UNIVERSITI PUTRA MALAYSIA

DIVERSITY AND POPULATION DYNAMICS OF ESTUARINE FISHES AND CRUSTACEANS IN MARUDU BAY, MALAYSIA

MOHD AZIM BIN MOHD KHATIB

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By

MOHD AZIM BIN MOHD KHATIB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

December 2014

DEDICATION

To my parents who always kept praying for me to achieve my goal

To my brother and sister

and

To all my friends who supported me all those past years

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree in Master of Science

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Chairperson: S. M. Nurul Amin, PhD

Faculty: Agriculture

A study was conducted on fish composition, spatio-temporal distribution, catch-per-unit-effort (CPUE), species diversity index and population dynamics of selected fishes and crustaceans from the estuarine area of Marudu Bay, Sabah, Malaysia from October 2012 to September 2013. There were five sampling stations (St1 - N 06º 36.169' E 116º 46.400', St2 - N 06º 36.651' E 116º 48.895', St3 - N 06º 36.700' E 116º 47.775', St4 - N 06º 36.751' E 116º 47.816' and St5 - N 06º 37.502' E 116º 47.775') for the study. Each sampling station was approximately 1 km apart from each other. Fish samples were collected by using gill nets. In total, 40 species of fish belonging to 29 families were identified from the estuarine waters of Marudu Bay, Sabah, Malaysia. Among them, 31 species occurred at St1 and St2, 26 species at St3, 25 species at St4 and 29 species at St5. Five species (*Sardinella melanura*, *Gerres oyena*, *Leiognathus equulus*, *Atule mate* and *Sillago sihama*) were the most dominant in the investigated areas. The higher total mean catch-per-unit-effort (CPUE) were observed at St1 (13.70 kg/net/hr) and St2 (13.30 kg/net/hr) which were just 1 and 2 km away from the river mouth, respectively, while lower total CPUE were found at St3 (2.51 kg/net/hr), St4 (1.61 kg/net/hr) and St5 (1.31 kg/net/hr) which were approximately 3, 4 and 5 km away from the river mouth, respectively. The Shannon-Wiener index was significantly higher in the monsoon seasons peaking in the months of January - February and June – August 2013. None of the diversity indices were significant among stations, with the exception of evenness, which was significantly ($p < 0.05$) higher at St3 than St2. The family richness results clearly indicated two peaks in a year; one peak was in December - March and another in August. The abundance of 10 species was found to be correlated (positive or negative) with the water parameters. The highest and significant regression coefficient was observed for *Pseudorhombus cinnamoneus* which indicated that 29% of their abundance was influenced by the major water parameters and the remaining 71% by other factors. The growth, mortality, recruitment and relative yield per recruit of the five selected dominant fish species (*Rastrelliger kanagurta*, *Gerres oyena*, *Atule mate*, *Sillago sihama* and *Sardinella brachysoma*) from Marudu Bay were investigated based on monthly length-frequency data, using FiSAT software. In terms of length-weight relationships, *G. oyena*, *S. sihama* and *S. brachysoma* showed a negative allometric

nature of growth while *R. kanagurta* and *A. mate* showed a positive allometric nature of growth in the estuarine waters of Marudu Bay. For the record, only *G. oyena* had a continuous recruitment pattern with only one major cohort produced per year while the other four other species (*R. kanagurta*, *A. mate*, *S. sihama* and *S. brachysoma*) showed two major recruitment events per year indicating two cohorts were produced in a year. Results from the analysis of the exploitation rate (E) based on the fishing mortality estimates, indicate that the fishery of the selected five dominant fish species in Marudu Bay are below the optimum level of exploitation. This implies that the fish stocks in Marudu Bay are still abundant but any further unrestrained increase in fishing effort in the future might drive the fish stocks down and leads to economic losses.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

DIVERSITI DAN POPULASI DINAMIK IKAN DAN KRUSTASIA ESTUARI DI TELUK MARUDU, MALAYSIA

Oleh

MOHD AZIM BIN MOHD KHATIB

Disember 2014

Pengerusi: S. M. Nurul Amin, PhD

Fakulti: Pertanian

Satu kajian mengenai komposisi ikan, taburan kawasan dan masa, tangkapan-per-unit-usaha, indeks kepelbagaian spesies dan populasi dinamik bagi ikan dan krustasia yang terpilih dari kawasan estuari Teluk Marudu, Sabah, Malaysia telah dijalankan dari Oktober 2012 hingga September 2013. Terdapat 5 stesen (St1 - N 06º 36.169' E 116º 46.400', St2 - N 06º 36.651' E 116º 48.895', St3 - N 06º 36.700' E 116º 47.775', St4 - N 06º 36.751' E 116º 47.816' and St5 - N 06º 37.502' E 116º 47.775') persampelan untuk kajian ini. Setiap stesen persampelan adalah berjarak 1 km antara satu sama lain. Sampel ikan telah dikutip dengan menggunakan pukat hanyut. Secara keseluruhannya, 40 spesies ikan yang berasal dari 29 famili telah dikenal pasti dari perairan estuari Teluk Marudu, Sabah, Malaysia. Di kalangan mereka, 31 spesies ada di St1 dan St2,iii 26 spesies di St3, 25 spesies di St4 dan 29 spesies di St5. Lima spesies (*S. melanura*, *G. oyena*, *L. equulus*, *A. mate* dan *S. sihama*) adalah yang paling dominan di kawasan kajian. Jumlah purata tangkapan-per-unit-usaha (TPUU) yang lebih tinggi diperhati pada St1 (13.70 kg/pukat/jam) dan St2 (13.30 kg/pukat/jam) yang hanya terletak 1 dan 2 km dari muara sungai, manakala jumlah purata TPUU yang lebih rendah telah didapati pada St3 (2.51 kg/pukat/jam), St4 (1.61 kg/pukat/jam) and St5 (1.31 kg/pukat/jam) yang terletak lebih kurang 3, 4 dan 5 km dari muara sungai. Indeks berkepelbagaian Shannon-Wiener ketara pada musim tengkujuh dan musim antara tengkujuh yang memuncak pada bulan Januari – Febuari dan Jun – Ogos 2013. Tiada satu pun indeks kepelbagaian yang menunjukkan perbezaan ketara antara stesen melainkan kesama rataan yang ketara ($p < 0.05$) iaitu lebih tinggi di St3 berbanding St2. Kepelbagaian famili jelas menunjukkan dua puncak pada satu tahun, satu puncak adalah di Disember - Mac dan satu lagi Ogos. Kepadatan 10 spesies didapati mempunyai korelasi (positif atau negatif) dengan parameter-parameter air. Regresi koefisien yang tertinggi dan signifikan diperhati pada *P. cinnamoneus* yang menunjukkan 29% kepadatan *P. cinnamoneus* adalah dipengaruhi oleh parameter air utama dan baki 71% oleh faktor lain. Pertumbuhan, kadar kematian, pemulihan dan hasil perolehan relatif per pemulihan bagi lima spesies ikan dominan yang terpilih (*R. kanagurta*, *G. oyena*, *A. mate*, *S. sihama* and *S. brachysoma*) di Teluk Marudu dikaji berdasarkan data bulanan kekerapan panjang, dengan menggunakan perisian FiSAT. Dari sudut

hubungan panjang-berat, *G. oyena*, *S. sihama* dan *S. brachysoma* telah menunjukkan keadaan alometrik yang negatif bagi pertumbuhan manakala *R. kanagurta* dan *A. mate* menunjukkan keadaan alometrik yang positif bagi pertumbuhan di perairan estuari Teluk Marudu. Untuk rekod, hanya *G. oyena* yang pernah mengalami corak pertumbuhan yang berterusan dengan hanya satu kohot utama yang dihasilkan per tahun manakala empat spesies lain (*R. kanagurta*, *A. mate*, *S. sihama* and *S. melanura*) menunjukkan dua sesi pemulihan per tahun menunjukkan dua kohot dihasilkan dalam setahun. Kadar eksploitasi (E) bagi lima spesies ikan dominan yang terpilih di Teluk Marudu adalah di bawah tahap optimum eksploitasi. Ini bermaksud stok ikan di Teluk Marudu masih banyak tetapi sebarang peningkatan kekerapan usaha perikanan tanpa pengawalan pada masa hadapan akan menyebabkan penurunan stok ikan seterusnya mengakibatkan kerugian dari segi ekonomi.

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I certify that a Thesis Examination Committee has met on 16 December 2014 to conduct the final examination of Mohd Azim bin Mohd Khatib on his thesis entitled "Diversity and Population Dynamics of Estuarine Fishes and Crustaceans in Marudu Bay, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Che Roos b Saad, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Annie Christianus, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Ahmed Jalal Khan Chowdhury, PhD
Professor
Kulliyyah of Science
International Islamic University Malaysia
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 26 February 2015

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree in Master of Science. The members of the Supervisory Committee are as follows:

S.M. Nurul Amin, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Aziz Arshad, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
b	Growth coefficient of length-weight relationship
CI	Confidence interval
CPUE	Catch per unit effort
D	Family richness
DO	Dissolved oxygen
E	Exploitation rate
E_{max}	Maximum allowable limit of exploitation
ELEFAN	Electronic Length Frequency Analysis
FiSAT	FAO ICLARM Stock Assessment Tools
FAO	Food and Agriculture Organization
H	Shannon -Wiener of diversity
J	Pielou's evenness index
K	Growth co-efficient of VBGF
Lc	Length at first capture
$L\infty$	Asymptotic length
L_{max}	Predicted extreme length
M	Natural mortality
ML	Mid length
MSY	Maximum Sustainable Yield
N	Number of individuals
PRIMER	Plymouth Routines In Multivariate Ecological Research
R^2	Regression coefficient
Rn	Response surface
SE	Standard error
SPSS	Statistical Package for Social Science
St	Station
TL	total length
Wt	Weight
Z	Total mortality
φ'	Growth performance index

^{0}C	Degree Celsius
%	Percentage
<	Less than
>	More than

CHAPTER 1

GENERAL INTRODUCTION

1.1. Background of the study

Fish is well known around the world as a cheap source of protein. Stock assesssment and study of population dynamic of commercial fishes are important in estimating nations' performance in capture fisheries. A given population grows or shrinks over time, as controlled by birth and death, as well as emigration or immigration, which can be described as population dynamics (Krause *et al.*, 1998). Understanding fisheries patterns and issues such as habitat destruction, predation and optimal harvesting rates are the basis of population dynamic studies (Kohlers *et al.*, 1995). Over-simplistic modeling of fisheries has resulted in the collapse of key stocks (Anderson & Gutreuter, 1983). Therefore, care is needed when applying population dynamics to real world fisheries (Pauly, 1984). In fish stock assessments, knowledge of length-weight relationships is crucial in estimating the standing stock biomass and comparing the developmental history of fish populations from different regions (Odedeyi *et al*., 2007; Petrakis and Stergiou, 1995).

The planning and management of aquatic species resources cannot be acheived until an understanding of various population parameters such as asymptotic length (L_∞) and growth coefficient (K), mortality (natural and fishing) and exploitation level (E) is obtained. There are many tools in estimating various population parameters and status of stocks. Of these, FiSAT (FAO-ICLARM Stock Assessment Tools) is often used to estimate population parameters of fishes and shrimps (Amin *et. al.*, 2006; Jayawardane *et. al.*, 2003; Papaconstantinou and Kapiris, 2001; Tuaycharden *et. al.*, 1988) as it only requires length-frequency data. It is imperative that any fish stock can be accessed via this technique within 1 year if sufficient length-frequency data is available.

Nowadays, the management of fish production and yield in estuarine areas should be monitored carefully by authorities to prevent over-fishing. Basically, the high rate catch of trash fish or by-catch are known to be harmful to estuarine ecosystems (Murawski, 1991). Long-term effects of constant declination of fish stocks in estuaries will become evident if fishermen and the authorities do not take on their respective roles (National Oceanic and Atmospheric Administration, 1991). Frankly, it is difficult to predict the actual yield of estuarine fishes as the trophic dependencies and transfer efficiencies limits of estuaries are varied according to seasons and climate (Peters and Schaaf, 1991).

1.2. Statement of the problems

The fisheries sector in Malaysia plays an essential socio-economic role as Malaysia is one of countries in South-east Asia that is blessed with a vast coastline. After the implementation of the Malaysian Exclusive Economic Zone (EEZ) in 1981, the total fishing grounds of Malaysia has been extended to 548,800 km^2 (Abu Talib *et al.*, 2003). Additionally, the EEZ implementation in this country has proved to emulate and enhance the development of the nation's employment, fish export (transaction of foreign exchange) and, more importantly, to supply enough food for a growing

population of people (Biusing, 2001). Moreover, the Department of Fisheries (DoF) in Malaysia had found that the enforcement of the EEZ has helped the country to achieve at least a 5% growth rate in the investment of the fisheries sub-sector and it is estimated that by the year 2010, the total national fish production will be worth RM 9.36 billion with 1.93 million metric tonnes in total weight (Rayner, 2001).

Geographically, the state of Sabah is located in the northern part of Borneo Island. This state is well known for its large area, which is estimated to be about 74,236 km^2 and with a total coastline length, including islands and lagoons, is about 4,315 km thus making it the state in Malaysia with the longest coastline (Chia, 1992). Furthermore, the state enjoys a high rate of growth in the fisheries sector, although the tourism industry remains the main sector in driving the economic growth of the state (Sabah Tourism, 2002). Basically, there are three main fishing grounds (zones) in Sabah, comprised of the West coast region, Kudat coast region and East coast region (Ambak, 2002).

As one of major estuarine areas in Sabah, Marudu Bay, which is located on the northern part of Sabah, it plays a significant role as fishing areas for local fishermen (Weatherly and Mannan, 1982). Many commercially important aquatic species are known to inhabit the area, due to the fact that the bay is largely fringed with mangroves (Fatimah *et al.*, 2012). Unfortunately, the recent decline in the catch composition of fishes seems to be one of major problems of overfishing and degradation of the environmental parameters in Marudu Bay (Chong *et al.*, 2010). Several studies which were related to examining the sustainability of mangrove ecosystems have been conducted in the mangrove area of Marudu Bay (Chong, 2006; Jakobsen *et al.*, 2007; Faridah-Hanum *et al.*, 2012). There is, however, no published report on population dynamics or the exploitation status of some commercially important estuarine fishes and shrimps in Marudu Bay. Therefore, the aim of this study was to determine the status of fisheries stock in Marudu Bay, Sabah.

1.3. Objectives of the study

The general objective of the study was to document the assessment of exploited fisheries stock in Marudu Bay, Sabah, for sustainable management. The following specific objectives were undertakened in order to achieve the overall objective of the study:

(a) to identify the fishes to the species level found in the estuarine areas of Marudu Bay, Sabah.

(b) to determine the fishes spatio-temporal distribution, catch-per-unit-effort and diversity in the Marudu Bay, Sabah.

(c) to estimate the population parameters such as asymptotic length (L_∞), growth co-efficient (K), fishing mortality (F), natural mortality (M), total mortality (Z), recruitment pattern, exploitation rate (E), yield per recruit (Y/R) and biomass per recruit (B/R) of five commercially important estuarine fishes from Marudu Bay, Sabah.

1.4. Organization of the study

This thesis is divided into seven chapters. Fisheries stock overview and assessment, the problem statement, significance of the study, objectives and link among chapters are discussed in the introduction (Chapter 1). Chapter 2 provides a review of relevant literature that serves as a rational background for understanding research problems and to develop appropriate methodologies to address the study objectives. General researh methodology is presented in chapter 3. Chapters 4, 5 and 6 report the experimental results of the study, including detailed methodology and statistical analysis. The concluding chapter 7 represents the summary, conclusion and recommendations for future research which also includes policy suggestions.

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