



Department of Natural and Environmental Resources of Puerto Rico  
Forest Service Bureau, Management Division, Guánica State Forest

**Annual Report**

**Development of Sport Fisheries at Guánica State Forest**

**2002-2003**



As Required by Federal Aid in Sport Fish Restoration  
Project F-19

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## Annual Report

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## INTRODUCTION

The Guánica State Forest and Coastal Reserve is an International Biosphere Reserve that comprises an area of approximately 5000 hectares including 14 kilometers of shoreline located between the municipalities of Guánica, Yauco and Guayanilla at Puerto Rico's south-southwest coast. Guánica State Forest was designated as an International Biosphere Reserve in 1981 by UNESCO. In 1985, it was designated by the Puerto Rico Planning Board as Natural Reserve that included marine environment. Both designations are justified based on its high diversity of plants associations, bird fauna and natural ecosystems present.

The Biosphere Reserve is largely a terrestrial landscape, but extends over one nautical mile seaward to include coastal and marine environments such as saltwater lagoons, rocky and sandy beaches, fringing mangrove habitats, sea grass beds, several offshore mangrove keys, reef lagoons, coral reefs, hard ground platforms and estuarine environment. All those make Guánica Biosphere Reserve as ideal place for developing an array of recreational activities such as sport fishing, kayaking, snorkeling, boating, scuba diving, birds watching, sunbathing and socializing.

The *Development of Sport Fisheries at Guánica State Forest* project has been the basis for a multi-year sport fish development and management program. Since 1987, the Department of Natural and Environmental Resources (D.N.E.R) with federal aid assistance through the Sport Fish Restoration Program, has been successfully promoting and developing the recreational fisheries at the Reserve by different approaches, strategies and activities. During this segment F-19-14 (2002-2003), our efforts were directed towards activities for: infrastructure development and maintenance of facilities at the shoreline fishing access points, environmental maintenance of marine communities adjacent to fishing areas, promotion of sport fisheries, educational activities, sport fish habitat enhancement, fish population assessments, and creel surveys. At present, sport fishing still remains as one of the most popular activities at the Reserve. But is necessary develop additional management strategies to continue enhancing the angler experience at Guánica State Forest and Coastal Reserve.

### A- MAINTENANCE

Job 1- Maintenance of five fishing accesses point, underwater habitat and equipment.

Objective: Provide maintenance and enhancement of five fishing access point, underwater habitat, equipment and vehicles.

Activity 1.1 Weekly maintenance of five fishing access point at the Reserve (Jaboncillo, Los Congres, El Barquito, Atolladora and Tamarindo) was done during this project segment. That included the replacement of the existence garbage cans for new ones and the installation of additional garbage cans at Playa Jaboncillo, Atolladora, Los Congres, El Barquito and Tamarindo fishing areas. Weekly pickup and disposal of the garbage generated by the anglers such as cans, bottles, broken fishing lines and others was done. An additional trail that provides access to El Barquito fishing area was restored and ready to use.

Activity 1.2 Maintenance to all vehicles, boats, out board motor engine, and SCUBA dive equipment was done as programmed. Maintenance included tune-up for project vehicle every four-month and also repairs when necessary. Maintenance and repair of 29 feet long fiberglass project boat (“*Lutjanus*”) was done. This included tune-up of two out board motor engines (Yamaha 200 HP), installation of new navigation lights and installation of additional fuel/water separation system. In addition, project personnel repaired one small fibber glass boat (17 feet long Boston Whaler) to be used for project activities. This included hull restoration, painting and installation of one out board motor engine (Yamaha 40 HP).

Activity 1.3 Monthly collection of underwater garbage was done as scheduled at the five fishing access points (Jaboncillo, Los Congres, El Barquito, Atolladora and Tamarindo) and adjacent environment during this project segment. This included pick-up broken fishing line, cans, plastic, glasses and other types of garbage related to fishing activities.

Activity 1.4 Maintenance of the concrete reef modules was done. This included pick up entangled fishing lines and drift garbage, lift the structure to prevent sediment accumulation and re-arrangement the structure when necessary.

Activity 1.6 The construction of new one BBQ at Playa Jaboncillo, Los Congres, El Barquito, Atolladora and Tamarindo was done during this segment project. Two BBQ’s were constructed and three garbage cans were installed at Pitirrele area. Maintenance and replacement of the existing BBQ’s and garbage can was done at all fishing access points.

Significant Deviation – None, all maintenance activities were 100% accomplished.

## B- Operation

### Job- 1 Sport Fisheries Promotion

Objective- To promote recreational fishing activities within our sampling universe.

Activity 1.1- The following information material were distributed to anglers and visitors at fishing areas within our sampling universe.

A- Over 2,000 copies of project goal information brochure and other educational materials were distributed to anglers and visitors in the Reserve areas such as Jaboncillo, Los Congres, El Barquito, Atolladora, Tamarindo, La Bahía, San Jacinto, Cayo Aurora Island and Visitor Center located in the Guánica State Forest Headquarters. In addition, this information was distributed on other educational activities outside of Guánica State Forest where project personnel participated.

B- Over 2,000 copies of fishing access points map was reproduced and distributed to anglers and visitors.

C- Over 2,500 copies of information materials prepared by Education Program of Aquatic Resources (P.E.R.A) were distributed during the creel surveys, talks and conferences and other educational activities where project personnel participated. These included other literature appropriate to the marine environment as well as fishing techniques.

Activity 1.2- During this project segment (2002-2003), one hundred fifteen talks and conferences were conducted by project personnel at the Guánica State Forest Visitor Center. During these activities, the project goals and achievements were presented to 1,233 participants who included university, high school and elementary school students, community groups and other visitors. Also project goals were exposed in educational activities, public activities, and local newspaper, television and radio programs.

In addition, project personnel organized and conducted a total of ten fishing clinics during this project segment. A total of 156 anglers participated on these fishing clinics in which seventy three percent of the participants were children between 3 to 15 years old and the twenty seven percent were adults. Most of the adults were the child parents. The majority (51%) of the participants came from community groups of different municipalities close to the forest such as El Rosario (22%), Maricao (15%) and Las Marias (13%). The other groups came from elementary schools of Guánica and Yauco, University of San German, Boys Scout of Puerto Rico and “Club

4H” of Mayaguez. All fishing clinics were conducted at Jaboncillo fishing area during weekends.

Activity 1.3- Construction of one bulletin board at Playa Jaboncillo, Tamarindo and Atolladora fishing access points were done during this project segment. The bulletin board has a map that identifies the shoreline fishing access point, photographs and information related to project goals, activities, marine environment and marine sport fisheries.

Activity 1.4- The full color brochure related to sport fisheries at Guánica State Forest is about to be finished. The brochure is on draft version. This activity is on 80% accomplished. This brochure will be reproduced at Project F-19 headquarter by using a Hewlett Packard 930 inkjet printer and distributed by project personnel during the creel surveys and other activities. Activity will be completed within the next month.

Activity 1.5- The design and installation of one 8’x4’ aluminum lettering at PR 333 road was done. These lettering guides visitors to the recreational fishing sites at Guánica State Forest shoreline.

## C- Study 1 : Survey and Inventory

### Job 1- Creel Survey

Objective: Conduct a creel survey at six fishing access point and San Jacinto landing area.

Activity 1.1- A stratified random creel survey using non-uniform probabilities was done by sampling ten days per month in three time periods. A total of 120 sampling days per year were recorded at all fishing access point including San Jacinto landing area.

Activity 1.2- Creel survey data were stored and analyzed on computer using Microsoft Word and Excel Graphic programs.

## Results and Analysis

### Creel Survey Methodology

During this project segment we used the same creel survey methodology as last years. A total of 120 sampling dates were randomly selected consisting of four weekdays and six weekend days. Weekend days consisted of holidays and from Friday through Sunday. Sampling days were divided into three time blocks, 8:00 AM – 12:00 PM; 12:00



PM – 4:00 PM; 4:00 PM – 8:00 PM. Time blocks were selected randomly with equal probabilities. The areas sampled were La Bahía (from the fishermen association in the Eastern Shore of Guánica Bay to the Port's Authority area), Playa Jaboncillo, Los Congres, El Barquito, Atolladora, and Tamarindo. All access points are located on road 333. Each site was progressively roved for 40 minutes; therefore the progressive counts and interview procedure lasted four hours. The boat landing point at San Jacinto was treated as a different creel survey for statistical purposes. Sampling days is similar to the shoreline fishing areas but sampling periods is one hour before and after each time period of two hours every sampling day. The interview sheet was similar to past surveys.

## Results

From October 2002 through September 2003, 74 angler's interviews were conducted on our sampling universe at Guánica State Forest and Coastal Reserve. A total of 205 recreational anglers were registered in the creel survey. One hundred ninety two (192) anglers were recorded in 69 interviews at six shoreline fishing access points (Playa Jaboncillo, Los Congres, El Barquito, Atolladora, Tamarindo and La Bahía) and thirteen boat anglers in five interviews at San Jacinto landing point. The number of recreational anglers interviewed during this year (2002-2003) at the shoreline fishing access points showed a decrease of 32% as compared to 2001-2002. The same happened to other recreational activities at the Reserve. That can be attributable to bad weather condition and user conflicts. Thirty nine percent of the interviews were conducted at Atolladora area, 14% at El Barquito, 13% at Jaboncillo, 13% at Los Congres, 11% at Tamarindo, 8% at La Bahia. (See Appendix 2, Figure 1). More anglers were observed using El Barquito fishing area during this project segment. This fishing area was restored during this project segment. The traditional fishing access to El Barquito fishing area remained interrupted since access through the parking facilities of Caña Gorda beach was closed after 5:00 PM. Tamarindo area was closed during October, April and September after heavy rains flooded the parking area. The angler interviews were conducted at three-time period at weekday and weekend. Weekend period represented 78% of all interviews. Fifty-three percent of interviews in shoreline were conducted at P.M., 25% A.M. and 22% M. (Appendix 2, Figure 2). Anglers concentrated their fishing effort before 7:00 P.M during P.M. periods. No angler interviews were recorded after that time at shoreline fishing access points. For San Jacinto landing point, weekday periods represented 60% of all interviews. The boat angler interviews at San Jacinto landing point were conducted at P.M period (40%), M.(40%) and A.M. (20%). As well as the shoreline anglers, recreational boat anglers at San Jacinto concentrate their fishing effort before 7:00 P.M during P.M. periods.

According to creel survey results, more families and young anglers' were involved on recreational fishing activities at Guánica Coastal Reserve. Forty-nine percent of anglers recorded in the creel survey were interviewed by first time fishing at the Reserve area and all of those were considered as newcomers. (See Appendix 2, Figure 3). Twenty-five percent (25%) of the shoreline anglers were 31 to 40 years of age, 24% were between 41-50 years, 21% are between 21-30, 17% were less than 20 years and 12% were more than 51 years old. Anglers' age distribution is shown in Appendix 2, Figure 4.

The angler's sex distribution was 63% male, 27% female and 10% child. The majority of anglers came from Yauco (35%), Guánica (30%) and Sabana Grande (11%). Only one angler from other country (NY) was interviewed fishing at the reserve during this segment. The most common fishing gears used by shoreline anglers in their fishing expeditions were hand reels (68%) and rods (32%). The most common baits used by shoreline anglers were the squid (66%) and sardines (25%). Nine percent (9%) of baits used by angler were mullet, ballyhoo and artificial lures. Only 4% of the angler used artificial baits (Appendix 2, Figure 6).

According to creel survey data, the typical angler fishing at the Reserve during this project segment was a male from Yauco, 31-40 years old fishing with hand reels and natural baits (squid) from 3:00 to 7:00 PM during the weekends in the Atolladora area.

Total anglers' effort for the shoreline fishing access points was estimated at 4975.16 angler-hours and average monthly effort was estimated at 414.59 angler-hours (See Appendix 1, Table 1). This represents a decrease of approximately 50% as compared to fishing effort recorded last year (2001-2002) (See Appendix 2, Figure 7). During this project segment no fishing tournaments or fishing clinics were recorded on our creel survey, as done last year. Monthly effort was highest during January, May and September. The lowest was recorded in October and November (Appendix 2, Figure 8).

For San Jacinto landing point, a total of 227.25 boat anglers-hours were estimated during this project segment. The average monthly effort was 18.93 angler-hours (See Appendix 1, Table 2). Fishing effort at San Jacinto showed a decrease of 30% on effort as compared to last year (2001-2002). Over 40 small recreational boats can be observed anchored at San Jacinto landing area. According to boat owners, their boats are normally used for recreational activities such as fishing and visiting "Punta Ballena" bathing area and "Cayo Aurora" facilities. During the last three years many boat anglers have changed their recreational fishing gear (fishing line and hook) for gill nets and other fishing gear. They started performing as commercial fisherman (selling their harvest) and we are not considering them as recreational anglers any more. The higher fishing effort for San Jacinto access point was recorded in September. (See Appendix 2, Figure 13).

Recreational anglers landed at the Guánica area an estimated of 2,469 fishes during this project segment (2002-2003). For shoreline fishing access points, 42 fishes and fifteen fish species were recorded during the creel surveys. *Haemulon plumieri* (19%), *Caranx ruber* (14.3%) and *Haemulon flavolineatum* (12%), were the most common species harvested by recreational anglers (see Appendix 1, Table 3). Estimated number of fish harvested per month was  $197.04 \pm 89.1$  (R.S.E.= 45%). Highest monthly harvest was estimated during January, April and September (see Appendix 2, Figure 10) at Jaboncillo and El Barquito access points. For San Jacinto access point a total of 22 fishes of eight species were recorded in creel surveys. *Sphyraena barracuda* (24.4%) and *Ocyurus chrysurus* (20.4 %) were the most representative species (See Appendix 1, Table 4). Estimated number of fish harvested per month was  $8.66 \pm 5.76$  (R.S.E.= 66.58%) (See Appendix 1, Table 2).

Average harvest per unit of effort (H.P.U.E.) along the shoreline was  $0.16 \pm 0.06$  (R.S.E.= 38.6%). Monthly H.P.U.E for shoreline is presented in Appendix 1, Table 1. Highest H.P.U.E was observed during December, February and May. See Appendix 2, Figure Monthly average H.P.U.E at San Jacinto access point was  $0.19 \pm 0.01$  (R.S.E.= 68.4%) (Appendix 1, Table 2).

Angler expenditure information regarding fishing expedition costs (gas, bait, food and lodging) and durable goods cost was recorded through creel surveys interviews. An estimated of \$44,044.00 was spent on fishing trips by anglers visiting Guánica Reserve. On average an angler-hour cost approximately \$6.68. Monthly, anglers spent \$3,668.00 to fish in Guánica approximately. A total of \$10,785.00 was spent on durable goods. The value of durable goods is amortized by determining the percentage of time the equipment is used at particular site. Since 98% of all anglers interviewed are from the South area the vicinity of Guánica we assume that the majority of equipment is used in Guánica. Therefore, durable costs were multiplied by .98 to yield \$ 10,570.00.

According to creel survey data, 66% of anglers interviewed made some suggestion to the project personnel for improving the recreational fishing in the area. The suggestions given by shoreline and San Jacinto anglers to improve their fishing experience are presented in Appendix 1, Tables 5 and 6. Improve Security (19%), improve fishing facilities (15%), more fishing regulation (15%) and more promotional fishing activities such as fishing tournaments were the principal suggestions given by shoreline anglers. For San Jacinto anglers, new pier facilities (70%), new fishing regulations (15%), and regulation to eliminate speedboats on fishing areas (15%) were the main suggestions.

### Study #3 Fish Population Assessment

Job # 1 Fish Population assessment at five fishing access point.

Objective: Assess the fish species diversity and density in our five fishing access points (Jaboncillo, Los Congres, El Barquito, Atolladora and Tamarindo).

Activity 3.1- Monthly assessment of fish species composition and density in Jaboncillo, Los Congres, El Barquito, Atolladora and Tamarindo areas were done by using visual census technique (belt transects and active search census).

Methodology:

A 100 meter transect line was laid down across representative areas of the study site. Two divers using skin diving or SCUBA diving equipment, depending on depth and sea conditions, identified and counted all fishes through their counting path, 2.5 meters wide on each side of the transect line, and recorded in an underwater slate. The two

counts were added to get totals of fishes inside the transect path. N= Total number of fishes counted and S= Total of species recorded. Additional diver swam around the study site to identify additional fish species present but not counted inside the belt transect. All fish species identified were listed on an underwater slate.

#### Analysis and Results:

The fish population assessments were conducted at Playa Jaboncillo, Los Congres, El Barquito, Atolladora and Tamarindo fishing areas. Fifty nine fish species (S=59) were reported for all fishing areas where thirty three species were considered by Guánica anglers as recreational fish species.

Twenty-four fish species (N=463) were identified at Playa Jaboncillo fishing access point. Fifty percent of the fish species composition is considered as recreational fish species at Guánica area. See Appendix 1, Table 7. *Lutjanus synagris* (14.0%), *Lutjanus griseus* (9.0%), *Haemulon carbonarium* (9.0%), and *Ocyurus chrysurus* (5.0%) were the most abundant recreational species at Playa Jaboncillo area. Some recreational and commercial fish species such as; *Lutjanus synagris*, *Haemulon carbonarium*, *Haemulon flavolineatum*, *Lutjanus griseus*, *Haemulon plumieri*, *Haemulon sciurus*, *Sparisoma viride*, *Lutjanus analis*, *Lachnolaimus maximus* and *Diodon hystrix* were other fish species observed inside the reef dome structures (Reef Balls). In addition, other fish species like *Sphyraena barracuda*, *Caranx ruber*, *Caranx latus* (small < 15cm), *Calamus pennatula*, *Mulloidichthys martinicus*, *Megalops atlanticus* and *Pseudupeneus maculatus* were observed outside of the transect line. During April 2003, a big group of small Caribbean Spiny Lobsters (*Panulirus argus*) and Banded Coral Shrimp (*Stenopus hispidus*) were observed inside the reef dome structures. During this project segment, we observed an increase in the collection of ornamental organisms by scuba diver and use of spear gun and gill nets by fisherman at this area. Maybe this is one of the main factors affecting the fish recruitment and diversity at this study site. Management strategies will be devised to address to this problem.

For Los Congres fishing area, twenty four fish species (N= 385) were identified (See appendix 1, table 8). *Stegastes sp* (20.5%), *Haemulon flavolineatum* (19.7%), *Haemulon sciurus* (9.6%) and *Acanthurus bahianus* (8.3%) were the most abundant fish species at this study site. Sixty three percent of the fish species composition for this fishing area is considered recreational fish species. *Haemulon flavolineatum* and *Haemulon sciurus* were the most representative recreational fish species for Los Congres area. The *Stegastes sp* included all the Damselfish of the genera *Stegastes* observed at the study site such as Dusky Damselfish, Three Spot Damselfish and Beaugregory. Yellowtail Damselfish (*Microspathodon chrysurus*) were observed in the area, but not inside of the transect line. The *Halichoeres sp.* included all the Wrasses of the genera *Halichoeres* observed at the study site, such as *Halichoeres radiatus*, *Halichoeres bivittatus*, *Halichoeres maculipinna* (Initial phase) Small groups (<10 individuals) of Yellowtail Snapper and Parrotfish were observed out side of the transect line.

At El Barquito fishing area, forty two fish species (N=526) were identified inside the transect line. Fifty two percent of the fish species composition for this study site is considered as recreational fish species at Guánica area. See Appendix 1, Table 9. The twenty four percent of fish species composition were dominated by Wrasses (14.4%) and Damsel fish (12.0%). The *Stegastes* sp included all the Damsel fish of the genera *Stegastes* observed at the study site such as Dusky Damsel fish, Three Spot Damsel fish, Cocoa Damsel fish and Beaugregory. The *Halichoeres* sp. included all the Wrasses of the genera *Halichoeres* observed at this study site, such as *Halichoeres radiatus*, *Halichoeres bivittatus*, *Halichoeres maculipinna* (Initial phase). Other fish species of Parrotfish (*Sparisoma aurofrenatum* and *Scarus taeniopterus*), Wrasses (*Halichoeres poeyi* and *Bodianus rufus*) and Goatfish (*Pseudupeneus maculatus*) were observed outside of transect line.

Thirty-two fish species (N=394) were identified at Atolladora, during this project segment (See Appendix 1, Table 10). *Halichoeres* sp. (28.2%) of the Labridae family and *Acanthurus bahianus* (28.2%) of the Acanthuridae family were the most representative fish species at Atolladora study site. The *Halichoeres* sp. included all the Wrasses of the genera *Halichoeres* observed at this study site, such as *Halichoeres radiatus*, *Halichoeres bivittatus*, *Halichoeres maculipinna* and *Halichoeres poeyi*. One Yellowhead Wrasse (*Halichoeres garnoti*) was observed outside of the transect line. For Atolladora, The Parrotfish were divided in two groups, *Sparisoma* sp. and *Scarus* sp.. The *Sparisoma* sp included *Sparisoma viride* (most abundant), *S. radians*, *S. atomarium* and *S. rubripinne*. The *Scarus* sp. included *Scarus croicensis* and *S. taeniopterus*. *Acanthurus bahianus*, *Sparisoma viride*, *Sparisoma rubripinne*, *Pomacanthus paru* (juvenile), *Scorpaena plumieri*, *Chaetodon capistratus*, *Diodon hystrix*, *Anisotremus virginicus*, *Lutjanus analis* and *Haemulon carbonarium* were observed inside the concrete reef structures. Other marine organisms such as *Panulirus argus* (Caribbean Spiny Lobster), and *Octopus vulgaris* (Common Octopus) were observed inside the concrete reef structures. During this project segment, we observed an increase in the use of spear guns by fisherman at the concrete reef dome areas. Maybe this is one of the main factors affecting the fish recruitment and diversity at this study site. Management plans need to address this problem.

Thirteen fish species (N=275) were identified at Tamarindo study site. See Appendix 1, Table 11. The Wrasses (26%) and Parrotfish (26%) represented fifty two percent of fish composition at Tamarindo area. The most common fish species was *Acanthurus bahianus* (21%) in adult phase. Other fish species such as *Ocyurus chrysurus*, *Lutjanus apodus*, *Lutjanus analis* and *Caranx crysos* were identified at this fishing area. Juvenile of *Anisotremus virginicus*, *Pomacanthus paru* and *Acanthurus coeruleus* (Intermediate phase) were observed close to reef structure. During the last two years, we observed an increase in the use of gill nets by fisherman at this area. Maybe this is one of the main factor affecting the fish recruitment and diversity at the study sites. Management plans need to address this problem.

Study #4 Restoration and enhancement of sport fish habitat.

Job #1: Construction of 20 concrete reef domes.

Objective: Construction of 20 concrete reef domes.

Activity 1.1- A total of 20 concrete reef domes were constructed on land using two fiberglass molds made by “Reef Balls Unlimited”. The concrete were retrieved from the molds and stored at DNER headquarters facility area.

This activity was 100% accomplished.

Job #2: Deployment of the 20 concrete reef domes

Objective: Deploy 20 concrete reef domes at two study sites (Jaboncillo and Atolladora).

Activity 2.1- A total of 20 concrete reef domes were transported and deployed on two shoreline fishing access points at Guanica State Forest and Coastal Reserve. Ten concrete reef domes were deployed per fishing site using a towing boat, flotation device and divers. The structures were set between the existing ones at depth of 3to 6 meter and 50 meter from the shoreline.

This activity was 100% accomplished.

Job #3 Transplanting coral colonies

Objective: Implant coral fragment into the new concrete reef domes structure.

Activity 3.1- No coral fragments were implanted into the new concrete domes. The structures were installed very late during this project segment. The concrete domes structures were placed in position but weather conditions delayed coral transplantation. This job will be continued during the next project segment with a minimum of five coral fragments implanted in each reef balls.

Job #4 Assessment of sessile organism recruitment and survivorship of transplanted colonies in the concrete modules.

Objective: Assessment of sessile organism recruited and the survivorship of the transplanted coral colonies.

Activity 4.1- Assessment of sessile organism recruited by concrete domes and survivorship of transplanted colonies were done.

## Analysis and results:

### Methodology for Restoration and enhancement of sport fish habitat

Construction of the concrete reef dome structure: Twenty concrete dome structures were built on land using two fiberglass molds made by Reef Balls Unlimited Inc. donated to the project by Coralations Inc. and the Sea Grant College Program. Small reef ball models (1.2m height x 1.2m width) were used. The concrete structures were constructed following a modification of protocol techniques developed by Reef Balls Unlimited. The modifications were 1- no silicates compound was used. 2- Gravel was added to the mix. No circular Styrofoam pieces were incorporated into the inner part of the molds to create small holes to attach coral colonies on this project segment. Ten (3 gal.) buckets of sand and five (3 gal.) buckets of gravel added to five bags (47 lbs.) of Portland Type-one cement mixed manually with 6 gallons of water per reef ball mold. The molds were filled manually to obtain the required consistency. After 24 hours, the reef balls were retrieved from the mold and stored at the Headquarter of Guánica State Forest. Two molds were filled per day.

Deployments of concrete reef domes: Reef ball structures were moved from DNER facilities to the two fishing access point areas (Jaboncillo and Atolladora,) using a pick-up truck and trailer for transportation. The structures were dropped at the shore and moved manually seaward until we reached one-meter depth. One EFB 500 lift-bag system was tied to the reef ball for flotation so a boat or a swimmer can tow them one by one to the study site. Once at the site, the lift bag was deflated and diver manipulated them to the bottom using controlled descent lift-bag technique to prevent sediment resuspension. Once placed in the bottom, the lift-bag was released. The reef ball units were placed in a linear arrangement, between the existing ones, 2,5 meters (7.5 feet aprox.) from each other, at depths ranging from 2.4 to 5 meters (8 to 15 feet) and about 50 meter (150 feet) seaward from the shoreline and parallel to it.

Transplanting coral colonies: The concrete reef structures were installed very late during this project segment. The structures were placed in position but weather conditions delayed coral transplantation. This job will be finished during the next segment with a minimum of five coral fragments implanted in each reef balls.

Assessment of sessile organism recruitment and survivorship of transplanted coral colonies: A diver did a survey at the existing concrete reef units in order to identify sessile organisms recruited by the structure. Sessile organisms were divided in massive coral juvenile, macroalgae, calcareous algae, zoanths, and sponges. The data was recorded and analyzed in order to compare with the others study sites.

## Results:

At this moment, a total of seventy concrete reef structures were constructed and deployed at Playa Jaboncillo, Atolladora and Tamarindo sites. All these sites are located at the

Guánica Biosphere Reserve Coastline and are considered as shoreline fishing access points by recreational anglers. A total of two hundred fragments and juvenile colonies of Caribbean reef building corals were collected, attached to the concrete reef modules and monitored during the last three years. No new coral fragments were attached to the concrete reef structure during this project segment.

A total of 30 concrete reef structures were installed at this moment in Playa Jaboncillo. A total of 100 coral fragments or small colonies (>12 cm) of seven scleractinian coral species (*Diploria strigosa*, *Diploria clivosa*, *Monstrastrea annularis*, *Porites astreoides*, *Siderastrea siderea*, *Mycetophillia lamarckiana*, *Monstrastrea cavernosa*, *Monstrastrea faveolata*, and *Meandrina meandrites*) were attached to ten concrete reef domes at this study site. Ten coral colonies were attached per concrete reef structure. At this moment, coral colony survivorship was estimated at 19%, where the species of *D. strigosa*, *M. annularis*, *P. astreoides*, *S. siderea*, *M. cavernosa* and *M. faveolata* are still in place and growing. Recruitment over the concrete reef structures of coral species such as *Porites sp.*, *Favia sp.*, *Diploria sp.*, and *Siderastrea sp.* were recorded during this survey. Small colonies ( $\pm 5$  cm) of scleractinian corals such as; *Diploria strigosa*, *Porites astreoides* and *Siderastrea radians* were observed growing over the concrete structures. Few species of macroalgae including *Dictyota caribea*, *Halymenia florensia*, *Gracilaria caudate*, *Dasya crouaniana*, *Enteromorpha flexuosa*, *Acanthophora spicifera*, *Spyridia filamentosa*, *Caulerpa mexicana*, encrusting calcareous algae and other species of sponges such as *Clathrina canariensis* and *Tedania ignis* were identified and observed growing over the structure surface. Other algal species have not been identified yet. Inside the concrete reef structures were observed and identified some invertebrates such as Caribbean Spiny Lobsters (*Panulirus argus*), Banded Coral Shrimp (*Stenopus hispidus*), Arrow Crab (*Stenorhynchus sp.*), Long-spined Urchin (*Diadema antillarum*), Rock-boring Urchin (*Echinometra lucunter*), West Indian Sea Egg (*Tripneustes ventricosus*), Banded-Arm Brittle Star (*Ophioderma appressum*), Common Octopus (*Octopus vulgaris*), Lettuce Sea Slug (*Tridachia crispata*) and Stocky Cerith (*Cerithium litteratum*). Ball shape and encrusting sponges were observed but not identified yet.

Is important to mention that during this project segment, the human activities at the deployment site increased drastically. Human activities such as collection of ornamental marine organisms by using scuba diving, boat anchoring and fishing (using gill nets and spear guns) were observed at the study site. Most of coral colonies were detached by entanglement of fishing nets and anchors. Many of these coral colonies were observed dead near the transplanting site. In addition an increase in environmental stressors such as run off, high sediment influx, high water turbidity and algal over growth was observed too at this site. All these factors affect the coral colonies survivorship at this site and are important for monitoring these parameters and factors to improve new management option for this area.

For Atolladora area, additional ten concrete reef structures were installed during this project segment for a total of 30 concrete reef domes at this site. Eleven scleractinian coral species including *Diploria strigosa*, *Porites astreoides*, *Diploria clivosa*, *Diploria*



*labyrinthiformis*, *Porites astreoides*, *Monstrastrea annularis*, *Montastrea cavernosa*, *Montastrea faveolata*, *Manicina areolata*, *Meandrina meandrites* and *Siderastrea siderea* were collected and transplanted to this location during the project segment F-19-12. A total of one hundred coral colony or fragments (ten per reef ball structure) were collected, attached to reef ball structures and monitored during the past three years. The coral colony survivorship was estimated at 51% where species of *D. strigosa*, *M. annularis*, *P. astreoides*, *S. siderea*, *M. cavernosa* and *M. faveolata* still remained and growing. Recruitment of coral species such as *Diploria* sp., *Siderastrea* sp., *Favia fragum* and *Porites astreoides* were observed growing at the structure. Few species of macroalgae including *Dictyota caribea*, *Padina jamaicensis*, *Sargassum hystrix*, *Galaxaura* sp., *Caulerpa* sp., sponge species (not identified yet), turf algae and encrusting calcareous algae were observed growing over the structure. Sponges such as Orange Icing Sponge (*Mycale laevis*) and Red Boring Sponge (*Cliona delitrix*) were observed growing on coral species of *Monstrastrea faveolata* and *Monstrastrea annularis*. The human activities increased during this project segment as well as Jaboncillo area. Most of coral colonies were detached by entanglement of boat anchors and heavy wave energy during bad weather. Installation of anchor buoys and implementation of fishing regulation (no gill nets or spear guns) at this site will be considered to prevent conflicts between visitors and the project goal.

For the Tamarindo area, no coral colonies or fragments were attached to the concrete reef structures. During this project segment, the marine floor at Tamarindo area presented a dense drift algal mat that covered practically the concrete reef domes. This type of environment is not good for many coral species and that make very difficult to develop the survey. Most of the coral colonies were detached by commercial fishing activities such as entanglement of fishing nets and high wave energy by bad weather. The coral colony survivorship was less than 10%. Is important to mention that recruitment of scleractinian coral species were observed at this site. Small colonies of *Favia fragum*, *Siderastrea radians* and *Porites astreoides* were observed growing over the structure surface. Few species of macroalgae including *Dictyota caribea*, *Acanthophora spicifera*, *Spyridia filamentosa*, *Caulerpa recemosa*, *Padina jamaicensis*, brown algae (not identified yet), turf algae were observed growing at the structure surface. Sessile barnacles, West Indian Sea Egg (*Tripneustes ventricosus*), Lettuce Sea Slug (*Tridachia crispata*) and Smooth Goose-Neck Barnacle (*Lepas anatifera*) were observed too.

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## **Appendix 1**

**Table 1. Monthly and Annual Means for Recreational Fishing Effort  
(Angler/hours)  
Harvest and H.P.U.E. for Shoreline  
October, 2002 through September, 2003**

<b>Month</b>	<b>E</b>	<b>H.U.E</b>	<b>H</b>
October	24.24	0	0
November	32.32	0.044	16.16
December	282.3	0.742	45.22
January	932.23	0.248	671.6
February	460.56	0	0
March	532.27	0	0
April	371.18	0.155	170.95
May	763.56	0.358	975.00
June	234.22	0.070	51.51
July	537.32	0.154	176.72
August	484.80	0.03	53.40
September	857.49	0.12	204.00
Annual	4975.16	1.92	2364.56
Mean	414.59	0.16	197.04
Std. Deviation	359.01	0.21	308
Std. Error	103.76	0.06	89.10
R.S.E. (%)	25	38.6	45

R.S.E.= Relative Standard Error

**Table 2 Monthly and Annual Means for Recreational Fishing Effort  
(Angler / Hour)  
Harvest and H.P.U.E for San Jacinto Access Point  
October, 2002 through September, 2003**

<b>Month</b>	<b>E</b>	<b>H.P.U.E</b>	<b>H</b>
October	0	0	0
November	32.32	0.044	16.16
December	0	0	0
January	0	0	0
February	0	0	0
March	0	0	0
April	52.52	0.025	19.69
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	0
September	142.41	0.152	68.03
Annual	227.25	0.223	103.89
MEAN	18.93	0.019	8.66
Std. Deviation	42.40	0.045	19.95
Std. Error	12.25	0.013	5.76
R.S.E (%)	64.73	68.45	66.58

R.S.E.= Relative Standard Error

**Table 3 Species Composition of Fish Captured by Shoreline Anglers**  
October, 2002 through September, 2003

Species	Common Name	Capture (%)	Quantity (g)
<i>Haemulon plumieri</i>	White Grunt	19.0	1355
<i>Caranx ruber</i>	Bar Jack	14.3	960
<i>Haemulon flavolineatum</i>	French Grunt	12.0	1040
<i>Caranx latus</i>	Horse-eye Jack	10.0	710
<i>Lutjanus apodus</i>	Schoolmaster	7.0	280
<i>Haemulon parra</i>	Sailors Choice	7.0	200
<i>Gymnothorax vicinus</i>	Purplemouth Moray	7.0	1140
<i>Lutjanus analis</i>	Mutton Snapper	5.0	280
<i>Halichoeres bivittatus</i>	Slippery Dick	5.0	280
<i>Lutjanus griseus</i>	Gray Snapper	2.0	100
<i>Lutjanus synagris</i>	Lane Snapper	2.0	375
<i>Epinephelus guttatus</i>	Red Hind	2.0	140
<i>Sphoeroides testudineus</i>	Checkered Puffer	2.0	70
<i>Echidna catenata</i>	Chain Moray	2.0	220
<i>Labrisomus nuchipinnis</i>	Hairy Blenny	2.0	90
Species = 15		N= 42	7,240g

**Table 4 Fish Species Composition Captured by San Jacinto Anglers**  
October, 2002 through September, 2003

Species	Common Name	Capture (%)	Quantity (g)
<i>Lutjanus analis</i>	Mutton Snapper	24.0	555
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	19.0	1085
<i>Sphyraena barracuda</i>	Great Barracuda	14.0	1300
<i>Lutjanus apodus</i>	Schoolmaster	14.0	200
<i>Melichthys niger</i>	Black Durgon	14.0	1620
<i>Caranx ruber</i>	Bar Jack	5.0	320
<i>Lutjanus griseus</i>	Gray Snapper	5.0	100
<i>Epinephelus guttatus</i>	Red Hind	5.0	150
Species = 8		N= 21	5,330g

**Table 5****Suggestions given by Shoreline Anglers**  
October, 2002 through September, 2003

<b>Suggestions</b>	<b>Percent (%)</b>
1. Security	19.0
2. New Fishing Facilities	15.0
3. New Fishing Regulations	15.0
4. Tournaments	10.0
5. New Educational Materials	3.5
6. Waste Management	3.5
7. No Opinion	34.0

**Table 6****Suggestions given by Anglers for San Jacinto Access Point**  
October, 2002 through September, 2003

<b>Suggestions</b>	<b>Percent (%)</b>
1. New Pier Facilities	50.0
2. New Parking Area	20.0
3. More Fishing Regulations	15.0
4. Eliminate Jet-skis and Speed Boats on Fishing Areas	15.0
5. No Opinion	0.0

**Table 7****Fish Species Composition for Jaboncillo Access Point**  
October, 2002 through September, 2003**(N=463)**

<b>Species</b>	<b>Common Name</b>	<b>Composition (%)</b>
1. <i>Lutjanus synagiris</i>	Lane Snapper	14.0
2. <i>Acanthurus bahianus</i>	Ocean Surgeon Fish	14.0
3. <i>Lutjanus griseus</i>	Gray Snapper	9.0
4. <i>Haemulon carbonarium</i>	Cesar Grunt	9.0
5. <i>Halichoeres sp.</i>	Wrasse	8.0
6. <i>Sparisoma viride</i>	Stoplight Parrotfish	7.0
7. <i>Ocyurus chrysurus</i>	Yellowtail Snapper	5.0
8. <i>Eucinostomus melanopterus</i>	Flagin Mojarra	5.0
9. <i>Haemulon flavolineatum</i>	French Grunt	5.0
10. <i>Haemulon sciurus</i>	Bluestriped Grunt	4.5
11. <i>Anisotremus virginicus</i>	Porkfish	3.8
12. <i>Lutjanus apodus</i>	SchoolMaster	3.0
13. <i>Stegastes sp</i>	Damselfish	3.0
14. <i>Selar crumenophthalmus</i>	Bigeye Scad	1.9
15. <i>Haemulon aurolineatum</i>	Tomate	1.5
16. <i>Haemulon plumieri</i>	White Grunt	1.3
17. <i>Chaetodon capistratus</i>	Foureye Butterflyfish	1.3
18. <i>Pomacanthus paru</i>	French Angelfish	0.9
19. <i>Lutjanus analis</i>	Motton Snapper	0.4
20. <i>Diodon hystrix</i>	Porcupinefish	0.4
21. <i>Scarus taeniopterus</i>	Princes Parrotfish	0.4
22. <i>Lachnolaimus maximus</i>	Hog Fish	0.2
23. <i>Scorpaena plumieri</i>	Spotted Scorpionfish	0.2
24. <i>Synodus intermedius</i>	Sand Diver	0.2
<b>Species = 24</b>		<b>N=463</b>

**Table 8. Fish Species Composition for Los Congres Access Point**  
 October, 2002 through September, 2003  
 (N=385)

Species	Common Name	Composition (%)
1. <i>Stegastes sp</i>	Damselfish	20.5
2. <i>Haemulon flavolineatum</i>	French Grunt	19.7
3. <i>Haemulon sciurus</i>	Blue Striped Grunt	9.6
4. <i>Acanthurus bahianus</i>	Ocean Surgeon Fish	8.3
5. <i>Sparisoma sp.</i>	Parrotfish	6.2
6. <i>Lutjanus apodus</i>	Schoolmaster	6.2
7. <i>Abudefduf saxatilis</i>	Sergeant Major	5.4
8. <i>Thalassoma bifasciatum</i>	Blue Head	5.2
9. <i>Halichoeres sp.</i>	Wrassess	4.7
10. <i>Haemulon carbonarium</i>	Cesar Grunt	4.4
11. <i>Ocyurus chrysurus</i>	Yellowtail Snapper	3.6
12. <i>Acanthurus coeruleus</i>	Blue Tang	2.3
13. <i>Holocentrus acensionis</i>	Squirrel Fish	2.1
14. <i>Lutjanus synagris</i>	Lane Snapper	1.8
15. <i>Mulloidichthys martinicus</i>	Yellow Goatfish	1.5
16. <i>Caranx latus</i>	Horse-eye Jack	1.0
17. <i>Haemulon parra</i>	Sailor Choice	0.7
18. <i>Aulostomus maculatus</i>	Trumpet Fish	0.5
19. <i>Anisotremus virginicus</i>	Pork Fish	0.5
20. <i>Chaetodon striatus</i>	Banded Butterflyfish	0.5
21. <i>Epinephelus adscensionis</i>	Rock Hind	0.3
22. <i>Lachnolaimus maximus</i>	Hogfish	0.3
23. <i>Lactophrys polygonia</i>	Honeycomb Cowfish	0.3
24. <i>Haemulon macrostomum</i>	Spanish Grunt	0.3
<b>Species = 24</b>		<b>N = 385</b>

**Table 9. Fish Species Composition for El Barquito Access Point**  
 October, 2002 through September, 2003  
 (N=526)

Species	Common Name	Composition (%)
1. <i>Halichoeres sp.</i>	Wrassess	14.4
2. <i>Stegastes sp</i>	Damselfish	12.0
3. <i>Haemulon sciurus</i>	Bluestriped Grunt	10.0
2. <i>Sparisoma viride</i>	Stoplight Parrot Fish	9.0
5. <i>Mulliodichthys martinicus</i>	Yellow Goatfish	7.0
6. <i>Haemulon parra</i>	Sailor Choice	5.0
7. <i>Haemulon flavolineatum</i>	French Grunt	3.8
8. <i>Lutjanus apodus</i>	Schoolmaster	3.0
9. <i>Abudefduf saxatilis</i>	Sergeant Major	2.8
10. <i>Thalassoma bifasciatum</i>	Blue Head	2.8
11. <i>Acanthurus bahianus</i>	Ocean Surgeon Fish	2.4
12. <i>Acanthurus coeruleus</i>	Blue Tang	2.4
13. <i>Holocentrus acensionis</i>	Squirrel Fish	2.1
14. <i>Lutjanus griseus</i>	Gray Snapper	2.1
15. <i>Ocyurus chrysurus</i>	Yellowtail Snapper	1.7
16. <i>Aulostomus maculatus</i>	Trumpet Fish	1.5
17. <i>Lutjanus synagris</i>	Lane Snapper	1.3
18. <i>Haemulon carbonarium</i>	Cesar Grunt	1.3
19. <i>Chromis multilineata</i>	Brown Chromis	1.1

20. <i>Hypoplectrus puella</i>	Barred Hamlet	1.1
21. <i>Myripristis jacobus</i>	Black Bar Soldier Fish	0.9
22. <i>Lactophrys triqueter</i>	Smooth Trunkfish	0.9
23. <i>Scorpaena plumieri</i>	Scorpion Fish	0.9
24. <i>Chaetodon striatus</i>	Banded Butterfly Fish	0.9
25. <i>Lutjanus analis</i>	Mutton Snapper	0.8
26. <i>Chaetodon capistratus</i>	Four Eye Butterfly Fish	0.8
27. <i>Epinephelus adscensionis</i>	Rock Hind	0.8
28. <i>Anisotremus virginicus</i>	Pork Fish	0.8
29. <i>Acanthurus chirurgus</i>	Doctor Fish	0.5
30. <i>Canthigaster rostrata</i>	Sharpnose Puffer Fish	0.5
31. <i>Caranx ruber</i>	Bar Jack	0.5
32. <i>Gerres cinereus</i>	Yellowfin Mojarra	0.4
33. <i>Lutjanus mahogani</i>	Mahogany Snapper	0.4
34. <i>Lutjanus cyanopterus</i>	Cubera Snapper	0.2
35. <i>Alphestes afer</i>	Mutton Hamlet	0.2
36. <i>Synodus intermedius</i>	Sand Diver	0.2
37. <i>Diodon hystrix</i>	Porcupine Fish	0.2
38. <i>Pomacanthus paru</i>	French Angelfish	0.2
39. <i>Haemulon macrostomus</i>	Spanish Grunt	0.2
40. <i>Mycteroperca rubra</i>	Comb Grouper	0.2
41. <i>Epinephelus cruentatus</i>	Graysby	0.2
42. <i>Lactophrys polygona</i>	Honeycomb Cowfish	0.2
<b>Species = 42</b>		<b>N=526</b>

**Table 10**                      **Fish Species Composition for Atolladora Access Point**  
October, 2002 through September, 2003  
(N=394)

<b>Species</b>	<b>Common Name</b>	<b>Composition (%)</b>
1. <i>Halichoeres sp</i>	Wrassess	28.2
2. <i>Acanthurus bahianus</i>	Ocean Surgeon	28.2
3. <i>Sparisoma sp.</i>	Parrotfish	7.8
4. <i>Anisotremus virginicus</i>	Pork Fish	7.6
5. <i>Hemipteronotus splendens</i>	Green Razorfish	3.6
6. <i>Thalassoma bifasciatum</i>	Bluehead	3.3
7. <i>Scarus sp.</i>	Parrotfish	2.8
8. <i>Acanthurus coeruleus</i>	Blue Tang	2.3
9. <i>Pomacanthus paru</i>	French Angelfish	1.8
10. <i>Equetus acuminatus</i>	High Hat	1.8
11. <i>Chaetodon striatus</i>	Banded Butterflyfish	1.3
12. <i>Caranx latus</i>	Horse-eye Jack	1.3
13. <i>Stegastes sp.</i>	Damselfish	1.2
14. <i>Haemulon carbonarium</i>	Cesar Grunt	1.0
15. <i>Scorpaena plumieri</i>	Spotted Scorpionfish	1.0
16. <i>Ocyurus chrysurus</i>	Yellowtail Snapper	1.0
17. <i>Haemulon flavolineatum</i>	French Grunt	0.7
18. <i>Scomberomorus regalis</i>	Cero	0.7
19. <i>Calamus pennatula</i>	Pluma	0.7
20. <i>Ophioblennius atlanticus</i>	Redlip Blenny	0.7
21. <i>Lutjanus analis</i>	Mutton Snapper	0.5
22. <i>Abudefduf saxatilis</i>	Sargent Major	0.5
23. <i>Equetus lanceolatus</i>	Jacknife Fish	0.5



24. <i>Diodon hystrix</i>	Porcupindefish	0.5
25. <i>Rypticus saponaceus</i>	Greater Soapfish	0.3
26. <i>Eucinostomus melanopterus</i>	Flagfin Mojarra	0.3
27. <i>Haemulon sciurus</i>	Bluestriped Grunt	0.3
<b>Species = 32</b>		<b>N = 394</b>

**Table 11**                      **Fish Species Composition for Tamarindo Access Point**  
October, 2002 through September, 2003  
(N=275)

<b>Species</b>	<b>Common Name</b>	<b>Composition (%)</b>
1. <i>Halichoeres sp.</i>	Wrasse	26.18
2. <i>Sparisoma sp</i>	Parrotfish	26.18
3. <i>Acanthurus bahianus</i>	Ocean Surgeon Fish	21.1
4. <i>Pseudopeneus maculatus</i>	Spotted Goatfish	13.1
5. <i>Haemulon carbonarium</i>	Cesar Grunt	6.5
6. <i>Anisotremus virginicus</i>	Pork Fish	2.2
7. <i>Ocyurus chrysurus</i>	Yellowtail Snapper	1.1
8. <i>Lutjanus synagris</i>	Lane Snapper	1.1
9. <i>Lutjanus analis</i>	Mutton Snapper	0.7
10. <i>Equetus acuminatus</i>	High Hat	0.7
11. <i>Eucinostomus melanopterus</i>	Flagfin Mojarra	0.4
12. <i>Sphoeroides testudineus</i>	Checkered Puffer	0.4
13. <i>Haemulon macrostomus</i>	Spanish Grunt	0.4
<b>Species = 13</b>		<b>N=275</b>

## **Appendix 2**