03/04/10

FINAL

REGULATORY AMENDMENT TO THE FISHERY MANAGEMENT PLAN FOR THE REEF FISH FISHERY OF PUERTO RICO AND THE U.S. VIRGIN ISLANDS MODIFYING THE BAJO DE SICO SEASONAL CLOSURE INCLUDING A REGULATORY IMPACT REVIEW AND AN ENVIRONMENTAL ASSESSMENT

March 2010

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Finding of No Significant Impact (FONSI) for the Regulatory Amendment to the Fishery Management Plan (FMP) for the Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands Modifying the Bajo de Sico Seasonal Closure (Regulatory Amendment)

National Marine Fisheries Service

National Oceanic and Atmospheric Administration Administrative Order 216-6 (NAO 216-6) (May 20, 1999) contains criteria for determining the significance of the impacts of a proposed action. In addition, the Council on Environmental Quality regulations at 40 C.F.R. 1508.27 state that the significance of an action should be analyzed both in terms of "context" and "intensity." Each criterion listed below is relevant in making a finding of no significant impact and has been considered individually, as well as in combination with the others. The significance of this action is analyzed based on the NAO 216-6 criteria, CEQ's context and intensity criteria, and National Marine Fisheries Service Instruction 30-124-1, July 22, 2005, Guidelines for the Preparation of a Finding of No Significant Impact.

Subsequent references throughout the following FONSI refer to the consolidated document containing the Environmental Assessment (EA) and Regulatory Amendment.

These criteria include:

1) Can the proposed action reasonably be expected to jeopardize the sustainability of any target species that may be affected by the action?

Response: No. The purpose of the action is to provide further protection to red hind spawning aggregations and large snappers and groupers, and better protect the essential fish habitat (EFH) where these species reside. The action proposes to prohibit the harvest and possession of Council-managed reef fish during 6 months of each year, which will actually help increase the sustainability of those species. Supporting analysis can be found in Section 5.1.1 of the consolidated EA and Regulatory Amendment.

2) Can the proposed action reasonably be expected to jeopardize the sustainability of any non-target species?

Response: No. The Caribbean Fishery Management Council reef fish fishery management unit includes over 85 species, many occurring at or nearby Bajo de Sico. Many species of reef fish in the area will be protected during the proposed 6-month seasonal closure. Also, harvest of coral and queen conch has been prohibited in the Caribbean exclusive economic zone (EEZ) for many years and will not be impacted by fishing or the use of bottom tending gear. Spiny lobster will remain open for harvest during the extended closed season but fishing effort directed toward spiny lobster is minimal in the area due to existing environmental conditions (i.e. fast currents and deep water) coupled with the anchoring prohibition and is not expected to increase (Section 3.1).

3) Can the proposed action reasonably be expected to cause substantial damage to the ocean and coastal habitats and/or essential fish habitat as defined under the Magnuson-Stevens Act and identified in FMPs?

Response: No. The proposed action would reduce fishing pressure by limiting allowable fishing activities for a longer period of time. According to Section 5.1.1 of the Regulatory Amendment, the reduction in fishing pressure would equate to reduced impacts on the ocean and EFH by reducing interactions with gear and reduced fishing effort. The proposed action will also prohibit anchoring within Bajo de Sico and provide additional protection to EFH by limiting the interaction and threats to coral and other reef benthic species by anchors (Section 5.2.1).

4) Can the proposed action be reasonably expected to have a substantial adverse impact on public health or safety?

Response: Modifying a closed season will not affect harvest methods, the safety of fishermen at sea, nor will it change the quality or safety of seafood harvested in the area. According to Section 5.1, the proposed action is designed to protect the biological environment of reef fish and coral populations as well as provide additional protection to EFH. Therefore, the proposed actions are not likely to affect public health and safety.

5) Can the proposed action reasonably be expected to adversely affect endangered or threatened species, marine mammals, or critical habitat of these species?

Response: No. Two coral species found in the Caribbean are listed as threatened. However, since fishing activities within Bajo de Sico will be limited for a longer period of time than the current closure, there are no adverse impacts expected to the threatened corals or other endangered and threatened species. According to Section 5.1.1.1, incidental catch and interactions, including entanglements, with threatened or endangered species, (i.e. coral and turtles) and to their critical habitat is likely to be reduced as a result of reduced fishing pressure on the area.

6) Can the proposed action be expected to have a substantial impact on biodiversity and/or ecosystem function within the affected area (e.g., benthic productivity, predator-prey relationships, etc.)?

Response: The proposed action is expected to have a positive (beneficial) long-term impact on biodiversity and ecosystem function in the area by providing further protection for red hind spawning aggregations and large snappers and groupers, and better protect the EFH where these species reside (Section 5.1.1). Also, the proposed no anchoring provision is expected to have a positive impact on existing habitat by eliminating potential interactions with anchors (Section 5.2.1). The purpose of the closed area would be to conserve the stocks and habitat that already exists in the area.

7) Are significant social or economic impacts interrelated with natural or physical environmental effects?

Response: No. According to Sections 3.1 and 5.1.2, environmental (i.e. fast currents and deep water) and weather conditions often prevent certain fishers from utilizing Bajo de Sico during the proposed closed season. As a result, current fishing pressure within the area is not substantial during the proposed extended closure. Fishers will be able to fish for coastal and highly migratory species during the year and should not be economically impacted by the management action. Consequently, proposed regulations are not expected to result in significant social or economic impacts.

8) Are the effects on the quality of the human environment likely to be highly controversial?

Response: No. The seasonally closed area concept has historically been used in the U.S. Caribbean and elsewhere for fisheries management and allows fishers to adjust their fishing targets accordingly. The proposed regulations have also been subject to public comment and are not likely to cause controversy. The area has historically been subject to seasonal spawning closures and gear restrictions and stakeholders generally agree with the current management philosophy.

9) Can the proposed action reasonably be expected to result in substantial impacts to unique areas, such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers or ecologically critical areas?

Response: No. In the area where regulations are proposed, no known historic or cultural resources are found. Also, ecologically critical areas (such as coral reef habitats) have been identified and would be afforded additional protection by the proposed actions through reduced fishing pressure and prohibition on anchoring (Sections 3.1, 3.2, 5.1.1 and 5.2.1). No adverse impacts are expected as a result of the proposed actions.

10) Are the effects on the human environment likely to be highly uncertain or involve unique or unknown risks?

Response: No. As outlined in Sections 5.1.1 and 5.2.1, the proposed regulations are designed to protect spawning reef fish and essential fish habitat by reducing fishing activities and prohibiting anchoring in Bajo de Sico. The management measures being proposed are commonly used throughout fishery management and are well understood. As a result, no highly uncertain, unique, or unknown risks are anticipated.

11) Is the proposed action related to other actions with individually insignificant, but cumulatively significant impacts?

Response: No. The proposed action is administrative in nature and will not be cumulatively significant or result in significant changes to the area. As outlined in Section 3.1, Bajo de Sico is currently managed with a closed season. The action proposes to modify the seasonal closure. In addition, there are no additional actions pertaining to Bajo de Sico that may result in cumulatively significant impacts. This rule is not directly related to any other future action currently under consideration.

12) Is the proposed action likely to adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural or historical resources?

Response: No. Bajo de Sico is not in proximity of any locations listed in or eligible for listing in the National Register of Historic Places. As a result, the proposed action is not expected to have any effect on such locations or cause loss or destruction of significant scientific, cultural, or historical resources.

13) Can the proposed action reasonably be expected to result in the introduction or spread of a nonindigenous species?

Response: No. The proposed action to modify the seasonal closure of Bajo de Sico (Section 3.1) proposes only to limit extractive uses by prohibiting fishing for and possession of Council-managed reef fish in the area and will neither introduce nor spread non-indigenous species.

14) Is the proposed action likely to establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration?

Response: No. As outlined in Sections 3.1 and 3.2, the action proposes to modify the seasonal closure to six-months as well as prohibit anchoring within Bajo de Sico year round. Establishing seasonal closed areas to protect fishery resources and habitat is a well-established management strategy that has historically been used in fishery management. As a result, this action does not present any new or unusual issues for future consideration.

15) Can the proposed action reasonably be expected to threaten a violation of Federal, State, or local law or requirements imposed for the protection of the environment?

Response: No. The Regulatory Amendment was developed under the guidelines of various federal laws, including National Environmental Policy Act and Magnuson-Stevens Fishery Conservation and Management Act. The Regulatory Amendment outlines the action's effect on other applicable laws (Section 8.0).

16) Can the proposed action reasonably be expected to result in cumulative adverse effects that could have a substantial effect on the target species or non-target species?

Response: No. The cumulative adverse effect is not expected to have a substantial effect on any target species. Instead, cumulative overall effects on species found within Bajo de Sico are expected to be beneficial. The proposed action prohibits harvest and possession of Council-managed reef fish during a 6-month period, which will prevent further population declines and any adverse effects to those species. By reducing fishing pressure, reef fish and coral populations will have long term positive cumulative effects. Reduced fishing effort will provide protection to species as well as allow for these populations to thrive and rebuild (Section 5.1.1). The prohibition on anchoring will provide even further protection to EFH and coral populations. Because fisheries for coastal and highly migratory species will be allowed in the area, bycatch of reef fish species and entanglement of pelagic gear with the reef is possible. Depending on the extent of such interaction, adverse impacts are possible. Without further information, the extent of such impacts cannot be determined or estimated. Non-target reef fish species will also be protected with the gear restrictions and anchoring prohibition, thus promoting long-term sustainability (Section 5.2.1).

DETERMINATION

In view of the information presented in this document and the analysis contained in the supporting Environmental Assessment prepared for Regulatory Amendment to the Fishery Management Plan (FMP) for the Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands modifying the Bajo de Sico Seasonal Closure, it is hereby determined that the regulatory amendment will not significantly impact the quality of the human environment as described above and in the supporting Environmental Assessment. In addition, all beneficial and adverse impacts of the proposed action have been addressed to reach the conclusion of no significant impacts. Accordingly, preparation of an EIS for this action is not necessary.

Roy E. Crabtree, Ph.D., SERO Regional Administrator, NOAA — 1/19/10 (Date)

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1.0 EXECUTIVE SUMMARY

The Bajo de Sico area closure was first implemented as a means to protect spawning aggregations of red hind. All reef fish species differ in their vulnerability to fishing, the most vulnerable species undoubtedly include the hinds and groupers (Munro, 2006). Groupers in general are extremely vulnerable to overfishing due to a combination of life history traits typical in large serranid fish of the genera *Epinephelus and Mycteroperca* (Frias-Torres, 2008). These traits are slow growth, long life, late sexual maturity, strong site fidelity, and formation of spawning aggregations (Levin and Grimes 2002). Species that aggregate to spawn are extremely vulnerable to overfishing and it is clear that the survival of some stocks of hinds and groupers will depend on the creation of fishery reserves, preferably that include spawning aggregation sites and are of sufficient size to encompass the home range and depth range of much of the local stock (Munro, 2006). Bajo de Sico has been identified as an important site for resident groupers including the red hind, Nassau and yellowfin groupers, and as an important site for foraging for these and numerous other species. The site has also been described as a diverse coral and sponge habitat, which provides a forage area and a high relief profile used for protection by many fishes in the area (García-Sais *et al.*, 2007). Consequently, Bajo de Sico is an ecologically important site needing protective management. The use of bottom tending gear (traps, pots, gill and trammel nets, and bottom longlines) in Bajo de Sico is prohibited year-round to enhance protection of essential fish habitat (EFH). This amendment includes two management actions. Preferred Alternative 2 for Action 1 proposes to modify the seasonal closure of Bajo de Sico to a 6 month closure from October 1 through March 31 each year to provide better protection for red hind spawning aggregations, large snappers and groupers, and coral reef habitat. Sub-Alternative 2d defines the closure as prohibiting fishing for and possession of all reef fish species managed by the Caribbean Fishery Management Council (Council). Preferred Alternative 3 for Action 2 proposes to prohibit anchoring year-round in Bajo de Sico to provide further EFH protection.

2.0 INTRODUCTION AND PURPOSE AND NEED

2.1 Purpose and Need

The purpose of implementing this regulatory amendment is to protect the red hind spawning aggregations and large individuals of snappers and groupers found in the area from directed fishing pressure to achieve a more natural sex ratio, age, and size structure, while minimizing adverse social and economic effects. Investigations by García-Sais *et al.* (2007) described Bajo de Sico populations of snapper and groupers as composed of relatively large individuals many of which exhibit behaviors indicating they are approaching a spawning condition (i.e., sexual dimorphic color patterns and aggressive behaviors normally associated with spawning). The area is also known to be comprised of pristine coral habitats. The Council wants greater protection of the area in order to preserve the current spawning fish populations and habitat conditions.

Currently, the area is closed to all fishing activity from December 1 through the end of February, each year. In addition, fishing with pots, traps, bottom longlines, gillnets or trammel nets is prohibited year-round. From April through November of each year, fish populations are vulnerable to fishing activities. As a result, the Council intends to prohibit certain fishing activities and anchoring to protect the associated pristine coral habitats by modifying the seasonal closure of Bajo de Sico.

2.2 Background

The area off the west coast of Puerto Rico, known as Bajo de Sico, was open to all fishing activities prior to regulations being implemented in 1996. This area was a location where fishers targeted red hind populations, particularly spawning aggregations. However, commercial fishermen in the area noticed decreases in fish size and total catch (pounds) and a decrease in the number of individuals comprising the spawning aggregations. Therefore, commercial fishermen proposed to implement seasonal area closures to protect the spawning aggregations and in 1996, a regulatory amendment to the Reef Fish Fishery Management Plan (FMP) established a closed season from December 1 through the last day of February for three areas of nine square miles (61 FR 64485). These areas were Bajo de Sico, Tourmaline Bank and Abrir La Sierra (Figure 2.2.1). The Bajo de Sico and Tourmaline Bank areas include portions in federal waters (i.e., the Exclusive Economic Zone (EEZ)) as well as Puerto Rico territorial waters. The Bajo de Sico area is about 60% EEZ waters, while the Tourmaline area is approximately 40% EEZ waters. When the 1996 regulatory amendment was established in the Caribbean EEZ, the government of Puerto Rico implemented compatible regulations. The government of Puerto Rico has indicated their intent to implement comptabile regulations if the proposed actions in this amendment are approved by the Secretary of Commerce and implemented in federal waters. Therefore, analysis contained within this document assumes compatible regulations will be implemented by the government of Puerto Rico.

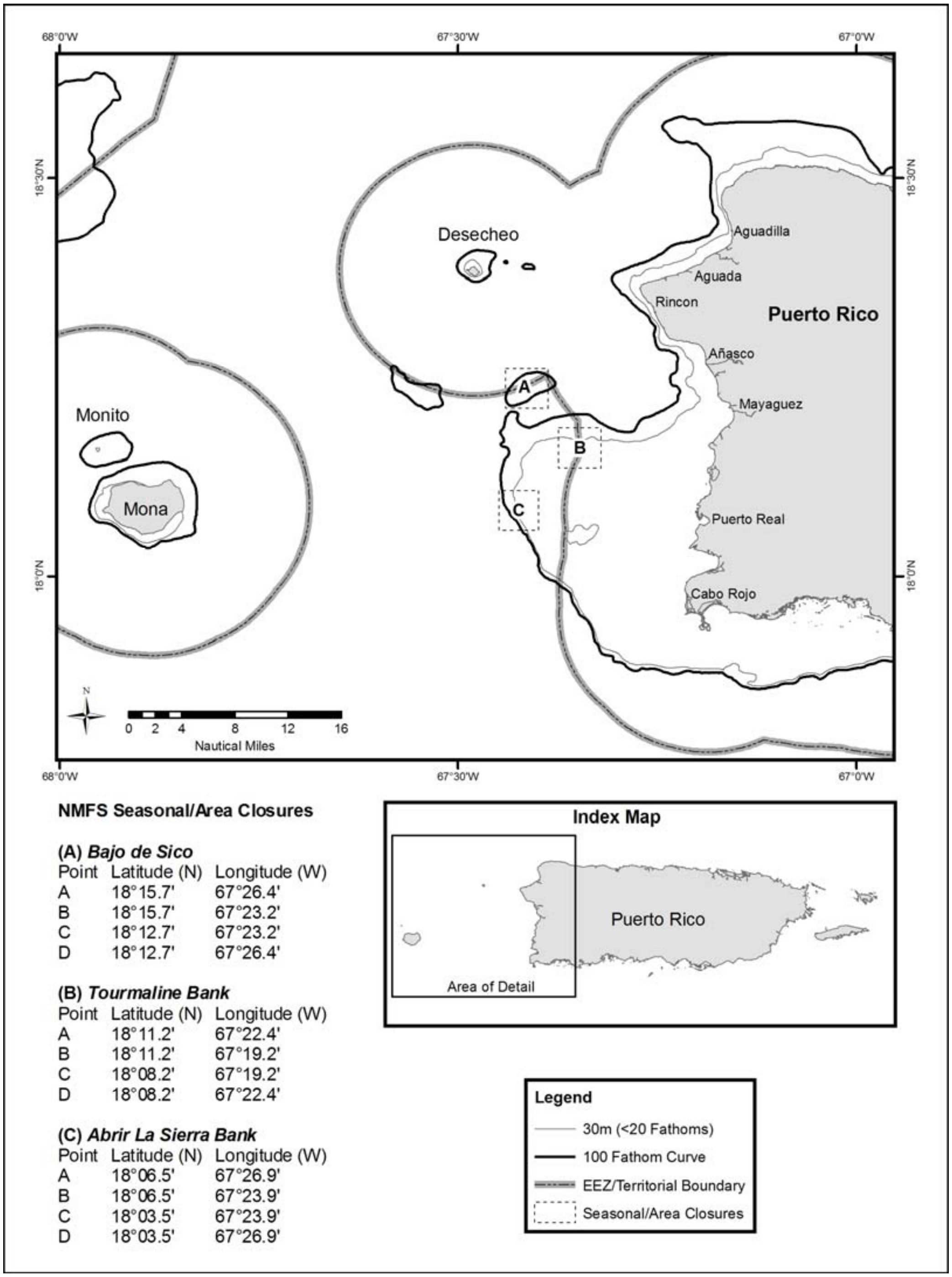

Figure 2.2.1: Three seasonally closed areas implemented in 1996, on the west coast of Puerto Rico: Bajo de Sico, Tourmaline and Abrir La Sierra

Anecdotal information suggests implementation of the seasonal closure has allowed red hind populations in the area to increase in size and abundance. In 2005, the Comprehensive Sustainable Fisheries Act Amendment to the Spiny Lobster, Queen Conch, Reef Fish, and Corals and Reef Associated Plants and Invertebrates FMPs (Comprehensive SFA Amendment) was implemented to prohibit the use of bottom tending gear (traps, pots, gill and trammel nets, and bottom longlines) in all seasonally closed areas, including Bajo de Sico, to enhance protection of EFH. The Comprehensive SFA Amendment also implemented the requirement for an anchor retrieval system for all fishing vessels designed to minimize anchor damage to EFH but the current amendment proposes to prohibit anchoring at Bajo de Sico. Recently, newly discovered and nearly pristine coral reef formations in high densities have been documented (García-Sais *et al.*, 2007) and within this coral reef habitat, large individuals of snapper and grouper have been identified, including one of the largest aggregations of federally protected Nassau groupers off the west coast of Puerto Rico (García-Sais *et al.*, 2007).

For commercial and recreational fishers, Bajo de Sico is a productive fishing zone for yellowfin tuna as well as other species in the Highly Migratory Species (HMS) group. Commercial fishers use the area as a source of bait (e.g., little tunny and blackfin tunas), and recreational fishers target other species such as dolphin and king mackerel (see Table 2.2.1). Not all the species reported by recreational fishers are harvested at Bajo de Sico but are included for the data from all fishing modes and areas.

Table 2.2.1. Recreational landings in number of fish both observed and not observed during MRFSS intercepts off Puerto Rico west coast during 2004-2007 by municipalities and species

	Aguada	Aguadilla	Añasco	Cabo Rojo	Mayagüez	Rincón	**2004-2007 Totals**
AGUJON	0	0	0	0	0	2	**2**
ATLANTIC BUMPER	15	0	0	0	0	0	**15**
ATLANTIC CUTLASSFISH	0	0	0	0	1	0	**1**
ATLANTIC SPADEFISH	0	0	0	1	0	0	**1**
ATLANTIC TARPON	2	0	0	100	24	0	**126**
ATLANTIC THREAD HERRING	0	1	0	0	0	0	**1**
BAR JACK	0	0	0	4	0	1	**5**
BARBU	10	0	0	6	13	2	**31**
BERMUDA CHUB	0	0	0	1	0	0	**1**
BLACK DURGON	0	0	0	0	21	0	**21**
BLACK JACK	0	0	0	0	5	1	**6**
BLACKFIN SNAPPER	0	0	0	1	0	0	**1**
BLACKFIN TUNA	0	0	0	1	0	11	**12**
BLACKTIP SHARK	0	0	0	6	0	0	**6**
BLUE CHROMIS	0	0	0	0	1	0	**1**
BLUE MARLIN	0	0	0	7	1	2	**10**
BLUE RUNNER	4	3	1	8	74	3	**93**
BLUEHEAD	0	1	0	0	0	0	**1**
BONEFISH	0	0	0	4	4	0	**8**
BURRO GRUNT	0	0	0	2	7	0	**9**
CERO	5	0	3	7	4	8	**27**
COMMON SNOOK	2	0	0	57	27	2	**88**
CONEY	3	0	0	46	130	18	**197**
CREVALLE JACK	10	0	1	34	6	10	**61**
CUBERA SNAPPER	0	0	0	1	0	0	**1**

Table 2.2.1 Cont. Recreational landings in number of fish both observed and not observed during MRFSS intercepts off Puerto Rico west coast during 2004-2007 by municipalities and species

	Aguada	Aguadilla	Añasco	Cabo Rojo	Mayagüez	Rincón	**2004-2007 Totals**
DOG SNAPPER	0	0	0	1	6	0	**7**
DOLPHIN	4	0	12	26	4	33	**79**
DRUM FAMILY	0	0	0	1	1	0	**2**
FRENCH GRUNT	0	0	0	0	1	6	**7**
GOLIATH GROUPER	0	0	0	1	0	0	**1**
GRAY SNAPPER	0	0	0	115	10	0	**125**
GRAYSBY	1	0	0	2	4	12	**19**
GREAT BARRACUDA	0	0	21	24	5	38	**88**
GREATER AMBERJACK	0	0	0	0	1	0	**1**
GREEN MORAY	0	0	0	0	8	0	**8**
GRUNT FAMILY	0	0	0	0	1	0	**1**
HAIRY BLENNY	0	0	0	0	1	0	**1**
HERRING FAMILY	0	6	0	0	0	0	**6**
HORSE-EYE JACK	1	3	0	3	14	3	**24**
HOUNDFISH	0	0	0	5	0	0	**5**
KING MACKEREL	0	0	2	5	1	11	**19**
LADYFISH	0	1	0	16	0	0	**17**
LANE SNAPPER	1	0	0	40	42	12	**95**
LITTLE TUNNY	0	0	5	5	1	47	**58**
MACKEREL FAMILY	0	0	0	1	0	0	**1**
MAHOGANY SNAPPER	0	0	0	4	0	0	**4**
MOJARRA FAMILY	7	0	0	0	0	0	**7**
MOTTLED MOJARRA	0	0	0	1	0	2	**3**
MUTTON SNAPPER	5	0	0	19	13	3	**40**
NURSE SHARK	0	0	0	0	1	0	**1**
OCEAN TRIGGERFISH	0	0	0	0	5	0	**5**
PALOMETA	0	0	0	10	8	4	**22**

Table 2.2.1 Cont. Recreational landings in number of fish both observed and not observed during MRFSS intercepts off Puerto Rico west coast during 2004-2007 by municipalities and species

	Aguada	Aguadilla	Añasco	Cabo Rojo	Mayagüez	Rincón	**2004-2007 Totals**
PERMIT	10	0	0	0	1	1	**12**
PLUMA PORGY	0	1	0	3	5	3	**12**
PORCUPINEFISH	0	1	0	1	0	0	**2**
PORGY FAMILY	1	0	0	0	0	0	**1**
PUDDINGWIFE	0	1	0	0	6	0	**7**
QUEEN SNAPPER	0	0	0	7	0	4	**11**
QUEEN TRIGGERFISH	0	0	0	3	3	2	**8**
RAINBOW RUNNER	0	0	0	0	0	11	**11**
RED GROUPER	0	0	0	1	0	0	**1**
RED HIND	0	0	0	45	58	9	**112**
REDBAND PARROTFISH	0	0	0	0	0	1	**1**
REDEAR SARDINE	0	0	0	1	0	0	**1**
REQUIEM SHARK FAMILY	0	0	0	0	1	0	**1**
ROCK HIND	0	0	0	1	0	0	**1**
SAILORS CHOICE	0	0	0	0	1	0	**1**
SAND DIVER	0	0	0	1	3	0	**4**
SAND DRUM	1	0	3	0	1	2	**7**
SAND TILEFISH	0	0	0	1	4	0	**5**
SCALED SARDINE	30	0	0	0	1	50	**81**
SCHOOLMASTER	1	0	4	5	10	1	**21**
SILK SNAPPER	5	0	0	11	19	23	**58**
SKIPJACK TUNA	0	0	0	0	1	27	**28**
SMALLMOUTH GRUNT	0	0	0	0	0	1	**1**
SOUTHERN SENNET	4	0	0	0	0	0	**4**
SOUTHERN STINGRAY	0	0	0	2	3	0	**5**
SPANISH GRUNT	0	0	0	0	0	1	**1**
SPANISH SARDINE	0	0	110	0	36	1	**147**

Table 2.2.1 Cont. Recreational landings in number of fish both observed and not observed during MRFSS intercepts off Puerto Rico west coast during 2004-2007 by municipalities and species

	Aguada	Aguadilla	Añasco	Cabo Rojo	Mayagüez	Rincón	**2004-2007 Totals**
SPOTFIN MOJARRA	0	0	0	0	1	3	**4**
SPOTTED GOATFISH	0	0	0	0	2	0	**2**
SPOTTED MORAY	1	0	0	0	0	1	**2**
SQUIRRELFISH	0	0	0	1	25	3	**29**
STRIPED CROAKER	0	0	0	0	2	0	**2**
STRIPED MOJARRA	0	0	1	1	0	0	**2**
TARPON FAMILY	0	0	0	0	2	0	**2**
TIGER SHARK	0	0	1	0	0	0	**1**
TOMTATE	0	0	0	2	0	9	**11**
TRIPLETAIL	0	0	0	0	3	0	**3**
TRUNKFISH	5	0	0	2	20	0	**27**
TUNA GENUS	0	0	0	3	0	0	**3**
UNIDENTIFIED FISH	0	0	0	0	1	2	**3**
UNIDENTIFIED SHARKS	0	0	0	1	1	0	**2**
UNKNOWN	0	0	0	0	1	0	**1**
VERMILION SNAPPER	5	0	1	0	3	1	**10**
WAHOO	0	0	3	9	0	22	**34**
WHITE GRUNT	0	1	0	5	3	1	**10**
WHITE MULLET	0	0	0	3	0	0	**3**
YELLOW GOATFISH	1	0	0	0	3	0	**4**
YELLOW JACK	4	0	0	0	3	1	**8**
YELLOWFIN GROUPER	0	0	0	1	0	0	**1**
YELLOWFIN MOJARRA	0	0	0	1	3	0	**4**
YELLOWFIN TUNA	0	0	1	0	0	2	**3**
YELLOWTAIL SNAPPER	7	0	2	39	18	3	**69**
TOTAL	**145**	**19**	**171**	**715**	**689**	**416**	**2155**

NOTE: queen conch and spiny lobster are not reported in the MRFSS data set

Recreational divers also utilize Bajo de Sico, despite strong currents and deep waters, which often combine to create unsafe diving conditions. Free divers (i.e., divers without SCUBA) visit the area to spear pelagics such as wahoo, tunas and dolphin fish (E. Ojeda, pers. com.). However, some dive charter operators note trips generally occur during the closed season (December through February), the divers stay fairly shallow (<100 ft), and do not spear fish. However, during the open season, the divers have often speared fish or taken lobster.

As previously discussed, two other nine square mile areas off the west coast of Puerto Rico (Abrir la Sierra Bank and Tourmaline Bank) are closed seasonally from December 1 to the end of February each year to protect spawning aggregations of red hind. Also, there are a number of other seasonal closures that prohibit harvesting certain species within federal waters which apply to the EEZ around Puerto Rico and the US Virgin Islands. Red, black, tiger, yellowfin, and yellowedge grouper are closed from February 1 through April 30 (50 CFR §622.33 (a) (4)). From October 1 through December 31, harvesting vermilion, black, silk, and blackfin snapper is prohibited (50 CFR §622.33 (a) (6)). Similarly, lane and mutton snapper are closed from April 1 through June 30 (50 CFR §622.33 (a) (7)).

New technology (e.g., electronic navigational systems) and more efficient gear have become available to fishers and pose an increased fishing potential to resident fish stocks and potential for damage to pristine coral formations. For example, some recreational fishers are using a new deep jigging technique and are fishing at depths of 600-800 ft. In an area such as Bajo de Sico where the bottom is irregular, often with high relief, such fishing gear may become entangled on the bottom (in sponges as well as in hard and soft corals), increasing the potential for damaging the coral reef and other EFH. Also, some new accessories to SCUBA gear, such as re-breathers and nitrox systems, allow divers to go deeper and stay at depths longer, which increases dive time and opportunities for harvesting fish, leading to an increase in fishing mortality. In summary, an increase in fishing potential and efficiency of gear could prove detrimental to fully exploited fish stocks.

In 2007, Griffith *et al.* conducted a study on the effect of area/seasonal fishing closures on fishing communities, including Bajo de Sico. The study concluded between 70% and 90% of the fishers surveyed strongly agree that closures protecting spawning aggregations restore or maintain habitat quality, improve the quantity of fish, both inside and adjacent to the closure, and protect species in vulnerable areas. When asked their opinion of closed areas, fishers seemed to view them with a kind of indifference and acceptance (Griffith *et al*, 2007).

However, a recent survey examining small-scale fishermen's perceptions regarding likely socio-economic impacts on fishing practices, families, and community revealed the majority of the fishermen were against a longer seasonal closure in the Bajo de Sico area because of perceptions about reduced revenues, effort-shifts, and safety at sea (Tonioli and Agar 2008).

2.3 History of Federal Fisheries Management

The Council manages 179 fish stocks under four FMPs:

- FMP for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands
- FMP for the Queen Conch Resources of Puerto Rico and the U.S. Virgin Islands
- FMP for the Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands
- FMP for the Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the U.S. Virgin Islands

The HMS Management Division of National Marine Fisheries Service (NMFS) manages Atlantic albacore tuna, bigeye tuna, bluefin tuna, skipjack tuna, oceanic sharks, swordfish, white marlin, blue marlin, sailfish, and longbill spear fish under two FMPs:

- FMP for Atlantic Tunas, Swordfish, and Sharks
- FMP for the Atlantic Billfishes

The history of management measures developed and implemented under each Council FMP and subsequent generic amendments is detailed in Sections 2.3.1 - 2.3.5. The history of management measures developed and implemented under each HMS Management Division FMP is detailed in Section 2.3.6.

2.3.1 Fishery Management Plan for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands

The Council's Spiny Lobster FMP (CFMC 1981; 49 FR 50049) was implemented in January 1985, and was supported by an Environmental Impact Statement (EIS). The FMP defined the Caribbean spiny lobster fishery management unit as Caribbean spiny lobster (*Panulirus argus*), described objectives for the spiny lobster fishery, and established management measures to achieve those objectives. Primary management measures included:

- The definition of Maximum Sustainable Yield (MSY) as 830,000 lbs per year;
- The definition of Optimum Yield (OY) as “all the non-[egg-bearing] spiny lobsters in the management area having a carapace length of 3.5 inches or greater that can be harvested on an annual basis,” which was estimated to range from 582,000 to 830,000 lbs per year;
- A prohibition on the retention of egg-bearing (berried) lobsters (berried female lobsters may be kept in pots or traps until the eggs are shed), and on all lobsters with a carapace length of less than 3.5 inches;
- A requirement to land lobster whole;
- A requirement to include a self-destruct panel and/or self-destruct door fastenings on traps and pots;
- A requirement to identify and mark traps, pots, buoys, and boats; and
- A prohibition on the use of poisons, drugs, or other chemicals, and on the use of spears, hooks, explosives, or similar devices to take spiny lobsters.

Amendment 1 to the Spiny Lobster FMP (CFMC 1990a; 56 FR 19098), implemented in May 1991, added to the FMP definitions of overfished and overfishing, and outlined framework actions that could be taken should overfishing occur. The amendment defined "overfished" as a biomass level below 20% of the spawning potential ratio (SPR). It defined "overfishing" as a harvest rate that is not consistent with a program implemented to rebuild the stock to the 20% SPR. That amendment was supported by an Environmental Assessment (EA) and a finding of no significant impact (FONSI).

Amendment 2 to the Spiny Lobster FMP was approved in 2005 with the implementation of the Comprehensive Sustainable Fisheries Act Amendment to the Spiny Lobster, Queen Conch, Reef Fish, and Coral and Coral Reefs Fishery Management Plans (Comprehensive SFA Amendment). The amendment implemented modifications to the pots and traps, prohibited gear, EFH designation, among others. Primary management measures include:

- A requirement for fish traps to have an 8 inches by 8 inches panel (with mesh not smaller than the mesh of the trap) on one side of the trap (excluding top, bottom and the side of the door) attached with untreated jute twine (diameter less than 1/8 inch);
- A requirement for individual traps or pots to have at least one buoy attached that floats on the surface;
- A requirement for traps or pots that are tied together in a trap line to have at least one buoy that floats to the surface at each end of the trap line;
- Prohibits the use of gillnets and trammel nets in the EEZ;
- Prohibits all bottom tending gear (pots, traps, gillnets, trammelnets, bottom longlines) from all seasonally closed areas year-round;
- Describes an anchor retrieval system required for anyone fishing or possessing Caribbean reef fish species;

For more information regarding the Comprehensive SFA Amendment, see section 2.3.5 (Generic FMP Amendments).

Amendment 4 to the Spiny Lobster FMP examined two actions with various alternatives restricting imports of Caribbean spiny lobster (*Panulirus argus*) into the United States to minimum conservation standards to achieve an increase in the spawning biomass of the spiny lobster stock and increase long-term yields from the fishery. It limits Caribbean spiny lobster imports to minimum sizes necessary to protect juvenile spiny lobster, prohibit the importation of berried (egg-bearing) females, or those lobsters whose eggs, pleopods, or swimmerets have been removed, and prohibits the importation of tail meat without the shell attached. These actions are designed to protect juveniles and actively reproducing individuals, which will help enhance the reproductive potential of Caribbean spiny lobster.

2.3.2 Fishery Management Plan for the Queen Conch Resources of Puerto Rico and the U.S. Virgin Islands

The Council's Queen Conch FMP (CFMC 1996a; 61 FR 65481) was implemented in January 1997, and was supported by an EIS. The FMP defined the queen conch fishery management unit, described objectives for the queen conch fishery, and established management measures to achieve those objectives. Primary management measures included:

- The definition of the MSY of queen conch as 738,000 lbs per year;
- The definition of the OY of queen conch as "all queen conch commercially and recreationally harvested from the EEZ landed consistent with management measure set forth in this FMP under a goal of allowing 20% of the spawning stock biomass to remain intact;"
- A prohibition on the possession of queen conch that measure less than 9 inches total length or that have a shell lip thickness of less than 3/8 inches;
- A requirement that all conch species in the fishery management unit be landed in the shell;
- A prohibition on the sale of undersized queen conch and queen conch shells;
- A recreational bag limit of three queen conch per day, not to exceed 12 per boat;
- A commercial catch limit of 150 queen conch per day;
- An annual spawning season closure that extends from July 1 through September 30; and
- A prohibition on the use of hookah gear to harvest queen conch.

In 2005, the Comprehensive SFA Amendment provided a rebuilding plan for queen conch as Amendment 1 to the Queen Conch FMP. To implement a rebuilding plan, the Council prohibited commercial and recreational harvest, and possession of queen conch in federal waters of the U.S. Caribbean, with the exception of Lang Bank near St. Croix. More specifically, the amendment:

- Establishes new Fishery Management Units for the queen conch;
- Prohibit the harvest and possession of queen conch from the EEZ, west of 64°34'W, East of this coordinate, fishing and possession are prohibited between July and September;
- Where fishing is allowed in the EEZ, conch must be maintained intact and all other regulations of bag limits, gear restrictions, and minimum size apply;
- All fishing is prohibited in Grammnik Bank, south of St. Thomas from February 1 through April 30 of each year;
- Establishes MSY, OY, MSST, MFMT for the FMUs

For more information regarding the Comprehensive SFA Amendment, see section 2.3.5 (Generic FMP Amendments)

2.3.3 Fishery Management Plan for the Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands

The Council's Reef Fish FMP (CFMC 1985; 50 FR 34850) was implemented in September 1985. The FMP, which was supported by an EIS, defined the reef fish fishery management unit to include shallow water species only, described objectives for the shallow water reef fish fishery, and established management measures to achieve those objectives. Primary management measures included:

- The definition of MSY as equal to 7.7 million lbs;
- The definition of OY as "all of the fishes in the management unit that can be harvested by U.S. fishermen under the provisions of the FMP...This amount is currently estimated at 7.7 million lbs;"
- The specification of criteria for the construction of fish traps, which included a minimum 1 1/4-inch mesh size requirement and a requirement that fish traps contain a self-destruct panel and/or self-destruct door fastening;
- A requirement to identify and mark gear and boats;
- A prohibition on the use of poisons, drugs, and other chemicals and explosives to take reef fish;
- A prohibition on the take of yellowtail snapper that measure less than 8 inches total length for the first fishing year, to be increased one inch per year until the minimum size limit reached 12 inches;
- A prohibition on the take of Nassau grouper that measure less than 12 inches total length for the first fishing year, to be increased one inch per year until the minimum size limit reached 24 inches; and
- A prohibition on the take of Nassau grouper from January 1 to March 31 each year, a period that coincides with the spawning season of this species.

Amendment 1 to the Reef fish FMP (CFMC 1990b; 55 FR 46214) was implemented in December 1990. That amendment was supported by an EA with a FONSI. Primary management measures included:

- An increase in the minimum mesh size for traps to 2 inches;
- A prohibition on the take or possession of Nassau grouper; and
- A prohibition on fishing in an area southwest of St. Thomas, USVI from December 1 through the end of February of each year, a period that coincides with the spawning season for red hind (this seasonal closure would later become a year round closure with the implementation of the Hind Bank Marine Conservation District through Amendment 1 to the Coral FMP).

Amendment 1 also defined overfished and overfishing for shallow water reef fish. "Overfished" was defined as a biomass level below 20% of the spawning stock biomass per recruit (SSBR) that would occur in the absence of fishing. For stocks that are overfished, "overfishing" was defined as a rate of harvest that is not consistent with a program that has been established to rebuild a stock or stock complex to the 20% SSBR level. For stocks that are not overfished, "overfishing" was defined as "a harvesting rate that if continued would lead to a state of the stock or stock complex that would not at least allow a harvest of OY on a continuing basis."

A regulatory amendment to the Reef Fish FMP (CFMC 1991; 56 FR 48755) was implemented October 1991. The primary management measures contained in this amendment, which was supported by an EA with a FONSI, included:

- A modification to the mesh size increase implemented through Amendment 1 to allow a mesh size of 1.5 inches for hexagonal mesh, and a change in the effective date of the 2-inch minimum mesh size requirement for square mesh to September 13, 1993; and
- A change in the specifications for degradable panels for fish traps related to the required number of panels (required two panels per trap), and their size, location, construction, and method of attachment.

Amendment 2 to the Reef Fish FMP (CFMC 1993; 58 FR 53145), implemented in November 1993, was supported by a supplemental EIS. That amendment redefined the reef fish fishery management unit (Appendix A) to include the major species of deep water reef fish and marine aquarium finfish. Primary management measures implemented through this amendment included:

- A prohibition on the use of any gear other than hand-held dip nets and slurp guns to collect marine aquarium fishes;
- A prohibition on the harvest or possession of Goliath grouper (formerly known as jewfish);
- A prohibition on the harvest, possession, and/or sale of certain species used in the aquarium trade, including seahorses and foureye, banded, and longsnout butterflyfish;
- A prohibition on fishing in an area off the west coast of Puerto Rico (Tourmaline Bank) from December 1 through the end of February each year, a period that coincides with the spawning season for red hind;
- A prohibition on fishing in an area off the east coast of St. Croix, USVI (Lang Bank) from December 1 through the end of February each year, a period that coincides with the spawning season for red hind; and
- A prohibition on fishing in an area off the southwest coast of St. Croix, USVI from March 1 through June 30 each year, a period that coincides with the spawning season for mutton snapper.

Existing definitions of MSY and OY were applied to all reef fish within the revised FMU, with the exception of marine aquarium finfish. The MSY and OY of marine aquarium finfish remained undefined.

A technical amendment to the Reef Fish FMP (59 FR 11560), implemented in April 1994, clarified the minimum mesh size allowed for fish traps.

An additional regulatory amendment to the Reef Fish FMP (CFMC 1996b; 61 FR 64485) was implemented in January 1997. That action, supported by an EA, reduced the size of the Tourmaline Bank closure that was originally implemented in 1993, and prohibited fishing in two areas off the west coast of Puerto Rico (Abrir La Sierra Bank (Buoy 6) and Bajo de Sico) from 1 December through the end of February of each year, a period that coincides with the spawning season of red hind.

Amendment 3 of the Reef Fish FMP was implemented in 2005 with the approval of the Comprehensive SFA Amendment, in which the Council redefined the fishery management units as well defined rebuilding plans for overfished species. Primary management measures implemented through this amendment are as follows:

- Establishes new Fishery Management Units (FMU) for the reef fish;
- A requirement for fish traps to have an 8 inches by 8 inches panel (with mesh not smaller than the mesh of the trap) on one side of the trap (excluding top, bottom and the side of the door) attached with untreated jute twine (diameter less than 1/8 inch);
- A requirement for individual traps or pots to have at least one buoy attached that floats on the surface;
- A requirement for traps or pots that are tied together in a trap line to have at least one buoy that floats to the surface3 at each end of the trap line;
- Prohibits the use of gillnets and trammel nets in the EEZ;
- A prohibition on the use of bottom tending gear (traps, pots, gillnets, trammelnets, bottom longlines) in the seasonally closed areas including the most recent area established (Grammanik Bank south of St. Thomas);
- Requires an anchor retrieval system for anyone fishing or possessing Caribbean reef fish species;
- A prohibition on the filleting fish at sea;
- Establishes a seasonal area closure in the area known as Grammanik Bank;
- Establish seasonal closures (no fishing or possession), every year during the specified months for (1) Snapper Unit 1 (silk, black, blackfin and vermillion snappers) from October 1 through December 31, (2) Grouper Unit 4 (tiger, yellowfin, yellowedge, red and black) from February 1 through April 30, (3) red hind from December 1 through the last day on February, and (4) lane and mutton snapper from April 1 through June 30;
- Establishes MSY, OY, MSST, MFMT for the FMUs.

For more information regarding the Comprehensive SFA Amendment, see section 2.3.5 (Generic FMP Amendments)

2.3.4 Fishery Management Plan for the Corals and Reef Associated Invertebrates of Puerto Rico and the U.S. Virgin Islands

The Council's Coral FMP (CFMC 1994; 60 FR 58221) was implemented in December 1995. The FMP, which was supported by an EIS, defined the coral fishery management unit (Appendix B), described objectives for Caribbean coral resources, and established management measures to achieve those objectives. Primary management measures included:

- A prohibition on the take or possession of gorgonians, stony corals, and any species in the fishery management unit if attached or existing upon live rock;
- A prohibition on the sale or possession of any prohibited coral unless fully documented as to point of origin;
- A prohibition on the use of chemicals, plants, or plant-derived toxins, and explosives to take species in the coral fishery management unit; and
- A requirement that dip nets, slurp guns, hands, and other non-habitat destructive gear types be used to harvest allowable corals.

The FMP also required that harvesters of allowable corals obtain a permit from the local or federal government.

Amendment Number 1 to the Coral FMP (CFMC 1999; 64 FR 60132) was implemented in December 1999. Supported by an SEIS, the amendment established a closed area in the U.S. EEZ southwest of St. Thomas, USVI known as the Hind Bank Marine Conservation District (MCD). Fishing for any species, and anchoring by all fishing vessels, is prohibited in the Hind Bank MCD year round.

The Comprehensive SFA Amendment was implemented in November 28, 2005, (70 FR 62073) and was supported by a Supplemental EIS, added to the FMP (Amendment 2) gear prohibitions among others. Primary management measures implemented through this amendment are as follows:

- A requirement for individual traps or pots to have at least one buoy attached that floats on the surface;
- A requirement for traps or pots that are tied together in a trap line to have at least one buoy that floats to the surface at each end of the trap line;
- Prohibits the use of gillnets and trammel nets in the EEZ;
- A prohibition on the use of bottom tending gear (traps, pots, gillnets, trammelnets, bottom longlines) in the seasonally closed areas including the most recent area established (Grammanik Bank south of St. Thomas);
- Requires an anchor retrieval system for anyone fishing or possessing Caribbean reef fish species;
- Establishes a seasonal area closure in the area known as Grammanik Bank;

For more information regarding the Comprehensive SFA Amendment, see section 2.3.5 (Generic FMP Amendments)

2.3.5 Generic Essential Fish Habitat Amendment to FMPs

The Council submitted the Generic Essential Fish Habitat Amendment to the Spiny Lobster, Queen Conch, Reef Fish, and Coral Fishery Management Plans (Generic EFH Amendment) with an EA to NMFS in 1998 to comply with the EFH provisions of the

Magnuson-Sevens Fishery Conservation and Management Act (MSFCMA). NMFS partially disapproved that amendment on March 29, 1999, finding that it did not evaluate all managed species or all fishing gears with the potential to damage fish habitat (64 FR 14884). The document was subsequently challenged by a coalition of environmental groups and fishing associations on the grounds that it did not comply with the requirements of the MSFCMA and NEPA (*American Oceans Campaign et al. v. Daley et al.*, Civ. No. 99-982 [D.D.C.]). The federal court opinion upheld the plaintiffs' claim that the Generic EFH Amendment with an EA was in violation of NEPA, but determined that the amendment was in accordance with the MSFCMA. The Council recently completed an FEIS for the Generic EFH Amendment to comply with the September 14, 2000 court order. The notice of availability of the draft EFH EIS was published in the *Federal Register* on August 1, 2003 (68 FR 45237). The comment period on that document ended on October 30, 2003. The notice of availability for the Record of Decision on the EFH FEIS was published in the *Federal Register* on May 25, 2004 (69 FR 29693)**.**

The Comprehensive SFA Amendment prepared by the Council and noticed in the *Federal Register* on January 25, 2002 (67 FR 3679), was intended to amend all four council plans to meet additional requirements added to the MSFCMA in 1996 through a Congressional amendment known as the Sustainable Fisheries Act (SFA). But a federal review determined that the Comprehensive SFA Amendment was inconsistent with the requirements of the SFA and NEPA. The lack of an adequate range of alternatives for defining biological reference points, rebuilding schedules, and bycatch reporting standards were the primary deficiencies cited in the notice of agency action to disapprove the document. The notice was published in the *Federal Register* on May 1, 2002 (67 FR 21598). In 2005, the Council implemented a revised Comprehensive SFA Amendment (Amendment 2 to the Spiny Lobster FMP, Amendment 1 to the Queen Conch FMP, Amendment 3 to the Reef Fish FMP, and Amendment 2 to the Coral FMP). The amendment established status determination criteria for each species in each FMP under management, rebuilding plans and schedules for overfished species, and ending overfishing through implementation of regulations to reduce fishing mortality. In addition to the modifications to the aforementioned FMPs, through the Comprehensive SFA Amendment, the Council prohibited the use of gill and trammel nets in federal waters, except those nets that were used to harvest ballyhoo, gar, and flying fish. The Comprehensive SFA Amendment also established the Grammanik Bank as a seasonally closed area from February 1 through April 30 each year as well as modified the requirements of trap construction. EFH was also defined in the amendment and impacts to EFH were addressed, including anchoring and gear restrictions.

2.3.6 Highly Migratory Species Management

Prior to 1990, the five Atlantic Regional Fishery Management Councils (New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, and Caribbean) had authority to manage Atlantic HMS in their regions. In 1985, those councils implemented the original Swordfish FMP and, in 1988, the original Billfish FMP.

On November 28, 1990, the President of the United States signed into law the Fishery Conservation Amendments of 1990. This law amended the Magnuson Act and gave the Secretary of Commerce the authority to manage Atlantic tuna and other HMS in the exclusive economic zone (EEZ) of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea (16 U.S.C. 1811 and 16 U.S.C. 1854(f)(3)). The Secretary subsequently delegated this authority to manage these HMS to NOAA Fisheries. In 1996, Congress amended the Magnuson Act with the Sustainable Fisheries Act, re-naming it the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), to require that NOAA Fisheries establish advisory panels (APs) to assist in the development of FMPs and FMP amendments for Atlantic HMS. As a result, NOAA Fisheries established the Atlantic HMS and Billfish APs and, in 1999, finalized and implemented the 1999 Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks (1999 FMP) and Amendment 1 to the Atlantic Billfish FMP. In 2003, NOAA Fisheries amended the 1999 FMP. In 2006, NOAA Fisheries published the 2006 Consolidated HMS FMP which consolidated the 1999 FMP and the Atlantic Billfish FMP and their amendments and combined the two separate APs into a single panel. The 2006 Consolidated HMS FMP has since been amended by Amendment 2 to the Consolidated HMS FMP in 2008, which focuses on shark management measures. NOAA Fisheries is currently working on Amendment 1 to the Consolidated HMS FMP, which focuses on essential fish habitat. NOAA Fisheries is also working on Amendment 3 to the Consolidated HMS FMP which will focus on management measures for small coastal sharks, and Amendment 4 to the Consolidated HMS FMP which will focus on management measures in the U.S. Caribbean Region. The regulations for Atlantic HMS can be found at 50 CFR part 635.

Further, since 1966, the International Commission for the Conservation of Atlantic Tunas (ICCAT) has been responsible for international conservation and management of tuna and tuna-like species. ICCAT currently includes 46 contracting parties, including the United States, and its stated objective is to “cooperate in maintaining the populations of these fishes at levels which will permit the maximum sustainable catch for food and other purposes.” Atlantic tunas, swordfish, and billfish are subject to ICCAT management authority. ICCAT also assesses the stock status of some pelagic shark species.

Recommendations adopted by ICCAT are promulgated in the United States under the Atlantic Tunas Convention Act (ATCA), which was signed in 1975 (16 U.S.C. 971) and authorizes the Secretary of Commerce to administer and enforce all provisions of ICCAT.

2.3.6.1 Management History

2.3.6.1.1 North Atlantic Swordfish

The U.S. Atlantic swordfish fishery is managed under the Consolidated HMS FMP under the authority of the Magnuson-Stevens Act and ATCA. There are two distinct management units for swordfish in the Atlantic Ocean, north and south, divided at 5° N latitude. Because the southern stock is located south of 5° N latitude, South Atlantic swordfish are not within the management authority of the Magnuson-Stevens Act.

However, the stock and its fishery are included in the Consolidated HMS FMP because South Atlantic swordfish are managed by ICCAT and because there are U.S. fishermen who fish in the South Atlantic.

The first Atlantic swordfish FMP was completed and implemented in 1985 by the South Atlantic Fishery Management Council in cooperation with other Atlantic Fishery Management Councils. This FMP laid the groundwork for defining approved fishing methods, determining optimum yield and status of the stocks, implementing variable season closures, and regulating foreign fishing in U.S. waters. Swordfish management was transferred from the Fishery Management Councils to NOAA Fisheries in 1991. Since that time, numerous management initiatives have been implemented including a minimum size limit, commercial quotas changes, and a prohibition on drift gillnets for swordfish.

In response to a 1996 stock assessment that indicated that biomass was only 58% of that needed to support MSY, ICCAT further reduced North Atlantic swordfish quotas for 1997 through 1999, although the TAC still exceeded replacement yield. In 1997, the SCRS determined that the failure to achieve significant overall reductions in North Atlantic fishing mortality, due in part to non-compliance by some fishing nations, resulted in the need for more severe reductions to achieve the recovery of this over-exploited species. Also in 1997, as a result of changes to the Magnuson-Stevens Act, NOAA Fisheries began the process of establishing a rebuilding plan for North Atlantic swordfish. This process was completed in 2000, with the publication of the 1999 FMP and a 2000 rulemaking, that revised quotas for swordfish, established size and retention limits, enacted bycatch reduction measures, and initiated swordfish LAPs. Since that time, other management measures affecting commercial swordfish fishermen have been implemented, including: time/area closures and mandatory use of circle hooks in the PLL fishery; bait restrictions; gear requirements; mandatory workshop training; mandatory vessel monitoring systems (VMS); and, changes to authorized gears and vessel upgrading restrictions. The implementation of these measures has resulted in the North Atlantic swordfish stock being almost fully rebuilt (B = 0.99 Bmsy) as of 2007. However, the numbers of active participants and permit holders in the pelagic longline fishery have declined significantly over the past decade.

2.3.6.1.2 Atlantic Tunas

Bluefin tuna (BFT) are managed under the Consolidated HMS FMP. ICCAT determines quotas for BFT based on recommendations from its Standing Committee on Statistics and Research (SCRS), and NOAA Fisheries implements the quotas pursuant to ATCA. In 1998, ICCAT adopted a recommendation for a rebuilding program for western Atlantic BFT with the goal of reaching stock levels to support maximum sustainable yield (MSY) in 20 years. The annual western Atlantic BFT total allowable catch (TAC) of approximately 1,900 metric tons (mt) whole weight (ww) is shared between the United States, Japan, Canada, the United Kingdom territory of Bermuda, the French territories of St. Pierre and Miquelon, and Mexico. The BFT rebuilding program provides NOAA

Fisheries with flexibility to alter the TAC, the MSY target, and/or the rebuilding period based on scientific advice.

All tuna species comprising the bigeye (BET), albacore (ALB), yellowfin (YFT), and skipjack (SKJ) complex (referred to as BAYS tunas) are also managed under the Consolidated HMS FMP and are subject to ICCAT and ATCA provisions. Detailed information regarding the management history of BFT and BAYS tunas is provided in the Consolidated HMS FMP and the 2007 Stock Assessment and Fishery Evaluation (SAFE) report.

2.3.6.1.3 Atlantic Billfish

The Atlantic billfish complex includes Atlantic blue marlin, Atlantic white marlin, west Atlantic sailfish, and longbill spearfish. Billfish present unique challenges for fisheries management in the United States due to their distributional and behavioral patterns. Atlantic billfish management strategies are guided by international and national mechanisms. International management is required because Atlantic billfish are widely distributed throughout the Atlantic as well as the U.S. EEZ. Atlantic billfish have historically been landed as the incidental catch of foreign and domestic commercial pelagic longline vessels, or in directed recreational and subsistence handline fisheries. On the national level, revisions to the Magnuson-Stevens Act in 1996 prompted NOAA Fisheries to initiate rebuilding schemes for overfished stocks of Atlantic blue marlin, Atlantic white marlin, and west Atlantic sailfish. Atlantic billfish are currently managed under the Consolidated HMS FMP under the authority of the Magnuson-Stevens Act and ATCA.

In 1997, ICCAT made its first binding recommendation for Atlantic blue and white marlin, requiring reductions in landings and noting the need for improvements in data and monitoring. The United States sponsored a resolution at the 1998 ICCAT meeting resulting in a recommendation that the SCRS develop stock recovery scenarios following stock assessments for Atlantic blue marlin and Atlantic white marlin in 2000 and 2002, respectively. In November 2000, ICCAT adopted a two-phased marlin rebuilding program. Phase I of the plan required, among other things, that countries reduce landings of white marlin from pelagic longline and purse seine fisheries by 67% and blue marlin landings by 50% from 1999 levels; the United States had previously prohibited commercial retention of billfish in the 1988 Atlantic Billfish FMP. For its recreational fishery, the United States has agreed to limit annual landings to 250 Atlantic blue and white marlin, combined, annually through 2010. In addition, over the past decade, marlin bycatch has been reduced as a result of reductions in ICCAT's commercial North Atlantic swordfish quotas.

The 1999 Billfish FMP amendment included measures to: address overfished populations of Atlantic blue and white marlin; reduce bycatch and discard mortality of billfish; comply with 1997 ICCAT recommendations to reduce landings, improve monitoring and data collection; and determine the status of sailfish and spearfish populations. The current size limits (Atlantic blue marlin, 99 inches (251 cm) lower jaw fork length

(LJFL); Atlantic white marlin, 66 inches (168 cm) LJFL; west Atlantic sailfish, 63 inches (160 cm) LJFL) are intended to provide an increase in reproductive potential, and thus, lead to a long-term benefit for the Atlantic-wide stock. To facilitate compliance with the ICCAT rebuilding plan, NOAA Fisheries implemented regulations effective March 2003, requiring (1) an Atlantic HMS recreational angling permit, (2) mandatory self-reporting of all non-tournament landings of billfish, and (3) reporting of tournament landings via the Recreational Billfish Survey. Effective January 2008, in an effort to reduce post-release mortality of Atlantic billfish, NOAA Fisheries required anglers fishing from HMS permitted vessels and participating in billfish tournaments to use only non-offset circle hooks when deploying natural bait or natural bait/artificial lure combinations.

Additionally, it is illegal to sell Atlantic billfish. This prohibition on sale precludes the possession of Atlantic billfish by commercial fishermen, seafood dealers, and restaurants with the intent to sell. While billfish are still caught incidentally in commercial fishing operations, the sale prohibition has ended directed fishing effort on these species, which supports rebuilding.

On September 4, 2001, NOAA Fisheries received a petition to list the Atlantic white marlin as endangered or threatened throughout its range, and to designate critical habitat under the Endangered Species Act (ESA). NOAA Fisheries conducted a status review of Atlantic white marlin in 2002 and a determination was published that listing was not warranted (67 FR 57204; September 9, 2002). As a result of subsequent litigation and a settlement agreement with the Center for Biological Diversity, NOAA Fisheries agreed to initiate a status review following the 2006 stock assessment by the ICCAT. In 2007, NOAA Fisheries conducted a status review of Atlantic white marlin and a determination was published indicating again that listing was not warranted (73 FR 843; January 4, 2008). While Atlantic white marlin was determined not to be endangered or threatened throughout its range, NOAA Fisheries retains Atlantic white marlin on the Species of Concern list.

2.3.6.1.4 Atlantic Sharks

Sharks have been managed by the Secretary of Commerce since 1993. At that time, NOAA Fisheries implemented the FMP for Sharks of the Atlantic Ocean, which established three management complexes: large coastal sharks (LCS), small coastal sharks (SCS), and pelagic sharks. This 1993 FMP implemented commercial quotas for LCS and pelagic sharks and established recreational retention limits for all sharks, consistent with the LCS rebuilding program. As a result of the 1996 amendments to the Magnuson-Stevens Act, the 1999 FMP revised much of the management of Atlantic sharks, including establishing new commercial quotas, a commercial size limit, a recreational bag limit, a new rebuilding plan for LCS, and a limited access program for the commercial fishery.

In 2002, based on new stock assessments for LCS and SCS, NOAA Fisheries began the process to develop Amendment 1 to the 1999 FMP. Final Amendment 1 and its implementing regulations were published in late 2003 and included: aggregating the LCS complex, using maximum sustainable yield as a basis for setting commercial quotas, eliminating the commercial minimum size, establishing regional commercial quotas and trimester commercial fishing seasons, adjusting the recreational bag and size limits, establishing gear restrictions to reduce bycatch and bycatch mortality, establishing a time/area closure off the coast of North Carolina, removing the deepwater/other sharks from the management unit, establishing a mechanism for changing species on the prohibited species list, updating essential fish habitat identifications for five species of sharks, and changing the administration for issuing permits for display purposes.

In the Consolidated HMS FMP, NOAA Fisheries, among other things, required that sharks be landed with their second dorsal and anal fin still attached, required shark dealers to attend shark identification workshops, and required gillnet, bottom longline, and pelagic long fishermen to attend workshops on the safe handling and release of protected resources.

In Amendment 2 to the Consolidated HMS FMP, NOAA Fisheries focused on additional shark management measures. These included, but were not limited to, removing sandbar sharks from the LCS complex and establishing a non-sandbar LCS complex; setting new sandbar, non-sandbar LCS, and porbeagle shark commercial quotas; establishing a sandbar shark research fishery with prohibition on the retention of sandbar sharks outside the shark research fishery; creating one region for SCS, sandbar, and pelagic sharks and two regions (Gulf of Mexico and Atlantic regions) for non-sandbar LCS; creating eight marine protected areas as requested by the South Atlantic Fishery Management Council to prohibit the use bottom longline gear in those areas; establishing new non-sandbar LCS retention limits for directed and incidental shark permit holders; establishing a fishing year for sharks that begins on January 1 of each year; limiting the carry over of underharvest to 50% of the base quota for shark stocks whose status are healthy and prohibiting the carry over of underharvest for shark stocks whose status are overfished, experiencing overfishing, or are determined to be unknown; deducting overharvests from the following fishing year, or multiple years (up to five year maximum), based on the level of overharvest; requiring HMS dealer reports to be received by NOAA Fisheries within 10 days of the end of a reporting period; requiring sharks to landed with fins on; and, proportioning unclassified sharks out among each shark species/complex based on observer and dealer reports.

3.0 MANAGEMENT ALTERNATIVES

The following section provides a discussion of the two actions considered by the Council for this regulatory amendment. Section 5.0 examines the various actions and their alternatives relative to each other within the physical, biological, ecological, economic, social, and administrative environments.

3.1 Action 1: Modify the closed season for Bajo de Sico (year round gear restrictions already in place will not be affected)

Alternative 1: No Action - do not modify the seasonal closure of Bajo de Sico.

Alternative 2 (Preferred): Modify the seasonal closure of Bajo de Sico to a 6 month closure from October 1 – March 31 in order to provide better protection for red hind spawning aggregations, large snappers and groupers, and diverse coral reef habitat.

> **Sub-alternative a:** Prohibit fishing for all species, including HMS
>
> **Sub-alternative b:** Prohibit fishing for and possession of all species, including HMS
>
> **Sub-alternative c:** Prohibit fishing for council-managed reef fish species
>
> **Sub-alternative d (Preferred):** Prohibit fishing for and possession of council-managed reef fish species

Alternative 3: Modify the seasonal closure of Bajo de Sico to a 6 month closure from December 1 – May 31 in order to provide better protection for red hind spawning aggregations, large snappers and groupers, and diverse coral reef habitat.

> **Sub-alternative a:** Prohibit fishing for all species, including HMS
>
> **Sub-alternative b:** Prohibit fishing for and possession of all species, including HMS
>
> **Sub-alternative c:** Prohibit fishing for council-managed reef fish species
>
> **Sub-alternative d:** Prohibit fishing for and possession of council-managed reef fish species

Alternative 4: Modify the closure of Bajo de Sico to 12 months in order to provide full protection for all spawning aggregations present, large snappers and groupers, and diverse coral reef habitat.

> **Sub-alternative a:** Prohibit fishing for all species, including HMS
>
> **Sub-alternative b:** Prohibit fishing for and possession of all species, including HMS
>
> **Sub-alternative c:** Prohibit fishing for council-managed reef fish species
>
> **Sub-alternative d:** Prohibit fishing for and possession of council-managed reef fish species

<u>Discussion</u>

Alternative 1 would maintain the status quo. The area would remain closed to all fishing activities, including HMS, from December 1 to the last day of February, in addition to the current year round bottom tending gear restrictions (pots, traps, bottom longlines, gillnets, and trammel nets). The closure was originally implemented in 1996 to protect spawning populations of red hind. Since then, red hind stocks have increased in size and abundance but scientists have recently discovered spawning populations of snappers and other groupers as well as nearly pristine coral reef formations. Maintaining the current regulations (i.e., a 3-month closure) would allow capture of Council–managed reef fish species for 9-months of the year and cause these populations to be more vulnerable to fishers. However, there are also closures for red, black, tiger, yellowfin, and yellowedge grouper from February 1 through April 30 for the entire EEZ, which includes a portion of Bajo de Sico. There is also a closure of the EEZ, including portions of Bajo de Sico, to harvest of vermilion, black, silk, and blackfin snapper during October 1 through December 31. There is a third closure from April 1 to June 30 for lane and mutton snapper in the EEZ. These management measures combined results in closures for one or more snapper and grouper species within Bajo de Sico run from October 1 through June 30. Important coral habitat would also be in danger by anchoring vessels and possible gear interactions. The García-Sais *et al*. (2007) report shows monofilament fishing line wrapped around corals, indicating unintended but adverse fishermen-coral interactions. Among the gears still allowed in Bajo de Sico are the vertical longlines, bandit type gear, hook and line and spearfishing, as well as the harvest by hand.

Preferred Alternative 2 and **Alternative 3** would modify the seasonal closure at Bajo de Sico for 6-months each year for all Council-managed reef fish species (See Appendix A). Fishing for highly migratory species (HMS), coastal migratory pelagics (dolphin, wahoo, jacks, and mackerel) and spiny lobster would be allowed all year and the species specific closures as described above would still apply. During this period, however, incidental catch of large individuals of snappers or groupers, possibly in or near spawning condition, could occur and thus contribute to their mortality. However, such incidental harvest is unlikely from the gear and methods used to harvest pelagic species and lobsters.

Preferred Alternative 2 would establish a seasonal closure to prohibit certain fishing activities from October 1 through March 31. In addition to the time frame of the original seasonal closure for Bajo de Sico, (i.e., December through the end of February) **Preferred Alternative 2** would include the seasonal closure for vermilion, black, silk, and blackfin snapper, which occurs from October 1 through December 31. In addition to the seasonal closure of Bajo de Sico, there is a closure from December 1 through February which prohibits the harvest of red hind from the Caribbean EEZ west of 67°10' W longitude. Harvest of red, black, tiger, yellowfin, and yellowedge grouper is prohibited from February 1 through April 30. . The above mentioned species, while not observed in the García-Sais *et al*. (2007) report, occur in surrounding waters year round and are part of the commercial and recreational catch (Erdman, 1976; Boardman and Weiler, 1978; Kimmel, 1985). Also, **Preferred Alternative 2** will provide greater protection from fishing for reef fish species not included in the seasonal closures.
Since there is a high probability of catching prohibited species incidentally when targeting other reef fish species, fishers may tend to avoid areas where such species comingle. Consequently, under current species specific closures, an area such as Bajo de Sico would not be an ideal place to target species that are allowed because of the high probability of capturing a prohibited species, thus increasing mortality on species needing protection, and the costs (i.e fuel, bait) associated with those activites. Also, if the area is fished, there will be costs associated with the purchase of bait and fuel, as well as time spent fishing to capture species that would have to be discarded due to regulatory requirements.

Under **Preferred Alternative 2**, however, Bajo de Sico would be closed to fishing for Council-managed reef fish during all the overlapping species specific seasonal closures, with the exception of the months of April through June. As a result of the additional seasonal closures, **Preferred Alternative 2** will have an added positive impact on the species protected within those closures. Lane and mutton snapper fisheries are currently closed from April 1 through June 30 but **Preferred Alternative 2** will extend the time when fishing for those species is prohibited, potentially provided greater protection by reducing fishing mortality directed at them. In addition to the current closure, harvest of lane and mutton snapper will be prohibited from October 1 through March 31, creating a total closure of October 1 through June 30. These species, while not observed in the García-Sais *et al*. (2007) report, occur in surrounding waters year round and are part of the commercial and recreational catch (Erdman, 1976; Boardman and Weiler, 1978; Kimmel, 1985). Similarly, **Preferred Alternative 2** coupled with the current closure of fisheries for red, black, tiger, yellowfin, and yellowedge grouper would provide 2 more months of protection for those species (October and November), essentially prohibiting harvest from October 1 through April 30. In terms of spawning aggregations, **Preferred Alternative 2** prohibits fishing with gear likely to result in the harvest of any potentially aggregating snapper grouper species during the months aggregations are known to be present here and in other areas.

Preferred Alternative 2 is expected to have the least amount of impact on the recreational sector, due to historical weather patterns and sea conditions in the Mona Passage. October marks the beginning of marginally bad weather for the area, which lasts until March or April. Persistently high winds and associated sea conditions often create unsafe sea conditions which affect the amount of time available to fish and dive. Since the Council selected **Preferred Alternative 2**, the modified closure would be in effect during that time, leaving more favorable weather for recreational fishers to utilize during other times of the year.

Under **Preferred Alternative 2**, four sub-alternatives were included for analysis. Under **Sub-alternative a**, fishers could not fish for any species, including HMS, within the limits of Bajo de Sico. **Sub-alternative b** would prohibit fishing for[1] and possession of all species, including HMS within Bajo de Sico. **Sub-alternative c** would prevent fishermen from fishing for reef fish managed under the Council's Reef Fish FMP (See Appendix A) within the limits of Bajo de Sico for the duration of the closure. Under **Preferred Sub-alternative d,** fishing for or possession of any Council-managed reef fish would be prohibited.

Preferred Sub-alternative d will prohibit the harvest and possession of all Council-managed reef fish. Under this sub-alternative, fishers would not be allowed to fish for or possess reef fish. Spiny Lobster will not be managed under these regulations and thus will remain open year-round. **Preferred Sub-alternative d** will also allow fishers to harvest species not managed by the Council, including HMS or other coastal migratory pelagics not part of HMS or managed by the Council. The Council heard testimony from HMS fishers who stated the gear they use (trolling gear designed to catch pelagic fishes) is pulled behind a moving vessel and fishes the upper portion of the water column where pelagic species occur. Such fishing activity is not expected to result in a significantly higher mortality for the demersal fish species, like snappers and grouper for which this amendment is designed to protect. During this period, however, incidental catch of large individuals of snappers or groupers, possibly in or near spawning condition, could occur and thus contribute to their mortality. Similarly, the harvesting of spiny lobster by hand is not expected to result in futher mortality to grouper or snapper species. The fishing practices described for pelagics species and spiny lobster are not expected to present any threat to the coral reef resources or to other habitat structures.

Alternative 3 would establish a modified closure from December 1 through May 31. In addition to the original seasonal closure of Bajo de Sico (i.e., December through the end of February), **Alternative 3** would include seasonal closures for other snapper grouper species. February 1 through April 30 is the closed season protecting spawning of red, black, tiger, yellowfin, and yellowedge groupers. Similarly, targeting lane and mutton snapper is prohibited April 1 through June 30. These species, while not observed in the García-Sais *et al*. (2007) report, occur in surrounding waters year round and are part of the commercial and recreational catch (Erdman, 1976; Boardman and Weiler, 1978;

[1] Regulations define fishing as, "*Fishing*, or *to fish* means any activity, other than scientific research conducted by a scientific research vessel, that involves: (1) The catching, taking, or harvesting of fish; (2) The attempted catching, taking, or harvesting of fish; (3) Any other activity that can reasonably be expected to result in the catching, taking, or harvesting of fish; or (4) Any operations at sea in support of, or in preparation for, any activity described in paragraphs (1), (2), or (3) of this definition." (50 CFR § 600.10) However, a vessel that has gear on board, which is properly stowed, would not be considered fishing.

Kimmel, 1985). December 1 through the last day in February prohibits harvesting red hind in the entire Caribbean EEZ, west of 67°10’ W longitude.

Alternative 3 would have a greater impact on fishers utilizing the area as May through July are the busiest months for the commercial fishery and March -August are busiest for recreational fishing in Puerto Rico. October and November brings a large decrease in recreational fishing (Griffith *et al*, 2007).

Alternative 4 would establish a year-round closure of Bajo de Sico, thus creating a marine protected area for Council-managed reef fish species and possibly highly migratory species depending on the Sub-alternative chosen by the Council. **Alternative 4** would provide the greatest protection to red hind spawning aggregations, larger snapper and grouper individuals, and their habitat. However, it is also the most restrictive and results in the most negative economic and social impacts to the fishermen and their communities.

Overall, proposed restrictions in the area are intended to provide protection of habitat, as well as protection to aggregating and individual reef fish species during spawning seasons, and for some, additional protection during times before or after spawning. The existing year-round prohibitions on the use of bottom tending gear (pots, traps, bottom longline, gillnets, and trammel nets) in the area provide sufficient protection for the coral reefs, and the associated habitats. The allowable use of vertical hook and line gear is unlikely to present a significant risk of adverse impact to bottom habitats. In terms of spawning success, the **Preferred Alternative 2** coupled with established seasonal closures likely result in the protection of spawning grouper and snapper species at most times when those individuals or aggregations are likely in or near spawning condition.

Table 3.1.1 Summary of Action 1 Alternatives

	Fishing for: Reef Fish	Fishing for: HMS	Fishing for: Spiny Lobster	Fishing for: Other Species (e.g. Baitfish)	Fishing Method: Bottom-Tending Gear	Transit with Fish on Board
Alternative 1	Prohibited December 1 through End of February each year	Prohibited December 1 through End of February each year	Prohibited December 1 through End of February each year	Prohibited December 1 through End of February each year	Prohibited Year-Round	Allowed
Alternative 2a	Prohibited October 1 through March 31 each year	Prohibited October 1 through March 31 each year	Prohibited October 1 through March 31 each year	Prohibited October 1 through March 31 each year	Prohibited Year-Round	Allowed
Alternative 2b	Prohibited October 1 through March 31 each year	Prohibited October 1 through March 31 each year	Prohibited October 1 through March 31 each year	Prohibited October 1 through March 31 each year	Prohibited Year-Round	Prohibited October 1 through March 31 each year
Alternative 2c	Prohibited October 1 through March 31 each year	Allowed	Allowed	Allowed	Prohibited Year-Round	Allowed

	Fishing for: Reef Fish	Fishing for: HMS	Fishing for: Spiny Lobster	Fishing for: Other Species (e.g. Baitfish)	Fishing Method: Bottom-Tending Gear	Transit with Fish on Board
Preferred Alternative 2d	Prohibited October 1 through March 31 each year	Allowed	Allowed	Allowed	Prohibited Year-Round	Transit with Council-Managed Reef Fish Species Prohibited October 1 through March 31 each year
Alternative 3a	Prohibited December 1 through May 31 each year	Prohibited December 1 through May 31 each year	Prohibited December 1 through May 31 each year	Prohibited December 1 through May 31 each year	Prohibited Year-Round	Allowed
Alternative 3b	Prohibited December 1 through May 31 each year	Prohibited December 1 through May 31 each year	Prohibited December 1 through May 31 each year	Prohibited December 1 through May 31 each year	Prohibited Year-Round	Prohibited December 1 through May 31 each year
Alternative 3c	Prohibited December 1 through May 31 each year	Allowed	Allowed	Allowed	Prohibited Year-Round	Allowed

	Fishing for: Reef Fish	Fishing for: HMS	Fishing for: Spiny Lobster	Fishing for: Other Species (e.g. Baitfish)	Fishing Method: Bottom-Tending Gear	Transit with Fish on Board
Alternative 3d	Prohibited December 1 through May 31 each year	Allowed	Allowed	Allowed	Prohibited Year-Round	Transit with Council-Managed Reef Fish Species Prohibited December 1 through May 31 each year
Alternative 4a	Prohibited Year-Round	Prohibited Year-Round	Prohibited Year-Round	Prohibited Year-Round	Prohibited Year-Round	Allowed
Alternative 4b	Prohibited Year-Round	Prohibited Year-Round	Prohibited Year-Round	Prohibited Year-Round	Prohibited Year-Round	Prohibited Year-Round
Alternative 4c	Prohibited Year-Round	Allowed	Allowed	Allowed	Prohibited Year-Round	Allowed
Alternative 4d	Prohibited Year-Round	Allowed	Allowed	Allowed	Prohibited Year-Round	Transit with Council-Managed Reef Fish Species Prohibited Year-Round

3.2 Action 2: Prohibit anchoring by fishing vessels in Bajo de Sico.

Alternative 1: No Action - do not prohibit anchoring by fishing vessels in Bajo de Sico.

Alternative 2: Prohibit anchoring for 6 months in Bajo de Sico. The 6-month closure will coincide with the closure period chosen in Action 1.

Preferred Alternative 3: Prohibit anchoring year-round in Bajo de Sico.

Discussion

Alternative 1 would maintain the status quo. Under **Alternative 1**, fishing vessels[2] would be able to anchor in Bajo de Sico.

Alternative 2 would prohibit fishing vessels from anchoring in Bajo de Sico for 6 months. The anchoring prohibition would coincide with the 6 month closure period if the Council chooses Alternative 2 or Alternative 3 from Action 1. For instance, if the Council choses **Alternative 2** in both Action 1 and 2, anchoring will be prohibited from October 1 through March 31.

Preferred Alternative 3 would prohibit anchoring for the entire year. Under **Alternative 3**, fishing vessels would not be allowed to anchor in Bajo de Sico.

4.0 AFFECTED ENVIRONMENT

4.1 Description of Affected Physical Environment

The rectangular-shaped island of Puerto Rico is the smallest and the most eastern island of the Greater Antilles and is located between the North Atlantic Ocean and the Caribbean Sea (CFMC 2002). The island measures about 110 mi from east to west and 40 mi from north to south. The overall area of Puerto Rico, including its principal offshore islands of Vieques, Culebra, and Mona, is estimated at 3,471 mi^2 (Olcott 1999); the combined length of its coasts, 700 mi (CFMC 2002).

The nearshore waters of Puerto Rico range from 0-20 m in depth and outer shelf waters range from 20-30 m in depth at the shelf break. The north coast of Puerto Rico is marked by a narrow insular shelf that is only 2-3 km wide. Depths extend to over 1,200 ft (400 m) beyond the shelf break (CFMC 2002); the deepest point in the Atlantic Ocean, the

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[2] Regulations define "fishing vessel" as: any vessel, boat, ship, or other craft that is used for, equipped to be used for, or of a type that is normally used for: (1) Fishing; or (2) Aiding or assisting one or more vessels at sea in the performance of any activity relating to fishing, including, but not limited to, preparation, supply, storage, refrigeration, transportation, or processing (CFR 600.10). Important coral habitat would also be in danger by anchoring vessels and possible gear interactions.

Milwaukee Depth, lies at a depth of 27,493 feet (8,380 m) in the western end of the Puerto Rico Trench, about 100 miles (160 km) northwest of the island. Mona Passage, measuring about 75 mi (120 km) wide and more than 3,300 ft (1,000 m) deep, separates Puerto Rico from Hispaniola to the west. The southeast coast has a narrow shelf approximately 8 km wide (CFMC 2002), after which the sea bottom descends to the 16,400 ft (5,000 m) deep Venezuelan Basin of the Caribbean Sea. The east coast lies on the same geological platform as the USVI of St. Thomas and St. John. Waters in that area extend to depths of less than 240 ft (73 m) throughout (CFMC 2002).

The coastal-marine environment of Puerto Rico is characterized by a wide variety of habitat types. NOAA's National Ocean Service has mapped 21 distinct benthic nearshore habitat types using aerial photographs acquired in 1999. Those maps display 49 km^2 of unconsolidated sediment, 721 km^2 of submerged vegetation, 73 km^2 of mangroves, and 756 km^2 of coral reef and colonized hard bottom over an area of 1600 km^2 in Puerto Rico. Coral reefs, seagrass beds, and mangrove wetlands are the most productive marine habitat areas (CFMC 2002). In-depth descriptions of the distribution of these habitats, along with information on their ecological functions and condition can be found in CFMC (2002).

Generally, the north coast of Puerto Rico is characterized by a mixture of coral and rock reefs. The east coast is characterized by a sandy bottom, which commonly contains algal and sponge communities. The southern shelf is characterized by hard or sand-algal bottoms with emergent coral reefs, seagrass beds, and shelf edge. A small seamount known as Grappler Bank lies 70 m below the surface waters about 25 mi (40.3 km) off the southeast coast of the island. An extensive seagrass bed extends 9 km off the central south coast to Caja de Muertos Island. Habitats along the southern portion of the west coast are similar to those of the south coast (CFMC 2002).

Bajo de Sico is a seamount that ascends from a deep platform of the narrow slope on the west coast of Puerto Rico. Reef bathymetry conducted by R/V Nancy Foster depicts the area as a ridge of rock outcrops (Figure 4.1; García-Sais *et al.*, 2007). The ridge rises to a reef top at 25 m and consists of a mostly flat, homogeneous slightly sloping shelf. The shelf ends as a vertical wall, which reaches to depths of 300m. The water column consists of warm mixed surface water, strong surface currents, and 1% light penetration to depths of about 80 m (García-Sais *et al.*, 2007).

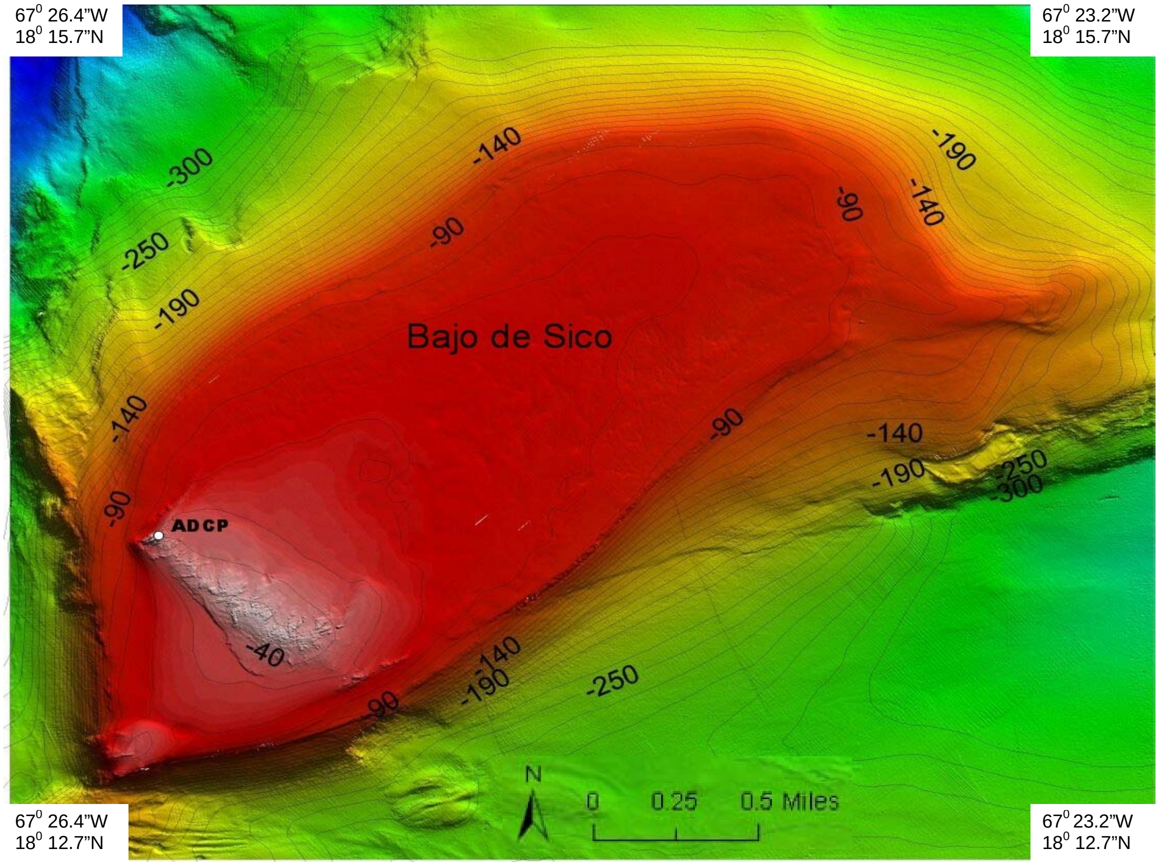

Figure 4.1: Bathymetry of Bajo de Sico from the top as adapted from National Centers for Coastal Ocean Science (NCCOS). Source: Battista & Stetcher, 2007.

Of particular interest to this amendment, a Coral Reef Conservation grant (NOAA) awarded to the Council has defined 3 predominant benthic habitat types within the area known as Bajo de Sico off the west coast of Puerto Rico (García-Sais *et al.*, 2007). The first habitat type, promontory reef tops, can be found at depths of between 85 and 100 feet (25–30 m). The reef substrate cover is dominated by benthic algae with erect and encrusting sponges being the prevailing sessile-benthic invertebrates (Table 4.1.1). There are a total of 86 species of fish found on the promontory reef tops with an average abundance of about 248 individuals/30 m^2 (García-Sais *et al.*, 2007).

Table 4.1.1: Percent substrate cover by sessile-benthic categories at Bajo de Sico, Reef Top habitat. Depth 26-30 m *

Substrate Cover	**Mean Percent Cover**
Abiotic	1.1
Unidentified	2.9
Benthic algae	
Algal Turf – mixed assemblages	27.6
Lobophora variegate	22.1
Calcareous/Coralline algae	2.3
Total Benthic Algae	52.0
Hydrozoa	
Plumaria (habereri)	0.8
Millepora alcicornis	1.7
Total Hydrozoa	2.9
Octocorals	
Iciligorgia schrammi	0.6
Pseudopterogorgia sp.	3.2
Total Octocorals	4.8
Scleractinian Corals	
Agaricia spp.	2.4
Porites astreoides	1.3
Montastraea cavernosa	1.1
Meandrina meandrites	1.1
Tubastrea coccinea	0.8
Eusmilia fastigiata	0.3
Madracis decactis	0.2
Montastraea annularis	0.2
Siderastrea siderea	0.2
Unid. Coral	0.1
Colpophyllia natans	0.1
Diploria sp.	0.1
Isophyllia rigida	0.1
Total Stony Corals	8.0

Table 4.1.1 continued: Percent substrate cover by sessile-benthic categories at Bajo de Sico, Reef Top habitat. Depth 26-30 m *

Substrate Cover	**Mean Percent Cover**
Sponges	
Unidentified Sponges	8.9
Agelas clathrodes	3.4
Xestospongia muta	5.0
Agelas dispar	3.1
Agelas conifera	1.6
Verongula gigantea	0.9
Plakortis angulospiculatus	1.6
A. crassa	0.2
Callyspongia vaginalis	0.2
Ircinia sp.	1.0
Neofibularia nolitangere	0.3
Aplysina cauliformis	0.1
Verongula rigida	0.2
Total Sponges	26.5
* García-Sais *et al.*, 2007	

The second type of habitat found in Bajo de Sico is the promontory reef wall, where a number of large, commercially valuable species can be found. Depths on the reef wall range from 115 to 130 feet (35-40 m) (García-Sais *et al.*, 2007). On the reef wall, erect and encrusting sponges are the principal reef substrate cover followed by benthic algae and deepwater sea fans (Table 4.1.2). A total of 66 fish species can be found associated with the reef wall at a mean abundance of about 85 individuals/30 m^2 (García-Sais *et al.*, 2007).

Table 4.1.2: Percent substrate cover by sessile-benthic categories at Bajo de Sico, Reef Wall. Depth 30-40 m *

Substrate Cover	**Mean Percent Cover**
Abiotic	4.16
Benthic algae	
Turf – mixed assemblages	7.55
Lobophora variegate	17.9
Halimeda spp.	0.16
Total Benthic Algae	25.61
Hydrozoa	
Unid. colonial hydrozoan	2.16
Millepora alcicornis	0.08
Antipatharians	3.02
Octocorals	
Iciligorgia schrammi	12.54
Pseudopterogorgia sp.	0.29
Unid. Gorgonian	0.69
Total Octocorals	13.52
Scleractinian Corals	
Montastraea cavernosa	1.7
Agaricia spp.	1.48
Tubastrea coccinea	1.03
Porites astreoides	0.36
Montastraea annularis	0.21
Madracis decactis	0.2
Diploria labyrinthiformis	0.2
Leptoseris cucullata	0.12
Meandrina meandrites	0.12
Eusmilia fastigiata	0.08
Siderastrea siderea	0.04
Total Scleractinian Corals	5.54

Table 4.1.2 continued: Percent substrate cover by sessile-benthic categories at Bajo de Sico, Reef Wall. Depth 30-40 m *

Substrate Cover	**Mean Percent Cover**
Sponges	
Unidentified Sponges	20.81
Agelas conifera	8.3
Plakortis angulospiculatus	5.71
Agelas clathrodes	2.4
Agelas dispar	1.9
Xestospongia muta	1.64
Callyspongia fallax	0.74
Ircinia sp.	0.84
Callyspongia plicifera	0.37
Callyspongia vaginalis	0.16
Aplysina cauliformis	0.04
Svenzea zeai	0.2
Total Sponges	43.11

* García-Sais *et al.*, 2007

Lastly, the deep Rhodolith reef habitat ranges in depth from 157 to 174 feet (48-53 m) (García-Sais *et al.*, 2007). Similar to the reef tops, benthic algae and encrusting sponges are the dominant substrate cover. Nine species of stony corals have also been identified with the deep rhodolith reef (Table 4.1.3).

Table 4.1.3: Percent substrate cover by sessile-benthic categories at Bajo de Sico, Deep Rhodolith Reef. Depth 48-53 m *

Substrate Cover	**Mean Percent Cover**
Abiotic	3.28
Unidentified	3.4
Benthic algae	
Turf – mixed assemblages	13.2
Fleshy Algae	
Lobophora variegate	42.0
Codium sp.	0.9
Sargassum histrix	0.2
Calcareous Algae	
Halimeda spp.	8.7
Total Benthic Algae	65.0
Hydrozoa	1.9

Table 4.1.3 continued: Percent substrate cover by sessile-benthic categories at Bajo de Sico, Deep Rhodolith Reef. Depth 48-53 m *

Substrate Cover	**Mean Percent Cover**
Live Stony Corals	
Agaricia spp.	2.96
Montastraea annularis	0.68
Porites astreoides	0.52
Leptoseris cailleti	0.48
Eusmilia fastigiata	0.08
Montastraea cavernosa	0.04
Meandrina meandrites	0.04
Unid. coral	0.04
Colpophyllia natans	0.04
Total Stony Corals	4.88
Sponges	
Unidentified Sponges	11.8
Aplysina cauliformis	3.7
Xestospongia muta	1.8
Agelas clathrodes	1.8
Agelas dispar	1.3
Aiolochroia crassa	0.5
Agelas conifera	0.4
Verongula gigantea	0.4
Plakortis angulospiculatus	0.2
Verongula rigida	0.1
Aplysina lacunosa	0.1
Total Sponges	20.2

* García-Sais *et al.*, 2007

An Active Search Census of Bajo de Sico produced data that identifies the reef top and reef wall as critically important residential habitats for commercially exploited large grouper and snapper assemblages including Nassau, yellowfin, yellowmouth and red hind groupers, and yellowtail, schoolmaster, dog and cubera snappers. Densities of the large groupers are the highest ever reported outside spawning aggregations in Puerto Rico, and may represent one of the few remaining reproductively active populations in the reef systems of Puerto Rico.

Other predominant benthic habitat types found within the Bajo de Sico area include colonized pavement/sand and rhodolith/gravel slopes. Further, the seamount serves as a foraging area for large pelagic fishes, including wahoo (*Acanthocibium solanderi*), Mahi-Mahi (*Coryphaena hippurus*), Tunas (*Thunnus spp*.) and marlins (*Makaira nigricans*). The reef system at Bajo de Sico also serves as an important foraging and residential habitat for the endangered hawksbill turtle (*Eretmochelys imbricata*). The population at Bajo de Sico is impressive because of the large size and high abundance of individuals.

Studies of benthic habitat in Bajo de Sico have identified at least five main reefs, including an extensive deep terrace (mesophotic) reef system that may be the largest continuous reef system of Puerto Rico. This reef is also important due to the presence of hermatypic corals growing to depths of 90 m.

4.2 Description of Affected Biological Environment

In addition to conducting the study on habitat within Bajo de Sico, García-Sais et al. (2007) surveyed the biological environment of the area. It was determined that Bajo de Sico was comprised of a combination of reef fish species, demersal predators (snappers and groupers), and HMS species. Smaller schooling fish served as the main food source for larger, pelagic and demersal species (García-Sais et al., 2007). Table 4.2 outlines the size-frequency distribution of species observed while surveying in Bajo de Sico. The table states the species observed during sampling and does not necessarily represent all species found within Bajo de Sico.

Table 4.2: Size-frequency distribution of large and/or commercially important reef fish identified during surveys at Bajo de Sico*

Species	Common Name	Size range (TL - in)	Total Stock**
Acanthocybium solanderi	Wahoo	60-90	4
Balistes vetula	Queen Triggerfish	12-18	4
Caranx crysos	Blue Runner	12-20	6
Caranx latus	Horse-eye Jack	15-20	32
Caranx lugubris	Black Jack	16-30	7
Carcharhinus perezi	Caribbean Reef Shark	36-50	3
Dasyatis Americana	Southern Stingray	32-56	2
Elagatis bipinnulatus	Rainbow Runner	20-30	32
Epinephelus guttatus	Red Hind	12-18	7
Epinephelus striatus	Nassau Grouper	20-32	12
Lutjanus apodus	Schoolmaster Snapper	15-20	50
Lutjanus cyanopterus	Cubera Snapper	28-36	3
Lutjanus jocu	Dog Snapper	15-20	2
Lutjanus mahogany	Mahogani Snapper	Unknown	1
Mycteroperca bonaci	Black Grouper	28-32	3
Mycteroperca interstitialis	Yellowmouth Grouper	22-28	2
Mycteroperca venenosa	Yellowfin Grouper	20-30	7
Ocyurus chrysurus	Yellowtail Snapper	15-20	50
Scarus guacamaia	Rainbow Parrotfish	32	1
Scomberomorus cavalla	Great Mackerel	34	2
Scomberomorus regalis	Cero Mackerel	18-34	3
Sphyraena barracuda	Great Barracuda	24-32	3

Table 4.2.1 continued: Size-frequency distribution of large and/or commercially important reef fish identified during surveys at Bajo de Sico

Species	Common Name	Size range (TL - in)	Total Stock**
Invertebrates			
Panulirus argus	Spiny Lobster	4-5	3
Strombus gigas	Queen Conch	14	1
Sea Turtles			
Chelonia midas	Green Sea Turtle	36	1
Eretmochelys imbrica	Hawksbill Turtle	26-36	9

* García-Sais *et al.*, 2007
** "Total Stock" represents the number of individuals observed during sampling, not the entire population within Bajo de Sico

<u>Others:</u> *Thunnus albacores, Amblycirrhitus pinos, Pomacanthus arcuatus, Pomacanthus paru, Mulloides martinicus, Kyphosus bermudensis, Cantherhines macrocerus, Hemiramphus brasiliensis, Decapterus macarellus, Ablennes hians, Tylosurus crocodilus, Chaetodipterus faber, Canthidermis sufflamen, Xanthichthys ringens, Chaetodon aculeatus, Anisotremus surinamensis, Gymnothorax funebris, Coryphaena, Caranx bartholomaei*

This section also summarizes the available information on the biology, life history, and status of Caribbean Council-managed species. NMFS' 2001 report to Congress on the status of U.S. fisheries classifies most stocks in the U.S. Caribbean as "unknown" (NMFS 2002). Because information on the status of stocks is required to calculate the biological parameters and stock status determination criteria proposed in this amendment, the Sustainable Fisheries Act (SFA) Working Group established by the Council was required to make determinations on the status of those stocks for which no formal determination has been made. As stated in Restrepo *et al.* (1998), "in cases of severe data limitations, qualitative approaches may be necessary, including expert opinion and consensus-building methods."

The status determinations of the SFA Working Group reported in the following sub-sections are based on best professional judgment, informed by available scientific and anecdotal information on a variety of factors, including the anecdotal observations of fishermen as reported by fishery managers, life history information, and the status of individual species as evaluated in other regions. The discussion resulting in these determinations took place at the 23-24 October 2002 meeting of the SFA Working Group in Carolina, Puerto Rico. Notice of the meeting location, date, and agenda was provided in the *Federal Register* (67 FR 63622). The minutes of that meeting are available by request from the Council.

Detailed identification and description of EFH for managed species can be found in the EFH FSEIS (CFMC 2004).

4.2.1 Snappers, Lutjanidae

The Lutjanidae family contains 103 species in 17 genera, distributed in the tropical and subtropical Atlantic, Indian, and Pacific Oceans (Nelson 1984 in Froese and Pauly 2002). These fishes are generally slow-growing and moderately long-lived. Sexes are separate (Thompson and Munro, 1974a). Some species are sequential hermaphrodites, but no indications of hermaphroditism have been observed for Caribbean Council-managed species. Genera represented in the Caribbean reef fish fishery management unit include *Apsilus*, *Etelis*, *Lutjanus*, *Ocyurus*, *Pristipomoides*, and *Rhomboplites*.

Most species are believed to exhibit sexually dimorphic growth rates and sizes at maturity (Thompson and Munro, 1974a). These fishes are generally serial spawners, releasing several batches of eggs over a spawning season that sometimes extends year round (SAFMC, 1999). Spawning activity generally peaks in the spring and summer months in the northeastern Caribbean (Erdman, 1976). Annual fecundity reportedly ranges from one hundred thousand eggs released by young snappers and smaller species, to millions of eggs released by older snappers and larger species (SAFMC, 1999; Thompson and Munro, 1974a).

All species have complex life histories, with most dependent on different habitats during the egg, larval, juvenile, and adult phases of their life cycle. Eggs and early larvae are typically pelagic (AFS, 2001). No long-lived oceanic larval or post-larval phases have been reported for snappers, as have been reported for many other reef fish families. Thus, they probably have a relatively short planktonic larval or post-larval life (Thompson and Munro, 1974a). Larvae settle into various nearshore nursery habitats such as seagrass beds, mangroves, oyster reefs, and marshes (AFS, 2001). Very early juvenile stages of snappers are not often seen but do not appear to be as secretive as hinds and groupers (Thompson and Munro, 1974a).

Adults are generally sedentary and residential. Movement is generally localized and exhibits an offshore-inshore pattern, usually associated with spawning events. Many species have been reported to form mass spawning aggregations, where hundreds or even thousands of fish convene to reproduce (Rielinger, 1999). Other species also aggregate to swim (Froese and Pauly, 2001; SAFMC, 1999). Generally, larger snapper inhabit deeper areas than smaller snapper, although there are many exceptions.

Juveniles occupying inshore areas generally feed on shrimp, crab, worms and small fish. Fish becomes a more important component of their diet as they grow and move offshore (SAFMC, 1999). On reefs, snappers must certainly compete among themselves for food and space. A 1967 study reported that snappers in the Virgin Islands feed primarily on crabs and fishes, with shrimps, lobsters, gastropods, stomatopods and octopus completing the diet (Thompson and Munro, 1974a). Competition with groupers (Serranidae), jacks (Carangidae), moray eels (Muraenidae) and grunts (Pomadasyidae) probably also occurs, although the extent of competition is not known. Predators of juvenile snappers include large carnivorous fishes, such as jacks, groupers, sharks, barracudas, and morays, as well as large sea mammals and turtles (SAFMC, 1999). Major reef predators such as sharks, groupers and barracuda are probably the most important predators of adult snappers (Thompson and Munro, 1974a).

4.2.1.1 Dog snapper, *Lutjanus jocu*

The dog snapper occurs in both the Western and Eastern Atlantic. In the Western Atlantic, it ranges from Massachusetts (USA), southward to northern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is taken in commercial fisheries and also is utilized in the aquarium trade. It can be ciguatoxic (Allen, 1985 in Froese and Pauly, 2002).

The dog snapper is found from 5-30 m depth. Adults are common around rocky or coral reefs. Young are found in estuaries, and occasionally enter rivers (Allen, 1985 in Froese and Pauly, 2002). This species is of low resilience, with a minimum population doubling time of 4.5 – 14 years (K = 0.10; tm = 5.5). Maximum reported size is 128 cm TL (male); maximum weight, 28.6 kg (Allen, 1985 in Froese and Pauly, 2002). Size at maturity and age at first maturity are estimated as 47.6 cm TL and 6.2 years, respectively. Approximate life span is 28.7 years; natural mortality rate, 0.333 (Ault *et al.*, 1998). Dog snapper are reported to spawn throughout the year off Cuba (García-Cagide *et al.*, 1999). A Caribbean study collected ripe females in February-March, and one ripe female and one spent male in November (Thompson and Munro, 1974a). In the northeastern Caribbean, individuals in spawning condition have been observed in March (Erdman, 1976). The dog snapper feeds mainly on fishes and benthic invertebrates, including shrimps, crabs, gastropods and cephalopods (Allen, 1985 in Froese and Pauly, 2002).

4.2.1.2 Yellowtail snapper, *Ocyurus chrysurus*

The yellowtail snapper occurs in the Western Atlantic, ranging from Massachusetts (USA) to southeastern Brazil, including the Gulf of Mexico and Caribbean Sea. This species is most common in the Bahamas, off south Florida, and throughout the Caribbean. It is taken in both the commercial and recreational fisheries, is cultured commercially, and is utilized in the aquarium trade (Allen, 1985 in Froese and Pauly, 2002). Dammann (1969), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The yellowtail snapper inhabits waters to 180 m depth, and usually occurs well above the bottom (Allen, 1985 in Froese and Pauly, 2002). A Jamaican study reports this species was most abundant at depths of 20-40 m near the edges of shelves and banks (Thompson and Munro, 1974a). Early juveniles are usually found over seagrass beds (Allen, 1985 in Froese and Pauly, 2002; Thompson and Munro, 1974a). Later juveniles inhabit shallow reef areas. Adults are found on deeper reefs (Thompson and Munro, 1974a). This fish wanders a bit more than other snapper species (SAFMC, 1999). But the extent of its movement is unknown. It also exhibits schooling behavior (Thompson and Munro, 1974a).

This species is of low resilience, with a minimum population doubling time of 4.5-14 years (K = 0.10-0.16; tm = 2; tmax = 14). Maximum reported size is 86.3 cm TL (male); maximum weight, 4,070 g (Allen, 1985 in Froese and Pauly, 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 42.5 cm TL and 4 years, respectively. Figuerola and Torres (1997) estimate size at 50% maturity as 22.4 cm FL (males) and 24.8 cm FL (females), based on fishery independent and dependent data collected off Puerto Rico. Maximum reported age is 14 years (Allen, 1985 in Froese and Pauly, 2002); estimated natural mortality rate, 0.21 (Ault *et al.*, 2002).

Spawning extends over a protracted period (Allen, 1985 in Froese and Pauly, 2002; Figuerola and Torres, 1997), peaking at different times in different areas (Allen, 1985 in Froese and Pauly, 2002). Figuerola and Torres (1997) report that, in the U.S. Caribbean, the reproductive season of this fish extends from February to October, with a peak from April to July. Erdman (1976) reports that 80% of adult yellowtails captured off San Juan from March through May, and over Silver Bank in early September, had ripe or sub-ripe gonads. Evidence indicates that spawning occurs in offshore waters (Figuerola and Torres, 1997; Thompson and Munro, 1974a) and during the new moon (Figuerola and Torres, 1997). Fecundity ranged from 100,000 to 1,473,000 eggs per fish in four individuals captured off Cuba (Thompson and Munro, 1974a).

Juvenile yellowtail snappers feed primarily on plankton (Allen, 1985 in Froese and Pauly, 2002; Thompson and Munro, 1974a). Adults feed mainly at night on a combination of planktonic (Allen, 1985 in Froese and Pauly, 2002), pelagic (Thompson and Munro, 1974a), and benthic organisms, including fishes, crustaceans, worms, gastropods and cephalopods (Allen, 1985 in Froese and Pauly, 2002).

4.2.1.3 Vermilion snapper, *Rhomboplites aurorubens*

The vermilion snapper occurs in the Western Atlantic, ranging from Bermuda and North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea (Allen 1985 in Froese and Pauly 2002).

The vermilion snapper is a demersal species, commonly found over rock, gravel, or sand bottoms near the edge of the continental and island shelves (Allen 1985 in Froese and Pauly 2002). Suitable bottom type is probably more important than depth in influencing the distribution of this species (Boardman and Weiler 1979). According to Allen (1985), in Froese and Pauly (2002), this fish is found in moderately deep waters from 180-300 m. But most fish taken in fish traps during a 1978 survey off Puerto Rico were captured at 75-110 m depth (Boardman and Weiler 1979). Vermilions often form large schools; particularly the young, which generally occur at shallower depths (Allen 1985 in Froese and Pauly 2002).

This fish is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K= 0.20; tm = 3; tmax = 10) (Allen 1985 in Froese and Pauly 2002). Maximum size and weight reported by Allen (1985), in Froese and Pauly (2002), is 60 cm TL (male) and 3,170 g, respectively. The modal length of both males and females collected in a three-year fish trap survey in Puerto Rican waters was 23 cm FL; maximum size, 38 cm. Size at maturity was 14 cm FL (males) and 20 cm FL (females) (Boardman and Weiler 1979). Size at maturity and age at first maturity for this species are estimated in Froese and Pauly (2002) as 34.5 cm TL and 3.3 years, respectively. Maximum reported age is 10 years (Allen 1985 in Froese and Pauly 2002); natural mortality rate, 0.23 (Ault *et al.* 1998).

According to Boardman and Weiler (1979), this fish spawns year-round in the U.S. Caribbean and in relatively large numbers. Erdman (1976) reports that the majority of fishes collected off the south coast of Puerto Rico in February, March, April, and June had sub-ripe or ripe gonads. A study off Jamaica captured one active male during May, and one ripe and three active females during October (Thompson and Munro 1974a). Prey items include fishes, shrimps, crabs, polychaetes, other benthic invertebrates, cephalopods, and planktonic organisms (Allen 1985 in Froese and Pauly 2002).

4.2.1.4 Silk snapper, *Lutjanus vivanus*

The silk snapper occurs in the Western Atlantic, as far north as Bermuda and North Carolina (USA), southward to central Brazil. It is most abundant around the Antilles and the Bahamas. A good food fish, this species is taken in both commercial and recreational fisheries. It can be ciguatoxic (Allen 1985 in Froese and Pauly 2002).

The silk snapper is mainly found from 90-140 m depth, commonly near the edge of the continental and island shelves, but also beyond the shelf edge to depths of 300 m. Adults are generally distributed further offshore than juveniles (SAFMC 1999), and usually ascend to shallow water at night (Allen 1985 in Froese and Pauly 2002). Suitable bottom type is probably more important than depth in influencing the distribution of this species. According to Rivas (1970), silk snapper are the only deep water snappers found over mud substrate in the Western Atlantic. Most fish taken in fish traps during a 1978 survey off Puerto Rico were captured at 112-165 m depth. Silk snapper have been reported to school in size groups (Dammann *et al.* 1970). Boardman and Weiler (1979) suggest that silk snapper are commonly associated with blackfin snapper and vermillion snapper, though silk snapper are usually found at a slightly deeper depth.

This species is of low resilience, with a minimum population doubling time of 4.5 - 14 years (K= 0.09-0.32; tm = 5). Maximum reported size is 83 cm TL (male); maximum weight, 8,320 g (Allen 1985 in Froese and Pauly 2002). The predominant lengths for males and females surveyed with trap gear in Puerto Rican waters were 29 cm FL and 26 cm FL, respectively, as determined from length-frequency curves. But trap-caught silk snapper tend to be smaller than those caught by hook and line gear. The maximum size of fish taken in that study was 71 cm FL. Females and males appeared to mature at 50 cm FL and 38 cm FL, respectively (Boardman and Weiler 1979). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 43.4 cm TL and 6.3 years, respectively. A Jamaican study estimates mean sizes of maturity as 55-60 cm FL (males) and 50-55 cm FL (females) (Thompson and Munro 1974a). The approximate life span of this fish is 28.7 years; natural mortality rate, 0.23 (Ault *et al.* 1998). However, Tabash and Sierra (1996) suggested a maximum life span of seven years and estimated an M using Ralston's (1987) method to be 0.86, which was also advocated by the SEDAR process.

The findings of Boardman and Weiler (1979) indicate that this species spawns year-round in the U.S. Caribbean, in low percentages. But the small number of ripe fish observed in that study may have been due to the majority of the catch being smaller than estimated size at maturity. Apparent peaks in spawning in July-September and October-December were probably due to chance collection of spawning groups of a few large fishes (Boardman and Weiler 1979). In the northeastern Caribbean, individuals in spawning condition have been observed from February through April, and in September and November (Erdman 1976). Ripe fishes have been observed off the coast of Jamaica in March-May and August, September and November (Thompson and Munro 1974a).

Prey items include mainly fishes, shrimps, crabs, gastropods, cephalopods, tunicates and some pelagic items, including urochordates (Allen 1985 in Froese and Pauly 2002). The main items in the stomachs of fishes captured off the Virgin Islands consisted of fish (50.1%), shrimp (17.8%), and crabs (11%), with isopods and other invertebrate groups completing the diet (Thompson and Munro 1974a).

4.2.1.5 Blackfin snapper, *Lutjanus buccanella*

The blackfin snapper occurs in the Western Atlantic, as far north as North Carolina (USA) and Bermuda, south to Trinidad and northern Brazil, including the Gulf of Mexico and Caribbean Sea (Allen 1985 in Froese and Pauly 2002). This species is very common in the Caribbean, particularly in the Antilles. It is considered to be a good food fish, but can be ciguatoxic (Allen 1985 in Froese and Pauly 2002).

The blackfin snapper is a demersal species, found from 20-200 m depth. Adults inhabit deeper waters over sandy or rocky bottoms, and near drop-offs and ledges. Juveniles occur in shallower waters, often between about 35 and 50 m (Allen 1985 in Froese and Pauly 2002), and sometimes in small schools (Thompson and Munro 1974a). Suitable bottom type is probably more important than depth in influencing the distribution of this species. Most fish taken in fish traps during a 1978 survey off Puerto Rico were captured at 75-110 m depth (Boardman and Weiler 1979).

This species is moderately resilient, with a minimum population doubling time of 1.4-4.4 years (K = 0.10 - 0.70). Maximum reported size is 75 cm TL (male); maximum weight, 14 kg (Allen 1985 in Froese and Pauly 2002). The modal lengths for male and female blackfins taken in the Puerto Rican survey were 26 cm FL and 23 cm FL, respectively. Maximum size was 47 cm FL. Estimated lengths of maturity for females and males were 20 cm FL and 38 cm FL, respectively (Boardman and Weiler 1979). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 34 cm TL and 1.9 years, respectively. Approximate life span is 8.2 years; natural mortality rate, 0.23 (Ault *et al.* 1998).

The findings of Boardman and Weiler (1979) indicate that spawning occurs year-round in the U.S. Caribbean, in relatively large numbers. In the northeastern Caribbean, individuals in spawning condition have been observed in February, April, and September (Erdman 1976). Ripe fishes have been observed in Jamaican waters in February-May and in August-November, with maxima in April and September (Thompson and Munro 1974a). Allen (1985), in Froese and Pauly (2002) identify fishes as the primary prey. Thompson and Munro (1974a) report that the main items in the stomachs of this species taken at the Virgin Islands were isopods (37.5%) and fish (33.3%), with shrimps, spiny lobsters, crabs, octopus and squid making up the rest of the diet. Tunicates have been found in the stomachs of some adults (Thompson and Munro 1974a).

4.2.1.6 Wenchman, *Pristipomoides aquilonaris*

The wenchman occurs in the Western Atlantic, ranging from North Carolina (USA) to Guiana, including the Caribbean Sea. Although considered to be a good food fish, this species is believed to be of minor importance to commercial fisheries (Allen 1985 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The wenchman is a demersal species, found from 24-370 m depth. Maximum reported size is 56 cm TL (male); maximum weight, 1,990 g (Allen 1985 in Froese and Pauly 2002). Size at maturity is estimated as 32.1 cm TL; natural mortality rate, 0.44 (Froese and Pauly 2002). Its diet is composed primarily of small fishes (Allen 1985 in Froese and Pauly 2002).

4.2.1.7 Black snapper, *Apsilus dentatus*

The black snapper occurs in the Western Central Atlantic, off the Florida Keys (USA), and in the western Gulf of Mexico and Caribbean Sea. This species is considered to be a good food fish (Allen 1985 in Froese and Pauly 2002). But Halstead (1970), in Froese and Pauly (2002), report that it can be ciguatoxic.

A demersal species, the black snapper is primarily found over rocky bottom habitat, although juveniles are sometimes found near the surface (Allen 1985 in Froese and Pauly 2002). It moves offshore to deep-water reefs and rocky ledges as it grows and matures (SAFMC 1999). Allen (1985), in Froese and Pauly (2002) reports depth range as 100-300 m. The findings of a Caribbean study indicate that it is most abundant at depths of 60-100 m off Jamaica (Thompson and Munro 1974a).

Maximum reported size is 65 cm TL (male). Maximum reported weight is 3,170 g (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity estimated in Froese and Pauly (2002) are 34.9 cm TL and 1 year, respectively. Observed maximum fork lengths of catches taken in a Jamaican study were 56 cm FL and 54 cm FL for males and females, respectively; estimated mean sizes of maturity, 43-45 cm FL and 39-41 cm FL for males and females, respectively (Thompson and Munro 1974a). Aida Rosario (unpublished data; personal communication) reports that females with ripe gonads were collected from December to May and from August to September, and were collected with the highest frequency in March and September. In the northeastern Caribbean, individuals in spawning condition have been observed from February through April, and in September (Erdman 1976). Thompson and Munro (1974a) reports that, off Jamaica, the greatest proportions of ripe fishes were found in January-April and September-November (Thompson and Munro 1974a).

Approximate life span is 4.4 years; natural mortality rate, 0.30 (Ault *et al.* 1998). Large catches occasionally obtained over a short period of time suggest a schooling habit for this species (Thompson and Munro 1974a). Prey includes fishes and benthic organisms, including cephalopods, tunicates (Allen 1985 in Froese and Pauly 2002), and crustaceans (Thompson and Munro 1974a).

4.2.1.8 Queen snapper, *Etelis oculatus*

The queen snapper occurs in the Western Atlantic, ranging from Bermuda and North Carolina (USA) to Brazil, including the Gulf of Mexico and Caribbean Sea. It is commonly found near oceanic islands, and is particularly abundant in the Bahamas and the Antilles. This species is considered to be a good food fish (Allen 1985 in Froese and Pauly 2002).

The queen snapper is a bathydemersal species (Allen 1985 in Froese and Pauly 2002). It moves offshore to deep-water reefs and rocky ledges as it grows and matures (SAFMC 1999). Allen (1985), in Froese and Pauly (2002) indicate it is primarily found over rocky bottom habitat, in depths of 100-450 m. Thompson and Munro (1974a) report it was caught on mud slopes of the south Jamaica shelf at a depth of 460 m (Thompson and Munro 1974a). This fish is a moderately resilient species, with a minimum population doubling time 1.4-4.4 years (K = 0.29 - 0.61). Maximum reported size is 100 cm TL (male). Maximum reported weight is 5,300 g (Allen 1985 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 53.6 cm TL and 1 year, respectively. Spawning is reported to occur during April and May off St. Lucia (Murray *et al.* 1992). Approximate life span is 4.7 years; natural mortality rate, 0.76 (Froese and Pauly 2002). Primary prey items include small fishes and squids (Allen 1985 in Froese and Pauly 2002; Gobert et al. 2003).

4.2.1.9 Cardinal snapper, *Pristipomoides macrophthalmus*

The cardinal snapper occurs in the Western Central Atlantic, ranging from the Straits of Florida, Bahamas, Greater Antilles to the Caribbean coast of Nicaragua and Panama (Froese and Pauly 2002). The cardinal snapper is a benthopelagic species and most commonly found in deeper waters of the shelf between 110 and 550, near the edge of the continental slope. (Allen 1985b; Froese and Pauly 2002) According to Froese and Pauly (2002), cardinal snappers feed on small fishes and larger planktonic animals. This fish is a moderately resilient species, with a minimum population doubling time 1.4-4.4 years (Preliminary K). Maximum reported size is 50 cm TL (male). (Froese and Pauly 2002).

4.2.2 Groupers, hinds, and sea basses, Serranidae

The Serranidae family contains 449 species in 62 genera, distributed in tropical and temperate oceans across the globe. These species are monoecious, with some functional hermaphrodites (Nelson, 1994 in Froese and Pauly, 2002). Protogynous hermaphroditism is known to occur in several species of groupers, although in related serranids synchronous hermaphroditism is also encountered. A broad overlap of the length distributions of the sexes is encountered in most species and suggests that there is no close correlation of age or size with sexual transition (Thompson and Munro, 1974b). Seven genera are represented in the Caribbean reef fish fishery management unit: *Epinephelus*, *Mycteroperca*, *Hypoplectrus*, *Liopropoma*, *Paranthias*, *Rypticus*, and *Serranus*. Many groupers, but especially the largest Epinephelus species, appear to be the resident apex predators of the reef systems that they inhabit (Huntsman *et al.*, 1999).

4.2.2.1 Red hind, *Epinephelus guttatus*

The red hind occurs in the Western Atlantic, ranging from North Carolina (USA) to Venezuela, including the Caribbean Sea. An excellent food fish, this species is readily caught on hook and line, and is easily speared by divers. It is taken in both commercial and recreational fisheries, and is utilized in the aquarium trade (Heemstra and Randall, 1993 in Froese and Pauly, 2002). Halstead (1970), in Froese and Pauly (2002), reports that it can be ciguatoxic.

The red hind is found in shallow reefs and rocky bottoms, from 2-100 m depth. It is usually solitary and territorial. This species is moderately resilient, with a minimum population doubling time of 1.4 - 4.4 years (K=0.12-0.24; tm=3; tmax=17; Fec=96,000). Maximum reported size is 76 cm TL (male); maximum weight, 25 kg (Heemstra and Randall, 1993 in Froese and Pauly, 2002). Size at maturity and age at first maturity are estimated in Froese and Pauly (2002) as 31.4 cm TL and 5.5 years, respectively. Figuerola and Torres (2000) estimate size at maturity as 21.7 cm FL based on data collected in a study conducted off the west coast of Puerto Rico. The approximate life span of this fish is 23.8 years; natural mortality rate, 0.18 (Ault *et al.*, 1998). One study showed 233,273 eggs for a specimen of 35.8 cm SL (Thompson and Munro, 1974b).

The red hind is a protogynous hermaphrodite (Thompson and Munro, 1974b). Thompson and Munro (1974b) report that mean size at sex reversal appears to be in the region of 38 cm TL. But, according to Heemstra and Randall (1993), in Froese and Pauly (2002), some individuals have been observed to undergo sexual inversion at just 28 cm TL. CFMC (1985) reports size at sex reversal as 35 cm TL. Most fish larger than 40 cm are males, which is important in terms of numbers caught and total weight of landings in the Caribbean (Heemstra and Randall, 1993 in Froese and Pauly, 2002).

This species aggregates in large numbers during the spawning season (Coleman *et al.* 2000; Sadovy *et al.* 1994). A number of spawning aggregation sites have been documented in the U.S. Caribbean. Three sites are located off the western coast of Puerto

Rico. A fourth site is located near the shelf edge off the southwest coast of Puerto Rico, El Hoyo and La Laja, and is utilized by as many as 3,000 individuals at 20-30 m depth. A fifth site is located on the Lang Bank, north-northeast of St. Croix, and is characterized by aggregations from 38-48 m depth. Finally, a sixth site is located south of St. Thomas, USVI. That aggregation also generally occurs at 38-48 m depth. The timing of aggregations is somewhat variable. Aggregations off Puerto Rico generally occur from January through March in association with the full moon, while those off the USVI generally occur from December through March in association with the full moon (Rielinger 1999). The red hind feeds mainly on crabs and other crustaceans, fishes, such as labrids and haemulids, and octopus (Heemstra and Randall 1993 in Froese and Pauly 2002).

4.2.2.2 Nassau grouper, *Epinephelus striatus*

The Nassau grouper occurs in the tropical Western Atlantic, ranging from Bermuda, the Bahamas, and Florida (USA) to southern Brazil. It is not known from the Gulf of Mexico, except at the Campeche Bank off the coast of Yucatan, at Tortugas, and off Key West. This species is a popular food fish and also is utilized in the aquarium trade (Heemstra and Randall 1993 in Froese and Pauly 2002). However, the take and possession of Nassau grouper is prohibited in federal waters. Furthermore, Puerto Rico implemented new regulations on March 12, 2004, to prohibit the possession or sale of Nassau grouper. Its flesh is marketed fresh (Heemstra and Randall 1993 in Froese and Pauly 2002). Olsen *et al.* (1984), in Froese and Pauly (2002), report that it can be ciguatoxic.

The Nassau grouper occurs from the shoreline to at least 90 m depth. It is a sedentary, and reef-associated species, usually encountered close to caves; although juveniles are common in seagrass beds (Heemstra and Randall 1993 in Froese and Pauly 2002). Adults lead solitary lives outside of spawning aggregations (NMFS 2001b).

This fish is of low resilience, with a minimum population doubling time of 4.5 - 14 years (Froese and Pauly 2002). Maximum reported size is 122 cm TL (male); maximum weight, 25 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 47.5 cm TL and 6.9 years, respectively. Approximate life span is 31.9 years (Froese and Pauly 2002); maximum reported age, 16 years (Heemstra and Randall 1993 in Froese and Pauly 2002). Ault *et al.* (1998) estimate natural mortality rate to be 0.18.

This fish was initially characterized as a protogynous hermaphrodite. But recent investigations of histological and demographic data, and the nature of the mating system, indicates that Nassau grouper may not be strictly protogynous. Thus, it has been characterized as gonochoristic (separate sexes), with a potential for sex change (NMFS 2001b). One study reported 785,101 eggs for a specimen of 35.8 cm SL (Thompson and Munro 1974b).

The Nassau grouper aggregates to spawn at specific times and locations each year (Coleman *et al.* 2000; Sadovy *et al.* 1994), reportedly at some of the same sites utilized by the tiger, yellowfin, and black groupers (Sadovy *et al.* 1994). Concentrated aggregations of a few dozen (NMFS 2001b) up to 30,000 Nassau groupers have been reported from the Bahamas, Jamaica, Cayman Islands, Belize, and the Virgin Islands (Heemstra and Randall 1993 in Froese and Pauly 2002). Spawning aggregations composed of about 2000 individuals have been documented north and south of St. Thomas, USVI, at 10-40 m depth, from December through February, around the time of the full moon (Rielinger 1999).

According to NMFS (2001b), spawning aggregations occur in depths of 20-40 m at specific locations of the outer reef shelf edge always in December and January around the time of the full moon in waters 25-26 degrees Celsius. Thompson and Munro (1974b) indicate that the spawning season probably extends from January to April in Jamaican waters. They report that spawning aggregations lasting up to two weeks have been encountered annually during late January to early February around the Cayman Islands (Thompson and Munro 1974b). In the northeastern Caribbean, individuals in spawning condition have been observed in March (Erdman 1976).

It is a top-level predator. Juveniles feed mostly on crustaceans, while adults (>30 cm) forage alone, mainly on fish (NMFS 2001b), but also on crabs and, to a lesser extent, other crustaceans and mollusks (Heemstra and Randall 1993 in Froese and Pauly 2002).

4.2.2.3 Yellowfin grouper, *Mycteroperca venenosa*

The yellowfin grouper occurs in the Western Atlantic, ranging from Bermuda to Brazil and Guianas, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries, and also is utilized in the aquarium trade. Although often implicated in ciguatera poisonings, it is a desirable food fish. Even large (5-10 kg) fish taken from areas that are considered to be safe are sold in markets (Heemstra and Randall 1993 in Froese and Pauly 2002).

The yellowfin grouper occurs from 2-137 m depth. Juveniles are commonly found in shallow turtle grass beds; adults, on rocky and coral reefs. This fish is of low resilience, with a minimum population doubling time of 4.5-14 years (K=0.09-0.17; tmax=15; Fec=400,000). Maximum reported size is 100 cm TL (male); maximum weight, 18.5 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Size at maturity and age at first maturity are estimated as 45.6 cm TL and 3.7 years, respectively. Approximate life span is 16.9 years; natural mortality rate, 0.18 (Ault *et al.* 1998). This fish is believed to be a protogynous hermaphrodite. One studied specimen contained a total of 1,425,443 eggs (Thompson and Munro 1974b). The yellowfin grouper reportedly aggregates at some of the same sites utilized by the tiger, Nassau, and black groupers (Sadovy *et al.* 1994). Three spawning aggregation sites have been documented off the USVI. Sites located north and south of St. Thomas are utilized from February through April. A third site located in the USVI National Park off St. John, USVI, is utilized year-round. Individuals aggregating at that site number about 200 (Rielinger 1999). Spawning has been observed in Puerto Rican waters in March. Most spawning appears to occur in Jamaican waters between February and April (Thompson and Munro 1974b). It feeds mainly on fishes (mostly on coral reef species) and squids (Heemstra and Randall 1993 in Froese and Pauly 2002).

4.2.2.4 Misty grouper, *Epinephelus mystacinus*

The misty grouper occurs in both the Western and Eastern Atlantic Ocean. In the Western Atlantic, it ranges from Bermuda and North Carolina (USA) to Mexico, including the Gulf of Mexico and Caribbean Sea. This species is taken in both commercial and recreational fisheries, and is marketed fresh (Heemstra and Randall 1993 in Froese and Pauly 2002).

The misty grouper is a solitary, bathydemersal, deep-water species, ranging from 30-400 m depth. Juveniles occur in shallower waters. Virtually nothing is known about the age, growth, and reproduction of this species. Maximum reported sizes are 160 cm TL and 100 cm TL for males and females, respectively. Maximum reported weight is 107 kg (Heemstra and Randall 1993 in Froese and Pauly 2002). Estimated size at maturity is 81.1 cm TL; natural mortality rate, 0.14 (Froese and Pauly 2002). In the northeastern Caribbean, individuals in spawning condition have been observed in January, April, August, and November (Erdman 1976). Prey items include fishes, crustaceans, and squids (Heemstra and Randall 1993 in Froese and Pauly 2002).

4.2.3 Protected Species, Including Threatened and Endangered Species

NOAA Fisheries is responsible for the protection of threatened and endangered species under the Endangered Species Act (ESA) of 1973 and the Marine Mammal Protection Act (MMPA) of 1972. The ESA promotes the protection of the ecosystems on which threatened and endangered species depend and a program for the conservation of threatened and endangered species. ESA-listed species under the purview of NOAA Fisheries that occur in area that would be affected by the proposed fishery closure include hawksbill sea turtle (*Eretmochelys imbricata*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), humpback whale (*Megaptera novaeangliae*), blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), sei whale (*B. borealis*), sperm whale (*Physeter macrocephalus*), elkhorn coral (*Acropora palmata*), and staghorn coral (*A. cervicornis*). The MMPA establishes a national policy to prevent marine mammal species and population stocks from declining beyond the point where they cease to be significant functioning elements of the ecosystems of which they are a part. All marine mammals, regardless of their listing status under the ESA, are protected under the Marine Mammal Protection Act.

4.2.3.1 Marine Mammals

Marine mammals are primarily ocean-dwelling animals including cetaceans (whales, dolphins, and porpoises), sirenians (manatees), and pinnipeds (seals). In Puerto Rico, whales and dolphins commonly transit waters around the island and sometimes strand on beaches. Cetaceans are divided into two groups, the toothed whales, which also include dolphins and porpoises, and baleen whales. Baleen whales are usually larger than toothed whales and have baleen plates rather than teeth that enable them to filter water in order to separate out food such as krill and small fish. Baleen plates are flat and flexible with frayed edges that look like hair. In fact, the plates are made of the same material as hair, keratin.

NMFS lists five species of marine mammals that are known to transit through waters around Puerto Rico, including in the area of Bajo de Sico, as in danger of extinction under the ESA. In addition to the five whale species under NMFS' jurisdiction, the endangered manatee is also known to occur in the area of Bajo de Sico. The U.S. Fish and Wildlife Service (USFWS) has jurisdiction over the manatee.

The Antillean manatee, *Trichechus manatus manatus*, is listed as endangered under the ESA. The manatee was listed on March 11, 1967, and is also protected under the MMPA. The West Indian manatee includes two distinct subspecies, the Florida manatee and the Antillean manatee. Antillean manatees are found in coastal and riverine systems in South and Central America (from Brazil to Mexico) and in the Great and Lesser Antilles throughout the Caribbean Basin. In Puerto Rico, Antillean manatees are found around the main island, as well as commonly around the island of Vieques and occasionally around the island of Culebra. NMFS identified the Caribbean gillnet and Caribbean haul/beach seine fishery as the Category III commercial fisheries that could result in impacts to manatees (73 FR 73032). However, Category III is the category with the lowest level of serious injury and mortality to marine mammals and the USFWS has no data indicating take of manatees by these fisheries is occurring (USFWS, 2009). Collisions with boats may also be affecting the Puerto Rican manatee population as well. In 2006, five adult manatees in a mating herd were killed at one time as the result of a collision with a vessel in the Port of San Juan in San Juan Bay (USFWS, 2007). Antillean manatee distribution and movements around Puerto Rico taken from the capture of wild-caught animals tracked by USGS-FISC indicate that the west coast of Puerto Rico is heavily transited by these animals (USFWS, 2007). Thus, manatees transit through the area of Bajo de Sico and are often found concentrated in the area of the Guanajibo River east of Bajo de Sico.

The most common marine mammals under NMFS' jurisdiction that are found in the area of Bajo de Sico are the humpback whale, in particular during its winter migration along the west coast of Puerto Rico and the bottlenose dolphin (*Tursiops truncates*). Only the whale species listed as endangered are discussed in more detail below.

According to the List of Fisheries proposed by NMFS for 2009 as required by the MMPA, the Caribbean gillnet fishery is listed as Category III with the possibility of incidental death or injury to the West Indian manatee as the only potential impact of this fishery on listed species. The Caribbean snapper-grouper and other reef fish bottom longline/hook-and-line, pelagic hook-and-line/harpoon, mixed species trap/pot, and spiny lobster trap/pot have not resulted in the documentation of any death or injury to marine mammals as a result of these fisheries and are in Category III (FR 73(115): 33760-33800).

4.2.3.1.1 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is a large baleen whale and was listed as endangered throughout its range under the ESA on June 2, 1970. Humpbacks are considered depleted under the MMPA.

The humpback whale is distributed worldwide but is less common in Arctic waters. Humpback whales migrate seasonally. During the winter, which is their breeding season, they are typically found in temperate and tropical waters. In summer, which is their feeding season, humpbacks are usually in higher latitude waters of high productivity. There are currently four recognized stocks of humpback whales in the U.S. designated based on geographically distinct winter ranges: The Gulf of Maine stock (previously known as the western North Atlantic stock), the eastern North Pacific stock (previously known as the California-Oregon-Washington stock), the central North Pacific stock, and the western North Pacific stock.

Humpback whales are affected by human activities in many parts of their range, which may impede recovery of the species. Humpback whales were historically hunted for their meat and blubber. Entanglements and collisions with vessels are factors that may slow recovery of the population. Disturbance by whale watching may also be an issue in some areas of the humpback's range as this industry continues to grow. In Puerto Rico, there are several businesses dedicated to whale watching during the winter migratory season in the area of Rincón. Pollution and habitat alteration and destruction from coastal development may also affect humpback whales.

A visual and passive acoustic survey of the area around Puerto Rico found winter aggregations of humpbacks around Cabo Rojo and the northern shore of Mona Island that appear to be as dense as those in waters of the Dominican Republic (Swartz *et al* 2001). The highest concentrations of humpbacks have been found to occur along the northwestern coast of Puerto Rico, in particular around Punta Higuero in Rincón and Punta Agujereada in Aguadilla, Cabo Rojo, and Mona Passage (CFMC 2004). In April 2008, a female gave birth in Guayanilla Bay and then continued migrating through Mona Passage. Thus, the area of Bajo de Sico contains groups of humpback whales, in particular during their winter migration between November to May.

4.2.3.1.2 Blue Whale (*Balaenoptera musculus*)

The blue whale is listed as endangered under the ESA and protected under the MMPA. Blue whales are also listed as endangered under the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species.

The blue whale, a baleen whale, is the largest animal ever known to have lived on Earth. Blue whales are found in oceans worldwide and are separated into North Atlantic, North Pacific, and Southern Hemisphere populations. The blue whale has also been subdivided into three subspecies: *B. musculus intermedia* found in Antarctic waters, *B. musculus musculus* found in the Northern Hemisphere, and *B. musculus brevicauda* found in the southern Indian Ocean and southwest Pacific Ocean. In the U.S., blue whale stocks are divided into the western North Atlantic stock, the eastern North Pacific stock, and the Hawaiian stock. The stocks of blue whales were severely depleted by past hunting activities. Now, blue whales are at least occasionally injured or killed by ship collisions based on observations in California and the Gulf of St. Lawrence.

The blue whale is considered an occasional visitor in the U.S. Atlantic EEZ and the actual southern limit of its range in unknown, as is its population size (NMFS 2002). Blue whales are found both on the continental shelf and far offshore in deep water. While the Navy's Sound Surveillance System program has tracked blue whales in the North Atlantic, including subtropical waters north of the West Indies (NMFS 2002), no blue whales have been reported in waters of Puerto Rico.

4.2.3.1.3 Fin Whale (*B. physalus*)

The fin whale was first listed as endangered under the ESA on June 2, 1970. It is now designated as endangered throughout its range.

Fin whales were greatly depleted by whaling but large numbers of these species still remain worldwide. These whales are still hunted in Greenland as part of permitted aboriginal subsistence hunting and Japan is beginning to kill these whales as part of its scientific program. Other potential threats to finback whales are collisions with vessels, entanglement in fishing gear, habitat degradation, and disturbance from low-frequency noise. In addition, because fin whales rely on large schools of fish for their diet in many areas, trends in fish populations, whether driven by fishery operations, human-caused environmental deterioration, or natural processes, may strongly affect the size and distribution of fin whale populations (NMFS 2006).

Populations of fin whales in the North Atlantic, North Pacific, and Southern Ocean probably mix rarely (if at all), and there are geographical populations within these ocean basins (NMFS 2006). In U.S. waters, fin whales are divided between the North Atlantic and North Pacific (Alaska (Northeast Pacific), California/Washington/Oregon, and Hawaii) stocks. Fin whales do not have an obvious north/south migration pattern like other baleen whales. However, acoustic studies indicate that there is a southward movement in the fall into the West Indies. Limited sightings of fin whales are reported for Puerto Rico, in particular in the winter (December-January), which corresponds with the breeding season of this species (CMFC 2004). Sighting have been in the area north of Mona Island and south of Cayo Ratones, Salinas; however, reports do not distinguish between fin and sei whales, which are very similar in appearance (CFMC 2004).

4.2.3.1.4 Sei Whale (*B. borealis*)

Sei whales are another of the baleen whales and were listed as endangered under the ESA on December 2, 1970 and are considered depleted under the MMPA.

Sei whales are divided into two subspecies: *B. borealis borealis* in the Northern Hemisphere and *B. borealis schlegellii* in the Southern Hemisphere. Sei whales occur in subtropical, temperate, and subpolar waters worldwide. Sei whales in U.S. waters have been divided into four stocks: Hawaiian, Eastern North Pacific, Nova Scotia, and Western North Atlantic. There are no current population estimates for the stocks in Nova Scotia and the Western North Atlantic. Sei whales were greatly depleted by past commercial hunting and whaling. Ship strikes and interactions with fishing gear, such as traps and pots, may affect current populations of sei whales.

Sei whales are commonly found in the Gulf of Maine and on Georges Bank and Stellwagen Bank in the western North Atlantic during the summer. However, the entire distribution and movement patterns of this species are not well known. Some populations of sei whales may migrate seasonally toward lower latitudes during the winter and higher latitudes during the summer. Limited sightings of sei whales have been reported from the U.S. Caribbean, although some of these reports may actually be for fin whales as these two species are difficult to separate visually in the field. Sightings have been from north of Mona Island and south of Cayo Ratones, Salinas, in Puerto Rico (CFMC 2004).

4.2.3.1.5 Sperm Whale (*Physeter macrocephalus*)

Sperm whales are the largest of the toothed whales. Sperm whales were listed as endangered under the ESA in 1970 and are considered depleted under the MMPA throughout their range.

Sperm whales inhabit oceans worldwide. Sperm whale migrations are not as well understood as those of most baleen whales, although their distribution is likely dependent on their food source and breeding conditions. In temperate and tropical waters, there appears to be no obvious seasonal migration. In U.S. waters, sperm whales have been divided into five stocks: California-Oregon-Washington, North Pacific (Alaska), Hawaiian, Northern Gulf of Mexico, and North Atlantic. Hunting of sperm whales in the past greatly depleted all populations of this species. Sperm whales are still targeted in a few areas such as Indonesia and Japan in limited numbers but there is some evidence that illegal hunting in some areas of the world is still occurring. Sperm whales may be harmed by ship strikes and entanglement in fishing gear, though the tendency of sperm whales to be in extremely deep offshore waters may reduce the probability of these interactions. Coastal pollution and noise in areas of oil and gas exploration and commercial shipping may also affect these whales.

Both large and small adults and calves and juveniles occur in the southeastern Caribbean, in particular sightings have been from the leeward sides of islands (NMFS 2002). Recorded sightings from Puerto Rico reported sperm whales off the coast of Mona Island in the Mona Passage, as well as off the coast of Rincón, Ponce, San Juan, and Loíza, and south of Vieques (CFMC 2004). Swartz *et al.* 2001 detected sperm whales in deep waters, in particular in areas of high bottom relief, southwest of Puerto Rico and in Mona Passage using acoustics.

4.2.3.2 Sea Turtles

Sea turtles are distinguished from the rest of the turtles by their two pairs of legs modified into fins, which are poorly adapted for moving in the terrestrial environment but provide them with the ability to swim well in the oceanic environment. Sea turtles are important components of tropical seas and the marine food web. However, due to the overfishing of all sea turtle species for use of their meat as well as for use of their shell in artisanal and utilitarian articles, sea turtles are considered to be threatened or in danger of extinction in the United States and in other countries.

Four species of sea turtles nest on sandy beaches around Puerto Rico, although nesting by the loggerhead sea turtle is infrequent and these animals are rarely seen in waters around Puerto Rico. Sea turtles that nest in Puerto Rico have similar life cycles. Basically, all the species migrate, at least short distances, from the feeding areas to the breeding grounds, which are near nesting areas. Following breeding, the males are thought to return to the feeding areas while the females move to nesting areas. Females return to the feeding areas and begin to prepare for the next reproductive season once nesting is complete. In order to ensure reproductive success, most sea turtles exhibit iteroperous reproduction, which means they produce their offspring in a series of separate events. Several clutches are laid during nesting season and, in tropical areas, nesting is often year-round with peak periods. In general, sea turtles need at least 10 years to reach sexual maturity, although this can vary even among individuals of the same species. Based on data from the U.S. Fish and Wildlife Service (unpublished), sea turtle nesting is reported from beaches in Cabo Rojo, Mayagüez, Añasco, and Rincón, in particular nesting by hawksbill and leatherback sea turtles.

Based on stranding data for western Puerto Rico, including Guánica, Lajas, Cabo Rojo, Mayagüez, Añasco, Rincón, and Aguadilla, from the Puerto Rico Department of Natural and Environmental Resources (DNER) for the period from 1999-2007, fishing gear impacted several species of sea turtles. Hawksbill and green sea turtles were particularly affected by fishing gear and most interactions with fishing gear resulted in mortality. DNER notes that these numbers are very low as they depend upon DNER receiving a stranding report from the public or another agency or finding the animals while on patrols. Stranding data included two hawksbill sea turtles killed by entanglement in fishing line; one green and two hawksbill sea turtles with fishing hooks in their throats that were rehabilitated and liberated; one green turtle that drowned entangled in a fish trap; two hawksbill sea turtles killed by spear guns; four green sea turtles entangled in nets one of which was found alive and liberated, five hawksbill sea turtles entangled in nets two of which were found alive, rehabilitated and later liberated, and one leatherback killed by entanglement in a net (DNER 2008).

4.2.3.2.1 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

Hawksbill sea turtles were listed as endangered in 1970 under the ESA and is also listed locally in Puerto Rico as endangered.

Hawksbill sea turtles are found in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. In the continental U.S., the species is recorded from all the gulf states and along the eastern seaboard as far north as Massachusetts, with the exception of Connecticut, although sightings north of Florida are rare. In the U.S. Caribbean, the species is very common. Hawksbill sea turtles nest year-round in Puerto Rico and adults and hatchlings can be found in waters around the island throughout the year. Nesting occurs in Cabo Rojo, Mona Island, Mayagüez, Añasco, Guánica, Guayanilla, Ponce, Caja de Muertos, Santa Isabel, Salinas, Guayama, Arroyo, Maunabo, Humacao, Ceiba, Fajardo, Luquillo, Río Grande, Loíza, Vieques, Culebra, and larger cays within the La Cordillera Reefs Natural Reserve off the coast of Fajardo based on annual DNER nesting surveys. Mona Island supports one of the largest nesting populations of hawksbills in Puerto Rico. For this reason, the USFWS designated the beaches of Mona Island as critical habitat for hawksbill sea turtles under the ESA and NMFS designated the waters up to three nautical miles around Mona and Monito Islands as critical habitat. A recent survey of the marine communities of Bajo de Sico (García-Sais *et al*., 2007) found the area to harbor a large number of adult hawksbill turtles that utilized the reef promontories as foraging and refuge habitat.

The greatest threat to hawksbill sea turtles is poaching as their eggs, shell, and meat continue to be in demand. Stranding data from DNER for the period from 1999-2007 contain reports of seven hawksbill deaths as a result of illegal poaching and the successful rehabilitation and liberation of three others that were hunted illegally. This is an underestimate as these are only the animals recovered by DNER. Another threat is boat strikes. DNER (2008) stranding data indicate that five hawksbills were killed by boat strikes during 1999-2007 and these are only the animals that were reported. Coastal development may also affect these animals through the loss or degradation of habitat, pollution, and entanglement in or ingesting of marine debris. Hawksbills are also impacted by interactions with fishing gear as indicated above.

4.2.3.2.2 Green Sea Turtle (*Chelonia mydas*)

Green sea turtles were listed as threatened except the breeding population off the Florida coast and the Pacific coast of Mexico, which are listed as endangered under the ESA. The species was listed on July 28, 1978. Locally, DNER lists this species as endangered. NMFS has designated critical habitat for green sea turtles as the area up to three nautical miles around the Island of Culebra and its surrounding islands and cays.

In the southeastern U.S., green sea turtles are found around the U.S. Virgin Islands, Puerto Rico, and the continental U.S. from Texas to Massachusetts. Adults and juveniles of this species can often be seen in the U.S. Virgin Islands and Puerto Rico, particularly in the area of Culebra. Green sea turtle nests are reported in Manatí, Loíza, Fajardo, Ceiba, Naguabo, Culebra, Vieques, Caja de Muertos, Mona Island, and larger cays within the La Cordillera Reefs Natural Reserve off the coast of Fajardo based on annual DNER nesting surveys.

Green sea turtles are still threatened by illegal poaching of eggs, juveniles and adults. Stranding data from DNER for the period from 1999-2007 contain reports of five green sea turtle deaths as a result of illegal poaching and the rehabilitation and liberation of two others that were hunted illegally. This is an underestimate as these are only the animals recovered by DNER. Two green sea turtles were killed by boat strikes during 1999-2007 based on DNER data. Coastal development may also affect these animals through the loss or degradation of habitat, pollution, and entanglement in or ingesting of marine debris. Green sea turtles are also impacted by interactions with fishing gear as indicated above.

4.2.3.2.3 Leatherback Sea Turtle (*Dermochelys coriacea*)

Leatherback sea turtles were listed as endangered throughout their range on June 2, 1970 under the ESA. NMFS has designated critical habitat for this species around Sandy Point, St. Croix, U.S. Virgin Islands due to the importance of this area as a nesting beach and the concentration of leatherbacks in the water in this area during the nesting season.

The range of this species extends from Cape Sable, Nova Scotia, south to the U.S. Caribbean. Adults and juveniles of leatherback sea turtles can be observed in the area of Bajo de Sico, in particular during their nesting peak in April-August. Leatherbacks nest on beaches in Mayagüez, Mona Island, Añasco, Isabela/Quebradillas, Guánica, Arecibo, Manatí, Isla Verde, Loíza, Río Grande, Luquillo, Fajardo, Humacao, Vieques, and Culebra based on annual DNER nesting surveys. The greatest concentration of leatherback nests in Puerto Rico is in the area of San Miguel, Luquillo/Fajardo.

Leatherbacks are still occasionally hunted for meat or their eggs are collected illegally, although this threat is only during the nesting season as the rest of the time these turtles are offshore. Leatherbacks can become entangled in fishing gear, in particular longlines, and are susceptible to injuries from marine debris, which they frequently ingest. Leatherbacks are also vulnerable to impacts from boat collisions and the death of a leatherback off Sandy Point, St. Croix, was reported by the Department of Planning and Natural Resources during the 2008 nesting season due to a boat strike.

4.2.3.2.4 Loggerhead Sea Turtle (*Caretta caretta*),

The loggerhead sea turtle was listed as threatened throughout its range on July 28, 1978. In the Atlantic, loggerheads are found from Newfoundland to Argentina.

Loggerhead sea turtle nests have been reported by DNER in Loíza, Humacao, Vieques, and Culebra but nesting is infrequent and these turtles are not common in waters of Puerto Rico. No loggerhead nests have been reported on the west coast of Puerto Rico. DNER stranding data (2008) did contain a report of a loggerhead that was injured off the west coast of Puerto Rico in an attempt to hunt the animal but the animal was rehabilitated and released.

Marine debris, dredging impacts related to habitat loss as well as direct injury to these turtles, bycatch during commercial fishing operations, collisions with vessels, entanglement in discarded fishing gear, and coastal pollution are some of the threats facing loggerhead sea turtles.

4.2.3.3 Corals

Almost 50 species belonging to 12 different families are represented in the Caribbean coral reef fishery management unit. Due to the numerous scleractinian species included in the coral reef fishery management unit, and that the ecological importance of corals is widely accepted and understood by the public, the following is only a survey of the major species and species groups found within Bajo de Sico.

Scleractinians are the principal reef builders. They are calcium secreting, anemone-like animals that can form colonies comprised of many physically and physiologically linked polyps or else can be solitary or consisting of one polyp. Tentacles occur in multiples of six and the digestive cavities are divided by partitions (sclerosepta and sarcosepta) that radiate from the center of the polyp. The polyps of stony corals are somewhat similar to those of sea anemones but produce a calcium carbonate cup (the corallite) and are usually colonial, producing a massive calcareous skeleton (the corallum) from the many corallites. In contrast to anemones they produce calcium carbonate, aragonitic skeletons that can reach considerable sizes (e.g., over 5 m in diameter and height in individuals of *Montastrea annularis*). The skeleton is internal, in contrast to other skeleton forming cnidarians (Goenaga and Boulon 1991). Often scleractinians are considered in two informal groups, the hermatypic or reef-building corals (those making a significant contribution to reef structure) and ahermatypic or non-reef building corals (often small, solitary species without large skeletons) (Colin 1978).

Many stony corals, particularly those that are hermatypic, contain small unicellular plants called zooxanthellae (dinoflagellata) in their gastrodermis. These zooxanthellae are pigmented, giving corals most of their color, and play a role in the production of calcium carbonate by the coral polyp. The exact nature of their contribution is not known and seems to vary within species of corals. Generally, however, ahermatypic corals lack zooxanthellae while hermatypic species possess large numbers. The zooxanthellae can be expelled by a coral (usually termed bleaching) when under stress (Colin 1978).

It is believed that the requirement of light for the zooxanthellae is the reason why coral reefs are limited to fairly shallow waters. With increasing depth below about 30 m corals are generally less heavily calcified than in shallower water and the ability to form reef structures is much less than in shallow water. Reef corals may occur to depths approaching 90-100 m in extremely clear water, but below 45-50 m in their constructional abilities are severely limited and may be surpassed by those of other groups of organisms such as the sclerosponges (Colin 1978).

Within a colony, all reproduction is asexual. New polyps are budded from other polyps as the colony increases in diameter or length. The rate of growth is variable between species, with branched species generally growing faster than massive species, and is strongly influenced within each species by environmental conditions. Sexually produced larvae, termed planulae, result in the establishment of new colonies. Larvae may either swim (entering the plankton and covering large distances) or crawl (staying close to the parent) until they attach to the bottom to initiate a new colony (Colin 1978).

A number of organisms prey directly on corals. Certain fishes pick polyps from the surface of the colony (butterflyfishes) while others ingest or scrape portions of skeleton with their attached polyps (puffers, parrotfishes). Some gastropod mollusks feed on coral polyps by inserting their proboscis into the polyp, and a few polychaete worms feed on branched corals by engulfing the tip of a branch in their mouth (Colin 1978). Boring sponges and clams occur in the skeleton and weaken it by their mechanisms of removing calcareous material (Colin 1978).

4.2.3.3.1 Genus Montastrea

Montrastrea annularis (boulder star coral) and M. cavernosa (great star coral) are generally the most common species of coral on Atlantic and Caribbean reefs at moderate depths (Colin 1978, Borneman 2001). M. annularis forms massive boulders or heads reaching several meters across in shallow water (1-20 m) and flattened heads or plate-like colonies in deeper water (below 20 m). It reaches depths of at least 60 m (Colin 1978). There is great variation in this species, and much of it seems related to depth. This species is slow growing compared to branching corals such as A. cervicornis, but rates of 1.0-2.5 cm per year increase in height have been recorded. M. annularis is attached by a wide variety of organisms other than corals. Boring sponges are quite abundant in this species, gastropod mollusks of the genus Coralliophila feed either on the polyps or on plankton ingested by the polyps, and filamentous algae occur on areas where coral tissue was removed by mechanical action. This star coral often forms massive mounds that are important structural elements of buttresses and other fore reef elements at moderate depth. Colonies become more plate-like as depth increases. This is frequently the dominant reef-builder in buttresses and fore reef slopes (Sefton and Webster 1986).

In many localities at moderate depths, M. cavernosa is the predominant species of coral present. Either this species or M. annularis is generally the most common coral between 10-30 m in buttressed or sloping areas of Atlantic reefs lacking sizable thickets of A. cervicornis. Below 30 m, M. cavernosa clearly predominates over M. annularis, but increasing importance of agariciid corals and sclerosponges in reef construction somewhat diminishes its contribution. M. cavernosa is one of the most effective zooplankton feeders among stony corals. It is one of the deepest occurring hermatypic corals, found at depths from only a few meters to at least 90 m (Colin 1978). M.

cavernosa is somewhat less common than M. annualris but, nevertheless, is an important reef-builder in many areas (Sefton and Webster 1986).

Although all of Montastrea's corallites have individual, distinct walls, each one is separated from one another by a thin layer of coenosteum. This distinction may originate from the extratentactacular budding process of the asexual growth of the colony (Borneman 2001). Montastrea are known to form long, sweeping tentacles at night when the feeding tentacles are exposed. The presence of these sweeping tentacles appears to be simply for defense and will respond to encounters by increasing localized growth after an encounter (Borneman 2001).

4.2.3.3.2 Black corals, Order Antipatharia

Entire colonies are harvested for artisanal purposes in some regions of the Caribbean. In 1970, the local precious coral jewelry industry (black and pink coral) was estimated to have a retail value of more than 4 million dollars. Their axial skeleton is polished and attains considerable thickness in some species, rendering them commercially valuable in the jewelry trade to humans. Species that do not branch are bent for making necklaces. In Puerto Rico and the Virgin Islands, commercial harvesting is apparently uncommon but is known to occur (Goenaga and Boulon 1991).

The ecology and life history of these organisms is, for the most part, unknown. Taxonomy, to a large extent, is also unknown. Two genera are represented in the Caribbean coral reef fishery management unit: *Antipathes spp.* (bush black corals) and *Stichopathes spp.* (wire corals) (Goenaga and Boulon 1991). Black corals are typically deep sea, slow growing colonial anthozoans usually occurring under ledges, possibly because their larvae is negatively phototactic. The axial skeleton is black, spiny and scleroproteinaceous, and is secreted in concentric layers around a hollow core. The polyps overlay the horny skeleton, are interconnected and possess six non-retractile, unbranched tentacles. They usually contain a diverse array of internal and external unstudied commensal organisms that include palaemonid crustaceans, lichomolgid copepods, and pilargiid polychaetes. Available evidence suggests that recruitment is infrequent.

Thick stemmed, branched, and large (i.e., potentially important economically) bush black corals occur in water depths below 50 m in La Parguera, Puerto Rico. Unbranched, thin stemmed wire corals are present at depths of 20 m. Both genera can also occur sparsely in very shallow, turbid waters off Mayaguez, western Puerto Rico and in La Parguera, southwestern Puerto Rico. Individual *Antipathes spp.* have been observed above depths of 8 m south of Arrecife La Gata, La Parguera, indicating that adult colonies of these species do not require deep waters. In the Virgin Islands, these species are most common at depths exceeding 30 m but can be found on the north shore of St. Croix and north of St. John (e.g., Haulover Bay) at depths of less than 20 m. Some of these colonies have been observed to have been harvested over a several year period which would indicate either cautious harvesting (some of these areas being within the VI National Park) or personal collecting for low level jewelry production (Goenaga and Boulon 1992).

4.2.3.3.3 Genus Siderastrea

Siderastrea corals are commonly found on rocky or sandy substrates in shallow water. They form partially immersed colonies ranging in shapes, from flat to slightly domed. The star-like appearance is attributed to the corallites being highly immersed, with septa that nearly reach the interior (Borneman 2001). Colonies tend to remain very small and are usually strongly attached to the substrate. Siderastrea are known to tolerate extreme conditions that other corals would be unable to survive. The gelatinous substance that is secreted is essential in removing debris from the surface (Borneman 2001).

4.2.3.4 Sponges, Phylum Porifera

Sponges are classified into four classes, though only the class Demospongiae is represented in the Caribbean coral reef fishery management unit. This is the largest class of sponges, both in number of species and range of distribution (Colin 1978).

Sponges are the least complex of all multi-cellular animals (Sefton and Webster 1986), typically attached to hard substrates and possessing various specialized cells but lacking organization of such cells into organs and tissues (Colin 1978). They are all sessile and exhibit little detectable movement (CFMC 1994).

The sponges display great variability in size and shape, with growth rates and body form highly dependent on space availability, the inclination of the substrate, and current velocity (CFMC 1994). Although their basic body plan is simple, some species attain surprising size (hundreds of pounds in weight out of water). The demosponges are encrusting to massive, ranging from nearly microscopic to over 2 m in diameter (Colin 1978).

Sponges reproduce sexually as well as asexually, by fragmentation or budding. Sperm are released to the sea, sometimes in numbers so great that the sponges seem to be "smoking," and many sponges of the same species may release sperm simultaneously. Fertilization is internal. Larvae are planktonic for some period of time before settling and growing in some unoccupied patch of reef habitat (Colin 1978).

While the sponges are ancient in origin (abundant in reef habitats for at least 200 million years), their biological importance should not be underestimated. In some areas of the reef, the biomass of sponges present can exceed that of any other group, including reef-building corals (Colin 1978). They are important colonizers of bare reef rock, shipwrecks, and other newly available space. In turn, they house an amazing array of commensal "guests" such as worms, shrimps, brittle stars, fishes, and algae (Sefton and Webster 1986).

Some species bore into the limestone reef framework, weakening its structure and making it more susceptible to storm damage. Others produce extensive, nearly stony skeletal structures which cement and stabilize reef rubble and add to the structure of the reef. All combine in their nearly constant filtering activity to remove bacteria, small planktonic organisms, and larger organic particles from the water and are, thus, partially responsible for the clarity of the water above the reef (Sefton and Webster 1986).

Demosponges range from intertidal to abyssal depths in the ocean. *Agelas wiedenmyeri* inhabits reef tops and often grows around the base of coral heads has smooth, brown tubes growing from a common basal mass. The openings to the tubes are oftentimes irregular shaped and may appear to be pinched in (Humann 1992). *Agelas clathrodes* are found along reefs and reef walls and prefer areas with some movement of water. *A. clathrodes* appear as a mass of thick, rubbery orange sponge, often with a pitted and convoluted surface texture. Growth patterns vary greatly, ranging from huge mounds to mat-like formations. (Humann 1992). Xestospongia muta inhabits mid-range to deep coral reefs, especially abundant on steep slopes. X. muta are gray, brown, or red-brown and have a huge, barrel-shaped appearance. The surface is a rough, jagged, stone-hard exterior (Human 1992).

4.2.4 Highly Migratory Species (HMS)

HMS fishermen in the United States encounter many species of fishes, some of which are marketable, others are discarded for economic or regulatory reasons. Species frequently encountered are swordfish, tunas, and sharks, as well as billfish and other finfish species. On occasion, HMS fishermen also interact with sea turtles, marine mammals, and seabirds, known collectively as "protected" species. All of these species are federally managed, and NMFS seeks to control anthropogenic sources of mortality. Detailed descriptions of those species are given in the Final Consolidated Atlantic Highly Migratory Species (HMS) Management Plan (NMFS, 2006), and the previously released Atlantic HMS Stock Assessment and Fishery Evaluation (SAFE) Reports (NMFS, 2003 – 2008). An update to this information is contained in the final 2008 Final SAFE Report (NMFS, 2008) and is briefly summarized here. A description of the management history, status of the stocks, a description of the shark BLL fishery, bycatch species, and the number of permit holders are summarized below.

4.2.4.1 Status of Stocks

The methods used to determine the status of HMS are fully described in the Consolidated HMS FMP. In summary, a species is considered overfished when the current biomass (B) is less than the minimum stock size threshold. The minimum stock size threshold is determined based on the natural mortality of the stock and the biomass at Maximum Sustainable Yield (B_{MSY}). The MSY is the maximum long-term average yield that can be produced by a stock on a continuing basis. Overfishing is occurring on a species if the current fishing mortality (F) is greater than the fishing mortality at MSY (F_{MSY}). When a species is declared overfished, a rebuilding plan is needed within one year. A species is considered rebuilt when B is greater than B_{MSY} and F is less than F_{MSY}. A species is considered healthy when B is equal to the biomass at optimum yield (B_{OY}) and F is equal to the fishing mortality at optimum yield (F_{OY}).

Stock assessments for Atlantic tunas, swordfish, and billfish are conducted by ICCAT's SCRS. Stock assessments for Atlantic sharks have traditionally been done by NOAA Fisheries; however, ICCAT's SCRS has conducted stock assessments on some species of pelagic sharks that are caught throughout the Atlantic basin. Tables 4.2.1 and 4.2.2 present data on the current status of HMS species that are extracted from the 2008 SAFE Report. For further information on status of stocks and landings, please see the 2008 SAFE Report and the Consolidated HMS FMP.

Table 4.2.1 Tuna, Swordfish, and Billfish Stock Assessment Summary.

Species	Current Relative Biomass Level	Minimum Stock Size Threshold	Current Relative Fishing Mortality Rate	Maximum Fishing Mortality Threshold	Outlook
West Atlantic Bluefin	SSB_{07}/SSB_{MSY} = 0.57 (0.46-0.70) SSB_{07}/SSB_{1975} = 0.25	$0.86SSB_{MSY}$	$F_{04\text{-}06}/F_{MSY}$ = 1.27	F_{year}/F_{MSY} = 1.00	Overfished; overfishing is occurring
Atlantic Bigeye Tuna	B_{06}/B_{MSY} = 0.92 (0.85-1.07)	$0.6B_{MSY}$ (age 2+)	F_{05}/F_{MSY} = 0.87 (0.70-1.24)	F_{year}/F_{MSY} = 1.00	Rebuilding; overfishing is occurring.
Atlantic Yellowfin Tuna	B_{06}/B_{MSY} = 0.96 (0.72 - 1.22)	$0.5B_{MSY}$ (age 2+)	$F_{current}/F_{MSY}$ = 0.87 (0.0.70-1.05)	F_{year}/F_{MSY} = 1.00	Approaching an overfished condition.
North Atlantic Albacore Tuna	B_{05}/B_{MSY} = 0.81 (0.68-0.97)	$0.7B_{MSY}$	F_{05}/F_{MSY} = 1.5 (1.3-1.7)	F_{year}/F_{MSY} = 1.00	Overfished; overfishing is occurring.
West Atlantic Skipjack Tuna	B_{06}/B_{MSY} = most likely >1	*Unknown*	F_{06}/F_{MSY} = most likely <1	F_{year}/F_{MSY} = 1.00	Unknown
North Atlantic Swordfish	B_{06}/B_{MSY} = .99 (0.87-1.27)	*Unknown*	F_{05}/F_{MSY} = 0.86 (0.65 - 1.04)	F_{year}/F_{MSY} = 1.00	Rebuilding; overfishing not occurring
South Atlantic Swordfish	Likely >1	*Unknown*	Likely <1	F_{year}/F_{MSY} = 1.00	Unknown
Blue Marlin	$B_{04}<B_{MSY}$; Yes	$0.9B_{MSY}$	$F_{2004}>F_{MSY}$; Yes	F_{year}/F_{MSY} = 1.00	Overfished; overfishing is occurring
White Marlin	$B_{04}<B_{MSY}$; Yes	$0.85B_{MSY}$	$F_{2004}>F_{MSY}$; Possibly	F_{year}/F_{MSY} = 1.00	Overfished; overfishing is occurring
West Atlantic Sailfish	*Unknown*	$0.75B_{MSY}$	*Unknown*	*Not estimated*	Overfished: Overfishing is occurring
Spearfish	*Unknown*	*Unknown*	*Unknown*	*Not estimated*	*Unknown*

Table 4.2.2 Shark Stock Assessment Summary.

Species	Current Relative Biomass Level	Minimum Stock Size Threshold	Current Relative Fishing Mortality Rate	Maximum Fishing Mortality Rate	Outlook
LCS	*Unknown*	*Unknown*	*Unknown*	*Unknown*	*Unknown*
Sandbar	SSF_{04}/SSF_{MSY} = 0.72	4.75-5.35E+05	F_{04}/F_{MSY}=3.72	F_{MSY} = 0.015	Overfished; Overfishing is occurring
Gulf of Mexico Blacktip	SSF_{04}/SSF_{MSY} = 2.54-2.56	0.99-1.07E+07	F_{04}/F_{MSY}= 0.03-0.04	F_{MSY} = 0.20	Not overfished; overfishing not occurring
Atlantic Blacktip	*Unknown*	*Unknown*	*Unknown*	*Unknown*	*Unknown*
Dusky Sharks	B_{2003}/B_{MSY} = 0.15 - 0.47	*Unknown*	F_{03}/F_{MSY}=1.68-1,810	F_{MSY} = 0.00005 – 0.0115	Overfished; Overfishing is occurring
SCS	N_{2005}/N_{MSY} = 1.69	2.1 E + 07	F_{2005}/F_{MSY} = 0.25	F_{MSY} = 0.091	Not overfished; overfishing not occurring
Bonnethead Sharks	SSF_{2005}/SSF_{MSY} = 1.13	1.4 E+ 06	F_{2005}/F_{MSY} = 0.61	F_{MSY} = 0.31	Not overfished; overfishing not occurring
Atlantic Sharpnose Sharks	SSF_{2005}/SSF_{MSY} = 1.47	4.09 E + 06	F_{2005}/F_{MSY} = 0.74	F_{MSY} = 0.19	Not overfished; overfishing not occurring
Blacknose Sharks	SSF_{2005}/SSF_{MSY} = 0.48	4.3 E + 05	F_{2005}/F_{MSY} = 3.77	F_{MSY} = 0.07	Overfished; Overfishing is occurring
Finetooth Sharks	N_{2005}/N_{MSY} = 1.80	2.4 E + 06	F_{2005}/F_{MSY} = 0.17	F_{MSY} = 0.03	Not overfished; overfishing not occurring
Pelagic sharks (SCRS)	*Unknown*	*Unknown*	*Unknown*	*Unknown*	*Unknown*
Porbeagle Sharks (COSEWIC)	SSN_{2004}/SSN_{MSY} = 0.15 – 0.32	*Unknown*	F_{2004}/F_{MSY} = 0.83	F_{MSY} = 0.033 – 0.065	Overfished; overfishing is not occurring

4.2.4.2 Description of Fishery and Fishery Participants

4.2.4.2.1 Description of the Swordfish Fishery

The U.S. directed fishery for North Atlantic swordfish is limited by regulation to two gear types: longline and handgear. Pelagic longlining accounts for the majority of U.S. swordfish landings; however, there is increasing effort in the commercial handgear and recreational fisheries. Driftnets were allocated 2% of the U.S. North Atlantic directed fishery quota in the past; however, this gear was prohibited by NOAA Fisheries in 1999. Also in 1999, NOAA Fisheries limited access to the commercial fishery. Incidental catches by fishing gears other than pelagic longline and handgear are restricted by incidental commercial retention limits of 15 to 30 swordfish per trip depending on gear type and are counted against the incidental catch quota. As of May 2008, there were a total of 171, 72, and 79 LAPs issued for directed, incidental, and handgear swordfish fishing, respectively. Currently, no LAPs allowing commercial swordfish fishing are held by residents of Puerto Rico or the USVI. One swordfish dealer permit is issued to a business in Puerto Rico. In 2006 and 2007, 88.9 mt and 27.7 mt of swordfish were reported as harvested from the Caribbean, respectively (NOAA Fisheries, 2008). All of those landings were reported as harvested with pelagic longline gear and likely by vessels not based in Caribbean ports.

The recreational swordfish fishery interacted with few Atlantic swordfish in the past. However, the 1999 FMP required that all recreational swordfish landings be subtracted from the U.S. incidental quota, and mortality be reported to ICCAT. One objective of the 1999 FMP was to rebuild the swordfish stock such that recreational fishermen may enjoy an enhanced recreational experience through higher interactions with swordfish. As the North Atlantic swordfish stocks rebuilt, the recreational swordfish fishery became very popular. In 2007 and 2008, recreational fishermen reported 716 and 368 swordfish, respectively, harvested in the recreational non-tournament swordfish fishery. An additional 274 swordfish were harvested in recreational fishing tournaments and reported to NOAA Fisheries through the Recreational Billfish Survey (RBS). Final 2008 RBS numbers are not yet available. In 2007 and 2008, no recreationally landed swordfish were reported from Puerto Rico or the USVI.

Swordfish may be retained on recreational vessels permitted in the HMS Angling or Charter/Headboat category. As discussed above, as of May 2008, there were 25,356 Angling and 4,097 Charter/Headboat category permits issued. Of those 29,453 permits, 805 Angling and 21 Charter/Headboat category permits were issued to fishermen in Puerto Rico; 28 Angling and 10 Charter/Headboat category permits were issued to fishermen in St. Thomas; 26 Angling and 4 Charter/Headboat category permits were issued to fishermen in St Croix; and 2 Angling and 7 Charter/Headboat category permits were issued to fishermen in St John.

Detailed information on swordfish landings can be found in the Consolidated HMS FMP and the 2008 SAFE Report.

4.2.4.2.2 Description of the Atlantic Tunas Fisheries

In the United States, Atlantic tuna permits are currently issued in seven categories: General, Angling, Charter/Headboat, Harpoon, Purse Seine, Longline, and Trap. The Purse Seine category has been managed under an Individual Transferable Quota (ITQ) system since 1982. After issuance of the 1999 FMP, the Angling and Charter/Headboat categories were changed from tuna-specific to all HMS. The HMS Angling category permit is required to fish for sharks, swordfish, billfish, and/or tunas recreationally, and the HMS Charter/Headboat permit is required for vessels that are for-hire and target HMS. The Longline category permit is only valid if the vessel owner also holds both an

Atlantic swordfish and an Atlantic shark limited access permit (LAP). The General, Trap, and Harpoon category permits are open access and only allow for the harvest of tunas. Federal dealers for HMS are also required to have a Federal dealer permit.

As of May 2008, there were approximately 33,627 vessels permitted to participate in the Atlantic tuna fisheries, including: 25,356 Angling category vessels; 3,906 General category vessels; 4,097 Charter/Headboat category vessels; 230 Longline category vessels; 25 Harpoon category vessels; 9 Trap category vessels; and 4 Purse Seine category vessels. Of these permits, 99 General, 21 Charter/Headboat, and 805 Angling category permits were held by fishermen in Puerto Rico; 6 General, 10 Charter/Headboat, and 28 Angling category permits were held by fishermen in St. Thomas; 13 General, 4 Charter/Headboat, and 26 Angling category permits were held by fishermen in St. Croix; and 1 General, 7 Charter/Headboat, and 2 Angling category permits were held by fishermen in St. John.

As of May 2008, there were approximately 349 BAYS and 320 BFT dealer permits issued. Of those permits, 6 BAYS and 1 BFT dealer permit were issued to businesses in Puerto Rico; 1 BAYS and 1 BFT dealer permit were issued to businesses in St. Thomas; 2 BAYS dealer permits were issued to businesses in St. Croix; and 1 BAYS dealer permit was issued to a business in St. John.

In the Caribbean, commercial tuna fishermen primarily use pelagic longline, rod and reel, and handline gears. In 2006, vessels fishing in the Caribbean landed approximately 188.0 mt of YFT, 18.2 mt of SKJ, 11.0 mt of BET, and 10.9 mt of ALB. Of the 228.1 mt of tunas landed, 201.7 mt was reported as captured with pelagic longline (PLL) gear (NOAA Fisheries, 2007). In 2007, vessels fishing in the Caribbean landed approximately 277.1 mt of YFT, 13.9 mt of SKJ, 3.4 mt of BET, and 1.4 mt of ALB. Since no longline category permits are held by residents of Puerto Rico or the USVI, it can be assumed that these tuna landings were reported by vessels fishing in the Caribbean but based out of other U.S. ports. Approximately 26.4 mt and 35.6 mt of tunas were reported as harvested with handline and rod and reel gears by fishermen in the Caribbean in 2007 and 2008, respectively (NOAA Fisheries, 2008). The handline and rod and reel landings were likely reported by Caribbean fishermen fishing under General or Charter/Headboat category permits.

4.2.4.2.3 Description of the Atlantic Billfish Fisheries

NOAA Fisheries authorizes only recreational anglers to target and harvest Atlantic billfish. Billfish caught in the Atlantic pelagic longline and shark fisheries cannot be retained and are considered bycatch. Post-release survival rates are identified as a critical data need for Atlantic billfish management. Atlantic blue marlin and white marlin seasons generally begin in May, although tournaments in warmer-water areas start in March. Marlins move up along the coast of the United States as waters warm during the summer, with relatively more white marlin traveling farther north and caught off mid-Atlantic and southern New England during July to September. The Atlantic marlin season generally ends by October for the continental United States, but fish are still caught past October in the warm Caribbean waters off Puerto Rico and the U.S. Virgin Islands. Currently, minimum size limits (lower jaw fork length) of 99 inches, 66 inches, and 63 inches are in place for blue marlin, white marlin, and sailfish, respectively, with a ban on harvest of longbill spearfish. All tournament and non-tournament landings must be reported and, under an ICCAT recommendation, up to 250 blue and white marlin (combined) may be harvested annually in the United States.

Billfish may be retained on recreational vessels permitted in the HMS Angling or Charter/Headboat category. Please see the number of HMS Angling and Charter/Headboat permits discussed in the recreational swordfish section above.

In 2007, 5 Atlantic blue marlin, 4 Atlantic white marlin, and 101 west Atlantic sailfish were reported to NOAA Fisheries by fishermen participating in the recreational non-tournament billfish fishery. Of those landings, 2 Atlantic blue marlin were reported from Puerto Rico. An additional 42 Atlantic blue marlin, 31 Atlantic white marlin, and 1 west Atlantic sailfish were harvested in recreational fishing tournaments and reported to NOAA Fisheries through the Recreational Billfish Survey. Of those landings, 6 Atlantic blue marlin were reported from Puerto Rico. In 2008, 7 blue marlin, 4 white marlin, and 141 west Atlantic sailfish were reported to NOAA by fishermen participating in recreational non-tournament billfish fishery. Of those, 6 BUM, were reported from fishermen in Puerto Rico. Final numbers from the RBS for 2008 are not yet available.

4.2.4.2.4 Description of the Atlantic Shark Fisheries

The Atlantic commercial shark fisheries primarily use bottom longline, pelagic longline, and gillnet gears. Prior to the implementation of Amendment 2 to the Consolidated HMS FMP in 2008, the primary target species in the fisheries were sandbar and blacktip sharks, although many other shark species are caught as well. In May 2008, 207 vessels were permitted to directly fish for sharks and another 274 vessels had incidental shark LAPs. In May 2008, no shark LAPs or shark dealer permits were held by residents of Puerto Rico, St. Thomas, St. Croix, or St. John.

Recreational fishing for Atlantic sharks takes place from New England to the Caribbean Sea and is increasing in popularity due to the accessible nature of the resources. Sharks can be caught virtually anywhere in salt water, from the surf to offshore areas. Charter vessel fishing for sharks is also becoming increasingly popular. Currently, Federal regulations state that recreational anglers can retain blacktip, spinner, bull, lemon, nurse, great hammerhead, smooth hammerhead, scalloped hammerhead, tiger, bonnethead, Atlantic sharpnose, finetooth, blacknose, porbeagle, common thresher, shortfin mako, oceanic whitetip, and blue sharks. Recreational anglers can not retain any prohibited species, sandbar, or silky sharks. Recreational anglers can land one shark from the above list with a minimum fork length of 54 inches per vessel per trip, in addition to one Atlantic sharpnose (no minimum size) and one bonnethead shark (no minimum size) per person per trip.

Sharks may be retained on recreational vessels permitted in the HMS Angling or Charter/Headboat categories. Please see the number of HMS Angling and Charter/Headboat permits discussed in the recreational swordfish section above.

Puerto Rico reported approximately 10.1 mt of commercial shark landings for 2006 (PR DNER, 2007). It is not clear what portion of these landings or what species were harvested from Federal waters. Additional information on recreational and commercial Atlantic shark landings is provided in Amendment 2 to the Consolidated HMS FMP and the 2008 SAFE Report.

4.2.4.3 Recent Catches and Landings

4.2.4.3.1 Pelagic Longline

The U.S. PLL fishery for Atlantic HMS primarily targets swordfish, yellowfin tuna, and bigeye tuna in various areas and seasons. Secondary target species include dolphin, albacore tuna, and to a lesser degree sharks. Although this gear can be modified (*e.g.*, depth of set, hook type, *etc*.) to target swordfish, tunas, or sharks, it is generally a multi-species fishery. These vessel operators are opportunistic, switching gear style and making subtle changes to target the best available economic opportunity of each individual trip. PLL gear sometimes attracts and hooks non-target finfish with little or no commercial value as well as species that cannot be retained by commercial fishermen due to regulations, such as billfish. Pelagic longlines may also interact with protected species such as marine mammals, sea turtles, and seabirds. Thus, this gear has been classified as a Category I fishery with respect to the MMPA. Any species (or undersized catch of permitted species) that cannot be landed due to fishery regulations is required to be released, regardless of whether the catch is dead or alive.

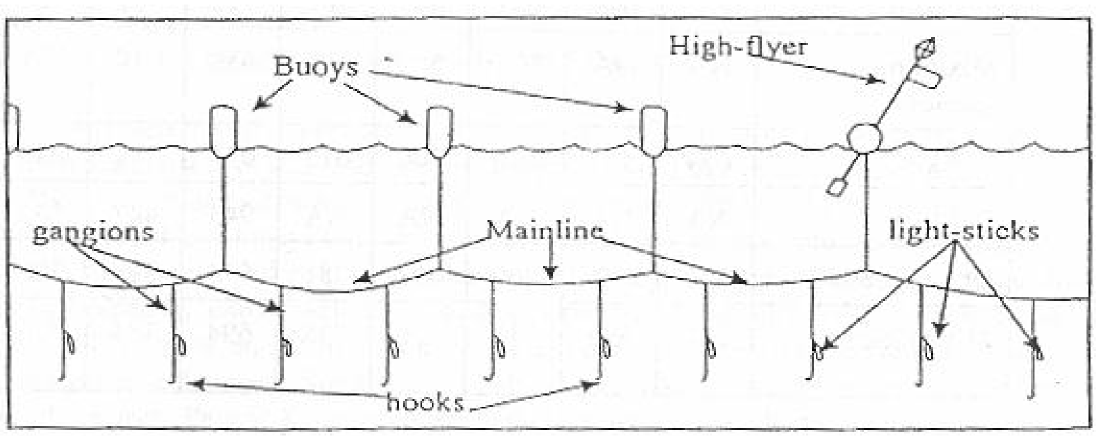

Figure 4.2.1 Typical U.S. Pelagic Longline Gear. Source: Arocha, 1996.

PLL gear is composed of several parts. The primary fishing line, or mainline of the longline system, can vary from five to 40 miles in length, with approximately 20 to 30 hooks per mile. The depth of the mainline is determined by ocean currents and the length of the floatline, which connects the mainline to several buoys, and periodic markers which can have radar reflectors or radio beacons attached. Each individual hook is connected by a leader, or gangion, to the mainline. Lightsticks, which contain chemicals that emit a glowing light, are often used, particularly when targeting swordfish. When attached to the hook and suspended at a certain depth, lightsticks attract baitfish, which may, in turn, attract pelagic predators (NMFS, 1999).

When targeting swordfish, PLL gear is generally deployed at sunset and hauled at sunrise to take advantage of swordfish nocturnal near-surface feeding habits (NMFS, 1999). In general, longlines targeting tunas are set in the morning, deeper in the water column, and hauled in the evening. Except for vessels of the distant water fleet, which undertake extended trips, fishing vessels preferentially target swordfish during periods when the moon is full to take advantage of increased densities of pelagic species near the surface. The number of hooks per set varies with line configuration and target species (NMFS, 1999). The PLL gear components may also be deployed as a trolling gear to target surface feeding tunas. Under this configuration, the mainline and gangions are elevated and actively trolled so that the baits fish on or above the water's surface. This style of fishing is often referred to as "green-stick fishing," and reports indicate that it can be extremely efficient compared to conventional fishing techniques. Pelagic longline landings for the period 1999 – 2007 are summarized in Table 4.2.3 below.

Table 4.2.3 **Reported Landings in the U.S. Atlantic Pelagic Longline Fishery (in mt ww) for 1999-2007.** Source: NMFS 2008.

Species	1999	2000	2001	2002	2003	2004	2005	2006	2007
Yellowfin Tuna	3,374	2,901	2,201	2,573	2,164	2,492	1746.2	2009.9	2387.9
Skipjack Tuna	2.0	1.8	4.3	2.5	1.4	0.7	0.6	0.2	0.0
Bigeye Tuna	929.1	531.9	682.4	535.8	283.9	310.1	311.9	520.6	374.5
Bluefin Tuna*	73.5	66.1	37.5	49.9	133.9	275.4	211.5	204.6	164.3
Albacore Tuna	194.5	147.3	193.8	155	107.6	120.4	108.5	102.9	126.1
Swordfish N.*	3,362.4	3,315.8	2,483	2,598.8	2,756.3	2,534.2	2,272.8	1,960.8	2,453
Swordfish S.*	185.2	143.8	43.2	199.9	20.5	15.7	0.0	0.0	0.0

* Includes landings and estimated discards from scientific observer and logbook sampling programs.

4.2.4.3.2 Commercial Handgear

Commercial handgears, including handline, harpoon, rod and reel, buoy gear and bandit gear are often used to fish for Atlantic HMS by fishermen on private vessels, charter vessels, and headboat vessels. Rod and reel gear may be deployed from a vessel that is at anchor, drifting, or underway (*i.e.*, trolling). In general, trolling consists of dragging baits or lures through, on top of, or even above the water's surface. While trolling, vessels often use outriggers to assist in spreading out or elevating baits or lures and to prevent fishing lines from tangling. Operations, frequency and duration of trips, and distance ventured offshore vary widely. Most of the vessels are greater than seven meters in length and are privately owned by individual fishermen. Table 4.2.4 summarizes domestic commercial handgear landings by gear, species, and region for the period 1999 – 2007.

Table 4.2.4 Domestic Landings for the Commercial Handgear Fishery by Species and Region for 1999-2007 (mt ww). Source: U.S. National Report to ICCAT: 2008.

Species	Region	1999	2000	2001	2002	2003	2004	2005	2006	2007
Bluefin Tuna	NW Atl	774.4	778.3	1,000.8	938.3	607.3	395.6	260.4	194.7	143.3
Bigeye Tuna	NW Atl	11.9	4.1	33.2	13.8	6.0	3.3	6.2	21.5	17.8
	GOM	0.2	0.1	0.5	0.6	0.3	0.2	0.1	1.5	1.2
	Caribbean	0.2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Albacore Tuna	NW Atl	0.6	2.9	1.7	3.9	1.7	6.1	3.0	2.6	5.6
	GOM	≤ .05	0.0	0.0	0.0	≤ .05	0.0	0.1	0.1	0.2
	Caribbean	3.8	5.0	2.2	2.7	2.6	2.1	1.1	0.4	0.2
Yellowfin Tuna	NW Atl	192.0	235.7	242.5	137.0	149.1	213.2	105.1	105.1	118.1
	GOM	12.7	28.6	43.4	100.0	39.9	28.3	45.5	49.9	34.3
	Caribbean	14.5	19.4	14.3	7.0	10.7	7.0	9.7	7.8	9.1
Skipjack Tuna	NW Atl	0.2	0.2	0.2	0.2	0.2	0.6	0.9	0.2	0.3
	GOM	0.4	0.7	0.0	0.0	0.0	0.2	0.0	0.0	0.2
	Caribbean	5.8	8.8	10.3	12.5	12.9	9.6	12.9	10.0	13.7
Swordfish	NW Atl	5.0	8.3	16.0	11.6	10.8	19.2	34.4	32.8	126.0
	GOM	≤ .05	1.2	0.3	2.9	9.8	4.0	0.3	0.1	3.1

4.2.4.3.3 Recreational Handgear

The recreational landings databases for HMS consists of information obtained through surveys including the Marine Recreational Fishery Statistics Survey (MRFSS), Large Pelagic Survey (LPS), Southeast Headboat Survey (HBS), Texas Headboat Survey, and Recreational Billfish Survey (RBS) tournament data, and the Recreational non-tournament swordfish and billfish landings database. Descriptions of these surveys, the geographic areas they include, and their limitations, were discussed in Section 2.6.2 of the 1999 FMP and Section 2.3.2 of the 1999 Billfish Amendment.

Historically, fishery survey strategies (including the MRFSS, LPS, and RBS) have not captured all landings of recreationally-caught swordfish. Although some swordfish handgear fishermen have commercial permits[1], many others land swordfish strictly for personal consumption. Therefore, NMFS has implemented regulations to improve recreational swordfish and billfish monitoring and conservation. These regulations stipulate that all non-tournament recreational landings of swordfish and billfish must be reported using either a toll-free call-in system (which became operational in 2003), or an

[3] Access to the commercial swordfish fishery is limited; hand gear fishermen however may purchase permits from other permitted fishermen because the permits are transferable.

Internet-based reporting portal (which became operational in 2008). Accordingly, all reported recreational swordfish landings are counted against the incidental swordfish quota. Updated landings for all recreational rod and reel fisheries are presented below in Table 4.2.5 from 2000 through 2007. Recreational landings of swordfish are monitored by the LPS, MRFSS, RBS, and mandatory recreational reporting requirements (http://www.hmspermits.gov). Table 4.2.5 summarizes domestic landings for Atlantic tunas, swordfish, and billfish in the domestic recreational rod and reel fishery between 2000 and 2007.

Table 4.2.5 Updated Domestic Landings for the Atlantic Tunas, Swordfish and Billfish Recreational Rod and Reel Fishery, 2000-2007 (mt ww)*. Sources: NMFS, 2004; NMFS, 2005; NMFS, 2006; NMFS, 2007)

Species	Region	2000	2001	2002	2003	2004	2005	2006	2007
Bluefin Tuna**	NW Atlantic	449.5	242.9	519.4	314.6	329	254.4	158.2	398.6
	GOM	0.9	1.7	1.5	0	0	0.0	0.6	0.0
	Total	**450.4**	**244.6**	**520.9**	**314.6**	**329**	**254.4**	**158.8**	**398.6**
Bigeye tuna**	NW Atlantic	34.4	366.2	49.6	188.5	94.6	165.0	422.0	126.8
	GOM	0	0	0	0	6	0	24.0	0
	Caribbean		0	0	4.0	0	0	0	0
	Total	**34.4**	**366.2**	**49.6**	**192.5**	**100.6**	**165.0**	**446.0**	**126.8**
Albacore**	NW Atlantic	250.75	122.3	323.0	333.8	500.5	356.0	284.0	393.6
	GOM	0	0	0	0	0	0	0	0
	Total	**250.75**	**122.3**	**323.0**	**333.8**	**500.5**	**356.0**	**284.0**	**393.6**
Yellowfin tuna**	NW Atlantic	3,809.5	3,690.5	2,624	4,672	3,434	3,504.0	4,649.0	2,756
	GOM	52.3	494.2	200	640	247	147.0	258.0	227.6
	Caribbean	0	0.1	7.2	16	0	0	0	12.4
	Total	**3,861.8**	**4184.7**	**2,831.2**	**5,328**	**3,681**	3,651.0	**4,907.0**	**2,996**
Skipjack tuna**	NW Atlantic	13.1	32.9	23.3	34.0	27.3	8.0	35.0	27.4
	GOM	16.7	16.1	13.2	11.0	6.3	3.1	6.4	23.9
	Caribbean	0	0	13.2	15.7	40.4	4.0	8.0	0.2
	Total	**29.8**	**49.0**	**49.7**	**60.7**	**74.0**	**15.1**	**49.4**	**51.5**
Blue marlin***	NW Atlantic	13.8	9.0	-	-	-	-	-	-
	GOM	4.7	5.1	-	-	-	-	-	-
	Caribbean	5.7	2.3	-	-	-	-	-	-
	Total	**24.2**	**16.4**	**5.6**	**19**	**24**	**15**	**17**	**10**

Table 4.2.5 Cont Updated Domestic Landings for the Atlantic Tunas, Swordfish and Billfish Recreational Rod and Reel Fishery, 2000-2007

Species	Region	2000	2001	2002	2003	2004	2005	2006	2007
White marlin ***	NW Atlantic	0.23	2.8	-	-	-	-	-	-
	GOM	0	0.3	-	-	-	-	-	-
	Caribbean	0	0	-	-	-	-	-	-
	Total	**0.23**	**3.1**	**5.6**	**0.6**	**0.8**	**0.8**	**1.1**	**0.9**
Sailfish***	NW Atlantic	1.75	61.2	-	-	-	-	-	-
	GOM	0.24	0.6	-	-	-	-	-	-
	Caribbean	0.06	0	-	-	-	-	-	-
	Total	**2.05**	**61.8**	**103**	**53**	**33**	**0.08**	**0.08**	**0.03**
Swordfish	**Total**	**15.6**	**1.5**	**21.5**	**6.1**	**25.2**	**53.1**	**52.7**	**68.2**

* Rod and reel catches and landings for Atlantic tunas represent estimates of landings and dead discards based on statistical surveys of the U.S. recreational harvesting sector.
** Rod and reel catch and landings estimates of bluefin tuna less than 73" curved fork length (CFL) based on statistical surveys of the U.S. recreational harvesting sector. Rod and reel catch of bluefin > 73" CFL are commercial and may also include a few metric tons of "trophy" bluefin (recreational bluefin 73").
*** Blue marlin, white marlin, and sailfish landings are based on prior U.S. National Reports to ICCAT and consist primarily of reported tournament landings.

4.2.4.3.4 Atlantic Billfish Recreational Fishery

The recreational Atlantic billfish fishery is an important fishery in the southeastern U.S., the U.S. Gulf of Mexico, and the U.S. Caribbean. It is primarily a catch and release fishery, with the majority of landings occurring in fishing tournaments. The United States is limited to landing 250 blue and white marlin, combined, on an annual basis as a result of binding international measures. Table 4.2.6 below provides preliminary tournament billfish landings for the period 2000 – 2007.

Table 4.2.6 **Preliminary RBS Recreational Billfish Landings in Numbers of Fish (calendar year).** Source: NMFS Recreational Billfish Survey (RBS).

Species	2000	2001	2002	2003	2004	2005	2006	2007
Blue Marlin	117	75	84	96	110	64	72	46
White Marlin	8	22	33	20	25	26	36	31
Sailfish	18	11	14	24	9	3	4	1
Swordfish	-	-	16	48	168	385	207	274

4.2.4.4 Habitat

Section 303(a)(7) of the Magnuson-Stevens Act, 16 U.S.C. §§ 1801 *et seq*., as amended by the Sustainable Fisheries Act in 1996, requires FMPs to describe and identify essential fish habitat (EFH), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat. A complete description of EFH for Atlantic sharks can be found in Chapter 10 and Appendix B of the Final Consolidated HMS FMP (NMFS, 2006). On September 19, 2008, NOAA Fisheries released a draft Environmental Impact Statement (73 FR 66844) updating essential fish habitat (EFH) for HMS, including for species in the Caribbean.

4.2.4.5 Bycatch, Incidental Catch, and Protected Species

4.2.4.5.1 Pelagic Longline Fishery

U.S. PLL catch (including bycatch, incidental catch, and target catch) is largely related to vessel and gear characteristics, but is summarized for the whole fishery in Table 4.2.7. From May 1992 through December 2000, the Pelagic Observer Program (POP) recorded a total of 4,612 elasmobranchs (15% of the total catch) caught off the southeastern U.S. coast in fisheries targeting tunas and swordfish (Beerkircher *et al.*, 2004). Of the 22 elasmobranch species observed, silky sharks were numerically dominant (31.4% of the elasmobranch catch), with silky, dusky, night, blue, tiger, scalloped hammerhead, and unidentified sharks making up the majority (84.6%) (Beerkircher *et al.*, 2004). Table 4.2.7 below summarizes landings and discards of a number of species caught in the pelagic longline fishery.

Table 4.2.7 Reported Catch of Species Caught by U.S. Atlantic PLLs, in Number of Fish, for 2000-2007. Source: PLL Logbook Data.

Species	2000	2001	2002	2003	2004	2005	2006	2007
Swordfish Kept	62,978	47,560	49,320	51,835	46,440	41,139	38,241	45,933
Swordfish Discarded	17,074	13,993	13,035	11,829	10,675	11,134	8,900	11,823
Blue Marlin Discarded	1,443	635	1,175	595	712	567	439	611
White Marlin Discarded	1,261	848	1,438	809	1,053	989	557	744
Sailfish Discarded	1,091	356	379	277	424	367	277	321
Spearfish Discarded	78	137	148	108	172	150	142	147
Bluefin Tuna Kept	235	177	178	273	475	375	261	337
Bluefin Tuna Discarded	737	348	585	881	1,031	765	833	1,345
Bigeye, Albacore, Yellowfin, Skipjack Tunas Kept	94,136	80,466	79,917	63,321	76,962	57,132	73,058	70,390

Table 4.2.7 cont Reported Catch of Species Caught by U.S. Atlantic PLLs, in Number of Fish, for 2000-2007. Source: PLL Logbook Data.

Species	2000	2001	2002	2003	2004	2005	2006	2007
Pelagic Sharks Kept	3,065	3,460	2,987	3,037	3,440	3,149	2,098	3,504
Pelagic Sharks Discarded	28,046	23,813	22,828	21,705	25,355	21,550	24,113	27,478
Large Coastal Sharks Kept	7,896	6,478	4,077	5,326	2,292	3,362	1,768	546
Large Coastal Sharks Discarded	6,973	4,836	3,815	4,813	5,230	5,877	5,326	7,133
Dolphin Kept	29,125	27,586	30,384	29,372	38,769	25,707	25,658	68,124
Wahoo Kept	4,193	3,068	4,188	3,919	4,633	3,348	3,608	3,073
Turtle Interactions	271	424	465	399	369	152	128	300
Number of Hooks (x 1,000)	*7,976*	*7,564*	*7,150*	*7,008*	*7,276*	*5,911*	*5,662*	*6,291*

Sea Turtles

Historically, sea turtle interactions with pelagic longline gear have occurred throughout the range of the fishery. However, the majority of leatherback interactions have occurred in the Gulf of Mexico while most loggerhead interactions occur in the offshore Atlantic Ocean areas like the NED and NEC (Figure 4.2.1). Most of the sea turtles are released alive. In the past, the bycatch rates were highest in the third and fourth quarters. In general, sea turtle captures are rare, but takes appear to be clustered (Hoey and Moore, 1999).

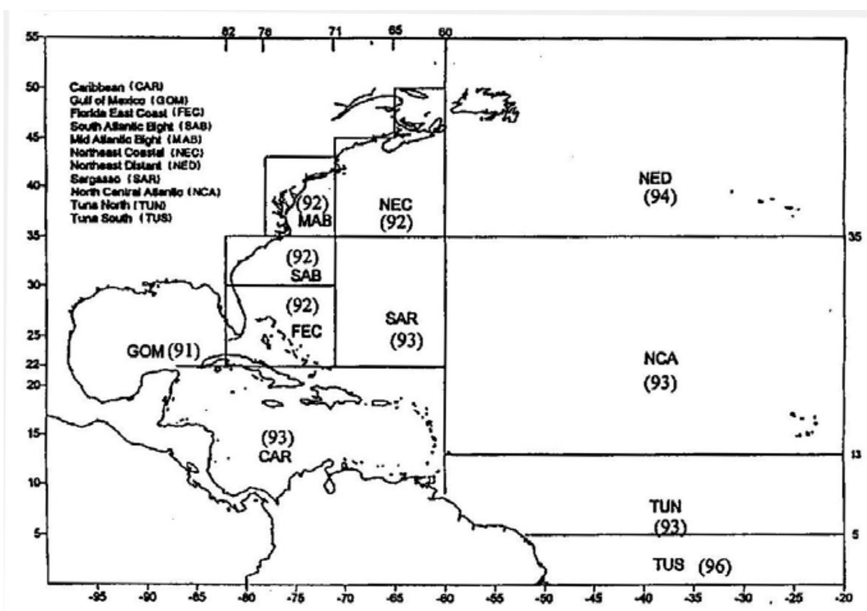

Figure 4.2.1 Geographic Areas Used in Summaries of Pelagic Logbook Data. Source: Cramer and Adams, 2000

The estimated take levels for 2000 were 1,256 loggerhead and 769 leatherback sea turtles (Yeung, 2001). The estimated sea turtle takes for regular fishing and experimental fishing effort for 2001 - 2007 are summarized in Table 4.2.8 and 4.2.9. The majority of leatherback interactions have occurred in the Gulf of Mexico. Loggerhead interactions are more widely distributed, however, the NED, and the NEC appear to be areas with high interaction levels each year.

In 2007, the pelagic longline fishery interacted with an estimated 499 leatherback sea turtles and 542 loggerhead sea turtles outside of experimental fishing operations. During 2007, the interactions with leatherback sea turtles were highest in the Gulf of Mexico (212 animals). The majority of loggerhead sea turtle interactions occurred in the NED, and the MAB areas (Fairfield and Garrison, 2008). NMFS monitors observed interactions with sea turtles and marine mammals on a quarterly basis and reviews data for appropriate action, if any, as necessary.

Table 4.2.8 Estimated number of loggerhead sea turtle interactions in the U.S. Atlantic pelagic longline fishery, 2001-2007 by statistical area. Sources: Walsh and Garrison, 2006; Garrison, 2005; Garrison and Richards, 2004; Garrison 2003; Fairfield-Walsh and Garrison, 2007; Fairfield and Garrison, 2008.

Area	2001	2002	2003	2004	2005	2006	2007
CAR	27	43	36	61	40	16	7
GOM	0	170	135	45	19	17	10
FEC	0	99	137	99	0	40	83
SAB	39	22	52	194	34	18	34
MAB	43	94	18	92	54	70	155
NEC	117	147	241	150	67	135	48
NED	72	0	0	52	20	235	200
SAR	0	0	70	41	38	19	4
NCA	13	0	39	0	3	10	2
TUN	0	0	0	0	0	0	0
TUS	0	0	0	0	0	0	0
Total	312	575	728	734	275	559	543
NED exp'tal fishery (2001-03)	142	100	92	-	-	-	-
Exp'tal fishery (2004-05)	-	-	-	0	8	0	0
Total	454	675	820	734	283	559	543

Table 4.2.9 Estimated number of leatherback sea turtle interactions in the U.S. Atlantic pelagic longline fishery, 2001-2007 by statistical area. **Sources: Walsh and Garrison, 2006; Garrison, 2005; Garrison and Richards, 2004; Garrison 2003; Fairfield-Walsh and Garrison, 2007; Fairfield and Garrison, 2008.**

Area	2001	2002	2003	2004	2005	2006	2007
CAR	61	0	0	17	2	4	1
GOM	393	695	838	780	179	109	212
FEC	313	100	27	64	62	28	7
SAB	241	93	75	164	7	39	0
MAB	139	70	94	184	11	30	114
NEC	30	5	76	33	6	73	76
NED	32	0	0	98	63	116	84
SAR	0	0	0	18	20	14	5
NCA	1	0	2	0	0	1	0
TUN	0	0	0	0	0	0	0
TUS	0	0	0	0	0	0	0
Total	1208	962	1113	1359	351	415	499
Area	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
NED exp'tal fishery (2001-03)	77	158	79	-	-	-	-
Exp'tal fishery (2004-05)	-	-	-	3	17	-	-
Total	1285	1120	1192	1362	368	415	499

4.2.4.5.2 Recreational Rod and Reel Fishery for HMS Species

Bycatch in the recreational rod and reel fishery is difficult to quantify because many fishermen simply value the experience of fishing and may not be targeting a particular pelagic species. Recreational "marlin" or "tuna" trips may yield dolphin, tunas, wahoo, and other species, both undersized and legal sized. Bluefin tuna trips may yield undersized bluefin, or a seasonal closure may prevent landing of a bluefin tuna above a minimum or maximum size. Sharks may be discarded because they are a prohibited species. In some cases, therefore, rod and reel catch may be discarded. The Magnuson-Stevens Act (16 USC 1802 (2)) stipulates that bycatch does not include fish under recreational catch-and-release.

The 1999 Billfish Amendment established a catch-and-release fishery management program for the recreational Atlantic billfish fishery. As a result of this program, all Atlantic billfish that are released alive, regardless of size, are not considered bycatch. NMFS believes that establishing a catch-and-release fishery in this situation solidifies the existing catch-and-release ethic of recreational billfish fishermen, and thereby increases release rates of billfish caught in this fishery. Current billfish release rates range from 89 to 99%. The recreational white shark fishery is by regulation a catch-and-release fishery only, and white sharks are not considered bycatch.

Bycatch can result in death or injury to discarded fish. Therefore, bycatch mortality is incorporated into fish stock assessments, and into the evaluation of management measures. Rod and reel discard estimates from Virginia to Maine during June – October could be monitored through the expansion of survey data derived from the LPS (dockside and telephone surveys). However, the actual numbers of fish discarded for many species are so low that presenting the data by area could be misleading, particularly if the estimates are expanded for unreported effort in the future. .

An outreach program to address bycatch and to educate anglers on the benefits of circle hooks has been implemented by NMFS. One of the key elements of the outreach program is to provide information that leads to an improvement in post-release survival from recreational gear by encouraging recreational anglers to use circle hooks. The initial implementation of this outreach program began in 2007 with the distribution of DVDs to tournament operators showing the proper rigging and deployment of circle hooks with natural baits. This outreach program is anticipated to be expanded by NMFS in future years. Also, a final rule to require the mandatory use of circle hooks when fishing with natural baits in billfish tournaments was published in May 2007 (72 FR 26735, May 11, 2007) and became effective on January 1, 2008.

4.3 Description of the Affected Social and Economic Environments

U.S. Caribbean fisheries are multi-gear, multi-species, artisanal in nature, and primarily coral reef-based. A complete description of these fisheries, and fisheries specific to the Commonwealth of Puerto Rico, can be found in the Council's SFA Amendment to its Fishery Management Plans (CFMC, 2005). However, because the actions currently under consideration in this amendment are expected to only affect fisheries on Puerto Rico's west coast, the following discussion only examines the human environment in that particular region and, thus, covers the municipalities of Aguada, Aguadilla, Anasco, Cabo Rojo, Mayaguez, and Rincon and, to a lesser extent, certain landing centers or communities within each of these municipalities. Figure 4.3.1 displays Bajo de Sico in proximity to municipalities, other seasonal closures and fishing grounds. Because Griffith et al. (2007) indicate that some commercial fishermen from Pescaderia Martinez fish for deep water snapper species in Bajo de Sico and, thus, could be potentially affected by the actions currently under consideration, some uncertainty exists as to whether Lajas should be included in the description of the human environment. However, Lajas fishermen primarily use traps to harvest deep water snapper, which was permissible at the time Griffith et al. (2007) conducted their fieldwork. Since all bottom-tending gear, including traps, was banned from Bajo de Sico in 2005, it is believed that Lajas fishermen no longer fish in that area and, therefore, Lajas and its fishermen are not considered further in the analysis.

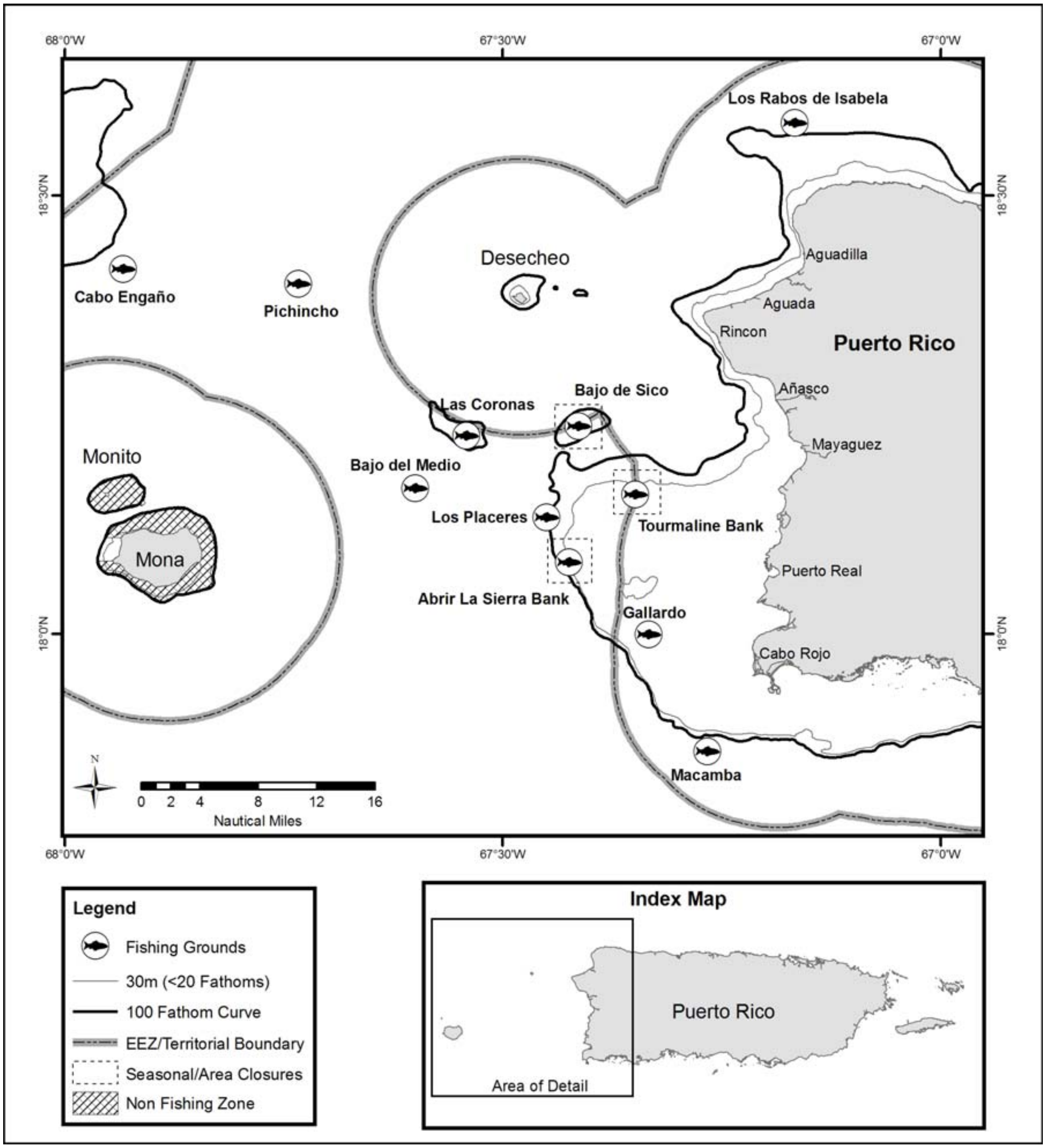

Figure 4.3.1: Bajo de Sico in realtion to the west coast of Puerto Rico, other seasonal closures, and fishing grounds.

Commercial Vessels and Permits

Historical information regarding the nature of Puerto Rico's fishermen and their vessels can be found in CFMC (2005) and is incorporated herein by reference. The following information focuses on the current status of Puerto Rico's west coast fisheries, with a few references to changes that have taken place in recent years. Data from Puerto Rico's 2008 Comprehensive Census of marine fisheries, hereafter referred to as the fisherman Census, are used to describe the commercial fishermen and vessels in the west coast fisheries. This data is thought to be complete for Puerto Rico's west coast but should be considered preliminary until the Puerto Rico Department of Natural and Environmental Resources (PRDNER) has issued its final report to NMFS. As explained in Matos (2004), due to the complex, dynamic, and artisanal nature of Puerto Rico's commercial fisheries, assessing the status of these fisheries through a census is necessary. The purpose of the fisherman Census is to obtain and provide information on the universe of commercial fishermen and vessels (for e.g., the number of active commercial fishermen, number of vessels, amount of fishing gear, and certain socioeconomic data) that accurately describes their operations, which in turn can be used to improve the management of fishery resources.[4]

According to the 2008 fisherman Census data, 236 vessels were available for commercial fishing purposes. This figure represents a decrease of approximately 10% from the number of commercial vessels recorded in the 2002 fisherman Census (Matos, 2004). It cannot be determined how many of these vessels have commercially fished in recent years as vessel identifiers are not recorded on Puerto Rico's trip tickets. According to the information in Table 4.3.1, these vessels average 20 feet in length, but range between 12 to 51 feet, with the vast majority being between 15 and 25 feet. These vessels have an average horsepower of approximately 77, though considerable variability exists within the fleet, even among vessels of comparable length. The age of these vessels is approximately nineteen years on average. The majority of vessels are made of fiberglass (63%), though wood hulls and wood and fiberglass composite hulls are relatively common, accounting for 19% and 18% of the fleet, respectively. On average, each vessel carries two fishermen, typically one captain and one helper/crewman.

As can be seen from the information in Table 4.3.2, these vessels are not evenly distributed across the various municipalities. More than half (51%) of the commercial fishing fleet is located in Cabo Rojo, with one-third of the fleet located in Rincon and Mayaguez (18% and 15%, respectively), 10% located in Aguadilla, and the remaining 6% located in Aguada and Anasco combined. This distribution of vessels across municipalities differs somewhat from its distribution in 2002. Specifically, although Cabo Rojo had the most commercial fishing vessels in 2002, its share of the fleet was much smaller (35%). The same is true of Rincon, which only had 9% of the fleet in 2002. Conversely, Aguadilla, Aguada, and Anasco each had higher proportions of the total fleet (18%, 9%, and 9%, respectively). There has been a significant shift of vessels from these latter three municipalities to Rincon and Cabo Rojo. In general, the distribution of vessels across municipalities was much more even in 2002 than in 2008, with vessels becoming more concentrated in Rincon and Cabo Rojo during recent years, likely resulting in economic benefits to these two municpalities.

Vessel characteristics differ, sometimes considerably, across municipalities. For example, vessels in Cabo Rojo and Anasco are slightly larger on average than vessels in the other municipalities. Similarly, vessels in these two municipalities also have larger engines on average than vessels in the other municipalities and use slightly more crew.

[4] The 2008 Census form and thus the resulting data are somewhat different from the form and data reported in Matos (2004).

Conversely, vessels from Aguada and Aguadilla are smaller in length, have smaller engines, and use slightly fewer crew on average. With respect to hull types, the vast majority (81%) of Cabo Rojo's vessels are made of fiberglass or fiberglass and wood (12%). Fiberglass vessels are also most common in Rincon (59%) and Mayaguez (50%). Conversely, wood vessels are most common in Aguadilla (65%), Anasco (60%) and Aguadilla (50%). In most fisheries, larger and more powerful vessels are typically associated with newer vessels. However, the opposite appears to be the case in Puerto Rico's west coast fisheries. The fleet in Cabo Rojo is much older on average (25 years) than the fleets in the other municipalities, while those in Aguada and Aguadilla are much newer (7 years and 10 years, respectively).

At present, vessels are not required to possess federal permits in order to harvest Reef fish in the Caribbean. The same is true of dealers that purchase landings of Reef fish. However, the harvest and purchase of Atlantic tunas (e.g., albacore, bigeye, bluefin, skipjack, and yellowfin) are managed by the HMS Division of NMFS as specified under its Consolidated Atlantic Highly Migratory Species Fishery Management Plan (FMP). The HMS FMP requires that commercial vessel owners who harvest and intend to sell Atlantic tunas must possess an Atlantic tunas (general) permit. In turn, these vessel owners can only sell Atlantic tunas to dealers that possess an Atlantic tunas dealer permit. Data regarding these two types of permits was compiled for 2008 and is discussed in the following paragraphs.

In 2008, only six Atlantic tuna dealer permits were issued to dealers in Puerto Rico, five of which were held by dealers on the west coast. Since Atlantic tunas can only be sold to federally permitted dealers, this finding suggests that the core of Puerto Rico's commercial tuna fishery is located on the west coast. More specifically, since four of these permitted dealers are in Aguadilla, with the other located in Aguada, the commercial tuna fishery would appear to be primarily located in Aguadilla. This statement is supported by information discussed later in this section which indicates that landings of yellowfin and skipjack tuna, which are the predominant Atlantic tuna species landed on the west coast, are economically significant only in Aguadilla. Since individual dealers are not identified in the trip ticket data, the distribution of these landings across dealers and, thus, the relative importance of these landings to these dealers, cannot be ascertained.

Ninety vessels were issued an Atlantic tunas general permit in Puerto Rico in 2008. Most of these vessels (67%) use handline gear, while the remainder employ either rod and reel (31%) or harpoon (2%) gear. The vessels possessing these permits are not significantly different from commercial fishing vessels in general (see Table 4.3.1) in terms of their physical characteristics. On average, vessels possessing these permits are slightly smaller (18.6 ft) and less powerful (65.1 HP) than the "typical" commercial fishing vessel on the west coast. However, on average, these vessels are considerably newer (by approximately 7 years) and use more crew (one additional helper per vessel). The reasons for these last two differences are unknown.

With respect to the geographic distribution of these vessels, based on their principal port of landing, similar to the distribution of dealers, the vast majority (63%) are located in Aguadilla, followed by Rincon (21%), Aguada (12%), and Cabo Rojo (4%). A similar distribution pattern is found for the owners of these vessels with respect to their place of residence. Of potential concern is the fact that, as discussed later in this section, and consistent with the distribution of vessels, noticeable landings of skipjack and yellowfin tuna do occur in Rincon even though no dealers in that municipality possess the required Atlantic tunas dealer permit.

Commercial Fishermen

The 2008 fisherman Census data also provides considerable information on Puerto Rico's west coast commercial fishermen, as reflected in Table 4.3.1. The 2008 fisherman Census documented 306 commercial fishermen on the west coast. This figure reflects a decrease of approximately 6% from the 325 west coast commercial fishermen reported in the 2002 fisherman Census (Matos, 2004). As the number of fishermen exceeds the number of vessels, it is obvious that not all fishermen own vessels (i.e., some are only helpers). Additionally, although most fishermen own only one vessel, 15 fishermen were identified as owning two or three vessels.

Puerto Rico's west coast commercial fishermen are approximately 47 years old on average, with the majority (64%) being between 32 and 62 years of age. They are also highly experienced in their vocation, averaging nearly 27 years of commercial fishing experience. Each fisherman supports approximately three dependents on average, which translates to an average household family size of four persons. These fishermen spend approximately 34 hours per week commercially fishing, with an additional 13 hours per week spent on vessel and gear maintenance and nearly four hours spent on selling fish. Thus, on average, each fisherman spends an average of approximately 51 hours per week on commercial fishing related activities. Given this sizeable expenditure of time resources, it is not unexpected that these individuals are highly dependent on income from commercial fishing, which represents more than 85% of their household income on average. The fisherman Census data also indicates that these fishermen have relatively little formal education compared to their U.S. mainland counterparts. For example, more than half (54%) have less than a high school level of education, 35% have a high school level of education, and 11% have some additional education beyond high school. As a result of their limited level of formal education and relatively long history of being commercial fishermen, it is likely that many of these individuals would be relatively limited in their ability to find other forms of employment outside of commercial fishing regardless of general economic conditions in their respective communities.

In addition to documenting that not all west coast commercial fishermen own fishing vessels, the fisherman Census data also indicates that not all commercial fishermen possess commercial fishing licenses. For example, nearly 28% of the surveyed commercial fishermen do not possess any type of commercial fishing license. As is more fully discussed later, the relatively high level of unlicensed fishermen is likely the result of fishermen's distrust of the government as well as dissatisfaction with commercial fishing regulations and the lack of regulations they perceive regarding other activities they believe adversely impact the marine resources upon which they are economically dependent (Matos 2007, Griffith et al. 2007).

Puerto Rico offers three different types of commercial fishing licenses: full-time, part-time, and beginner. More than 56% of the west coast commercial fishermen included in the fisherman Census have a full-time license, 13% have a beginner's license, and the remaining 3% possess a part-time license. A further examination of the data indicates that, on average, 84% of unlicensed fishermen's household income comes from commercial fishing compared to 90%, 66%, and 73% for fishermen with full-time, part-time, and beginner licenses, respectively. Thus, it is likely that most of the unlicensed individuals are full-time commercial fishermen and, in turn, 75-80% of all west coast commercial fishermen are likely full-timers. In addition, approximately 67% of the fishermen identify themselves as captains, 28% as helpers/crew, and 3% serve in both capacities.[5] Since it is more likely that full-time fishermen who are also captains are more likely to own a fishing vessel, consistent with the information provided above is the finding that approximately 70% of the commercial fishermen own commercial fishing vessels while 30% do not. Finally, nearly 47% belong to fishing associations, which indicates a relatively high degree of organization, coordination, and cooperation among commercial fishermen.

As was the case with commercial fishing vessels, the commercial fishermen are not evenly distributed across the various municipalities and their characteristics vary by municipality. For example, as seen in Table 4.3.2, nearly 50% of the commercial fishermen reside in Cabo Rojo, followed by Rincon (18%), Mayaguez (13%), Aguadilla (12%), and the remainder (7%) residing in Aguada and Anasco. As would be expected, the trends with respect to changes in the distribution of commercial fishing vessels across municipalities also apply for the distribution of commercial fishermen. That is, Cabo Rojo and Rincon have gained commercial fishermen while Aguada, Aguadilla, and Anasco have lost commercial fishermen, and the distribution of commercial fishermen has become much more concentrated in the former two municipalities.

With respect to age, commercial fishermen in Cabo Rojo and particularly Rincon and Anasco are much younger (by 10 years or more) on average than those in Aguada, Aguadilla, and Mayaguez. However, as a result, they also have much less fishing experience, with fishermen in Aguada having more than twice the amount of commercial fishing experience on average (38 years) than those in Anasco (17 years). Differences with respect to the number of dependents each fisherman supports are much less significant on average, with Cabo Rojo's fishermen supporting somewhat more people on average (3.2 dependents) than fishermen in Aguada (2.5 dependents). On the other hand, differences with respect to the time fishermen spend on fishing and fishing related activities are quite significant. For example, commercial fishermen in Anasco and Mayaguez spend less than 30 hours per week fishing on average, while Aguada's and Rincon's fishermen spend nearly 39 and 43 hours per week fishing on average, respectively. That is, Rincon fishermen spend 40% more time fishing each week than

[5] The remaining 2% did not indicate whether they were a captain or helper.

Anasco's fishermen. Somewhat similarly, Anasco's fishermen spend only about 8 hours per week on other fishing related activities while fishermen in Aguada spend more than 24 hours per week on such activities on average. Commercial fishermen in the other municipalities spend 10-14 hours per week on average on such activities. These findings are generally consistent with the fact that only 30% of Anasco's fishermen possess a full-time commercial fishing license while 60% or more of fishermen in Rincon, Cabo Rojo, and Aguadilla possess full-time licenses. In fact, 70% of Anasco's commercial fishermen do not possess any kind of commercial fishing license. And while only 36% of Aguada's fishermen possess full-time licenses, an additional 27% possess part-time licenses, far more than in any other municipality. Mayaguez has the largest proportion of fishermen with beginner's licenses (37%), which seems at odds with the relatively high average level of experience and age for fishermen in this municipality.

Regarding economic dependence on commercial fishing, and consistent with the above findings regarding the distribution of license types within each municipality, Anasco's commercial fishermen are the least dependent on income from commercial fishing, with income from such activities representing only 55% of their total household income on average. The high proportion of fishermen with beginner's licenses partially explains the relatively lower dependence on commercial fishing income for Mayaguez's commercial fishermen, which accounts for only 73% of their total household income. However, because of the high proportion of fishermen with full-time licenses, it would have been expected that Aguada's commercial fishermen would be relatively more dependent on income from commercial fishing, which represents only 78% of their total household income, than the data indicates. Commercial fishermen from Rincon, Aguadilla, and particularly Cabo Rojo are the most dependent on income from commercial fishing, with such income accounting for between 86% and 91% of their total household income on average.

With respect to their level of formal education, again, significant differences exist across certain municipalities. For example, Rincon's fishermen have higher levels of formal education, on average, than their counterparts in the other municipalities, with 26% having a greater than high school level of education and only 35% having less than a high school level of education. Thus, even though these fishermen, on average, derive a high portion of family income from fishing, they are less likely to be as limited with respect to finding alternative forms of employment, all other things being equal. Conversely, Aguadilla's fishermen have, on average, less formal education than fishermen in other municipalities, with 79% possessing less than a high school level of education and less than 3% having more than a high school level of education. Thus, Aguadilla's commercial fishermen would be expected to be particularly limited with respect to alternative employment opportunities outside of commercial fishing, especially given the relatively high proportion of household income that is derived from commercial fishing.

Regarding vessel ownership, Mayaguez has the highest proportion (78%) of commercial fishermen who are also boat owners, while Aguada (55%) and Anasco (50%) have the lowest level of fishermen who are boat owners. Again, these findings are consistent with the findings on licensing, with only 36% and 30% of Aguada's and Anasco's fishermen having full-time licenses,. Similarly, 78% of Mayaguez's fishermen reported being captains, while 60% and 55% of Anasco's and Aguada's fishermen are captains.

Finally, with regard to fishing association membership, commercial fishermen in Rincon (67%) and Aguadilla (63%) have the highest level of memberships in such associations. The high level of membership in Rincon, along with the relatively higher level of education, is consistent with other reports of Rincon's fishermen making a concerted effort to increase the level of "professionalization" in their occupation (Griffith et al., 2007). Conversely, Anasco (10%) and Cabo Rojo (37%) have the lowest levels of memberships in fishing associations.

Commercial Landings and Revenue

The most currently available landings and revenue data for Puerto Rico's west coast fisheries is for calendar years 2006 and 2007. In some instances, it is helpful to analyze the data for these two years combined, while in others (e.g., when they are important changes from one year to the next), it is useful to examine the data from the two years separately. Landings and revenue data and, thus, price information, come from Puerto Rico's trip ticket data as maintained by the Southeast Fisheries Science Center (SEFSC).

As has been reported elsewhere (Matos 2001, Matos 2007, Griffith et al. 2007), problems with Puerto Rico's trip ticket data program have hampered efforts to use this data for analytical purposes. In the past, it was commonly believed that many fishermen were not reporting their landings, presumably due to the voluntary nature of the data collection program. In more recent times, since data reporting became mandatory in 2004, the more commonly perceived problem is that fishermen under-report their landings and revenue, presumably to avoid paying or reporting taxes or the loss of public assistance payments. In either case, the conclusion is that the reported landings have always been believed to be below the actual level of landings. As such, various methods have been used to adjust or correct the reported landings in order to generate a more accurate accounting of commercial fishing activity (Matos 2001, Matos 2007). Without such an adjustment, the importance of commercial fishing activity and its potential impacts on local economies, as well as on the fish stocks, and the impact of new regulations on that activity would likely be systematically underestimated. Thus, correction factors have been developed and applied to the trip ticket reported landings in order to generate more accurate estimates of commercial landings. These correction factors are provided below.

In recent years, separate correction factors have been developed for each coastal region (i.e., west, east, north, and south). Typically, these correction factors are applied at the aggregate level (i.e., to determine total landings) for each coast and then the totals for each coast are summed to generate an estimate for the entire Commonwealth. For the current assessment, the correction factor for the west coast has been applied to landings at the various disaggregated levels (month, species, municipality, trip, etc.). This approach has been used in order to maintain consistency. That is, when the landings are aggregated across months, municipalities, species, trips, etc., the same aggregate total of estimated landings will be generated. Furthermore, as implied above, this approach will avoid the problems associated with underestimating the results and impacts of commercial fishing activity and is, therefore, appropriate and reasonable. However, it cannot be overemphasized that the landings and revenue figures reported in the following sections should be considered estimates. Furthermore, these estimates will often differ from estimates in other reports which are based on reported landings (e.g. Matos, 2007). Conversely, other statistics, such as the number of active commercial fishermen, seafood prices, and number of trips are not affected by this methodology and, thus, reflect the actual reported data.

For Puerto Rico's west coast, the correction factors were 0.99 for 2006, implying a minor adjustment to the reported landings, and 0.69 for 2007, indicating a much more significant adjustment to the reported landings. Upon applying these factors, total landings and ex-vessel revenue for Puerto Rico's west coast commercial fisheries were 743,124 pounds worth an estimated $2.031 million in 2006 and 955,207 pounds worth an estimated $2.695 million in 2007. Thus, production and revenue increased between 2006 and 2007 by approximately 28% and 33%, respectively. Conversely, the number of active commercial fishermen decreased from 374 in 2006 to 294 in 2007, representing a 21% decrease, which is a significant decrease for a single year if accurate.[6] While the 2007 figure seems reasonable, given that it is less than the number of commercial fishermen identified in the 2008 fisherman Census and the general belief is that the number of commercial fishermen has declined in recent years (Matos 2007, Griffith et al., 2007), the count of fishermen for 2006 must be viewed with caution given that it is considerably higher than the number reported in both the 2002 and 2008 fisherman Censuses and it is commonly acknowledged that some commercial fishermen do not report their landings through the trip ticket program (i.e., the number of fishermen identified in the trip ticket data should be less than the number identified in the fisherman Census data). Regardless, as a result of the significant increase in production and revenue combined with the significant decrease in the number of active commercial fishermen, average landings and revenue per fishermen increased dramatically, between 60% and 70%, from 2006 to 2007 (see Table 4.3.3). Still, in an absolute sense, the average annual gross revenue per fisherman of slightly more than $9,100 is quite low by U.S. mainland standards, particularly when considering this is gross revenue rather than net revenue (income to the fishermen after expenses are accounted for) and, thus, net revenue must be even lower. Since information on operating costs is not available at this time, net revenue estimates cannot be provided.

As is typically the case in most commercial fisheries, there are noticeable seasonal trends in Puerto Rico's west coast fisheries in terms of production, revenue, and number of participating fishermen, as reflected by the information in Table 4.3.4. Specifically, in the aggregate, production, revenue, and the number of active fishermen are relatively high at the beginning of the year but steadily decline through the course of the year. On a proportional basis, the decline over the course of the year is greater with respect to the number of fishermen and less pronounced with respect to revenue because the average price associated with landings in the latter part of the year is higher, likely because higher

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[6] The number of active commercial fishermen is based on the number of unique commercial fishing license numbers present in the trip ticket data within a specific year.

valued species constitute a relatively higher proportion of the total landings than at other times of the year, particularly Spring and Summer.

To illustrate which species are higher-valued, information in Table 4.3.5 shows the distribution of landings and revenue across different species, and the prices associated with each. For the purposes of this assessment, only the most economically significant species are reported. Results are reported for each year separately to reveal potential changes between 2006 and 2007. In general, it is obvious that the four most economically important species for west coast commercial fishermen are spiny lobster, queen snapper, queen conch, and silk snapper, with lane snapper, dolphin, yellowtail snapper, and boxfishes representing the next tier of important species. Not surprisingly, the top four species with respect to total revenue are also the species commanding the highest price on a per pound basis. And although lane, yellowtail and other snappers are relatively important, it is clear that queen and silk snapper are economically dominant as their average price is more than a $1 per pound greater than any other snapper or grouper species. Since the majority of the Bajo de Sico area lies within EEZ waters, while the queen conch fishery lies entirely within territorial waters, the following discussion focuses primarily on the four deepwater snapper species, particularly queen and silk snapper, and spiny lobster.

Some of the more noticeable trends for these species are as follows. First, as previously indicated, production and revenue increased for most of the economically important species between 2006 and 2007. Increases were most noticeable for queen snapper, lane snapper, and spiny lobster. As a result, queen snapper and lane snapper became relatively more important to commercial fishermen. Further, the average nominal price of the four most economically important species also increased.

Table 4.3.6 provides landings and revenue data for spiny lobster, lane snapper, queen snapper, silk snapper, and yellowtail snapper by month, with 2006 and 2007 data combined, to facilitate examination of potential seasonal variability in harvests. Although the landings of most species exhibit seasonal trends throughout the year (for e.g., due to changes in abundance or migratory patterns), for current purposes, of more specific interest is whether the most economically important species demonstrate such trends and, further, whether those trends may be related to the current seasonal closure of the Bajo de Sico area occurs between December and February. Care must be taken with respect to placing too much emphasis on the higher than expected level of lane snapper landings in April and May, given the current regulations, as this could be an artifact of how the correction factors have been applied. And, in any case, the landings of each species in absolute terms are not critical for this part of the analysis. Rather, for current purposes, differences in landings between the months when Bajo de Sico is open versus when it is closed are of the most interest.

According to the information in Table 4.3.6, each of these species exhibits some seasonal variability. However, of greater importance is the finding that, in the months of December through February, when Bajo de Sico is closed, the landings of most of the economically important species are not particularly low. In fact, for some of these species, landings are at some of their highest levels during the year. This finding suggests that the closure did not adversely affect the landings of these species because they were not traditionally harvested from this area or because fishermen have been able to compensate by harvesting these species in other areas. The lone exception to this finding is silk snapper. Current regulations prohibit the harvest of silk snapper during October through December, though Puerto Rico did not implement their compatible regulations until 2007. Thus, landings for silk snapper would be expected to be low during these months. Although the landings of silk snapper increase somewhat in January and February, the landings remain relatively low compared to the other months of the year, suggesting that the current Bajo de Sico closure may be forcing commercial fishermen to forego the harvest of silk snapper during the months of January and February. Although this result by itself is likely not sufficient to support this hypothesis, additional information presented in section 5.1.2 provides additional evidence.

Table 4.3.7 presents information on the distribution of landings and revenue in 2006 and 2007 by the most important gear types. According to this information, SCUBA and bottom lines are clearly the most economically important gear types for west coast commercial fishermen. In terms of production, bottom lines generate the highest landings. However, SCUBA gear yields higher revenue likely because this gear is used to harvest the relatively more valuable species and possibly because SCUBA harvest yields a higher quality product which can in turn command a higher market price. The same relationship may also apply to seafood caught using fish pots as opposed to troll lines (i.e., production from troll lines is greater, but fish pots yield higher revenue), which are of secondary importance to commercial fishermen. Trammel nets and gill nets are also somewhat important to commercial fishermen.

Some gears are used more often to harvest particular species. Again, this is of potential interest given that “bottom-tending” gears such as fish pots are not allowed in Bajo de Sico even when it is not seasonally closed. Contrary to what the name of the gear may seem to imply, “bottom lines” are not “bottom-tending” gear under the regulations. In Puerto Rico’s commercial fisheries, “bottom line” gear is most closely related to “bandit” gear in Gulf of Mexico and South Atlantic commercial fisheries. In general, bottom line gear is a vertical line gear that relies on electric reels and has a larger number of hooks than “hook and line” gear. According to the information in Table 4.3.8, the most economically important “fisheries” are the SCUBA fisheries for spiny lobster and queen conch followed by the bottom line fisheries for queen snapper and silk snapper. The fish pot fishery for spiny lobster is also relatively economically important, followed by the bottom line fisheries for yellowtail and lane snapper. Again, the queen conch fishery is not examined in this assessment for reasons already explained, nor is the fish pot fishery for spiny lobster given the previously noted prohibition. Also, it is unlikely that the SCUBA fishery for spiny lobster is prosecuted in Bajo de Sico. Thus, the bottom line fishery for deep water snappers and groupers, particularly queen and silk snapper and red hind, are those that could be of interest with respect to the particular alternatives contained in this amendment, at least with respect to potential impacts on commercial fishermen.

Though not directly based on landings data, it is worth noting that, according to the 2008 fisherman Census data, approximately 52% of commercial fishermen indicate that they target deep water snapper-grouper species. While more of these fishermen reside in Cabo Rojo than in other municipalities, the proportion of fishermen in Cabo Rojo that report targeting deep water snapper-groupers is the lowest (33%) of all the municipalities. Much higher percentages of fishermen in the other municipalities report targeting deep water snappers, particularly in Aguadilla (87%) and Rincon (82%).

While the fisherman Census data indicates which species commercial fishermen intend to catch, the landings data show what species are actually caught and, in turn, those species that are of relatively greater importance to commercial fishermen with respect to revenue generation. The information in Table 4.3.9 is illustrative in this regard. For example, commercial fishermen in Mayaguez are quite dependent on landings of all three species of primary interest (i.e., silk snapper, red hind, and queen snapper) as they rank 4th, 8th, and 9th respectively in terms of revenue. And, although landings of red hind are not particularly important to Rincon's or Anasco's commercial fishermen, landings of queen snapper and silk snapper rank 1st and 3rd and 1st and 2nd respectively in terms of revenue. For Aguadilla's commercial fishermen, while landings of queen snapper are not particularly important, they are relatively dependent on landings of silk snapper and red hind, which rank 1st and 9th in revenue terms. Landings of silk snapper are important to Aguada's commercial fishermen, ranking 1st in terms of revenue, but landings of queen snapper and red hind are not significant. Finally, Cabo Rojo's commercial fishermen appear to be the least dependent on landings of these three species, with only queen snapper, ranking 6th in terms of revenue, being particularly important. Regarding the management of Bajo de Sico, this information should be somewhat instructive with respect to which municipalities may be the most impacted by particular alternatives under consideration by the Council.

As was the case with commercial fishing vessels and fishermen, commercial landings and revenue are not evenly distributed across the west coast's municipalities (see Table 4.3.10). Similar to the distribution of vessels and fishermen, commercial fishermen in Cabo Rojo account for the largest proportion of landings and revenue. Specifically, Cabo Rojo represents between 45% and 49% of total production and approximately 55% of total revenue on the west coast. Commercial fishermen from Rincon account for the next largest proportion of landings and revenue, accounting for approximately 19% of overall production and 22% of total revenue. Aguadilla follows in terms of its share of production, with its commercial fishermen accounting for 14% of total production. However, Aguadilla's fishermen harvest less valuable species and only account for 7-8% of total revenue. Conversely, fishermen in Mayaguez only accounted for 10% of total production in 2006, though this increased in 2007 to 13%. Similarly, these fishermen accounted for only 8% of total revenue in 2006, though their share increased to 10% in 2007. Aguada's fishermen accounted for 8% of total production in 2006, and only 6% in 2007. Aguada's share of total revenue was approximately 4%. Anasco's fishermen accounted for less than 1% of total production and revenue in 2006, though their share of each increased to nearly 3% in 2007. When combined with the previous information on vessels and information, the information regarding the distribution of landings and revenue makes it clear that the core of the west coast's commercial fishing industry lies in Cabo Rojo, with Rincon being the second most important municipality.

However, this finding should not be construed to imply that commercial fishing interests are not important in the other municipalities as that determination is dependent on the economic and social conditions in those particular municipalities (i.e., the determination of significant effects is based on relative not absolute measures). Nor should this result be thought to imply that fishermen in Cabo Rojo or Rincon are necessarily better off economically than their counterparts in the other municipalities. A determination of this nature is partly dependent on the number of active commercial fishermen in each municipality, which in turn affects how widely the production and revenue must be distributed between fishermen. This information is presented in Table 4.3.11 and discussed in the following paragraphs.

In 2006, it appears that, on average, commercial fishermen in Cabo Rojo and Rincon were better off than their counterparts in other municipalities. Even though there were more active fishermen in Cabo Rojo and Rincon, they were also relatively more productive, with Rincon's fishermen being the most productive in terms of both landings and, particularly, revenue. As a point of comparison, in 2006, Rincon and Aguadilla had nearly the same number of active commercial fishermen. However, production per fisherman was nearly 25% higher in Rincon compared to Aguadilla and revenue per fisherman was more than 260% higher, indicating that Rincon fishermen target or have access to more valuable species relative to Aguadilla fishermen.

Further, as was noticed in the analysis of the aggregate landings and revenue data, landings and revenue per fisherman increased in every municipality between 2006 and 2007. In most cases, this change coincided with a decrease in the number of active commercial fishermen, with the lone exception being in Mayaguez where the number of active fishermen increased. And while the increase was significant in Cabo Rojo and Rincon, where productivity basically doubled, and more modest in Mayaguez, Aguada, and Aguadilla, the most drastic increase took place in Anasco. With only four fishermen, it is surprising that productivity could increase by six-seven fold and, as a result, surpass that of the highly productive fishermen in Cabo Rojo and Rincon. This result likely deserves further investigation.

Recreational Fishing and Permits

As described in the Council's SFA Amendment to its FMPs, estimates of recreational effort and landings are produced for Puerto Rico on an island-wide basis and are not broken down on a regional basis. Thus, no estimates of recreational effort or landings for the west coast, comparable to data for the commercial sector, are available at this time. Further, such estimates are also not available at the municipality level. However, some basic information on the recreational fishing sector can be gleaned from Griffith et al. (2007) and the raw MRFSS intercept data. Raw intercept data are collected directly from the angler through the shore-side interview and do not include total estimates of catch or effort that result from combination of the shore-side data with the telephone effort survey data.

Griffith et al. (2007) indicate that, although there are a large number of recreational boats in Puerto Rico and, thus, by extension, on the west coast, a relatively small percentage of those boats are used for fishing. Further, for the most part, the recreational fishing that occurs is primarily conducted for “sport” rather than “leisure” purposes. “The term recreational refers to fishers who fish primarily as a leisure or casual activity, catching a little food as well, while sport fishers tend to target game (hard-fighting) fish, participate in tournaments, and often belong to associations or clubs that advocate on behalf of sport fishers…the term *pescador deportiva* (sport fisher) is more common in Puerto Rico than the term *pescador recreativa* (recreational fisher)” (Griffith et al., 2007: 18). The most important component of the recreational fishing “community” is the charter boat sector. With respect to recreational catch from the EEZ, it is dominated by pelagic and HMS species such as dolphin and tuna.

On the west coast, Griffith et al. (2007) suggests that the greatest concentration of recreational fishing interests, like the commercial fishing sector, exists in Cabo Rojo. For example, several important recreational fishing tournaments in Cabo Rojo (specifically Boqueron and Puerto Real) and Mayaguez target blue marlin, dolphin, or wahoo, though catches of king mackerel, barracuda, and tunas are also common.

More detailed information regarding these tournaments is provided by Rodriguez-Ferrer and Rodriguez-Ferrer (2006, 2007). According to these two reports, eight recreational tournaments were held on the west coast in both 2006 and 2007. Though each tournament is held by a specific local sport fishing club, they are generally sponsored by the Puerto Rico Sport Fishing Association. In previous years, additional fishing tournaments were sponsored by commercial fishing associations.[7] However, organizers of these tournaments decided not to hold them as a result of new fishing regulations. Regardless, in these two years, six and seven of these recreational tournaments were held in Cabo Rojo, while the other(s) were in Mayaguez. Further, five of the tournaments were held in the months of September or October, with the other three taking place in November, February, and March, respectively. The tournaments in September/October target blue marlin, while those in the other months target dolphin and/or wahoo. Blue marlin tournaments are typically the most widely advertised and attract the largest number of participants. For example, the blue marlin tournament sponsored by the Club Deportivo del Oeste in September attracted the largest number of participants (500) and boats (124) of all the recreational tournaments in Puerto Rico during 2007. Based on 2007 data, the blue marlin tournaments also charge a higher fee per boat ($756) than the dolphin/wahoo tournaments (approximately $340 per boat). The number of participants and boats participating in these tournaments declined slightly between 2006 and 2007

[7] It is not clear from the reports which if any these previously held commercially sponsored tournaments took place on the west coast.

from 1,256 participants and 314 boats to 1,108 participants and 276 boats respectively.[8] For 2007, 47 boats participated in dolphin/wahoo tournaments, while 229 boats participated in blue marlin tournaments. Thus, the estimate of total boat fees paid in association with these tournaments was approximately $189,200.

Changes in regulations have allegedly impacted how these tournaments are operated. Specifically, the fishing quota for dolphin was reduced from 20 to 10 fish per boat, though tournament organizers are allowed to apply for an exemption that would allow boats to catch the previous 20 fish/boat quota. Even with the exemption, the majority of clubs changed the basis for awarding prizes from the largest number of fish caught or smallest fish to the most pounds of fish caught. In some cases, minimum weight limits were established for particular species. As a result, this provided tournament participants with an incentive to land larger fish. Also, most tournaments have switched to tag and release, particularly those targeting blue marlin. As a result, the number and weight of fish landed has decreased.

Under PRDNER regulations, organizers must obtain a permit for each recreational fishing tournament.[9] Under the terms of the permit, the organizers specify the area within which tournament participants will be fishing. However, an examination of this information indicates that the areas typically specified are quite large, often all of the territorial and EEZ waters off the west coast. In a few instances, the specified areas were slightly smaller. Nonetheless, this information is insufficient to determine how many tournament participants access the waters in Bajo de Sico, or any other specific area, or how frequently. As such, little information exists with respect to determining how important the Bajo de Sico fishing grounds are to recreational tournament participants and organizers.

As Rodriguez-Ferrer and Rodriguez-Ferrer (2006, 2007) note, as of 2003, all recreational vessels used to fish for, take, retain, or possess Atlantic billfish, tunas, swordfish, or sharks must possess an Atlantic HMS Angling (recreational) permit. Further, owners of charter boats used for this same purpose must possess an Atlantic HMS charter/headboat permit. As with the previously discussed commercial Atlantic tunas (general) permit, data regarding these permits was compiled for 2008. These data are presented in Tables 4.3.12 and 4.3.13 and discussed in the following paragraphs.

In 2008, 198 vessels held HMS recreational angling permits. While these vessels may operate as private recreational fishermen, they undoubtedly participate in the aforementioned blue marlin fishing tournaments and possibly the dolphin/wahoo tournaments as well. Similar to commercial vessels, the vast majority (91%) of the recreational vessels have fiberglass hulls. However, in practically all other respects, these recreational vessels differ considerably from their commercial counterparts. Contrary to commercial vessels, which rely primarily on SCUBA and bottom lines, and

[8] These figures represent an aggregation of the number of participants and boats from each individual tournament. Since some individuals and boats participate in more than one tournament, these figures are overestimates of the actual number of unique individuals and boats participating in west coast tournaments.
[9] Blue marlin tournaments must also be registered with the HMS Division of NMFS.

commercial HMS vessels, which primarily use handline gear, most HMS recreational vessels (96%) use rod and reel gear, while the remainder (4%) use handline gear. Further, compared to commercial vessels, recreational vessels are considerably longer (by approximately 50%), newer, (by approximately 6 years), and have far greater engine power (HP is approximately 7-8 times greater), on average. These findings suggest that recreational vessels, particularly while participating in tournaments, are likely to travel farther, longer, and at greater speeds relative to commercial vessels. And while vessel purchase price data is not available, these distinctions also strongly suggest that recreational vessels are considerably more expensive than commercial vessels. These findings support the notion that, "particularly in the context of tournaments…recreational fishing is an upper class activity" (Griffith et al., 2007: 19) and the culture associated with recreational fishing is substantially different and distinct from that of commercial fishing.

Consistent with the locations of the recreational fishing tournaments, the majority of these recreational vessels are ported in Cabo Rojo. Specifically, 52% of these vessels are principally ported in Cabo Rojo, with 12% each located in Mayaguez, Rincon, and Aguadilla respectively. The other 12% are ported in Aguada, Anasco, and municipalities outside the west coast. The fact that recreational vessels are not more concentrated in Cabo Rojo and Mayaguez is likely because these vessels and their owners have the ability to range farther from their home ports relative to most commercial vessels and operators. Similarly, it is worth noting that, with respect to place of residence, these vessels' owners are even more geographically dispersed, with more than 28% living away from Puerto Rico's west coast, some as far away as the U.S. mainland. In fact, the most common places for these owners to live are Mayaguez (25%), Aguadilla (16%), and Cabo Rojo (14%). Thus, it is apparently not uncommon for recreational vessel owners to port their vessels in locations away from where they live, and sometimes at relatively great distances.

In 2008, eight vessels on Puerto Rico's west coast possessed HMS charter/headboat permits. All of these are charter operations as there are no known headboat operations in this area. Similar to the commercial vessel sector, where fiberglass hulls are predominant, all eight charter vessels are made of fiberglass. However, these charter vessels differ considerably from their commercial counterparts and, instead, are much more similar to recreational vessels. Like HMS recreational vessels, the majority of the HMS charter vessels (seven) use rod and reel gear, while only one vessel uses handline gear. Furthermore, these vessels are longer (by approximately 33%-40%) and considerably more powerful (HP is 5-6 times greater) on average than general commercial and commercial HMS vessels. They are also much newer (by more than a decade) than general commercial vessels. These differences are likely due to the fact that the charter sector is a relatively newer business enterprise compared to commercial fishing, and charter vessels typically carry more individuals, in terms of crew and passengers, and, thus, must have the engine power to accommodate the additional weight. When compared to the HMS recreational angling vessels, charter vessels carry three more passengers, are slightly newer and shorter in length, but have less engine power on average.

With respect to geographic distribution, four of these vessels (50%) are located in Rincon, with two vessels each located in Aguadilla and Cabo Rojo. In terms of target species, Griffith et al. (2007) indicate that dolphin, blue marlin, wahoo, and yellowfin tuna are targeted most frequently by charter operators, though this is also the case for all such operations in Puerto Rico as opposed to the west coast only. Nonetheless, this information is generally consistent with the limited survey data collected by Tonioli and Agar (2008) indicating that wahoo, dolphin, and tunas are the primary target species of charter operators on the west coast.[10] That is, charter operators appear to target HMS and pelagic species not directly managed by the Council. Under HMS' regulations, commercial size tunas taken aboard HMS permitted charter vessels may be sold to dealers with HMS Atlantic tuna dealer permits.

According to Griffith, et al. (2007), charter fishermen have approximately 25 years of fishing experience, which is almost identical to west coast commercial fishermen. On the other hand, their busiest time of the year begins in October or December, which is the least active time of the year for commercial fishermen, and runs through May. On the west coast, they also report that there are three primary fishing areas: 1) 20 miles off the west coast near La Mona, 2) inshore Cabo Rojo, and 3) Desecheo/Mona-Monito. Interestingly, anecdotal information suggests that these vessels do not typically participate in the previously discussed recreational fishing tournaments. Griffith et al. (2007) also reports that, on average, charter operators take approximately 190 trips per year. Data from Tonioli and Agar suggest that, for those surveyed on the west coast, the average may be slightly lower at approximately 150-160 trips per year. Their data also suggests that these operations specialize in half-day trips, rather than full-day trips, which Griffith et al. (2007) report to cost $526 on average, though this cost has likely increased since the time they conducted their research.

An examination of the raw MRFSS intercept data on the west coast for 2004-2007 supports these general findings with respect to which species are most commonly targeted and the municipalities for which recreational fishing is the most important. For example, this data generally supports the notion that the highest level of recreational fishing activity and, thus, catch likely comes from Cabo Rojo, with Mayaguez likely being of secondary importance. In terms of catch, the most commonly encountered species on these intercepts were coney, Spanish sardine, Atlantic tarpon, gray snapper, and red hind (see Table 2.1.1). However, these results represent catch success/activities and do not mean that these were necessarily the most commonly targeted species. On the contrary, although Atlantic tarpon and, to a lesser extent, red hind are sometimes targeted, wahoo, dolphin, blue marlin, crevalle jack, and common snook are more commonly reported as the primary target species. Further, if only targeting behavior for trips in the EEZ is considered, it becomes clear that dolphin, wahoo, and blue marlin are the most desired species by recreational fishermen. Although these findings cannot be considered conclusive, given the small sample sizes and lack of statistically-based estimates of catch and effort, management alternatives that would only affect the harvest of reef fish are not expected to significantly affect the recreational fishery. This

[10] Three of the eight HMS charter vessels were surveyed by Tonioli and Agar, with all three coming from Rincon.

conclusion is supported by additional, though limited, empirical information from the Council's scoping meetings and other fieldwork conducted by the SEFSC, the latter of which is discussed more fully in section 5.1.2.

Table 4.3.1. Puerto Rico West Coast Commercial Fisherman and Vessel Statistics

	Fisherman Statistics								Vessel Statistics			
Statistic	Age	Experience (years)	Number of Dependents	Household Income (%)	Hours Fishing	Hours Vessel Maintenance	Hours Gear Maintenance	Hours Selling	Year Built	Horsepower	Length (ft)	Crew
Observations	304	306	306	301	302	299	298	304	214	217	218	300
Minimum	18	0	0	0	0	0	0	0	1960	7	12	1
Maximum	86	70	10	100	120	48	75	25	2008	735	51.2	9
Average	47.3	26.7	3.0	85.4	34.3	6.5	6.5	3.8	1989	76.7	20.0	2.0
Standard Dev	15.3	15.5	1.7	23.4	16.3	6.2	8.8	4.6	12.1	88.1	4.7	0.9

Table 4.3.2. West Coast Commercial Fisherman and Vessel Statistics by Municipality

		Fisherman Statistics								Vessel Statistics			
Municipality	Statistic	Age	Experience (years)	Number of Dependents	Household Income (%)	Hours Fishing	Hours Vessel Maintenance	Hours Gear Maintenance	Hours Selling	Year Built	Horsepower	Length (ft)	Crew
Aguada	Observations	11	11	11	11	11	11	11	11	5	6	6	11
	Minimum	20	1	0	25	4	0	0	0	1998	15	15	1
	Maximum	85	70	6	100	50	20	75	15	2004	85	22	3
	Average	56.1	37.9	2.5	78.2	38.5	7.2	13.4	4.2	2001	42.5	18.2	1.8
	Standard Dev	17.6	17.1	1.6	26.1	16.1	5.4	21.0	5.5	2.6	27.0	2.6	0.6
Aguadilla	Observations	38	38	38	38	38	38	38	38	23	23	23	38
	Minimum	20	0	0	50	8	0	0	0	1984	15	13	1
	Maximum	86	70	7	100	72	12	15	15	2008	120	22	3
	Average	55.1	34.9	2.7	88.2	32.6	4.2	3.4	2.5	1998	33.3	17.8	1.8
	Standard Dev	13.8	16.4	1.7	20.7	15.5	3.3	2.9	2.5	6.7	21.2	1.9	0.4
Anasco	Observations	10	10	10	10	10	10	10	10	5	5	5	9
	Minimum	18	4	0	20	8	1	1	1	1976	15	14	2
	Maximum	72	50	5	100	72	6	6	6	2006	270	30	3
	Average	42.5	16.8	2.9	55.0	25.0	2.9	2.8	2.8	1996	85.0	20.2	2.2
	Standard Dev	16.5	14.5	1.5	20.1	18.0	1.6	1.9	1.8	11.9	105.4	5.9	0.4

Table 4.3.2 Cont. West Coast Commercial Fisherman and Vessel Statistics by Municipality

		Fisherman Statistics								Vessel Statistics			
Municipality	Statistic	Age	Experience (years)	Number of Dependents	Household Income (%)	Hours Fishing	Hours Vessel Maintenance	Hours Gear Maintenance	Hours Selling	Year Built	Horsepower	Length (ft)	Crew
Cabo Rojo	Observations	151	152	152	152	148	146	145	151	112	112	151	152
	Minimum	18	0	0	0	5	0	0	0	1960	7	18	0
	Maximum	79	56	10	56	120	48	30	25	2006	735	79	10
	Average	45.3	24.3	3.2	24.3	33.5	7.7	6.3	4.3	1983	91.5	45.3	3.2
	Standard Dev	14.8	13.8	1.8	13.8	12.9	7.1	6.9	5.2	11.5	113.3	14.8	1.8
Mayaguez	Observations	40	41	41	40	41	41	41	41	31	32	32	39
	Minimum	24	0	0	25	5	0	0	0	1970	10	13	1
	Maximum	81	65	5	100	72	15	72	18	2007	275	26	4
	Average	52.9	31.4	2.8	72.7	29.0	5.3	7.6	3.3	1992	63.8	18.6	1.7
	Standard Dev	15.0	15.4	1.4	27.7	16.1	4.3	11.6	3.8	9.9	50.7	3.2	0.6
Rincon	Observations	54	54	54	54	54	53	53	53	38	39	38	54
	Minimum	18	2	0	15	0	0	0	0	1970	9	12	1
	Maximum	78	70	7	100	112	36	42	15	2007	150	24	9
	Average	42.2	23.8	2.9	85.7	42.6	6.3	7.5	3.7	1996	74.6	19.5	2.2
	Standard Dev	14.2	16.0	1.7	23.4	21.6	6.2	9.6	4.3	8.9	30.5	2.8	1.3

Table 4.3.3. Commercial Landings (Corrected) and Revenue Statistics by Year, West Coast Fishermen, 2006-07

Year	Statistic	Landings (lbs)	Revenue ($)
2006	Observations	374	374
	Minimum	3	$6
	Maximum	28,276	$105,297
	Average	1,987	$5,431
	Standard Dev	3,207	$10,310
2007	Observations	294	294
	Minimum	12	$23
	Maximum	30,878	$138,039
	Average	3,248	$9,168
	Standard Dev	4,470	$15,993

Table 4.3.4. West Coast Commercial Landings (Corrected), Revenue, and Number of Fishermen by Year and Month, 2006-07

Year	Month	Number of Fishermen	Landings (lbs)	Revenue ($)
2006	Jan	187	71,992	$207,969
	Feb	177	73,455	$184,748
	Mar	161	79,858	$201,341
	Apr	136	66,691	$171,900
	May	145	62,457	$171,370
	June	153	64,400	$172,284
	July	152	44,965	$114,016
	Aug	137	54,923	$136,105
	Sept	146	61,788	$168,709
	Oct	153	65,142	$200,270
	Nov	147	50,442	$160,365
	Dec	133	47,012	$142,015
2007	Jan	141	81,110	$232,515
	Feb	152	75,493	$208,547
	Mar	144	83,980	$234,470
	Apr	145	86,957	$240,798
	May	152	101,210	$281,014
	June	149	101,138	$281,028
	July	138	68,922	$175,971
	Aug	142	72,826	$210,125
	Sept	122	66,806	$193,387
	Oct	129	72,004	$211,191
	Nov	121	74,780	$226,383
	Dec	116	69,783	$199,851

Table 4.3.5. West Coast Commercial Landings (Corrected), Revenue, and Prices by Year and Species, 2006-07

Year	Species	Landings (lbs)	Revenue ($)	Average Price ($)
2006	lobster,spiny	84,346	$480,715	$5.70
	conch,queen	106,596	$341,105	$3.20
	snapper,queen	99,120	$335,782	$3.39
	snapper,silk	59,124	$197,263	$3.34
	dolphin	32,336	$58,014	$1.79
	snapper,yellowtail	28,086	$56,123	$2.00
	snapper,lane	25,369	$55,636	$2.19
	boxfishes	23,220	$50,024	$2.15
	mackerel,king	20,093	$37,856	$1.88
	hind,red	17,480	$34,512	$1.97
	grunt,white	24,629	$34,276	$1.39
	snapper,mutton	14,314	$31,618	$2.21
	wrasses	11,184	$31,318	$2.80
	tuna,blackfin	20,098	$24,238	$1.21
	tuna,yellowfin	18,346	$20,373	$1.11
	tuna,skipjack	22,304	$19,989	$0.90
2007	lobster,spiny	110,678	$649,701	$5.87
	snapper,queen	149,442	$527,143	$3.53
	conch,queen	110,991	$433,409	$3.90
	snapper,silk	69,043	$237,842	$3.44
	snapper,lane	44,262	$95,545	$2.16
	snapper,yellowtail	42,129	$79,318	$1.88
	dolphin	40,781	$69,227	$1.70
	boxfishes	28,777	$61,858	$2.15
	snapper,mutton	23,630	$47,568	$2.01
	mackerel,king	21,909	$39,927	$1.82
	shark,requiem	19,870	$36,307	$1.83
	wrasses	11,817	$34,818	$2.95
	hind,red	17,571	$33,414	$1.90
	tuna,yellowfin	28,700	$32,942	$1.15
	tuna,skipjack	43,567	$32,892	$0.75
	tuna,blackfin	30,468	$32,585	$1.07
	ballyhoo	19,519	$29,875	$1.53

Table 4.3.6. West Coast Commercial Landings (Corrected) and Revenue by Month for Important Species, 2006-07 Combined

Month	Spiny Lobster Landings (lbs)	Spiny Lobster Revenue ($)	Lane Snapper Landings (lbs)	Lane Snapper Revenue ($)	Queen Snapper Landings (lbs)	Queen Snapper Revenue ($)	Silk Snapper Landings (lbs)	Silk Snapper Revenue ($)	Yellowtail Snapper Landings (lbs)	Yellowtail Snapper Revenue ($)
Jan	21,654	$124,432	7,951	$16,950	21,799	$75,912	9,327	$31,385	3,597	$7,090
Feb	17,063	$95,154	5,990	$12,740	19,071	$64,318	8,508	$29,098	6,586	$12,730
Mar	16,193	$93,851	6,387	$13,444	24,146	$81,328	10,406	$34,070	7,925	$15,630
Apr	15,321	$89,355	4,629	$9,693	17,889	$60,313	12,783	$42,735	9,792	$19,417
May	14,418	$84,335	4,361	$9,494	18,599	$65,636	17,496	$61,751	5,589	$11,193
June	13,547	$79,083	5,256	$11,608	21,372	$76,385	17,627	$60,767	4,605	$8,973
July	14,053	$81,911	7,011	$15,333	12,954	$44,900	12,706	$42,886	2,841	$5,148
Aug	18,324	$107,853	5,441	$11,445	18,558	$64,287	15,106	$51,044	5,687	$10,523
Sept	18,316	$105,195	5,050	$11,211	25,154	$88,003	13,474	$45,065	7,067	$13,660
Oct	12,640	$73,293	5,630	$12,796	25,763	$90,974	5,477	$18,589	8,258	$15,833
Nov	16,457	$96,389	6,019	$13,379	22,891	$82,296	2,958	$9,970	4,039	$7,724
Dec	17,038	$99,564	5,904	$13,088	20,366	$68,575	2,300	$7,746	4,229	$7,520

Table 4.3.7. West Coast Commercial Landings (Corrected) and Revenue by Selected Gear Types, 2006-07 Combined

Gear	Landings (lbs)	Revenue ($)
SCUBA DIVING	506,749	$1,941,435
BOTTOM LINE	679,057	$1,728,911
FISH POT	123,131	$385,790
TROLL LINE	240,315	$372,871
TRAMMEL NET	75,874	$170,228
GILL NET	42,883	$65,043

Table 4.3.8. West Coast Commercial Landings (Corrected), Revenue, and Prices by Gear and Species, 2006-07 Combined

Gear	Species	Landings (lbs)	Revenue ($)	Average Price ($)
SCUBA DIVING	lobster,spiny	138,437	$812,741	$5.87
SCUBA DIVING	conch,queen	212,049	$759,653	$3.58
BOTTOM LINE	snapper,queen	197,520	$699,713	$3.54
BOTTOM LINE	snapper,silk	110,574	$377,167	$3.41
FISH POT	lobster,spiny	36,061	$207,037	$5.74
BOTTOM LINE	snapper,yellowtail	65,285	$125,373	$1.92
BOTTOM LINE	snapper,lane	48,096	$102,254	$2.13
SCUBA DIVING*	snapper,queen	29,005	$92,780	$3.20
TROLL LINE	dolphin	49,207	$85,970	$1.75
TROLL LINE*	snapper,queen	21,333	$67,969	$3.19
TRAMMEL NET	lobster,spiny	13,055	$67,907	$5.20
BOTTOM LINE	mackerel,king	34,989	$64,607	$1.85
BOTTOM LINE	snapper,mutton	27,995	$56,555	$2.02
SCUBA DIVING	wrasses	17,943	$51,669	$2.88
FISH POT	boxfishes	20,273	$43,859	$2.16
TROLL LINE	tuna,skipjack	47,737	$38,976	$0.82
TROLL LINE	tuna,blackfin	34,022	$38,625	$1.14
TROLL LINE	tuna,yellowfin	31,567	$36,688	$1.16
SCUBA DIVING	boxfishes	16,966	$36,673	$2.16
TRAMMEL NET	grunt,white	24,960	$35,877	$1.44
BOTTOM LINE	dolphin	20,190	$33,501	$1.66
FISH POT	snapper,lane	13,816	$32,402	$2.35
FISH POT	snapper,silk	10,099	$31,749	$3.14
BOTTOM LINE	shark,requiem	16,409	$28,683	$1.75
SCUBA DIVING	hind,red	11,934	$25,343	$2.12
TRAMMEL NET	boxfishes	10,771	$22,851	$2.12
BOTTOM LINE	grouper,misty	9,065	$20,978	$2.31
SCUBA DIVING	sea basses	10,350	$20,837	$2.01
BOTTOM LINE	hind,red	10,674	$19,089	$1.79
GILL NET	ballyhoo	20,112	$19,053	$0.95

* - Queen snapper are not subject to harvest by SCUBA or troll line gear, but rather bottom lines, and thus these data likely indicate gear coding errors in the trip ticket data.

Table 4.3.9. West Coast Commercial Landings (Corrected) and Revenue for Economically Important Species by Municipality, 2006-07 Combined

Municipality	Species	Landings (lbs)	Revenue ($)
Aguada	snapper,silk	10,855	$33,923
	lobster,spiny	4,970	$28,394
	tuna,blackfin	14,620	$15,513
	dolphin	7,944	$10,658
	tuna,skipjack	10,276	$9,122
	tuna,yellowfin	7,437	$8,201
	snapper,yellowtail	3,671	$7,343
	tuny,little	7,665	$7,341
	mackerel,king	3,633	$6,404
	snapper,lane	2,817	$6,056
Aguadilla	snapper,silk	23,438	$66,663
	dolphin	42,817	$65,896
	tuna,yellowfin	32,459	$35,144
	tuna,skipjack	46,430	$31,534
	tuna,blackfin	27,617	$27,519
	snapper,yellowtail	13,426	$26,029
	lobster,spiny	3,206	$18,092
	mackerel,king	7,750	$12,786
	hind,red	8,396	$12,495
	snapper,mutton	4,757	$9,468
Anasco	snapper,queen	19,721	$74,669
	snapper,silk	2,289	$8,231
	grouper,misty	1,572	$4,372
	dolphin	1,501	$3,702
	lobster,spiny	627	$3,134
	snapper,lane	584	$1,640
	barracudas	664	$921
	shark,requiem	397	$730
	mackerel,cero	335	$670
	mackerel,king	241	$432
Cabo Rojo	lobster,spiny	155,705	$903,874
	conch,queen	203,891	$738,377
	snapper,silk	52,658	$190,895
	snapper,lane	52,280	$115,761
	boxfishes	45,110	$97,867
	snapper,queen	25,944	$95,625
	wrasses	21,771	$63,052
	grunt,white	34,969	$45,693
	snapper,mutton	16,505	$39,265
	ballyhoo	30,123	$38,015

Table 4.3.9. Cont. West Coast Commercial Landings (Corrected) and Revenue for Economically Important Species by Municipality, 2006-07 Combined

Municipality	Species	Landings (lbs)	Revenue ($)
Mayaguez	snapper,yellowtail	41,808	$78,476
	lobster,spiny	10,695	$61,594
	mackerel,king	25,021	$47,368
	snapper,silk	11,898	$40,649
	conch,queen	12,734	$33,235
	snapper,mutton	13,848	$24,760
	snapper,lane	11,711	$23,404
	hind,red	9,897	$20,186
	snapper,queen	5,291	$17,634
	snook,common	8,132	$13,021
Rincon	snapper,queen	196,386	$671,499
	lobster,spiny	19,822	$115,328
	snapper,silk	27,029	$94,743
	shark,requiem	19,642	$41,774
	dolphin	13,623	$33,715
	grouper,misty	10,556	$23,954
	tuna,blackfin	8,187	$13,363
	snapper,cardinal	4,207	$13,063
	tuna,skipjack	8,705	$11,775
	tuna,yellowfin	6,410	$9,048

Table 4.3.10. West Coast Commercial Landings (Corrected) and Revenue by Year and Municipality, 2006-07

Year	Municipality	Landings (lbs)	Revenue ($)
2006	CABO ROJO	362,894	$1,137,942
	RINCON	140,790	$463,562
	AGUADILLA	107,352	$168,234
	MAYAGUEZ	70,770	$162,203
	AGUADA	56,867	$86,107
	ANASCO	4,783	$13,454
2007	CABO ROJO	427,078	$1,457,743
	RINCON	181,959	$587,159
	MAYAGUEZ	127,516	$275,574
	AGUADILLA	135,254	$179,681
	AGUADA	58,470	$106,746
	ANASCO	24,236	$86,922

Table 4.3.11. Number of Active Commercial Fishermen, Average Landings (Corrected) and Revenue per Fisherman by Year and Municipality, West Coast, 2006-07

Year	Municipality	Number of Fishermen	Average Landings (lbs)	Average Revenue ($)
2006	AGUADA	29	1,950	$2,955
	AGUADILLA	62	1,731	$2,713
	ANASCO	4	1,196	$3,364
	CABO ROJO	176	2,062	$6,466
	MAYAGUEZ	54	1,311	$3,004
	RINCON	65	2,166	$7,132
2007	AGUADA	24	2,436	$4,448
	AGUADILLA	51	2,652	$3,523
	ANASCO	4	6,059	$21,730
	CABO ROJO	120	3,561	$12,152
	MAYAGUEZ	64	1,994	$4,308
	RINCON	41	4,442	$14,341

Table 4.3.12. Puerto Rico West Coast HMS Charter Vessel Statistics

Statistic	Length	Horsepower	Year Built	Number Passengers
Observations	8	8	8	7
Minimum	17	30	1984	2
Maximum	33	750	2008	12
Average	26.6	357.5	1999.8	6.9
Standard Dev	6.5	289.4	8.0	3.8

Table 4.3.13. Puerto Rico West Coast HMS Recreational Angling Vessel Statistics

Statistic	Length	Horsepower	Year Built	Number Passengers
Observations	198	198	198	189
Minimum	14	15	1961	1
Maximum	64	4000	2009	9
Average	29.0	448.6	1995.0	3.9
Standard Dev	10.2	503.6	10.5	2.2

Municipalities/Communities

Although some basic information regarding vessels, fishermen, landings and revenue has been presented that partially describes the municipalities on Puerto Rico's west coast, that information does not provide a complete picture of these municipalities or the individual communities in those municipalities. Griffith et al. (2007) provides such descriptions at a high level of detail. The following sections provide qualitative descriptions of these municipalities and select communities, based on the information contained in their report. However, Griffith et al. (2007) rely on U.S. Census data from 2000 to describe the economic conditions in each municipality and community. As discussed in section 5.1.2, economic conditions (for e.g., unemployment rates) may have changed over the past several years, which would in turn potentially affect the assessment of the economic and social impacts resulting from the actions and alternatives considered in this Amendment. Nonetheless, in terms of emphasis, the discussion of municipalities and communities is somewhat driven by the conclusions of Griffith et al. (2007) regarding which communities are the most fisheries dependent. These conclusions are based on an index of rankings across various fishing related factors for each community. Their assessment concluded that Puerto Real, Cabo Rojo and Parcelas Estela, Rincon are the most fisheries dependent communities on the west coast, with El Seco, Mayaguez and El Combate, Cabo Rojo also being relatively dependent on fisheries.

On the other hand, the dependence of a particular municipality or community does not necessarily determine the extent to which it may be affected by a particular management action. A management action's impacts on a particular place are also a function of the extent to which a particular community's fishery participants are engaged in fishing activities that will be potentially restricted by that action. Due to the lack of important secondary data (e.g., lack of specific fishing location data for both commercial and recreational fishing), there are significant obstacles with respect to rendering such determinations with a high degree of certainty. Further, the impacts are dependent on which alternatives the Council selects. However, as discussed in section 5.1.2, it is believed that, should the Council select alternatives that only affect activities associated with the harvest of species it directly manages (e.g., deep water snapper-groupers), then the most significant impacts (in absolute or relative terms) will likely be experienced in Anasco, Mayaguez, Rincon, and, to a lesser extent, Aguadilla, with Aguada and Cabo Rojo seeing minimal impacts. Conversely, if the Council selects alternatives that will also impact the harvest of species it does not directly manage (e.g., HMS/pelagics), then additional impacts will possibly occur in Cabo Rojo, Rincon, Mayaguez, and Aguadilla. Aguada is least likely to be impacted by any of the alternatives under consideration.

Cabo Rojo

As previously discussed, Cabo Rojo has the highest annual commercial landings and revenue, the largest number of commercial fishing vessels and fishermen, and the most productive commercial fishermen. As such, of the municipalities on Puerto Rico's west coast, it is the most dependent on commercial fisheries.

> Puerto Rico's southwest coast has been and continues to be home to its most productive commercial fisheries, even in light of distinctive and elaborate developments in other municipalities, such as the increasing integration of commercial fishing and tourism in Ponce or Fajardo or efforts to professionalize fisheries in Rincon. Puerto Real, Cabo Rojo was the site of Valdés Pizzini's doctoral dissertation (1985), which was among the first anthropological studies of fishing in Puerto Rico and which encouraged and set the stage for several other related works on Puerto Rico's coastal communities. Two other significant sites in Cabo Rojo, Boquerón and El Combate, represent alternatives to the fishing styles of Puerto Real. (Griffith et al., 2007: 144)

Cabo Rojo has seven landing centers and other important sites where fishermen congregate: four to five in Puerto Real, two in Boqueron, and one in Combate. According to Griffith et al. (2007), Puerto Real has been and continues to be a home port for many deep water snapper-grouper fishermen and divers who fish the Mona Passage. Many of these fishermen sell to private fish buyers rather than to fishing associations. Commercial fishing in Puerto Real began to expand after Puerto Ricans were granted U.S. citizenship.

> In the 1930s, Puerto Real fishers began selling fish up and down the west coast as fish dealers concentrated their efforts in this port city. These dealers, who eventually gained partial control of the fisheries of Puerto Real, established merchant capital ties to fishers, extending them credit and enabling fishing on the condition they sell to them. Eventually, through marriage, *compadrazgo* (ritual co-parenthood), and other cultural ties, dealers' families and fishers' families became intertwined, yet dealers continued to dominate the fisheries, investing in harbor infrastructure such as piers and ramps as well as in freezers. By the 1970s, fish dealers organized the fisheries of Puerto Real, although fishing across the rest of Cabo Rojo, from ports like Boquerón and Combate, were smaller and less prone to the control of Puerto Real. Through the exploitation of the substantial grouper and snapper stocks in the Mona Passage, west of Puerto Real, however, Puerto Real fishers became the premier fishers of Puerto Rico in terms of landings and income. (Griffith et al., 2007: 148)

Until 1992, Puerto Real's commercial fishermen used to operate in waters across much of the Caribbean. These fishermen would land their catch at Puerto Rican ports, undoubtedly to these ports' economic benefit. These fishermen would spend up to three weeks at sea, fishing off of Haiti, the Dominican Republic, and others' waters (Valdes Pizzini, 1985). As Caribbean nations created their own EEZs, these fishermen lost access to traditional fishing grounds located in the waters of other nations. Once countries such as the Dominican Republic and Haiti established and began enforcing their EEZ boundaries, fishermen from Cabo Rojo who still fished in their waters were arrested and jailed, which eventually forced these fishermen to change their fishing patterns. Cabo Rojo's fishermen now primarily operate in near-shore and shallow waters, and occasionally fish around La Mona after transporting hunters there to camp.

Despite its dependence on commercial fishing, according to Griffith et al. (2007), Cabo Rojo has been experiencing gentrification for the past several years, with plans for major coastal development projects to the south and north of the town of Puerto Real. As a result of this growth, crowding problems have surfaced in Puerto Real and other communities, with commercial and recreational boats often being forced to tie-up side by side due to the lack of docking space. Significant construction projects for high-priced condominiums and an expansion in tourism has led to even more severe crowding problems in Boqueron. Along with an area across the bay from Puerto Real, Combate's coastal growth problems have been somewhat different, characterized by an increase in the number of people mobile homes being placed in near-shore areas.

As illustrated by the information in Table 4.3.14, over the past few decades, Cabo Rojo has experienced an increase in unemployment and a decline in the number of people employed in extractive industries such as commercial fishing and agriculture. On the other hand, fewer people are living below the poverty line and per capita income has increased. These trends have also been seen in the other west coast municipalities. Similarly, between 1990 and 2000, retail employment increased slightly and employment in construction increased significantly (by nearly 50%). Conversely, employment in manufacturing has decreased by approximately 10%. Griffith et al. (2007) believe these trends in employment and income to be at least partly the result of gentrification.

Table 4.3.14. Cabo Rojo Demographic Information*

CABO ROJO	1950	1960	1970	1980	1990	2000
Population Characteristics						
Population [1]	29,546	24,868	26,060	34,045	38,521	46,911
Civilian Labor Force (CLF) [2]	9,311	6,220	7,395	10,040	13,483	15,701
CLF - Employed	9,174	5,948	7,041	8,934	10,501	12,801
CLF - Unemployed	137	272	354	1,106	2,982	2,900
Percent of unemployed persons	1.47	4.37	4.79	11.02	22.12	18.47
Industry of employed persons [3]						
Agriculture, forestry, fishing and mining [4]		2,516	1,649	690	608	388
Construction		228	624	636	749	1,118
Manufacturing		888	1,580	2,826	2,462	2,221
Retail trade		856	1,135	1,226	1,852	1,896
Socioeconomic Characteristics						
Mean travel time to work (minutes) [5]		N/A	N/A	N/A	20.3	24.6
Persons who work in area of residence [6]		4,908	4,630	4,887	5,762	5,957
Per capita Income (dollars) [7]			788	1,856	3,823	8,070
Median Household Income (dollars) [8]		844	1,994	4,478	7,832	13,580
Individuals below poverty level [9]			18,216	22,049	23,711	21,995
Percent of Individuals below poverty level			69.90	64.76	61.55	46.89

*(Griffith et al., 2007): 146

Nonetheless, Griffith et al. (2007) still consider fisheries to be economically important to Cabo Rojo's communities.

> Fishing remains a cornerstone of the economy of Puerto Real and a significant component of the economies of Boquerón and Combate as well. In each of these communities, seafood consumption is one of the principal draws for tourists, and weekend tourist traffic generates income for large and small businesses in all these areas. Joyuda, north of Puerto Real, is lined with seafood restaurants and beach hotels, and Boquerón is well known for its roadside oyster bars and booths that sell *pinchos* and *empanadillas* made with a variety of marine species of fish and shellfish, including octopus, lobster, trunkfish, and shrimp. Thousands of tourists visit the Cabo Rojo coast every weekend, and consuming local seafood is a significant part of its attraction." Apparently, fishermen consider gentrification and tourism to be a mixed blessing. Of the commercial fishermen in Cabo Rojo, Boquerón fishermen hold the most negative views towards these recent changes since it is there that gentrification, as a result of increased tourism, has been the most pronounced. (Griffith et al., 2007: 147)

Puerto Real is likely one of the most fishing dependent communities in Puerto Rico. Although Puerto Real has changed in many ways since the time of Pizzini's research in the mid-1980s, commercial fishing still occupies a central role in the community. The proposed developments to the north and south of town have produced mixed reactions with respect to how the community has been changing. According to some, these changes have added to the current problems arising from inadequate dock space for boats. Others see the potential economic benefits to fishermen and the community at large. For example, new marinas may attract more tourists and thereby create more jobs and higher incomes.

> Cabo Rojo presents a unique case in the fisheries of Western Puerto Rico, but not only for its productivity and the size and diversity of its fishing community. The importance of fish dealers and marine suppliers in organizing fishing fleets in Cabo Rojo is a phenomenon worth further investigation, in that the dealers/ suppliers occupy potentially powerful positions vis-à-vis other fishers in the community, restaurant owners along Puerto Rico's west coast, and Department of Natural Resources personnel. That they supply primarily restaurant owners, with sales to *guagüeros* and the general public secondary in their operations, suggests that they are deeply tied into the restaurant trade and that a larger part of the west coast tourist trade depends on them for fresh fish. These are full-time fishers, supporting families from fishing resources while contributing to local society in ways that transcend mere economic calculus. The fish they catch enhances visitors' experiences up and down the west coast of Puerto Rico. Well-known seafood restaurants in crowded weekend destinations like Joyuda, La Parquera, and Boquerón depend on fish from the lines, traps, spears, and other gear of Cabo Rojo fishers. While imported fish have cut into their markets, they maintain that they have been able to compete because of the high quality of local, fresh seafood, particularly highly prized species such as lobster and conch, as compared to

> imported fish. The fishers of Cabo Rojo defend themselves with quality. (Griffith et al., 2007: 159)

Contrary to the decline of commercial fishing in recent years, recreational fishing has become relatively more important in Cabo Rojo. In combination with recreational boating, this increase in recreational fishing has created slip space problems in Boquerón and Puerto Real. As previously discussed, Cabo Rojo has two charter fishing boats, one of which has been in business for over a decade. Along with its Clubs Nauticos and associated recreational fishing tournaments, of which there have been six annually in recent years, the increased importance of the charter and recreational sectors has strengthened Cabo Rojo's relationship with marine fisheries, which in turn has caused it to be even more dependent on fishing in all its forms.

Given its locatation at the end of a dead-end road, isolation may play an important role in Combate's dependence on fisheries. Combate's isolation grants both costs and benefits. In terms of benefits, this isolation helps to reduce competition from other fishermen in Cabo Rojo. When Puerto Real's commercial fishermen cannot supply enough fish to meet the local demand, fish buyers will turn to Combate's fishermen as another source of supply. On the other hand, this isolation may contribute to the perceived marginalization of its association and lack of government assistance.

Combate has several seafood restaurants in its downtown area. It is also home to a phenomenon somewhat rare in Puerto Rico: mobile homes. There are hundreds of small mobile homes, slightly larger than campers but not quite as large as the single and double-wide mobile homes commonly seen on the U.S. mainland. These types of dwellings suggest the community is home to many seasonal or part-time residents who likely enjoy local seafood when staying in town. Combate is a town whose population and demand for marine resources fluctuates through the week.

Near the downtown area of Combate is an active fishing association that is currently repairing a large pier in front of its facilities. Adjoining the association is a small beach with cabanas and other infrastructure that is quite active on weekends. Although the association's facilities are less elaborate and older than those at Aguadilla, they nevertheless seem fairly complete with 20 storage lockers, at least two cleaning facilities, and a shaded area where the fishermen gather and talk when they are not fishing. According to the president of the association, although 24 fishermen belong to this association, the association's viability is in question.

> One of the underlying reasons for the association's lack of viability is that it has received little to no help from the government through the years. The small shed where they process the fish needs between $10,000 and $12,000 in repairs. They cannot afford these repairs in part because of recent licensing requirements, which have placed additional costs on fishing, with separate licenses required for some species. The president viewed himself and the others of the association as poor and powerless, and he believes that government funding has been unevenly distributed over fishing associations around the island. "All of the fishing

> programs," he said, 'stay in Ceiba and Fajardo' (both on the Eastern side of the Island and common recreational destinations for people from San Juan). Other than these programs, the government has, according to Combate fishers, cut benefits for most fishers and fishing communities. One said, 'We are 2,000 fishermen [in Puerto Rico] and we can neither knock the government down or raise it up,' reiterating the powerlessness this fisher perceives. These are fishers' *perceptions*, which may not be 100% accurate yet do reflect the reality of fishing folk in Puerto Rico. (Griffith et al., 2007: 151)

Although residency in Combate is required to have a locker at the association, members need not sell their fish to the association. Instead, the association's primary use is that it provides a place where fishermen can repair their vessels. In order to fish more efficiently with gill nets and beach seines (for bait), the association probably needs at least two more vessels.

At present, Combate's commercial fishermen primarily use hook and line gear, diving gear (i.e. SCUBA), and trammel nets. The fishermen who use diving gear are quite different from those who use the other gears. For example, while divers target conch and lobster, the others primarily target parrotfish, snapper-grouper, and dolphin. Further, divers sell to restaurants in Combate and outside of the community instead of to the association, while the other fishermen sell locally and to two or three buses that periodically come to the association from nearby municipalities. Unlike the hook and line and net fishermen, the diver fishermen also buy most of their equipment from outside the community.

The non-diver fishermen also sell to eight to ten local small grocery stores and supermarkets, including Mr. Special and Pitusa. Typically, these non-diver fishermen operate six to seven miles off shore, or close to Abrir la Sierra and Boya 8. While fishing these areas, they often catch fish they cannot sell and for which they may be fined. Several species, such as barracuda, are candidates for ciguatera poisoning and, therefore, must be discarded. When these fishermen use longlines, they often catch sharks accidentally which must be discarded if they lack the proper permits. When certain snappers and groupers are harvested from relatively deep water (i.e., more than 20 fathoms) during months when they cannot be landed, these fish will oftentimes die after they are discarded. Although many fishermen consider this a wasteful practice, they must comply or run the risk of being fined.

Mayaguez

Mayaguez is the second largest metropolitan area in Puerto Rico. Mayaguez is the center of marine science and, therefore, quite important to Puerto Rico's fisheries. It is the location of the DNER Offices and the University of Puerto Rico (UPR), Recinto Universitario Mayaguez (RUM). The university is home to the UPR Sea Grant College Program, which has a marine advisory service, an active research program, and established relationships with research stations in Parguera and La Mona. In the past, Mayaguez was also home to several large tuna canneries near El Maní. Although the tuna canneries closed in the late 1990s and early 21st century after being in operation for nearly 40 years, Mayaguez still has three active fishing associations and an increasingly important recreational fishing sector. Located just to the north in Anasco is another small landing center, Tres Hermanos. Many residents commute from here to work in Mayaguez.

The municipality of Mayaguez has three significant commercial fishing centers, one active recreational fishing center, and several other locations where some fishermen store their small vessels and land their catch. Given its metropolitan nature and relatively large geographic size, Mayaguez is more economically diverse than many of the other, predominantly rural municipalities on Puerto Rico's west coast. In terms of employment, Mayaguez's manufacturing sector has become less important over the past decade while the retail sector has become relatively more important (see Table 4.3.15).

Table 4.3.15. Mayaguez Demographic Data*

MAYAGÜEZ	1950	1960	1970	1980	1990	2000
Population Characteristics						
Population [1]	87,307	83,850	85,857	96,193	100,371	98,434
Civilian Labor Force (CLF) [2]	27,906	22,968	24,289	29,512	34,549	29,691
CLF - Employed	26,631	21,488	23,142	25,101	27,615	22,867
CLF - Unemployed	1275	1480	1,147	4,411	6,934	6,824
Percent of unemployed persons	4.57	6.44	4.72	14.95	20.07	22.98
Industry of employed persons [3]						
Agriculture, forestry, fishing and mining [4]		2,640	1,007	593	451	260
Construction		1,848	2,163	1,483	1,780	1,615
Manufacturing		5,384	6,456	6,659	6,738	3,982
Retail trade		3,212	3,786	3,757	4,361	3,401
Socioeconomic Characteristics						
Mean travel time to work (minutes) [5]		N/A	N/A	N/A	18.8	22.9
Persons who work in area of residence [6]		19,248	19,172	19,048	23,933	18,167
Per capita Income (dollars) [7]			1,007	2,313	4,380	8,003
Median Household Income (dollars) [8]		1,062	2,354	5,533	8,007	11,775
Individuals below poverty level [9]			53,425	54,240	57,902	50,805
Percent of Individuals below poverty level			62.23	56.39	57.69	51.61

*(Griffith et al., 2007): 222

Relative to manufacturing and retail, commercial fishing plays a relatively minor role in the local economy at present. However, as recently as several years ago, the tuna canneries employed several hundred workers, far below the 3,000 to 4,000 workers employed historically. Upon the closing of the tuna canneries, most of the former workers found work in the underground economy, entered the ranks of the unemployed, or migrated to the U.S. mainland. Mayaguez's commercial fishermen employ many types of gear, but primarily rely on hook and line gear, locally referred to as "cordel."

On the northern edge of the city of Mayaguez lies one of the primary landing centers, El Seco, which adjoins a long strip of road that follows the curve of the bay past a housing project called "Concordo." A few fishermen clubs are located at the north end of the road nearest the housing project. Among the area's attractions is a large anchor. According to the Corporation for the Development of the West, this 300-year-old anchor was placed in this location with the aid of three fishing families, two of which have the last name of a famous fishing/ maritime family in this area.

> This anchor is significant in a metaphorical sense: the anchor and the festival of the Virgen del Carmen are reflections of one another. The festival is one way of anchoring the fishing community to the larger community/coastal barrios of Mayaqüez, with the anchor there to suggest that however much fishing families may be drifting about in a sea of regulations, alternative employment opportunities, trends in seafood markets, and so forth, they are still bound to this place, this location, and they have this three-hundred year-old artifact of maritime trades and this annual rite of intensification (the festival) to prove it. (Griffith et al., 2007: 224-225)

Along with a restaurant and bar, a stand where cooked seafood is sold, and the typical lockers, numerous small boats can be found at El Seco, on the south end of Calle Carmen. Another group of boats is located at the north end. As a result of its public beach lined with picnic pavilions, and its proximity to the city of Mayaguez and significant marine recreational infrastructure, El Seco has close ties to the recreational fishing sector as well.

Every Sunday in July following the day of the Virgen del Carmen (Virgen of Carmen), the patron saint of fishermen, the relationship between commercial fishermen and the community, including the recreational sector, becomes apparent. It is through this festival that commercial fishermen display their moral claim over the region's marine resources, while also expressing their commitment to commercial fishing to the community at large. Similar celebrations and processions occur at all the landing centers and communities where commercial fishing is important, even those where full-time commercial fishing has become less economically important. The Celebration of the Virgen of Carmen is a culturally significant event.

> Through events of this nature, the community/parcelas/neighborhood immediately adjacent to fishing centers, along with others from deeper inside the Puerto Rican interior, from Mayaguez and other municipalities, embrace while appropriating the fishing identity just as the fishing families embrace while appropriating the community as part of its being, its identity, and, most importantly, the seat of its soul, where the little chapel that houses the Virgin all year stands. In this way, the two become intertwined in a way, for a moment at least, that makes them difficult to extract from one another. How to sustain this over the course of the year is something left up to the markets, but this event is not without its economic significance. In a time when much is being lost, when poverty and unemployment are high, events of this nature may enable some jump-starting of economic processes. (Griffith et al., 2007: 227)

Anasco

As previously noted, Anasco lies to the north of Mayaguez and is home to a small landing center called Tres Hermanos (Three Brothers). Tres Hermanos is the only landing center in Anasco and is part of the larger community of La Playa. It adjoins a long public beach which has basically been closed to the public with the exception of the local fishing association's entrance. The association's ramp and adjacent wooden pier are used by commercial, subsistence and recreational fishermen.

Table 4.3.16. Anasco Demographic Data*

AÑASCO	1950	1960	1970	1980	1990	2000
Population Characteristics						
Population [1]	17,235	17,200	19,416	23,274	25,234	28,348
Civilian Labor Force (CLF) [2]	5,472	4,176	4,758	6,508	9,056	8,922
CLF - Employed	5,363	4,044	4,425	5,696	7,269	6,808
CLF - Unemployed	109	132	333	812	1,787	2,114
Percent of unemployed persons	1.99	3.16	7.00	12.48	19.73	23.69
Industry of employed persons [3]						
Agriculture, forestry, fishing and mining [4]		1,952	747	420	364	142
Construction		248	475	453	474	706
Manufacturing		1,024	1,580	2,283	3,256	2,173
Retail trade		284	416	575	746	541
Socioeconomic Characteristics						
Mean travel time to work (minutes) [5]		N/A	N/A	N/A	18.9	24.7
Persons who work in area of residence [6]		2,948	2,074	2,506	3,978	3,214
Per capita Income (dollars) [7]			641	1,711	3,289	6,613
Median Household Income (dollars) [8]		615	2,050	5,199	8,776	12,620
Individuals below poverty level [9]			14,776	15,260	15,531	14,611
Percent of Individuals below poverty level			76.10	65.57	61.55	51.54

*(Griffith et al., 2007): 232

Anasco has apparently not benefited economically as a result its proximity to the city of Mayaguez. Anasco is a smaller municipality than either Mayaguez or Aguada, the municipality to the north, in terms of population and also has a relatively higher unemployment rate (see Table 4.3.16). Similar to the other west coast municipalities, Anasco's unemployment rate has increased over the past decade while its poverty rate, which still remains relatively high, has declined.

Members of the Tres Hermanos fishing association operate several small businesses and other nearby organizations, including a Seventh-day Adventist Church, two bakeries, a small grocery store, rental apartments, a gas station, a school, a laboratory, and two beauty shops. Along the shore to the south of Tres Hermanos is another small area called El Puente (the bridge). This area is characterized by a few large summer houses, another small grocery store, a Club Nautico founded in 1993 that rents out its facilities, trailers, and a small cluster of wooden buildings that also rent to tourists or others. El Puente and Tres Hermanos represent the majority of Anasco's coastal population.

According to local fishermen, the quality of water and mix of fish species in local waters has been altered by recent declines in sugar cane production. As a result, these fishermen have changed the mix of fishing gears they employ. Previously, these fishermen used beach seines to harvest fish at the mouth of the river and farther upstream. However, this approach is no longer feasible due to the increased density of sea grasses. In order to avoid this problem, some fishermen have switched to traps. However, in general, various types of hook and line gear remain more popular than traps with the local fishermen.
There are conflicting reports about the number of active commercial fishermen that sell their catch to the local fishing association, with estimates ranging between four and ten. Regardless, the full-time commercial fishermen who sell to the association target lobster, snook, and snappers, and also tend to be younger, typically in their early twenties, than the part-time fishermen. Some local fishermen report that, since the large parking area and ramp can accommodate several trailered vessels, some vessels that land in Anasco come from as far away as Rincon and Cabo Rojo.

According to Griffith et al. (2007), in addition to the previously mentioned amenities, the Tres Hermanos association's facilities also include a small boat storage area and metal lockers. Built with corrugated metal and wood, the lockers are quite different from those of other associations. Relative to newer and more modern facilities located at other associations, such as Crash Boat in Aguadilla, the facilities at Tres Hermanos appear to be of lesser quality. The poorer condition of the local facilities could reflect the association's lack of political power.

Some interviews conducted by Griffith et al. (2007) indicated that the local association was in a weakened political state. However, other reports indicated that the situation was reflective of a change in the use of marine resources by the local community. Specifically, the nature of the local fishing activity has been changing from primarily commercial to mixed-purpose (i.e., a combination of commercial, recreational, and subsistence fishing with other types of seasonal activities). Some locals indicated that the area was becoming a more popular recreational fishing site, partly as a result of some fishermen shifting to tourist-driven fishing activities (e.g., taking tourists to La Mona). Given the presence of more summer and rental housing in the area, as well as other amenities such as the public beach, and the popularity of certain seafood restaurants during the summer tourist season, it is likely that Anasco is becoming more closely associated with the recreational sector. In fact, local government officials have been promoting this image to potential tourists and spent more than $2 million on a project to enhance the public beach, which allegedly created 30 new jobs.

Rincon

Rincon's investment in its fisheries and recent expansion of its commercial fishing fleet is unique among the west coast's municipalities. Rincon's fishermen have attempted to become the most professional deep water fishing fleet on the west coast by prosecuting the waters between Rincon's coast and La Mona. These fishermen are politically involved and inventive with respect to their fishing methods.

Even though Rincon is ranked relatively high in terms of commercial landings and dependency on commercial fishing, it is better known as a surfing than a fishing location given the fact that it extends out from the rest of the coastline. Still, one of the Rincon fishing association's members has previous experience as a member of the Caribbean Fishery Management Council. And, more importantly, unlike in other municipalities, the economic importance of commercial fishing in Rincon appears to have increased in recent years.

Table 4.3.17. Rincon Demographic Data*

RINCÓN	1950	1960	1970	1980	1990	2000
Population Characteristics						
Population [1]	9,888	8,706	9,094	11,788	12,213	14,767
Civilian Labor Force (CLF) [2]	3,100	1,924	2,222	2,918	4,125	4,321
CLF - Employed	3,073	1,852	2,156	2,251	3,277	3,372
CLF - Unemployed	27	72	66	667	848	949
Percent of unemployed persons	0.87	3.74	2.97	22.86	20.56	21.96
Industry of employed persons [3]						
Agriculture, forestry, fishing and mining [4]		956	405	100	80	58
Construction		96	245	180	363	394
Manufacturing		308	720	758	916	607
Retail trade		168	185	279	381	353
Socioeconomic Characteristics						
Mean travel time to work (minutes) [5]		N/A	N/A	N/A	20.1	25.2
Persons who work in area of residence [6]		1,520	1,461	1,299	1,956	1,627
Per capita Income (dollars) [7]			570	1,323	3,166	6,610
Median Household Income (dollars) [8]		598	1,451	3,277	7,293	11,460
Individuals below poverty level [9]			7,549	9,071	8,483	8,301
Percent of Individuals below poverty level			83.01	76.95	69.46	56.21

*(Griffith et al., 2007): 239

Rincon is a small municipality in terms of population and physical size. At present, some of Puerto Rico's wealthiest and most famous citizens consider it a highly desirable place to live. Several coastal real estate projects have led to increases in the demand for sand and increases in construction employment over the past decade. Even though the mining of sand from littoral and marine areas created considerable problems for one of Rincon's formerly most heavily used marinas, the mining of sand from former sugar cane fields is currently occurring. With the exception of construction, employment in all other sectors has declined over the past decade (see Table 4.3.17). It is highly likely that most of the few jobs that remain in agriculture, forestry, fishing, and mining represent employment in commercial fishing.

As Rincon became less dependent on agriculture through the latter part of the 20th century, tourism, which is economically linked to fishing, became increasingly important to the local economy. In combination with tourism, the construction of luxury, seaside homes has been a driving force within Rincon's economy in recent years, with former sugar properties now being mined for sand for the construction industry.

As a result of the peviously discussed change in the fishing patterns of Cabo Rojo's fishermen, Rincon's fishermen have taken advantage by fishing in waters off their coast more heavily. The waters off Rincon drop off relatively quickly, and thus the waters prosecuted by Rincon's fishermen in a corridor from the shore to La Mona, passing Desecheo, are all deep water. High value, deep water snapper and grouper species are the primary targets in these waters.

Rincon's fishermen are known for their high level of cooperation. Rincon's fishermen benefit each other by pooling their different sets of fishing skills. They have also been known to provide financial assistance to each other in cases of a family emergency. Rincon's fishermen will also work cooperatively with fishermen from municipalities, as in situations when they have more fish than they can sell and barter those fish in exchange for bait from other fishermen. They also have built goodwill with non-fishermen in the local community by giving away small fish. The creation of such goodwill serves to enhance their reputation in the community, which in turn improves their position within the local political power structure.

Rincon has two commercial fishing associations or "unions" comprised of 15 captains and 10 captains respectively. Because each captain uses a single crewman or helper, an estimated 50 full-time commercial fishermen belong to these two associations. Ten additional fishermen specialize in harvesting lobster. All members sell their catch through the association. In turn, the association sells this catch to local seafood places along the west coast, including Las Brisas in Puerto Real. The local community has supported its commercial fishermen by purchasing modern boats and allowing them to be used under a set of specific conditions, such as keeping the boats properly maintained, using them solely for legal purposes (as opposed to running drugs), and maintaining accurate records of all their landings. Due to problems with the existing ramp, local government leaders are also attempting to open a new marina for the commercial fishermen's use.

The proficiency with which their vessels are operated is reflective of Rincon's commercial fishermen's attempts to "professionalize" their fishery. The fishing associations' leaders indicate that accurate record-keeping is important to them insofar as those records legitimize the fishery's operations and help them gain access to various sources of financial capital (e.g. bank loans and the Bona Fide program). In effect, the fishing associations operate like corporations, as they are responsible for maintaining accurate landing and financial records and issue checks to member fishermen in exchange for their catch. Most of Rincon's commercial fishermen believe that the costs of maintaining accurate financial records are outweighed by the benefits. However, some fishermen remain concerned that, if they maintain proper records, they will end up paying higher taxes or lose public assistance payments and, as a result, be economically worse off.

A young fisherman in Rincon must typically have at least 10-15 years of fishing experience before he can obtain his own boat. During the time he is acting as a crewman or helper, the younger fisherman is considered a type apprentice. By putting the younger fishermen through this rite of passage, the more established, experienced fishermen are ensuring that the occupation of commercial fisherman is being handed down to individuals capable of maintaining the professional standards they have worked hard to establish. Once a new fisherman obtains a boat, particularly if it has been acquired under contract with the municipality, he can use the boat as leverage (i.e. collateral) to obtain access to additional financial capital.

Rincon's fishermen have attempted to professionalize their fishery further by emphasizing the need to supply high quality seafood to their primary customers (i.e. local seafood restaurants). According to these fishermen, they have focused on selling to the "local" (i.e., west coast) seafood restaurants because these places are dependent on the business of return customers. Customers will return only if they are provided with high quality, "fresh" (i.e., local) seafood. The fishermen believe that these local seafood places have become critical to the local communities, both economically and culturally. Conversely, these fishermen maintain that Rincon's hotels are not dependent on return customers to their restaurants, but rather emphasize the value and high quality of their rooms. As such, the hotel restaurants primarily rely on lower quality, imported seafood. Association leaders estimate that approximately 90% of their seafood is sold outside of Rincon.

Although the vast majority of Rincon's full-time commercial fishermen belong to one of the two fishing associations, some local fishermen are not members. In general, these fishermen are part-timers that sell to dealers in other municipalities on an irregular basis. According to Griffith et al. (2007), these fishermen are not as concerned with providing high-quality seafood to their customers as the full-time fishermen.

Most of the associations' fishermen live in Parcela Estela, which is adjacent to the waterfront. Most of these fishermen used to live directly on the water, but have since begun renting out their beach properties to tourists or sold their property to wealthier individuals. Some remain living on the waterfront, which may work to their long-term economic advantage, though these fishermen report that the wealthy people do not appreciate their presence. One association leader stated: "We have a saying…they like the bird cage, they just don't like the birds" (Griffith et al., 2007: 245)

As in Cabo Rojo, many large and expensive construction projects have taken place in Rincon, leading to considerable gentrification. Many individuals from the U.S. mainland have purchased waterfront homes and converted them into guesthouses. In some cases, these people are very wealthy and famous (e.g., Steve Forbes). Some Colombians also purchased a Heinz mansion and its grounds for more than $3 million, and have plans to build small villas around the mansion and two large high-rise condominiums as well. On the other hand, the attraction of Rincon to surfers, who tend to be younger, socially active, though not particularly wealthy, has added a completely different aspect to its socio-cultural identity.

As previously noted, the gentrification resulting from the new construction has led to an increase in the demand for sand. This increase in the demand for sand has been primarily met by a shift in the use of land from sugar cane production to sand mining. The higher demand for sand also provided the owner of the former marina with an incentive to dredge out the nearby sand. However, the dredging process caused the marina's entrance to become clogged thereby rendering it unusable and unsalable.

Rincon's fishermen "can make up to $1,000 per day in fish sales, which is good for the local economy" (Griffith et al., 2007: 245). But, due to seasonal fluctuations, they more typically "make an average of around $20,000 per year, contributing as much as $500,000 to the local economy. The association also has a little chapel where they keep the Virgen. They take her out onto the water for the July celebration" (Griffith et al., 2007: 245).[11]

Rincon's commercial fishermen have considerable issues with the recreational sector. For example, they believe that, at most, there are approximately 2,500 commercial fishermen in Puerto Rico. Conversely, they maintain that there are at least 100 times as many recreational fishermen (i.e., 250,000) and that they are responsible for at least half of the catch. The commercial fishermen think that recreational bag limits need to be established for more species and the current recreational bag limits are generally too high. For example, commercial fishermen believe that the current bag limits of five fish per fisherman for dolphin, king mackerel, and wahoo are too high. Commercial fishermen further claim that the recreational fishermen's ability to catch fish far outweighs their need because they have superior boats and considerably more money at their disposal. Furthermore, they claim that the recreational fishermen often sell their catch to local restaurant owners, in order to cover their trip expenses, which increases the supply of local fish and depresses the price that commercial fishermen receive for their catch. According to Griffith et al. (2007), the commercial fishermen refer to this as "market destruction."

Gear use by Rincon commercial fishermen varies throughout the year according to sea conditions. When sea conditions are calm, the commercial fishermen employ bottom lines. However, when the water becomes too rough, they use longline gear.[12] During hurricane season, they leave earlier in the morning while the sea is still calm, fish closer to shore (for safety reasons), and typically return to port earlier in the day. Also, commercial fishermen must abide by a variety of time and area closures throughout the

[11] Griffith et al's estimate of $500,000 is very close to the estimates provided in Table 5.3.9, assuming they are estimating gross ex-vessel revenue. However, their estimate of $20,000 per fisherman on average is considerably higher than the estimates in Table 5.3.10, though it is unclear whether they are estimating gross revenue or net revenue (i.e. take-home income). There does appear to be an inconsistency in Griffith's estimates given that they reported 50 full-time fishermen each earning an average of $20,000, which would lead to an estimate of $1 million rather than $500,000 in gross revenue.

[12] Trip ticket data does not suggest that longline gear is used much if at all by Rincon's commercial fishermen.

year, the primary purpose of which is to protect snapper-grouper species and queen conch when they are spawning. The closure for certain deep water snappers was negotiated with the commercial fishermen in order to overlap with months during which the weather and seas were not conducive to fishing.

Some of Rincon's fishermen believe that reef fishing should no longer be practiced, and that the reefs need to be protected in order to support local tourism. At least one local industry spokesperson has also advocated for a change from 2-cycle to 4-cycle engines as they generate less pollution. These attitudes imply a change in fishermen's environmental ethic. Some fishermen have also pointed out that the growth of the hotel industry may be harmful for certain local environments as their sewage is oftentimes flushed into the estuaries, altering the salinity levels, which in turn changes the mix of species in local waters. The water quality problem is exacerbated in areas where the water is shallow and there has also been an increase in the number of marinas. According to some fishermen, the growth in marinas has damaged local fish populations and led to increased marine traffic problems.

Aguada

Aguada is located on the northwest coast between Rincon and Aguadilla. With a population of more than 40,000 people, the structure of Aguada's economy has changed significantly over the past few decades. Some of these changes are illustrated in Table 4.3.18.

As in other west coast municipalities, Aguada's recent economic performance has been mixed. For example, over the past half-century, the unemployment rate has increased by more than ten-fold, with most of that increase occurring in the 1970's (see Table 4.3.18). Particularly significant were the job losses in agriculture, forestry, and fisheries. Conversely, the percentage of persons living below the poverty line has decreased significantly. The expansion of government transfer payments likely explains why the rate of poverty declined while unemployment increased. Aguada's population basically doubled over the last half of the 20th century, with a significant part of that increase (16%) occurring in the last decade. While manufacturing jobs declined by a similar rate during this same time, per capita income rose dramatically (by 103%). Factors contributing to this increase in incomes are varied. Gentrification may have played a role. For example, very wealthy individuals have moved into the coastal areas, thereby raising average income for the municipality as a whole. Construction employment has increased, and these jobs typically pay relatively well compared to jobs in agriculture and fishing. People may also be earning income from a variety of sources, such as pensions and investments in the case of retirees who have moved here from the U.S. mainland, or informal economic activities. In this type of economic environment, fishing may be a source of high quality food and sporadic income, particularly for those who are unemployed.

Table 4.3.18. Aguada Demographic Data*

AGUADA	1950	1960	1970	1980	1990	2000
Population Characteristics						
Population [1]	20,743	23,234	25,658	31,567	35,911	42,042
Civilian Labor Force (CLF) [2]	6,633	4,648	4,397	7,702	12,092	12,521
CLF - Employed	6,546	4,464	4,132	6,024	9,359	9,755
CLF - Unemployed	87	184	265	1,678	2,733	2,766
Percent of unemployed persons	1.31	3.96	6.03	21.79	22.60	22.09
Industry of employed persons [3]						
Agriculture, forestry, fishing and mining [4]		2,040	865	343	303	160
Construction		304	493	604	579	1,018
Manufacturing		788	846	1,929	2,914	2,442
Retail trade		380	529	740	1,535	1,183
Socioeconomic Characteristics						
Mean travel time to work (minutes) [5]		N/A	N/A	N/A	17.8	23.6
Persons who work in area of residence [6]		3,636	2,750	3,902	5,323	4,684
Per capita Income (dollars) [7]			524	1,378	2,993	6,100
Median Household Income (dollars) [8]		574	1,535	4,147	7,404	11,384
Individuals below poverty level [9]			21,478	24,175	25,004	24,880
Percent of Individuals below poverty level			83.71	76.58	69.63	59.18

*(Griffith et al., 2007): 251

Aguada is home to "several unlicensed, unaffiliated, and more or less independent fishers who fish part-time, either by themselves or in pairs," (Griffith et al., 2007: 251) who have likely not been counted in the fisherman Census. There is also one fishing association in Espinar whose relationships throughout the seafood marketing and distribution chain are known to be extensive. However, one local political official claims that the fishing association primarily exists in name only, and that its facilities are currently being used as a private fish market. While this official believes the local fishermen are well-organized, this occurs outside of the association's structure. The nature of Aguada's coastline has allegedly inhibited the development of a large, well-developed fishing fleet. Though attractive to surfers, the heavy surf that pounds the beach makes it difficult for fishermen to land their fish. There are no highly sheltered bays in the vicinity, and the pier near the Espinar fishing association is scarcely used and in disrepair.

Aguada's commercial fishermen target snook, pelagics, and deep water snapper-grouper species using a variety of gears, including, in order of importance, lines (particularly handlines), nets, and traps. According to Griffith et al. (2007), although lobster can be found in the local seafood markets, Aguada's fishermen are not divers nor do they use their traps to harvest lobster. Again, the nature of Aguada's coastline and associated heavy surf may preclude the setting and checking of traps in nearshore waters. It is, therefore, likely that fishermen from outside of Aguada are the source of lobster supplies in the local seafood markets.

The Espinar fishing association lies between the water and a group of seafood restaurants on the northwest edge of the city of Aguada, the municipality's primary community. Even though the association's facilities are comparable to those found in other municipalities, the association is more of a family-operated, private fish market than a fisherman's cooperative. Unlike other fishing associations, it receives little or no financial assistance from the government. There are approximately 30 members of the association. The members are simply those individuals who sell their catch to the association on a regular basis. In fact, selling to the association is a condition of membership. Only members are granted access to the association's facilities (e.g. lockers, freezers, etc.). The market is staffed on a daily basis by the association president, who also serves as the fish merchant. The market has two freezers, the contents of which are separated according to the manner in which the fish were harvested (i.e., one freezer contains fish harvested using lines, such as dolphin, kingfish, tuna, and silk snapper, and one contains fish harvested using traps, mainly lobster).

The seafood restaurants in Espinar serve octopus, conch, land crab, trunkfish, kingfish, and a variety of other fish species. Most of the restaurants and fish markets are only open on the weekends, with only two restaurants open during the week. Espinar is heavily dependent on the association's facilities, its fish markets, and seafood restaurants. If Aguada has a "fishing community," Espinar would be that place. Espinar also has several small food stores, three churches, a service station, a school, bakery, and a Head Start center. Recreational fishermen were attempting to establish a Club Nautico in 2007, which would potentially increase Espinar's dependence on fishing and fishing related activities.

The fish market's owner has created a highly complex seafood exchange operation that reaches across several municipalities. Because its members come not only from Aguada, but also Mayaguez, Aguadilla, and Rincon, the association buys and sells seafood with many individuals and business entities outside of Aguada. This exchange of seafood creates income and employment for families and neighborhoods across multiple municipalities. Although the association is composed of approximately 30 fishermen, only six fishermen supply the market with fish on a full-time basis. Most of these are fishermen from Rincon who use relatively larger (greater than 20 ft in length) vessels that operate in the Mona Passage to as far away as the Dominican Republic in order to target deep water snapper-grouper and lobster. Approximately 21-24 local fishermen from Aguada are the primary suppliers of pelagic species, such as tuna and king mackerel. Fishermen from other municipalities, such as Mayaguez (El Mani in particular) and Anasco supply the market with fish on a more irregular basis. These fish are then sold to a variety of seafood marketing outlets across the island. For example, the market owner commonly sells fish to three seafood restaurants in Cabo Rojo, a dealer in Isabela, several buyers in Tamarindo and Higuey, Aguadilla, and multiple street vendors in Aguada, Rincon, San Sebastien, Aguadilla, and Dorado (near San Juan).

In addition to the fishermen who supply the fish market, a small group of independent net fishers operate out of Espinar as well. Some of these individuals also work as street vendors. That is, they not only harvest their own fish, but also sell it, typically from the back of their trucks and cars. Some of the other independent fishermen sell to other seafood buyers not affiliated with the association. A few fishermen do not sell their fish at all and instead use it for personal consumption (i.e. subsistence).

Espinar's fishing association is part of a larger community, which includes a business district that is in turn adjacent to a private recreational area near the Rio Culebrinas. Several wealthy families from outside of the local community have settled along this latter area, including the owner of one of the largest transportation lines in western Puerto Rico. As previously noted, recreational fishermen are attempting to establish a Club Nautico near the fishing association. These are the first signs of gentrification in the area. Opposition to the Club Nautico has surfaced based on environmental concerns, including but not limited to the fact that the shore area is critical habitat for both manatees and land crabs.

In addition to Espinar, a number of independent fishermen live and operate out of a neighborhood across from the beach just to the south of Espinar. Due to the high wave action, these fishermen primarily use beach seines and operate from relatively small 18-20 foot boats. Some of these fishermen store their boats and fishing gear in their back yards, while others tie up near a small municipal gazebo. According to Griffith et al. (2007), all of these fishermen are unlicensed and operate on a part-time basis. In general, these fishermen work together, fishing in groups, but only on weekends. They claim that they must work other jobs during the week and only fish on the weekends because it is impossible to earn a living from fishing commercially on a full-time basis. Further, these fishermen claim that Aguada has many fishermen like themselves.

Aguadilla

The changes in Aguadilla's economic structure in recent decades are comparable to those experienced in Aguada. For example, though the percentage of people living under the poverty line has decreased, unemployment has risen significantly (see Table 4.3.19). Further, as in the other west coast municipalities, the decrease in the number of people employed in agriculture, forestry, and fisheries since 1960 has fallen precipitously (more than 90%). Although some of the displaced workers were originally able to find employment in the expanding construction and manufacturing sectors, the latter has contracted during the past decade as the result of expiring tax breaks under the "936" laws. Commuting to and from work has also become an increasingly frequent problem for many workers. Specifically, transiting time and the associated costs have increased as workers have had to seek out jobs farther away from their homes. Further, according to Griffith et al. (2007), some people have avoided taking night jobs or night classes as they have become fearful of traveling through dangerous neighborhoods at night. Based on their interviews with fishermen, they also report that a high percentage (45%) work in the construction industry. However, more than half (54%) still rely on commercial fishing as their primary source of income and many are of the belief that they could not find employment outside of fishing.

Table 4.3.19. Aguadilla Demographic Data*

AGUADILLA	1950	1960	1970	1980	1990	2000
Population Characteristics						
Population [1]	44,357	47,864	51,355	54,606	59,335	64,685
Civilian Labor Force (CLF) [2]	11,332	9,564	10,647	14,229	18,576	18,890
CLF - Employed	10,676	8,620	9,876	11,062	13,427	14,108
CLF - Unemployed	656	944	771	3,167	5,149	4,782
Percent of unemployed persons	5.79	9.87	7.24	22.26	27.72	25.31
Industry of employed persons [3]						
Agriculture, forestry, fishing and mining [4]		1,876	978	212	297	177
Construction		704	811	787	689	1,105
Manufacturing		864	1,482	3,063	3,004	2,770
Retail trade		1,496	1,856	1,395	2,271	1,490
Socioeconomic Characteristics						
Mean travel time to work (minutes) [5]		N/A	N/A	N/A	17.7	23.8
Persons who work in area of residence [6]		9,972	10,259	8,286	10,684	11,120
Per capita Income (dollars) [7]			992	1,803	3,722	6,996
Median Household Income (dollars) [8]		1,291	2,360	4,430	7,116	11,476
Individuals below poverty level [9]			32,740	36,033	38,109	35,027
Percent of Individuals below poverty level			63.75	65.99	64.23	54.15

*(Griffith et al., 2007): 260

One of the most politically active, organized, equipped, and largest fishing associations in Puerto Rico, Crash Boat, is located in Aguadilla. Its president is an accomplished, artisanal boat builder who has been supplying local fishermen with unique vessels for some time. Aguadilla’s fishermen have often served as political advocates for fishermen across the island. In the late 1980’s, these fishermen were highly active in the fight to prevent the creation of a marine sanctuary in Parguera (Valdes-Pizzini 1990; Griffith and Valdes 2002).

The fishing association in Crash Boat lies on a long beach, bordered by tourist and recreational infrastructure. A large pier currently used by bathers, though not by the association, was previously used to service oil tankers. In the parking lot next to the association is a small bar that operates through the week and a small food truck/cart that typically operates on weekends. The association occupies approximately 9,000 square feet.

The association president builds his boats with:

> An upward-sweeping, pointed hull that is perfect for the way they land their vessels here: running them up onto the beach. These designs differ from those farther south, around Parguera, where the front end is less pointed. Beaching a boat, Aguadilla fishers cruise parallel to the shore behind the wave line, then make a quick turn toward shore and run the boat up onto the beach. Several people (usually 3-4) greet the boat, mostly younger men who have been hanging

> around the association, but old men as well, and they help carry the plastic gas tanks, the gear, and the motor, hoisting their 40 hp Johnson outboards onto their shoulders to carry to the lockers. Landing the day's catch thus becomes a group rather than individual effort. (Griffith et al., 2007: 262)

The boats used by Crash Boat's fishermen are typically 18 ft in length, made from wood with a protective fiberglass coating, freshly painted, are well-maintained, and stored on the beach. The fleet's excellent condition is likely a reflection of the association president's boat building and maintenance skills. When a fisherman lands his catch, he typically stores it in black boxes comparable to Tupperware® tubs which are then carried to the association. The association has modern freezer facilities, lockers, and an area to clean fish. The cleaning area has a hose, sinks, and a band saw to cut larger fish such as yellowfin tuna. Fish are sold in a well-kept and air-conditioned market area in front of the cleaning area.

The fishing association in Crash Boat is the largest in the municipality. Because it buys fish from members and non-members, the number of fishermen who sell to the association is larger than its membership. However, although non-members can sell to the association, only members can use its facilities. Further, members can rely on the association's political support in their battles against economic developments and fishery regulations they consider undesirable.

Although Crash Boat's fishermen primarily target deepwater snapper, such as silk snapper, they also target various HMS/pelagic species such as yellowfin tuna, skipjack tuna, and dolphin. Like the fishermen in Aguada, these fishermen are not divers and, instead, primarily rely on a variety of hook and line gears, particularly hand lines and troll lines. A relatively high percentage of these fishermen do not sell their catch and, thus, apparently fish for subsistence purposes.

Aguadilla has two other fishing associations, Higuey and El Tamarindo, both of which are located near downtown Aguadilla's waterfront area. These associations are not nearly as socially or economically significant as Crash Boat's. Because Griffith et al. (2007) were not able to conduct any interviews with members of these two associations, Wilson et al. (1998) is the most recent source of fieldwork information on these associations. At the time Wilson et al. (1998) conducted their research, the Higuey association had 19 members and another five independent fishermen that sold their harvests to the association. Wilson et al. (1998) did not report how many fishermen belonged to the El Tamarindo association. However, their research indicated that these two associations were both in decline at the time, though the reasons for this decline were not apparent. Wilson, et al. reported that local government officials did not consider commercial fishing an important part of the local economy. They also reported that commercial fishermen thought the local government was attempting to force them out of the area by developing a marina near their facilities as part of an effort to develop a port. However, the effort was apparently unsuccessful. As a result of this project, sand was redistributed away from Higuey's beach to El Tamarindo's beach, which caused the waterway to be blocked, preventing large ships from entering.

Wilson et al. (1998) also indicated that Higuey's commercial fishermen in particular held a great deal of mistrust towards fishery regulators and regulations. These commercial fishermen believed that the regulators were biased in favor of recreational fishermen who operate from the Club Nauticos and target blue marlin and other sport game fish in various fishing tournaments. The commercial fishermen claimed that as many as 200 marlin were harvested at each tournament, many of which were allegedly sold on the black market. These commercial fishermen also had concerns with younger fishermen involved in the aquarium/ornamental fish industry, claiming that they were harvesting too many of these fish from the local reefs using toxic or otherwise harmful liquid solutions.

At the time, the local commercial fishermen's primary concern was with longline fishermen that had arrived from the U.S. mainland to harvest HMS/pelagic species, particularly tunas. Although they claimed to have filed many complaints with DNER officials, no action was allegedly taken at the time. As a result, they reportedly dealt with the situation on their own by cutting the longline fishermen's lines at night, an action reflecting their willingness to actively protect their fishing and economic interests.

5.0 ENVIRONMENTAL CONSEQUENCES

5.1 Action 1: Modify the closed season for Bajo de Sico

The Bajo de Sico area closure was first implemented as a means to protect spawning aggregations of red hind. All reef fish species differ in their vulnerability to fishing, the most vulnerable species undoubtedly include the hinds and groupers (Munro, 2006). Red hind (as well as Nassau grouper) are extremely vulnerable to overfishing due to a combination of life history traits typical in large serranid fish of the genera *Epinephelus and Mycteroperca* (Frias-Torres 2008). These traits are slow growth, long life, late sexual maturity, strong site fidelity, and formation of spawning aggregations (Levin and Grimes 2002). Species that aggregate to spawn are extremely vulnerable to overfishing and it is clear that the survival of some stocks of hinds and groupers will depend on the creation of fishery reserves, preferably that include spawning aggregation sites and are of sufficient size to encompass the home range and depth range of much of the local stock (Munro, 2006).

The use of marine reserves or protected areas has been advocated as a cost-effective strategy to protect critical spawning-stock biomass to ensure recruitment supply to fished areas via larval dispersal, and possible maintenance or enhancement of yields in areas adjacent to reserves by adult movements (Alcala and Russ 1990, Bohnsack 1990, 1993, Roberts and Polunin 1991, 1993, Dugan and Davis 1993, Russ et al. 1993). While outmigration from a reserve might have some impact on harvests in adjacent areas, the increased spawning stock biomasses within the reserve are of overwhelming importance (Munro, 2006). Recruitment rates will be determined by spawning stock biomasses, events in the pelagic phase, and post-settlement dynamics. Of these factors, only the maintenance of spawning stock biomasses at prudent levels and protection of nursery areas are realistically within the control of fishery managers (Munro, 2006).

Russ and Alcala (1996) found density of large predatory fish to be an excellent indicator of the effects of marine reserve protection and fishing. They found significant increases of the abundance and size of such species in response to marine reserve protection and substantial decreases of thes factors when reserves were opened to fishing, they show the recovery rates of density, and particularly biomass, are slow and that such recovery can be reversed quickly. The study also suggests that gains in density, and particularly biomass (assumed to be equivalent to spawning-stock biomass) of a magnitude potentially useful in fisheries management are likely to occur in reserves on scales of 5 - 10 years, rather than just a few years (Russ and Alcala 1996) or through seasonal closures.

5.1.1 Direct and Indirect Effects on the Physical, Biological, and Ecological Environments

Modifying the seasonal closure of Bajo de Sico is expected to benefit the physical, biological, and ecological environments. By reducing or eliminating fishing activities, less impact on the bottom habitat would be expected. In the Bajo de Sico area, scientists have recently described nearly pristine coral reef formations. Reducing gear interactions with the bottom would be expected to benefit these formations.

Alternative 1 would maintain the status quo. Bajo de Sico would remain closed to all fishing activitie from December 1 through the last day in February. Under the status quo, the potential to damage the coral reef populations from man's activity in this area would remain without further protections. These important coral habitats would be in danger of anchoring, entanglements, and other gear interactions. Maintaining the current regulations would not benefit the physical environment and may in fact lead to declines of the physical environment as important reef processes are interrupted due to intense fishing activities. The coral reef population's ability to survive and replenish degraded habitat may be unable to withstand interruptions in these processes. Without healthy coral populations, reef ecosystems may begin to decline, affecting EFH which ultimately impacts the biological and ecological environment by reducing biodiversity and limiting habitat.

Alternatives 2 (Preferred), **3**, and **4** will provide extended protection to the habitat not provided under the current regulations. Currently, diverse coral formations are found within Bajo de Sico and are threatened by the potential for gear or anchor interactions, including entanglements. Restricting fishers' ability to fish within Bajo de Sico will reduce the likelihood of gear interactions with the benthic habitat. The existing year round prohibitions on specific gears (pots, traps, bottom longline, gillnets, and trammel nets) also provide ample protection for the coral reefs, and the associated habitats. Gear used for HMS, pelagic species, and spiny lobster are not expected to pose a significant threat to the habitat because HMS and pelagic species are targeted higher in the water column. However, incidental catch of large individuals of snappers or groupers, possibly in or near spawning condition, could occur while fishing for pelagic (especially when planers or down-weights are used) and thus contribute to their mortality. Similarly, since traps and other bottom gear types are prohibited, any spiny lobster harvest will be done by hand and thus poses no threat to habitat.

Alternatives 2 (Preferred) and **3** would modify the seasonal closure of Bajo de Sico to six months. **Preferred Alternative 2** would modify the closure to October 1 through March 31 and **Alternative 3** would modify the closure to December 1 through May 31. **Alternative 4** would modify the seasonal closure to include a year-round closure of specified fishing activities. **Alternatives 2 (Preferred), 3,** and **4** would benefit the physical environment by decreasing gear and bottom interactions. **Alternative 4** would provide the greatest benefit (as compared to **Alternatives 1**, **2**, and **3**) to the physical environment because closing fishing for the entire year provides the least amount of time for fishing gear to damage important fish habitat. When compared to **Preferred Alternative 2**, **Alternative 3** would provide greater protection to the physical environment because **Preferred Alternative 2** prohibits fishing for and possession of reef fish during the time of year in which the weather consists of poor fishing conditions. During this time of year, fishers may not fish within Bajo de Sico as frequently due to weather constraints. **Alternative 3** would prohibit fishing for and possession of reef fish during better weather months, providing additional protection during months that are typically utilized in Bajo de Sico. Similarly, according to Griffith *et al* (2007), March through August are the busiest months for recreational fishing in Puerto Rico. **Alternative 3** would prohibit fishing for and possession of reef fish species for a portion of the busy recreational season, thus providing better protection to habitat as compared to **Preferred Alternative 2**.

Under **Preferred Alternative 2**, prohibiting fishing activities from October 1 through March 31 may result in a shift in effort to another time of the year, causing the extended protection to be less effective than expected.

Within all **Alternative 1** (No Action), **Sub-alternatives a-d** specify the various fishing activities that would be prohibited. **Sub-alternative a** would prohibit fishing for all species, including HMS. **Sub-alternative b** would prohibit fishing for and possession of all species. **Sub-alternative c** would prohibit fishing for Council-managed reef fish species and **Sub-alternative d** would prohibit fishing for and possession of Council-managed species. **Sub-alternatives a** and **b** would provide better protection to the physical environment than **Sub-alternatives c** and **d** because if all fishing activities are prohibited, there is less probability of gear interaction with habitat. **Sub-alternatives c** and **d** would still allow for some gear to be used in Bajo de Sico, potentially posing a risk to the habitat and an increase in incidental capture (increasing mortality) for some fish species. However, all bottom-tending gear will remain prohibited year-round and the Council heard testimony from fishers indicating fishing practices described for pelagic species and spiny lobster are not expected to present any threat to the coral reef resources or to other habitat structures.

The biological environment would benefit by providing extended protection to populations of commercially important snapper and grouper species. Within this coral reef habitat, large individuals of snapper and grouper have been identified, including one of the largest aggregations of federally protected Nassau groupers found on the west coast of Puerto Rico.

Additionally, the ecological environment is expected to benefit from a modified seasonal closure. Overfishing has been identified as one of the three most serious threats to coral reef ecosystems (Roberts 1993). Data on reef fishing reveals that: 1) it can lead to major direct and indirect shifts in community structure, both of fishes and of reef communities as a whole; 2) it reduces species diversity on reefs; 3) it can result in loss of keystone species, which in turn can lead to major effects on reef processes; and 4) it may lead to loss of entire function groups of species (Roberts 1995). Where fishing is of such intensity to cause such shifts, it has been termed "ecosystem overfishing" (Pauly 1988). A modified seasonal closure could help alleviate some of these problems identified with overfishing.

Alternative 1 would maintain the current three month seasonal closure from December 1 to February 28 to protect red hind; the current three month closure from October 1 to December 31 to protect black, blackfin, silk and vermilion snapper; the three month closure from February 1 to April 30 to protect red, black, yellowedge, and yellowfin grouper; and the three month closure from April 1 to June 30 to protect mutton and lane snapper, each year and the current year round bottom-gear restrictions. Without any additional regulations, no change in the biological environment would be expected. Under the status quo, the snapper and grouper populations would continue to be vulnerable to fishing mortality and bycatch mortality during the longer open seasons. **Alternatives 2 (Preferred), 3,** and **4** would benefit the biological and ecological environments by providing extended protection to important fish stocks. By limiting the fishing activities and prohibiting harvest of Council-managed reef fish, gear used to target such demersal species will be eliminated during the respective closures, thereby contributing to extended protection of fishes and habitat. Resticting fishing for a longer period, and thus eliminating use of such fishing gear will provide greater benefits to reef fish because the opportunity for being caught as bycatch will be greatly reduced. During this period, however, incidental catch of large individuals of snappers or groupers, possibly in or near spawning condition, could occur and thus contribute to their mortality. There are also a number of other seasonal closures that already prohibit harvesting certain species within federal waters which apply to the EEZ around Puerto Rico and the US Virgin Islands. Red, black, tiger, yellowfin, and yellowedge grouper are closed from February 1 through April 30 (50 CFR §622.33 (a)(4)). From October 1 through December 31, harvesting vermilion, black, silk, and blackfin snapper is prohibited (50 CFR §622.33 (a)(6)). Similarly, lane and mutton snapper are closed from April 1 through June 30 (50 CFR §622.33 (a)(7)). These closures protect various snapper and grouper species, so modifying the seasonal closure of Bajo de Sico would also benefit species not protected under the original seasonal closures (including, but not limited to, yellowmouth grouper, schoolmaster snapper, yellowtail snapper, cubera snapper, and dog snapper) as well as added protection for longer periods of the year for those protected by the other seasonal closures. The above mentioned species, while not observed in the García-Sais *et al*. (2007) report, occur in surrounding waters year round and are part of the commercial and recreational catch (Erdman, 1974; Boardman and Weiler, 1978; Kimmel, 1985).

Alternative 4 would provide the greatest protection to the biological and ecological environments by prohibiting specified fishing activities for the entire year.

Lane and mutton snapper is currently closed from April 1 through June 30 but **Preferred Alternative 2** will extend the time when fishing for those species is prohibited. In addition to the original closure, harvest of lane and mutton snapper will be prohibited from October 1 through March 31, creating a closure of October 1 through June 30 in Bajo de Sico. Similarly, **Preferred Alternative 2** coupled with the original closure for red, black, tiger, yellowfin, and yellowedge grouper would provide two more months of protection for those species (October and November), essentially prohibiting harvest from October 1 through April 30. These increased protections may increase the spawning stock biomass of the fish populations present as well as increase the percent cover of sessile invertebrates in the area creating a more diverse and healthier ecosystem.

Alternative 3 would extend the prohibition of black, blackfin, vermilion and silk snapper by five months to October 1 through May 31. Similarly, harvest and possession of mutton and lane snapper would be prohibited from December 1 through June 30, an increase of four months from the original closure. **Alternative 3** would also extend the closure for red, black, tiger, yellowfin, and yellowedge grouper to three months longer than the current prohibitions. The above mentioned species, while not observed in the García-Sais *et al*. (2007) report, occur in surrounding waters year round and are part of the commercial and recreational catch (Erdman, 1974; Boardman and Weiler, 1978; Kimmel, 1985).

Under **Sub-alternatives a** and **b**, all species, including HMS, will be equally protected, whereas **Sub-alternatives c** and **d (Preferred)** would only provide protection to reef fish species under council management. Under **Alternatives 2 (Preferred)** and **3**, these sub-alternatives would provide protection for the species found in Bajo de Sico during the respective closure period. HMS fishers indicated the gear they use (trolling gear designed to catch pelagic fishes) is pulled behind a moving vessel and fishes the upper portion of the water column where pelagic species occur. Such fishing activity is not expected to result in significantly higher mortality for the demersal fish species, like snappers and grouper for which this amendment is designed to protect. Also, this type of fishing activity for pelagic fishes is unlikely to result in a significantly higher capture of more sedentary species such as grouper and snapper species. During this period, however, incidental catch of large individuals of snappers or groupers, possibly in or near spawning condition, could occur and thus contribute to their mortality. Similarly, the harvesting of spiny lobster by hand is not expected to result in futher mortality to grouper or snapper species.

The intention of the action is to provide equal protection to desired species based on which sub-alternative the Council chooses. However, HMS are migratory, therefore have a greater risk of being harvested outside Bajo de Sico. The site fidelity of other species provides more predictable protection.

Due to limitations in data and data collection, NOAA Fisheries Service cannot determine to what extent landings will be affected by the extended seasonal closure. Effects of the original closure of Bajo de Sico are unknown as a result of the lack of spatial and temporal data specific to the area of Bajo de Sico. Without a determination of the effects of the original seasonal closure, NOAA Fisheries will be unable to determine to what degree landings will be reduced.

5.1.1.1 Consequences of Management Alternatives on Protected Resources

Alternative 1 (no action) would not modify the seasonal closure for Bajo de Sico that is already in place as part of the FMP for the Reef Fish Fishery of Puerto Rico and the United States Virgin Islands. Therefore, this alternative will provide no additional impacts to protected resources, including marine mammals, sea turtles, and listed corals. Under this alternative, the area would remain closed from December 1 to the last day of February of each year. Existing restrictions result in indirect benefits to protected species related to a decrease in the likelihood of impacts from entanglement in fishing gear and interactions with fishing vessels during the closed season. However, the benefits are short-term and, for instance, do not extend throughout the entire period of humpback migration. The prohibitions on bottom tending gear already in place for areas containing coral habitat also result in indirect benefits to protected species by minimizing the impacts of these gears on benthic habitat utilized by sea turtles and listed corals in particular.

Preferred Alternative 2 would modify the seasonal closure in Bajo de Sico to 6 months (October 1 –March 31) in order to provide better protection for spawning aggregations of large snappers and groupers and coral reef habitat. This alternative would result in indirect benefits to protected resources beyond those provided by the current management strategy. Under **Sub-alternatives a** and **b**, all fishing would be prohibited in Bajo de Sico thus eliminating potential impacts of commercial and recreational fishing activities, including gear and vessel traffic, to listed species and habitats they utilize that are present in the area of Bajo de Sico during the closed season. The elimination of all fishing under **Sub-alternatives a** and **b** would eliminate the potential impacts from entanglement in fishing gear and incidental catch of listed species during the closed season because the deployment of fishing gear in the area of Bajo de Sico would not be allowed. The elimination of all fishing would also be expected to greatly lower the traffic of commercial and recreational fishing vessels in the area thus reducing the potential for collisions between vessels and listed sea turtles and marine mammals.

Under **Sub-alternative c** and **Preferred Sub-alternative d**, the area would be closed for 6 months to the fishing of all Council-managed reef fish species. This alternative would reduce the potential for impacts of fishing activities on listed species and other marine mammals by limiting the time during which fishers and fishing gear, other than those targeting species not managed under the Council’s reef fish FMP, are present in the area of Bajo de Sico. In addition, allowing some fishing in the area during the closed season means that traffic of commercial and recreational fishing vessels will continue in the area.

It is expected, however, that the numbers of fishing vessels would decrease during the closed season and thus the possibility of interaction will be reduced.

Alternative 3 would modify the seasonal closure of Bajo de Sico to 6 months (December 1-May 31) in order to provide better protection for spawning aggregations of large snappers and groupers and coral reef habitat. This alternative would result in indirect benefits to protected resources beyond those provided by the current management strategy. Under **Sub-alternatives a** and **b**, all fishing would be prohibited in Bajo de Sico thus eliminating potential impacts of commercial and recreational fishing activities, including gear and vessel traffic, to listed species and habitats they utilize that are present in the area of Bajo de Sico during the closed season. The elimination of all fishing under **Sub-alternatives a** and **b** would eliminate the potential impacts from entanglement in fishing gear and incidental catch of listed species during the closed season because the deployment of fishing gear in the area of Bajo de Sico would not be allowed. The elimination of all fishing would also be expected to greatly lower the traffic of commercial and recreational fishing vessels in the area thus reducing the potential for collisions between vessels and listed sea turtles and marine mammals. Due to the timing of the proposed closure during the peak migration period of the humpback whale, which is the most common whale species in the area during its winter migration, **Sub-alternatives a** and **b** of this alternative are likely to provide greater indirect benefits to this species than **Sub-alternatives a** and **b** under **Preferred Alternative 2**.

Under **Sub-alternatives c** and **d**, the area would be closed for 6 months to the fishing of council-managed reef fish species. This alternative would reduce the potential for impacts of fishing activities on listed species and other marine mammals by limiting the time during which fishers and fishing gear, other than those targeting not mananaged under the Council's reef fish FMP, are present in the area of Bajo de Sico. In addition, allowing some fishing in the area during the closed season means that traffic of commercial and recreational fishing vessels will continue in the area, although it is expected that the numbers of fishing vessels would decrease during the closed season.

Alternative 4 would make the seasonal closure in Bajo de Sico year-round in order to provide full protection for spawning aggregations of large snappers and groupers, as well as coral reef habitat. This alternative would result in indirect benefits to protected resources, including threatened and endangered species and marine mammals. Under **Sub-alternatives a** and **b**, all fishing would be prohibited in Bajo de Sico thus eliminating potential impacts of commercial and recreational fishing activities, including gear and vessel traffic, to listed species and habitats they utilize that are present in the area. The elimination of all fishing under **Sub-alternatives a** and **b** would eliminate the potential impacts from entanglement in fishing gear and incidental catch of listed species because the deployment of fishing gear in the area of Bajo de Sico would not be allowed. The elimination of all fishing would also be expected to greatly lower the traffic of commercial and recreational fishing vessels in the area thus reducing the potential for collisions between vessels and listed sea turtles and marine mammals. Under **Sub-alternatives c** and **d**, this alternative would result in the greatest minimization of impacts of fishing activities, other than those targeting not mananaged under the Council's reef fish FMP, on listed species and marine mammals in the area of Bajo de Sico, in comparison with **Sub-alternatives c** and **d** for **Alternatives 2** and **3** and **Alternative 1**.

5.1.2 Direct and Indirect Effects on the Economic and Social Environments

Prior to discussing the expected social and economic effects of the various alternatives for the management actions under consideration within this Amendment, an analysis of the effects generated by the current seasonal closure of Bajo de Sico would provide useful background information from which to evaluate any potential modifications to that closure. Griffith et al. (2007) conducted such an analysis. However, their analysis is primarily focused on social effects, with only very limited discussion of general, non-quantitative "estimates" of economic effects. Further, their analysis is generally limited to reporting fishermen's perceptions of these effects as opposed to an analysis based of pre- and post-closure primary or secondary data. A summary of their findings is presented below. Tonioli and Agar (2008) conducted a more recent follow-up study, though they primarily focused on the expected effects of potential modifications to the existing closure, as well as the recent ban on bottom-tending gear to a more limited extent.

Regulatory Changes Related to the Bajo de Sico Closure

Since Griffith et al. (2007) conducted their research, additional regulations have been implemented that are at least indirectly related to the Bajo de Sico closure. First, as previously noted, a prohibition on bottom-tending gear (e.g., bottom longlines, gillnets, trammel nets, and traps) in the seasonally closed areas was implemented in 2005 to protect essential fish habitat for reef fish species. Second, a prohibition on fishing for or possession of red hind in or from the Caribbean EEZ west of 67° 10´ W. longitude was implemented in late 2006 for the period during which Bajo de Sico is closed (i.e. December 1 through the last day of February). As a result of when the regulation was approved, the regulation did not become effective until November 1, 2007. Puerto Rico implemented this prohibition for its territorial waters in 2004. The purpose of the prohibition is to afford additional protections to red hind spawning aggregations and, thereby, promote recovery from its overfished condition. According to Marshak (2007), although the closures of Bajo de Sico, Tourmaline, and Abrir la Sierra initially resulted in higher red hind catch rates in these and other nearby areas, increases and shifts in effort, particularly in times and areas outside the closures, have reversed this trend and led to lower catch rates in recent years. Furthermore, consistent with Griffith et al. (2007), Marshak (2007) indicates that lack of compliance with and insufficient enforcement of the closure regulations have reduced their effectiveness. Thus, he concludes that the red hind stock is still in very poor health, contrary to the views of commercial fishermen, and possibly in need of additional protections beyond the recently enacted prohibition. Regardless, these additional regulations would be expected to increase the adverse cumulative social and economic effects on commercial fishermen and local communities, depending on the extent to which fishermen are complying with regulations in general.

Direct and Indirect Effects of the Current Bajo de Sico Closure

According to Griffith et al. (2007), 79-87% of the fishermen they interviewed felt that the current seasonal closure of Bajo de Sico had generated positive biological effects with respect to the protection of spawning aggregations, species abundance, particularly deep water snapper-grouper, and habitat protection. Tonioli and Agar (2008) found that, while most fishermen still agreed that the current closure has been effective in protecting spawning aggregations, they disagreed that the closure had enhanced abundance. While these findings may appear contradictory, it is important to keep in mind that Griffith et al. (2007) conducted their research in 2005. Further, as reported by Marshak (2007), although red hind abundance and catch rates initially increased after the closure was implemented, catch rates have recently fallen off and, thus, the fishermen's change in attitude may be reflective of this recent decline.

According to Griffith et al. (2007), approximately 30% of the interviewed fishermen reported that the current closure had also created employment or investment opportunities in their communities. However, approximately 33% of the interviewed fishermen reported that the closure had caused adverse social or economic effects for them or their families (direct effects) and nearly 57% reported that the closure had adversely affected their local communities (indirect effects). The findings were nearly identical for the Tourmaline Bank, Abrir la Sierra, Desecheo, and La Mona/Monito closures. Tonioli and Agar (2008) report that most fishermen believe that the ban on bottom-tending gear has also had adverse social and economic effects on their local communities, particularly restaurants, hotels, fishing associations, and support service businesses.

The magnitude of the adverse social and economic effects arising from the seasonal closure of Bajo de Sico was not enumerated by either Griffith et al. (2007) or Tonioli and Agar (2008). Griffith et al. (2007) did estimate that between 250 and 300 fishing families were adversely affected by the combination of the Bajo de Sico and Tourmaline Bank seasonal closures, though their report does not indicate whether or what proportion of those impacted were families of full-time as opposed to part-time fishermen. Regardless, these impacts were concentrated in the west coast municipalities. With respect to the closure of Tourmaline Bank, although they reported that one-third of the impacted families were from Cabo Rojo, with another third coming from Rincon and Mayaguez, respectively, no such breakdown of the geographic distribution of the impacts associated with the Bajo de Sico closure were provided. Some of the adverse effects were due to the increase in transiting time and, thus, transiting (e.g., fuel) costs, associated with avoiding Bajo de Sico while it is closed. However, because the current closure does not preclude transit, and fishermen are avoiding it in order to minimize potential conflicts with enforcement agents, these effects are indirect in nature.

However, Griffith et al. (2007) do report that, while fishermen from Mayaguez have continued to operate in Bajo de Sico after the closure's implementation, fishermen from Boqueron (Cabo Rojo) who had previously fished in Bajo de Sico were no longer fishing there. They also emphasized that there have been cumulative social and economic effects resulting from the various area closures on the west coast (i.e., Tourmaline Bank, Bajo de

Sico, Abrir la Sierra, Desecheo, and La Mona/Monito), as well as the other seasonal closures for numerous commercially important species (e.g., several deepwater snapper species between October and December and several grouper species between February and April). Similar to the Bajo de Sico closure, these latter closures are meant to protect these species during their spawning season.

On the other hand, Griffith et al. (2007) point out that the seasonal closure of Bajo de Sico avoided the imposition of more restrictive size limits, which the fishermen dislike more than any other regulation as they believe such rules result in the wasteful discarding of fish. Further, some fishermen have avoided these adverse impacts, as reported in Griffith et al. (2007), by not complying with the various area closures, such as Bajo de Sico, as well as other regulations (e.g., licensing and reporting requirements), which has in turn led to certain unintended adverse effects (e.g., reduced ability to accurately assess the fishery). Enforcement issues have exacerbated these problems. For example, due to insufficient enforcement on the water, non-compliance was reported to have increased, causing resentment on the part of compliant fishermen, which may in turn further reduce compliance. Griffith et al. (2007) also note that, as long as imports undersized fish continues to be allowed, market forces cannot be relied upon as a means to help enforce minimum size regulations.

Finally, Griffith et al. (2007) point out that the purpose of the current Bajo de Sico closure is to help protect red hind spawning aggregations. If there is a desire to protect corals in this area as well, then fishermen believe that the behavior of recreational boaters and divers must also be regulated since their actions affect corals, too. If not, any new regulations on the fishermen will not only be unfair, but ineffective as well. Griffith et al. (2007) also report that the fishermen think the biological goals of the current closures, including Bajo de Sico, have been met. Prior to the implementation of any new closures, the fishermen think that studies should be conducted to verify or refute these claims. In the opinion of Griffith et al. (2007), the west coast fisheries of Puerto Rico may already be overly protected.

Direct and Indirect Effects on Affected Vessel Owners

Given the lack of information on fishing location within the commercial trip ticket data, and the previously discussed reporting problems, Tonioli and Agar (2008) attempted to assess the social and economic effects associated with alternatives that would lengthen the seasonal closure of Bajo de Sico. Their assessment is based on data collected from informal, voluntary discussions with 65 west coast fishermen. While their assessment provides useful insights, it cannot be solely relied upon to evaluate the current set of alternatives for Action 1 as the alternatives have changed from those that were under consideration at the time the data was collected. Of most concern is their assumption that the current Bajo de Sico closure and, thus, any extension thereto, precludes all fishing during the specified period of time with the exception of fishing for HMS and coastal pelagic species. However, the current closure actually applies to all fishing activities regardless of species. Further, under the current set of alternatives and sub-alternatives, any extension of the closure would either apply to all species (**Alternative 2a**,

Alternative 3a, and **Alternative 4a**), including those not managed by the Council (e.g,. HMS, coastal pelagics, and baitfish), or only reef fish, as is the case for under **Alternative 2c**, **Alternative 3c**, and **Alternative 4c**. **Alternative 2b**, **Alternative 3b**, and **Alternative 4b** only differ from **Alternative 2a**, **Alternative 3a**, and **Alternative 4a,** respectively, in that they would implicitly preclude transiting through Bajo de Sico with the prohibited species onboard when it is closed, which is not prohibited under the current closure. This difference also applies to **Preferred Alternative 2d**, **Alternative 3d**, and **Alternative 4d** in comparison to **Alternative 2c**, **Alternative 3c**, and **Alternative 4c,** respectively.

In general, the findings of Griffith et al. (2007) would be representative of the expected social and economic effects under **Alternative 1**, no action. However, those findings can be modified and expanded on based on some of Tonioli and Agar's (2008) research. Specifically, although Griffith et al. (2007) provided information on the total number of families impacted by the combination of the Tourmaline and Bajo de Sico closures, and the geographic distribution of families affected by the Tourmaline closure, Tonioli and Agar's (2008) research specifically focused on fishermen, particularly commercial fishermen, that currently fish at Bajo de Sico. As a result of the snowball sampling technique they used, Tonioli and Agar (2008) believe they surveyed or attempted to survey the vast majority of commercial fishermen who use the Bajo de Sico fishing grounds. This conclusion is supported by local PRDNER staff. Accordingly, it is estimated that approximately 64 commercial fishermen currently use the Bajo de Sico fishing grounds. An important qualification to this statement is the fact that their research did not cover recreational fishermen that may use those grounds during recreational fishing tournaments and, therefore, it is unknown how many such fishermen may use these grounds. Also, although Tonioli and Agar (2008) surveyed three charter fishermen, it is not clear that these are the only three charter vessels that that use the Bajo de Sico fishing grounds and, thus, a higher number of such operations may be affected.

With respects to demographics, the interviewed fishermen are quite similar to the average commercial fisherman on Puerto Rico's west coast, though there are some important differences. Specifically, the fishermen who fish at Bajo de Sico have approximately the same level of fishing experience (median = 24 years), typically use the same number of crew per boat (60% use one crewman), and support the same household size (about four persons). However, a much higher percentage of the interviewed fishermen (i.e. those who use Bajo de Sico) appear to be part-time rather than full-time commercial fishermen.[13] Similarly, while 65% of the interviewed fishermen rely on commercial fishing for more than 50% of their household income, west coast commercial fishermen are generally much more dependent on income from commercial fishing, which accounts for 85% of their total household income on average. The interviewed fishermen also appear to more frequently use hook and line gear with respect to the harvest of deep

[13] Though Tonioli and Agar refer to "subsistence" fishermen, no such license type exists within the fisherman Census data for comparison purposes. Also, although they treat charter and part-time commercial fishermen separately, charter fishermen must at least possess a part-time if not a full-time commercial fishing license in Puerto Rico.

water snapper-grouper species, whereas bottom line is generally the preferred gear type for harvesting these species according to landings data.[14]

Though not directly related to the management alternatives currently under consideration, Tonioli and Agar (2008) asked these fishermen about the impacts of the 2005 prohibition on bottom-tending gear in Bajo de Sico. Most of the interviewed fishermen indicated that the ban had "contributed to the deteriorating economic condition of the fishery." (Tonioli and Agar 2008: 7) In general, fishermen reported that they had been forced to become more economically dependent on income from non-fishing occupations as a result of declining catches, higher fuel costs, and the ever-increasing burden of fishing regulations. Tonioli and Agar also report that these fishermen were more adversely affected by the bottom-tending gear ban than the seasonal closure, based on a comparison of their findings with those by Griffith et al. (2007).

With respect to **Preferred Alternative 2** and **Alternative 3**, and the sub-alternatives under each, Tonioli and Agar (2008) report that, in effect, the expected adverse social and economic effects of these two alternatives on affected commercial fishermen, each of which would modify the current closure of Bajo de Sico from three months to six months, are equivalent. That is, given that December, January, and February would continue to be three of the six closed months, the specific timing of the other three months (October, November, and March as opposed to March through May) is irrelevant with respect to the expected magnitude of the social and economic effects on affected commercial fishermen. Presumably, this result is driven by the timing of the other seasonal prohibitions on snapper species from October through December and grouper species from February through April. The logic behind this conclusion, given other information, will be examined later in this analysis. Regardless, Tonioli and Agar's (2008) findings suggest that the expected adverse social and economic effects of each comparable sub-alternative under **Preferred Alternative 2** and **Alternative 3** will be the same (i.e. the effects of **Alternative 2a** and **Alternative 3a** are equivalent, the effects of **Alternative 2b** and **Alternative 3b** are equivalent, etc.).

Specifically, they report that most affected commercial fishermen would lose between 10% and 80% of their household income, with an average loss of 43% under a 6 month closure (**Preferred Alternative 2** and **Alternative 3**). As previously indicated, caution must be used in applying this estimate to any of the specific sub-alternatives under these two alternatives since their assumption of which species would be covered by the closure does not exactly match any of the four sub-alternatives, though it most closely approximates the species covered under sub-alternatives c and d (i.e. **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, and **Alternative 3d**). Tonioli and Agar (2008) attempted to determine the exact causes for these relatively high expected losses in household income. They found that the losses were due to a number of interrelated factors.

[14] However, the term "hook and line" appears to have been used in a very generic manner by the interviewed fishermen and thus this apparent difference may not be real.

Specifically, and most directly, commercial fishermen consider Bajo de Sico to be one of the most productive fishing grounds for baitfish and snapper-grouper species, as evidenced by the fact that 95% of the interviewed commercial fishermen reported Bajo de Sico as being their first choice with respect to fishing grounds.[15] If it were closed by an additional three months, most of these fishermen's landings per trip are expected to decrease between 20% and 90%, or by an average of 48%. Similarly, a six month closure would cause gross revenue per trip for most fishermen to decrease between 20% and 80%, or by an average of 47%.

Another important factor explaining the relatively high losses in household income is transiting time and the associated fuel costs. As previously noted, transit is not precluded under the current closure. However, the affected commercial fishermen report that, regardless of whether it is technically prohibited or not, they avoid the area during the closure nonetheless in order to avoid potential conflicts with the Coast Guard and the fines associated with those encounters. Allegedly, if the Coast Guard boards a vessel in Bajo de Sico when it is closed and it has fish on board, there is a presumption that the fish were caught illegally (i.e. in Bajo de Sico) and the fisherman will be fined. Apparently, the number of fines have increased to the point where the fishermen believe the probability of being fined, in combination with the size of the fines, is sufficiently high to provide an incentive to avoid the area completely during the closure (i.e. the expected costs of being fined exceed the expected costs from increased steaming time). This effect is exacerbated during the current closure because Tourmaline and Abrir la Sierra are closed at the same and similarly avoided. The fishermen assert that avoiding Bajo de Sico during the current closure increases their steaming time to other fishing grounds, particularly more distant grounds, thereby increasing their fuel costs and decreasing their profits. Even though the size of the closed area is relatively small, the small size of most fishermen's vessels limits their range.

Thus, if the closure was modified from three to six months, the fuel costs associated with increased steaming time would increase even more, thereby further decreasing their profits. More generally, commercial fishermen reported that their operating costs would increase between 5% and 175%, with an average increase of 57%.

However, it should be noted that, if the description of commercial fishermen's current behavior is accurate, then the additional costs associated with an explicit prohibition on transit during the current closure will be minimal at most. Nonetheless, and even though the closed area is only nine square miles, operating and particularly fuel costs would be expected to increase for these commercial vessels during the three extended closure months since they: 1) are relatively small (less than 20 feet on average), 2) would have to travel around Bajo de Sico during the additional three months it is closed, and 3) would potentially have to travel to more distant fishing grounds in order to harvest deepwater snappers. Thus, in turn, the expected adverse social and economic effects associated with **Alternative 2b** and **Alternative 3b** should be only minimally greater than those arising from **Alternative 2a** and **Alternative 3a** respectively, with the same conclusion applying

[15] Tourmaline and Abrir la Sierra were their second and third choices respectively with regard to fishing grounds.

to a comparison of **Preferred Alternative 2d** and **Alternative 3d** as opposed to **Alternative 2c** and **Alternative 3c** respectively as well.

With respect to comparisons of **Alternative 2a** with **Alternative 2c** and **Alternative 3a** with **Alternative 3c**, although harvest of baitfish species such as ballyhoo and skipjack tuna would not be precluded under **Alternative 2c** or **Alternative 3c**, the fishermen noted that they would be less likely to take trips to Bajo de Sico under these alternatives since, upon harvesting the baitfish, they would have to travel elsewhere to harvest snapper-grouper. Given the higher fuel costs associated with that scenario, the fishermen would apparently be economically better off choosing an alternative location where they can harvest both baitfish and snapper-grouper or purchase their bait onshore. If the alternative locations are farther from shore, then both sub-alternatives would increase operating costs.

Further, according to the interviewed fishermen, the current three month closure is a *de facto* five month closure due to the predominant bad weather conditions and strong currents that often preclude fishing for extended periods of time in September and October. When combined with the aforementioned seasonal bans on landing economically important snapper and grouper species, the fishermen claim that a six month closure would impact them nearly as much as a year-round closure.

This perception is reflected in Tonioli and Agar's (2008) results regarding the expected adverse social and economic effects resulting from a 12 month closure (**Alternative 4**). For example, most commercial fishermen indicated that their household incomes would decrease between 10% and 80%, with an average decrease of 48%. Thus, the expected average loss in household income is only 5% greater under a 12 month closure (Alternative 4) relative to a 6 month closure (**Preferred Alternative 2** and **Alternative 3**). Landings per trip are expected to decline by 25% and 100% for most fishermen, or on average by 57%. Thus, the expected average decrease in landings per trip is only 9% greater under a 12 month closure (**Alternative 4**) relative to a 6 month closure (**Preferred Alternative 2** or **Alternative 3**). Similarly, gross revenue per trip is expected to decline by 25% and 100% for most fishermen, or on average by 55%. Thus, the expected average decrease in gross revenue per trip is only 8% greater under a 12 month closure (**Alternative 4**) relative to a 6 month closure (**Preferred Alternative 2** or **Alternative 3**). Finally, operating costs are expected to increase between 5% and 175% for most fishermen, or on average by 59%. Thus, the expected average increase in operating costs is only 2% greater under a 12 month closure (**Alternative 4**) relative to a 6 month closure (**Preferred Alternative 2** or **Alternative 3**).

Tonioli and Agar (2008) also report that affected commercial fishermen would not stop fishing or fish less, switch gears, or change target species under either of the six month closure alternatives (**Preferred Alternative 2** and **Alternative 3**) or the 12 month closure alternative (**Alternative 4**). That is, effort would remain the same, but shift to areas other than Bajo de Sico, and fishermen would still use hook and line, bottom line, and longline gears to harvest snapper-grouper species. Some commercial fishermen indicated they could not stop fishing since fishing is all they know how to do (i.e. they lack the necessary skills and experience to shift occupations). However, given the estimated income losses, other fishermen indicated they would attempt to compensate by finding additional part-time work in non-fishing occupations. This result is somewhat surprising since many of these fishermen already have part-time jobs outside of fishing and they readily admit that finding such jobs can be difficult in their local communities. The main implication of these findings is that, in relative terms, the expected adverse social and economic effects are likely to be greater on older, full-time fishermen with more fishing experience compared to younger, part-time fishermen with less fishing experience.

Nonetheless, it may be the case that, in general, employment opportunities outside of fishing have become easier to find in recent years. As discussed in section 5.3, according to U.S. Census Bureau data, unemployment rates on the west coast were relatively high in 2000, ranging from 18.5% in Cabo Rojo to 25.3% in Aguadilla. But, in 2005-07, the U.S. Census Bureau data indicated that unemployment rates on the west coast had decreased by approximately 32% on average, ranging from 10% in Cabo Rojo to 18.7% in Mayaguez.[16] Lower levels of unemployment may allow adversely affected fisherman an opportunity to compensate for the expected income losses in the manner described.[17]

Although Tonioli and Agar's (2008) results are likely accurate in general and thus should be heavily relied upon with respect to assessing the impacts of the alternatives and sub-alternatives for Action 1, additional information from their interviews with the potentially affected commercial fishermen, the landings data for these particular fishermen, and the description of the fishery's social and economic environment (see section 5.3), can be used to refine these results. In order to arrive at a more accurate ranking of the alternatives and sub-alternatives with respect to the relative magnitude of their potential adverse social and economic impacts, Tonioli and Agar's (2008) results must be modified to account for the differences between the species they assumed would be covered by an extension of the closure and the species actually covered in the current set of alternatives and sub-alternatives.

For example, according to Tonioli and Agar's interview data, silk snapper was reported as being the primary target species by approximately 75% of the commercial fishermen who fish in Bajo de Sico. Queen snapper and red hind were the most frequently mentioned secondary target species. A few fishermen reported that they target HMS/pelagic species. As such, these commercial fishermen appear to be most dependent on revenue from the harvest of reef fish species, and thus are likely to be most concerned with management policies that would reduce harvests of such. Importantly, these particular species are managed by the Council under its Reef Fish FMP.

Also, as previously discussed, queen and silk snapper are two of the four most economically important species for commercial fishermen on the west coast, with red hind ranking much lower in terms of total revenue and in terms of average price per

[16] The updated unemployment rates for each municipality can be found by searching the following website: http://factfinder.census.gov/servlet/ADPGeoSearchByListServlet?_lang=en&_ts=253122787947
[17] On the other hand, it is recognized that macroeconomic conditions have deteriorated significantly on a worldwide basis and it is likely that local economic conditions have similarly worsened over the past year.

pound. Furthermore, landings of silk snapper are already prohibited from October through December, and October is a month during which bad weather and currents limit the amount of fishing activity that can occur. Also, only silk snapper landings exhibit any seasonality in relation to the current closure of Bajo de Sico, with landings being at relatively low levels in January and February compared to other months.

Since these commercial fishermen are relatively dependent on silk snapper landings, silk snapper harvests have been affected by the current closure, and silk snapper cannot currently be landed in October and November, **Preferred Alternative 2** would only limit silk snapper landings in March whereas **Alternative 3** would limit silk snapper landings in March, April, and May. Therefore, with respect to the adverse social and economic impacts on commercial fishing vessel owners associated with the two six month closures (**Preferred Alternative 2** and **Alternative 3**), it is concluded that the adverse impacts under **Alternative 3a**, **Alternative 3b**, **Alternative 3c**, and **Alternative 3d** would be greater than those under **Alternative 2a**, **alternative2b**, **Alternative 2c**, and **Preferred Alternative 2d** respectively. Although data limitations preclude a definitive conclusion with respect to the magnitude of this difference, the available evidence suggests that the difference could be significant.

In addition, an attempt was made to analyze the interviewed commercial fishermen's landings and revenue data for 2006/07 to determine the magnitude of their commercial fishing activities and their relative dependence on the harvests of particular species/species groups (e.g. reef fish as opposed to HMS/pelagics, bait fish, etc.). Such an analysis should help determine the relative impacts of the various sub-alternatives under **Preferred Alternative 2**, **Alternative 3**, and **Alternative 4**. In order to conduct this analysis, it was necessary to determine the interviewed fishermen's commercial fishing license numbers during those years and then identify landings in the PRDNER trip ticket data matching those license numbers. Statistical results from that analysis at the fisherman level are presented in Tables 5.1.1 and 5.1.2.

Table 5.1.1. Landings (Corrected) and Revenue Statistics for Interviewed Commercial Fishermen with Licenses and Reported Landings, 2006-07

Statistic	Landings (lbs)	Revenue ($)	Percent Revenue from Baitfish	Percent Revenue from Other	Percent Revenue from HMS/Pelagics	Percent Revenue from Reef fish	Percent Revenue from Conch	Percent Revenue from Lobster
Observations	27	27	27	27	27	27	27	27
Minimum	51	$152	0.0	0.0	0.0	10.2	0.0	0.0
Maximum	22,032	$80,414	45.7	34.3	44.2	100.0	38.9	81.8
Average	6,402	$17,296	5.7	4.1	12.0	63.9	1.7	12.5
Standard Dev	5,395	$18,317	10.3	7.3	13.2	25.9	7.5	23.8

Table 5.1.2. Landings (Corrected) and Revenue Statistics by Year for Interviewed Commercial Fishermen with Licenses and Reported Landings, 2006-07

Year	Statistic	Landings (lbs)	Revenue ($)
2006	Observations	14	14
	Minimum	51	$152
	Maximum	13,159	$56,401
	Average	5,013	$13,883
	Standard Dev	4,194	$14,655
2007	Observations	13	13
	Minimum	436	$1,362
	Maximum	22,032	$80,414
	Average	7,899	$20,971
	Standard Dev	6,272	$21,588

Of the 62 commercial fishermen interviewed by Tonioli and Agar, only 22 (35%) had commercial fishing licenses. Further, of the 22 fishermen with commercial fishing licenses, only 17 (27%) had reported commercial landings in 2006 or 2007 (14 and 13 fishermen reported landings in 2006 and 2007 respectively yielding 27 total observations). These findings provide additional empirical support for claims that a large percentage of commercial fishermen are not complying with PRDNER's license or reporting requirements. Given this relatively low level of coverage, the statistical results from this analysis must be used with caution.

First, as previously noted, compared to west coast commercial fishermen in general, Tonioli and Agar (2008) report that a higher percentage of the potentially affected commercial fishermen are part-time fishermen or, conversely, that a lower percentage are full-time commercial fishermen. Also note that, for all west coast commercial fishermen, average gross revenue per fisherman was $5,431 and $9,168 in 2006 and 2007 respectively, or $7,076 across both years. However, with respect to the potentially affected fishermen that were interviewed and reported their landings, average gross revenue per fisherman was $13,883 and $20,971 in 2006 and 2007 respectively, or $17,296 across both years. These results suggest that the fishermen who are complying with the licensing and reporting requirements are most likely full-time fishermen, and possibly economic highliners.

Nonetheless, according to these results, the potentially impacted commercial fishermen are most dependent on revenue from reef fish landings, which account for approximately 64% of their annual gross revenue on average. This result is consistent with previously discussed findings indicating that these fishermen are dependent on specific species such as silk snapper, queen snapper and, to a lesser extent, red hind. Revenue from HMS/pelagic and spiny lobster landings each account for approximately 12% of annual gross revenue on average. Revenue from baitfish, other species, and queen conch landings account for the remaining 6%, 4% and 2% respectively.[18] In the case of baitfish, these results likely underestimate the actual economic importance of these species to commercial fishermen since they most likely use, rather than sell, most of their baitfish in order to harvest reef fish. Since trip tickets only record landings rather than catch, it is not possibly to estimate the amount of baitfish that is caught and not sold and thus in turn its implicit value to commercial fishermen. However, the value of these baitfish catches should be captured by the market value of the harvested and sold reef fish.[19]

Given the fishermen's stated preferences regarding their primary target species and assuming these revenue distributions are generally representative of fishermen's revenue from their fishing activities in Bajo de Sico, it is reasonable to conclude that these fishermen are predominantly dependent on revenue from reef fish. If fishing for non-reef fish species (e.g. HMS/pelagics, baitfish, etc.) is allowed during a Closure (**Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, and **Alternative 4d** respectively), the adverse social and economic effects on affected commercial fishing vessel owners are likely to be slightly less than if the harvest of all species is prohibited (**Alternative 2a**, **Alternative 2b**, **Alternative 3a**, **Alternative 3b**, **Alternative 4a**, or **Alternative 4b** respectively). The difference is likely to be noticeable only for the relatively few affected commercial fishermen who are somewhat dependent on revenue from HMS/pelagic landings, particularly if, as previously discussed, most of the affected commercial fishermen will not go to Bajo de Sico to harvest baitfish if they cannot also harvest reef fish. Affected commercial fishermen who currently possess and use troll lines could mitigate the adverse effects of a modified closure by reallocating their fishing effort to targeting dolphin and tunas rather than using bottom lines to target reef fish. Specifically, if fishing for non-reef fish species is allowed during the Closure, these fishermen will gain access to Bajo de Sico's non-reef fish resources, particularly HMS/pelagic species, in the months of December, January, and February which they do not currently possess under the status quo (**Alternative 1**).[20] For these particular fishermen, the potential landings and revenue of HMS/pelagic species resulting from such access could partially offset the adverse effects of a modified closure.

Since Tonioli and Agar (2008) assumed that the harvest of HMS/pelagic species would not be prohibited under a potential extension of the Bajo de Sico closure, they in turn concluded that the charter/recreational sector would not be impacted by any of the alternatives to modify the closure. Such a conclusion is accurate only under **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, and **Alternative 4d**. That conclusion is most likely not accurate under **Alternative 2a**, **Alternative 2b**, **Alternative 3a**, **Alternative 3b**, **Alternative 4a**, or **Alternative 4b**.

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[18] The percentages of annual gross revenue across species groups did not vary noticeably between 2006 and 2007.

[19] In effect, baitfish are an intermediate output used in the production of reef fish, and the market value of the final output should encompass the value of all intermediate outputs.

[20] The ability of affected commercial fishermen to shift effort to HMS/pelagic species during the extended Closure months (e.g., October, November, and March under Alternative 2c and **Preferred Alternative 2d**), as opposed to the months of the current closure, has presumably already been taken into account in Tonioli and Agar's (2008) analysis.

Although Tonioli and Agar (2008) only interviewed three charter fishermen, there are only eight HMS permitted charter vessels on the west coast and thus the interviewed charter fishermen represent approximately 38% of the potentially affected charter operations. As previously discussed, these fishermen reported that they exclusively target HMS/pelagic species. As such, and consistent with Tonioli and Agar's (2008) assumption, these charter fishermen indicated that they would not be affected by an extension of the closure. In part, their conclusion appears to have been based on a mistaken belief that the current closure does not apply to the harvest of non-Council managed species such as HMS/pelagics.

Given the false assumptions under which Tonioli and Agar (2008) as well as the interviewed charter fishermen were operating, no specific estimates are available with respect to potential losses in gross revenue, losses of household income, or increased operating costs under **Alternative 2a**, **Alternative 2b**, **Alternative 3a**, **Alternative 3b**, **Alternative 4a**, or **Alternative 4b**. However, similar to the commercial vessel owners, all three charter operators indicated that Bajo de Sico is their first choice with respect to fishing grounds. As such, it is likely that charter fishermen's dependency on fishing activities in that area is comparable to the commercial fishermen's. However, as previously discussed, the busiest time of the year for charter operators typically begins in October or December, the least active time of the year for commercial fishermen, and runs through May. Thus, for charter operators, a six month closure that includes prohibitions on harvesting all species (**Alternative 2a**, **Alternative 2b**, **Alternative 3a**, and **Alternative 3b**) will likely result in significant losses in revenue and household income. Also, the difference in impacts between the two six month closures (**Preferred Alternative 2** as opposed to **Alternative 3**) is likely negligible since all of the closed months under each alternative would fall in their busy season. Furthermore, the difference in losses under a six month closure (**Preferred Alternative 2** and **Alternative 3**) as opposed to a 12 month closure (**Alternative 4**) is also likely negligible for these charter operators, even more so than for the commercial fishermen, since the months that Bajo de Sico would be open under either of the six month closures are "slow" times of the year.

In terms of comparing **Alternative 2a** with **Alternative 2b**, **Alternative 3a** with **Alternative 3b**, and **Alternative 4a** with **Alternative 4b**, like the commercial fishermen, it seems likely that the charter fishermen would choose to avoid the area while it is closed regardless of whether possession of fish is allowed or not. Since their clientele or crew are likely to retain most of what they catch, but it could be difficult to prove that it was caught outside of Bajo de Sico when transiting through the area, these charter fishermen will likely want to avoid any potential conflicts with enforcement agents and the risk of fines. Thus, it is unlikely that there will be any perceptible differences in the impacts between these alternatives (i.e. **Alternative 2a** as opposed to **Alternative 2b**, or **Alternative 3a** as opposed to **Alternative 3b)** for charter fishermen.

Conversely, since the current closure applies to all species, these eight charter operations would likely be better off (i.e. they would experience economic benefits) under **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, and **Alternative 4d** relative to **Alternative 1** (status quo). At the present time, these vessels are precluded from operating in Bajo de Sico between December 1 and the end of

February. Further, Bajo de Sico is allegedly a highly productive area for HMS/pelagic species. Since these vessels exclusively target HMS/pelagic species, the harvest of these species would no longer be prohibited within Bajo de Sico, and the months of December, January, and February fall within their "busy" season, it is likely that most if not all of these charter vessels would take advantage of the opportunity to fish in these waters during the currently closed three-month time period. Further, since they could legally transit through the area if they only have non-Reef fish on-board, these charter operators would no longer run the risk of being fined. They would also no longer have a reason to avoid the area and thus could reduce their fuel expenses. As such, the magnitude of these economic benefits to each of these eight charter operations will largely depend on whether these vessels take additional fishing trips, which would result in additional revenue, or spatially redistribute their current trips from other areas to Bajo de Sico as a result of this regulatory change. That is, the economic benefits will be greater to the extent that the regulatory change causes these vessels to expend additional fishing effort rather than spatially redistribute their current fishing effort.

With respect to owners of private recreational vessels, the most likely source of impacts resulting from an extension of the current closure would be potential effects on fishing tournament activities. That is, if tournament participants use the Bajo de Sico grounds during these tournaments, then a modified closure may remove this area from their set of fishing location options. The current value of that option is unknown due to the lack of data on whether, how many, and how frequently fishing tournament participants actually use the Bajo de Sico fishing grounds. If its value were great enough, in theory, some recreational fishermen could potentially forego participating in particular tournaments, which would in turn reduce tournament revenue and thereby impose adverse social and economic impacts on tournament organizers.

Similar to charter vessels, some information is available by which to at least gauge which alternatives/sub-alternatives would be most likely to generate adverse social and economic impacts on recreational fishermen and, in turn, tournament organizers. For example, as previously discussed, participants in all of the west coast recreational fishing tournaments target HMS/pelagic species (i.e. blue marlin, dolphin, or wahoo). While other species are caught as bycatch, the majority of the bycatch is also non-reef fish species (e.g., king mackerel, barracudas, and tunas). Further, the value to the recreational fishermen from participating in these tournaments arises from their catch of the target species, primarily because the catch of these species serves as the basis for receiving prize money as well as prestige. As such, it is concluded that no adverse social or economic impacts would be imposed on private recreational fishermen or tournament organizers under **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, or **Alternative 4d**.

Also as previously discussed, the timing of these tournaments is critical, at least with respect to a comparative evaluation of the six month closure alternatives (**Alternative 2a**, **Alternative 2b**, **Alternative 3a**, and **Alternative 3b** respectively) and the 12 month alternative (**Alternative 4a** and **Alternative 4b** respectively). Specifically, during 2006 and 2007, nine different recreational fishing tournaments took place on the west coast.

These tournaments attracted approximately 300 vessels and more than 1,100 individual anglers each year. Of these tournaments, only one occurred during the current closure (a dolphin/wahoo tournament in February out of Cabo Rojo). Further, only one tournament took place between March and May. Specifically, one dolphin tournament based out of Cabo Rojo that included 80 participants and 20 vessels was held in March 2007. Conversely, five tournaments were held during the months of October, November, and March. In addition to the just mentioned dolphin tournament in March, two blue marlin tournaments were held in October (one in Cabo Rojo and Mayaguez) and two wahoo tournaments took place in November (one each in Cabo Rojo and Mayaguez). A total of 288 fishermen and 72 vessels participated in these tournaments. The remaining three tournaments took place in September, with all three operating out of Cabo Rojo and targeting blue marlin. These three tournaments are the largest recreational tournaments on the west coast, encompassing a total of 776 fishermen and 193 vessels. Furthermore, entry fees for blue marlin tournaments are much higher than for dolphin/wahoo tournaments ($756/vessel as opposed to $340/vessel). Given the higher participation rates and fees, the organizers' revenue is also much larger for these tournaments.

Although recreational fishermen's use of the Bajo de Sico fishing grounds during tournaments is unknown, the permits that organizers must obtain to legally operate these tournaments indicates that participants can access a relatively large area of water. In most cases, they can fish in all west coast territorial and EEZ waters that are not closed for other reasons (e.g. marine reserves at La Mona). Thus, it seems unlikely that the Bajo de Sico fishing grounds would constitute a high value option to these fishermen.

Nonetheless, if these grounds are valued by recreational fishermen, the above information suggests that, as between the alternatives that would modify the current closure, the smallest adverse social and economic impacts are likely to occur under **Alternative 2a** and **Alternative 2b** as only one relatively small tournament would be potentially affected. The adverse social and economic impacts under **Alternative 3a** and **Alternative 3b** are likely to be greater given that several additional tournaments would be potentially affected. The largest adverse social and economic impacts are likely to arise from **Alternative 4a** and **Alternative 4b** given that participants in all recreational fishing tournaments could be potentially affected, particularly participants in the larger, more valuable tournaments based out of Cabo Rojo that occur in September.

With respect to comparing the likely effects under **Sub-alternative a** as opposed to **Sub-alternative b** for **Preferred Alternative 2**, **Alternative 3**, and **Alternative 4** (i.e. **Alternative 2a** versus **Alternative 2b**, **Alternative 3a** versus **Alternative 3b**, and **Alternative 4a** versus **Alternative 4b**), unlike commercial and charter fishermen, the inclusion of the possession prohibition under **Sub-alternative b** may have some additional adverse impacts on at least some private recreational fishermen. As previously noted, many of the recreational fishing tournaments have converted to catch and release practices. As such, many recreational fishermen are unlikely to have fish that they caught on board when they return to port. If only fishing is prohibited during the closure, it seems likely that the recreational fishermen that practice catch and release would not have an incentive to circumnavigate the area. Conversely, if possession is also precluded, which would include baitfish species that recreational harvesters use to target HMS/pelagic species, then they would be forced to avoid the area completely during a closure, which would in turn increase their fuel and operating costs. Therefore, the adverse impacts on the private recreational sector are likely to be slightly greater under **Sub-alternative b** than **Sub-alternative a** (i.e. the adverse impacts under **Alternative 4b** would be slightly greater than under **Alternative 4a**, the adverse impacts under **Alternative 3b** would be slightly greater than under **Alternative 3a**, etc.).

As with the charter operations, since the current closure applies to all species, recreational fishing tournament participants would likely be better off (i.e., they would experience economic benefits) under **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, and **Alternative 4d** relative to **Alternative 1** (status quo). Again, at the present time, these fishermen are precluded from operating in Bajo de Sico between December 1 and the end of February. Since these fishermen exclusively target HMS/pelagic species, most of their bycatch is composed of non-reef fish species, and the harvest of these species would no longer be prohibited within Bajo de Sico, they might take advantage of the opportunity to fish in and transit through these waters during the currently closed three-month time period. However, as noted above, only one relatively small dolphin/wahoo tournament (approximately 25 vessels and 100 recreational anglers) takes place during during this time period. Furthremore, Bajo de Sico is a relatively small area (9 square miles) compared to the area covered by recreational fishing tournament participants, which can often encompass all waters off of Puerto Rico's west coast. As such, the benefits to these fishermen in terms of increased fishing opportunities and reduced fuel expenses may also be relatively small. Recreational fishing tournament participants and organizers could experience greater economic benefits under these alternatives if, in the future, additional tournaments were to take place during this three-month time period.

Therefore, based on all of the above findings, it is concluded that the following rankings apply to the various alternatives and sub-alternatives being considered for **Action 1** (see Table 5.1.3), with the alternative/sub-alternative generating the least adverse social and economic impacts in the short-term having the highest ranking and the alternative/ sub-alternative generating the most adverse social and economic impacts in the short-term having the lowest ranking:

Table 5.1.3. Ranking of Alternatives/Sub-alternatives for Action 1 with respect to Minimizing Adverse Social and Economic Effects on Affected Vessel Owners

Ranking	Alternative
1	Alternative 1
2	Alternative 2c
3	Alternative 2d **(Preferred)**
4	Alternative 2a
5	Alternative 2b
6	Alternative 3c
7	Alternative 3d
8	Alternative 3a
9	Alternative 3b
10	Alternative 4c
11	Alternative 4d
12	Alternative 4a
13	Alternative 4b

Direct and Indirect Effects on Local Communities

According to Tonioli and Agar (2008), potentially affected commercial and charter fishermen are nearly unanimously of the belief that any extension of the current closure would significantly impact local businesses directly and indirectly associated with the fishing industry, though the magnitude of these effects could not be estimated. These effects would be expected to spread throughout the local seafood industry (i.e. support services, wholesale, distribution, marketing, and retail sectors).

Furthermore, as previously noted, any extension of the current closure would increase commercial vessel owners' operating costs. Commercial vessel owners would be forced to absorb these increased expenses (i.e. profits would be reduced) since they lack the ability pass these costs on to consumers. Competition from cheaper, imported seafood products precludes local fisherman from controlling the prices of their products. Since profits will be lower, payments to crew will also be reduced. With reduced income from fishing, crew will be forced to seek additional employment elsewhere, either outside of fishing or on vessels not affected by the modified closure. Although vessel owners indicate that they would not reduce the number of crew on their vessels, since each vessel typically uses only one crew and eliminating that crewman would create significant safety issues, crewmen may choose to leave, potentially making it more difficult for the vessel owners to obtain new crew. Also, crewmen often provide unpaid labor to vessel owners in the form of devoting time to vessel and gear maintenance. If they are being paid less, it is less likely they would be willing to engage in such unremunerated services, which Tonioli and Agar (2008) believe would weaken kinship relationships and community cohesion.

Any extension of the current closure would also be expected to reduce commercial vessel owners' expenditures on fishing supplies, fishing equipment, fuel, and vessel/gear maintenance, which would in turn adversely affect the local businesses that supply these products and services. Although the magnitude of these effects cannot be estimated, Griffith et al. (2007) noted that these types of expenditures contribute greatly to the local economies. Though estimates are not available specifically for west coast communities, they estimated that 98%, 94%, 71%, 71%, and 43% of commercial fishermen's expenditures on vessel maintenance, engine maintenance, vessel construction, fishing gear, and electronic equipment respectively were made locally.

With respect to effects on commercial fishing associations, although it is expected that a longer closure would reduce income and employment opportunities, the most important adverse effect was expected to be the loss of market share. Local hotels and restaurants would have an even greater incentive to substitute cheaper, readily available imported seafood in place of locally produced seafood if the latter is not consistently available throughout the year. Local fishermen believe that their ability to provide fresh seafood on a year-round basis is what allows them to compete with imports. Losing this ability would potentially lead to a loss in buyers and thus market share, further exacerbating the aforementioned economic and social effects of a modified closure.

On the other hand, the potential opening of Bajo de Sico to private recreational vessels and particularly charter vessels during the months of the current closure (i.e., December through February) could help to mitigate these adverse effects on certain local businesses. Specifically, if the harvest of HMS/pelagic and other non-reef fish species is allowed in Bajo de Sico, it is likely that charter vessels will take more trips to Bajo de Sico during these months. If these trips represent additional as opposed to spatially redistributed fishing effort, then these charter operations should spend relatively more on fishing supplies, gear, and fuel. These additional expenditures would help to partially offset the loss of expenditures by commercial fishermen. However, given that 64 commercial fishing vessels are expected to reduce their expenditures and, at most, eight similarly sized charter vessels might increase their expenditures, such effects would only be expected to result in partial mitigation. Further, they would not be expected to reduce the impacts on seafood buyers, distributors, and sellers.

The potentially affected commercial and charter fishermen also indicate that a modified closure would likely lead to increased conflicts between commercial fishermen and between commercial and charter/recreational fishermen. A reduction in fishable area will lead to increased competition on the open fishing grounds, both directly (physical encounters) and indirectly (catch competition). Such conflicts would only exacerbate the resentment that commercial fishermen already feel towards charter/recreational fishermen as a result of the latter allegedly selling their catches, increasing the local supply of seafood and decreasing the prices paid to commercial fishermen at a time when commercial fishermen are already struggling economically.

Finally, and somewhat related to the increased conflict issue, the potentially affected commercial and charter fishermen expressed an important concern that could not only lead to additional social and economic effects, but adverse biological and administrative effects that could potentially counteract some of the intended effects of a modified closure.

Specifically, assuming the potentially affected commercial fishermen respond to the modified closure in the manner described (i.e. total effort on reef fish species is not reduced but rather shifted to other locations), it is most likely that effort will shift to the more popular, easily accessible fishing areas. These fishermen indicate that the most likely alternative areas are Tourmaline and Abrir la Sierra, which they believe are showing signs of over-exploitation. That belief is supported by other research (Marshak 2007) that shows high levels of effort in Tourmaline as a result of relatively high red hind spawning aggregations (high catch rates) and proximity to the coast (low transit/fuel costs). Higher effort will likely lead to reduced abundance of reef fish species in these areas, which may in turn cause the Council to consider longer closures there as well, which would lead to additional adverse social and economic effects on fishermen and local communities. In general, Marshak's research shows that, at least with respect to red hind, policies that only cause spatial-temporal shifts rather than overall reductions in effort are unlikely to increase abundance in the long-term (i.e. benefits in this respect are minimal) and instead are likely to generate higher social, economic, and administrative costs.

On the other hand, the commercial and charter fishermen's comments in this regard do not take into account the potential benefits to corals that would presumably result from a modified closure. This is likely due to the fact that, in the fishermen's opinion, the coral in Bajo de Sico are located very deep in the water column and their fishing gear does not operate at those depths. However, this perspective does not recognize that it is the entire coral reef ecosystem that is being protected, rather than particular individual components.

Tonioli and Agar (2008) only discuss potential adverse community level social and economic impacts in the aggregate (i.e. across all west coast municipalities). However, just as impacts will likely be distributed unevenly across fishermen, it is also likely that these impacts will be distributed unevenly across the various municipalities. The geographic distribution of the potentially affected commercial and charter fishermen is one critical piece of information in this regard. Either in terms of where they land or where they live, that distribution is as follows: Mayaguez (29.8%), Anasco (22.4%), Rincon (22.4%), Aguadilla (16.4%), Aguada (6%) and Cabo Rojo (3%). It should be noted that, although multiple attempts were made, the two fishermen from Cabo Rojo who allegedly fish at Bajo de Sico were not in fact interviewed and thus are not represented in Tonioli and Agar's (2008) results. Furthermore, all three charter fishermen they interviewed are from Rincon. Thus, in terms of potentially affected commercial fishermen only, the geographic distribution differs slightly and is as follows: Mayaguez (31.2%), Anasco (23.4%), Rincon (18.8%), Aguadilla (17.2%), Aguada (6.3%) and Cabo Rojo (3.1%).

As previously discussed, the characteristics of all the commercial fishermen potentially affected by a modified closure differ greatly from those who are not only potentially affected but also possess commercial fishing licenses and report their landings through the trip ticket program. The same holds true for the geographic distribution of the latter group, which is as follows: Rincon (44.4%), Mayaguez (22.2%), Aguada (14.8%), Anasco (11.1%), and Aguadilla (7.4%). Consistent with information discussed in section 5.3, Rincon's fishermen tend to be more organized and "professional," at least with respect to their compliance with licensing and reporting requirements. Similarly, compliance with license and reporting requirements appears to be particularly problematic in Anasco, which has a relatively small and weak commercial fishing association, and Aguadilla, which is dominated by a politically active association that does not look favorably upon many of PRDNER's regulations.

Regardless, according to information in Table 5.1.4, potentially affected commercial fishermen from Anasco have much higher annual gross revenue on average ($34,508) than those from other municipalities, followed by fishermen from Rincon, ($19,035), Aguadilla ($16,020), and Mayaguez ($12,839), while those from Aguada have the lowest annual gross revenue on average ($6,454). These results suggest that the affected commercial fishermen from Anasco are likely full-time fishermen, those from Aguada are likely part-time fishermen, and those from the other municipalities are likely a mix of the two groups.

Table 5.1.4. Landings (Corrected) and Revenue Statistics by Municipality for Interviewed Commercial Fishermen with Licenses and Reported Landings, 2006-07

Municipality	Statistic	Landings (lbs)	Revenue ($)	Percent Revenue from Baitfish	Percent Revenue from Other	Percent Revenue from HMS/Pelagics	Percent Revenue from Reef fish	Percent Revenue from Conch	Percent Revenue from Lobster
Aguada	Obs	4	4	4	4	4	4	4	4
	Minimum	51	$152	0.0	0.0	0.0	34.6	0.0	0.0
	Maximum	10,846	$15,649	19.4	34.3	17.4	100.0	0.0	0.0
	Average	4,466	$6,454	12.1	11.3	11.5	65.1	0.0	0.0
	Standard Dev	4,843	$6,916	8.7	16.2	7.8	26.8	0.0	0.0
Aguadilla	Obs	2	2	2	2	2	2	2	2
	Minimum	***	***	4.7	2.1	27.2	49.6	0.0	0.0
	Maximum	***	***	17.2	2.3	30.8	65.9	0.0	0.0
	Average	***	***	11.0	2.2	29.0	57.8	0.0	0.0
	Standard Dev	***	***	8.8	0.1	2.5	11.5	0.0	0.0
Anasco	Obs	3	3	3	3	3	3	3	3
	Minimum	612	$1,808	0.0	0.1	0.0	82.2	0.0	0.0
	Maximum	22,032	$80,414	0.0	8.4	9.4	95.0	0.0	8.2
	Average	9,860	$34,558	0.0	2.9	4.6	89.6	0.0	2.9
	Standard Dev	11,005	$40,909	0.0	4.7	4.7	6.6	0.0	4.6

Table 5.1.4. Cont. Landings (Corrected) and Revenue Statistics by Municipality for Interviewed Commercial Fishermen with Licenses and Reported Landings, 2006-07

Municipality	Statistic	Landings (lbs)	Revenue ($)	Percent Revenue from Baitfish	Percent Revenue from Other	Percent Revenue from HMS/Pelagics	Percent Revenue from Reef fish	Percent Revenue from Conch	Percent Revenue from Lobster
Mayaguez	Obs	6	6	6	6	6	6	6	6
	Minimum	436	$1,362	0.0	0.0	0.0	18.9	0.0	0.0
	Maximum	14,061	$24,774	0.0	04.1	35.9	92.7	38.9	57.8
	Average	5,887	$12,839	0.0	1.7	10.5	56.3	7.3	24.1
	Standard Dev	4,756	$8,238	0.0	1.9	14.9	26.6	15.6	26.2
Rincon	Obs	12	12	12	12	12	12	12	12
	Minimum	149	$256	0.0	0.0	0.0	10.1	0.0	0.0
	Maximum	14,133	$56,401	0.457	14.2	44.2	94.8	0.9	81.8
	Average	5,830	$19,035	0.070	3.6	12.0	61.9	0.1	15.4
	Standard Dev	4,646	$17,477	0.132	5.1	14.9	28.8	0.3	28.7

*** - Data is confidential

Furthermore, Anasco's commercial fishermen are much more dependent on revenue from the harvest of reef fish, which accounts for 90% of their annual gross revenue, than fishermen from the other municipalities, which account for between 56% and 65% of their annual gross revenue. Only in Mayaguez (24%) and Rincon (15%) does revenue from spiny lobster harvests account for a relatively significant percentage of commercial fishermen's annual gross revenue. However, it is unlikely that much of this harvest comes from Bajo de Sico given the commercial fishermen's stated targeting preferences in terms of species and gear. As expected, given the geographic distribution of HMS general category permits, only in Aguadilla does the harvest of HMS/pelagic species account for a relatively significant proportion of the potentially affected commercial fishermen's average annual gross revenue (29%). With respect to all non-reef fish species, Mayaguez's commercial fishermen are most dependent on such harvests which account for 44% of their annual gross revenue on average, followed by Aguadilla (42%), Rincon (38%), Aguada (35%), and Anasco (10%).

Given the above information, on a per commercial vessel/fisherman basis, it appears likely that, under all sub-alternatives for **Preferred Alternative 2**, **Alternative 3**, and **Alternative 4**, the largest adverse economic impacts would be felt by Anasco's commercial fishermen. For Anasco's commercial fishermen, this is even more so the case in relative terms if the closure modification only applies to reef fish (i.e. **Alternative 2a**, **Alternative 2b**, **Alternative 3a**, **Alternative 3b**, **Alternative 4a**, and **Alternative 4b**). The exclusion of non-reef fish species, particularly HMS/pelagics, from the closure modification (i.e. **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, and **Alternative 4d**) would seem to benefit Aguadilla's commercial fishermen the most (in terms of reducing the adverse economic impacts associated with the closure), with Aguada's and Rincon's commercial fishermen benefitting to a lesser extent.

At the municipality level, given the above information on the number of potentially affected commercial fishermen, average annual gross revenue per commercial fisherman, dependency on reef fish, and previous information reported in section 5.3 regarding each municipality's dependence on the key reef fish species (silk snapper, queen snapper and, to a lesser extent, red hind), the largest adverse social and economic effects arising from impacts on the commercial fishing sector are likely to be experienced in Anasco, followed by Mayaguez, Rincon, and Aguadilla, with Aguada and Cabo Rojo experiencing significantly lesser impacts. This ranking of relative impacts on municipalities due to effects on the commercial sector and associated businesses should be true regardless of whether the Council selects **Preferred Alternative 2**, **Alternative 3**, or **Alternative 4**. The only difference between **Preferred Alternative 2**, **Alternative 3**, and **Alternative 4** and their various sub-alternatives is with respect to the absolute magnitude of these impacts, which would in general be similar to those noted above for affected commercial fishing vessel owners (i.e. **Alternative 4b** would generate the largest while **Alternative 2c** would generate the least adverse social and economic impacts in absolute terms across all municipalities). However, the absolute impacts would be somewhat less in Rincon, Aguada, and particularly Aguadilla if **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, or **Alternative 4d** were selected rather than **Alternative 2a**, **Alternative 2b**, **Alternative 3a**, **Alternative 3b**, **Alternative 4a**, or **Alternative 4b**.

With respect to differential impacts on the charter sector across municipalities, given the lack of detailed information on these vessels' operations, the only pertinent, available information is: 1) these vessels' exclusively target HMS/pelagic species and 2) the eight potentially affected charter vessels are geographically distributed across Rincon (four vessels), Cabo Rojo (two vessels), Aguadilla (two vessels). No adverse social or economic impacts as a result of effects on the charter sector are expected in any municipality under **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, or **Alternative 4d**. In fact, Cabo Rojo, Aguadilla, and particularly Rincon should experience some economic benefits under these particular alternatives relative to **Alternative 1** (status quo) since, as previously discussed, these charter vessels would be able to harvest non-Reef fish from the Bajo de Sico fishing grounds during the months of the current Closure (December, January, and February). Conversely, **Alternative 2a**, **Alternative 2b**, **Alternative 3a**, **Alternative 3b**, **Alternative 4a**, and **Alternative 4b** are expected to result in generally equivalent adverse social and economic effects on the charter sector. Thus, Rincon would experience the largest adverse social and economic impacts due to effects on the charter sector and related businesses, with Cabo Rojo and Aguadilla experiencing somewhat lesser impacts. Given the lack of charter operations, Anasco, Aguada, and Mayaguez would not be expected to experience any adverse social or economic impacts under **Preferred Alternative 2**, **Alternative 3**, or **Alternative 4** as a result of effects on the charter sector.

Differential impacts across municipalities due to effects on the private recreational sector are primarily driven by the species targeted in each tournament, the geographic distribution of potentially affected recreational fishing tournaments, the number of such tournaments, and the "size" of those tournaments in terms of the number of participating fishermen, vessels, and potential revenue to tournament organizers. As previously noted, since only HMS/pelagic species are targeted in these tournaments, no adverse social or economic impacts are expected to occur in any municipality as a result of effects on the private recreational sector under **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d**, **Alternative 4c**, or **Alternative 4d**. In fact, Cabo Rojo may experience some economic benefits under these particular alternatives relative to **Alternative 1** (status quo) due to effects on the private recreational sector. As previously discussed, private recreational vessels would be able to harvest non-reef fish species from and transit through the Bajo de Sico fishing grounds during recreational tournaments that occur in the months of the current Closure (December, January, and February). However, only one relatively small dolphin/wahoo tournament in Cabo Rojo falls within this three-month time period, and thus the economic benefits are likely to be minimal.

And in general, given the relatively large area that recreational fishing participants can fish during these tournaments, it is not expected that the adverse social and economic impacts under **Alternative 2a**, **Alternative 2b**, **Alternative 3a**, **Alternative 3b**, **Alternative 4a**, or **Alternative 4b** will be significant in magnitude. Nonetheless, such impacts are possible and more likely under particular alternatives and sub-alternatives. Furthermore, regardless of which of these alternatives and sub-alternatives are selected, the vast majority of these impacts are expected to occur in Cabo Rojo.

Specifically, the greatest adverse social and economic impacts as a result of effects on the private recreational sector are expected under **Alternative 4**, particularly **Alternative 4b**, which has the potential to affect all nine recreational fishing tournaments. Seven of these tournaments are run out of Cabo Rojo, three of which are by far the largest (in terms of participants and fishermen) and most valuable recreational fishing tournaments on the west coast. The other two tournaments are much smaller and organized in Mayaguez, which would be the only other municipality expected to experience any measurable adverse social and economic impacts.[21]

The next largest adverse social and economic impacts are expected to occur under **Alternative 3**, particularly **Alternative 3b**, which would potentially affect six of the nine recreational fishing tournaments, four tournaments in Cabo Rojo and the two tournaments in Mayaguez. In this case, the three largest, most valuable tournaments in Cabo Rojo would not be affected, and thus the adverse impacts should be considerably less in the aggregate and particularly in Cabo Rojo. Conversely, the adverse impacts in Mayaguez would likely not differ from those experienced under **Alternative 4** since the same two tournaments could be potentially affected. Finally, only minimal adverse social and economic impacts are expected under either **Alternative 2**a or **Alternative 2b** since only one small tournament would be potentially affected. These impacts would occur in Cabo Rojo.

In summary, given the above information on the distribution of expected social and economic impacts across municipalities due to effects on the commercial, charter, or private recreational sector and the businesses associated with each, it is expected that the adverse impacts arising from effects on the commercial sector would be the most significant in magnitude, with impacts (adverse or beneficial) arising from effects on the charter and private recreational sectors being of less magnitude at the municipality/community level. Even though the charter and private recreational sectors would be better off under **Alternative 1**, adverse social and economic impacts for all municipalities would be minimized under the no action alternative since no additional adverse social or economic impacts are expected for the commercial sector.

Also, with respect to all of the alternatives and sub-alternatives that would modify the Bajo de Sico closure in some manner (**Preferred Alternative 2**, **Alternative 3**, and **Alternative 4**), it is expected that the most significant adverse social and economic impacts would be experienced in Anasco, followed by Rincon and Mayaguez (impacts would be of similar magnitude in these two municipalities), Aguadilla, Cabo Rojo, with the least adverse social and economic impacts being seen in Aguada. From the perspective of each individual municipality, the previously noted rankings of alternatives with respect to direct and indirect effects on affected vessel owners (see Table 5.1.3) would be the same for the

[21] While it is true that some recreational vessels port in other municipalities, particularly Rincon and Aguadilla, it is assumed that the majority of the economic impacts arising from recreational tournament activity will occur in the hosting municipalities rather than where the owners port their vessels.

municipalities of Aguadilla, Cabo Rojo, Mayaguez, and Rincon. For Aguada, the impacts between **Sub-alternatives c** and **d** for each of these alternatives (i.e. **Alternative 2c** compared to **Preferred Alternative 2d**, **Alternative 3c** compared to **Alternative 3d**, and **Alternative 4c** compared to **Alternative 4d**) would basically be equivalent, as would the impacts between **Sub-alternatives a** and **b** for each alternative (i.e. impacts under **Alternative 2a** would be the same as under **Alternative 2b**, impacts under **Alternative 3a** would be the same as under **Alternative 3b**, etc.), though the impacts from **Sub-alternatives c** and **d** would be greater than those from **Sub-alternatives a** and **b** for each of these alternatives (i.e. the impacts under **Alternative 2a** and **Alternative 2b** would exceed those under **Alternative 2c** and **Preferred Alternative 2d**, the impacts under **Alternative 3a** and **Alternative 3b** would exceed those under **Alternative 3c** and **Alternative 3d**, etc.). And for Anasco, the impacts across all of the sub-alternatives (a, b, c, and d) would generally be equivalent for each of these alternatives (e.g. the impacts of **Alternative 2a**, **Alternative 2b**, **Alternative 2c**, and **Preferred Alternative 2d** would be approximately the same). Thus, only the choice of alternative would be important with respect to minimizing impacts in Anasco, with **Preferred Alternative 2** generating less adverse social and economic impacts than **Alternative 3** and **Alternative 4** generating the most adverse social and economic impacts.

5.1.3 Direct and Indirect Effects on the Administrative Environment

Bajo de Sico is currently closed to all fishing activity from December 1 through the last day of February each year. In addition, fishing with pots, traps, bottom longlines, gillnets or trammel nets is prohibited year-round. Modifying the seasonal closure is an administrative action designed to benefit the biological environment of the spawning populations of snapper and grouper aggregations and the coral reef populations found in the area. The action is also intended to benefit the physical and ecological processes of Bajo de Sico. The actions in this amendment will increase the burden on the administrative environment. This amendment will affect three valued environmental components within the administrative environment: management, law enforcement, and industry.

Promulgating regulations is a management action that requires development, implementation, and monitoring of the regulations and their effects. **Alternatives 2 (Preferred)**, **3**, and **4** would not require any additional efforts by managers than what is currently experienced through the present closure (**Alternative 1**). Regardless of the length of the closure, managers will be required to ensure fish stocks are not being harmed by fishing vessels and that the proposed benefits of this action are being seen. If the desired effects are not seen within the snapper and grouper population, management will need to evaluate the regulations and adjust accordingly to achieve the goals identified in the purpose and need section.

The other necessary component of regulations is the enforcement of those regulations. Without the efforts of law enforcement officials, no change in the snapper and grouper stocks would be expected regardless of the regulations developed and implemented. The new regulations may increase the burden on law enforcement due to the need for monitoring of a closed area. However, the volume of fishers is likely to decrease throughout the area. Therefore, a stronger regulatory framework to work under will provide relief to law enforcement officials. **Alternatives 2 (Preferred),** and **3**, in conjunction with the other seasonal closures previously mentioned, would ease enforcement efforts as compared to current regulations. Under **Alternative 1**, it would be difficult for law enforcement agents to enforce the closure for some species at one time, and then changing protection to the other seasonal closures. **Alternative 4** would require more enforcement for longer periods of time and thus would result in an extra burden on law enforcement agents.

The third administrative environment affected by modifying the seasonal closure is that of the industry itself. **Alternatives 2 (Preferred), 3,** and **4** are expected to increase spawning stock biomass of important commercially exploited species. As the biomass inside the closed area increases, movement out of the area into new areas by snapper and grouper species would be expected as they attempt to exploit available resources in nearby habitats (Russ and Alcala, 1996). As stocks are increased in areas outside of Bajo de Sico, fishery administrators can better manage and protect fish populations through less restrictive regulations.

5.2 Action 2: Prohibit anchoring by fishing vessels in Bajo de Sico

5.2.1 Direct and Indirect Effects on the Physical, Biological, and Ecological Environments

Scientists agree that anchoring has been known to cause substantial and long lasting damage to coral populations (Tratalos and Austin, 2001). Not only is setting anchors harmful to coral populations, but retrieval of the anchors and the movement of the anchor or anchor chain while on the ocean floor can cause damage as well (Dinsdale and Harriott, 2004). Each time a fishing vessel drops their anchor onto a coral reef, or an anchor strikes against corals, they are in danger of fractures. Fractures are not the only threat posed by anchors. The coral surface tissue and carbonate skeletons could suffer abrasion, the coral colonies could be removed from the substratum, or even death could occur (Dinsdale and Harriott, 2004).

Anchoring can also indirectly impact the long-term growth of coral populations. As corals are damaged, they must expend the energy on repair, rather than growth (Dinsdale and Harriott, 2004). If coral populations, an essential part of the ecology of reef environments, are decreased, fish populations could also be indirectly impacted by lack of available habitat. Some scientists argue reefs damaged by anchoring activities may take more than 50 years to recover, if they are ever able to do so. (Allen, 1992)

Currently, there are no restrictions on anchoring within Bajo de Sico. Without any additional regulations, as under **Alternative 1**, no change in the biological environment would be expected, therefore the coral reef populations would continue to be vulnerable to damage caused by anchors. Maintaining the current regulations would not benefit the physical environment and may in fact lead to declines of the physical environment as important reef processes are interrupted due to interactions with anchors, as previously discussed. The coral reef population's ability to survive and replenish degraded habitat may be unable to withstand interruptions in these processes. Without healthy coral populations, reef ecosystems may begin to decline, affecting EFH which ultimately impacts the biological and ecological environment by reducing biodiversity and limiting habitat.

Alternative 2 would prohibit anchoring for 6 months. If the Council chose **Alternative 2**, the anchoring prohibition would coincide with the 6 month closure period chosen in Action 1. For instance, anchoring would be prohibited October 1 through March 31 under Action 1, **Preferred Alternative 2** or December 1 through May 31 under Action 1, **Alternative 3**. The physical environment would be given better protection under **Action 2 Alternative 2** if paired up with **Action 1 Alternative 3** rather than **Action 1 Preferred Alternative 2** because more fishing activity occurs in the earlier months of the year due to weather patterns. October marks the beginning of marginally bad weather in the Mona Passage and lasts until March or April. Persistently high winds and associated sea conditions often create unsafe sea conditions which affect the amount of time available to fish and dive. **Action 2 Alternative 2 and Action 1 Alternative 3** would prohibit anchoring during better weather months, providing additional protection to corals during months that are typically utilized in Bajo de Sico.

The choice of **Action 2 Alternative 2** is associated with the choice of either **Action 1 Preferred Alternative 2** or **Action 1 Alternaitve 3**. If the prohibition on fishing in **Action 1** prevents fishing vessels from anchoring within Bajo de Sico, then a 6-month prohibition on anchoring would not achieve any additional biological benefits. Benefits would be achieved due to the management effects of **Action 1**.

Anchoring has a high probability of damaging essential coral reef populations. These coral populations are very vulnerable and slow growing. Even slight damage can require years of recovery. Although anchoring would be prohibited for 6 months, **Alternative 2** still poses a threat to coral populations. During the open season, anchoring could damage coral beyond recovery. The decline in coral reef populations signifies a possible decline in both EFH and biodiversity.

Preferred Alternative 3 would prohibit anchoring year-round, providing the greatest benefit to the physical and biological environments. Without threat of damage caused by anchoring, coral reef populations can continue to grow and provide habitat to snapper and grouper species as well as other species important to the overall health of Bajo de Sico.

If **Preferred Alternative 3** is chosen, **Action 1 Alternative 1** would provide better protection to the physical and biological environments than **Action 1 Alternative 1** if **Alternatives 1 or 2** are chosen in **Action 2**. However, if **Action 1 Alternative 4** is chosen, there wouldn't be as much protection from a 12-month anchoring prohibition if Bajo de Sico is already closed for 12 months. Fishers would already be discouraged from utilizing Bajo de Sico because it is closed to fishing for reef fish the entire year.

If **Preferred Alternative 2** or **Alternative 3** is chosen in **Action 1**, and **Preferred Alternative 3** is chosen in **Action 2**, prohibiting anchoring within Bajo de Sico may alleviate the incentive for fishers to shift their efforts to other times of the year. If anchoring is prohibited year round, fishers would still not be able to anchor, regardless of the time of year.

5.2.1.1: Consequences of Management Alternatives on Protected Resources

Alternative 1 would not prohibit anchoring by fishing vessels in Bajo de Sico. Only the bottom-tending gear prohibitions and requirements related to the use of an anchor retrieval system, if applicable, that are already in place as part of the Fishery Management Plan for the Reef Fish Fishery of Puerto Rico and the United Stated Virgin Islands would apply. Therefore, the impacts of this alternative on protected resources, including marine mammals, sea turtles, and listed corals, would remain the same. Under this alternative, anchoring of fishing vessels and any associated damages to benthic habitats would continue.

Alternative 2 would prohibit anchoring by commercial and recreational fishing vessels during the 6-month closed season selected under Action 1. This alternative would result in indirect benefits to listed corals falling within the boundaries of the Bajo de Sico managed area by minimizing the impacts of anchoring on the corals themselves. Also, this alternative results in indirect benefits to other protected species, in particular hawksbill sea turtles due to abundance of these turtles utilizing the area as forage and refuge habitat (García-Sais *et al*., 2007), related to minimizing the impacts of anchoring on benthic habitat utilized by listed species.

Preferred Alternative 3 would prohibit anchoring by commercial and recreational fishing vessels in Bajo de Sico year-round. This alternative would result in the greatest indirect benefits to protected species, in particular hawksbill sea turtles, as it would eliminate all anchoring by recreational and commercial fishing vessels year-round. Especially if coupled with the selection of an alternative under Action 1 that would greatly reduce or eliminate the fishing effort in the area, this alternative has the greatest likelihood of resulting in recovery or improvement in habitat quality in the area of Bajo de Sico due to the elimination of anchoring impacts from fishing vessels.

5.2.2 Direct and Indirect Effects on the Economic and Social Environments

Direct and Indirect Effects on Affected Vessel Owners

Under **Alternative 1**, no action, no additional adverse social or economic effects on commercial, charter, or private recreational vessel owners are expected. This action was not under consideration when Tonioli and Agar (2008) conducted their interviews with commercial and charter fishermen that fish in Bajo de Sico, and thus their findings are not directly instructive with respect to the potential social and economic effects under **Alternative 2** and **Preferred Alternative 3**.

However, some of the previously discussed findings with respect to **Action 1** are relevant. Specifically, their research indicated that commercial and charter fishermen have a strong incentive to avoid Bajo de Sico when it is currently closed and in fact already do so. As such, it is expected they would continue to avoid the area during an extension of the current closure that continues to prohibit the harvest of all species. If this is an accurate assessment of their behavior, then an anchoring prohibition that applies during a time when Bajo de Sico is closed to all fishing would not generate any additional adverse social or economic impacts on commercial or charter fishermen beyond those already noted in the analysis of alternatives and sub-alternatives for **Action 1**. So, for example, if **Alternative 2a**, **Alternative 2b**, **Alternative 3a**, or **Alternative 3b** is selected under **Action 1**, no additional adverse social or economic impacts on commercial or charter fishermen are expected under **Alternative 2** for **Action 2**. The same result would apply to the expected impacts on commercial and charter fishermen for **Preferred Alternative 3** under **Action 2** if **Alternative 4a** or **Alternative 4b** is selected under **Action 1**.

If **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, or **Alternative 3d** is selected under **Action 1**, the same result would apply to commercial fishermen (i.e., no additional adverse social or economic impacts are expected) under **Alternative 2** for **Action 2** as they would likely continue to avoid the area during the Closure even if it only applies to reef fish. And again, this result would be expected for **Preferred Alternative 3** under **Action 2** if **Alternative 4a** or **Alternative 4b** is selected under **Action 1** with respect to commercial fishermen.

However, since charter fishermen would likely no longer avoid Bajo de Sico if **Alternative 2c**, **Preferred Alternative 2d**, **Alternative 3c**, **Alternative 3d, Alternative 4a** or **Alternative 4b** is selected under **Action 1**, the same argument cannot be applied. However, public comments indicate that, due to the nature of the gear and fishing that charter fishermen use and engage in, and the general availability of mooring buoys, they do not drop anchor when targeting HMS/pelagic species in Bajo de Sico. Therefore, it is still the case that no adverse social or economic impacts on charter operations are expected under either **Alternative 2** or **Preferred Alternative 3** for **Action 2**.

On the other hand, as previously discussed, it is not clear that private recreational fishermen would behave in the same manner as they likely would not have the same incentive to avoid the area when it is closed. As such, it is possible that additional adverse social and economic impacts could be experienced in the private recreational sector. However, these impacts are expected to be minimal, particularly given the relatively small area covered by the closure in relation to the area covered by these vessels during recreational fishing tournaments. As reported by Macko et al. (2008), there is a general shortage of mooring buoys in the waters around Puerto Rico, and these buoys are commonly used by both charter and private recreational vessels. Given the shortage, which could become particularly problematic during popular recreational tournaments when hundreds of private recreational vessels are fishing at the same time, these vessels are commonly forced to circle and wait for a mooring buoy to become available, or drop anchor. If anchoring is no longer an option, private recreational vessels will be forced to expend fuel while waiting for a buoy to become available or travel outside of Bajo de Sico to find an available buoy or drop anchor. Given Bajo de Sico's relatively small size, the potential fuel expenditure to wait or move to another location should be relatively small, particularly in comparison to their total fuel expenditures while participating in a recreational fishing tournament. Nonetheless, given previous information regarding the timing, number, and size of the recreational fishing tournaments, it is expected that these minimally adverse impacts would be greater under **Preferred Alternative 3** relative to **Alternative 2** for **Action 2**.

If the Council selects **Alternative 1** (no action) under **Action 1**, then it is likely that **Preferred Alternative 3** under **Action 2** would generate minimal adverse social and economic impacts on private recreational, charter, and possibly a few commercial fishing vessel owners. That is, if the closure is not modified, then fishermen will not have an incentive to avoid the area when it is open to fishing. Whether an anchoring prohibition would give fishermen an incentive to avoid fishing in Bajo de Sico may vary by type of fisherman.

For example, given that the vast majority of charter and private recreational fishermen use rod and reel or handline gear, it would not be necessary for them to anchor in order to fish in a particular location. As discussed above, these vessels may need to anchor for other reasons (e.g. if they intend to remain in the area for an extended period of time). In such instances, they would incur minimal, additional fuel expenditures if sufficient mooring buoys are not immediately available in the Bajo de Sico fishing grounds and therefore need to move outside of the area.

Similarly, commercial vessel owners that use troll lines to target non-reef fish species such as HMS/pelagics do not need to anchor in order to fish. Most commercial fishermen that target deep water snapper-grouper species, particularly silk and queen snapper, use bottom line gear. It is believed that the vast majority of these fishermen do not anchor when fishing. Moreover, it is not necessary for bottom line fishermen to anchor in order to conduct their fishing operations. Thus, at most, the inability to anchor would generate a minor inconvenience to a few of these fishermen. Nonetheless, **Preferred Alternative 3** under **Action 2** would generate minimally greater adverse social and economic effects if **Alternative 1** is selected under **Action 1** rather than **Alternative 4**.

Direct and Indirect Effects on Local Communities

As with vessel owners, no adverse social or economic effects on the local municipalities are expected under **Alternative 1**. Further, given the low probability and minimal magnitude associated with any adverse social and economic effects on private recreational vessel owners, measurable adverse impacts at the municipality level are also not anticipated under **Alternative 2**. With respect to **Preferred Alternative 3**, it is still expected that any adverse social and economic effects on the private recreational, charter, and commercial sectors will be so minimal that impacts at the municipality level will be imperceptible. However, the probability such impacts will be experienced is somewhat greater if **Alternative 1** rather than **Alternative 4** is selected under **Action 1**.

5.2.3 Direct and Indirect Effects on the Administrative Environment

Anchoring in Bajo de Sico is currently allowed. Prohibiting anchoring is an administrative action designed to benefit the physical and biological environments of the area. Therefore, the actions in this amendment will affect the administrative environment. This amendment will affect two valued environmental components within the administrative environment: management and law enforcement.

Promulgating regulations is a management action that requires development, implementation, and monitoring of the regulations and their effects. However, due to the longevity of the action, as discussed above, closely monitoring the area may be necessary in a 6-month seasonal closure. Simply prohibiting anchoring year-round would alleviate the need for constant monitoring of the habitat in order to determine the need to close the area to fishing activities. With a year-round prohibition, managers can safely predict the condition of the habitat because they know anchoring is prohibited and hence does not pose a threat to the health of the habitat. Management should still occasionally monitor the conditions of the coral reef populations and ensure the regulations are having the desired effects on the habitat. If the desired effects are not seen, management will need to evaluate the regulations and adjust accordingly to achieve the goals identified in the purpose and need section.

Enforcement is an essential part of the success of any set regulations. Without the efforts of law enforcement officials, no benefits to the coral population would be expected regardless of the regulations developed and implemented. The new regulations may increase the burden on law enforcement due to the need for monitoring of a closed area. However, the volume of fishing vessels is likely to decrease throughout the area. Therefore, a stronger regulatory framework to work under will provide relief to law enforcement officials.

6.0 REGULATORY IMPACT REVIEW

6.1 Introduction

The NOAA Fisheries Service requires a Regulatory Impact Review (RIR) for all regulatory actions that are of public interest pursuant to Executive Order (E.O.) 12866, as amended. The RIR: (1) provides a comprehensive review of the level and incidence of impacts associated with a proposed or final regulatory action; (2) provides a review of the problems and policy objectives prompting the regulatory proposals and an evaluation of the major alternatives that could be used to solve the problem; and (3) ensures that the regulatory agency systematically and comprehensively considers all available alternatives so that the public welfare can be enhanced in the most efficient and cost-effective way. The RIR provides the information needed to determine whether the proposed regulations constitute a "significant regulatory action" under the criteria provided in E.O. 12866 and serves as the basis for determining if the actions will have a significant economic impact on a substantial number of small entities as per the requirements of the Regulatory Flexibility Act (RFA). This RIR analyzes the expected impacts of these actions on Puerto Rico's west coast fisheries. Additional details on the expected economic effects of the various alternatives under each action are included in **Section 6.0** and are incorporated herein by reference.

6.2 Problems and Objectives

The purpose and need, issues, problems, and objectives of the proposed amendment are presented in **Section 3.0** and are incorporated herein by reference. The Council's stated objective to be addressed by actions in this amendment is to protect snapper and grouper spawning aggregations and the associated habitat, particularly pristine coral, from directed fishing pressure to achieve a more natural sex ratio, age, and size structure, while minimizing adverse social and economic effects.

6.3 Methodology and Framework for Analysis

This RIR assesses management measures from the standpoint of determining the resulting changes in costs and benefits to society. To the extent practicable, the net effects of proposed measures should be stated in terms of producer and consumer surplus, changes in profits, and employment in the direct and support industries. However, given the competitive nature of local markets, potential changes in local production due to changing regulations are not expected to affect prices and thus consumer surplus. Further, given the lack of production cost data, estimates of producer surplus and profits are not currently available for commercial vessels operating in Puerto Rico's west coast fisheries. Detailed, quantitative data for charter and private recreational vessels are also not available. Therefore, costs and benefits are stated in terms of losses or gains in landings and gross revenue where possible. In addition, the public and private costs associated with the process of developing and enforcing regulations regarding the closure of Bajo de Sico are provided.

6.4 Description of the Fishery

A description of Puerto Rico's west coast fisheries is contained in **Section 5.3** and is incorporated herein by reference.

6.5 Impacts of Management Measures

Details on the economic impacts of all alternatives are included in **Section 6.0** and are included herein by reference. The following discussion includes only the expected impacts of the preferred alternatives.

6.5.1 Modify the Closed Season for Bajo de Sico (Action 1)

Under current regulations, Bajo de Sico is closed from December 1 through the last day of February. Initially implemented in order to protect red hind spawning aggregations, this seasonal closure applies to the harvest of all species, and thus includes species managed by the Council (e.g., reef fish and spiny lobster) and those not managed by the Council (e.g., HMS, pelagics, and baitfish). In effect, all fishing is currently prohibited within the area during these three months. However, transiting through Bajo de Sico during the closure is not expressly prohibited under the current regulations. Nonetheless, many commercial and charter fishermen typically do not transit through the area at present. Even though navigating around the area may slightly increase travel costs to other fishing grounds, many commercial and charter fishermen prefer to avoid the appearance of fishing illegally and, in turn, the potential for incurring costly fines. It is unknown whether private recreational fishermen behave similarly.

Under **Preferred Alternative 2d**, the Bajo de Sico closure would be modified in three important ways: 1) the closure would be modified to the months of October, November, and March, 2) the closure would only apply to the harvest of reef fish, and 3) transit through the area during the closure would be effectively prohibited for vessels with reef fish onboard. By modifying the closure in this manner, additional protections would be afforded to spawning aggregations of various reef fish species and their associated habitat (coral).

By, in effect, exempting activities involving the harvest of non-reef fish species, private recreational fishermen are expected to experience economic benefits under **Preferred Alternative 2d** in the short-run relative to the status quo. Private recreational fishermen exclusively target HMS/pelagic species (e.g., blue marlin, dolphin, and wahoo) and the vast majority of their bycatch is composed of other non-reef fish species (i.e., king mackerel, barracuda, and tunas). Attracting approximately 300 vessels and more than 1,100 individual anglers in a given year, recreational fishing tournaments are the most economically important events in which private recreational vessel owners participate. This is particularly true of the tournaments in which blue marlin are targeted, which have much higher participation rates and entrance fees. Catch and release is practiced in most of these tournaments. The economic value derived from participation in these tournaments arises from their catch of the target species since this serves as the basis for monetary and non-monetary awards. Thus, extending the closure for three additional months is not expected to generate any adverse economic impacts on the private recreational sector.

Furthermore, under **Preferred Alternative 2d**, private recreational fishermen would be able to harvest and retain non-reef fish species from Bajo de Sico during the three months covered by the current closure. Assuming they only have non-reef fish species onboard, private recreational vessel owners would also not have an incentive to avoid transiting through the area during this time. At present, only one relatively small, lower value dolphin/wahoo tournament, attracting approximately 25 vessels and 100 individual anglers, occurs during these three months. Furthermore, Bajo de Sico is a relatively small area (nine square miles) compared to the area covered by recreational fishing tournament participants, which can often encompass all waters off of Puerto Rico's west coast. As such, the direct economic benefits to these fishermen in terms of increased access to HMS/pelagic fishery resources and reduced fuel expenses are probably minimal individually and in the aggregate. Private recreational fishing tournament participants and organizers could experience somewhat greater economic benefits in the long-term under **Preferred Alternative 2d** if, in the future, additional tournaments were to be held during this three-month time period.

For similar reasons, charter vessel operations are also expected to experience economic benefits under **Preferred Alternative 2d** relative to the status quo. The eight potentially affected charter vessels exclusively target HMS/pelagic species. Under **Preferred Alternative 2d**, these vessels could fish in Bajo de Sico during the closure if they only harvest non-reef fish species such as HMS/pelagics. Thus, extending the closure for three additional months is not expected to generate any adverse economic impacts on the charter sector. Further, most of these vessels presently avoid transiting through Bajo de Sico during the current closure due to concerns with potential fines. Assuming they only have non-reef fish species onboard, charter vessel owners would no longer face the risk of being fined under **Preferred Alternative 2d**. Further, these vessels would no longer have an incentive to avoid transiting through the area during the closure and thus could reduce their fuel expenses.

Since Bajo de Sico is currently closed to all fishing, these vessels are precluded from fishing in the area between December and February. These particular months fall within the busy season for charter operations. Under **Preferred Alternative 2d**, these charter vessels would be able to harvest and retain non-reef fish species from Bajo de Sico during these months. The magnitude of the economic benefits arising from this increased access to fishery resources will largely depend on whether these charter vessels take additional fishing trips or spatially redistribute their current trips from other areas to Bajo de Sico as a result of this regulatory change. That is, the direct economic benefits to the charter sector will be greater to the extent that the regulatory change causes these vessels to expend additional fishing effort, which would result in additional revenue, rather than spatially redistribute their current fishing effort. Additional fishing effort by these charter vessels is also expected to generate indirect economic benefits to certain local businesses. Additional trips should result in additional expenditures on fishing supplies, fishing gear, and fuel, which would benefit the owners of businesses that sell these supplies to charter vessel owners.

Commercial vessel owners are expected to experience adverse economic impacts under **Preferred Alternative 2d** relative to the status quo. Specifically, approximately 64 commercial vessels fish in Bajo de Sico during the months it is currently open (i.e., March through October), or about 22% of the 294 commercial vessels active in Puerto Rico’s west coast fisheries during 2007, and thus would be directly affected by an extension of the closure. According to a recent survey, affected commercial fishermen indicated that an extension of the closure from three to six months would, on average, reduce their landings per trip by 48%, gross revenue per trip by 47%, operating costs by 57%, and household income by 43%. Many commercial vessel owners indicated that they would attempt to seek additional part-time employment in other industries in order to compensate for the projected reductions in household income, which could be difficult given current macroeconomic conditions. These fishermen indicated such effects would occur regardless of which three additional months Bajo de Sico is closed. However, other available information suggests otherwise and, further, that these effects are likely overestimated.

The affected commercial fishermen are primarily dependent on revenue generated from landings of reef fish species, which are generally harvested using bottom line gear. Silk snapper is the predominant target species when these fishermen are operating in Bajo de Sico, with queen snapper and red hind being secondary target species. Available information does suggest that the current closure has reduced these fishermen's harvests of silk snapper. However, two of the months included in the closure's extension under **Preferred Alternative 2d**, October and November, are "off-season" for many commercial fishermen, in part due to poor weather and sea conditions. More importantly, commercial fishermen are already prohibited from landing silk snapper during these months under other federal and state regulations. As such, it is difficult to reconcile these facts with the aforementioned estimates of adverse effects on landings and gross revenue. Furthermore, many of these fishermen also reported that they already avoid transiting through Bajo de Sico while it is closed, and so the additional fuel expenses from navigating around the area during the currently closed months have, in effect, already been taken into account. Nonetheless, and even though the closed area is only nine square miles, operating and particularly fuel costs would be expected to increase for these commercial vessels during the three additional closure months since they: 1) are relatively small (less than 20 feet on average), 2) would have to travel around Bajo de Sico during the additional three months it is closed, and 3) would potentially have to potentially travel to more distant fishing grounds in order to harvest reef fish.

At the present time, production cost and household income data are not available for individual commercial fishermen in Puerto Rico. However, trip tickets should provide estimates of these fishermen's landings and gross revenue. Attempts to link survey, license, and trip ticket data revealed that some of the affected fishermen do not have commercial fishing licenses and others do not report their landings and revenue. As such, estimates of the affected commercial fishermen's landings and revenue from these data sources must be used with caution, particularly since an analysis of the detailed data suggests that the fishermen who possess commercial fishing licenses and report their landings and revenue appear to be economic highliners (i.e., their landings and revenue are considerably higher, more than 140%, than the average commercial fisherman on Puerto Rico's west coast). In combination with the issues raised above regarding the timing of the closure's extension, the loss of commercial landings and revenue will, on average, be overestimated for individual fishermen and thus for the commercial fishing sector as a whole.

Specifically, available data indicates that the average landings and revenue in 2006-07 for the affected commercial fishermen were approximately 6,400 pounds and $17,300 respectively. Using the percentage losses in landings and revenue noted above leads to an average loss of 3,080 pounds in landings and $8,130 in revenue per fisherman, or approximately 197,000 pounds and $520,000 for the commercial fishing sector as a whole. The vast majority of these losses are expected to be due to a reduction in landings of reef fish, with a loss in landings of baitfish being of far less importance. Although harvest of baitfish would be allowed under **Preferred Alternative 2d**, most of the affected commercial fishermen indicated they would not go to Bajo de Sico to harvest baitfish if they could not also harvest reef fish. These estimates represent a loss of approximately

22% of total commercial fishing production and revenue on Puerto Rico's west coast which, for reasons previously discussed, is an overestimate of the closure modification's expected economic effects.

These direct adverse economic effects on the commercial fishing sector are expected to indirectly generate adverse economic impacts on commercial vessel crew, commercial fishing associations, and other local businesses that provide fishing supplies, gear, fuel, and vessel/gear maintenance services. Although commercial fishing vessel owners are not expected to reduce the number of crew they currently hire, the projected reductions in revenue and increases in costs will reduce profits and in turn lead to reductions in crew compensation. As a result, crew are expected to seek additional part-time employment opportunities in other industries which, as noted for commercial vessel owners, could be difficult in the current economic climate. Reduced revenue in the commercial fishing sector is also expected to lead to lower expenditures on fishing supplies, gear, fuel, and vessel/gear maintenance services, which will reduce sales and profits for those businesses. Reduced commercial harvests are expected to reduce the amount of local seafood for sale by commercial fishing associations. In turn, reduced availability of locally produced seafood on a regular, year-round basis will reduce these businesses' market share by giving restaurants, hotels, and other seafood retailers a greater incentive to substitute imports in place of locally produced seafood.

Some of the adverse economic impacts on certain commercial fishing vessels may be mitigated by the fact that Bajo de Sico will be opened to the harvest of HMS, pelagics, and other non-reef fish species, which would include the months the area is currently closed to all fishing. For vessels that currently possess troll line gear, which is the predominant gear used by commercial vessels to target HMS/pelagic species, they could expend more effort towards targeting HMS/pelagic species during the months of the current and modified closure rather than search for less productive and potentially more distant fishing grounds for reef fish species. Further, if they only harvest non-reef fish species, they would save on fuel expenses by avoiding the need to transit around Bajo de Sico while it is closed. However, relatively few of the affected commercial fishermen currently possess troll line gear and are somewhat dependent on revenue from HMS/pelagic landings. Further, few of the affected fishermen that currently use bottom line gear to target reef fish indicated any willingness to change their gear or target species. Thus, the opening of Bajo de Sico to fishing for non-reef fish species during the currently closed months is only expected to mitigate the adverse economic effects under **Preferred Alternative 2d** for a few of the affected commercial fishermen. In turn, mitigation of these adverse effects on local, onshore businesses is also likely to be minimal.

Other indirect, adverse economic effects could result if the affected commercial fishermen shift their effort on snapper-grouper species to other areas. Specifically, reducing the area in which commercial vessels can fish for reef fish may cause crowding effects (i.e., catch competition on the fishing grounds) and the potential for direct conflicts between commercial fishermen and between commercial and recreational fishermen. Furthermore, should the effort in the extended closure months shift to other popular fishing areas currently managed by the Council, such as Tourmaline Bank and Abrir la Sierra, local stocks of reef fish could become depleted in those areas. Some commercial fishermen believe stocks in some areas are already stressed. As such, further reductions could lead to additional management measures in the future (e.g., closure extensions in those areas), which would likely lead to additional adverse economic impacts on commercial fishermen.

6.5.2 Prohibit anchoring by fishing vessels (Action 2)

Under current regulations, fishing vessels are allowed to drop anchor in Bajo de Sico. It is believed that dropping anchor has a high probability of damaging pristine coral within this area. Coral serves as important habitat for a variety of reef fish species.

Under **Preferred Alternative 3**, fishing vessels would be prohibited from dropping anchor on a year-round basis. The vast majority of charter and private recreational fishermen use rod and reel or handline gear to target HMS/pelagic species. As such, it is not necessary for them to anchor in order to fish in a particular location. Similarly, commercial vessel owners that use troll lines to target non-reef fish species such as HMS/pelagics do not need to anchor in order to fish. Therefore, in general, it is not expected that these vessels would incur measurably adverse economic impacts under **Preferred Alternative 3**. However, some private recreational vessels may need to anchor for other reasons (e.g., if they intend to remain in the area for an extended period of time during a tournament). In such instances, if sufficient mooring buoys are not immediately available in the Bajo de Sico fishing grounds and these vessels need to move outside of the area, they would incur minimal, additional fuel expenditures.

Most commercial fishermen that target reef fish, particularly silk and queen snapper, use bottom line gear. Since fishing for reef fish would be prohibited in Bajo de Sico from October through March under **Preferred Alternative 2d** for **Action 1**, an anchoring prohibition during those months would be irrelevant with respect to generating any additional adverse economic impacts. With respect to bottom line fishermen that will target reef fish between April and September, it is believed that the vast majority of these fishermen do not anchor when fishing. Moreover, it is allegedly not necessary for them to anchor in order to conduct their fishing operations. Thus, at most, the inability to anchor would generate a minor inconvenience to a few of these bottom line commercial fishermen.

6.6 Public and Private Costs of Regulations

The preparation, implementation, enforcement, and monitoring of this or any Federal action involves the expenditure of public and private resources which can be expressed as costs associated with the regulations. Costs associated with this amendment include:

Council costs of document preparation, meetings, public hearings, and information dissemination…………………………………………………………………	$30,000
NOAA Fisheries Service administrative costs of document preparation, meetings, and review……………………………………………………………………..	$100,000
Annual law enforcement costs……………………………………………………...	$0
TOTAL…………………………………………………………………...	$130,000

Law enforcement currently monitors regulatory compliance in Puerto Rico's fisheries under routine operations and does not allocate specific budgetary outlays to these fisheries, nor are increased enforcement budgets expected to be requested to address any component of this action.

6.7 Determination of Significant Regulatory Action

Pursuant to E.O. 12866, a regulation is considered a 'significant regulatory action' if it is expected to result in: (1) an annual effect of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities; (2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights or obligations of recipients thereof; or (4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in this executive order. Based on the information provided above, this action is determined to not be economically significant for the purposes of E.O. 12866.

7.0 REGULATORY FLEXIBILITY ANALYSIS

7.1 Introduction

The purpose of the Regulatory Flexibility Act (RFA) is to establish a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration. The RFA does not contain any decision criteria; instead, the purpose of the RFA is to inform the agency, as well as the public, of the expected economic impacts of various alternatives contained in the FMP or amendment (including framework management measures and other regulatory actions) and to ensure that the agency considers alternatives that minimize the expected impacts while meeting the goals and objectives of the FMP and applicable statutes.

With certain exceptions, the RFA requires agencies to conduct a regulatory flexibility analysis for each proposed rule. The regulatory flexibility analysis is designed to assess the impacts various regulatory alternatives would have on small entities, including small businesses, and to determine ways to minimize those impacts. In addition to analyses conducted for the RIR, the regulatory flexibility analysis provides: (1) a statement of the reasons why action by the agency is being considered; (2) a succinct statement of the objectives of, and legal basis for the proposed rule; (3) a description and, where feasible, an estimate of the number of small entities to which the proposed rule will apply; (4) a description of the projected reporting, record-keeping, and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirements of the report or record; (5) an identification, to the extent practical, of all relevant Federal rules which may duplicate, overlap, or conflict with the proposed rule; and (6) a description of any significant alternatives to the proposed rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the proposed rule on small entities.

7.2 Statement of Need for, Objectives of, and Legal Basis for the Rule

The purpose and need, issues, problems, and objectives of the proposed rule are presented in **Section 3.0** and are incorporated herein by reference. In summary, the purpose of this amendment is to protect the snapper and grouper spawning aggregations and the associated habitat from directed fishing pressure to achieve a more natural sex ratio, age, and size structure, while minimizing adverse social and economic effects. Bajo de Sico populations of snapper and grouper are composed of relatively large individuals, many of which exhibit behaviors indicating they are approaching a spawning condition. The area is also known to be comprised of pristine coral habitats. Through the actions in this amendment, the Council intends to achieve greater protection of the area in order to preserve the current spawning fish populations and habitat conditions.

7.3 Identification of All Relevant Federal Rules Which May Duplicate, Overlap, or Conflict with the Proposed Rule

No duplicative, overlapping, or conflicting Federal rules have been identified.

7.4 Description and Estimate of the Number of Small Entities to Which the Proposed Rule will Apply

This proposed action is expected to directly impact commercial, charter, and private recreational fishing vessels. The Small Business Administration (SBA) has established size criteria for all major industry sectors in the U.S. including fish harvesters. A business involved in fish harvesting is classified as a small business if it is independently owned and operated, is not dominant in its field of operation (including its affiliates), and has combined annual receipts not in excess of $4.0 million (NAICS code 114111 and 114112, finfish and shellfish fishing) for all its affiliated operations worldwide. For for-hire vessels, the other qualifiers apply and the annual receipts threshold is $6.5 million (NAICS code 713990, recreational industries).

At present, federal permits are not required to participate in Council managed fisheries on Puerto Rico's west coast and therefore it is unknown how many fishermen or vessels participate in the federal component of these fisheries. However, landings data from Puerto Rico's trip ticket program indicate that 294 fishermen had commercial landings on Puerto Rico's west coast in 2007. Some of these fishermen do not possess commercial fishing licenses and the vessels used by these fishermen are not identified in the data. Preliminary fisherman Census data for 2008 indicates that 95% of commercial fishermen own one vessel, and thus it is assumed for current purposes that each commercial fisherman represents a single commercial fishing vessel. Further, all charter and headboat vessels used to fish for, take, retain, or possess Atlantic billfish, tunas, swordfish, or sharks must possess an Atlantic HMS charter/headboat permit. In 2008, eight charter vessels held HMS charter/headboat permits.

In Puerto Rico's west coast fisheries, commercial fishing vessels average 20 feet in length, but range between 12 to 51 feet, with the vast majority being between 15 and 25 feet. These vessels have an average horsepower of approximately 77, though considerable variability exists within the fleet, even among vessels of comparable length. The age of these vessels is approximately nineteen years on average. The majority of vessels are made of fiberglass (63%), though wood hulls and wood and fiberglass composite hulls are relatively common, accounting for 19% and 18% of the fleet, respectively. On average, each vessel carries two fishermen, typically one captain and one crewman.

According to the 2008 fisherman Census, 72% of Puerto Rico's west coast commercial fishermen possess some type of commercial fishing license while 28% do not. Of those fishermen that hold a commercial fishing license, the vast majority (78%) possess a full-time license, while the others possess either a beginner's license (18%) or a part-time license (4%). These fishermen are approximately 47 years old on average and have nearly 27 years of commercial fishing experience. Each fisherman supports approximately three dependents on average, which translates to an average household family size of four persons. Each fisherman spends an average of approximately 51 hours per week on commercial fishing related activities. These individuals are highly dependent on income from commercial fishing, which represents more than 85% of their household income on average. More than half of these fishermen (54%) have less than a high school level of education, 35% have a high school level of education, and 11% have some additional education beyond high school.

Based on corrected landings estimates, average gross revenue per commercial fisherman was $5,431 and $9,168 in 2006 and 2007 respectively, or $7,076 across both years. The maximum gross revenue for a single commercial fisherman in either year was approximately $138,000. Commercial fishermen are mainly dependent on revenue from spiny lobster, queen conch, and reef fish, particularly queen snapper and silk snapper. However, harvest of queen conch is prohibited in the EEZ around Puerto Rico and bottom-tending gear (e.g, fish and lobster traps) is prohibited in Bajo de Sico. Scuba diving and bottom line are the predominant gears used by commercial fishermen. The bottom line fishery for reef fish is most relevant for the actions considered in this amendment.

In 2008, eight vessels on Puerto Rico's west coast possessed HMS charter/headboat permits. All eight charter vessels are made of fiberglass. The majority of the HMS charter vessels (seven) use rod and reel gear, while only one vessel uses handline gear. Furthermore, these vessels are 27 feet in length and have 358 HP on average and thus are slightly longer and considerably more powerful on average than commercial fishing vessels. These vessels are approximately 8 years old on average and are thus also much newer than commercial fishing vessels. Charter vessels also typically carry more individuals in terms of crew and passengers (approximately seven on average) than commercial vessels. Charter vessels most frequently target dolphin, blue marlin, wahoo, and yellowfin tuna. Charter fishermen have approximately 25 years of fishing experience. Charter operators in Puerto Rico take approximately 190 trips per year, though recent survey data suggests that charter vessels on the west coast may average only 150-160 trips per year. This survey data also suggests that these west coast charter operations specialize in half-day trips rather than full-day trips, the latter of which was reported to cost $526 on average in 2005. Annual landings and revenue data for these charter operations is not presently available. However, it is assumed that these vessels' operations are relatively similar in scale to commercial vessels with respect to annual revenue.

Action 1 will directly affect 64 of the 294 (22%) of the commercial fishermen/vessels and all eight (100%) of the charter vessels. **Action 2** may directly affect a small number of the 64 commercial fishermen/vessels affected under **Action 1**, but is not expected to affect any of the eight charter vessels.

7.5 Description of the Projected Reporting, Record-keeping and Other Compliance Requirements of the Proposed Rule, Including an Estimate of the Classes of Small Entities Which will be Subject to the Requirement and the Type of Professional Skills Necessary for the Preparation of the Report or Records

Management measures considered in this proposed rule do not affect the reporting or record-keeping requirements for commercial, charter, or private recreational vessels. This proposed action, which only modifies the seasonal closure of Bajo de Sico, does not require additional records or report preparation.

7.6 Substantial Number of Small Entities Criterion

The proposed action would be expected to directly affect approximately 64 of 294 (22%) commercial vessels and all eight (100%) charter vessels. All affected entities have been determined, for the purpose of this analysis, to be small entities. Therefore, it is determined that the proposed action will affect a substantial number of small entities.

7.7 Significant Economic Impact Criterion

The outcome of 'significant economic impact' can be ascertained by examining two issues: disproportionality and profitability.

<u>Disproportionality</u>: Do the regulations place a substantial number of small entities at a significant competitive disadvantage to large entities?

All entities that are expected to be affected by the proposed rule are considered small entities so the issue of disproportionality does not arise in the present case.

<u>Profitability</u>: Do the regulations significantly reduce profit for a substantial number of small entities?

Action 1 is expected to directly benefit eight charter vessels by giving them access to Bajo de Sico's HMS/pelagic resources during the three months (December through February) the area is currently closed to all fishing. The magnitude of these economic benefits depends on the extent to which these vessels take additional trips to Bajo de Sico as opposed to reallocating current trips from other areas. An estimate of how many additional trips these charter vessels might take is not currently available. However, additional trips would be expected to result in higher revenue and thus higher profit.

Conversely, the 64 commercial fishermen/vessels directed affected by **Action 1** are expected to experience a reduction in landings, revenue, and therefore profit as a result of modifying the closure of Bajo de Sico to the months of October, November, and March. The affected vessels averaged approximately 6,400 pounds in landings and $17,300 in gross revenue in 2007. Given the current lack of cost data, the reduction in profit for these vessels cannot be directly estimated. However, the available data indicates these vessels are expected to experience a 48% reduction in landings and a 47% reduction in gross revenue, or approximately $8,130 per vessel. Most of these losses are due to reductions in the harvest of reef fish, particularly deepwater snappers. Since these relatively small vessels will not be able to transit through Bajo de Sico and may have to travel to more distant fishing grounds in order to harvest deepwater snappers, operating costs are expected to increase by 57%. Further, the data also indicate these fishermen are expected to experience a 55% percent reduction in household income. As household income is generally indicative of net revenue or profit, this figure represents the best available estimate of reduction in profits for these entities. A few vessels may be able to partially mitigate these losses by reallocating some of their fishing effort out of the bottom line fishery for reef fish into the troll line fishery for HMS/pelagic species during the months that Bajo de Sico will be closed, if they currently possess the proper gear. Furthermore, since October and November are off-season for many commercial fishermen due to poor weather and sea conditions, and given that the harvest of their primary target species, silk snapper, is already prohibited during these months, the reductions in landings, revenue, and household income are likely overestimated.

Action 2 is not expected to generate adverse economic impacts on the eight charter vessels since they do not drop anchor when fishing. It is possible though not likely that a few of the commercial vessels/fishermen affected under **Action 1** may experience minimal adverse economic effects. Though it is not necessary for bottom line fishermen to drop anchor when they are fishing, such behavior may occur on occasion. As such behavior would no longer permissible, fishermen would be required to move out of the area, and thereby expend fuel, if they want to drop anchor. The effects resulting from the occasional need for a few vessels to expend additional fuel would likely be imperceptible and therefore probably have no impact on these vessels' profitability.

7.8 Description of Significant Alternatives

Four alternatives, including the status quo, were considered for the action to modify the closed season for Bajo de Sico. Three of the alternatives include multiple sub-alternatives that determine which species and specific activities are covered by the closure. The first alternative, the status quo, would not have modified the seasonal closure for Bajo de Sico or prohibited possession of reef fish onboard when transiting through the area during the closure. Further, the seasonal closure would have continued to apply to all fishing, including fishing for non-reef fish species such as HMS/pelagics. This alternative is inconsistent with the Council's objective of providing greater protection for spawning aggregations of reef fish species in the area as well as pristine coral that provide critical habitat for these species.

The second alternative, which would extend the seasonal closure by three months to the months of October, November, and March, had three sub-alternatives other than the one that was selected. The first sub-alternative would have prohibited fishing for all species, including those not managed by the Council, during the closure. The second sub-alternative would have prohibited fishing for and possession of all species, including those not managed by the Council, during the closure. The third sub-alternative would have prohibited fishing for reef fish during the closure. The first two sub-alternatives were not selected since fishing for HMS/pelagic species using troll, rod and reel, and handline gear near the surface is not expected to result in the incidental harvest of reef fish or damage coral. As such, prohibiting fishing for and possession of these species would generate unnecessary economic and social impacts on charter, private recreational, and commercial vessels. The third sub-alternative was not selected since it would still effectively allow transit through Bajo de Sico during the closure with reef fish onboard. Allowing possession of reef fish onboard would make it difficult to prove where they were harvested from, which would in turn make enforcement of the closure more difficult and thereby less effective.

The third alternative, which would extend the seasonal closure by three months to the months of March, April, and May, had four sub-alternatives. Although this alternative would also close Bajo de Sico for six months, and thereby generate comparable biological benefits in terms of protecting spawning aggregations of reef fish species and coral, it would create greater adverse social and economic impacts on commercial fishermen and associated onshore businesses and no additional benefits to charter or private recreational fishermen relative to the proposed action. Thus, this alternative would result in lower net benefits to society compared to the proposed action.

The fourth alternative, which would implement a year-round closure of Bajo de Sico, had four sub-alternatives. This alternative would have generated greater biological benefits with respect to protecting coral and reef fish populations. However, the additional benefits of a year-round closure to reef fish spawning aggregations were not believed to be significantly greater compared to a six-month closure and additional protections to coral habitat are being accomplished by the other proposed action. Further, by completely prohibiting access to Bajo de Sico's reef fish and, in effect, baitfish resources, this alternative would have generated much greater adverse social and economic impacts on commercial fishermen and associated onshore businesses and no additional benefits to charter or private recreational fishermen relative to the proposed action. Given the amendment's objectives, the Council concluded these considerably larger social and economic costs outweighed the additional biological benefits and thus would have resulted in lower net benefits to society compared to the proposed action.

Three alternatives, including the status quo, were considered for the action to prohibit anchoring in Bajo de Sico. The first alternative, the status quo, would not have implemented any restrictions on anchoring in Bajo de Sico. Anchoring is thought to cause substantial and long lasting damage to coral populations. Anchoring can also indirectly impact the long-term growth of coral populations. Coral populations are an essential part of the ecology of reef environments. If coral populations are decreased, reef fish populations could also be indirectly impacted by lack of essential habitat. Thus, this alternative is contrary to the Council's objective of providing additional protections to important coral habitat.

The second alternative would have prohibited anchoring for six months. Anchoring has a high probability of damaging essential coral reef populations. These coral populations are very vulnerable and slow growing and even slight damage can require years of recovery. Anchoring during the open season could damage coral beyond recovery. Coral populations are an essential part of the ecology of reef environments. If coral populations are decreased, reef fish populations could also be indirectly impacted by lack of essential habitat. Thus, this alternative is contrary to the Council's objective of providing additional protections to important coral habitat.

8.0 OTHER APPLICABLE LAWS

The MSFCMA (16 U.S.C. 1801 et seq.) provides the authority for U.S. fishery management. But fishery management decision-making is also affected by a number of other federal statutes designed to protect the biological and human components of U.S. fisheries, as well as the ecosystems within which those fisheries are conducted. Major laws affecting federal fishery management decision making are summarized below.

8.1 Administrative Procedures Act

All federal rulemaking is governed under the provisions of the Administrative Procedure Act (APA) (5 U.S.C. Subchapter II), which establishes a "notice and comment" procedure to enable public participation in the rulemaking process. Under the APA, NOAA Fisheries is required to publish notification of proposed rules in the *Federal Register* and to solicit, consider and respond to public comment on those rules before they are finalized. The APA also establishes a 30-day wait period from the time a final rule is published until it takes effect.

8.2 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972 (16 U.S.C. 1451 et seq.) encourages state and federal cooperation in the development of plans that manage the use of natural coastal habitats, as well as the fish and wildlife those habitats support. When proposing an action determined to directly affect coastal resources managed under an approved coastal zone management program, NOAA Fisheries is required to provide the relevant state agency with a determination that the proposed action is consistent with the enforceable policies of the approved program to the maximum extent practicable at least 90 days before taking final action.

8.3 Data Quality Act

The Data Quality Act (DQA) (Public Law 106-443), which took effect October 1, 2002, requires the government for the first time to set standards for the quality of scientific information and statistics used and disseminated by federal agencies. Information includes any communication or representation of knowledge such as facts or data, in any medium or form, including textual, numerical, cartographic, narrative, or audiovisual forms (includes web dissemination, but not hyperlinks to information that others disseminate; does not include clearly stated opinions).

Specifically, the Act directs the Office of Management and Budget (OMB) to issue government wide guidelines that "provide policy and procedural guidance to federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by federal agencies." Such guidelines have been issued, directing all federal agencies to create and issue agency-specific standards to 1) ensure Information Quality and develop a pre-dissemination review process; 2) establish administrative mechanisms allowing affected persons to seek and obtain correction of information; and 3) report periodically to OMB on the number and nature of complaints received.

Scientific information and data are key components of FMPs and amendments and the use of best available information is the second national standard under the MSFCMA. To be consistent with the Act, FMPs and amendments must be based on the best information available, properly reference all supporting materials and data, and should be reviewed by technically competent individuals. With respect to original data generated for FMPs and amendments, it is important to ensure that the data are collected according to documented procedures or in a manner that reflects standard practices accepted by the relevant scientific and technical communities. Data must also undergo quality control prior to being used by the agency.

8.4 Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. Section 1531 et seq.) requires that federal agencies use their authorities to conserve endangered and threatened species, and that they ensure actions they authorize, fund, or carry out are not likely to harm the continued existence of those species or the habitat designated to be critical to their survival and recovery. The ESA requires NOAA Fisheries, when proposing a fishery action that "may affect" critical habitat or endangered or threatened species, to consult with the appropriate administrative agency (itself for most marine species, the U.S. Fish and Wildlife Service for all remaining species) to determine the potential impacts of the proposed action. Consultations are concluded informally when proposed actions "may affect but are not likely to adversely affect" endangered or threatened species or designated critical habitat. Formal consultations, resulting in a biological opinion, are required when proposed actions may affect and are "likely to adversely affect" endangered or threatened species or designated critical habitat. If jeopardy or adverse modification is found, the consulting agency is required to suggest reasonable and prudent alternatives.

As provided in 50 CFR 402.16, reinitiation of formal consultation is required when discretionary involvement or control over the action has been retained (or is authorized by law) and: (1) the amount or extent of the incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not previously considered; or (4) if a new species is listed or critical habitat designated that may be affected by the identified action.

8.5 Rivers and Harbors Act of 1899

The Rivers and Harbors Act was created in 1899 to prevent navigable waters of the United States from being obstructed. Section 10 of the Act requires that anyone wishing to dredge, fill, or build a structure in any navigable water and associated wetlands obtain a permit from the Army Corps of Engineers (ACOE). An activity affecting wetlands may require a

Section 404 and Section 10 permit, thus both sections are often included together in a permit notice. When these activities are allowed, and there is direct loss of submerged habitat, such as seagrasses, then mitigation is often required to compensate for this loss.

8.6 Clean Water Act

In 1972, Congress passed the Clean Water Act (CWA) - also known as the Water Pollution Prevention and Control Act - to protect the quality of the nation's waterways including oceans, lakes, rivers and streams, aquifers, coastal areas, and aquatic resources. The law sets out broad rules for protecting the waters of the United States; Sections 404 and 401 apply directly to waters and aquatic resources protection.

Section 404 of the Clean Water Act (often referred to as "Section 404" or simply "404") forbids the unpermitted "discharge of dredge or fill material" into waters of the United States. Section 404 does not regulate every activity in aquatic resources or coastal areas, but requires anyone seeking to fill any area to first obtain a permit from the ACOE. Constructing bridges, causeways, piers, port expansion, or any other construction or development activity along a waterway or in aquatic resources generally requires a 404 permit. When a fill project is permitted, there may be mitigation required to replace lost aquatic resources.

Section 401 of the Clean Water Act requires that an applicant for a Section 404 permit obtain a certificate from their state's environmental regulatory agency (if the state has delegated such authority to the agency) that the activity will not negatively impact water quality. This permit process is supposed to prevent the discharge of pollutants (pesticides, heavy metals, hydrocarbons) or sediments into waters, which may be above acceptable levels, because decreased water quality may endanger the health of the people, fish, and wildlife. However, acceptable pollutant levels have not been established for many aquatic resources, which make it difficult for state agencies to fully assess a project's impact on water quality.

8.7 National Marine Sanctuaries Act

Under the National Marine Sanctuaries Act (NMSA) (also known as Title III of the Marine Protection, Research and Sanctuaries Act of 1972), as amended, the Secretary of Commerce is authorized to designate National Marine Sanctuaries to protect distinctive natural and cultural resources whose protection and beneficial use requires comprehensive planning and management. The National Marine Sanctuaries are administered by NOAA's National Ocean Service. The Act provides authority for comprehensive and coordinated conservation and management of these marine areas. The National Marine Sanctuary System currently comprises 13 sanctuaries around the country, including sites in American Samoa and Hawaii. These sites include significant coral reef and kelp forest habitats, and breeding and feeding grounds of whales, sea lions, sharks, and sea turtles. A complete listing of the current sanctuaries and information about their location, size, characteristics, and affected fisheries can be found at http://www.sanctuaries.nos.noaa.gov/oms/oms.html.

8.8 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act protects the quality of the aquatic environment needed for fish and wildlife resources. The Act requires consultation with the Fish and Wildlife Service and the fish and wildlife agencies of States where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified" by any agency (except TVA) under a Federal permit or license. NOAA Fisheries was brought into the process later, as these responsibilities were carried over, during the reorganization process that created NOAA. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources", and to ensure that the environmental value of a body of water or wetland is taken into account in the decision-making process during permit application reviews. Consultation is most often (but not exclusively) initiated when water resource agencies send the FWS or NOAA Fisheries a public notice of a Section 404 permit. FWS or NOAA Fisheries may file comments on the permit stating concerns about the negative impact the activity will have on the environment, and suggest measures to reduce the impact.

8.9 Executive Orders

8.9.1 E.O. 12114: Environmental Assessment of Actions Abroad

The purpose of this Executive Order is to enable responsible officials of Federal agencies having ultimate responsibility for authorizing and approving actions encompassed by this Order to be informed of pertinent environmental considerations and to take such considerations into account, with other pertinent considerations of national policy, in making decisions regarding such actions. While based on independent authority, this Order furthers the purpose of the National Environmental Policy Act (NEPA) and the Marine Protection Research and Sanctuaries Act and the Deepwater Port Act consistent with the foreign policy and national security policy of the United States, and represents the United States government's exclusive and complete determination of the procedural and other actions to be taken by Federal agencies to further the purpose of the NEPA, with respect to the environment outside the United States, its territories and possessions.

Agencies in their procedures shall establish procedures by which their officers having ultimate responsibility for authority and approving actions in one of the following categories encompassed by this Order, take into consideration in making decisions concerning such actions, a document described in Section 2-4(a):
(a) major Federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation (e.g., the oceans or Antarctica);
(b) major Federal actions significantly affecting the environment of a foreign nation not participating with the United States and not otherwise involved in the action;
(c) major Federal actions significantly affecting the environment of a foreign nation which provide to that nation:

(1) a product, or physical project producing a principal product or an emission or effluent, which is prohibited or strictly regulated by Federal law in the United States because its toxic effects on the environment create a serious public health risk; or

(2) a physical project which in the United States is prohibited or strictly regulated by Federal law to protect the environment against radioactive substances.

(d) major Federal actions outside the United States, its territories and possessions which significantly affect natural or ecological resources of global importance designated for protection under this subsection by the President, or, in the case of such a resource protected by international agreement binding on the United States, by the Secretary of State. Recommendations to the President under this subsection shall be accompanied by the views of the Council on Environmental Quality and the Secretary of State.

8.9.2 E.O. 12866: Regulatory Planning and Review

Executive Order 12866: Regulatory Planning and Review, signed in 1993, requires federal agencies to assess the costs and benefits of their proposed regulations, including distributional impacts, and to select alternatives that maximize net benefits to society. To comply with E.O. 12866, NOAA Fisheries prepares a Regulatory Impact Review (RIR) for all fishery regulatory actions that either implement a new fishery management plan or significantly amend an existing plan. RIRs provide a comprehensive analysis of the costs and benefits to society associated with proposed regulatory actions, the problems and policy objectives prompting the regulatory proposals, and the major alternatives that could be used to solve the problems. The reviews also serve as the basis for the agency's determinations as to whether proposed regulations are a "significant regulatory action" under the criteria provided in E.O. 12866 and whether proposed regulations will have a significant economic impact on a substantial number of small entities in compliance with the RFA. A regulation is significant if it is likely to result in an annual effect on the economy of at least $100,000,000 or has other major economic effects.

8.9.3 E.O. 12630: Takings

The Executive Order on Government Actions and Interference with Constitutionally Protected Property Rights, which became effective March 18, 1988, requires that each federal agency prepare a Takings Implication Assessment for any of its administrative, regulatory, and legislative policies and actions that affect, or may affect, the use of any real or personal property. Clearance of a regulatory action must include a takings statement and, if appropriate, a Takings Implication Assessment.

8.9.4 E.O. 13089: Coral Reef Protection

The Executive Order on Coral Reef Protection (June 11, 1998) requires federal agencies whose actions may affect U.S. coral reef ecosystems to identify those actions, utilize their programs and authorities to protect and enhance the conditions of such ecosystems; and, to the extent permitted by law, ensure that actions they authorize, fund or carry out not degrade the condition of that ecosystem. By definition, a U.S. coral reef ecosystem means those species, habitats, and other national resources associated with coral reefs in all maritime areas and zones subject to the jurisdiction or control of the United States (e.g., federal, state, territorial, or commonwealth waters).

8.9.5 E.O. 13112: Invasive Species

The Executive Order requires agencies to use authorities to prevent introduction of invasive species, respond to and control invasions in a cost effective and environmentally sound manner, and to provide for restoration of native species and habitat conditions in ecosystems that have been invaded. Further, agencies shall not authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species in the U.S. or elsewhere unless a determination is made that the benefits of such actions clearly outweigh the potential harm; and that all feasible and prudent measures to minimize the risk of harm will be taken in conjunction with the actions. The actions undertaken in this amendment will not introduce, authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species in the U.S. or elsewhere.

8.9.6 E.O. 13132: Federalism

The Executive Order on federalism requires agencies in formulating and implementing policies that have federalism implications, to be guided by the fundamental federalism principles. The Order serves to guarantee the division of governmental responsibilities between the national government and the states that was intended by the framers of the Constitution. Federalism is rooted in the belief that issues that are not national in scope or significance are most appropriately addressed by the level of government closest to the people. This Order is relevant to FMPs and amendment given the overlapping authorities of NOAA Fisheries, the states, and local authorities in managing coastal resources, including fisheries, an the need for a clear definition of responsibilities. It is important to recognize those components of the ecosystem over which fishery managers have no direct control and to develop strategies to address them in conjunction with appropriate state, tribes and local entities. The proposed management measures in this amendment have been developed with the local and federal officials.

8.9.7 E.O. 13141: Environmental Review of Trade Agreements

This Executive Order requires the U.S. Trade Representative, through the interagency Trade Policy Staff to conduct environmental reviews of three of the most common agreements: comprehensive multilateral trade rounds, bilateral or multilateral free-trade agreements, and major new trade liberalization agreements in natural resource sectors. Although the procedures for environmental impact assessment in Executive Order 13141 are not subject to NEPA, they follow similar guidelines.

8.9.8 E.O. 13158: Marine Protected Areas

Executive Order 13158 (May 26, 2000) requires federal agencies to consider whether their proposed action(s) will affect any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural or cultural resource within the protected area.

8.9.9 E.O. 12898: Environmental Justice

This Executive Order mandates that each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. Federal agency responsibilities under this Executive Order include conducting their programs, policies, and activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons from participation in, denying persons the benefit of, or subjecting persons to discrimination under, such, programs policies, and activities, because of their race, color, or national origin. Furthermore, each federal agency responsibility set forth under this Executive Order shall apply equally to Native American programs.

Specifically, federal agencies shall, to the maximum extent practicable; conduct human health and environmental research and analysis; collect human health and environmental data; collect, maintain and analyze information on the consumption patterns of those who principally rely on fish and/or wildlife for subsistence; allow for public participation and access to information relating to the incorporation of environmental justice principals in Federal agency programs or policies; and share information and eliminate unnecessary duplication of efforts through the use of existing data systems and cooperative agreements among Federal agencies and with State, local, and tribal governments. The proposed actions would be applied to all participants in the fishery, regardless of their race, color, national origin, or income level, and as a result are not considered discriminatory. Additionally, none of the proposed actions are expected to affect any existing subsistence consumption patterns. Therefore, no environmental justice issues are anticipated and no modifications to any proposed actions have been made to address environmental justice issues.

8.10 Marine Mammal Protection Act

The MMPA established a moratorium, with certain exceptions, on the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas. It also prohibits the importing of marine mammals and marine mammal products into the United States. Under the MMPA, the Secretary of Commerce (authority delegated to NOAA Fisheries) is responsible for the conservation and management of cetaceans and pinnipeds (other than walruses). The Secretary of the Interior is responsible for walruses, sea otters, polar bears, manatees, and dugongs.

In 1994, Congress amended the MMPA, to govern the taking of marine mammals incidental to commercial fishing operations. This amendment required the preparation of stock assessments for all marine mammal stocks in waters under U.S. jurisdiction; development and implementation of take-reduction plans for stocks that may be reduced or are being maintained below their optimum sustainable population levels due to interactions with commercial fisheries; and studies of pinniped-fishery interactions. The MMPA requires a commercial fishery to be placed in one of three categories, based on the relative frequency of incidental serious injuries and mortalities of marine mammals. Category I designates fisheries with frequent serious injuries and mortalities incidental to commercial fishing; Category II designates fisheries with occasional serious injuries and mortalities; Category III designates fisheries with a remote likelihood or no known serious injuries or mortalities. To legally fish in a Category I and/or II fishery, a fisherman must obtain a marine mammal authorization certificate by registering with the Marine Mammal Authorization Program (50 CFR 229.4) and accommodate an observer if requested (50 CFR 229.7(c)) and they must comply with any applicable take reduction plans. According to the List of Fisheries for 2009 published by the National Marine Fisheries Service, the Caribbean Reef Fish fishery is considered Category III (73 FR 73032).

8.11 Paperwork Reduction Act

The Paperwork Reduction Act (PRA) of 1995 (44 U.S.C. 3501 et seq.) regulates the collection of public information by federal agencies to ensure that the public is not overburdened with information requests, that the federal government's information collection procedures are efficient, and that federal agencies adhere to appropriate rules governing the confidentiality of such information. The PRA requires NOAA Fisheries to obtain approval from the Office of Management and Budget before requesting most types of fishery information from the public. This action contains no new collections of information.

8.12 Small Business Act

The Small Business Act of 1953, as amended, Section 8(a), 15 U.S.C. 634(b)(6), 636(j), 637(a) and (d); Public Laws 95-507 and 99-661, Section 1207; and Public Laws 100-656 and 101-37 are administered by the SBA. The objectives of the act are to foster business ownership by individuals who are both socially and economically disadvantaged; and to promote the competitive viability of such firms by providing business development assistance including, but not limited to, management and technical assistance, access to capital and other forms of financial assistance, business training and counseling, and access to sole source and limited competition federal contract opportunities, to help the firms to achieve competitive viability. Because most businesses associated with fishing are considered small businesses, NMFS, in implementing regulations, must make an assessment of how those regulations will affect small businesses.

8.13 Magnuson-Stevens Act Essential Fish Habitat Provisions

The Magnuson-Stevens Act includes EFH requirements, and as such, each existing, and any new, FMPs must describe and identify EFH for the fishery, minimize to the extent practicable adverse effects on that EFH caused by fishing, and identify other actions to encourage the conservation and enhancement of that EFH. The Council and NMFS have determined there are no adverse effects to EFH in this amendment as discussed in the Environmental Consequences section (Section 5.0).

8.14 National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 et seq.) requires federal agencies to consider the environmental and social consequences of proposed major actions, as well as alternatives to those actions, and to provide this information for public consideration and comment before selecting a final course of action. This document contains an Environmental Assessment to satisfy the NEPA requirements. The statement of need can be found in Section 2.0, Alternatives are found in Section 3.0, the environmental impacts are found in section 5.0, and a list of agencies/people consulted is found in Section 11.0.

8.15 Regulatory Flexibility Act

The purpose of the Regulatory Flexibility Act (RFA 1980, 5 U.S.C. 601 et seq.) is to ensure that federal agencies consider the economic impact of their regulatory proposals on small entities, analyze effective alternatives that minimize the economic impacts on small entities, and make their analyses available for public comment. The RFA does not seek preferential treatment for small entities, require agencies to adopt regulations that impose the least burden on small entities, or mandate exemptions for small entities. Rather, it requires agencies to examine public policy issues using an analytical process that identifies, among other things, barriers to small business competitiveness and seeks a level playing field for small entities, not an unfair advantage.

After an agency determines that the RFA applies, it must decide whether to conduct a full regulatory flexibility analysis (IRFA or Final Regulatory Flexibility Analysis) or to certify that the proposed rule will not "have a significant economic impact on a substantial number of small entities. In order to make this determination, the agency conducts a threshold analysis, which has the following 5 parts: 1) Description of small entities regulated by proposed action, which includes the SBA size standard(s), or those approved by the Office of Advocacy, for purposes of the analysis and size variations among these small entities; 2) Descriptions and estimates of the economic impacts of compliance requirements on the small entities, which include reporting and recordkeeping burdens and variations of impacts among size groupings of small entities; 3) Criteria used to determine if the economic impact is significant or not; 4) Criteria used to determine if the number of small entities that experience a significant economic impact is substantial or not; and 5) Descriptions of assumptions and uncertainties, including data used in the analysis. If the threshold analysis indicates that there will not be a significant economic impact on a substantial number of small entities, the agency can so certify. The IRFA for this action can be found in Section 7.0.

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National Marine Fisheries Service Silver Spring Office
National Marine Fisheries Service Office of Law Enforcement
Puerto Rico Department of Natural and Environmental Resources
United States Coast Guard
United States Fish and Wildlife Services
USVI Department of Planning and Natural Resources

12.0 INDEX

APPENDIX A: CARIBBEAN REEF FISH

(50 CFR 622 Appendix A Table 2)

Lutjanidae--Snappers

Unit 1

- Silk snapper, Lutjanus vivanus
- Blackfin snapper, L. buccanella
- Black snapper, Apsilus dentatus
- Vermilion snapper, Rhomboplites aurorubens

Unit 2

- Queen snapper, Etelis oculatus
- Wenchman, Pristipomoides aquilonaris

Unit 3

- Gray snapper, Lutjanus griseus
- Lane snapper, Lutjanus synagris
- Mutton snapper, Lutjanus analis
- Dog snapper, Lutjanus jocu
- Schoolmaster, Lutjanus apodus
- Mahogany snapper, Lutjanus mahogani

Unit 4

- Yellowtail snapper, Ocyurus chrysurus

Serranidae--Sea basses and Groupers

Unit 1

- Nassau Grouper, Epinephelus striatus

Unit 2

- Goliath grouper, Epinephelus itajara

Unit 3

- Red hind, Epinephelus guttatus
- Coney, Epinephelus fulvus
- Rock hind, Epinephelus adscensionis
- Graysby, Epinephelus cruentatus
- Creole-fish, Paranthias furcifer

Unit 4

- Red grouper, Epinephelus morio
- Yellowedge grouper, Epinephelus flavolimbatus
- Misty grouper, Epinephelus mystacinus
- Tiger grouper, Mycteroperca tigris
- Yellowfin grouper, Mycteroperca venenosa

Haemulidae--Grunts

- White grunt, Haemulon plumieri
- Margate, Haemulon album
- Tomtate, Haemulon aurolineatum
- Bluestriped grunt, Haemulon sciurus
- French grunt, Haemulon flavolineatum
- Porkfish, Anisotremus virginicus

Mullidae--Goatfishes

Spotted goatfish, Pseudupeneus maculatus
Yellow goatfish, Mulloidichthys martinicus

Sparidae--Porgies

Jolthead porgy, Calamus bajonado
Sea bream, Archosargus rhomboidalis
Sheepshead porgy, Calamus penna
Pluma, Calamus pennatula

Holocentridae--Squirrelfishes

Blackbar soldierfish, Myripristis jacobus
Bigeye, Priacanthus arenatus
Longspine squirrelfish, Holocentrus rufus
Squirrelfish, Holocentrus adscensionis

Malacanthidae--Tilefishes

Blackline tilefish, Caulolatilus cyanops
Sand tilefish, Malacanthus plumieri

Carangidae--Jacks

Blue runner, Caranx crysos
Horse-eye jack, Caranx latus
Black jack, Caranx lugubris
Almaco jack, Seriola rivoliana
Bar jack, Caranx ruber
Greater amberjack, Seriola dumerili
Yellow jack, Caranx bartholomaei

Scaridae--Parrotfishes

Blue parrotfish, Scarus coeruleus
Midnight parrotfish, Scarus coelestinus
Princess parrotfish, Scarus taeniopterus
Queen parrotfish, Scarus vetula
Rainbow parrotfish, Scarus guacamaia
Redfin parrotfish, Sparisoma rubripinne
Redtail parrotfish, Sparisoma chrysopterum
Stoplight parrotfish, Sparisoma viride
Redband parrotfish, Sparisoma aurofrenatum
Striped parrotfish, Scarus croicensis

Acanthuridae--Surgeonfishes

Blue tang, Acanthurus coeruleus
Ocean surgeonfish, Acanthurus bahianus
Doctorfish, Acanthurus chirurgus

Balistidae–-Triggerfishes

Ocean triggerfish, Canthidermis sufflamen
Queen triggerfish, Balistes vetula
Sargassum triggerfish, Xanthichthys rigens

Monacanthidae-–Filefishes

Scrawled filefish, Aluterus scriptus
Whitespotted filefish, Cantherhines macrocerus
Black durgon, Melichthys niger

Ostraciidae--Boxfishes

Honeycomb cowfish, Lactophrys polygonia
Scrawled cowfish, Lactophrys quadricornis
Trunkfish, Lactophrys trigonus
Spotted trunkfish, Lactophrys bicaudalis
Smooth trunkfish, Lactophrys triqueter

Labridae--Wrasses

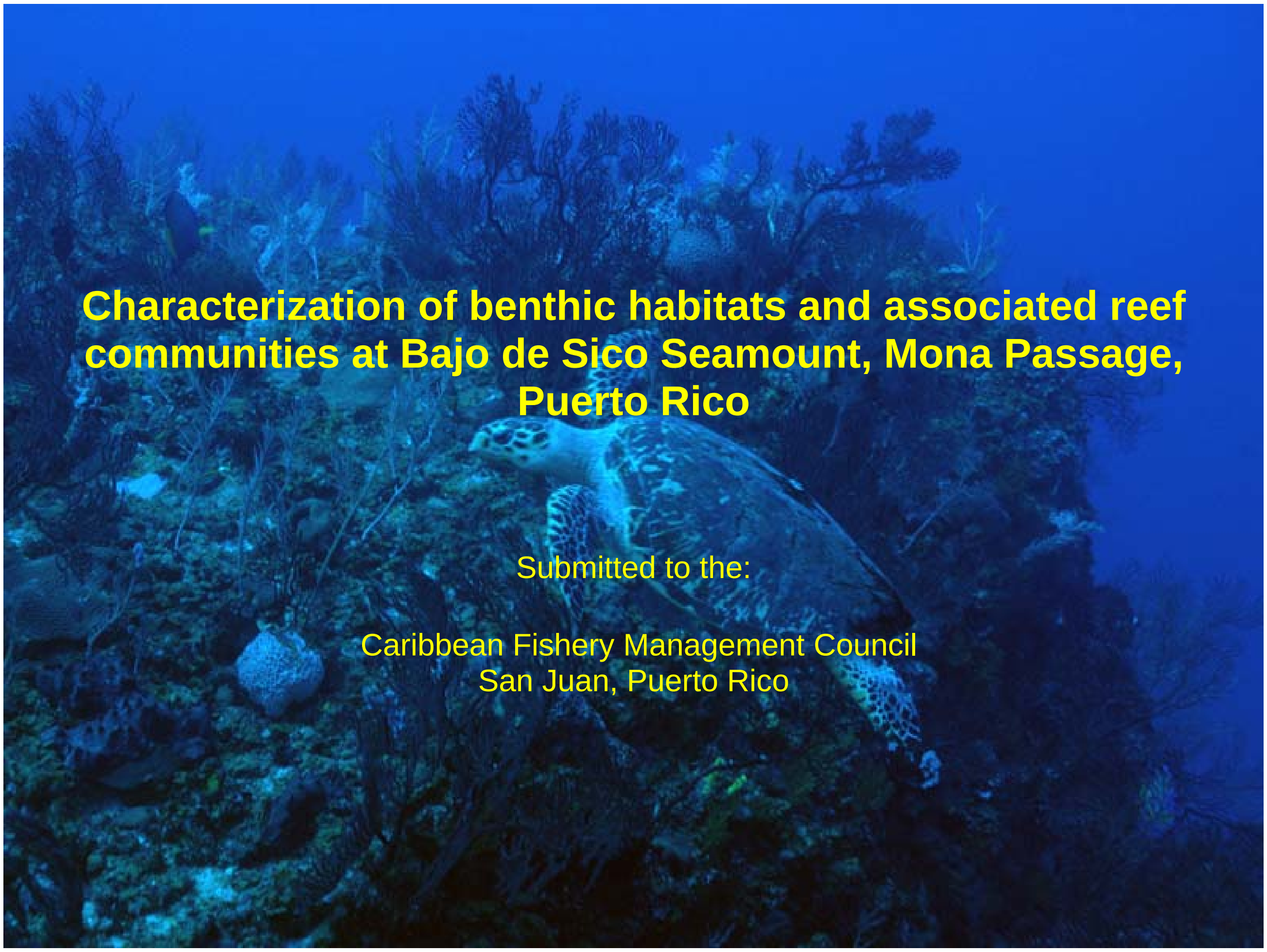
Hogfish, Lachnolaimus maximus
Puddingwife, Halichoeres radiatus
Spanish hogfish, Bodianus rufus

Pomacanthidae--Angelfishes

Queen angelfish, Holacanthus ciliaris
Gray angelfish, Pomacanthus arcuatus
French angelfish, Pomacanthus paru
Aquarium Trade–-The following aquarium trade species are included for data collection purposes only:
Frogfish, Antennarius spp.
Flamefish, Apogon maculatus
Conchfish, Astrapogen stellatus
Redlip blenny, Ophioblennius atlanticus
Peacock flounder, Bothus lunatus
Longsnout butterflyfish, Chaetodon aculeatus
Foureye butterflyfish, Chaetodon capistratus
Spotfin butterflyfish, Chaetodon ocellatus
Banded butterflyfish, Chaetodon striatus
Redspotted hawkfish, Amblycirrhitus pinos
Flying gurnard, Dactylopterus volitans
Atlantic spadefish, Chaetodipterus faber
Neon goby, Gobiosoma oceanops
Rusty goby, Priolepis hipoliti
Royal gramma, Gramma loreto
Creole wrasse, Clepticus parrae
Yellowcheek wrasse, Halichoeres cyanocephalus
Yellowhead wrasse, Halichoeres garnoti
Clown wrasse, Halichoeres maculipinna
Pearly razorfish, Hemipteronotus novacula
Green razorfish, Hemipteronotus splendens
Bluehead wrasse, Thalassoma bifasciatum
Chain moray, Echidna catenata
Green moray, Gymnothorax funebris
Goldentail moray, Gymnothorax miliaris
Batfish, Ogcocepahalus spp.

Goldspotted eel, Myrichthys ocellatus
Yellowhead jawfish, Opistognathus aurifrons
Dusky jawfish, Opistognathus whitehursti
Cherubfish, Centropyge argi
Rock beauty, Holacanthus tricolor
Sergeant major, Abudefduf saxatilis
Blue chromis, Chromis cyanea
Sunshinefish, Chromis insolata
Yellowtail damselfish, Microspathodon chrysurus
Dusky damselfish, Pomacentrus fuscus
Beaugregory, Pomacentrus leucostictus
Bicolor damselfish, Pomacentrus partitus
Threespot damselfish, Pomacentrus planifrons
Glasseye snapper, Priacanthus cruentatus
High-hat, Equetus acuminatus
Jackknife-fish, Equetus lanceolatus
Spotted drum, Equetus punctatus
Scorpaenidae--Scorpionfishes
Butter hamlet, Hypoplectrus unicolor
Swissguard basslet, Liopropoma rubre
Greater soapfish, Rypticus saponaceus
Orangeback bass, Serranus annularis
Lantern bass, Serranus baldwini
Tobaccofish, Serranus tabacarius
Harlequin bass, Serranus tigrinus
Chalk bass, Serranus tortugarum
Caribbean tonguefish, Symphurus arawak
Seahorses, Hippocampus spp.
Pipefishes, Syngnathus spp.
Sand diver, Synodus intermedius
Sharpnose puffer, Canthigaster rostrata
Porcupinefish, Diodon hystrix

FINAL REPORT
Coral Grant 2004
NA04NMS4410345



Characterization of benthic habitats and associated reef communities at Bajo de Sico Seamount, Mona Passage, Puerto Rico

Submitted to the:

Caribbean Fishery Management Council
San Juan, Puerto Rico

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Acknowledgements

The authors wish to acknowledge the contribution of Dr. Tim Batista and the crew of the R/V Nancy Foster (NOAA) for the mutibeam bathymetry survey of Bajo de Sico, with "on-site" collaboration from Reef Survey's staff. Dr. Dennis Opresco examined SEM and digital photographs of black corals (Antipatharians) from Bajo de Sico and provided preliminary identifications for the specimens. SEM photographs of black corals were facilitated by Dr. Wilfredo Otaño (professor) and José R, Gonzalez (SEM operator) at the University of Puerto Rico, Cayey Campus. Stacey Williams and Alex Rivera, graduate students UPR-RUM, assisted in the field identification of gorgonians and sponges, respectively. Hector Ruiz provided identifications for benthic algae at the deep rhodolith reef. This research was supported by a NOAA/CFMC Coral Grant NA04NMS4410345 awarded under contract to Dr. Jorge R. García Sais.

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I. Executive Summary

Bajo de Sico (BDS) is a seamount that rises from a deep platform (177 m) of the insular slope in the west coast of Puerto Rico. Reef bathymetry is characterized by a ridge of rock promontories aligned southeast – northwest which rise from a platform at 45 m to a reef top at 25 m, and an extensive, mostly flat, homogeneous and gradually sloping shelf that ends as a vertical (shelf-edge) wall at depths between 90 – 100 m reaching down to depths of 200 – 300 m. Salient oceanographic features of the water column influencing the reef system include a warm mixed surface water mass with a summer thermocline at a depth of 45 – 50 m, strong, persistent northwesterly surface currents, and high water transparency with 1% light penetration reaching depths of almost 80 m.

Benthic habitats that were identified and field verified to a maximum depth of 50 m at BDS include: a reef top and a vertical reef wall associated with rock promontories, colonized pavement and sand channels at the base of promontories, uncolonized gravel and rhodoliths at the reef slope, and a colonized rhodolith reef habitat surrounding the rock promontories at least to a depth of 50 m. Benthic habitats beyond 50 m have not been field verified, but several video images produced by the R/V Nancy Foster detected coral growth down to a maximum depth of 90 m along the deep shelf platform at BDS. From the multi-beam bathymetry survey of the reef produced aboard the R/V Nancy Foster, the total extension of BDS includes a surface area of approximately 11.1, km^2 of which only 3.6 % is associated with rock promontories (0.4 km^2) and more than 88 % corresponds to the deep shelf platform at depths below 50 m.

The sessile-benthic community at the reef top was characterized by a highly diverse assemblage comprised by benthic algae (52%), sponges (26%), scleractinian corals (8%), octocorals (5%) and hydrozoans (3%), with an abiotic cover of less than 1.5%. Scleractinian corals were represented at the reef top by 13 species within transects surveyed, with a mean substrate cover of 8.0% and a mean density of almost 20 colonies/m^2. Growth of scleractinian corals at the reef top was characterized by a species rich and numerous assemblage of small, isolated encrusting colonies that contributed minimal topographic relief. Lettuce corals, mostly *Agaricia lamarki* and *A. grahame* were the dominant assemblage in terms of reef substrate cover and density of colonies. *Tubastrea coccinea, Porites astreoides* and *Montastraea cavernosa* were also common at the reef top. Sponges, represented within transects by at least 12 species were the dominant sessile-benthic invertebrate in terms of reef substrate cover (mean: 26%) at the reef top. Due to their large size and abundance, sponges contributed substantially to the reef topographic relief and served as an important habitat for fishes and invertebrates.

The reef wall habitat was characterized by irregular formations that appear to have been influenced by erosional processes, with deep crevices, undercuts, gaps, ledges and other substrate irregularities. The sessile-benthos of the reef wall habitat resembled the reef top in that it was also highly diverse and taxonomically complex, comprised by sponges (43%), benthic algae (26%), octocorals (14%), scleractinian corals (5.5%), antipatharians (3%) and hydrozoans (2%). Abiotic cover was approximately 4%. Sponges were the most prominent component of the sessile-benthos at the reef wall, with at least 11 species present within transects surveyed and the prevalence of large erect and branching growth forms providing substantial topographic relief and reef substrate complexity. Octocorals (gorgonians), particularly the deep sea fan, *Iciligorgia schrammi* combined with black corals (Antipatharians), mostly the Caribbean bushy coral, *Antipathes caribbeana* to contribute an average reef substrate cover of 17%, adding to the benthic substrate heterogeneity and providing protective habitat for fishes at the reef wall. As in the reef top, scleractinian corals were present as a species rich assemblage of numerous, but small isolated colonies growing encrusted to the hard ground substrate and contributing minimally to the reef topographic relief.

The deep platform rhodolith reef, at least down to the maximum surveyed depth of 50 m, appears to be a vast deposit of crustose algal nodules or rhodoliths overgrown by a dense macroalgal carpet, mostly the encrusting fan-leaf alga, *Lobophora variegata*. The sessile-benthic invertebrate community was characterized by relatively low taxonomic diversity, with virtual absence of gorgonians and antipatharians, low substrate cover and species composition by scleractinian corals and a marked decline of cover and species composition by sponges, relative to the reef top and wall habitats. With few exceptions, scleractinian corals and sponges grow attached to rhodoliths, and are therefore not fixed to the bottom. Lettuce corals, *Agaricia spp*. were the dominant scleractinian taxa in terms of reef substrate cover.

Reef fishes associated with BDS were comprised by a combination of the typical shallow water reef species, a small assemblage of deep reef species, large demersal predators (snappers and groupers), and the group of pelagic highly migratory oceanic predators. Zooplanktivorous schooling fish populations are abundant at BDS and appear to serve as the main forage for large pelagic and demersal piscivorous fishes of the reef. Both fish abundance and species richness declined markedly with increasing depth at the benthic habitats studied. Variations of fish taxonomic composition and abundance between habitats appear to be influenced by the availability only of microhabitats at the deep rhodolith reef and the limited assemblage of species adapted for the vertically oriented habitat of the reef wall.

Reef promontories at BDS represent an important residential and foraging habitat for a group of large, commercially important species of snappers (*Lutjanus cyanopterus, L. jocu*) and groupers (*Epinephelus striatus, Mycteroperca bonaci, M. venenosa, M. interstitialis*) that have virtually disappeared from most reef systems in Puerto Rico. It also represents a spawning aggregation site for red hind (*Epinephelus guttatus*), and possibly other groupers within Mona Passage. The deep rhodolith reef appears to be the residential habitat for the red hind and for an assemblage of fishes that are typical of deep reefs, including some of which are highly valuable for the aquarium trade industry.

The reef system at BDS serves as an important foraging and residential habitat for the endangered hawksbill turtle (*Eretmochelys imbricata*). Its population in the reef promontories is impressive because of the large size and high abundance of individuals. The seamount also functions as a foraging area for large migratory pelagic fishes, including the wahoo (*Acanthocibium solanderi*), mahi-mahi (*Coryphaena hippurus*), tunas (*Thunnus spp*.) and marlins (mostly *Makaira nigricans*).

From the field survey at BDS, the following recommendations are included:

a. A year-round permanent closure for fishing of demersal fish species at the entire reef platform is recommended for the protection of what could be one of the few remaining actively reproducing populations of black, yellowmouth, yellowfin and Nassau groupers in Puerto Rico.

b. Characterization of benthic habitats and associated communities of the deep shelf platform below depths of 50 m using autonomous underwater vehicles (AUV) or similar systems that could provide high resolution images of the reef substrate.

c. The hermatypic and ahermatypic coral assemblage at BDS consists of species that have not been previously reported for coral reef systems in PR, and a more comprehensive characterization will require further exploration and research

d. The Caribbean Fishery Management Council (CFMC) should convey further research attention to the large grouper-snapper populations at BDS, particularly aspects of their reproductive biology, trophic interactions and larval dispersal and recruitment dynamics

II. Introduction

The study of Bajo de Sico (BDS) in Mona Passage represents a pioneer effort towards characterization of benthic habitats and associated deep reef communities on a submerged seamount of Puerto Rico. The work forms part of the research program priorities of the Caribbean Fishery Management Council (CFMC) for scientific documentation of closed fishing areas under Federal jurisdiction in Puerto Rico and the US Virgin Islands (CFMC, 2000). BDS is a known red hind (*Epinephelus guttatus*) spawning aggregation site that was proposed for seasonal closure (December – February) by west coast fishermen as a management strategy for protection of the commercially valuable grouper stock. The reef was officially closed to fishing seasonally on December 7, 1996 (CFMC, 1996).

BDS is a preferred fishing ground for local and international sport fishermen of highly migratory pelagic species, such as wahoo, mahi-mahi, great mackerel, yellowfin, blackfin and skipjack tuna, and the sailfish, white and blue marlin. The reef is fished for its deep sea snappers (silk, queen, wenchman, vermilion) and deep sea grouper (misty grouper) resources by artisanal fishers of the west coast. Also, a small number of spear-fishers hunt the large reef groupers and snappers, including the Nassau, yellowfin, yellowmouth and black groupers, and the cubera, mutton and dog snappers. Thus, the wide variety of pelagic and demersal fishery resources associated with BDS and its undocumented (anecdotal) history of its fishery exploitation conveyed for the scientific characterization of its benthic habitats and associated reef communities.

Because of the inherent logistic and technical constraints, deep hermatypic reef systems, or mesophotic reefs, have received very limited research attention in Puerto Rico and the US Virgin Islands. Sessile-benthic communities associated with the upper insular slope off La Parguera, southwest coast of Puerto Rico were described by Singh et al. (2004) from photo mosaics of the seafloor produced by the SeaBED Autonomous Underwater Vehicle (AUV). A more comprehensive characterization of marine communities associated with a mesophotic reef system off the southwest coast of Isla Desecheo (Agelas Reef) was recently provided by García-Sais et al. (2005) from direct observations by divers using re-breather diving technology. Concurrent with the present research at BDS, a team from the University of the US Virgin Islands, led by Dr. Richard

Nemeth is conducting a biological characterization of the marine communities associated with the outer shelf reef system at the Marine Conservation District (MCD), south of St. Thomas, USVI sponsored by the CFMC/NOAA (Nemeth, personal communication).

The US Caribbean Economic Exclusion Zone (EEZ) lacks information on the location and status of the corals and coral reefs from the insular slope. The National Ocean Service (NOS) benthic maps extend only to State water and only to the very nearshore environments. The CFMC through the Coral Reef Conservation Grant Program is working toward the mapping and characterization of benthic marine habitats in the U.S. Caribbean EEZ. Previous to our survey of BDS, the only available scientific information regarding this reef system was a side-scan sonar survey of the shallow reef section produced by Department of Natural and Environmental Resources (DNER). Bathymetry data, limited to a few depth contours was available from the 25671-NOAA nautical chart. Fishery statistics for the reef were inexistent, except for the anecdotal accounts of the red hind aggregation and its seasonal fisheries by west coast fishermen. Taxonomic inventories of marine flora and fauna, nor descriptions of benthic habitats present had ever been reported for BDS.

III. Study Objectives:

1) Provide a baseline quantitative and qualitative characterization of the benthic habitats and associated sessile-benthic and fish communities at BDS down to a maximum depth of 50 m.
2) Construct a georeferenced map of the main reef benthic habitats field verified down to a maximum depth of 50 m
3) Produce a detailed bathymetric map of BDS down to a maximum depth of 100 m
4) Provide a preliminary assessment of the commercially important grouper and snapper populations associated with BDS down a to depth of 50 meters
5) Contribute a digital photographic documentation of deep reef communities from BDS.

IV. Research Background

Most of the information regarding deep reefs in Puerto Rico and the USVI was produced more than 100 years ago, during the early exploration surveys that included the Voyage of the H. M. S. Challenger in 1873, dredging surveys by the "Blake" during 1878-79, U. S. Commission "Fish Hawk" in 1899, and the Johnson-Smithsonian Expedition aboard the Yacht Caroline in 1933. Taxonomic records and benthic habitat descriptions from these early cruises were reviewed and summarized by García-Sais et al. (2005). After the early explorations directed to describe the species composition and biogeography of deep reef habitats in PR and the USVI, research attention was particularly directed toward fishery resources.

Assessment surveys of the deep sea snapper and grouper fisheries potential were performed during the late 1970's and throughout the 1980's by the National Marine Fishery Service in collaboration with the local governments of Puerto Rico, U. S. Virgin Islands and the Caribbean Fishery Management Council (Juhl, 1972; Silvester and Dammann, 1974; Collazo, 1980; NOAA, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1987; Appeldoorn, 1985; Nelson and Appeldoorn, 1985; Rosario, 1986). Summarized fisheries data from these cruises, including the species composition, catch data, and geographic location of prime deep snapper/grouper fishing grounds along the insular slope habitats of PR and the USVI is available in García-Sais et al. (2005).

These surveys consisted of at least 11 cruises, including the Seward Johnson-Sea Link II submersible survey of the insular slope of PR and the U.S. Virgin Islands in 1985. Despite the generalized conclusion from these surveys that deep sea fish stocks were depauperate, deep sea snapper fisheries still represent a main fisheries resource in terms of catch and value in the U. S. Caribbean. Surprisingly, our understanding of the life histories, reproductive biology, feeding ecology and habitat preferences of deep sea snappers and groupers is still very limited and constrains our ability to manage the resource (García-Sais et al., 2005).

The Seward Johnson-Sea Link II submersible survey provided an unprecedented and exceptional insight of our deep sea reef communities at depths between 100 – 450 meters. Whereas observations about a rich and highly complex reef community near the top of the insular shelf appear in the Seward Johnson-Sea Link II report (Nelson and Appeldoorn, 1985), the upper slope reef communities were left undescribed. García-Sais et al. (2005) analyzed the depth and habitat distributions of the fish species reported by scientists aboard the Sea Link submersible and noted a high level of plasticity in terms of depth range and habitat of occurrence by numerically prominent populations throughout the insular slope. Such effective connectivity suggests that the insular slope of PR and the USVI represents an integral ecological system (García-Sais et al., 2005).

Quantitative assessments of sessile-benthic communities associated with mesophotic reefs of Puerto Rico and the USVI include observations of the upper insular slope at depths between 20 – 125 m off La Parguera, southwest coast of Puerto Rico by Singh et al. (2004). Data on percent substrate cover by corals and other sessile-benthic categories was obtained from photo mosaics of the seafloor produced by the SeaBED Autonomous Underwater Vehicle (AUV). From these data, Singh et al (2004) noted that scleractinian corals were the dominant sessile-benthic invertebrate down to 30 m, with maximum reef substrate cover (ca. 25%) at the 24 – 30 m depth interval. Below 30m, sponges were the dominant sessile-benthic invertebrate, although with a reef substrate cover not exceeding 10% (Singh et al., 2004). Benthic algae, sand and other abiotic substrate categories prevailed down the insular slope of La Parguera down to a depth of 125 m. Black corals (*Antipathes sp*p.) were reported from the deepest section of the transect (90-100 m). Only one transect perpendicular to the seafloor was produced by the SeaBED AUV. The limited data from the AUV constrains analysis of variability associated with the vertical distribution of sessile-benthic substrate categories at La Parguera.

The SeaBED AUV imaging platform was also used to survey benthic habitats of the Hind Bank in a marine protected area located near the shelf-edge, south of St. Thomas, USVI known as the Marine Conservation District (MCD) (Armstrong et al., 2006). The survey of reef benthic communities encompassed a depth range of 32 to 54 m. Four digital photo-transects provided data on benthic species composition and percent cover of reef substrate. Within the western side of the MCD, a well-developed hermatypic coral reef with 43% mean living coral was found. A flattened growth form of boulder star coral, *Montastraea annularis* (complex) was the dominant taxonomic component of the sessile-benthos at all four sites surveyed. Maximum coral cover found was 70% at depths of 38 - 40 m. Armstrong et al. (2006) reported 10 species of scleractinian corals, 10 gorgonians, one antipatharian, two hydrozoans, 17 sponges and several motile-megabenthic invertebrates and benthic algae within photo-transects surveyed at the MCD. Partial field validation of the SeaBED AUV results in characterization of benthic communities at the MCD were later produced by Nemeth et al. (2004) and Herzlieb et al. (in press).

A smaller, but morphologically similar mesophotic reef formation, known as Black Jack Reef was studied off the south coast of Vieques, PR by García-Sais et al. (2001). The reef is associated with the upper slope of a seamount that rises from a depth of 51 m to a reef top at 30 m. A total of 25 species of scleractinian corals, two antipatharians and one hydrocoral were identified. Live coral cover averaged 28.8% (range 25.0 – 40.4%) within surveyed transect areas. Boulder star coral (*Montastraea annularis* complex) was the dominant coral species in terms of substrate cover (mean: 21.9%), representing 76% of the total live coral cover at depths between 36 – 40 m. As in the MCD, boulder star coral exhibited a laminar or flattened growth with closely spaced colonies of moderate size and low relief. Corals grow from a pedestal of unknown origin, creating protective habitat underneath the coral.

Menza et al. (2007), working off the NOAA R/V Nancy Foster reported on the benthic community structure of a mesophotic reef known as MSR-1, located off the outer shelf south of St. John, USVI at depths between 30 – 40 m. High resolution still images of the seafloor were taken with a Spectrum Phantom S2 remotely operated vehicle (ROV). The reef MSR-1 presented an average live coral cover of 37.8% (SE=4.9%), with maximum cover of approximately 80% at a depth of 34.4 m. As in the MCD and Black Jack reefs, boulder star coral, *Montastraea annularis* complex, including *M. annularis, M. faveolata* and *M. franksi*) were the principal reef building species at MSR-1, with *M. cavernosa, Agaricia lamarki* and *Siderastrea siderea* representing less than 5% of the total live coral cover. Menza et al. (2007) described *Montastraea* colonies forming discrete horizontal plates, where distinct colonies overlapped each other vertically, creating a complex three-dimensional structure with high rugosity. Interestingly, a relatively high percentage of recently dead coral overgrown by turf algae (DCA) was reported for the deepest sections of transects surveyed (Menza et al., 2007).

Mesophotic reefs have also been discovered on the southwest coast of Isla Desecheo (Mona Passage) by García Sais et al. (2005). These include the SW Wall Reef, at depths between 30-40 m, and Agelas Reef, at depths between 45 – 70 m. Substrate cover at the SW Wall Reef was dominated by benthic macroalgae (mostly *Lobophora variegata*), sand, sponges, and massive corals. Sponges were highly prominent (mean surface cover: 17.3%), growing mostly as large erect and branching forms that produced substantial topographic relief and protective habitat for fishes and invertebrates. In many instances, sponges were observed growing attached to stony corals, forming sponge-coral bioherms of considerable size. One of the most common associations involved brown tube (*Agelas conifera, A. sceptrum*) and row pore sponges (*Aplysina spp*.) with star corals (*Montastraea cavernosa, M. annularis*-complex). A total of 25 scleractinian corals, three hydrocorals and two antipatharian (black coral) species were present along the SW Wall Reef. Star corals (*M. cavernosa, M. annularis* complex) were the dominant species of scleractinian corals at the SW Wall Reef (García-Sais et al., 2005).

Agelas Reef (45 – 70 m) appears to be a depositional zone of crustose (calcareous) algal rhodoliths densely colonized by encrusting brown algae (*Lobophora variegata*), large erect and branching sponges (*Agelas conifera, Agelas spp., Aplysina spp*.) and lettuce corals (*Agaricia lamarki, A. grahamae, Agaricia spp.*). Sessile-benthic biota grows over a vast deposit of rhodolith nodules loosely anchored to the bottom. The reef has very low topographic relief as it lies over an essentially flat platform and massive corals do not contribute significantly to its rugosity. A total of 18 species of scleractinian corals, two hydrozoans (*Millepora alcicornis* and *Stylaster roseus*) and the antipatharian black wire coral (*Stichopathes lutkeni*) were identified from Agelas Reef. The combined mean substrate cover by the nine species of scleractinian corals within transects surveyed was 13.1% (range: 7.4 – 36.4 %). Irregular sheets or laminar growth by lettuce corals (*Agaricia spp*.) prevailed at depths between 45 and 53 m (148 – 175'), with a combined substrate cover of 8.9%, representing 70% of the total cover by scleractinian corals. Lamark's sheet coral (*Agaricia lamarki*) appeared to be the main species present (García-Sais et al., 2005).

A total of 70 fish species were identified from depths beyond 30 m at Isla Desecheo. An assemblage of 10 species accounted for 85.4% of the total fish abundance at 30m. The blue chromis (*Chromis cyanea*) was the numerically dominant species with a study mean abundance of 79.2 Ind/30 m^2, representing 31.5% of the total fish abundance within belt-transects. The creole wrasse (*Clepticus parrae*), bicolor damselfish (*Stegastes partitus*), fairy basslet (*Gramma loreto*), bridled, masked, peppermint and sharknose gobies (*Coryphopterus glaucofraenum, C. personatus, C. lipernes, Gobiosoma evelynae*), brown chromis (*C. multilineata*) and the blue-head wrasse (*Thalassoma bifasciatum*) comprised the rest of the numerically dominant assemblage at the SW Wall Reef at 30 m (García-Sais et al., 2005). At a depth of 40 m, an assemblage of seven species accounted for 82.5% of the total individuals surveyed within belt-transects at the SW Wall Reef. The blue chromis was the numerically dominant species, representing 32.6% of the total fish abundance within transects, followed by the masked goby, creole fish, sunshine chromis (*C. insolata*), bridled goby, bicolor damselfish and fairy basslet, among others. Only a few species not typical of shallow reefs, such as the cherubfish (*Centropyge argi*), longsnout butterflyfish (*Chaetodon aculeatus*) and the Sargassum triggerfish (*Xanthichthys ringens*) were common at the SW Wall Reef (García-Sais et al., 2005). At 50 m on Agelas Reef, an assemblage of five species accounted for almost 80% of the total individuals surveyed within belt-transects by García-Sais et al. (2005). The bicolor damselfish was the most abundant, followed by the blue chromis, peppermint goby, sunshine chromis and the cherubfish.

In general, the ichthyofauna from depths between 30 – 50 m at reefs studied in Isla Desecheo was dominated by zooplanktivorous taxa, suggesting that planktonic food webs are most relevant in these mesophotic reef habitats (García-Sais et al., 2005). These reefs are also the natural habitats of many exploited commercially important food fishes, such as large groupers (Nassau, yellowfin, red hind) and snappers (dog, cubera) and target species of the aquarium trade (blue chromis, fairy basslet, cherubfish, butterflyfishes, jawfishes and hawkfishes, among others). The deeper habitats (below 100 m) of the reef slope at Isla Desecheo, are well known fishing grounds for “deep sea” snappers, such as, silk snapper (*Lutjanus vivanus*), blackfin snapper (*L. buccanella*), vermilion snapper (*Rhomboplites aurorubens*), queen snapper (*Etelis oculatus*) and wenchman (*Pristipomoides macrophthalmus*). Also, the particularly high abundance of post-settlement juveniles of coneys (*Cephalopholis fulva*), blue chromis and fairy basslet reported for the deep reefs of Isla Desecheo (García-Sais et al., 2005) suggests that these mesophotic reefs may also function as prime recruitment sites for these and other reef fish populations.

From the initial exploratory surveys of the recently discovered mesophotic reefs of Puerto Rico and the USVI (including this study), it is evident that there are at least two main reef formations. One type is found associated to hard ground platforms and biologically dominated by a flattened morphotype of boulder star coral, *Montastraea annularis* complex. Such reef formation appears to be typical of the south coast outer shelf USVI region (e.g. MCD, MSR-1; Armstrong et al., 2006; Menza et al., 2007) and southeast Puerto Rico (e.g. Vieques Island; García-Sais et al, 2004). The other type of mesophotic reef formation is associated with extensive algal rhodolith deposits and dominated by benthic algae (e.g. *Lobophora variegata*), sponges and lettuce corals of the *Agaricia lamarki/grahame* combination. These reefs appear to be typical of oceanic islands and seamounts in Mona Passage, such as Desecheo Island (García-Sais et al., 2005) and Bajo de Sico (this study).

Extensive mesophotic reef systems, such as Pulley Ridge, Flower Banks (East and West) and Sherwood Forest Reef (Dry Tortugas) are found in the Gulf of Mexico and the Florida shelf. Pulley Ridge, regarded as the deepest coral reef in the United States extends over 200 km along the western margin of the south Florida shelf at depths between 58 – 75 m (Halley et al. 2003; http://coastal.er.usgs.gov/pulley-ridge/). The reef grows over a relatively flat deep terrace where hermatypic (symbiotic) lettuce corals, mostly *Agaricia spp*. and *Leptoseris spp*. cover as much as 60% of the reef substrate in some localities (Halley et al. 2003). Fleshy brown, red and calcareous macroalgae, including *Lobophora variegata*, *Halimeda tuna* and *Andaymonene menzeii* are also reported to be highly abundant at certain regions of the reef forming "lettuce fields growing in the dusk", but also reported to occupy reef surfaces between corals, along with sponges and octocorals (Halley et al. 2003; http://coastal.er.usgs.gov/pulley-ridge/). Interestingly, vast deposits of coralline algal nodules (rhodoliths) and cobble zones surround much of the ridge in deeper water (>80 m). The flat terrace reef geomorphology, with high abundance of lettuce corals (*Agaricia spp. Leptoseris spp*), fleshy macroalgae and sponges, and the presence of rhodolith deposits at Pulley Ridge convey some relevant physical and biological similarities with the recently discovered mesophotic reefs of Isla Desecheo and Bajo de Sico in Mona Passage (García-Sais et al., 2005, this study).

More than 60 species of fishes have been identified from the Pulley Ridge reef system. The fish assemblage is comprised by a mixture of shallow water and deep species. Commercial species include *Epinephelus morio* (red grouper) and *Mycteroperca phenax* (scamp). Typical shallow-water tropical species include *Thalassoma bifasciatum* (bluehead), *Stegastes partitus* (bicolor damselfish), *Cephalopholis fulva* (coney), *Lachnolaimus maximus* (hogfish), *Malacanthus plumieri* (sand tilefish), *Pomacanthus paru* (French angelfish), and *Holacanthus tricolor* (rock beauty). The deepwater fauna is represented by *Chaetodon aya* (bank butterflyfish), *Sargocentron bullisi* (deepwater squirrelfish), *Bodianus pulchellus* (spotfin hogfish), *Pronotogrammus martinicensis* (roughtongue bass), and *Liopropoma eukrines* (wrasse bass).

The reef system at the Flower Gardens Banks National Marine Sanctuary (FGBNMS), located in the northwestern Gulf of Mexico, approximately 192 km southeast of Galveston Texas was described by Rezak et al. (1985), Gardner et al. (1998) and Hickerson and Schmahl (2005) (see also http://flowergarden.noaa.gov/about/facts.html). At least six of these banks harbor important populations of scleractinian coral, these include the larger East Flower Garden Banks (EFGB) and West Flower Garden Banks (WFGB), the West Bright Bank, Sonnier Bank, Geyer Bank, and McGrail Bank. Most of the biological characterization and coral reef monitoring work has been limited to the reef top, at depths between 18 – 25 m. Within this depth range, reef substrate cover by live corals averaged 53.9% and 48.8% at the EFGB and the WFGB reefs, respectively. In both reef systems, the dominant coral species was boulder star coral, *Montastraea annularis* (complex). Symmetrical brain coral (*Diploria strigosa*) and mustard-hill coral (*Porites astreoides*) were also prominent species of the coral assemblage at both reef sites (Hickerson and Schmahl, 2005). More recent investigations of deeper reef zones at McGrail Bank revealed that blushing star coral (*Stephanocoenia intersepta*) covers up to 30% of the reef substrate at depths between 45 – 60 m (Schmahl and Hickerson, in press).

Over 170 species of fish are known to inhabit the Flower Garden Banks Reef system. Fishes of the families Labridae, Pomacentridae and Serranidae were the most abundant during coral reef monitoring surveys at depths between 18 – 25 m, with densities ranging between 6.9 Serranids per 100 m^2 at the EFGB in 2002 to 70.4 Labrids per 100m^2 at the EFGB in 2003. Pomacentridae, Serranidae and Labridae were also the three most specious fish families with 12, 10, and 6 species present, respectively (Hickerson and Schmahl, 2005).

V. Methods

Geographic location of Bajo de Sico

Bajo de Sico (BDS) is located in Mona Passage, about 27 kilometers off Mayagüez in the west coast of Puerto Rico (Figure 1). It is part of a ridge, known as the great southern Puerto Rico fault zone (Glover, 1967; Garrison and Buell, 1971), a submerged section of the Antillean ridge that extends across the entire Mona Passage, connecting Puerto Rico with La Hispaniola. The ridge rises from a depth of approximately 3,500 m and includes the islands of Mona, Monito and Desecheo, as well as submerged seamounts that reach depths of less than 100 m, such as BDS, Bajo Esponjas and Bajo Pichincho in PR, and Cabo Engaño, partially within Dominican Republic waters. The seamount promontories at BDS rise from a submerged platform that extends out to the north from the insular slope of western Puerto Rico.

Bathymetric Map

An initial bathymetric map of BDS consisting of approx. 13,000 single beam (echosounder) data points was prepared for the seamount reef top. A grid of 73 planned lines within an area of approximately 0.5 km x 1.5 km was prepared in Hypack Software. The bathymetry line grid was georeferenced over an existing side-scan sonar TIF image file of BDS prepared by DNER. A Garmin Model 2006 GPS unit with an integrated echosounder was used to navigate over the planned lines. The GPS/echosounder unit was interfaced to an on-deck computer and the data stored and processed by Hypack Software to produce an XYZ data set. The XYZ data points were limited by the range of

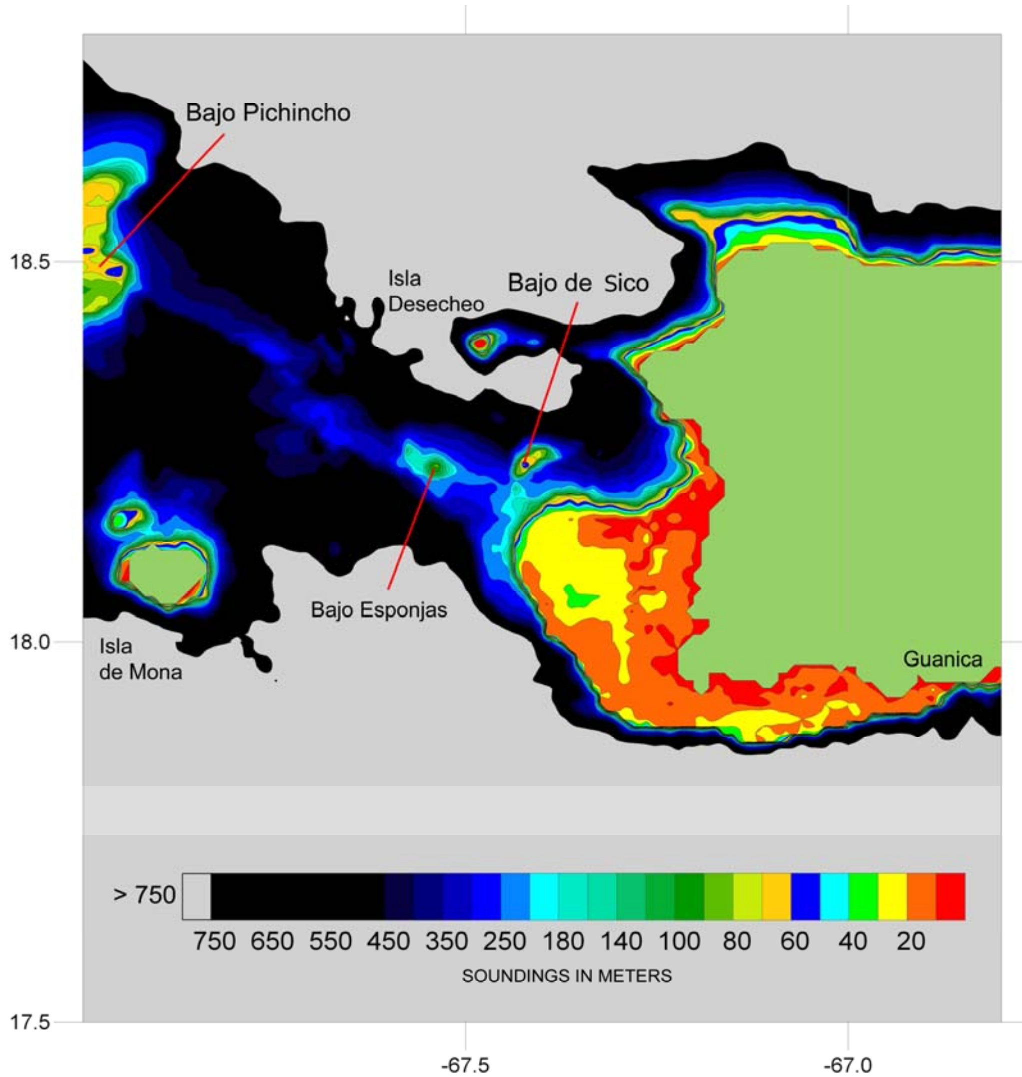

Figure 1. Location of Bajo de Sico in Mona Passage

the echosounder to a depth of approximately 100 m. The final bathymetry contours over the BDS reef top were plotted using Golden Software Surfer v.8 (Figure 2).

The bathymetry survey of BDS was expanded to the entire reef platform and the resolution significantly enhanced by the multi-beam mapping provided by the R/V Nancy Foster in April 2007. Multibeam data was collected with a hull-mounted Simrad EM 1002 and a hull-mounted Reson 8124 multibeam SONAR and were processed by a NOAA contractor using CARIS HIPS/SIPS v.6.1 software.

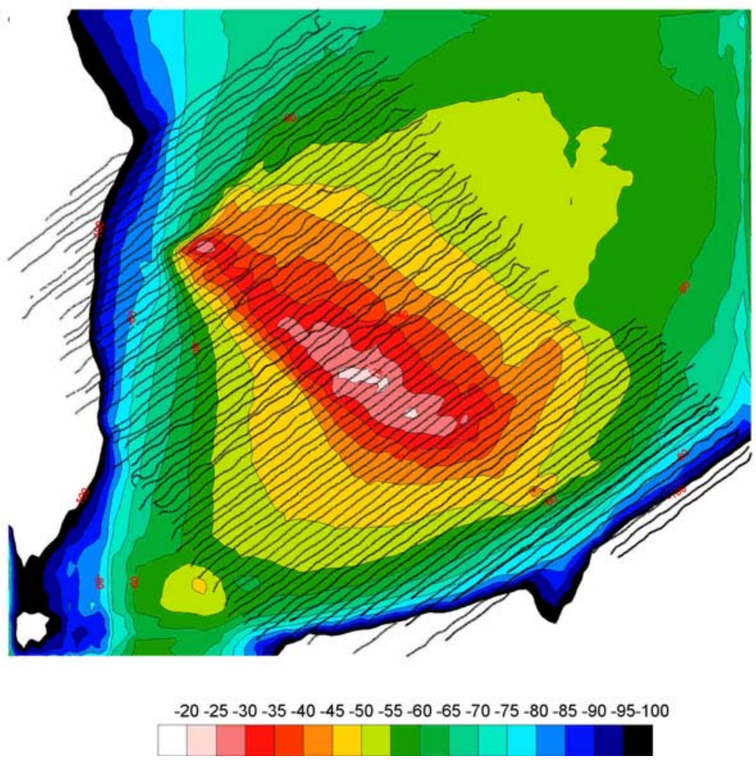

Figure 2. Bathymetry contours of the BDS reef top produced from a single beam echosounder and the corresponding surveyed lines

<u>Benthic Habitat Map</u>

A digitized benthic habitat map of Bajo de Sico was produced down to a depth of 50 m (165 feet). An initial (preliminary) blueprint of reef promontories and other salient topographic features of BDS were constructed from a side-scan sonar mosaic image file provided by the DNER. The bathymetric and backscatter data produced by the multibeam survey of the reef by the R/V Nancy Foster of NOAA (http://ccma.nos.noaa.gov/products/biogeography/usvi_nps/data.html) was used to prepare the final blueprint of the reef benthic habitats. Field verification of the main reef bathymetric features and benthic habitats was produced by divers using Inspiration re-breathers. Field verification of benthic habitats included a combination of exploratory drift dives across the reef, bounce (point) dives at strategic locations, and dives for biological assessment (Figure 3). The final benthic habitat map was prepared in Arc-View software with NOAA Habitat Digitizer extension.

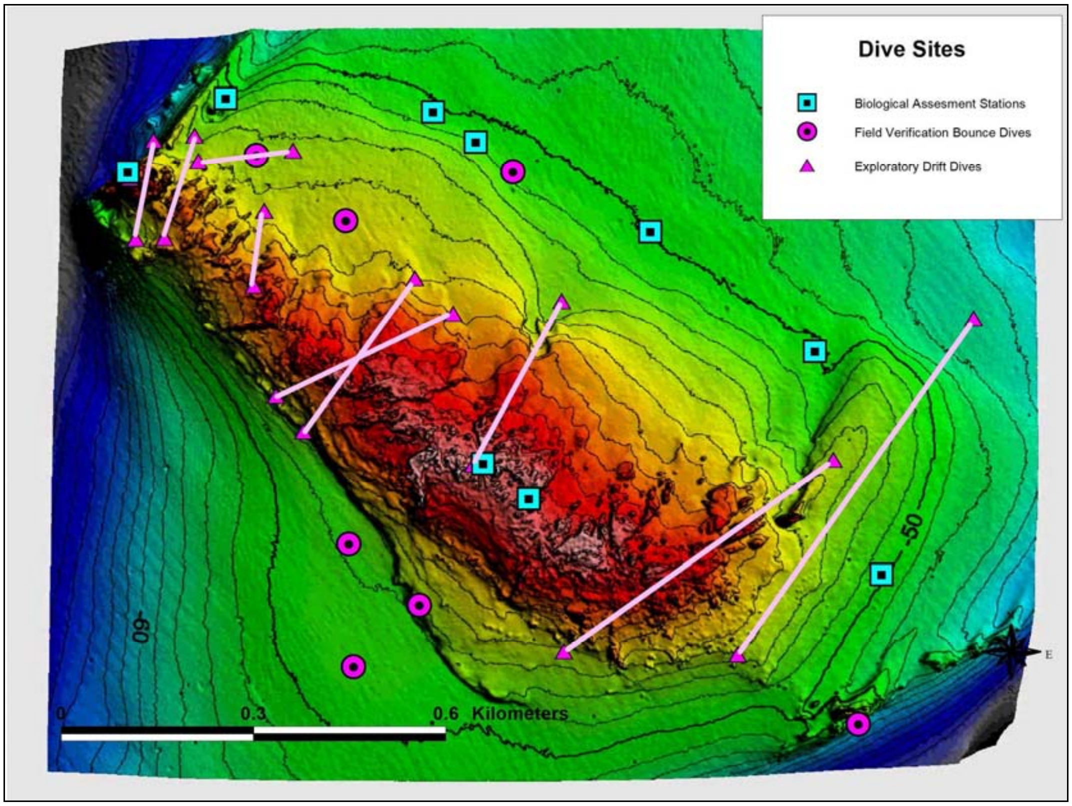

Figure 3. Field verification dives performed for validation of benthic habitat map of BDS to 50 m depth.

Physical Oceanographic Data

<u>CTD Profiles</u>

Profiles of the water column temperature and salinity were obtained with a Seabird Electronics CTD (Model SBE19). Water column profiles were taken to a depth of 60 m during June, July, August and September, 2007. Hobo temperature data loggers were installed at depths of 30 and 50 m in Bajo de Sico on February 23, 2007. Data loggers were programmed to record water temperature at one hour intervals for a duration of 12 months. Hobo's were retrieved on September 26, 2007. The unit at 30 m depth recorded temperature until May 23, 2007. After this date the unit stopped recording, apparently due to battery malfunction. The Hobo installed at a depth of 50 m flooded and returned no data.

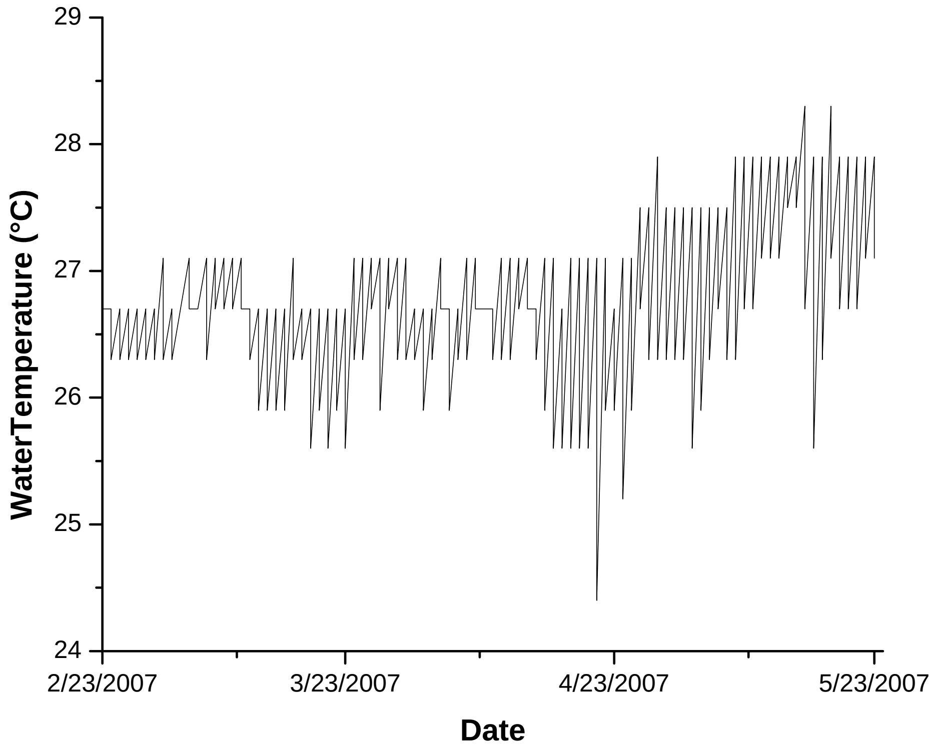

Figure 4. Water temperature data from Hobo data logger at 30 m depth

Water Currents

Water current velocities and directions from depths between 2.3 m and 38.4 m were measured at Bajo de Sico using an Acoustic Doppler Current Profiler (ADCP) during a 10 week period between February 23 and May 9, 2007. Geographic coordinates, depths and other statistics of the ADCP deployment (BS01) are summarized in Table 1.

Table 1. ADCP deployment at Bajo de Sico. Depth in meters (feet) relative to MLLW.

Event	Start	End	Lat (N)	Lon (W)	Bottom Depth	Xducer Depth	6% Xducer Depth
BS01	23-Feb-07	9-May-07	18° 13.808	67° 25.786	38.8 (127)	38.4 (126)	2.3 (7.6)

Table 2: Sentinel ADCP configuration.

Bin size	1.0 m (3.28 ft)
Currents and tide sampling interval	30 minutes
Pings per sampling interval	300
Standard deviation (ADCP only)	0.35 cm/s
Distance to center of deepest bin	2.12 m (6.95ft)

An RD Instruments 600 KHz Workhorse Sentinel ADCP was used in this study. The BS01 ADCP configuration parameters are listed in Table 2. The ADCP was bottom mounted near the top of the reef promontory at the biological benchmark survey station BDS-1 (Figure 5). Bottom contours at BDS-1 are oriented along a north-south axis, sloping down towards the west. The center depths and depth limits of the ADCP data bins are provided in Table 3. The RDI Sentinel ADCP has a beam angle of 20°, which restricts useful data to depths greater than 6% (= 1 - cos (20°)) of the transducer depth (Xducer depth in Table 1). Considering these limitations, at a bottom depth of 38.8 m the 600 kHz ADCP provided usable data in the depth range of 3 – 36 m (bin center depths), which by taking into account the bin depth limits becomes 2.79 – 36.79 m (top of first bin to the bottom of the last bin, see Table 3). The ADCP was configured to sample 40 bins, 34 of which were below the 6% depth level indicative of good velocity data (Table 3).

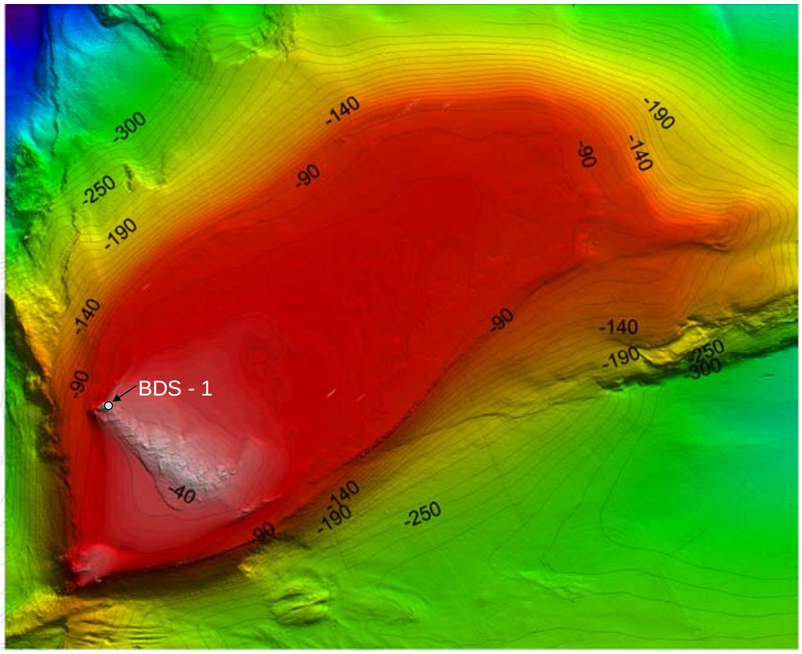

Figure 5. Location of ADCP current meter at benchmark station BDS-1.

Optical Measurements

Planar downwelling irradiance Ed (watts per meter) was measured at noon with the Underwater Irradiance Meter LI -1400 at 5 m and 10 m in an area where the water column was hit directly by the sun. Seven to eight readings where taken at each depth over Bajo de Sico. The diffuse attenuation coefficient Kd (inverse meters) was calculated using the equation:

$$K_d = 1/(z_1-z_2) * \ln E_d(z_1)/Ed(z_2)$$

where E_d (watts per square meter) is planar downwelling irradiance and z (in meters) is depth positive downward from the sea surface. K_d is an indicator of the penetrative component of solar radiation. The euphotic zone is defined as the depth at which E_d decreases to 1% of the E_d value just underneath the surface. The depth of the euphotic zone (Z_{eu}) was calculated using the equation:

$$Z_{eu} = 4.6/K_d$$

Table 3. MR01 bin placement. Center Height is the distance measured from the transducer to the center of a bin. Center Depth is the depth from the sea surface to the center of a bin. Top and Bottom are the depth from the sea surface to the top and bottom of a bin. Distances in meters (first row for each bin) and feet (second row). Bin numbers from the bottom (first row), from the top (second row). Bins corresponding to 10%, 50% and 90% depths, are indicated in bold.

Bin	Center Height	Center Depth	Bin Top	Bin Bottom	Bin	Center Height	Center Depth	Bin Top	Bin Bottom
34	35.12	3.29	2.79	3.79	17	18.12	20.29	19.79	20.79
1	115.19	10.81	9.17	12.45	18	59.43	66.57	64.93	68.21
33	**34.12**	**4.29**	**3.79**	**4.79**	16	17.12	21.29	20.79	21.79
2	**111.91**	**14.09**	**12.45**	**15.73**	19	56.15	69.85	68.21	71.49
32	33.12	5.29	4.79	5.79	15	16.12	22.29	21.79	22.79
3	108.63	17.37	15.73	19.01	20	52.87	73.13	71.49	74.77
31	32.12	6.29	5.79	6.79	14	15.12	23.29	22.79	23.79
4	105.35	20.65	19.01	22.29	21	49.59	76.41	74.77	78.05
30	31.12	7.29	6.79	7.79	13	14.12	24.29	23.79	24.79
5	102.07	23.93	22.29	25.57	22	46.31	79.69	78.05	81.33
29	30.12	8.29	7.79	8.79	12	13.12	25.29	24.79	25.79
6	98.79	27.21	25.57	28.85	23	43.03	82.97	81.33	84.61
28	29.12	9.29	8.79	9.79	11	12.12	26.29	25.79	26.79
7	95.51	30.49	28.85	32.13	24	39.75	86.25	84.61	87.89
27	28.12	10.29	9.79	10.79	10	11.12	27.29	26.79	27.79
8	92.23	33.77	32.13	35.41	25	36.47	89.53	87.89	91.17
26	27.12	11.29	10.79	11.79	9	10.12	28.29	27.79	28.79
9	88.95	37.05	35.41	38.69	26	33.19	92.81	91.17	94.45
25	26.12	12.29	11.79	12.79	8	9.12	29.29	28.79	29.79
10	85.67	40.33	38.69	41.97	27	29.91	96.09	94.45	97.73
24	25.12	13.29	12.79	13.79	7	8.12	30.29	29.79	30.79
11	82.39	43.61	41.97	45.25	28	26.63	99.37	97.73	101.01
23	24.12	14.29	13.79	14.79	6	7.12	31.29	30.79	31.79
12	79.11	46.89	45.25	48.53	29	23.35	102.65	101.01	104.29
22	23.12	15.29	14.79	15.79	5	6.12	32.29	31.79	32.79
13	75.83	50.17	48.53	51.81	30	20.07	105.93	104.29	107.57
21	22.12	16.29	15.79	16.79	4	5.12	33.29	32.79	33.79
14	72.55	53.45	51.81	55.09	31	16.79	109.21	107.57	110.85
20	21.12	17.29	16.79	17.79	3	4.12	34.29	33.79	34.79
15	69.27	56.73	55.09	58.37	32	13.51	112.49	110.85	114.13
19	20.12	18.29	17.79	18.79	**2**	**3.12**	**35.29**	**34.79**	**35.79**
16	65.99	60.01	58.37	61.65	**33**	**10.23**	**115.77**	**114.13**	**117.41**
18	**19.12**	**19.29**	**18.79**	**19.79**	1	2.12	36.29	35.79	36.79
17	**62.71**	**63.29**	**61.65**	**64.93**	34	6.95	119.05	117.41	120.69

The remote sensing attenuation coefficient was obtained by accessing the NASA ocean color web page. For the BDS site using SEADAS software the level 2 product from both MODIS Terra and Aqua where processed using the K490 algorithm in order to obtain higher spatial and temporal resolution. A digital value for K490 was obtained for the exact location where field measurements where taken at BDS.

Biological Characterization of Reef Communities

Quantitative assessments of the predominant sessile-benthic and motile-megabenthic and fish populations were performed at the main reef benthic habitats down to a maximum depth of 50 m at BDS. Location of sampling stations is shown in Figures 5 and 6. The benthic habitats studied included 1) reef top promontories at depths between 26 – 31 m, 2) vertical wall promontories at depths between 32 – 40 m, and 3) deep rhodolith reef at depths between 46 – 53 m. Communities at the reef top were surveyed from the benchmark station BDS-1 and another location near the center of the promontories' ridge (Figure 6). Transects for characterization of the reef wall were studied from three different locations within BDS-1 (Figure 7). The deep rhodolith reef community was studied from transects established in (replicate) pairs at five different locations along the northern section of the BDS platform.

At each benthic habitat, a total of 10, 10-meter long transects were established for biological assessments. A fiberglass tape measure was stretched between two points to mark the transects. Sessile-benthic communities at the deep rhodolith reef and at the vertical wall promontories habitats were quantitatively characterized by photo transects. The reef top promontories were characterized by a combination of five video-transects and five photo-transects. Initially all data for sessile-benthic characterizations was collected using video-transects, but lack of resolution caused by poor illumination at the deep rhodolith reef habitat, and the irregular three-dimensional features (gorgonians and antipatharians) of the vertical wall habitat rendered video images useless for taxonomic identifications. Collection of photographic and visual data on reef communities at BDS were produced by divers using closed circuit (Inspiration) rebreathers.

A total of ten non-overlapping digital images (still photos or video frames) from each transect were analyzed using the Coral Point Count software v.3.2. A template of 25

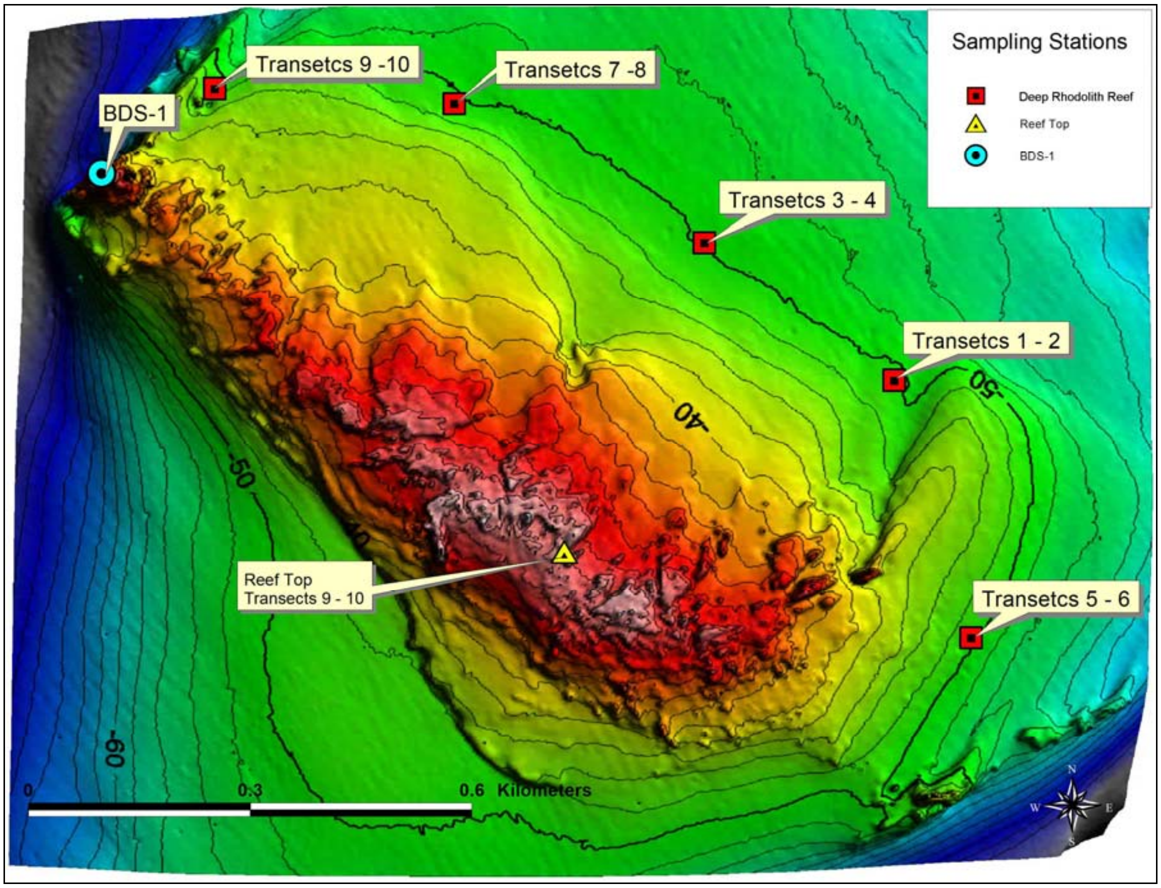

Figure 6. Location of sampling stations over each benthic habitat

random points was overlaid on each image and the substrate categories under each point identified. The cumulative number of points over each substrate category in the ten images analyzed per transect was divided by the total number of points overlaid per transect (e.g. 25 points per image x 10 transects = 250 points) and reported as the percent reef substrate cover for that transect. The total number of scleractinian, hydrozoan and antipatharian colonies present in all images analyzed were identified to the lowest possible taxon and enumerated for determination of coral colony density (in colonies per square meter). The area of the reef included in each image was calculated from the tape measure included as a "scale" in each image. The reef substrate area encompassed in video and still images ranged between 0.85 and 1.0 m^2, respectively. A greater area (1.3 m^2) was captured on the reef wall habitat in order to include entire colonies of gorgonians and antipatharians projecting outward from the wall.

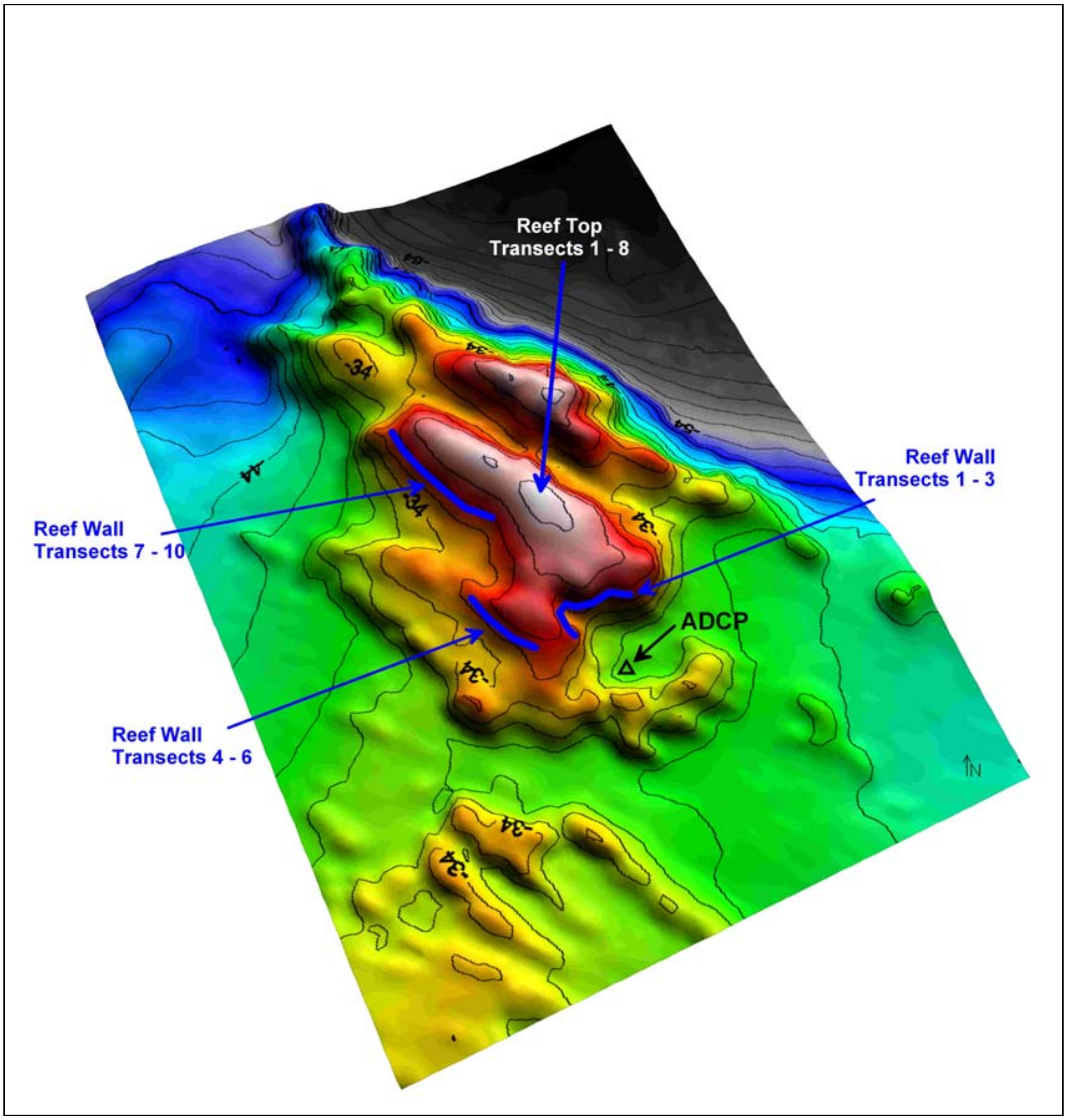

Figure 7. Detailed map of benchmark station BDS-1 indicating the location of characterization transects

Common names and coral taxonomy followed Veron (2000) and Humann and Deloach (2003)

Sessile-benthic reef categories included in the photographic image analysis included the following:

Scleractinian corals – percent cover and density of colonies per transect reported by species. Both hermatypic (e.g. *Montastraea cavernosa*) and ahermatypic (e.g. *Tubastrea coccinea*) taxa included.

Octocorals - (soft corals) percent cover and density of colonies per transect reported by species; or lowest identifiable taxon; includes vertically projected colonies, such as *Iciligorgia schrammi* and encrusting colonies, such as *Erythropodium caribaeorum*)

Antipatharians – (black corals), percent cover and density of colonies per transect reported to the lowest identifiable taxon;

Hydrocorals – (fire and lace corals), percent cover and density of colonies per transect reported by species; or lowest identifiable taxon; includes vertically projected colonies, such as *Stylaster roseus,* and encrusting colonies, such as *Millepora spp*.

- **Sponges** – percent cover reported by species, or lowest possible taxon
- **Algal Turf** – consisting of a mixed assemblage of short articulate coralline algae, intermixed with red, brown macroalgae and other small epibenthic biota forming a mat or carpet over hard substrate
- **Calcareous Algae** – reported as total calcareous algae, or lowest possible taxon
- **Fleshy Algae** – vertically projected, mostly brown, red and green macroalgae reported as total fleshy algae, or lowest possible taxon (e.g. *Lobophora variegata*)
- **Abiotic Substrate** – includes unconsolidated sediment, bare rock, deep holes and gaps.

Characterization of Fishes and Motile Megabenthic Invertebrates

Densities of demersal (non-criptic) reef fish populations and motile megabenthic invertebrates were estimated from a total of 10 – 3 m wide by 10 m long (30 m^2) belt-transects surveyed per benthic habitat (e.g. reef top promontories, vertical wall and deep terrace reef). Belt-transects were centered along the reference line of transects used for sessile-benthic reef characterizations. A more detailed description of this survey method was given in García-Sais et al. (2005).

Large, elusive fish populations, which include many commercially important and recreationally valuable populations were surveyed using an Active Search Census (ASEC). This is a non-random, fixed-time method designed to optimize information of the species and numbers of fish individuals present at the main reef habitats, providing simultaneous information on taxonomic composition, size frequency distributions and population density estimates. Because of the wide home ranges and relatively high mobility of large fishes associated with the reef promontories at BDS, the reef top and vertical wall sections of the promontories were considered as one habitat for ASEC surveys. A total of five ASEC surveys were performed at the promontories reef top/wall habitat to provide assessments of large fish populations within one short-acre (ca. 4,000 m^2) of the reef at the benchmark station BDS-1. Areal cover by ASEC surveys was estimated from the markings in the GPS as the boat captain followed a marker buoy from divers executing the survey. Due to the lack of underwater topographic relief or substrate discontinuities, ASEC surveys at the deep rhodolith reef were performed along 50 m long by 3 m wide line transects. Five ASEC surveys were performed at the deep rhodolith reef for a total areal coverage of 750 m^2. Common names of reef fishes were taken from Humann and Deloach (2006).

VI. Results and Discussion

1.0 Physical Oceanography Data

1.1 CTD Water Column Profiles

Water temperature and salinity profiles of the top 50 m at BDS during June, 2007 are presented in Figure 8. Water temperature ranged between 28.85 °C at the surface and 27.30°C at a depth of 52 m. A sub-surface thermocline of gradual temperature decline encompassing depths between 8 – 13 m was registered. Water temperature remained virtually constant down to a depth of 42 m, and then declined sharply along a thermocline at depths between 45 – 50 m. A corresponding increment of salinity (halocline) was associated with the thermocline at 45 m, suggesting the influence of different water masses. The density profile essentially followed the salinity profile, but appeared to be more strongly influenced by the temperature variations in the 40 – 50 m range. From this data it is apparent that the deep rhodolith reef communities were living just below the early summer thermocline, whereas the reef top and reef wall communities were living within the surface mixed layer during June, 2007.

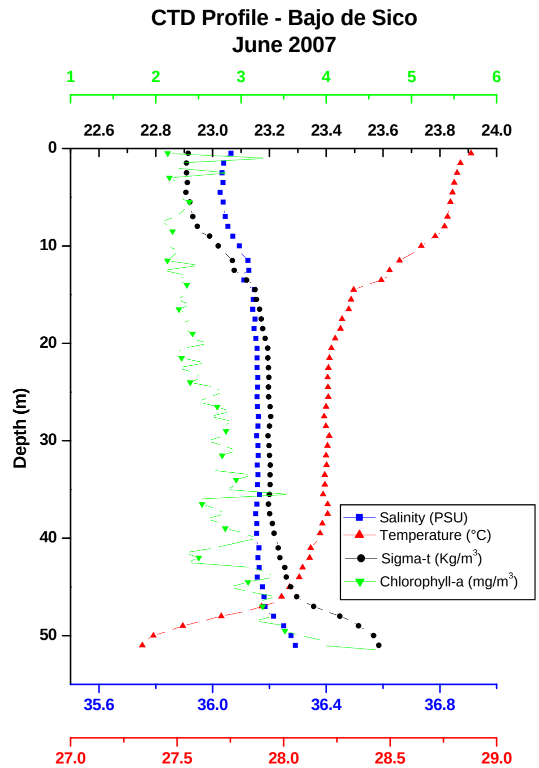

Figure 8. Water temperature and salinity profile taken with a CTD at Bajo de Sico

1.2 Water Currents

Mean flow estimates of the 75 day ADCP deployment at BDS are presented in Table 4 and Figures 9 and 10. The mean strength of the flow is represented by the mean speed (the scalar average) and the 50th percentile (median) profiles which exhibited relatively high speeds in the order of 41 cm/s and 38 cm/s (1 knot = 51 cm/s), respectively, with the higher values observed in the subsurface 5 -15 m depth layer (Figure 9). Mean speeds decreased markedly with increasing depth. Both surface and bottom boundary layers were evident. Median speeds were similar to the mean speeds indicating a nearly-symmetrical speed distribution (Figure 9). R/S ratios of ~0.5 are indicative of both a strong mean flow and highly oscillatory (probably tidally and wind-driven) flow. Below a depth of approximately 4 m the mean (resultant) flow was directed northward, a heading of 0°. Closer to the surface, in the wind-driven surface boundary layer, the mean flow rotated westward, while the bottom boundary layer flowed towards the southeast along bottom contours. The 90th percentile speeds (Figure 10), usually resulting from peak tidal or peak sea breeze currents were in the order of 70-74 cm/s (1.4-1.5 kt). Maximum observed speeds were in excess of 122 cm/s (2 kts).

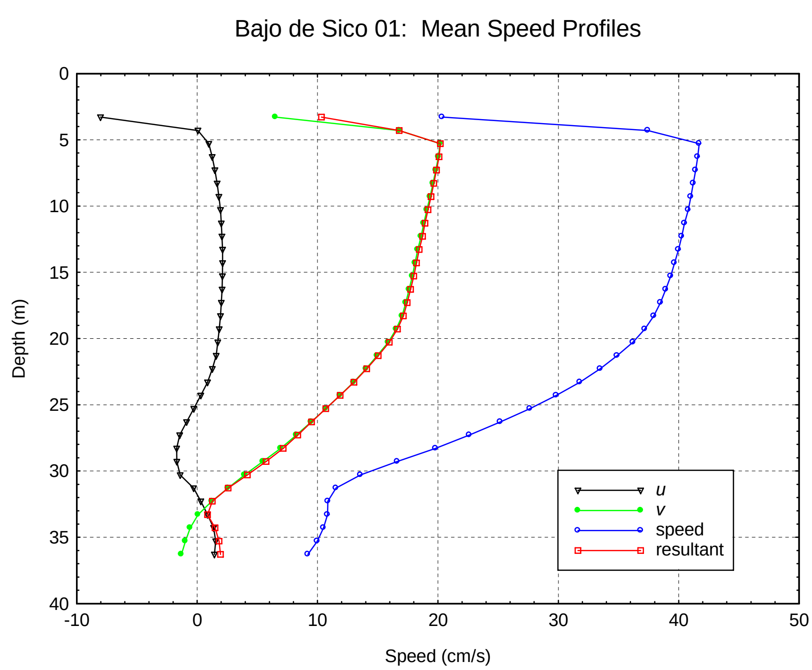

Figure 9. Mean water current speed profiles of the top 38 m at Bajo de Sico during the period between February 23 and May 9, 2007.

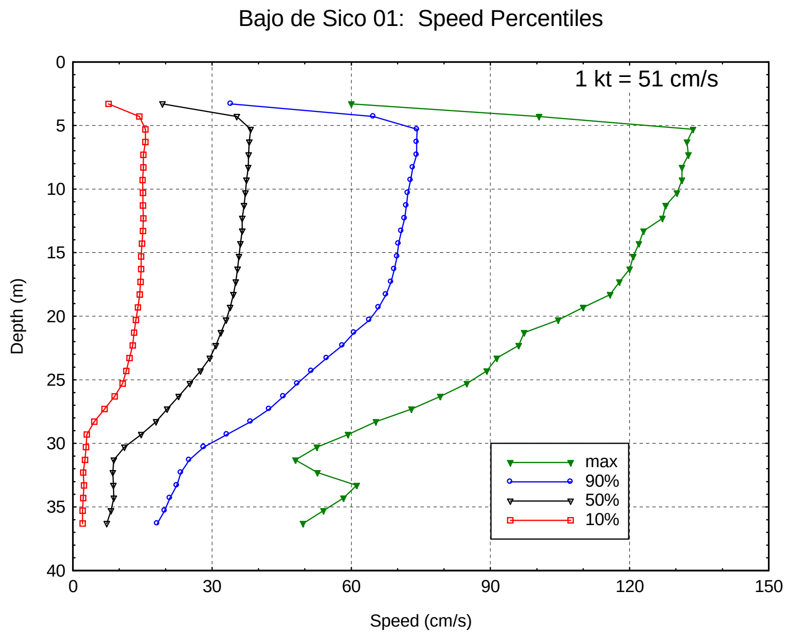

Figure 10. Water current speed percentile profiles of the top 38 m at Bajo de Sico during the period between February 23 and May 9, 2007.

The progressive vector (PV) pseudo-trajectories shown in Figure 11 and the directional transport distributions in Figure 12 show the prevalence of a persistent interior northward flow, semidiurnal tidal current oscillations and more rectified flow near the bottom.

Full record, tidally smoothed, *v* (north-south component) time series are presented in Figure 13. Near surface and mid-water currents displayed a similar pattern in both amplitude and phase, while the near-bottom currents were much weaker. Flow variability at multiple time scales was evident. Despite a very prominent northward mean flow, periods of sustained southward flow were observed in the 75-day record. Southward mean flow prevailed during February 24-28, and later over a one week period during April 7-14. The Punta Ostiones tidal current predictions maintained a near-zero mean across several tidal cycles, whereas the observed flow at BS01 exhibited a persistent northward mean flow (Figure 14). A strong northward mean flow of more than 1 kt prevailed over a three-day period, decreasing to a near-zero mean by the time the ADCP was recovered.

Table 4. BS01 mean statistics and percentiles. Depth in meters and speeds in cm/s. **Scalar**=scalar speed average, **Res**=magnitude of the resultant vector, **Dir**=direction of the resultant vector, **R/S**=**Res/Scalar** ratio, **u**=average of the *u* component, **v**=average of the *v* component. Data at 10%, 50% and 90% depth are highlighted in bold.

Depth	Scalar	Res	Dir	R/S	u	V	10	50	90	max
3.30	20.4	10.3	309	0.51	-8.0	6.5	7.7	19.3	34.0	60.0
4.30	**37.4**	**16.8**	**0**	**0.45**	**0.1**	**16.8**	**14.3**	**35.3**	**64.8**	**100.5**
5.30	41.7	20.2	3	0.48	1.0	20.2	15.6	38.3	74.2	133.7
6.30	41.6	20.1	4	0.48	1.2	20.1	15.6	38.0	74.1	132.4
7.30	41.4	19.9	4	0.48	1.5	19.8	15.2	37.9	74.1	132.7
8.30	41.2	19.7	5	0.48	1.7	19.6	15.2	37.8	73.3	131.3
9.30	41.0	19.4	5	0.47	1.8	19.3	15.0	37.4	72.8	131.3
10.30	40.8	19.2	6	0.47	1.9	19.1	15.1	37.2	72.2	130.2
11.30	40.5	18.9	6	0.47	2.0	18.8	15.1	36.9	71.9	127.8
12.30	40.3	18.7	6	0.46	2.1	18.6	15.2	36.5	71.5	127.1
13.30	40.0	18.4	7	0.46	2.1	18.3	15.1	36.5	70.8	123.0
14.30	39.7	18.2	7	0.46	2.1	18.1	14.9	36.1	70.2	122.0
15.30	39.3	18.0	7	0.46	2.1	17.9	14.7	35.8	69.9	120.8
16.30	38.9	17.7	7	0.46	2.1	17.6	14.7	35.5	69.3	120.0
17.30	38.5	17.5	7	0.45	2.0	17.3	14.6	35.1	68.6	117.8
18.30	37.9	17.1	7	0.45	1.9	17.0	14.4	34.6	67.5	115.8
19.30	**37.2**	**16.6**	**6**	**0.45**	**1.8**	**16.5**	**14.0**	**33.9**	**65.9**	**110.0**
20.30	36.2	16.0	6	0.44	1.7	15.9	13.6	33.0	63.9	104.6
21.30	34.9	15.0	6	0.43	1.6	15.0	13.2	31.9	60.6	97.3
22.30	33.5	14.1	5	0.42	1.3	14.0	12.9	30.8	58.1	96.1
23.30	31.8	13.0	4	0.41	0.9	13.0	12.2	29.5	54.7	91.4
24.30	29.8	11.9	1	0.40	0.3	11.9	11.5	27.5	51.4	89.2
25.30	27.7	10.7	358	0.39	-0.3	10.7	10.7	25.2	48.4	84.9
26.30	25.2	9.5	355	0.38	-0.9	9.5	9.0	22.8	45.4	79.2
27.30	22.6	8.4	350	0.37	-1.4	8.2	6.8	20.3	42.3	73.0
28.30	19.8	7.1	346	0.36	-1.7	6.9	4.6	17.9	38.3	65.3
29.30	16.6	5.7	343	0.34	-1.7	5.5	3.0	14.7	33.2	59.3
30.30	13.6	4.2	340	0.31	-1.4	3.9	2.8	11.1	28.2	52.6
31.30	11.5	2.6	353	0.22	-0.3	2.6	2.6	8.8	25.1	48.0
32.30	10.9	1.3	15	0.12	0.3	1.2	2.2	8.6	23.3	52.7
33.30	10.8	0.9	84	0.08	0.9	0.1	2.4	8.7	22.4	61.2
34.30	10.5	1.5	113	0.14	1.4	-0.6	2.2	8.8	20.9	58.3
35.30	**10.0**	**1.8**	**122**	**0.18**	**1.5**	**-1.0**	**2.1**	**8.2**	**19.8**	**54.0**
36.30	9.2	1.9	132	0.21	1.4	-1.3	2.1	7.3	18.2	49.6

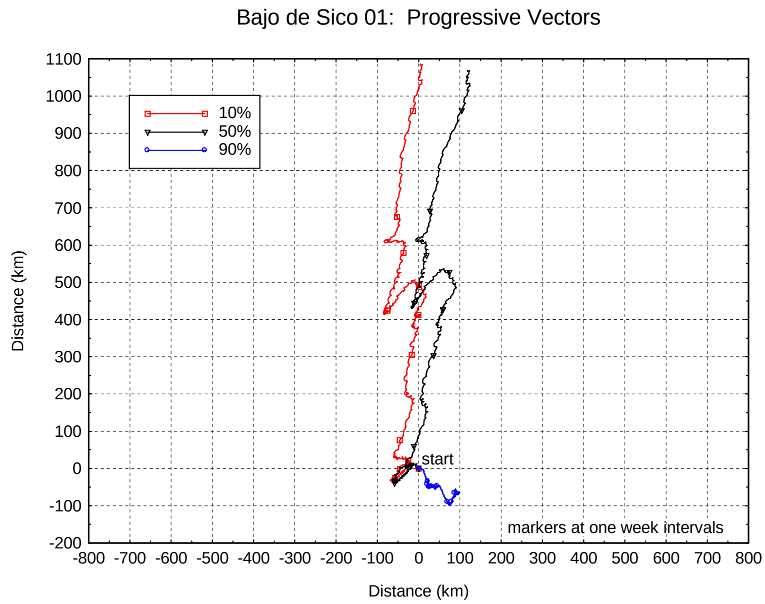

Figure 11. Water current progressive vector pseudo-trajectories at BDS during the period between February 23 and May 9, 2007.

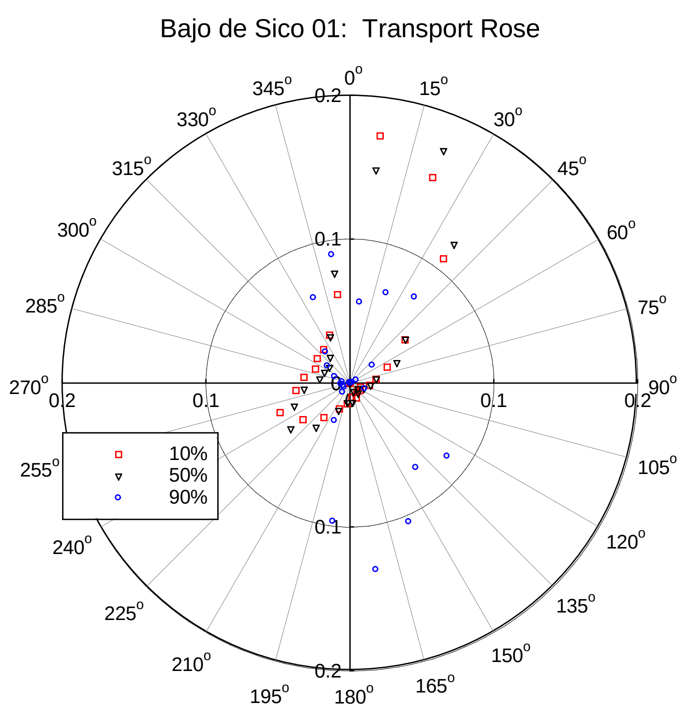

Figure 12. Water current directional transport rose at BDS during the period between February 23 and May 9, 2007. The radial position of each depth marker represents the percentage of the total transport that lies in any given 15° bin. Each radial division indicates 10% of the total transport

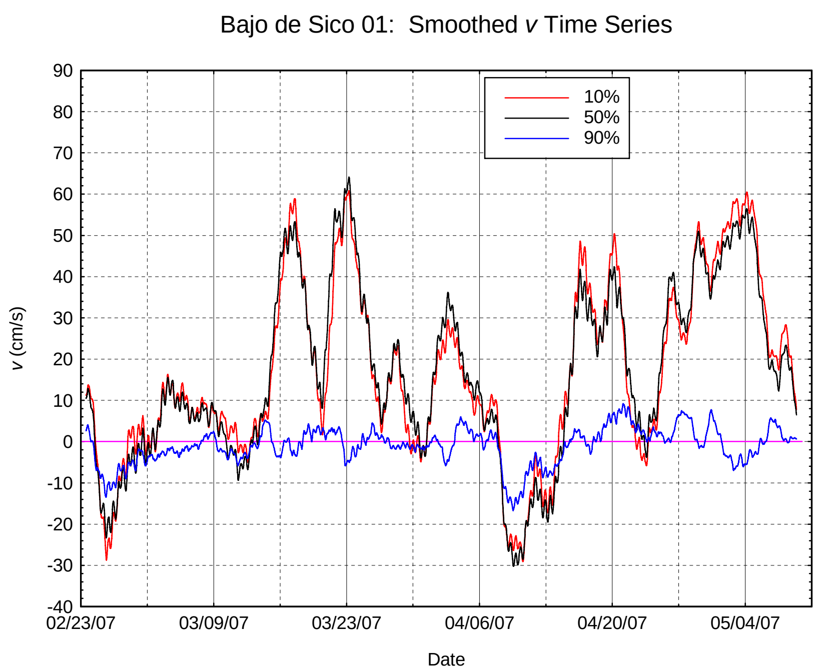

Figure 13. Full record, smoothed *v* time series at 10%, 50% and 90% depths during Feb 23 – May 9, 2007

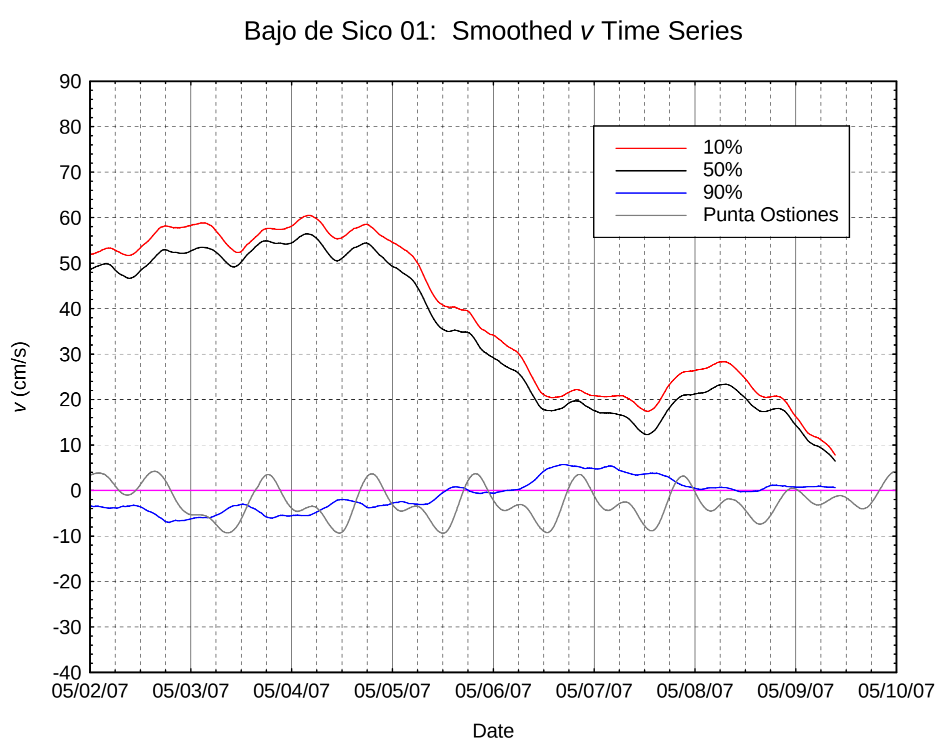

Figure 14. Punta Ostiones predicted tide (NOAA) and *v* time series at 10%, 50% and 90% depths during May 2-10, 2007.

1.3 Water Column Optical Data

The diffused attenuation coefficient K_d and the depth of the euphotic zone are shown in Figure 15. Optical field measurements contain inherent sources of error due to light refraction by surface waves, cloud cover, boat shadow, and instrument shadow. During the BDS sampling date weather conditions were close to ideal and consequently the remote sensing attenuation coefficient K490 was the most similar to the corresponding K_d field measurements. The depth of the euphotic zone calculated from the satellite data for the same date and time of field measurements was less than 7.0 m shallower than the 70.39 m euphotic zone (1% incident light) given by the field measurements. The site was visited during early September, which falls in the middle of the Caribbean hurricane season. This is probably the time when the attenuating effect of terrigenous sediments is most felt in the adjacent shelf waters as can be seen in the satellite image.

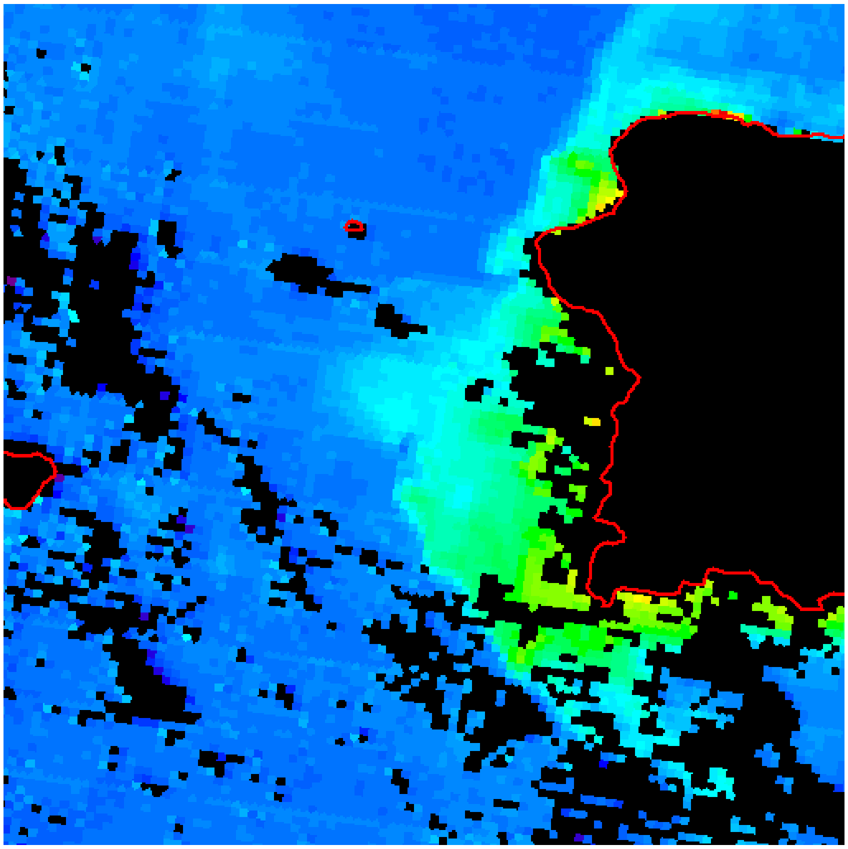

Figure 15. MODIS-K 490 satellite image of the Mona Channel (9/7/07) and depth of the euphotic zone for field measured Kd and remote sensed K490

2.0 Bathymetry of Bajo de Sico

BDS seamount has a maximum length of approximately 6.0 km along its southwest to northeast axis, and a maximum width of approximately 2.5 km across the northwest to southeast axis. The total surface area of the seamount within the 100 m depth contour is of approximately 11.1 km^2. BDS is connected to the insular shelf of Puerto Rico by the deepest and widest of a series of hard ground platforms that extend west and north towards Mona Passage at about 28 km due west off Punta Guanajibo in the Cabo Rojo platform (Figure 16). The deep shelf platform of BDS rises gradually from a depth of 190 m towards the north reaching a minimum depth of 24 m at the top of the seamount. The edge of the deep shelf platform at BDS is found at depths that range between 90 – 115 m. The slope of the seamount is an abrupt, almost vertical wall towards the bottom at depths that increase sharply from 200 m in the southern margin to depths of more than 300 m in the northern margin of the seamount.

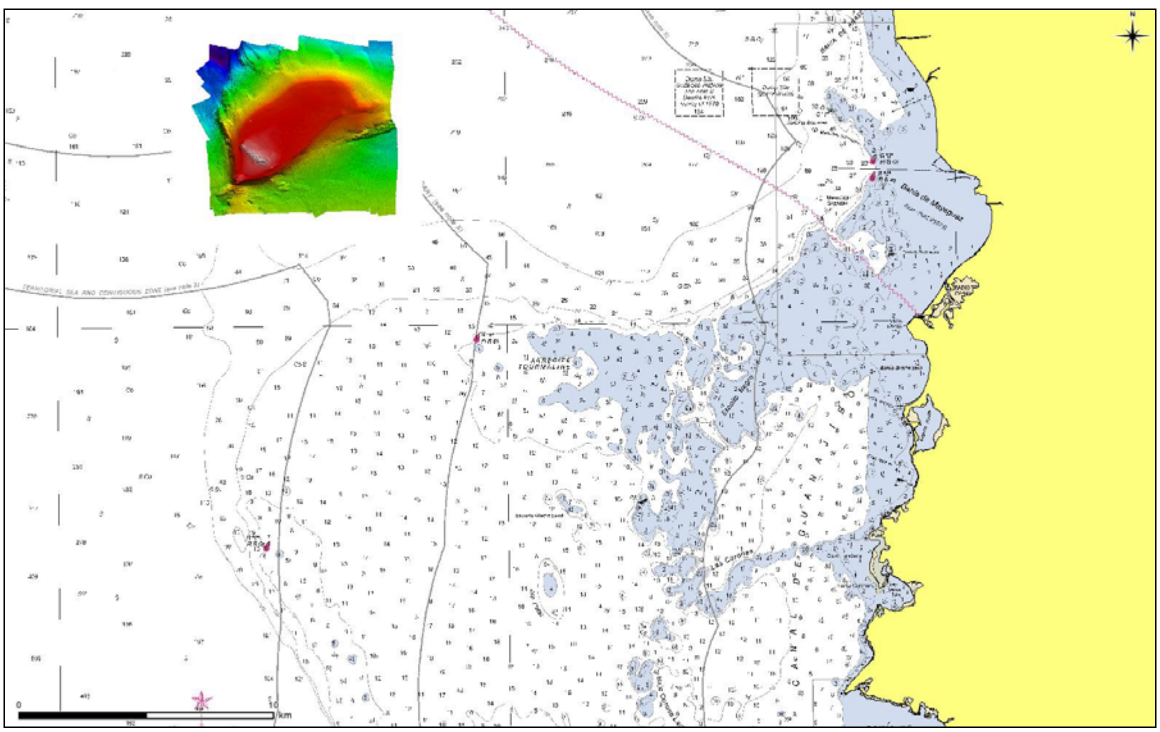

Figure 16. Nautical chart of the west coast of Puerto Rico (NOAA 25671) showing bathymetric features of the west coast insular slope and the Bajo de Sico seamount.

The most salient bathymetric feature of BDS is a series of promontories located at the southwest margin of the seamount. Promontories rise from a basal depth of approximately 40 m and extend along a southeast to northwest axis, occupying a surface area of approximately 0.4 km^2, or 3.6% of the total seamount surface area within the 100 m depth contour (Figures 17 and 18). Depth increases gradually along a series of mostly flat homogeneous platforms oriented towards the northeast, the larger of which sits within the 60 – 70 m depth contours and occupies a surface area of approximately 2.84 km^2, or 25.5% of the total BDS shelf surface area. Table 5 provides area estimates of the various depth provinces at BDS.

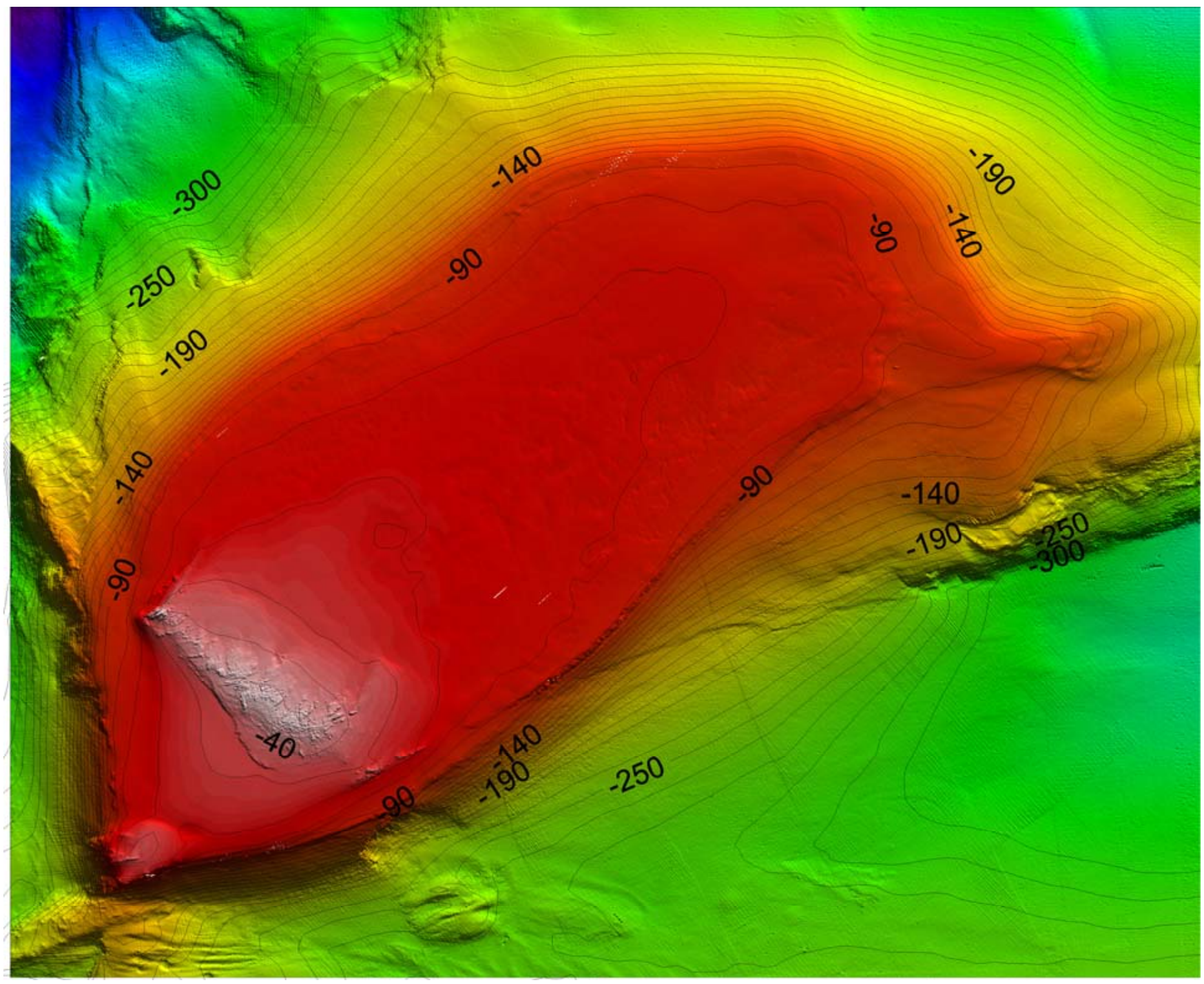

Figure 17. Bathymetry of Bajo de Sico viewed from the top to show the main reef platforms oriented along a southwest to northeast axis.

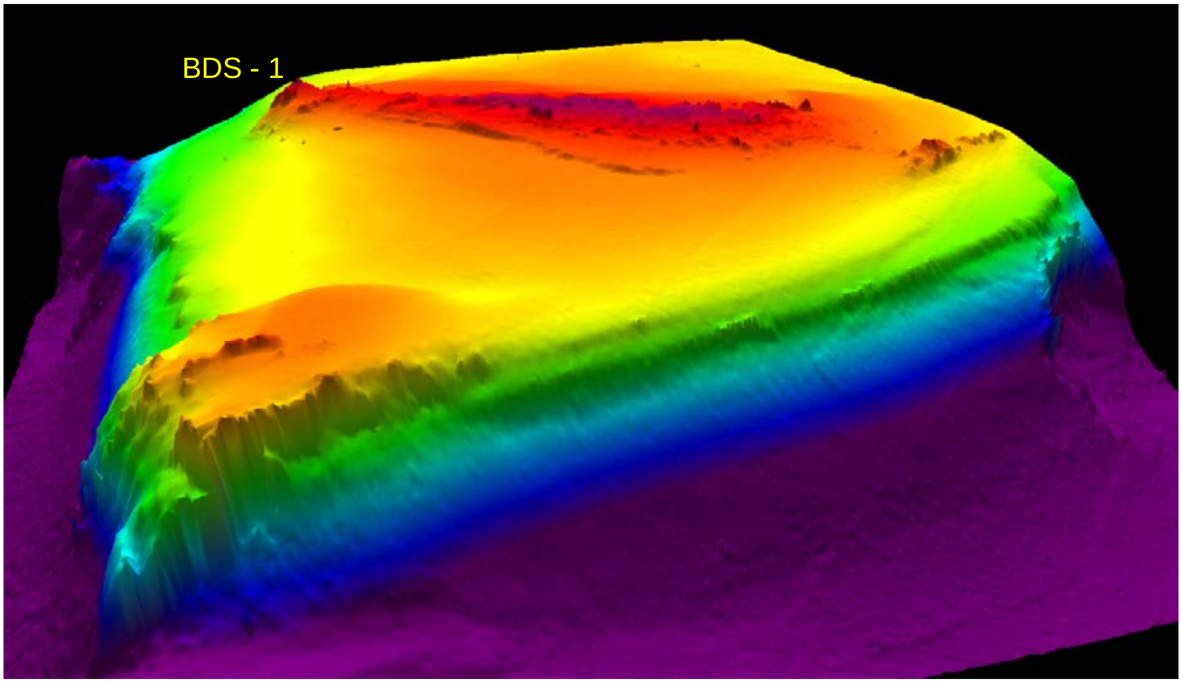

Figure 18. Bathymetry of Bajo de Sico viewed from the side to show the main reef promontories

Table 5. Estimates of surface area covered by depth provinces within 100 m at Bajo de Sico

Depth Province (m)	Estimated Surface Area (Km2)	% Total Area
25 - 40	0.40	3.6
41 - 50	0.90	8.1
	1.30	**11.7**
51 - 60	1.74	15.6
61 - 70	2.84	25.5
71 - 80	1.04	9.3
81 - 90	1.90	17.1
91 - 100	2.30	20.7
	11.12	**96.3**

3.0 Benthic Habitat Map

Five main benthic habitats distributed within a depth range of 23.5 to 50.0 m were field verified by direct diver observations at BDS. The total area within the 50 m depth contour was 1.3 km^2, or 11.7% of the total seamount's surface area (e.g. 11.1 km^2). The distribution of the main benthic habitats at BDS is presented in Figure 19. A ridge of rock promontories aligned southeast to northwest located on the southern section of the seamount is the main topographic feature of BDS. Promontories rise from a hard ground platform at a depth of 40 – 45 m up to a minimum depth of 23.5 m on the north-western margin of the ridge. There is an additional promontory that stands as a solitary mount rising to a depth of 27.0 m at the southern tip of the seamount (Figure 19).

Rock promontories exhibited two main benthic habitats, the reef top and the reef wall. The reef top habitat was highly irregular, with many substrate discontinuities, outcrops, holes, crevices and the rugosity contributed by large erect sponges and some massive corals. It is a horizontally projected, well illuminated hard ground surface characterized by a distinct assemblage of reef biota dominated in terms of substrate cover by benthic algae and sponges. Scleractinian corals presented their highest substrate cover at the reef top.

The reef wall is a vertically projected, highly irregular habitat, with caves, gaps and holes at the wall's face, and undercuts near the base. Light declines rapidly with increasing depth down the reef wall, and instead of benthic algae, the substrate at the wall is dominated by sponges. Instead of scleractinian corals, gorgonians and black corals are prominent at the reef wall. Also, benthic algae were less prominent at the reef wall, compared to the reef top. The total surface area of the reef promontories (including the reef top and wall habitat) was calculated as 0.40 km^2, representative of 3.6% of the total seamount area (Table 5). Due to the vertical projection of the reef wall, its surface area was underrepresented on the benthic habitat map, and mostly unaccounted in terms of areal distribution by benthic habitats at BDS.

A highly heterogeneous benthic habitat of colonized pavement and sand was found on channels separating adjacent promontories, and surrounding the ridge at its base within a depth range of 40 – 45 m. Isolated coral heads, sometimes associated with sponges, gorgonians, colonial hydrozoans and benthic algae colonized the hard ground between and around promontories. Coarse sand and rubble prevailed at the channels separating promontories, whereas the habitat surrounding the rock promontories presented uncolonized gravel and small rhodoliths dispersed over a compacted sandy substrate that gradually sloped down to the main platform of the seamount. An array of rock promontories generally smaller than the ones found within the main ridge colonized by benthic algae and encrusting biota, including scleractinian corals were present interspersed within the slope.

An extensive hard ground platform that extends north of the main seamount ridge was found at depths between 45 – 90 m. The total surface area of the deep platform below 50 m was estimated at 9.82 km^2, representing 88.2% of the seamount surface area. The shelf edge is an abrupt vertical wall mostly throughout the seamount, except along the southeast section where the seamount appears to be connected to the main island of Puerto Rico by a horizontal displacement of the insular slope forming a deep terrace at a depth of 177 m.

The deep shelf platform of BDS, down to the maximum surveyed depth of 50 m was found to be mostly covered by a vast deposit of algal rhodoliths. Two main benthic habitats can be discerned from this deep platform section of BDS. At the northern section of the platform, rhodoliths and other relict carbonate materials are densely overgrown by benthic algae, mostly the encrusting alga, *Lobophora variegata*, sponges, and scleractinian corals. Although of low topographic relief, the sharp increment in biotic cover and biodiversity relative to the adjacent slope environment serve as criteria to classify this habitat as a mesophotic reef system. South of the main ridge and at the western and eastern edges of the ridge, extensive rhodoliths deposits were also found. In contrast to the northern section, rhodolith nodules were mostly uncolonized by encrusting reef biota and appeared to be in a more dynamic state, as suggested by ripple formations observed in some areas.

There is at present very little information of the habitat features of the deep shelf platform beyond 50 m. During its multi-beam bathymetry survey of BDS, the R/V Nancy Foster was able to obtain video images of the seafloor along the deep platform beyond 50 m. From the limited resolution of the images, scleractinian corals could be discerned down to a maximum depth of 90 m along the northern section of the seamount's deep platform. Backscatter data from the R/V Nancy Foster multi-beam bathymetry survey was used in an effort to differentiate benthic habitats at BDS. The map of backscatter data differentiates substrates types between the main ridge and the deep platform (Figure 19), but does not provide enough resolution to discern benthic habitat differences (e.g. live reef vs abiotic) within the deep platform.

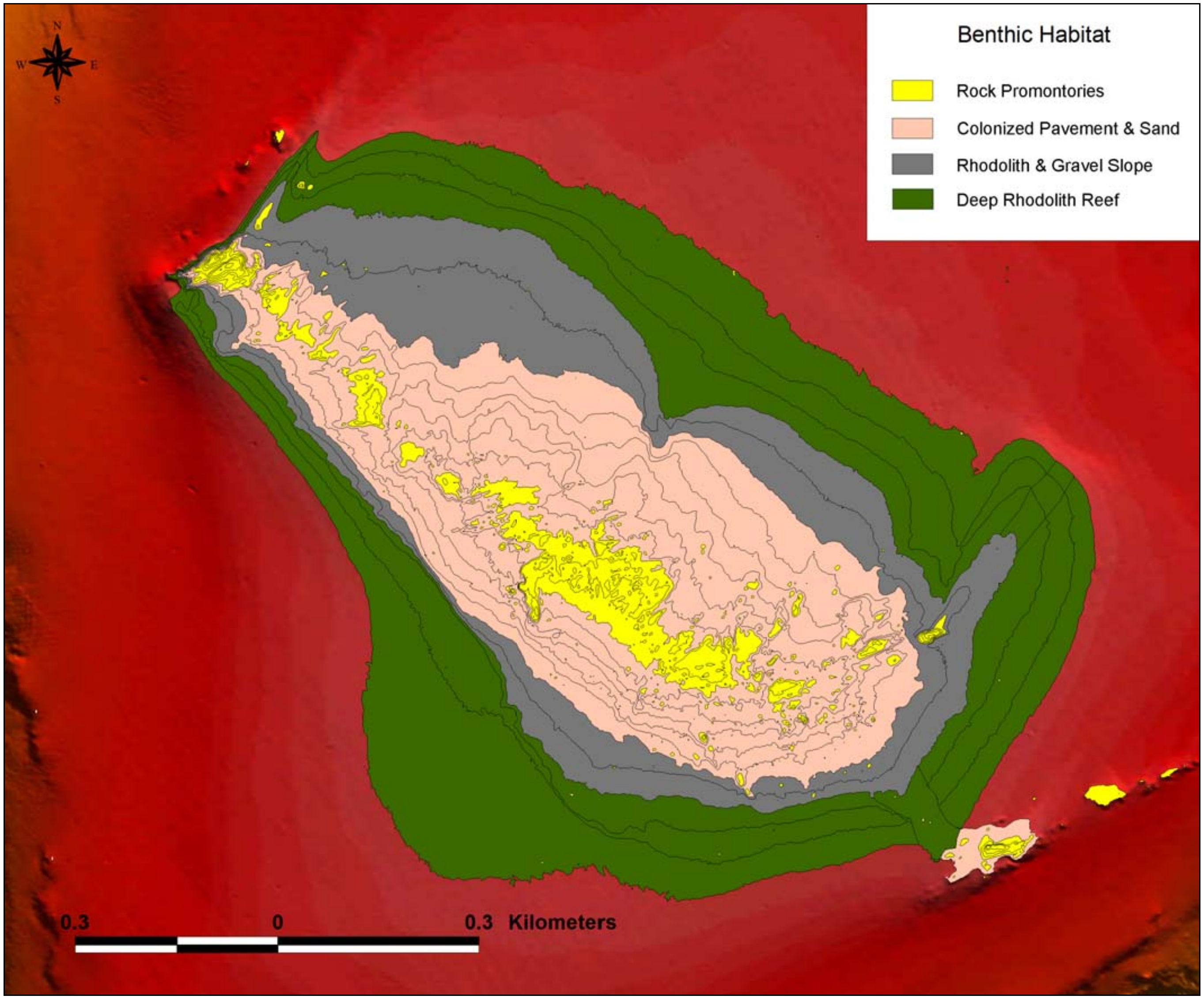

Figure 19. Benthic habitat map of Bajo de Sico up to a maximum depth of 50 m

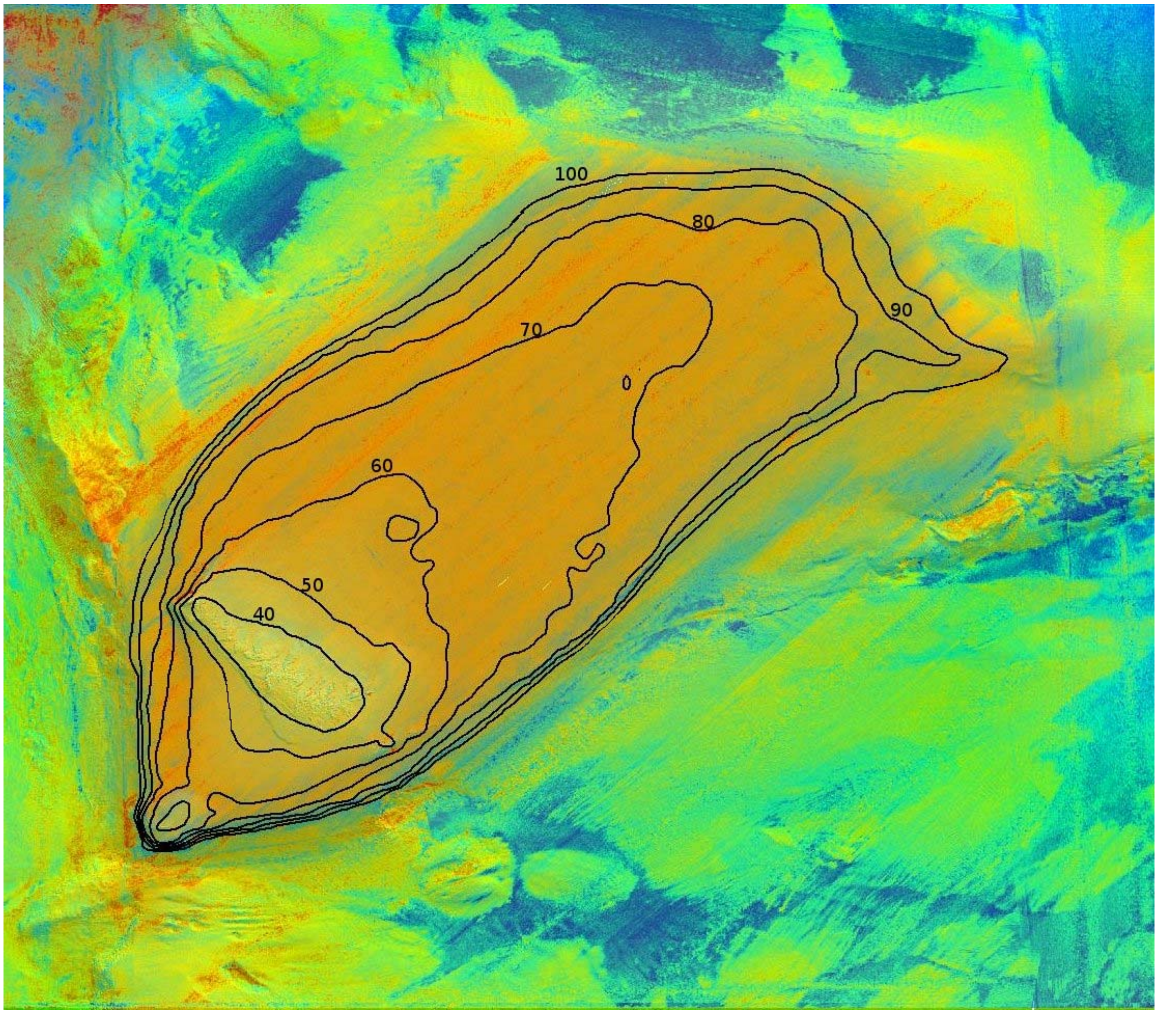

Figure 20. Backscatter data of Bajo de Sico produced by the R/V Nancy Foster multibeam survey on April 2007.

4.1 Biological characterization of marine communities associated with the main benthic habitats at Bajo de Sico

4.1 Sessile-benthic Community

4.1.1 Reef Top

The sessile-benthic community at the reef top of BDS was studied from a set of 10 permanent transects established on top of two reef promontories at depths between 26 – 30 m (for location see Figure 6). Turf algae, a mixed assemblage of short red and brown macroalgae was the dominant sessile-benthic category with an average reef substrate cover of 27.6% (range: 12.4 – 47.6%). Turf algae were observed growing as a carpet over hard abiotic substrates at the reef top habitat. encrusting fan-leaf algae, *Lobophora variegata* was the most prominent species of benthic macroalgae at the reef top of BDS. It was present in all ten transects surveyed with a mean cover of 22.1% (range: 17.6 – 28.8%). *Lobophora* was observed growing in large patches over hard substrates, sometimes intermixed with turf algae. Tufts of calcareous algae, including *Halimeda sp*. and encrusting coralline red macroalgae were present in eight out of the ten transects surveyed at the reef top with a mean cover of 2.3%. *Halimeda sp*. was observed in substrate depressions and at the base of coral heads. The leafy flat blade alga, *Stypopodium zonale* (Phaeophyta), the Y-twig alga, *Amphiroa sp.* (Rhodophyta) and a red coralline encrusting alga were also common. The total reef substrate cover by the combined assemblage of benthic algae at the reef top of BDS was 52.0% (Table 6). Views of the reef top at BDS habitat and associated sessile-benthic communities are shown in Appendix 1.

Sponges, represented within transects by at least 12 species were the dominant sessile-benthic invertebrate in terms of reef substrate cover at the reef top of BDS with a mean of 26.5% (range: 17.2 – 40.4%). Rope sponges (*Agelas clathrodes, A. dispar* and *A. conifera*) and the basket sponge (*Xestospongia muta*) were the most abundant within transects among identified species. Basket sponges were observed to reach a very large size, acting as an important protective microhabitat for several species of invertebrates and fishes. Spiny lobsters (*Panulirus argus*) and red hind groupers (*Epinephelus guttatus*) were observed inside sponges during our survey of the reef top.

Table 6. Percent substrate cover by sessile-benthic categories at Bajo de Sico, Reef Top habitat. Depth: 26 – 30 m

	TRANSECTS										
SUBSTRATE CATEGORY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**MEAN**
Abiotic	0.4	0.4	0.0	0.4	0.0	0.4	3.6	0.8	0.8	4.4	**1.1**
Unidentified	0.0	0.4	0.4	0.8	1.4	5.2	10.0	7.2	2.4	1.6	**2.9**
Benthic algae											
Algal Turf - mixed assemblage	39.0	41.4	47.6	23.6	25.6	12.4	14.8	14.8	29.2	27.6	**27.6**
Lobophora variegata	24.4	18.8	17.6	20.0	27.2	24.4	15.2	19.6	25.2	28.8	**22.1**
Calcareous/Coralline algae	3.6	3.6	5.2	0.8	4.0	0.0	0.0	2.8	2.0	0.8	**2.3**
Total Benthic Algae	67.0	63.8	70.4	44.4	56.8	36.8	30.0	37.2	56.4	57.2	**52.0**
Hydrozoa											
Plumaria (habereri)	0.2	0.8	0	0	0	0.4	0.8	0.8	3.2	2.0	**0.8**
Millepora alcicornis	0.4	4.4	0.8	12.8	2.0	0	0	0	0	0	**1.7**
Total Hydrozoa	0.6	5.2	0.8	12.8	2.0	0.4	0.8	0.8	3.2	2.0	**2.9**
Octocorals											
Iciligorgia schrammi	0	0	0	0	0	0	0	6.0	0	0	**0.6**
Pseudopterogorgia sp.	4.0	6.4	4.4	4.0	8.8	2.8	2.8	0.4	1.2	0	**3.2**
Total Octocorals	4.0	6.4	4.4	4.0	8.8	2.8	2.8	6.4	1.2	0.0	**4.8**
Scleractinian Corals											
Agaricia spp.	0.0	0.8	0.0	0.0	0.0	6.4	6.4	5.6	3.6	1.2	**2.4**
Porites astreoides	0.4	1.6	2.8	0.4	0.4	0.8	1.6	2.8	1.2	0.8	**1.3**
Montastraea cavernosa	0	0	0.4	0.0	0.0	0.8	0.8	1.2	3.2	4.8	**1.1**
Meandrina meandrites	4.4	0	0.0	0.4	0.0	1.2	0.0	1.2	2.0	1.6	**1.1**
Tubastrea coccinea	0	0	0.0	1.2	0.4	2.4	0.4	2.8	0.4	0.0	**0.8**
Eusmilia fastigiata	0.4	0	0.0	0.0	0.0	0.8	0.4	0.0	0.8	0.4	**0.3**
Madracis decactis	0	0	0	0	0	0.8	0.8	0.4	0.0	0.0	**0.2**
Montastraea annularis	0	0	0	0	0	0.0	1.6	0.0	0.0	0.0	**0.2**
Siderastrea siderea	0	0	0	0	0	0.0	0.0	0.0	1.2	0.4	**0.2**
Unid. coral	0.8	0.4	0.0	0.0	0.0	0.o	0.0	0.0	0.0	0.0	**0.1**
Colpophyllia natans	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.0	0.0	**0.1**
Diploria sp.	0	0.0	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	**0.1**
Isophyllia rigida	0	0	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	**0.1**
Total Stony Corals	6.4	7.2	4.0	16.4	2.8	14.0	12.8	14.8	12.4	9.2	**8.0**
Sponges											
unidentified sponges	5.6	12.0	5.2	8.8	14.8	14.4	12.4	11.2	7.2	7.6	**8.9**
Agelas clathrodes	0	0	0	0	0	9.6	7.2	4.4	4.0	5.2	**3.4**
Xestospongia muta	10.0	0.8	4.4	6.0	4.0	4.4	5.2	2.8	8	4	**5.0**
Agelas dispar	0	2.0	4.0	4.0	4.4	4.0	3.2	2.8	0.8	6.0	**3.1**
Agelas conifera	0	0	0	0	0	1.2	7.6	6.0	0.4	0.8	**1.6**
Verongula gigantea	0	0	3.6	1.2	4.0	0	0	0	0	0	**0.9**
Plakortis angulospiculatus	2.4	0	0	1.2	0	6.0	2.4	3.6	0.8	0.0	**1.6**
A. crassa	0.8	0.4	0	0	0.4	0	0	0	0	0	**0.2**
Callyspongia vaginalis	0.4	1.2	0.4	0	0	0	0	0	0	0	**0.2**
Ircinia sp.	2.8	0.4	2.4	0.8	0.4	0.4	0.8	0.8	0.4	1.2	**1.0**
Neofibularia nolitangere	0	0	0	0	0	0.0	0.0	0.0	1.6	1.2	**0.3**
Aplysina cauliformis	0	0	0	0	0	0.4	0.0	0.0	0.4	0.0	**0.1**
Verongula rigida	0	0	0	0	1.6	0.0	0.0	0.8	0.0	0.0	**0.2**
Total Sponges	22.0	17.2	20.0	22.0	29.6	40.4	38.8	32.4	23.6	26.0	**26.5**

These organisms seem to use the sponge "basket" as a protective hideout from the strong currents that prevail at the reef top.

An assemblage of 13 species of scleractinian corals combined for a mean reef substrate cover of 8.0% (range: 2.8 – 16.4%) within transects at the reef top of BDS. Lettuce corals, *Agaricia spp*., mostly the *lamarki/grahame* species combination were the numerically dominant taxa in terms of substrate cover with a mean of 2.4%. Mustard hill coral, *Porites astreoides* ranked second in terms of reef substrate cover with only 1.3%, but was present in all transects surveyed. Great star coral, *Montastraea cavernosa*, maze coral, *Meandrina meandrites*, and the ahermatypic orange cup coral, *Tubastrea coccinea* were present in six out of the 10 transects surveyed, but with very low substrate cover (< 1.2%). The *Agaricia spp*. combination, orange cup coral, mustard hill coral and great star coral were the dominant scleractinian coral taxa in terms of density of colonies within photo-transects (Table 7). Their combined density represented 84.3% of the total coral colonies. The *Agaricia spp*. combination, with an average of 75.8 col/10 m^2 was the dominant taxa. A total of nine species of scleractinian corals were present in all five transects surveyed for coral density determinations.

Table 7. Density of scleractinian coral colonies at the reef top habitat of Bajo de Sico, Depth: 26 – 30 meters (photo transects 6 – 10).

	TRANSECTS					
CORAL SPECIES	**6**	**7**	**8**	**9**	**10**	**MEAN**
Agaricia spp.	95	81	101	59	43	**75.8**
Tubastrea coccinea	75	29	80	24	7	**43.0**
Porites astreoides	28	29	46	9	17	**25.8**
Montastrea cavernosa	15	18	21	31	32	**23.4**
Eusmilia fastigiata	6	6	3	23	3	**8.2**
Madracis decactis	15	14	6	1	2	**7.6**
Meandrina meandrites	2	3	4	7	9	**5.0**
Siderastrea siderea	0	2	1	3	8	**2.8**
Isophyllia rigida	5	4	1	1	1	**2.4**
Montastraea annularis	1	2	3	1	5	**2.4**
Diploria sp.	4	0	0	1	1	**1.2**
Colpophyllia natans	0	2	2	0	0	**0.8**
Isophyllia sinuosa	2	0	1	0	0	**0.6**
Mycetophyllia aliciae	1	0	0	0	0	**0.2**
TOTALS	249	190	269	160	128	**199.2**

In general, scleractinian corals were mostly present as a species rich assemblage of small isolated encrusting colonies not forming massive buildups at the reef top of BDS. Even species that commonly form massive structures, such as *Montastraea cavernosa, M. annularis* and *Colpophyllia natans* were present as rather small, low relief colonies. The relatively low substrate cover of boulder star coral, *M. annularis* from the reef top at BDS is in sharp contrast with previous observations of reef community structure at similar depths (Garcia-Sais et al., 2005), where this species complex generally represents one of the dominant taxa. For example, in the west coast of Puerto Rico, *M. annularis* complex was the dominant species at Isla Desecheo in two reefs studied within the 25 – 30 m depth range (García-Sais et al., 2005), and also at Tourmaline Reef in the shelf-edge off Mayagüez Bay (García-Sais et al., 2007). At Puerto Canoas (Isla Desecheo), *M. annularis* complex averaged a reef substrate cover of 16.0%, representing 54% of the total substrate cover by scleractinian corals within the 25-30 m depth (García-Sais et al., 2007). Also from Isla Desecheo, in the SW Wall Reef, the *M. annularis* complex presented the highest cover (tied with *M. cavernosa*) among scleractinian corals at a depth of 30 m (García-Sais et al., 2005).

Recent observations of substrate cover from reefs on the east coast of PR and the USVI within the 25 - 30 m depth range highlight the fact that *Montastraea annularis* complex is the main reef builder and predominant scleractinian coral in terms of reef substrate cover. This includes reports of Black Jack Reef, on the south coast of Vieques by García-Sais et al. (2004) where *M. annularis* complex accounted for 76% of the total cover by live coral at depths between 36 – 40 m. At the MCD Reef system south of St. Thomas, USVI, Armstrong et al. (2006) estimated maximum cover by *M. annularis* as of approximately 70% at depths of 38 – 40 m. Likewise, Menza et al. (2007) identified a flattened growth form of *M. annularis* complex as the dominant coral structuring the MSR-1 Reef, located off the south coast of St. John, USVI.

The limited development of *Montastraea annularis* complex at the reef top of BDS may be related to a combination of factors, such as the prevailing heavy surge associated with wave action and currents and/or the competition for space from other sessile-benthic components that appear to have more favorable growth conditions, such as benthic algae, sponges and/or lettuce corals. We suggest that the lack of larval availability would not be expected to be a limiting factor because small colonies of *M.*

annularis are present throughout the reef top at BDS. A few relatively large flattened colonies of *M. annularis* were observed at the reef top promontories during reconnaissance dives for benthic habitat mapping. But over large (habitat) spatial scales, the pattern was of prevalence of the small encrusting coral colonies and relatively low incidence of the large colonies of boulder star coral and other massive coral species.

During November 2005, a massive coral bleaching was observed at the reef top of BDS (Plate 1). The coral bleaching event preceded our quantitative observations of percent reef substrate cover by live corals and other sessile-benthic biota at the reef top. Thus, it is uncertain if the estimates of live coral cover presented in this report reflect a significant mortality impact associated with the massive bleaching event. Nevertheless, recently dead coral colonies were not evident during our quantitative assessment of the reef top habitat at BDS-1. Qualitative field observations of bleached coral species included boulder star and great star corals (*Montastraea annularis* complex; *M. cavernosa*), mustard-hill coral (*Porites astreoides*), lettuce coral (*Agaricia spp*), maze coral (*Meandrina meandrites*), and fire corals (*Millepora spp.*). Bleached corals were observed down to a maximum depth of 42.5 m.

Soft corals (gorgonians), were represented by only two species at the reef top with a combined cover of 4.8%, but the sea whip, *Pseudopterogorgia* sp. was common at the reef top with colonies in all of the 10 transects surveyed. The deepwater fan, *Iciligorgia schrammi* was only present in one transect. The latter was observed to attain a fairly large size (height up to a meter), whereas colonies of *Pseudopterogorgia* sp. were generally small (up to 30-40 cm. *Plumaria (haberi)*, a vertically projected colonial hydrozoan growing as a small (up to 30 cm), black shrub was ubiquitous over the reef top, contributing an average of 1.4% to the reef substrate cover. An unidentified colonial hydrozoan was observed growing (encrusted) over standing dead black coral colonies (dead *Antipathes caribbeana*). Antipatharians (black corals) were present at the reef top, but were not abundant. One colony of the bushy black coral, *A. caribbeana* (Opresco) was observed within transects at the reef top.

The substrate at the reef top was mostly consolidated, without sand pockets and/or other unconsolidated sediments. The abiotic categories averaging less than 1.5% within transects surveyed were associated with holes and gaps in the rock promontories.

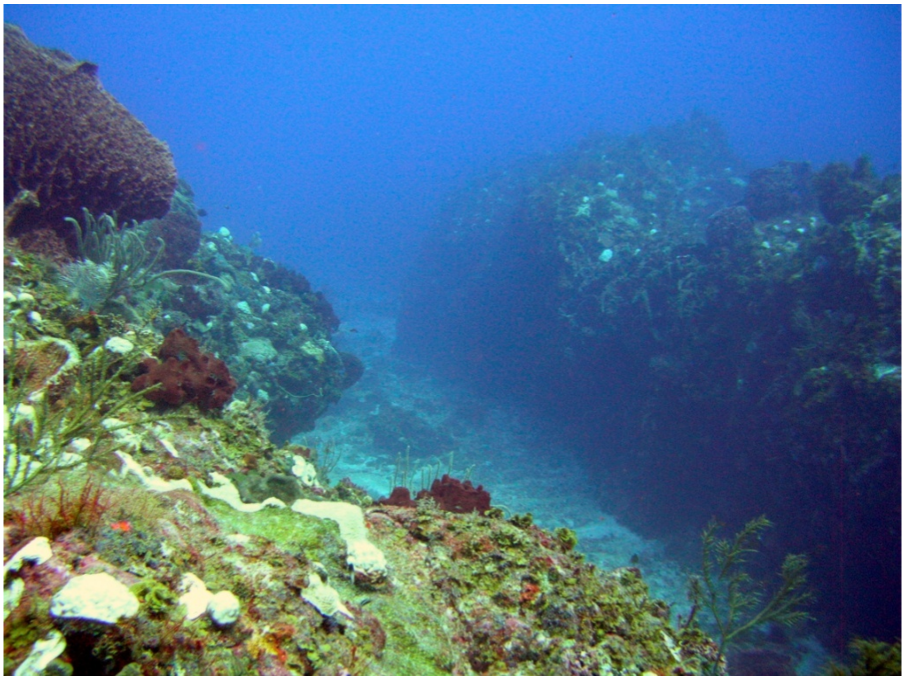

Plate 1. Reef promontories at BDS. Note the prevalence of small encrusting coral colonies bleached during November, 2005.

4.1.2 Reef Wall

Most reef promontories at BDS end laterally with abrupt slopes that create almost vertical walls down to the base of the reef, a sandy channel with scattered rocks and rubble (Plate 1). Reef walls are typically irregular formations that appear to have been influenced by erosional processes, with deep crevices, undercuts, gaps, ledges and other substrate discontinuities (Plate 2). The depth range of the wall habitat associated with reef promontories was typically found between 30 – 45 m. Reef walls that slope down vertically from the reef top promontories to more than 200 m depths are found in the southwest section of BDS. Deep wall habitats are also associated with the edge of the reef at depths from approximately 90 – 300 m (see Figures 6-7). Our survey of the reef wall habitat was performed at depths between 30 – 40 m at the benchmark station BDS-1. A total of 10 line transects were surveyed from three sites within BDS-1 (for location see Figure 7). Panoramic views of the reef wall habitat are presented as Appendix 2.

Plate 2. Reef wall habitat at BDS showing irregular formations with deep crevices, undercuts and other substrate discontinuities.

Sponges were the dominant sessile-benthic category at the reef wall habitat in terms of substrate cover with a mean of 43.1% (range: 22.4 – 64.4%). At least 11 species were present within surveyed transects (Table 8). *Agelas conifera, Plakortis angulospiculatus, A. clathrodes, A. dispar,* and *Xestospongia muta* combined for a mean reef substrate cover of 19.9%, representing the main assemblage of sponges at the reef wall. All these sponges presented erect and/or branching growth forms, typically reaching large sizes. Their structure contributed significantly to the reef topographic relief and represented an important protective habitat for fishes and invertebrates (Plate 3). Sclerosponges (possibly *Ceratoporella nicholsoni*) were commonly found growing as spherical colonies underneath ledges, and on the wall and ceiling of deep crevices. Sclerosponges were also observed growing as encrusting colonies in exposed sections of the wall habitat. Sponges are the main food source of the hawksbill turtle, *Eretmochelys imbricata* (Diez, 2002, León and Bjorndal, 2002) and may explain the exceptionally large adult population of these turtles at BDS. Branching sponges at the wall were observed to function as a recruitment habitat for several species of reef fishes, such as the blue and sunshine chromis, *Chromis cyanea* and *C. insolata*. They are also the main food source of angelfishes (*Holacanthus ciliaris, H. tricolor, Pomacanthus spp*) (Randall, 1967).

Table 8. Percent substrate cover by sessile-benthic categories at station BDS-1. Bajo de Sico. Reef Wall 30 - 40 m

	TRANSECTS										
SUBSTRATE CATEGORY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**MEAN**
Abiotic	4.0	4.0	6.8	4.0	7.6	0.0	2.8	2.8	5.6	4.0	**4.16**
Benthic algae											
Turf-mixed assemblage	2.8	5.2	6	8.8	8	5.2	13.2	6	6.8	13.5	**7.55**
Lobophora variegata	30.8	33.6	26.4	7.6	4.8	3.2	20	19.6	18	15	**17.9**
Halimeda spp.	0	0	0	0.4	0	0.8	0	0.4	0	0	**0.16**
Total Benthic Algae	33.6	38.8	32.4	17	13	9.2	33.2	26	24.8	28.5	**25.61**
Hydrozoa											
Unid. colonial hydrozoan	0	1.2	1.2	3.2	3.2	11.2	1.2	0.4	0	0	**2.16**
Millepora alcicornis	0	0	0	0	0	0	0	0.8	0	0	**0.08**
Antipatharians	1.2	3.2	2.0	20.0	0	0	0	1.2	1.6	1.0	**3.02**
Octocorals											
Iciligorgia schrammi	14	6.4	0	8.8	9.2	5.2	4.8	32.0	30.0	15.0	**12.54**
Pseudopterogorgia sp.	0	0	1.2	0	0	0	0.4	0.8	0	0.5	**0.29**
Unid. Gorgonian	0.8	0.4	1.6	1.6	1.2	0	0.8	0	0	0.5	**0.69**
Total Octocorals	14.8	6.8	2.8	10	10	5.2	6	32.8	30	16	**13.52**
Scleractinian Corals											
Montastrea cavernosa	0	2.4	3.2	0.8	0	0	3.2	1.6	0.8	5	**1.7**
Agaricia spp.	2	2.8	0.4	2	0.8	0.4	3.2	0.8	2.4	0	**1.48**
Tubastrea coccinea	0.8	1.2	0	1.2	0	0	1.2	3.2	1.2	1.5	**1.03**
Porites astreoides	0.8	1.6	0.4	0	0	0	0.4	0	0.4	0	**0.36**
Montastrea annularis	0	1.2	0	0	0	0	0	0.4	0	0.5	**0.21**
Madracis decactis	0	0.8	0	0	0	0	0	1.2	0	0	**0.2**
Diploria labyrinthiformis	0	2	0	0	0	0	0	0	0	0	**0.2**
Leptoseris cucullata	0	0.4	0.8	0	0	0	0	0	0	0	**0.12**
Meandrina meandrites	0	1.2	0	0	0	0	0	0	0	0	**0.12**
Eusmilia fastigiata	0	0	0	0	0	0		0.8	0	0	**0.08**
Siderastrea siderea	0	0	0	0	0	0	0.4	0	0	0	**0.04**
Total Scleractinian Corals	3.6	13.6	4.8	4	0.8	0.4	8.4	8	4.8	7	**5.54**
Sponges											
unidentified sponges	10	5.2	20.4	22	38	37.2	17.2	16.4	15.2	26.5	**20.81**
Agelas conifera	15.6	6.8	9.6	12	9.6	2.4	4	7.2	6.8	9	**8.3**
Plakortis angulospiculatus	8.4	6.4	14.8	2.4	6.4	6.8	5.6	1.2	1.6	3.5	**5.71**
Agelas clathrodes	0.4	1.6	1.6	2.8	4.4	2.4	5.2	1.6	2	2	**2.4**
Agelas dispar	0.8	1.2	0.4	1.6	4.8	3.6	4.4	0.8	0.4	1	**1.9**
Xestospongia muta	0	0	0	0	0	2.4	9.2	0	4.8	0	**1.64**
Callyspongia fallax	0.4	0.4	0	0	1.2	2.8	0	0	1.6	1	**0.74**
Ircinia sp.	0.8	0.8	0.8	0.8	0.4	2.4	1.6	0.4	0.4	0	**0.84**
Callyspongia plicifera	0.8	0	0.4	0	0	1.6	0	0	0.4	0.5	**0.37**
Callyspongia vaginalis	0.8	0	0	0	0	0	0.8	0	0	0	**0.16**
Aplysina cauliformis	0	0	0	0	0	0	0	0	0.4	0	**0.04**
Svenzea zeai	0	0	2	0	0	0	0	0	0	0	**0.2**
Total Sponges	38	22.4	50	42	64	61.6	48	27.6	33.6	43.5	**43.11**

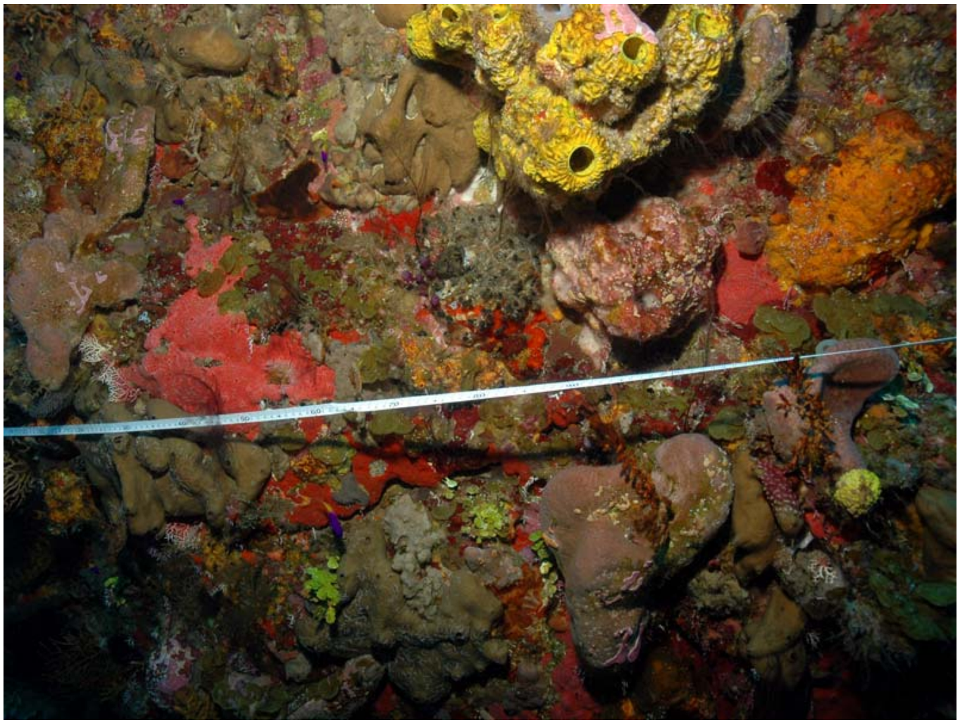

Plate 3. Sponge dominated reef wall habitat

Benthic algae, comprised mostly by the encrusting fan-leaf algae, *Lobophora variegata* (mean cover: 17.9%) and to a lesser extent by turf (mean cover: 7.6%) and calcareous macroalgae (mean cover: 0.2%) ranked second in terms of reef substrate cover at the wall habitat with a combined mean of 25.6% (range: 9.2 – 38.8%) (Table 8). The vertical inclination of the wall habitat with its undercuts, ledges and crevices tend to reduce illumination of the reef substrate, providing perhaps a competitive advantage to sponges, gorgonians and black corals that grow out of the wall towards the water column.

The deepwater fan, *Iciligorgia schrammi* was one of the most prominent features of the wall habitat sessile-benthos, with a mean reef substrate cover of 12.5% (range: 0 – 32.0%), representing more than 95% of the total cover by gorgonians (octocorals) at the wall habitat (Table 8). Substrate cover by the deepwater fan is probably underestimated by the fact that it grows perpendicular to the wall, and therefore, the angle of the photograph used for quantitative determinations of substrate cover provides only a fraction of its total surface extension. This gorgonian grows to a relatively large size (more than one meter) and generally presented aggregated (patchy) distributions in the wall (Plate 4). It is a rigid, branching skeleton and its patchy distribution creates a complex structure that adds substantial topographic relief and serves as protective micro habitat for reef organisms. In addition to the deepwater fan, the sea plume, *Pseudopterogorgia sp*., the long sea whip, *Ellisella sp*. and an unidentified bright red gorgonian were the octocoral species observed at the wall habitat.

Black corals (Antipatharians) were present in seven out of the 10 transects surveyed at the wall habitat with a mean substrate cover of 3.0% (range: 0-20%). At least five species were present within surveyed transects (Appendix 5), but the bushy black coral, *Antipathes caribbeana* was the dominant species because of its much larger size and abundance relative to other species of black corals in the wall of BDS. At present, black coral specimens are under taxonomic evaluations involving molecular analyses and the final taxonomy of the other species will be reported elsewhere. As with the deepwater fan, due to their considerably large size and branching growth, black corals create topographic relief in the reef, and thereby protective microhabitat for fishes. Black corals displayed a highly aggregated distribution, as inferred by the wide range of substrate cover in transects surveyed (Table 8). Black corals were most abundant at the southern

Plate 4. Deep sea fan, *Icilligorgia schrammi* at the reef wall habitat on BDS

walls, where they grow in patches as moderate to large colonies. The southern walls are regions that are fully exposed to the prevailing northerly directed current flow (see section 1.1). Growth of black corals may be favored by environments with strong water currents due to the advantage of increased flow for feeding upon zooplankton. As in the reef top habitat, a small (unidentified) branching colonial hydrozoan was ubiquitously distributed at the reef wall of BDS. Its mean cover within surveyed transects was 2.16% (range: 0 – 11.2%).

Scleractinian corals were represented by a total of 11 species within transects at the reef wall of BDS with a mean cover of 5.5% (range: 0.8 – 13.6%). An additional 11 scleractinian coral species were observed outside transects at the wall (Appendix 4). Great star coral, *Montastraea cavernosa* and lettuce corals, *Agaricia spp*. (mostly the *lamarki/grahame* combination) were the dominant taxa in terms of substrate cover, but with means of only 1.7% and 1.5%, respectively. As in the reef top, scleractinian corals were present mostly as a specious rich assemblage of small isolated colonies growing encrusted on the substrate without contributing significantly to the reef topographic relief. Scleractinian corals appear to be out competed for space by heterotrophic taxa, such as sponges and have the additional competition of the deepwater fan and black corals at the wall. Nevertheless, scleractinian corals contribute, along with black corals (3.0%), hydrozoans (2.2%) and octocorals (13.6%) to a combined reef substrate cover by cnidarians of almost 25% at the reef wall of BDS. The high amount of scleractinian coral species represents also an important contribution to the biodiversity of the reef.

Orange cup coral, *Tubastrea coccinea* was the most abundant scleractinian coral at the reef wall habitat, representing 53.1% of the total density of coral colonies within transects with a mean of 52.7 colonies/10m^2 (range: 3 – 139 colonies/10m^2). This is an aposymbiotic species that forms rather small hemispherical colonies attached to hard reef substrates. It was present in all seven transects analyzed for determinations of coral density at the reef wall habitat (Table 9). Lettuce corals, *Agaricia spp*., great star coral, *Montastrea cavernosa,* mustard- hill coral*, Porites astreoides* and ten-ray star coral, *Madracis decactis* combined for an additional 42% of the total density of coral colonies and comprised, along with orange cup coral, the main species assemblage of scleractinian corals in terms of coral densities at the wall.

Table 9. Density of coral colonies within photo transects 4 – 10 at the reef wall of BDS-1. Bajo de Sico. Depth 30 – 40 m.

SCLERACTINIAN	TRANSECTS							
CORALS	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**MEAN**
Tubastrea coccinea	31	3	9	62	139	56	69	**52.7**
Agaricia spp.	19	9	7	95	29	20	11	**27.1**
Montastrea cavernosa	5	0	0	20	14	11	14	**9.1**
Porites astreoides	2	0	0	11	4	1	2	**2.9**
Madracis decactis	0	0	0	8	8	1	1	**2.6**
Siderastrea siderea	0	0	0	2	0	0	7	**1.3**
Eusmilia fastigiata	0	0	0	3	6	0	0	**1.3**
Meandrina meandrites	0	0	0	2	1	4	1	**1.1**
Montastrea annularis	0	0	0	1	3	0	1	**0.7**
Diploria labyrinthiformis	0	0	0	1	0	0	0	**0.1**
Dichocoenia stokesi	0	0	0	1	0	0	0	**0.1**
Diploria sp.	0	0	0	0	1	0	0	**0.1**
Isophyllia rigida	0	0	0	0	1	0	0	**0.1**
Totals	57	12	16	206	206	93	106	**99.4**
HYDROCORALS								
Millepora alcicornis	0	0	0	0	1	0	0	**0.1**
Stylaster roseus	11	26	94	8	4	17	12	**17.2**
OCTOCORALS								
Iciligorgia schrammi	16	16	12	13	70	72	33	**33.1**
Pseudopterogorgia sp.	4	0	0	2	5	3	3	**2.4**
Ellisella sp.	0	0	1	3	0	0	0	**0.6**
unidentified gorgonian	0	0	0	0	0	0	2	**0.3**
Totals	20	16	13	18	75	75	38	**36.4**
ANTIPATHARIANS	17	6	4	2	5	4	2	**5.7**

Among octocorals, the deepwater fan, *Iciligorgia schrammi* was present from all photo transects analyzed for densities of coral colonies with a mean of 33.1 colonies/10m^2 (range: 12- 72 colonies/10m^2). A few colonies of the long sea whip, *Ellisella sp*. and of the sea plume, *Pseudopterogorgia sp*. were present within transects surveyed at the wall. Black corals (Antipatharians), particularly the bushy black coral, *Antipathes caribbeana* were present in all seven transects with a mean density of 5.7 colonies/10m^2 (range: 2 – 17 colonies/10m^2). The rose lace coral, *Stylaster roseus* was the most abundant hydrocoral with a mean density of 17.2 colonies/10m^2. It is perhaps one of the most abundant sessile-benthic invertebrate components of the reef wall, but it's small colony size and typically cryptic growth within crevices, holes and other substrate irregularities undermines its quantitative characterization from photo images.

4.1.3 Deep Rhodolith Reef

The deep rhodolith reef was surveyed by a total of 10 transects, distributed in sets of two (replicate) transects at five different stations within the northern shelf of BDS. Location of sampling stations is shown in Figure 6. Benthic algae, comprised by an assemblage of turf, fleshy and calcareous macroalgae were the dominant component of the sessile-benthos at all transects surveyed with a mean substrate cover of 65.0% (range: 51.6 – 71.6%). Table 10 shows the percent cover by sessile-benthic categories at transects surveyed from the deep rhodolith reef. The encrusting fan-leaf alga, *Lobophora variegata* was the most prominent component of the benthic algae assemblage with a mean cover of 42.0% (range: 26.4 – 66.0%). *Lobophora* was observed growing as a carpet over extensive sections of the deep rhodolith reef. Its cover of the reef substrate was interrupted only by scattered growth of erect and branching sponges, isolated coral colonies and a few abiotic patches. *Lobophora* appears to be the main stabilizing agent of a vast deposit of mostly unconsolidated sediments, comprised by rhodoliths, coarse sand and what appear to be relict coral fragments. Small tufts of calcareous macroalgae, mostly *Halimeda spp*. were observed growing intermixed with *Lobophora*, averaging a reef substrate cover of 8.7%. An additional 37 species of benthic algae were identified from the deep rhodolith reef (Appendix 4). Panoramic views of the deep rhodolith reef are included as Appendix 3.

Sponges, represented within transects by an assemblage of at least 10 species were the main invertebrate taxa in terms of substrate cover at the deep rhodolith reef with a mean cover of 20.2% (range: 8.8 – 32.8%). Among the identified species of sponges within transects, *Aplysina cauliformis, Agelas clathrodes, A dispar* and the basket sponge, *Xestospongia muta* presented the highest mean substrate cover (Table 10). Sponges grow from an essentially flat and homogeneous seafloor at the deep rhodolith reef and thereby, are the most prominent structures providing topographic relief. The basket sponge grows attached to the hard ground reef platform, but most other sponges were observed growing from rhodoliths and/or other unidentified carbonate structures lying unattached over the seafloor.

Scleractinian corals were represented within transects by an assemblage of eight species with a mean substrate cover of 4.9% (range: 0 – 14.0 %). Reef substrate cover by scleractinian corals was below 1.5% in two out of the five sampling stations

Table 10. Percent substrate cover by sessile-benthic categories at the deep rhodolith reef. Bajo de Sico. Depth: 48 -53 m

	TRANSECTS										
SUBSTRATE CATEGORY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**MEAN**
Abiotic	6.4	5.2	2.4	3.2	2.4	2.0	0.0	2.0	2.4	6.8	**3.28**
Unidentified	0.4	5.6	3.6	3.6	6.4	1.2	6.0	4.8	2.0	0.4	**3.4**
Benthic algae											
Turf-mixed assemblage	0.0	0.0	15.2	10.4	10.4	26.0	10.0	16.4	18.0	25.6	**13.2**
Fleshy Algae											
Lobophora variegata	66.0	52.4	49.6	46.4	34.8	38.8	38.0	37.2	30.4	26.4	**42.0**
Codium sp.	0.0	0.0	4.4	4.4	0.0	0.0	0.4	0.0	0.0	0.0	**0.9**
Sargassum histrix	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**
Calcareous algae											
Halimeda spp.	2.4	4.8	2.4	9.2	6.4	2.8	22.8	12.4	15.6	8.8	**8.7**
Total Benthic Algae	70.0	57.2	71.6	70.4	51.6	67.6	71.2	66.0	64.0	60.8	**65.0**
Hydrozoa	0	0	0	0	2.4	4.4	0	0	4.0	4.4	**1.9**
Live Stony Corals											
Agaricia spp.	3.6	7.6	4.8	2.8	0.8	0.4	4.8	4.4	0.0	0.4	**2.96**
Montastrea annularis	0	0	0.0	0.0	0.0	0.0	6.0	0.8	0.0	0.0	**0.68**
Porites astreoides	0.8	0	0.8	0.4	0.0	0.0	2.0	0.4	0.0	0.8	**0.52**
Leptoseris cailleti	1.6	1.2	1.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	**0.48**
Eusmilia fastigiata	0	0	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.0	**0.08**
Montastrea cavernosa	0	0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	**0.04**
Meandrina meandrites	0	0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	**0.04**
Unid. coral	0.4	0	0	0	0	0	0	0	0	0	**0.04**
Colpophyllia natans	0	0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	**0.04**
Total Stony Corals	6.4	8.8	6.8	4.0	1.2	0.4	14.0	6.0	0.0	1.2	**4.88**
Sponges											
unidentified sponges	18	10	5.6	8	16.4	14.8	4.8	10.4	17.6	12.0	**11.8**
Aplysina cauliformis	nd	nd	5.6	6.4	10.8	4.0	0.0	0.0	2.0	0.8	**3.7**
Xestospongia muta	0	0	0.4	0.8	0.4	4.4	0.8	3.2	2.8	5.6	**1.8**
Agelas clathrodes	nd	nd	0	1.6	1.6	0.0	2.0	2.8	2.4	4.0	**1.8**
Agelas dispar	nd	nd	1.6	1.2	1.2	0.0	1.2	4.0	0.8	0.0	**1.3**
Aiolochroia crassa	nd	nd	0.8	0	0	0.0	0.0	0.0	0.0	2.8	**0.5**
Agelas conifera	nd	nd	0	0.4	0.8	0.4	0.0	0.0	0.0	1.6	**0.4**
Verongula gigantea	nd	nd	0	0	0	0.4	0.0	0.8	1.6	0.0	**0.4**
Plakortis angulospiculatus	nd	nd	0	0	1.2	0.0	0.0	0.0	0.0	0.0	**0.2**
Verongula rigida	nd	nd	0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	**0.1**
Aplysina lacunosa	nd	nd	0	0	0	0.4	0.0	0.0	0.4	0.0	**0.1**
Total Sponges	18.0	10.0	14.0	18.8	32.8	24.4	8.8	21.2	27.6	26.8	**20.2**

surveyed, which included the sets of paired transects 5-6 and 9-10. These sets of transects correspond to the eastern and western margins of the northern shelf of BDS, and thus, may well represent the lateral boundaries of scleractinian coral development within the 50 m depth range. Bounce and drift dives performed along the eastern, western and southern shelf of BDS at depths between 40 – 50 m confirmed the virtual absence of coral development along these shelf sections, characterized by extensive coverage of benthic algae along the eastern and western shelf sections, and by vast deposit of algal rhodoliths and lightly colonized pavement throughout most of the southern shelf.

Lettuce corals, *Agaricia spp*. (mostly the *A. lamarki/grahame* combination) were the most prominent scleractinian taxa within transects surveyed at the deep rhodolith reef. The mean substrate cover of lettuce corals was 3.0% (range: 0 – 7.6%) and were present in nine out of the 10 transects surveyed (Table 10). The *A. lamarki/grahame* combination was also the dominant taxa in terms of density of colonies with a mean of 23.2 colonies/10m^2 (range: 1 – 45 colonies/10m^2). Boulder star coral, *Montastraea annularis* complex exhibited variable growth forms at the deep rhodolith reef with a mean substrate cover of 0.7% (range: 0 – 6.0%) and a mean density of 1.3 colonies/10m^2 (Table 11). Colonies of boulder star coral were present in only two of the ten transects surveyed. Flattened colonies of up to 0.5 m diameter were observed growing from a short pedestal attached to the hard ground reef platform, but encrusting growth over rhodoliths and other unidentified substrates was also observed. Mustard-hill coral, *Porites astreoides* was present in 9 out of the 10 transects surveyed with a mean substrate cover of 0.5% (Table 10), and a mean density of 5.2 colonies/10m^2 (Table 11). At the deepest transects surveyed, the lacy lettuce coral, *Leptoseris cailleti* was common, with substrate cover and densities at transects 1- 4 ranging between 0.8 – 1.6%, and 5 – 14 colonies/10m^2, respectively (Tables 10 and 11). Due to its cryptic growth intermixed with benthic algae; substrate cover by this coral was most likely underestimated. Likewise, the diffuse ivory coral, *Oculina sp*. (*vericosa*) was impossible to discern from photos due to its cryptic growth intertwined with sponges and benthic algae.

Table 11. Density of scleractinian coral colonies within photo transects at the deep rhodolith reef. Bajo de Sico. Depth: 50 m.

	TRANSECTS										
CORAL SPECIES	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**MEAN**
Agaricia spp.	14	23	45	44	3	1	34	60	4	4	**23.2**
Porites astreoides	4	0	4	3	2	0	26	11	1	1	**5.2**
Leptoseris cailleti	6	5	14	13	0	0	0	2	0	0	**4.0**
Montastrea annularis	0	0	0	0	0	0	9	4	0	0	**1.3**
Montastrea cavernosa	0	0	1	2	1	0	1	1	0	0	**0.6**
Meandrina meandrites	0	0	1	0	0	0	2	0	1	0	**0.4**
Eusmilia fastigiata	0	0	0	0	0	0	1	1	0	0	**0.2**
Unid. coral	2	0									**0.2**
Colpophyllia natans	0	0	0	0	0	0	1	0	0	0	**0.1**
Dichocoenia stokesi	0	0	0	0	0	0	1	0	0	0	**0.1**
TOTALS	**12**	**5**	**20**	**18**	**3**	**0**	**41**	**19**	**2**	**1**	**12.1**

Perhaps with the exception of boulder star coral, species comprising the main scleractinian coral assemblage at the deep rhodolith reef of BDS (*Agaricia spp, Leptoseris cailleti, Porites astreoides*) exhibited highly aggregated or patchy distributions. This may be related to physical factors influencing availability of substrates for attachment, but may also respond to limitations imposed by larval dispersion associated with sexual reproduction.

4.2 Fish and Motile Mega-benthic Invertebrate Communities

4.2.1 Reef Top

A total of 80 species of reef fishes were identified at the reef top of BDS, including 53 species within belt transects surveyed at depths between 25 – 30 m. Mean abundance within belt-transects was 247.7 Ind/30m^2 (range: 128 – 362 Ind/30m^2). The mean number of species within transects was 19.8 (range: 17 – 25). The combined abundance of three species, bicolor damselfish (*Stegastes partitus*), bluehead wrasse (*Thalassoma bifasciatum*) and brown chromis (*Chromis multilineata*) accounted for 83.1 % of the total fish abundance within transects (Table 12). The aforementioned species and two additional species, the coney (*Cephalopholis fulva*) and the squirrelfish (*Holocentrus rufus*) were the only fishes present in all ten transects surveyed.

Table 12. Taxonomic composition and abundance of fishes within belt-transects at Bajo de Sico (BDS). 2005-07. reef top: 25 - 30 m

		BELT – TRANSECTS (Area: 30 m^2)										
SPECIES	COMMON NAME	**T-1**	**T-2**	**T-3**	**T-4**	**T-5**	**T-6**	**T-7**	**T-8**	**T-9**	**T-10**	**MEAN**
Stegastes partitus	bicolor damselfish	132	171	73	91	80	130	126	42	152	202	**119.9**
Thalassoma bifasciatum	bluehead wrasse	57	79	80	35	16	28	17	15	45	73	**44.5**
Chromis multilineata	brown chromis	17	66	45	3	1	115	130	35	2	3	**41.7**
Cephalopholis fulva	coney	3	5	6	1	5	4	2	2	5	4	**3.7**
Paranthias furcifer	creole fish				3	2	2		26		1	**3.4**
Amblycirrhitus pinos	red-spotted hawkfish	3	3	4		2	8	5	3	1		**2.9**
Clepticus parrae	creole wrasse	3	6	18		1						**2.8**
Halichoeres maculipinna	clown wrasse	3	3	6		1				4	8	**2.5**
Holocentrus rufus	squirrelfish	4	1	5	4	1	2	3	2	1	2	**2.5**
Chromis cyanea	blue chromis	4					3	7	3	3	4	**2.4**
Scarus iserti	stripped parrotfish	1	6	4	2	1			1	6		**2.1**
Melichthys niger	black durgon	2	3	1	1	2		1	6	1		**1.7**
Halichoeres garnoti	yellowhead wrasse	5	3	1	1	2			1	3		**1.6**
Acanthurus chirurgus	doctorfish	1	4	3	1		1	1		1	2	**1.4**
Caranx crysos	blue runner				10	4						**1.4**
Bodianus rufus	spanish hogfish	1		3	2	2	1	1		1	1	**1.2**
Acanthurus coeruleus	blue tang	1	1	2	2	1	1	1	1	1		**1.1**
Sparisoma radians	bucktooth parrotfish		1			1	2	3	2	1	1	**1.1**
Chaetodon capistratus	four-eye butterflyfish		2	2	2				1	2		**0.9**
Cephalopholis cruentatus	graysbe	1	4					2	1			**0.8**
Gramma loreto	fairy basslet						4	3				**0.7**
Scarus taeniopterus	princess parrotfish								7			**0.7**
Acanthurus bahianus	ocean surgeon	1		1	1	3						**0.6**
Caranx ruber	bar jack	4		1	1							**0.6**
Chaetodon striatus	banded butterflyfish	2						2	1			**0.5**
Sparisoma viride	stoplight parrotfish		1				3	1				**0.5**
Canthigaster rostrata	caribbean puffer	2				1			1			**0.4**
Epinephelus guttatus	red hind					2	1				1	**0.4**
Coryphopterus lipernes	peppermint goby								3			**0.3**
Elagatis bipinnulata	rainbow runner				3							**0.3**
Holacanthus tricolor	rock beauty						1		1		1	**0.3**
Sparisoma aurofrenatum	parrotfish	1		1					1			**0.3**
Cantherhines pullus	tail-light filefish		1						1			**0.2**
Gobiosoma evelynae	sharknose goby		1								1	**0.2**
Holacanthus ciliaris	queen angelfish	1					1					**0.2**
Microspathodon chrysurus	yellowtail damselfish					1	1					**0.2**
Pomacanthus paru	french angelfish										2	**0.2**
Scarus vetula	queen parrotfish	1		1								**0.2**

Table 12. Continued

Anisotremus surinamensis	black margate									1		**0.1**
Anisotremus virginicus	porkfish						1					**0.1**
Caranx lugubris	black jack								1			**0.1**
Centropyge argi	cherubfish		1									**0.1**
Chaetodon ocellatus	spotfin butterflyfish	1										**0.1**
Coryphopterus glaucofraenum	bridled goby										1	**0.1**
Sparisoma atomarium	greenblotch parrotfish								1			**0.1**
Halichoeres cyanocephalus	wrasse									1		**0.1**
Holocentrus coruscus	reef squirrelfish								1			**0.1**
Sparisoma chrysargyreum	redtail parrotfish										1	**0.1**
Serranus baldwini	lantern bass							1				**0.1**
Sphyraena barracuda	great barracuda										1	**0.1**
Halichoeres radiatus	puddinwife			1								**0.1**
Scomberomorus regalis	cero mackerel										1	**0.1**
	TOTAL SPECIES	**24**	**20**	**20**	**17**	**19**	**19**	**17**	**25**	**18**	**19**	**19.8**
	TOTAL INDIVIDUALS	**251**	**362**	**258**	**163**	**129**	**309**	**306**	**159**	**231**	**310**	**247.8**

The bicolor damselfish was numerically dominant at the reef top with a mean abundance of 119.9 Ind/30 m^2 (range: 42 – 202 Ind/30m^2), representing 48.4% of the total fish abundance. Its abundance variance to mean ratio (e.g. 48.7) (Table 13) reflects a moderately aggregated spatial distribution. The coefficient of variation between transects for the bicolor damselfish was the lowest among the top 10 most abundant fishes (40.6%), indicative of low abundance variability between transects in relation to its (high) mean abundance. It was the most abundant fish in eight out of the ten transects surveyed. The squirrelfish and the coney presented the lowest abundance variance to mean ratios among the top ten most abundant fishes, indicative of near random spatial distributions at the reef top. Relative to their mean abundance within transects, their coefficient of variation was moderately low as well. Three fishes that were present in at least eight out of the ten transects (e.g. spanish hogfish, blue tang, and doctorfish) presented abundance variance to mean ratios below 1, indicative of spatially uniform distributions. Schooling fishes that live closely associated to the reef benthos, such as the creole wrasse (*Clepticus parrae*), creole fish (*Paranthias furcifer*), brown and blue chromis (*Chromis multilineata, C. cyanea*) presented both a high abundance coefficient of variation and high variance to mean ratios, indicative of highly aggregated or patchy spatial distributions.

Table 13. Descriptive statistics of fish abundance for the numerically dominant species within belt-transects at the reef top. Bajo de Sico (BDS).
Depth: 25 - 30 m

Species	**Common Name**	**Mean**	**StDev**	**Var**	**Var/X**	**Coeff. Variation %**
Stegastes partitus	Bicolor Damselfish	119.9	48.7	2373.7	48.7	40.6
Thalassoma bifasciatum	Bluehead Wrasse	44.5	26.3	691.2	26.3	59.1
Chromis multilineata	Brown Chromis	41.6	48.5	2351.7	48.5	116.6
Cephalopholis fulva	Coney	3.7	1.6	2.7	1.6	44.2
Paranthias furcifer	Creole Fish	3.4	8.0	64.3	8.0	235.8
Clepticus parrae	Creole Wrasse	2.8	5.7	32.4	5.7	203.3
Halichoeres maculipinna	Clown Wrasse	2.5	2.8	8.1	2.8	113.5
Holocentrus rufus	Squirrelfish	2.5	1.4	2.1	1.4	57.3
Chromis cyanea	Blue Chromis	2.4	2.4	5.6	2.4	98.6
Scarus iserti	Stripped Parrotfish	2.1	2.4	5.7	2.4	113.2

The reef promontories at BDS, including the reef top and reef wall appear to function as one large residential and foraging habitat for a varied assemblage of top reef demersal predators, such as the Nassau, black, yellowmouth and yellowfin groupers (*Epinephelus striatus, Mycteroperca bonaci, M. interstitialis, M. venenosa*) and the cubera and dog snappers (*Lutjanus cyanopterus, L. jocu*). These species, all of which are of high commercial value, were observed mostly in their upper range of adult sizes (Table 14). Juvenile stages were not observed for any of the aforementioned species. Nassau groupers were generally observed inside hideouts near the top of the promontories, whereas yellowfin, black and yellowmouth groupers were typically observed swimming at or near the base of the promontory and along the sand channels in the deeper sections of the reef.

Table 14 includes standing stock estimates for large, commercially important reef fishes based on the number of individuals observed during Active Search (ASEC) surveys at station BDS-1. These numbers are only from fishes observed during daytime surveys, and because of bottom time limitations and the highly complex habitat of reef promontories at BDS-1 a comprehensive, all inclusive scan of the study area was not achieved. Therefore, the numbers of individuals reported in Table 14 represent a conservative, minimum estimate of the stocks from an area of approximately 1 acre (0.004 km^2) comprised within the geographic boundaries of station BDS-1. The surface area of station BDS-1 (0.004 km^2) represents approximately 1 % of the total surface area of reef promontory habitat at BDS (e.g. 0.4 km^2). During our benthic habitat mapping effort, many of the commercially important fish species reported in Table 14 were also observed in reef promontories outside BDS-1, suggesting that despite the inherent variability in depth and size dimensions of reef promontories, these reef structures appear to function as a cohesive and continuous residential and foraging habitat for commercially exploited large demersal and pelagic fishes, lobsters and sea turtles at BDS.

Intermediate sized demersal predators at the reef promontories include the red hind (*E. guttatus*), the schoolmaster and yellowtail snappers (*L. apodus, Ocyurus chrysurus*) and the queen triggerfish (*Balistes vetula*). These were also present as adults, including very large individuals, particularly red hinds (Table 14). Schoolmaster snappers were always observed as one very large school of approximately 50 individuals in the face of a wall at BDS-1. Red hinds were observed in relatively low numbers (7), considering that BDS is a known spawning aggregation site for this species. Most of the red hinds were observed in the promontories during the surveys of August through October. Red Hinds spawn at BDS during late December through January, but it was not possible to survey the reef promontories of BDS during the winter season because of rough sea conditions. Thus, from our observations at BDS-1 and other reef promontory sites surveyed during benthic habitat mapping activities, it was perceived that the reef promontories are not the main residential habitat for red hinds at BDS. Red hinds may be undertaking a migration from unidentified habitats within or outside BDS, and gradually build-up a spawning aggregation at the shallow reef promontories during the winter. Red hinds were observed in much higher densities at the deep rhodolith reef habitat of BDS surveyed down to a maximum depth of 53 m. It is unknown if red hinds inhabit the entire deep shelf platform down to depths of 100 m or more down the reef slope, but anecdotal information from local fishermen suggests that they are distributed at least to the 90 m range of the shelf at BDS.

Table 14. Size-frequency distribution of large and/or commercially important reef fishes identified during ASEC surveys at Bajo de Sico, BDS - 1

Depth : 25 - 40 m

SPECIES	**COMMON NAME**	**Numbers -Total Length (Inches)**			**Total Stock**
Acanthocybium solanderi	wahoo	1-60	3 (60-90)		4
Balistes vetula	queen triggerfish	1-12	2-15	1-18	4
Caranx crysos	blue runner	3-12	2-16	1-20	6
Caranx latus	horse-eye jack	25-15	7-20		32
Caranx lugubris	black jack	3-16	1-20	3-(24-30)	7
Carcharhinus perezii	reef shark	1-36	1-42	1-50	3
Dasyatis americana	southern stingray	1-32	1-56		2
Elagatis bipinnulata	rainbow runner	10-20	12-30		32
Epinephelus guttatus	red hind	2-12	3-15	2 - 18	7
Epinephelus striatus	Nassau grouper	3-20	4-26	5-(30-32)	12
Euthynnus alletteratus	little tuna	n/d			
Lutjanus apodus	schoolmaster	50-(15-20)			50
Lutjanus cyanopterus	cubera snapper	1-28	1-32	1-36	3
Lutjanus jocu	dog snapper	1-15	1-20		2
Lutjanus mahogany	mahogani snapper	1			1
Mycteroperca bonaci	black grouper	3–(28–32)			3
Mycteroperca interstitialis	yellowmouth grouper	1-22	1-28		2
Mycteroperca venenosa	yellowfin grouper	2-20	3-24	2-30	7
Ocyurus chrysurus	yellowtail snapper	30-15	15-18	5-20	50
Scarus guacamaia	rainbow parrotfish	1-32			1
Scomberomorus cavalla	great mackerel	2-34			2
Scomberomorus regalis	cero mackerel	1-18	1-28	1-34	3
Sphyraena barracuda	great barracuda	1-24	1-28	1-32	3
Invertebrates					
Panulirus argus	spiny lobster	3- (4-5 lb)			3
Strombus gigas	queen conch	1-14			1
Mithrax spinosissimus	channel clinging crab				
Sea Turtles					
Chelonia midas	green sea turtle			1-36	1
Eretmochelys imbricata	hawksbill turtle	5-(26-30)	2-30	2-36	9

Others
Thunnus albacores, Amblycirrhitus pinos, Pomacanthus arcuatus, Pomacanthus paru, Mulloides martinicus, Kyphosus bermudensis, Cantherhines macrocerus, Hemiramphus brasiliensis, Decapterus macarellus, Ablennes hians,Tylosurus crocodilus, Chaetodipterus faber, Canthidermis sufflamen, Xanthichthys ringens, Chaetodon aculeatus, Anisotremus surinamensis, Gymnothorax funebris, Coryphaena hippurus, Caranx bartholomaei

Pelagic reef predators are abundant in the water column above the reef promontories at BDS. Schools of horse-eye, black jacks and blue runners (*Caranx latus, C. lugubris, Carangoides crysos*) remain throughout the year at BDS, were they are the most prominent assemblage because of their high abundance. Large schools of more than 20 individuals of rainbow runners (*Elagatis bipinnulata*) were observed during late summer and fall (August – October), which coincided with the visit of Wahoo (*Acanthocybium solanderi*) and dolphinfish (*Coryphaena hippurus*). At least three reef sharks (*Carcharhinus perezii*) are year-round residents of the reef promontories at BDS-1, since they were observed throughout our field survey at this station. No other sharks were observed during our field survey. Great barracudas (*Sphyraena barracuda*) were common throughout the year over the reef. Large schools of little tunny and blackfin tuna (*Euthynnus alletteratus, Thunnus albacores*) were observed during the summer (June - August) feeding close to the surface in the periphery of BDS-1. Great and cero mackerels (*Scomberomorus cavalla, S. regalis*) were also observed during the summer at BDS, although cero mackerel were present throughout the year. Ocean triggerfish (*Canthidermis sufflamen*) and black durgon (*Melichthys niger*) both maintained large year-round populations associated with the reef promontories at BDS-1. The ocean triggerfish typically occupied the upper water column, whereas black durgons were generally observed closer to the reef. Billfishes are commonly fished over the reef at BDS, but none were observed during our field survey.

A varied assemblage of schooling zooplanktivorous fishes serves as forage for the rich and abundant community of piscivorous fish populations at the reef promontories of BDS. Mackerel scad (*Decapterus macarellus*), ballyhoo (*Hemiramphus brasiliensis*), flat needlefish (*Ablennes hians*), and flying fishes (Exocoetidae) appear to be the main food for large pelagic fishes that feed near the surface, such as wahoo, dolphinfish, blackfin tuna, great mackerel, and billfishes. Large schools of creole wrasse (*Clepticus parrae*), creole fish (*Paranthias furcifer*) and brown chromis (*Chromis multilineata*) were observed closer to the reef and may be more important as prey for demersal reef predators and pelagic fishes that feed closer to the reef, such as great barracuda, jacks, cero mackerel and the large groupers and snappers previously mentioned. Given the very large biomass associated with the high abundance and size of demersal and pelagic fish predators and their close feeding association with zooplanktivorous fish populations, it is evident that plankton food webs are of outmost relevance in the trophic structure of BDS.

Small opportunistic carnivores, such as wrasses (Labridae), gobies (Gobiidae), squirrelfishes (Holocentridae), sea basses (Serranidae), basslets (Grammatidae), trunkfishes (Ostraciidae) and puffers (Tetraodontidae) represent a highly specious and abundant assemblage at the reef promontories and may function as keystone food sources for juvenile stages of piscivorous fishes, as well as for the small demersal predators.

The herbivorous fish assemblage, mostly represented by doctorfishes (Acanthuridae) and parrotfishes (Scaridae) was comprised by a few species present in relatively low abundance. The combined abundance of doctorfishes and damselfishes (excluding the bicolor damselfish) represented only 3.2% of the total abundance of fishes within belt-transects at the reef top. Sea turtles, mostly hawksbill (*Eretmochelys imbricata*) maintain an impressive population at the promontories of BDS. At least seven large individuals were observed within station BDS-1 (Table 14), but many more were seen basking at the surface throughout the reef. One green turtle (*Chelonia midas*) was also observed.

Motile megabenthic invertebrates were present in very low abundance and species richness at the reef promontories of BDS. The most common were the arrow crab (*Stenorhynchus seticornis*) and the pederson cleaner shrimp (*Periclimenes pedersoni*), which were present in three and two of the 10 transects surveyed (respectively) (Table 15). Several large spiny lobsters (*Panulirus argus*) were present outside transects. One adult queen conch (*Strombus gigas*) was observed at the sandy interface of the reef promontories. According to reports by local fishermen, an adult queen conch population has been harvested from depths of 30 – 40 m in BDS, but we did not detect any aggregation of queen conch in the vicinity of the reef promontories, nor at any other habitat during our field survey.

Table 15. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at Bajo de Sico (BDS). 2005-07. Reef Top: 25 - 30 m

SPECIES	COMMON NAME	**T-1**	**T-2**	**T-3**	**T-4**	**T-5**	**T-1**	**T-2**	**T-3**	**T-4**	**T-5**	**MEAN**
Stenorhynchus seticornis	Arrow Crab				1			1	3			**0.5**
Periclimenes pedersoni	Pederson Cleaner Shrimp			1			1					**0.2**
Stenopus hispidus	Banded Coral Shrimp					1						**0.1**
Ophiocoma sp.	Sponge Brittle Star					12						**1.2**
	TOTAL SPECIES	**0**	**0**	**1**	**1**	**2**	**1**	**1**	**1**	**0**	**0**	**0.7**
	TOTAL INDIVIDUALS	**0**	**0**	**1**	**1**	**13**	**1**	**1**	**3**	**0**	**0**	**2.0**

4.2.2 Reef Wall

A total of 52 species of reef fishes were identified at the reef wall of BDS, including 41 species within belt transects surveyed at depths between 30 – 45 m. Mean abundance within belt-transects was 99.1 Ind/30m^2 (range: 42 – 165 Ind/30m^2). The mean number of species within transects was 13.8 (range: 11 – 16). The combined abundance of five species, fairy basslet (*Gramma loreto*), bicolor damselfish (*Stegastes partitus*), brown and sunshine chromis (*Chromis multilineata, C. insolata*), and bluehead wrasse (*Thalassoma bifasciatum*) accounted for 74.4% of the total fish abundance within transects (Table 16). The fairy basslet was the numerically dominant species (mean : 33.6 Ind/30m^2) and the only species present in the 10 transects surveyed. The bicolor damselfish, brown chromis, yellowhead wrasse, creole fish and the squirrelfish were present in at least seven transects.

Both fish abundance and species richness declined sharply at the reef wall relative to the reef top habitat. Abundance declined almost 2.5 fold and the number of species/transect declined 30%. A total of 11 fish species, or 27.6% of the total species within transects were only represented by one individual at the reef wall. Only 12 species were present in at least five of the 10 belt-transects surveyed. The banded coral shrimp (*Stenopus hispidus*) was the only motile megabenthic invertebrate observed within belt-transects at the reef wall (Table 18). One large spiny lobster (*Panulirus argus*) was present outside transects.

Table 16. Taxonomic composition and abundance of fishes within belt-transects at the reef wall of Bajo de Sico (BDS-1).

BDS 1. Reef Wall

	Depth	117	120	130	111	107	103	112	117	114	125	
SPECIES	**COMMON NAME**	**T-1**	**T-2**	**T-3**	**T-4**	**T-5**	**T-6**	**T-7**	**T-8**	**T-9**	**T-10**	**MEAN**
Gramma loreto	fairy basslet	43	19	19	14	5	16	112	87	12	9	33.6
Stegastes partitus	bicolor damselfish	25	14	7	10	0	56	4	5	24	30	17.5
Chromis multilineata	brown chromis	0	0	8	28	12	30	8	4	4	6	10.0
Chromis insulata	sunshine chromis	5	32	26	0	0	0	0	0	0	0	6.3
Thalassoma bifasciatum	bluehead wrasse	3	0	4	17	4	32	3	0	0	0	6.3
Coryphopterus personatus	masked goby	0	0	27	0	0	0	0	0	3	0	3.0
Paranthias furcifer	creole fish	2	0	14	6	0	1	1	1	1	4	3.0
Halichoeres garnoti	yellowhead wrasse	0	3	3	3	3	3	9	0	3	1	2.8
Bodianus rufus	spanish hogfish	0	1	1	0	3	2	2	12	0	0	2.1
Clepticus parrae	creole wrasse	1	0	0	0	4	10	1	3	0	0	1.9
Holocentrus rufus	squirrelfish	2	3	0	2	1	2	1	0	3	3	1.7
Cephalopholis fulva	coney	2	2	5	2	1	0	0	0	2	0	1.4
Sparisoma radians	bucktooth parrotfish	1	5	3	0	0	0	0	0	0	0	0.9
Coryphopterus lipernes	peppermint goby	0	0	0	0	0	0	2	0	0	6	0.8
Canthigaster rostrata	caribbean puffer	2	1	1	0	1	0	1	0	0	0	0.6
Acanthurus coeruleus	blue tang	0	0	1	1	0	3	0	1	0	0	0.6
Cephalopholis cruentatus	graysby	1	0	0	0	0	2	0	1	1	1	0.6
Gramma linki	yellow-cheek basslet	0	0	0	0	0	0	6	0	0	0	0.6
Chromis cyanea	blue chromis	0	0	0	0	0	0	0	3	0	3	0.6
Melichthys niger	black durgon	0	1	0	2	1	1	0	0	0	0	0.5
Chaetodon capistratus	four-eye butterflyfish	0	0	2	1	0	0	0	1	1	0	0.5
Chaetodon aculeatus	longsnout butterflyfish	1	1	0	0	0	0	1	2	0	0	0.5
Flammeo marianus	longspine squirrelfish	0	0	0	1	0	0	1	1	1	0	0.4
Lutjanus apodus	schoolmaster snapper	0	0	0	0	3	0	0	0	0	0	0.3
Carangoides crysos	blue runner	0	0	0	0	0	3	0	0	0	0	0.3
Amblycirrhitus pinos	redspotted hawkfish	0	0	0	0	0	2	0	0	0	1	0.3
Apogon sp.	cardinalfish	0	0	0	0	0	0	3	0	0	0	0.3
Lactophrys triqueter	smooth trunkfish	1	1	0	0	0	0	0	0	0	0	0.2
Mulloides martinicus	yellowtail goatfish	0	0	0	0	2	0	0	0	0	0	0.2
Chaetodon striatus	banded butterflyfish	0	0	0	0	0	0	2	0	0	0	0.2
Acanthurus bahianus	ocean surgeon	1	0	0	0	0	0	0	0	0	0	0.1
Acanthurus chirurgus	doctorfish	0	0	0	0	1	0	0	0	0	0	0.1
Holacanthus ciliaris	queen angelfish	0	0	0	1	0	0	0	0	0	0	0.1
Holacanthus tricolor	rock beauty	0	0	1	0	0	0	0	0	0	0	0.1
Ocyurus chrysurus	yellowtail snapper	0	0	0	1	0	0	0	0	0	0	0.1
Sparisoma viride	stoplight parrotfish	0	0	0	0	1	0	0	0	0	0	0.1
Scarus taeniopterus	princess parrotfish	0	0	0	0	0	1	0	0	0	0	0.1
Gobiosoma evelynae	sharknose goby	0	0	0	0	0	1	0	0	0	0	0.1
Sparisoma aurolineatum	redband parrotfish	0	0	0	0	0	0	0	1	0	0	0.1
Aulostomus maculatus	trumpetfish	0	0	0	0	0	0	0	0	0	1	0.1
Coryphopterus sp.	goby	0	0	0	0	0	0	0	0	0	1	0.1
	TOTAL SPECIES	**14**	**12**	**15**	**15**	**14**	**16**	**16**	**13**	**11**	**12**	**13.8**
	TOTAL INDIVIDUALS	**90**	**83**	**122**	**89**	**42**	**165**	**157**	**122**	**55**	**66**	**99.1**

Table 17. Descriptive statistics of fish abundance for the numerically dominant species within belt-transects at the reef wall habitat. Bajo de Sico (BDS).

SPECIES	COMMON NAME	MEAN	STDEV	Var	Var/X	Variat Coeff
Gramma loreto	fairy Basslet	33.6	36.7	1344.0	36.7	109.1
Stegastes partitus	bicolor damselfish	17.5	16.9	284.5	16.9	96.4
Chromis multilineata	brown chromis	10.0	10.7	113.8	10.7	106.7
Chromis insulate	sunshine chromis	6.3	12.1	147.6	12.1	192.8
Thalassoma bifasciatum	bluehead wrasse	6.3	10.4	107.3	10.4	164.5
Coryphopterus personatus	masked goby	3.0	8.5	72.0	8.5	282.8
Paranthias furcifer	creole fish	3.0	4.3	18.4	4.3	143.2
Halichoeres garnoti	yellowhead wrasse	2.8	2.5	6.4	2.5	90.4
Bodianus rufus	spanish hogfish	2.1	3.6	13.2	3.6	173.1
Clepticus parrae	creole wrasse	1.9	3.2	10.1	3.2	167.3

Table 18. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at Bajo de Sico (BDS). 2005-07. Reef wall:30 - 40 m

SPECIES	COMMON NAME	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9	T-10	MEAN
Stenopus hispidus	banded coral shrimp		1		3	2			0			**0.6**
	TOTAL SPECIES	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
	TOTAL INDIVIDUALS	**0**	**1**	**0**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0.6**

4.2.3 Deep Rhodolith Reef

A total of 47 species of fishes, including 23 within belt-transects were identified from depths of 45 – 53 m at the deep rhodolith reef habitat of BDS. The bicolor damselfish (*Stegastes partitus*) was the numerically dominant species with a mean abundance of 47.9 Ind/30m^2 (range: 17 - 79 Ind/30m^2), representing 61.4% of the total fish abundance within the 10 belt-transects surveyed. An assemblage of five species, including the bicolor damselfish, blue chromis (*Chromis cyanea*), cherubfish (*Centropyge argi*) and the bluehead and yellowhead wrasses (*Thalassoma bifasciatum, Halichoeres garnoti*) represented 91.9% of the total fish abundance within belt-transects. The bicolor damselfish and the bluehead wrasse were the only species present in all transects surveyed. The blue chromis, cherubfish, coney and yellowhead wrasse were present in at least seven of the 10 transects. A total of nine (9) species were only observed in one transect (Table 19).

Among the top ten most abundant fish species at the deep rhodolith reef, the bicolor damselfish, blue chromis and cherubfish presented aggregated or patchy spatial distributions (var/mean > 1.0), whereas both the bluehead and yellowhead wrasses presented mostly random distributions (var/mean ~ 1.0) (Table 20). The random distribution of wrasses at the deep rhodolith reef is in sharp contrast to the aggregated distributions that are typical for these species in shallow reefs, where they often form harems and swim about reefs in schools. The maximum number of bluehead wrasse individuals observed in a belt-transect was five, but most of the sightings were of one or two individuals per transect, indicative that their typical reproductive behavior consisting of one male and the female harem is not common at the deep rhodolith reef. Cherubfish typically live in pairs or small groups composed of a large male and female and several smaller, possibly immature individuals (Deloach and Humann, 1999), thereby influencing their patchy distribution at the deep rhodolith reef. The coney (*Cephalopholis fulva*) presented a highly uniform spatial distribution at the deep rhodolith reef (var/mean < 1.0). It was present in seven transects with abundance ranging between 0 – 2 individuals per transect and a total of six transects with one individual. The uniform distribution may be a density dependent condition associated with food resources and/or habitat spatial limitations at the deep rhodolith reef.

Table 19. Taxonomic composition and abundance of fishes within belt-transects at the deep rhodolith reef. Bajo de Sico. 2005-07. Depth: 45 - 53 m

Species	**Common Name**	**T-1**	**T-2**	**T-3**	**T-4**	**T-5**	**T-6**	**T-7**	**T-8**	**T-9**	**T-10**	**Mean**
Stegastes partitus	bicolor damselfish	60	17	40	34	63	71	44	79	41	30	**47.9**
Chromis cyanea	blue chromis	3	17	9	0	5	36	30	2	27	8	**13.7**
Centropyge argi	cherubfish	23	0	0	2	5	4	6	6	6	0	**5.2**
Thalassoma bifasciatum	bluehead wrasse	2	5	3	1	1	3	2	1	1	3	**2.2**
Halichoeres garnoti	yellowhead wrasse	3	0	0	3	1	2	3	2	2	0	**1.6**
Chromis insolata	sunshine chromis	0	0	0	2	0	8	1	0	0	0	**1.1**
Coryphopterus lipernes	peppermint goby	0	0	3	0	0	0	0	0	0	7	**1.0**
Cephalopholis fulva	coney	1	1	0	2	0	1	1	1	0	1	**0.8**
Sparisoma radians	bucktooth parrotfish	1	1	0	0	4	1	0	0	0	0	**0.7**
Sparisoma atomarium	greenblotch parrotfish	0	0	0	0	0	0	1	1	2	3	**0.7**
Holocentrus rufus	squirrelfish	0	1	1	4	0	0	0	0	0	0	**0.6**
Halichoeres cyanocephalus	yellowcheek wrasse	1	1	0	1	1	1	0	0	0	0	**0.5**
Amblycirrhitus pinos	redspotted hawkfish	0	1	1	0	0	0	0	0	1	0	**0.3**
Paranthias furcifer	creole fish	0	0	0	0	3	0	0	0	0	0	**0.3**
Serranus tigrinus	harlequin bass	1	1	0	0	1	0	0	0	0	0	**0.3**
Scarus iserti	striped parrotfish	0	0	2	0	0	0	0	0	0	0	**0.2**
Chaetodon aculeatus	longsnout butterflyfish	0	0	0	0	0	1	0	0	0	1	**0.2**
Cephalopholis cruentata	graysby	0	0	0	0	0	0	0	0	0	2	**0.2**
Sparisoma aurofrenatum	redband parrotfish	0	1	0	0	0	0	0	0	0	0	**0.1**
Serranus annularis	orangeback basslet	0	0	0	1	0	0	0	0	0	0	**0.1**
Flammeo marianus	longspine suirrelfish	0	0	0	0	0	0	0	0	0	1	**0.1**
Gobiosoma evelynae	sharknose goby	0	0	0	0	0	0	0	0	0	1	**0.1**
Epinephelus guttatus	red hind	0	0	0	0	0	0	0	0	0	1	**0.1**
	Total Species	**9**	**10**	**7**	**9**	**9**	**10**	**8**	**7**	**6**	**11**	**8.6**
	Total Abundance (Ind/30m2)	**95**	**46**	**59**	**50**	**84**	**128**	**88**	**92**	**80**	**58**	**78**

Large demersal fishes were rare at the deep rhodolith reef. A protective, residential habitat is not available for them, since the bottom is essentially flat and without any significant topographic relief. The deep rhodolith reef may represent a foraging habitat for large groupers and snappers, but none were observed during our daytime surveys. The only relatively large (> 90 cm) demersal fish observed at the deep rhodolith reef was a nurse shark (*Ginglymostoma cirratum*) (Table 21). Queen triggerfish (*Balistes vetula*), red hinds (*Epinephelus guttatus*) and coneys (*Cephalopholis fulva*) appear to act as the main residential demersal predators of the reef. Smaller opportunistic carnivores were represented by squirrelfishes (*Holocentrus rufus, H. adscensionis, Flammeo marianus*)

Table 20. Descriptive statistics of fish abundance for the numerically dominant species within belt-transects at the deep rhodolith reef habitat. Bajo de Sico (BDS). Depth: 45 – 53 m

Species	**Common Name**	**Mean Abundance (Ind/30m2)**	**StDev**	**Var**	**Var/X**	**Variation Coeff.**
Stegastes partitus	Bicolor Damselfish	47.9	19.6	385.4	8.0	41.0
Chromis cyanea	Blue Chromis	13.7	13.0	168.9	12.3	94.9
Centropyge argi	Cherubfish	5.2	6.8	45.7	8.8	130.1
Thalassoma bifasciatum	Bluehead Wrasse	2.2	1.3	1.7	0.8	59.8
Halichoeres garnoti	Yellowhead Wrasse	1.6	1.3	1.6	1.0	79.1
Chromis insolata	Sunshine Chromis	1.1	2.5	6.3	5.7	228.6
Coryphopterus lipernes	Peppermint Goby	1	2.3	5.3	5.3	230.9
Cephalopholis fulva	Coney	0.8	0.6	0.4	0.5	79.1
Sparisoma radians	Bucktooth Parrotfish	0.7	1.3	1.6	2.2	178.8
Sparisoma sp. (atomarium)	(Greenblotch) Parrotfish	0.7	1.1	1.1	1.6	151.3

Table 21. Size-frequency distribution of large and/or commercially important reef fishes identified during ASEC surveys at the deep rhodolith reef habitat. Bajo de Sico, BDS – 1. 2005 – 07. Depth : 25 - 40 m

SPECIES	**COMMON NAME**	Numbers -Total Length (Inches)		
Acanthocybium solanderi	wahoo	3-70		
Balistes vetula	queen triggerfish	1-15	3-18	
Caranx crysos	blue runner	3-(15-18)		
Caranx lugubris	black jack	2-20	1-24	
Elagatis bipinnulata	rainbow runner	30-(15-20)	20-(21-30)	
Epinephelus guttatus	red hind	6-(8-10)	9-(11-15)	
Epinephelus striatus	Nassau grouper	1-20		
Decapterus macarellus	mackerel scad	n/d		
Euthynnus alletteratus	little tuna	n/d		
Ginglymostoma cirratum	nurse shark	1-(48)		
Scomberomorus regalis	cero mackerel	2-18	1-24	
Sphyraena barracuda	great barracuda	1-24	2-30	1-36

Others: *Scarus taeniopterus, Priacanthus sp., Serranus annularis, Serranus tabacarius, Malacanthus plumieri, Opistognathus aurifrons, Xanthichthys ringens, Haemulon adscensionis, Acanthurus chirurgus, Acanthurus bahianus, Clepticus parrae, Canthigaster rostrata, Chaetodon striatus, Bodianus rufus, Malacoctenus triangulatus, Holacanthus ciliaris* and wrasses (*Thalassoma bifasciatum, Halichoeres garnoti, H. cyanocephalus*). Zooplanktivorous fish species, including the bicolor damselfish, blue and sunshine chromis (*Chromis cyanea, C. insolata*) accounted for 80.4% of the total fish abundance within transects and thus, may represent important forage for the larger demersal predators. Despite the exceptionally high reef substrate cover by benthic algae at the deep rhodolith reef (>60%), herbivorous fishes presented a combined abundance of only 9% within belt-transects. These were mostly represented by the cherubfish (*Centropyge argi*) and several species of small parrotfishes (*Sparisoma radians, S. aurofrenatum, S. atomarium, Scarus taeniopterus, S. iserti*). Large pelagic fishes, including wahoo, great barracuda, black jacks, rainbow runners and cero mackerels were observed at the deep rhodolith reef (Table 21), but appeared to be foraging on water column prey, such as mackerel scad and ballyhoo.

Both fish abundance and species richness declined at the deep rhodolith reef relative to the reef wall habitat, establishing a well defined pattern of decreasing fish abundance and richness with increasing depth (Figure 21). A similar observation was reported by Garcia-Sais et al (2005) for Agelas Reef, a mesophotic reef system studied at Isla Desecheo. The absence of substrate heterogeneity and topographic relief constrains fish diversity at the deep rhodolith reef because of the limited kinds of microhabitats available. Also, the low substrate cover by live corals may be also limiting fish diversity because of the direct and indirect relationships between reef fishes and stony corals. This condition is exacerbated by the limited availability of black corals and gorgonians at the deep rhodolith reef. Structures that provide topographic relief at the deep rhodolith reef include large branching and erect sponges, such as *Agelas spp*. and *Xestospongia muta*. Branching *Agelas spp*. serve as a recruitment habitat for post-settlement and early juvenile *Chromis spp* (e.g. *Chromis insolata, C. cyanea*). Large basket sponges (*X. muta*) are used by red hinds as shelter.

Two fish species showed a marked increment of abundance at the deep terrace reef, relative to other shallower habitats studied at BDS, these were the cherubfish and the blue chromis. The orangeback bass (*Serranus annularis*), the tobacco fish (*Serranus tabacarius*), the greenblotch parrotfish, *Sparisoma atomarium*) and the nurse shark (*Ginglymostoma cirratum*) were only observed from the deep rhodolith reef at BDS.

The deep rhodolith reef appears to be a residential habitat of red hind (*Epinephelus guttatus*). A total of 15 individuals, ranging in size between 20 – 38 cm were observed during ASEC surveys within an estimated reef surface area of 700 m^2, or about 2 Red Hinds per 100 m^2 of reef at depths between 45 - 53 m.

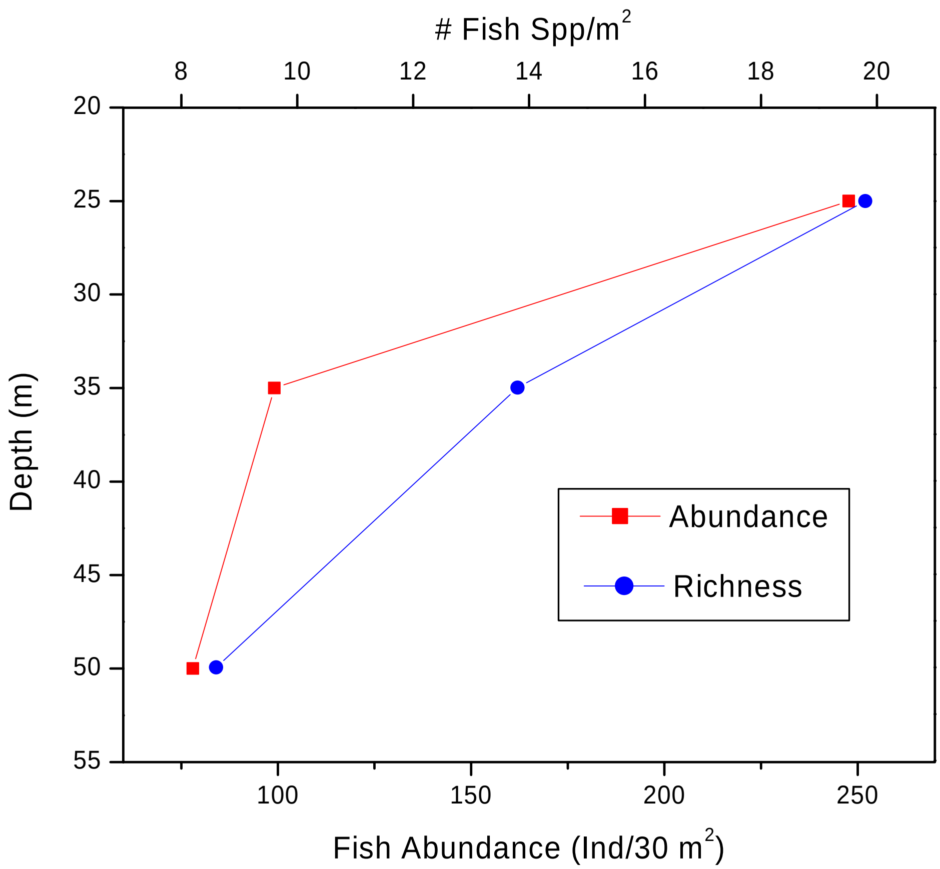

Figure 21. Variations of fish abundance and species richness with increasing depth at benthic habitats surveyed in Bajo de Sico. 2005 – 07. Data are means of 10 10 x 3 m belt-transects at the reef top (25 – 30 m), reef wall (30 – 40 m), and the deep rhodolith reef habitat (45 -53 m).

VII. Conclusions and Recommendations

1. Bajo de Sico is a seamount that rises from a deep platform of the insular slope in the west coast of Puerto Rico

2. The reef bathymetry is characterized by a ridge of rock promontories aligned southeast – northwest which rise from a platform at 45 m to a reef top at 25m, and an extensive, mostly flat, homogeneous and gradually sloping deep rhodolith reef that ends as a shelf-edge wall at depths between 90 – 100 m reaching down to depths of 200 – 300 m.

3. Salient oceanographic features of the water column influencing the reef system include a warm mixed surface water mass with a summer thermocline at a depth of 45 – 50 m, strong, persistent northwesterly surface currents, and high water transparency with 1% light penetration reaching to depths of almost 80 m.

4. At least five (5) main benthic habitats have been identified and field verified to a maximum depth of 50 m, these include a reef top and a vertical reef wall associated with rock promontories; colonized pavement with sand channels at the base of promontories; uncolonized rhodoliths and gravel at the reef slope; and a colonized rhodolith mesophotic reef.

5. From the multi-beam bathymetry survey of the reef, the total extension of Bajo de Sico includes a surface area of approximately 11.1 square kilometers, of which only 3.6 % is associated with the rock promontories (0.4 km^2) and more than 88 % corresponds to a deep shelf platform at depths between 45 - 100 m.

6. The sessile-benthic community at the reef top was characterized by a highly diverse assemblage comprised by benthic algae (52%), sponges (26%), scleractinian corals (8%), octocorals (5%) and hydrozoans (3%), with an abiotic cover of less than 1.5 %.

7. Scleractinian corals were represented at the reef top by an assemblage of 13 species within transects surveyed, with a mean substrate cover of 8.0 % and a mean density of almost 20 colonies per square meter.

8. Growth of scleractinian corals at the reef top was characterized by a species rich and numerous assemblage of small, isolated encrusting colonies that contributed minimal topographic relief.

9. Lettuce corals, mostly *Agaricia lamarki* and *A. grahame* were the dominant assemblage in terms of reef substrate cover and density of colonies. *Tubastrea coccinea, Porites astreoides* and *Montastraea cavernosa* were also common at the reef top.

10. Sponges, represented within transects by at least 12 species were the dominant sessile-benthic invertebrate in terms of reef substrate cover (mean: 26 %) at the reef top. Due to their large size and abundance, sponges contributed substantially to the reef topographic relief and served as habitat for fishes and invertebrates.

11. The reef wall habitat was characterized by irregular formations that appear to have been influenced by erosional processes, with deep crevices, undercuts, gaps, ledges and other substrate discontinuities

12. The sessile-benthos of the reef wall habitat resembled the reef top in that it was also highly diverse and taxonomically complex, comprised by sponges (43%), benthic algae (26%), octocorals (14 %), scleractinian corals (5.5%), antipatharians (3%) and hydrozoans (2%). Abiotic cover was 4%.

13. Sponges were the most prominent component of the sessile-benthos at the reef wall, with at least 11 species present within transects surveyed and the prevalence of large erect and branching growth forms providing substantial topographic relief and reef substrate complexity.

14. Octocorals (gorgonians), particularly the Deep Sea Fan, *Iciligorgia schrammi* combined with black corals (Antipatharians), mostly the Caribbean Bushy Coral, *Antipathes caribbeana* contributed an average reef substrate cover of 17 %, adding to the benthic substrate heterogeneity and providing protective habitat for fishes at the reef wall.

15. As in the reef top, scleractinian corals were present as a species rich assemblage of numerous, but small isolated colonies growing encrusted to the hard ground substrate and contributing minimally to the reef topographic relief.

16. The deep rhodolith reef habitat of BDS, at least down to a maximum surveyed depth of 50 m, appears to be a vast deposit of algal rhodoliths. At the northern section of the platform rhodoliths are overgrown by a dense macroalgal carpet, mostly the encrusting fan-leaf alga, *Lobophora variegate*, sponges and scleractinian corals.

17. The sessile-benthic invertebrate community at the deep rhodolith reef was characterized by relatively low taxonomic diversity, with virtual absence of gorgonians and antipatharians, low substrate cover and species composition by scleractinian corals and a marked decline of cover and species composition by sponges, relative to the reef top and wall habitats. Nevertheless the sharp increment in biotic cover and biodiversity compared to the adjacent slope environment serves as criteria to classify this habitat as a mesophotic reef system.

18. With few exceptions, scleractinian corals and sponges grow attached to rhodoliths, and are therefore not fixed to the bottom. Lettuce corals, *Agaricia spp*. were the dominant scleractinian taxa at the deep rhodolith reef in terms of reef substrate cover.

19. Reef fishes associated with BDS were comprised by a combination of the typical shallow water reef species assemblage, a group of deep reef species, large demersal predators (snapper s and groupers), and a species rich and abundant assemblage of reef and oceanic pelagic predators.

20. Zooplanktivorous schooling fish populations are abundant at BDS and appear to serve as the main forage for large pelagic and demersal piscivorous fishes of the reef.

21. Both fish abundance and species richness declined markedly with depth at the benthic habitats studied at BDS. Variations of taxonomic composition and abundance appear to be associated with the low availability of protective habitat at the deep rhodolith reef and the limited assemblage of species adapted for the vertically oriented habitat of the wall.

22. Reef promontories at BDS represent an important residential and foraging habitat for a group of large, commercially important species of snappers (*Lutjanus cyanopterus, L. jocu*) and groupers (*Epinephelus striatus, Mycteroperca bonaci, M. venenosa, M. interstitialis*) that has virtually disappeared from most reef systems in Puerto Rico. It also represents a spawning aggregation site for red hind (*Epinephelus guttatus*), and possibly other groupers within Mona Passage.

23. The deep rhodolith reef appears to be the residential habitat for the red hind, as higher densities of this species were observed relative to the reef top and wall habitats. It is possible that the smaller habitats of the deep rhodolith reef and the strong competition by larger groupers at the reef promontories influence the distribution of red hinds at the deep rhodolith reef.

24. The reef system at Bajo de Sico (BDS) serves as an important foraging and residential habitat for the endangered Hawksbill turtle (*Eretmochelys imbricata*). Its population at BDS is impressive because of the large size and high abundance of individuals.

25. The seamount serves as a foraging area for large migratory pelagic fishes, including the Wahoo (*Acanthocibium solanderi*), Mahi-Mahi (*Coryphaena hippurus*), Tunas (*Thunnus spp*.) and Marlins (mostly *Makaira nigricans*)

26. From the field survey at Bajo de Sico, the following recommendations are proposed:

    e. A year-round permanent closure for fishing of demersal fish species at the entire reef platform is recommended for the protection of what could be one of the few remaining actively reproducing populations of Black, Yellowmouth, Yellowfin and Nassau groupers in Puerto Rico.

    f. Characterization of the benthic habitats and associated communities at the deep shelf platform below depths of 50 m using Autonomous Underwater Vehicles (AUV) or similar systems that could provide high resolution images of the reef substrate.

    g. The hermatypic and ahermatypic coral assemblage of the deep shelf platform at BDS consists of species that have not been previously reported for coral reef systems in PR, and a more comprehensive characterization will require further exploration and research

    h. The CFMC should convey further research attention to the large grouper-snapper populations at BDS, particularly aspects of their reproductive biology, trophic interactions and larval dispersal and recruitment dynamics

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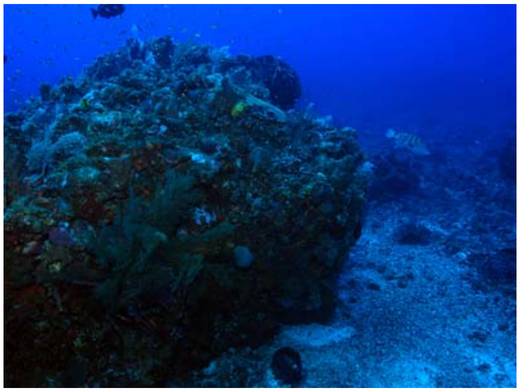
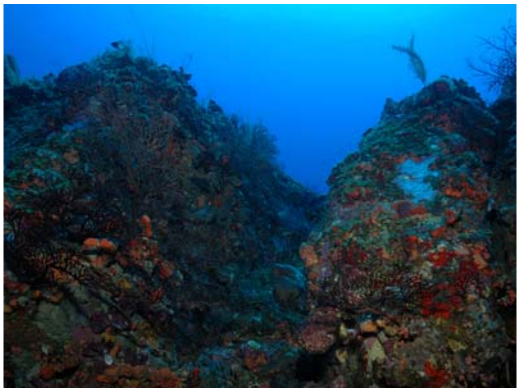
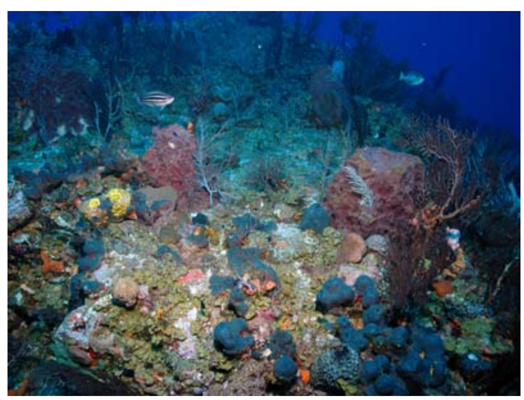
IX. Appendices

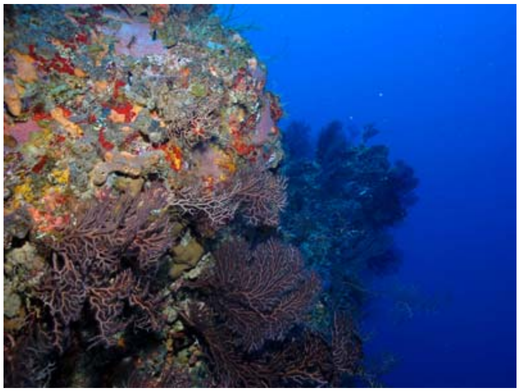
Appendix 1. Photo Album Reef Top



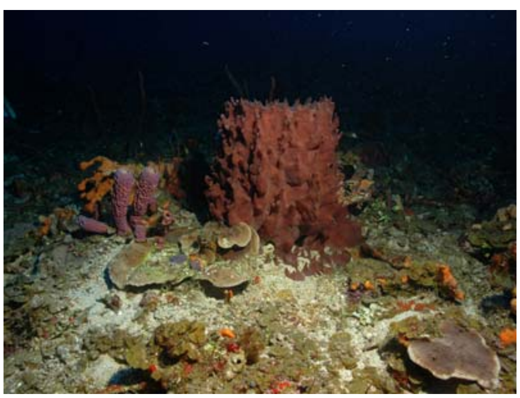


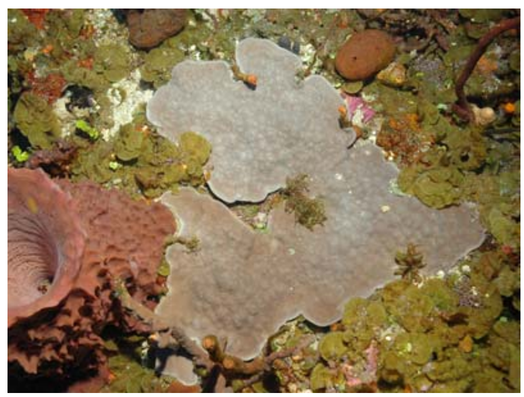


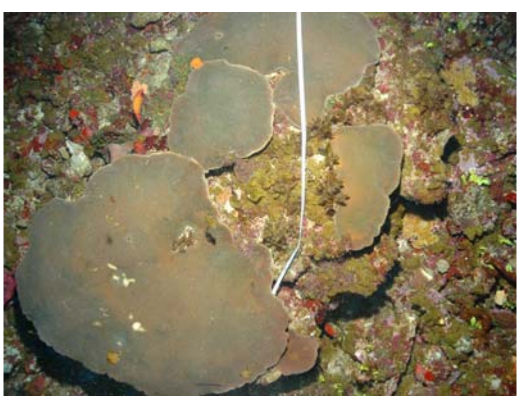
Appendix 2. Photo Album Reef Wall

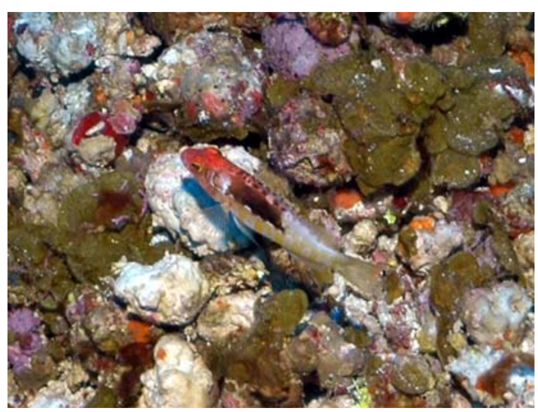


Appendix 3. Photo Album Deep Terrace Reef









Appendix 4. Master species list

				Reef Top	Wall	Deep Terrace
Cnidaria	Anthozoa	anemone	*Ricordea florida*			X
Cnidaria	Anthozoa	anemone	*unident. Anemone*			X
Chordata	Ascidiacea	ascidian	*Ascidiacea (colonial ascidian)*			X
Cnidaria	Anthozoa	black coral	*Antipatharia*		X	
Cnidaria	Anthozoa	black coral	*Stichopathes*	X	X	
Bryozoa		bryozoan	*Bryozoa*		X	X
Cnidaria	Anthozoa	coral	*Agaricia agaricites*	X	X	X
Cnidaria	Anthozoa	coral	*Agaricia grahamae*	X	X	X
Cnidaria	Anthozoa	coral	*Agaricia lamarcki*	X	X	X
Cnidaria	Anthozoa	coral	*Colpophyllia natans*	X	X	X
Cnidaria	Anthozoa	coral	*Dichocoenia stokesi*		X	X
Cnidaria	Anthozoa	coral	*Diploria labyrinthiformis*		X	
Cnidaria	Anthozoa	coral	*Diploria strigosa*	X	X	
Cnidaria	Anthozoa	coral	*Eusmilia fastigiata*	X	X	X
Cnidaria	Anthozoa	coral	*Isophyllia rigida*	X	X	
Cnidaria	Anthozoa	coral	*Isophyllia sinuosa*	X	X	
Cnidaria	Anthozoa	coral	*Leptoseris cailleti*			X
Cnidaria	Anthozoa	coral	*Leptoseris cucullata*		X	
Cnidaria	Anthozoa	coral	*Madracis decactis*	X	X	X
Cnidaria	Anthozoa	coral	*Meandrina meandrites*	X	X	X
Cnidaria	Anthozoa	coral	*Montastrea aliciae*		X	
Cnidaria	Anthozoa	coral	*Montastrea annularis*	X	X	X
Cnidaria	Anthozoa	coral	*Montastrea cavernosa*	X	X	X
Cnidaria	Anthozoa	coral	*Mycetophyllia aliciae*	X	X	X
Cnidaria	Anthozoa	coral	*Mycetophyllia lamarckiana*	X		X
Cnidaria	Anthozoa	coral	*Oculina (varicosa)*			X
Cnidaria	Anthozoa	coral	*Porites astreoides*	X	X	X
Cnidaria	Anthozoa	coral	*Scolymia cubensis*	X		
Cnidaria	Anthozoa	coral	*Siderastrea siderea*	X	X	
Cnidaria	Anthozoa	coral	*Stephanocoenia michelini*		X	
Cnidaria	Anthozoa	coral	*Tubastrea coccinea*		X	X
Cnidaria	Anthozoa	coral	*unident. Coral*			X
Crustacea	Arthropoda	crab	*Stenopus hispidus*	X		X
Crustacea	Arthropoda	crab	*Stenorhynchus seticornis*	X		
Crustacea	Arthropoda	crab	*Xanthidae*			X
Echinodermata	Crinoidea	crinoid	*unident. Crinoid 1*		X	
Echinodermata	Crinoidea	crinoid	*unident. Crinoid 2*		X	
Protozoa	Foraminifera	foraminifera	*Homotrema rubens*			X
Cnidaria	Anthozoa	gorgonian	*Ellisella sp.*		X	
Cnidaria	Anthozoa	gorgonian	*Eunicea laxispica*	X		
Cnidaria	Anthozoa	gorgonian	*Iciligorgia schrammi*	X	X	X
Cnidaria	Anthozoa	gorgonian	*Pseudopterogorgia acerosa*	X		
Cnidaria	Anthozoa	gorgonian	*Pseudopterogorgia sp.*		X	X
Cnidaria	Anthozoa	gorgonian	*Pterogorgia citrina*	X		
Cnidaria	Anthozoa	gorgonian	*unident. Gorgonian*		X	

Echinodermata	Holothuroidea	holothuroid	*Holothuria sp.*	X		
Cnidaria	Hydrozoa	hydrozoa	*Hydrozoa*	X	X	X
Cnidaria	Hydrozoa	hydrozoa	*Millepora alcicornis*	X	X	
Cnidaria	Hydrozoa	hydrozoan	*Stylaster roseus*		X	X
Crustacea	Arthropoda	lobster	*Panulirus argus*		X	
Echinodermata	Ophiuroidea	ophiuroid	*Ophiuroidea*			X
Annelida	Polychaeta	polychaete	*Serpulidae*		X	X
Annelida	Polychaeta	polychaete	*Sabellidae*		X	
Crustacea	Arthropoda	shrimp	*Periclimenes swensoni*	X		
Crustacea	Arthropoda	shrimp	*Periclimenes pedersoni*	X		
Porifera	Demospongia	sponge	*Agelas clathrodes*	X	X	X
Porifera	Demospongia	sponge	*Agelas conifera*	X	X	X
Porifera	Demospongia	sponge	*Agelas dispar*	X	X	X
Porifera	Demospongia	sponge	*Agelas sp.*			X
Porifera	Demospongia	sponge	*Aiotochroia crassa*			X
Porifera	Demospongia	sponge	*Aplisina cauliformis*	X	X	X
Porifera	Demospongia	sponge	*Aplisina fistularis*		X	X
Porifera	Demospongia	sponge	*Aplisina insularis*		X	X
Porifera	Demospongia	sponge	*Aplisina lacunosa*		X	
Porifera	Demospongia	sponge	*Aplisina sp.*			X
Porifera	Demospongia	sponge	*Callispongia fallax*		X	X
Porifera	Demospongia	sponge	*Callispongia plicifera*		X	X
Porifera	Demospongia	sponge	*Callispongia vaginalis*		X	X
Porifera	Demospongia	sponge	*Ectyoplasia sp.*		X	
Porifera	Demospongia	sponge	*Halisarca caerulea*		X	X
Porifera	Demospongia	sponge	*Ircinia felix*		X	X
Porifera	Demospongia	sponge	*Ircinia sp.*	X		X
Porifera	Demospongia	sponge	*Ircinia strobilina*		X	
Porifera	Demospongia	sponge	*Monanchora sp.*		X	
Porifera	Demospongia	sponge	*Neofibularia nolitangere*	X		
Porifera	Demospongia	sponge	*Niphates erecta*		X	X
Porifera	Demospongia	sponge	*Plakortis angulospiculauts*	X	X	X
Porifera	Demospongia	sponge	*Aiolochroia crassa*			X
Porifera	Demospongia	sponge	*Pseudoceratina sp.*			X
Porifera	Demospongia	sponge	*Scopolina ruetzleri*		X	X
Porifera	Demospongia	sponge	*Siphonodictyon sp*		X	
Porifera	Demospongia	sponge	*Svensea zeaii*		X	X
Porifera	Demospongia	sponge	*Verongia sp.*		X	
Porifera	Demospongia	sponge	*Verongula gigantea*		X	X
Porifera	Demospongia	sponge	*Verongula reiswige*		X	X
Porifera	Demospongia	sponge	*Verongula rigida*	X		
Porifera	Demospongia	sponge	*Xestospongia muta*	X	X	X
Porifera	Sclerospongia	sclerosponge	*Ceratoporella sp.*		X	
Annelida	Polychaeta	worm	*Sabellids*		X	
Annelida	Polychaeta	worm	*Serpulids*		X	X
Heterokontophyta		brown algae	*Dictyota recurvata*			X
Heterokontophyta		brown algae	*Dictyota sp.*		X	
Heterokontophyta		brown algae	*Lobophora variegata*	X	X	X
Heterokontophyta		brown algae	*Padina sp.*		X	

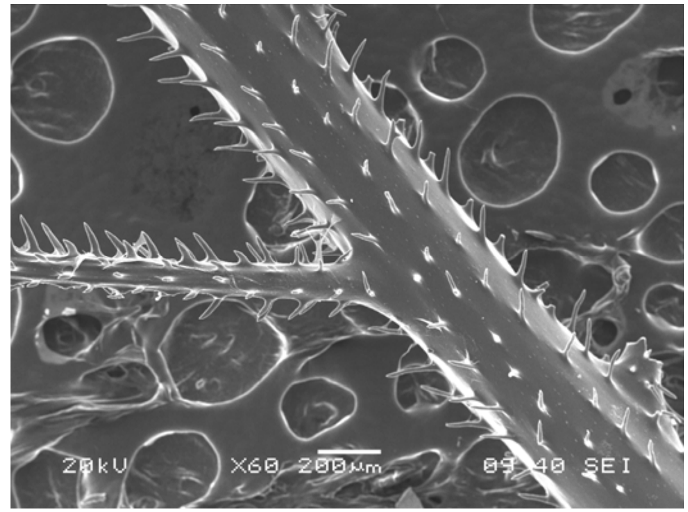
Heterokontophyta	brown algae	*Sargassum hystrix*			X
Heterokontophyta	brown algae	*Stypopodium zonale*	X		
Chlorophyta	green algae	*Anadyomene stellata*			X
Chlorophyta	green algae	*Caulerpa racemosa var. peltata*			X
Chlorophyta	green algae	*Codium sp.*			X
Chlorophyta	green algae	*Halimeda discoidea*	X	X	X
Chlorophyta	green algae	*Halimeda tuna*			X
Chlorophyta	green algae	*Rhipocephalus phoenix*		X	X
Chlorophyta	green algae	*Udotea sp.*			X
Chlorophyta	green algae	*Valonia sp.*			X
Chlorophyta	green algae	*Ventricaria ventricosa*		X	X
Rhodophyta	red algae	*Amphiroa sp.*	X	X	X
Rhodophyta	red algae	*Galaxaura sp.*	X	X	
Rhodophyta	red algae	*Peyssonnelia sp.*			X
Cyanophyta	cyanobacteria	*Schyzothrix sp.*			X

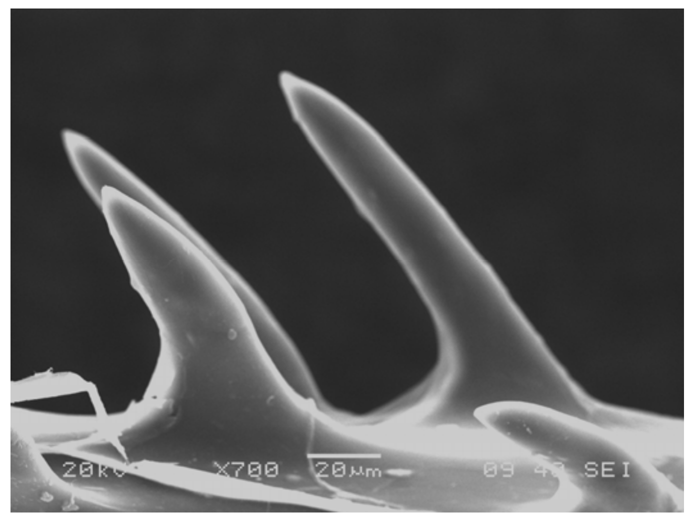
Other algae

Heterokontophyta	brown algae	*Dictyota cervicornis*
Heterokontophyta	brown algae	*Dictyota hamifera*
Heterokontophyta	brown algae	*Dictyota humifusa*
Heterokontophyta	brown algae	*Dictyota pulchella*
Heterokontophyta	brown algae	*Sargassum sp.*
Heterokontophyta	brown algae	*Stypopodium sp.*
Chlorophyta	green algae	*Anadyomene sp.*
Chlorophyta	green algae	*Caulerpa macrophysa*
Chlorophyta	green algae	*Caulerpa webbiana*
Chlorophyta	green algae	*Halimeda copiosa*
Chlorophyta	green algae	*Halimeda cuneata*
Chlorophyta	green algae	*Halimeda discoidea*
Rhodophyta	red algae	*Amphiroa rigida*
Rhodophyta	red algae	*Ceramium bisporum*
Rhodophyta	red algae	*Crouania sp.*
Rhodophyta	red algae	*Galaxaura lapidescons*
Rhodophyta	red algae	*Gloiocladia atlantica*
Rhodophyta	red algae	*Herposiphonia sp.*
Rhodophyta	red algae	*Hypoglossum cologlossoides*
Rhodophyta	red algae	*Hypoglossum rhizophora*
Rhodophyta	red algae	*Nitophyllum adherens*
Rhodophyta	red algae	*Peyssonnelia flavescens*
Rhodophyta	red algae	*Polysiphonia gorgoniae*

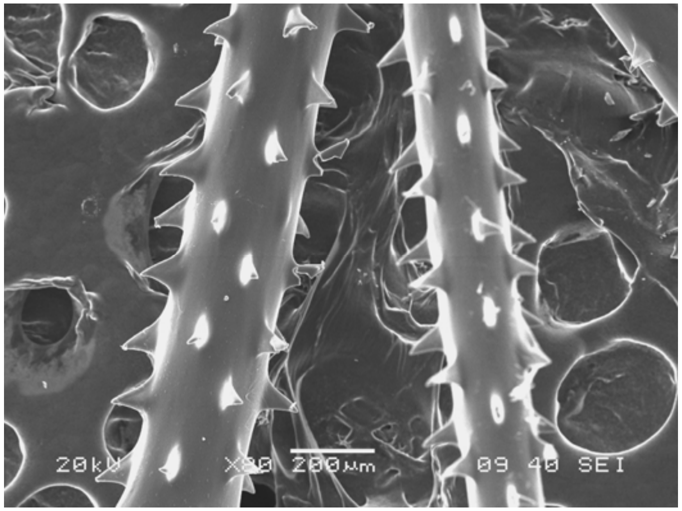
Appendix 5. Antipatharians

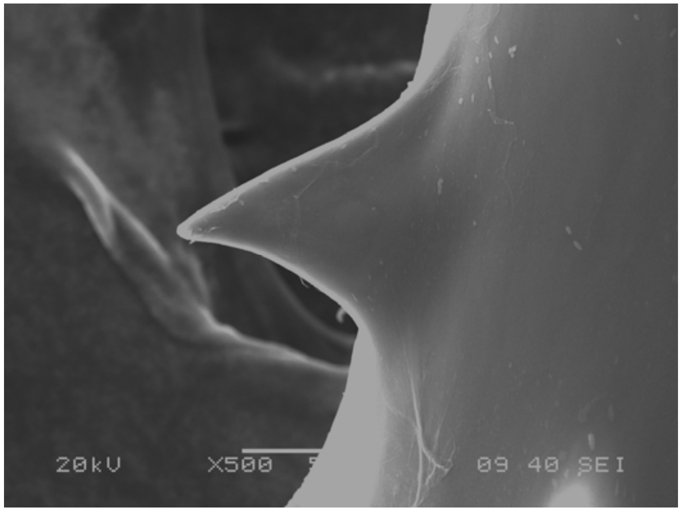
2.1 *Plumapathes*-like, or a related species



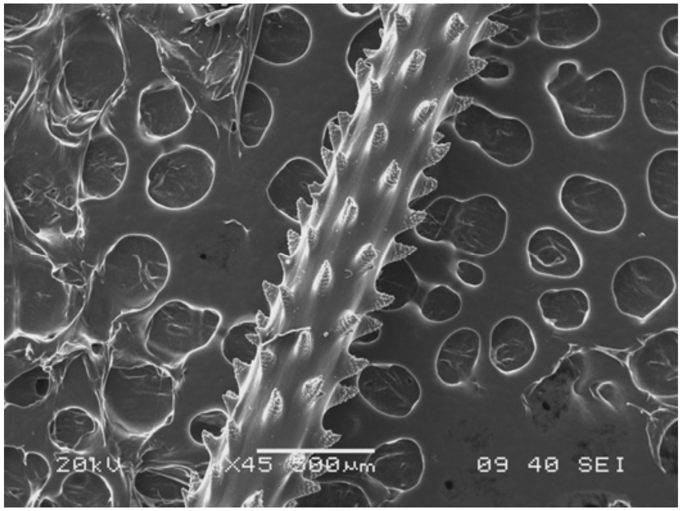


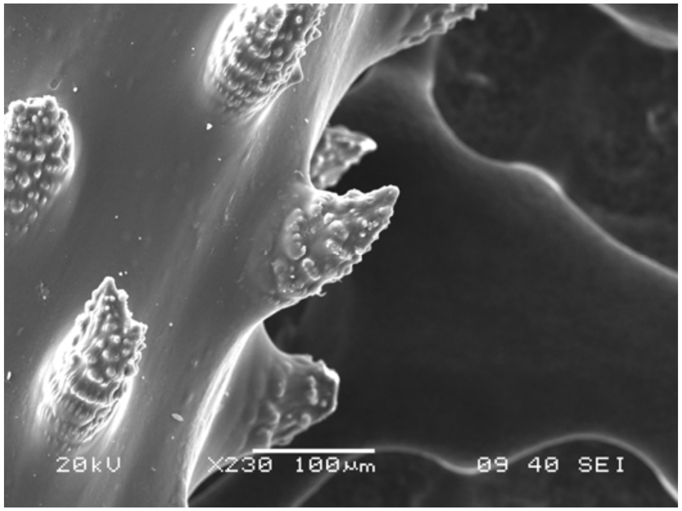
2.2 Variant of *Antipathes atlantica* / *gracilis*



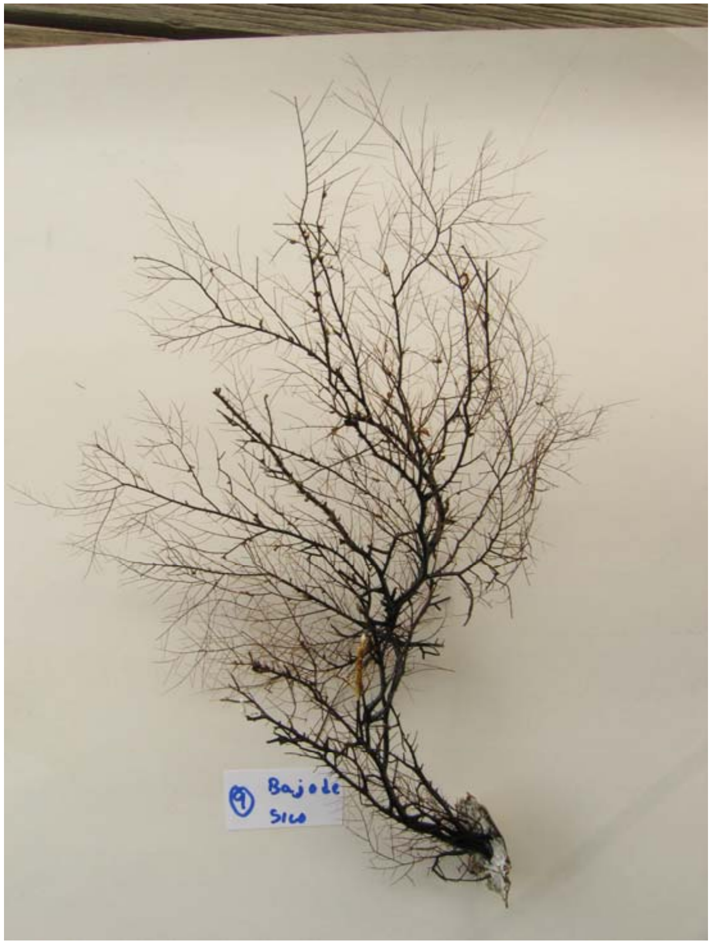


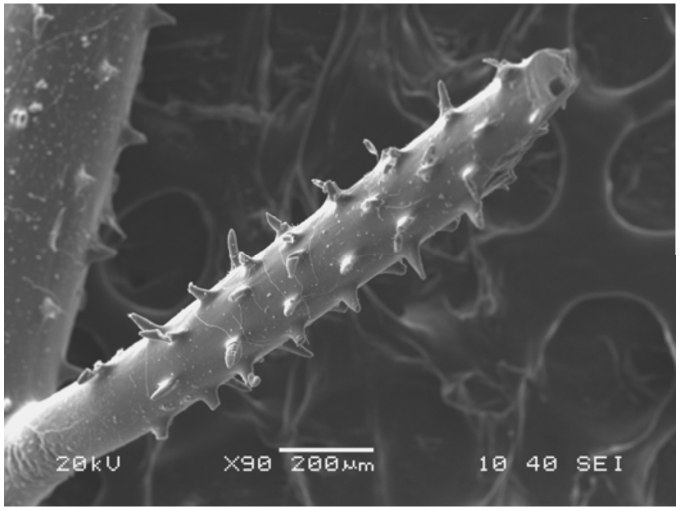
2.3 Variant of *Antipathes caribbeana*

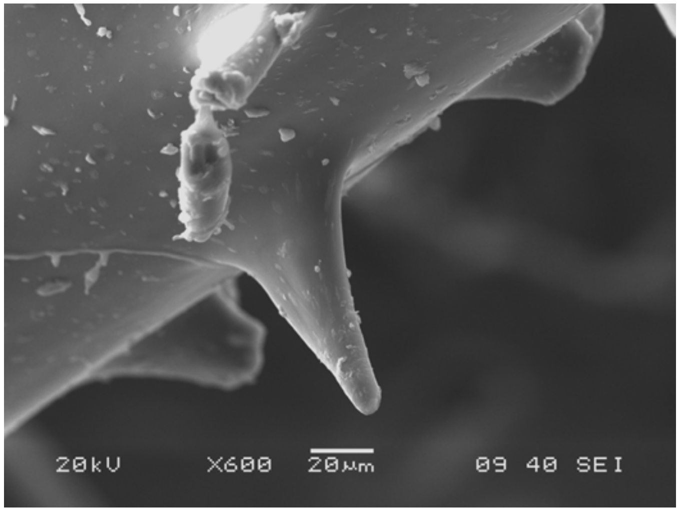




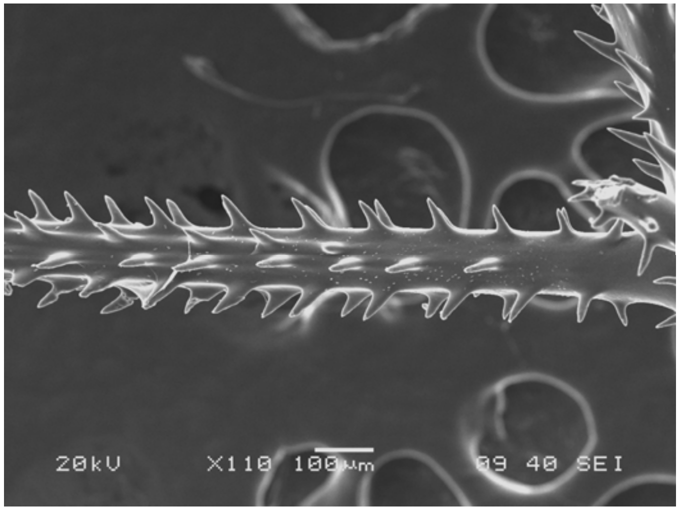
2.4 Close to *Antipathes atlantica/gracilis*

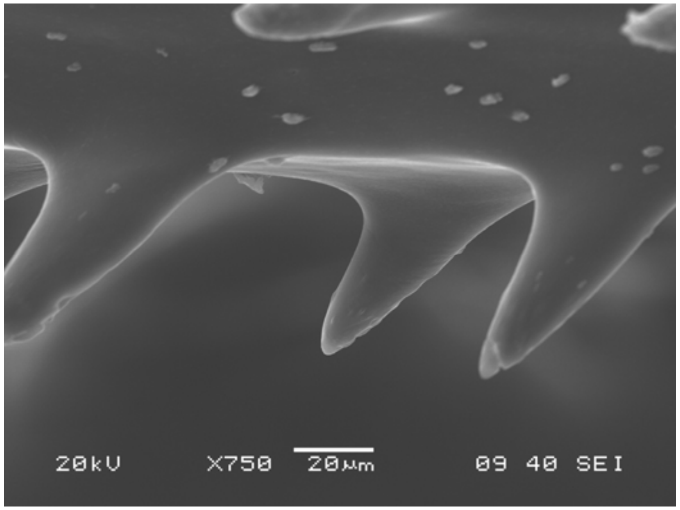




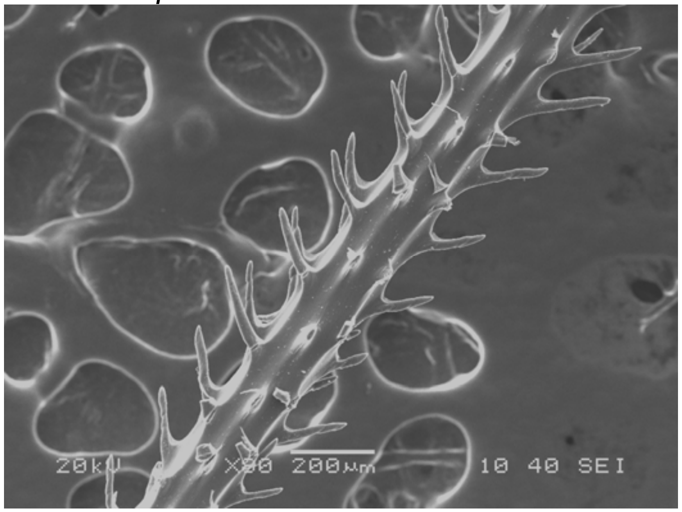


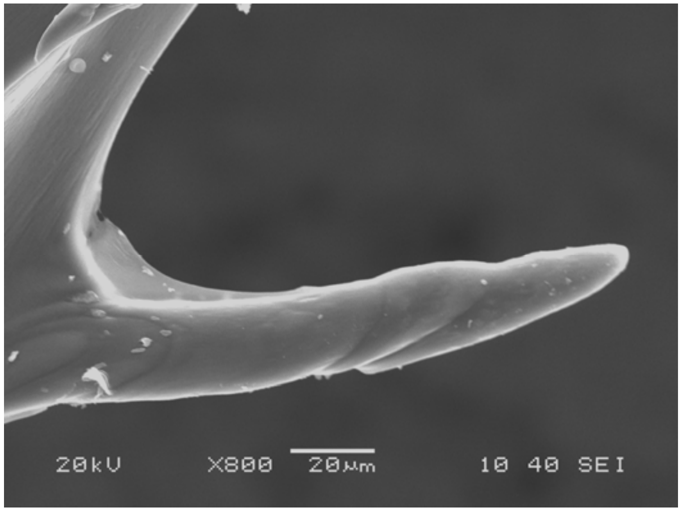
2.5 *Myriopathes*-like





2.6 *Plumapathes*-like





2.7 *Plumapathes*, *Tanacetipathes* or *Myriopathes*-like