AN ASSESSMENT OF THE QUEEN CONCH (STROMBUS GIGAS) STOCK STATUS OF THE TURKS BANK AND THE FEASIBILITY OF EXPANDING THE FISHERY AS AN EXPORT INDUSTRY FOR THE TURKS AND CAICOS ISLANDS

A Thesis

Submitted in Partial Fulfilment of the Requirement

for the Degree of **Master of Science**

(Natural Resource Management; Biological

Approaches to Ecosystem Management) of

The University of the West Indies
Wesley Vincent Clerveaux 2003

Department of Life Sciences
Faculty of Pure and Applied Science
Mona Campus
Jamaica, W.I

ABSTRACT

An Assessment of the Queen Conch (*Strombus gigas*) Stock Status of the Turks Bank and the Feasibility of Expanding the Fishery as an Export Industry for the Turks and Caicos Islands

Wesley Vincent Clerveaux

Queen conch is the second most important export resource in the Turks and Caicos Islands, with an ex-vessel value of more than U.S. 1.5 million dollars and a market value of more than U.S. 3.2 million dollars at a current annual export level of approximately 720,000 kg.

Despite the economic value of queen conch, large scale commercial exploitation of this product has transpired almost exclusively on the Caicos Bank, while the Turks Bank has remained relatively underexploited. Less than 15 registered fishers operate full time on the Turks Bank, providing products to local restaurants and subsistence use.

The Turk Bank is situated to the east of the Caicos Bank, separated by a deep water passage. The partial isolation of the queen conch stocks on the Turks Bank, suggests the need for a management plan which is independent of that for the Caicos Banks, guided by an independent assessment of the stock status on the Turks Bank.

Nevertheless, it is the objective of the Government of the Turks and Caicos Islands to expand the queen conch fishery of the Turks Bank, to facilitate the export markets of the United States and possibly Europe.

This study was geared primarily at determining the potential exploitable yield of queen conch on the Turks Bank which can be harvested without adversely affecting the stock. A secondary aim of this study was to assess the potential biological, economic and social impacts (if any) on the resource and resource users by the introduction of an ‘A Class’ fish processing facility to the island of Grand Turk, which would principally cater for the export markets.

The results from a visual abundance survey generated several potential yield estimates, however, this study recommend that the most conservative estimate of 9.46 MT of conch be used in setting the harvesting limit for the queen conch fishery of the Turks Bank.

Additionally, the study also indicate that the introduction of an ‘A Class’ processing plant can have some positive as well as some negative impact on the resources and resource users of the Turks Islands. Most importantly, the conch resource of the Turks Bank is not sufficient to support, the resident population, the visiting tourist population as well as accommodate the export market.

ACKNOWLEDGEMENT

This thesis was largely funded by the Government of the Turks and Caicos Islands, and I would like to express my thanks for giving me such a great opportunity. I would also like to extend my sincerest gratitude to the following individuals who have contributed immensely throughout the course of this study.

Many thanks to Dwaine Cox, my comrade, the staff of D.E.C.R. for their technical as well as field assistance in conducting this project.

Thanks to Dr. Peter Vogel, my project supervisor for all the assistance and critical analysis of this paper.

Thanks to Mr. Karl Aiken, Dr. Paul Medley, Ms. Kerry-Ann Curtis, and Dr. Balfour Spence for their inputs, patience and understanding.

Special thanks to a dear friend, Ms. Tatum Fisher, your invaluable assistance cannot be expressed in word.

And to my family, you have been the rock from which I have laid my foundation. Thanks for being such a strong support.

DEDICATION

This thesis is dedicated to my mother and father, who always remind me that education can open many doors.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Historical Exploitation Pattern of the Queen Conch Fishery of the Turks and Caicos Islands.

The queen conch (Strombus gigas) is a very important resource and has become an integral part of life to the people of the Turks and Caicos Islands. For generations the indigenous Lucayan Indians have fished conch as a subsistence-level food, even before the arrival of Columbus. Today it remains an important source of protein in the Islands, second only to finfish as a staple food even while high imports to the United States have been sustained since the mid-1960.

With the development of the trading sloops in the late 1800's, and the strengthening of the trade ties with the Republic of Haiti, millions of conchs were dried (appendix I. figure a) and shipped to Haiti where they were bartered for fresh fruits and rum. Today exports to the United States are set at the Total Allowable Catch (TAC) of 720,000 kg with a market value of more than 3.2 million U.S. dollars.

The value of the conch fishery is multiplied several fold by considering the industry as an extraction process (although renewable) that creates new wealth (Appeldoorn, 1997), due to job creation in the processing and marketing of conch meat, particularly through the tourist and restaurant trade.

Commercial fishing is historically based on Caicos Bank, the largest of the three areas of shallow water banks, while a small number of vessels periodically engage in subsistence level artisanal fishing in the Turks Bank, providing products for local consumption for the neighbouring islands of Grand Turk and Salt Cay. On the other hand, very little attention has been placed on the Mouchior Bank because of its distance from fish landing sites.

Patterns of local consumption in the Turks Islands is unknown, in comparison to other islands of the Turks and Caicos archipelago such as South Caicos and Providenciales where the bulk of the fishers are registered complemented with existence of three (3) fish processing plants on each island.

There are approximately, nine (9) licensed restaurants and seven (7) cafés, and/or saloon ("bar rooms") on the Turks Islands which offer marine products on their menu. The demands for marine products, in particularly queen conch are not high or constant. Hence, fishers operate on a demand basis, electing to fish only the requested quantity and species to supply their specific clienteles. However, with the increases in tourist arrivals and the development of the Island of Grand Turk, local consumption of queen conch is expected to increase.

Effective management of the queen conch stock of the Turks Bank has been impeded due to a lack of reliable information about the status of the resource, resulting in an inability to establish management guidelines and subsequently enforce regulations for the conservation of the queen conch stock.

The likely success of a management plan for the effective and optimal utilisation of queen conch will be directly related to how much is known about the resource and its dynamics, taking into consideration social and economic externalities associated with the fishery (Chakalall & Cochrane, 1997).

1.2 Government Objectives for the Fishery of the Turks Bank

The main management objectives of the Government of the Turks and Caicos Islands are therefore twofold;

1. To assess the stock / biomass status of the queen conch fishery of the Turks Bank and determine harvesting threshold such as the Maximum Sustainable Yield (MSY) level that can be used as a guideline for the management of the Turks Bank queen conch fishery.

2. To examine the feasibility of expanding the fishery (into an export industry by the establishment of a 'Class A' fish processing plant in the island of Grand Turk) to facilitate optimal utilisation of the resource within the boundaries of a preset sustainable target reference point.

3. To assess the potential economic and social impact that optimal exploitation of queen conch in the Turks Bank might pose on the ancillary industries, such as the restaurant / fish market, local consumption.

1.3 Aim of the Research

This research aims to assess the queen conch stock status on the Turks Bank and generate sustainable yield estimates to be used as guidelines for the management and exploitation of the resource.

A secondary aim of this research is to determine the potential impact of developing the fishery, and to suggest guidelines to be implemented by the Government of the Turks and Caicos Islands in order to ensure sustainability of the resource.

1.4 Site description

The Turks and Caicos Islands are a group of calcareous islands located at the southern end of the Bahamian archipelago in the Atlantic Ocean bisected by three shallow water banks: the Caicos Bank, the Turks Bank and the Mouchoir Bank (Figure 1). The Turks Bank is situated approximately 35.5 km east of the Caicos Bank. It is separated from the Caicos Bank by a deep-water passage known as the Turks Island Passage ranging in depth from 1500-2000 m in some areas.

The Turks Bank has a total area of approximately 698 km2, encompassing two major islands (Grand Turk and Salt Cay) and a series of eight (8) small uninhabited islets. There are two marine protected areas systems; the Grand Turk Land and Sea National Park, which is an area of 1.56 km2, south-east of the Island of Grand Turk encompassing the cays and the surrounding 120 m of waters. Columbus Landfall Marine National Park spans the entire western coast of Grand Turk, encompassing an area of approximately 5.16 km2 (the area of sea from the high water mark to the reef wall).

Depth contours on the Turks Bank ranges from less than 1 m in the shallow coastal areas, to just over 20 m at the deepest point, before abruptly descending to a depth of more than 1500 m at the reef wall of the Turks Island Passage. The average depth for the Turks Banks however, is approximately 15 m.

The periphery of the bank is lined with large boulders and fast growing branching corals making up the fringing reef system, while patch reefs are scattered throughout the bank. The habitat of the Turks Bank is predominantly sandy to coarse gravel with a few patches of seagrass and algae encrusted coral rubble plains.

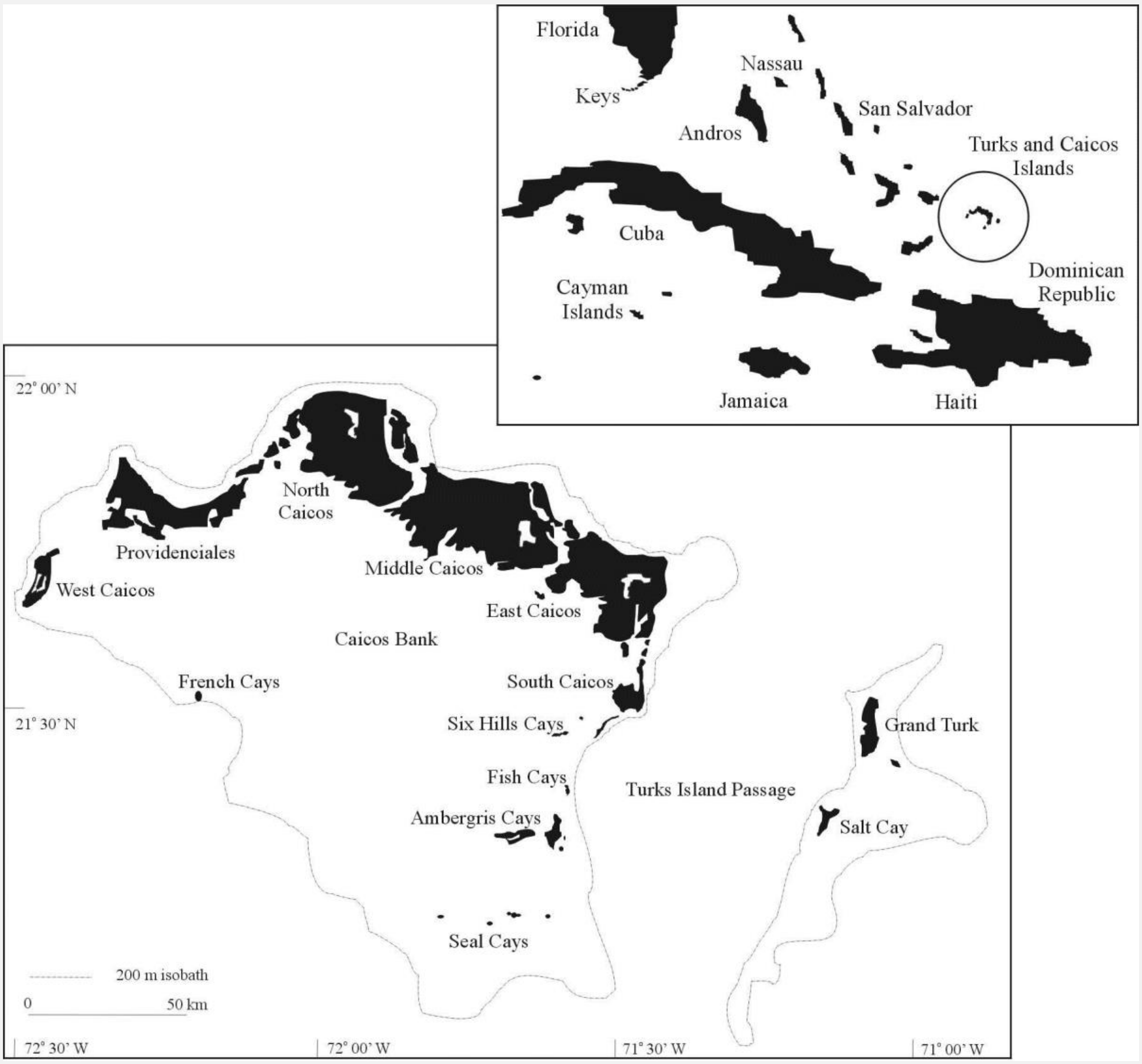


Figure 1 General Location of the Turks and Caicos Islands in the Caribbean region highlighting the fishing banks (Caicos and Turks banks) important for commercial fishing of queen conch (Strombus gigas).

Queen conchs are normally found inhabiting seagrass flats and sandy bottoms that are stable enough to support the growth of algae upon which they feed (Brownell and Stevely, 1981). They are sedentary organisms (as described by Randall (1964), D'Asaro (1965), Little (1965), Robertson (1959), Alcolado (1976), Appeldoorn (1994)) with a peculiar mode of locomotion of thrusting the heavy mantel shell forward in a motion regarded as leaping. The 1982 United Nations Convention on the Law of the Sea (Part VI: Continental Shelf) in article 77 (4) describes a sedentary organism as a species which at the harvestable stage, is either immobile on or under the seabed or is unable to move except in constant physical contact with the seabed of the subsoil.

The Turks Islands Passage creates a natural barrier to active migration between the Turks Bank, the Caicos Bank or the Mouchoir Bank, thereby isolating the stocks of the Turks Bank. However, the life history of conch provides for an extensive period of larval dispersal during which time larvae may be carried significant distances via ocean currents (Berg et al., 1986; Mitton et al., 1989; Campton et al., 1992; Tewfik, 1997). Therefore, it cannot presumed that the populations are completely isolated, with no gene flow between the stocks of the Turks and that of neighbouring stocks.

However, there is no evidence, thus far, of direct dependency or linkages to neighbouring banks such as the Caicos Bank. The separation of the queen conch stocks on the Turks Banks suggests that management plans developed for the Caicos Bank may not be applicable or appropriate to the Turks Bank. Such a management plan for example, may fail to take into account an increase in effort (caused by increased in fishers) on the Turks Bank, which may lead to overexploitation of the limited stock.

It seems then, that the management of the queen conch stock of the Turks Bank should be independent of the Caicos Bank, with objectives and management goals based on unique scientific findings relating to each individual stock.

1.5 Sociological Description of the Fishery.

The islands of Grand Turk and Salt Cay are two of the smaller inhabited islands of the Turks and Caicos archipelago with an approximate area of 20.4 and 7.84 km^2, respectively. According to the 1990 Census of Housing and Population, the Turks and Caicos Islands had a total resident population of 12,350 individuals, of which Grand Turk accounted for 30.5% (3,705 people) and Salt Cay 1.7 % (185 people) of the population.

In 1990 over 71,000 tourists visited the Turks and Caicos Islands, of which 7.1% (5,041 people) were reported to have visited the Islands of Grand Turk and Salt Cay. Since then, the numbers of tourist visiting the islands have increased tremendously to approximately 174,474 tourists in 2001. Similarly, the resident population for the entire country for that same year has more than doubled to approximately 20,164 individuals, although the population in the Turks Islands remain relatively stable, with Grand Turk accounting for only 3,975 individuals in 2001.

(a)

(b)

Figure 2 Aerial photograph of the island of Grand Turk (a) and Salt (b), the two inhabited islands of the Turks Island archipelago, of the Turks and Caicos Islands. The islands are sparsely populated, somewhat in a state of underdevelopment experiencing very li

However, with the development of a Cruise Ship Industry on the Island of Grand Turk since November 2002, the number of visitors to the Island of Grand Turk is believed to have increased several fold, with nearly 30,000 individuals visiting thus far from the Cruise Ships.

The main sectors of employment on the Islands (Grand Turk and Salt Cay) are in Government Civil Service, with a handful of individuals in the service industry, such as restaurant, hotels and bars. Far less individuals are employed in the fishing industry, including only 32 registered fishers (Figure 3) that supply marine products to the hotels and restaurants by demand with the surplus in products sold directly to residents.

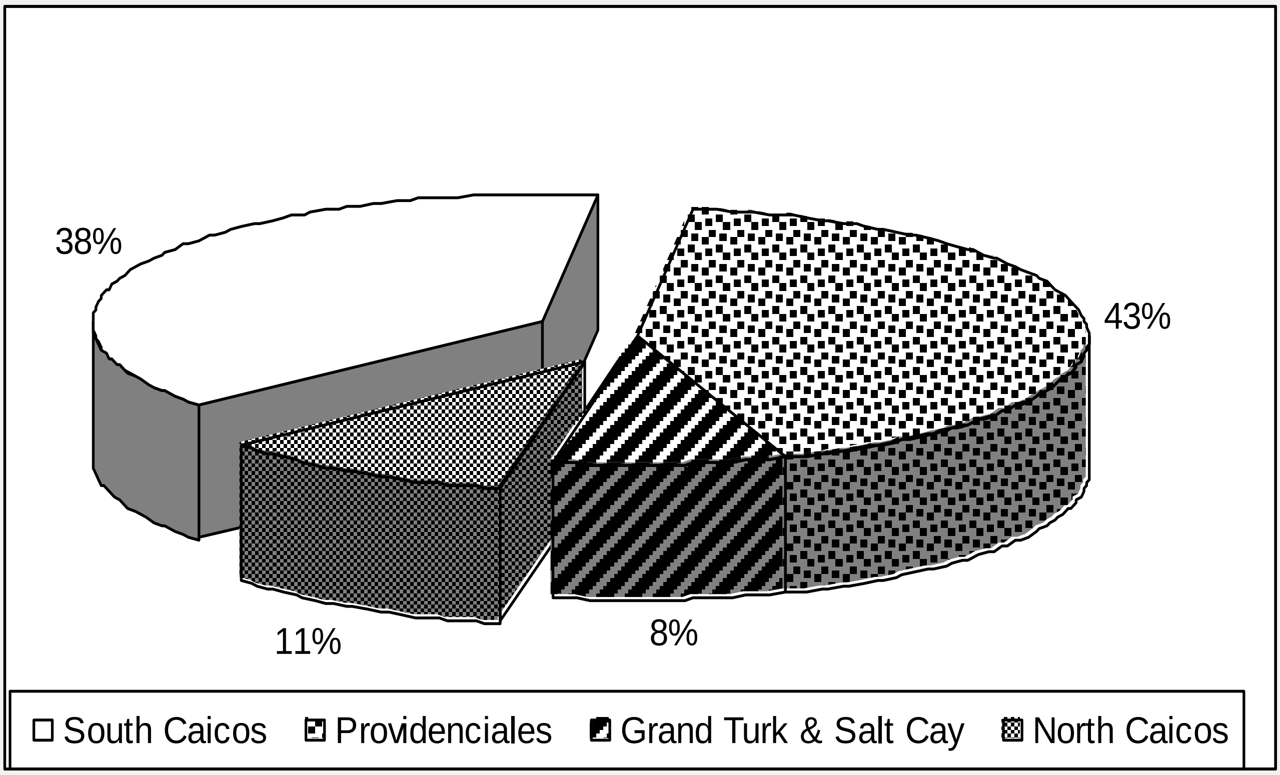


Figure 3Mean number of registered fishers (1999-2001) categorised by the four main islands important for fishing in the Turks and Caicos Islands. Only 8% of registered fishers are based from the Islands of Grand Turk and Salt Cay, and as such fish on the Turks B

2.0
PROJECT BACKGROUND

2.1 Development Stages of a Fishery

Many authors have described the developmental process of fisheries as sequentially following a string of four phases; underdeveloped, developing, mature and senescent (Caddy et al, 1983; Caddy, 1984; Welcomme, 1995; FAO 1996) (Figure 4).

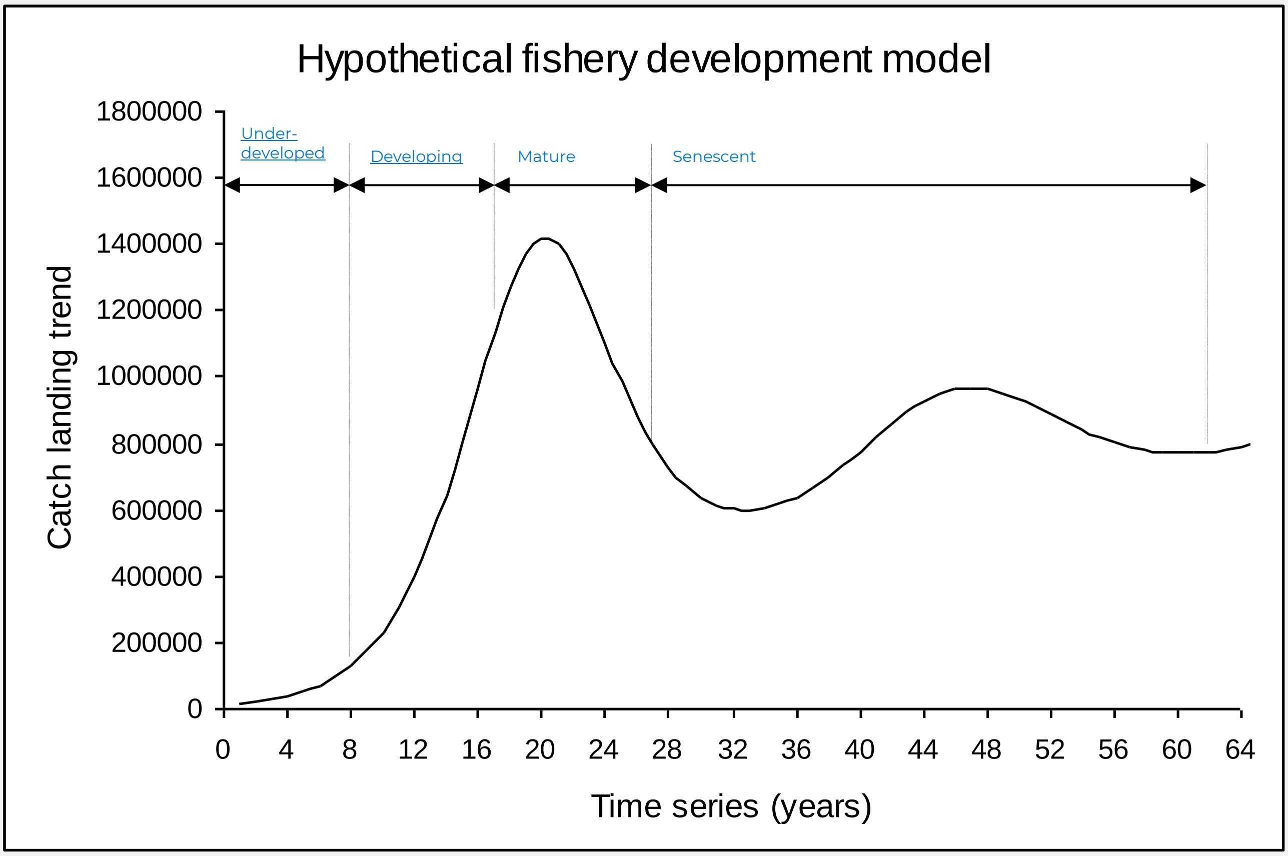


Figure 4 A generalised fishery model highlighting the four phases of development in a hypothetical fishery; underdeveloped, growth or developing, maturity follows by senescent.

The first phase in which the fishery is underdeveloped, is also known as the 'initiation phase through exploratory activity' (Bènè and Tewfik, 2001) whereby the resource users explore catching techniques as well as market niches. This is followed by the growth or developing phase. The realization of the economic potential of the fishery rapidly attracts new fishers into the fishery, and leads to the growth of the industry.

The third phase in the development of a fishery is known as the mature phase. This phase is apparent when catch landings have reached a plateau, and any additional increase in effort to the fishery does not necessarily produce an increase in landings. Commonly, this is followed by decrease in catch landings and reduction in the return on the fishers' financial investment. This trend continues to a point where it is economically unattractive to continue fishing, and forces many fishers to recede from the fishery (Clerveaux and Vaughn, 2001).

With the exodus of many fishers out of the fishery, less pressure is exerted on the stock, thereby allowing the stock to rebound. This is described as the fourth phase of the fishery model; the senescent phase, in which catches fluctuates at a lower level. However, many fisheries do not have the chance to rebound, but instead succumb to a level of overexploitation from which it is difficult to recover and ultimately the stock is considered to have collapsed.

2.2 Introduction to Overfishing and its Definition

T.H. Huxley in his address to the International Fisheries Exhibition, in London England in 1883 stated in King (1995) that he believed,

> 'that the cod fishery, the herring fishery, pilchard fishery, the mackerel fishery, and probably all the great sea fisheries are inexhaustible: that is to say that nothing we do seriously affects the numbers of fish. And any attempt to regulate these fisheries seems consequently from the nature of the case to be useless'.

Huxley, like many other believers of similar principles, was mistaken. Most of the world's most important fish stocks have been fished to the limit of sustainability and beyond, into decline, and several have collapsed altogether (Nixon, 1997).

Overfishing is not a recent issue, but has been recognized internationally since the early 1890s in the North Atlantic and the Pacific Fisheries, and was the subject of the London Conference on Overfishing in 1946. (Major Issues in World Fisheries, FAO 1997)

The definition of overfishing is variable and can be described in terms of pre-defined criteria or proxies, such as fishing mortality, stock biomass or Maximum Sustainable Yield (MSY) estimates. As such, a stock may be considered overfished if the biomass is below a specified limit or fishing mortality rate is above a prescribe threshold (NMFS, 2001)

Overexploitation of commercially important marine species has become prevalent in most fishing areas, both in developing and developed countries. Overfishing has become particularly severe in densely populated coastal regions and in productive offshore areas (Major Issues in World Fisheries, FAO, 1997). So much so, that many authors have predicted that, by the end of the 20th Century, many of the world's largest commercial fisheries will be seriously overfished and possibly collapse (Roughgarden and Smith, 1996; Cook et al. 1997; Lauck et al. 1998; Post et al. 2002).

2.3 The International Crisis of Overexploitation / Overfishing

Commercially exploited marine species are generally in an advanced state of exploitation (FAO, 1996). Very few commercially important stocks are still considered to be in a good condition, and will require better management to meet future demand.

The Food and Agricultural Organization (FAO) of the United Nations using a robust model and landings data from the world's conventional marine resources under current exploitation regimes, showed in 1996 that about 35% of the 200 major fishery resources were in a state of senescence (i.e. showing declining yields or in a state of overexploitation), while about 25% were mature (i.e. reaching a plateau at high-exploitation levels), 40 percent were still developing and none was at a low-exploitation level (underdeveloped).

The FAO (1996) report went on to explain that the annual relative rate of increase of world reported landings had significantly decreased since 1950, approaching zero. A host of economically important pelagic and demersal species from the Sea of Japan are in a state of overexploitation, with catches decreasing from 2.1 million tonnes in 1970 to 0.9 million tonnes in 1993, almost 60% decrease in catch levels. Similarly, the demersal stocks of the Mediterranean Sea, are considered to be fully exploited or overexploited in most cases (FAO, 1996).

Sixteen percent (16%) of the major commercially important marine stocks of the United States are threatened to become overfished. Another twenty percent is already overfished. (NMFS, 2001)

In the southwest and northwest Atlantic (Latin America and the Caribbean), up until the 1980's the fishery was considered to be underexploited with prospects for expansion (FAO, 1996). However, with the introduction of large fishing fleets and the industrialization of the fishery, most of the fish stocks are now considered to be fully or overexploited, including the queen conch fishery (FAO, 1996).

2.4 Queen conch Biology and Geographic Distribution

Strombus gigas is a large marine gastropod mollusc of the order Mesogastropoda, commonly called queen conch and was first described by Linnaeus, 1758, (Randall, 1964). The family Strombidae occurs in warm waters throughout the world, however, only six species of the family Strombidae (Strombids or conchs) are fully recognized in the western north Atlantic: S. raninus, S. gigas, S. gallus, S. pugilis, S. costatus, S. goliath (Randall, 1964; Tewfix, 1996). Other forms of S. gigas have been recognized but their taxonomic status is not certain, for example S. g. samba (Dodge, 1956; Clench and Abbott, 1941; Randall; 1964; Darcy, 1981; Theile, 2001).

The shell of the queen conch has a relatively long and narrow aperture, which is oblique with a slight developed stromboid notch near the base of the outer lip. The outer lip is large and flaring, with the upper end of the lip being broad and raised, but usually no higher than the spire (Clench and Abbott, 1941). The outer shell is roughly sculptured and generally tan in colour, while the interior of the aperture is suffused with a pink colour (Clench and Abbott, 1941; Tewfik, 1997).

Considerable knowledge on the basic biology, movement, growth, distribution, natural mortality, reproduction and stock status of Strombus gigas has been amassed throughout its spatial range. Its geographical distribution extends from Bermuda, the Bahamas, southern Florida, southern Gulf of Mexico, and the entire Caribbean basin and into northern coast of South America, as far south as Brazil (see Appendix III, figures a-d) (Clench and Abbott, 1941; Randall, 1964; Cresswell and Davis, 1991; Tewfik, 1996).

Queen conchs are described as having two distinct phases within their life history; the planktonic followed by the benthic phase. Approximately three to five days after spawning, they hatch as planktonic veliger larvae which can be carried significant distances in the initial weeks of life, depending on ocean currents and water circulation.

By the third to fourth week, the veligers settle out of the water column and metamorphose into a juvenile queen conch. They then develop a small white shell about 2mm long (Berg et al., 1986; Mitton et al., 1989; Stoner et al., 1992; Tewfik, 1997; Theile, 2001). Queen conch movement and migration after they have metamorphosed into a benthic dwelling organism is relatively limited.

2.5 Status of the Queen Conch Stocks; Threat to Overexploitation and CITES.

The Queen conch fishery has a long tradition in the region dating back to pre-Columbian times (Sadler, 1997; Clerveaux and Danylchuck, 2001; Theile, 2001). The fishery is considered as one of the most important fishery resources in the Caribbean, being surpassed in value only by the Spiny Lobster fishery (Panulirus argus) in terms of economic worth and by the fin-fish as a protein supplement (Brownell and Stevely, 1981).

Despite the long historical use of conch as a dietary supplement, the earliest records of commercial harvest and inter-island trade are only available from 1887, when dried conch meat from the Turks and Caicos Islands was bartered in Haiti for fresh fruits and rum (Doran, 1958; Hesse and Hesse, 1976; Ninnes, 1994; Bènè and Tewfik, 2001, Clerveaux and Danylchuck, 2001).

With advances in freezer technology and a shift to trade in frozen meat, Appeldoorn (1994) noted that the queen conch fishery has grown considerably within the past 20 years, fueled by the increasing demand to satisfy export markets and to a lesser extent, the local tourist industry of individual states. Today, over-harvesting to meet these demands is considered to be the major cause of decline in stocks that are reported by numerous countries throughout the region (Theile, 2001).

Once abundant throughout the Caribbean, the marine gastropod (queen conch) have been fished to such low levels in many countries that a viable fishery no longer exists in many of these locations (see Appendix III, figures a & b) (Brownell and Stevely, 1981; Appeldoorn, 1991 and 1992).

Queen conch population densities in the Caribbean vary from areas that were severely over-exploited in the past and show little signs of recovery, to a few areas where the overall populations may still be considered stable (Theile, 2001). For example, Mulliken (1996) reported that with the exception of St. Lucia, all queen conch populations in the Lesser Antilles are considered as having been overfished (see Appendix III, figure c).

Correspondingly, localised coastal stock in some areas of South and Central America, such as Belize, Columbia (Berg, 1987; Appeldoorn, 1994; Mora, 1994) and Venezuela (Mulliken, 1996) are considered overfished, and in other areas populations are showing signs of decline, for example in Mexico (Rodriguez Gil, 1994; and Mulliken, 1996) and Costa Rica (see Appendix III, figure b).

In March 1992, queen conch was listed in Appendix II of the Convention on International Trade of Endangered Species (CITES) in response to stock collapses and fishery closures in several areas throughout its' range (Mulliken 1996). Appendix II listed species are not threatened with extinction, but may become so unless trade of such species is subjected to strict regulation to avoid utilization that is incompatible with their survival (Appleddorn, 1992). Trade in a listed species is allowed only under permit, and only if such export will not threaten its survival. As such under the CITES agreement, signatory nations and countries that export queen conch to signatory nations, must report all international exports of queen conch and implement a management plan to avoid over-harvesting (Clerveaux and Danylchuk, 2001; Theile, 2001).

Other regulations that may affect the international trade of queen conch include the protocol of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region under Appendix III of the Specially Protected Areas and Wildlife (SPAW). Species in Appendix III are considered in need of management for sustainable use, and member nations are obligated to enact such management (Theile, 2001).

2.6 Management Strategies Implemented Throughout the Region

In an effort to confer some protection and in an attempt to prevent further declines of already overexploited queen conch stocks, most queen conch range States have adopted some form of management strategy (see Appendix III, figure d) to ensure a sustainable fishery within their Exclusive Economic Zone (EEZ) (Theile, 2001).

Management strategies range from input controls (regulate fishing effort) to output controls which regulates extraction of the resource, some of these include;.

a) Input controls

i. Close areas and seasons

Fishing activity can be effectively controlled via closure of the fishery, either by spatial closure (closing particular areas) or by temporal closure (closing the fishery for an established period). Closures are often implemented to either directly protect a portion of the stock (usually juveniles or the breeding adults) or the species' habitat).

In theory, close areas function by prohibiting commercial and/or subsistence harvesting in specific areas. Such protected areas allow the undisturbed aggregation of parental stock which would facilitate higher fertilisation success. This is believed to result in increased recruitment and dispersal to surrounding unprotected areas (King, 1995). Thus, for closed areas to be effective, critical spawning sites and nursery grounds have to be identified and protected from exploitation.

In the case of the queen conch Fishery, closed areas could also include important deep-water refugia where older conches are protected from being harvested even within open fishing season.

Another approach is to use close season which is implemented to ensure longevity of stock, by protecting the breeding population. During the spawning season queen conchs are known to migrate to shallow waters where they can be found in large aggregations. Seasonal closures are therefore designed to ensure a biological significant portion of the breeding population as well as the migratory corridors to spawning sites remain unfished, and therefore cover three to four months of the most important reproduction period (Theile, 2001).

Seasonal closures have been established in several range States, however, they are not yet harmonised at the regional or sub-regional levels (Theile, 2001). At the same time, there are several countries that have not yet instituted a closed season (e.g. Antigua and Barbuda, British Virgin Islands, Grenada, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines) for the queen conch fishery.

Alternatively, in some instances (usually when the fishery is severely over-fished) States have elected to close the fishery for an extended period. For example, in Bermuda and Florida there is an imposed moratorium of the queen conch fishery within their coastal waters. Similarly, the fishery off St. Thomas and St. John in the U.S. Virgin Islands has been closed for 5 years, likewise over varying periods in Bonaire, Cuba (Berg and Olsen, 1989) and Venezuela.

ii. Gear restriction

Gear restrictions can be placed on type, size and number of gear utilised in harvesting. Some gears are very effective or highly efficient, thereby permitting fishers to capture a large portion of the stock within a short time period or with very little effort.

Today, the modern techniques being used in the queen conch fishery (such as free-diving, SCUBA and hookah) have greatly impacted the fishery by increasing the catch rate. For example, the shift from hooking conch from the vessel using an 8 m pole (Berg et al., 1989; Doran, 1958; Clerveaux and Danylchuck, 2001) to free-diving has significantly increased the efficiency of the fishers of the Turks and Caicos Islands. The catch rate is higher, thereby maintaining a high catch per unit of effort (CPUE) although their effort (man-days) has decreased (Table 1).

Table 1. Landings and effort figures (1974-1975) comparing effectiveness of two techniques of fishing (diving versus hooking) in the queen conch fishery of the Turks and Caicos Islands (adapted from unpublished report to TCI Government by C. Hesse).

Fishers	Method	Total Conch (#)	Effort (Man-days)	CPUE (Conch/man-day)
A	Hook	40,408	64	631
B	Hook	28,594	64	447
C	Dive	10,220	15	682
D	**Dive**	**13,556**	**21**	**646**

Additionally, the use SCUBA and hookah have further increased the efficiency of exploiting the resource. Divers are now able to exploit populations which were considered important spawning stock refugia and which were normally not accessible to free divers. For example deep-water populations are known to be heavily exploited in countries that use SCUBA (e.g. Dominican Republic, Puerto Rico, Virgin Islands, and Honduras), but are considered to be in a healthy state in areas where SCUBA is prohibited (e.g. the Bahamas, Turks and Caicos Islands) (Appeldoorn, 1997; Theile, 2001).

According to Theile (2001), regulations imposed by range States on the use of these diving techniques in the queen conch fishery range from total ban on the use of hookah and SCUBA gear (e.g. in Belize, Colombia, Cuba, Guadeloupe, Turks and Caicos Islands), to a seasonal prohibition (e.g. in the Bahamas) or to a ban on the use of only one of the two techniques (e.g. hookah in Puerto Rico and the Virgin Islands of the United States, SCUBA in Martinique). Other Countries such as St. Kitts and Nevis and St. Lucia have tried to regulate the use of SCUBA and hookah gear by introducing provisions that require the registration and licensing before such gear may be used commercially.

b) Output controls

i. Minimum size restrictions

Minimum size regulations have been widely used in many fisheries as a management control tool, to restrict or confer some degree of protection to particular parts of the stock. This is based on the strategy of restricting the harvesting of juveniles or releasing to the sea, captured individuals smaller than some prescribed minimum size. This allows individual fish to attain sexual maturity and reproduce at least once before capture, thus replenishing the stock.

In the case of the queen conch fishery, many range States have implemented size restrictions base on minimum shell length parameters although the use of shell length is well criticized and the use of shell lip thickness is suggested as a better indicator of size at maturity. This is because of the deterministic growth characteristics of the species. Maximum shell length for the most part is fixed at the time of sexual maturity (at the approximate age of 3 years), but growth continues to produce a flared lip, which increases in thickness with age (Appeldoorn, 1988, Tewfik, 1997).

Appeldoorn (1994 b) argues the switch to the use of lip thickness and conch anatomy as an index of maturity is based on two principal factors. Firstly, the switch to lip thickness is a more representative index of maturity than shell length measurement. Secondly, the conversion of shell length to meat weight does not produce a precise figure which can be utilised as an index of maturity.

Despite the difficulties surrounding the use of queen conch shell length as an index of sexual maturity, minimum size based on shell length measurement is still found in many legislations throughout the region including the TCI.

ii. Stock Assessment and Implementation of Harvesting Quota

All management of fisheries depends on biological information to predict the likely consequences of alternative management actions. In making his predictions, the fishery scientist must use some model to determine the productivity of a fishery resource, the effects of the fishing on that resource, and the impact (on the resource and the fishery) of changing the patterns of fishing (Gulland, 1983).

In studying the state of the fish stocks and the effect of fishing on them, the fishery biologist should carry out his analysis in precise quantitative terms. This requires mathematical models, which however, replaces complexities of the real situation by more or less simplified and abstract but relevant mathematical equations (Gulland, 1969). In other cases these models sometimes quite complex in an attempt to represent the events that occur in the fish stock in the sea. The models basically use information on the stock (biological data) as well as the level of exploitation (effort, catch rate, and gear type) to predict the dynamics of the stock based on historical trends. If the model is a useful one to the manager, a whole range of possible actions can be analysed, and the results predicted by the model will correspond reasonably closely to what would actually happen in practice (Gulland, 1974).

According to Gulland (1983), stock assessment studies are needed (with few exceptions) whenever fishery policies are being made, and decisions are being taken that will affect the fishery. Particularly in highly exploited fisheries which are managed based on enforcing a catch quota, or total allowable catch (TAC), the manager needs to know what level of total catch should be allowed in the coming season to achieve certain objectives.

The models used by fisheries biologists can be conveniently grouped into two main categories;

1. Surplus or Holistic models – this modelling approach is the simpler of the two, as it uses fewer population parameters. The model considers a fish stock as a homogeneous biomass; it considers the fish population as a whole and does not take into account the structure of the population, for example the length or age-structure of the stock (Sparre and Venema, 1992).

   Surplus production models are therefore based on the assumption that the net growth rate of a stock is related to its biomass (B). For example, the Schaefer model (Schaefer, 1954) assumes that the increase in stock biomass conforms to a symmetrical S-shaped or logistic curve, in which ‘r’ is the rate of increase (the stock growth rate), and $B\infty$ is the maximum biomass at the carrying capacity of the environment (sometimes referred to as K) (King, 1995).

2. Analytical models on the other hand, are based on a more detailed description of the stock and they are more demanding in terms of quality and quantity of the input data. As a consequence of the more intensive data requirements,

analytical models are therefore considered, and can give more reliable predictions where the data allow (Sparre and Venema, 1992).

Gulland (1969) states that the value of a model may be judged by its simplicity and the closeness with which events or values predicted by the model fit the actual observation. Thus, a model cannot be considered as being either right or wrong, but has given a satisfactory fit to the facts over a wide or narrow range of situations.

Moreover, in describing characteristics of a model, Sparre and Venema (1992) went on to say that a model is only as good as its inherent assumptions and input parameters.

Some of the assumptions of the Surplus Production Models (Seijo et al., 1998) are;

a) Fishing technology remains steady, and therefore catchability coefficient q is constant over time. Where q is a measure of the ability of the gear to catch fish (Sparre and Venema, 1992).

b) Assuming that catchability coefficient (q) is constant, fishing mortality (F) is proportional to effort (f);

$$F = \frac{q}{f}$$

c) The catch per unit of effort *(CPUE)* is a relative index of population abundance (where Y is total yield or catch, and B is biomass):

$$CPUE = \frac{Y}{f} = (1\text{-}e^{-q})\, B$$

d) The stock is constrained by a constant carrying capacity (*K*) of the environment.

Surplus production models are widely popular in tropical fish stock assessment, owing to the simplicity and the low data requirement of the models. These models (such as the Schaefer and Fox models) can be applied when reasonable estimates of the total yield (by species) and /or the catch per unit of effort (CPUE) by species and the related fishing effort over a number of years are available (Sparre and Venema, 1992).

The Turks and Caicos Islands have one of the longest historical catch and effort data set in the region, dating as far back to 1966 for the queen conch fishery of the Caicos Bank. This information was plugged into the dynamic form of the Schaefer model (Medley and Ninnes, 1999) expressed as;

$$B_{t+1} = B_t + rB_t(1 - \frac{B_t}{K}) - Y$$

$$Y = qfB_t$$

This model was used as the basis for estimating the yearly total allowable catch (TAC or quota) for the queen conch fishery of the Caicos Bank.

Most fisheries do not have extensive information on past effort and yields from a fishery. Where there is only little information, alternative methods based reasonable (but subjective) parameter estimates can be used to indicate the potential yield from a stock. It should be noted that these methods may give poor results when tested against real yields from a fishery.

On the other hand, in situations when extended catch and effort data are not available for exploited fish stocks, but the biomass of the stock is known (for example from a visual abundance survey of the stocks) an alternative model is proposed by Cadima (in Troadec 1977).

$$MSY = 0.5Y_c + BM$$

where B is the average annual biomass, Y_c is current yield and M is natural mortality. The above equation can be re-written (Garcia, et al., 1989; Appeldoorn, et al., 1996) as;

$$MSY_F = MB^{(\frac{y_c}{MB}-1)}$$

$$MSY_s = \frac{BM^2}{2M - F}$$

where MSY_F and MSY_S are the maximum sustainable yields for the Fox and Schaefer versions of the model, respectively.

However, in the case of an unexploited fishery where it is assumed that the fishing mortality is equal to zero (F = 0), then the above equation (in the Schaefer version of the model) can be differentiated to give the following equation;

$$MSY = \frac{BM^2}{2M} = \frac{BM}{2}$$

or rewritten as;

$$MSY = 0.5B_v M$$

where M is the instantaneous natural mortality, B_v is the virgin biomass.

Gulland (1971) proposed this as an empirical formula for the rough estimation of maximum sustainable yield based for fisheries in which with limited stock information.

$$MSY = 0.5\ M\ B_v$$

Many researchers believe that the relationship of 0.5 in the formula is too high and this may result in the overestimation of the yield 2 or 3 fold (Caddy and Csirke, 1983; Tewfik 1996). The relationship of 0.3 or 0.4 may prove better in estimating the potential yield (Gulland, 1983).

Kirkwood et al. (1994) (in Tewfik, 1996) showed that the multiplier ranged between 0.1-0.3. Nonetheless, Beddington and Cooke (1983) proposed that the multiplier should be reduced to 0.2. However, Tewfik (1996) used a multiplier value of 0.3 to estimate the MSY for the queen conch stock in depth zones ranging 20-30 m of the Pedro Bank in Jamaica.

This he felt was conservative in that it would not overestimate nor underestimate the potential yield.

On the other hand, if biological information such as natural mortality (*M*) is unknown, Pauly (1980) proposed the following formula;

$$MSY = 2.3\ B_v\ W^{-0.26}$$

where *W* is the mean weight (in grams) of the adult animals under consideration.

Alternatively, another approach of estimating the potential yield for the fishery was analysed. This approach was first proposed in March of 1999 (at the "Queen Conch Stock Assessment and Management Workshop" held in Belize City), in an attempt to provide harvesting guidelines for countries which lack data to conduct an appreciable assessment of their queen conch stocks (pers. com. Paul Medley, July 2003).

Several assumptions are made in the use of this model;

- The stocks are shared, or are in close proximity that they influence each other.
- The productivity of the two areas are similar,
- The population parameters such as natural mortality (m), growth rate (r), and recruitment are the same.

If the above assumptions hold true and the size as well as the stock status of the neighbouring country is known then the potential yield can be extrapolate base on the size ratio of the two fishing banks under consideration.

Consider country ***A*** and ***B*** is in close proximity and therefore sharing stocks. Country ***A*** has a fishing area of 2000 km^2, and harvest at a maximum sustainable yield 500 MT of queen conch annually. Country ***B*** has a fishing area of 4000 km^2, it is therefore proposed that country ***B*** would be able to harvest at an MSY level of 1000 MT.

3.0 METHOD

3.1 Visual survey

The marine habitat of the Turks Bank is not homogeneous, but instead it is characterised by patches of high productivity separated by corridors of unproductive sand plains. Hence, queen conchs are not evenly distributed, but are limited by habitat, depth and/or geography.

Local knowledge of queen conch traditionally fished areas was acquired by the administering of a questionnaire to the local fishers. Because of time, financial and human resource constraints as well as personal safety consideration, the 30 m depth contour line in combination with the results of the questionnaires (on local fishing areas) were used to design the sampling area on a local marine navigational map of the area (see Appendix III, figure h). A remote sensing image (a Landsat 7 Thematic Mapper image) and IDRISI 32 (Clark Labs, Worcester, MA, USA) program was used to randomly select sites within the traditionally fished areas, while a Global Positioning System (GPS) was used to navigate to the locations.

Seventy-six (76) sites were surveyed using triplicate three meter (3m) wide belt transects of thirty meters (30 m) long, for a total survey area of 90 m^2 per transect and 270 m^2 per site.

A lead weight was tied to one end of the 30-meter measuring tape, which was unwound as the diver swam in a specific cardinal direction using an underwater compass. On occasions when the force of the current was too strong, the transect lines were laid in the direction or parallel to the current, rather than against it. The three transects were deployed parallel to each other with approximate spacing not less than four meters (4 m) apart.

Two divers swam the length of the transect line, each sampling one side. Queen conch within the belt transects were enumerated and categorized by size/age characteristics, based on shell (siphonal) length (SL), development of the shell lip, and the physical properties of the shell (Table 2).

Once the transect lines were completed, the divers recoiled the lines as they swam to the surface or while in the boat.

Table 2. Size/age categories used in the classification of queen conch on the Turks Bank (adapted from Tewfik and Béné 2000).

Category	Code	Description
Small Juvenile	SM	<150 mm siphonal length, no shell lip
Medium Juvenile	ME	150-200 mm siphonal length, no shell lip
Large Juvenile	LG	>200 mm siphonal length, no lip
Sub-adult	SA	Shell lip thickness < 4 mm
Young adult	YA	Shell lip thickness >4 mm, broad flaring shell lip, prominent spines, limited effects of bioerosion
Old adult	OA	Shell lip thickness >4 mm, worn, thick shell lip, worn spines, moderate to heavy effects of bioerosion

The abundance of queen conch in each size/age category was determined for each transect, and the mean abundance of each category was calculated for each site (Table 13, Appendix IV). Mean abundances were then convert to densities (number of conchs per hectare) for each site. Subsidiary information on habitat type and depth was also recorded, which allowed further classification of the conch survey based on habitat type (Table 3). Although, seven (7) types of habitat were defined by Tewfik and Bėnė (2000), only four types were encountered during the visual survey on the Turks Bank; algal plains, seagrass meadows, sand plains and coral rubble (see Appendix III, figure h).

Table 3. Substrate/habitat categories adapted from Tewfik and Bėnė (2000) used in classifying surveyed sites from the queen conch visual survey on the Turks Bank (Turks and Caicos Islands).

Category	Code	Description
Algal Plain	AP	Fine mud, coarse sand, rubble bottom dominated by benthic algal cover (*Pencillus spp. Caulerpa spp., Halimeda spp., Udotea spp., Laurencia spp.,*
Seagrass Meadows	SG	Coarse sand bottom dominated by Turtle (*Thalassia sp.)* and Manatee (*Syringodium sp.)* seagrass beds.
Sand Plain	SP	Coarse sand bottom with sparse benthic algae or seagrass cover.
Patch Reef	PR	Large reefs composed of multiple colonies of various reef morphologies including branching (*Acropora spp.*), boulder (*Montastrea spp.*), and brain (*Diploria spp.*)¸
Coral Heads	CH	Small patches of coral (dominated by a single colony of various reef morphologies scattered amongst sand bottom.
Coral Rubble	CR	Rubble bottom composed of dead and broken coral forming patches with sparse benthic algae or seagrass cover
Gorgonian Plains	GS	Hard bottom areas with various levels of soft coral and sponge cover.

3.2 Morphometric Sampling

A random sample of conchs were collected from each surveyed site (depending on availability of conchs at the site) and morphometric parameters were measured (see Appendix II). These included:

- Tissue Weight (Total weight of intact animal, after removal from the shell)
- Shell/Siphonal length (Length of the shell from the tip of the spire to the end of the siphonal canal)
- Lip Thickness (thickness of the lip measured at the mid-point along the outer edge)
- Meat weight (with and without viscera)
- Sex (male, female)
- Relative Maturity (genital formation and or gonad index)

3.3 Estimating Potential Yield from Standing Stock Biomass

In order to estimate the standing stock biomass available for harvest, the average wet tissue weight (unprocessed weight) was determined for 200 young (YA) and old adult (OA) conchs collected from the survey. The biomass per hectare of the harvestable stock was estimated by multiplying the average meat weight with the combined density estimate of young (YA) and old adult (OA) conch from the survey. The result was then be multiplied by the total fished area to produce an estimate of standing stock biomass.

The potential yield for the Turks Bank was therefore estimated using four approaches which was previously described above;

- The Gullands (1971) empirical formula
- The modified version of the Gulland's formula (using 0.3 as the multiplier)
- The formula proposed by Pauly (1983) base on adult meat weight in grams
- The approach of estimating yield base on the comparative productivity of neighbouring fishing grounds.

The conch biomass available for exploitation the following year (i.e., recruitment yield) was also estimated by inputting the combine density of the Large Juveniles and Sub-adults in the fished areas into the following negative exponential model,

$$N2 = N1\exp(-M(t1-t2))$$

where N2 is the density at time t2, N1 is the density at time t1, and M is natural mortality

3.4 Social and Economic Impact Census

Two sets of questionnaires were administered, one set targeted the general population and the other set was administered to restaurants and hotel entrepreneurs/ managers residing on the Island of Grand Turk and Salt Cay (predominant users of the resource).

The responses to the questionnaires were uploaded into a statistical software program (SPSS for windows ® version 8.0), in which the data was analysed. The census was conducted so as to better understand the issues relating to queen conch consumption, such as the frequency of consumption, availability and distribution pathways, perceptions of the queen conch stocks status, as well as the consumption capacity of the community in order to assess the potential economic and social impacts which may result from industrializing the industry.

3.5 Potential queen conch consumption capacity

The potential consumption capacity of queen conch meat was calculated for the Turks Bank to determine if the calculated queen conch abundance on the Turks Bank can support the resident as well as the visiting population.

An annual queen conch meat consumption index of 4.93 kg per resident of the Turks and Caicos Islands was tailored for the Turks Island, by multiplying the index by the potential percentage of the population which ate conch frequently.

Similarly, the potential queen conch consumption by tourist was calculated by multiplying the estimated annual number of visiting tourist to the Turks Islands by the tourist queen conch meat consumption index of 0.28 kg per visiting tourist. The consumption indices were obtained for the Turks and Caicos Islands from a previous census in 2001 conducted by the Department of Environment and Coastal Resources (D.E.C.R.).

4.0
RESULT

4.1 Population Density and Abundance

A total of seventy six (76) sites were examined for an approximate total area of 2.05 hectares of the Turks Bank surveyed. A Wilks' Lambda Multivariate test found no significance in the interaction between habitat and depth (P = 0.228). However, the multivariate test also showed that there is an overall significant influence by habitat (P = 0.007) on the observed densities, but a depth did not have such a strong influence overall with a P value of 0.063 (Table 4).

Table 4. Wilks Lambda Multivariate test to determine if there is an overall significant influence of habitat and/or depth on the densities observed. The test suggests that habitat had a significant influence on the observed densities while water depth only had a minor influence.

Wilks' Lambda Multivariate Test			
Effect	**Value**	**F**	**Sig.**
Habitat + Depth	0.715	1.248	0.228
Depth	0.838	2.12	0.063
Habitat	0.592	2.121	0.007

However, a univariate analysis of variance (of the General Linear Models) for the influence of depth on the densities of individual queen conch size categories showed that depth had some influence only on the densities of small juveniles (P = 0.09) and old adults (P = 0.077), but the influence was not significant, only a trend towards being significant (Table 5).

On the other hand, the model showed that habitat had a significant influence on all queen conch densities except for densities of medium juveniles with a P value of 0.247 (Table 5).

Table 5. A Univariate analysis of variance to test the influence of habitat and depth on density of individual queen conch size categories. Habitat had significant influence on all size categories except medium juveniles, while depth only showed a trend of significantly influencing the densities of small juveniles.

Effect	Univariate Analysis of Variance			
	Dependent Variable	**Mean Squares**	**F**	**Sig.**
Depth	SJ	33638.14	2.96	***0.090***
	MJ	14646.53	2.16	0.146
	LJ	741.72	0.60	0.440
	SA	287.23	0.05	0.823
	YA	27.06	0.00	0.976
	OA	27852.94	3.21	***0.077***
Habitat	SJ	30499.33	2.68	***0.053***
	MJ	9556.57	1.41	0.247
	LJ	3391.75	2.76	***0.049***
	SA	16050.22	2.82	***0.045***
	YA	95032.96	3.12	***0.031***
	OA	63417.60	7.31	***< 0.001***

A one-way ANOVA (analysis of variance) was performed on the data set, to very the results of the univariate analysis. The ANOVA test showed similar results as that of the univariate analysis. Habitat significantly influenced the densities observed for all queen conch size categories except for the medium juveniles (P = 0.175) which was not significant (Table 6).

Table 6. One-way ANOVA to test the influence of habitat on the densities observed for individual queen conch size classes. The test indicates significance for all size classes except at the medium juvenile size class.

One-Way ANOVA		
	F	**Sig**
SJ	5.799	0.001
MJ	1.701	0.175
LJ	2.930	0.390
SA	2.848	0.430
YA	3.169	0.290
OA	6.880	< 0.001

There was some concern that the data was not normally distributed, owing to not having found any conch at a number of sites. As such, a non-parametric test (Kruskal-Wallis Test) was also performed on the data set. The Kruskal-Wallis test agreed well with the result generated by the univariate analysis as well as the ANOVA. However, in addition, the Kruskal-Wallis test also proved significance for medium juveniles (Table 7).

Table 7. The Kruskal-Wallis no-parametric test was performed on the queen conch data for the Turks Bank of the Turks and Caicos Islands. This is because doubts were cast about the normality of the data set. Irregardless, the non-parametric test generated similar result as that of the ANOVA.

Kruskal-Wallis Non-Parametric Test						
	SJ	**MJ**	**LJ**	**SA**	**YA**	**OA**
Chi-Square	14.592	13.558	8.507	10.397	16.005	12.743
Df	3	3	3	3	3	3
Asymp. Sig.	0.002	0.004	0.037	0.015	0.001	0.005

The influence of depth can best be visualized on a series of scatter plots (see Appendix V, figures a-f). In figure a, of appendix V, the clusters of conch are found towards the left of the graph, at low water depth. However, figures b-e showed no noticeable clustering at long the depth axis of the graph, while old adults in figure f, showed considerable clustering towards the right of the graph.

Similarly, habitat influence is apparent when looking at the mean densities of queen conch sizes in table 8. There is a gradual shift in queen conch density levels from seagrass beds to algal plains, with increase in size classes of conch. In the small juvenile stage, the greatest density is found in the seagrass habitat (145.3 conchs ha^{-1}). It can be seen that in the medium juvenile stage, the shift in density towards the algal plain habitat is initiated. Although the highest density of 58.6 conchs ha^{-1} is found in the algal plain habitat, there is still a considerable number of conchs that were still found in the seagrass habitat (31.3 conchs ha^{-1}).

From the large juvenile to old adult size classes, the shift in density to the algal plain is more pronounced, for example, densities of old adults in algal plains were 154.3 conchs ha^{-1} whereas in all other habitats, densities were less than 25 conchs ha^{-1} (Table 8).

Table 8. Queen conch (Strombus gigas) densities (conch/ha) of the Turks Bank of the Turks and Caicos Islands, categorised by habitat type.

Habitat	Parameters	SJ	MJ	LJ	SA	YA	OA	Overall Densities
Sea-grass	Mean Density	145.3	31.3	8.5	5.7	14.2	11.4	***216.5***
	N	13	13	13	13	13	13	13
	Std. Dev.	250.5	54.2	22.2	13.9	32.2	31.7	262.7
Corral Rubble	Mean Density	0.0	9.3	0.0	4.6	0.0	9.3	***23.1***
	N	8	8	8	8	8	8	8
	Std. Dev.	0.0	26.2	0.0	13.1	0.0	26.2	44.0
Sand Plain	Mean Density	10.3	0.9	0.9	0.9	3.4	25.0	***41.3***
	N	43	43	43	43	43	43	43
	Std. Dev.	45.2	5.6	5.6	5.6	13.6	81.5	97.4
Algal Plain	Mean Density	6.2	58.6	34.0	71.0	172.8	154.3	***496.9***
	N	12	12	12	12	12	12	12
	Std. Dev.	14.4	203.1	85.7	190.5	441.2	177.9	830.9
Total	**Mean Density**	***31.7***	***16.1***	***7.3***	***13.2***	***31.7***	***41.4***	***141.3***
	N	76	76	76	76	76	76	76
	Std. Dev.	118.0	84.1	36.3	77.6	180.6	105.1	382.4

Overall, queen conchs on the Turks Bank were found in greatest abundance on algal plains habitats with a mean density of 496.9 conchs ha^{-1} followed by densities in seagrass beds, coral rubble, sand plains with densities of 216, 41.3, 23.1 conchs ha^{-1} respectively (Table 8).

Further examination of table 8 of the densities categorising by queen conch size class instead of habitat indicate that old adult (OA) conchs were most abundant with a mean density of 41.4 conchs ha^{-1}. Young adults (YA) and small juveniles (SJ) conchs accounted for the second highest density of 31.68 conchs ha^{-1} each, while medium juveniles(MJ), sub-adult (SA) and large juveniles (LJ) recorded densities of 16.08, 13.16 and 7.31 conchs ha^{-1} respectively (Table 8). For management purposes and the estimating of the potential yield, the recorded densities were grouped into three main categories; the adults or exploited population size range (see Appendix III, figure e) which comprises the old adult (OA) and young adult (YA), the population size which is recruited yearly into the fishery (LJ and SA) (see Appendix III, figure f) and the juvenile population (SJ and MJ) (see Appendix III, figure g).

Assessment of productivity by habitat type indicated that algal plains were most productive with over 70% of the biomass for the exploitable adult queen conch (YA & OA) population for the Turks Bank was found within this habitat. The sand plain habitat was the second most productive, accounting for 22% of the total biomass on the fishing areas of the Turks Bank (Table 9).

Table 9. Table showing the productivity of the Turks Bank for exploitable adult queen conch population (YA + OA), characterised by habitat types. Algal plains were most productive, accounting for over 70% of the total biomass in the fishing areas of the Turks Bank, followed by sand plain habitats.

Habitat	Population(n)	Area (ha)	Density (n/ha)	Mass (g)	Biomass (t)	% Biomass
AP	0.158	1252.6	327.1	236	96.7	70.7
CR	0.105	835.1	9.3	236	1.8	1.3
SG	0.171	1357	25.6	236	8.2	6
SP	0.566	4488.4	28.4	236	30.1	22

4.2 Estimating Potential Yield from Standing Stock Biomass

The combined mean density of YA and OA (exploited adult population) (see Appendix III, figure e) from the visual survey of the Turks Bank was 73.1 conchs ha^{-1}. This value, in combination with an average queen conch meat weight of 236g per individual obtained from the morphometric sampling was multiplied by the total area surveyed (7933 ha). This produced a standing stock biomass of 137.2 MT available for harvest in traditionally fished areas of the Turk Bank with an upper and lower confidence limit of 143.1 and 131.2 MT at the 95% confidence level derived from using a bootstrap method (Table 10). The non-parametric bootstrap obtains robust variance estimates from repeated re-sampling with replacement from the data.

The standing stock biomass when plugged into the Gulland (1971) equation with a multiplier of X= 0.3 (Tewfik, 1996) and a natural mortality[1] (M) value of 0.23 for adult conchs, produced a Maximum Sustainable Yield (MSY) value of 9.46 MT (Table 10).

Table10. Parameter estimates used in the estimating MSY for the queen conch fishery of the Turk Bank, of the Turks and Caicos Islands and 95% confidence intervals for the modified Gulland (1971) formula (see Tewfik, 1996). Note: X = multiplier, M= natural mortality, MSY = maximum sustainable yield and B_v = virgin biomass.

Parameters	Estimates	95% Confident Level	
		Upper Limit	Lower Limit
Multiplier (X)	0.3		
M	0.23		
B_v (MT)	137.2	143.1	131.2
MSY (MT)	9.46	14	6.6

The Gulland (1971) estimator on the other hand generated a higher potential harvesting level of 16 MT with greater variance range of confidence interval. Similarly, the approach of estimating the MSY base on the ratio of fishing grounds did not do much better; it produced the second highest potential harvesting level at 54 MT for the MSY (Table 11). The Pauly (1980) estimator on the other hand generated the highest potential yield, with an estimated MSY value of 67.5 MT.

Nevertheless, using a combined density of 20.5 conchs ha^{-1} for LG and SA and a value of 0.80 for juvenile mortality value $M(t_1\text{-}t_2)$ within the region (A. Tewfik, pers. comm.), it was estimated with these values plugged in the negative exponential model that 5.5 MT of conch meat or 72,931 individual conch would be recruited to the fishery annually.

Table11. Three approaches were utilised to estimate the MSY level for the Queen conch fishery of the Turks Bank. The approach by Tewfik (1996) of using a lower multiplier of 0.3 generated the lowest MSY level with a smaller C.I. range.

Method of Estimating Yield (MSY)	MSY	95 % C. I.	
		Upper Ltd.	Lower Ltd.
In Tewfik (1996) **MSY= 0.3*MB$_v$**	9.46 MT	14 MT	6.6 MT
Gulland (1971) **MSY= 0.5*MB$_v$**	16.0 MT	22.9 MT	12.9 MT
Size Ratio Formula	54.0 MT		
Pauly (1980) **MSY = 2.3 (B$_v$* W$^{-0.26}$)**	67.5 MT		

4.3 Social and Economic Impact Census

The socio-economic census consisted of two sets of questionnaires which targeted two specific groups; the general population, and the restaurant managers/owners.

There were 80 respondents from the general population questionnaire set, of which 50% were male, 46.3 % female and 3.8 % did not indicate there gender. The ages of the respondents were well spread, ranging from 15 to 55 years. The majority of the respondents were between the ages of 26-35 (37.5%), followed by the age groups 36-45, 15-25, and greater than 45 years accounting respectively for 31.3%, 22.5% and 8.8% of the respondents (see appendix VI, figures a, b).

Ninety percent (90%) of the respondents in the general population questionnaire ate marine products. Furthermore, over 32% selected Queen conch as their preferred first meat choice to eat at home or a restaurant, with finfish trailing second with 22.5% of the respondent, followed by spiny lobster (187.8%), white meat such as chicken (16.3 %) and red meat such as beef (7.5%), while only 2.5 % selected other meats such as shark, turtle as their first choice (see appendix VI, figure c).

The majority of the respondents (51%) ate conch bi-weekly; that is to say at every two weeks or at least once per month, while 40 % ate conch more regularly at least once per week. On the other hand, nearly 9% did not eat conch often but preferred other meat instead (see appendix VI, figure d).

Three main factors were identified to have influence the frequency at which queen conch is consumed; namely a desire to eat conch, cost of the product, and availability. Over forty six percent (46.3%) of the respondent indicate that desire is the single most influential factor, while 31.3% of the respondents expressed the relatively high cost for a meal of conch tends to dissuade their selection of queen conch as a primary choice. On the other hand, 22.5% highlighted the unavailability of the product as the single most influential factor which affects the frequency, they consume the product (see appendix VI, figures e, h).

Of the respondents which acknowledge to eating conch, 67.5% purchase conch from the local restaurants, while only 23.8% buy conch directly from the fisher, and even a lesser percentage (2.5%) purchase from fish markets or other fish vending facilities (6.3%) such as the processing plants on the neighbouring island of South Caicos (see appendix VI, figure g).

Probe into the general population's perception of the availability of queen conch depicted that the queen conch was available to the community, but not to abundantly satisfying level. Only 8.8 % of the respondents were satisfied with the availability of queen conch, while 63.8% although acknowledging the availability was also eager to suggest the need for improvement in the accessibility of the product. Over twenty seven percent (27.6%) of the respondents were dissatisfied, of which 26.3% require drastic improvement, while 1.3% declared there utter disgusted of the accessibility of queen conch to the community of Salt Cay and Grand Turk (see appendix VI, figure f).

A logistic regression analysis was performed to determine if availability, cost of conch to the consumers, meat preference (desire), age and gender of respondents affected the frequency that which conch was consumed.

The model suggests that availability might have an impact on the frequency at which conch is consumed. The ratio of conch consumed on a weekly basis increased significantly from five (5) to twenty seven (27), by a factor of almost 4.5 if availability increases from low to high (Table 12).

Table 12. Table displaying results of the logistic regression analysis to determine if the frequency of queen conch consumption is influenced by variability in the availability of the product. The model suggests that when availability is high, people that eat conch often, increase their consumption frequency by a factor of more than 4 times.

Availability level of Queen conch	Queen conch Consumption Frequency			
	Not Often (< Weekly)	%	Very Often (Weekly)	%
Low to None	17	35.4%	5	15.6%
Moderate to High	31	64.6%	27	68.8%
Total	48		32	

Overall, the logistic regression model suggest a very weak influence of the independent variables (age, gender, cost etc) on the frequency that which conch is consumed. However, on individual basis, availability shows significant influence on frequency of consumption although not strongly, with a significant probability value of 0.0379 which is less than P= 0.005 (Table 13).

Table 13. Table showing the results of the logistic regression analysis to determine if the influences of various variables on the frequency that which conch is consumed is significant. The model indicate that of all the variable, availability has the most significant influence, while conch meat as a preferred first choice shows a trend towards being significant.

Variables	B	S.E.	df	Sig
Availability of conch	1.2509	0.6027	1	**0.0379**
Conch as preferred meat choice	1.1137	0.6001	1	**0.0635**
Cost of conch meat	-0.0794	0.5293	1	0.8808
Other Marine Meat	-0.9454	0.6368	1	0.1377
Age group of respondents	-0.1054	0.2872	1	0.7136
Gender of respondents	-0.0737	0.5106	1	0.8852

The model also proposes the tendency for the selection of conch meat above other meat, including marine meat to be significant, with a probability value of 0.0635 (Table 13). That is to say, people who prefer conch, seems to eat more conch when availability is high. Approximately 54% of the conch consumers eat conch weekly, while those that do not prefer conch (46.2 %) does not eat it as often (Table 14).

Table 14. This table show the results of a pivot table analysis to determine if frequency of queen conch consumption is influenced by availability or by desire. The results indicate that when queen conch is available, weekly conch consumers eat and prefer conch above all other meat.

Frequency of consumption	Preferred choice of meat			
	All Non-conch Meat		Conch Meat	
	Count	%	Count	%
< weekly	36	66.7%	12	46.2%
Weekly	18	33.3%	14	53.8%
Total	54	100.0%	26	100.0%

Despite some concern about the availability of queen conch to the residents of Grand Turk and Salt Cay, 52.5 % of the respondents did not foresee the introduction of a fish processing plant to the island as a vehicle which would positively influence the frequency that which they consume queen conch, whereas 35% did, and 12.5 % of the respondents were indecisive (see appendix VI, figure i).

As such, very few of the respondents (25.1%) accepted and welcomed the concept of implementing a fish processing plant on the Island of Grand Turk. Of which, 13.8% saw the introduction of the plant as a great opportunity which would increase the diversity of marine products available for consumption, similarly, 11.3% accepted the implementation of the plant as this would tend to centralize the vending of marine products, instead of the current practice of loafing at the bay-side awaiting the return of fishers so as to purchase their catch.

On the other hand, the majority of the respondents were against the introduction of a major class fish processing facility, mainly because it is feared that the price paid for marine products would increase exorbitantly, as expressed by over 56% of the respondents. Alternatively, 15 % of the respondents were more concern about the environment and the status of the queen conch stocks, which they felt would decrease significantly with the introduction of a fish plant and possibly lead to overfishing of the stocks (see appendix VI, figure j).

The second questionnaire which was administered to the restaurant entrepreneurs and managers was equally beneficial. There were twelve (12) respondents in total, all of whom offered queen conch on their menus. 41.7% of the respondents acknowledge that they offered queen conch on a daily basis, while 50% offered it a minimum of twice per week and the remaining 8.3% offered conch at their establishment only once per week (appendix VII, figure a).

Nevertheless, 66.7% of the respondents agreed that the demand for queen conch by their customers is the most influential factors which affect the frequency they offer it on their menu. Twenty five percent (25%) on the other hand, stated that availability of the product have a greater influence on the frequency that they offer conch, while 8.3% was more concern about the high cost of purchasing conch which reduced their profit margin (see appendix VII, figure b).

However, with the introduction of a Cruise Ship Industry to the Island of Grand Turk, all the respondents agreed that this have increased the sale of queen conch by their establishment (see appendix VII, figure c).

Nevertheless, despite the increase in queen conch sales and increasing demand for the product, only 16.7% of the respondents welcomed the introduction of a fish processing plant as the solution to increase the availability of conch. The majority of the respondents (58.3%) argued against the implementation of a processing plant, as they believe this would more than likely result in an increase in the unit price of conch meat. Another, 25% believe that the introduction of the processing plant will lead to overfishing in order to fulfil the demand for the local market as well as the export market (see appendix VII, figure d).

4.4 Potential queen conch consumption capacity

Information on resident population and number of visiting tourist (other than Cruise Ship tourist) to the islands of Grand Turks and Salt Cay were not available. However, the most recent population information of 2001 was used, assuming that the population size had not changed significantly over the past two years.

Forty percent (40%) of the respondents in the general population questionnaire ate conch regularly, this was transpose to the entire Turks Island population, which accounted for only 1,590 individuals, and this was used in the consumption capacity assessment.

The assessment generated an overall potential local consumption level of 15,292 kg of conch meat annually, of which the local resident population is estimated to consume approximately 50% of the queen conch meat consumed locally (Table 15).

Table 15. Table showing local consumption index for queen conch in the Turks and Caicos Islands, which was used to estimate the potential queen conch consumption capacity for the Turks Bank.

Population Structure	Consumers in Grand Turk & Salt Cay	Consumption Index (kg)	Local Consumption (kg)
# Tourist visits in 2001	5,041	0.28	1,411
40 % of Resident Pop. In 2001	1,590	4.93	7,839
Cruise Ship Tourist in 2003	21,579	0.28	6,042
Total	**30,595**		**15,292**

5.0 DISCUSSION

5.1 Population Density and Abundance

The queen conchs on the Turks Bank were found in four main habitat type; algal plains, sand plains, coral rubble and seagrass beds. Of the four habitats, conchs were found in highest densities in the algal plain habitat which were dominated by sexually mature adult conchs (YA and OA) followed by densities in the seagrass beds dominated by small juveniles.

The data displays a gradual shift in habitat as queen conch increase in size, moving from seagrass beds during the small juvenile stage to algal plains at the adult stage. The ANOVA as well as the non-parametric test (Kruskall-Wallis test) showed similar results of significance in the influence of habitat on the observed densities.

This trend agrees with what is already known about the biology and behaviour of the species. Habitats provide two main functions to queen conch; food and shelter. These functions can best be visualized along a polar continuum, with each utility at opposite ends of the gradient.

During the juvenile stage, shelter is more important for the juvenile cohorts, thus they commonly occur on seagrass flats, primarily turtle grass (Thalassia testudinum), manatee grass (Syringodium filiforme), and shoal grass (Halodule wrightii). The tall seagrass blades provided ample shelter within the seagrass beds, while patches of sand, loose substrate allows easy burial. Detritus associated with seagrass is also available, which is the primary food for the growing juvenile conch (Randall, 1964; Tewfik, 1997).

As the juvenile queen conch increases in size (length as well as shell thickness), it is now more resilient and can escape attach by predators such as spiny lobsters, stingrays and sea-turtle by seeking refuge within its' hard calcareous shell. Shelter is no longer a major concern, as such older conchs were often found in deeper waters with increasing distances from the seagrass beds, into alternative habitats such as sand plains, coral rubble, gravels, and beach rocks encrusted with macrophytic or macroscopic unicellular algae (e.g. Laurencia & Batophora spp.) (Randall, 1964; Brownell and Stevely, 1981; Tewfik, 1997).

The most productive habitat for mature adult queen conch was algal plains, which supported over 70% of the exploitable stock biomass, followed by sand plain habitat. Coral rubble and seagrass flats supported the least densities of conch, but these only represented 11% and 17% of the sites sampled.

Similar observations were made for the Caicos Bank, in which algal plains supported 66.9 % of the adult biomass, followed by sand plains (10.7 %), seagrass (8.4%), coral rubble (8.2%) and gorgonian sponge habitat supporting 5.3 % of the exploitable adult (YA+OA) queen conch stock.

Tewfik, (1996) also made parallel observation on the Pedro Bank, of Jamaica in which habitats of algal and sand plains supported the largest population of adult conch. However, Friedlander et al. (1995) in Tewfik (1997) reported coral rubble and seagrass habitat supporting the highest densities of conch in the U.S. Virgin Islands.

Overall, the queen conch population on the Turks Bank is dominated by sexually mature young and old adult conchs (YA and OA), combine they represent nearly 52% of the population.

Small juvenile conchs were the second most dominant size group, accounting for 22 % of the population, while the transitory life stage categories of medium juveniles, large juvenile and sub-adults accounted for 11%, 5%, and 9% of the queen conch stocks on the Turks Bank in that order.

The above trend agrees with the expectations for an underexploited fishery where there is very little fishing pressure, as such the adult population is expected to be high. Consequently, the more adults in the stock the greater is the fecundity potential of the stock, which may explain the high density of small juveniles observed, due to internal as well as regional larval recruitment on the Turks Bank.

On the other hand, the large juvenile (LJ) and sub-adult (SA) size categories displayed the two lowest overall densities. These size categories are the transition stage from sexually immature to mature reproductive adults. This stage is very brief, in which sexual maturity occurs between five (5) and ten (10) months from the initial onset of shell lip growth (Appeldoorn, 1988; Tewfik, 1997). It is plausible therefore, that the low densities observed is related to the brief transitory phase to adulthood.

5.2 Estimating Potential Yield from Standing Stock Biomass

There are very few useful models available in the fisheries literatures from which potential yield can be estimated based on standing stock biomass. Far less models are available which encompasses data from an underexploited fishery, in which the biomass is still considered virgin.

The Gulland (1971) empirical formula is one such method available. Although highly criticised for its' inherent tendency of overestimating the MSY, its usefulness is still recognised even if only as a harvesting guidelines to fisheries managers base on the precautionary principle of Article 7.5 of the FAO Technical Guidelines for responsible Fisheries (1996). The context of the article is made clear in Principle 15 of the Rio Declaration of the UN Conference on Environment and Development which states:

'In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.'

Gulland empirical formula is widely used for fisheries which lack sufficient catch and effort or biological growth data to perform a more elaborate assessment of the stocks. For example, Smith and van Nierop (1986) used the Gulland (1971) empirical formula to estimate potential yield of spiny lobster and queen conch for the Bahamas Bank, Pitcher et al. (1992) estimated the potential yield of tropical lobster in the Torres Strait using a similar approach. Likewise, Tewfik (1996) used a similar approach to determine the MSY limit for the Jamaican Industrial fishery, which is currently the basis of the year TAC.

The approach of using 0.3 as the multiplier in the Gulland (1971) formula generated the most conservative potential yield of 9.46 MT (C.I. = 9.1-9.9 MT) whereas, the original Gulland (1971) formula with a multiplier of X = 0.5 generated a higher potential yield of 16 MT with a greater confidence range (C.I.= 12.9-22.9 MT). On the other hand, the size ratio as well as the approach proposed by Pauly (1980) generated a very high potential yield level.

Gulland (1969) proposed that a model cannot be judged as being right or wrong, but it can be criticised base on the closeness of the model's prediction to actual observation. In the case of a virgin fishery, there are no precedents such as yield values, with which to compare, hence in the light of such, it is best to take a precautionary approach. This is because, with increase in fishing pressure as the fishery develops, the stock is expected to decrease significantly within one to two years, possibly below the maximum sustainable yield level (Tewfik, 1996). As such, a more conservative potential yield may protect the stock from a possible collapse within a short time period.

5.3 Social and Economic Impact Census

The introduction of a fish processing plant on one of the island of the Turk Bank can potentially have both positive as well as negative economic, sociological and biological impacts. In deciding 'for' or 'against' the implementation of the plant, the positive impacts must be weighed against the negative impact, keeping in mind the ultimate goal is the sustainability of the fishery.

a) Potential Positive Impacts

- The availability or the accessibility of queen conch to the consumers of Grand Turk and Salt Cay may increase with the introduction of the processing plant, which may in turn, influence the frequency that which conch or other marine products are consumed locally.
- Fishers will land their products at a standardized location. This would facilitate ease in monitoring and collecting of catch and effort data by the D.E.C.R.
- At present, fishers are indirectly limited in the number of days fished as well as the quantity of products that they land. This is because fishers generally fish to satisfy special orders made by a restaurant. Alternatively, fishers often truck their products around the town offering for sale at a bargaining price to the local community. The introduction of a processing plant would serve to eliminate some of these practices. Fishers would have confident in the knowledge that there is a ready market available to accept their products daily at a reasonably fixed price.
- The introduction of a fish processing plant would more than likely promote the increase in the price paid to fishers for marine products, owing to competition with the restaurant industry for products.
- The introduction of a fish processing plant may create employment opportunities for residents of the community.

b) Potential Negative Impacts

- The cost of marine products, such as conch may increase exorbitantly to the local consumers.

- The introduction of a fish processing plant may promote a 'race-to-fish' scenario fuelled by locked competition; both by the consumers as well as the fishers. This may have a significant contribution to the over-exploitation of the stocks.
- There are only 32 registered fishers operating on the Turks Bank, of which only 25-40 % operates full-time. The others approach fishing as a secondary means of supplementing their income or as recreation thereby resorting to fishing less than 40 days for the year.
- A 'Class A' fish processing plant, similar in size and processing capacity as the fish processing plants in the other Caicos Islands of South Caicos and Providenciales, would need to process a minimum of 7-13 MT of marine products (fin-fish, spiny lobster and queen conch) annually so as to maintain a profit. In managing the fishery, the Government of the Turks and Caicos Islands, must take precaution not to promote overcapitalization into the fishery which may lead to competition and ultimately over-exploitation.

5.4 Potential queen conch consumption capacity.

The potential local consumption of queen conch estimated in table 12 above is not assumed to be precise. The calculations were base on the minimum population estimates for the Turks Islands. However, with the revitalization of the tourism industry in the Turks Islands, it is expected that tourist as well as the resident population levels would increase, in so doing increasing consumption patterns as well. Therefore, the consumption levels estimated should only be used as guideline for consideration in the developing of the fishing industry of the Turks Bank.

5.0 CONCLUSION & RECOMMENDATION

The following recommendations are proposed for the sustainable management of the Turks Bank queen conch fishery resource of the Turks and Caicos Islands;

- It is recommended that a Total Allowable Catch (TAC) exploitation strategy is utilised for the queen conch fishery of the Turks Bank.
- It is strongly advisable that the estimated potential yield or MSY is used as the Limit Reference Point (LRP) and not as the Target Reference Point (TRP) . The TRP can be estimated by using a ratio of the estimated potential yield (e.g. 90%of the MSY or TAC = 0.9 MSY)
- It recommended that the most conservative estimation of potential yield is utilised for exploitation of the fishery, which is 9.5 MT. Considering that 5.5MT of conch meat (72, 931 individual conchs) become sexually mature adults and are recruited into the fishery annually, this suggest that more than half of the MSY that would be harvested would be surplus of yearly recruitment.
- It is also recommended that a data collection system is implemented in all restaurants and other establishments which offer marine products for sale. Alternatively, these establishments can be asked give a periodic report of products purchase and sold following a standardized the guideline. This is important in order to determine when the Targeted Reference Point, in this case the Total Allowable Catch is achieve.
- The North-Western coastline of the island of Grand Turk is important for small juveniles. It is recommended that this are be considered for legislative protection, as such closed to fishing.
- The study does not recommend the implementation of an ‘A Class’ processing facility which would cater to the export market, however, as alternative the facility can be establish but limited to the supply of products only to the local market for local consumption.
- It is also recommended that a fishery management plan is developed for the queen conch fishery of the Turks Bank.

6.0 REFERENCE

Alcolado, P.M. 1976. Crecimiento variaciones morfológicas de la concha y algunos datos biológicos cobo *Strombus gigas* L. (Mollusca, Mesogastropoda). Acad. Cienc. Cuba. Ser. Oceanol. 34:36p.

Appeldorn, RS & DL Ballantine. 1983. Field release of culture queen conch in Puerto Rico: implications for stock restoration. Proceedings of the Gulf and Caribbean Fisheries Institute 35: 89-98.

_________. 1985. Growth, mortality and dispersion of juvenile laboratory reared conchs, *Strombus gigas* and *S. costatus,* released at an offshore site. Bulletin of Marine Science 37 (3): 785-793.

_________. 1987. Practical considerations in the assessment of the queen conch fisheries and population dynamics. Proceedings of the Gulf and Caribbean Fisheries Institute 38: 307-323.

_________. 1988. Age determination, growth, mortality and age of first reproduction in adult queen conch *Strombus gigas* L., off Puerto Rico. Fisheries Research 6:363-378.

_________. 1991. History and recent status of the Puerto Rican conch fishery. Proc. Gulf. Caribb. Fish. Inst. 40: 267-282.

_________. 1992. Preliminary calculations of sustainable yield for queen conch (*Strombus gigas)* in Puerto Rico and the U.S. Virgin Islands. . Gulf. Caribb. Fish. Inst. 41: 95-105.

_________. 1994. Queen conch management and research: status, needs and priorities. In: Queen Conch Biology, Fisheries and Mariculture (RS Appledorn & B Rodriguez, eds) pp301-320.

_________. 1994 b. Spartial variability in the morphology of queen conch and its implication for Management regulatons. In: Queen Conch Biology, Fisheries and Mariculture (RS Appledorn & B Rodriguez, eds) pp145-158.

__________. 1997. Deep water populations of conch and the effects of overexploitation. In: Lobster and Conch Subproject and Specification and Training Workshop Proceedings. Caricom Fisheries Document No. 19. pp118-121.

__________. 1997. Status of the queen conch fishery in the Caribbean Sea. In: Proceedings: International Queen Conch conference, San Juan, Puerto Rico. (JM Posade & G Garcia-Molinev, eds). 40-59.

__________ and Rolke, W. 1996. Stock abundance and potential yield of the Queen Conch Resources in Belize. Unpublished reports of the Caribbean Fisheries Resource Assessment and Management Progam (CFRAMP) and the Belize Department of Fisheries, Belize City, Belize.

Auil-Marshalleck. S. 1997. Biological data collection in participating countries. In: Lobster and Conch Subproject and Specification and Training Workshop Proceedings. Caricom Fisheries Document No. 19. pp.182-194.

Beddington, J.R. and J.G. Cooke. 1983. The potential yield of fish stocks. FAO Fish.Tech.Pap., No. 242: 47 p.

Bėnė, C., and A. Tewfik. 2001. *Analysis of fishing effort allocation and fishermen behaviour through a system approach*. Research paper 155. Centre for Economics and Management of Aquatic Resources. University of Portsmouth. United Kingdom. 29 pp.

Berg, C.J., Jr., & J.B. Mitton, & K.S. Orr. 1986. Genetic analyses of queen conch, *Strombus gigas*. Preliminary implications for fisheries management. Proc. Gulf Caribb. Fish. Inst. 37: 112-118.

Berg, C.J., Jr. 1987. Current status of conch fisheries in the Caribeean and exports to the United States. *Proc. Gulf Carib. Fish. Inst.* Vol **38**.Pp.293.

Berg, C.J., Jr., & DA Olsen. 1989. Conservation and management of queen conch (*Strombus gigas)* fisheries in the Caribbean. In: Marine Invertebrate Fisheries: Their Assessment and Management (JF Caddy, ed). John Waely & Sons. pp 429-442.

__________ & RA Galzer. 1995. Stock Assessment of a large marine gastropod (*Strombus gigas*) using Randomized and stratified towed-diver censusing. ICES Marine Science Symposium 199: 247-258.

Brownell, W.N., and J. M. Stevely. 1981. The biology, fisheries, and management of the queen conch, *Strombus gigas*. Mar. Fish. Rev. 43 (7): 1-12.

Caddy, J.F. 1984. An Alternative to equilibrium theory for management of fisheries. *In* FAO Fisheries Report No. 289 Supplement 2. Rome. 214 pp.

Caddy, J.F. and J. Csirke. 1983. Approximation to sustainable yield for exploited and unexploited stocks. Oceanogr. Trop. 18:3-15.

Caddy, J.F., and Gulland, J.A. 1983. Historical patterns of fish stock. *Marine Policy,* 7: 267-278.

Chakalall, B & Cochrane, KL. 1997. The queen conch fishery in the Caribbean- An approach to responsible fisheries management. Proceedings: International Queen Conch conference, San Juan, Puerto Rico. (JM Posade & G Garcia-Molinev, eds). pp 61-77.

Chen, V. (Unpublished report). The conch sizes are becoming smaller. Is it a myth, or is it true? School for Field Studies. July. 1992.

Clench, W.J., and R.T. Abbott. 1941. The genus *Strombus* in the western Atlantic. Johsonia 1 (1): 1-16.

Clerveaux, W., and A. Danylchuk. 2001. Visual assessment of Queen Conch (*Strombus gigas*) stocks in the Turks and Caicos Islands. *Proc. Gulf Carib. Fish. Inst.* Vol **54**.

Clerveaux, W., and D. Vaughn. 2001. An Investigation of the Effects of Increasing Fishing Efficiency on the Productivity of the Queen Conch (*Strombus gigas*) and Caribbean Spiny Lobster (*Panulirus argus*) Fisheries within the Turks and Caicos Islands. *Proc. Gulf Carib. Fish. Inst*. Vol **54**.

Cook, R. M., A. Sinclair, and G. SStefanson. 1997. Potential collapse of North Sea cod stocks. Nature 385:521-522.

Cresswell, L., and M. Davis. 1991. The queen conch, well-bred queen of the Caribbean. J. World Aquaculture Soc. 22 (1): 28-41.

D'Asaro, C.N. 1965. Organogenesis, development and metamorphosis in the queen conch, *Strombus gigas,* with notes on breeding habits. Bull. Mar. Sci. 15: 359-416.

Davis, M. 1994. Mariculture techniques for queen conch (*Strombus gigas* L.) Egg mass to juvenile stage. In: Queen Conch Biology, Fisheries and Mariculture (RS Appledorn & B Rodriguez, eds) pp231-253.

Doran, E. 1958. The Caicos conch trade. *Geographic Review* 48:388-401.

FAO. 1996. *The state of the world fisheries and aquaculture*. FAO Fisheries circular, No. 40. Rome. 125 pp.

FAO. 1996. FAO Technical Guidelines for Responsible Fisheries No. 2. Rome, 54p.

Forbes, M & Garland, JL. 1997. Status of the queen conch, *Strombus gigas* in the Turks and Caicos Islands. : Proceedings: International Queen Conch conference, San Juan, Puerto Rico. (JM Posade & G Garcia-Molinev, eds). Pp.120-122.

Friedlander, A., R. Appeldoorn, and J. Beets. 1994. Spatial and temporal variations in stock abundance of queen conch, *Strombus gigas,* in the U.S. Virgin Islands. In: Queen conch biology, fisheries and mariculture. R.S. Appeldoorn and B. Rodiquez, Eds. Fundacion Cientifica Los Roques, Caracas, Venezuela. Pp.51-60.

Garcia, S., P. Sparre and J. Csirke, 1989. Estimating surplus production and maximum sustainable yield from biomass data when catch and effort time series are not available. Fish.Res. , 8:13-23

General Environmental Multilingual Thesaurus. 2000. http://glossary.eea.eu.int/EEAglossary/o/overexploitation.

Glazer, RA & Berg, CJ, Jr. 1994. Queen conch research in Florida: An overview. In: Queen Conch Biology, Fisheries and Mariculture (RS Appledorn & B Rodriguez, eds) pp79-98.

Gulland, J.A. 1969. Manual of methods for fish stock assessment. Part 1. Fish population analysis. FAO Man.Fish.Sci., (4):154 p. Issued also in French and Spanish

Gulland, J.A. 1983. Stock assessment: Why? FAO Fisheries circular. No. 759. 17 pp.

Gulland, J.A. 1974. *The management of marine fisheries*. SCIENTECHNICA (Publishers) LTD. Bristol. 198 pp.

Hesse, C. (Unpublished report). The conch industry in the Turks and Caicos Islands. A report prepared for the Turks and Caicos Island Government and Fisheries Department.

Hill, H. (Unpublished report). The effects of habitat selection and release size on mortality rates of Hatchery-reared juvenile queen conch, *Strombus gigas,* on South Caicos, TCI. December. 1992.

King, M. 1995. *Fisheries Biology and Management*. Fishing News Books. Oxford. United Kingdom. 341 pp.

Kirkwood, G.P., J.R. Beddington, and J.A. Rossouv. 1994. Harvesting species of different life spans. In: Large-scale ecology and conservation biology. P.J. Edwards, R. May, and N.R. Webb Eds. Blackwell Scientific Publ., Oxford. pp 199-227.

Lauck, T., C.W. Clark, M. Mangel, and G.R. Munro. 1998. Implementing the precautionary principle in fisheries management through marine reserves. Ecological Applications 8:S72-S78.

Little, C. 1965. Notes on the anatomy of the queen conch, *Strombus gigas.* Bull. Mar. Sci. 15: 338-358.

Luckhurst, B. 1997. Stratergies for Lobster and Conch Assessment. In: Lobster and Conch Subproject and Specification and Training Workshop Proceedings. Caricom Fisheries Document No. 19. pp. 175-177.

Mawaring, G. 1997. Overview of Caricom countries catch & effort data collection activities. In: Lobster & Conch Subproject and Specification and Training Workshop Proceedings. Caricom Fisheries Document No. 19. pp. 178-181.

Medley, P & Clerveaux, W. 1998. Conch stock assessment of the Turks and Caicos Islands. Proceedings: Queen conch workshop, Belize City, Belize.

Medley, P. A. H., and C. H. Ninnes. 1999. A stock assessment for the conch (Strombus gigas L.) fishery in the Turks and Caicos Islands. *Bull. Mar. Sci.* **64**:399-406.

Menger-Anderson, LR. (Unpublished report). Salinas channel: Assessment of potential as a grow-out site for juvenile queen conch, *Strombus gigas*. The effect of size and density on survival and growth. School for Field Studies. April 1993.

Mitton, J.B., C.J. Berg Jr., K.S. Orr. 1989. Population structure, larval dispersal, and gene flow in the queen conch, *Strombus gigas,* of the Caribbean. Biol. Bull. 177: 356-362.

Mora, O. 1994. Analisis de la pesqueria del caracol pala (*Strombus gigas* L.*)* en Colombia. In: Appeldoorn, R.S. and Rodriguez. B. (Eds.) *Strombus gigas.* Queen Conch Biology, Fisheries and Mariculture, Fundacion Cientifica Los Roques, Caracas, Venezuela. Pp. 137-144.

Mulliken, T.A. 1996. Status of the queen conch fishery in the Caribbean. *TRAFFIC Bull.* **16:**17-28.

Ninnes, C. 1994. A review on Turks and Caicos Islands fisheries for *Strombus gigas* L. In: Queen Conch Biology, Fisheries and Mariculture (RS Appledorn & B Rodriguez, eds) pp. 67-72.

________& Medley, P. 1997. Fisheries assessment and management in the Turks and Caicos Islands. In: Lobster and Conch Subproject and Specification and Training Workshop Proceedings. Caricom Fisheries Document No. 19. pp. 264-290.

Nixon, A. 1997. World fisheries: the current crisis. http://www.parl.gc.ca/information/library/ PRBpubs/bp434-e.htm

NMFS, 2001. Report to congress: Status of the fisheries of the United States. http://www.fisheries.org/marinestocks_index.htm

Osprey, O. 2002. Olivia Osprey's Tour of the Turks and Caicos Islands. Mark Woodring, DVM.

Paulos, N. (Unpublished report). Density dependent and size related effects on the growth of *Strombus Gigas* juveniles in South Caicos, BWI. School For Field Studies. August 1992.

Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. FAO Fish. Circ. No. 729. 54 pp.

Pitcher, C. R., T. D. Skewes, D. M. Dennis, and J. H. Prescott. 1992. Estimation of the abundance of the tropical lobster *Panulirus ornatus* in Torres Strait, using visual transect-survey methods. Mar. Bio. 113, 57-64.

Post, John. R., and F.D. Johnson. 2001. The status of bull trout (*Salvelinus confluentus*) in Alberta. Wildlife status report. Alberta Environment, Fisheries and Wildlife Management Division and Alberta Conservation Association.

Post, John. R. et al. 2002. Canada's recreational fisheries: The invisible collapse? http://www.fishries.org/fisheries/f0201/f02016-17.pdf

Randall, J.E. 1964. Contributions to the biology of the queen conch *Strombus gigas*. Bull. Mar. Sci. Gulf Caribb. 14: 246-295.

Robertson, R. 1959. Observations on the spawn and veligers of conchs (*Strombus*) in the Bahamas. Proc. Malacol. Soc. Lond. 33: 164-171.

Robertson, R. 1961. The feeding of *Strombus* and related herbivorous marine gastropods : with a review and field observations. Not. Nat., Acad. Nat. Sci. Phila. 343: 1-9.

Roughgarden, J., and F. Smith. 1996. Why fisheries collapse and what to do about it. Proceedings of the National Academy of Science 93:5078-5083.

Sadler, H.E. 1997. *Turks and Caicos Landfall. A history of the Turks and Caicos Islands.* United Cooperative Printers, Kingston, Jamaica, 299 pp.

Seijo, J.C., Defeo, O. and S. Salas. 1998. *Fisheries bioeconomics: theory, modelling and management*. FAO Fish. Tech. Paper 368. Food and Agriculture Organization, Rome. 108 pp.

Schaefer, M., 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bull.I-ATTC/Bol.CIAT, 1 (2): 27-56

Smith, G. B. and van Nierop, M. 1984. Distribution, Abundance and the Potential Yield of Shallow Water Fishery Resources of the Little and great Bahama Banks. UNDP/FAO Fish. Dev. Proj. BHA/82/002:1-78.

Sparre, P., and S.C. Venema. 1992. *Introduction to tropical fish stock assessment, part one-manual*. FAO Fish. Tech. Paper. 306/1- Rev 1. Food and Agriculture Organization, Rome. 376 pp.

Stoner, AW, et al. 1992. Seasonality in reproductive activity and larval abundance of queen conch *Strombus gigas*. In: Fisheries Bulletin, U.S. 90: pp161-170.

__________ et al. 1994. Large scale distribution of queen conch nursery habitats: Implication for stock Enhancement. In: Queen Conch Biology, Fisheries and Mariculture (RS Appledorn & B Rodriguez, eds) pp169-190.

__________ 1994. Significance of habitat and stock pre-testing for enhancement of natural fisheries: Experimental analyses with queen conch *Strombus gigas*. In: Journal of the world aquaculture society. pp 155-165.

__________& Davis, M. 1997. Abundance and distribution of queen conch veligers (*Strombus gigas* L) In the Central Bahamas. I. Horizontal patterns in relation to reproductive and nursery grounds. In: Journal of Shellfish Research, Vol. 16, No. 1. pp 7-18.

__________ et al. 1997. Recruitment of *Strombus* veligers to the Florida Keys reef tract: Relation to hydrographic events. In: Journal of shellfish research.Vol.16.pp1-6

__________ 1997. Status of queen conch research in the Caribbean. Proceedings:

International Queen Conch conference, San Juan, Puerto Rico. (JM Posade & G Garcia-Molinev, eds). pp 22-39.

Tam, L. (Unpublished report). Predation of hatchery reared juvenile *Strombus gigas* in South Caicos: Day vs. night. School for Field Studies. August. 1992.

Tewfik, A.1996. An assessment of the biological characteristics, abundance and potential yield of the queen conch (*Strombus gigas*) fishery of the Pedro Bank off Jamaica. MS Thesis, Acadia Univ., Wolfville, N.S., Canada. 139 p.

Tewfik, A. 1997. Life history, ecology, fisheries, stock status, and management measures of the queen conch, *Strombus gigas*. In: Lobster and conch subproject specification and training workshop proceedings, 9-12 October, 1996, Kingston, Jamaica. CARICOM Fisheries Research. Doc. No. 19. pp 84-117.

Tewfik, A. and Bėnė, C. 2000. Densities and age structure of fished versus protected populations of Queen Conch (*Strombus gigas* L.) in the Turks and Caicos Islands. In: Proceedings of the 51st Annual Gulf and Caribbean Fisheries Institute. Fort Pierce, Florida.

Theil, S. 2001. Queen Conch fisheries and their management in the Caribbean. Technical report to the CITES Secretariat. TRAFFIC Europe, Brussels, Belgium.

Troadec, J.-P., 1977. Méthodes semi-qunatitatives d'évaluation. FAO Circ. Pêches, (701): 131-141.

Welcomme, R.L. 1995. Status and trends of global inland fisheries. *In* N.B. Armantrout and R.J. Wolotra. *Conditions of the world's aquatic habitats.* Proceedings of the World Fisheries Congress, Theme 1, p. 122-138. Oxford & IBH Publishing Co.

ACRONYMS

CITES	Convention on International Trade of Endangered Species
CPUE	Catch Per Unit Effort
D.E.C.R.	Department of Environment and Coastal Resources
FAO	Food and Agriculture Organization of the United Nations
LRP	Limit Reference Point
MSY	Maximum Sustainable Yield
NMFS	National Marine Fisheries Service
SPAW	Specially Protected Areas & Wildlife
TAC	Total Allowable Catch
TRP	Target Reference Point
TCI	Turks and Caicos Islands

APPENDIX I

PHOTO GALLERY OF THE CONCH INDUSTRY OF THE TURKS AND CAICOS ISLANDS

(a)

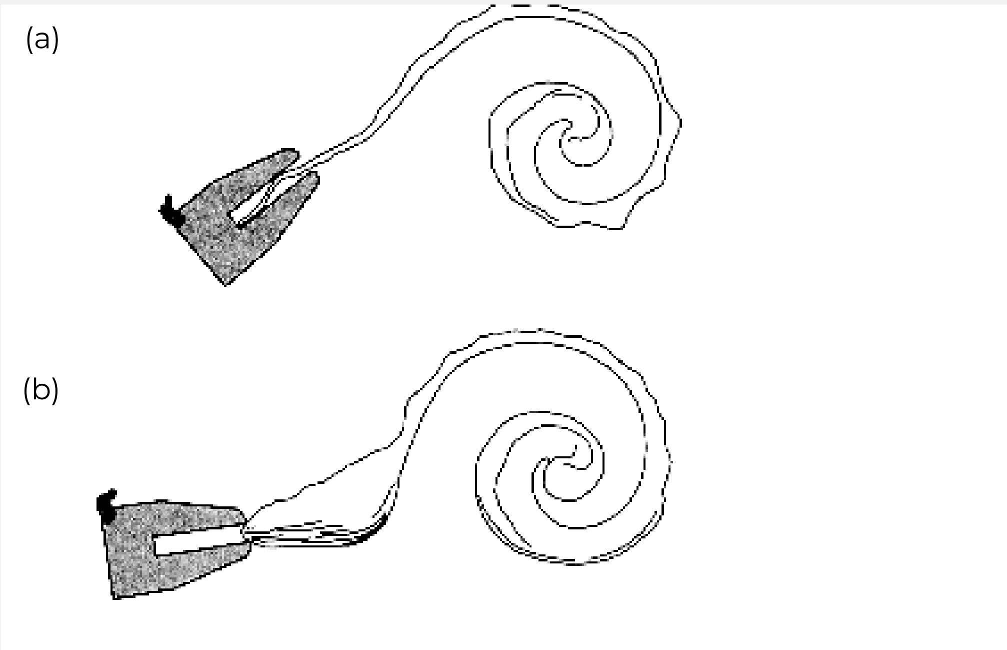
(b)

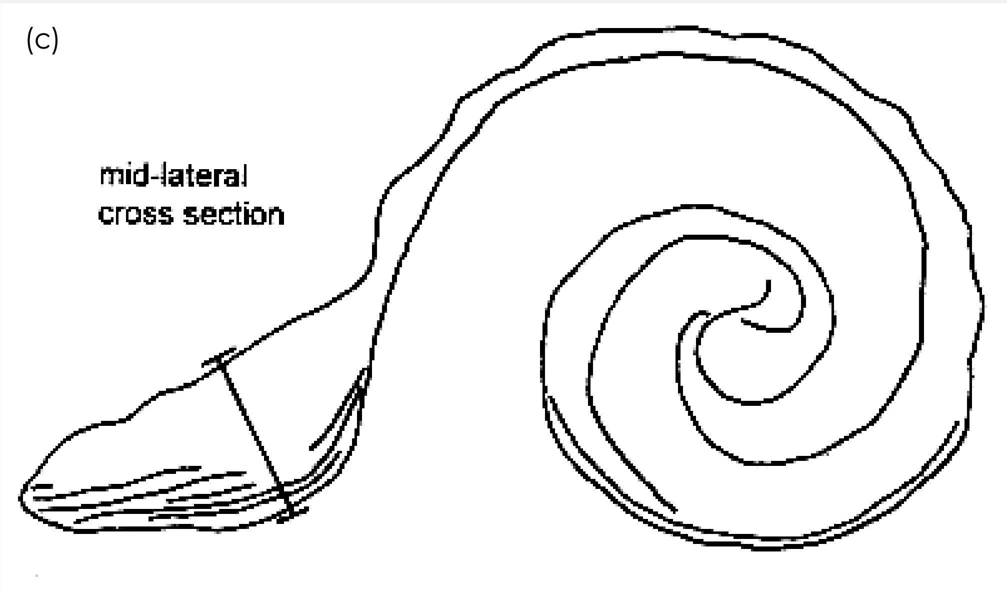
(c)

Queen conch (*Strombus giags*) has been exploited in the Turks and Caicos Islands for more then a century. The earliest record of exploitation dates back to 1887, in where conch was dried, shipped to Haiti and bartered for fresh fruits and rum. Figure (a) is a boy with a pack of dried conchs on his head, possibly on his way to trade with visiting merchants from Haiti. Figure (b) shows a dug-out sailing canoe which was traditionally used in the conch fishery in the early 1900 until the mid 1960 when motor powered speedboats replaced them. Figure (c) is a picture of fresh conch being landed at one of the processing plants on the island of South Caicos.

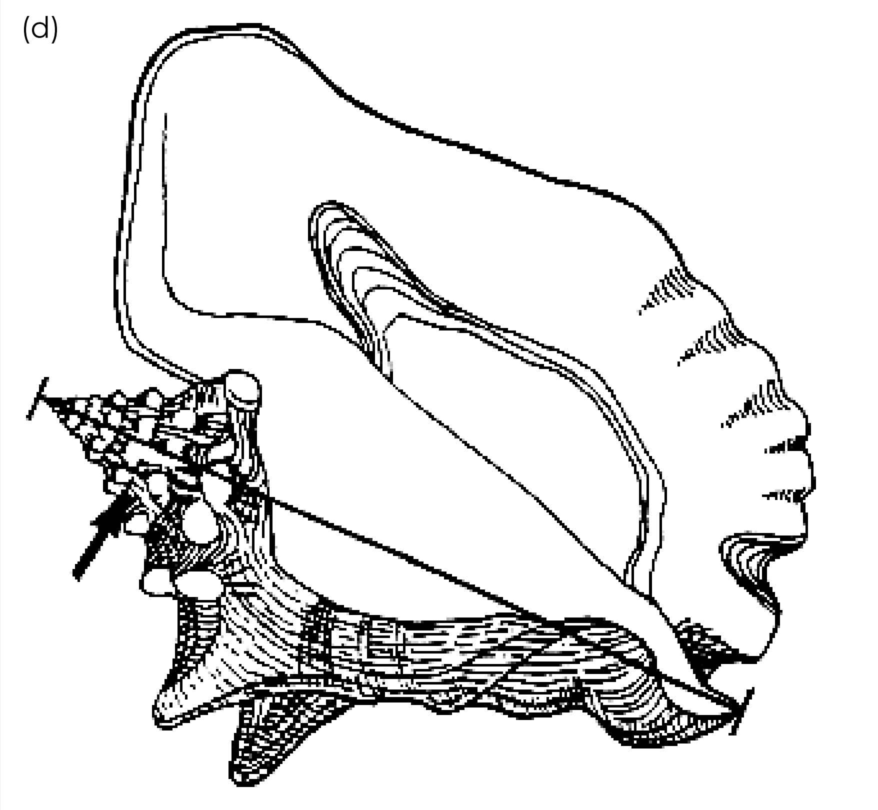
APPENDIX II

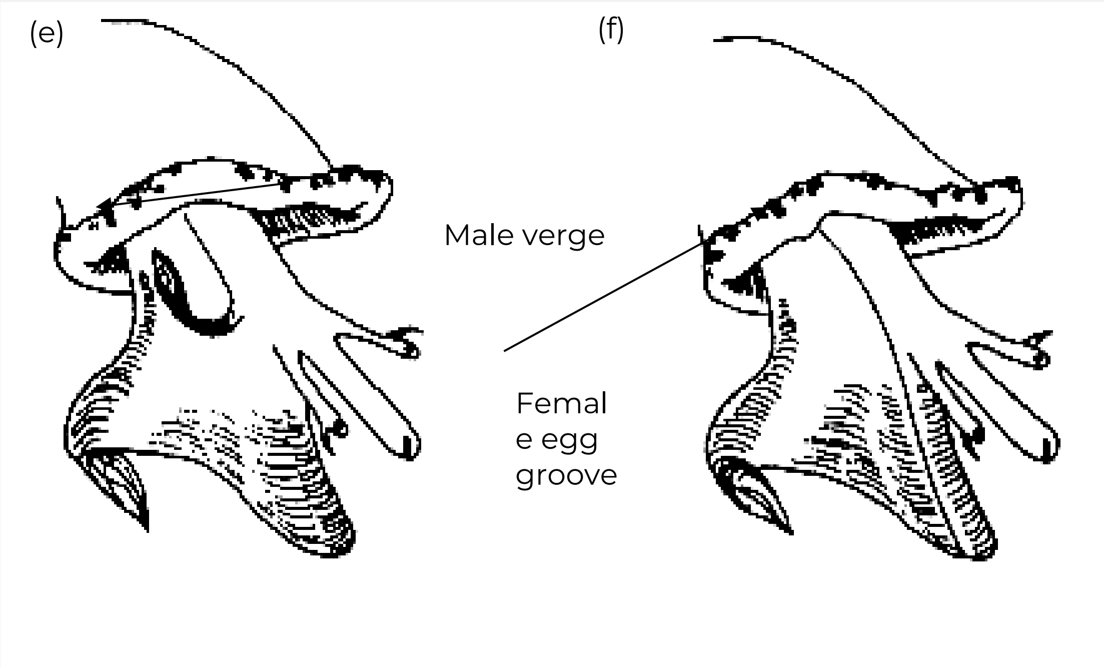
Illustrations of morphometric measurements on the queen conch.

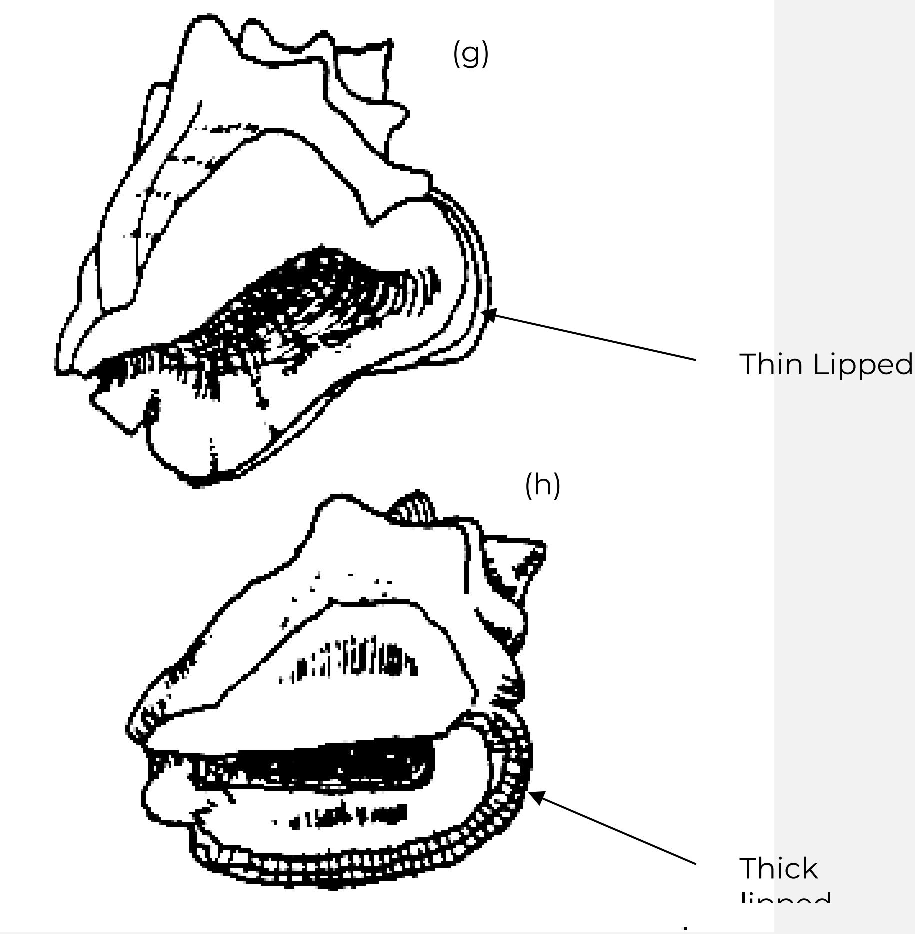




2





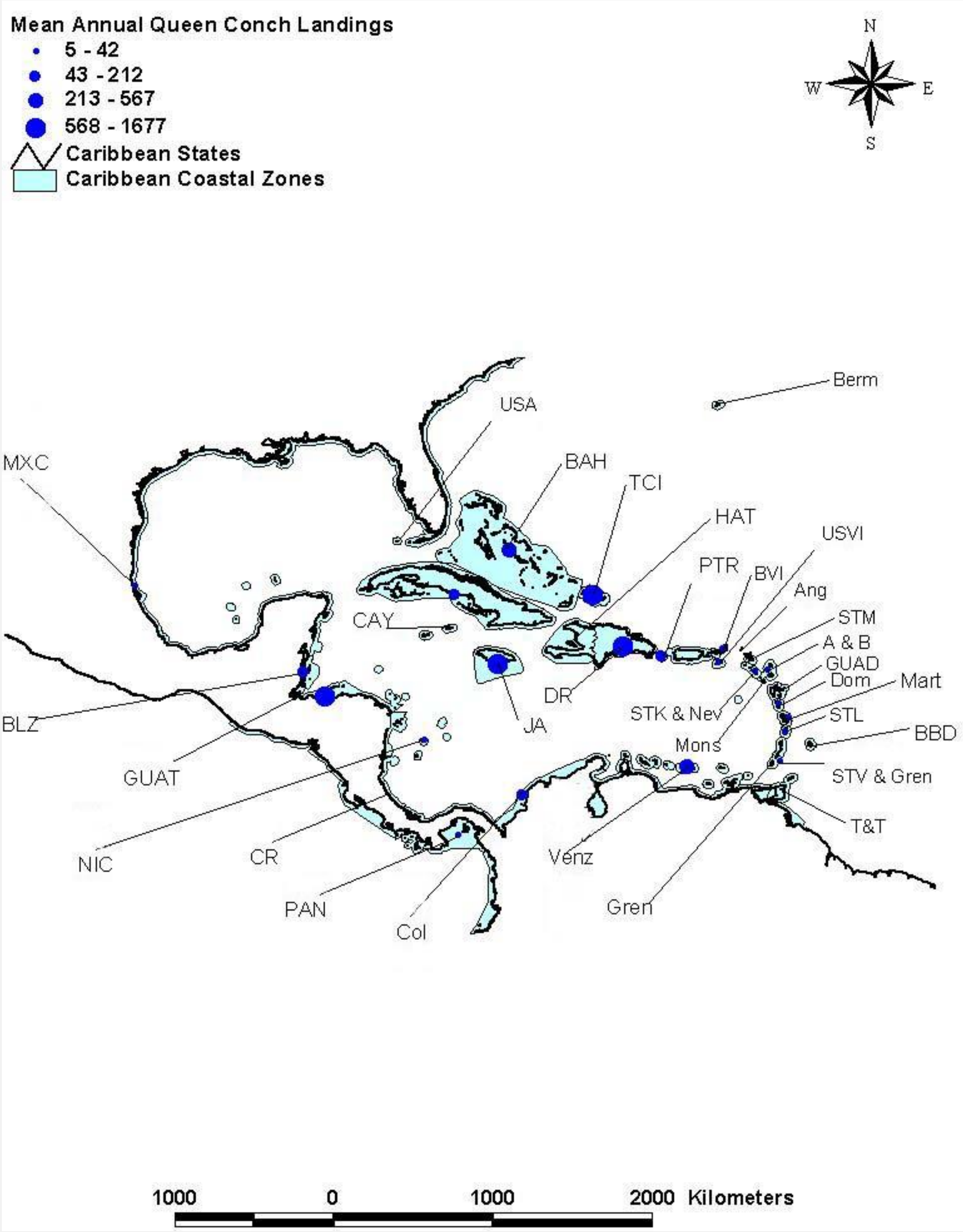


During the juvenile stage, queen conchs grow in shell length. However, at the on-start of sexual maturity, they began to form a flaring lip with thickened with age. Figure (a) and (b) is a cross section of a queen conch shell with a caliper measuring the shell lip. A conch greater then 200 mm in shell length but less then 4 mm shell lip thickness, it is therefore not yet mature and is classed as sub adult. Figure (c) is displaying the correct procedure for measuring shell lip thickness and figure (d) for shell length. The male (figure e) queen conch can be easily distinguished from the female (figure f) by the presence of the male verge and egg groove in female. Figure (g) and (h) is showing the difference between a thick lipped old adult conch and that of a young adult.

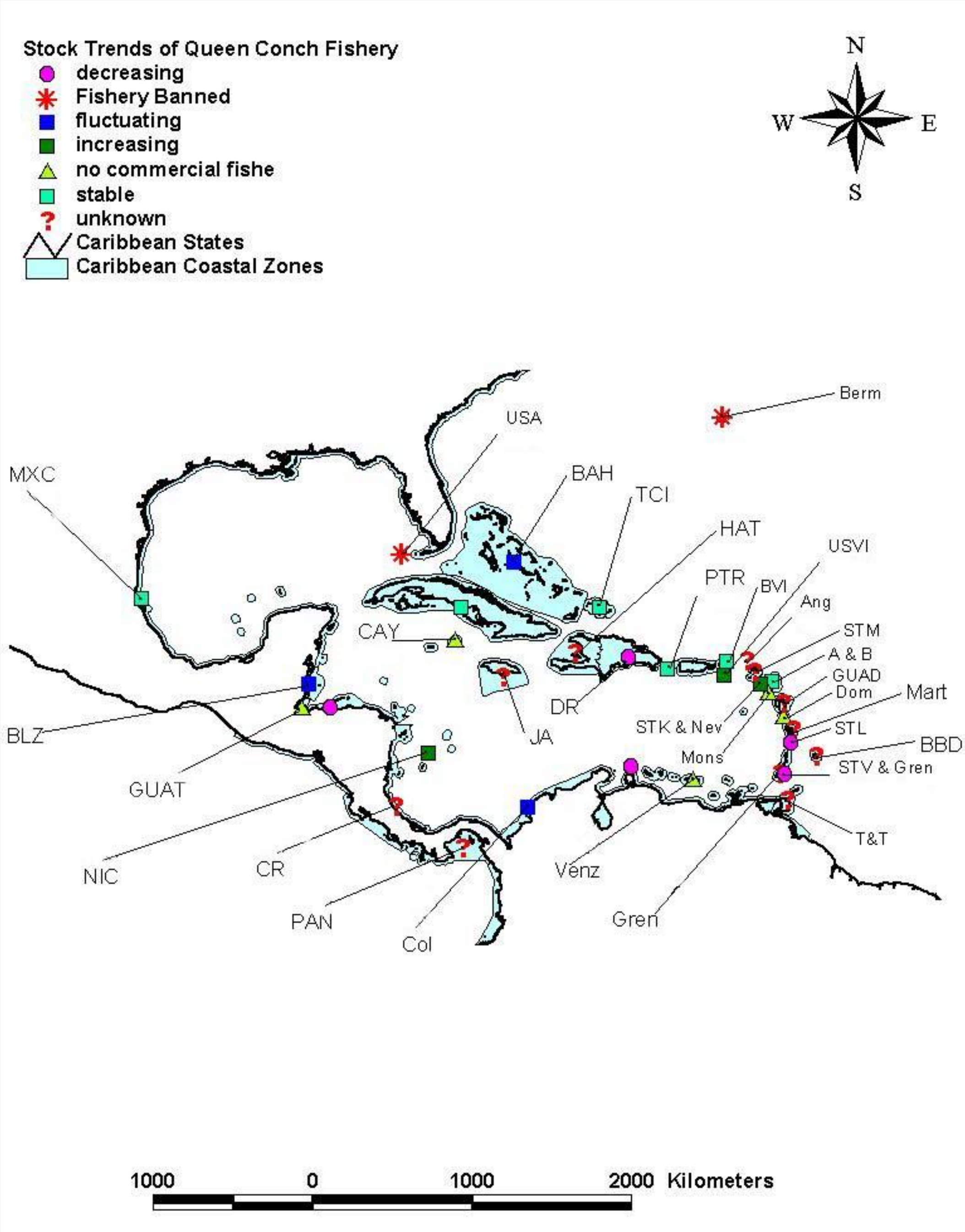
APPENDIX III

Graphical representation of queen conch distribution, stock status and management strategies for the region and the study area (Turks Bank)

(a)

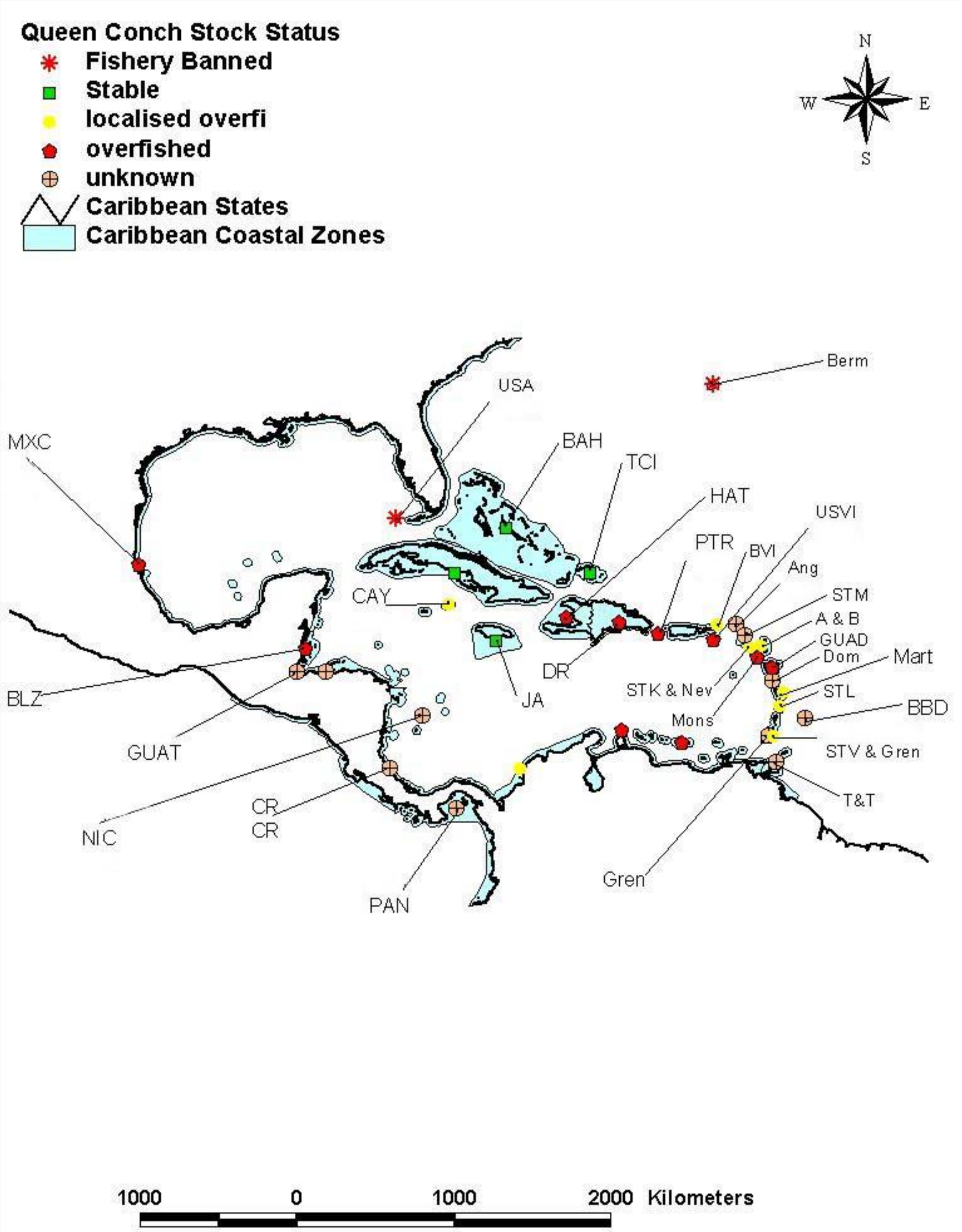


(b)



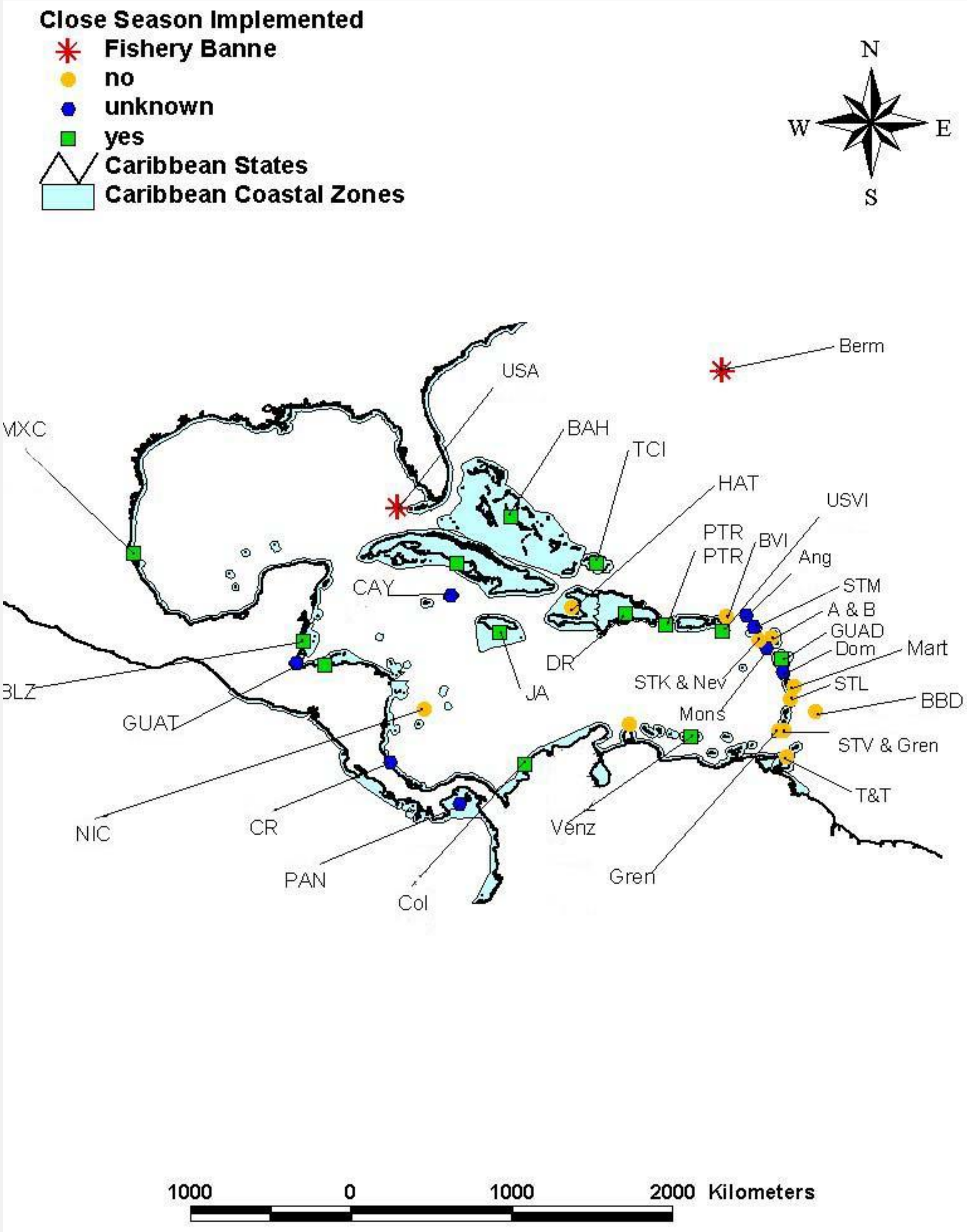
Stock Trends of Queen Conch Fishery
decreasing
Fishery Banned
fluctuating
increasing
no commercial fishe
stable
unknown
Caribbean States
Caribbean Coastal Zones
N
W
E
S
Berm
USA
MXC
BAH
TCI
HAT
USVI
PTR
BVI
Ang
STM
A & B
GUAD
Dom
Mart
CAY
DR
JA
BLZ
GUAT
STK & Nev
Mons
STL
BBD
STV & Gren
T&T
NIC
CR
PAN
Col
Venz
Gren
1000
0
1000
2000 Kilometers

(c)

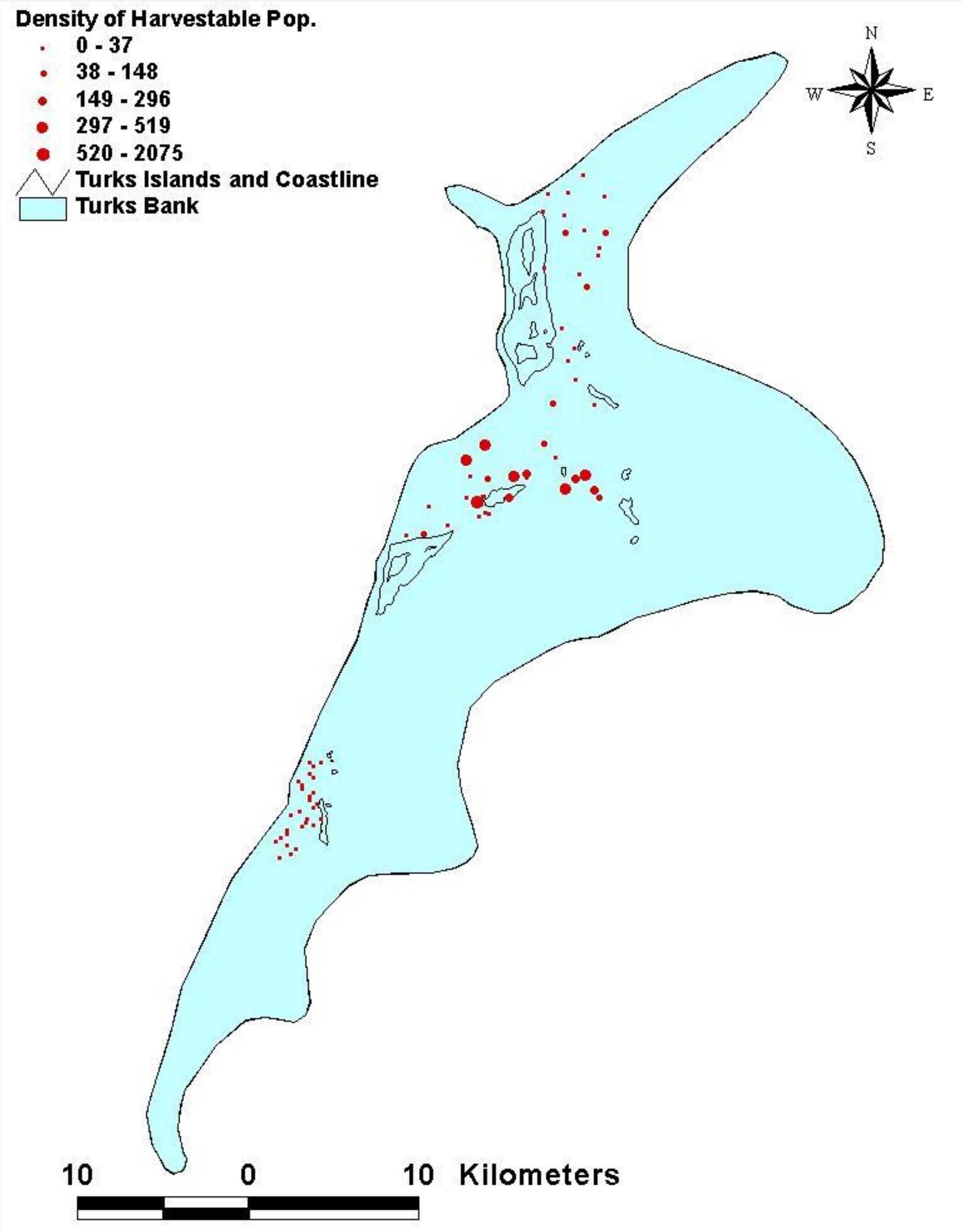


Queen Conch Stock Status
Fishery Banned
Stable
localised overfi
overfished
unknown
Caribbean States
Caribbean Coastal Zones
N
W
E
S
Berm
USA
MXC
BAH
TCI
HAT
USVI
PTR
BVI
Ang
STM
A & B
GUAD
Dom
Mart
CAY
DR
JA
STK & Nev
STL
BBD
Mons
STV & Gren
BLZ
GUAT
NIC
CR
CR
T&T
PAN
Gren
1000
0
1000
2000
Kilometers

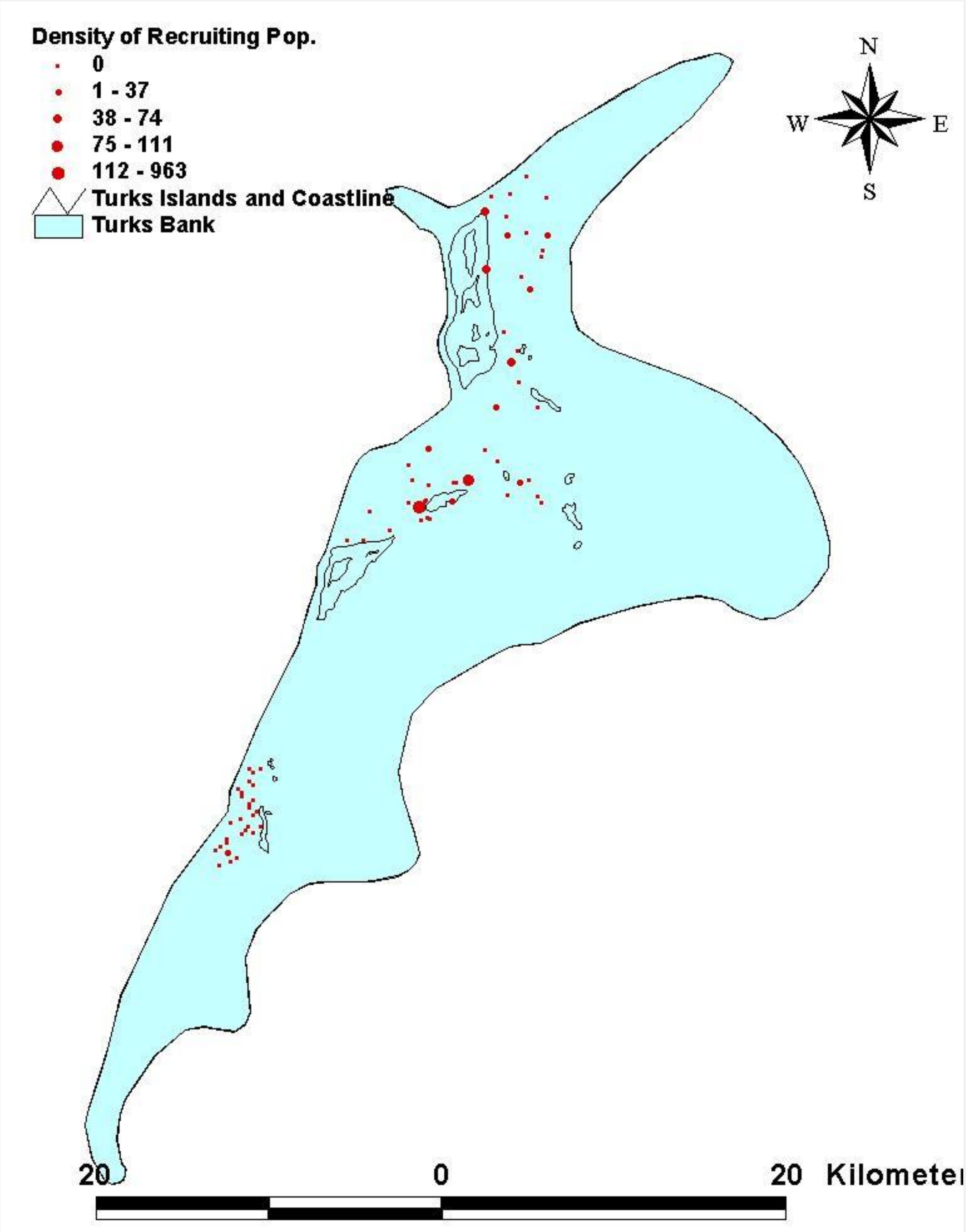
(d)


Close Season Implemented
Fishery Banne
no
unknown
yes
Caribbean States
Caribbean Coastal Zones
N
W
E
S
Berm
USA
MXC
BAH
TCI
HAT
USVI
PTR
PTR
BVI
Ang
STM
A & B
GUAD
Dom
Mart
STL
BBD
STV & Gren
T&T
CAY
DR
JA
STK & Nev
Mons
BLZ
GUAT
NIC
CR
PAN
Col
Venz
Gren
1000
0
1000
2000 Kilometers

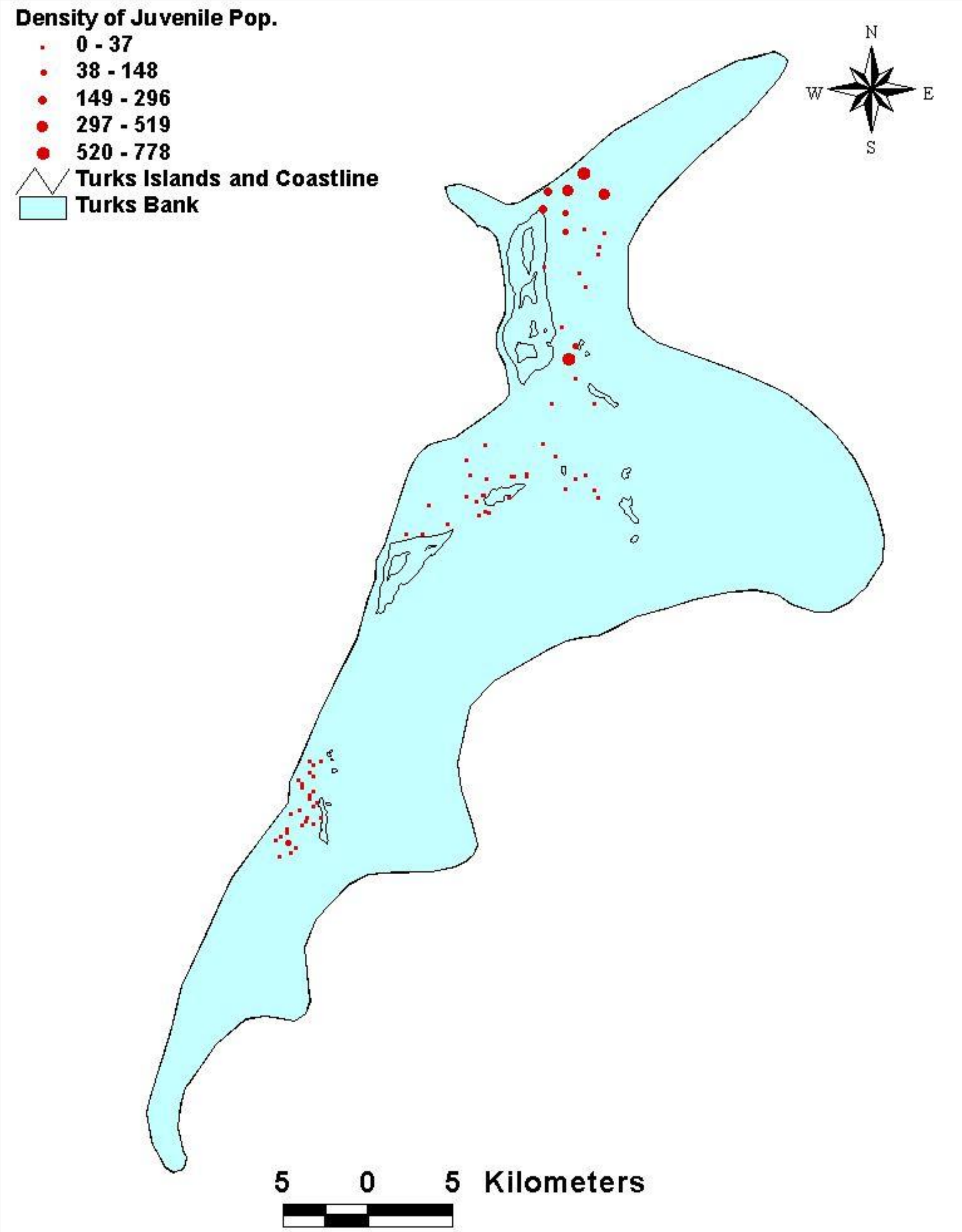
(e)


Density of Harvestable Pop.
0 - 37
38 - 148
149 - 296
297 - 519
520 - 2075
Turks Islands and Coastline
Turks Bank
N
W
E
S
10
0
10
Kilometers

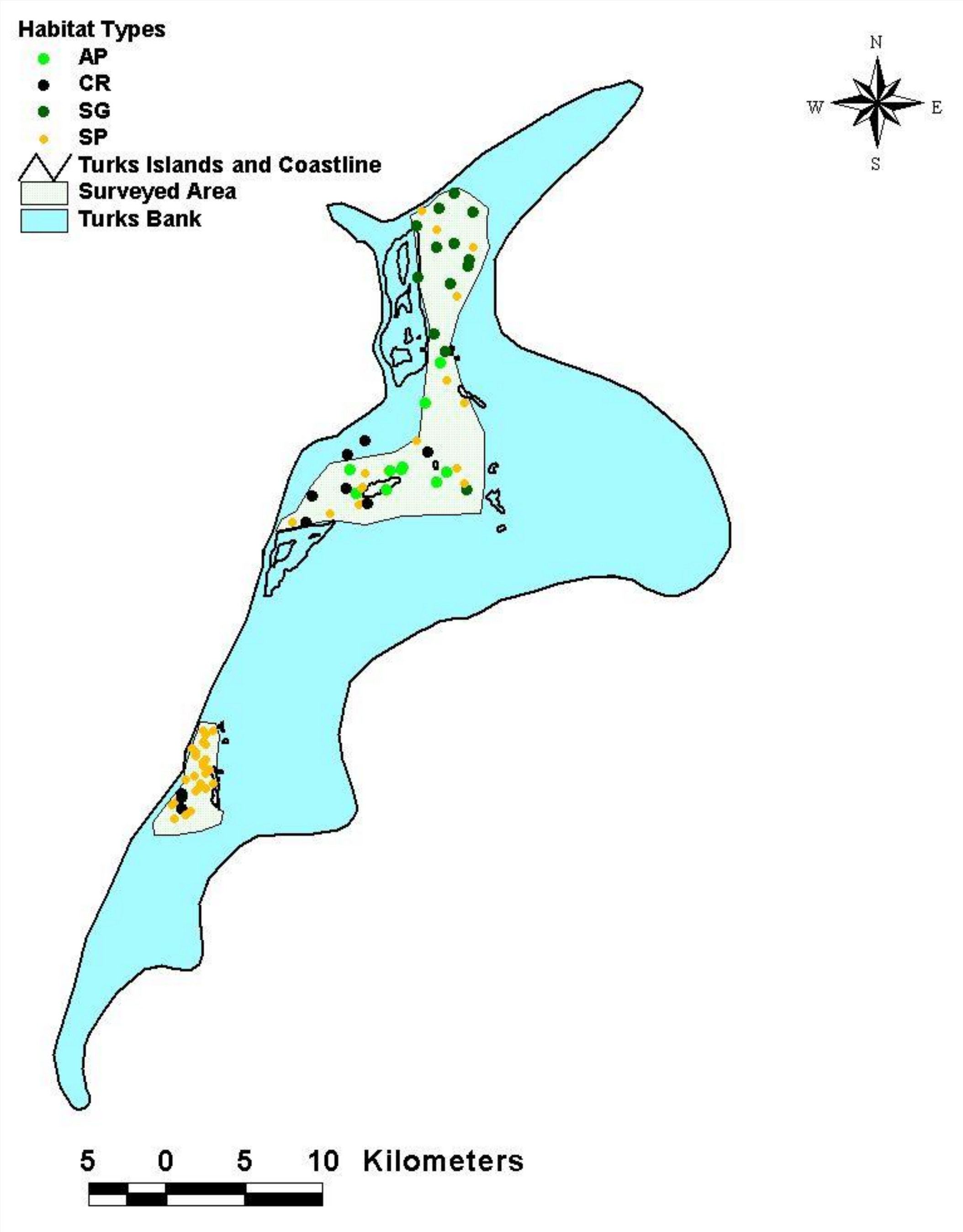
(f)


Density of Recruiting Pop.
0
1 - 37
38 - 74
75 - 111
112 - 963
Turks Islands and Coastline
Turks Bank
N
W
E
S
20
0
20 Kilometer

(g)


Density of Juvenile Pop.
0 - 37
38 - 148
149 - 296
297 - 519
520 - 778
Turks Islands and Coastline
Turks Bank
N
W
E
S
5 0 5 Kilometers

(h)


Habitat Types
AP
CR
SG
SP
Turks Islands and Coastline
Surveyed Area
Turks Bank
N
W
E
S
5 0 5 10 Kilometers

APPENDIX IV

Table 14. Mean density (per hectare) by site categorised by habitat and size age on the Turks Bank of the Turks and Caicos Islands during the 2001-2002 visual survey.

Site Coordinates		Habitat	Density by Conch Size Categories						Total	Depth
X	Y	Type	SJ	MJ	LJ	SA	YA	OA	Density	(ft)
-71.21	21.34	SP	0	0	0	0	0	0	0	20
-71.20	21.34	CR	0	0	0	0	0	74	74	20
-71.19	21.36	CR	0	0	0	0	0	0	0	30
-71.18	21.35	SP	0	0	0	0	0	0	0	25
-71.17	21.36	AP	0	0	296	667	1556	519	3037	26
-71.17	21.35	SP	0	0	0	0	0	0	0	35
-71.17	21.36	SP	0	0	0	0	0	0	0	40
-71.16	21.36	SP	0	0	0	0	0	0	0	36
-71.16	21.36	SP	0	0	0	0	0	0	0	36
-71.15	21.37	SP	0	0	0	0	0	0	0	20
-71.15	21.37	AP	0	0	0	0	37	444	481	10
-71.14	21.38	AP	0	0	0	0	0	148	148	30
-71.14	21.38	AP	0	0	0	0	0	222	222	25
-71.13	21.41	AP	0	0	37	0	74	0	111	18
-71.12	21.37	AP	0	0	0	0	222	185	407	28
-71.12	21.44	AP	37	704	74	0	0	0	815	18
-71.12	21.44	SG	74	0	0	0	0	0	74	20
-71.11	21.53	SG	741	37	0	0	0	37	815	10
-71.13	21.51	SG	74	185	74	0	37	0	370	11
-71.12	21.45	SG	0	37	0	0	0	0	37	11
-71.13	21.48	SG	0	0	37	37	37	0	111	12
-71.12	21.50	SG	37	74	0	37	111	0	259	13
-71.11	21.48	SG	0	0	0	0	0	0	0	13
-71.11	21.47	SP	0	0	37	0	37	37	111	13
-71.10	21.52	SG	519	0	0	0	0	0	519	14

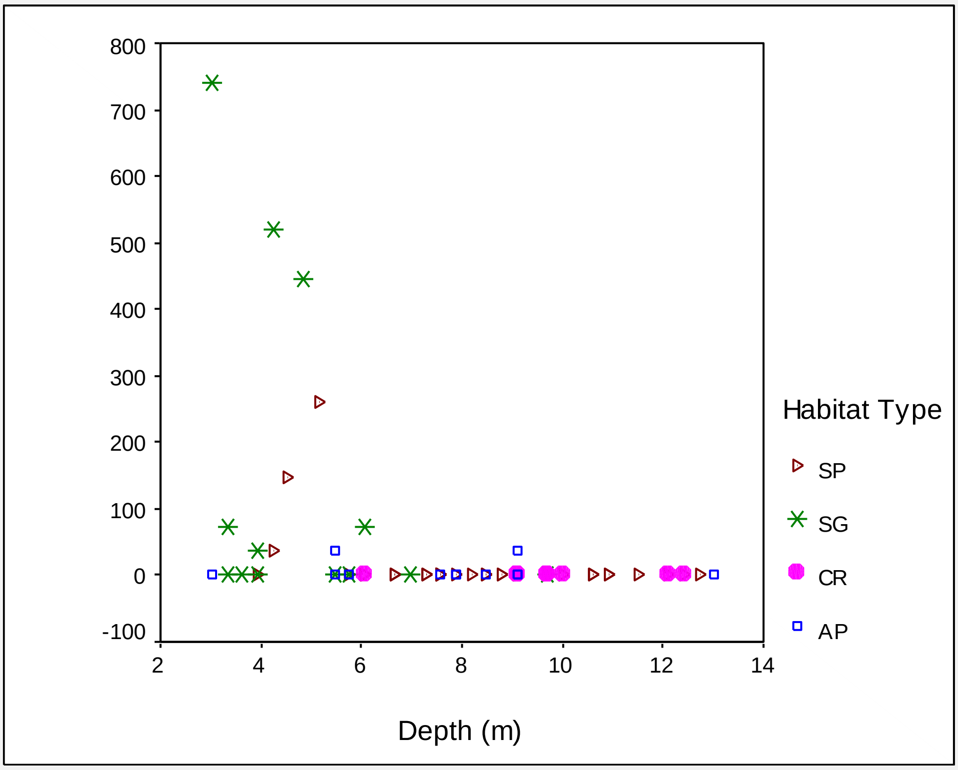
-71.10	*21.50*	SP	37	0	0	37	0	74	148	14
-71.12	*21.51*	SP	148	0	0	0	0	37	185	15
-71.12	*21.52*	SG	444	74	0	0	0	0	519	16
-71.13	*21.52*	SP	259	37	0	0	0	0	296	17
-71.11	*21.50*	SG	0	0	0	0	0	0	0	18
-71.10	*21.49*	SG	0	0	0	0	0	0	0	19
-71.10	*21.49*	SG	0	0	0	0	0	0	0	23
-71.17	*21.36*	CR	0	0	0	0	0	0	0	41
-71.16	*21.36*	SP	0	0	0	0	0	0	0	35
-71.16	*21.35*	CR	0	0	0	0	0	0	0	33
-71.15	*21.36*	AP	0	0	0	37	148	111	296	30
-71.14	*21.37*	AP	37	0	0	111	37	0	185	30
-71.16	*21.37*	SP	0	0	0	0	74	74	148	30
-71.17	*21.37*	AP	0	0	0	0	0	0	0	26
-71.13	*21.39*	SP	0	0	0	0	0	74	74	33
-71.10	*21.36*	SG	0	0	0	0	0	111	111	32
-71.11	*21.37*	SP	0	0	0	0	0	444	444	42
-71.27	*21.18*	SP	0	0	0	0	0	37	37	38
-71.27	*21.17*	SP	0	0	0	0	0	0	0	33
-71.27	*21.18*	SP	0	0	0	0	0	0	0	32
-71.27	*21.19*	CR	0	0	0	0	0	0	0	32
-71.27	*21.19*	CR	0	0	0	0	0	0	0	32
-71.27	*21.18*	CR	0	74	0	37	0	0	111	30
-71.27	*21.20*	SP	0	0	0	0	0	0	0	30
-71.27	*21.18*	SP	0	0	0	0	0	0	0	29
-71.26	*21.18*	SP	0	0	0	0	0	0	0	29
-71.26	*21.21*	SP	0	0	0	0	0	0	0	28
-71.26	*21.20*	SP	0	0	0	0	0	0	0	28
-71.26	*21.19*	SP	0	0	0	0	0	0	0	27
-71.26	*21.21*	SP	0	0	0	0	0	0	0	26

-71.26	21.21	SP	0	0	0	0	0	0	0	25
-71.26	21.19	SP	0	0	0	0	0	0	0	25
-71.26	21.19	SP	0	0	0	0	0	0	0	25
-71.26	21.20	SP	0	0	0	0	0	0	0	25
-71.26	21.22	SP	0	0	0	0	0	0	0	25
-71.26	21.22	SP	0	0	0	0	0	0	0	25
-71.26	21.21	SP	0	0	0	0	0	0	0	25
-71.25	21.19	SP	0	0	0	0	0	0	0	25
-71.25	21.22	SP	0	0	0	0	0	0	0	25
-71.25	21.20	SP	0	0	0	0	0	0	0	24
-71.25	21.21	SP	0	0	0	0	0	0	0	24
-71.25	21.22	SP	0	0	0	0	0	0	0	22
-71.25	21.20	SP	0	0	0	0	0	0	0	22
-71.25	21.22	SP	0	0	0	0	0	0	0	20
-71.25	21.19	SP	0	0	0	0	0	0	0	19
-71.11	21.41	SP	0	0	0	0	37	0	37	20
-71.12	21.43	SP	0	0	0	0	0	0	0	22
-71.11	21.37	SP	0	0	0	0	0	296	296	41
-71.12	21.37	AP	0	0	0	37	0	222	259	43
-71.13	21.38	CR	0	0	0	0	0	0	0	40
		Total	2407	1222	555	1000	2407	3146	10737	
		Mean	32	16	7	13	32	42	143	25
		Standard Deviation	119	85	36	78	182	106	385	8

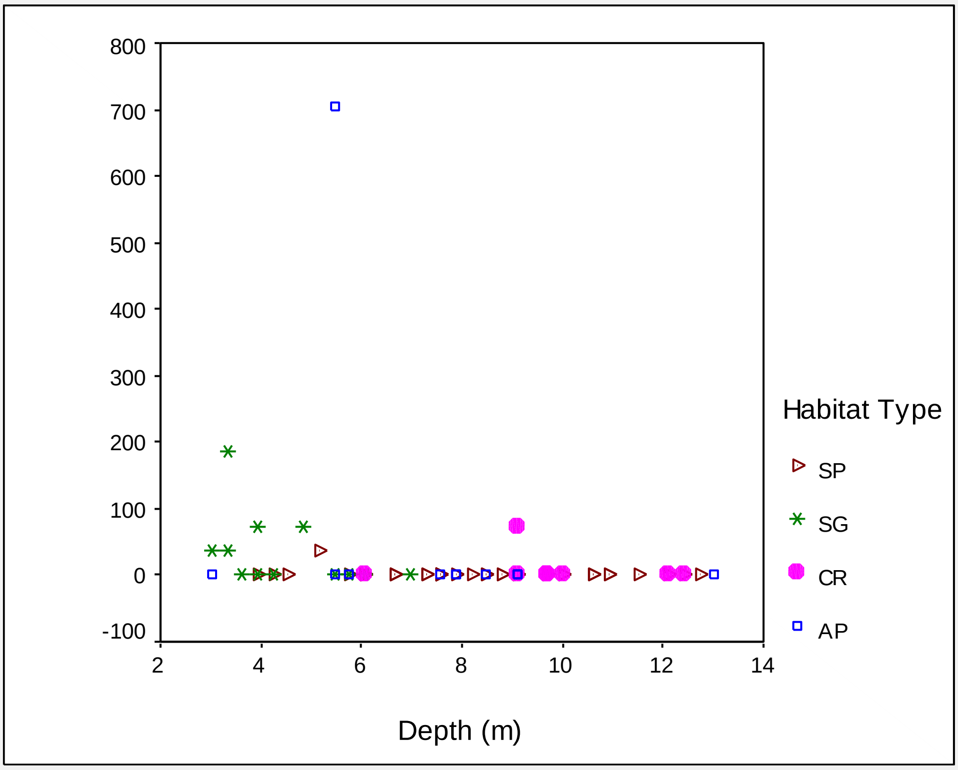
APPENDIX V

GAPHICAL DISPLAY OF THE INFLUENCE OF DEPTH ON THE DENSITY OF QUEEN CONCH ON THE TURKS BANK

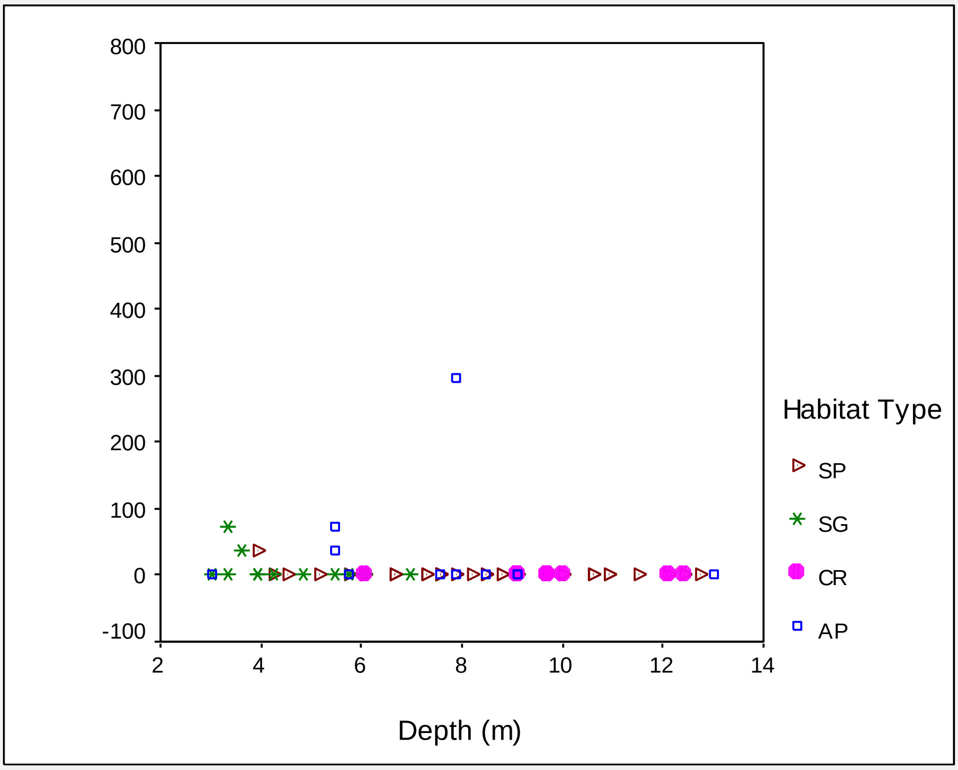
(a)



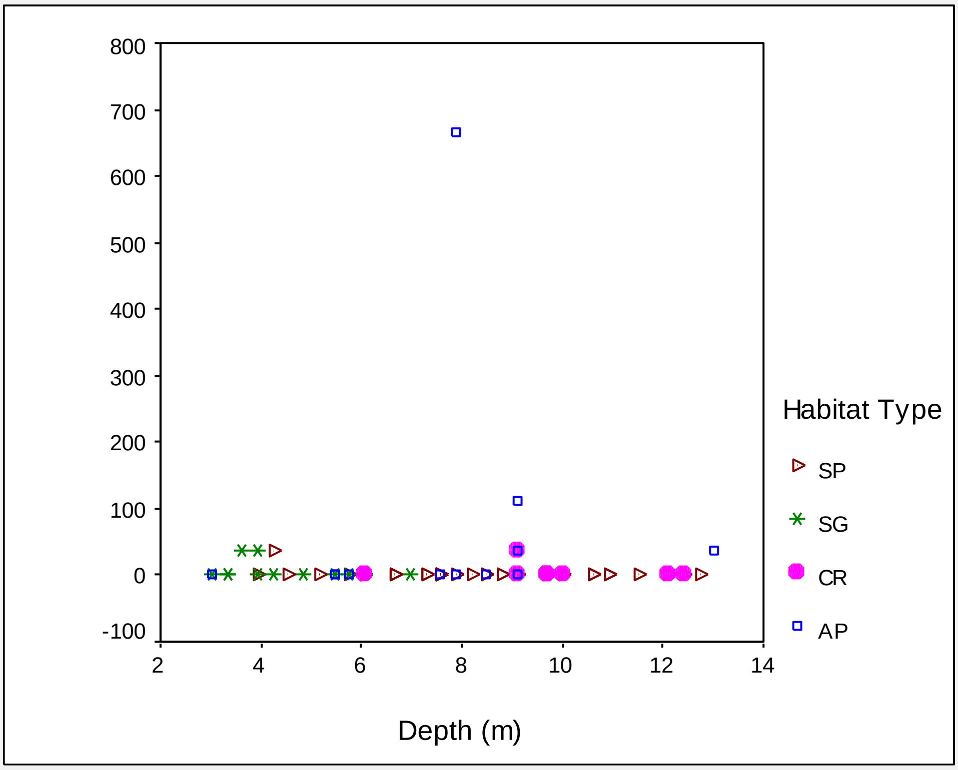
(b)


800
700
600
500
400
300
200
100
0
-100
2
4
6
8
10
12
14
Depth (m)
Habitat Type
SP
SG
CR
AP

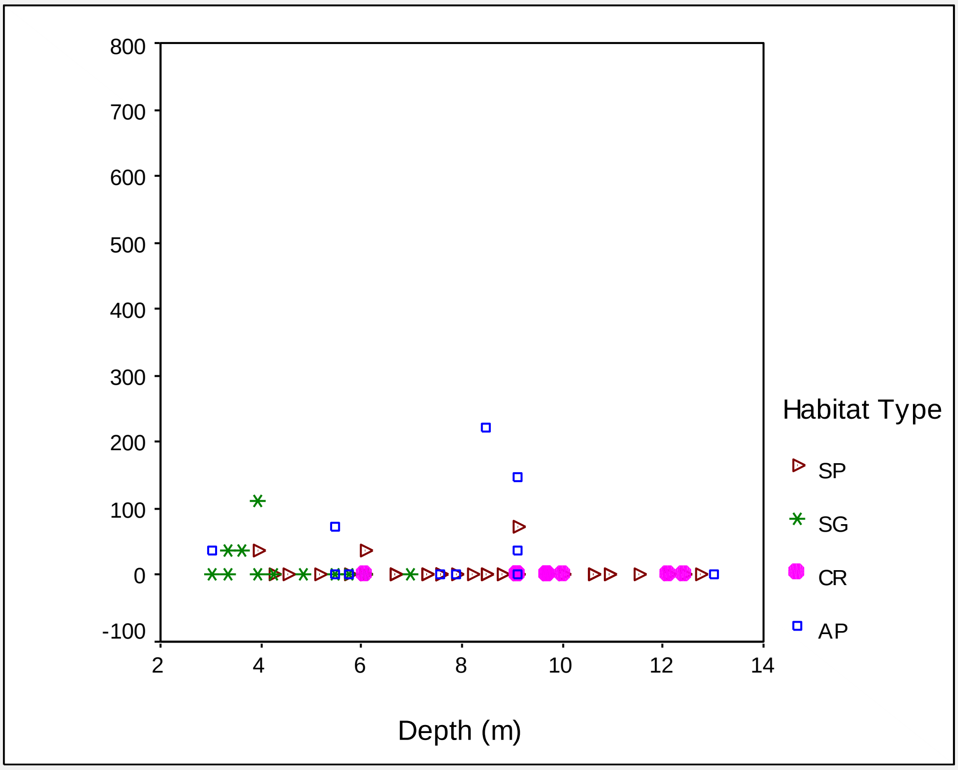
(c)


800
700
600
500
400
300
200
100
0
-100
2
4
6
8
10
12
14
Depth (m)
Habitat Type
SP
SG
CR
AP

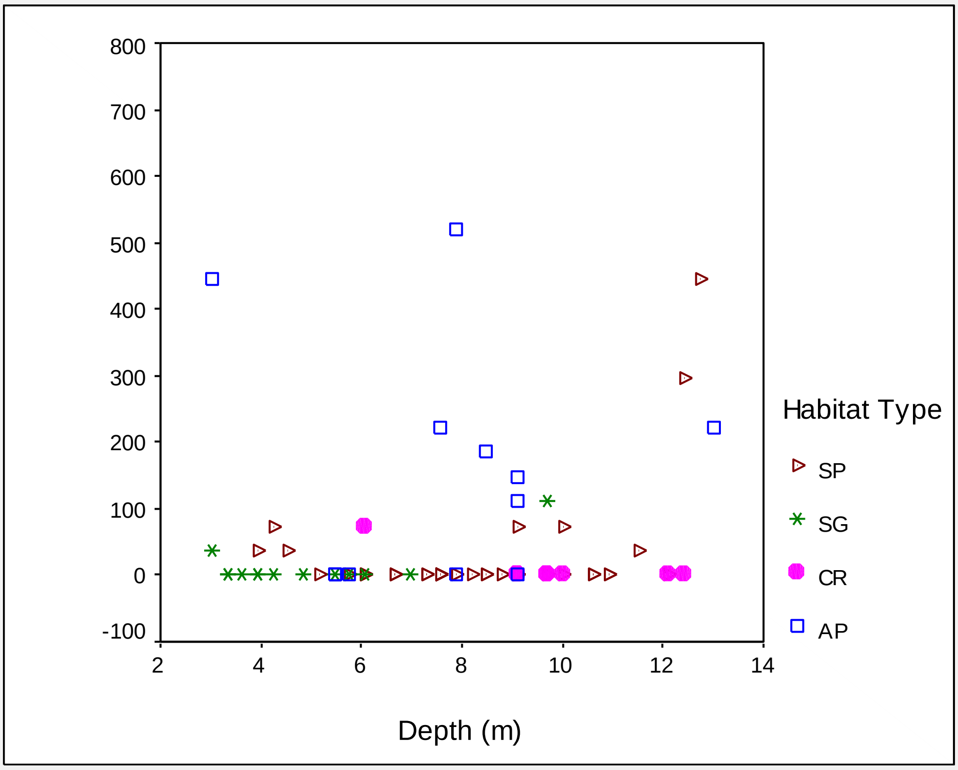
(d)


800
700
600
500
400
300
200
100
0
-100
2
4
6
8
10
12
14
Depth (m)
Habitat Type
SP
SG
CR
AP

(e)


800
700
600
500
400
300
200
100
0
-100
2
4
6
8
10
12
14
Depth (m)
Habitat Type
SP
SG
CR
AP

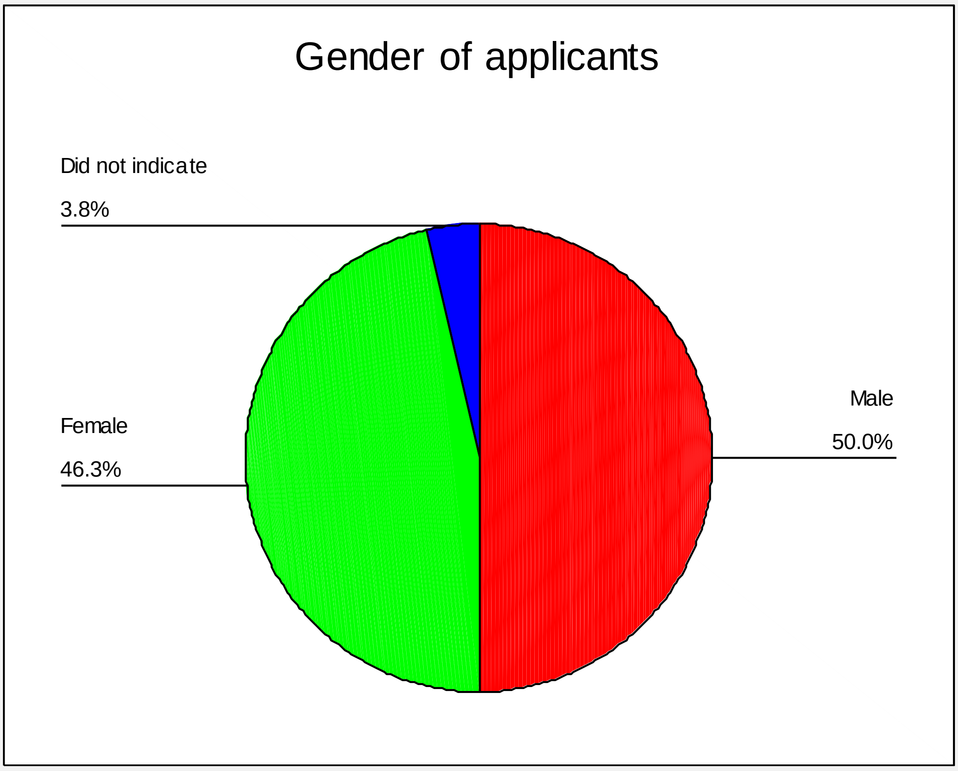
(f)


800
700
600
500
400
300
200
100
0
-100
2
4
6
8
10
12
14
Depth (m)
Habitat Type
SP
SG
CR
AP

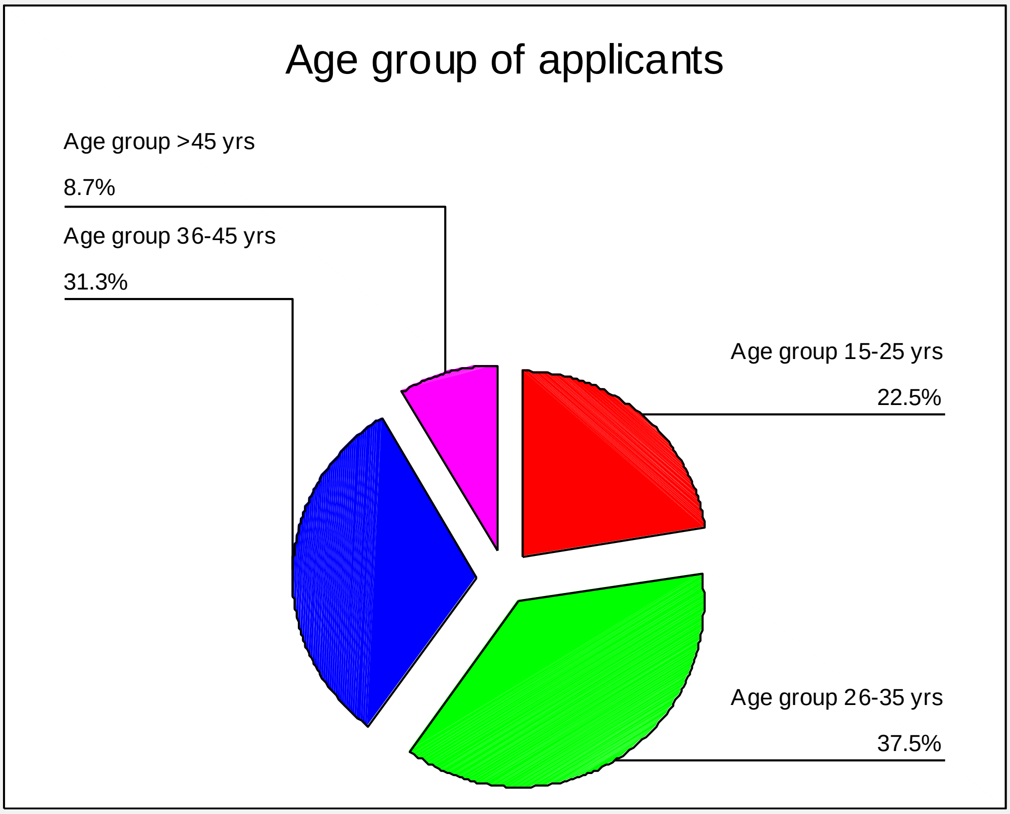
APPENDIX VI

SOCIO-ECONOMIC CENSUS OF GENERAL POPULATION

(a)



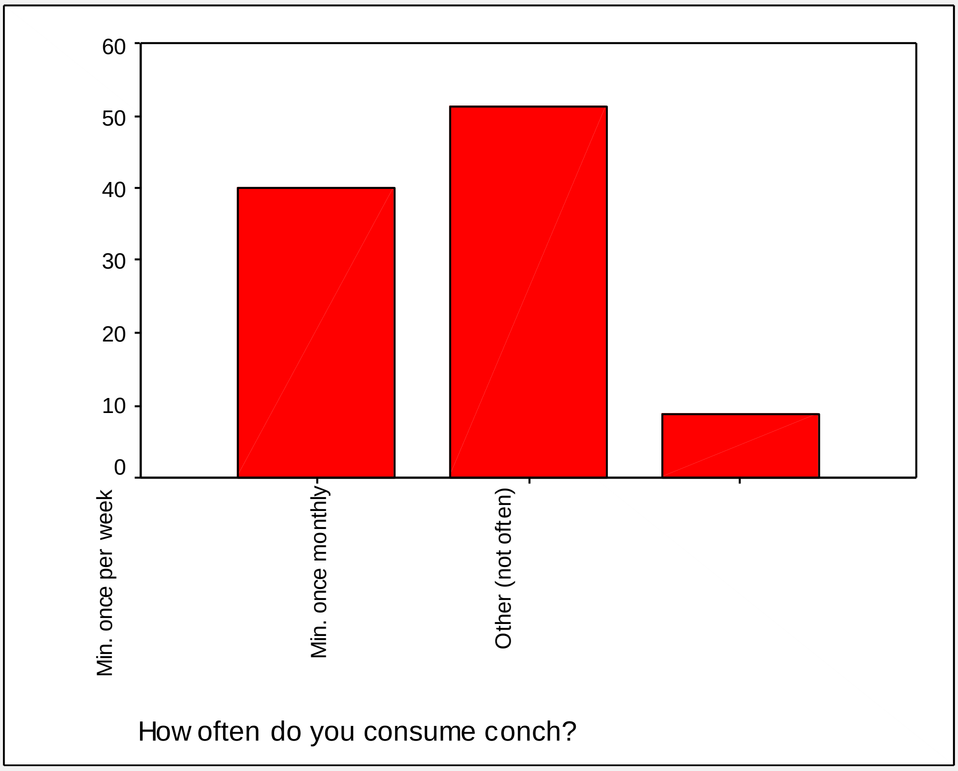
(b)



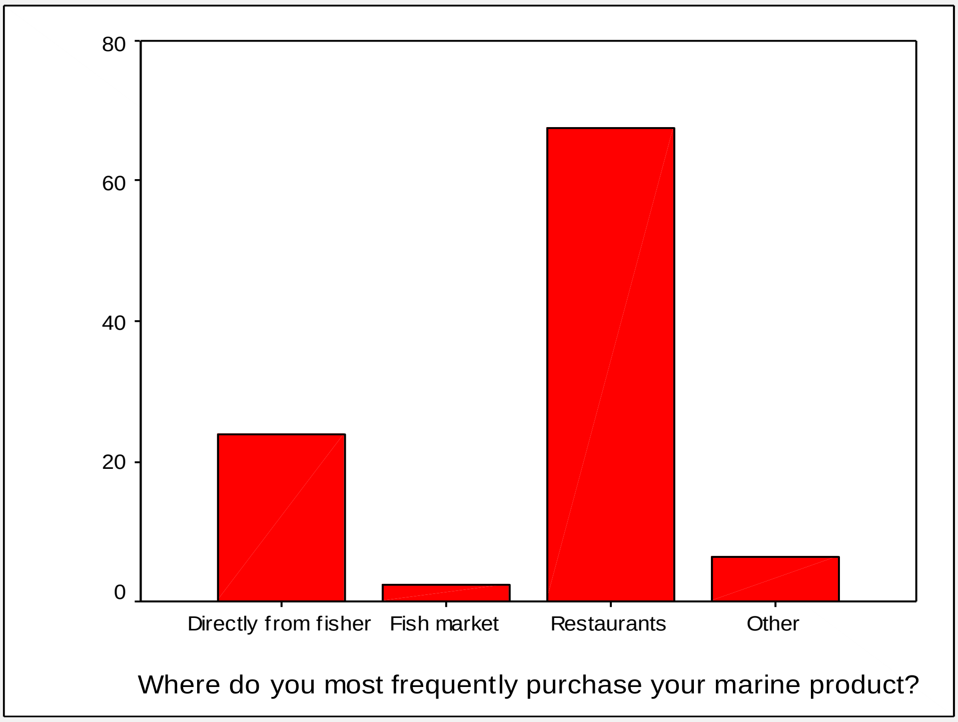
(c)

What marine product is your preferred first choice to eat?		
Products	Frequency	Percent (%)
Spiny Lobster	15	18.8
Queen Conch	26	32.5
Fin-fish	18	22.5
White Meat (e.g. Chicken)	13	16.3
Red Meat (e.g. Oxtail)	6	7.5
Other	2	2.5
Total	80	100.0

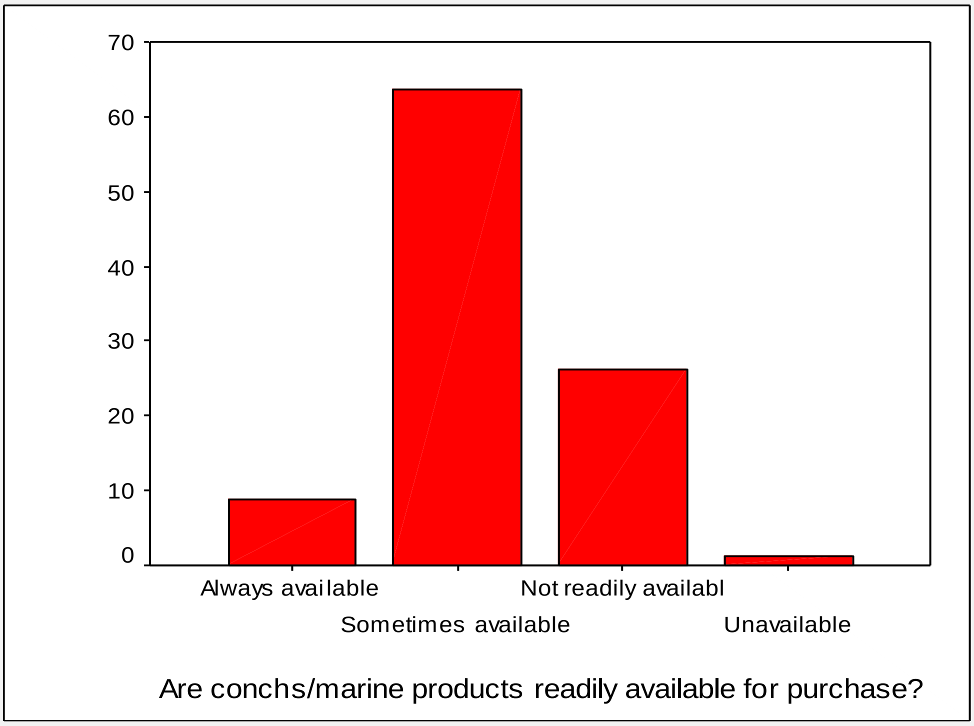
(d)


60
50
40
30
20
10
0
Min. once per week
Min. once monthly
Other (not often)
How often do you consume conch?

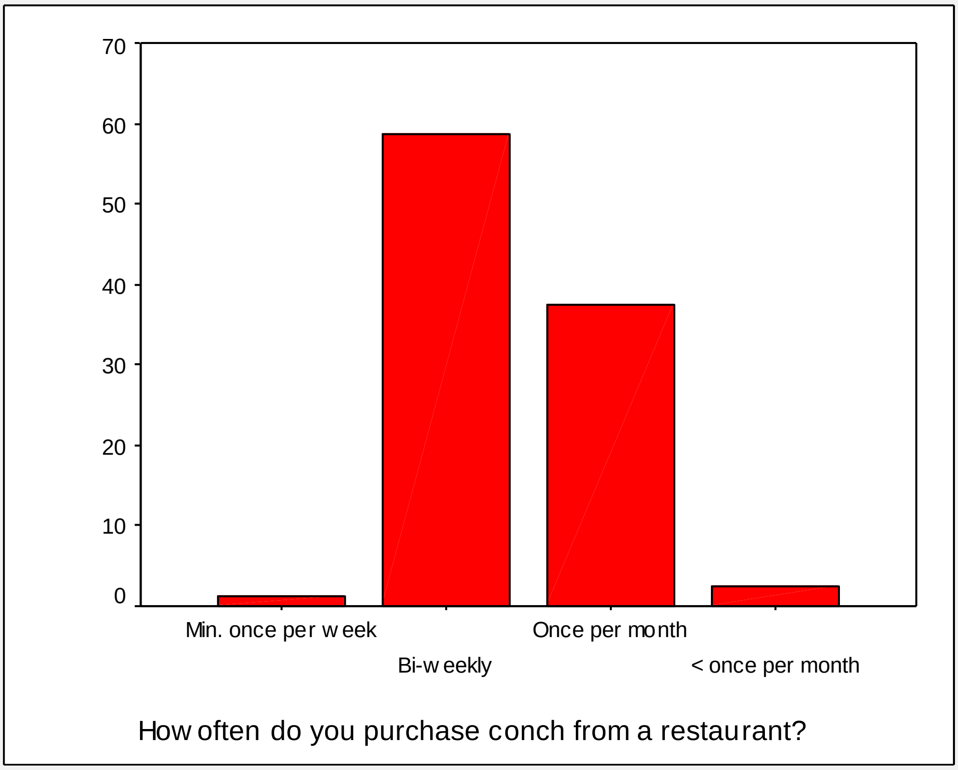
(e)


80
60
40
20
0
Directly from fisher
Fish market
Restaurants
Other
Where do you most frequently purchase your marine product?

(f)


70
60
50
40
30
20
10
0
Always available
Not readily availabl
Sometimes available
Unavailable
Are conchs/marine products readily available for purchase?

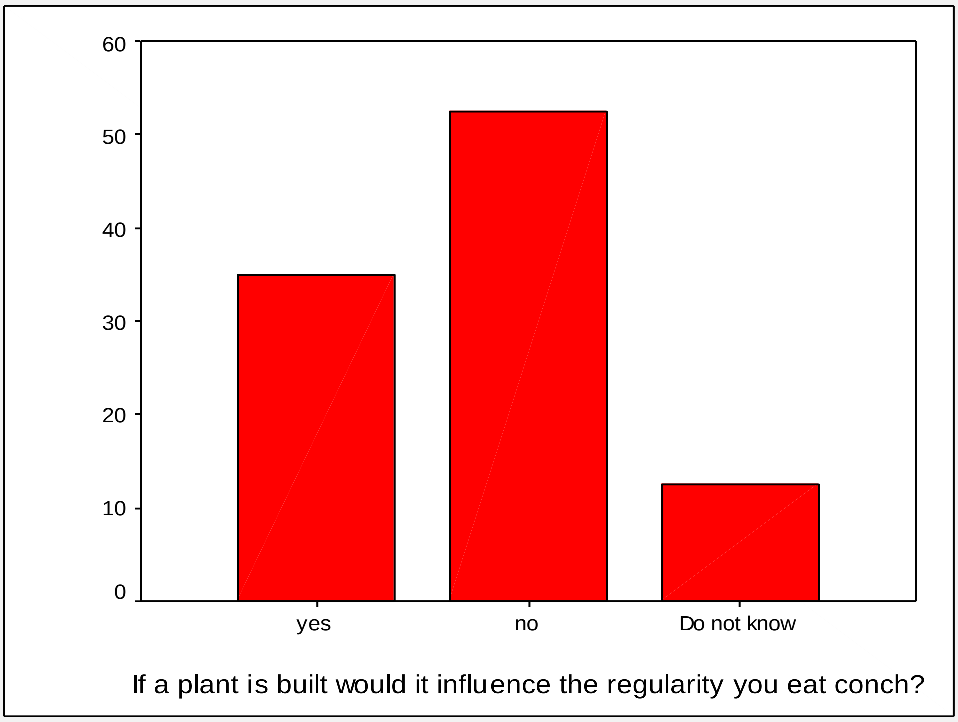
(g)


70
60
50
40
30
20
10
0
Min. once per w eek
Once per month
Bi-w eekly
< once per month
How often do you purchase conch from a restaurant?

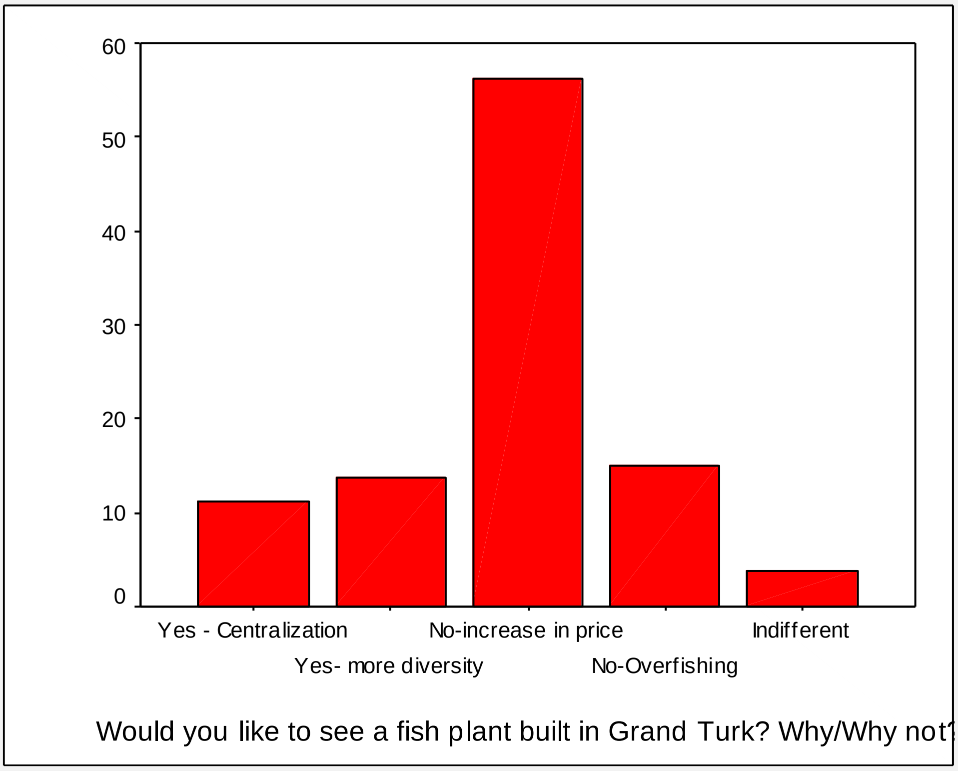
(h)


50
40
30
20
10
0
Desire
Availability of prod
Price of product
1 influence in your choice of meat you eat at a restaurant

(i)


60
50
40
30
20
10
0
yes
no
Do not know
If a plant is built would it influence the regularity you eat conch?

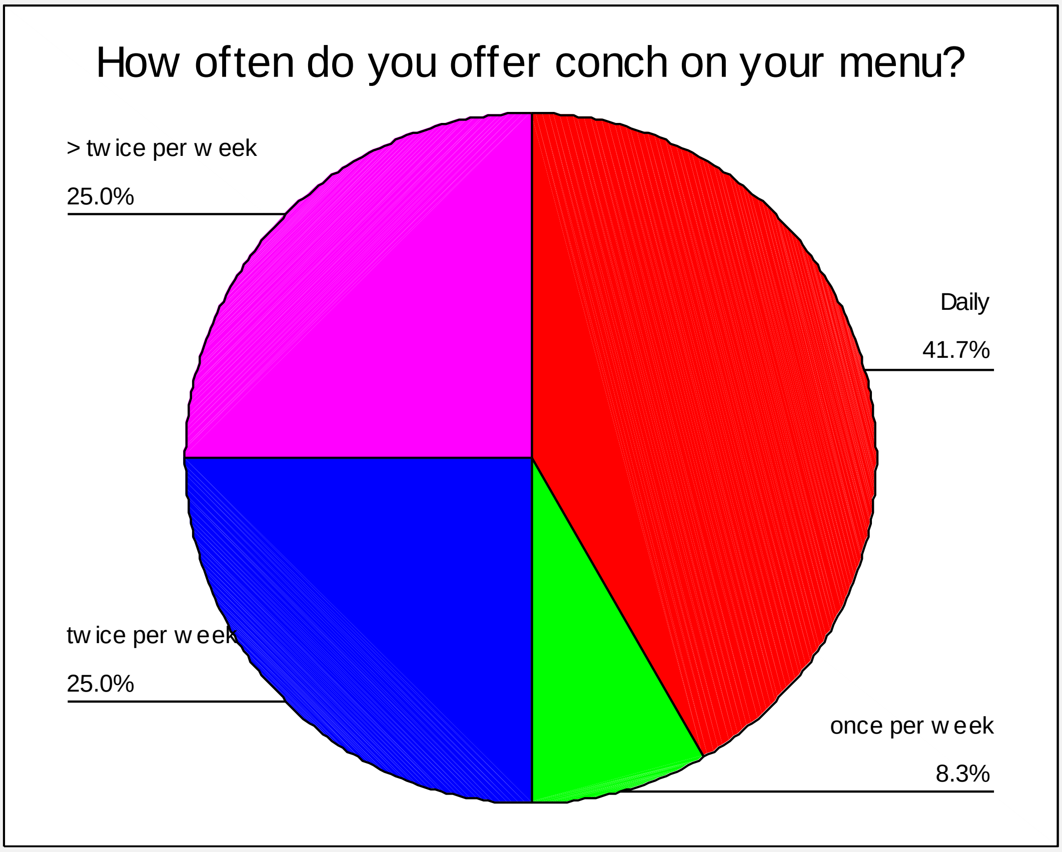
(j)


60
50
40
30
20
10
0
Yes - Centralization
Yes- more diversity
No-increase in price
No-Overfishing
Indifferent
Would you like to see a fish plant built in Grand Turk? Why/Why not?

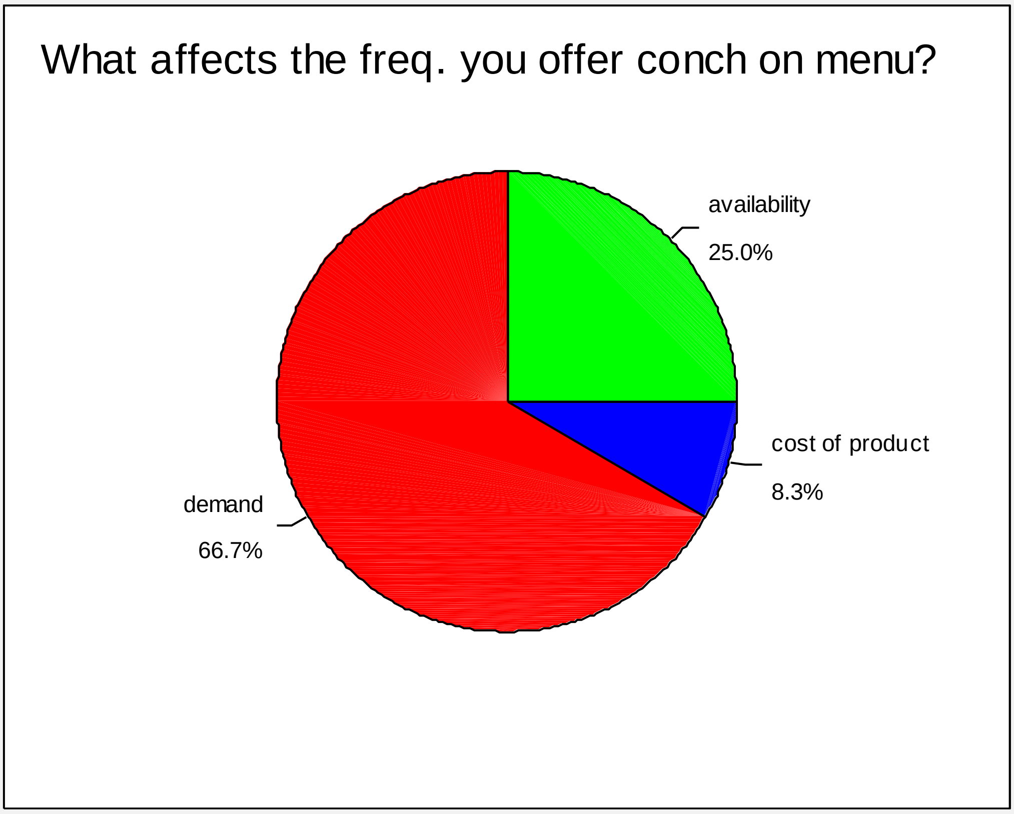
APPENDIX VII

SOCIO-ECONOMIC QUESTIONNAIRE ON RESTAURANT MANAGERS/OWNERS.

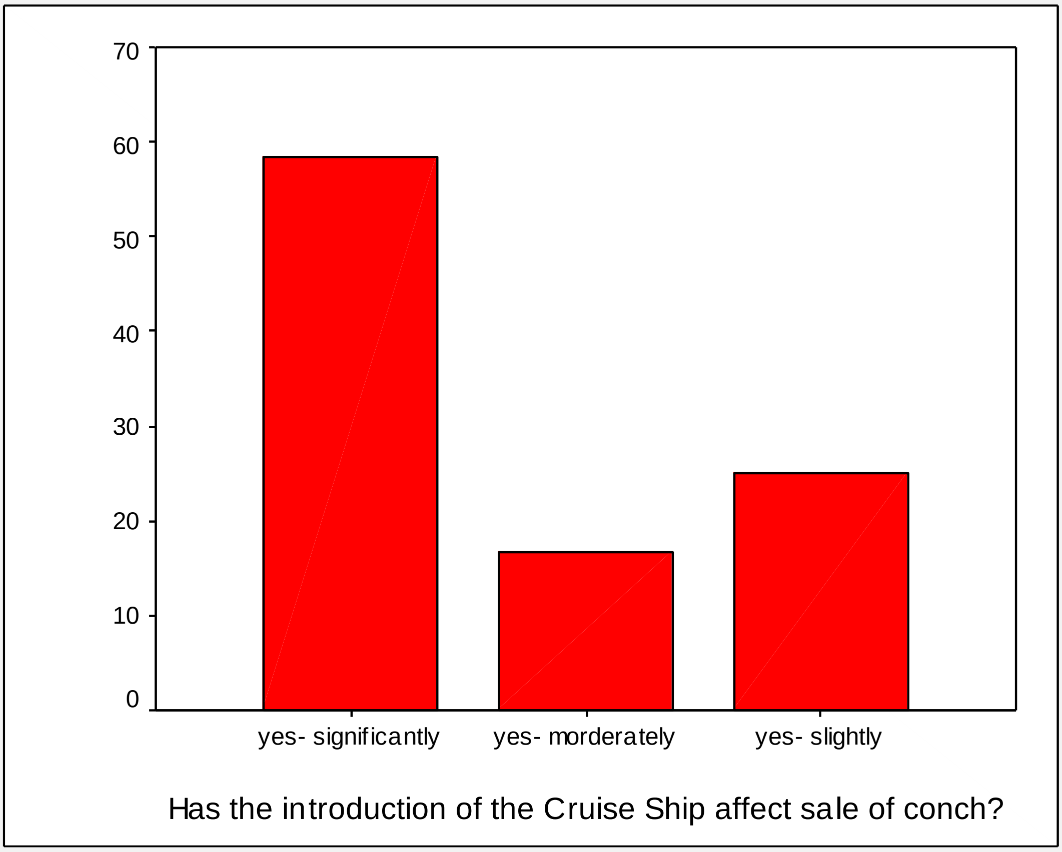
(a)



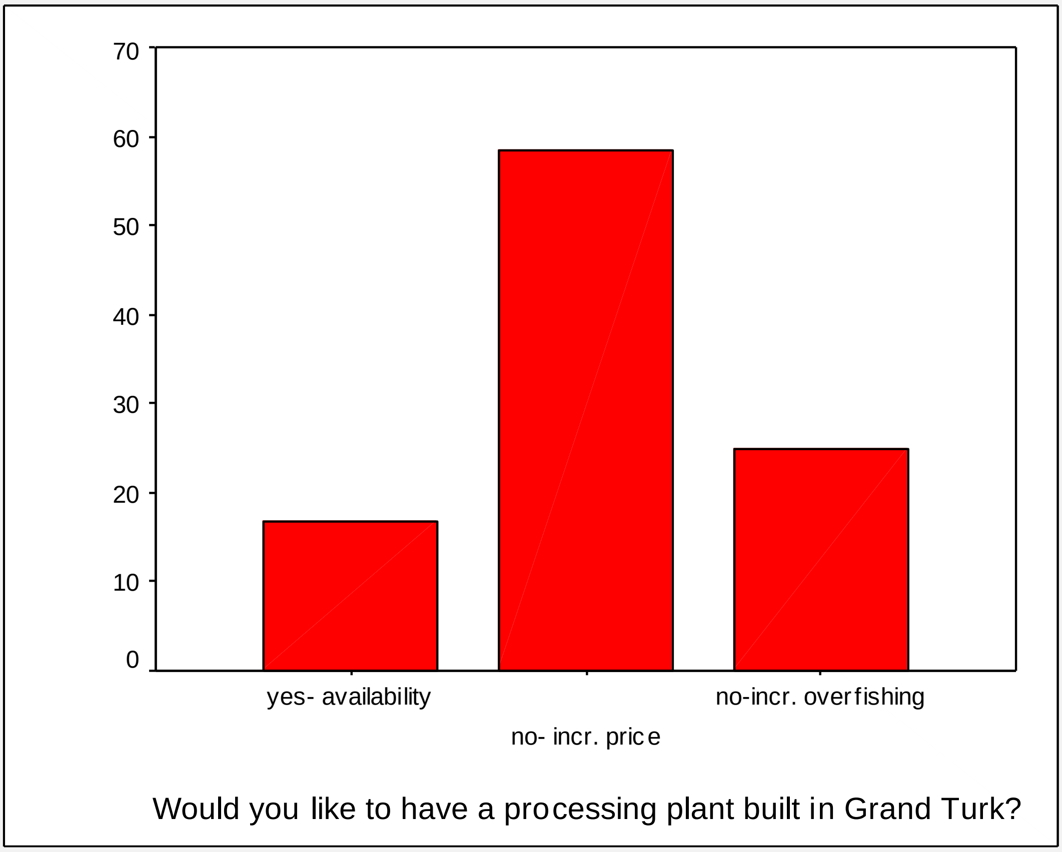
(b)


What affects the freq. you offer conch on menu?
availability
25.0%
cost of product
8.3%
demand
66.7%

(c)


70
60
50
40
30
20
10
0
yes- significantly
yes- morderately
yes- slightly
Has the introduction of the Cruise Ship affect sale of conch?

(d)


70
60
50
40
30
20
10
0
yes- availability
no- incr. price
no-incr. overfishing
Would you like to have a processing plant built in Grand Turk?