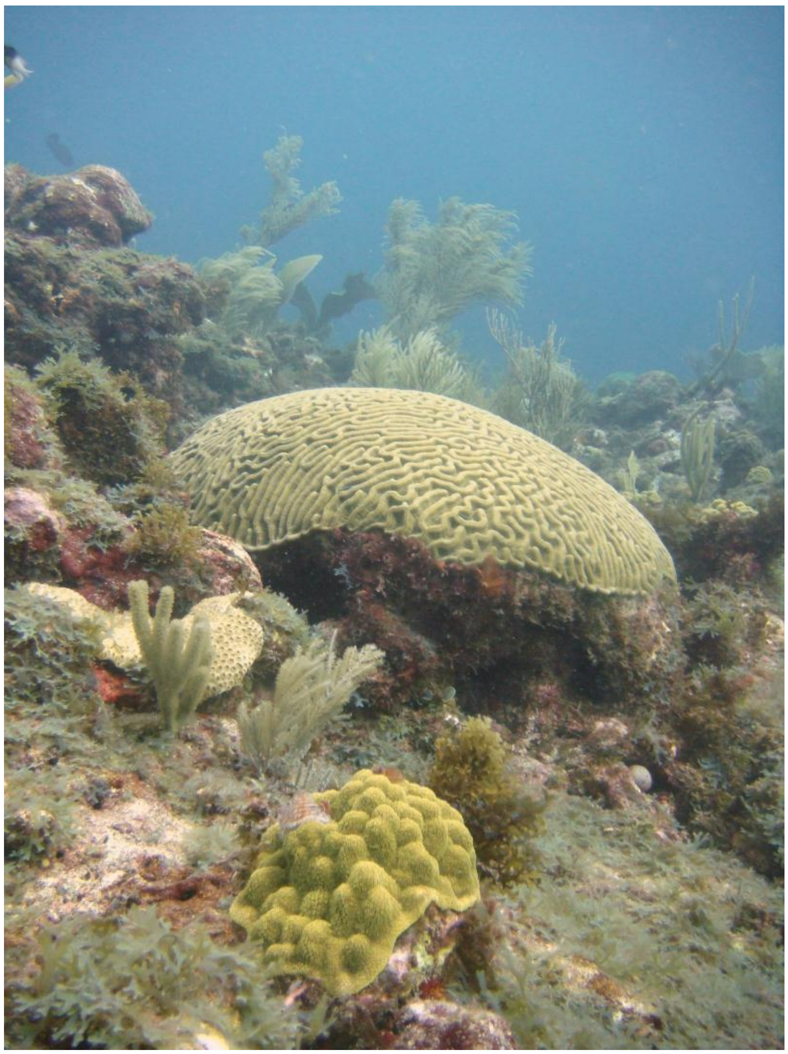
Status of Anguilla's Marine Resources 2010



Based on data collected as part of the Anguilla Marine Monitoring Programme 2007 – 2009

Produced by the Department of Fisheries and Marine Resources for the Government of Anguilla. The conclusions and recommendations of this report are solely the opinions of the author and other contributors and do not constitute a statement of policy, decision, or position on behalf of the Government of Anguilla. Citation: Wynne S. (2010). Status of Anguilla's Marine Resources 2010. 2009 AMMP Report. Copies can be obtained by contacting fisheriesmr@gov.ai. Cover photograph by S.Wynne, taken at Black Garden Reef, Anguilla, September 2009.

Status of Anguilla's Marine Resources 2010

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Executive Summary

The Anguillian Marine Monitoring Programme (AMMP) began in 2007 with a pilot study that served to test methodologies and train staff in survey protocol. Following this, monitoring began at fifteen sites during 2008 & 2009. The main focus of this monitoring was to assess benthic habitats and their associated fish populations, although other aspects of the marine ecosystem were also assessed, including (but not limited to) coral recruitment and water quality. This report uses these data to draw conclusions on the current status of Anguilla's marine resources.

Overall, shallow water benthic habitats (areas less than 15m in depth) are in a poor state of health with low hard coral cover, abundant macroalgae and high levels of sediment covered bare rock with turf algae. Although coral cover has reduced markedly over the last twenty years, macroalgae and 'bare' rock have remained high suggesting that changes from the historical coral reef 'norm', i.e. high hard coral cover and low macroalgae cover, began prior to the 1990's. It is thought that coral cover has been reduced mainly through the proliferation of coral diseases and sporadic bleaching events over the last thirty years. Corals have not recovered significantly from these events because juvenile recruitment is low. This is especially the case on the south coast where eroding reefs have very low hard coral cover and virtually no juvenile recruitment. The variation in coral recruitment around Anguilla is currently unexplained, but it is likely that suspended sediment, organic nutrient input, and other pollution sources play a big role. Northern coastal regions are generally in a better state of health than southern coastal regions, but areas of even moderate health are sparse and generally patchy. Some northern coastal regions appear to be suffering the same fate as the southern coast, but due to reduced wave action erosional processes are slower so reefs are in a better physical state. High macroalgae levels are thought to be predominantly due to increased organic nutrient input, reduced (but recovering) numbers of *Diadema antillarum*, and overfishing of herbivorous species of fish, for example parrotfish. If this situation does not reverse over coming decades it is probable that Anguilla's shallow reef areas will erode away, reducing their potential to support healthy fish populations. This will in turn negatively affect many local livelihoods. As the reef erodes the dynamics of the beaches that lay beyond them will change, which may ultimately lead to their loss or overall general detriment. Thus, the resource that makes Anguilla attractive to tourists is under threat, and as such, especially in light of recent economic pressures, measures need to be taken urgently in an attempt to mitigate against this.

Fish populations in shallow reef areas (<15m) appear to be markedly reduced from those present historically. Large fish are rare with populations usually dominated by small species or juveniles. The mean size of commercially or ecologically important fish species in these areas is 10 to 15cm, with overall abundances low. Certain species are of particular concern because shallow reef areas presently house very low numbers, for example species of grouper, snappers and jacks. Fishers still catch high numbers of these species in areas other than those studied as part of AMMP, but the ability of these areas to sustain such catches is brought into question by the results presented here. There is further concern relating to sustainability because immature individuals of certain commercially attractive species, for example the Coney (*Cephalopholis fulvus* – known locally as the Butterfish) and Hind (*Epinephelus sp.*), are often seen being sold at local outlets.

In terms of other fisheries (for example lobsters and conch) all appear to be under continued threat and a number of recommendations have been made at the end of this report (section 9) to address this issue. A summary of these recommendations is presented on the following page.

- The input of particulates, organic nutrients and other pollutants into the marine environment needs to be avoided at all cost. Although some nutrient load comes from regional sources, local point sources need to be addressed urgently. Salt ponds should not be connected to the ocean as they collect and store organic nutrients. Dunes should not be removed as they trap particulates, restrict sand movement, and act as a sand bank to replenish beaches after storm events. Coastal flora should be protected as it absorbs nutrients carried in rain water runoff and reduces beach erosion. Regulation of septic tank construction is needed that should restrict their proximity to the coastline, and encourage their proper maintenance. The policy guiding development setbacks in Anguilla should be made law or legislated and strictly enforced to achieve this. Beach lighting needs regulating to reduce its impact on nesting turtles, who will also benefit greatly from the protection of natural beach structure. All other potential sources of pollution, including the Corito Bay landfill site, should be fully assessed. A national water treatment facility, including provisions to cater for waste from marine vessels, should be considered. Stricter controls, including greater surveillance and spot checks on holding tanks, need to be introduced to address the dumping of waste water at sea.

- Fisheries legislation needs to be urgently updated to help sustain established fisheries on into the future. This should include (but not be limited to): Changes in regulations relating to spearfishing, including the introduction of catch limits; minimum sizes for certain fish species are needed which will allow juveniles to reach maturity; areas closed to certain fishing types should be considered to allow the greatest possible chance for recovery and the repopulation of surrounding regions; the turtle moratorium should under no circumstance be prematurely lifted and consideration should be given to extending it beyond 2020 (pending full assessment closer to this date); full assessments should be made of the lobster and conch fisheries as current legislation appears insufficient. Conch maturity assessment needs updating to encompass lip thickness rather than shell length and consideration needs to be given to closed areas or closed seasons for the lobster fishery; the crayfish fishery needs similar measures introduced to the lobster fishery combined with a minimum landing size to bring management up to date with current research; the fish trap tagging system already legislated for needs to be enforced and fisheries officers should have the power to issue fines and confiscate equipment.

Note

It is understood that not all of these recommendations are viable at the present time, but it is emphasised that changes need to be made as soon as feasibly possible. This is especially the case for updating fisheries legislation. DFMR also needs continued capacity to conduct surveillance and, when the economy allows, increases in its budget that will facilitate a greater presence on the water to carry this out. Such increases should include provisions for a new vessel that would be dedicated to surveillance and enforcement, crewed by specially trained staff members, and equipped with an enclosed dry wheelhouse to allow these officers to professionally carry out their duties. The existing vessel(s) would then be able to focus on research and other Departmental duties.

Part 1: Introduction

Anguilla (18°12.80N and 63°03.00W), is a low lying coralline island surrounded by a mixture of patch, barrier and fringing reefs interspersed with seagrass beds, sand channels and algal flats. The islands economy is largely driven by tourism and offshore financial services, with fishing only accounting for approximately 2% of its GDP. The majority of fishing that takes place in Anguilla targets reef fish with traditional Antillean arrowhead traps, although some fishers do use hook and line techniques to target particular species (mainly snappers and groupers). Seine nets are used on occasion to land schools of jacks, and spearfishing is currently permitted anywhere in Anguillian waters but only by local residents. There is also a small conch fishery, with most fishers nowadays having to use SCUBA equipment because of the paucity of suitable shallow habitat where conch populations persist. Spiny lobsters, primarily *Panulirus argus* but also the species known locally as a Crayfish (*Panulirus guttatus*), are caught using traps, but a small yet increasingly popular hand-capture fishery also exists where fishers snorkel at night to capture foraging individuals (primarily *P.guttatus*). The most recent detailed synopsis of Anguilla's fishing industry was produced by Biodiversity Conservation Inc. (Lum Kong, 2007).

Despite contributing only c.2% to the islands GDP, it is believed that fishing, combined with other anthropogenic factors, is having a profound effect on the local marine environment. This effect is not however restricted to Anguilla, but is Caribbean wide, with a reported 70% decline in coral cover over the last thirty years (Gardner *et al*., 2003). It is believed that this decline has happened for two reasons: Regional factors, for example unusually high sea surface temperatures causing severe bleaching events; and local factors, for example overfishing. There are potential synergistic interactions between detrimental factors (known as stressors) that may lead to more elevated levels of habitat degradation than one might expect if the stressors were acting independently. Thus, a seemingly minimal action may have a more profound effect on ecosystem health than might be predicted. Even though some of these stressors can't be directly managed locally (i.e. Sea surface temperature), it is probable that stressors that can be effectively management on a local level (i.e. Fishing) may mitigate against the regional ones, especially if synergism is occurring. To accomplish effective management it is first essential to assess the current situation and compare it to historical data, before deciding upon a long-term strategy. It is also prudent to conduct thorough literature reviews to learn lessons and gain insights from other sources.

Unfortunately, historical data in Anguilla is limited. Prior to the 1990's only a small amount of work was conducted that related to the marine environment. The vast majority of these studies were assessments of Anguilla's fishing industry with recommendations for its future prosperity. In 1991, the Department of Fisheries and Marine Resources (DFMR) was established, and the following year five marine parks were created. During this decade only a handful of studies were conducted. In terms of this status report the most notable of these was conducted by the Bellairs Research Institute, Barbados (Oxenford and Hunte, 1990). This study attempted to establish long-term monitoring sites around the island that could be regularly assessed by the newly formed DFMR. Although this sadly didn't happen, the project did yield a 'snapshot' dataset that was able to be used to make a twenty year temporal comparison in part 4 of this report. Another important project conducted during this decade was the long-line fishing project, where considerable funds were put into assessing the viability of a long-line fishery in Anguilla. Although this project concluded that such a fishery was viable and encouraged fishers to move away from trap-fishing no known long-line fishery exists today. Exact reasons for this are not know but likely include the substantial investment needed to switch from a relatively artisanal trap-fishing livelihood to a more commercial pelagic long-line industry, and the absence of a 'proper' fish processing facility on Island.

Following the 1990 study by Oxenford and Hunte, there is very little evidence for the collection of any marine ecological data. A study was completed in 2004 by the Marine Conservation Society that looked into the status of turtle populations, but the majority of the work was based on qualitative information and so no firm figures are available for comparison. Also, a coastal survey was conducted in 2004 that collected data to be fed into a GIS database (designed to supersede the Natural Resource Institute atlas produced in 1994), but no data are available as again the surveys were more qualitative than quantative. Finally, the Reef Check initiative was introduced here in 2001 & 2004, but few surveys were ever completed and no reports produced. It appears to have been treated more as a training exercise for DFMR staff.

The situation changed in 2007 when DFMR began the Anguillian Marine Monitoring Programme (AMMP). This programme is now in it's fourth year, and currently fifteen permanent monitoring sites have been established around the island which are monitored annually. Full benthic surveys are conducted, together with fish censuses. Over the last three years other aspects have been covered through the programme including (but not limited to): Water quality monitoring; coral recruitment studies; and a specific study revisiting the sites surveyed by the Bellairs Institute in 1990. DFMR have also collected baseline data for Anguilla's five Marine Parks (Wynne, 2007a); conducted translocation studies with the Long-Spined Sea Urchin (*Diadema antillarum,* Wynne 2008c); made an assessment of the Crayfish (*Panulirus guttatus*) fishery (Wynne 2009c); and continue to monitor the status of turtle populations at selected in-water sites and nesting beaches around the island (Wynne 2009b). A chronological history of the marine related research conducted in Anguilla prior to 2006 can be found in Appendix 1.

This report is not only an end of year report for the 2009 AMMP season but also seeks to combine all the in-water work conducted by DFMR over the last three years. The different facets of this work have been split into seven subsequent sections, with a final section containing conclusions and recommendations for the management of Anguilla's marine resources for the coming decade. It is essential that if any of these recommendations are to be followed, they must be backed up by a continued monitoring effort that assesses the success of such management measures and adapts to any changes that it brings about. Such adaptive management is vital when managing the marine environment or any other natural habitat. It is hoped that this work, representing the largest amount of ecological survey effort ever conducted in Anguilla, plays a vital role in protecting the marine environment for many generations to come.

Fishing boat with trap for repair – Island Harbour

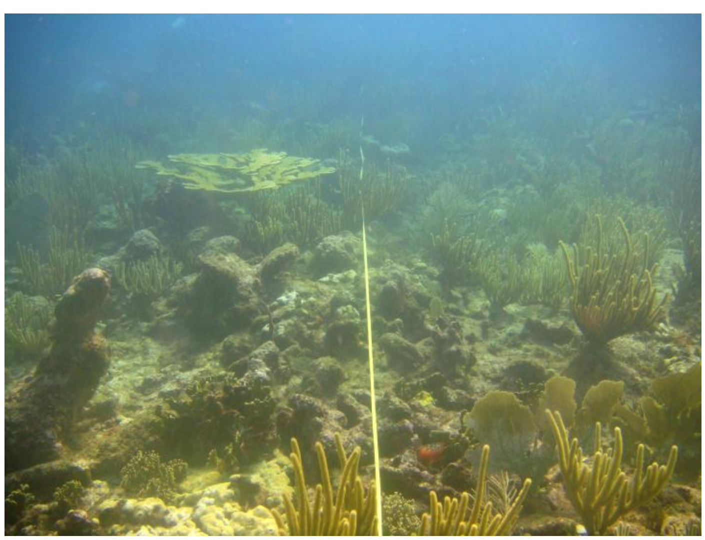
Part 2: Benthic Surveys

Methodology and Rationale

Following on from the pilot study conducted in 2007 (Wynne, 2008a) that tested survey protocol and acted as a training platform for staff, twelve permanent monitoring sites (PMS) were established in 2008. The results from this initial years work (Wynne, 2008b) have been combined in this section with those obtained during the 2009 monitoring season. This serves to provide a robust baseline of these twelve sites, especially important because hurricane Omar hit Anguilla in October 2008. As this was the first hurricane to make landfall in almost ten years, combining what should be 'pristine' 2008 results with post-hurricane 2009 results should provide a good mean 'snapshot' for these sites. It should be noted however that two new reef sites (Sile Bay & Little Harbour) were added in 2009 along with one new seagrass site (Crocus Bay), thus data from these sites only represents the situation post-hurricane. It is not expected however that this will effect long-term analysis of data as these sites did not take a major hit when Omar made landfall. The only site that suffered direct impact was Anguillita, a fact that will be discussed later in this section.

Full methodologies can be found in the AMMP protocol document (Wynne 2007b). To summarise, transects are laid parallel and perpendicular to the reef slope using a permanent marker as reference. At seagrass sites the coastline is used as directional reference. Along each transect quadrats are placed at 5m intervals and percentage cover of biota is recorded. At seagrass sites blade lengths are measured and mean blade number per plant also calculated. Reef sites further undergo line intercept transects that record underlying substrate and take detailed measurements of corals, including incidences of disease (following Kramer *et al.*, 2005). Invertebrate counts are also carried out, and coral bleaching surveys are conducted later in the year as necessary.

Note: There is some cross-over between the quadrat and line intercept surveys (e.g. both record hard coral cover), and because of the nature of such sampling methodologies different mean values will be obtained. It is suggested that if results are to be quoted beyond this report then such results should be combined thus increasing the robustness of the final value.



The transect line – Scrub Island reef site

Results

Table 2.1 – Mean % cover of main habitat characteristics at the ten reef sites for the 2008 and 2009 monitoring seasons combined using quadrat sampling method. It should be noted that sampling at Little Harbour and Sile Bay didn't begin until 2009 and so data for these sites are mean values for one year only. Macroalgae combines 'fleshy algae' (i.e. *Dictyota sp.)* and 'other algae' (i.e. *Caulerpa sp.*), but does not include 'calcareous algae' (i.e. *Halimeda sp.*). Fleshy algae, for all ten sites, was the dominant type. Remaining cover not included in this table consisted of fire coral (*Millepora sp.*), White Encrusting Zoanthids (*Palythoa caribaeorum*), Long-Spined Sea Urchins (*Diadema antillarum*) and other invertebrates. It should also be noted that there may be some cross over with line intercept surveys (table 2.3) – see methodology & rationale.

Site Name	Sand	Turf/ Sediment	Coralline Algae	Calcareous Algae	Macro-algae	Cyano-bacteria	Hard Coral	Soft Coral	Sponges
Anguillita	4.0	81.7	0	0	0.7	3.5	3.9	3.8	2.4
Sandy Island	21.7	53.5	0.5	1.1	5.5	0.7	11.8	1.4	3.3
Long Reef	9.0	64.1	2.5	5.3	3.1	1.7	7.0	2.1	1.1
Limestone Bay	0	56.8	0.8	0.3	27.3	0.4	5.3	3.5	4.2
Shoal Bay East	0.3	63.1	2.1	3.4	19.1	1.1	6.1	2.4	0.3
Island Harbour	2.9	59.6	1.5	4.1	27.3	1.6	0.7	1.6	0.7
Scrub Island	4.5	62.8	2.9	0.2	18.2	0.7	1.4	1.3	0.7
Forest Bay	2.1	79.4	4.7	2.4	8.2	1.0	1.6	0.5	0
Little Harbour	0	82.2	0.8	0.2	10.9	0.2	2.3	1.0	2.0
Sile Bay	14.5	60.5	5.8	1.6	13.2	0.8	0.6	0	0
Means	5.9	66.4	2.2	1.9	13.4	1.2	4.1	1.8	1.5

*sites with over 2% sponge coverage might house highest Hawksbill Turtle populations and as such should be prioritised when seeking new in-water turtle monitoring sites (see section 7). At present only Limestone Bay is regularly assessed.

Table 2.2 – Mean habitat characteristics at the five seagrass sites for 2008 & 2009 combined. Length (mm) is the mean length of seagrass blades and Blade Count is mean number of blades per plant. Calc % refers to the percentage cover of calcareous algae (*Halimeda sp.*) and Other refers to all other types of algae. Cyanobacteria has been grouped with the alga because of its overall appearance, however it should be appreciated that this is in fact a member of a completely different kingdom. Hard and soft corals at these sites are in negligible quantities and so have not been include in the table.

Site Name	Sand %	Turtle Grass			Manatee Grass			Algae			Sponge %
		% Cover	Length (mm)	Blade Count	% Cover	Length (mm)	Blade Count	Calc %	Cyano %	Other %	
Merrywing Bay	0.4	37.2	126	2.9	15.5	116	1.3	9.8	7.1	3.8	0.2
Road Bay	20.6	53.0	142	3.1	0.6	122	2.6	6.7	12.0	6.8	0.1
Little Bay	34.9	36.9	132	3.2	0	n/a	n/a	15.2	5.5	7.3	0.1
Forest Bay	28.3	45.9	134	2.6	21.5	126	1.4	2.1	0.4	1.8	0
Crocus Bay	16.1	57.5	146	3.5	0	n/a	n/a	15.5	0.2	10.2	0.3
Means	20.1	46.1	136	3.1	7.5	121	2.2	9.9	5.0	6.0	0.1

* Turtle Grass refers to *Thalassia testudinum* & Manatee Grass to *Syringodium filiforme*.

Table 2.3 – Mean habitat characteristics at the ten reef sites for the 2008 and 2009 monitoring seasons combined using line intercept sampling method. It should be noted that sampling at Little Harbour and Sile Bay didn't begin until 2009 and so data for these sites are mean values for one year only. It should also be noted that there may be some cross over with quadrat surveys (table 2.1) – see methodology & rationale.

Variable	Angui-llita	Sandy Island	Long Reef	Lime-stone	Shoal Bay E	Island Harb.	Scrub Island	Forest Bay	Little Harb	Sile Bay
Sand % Cover	1.2	19.5	9.3	0.2	0.1	3.3	4.1	0.2	0.0	11.9
Rubble % Cover	0.2	28.8	5.5	6.2	1.6	0.4	5.6	0.0	0.0	0.0
Hard Substrate % Cover	94.0	34.6	70.0	88.8	83.9	95.0	84.1	95.5	96.1	87.0
Hard Coral % Cover	4.6	17.2	15.2	4.8	14.4	1.2	6.2	4.4	3.9	1.1
% Coral Tissue Healthy	97.3	81.1	92.1	98.6	87.7	97.0	96.2	100	94.9	100
% of Colonies 100% Healthy	92.8	45.5	77.6	94.8	75.0	76.4	90.7	100	79.3	100
% Coral Tissue Diseased	0.3	0.1	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
% of Colonies with Disease	1.9	1.3	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0
% Coral Tissue Recently Dead	0.3	2.6	1.0	0.0	1.7	0.9	0.2	0.0	0.9	0.0
% Coral Tissue Long Dead	2.2	16.2	6.9	1.4	10.2	2.1	3.6	0.0	4.2	0.0
% of Colonies with Some Mortality	7.2	54.5	22.4	5.2	25.0	23.6	9.3	0.0	20.7	0.0

Table 2.4 – Mean numbers of key Invertebrates recorded (ha^{-1}) observed at both reef sites (light grey) and seagrass sites (dark grey) for both 2008 & 2009 monitoring seasons Little Harbour and Sile Bay were visited late in the year and so were not included in this analysis in an attempt to avoid biasing results. *P. caribaeorum* refers to colonies (irrespective of size) not individuals.

Site Name	Diadema antillarum	Palythoa caribaeorum	Panulirus argus	Panulirus guttatus	Strombus gigas	Oreaster reticulates
Anguillita	0	200	0	0	N/A	N/A
Sandy Island	730	500	0	0	N/A	N/A
Long Reef	480	1400	0	0	N/A	N/A
Limestone Bay	2380	1450	0	0	N/A	N/A
Shoal Bay East	350	2350	0	0	N/A	N/A
Island Harbour	1150	130	0	0	N/A	N/A
Scrub Island	0	6480	0	0	N/A	N/A
Forest Bay	80	450	0	0	N/A	N/A
Merrywing Bay	N/A	N/A	30	0	30	230
Road Bay	N/A	N/A	0	0	350	250
Little Bay	N/A	N/A	0	0	30	180
Forest Bay	N/A	N/A	0	0	0	0
Crocus Bay	N/A	N/A	0	0	100	200

Bleaching – surveys were not undertaken in either 2008 or 2009 because little or no bleaching was observed during rapid assessments (Sept to Oct each year). This is largely due to water temperatures not exceeding those that reportedly cause bleaching for any considerable lengths of time (Brown *et al.,* 1996). During 2008 temperatures did begin to exceed 30°C but after hurricane Omar had passed they dropped back down to 27-29°C (Wynne 2009a). During 2009 temperatures generally did not exceed 30°C at all. Only a scattering of bleached colonies were observed around Anguilla (<1%) during each year.

Discussion

The results presented in this section do not paint an encouraging picture as to the state of Anguilla's shallow water (<15m) benthic reef environment (table 2.1 & 2.3). On the whole coral cover is low, with reef areas generally being dominated by macroalgae or rock covered in turf algae and sediment. Mean results from combining line-intercept and quadrat methodologies show that only three sites have a hard coral percentage cover higher than 10%, with all the remaining sites around or under 5% cover. This is of concern because without hard coral growth the reef structure will slowly degrade and become less and less able to support healthy fish populations or protect the coastline from storm surges. Of particular concern is the fact that all the sites on the south coast have exceptionally low coral cover (between 1 and 3%) and these areas historically had extensive reef systems, as evidenced by the skeletal remains still present. The reason for their demise is unclear but as they have relatively low levels of macroalgae (between 8 and 13%) it suggests that it is not the coral-algae phase shift that has been reported throughout the region (Hughes, 1994). In fact, looking specifically at these sites (Forest Bay, Sile Bay and Little Harbour), we not only see low coral and relatively low macroalgae percentage covers, but also low covers of other benthic organisms. Although nothing conclusive can be stated at this stage it seems likely that the *Acropora* dominated reefs around Anguilla suffered high mortality from White Band Disease back in the late seventies/early eighties (Bythell & Buchan, 1996) and have only made a very limited recovery to date. The reef areas on the north side of Anguilla maintain a higher percentage cover of hard coral to those on the south, not due to a recovery of the *Acropora* reefs, but due to other coral species growing there. These other species do not occur as frequently on the south coast. Even though this might be in part due to it being exposed to greater wave action, this can't explain the extent of coral paucity as there are many sheltered areas that still do not exhibit higher coral covers. On the whole, the sites in the best condition are those located away from mainland Anguilla.

Montastraea dominated reefs have also suffered huge declines over recent decades and today are very limited in extent. From looking at surviving colonies it seems clear that this mortality is due to Yellow Blotch Disease which is still affecting many of those present in areas such as Shoal Bay East, Island Harbour and Sandy Island. It is believed that coral diseases have been on the increase over the last three decades due to nutrification (Bruno *et al.,* 2003) and other forms of pollution.

As the dominating reef types historically in Anguilla were *Acropora* and *Montastraea* species, their demise over recent decades means big changes for the benthic community. Although the long-term effects of this remains to be seen it is likely that if recovery continues to fail the remaining reef structure will slowly erode and as a by-product fish species composition will drastically change (see following section) and the coastline will undergo significant alterations as erosional processes are gradually modified.

At this stage it is not possible to draw conclusions about the status of the five seagrass sites. Their results have been presented for reference only (table 2.3). This is largely due to the fact that the sites were placed in the middle of relatively dense beds and so change will only be noticed when significant differences in seagrass distribution occurs (in a similar way to temporal studies being needed to confirm how coral cover is changing). What is known is that relatively high amounts of sediment are present covering the seagrass blades, as is cyanobacteria (12%

coverage in Road Bay – possibly due to nutrification). This is not a positive sign for the future. Backing this up is somewhat anecdotal reports that seagrass beds have been shrinking over recent decades and are now not as expansive as they used to be. This can be qualified to a certain extent by referring to the NRI resource atlas produced for Anguilla in 1994 that documents more extensive seagrass beds than are seen today. This may be due to the reportedly severe impact hurricane Luis had in 1995. Damage to seagrasses can often observed, as illustrated by the picture below taken close to Scilly Cay (near Island Harbour – not an AMMP seagrass PMS) that was presumably caused by a twin engine vessel being throttled vigorously in shallow water.

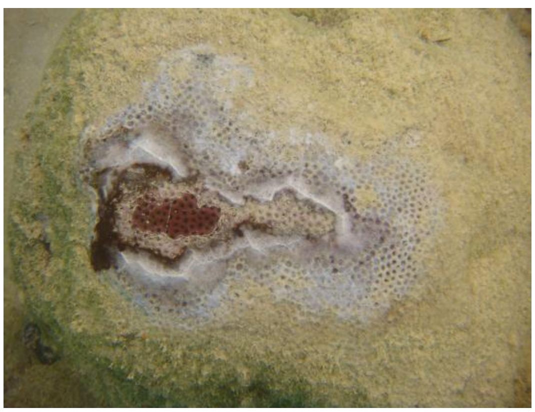
Table 2.4 presents the results of the benthic invertebrate surveys. Only the larger, more significant species have been detailed as the smaller invertebrates are unrealistic to quantify given the time and resources available. The results for *Diadema antillarum*, *Strombus gigas* and *Panulirus sp.* will be referred to in part 8. The other results are presented for reference purpose only.

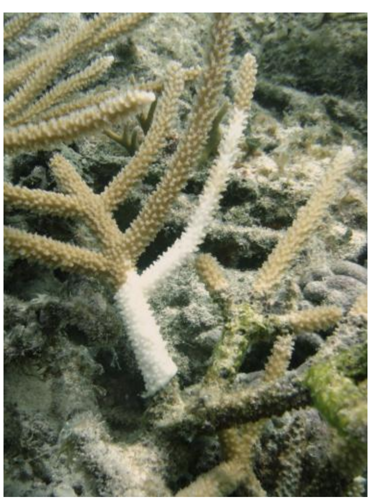
Note: Influence of Hurricane Omar – Generally data from 2008 did not vary greatly from that collected in 2009. The site at Anguillita is an exception however as it took a direct hit and was devastated, being stripped of virtually all soft corals (7% cover down to 1% cover) and other benthic organisms. Turf algae/sediment cover increase by 20% to 92% cover. Long-term monitoring of this site will reveal recovery times for soft coral dominated reefs but the site's exposed nature likely explains it's overall mean characteristics. Such differences illustrate why direct inter-site comparisons must be made with care as the intrinsic nature of each location may vary greatly.

Line-intercept transect surveys at Little Harbour (left) and seagrass quadrats at Road Bay (right)

Picture illustrating damage caused by boat engines to shallow seagrass bed

Examples of coral diseases recorded in Anguilla – Clockwise from top left. Black Band disease on Massive Starlet (*Siderastrea siderea*); Cyanobacteria infection on Lobed Star (*Montastraea annularis*); Boulder Brain Coral (*Colpophyllia natans*) being smothered by cyanobacteria, algae and sediment (possibly an infection); Yellow Blotch disease on *M.annularis;* White Band disease on Staghorn Coral (*Acropora cervicornis*); and unidentified infection on *S.siderea* (possibly cyanobacteria – note only a small area of live tissue is still present).





Part 3: Fish Surveys

Methodology and Rationale

Following on from the pilot study conducted in 2007 (Wynne, 2008a) that tested survey protocol and acted as a training platform for staff, twelve permanent monitoring sites (PMS) were established in 2008. The results from this initial years work (Wynne, 2008b) have been combined in this section with those obtained during the 2009 monitoring season. This serves to provide a robust baseline of these twelve sites, especially important because hurricane Omar hit Anguilla in October 2008. As this was the first hurricane to make landfall in almost ten years combining what should be 'pristine' 2008 results with post-hurricane 2009 results should provide a good mean 'snapshot' for these sites. It should be noted however that two new reef sites (Sile Bay & Little Harbour) were added in 2009 along with one new seagrass site (Crocus Bay), thus data from these sites only represents the situation post-hurricane. It is not expected however that this will effect long-term analysis of data as these sites did not take a major hit when Omar made landfall. The only site that suffered direct impact was Anguillita, a fact that will be discussed later in this section.

Full methodologies can be found in the AMMP protocol document (Wynne 2007b). To summarise, transects are laid parallel and perpendicular to the reef slope using a permanent marker as reference. At seagrass sites the coastline is used as directional reference. Along each transect fish counts were conducted where species of commercial or ecological importance (CEI) occurring within a 5m belt are placed into their respective size class category. This allows relative biomass to be calculated based on fish length. Surveys using the roving diver technique (RDT) are also conducted where a circular path is followed to encompass the whole site, and total counts of all fish species present are recorded. As these counts only record those fish within a 5m belt and a constant swim speed maintained throughout the complete timed survey (30 minutes), densities of each species can be calculated. Although there is some overlap between these two survey types each has its value where transect surveys capture valuable size class information for important species but RDTs capture a complete picture of fish species composition at the site. RDT surveys are also valuable to capture information that relates to lesser common species that transect surveys might miss.

Note: Effort is made to conduct surveys at the same time each season to avoid temporal biasing (April to June – weather depending). Due to logistical constraints the two additional sites for 2009 (Sile Bay and Little Harbour) were not visited until much later in the year and so to avoid biasing results size class transect surveys were not conducted here. Biasing would, for example, be due to growth of juvenile fish that are abundant at some sites earlier in the year.

It should also be noted that when discussing the CEI families the term 'silveries' has been used to generically classify jacks, mackerel, tunas, barracuda, and similar families. This classification avoids the creation of too many family units that may clutter result tables and figures. The grouping 'others' is used in two different ways. First and foremost if refers to large individuals from families not usually targeted by fishers but whom may be considered significant by them due to their size (e.g. boxfishes). Secondly it is used in certain analysis to categorise the grouping together of families who only comprise negligible numbers, and thus, in the same way as the category 'silveries' it avoids the cluttering of data. For example, in figure 3.2 the category 'other' refers to all CEI families other than those listed in the legend (i.e. Goatfishes, angelfishes, butterflyfishes, squirrelfishes, large wrasses and other large individuals of interest such as boxfishes).

Results

Table 3.1 – The seven most common fish species at the ten reef sites for 2008 and 2009 RDT surveys combined. Numbers equate to the mean number of individuals seen during each 30 min survey. Site mean total is mean total number of fish counted during each 30 min survey. The species with a mean abundance higher than 25 were (in order, all sites combined): BHW (93), BTa (65), OcSu (63), StrP (59), BrCh (31), BlCh (30), StoP (27) and RBP (25)*.

Site	Species #1	Species #2	Species #3	Species #4	Species #5	Species #6	Species #7	Site Mean Total
Anguillita	BHW 172	BiD 51	BlCh 46	OcSu 35	BBS 33	RBP 30	FrG 21	652
Sandy Island	BHW 111	StrP 88	BiD 73	BrCh 70	BlCh 67	BTa 42	JuvG 40	814
Long Reef	StrP 123	BHW 88	BTa 81	BlCh 67	StoP 44	BrCh 43	OcSu 41	800
Limestone Bay	OcSu 94	BHW 88	BTa 43	BiD 36	BlCh 32	RBP 30	PrP 29	573
Shoal Bay East	BHW 80	StrP 60	BrCh 42	OcSu 36	RBP 26	StoP 24	JuvG 23	508
Island Harbour	BHW 122	OcSu 67	BTa 55	StrP 54	RBP 30	StoP 28	Steg 27	535
Scrub Island	BHW 133	BTa 128	BlCh 69	BrCh 54	SerM 42	StoP 41	BiD 33	897
Forest Bay	StrP 97	OcSu 80	BTa 79	StoP 28	Steg 17	RBP 10	BHW 9	390
Little Harbour	BHW 79	StrP 63	OcSu 58	BrCh 43	RBP 43	FrG 39	SliD 38	604
Sile Bay	BTa 161	OcSu157	StrP 75	YeG 75	BHW 59	StoP 33	QuP 32	823

*BHW (Bluehead Wrasse – *Thalassoma bifasciatum*), BiD (Bicolour Damselfish – *Stegastes partitus*), BlCh (Blue Chromis – *Chromis cyanea*), OcSu (Ocean Surgeonfish – *Acanthurus bahianus*), BBS (Black Bar Soliderfish – *Myripristis jacobus*), RBP (Redband Parrotfish – *Sparisoma aurofrenatum*), FrG (French Grunt – *Haemulon flavolineatum*), StrP (Striped Parrotfish – *Scarus iserti*), BrCh (Brown Chromis – *Chromis multilineata*), BTa (Blue Tang – *Acanthurus coeruleus*), JuvG (juvenile grunts – *Haemulon sp.*), StoP (Stoplight Parrotfish – *Sparisoma viride*), PrP (Princess Parrotfish – *Scarus taeniopterus*), Steg (*Stegastes sp.* – see paragraph below), SerM (Sergeant Major – *Abudefduf saxatilis*), SliD (Slippery Dick – *Halichoeres bivittatus*), YeG (Yellow Goatfish – *Mulloidichthys martinicus*), QuP (Queen Parrotfish – *Scarus vetula*). Steg (Dusky Damselfish (*S.adustus*), Longfin Damselfish (*S.diencaeus*), Cocoa Damselfish (*S.variabilis*) and the Beaugregory (*S.leucostictus*) – see note following.

Note: During analysis four species of damselfishes from the genus *Stegastes* have been grouped together because differentiating them can sometimes be problematic. These four species are the Dusky Damselfish (*S.adustus*), Longfin Damselfish (*S.diencaeus*), Cocoa Damselfish (*S.variabilis*) and the Beaugregory (*S.leucostictus*). Based on continued observation of these four species, especially from the often easy to identify juvenile phases, it is thought that *S.leucostictus* is the most common species present in Anguillian waters followed by *S.diencaeus, S.adustus,* and finally *S.variabilis*. Two other species from this genus, namely *S.partitus* (Bicolor Damselfish) and *S.planifrons* (Threespot Damselfish) are more reliable to correctly identify and so have been treated separately. Of these two species (and in fact of all *Stegastes*) *S.partitus* is the most abundant, although on certain reefs *S.planifrons* can also be in relatively high numbers, dominating the damselfish community.

Conducting underwater fish transects

Table 3.2 – Mean results from 2008 & 2009 fish belt transects that illustrates size class structure (cm) by percentage (mean numbers per quadrat) for all ecologically and commercially important fish species combined at eight of the reef sites. Little Harbour and Sile Bay were visited late in the year and so were not included in this analysis in an attempt to avoid biasing results through juvenile growth.

Site	<5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50>
Anguillita	5.2	26.2	35.1	18.8	5.7	1.9	3.4	0.2	0.4	3.0	0.2
Sandy Island	44.4	21.7	18.5	8.3	3.7	1.6	1.1	0.6	0.0	0.0	0.1
Long Reef	10.2	45.3	19.0	18.1	3.1	1.3	1.5	1.1	0.1	0.1	0.2
Limestone Bay	33.2	29.3	29.4	4.6	2.0	0.5	0.7	0.2	0.0	0.0	0.1
Shoal Bay East	33.6	32.3	25.4	4.6	3.1	0.7	0.0	0.0	0.0	0.3	0.0
Island Harbour	24.7	37.3	22.8	7.5	3.4	1.6	1.5	0.8	0.3	0.0	0.0
Scrub Island	4.1	9.8	29.5	37.6	11.4	4.1	2.7	0.8	0.0	0.0	0.0
Forest Bay	15.6	26.2	51.5	5.4	1.0	0.2	0.1	0.0	0.0	0.0	0.0

* notes: Anguillita, Long Reef, Limestone Bay were very different between years – these differences will be interesting to explore over subsequent years as the dataset increases temporally

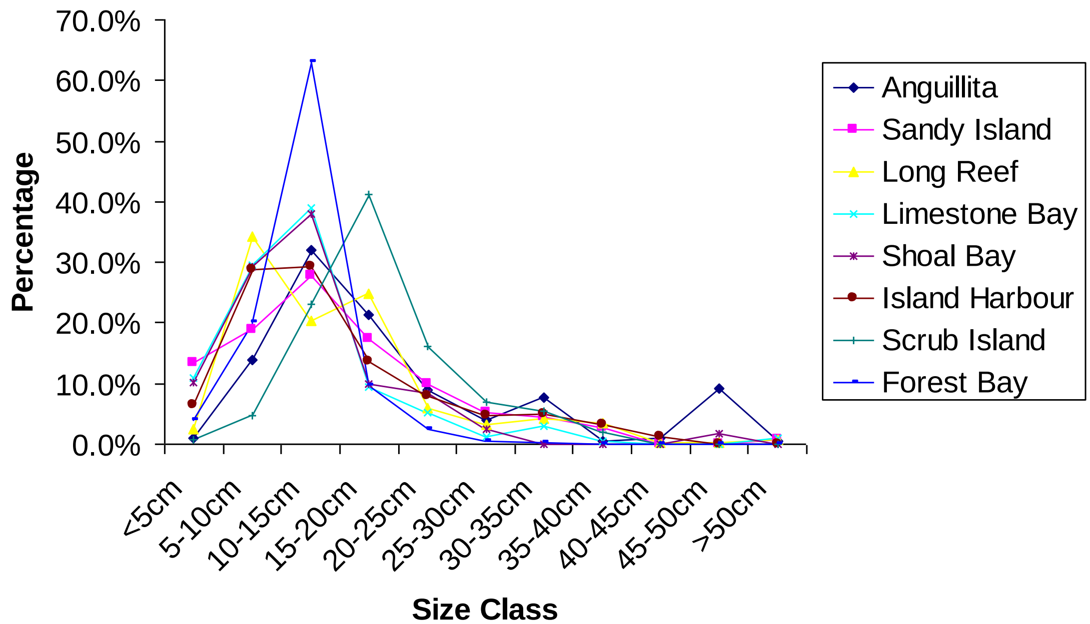


Figure 3.1 – Mean results from 2008 & 2009 fish belt transects that illustrates relative biomass of CEI species within each size class across eight reef sites. Little Harbour and Sile Bay were visited late in the year and so were not included in this analysis in an attempt to avoid biasing results through juvenile growth.

Table 3.3 Mean results from 2008 & 2009 fish belt transects split into families across eight reef sites, with the first column for each site (N) representing the mean number of individuals recorded per transect and the second (%) representing their percentage. Little Harbour and Sile Bay were visited late in the year and so were not included in this analysis in an attempt to avoid biasing results through juvenile growth.

Fish Family	Anguillita		Sandy Island		Long Reef		Limestone Bay		Shoal Bay East		Island Harbour		Scrub Island		Forest Bay	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Surgeonfishes	17.5	37	19.7	14	89.8	55	63.5	72	52.8	56	50.4	56	67.9	48	135	67
Parrotfishes	8.9	19	66.6	47	58.2	36	21.9	25	38.9	41	32.5	36	29.2	21	63.6	32
Grunts	4.2	9	31.4	22	0.4	0.2	0.1	0.1	0	0	0.9	1	14.9	11	0.1	0.1
Snappers	1.5	3	1.5	1	0.4	0.2	0.8	0.9	0.4	0.5	0.1	0.1	0.4	0.2	0	0
Groupers	2	4	1.2	0.8	0.6	0.4	0.6	0.7	0	0	0.2	0.2	3.1	2	0.1	0.1
Silveries	5.4	11	1.2	0.8	0.4	0.2	0.4	0.5	0	0	0.3	0.3	6.1	4	0.2	0.1
Triggerfishes	0	0	0	0	1.9	1	0	0	0	0	0	0	11.7	8	0	0
Goatfishes	1.1	2	5.7	4	3.5	2	0.4	0.5	0	0	0.8	0.9	6.3	4	0	0
Angelfishes	0	0	0.4	0.3	0.6	0.4	0	0	0	0	0.2	0.2	0.4	0.2	0	0
Butterflyfishes	3.6	7	0.5	0.4	0	0	0.3	0.3	0.9	1	0	0	0.1	0.1	0.5	0.2
Squirrelfishes	0.7	1	13.3	9	0.5	0.3	0	0	0.5	0.5	0	0	0.4	0.2	0	0
Large Wrasses	0.5	1	0.2	1	0.4	0.2	0	0	0.4	0.5	1.2	1	0.7	0.5	0	0
Other	1.6	3	0.1	0.1	5.2	3	0.2	0.2	0.1	0.1	4.2	5	0.6	0.4	0.7	3

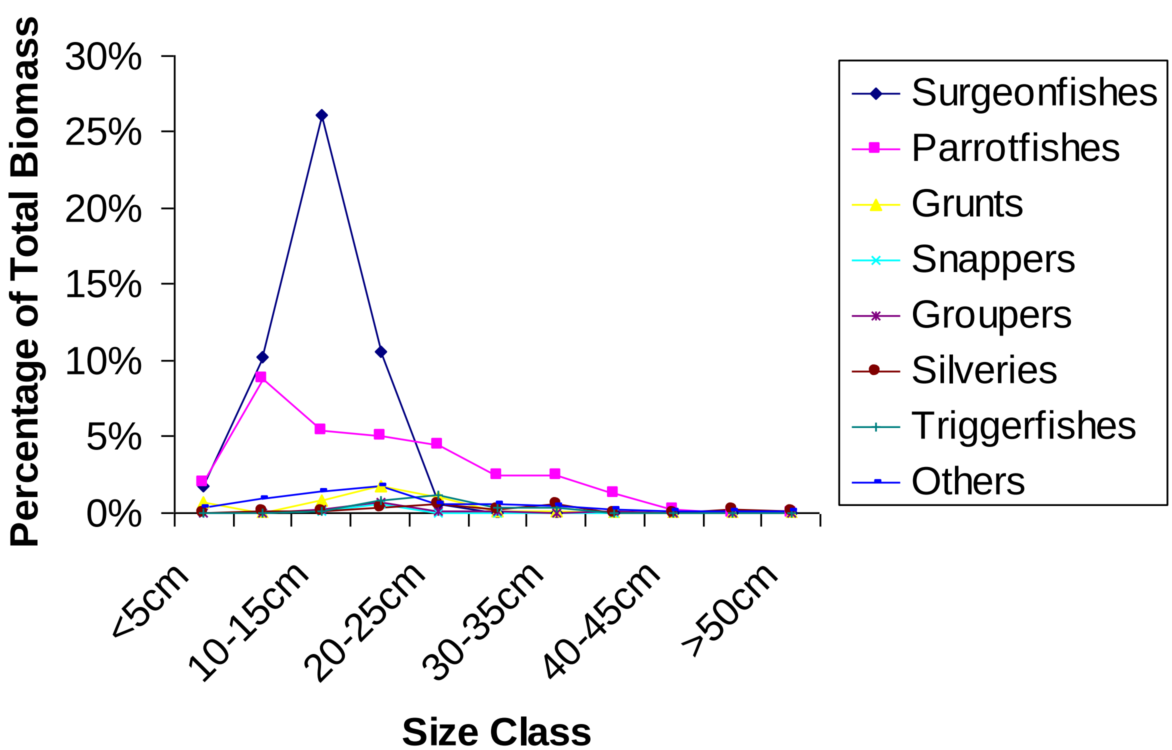


Figure 3.2 – Mean results from 2008 & 2009 fish belt transects that illustrates the percentage of relative biomass that each size class of each CEI fish family accounts for combined across all sites. Little Harbour and Sile Bay were visited late in the year and so were not included in this analysis in an attempt to avoid biasing results through juvenile growth.

Table 3.4 – Mean results from 2008 & 2009 fish belt transects that details the size class distribution of biomass by percentage within each CEI family/group surveyed for all sites combined. Little Harbour and Sile Bay were visited late in the year and so were not included in this analysis in an attempt to avoid biasing results through juvenile growth.

Fish Family	<5cm	5-10cm	10-15cm	15-20cm	20-25cm	25-30cm	30-35cm	35-40cm	40-45cm	45-50cm	>50cm
Surgeonfishes	3.5%	20.7%	53.1%	21.6%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Parrotfishes	6.2%	27.3%	16.8%	15.8%	13.8%	7.8%	7.5%	4.2%	0.6%	0.0%	0.0%
Grunts	15.7%	0.9%	17.4%	38.9%	22.0%	2.3%	1.7%	1.2%	0.0%	0.0%	0.0%
Snappers	0.5%	1.4%	22.0%	71.2%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Groupers	0.3%	2.8%	16.7%	52.7%	10.8%	5.7%	3.3%	7.7%	0.0%	0.0%	0.0%
Silveries	0.3%	6.0%	3.9%	13.3%	27.0%	9.3%	23.3%	2.4%	0.0%	8.0%	6.6%
Triggerfishes	0.0%	0.0%	6.0%	28.8%	39.8%	11.8%	11.7%	1.9%	0.0%	0.0%	0.0%
Goatfishes	0.0%	1.1%	40.7%	53.2%	2.5%	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%
Angelfishes	0.0%	0.0%	4.7%	17.7%	17.0%	27.8%	32.8%	0.0%	0.0%	0.0%	0.0%
Butterflyfishes	3.3%	92.2%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Squirrelfishes	42.7%	7.2%	26.5%	19.1%	4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Large Wrasses	4.0%	11.3%	3.3%	14.0%	28.0%	22.0%	17.3%	0.0%	0.0%	0.0%	0.0%
Other	3.9%	21.6%	6.9%	4.4%	13.7%	13.7%	12.6%	11.4%	3.5%	3.9%	4.4%

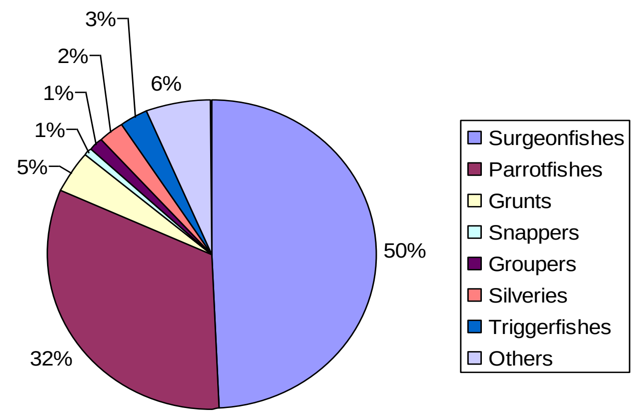
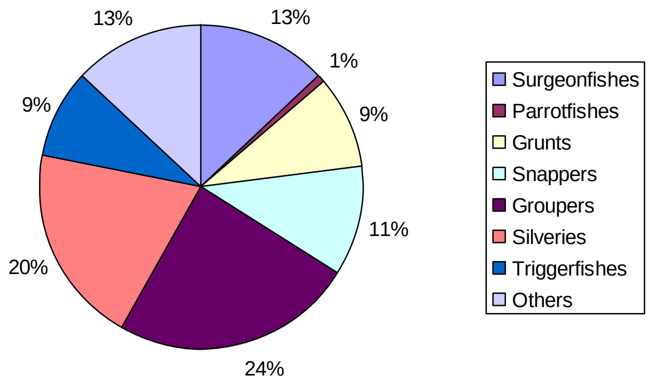


Figure 3.3

Mean results from 2008 & 2009 fish belt transects that illustrates the percentage of total relative biomass that each CEI family/group accounts for across all sites. Little Harbour and Sile Bay were visited late in the year and so were not included in this analysis in an attempt to avoid biasing results through juvenile growth.



Percentage weight of total catch landed by fishers split into each CEI family/group. Data collected were not done so as part of AMMP, rather as part of DFMR's fish catch data collection. Data do not include those fishers who primarily targeted lobsters or conch. In total 120 fishing trips were assessed in 2009. These data will be the subject of subsequent reports.

Table 3.5 – Mean results from 2008 & 2009 fish belt transects that illustrates the number of fish recorded within each size class (cm) for all fish species combined at the five seagrass sites. As monitoring only began in Crocus Bay during 2009 the results from this site are for that year only.

Site	<5	5-10	10-15	15-20	20-25	25-50 (combined)	50>	Total
Merrywing Bay	7.7	1.9	0.2	0.0	0.0	0.0	0.2	10.0
Road Bay	72.2	13.9	0.2	0.0	0.0	0.0	0.2	86.5
Little Bay	47.8	17.3	0.9	10.4	0.0	0.0	0.0	76.4
Forest Bay	1.7	1.2	0.3	0.0	0.0	0.0	0.0	3.2
Crocus Bay	19.3	7.3	1.0	25.0	0.3	0.0	0.3	53.2

Discussion

From the results presented in this section, even with the paucity of historical ecological surveys, it seems likely that Anguilla's reef fish populations have suffered some severe declines over recent decades. This has occurred at different levels across the study sites, and has affected both fish abundances and size class structure. It has also affected the various fish families differently depending on their life histories and the demand for them there is as food.

In terms of the abundance of all species across PMS (table 3.1) the most dominant fish are small wrasses, surgeonfishes and juvenile parrotfishes. This is to be expected as trophically smaller species and juveniles should be more abundant than larger species/individuals. However, it is the almost complete lack of larger individuals from these species at some sites that is of concern. On the whole, overall fish abundances are highest on the offshore sites (Scrub Island, Long Reef and Sandy Island), although high abundances were also recorded at Sile Bay. This site has however only been surveyed once and so subsequent visits will reveal if this result was anomalous or not. The reasons for offshore sites having higher abundances than nearshore sites are likely complex and require a detailed analysis that is beyond the scope of this status report (i.e. habitat health and interactions with fishing pressure). In part it would appear that some of this variation is due to high numbers of these smaller individuals (including schools of small silveries and surgeonfishes), but often it cannot be explained by such. Anguillita, for example, has the highest numbers of Bluehead Wrasse (*Thalassoma bifasciatum*) across all sites although it only ranks midway in terms of overall fish numbers because other species are far less common in comparison. In this case it is probable that this is due to the nature of the site, being of relatively low complexity yet surrounded by small drop-offs that attract species such as Black Bar Soldierfish (*Myripristis jacobus*) and French Grunts (*Haemulon flavolineatum*). It is therefore important to compare similar sites when making comparisons between them. For example, the nearshore sites of Limestone Bay, Shoal Bay East and Island Harbour may be compared with the offshore sites of Sandy Island, Long Reef and Scrub Island. Even though these sites are not identical they are similar enough to make comparisons (i.e. of relatively high topological complexity). Thus one would expect that historically these offshore sites would have had a similar fish species composition (at very least density) to the nearshore sites although today densities vary greatly. Aside from habitat health it is also probable that the differences are also related to fishing of CEI species, as discussed in the following paragraphs.

A brief analysis of the size class/relative biomass of CEI species demonstrates a clearer pattern. This type of analysis is useful as it removes the numerous smaller species (e.g. most wrasses and damselfishes) and leaves in those mainly targeted or inadvertently caught by fishers. It is rare for Anguillian fishers to discard any fish caught as at very least they will be used to bait their fish traps, and as the CEI species are generally those that can grow larger than minimum trap mesh size, size class and biomass analysis can, at least in part, be used to look for an effect of fishing. Fishing is known to occur at all the study sites, but on the whole occurs more frequently at those closer to the mainland, especially spearfishing. Habitat variations will also play a part (i.e. an areas ability to maintain a sizable population of larger fish), but as stated in the previous paragraph a detailed analysis that is beyond the scope of this status report would be required to assess this.

The results from the CEI transect surveys (see table 3.2 and figure 3.1) at the reef sites illustrates the present concern that many fish species in Anguilla are overfished. At most sites the vast majority of CEI species are less than 15cm in length. At some sites, for example Shoal Bay East and Limestone Bay, at least 90% are smaller than this (to reiterate, this is of special concern because as stated before, this analysis does not include smaller species). Of all PMS, Scrub Island, Long Reef, Sandy Island and Anguillita generally have the highest proportions of CEI species in size classes larger than 15cm, although quantities are still relatively low compared to what is thought to have occurred historically.

Further to this, table 3.3 (and figure 3.2) illustrates how at all of the sites surgeonfishes and parrotfishes account for the majority of CEI species, although consulting table 3.4 shows that the majority of these two families are less than 15cm in length. Parrotfishes are better represented in the larger size classes than surgeonfishes, a result that one might expect as surgeonfishes do not grow to the same size as many parrotfish species. However this is probably a good example of 'shifting baselines' as some surgeonfishes are documented to grow to almost 40cm in length – we are just not accustomed to seeing these sizes today. Equally, if parrotfishes size classes were broken down into species it would show that the majority present are the smaller growing species (e.g. Striped Parrotfish – *Scarus iserti* or Redband Parrotfish – *Sparisoma aurofrenatum*), and the larger growing species that are favoured by fishers are generally not as prevalent (e.g. Queen Parrotfish – *Scarus vetula* and Stoplight Parrotfish – *Sparisoma viride*), at least not sizeable individuals. It is apparent that sizeable species can be targeted to almost local extinction as Blue Parrotfish (*Scarus coeruleus*), known locally as the Hammernose, used to be caught in large numbers by spearfishers in years gone by but now are only caught in extremely rare cases, and similarly the Rainbow Parrotfish (*Scarus guacamaia*), known to be relatively common historically, has only been sighted twice during DFMR's last four years in-water work (but not during AMMP surveys). Again, this is suggested to be due to spearfishing.

In terms of the other CEI families table 3.4 illustrates how size classes generally peak in the 15-20cm category (e.g. groupers, snapper and grunts) or the 20-25cm category (e.g. triggerfishes and large wrasses). Although at first glance this may seem more encouraging, considering the sizes that the species can obtain, these values are actually very low, and because overall abundances are minimal (table 3.3) their contribution to overall fish biomass on Anguilla's shallow water (<15m) reef systems is markedly smaller than historically thought (figure 3.2). Sizable individuals can often be observed around ship wrecks or on deeper reefs, but their relative inaccessibility to fishers probably offers an explanation. This is also probably the reason for the offshore PMS having slightly 'healthier' fish assemblages. Having said this, fishers do land large reef dwelling species, but again this is likely a case of 'shifting baselines'. It is easy to say fish populations are still healthy because large individuals are often still landed, but what constitutes a large individual and what frequency of landing is considered 'often' has probably changed significantly over time. It also needs to be recognised that there are probably still fishing grounds out at sea that house 'healthier' populations, but these areas shouldn't be used to mask the dwindling populations closer to mainland Anguilla. In fact, these dwindling areas should be classed as an early warning system for the more distant ones. If there is any doubt to this statement, local fish outlets can be used as 'yard sticks'. Visiting these locations reveal the vast majority of reef fish sold are immature or undersized individuals, and that even without historical data to compare current findings to, it is high time the precautionary principle be applied to Anguilla's fishing industry.

Figure 3.3 offers a comparison between relative biomass of CEI species recorded at the reef sites and the relative weight of CEI species landed by fishers in 2009. It should be noted that fishers will often target specific species and use any bycatch as bait, thus these are not included in the figures. Parrotfish are often used in this way rather than being landed. Furthermore, the areas visited by fishers include many areas not studied as part of AMMP and so the comparison made is not one that compares fish landed with natural populations in those specific areas fished. Many of the AMMP sites are close to the coast and so visited often by spearfishers who target species of parrotfish (for example) that may not be landed by boat owning fishers. This may explain the paucity of large parrotfish at many of the AMMP sites that will not be reflected in the data recorded as part of DFMR's fish catch data collection. What this comparison is useful for however is to show how AMMP reef sites appear to have been depleted of many CEI families, especially those favoured today by fishers who now go further afield to catch them. If this continues unchecked it is likely that these further afield areas will soon become depleted of these species in a similar fashion. Deeper dwelling species such as Red Snapper (*Lutjanus campechanus*) may escape this fate at least in the short term because their habitat of choice is often harder to reach and areas of such habitat may go unnoticed by those targeting them.

Seagrass sites (table 3.5) are important for many juvenile reef fish families (e.g. snappers, grunts and surgeonfish). It is interesting to note that some of the sites house relatively high numbers of these small juvenile fish while others do not. As a general pattern it seems clear that the seagrass PMS on the north coast of Anguilla have higher abundances than those on the south coast. Although the reasons for this remain unclear it does draw a parallel with the reef PMS in terms of both fish populations and the benthic community. As stated earlier it is felt that the differences seen between the north and south coasts cannot simply be explained by variations in wave exposure and other physical characteristics.

As a final note, habitat quality needs significant consideration. The previous section suggests that the benthic reef environment is in poor condition. This is probably due to many factors including (but not limited to) fishing, eutrophication, pollution and climate change. These factors may interact with each other in a synergistic fashion (where, for example, the total effect of two or more factors is greater than the sum of such factors when acting on their own) or induce positive feedback loops (or a combination of the two). Such effects can have significant roles when managing fisheries. To illustrate, fishing that removes herbivores and eutrophication that promotes algae growth, might, when combined, lead to a greater decrease in coral cover (and ultimately more severe habitat degradation) than the sum of the damage contributed by either when acting independently. Such interactions need considering when introducing management measures, as, if based solely on fishing pressure, strategies may not be sufficient to stop habitat degradation. Thus, as the unaccounted for synergism causes habitat degradation, less fish can be supported by the reef and so the catch limits set begin to remove a greater and greater proportion of the population. This synergism combined with a positive feedback loop can lead to unforeseen population crashes on a reef system. The ability of different habitat types to support fish populations can be seen in the images below. Shoal Bay East would have had a much greater topological complexity that Limestone Bay historically, and as such would have been able to support a greater abundance of fish. Today, however, abundances are very similar.

Reef at Shoal Bay East monitoring site (left) and Limestone Bay monitoring site (right) illustrating how two historically different habitat types begin to resemble each other when one suffers increased habitat degradation than the other (In this case Shoal Bay East)

Part 4: Temporal Changes 1990 – 2009

Methodology and Rationale

Although not part of the current complement of AMMP sites, the locations set up during the Bellairs Institute study (Oxenford and Hunte, 1990) in 1990 represent the first concerted effort to begin long-term monitoring in Anguillian waters. Unfortunately once the initial study had been conducted monitoring at the sites did not continue. However, this work does represent the only dataset available to conduct temporal analysis on, and as such is a valuable resource.

Thus, as the current AMMP work does not span a large enough time range for temporal analysis, by estimating the locations of the sites studied during the Bellairs Institute's work such an analysis, albeit limited, is possible. The limitations of such an analysis include the fact that the 1990 study was conducted before GPS became widely available, and as such the precise location of the sites are almost impossible to establish. At two of the sites, Little Bay & Corito Bay, old sediment traps were found that served also as corner markers to the sites, therefore these two sites are known to be in the correct location - the other permanent markers used did not stand the test of time. All other site locations had to be estimated from hand drawn maps with many visual references that no longer existed. Although locations could also be estimated by comparing current habitat type with descriptions made in 1990, some sites had changed so much over the last twenty years that this could not be done with any accuracy. Ultimately eight reef sites and two of seagrass sites were identified that could be estimated reliably enough to justify this study taking place.

Surveys conducted in 2009 followed the original methodology as closely as possible, although some differences should be noted. The fish belt transects covered an area of 100m^2 and counted all fish present: In the recent survey work five transects, each with a width of 2m were used to cover this area, whereas in 1990 ten transects each with a width of 1m were assessed. This change was decided upon as it would speed up the surveying process without compromising or biasing results. A second methodological change took place when conducting benthic reef surveys. In 1990 line-intercept transects were used to count all sessile organisms including hard corals, soft corals, sponges and algae. Although this method is still accepted as useful when collecting underlying substrate information (including hard corals – Kramer *et al.*, 2005), it is known to suffer a number of general limitations and is also questionable when surveying biota with a limited surface area (for example, macroalgae and many of the soft corals). Furthermore, some questions came up regarding precise methodological details (for example, how percentage cover was arrived at – in some of the original surveys a total of more than 100% was recorded, whereas in others the final value was much lower than 100%). For these reasons it was decided use a more generic, simplified methodology, in the hope that fewer biases would occur than if attempting to follow the old survey protocols. Twenty quadrats measuring 50cm x 50cm, thrown randomly within the study area, were used as an alternative. Percentage cover results could be compared directly despite this change, although numbers of individuals counted did have to be standardized. This was done based on the assumption that the line-intercept transects would cover approximately 10% of the 100m^2 study site. Mean results from the twenty quadrats could then be multiplied by forty to arrive at a comparable figure. During these benthic surveys descriptor groups, as set out by Oxenford & Hunte (1990) were assessed in an identical fashion (table 4.2).

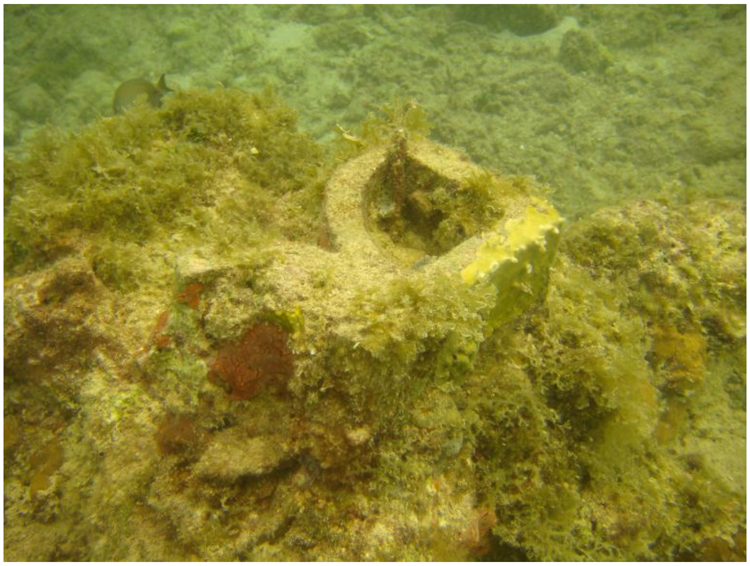
Seagrass surveys were not conducted separately in 2009, instead results from the 2009 AMMP surveys were used. This was possible because two of the AMMP seagrass sites are in almost identical locations to those surveyed in the Bellairs study. The Bellairs study uses a mixture of 25m line-intercept transects (to assess seagrasses) and 25cm x 25cm quadrats (to assess macroalgae). Sand percentage cover was not measured at the seagrass sites during 1990, so comparisons of this variable were not possible. In terms of these benthic surveys, because only seagrass blade length and percentage cover of seagrasses and macroalgae were assessed, the

AMMP quadrat methodology (50cm x 50cm) could be compared directly without standardization. The fish surveys however did need to be standardized to account for the fact that larger areas are surveyed during AMMP work. Reducing the AMMP results by a factor of 2.5 accounted for this.

Unfortunately the sites at Scrub Island and Dog Island were not able to be surveyed in 2009 because of logistical constraints. This means that all the sites available for comparisons were coastal mainland sites, and hence may be under a biased amount of anthropogenic pressure. Therefore, comparisons being made from the results of this temporal study to offshore regions can only be done tentatively. It is also unfortunate that the 1990 study did not survey areas such as Shoal Bay – Island harbour, Sandy Island or Prickly Pear – Seal Island Reef. These are important shallow reef areas that are now Marine Parks, and so a temporal comparison would be very useful. It is thought that these areas were not surveyed because at the time the original study was conducted many different areas were being considered for Marine Park designation, and it seems some priority was being given to the south coast.

The original surveys were conducted at the same time of year as those undertaken as part of AMMP (21st May 1990), although they were concluded slightly later than AMMP sets out to (16th August 1990). AMMP usually runs from May to June/July each year weather depending. It is unlikely these temporal differences will influence comparisons as the 1990 study did not assess fish sizes, purely numbers of individuals, and as such biases will be largely avoided.

Note: The Simpsons diversity index was calculated during the 1990 portion of the study, but it appears a different method was used to that accepted today because final value ranges differ. Once calculated a final value between 0 and 1 is obtained, where 0 is a perfectly homogenous population and 1 is a perfectly heterogenous population. Oxenfiord and Hunte (1990) quote end results that range from less than 1 to over 10, thus meaningful comparisons can't be made. In general, the Shannon's diversity index seems to be one of the most widely used, and it is this that is usually quoted in DFMR reports.



One of the original sediment trap markers from the 1990 study (Little Bay)

Results

Table 4.1 – Fish survey results from both 1990 & 2009 at eight of the sites studied during the Bellairs Institute study (Oxenford and Hunte, 1990). Results presented are total number of species seen in each $100m^2$ study site and total number of individuals recorded in each $100m^2$ study site (or the equivalent). Site names have been given that were used in the 1990 study (in brackets) as well as their modern name (bolded heading).

Site		1990	2009
Little Bay Rocks (Site 2H)	Species	25	40
	Individuals	155	213
Crocus Bay Reef (Site 2P)	Species	17	33
	Individuals	103	230
Crocus Bay Seagrass (Site 2S)	Species	18	14
	Individuals	257	21
Forest Bay Reef (Site 5H)	Species	25	24
	Individuals	428	205
Forest Bay Seagrass (Site 5S)	Species	3	4
	Individuals	5	1
Corito Bay Reef (Site 4H)	Species	25	29
	Individuals	100	161
Black Garden Inner Reef (Site 1Hi)	Species	20	24
	Individuals	247	188
Black Garden Outer Reef (Site 1Ho)	Species	31	32
	Individuals	472	362
Sandy Hill Inner Reef (Site 6H)	Species	26	30
	Individuals	122	126
Sandy Hill Outer Reef (Site 6P)	Species	27	25
	Individuals	335	92

Note: The total number of fish species seen across all sites in 1990 totalled 68, whereas in 2009 the total was 71 and as such can be considered virtually unchanged. Having said this, close examination of findings does show a change in species composition. For example, in 1990 no Striped Parrotfish (*Scarus iserti*, formally *Scarus croicensis*) were recorded whereas today it is one of the most common fish sighted on reefs. Also, the Midnight Parrotfish (*Scarus croicensis*) was recorded at selected sites in 1990, whereas today it is thought to be locally extinct.

Table 4.2 – Main community descriptors for the two seagrass sites as lain out by Oxenford and Hunte (1990), with results from the 1990 and 2009 studies. Results presented are mean percentage cover for each community descriptor and mean blade length in centimetres (seagrasses only).

Site			Algae	Turtle Grass	Manatee Grass
Crocus Bay Seagrass (Site 2S)	**1990**	Blade Length	n/a	17.40	n/a
		% Cover	11.60	82.28	0
	2009	Blade Length	n/a	14.61	n/a
		% Cover	25.65	57.45	0
Forest Bay Seagrass (Site 5S)	**1990**	Blade Length	n/a	13.10	16.60
		% Cover	22.20	38.90*	38.90*
	2009	Blade Length	n/a	13.95	12.62
		% Cover	6.45	53.80	23.60

* results quoted in Oxenford and Hunte (1990) are unclear as they state 100% cover for both species of seagrass combined, also quoting algae cover as 22.2%. Hence 100% minus 22.2% has been assumed as total seagrass cover, split equally for each species (38.9%).

Table 4.3 – Main community descriptors for the eight reef sites as lain out by Oxenford and Hunte (1990), with results from the 1990 and 2009 studies. Results represented are standardised total number of individuals recorded at each 100m^2 study site and mean percentage cover of each site descriptor group (hard coral, sponge etc). Site names have been given that were used in the 1990 study (in brackets) as well as their modern name (bolded heading).

Site			Hard Coral	Soft Coral	Sponge	Algae	Sand	Rock
Little Bay Rocks (Site 2H)	**1990**	Individuals	140	80	72	n/a	n/a	n/a
		% Cover	10.59	n/a	2.64	12.01	0	68.67
	2009	Individuals	36	20	28	n/a	n/a	n/a
		% Cover	2.25	n/a	1.75	7.50	0.50	78.85
Crocus Bay Reef (Site 2P)	**1990**	Individuals	80	165	102	n/a	n/a	n/a
		% Cover	5.57	n/a	4.91	14.52	0	74.57
	2009	Individuals	60	28	50	n/a	n/a	n/a
		% Cover	6.00	n/a	4.60	15.40	0.35	65.60
Forest Bay Reef (Site 5H)	**1990**	Individuals	126	157	49	n/a	n/a	n/a
		% Cover	12.67	n/a	1.64	10.25	0.38	66.18
	2009	Individuals	2	12	10	n/a	n/a	n/a
		% Cover	0.15	n/a	0.85	17.80	0	76.75
Corito Bay Reef (Site 4H)	**1990**	Individuals	66	229	1	n/a	n/a	n/a
		% Cover	7.32	n/a	0.5	28.38	0.78	57.52
	2009	Individuals	46	102	10	n/a	n/a	n/a
		% Cover	3.90	n/a	1.05	16.95	0	72.45
Black Garden Inner Reef (Site 1Hi)	**1990**	Individuals	101	46	44	n/a	n/a	n/a
		% Cover	10.10	n/a	2.77	7.46	0	78.83
	2009	Individuals	24	14	4	n/a	n/a	n/a
		% Cover	1.15	n/a	0.20	17.25	0	78.90
Black Garden Outer Reef (Site 1Ho)	**1990**	Individuals	154	156	63	n/a	n/a	n/a
		% Cover	14.01	n/a	2.23	26.34	3.88	44.92
	2009	Individuals	70	38	40	n/a	n/a	n/a
		% Cover	6.20	n/a	2.95	17.50	0	65.95
Sandy Hill Inner Reef (Site 6H)	**1990**	Individuals	76	80	1	n/a	n/a	n/a
		% Cover	6.43	n/a	0.03	19.40	13.62	57.02
	2009	Individuals	10	6	2	n/a	n/a	n/a
		% Cover	1.65	n/a	0.20	21.95	0	71.70
Sandy Hill Outer Reef (Site 6P)	**1990**	Individuals	101	274	49	n/a	n/a	n/a
		% Cover	6.15	n/a	1.59	27.27	0	59.09
	2009	Individuals	30	34	22	n/a	n/a	n/a
		% Cover	2.10	n/a	1.45	30.50	1.45	60.70

Discussion

From the results presented in table 4.1, on the whole more species were recorded in 2009 at the sites than in 1990. Reasons for this remain unclear as it seems unlikely this would be due to any methodological issues.

In terms of numbers of fish present, many of the sites have suffered a relatively large decline over the last twenty years, with some of those on the south side of Anguilla being the most severe: Forest Bay has undergone a 52% and Sandy Hill Bay (outer reef) a 72% decline. Other sites on the south side have only undergone slight decreases or relatively small increases. On the north coast some sites have again undergone decline, with both Black Garden sites exhibiting c.25% reductions and the Crocus Bay seagrass site showing losses of over 90%. Both Crocus and Little Bay reef sites on the other hand have shown positive increases over the last twenty years.

Of the two seagrass sites surveyed the benthic changes (see table 4.2) can be summarised as Crocus Bay being in worse condition than twenty years ago with more algae cover and less turtle grass and Forest Bay being in better condition with reduced algae cover and increased seagrass cover. The change at Crocus Bay might explain the result for this site described in the previous paragraph, but changes at Forest Bay are drawn into question due to a methodological anomaly noticed in the 1990 study (see note under table 4.2).

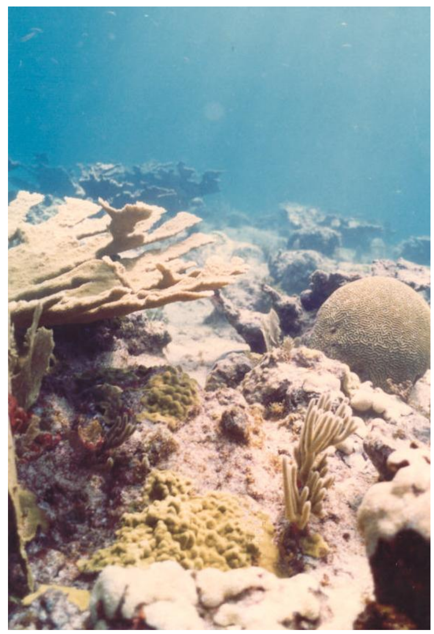
Changes in the benthic cover of the reef sites over the last twenty years based on the results here are more consistent (table 4.3). Classed as community descriptor groups in the 1990 study, the vast majority have decreased markedly, aside from 'bare' rock, which in most cases has increased. Of particular interest is hard coral cover which at most sites has at least halved. In some cases these drops have been dramatic, with Forest Bay suffering an almost 99% decline (it should be noted that this site is however in a different location to the AMMP Forest Bay site). Other sites with large decreases include Sandy Hill Bay (inner reef) with a 74% loss; Sandy Hill (outer reef) with a 65% loss; and Black Garden (inner reef) with an 88% loss.

On the whole the 1990 study seems to paint a similar picture to recent work. That is, the south coast appeared to be in a worse state at the time than the north coast. Although on the whole many of the sites were in a better state than they are today, none were 'pristine', and so whatever has caused the decline in habitat health today seems to have already been of influence in 1990. From reviews of the literature on this it is largely concluded that the decline in coral cover started initially with White Band disease killing off the massive Elkhorn stands and Staghorn forests, and moved on to Yellow Blotch disease killing other species, especially *Montastraea sp*. that also formed extensive reef systems here in Anguilla. Today, although scatterings of Elkhorn and *Montastraea sp.* still exist they are much less abundant than historically and many colonies show signs of their respective diseases (for examples see page 12). The exact cause of these diseases are still being studied, but many can be attributed to cyanobacterial infections (e.g. Red Band disease) or other factors that are likely due to a reduction in water quality and/or increases in organic nutrients.

It is unfortunate that the 1990 study did not assess fish size or survey any of the offshore areas studied during AMMP as these data would likely provide important insights into the changes over the last twenty years. This is because fishing efficiency and frequency is thought to have increased over the last twenty years and the offshore sites are generally those currently concluded to be the most healthy. However, the 1990 study does offer a rare glimpse into Anguilla's recent past that is invaluable considering the paucity of other such research materials.

Note: No conclusions on Queen Conch (*Strombus gigas*) or Long-Spined Sea Urchin (*Diadema antillarum*) populations could be drawn as numbers were too limited in both studies. More extensive targeted studies would be needed but the lack of historical resources restricts the comparative potential of such a project.

Comparison photographs: The below images illustrate habitat degradation that has occurred over the last twenty years at two of the sites that were part of the Bellairs study. Top left is Forest Bay reef in 1990, bottom left shows how it is today. Top right is Black Garden inner reef in 1990, bottom right shows how it is today. Aside from the obvious physical degradation, macroalgae seems to dominate the sites far more today than it did twenty years ago. Furthermore, the images seem to illustrate a difference in water clarity between the two study periods. Although this is a subjective measure and may be due to differing photographic techniques it is interesting and maybe important to note the water at these sites appears far more turbid in 2009 than it did in 1990. This suggests increases in phytoplankton that might be explained by increasing nutrients. Such nutrification would in turn promote the algae dominance (potentially accentuated by removal of herbivorous fish through fishing). This phenomenon has been documented in other parts of the Caribbean over recent years.



Part 5: Coral Recruitment Study

Methodology and Rationale

Terracotta tiles measuring 10cm x 10cm x 1cm were placed at ten reef sites around Anguilla between 13th and 27th August 2008. These dates coincided with the first reported coral spawnings in the Caribbean region, primarily *Acropora sp.* and *Montastraea sp.* (Coral-list reports vol 62 issue 25 & 27; vol 63 issue 3). Other species reportedly spawned during subsequent weeks. As corals have a significant 'free-swimming' larval phase, the tiles were left in place for a period of approximately six months, with collection beginning early in 2009. Weather conditions meant that some of the sites were visited slightly later in the year than others.

Thirty tiles were placed at each site at a depth of 5m, and thirty at a depth of 10m. Sites with no 10m areas only had the 5m sets placed. Care was taken to ensure orientation on the reef was random. This random methodology was followed because settlement choices of corals recruits are well documented (McWilliams, 2005) and the present study was conducted solely to look at recruitment rates and not to assess such settlement choices. The tiles were attached via a cable tie through a hole drilled into their centre. The size of the tiles and their attachment method was chosen based on work conducted in Anguilla by McWilliams (2005). After collection the tiles were soaked over-night in diluted bleach and left to dry for later examination.

Of the sites chosen, all suitable AMMP reef sites were used apart from Scrub Island. This was due to adverse weather conditions. Instead tiles were placed at Savannah Bay, a location that was under consideration as an AMMP site, but later replaced by Sile Bay. Tiles were also not placed at The Anguillita site due to lack of potential attachment points (it is a low relief reef area), and so were instead placed at Blowing Rock, a nearby location.

Images illustrating tiles immediately after placement at Long Reef (left) and six months after placement at Little Harbour (right)

Results

Table 5.1 – Results from the 2008/2009 coral recruitment study. It should be noted that all recruits were found on the underside of the tiles, as expected based on the results of McWilliams (2005). The topside of all tiles had a thick covering of coralline algae, turf algae and embedded sediment.

Site Name	Mean Recruits Per Tile	Dominating Biota
Sandy Island	2.26	Worms, Coralline Algae & Encrusting Sponges
Limestone Bay	7.86	Worms, Coralline Algae & Encrusting Sponges
Shoal Bay East	4.32	Worms, Coralline Algae & Encrusting Sponges
Island Harbour	2.34	Worms & Coralline Algae
Long Reef	2.06	Worms, Coralline Algae & Encrusting Sponges
Forest Bay	0.00	Worms & Coralline Algae
Sile Bay	0.00	Worms & Coralline Algae
Little Harbour	0.30	Worms, Coralline Algae & Encrusting Sponges
Savannah Bay	0.00	Worms & Coralline Algae
Blowing Rock*	0.00	Worms & Coralline Algae

*most tiles from this site had been dislodged (presumably) by Hurricane Omar and so very few were found

Discussion

From these results it is clear that recruitment of corals on the south coast of Anguilla is extremely limited, with three out of four sites having no recruits whatsoever. Limestone Bay had the highest recruitment rate, followed by Shoal Bay East. The other three sites on the northern side of the island, although not as high, still had consistent recruitment rates.

Reasons for the low recruitment rate along the south coast are not currently clear and as such it is recommended that further studies be prioritised to assess this. One possibility is marine snow that has been documented to inhibit the survival rate of coral recruits (Fabricius *et al*., 2003). Indeed, the south coast does often have poor visibility due to (among other things) the presence of this material. Marine snow is composed of dead/dying plankton, faecal matter and other inorganic dust stuck together by transparent exopolymer particles (TEP) that are exuded as a natural waste product of bacteria. Fabricius *et al.,* (2003) reports that even low levels of sediment, when combined with TEP, kills newly settled coral recruits, whereas the same amount of sediment without TEP does not reduce their short-term survival. Sedimentation of any kind can also smother adult coral species, and as such the marine snow, as observed in many locations along the south coast, could be a major factor reducing both recruitment and overall hard coral cover (see part 2). It should be noted that marine snow has been observed all around Anguilla, and is likely a seasonal phenomenon.

Another factor to consider relating to the south coast is the close proximity of the island's landfill site, and unconfirmed reports of leeching that occurs into the surrounding ocean. Again, further studies are needed to investigate this.

Part 6: Water Quality Monitoring

Methodology and Rationale

A pilot study was conducted in 2008 where eighty sites were sampled two to three times over a three month period beginning in September. From the results of this pilot (Wynne, 2009a) forty two priority sites were selected for continued study, proposed to begin in 2009. Unfortunately, only a limited amount of samples were able to be collected due to reduced laboratory capacity, but it is hoped that sampling will continue once capacity has been increased again. The Government Water Lab has recently been completed and so it is proposed that they will work alongside DFMR to fulfil this aspect of AMMP. Mean results for the forty two priority sites are presented in table 6.1. Sediment samples were also taken at selected sites, the results from which can be found in Wynne (2009a), along with all sampling methodologies used. Sediment samples were not taken during 2009 because of the limitations mentioned above.

Results (see table 6.1 over page)

Discussion

From the results presented in table 6.1 a number of parameters appear to be reasonably stable across all the sites, whereas others seem to be less so. For example pH, conductivity and total dissolved solids seem relatively stable and no sites vary greatly around the mean value. Conversely, some parameters, for example nitrate, phosphate and chemical oxygen demand do vary considerably. In fact, nitrate and phosphate levels should barely be detectable in naturally oligotrophic coral reef ecosystems (Goreau & Thacker, 1994), and as such the mean value across all sites for both variables should be zero. A positive mean value indicates that Anguilla's waters are eutrophic, which is not favourable if corals are to prosper. For example, increasing nutrient levels allow algae to flourish and out-compete recruiting corals (Szmant, 2002). This, in combination with other detrimental factors, for example over-fishing of herbivorous fish (see parts 3 & 4), can lead to an algae dominated ecosystem that will ultimately lead to the demise of topologically complex reef systems through erosion processes

Another variable that fluctuates across the sites is turbidity. Light penetration influences photosynthesis in both zooxanthellae and seagrasses (AIMS, 2008), and as such a high turbidity is not beneficial to either seagrasses or corals. Interestingly however, sites on the south coast did not have particularly high turbidity values, which is not consistent with observations made in these areas. Often, locations such as Forest Bay, Little Harbour, Sile Bay have poor visibility due to what looks like marine snow (see part 5). Reasons for this are uncertain, but the situation will be clarified if sampling continues over subsequent years.

From this work, in terms of organic nutrients, sites of special concern include (but are not limited to) Road Bay, Little Bay, Little Harbour, Corito Bay, Scrub Island and Prickly Pear. Of these, the first four are of little surprise because they all have known stresses. For example, Road Bay and Corito Bay are probably the most 'industrialised' in Anguilla; Little Harbour has been almost enclosed by a berm (reportedly by past hurricanes) that restricts water circulation and it's salt pond is permanently connected to the sea; and Little Bay is relatively sheltered with high volumes of tourist boats. Scrub Island on the other hand is somewhat of a mystery as the site is well flushed via currents and there is little activity there apart from fishing. It is possible the currents themselves bring in nutrients from further afield, or that it is an anomalous result. Prickly Pear too is reasonably well flushed, but does have high volumes of large tourist catamarans and two beach barbeque bars which may explain results. For site specific conclusions however this monitoring needs to continue for at least one complete annual cycle – which unfortunately is not presently possible on such a scale due to current logistical and financial limitations.

Table 6.1 – Results from the 2008/2009 water monitoring study for the forty two sites prioritised during the initial pilot study. The bottom row of the table details mean values across all the sites - a good indication of which sites need special attention are those that are above this mean value. (DO = Dissolved Oxygen, TDS = Total Dissolved Solids, COD = Chemical Oxygen Demand)

Site Name	Temp C	DO (mg/L)	pH	Conduct-ivity (µs)	TDS (ppt)	Ammonia (as N mg/L)	Nitrate (as N mg/L)	Phosph-orous (mg/L)	COD (mg/L)	Turbidity (NTU)
Road Bay – Fishing Pier	28.0	7.32	8.14	51.7	52.9	0.13	0.98	0.06	927	1.365
Road Bay – Wooden Pier	27.1	8.64	8.20	52.7	54.2	0.01	1.58	0.08	1078	0.893
Road Bay – Main Jetty	27.4	8.32	8.18	52.1	53.6	0.05	0.28	0.00	1114	0.748
Road Bay – Mid-moorings	29.3	7.59	8.23	50.1	53.3	0.06	0.55	0.00	772	0.560
Crocus Bay – Mega Yachts	28.7	7.45	8.23	50.0	54.0	0.02	0.15	0.00	1231	0.340
Little Bay	27.4	7.92	8.17	51.8	53.4	0.02	0.28	0.11	1175	0.720
Limestone Bay	27.8	8.72	8.12	50.3	54.2	0.00	0.03	0.00	667	0.750
Shoal Bay East – Fountain	27.8	8.25	8.18	51.9	53.0	0.00	0.10	0.00	804	0.905
Shoal Bay East – Ernies	28.1	7.74	8.08	51.0	54.7	0.08	0.01	0.00	829	2.481
Shoal Bay East – Gwens	28.6	7.97	7.79	50.8	52.3	0.00	0.11	0.05	625	1.065
Shoal Bay – Island Harbour	28.3	8.53	8.20	51.9	53.9	0.00	0.07	0.00	766	0.795
Island Harbour Jetty	28.3	6.78	8.06	50.2	53.9	0.60	0.08	0.03	794	0.900
Scrub – Little Scrub	28.3	7.53	8.34	50.6	53.7	0.01	0.40	0.32	746	1.100
Junks Hole	28.6	8.77	8.15	50.0	53.8	0.30	0.08	0.00	606	0.605
Sile Bay	28.7	9.20	8.20	52.0	52.9	0.01	0.15	0.00	462	0.445
Sandy Hill Bay	28.5	8.59	8.13	49.8	53.9	0.00	0.00	0.00	459	0.585
Conch Bay	28.8	7.17	8.28	50.8	53.5	0.00	0.10	0.00	380	0.160
Forest Bay - Seagrass	28.6	9.42	8.13	51.5	53.1	0.01	0.20	0.00	681	0.870
Forest Bay - Channel	28.9	6.63	8.23	51.8	53.0	0.01	0.20	0.00	259	0.310
Corito Bay	28.2	9.16	8.22	51.3	55.2	0.02	0.45	0.01	574	0.706
St Martin Channel (Shallow)	28.0	7.78	8.41	51.9	50.4	0.12	0.05	0.00	685	0.885
St Martin Channel (Deep)	28.0	8.42	8.41	52.4	50.8	0.00	0.15	0.00	1179	0.780
Little Harbour - Beach	28.1	8.61	8.19	50.5	52.2	0.00	0.18	0.00	1096	0.670
Little Harbour - Berm	28.8	7.76	8.26	50.6	53.4	0.00	0.15	0.21	400	1.430
Blowing Point – Ferry Terminal	27.7	7.80	8.06	51.5	52.7	0.06	0.08	0.00	471	0.705
Blowing Point – Sandy Point	27.2	7.42	8.07	51.4	52.4	0.02	0.17	0.00	801	0.528
Rendezvous Bay – Great House	28.1	7.42	8.11	51.3	52.9	0.04	0.13	0.00	647	1.230
Rendezvous Bay - Merrywing	27.8	6.93	8.18	51.6	53.0	0.15	0.18	0.00	836	1.855
Cove Bay – Fishing Pier	27.7	8.69	8.23	51.6	52.7	0.10	0.08	0.00	550	0.678
Cove Bay - Westend	27.8	6.59	8.21	51.2	53.0	0.00	0.05	0.00	650	1.010
Cap Jaluca - Pimms	27.5	7.74	8.20	51.2	52.9	0.01	0.03	0.00	815	0.290
Cap Jaluca – Villa 19	28.0	7.10	8.21	50.9	52.5	0.00	0.03	0.00	614	1.045
Shoal Bay West - Altamar	28.0	7.05	8.23	51.0	52.6	0.00	0.15	0.04	651	0.555
Anguillita	28.5	7.95	8.36	50.7	54.0	0.00	0.05	0.00	863	0.670
Barnes Bay – Viceroy	28.2	6.94	8.20	51.6	53.5	0.08	0.18	0.00	854	0.830
Meads Bay - Viceroy	28.2	6.92	8.18	51.1	52.9	0.08	0.08	0.00	779	0.490
Meads Bay – Mid Bay	28.2	7.74	8.34	50.5	52.7	0.11	0.05	0.00	438	0.960
Long Bay	27.8	6.89	8.16	50.8	53.3	0.00	0.00	0.00	703	0.515
Sandy Island	28.8	7.23	8.23	49.3	54.1	0.01	0.10	0.00	819	0.670
Prickly Pear	29.0	8.24	8.34	50.2	53.1	0.06	0.15	0.93	918	0.770
Dog Island	28.9	7.74	8.33	50.7	53.9	0.01	0.10	0.00	1121	1.100
Long Reef	28.7	8.16	8.33	49.8	53.7	0.03	0.05	0.00	931	0.310
Mean Overall	28.2	7.83	8.20	51.0	53.2	0.05	0.19	0.04	756	0.816

Part 7: Marine Turtle Surveys

Methodology and Rationale

A moratorium was introduced in 1995 that, for a five year period, made it an offence to harvest turtles, their eggs, or be found in possession of any turtle product. In 2000 the moratorium was extended for a further five years. During this period a project was conducted across many UK Caribbean Overseas Territories assessing the status of turtle populations (Godley *et al.*, 2004). Anguilla was among the countries that hosted this project, with the results playing a role in the decision to extend the existing moratorium a further 15 years, and also encouraging the long-term monitoring of turtle populations by DFMR. This work began in 2002 with DFMR receiving sporadic help from the Anguilla National Trust (ANT) and the Department of Environment, ultimately becoming a weekly scheduled monitoring effort in 2007 that has continued ever since. A progress report was produced in 2009 that detailed the results of the work conducted in 2007 & 2008 (Wynne, 2009b). 2009 also saw the first steps taken towards building an organisation focused on the conservation of Anguilla's turtle populations (Save Our Sea Turtles: Anguilla - SOSAXA), the running of which was initially overseen by the ANT. An ultimate goal is for SOSAXA and DFMR to share coordinated turtle monitoring efforts. During 2009 DFMR undertook the initial training of SOSAXA volunteers.

Weekly in-water Hawksbill Turtle (*Eretmochelys imbriocota*) monitoring was undertaken at eight permanent monitoring sites (PMS). These sites had been chosen based on previous years work where a number of potential survey sites were assessed. Further potential sites were also visited in 2009 with the aim of adding any found to be suitable (those with highest Hawksbill abundances). As DFMR can only feasibly visit a limited number of sites on a weekly basis, it is important that those included in the project are the most suitable areas known, and as such, at least in the short term, the list of PMS not be static until all areas around Anguilla have been rapidly assessed. Furthermore, even after this ultimate PMS list in completed, it is crucial that those sites 'rejected' are rapidly assessed sporadically (once every couple of years) to establish if any changes may have occurred to turtle populations in the area. At the time of writing almost thirty sites had been assessed (Wynne, 2009b). To surmise; An ultimate goal is to have eight to ten PMS that house the largest Hawksbill populations (thus changes to abundances are more readily visible) with all other suitable sites visited on a rotational basis. Sites that have been surveyed over the past three years where no Hawksbills were observed include: Lockrum & Little Harbour, Forest Bay (Inner east reef), Savannah Bay, Sea Feathers, Forest Point, Black Garden to Fountain Beach, Seal Island, Mimi Bay, Blowing Point, Sandy Point, and Sandy Island (Sandy Shallow dive site). It would be prudent to revisit these sites in the future to look for change.

Nesting beach monitoring occurred at eight index beaches on a regular basis (weekly during peak nesting season), with sporadic visits to other beaches. As with Hawksbill sampling these latter beaches were visited with the long-term goal of modifying the PMS that are included in this project. The original list of index beaches was established a number of years ago, but since then various changes have happened around Anguilla reducing or increasing beach suitability for nesting. For example, sand mining at Windward Point Bay, one of the eight original index beaches, has left virtually no sand remaining. Conversely, the large tourist orientated beaches on the south western coast are not currently considered index beaches although turtle nesting has been documented there.

Note: Due to logistical constraints Green Turtle sampling using a seine net did not take place in 2009. For full survey methodologies of this and other sampling techniques please refer to Wynne (2009b).

Note on beach profiles – Although DFMR is only responsible for areas below high water mark it has continued beach profiling work on a regular basis for many years as it makes logical sense that such work should be conducted by this Department. Also, it can be argued that high water mark, in terms of storm surges, covers the whole beach. Technically however the Department of Lands & Surveys are responsible for beach jurisdiction. Due to this crossover, and because the beach profiling work predates AMMP by a number of years, results from this work will be the subject of a subsequent report.

Nesting beach survey work being conducted as part of a training exercise for SOSAXA volunteers

Results

Table 7.1 – Results from Hawksbill in-water sampling during 2009 for all eight PMS. Encounter rate equates to the number of individuals a snorkelling survey pair can expect to see per hour.

Site Name	Hawksbill Encounter Rate hr^{-1}
Isaacs Cliffs	4.22
Katouche North Cliffs	3.12
Pelican – Flat Cap Point	1.77
Limestone – Black Garden	1.71
Shoal Bay East Inner	0.55
Island Harbour – Shoal Bay East Inner	0.50
Sile Bay	1.64
Forest Bay Inner (west)	1.09

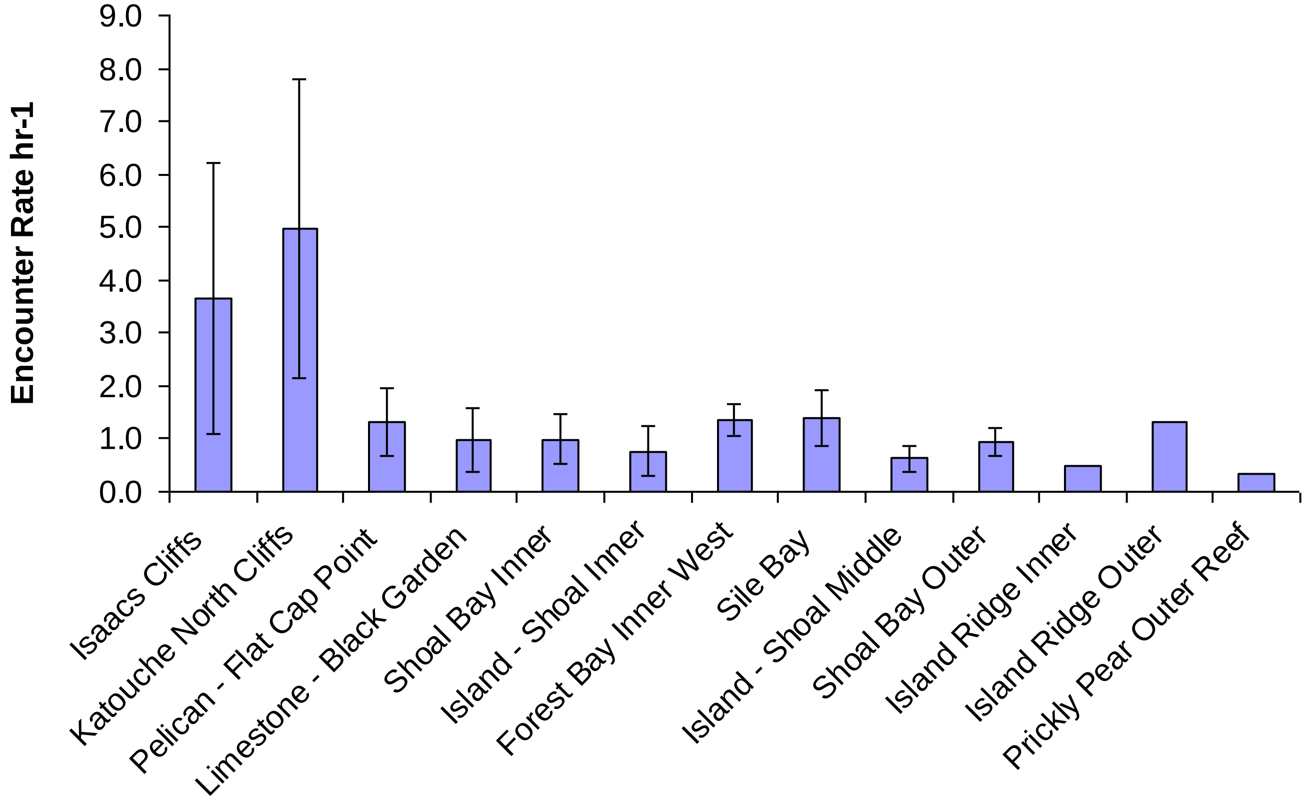


Figure 7.1 – Mean results of Hawksbill sampling 2007 to 2009 (all sites). Error bars indicate the standard deviation at each site. Note that the latter three sites have only been replicated once and hence have no error bars present. Replicate numbers were, on the whole, greater for the first eight sites as these are the current PMS used.

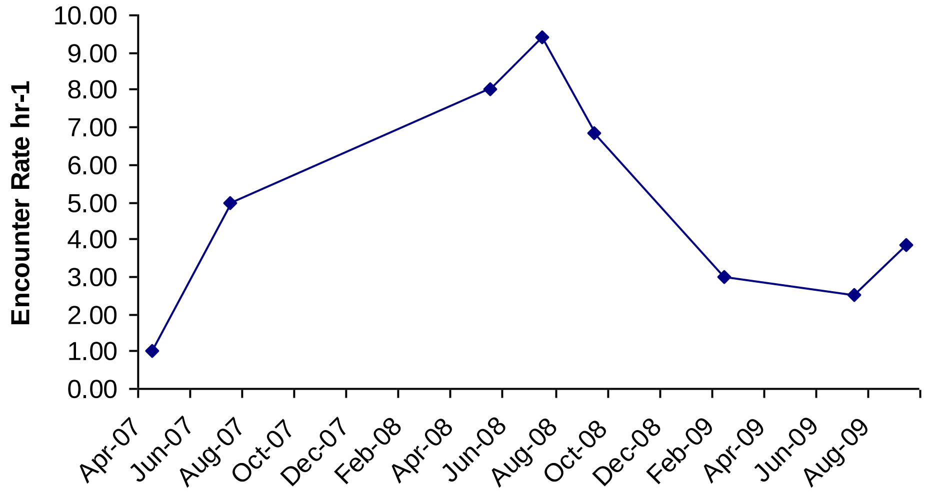


Figure 7.2 – Encounter rate of Hawksbill Turtles at Katouche North Cliffs (PMS) over three year study period illustrating a peak in August 2008.

Table 7.3 – Results from nesting surveys for those beaches regularly monitored. Note that those visited include the eight index beaches (with the exception of Windward Point Bay) together with three other exploratory sites (Mimi Bay, Katouche Bay & Shoal Bay West). The Predominant Species column details the species recorded most frequently at each site, however, on a number of occasions species remained unidentified. Although not predominant, Green Turtle activity was also noted at selected beaches.

Beach Name	No of Visits 2009	Number of False Crawls Recorded	Number of Nests Recorded	Predominant Species
Black Garden	39	8	2	Hawksbill
Captains Bay	43	1	7	Leatherback
Junks/Savannah	28	1	2	Hawksbill
Katouche Bay	16	0	0	n/a
Shoal Bay East	26	2	3	Hawksbill
Long Bay	27	0	0	n/a
Meads Bay	31	2	2	Leatherback
Mimi Bay	23	6	0	Hawksbill
Shoal Bay West	32	1	1	Hawksbill

Discussion

From the results presented above, and backed through qualitative observations, it is clear that turtle populations are highest on the northern coast of Anguilla, especially the strip of coastline between Isaacs Cliffs and Little Bay. Turtles can however be observed island wide, albeit usually in low densities (compared to abundances reported in anecdotal historical records).

Currently it is too early to make a temporal analysis of the data presented, and as such assess the effectiveness of the moratorium. For example, although an interesting abundance peak was noticed at Katouche North Cliffs (figure 7.2) in July 2008 it is not possible to conclude whether this due to an increase and subsequent decrease in numbers around this date, or if it is due to natural variation of Hawksbill abundances (moon phases, weather conditions etc). It is very important that this project be continued on into the future to examine such trends and establish reasons for them because, for example, poachers have been witnessed illegally harvesting turtles at Katouche and as such any effect this is having on turtle numbers needs to be established. This can only be accomplished by replicating surveys as many times as possible throughout the year and encompassing variables such as moon phase and weather conditions into the analysis.

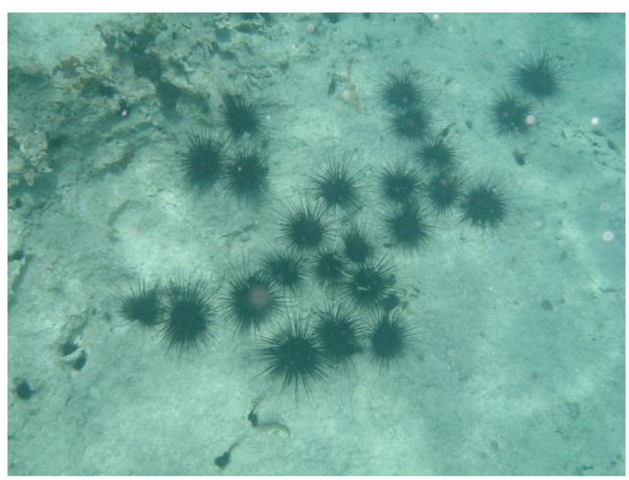
As turtles take a number of decades to reach maturity (depending on species) any impact that the moratorium will have on nesting populations will not be visible for a number of decades to come. Considering the number of nesting beach surveys that took place in 2009, combined with the fact that most beaches have regular visitors who notify DFMR of potential activity, the number of nests recorded is very low. This, together with the relatively limited foraging populations, suggest that Anguilla's turtle populations will need protecting beyond the current moratorium. Furthermore, in order for the moratorium to be successful a greater surveillance effort is needed to dissuade potential poachers from continuing to flout the law.

Part 8: Other Key Species

Long-Spined Sea Urchin

Although not part of the AMMP project, rapid assessments of Long-Spined Sea Urchin (*Diadema antillarium*) were conducted in 2007 around the Shoal Bay – Island Harbour Marine Park as part of a study that looked into the potential to translocate this species from a threatened habitat into a safe area (Wynne 2008c). Receiving sites were chosen by looking for Marine Park areas where populations had not yet recovered since the 1980 mass mortality event. *Diadema* are considered a keystone species, and one that plays a major role regulating the algae/coral balance on reef systems (Tuya *et al.,* 2004). Since the 1980 mass mortality event that spread across the Caribbean, *Diadema* populations have yet to recover to densities present prior to this event; however, it should be pointed out that as no studies were conducted in Anguilla prior to the 1990's, actual densities before the mass mortality event can only be estimated based on studies conducted elsewhere. Since the mortality event algae levels have escalated in many areas and coral cover has dropped dramatically, although it should be noted that this is also likely due to many other factors including, but not limited to, eutrophication (part 6), and overfishing of herbivorous fish (part 3), that have potentially increased over the same time period.

Aside from this translocation work, visual estimates of *Diadema* populations were also made at various sites around the island including Little Bay, Pelican Point, Meads Bay, Maundays Bay, Sandy Hill Bay and Sile Bay. Furthermore, through AMMP's regular benthic monitoring (part 2) densities are assessed, and as such temporal comparisons will be possible in the future. In all, it seems apparent that populations are finally recovering, although this recovery is patchy and happening in an unexpected way. Low relief areas (for example Maundays Bay - see inset picture) with rocks interspersed with large sandy regions are, on the whole, among those areas with highest densities. In some parts densities are so high that the urchins are aggregating on the sand itself – unusual behaviour for this species, whom, despite their fierce array of sharp spines, do suffer from significant predation by a wide range of creatures (see Bruno, 2010). In contrast, many areas that seem perfect for *Diadema* due to high topological complexity (for example areas such as Forest Bay and Shoal Bay East), seem to be recovering more slowly. Night snorkels in these locations were also undertaken to confirm urchins weren't simply hiding within reef recesses during the day. Reasons for this anomaly are unclear, but it is possible that predator-prey interactions may be a contributing factor combined with larval supply from prevailing currents (Miller *et al.,* 2003). Another possibility is that these areas with high topological complexity are less suited for urchin settlement. For example, Forest Bay reef is largely dead, and due to erosion the old Elkhorn (*Acropora palmata*) stands are relatively smooth, thus offering a restricted number of settlement sites for recruiting *Diadema* larvae. Conversely, sites such as Maundays Bay (see inset picture), although low in complexity, do have highly pitted surfaces which could act as settlement sites. Furthermore, such areas appear to harbour a high diversity of life (although surveys have yet to be conducted to quantify this), and are usually in bays that are relatively sheltered yet well flushed. This all suggests these sites may be in better overall 'health' than those areas yet to recover.



Spiny Lobsters

The survey work conducted through AMMP does not provide a great deal of data that relate to the two lobster fisheries on Anguilla. Past assessments (see appendix 1) have taken place for the Caribbean Spiny Lobster (*Panulirus argus*), the main lobster fishery, but no work was conducted on the smaller Spotted Spiny Lobster (*Panulirus guttatus*) fishery prior to 2004. This latter species is known locally as the crayfish.

From qualitative information collected over recent years it would appear that *P.argus* populations are in decline. Fishers are reporting that they have to go out greater distances to land catches that are smaller than they were during past decades, and that lobster fishers fish more infrequently (W. Harrigan pers.comm.). The same fishers are also beginning to suggest closing the lobster season at certain times of the year to help improve catches. From this information one can only assume that lobster populations around Anguilla are in significant decline.

A brief assessment of the *P.guttatus* fishery was conducted in 2004 that also looked at ecological aspects of this species and the impact fishing has on it (Wynne 2004; Wynne & Côté 2007). This project was expanded upon during 2007 & 2008 (Wynne 2009c) to get a better understanding of the fishery, make an assessment of its health, and deduce which management measures could be introduced to promote its sustainability. The results of this work indicated that although some reef areas no longer house populations of *P.guttatus* as dense as they likely once were, populations were still at a high enough level to not detect a significant fishing effect. Based on the presumption that this is a relatively young fishery, and one that appears to be growing as it is driven by an expanding tourist industry, it is likely that such an effect will soon be possible to detect. In fact, during the 2007/2008 portion of the study, some areas of reef were no longer favoured as much by fishers as others due to reductions in catch. This study also uncovered that there is a peak in the reproductive activity of *P.guttatus* in Anguilla between January and April each year, and that males reach first physical maturity at c.51mm carapace length, and 50% of females begin to exhibit reproductive activity at c.46mm carapace length.

Queen Conch

No known specific assessments have taken place on Queen Conch (*Strombus gigas*) populations in Anguilla, although through AMMP benthic surveys of the five seagrass sites some recent estimations have been produced (see part 2). From these estimations, combined with the presence of conch middens in places such as Sandy Ground and the knowledge that shallow seagrass areas are not particularly extensive around Anguilla, it can be deduced that suitable accessible conch grounds have been overfished and now only house limited populations. Furthermore, conch legislation is inadequate based on current scientific thinking, where it is now largely agreed that a conch should have a well developed lip to be considered mature (Berg, 1976). Fisheries legislation in some other Caribbean states stipulates that a conch should have a developed lip with a thickness of at least 5mm for it to be considered sufficiently mature to promote sustainability within the fishery. However, studies in Puerto Rico have shown that a high proportion of conch with a lip thickness of 5 mm were still immature, consequently the minimum lip thickness was increased to 9.5 mm to ensure harvesting is mainly of mature animals (Theile, 2001). Currently, Anguilla's legislation states that a conch only has to be 18cm in length, from base end of the aperture to terminal end of the apex. Conch of these dimensions are very much smaller than those with a well developed lip, and as such immature individuals can be legally landed. In fact, studies have shown that at 18cm up to 94% of a population may still be legally fished before they mature and so have had the chance to reproduce (Blakesley, 1977).

Most conch catches today are caught by using SCUBA gear. Although conch can live below safe diving limits (and as such have a population haven) the management of those within safe diving limits needs urgent attention if it is to remain a viable fishery on the island.

Part 9: Conclusions and Recommendations

Benthic Habitat

Anguilla's shallow water (<15m) benthic habitats are generally in a poor state of health with an overall low hard coral cover and areas dominated with high levels of macroalgae. The southern coastline is comprised mainly of slowly eroding hard coral skeletal fragments or intact structures, and in worse condition than the northern coastline, although levels of macroalgae are generally lower. The majority of southern areas show very little recent coral growth whereas in northern areas new corals do appear to be growing, albeit to a somewhat limited extent. This was confirmed by a coral recruitment study that demonstrated that the southern coastal region has extremely limited levels of coral recruitment compared to northern areas. Reasons for this remain unclear although it is probably, at least in part, due to the southern coastline being more exposed to potential sources of contamination. These include (but are not limited to): Corito Bay landfill and petroleum facility; Blowing Point port facility; and coastal salt ponds that are known to be polluted, one of which has been connected to the sea via underground pipes. Others salt ponds are sporadically breached during storm surges. The south coast is more exposed than the north coast and as such the reef system that existed there would have historically been different from those in other areas around Anguilla, with species that favour these conditions, for example Elkhorn (*Acropora palmata*), proliferating. Elkhorn populations were regionally decimated by disease and have yet to recover. Away from the south coast species diversity is generally greater, a fact that increases reef resilience. Further to (but also connected with) contamination, exposure, and disease, sedimentation (marine snow) and eutrophication are also likely affecting coral recruitment and therefore overall recovery. Eutrophication/pollution is also known to increase macroalgae blooms and encourage certain coral diseases, especially those derived from Cyanobacteria infections. Although these phenomenon are occurring throughout the Caribbean and may be influenced by regional stressors that can't be managed for on a local level, it is still important to minimise local point sources. Not only will this mitigate against regional sources, but it is only by all nations taking responsibility for their own point source stressors that these regional factors will be addressed. Listed below are a series of recommendations that may be followed to address the current benthic situation or to increase understanding as to what is happening there.

- A study should be conducted to assess the Corito Bay landfill site and ascertain if any leeching is occurring into the marine environment. If so, a feasibility study needs to be conducted to look into reducing this leeching either by construction of non-permeable barriers between the landfill and the ocean or by relocating the landfill site to a more suitable area. A similar assessment should be conducted for the Corito Bay petroleum facility, especially in light of the proposed port facility at this site. This new facility, if constructed, should aim to minimise any contamination into the ocean.
- Consideration should be given to cleaning up the coastal salt ponds and very careful thought and planning be employed if any further direct connections are to be made to the sea. Salt ponds act as nutrient traps for their surrounding water catchment area and so a connection to the sea allows direct nutrient introduction into the marine system.
- The use of septic tanks should be prohibited for new developments that are close to the coast. Existing sewage treatment plants should be properly maintained. Waste water treatment plants should be located well away from low lying areas close to the coast. After hurricane Omar the waste water treatment plant at Cap Jaluca was reportedly inundated and as a result much of its contents flushed into the bay. The result was foul smelling bay water that lasted more than a week while clean up efforts were underway. Some of this suspected contamination may have also originated from Gull Pond that breached during the storm. A feasibility study is recommended that looks into an island wide governmentally run waste water infrastructure.

- Coastal development needs to be under stricter control. EIA's should be mandatory and legislated for. Sea backs should be required by law and the removal of beach flora prohibited (except toxic species). Dune removal and sand mining legislation needs to be updated urgently, and existing legislation enforced. Dunes are an essential resource that not only act as a coastal defence during storm surges but also replenish sand into beach systems after severe erosional events.
- The Blowing Point port, especially the aging ferry fleet, should undergo assessment to address any sources of contamination entering the marine environment. It is necessary to revisit the legislation as to how it relates to oil (etc) emissions from vessels. There have been a number of complaints in recent years regarding slicks that have been seen emanating from some of them.
- Stricter control over dumping of grey water by visiting yachts (etc) needs to be undertaken which will involve improving surveillance capabilities and introducing holding tank spot checks. For example, a vessel with an empty holding tank that has been in Anguillian waters for a week would be seen as suspicious. To allow measures like this to be employed a water treatment plant needs to be established at the check-in port. Visiting vessels should be obliged to empty their holding tanks here when they arrive (if sufficiently full), thus discouraging dumping in the first place while allowing realistic spot checks of larger, longer visiting vessels. Full documentation of waste water plant usage should also be insisted upon.
- Tighter control of fishing practices need implementing (many of these will be detailed in the following sub-section). Protection of certain herbivorous fish species, for example parrotfishes, needs encouraging. Trap fishing needs greater control as these gear types can cause a lot of damage to the reef if not used responsibly. Consideration needs to be given to closing certain areas to this type of fishing. In fact, it is suggested that Government initiatives attempt to move Anguilla's fishing industry away from trap/spear fishing all together and encourage the fishing of pelagic species. It might also be prudent to investigate aquaculture options to move reliance away from reef dwelling fish species. Such options need very careful consideration however as side effects from aquaculture can be detrimental to benthic habitat health and overall water quality.

Fish Populations

Fish populations in Anguilla's shallow reef habitats (<15m) are much reduced from those present historically. Anecdotal reports, archaeological evidence, and fish catch data all suggest this, thus although the current span of AMMP means temporal quantifications cannot be made, the precautionary approach to fisheries management should be applied to strive towards a sustainable fisheries future. The size class structure of reef fish present is different from that expected in a 'natural' population with far fewer large individuals present. Fish available for purchase from various outlets around the island are often undersized. Species targeted by fishers are, in many cases, almost absent from some reef areas and those present are usually undersized, immature individuals. It is likely that environmental factors are playing a role in these declines, but fishing is probably the dominating influence removing the larger individuals. These environmental factors, in complex interactions between themselves and fishing, are the most likely reason for the habitat degradation discussed in the previous subsection. Habitat degradation then induces a positive feedback loop that further decreases the ability for the reef environment to sustain healthy fish populations and increases the susceptibility of the habitat to further degradation. It is essential that steps are taken to address this problem immediately before the situation gets worse. Below are listed a series of recommendations that should be followed to do this.

- Spearfishing, that selectively and efficiently targets reef fish in shallow areas, needs urgent control. It is suggestive that it be prohibited across all shallow reef areas, at least in the short term, to allow these environments a period of recovery. During this period assessments should be conducted to investigate recovery and, based on the results, management measures can be modified. In the long-term spearfishing should be prohibited in Anguilla's marine parks and controlled in other areas by, for example, establishing daily catch limits and placing restrictions on certain species.

- Minimum sizes need to be introduced for a number of species, although catching of immature individuals of any species should be discouraged. It is understood that undersized catch is often used as bait before returning to dock, but the sale of such individuals should be prohibited. This will involve much research into size of maturity for different species, so to begin with it is suggested only for those currently known to be under pressure, for example, species of grouper, snapper and jacks.
- Fisheries management zones urgently need to be established to control the islands fisheries better. Areas closed to all types of fishing should be implemented, as should those that permit only certain gear types or the landing of certain species. It is suggested that to begin with Anguilla's Marine Parks be used for this purpose. This could also be expanded to include other reef areas less than 10 metres deep.
- In order to manage the various fisheries better it is important that traps be correctly tagged with the owners licence number. The legislation already exists for this, but compliance and enforcement has yet to be established. This should happen as soon as possible so that when no fishing zones (etc) are established violators can be easily identified. Fisheries officers should have the power to remove/confiscate any gear violating regulations and issue fines to the owners.

Turtles

Turtle populations in Anguilla appear steady for the time being, although data will need to be collected for many years to come to confirm this. Abundances of foraging juvenile Green and Hawksbill Turtles are moderately healthy at certain select sites, although nowhere in our waters are they close to levels thought present historically. On the whole the situation is encouraging but only their continued protection will facilitate increasing their numbers. The nesting population is less encouraging with fewer than twenty recorded nests in 2009. Considering the profusion of suitable beaches that Anguilla offers this number is of even greater concern, but it is recognised that actual nest numbers may be considerably higher when including the sparsely monitored offshore cays. It is probable that nesting numbers are low because of over-harvesting in the proceeding decades. It takes many years for maturity to be reached so it is hoped that in decades to come, if the current protection continues, numbers will gradually begin to increase. In light of this three main recommendations can be made.

- The current moratorium (which expires in 2020) should under no circumstances be abolished prematurely. It is highly likely that for populations to increase significantly, especially the all important nesting populations, further moratoriums will be needed for a considerable time into the future.
- Developmental set back zones should be implemented to restrict light and other disturbances to nesting turtle populations. A beach lighting policy should be implemented.
- Regular monitoring of the offshore cays should begin as it is likely that their remoteness (especially Dog Island) and minimal human activity/development has left nesting populations indicative of actual nesting populations. With the creation of an Anguilla based turtle conservation organisation it is proposed that many of the mainland beaches be handed over to them for monitoring so that DFMR can concentrate on the areas that can only be reached by boat.

Diadema

Diadema antillarum populations, although still somewhat patchy, appear to be recovering from the 1980's mortality event. Some areas have very high densities present, and as a consequence these areas generally have very sparse macroalgae growth. Even though macroalgae is encouraged by nutrification which is occurring in Caribbean waters, *D.antillarum* appear to be able to keep it under control. In areas where their populations have yet to recover macroalgae usually dominates. An exception to this is Forest Bay which has very few *D.antillarum* and very little macroalgae. This is not likely due to populations of grazing surgeonfish that are profuse in the area as they are also in high abundances at Sile Bay where macroalgae dominates. In light of this patchy recovery and the profound effect they have on their habitat the following recommendation can be made.

- Any coastal development that is undertaken in an area with healthy *D.antillarum* populations that may be detrimentally affected by the development should seek to relocate the urchins to an area that has yet to recover. Translocation methodology and recommendations as to how a receiving site should be selected can be found in Wynne (2008c)

Lobster

Work conducted on the Crayfish (*Panulirus guttatus* – Wynne 2004 & Wynne & Côté 2007) suggests that populations are being affected by fishing but that presently this effect has yet to cause significant decline in numbers, at least at the majority of sites. This will not continue if the present levels of fishing persist (or indeed increase as they are likely to as tourism demand increases as projected). Indeed, already fishers are reporting reduced catches in certain areas (R.Webster, pers. comm.), and once popular fishing sites are now visited less frequently (S.Wynne pers.obs.). The precautionary principle means measures need to be undertaken to sustain this fishery on into the future. No minimum landing size for this species exists as it does for the Caribbean Spiny Lobster (*Panulirus argus*). Although no specific studies have yet been conducted for *P.argus* it is known that fishers catches are reduced and they now have to travel further distances and set their traps deeper to catch substantial numbers. In order to protect the interest of fishers within these two fisheries the following recommendations can be made.

- A full assessment of the *P.argus* fishery should be undertaken to ascertain population health, changes in catch, and changes in fishing grounds. This information can then be used to make more informed management decisions.
- Closed seasons during peak lobster breeding periods should be introduced for both *P.argus* (based on regionally accepted studies) and *P.guttatus* (as recommended in Wynne (2009c).
- Closed areas would be beneficial to help populations in selected areas recover fully from exploitation and act as seeding grounds for the Caribbean as a whole. As other nations follow suit there will always be plentiful supplies of larvae to restock fishing areas. The closed areas could be incorporated into the same zones as suggested for reef fish.
- A minimum landing size should be introduced for *P.guttatus* as recommended by Wynne (2009c). This will help protect immature individuals which will become more favourable to target as larger individuals become less abundant.

Conch

No exclusive study has been conducted for the conch fishery and so details have not been quantified (as with *P.argus* mentioned previously). However, a number of observations have been made over recent years which suggest management measures currently in place are insufficient to sustain it into the future. For example, suitable conch habitat is not in abundance around Anguilla and yet relatively large numbers are still landed on a weekly basis. All conch fishing today can only be carried out using SCUBA gear, and fishers are reportedly venturing into deeper and deeper waters to make a living. Conch can live below safe diving limits so they will always have a 'safe haven', although this does raise questions into the safety of those diving for conch as a living. Vast middens are visible in areas such as Sandy Ground, and on close inspection the vast majority of conchs are immature, even though most are within legal size limits. This suggests a flaw in the current legislation. In order to strive towards a prosperous future for this fishery the following recommendations can be made.

- A full assessment of the fishery should be undertaken, including stock assessment, the documentation of recognised conch grounds, and historical catch analysis.
- The minimum landing size of conch should be changed and based instead on the thickness of their aperture lip. This lip should be at least 5mm in thickness, but thicker sizes are often recommended in order to guarantee maturity has been reached for at least two years.
- A maximum depth for safe conch diving should be publicised in order to avoid potential future accidents. This is especially important as the nearest hyperbaric chamber is in Saba which, although close, is realistically a number of hours away. Even if it could be reached in time it is likely fishers would not be able to pay for treatment or not be sufficiently insured.

Note on Lionfish Invasion

During the latter part of 2009 DFMR, in collaboration with the Anguillian National Trust and Department of Environment, lead a public awareness initiative to inform people of the pending arrival of the invasive Lionfish (*Pterois volitans*). DFMR also laid out a targeted eradication response plan (Wynne, 2009d) that would be initiated once their arrival had been confirmed. This confirmation did not come until a local dive operator sighted the species close to Anguillita Cay on the 16^{th} August 2010, and submitted a report to DFMR who later went in search of it. During the days that followed the specimen was captured by one of DFMR's Fisheries Officers via spear-gun, photographed, and brought ashore for positive identification. DFMR are currently requesting that people collect GPS coordinates of any sighted specimens and submit them to the Department as soon as possible. As an interesting note, after confirmation of their arrival occurred, DFMR received an email from a tourist who claimed to have photographed a Lionfish in Anguillian waters a number of years ago. After receiving a copy of the photograph the Department confirmed the species pictured was in fact a Lionfish. Although at the time of writing the authenticity of the photograph or location where it was taken had yet to be validated, it might signify that the spread of the species is far more rapid than currently thought. Another possibility is that their spread started earlier than originally reported, with specimens settling in deeper areas where they remain for a number of years before moving into shallower waters. Even though the chronology of sightings across the Caribbean is so 'perfect' it seems to suggest this could not be the case, it is certainly worth investigating because if correct it would have important implications for: Existing studies on the effect of their invasion; current understanding of the mechanisms behind their spread; and, more importantly, management decisions to mitigate against this species, including increased vigilance of nations who believe they are far enough away from this invasion to not currently consider it a threat.

Appendix 1
Marine related work conducted in Anguilla prior to 2006
(This list is not exhaustive: Compiled by author based on investigations through DFMR records)

Survey of Anguilla's Lobster Fishery – (Peacock, 1972 & 1975). Cited in later report by T.P. Jones.

Report and Recommendations for Anguilla's Fishing Industry – (Comacho, 1974). Cited in later report by T.P. Jones.

A preliminary management strategy for the utilization of the critical marine resources of Anguilla (Unpublished report by ECNAMP, as part of the Anguilla Resources Development Project) & **Plan of action for the development of marine parks (**Anguilla, Caribbean Conservation Association). Jackson, I. 1981 (sometimes cited as 1987).

Management Planning for Anguilla's Fishing Industry – (Olsen & Ogden, 1982). Cited in later report by T.P. Jones.

The Fishing Industry of Anguilla – A report prepared by T.P. Jones in 1985 that examines all aspects of Anguilla's fishing industry.

Marine Habitats Survey – Bellairs Research Institute 1990. 'A Survey of Marine Habitats Around Anguilla with Baseline Community Descriptions for Coral Reefs and Seagrass Beds'.

NRI Anguilla Natural Resource Assessment – Fieldwork carried out by UK bodies in 1994 that produced the NRI Natural Resource Atlas.

Long-line Project – Conducted during the late 1990's to assess viability of creating a long-line fishing industry on the island. Although considered a success in terms of confirming such an industry was possible, no future developments occurred.

Socio-Economic Impact Assessment of the Anguilla Offshore Fisheries Development Project – T.A. Rajack-Talley (MacAllister Elliot & Partners). 1999. Mainly based on interviews with fishers, this is one of a number of fisheries related reports (not necessarily based on any survey work) produced around this time (+/- a few years).

Reef-Check 2001 & 2004 – Used as a staff training exercise with workshop teaching survey techniques and species identification. No follow-up surveys took place.

The Status of Stocks of Groupers and Hinds in the Northern Caribbean – John Munro & Lauren Blok (undated) – paper presented at the 56th Annual Meeting of the Gulf of Caribbean Fisheries Institute. This work has a small section on Anguilla but it is unclear if any survey work was conducted.

REEF Surveys – 16 surveys were conducted prior to 2006, all likely collected by a single initiative (reports suggest these were lead by Susan Thompson?). Date of surveys is unclear but it is known they took place earlier than 2004.

MCS (TCOT) – Survey work to create 'An Assessment of the Status and Exploitation of Marine Turtles in Anguilla'. Pdf version of this report can be downloaded from the link http://www.seaturtle.org/mtrg/projects/tcot/finalreport/section4.pdf Work carried out by the Marine Conservation Society, headed by Peter Richardson. This three year project was completed in 2004.

Anguilla Coastal Survey 2004 - ACRAMAM (Anguilla Coastal Resource Assessment Monitoring and Management). Actual survey work conducted was poorly documented. Anguilla Coastal Resource Information System (AXACRIS) was produced as a result of some of this work.

Overseas Students Research Projects – Five known studies carried out by students from University of East Anglia between 2003 & 2005. Projects on: Turtle nesting; Coral recruitment; Sex change in reef fish; Crayfish fishery; and socioeconomic work on fishing effort. Other students have since visited the Island through DFMR. For details please contact fisheriesmr@gov.ai

DFMR & ANT Socioeconomic survey of Shoal Bay & Island Harbour – Carried out by James Gumbs (DFMR) & Farah Mukhida (ANT) during 2005/2006. Looked into socioeconomic considerations relating to Shoal Bay and Island Harbour Marine Park.

Survey of the Fish & Coral Fauna on Sombrero Island (undated) – Produced by Christoph Grueneberg (Overseas Student) in collaboration with the Anguilla National Trust. A brief unquantified report was written as a result of this work.

DFMR Beach Monitoring – Carried out on a regular basis since c.1992. Data has been entered into database. Reports on this data are pending.

Additional Information

Following production of this document, reports were made in early July 2010 of exceptionally green water present in certain areas around Anguilla. DFMR subsequently dived at the Anguillita and Oosterdiep dive sites (where the reports had originated) and confirmed the waters were incredibly turbid with visibility at times lower than one or two meters. The inserted (unedited) photo was taken on the 7th July 2010 at Anguillita and illustrates the water colour and turbidity: The colour is a good representation of that observed and the divers arm is only approximately one metre away. Visibility in Anguillian waters can often exceed 25m. Reasons for these conditions remain unclear but it is almost certainly due to phytoplankton and thus nutrient rich water. This observation is highly relevant to sections 2, 4, 5 and 6 of this document. Indeed, the source of this water might well be the main contributing factor to eutrophication in Anguillian waters, and even the Caribbean as a whole. More regional research is needed, but subjective reports also occurred during the same period in 2009 on various online networking sites (for example coral-list) where abnormal nutrient rich waters were surrounding the Virgin Islands. The Orinoco's outflow plume was stated as the source, with anecdotal observations describing sudden changes to species composition and behaviour in local waters. If such a situation is indeed confirmed it suggests that the Orinoco may be one of the main sources of the Caribbean's recent increases in nutrient rich water. If so, this might signify the need for huge international efforts to manage the outflow of nutrients from this great river system in order to reverse, or at least mitigate against, the dramatic negative trends documented throughout Caribbean coral reefs over recent decades.

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