Thesis for the Degree of Master of Fisheries Science

INSHORE FISHERIES MANAGEMENT IN FIJI

by

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KOICA-PKNU International Graduate Program of Fisheries Science

Graduate School of Global Fisheries

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List of Acronyms

CBFRM	Community-Based Fisheries Resource Management
CI	Conservation International
CPUE	Catch Per Unit of Effort
EEZ	Exclusive Economic Zone
FLMMA	Fiji Locally Marine Managed Area
IAS	Institute of Applied Science
MEY	Maximum Economic Yield
MPA	Marine Protected Area
MSLFE	Minimum Safe Level of Fishing Effort
MSY	Maximum Sustainable Yield
NGOs	Non-government Organisations
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

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Abstract

Fiji's inshore fisheries is a multispecies fisheries which employs a complex exploitation regime. Additionally, it has dual ownership; thus, it is managed by both the national government through the fisheries department and the communities through the marine tenure system. Overfishing became a prevailing issue in Fiji's inshore fisheries as it was indicated by the decreasing trend of CPUE from 2003 to 2011. This research was; therefore, conducted to examine the current management regulations and to evaluate the current status of Fiji's inshore fisheries. Thus, bio-economic model was performed by the Schaefer Model to evaluate the 20 years catch and effort data for artisanal inshore finfish fisheries. Results revealed that the fishing effort at maximum sustainable yield and maximum sustainable yield were 1,750 licences and 5,512.5 metric tonnes respectively. In addition, optimal fishing effort and maximum economic yield were 1,391 licences and

5,280.9, respectively. Current fishing effort is well beyond the effort at maximum sustainable yield which led to overfishing. Overfishing in turn had caused negative impact on fish stock and economic benefit. Furthermore, the percentage of current stock size over the stock at maximum sustainable yield is 44%, which is lower than 80%, the percentage criteria for evaluating stock size. With the current fishing effort which is 3,000 licences, estimated fish stock for the next 25 years show a decreasing trend. To maximize production and economic benefit while conserving sustainable fish stock size simultaneously, fishing effort has to be reduced by 42% and 54% respectively. A minimum safe level of fishing effort, however, was established which requires only a 14% reduction in fishing effort. The Fisheries Act, on the other hand, is not sufficient to effectively protect and manage the fisheries resources. Thus, it requires amendment and incorporation of proper fisheries' management guidelines. Fiji's inshore fisheries can be considered unsustainable and the driving forces behind overfishing are population growth, introduction and globalisation of fish markets and limited sources of alternative livelihood.

Chapter 1. Introduction

1.1 Research Background

The fisheries resources had been contributing significantly to the livelihood of the Pacific Island people including Fijians; hence, it requires proper management for generations to come. Fiji's ocean is quite extensive compared to the total land mass of the Fiji islands, hosting a wide range of fisheries resources. Fiji's fisheries are divided into offshore and inshore or coastal fisheries which contribute significantly to the national economy, life styles, and livelihoods of the people. The extensive area of Fiji's ocean has fisheries resources of a high diversity and of high economic value. Thus, it attracted the interest of foreign investors and local fishermen to utilize fisheries resources.

During the last decade, Fiji's Fisheries sectors, the offshore and coastal fisheries, have contributed consistently to the Gross Domestic Production (GDP) being the second highest earner among the resource based sectors, trailing the Agriculture sector. The Fisheries sector's contribution to the national GDP maintained a steady trend from 2005 to 2010, and it reached its peak of 3.14% in 2008 which accounted for F$150.5 million. In 2010, however, its contribution dropped to 2.75%, an amount of F$137.4 million (Fiji's Fisheries Department, 2011). The reduction in economic contribution by the fisheries sector was attributed to the decline in fish stocks; this indicates the current fisheries management system has not been effective.

On the other hand, Fiji's inshore fisheries contribution to the economy was almost equal to that of offshore fisheries (Minter, 2008). In Fiji, the local communities mainly engaged in inshore fisheries for subsistence fishing for diet and artisanal fishing for income generation. Inshore fisheries forms an integral part of the lives of local communities in terms of nutrition, welfare, employment, recreation and culture. Thus, the maintenance of these lifestyles depends on the sustainability of these living resources (Robert, 2011). The traditional knowledge gained by local communities over the coastal resources was attributed to the close link between the people and the ocean. Hence, it allows communities to manage these resources through Customary Management Systems (CMS). CMS is defined as local practices that are designed to regulate the use, access and transfer of resources (Cinner et al., 2007). The Department of Fisheries, however, as stipulated in the Fisheries Act Cap 158 is responsible for governing and regulating the inshore fisheries in Fiji in terms of exploitation and management of the resources. The Act also recognises and protects the rights of *I-taukei* (traditional resource owners) over their respective traditional fishing ground which is known as *I-Qoliqoli*.

At present, population growth which reached 883,125 in 2011 contributed to the gradual rise in fishing pressure on inshore fisheries resources. Additionally, the introduction and globalisation of the fisheries markets accelerated the demand of inshore fisheries resources as harvests have to meet the market needs in addition to the subsistence needs. Though marketing brings economic benefit to the people, it does also increase the exploitation rate of fisheries resources and attract more people to fishing activities which has resulted in the depletion of the inshore fish stocks. Customary management systems have been weakened by socioeconomic transformation such as population growth and economic modernisation (Cinner et al., 2007), resulting in serious over-fishing conditions in Fiji. This situation has been worsened by first, the use of the Act which is outdated and lacking many features of Fisheries Management Law and does not achieve comprehensive coastal marine protection (Minter, 2008); second, by a development of policies that continue to emphasize increasing production rather than conservation (DeMers and Kahui, 2012); third, by a lack of and or the outdated information that affects the formation of effective policies (Veitayaki and Novaczek, 2005); fourth, by a lack of cooperative works among relevant stakeholders and lastly, by limited enforcement and compliance of regulations.

For the conservation of the fisheries resources, fishing access should be regulated and exploited in a sustainable manner. Furthermore, effective and proactive fisheries management systems and development policies should be implemented to protect the fisheries stocks and to maximize fisheries resource rent.

1.2 Research Objectives

The objective of this research is to determine the sustainable fishing effort for the inshore fisheries in Fiji, which is currently needed, by analysing the artisanal inshore catch-effort data from 1992 to 2011 by the Schaefer's Logistic Model. Regulating the fishing effort would maximize production and allow for sustainable exploitation of the inshore fisheries resources. In addition, this study aims to test the hypothesis that the decline in inshore fish stocks has been caused by the ever increasing fishing effort exceeding a sustainable level.

Thus, this research seeks first, to ascertain the main causes of problems prevalent within Fiji's coastal fisheries management by examining the current management regulations and highlighting the areas that need immediate attention for the management of the fisheries resources; and second, to evaluate the current status and predict the future trend of the inshore fisheries based on the current fishing effort. On the basis of the information gathered and bio-economic analysis outcomes, this study will present practical implications and recommendations to improve the current status of Fiji's inshore fisheries.

Chapter 2. Current Situation of Fiji's Inshore Fisheries

Fiji Islands is located in the South Pacific Ocean at 18^0 00'S and 75^0 00'E and has a tropical marine climate due to its geographical location. Fiji consists of 322 islands which were formed by volcanic eruptions and 106 islands are inhabited (Vuki et al., 2000). In addition, there are 522 islets which were formed by coral reefs making it impossible to be occupied by humans, however, these islands are important habitats for numerous marine creatures. The total land mass of the Fiji Islands is 18,270 km^2 where 10.95% of it is arable, hence, limited land for cultivation. Though the total land mass is limited, the vast ocean has been responsible for supporting the livelihoods of the people of Fiji.

The islands of Fiji are distributed over a large area and surrounded by ocean. It has a total coastline of 1,130 km (Dumaru, 2011) and 1,290,000 km^2 of exclusive economic zone (EEZ) as stated in the Marine Space Act 1978 (Chapter 158A). Fiji's vast ocean has abundant and diverse fisheries resources that play an important role in the dietary and livelihood of the people (McManus, 1997) in Fiji. Like other Pacific Islands, local communities reside along the coastal areas which allow them to depend heavily on fisheries resources. The majority of Fiji's population is living along the coasts (Hastings et al., 2012). These coastal communities rely heavily on fishing for both subsistence and commercial purposes. Coastal fisheries supports the livelihood of 80% of Fiji's coastal communities with over 70% of their catch being sold for monetary returns (IAS, 2009). Coastal fisheries resources and marine ecosystems form an integral part of the coastal life as well as the basis for tradition and culture in most villages in Fiji (Cakacaka et al., 2010).

Fiji's capture fisheries are categorized into two namely Offshore Fisheries and Inshore Fisheries. The Offshore Fisheries which is commonly known as Industrial Fisheries mainly involves foreign and local fleets which usually focus their catch on the tuna. On the other hand, Inshore Fisheries, also called Small-scale Fisheries usually targets reef fishes (finfish and non-finfish) and is further divided into Subsistence and Artisanal fisheries.

An Offshore Fisheries in Fiji is solely managed by the national government through the Fisheries Department. Like all Western and Central Pacific Countries, domestic tuna fisheries is mostly small scale but the total catch in the national waters is normally dominated by distant water fleets (Havice and Campling, 2009). Distant water fleets began their operations in the 1960's with the Japanese fleets being the pioneers. The Taiwanese and East and Southeast Asian fleets were later joined in the 1980's (Havice and Campling, 2009). Operating in Offshore Fisheries is often associated with high costs in that it requires high operations expenditure and investment with more inputs and outputs. Due to these factors, this fisheries is regarded as an industrial fisheries and mostly companies with well equipped vessels are involved in this type of fisheries. Most of the catch is exported to international markets such as the European Union (EU), The United States and Japanese markets as frozen and/or processed products.

The Inshore Fisheries on the other hand which is the main focus of this research is dominated by local fishermen who reside along the coastal areas. Inshore fishing is commonly practiced in coastal waters known as *I-Qoliqoli* or traditional fishing grounds. Fiji's coastal water houses more than 1,200 species of reef fish which includes the recently endangered species of Napoleon Wrasse and Giant Grouper. In addition, 300 species of hard corals and 10,000 species of plants and invertebrates are living in Fiji's coastal water. Fiji's reef covers a total area of 6,704 km^2 which is equivalent to 3% of the world's reef (Burke et al., 2011) and it includes the third longest barrier reef in the world which is the Great Sea Reef (GSR). The Fisheries Department is responsible for managing the inshore fisheries resources and works in conjunction with other relevant stakeholders to provide effective services. Prior to modernisation, traditional knowledge played a significant role in sustaining the inshore fisheries without the need for implementing western science and knowledge (Pauly and Zeller, 2014). More recently, inshore fisheries had become commercialized providing a source of employment for the people in addition to subsistence need. Eighty percentage of Fiji's population relies both directly and indirectly on these resources for their livelihood.

Since the early 1990's, population increased and the introduction of markets resulted in the high demand of inshore fisheries resources (Teh et al., 2009). People have been relying on fisheries resources to meet their basic needs and wants. With the increasing demand by the local and overseas markets, the harvest and exploitation rate of inshore fisheries was accelerated. Currently, markets are available even at isolated villages through middlemen who are either based at the site or are travelling regularly to the villages. Such circumstances provide added incentive for subsistence fishermen to catch more fish. The fishermen's' surplus catch is occasionally sold (Richards et al., 1994) to middlemen in order to earn a substantial amount of money for their families. Consequently, inshore fishing pressure continues to rise and the fisheries resources are at risk of depletion. This situation could be aggravated if nothing is done to address this issue. The recent national fisheries assessment conducted reveals that out of the 410 *I-Qoliqoli*, 70 are over-exploited, 250 are fully utilized and the remaining 90 which are isolated and far from the markets are in a sustainable condition (Hand et al., 2005). The high demand for fish and poor management strategies, however, will continue to worsen such impacts and will affect all fishing grounds in the future. As such, there is a need to develop and implement proper management measures to conserve Fiji's inshore fisheries resources for present and future generations.

2.1 Inshore Fishing Ground

Fiji's inshore fishing area is divided into several traditional fishing grounds known as *I-Qoliqoli*. These *I-Qoliqoli* are located in the coastal zone which comprises of coastal and inland waters. Currently, the coastal water is divided into 411 registered *I-Qoliqoli* (Lin, 2013) with a total area of 31,000 km^2 (Dumaru, 2011). The *I-Qoliqoli* is an important part of the tribal land sea estate that stretches from the watershed seaward to the outer margin of the seaward slope of the fringing reef (Muehlig-Hofmann et al., 2005). It includes the internal water zone which encloses the entire exterior of Fiji's reefs and lagoon. The presences of natural productive ecosystems such as coral reefs, mangroves, estuaries, lagoons, seagrass beds, etc has offered high biodiversity of marine flora and fauna in the *I-Qoliqoli* (Fiji's Department of Environment, 2010).

I-Qoliqolis' are legally recognised in the *Fisheries Act Cap 158* (Hasting et al., 2012) where indigenous communities are given exclusive rights in their customary fishing ground (Lin, 2013) and the qoliqolis' boundaries are clearly demarcated. The *I-Qoliqoli* Bill 2006 sought to propose that the *i Qoliqoli* areas be transferred from the state to the *I-Qoliqoli* owners and who are to be declared the rightful and proprietary owners of their respective *I-Qoliqoli*, however this was not the case. As stipulated in Section 9 of the Marine Space Act and Section 2 of the Crown of Land Act, the ownership of the physical space of the inshore territorial waters is vested in the state (Lin, 2013). It is officially known that these *I-Qoliqoli* when interpreted should mean the Customary Fishing Rights Areas and they vary in size from one from place to place.

The resource owners who are members of the communities have the right to manage and access their respective fishing ground for subsistence purpose only, however, as stated in the Fisheries Act, every person including resource owners require a licence for commercial fishing. Commercial fishermen from outside the community are able to fish in any fishing ground provided they have a valid fishing license in addition to permit for that particular fishing ground.

2.2 Inshore Fishing Licence

A fishing permit is the major pre-condition of obtaining an inshore fishing licence. Obtaining a permit, however, requires the acquisition of a community consent letter. Upon receiving the letter, the respective Provincial Office has to vet the letter to ensure that it is signed by the right person and provide a supporting letter whereby both, the consent and support letter are then taken to the Divisional Commissioner's Office where the permit is given. The permit is issued by the Divisional Commissioner who also lays down the conditions to it taking into consideration the contents of the consent letter. Finally, the permit is taken to the Fisheries Department office where the license is then issued by a licensing officer.

Fishing licences used for inshore fishing are known as Inside Demarcated Area (IDA) licences and are issued solely by the Department of Fisheries upon the provision of a fishing permit. They are valid until the 31st of December of the same year irrespective of when it is issued; hence, they are subject to renewal every year. At present, the licence costs are F$6.07 for a licence holder and F$1.52 per crew. In addition, if a licence holder owns a fishing vessel, the vessel registration fee costs F$6.07 and F$1.52 for powered and non-powered vessels respectively. A fisherman with a single licence may have fishing permits for more than one fishing grounds which allows them to extend their fishing boundaries and maximize their production provided they obtain permits for those particular fishing grounds. Currently, there is no limit indicated for the number of inshore fishing licences, crews and fishing vessels. Designated Fisheries Officers and others empowered by the Fisheries Act are responsible for setting conditions to the IDA licence as they see fit in accordance with provisions made under the Act. In addition, a fishing permit encompasses By-laws for a particular fishing ground established by the community members themselves in an attempt to conserve their fisheries resources. With the IDA license not being specific to the type of fishing method to be used or to the species of fish to be caught, fishermen are at liberty to use any of the legal fishing methods within the fishing ground that they have been permitted to access. Additionally, the license legally allows fishers to trade fish in order to earn income. Because of the high demand of fisheries resources and unregulated fishing access, fishing efforts continues to increase every year.

2.3 Inshore Fishing Efforts

2.3.1. Number of Licence and Crews

Prior to World War II and even late into the 1940's, fishing in Fiji was characterized as low technology and low intensity that resulted in less impact on the natural environment (DeMers and Kahui, 2012). At this time, people depend on the fisheries resources mainly for subsistence purposes. After the Second World War, however, the inshore fisheries became increasingly commercialized with the development and commercialisation of this sector. Today, markets have expanded to remote areas and the demands for fish are continuingly increasing significantly. Consequently, fishing has become an instant source of income to the people in order to meet their family needs such as children's education, food items from the shops, transportation, and health costs etc (Dumaru, 2011). Though inshore fisheries is being dominated by small-scale fishers, the continuous increase in the number of fishermen over the years has caused an increase in fishing pressure to coastal waters.

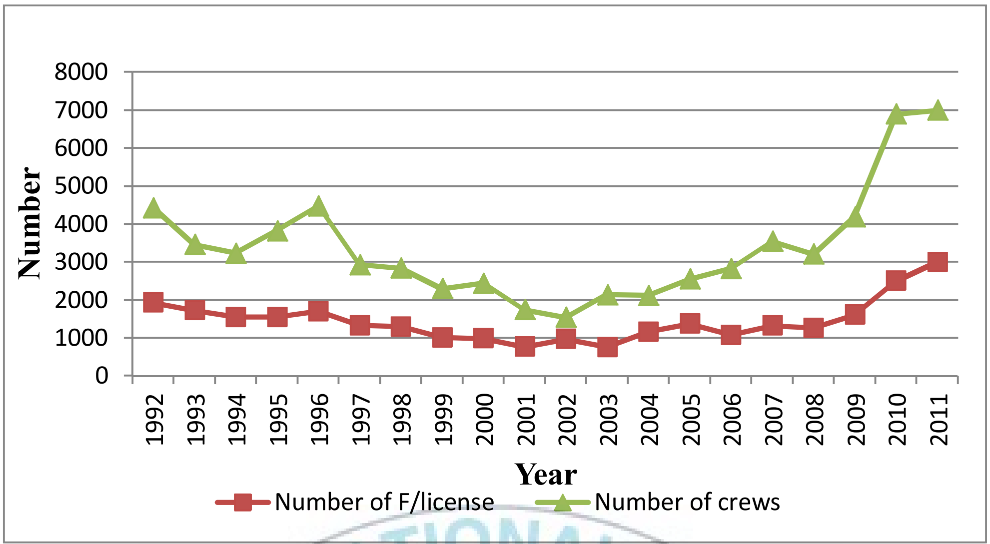

Figure 1. Trend of fishing efforts for the past 20 years, 1992-2011.

(Source: Fiji Fisheries Department, Annual Fisheries Reports).

Over the 4 years period between 2008 and 2011, a 57% increase in license number was observed from 1,265 to 3,000. Additionally, the number of crews increased accordingly by 54% in the same period from 3,210 to 7,000 (Fiji Fisheries Department, 2011). In 2011, the number of licensed fishermen with crews added up to 10,000 which indicate the number of people who are directly involved in inshore artisanal fishing. In the same period, the number of licences only reached its peak with a record of 3,000 licences issued with 50% of this figure coming from the Northern Division.

This occurrence was a result of the government subsidy scheme which assists northern fishermen to purchase fishing boats and engines (Fiji Fisheries Department, 2011). The scheme aims to boost economic productivity and to enhance rural fishermen living standard in Fiji's northern division. The scheme, however, unintentionally caused high fishing pressure on the fisheries resources.

Apart from this data, it is believed that there is other unrecorded data that could increase these figures and would cause dramatic effects in terms of fisheries management. These are unlicensed fishermen who are involved in illegal commercial fishing and who have purposefully avoided the need for a fishing licence.

Fishing effort for subsistence fishing on the other hand has not been accurately recorded; however, approximately 20,000 people are employed through subsistence fishing (Fiji Fisheries Department, 2011). It is acknowledged through such estimates that the majority of coastal communities in Fiji are involved in subsistence fishing. The open accessed nature of Fiji's inshore fisheries causes the increase in number of fishermen. As a result, competitions for fisheries resources have become obvious among fishermen and they tend to invest on motorised vessels and advanced fishing gears to increase their productions within shorter spans of time.

2.3.2. Fishing Vessels and Fishing Methods

In the olden days when people relied on fisheries resources for subsistence purpose, there were low technology fishing vessels and gears used. Vessels such as fishing punts which were often operated by manpower using oars and sail were often used. The twentieth century has marked the turning point for inshore fisheries in that it has been modernized, intensified and commercialized in order to provide a source of living and employment for rural communities (Demers and Kahui, 2012). The fisheries development was further boosted in the early 1970's by extending it to remote areas through policies and loans provided by the Fiji National Government and Fiji Development Bank (DeMers and Kahuil, 2012). Such policies allowed more people to become fulltime fishermen who also invested on more advanced vessels and fishing gears in order to gain more economic benefit (Allision and Ellis, 2001). More recently, the number of inshore fishing vessels continues to rise as people have invested more time and effort on fishing. Despite the use of sail boats and rowing punts by some fishermen, the majority are opting to use more advanced motorised boats.

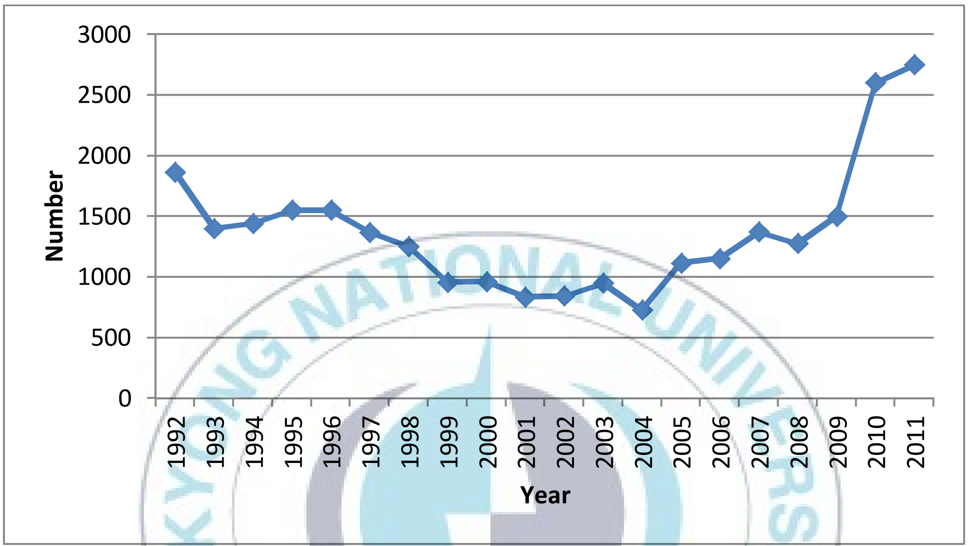

Figure 2. Trend of inshore artisanal fishing vessels from 1992 to 2011.
(Source: Fiji Fisheries Department, Annual Fisheries Reports).

From 1992 to 2004 the artisanal fishing vessels showed a generally decreasing trend, however, since then the trend continue to rise tremendously as a result of increased demand of inshore fisheries resources and a government subsidy program which aims to increase fisheries production.

The two most common types of inshore fishing vessels used in Fiji are launch and fibreglass boats. Launches are normally 28 feet long with a 25hp inboard engine and usually spend an average of 5 consecutive days at sea. Launches have higher storage capacity on board with a maximum of 500 kg and an average of approximately 170 kg of catch per trip for 2 trips per month in a year. These fishing vessels usually travel to distant and deeper waters within a fishing ground for fishing; hence, handline fishing method is commonly used by fishermen that use launches. On the contrary, fibreglass boats vary in size and horse power with a maximum size of 23 feet and 60 hp outboard engines. Fishing operation is done on a daily basis and at nearby fishing grounds with an average of 3 days of fishing trips per week in a year with an average production of 80 kg per week per boat. The common fishing methods used include handline, diving and gill net fishing. Generally, *Indo-Fijian* fishermen prefer hand line fishing while *I-taukei* Fijian fishermen prefer diving: using hand spears and spear guns, and gillnet. A survey in 4 villages in Kubulau and Macuata (Qoliqoli Cokovata) fishing grounds found that 71% and 45% of their catch respectively were caught by diving (Cakacaka et al., 2010; Navuku and Tabunakawai). Despite the differences between the two types of fishing vessels in terms of how they operate and the number of fishing days they spent at sea, their average productions and expenditure per month do not show significant difference. The difference in fishing times, gears and methods used have caused diversification in the composition of catch; hence, Fiji's inshore fishery is characterized as a multi-species fisheries.

2.4 Status of Inshore Fisheries

2.4.1 Production and Marketing

Fiji's inshore fisheries is unique for its abundance and rich biodiversity of both vertebrate (finfish) and invertebrate fishes. The high value of inshore fishes has allowed the inshore fisheries sector to contribute to Fiji's economy almost equal to that of offshore fishery in the past recent years (Minter, 2008).

Invertebrates comprise of holothurians, shellfish, octopus and others with holothurians being the most valuable invertebrates due to the high demand in overseas markets. Holothurians are exclusively harvested for export to overseas markets as they are not commonly consumed by local Fijians. In the 1970's, the holothurian trade came back into the fisheries market after a lapse of many years with most of the highly valued species or targeted species such as *Holothuria fusccogilva, Holothuria scubra* and *Holothuria nobilis* being exported to the Hong Kong markets. With the renewed trade links with China, however, sea slugs including the low grade species are being harvested due to the increasing availability of markets. Currently, sea slugs are now being exported to many parts of the world including China, USA, New Zealand, Japan, etc with most of the exports being from foreign investors who operate in Fiji. Foreign investors have employed locals in order to access remote areas to get as many sea slugs as possible. In 2011, 397,517 kg of beache-de-mer was exported (Fiji Fisheries Department, 2011). The price for these slugs in the local market is determined by the middleman who considers factors such as size and quality of the sea slugs, however, overseas markets price is approximately $30 USD per kg. In the same year, invertebrates accounted for 35% of the total inshore production which was approximately 2,620.2 metric tonnes with an average of 2,500 tonnes being retailed or sold locally. These figures are true for sea slugs, shellfish, crabs, seaweed, and other invertebrates that are found in Fiji's waters (Fiji Fisheries Department, 2011).

Unlike holothurians, finfish have a higher demand at both local and overseas markets. In local markets fish are sold according to their weight or in bundles. Fish are usually graded when sold with an A grade being the most expensive and a C the cheapest. The general marketing channel is from fishermen to middlemen and then to consumers or from fishermen to retailers/hotels/resorts where they are then sold to consumers. At times, fishermen do sell their catch directly to consumers at municipal markets, along the road sides or by going from house to house in the villages. Prices of fish depend on its grade which range from A, B and C with an average price of F$6.50/kg, F$4.50/kg and F$3.00/kg, respectively. The average amount of finfish sold or retailed locally is 4,500 tonnes per annum (Fiji Fisheries Department, 2011). Inflation of retail prices for both finfish and non finfish are currently being witnessed and are attributed to the increasing operational costs, in particular fuel prices. Like sea slugs, finfish also have a high biodiversity which make up of approximately 1,200 different species. In 1998, Live Reef Food Fishery (LRFF) was exported to overseas markets such as Hong Kong and Southeast Asian countries. The number of export companies of LRFF was then decreased from 8 to 2 (Teh et al, 2009) due to the economic crisis. At present, however, other fish processing companies have begun to export reef food fishes. Reef fish export reached its peak in 2006 and then it dropped significantly in the following two years before it picked up again in 2009. In 2011, reef fish exports reached its peak again with 13,624 tonnes after a lapse of 4 years due to the high demand in overseas countries where there is a high population of Fiji nationals such as New Zealand, Australia and USA (Fiji Fisheries Department, 2011).

Subsistence production on the other hand stood at 17,400 tonnes in 2007 (Gillet, 2009).On the basis of the information gathered from the National Nutrition Survey conducted in 2004, fish consumption was 23.4% and 2.4% by indigenous Fijians and Indo-Fijian households on a daily basis respectively and fish consumption per capita is 21 kg.

The globalisation of the fisheries resource markets and the increasing population has resulted in the high intensity of fish harvest.

2.4.2. Fish Stock

Over capacity in the inshore fisheries sector has led to overfishing and has also posed threats to the current fish stock in Fiji. In addition, emphasis on increasing economic status and coastal marine environment productivity are creating adverse impacts on fish stock (Muehlig-Hofmann et al., 2005). A personal interview with Macuata fishermen in the Northern part of Fiji has revealed that in the past 10 years, the production per fishing boat is higher with minimal fishing efforts. Recent years' productions; however, reveal that there is a great reduction in fish catch and fishermen have to increase their fishing efforts in order to produce the same amount that they usually catch in the past years. This is evident when fishermen are willing to invest in modern fishing vessels that are powered by engine and increase their number of crews in order to meet their targets. This investment has seen fishermen staying out at sea for longer periods which is very costly due to high fuel prices and fish preservation. Today, in an effort to meet the peoples' needs and market demands, the inshore fish resource is intensively overexploited (Teh et al., 2009). There have been reports of certain species being overfished in areas that are situated away from market centres. This is mainly due to the continued increase in number of fishermen and the use of more efficient fishing technology (Muehlig-Hofmann et al., 2005). In the early 1990s, species such as Mullidae, Signadidae, Giant groupers and Bumphead wrass (*Bolbometapon muricatum*) were increasingly becoming reduced or in most cases depleted. From 2008 to 2011, there has been a decrease of approximately 4% in the general production of artisanal finfish fisheries in Fiji's inshore fisheries area which was reflected in a reduction from 4,886 to 4,675 metric tonnes (Fiji Fisheries Department, 2011). Fiji's inshore fisheries shows a gradual rise in CPUE from 1992 to 2001. From 2003 to 2011; however, CPUE shows a significant decreasing trend. The following graph illustrates such pattern (Fiji Fisheries Department, 2011).

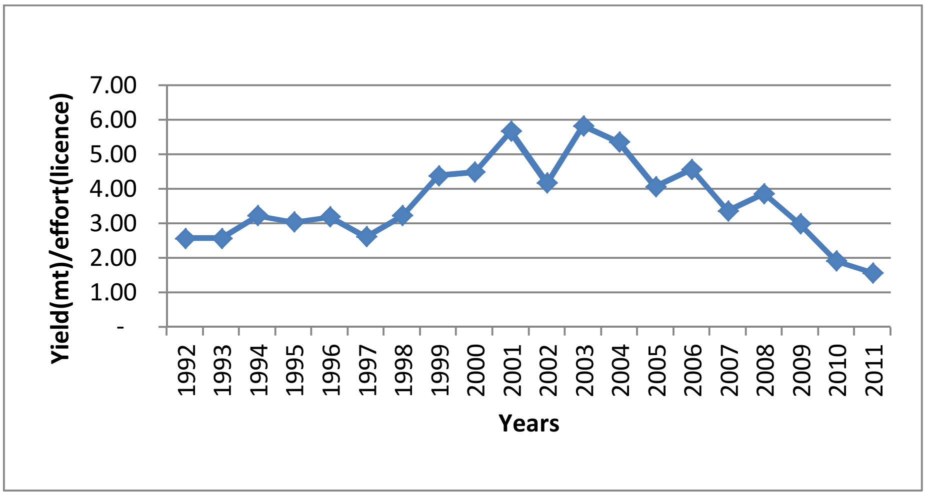

Figure 3. Trend of inshore fisheries CPUE from 1992 to 2011.

(Source: Fiji Fisheries Department, Annual Fisheries Reports).

CPUE is an indirect measure of fish stock abundance which can be computed by catch-effort data. The decreasing trend of CPUE is a clear indication of overfishing (Fulanda et al., 2011). The fishing effort used in the graph above reflects the number of fishing licence (Figure 1) which in this case is increasing, and has unfortunately contributed or led to constant overfishing.

In addition to the fish stock depletion, the individual fish size caught by fishermen also reduced which means that fishermen were catching smallsized fish. Preliminary results from Catch Per Unit Effort (CPUE) data collected across Fiji indicated that more than 50% of fish caught were not fully grown in terms of their sexual maturity size except in the two provinces of Rewa and Lau (IAS, 2009). Some area-specific surveys found that fishing grounds such as Macuata (Qoliqoli Cokovata) and Kubulau generally have higher CPUE; however, the high youth population, lack of alternative source of livelihood and high investment on motorised fishing vessels in these areas are likely to cause intensive exploitation of fisheries resources if no proper management measures are implemented (Cakacaka et al., 2009; Navuku and Tabunakawai). The most targeted inshore fish include Acanthuriday, Balistiday, Carangidae, Carcharhinidae, Chaetodontidae, Ephippidae, Haemulidae, Kyphosidae, Labridae, Lethirinidae, Lutjanidae, Mullidae, Nemipteridae (groupers only), Siganidae, Sphraenidae and Zanclidae. These species are preferred food fish and some including emperors, snappers, groupers, trouts, unicorn, mullets, parrotfish and surgeon fish (Navuku and Tabunakawai) are commercially valuable as well making them commercially targeted reef species.

2.5 Biological and Socio-economic Impact of Overfishing

Overfishing is defined as the rate or level of fishing mortality that jeopardises a fisheries ability to produce maximum sustainable yield on a continuous basis. It is simply the imbalance between the rate of harvest by fishermen and the rate of reproduction by fish due to the increase in fishing pressure. Such a phenomenon leads to the depletion or extinction in most fisheries stocks and becomes a major threat to fisheries management. Overfishing is a prevailing issue in Fiji's inshore fisheries which has significant biological and economical impact on stock biomass and fishing business respectively.

2.5.1 Biological Impacts

All organisms in an ecosystem play an important role in sustaining the natural operation of an ecosystem. These organisms are linked to each other through a food web; therefore, removing certain species will certainly have a negative impact on other species. A study in Kubulau District in Fiji by WCS, found that species of surgeon fish (Acanthuridae) and parrotfish (Scaridae) were the most targeted species by Navatu fishermen who employ spear guns for catching them. These fishes are important reef grazers and scrapers/excavators and their feeding behaviour provides an essential function in maintaining resilience on coral reefs (Mumby et al., 2007). The negative impact of overfishing on the marine ecosystem is magnified through the use of unsustainable fishing practices and anthropogenic activities. Practices such as harvesting of undersized fish, use of dynamite fishing, use of plant poison, and land-based pollution contribute immensely to the negative impacts on the marine ecosystem. The harvesting of undersized fish through the use of small mesh-size gill nets is problematic and detrimental to the sustainability of our fisheries as it prohibits fish from reaching mature size; hence, preventing them from reproducing and causes recruitment overfishing. IAS 2009 revealed that 88% and 74% of the two major targeted catches, the lutjanidae and lethrinidae, were undersized while in the provinces of Ba and Cakaudrove, there was a record of 70% undersized fish caught. The use of dynamite fishing destroys coral reefs which is an important habitat for fish. The use of plant poison which is known as duva in Fijian, kills any fish size including non-targeted species. Additionally, land-based pollution has also affected fishing grounds and fresh waters which are mostly used by 10-12% of reef fishes for spawning, nurseries or feeding grounds (Fiji Department of Environment, 2011). Agriculture run-offs, siltation and industrial pollution are the main types of land-based pollution. The land-based pollution does not only affect the fish but the marine ecosystem as a whole. For instance, agriculture run-offs may cause ecosystem shift and eutrophication in marine and freshwater environment. Siltation affects the growth of coral by blocking out the sunlight; hence, disrupting the process of photosynthesis by the symbiotic algae called zooxanthallae. The combination of overfishing and other external factors mentioned above pose risks of biological stocks depletion for inshore fisheries. In general, the relationship between fishing effort and production is directly proportional; however, this is not the case for Fiji's inshore fisheries.

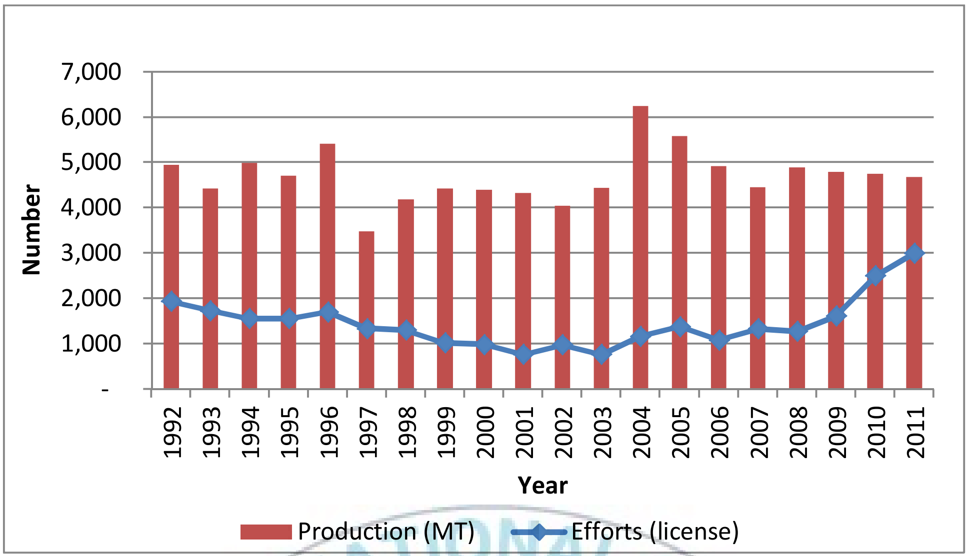

Figure 4. Trend of inshore artisanal catch and fishing effort.

(Source: Fiji Fisheries Department, Fisheries Annual Reports).

Though there is no drastic decline shown in the graph, fluctuation of catch as compared to an increasing trend is not sustainable. Fisheries having such condition are at a risk of detrimental stock size decline in the future. Since, 2008, the production was fairly stable, though fishing effort increased significantly. Overfishing may not only caused depletion in the biological stocks but may also create socio-economic issues regarding food security and income.

2.5.2 Business Condition

Furthermore, the economic benefit from inshore fisheries resources should not be underestimated as it plays a significant role in the development of small Pacific Island Countries including Fiji. Fiji's ocean (EEZ) is 71 times larger than the land mass and the commercialisation of fisheries resources prompted the ability for these resources to generate sufficient income for development at national and community level. The combination of vast ocean area, rich in biodiversity and the high value of fisheries resources gives this sector the potential to become one of the leading natural resource based industry for future economic development. Fisheries resources had attracted foreign investors that could boost Fiji's economy by bringing in foreign currencies and providing more employment to the local people.

In 2010, the contribution of the fisheries sector to the national Gross Domestic Product (GDP) was 2.75% which is equivalent to F$132 million. Furthermore, the fisheries sector is the second largest export commodity which contributes 13% of the total export earnings (Fiji Fisheries department, 2011). In recent years, the inshore fisheries contribution to the economy was almost equal to that of offshore fisheries (Minter, 2008). In creating employment for the people, inshore fisheries not only provide a source of income but it also improves their standard of living. The Fisheries Department estimated the annual average of employment by subsistence and artisanal fisheries to 20,000 and 6,000 respectively. A survey carried out in Fiji showed that between 2008 and 2009, more than 70% of the fish catches were sold (IAS, 2009).

The average annual amount of finfish and non-finfish sold or retailed is approximately 4,500 tonnes and 2,500 tonnes, respectively. It is also important to note that there is an increase in retail price of fish and non-finfish which is attributed to the high fishing operating costs (Fiji's Fisheries Department, 2011).

A survey carried out in Fiji, (result mentioned above) is complemented by a survey conducted in four villages in Macuata which revealed that 60% of catch is sold and 16% is used for household consumption and the rest is given away. A WWF survey reveals that the average monthly income from fishing for the following 4 villages: Naduri, Nakalou, Nakawaga and Korotubu, are F$235, F$127.89, F$183.18 and F$264 respectively. Agriculture activity is not well developed in these villages; therefore, fishing accounts for a significant portion of household income. Another survey in Kubulau suggests that fishermen from the village of Navatu sell most of their catch in the market through a middleman (Cakacaka et al., 2010).

In 2012 to 2013, a survey was conducted on commercial fishermen by the northern fisheries department. The survey aims to collect data such as fish catch and revenue from fishermen on a monthly basis to identify the trend of fish production and revenue over the years. The data revealed that the average production per month for 2012 and 2013 was 603.25 kg and 347.44 kg, respectively.

Table 1. Result of economic analysis from a monthly survey on Macuata artisanal fishermen

Average	2012	2013
Production per month (kg)	603.25	347.44
Revenue per month (FJD)	$2,528.66	$1,992.07
Costs per month (FJD)	$1,045.00	$1,141.00
Profit per month (FJD)	$1,483.66	$851.07

An average monthly fish catch had significantly reduced from 603.25 kg to 347.44 kg which led to the reduction in monthly fishing revenue from $2,528.66 to $1,992.07.

The impact of the decline in fish catch on fishing revenue is exacerbated by the increase in fishing costs which was observed over the two years period. The fishing operation cost per month increase from $1,045.00 to $1,141.00 which includes fuel costs, labour costs, ice, boat maintenance, transportation, fishing gears, etc. Fishing expenditure trend is assumed to increase continuously over the years due to the increasing in fishing operation costs. This situation had resulted in the decrease in fishing profit and if continues, fishing business will become a non-profitable business in the future and fishing communities will become poor. It is important to note that most of the fishermen that take part in the survey are entirely rely on fishing as their primary source of income. Therefore, revenue earned from fishing caters not only for their fishing operation costs but for their family living expenses as well.

At national level, the decline in fisheries resources means that the export earnings from the fisheries sector will drop and contribution to GDP will also drop accordingly. A declining trend of fisheries contribution to national GDP had already been realized from 2008 (3.14%) to 2010 (2.75%). Furthermore, people who are indirectly rely on these resources such as market vendors, middlemen, fisheries industry employees, etc will also lose their source of employment.

Currently, the combination of resource depletion and the increasing fishing operation expenses have devastating and detrimental economical impact at both national and community level. Continuation of this trend may result in the increase in poverty and hunger. But the maximum economic benefits from fisheries resources can only be achieved, if these resources are exploited sustainably.

2.6 Institutional Framework

The following section deals with the legal and institutional aspects of Fiji's Inshore Fisheries. It includes identifying the authority responsible for the management and conservation of the fisheries resources and evaluating the relevant legislations that have been established for the management and conservation the fisheries resources. It also attempts to identify the relevant provisions which accommodate and regulate the area of inshore fisheries and indicate the limitations of such legislations. In summary, this section seeks to ascertain whether Fiji's legal framework in terms of its legislations and institutions are sufficient in the management and conservation of its fisheries particularly, the area of inshore fisheries.

In spite of its current political stance, Fiji employs a bureaucratic system of government whereby different Ministries and Departments are established for specific purposes to ensure that the executive government achieves its goals and targets. The Fisheries Department of the Ministry of Fisheries and Forests was established for the purpose of administering Fiji's fisheries resources by ensuring that such resources are managed through sustainable utilisation. It is also responsible for creating awareness on the conservation of such important yet vulnerable resource to all communities. Additionally, it makes proposals for amending legislations governing its fisheries in order to meet international obligations as well as to make laws more meaningful and practical. This proposal will divide the current Fisheries Act into Offshore Decree, Inshore Decree and Aquaculture Decree.

2.6.1 Legal Framework

The Fisheries Act which is the principle fisheries legal framework was adopted in 1942 for the management of Fiji's marine resources for both foreigners and indigenous Fijians (Lin, 2013). This Act provides for the protection of inshore fisheries through the implementation of the Permit and License schemes. Under these schemes, the Act empowers licensing officers to also lay down terms and conditions to such permits and licences, as they deem fit and necessary. The involvement of communities' consultation as pre-condition for acquiring permits and licences from those engaging in fisheries related activities is an indirect way of enforcing community fisheries By laws including the communities *tabu*, which is an effort to manage the *I-Qoliqoli*. Under the permit system, resource owners' right are protected as they are allowed to fish for subsistence purpose without a permit. Non-resource owners on the other hand are given the opportunity to access such *I-Qoliloli* for subsistence fishing provided they obtain a permit. Non-resource owners and resource owners who wish to fish for 'trade or business'; however, are required to obtain a licence under the licence system in addition to the permit. It is important to note that obtaining a permit is a pre-condition for a fishing licence and for subsistence fishing for non resource owners. The current practice; however, is that permit are used only as a precondition for fishing licence; hence, subsistence fishermen who are not required to get a licence are not covered by such By laws as they do not obtain a permit.

The Act also provides for the gazettal of *tabu* areas and the sole purpose of this is to inform people that such areas are protected and no one is permitted to fish in those areas unless they have been authorised in writing by the Commissioner of the Division in the manner provided for under the Fifth Schedule of the subsidiary legislation. In this way, the fisheries resources is being managed sustainably in that it allows for this restricted areas to recuperate or even grow a healthy population in order to cause spill-over effect. With the exception clause provided for in relation to accessing these prohibited areas, there is a tendency that accessibility to marine reserves is not totally banned due to the exclusive power given to the Commissioner of Division to authorise any person to fish in marine reserves (Minter, 2008). This occurrence would mean that these areas would be subject to exploitation and would defeat the purpose of its establishment which is management and conservation.

To ensure that the people do not exploit the inshore fisheries, the Act empowers the Minister to make Regulations which restricts the catching of under-sized fishes, certain species and stipulates the methods of fishing which are prohibited to use in inshore fishing grounds. This would allow for inshore fish to grow to sexual maturity in order to reproduce and keep a healthy population. With the advanced in science knowledge and research, it is clear that more species of fish are continuously being identified, some of which are endangered but are not acknowledged by the Fisheries Act. This clearly indicates that there is a need to revise the Act to update with the current situation and incorporate effective management guidelines that suite the current situation.

Considering Fiji's scattered land mass, the Fisheries Department faced with difficulty to fully monitor and control fishing activities that occurs on a wide-scale throughout the communities. Fortunately, the Act makes provisions for the appointment of fish wardens within the various communities. The roles of these fish wardens are to ensure that people comply with the provisions of the Act and any subsidiary laws made subsequently. In instances where fisheries officers or police officers may not always be around, the fish wardens are tasked with detecting, preventing and reporting the violation of the Act. They are somewhat bestowed powers similar to that of police and fisheries officers but clearly only to the extent where their roles and functions of establishment would permit. The lack of quality training, recognition and qualification of these wardens; however, makes their job very difficult to do (Minter, 2008) and also the lack of awareness by the people contributes to the ineffectiveness of their jobs. A classic example of how fish wardens are being taken lightly by communities and even by the law is that people fear police officers and comply with instructions handed to them more seriously then when instructed to do so by fish wardens. The law not providing for their proper recognition as in the case of police officers indicates the type of attitude we have towards the management of our inshore fisheries.

It should be noted that even with the Fisheries Act (Cap. 158) capturing a lot of offences related to the administering of inshore fisheries, the penalties; however, are found to be very lenient (Teh et al., 2009). The offences identified by the Act are quite encompassing in that it includes almost all the offences that can be found in the area of fisheries. This is encouraging because perpetrators will have little or no chance of escaping prosecution and or fines for their acts of non- compliance. Because of the lenient penalties which are too little compared to the amount of goodwill or catch that is being possessed, the perpetrators are likely to re-offend and cause much more harm to the marine resources than they already have. Comparing the penalty scheme outlined in the Fisheries Act with other Pacific Island Countries preliminary reviewed penalties, Fiji's penalty can be considered outdated (Minter, 2008).

2.6.2 Institutional Framework for Inshore Fisheries Resources Management

The Department of Fisheries, under the Ministry of Fisheries and Forests is solely empowered to administer and implement the provisions stipulated in the Fisheries Act. The department core functions include fisheries management and development, and ensuring the sustainable use of fisheries resources. In order to carry out its functions effectively, the department's functional roles are divisionalized. The four divisions in Fiji, being the Northern, Central, Western and Eastern that have divisional headquarters located in Labasa, Nausori, Lautoka and Lami respectively, and these are headed by the Principal Fisheries Officer. Additionally, other supporting offices are located within the divisions of the two main islands of Fiji and with some being located in maritime islands.

The implementation of the Act is also supported by other government agencies and NGOs that focus on conservation and management of the fisheries resources through sustainable utilisation and protection of endangered fisheries species. These government agencies include the Provincial Council Office and the Divisional Commissioner's Office which are established with specific purpose. The Provincial Council Office (PCO) is located at each province and it is established under the *I*-Taukei Affairs Act. Its core functions include promoting health, welfare and good governance to the residents in the different provinces (Minter, 2008). With these functions, the PCO is empowered to create and enforce by-laws pertaining to fisheries issues. The by-laws are only applicable to community matters that are not serious and are effective only on those whom it has been established for. In the case of obtaining fishing permits, the Divisional

Commissioner is responsible for granting them under the condition that other pre-requirements are satisfied.

Furthermore, in an effort to counter the deterioration of inshore fisheries, the fisheries division helped to established and or re-established several Locally Marine Managed Area (LMMA). The Fiji Locally Managed Marine Area (FLMMA) network was established in 2000 and works effectively to implement such management regime (DeMers and Kahui, 2012). The network comprises of organisations involved in community-based fisheries management which include Government Agencies, Non Government Organisations (NGOs) and Private Sectors (Muehling-Hofmann et al., 2005). Conservation NGOs such as IAS, WWF, WCS, etc have fully committed to support the implementation and conservation of fisheries resources at community level through the establishment of fisheries management committees, implementation of management tools, capacity-building within the community, scientific research at *I-Qoliqoli* and awareness programs. Some NGOs have also provided financial assistance for the fish warden trainings particularly in communities with which they work closely.

Additionally, for the enforcement of Fisheries regulations and policies, the role of the fish wardens are established and is crucial to note that fish wardens are not empowered to enforce the provisions of the by-laws, rather the Roko Tui or other appointed officers from the Provincial Council Office (Minter, 2008). The Act also empowers fisheries extension officers to conduct enforcement activities at sea and on land in order to bring to task all those engaging in illegal fishing-related activities emphasising that any illegal operations identified by fish wardens or fisheries officers are to be reported to the nearest port or police station. It is essential to note that police officers play a very significant role for both law enforcement and prosecution of illegal fishing cases. Furthermore, the Fiji Navy continues to offer assistance to the Fisheries Department in law enforcement through sea patrol in which illegal fishers are reported to police and their catch are being confiscated.

2.6.3 Marine Tenure System

Fiji inshore fisheries employ dual ownership which involves the national government and the resource owners (Muehlig-Hofmann et al., 2005).

Traditionally, Fiji's coastal waters are managed by communities that live adjacent to it (Teh et al., 2009) and who are legally referred to as the rightful resource owners. This system is known as traditional marine tenure system and it is commonly used to manage inshore fisheries in Fiji. Each of these communities is headed by a chief who makes decisions at community level regarding community matters pertaining to fisheries matters. Some communities; however, had established an *I-Qoliqoli* committee which deals specifically with the management of their fishing grounds. Community members or resource owners have the right to fish for subsistence purposes, within their fishing grounds without any permission from the government.

Community rights are protected by the permit scheme established in the Fisheries Act where they can use it to raise their voice over their fishing ground. Through the permit scheme, communities have to be consulted by any fisher prior to operating fishing activities in their fishing ground. Without, the community consent which in most cases is given by their chief through writing, fishermen could not get a fishing permit from the government. The consent letter contains the prohibitions or community By-laws of their respective fishing ground. These By-laws are established by community members following the community consultation and awareness workshop conducted by the Fisheries Department and NGOs. These include restrictions on the use of night diving, underwater breathing apparatus and gill net with less than 3 inch mesh size, fishing in tabu areas and so forth. Some of these By-laws overlap with the prohibitions stipulated in the Fisheries Act (Cap 158).

Additionally, it is the chiefs who are entitled to setting and receiving the amount of goodwill that fishers have to pay in order to obtain their consent letter. In most cases, this amount is not fixed nor written down and so it varies from one person to another. In the case of the northern division in Fiji, the good will ranges from F$0.00 to F$1,000.00 per letter.

In some cases; however, when the Fisheries Department conducts its law enforcement out at sea, it finds that some commercial fishermen are catching fishing without a fishing license. According to these fishermen, they have been given authorisation by the chief of that particular fishing ground. This incident indicates that there is a need to clearly define the limit and role of resource owner over their fishing right area. Under the Fisheries Act (Cap 158), it is mandatory for commercial fishermen to have a fishing licence from the Fisheries Department only. Currently, the permit scheme is used mainly as a pre-condition for the issuance of a fishing licence. It is vital to note that in the case of subsistence fishermen, there is no need for the resource owners to obtain a permit as they are not required to but non-resource owners or fishermen who do not belong to such fishing ground are required to obtain a permit.

Chapter 3. Data and Methodology

3.1 Type of Data Used

Inshore fisheries data collection is often a major challenge for the department of fisheries in Fiji. Inshore fisheries employs a complex exploitation regime in that it consists of multispecies fisheries, use of various fishing gears and different types of fishing vessels. Additionally, not only does communities who are regarded as resource owners use their respective fishing ground (*I-Qoliqoli*) but other fishermen outside these communities who travel frequently to such fishing grounds. Mostly, inshore fisheries production comes from rural areas which are hardly visited for data collection. Artisanal catches; however, have been ending up in the main centres in Fiji through middlemen who are based in such areas or by commercial fishermen themselves who often travel to the main centres to sell their catch. These catches are mostly sold at municipal markets and or fish outlets in main centres such as Savusavu, Labasa, Suva, Nausori, Lautoka and others.

Considering the spatial distribution of fishing communities in Fiji, data collection is often time consuming and costly; thus, the fisheries department has been focusing on major municipal markets and fish outlets in main centres to capture data. The type of data that have been collected through market survey include weight and price of fish.

This data obtained were not for individual species but rather as categories of finfish and non-finfish. Thus, data used in this research is solely based on artisanal inshore finfish fisheries which were extracted from the fisheries department's annual and statistic reports. In addition, from the same reports, fishing efforts such as number of fishing licence, fishing vessels and crews was obtained.

For bio-economic analysis, 20 years catch-effort data from 1992 to 2011 were used to calculate CPUE. Fishing effort used is number of fishers which are equivalent to the number of licence issued over the years. Additionally, the revenue data collected was used to estimate the economic indicators of inshore fisheries.

Table 2. Fish production and revenue with respect to different level of fishing effort for 20 year period

Years	Number of fishing licence (fishers)	Commerical finfish Production (MT)	Revenue (FJD)
1992	1930	4,954.54	$ 16,647,254.40
1993	1727	4,428.00	$ 15,976,000.00
1994	1551	4,997.00	$ 16,702,000.00
1995	1549	4,707.00	$ 16,356,000.00
1996	1699	5,417.00	$ 19,821,000.00
1997	1334	3,485.00	$ 17,103,000.00
1998	1297	4,182.91	$ 14,654,577.00
1999	1012	4,430.98	$ 14,888,092.80
2000	982	4,405.00	$ 18,250,000.00
2001	763	4,329.00	$ 18,520,000.00
2002	969	4,039.56	$ 13,880,000.00
2003	762	4,439.20	$ 18,980,000.00
2004	1165	6,241.00	$ 27,093,527.00
2005	1372	5,581.50	$ 26,046,763.50
2006	1077	4,922.00	$ 25,000,000.00
2007	1324	4,450.00	$ 19,026,307.00
2008	1265	4,886.00	$ 24,755,164.00
2009	1610	4,801.00	$ 25,000,000.00
2010	2499	4,750.00	$ 26,000,000.00
2011	3000	4,675.00	$ 28,000,000.00

(Source: Fiji Fisheries Department, Fisheries Annual Reports).

Additionally, the annual fishing operation costs were acquired by interviewing 38 and 28 fishermen in the province of Macuata in 2011 and 2012 respectively. Labour and fuel costs contributed high percentage of costs when combined accounted for 78% and 70% in 2011 and 2012 respectively. Standard fishing duration for artisanal fisheries used in this research was 40 weeks in a year as the other 12 weeks were attributed to bad weather and other commitments. Moreover, fishing operation cost for Macuata artisanal fishers were used for inshore artisanal fisheries in the whole of Fiji.

Table 3. Average fishing costs for inshore fishers

Fishing Operation (40 wks)	Average annual costs (FJD)	
	2011	2012
Labour cost	2,000	3200
ice	500	400
fuel	1,600	2,400
food ration	2,000	800
repair & maintenance	100	200
transportation	300	400
fishing gears	100	200
others	2,000	150
Total	6,600	7,750
Average for 2011 & 2012	7,175	

The challenge for data collection in Fiji is attributed to the combination of being an archipelago with scattered islands over wide area and an absence of common landing sites and an absence of a data reporting system

3.2 Methodology

Surplus Production Models (SPMs) are commonly used in fish stock assessment which aims at estimating exploitation rate in an exploited fisheries by deriving the Maximum Sustainable Yield (MSY). In addition, SPMs are used to predict future productions and sustainability of stock biomass level at varied level of fishing efforts (Fulanda et al., 2011). MSY is referred to a biological reference point or a management criterion derived from biological consideration and surplus production is the amount of fish stock biomass that can maintain a sustainable fishery when harvested from the fish population. Therefore, a harvesting of surplus production will not affect the abundance of fish stock over the years as SPMs assume that surplus production equals the population's capacity to increase. It is important to note that SPMs consider fish stock as homogeneous biomass (Jensen, 2005). In addition, SPMs assume that fish stock and fishing efforts are distributed equally throughout the fishing ground. SPMs; however, could be applied in data limited conditions such as Fiji's inshore fisheries and it is less costly compared to other stock assessment methods. For this study, CYP and Schaefer model were used for data analysis. The result for the CYP model, however, was statistically insignificance, thus, impossible to apply. Hence, the Schaefer model was the preferred one.

The Schaefer's Model

The Gordon-Schaefer model is a simple, useful and convenient method for assessing the fish stock as it only requires indices of stock size including CPUE which is easily obtained through catch and effort data. It is a bioeconomic comparative static fishery model which is based on logistic biological growth, and harvest linear in stock biomass and fishing effort. The growth logistic model is expressed as:

$$G(x) = r \cdot X \cdot \left(1 - \frac{X}{K}\right)$$

This equation represents the dynamics of an unexploited fish stock where r is intrinsic growth rate, X is stock size and K is the environment carrying capacity. A common objective of renewable resources management such as fisheries resources is to maintain the standing stock that can provide MSY. Mathematically, in terms of continuous time model, sustainable yield can be maximise through achieving equilibrium state; $H = G(X)$. This requires maximization of growth for fish biomass, $\frac{dG_x}{dX} = 0$.

$$\frac{G(X)}{dX} = r - \frac{2rX}{k} = 0$$

$$X = \frac{k}{2}$$

This stock size which is half the environment carrying capacity needs to be maintained or rebuild in order to maximize fish growth over time. Therefore, maximum sustainable yield can be obtained through maximum growth:

$$H_{MSY} = rX\left(1 - \frac{X}{k}\right)$$

Where $X = \frac{k}{2}$, substituting X into the above formula, the sustainable yield function can be rewritten as:

$$H_{MSY} = \frac{rk}{4}$$

Maximum growth and maximum sustainable yield can only be realized when growth and harvest rate are equal.

In exploited fishery, the yield function is added to the growth function which can be expressed as:

$$\frac{G(X)}{dt} = r.X\left(1 - \frac{X}{k}\right) - H$$

Where yield as define in terms of fishing effort is express as H= qEX where q is the catchability coefficient, E is fishing effort and X is stock biomass. Furthermore, the Schaefer's model assumes that stock biomass is at an equilibrium state which means that $\frac{G(X)}{dt} = 0$. Therefore, growth rate equal harvest rate and can be expressed as:

$$G(X) = H$$

$$r \cdot X \cdot \left(1 - \frac{X}{k}\right) = qEX$$

From the above equation, Stock at equilibrium can be derived as: $X^* = k - \frac{qkE}{r}$. It is important to note that harvest should be maintain at X* in order to maintain the stock at equilibrium state. Substituting X* function in the Yield function gives the equation that was used to compute MSY and MEY in terms of alpha (α) and beta (β):

$$H = qEX^*$$

$$H = qE\left(k - \frac{qkE}{r}\right)$$

$$H = qkE - \frac{q^2k}{r}E^2$$

Where $qk = \alpha$ and $\frac{q^2K}{r} = \beta$, therefore the above equation can be rewritten as:

$$H = \alpha E - \beta E^2$$

The value α and β respectively were obtained by simple regression analysis using excel in order to estimate MSY, E_{MSY} , MEY and E_{MEY}. In regression, CPUE and fishing effort for the 20 year period were used as dependent variable and independent variable, respectively.

The function for fishing effort at MSY (E_{MSY}) was derived by differentiating the harvest function with respect to effort: $\frac{dH}{dE} = 0$.

$$\alpha - 2\beta E = 0$$

$$E_{MSY} = \frac{\alpha}{2\beta}$$

The fishing effort at MSY was calculated first and then the value obtained was substituted in the harvest function to get the value of MSY.

On the other hand, economic consideration is important not only for stock conservation but also for fishing benefit. Economic parameters such as Maximum Economic Yield *(MEY)* and optimal fishing effort (E_{MEY}) were used to determine the level of production and fishing effort that can maximize the economic benefit. *MEY* can be calculated using the same harvest function; however, at this time the value of fishing effort at MEY was substituted in the equation. The E_{MEY} was calculated using the economic profit equation as shown below:

π =TR-TC

Where TR is total revenue which can be expressed as TR=HP, where H is production and P is unit price. In this case, the unit price (P) was calculated using the unit price average for the last three years (2009-2011) which is equivalent to F$5,556.75/MT (Table 2). TC is total cost which can be expressed as TC=cE, where c is the unit cost and E is the fishing effort. Unit cost (c) is the price of fishing operation per boat for the year which was $7,175.00 (Table 3).

The yield function, H= $\alpha E-\beta E^2$ was substituted into the economic profit equation and, hence, for maximization of yield, differentiation was done with respect to effort (E) which gave the formula for optimal effort at MEY:

$\frac{d\pi}{dE} = 0$

$$\pi = (\alpha E - \beta E^2)p - cE$$

$$\frac{d\pi}{dE} = \alpha p - 2\beta E p - c = 0$$

$$E_{MEY} = \frac{\alpha . p - c}{2\beta p}$$

Bio-economic Modelling

For predicting the future stock size, the Schaefer function was used which is expressed as:

$$\frac{\bar{U}_{t+1} - \bar{U}_t}{2\bar{U}_t} = r - \frac{r}{qk}\bar{U}_t - q\tilde{E}_t$$

Where $\bar{U}_{t+1}$ represent CPUE at time t + 1, $\bar{U}_t$ represent CPUE at time t and $\tilde{E}_t$ represent fishing effort at time t.

The Schaefer function was used to compute the dependent and independent variables from the 20 years catch-effort data. These variables were used to conduct a multiple regression analysis. The dependent variable was represented by $\frac{\bar{U}_{t+1}-\bar{U}_t}{2\bar{U}_t}$ and the independent variables 1 and 2 were represented by $\bar{U}_t$ and $\tilde{E}_t$ respectively. Multiple regression result provides the value of the constants a, b and c which were used to calculate the value of the coefficients: intrinsic growth rate (r), catchability coefficient (q) and environment carrying capacity (k). The coefficients r is equal to a, $\frac{r}{qk}$ is equal to b, q is equal to c. Upon gaining the values of r, q and k, growth function, yield function and stock biomass function were used to estimate the growth, harvest and stock size respectively over time.

Bio-economic modelling was conducted to determine the future trend of fish production over the next 25 years. In the analysis, population parameters such as recruitment and natural mortality were assumed to be constant. Schaefer's production term, $G(X) = r \cdot X \cdot \left(1 - \frac{X}{k}\right)$ was used to estimate the stock growth over the years based on the current fish stock (5,194.44 MT) which was obtained by the function: $X = \frac{H}{qE}$ where H is the current production and E is the current effort for the year of 2011. Additionally, the harvest function: $H(E, X) = qEX$ was used to estimate the harvest over time based on the current fishing effort which was equivalent to the number of licence in 2011. The bio-economic model which was used to predict the future stock biomass over the years is expressed as:

$$X_{t+1} = X_t + G(X_t) - H(X_t)$$

Where X_{t+1} is the biomass in time t +1, X_t is the biomass in time t, $G(X_t)$ is the growth function in time t and $H(X_t)$ is the production in time t.

The estimated revenues were also calculated by multiplying the different level of catch with a unit price (F$5,556.75/MT) which was assumed to be constant over the year. The estimated profits were then calculated by subtracting the revenue with the constant fishing operation cost which is F$7,175.00.

Chapter 4. Results

4.1 Calculation of MSY, E_{MSY}, MEY and E_{MEY}

The dependent and independent variables which were derived from the 20 years catch-effort data were used to produce the linear regression analysis result as shown in the table below.

Table 4. Result of linear regression analysis

	Coefficient	*Standard Error*	*T stat*	*P-value*
Intercept	6.2998	0.3921	16.0671	0.0000
Effort	-0.0018	0.0003	-7.2670	0.0000
R-Square = 0.7458, F = 52.8094, P-value = 0.0000				

The regression analysis result shows that the value of alpha (α) and beta (β) were 6.2998 and 0.0018 respectively. Thus, using the equations mentioned in the methodology section, the fisheries performance indicators for Fiji's inshore fisheries were obtained as follow: *MSY*=5,512.5 metric tonnes, E_{MSY}=1,750 licences, *MEY*=5,280.9 metric tonnes and E_{MEY}=1,391 licences.

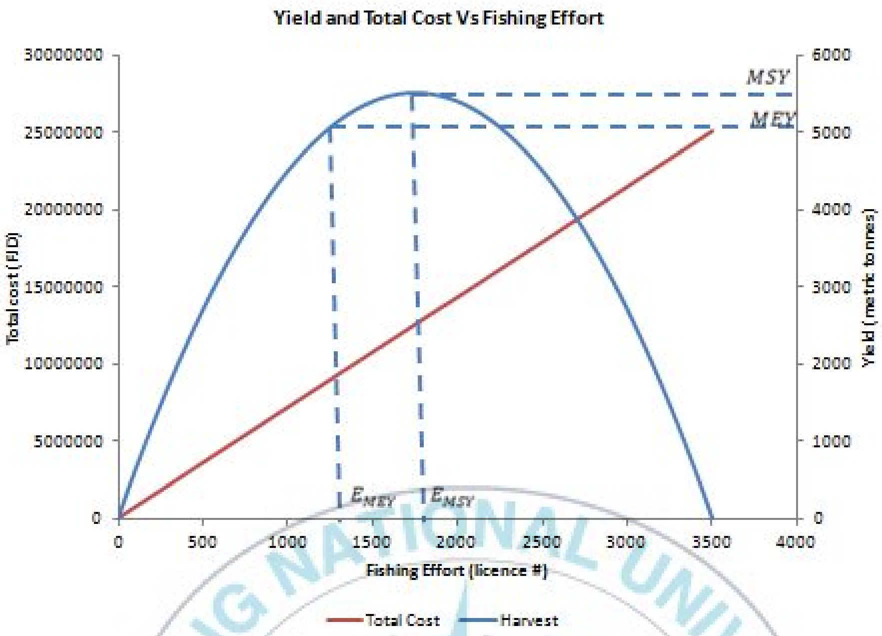

Figure 5. Relationship between yield and total cost against fishing effort.

The graph clearly displays the trend of fish production and fishing costs against fishing effort. As the fishing effort increase, the yield also increase until it reaches a certain level whereby when fishing effort continues to rise, the yield start to decrease. The fishing costs; however, continues to increase with an increase in fishing effort. The peak point shown in the graph is equal to MSY and the effort required to obtain MSY is fishing effort at

MSY (E_{MSY}). The values of MEY and E_{MEY} are always less than MSY and E_{MSY}, respectively.

4.2 Estimation of future stock biomass

The intrinsic growth rate (r), catchability coefficient (q) and environment carrying capacity are important parameters to determine the future trend of fish stock biomass. Their values were obtained by multiple regression analysis which is shown below.

Table 5. Result of multiple regression analysis

	Coefficient	*Standard Error*	*t stat*	*P-value*
a	0.9454	0.2821	3.3519	0.0041
b	-0.1324	0.0400	-3.3127	0.0044
c	-0.0003	0.0001	-3.1772	0.0059
R-square = 0.4152, F = 5.6796, P-value = 0.01368				

The value of a, b and c were 0.9454, 0.1324 and 0.0003 respectively which were attained from the above table. These coefficients provide the value of r as 0.9454, q as 0.00033 and k as 23,801.61 which were used in the following functions to estimate the stock growth, fish production and future stock biomass.

Growth function: $G(X) = r \cdot X \cdot \left(1 - \frac{X}{K}\right)$

Harvest function: $H = qEX$

Stock biomass function: $X_{t+1} = X_t + G(X_t) - H(X_t)$

The current stock biomass, X_t, for 2014 was 5,194.44 MT which was attained from the catch and effort data at the current year (2014), which were 4,675 metric tonnes and 3,000 respectively. Additionally, the percentage of current stock over the stock at MSY (X_{MSY}) is 44% which is less than 80%, a criteria for evaluating stock depletion. The X_{MSY} is a stock size at half the environment carrying capacity and could maintain the maximum sustainable yield.

Furthermore, the estimated values of revenue and profit were derived using an average price of fish which was F$5,556.75/MT and an annual average fishing cost, which was F$7,175.00.

Scenario (I): Status Quo

From the Schaefer Model used for bio-economic modelling, the graph of stock size was developed to show the trend over the next 25 years based on the current fishing effort which is 3,000 licences. Assuming that the fishing effort is constant over the years, the inshore fisheries stock biomass showed a clear declining trend in the future.

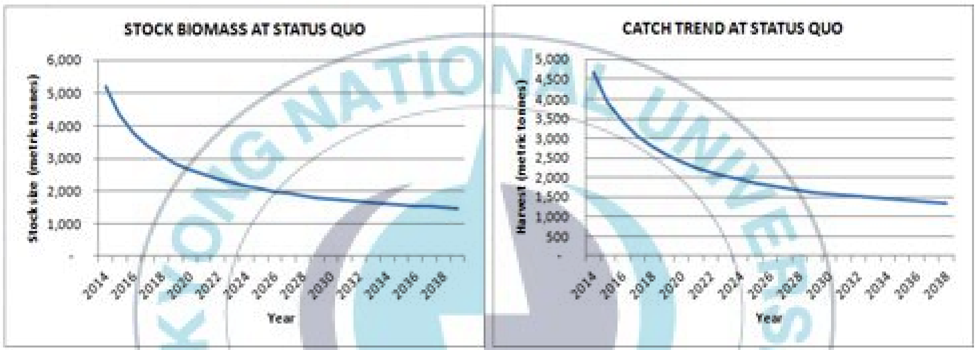

Figure 6. Changes of fish stock biomass and catch at a current level of fishing effort.

Additionally, assuming that the unit price of fish and annual fishing operation costs are constant over the next 25 years, the fishing benefit was estimated.

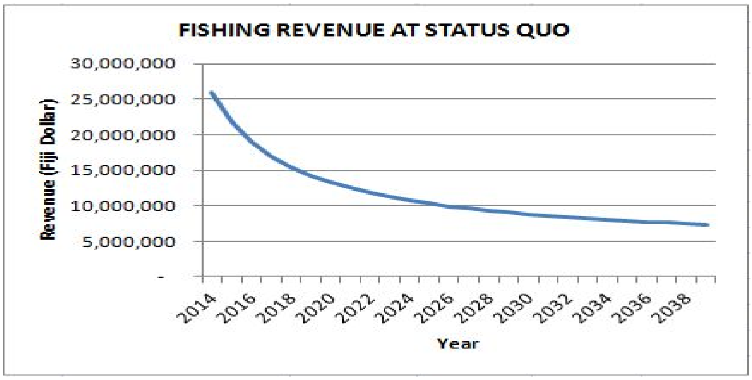

Figure 7. Changes of fishing revenue trend for the next 25 years at a current level of fishing effort.

The above figure displays the impact of stock depletion on the economic benefit of fishing. As the fish stock declines over the years, fishing revenue drop accordingly and consequently, fishing business will be facing reduction in profit which will pose threats to fishers' livelihood.

Scenario (II): Reduction of Fishing Effort to E_{MSY}

At E_{MSY}, 42% was deducted from the current fishing effort causing a gradual increase in stock size from 2016 to 2021 then a steady trend afterwards. Thus, revenue and profit increase accordingly over time.

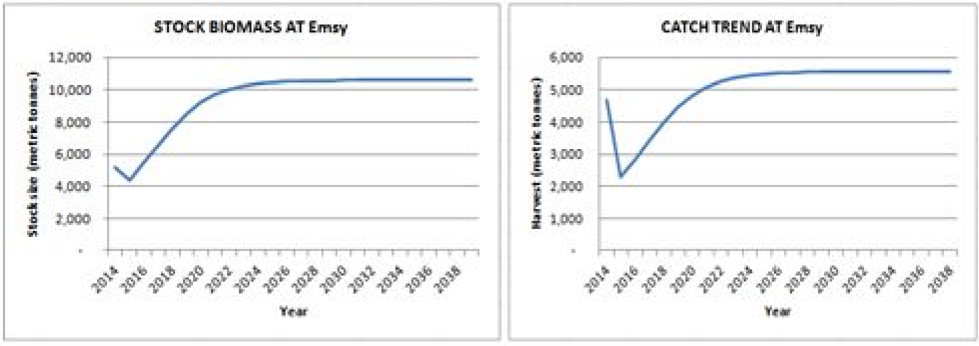

Figure 8. Changes of stock size and catch at $\boldsymbol{E_{MSY}}$.

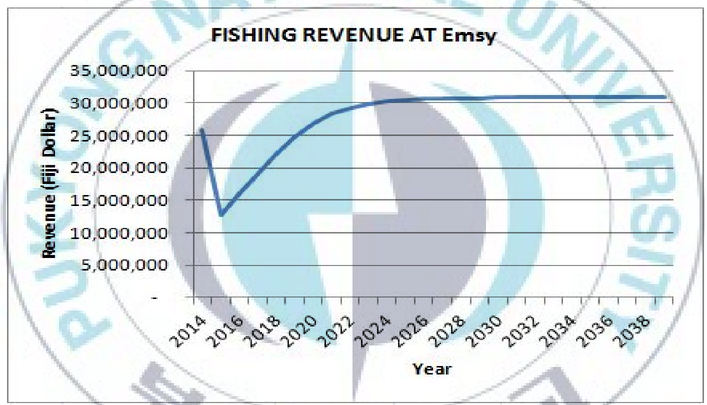

Figure 9. Change of revenue at $\boldsymbol{E_{MSY}}$.

Scenario (III): Reduction of Fishing Effort to E_{MEY}

With 54% reduction of fishing effort from the current fishing, an optimal fishing effort can be achieved which lead to a sharp increase in stock size as compared to E_{MSY} which in turn allows for a higher amount of catch. This scenario helps enhance fish stock and at the same time maximizes fishing benefit.

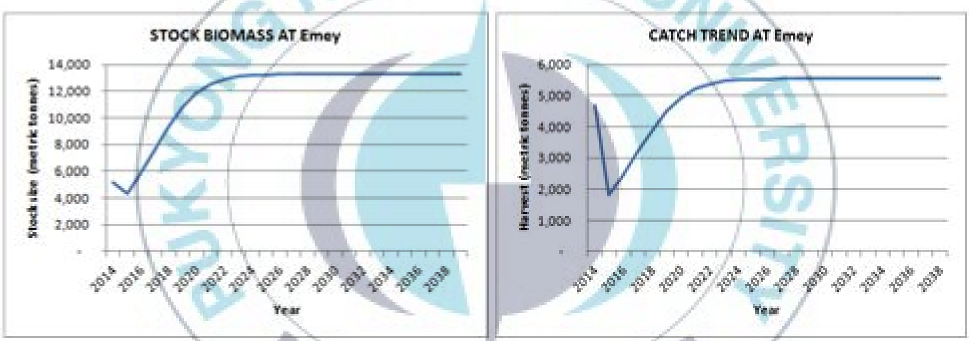

Figure 10. Changes of stock size and catch at $\boldsymbol{E_{MEY}}$.

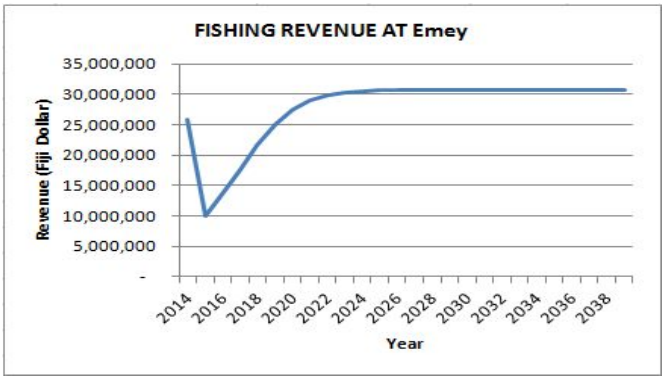

Figure 11. Change of revenue trend at $\boldsymbol{E_{MEY}}$.

Scenario (IV): Reduction of Fishing Effort to Minimum Safe Level of Fishing Effort (MSLFE)

This level of fishing effort is a minimum level that can maintain the current stock size over the years. This could be achieved through reduction of the current fishing effort (3,000 licences) by 14% which is equivalent to 2,570 licences.

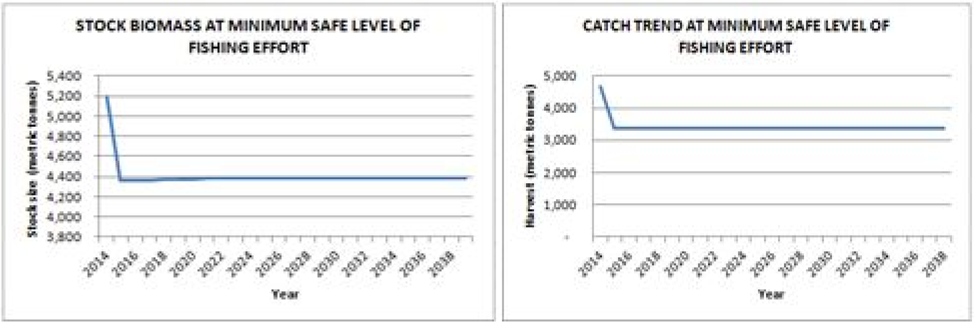

Figure 12. Changes of stock size and catch at MSLFE.

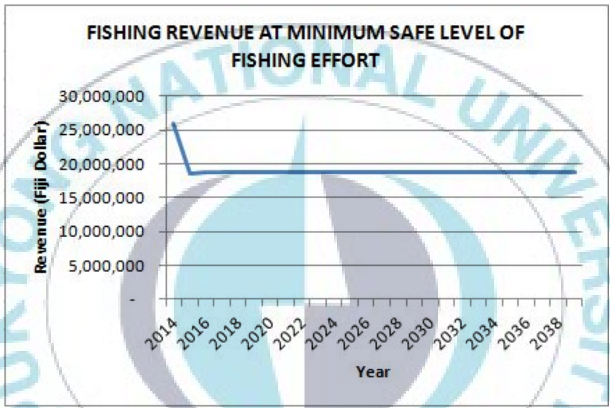

Figure 13. Change of revenue trend at MSLFE.

Though this scenario maintains the current stock size, catch and revenue, it does not allow for the realization of MSY and MEY. Implementation of this scenario (14% reduction of fishing effort); however, could be more practical and acceptable.

Chapter 5. Policy Implications and Conclusion

Inshore fisheries plays a significant role in sustaining the livelihood of the people of Fiji. In the twentieth century, the high demand of fish and the introduction of advanced fishing gears has led to overexploitation of fisheries resources (DeMers and Kahui, 2012). This research finding reveals that overcapacity had been a major concern in terms of management and had contributed significantly to overfishing. Overfishing had created adverse biological impact on fish stock and economical impacts on people. Additionally, the research outcomes support the hypothesis that depletion of inshore fisheries stock was due to the increasing in fishing effort. Meanwhile, the Fisheries Act, which is currently governs our inshore fisheries does not provides resource management guidelines aside from denoting the protection of customary right owners (Teh et al., 2009). Fish being a source of income and food (protein) for the people, the reduction in fish stock is a critical issue which requires implementation of proper management strategies and policies to recover or maintain fish stock at a sustainable level. Therefore, implications will be highlighted below based on the outcomes of the Fisheries Act evaluation and bio-economic modelling in order to improve the current management Act and promote sustainable and responsible fisheries.

5.1 Fisheries Act Evaluation

The examination of the Fisheries Act reveal that, the Act provides possible management tools such as permit scheme, licence scheme, marine reserves, penalty fees and fish size restriction. The exemptions made for such tools; however, act as a drawback for effective conservation of the inshore fisheries resources. Therefore, these limitations have prompted a need for amendments of the Act in order to manage and protect the resources efficiently.

First, the statutory permit scheme which is currently used as a precondition of fishing licence only, needs to be implemented in a manner outlined in the Act. As stated in the Act, the permit scheme is applicable to all non-resource owners undertaking subsistence fishing in a registered I-qoliqoli and as a pre-condition of obtaining a fishing licence. In addition, exemptions for permit means that not all non-resource owners are required to get a permit;

hence, this limits the application of permit conditions which include community By-laws. Such exceptions include person taking fish with hook and line, spear or portable fish trap which can be handle by a single person and who does not require a fishing licence. Therefore, removal of these exceptions will ensure that all non-resource owners and commercial fishermen are required to obtain a permit. Since permit can be used to legalize the community fisheries By-laws, omission of such exemptions would allow all non-resource owners to comply with community fisheries by-laws; thus, contribute to resource conservation and community empowerment.

Second, licence scheme has conditions which provide provisions for resource management such as restricting the use of destructive fishing methods, catching of undersize fish, etc which are applicable to any person engage in commercial fishing including resource owners. Licence conditions are vital for resource conservation; however, like permit scheme, exemptions made for licence limit its effectiveness to manage fisheries resources. Such exemptions include a person takes fish with a line from the shore or with a spear and where the minister exempts a person or class of persons from needing a licence (Minter, 2008). For the licence regime to be effectively used as a management tools, such exemptions need to be eliminated to ensure that all commercial fishers are required to obtain a licence irrespective of what fishing gear they use or where they catch fish in order to abide by its conditions. Additionally, the validity period of licence which is up to 31st of December at the same year irrespective of when it is issued is too brief considering the amount of money fishermen pay for good will. Since the permit can be valid for 3 years from the date of issuance, it is recommended that licence validity period could also be extended to 3 years. Combination of yearly renewal of licence, high and varying cost of good will provide disincentive for fishermen to manage the fisheries resources and to obtain a licence. The reason being is that with little time and high cost paid for the licence, fishermen tends to favour short-term benefit rather than long-term benefit. The risk of non renewal of licence and payment of good will every year encouraged fishermen to make use of the opportunity they have by increasing their production rather than using the resources sustainably.

Third, the Fisheries Act provides scope for regulating fishing in restricted areas. Exceptions of some fishing methods such as hand net, wading net, spear or line and hook; however, does not create proper MPA regime. Therefore, to realise the benefit of restricted area in terms of increasing fish stock biomass or spill-over effect, such exceptions have to be omitted so that all sorts of fishing activities are totally forbidden in restricted areas.

Fourth, Minter 2008 stated that as much as the Act criminalises the breaching of the provisions of the Act, the penalties provided in the Act do not act as a deterrent for those who offend. The penalty fines and the imprisonment terms for breaching the provisions are very small that first-time offenders are not deterred from re-offending a second or subsequent time (Eric, 2005). Therefore, the penalty provisions need to be increased so that people are deterred from offending or re-offending a second or subsequent time. If the penalty fines and imprisonment terms are high, people are more deterred from offending. For reviewing the penalty fee, it is important to consider the costs of licence including the good will that varies widely and in some areas cost thousands of dollars (FJD) and yet fishermen have to pay every year. If licence fee is higher than a penalty fee then this could discourage fishers from paying licence as it is cheaper to pay for the fine.

Fifth, breaching of Fisheries Act provisions is another major setback for fisheries resource management. The lack of compliance with the Fisheries Act could very well be answered by the fact that there is very little or no enforcement at all of the provisions stipulated in the Fisheries Act (Cap. 158) even by fish wardens. Ineffectiveness of fish wardens could be attributed to the limit in number and unclear responsibilities (Minter, 2008). Therefore, the Fisheries Department should meet regularly with their fish wardens to identify areas that need improvement and provide incentives for fish wardens to carry out their tasks effectively. Moreover, law cannot be enforced by the right people unless it is clearly understood by those authorized people. The Fisheries Act (Cap. 158) is quite comprehensive when it comes to ensuring the protection of inshore fisheries; however, it is vital and crucial that the enforcers of this law are very well educated and know the content of the law. In order to achieve this, there is a need to have an intense training for those officers who have the responsibility of enforcing the provisions of the Act. These officers should include fisheries department law enforcement officers, police officers, navy officers, military officers, fish wardens, etc so that the law is interpreted in the right and same way by all. This training should not be limited to a one-off event but a series of workshops within the year every year. The next positive step that can be undertaken is ensuring that all law enforcement officers within the Act have a copy of the Act at all times so that in events of monitoring, they have the law with them whenever they need to reference any provision. Additionally, for higher compliance of community fisheries By-laws and prevention of conflict between fishers and resource owners, it is important that the good will amount is equal to all.

Last, the fish size limit outline in the Fisheries Act is not clear and does not consider all targeted inshore fishes. It generalised fish into family level or common name which makes it hard to enforce. High diversity of Fiji's inshore fishes means that one fish family may have several species with different maturity size. For instance, parrotfish size limit in the Fisheries Act is 250 mm and does not specify which species; therefore, it could be used in reference to any species of parrotfish. Average adults size; however, range from 1 to 6 feet long with some even growing to 12 feet long. Furthermore, the genus *Lutjanus* in the Family Lutjanidae consists of 60 species which are common target species in the pacific. These species can grow up to 25 and 35 cm and reaches maturity reproductive size at about 45% of their maximum size (i.e., 11 to 16 cm) depending on the species. The Act does not recognize different species and generalizes the size limit to 30 cm. This situation may cause difficulties and confusion when it comes to law enforcement and more importantly it may accelerate fish stock depletion if immature fish are continue to be harvested. Therefore, classification of reef fishes to species level (in particular target species) and identifying their actual maturity size per species could be incorporated in a fish size limit table sketch out in the Fisheries Act to avoid confusion and to prevent growth overfishing.

5.2 Bio-economic Analysis

Teh et al., 2009, stated that the Fisheries Department need to pay more attention to resource management rather than focusing on increasing production. This was reflected in the increasing fishing effort which was also found in this research. The licence scheme used by the department needs additional provisions that can regulate fishing accessibility apart from the amendments mentioned earlier. Though licence's conditions provided can help protect fisheries resources, its failure to control fishing effort has limited it efficiency to manage our inshore fisheries. Consequently, Fiji's inshore fishery is faced with over-capacity which leads to over-fishing.

The 1992-2011 catch-effort data revealed that CPUE which is an indirect measure of stock abundance has been declining since 2001 (Figure 3) which is attributed to the high number of fishing effort. Additionally, the percentage of current stock size (X_t) over stock size at MSY (X_{MSY}) is 44% which is less than 80%, the percentage criteria for evaluating stock depletion. Thus, these indicate that Fiji's inshore fisheries is unsustainable. The research outcome shows that E_{MSY} is 1,750 licences with maximum sustainable yield (MSY) of 5,512.50 MT. Meanwhile, the E_{MSY} was exceeded in 1992, 2010 and 2011 which accounted for 1930, 2499 and 3000 licences respectively. In addition, following an excessive harvest in 2004 and 2005 which surpassed the MSY, fish production started declining from 2006 to 2011. Figure 5 displayed that at E_{MSY}, MSY can be achieved; however, beyond the E_{MSY}, production begins to decline. Therefore, production maximization does not mean that fishing effort has to be increased but rather set at E_{MSY}.

Furthermore, since fishing is one of the main sources of income for the people, consideration of profit maximization is necessary to ensure that fishing consistently provide sufficient or maximum economic benefit to fishers over the years. The optimal fishing effort (E_{MEY}) is 1,391 licences and maximum economic yield (MEY) is 5,280.90 MT which are less than E_{MSY} and MSY respectively. At E_{MEY}, fishing operation will be done at a minimal possible costs; thus, fishing profit maximization could be realised in addition to resource conservation. Excess capacity and high fishing costs often result in poor economic outcomes per fisher per vessel. Thus, at E_{MEY} number of fishers is reduced which then lead to higher harvesting possibilities and in turn produce high profit and potential high taxes (Schmidt, 2012).

Furthermore, maintaining the current fishing effort of 3,000 licences, future stock biomass and catch for inshore finfish show a declining trend for the next 25 years as this level of fishing effort is well beyond the sustainable fishing effort (Figure 6). On the other hand, assuming a constant fish price over the years, the economic benefit will also decrease due to the decline in yield. This situation can have more devastating biological and economic effect if fishing effort and fishing operation cost respectively continue to increase in the future. Reducing the fishing effort to E_{MSY} could help recover and sustain the declining stock size at or beyond MSY in the year 2017. E_{MEY} on the other hand, could provide full realization of economic benefit in the year 2016 and cause a drastic increase in fish stock compared to E_{MSY}. Reducing the fishing effort to E_{MSY} and E_{MEY} ; however, require a reduction of 42% and 52% respectively from the current fishing effort. The high reduction percentage may lead to social issues as some fishers will benefit while others might lose their source of livelihood; thus, a maximum safe level of fishing effort was established. At this level, 14% will be reduced from the current fishing effort which is equivalent to 2,570 licences and higher than E_{MSY} . Therefore, this level of fishing effort can only maintain the current stock size but maximum sustainable yield and maximum economic yield could not be realised. It is important that before implementing such reform, reform objectives have to be clearly defined and shared amongst various feasible stakeholders (Schmidt, 2012).

Since, SPM focus only on stock sustainability and economic benefit with limited indicators used such as CPUE and fishing effort, other management measures that consider biodiversity and habitat quality need to be implemented simultaneously. Fish stock enhancement programs which include artificial reef, marine ranching, seaweed forest and fry releasing targeting commercial important species could be implemented. Policy measures that can improve environment and reduce contamination of fishing grounds must be implemented (Lee and Midani, 2014). The key in fisheries resource management is “no one size fits all” meaning that no single management tool or system is a panacea to fisheries management challenges (Schmidt, 2012).

5.3 Proposed Fisheries Management System

Since Fiji’s inshore fisheries have dual ownership between the state and resource owners, it is necessary to integrate both customary with modern management systems. Integration of the two systems will strengthen fisheries co-management between government agencies, communities as well as NGOs. Co-management could be strengthen by adopting a

Community-Based Fisheries Resource Management (CBFRM). CBFRM is regarded as a fisheries management system created at the initiative of the fishermen. This system is similar to the community-based management (CBM) that has been practiced in Fiji; however, CBFRM has additional features which encompass the management of fisheries resources, fishing grounds and fishing effort (Fulanda et al., 2011). Other researchers have also supported the inclusion of community due to the failure of western command and control fisheries management instructions and more recently the lack of success in implementing MPAs in developing countries (Cinner and Aswani, 2007) including Fiji. CBFRM will allow government and communities to establish their own fisheries regulations, assess fish stocks, set catch limit and monitor their own fishing ground and have the authority to fine or suspend violators.

A good example of effective co-management was experience in Kayar village in Senegal (Western Africa) where fishermen faced with a decline in fish price due to oversupply in the market. Through collaborative work between government agencies and the community, the villagers responded by forming a fisheries committee that regulates the amount of catch of commercially important fish known as Pandora and as a result there was a substantial increase in price and fishermen were able to control the market price (Alioune and Catanzano, 2005). The example deals with economic crisis and at the same time manage the fish stock through controls of production. In Fiji, the Navakavu MPA, a community managed area is a good role model for effective co-management between relevant stakeholders. It offers many benefits such as increase in biomass, increase in the variety of fish, increase in the size of fish, helps in the recovery of endangered species and increase earning by communities (Fiji Department of Environment, 2010). Many authors have also suggested that conservation strategies that incorporate indigenous knowledge, practices and customary sea tenure institution have a high rate of acceptance and consequently greater value of conservation (Cinner and Aswani, 2007). From Navakavu MPA case study, it is recommended that permit scheme is more ideal than gazettal process for legalizing MPAs in Fiji. Permit scheme promotes community participation and ownership which are the keys for the success of an MPA. Gazettal process on the other hand is often slow and eliminates the power of the community over their MPA. Out of the 235 MPAs in Fiji today, only Ulunikoro Marine Reserve in Kadavu which was established in 2002 was gazetted and managed by the state (Lin, 2013).

The CBFRM increases the commitment of fisher folks, employing traditional fisheries management and retain community-based bottom up approach to resource management. It also presents a low cost approach to data collection, assessment of stock-size and law enforcement. But, legal framework is necessary to clearly state the operation mechanism of CBFRM and the role of different stakeholders involve.

5.4 Support for Fisheries Management

It is important that fisheries development goals are parallel with fisheries resource conservation. Though some government development programs assist communities but at the same time accelerate exploitation rate of fisheries resources. For instance, the provision of financial assistance through subsidy and loan to the people to purchase fishing boat and engine. The greater capital investment is unintentionally prohibits the mobility of individuals from fisheries sector to other activities (Allision and Ellis, 2001) as people have to continuously fishing in order to meet their monthly loan payment. The fisheries report reveals that in 2011, 50% of 3000 licence was from the northern division because licence is the one of the pre-condition for one of the government subsidy program (Fiji Fisheries Department, 2011). It is therefore, strongly recommended that such assistance and other government subsidies for fisheries development could be diverted from capture fisheries to aquaculture development or other viable income generating projects which could assist in the reduction or maintenance of fishing effort at sustainable level and at the same time provide alternative source of livelihood to the potential losers when fishing access is regulated. In addition, subsidies funds could be used to finance the fisheries research programs such as stock assessment, stock rebuilding programs and socio-economic survey in order to better manage Fiji's fisheries resources in the future.

5.5 Recommended Future Research and Data Collection System

The Schaefer Model is based on the assumptions that fish stock are at equilibrium (i.e., growth rate equals harvest rate), and fishing effort and stocks size are uniformly distributed throughout the fishing area. Given that

Fiji inshore fishing grounds (*I-Qoliqoli*) have different sizes with different level of fishing effort, it is important that fishing effort at each fishing ground (*I-Qoliqoli*) are set differently. This requires stock assessment at each inshore fishing ground. Result of such assessment and data analysis could be used to find the fishing effort at MSY (E_{MSY}) per fishing ground. Additionally, since the licence procedure begins from obtaining consent letter from resource owners, sharing of stock assessment outcomes to resource owners is critical so that they aware of the status of their fisheries resources and play a role with the fisheries department in controlling fishing efforts. Furthermore, inshore fishes identification at species level with their respective maturity size is required in order to effectively regulate the catch of undersize fish.

Moreover, DeMers and Kahui, 2012, stated that Fiji is often faced with outdated and inaccurate data; however, for fisheries policy-making, data collection forms a sufficiently solid information base required for reform processes (Schmidt, 2012). Effective data collection could be done through renewal of fishing licence. Renewal of licence should subject to the submission of monthly catch data by all licence fishermen to the fisheries department. Therefore, submission of monthly catch data have to be incorporated as one of the licence conditions and enforce strictly to ensure that everyone comply with it. In addition, middlemen and trading companies that buy and sell fisheries products have to register at the Fisheries Department as well and the same condition on data reporting should apply to them. It is important that both middlemen and fishers are consulted before this reform is made to make them aware of the importance of their data. Therefore, standard data sheet for Fiji's inshore fisheries have to be designed for both fishermen and middlemen. This data collection method could be used, to capture recent inshore artisanal fisheries data from licence fishers, in addition to the market survey that fisheries department is doing.

To ensure consistency and timely submission of data sheets, proper reporting system for fishermen has to be established by considering the fishermen's literacy level and location. Data forms have to be simple and written in such a language that fishermen understand. Additionally, considering the distance between fisheries department offices and fishing communities and transportation constraint, traditional community organization could be used to assist in the timely submission of data. Village head (*Turaga-ni-koro*) could be used as a focal point for data submission at village level and then submitted to the district heads (*chiefs*) where it finally submitted to the fisheries department. The participation or involvement of communities could also aid with the enforcement of data submission and build a closer relationship with the community. Based on the information derived from these data, the government, community members and other relevant stakeholders can establish fisheries resource management plans for the respective fishing grounds.

5.6 Conclusion

Commercialisation of inshore fisheries resources, population growth and lack of alternative source of livelihood are the driving factors behind the increasing demand of fisheries resources. Consequently, Fiji's inshore fisheries is faced with an issue of overfishing. The current fishing effort of 3,000 licences exceeds E_{MSY} and MSY was surpassed in the year 2004 and 2005 which led to catch depletion and reduction in economic benefit. Decreasing trend of CPUE and low percentage of current stock size over X_{MsY} are clear indication that Fiji's inshore fisheries is currently unsustainable. Therefore, there is a need to review the current management Act and to incorporate effective fisheries management guidelines to match the dynamic nature of Fiji's inshore fisheries. In doing so, effective data collection mechanism is required to obtain recent and reliable data and active involvement of stakeholders. In addition, due to the dual ownership of inshore fishing grounds there is a need to strengthen and provide proper legal framework for the proposed co-management system (CBFRM). Development of alternative sources of livelihood are necessary flanking measure that can allow the movement of people to other activities apart from fishing which could effectively support the implementation of fishing effort control. Diversification of livelihood sources can also help reduce fishing pressure and at the same time generate income for the people. A survey conducted by WWF, stated that in areas like Macuata where source of income is limited, fishing forms major portion of income and people spent more time on fishing (Navuku and Tabunakawai).

References

Alifereti, T. (2007). Scaling-Up Networks of Locally Managed Marine Areas (LMMAs) to Island Wide Ecosystem Management while Decentralising the Effort of Fiji LMMA Network and its Implementation from National to Provincial Levels [unpublished].

Alioune, S. Y. and Catanzano, J. (2005). Self Regulation of Senegalese Artisanal Fisheries: A Case Study of Kayar. Successful Fisheries Management, Pg 149-167.

Allison, E. H. and Ellis, F. (2001). The Livelihoods Approach and Management of Small-scale Fisheries. Marine Policy, 25: 377-388.

Burke, L., Reytar, K., Spalding, M. and Perry, A. (2011). Reefs At Risk Revisited, World Resources Institute, Washington DC. 130pp.

Cakacaka, A., Jupiter, S. D., Egli, D. P. and Moy, W. (2010). Status Of Fin Fisheries in a Fijian Traditional Fishing Ground, Kubulau, District, Vanua-Levu. Wildlife Conservation Society Fiji Technical Report no 06/10. Suva, Fiji, 21pp.

Cinner, J. E. and Aswani, S. (2007). Integrating Customary Management into Marine Conservation. Bilogical Conservation, 140: 201-216.

Hand, T., Davis, D. and Gillett, R. (2005). Republic of the Fiji Islands: Fisheries Sector Review. Asian Development Bank, Manila, 95pp.

Demers, A. and Kahui, V. (2012). An Overview Of Fiji's Fisheries Development. Marine Policy; 36: 174-179.

Dumaru, P. (2011). Integrated Coastal Management Framework Of The Republic Of Fiji. Fiji's Department of Environment, 61pp.

Eric, K. (2005). ‘Session 12: The Implementation and Enforcement Of Fisheries Regulations’ Presentation Given At The SPC/WPRFMC/FAO Regional Workshop on Fisheries Legislation and Community-based Fisheries Management’. April 4–8, Honolulu Hawaii, 42-43.

FAO (2011). “Review of The State of World Fishery Resources”. Marine and Inland Fisheries Service, Fisheries and Aquaculture Resources Use and Conservation Division, FAO Fisheries and Aquaculture Department. FAO Fisheries and Aquaculture Technical Paper. No. 569. Rome, 354pp.

Fiji Locally Marine Managed Area (FLMMA) Network. <http://www.lmmanetwork.org/fiji>. Accessed March, 2014.

Fiji Department of Environment. (2010). Fiji’s Fourth National Report to The United Nations on Biological Diversity, 127pp.

Fiji Department of Fisheries. (2011). Key Fisheries Statistics Report 2011. Department of Fisheries, 2011, 38pp.

Fiji Wildlife Conservation Society. <http://www.wcs.org/where-we-work/oceans/coral-triangle/fiji.aspx>. Accessed February 2014.

Fuland, B., Ohtomi, J., Mueni, E. and Kimani, E. (2011). Fishery Trends, Resource-use and Management System in The Ungwana Bay Fishery Kenya. Coastal and Ocean Management; 54: 401-414.

Gillet, R. (2009). Fisheries in the Economies of the Pacific Island Countries and Territories. Mandaluyong City, Phillipines: Asian Development Bank, 521pp.

Hastings, J., Gruby, R. L. and Sievanen, L. S. (2012). Science-based Coastal Management in Fiji: Two Case Studies From the NGO Sector. Marine Policy; 36: 907-914.

Havice, E. and Campling, L. (2009). Are Pacific Island States Losing Their Rights to Tuna Resources? Centre for Development Policy and Research; 43: 2pp.

IAS (2009). A Nation-wide Survey of Village-based Fishing Pressure in Fiji. In:Jenkins AP, Prasad SR, Bacchiochi J, Skelton P, Yakub N (eds), Proceedings of the Inaugural Fiji Islands Conservation Science Forum, Wetlands International-Oceania, Suva, Fiji.

Jupiter, S. D. and Egli, D. P. (2010). Ecosystem-based Management in Fiji: Successes and Challenges After Five Years of Implementation. Marine Biology, 2011: 14pp.

Lee, S. and Midani, A. R. (2014). National Comprehensive Approaches for Rebuilding Fisheries in South Korea. Marine Policy, 45: 156-162.

Lin, H. (2013). Breathing Spaces At The Sea: The Ambiguity of Fiji Inshore Territorial Ownership. Legal Ground: Land and Law in Contemporary Taiwan and the Pacific, 12pp.

McManus, J. (1997). Tropical Marine Fisheries and The Future of Coral Reefs: A Brief Review With Emphasis On Southeast Asia. Coral Reefs; 16(5): S121-S127.

Minter, A. (2008). Compliance and Enforcement For Coastal Fisheries Management in Fiji, IUCN Regional Office for Oceania, Suva, Fiji, 61pp.

Muehlig-Hofmann, A., Veitayaki, J., Polunin, N. V. C., Stead, S. and Graham, N. A. J. (2005). Community-based Marine Resource Management in Fiji – From Yesterday to Tomorrow. University of the South Pacific, Marine Studies Programme, P.O. Box 1168, Suva, Fiji. University of Newcastle, Upon Tyne, Marine Science and Technology, NE1 7RU, U.K., 8pp.

Mumby, P. J., Hastings, A. and Edwards, H. J. (2007). Thresholds and the Resilience of Caribbean Coral Reefs. Nature; 450: 98-101.

Navuku, S. and Tabunakawai, K. Trends and Influences in Coastal Fisheries: Exploring the Social and Economic Aspects of Catch Per Unit Effort in Qoliqoli Cokovata; Macuata, Fiji. WWF Fiji Technical Report, 25pp.

Pauly, D. and Zeller, D. (2014). Accurate Catches and the Sustainability of Coral Reef Fisheries. Environmental Sustainability; 7: 44-51.

Richards, A., Ligabalavu, M., Sharma, S. and Swamy, K. (1994). Fiji Fisheries Resources Profiles. FFA Report No. 94/4, 231pp.

Robert, G. (2011). Fisheries of the Pacific Islands: Regional and National Information. Food and Agriculture Organisation for the United Nations Regional Office for Asia and the Pacific Bangkok, 290pp.

Schmidt, C. (2012). Good Governance for Ensuring Food Security in Fisheries. Head of the Fisheries Policies Division, OECD, Paris, France, 110-118.

Science-to-Action. <http://www.science2action.org/index.php?option=com content&view=article&id=121&Itemid=140> Accessed January 2014.

Secretariat of the Pacific Community (SPC). <http://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/Anon_11_ISFC_05_ReefSnappers.pdf>. Accessed March 2014.

Sievanen, L., Gruby, R. L. and Campbell, L. M. (2013). Fixing Marine Governance in Fiji? The New Scalar Narrative of Ecosystem-based Management. Global Environment Change; 23; 206-216

Teh, L. CL., Teh, L. SL., Starkhouse, B. and Sumaila, U. R. (2009). An Overview of Socio-economic and Ecological Perspectives of Fiji's Inshore Reef Fisheries. Marine Policy; 33: 807-817.

Veitayaki, J. and Novaczek, I. (2005). Voices, Lenses and Paradigms: Understanding Fisheries Development in the Pacific. In: Novaczek I, Mitchell J, Veitayaki J, editors. In Pacific Voices: Equity and Sustainability in Pacific Island Fisheries. Suva: University of the South Pacific; 247pp .

Vuki, V., Naqasima, M. and Vave, R. (2000). Status of Fiji's Coral Reefs: Global Coral Reef Monitoring Network (GCRMN) Report.

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