UNIVERSITI PUTRA MALAYSIA

CATCH COMPOSITION, DIVERSITY AND TEMPORAL CHANGES IN TRAWL NET FISHERY IN INSHORE WATERS OF BINTULU COAST, SARAWAK, MALAYSIA

UTTAM KUMAR

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By

UTTAM KUMAR

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

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DEDICATION

I would like gto dedicate this work to those who taught, motivated and helped me throughout my study. To my respected father and mother who sacrificed their golden time for my study abroad. And my mother, who always keep praying for me day and night to achieve my goal

and

To all my friends, teacher and colleague who supported me all those past years

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

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January 2019

Chairman: **Associate Professor Abu Hena Mustafa Kamal, PhD**
Faculty: **Agriculture, Science and Technology, Bintulu Campus**

Declining diversity is a common problem in many habitat especially in inshore waters. Past researches reported that trawl fisheries has been damaging inshore ecosystem over the last few decades. Trawl net is the most common fishing gear operating in Sarawak as well as Malaysian inshore waters. Few studies on fish composition, population dynamics has been done in coastal waters of Bintulu, Sarawak. Despite it has significant contribution to the Bintulu fisheries economy, the studies on the composition and diversity of trawl net fishery is poorly understood. Therefore, temporal changes in diversity and composition of the fisheries assemblages in association with ecological factors in Bintulu inshore waters were examined on collected data from trawl net fishing over four seasons of Southwest monsoon (SWM), Inter-monsoon October (IMO), Northeast monsoon (NEM) and Inter-monsoon April (IMA) of 2016-2017. Furthermore, length-weight relationships of most abundant and unreported species caught by trawl net were analyzed. A total of 63 species belonging to 40 families were identified where, 11 species found omnipresent. Species diversity was recorded higher (H´=2.61) in NEM and lower (H´=0.51) in IMA. Among the species *Kurtus indicus* was the highest abundant (58% of the total catch) followed by *Photopectoralis bindus* (15%), and *Opisthopterus tardoore* (7%). Fish abundance showed significant temporal changes but species diversity, plankton abundance were not significant with temporal difference. Temperature, salinity, pH, dissolved oxygen (DO) and rainfall showed classical temporal difference ($P<0.05$). No significant temporal difference was found on chlorophyll *a* and water nutrients. Canonical Correspondence Analysis (CCA) indicated that dissolved oxygen, total suspended solid (TSS), rainfall and salinity were the most important ecological factors affecting fish assemblage structure. Relation of ecological parameters with individual species (Spearman rank) like *Secutor interruptus* were significantly correlated with DO ($P<0.001$; $r2=0.898$). In terms of temporal impact on parameters (Rank Analysis-Wilcoxon), SWM showed parallel similarity with environmental parameters and fish abundance. The highest abundant *Kurtus indicus* showed significant positive correlation with TSS, salinity and conductivity and negative correlation with temperature ($P<0.05$; $r2=-0.618$). Comparing to existing database, 84% from captured species has commercial value and among those 38% were encountered in trawl net as juvenile. Among the analyzed species, *Nibea semifasciata, Filimanus similis, Opisthopterus tardoore and K. indicus* showed positive allometric growth ($b=3$), which indicates the food availability and the overall supportive environment were good for those species. Fish composition and diversity in the inshore waters of Bintulu discovered immensely rich and highly related to eco-biological factors in this study. The findings of this study would help to understand the inshore fishery resources, status and its ecosystem profile which will help to manage this fishery resource of Bintulu as well as Sarawak, South China Sea region in future.

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

KOMPOSISI TANGKAPAN, DIVERSITI DAN PERUBAHAN MUSIM DALAM PERIKANAN TRAWL NET DI PERAIRAN PESISIRAN PANTAI DI BINTULU, SARAWAK, MALYASIA

Oleh

UTTAM KUMAR

January 2019

Pengerusi: **Profesor Madya Abu Hena Mustafa Kamal, PhD**
Fakulti: **Pertanian Sains dan Teknologi, Kampus Bintulu**

Penurunan diversiti merupakan masalah yang sering dihadapi di kebanyakan habitat terutamanya di perairan pesisir pantai. Kajian lepas mendapati, aktiviti perikanan menggunakan trawl net, telah merosakkan ekosistem pesisir pantai sejak bebarapa dekad yang lepas. Trawl net merupakan peralatan penangkapan ikan yang paling biasa digunakan di perairan pesisir pantai Sarawak dan juga di Malaysia. Beberapa kajian tentang komposisi ikan dan dinamik populasi telah dijalankan di kawasan perairan Bintulu. Walaupun memberi sumbangan yang signifikan terhadap ekonomi perikanan Bintulu, Sarawak. Kajian tentang komposisi dan diversiti perikanan trawl net masih kurang difahami. Oleh itu, kajian tentang perubahan musim dalam diversiti dan komposisi perkumpulan ikan yang berkaitan dengan faktor ekologi di perairan pesisir pantai di Bintulu telah dijalankan dengan mengumpul data dari perikanan *trawl net* selama empat musim iaitu, monsun barat daya (MBD), monsun Inter-Oktober (MIO), monsun timur laut (MTL) dan monsun Inter-April (MIA) pada tahun 2016-2017. Selain itu, hubungan panjang-berat spesis terbanyak dan sepsis yang tidak dilaporkan yang ditangkap melalui trawl net juga dianalisa. Sebanyak 63 spesis yang terdiri daripada 40 famili telah direkodkan, di mana terdapat 11 spesis dijumpai secara meluas. Diversiti spesis (H´=2.61) direkodkan lebih tinggi pada MTL dan lebih rendah (H´=0.51) pada MIA. Spesis *Kurtus indicus* merupakan spesis terbanyak (58% daripada jumlah tangkapan) diikuti dengan *Photopectoralis bindus, Opisthopterus tardoore* dan *Leiognathus equulus*. Perubahan musim memberikan kesan signifikan terhadap taburan ikan walaubagaimanapun, diversiti spesis dan taburan plankton tidak menunjukkan kesan signifikan terhadap perubahan musim. Suhu, kemasinan, pH, oksigen terlarut dan taburan hujan menunjukkan kelainan musim yang klasik ($P<0.05$). Tiada kesan signifikan ditunjukkan oleh klorofil *a* and nutrisi air. *Canonical Correspondence Analysis (*CCA) menunjukkan oksigen terlarut, secchi-kejernihan, jumlah pepejal terampai, taburan hujan dan kemasinan merupakan faktor ekologi yang paling penting yang mempengaruhi struktur perkumpulan ikan. Hubungan antara parameter ekologi dengan spesis individu (Spearman rank) seperti *Secutor interruptus* menunjukkan korelasi yang signifikan dengan oksigen terlarut ($P<0.001$; $r2=0.898$). Kesan musim terhadap parameter (Rank Analysis-Wilcoxon), MBD menunjukkan persamaan yang selari dengan parameter alam sekitar dan taburan ikan. Taburan yang tertinggi (*Kurtus indicus*), menunjukkan korelasi positif yang signifikan dengan jumlah pepejal terampai, kemasinan, dan konduktiviti dan berkorelasi negatif dengan suhu ($P<0.05$; $r2=-0.618$). Setelah dibandingkan dengan data sedia ada, 84% daripada spesis tangkapan mempunyai nilai komersial dan 38% daripada peratusan tersebut, yang ditangkap menggunakan *trawl net* merupakan spesis yang masih juvana. Diantara sepsis yang telah dianalisa, *Nibea semifasciata, Filimanus similis, Opisthopterus tardoore* dan *K. indicus* menunjukkan tumbesaran alometrik positif ($b=3$), yang menandakan keberadaan makanan dan persekitaran yang baik untuk spesis tersebut. Komposisi dan diversiti ikan di persisir perairan pantai di Bintulu dalam kajian ini membuktikan kekayaan diversiti dan berkait rapat dengan faktor eko-biologi. Penemuan daripada kajian ini dapat meningkatkan pemahaman tentang sumber perikanan persisiran pantai, status dan ekosistemnya dimana ianya akan membantu dalam pengurusan sumber perikanan di Bintulu, dan juga di Sarawak, kawasan Laut China Selatan pada masa akan datang.

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Uttam Kumar

This thesis was submitted to the Senate of University Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Masters by Research. The member of the Supervisory committee were as follows-.

Members of the Thesis Examination Committee were as follows:

Abu Hena Mustafa Kamal, PhD
Associate Professor
Faculty of Agriculture, Science and Technology
Universiti Putra Malaysia, Bintulu Campus
(Chairman)

Amy Halimah Binti Rajaee, PhD
Senior Lecturer
Faculty of Agriculture, Science and Technology
Universiti Putra Malaysia, Bintulu Campus
(Member)

Mohd Hanafi Idris, PhD
Associate Professor and Deputy Dean
School of Fisheries and Aquaculture Science
Universiti Malaysia Terengganu
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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LIST OF ABBREVIATIONS

Amate	*Atule mate*
CCA	Canonical Corresponded Analysis
DO	Dissolved Oxygen
e. g.	Exampli gratia or For example
FL	Fork Length
FRP	Fibre reinforced plastic
Fsim	*Filimanus similis*
g/b/t	grams/boat/per fishing trip
GRT	Gross Registered Tonnes
IMA	Inter Monsoon April
IMO	Inter Monsoon October
ind.m^{-3}	Individual per cubic meter
Kind	*Kurtus indicus*
Leq	*Leiognathus equulus*
n	Number
n.b	Nota bene
n.e.	Not established in FishBase
NEM	North East Monsoon
NTU	Nephelometric Turbidity Unit
Otar	*Opisthopterus tardoore*
Pbin	*Photopectoralis bindus*
SCS	South China Sea
Sint	*Secutor interruptus*
SL	Standard Length
SL_{max}	Standard Length Maximum
Sp.	Species
SWM	South West Monsoon
TL	Total Length
TSS	Total Suspended Solid
UPMKB	Universiti Putra Malaysia Kampus Bintulu

CHAPTER 1

INTRODUCTION

Malaysia has one of the highest faunal diversity in the world, and the coasts of Malaysia favor the world's richest sites for fishes (Arai, 2015). Additionally, Malaysian coast of South China Sea (SCS) is one of the world's 12 mega-diversity centers and belongs to one of the six countries of the coral triangle, which shifts the highest biodiversity enriched coral reefs of the world with more than 3365 fish species (Arai, 2015).

Species composition is the basic study to observe on an ecosystem and to take management policy. It is a growing need for current world when the earth is observing severe carbon dioxide influx to the environment and warming up the sea consequencing species extinction, habitat deformation as well as debilitating the trophic ecosystems. Observing species composition could sum up with decision of conservation planning, giving the trophic functioning, record for future policy making and the change detection study. Now a day's marine ecosystem in all over the world witnessing serious habitat loss due to coral bleaching, overfishing and associated bycatch and discard. Plastic especially micro plastic accumulation into the marine species is concern of world interest which not only causing marine pollution but deliberating alarming level of food associated human catastrophe. Species diversity is another terms of concern for marine ecology conservation and an indicator for health of an ecosystem. Marine pollution, selective fishing gear, global warming, and exotic or excessive single species recruitment causing biodiversity loss all over the world. Apart from that, habitat loss is a strong destructive reason for degrading biodiversity in sea. Knowledge about ecosystem conservation was less mostly unaccusable to seek interest of greater community unlike technological advancement of present days. Many international organizations are working to transfer conservation knowledge to mass concern and taking measures to resist possible extinctions. Though there is growing concern of conservation, yet the level of literacy on ecosystem conservation is still a major hindrance (Bjorkland and Pringle, 2001).

One of the major limitation about conservation approaches for current time is the science of exact number of species is not concrete and might be underestimated. Therefore, the extinction rate of species is so high because of human disturbance and climate change that the pace of the conservation approaches merely touch the species before it get extinct. The current extinction rate is 100 to 1000 time higher than the past rate which is very alarming that a mass extinction would devastate the earth's diversity into an unpredictable stage which is caused mainly by human activities (Pham, 2015). In past data inadequacy with irregular bias sampling, lack of compilation from surveyed data, geographic coverage has made the effort comparatively less effective (Hortal et al., 2007). Some studies for Bintulu marine fisheries has been done, yet there is significant lack of conservation measures. The South China Sea (SCS) of Malaysian waters are generally divided into four sub-areas; the west and the east coast of Peninsular Malaysia, the coast of Sarawak and the coast of Sabah. Like many coastal countries, most of the human settlement in Sarawak has been established near SCS coast including Bintulu. All of the commercial development such as sea port activities, oil and gas exploitation, tourism, light and heavy industries, fishing and fisheries industrial activities in Bintulu has been established based on coastal resources and its utility. Most of the fishing activities have done within 30 km from the shore in Bintulu where trawl net fishing is the superior fishing gear. Tropical estuaries of the Indo-West Pacific are inhabited by more fishes than their temperate counterparts (Day et al., 1989) and estuaries along with inshore fishing areas are supporting the rural economy such as Kuala Nyanalu, Bintulu. Fishing has been considered as the most widespread human exploitative activity in the coastal environment and has significant direct and indirect effects on habitat, diversity, community structure (Jennings and Kaiser, 1998). These effects can be measured by comparing the structure of fish composition through sampling over time intervals (Pet-Soede et al., 2001).

Marine species from intertidal zone are subject to influenced by environmental conditions that change over a variety of time scales (Selleslagh and Amara, 2008). Inter season fluctuation in water temperature, turbulence, and other water factors creat different stressors on intertidal organism including fishes (Horn et al., 1999). Likewise, marine environment in Sarawak and Sabah are influenced to a very large extent by monsoon pattern (Garces et al., 2003). In fact, almost every feature of the oceanographic environment of the SCS is conditioned by the monsoons (Saadon et al., 1997). Surface currents in the SCS flow in

accordance with the monsoon-driven wind system. As the largest marginal sea in the tropics, the SCS exerts a significant influence on climate change playing a significant role in water mass and energy exchange between the Pacific and Indian Oceans (Zeng et al., 2014). Two transitional periods occur between these two monsoons, in April and in October, respectively when both transitional periods last from about three to seven weeks (Morgan and Valencia, 1983). Although the abundance of fish can be correlated with environmental variables, the actions and interactions of these variables are often so complex that the cause-effect relationships cannot be explain unequivocally (Ansari et al., 1995).

Fish stock assessment has always been required for fisheries management and necessity for such information has been increased now a day to determine the effects of fishing (Jalal et al., 2012). As in Sarawak, reliable fish stock assessment is not readily available (Rajali et al., 1998). A total of 13 surveys have been conducted off the coast of Sarawak and the west coast of Sabah since 1972 (Abu Talib et al., 2003) when the fisheries resources of Sarawak are such that major fishing took place in the near shore waters (Garces et al., 2003). Moreover, limited studies on changes in species composition and abundance over time in marine or other ecosystem (Choo, 1998) and fish assemblage structure (Nyanti et al., 2014) has been done. However, studies on species composition and diversity in relation to temporal changes of ecological factors are not well documented (Abu Hena et al., 2016) nor any detail study on trawl net fishery in Sarawak waters, Malaysia. Therefore, in the present study it was considered that the trawl net fishery in Bintulu inshore waters is hypothetically rich in composition and biodiversity and has significant correlation with ecological parameters temporally. The outcomes of this study will help to make decisions for marine ecologist, conservationist as well as Bintulu coastal policy makers and will work for future study on Bintulu coastal waters resources, Sarawak, SCS.

1.1 Objectives

i. To relate the temporal changes of catch composition and diversity of fish caught by trawl net
ii. To measure the temporal variation in ecological parameters and relate with fish assemblages
iii. To estimate the length-weight relationships for common species caught by trawl net

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