FIELD REPORT

Marketing title

Bahamian Reef Survey

PI name

John Rollino

Research site/ region

San Salvador Island

Country

The Bahamas

Research site latitude/ longitude

24N; 73.4W

Protected area status

None

Date field report completed

26 March 2010

Period covered by this report

2009 field season

Report completed by

John Rollino

SECTION ONE

Dear Bahamian Reef Survey Volunteers,

Since the project's inception in 1992, there has been a marked decline in coral reefs around the world. The data you have helped to collect over the last 17 years has, unfortunately, shown that even San Salvador is not immune to reef decline. The data indicate that for several of our study sites, we have lost approximately half the hard coral cover since 1992 and that the algal population has increased. Moreover, what really makes this statistic striking is that San Salvador is a remote location with markedly less anthropogenic pressure than other more developed tropical islands in the region.

In an effort to reverse the declining trend of corals on San Salvador and elsewhere, in 2008, the Bahamian Reef Survey began initial reef restoration experiments. These experiments included: coral transplants, construction of artificial coral heads, and recruitment studies. Our hope is that these experiments will assist me to develop a low-cost, low-tech method(s) for reef restoration.

In the summer of 2009, the initial reef restoration efforts were initiated, Earthwatch volunteers constructed artificial coral heads. The volunteers placed the coral heads on the reef, as well as transplanted rescued corals – including endangered species. In November 2009, observations of the artificial coral heads revealed that the structures did recruit corals. Also, all of the transplanted corals had survived.

To date, we have had over 800 volunteers participate in the project. In 2009, a total of 61 Earthwatch volunteers participated in the project. Volunteers included Bahamian students from San Salvador' high school, American and European teen volunteers, teachers, and professionals from all walks of life.

All of the project's achievements and successes would not have been possible without your time, energy, good cheer, and contributions. On behalf of myself, my co-principal investigators, and the project's staff scientists – I want to say THANK YOU! You are all warmly welcomed back to San Salvador, but if you cannot make it back, at the very least, please do stay in touch!!

Sincerely,

John Rollino

Top highlight from the past field season

The 2009 research season was simply the best in the 18 year history of the project. In July, students from San Salvador's local high school participated as teen team volunteers. These students as well as other teen volunteers from Europe and North America, successfully rescued corals and transplanted these rescued corals on to the reef. Subsequent investigations in November 2009 determined that all of the rescued corals were thriving when investigated in November 2009. Also, in the summer of 2009, an adult team built numerous rugosity enhancing devices and placed them on the reef. The structures, made out of concrete, where positioned over and placed on the reef using nothing more than simple floats and ropes. These structures were observed to attract fish and serve as a substrate to recruit corals. Thus, our original goal of low-cost, reef restoration is quickly becoming a reality. Moreover, having Bahamian students actively repair their own reefs is an added bonus.

Non-technical overview of results

The Bahamian Reef Survey, which is one of the longest-running coral reef research projects in the world, is comprised of two main components: 1) Long-term monitoring; and 2) An experimental reef restoration effort.

1- Long-Term Monitoring

In 2009, the Bahamian Reef Survey conducted field research activities between the dates of Feb 15-28, June 20th to July 12th, and Nov 20-27. Over 60 Earthwatch volunteers participated in the project in 2009, including a high school biology class from Washington State, San Salvadorian High School Students, approximately one dozen teachers, and other professionals from all walks of life.
The long-term monitoring research activities that were conducted in 2009 were the following: monitoring transects for newly bleached or diseased corals; point Intercept studies; transect mapping; coral biomass measurements; rugosity; algae, fish, and sea urchin studies; water chemistry; and beach profiles.

1.1 Transect Monitoring

The monitoring of the permanent transects was accomplished by the adult and teenage volunteers. The data were field corroborated by the project Principal Investigator (PI) and Project Staff Scientist (PSS). The data that were collected for the transects show typical, seasonal, air and water temperatures, pH and salinity readings, and typical visibility measurements for the waters around San Salvador. The numbers of corals exhibiting bleaching too were consistent with normal levels. Also, little bleaching was identified on the transects - this marks four consecutive years that a major bleaching event has not occurred on San Salvador. Also, major bleaching events were not reported elsewhere in the Bahamas in 2009 either.

1.2 Point Intercept Studies / Algae and Sea urchin studies

The point intercept (PTI) studies were accomplished through the use of 1-square meter (sq m) frames. The PTI studies are used to determine the percent coverage of the seven reef covertypes (i.e., hard coral, soft coral, algae, sponge, sand, rock, and other) on each reef. The PTI data show that Lindsay's reef and Rocky point have substantially higher amounts of hard coral coverage than Rice Bay. Conversely, the percentage of algae coverage in Rice bay is substantially higher in Rice Bay then Rocky Pt or Lindsay's Reef. These findings are consistent with the findings of past expeditions. However, the long-term trend of hard coral coverage has declined on all reefs since the inception of the study in 1992 (see Chart 1).

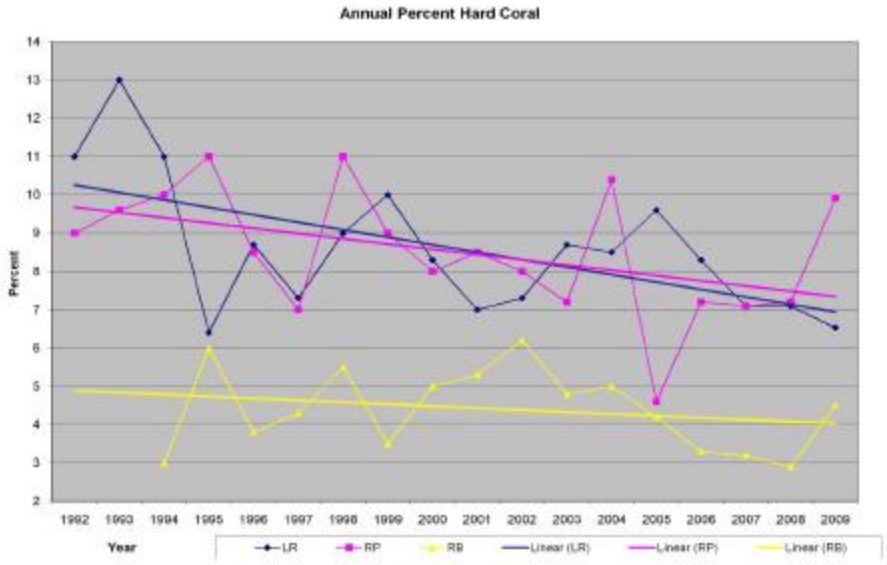

Chart1: Average percent of Hard Corals on the Three Study Sites.

Algae were further studied in depth by the adult and teen teams. The purpose of the algae study is to determine the percentage of algae, as per functional groups (turf, encrusting, fleshy, and calcareous). The purpose of the sea urchin study is to determine the number of Caribbean long-spine sea urchins (*Diadema antillarum)*, a major reef herbivore, along the transect and within the study plots. The overall percentage of algae on the reefs remains very high; moreover, (as reported in previous years) the percentage of flesh algae is significantly higher than the other three functional groups combined. Fleshy algae poses significant threats to coral as that group of algae is much larger and may out compete corals for sunlight.
The number of Caribbean long-spined sea urchins remains low (compared to historical records). However, the continued consistent sighting of urchins over the last few years is encouraging. Prior to 2005, the sighting of urchins on the study sites was very limited.

1.3 Transect Mapping

Adult and teen volunteers participated in transect mapping. The mapping exercise is accomplished by volunteers mapping every hard coral to scale within the 10-sq m area (1Mx10M) that comprises the transect. Mapping of transects is a useful to the PI as they are a definite measure of annual recruitment and mortality. As reported in last year's field report, there were two disturbing trends: 1) The numbers of mapped coral heads on each reef declined; 2) the number of recruits (i.e., new corals) was less in 2008 then 2007. Unfortunately, this trend continued in 2009.

1.4 Biomass Measurements

Biomass measurements were accomplished by the adult and teenage volunteers. Biomass measurements consist of measuring the length and width of each coral head. The measurements are utilized to calculate the surface area of coral tissue. This allows the PI to determine relative biomass of hard corals on the reef. The 2009 results for coral biomass measurements continue to indicate that certain key reef species, most notably, mountainous star coral (*Montastrea annularis)* and elliptical star coral (*Dichocenia stokesii)* are declining in numbers and size on our study reefs. Certain coral diseases (e.g., rapid wasting disease, etc.) and other environmental stressors are likely the cause. Nonetheless, the loss of key reef building species will present a new set of challenges for coral reefs and their ecology.

1.5 Physical Measurements (rugosity, reef height, Beach profiles)

Physical reef measurements showed little variation between 2008 and 2009. This findings is not unexpected as no severe climatic (e.g., event hurricane, tropical storm [s], etc.) impacted the Bahamas. Beach profiles showed that no significant erosion occurred between 2008 and 2009.

1.6 Water Chemistry

Water chemistry analyses were conducted by the teen volunteers during the summer expedition. Water chemistry sample are analyzed for 14 parameters including: ammonia, boron, calcium, copper, iodine, alkalinity, magnesium, nitrate, nitrite, dissolved oxygen, phosphate, silicate, and strontium. Water quality results were consistent with past results.

1.7 Monitoring Data Summary

Review of the monitoring data shows that the reefs are still in a state of decline. Water chemistry measurements show that pollution or other localized stressors are likely not the cause. In the 17-year history of the project, several bleaching events (caused by increased water temperatures) have resulted in a decline of corals. Also, algae, especially fleshy algae, which can compete with coral for space and sunlight continues to increase as a percent covertype on the reef. These findings have resulted in the project initiating a reef restoration effort, which is described in Section 2.

2- Coral Reef Restoration and Endangered Species Rescue

2.1 Reef Restoration

Due to the rapid and observed decline of coral reefs on San Salvador and elsewhere around the world, the Bahamian reef Survey began initial coral reef restoration efforts on the island of San Salvador in 2008. These efforts included the transplanting of coral heads (to increase biomass) and the construction and placement of artificial coral heads (Rugosity Enhancing Devices) (See photo 1) to increase rugosity,promote fish usage increase herbivory, and increase recruitment of hard corals.

Photo 1. Rugosity Enhancing Devices placed on the Reef

One of the project's PIs has explored the reefs of San Salvador since the late 1970s. This project has formally surveyed the island's reefs three times a year since 1992. What makes this restoration effort unique is that the PIs have witnessed first hand the decline of the reefs for over 30 years. Moreover, they also possess a robust quantitative data set. As such, they would be able to correlate the efficacy of restoration attempts to the reef's previous conditions.
The decline of coral reefs has been expressed by “phase shifts” or dramatic measurable changes in the percent cover of corals and algae, as well as the species composition. Within the past few decades major outbreaks of disease and bleaching have reduced the percentage of hard corals in reefs in the region. Also, the die-off of the Caribbean long-spine sea urchin (*Diadema antillarum)* has contributed coral reduction by increasing algae, especially fleshy algae, which retards coral settlement and recolonization, Many scientists have speculated that the level of degradation has become so pronounced that even if the global stressors abate, the reefs may not have the capacity to reverse the phase shifts that have occurred, unless restoration efforts are also undertaken. Moreover, key reef-building *scleractinian* species (i.e., *Montastrea annularis)* suite may not be able to attain their pre-decline numbers through current recruitment. Thus, restoration methods need to be developed that provide for the following:

- Add hard substrate for coral recruitment,
- Increase rugosity to provide additional habitat for fish and reef herbivores,
- Increase species diversity; especially species that would have “positive interactions” - one species that makes conditions more favourable for another species. For instance, an increase in *Acropora* sp, endangered corals that form branching structures, would further increase available habitat, diversity and rugosity; and
- Involve local support, be low cost so as to feasible for other communities to adopt, and, when possible, utilize recyclable and non-toxic materials.

The Bahamian Reef Survey began initial coral reef restoration efforts on the island of San Salvador in 2008. These efforts included the construction and placement of artificial coral heads to increase rugosity to promote coral recruitment and to serve as a platform for transplanting of coral heads and fragments (to increase biomass). The artificial coral heads, hereafter referred to as Rugosity Enhancing Devices (REDs), are often constructed in the shape of small reef balls or branching structures to mimic the structure of *Acropora* sp.
A RED was constructed in February 2008, and placed on Rocky Point Reef in the summer of 2008. In the winter of 2009, the RED was investigated. The coral head did attract the recruitment of a hard coral and was utilized as a habitat by a damselfish. The RED was subjected to several storms and no structural defects were observed. Building on this success, ten additional REDs were constructed in the winter of 2009, and placed on the reef in the summer of 2009. Acroporids were transplanted on to these REDs. In November 2009, the Acroporids fragments were all alive with no signs of new bleaching or disease. The REDs were colonized by marine life, algae growing on the structures were observed to be grazed by parrotfish.

Methods & Activities

In order to construct the REDs and place them on the reef, the following procedures were employed:

1) Molds are prepared. The molds are either dug into the beach sand or sand is placed in a wooden box measuring 1.2 m X 1.2 m X 1.2 m (see photo 2) . These REDs may vary in size and may measure up to one meter in width and one meter in height. The central stalk of the RED (portion that is attached to the reef) measures up to 12 cm in diameter.
2) Once the mold is dug and stabilized using either wetted sand or pieces of shoring, a 0.75-inch PVC pole is placed vertically thought the mold. The PVC pipe is wrapped in plastic wrap for ease of removal after the concrete is set.

3) Steel construction mesh is then placed within the mold to increase the RED's structural integrity.
4) Quick setting concrete or grout is then mixed and poured into the mold. (Commercially available additives will be added to future structures to make them pH neutral). The concrete is poured in such manner that all of the supporting construction mesh is encased within the concrete. The RED is then left to harden (usually 48 hours).
5) The RED is dug out of the beach sand and the PVC rod is then removed, which results in a branching structure that mimics an *Acropora palmata* or *A. cervicornis*. The RED also has a continuous vertical hole running through the vertical axis of the structure. Some other molds are shaped as shallow ellipses with large holes in the structure. These holes allow fish, urchins, and/or crustaceans to seek refuge in the structure.
6) An area of attachment is selected on the reef. This area has no living hard or soft coral located within the contact footprint of the reef's surface and the bottom of the RED, which are places in water depths between of 1-2 m.
7) Using a pneumatic drill powered by an air tank with a rock coring bit (see photo 3), an approximate 2.1-cm wide hole is drilled approximately 25 cm into the reef.
8) Fast drying aquarium cement or grout is placed in the hole. Then, a piece of 2.1-cm rebar (approximately 0.6 m in length) is inserted into the drilled hole.
9) The RED is than attached to a sturdy PVC float rig. The PVC is constructed out of six-inch PVC pipes. Additional floats are attached to the PVC to increase buoyancy. Once over the rebar, the vertical hole in the RED is aligned with the rebar and the RED is lowered by rope on to the rebar.
10) Prior to placement, the vertical hole of the RED is filled with aquarium cement or grout. Care is taken so that no cement or grout spills on to the reef.
11) Once the RED is placed on the rebar, the aquarium cement hardens securing the RED to the reef. Coral recruitment collection plates and/or coral fragment transplants were then attached to the RED.

Photo 2. Earthwatch Volunteers dig in beach sand to construct a mold for the RED

Photo 3. PI John Rollino and project Staff Scientist Ms. Anne Paul, use a pneumatic drill to secure a RED to the reef.

2.2 Endangered Species Conservation and Coral Rescue

This objective studies and/or promotes the conservation of the following three endangered species:

· elkhorn coral (*Acropora cervicornis)*,
· staghorn coral (*Acropora palmate)*, and
· Caribbean long-spined sea urchin (*Diadema antillarum)*

The two *Acropora* species are the only coral species protected by the United States Endangered Species Act. For many of the patch reefs around San Salvador, *Acropora* sp. suffered a near complete mortality in the late 1990s. In 1983-1984, *D. antillarum*, a major herbivore on the reef, almost suffered an extinction with an estimated 97 percent of the world's population dying in one year.
In the summer of 2009, rescued *Acropora* fragments (N=12) and a Porites asteroids colony (approximately 10 cm in diameter) were reattached to REDs on Rocky Point Reef using aquarium cement and/or cable ties (see photo 4). Inspection of all reattached corals in late November revealed that this method proved very effective for keeping corals in place. Moreover, all transplanted corals survived with some exhibiting new growth. Also, following the methods described in Brownden-Kirby, 2001, a few pieces were scattered on the reef in low algae areas of exposed rock in July 2009. These fragments too were observed to have healthy tissue in late November, 2009.

Photo 3. Earthwatch Volunteer and San Salvador High School student, Mr. David Romer, secures a fragment of an endangered species (elkhorn coral) to a RED.

2.3 Summary

The initial restoration efforts results proved very favorable. Volunteers with little, if any, experience in habitat restoration, construction, transplanting, etc, were trained and mastered the tasks in short order. Moreover, some of the volunteers who participated in the restoration were residents of San Salvador. Building on the success of the 2009 season, the PI will continue to build and monitor REDs and transplant corals in established study plots. The objective being that the PI and Earthwatch volunteers, working with local residents, will be successful in finding and refining low-cost, reef restoration methods.

Acknowledgements

I would like to thank the 800 volunteers who have participated on this project since 1992. I would also like to thank Earthwatch for their continued support.

The Charlotte Country Day School in Charlotte, NC, has provided material support on behalf of the project.

SECTION TWO - TECHNICAL RESULTS

REPORTING ON RESEARCH OBJECTIVES

Objective 1

Continuation of data set / Continue the long-term comprehensive study of a shallow-water coral reef

Progress report on objective 1

To date, the Bahamian Reef Survey coral reef research project is one of the longest-running scientific coral reef research projects in the world. Research has been collected continuously, each season, since 1992.
The project's data set represents one of the most comprehensive and continuous data collection efforts on coral patch reefs in the Atlantic Ocean. Moreover, few scientific studies have focused on patch reefs, which are shallow, easily accessible reefs close to the shoreline. Their close proximity to anthropogenic resources results in increased impacts from pollution, runoff, fishing, and tourism-related activities.
In 2009, the PI initiated long-term monitoring efforts on two additional reefs around San Salvador. Both of these reefs are in close proximity to sea grass beds. Through long-term study the PI will be able to determine the effect (if any) sea grass beds have on the reefs.
The PI currently has research activities associated with this project planned through 2018.

Objective 2

Determine long-term trends (seasonal, annual, and decadal) of floral and faunal assemblages that live on coral reefs. Correlate these trends to variation in species population(s), change in physical and chemical parameters, incidences of bleaching events and disease, local and regional recovery or morality of corals, and/or changes to reef ecology (e.g., introduction of invasive species, etc.).

Progress report on objective 2

With respect to the project's long-term monitoring activities, the findings of 2009 are similar to the findings of the past three years. No major bleaching event or climatic event (e.g., hurricane, etc.) has impacted the island's reefs.2009. A synopsis of the findings are as follows:

- Since the inception of the project, there has been an observed decline of the percent of hard coral coverage on the project's study sites. During that same time period there has been an increase in the percentage of algae on the reefs. T
- Analysis of the data indicates there has been a decrease in the number of valuable branching and reef building corals.
- Five select species are measured for biomass. The species are *Dichocenia stokesii, Diploria sp., Favia fragum, Montastrea annularis*, and *Porites asteroides*. All five of these species have exhibited dramatic reductions in biomass. Four of these species are major reef builders on San Salvador's patch reefs. Although, no proximal cause was directly observed for their decline in 2009, the hard coral species are susceptible to coral diseases (e.g., black band disease, rapid wasting disease, etc.). These diseases can kill a mature coral in a matter of days under the proper conditions. It is theorized that disease(s), the dramatic increase and algae, and other ecological stressors have accelerated the decline of these species.
- The functional ecological groups of the reefs' algal population(s) has continued to shift. Fleshy algae, a key competitor of corals for sunlight, has begun to dominate all the study sites.
- Overall rugosity (reef three-dimensionality) has shown a slight decline. The removal of major reef building hard corals and subsequent erosion has reduced the reefs' three dimensionality. Further decline of reef three-dimensionality will lead to increased beach and island erosion and reduce available fish habitat
- Fish populations still remain low. Key predatory fish are targeted for subsistence and very minor commercial fishing interests. Despite the increase in algae and decrease in

predatory fish populations, the herbivorous fish populations remain low. This may be a result of habitat pressure and the reduction of surface area on the reef(s).

- Lionfish, *Pterois* sp., an invasive species from the Pacific region, have appeared on San Salvador's reefs. Lionfish are voracious, piscivorous predators. Collection of fish population data will be analyzed to determine what impact/effect lionfish may have on the local fish populations.
- There have been reappearances of endangered species (most notably the Caribbean Long-spined sea urchin (*Diadema antillarum*), a key reef herbivore). These populations will be closely monitored to determine if an increase in their numbers corresponds to a decrease in algal coverage.

Studies documenting the long term trends will continue on the project, and new studies designed to quantify emerging trends will be initiated when appropriate.

Objective 3

Correlate physical and/or chemical changes in the shallow water, near-shore environment(s) to the overall health of coral reefs on San Salvador

Progress report on objective 3

Three times a year, water quality samples have been collected for analysis in near shore environments (depth 1-2 meters) around the island. Also, for purposes of comparison, samples have been collected approximately 0.8 kilometres offshore. Water quality samples were/are analyzed for two suites of data:

- Physical Parameters (i.e. pH, salinity, visibility) and
- Chemical Parameters (i.e. ammonia, boron, calcium, copper, iodine, DKH/alkalinity, magnesium, nitrate, nitrite, dissolved oxygen, phosphate, silicate and strontium).
- At the end of each expedition in 2009, the water quality results were analyzed and the results compared to standard tropical sea water measurements. The analysis can be summed up in two points:
    1) The water quality samples collected at the various study sites are remarkably homogenous. Surface water samples collected from patch reefs within the island's bays were very similar to surface water samples collected just off shore.
    2) No measured parameter was outside the range of normal tropical sea water measured in the region. As such, water quality is not believed to be a significant factor in the observed trends. This also further lends weight to the argument for of study coral reefs on San Salvador. The limited human population has not significantly contributed to water quality degradation and/or the input of organic elements that would increase algae growth.

Water quality samples will continue to be collected in the future.

Objective 4

Reef Restoration Experiments - New studies introduced to document and follow observed emerging trends in coral reef ecology

Progress report on objective 4

In the winter of 2009, project staff and volunteers constructed ten Rugosity Enhancing Device (REDs). These REDs were placed on the reef in the Summer of 2009. Also in the summer of 2009, rescued Acropora fragments (N=12) and a *Porites asteroids* colony (approximately 10 cm in diameter) were reattached to REDs on Rocky Point Reef using aquarium cement and/or cable ties. Inspection of all reattached corals in late November revealed that this method proved very effective for keeping corals in place. Moreover, all transplanted corals survived with some exhibiting new growth. Also, following the methods described in Brownden-Kirby, 2001, a few pieces were scattered on the reef in low algae areas of exposed rock in July 2009. These fragments too were observed to have healthy tissue in late November, 2009.

DISSEMINATION

Printed:

The last peer-reviewed publication was in 2007. Since the inception of the project there have been other papers and conference presentations. It is envisioned that two documents will be submitted for publication published in late 2010. One document would be a paper analyzing the changes to the study reef based on comparison of three bleaching events. One will be of a scientific nature detailing our experiments, coral recruitment and growth rates, etc. The second would likely be of a resource management/economic nature identifying man power estimates, expenses, etc. of reef restoration for remote communities associated with respect to the reef restoration efforts that are currently being conducted. In the future, Peer-reviewed journals that papers may be submitted to would include journals focused on ecology, marine science coastal management (e.g., Bulletin of Marine Science, Ecology, Ecological Monographs, Ocean and Coastal Management)

Meetings and conferences:

When possible the PI attends or presents at conferences and/or local events.
The next event the PI has scheduled is in the spring of 2011, where he will present a paper at the Natural History Conference of the Bahamas.

Educational resources:

Many of the project staff scientists are teachers. They often incorporate the research in their lesson plans.

Other:

The PI is currently developing a Facebook page for the project.

CAPACITY DEVELOPMENT AND EDUCATION

The project would seek to continue having San Salvador high school students participate as volunteers on the project's teen team. The project would seek to have adult members of the local community participate in a role as "reef caretaker". These persons would make observations; oversee the raising of coral fragments during time periods when Earthwatch groups and/or the PI and staff are not present on the island.
Finally, the PI will continue to speak to the local public regarding the state of the reefs, endangered taxa, and Earthwatch's role in reef restoration activities.

CONTRIBUTIONS TO INTERNATIONAL CONVENTIONS, AGENDAS, POLICIES, MANAGEMENT PLANS

The restoration activities look to seek and refine methods of low-cost restoration efforts. If successful, these methods could be utilized by other nations who contain coral reefs within their borders. Many nations with coral reef are often small island states or lesser developed nations - as such, low-cost restoration efforts may prove invaluable.
Also, the reef restoration efforts look to increase the conservation, biomass, and/or study of three endangered taxa.

CONTRIBUTIONS TO LOCAL, NATIONAL AND REGIONAL CONVENTIONS, AGENDAS, POLICIES, MANAGEMENT PLANS

A marine park has been proposed for the island of San Salvador. If enacted, the data collected by the project (which has study sites in and out of the proposed park) can determine the park's effectiveness. Moreover, reef restoration activities may determine if simply enacting a marine park is sufficient, or do the reefs need the synergistic effect of marine park regulation and restoration activities.

ACTIONS OR ACTIVITIES THAT ENHANCE NATURAL AND SOCIAL

The original premise of the project was to answer a call from the scientific community to initiate and maintain a long-term data base of coral reef ecology to document the incidence of bleaching, disease, and climatic events (storms) and the corals' subsequent recovery or mortality. To date, the project is one of the longest-running coral reef research projects in the world.
The project also works with the local community in restoring degraded coral reefs. This provides opportunities for the residents of San Salvador to be directly involved with the enhancement of their own natural communities. Moreover, the project provides a teaching forum of the local ecologic community to island's students. Local high school students on San Salvador have participated as volunteers on the project's summer teen team.
Our target is to continue to work with the local community - especially high school students who will participate as research volunteers
in the future.

LONG TERM IMPACT OF PROJECT

Taxa of conservation significance enhanced, restored or maintained

At present three species. These include the following: elkhorn coral (*Acropora cervicornis)*; staghorn coral (*Acropora palmata)*, and Caribbean long-spined sea urchin (*Diadema antillarum)*.
The two *Acropora* species are the only coral species protected by the United States Endangered Species Act. In 1983-1984, the Caribbean long-spined sea urchin, a major herbivore on Bahamian and Caribbean reefs, almost suffered an extinction with an estimated 97 percent of the world population dying in one year. The project has begun to restore Acroporids on one reef. In three years, the project plans to have *Acropora* restoration on at least five reefs. The project also plans to have a robust *D. antillarum* study in place and within three years transplant *D.antillarum* to established study plots to determine there potential effectiveness in reef restoration.

Habitats enhanced, restored or maintained

Tropical Coral. It should be noted that this project's focus is shallow-water patch reefs. These reefs, due to their close proximity to land, often receive a disproportionate share of anthropogenic perturbations (e.g., pollution, sedimentation overfishing, tourism, etc.). There have been few scientific studies in the last decade that have studied the shallow-water patch reefs. Restoration efforts by this project will result in positive changes to the reefs.

Ecosystem services enhanced, restored or maintained

The project enhances, restores, and/or maintains all five ecosystem services. With respect to Provisioning Services, restoration efforts will increase the biomass. Regulating services are accomplished by rescuing corals/restoration efforts that will further sequester carbon. For supporting services, a healthy reef will remove small amounts of nutrients from the water column. For Cultural Services – Restored reefs are a boon to tourism; moreover, for ecotourism, participation in the Earthwatch project provides a venue for concerned citizens to participate in reef restoration. For Preserving Services, the restoration activities seek to increase the ecologic value of the reefs, including three endangered taxa, and ultimately to provide a methodology(s) manual for isolated and/or low income communities to restore their own reefs. Finally, with a proposed marine mark being considered by parliament, the project's research sites (located in and outside of the proposed park's boundaries) can assist in demonstrating the park's effectiveness.

Cultural heritage enhanced, restored or maintained

The restoration of coral reefs would increase fish and benthic invertebrate populations. Some of these species (e.g., grouper, lobsters, etc.), are traditional foods consumed during holidays and special events.

Livelihoods enhanced, restored or maintained

The research station is one of the biggest employers on the island. The research station typically has about 1,000 – 1,200 persons stay at the station during the course of the year. The Bahamian Reef Survey has approximately 50 - 70 persons stay at the station each year.
The local economy of the island is also aided by the project staff and volunteers who frequent local shops, craftsmen, etc. Also, it is not uncommon for volunteers to come back to the island for vacation; or, stay on the island after the expedition for a period of time.