Bermuda's Fishery Past, Present and Future

By

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Abstract

Bermuda is a key marine indicator located in a corner of the SargassoSea and in the middle of the Atlantic Ocean. It is the world's most northern coral island, whose unique marine habitat, mild climate and depths of more than 12,000 feet have attracted visiting geologists like William Beebe, Otis Barton and pioneering environmentalist like Bermudian born LouisMowbray. Men like Beebe and Barton have made ground-breaking discoveries that show the need to protect our environment's fragile coral reefs, marine ecosystem, endangered species and to maintain a healthy marine habitat (Jones, 2004).

Louis Mowbray returned to Bermuda from Europe in 1907 and was hired to help create and operate the Island's first Aquarium and marine research center on Agar's Island in Hamilton harbor.Years later after designing the Boston, New York and Miami aquariums, he returned to Bermuda in 1926, on an invitation from the Bermuda government, to design and curate the new Bermuda aquarium in Flatts. Major accomplishments by Mowbray include his participation in overseas expeditions to bring back many interesting species(Jones, 2004).

On June 6, 1930 William Beebe and Otis Barton left their Nonsuch Island headquarters to performed a test run of the 'Bathysphere,' an odd looking contraption, that made history in Bermuda's waters, to record breaking ocean depths, which, until then had been strictly the realm of science fiction. Their unprecedented journey took them farther than any human being to a history making

dive of 803 feet and on August 15, 1934, the pair reached a new record depth of 3,028 feet; winning themselves and Bermuda headlines around the world (Jones, 2004).

As a result, the Bermudian society has witnessed a renewed sense of accountability for the environment with government acting to prevent pollution, over fishing and damage to the islands fragile reef system of sea grass, mangroves, salt marshes, ponds, and various types of corals.The Department of Fisheries is a sub section of the Bermuda Department of Environment. Their role and responsibility is to control and monitor the marine environment, identify any threat to the ecosystem and to take steps to protect the surrounding marine environment, enforce rules and regulations on fishing methods and techniques, provide conservation plans; to sustain the food chain, and to provide citations for law breakers. Many species of fish are protected with quotas and restrictions by the Division of Fisheries, whose aim is to protect the shores and surrounding reefs from any threat including illegal overfishing, pollution and other marine life invading our shores. Today, the'lionfish' invasion is a topic of great concern, as this species has decimated marine life of the Caribbeanand now a major threat to our marine ecosystem (Bermuda Sun, 2012; 2013).

Year round participants and stakeholders, who frequent the surrounding waters, are commercial and local boaters, fishermen,swimmers, divers and the ferry operations. Bermuda is also a prime location for recreational fishing with the triple-crown fishing tournament held annually from July 4, to July 21. These participants are also stakeholders in the quest to maintain a healthy marine environment. These tournaments attract anglers from around the world and

contribute millions of dollars to the Bermuda economy (Bermuda Sun, 2012; 2013).

Although the Department of Fisheries'role is expansive, with a vast territory to cover, the literature shows that current resources to perform and manage the job efficiently and effectively are inadequateor outdated. The literature also highlights critical areas in need of immediate attention.In particular, evidence for best practice, from sound scientific research is either currently unavailable or non-existent. However the overall need is change for strong leadership and management of future responsibility and accountability for the Division.

In conclusion, if Bermuda is to maintain a healthy, viable marine ecosystem and become a world leader by setting the stage for continuing global progress in marine conservation, there must be immediate steps to improve methods of managing its Division of Fisheries. The evidence from sound scientific research, must consider the past and the present,while embracing the latest technological advances in marine conservation to determine the right course of action for future.

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EEZ	Exclusive Economic Zone
GDP	Gross Domestic Product
TEC	Total Economic Value
TAC	Total Allowable Catch
CPUE	Catches Per Unit of Effort

Bermuda's Fisheries; Past, Present and Future

1 Introduction

The island of Bermuda is located in the mid-Atlantic ocean, in a corner of the Sargasso Sea. It has a marine area of 4,236.1km_2, and is home to one of the world's healthiest coral reef ecosystems (Bermuda Government Department of Statistics, 2012; Pieter et. all, 2010). Bermuda's unique location, mild climate and marine habitat, offer an ideal location and laboratory setting for studying marine life and the ecosystem. It is also an attractive location for commercial fishing, recreational fishing, and boating. In addition, it boasts ocean depths of more than 12,000 feet, which can be easily reached from the shores, year round (Jones, 2004).

As the world's northern most coral island, it possesses an enigma that has attracted numerous visiting geologists like William Beebe and Otis Barton, pioneering environmentalist like Bermudian born Louis Mowbray and other renowned scientists. These scientists all have carried out their work in the surrounding waters of Bermuda. Men like Beebe and Barton have made groundbreaking discoveries that show the need to protect our environment's fragile coral reefs, marine ecosystem, endangered species; and the need to maintain a visiting healthy marine habitat (Jones, 2004).

Bermudian born Louis Leon Arthur Mowbray a pioneering environmentalist was known to have a love for the sea and everything in it (Jones, 2004). In 1907, Mowbray returned to Bermuda from Europe and helped to create and operate the Island's first Aquarium and marine research center on Agar's Island in Hamilton harbor. In 1911 it is recorded that Mowbray moved to Boston to design and direct a new aquarium there and three years later, was chosen to serve as superintendent of the New York aquarium. In 1920, he built and directed the Miami Beach aquarium and in 1926 returned to Bermuda on an invitation from the Bermuda government, to design and curate the new Bermuda aquarium in Flatts (Jones, 2004). The aquarium opened two years later and remains a major attraction for tourists and locals alike. Other major accomplishments for Mowbray include his participation in overseas expeditions, which helped to bring back many interesting species. The author concludes that after a trip to the Galapagos Islands, Mowbray returned to Bermuda with thirty tortoises. He expanded the aquarium into a zoo and later added penguins. His contribution placed the Bermuda aquarium and zoo on the conservation map (Jones, 2004).

On June 6, 1930, William Beebe and Otis Barton left their Nonsuch Island headquarters to perform a test run of the 'Bathysphere,' an odd looking contraption that made history in Bermuda's waters. This spherical phenomenon at the time carried Beebe and its inventor, Otis Barton to record breaking ocean depths (Jones, 2004). The author reports that until then this endeavor had been strictly the realm of science fiction and the Bathysphere; designed to carry the

two scientists to the record breaking depths took them 10 miles off Bermuda, on their first attempt where the sea floor fell to more than a mile and a half (Jones, 2004).

Reports later indicate that this unprecedented journey took the pair farther than any human being, to a history-making dive of 803 feet (Jones, 2004). However, it concludes that on August 15th, 1934, they reached a new record depth of 3,028 feet (Half a nautical mile); winning themselves and Bermuda headlines around the world. The two scientists describe their experience as being in an abyss of "ever deepening twilight," of a deep blue-black world, beyond a canopy of bluish green paradise (Jones, 2004 pg 159). This remained the backdrop for images of exotic fish and spectacular creatures and fauna never seen before, and that were captured and preserved for the world of science and empirical study (Jones, 2004). Beebe is cited as documenting, "Imaginary creatures; iridescent fish, silvery eels, flying snails, mist of crustaceans including a golden-tailed serpent dragon" (Jones, 2004, p 159). In addition, some 300 paintings and drawings were published in the National Geographic**.**

As a result, the Bermuda government and society have gained a renewed sense of responsibility; highlighting the importance of protecting the environment, and maintain a healthy marine ecology through scientific study; taking action to prevent pollution, protect from surrounding threats of local

species and damage to the coral reefs, sea grass, mangroves, salt marshes, inland ponds and local caves.

Bermudians have enjoyed fishing and boating since the island was colonized in the early 1600's. Fishing has grown on the island to encompass many commercial and recreational anglers alike. Over the years fishermen were allocated to various locations on and off the island and monitored for various fishing methods and techniques, including type of equipment and gear. Today many species of fish are protected by quotas and restrictions developed by the Division of Fisheries. This includes the spotted and spiny lobster species. Bermuda is also considered to be one of the prime locations around the world for recreational fishing being winner of six Blue Marlin World Cup titles and boasting the two largest catches ever in the history of the tournament, it is a proven fishing ground that is frequented by many foreign anglers (Blue Marlin World Cup, 2010).

The Department of Fisheries is a sub section of the Bermuda Department of Environment. Their role and responsibility is to control and monitor the marine environment, identify any threat to the ecosystem and to take steps to protect the shores and surrounding reefs from any threat including pollution, overfishing, and other marine life invading our marine environment. Today, the 'lionfish' invasion is a topic of great concern, as this species has decimated marine life of the Caribbean and now considered a major threat to the marine ecosystem in Bermuda (Royal Gazette, 2005; 2009; 2011). This species that has

invaded the island waters threatening local indigenous species; thus threatening the food chain and Bermuda's food supply (Royal Gazette, 2005; 2009; 2011). This division is also mandated to enforce rules and regulations on fishing methods and techniques, and to provide conservation plans for sustaining the food chain as well as issue citations for lawbreakers.

Review of the literature shows as coral reef ecosystems deteriorate around the world, Bermuda's unique, isolated, mid-Atlantic location, healthy reefs and marine environment can offer excellent indicators and benchmarks for studying the health of other global ecosystems (Atlantic Conservation Partnership, 2012).

In conclusion, if Bermuda is to maintain a healthy viable marine ecosystem and become a world leader; setting the stage for continuing global progress in marine conservation, steps must be taken to improve methods of managing the Department of fisheries. This includes collecting data from sound scientific research that considers the past and the present, while embracing the latest technological advances in marine conservation and fisheries to determine the right course for the future. The literature also highlights critical needs of regarding adequate manpower, resources and budgeting for effective enforcement of rules and regulations and much needed technology to replace antiquated or outdated systems.

The aim of this paper is to discuss Bermuda's physical marine environment consisting of sea grass, mangroves, salt marshes, inland ponds,

marine ponds, caves, varied coral reef species; describe the Bermuda Fisheries inshore versus offshore; discuss control and restrictions placed on certain marine species such as the spotted and spiny lobster; identify threats to the marine ecosystem including the "Lion fish" invasion; describe stakeholders in commercial and recreational fishing industry and to describe methods and techniques used by local and commercial anglers alike.

The overall aim is to evaluate the roles and responsibilities of Bermuda's Division of Fisheries, including enforcement of policies, evaluate the past and present, to recommend improvements for change based on empirical evidence for best outcomes and to maintain a sustainable, healthy ecosystem for Bermuda and the global community.

2 The Physical Environment

Bermuda is an isolated oceanic island with a marine area of 4,236.1km2. This includes the Bermuda platform with over 700 km2 of coastal water and Bermuda's 200-mile Exclusive Economic Zone (EEZ) (Hodgson, 2000).

The island owes its warm waters from the Gulf Stream that flows year round (Encyclopedia Britannica Online, 2010). The Gulf Stream is defined as "a part of a general clockwise-rotating system of currents in the North Equatorial Current moving from North Africa to the West Indies" bringing warm ocean currents towards the North Atlantic (Encyclopedia Britannica Online, 2010).

These currents warm the waters of Bermuda and allow the temperatures to remain high despite its northern location (Hodgson, 2000).

The coastal waters of Bermuda consist of sea grass beds and coral reefs. Intertidal waters consist of swamps, mangroves, rocky shoreline, and sandy shoreline (Hodgson, 2000). Much of Bermuda's marine life is believed to have been transported to the island by the Gulf Stream and is considered to be living under stress because they thrive in the warmer waters of the Gulf of Mexico (Hodgson, 2000).

Seagrass are unique flowering plants that can survive completely submerged under salt water. They are commonly found in shallow marine waters like lagoons and bays. Seagrass plays a significant role in the marine ecosystem and are considered to be the third most valuable ecosystem globally and are preceded by wetlands and estuaries (Costanza et al. 1997). Seagrass beds are highly productive as they are able to quickly process dead material and grow rapidly. They are known to remove carbon dioxide from the water and produce oxygen through photosynthesis (McKenzie et al, 2006-2009).

Bermuda has four species of seagrass namely; Manatee Grass (Syringodium filiforme), Shoal Grass (Halodule wrightii), Turtle Grass (Thalassia testudinum) and paddle Grass (Halophila decipiens)(Murdoch et al, 2004).

Seagrass form large underwater beds called seagrass beds. In Bermuda they can be found in water up to five fathoms deep (thirty feet) (Hodgson, 2000).

The root systems help to stabilize the seafloor and prevent erosion, similar to how land grass prevents soil erosion. The leaves of seagrass act as baffles slowing water currents and trapping suspended particles, which helps to maintain the quality of the water. The beds act as a nursery ground by providing food and shelter to many marine creatures. Many juvenile recreational and commercially targeted fish species and crustaceans live in the seagrass beds. Seagrass beds also allow for both juvenile and adult fish to escape predators. Research shows that Bermuda's fish stocks would be very difficult to maintain without the help of seagrass beds (Fish and Wildlife Research Institute, 2009.)

Mangroves are trees that are able to tolerate both salt and fresh water and are known to grow along coastlines and bays (Lee Country Government, 1996). Hodgson reports that mangroves arrived to Bermuda naturally by their floating plant seeds, and of the sixty species of mangroves worldwide, Bermuda has three, with two of the most common being the Red Mangrove (Rhizophora mangle), and the Black Mangrove (Avicennia nitida) (Hodgson, A. 2000).

The mangrove root system holds sediment in place and protects the coastline from erosions and other weather related damage. Their roots provide a place to hide for many juvenile marine creatures. Mangrove roots have also been found to be an excellent structure for the marine plants and creatures to grow on (Lee County Government, 1996). In Bermuda the mangroves provide shelter to two endangered and rare crabs, the land hermit crab (Coenobita cypeatus) and the giant land crab (Cardisoma guanhumi). Mangroves also provide a very nutrient rich food source for many marine creatures. The

productivity of Bermuda's fisheries would decline rapidly if the mangroves were not present (Hodgson, A. 2000).

Salt marshes occupy sheltered coastlines; often referred to as tidal marshes. They are wetlands that are located near the coast. These wetlands are rich in marine life. Salt marshes do not develop near high – energy coast lines, therefore they are able to provide shelter to a number of rare and endangered creatures and plants (Department of Environmental Protection, Florida Marine Research Institute, 2008). It is noted that human development in Bermuda has greatly reduced the number of salt marshes. They provide shelter to many of Bermuda's rare and endangered marine life like the land hermit crab (Hodgson, 2000).

Inland ponds uncommon around the world, are found only around volcanic and limestone shores lines. Marine ponds lie below sea level and are fed by salt water from the sea, which flows into the pond by fissures, cracks or submerged caves. Much of Bermuda rests on top of limestone allowing any depression that falls below sea level to become a marine pond (Hodgson, 2000).

Marine pond also called saltwater ponds offer the most shelter for marine organisms in Bermuda. Marine ponds are located at low points around Bermuda and are filled with salt water. This occurred when the sea level rose at the end of the last ice age. Caves connect the saltwater ponds to the ocean. The amount of water transfer depends on the size of the connection to the ocean and when the tide falls and rises (Bermuda Conservation Services, 2012).

Marine ponds are rich sources of food for marine life and are home to delicate animals and plants. They attain their food from two primary sources: runoff from the land, and leaves that fall into the pond and decay. Mangroves surround many of Bermuda's inland ponds protecting them from strong winds. Many of Bermuda's marine ponds contain sponges, seaweeds and sea squirts and Bermuda's endemic killifish. Other rare species such as the diamondback terrapin (Malaclemys terrapin), the endemic Bermuda sargassum seaweed (Sargasssum bermudense) and the American eel (Anguilla rostrata) have also found in Bermuda's Marine ponds. Dr. De Laubenfels, a world – renowned sponge expert called Bermuda's Watlington pond the "sponge metropolis of the world." (Thomas, 1998, p40.)

Bermuda's caves were formed by fresh water, which is left on limestone for extended periods of time. Over time the fresh water dissolves the calcium carbonate in the limestone creating the cave. Marine caves provide excellent protection for many of Bermuda's marine creatures. Caves systems that have access to light act like marine ponds, and help protect many marine animals and plants. Cave systems that don't have access to light also support marine life. Dark caves in Bermuda were found to house shrimp like crustaceans that have not been found anywhere else in the world (Hodgson, 2000).

Globally coral reefs grow between latitudes of 30° North and South of the equator. However it is unusual that coral reefs are present in Bermuda since

Bermuda is 32° North of the equator. Bermuda owes its coral reef ecosystem to the warm waters brought to the island by Gulf Stream (Vieros, 1993).

Therefore Bermuda's coral reefs in Bermuda can be considered high latitude reefs. In general Bermuda's reefs are high latitude reefs. High latitude reefs are normally found to have high levels of nitrates, however these high nitrate levels were not found in Bermuda's reefs. Both high latitude reefs and Bermuda reefs tend to have seasonal characteristics because of the changing water temperature and light (Hodgson, 2000).

It is estimated that there are about 800 species of coral worldwide. Bermuda has fifty-eight corals comprised of thirty-four species of hard corals and twenty-four species of soft corals (Hodgson, 2000). Eighty percent of Bermuda's corals are comprised of Bermuda's reef – building corals. Reef building corals are comprised of four types of corals in Bermuda. They are the Great Star Coral (Montastrea cavernous), Brain Coral (Diploria strigosa and Diploria labyrinthiformis), Mustard Coral (Porites astreoides), and the Small Star Coral (Montastrea annularis) (Vieros, 1993).

Many corals form at different depths in Bermuda's waters. At the northern part of the Bermuda platform reefs start forming at depths of 250 feet (41.6 fathoms) to 65 feet (10.8). These reefs are known as the Fore Reef Slope. The Fore Reef Slops only cover about 25% of the sea floor (Hodgson, 2000) and are mainly comprised of the reef building corals; Mustard coral (Porites

astreoides), Great Star Coral (Montastrea cavernosa), and Brain Coral (Diploria strigosa) (Bermuda Government Department of Conservation Services, 2001).

Main Terrace Reefs are the next type of coral reef found on the northern part of the Bermuda Platform. These reefs grow at depths ranging from 75 feet (12.5 fathoms) to 45 feet (7.5 fathoms) (Hodgson, 2000). Main Terrace Reefs cover over 50% of the sea floor and cover the largest area of the Bermuda Platform (Bermuda Government Department of Consecration Services, 2001). Table 1 below shows the different types and percentages of corals that comprise of the Main Terrace Reefs.

Table 1

Percentage of Coral Species typically found in the Main Terrace Reefs

Coral	Percentage
Symmetrical Brain Coral	44.08%
Small Star Coral	30%
Grooved Brain Coral	16%
Great Star Coral	8%
Mustard Coral	1%
Elliptical Star Coral	0.02%

Table 1 shows the percentages of coral species typically found in the Main Terrace Reefs. Copied from the Bermuda Government Department of Conservation Services, 2001, *Bermuda Biodiversity Country Study*, p5.

Rim Reefs are the third type of coral reef and are located on the northern side of the Bermuda platform. These reefs can be found in depths ranging from 45 feet (7.5 fathoms) to 3 feet (0.5 fathoms). They also completely surround an area known as the North Lagoon (Hodgson, 2000). They are less diverse than the Main terrace Reefs (Bermuda Government Department of Conservation Services,

2001). Table 2 below shows the different types and percentages of corals that comprise the Rim Reefs.

Table 2

Percentage of Coral Species typically found in the Rim Reefs

Coral	Percentage
Symmetrical Brain Coral	47.5%
Grooved Brain Coral	21.74%
Small Start Coral	19%
Mustard Coral	7%
Great Star Coral	4%
Golfball Coral	0.19%
Finger Coral	0.16%
Ten-ray Start Coral	0.11%
Rose Coral	0.08%
Hat Coral	0.07%
Yellow Pencil Coral	0.05%
Elliptical Start Coral	0.04%
Maze Coral	0.02%
Artichoke Coral	0.01%

Table 2 shows the percentage of coral species typically found in the Rim Reefs. Copied from the Bermuda Government Department of Conservation Services, 2001, *Bermuda Biodiversity Country Study*, p5.

The Lagoonal Reefs are found in the North Lagoon. These reefs cover 15% of the sea floor in the North Lagoon (Hodgson, 2000) and are made up of a variety of different corals (Bermuda Government Department of Conservation Services, 2001). Table 3 below displays the types of coral species that are typically found in Lagoonal Reefs.

Table 3

Percentage of Coral Species typically found in the Lagoonal Reefs

Coral	Percentage
Small Star Coral	34.5%
Symmetrical Brain Coral	25.7%
Mustard Coral	14.84%

Yellow Pencil Coral	9%
Ten-ray Star Coral	3%
Great Star Coral	3%
Hat Coral	0.24%
Golfball Coral	0.20%
Lesser Starlet Coral	0.19%
Rose Coral	0.16%
Finger Coral	0.14%
Elliptical Star	0.003%

Table 3 shows the percentages of coral species typically found in the lagoonal Reefs. Copied from Bermuda Government Department of Conservation Services, 2001, *Bermuda Biodiversity Country Study*, p5.

The reefs to the South and South East of Bermuda are quite different from the reefs to the North. The reefs to the South of Bermuda are known as Boiler Reefs (Thomas and Stevens, 1991). Boiler reefs are small and hollow and resemble the shape of a wine glass (Bermuda Government Department of Conservation Services, 2001). Waves continuously break over boilers, giving the illusion of boiling water (Bermuda Biological Station for Research and College of Exploration, 1999).

In 2007 the coral reefs represented 12% of Bermuda's total Gross Domestic Product (GDP) (Sarkis et al, 2010). A study was conducted by the Department of Conservation Services to determine the Total Economic Value (TEV) of Bermuda's coral reef. This study looked at good and services generated from the marine ecosystem. The study revealed that six groups of goods and services where generated from the coral reefs. Tourism was the first group and had an annual average value of $405 million. Coastal protection (the damages the coral reef helps the island avoid) was the second group and had an annual average value of $266 million. The third group was recreational cultural had an

annual average value of $36.5 million. The fourth group the fisheries (commercial and recreational) had an annual average value of $4.9 million. The fifth group was the value coral reef added to the real estate, which had an annual average value of $6.8 million. Research and education was the sixth group, and had an annual average value of $2.3 million. Table 4 below shows the six groups of goods and services generated from Bermuda's Coral Reefs their average and percentage value arranged in ascending order.

Table 4

Value of Bermuda's Reef Broken Down into Good and Services

Services	Average Annual Value	Percentage Value of TEV
Tourism	$405 Million	56%
Costal Protection	$266 Million	37%
Recreational and Cultural	$36.5 Million	5%
Amenity	$6.8 Million	1%
Fishery	$4.9 Million	0.7%
Research and Education	$2.3 Million	0.3%

Table 4 shows the total value of Bermuda's reefs broken down into goods and services. This table is copied from Sarkis et al, 2010 *Total Economic Value of Bermuda's Coral Reefs*, p99.

Combined the six groups show that total economic value (TEV) for Bermuda's coral reef is $722 Million, making it Bermuda's most valuable ecosystem (Sarkis et al, 2010). For example, Bermuda's coral reef maintains 100% of the lobster fishery, 72% of the recreational fishery and 42% of the commercial finfish fishery (Sarkis et al, 2010). Coral reefs are also instrumental in reducing damage created by natural storms, flooding, and costal erosion (Bermuda Government Department of Conservation Services, 2001).

3 Bermuda's Fisheries

Bermuda's fishery is considered one of the best sport fishing destinations world wide (Overproof Fishing, 2012). With a marine area of 4,236.1km2 (Bermuda Government Department of Statistics, 2011) fishermen from all over the world are lured to Bermuda's waters in hopes of landing the big one (Bermuda.com, 2012). The island's fishery is divided into three categories; the inshore fishery, the offshore fishery, and the lobster fishery.

The depths of the inshore fishery range between 10 and 25 fathoms (60 – 150 feet) (Johnston, 1976). Ocean and tidal surges are the strongest among the reefs at these depths. As a result fish populations flourish due to high levels of nutrients created by the upwelling. This author reports that most fishermen who fish in the inshore fishery, target bottom fish namely; rockfish, porgies, yellow tail snapper, jacks, chubs, triggerfish, and hinds (Faiella, 2003). The inshore fishery has historically been targeted strongly by inshore fishermen.

In the 1950s 450,000kg of fish was harvested annually in Bermuda. Of the 450,000kg, 92% (405,900kg) comprised of the inshore fishery. Table 5 indicates the subgroups of the annual fish harvest in Bermuda from the 1950s.

Table 5
1950s Catch Composition

Fish	Percentage
Grouper	70%
Snapper	20%

Jacks, Mackerel and Tuna	9%
Other	1%
Table 5 shows the breakdown of the 1950s annual harvest into species and percentages. Copied from the discussion paper by Arthur D.O Hodgon, 2000, *Marine Resources and the Fishing Industry in Bermuda*, p5.	

Local fishermen have played a large role in teaching others about Bermuda's reef fishery. It is reported that local fishermen were the first to discover the location of the rockfish spawning grounds during the summer months. Today areas located in the North East and the South West have become seasonally protected (Trott, 2008).

In the late 1970s and early 1980s the United Nations attempted to help Bermuda's inshore fishery by sponsoring a project aimed to turn the local fishermen's attention off from the inshore fishery, towards the offshore fishery, where there was an abundant and underutilized species of Wahoo and Tuna (Hodgson, 2000).

Instead the project has had an opposing effect on the local fishermen. The local fishermen learned how to better market their product and invent the Bermuda Fish Fillet. This product is composed of not one inshore fish, but multiple fish from the inshore fishery offering a mixed sampling of fish. The fishermen utilize fish caught inshore and further focused their attention to the inshore fishery. This resulted in increases in effort toward the product, with predictable decreases in catch rates (Hodgson, 2000).

In contrast to the inshore fishery Bermuda's offshore fishery begins at the edge of the Bermuda Platform, where the platform steepens into the deep. The depth of the water on the edge of the Bermuda Platform ranges from 20 – 30 fathoms (120ft – 180ft) (Faiella, 2003). However Bermuda has very little control over the pelagic fish in the offshore fishery they often migrate over vast distances (The Pelagic Freezer – Trawler Association, 2009).

Lobster Fishery

The literature search shows that the Bermuda lobster fisheries were developed after the ban on fish pots in the 1990s. Originally fishermen were using fish pots to capture both fish and lobsters. The pots were constructed from antaillian arrowhead wire and baited according to what the fishermen was targeting at that time. Fishermen complained that the fish pot ban had caused them to lose out on income generated from the lobsters previously caught in these pots. As a result, the division of Fisheries established a separate fishery for lobsters, where traps were designed for catching only lobsters (Hodgson, 2000).

The two lobster fisheries currently approved are:

- Spiny Lobster (Panulirus argus) Fishery
- Spotted Spiny Lobster (Panulirus guttatus) Fishery

Spiny Lobster (Panulirus argus) Fishery

Table 6 below shows the number of Spiny Lobsters (Panulirus argus) caught before the fish pot ban in 1990 (Hodgson, 2000).

Table 6

Spiny Lobster Landings from 1975 – 1989

Year	Number of Lobsters
1975	29.408
1976	31,740
1977	29,356
1978	22,119
1979	28,380
1980	33,922
1981	21,303
1982	23,265
1983	30,965
1984	32,667
1985	32,758
1986	31,102
1987	27,001
1988	25,557
1989	35,193

Table 6 shows the number of Spiny Lobsters (Panulirus argus) caught in the fish pots before the fish pot ban in 1990. Copied from the discussion paper by Arthur D.O. Hodgson, 2000, *Marine Resources and the Fishing Industry in Bermuda*, p129.

The Division of Fisheries determined that the number of Spiny Lobsters (Panulirus argus) caught before the fish pot ban was extremely high and feared that it might be unsustainable. They decided that if a Spiny Lobster fishery (Panulirus argus) was to be established in Bermuda it must be regulated. It had already been agreed that Bermuda's fishery was on the verge of extinction because of the use of fish pots, so they set out to control the traps that would be used in the potential Spiny Lobster (Panulirus argus) fishery (Hodgson, 2000).

The Division of Fisheries determined that the lobster traps used in the Spiny Lobster (Panulirus argus) fishery should yield the lowest amount of inshore fish bycatch possible. Government determined it would be best to provide the lobster traps for the fishermen in order to control the amount of Spiny Lobster (Panulirus argus) traps being used in the fishery. They believed that this method of distribution would ease the financial burden of the fishermen having to provide their own traps (Hodgson, 2000).

The Division of Fisheries determined that in order to prevent the use of illegal fishing gear, traps for the Spiny Lobster (Panulirus argus) fishery should be located in deep water. The ideal depths being anywhere between 20 and 30 fathoms (120ft – 180ft) were proven to be the most productive strategy for Spiny Lobsters (Panulirus argus) (Hodgson, 2000).

In 1990 a pilot experimental lobster fishery was established. Fifteen traps with various escape hatches and funnel designs were created. The experiment ran for four months. Two different fishermen were recruited to conduct the experiment. They were permitted the use of five additional lobster traps so that they could test their own designs. The lobster traps were hauled in twice a week, in the presence of fisheries staff that accurately recorded data from each catch (Hodgson, 2000).

A total of 4,803 spiny lobsters (Panulirus argus) where caught during the pilot experiment. All traps used in the experiment were shown to be effective in catching lobsters with no damage to the fish stocks. The results from the

experiment allowed the Division of Fisheries to estimate a Total Allowable Catch (TAC). The experiment was deemed such a success that the Division of Fisheries extended it for three more years. This allowed them to further estimate the potential for the Spiny Lobster (Panulirus argus) fishery (Hodgson, 2000).

By 1994 the Division of Fisheries had collected sufficient data to determine that the TAC was not being met. This resulted in extending the Spiny Lobster (Panulirus argus) Fishery into the inshore. However access to the inshore Spiny Lobster (Panulirus argus) fishery would only be available late into the lobster season (December to March) (Luckhurst et all, 2002). The table below shows the number of Spiny Lobsters (Panulirus argus) that were caught during the experimental lobster fishery 1992 – 1995 (Hodgson, 2000).

Table 7

Number of Spiny Lobsters (Panulirus argus) caught during the experiment

Year	Number of Lobsters
1992	11,599
1993	14,157
1994	15,238
1995	10,360

Table 7 shows the number of Spiny Lobsters (Panulirus argus) that were landed during the years 1992 – 1995. Copied from the discussion paper by Arthur D.O. Hodgson, 2000 *Marine Resources and the Fishing Industry in Bermuda*, p129.

Following the pilot experiment, the first Spiny Lobster (Panulirus argus) Fishery opened 1996 / 1997 but was restricted to only sixteen entrants, each receiving nineteen Spiny Lobster (Panulirus argus) traps. The sixteen entrants were allowed to set their traps on the edge of the Bermuda platform from

September to December. The inshore extension of the Spiny Lobster Fishery was permitted from January to March, however only ten Spiny Lobster traps were allowed inshore which had to be hauled on designated days determined by the Division of Fisheries (Hodgson, 2000).

The Spiny Lobster (Panulirus argus) Fishery started to grow and generate economic success for the fishermen involved. Other fishermen became interested and began requesting entry into the fishery. The division of Fisheries allowed the fishermen to participate however they controlled the number of traps by reducing the maximum allocated to an individual fisherman from nineteen to fifteen (Hodgson, 2000).

The Division of Fisheries decided that with the increase in demand to enter a limited entry fishery a system was needed. It was decided that a lottery would decide entrance into the Spiny Lobster (Panulirus argus) Fishery. In order to limit the number of entries into the lottery fishermen must meet three requirements;

1) Fishermen must be a full time fishermen
2) Fishermen must have good standing with the Division of Fisheries and the law
3) The fishermen must have a vessel that is suitable for operating in the Spiny Lobster (Panulirus argus) Fishery.

Winners of the lottery are allowed access to the Spiny Lobster (Panulirus argus) Fishery for three years. Table 8 shows the landings of Spiny Lobsters (Panulirus argus) between the years 1996 and 1998. This report is important since it highlights catches performed. The lobster fishing was remodeled with an additional inshore option.

Table 8

Numbers of Spiny Lobsters (Panulirus argus) Caught During the Years 1996-1998

Year	Number of Lobsters
1996	9,446
1997	34,403
1998	26,992

Table 8 shows the number of Spiny Lobsters (Panulirus Argus) that were landed during the years 1996 – 1998. Copied from the discussion paper by Arthur D.O. Hodgson, 2000, *Marine Resources and the Fishing Industry in Bermuda*, p129.

Spiny Lobster (Panulirus argus) pots are 5' X 4' X 2'. The escape gaps on the Spiny Lobster (Panulirus argus) pots are 8 ¾ long. All pots are made out of 1 ½ square mesh and are owned, inspected, allocated, and collected by the government's Division of Fisheries (Hodgson, 2000).

Guinea Chick Lobster Fisheries

Bermuda is the only country in the world that commercially harvests Spotted Spiny Lobsters (Panulirus guttatus). Locally known as Guinea Chicks, the Spotted Spiny Lobsters (Panulirus guttatus) were originally being caught in fish pots. Fishermen benefitted from these catches due to the small market for them

(Hodgson, 2000). Table 9 shows the Spotted Spiny Lobsters (Panulirus guttatus) landings before the fish pot ban between the years 1980 and 1989.

Table 9

Number of Guinea Chick Lobsters (Panulirus guttatus) Landed by the Commercial Fishery 1980 1989

Year	Number of Guinea Chicks Landed
1980	28,342
1981	13,995
1982	12,072
1983	25,410
1984	27,006
1985	31,952
1986	33,821
1987	26,008
1988	25,949
1989	15,327

Table 9 shows the number of Guinea Chick Lobsters (Panulirus guttatus) that were landed before the fish pot ban between the years 1980 and 1989. Copied from the discussion paper by Arthur D.O. Hodgson, 2000, *Marine Resources and the Fishing Industry in Bermuda*, p135.

The Division of Fisheries decided to conduct a two-year survey to determine if the Spotted Spiny Lobster (Panulirus Guttatus) could be sustainably harvested in Bermuda (Trott et al, 2002). The aim of the experiment was to collect crucial biological data on the species as well as to determine which trap would be best suited for the potential fishery. Two types of traps were tested during this experiment, the A1 type trap and the Fathom Plus trap. Each fisherman was provided with fourteen Spotter Spiny Lobster traps (Hodgson, 2000). Seven of these were A1 traps, while the remaining seven where Fathom Plus traps (Trott et al, 2002).

The A1 traps are identical to the trap used in the first years of the Spiny Lobster experimental fishery. These traps are rectangular in size and are made of galvanized green vinyl coated square mesh. The Fathom Plus traps were oval shaped and made of black plastic mesh. These types of traps are extensively used in the U.S commercial fishery, specifically targeting crustaceans. Both types of traps are fitted with a funnel containing a PVC ring 4" in diameter located at the inner end of the funnel.

The Division of Fisheries selected four fishermen to enter the experimental Spotted Spiny Lobster (Panulirus guttatus) Fishery and provide them with statistical data. The following data was collected:

- Water Depth
- Area Fished
- Number of Spotted Spiny (Panulirus Guttatus) Lobsters caught (both live and dead).
- Number of female berried Spotted Spiny (Panulirus Guttatus) Lobsters caught

Table 10 below shows the results from the experimental Spotted Spiny Lobster (Panulirus guttatus) from April 1998 – March 1999.

Table 10

Number of Experimental Guinea Chick Trap Hauls, Catches and Per Unit Effort for April 1998 through March 1999.

Month	Number of Hauls	Number of Guinea Chick Lobsters	Catch Per Unit Effort (CPUE)
April 98	507	435	0.86
May 98	547	597	1.10
June 98	738	1,218	1.64
July 98	819	1,679	2.10
Aug. 98	802	1,558	1.94
Sept. 98	455	855	1.99
Oct. 98	709	1,672	2.32
Nov. 98	583	1,175	1.97
Dec. 98	583	1,046	1.81
Jan. 99	295	350	1.19
Feb. 99	329	299	0.86
Mar. 99	282	235	0.88
Totals	6,649	11,119	1.64 (ave.)

Table 10 Shows the results from the experiment from April 1998 – March 1999. It shows the number of experimental Guinea Chick trap hauls, catches and per unit effort for April 1998 through March 1999. Copied from the discussion paper by Arthur D.O. Hodgson, 2000, *Marine Resources and the Fishing Industry in Bermuda*, p136.

Table 10 shows that for every trap hauled an average of 1.65 Spotted Spiny Lobsters (Panulirus guttatus) were caught. The experiment also identified which trap preformed better for Bermuda. Results for each of the traps are displayed in Table 11 below.

Table 11

Results of the different trap designs used in the experimental Guinea Chick (Panulirus guttatus) Lobster Fishery.

Trap Type	Mean CPUE	St. Dev.	No. of Hauls	No. of Guinea Chicks Landed	Bycatch		
					Spiny Lobsters	Fish	Other Inverts.
A1	1.39	0.48	2675	3663	12	2782	50
Fathoms Plus	1.70	0.43	3456	6758	19	519	20

Table 11 displays which trap preformed better during the Experimental Guinea Chick Lobster (Panulirus Guttatus) Fishery from April 1998 – March 1999. Copied from the discussion paper by Arthur D.O. Hodgson, 2000 *Marine Resources and the Fishing Industry in Bermuda*, p137.

Table 11 show the Fathoms Plus traps as the best trap in the potential Spotted Spiny Lobster (Panulirus guttatus) Fishery since it produced the most Spotted Spiny Lobsters (Panulirus guttatus) with the lowest bycatch.

Between the months of April and June trends emerged to indicate that the catch per unit of effort (CPUE) increased during these months for both traps. The Fathom Plus trap had the highest mean CPUE with 1.70. This CPUE started to decrease from August to October while CPUE for the A1 traps continued to increase until October. However both traps showed a decline in the CPUE from October onwards (Hodgson, 2000).

After the first year the Spotted Spiny Lobster (Panulirus guttatus) experiment provided the Division of Fisheries with essential information for the fishery. A total of 1,238 of the 11,119 Spotted Spiny Lobsters (Panulirus Guttatus) landed during the experiment were measured and sexed. From these measurements it was determined that males were the larger of the species having an average carapace length of 67mm (Hodgson, 2000).

Three conclusions were reached based upon the results from the experiment.

1. It is difficult to effectively assess the reproductive state of the stock because the large male population (90.8% of the measured landings). However the small female landings (0.9%) showed that reproduction was from May to September.

2. Males were the larger of the species with an average carapace length of 7mm larger than the females.

3. The winter months provided the lowest catch rates, while the summer and fall months provided the higher catch rates. It was suggested that this might occur because of the changing water temperatures during the seasons. The water temperature during the summer and fall are considerably warmer, which could lead to higher levels of activity.

The Division decided to continue on with year two of the Spiny Spotted Lobster (Panulirus guttatus) Fishery. Results from May 1999 to June 1999 showed that the CPUE for these months were extremely higher than the same months last year (Hodgson, 2000). Table 12 below shows these results.

Table 12 Results from Year Two of the Experimental Spotted Spiny Lobster (Panulirus guttatus) Fishery (May 1999 – July 1999)			
Month	Number of Hauls	Number of Spotted Spiny Lobsters	Catch Per Unit Effort (CPUE)
May 99	273	916	3.44
June 99	427	1386	3.43
July 99	380	1805	4.75
Totals	1080	4107	3.87 (ave.)
Table 12 shows the results from year two of the spotted spiny lobster (Panulirus Guttatus) Experimental Fishery. Copied from the discussion paper by Arthur D.O. Hodgson, 2000 *Marine Resources and the Fishing Industry in Bermuda*, p138.			

4 Lionfish Invasion of Bermuda

The Indo – Pacific Lionfish (Ptrois volitans) have invaded Bermuda waters and other parts of the Atlantic Ocean (Royal Gazette, 2011). Their invasion not only threatens human health and native fish communities, but fisheries resources also (Morris et al. 2009).

The lionfish invasion represents one of the fastest growing biological invasions in history. Whitfield (2002) explains that biological invasions consist of "the arrival, survival, successful reproduction and dispersal off a species in an ecosystem where the species did not previously exist." (Whitefield et al, 2002, p289)." The establishment of the Indo – Pacific Lionfish Pterois volitans represents the first successful introduction of a marine fish form the Western Pacific to Atlantic costal waters of the United States" (Whitefield et al, 2002, p290). It is still debated what caused the invasion, however it is strongly believed that the invasion was the result of lionfish being released from marine

aquariums in the United States. The first known release of lionfish occurred in Florida of August 24, 1992. Hurricane Andrew destroyed a large marine aquarium and six lionfish were released into the Biscayne Bay (Whitefield et al, 2002).

Four main attributes contributed to the success of the lionfish invasion in the Atlantic, which give a competitive edge over the native fish population.

The lionfish's hunting strategy is to ambush its prey (Robins, 2004). The lionfish uses camouflage to aid this strategy where its pectoral rays hide the motion of its caudal fin and natural colorful stripes also help it camouflage with the reef (Wood, 2001). Lionfish attacks are quick. This predator sucks their prey into its mouth and swallows it whole (Robins, 2004). Attacks are so fast that if a lionfish was ambushing a group of fish and ate one of the group members the others in the group would not notice the attack (Wood, 2001).

The lionfish's stomach has the ability to expand over thirty times in volume when eating a large meal (Fishelson, 1997). As a result their large stomach allows them to not only eat large prey in size, but also to survive for long periods of time without food. Fishelson (1997) determined from his experiments that lionfish could survive without food for over twelve weeks. The actual length of time was not determined because the fish were not kept from food to the point where they died. Fishelson (1997) experiments also showed that lionfish ate as much as 6% of their own body weight per day at temperatures ranging between 25°C and 26°C. However the author concluded it

is possible for lionfish to consume more than 6% of their body weight (Fishelson, 1997).

Reports reveal that lionfish have a total of eighteen venomous spines; thirteen dorsal spines, two pelvic spines and three anal spines (Halstead et al, 2005). The report further reveals that each spine is surrounded with integumentary sheaths that are colored with alternating white, dark red and black hues. Some of the venomous spines are curved at the top in a craniad direction (Halstead et al, 2005). The sheaths contain two grooves of glandular epithelium, which is the source of the venom producing tissue and extends three quarters of the way from the base of the spine towards the tip (Morris et al. 2009).

The author reports that "Lionfish envenomation occurs when the spine's integumentary sheath is depressed as it enters the victim, a process that tears the glandular tissue allowing the venom to diffuse into the puncture wound." (Morris et al, 2009 p3). The venom was found to contain a neurotoxin that affects neuromuscular transmission and believed to be very dangerous. The venom has been found to cause cytolytic, neuromuscular, and cardiovascular effects (Morris et al. 2009). While in extreme cases the venom has been found to cause paralysis. Mild reactions to it are swelling, pain, shortness of breath, nausea, headache, and hypotension. "The antivenom of the stone fish was found to be extremely effective neutralizing lionfish venom activity" (Morris et al, 2009, p3). Ternay (2008) describes lionfish venom as a thermolabile meaning that it the venom breaks down under heat. The venomous spines act as a defense

against predicators, however the actual effectiveness of this defense is still unknown (Morris et al, 2009). Behavior studies have shown that groupers actively avoided lionfish. Yet others report that several groups have been caught in the wild and their stomach contents showed that they also (Morris, J, et all, 2008).

An experiment was conducted by Mark A. Albins and Mark A. Hixon (2008) to determine what effect lionfish had on reefs. Reef ecologists Jennings, Kaiser, and Reynolds (2001, p70) define recruitment as "the number of individuals that reach a specified stage of the life cycle. Recruitment is measured when larvae first settle on a reef and can be counted by underwater visual census techniques." Albins and Hixon (2008) paired twenty reefs so that one ref had no lionfish and one reef had lionfish. The groups of reef without lionfish were known and the control while the groups of reef with lionfish was known as the treatment. For five weeks the reefs were checked once a week. Albins and Hixon (2008) predicted that their study would show net recruitment would be higher on the groups of reef without lionfish (control) than the groups of reefs with lionfish (treatment). Their results revealed that the groups of reef with lionfish present (treatment) experienced a net recruitment reduction of 79%. It was argued that lionfish being present on the reef did not necessarily cause this reduction in recruitment. In an attempt to show that the results obtained from the experiment were due to lionfish presence on the reef Albins and Hixon (2008) examined the stomach contents of this species. Based on the stomach contents of the lionfish and the observations made during this experiment it was determined that the 79% net reduction on recruitment was caused by the

predation of the lionfish. Observations of the stomach contents of lionfish also showed that the lionfish was capable of eating food relative to their current size (Albins, Hixons, 2008.)

In response to the crisis Bermuda has launched a lionfish-culling program encouraging fishermen and divers to hunt the lionfish. Plans are underway to license a few dedicated fishermen to search the reefs for lionfish and to spear them on protected dive sites, as well as within the one mile no spear-fishing boundary (Royal Gazette, 2009). This program was launched by Chris Flook, who worked for Bermuda's department of Conservation Services. Mr. Flook believes it will be impossible to completely eradicate the lionfish from Bermuda's waters, however he is confident that the problem can be contained with pressure from deliberately hunting them. Any lionfish that are caught by any means are brought back to Chris Flook so that he may study them to learn more about their interaction within Bermuda's ecosystem. It is believed that Bermuda is the first country to set up a program that licenses divers to hunt lionfish (Royal Gazette, 2009).

5 Stakeholders

There are two main groups of stakeholders in Bermuda are: Commercial Fishermen and Recreational Fisherman

Commercial Fishermen

Commercial Fishermen in Bermuda have existed since the island colonized in 1609. These Fishermen sold or traded fish for other goods, or services (Faillea, 2003; Hodgson, 2000).

This fishing industry is considered a limited entry fishery, where fishermen are required by law to submit statistics for every fishing trip. In addition to maintaining their commercial fishing license they are required to make a minimum of one hundred fishing trips a year (Luckhurt et al, 2003).

Table 13 below was copied from the Bermuda Department of Statistics Environmental Statistics Compendium for 2011, page 67. It shows the total catch by hours at sea and the number of fishermen registered from 2005 - 2010.

Table 13

Total Catch by Hours at sea, number of registered fisherman from 2005 - 2010

Indicators	2005	2006	2007	2008	2009	2010
Total Catch	402.87	383.85	418.47	400.98	424.17	391.37
Total Hours at Sea	71,770	67,783	70,599	67,563	70,546	68,528
Hours at Sea per Vessel	492	510	504	466	466	387
Registered Fishermen	335	320	331	306	306	305

Table 13 shows the total catch by hours at sea and the number of fishermen registered from 2005 – 2010. Table 13 was copied from the Bermuda Government Department of Statistics, 2011, *Environmental Statistics Compendium*, p67.

Recreational Fishermen

Recreational fishermen (include both residents and visitors) are not required to have a license to fish in Bermuda (Hodgson, 2000). It is estimated that 30% of all households on the island have at least one person who fishes (Bermuda Government Department on Environmental Protection, 2012).

6 Commercial Fishing Methods in Bermuda

Bermuda uses many different fishing methods with multiple types of fishing gear. The Food and Agriculture Organization of the United Nation (2009) defines fishing gear as "the tool with which aquatic resources are captured." They also define fishing method as "how the gear is used to capture these resources"

Bermuda historical knowledge about fishing has been passed down from generation to generation. Most of this knowledge is acquired by experimenting with whatever works taking into account location, currents, time of day, phase of the moon, tide levels, and the behavior of the fish (Faiella, 2003).

Equipment and Components used in Line Fishing

The earliest known fishing line used in Bermuda was constructed from natural fibers such as flax, hemp rope, strands of palmetto leaf, and shoe lacings (Faiella, 2003).

After the Second World War fishermen started using fishing line that was made out of dacron, in order to catch game fish located offshore which resulted in sport fishing exploding (Faiella, 2003). Dacron is commonly known as polyester and was braided so that it became soft and thin (Stickles, 2007). Dacron was not the best choice of fishing line because it would deteriorate due to exposure to the sun (Faiella, 2003).

Today the most commonly used fishing line is constructed out of monofilament which is an excellent choice for fishing line because it is difficult to be seen in the clear waters of Bermuda this line has great transparency, flexibility and strength and deteriorates slower than dacron and sinks faster in water (Faiella, 2003).

The Bermudians choice for size of the fishing line (test strength) is dependent on the type of fish being targeted or the challenge for each fisherman. Faiella (2003) describes two types of fishing tackle; light tackle and heavy tackle. Heavy tackle is any test line ranging from 80lb to 130lb, while light tackle is any test line up from 25lb weight.

Leader

The leader is a length of fishing line or wire that acts as a link between the main line and the hook. The leader is usually a stronger test strength than the main line. It is best preferred in situations where the desired fish is powerful enough to break or cut the original line. The main line can be cut or broken by the fins or tail of a large fish from lighting, abrasion, sharp teeth, or shock from a strike (Faiella, 2003).

Wire was previously the preferred choice of leader in Bermuda for targeting game fish. Monofilament is now the dominant choice of leader due to its great transparency in water. However wire is still considered the better choice for the following reasons:

1) Many game fish attack bait form behind and thus they would never see the wire leader.
2) Vessels have to travel at speeds ranging between 5 and 8 knots to troll and this creates a wake of waves that would conceal the wire leader (Faiella, 2003).

Hooks

The majority of the fish hooks that are used in Bermuda are manufactured by the Mustad Company, which is considered to be the number one fish hook brand world wide (Mustad Company, 2009; Faiella, 2003). Hooks are available in

various sizes and numbered accordingly. The larger numbers identifies smaller hooks while smaller numbers identify larger hooks.

Bait and Lures

Most of the local fishermen possess a large selection of bait on every fishing trip. Bait may range from Fry, Anchovy, Squid, Crustaceans, Garfish, Robin and Bread (Faiella, 2003).

Chumming as it is commonly known, continues to be a popular fishing method in Bermuda for many years, helps increase chances of catching fish (Faiella, 2003). Chumming is the process of strategically placing a selection of food in order to attract fish to a designated area (Keyes, 1992). In Bermuda chumming involves a selection of chopped up pieces of small baitfish and crushed fry or anchovy mixed with sand. The objective is to allow the sand and the bait to drift from the boat together following the tide to reach a larger distance in luring fish,

Fishing lures are objects that are manufactured to resemble foods that fish would naturally be attracted to in the wild. (How things are made, 2006). Lures come in many different colors and sizes. Small lures are usually trolled from the stern of the boat using flat lines while large lures target large game fish and are trolled from outriggers or down riggers (Faiella, 2003).

Down Riggers

The Chicago Sport – Fishing Association (2009) explains that down riggers are machines that are able to get a trolled fishing lure down to depths where fish feed. Down Riggers work by using a steel cable, a large weight and a release line. The release line is attached to the main line from the fishing rod. The weight lowers the main line down to the depths where the fish are located. When a fish attacks the lure it releases the down – rigger from the main line. (The Chicago Sport – Fishing Association, 2009.)

Kite

Many skilled big game fishermen in Bermuda use kites to troll bait from behind the stern of the boat. The kite is attached to the stern of the boat, while the main line from the fishing rod attaches from the kite to the bait. The preferred bait with this fishing technique is a flying fish. The flying fish is rigged so that its fins are displayed in the flying position. This design allows for the flying fish to fly in and out of the water mimicking a real flying fish. When a fish attacked the line, the strike breaks the main line away from the release line. It is believed that tuna in particular love flying fish rigged in this style (Faiella, 2003).

Rods and Reels

The only two types of rods and reels used in Bermuda are trolling tackle and spinning tackle (Faiella, 2003).

Trolling Tackle

Marriam – Webster Online Dictionary (2009) defines trolling as "Fishing by trailing a lure or baited hook from a moving boat. In Bermuda fishermen usually troll on the edges of the Bermuda Platform. Trolling uses heavy-duty tackle that targets fish ranging form 5lbs – 500lbs. Heavy-duty tackle is preferred because less pressure is placed on the fishermen and more on the fish (Faiella, 2003).

The author describes two types of trolling tackle reels available in Bermuda; Star – Drag Reels and Dual – Drags Reels (Faiella, 2003).

Star – Drag Reels

Free Patents Online (2009) explains that Star – Drag Reels are fishing reels that have a drag assembly that is actuated by a star drag wheel. This drag wheel is mounted on a common axis with a crank lever and a drag plate is engaged with a slide drag actuator. This action allows the star drag wheel to move the drag plate causing either increase or decrease in the pressure the drag plate applies to the line spool.

Dual – Drag Reels

Free Patents Online (2009) explains that Dual – Drag Reels are an improved version of the spinning reel. A root drag system is located in the handle. This system allows for the fisherman to apply a selective amount of friction force to the reel handle and to the reel main drive gear. When the selective frictional force is set less than the spool drag assembly, it allows for the fishing reel rotor and the reel main drive gear to remain stationary while fishing. The result is the same even when the reel handle is being turned. This design prevents twists from occurring on the fishing line. In addition the rotor drag assemble in the dual drag reel reportedly contains an input shaft that engages the spool drive shaft. A clutch plate located between the input handle and the reel handle provides selective transmission of the rotational handle force to the input shaft.

Spinning Tackle

It is reported that spinning rod and reel are designed for light tackle fishing only. The size of the spinning reels depends on the amount of test strength that this tackle is under. It is commonly know in Bermuda that fishermen have the option of purchasing rods with spinning reel attached or separate (Faiella, 2003).

Nets

The practice of using nets within Bermuda's waters is prohibited in protected areas as well as Bermuda's exclusive economic zone. The exception to this rule is in the practice of capturing bait fish such as; Rush Fry, Blue Fry, Herring, Anchovies, Half Beaks, Jacks (except Pompano), Yellow Tail Snapper, mackerel, and Flying Fish (Fisheries [use of net] Order 1990).

There are four areas located around Bermuda where Net fishing permanently banned. They are Somerset Long Bay, Shelly Bay, Whalebone Bay, and Coot Pond (Fisheries [use of net] Order 1990). Net fishing is further restricted for recreational fishermen. The rules stipulate that they are only able to use a bait net or cast net that are 75ft (23 meters) long and 9 ft deep (2.7 meters) (Bermuda Government Department of Environmental Protection & Department of Conservation Services, 2006).

Spear Fishing

Spear – Fishing is a practice, which is allowed in Bermuda, however it must be conducted in areas on nautical mile from the baselines and is prohibited in protected areas. As a result restrictions prevent spear – fishing in any bays, harbors or shores of Bermuda (Bermuda Government Department of Environmental Protection & Department of Conservation Services, 2006).

The pole pear is the only spear that is legal in Bermuda used to spearfish. The Hawaiian sling and the spear gun are both types of spears that are illegal in Bermuda (Bermuda Government Department of Environmental Protection & Department of Conservation Services, 2006).

Since spear fishing must be conducted while free diving it is illegal to spearfish using an aqua-lung. There is a bag limit for spearfishing where two fish of any one species per person is allowed per day. In addition fish speared may not be sold (Bermuda Government Department of Environmental Protection & Department of Conservation Services, 2006). Spear fishing now requires a license, which can be attained from the Bermuda Government's Department of Environmental Protection (Bhattacharya, 2012).

Lobster Diving

Lobster diving is the only way that recreational fishermen have access to Spiny Lobsters (Panulirus argus) Fishery. They must obtain an annual license from the Department of Environmental Protection in order to access this fishery during open season (Bermuda Government Department of Environmental Protection & Department of Conservation Services, 2006). Recreational fishermen are prohibited to take any Spiny Lobsters (Panulirus argus) during the five months of April 1st – August 31st when the season is closed (Bermuda Government Department of Environmental Protection & Department of Conservation Services, 2006).

Recreational divers are only allowed to capture (Panulirus argus) using a lobster nose. Capturing them any other way including spearing is illegal. Lobster diving must be conducted without the assistance of an aqua-lung. Each licensed diver is allowed to take two Spiny Lobster (Panulirs argus) a day and any captured lobster must have a minimal carapace length of 92mm. To ensure legal sizes a measuring tool must be carried at all times. In addition to the rules and regulations all lobsters caught must be brought back to shore whole. License holders are required to provide statistics on their catches using the government website www.fisheries.gov.bm (Bermuda Government Department of Environmental Protection & Department of Conservation Services, 2006).

Fish Pots

Fish pots were a fishing method used by the older generations of Bermudians as far back as the beginning of the 20th century (Faiella, 2003). By 1990 were eventually phased out due to unsustainable levels of harvesting on the reef fishery (Butler et all, 1993).

Long-Lining

Long lining has existed in Bermuda since the 1960s and the literature shows that many countries use vessels to long line around Bermuda. The Division of Fisheries conducted experiments to determine the possibility of Bermudians joining the long lining fishery (Faiella, 2003).

In 1955 the very first long lining experiment was conducted in 1955 where lines constructed from hemp were set at two miles long. This experiment conducted on the south shore and was a success in catching Mako Shark, Yellow Fin Tuna, Wahoo, Blue Marline, Blackfin Tuna, and White Marlin (Faiella, 2003.)

In 1981 the Division of Fisheries conducted anther experiment using the research vessel CALAMS which was outfitted with long line that targeted Albacore. During the frst attempt lines were set between 1 and 2 miles long. It was shown that lines at this length landed mostly sharks (Hodgson, 2000).

The experiment continued in 1982 and CALAMUS was outfitted with long lines set 5 miles. It is shown that at this length lines the lines captures many different types of sharks and tuna. Regrettably the experiment was terminated due to lack of funding (Hodgson, 2000).

7 Fisheries Administration and Enforcement

Division of Fisheries

Any issues regarding fisheries originally came under the board of trade act in 1921. In the 1950's Bermuda's fisheries management responsibilities were transferred to the Trade and Development Board, which today is the Ministry of Tourism (Hodgson, A, 2000).

In 1958 as question was raised; can Bermuda's fishery be organized into a professional and commercial industry? A study was conducted by John E. Baradach to answer this question. His results were published in a report titled "Bermuda Fisheries Research Program". In the report Baradach makes three important recommendations (Baradach et all, 1958):

- Matters regarding the fishing industry should be placed under the Department of Agriculture.

- The Department of Agriculture should then be changed to the Department of Agriculture and Fisheries

- The director of the Department of Agriculture should then become the director of the Department of Agriculture and Fisheries.

In 1961 following the recommendations of John E. Baradach, the Division of Fisheries was created and placed in the Department of Agriculture. Bermuda's Department of Agriculture then became the Department of Agriculture and Fisheries. The Division of Fisheries was considered the future platform for fisheries development, management and research (Faiella, 2003).

The Division of Fisheries is currently a sub section in the Department of Environmental Protection. This department falls under the Ministry of Environment and Sports (Bermuda Government, 2009).

Bermuda's Government has two main goals when regulating Bermuda's Fishery (Faiella, 2003):

- To develop and support the fishing industry.

- To exploit the harvestable resources to the maximum sustainable levels.

In 1975 the Division of Fisheries stated that the majority of their existing regulations for fisheries conservation and management were not based on sound scientific research. In order to ensure that this is not the case for future regulations the Division of Fisheries main goal is to collect information regarding Bermuda's fishery in order to effectively manage the resource (Faiella, 2003).

The Division of Fisheries was a fully staffed division within the Department of Environmental Protection. There was twelve staff members employed within this division. These twelve members were the senior fisheries officer, the fisheries officer biologist, fisheries officer gear technologist, fisheries officer extension, administrative assistant, fisheries technician biologist, captain of R/V CALAMUS, head warden, and four wardens (Hodgson, 2000).

There has been a reduction in staff members within the Division of Fisheries. There are currently only eight full time staff members working for the Division of Fisheries. The current Division of Fisheries has four fisheries

wardens, one head fisheries warden, one senior fisheries officer, a fisheries officer biologist and a marine resources officer (Bermuda Government, Department of Environmental Protection, 2009).

Bermuda's Division of Fisheries manages the fishery resource by implementing regulations. These regulations are designed to control the fishing industry, allowing for sustainable harvesting and the protection of Bermuda's marine resource (Faiella, 2003).

Fisheries Wardens

The fisheries wardens enforce the fisheries regulations of Bermuda. A fisheries warden is not the same as marine police officer and does not receive the support of the police department. They are civil servants and work a thirty-five hour workweek (Hodgson, 2000). The Department of Environmental Protection's strategy for sustainable use of Bermuda living resource highlights a need for an increase in the number of fisheries wardens employed. The demands and responsibilities attached to the warden's job have increased drastically. Four fisheries wardens and one head warden (manager) are insufficient to enforce Bermuda's fishery.

Fishery warden's job requires them to focus on seven key areas;

- Marine Protected Areas
- Fisheries Statistics

- Annual Licensing of Commercial Fishermen
- Lobster Season
- Supermarkets, Hotels and Restaurants
- Illegal Fishing Gear
- Fisheries Imports

Bermuda's marine protected areas are comprised of two coral reef preserves, three seasonal protected areas and twenty-nine protected dive sites (Bermuda Government Department of Statistics, 2011). These thirty-four areas constitute seven percent of the Bermuda's total marine area. The fisheries wardens are responsible for patrolling these protected areas to ensure that fishermen (recreational and commercial) are obeying the laws (Hodgson, 2000).

Commercial fishermen required by law to provide statistics on their catches. Statistics are dropped off at drop boxes located at specific docks around the island. Fisheries wardens are responsible for physically collecting statistics forms from drop boxes every week (Hodgson, 2000).

The fishermen are also required by law to have their fishing boats inspected by fisheries wardens for safety reasons. This process occurs from January to the end of March and any boat that has failing inspection has to be re-inspected at another date (Hodgson, 2000).

The fisheries wardens allocate lobster traps to commercial fishermen who have been granted access to the lobster fishery. The lobsters traps are

government issued therefore it is the fisheries wardens' responsibility as civil servants to repair any traps that are damaged before the allocation process (Hodgson, 2000).

In Bermuda lobster season opens September 1st for both commercial and recreational fishermen. The wardens perform many different tasks involving accurate operations and evaluations for the lobster fishery. These tasks apply to both commercial and recreational participants. Duties include accompanying vessels to sea at sea, boat inspections at sea as well waiting for boat returns with catches to be tabulated. The lobster season closes April 1st for both commercial and recreational fishermen alike and commercial fishermen are required to return the government issued traps to the fisheries wardens who store the traps until the next season (Hodgson, 2000).

There are 14 supermarkets, 14 hotels and over 150 restaurants in Bermuda (Bermuda4u.com, 2009). The fisheries wardens are responsible for ensuring that these establishments comply to the rules and regulations concerning the legality of all fish stocks. In particular, to determine whether fish was purchased from a commercial fishermen or a wholesale distributor and they meet requirements and legal standards. In addition, that particular information on menus pertaining to fish is correct, and any catches are correctly identified to the public (Hodgson, 2000).

The wardens are responsible for duties that involve other departments or agencies such as the Department of Environmental Protection. This agency

provides marine transport to ferry several youth groups and staff members to various islands around Bermuda. Wardens possess class C pilot's license that qualifies them as chauffeurs to preform the role. Customs officers contact the fisheries wardens with any queries regarding duty free vessels. Harbor radio immediately contacts the fisheries wardens for assistance with oil spills or for individuals in need while on the water. The Department of Planning contacts fisheries wardens when they are investigating illegal dumping (Hodgson, 2000).

Problems with Enforcement

Currently the organizational structure for staffing the Division of Fisheries shows one head warden and four wardens, which is shown to be insufficient for the job at hand. Understaffing, inefficiency for role responsibility and ineffective performance for positive outcomes have affected job morale. The roles and responsibilities outlined highlight the inability of the wardens to effectively and successfully enforce rules and regulations set forth (Hodgson, 2000)

The author concludes those employed with the Division of Fisheries are experiencing a negative effect in their ability to enforce regulations while carrying out their duties and responsibilities (Hodgson, 2000). Most agree, that understaffing compounds the problem of low morale (Hodgson, 2000)

As civil servants, the wardens have a thirty–five hours workweek. which works out to seven hours a day, five days a week. Hodgson (2000) explains that low morale and performance also results from a combination of factors including low wages, public criticism and inadequate government support. To compound the issue even more, research shows that the wardens receive extremely low wages.

The fisheries wardens are not police officers, but civil servants who possess a class C pilots license and a credited drivers license, which deems them more skilled than police constables (Hodgson, 2000). However the starting salary for a police constable is $70,000 a year (Bermuda Police Service, 2008): a considerable difference compared to the annual salary of $57,711 a year for the fisheries wardens (Bermuda government, 2009).

Unlike most civil servants the fisheries wardens have a choice selecting two off days during the week. Since weekends are normally the busiest time of the week, the wardens are usually compelled to take off, two week days. This strategy allows the Division of Fisheries to have at least two wardens working every weekend (Hodgson, 2000).

Considering understaffing and role responsibility, the literature reveals a vast ocean area that the wardens are required to patrol. The literature reveals that the Bermuda oceanic platform is 800 square nautical miles (20 nautical miles X 40 nautical miles), based on 100 fathoms as boarder line. This area includes both inland waters and shoreline, but does not include the offshore

banks, Argus and Challenger. It is evident that such a vast area patrolled by a minimum of two wardens warrants revisiting (Hodgson, 2000). As the author suggests how positive outcomes to performance are continually being plagued by many other factors, leading to low morale, public criticism and poor governmental support.

The fisheries wardens face many criticisms from the public with the two main complaints being familiarity (conflict of interests) and laxity in role performance. Some members of the public make allegations, that a particular warden is a friend or relative to one of the fisherman; thus resulting in unfair practices and treatment (Hodgson, 2000). The author concludes that Bermuda's small size of twenty-one square miles and dense population may contribute to conflicts of interests and unfair treatment.

With the perceived allegations of laxity, many believe that the wardens are not performing their roles adequately; resulting in relaxed enforcement of rules. After a 1991 Commission of Inquiry was conducted, the report revealed that enforcement was indeed relaxed (Towle et all, 1991). Hodgson (2000) notes that this may still be true today.

Table 14 below highlights the number of offensives related to fisheries regulations that have been brought before the court between the years 1990 and 1998.

Table 14 History of Offensives Relating to the Fisheries Regulations brought before the court between the years 1990 -1998					
Year	No. of Charges Brought	No. of Convictions	No. of Conditional Discharges	No. of Cases Dismissed, Charges Dropped, ect	Departmental Cautions
1990	32	20	-	3	-
1991	23	21	-	-	-
1992	20	9	-	-	1
1993	14	9	0	6	-
1994	12	9	-	-	6
1996	15	6	-	1	-
1997	19	-	-	2	54
Table 14 shows the Offensives Relating to the Fisheries Regulations brought before the courts1990 – 1998. Copied from the discussion paper by Arthur D.O. Hodgson, 2000, *Marine Resources and the Fishing Industry in Bermuda*, p45.					

The data in table 14 shows a trend of history of offenses issued by wardens on regulations and brought before the courts, to be decreasing over time. Furthermore another trend emerges highlighting that the number of departmental caution handed out over time has also increased.

A departmental caution is similar to a police simple caution, as discussed by the Home Office of the UK (Ministry of Justice, 2011). It is a method of officially notifying people that their current behavior is unacceptable and warns them about consequences, should they choose to commit further acts. This simple caution aims to divert less serious crimes away from court.

8. Policy Options

It is now clear that Bermuda has a very vast marine ecosystem, which is not surprising for a small isolated island situated in the middle of the Atlantic Ocean. However, resources available in the Division of Fisheries compared to the size of the island are insufficient. Current resources are also inadequate, ineffective and do not meet the needs and demands to run effectively. They do not equate equitably for expert outcomes. Changes must be made so that current resources are used more efficiently. Implementing research and practice for best outcomes should lead to improving better enforcement of rules and regulations and a stronger Fisheries Division for the future.

1) Implement Ticketing Scheme

A suggestion to implement a ticketing scheme may improve enforcement. This strategy would serve as a substitution for departmental cautions. The aim is to address less serious crimes like being in possession of an illegal undersize catch or a catch that surpasses the regulated bag limit. Another suggestion for this strategy is that tickets would have set fines for various offenses. This strategy would offset the need for judiciary department support for the small criminal offenses; however it is the responsibility of the judiciary department to set charges indicated by the offense incurred. A ticketing system should also decrease the burden of administrative time for the wardens, allowing them to focus on more serious crimes.

2) Educate the Judiciary

The judiciary plays a key role in making fisheries enforcement effective. In many cases it is up to them to create the deterrence. The fisheries wardens rely on positive outcomes for change as a result of convictions served. It is believed that effective enforcement and increased convictions would not only improve division moral, but also affect individual attitudes towards fisheries authorities and the need of additional support for wardens to perform effectively. In order to accomplish this, the judiciary department needs to be aware and better understand fisheries legislation.

There is also a belief that the judicial department can be of greater support when the needs of the Fisheries Department are met. To initiate progress for the Division, a needs assessment based on current status of the department is imperative. An accurate complication of data can be used to assist in providing a report that better explains the need for additional support as well as highlight the importance of role responsibilities of fisheries wardens.

The wardens can help achieve this step by preparing a report for the judiciary department, that effectively explains the purpose of fisheries legislations, along with examples suitable penalties for certain fisheries offenses. For a more direct approach the Division of Fisheries could organize a workshop for the judiciary, as an effective strategy in delivering knowledge and awareness about the Division as it relates to legislation and enforcement.

3) Improve Relationships with the Public

The public needs to better understand the role of the Division of Fisheries and to understand the current and ongoing concerns of the need for legislation and marine protection.

Many agree that the fisheries wardens need to improve relationships with the public as a means for better communication and outcomes, in spite of limited resources. Research shows that relationships improve with better lines of communication (Atom Content Marketing, 2013). Improved lines of communication and accepting a sense of responsibility is shown to lead to better relationships. Currently there are only five fisheries wardens responsible to enforce regulations (one head warden and four wardens)(Bermuda Government Department of Environmental Protection, 2009). This factor is taken into consideration when the burden is overwhelming and the morale is low, it has already been shown how it affects relationships with the public and impacted negative outcomes.

In an age of exploding technology, the Internet has shown to be an extremely powerful learning tool. There fore, a website for the Division of Fisheries is excellent example of providing information. To date, the literature shows no up-to-date information regarding Bermuda's marine protected areas. The Department of Environmental Protection is a branch of the Bermuda Government responsible for protecting Bermuda's environment, and the Division of Fisheries falls under and is accountable to this agency (Bermuda

Government Department of Environmental Protection, 2009). However, the Environmental protection provides their own website, which currently has no information on the Division of Fisheries. Hence we see an urgent need for the Division of Fisheries to introduce their own website.

Suggestions for creating a Bermuda Fisheries Division website may include the following with downloadable features;

- Email address with telephone numbers to improve communication
- A Q/A section for queries, comments or complaints to avoid an influx of calls with limited manpower
- Up to date map of all of the marine protected areas; with the opening and closed dates
- Examples, descriptions and updated information on local species and protected marine life
- Updated regulations on size of catch and bag limits.

It is highly recommended that the Division of Fisheries produce annual reports to highlight vision, goals objectives and mission. The report should also show activities within the division regarding marine conservation, protecting local species and enforcement of fisheries legislation. Activities may be represented using tables and graphs that tracks progress including numbers of offenses and those prosecuted as well as highlight the need for financial support etc.

Another suggestion for the Division is to create a Facebook and Twitter page. These tools could be implemented immediately and is cost free. This may increase awareness and rebrand Bermuda's Fisheries Division, which is already in need of an overhaul to change public perception of their role. Facebook and Twitter are avenues where the Division of Fisheries can post its current activities, pictures of marine life, information on protected species and maps of patrol areas, It can also become a tool for case reporting, comments and posting open and close dates for protected areas as well as legislative updates and warnings.

Research has show that law enforcement agencies around the world are realizing the benefits to using social media as a law enforcement tool (Stuart, 2013). Many authorities have discovered that social media assists with criminal investigations, public relations and public awareness. For example relying on social media helps to maintain ongoing dialog with the community they serve. Where as in the past communication was limited to face-to-face encounters or over the telephone.

4) Educate the Public

A priority for the Division of Fisheries is public awareness in the quest to enforce rules and regulations unique to protecting the marine ecosystem. Studies have already shown the effectiveness of various avenues and strategies to improving public awareness and education.

Some recommendations are:

- Radio talk shows and public service announcements (PSA)
- Division of Fisheries website
- Facebook group
- Twitter page
- Conduct lectures to various groups including schools
- Town meetings
- Displaying banners and targeting morning commuters
- Provide in-services to other governmental departments

5) License Recreational Fishermen

A main goal of the Division of Fisheries is to license recreational fishermen as a strategy to collecting information on the Division's effective management of current resources. It is believed that the recreational fishermen are important stakeholders with a vast amount of data that may assist in identifying needs and strategies to aid the Division. This strategy would be a mandatory where the fishermen would be required to provide numbers and description of their catches. Once the data is collected and analyzed, the Division can be better equipped to make more informed decisions in operations and sustainability and be able to answer the following questions:

- What are the numbers of vessels that make up the recreational fishermen group?

- What species of fish or marine life are being targeted at a given time?
- What are the numbers of species being caught?
- How many fishing tournaments are being held a year?

In conclusion, it is believed that the newly collected data would be of a great benefit to the Division of Fisheries for understanding how individual or collective actions, measure the outcomes for a sustainable fishery to exist.

6) Reorganized Fisheries Warden's Patrols

A reorganization of the warden's roles and responsibilities with change in the division function and direction may not only promote leadership and accountability but may also lead to better outcomes.

Currently wardens re considered civil servants who work a 35-hour week. For starters, it would be beneficial for the Division organizational chart to be evaluated where the manager; also the head fisheries warden, focuses on appropriately assigned administrative duties while the remaining wardens focus on their roles. A clear organizational chart with duties and responsibilities outlined can help to maximize detection and minimize overall cost. Since many fishermen return to public docks and hot spots to fillet their fish and clean their boats, this can present as an ideal time for wardens to intercept them and inspect

their catches. It would be an ideal opportunity to maintain visibility to the public but to also:

- Collect data
- Document numbers and identify catches
- Improve public awareness
- Offer warnings and citations are required

Effective and safe ocean patrols require a minimum of three people. It has also been shown that patrols must focus on obtaining results versus what appears to some as just 'cruising' around the island. One suggestion is to limit patrols to nighttime schedules that focus on fishing hotspots and protected areas of interest. A reorganization of the Division with proper planning and scheduling may assist wardens in making appropriate use of patrols that focus on areas of interest.

7) Revolutionize Leadership

Review of the literature shows that Bermuda's Division of Fisheries must become a leader within its own boarders, before it can become a world leader and a benchmark in sustaining a healthy marine ecosystem and lucrative fisheries industry. Considering the low staffing levels, workload with responsibility, and scope of accountability in addition to a low morale as well as perceived laxity in execution of the leadership role, change is imperative. Review of this paper shows a need for proper direction, purpose accountability, effective

leadership and improved methods for collecting data and enforcing rules and regulations of the Division as a goal to turning things around.

Analysis of Table 14 on page 54; reveals a discouraging trend of missed opportunities in the category of enforcement. For a period of years there were many missed opportunities to collect important data and prosecute violators of fisheries rules and regulations. Further review on the lack of cases being prosecuted shows a correlation between low morale of the warden's and public criticism. It is believed that this factor alone has a direct impact on the public's perception of the fisheries wardens with a linear effect on the morale of the wardens.

In conclusion, the review shows a serious need to realize improvements for an effective efficient fisheries division is imperative in sustaining the marine ecosystem and the island's fisheries industry to become the global leader it once was.

Critical questions need to be answered, such as;

- How does the Division of Fisheries measure success? How can information be more readily available?
- What incentives will be used to encourage employees to perform to the best of their abilities?
- Can improving the quality of data collection with increased prosecution and fines support proposals for funding salary increases and increase supplies?

Enforcement with increased prosecutions is a must in order to adequately staff the division with additional wardens. As a strategy to recruitment and retention, incentives have show to be effective. Increasing the number of wardens to meet the demands is a strategy towards sustainability. Improvement in enforcement and increase in fines may also offset the need to increase salaries and recruit additional wardens.

The Division of Fisheries needs to become more aware of the needs outlined and actively motivated toward change and focus more on research studies and lobby for increased manpower. Develop recommendations and seek out the latest technological advances that offset archaic method for data collection and evaluation.

The United States Department of Justice (2003) explains that an active supervisor is a supervisor that believes in leading by example and works alongside patrol officers in the field and works as street officer if needed. The fisheries wardens desperately need this for several reasons. The literature reveals that when the head warden is active in the field, one or more person(s) is committed to be active elsewhere (The United States Department of Justice, 2003). Secondly with the head fishing warden spending a large portion of his time alongside the wardens may impact what is currently viewed as laxity. The head warden's presence may produce increased productivity with quality outcomes. Finally with the head fisheries warden taking the role of an active

supervisor creates accountability. With the head fisheries warden active in the field, he can have a clear understanding of how enforcement is being managed by his subordinates. The role of an active supervisor also allows for higher-level management holding the head fisheries wardens accountable for their actions and responsibilities. In the role of active supervision, the head warden exercises a higher-level management to model appropriate behaviors and enforce rules and regulations of the Division. This strategy should produce different results and open the door for policy change with improvement that meets the demands of the Division's mandates and quotas. If results do not occur from this strategy there may be further questions.

8) Monitor and Encourage Public Participation

As noted in the literature, it is essential that the fisheries wardens gain support of the public. Without the publics support the large amount of responsibilities become even more difficult to uphold. Coeffey (2005, pg28) defines public participation as "the process through which the public participates, influences, and shares control over decision making." The author argues that public participation is essential to the governance of any natural resource and concludes that public participation can occur at any level along the decision making process.

The author describes the stages of decision-making as the initial identification of needs for policy formulation, execution, monitoring,

enforcement, and final review (Coffey, 2005). He concludes that the public is influenced by the cost of participating weighed against the cost of not participating. The report reveals that smaller numbers of participants tend to show stronger participation than larger groups. In addition he adds that it is important to understand that those who are allowed to participate and the methods chosen for participating are clearly defined (Coffey, 2005).

One can surmise that public participation is important to the Division of Fisheries for three reasons. Firstly, consideration of public participation in the decision making process may produce quality outcomes. Coffey (2005) asserts that when the public engages in the decision-making, outcomes have shows favorable when values and ideas are taken into consideration. Public participation in the decision making process has also been found to improve quality outcomes by even reducing or eliminating imbalances of the political process (Coffey, 2005).

Secondly, the author describes how public participation can influence conflict resolution. He asserts, "it provides the opportunity to discuss, manage and even resolve differences in views and positions" (Coffey, 2005, p30). This concept is key to the resolution of the current problems with the Bermuda's Fisheries Division and the public.

Thirdly, there are immediate and serious reasons to engage the public. One urgent example is the well documented and publicized lionfish invasion of Bermuda's ecosystem and surrounding waters of the Caribbean. Currently there

are spear fishermen who volunteer their time to capturing them. Coffey (2005, p30) points out that public engagement is now being seen as " a basic human right, to be defended and strengthened for its own sake" and the lionfish invasion is an extreme example.

Coffey (2005) concludes that there are three levels of public participation. The first level is weak participation, which is seen as just delivering a simple message. The second level is medium. This level of participation deals with more complex issues compared to weak participation. The final level is strong. Strong participation involves strong communication and co – management.

Gray (2005) also believes that participation is important to fisheries governance. He sates that "participation leads to more efficient and effective policies because people who are subjected to regulations know which policies work, and which do not work" (Gray, 2005, p344).

Public participation is important to the growth of Bermuda's Fisheries Division. The public is subjected to the regulations. They know which policies work and which do not. They have first hand knowledge as to what is effective and efficient. When the public is allowed to participate in policies the results showed that the policies were fairer. When groups feel that they are allowed to voice their concerns and their voices are being heard it has been found that there is a higher rate of compliance with the rules. This is believed to be the case because the public feels they can accept the rules that they participated in creating. Stakeholder involvement in the planning and implementation of

decisions is necessary in fisheries management. The fishery is the community's resource participation needs to be allowed and encouraged (Gray, 2005).

9.0 Conclusion

Bermuda is a small isolated island in the Atlantic Ocean. It is surrounded by a vast marine ecosystem that is extremely valuable to its inhabitants. A lot of issues regarding Bermuda's fishery past and present have been highlighted in this paper however what about the future? Coral Reef ecosystems around the world are dying. In 2011 it was estimated that seventy-five percent of the worlds coral reefs where in danger of dying. Now in 2012 the Caribbean's coral reefs are collapsing, over ninety percent of the coral reefs in the region dead (The Guardian, 2012).

Bermuda's Division of Fishery is facing a difficult task, regulating the current fishery with limited resources and minimal public support. While trying to control the impact humans have on the fishery a new challenge has presented itself. The lionfish invasion has been having a devastating affect on the Atlantic ecosystem. Bermuda's Division of Fisheries needs to make some crucial adjustments and additions.

Rebranding of the division should be the main goal. Evidence presented in previous sections with regards to laxity on the wardens part and severe reduction in the number of cases going to court makes the situation seem dire. The public is not going to continue to accept excuses like low manpower and

limited resources. In order to improve relations with the public dialog must be established and maintained.

This can be done relatively cost effective through the use of a website and social media tools like Facebook and Twitter. The dialog must be constant if change is going to occur and relations are to improve. Everything that the Division of Fisheries is doing must be communicated directly to the public in real time. However it can't be just anything that is communicated to the public. The Division of Fisheries has to be careful with what it communicates to the public. Statements like having a good day or comments about the weather would only make the situation worse. They must communicate their actions, like they would write in a daybook detailing what the wardens accomplished that day. These actions will help the dialog evolve. The public is either going to respond either positively or negatively, however it is from these responses that adjustments can be made to improve the relationship with the public.

Bermuda's Division of Fisheries needs to continue to set the bar with regards to containing the lionfish invasion. Bermuda is the benchmark for health in the Atlantic, much can be learned from this unique location. The lionfish invasion is one topic that must continue to be explained to the public. The seriousness of the situation they have created must be communicated. The lionfish invasion creates a problem that affects different groups, which should bring the community together under one banner.

Bermuda's Division of Fisheries is in a good position for the future because they know what their present weaknesses are. They need to make the correct decisions now before the situation deteriorates. However positive change cannot occur under the current situations. Communication, education, transparency and accountability must be developed and nurtured under strong aggressive leadership.

Amidst the global recession, recommendations put forth seem to focus on low budget ideas and reorganizing current available resources, in hopes of meeting current needs facing the Division of Fisheries. The goal is to position management strategically to lobby for additional resources that allow the division to function effectively and efficiently in future.

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