RELATIONSHIP OF ZOOPLANKTON AND ENVIRONMENTAL PARAMETER WITH EMPHASIS ON COPEPODS AT PULAU TINGGI, JOHOR, MALAYSIA

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PERPUSTAKAAN TUNKU TUN AMINAH

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I dedicate this thesis to my family for their encouragement and prayers, despite the hard time they went through, which gave me the strength to withstand the obstacles embedded throughout my academic struggles. I dedicate this thesis to my parents for their understanding, encouragement, and prayers to my success, despite their old age. I dedicate it to my brothers and friends that contributed immensely to the ideas used in this study.

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ABSTRACT

There is little information on the effect of environmental parameters on the zooplankton biomass and density in the marine ecosystem. This research added on to the knowledge as results proposes statistical modeling including aspects of biomass and density to environmental parameters. The objectives are (i) to determine the impacts of environmental changes on zooplankton density and biomass in the coastal water of Pulau Tinggi, Johor, (ii) To determine the community structure and biodiversity of copepods in the coastal water of Pulau Tinggi Johor, (iii) To apply multiple linear regression model on the relationship between the copepods and environmental parameters in the coastal water of Pulau Tinggi. The collected zooplankton samples were taken to the laboratory of UTHM and further analyzed for density and biomass of 3 size fractions. Environmental parameters were measured *in situ*. Biomass and density of zooplankton were dependent variables while environmental parameters were independent variables. Zooplankton was classified into seven taxonomic groups; copepods, larvaceans, chaetognaths, cnidarians, ctenophores, decapods and polychaetes. The copepods were categorized in to four orders; Calanoida, Poecilostomatoida, Cyclopoida and Harpacticoida. This included a total of 54 species, 26 genera and 19 families of copepods. Calanoida was the abundant group represented by 36 species in our study. The values of diversity index showed that Pulau Tinggi sea grass bed was considered the moderate diverse ecosystem during the research period. Results showed that statistical model of small size zooplankton (< 500 µm) is the best model for the zooplankton biomass. Water depth, turbidity, water current, temperature and salinity were significant variables for small size zooplankton model. This model could be used for the prediction and estimation of zooplankton biomass. The Principal component analysis (PCA) showed that environmental parameters like water current, rainfall, tide, nitrates and rainy days strongly influencing the biomass and density of copepod.

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ABSTRAK

Kesan parameter persekitaran terhadap biojisim dan ketumpatan zooplankton dalam ekosistem marin masih kurang diketahui. Kajian ini akan menambah pengetahuan tersebut dengan mencadangkan model statistik yang mengaitkan aspek biojisim dan ketumpatan dengan parameter persekitaran. Objektif kajian adalah (i) menentukan kesan perubahan persekitaran terhadap ketumpatan dan biojisim zooplankton di kawasan perairan Pulau Tinggi, Johor, (ii) menentukan struktur komuniti dan kepelbagaian kopepod di kawasan perairan Pulau Tinggi Johor, (iii) mengaplikasikan regresi linear berganda dalam mencari hubungan diantara kopepod dan parameter persekitaran di kawasan perairan Pulau Tinggi, Johor. Sampel zooplankton yang diperoleh telah dibawa ke makmal UTHM dan melalui analisis ketumpatan dan biojisim dalam tiga pecahan saiz. Parameter persekitaran diukur secara *in-situ*. Biojisim dan ketumpatan zooplankton merupakan pembolehubah bergerakbalas manakala parameter alam sekitar ialah pembolehubah yang dimalarkan. Zooplankton yang diperoleh telah diklasifikasikan kepada tujuh kumpulan taksonomi; kopepod, larvasea, chaetognath, cnidaria, ktenofor, decapod dan poliket. Kopepod telah dikategorikan kepada empat order; Calanoida, Poecilostomatoida, Cyclopoida, dan Harpacticoida merangkumi 54 spesies, 26 genera dan 19 famili. Calanoida merupakan kumpulan terbanyak dengan 36 spesies ditemui dalam kajian ini. Ketika kajian dilaksanakan, nilai indeks kepelbagaian menunjukkan kawasan rumput laut Pulau Tinggi mempunyai kepelbagaian yang sederhana. Hasil menunjukkan model statistik bagi zooplankton bersaiz kecil (< 500 µm) ialah model terbaik bagi biojisim zooplankton. Kedalaman, kekeruhan, arus, suhu, dan saliniti air merupakan pembolehubah paling bererti bagi model zooplankton bersaiz kecil. Model ini boleh digunakan untuk meramal nilai biojisim zooplankton. Analisis komponen prinsipal (PCA) menunjukkan parameter persekitaran seperti arus air, jumlah hujan, pasang surut, nitrat dan hari hujan mempunyai kesan yang kuat terhadap biojisim dan ketumpatan kopepod.

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LIST OF SYMBOLS AND ABBREVIATIONS

Mg	-	milli gram
µm	-	Micrometer
AFDM	-	Ash free dry mass
AHC	-	Agglomerative Hierarchical Clustering
CVT	-	Coral video transect
DO	-	Dissolved Oxygen
EJIA	-	East Johor Island Archipelagos
GFF	-	Glass fiber filter
LC	-	Luzon Current
MLR	-	Multiple Linear Regression
MSE	-	Mean Square error
NCB	-	Northern Coastal Bay of Bengal
NEC	-	North Equatorial Current
NECC	-	North Equatorial Countercurrent
NEM	-	Northeast monsoon
PCA	-	Principle Component Analysis
POC	-	Particulate Organic Carbon
PWS	-	Prince William Sound
SCB	-	Southern Coastal Bay of Bengal
SIMP	-	Sultan Iskandar Marine Park
SPM	-	Suspended Particulate Matter
STCC	-	Subtropical Countercurrent
SWM	-	Southwest monsoon
TP	-	Total Phosphorus
UTHM	-	Universiti Tun Hussein Onn Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Research background

Adequate information on marine biodiversity and the organism's adaptation are fundamental necessities in arranging estimates anticipated to safeguard organic balance. This knowledge is of specific significance in territories that are enormously influenced by expanding the human population and related anthropogenic exercises. A huge extent of the world's population is focused along the coastline and along the banks of the streams which channel into the beachfront waters. Thus, the impacts of human activities are the most obvious to the near shore waters. In the meantime, man has come to depend intensely on the waterfront waters for sustenance, transportation and entertainment. The two folds effect includes pollution while harvesting plants and animals put an extraordinary strain on a coastal aquatic environment (Matias-Peralta, 2010). The greater part of the world's human population lives within 60 kilometers of the coast, over 90% of the world's fisheries depend somehow on estuarine and nearshore natural surroundings (Smith, 2003). The marine coastal environment has incredible ecological and economic significance. It is delicate and variable due to terrestrial input and open seawater (Kurt and Polat, 2015). They include mangroves, coral reefs and sea grass areas, which support both local and international fisheries.

Sea grass habitats are essential in maintaining environmental and economic functions. Here, habitat is defined as a major ecological area occupied by sea grass community (Ooi *et al*., 2011). Sea grasses trap sediment due to terrestrial run-off. It is considered as a nursery for many invertebrates and fishes. Sea grass beds regarded important ecosystems in tropical coastal waters as biological production and biodiversity (Metillo *et al*., 2018). In addition, this complex ecosystem contains a wide

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variety of biodiversity, especially zooplankton. Being a major component of the marine ecosystem food chain, zooplankton has a key role in the marine ecosystem and act as a link between phytoplankton and higher organisms. Zooplankton study in oceanic as well as in coastal waters suggested that copepods, due to their ubiquitous distribution and high relative abundance, constitute the most important group in marine zooplankton communities.

Zooplankton performs a vital role in the aquatic ecosystem. They connect the primary producers, phytoplankton with the organisms of higher trophic level. Zooplankton was placed as a consumer in the second trophic level (Manjare, 2015). Zooplankton is regarded as the main food for the various species of plankton and invertebrates benthos also the food for commercially important fish in their larval, juvenile and adult stages. (Duarte *et al*., 2014). Mostly all types of fish used zooplankton for their food in their larval phases and some fishes depend on zooplankton as food in their whole lives (Bates, 2007). Zooplankton's importance as fish food both for adults and fry have been studied by various workers (Menon and Pillai, 2001). Zooplanktons are free floating aquatic invertebrates often considered as microscopic because of their usual small sizes that range from a few to several micrometers and rarely exceeding a millimeter (Bhavimani *et al*., 2016). An example of zooplankton is shown in Figure 1.1.

Figure 1.1: Zooplankton (*Calanoida*) image under compound microscope

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Malaysia has one of the biggest continental shelf areas within the tropical world. In comparison to different regions, this area is exceptionally wealthy in biodiversity, and considered to contain the best species diversity within seawater in the world (Mazlan, 2005). There are 13 main islands including Pulau Tinggi in Sultan Iskandar Marine Park (SIMP), Johor. Pulau Tinggi has an area of 16 sq.km and is regarded as the biggest island in SIMP off the East Coast of Peninsular Malaysia in the South China Sea (Tan and Abdul Rahim, 2018). Pulau Tinggi was proclaimed as Marine Park in 1994 under the Fisheries act 1985 and was incorporated into the control of the Department of Marine Parks, Malaysia (Ooi *et al*., 2011). Pulau Tinggi is rich in marine flora and fauna. The presence of coral and seagrasses around this island is probably influenced by the water circulation around the island (Tangang, 2007).

Zooplankton research needs much money to cover sampling effort, renting of the boat as well as assisting human resources. The present study was done to develop a statistical model for the forcasting of zooplankton in sea grass area. The model could be helpful in the determination of marine ecosystem health and the impacts of climate changes on this island. Predicting using models can be used as alternative way instead of doing actual measurements in the field. Zooplankton biodiversity will be helpful to determine the health (water quality) and wealth (fishery productivity) in the sea grass area of Pulau Tinggi.

1.2 Problem statement

Zooplankton plays a vital role in the nutrition of fish, in aquaculture as well as in-caged fisheries (Imaobong, 2013). Zooplanktons are fish food and components of food web interactions. Thus, it is important to understand the biotic and abiotic factors which affect the diversity and density of zooplankton in the marine ecosystem (Helenius, 2015). Moreover, they affect the population of fishes that determine the success and continuity of the fisheries industry. It was reported that in many countries fishery failure was due to the decrease in zooplankton especially copepods (Maqbool *et al*., 2014).

However, despite the importance of zooplankton in food web, the impacts of environmental changes on zooplankton biomass and density in the coastal water of Pulau Tinggi, Malaysia were not studied. Al-Najjar and El-Sherbiny (2008) studied

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the zooplankton biomass in 3 size fractions in the Gulf of Aqaba, Egypt but there is no information on the zooplankton biodiversity in various size fractions in the coastal water of Pulau Tinggi. There is no study in Malaysia regarding the statistical modeling for zooplankton biomass and density estimation. The present study was carried out to develop statistical model for zooplankton using the data collected from sea grass area of Pulau Tinggi. The multiple linear regression was used for the model development.

This research make use of biomass and density of zooplankton, models proposed could be used to determine the relationship between the zooplankton and environmental parameters in the coastal water. Maintaining fish and zooplankton diversity could enhance conservation of marine organisms in Malaysia, as needed in the world.

Biodiversity loss is one of the main environmental issues, undermining important ecosystem services and human benefits. Species disappearing rate is higher now than before the existence of humans (Ceballos *et al.*, 2015). Humans are responsible for the change in the ecosystem and hundreds of species become extinct from the world (Dias *et al.*, 2017). The present world is encountering its sixth "mass extinction event", due to anthropogenic activities, habitat destruction, overexploitation and species invasion (Boivin *et al*., 2016).

1.3 Objectives

The study aims to study the dynamics of the zooplankton population relating to various physico-chemicals and environmental changes at sea grass beds of Pulau Tinggi, Johor. Using biomass and density of the zooplankton models are generated. These models could be useful to relevant authorities in understanding the ecology of the zooplanktons of the waters of Johor Marine Park. The information obtained could be instrumental in ensuring a sustainable fishery industry in Malaysia. To achieve the aim, this project was carried out with the following objectives

i. To determine the impacts of environmental changes on zooplankton density and biomass in the coastal water of Pulau Tinggi, Johor
ii. To determine the community structure and biodiversity of copepods in the coastal water of Pulau Tinggi Johor.

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iii. To apply multiple linear regression model on the relationship between the copepods and environmental parameter in the coastal water of Pulau Tinggi, Johor.

1.4 Hypotheses

On the basis of above objectives, the following null hypotheses were tested:

i. Ho1: Environmental changes had no significant effect on the biomass and abundance of zooplankton.

Ho1 vs Ha_1: Environmental changes had significant effect on the biomass and abundance of zooplankton.

ii. Ho2: There were no significant differences in the community structure and biodiversity of copepods in the coastal water.

Ho2 vs Ha_2: There were significant differences in the community structure and biodiversity of copepods in the coastal water.

iii. Ho3: There were no significant differences in the relationship of copepods with the environmental parameter in the coastal water.

Ho3 vs Ha_3: There were significant differences in the relationship of copepods with the environmental parameter in the coastal water.

1.5 Significance of the research

There was a study by Matias-Peralta *et al*., 2011 on modelling of copepod in the Straits of Malacca. This study added on to the knowledge as results proposes statistical modelling including aspects of biomass and density of zooplankton in relation to physico-chemical parameters as well as environmental changes. As this is the first study on the eastern coast of Johor, results could be applied to the Johor Marine Parks management. Being an important component of the marine organism food chain, the models could be further used to forecast population dynamics of zooplankton in the coastal water.

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