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Temporal variation of salinity in marine water using statistical approaches

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ABSTRACT

Administration and biodiversity discussion of marine conditions has turned out to be vital worry to every nation around the globe. The nearness of ports, power plants and different exercises in beach front zones will affects physical and synthetic water parameters. Six monitoring stations in the Straits of Johor in the southern part of Peninsular Malaysia are considered in the study. This study attempts to determine trends of salinity from 2004 until 2014 using time series regression model and to identify the marine parameters which are temperature, dissolved oxygen and conductivity that have significant linear relationship with the salinity of surface water using Pearson correlation. Slope of the fitted regression model, B_1 shows significant positive increasing trend on salinity throughout the year with the highest value of 0.018 at B2 and B3 stations. Pearson correlation indicates strong positive linear relationship between salinity and conductivity for each station with *r* between .75 to .83. There is correlation between salinity and dissolved oxygen and conductivity at station B1, B2, B3 and A3. On the other hand, only conductivity affects salinity level at A2, while temperature and conductivity affect salinity level at A1 station. The physical parameters along Straits of Johor should be continuously monitored in order to maintain the ecosystem and to ensure the activities along the straits does not affect much towards the biodiversity along the area.

Key words: Salinity, time series regression model, Pearson correlation, surface water.

1. INTRODUCTION

Nature is an imperative resource of earth. Recently, administration and biodiversity discussion of marine conditions has turned out to be vital worry to each nation around the globe. The nearness of ports, power plants and different exercises in beach front zones will affects physical and synthetic water parameters hence, influences microscopic fish [1]. [2] expressed that human action could prompt nonstop

or occasional end of certain fish species. Present lifestyle has led to contamination of pharmaceutical items in the territory [3]. The ruining level depends on the material, physical properties, substance properties, profundity of water and the hydrographic conditions [4].

It is important to sustain an optimum level of physical and chemical marine parameters. The water quality level must be at certain level for the survival of marine life. The survival capacity of sea creatures is restricted because of the cutoff points of resistance to different abiotic elements [5]. The principle parameters of water quality that are distinguished will impact on fish dissemination incorporate temperature, salinity, dissolved oxygen and turbidity [6].

Sub-stream heterogeneous, qualities of residue, and vegetation influence the dispersion of fish through their impact on the accessibility of shots [7]. [8] said that the effects of salinity on the advancement and survival of a couple penaeid creature classes has been broadly researched. Recent study shows that salinity of the ocean water is one of the essential parameters in deciding the level of water quality [9][10]. High amount of dissolved salt in the water can cause corrosion of motor that passed through the area or even the near shore. High salt concentration can possibly cause declining in biodiversity, which in the same time could alter the ecosystem structures.

Salinities between 15 ppt and 25 ppt are seen as perfect for P. monodon culture [11][12]. It was represented by [13] that adult M. Rosenbergii can continue salinity level from 0 ppt to 25 ppt. [14] said the lethal salinities level, improvement and survival rate at different sub-fatal salinities for M. Rosenbergii are up 'til now vague. Changes in salinity and presentation to fish types can influence the declaration of qualities required in the direction of sodium and potassium particles and physiological anxiety [15].

Recently, the fluctuation of sea condition with regards to increase in sea level, recurrence of water surge and tropical violent winds could be the cause for excessive salt in freshwater which impact the fisheries sectors around the world [16]. Changes in hydrology and meteorology in the study can be a major impact on the salinity levels. Monsoonal effect in Malaysia climate affects the distribution of rainfall, which indirectly give impacts on salinity level in the study area. Significant changes in water salinity extended from 13.64 ± 6.24 ppt to 17.08 ± 8.03 ppt with an extension of 25.2% after tropical violent wind Aila happened in 2009 [17].

In order to explain a complex data structure, an appropriate strategy is required [18]. Time series regression and Pearson relationship examination were connected in this study. Linear regression and Pearson correlation are broadly used to give data about water quality. Regression also applied in other area [19] [20]. Study led by [21] utilized time series regression in evaluating the mean salinity, dissolved oxygen and temperature on west part of Johor Strait. The technique for relapse was utilized to decide and analyze the measurable criticalness drifts in salinity in study led by [22]. This study also implements the usage of time series regression and determine the relationship between marine parameters.

This paper presents temporal variation of water salinity along Johor straits Malaysia. The first objective is to determine trends of water salinity using time series regression model. Second objective is to identify the marine parameters such as temperature, conductivity and dissolved oxygen which significantly affect salinity of surface water using Pearson correlation method.

2. MATERIALS AND METHODS

This section consists of study area, data preparation, time series regression model and Pearson's correlation.

2.1 Study area

The study was conducted in Johor strait, known as Tebrau straits based in southern Peninsular Malaysia with a length of approximately 53 kilometers. It is quite narrow and shallow. Distance between Johor to Singapore straits is about 4 km.

It is an international strait which separate peninsular Malaysia with Singapore. six stations are considered in this study. A1, A2 and A3 stations are located in the west part whilst B1, B2 and B3 are located in the east side. Johor straits are located in between Malacca straits and South China Sea, located under semi-confined water body condition. Three of the station in the west overlap between Johor and Malacca straits whilst three of the station in the east part overlap between Johor straits and South China Sea. As shown in Fig. 1, station B2 and B3 are located near estuary where the mixing between fresh water and saline water occur. B1 are located at the eastern end of Johor straits while the other three (A1, A2, A3) which located at the west part of Johor Strait are located far from the estuary.

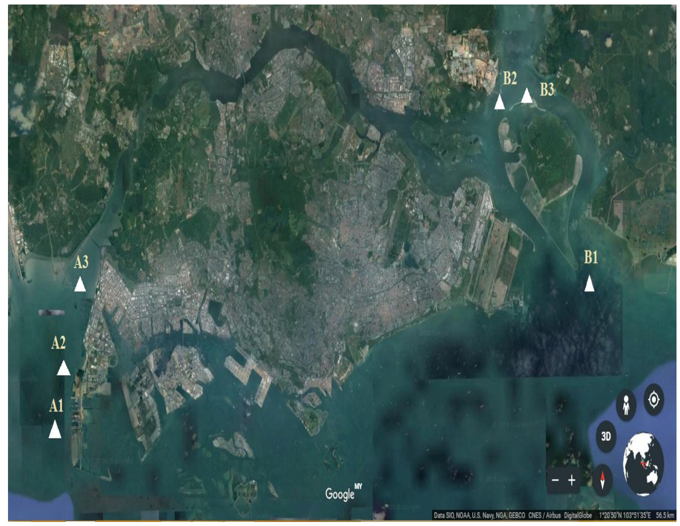


Figure 1: Location of study area and monitoring station

2.2 Data preparation

Data for this study were obtained directly from National University of Malaysia (UKM) between 2004 to 2014 (10 years data) for six monitoring stations namely A1, A2, A3, B1, B2 and B3 There are several parameters considered such as salinity, temperature, dissolved oxygen and conductivity. These data are taken on monthly basis.

2.3 Time series regression model

Time series regression analysis is widely used in various applications. It consists of linear and additive relationship between more than two variables. Time series regression analysis can be mathematically written as in equation 1:

$$Y_t = a + bX_t + e_t \quad (1)$$

Where Y_t is the dependent variable which depends on the independent factor, t_i where t=1,2,3,…,N and e_t is the error term which is assumed to be independent and identically distributed. There are a few assumptions for the error terms listed as follow [23]:

i. $E(e_t)=0$, error has zero mean.
ii. $E(e_t^2)=\sigma^2$, error has constant variance.
iii. $E(e_t,X_t)=0$ indicates that there is no correlation with *t*.
iv. $E(e_t,e_{t-1})=0$ implies that there is no autocorrelation.

2.4 Pearson's Correlation

Pearson product-moment correlation coefficient test is used to measure the existence and strength of a linear relationship between two variables. There are few assumptions to use this test. Firstly, the measured variables should be continuous numeric variables. Secondly, there exists a linear relationship between two variables. There are three types of linear relationship that may exist between these two variables namely positive linear correlation, negative linear correlation and no correlation. Then, there should not be any outliers in the data set. Outliers can greatly impact on the analysis and can lead to misleading result of the analysis. Hence, any outliers should be kept at minimum. In order to apply this test, assumption of homoscedasticity must not be violated. Homoscedasticity implies that the variances along the line of best fit remain similar along the line. These terms indicate that error at each level of independent variable is constant [24]. Last assumption of using Pearson's correlation is the data used in the study should be approximately normally distributed.

The hypothesis testing for Pearson correlation is as follow:

$$H_0 : \rho = 0$$
$$H_1 : \rho \neq 0$$

where ρ is the population correlation coefficient. When the population correlation coefficient is 0, hence indicate that there is no association between variables.

Based on this test, sample correlation coefficient between two variables is denoted in equation (2):

$$r_{xy} = \frac{cov(x,y)}{\sqrt{var(x)} * \sqrt{var(y)}} \qquad (2)$$

where *cov(x,y)* is sample covariance of *x* and *y*, *var(x)* is sample variance of *x* and *var(y)* is sample variance of *y*. This is a measure of the strength and direction of the linear relationship between the two variables. The correlation coefficient can range from -1 to +1, with -1 indicating a perfect negative correlation, +1 indicating a perfect positive correlation, and 0 indicating no correlation at all. A variable correlated with it will always have a correlation coefficient of 1.

3 RESULTS AND DISCUSSION

3.1. Exploratory Analysis

Based on the boxplot in Fig. 2, we can clearly see an uneven data scattering. Maximum salinity value for each month is different. The data spread for water salinity can be clearly seen on monthly basis. The spread of salinity data with highest level can be seen in April and September. Range between quarters for sea water salinity data in April is between 28.66 to 31.81 ppt while in September ranged from 27.22 to 30.85ppt. The spread of the distribution parameter data for salinity in December can be viewed as smallest value in the range of between quarters for the month ranged from 29.08 to 30.05 ppt.

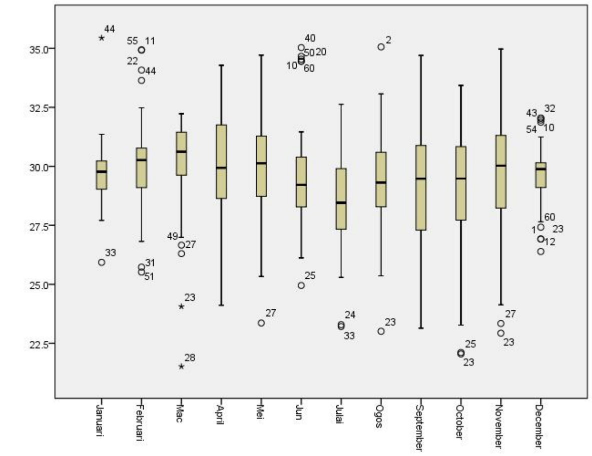


Figure 2: Boxplot of water salinity (ppt) based on month

The quantity of high precipitation overwhelms the hydrological cycle tropics [25]; [26] and prompt the arrangement of water with salinity bring down in surface water [27]; [28] that influences the flow and thermodynamics in tropical seas [29]; [28]. Through a study led by [30] , they demonstrated that the arrangement of momentum stream influences the rate of progress of the mass of water salinity. Scattering salinity found in Fig. 2 for April and September might be because of the storm. April and October are the transition month of monsoon in Malaysia specifically impact South China Sea area [31].

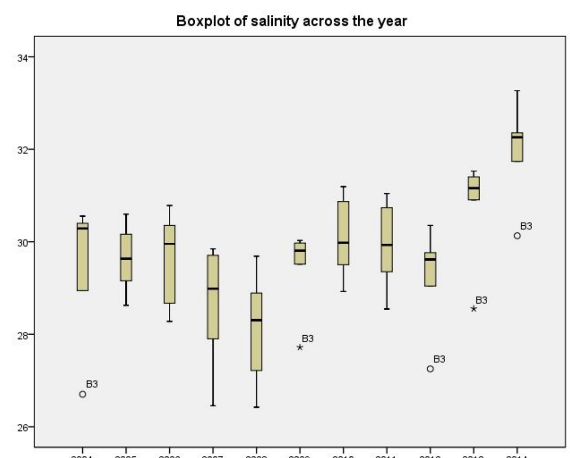


Figure 3: Boxplot of water salinity (ppt) across the year

Figure 3 shows boxplot of water salinity across the year. According to the graph, the average salinity is highest during 2014. Based on the data, minimum and minimum reading each between 30.13 to 30.35 ppt respectively. Highest salinity level for all station can be seen during 2014, while the lowest salinity recorded by each station can be seen during 2008.

3.2. Time Series Regression of Salinity

Table 1: Time series regression model

Station	B_0	*p*-value	B_1	*p*-value
B1	29.389	.000	0.016	.000
B2	28.787	.000	0.018	.000
B3	26.494	.000	0.018	.001
A1	29.539	.000	0.009	.018
A2	29.163	.000	0.009	.032
A3	28.193	.000	0.015	.001

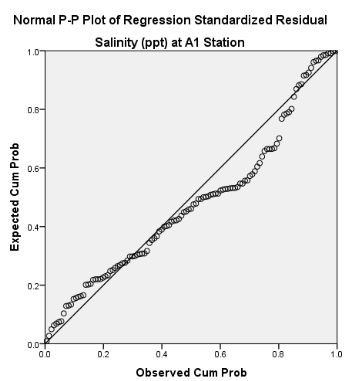
Table 1 show the result from time series regression analysis to obtain trend of surface water salinity for studied area. The positive value of B_1 for all stations shows the value of salinity increased by time.

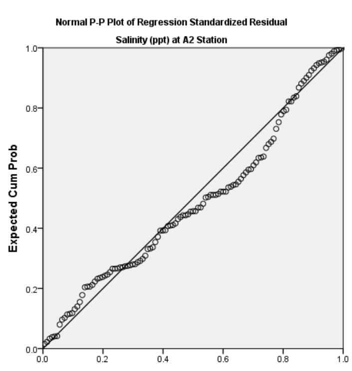
Durbin Watson result for salinity parameters at each station is calculated in Table 2.

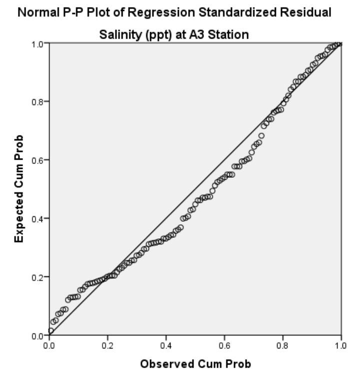
Table 2: Durbin-Watson test statistics

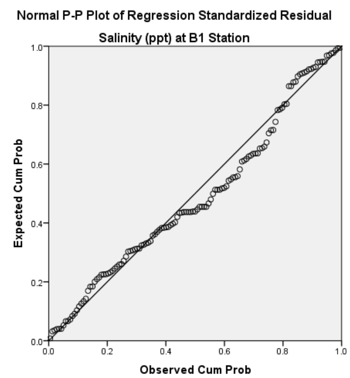
Station	Durbin Watson
A1	1.071
A2	0.936
A3	0.935
B1	1.137
B2	1.145
B3	1.661

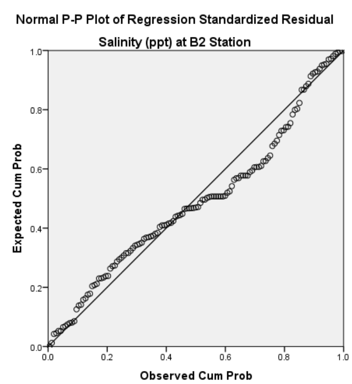
The model's assumptions were checked, and it shows that the errors are normally distributed with constant variance.











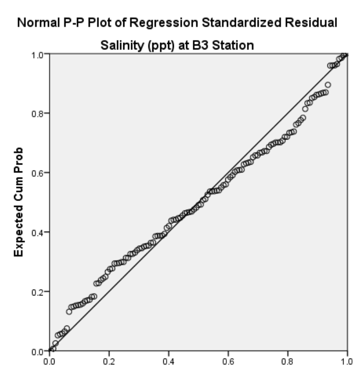


Figure 4: P-P plot of regression standardized residual salinity (ppt) at A1, A2, A3, B1, B2 and B3 station

The P-P plot in Figure 4 of standardized residuals shows that all the points are located close to the line, hence, the data is approximately normally distributed with zero mean and constant variance.

Based on linear regression investigation, all stations demonstrated an expansion of salinity by a positive value for B_1. B2 and B3 have most astounding increased levels of salinity for 2004 to 2014 and situated near to each other. The increase of salinity level at each station might be due to hydrological and meteorological factors. This shows the area of the station picked assume a vital part in this study.

3.3. Relationships of Salinity with Physical Parameters

Table 3: Results of Pearson's Correlation

Station		Temperature (^oC)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)
B1	*r*	- 0.029	**- 0.189**	**0.788**
	p-value	0.744	**0.030**	**0.000**
B2	*r*	-0.023	**- 0.313**	**0.768**
	p-value	0.793	**0.000**	**0.000**
B3	*r*	-0.134	**- 0.250**	**0.812**
	p-value	0.126	**0.004**	**0.000**
A1	*r*	**- 0.179**	- 0.038	**0.752**
	p-value	**0.041**	0.665	**0.000**
A2	*r*	- 0.009	- 0.136	**0.829**
	p-value	0.918	0.120	**0.000**
A3	*r*	- 0.114	**- 0.182**	**0.822**
	p-value	0.195	**0.038**	**0.000**

Based on Table 3, temperature and salinity were found to be negatively correlated with r=-.179, p<0.05 at station A1 and does not show any correlation at other stations. While for dissolved oxygen parameter, there is significant negative correlation at all station except at A1 and A2, with p<0.05. Analysis on correlation on conductivity and salinity at all stations shows that these two parameters are strongly correlated with p<0.05 and r between .75 to .83.

Salinity is the dissolved salt and minerals in the sea water. It is known as a function of several factors, where among the most major factors are temperature, conductivity and dissolved oxygen. Salinity in the ocean is affected by the location whether in estuaries or other river exits and undersea venting. High in salinity level could increase oxidation rate specially to ships and other motor vehicle which pass through the sea. Increase in temperature affect in decrement of salinity. This is due to the fact that higher temperature increases the space between water molecule and thus reduce the density. Salinity and density have a positive relationship such that increase in density also increase the amount of salt in the water. Hence, increase in temperature leads to decrease in salinity level. This shows an inverse relationship between the two parameters.

Seawater have more amount of salts, compared to fresh water. Salt which dissolved in water breaks into positive and negative ions. Conductivity measures the ability of water to conduct an electrical current with the dissolved ion acts as conductors. Dissolved ions will increase salinity and conductivity; hence these two parameters are said to be related with one another. Information on salinity taken to decide the development of water in the zone and scored from the conductivity estimation parameters, temperature and weight of the water [32].

Dissolved oxygen likewise assumes a critical part in changing levels of salinity in the Straits of Johor. Based on Pearson correlation, only four out of six stations showed that dissolved oxygen gives effects on changes in salinity levels. Station B1, B2, B3 and A3. The correlation amongst salinity and dissolved oxygen levels in B2 is the most intense stations than at the station in this study of the fact that the r estimation of the station for the relationship B2 is 0.313 with 0.000 essentialness respect. Dissolved oxygen crucial for the survival of marine life [32]. The fundamental wellspring of oxygen for marine water is from photosynthesis by plants in the ocean and furthermore by retention by air oxygen provided to the water surface. Marine water require oxygen least is 4 mg/L and ideally with 5 mg/L for the arrangement of biological community working with ideal levels to marine life [33]. Marine plants can't survive in high salinity water where photosynthesis process won't happen.

Lack in oxygen can prompt respiratory capture, bringing about dead fish, diminished nourishment for marine life and would meddle with the improvement of the fetus thusly decreases the rate of incubation facility for marine life because of absence of oxygen [34]. Hypoxia occur when oxygen concentration under 2 mg/l or 3 mg/l for specific frameworks and anoxia when dissolved oxygen at 0.0 mg/l, affect water quality and thus raise concerns on the shoreline range worldwide. The level of salinity additionally one of the imperative factors that influence the utilization of life forms in inundated zones [35]. Pearson correlation shows that salinity and dissolved oxygen have negative relationship, where increase in salinity will reduce dissolved oxygen level.

Relationship between temperature and salinity shows that only A1station have significant correlation with p=0.041, and r = - 0179. This implies an increasing in salinity levels will be in accordance with the lessening in temperature at A1 station. [36] clarifies that salinity levels will be diminished by the procedure of precipitation, expanded dissipation and changes to the way toward blending the distinctive ocean water salinity in the district. In a study led by [37] states that the rate of salinity will additionally diminish with expanding freshwater from the waterway that streams into the ocean and will build the dissipation procedure and the development of ice in the ocean. [38] expressed surface temperatures and ocean in the Straits of Johor is distinctive. Fish are extremely sensitive towards temperature changes. Sudden temperature changes [39] will make the movement of a few types of fish to different territories [34]. The temperature range of ocean water is between 28 ^{o}C to 32 ^{o}C [39].

In addition, Straits of Johor is the only route between two mainland and also in a strategic geographical position in the busiest shipping lanes [40]. Johor Strait supply natural resources and opportunities for both countries, Malaysia and Singapore through shipping. This study is important to investigate the impact of shipping activities and waste water discharge, also to determine whether storm water and waste water discharge from both countries have the potential to adversely affect water quality, thus affecting salinity level. The station location played an important role in this study. Each location salinity level affected by different parameters.

Peninsular Malaysia demonstrates the circulation of water is unequivocally affected by the ebb and flow streaming toward the south amid the upper east storm. Pearson correlation results come about for the correlation between the rate of salinity and temperature at the station A1 in opposition to the discoveries of analysts before is likely because of different variables. Environmental change is likely because of changes in sea streams, the development streams vertically, warming and cooling rates and distinctive rates of warmth via seawater water system in the zone.

4.CONCLUSION

This paper presents analysis on marine parameters at six monitoring stations along Johor straits. The time series regression model shows that increasing rate of salinity through time. Most astounding trend is seen at B2 and B3 stations with the highest coefficient value. There are three parameters which are used in this study to evaluate its effect on salinity at these six locations. Three from the monitoring stations are located near South China Sea and the other three stations are near Malacca straits. Based on the analysis, three stations located on the east of Johor straits and A3 station shows that salinity level is positively correlated with dissolved oxygen and conductivity with no significant relationship from temperature parameter. While three other stations which located at the west part of Johor straits shows different results. Salinity level at A1 station is correlated with temperature and conductivity, while A2 only significantly correlated with conductivity alone. Further analysis can be conducted to examine the monsoonal impacts on both study areas which is located near South China Sea and the other located near Malacca straits.

REFERENCES

1. Abowei, J. F. N., "**Salinity, Dissolved Oxygen, pH and Surface Water Temperature Conditions in Nkoro River, Niger Delta, Nigeria**", Advance Journal of Food Science and Technology, Vol. *2*(1), pp. 36–40. 2010.
2. Allen, M. R., and Ingram, W. J., "**Constraints on future changes in climate and the hydrologic cycle**", Journal of Nature, Vol. *419*, pp. 224–232, 2002. https://doi.org/10.1038/nature01092
3. Badjeck, M.-C. and Allison, E. H. et al., "**Impacts of climate variability and change on fishery-based livelihoods**", Marine Policy, Vol. 34(3), pp. 375–383, 2010.
4. Betts, A. K. and Ridgway, W., "**Climatic Equilibrium of the Atmospheric Convective Boundary Layer over a Tropical Ocean",** Journal of the Atmospheric Sciences, Vol. 46(17), pp. 2621–2641, 1989.
5. Blaber, S. J. M. and Blaber, T. G., "**Factors affecting the distribution of juvenile estuarine and inshore fish**", Journal of Fish Biology, Vol. 17(2), pp. 143–162, 1980. https://doi.org/10.1111/j.1095-8649.1980.tb02749.x
6. Cairns, S. D., "**Worldwide Distribution of the Stylasteridae (Cnidaria: Hydrozoa)**", Scientia Marina, Vol. 56(2–3), pp. 125–130, 1992.
7. Chand, B. K. and Trivedi, R. K. et al., "**Effect of salinity on survival and growth of giant freshwater prawn Macrobrachium rosenbergii (de Man)**", Aquaculture Reports, Vol. 2, pp. 26–33, 2015.
8. Schober, P. and Boer, C. et al., "**Correlation coefficients: Appropriate Use and Interpretation**", Anesthesia & Analgesia, Vol. 126 (5), pp. 1763-1768, 2018.
9. Chen, J.-C. and Lin, M.-N. et al., "**Survival, haemolymph osmolality and tissue water of Penaeus chinensis juveniles acclimated to different salinity and temperature levels**", Comparative Biochemistry and Physiology Part A: Physiology, Vol. 110(3), pp.253–258, 1995.
10. Clark, J. R., **Coastal zone management handbook**, Lewis Publishers, 1996.
11. Dall, W. and Hill, B. J. et al., "**The biology of the Penaeidae**", Advances in Marine Biology, Vol. 27, 1990.
12. Ferraris, R.P. and Parado-Estepa, F.D. et al., **Osmoregulation in Penaeus monodon: effects of molting and external salinity In: Mclean, J.L., Dizon, L.B., Hosillos, L.V. (Eds.)**, in *Proceeding of the First Asian Fisheries Forum*, Manila, 1986, pp. 637-640.
13. Fiedler, P. C., and Talley, L. D., "**Hydrography of the eastern tropical Pacific: A review**", Progress in Oceanography, Vol. 69, pp. 143–180, 2006. https://doi.org/10.1016/j.pocean.2006.03.008
14. Ghasemi, A. R., "**Changes and trends in maximum, minimum and mean temperature series in Iran**". Atmospheric Science Letters, Vol. 16(3), pp. 366–372, 2015.
15. Girjatowicz, J. P., and Swiatek, M., "**Salinity variations of the surface water at the southern coast of the Baltic Sea in years 1950–2010**", Continental Shelf Research, Vol. 126, pp. 110–118, 2016.
16. Girjatowicz, J. P. and Świątek, M. et al., "**The influence of atmospheric circulation on the water level on the southern coast of the Baltic Sea**", International Journal of

Climatology, Vol. 36(14), pp. 4534–4547, 2016.

17. Hamzah, F. M. and Jaafar, O. et al., "**Multivariate Analysis of Physical and Chemical Parameters of Marine Water Quality in the Straits of Johor, Malaysia**", Journal of Environmental Science and Technology, Vol. 9(6), pp. 427–436, 2016.
18. Ismail, A., "**A need for monitoring of heavy metals and organotin compounds in the east coast of johor**", Ekosistem Marin Malaysia: Penyelidikan Pantai Timur Johor Darul Takzim, pp. 163–176, 2016.
19. Ismail, M. and Baharim Hashim, N., et al., "**Estimating Dissolved Oxygen Depletion In Inner Western Johor Strait, Malaysia Using A Three Dimensional Water Quality Model**", Malaysian Journal of Civil Engineering, Vol. SI 28(3), pp. 240–251, 2016.
20. Jadhav, R. B. and Joshi, S. D. et al., "**A Software Defect Learning and Analysis Utilizing Regression Method for Quality Software Development**", International Journal of Advanced Trends in Computer Science and Engineering, Vol. 8(4), pp. 1275–1282, 2019. https://doi.org/10.30534/ijatcse/2019/38842019
21. Jiang, Z-B. and Zeng, J-N. et al., "**Potential impact of rising seawater temperature on copepods due to coastal power plants in subtropical areas**", Journal of Experimental Marine Biology and Ecology, Vol. 368(2), pp. 196-201, 2009.
22. Johnson, G. C. and Schmidtko, S. et al., "**Relative contributions of temperature and salinity to seasonal mixed layer density changes and horizontal density gradients**", Journal of Geophysical Research: Oceans, 117(C4), 2012.
23. Karim, Z. A. A. and Sidqi, M. A. et al., "**Exergy and Regression Analysis for Optimization of Electric Chillers at a Gas District Cooling Plant**", International Journal of Advanced Trends in Computer Science and Engineering, Vol. 8(1.3), pp. 98–102, 2019. https://doi.org/10.30534/ijatcse/2019/1981.32019
24. Kennish, M. J., "**Environmental threats and environmental future of estuaries**", Environmental Conservation, Vol. 29(01), pp. 78–107, 2002.
25. Kijewska, A. and Kalamarz-Kubiak, H. et al., "**Adaptation to salinity in Atlantic cod from different regions of the Baltic Sea**", Journal of Experimental Marine Biology and Ecology, Vol. 478, pp. 62–67, 2016.
26. Maes, C. and Ando, K. et al., "**Observed correlation of surface salinity, temperature and barrier layer at the eastern edge of the western Pacific warm pool**", Geophysical Research Letters, 33(6), 2006. https://doi.org/10.1029/2005GL024772
27. Marchand, J., "**The influence of seasonal salinity and turbidity maximum variations on the nursery function of the Loire estuary (France)**", Netherlands Journal of Aquatic Ecology, Vol. 27(2–4), pp. 427–436, 1993.
28. Marshall, S. and Elliott, M., "**Environmental Influences on the Fish Assemblage of the Humber Estuary, U.K**", Estuarine, Coastal and Shelf Science, Vol. 46(2), pp. 175–184, 1998
29. Mitra, A. and Halder, P. et al., "**Changes of selected hydrological parameters in Hooghly estuary in response to a severe tropical cyclone (Aila)**", Indian Journal of Geo-Marine Sciences, Vol. 40(1), pp. 32–36, 2014.
30. Mohd Akhir, M. F. and Chuen, Y. J., "**Seasonal variation of water characteristics during inter-monsoon along the east coast of Johor**", Journal of Sustainability Science and Management, Vol. 6(2), pp. 206–214, 2011.
31. New, M. B., "**Status of freshwater prawn farming: a review**", Aquaculture Research, Vol. 26(1), pp. 1–54, 1995.
32. Noor, A. and Tahir, A., "**Pengaruh derajat keasaman (pH) air laut terhadap konsentrasi kalsium dan laju pertumbuhan Halimeda sp**", Jurnal Ilmu Kelautan Dan Perikanan, Vol. 24(1), pp. 28–34, 1995.
33. Roseli, N. H. and Akhir, M. F. M., "**Variations of Southern China Sea characteristics near Pahang**", Sains Malaysiana, Vol. 43(9), pp. 1389–1396, 2014.
34. Sverdrup, H. U. and Johnson, M. W. et al., **The Oceans: Their Physics, chemistry and general biology,** 7th ed., New York: Prentice-Hall.1942.
35. Talley, L. D. **Salinity Patterns in the Ocean Encyclopedia of Global Environmental Change Salinity Patterns in the Ocean,** John Wiley & Sons, Ltd, Chichester, 2002, Vol. 1, pp. 629–640.
36. UNESCO World Heritage Centre **- New Inscribed Properties**, 1978, available at http://whc.unesco.org/en/newproperties/date=1978&mode=list
37. Verween, A. and Vincx, M. et al., "**The effect of temperature and salinity on the survival of Mytilopsis leucophaeata larvae (Mollusca, Bivalvia): The search for environmental limits**", Journal of Experimental Marine Biology and Ecology, Vol. 348(1–2), pp. 111–120, 2007. https://doi.org/10.1016/j.jembe.2007.04.011
38. Williams, M. N. and Gómez Grajales, C. A. et al., "**Assumptions of Multiple Regression: Correcting Two Misconceptions**", Vol. 18(11), 2002.
39. Yap, C. K. and Chee, M. W. et al., "**Assessment of Surface Water Quality in the Malaysian Coastal Waters by Using Multivariate Analyses**", Sains Malaysiana, Vol. 40(10), pp. 1053–1064, 2011.
40. Ziba Kazemi, **Evaluation of Impact of Freshwater on First-Order Transport Timescales in the Western part of Johor Strait**, Ph. D. dissertation, School of Civil Eng., Universiti Teknologi Malaysia, 2014.