.01 (Table 1).

To determine whether the data should be fitted using an FE or an RE model, the Hausman Specification test was conducted. The resulting p-value failed to reject the null hypothesis that the individual effects are uncorrelated with other regressors in the model. Hence, an RE model was used.

Table 1. Summary statistics of AverageCor for all sites.

Site	Mean	Std. Dev.	Min	Max
Clubhouse	26.65	7.97	17.38	36
Galvez	31.07	5.01	26.05	37.45
Layag-Layag	10.82	3.78	5.87	15.95
San Diego	19.79	4.29	11.85	24.51
Talim Inner	18.35	2.68	15.19	21.4
Talim Outer	20.39	2.34	18.1	23.69
Toroso	23.47	3.53	18.18	26.97

The best RE model with one significant variable NOAAMIN generated an overall R^2 value of 0.1649. A p-value=0.0013 indicates the significance of the fitted model. About 66.6% of the variance is due to the differences across panels as shown in the intra-class correlation (Table 2). Similar to the results presented by Arceo et al. in 2001, there was also an observed coral cover decline in Lian, Batangas. It was found that for every 1 degrees Celsius increase in NOAAMIN temperature, there is an expected absolute decrease of 1.5% in AverageCor across time and between sites.

Table 2. Parameter estimates for AverageCor Panel Regression Model

Variable	Parameter Estimates	Standard Error	Pr>|z|
Intercept	63.4753	13.2526	0
NOAAMIN	-1.5373	0.4774	0.001
Intraclass corr	0.6660		

The Breusch-Pagan LM test was applied to the best RE model for testing the null hypothesis that the variance across entities is zero (i.e., no panel effect). The test resoundingly rejected the null hypothesis with a p-value of approximately

0. There is a panel effect present in the RE model.

The presence of serial correlation must also be checked when using panel regression. Serial correlation tends to deflate the standard errors of the coefficients which in turn make the R^2 higher than its supposed value. A resulting p-value of 0.5658 for the Wooldridge test showed that first order autocorrelation is present in the data. This test also confirmed that the standard error and R^2 values of the model are accurate.

4. CONCLUSION

It was found through Panel data regression that an inverse relationship exists between AverageCor and NOAA, the satellite-derived SST. The resulting model for AverageCor with one variable, NOAAMIN, was considered as the best and parsimonious among all other RE models. This satisfied significance of model and NOAAMIN variable with an overall R^2 value of 0.1649.

Average coral cover was found to be decreasing by about 1.5% for every 1 degree Celsius increase in the monthly minimum NOAA temperature in Lian, Batangas.

Panel data regression model is recommended for future studies due to its ability to incorporate the effect of space and repeated measures of the data.

5. REFERENCES

Arceo, H. O., Quibilan, M. C., Alino, P. M., Lim, G., & Licuanan, W. Y. (2001). *Coral Bleaching in Philippine Reefs: Coincident Evidences with Mesoscale Thermal Anomalies.* Bulletin of Marine Science, 69(2): 579-593.

Bruno, J. F., & Selig, E. R. (2007). *Regional Decline of Coral Cover in the Indo-Pacific: Timing, Extent, and Subregional Comparisons.* PLoS ONE 2(8):e711. doi:10.1371/journal.pone.0000711.

Buchheim, J. (1998). *Coral Reef Bleaching.* Retrieved from http://www.marinebiology.org/coralbleaching.htm.

NOAA-NOMADS (2013). *Optimum Interpolation SST (AVHRR).* [Data file]. Retrieved from http://nomads.ncdc.noaa.gov/las/getUI.do

StataCorp (2011). *Stata Statistical Software: Release 12.* College Station, TX: StataCorp LP.

Walther, G, Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T. J. C., … Bairlein, F. (2002). *Ecological responses to recent climate change.* Nature, 416(6879), 389-395

Winter, A., Appeldoorn, R., Bruckner, A., Williams, E. & Goenaga, C. (1998). *Sea Surface Temperature and Coral Reef Bleaching off La Parguera, Puerto Rico (Northeastern Carribean Sea).* Coral Reefs 17: 377-382.