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Economic Impacts of Artificial Reefs: The Case of Fisher Households in Peninsular Malaysia

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WorldFish

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EXECUTIVE SUMMARY

Marine fishery resources in Malaysia have declined considerably over the past decades, primarily due to overfishing. Excessive fishing has also damaged marine habitats, a serious concern for the Malaysian government. To conserve and enhance natural fish stocks in various locations in marine waters, the government introduced the use of artificial reefs (ARs). ARs are expected to rehabilitate degraded fish stocks and secure the livelihood of the fishers along coastal villages. This study examines the impact of ARs on fisher households' income in Terengganu, Malaysia. The data were obtained from a survey involving 312 fisher-respondents in three contiguous districts: Besut, Setiu and Kuala Terengganu. Results indicate that there is a difference in value of catch between respondents fishing in AR and non-AR areas, with the former having a higher monthly catch value than the latter. Our regression models also indicate that fishing in AR areas helps reduce vessel operation costs. There is also significant difference in catch value between fishers with outboard-powered and inboard-powered vessels. Fishers operating an inboard-powered vessel obtained an average of RM5,935/month compared to the RM3,126/month received by those using outboard-powered vessels. We also found that Besut fishers with inboard-powered vessels are less dependent on ARs as they are able to fish further into the sea.

1.0 INTRODUCTION

1.1 Problem Description

The Malaysian fisheries sector plays a significant role in alleviating poverty and in achieving food security. Increase in fishing capacity and efficiency has resulted in an increase in fisheries output over the years. However, in the past decade, the increase in fishing activities has led to overfishing, resulting in a decline in fishery resources. Several studies found that fishing vessels operating in all Malaysian fishing zones have reached close to full technical efficiency and capacity utilization. Talib *et al.* (2003) found that the demersal species are already overexploited, with the level of fishing effort going beyond what is needed for maximum sustainable yield. Stobutzki *et al.* (2006) found that biomass has declined on both the east and west coast of peninsular Malaysia. Excessive fishing has also damaged marine habitats, which is a serious concern for the Malaysian government.

The current trend of fisheries exploitation affects the resources and livelihoods of small-scale artisanal fishers whose fishing methods are relatively less efficient than those of large-scale fishers such as trawls. To curb the problem of depleting fish stocks due to overfishing, the Malaysian government instituted measures such as the deployment of artificial reefs (ARs) or *tukuntiruan* in various marine water locations. AR deployment is expected to rehabilitate fish stocks and secure the livelihood of artisanal fishers along coastal villages. Artisanal fishers acquire exclusive rights to fish in the habitat, within less than five nautical miles from the shore, while larger fishing gears (trawls) are prohibited from fishing in this area.

ARs were initially deployed in the Malaysian coastal waters in 1975 by the Department of Fisheries (DOF) and the Fisheries Development Authority Malaysia (LKIM). The early ARs were made of tires, derelict boats and concrete cuboids until they were replaced by PVC, concrete, ceramic, reef balls, and abandoned oil rigs in 1985. The ARs are deployed more than three nautical miles (sandy habitat) away from the shore and at an average water depth of 15 to 20 m. The ARs are also specially designed to protect the habitat from trawl netting. On the other hand, the LKIM ARs, which are also known as *unjam-unjam,* are relatively smaller, placed on the seabed within three nautical miles (muddy habitat) from the shore. The LKIM *unjam-unjam* are installed on a request basis from artisanal fishers in their respective areas. The LKIM-managed ARs function as fish aggregating devices (FADs), which are mainly focused on increasing resource access, catches and artisanal fishers' income.

Kremen *et al.* (2000) point out that protection of natural resources generates global benefits (e.g., biodiversity conservation, recreation, and ecological services) as well as imposes greater opportunity costs on locals who are denied access to the natural resources being protected. For instance, AR deployment is expected to increase the fish stock in the surrounding areas and so fishers are expected to fish more frequently in these areas and spend less time searching for fishing locations. However, fishers living close to the ARs have more frequent access to these areas as compared to those living farther away. This results in an unequal distribution of costs and benefits of resource conservation. Hence, this study aims to generate empirical evidence on the distributional impact of ARs and their effect on the livelihood of artisanal fishers in Malaysia.

The socioeconomic objectives of ARs are to increase fishers' catches and incomes, reduce fishing operating costs, and deter trawlers from encroaching into inshore waters. However, the increase in fish density can also encourage fishing activities in AR areas (Whitmarsh *et al.* 2008). Poor management and lack of monitoring can result in illegal fishing, which further increases fishing intensity and threatens fishery resources. This scenario may deplete fishery resources within a short period of time and will negatively impact the sustainability of the catch and income of artisanal fishers.

Previous research in Malaysia has mainly focused on the design of AR modules, how they are placed and the materials used. None have conducted in-depth analysis of the economic benefits of ARs. This study will address this gap and generate useful information on the economic benefits of AR implementation to artisanal fishers. The study was conducted in Terengganu, a state located on the east coast of peninsular Malaysia.

1.2 Significance of the Study

Evidence shows that ARs have positive effects on the economy of local communities. Study results from Indonesia and the Philippines indicate that fishers can increase income from fish catches as a result of ARs and FADs (Delmendo 1991). The contributions of ARs or FADs to fishery resources and poor fishers' livelihood have not been studied in Malaysia. This study will provide information on how ARs can contribute to the income of local fishing communities.

The study findings will also tell us whether artisanal fishers have improved access to fishing activities and whether they experience any improvements in catch. The findings can provide valuable information to policymakers in designing ARs that distribute benefits more evenly and pay more attention to the people who are dependent on fishery resources. The study will also be able to provide information on whether equitable and sustainable benefits from AR programs can be achieved through support from various stakeholders in the community.

1.3 Research Objectives

In general, the study aims to assess the impact of ARs on fisher households' income in Terengganu, Malaysia. Specifically, it aims to:

1. Describe management arrangements and access to fishing for fisher households in the study area;
2. Describe the fishers' profile, income and employment status in the study area;
3. Compare the income of fishers living near ARs with those living relatively far from ARs;
4. Examine and analyze the major factors affecting household income for fishers living near ARs and fishers living relatively far from ARs; and
5. Provide policymakers with information on how to manage Malaysian marine fishery resources more effectively.

2.0 LITERATURE REVIEW

2.1 General Artificial Reef Studies

The primary motivations of ARs are to ensure the sustainability of economic resources and to protect the species, biodiversity and landscape of the marine area. However, in many cases, they are also meant to help attract or aggregate fish stocks in order to improve fishing efficiency (Delmendo 1991; Chou 1997). It is therefore clear that the intended function of ARs is both biological and socioeconomic. It could be argued that these two goals may conflict. On the one hand, ARs aim to attract juvenile fishes by providing nursery areas. However, this may lead to a large proportion of a fisher's catch at an AR site to consist of juveniles, which could threaten the species' population levels. For instance, Delmendo (1991) highlighted that juvenile stocks represented a large part of fish catches at AR sites in Thailand and the Philippines.

The success of ARs in meeting their objectives is surrounded by a lot of skepticism. Whitmarsh *et al.* (2008) examined the performance of ARs in coastal waters in Portugal. They report that although ARs serve the purposes of enhancement and aggregation of fisheries, these arrangements may attract more fishing effort. Bohnsack (1989) finds it unlikely that ARs can benefit existing overfished populations while Garcia (1991) stresses that the existence of ARs close to overexploited species' habitats should be avoided. Others believe that ARs may simply attract existing stocks without increasing stocks of fish which means that the catch is merely redistributed to other fishers (Viswanathan *et al.*1993). The latter argument encompasses what is better known in literature as the "aggregation versus production" debate. Bohnsack and Sutherland (1985) stressed the importance of adequately assessing the debate since, while literature generally agrees that ARs are effective fish attractants, there was no such consensus on the matter of enhancing productivity.

A review of literature by Bohnsack (1989) struggled to find adequate evidence which suggested ARs had increased production, except for one case. A later critical review by Pickering and Whitmarsh (1997) highlighted that while the design of the AR was important, the more crucial factor to successfully increase fish productivity was the presence of a good management strategy, which inhibited overharvesting. Chou (1997) also stressed the importance of design in his review of the development of ARs in the ASEAN region while Delmendo (1991) and Garcia (1991) agreed on the necessity of harvesting control policies. The age of the AR was considered by Viswanathan *et al.* (1993) as a potential factor affecting productivity; however, they did not pursue its effects in their study of ARs on Malaysia's coastline. Despite these findings, in the same vein as Bohnsack's earlier review on the debate, Grossman *et al.* (1997) could not find sufficient evidence in literature that confirms the ARs' ability to increase regional fish production rather than simply concentrating existing fish stocks. What they feel their review had indicated was that ARs could have potentially disastrous effects on existing reef fish populations, much in line with the concerns earlier mentioned by Bohnsack (1989) and Garcia (1991).

The mixed reviews found in literature on the economic performance of ARs make it difficult to draw clear conclusions. Having said this, it is important to recognize that several studies from across the world have given a positive impression of the economic performance of ARs. In Japan, data on catches before and after the installation of ARs found that there had been an increase in octopus production (Polovina and Sakai 1989), with similar results on other species being found in the case of Thailand (Yodee 1994). This latter empirical study used a bioeconomic model to assess the economic performance of the ARs and also estimated that the income of the local community had increased due to the installation of the ARs despite the price of the catch remaining almost constant during the studied period. A study on ARs in Southern California discovered that they had provided nine times greater catch than other non-AR areas in the region (Johnson *et al.* 1994). Similarly, Venkatasami and Mamode (1995), who looked at the use of FADs in Mauritius, found that these had increased fish productivity. Interestingly, Kolian and Sammarco (2006) looked at the impact of ARs on fish productivity in the Gulf of Mexico and estimated their socioeconomic effects in terms of job creation. They estimated that ARs could create enough fish biomass to create almost 19,000 jobs in the region.

Pattanayak (2004) argues that one of the major weaknesses in resource conservation programs is the failure to quantify the economic benefit of environmental services to the local community. As far back as the 1980s, it has been outlined that there is a lack of clear understanding of the economic impact of installing ARs and their ability to increase fish stocks and fish productivity (Bohnsack and Sutherland 1985). The need for scientific studies using quantitative estimations was called for (Bohnsack and Sutherland 1985; Delmendo 1991; Garcia 1991). Rey (1985) argued that while many studies had considered the biological aspects of ARs, few had focused on their socioeconomic impact. Likewise, a review of previous socioeconomic studies on ARs showed that few had directly looked at their economic performance (Milon 1989). Moreover, to add to the recommendations for further study, Viswanathan *et al.* (1993) suggested that future studies should consider the long-term economic consequences of ARs since they felt that time had a major part to play when considering AR economic performance. More recent studies have begun to pay more attention to the economic aspects of ARs.

The economic literature on ARs has provided limited empirical evidence on the socioeconomic benefits of this conservation method to fishers (Crowder *et al*. 2000; Carter 2003). Few studies have addressed both ecosystem and economic considerations in the selection of potential fish habitats for conservation via marine protected areas (MPAs) (Brown *et al.* 2001; Carter 2003; Ami *et al*. 2005; Morin 2004). Carter (2003) examines the benefits and costs of MPAs in terms of consumptive and non-consumptive marine resource interests. The consumptive benefits of MPAs are identified as the values enhanced by MPAs, such as net revenue of harvest from spillovers and enhanced species variety. Conversely, the costs identified include forgone fishing income and higher search costs. This study suggests that further research needs to be conducted to better understand the socioeconomic impact of MPAs.

Sutton and Bushnell (2007), in a review of various studies, attempt to identify and understand potential socioeconomic issues and information gaps surrounding the deployment of ARs in the Great Barrier Reef Marine Park. They divided the major stakeholders of ARs into the following groups: AR proponents such as government agencies, recreational fishers and divers, tourism and related businesses, management agencies, environmental organizations, scientific community, and the wider community. They argue that the social issues surrounding ARs include enhanced recreational opportunities, overfishing, changes in property and resource-use rights, and potential conflict within and between user groups. It is common that crowding and congestions at AR areas lead to conflict among users. The main economic impact identified in this study is increased tourism and recreational activity surrounding the reef areas. This study did not directly address the economic implications of ARs on local fishers.

2.2 Artificial Reef Studies in Malaysia

There has been a lot of interest in developing ARs and FADs in the ASEAN region, which can mainly be attributed to the fact that the region has suffered from intense overfishing and severe degradation of its marine and coastal habitats (Delmendo 1991; Chou 1997). Unfortunately, while the installation of ARs has been widespread, less consideration has been given to collecting the necessary baseline data that could help assess their economic performance (Delmendo 1991). Fortunately, assessing the performance of FADs (which are not fixed structures like ARs) on fish productivity is easier to perform and results from the Philippines have shown that they have been successful for tuna production (Delmendo 1991).

Overfishing around the Malaysian coastline has been well-documented (Lam and Pathansali 1977; Yahaya 1977; Yeh *et al.* 1981; Ch'ng 1983; Yahaya 1988, Yahaya 1993). Yahaya (1988) noted that the rapid expansion of trawl fishing in Malaysia around the end of the late 1960s had a severely negative effect on the livelihood of artisanal fishers who traditionally fish in shallower waters (0-5 miles from the coastline). Although these waters were reserved for artisanal fishers, intense competition has led to trawlers intruding in these restricted areas.

To enhance the fish resources around the coastal waters of peninsular Malaysia, the government installed the first AR at Pulai Telor, Kedah in 1975 (Delmendo 1991). The idea was that ARs would help promote sustainable development for artisanal fisheries (Yahaya 1993). The proliferation of AR installments on the Malaysian coastline has been substantial; however, there are surprisingly very few studies that have assessed their impact on improving artisanal fishers' livelihoods. Viswanathan *et al.* (1993) studied the issue and found interesting results. Using regression analysis they took data from 46 AR sites around peninsular Malaysia and found that the age, size, and location of the ARs significantly affected fishers' income. However, they did point out that more time is needed to assess the long-term economic impact of the ARs on artisanal fishers' income.

A related study, which looked into the impact of FADs on freshwater fish production in Terengganu, Malaysia, was done by Ibrahim *et al.* (2000). They were able to compare their results with baseline data and found that FADs were successful at attracting fish. More recently, a project near Pulai Langkawi in Kedah monitored the installment of ARs in 2007. Preliminary results suggested that the ARs slightly improved the income of the local fishing community; however, the study did not provide information on the longer-term economic impact as the ARs were only recently installed (DOF 2007).

A study by Squires *et al.* (2003) focused on the fishing practices of Malaysian artisanal fishers. They highlight that the artisanal fishers' fishery resources are overexploited but that the artisanal fishers are technically efficient. This suggests that increasing current marine resources rather than training the artisanal fishers to be more efficient is the best strategy. They also stressed the importance of fisheries as a key source of the local communities' livelihood as they found that in some of the communities almost all of their income came from marine fishing. Therefore, providing artisanal fishers with devices that help improve their fish productivity seems crucial. For this reason, an evaluation that quantitatively measures the contribution of ARs in increasing artisanal fishers' income is an important area of research.

2.3 Marine Fisheries in Malaysia

2.3.1 General regulatory framework

The main problem of the marine capture fisheries sector in Malaysia is excessive fishing, particularly in inshore areas. Several management regulations and policies have been implemented to manage fishery resources efficiently.

In peninsular Malaysia, the main regulatory method implemented to manage fishery resources is limited entry license through zoning. Through this regulation, fishing grounds are divided into fishing zones based on distances from the coastline:

1. Zone A - within five miles from the shore, reserved for traditional fishing gears;
2. Zone B - between 5-12 miles, reserved for trawlers and purse seiners using boats with less than 40 Gross Registered Tonnage (GRT);
3. Zone C1 - between 12-30 miles, reserved for trawlers and purse seiners using boats with greater than 40 GRT; and
4. Zone C2 - beyond 30 miles, reserved for trawlers and purse seiners using boats with greater than 70 GRT and above.

In addition to the zoning arrangements and license limitation, mesh-size regulation has been imposed to trawl nets. A policy for conservation with a moratorium on new licenses has also been implemented.

Encroachment by trawlers in the near shore fishing ground (zone A) has been identified as the main problem in protecting fishery resources and the livelihood of artisanal fishers in peninsular Malaysia. Due to unclear zoning area demarcation and lack of enforcement, it is difficult to reduce encroachment by trawlers. DOF and LKIM have deployed ARs to prevent trawler encroachment in zone A as well as to compensate the effects of stock depletion and to enhance the income of fishers. Hence, zone A fishing areas have been reserved exclusively for artisanal fishers surrounding the AR areas to provide them with easy access to fishing.

2.3.2 Fisheries Act 1985

The existing legislation for the Malaysian fisheries sector is implemented by the Fisheries Act 1985. The Act's objective is to conserve, manage and develop fisheries in this country so as to fulfill Malaysia' s commitment towards implementing the provisions stated in the United Nations Convention on the Law of the Sea (UNCLOS). It incorporates provisions for the monitoring, control and surveillance of fishing vessels operating in the Exclusive Economic Zone and international waters. The main provisions under the Fisheries Act 1985 covers:

1. Administration of fisheries in Malaysia;
2. Licensing and management of local and estuarine fishing operations;
3. Control of fishing by foreign fishing vessels in Malaysian fishing waters;

4. Prohibitions and control of certain methods of fishing;
5. Establishment of marine parks and marine reserves;
6. Undertaking legal procedures to implement this Act.

The Fisheries Act 1985 controls and manages maritime and estuarine waters. This Act provides inputs to make regulations for the management and conservation of marine resources. A number of fisheries regulations have been made under the Fisheries Act.

1. Fisheries Regulations 1985 (Licensing of local fishing vessels)
2. Fisheries Regulations 1990 (Marine culture system)
3. Establishment of Marine Parks & Marine Reserves Order 1994
4. Fisheries Regulations 1994 (Prohibited areas)
5. Fisheries Regulations 1996 (Close season for the catching of Grouper Fries)
6. Fisheries Regulations 1996 (Prohibited fishing methods for the catching of Grouper Fries)
7. Fisheries Regulations 1999 (Control of endangered species of fish)

2.3.3 Terengganu fisheries

The state of Terengganu is located in the east coast of peninsular Malaysia. This area has a high potential for marine fisheries. More than 11,000 fishers are directly involved in fishing in Terengganu, representing about 13% of the total number of fishers in peninsular Malaysia (DOF 2010).

Fisheries in Terengganu are mainly characterized by small-scale artisanal fishery with very low catch rates compared to larger scale commercial fishing. Poverty incidence is also very high among the artisanal fisher households in the area. To mitigate this problem, artisanal fishers are always included as a target group in fisheries development policies in Malaysia and various steps are taken by the government to improve their livelihood.

Since the 1970s, ARs are seen as a device that can support the goals of conservation of fishery resources as well as reduce the cost of fishing. DOF deployed ARs to protect fisheries from trawlers, enhance fish stocks in marine waters, and improve the income of artisanal fisher households. The deployments of ARs were initiated in Terengganu in 1975. Most of the ARs then were made of derelict wooden boats and rubber-based automobile tires. The LKIM started to deploy ARs (*unjam unjam*) in Terengganu in 1980. DOF and LKIM have been experimenting with various structures of ARs since then. More than 70% of the total ARs in peninsular Malaysia are located on the east coast.

A total of 14 different modules and designs of ARs have been deployed in Terengganu over the years. Materials used for ARs include reef balls, abandoned oil rigs, ceramic structures, and concrete-based ARs of various shapes and designs. The government has allocated a significant amount of funds to increase ARs in marine waters. About 268 ARs of various sizes and designs have been deployed on the sea bed across six districts in Terengganu.

The cost of ARs varies by size and materials. The average cost of relatively smaller ARs (concrete reef balls or cuboids) is approximately RM 1,000 while that of large ARs (comprised of 20 units of concrete blocks) is approximately RM 300,000. The total cost of AR deployment by the DOF in Terengganu from 2006 to 2010 is approximately RM 9.8 million, which accounts for 30% of AR investments in Malaysia during that period.

AR investment in Terengganu is the largest compared to other states. Sabah, the state with the next largest investment, receives only 9.8% of total AR investment. Most of the ARs in Terengganu have been deployed in Setiu and Kuala Terengganu districts.

According fisheries biologists working in DOF, ARs help increase biomass stock in the fishing ground after three to six months of installation. However, there is no information available on the social, biological and environmental impacts of ARs in Terengganu.

Local artisanal fishers have established exclusive rights to fisheries within the zone A fishing area. However, since ARs have attracted more fishers to the surrounding reef areas, fishing has become more competitive in zone A. In Terengganu, artisanal fishers have also deployed their own FADs in the marine waters. These FADs are made of coconut fronds and tree branches. Some fishers reported that they have deployed tires and derelict boats on the relatively productive fishing locations in zone A. Access and use of these private ARs and FADs are normally restricted to the fishers responsible for their construction. Fishers have established their own management regimes of these ARs and FADs, which may create conflicts in the near future.

Artisanal fishers obtain license from the DOF for fishing. License fees, paid annually, are decided based on the type of gear used. There are 7,322 fishing boats in Terengganu which accounts for 17% of total fishing boats in peninsular Malaysia in 2009. Currently, there are approximately 2,000 licensed artisanal fishers in Terengganu. In 2008, marine landings in Terengganu accounted for around 10% of the total landings in peninsular Malaysia. Total landings in peninsular Malaysia were 8,229 thousand MT in 1977 and declined to 1,055 thousand MT in 2008. The fish landings in Terengganu have also declined from 1,286 thousand MT to only 105 thousand MT in 2008 (DOF 2009). The decline in marine landings in Terengganu over the years is mainly due to global climate change and overexploitation of fishery resources.

The majority of fishing boats are powered either by inboard or outboard engines. Inboard-powered boats are mostly fitted with 40 HP engines. Most of the boats are made from wood or fiber glass, with the latter being more commonly used in the artisanal fishing community. The Terengganu artisanal fishers use a variety of fishing gears such as hand lines, long lines, traps, gill nets, and drift nets. Each gear type has a number of different designs and sizes to catch specific species.

LKIM provides a subsidy to licensed fishers. The subsidy covers a fishing boat and engine. Fishers are given fuel subsidy and also a monthly RM 200 allowance as an incentive to fish actively. LKIM also provides output incentives based on the quantity of fish sold at the jetty. These subsidies attract more people into the trade and also create more competition among the fishers. Fishers can transfer licenses to their family members, but they are not allowed to sell or transfer their license to others. However, private boat owners can transfer their license to others, and there are some fishers involved in recreational fishing in Terengganu. Fishers usually obtain a license to use a particular type of gear, but it was observed that they usually use two different gear types simultaneously. Hence, the gear stated in the license book may not be the current gear used by the fishers.

During the monsoon season between November and March, trawlers with relatively smaller boats are allowed to operate at any distance from the east coast. However, fishers are aware that they are not allowed to fish in the coral reef areas surrounding the marine parks, and that these areas are closely patrolled by marine park rangers. Fishing is permissible throughout the year.

Due to strong winds and high tidal waves, fishing activities are minimal between November and January. Fishers catch shrimp in the near-shore areas during the monsoon season. The peak season for fishing is between the months of June and August. Fishers usually make one fishing trip in a day, and squid fishing is done at night. Traps are usually retrieved twice a week. Some poor fishers rely on middlemen for capital equipment (e.g., nets, boat) and operation cost (e.g., fuel and ice). In return, the catch will be sold to these middlemen at relatively lower prices. This type of arrangement reduces the income from fishing.

2.3.4 Artificial reefs in selected districts in Terengganu

There are six fishing districts in Terengganu. The study focused on three of these districts, which were mainly the ones that have seen the largest deployment of ARs by DOF in recent years: Besut, Setiu and Kuala Terengganu.

Besut

In Besut district, 107 units of concrete blocks were deployed between April 2009 and April 2010, with a handful of the units dating back to 1990. As previously mentioned, around 20 units is seen as representing a complex or a separate AR. In the case of Besut, the total number of units can be classed as representing three separate ARs. Two of them (AR1 and AR2) are situated in the northwestern region of the district, whereas AR3 is located in the southeastern part of the district.

Of the three Besut ARs, AR1 is the densest and, by far, the largest in terms of the number of units being made up of 71 structural blocks, which is more than three times as many units as AR2 and AR3. AR3 covers the largest area, being twice as large as AR1 and over six times larger than AR2. However, although AR3 is the largest, it is also the least dense being the most sparsely covered area in unit blocks (Table 1).

Table 1. Distribution of artificial reefs in Besut

Besut ARs	AR1	AR2	AR3
No. of units	71	22	17
Size (m^2)	22,400	7,146	45,043
Density (units/m^2)	0.00317	0.00308	0.00038

The abovementioned AR size and density are calculated by creating a rectangular approximation to represent AR size[1]. However, a better judgment of the AR spatial features can be made by observing the plots of the units in each Besut AR (Appendix 1). Based on this, AR1 is the most densely clustered, with the majority of units being located in its western half. The units in AR2 seem to make two linear shapes that form an arrowhead, while AR3 forms one linear shape that stretches from the west to the east. It should also be noted that in the case of AR2, five units were seen as too far away from the rest of the units in the AR and were therefore excluded.

All of the units in AR1 were deployed in April 2009 and are of the soft-base type. Almost all of the units in AR2 were deployed in August 2009, and are a mixture of soft-base and cube structures. In AR3, the units consist of both the newest and oldest structures in the Besut district. Roughly half were installed in 1990 with the other half deployed in April 2010. Both the new and old units are of the soft-base variety.

Setiu

There are 131 units within Setiu district representing two ARs. They are located almost side by side in the northern part of the district. AR4 has almost twice as many units as AR5, but both can be considered fairly large. Although AR4 has more units, AR5 covers more than four times its area (Table 2). Nonetheless, AR4 is still almost four times larger than the area covered by AR3, the biggest in Besut. AR4 is almost ten times denser than AR5, but it is still not as dense as the most sparsely covered AR in Besut.

Table 2. Distribution of artificial reefs in Setiu

Setiu ARs	AR4	AR5
No. of units	85	44
Size (m^2)	176,350	814,200
Density (units/m^2)	0.00048	0.00005

In AR5, two units were determined as too far away from the bulk of the complex and were therefore excluded. Based on the plots of the Setiu AR units (Appendix 2), it is observed that the units in AR4 are fairly evenly scattered. However, in AR5, majority of the units are located in the northern part of the AR and form a linear shape from west to east. All of the units in AR4 and AR5 are cuboids and were deployed in September 2007.

Kuala Terengganu

There are 181 units within Kuala Terengganu, which means the district has the most number of units out of the three districts being studied. Majority of the units are located in the northern-central part of

[1]The rectangular approximation of AR size is done by taking the northernmost and southernmost latitude coordinates, as well as the easternmost and westernmost longitude coordinates, of the units within the AR complex. For each pair of coordinates, the distance between them is calculated.

the district. The units are divided into six complexes, making Kuala Terengganu the district with the largest number of ARs out of the three districts being studied as well. Four of the ARs in this district can be considered as small (less than 20 units), with the largest AR (AR8) having more units than the four smallest ARs combined (Table 3). All of the Kuala Terengganu ARs covered a wider area than the Besut ARs, but they have a much lower density of units. AR7 covers the largest area but AR8 is the densest, followed by AR10.

Table 3. Distribution of artificial reefs in Kuala Terengganu

Kuala Terengganu ARs	AR6	AR7	AR8	AR9	AR10	AR11
No. of units	19	18	68	26	16	10
Size (m^2)	250,681	409,194	269,912	226,467	76,472	77,622
Density (units/m^2)	0.00008	0.00004	0.00025	0.00011	0.00021	0.00013

Outlier units were discarded from AR6, AR7 and AR11. Based on the plots of the Kuala Terengganu AR units (Appendix 3), the units in AR6 can be roughly represented by a linear shape spreading across the northwest to the southeast region of the AR. In AR7, most of the units make a tight cluster in the western part of the AR. In contrast, the spread of the units in AR8, AR9, AR10 and A11 is much more scattered across the locations of the ARs.

In AR7, all of the units were installed between November and December 2007. Majority of the units are concrete. All of the units in AR8 are cubes, with six being deployed in 1988 while the remainder was deployed in April 2010. The largest complex, AR8, consisted entirely of cuboids, with almost all of the units being deployed in September and October 2007. The remainder was installed a little later, in May 2008. AR9 is very similar to AR8, as all of the units are cuboids and were deployed in October 2007 and May 2008. Finally, almost all of the units in AR10 and AR11 are cuboids, with the bulk deployed in April and May 2008.

3.0 RESEARCH METHODOLOGY

3.1 Model

The welfare of fishing households can be analyzed using the household production model. In economic literature, the value of time is considered as a determinant of household production and consumption behavior (Becker 1965; Pollak and Wachter 1975). Our study will examine the allocation of household time in a model explaining cross-sectional variations in fishing income among fisher households. The dependent variable is household fishing income, which consists of the value of various species caught by households. The independent variables are the time allocated for fishing; other effort variables such as type of vessel engine, crew size, fishing gear; and household demographic variables, which include age of household head, number of children below the age of 18, number of working members in the household, and education level. Fishing time can be further separated into the time spent fishing in AR locations and the time spent fishing in non-AR locations. More specifically, we define household fishing income function (Y) as

$$Y = f(t_{AR}, t_{NAR}, t_L, E, G, D) \qquad \text{(Equation 1)}$$

where,

t_{AR} - time spent fishing in AR locations
t_{NAR} - time spent fishing in non-AR locations
E - fishing experience
G - type of fishing gear
D - demographic factors

3.2 Questionnaire and Survey Design

The data for this study is obtained from face-to-face interviews of fishers using a structured questionnaire. Questionnaire development consisted of several stages. We began by constructing the draft questionnaire based on the objectives of the study. We conducted focus group discussions (FGDs) and key informants surveys (KIS) to improve and validate the questionnaire, improve the design of the survey, and gather other pertinent information. The FGDs were conducted in the Kuala Setiu fishing community to gather information on fishing practices, gear used, fishers' livelihood assets, and their institutional arrangements. Three FGDs were conducted, each involving participants from different major gear groups (i.e., hand lines, drift nets and traps). We discovered that only a few fishers use traps.

Two KISs were conducted. The first KIS was conducted in the DOF headquarters in Putrajaya; senior officers from the Licensing and Resources Development Section and the South East Asian Fisheries Development Center (SEAFDEC) participated. We received valuable feedback from the KIS participants and we incorporated some of their recommendations in our questionnaire. We managed to obtain information on AR locations during the meeting.

The second KIS was conducted in the office of the Area Fisherman Association, Kuala Setiu involving representatives from the Association and DOF officers. During the KIS, we managed to identify several issues pertaining to our survey, such as the uncharacteristic decline in fish catch currently experienced by fishers, which was identified as an impact factor on Terengganu fisheries in 2011. We managed to solicit information on the general concern of the participants and their role in AR management. Other important information gathered includes seasonal fishing calendars and harvest levels in general. All the information gathered were used to further refine the questionnaire.

A pilot survey was conducted in Kuala Setiu to pre-test the questionnaire. Twenty-four (24) respondents were interviewed by the principal researchers in the survey. We identified some minor issues, such as wordings of some of the questions, and made the necessary amendments to finalize the questionnaire. We also used the pre-test sessions to train our enumerators on interviewing techniques. The enumerators consisted mostly of officers from the DOF and LKIM.

The questionnaire consisted of five separate sections. Section A solicited information on household characteristics, which includes demographic information, occupation, fishing experience and monthly household expenditure. Section B collected information on fishing gear and values. Section C gathered information on fishing locations, catch and costs. We supplemented the questionnaire with a nautical map to assist the respondents in identifying and marking their approximate fishing locations. Computer software (XYit by GEOMATIX[2]) was then used to generate latitude and longitude coordinates of fishing locations using the markings on the maps. These fishing coordinates were used to calculate fishing distances from the respondent's jetty and from the nearest AR.

Section D gathered information on household fishing and non-fishing income. Section E collected information on fisheries management. The respondents were asked whether they were aware of certain formal and informal fishing rules and regulations. Section F gathered the respondent's perceptions on whether there have been improvements in their quality of life and assets in the past five years. The respondents were also asked to state their opinion on whether or not they agree that AR deployments have contributed to the improvement of their fishing income.

3.3 Sample and Data Collection

The survey was conducted in three contiguous districts in Terengganu: Besut, Setiu, and Kuala Terengganu. The list of artisanal fishers for each district was obtained from the Terengganu DOF office. The list indicates the fisher's name, ID number, vessel license number, engine power, gear use, and village name. Based on the list, it was noted that fishers mainly use three gears: hook and line, drift or gill net, and traps. The distribution of fishers, jetties and gear types in the three districts are presented in Table 4.

[2] A description of the computer software used can be found at http://www.geomatix.net/xyit/

Table 4. Number of jetties, fishers and gear types by sample district

District	No. of jetties	No. of fishers	Hook & line	Drift/gill net	Traps
Besut	7	296	203	84	9
Setiu	13	309	241	67	1
Kuala Terengganu	9	321	258	47	16
Total	**29**	**926**	**702**	**198**	**26**

Respondents were then randomly selected from the list of artisanal fishers from the three districts. The selected respondents were notified in advance about the interview, with the assistance of DOF officers and representatives from the local Area Fisherman Associations. It was difficult to find the respondents available for interview in the morning since most of them usually fish in the early morning and come back in the afternoon. Therefore, most interviews took place in the late afternoon or in the evening. During the interviews, we discovered that majority of the respondents have not updated the gear types in their respective licenses and most are using more than one gear type.

A total of 312 respondents were interviewed from September to November 2011. After the interview, we discovered that 10 respondents were actually purse seiners, although they were licensed as artisanal fishers. Since these fishers were not using traditional fishing gears, they were excluded from our analysis and we were left with a final sample of 302 respondents. The frequency distribution of the current sample by district, jetty and gear type is presented in Table 5.

Sample respondents from Besut, Setiu and Kuala Terengganu represent 32%, 31% and 37% of the total sample, respectively. Among the three gear types, traps are the least used. Most of the fishers used two types of gear (e.g., drift or gill net, and hook & line during the same fishing season). Majority of the respondents belong to the fisher group that uses two different gears (both drift or gill net, and hook & line). The study also covered fishers who only used hook & line for fishing.

Table 5. Respondent distribution by district, jetty and gear type

Jetty by district	Fisher-respondents		Number of fishers by gear type		
	Freq.	Percent	Hook & line	Trap	Net
Besut					
Ayer Tawar	9	2.9	9	4	6
Beting Lintang	35	11.6	26	3	41
Bukit Keluang	4	1.3	3	1	3
Kg Raja	2	0.7	2	1	0
Kuala Besut	48	15.9	34	6	54
Sub-total	**98**	**32.5**	**74**	**15**	**104**
Setiu					
Bari Kecil	5	1.7	5	0	4
Gong Batu	21	6.9	16	0	23
Kg Fikri	15	4.9	10	8	16
Kg Penarik	3	1.0	1	1	3
Kg Penarik Baru	7	2.3	5	0	7
Kuala Setiu	1	0.3	1	0	1
Mangkok	9	2.9	4	0	9
Merang	12	3.9	6	12	5
Nyatoh	1	0.3	1	0	1
Pandan Jaya	1	0.3	1	0	1
Pangkalan Gelap	1	0.3	1	0	1
Rhu 10	7	2.3	6	3	7
Telaga Papan	10	3.3	10	1	7
Sub-total	**93**	**30.8**	**67**	**25**	**85**

Table 5 continued

Jetty by district	Fisher-respondents		Number of fishers by gear type		
	Freq.	Percent	Hook & line	Trap	Net
Kuala Terengganu					
Batu Buruk	5	1.7	5	0	0
Batu Rakit	15	4.9	10	2	13
Kuala Ibai	25	8.3	24	1	9
Kuala Terengganu	6	1.9	6	0	3
Mengabang Teliput	2	0.7	2	1	1
Pengkalan Maras	8	2.6	3	0	8
Seberang Takir	18	5.9	13	4	12
Tanjung	16	5.3	14	2	9
TokJembal	16	5.3	4	0	16
Sub-total	**111**	**36.8**	**81**	**10**	**71**
All	**302**	**100**	**222**	**50**	**260**

4.0 RESULTS AND ANALYSIS

4.1 Descriptive Statistics

This section reports the descriptive analysis of the study. First the socio-demographic characteristics of the fisher households are reported, followed by information on their capital related to fishing, distances of fishing areas and ARs, and details of the fishing seasons and catch. Next, details of their income and expenditure are given. The final section reports the fishers' perceptions on the improvements in their income and the effect of the ARs on their well-being. The survey covered a total of 302 respondents.

4.1.1 Demographic characteristics of households

Statistics on the fishers' demographic characteristics (i.e., the household head's age, educational level, and marital status and the number of household members) can be found in Table 6. Generally, household heads surveyed are married and are relatively old, with less than one-fifth of the respondents being younger than 40 years old. This is in line with national statistics, which indicates that the average age of Malaysian fishers is increasing over the years. Majority received religious education (60.9%). Only a little over one-tenth of those surveyed received post-primary level education, which indicates that fisher households generally have a low education level.

Table 6. Respondents' demographic characteristics

Items	Frequency	Percentage
Age of household head		
Less than 30	13	4.3
30-39	41	13.6
40-49	79	26.2
50-59	102	33.8
60 and Above	67	22.2
Total	**302**	**100**
Education level of household head		
No schooling	35	11.6
Religious	184	60.9
Primary	52	17.2
Secondary	28	9.3
Degree/Diploma	3	1.0
Total	**302**	**100**

Table 6 continued

Items	Frequency	Percentage
Marital status of household head		
Unmarried	18	6.0
Married	278	92.1
Separate/Divorce	6	2.0
Total	**302**	**100**
Number of household members		
1-2	19	6.29
3-4	86	28.48
5-6	93	30.79
7-8	68	22.52
9-12	36	11.92
Total	**302**	**100**

Household family size is an important indicator for explaining total household income and their standard of living. Naturally, larger households have higher expenditure requirements. About 31% of the total household sample had 5-6 members while about 34% had 7-12 members.

4.1.2 Fishing capital

This section describes the fishers' human and physical capital. Fishers' experience in fishing activities is important in order to understand the household's income and dependency on fishing activities for their livelihoods. The study found that majority of the sampled fisher households had become fishers because it was the traditional occupation of their family. Almost one-third of the total respondents have been involved in fishing activities for over 40 years. Only 5% of the total respondents reported that they have been involved in fishing activities for less than 10 years (Table 7a). This confirms our prior assumption that fishing is the most important income source for artisanal fishers in the study area; in fact, the relative importance of fishing as an income source has increased due to the limited access fishers have to other forms of employment opportunities.

Table 7a. Distribution of sample households by fishing experience

Fishing experience (years)	No. of households	Percentage
Less than 10	15	5.0
10-19	51	16.9
20-29	64	21.2
30-39	77	25.5
40-49	76	25.2
50 and above	19	6.3
Total	**302**	**100**

Artisanal fishers employ a large variety of fishing methods and techniques such as hand lines, long lines, gill nets, and traps. The design and mode of operation of each gear type differs depending on the type of species caught and the fishing ground. Fishers usually use more than one type of gear and, in some cases, the gear used is different from those specified in their license. Long lines and drift nets are the most common gear mix used by the sampled fishers in the study area (Table 7b). Similar types of gear were found in all of the districts covered in the study. Fishers use various types of gear during their fishing activities. Many of the respondents use the hook and line, many of whom use it simultaneously with other gear, indicating its wide use in the study area (Table 7c).

Artisanal fishers use relatively smaller boats fitted with outboard engines. The majority of the boats in our sample (82%) are outboard-powered with the rest being inboard-powered (Table 7c). Most of the boats, locally called *sampan*, are made from wood or fiber glass. Fiber glass boats are common in the artisanal fishing community as they are suitable for operating in inshore waters. Moreover, outboard engine fishing boats are relatively cheaper compared to inboard engine vessels. The mean value of fishing boats is RM 8,535, with inboard-powered boats having a mean value of RM 12,739 and outboard-powered boats having a mean value of RM 7,599 (Table 7d).

Most of the vessels (79%) are not equipped with GPS, with no significant difference between inboard- and outboard-powered boats (Table 7e). GPS ownership is important as it helps fishers locate productive fishing areas more accurately. This can be seen in our subsequent analysis, where fishers with GPS tend to fish nearer to an AR site.

Table 7b. Type of fishing gear by district

Gear type	Besut (%)	Setiu (%)	Kuala Terengganu (%)	All (%)
Hook & Line	76	72	73	74
Drift net	56	58	62	59
Traps	15	27	9	17
Others	50	34	2	27

Note: Multiple response table since fishers used multiple gear simultaneously. Percentages based on total number of respondents per district: Besut (n=98), Setiu (n=93), and Kuala Terengganu (n=111).

Table 7c. Respondent distribution by type of gear used and vessel type

Fishing gear	Inboard engine	Outboard engine	Total
Hooks & line and drift net	3	72	75
Hook & line	5	51	56
Drift net	8	45	53
Hooks & line and others	5	17	22
Hooks & line, drift net, and others	1	16	17
Hooks & line and traps	4	12	16
Hooks & line, traps, and drift net	2	10	12
Traps	9	1	10
Drift net and others	5	5	10
Traps and drift net	4	1	5
Hooks & line, traps, and others	3	1	4
Traps and others	1	1	2
Hooks & line, traps, drift net, and others	2	0	2
Others	3	15	18
Total	**55 (18%)**	**247 (82%)**	**302**

Table 7d. Average value of fishing assets by vessel type (RM)

Statistics	Inboard engine	Outboard engine	All
Mean	12,739	7,599	8,535
Std. Deviation	8,861	4,013	5,585
Median	10,100	6,185	7,220
N	55	247	302

Note: Fishing assets include fishing gear, boats, engine, and other equipment.

Table 7e. Ownership of GPS by vessel type

Engine	No GPS		GPS		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Outboard	197	79.76	50	20.24	247	100
Inboard	43	78.18	12	21.82	55	100
Total	**240**	**79.47**	**62**	**20.53**	**302**	**100**

4.1.3 Description of distances of fishing areas and artificial reefs

This section presents the average distance from the fishers' jetty to their fishing areas and from the fishers' fishing areas to the closest AR. Results are separated by fishers using inboard- and outboard-powered boats. This is followed by a look at the effect of ARs on fishers' catch and concludes by displaying some statistics based on each district.

Before discussing the results, it is important for the reader to be aware of how the data was recorded from the fishers. While we are confident of the accuracy of the recorded locations of the ARs as these were obtained from the DOF, the fishing site locations are not as precise. Recorded fishing locations were obtained by giving fishers a map from which they indicated their fishing sites. This method only provides approximate coordinates of fishing locations. Thus, we would like to stress that attention should not be given too much on the actual distances recorded in the tables. Rather, it would be more useful to simply look at the relativity of the distances between fishers using inboard- and outboard-powered boats.

Table 8 shows that, on average, fishers who use inboard-powered boats travel one-and-a-half times further (21 km) than outboard fishers (14 km) to get to their fishing locations. This is to be expected as while fishers with outboard-powered boats are restricted to fishing close to the shoreline, inboard-powered boats have the ability to go much further out to sea.

Table 8. Distance from jetty to fishing area and from fishing area to nearest artificial reef by vessel type

Items	Mean	Std. Dev.	Frequency
Average distance from jetty to fishing area (km)			
Outboard	14.03	6.67	247
Inboard	21.41	9.97	55
All	**15.38**	**7.90**	**302**
Average distance from fishing area to nearest AR (km)			
Outboard	21.22	19.37	247
Inboard	30.75	19.52	55
All	**22.96**	**19.71**	**302**

The distance of the fishing location from the nearest AR was also calculated. In practice, fishers fish within the vicinity of several ARs. However our calculation only considers the distance of the fishing area from the closest AR. It was found that, on average, fishers with inboard-powered boats fish further away from ARs (31 km away) compared to fishers with outboard-powered boats (21 km away) (Table 8). Again, this might be expected as fishers using inboard-powered boats do not restrict themselves to solely fishing in shallow waters where the ARs are located. They can also take advantage of fish stocks further out to sea.

Table 9 presents the summary statistics of average distance between fishing area to the nearest AR according to vessel type and GPS ownership. The result implies that the mean average distance is lower for vessels equipped with a GPS unit irrespective of whether a vessel is outboard- or inboard-powered. This clearly proves that fishers with GPS can locate an AR site more effectively than fishers without one.

Table 9. Average distance from fishing area to nearest AR (km) by vessel type and GPS ownership

Items	Statistics	No GPS	GPS	Total
Outboard	Mean	22.33	16.86	21.22
	Std. Dev.	20.46	13.55	19.37
	N	197	50	247
Inboard	Mean	32.55	24.27	30.75
	Std. Dev.	21.37	8.32	19.52
	N	43	12	55
All	Mean	24.16	18.29	22.96
	Std. Dev.	20.95	12.98	19.71
	N	240	62	302

Table 10 shows the average value of catch per month for fishers who fish close to an AR and those who fish further away. The figures for fishers with outboard-powered boats match *a priori* expectations: fishers with outboard-powered vessels who fish close to ARs receive a greater catch value compared to fishers with the same vessel type who do not fish in AR areas. Interestingly, for fishers with inboard-powered boats, the results are the opposite. Fishers with inboard-powered boats fishing further away from ARs, on average, catch almost a third more fish, in terms of value, as compared to fishers with the same vessel type who fish close to an AR. This may seem strange at first, however, it is important to note that fishers with inboard-powered boats fishing further away from ARs are likely to be fishing further out to sea and therefore have more opportunities to increase their catch.

Table 10. Value of monthly catch by fishing area and vessel type

Items	Statistics	Non-AR area	AR area	Total
Outboard	Mean	3,861	4,417	4,174
	Std. Dev.	2,581	3,267	2,994
	Freq.	108	139	247
Inboard	Mean	7,946	6,035	6,904
	Std. Dev.	13,724	4,948	9,888
	Freq.	25	30	55
All	Mean	4,629	4,704	4,671
	Std. Dev.	6,497	3,658	5,097
	Freq.	133	169	302

Next we consider the variations between the three districts. Kuala Terengganu is the closest to an AR while, on average, Besut ARs are almost three times further away than Kuala Terengganu ARs (Table 11). Therefore, one may expect fishers in Kuala Terengganu to gain a higher catch value than fishers in the other districts as they can fit in more trips per day and spend less time travelling to fish close to AR sites. However, results presented in Table 11 suggest the contrary. On average, Kuala Terengganu fishers have a catch value of around RM 4,200/month whereas Besut fishers gain the highest average catch value, around RM 2,000/month more (almost 50%) than Kuala Terengganu fishers. This is a very interesting finding and a number of factors would be worth investigating, such as the effect of the AR characteristics in increasing fishers' catch rates (i.e., size and density). For instance, based on our earlier estimations of the density of ARs in the three districts, Besut ARs were much denser than Kuala Terengganu's and, although the latter district has twice as many ARs as the former, they are much smaller complexes. Furthermore, since Kuala Terengganu is the most urban district of the three, there may be opportunities to earn through other types of employment aside from fishing.

Table 11. Summary statistics of distance and monthly catch by district

Items	Mean	Std. Dev.	Freq.
Average distance between jetty and AR areas (km)			
Besut	50.85	18.20	98
Setiu	34.53	18.87	93
Kuala Terengganu	18.35	7.70	111
All	**33.88**	**20.50**	**302**
Value of monthly catch (RM)			
Besut	5,294.15	7,717.70	98
Setiu	4,513.66	3,225.90	93
Kuala Terengganu	4,253.04	3,052.66	111
All	**4,671.14**	**5,097.00**	**302**

4.1.4 Fishing seasons and catch

This section details the total catch for each season, categorized as: normal or main fishing season (Table 12a), shrimp season (Table 12b), and squid season (Table 12c). For each season, data was gathered on crew size per boat, number of trips made per month, and fish catch, which was used to estimate the annual fish catch per boat.

Fishing activities operate throughout the year in Terengganu. However, due to strong winds and unstable waters, fishing activities are disturbed between November and January. During this season, fishers catch shrimp in the near-shore areas. The duration of the shrimp and squid seasons is only 2-3 months. Moreover, although the fishers' catch is targeted to specific species during this season, they also operate other gear to meet subsistence needs.

Table 12a shows that the average crew size during the main season varies depending on whether the fishers have an inboard- or outboard-powered boat. The crew size for an inboard-engine boat was more than two, while outboard-engine boats are generally operated by a single crew member. The trip made by inboard-engine boats are 13 hours on average and the amount of fish catch per trip is double (52 kg) compared to the average catch from the outboard engine boats (26 kg). However, after breaking the data down by district, we can see that there is not much difference between inboard- and outboard-engine vessels operating in Setiu and Kuala Terengganu. Only inboard-engine vessels in Besut are operating differently from the outboard-engine vessels. During the main season, the average catch per trip for inboard-engine vessels in Besut is approximately twice the average catch for all the outboard-engine vessels in Terengganu[3].

Table 12a. Fishing operations and catch value during the main season by vessel type

District	Vessel	Statistics	Crew size	Fishing days	Trips/ week	Hours/trip	Catch (kg/trip)	Sale value (RM/trip)
Besut	Inboard	Mean	2.77	21.95	5.14	16.57	68.66	521.36
		Std. Dev.	0.87	5.83	1.28	23.74	124.13	967.22
		N	22	22	22	22	22	22
	Outboard	Mean	1.57	22.68	5.32	9.10	21.13	129.75
		Std. Dev.	0.61	4.44	1.10	6.41	25.29	101.20
		N	68	68	68	68	68	68
	Total	Mean	1.87	22.50	5.28	10.92	67.37	225.48
		Std. Dev.	0.85	4.79	1.14	13.20	32.75	507.04
		N	90	90	90	90	90	90
Setiu	Inboard	Mean	1.93	22.27	4.93	9.80	40.47	256.63
		Std. Dev.	0.70	5.36	1.49	2.02	25.33	157.35
		N	15	15	15	15	15	15
	Outboard	Mean	1.49	21.25	5.24	9.13	33.33	155.70
		Std. Dev.	0.50	4.38	0.95	1.81	29.99	105.26
		N	63	63	63	63	63	63
	Total	Mean	1.58	21.45	5.18	9.26	34.71	175.11
		Std. Dev.	0.57	4.56	1.07	1.86	29.13	122.58
		N	78	78	78	78	78	78
Kuala Terengganu	Inboard	Mean	1.40	22.60	5.40	8.30	16.20	110.20
		Std. Dev.	0.55	2.41	0.55	0.76	10.52	65.08
		N	5	5	5	5	5	5
	Outboard	Mean	1.73	22.68	5.47	8.63	25.29	172.56
		Std. Dev.	0.54	3.73	0.82	1.92	18.43	123.34
		N	105	105	105	105	105	105
	Total	Mean	1.72	22.67	5.46	8.62	24.87	169.73
		Std. Dev.	0.54	3.68	0.81	1.88	18.21	121.82
		N	110	110	110	110	110	110

[3] There is one outboard vessel that goes on a five-night journey per trip and this contributes to the high standard deviation for mean catch per trip for outboard vessels in Besut. After excluding this observation, the mean catch per trip in Besut is 45.18 with a standard deviation of 58.34.

Table 12a continued

District	Vessel	Statistics	Crew size	Fishing days	Trips/ week	Hours/ trip	Catch (kg/trip)	Sale value (RM/trip)
All	Inboard	Mean	2.31	22.14	5.10	13.17	52.35	377.87
		Std. Dev.	0.92	5.28	1.28	17.41	92.06	716.38
		Median	2	24	6	10	28	200
		N	42	42	42	42	42	42
	Outboard	Mean	1.62	22.30	5.36	8.90	26.24	155.72
		Std. Dev.	0.56	4.15	0.94	3.77	24.32	113.57
		Median	2	24	6	9	20	120
		N	236	236	236	236	236	236
	Total	Mean	1.73	22.27	5.32	9.54	30.18	189.29
		Std. Dev.	0.67	4.33	1.00	7.70	42.94	305.38
		Median	2	24	6	9	20	140
		N	278	278	278	278	278	278

We found that only Besut fishers using inboard-engine boats experience high catch. These inboard-powered vessels are fishing at further distances compared to the outboard-powered one, given their GRT and engine horsepower. Vessels fishing at a greater distance from the shore are also usually better equipped and have more crew members. However, the outboard-powered vessels in Besut have lower catch compared to Terengganu and Setiu. This is primarily due to the distance of the AR locations. Outboard-powered vessels are more dependent on closer AR sites due to their lower GRT and engine horsepower. We also found that the mean crew size, fishing days, and hours per trip in Besut (district with the farthest AR sites) are higher than Setiu and Kuala Terengganu. This indicates that Besut fishers are putting in a greater effort at fishing, which can explain the higher catch.

In the shrimp season, both inboard- and outboard-engine boats operate17 fishing days/month on average. They use gill nets with various mesh sizes for catching shrimp. The catch per trip is higher (19 kg) for inboard-engine boats compared to the catch from outboard-engine boats (7 kg) (Table 12b). However, the sale value of catch from inboard-engine boats is relatively lower compared to the value of catch from outboard-engine boats. This is because inboard-engines go relatively further to fish and catch smaller shrimp.

Table 12b. Fishing operations and catch value during the shrimp season by vessel type

District	Vessel	Statistics	Crew size	Fishing days	Trips/ week	Hours/ trip	Catch (kg/trip)	Sale value (RM/trip)
Besut	Inboard	Mean	2.69	20.19	4.75	10.09	19.19	236.00
		Std. Dev.	0.48	6.44	1.48	1.93	8.90	96.25
		N	16	16	16	16	16	16
	Outboard	Mean	1.70	18.09	4.09	8.02	5.55	165.00
		Std. Dev.	0.53	7.72	1.59	1.17	3.16	91.95
		N	33	33	33	33	33	33
	Total	Mean	2.02	18.78	4.31	8.69	10.00	188.18
		Std. Dev.	0.69	7.32	1.57	1.75	8.56	98.30
		N	49	49	49	49	49	49
Setiu	Inboard	Mean	2.00	16.14	3.71	11.00	17.71	211.43
		Std. Dev.	0.82	7.73	1.70	1.73	10.56	87.64
		N	7	7	7	7	7	7
	Outboard	Mean	1.61	15.83	3.93	8.62	8.05	223.12
		Std. Dev.	0.49	6.25	1.47	1.88	6.72	213.44
		N	41	41	41	41	41	41
	Total	Mean	1.67	15.88	3.90	8.97	9.46	221.42
		Std. Dev.	0.56	6.39	1.49	2.02	8.03	199.43
		N	48	48	48	48	48	48

Table 12b continued

District	Vessel	Statistics	Crew size	Fishing days	Trips/ week	Hours/ trip	Catch (kg/trip)	Sale value (RM/trip)
Kuala Terengganu	Inboard	Mean	2.00	22.50	5.00	6.00	17.50	117.50
		Std. Dev.	0	3.54	1.41	2.83	17.68	81.32
		N	2	2	2	2	2	2
	Outboard	Mean	-	-	-	-	-	-
		Std. Dev.	-	-	-	-	-	-
		N	-	-	-	-	-	-
	Total	Mean	2.00	22.50	5.00	6.00	17.50	117.50
		Std. Dev.	0	3.54	1.41	2.83	17.68	81.32
		N	2	2	2	2	2	2
All	Inboard	Mean	2.48	18.96	4.43	10.37	18.74	228.52
		Std. Dev.	0.67	6.94	1.59	1.88	9.22	92.44
		Median	3	20	5	11	16	225
		N	23	23	23	23	23	23
	Outboard	Mean	1.66	16.99	4.03	8.29	7.21	195.11
		Std. Dev.	0.5	6.96	1.51	1.67	6.08	170.24
		Median	2	15	4	8	5	150
		N	76	76	76	76	76	76
	Total	Mean	1.85	17.44	4.12	8.77	9.89	202.87
		Std. Dev.	0.64	6.97	1.53	1.93	8.44	155.88
		Median	2	15	4	9	6	160
		N	99	99	99	99	99	99

In the squid season, fishing is operated in particular fishing grounds where a large volume of squid can be found. However, squid frequently moves to other locations. Both inboard- and outboard-engine boats gather in particular fishing locations and use various types of hooks. Table 12c shows that inboard- and outboard-engine boats spend similar amounts of time on trips and also have a similar frequency of trips. However, their amount of catch is different because of the size and capacity of the boats. The average catch from inboard-engine boats is 38 kg while the catch from outboard-engine boats is 17 kg.

Table 12c. Fishing operations and catch value during the squid season by vessel type

District	Vessel	Statistics	Crew size	Fishing days	Trips/ week	Hours/ trip	Catch (kg/trip)	Sale value (RM/trip)
Besut	Inboard	Mean	2.64	21.36	5.00	12.57	34.71	338.64
		Std. Dev.	0.84	5.77	1.41	5.29	25.29	304.68
		N	14	14	14	14	14	14
	Outboard	Mean	1.68	20.03	4.76	9.76	15.24	145.71
		Std. Dev.	0.53	5.40	1.30	2.03	10.21	94.80
		N	34	34	34	34	34	34
	Total	Mean	1.96	20.42	4.83	10.58	20.92	201.98
		Std. Dev.	0.77	5.48	1.33	3.50	18.17	199.60
		N	48	48	48	48	48	48
Setiu	Inboard	Mean	1.55	20.20	4.80	8.98	45.85	304.65
		Std. Dev.	0.76	7.47	1.74	3.08	64.92	401.09
		N	20	20	20	20	20	20
	Outboard	Mean	1.34	15.18	3.73	11.05	21.30	212.97
		Std. Dev.	0.55	7.70	1.79	3.49	18.10	175.54
		N	32	32	32	32	32	32
	Total	Mean	1.42	17.08	4.13	10.26	30.57	247.57
		Std. Dev.	0.64	7.93	1.83	3.46	43.43	282.41
		N	52	52	52	52	52	52

Table 12c continued

District	Vessel	Statistics	Crew size	Fishing days	Trips/ week	Hours/ trip	Catch (kg/trip)	Sale value (RM/trip)
Kuala Terengganu	Inboard	Mean	1.25	21.25	5.00	14.00	11.25	108.75
		Std. Dev.	0.50	6.18	1.41	0.82	6.29	55.43
		N	4	4	4	4	4	4
	Outboard	Mean	1.68	17.92	4.24	11.33	15.92	160.33
		Std. Dev.	0.60	6.67	1.57	3.28	10.31	97.97
		N	72	72	72	72	72	72
	Total	Mean	1.66	18.09	4.28	11.47	15.67	157.62
		Std. Dev.	0.60	6.65	1.56	3.25	10.16	96.66
		N	76	76	76	76	76	76
All	Inboard	Mean	1.92	20.74	4.89	10.83	38.11	296.55
		Std. Dev.	0.94	6.62	1.56	4.34	50.07	346.41
		Median	2	24	6	10	20	156.5
		N	38	38	38	38	38	38
	Outboard	Mean	1.6	17.78	4.25	10.88	17.03	169.25
		Std. Dev.	0.59	6.82	1.6	3.13	12.7	121.93
		Median	2	20	4	11	15	150
		N	138	138	138	138	138	138
	Total	Mean	1.67	18.42	4.39	10.87	21.55	196.58
		Std. Dev.	0.69	6.87	1.61	3.41	27	199.08
		Median	2	20	5	10.5	15	150
		N	176	176	176	176	176	176

4.1.5 Fishers' income and expenditure

This section first looks at fishing income and expenditure, the latter being divided into operating and maintenance costs. It then displays information on the fishers' income from non-fishing activities and finishes by describing their overall expenditure and level of income compared to the poverty line.

Data collected include catch value per trip for the three different fishing seasons (i.e., main season, shrimp season, and squid season). This catch value per trip is multiplied by the number of fishing days per month to get the monthly catch value for each fishing season. These monthly values are then multiplied by the number of operating months for each season. The total catch values for all the seasons are divided by 12 to get the average monthly catch value. Based on this computation, the average monthly catch value is RM 5,935 and RM 3,126 for inboard- and outboard-engine boats, respectively (Table 13a).

Table 13a. Monthly household fishing income (RM) by vessel type

District	Statistics	Inboard	Outboard	Total
Besut	Mean	8,492	2,537	3,995
	Std. Dev.	11,561	1,764	6,376
	N	24	74	98
Setiu	Mean	2,533	3,348	3,311
	Std. Dev.	1,025	2,761	2,710
	N	5	106	111
Kuala Terengganu	Mean	4,160	3,426	3,626
	Std. Dev.	4,558	2,827	3,374
	N	25	67	92
All	Mean	5,935	3,126	3,630
	Std. Dev.	8,545	2,544	4,401
	N	55	247	302

There is a variation in the average catch, both in terms of weight and value, between different fishing seasons. As one might expect, the catch value is higher in the main fishing season compared to the shrimp and squid seasons. The average catch value is RM 3,499, RM 1,133, and RM 2,017 for the main season, shrimp season, and squid season, respectively (Table 13b). The average catch value also differs between inboard- and outboard-engine boats for the three seasons. In general, inboard-powered boats derive a higher amount of income from artisanal fisheries in the study areas (Table 13b).

Table 13b. Monthly fish catch (kg) and fish sale value (RM) by fishing season and vessel type

State	Fishing season	Statistics	Inboard		Outboard		Total	
			Fish catch (kg)	Value (RM)	Fish catch (kg)	Value (RM)	Fish catch (kg)	Value (RM)
Besut	Main season	Mean	1,025	7,867	424	2,530	571	3,837
		Std. Dev.	1,820	14,337	597	2,310	1,059	7,621
		N	24	24	74	74	98	98
	Shrimp season	Mean	252	3,200	45	1,339	96	1,795
		Std. Dev.	252	3,197	76	2,267	166	2,634
		N	24	24	74	74	98	98
	Squid season	Mean	390	3,846	130	1,224	194	1,866
		Std. Dev.	555	6,325	203	1,806	341	3,637
		N	24	24	74	74	98	98
Setiu	Main season	Mean	403	2,620	685	3,040	606	2,923
		Std. Dev.	441	2,942	769	2,339	703	2,512
		N	26	26	67	67	93	93
	Shrimp season	Mean	61	800	75	2,096	71	1,734
		Std. Dev.	124	1,498	91	2,805	101	2,568
		N	26	26	67	67	93	93
	Squid season	Mean	619	4,040	174	1,784	298	2,414
		Std. Dev.	1,026	6,592	346	3,554	642	4,680
		N	26	26	67	67	93	93
Kuala Terengganu	Main season	Mean	356	2,404	548	3,745	539	3,685
		Std. Dev.	247	1,404	423	2,816	418	2,778
		N	5	5	106	106	111	111
	Shrimp season	Mean	-	-	6	49	5	46
		Std. Dev.	-	-	48	418	47	408
		N	-	-	106	106	106	106
	Squid season	Mean	188	1,836	181	1,816	181	1,817
		Std. Dev.	160	1,511	209	2,011	206	1,986
		N	5	5	106	106	111	111
All	Main season	Mean	670	4,890	548	3,190	570	3,499
		Std. Dev.	1,267	9,934	592	2,589	760	4,860
		N	55	55	247	247	302	302
	Shrimp season	Mean	139	1,774	36	991	55	1,133
		Std. Dev.	211	2,654	76	2,112	119	2,236
		N	55	55	247	247	302	302
	Squid season	Mean	480	3,755	164	1,630	221	2,017
		Std. Dev.	800	6,141	252	2,481	426	3,531
		N	55	55	247	247	302	302

The cost of the day-to-day operation of a fishing vessel consists mainly of energy, food and bait. Data gathered on the operating costs of fishing activities show that fishers spend an average of RM 80/month. The costs required for each month differ between inboard- and outboard-engine boats (RM 185 and RM 56, respectively) (Table 13c).

Fishing boats require regular care of their engine, nets, and other fishing equipment. The maintenance costs of the engine, boat and other accessories were calculated on a monthly basis. The study found that monthly maintenance costs are about RM 418 with the cost of maintenance being higher for inboard-engine boats compared to outboard-engine boats (RM 550 and RM 389, respectively) (Table 13c). The high maintenance and repair costs of inboard-powered boats are mainly due to their rapid wear and tear compared to the outboard-powered boats.

Table 13c. Monthly operation cost and maintenance cost of fishing by vessel type

State	Statistics	Operation cost			Maintenance cost		
		Inboard	Outboard	Total	Inboard	Outboard	Total
Besut	Mean	328	47	116	467	537	520
	Std. Dev.	338	21	205	389	2,130	1,857
	N	24	74	98	24	74	98
Setiu	Mean	82	56	63	702	399	484
	Std. Dev.	62	27	41	1,149	768	895
	N	26	67	93	26	67	93
Kuala Terengganu	Mean	34	63	61	154	278	272
	Std. Dev.	9	33	33	114	443	435
	N	5	106	111	5	106	111
All	Mean	185	56	80	550	389	418
	Std. Dev.	258	29	123	840	1,265	1,199
	N	55	247	302	55	247	302

It is expected that fishing is the primary income source for artisanal fishers. The study shows that monthly household income from non-fishing activities is RM 522 (Table 13d). The non-fishing income of fishers using outboard-powered boats was relatively higher (RM 562) than inboard-powered boats (RM 340). This implies that fishers using outboard-powered boats rely more on non-fishing activities compared to their inboard counterparts, which is necessary to supplement their relatively lower catch values.

Table 13d. Average monthly household income from non-fishing activities by vessel type

State	Statistics	Inboard	Outboard	Total
Besut	Mean	285.42	359.93	341.68
	Std. Dev.	544.03	544.44	542.48
	N	24	74	98
Setiu	Mean	357.69	626.97	551.68
	Std. Dev.	615.25	1064.90	964.97
	N	26	67	93
Kuala Terengganu	Mean	506.00	663.02	655.95
	Std. Dev.	520.27	874.45	860.71
	N	5	106	111
All	Mean	339.64	562.44	521.86
	Std. Dev.	570.43	858.15	817.10
	N	55	247	302

The fishers' per capita income was calculated based on their income from fishing and non-fishing sources. In peninsular Malaysia, poverty is measured by taking the location of an individual's income relative to the poverty line. Table 13e shows the category of the households by level of income. Households with income of less than RM 480/month is categorized as extremely poor; 18.54% of the total household-respondents belong to this group. The same percentage of respondents (18.54%) belongs to the income group of RM 763 to RM 1,500. Almost half (46.36%) belong to the income category of RM 2,000 and above. As expected, poverty incidence is greater for the fishers with outboard-powered boats than those with inboard-powered boats.

Total expenditure on various food and non-food items purchased by households for a period of one month was also collected. The study shows that the mean value for non-food items is higher compared to food items. Monthly average expenditure for food items is around RM 414 while for non-food items it is around RM 455 (Table 13f). The higher share of the average fisher's expenditure on non-food items indicates that they have access to other development services in rural areas.

Table 13e. Respondent-household distribution by monthly income level category and vessel type (%)

State	Monthly income category	Inboard	Outboard	Total
Besut	<480	9.18	23.47	10.60
	480<763	-	3.06	3.06
	763-1500	3.06	14.29	17.35
	1500-2000	1.02	6.12	7.14
	>2000	11.22	28.57	39.80
	All	**24.49**	**75.51**	**100**
Setiu	<480	3.23	9.68	12.90
	480<763	1.08	8.60	9.68
	763-1500	5.38	12.90	18.28
	1500-2000	2.15	6.45	8.60
	>2000	16.13	34.41	50.54
	All	**27.96**	**72.04**	**100**
Kuala Terengganu	<480	0.90	9.91	10.81
	480<763	-	9.01	9.01
	763-1500	-	19.82	19.82
	1500-2000	-	11.71	11.71
	>2000	3.60	45.05	48.65
	All	**4.50**	**95.50**	**100**
All	<480	4.30	14.24	18.54
	480<763	0.33	6.95	7.28
	763-1500	2.65	15.89	18.54
	1500-2000	0.99	8.28	9.27
	>2000	9.93	36.42	46.36
	All	**18.21**	**81.79**	**100**

Table 13f. Average monthly household expenditure (RM)

State	Statistics	Food	Non-food
Besut	Mean	407.35	416.83
	Std. Dev.	181.15	274.26
	Median	400	360
	N	98	98
Setiu	Mean	377.42	487.86
	Std. Dev.	155.60	269.11
	Median	350	412
	N	93	93
Kuala Terengganu	Mean	451.80	461.65
	Std. Dev.	222.96	318.18
	Median	400	370
	N	111	111
All	Mean	414.47	455.18
	Std. Dev.	192.61	290.17
	Median	400	382
	N	302	302

4.1.6 Fishers' perceptions

This section focuses on the fishers' awareness of fishing rules, their perception on the improvement of their socioeconomic well-being, and the beneficial nature of ARs.

The respondents were asked a set of questions about their awareness of fishing rules in the study area. Most of the respondents stated that they are aware of the rules on obtaining fishing licenses, restrictions on fishing in certain areas, and restrictions on certain types of gears. However, the mixed answers obtained relating to fishing restrictions at certain seasons indicate that this restriction is not being followed fully by the fisher-respondents (Table 14a).

Table 14a. Respondents' awareness of fishing rules

Awareness of rules	Aware	%	Not aware	%
Fishing requires fee/license.	299	99.34	2	0.66
Fishing is not allowed in certain areas.	287	95.03	14	4.64
Certain gears are not allowed in certain areas.	272	90.07	29	9.60
Fishing is not allowed during certain seasons.	173	57.28	125	41.39
Only PNK members can fish in LKIM AR areas.	71	23.51	230	76.16

Note: Multiple response table. Percentages computed based on total number of respondents (n=302).

Respondents were asked a set of questions about their perceptions on their livelihood. Comparisons were made between their current status and that of five years ago. Majority of the respondents agreed that their livelihoods improved over the last five years (Table 14b). However, results indicate that their access to non-fishing income earning sources is relatively limited compared to fishing-related employment. This indicates that there is a lack of alternative employment opportunities, which is essential for artisanal fishers so that they can reduce their dependence on coastal fishing.

Table 14b. Respondents' perceptions on their household socioeconomic conditions over the last five years

Items	Improved		Unchanged		Deteriorated	
	Freq.	%	Freq.	%	Freq.	%
Food and nutrition	227	75.17	64	21.19	11	3.64
Education	233	77.15	44	14.57	1	0.33
Health and sanitation	281	93.05	14	4.64	6	1.99
Fishing assets (boats, engine, gear)	232	76.82	66	21.85	4	1.32
Household assets	215	71.19	84	27.81	2	0.66
Fishing income	220	72.85	38	12.58	42	13.91
Non-fishing income	89	29.47	54	17.88	3	0.99

Note: Multiple response table. Percentages computed based on total number of respondents (n=302).

There was a positive feeling amongst the fishers as to whether the AR project activities have resulted in extra fish production in their fishing areas. When asked about their perception on whether their income can be attributed to the deployment of ARs, 87% of the respondents responded positively (Table 14c).

Table 14c. Respondents' perceptions about the benefits of artificial reefs towards household income

Opinion	Frequency	%
Strongly agree	126	41.72
Agree	136	45.03
Neutral	25	8.278
Disagree	15	4.967
All	**302**	**100**

In conclusion, results indicate that, in general, fishers using inboard-powered boats are financially better off than outboard-powered boat users even though the latter have higher fishing expenses. Secondly, while outboard-powered boat users rely more on non-fishing activities to generate income, a greater proportion of them live in poverty. Finally, there is a general consensus that the fishers' standard of living has improved in the last five years and that the AR project has benefited them by increasing their income.

4.2 Regression Models

Table 15 presents the definition and also the summary statistics of the variables used in our catch value regression models. Only 276 observations are included for analysis since we excluded observations with crew members greater than five, as these fishers operate more like commercial vessels than artisanal fishers.

Table 15. Definition of variables and summary statistics

Variable	Definition	Mean	Std. Dev.
VALUE	Value of catch per month	4,655.94	3,323.50
AGE	Age of household head	50.28	11.09
INBOARD	Inboard-engine vessel in Besut (Yes=1, No=0)	0.07	-
CREW	Crew size	1.70	0.61
HOUR	Fishing hour per trip	9.14	3.90
COST	Operating cost per trip	75.02	103.15
AR	Fishing location is an AR area (Yes=1, No=0)	0.58	-
ARCOST	Interaction between *AR* and *COST*	49.42	107.23
FISHER	Number of artisanal fishers in the district	322.71	10.95
BIGAR	Number of large AR areas in the district	1.92	0.84

Note: n = 267

INBOARD is a dummy variable representing vessels with inboard engines operating in Besut. We did not classify the remaining 31 inboard-powered vessels in Setiu and Kuala Terengganu as *INBOARD* since they were found to operate more like outboard-powered artisanal fishing boats than inboard-powered vessels.

AR is a dummy variable representing fishers that are fishing in at least one AR area. A fisher is considered to be fishing in an AR area if the fishing distance from the center point of an AR area is less than 20 km. The summary statistics indicate that almost 60% of the respondents catch fish in an AR area. We also interacted *AR* with *COST* to capture the AR effects on costs.

FISHER measures the congestion due to fishing activities in a district. The congestion in a fishing district increases as the number of fishers increase.

BIGAR quantifies the effect of large AR complexes on fish catch in a district. An AR area is considered to be a large AR complex if the number of units deployed is greater than 40.

Statistical diagnostic checks were conducted before running our regressions. We identified residual outliers using the DFITS statistics and these observations are excluded from the final models. We checked for multicollinearity by computing the Variance Inflation Factors (VIF) for all the variables in each model. The largest VIF in Models 1 and 2 are less than 10 and this suggests that the two models are free from multicollinearity. However, we have detected a multicollinearity problem in Model 3 since the VIFs for *ARCOST* and *COST* are 12.19 and 10.54, respectively. Nevertheless, we decided to retain the variables as they are crucial in explaining the effects of ARs on fishing cost.

We also tested for heteroskedasticity by conducting the Breusch-Pagan/Cook-Weisberg test for all the three models. The results show that the critical chi-square value exceeds the obtained chi-square value at 10% level of significance, indicating that there is no presence of heteroskedasticity.

Table 16 reports the regression models for catch value. Model 1 is the basic catch value model that uses only demographic and fishing effort variables as dependent variables. Model 2 and Model 3 are extensions of the basic model. Model 2 incorporates the AR effect on the value of the catch and also operating costs. Model 3 takes into account district level effects by including fishing congestion and the number of large-sized AR variables. All the three models are statistically significant with an adjusted R-squared of 0.346, 0.244 and 0.253, respectively.

Table 16. Regression model results

Items	Model 1		Model 2		Model 3	
	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E
AGE	-33.58	11.87***	-42.43	10.78***	-40.76	10.70***
INBOARD	904.47	722.30	834.76	673.69	1,499.38	775.29*
CREW	271.95	241.66	245.57	238.83	202.20	231.53
HOUR	200.01	78.10**	209.69	78.57***	179.58	75.24**
COST	26.08	4.07***	28.45	5.69***	23.47	5.75***
AR			798.90	448.99*	244.22	544.39
ARCOST			-20.38	5.96***	-16.99	5.65***
FISHER					-23.33	15.08
BIGAR					-175.72	249.90
Constant	2,116.84	1,005.31**	2,563.20	1,043.41**	11,071.04	5,030.60**
Observations	262		257		258	
Adj.R-squared	0.346		0.244		0.253	

Note: Dependent variable = catch value per month
*Significant at 10% level; **Significant at 5% level; ***Significant at1% level.

All the fishing effort variables in Model 1 are statistically significant except for *INBOARD* and *CREW,* indicating that the positive relationship between inboard-engine boats and monthly catch value and that of crew size and monthly catch value are not statistically supported. All the coefficients in Model 2 are also statistically significant, except for inboard engine and crew size. The coefficients in Model 3 are statistically significant apart from crew size, artificial reefs (AR), and the district level variables (*FISHER* and *BIGAR*).

AGE is found to have a negative effect on catch value and this finding is consistent in all the three models. The results in all the three models also suggest that the fishing hour per trip increases the value of the catch. However, the effect of fishing hours on the value of the catch is greater in Model 1 when compared to the other two models.

Operating costs per trip are found to increase the value of the catch in all three models, which conforms to our prior expectation that an increase in fishing effort is likely to result in a higher catch. The effect of operating costs on catch is larger in Models 2 and 3 since we included the interaction between *COST* and *AR*. The negative coefficients of the interaction term in both models imply that those who fish in an AR area will benefit from lower operating costs per trip. It is plausible to also conclude that fishing in an AR area will reduce the cost of searching for a productive fishing location.

The *AR* variable in Model 2 is found to be statistically significant. The *AR* coefficient indicates that fishing in an AR location increases the value of the catch per month by RM 798. The *AR* and both the district level coefficients (*FISHER* and *BIGAR*) have the correct signs in Model 3, albeit not being statistically significant. The coefficient for *FISHER* infers that congestion reduces the value of the catch. The coefficient for *BIGAR* implies that the number of significantly-sized AR complexes deployed in a district will help increase the value of the catch.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Current knowledge supports ARs as an important tool in enhancing Malaysian marine fisheries. However, whether their use has economically benefited artisanal fishers has not been well studied. This gap is addressed by this study, which looks at the socioeconomic impact of ARs on the artisanal fishers in Terengganu.

Results indicate that there is a difference in the value of catch between fishers who fish in AR and non-AR areas. Respondents fishing near AR areas are found to benefit from a higher monthly catch value. Our regression models also indicate that fishing in AR areas help reduce vessel operating costs.

There is also a significant difference in catch value between fishers with outboard-powered and inboard-powered vessels. Fishers operating inboard-powered vessels obtained an average of RM 5,935/month compared to the average of RM 3,126/month received by fishers using outboard-powered vessels. We also found that Besut fishers with inboard-powered vessels are less dependent on ARs as they are able to fish further into the sea. The results on the catch value of fishers with inboard-powered vessels imply that the costs and fishing benefits are not equally distributed among the poor fishers. This result also suggests that ARs are not able to reduce the gap between inboard- and outboard-vessel fishers. Therefore, this issue relating to equity needs to be addressed by other policy measures to ensure access is limited to artisanal outboard-vessel fishers.

Moreover, results indicate that while fishing is the primary source of income for many poor fisher households in the study area, outboard-vessel fishers are more dependent on income sources other than fishing, which is primarily due to their relatively less productive catch compared to inboard-vessel fishers. Nevertheless, in general, fishers perceive that their standard of living has improved in recent years and that AR projects have benefited them by increasing their income.

While it is particularly true that the deployment of ARs has attracted more fish, fishing pressure surrounding the ARs will also increase in the near future. This is due to the absence of clear demarcation of AR sites and access to fishing remains virtually free for the artisanal fishers. This situation can lead to overfishing and it may still pose a threat to the fisheries stock. Therefore, management measures need to be instituted for AR sites to ensure the sustainability of fisheries resources.

The government has made significant investments in ARs through the DOF and LKIM since the 1970s. Approximately RM 10 million has been spent in Terengganu since 2006 to 2009, accounting for 30% of total AR investments in Malaysia. A recent satellite imaging study shows that some of the older AR complexes have been scattered away from the initial deployment locations. The study also found that some of the older ARs have been destroyed. This is particularly true for ARs made of derelict boats and tires. Thus, there is a need to update the locations and characteristics of remaining ARs, particularly the biological characteristics of the ARs. It is important to maintain an inventory of the species and total biomass of fish and the migration characteristics of fish between AR sites. This updated inventory of ARs is crucial to institute an effective reef management plan to optimize the impacts of ARs on artisanal fishers.

It should be noted that there are four government agencies with jurisdictions over fishery matters in Malaysia. Apart from the DOF and LKIM, the two other agencies are the Department of Marine Parks under the Ministry of Natural Resources and Environment, and the Malaysian Maritime Enforcement Agency (MMEA). The Department of Marine Parks is responsible for marine parks in Malaysia and has jurisdiction over ARs categorized as MPAs. On the other hand, MMEA is responsible for the enforcement of marine and fisheries policies. Coordination between these four agencies is very important in the management of ARs so that they are effective in conserving fish stocks as well as promoting sustainable fisheries.

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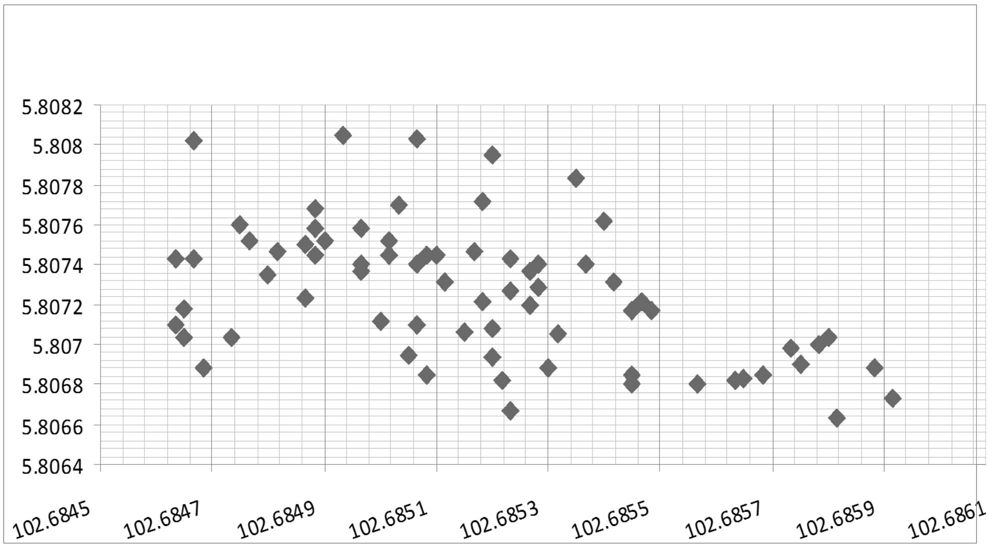
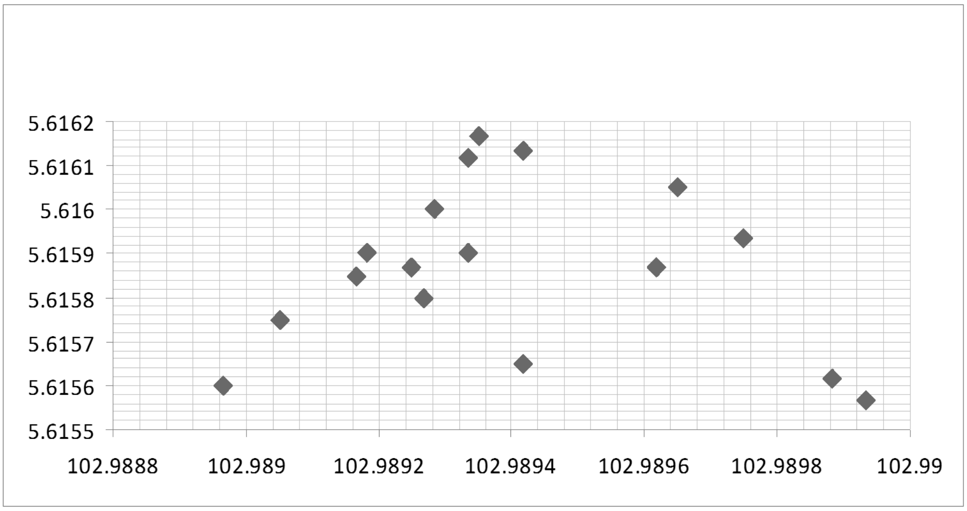
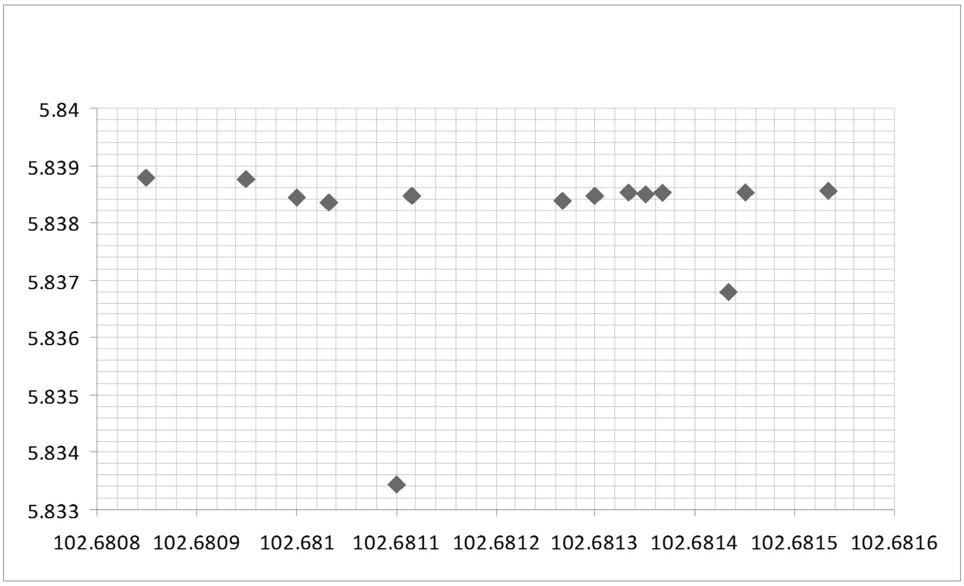
APPENDICES

Appendix 1. Plots of units for artificial reefs in Besut: AR1, AR2 and AR3

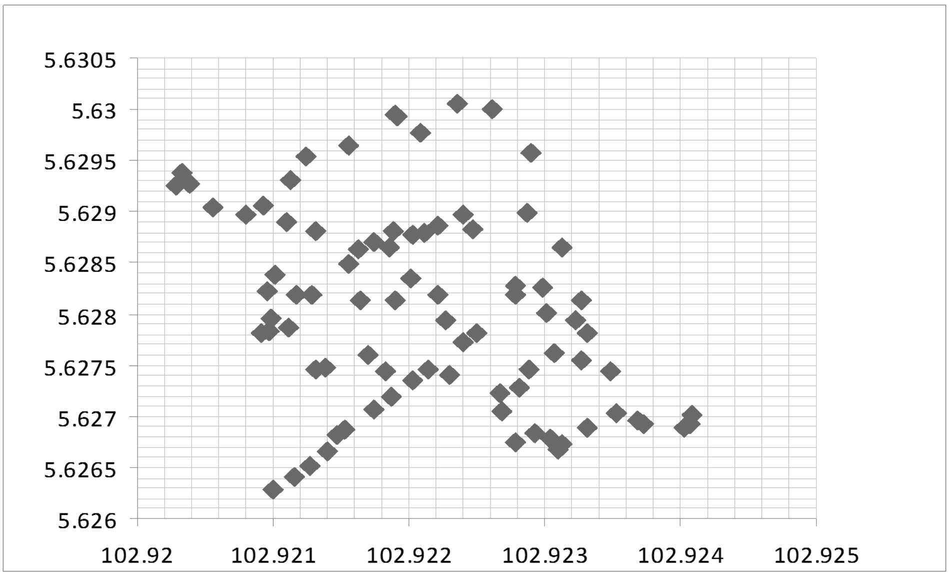


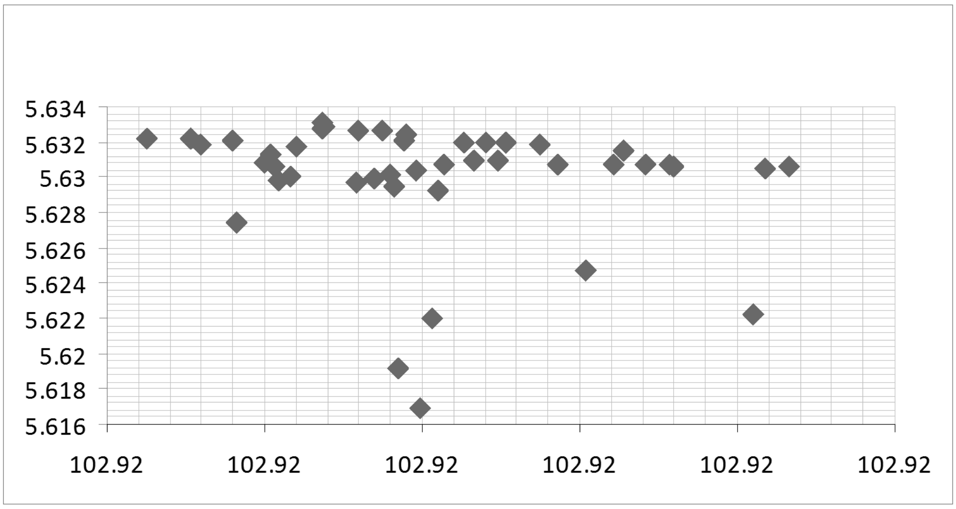




Source: Department of Fisheries Malaysia (2011)

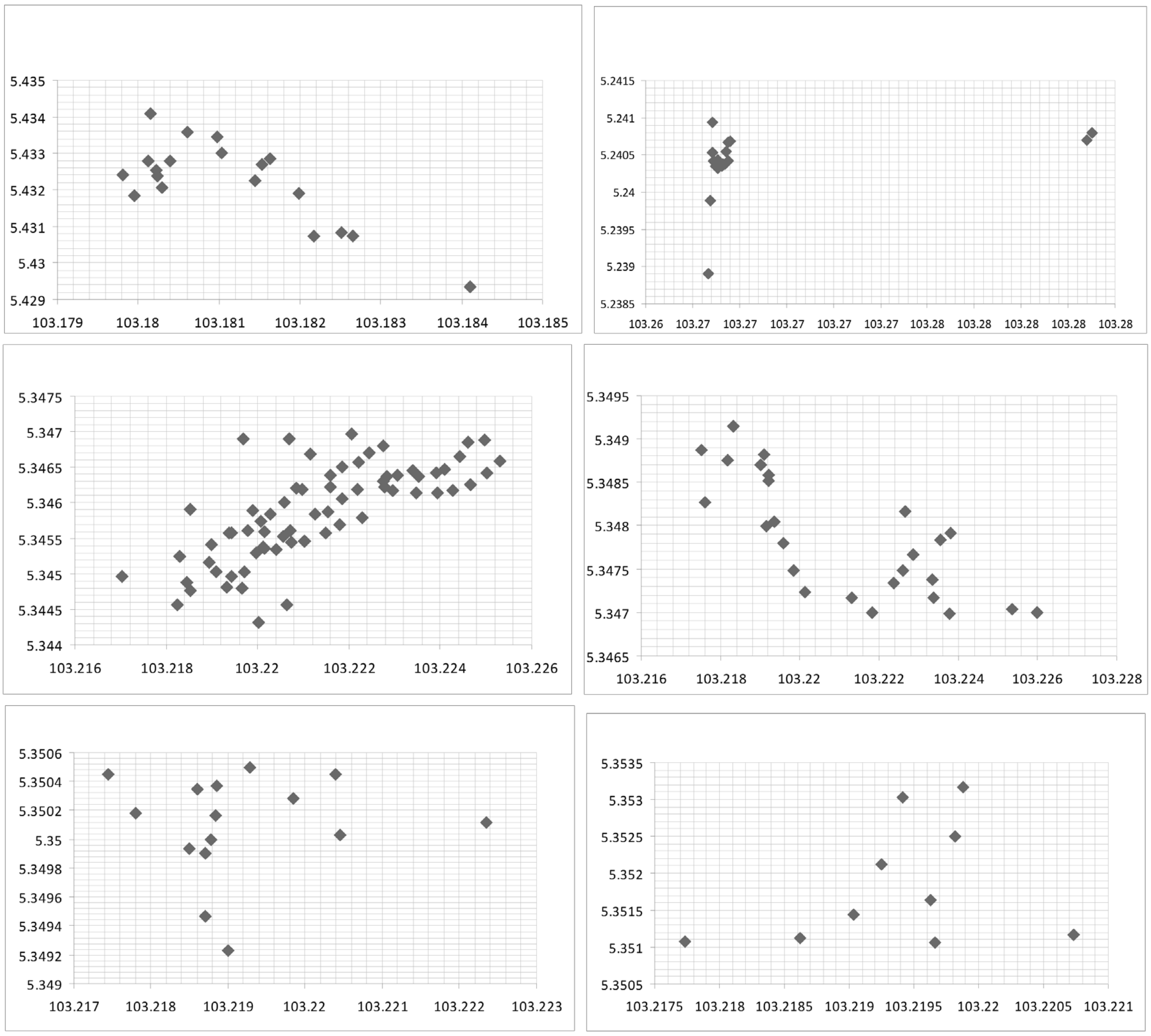
Appendix 2. Plots of units for artificial reefs in Setiu: AR4 and AR5





Source: Department of Fisheries Malaysia (2011)

Appendix 3. Plots of units for artificial reefs in Kuala Terengganu: AR6 and AR 7 (top row, left to right), AR 8 and AR 9 (middle row, left to right), AR 10 and AR 11 (bottom row, left to right)



Source: Department of Fisheries Malaysia (2011)

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