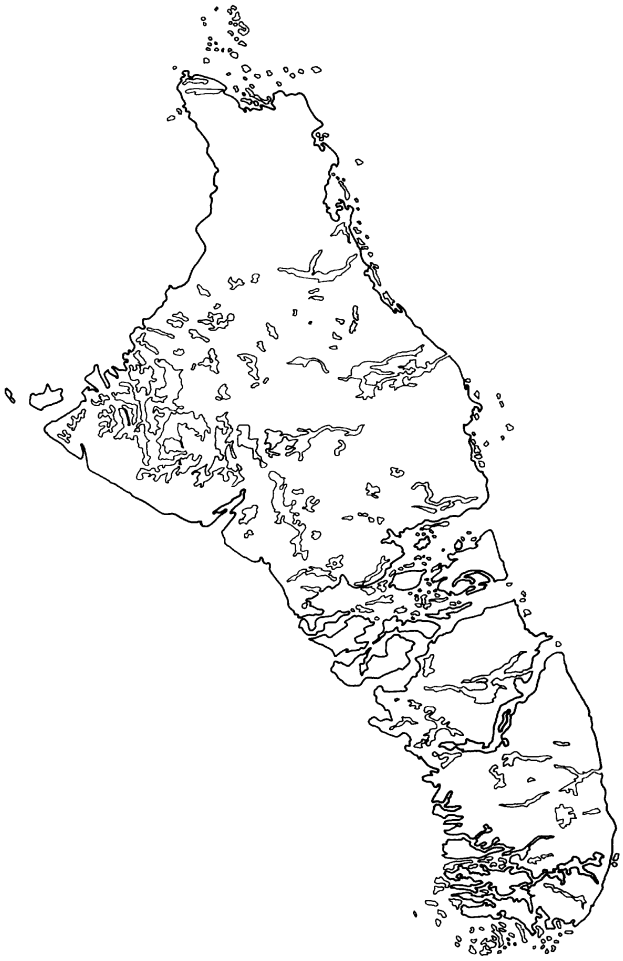
GREENFORCE

Andros Island Marine Project, Bahamas

2005 Annual Report

Reaching Objectives: Project Appraisal and Future Directions



Stuart P Wynne

GREENFORCE
11-15 Betterton Street,, Covent Garden, London. WC2H 9BP. UK
Tel: 020 7470 8888 Fax: 020 7470 8889
GREENFORCE@btinternet.com
www.greenforce.org

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Summary

The Greenforce Andros Island Marine Project, located in South Blanket Sound, is now well into it's fifth year. An end point has been reached with the first half of research work, which has been to collect baseline data within the northern Marine Replenishment Area on Andros Island in the Bahamas, and help where needed in collecting habitat information for mapping purposes. It is now time to hand this data over to the Bahamas National Trust for detailed analysis and take a step back to assess lessons learnt. This is essential before moving on to the second part of the project, which is to begin a similar assessment of the southern Marine Replenishment Area on Andros. This report contains a project appraisal and draws conclusions that should be addressed before moving on with the subsequent half of our work: Baseline data collection in the southern Marine Replenishment Area. Future directions are also laid out to enable the project to remain focused and head in a positive direction.

Introduction

The worldwide loss and degradation of coastal habitats and issues relating sustainability, particularly the effects of fishing on marine ecosystems and fisheries, have become a focus of concern over recent years (Turner *et al.,* 1999). Declining fish stocks are a major problem around the globe with threats to fishery collapses becoming commonplace, for example the Peruvian anchovy (Jahncke, 2003) and Newfoundland cod (FLMNH, 2002). In tropical regions, marine ecosystems, especially coral reefs, often provide the resource base upon which a sizable proportion of the population depend for both livelihoods and protein intake (Horrill *et al.*, 1996). Such dependency, especially in unmanaged situations, often leads to resource over-exploitation.

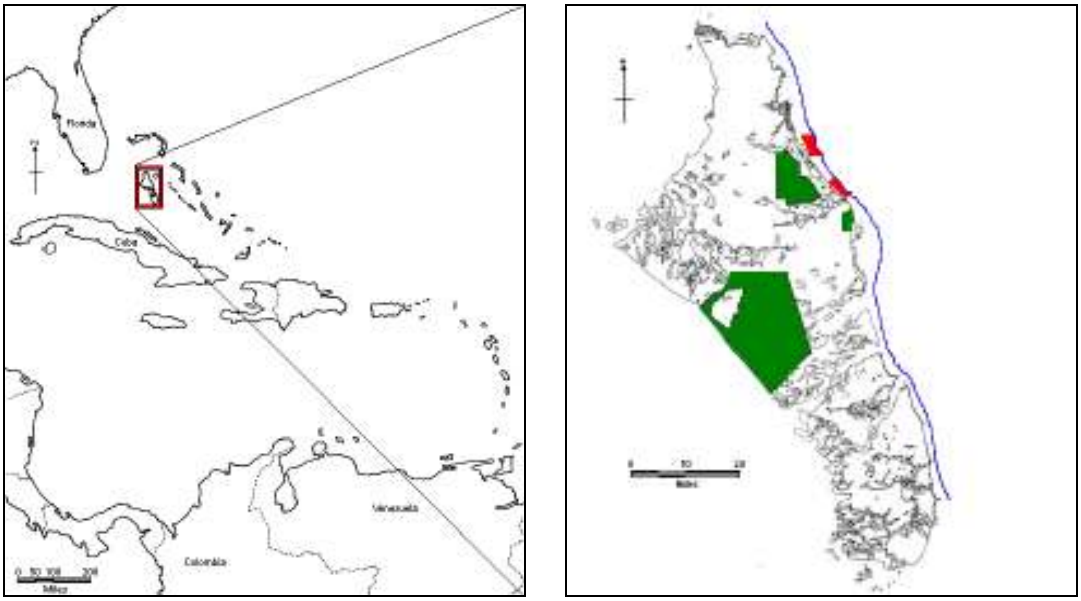
The issue of over-exploiting marine ecosystems is especially critical in small island states where natural resources are invariably limited (Andersson and Ngazi, 1995) and demand, often driven by an increasing tourist industry, can rise rapidly. This can lead to greater fishing effort and development of more efficient fishing methods, thus producing higher yields that raise issues with respect to sustainability of resources and biodiversity loss (Beger *et al.,* 2003). Even without such an increase, sustained artisanal fishing methods have also been documented to cause similar, if less severe, effects (Hawkins & Roberts, 2002). This often prompts the establishment of Marine Protected Areas or seasonal no take zones (Freidlander *et al., 2002*), seen to be effective not only for fish (Maliao, 2004) but invertebrate populations also (Davidson *et al.,* 2002).

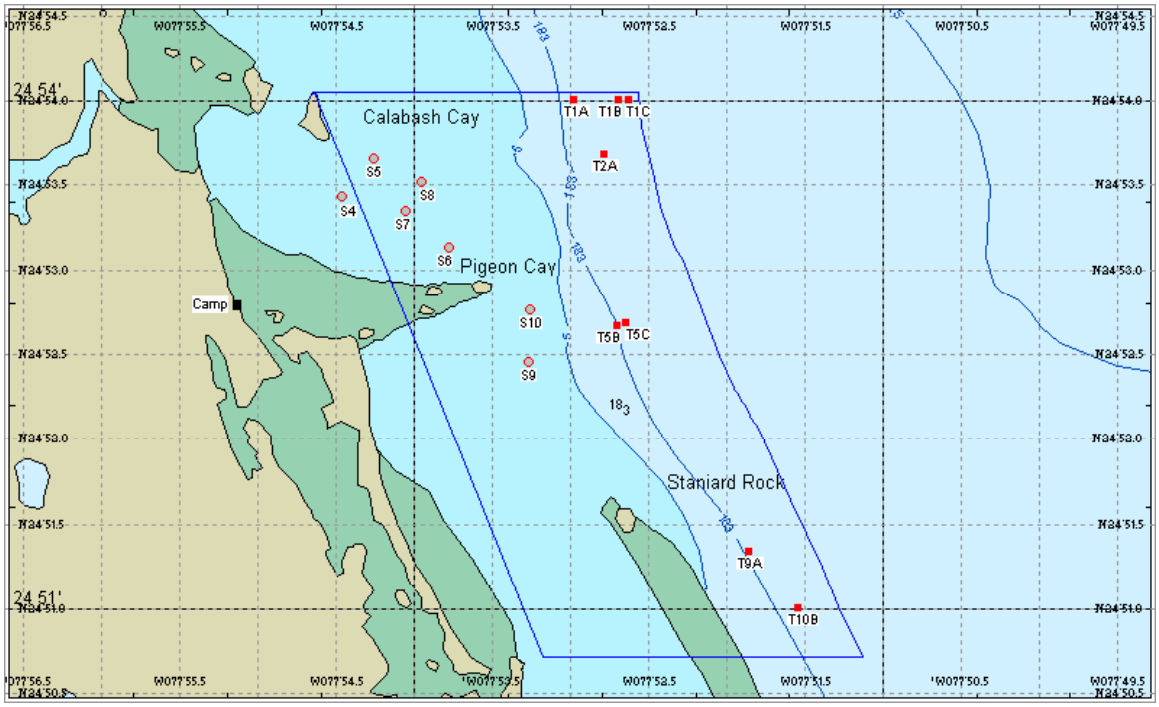
Such a course of action took place on Andros Island, Bahamas early this decade, prompted by concerns for selected fish species abundance (M.Birch, pers. comm.). Two areas off the east coast of North Andros (Figure 1) were gazetted as Marine Replenishment Zones (MRZ), later to become known as Marine Replenishment Areas (MRA). These areas, essentially marine parks or Marine Protected Areas (MPA), form part of the National Parks System for Central Andros. Currently, aside from the general legislation that exists within

Bahamian waters, no specific management plan has been established for the MRA's, and concerns exist that they will remain gazetted, yet unlegislated, 'Paper Parks' (pers. obs.). Further concerns exist because the current MRA boundaries do not include the shallower coastal areas, including extensive mangrove stands, that are known to be ecologically important for many a number of reasons and be susceptible to a variety of pressures (Ellison 2000).

With such concerns in mind, the Bahamas National Trust (BNT) invited Greenforce, a UK based non-profit organisation, into the area at the end of 2001 to conduct baseline surveys of fish assemblages within the parks and assess habitat characteristics. It is hoped that the information collected will furnish the BNT with the information they require to establish a realistic management plan for the area taking into consideration local stakeholders and fish species needs alike. This is vitally important as in the past uninformed and unrealistic legislative management enforced has caused a great deal of local resentment (Losada-Tosteson *et al.* 2001).

Currently in it's fifth year, the Greenforce Andros Island Marine Project has completed it's main objective in the northern MRA with the production of this report and provision of a raw baseline dataset (with some rudimentary analysis) to the BNT. It is hoped that these data will subsequently be thoroughly analysed to ensure management decisions are informed and realistic, thus benefiting the region as a whole while avoiding the problems mentioned above. The main aim of this report is to give a performance appraisal to the Greenforce northern MRA project as a whole, and establish it's future direction regarding research camp relocation enabling work to begin in the second MRA.



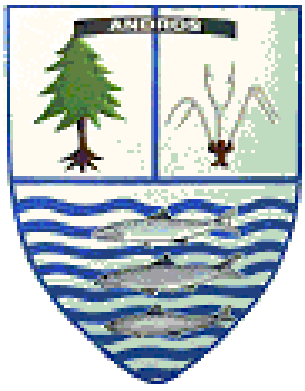


(C)

Figure 1: Area orientation maps for the Greenforce Andros Island Marine Project. (A) The wider Caribbean area with Andros highlighted and expanded into (B) Illustrating The Andros National Park System where green represents terrestrial parks, and red marine parks (north & south). The blue line marks the reef drop-off. Map (C) details the northern park, being the first MRA to be surveyed by the project, and illustrates the locations of both Permanent Monitoring Sites (PMS) and Seagrass survey sites.

Project history

The Greenforce Andros Island Marine Project began in September 2001 in South Blanket Sound on the recommendation of the BNT, in collaboration with the Andros Nature Conservancy and Trust (ANCAT). The project is split into four ten-week phases per year, each of which employs a new group of volunteers that are taught the necessary set of research skills. Initially all volunteers were enlisted from the UK by head office through open days at Universities. During the latter part of 2004 a program was started in collaboration with the Bahamian Environmental Research Centre (BERC) to bring Bahamian volunteers to the camp. Numbers of applicants after the first initiative fell, but it is hoped to restart this program in the near future (see Future Directions). With the establishment of Greenforce USA mid 2005 the Andros project has begun to receive volunteers from North America. For a full breakdown of past phases, together with summaries of work achieved, see Appendix I. As already mentioned above, the project is now in its fifth year.



Official crest of Andros Island

Methods

All methodologies follow the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocols (Kramer & Lang, 2003). For select differences compare 'The Greenforce Andros Island Marine Project' annual reports 2002 (Hughes & White) and 2003 (Chan *et al.*). All survey methods and volunteer teaching protocols have essentially remained the same since these publications.

To summarise, at 8 permanent monitoring sites (PMS), the roving diver technique (RDT) and belt transect methods are used separately to assess fish abundance and size class distributions. Habitat is quantified using both quadrat and line intercept methods which look mainly at coral/algae cover and substrate type. Invertebrate counts (excluding corals) are also conducted, together with rugosity measures to assess topological complexity. At selected shallow sandy sites, sea grass quadrats have also been employed to explore floral and faunal composition of these areas. For a summary of the PMS and sea grass survey sites, see Appendix II.

A further aspect of the project is to aid, where appropriate, the local community. Although this can range from litter sweeps to building renovations, the most important activities are fortnightly visits to Stafford Creek Primary School. These visits have previously focused on environmental education, although recently they have, on the Principles request, been orientated around teaching basic information technology skills to the students. For a complete breakdown of modules taught, see Appendix III.

Results and results discussion

An in-depth baseline dataset has been gathered by the end of 2005, which accompanies this report. Summaries for the data files containing raw data collected can be found in Appendix IV. For total numbers of the main surveys conducted that are contained within these data files see table 1 below.

Table 1: Index & number of surveys conducted within data files at the various sites. Names of the 'T' reef sites give information regarding their depth, where 'A' represents shallow areas (c.7-10m), 'B' mid-depth range (c.11-14m) and 'C' deeper sites (c.15-18m). Surveys deeper than 18m are not conducted.

Site	Fish RDT	Fish Transect	Habitat Transect	Seagrass Quadrat
T1A	97	54	59	N/A
T1B	111	91	59	N/A
T1C	87	72	38	N/A
T2A	113	75	60	N/A
T5B	106	80	51	N/A
T5C	103	70	46	N/A
T9A	59	35	39	N/A
T10B	59	38	31	N/A
S4	N/A	N/A	N/A	81
S5	N/A	N/A	N/A	160
S6	N/A	N/A	N/A	54
S7	N/A	N/A	N/A	113
S8	N/A	N/A	N/A	68
S9	N/A	N/A	N/A	43
S10	N/A	N/A	N/A	93

This report is presented on a CD that contains all the raw baseline data files, together with all past annual and quarterly reports. Rudimentary analysis of data collected can be found within these reports and is the main reason for their inclusion. Of special interest is the 2004 annual report (Knowles, 2005), that conducts a fairly in-depth analysis, which is Included with all of its analytical data files. It should be noted that although it is recognised that valuable information has been extracted through this analysis, the present author does not agree with all the conclusions drawn.

For example, it was concluded (with minimal statistical back-up) that over fishing is a problem within the MRA as seen, for example, with low Nassau Grouper (*Epinephelus striatus*) numbers and their small sizes. Having spoken to a number of local residents and fishers, and from personal observations, it seems apparent that fishing within the MRA is in fact reasonably low, although currently unquantified. For Greenforce data to be used to establish informed management plans, it is urged that robust statistical analysis is employed to reach such conclusions as otherwise many other influencing factors may be overlooked. For example, much of the Andros reef tract surveyed by Greenforce has a relatively low topological complexity, and topological complexity is known to correlate positively with juvenile fish settlement (Lindholm *et al.,* 2001) and adult fish abundance (McClanahan 1994). Alternatively increased nutrient loading leading to eutrophication and greater turbidity could be influential. Furthermore, many fish (including *Epinephelus striatus*) spawn in aggregations that occur away from their normal territory (Castro 1997), and overfishing of these aggregations has quite possibly caused the declines in numbers seen around Andros (as suggested by Humann & Deloach 2002). Although legislating fishing restrictions on *Epinephelus striatus* within the MRA may well temporarily benefit the existing individuals it avoids protecting the recruiting population during their most vulnerable times and does little to aid population recovery. For this, ideally spawning grounds would be located and protected instead.

Reaching objectives

It has been noted by past science staff that the project was reaching it's first primary objective, i.e. the collection of baseline data within the northern MRA, back in 2004. However, it hasn't been until recent phases that survey numbers have reached sufficiently high numbers, that of thirty replicates or more for each treatment (Field, 2000), for the dataset's desired use. The only exception to this are the rugosity surveys, a fact that is seen to be acceptable because the results they yield relating to topological complexity have a low amount of variance and appear representative (pers. obs.). Additionally these surveys produce an ultimate mean topological complexity figure for each survey site, and so would not be used as separate replicates within an analysis. For these reasons, this first primary objective has now been reached.

The secondary objective of the project was to aid in the production of habitat maps for the MRA by ground-truthing GIS (Geographical Information System) rendered aerial images (Figure 2) in combination with landsat data. Although an initially exciting part of the project, the most recent attempt to fulfil this goal has been through talks with the College of the Bahamas (COB). Unfortunately political considerations and logistical delays have meant the much talked about pilot study, has remained unproductive. It has since been established that reasonably detailed habitat maps of the MRA (and the Andros reef tract as a whole) have already been produced for the area by The Nature Conservancy, the University of Miami and also by teams from the American Natural History Museum. This means that although any future work related to this topic will not be turned down it should no longer be seen as an unfulfilled objective and stop the project's work moving forward. Our habitat data at the PMS are detailed, and on agreement with the BNT, can be shared with any legitimate party.

However, the Greenforce Andros Marine Project is still in discussions with COB as to whether there is any work they feel Greenforce can contribute towards, either in the northern MRA where our efforts have up until this point been focused, or the southern MRA where it is planned to focus our efforts in the near future (see Future directions).

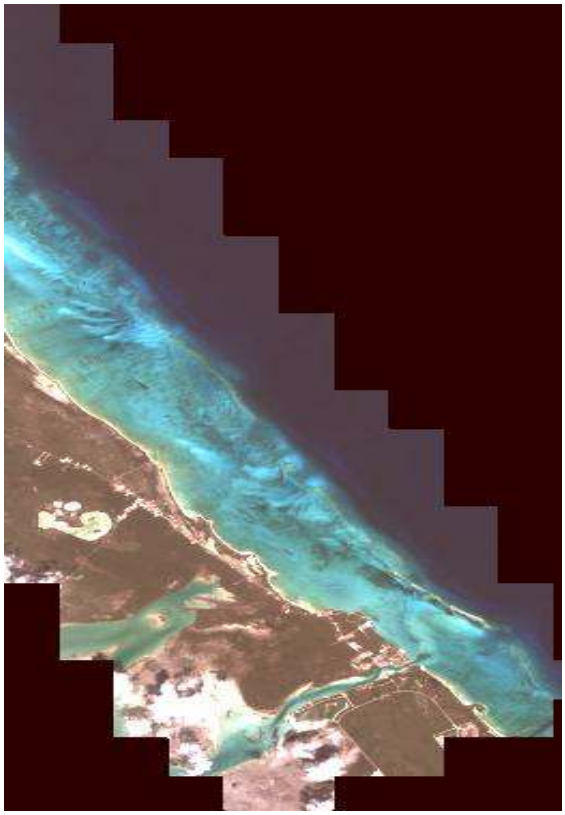


Figure 2: An example of an aerial photograph of the southern MRA that would be rendered into GIS software and ground-truthed through field surveys to confirm habitat types at specific locations.

Project appraisal

As a unit, the first half of the Greenforce Andros Marine Project, although taking longer than originally thought to complete has been a success. A large baseline dataset has been collected with good rapport established with local organisations, and an increasing level of integration within the local community. There are however a number of issues that should be addressed when considering the future directions of the project.

Dr Mark Spalding, during a short visit he made to the camp during 2003, raised a number of points that will be addressed first (see Appendix V). Some of the points raised have been dealt with to a certain extent, although others remain to be addressed which are discussed below.

- **Local Education:** Although the school visits have been well received and successful, there was an initiative set up to bring Bahamian volunteers into the project to learn the diving and scientific work conducted, which fell somewhat by the wayside very soon after it began. This involved BERC selecting young local volunteers and providing a small scholarship to cover their basic expenses. Greenforce funds covered the rest. After the first Bahamian volunteers this initiative slowed to a halt and no more joined camp. There were various reasons for this, including the young Bahamians finding it hard to acclimatize to living conditions on camp and lack of applicants. This scheme is seen to be highly valuable for both existing staff and volunteers, all-round integration with the local community and to the Bahamian volunteers educational development. It is also important to consider the long-term implications of such an initiative, because when Greenforce are finished with their work on Andros it would be beneficial for the MRA's to have a permanent monitoring scheme put in place to assess the effects of any future legislation that is established.

- **Scientific Thinking:** An important point raised was how well read the recruited scientists are and what materials they have access to. With a project such as this it is unavoidable that most of the scientific team will be reasonably fresh graduates/postgraduates looking to gain that all important experience. Indeed, as Dr Spalding points out, this is an extremely good opportunity for such people to learn and develop. Such an opportunity is going to be partially wasted if up-to-date scientific research isn't made obtainable, and thus far this has been the case. Greenforce need to consider registering with online journals to allow this to happen, although another option would be to register with COB and have access to their online materials.

  Following on from this, ideally the science staff would have more time to delve into such materials and analyse data. As Dr Spalding states 'Quick looks at the end of the day after entering data when tired and hungry are no good. If possible this might be done by relieving them of other duties e.g. compressor use.' This would give other staff extra work, but be highly valuable to the long-term goals of the project. Logistically however this is now very impractical because staff numbers have been cut from the previous complement of four (expedition leader/dive instructor, chief scientist, dedicated dive instructor & assistant scientist), to three. Over the last two phases there has been no dedicated dive instructor that has lead to an increase in individual workloads thus negating any possibilities for the science staff to explore findings. In the following phase the assistant scientist is also a dive instructor, thus potentially doubling their workload. Of all the suggestions raised here it is implored that this be an area to address immediately by the London headquarters. As stated by Dr Spalding 'I think a lot more could be done with additional support from London, (supplying papers and reports for the scientists), but also with a few changes to the workload of the scientists'. Presently in seems that more than a few changes are needed. Aside from the staff situation being in breech of the original Greenforce proposal to the BNT (Greenforce 2001), the two issues are intrinsically connected and must

be properly qualified if the project is to move forward in a positive direction to the new site.

- **Broader Directions:** In an ideal world it would be valuable for Greenforce, as 'The guys in the field', to study as many aspects of the local marine environment as possible. For example, studies into the mangrove areas could become crucial to getting the coastal region added to the area covered by the MRA - although it is already well documented that mangroves are important areas for fish and other animals, coastal defences and nutrient sinks (Barnes & Hughes 1999). This is the reason that mini-projects are encouraged throughout the phase, especially during bad diving weather. However, in real terms, most volunteers come to the project to dive, and snorkelling around in less than a meter of murky mangrove water doesn't do much to inspire. All the science staff can do is to actively encourage volunteers. One possible solution to this, if such studies would truly be valuable to the BNT, is to introduce the concept during volunteer recruitment days, or actively write it into their schedules once on camp.

  Another broader direction detailed in the original Greenforce proposal to the BNT (Greenforce 2001) that was never set up, is the monitoring of ambient environmental parameters including salinity, turbidity and light intensities. This information would be highly valuable during data analysis, and it is unfortunate that such activities were not undertaken. There is a secchi disc on camp that can be used to measure turbidity (water clarity), but the present author has not found any references to results from its use. It would also be beneficial to have the means to sample nutrient levels in the water, likely to be highly influential on coral/algae balance. It is possible that much of this information might be available from AUTEC (U.S. military base on Andros), although attempts to find this out have so far been fruitless. An alternative would be to have the ability to collect such variables ourselves.

Although not part of the original Greenforce proposal to the BNT it was quickly realised that for our data to be more valuable as part of a management tool it would be essential to establish out-of-park sites: I.e. Survey sites outside the MRAs. Such sites, effectively outside protection from present or future park legislation, would highlight the effect such legislation is having on the ecosystem. This allows subsequent legislation changes to be made in an informed manner. Such sites were recognised to be so important that in November 2002 two PMS were dropped from the survey schedule (see Appendix IV for justification), and methodologies were streamlined to allow time to be freed up to find and begin studies on such out-of-park sites. Indeed two such sites were located (named ON1 and ON2), and preliminary surveys conducted. However, the use of these sites was not continued. It is reported that the reason for this was budget related. Such sites have to be located a sufficient distance away from MRA boundaries to negate any 'edge effects' – the effect that park legislation has on park boundary areas. The distance suggested to reduce any such effect is greater than c.1km. This extra distance to travel, combined with boat capabilities in less than favourable weather, culminated in the need for more boat fuel, an increase that wasn't accounted for in the subsequent budget from London. Requests for a moderate increase in the boat fuel budget were not authorised, ultimately leading to the out-of-park sites being dropped (K. Knowles, pers.comm.).

Fuel and accessibility issues also come into play when considering the further away PMS (T9A & T10B), which inevitably get surveyed less. Inequality in survey effort isn't ideal when conducting research and needs to be addressed when looking at the projects relocation and future study of the southern MRA. The response from our London office when addressing such concerns was for the project to sacrifice other survey dives to save fuel for these further away sites (including ON1 & ON2), thus reducing the diving undertaken by volunteers (M.Colmer, pers. comm.). Staff repetitively saw such a situation as unacceptable because of the substantial fee volunteers pay to take part in the project. The solution to this issue would be a moderate increase in the field

budget, allocated specifically to cover fuel increases that allow out-of-park sites to be visited. This has been unsuccessfully suggested before.

As a unit data collected are in-depth and reliable (pers. obs.). Volunteers are trained to the highest standards, being required to pass computer identification tests and underwater tests with 100% accuracy. It is seen that this is essential to be able to justify the validity of our results. However, a couple of areas need to be addressed.

- **Data comparability:** Habitat surveys, together with fish belt transects, are conducted in the general vicinity of a GPS point that marks the PMS (with RDTs covering an area with a diameter of c.150m around this point). This therefore produces baseline data giving the general characteristics of the area once all replicates have been combined. Because the surveys did not take place in the exact same area, habitat characteristics cannot be directly compared to fish assemblages. This fact was realised during 2004, and an effort made to correct the methodology. A marker was placed on the seabed at the GPS point, and surveys conducted a short distance from it in a set direction. This saw the projects objectives move away from baseline data collection, aiming more at a long-term survey effort to look for temporal variations among variables (i.e. interactions between habitat and fish assemblages). Results from this sampling effort however could not be compared with past results that employed a randomly distributed design, and unfortunately the point at which this methodology changed was not formally recorded in the data files. Furthermore, observations in the field show that although the new design attempted to look at fixed locations, in reality different areas were being selected by the volunteer researchers to conduct their surveys. This could have been rectified by establishing permanent transects at each PMS, although it is unadvisable to do so halfway through a project. For this reason, and because the surveys conducted were essentially (if not intentionally) random, the original methodology was returned to and all data once again classed together as baseline.

In the future such implications need to be realised from the beginning if detailed interaction analysis are to be attempted. The present data can be used to look at temporal changes within the PMS as a whole (i.e. Is coral cover generally increasing?), although they cannot be used to infer why such changes are happening on a microhabitat level. This alteration of survey technique, and thus output direction, has caused some confusion to successive staff regarding comparability with previous data, reasons for change considering original objectives and the overall value of this shift. With legislation in place and baseline data collected from the two MRAs and out-of-park sites, the consideration of a permanent field station with permanently set transects (ideally staffed by local scientists and volunteers), would be valuable. This issue should be raised once survey work within the said areas approaches completion.

- **Roving Diver Technique (RDT):** Although this survey method is valued as a rapid reef assessment tool providing fish sighting frequencies and relative abundances, also collecting information on rarer species (Schmitt, 2002), it doesn't give the quantative results that belt transects provide. Our RDT data are subsequently passed onto the Reef Environmental Education Foundation (REEF) and so contribute to a wide reaching research initiative, however it might be beneficial to concentrate more on belt transects and habitat surveys to provide a larger amount of quantative data for our host country partners.

- **Replication:** When the number of survey sites were cut down from ten to eight, using cluster analysis to ensure the remaining sites represented a spread of habitat types (see Appendix VI), it would have been advisable to keep the same number of PMS across the three depth ranges thus giving equal replicates of each (i.e. nine sites, with three of each depth). This would be favourable when conducting future

statistical analysis, as it allows a better quantification of any depth effect. It is suggested that when planning research in the southern MRA this be considered. This is especially relevant as the reasons given for dropping the number of PMS down to eight were never satisfied.

- **Survey Effort:** Although it can be problematic with some survey sites being more accessible than others in unfavourable weather, it is advisable to keep survey effort as constant as possible across survey sites to ensure robustness of statistical analysis. This consistency should be temporal as well as generally numerical, although is not necessary to apply between incomparable survey sites (e.g. Seagrass sites and PMS). One way to alleviate this problem is to ensure sites chosen in the future are not located so far from camp as to cause visitation problems as with T9A & T10B, whose increased distance have made them suitable to visit only on very calm days with specially reserved boat fuel. They consequently suffered an approximate 50% drop in survey effort.

Future directions

Although many of these points have inevitably been mentioned elsewhere in this report, it is seen important to reiterate them again as way of a conclusion.

The first and foremost objective to reach is the handing over of baseline data, that being for the northern MRA PMS and seagrass sites. The dataset accompanies this report, and although there will be inevitable collection of subsequent information between the production of this report and the movement of the Greenforce camp to the new study area, it should be treated as an ultimately complete picture of the MRA PMS while the project was present. From here, these data are being handed to the BNT, and it is vitally important that they are adequately analysed to enable them to formulate a realistic management plan for the area. It would seem sensible to leave such a task to a PhD candidate, with data analysis forming a fundamental part of their thesis. This would also allow the candidate to visit the study area through Greenforce and get first hand experience of the area and organisation, including study criterion. Such an arrangement could be made with the University of Miami, or COB, to keep things in local hands.

It would be of great value to re-establish the initiative with BERC to bring Bahamian volunteers onto camp for ten-week periods. Discussions are currently underway to forward this.

Because our baseline dataset is complete and habitat maps are no longer seen to be an essential part of our work (E. Carey. Pers. comm.), it is now time to refocus our efforts within the Southern MRA and begin survey work. Plans regarding this are underway, and potential sites for our research camp to be located are currently being looked at. Of these, an area in Davis Creek has been chosen by staff as the most suitable. Peter Douglas (ANCAT) is currently in discussions to secure this site for our purposes, with initial survey duration lasting three years. The objective is for this move to have been completed by the end of 2006, with camp set-up beginning July 2006, and the

first phase of volunteers arriving at the new camp in October 2006. This first phase will finalise camp amenities and establish the new PMS. The next annual report will document the progress of this move.

It will be vitally important to establish out-of-park sites at the next camp location. By positioning the sites north of the southern MRA they will fall in between the new study area and the present one, thus being relevant for both MRAs. Both habitat and fish assemblage surveys will have to be conducted studies at these sites, and on completion an important gap in present data will have been filled. It is further suggested to give consideration to setting up permanent transects at both these out-of-park sites and new PMS within the southern MRA. This will give much greater flexibility during data analysis.

As part of the 'bad weather' initiative it has been suggested by BERC that Greenforce become involved with a creek restoration project behind Davis Creek (provided this is the finalised location for the new camp). This will be a valuable aspect of the project because volunteers can take part in the work before they pass their fish tests as only eight species are used as bio-indicators of creek health. The majority of current bad weather mini projects require completed fish tests and so are restricted to the latter six weeks of a phase. Currently windy days early on in a phase are fairly unproductive. Further bad weather work has been suggested relating to sustainable tourism on Andros, although details have yet to be discussed.

It is vital, especially when Greenforce move camp, to keep up contact with the local community. It is essential this continues at the new camp location. A number of involvements have been suggested both by ANCAT and BERC including work in an as yet uncompleted local library, and the local high school. It should be considered by the project to commit to one afternoon a week to such work, as opposed to the current one afternoon a fortnight: such work is highly valuable to the local community and Greenforce volunteers alike.

Conclusion

The first half of the Andros Island Marine Project, looking at the first of two Marine Replenishment Zones, has been a successful and rewarding experience for all involved. However, during the study period many lessons have been learnt and issues overcome. It is hoped that these experiences will prove a positive influence when the second half of the work begins in the coming months and camp is relocated. Of all the issues raised in this report it is suggested that the most important one to address at the present time is that of staff numbers and workloads. Time must be given to the scientists to allow them to conduct preliminary data analysis and assess the success of work being carried out. This allows any necessary changes to be made to the work along the way, rather than making nasty discoveries when the project draws to a close. Dr Mark Spalding first raised this point in 2003, and it still remains un-addressed, with the situation actually becoming worse due to the reduction London have recently made to staff numbers. It is hoped that this report will rectify this situation, as not only is it in breech of the original research agreement with the BNT, but overstretched staff are less likely to inspire the volunteer researchers and more likely to make mistakes. Furthermore annual reports containing detailed analysis of data will not take over six months to produce (i.e. Knowles 2005), and this current report would contain an analysis of it's own.

Appendix I – Phase dates and brief description.

Phase	Code	Date	Description
1	BA014	Oct-Dec 2001	Initial camp set-up
2	BA021	Jan-March 2002	Continued work finalising camp set-up. Initial study sites established and methodology pilots/appraisals conducted. Study sites reduced from ten to eight (see appendix IV).
3	BA022	April-June 2002	
4	BA023	July-Sept 2002	
5	BA024	Oct-Dec 2002	
6	BA031	Jan-March 2003	Study sites (PMS – Permanent Monitoring Sites) now established and full scale surveying underway. Introduction of sea grass surveys. School visits began during BA034.
7	BA032	April-June 2003	
8	BA033	July-Sept 2003	
9	BA034	Oct-Dec 2003	
10	BA041	Jan-March 2004	Continuation of surveys. School visits started to take on a more topic-orientated basis.
11	BA042	April-June 2004	
13	BA043	July-Sept 2004	
13	BA044	Oct-Dec 2004	
14	BA051	Jan-March 2005	Continuation of surveys and school visits. Collection of baseline data completed by the end of BA054, with considerations being made into relocation of camp.
15	BA052	April-June 2005	
16	BA053	July-Sept 2005	
17	BA054	Oct-Dec 2005	
18	BA061	Jan-March 2006	See contents of this report.

Appendix II – Site coordinates and details

Site type	Site Name	Depth (m)	Latitude	Longitude	Description
Reef Survey Sites (PMS)	T1A	6-9	24 54.002	77 52.968	High profile reef. Most coral structures rise more than four feet off the bottom. Sand between.
	T1B	15	24 54.000	77 52.685	Mixed profile reef. Some areas of high topological complexity.
	T1C	18	24 54.000	77 52.625	Low/Mixed profile reef. Some moderate topological complexity, but also many sandy areas.
	T2A	6-9	24 53.672	77 52.774	Mixed profile reef. Some areas of high topological complexity.
	T5B	15	24 52.667	77 52.693	Mixed profile reef. Some areas of high topological complexity
	T5C	18	24 52.679	77 52.642	Mixed profile reef. Many areas of high topological complexity, some sand.
	T9A	6-9	24 51.333	77 51.855	Low profile reef. Limited topological complexity and a lot of sandy areas.
	T10B	11-13	24 51.000	77 51.534	Mixed profile reef. A few areas of high topological complexity.
Sea grass	S4	2-5	24 53.422	77 54.450	Sandy / Sea grass
	S5	2-5	24 53.645	77 54.247	Sandy / Sea grass
	S6	2-5	24 53.337	77 53.775	Sandy / Sea grass
	S7	2-5	24 53.337	77 54.045	Sandy / Sea grass
	S8	2-5	24 53.511	77 53.947	Sandy / Sea grass
	S9	2-5	24 52.446	77 53.260	Sandy / Sea grass
	S10	2-5	24 52.753	77 53.250	Sandy / Sea grass

Appendix III – Local School teaching modules

Phase	Code	Date	Description
9	BA034	Oct-Dec 2003	Introduction to Greenforce. Who we are, what we do. Why we do this. Oceans. Surveys. Moon & tide.
10	BA041	Jan-March 2004	Special creatures of the sea. Included Turtles, Conch, Groupers and Corals. Why are they special and how can we help them?
11	BA042	April-June 2004	Zonation of the seas. Focusing on different areas of the sea from reefs to sea grass beds. Culminated in a wall display of student's pictures.
13	BA043	July-Sept 2004	Summer Break
13	BA044	Oct-Dec 2004	Garbage: Land, sea and air. Why is garbage bad and what can we do about it? Culminated in a successful school play illustrating the issues.
14	BA051	Jan-March 2005	Invasive species. What are invasive species, why are they bad, how do they get here and what can we do about them. Can they be good?
15	BA052	April-June 2005	Save our Seas. Threats to the oceans, where they come from and solutions. Can one person help?
16	BA053	July-Sept 2005	Summer Break
17	BA054	Oct-Dec 2005	Habitats of Andros (Bringing together past modules). Discussing which habitats are special on Andros and why. Are they unique and how can we protect them?
18	BA061	Jan-March 2006	Computers pt1. Introduction to word and computer art – 'write and draw a picture about your favourite animal, plant or person on paper and then reproduce them on the computer.' Will be continued next phase.

Appendix IV – Raw data summary

There are eight Excel files containing raw data that accompany this report. These datasets represent all the useable survey information collected since the project began. Specific details of each file follow, along with some notes aimed to help with future analysis. On the accompanying CD files names are those in bold below, with a suffix of 'BNT 2005'.

'Fish – Transects' Raw data from belt transects used to survey fish assemblages. Three full years of information is included, from phase 6 (BA031) until phase 17 (BA054). Surveys conducted in 2002 have been discarded due to concerns relating to their validity. For example, phase 5's (BA024) size estimations appeared somewhat elevated, as described by K.Knowles in the 2004 annual report. It is felt that three full years of survey data are sufficient for any subsequent statistical analysis, and it is advantageous to discard questionable information. These data are especially useful for calculating quantative fish numbers and biomass indicies, together with assessments of fish population size class structure for individual species. This data file also contains a survey summary sheet detailing specifics for each survey (date, tide times, current etc): empty cells either indicate the survey was part of a survey 'pair', carried out on the same dive as the previous survey; or represent lost information. A season summary sheet has also been added to give quick access to the temporal spread of surveys.

'Fish – RDTs' Raw data from surveys using the 'Roving Diver Technique'. These data, covering a four year survey time span cannot easily be converted into quantative information due to individual surveys covering an unspecified area. However, this survey method gives reliable fish species abundance categories and sighting frequency results, is likely to provide results for rare species, and complements the transect survey method mentioned next

(Schmitt *et al.* 2002). It is also useful as a species presence/absence indicator for each survey site. Care should be taken when analysing this information because more cryptic species, such as Blennies, Gobies and some Damselfish may elude surveyors, or at least a percentage of their population. Brief analysis has been included in this data file relating to sighting frequencies across all study sites during 2004, and presence/ absence of species at individual study sites for the same year. This data file also contains a survey summary sheet detailing specifics for each survey (date, tide times, current etc): empty cells represent lost information

'Habitat - Transects' Raw data from line intercept transects assessing substrate and coral cover. These data are excellent for assessing percentage cover of hard corals, sand, rubble and other non-living hard substrate at each survey site. Also included are data relating to coral disease and bleaching. When analysing this datasheet it should be noted that slight changes to variable collection occurred at the beginning of phase 5 BA024, which will need to be taken into consideration. These changes involved how coral cover and species present were recorded. This data file contains the survey summary sheet for these transects, which is also applicable to the subsequent two habitat survey files (empty cells represent lost information).

'Habitat – Algae Quadrats' Raw data from habitat survey algae quadrats. Survey summaries (times, dates etc) can be found in the previously described data file. Number of algae quadrat surveys varies from number of intercept transects due to a small number of volunteers having problems collecting all the information within the allotted time frame. These data provide valuable insights into macro-algae cover at the survey sites together with additional coral information assessing numbers of recruiting colonies. It should be noted however that network algae and small Octocorals were only assessed from phase 12 onwards (BA043).

'Habitat – Invert Counts' Raw data counts from invertebrates around the intercept transects. Survey details (times, dates etc) can be found in the intercept transect data file. Survey numbers are reduced due to survey time

constraints experienced with slower working volunteers. Caution should be taken when using this information for analysis because teaching volunteers to accurately identify the long invertebrates list is questionable, as is their ability to adequately survey the required area thoroughly in the restricted survey time frame. These data should only be used as a tentative presence/absence guide for invertebrates at each survey site.

'Seagrass Quadrats' Raw data from seagrass surveys conducted between phase 6 (January 2003) and phase 14 (January 2005), thus representing a two year study period. These data where collected at a number of sites established in addition to the permanent monitoring sites visited for all other survey methods. The dataset provides important information relating to the abundance and distribution of different plant species found at the sites, together with additional information regarding juvenile fish species and invertebrates. It should be noted that the methodology used was updated during phase 13 to encompass a third plant species (manatee grass *Syringodium filiforme*), in addition to the original two (turtle grass *Thalassia testudinum* & midrib seagrass *Halophila baillonis*).

'Species List' Raw data looking at species (fish, invertebrates and turtles) sighted throughout each phase of the project, irrelevant of their location (i.e. during all excursions into the ocean in our vicinity). This assessment began during phase 10 BA041, but data from a number of phases has been left out because the science staff at the time considered recording of information by volunteers to be incomplete. This list should be used as a presence/absence indicator for the local area of ocean, from Stafford Creek to Staniard Creek.

'Rugosity Indices' Raw data and brief analysis of topological complexity across main study sites.

Appendix V: Condensed Version - Mark Spalding: Thoughts on Greenforce Bahamas following field visit 19-21 March, 2003

This was a short visit. I was really impressed by the whole show, the leadership team, the volunteers, and the entire team spirit. From what I saw the scientific skills of staff and volunteers seemed to be of a very high level indeed. I'm extremely grateful for the generosity and warm welcome I received

The following are a set of thoughts and suggestions based on a short visit. They are meant to help, not to frustrate or annoy. Of course I only spent two days with the team, which means I perhaps didn't get a clear picture of things. I arrived at the end of a phase which meant that the volunteers were well trained and things were running smoothly, but of course it also meant, I think, that people were tired. Anyway have a think about all of this.

Scientific thinking

The science staff should try to find the time/space to think about the science as they go along. This would be very valuable for the scientific staff, and for the volunteers. At present I am a little worried that numbers are being poured into a computer but not really getting thought about until the end of a year. Working like this (and it is a common fault among scientists) can lead to missing some valuable leads which, with a few tweaks to their work, could lead to some exiting new findings. As it was, it was very difficult for me to even see the data that were being entered, and impossible to put these into any context.

If the scientists can have the space to think scientifically without the pressures of just "getting all data in" or "having to refill all the dive tanks before dinner" it will really help them to develop as scientists. It will also help raise the standards of the work, and it will enable them to communicate and educate the volunteers better not only on the generalities of what they are doing but on

what they have learned from data gathered at the end of a day, or a week. This will also help Greenforce to engage more confidently with the NGO community in the Bahamas.

Suggestions:

- They need time to do this. Quick looks at the end of the day after entering data when tired and hungry are no good. If possible this might be done by relieving them of other duties e.g. compressor duty, or by training selected (or all) volunteers to do the computer side of data entry (with checking and supervision as required).
- They could automate at least some of the analytical process so that after entering each new set of results a couple of quick graphics could be automatically produced which allow them to see how those fit with previous results or with other areas.
- The scientists also need to be better informed/well read. This is a tremendous opportunity for them to learn as well as teach. Greenforce UK must supply copies of latest papers. Also non-published reports by others which could provide inspiration and ideas for data gathering and analysis.

Local education

The field team generally should try to engage more with local Androsian people. Of course I didn't get the full picture of what they have done, and I know there has been a start with at least one school visit, but in two years I suspect this is not enough. This is not only good conservation practice, but will also be critical for the long-term acceptance of what they are doing. Without it there is a real risk that they will become regretted, as expat scientists putting little into the local community.

Suggestions:

- Training Androsians to dive and do the science. It would be very low cost to offer a place to one or two locals per phase, the challenge is to find good people. I think the NGOs would help if they too were more engaged
- Talking with fishers. Would possibly come from [other work].

Broader directions

I think there could be a real value in broadening their studies, geographically and perhaps terms of the questions they are asking. Ideas may flow from improved relations with the NGOs and other scientists. The work you are doing is valuable, but you could probably spend a little less time on it if there were other valuable contributions you could make. For example I think there was some possibility of doing some satellite ground-truthing (with Phil Kramer?). This would be fun, interesting and a useful contribution. Or perhaps developing an assessment of the fishing industry from the nearby villages.

So there's quite a few suggestions, not really on the nature of the science, because I don't think there is a very clear picture of this since the production of the last (very good) report. I think a lot more could be done with additional support from London, (supplying papers and reports for the scientists), but also with a few changes to the work-load of the scientists and a with a major drive to reach out to the local people and NGOs a bit. I suspect a lot of these comments could be applied also to Fiji and Malaysia.

Note: Dr Mark Spalding has worked on coral reefs in over 20 countries. In recent years much of Spalding's fieldwork has focused on the coral reef fish of the Indian Ocean. Spalding worked for the United Nations Environment Programme World Conservation Monitoring Centre, running a major program to map the world's coral reefs and mangrove forests. Spalding also does some of the most detailed research available on marine parks and reserves. This work included several publications, among others *The World Mangrove Atlas, Reefs at Risk*, and in 2001, *the World Atlas of Coral Reefs*.

Appendix VI – Condensed version of PMS reduction proposal.

'Rationale for changes in fish population and habitat survey methodologies, and a reduction in the number of survey sites at Blanket Sound, Andros' (Nov 2002).

The decision was taken during the fourth survey phase at Blanket Sound (Sept 2002) to reduce the number of survey sites within the proposed Marine Replenishment Zone (MPZ[1]).

Survey site reduction

Prior to September 2002 ten permanent sublittoral monitoring sites were regularly surveyed within the proposed MPZ at Blanket Sound, Andros. However, sites outside the proposed area were not surveyed and any observed changes in fish populations and/or habitat condition may be due to regional or local variations, and may not be limited to the MPZ on a spatial scale. This will prove extremely problematic when trying to elucidate any temporal changes observed within the MPZ and will negate any conclusions made as to its benefits. To resolve this problem, sites beyond the MPZ are required with a partial reduction of sites numbers inside. The standard method to reduce site numbers would be based on fish population and habitat data, whereby two sites which support similar communities are reduced to a single site. However, cluster analysis of data to date (November 2002) show no clear intersite differences with regard to coral or fish species composition. A decision to reduce site numbers was made based on percentage live coral cover (Figure1), average water depth and fundamental fish population parameters, which included total number of species recorded for a given site (Figure 2) and individuals m^{-2}.

[1] MPZ later became known as MRA, or Marine Replenishment Area

This resulted in the immediate loss of site 7A which supported the lowest living coral cover and the lowest density of fish per m^{-2}. Also, site 10C supported a low percentage of living coral cover and a low total species count, strongly suggesting its exclusion from the survey schedule. It is felt that the loss of these two sites, along with the removal of Fish Belt Transect survey methodology, will provide a large enough margin within survey periods to allow monitoring to occur at four sites outside the proposed MPZ. The actual geographical location of these four external points is currently undecided, but it must be emphasised that careful planning is required before they are chosen. Factors which need to taken into consideration are:

- Habitat type
- Water depth
- Distance from MPZ boundary
- Local hydrodynamic regime
- Acceptability of site to local and national groups
- Distance from base camp
- Accessibility during low tide

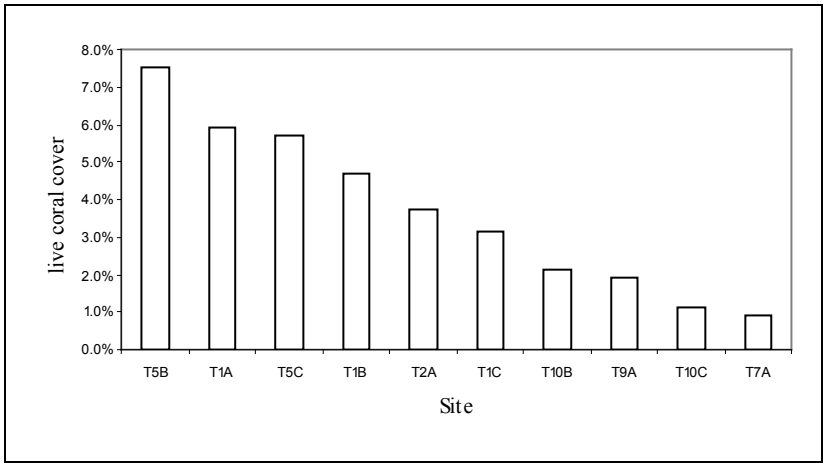


Figure 1. Percentage live coral cover at ten survey sites, Blanket Sound, Andros.

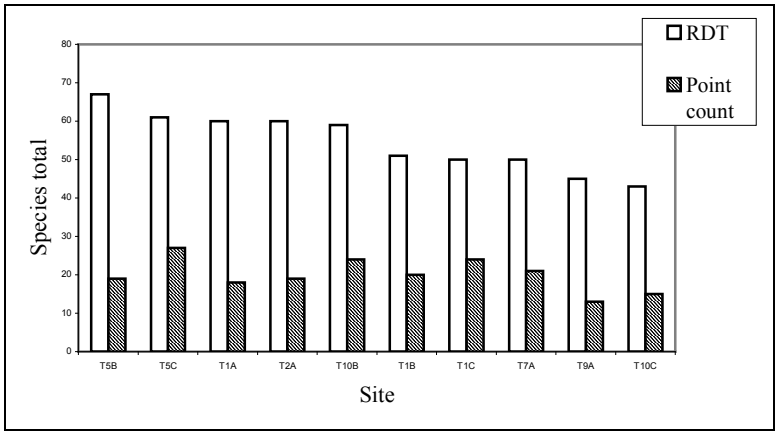


Figure 2. Total number of fish species detected by two survey methodologies at ten survey sites, Blanket Sound, Andros.

It is beyond the scope of this report, and data currently held, to suggest definitive locations for these four new sites. However, it is suggested that sites be located no less than 1km from the MPZ boundary, in areas which support habitat types and living coral cover approaching that within the sanctuary, and within the depths ranges normally surveyed (i.e.5m to 18m) within the MPZ.

NOTE: For a full copy of the above report please contact greenforce@greenforce.org

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