Technical Efficiency Performance of *Terubok* Fisheries in Sarawak

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Technical Efficiency Performance of *Terubok* Fisheries in Sarawak

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DECLARATION

I declare that the work of this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. It is original and is the result of my work, unless otherwise indicated or acknowledged. This thesis has not been accepted for any degree and is not concurrently submitted in candidature for any other degree.

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ABSTRACT

Terubok fish is an estuarine fish that is significant among local fishermen and in recent years, Sarawak has experienced a declining trend in the *Terubok* production. In order to increase

the production of the *Terubok* fish supply, the fishermen have to focus more on the production efficiency of the fisheries. Hence, this study was carried out to analyse the efficiency performance of *Terubok* fisheries in Sarawak. A sample of 200 active *Terubok* fishermen was selected through stratified random sampling and field survey were conducted in core areas of *Terubok* fish. Data Envelopment Analysis (DEA) and Tobit analysis were employed to determine the technical efficiency level and factors influencing technical efficiency among *Terubok* fishermen. The results showed that the level of technical efficiency, pure technical efficiency and scale efficiency was estimated at 0.304, 0.406 and 0.805 respectively. The regression results showed that there was a nexus between efficiency and hours in a day, days spent fishing in a month, engine horsepower and fishermen's association; while age, education, distance and length of vessels showed a negative relation towards efficiency. Additionally, age and hours of fishing were found to be significant with technical efficiency. These findings suggest that there is much room for improvement in efficiency among a large segment of *Terubok* fishermen. Thus, with appropriate training and the use of more advanced technologies of the fishermen, the level of *Terubok* fishermen's efficiency can be raised.

Keywords: Data envelopment analysis, *Terubok* fisheries, Tobit regression

Prestasi Kecekapan Teknikal Perikanan Terubok di Sarawak

ABSTRAK

Ikan Terubok adalah ikan muara yang penting dalam kalangan nelayan tempatan dan pada tahun-tahun kebelakangan ini, Sarawak telah mengalami tren menurun dalam pengeluaran

ikan Terubok. Untuk meningkatkan pengeluaran bekalan ikan Terubok, para nelayan perlu memberi tumpuan lebih kepada kecekapan pengeluaran perikanan. Oleh itu, kajian ini dijalankan untuk menganalisis prestasi kecekapan perikanan Terubok di Sarawak. Sampel 200 nelayan Terubok yang aktif dipilih melalui pensampelan rawak berstrata dan tinjauan lapangan dijalankan di kawasan teras ikan Terubok. Analisis Pensampulan Data (DEA) dan analisis Tobit digunakan untuk menentukan tahap kecekapan teknikal dan faktor yang mempengaruhi kecekapan teknikal di kalangan nelayan Terubok. Keputusan menunjukkan bahawa tahap kecekapan teknikal, kecekapan teknikal asas dan kecekapan skala dianggarkan masing-masing pada 0.304, 0.406 dan 0.805. Hasil regresi menunjukan bahawa terdapat hubungan antara kecekapan dan jam dalam sehari, hari-hari yang dibelanjakan memancing dalam sebulan, tenaga kuda enjin dan persatuan nelayan; manakala umur, pendidikan, jarak dan panjang kapal menunjukkan hubungan negatif ke atas kecekapan. Di samping itu, umur nelayan dan masa memancing didapati signifikan dengan kecekapan teknikal. Penemuan ini mencadangkan terdapat banyak ruang untuk meningkatkan kecekapan di kalangan segmen besar nelayan Terubok. Sehubungan itu, dengan latihan yang sesuai dan penggunaan teknologi yang lebih maju bagi para nelayan, tahap kecekapan nelayan Terubok dapat ditingkatkan.

Kata kunci: *Analisis pensampulan data, perikanan Terubok, regresi Tobit*

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CHAPTER 1

INTRODUCTION

1.1 Introduction

As part of people's main economic activities, fishing plays an outstanding role in the lives of populations around the world. Fish is a major source of food that provides nutrients and micronutrients needed for humans' cognitive and psychological development. Fish also constitutes almost two thirds of humans' animal protein supply and is more than half of the protein consumed in Malaysia (Labon, 1974). Other than that, fishing and other related occupations are an important source of income in rural areas. This sector supports the livelihood of about 8 – 12% of the global population, with 90% of these people directly depending on fisheries and aquaculture to live (Jentoft & Chuepagdee, 2015). Fisheries is a fundamental part for community and make important contributions to economic and wellbeing to developed and developing countries. It has been estimated that 60 million are employed in fisheries activities. The global production of fisheries products has tended around 90.9 million tonnes in 2016 (Food & Agriculture Organization, 2018). The products from these productions are used in a wide variety of business, such as from local consumption to around the world trade because the growing demand of fish and highly commercial value.

Despite this enormous importance and value, the world's fish resources are suffering the combined effects of heavy exploitation and environmental degradation (Garcia & Grainger, 2005). During 2015, there are 67% of the assessed fish stock were estimated to be exploited at biologically sustainable level (Food & Agriculture Organization, 2018). For example, the declining trend of inshore and coastal fisheries resources provides one of the catalysts behind

the transformation of Malaysia's fisheries policy towards the expansion of its domestic offshore fishing sector. Thus, overexploitation of demersal, pelagic and cephalopod species in the inshore and coastal waters of Malaysia has been academically documented since the 1970s (Silvestre, 2003). Other than that, most of the major coastal fishing ground in Southeast Asia, there is a conclusive evidence pointing to a marked decline in the biomass of the demersal and pelagic species in the coastal waters of the country, this is evident in the water off the west and east coast of Penisular Malaysia, as well as Sarawak coast (Ahmad et al., 2015).

A sustainable fishery helps sustain fish stocks, markets, fishers, and communities. The longterm sustainability of a fishery depends on respecting ecological limits identified through the use of reliable scientific information (Daw & Gray, 2005). Respecting these limits requires taking into account the ecosystems on which fish survival depends and uncertainties about how the ecosystem will change. Therefore, the fisheries industry contributes to rural development and poverty suppression around the world and promotes the socio-economic growth of a country. Although aquatic resources are renewable, they need to be properly managed with knowledge and development so that the supply of fish can be sustained (Caddy et al., 2005).

1.2 Overview of World Fisheries

In the history of the fisheries industry, fishermen have been thought of as a key factor in the rapid development of fish and fisheries production. The Food and Agriculture Organization (2018) reported that globally, a total of 59.6 million people was involved in the fisheries and aquaculture sectors in 2016. The past decade has seen the rapid development of fishermen in rural areas. Fisheries are important to generate income, either as main or additional

income. Many fishermen solely depend on fisheries and aquaculture to continue their livelihood. From the 59.6 million people engaged in this industry, 68% play the main role in fishing activities, while the remaining are involved in aquaculture. The number of fishers and fish farmers has decreased by 0.8% from year of 2015, indicating the stabilisation of employment mainly in marine capture due to the decrease in fishing efforts on the reason of the declining number of fish population (Gracia & Grainger, 2005). However, small scale operation fisheries still play a critical role in supporting rural livelihoods and contribute to food security and the alleviation of poverty, especially in developing countries.

More than 10% of the world population depend on fisheries for their livelihoods, and most of them are located in the Asian region. In terms of global fisheries production, 90.9 million metric tonnes were produced in 2016, a decrease of 1.9% from the previous year, which was at 92.7 million metric tonnes (FAO, 2018). The total fisheries production can be further divided into marine and inland capture. In 2016, marine catches by the fishermen around the world were 79.3 million metric tonnes, a decrease 2.4% compared to the previous year at 81.2 million metric tonnes have been produced in 2015. On the other hand, inland capture globally produced 11.6 million metric tonnes in 2016, increased 1.7% from 2015's production of 11.4 million metric tonnes. In 2016, 25 countries were recognised as major producers of fisheries production as they together contributed 64 million metric tonnes of marine capture out of the 79.3 million metric tonnes of the world's marine production.

Based on Table 1.1, since 2005, China has become a large producer of fisheries production globally with 15.3 million metric tonnes in 2016, followed by Indonesia with 6.1 million metric tonnes, and the United States of America (USA) with 5 million metric tonnes, and the United States of America (USA) with 5 million metric tonnes.

Table 1.1: Global Marine Landings

Country	**Production (tonnes)**		
	Average 2005 – 2014	2015	2016
China	13,189,273	15 314 000	15,246,234
Indonesia	5,074,932	6,216,777	6,109,783
USA	4,757,179	5,019,399	4,897,322
Russia	3,601,031	4,172,073	4,466,503
Peru	6,438,839	4,786,551	3,774,887
India	3,218,050	3,497,284	3,599,692
Japan	3,992,458	3,423,099	3,167,610
Vietnam	2,081,551	2,607,214	2,678,406
Norway	2,348,154	2,293,462	2,033,560
Philippines	2,155,951	1,948,101	1,865,213
Malaysia	1,387,577	1,486,050	1,574,443
Chile	3,157,946	1,786,249	1,499,531

Source: Food and Agriculture Organization (2018)

China's recent capture trends have led to a big gap between the country and other major producers with a variation of 60% - 95% in terms of marine fisheries production. To date, China's Fisheries Authorities (CFA) has adopted a strict management system to maintain and monitor production in terms of input control in accordance to the Regulation of Capture Fisheries Permit Management that was issued in 2002 (Zhang & Wu, 2017). This strategy enables the CFA to overcome the overall fishing capacity quota of capture and limitations to fishing vessels and gears. In addition, along with strategy and management concerning the sustainability of aquatic resources, China has also introduced hard-hitting punishments against overfishing and illegal fishing in order to protect the fish population in its Economic Exclusive Zone (EEZ). Fishing activities are the leading cause of high participation in the fisheries sector in Asia, where there is a growing population who are increasingly

economically active in the agricultural sector. This contributing factor serves as the reason behind Asians' high engagement in this sector.

1.2.1 Fish Trade, Utilization and Consumption

The demand for fish and fisheries products on the international market grows every year, while the supply is quite far from being totally delivered globally (Tall, 2002). Over the past century, there has been a great increase in fish import and export activities around the world. Several reasons found to be influencing the fish trade have been explored in several studies. First, trade in fish products is much more important than trade in many other food products. For example, 35% of global fish and fisheries products enter international trade; this indicates that the fisheries sector is incredibly globalised and vital. This fact in turn increases local production in domestic production factories. Moreover, trade flows all over the world for foreign exchange. Fish products travel from their source of origin through the production process and distribution channels and lastly, to consumers. Second, most of the production in the fisheries sector takes place in developing countries where these countries produce, process and export their fisheries products. The recent tremendous increase in fish trade indicates the importance of export activities and the distribution process which increases the economic value generated by a country through opportunities in employment and other activities related to fisheries products locally (Pithawala, 2017).

Furthermore, the fish trade is also significant to the economies of many developing countries that depend on their fisheries production, process and trade in order to obtain economic benefits from their natural aquatic resources. Lastly, so much of the trade takes place between developing and developed countries because countries like Germany, the United

Kingdom and the USA rely on imports from Malaysia, Vietnam and Indonesia to satisfy the needs of their domestic consumers with a variety of fish products. Fish trade plays an important role in the maintenance of fish supply among developed countries. As shown in Table 1.2, since 1976, the total export of fisheries products is on an upward trend, with 60 million metric tonnes equivalent to USD143 billion exported in 2016 (FAO, 2018).

Table 1.2: World Exports of Fish and Fishery Products

Country	**2006**	**2016**
	Value (million USD)	**Value (million USD)**
China	8,968	20,131
Norway	5,503	10,770
Vietnam	3,372	7,320
Thailand	5,267	5,893
USA	4,143	5,812
India	1,763	5,546
Chile	3,557	5,143
Canada	3,660	5,004
Denmark	3,987	4,696
Sweden	1,551	4,418
Top ten subtotal	41,771	74,734
Rest of the world total	44,523	67,796
World total exports	86,293	142,530

Source: Food and Agriculture Organization (2018)

China has become the largest exporter, importer and main producer of fish products entering the USA, Japan and other countries globally. China's export of fisheries products has gained the country USD20.5 billion in 2017. Along with its growth as the third largest importer of fisheries products in the world, the country has also managed to process import products from other countries and export it as new seafood products not produced naturally along its distribution channels (international market). Based on Table 1.2, Norway is the largest

exporter of salmon and rainbow trout (USD10.7 million), followed by Vietnam whose exports had reached USD7.320 million in 2016. Next, the highest importer of fish and fisheries products in the world is the USA with a total of USD20.5 million of imports from China, Japan and South Korea (CNBC, 2017). As a developed country with high income consumers and a large urban population, the country's high demand for fisheries products has outpaced its domestic production; thus, the USA depends on imports to match its consumers' demand. Table 1.3 shows that Japan is the second largest importer of fisheries products from China, Chile and Thailand with a total of USD13.8 million, followed by China with total a of USD8.7 million in 2016 (Food & Agriculture Organization, 2018).

Table 1.3: World Imports of Fish and Fishery Products

Country	**2006**	**2016**
	Value (million USD)	**Value (million USD)**
USA	14,058	20,547
Japan	13,971	13,878
China	4,126	8,783
Spain	6,359	7,108
France	5,069	6,177
Germany	4,717	6,153
Italy	3,739	5,601
Sweden	2,028	5,187
Korea	2,753	4,604
United Kingdom	3,714	4,210
Top ten subtotal	60,553	82,250
Rest of the world total	30,338	52,787
World total imports	90,871	135,037

Source: Food and Agriculture Organization (2018)

The increase in fisheries production in 2016 was mainly due to the greater catch of Anchoveta in the South East Pacific Sea. Anchoveta is a stock that is subject to massive fluctuations depending on the condition of global weather (Food & Agriculture Organization, 2018). These catches are generally reduced to fish meal and fish oil and form the largest single resource of fish used in the reduction. The world's fish production in 2016 accounted for 171 million tonnes; 88% were utilised for direct human consumption, while the other 12% were utilised for non-food purposes. The global use of fish for reduction was 15 million tonnes, where half of it were for non-food purposes, and the remaining was used to make aquaculture and livestock feeding materials. Furthermore, humans' direct consumption of fish in 2016 was estimated to be over 151.2 million tonnes, an increase of 1.85% than that produced in 2015 which was at 148.4 million tonnes. This increase represents a higher population growth rate from the previous year. In addition to that, per capita consumption has grown from 9.0 kg in 1961 to 20.5 kg in 2016 (Food & Agriculture Organization, 2018). The expansion of consumption is due to several factors such as improved utilisation of fisheries products, better channels of distribution environment, and increasing demand for fish globally.

1.3 Background of Fisheries Sector in Malaysia

Malaysia covers a total of 329.847 km^2 and a population over 32 million people in the year 2018 (Department of Statistics Malaysia, 2018). For centuries, Malaysia maintained the traditional practices of fishing activities in three maritime jurisdictions, which are internal waters, territorial seas and its Exclusive Economic Zone (EEZ) under the scope of the Fisheries Act 1985 (Saad et al., 2013). An EEZ is an area of sea zone not more than 200 nautical miles from the coast in which a country has special rights to in terms of exploration and the use of aquatic resources; this includes the production of energy such as wind and

water. A key aspect of the EEZ is its importance to the local livelihood in terms of food and employment. A summary of Malaysia's EEZ is provided in Figure 1.1.

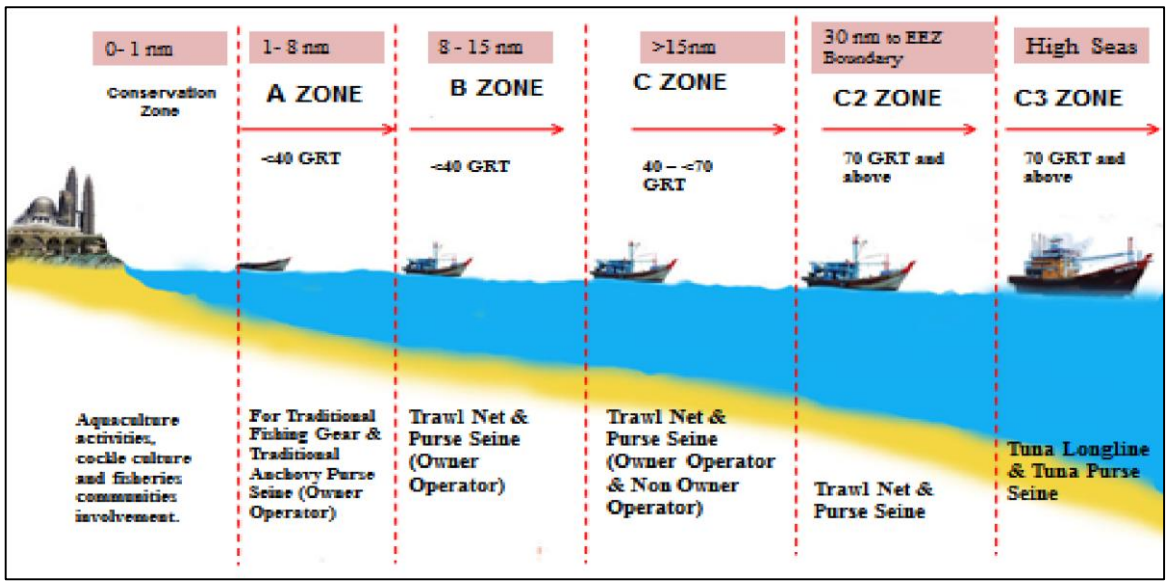

Figure 1.1: Fishing Zones in Malaysia
Source: Department of Fisheries, Malaysia (2018)

More advanced commercial fishing gears, for example trawlers and purse seine nets are forbidden to operate in inshore waters up to 8 nautical miles from the coast. This is because the areas below 8 nautical miles from the coast are designated as either conservation zones (0–1 nautical mile) or areas for the use of traditional fishing gear (1–8 nautical miles). In addition to that, a new management zone has been implemented to protect young fish that are often concentrated in the inshore water zones from fishing pressure by commercial vessels. The new management zoning system was introduced in 2014 to replace the earlier zoning system (1982) which was applied only in several states such as Selangor, Kedah, Penang, Perlis and Perak because these fishing zones had exceeded their maximum potential yield compared to similar zones in other states in Malaysia (Southern Asian Fisheries Development Center, 2018). Another importance of the EEZ is the spatial control and management of fisheries resources; this covers a component of the fisheries licensing system

and separates the distribution of fishing zones between small-scale and commercial fishing vessels and gears.

Table 1.4: Characteristic Between Coastal and Deep-sea Fisheries

Scope	Coastal Fisheries	Deep-sea Fisheries
Location	Less than 30 nautical miles from coastline.	More than 30 nautical miles within Exclusive Economic Zone (200 nautical miles).
Duration	Mostly on daily basis.	Weekly or monthly basis.
Scale	Small to medium scale for domestic market.	Large scale targeting for export market.
Captured Yield	*Selayang, Kembong, Bilis, Udang, Sotong, Ketam, Gelama.*	*Tenggiri, Tuna, Udang, Cencaru, Bawal.*
Gears	Traditional gears such as hooks and line, nets, driftnets.	Advance gears such as Ecosonar (fish detector device), purse seines.
Labor	Daily labor (family or relatives).	Trained labor for advanced gears application.

Source: Department of Fisheries, Malaysia (2018)

The fishing industry in Malaysia can be broadly categorised into two classes which are coastal fisheries (*pinggiran pantai*) and deep-sea fisheries (*laut dalam*) (Department of Fisheries Malaysia, 2015). Coastal or inshore fisheries operate within 30 nautical miles from the coastline, while deep sea fisheries operate beyond the 30 nautical miles up to 200 nautical miles from the coast. Fishing vessels range from the traditional type of commercial vessels of less than 70 GRT for coastal fisheries to more than 70 GRT vessels that are commonly used for deep sea fishing. Coastal fisheries have always been the main focus of

fishing activities and there is a general consensus that coastal fisheries have reached their maximum level of exploitation (Food & Agriculture Organization, 2001). A summary of coastal and deep-sea fisheries' characteristics is presented in Table 1.4. In Malaysia's EEZ, there are more than 1,000 species of fish; however, only 460 have commercial value, and these include demersal and pelagic species (Mohsin & Ambak, 1996). These fish species are usually captured by trawlers and purse seine vessels and are commonly found around the continental zone of Malaysia's EEZ.

Previous studies have reported that most demersal species captured by the local fishermen include *ikan kerisi, ikan pari, ikan cermin, ikan jenahak, ikan biji nangka* and *ikan merah* (Bako et al., 2013; Teh & Sumaila, 2013; Ahmad et al., 2015). However, the demersal fish population has apparently exceeded its maximum potential yield due to overexploitation in Peninsular Malaysia (Ahmad et al., 1991). On the other hand, pelagic species can be classified into several groups which are small and large pelagic, neritic and tuna species. The pelagic species is a species that usually moves about in groups or schools, and are commonly captured by purse seines in offshore fishing areas. Most of the species captured and landed are such as *ikan selayang, ikan bilis, ikan tamban, ikan selar kuning* and *ikan tenggiri* (Bako et al., 2013).

1.3.1 Marine Fish Landings

Malaysia's total production for 2017 was 1,465,113 metric tonnes with an estimated worth of around RM10,818.85 million (Department of Fisheries Malaysia, 2017). This amount includes both inshore and deep-sea production. Malaysia's total production for 2015 was 1,998,440.44 metric tonnes with an estimated worth of around RM12,690.14 million (Annual Fisheries Statistics, 2017). This amount includes inland and aquaculture production.

Figure 1.2 shows the trend of production in Malaysia from 2005 until 2017. The total landings of marine-captured production in 2017 had decreased by 7.5% compared to the previous year at 1,574,447 metric tonnes in total.

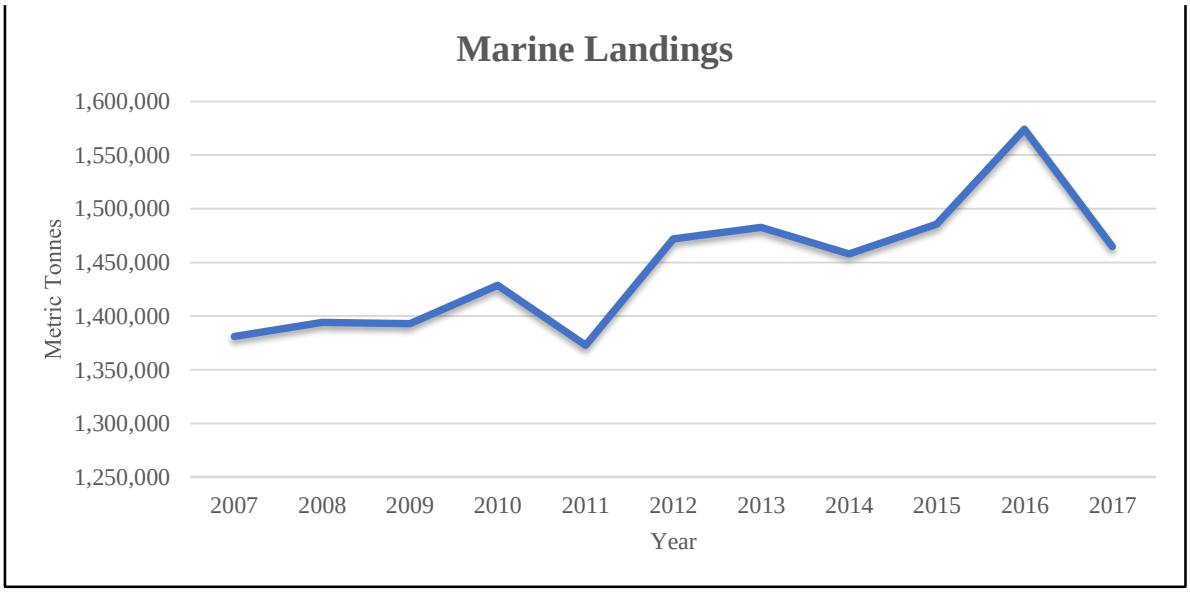

Figure 1.2: Total production of Fisheries Industry by Malaysia
Source: Department of Fisheries, Malaysia (2018)

The line indicates a declining trend from 2010 that almost reached to 1,450,000 metric tonnes of production. Factors such as lack of food supply at the global level, climate change, natural disasters, and increase in crude oil production may be reasons behind the serious decline in production in 2010. In addition, the impact of overfishing has contributed to the low level of fisheries production; the decrease in total catch may be due to the small size of species caught and the lower amount of catch per unit (Wordfish Center, 2005).

The trend increased from the year 2011 onwards. This can be explained by the authorities' success at conserving the population of fishes so that the food supply is maintained. The authorities' fisheries management strategy was to relocate fishermen's fishing efforts to under-exploited fishing grounds further offshore (Zaki, 2011). This effort not only increased