Fisheries Baseline Assessment of Statia Marine Park, St Eustatius, Netherlands Antilles

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Abstract

St. Eustatius Marine Park was established in 1996 and became actively managed in 1997 to conserve and protect the marine environment. It consists of a general use area and two no-take reserves. The purpose of this study is to collect baseline data regarding fish stock populations within the marine park and its reserves in order to evaluate the success or otherwise of the environmental management strategies of the Marine Park. Questionnaires and semi-structured interviews were conducted with eleven fishermen on the island in order to learn more about the St. Eustatius fisheries and to examine changes that have taken place within the last ten years. A visual fish census of the coral reefs was also carried out at sixteen dive sites. The abundance and diversity of fish species were observed, along with length estimations in order to determine the standing stock and population size structure of specific species. The Southern Reserve of the Marine Park was observed as having the most abundant fish population and on average, between twenty and thirty species were observed at each of the dive sites surveyed. Blair's Reef was identified as being the most diverse with over thirty-five species being observed. The diversity of the fish population in St. Eustatius has been proven to have increased dramatically in the last thirteen years, with the number of species currently present in the waters being on average 4.9 times greater than the number observed in 1992 at the same locations. When asked about the changes in the coral reefs and the fish populations over the past ten years, half of the fishermen said they saw no changes, while the other half said they had seen positive changes, citing more fish and less anchor damage. This clearly indicates that the establishment of the Marine Park nine years ago has been beneficial to the fish population within the local waters.

Introduction

St. Eustatius National Parks Foundation (STENAPA) is the only active environmental non-government organization on St. Eustatius. STENAPA was legislated in 1996 with a mandate from the Island Government to protect and manage the island's marine resources[1]. St. Eustatius Marine Park was established in 1996 and became actively managed in 1997 to conserve and protect 27.51km² of the marine environment surrounding the island from the high water line up to and including the 30 meter (100 feet) depth contour. The Marine Park consists of a general use zone (22.61km²) and two no-take reserves on both the northern and southern ends of the island (See Figure 1). The northern reserve (1.61km²) encloses Jenkins Bay up to the northern most point of the island[2]. The southern reserve (3.29km²) runs from Gallows Bay until White Wall[3].

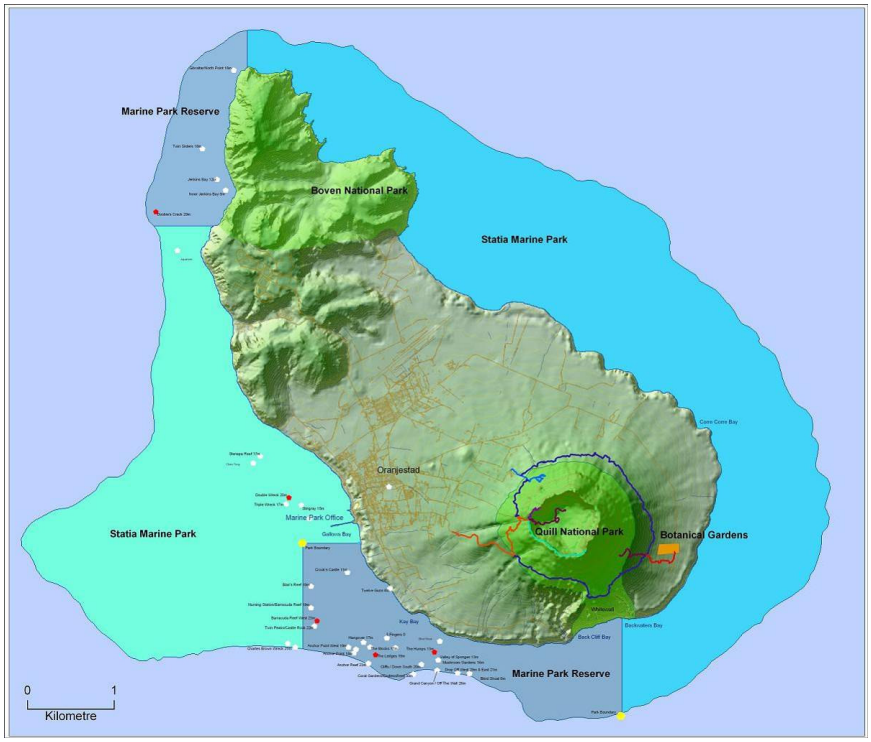


Figure 1 Boundary of Statia Marine Park showing the two reserves

[1] Designated as a management organization in the Marine Environment Ordinance of St. Eustatius (1996).
[2] Northern Marine Reserve coordinates: 17°30.5' N along the high waterline to the northern point, to the north to the 30 meter depth contour, to the west and south along the 30 meter depth contour until these lines pass the coordinate 17°30.5' N and back to Jenkins Bay.
[3] Southern Marine Reserve coordinates: 17°28.5' N along the high waterline to the point of White Wall, south out to sea for half a nautical mile, to the west following the 30 meter depth limit to the crossing with the 17°27.7' N coordinate, to the north 17°28.5' N and back to Gallows Bay.

Implementation of protected areas can infringe upon people's recreation and livelihoods. To maintain support for management strategies, it is imperative that indicators are measured and positive achievements for conservation are communicated. In order to determine whether the marine park strategy for ensuring the protection of resources is working and that the management plan is benefiting fish stock populations, baseline surveys of fish populations and coral health need to be carried out. However, since active management of the marine park started, no baseline fish population studies or subsequent population surveys have been carried out. The purpose of this study is to collect baseline data regarding fish stock populations within the marine park and its reserves. Future monitoring can then be compared with the data in order to assess the positive or negative impacts of the management of the Marine Park. The baseline data and future monitoring will benefit all stakeholder groups (e.g. fishermen, Marine Park, and Dive Operators) that use the Marine Park and will also determine whether the no-take fishing zones are achieving their objective of protecting the reef resources, primarily fish stocks. The long term goal of having no-take fishing zones is to create spill-over to the fishing zones. Evaluating the success or otherwise of environmental management improves conservation of natural resources by allowing for adaptive planning, raising awareness of success, and identifying areas of concern.

Fish communities are a major resource of coral reefs and marine protected areas. They play an important role in coral reef ecosystems and are commercially important for both fisheries and tourism. There are about 25 fishermen on the island of St. Eustatius, three of which can be considered professional fishermen. Most of the fishermen are part-time, as they have a fixed on-shore job. The aggregated value of the fishing sector is an important factor to the island economy (Dilrosun, 2004). Principal fishing methods used by fishermen were reported to be traps, hook and line, trawling and occasionally nets. Conchs, *Strombus gigas*, are caught by using scuba gear (Sybesma *et al.*, 1993). The Spiny Lobster, *Panulirus argus*, fishing industry is without a doubt the most important commercial fishery on the island. Consequently, the lobster trap is the most common fishing gear on the island, with each fisherman possessing approximately 15-20 lobster traps (Dilrosun, 2004). Depending on the weather, sea conditions, and season, the traps are hauled twice a week. The lobster fishery is a seasonal activity which begins in

September and ends in April. As the lobster season ends, the fishermen shift to targeting many different types of fish species, primarily by using fish traps (Dilrosum, 2004). One factor which limits their catch is a fish poison called ciguatera (Sybesma *et al.*, 1993; Dilrosum, 2004). Ciguatera is a neurotoxin found in the tissue of some fish that can be lethal to humans, causing various gastro-intestinal and neurological damage. It originates from micro algae (dinoflagellate), which builds up through the food chain (Sybesum *et al.*, 1993). Due to this poison, the consumption of large predatory demersal fish, such as Barracuda, *Sphyraena barracuda,* and large Jacks, *Carangidae*, is locally being avoided. Historically, traps and pots have been laid out around the island from shallow water to a maximum depth of 40 meters (Sybesum *et al.*, 1993). The principal fishing grounds were reported to be in four areas:

1. On the Atlantic side of the island in line with Bargine Bay to south of Compagnie Bay, from a depth of around 25 meters and for a distance of one nautical mile east.
2. In the area south of White Wall in waters of 15-30 meters depth.
3. On the Caribbean side of the island from Cocoluch Bay to Jenkins Bay from 30 meters depth and for a distance of around one nautical mile west.
4. Traps were also laid in Oranje Bay from 26-35 meters depth and in the area of Gallows Bay immediately south of the City Pier (Sybesma *et al.*, 1993)

Following an inventory of the fishing sector of St. Eustatius carried out in February 2004, it was stated that fisherman primarily fish on the narrow shelf surrounding the island (Dilrosun, 2004). This would correspond with the information from the earlier study on the fishing grounds that were used. However, the fishermen claim the best fishing grounds were designated to the marine reserves. There are two beach seines on the island, but in recent years, they were not used because the fishermen state the fishing grounds were transformed by recent hurricane activity and are now covered by rocks and coral rubble, which destroy the nets. Mostly, the part-time fishermen carry out hand lining and trawling during the weekends (Dilrosum, 2004). There is also some level of conflict which occurs within the marine park between the local fishermen and Statia

Terminal nV. Oil tankers going to Statia Terminals nV. damage the underwater biodiversity and the fishing grounds through anchoring and cut away the fish trap markers turning them into ghost traps. Passing sail boats and other boats also cut their lines (Dilrosun, 2004). One way to avoid conflict is to monitor the fishermen's perception of the status and trends of marine resources (Chiappone, 2001).

There are two studies that have been carried out in the past 15 years relevant to the focus of this research. The first study was conducted in 1992 by Sybesma *et al.* with the objective of conducting an inventory of the natural and cultural marine resources of St. Eustatius. The study presented qualitative data only for the fishing industry, describing the fish species at specific sites. It was reported that nearly all of the 30 sites surveyed were healthy (minimum physical damage, no signs of stress, and minimum garbage). The study reported that the reef fish community was somewhat impoverished in terms of fish and noted an absence of or a low number of the larger predators, such as Grouper, *Serranidae* and Snapper, *Lutjanidae*. This was generally assumed to be an indication of over-fishing. There was also an absence of large parrotfish, *Scaridae*, which have frequently become more abundant since the mass mortality of the Long-Spined Urchin, *Diadema antillarum*, in the Caribbean in 1983, thus showing another sign of fishing pressure. During this study, fishermen agreed that the fishery had declined and blamed the decline on habitat destruction by anchoring and on oil dispersant pollution causing a reduction in the number of eggs and larvae produced.

An additional relevant study carried out in the Marine Park was done by Grabowsky and Poort International nV., who carried out a quantitative survey of the fish population in 1994. The survey was conducted in the area north of the Terminal Jetty to the region of Jenkins Bay. They carried out nine survey dives, which totaled 5 hours and 15 minutes of observations. They observed a total of 60 different species, which comprised of 1,719 fish. The most frequently observed species were the Bicolor Damselfish, *Stegastes paritus,* with 282 individuals being observed, the Bluehead Wrasse, *Thalassoma bifasciatum*, with 280 individuals being observed, the Brown Chromis, *Chromis multilineata*, with 218 individuals being observed, and the Blue Chromis, *Chromis cyanea,* with 113 individuals being observed in total. These two studies will serve as a helpful comparison for the current research being conducted and

give a good indication of whether the marine resources in St. Eustatius have declined, remained the same, or improved.

The objective of this study is to carry out a fish population estimate of the St. Eustatius Marine Park. This can then be used as a baseline guide in future population studies to determine if the guidelines for managing the marine park are effective or not in sustaining and increasing fish populations. A fish population survey will then be carried out every two years for monitoring purposes. The results will be presented to all stakeholder groups, including fisherman, dive operators, Statia Terminal nV. employees, and the Marine Park staff.

Materials and Methods

Two widely used monitoring methods were used for the collection of data during this study:

- Semi-qualitative data was collected from relevant stakeholders of the Marine Park using questionnaires during Semi-structured interviews.
- Quantitative data was collected by observation using SCUBA-based surveys.

Semi-Structured Interviews

The importance of using questionnaires, during semi-structured interviews, for gathering information and data for marine resource management has become more important over the years. This is due to the increasing pressure coral reefs and fisheries are coming under from human activities.

There is a close link between how people use coral reefs and their socioeconomic background. Understanding the socioeconomic context of reef stakeholders is essential for assessing, predicting and managing reef use. To balance sustainable use and reef protection, the reef manager needs to know: the people that use and affect the reef, including their use patterns, perceptions of reef management and characteristics (Bunce *et al.*, 2000)

The methodology of Bunce *et al.* (2000) was used in the approach to the semi-structured interview, questionnaire construction, and analysis. The assessment was initially carried out using the basic steps outlined in Table 1 (Bunce *et al.*, 2000), and modified to take into account the requirements of the requisite goals and specific circumstances of St. Eustatius Marine Park.

The interview questions were related to fisheries based activities (including fish, lobsters and conch) as well as sociological characteristics. Questions also addressed any changes noticed over the past ten years in coral reefs or fish species. During the design of the questionnaires an independent survey of the fisheries of St. Eustatius was carried out and it was therefore decided that the execution of these questionnaires could be

delayed until after the quantitative data was collected. The questionnaires and semi-structured interviews were conducted in mid-October of 2004.

Table 1: Phases of socioeconomic assessment (Bunce *et al*., 2000)

1) Preparatory Activities	2) Planning and Reconnaissance	3) Field Data Collection	4) Final Analysis
Define Goals	Assess secondary data	Guiding principles	Basic principles for analysis
Define process to conduct assessment	Conduct reconnaissance survey	Data collection method	Conduct the data analysis
Identify stakeholders	Plan the field data collection phase	Visualisation techniques	
Identify study area and study sites		Field analysis	
Consult with stakeholders			
Determine stakeholder participation			
Define objectives			
Identify parameters and sub-parameters			
Identify assessment team			

Fish Census

The fisheries study was undertaken by carrying out a visual fish census of the coral reefs surrounding St. Eustatius. Visual census of fish is one of the most common quantitative and qualitative sampling methods used in coral reef surveys (English *et al.,* 1997). There are two parts to a visual census, the first detects differences in the assemblages of the reef fish at different sites using abundance categories. The second technique counts individual fish and estimates their total lengths in order to determine the standing stock and population size structure of specific species. The visual fish census will be carried out at 16 dive sites at various depths in the four different zones within the Marine Park.

Table 2: Survey Dive Site Locations

Zone	Site	#	Depth (M)	1992	Fishing	>15m	15-19m	20-30m
Artificial Reef	Double Wreck	23	17	Y	Y		X	
	STENAPA	25	17		Y		X	
	Charles Brown	30	30					X
General Use	Sting Ray	24	15	Y			X	
	Venus Bay		18	Y	Y		X	
	Corre Corre		22	Y	Y			X
	Aquarium		20					X
	South of Harbor		10		Y	X		
Northern Reserve	Jenkins Bay	27	12	Y		X		
	Twin Sisters	28	18	Y			X	
	Doobies Crack	26	29					X
Southern Reserve	Barracuda	18	23	Y				X
	Blair's	20	19	Y			X	
	Crook's	21	11	Y	Y	X		
	Drop off	2	29	Y				X
	Blocks	13	17	Y			X	

Having reviewed the survey data produced by van't Hof *et. al.* 1993, the dive locations listed in table 2 were selected for the fisheries baseline survey along with some additional sites that were created after or are known to be of interest since the last survey was undertaken (See Table 2). It was decided that the locations would fall into three depth categories: Less than 15 meters, between 15 and 19 meters, and between 20 and 30 meters.

The surveys were carried out along 20 meter transects. At each site, at least three transect lines were laid. The replicate transects were located haphazardly and did not overlap. Each of the replicates were separated by 10-20 meters. For each survey dive the survey team consisted of 2 divers and a boat handler. The census was split between the two divers, one measuring abundance categories and one counting and estimating lengths of specific target species. At each transect, the divers swam along for 20 meters, recording fish encountered within 2.5 meters on either side and 5.0 meters above the transect. The data was recorded on prepared data sheets, one for Fish Abundance

Estimates and one for Fish Density/Size Estimates. Each data sheet listed the dominant species found in the study area for sampling. The species list (See Appendix 1) was assembled using information obtained after reviewing findings from Dilrosun (2004), Grabowsky & Poort International NV (1994) and Sybesma *et al.* (1993). The surveys were conducted in July of 2004.

Size Estimation Training

Fish counts along with estimates of total length allow the population size structure of the species counted to be calculated. Using length-weight relationships, the estimates of the length of fish can produce 'first estimates' of standing crop (English *et al.*, 1997). Divers are trained to estimate the lengths of fish underwater using a modification of the methods developed by the Great Barrier Reef Marine Park Authority Workshop (GBRMPA, 1979).

Each observer was pre-trained in length estimation through an exercise called fiddle sticks to test the diver's ability to estimate fish lengths underwater, also described by English *et al.* (1997). The observer was also trained to estimate horizontal lengths of 2.5 meters and vertical heights of 5.0 meters before the fish census. A section of PVC electrical conduit was cut into lengths of between 0 and 100 centimeters. These were attached to a line to enable the divers to practice estimating total lengths of fishes whilst under water. The divers then went on different occasions to estimate the lengths of PVC. Divers were only allowed to estimate fish lengths when their accuracy was within 5 cm. Observers were also trained in species identification and went on several identification dives to increase their confidence in recognizing fish species.

Results

Semi-Structured Interviews

The results of the fisherman survey were quite useful in looking at changes and trends within the fishing industry, as well as the status of the benthic habitat, for the past ten years. Knowing which species fisherman aim to catch and at what time during the year they catch these species will greatly improve the Marine Park's management strategies.

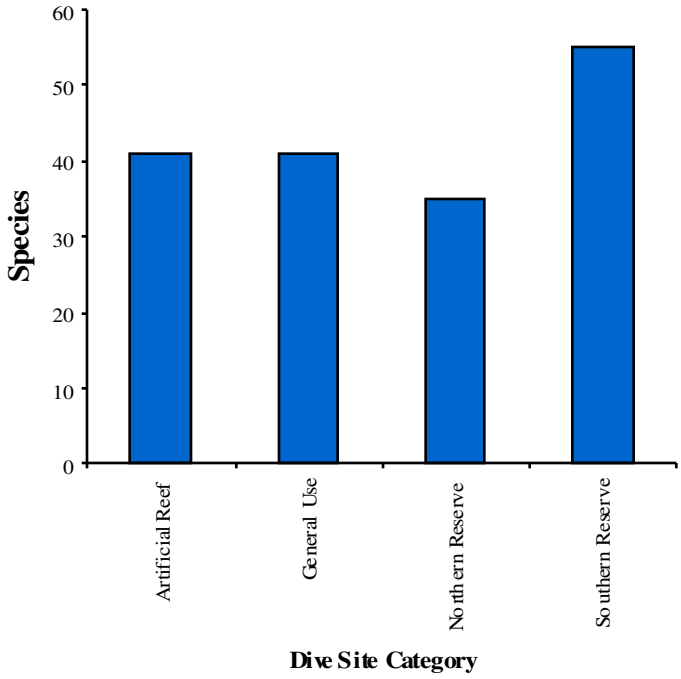
During mid-October eleven people were surveyed including two dive shop owners. In contrast to Dilrosun (2004), five fishermen were now considered full time, fishing between 15-20 hours a week, while the other half are part time fishermen, fishing between 4-10 hours a week. This comprises 50% of the 18 registered fishermen on St. Eustatius. All of the people surveyed have been fishing within the waters of St. Eustatius for over ten years, with quite a few fishing for over 20 years. The fishermen aim to catch various species including wahoo, tuna, dolphin, lobster, conch, snapper, and grouper using equipment such as boats, scuba gear, trawling, nets, and traps. Most of the people surveyed said the most valuable type of fish to catch is snapper or lobster. The lobster fishery takes place between September and December, while the remaining part of the year is constant, catching any of the above species in any given month. A few fishermen said there are fewer fish during the summer months.

When interviewed about the changes that have occurred over the past ten years, a variety of answers were received. About half of the fishermen said there has been no change in the coral reef, while the other half said there has been a positive change, citing more fish and less anchor damage. Also, half of the fishermen said there has been an increase in the lobster and fish population, while the other half claim it has declined. According to the fishermen, any of these changes taking place are due to the recent marine reserves set up, anchor damage from ships, oil spills from the terminal, or natural fish fluctuations. One thing the fishermen do agree on is the conch population, saying it has remained constant over the past ten years.

Fish Census

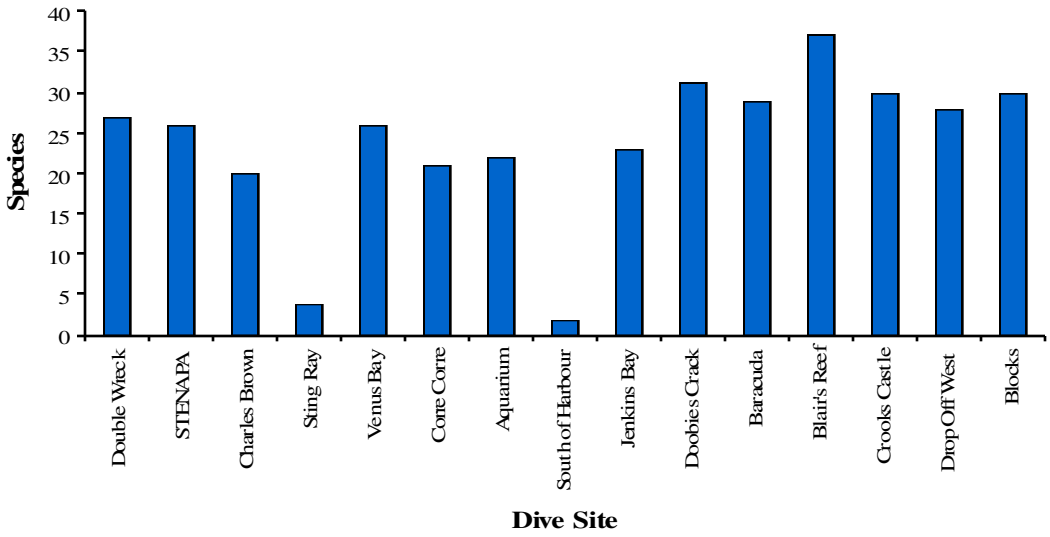
As shown by Figure 1 the survey identified the Southern Reserve to have the highest diversity of fish with over 50 different species being observed. The general use area and the artificial reefs have similar diversity with 40 species being observed during the survey. The Northern Reserve was found to be the least diverse out of the four regions of the Marine Park.

Figure 1: Total number of species observed within each of the four Marine Park Categories



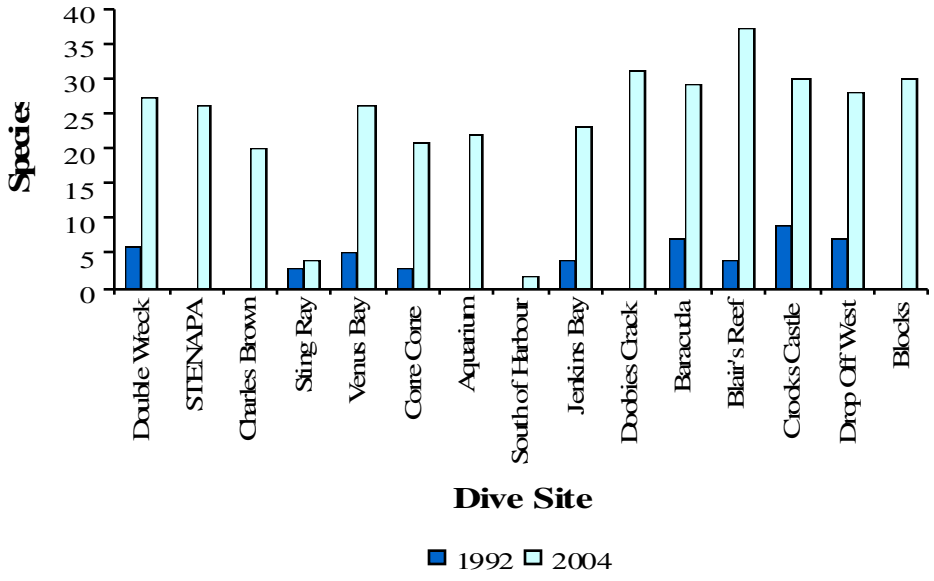
The majority of the dive sites surveyed were found to have between 20 and 30 different species, as shown in Figure 2. Blair's Reef was identified as having the most diverse population with over 35 different species being observed. The survey sites of Sting Ray and South of Harbor were found to be the least diverse. This is most likely due to the substrate in these locations being composed mainly of sand, and therefore not being suitable to support a wide variety of organisms.

Figure 2: Total number of species observed at each of the survey sites



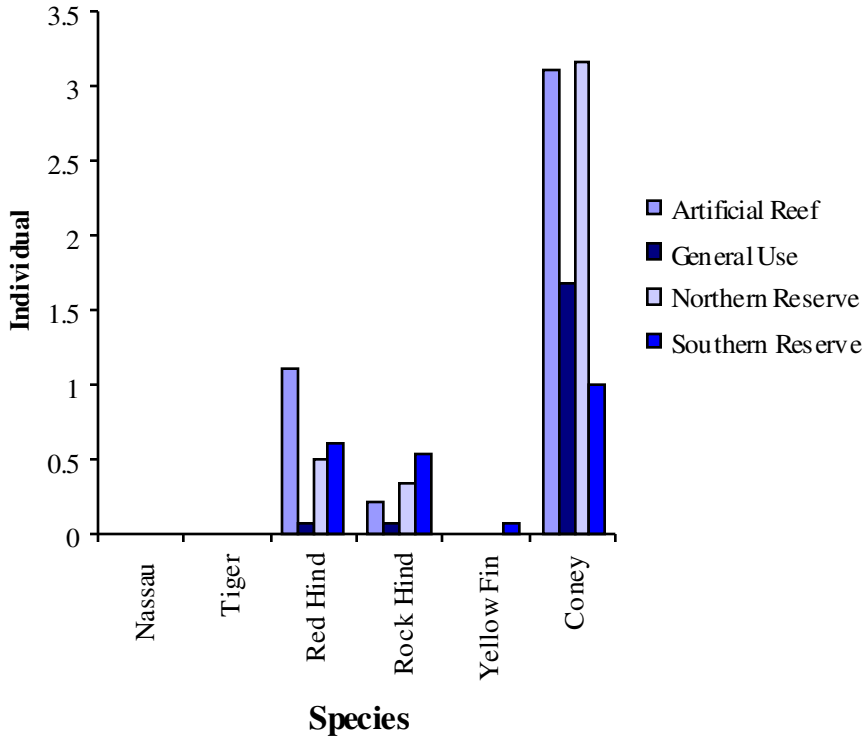
When comparing the results that were collected during this survey to data that was obtained in 1992 before the Marine Park was created, it can be clearly seen that there has been an increase in the total number of species (See Figure 3). In the 1992 survey the number of species observed at each site was found to be between 5 and 10, where as the recent survey found the number of species to generally be above 20.

Figure 3: Comparison of the total number of species observed from 1992 to 2004



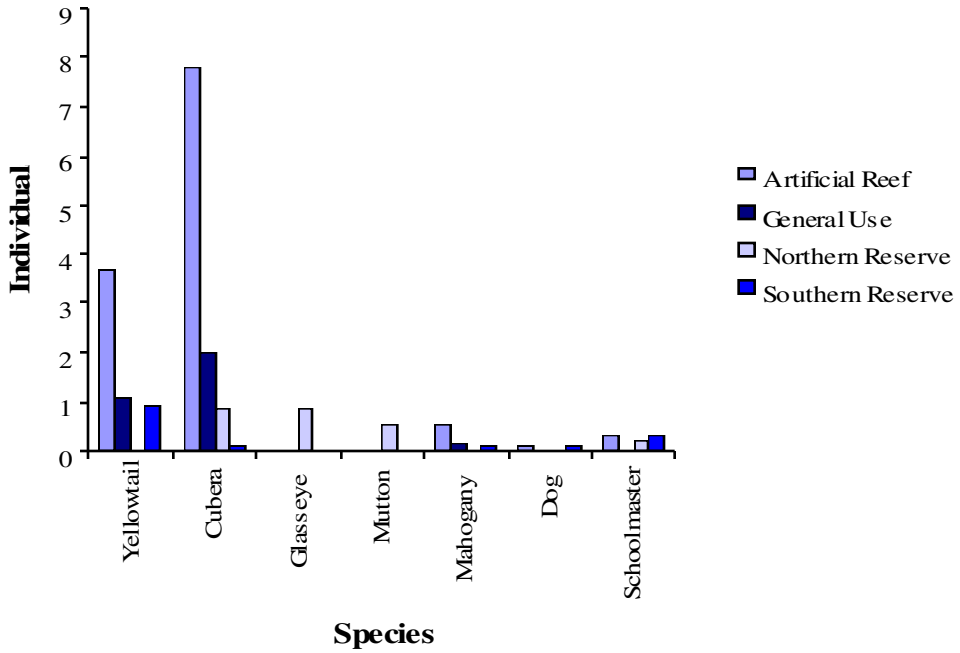
The most observed member of the Grouper family, *Serranidae*, was found to be the Coney, *Epinephelus fulvus* (See Figure 4). The Coney was found to be most numerous at the artificial reef sites and within the Northern Reserve. The Red Hind, *Epinephelus guttatus*, and Rock Hind, *Epinephelus adscensionis*, were also found to be present in all of the regions of the Marine Park. The Yellowfin grouper, *Mycteroperca venenosa*, was only observed within the Southern Reserve. There were no Nassau, *Epinephelus striatus*, or Tiger, *Mycteroperca tigris*, groupers observed during the survey.

Figure 4: Number of Groupers observed within the Marine Park



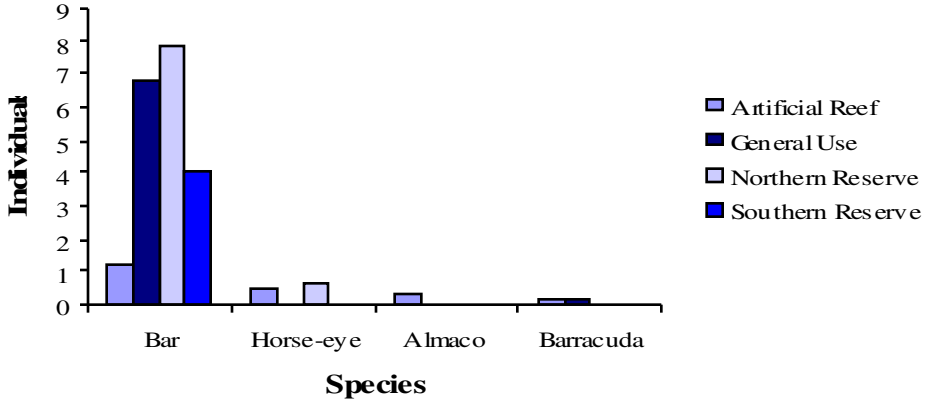
The Cubera snapper, *Lutjanus cyanopterus*, and the Yellowtail snapper, *Ocyurus chrysurus*, were the most observed species of the Snapper family, *Lutjanidae.* The greatest numbers of these species were observed at the artificial reef sites. As shown in Figure 5, the remaining five species of the snapper family were observed during the survey, but in extremely low numbers at all four zones in the Marine Park. The Dog snapper, *Lutjanus jocu*, was found to have the lowest number out of all the species in the Snapper family.

Figure 5: Total number of Snapper observed within the Marine Park



As shown in Figure 6 the most observed member of the Jack family, *Carangidae*, was the Bar Jack, *Caranx rubber*, with them being most numerous in the Northern Reserve and the General Use areas. The other three species of the Jack family were observed in low numbers in all of the Marine Park zones, except for the Southern Reserve.

Figure 6: Observed sightings of Jacks within the Marine Park



The French grunt, *Haemulon flavolineatum*, was found to be the most observed member of the Grunt family, *Haemulidae*, with individuals being observed in each of the four regions of the Marine Park (See Figure 7). The French Grunt was found to be most numerous at the Artificial Reef survey sites. The White grunt, *Haemulon plumieri*, and the Bluestripe grunt, *Haemulon sciurus*, were observed in low numbers in three out of four of the Marine Park areas.

Figure 7: Observed sightings of Grunts within the Marine Park

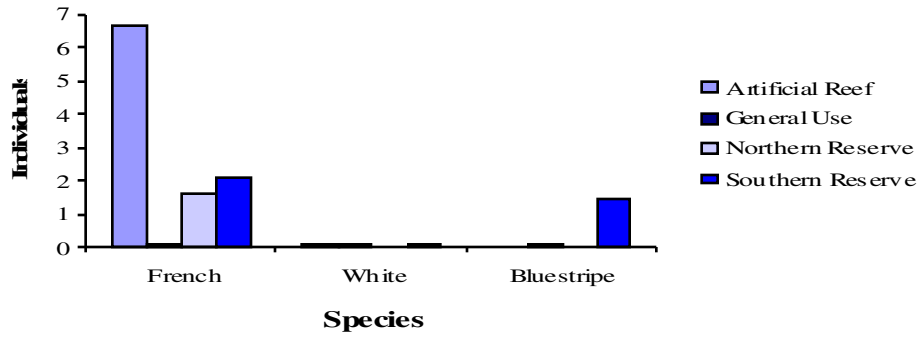
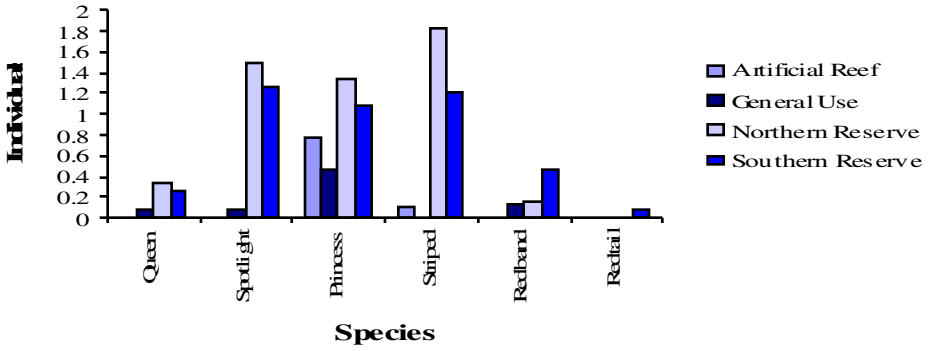


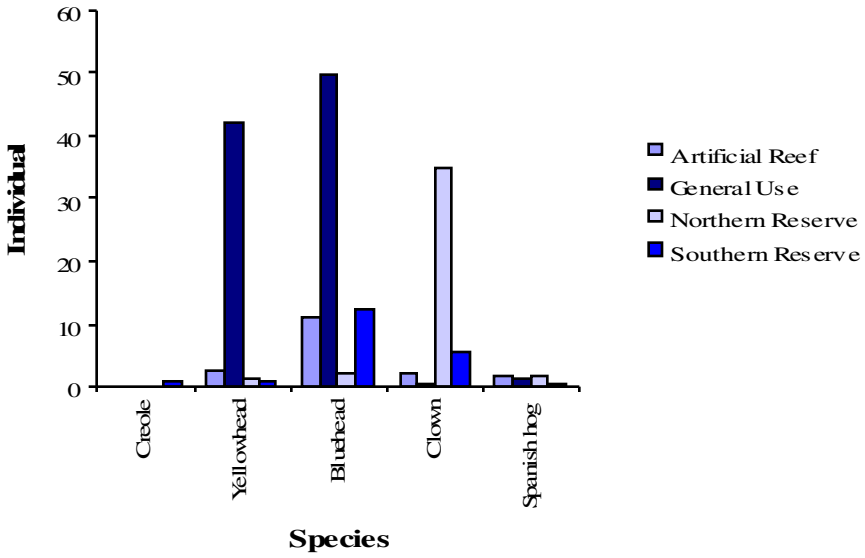
Figure 8 shows that the Princess Parrotfish, *Scarus taeniopterus*, was the only member of the Parrotfish family, *Scaridae*, which was found to be present in all of the regions of the Marine Park. The Striped, *Scarus croicensis*, and Spotlight, *Sparisoma viride*, parrotfish were also observed in the majority of the regions. The Redtail parrotfish, *Sparisoma Chrysopterum*, was only observed in the Southern Reserve.

Figure 8: Observed sightings of Parrotfish within the Marine Park



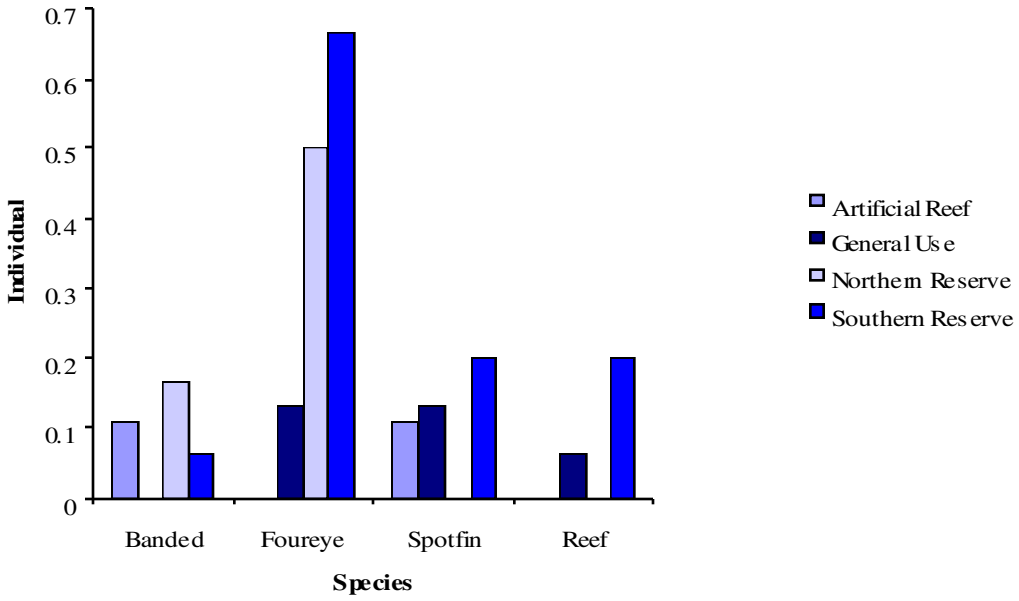
Members of the Wrasse family, *Labridae,* were observed in high numbers within the Marine Park during the survey (See Figure 9). The Bluehead wrasse, *Thalassoma bifasciatum*, and the Yellowhead wrasse, *Halichoeres garnoti*, were found to be the most numerous, with over 40 individuals being observed, within the general use area. The Clown wrasse, *Halichoeres maculipinna*, was also observed in high numbers, with it being identified as the most frequently observed member of the wrasse family within the Northern Reserve. The Creole wrasse, *Clepticus parrae*, was only observed in the Southern Reserve in small numbers.

Figure 9: Number of Wrasse observed within the Marine Park



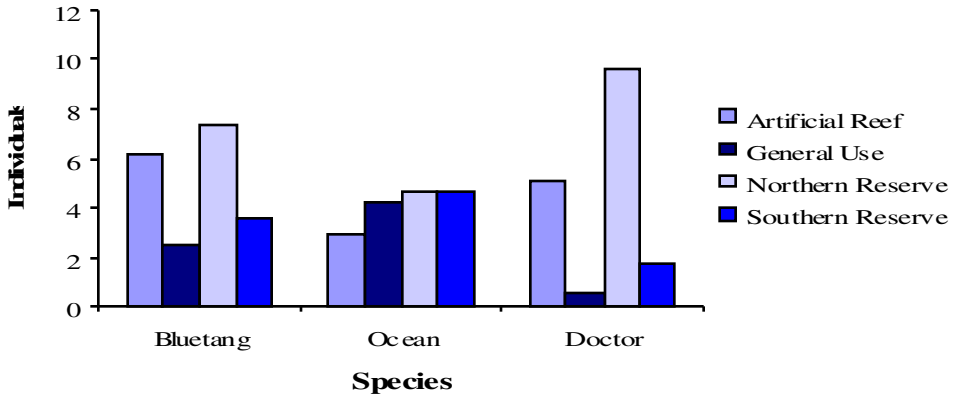
From the Butterflyfish family, *Chaetodontidae*, the Foureye butterflyfish, *Chaetodon capistratus,* was found to be the most numerous within the Marine Park, as shown in Figure 10. The Foureye butterflyfish population was found to be greatest within the Southern and Northern Reserves. All of the species within the butterflyfish family were found to be present within the Southern Reserve. The Reef butterflyfish, *Chaetodon sedentarius*, was found to have the lowest numbers observed out of all of the species in the butterflyfish family.

Figure 10: Number of Butterflyfish observed within the Marine Park



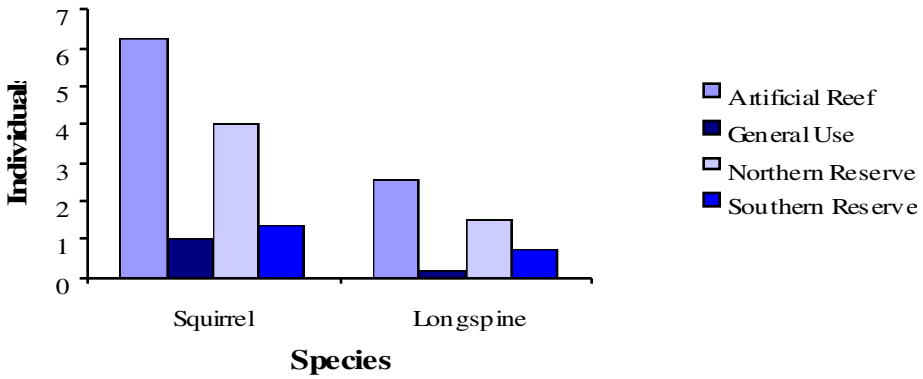
All of the species of the Surgeonfish family, *Acanthuridae*, were observed in all four Marine Park regions (See Figure 11). It was found that the Ocean Surgeonfish, *Acanthurus bahianus*, were evenly distributed between all of the regions. The Doctorfish, *Acanthurus chirurgus*, and Blue Tang, *Acanthurus coeruleus*, were observed in greatest numbers in the Artificial Reefs and the Northern Reserve.

Figure 11: Number of Surgeonfish observed within the Marine Park



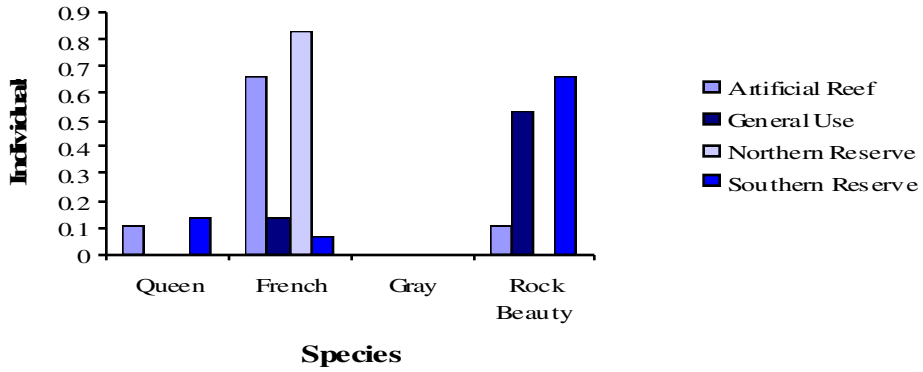
Both species of the Squirrelfish family, *Holocentridae*, were observed in all of the regions of the Marine Park. Both were seen in largest numbers on the Artificial Reefs and in the Northern Reserve, with the Squirrelfish, *Holocentrus adscensionis*, being observed most frequently.

Figure 12: Observed sightings of Squirrelfish within the Marine Park



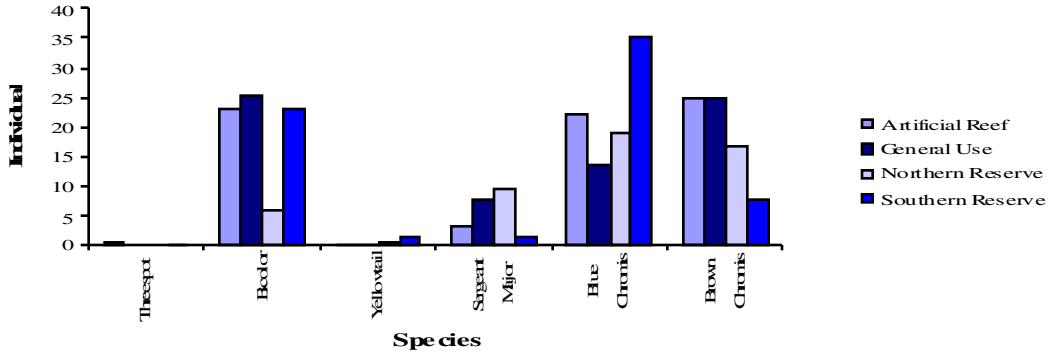
The only member of the Angelfish family, *Pomacanthidae*, which was found to be present in all of the regions of the Marine Park was the French Angelfish, *Pomacanthus paru* (See Figure 13). The French Angelfish was found to be most numerous in the Artificial Reefs and Northern Reserve regions. The Rock Beauty, *Holacanthus tricolor*, was the most numerous member of the Angelfish family within the Southern Reserve, while no Gray angelfish, *Pomacanthus arcuatus*, were observed.

Figure 13: Observed sightings of Angelfish within the Marine Park



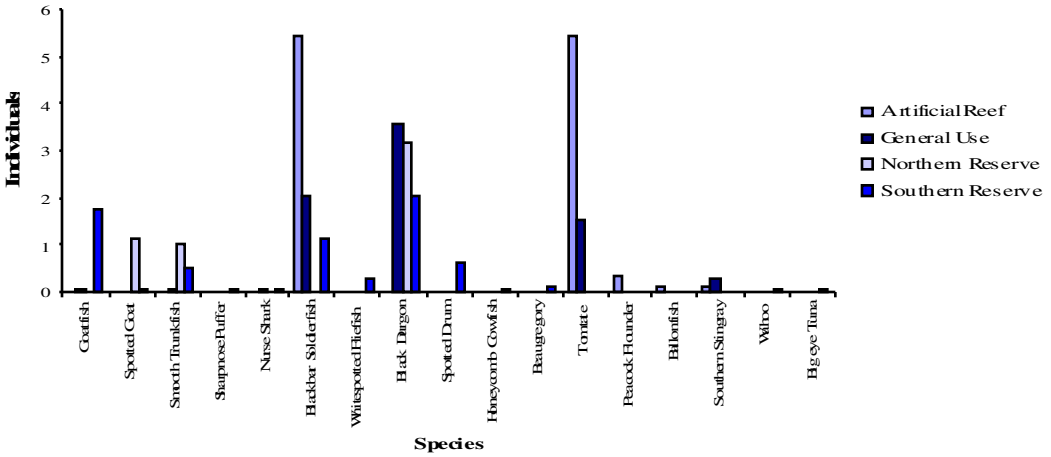
The Blue Chromis, *Chromis cyanea*, was found to be the most numerous within the Southern Reserve, while the Bicolor, *Stegastes partitus*, and the Brown Chromis, *Chromis multilineata*, were the most numerous within the Artificial Reefs and General Use areas. The Threespot, *Stegastes planifrons*, and Yellowtail, *Microspathodon chysurus*, were the least observed species in the damselfish family.

Figure 14: Observed sightings of Damselfish within the Marine Park



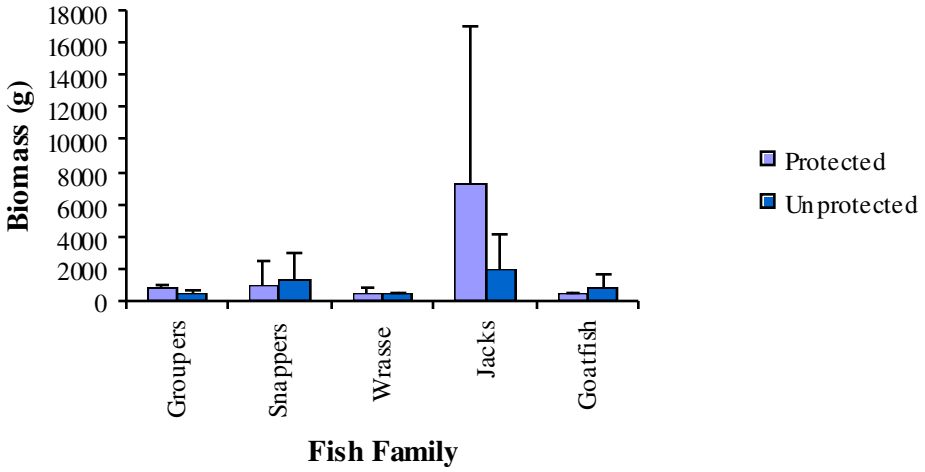
There were seventeen other species of fish observed during the survey, which are shown in Figure 15. Of these, the Blackbar Soldierfish, *Myripristis jacobus*, Black Durgon, *Melichthys niger*, and Tomtate, *Haemulon aurolineatum*, were the most frequently observed species.

Figure 15: Other Species Observed within the Marine Park Waters



When considering the density of the fish population within the Marine Park the Jack family, *Carangidae*, was found to have the greatest biomass out of all the fish families observed (See Figure 16). The biomass of the Grouper, *Serranidae*, Wrasse, *Labridae*, and Jack families were found to be greater in the marine protected reserves than in the other unprotected regions of the Marine Park.

Figure 16: Comparison of biomass between the protected reserve regions and the other regions of the Marine Park



Of the fish families that were observed the Jack family was found to make up the largest biomass within the Southern Reserve followed by the snapper and grouper families (See Figure 17). The Jack and Snapper families were found to be of higher biomass in the Artificial Reef and Southern Reserve while the other families were found to be of similar biomass in all four regions of the Marine Park.

Of the Grouper family, *Serranidae*, the Coney, *Epinephelus fulvus*, and Red hind, *Epinephelus guttatus*, were found to be the species with the greatest biomass (See Figure 18). The Coney was found to be in greater densities within the Reserve regions of the Marine Park in comparison to the unprotected regions. The density of the Red Hind was found to be the greatest within the Artificial Reef and Southern Reserve regions. The

Southern Reserve was found to produce on average greater densities of the grouper family.

Figure 17: Observed biomass of the fish families within the different regions of the Marine Park

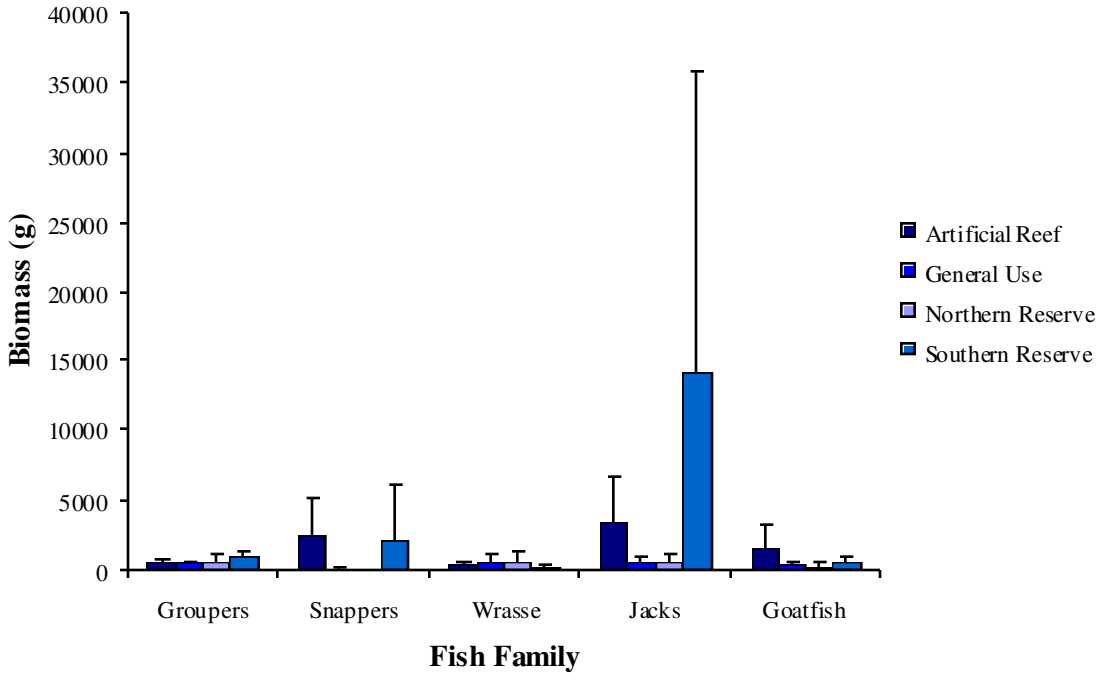
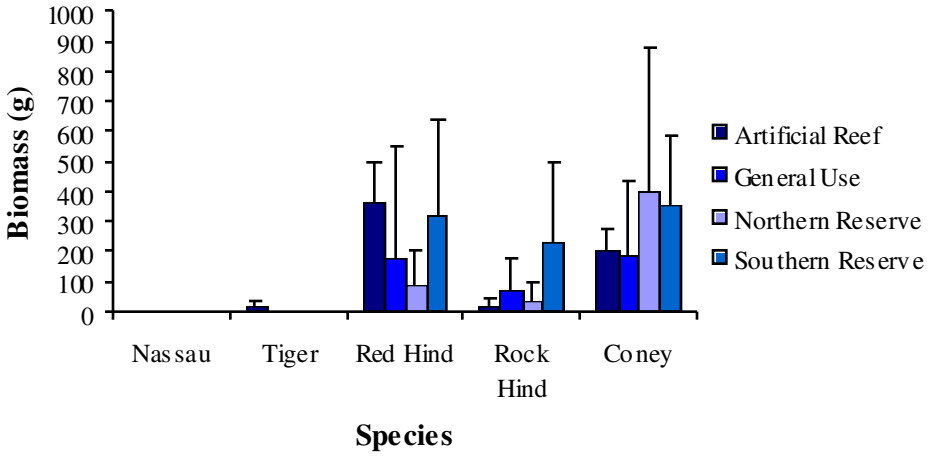
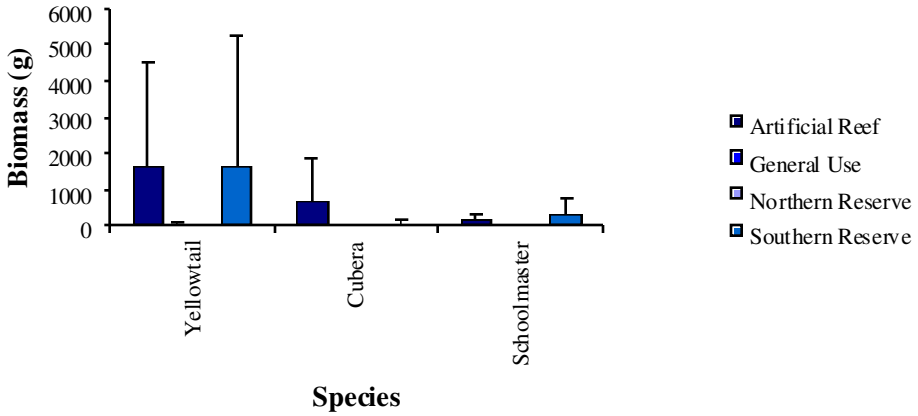


Figure 18: The observed biomass of the Grouper family within the Marine Park



Of the Snapper family, *Lutjanidae*, the Yellowtail snapper, *Ocyurus chrysurus*, was found to be the species with the highest density within the Marine Park, as shown in Figure 19. The Yellowtail snapper was found to be of greatest biomass within the Artificial Reef and Southern Reserve regions of the Marine Park.

Figure 19: The observed biomass of the Snapper family within the Marine Park



As shown in Figure 20 the Spanish Hogfish, *Bodianus rufus*, was found to be the species of highest density within the Wrasse family, *Ladridae*. The Spanish Hogfish was found to be of greatest biomass within the Northern Reserve. The Yellowhead Wrasse, *Halichoeres garnoti*, Bluehead Wrasse, *Thalassoma bifasciatum*, and the Clown Wrasse, *Halichoeres maculipinna*, were found to be of similar biomass within the four regions of the Marine Park.

Figure 20: The observed biomass of the Wrasse family within the Marine Park

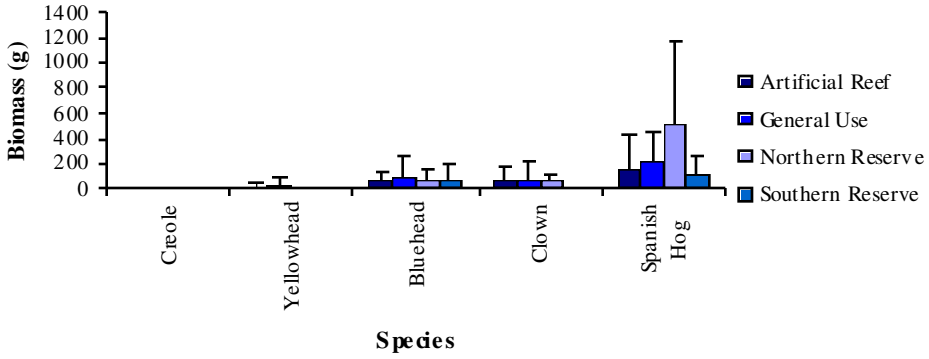
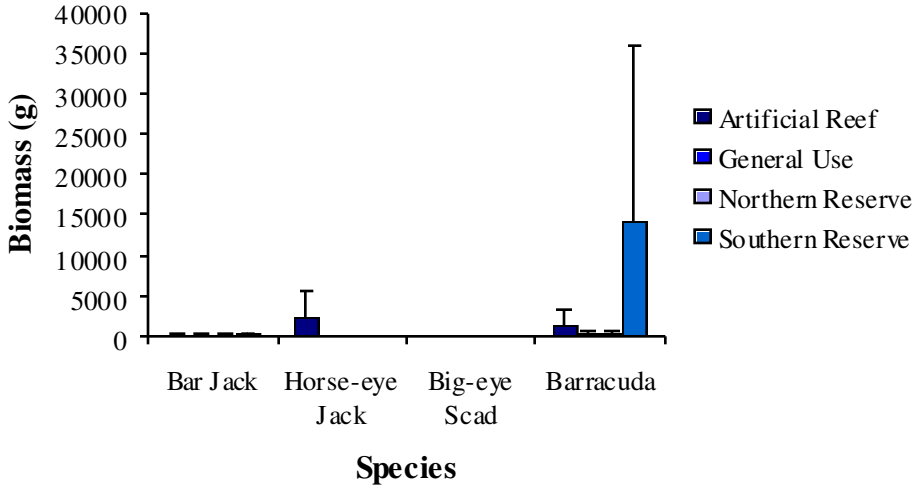


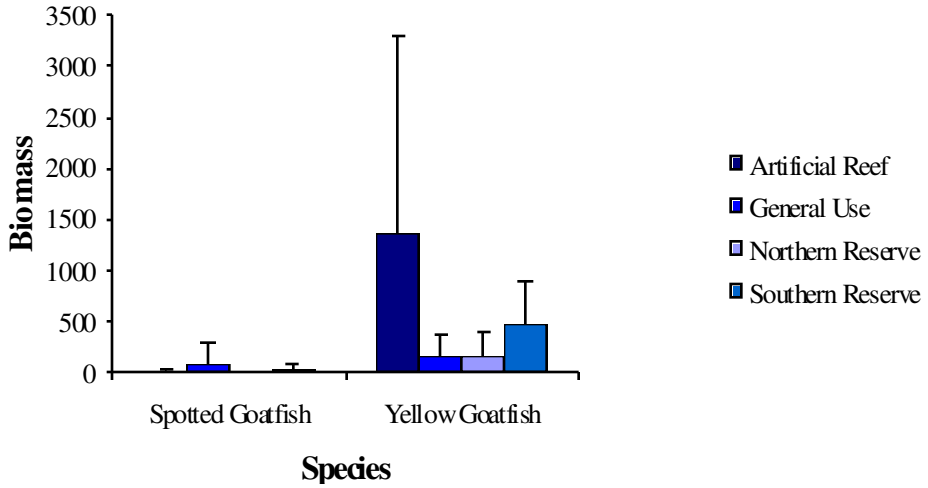
Figure 21 shows that the Barracuda, *Sphyraena barracuda*, was found to be of highest density within the Southern Reserve. Bar Jacks, *Caranx rubber*, were found in all of the regions of the marine park, while Horse-eye Jacks, *Caranx latus*, were only found to be present within the Artificial Reef region.

Figure 21: The observed biomass of the Jack and Barracuda families within the Marine Park



As shown by Figure 22 the Yellow Goatfish, *Mulloidichthys martinicus*, was the member of the Goatfish family, *Mullidae*, with the highest biomass within the Marine Park with the greatest density being within the Artificial Reef region.

Figure 22: The observed biomass of the Goatfish family within the Marine Park



Discussion

The fish population within the waters of St. Eustatius has been identified as being the most abundant within the Southern Reserve of the Marine Park. On average twenty to thirty species were observed to be present at each of the survey locations, with the location of Blair's Reef being found to be the most diverse with over thirty-five species being observed. The diversity of the fish population within the waters of St. Eustatius has been proven to have increased dramatically in the last thirteen years, with the number of species currently present in the waters being on average 4.9 times greater than the number observed in 1992 at the same locations. This clearly indicates that the establishment of the Marine Park nine years ago has been beneficial to the fish population within the local waters.

The most abundant fish family within the marine park was the Wrasse, *Labridae*. Of the wrasse family the most abundant species were the Yellowhead, *Halichoeres garnoti*, Bluehead, *Thalassoma bifasciatum*, and Clown, *Halichoeres maculipinna*. The second most abundant fish family was the Damselfish, *Pomacentridae*, with the Bicolor, *Stegastes partitus*, Blue Chromis, *Chromis cyanea*, and Brown Chromis, *Chromis multilineata*, being the most abundant species within the family.

The most abundant pelagic fish families within the Marine Park were found to be the Jack, *Carangidae*, and Snapper, *Lutjanidae*, with Bar Jacks, *Caranx rubber*, and Cubera Snapper, *Lutjanus cyanopterus* being the most abundant species respectively. The French Grunt, *Haemulon flavolineatum*, was found to be the most abundant member of the Grunt family, *Haemulidae*, within the Marine Park and three members of the Grouper family, *Serranidae*, were found to be present in all regions of the Marine Park.

It was established that there was a healthy population of reef fish within the Marine Park with members of the Surgeon, *Acanthuridae*, and Squirrelfish, *Holocentridae*, families being present in all regions of the Park. The Stoplight, *Sparisoma viride*, Princess, *Scarus taeniopterus*, and Striped, *Scarus croicensis*, Parrotfish were the most abundant members of the Parrotfish family. Of the Butterflyfish, *Chaetodontidae*, the Four-eye, *Chaetodon capistratus*, was the most abundant and the French Angel,

Pomacanthus paru, and Rock Beauty, *Holocanthus tricolor*, were the most abundant members of the Angelfish family, *Pomacanthidae*.

It was found that the Jack family, *Carangidae*, was the family with the largest biomass within the Marine Park. The density of the fish families was found to be fairly evenly distributed between the protected no-take reserves and unprotected general use areas of the Marine Park for all of the families observed except for the Jack family, which was found to be far more dense within the protected reserve regions of the Marine Park. The majority of the biomass of the Jack family was made up of Barracuda, *Sphyraena barracuda*, with the largest density being found within the Southern Reserve at just over 14000g.

The results of the fisherman survey were quite useful in looking at changes and trends within the fishing industry, as well as the status of the benthic habitat, for the past ten years. Knowing which species fisherman aim to catch and at what time during the year they catch these species will greatly improve the Marine Park's management strategies. The two main activities taking place within the park and outside the park are diving and fishing. The majority of the fishermen have been fishing within these waters for a long time, making their opinions valuable to the Marine Park. Due to the recent marine reserves set up and the enforcement of them, fishermen have had to change their fishing methods. They now fish in different locations outside the marine reserves and many of them say they now use more traps. Also, because of the high fuel prices, many fishermen have had to cut down on the amount of fishing trips they make per week. When asked about the changes in the coral reefs and the fish populations over the past ten years, half of the fishermen said they saw no changes, while the other half said they had seen positive changes, citing more fish and less anchor damage. These changes indicate the Marine Park is working, although fishermen have had to change some of their methods along the way.

In conclusion, the survey has identified that the presence of the Marine Park has been beneficial to the diversity of fish within the waters surrounding St. Eustatius. The number of species observed has greatly increased from 1992 to 2004. The Marine Park has also been identified as being beneficial to certain fish families by leading to an increase in their density within the protected regions of the Marine Park. This increase in

density within the protected regions of the Marine Park will have a beneficial knock-on effect to the density of species in the neighbouring regions and will therefore assist the local fisheries. The objective of the Marine Park is to sustain the fish populations and to create a spill-over effect from the marine reserves into the general use areas. The results of this survey show that this is taking place. To better manage the fisheries of St. Eustatius and to illustrate to the fishermen that the reserves are working, a similar fish population survey will be carried out every two years and the results presented to all of the stakeholders of the Marine Park.

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Appendix 1

Latin Names		Latin Names	
Chaetodontidae (Butterflyfish)		Pomacanthidae (Angelfish)	
Banded	*Chaetodon striatus*	Queen	*Holocanthus ciliaris*
Foureye	*Chaetodon capistratus*	French	*Pomacanthus paru*
Spotfin	*Chaetodon ocellatus*	Gray	*Pomacanthus arcuatus*
Reef	*Cheatodon sedentarius*	Rock Beauty	*Holocanthus tricolor*
Acanthuridae (Surgeonfish)		Carangidae (Jack)	
Bluetang	*Acanthurus coeruleus*	Bar	*Caranx rubber*
Ocean	*Acanthurus plumieri*	Horse-eye	*Caranx latus*
Doctor	*Acanthurus chirurgus*	Barracuda	*Sphyraena barracuda*
Harmulidae (Grunts)		Lutjanidae (Snapper)	
French	*Haemulon flavolineatum*	Yellowtail	*Ocyurus chrysurus*
White	*Haemulon plumieri*	Cubera	*Lutjanus cyanopterus*
Bluestripe	*Haemulon sciurus*	Schoolmaster	*Lutjanus apodus*
Pomacentridae (Damselfish)		Serranidae (Grouper)	
Threespot	*Stegastes planifrons*	Nassau	*Epinephelus striatus*
Bicolor	*Stegastes partitus*	Tiger	*Mycteroperca tigris*
Yellowtail	*Microspathodon chysurus*	Red hind	*Epinephelus guttatus*
Sergeant Major	*Abudefduf saxatilis*	Rock hind	*Epinephelus adscensionis*
Blue chromis	*Chromis cyanea*	Coney	*Epinephelus fulvus*
Brown chromis	*Chromis multilineata*		
Scaridae (Parrotfish)		Labridae (Wrasse)	
Queen	*Scarus vetula*	Creole	*Clepticus parrae*
Spotlight	*Sparisoma viride*	Yellowhead	*Halichoeres garnoti*
Princess	*Scarus taeniopterus*	Bluehead	*Thalassoma bifasciatum*
Striped	*Scarus croicensis*	Clown	*Halichoeres masculinpinna*
Redband	*Sparisoma aurofrenatum*	Spanish hog	*Bodianus rufus*
Readtail	*Sparisoma chrysopterum*		
Holocentridae (Squirrelfish)		Others	
Squirrel	*Holocentrus adscensionis*		
Longspine	*Holocentrus rufus*		