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Prediction of Vibrio Occurrence in Sea Water Associated To Oyster Farm on Ang-Sila Coastal In East of Thailand

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Abstract : *This paper explored to the correlation between the vibrio density and sea-water quality over the oyster farming on Ang-Sila coastal in East of Thailand. The methodology used the combination of field data, Geographic Information System (GIS) and Modelling. Thai Pollution Control Department (PCD) database was used to predict the vibrio occurrence in sea-water using the binary logistic regression model. The study found: (1) The vibrio occurred in the oyster are correlated to the single parameter of pH while the vibrio occurred in the sea-water are correlated to the temperature and salinity. (2) Salinity and temperature are implicated to use in the binary logistic regression model with confidential pseudo R^2 (Nagelkerke) of 0.84 for prediction of the vibrio occurrence in the sea-water. (3) According to the model predicted, the vibrio occurrences on the high-potential are shown in dry season while the low-potential are shown in rainy season. These results demonstrated by the GIS and the binary logistic regression are appropriated to use in the spatial-vibrio analysis and food-health safety management.*

Keywords*: Coastal water/Eastern Thailand, GIS, Oyster, Spatial, Vibrio*

I. Introduction

Members of the genus vibrio are gram-negative motile bacteria that were naturally occurring, free-living inhabitants of marine and estuarine environments throughout the world. These bacteria have been recognized as major food-borne pathogens which associated with consumption of raw or undercooked seafood, especially shellfish, or thorough wound [1]. Illnesses causes by vibrio are increasing worldwide including fatal acute diarrheal diseases, such as cholera, gastroenteritis, wound infections, and septicemia [2]. Hippocrates, in the fifth century B.C., observed that many specific human illnesses were linked to changes of season, local weather patterns, and other environmental factors such as temperature [3]. The global temperature increasing is impacted to the environmental condition growth of pathogens like vibrio which show the links between pathogens and changing ocean conditions, including human diseases such as cholera [4]. Up to the recently, human activities cause more impacts on ecological balances, potentially leading to new diseases associated with environmental changes. Anthropogenic climate change, influence by human activities is measurably affecting ecosystems, communities, and populations [5]. Diverse environmental factors influence the distribution, diversity, incidence, severity, and/or persistence of diseases and other health issues [6]. The effect of sea surface temperature increasing is promoting spread of vibrio in coastal and brackish waters [2]. Human diseases forecasting can be used as an important tool in understanding disease dynamics in water and climate factors controlling these dynamics [3].

Short term predictions can provide public health officials and the general public advance notice about the likelihood of a disease outbreak in a particular location, while long term forecasting can be used to simulate the consequences of climate change on microbial pathogens [7]. The abundance of vibrio increases during warmer months of the year and as a consequence of global warming and, therefore, may increase the occurrence of pathogenic vibrio that causes infections in humans [8].

An informative, robust system of identification of conditions associated with high risk requires quantifying the association of environmental factors with abundance of total vibrio density and potentially pathogenic vibrio. Given proven associations as predictors of vibrio abundance, the relevant environmental data can be collected by remote satellite sensing and the most research confirmed temperature and salinity were the key factors for prediction of vibrio occurrence [9, 10, 11].

Recently, the geo-informatics technology has been used for the spatial epidemiology management and overcome the limits of field observation which provided the benefit to large-surface analysis, high accuracy and minimized cost consumption. Remote sensing and Geographic Information System (GIS) methods have been

used for prediction of vibrio in coastal water [12, 13, 14] where using both information of sea surface salinity (SSS) and sea surface temperature (SST). Remote sensing method is a state-of-the-art for vibrio monitoring while the GIS required the high temporal-resolution on field temperature and salinity data. Most studies linked relationships from field and remote sensing data via common logistic regression for prediction vibrio associated to oyster [14]. Nevertheless currently, the SSS and SST are miss covered in some coastal zone particular in East of Thailand [15] which it is most importance zone for oyster economy in Thailand. For this reason, field water quality analysis or the water quality publish resource were needed. The Pollution Control Department (PCD) was a department under the Royal Decree on the Organizational Division of Pollution Control Department, Ministry of Science, Technology and Environment B.E. 2535(1992), as result of the Enhancement and Conversation of the National Environment Quality Act B.E. 2535 (1992). Water quality monitoring data from PCD were publish in 2 period per year as dry season and rainy season are used to implement in this research to predict the distribution of vibrio associate to the oyster farm.

The goal of the study is to predict the potential of vibrio occurrence in sea-water using field measurements, logistic regression and GIS over the Ang-Sila/oyster farm, East of Thailand. In the following, the study area and vibrio information are first described. Secondly, the modeling and the GIS technique are proposed, the results and commented are given respectively. Finally, the consequences of the results are discussed.

II. Study Area And Vibrio Information

The study area is Ang-Sila coastal in Chon Buri province, East Coast of Thailand which around 105 Ang-Sila oyster farms show in green dots located approximately at 707410, 1474560 UTM WGS 1984 Zone 48N (Fig. 1).

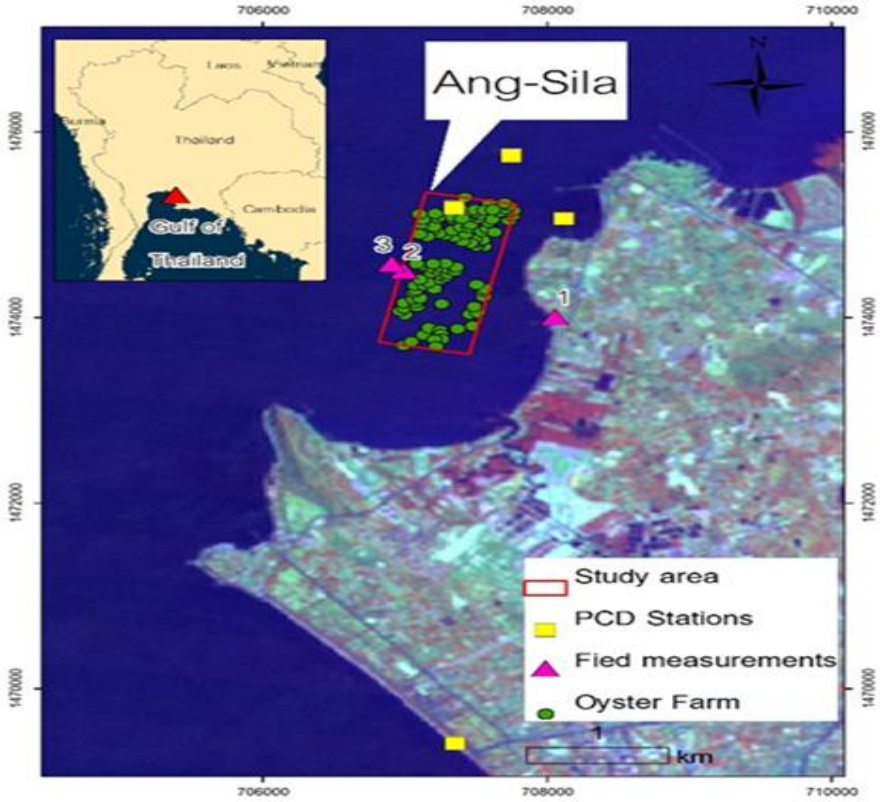

Figure 1 Map of Ang-Sila coastal, Chon Buri province, East coast of Thailand.

The study area show in the area under red rectangle which was near the PCD stations in yellow box and the field measurements show in pink tri-angle. In general there are four economically important species of oyster found in the coastal waters of Thailand. The species cultured are Saccostrea cucullata, Crassostrea belcheri and Crassostrea lugubris in the study area [16]. Vibrio are naturally-occurring bacteria, and pollution is not considered a factor for finding these bacteria in estuarine and marine surface waters and the most significant factors for investigating of vibrio in surface waters are temperature and salinity [17]

In general, the salinity of the Thai Gulf sea water is normally lower than the salinity of the Andaman Sea. In the Gulf of Thailand salinity values vary between 10–30 ppt due to numerous rivers flowing into this Gulf such as the Walu River in Chantaburi, Tapi River in Surat Thani and other small rivers and canals; values

varying between 29–33 ppt are typical of the Andaman Sea [18]. Annually, rainfalls occurring 120 days and cumulated rain is approximately 1,900 mm. In general, the rainfall season is covered on study area around July to October and the dry season covered on February to June. The average atmospheric temperature is about 28 °C and humidity of 60 to 90% [19].

III. Data And Methods

The method developed here need a field data obtained from Ang-sila coastal site investigation for building up the model of vibrio occurrence associated to oyster and sea-water, using Peason's correlation and binary logistic regression methods and then the vibrio occurrence map was evaluated using GIS techniques. These methods can be identified into 3 steps. First step is the data setting on vibrio and field measurements on sea-water quality. Second step, the correlation of vibrio in sea-water, oyster and there water parameters were cross evaluated. The Pearson's coefficient and significant were explored on this relationship analysis. Third step, the parallel methods were used for build the modeling of vibrio occurrence in sea-water using the binary logistic regression while the GIS technique was used for generating sea-water quality maps using Thai Pollution Control Department (PCD) databases. Finally, the results of vibrio occurrence prediction in sea-water associated to 105 oyster farms were explored to dry and rainy seasons.

3.1 Data setting

In this study, on the oyster farms sample 1, 2 and 3 which far from shore about 500 – 1,000 m (Fig. 1) have been collect and analysis for water parameters; Oxygen (mg/L), BOD (mg/L), Salinity (psu), Temperature (^oC), pH and the density of vibrio by MPN method for V. cholera (Vc), V. parahaemolyticus (Vp), V. vulnificus (Vv), V. alginolyticus (Va), V. mimicus (Vm), V. fluvialis (Vf), and V.spp in term of monthly.

3.2 Statistical analysis

The relationships of vibrio species in sea-water, oyster, salinity and the water parameters were cross evaluated using Pearson's correlation coefficient (1). Significantly cases obtained from the Pearson's coefficient were selected to predict vibrio occurrence.

Pearson's correlation formula:

$$r = \frac{S_{XY}}{\sqrt{S_{XX} S_{YY}}} \qquad (1)$$

Where: r is Pearson's correlation coefficient, S_{XY} is Sum of the cross-products and S_{XX}, S_{YY} is Sum of square of the X and Y values. The Pearson's coefficients give a value range in -1 to 1 for negative and positive correlation.

The binary logistic regression (2) was used to predict vibrio occurrence in sea water. The fit model was considered using the overall classification, pseudo R^2 (Nagelkerke), Hosmer and Lemeshow statistic. Then, the potential of vibrio occurrence obtained from logistic regression model were validated using field measurement in the location point of sample 3 (Fig.1).

Binary logistic regression formula:

$$P(Y = 1) = \frac{e^{\beta 0 + \beta_1 X_1 + \ldots \beta n Xn}}{1 + e^{\beta 0 + \beta_1 X_1 \ldots \beta n Xn}} \qquad (2)$$

Where: (Y = 1) is the vibrio occurrence (the result > 0.5 is potential occur while the result < 0.5 is potential non-occur), β_0, β_1-β_n, X_1 - X_n are constant value, coefficients and the water quality parameters respectively.

3.3 Prediction of vibrio occurrence associated to oyster farm

The vibrio occurrence model obtained by the binary logistic regression and the water quality maps obtained by the Pollution Control Department (PCD) database were used for predict to vibrio occurrence in sea-water associated in oyster farm. The water quality maps of dry and rainy seasons were first generated by the GIS technique. The study generated grid size 50 m with cover the oyster farms on offshore for defining the area scope around 1 km^2 for water surface interpolation (red frame in Fig. 1). The PCD database obtained from dry season and rainy seasons on 2006, 2007, 2008 and 2012 were used to inputting data. These PCD databases were interpolated using GIS inverse distance weighting (IDW).

IV. Results And Discussion

4.1 Correlation analysis

The correlation between vibrio in oyster and water parameters is shown in Table 1. From this result, Vibrio alginolyticus, Vibrio parahaemolyticus and Vibrio vulnificus were no result of the Pearson's correlation coefficient but Vibrio mimicus show the Peason's correlation coefficient of oxygen and BOD about 0.483 and 0.608 respectively. Vibrio spp. shows the Pearson's correlation coefficient of pH about 0.417.

Table 1 Show the correlation between vibrio in oyster and Water parameters (N = 32)

Vibrio	Oxygen (mg/L)	BOD (mg/L)	Salinity (psu)	Temp (°C)	pH
Va	-0.125	-0.143	0.056	-0.149	0.085
Vm	0.483**	0.608**	0.231	-0.264	0.274
Vp	0.316	0.151	-0.176	-0.22	0.22
Vv	-0.105	0.083	-0.015	-0.295	0.155
Vspp	0.192	0.056	0.081	-0.326	0.417*

Note: Vf and Vc not calculation

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

In parallel, the correlation between vibrio in water and water parameters is shown in Table 2. Vibrio alginolyticus show Pearson's correlation coefficient 0.659 of temperature. Vibrio cholera show 0.580 and 0.381 of salinity and temperature respectively. Vibro mimicus show 0.490 and 0.409 of salinity and temperature respectively. Vibro spp show 0.612 and 0.404 of salinity and temperature respectively but no Pearson's correlation coefficient for Vibrio parahaemolyticus.

Table 2 Show the correlation between vibrio in water and water parameters (N = 34)

Vibrio	Oxygen (mg/L)	BOD (mg/L)	Salinity (psu)	Temp (°C)	pH
Va	0.203	-0.166	0.171	0.659**	0.112
Vc	-0.018	-0.277	0.580**	0.381*	0.017
Vm	0.004	-0.169	0.490**	0.409*	0.059
Vp	-0.238	-0.237	0.012	-0.191	-0.123
Vspp	-0.028	-0.275	0.612**	0.404*	-0.006

Note: Vf and Vp not detected

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

4.2 Prediction of vibrio occurrence in sea-water associated to oyster farm

4.2.1 Vibrio occurrence modeling

Binary logistic regression was used to predict only vibrio occurrence in water because the correlation in oyster not significant and many researchers in the past propose to use temperature and salinity to predict vibrio occurrence. The relationships between vibrio and water parameters used for vibrio prediction show that salinity is good correlated as shown by the Pearson's correlation coefficient. The present work is corresponded to agreement of previously works of the identified a significant relationship between vibrio and salinity by [13] and [20]. Temperature is clearly a useful predictive parameter for vibrio [21] and the temperature of coastal water of the Southeast Asian region is always warm throughout the year.

In this study, the field data far from shore located on sample 3 (Fig.1) were selected to validation. The accuracy of the Ang-Sila empirical model of Va, Vc, Vm and Vspp are 90.6%, 65.6%, 56.3% and 46.9% respectively. Pseudo R^2 (Nagelkerke) of Va, Vc, Vm and Vspp are 1.00, 0.841, 1.00 and 0.841 respectively. Hosmer and Lemeshow Test of Va, Vc, Vm and Vspp for df and Sig. are 8.00 and 1.00, 8.00 and 0.997, 7.00 and 1.00, and 8.00 and 0.997 respectively. These data are shown in model summary Table 3.

Table 3 Model summary: Vibrio in water.

Parameter / Vibrio	**Va**	**Vc**	**Vm**	**Vspp**
Variables in the Equation				
Salinity	Non	0.8269	24.5705	0.8269
Temp	36.5359	0.0097	598.6600	0.0097
Constant	-1124.5723	-18.6066	-18550.9763	-18.6066
pseudo R^2 (Nagelkerke)	1.0000	0.8410	1.0000	0.8410
Hosmer and Lemeshow Test				
Chi-square	0.0000	1.2100	0.0000	1.2100
df	8.0000	8.0000	7.0000	8.0000
Sig.	1.0000	0.9970	1.0000	0.9970
Validation (compared with 2012 Ang-Sila field data)	90.6%	65.6%	56.3%	46.9%

4.2.2 Result implementing in PCD dataset

The vibrio occurrence prediction in Ang-Sila oyster farm obtained by the logistic regression model and PCD data are shown in Table 4.

Table 4 Show the predict result implemented on vibrio occurrence in year 2006, 2007, 2008 and 2012.

Year	Dry_Va	Rainy_Va	Dry_Vc	Rainy_Vc	Dry_Vm	Rainy_Vm	Dry_Vspp	Rainy_Vspp
2006	1	0	1	0	-	1	1	0
2007	0	1	1	0	1	-	1	0
2008	0	1	1	1	0	-	1	1
2012	0	0	1	0	-	0	1	0

Note: (-) can't calculate

The result in dry season: the vibrio occurrence of Va, the results show that in 2007, 2008 and 2012 are seem to low potential occurred (< 0.5) except in 2006, the vibrio occurrence of Va is contrasted. The vibrio occurrence of Vc and Vspp, the results show that in 2006, 2007, 2008 and 2012 are shown to high potential occurred (> 0.5). The vibrio occurrence of Vm in 2007 is shown to high potential occurred but in the 2008 is shown to low occurred of vibrio occurrence.

The result in rainy season: the vibrio occurrence of Va, the results show that in 2006 and 2012 are shown to low potential occurred (< 0.5) except in 2007 and 2008, the vibrio occurrence of Va is contrasted. The vibrio occurrence of Vc and Vspp, the results in 2006, 2007 and 2012 are shown to low potential occurred (< 0.5) while high potential occurred in 2008. The vibrio occurrence of Vm in 2006 is shown to high potential occurred but in the 2012 is shown to low occurred of vibrio occurrence.

For this future implementation of PCD data application for predicting the distribution of vibrio occurrence in water can be obtained by the binary logistic regression model. Health risk management should be properly managed on the PCD data and the oyster economic market season planning.

V. Conclusions And Perspectives

In this study, the Pearson's correlation between vibrio in oyster and water parameters were not show the significant on temperature and salinity but show the significant between vibrio in water and water parameters. This result show clearly correlation of the influence of water parameters such as water temperature and salinity on the distribution of vibrio in water but not in the oyster. For future study, should study more about the oyster feeding behavior, ecosystem and other water quality parameters such as the nutrients in sea water for accuracy prediction of the vibrio distribution in oyster.

Ang-Sila coastal located in East of Thailand which the annual mean temperature in rose by approximately one degree Celsius from 1981 to 2007 reported by Thailand's Department of Meteorology (Fig. 2). For this reason, cause the abundant of vibrio distribution in sea water and cause food health risk for consumption of raw or undercooked seafood, especially shellfish, or thorough wound by swimming.

Further, the number of rainy days and the level of precipitation in Thailand have decreased over the last fifty years which cause the rose of the salinity. (Fig. 3)

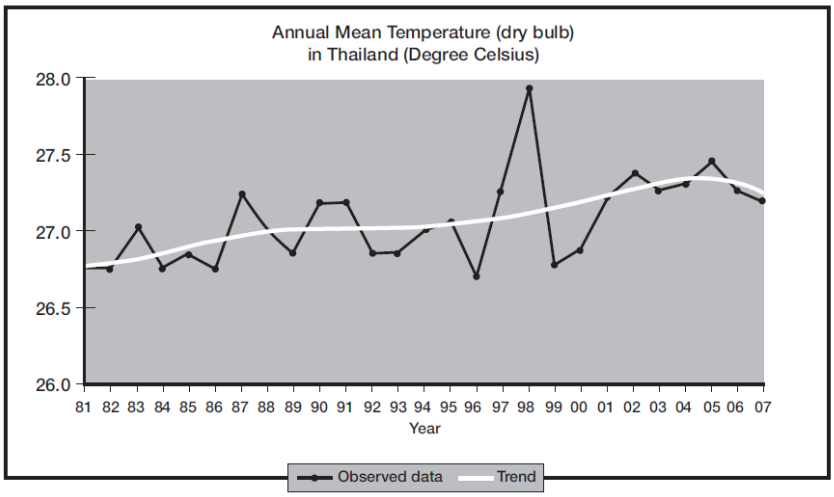

Figure 2 Annual mean temperatures in Thailand
(Source: Department of Meteorology, 2008)

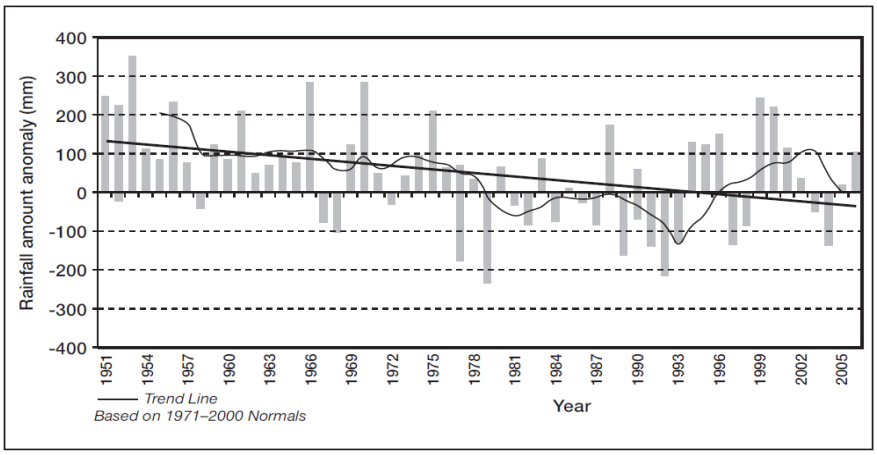

Figure 3 Annual rainfalls in Thailand
(Source: Department of Meteorology, 2008)

Some of the water parameter other than salinity and temperature should be analysis in the future study to clearly explain that some influence to the growth of vibrio in the study area and improve the Ang-Sila empirical model use for manage the environmental and food safety.

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References

[1]. Drake, S. L., DePaola, A., & Jaklus, L. A. (2007). An Overview of Vibrio vulnificus and Vibrio parahaemolyticus. Comprehensive Reviews in Food Science and Food Safety, 6, 120-144.
[2]. Vezzulli, L., Colwell, R. R., Pruzzo, C. (2013). Ocean warming and spread of pathogenic vibrios in the aquatic environment. Microbial Ecology, 65(4), 817-825.
[3]. James S. Clark, Steven R. Carpenter, Mary Barber, Scott Collins, Andy Dobson, Jonathan A. Foley, David M. Lodge, Mercedes Pascual, Roger Pielke Jr., William Pizer, Cathy Pringle, Walter V. Reid, Kenneth A. Rose, Osvaldo Sala, William H. Schlesinger, Diana H. Wall, David Wear Rees, R. (1996). Under the weather: climate and disease, 1700-1900. History Today, 46, 35-42.
[4]. Violeta, T. P. S. (2007). Influence of environmental factors on the presence of Vibrio cholera in the marine environment: a climate link. J Infect Developing Countries, 1(3), 224-241.
[5]. Walther, G. R., Post, E., Convey, P., Menzel, A., Parmesank, C., Beebee, T. J. C., Fromentin, J-M., Guldberg, O. H., and Bairlein, F. (2002) Ecological responses to recent climate change. Nature, 416, 389-395.
[6]. Anthes, R. A., Moore, B., Anderson, J. G., Barron, B. E. J., Brown, O. B. Jr., Cutter, S. L., De Fries, R., Gaiel, W. B., Hager, B. H., Hollingsworth, A., Janetos, A. C., Kelly, K. A., Lane, N. F., Lettenmaier, D. P., Traw, B. M., Mika, A. M., Washington, W. M., Wilson, M. L., Zoback, M. L. (2007). Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond. National Research Council of the National Academies, Space Studies Board, Division on Engineering and Physical Sciences. Washington DC, USA: The National Academies Press.
[7]. Constantin de Magny, G., Long, W., Brown, C. W., Hood, R. R., Huq, A., Murtugudde, R., et al. (2010). Predicting the distribution of Vibrio spp. in the Chesapeake Bay: a Vibrio cholerae case study. EcoHealth, 6, 378–389
[8]. Lipp, E., Huq, A., and Colwell, R. R. (2002). Effects of global climate on infectious disease: the cholera model. Clin Microbiol Rev, 15**,** 757–770.
[9]. Colwell, R. R. (1996). Global climate and infectious disease: the cholera paradigm. Science, 274, 2025–2031.
[10]. Lobitz, B., Beck, L., Huq, A., Wood, B., Fuchs, G., Faruque, A.S.G., and Colwell, R. R. (2000). Climate and infectious disease: use of remote sensing for detection of Vibrio cholera by indirect measurement. Proc Natl Acad Sci USA, 97, 1438–1443.
[11]. Zimmerman, A. M., et al. (2007). Variability of total and pathogenic Vibrio parahaemolyticus densities in northern Gulf of Mexico water and oysters. Appl. Environ. Microbiol., 73, 7589–7596.
[12]. Louis, V. R., Russek-Cohen, E., Choopun, N., Rivera, I. N., Gangle, B., Jiang, S. C., Rubin, A., Patz, J. A., Huq, A., Colwell, R. R. (2003). Predictability of Vibrio cholerae in Chesapeake Bay. Appl Environ Microbiol., 69(5), 2773-2785.
[13]. Phillips, A. M. B., Depaola, A., Bowers, J., Ladner, S., and Grimes, D. J. (2006). An Evaluation of the Use of Remotely Sensed Parameters for Prediction of Incidence and Risk Associated with Vibrio parahaemolyticus in Gulf Coast Oysters (Crassostrea virginica). Journal of Food Protection, 70(4), 879–884.
[14]. Jacobs, J. M., Rhodes, M., Brown, C. W., Hood, R. R., Leigh, A., Long, W., et al. (2010). Predicting the distribution of Vibrio vulnificus in the Chesapeake Bay. Cooperative Oxford Laboratory, Oxford, MD. pp 12.
[15]. Kevin Ward. NASA Earth Observations (NEO), Retrieved, From http://neo.sci.gsfc.nasa.gov
[16]. McCoy, E. W. and Y. Chareonvittayakul (1983). Proceedings of shellfish culture workshop. Subproject: Workshop. Phase I Project Report.
[17]. Maryland Department of the Environmental and Maryland Department of Health and Mental Hygient, Retrieved, From http://www.marylandhealthybeaches.org/vibrio.html
[18]. Suparp Pripanapong, retrieved, From http://www.fao.org/docrep/field/003/ab717e/ab717e07.htm#ref*4
[19]. Annual Weather Summary of Thailand in 2011, retrieved, From http://www.tmd.go.th/programs%5Cuploads%5CyearlySummary%5CAnnual2011_up.pdf
[20]. Vinita, Banakar et al,. Temporal and Spatial Variability in the Distribution of Vibrio vulnificus in the Chesapeake Bay: A Hindcast Study. DOI: 10.1007/s10393-011-0736-4.
[21]. Gil, A. I., Louis, V. R., Rivera, I. N., Lipp, E., Huq, A., Lanata, C. F., et al. (2004) Occurrence and distribution of Vibrio cholera in the coastal environment of Peru. Environmental Microbiology 6:699-706