International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 9, September 2018, pp. 1824–1830, Article ID: IJCIET_09_09_176
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=9
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

THE RELATIONSHIP OF SEDIMENT GRAIN SIZE AND ASIAN HARD CLAM DISTRIBUTION AS SUSTAINABLE MANAGEMENT INDICATOR

Nik Mohd Shibli Nik Jaafar, Yasmin Nur Diana Yunus and Marzuki Ismail
School of Marine and Environmental Sciences, Universiti Malaysia Terengganu,
21030, Kuala Nerus, Terengganu, Malaysia

Samsuri Abdullah
School of Ocean Engineering, Universiti Malaysia Terengganu,
21030, Kuala Nerus, Terengganu, Malaysia

Che Maslina Omar
World Wide Fund (WWF) Malaysia, 1 Jalan PJS 5/28A,
Petaling Jaya Commercial Centre (PJCC), 46150 Petaling Jaya, Selangor, Malaysia

ABSTRACT

Setiu Wetland located in Northern Terengganu is a highly important site for conservation and at the same time provides sustenance to the local communities. The wetland is under immense environmental pressure from growing population, agriculture and fishery activities. Asian hard clam (Meretrix meretrix) is one of many bivalve species that is consumed and provide income to the local communities, has been declining in numbers. This study aimed to identify habitat preferences indicator for the Asian hard clam and used as the indicator of sustainable management. The relationship between grain size and the clam was evaluated using Spearman correlation and simple linear regression. Results show that the population of the clam decreases as the location distant further from the river mouth. Medium coarse grain size (MC355) and coarse grain (C500) are significantly correlated with the clam population (MC355: r=0.360 & C500: r=0.361; P<0.05). These study findings provide a new viewpoint for practical management tools to determine Limit of Acceptable Changes to maintain Setiu Wetland's natural resources and safeguarding local communities' sources of livelihood.

Keywords: Asian Hard Clam, Limit of Acceptable Changes, Sediment Grain Size, Sustainable Development

Cite this Article: Nik Mohd Shibli Nik Jaafar, Yasmin Nur Diana Yunus, Samsuri Abdullah, Che Maslina Omar and Marzuki Ismail, The Relationship of Sediment Grain Size and Asian Hard Clam Distribution as Sustainable Management Indicator, International Journal of Civil Engineering and Technology, 9(9), 2018, pp. 1824–1830.

http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=9

1. INTRODUCTION

Molluscs are ecological and commercially important. These organisms play a major role in nutrient cycling and structuring of estuarine food web (Shumway, 2011) [13]. They are also used as bio-indicators to indicate pollution and other stresses (Wan et al., 2018) [15]. Highly dynamic hydrology patterns and landscape changes occurred around Setiu lagoon could impose negative impact on the abundance of bivalves and eventually local community's livelihood. Setiu Wetland is a unique and important ecosystem that needs to be conserved and sustainably developed. Setiu Wetland complex is one of the most bio diverse sites in the east coast of Peninsular Malaysia but face intense threat from infrastructural development & population growth (Salam et al., 2017) [8]. Majority of Setiu local communities is classified as Ecology Based Communities where they are highly dependent on natural resources from the wetlands such as fishermen, traditional craft making or aquaculture operators (Salim et al., 2015) [9].

There are countless studies on bivalves focused on feeding behaviour and ability to predict mollusc growth offers the prospect of a commercial activity that is economically stable (Sara and Mazola, 2004) [10]. In addition, molluscs are known to play important roles in transforming nutrients in sediments, however, guidelines to optimize sediment restoration are not available to maintain its population (Shen et al., 2016) [12]. Water quality particularly salinity is not the most important variable determining zonation in estuaries especially in temporarily open/closed estuaries that have very dynamic changes such as in Setiu Wetland (Teske and Wooldridge, 2003) [14]. Rare storm events could cause temporary changes but do not significantly affect bivalves, however continuous changes due to anthropogenic activities, on the other hand, has negative impact on bivalves (Norkko et al., 2006) [7]. Changes to sediment structure could compromise the existing benthic diversity (Chen & Bendell, 2013) [2]. These suggest that the crucial role of these habitats must be integrated into management perspectives (Barbier et al., 2007) [1] and currently, available information are difficult to be applied for management of an estuary.

The challenge for sustainable development is identifying what constitutes unacceptable environmental change, with little or no information about how long effects will last (Cooper, 2013) [3]. Limit of acceptable changes is variation or threshold changes allowed to occur without causing any changes in ecosystem's characteristics. The approach taken in this study offers a simple and cost-effective means of assessing the acceptability of changes in sediment composition that help outlines the management actions. This study objective is to correlate the relationship between the species abundance with sediment grain size and carbon content for better understanding the threat of changing substrate and support the idea to develop a practical monitoring tool without laborious and expensive laboratory analyses.

2. MATERIALS AND METHODS

2.1. Study Area

Setiu Lagoon is located in the northern part of Terengganu facing the South China Sea as shown in Figure 1. Setiu lagoon is an important location for fishery industry and majority of the fishermen in Setiu are still using traditional, small scale fishing techniques (Jani, 2015) [6]. The lagoon stretch about 13km and subjected to strong coastal current that flows relatively parallel to the coastline and strong wind during monsoon season that usually occurs at the end of the year (Yaacob and Mustapa, 2010) [16]. A common and highly valuable bivalves species selected for the study, *Meretrix meretrix* L. or Asiatic hard clam, is a triangular-shaped clam with smooth, glossy and multi-coloured shells that inhabits sandy substrates in the lower intertidal and shallow subtidal areas of Asia (Zhuang & Wang, 2004) [17].

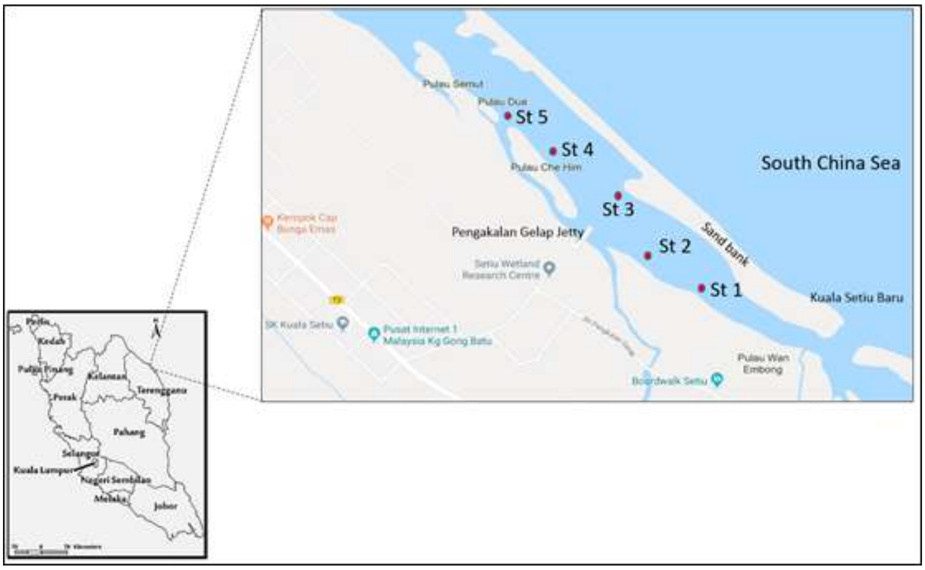

Figure 1 Location of sampling station in the Setiu Lagoon.

This study was conducted at 5 sampling stations (Figure 1and Table 1) with distances of approximately 1 km apart in an area along Setiu Lagoon stretching approximately 8km in length from the permanent river mouth of Kuala Setiu.

Table 1 The information on sampling stations

Station	Coordinates	Description
1	5o39’38.5”N ; 102o44’30.8”E	Setiu wetland lagoon has a total length of approximately 13km. The lagoon is feed with freshwater from Sg. Setiu and Sg Ular in the south and Sg Dendong in the north. The lagoon is active with aquaculture activity in the north near to Station 5 and 4. A jetty for local fishermen is located near to Station 3, whereas Station 2 and 1 locations are frequently dredged to enable fishing boats to traverse the lagoon to the jetty.
2	5o40’07.43”N; 102o43’ 56.45”E	
3	5o40’21.58”N; 102o43’21.72”E	
4	5o40’45.86”N; 102o42’44.95”E	
5	5o41’38.27”N; 102o42’08.07”E	

Samples were collected on sand banks during low tides 20m from shores. Three 10m transect lines were prepared and 3 quadrants in each transect line that cover about 100m^2 in each station. The sampling areas were scrape using garden rake until 20cm in depth to collect the species. Sediment samples also collected on for grain size analysis. Sediment samples were brought to laboratory was air dried prior to analyses. Fifty grams of dried sediment then were crushed with mortar and sieved through a stack of 7 different mesh size on an automated sieve shaker starting with 1000μm for very coarse grain (VC1000), followed by coarse: 500μm (C500), medium coarse: 355μm (MC355), medium: 250μm (M250), medium fine: 125μm (MF125), fine: 63μm (F) and ultra-fine: <63μm (UF). The weight of sediment in each sieve was then calculated in percentage for grain size composition. Total carbon in sediment samples was determined by lost on ignition method where 10 grams of sediment samples were ignited in a furnace at temperature of 700^{o}C for approximately 5 hours before the final samples were weighted again when cooled to obtain the amount of carbon that has been lost. The amount of carbon also represented in percentage. The distribution of all parameters is non-Gaussian, thus the Kruskal-Wallis and Spearman correlation analysis were applied in analysing the data. The statistical analysis is deemed for the 95 % confidence level. Statistical analyses were conducted with the help of SPSS® version 25.

3. RESULTS AND DISCUSSION

The composition for different grain size at each station was depicted in Figure 2. The Kruskal-Wall test revealed there exist statistically significant difference of grain size composition among sampling stations ($p<0.05$), except for coarse grain sediment (C500) size which has similar percentage ($p>0.05$). Overall, the composition is ranging from 13% to 27%. Station 1 which is nearer to the permanent river mouth was observed to compose of approximately 53% of very coarse to medium coarse grain and 47% of medium to ultra-fine grain. Station 4 and 5 have approximate 60:40 ratio of coarse and fine grain. This result is expected because usually station near to river mouth has more coarse grain as the lagoon-estuary hydrodynamic system which is mainly a combination of tide and river outflow. The distribution of sediment was also influenced by stronger wave and wind energy during the northeast monsoon season (Yaakob, 2010) [16]. Station 4 and 5 are located in the northern part of the lagoon where the Dendong River flows in. The rivers discharging into the lagoon originated from higher ground which usually has high flow and erosion rate (Satyamurthi, 2015) [11].

Station 2 has the lowest coarse grain which consists of 35% but the rest is the medium to ultra-fine grain. Although Station 2 is near to Ular River discharge, the river flow, however, has been altered due to construction of a dam at the upstream for irrigation purpose. Station 3 has extremely high coarse grain size with over 77% is very coarse grain. This sampling station is near to a sand pumping station that was positioned, close the break of the sand bank that occurred during the last monsoon season on several months before the sampling conducted. This station has very coarse sediment due to the anthropogenic relocation of sand from the beach and the sand pumping activity has re-worked of the sediment where the fine grain particles are churned up in the water column and moved elsewhere to calmer water.

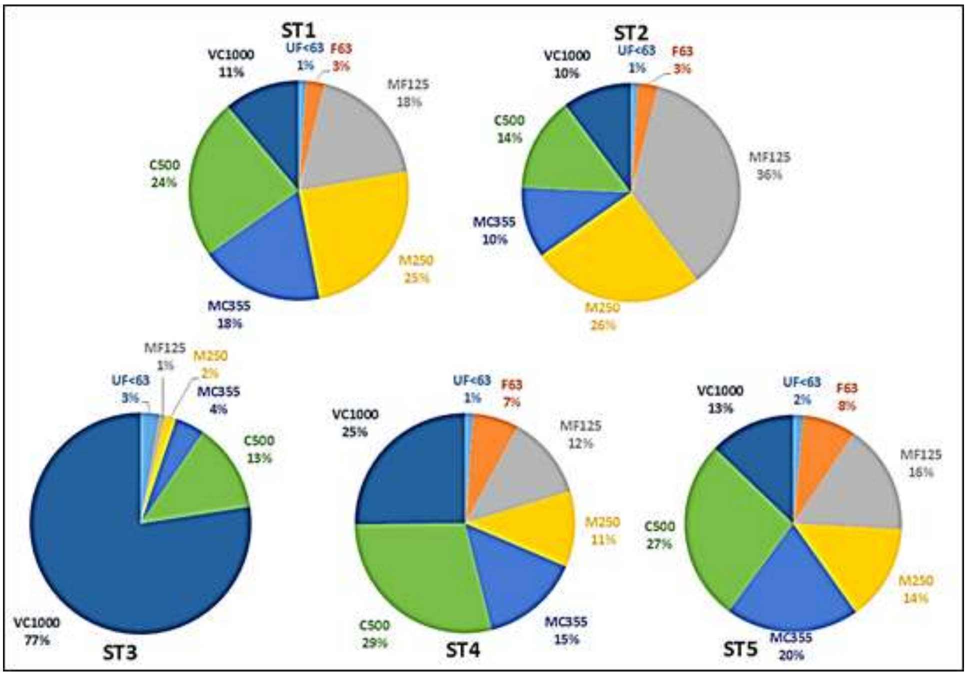

Figure 2 Composition of grain size (in %) at study area

The number of M. meretrix individuals and total carbon is tabulated in Table 2. It shows that Station 1 has the highest average number of *M. meretrix* collected with average of 10 individuals/m^2 while Station 2 and 3 have the lowest number collected with average of 1 individual. Total carbon, however, was observed at high percentage in station 2 and 4 with average of 1.23% and 1.15%, respectively. Station 1, 3 and 5, however, have slightly lower total carbon with average of 0.72%, 0.87% and 0.86%, respectively. It was found that there exists statistically significant different ($p<0.05$) of total carbon in each station.

Table 2 The evaluated chemical and physical contaminants at study area

Station	S1	S2	S3	S4	S5
Average number of individual (per m2)	10.33	1.11	1.00	2.78	2.56
Total carbon (%)	0.72	1.23	0.87	1.15	0.86

Table 3 shows that a positive and significant relationship between the species abundance with the presence of medium course (MC355) and coarse sediment (C500). Positive correlation between sediment structure and bivalves distribution is important to achieve long-term restoration of coastal ecosystems (Donadi et al, 2014) [4]. Although Station 3 has highest very coarse sediment (VC1000), it is not preferred by the species.

Table 3 Spearman correlation coefficient (r) between sediment grain size and *M. meretrix* abundance

	UF	F63	MF125	M250	MC355	C500	VC1000	MMeret
UF	1	-.254	-.512**	-.384**	-.137	-.184	.412**	.111
F63		1	.761**	.253	.370*	.072	-.468**	.033
MF125			1	.561**	.219	-.204	-.763**	-.004
M250				1	.551**	.052	-.838**	.233
MC355					1	.444**	-.430**	.360*
C500						1	.055	.361*
VC1000							1	-.160
MMeret								1

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level

The simple linear regression was established based on the MC355 grain size and C500 grain size with the M. meretrix. It shows that the MC355 has high R^2 compared to C500. Thus the medium coarse grain is more preferred by the *M. meretrix*. Hence, it is possibly composition of medium coarse, MC355 play an important role for the drifting *M. meretrix* larvae to settle down. Nonetheless, estuaries are highly dynamic ecosystem which experiences daily tidal rhythms, storm and surge events. Though the larvae may settle down in any of the stations that have the suitable composition of preferred grain size, the growth and mortality of the larvae are affected by other factors such as food sources, temperature and salinity. Sediment grain size and sampling date had greater influence on benthic community (Goldberg et al., 2014) [5]. Thus, this study set a merit for an in-depth study of *M.meretrix* growth in the future.

Table 4 Simple linear regression analysis of significant correlation for MC355 and C500 grain size

Grain size	R2	Equation
MC355	0.279	M. meretrix = 0.313(MC355) – 0.684
C500	0.026	M. meretrix= 2.270(C500) + 0.060

4. CONCLUSION

Preparing a management plan for sustainable development of Setiu Wetlands is a daunting task. This study provides important information needed to set the limit of acceptable changes of Setiu Lagoon. Although MC355 and C500 were identified as the preferred size for *M. meretrix* to settle, there is a need to correlate this study outcome with the species ecology and biology perspective. In addition, the existence of other bivalves' species also requires an in-depth study to determine possible competition or invasive species impact on the overall ecosystem. Results of this study provide new perspective for practical tool for coastal ecosystem restoration. Future studies urgently needed and have to consider several different time scales, the range of habitats and other environmental conditions.

ACKNOWLEDGEMENTS

The authors would like to thank the School of Marine and Environmental Sciences, Universiti Malaysia Terengganu and World Wide Fund (WWF) for the provision of instrumentations and laboratory for the study.

REFERENCES

[1] Barbier, P., Meziane, T., Forêt, M., Tremblay, R., Robert, R. and Olivier, F. Nursery Function of Coastal Temperate Benthic Habitats: New Insight From The Bivalve Recruitment Perspective. Journal of Sea Research. 121, 2009, pp. 11–23.

[2] Chen, K. and Bendell, L. I. Potential Effects of an Invasive Bivalve, Nuttallia obscurata, on Select Sediment Attributes Within The Intertidal Region of Coastal British Columbia. Journal of Experimental Marine Biology and Ecology. 444, 2013, pp. 66–72

[3] Cooper, K.M. Setting Limits for Acceptable Change in Sediment Particle Size Composition: Testing a New Approach to Managing Marine Aggregate Dredging. Marine Pollution Bulletin. 73, 2013, pp. 86–97

[4] Donali, S., van der Zee, E. M., der Heidi, T., Weerman, E. J., Piersma, T., de Koppel, J., Olff, H., Bartelds, M., Gerwen, I. and Eriksson, B.K. The Bivalve Loop: Intra-Specific Facilitation in Burrowing Cockles through Habitat Modification. Journal of Experimental Marine Biology and Ecology. 461, 2014, p. 44–52

[5] Goldberg, R., Rose, J. M., Mercaldo-Allen, R., Meseck, S. L., Clark, P., Kuropat, C and Pereira, J. J. Effects of Hydraulic Dredging on The Benthic Ecology and Sediment Chemistry on A Cultivated Bed of The Northern Quahog, Mercenaria mercenaria. Aquaculture. 428–429, 2014, p. 150–157

[6] Jani, J. M. Diverse fishing operations of Setiu small-scale fishery. Setiu Wetlands: Species, ecosystems and livelihood. UMT publishing. Terengganu. 2015, p. 177-198.

[7] Norkko, J., Hewitt, J. E. and Thrush, S. F. Effects of Increased Sedimentation on The Physiology of Two Estuarine Soft-Sediment Bivalves, Austrovenus stutchburyi and Paphies australis. Journal of Experimental Marine Biology and Ecology. 333, 2006, p. 12–26.

[8] Salam, M. R., Zulkifli, M. K. F. and Ahmad, W. J. W. 2017. Distribution & Rarity of Mangrove & Coastal Plants in Developing Indicators of Hotspots in Setiu Wetland. Proceeding of Setiu Wetland 2016 Scientific Expedition Seminar. WWF Malaysia. 2017, p. 14-23.

[9] Salim, J. M., Kamil, N. F. N and Komoo, I. Managing Setiu Wetlands for Ecosystem Services. Setiu Wetlands: Species, Ecosystems and Livelihood. UMT publishing. Terengganu. 2015, p. 217-228.

[10] Sara, G. and Mazzola, A. The Carrying Capacity for Mediterranean Bivalve Suspension Feeders: Evidence from Analysis of Food Availability and Hydrodynamics and Their Integration into a Local Model. Ecological Modelling. 179, 2004, p. 281–296

[11] Satyamurthy, E. S. Setiu River Basin: A brief Account of the Hydrologic Connections of Setiu Wetlands. Setiu Wetlands: Species, ecosystems and livelihood. UMT publishing. Terengganu. 2015, p. 101-107.

[12] Shen, H., Thrush, S. F., Wan, X., Li, H., Qiao, Y., Jiang, G., Sun, R., Wang, L. and He, P. Optimization of Hard Clams, Polychaetes, Physical Disturbance and Denitrifying Bacteria of Removing Nutrients in Marine Sediment. Marine Pollution Bulletin. 110, 2016, p. 86–92

[13] Shumway, S. E. Shellfish Aquaculture and the Environment, First Edition. John Wiley & Sons, Inc. 2011, p. 512

[14] Teske, P. R and Wooldridge, T.H. What Limits The Distribution Of Subtidal Macrobenthos in Permanently Open and Temporarily Open/ Closed South African Estuaries? Salinity vs. Sediment Particle Size. Estuarine, Coastal and Shelf Science. 57, 2003, p. 225–238.

[15] Wan, R., Meng, F., Su, E., Fu, W. and Wang, Q. Development of a Classification Scheme for Evaluating Water Quality in Marine Environment Receiving Treated Municipal Effluent by an Integrated Biomarker Approach in Meretrix meretrix. Ecological Indicators. 93, 2018, p. 697–703

[16] Yaacob, R and Mustapa, M. Z. Grain-Size Distribution and Subsurface Mapping at the Setiu Wetlands, Setiu, Terengganu. Environmental & Earth Sciences. 60, 2010, p. 975–984.

[17] Zhuang, S. H. and Wang, Z. Q. Influence of Size, Habitat and Food Concentration on The Feeding Ecology of The Bivalve, Meretrix meretrix Linnaeus. Aquaculture. 241, 2014, p. 689–699.