Akumal Coral Ecology Project 2004
Preliminary report

Background:

It is becoming increasingly acknowledged that coral reefs are globally threatened. Recent documented stresses to Caribbean reefs include Hurricanes, el Nino events, urchin die-offs, and anthropogenic impacts in the form of oil and sewage pollution, eutrophication, dredging, anchoring, over and destructive fishing, overzealous tourism and sedimentation. These factors are known to affect coral reef diversity, community structure and reproductive capacity. Reef deterioration is well documented in the Caribbean and coral bleaching is a ubiquitous concern in the region.

A further but less well understood threat to coral reefs is the emergence of novel pathologies of scleractinian corals. These novel diseases have been appearing at a progressively greater frequency and over a wider distribution than ever before. Their causes for the most part remain unknown; to date there is only one study to demonstrate the mechanism of coral tissue death by coral disease (Carlton & Richardson, 1995) and method of infection of all coral diseases remain unknown. However, they continue to induce a gradual shift in the vital status of coral reef ecosystems.

The reefs at Akumal form a part of the Mesoamerican Barrier Reef (Figure 1). This reef system extends from the southern half of the Yucatan Peninsula, Mexico to the Bay Islands of Honduras and is the second longest barrier reef in the world. It is unique in the Western hemisphere due to its length, composition of reef types, and diverse assemblage of corals and related species.

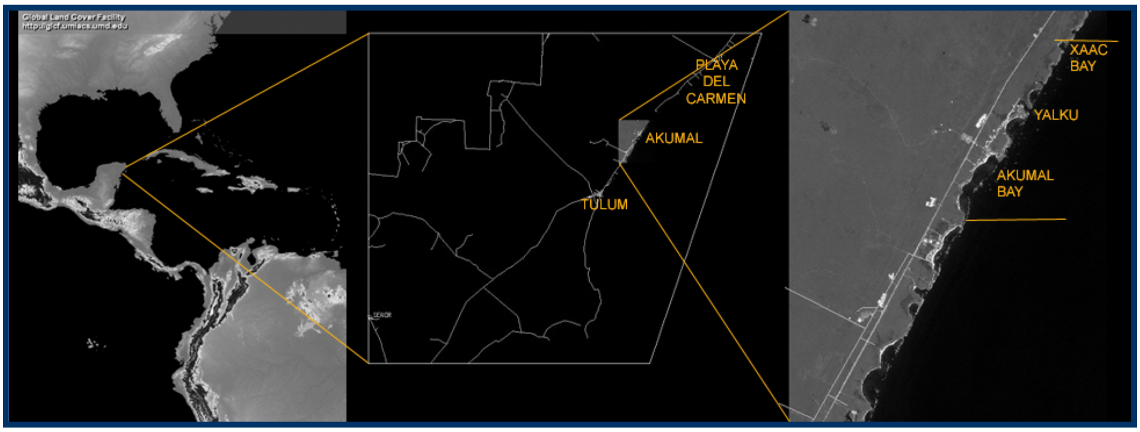

Figure 1: Our study site ranging from the southern most tip of Akumal Bay to Xaac Bay, in context in Quintana Roo, Mexico.

The aim of Akumal Coral Ecology research expedition was to document the distribution of Yellow Band Disease and to investigate the relationship between Yellow Band Disease incidence and environmental and community factors in and around Akumal bay.

Between June 28th and August 14th, we were supported and hosted by Centro Ecológico Akumal (CEA), an environmental not-for-profit organization dedicated to conservation through education, research and policy influence. Diving support was provided by Akumal Dive Shop.

Figure 2: The ACE team with Susanna Sokolow (UC Davis), Manager of Akumal Dive Shop, Pablo Diaz and his dog, Max.

Figure 3: The ACE team left to right: Lucy Jack, Marion Perutz and Loïc Lhopitallier, with CEA Director Paul Sanchez Navaro and Susanne Sokolow.

The team employed a multidisciplinary approach, working in conjunction with two other research groups and gathering information from a number of local and visiting sources (Figure 1 and 2).

Reef Community Ecology and Disease Distribution Research:

Introduction:

The team collaborated with Dr Janet Foley and Susanna Sokolow, veterinary epidemiologists from the University of California at Davis (UCD), and their group of research divers. Our methodologies were standardized and resources were shared when possible. The UCD team collected data on a larger geographical scale, whilst the ACE group surveyed more rigorously in the Akumal area. All data collected was exchanged at the end of the investigation to enhance the power of both of our studies.

The study site:

The coral reefs surveyed lie between 20°23.0′ N and 20°24.7′ N latitude and 87°17.5′ W and 87°19.2′ W longitude (Figure 4). The coastline is characterized by rocky headlands and shallow bays with sandy beaches. The reef crest cuts across the mouth of the bays and fringes the headlands in Akumal and Half moon bay to the north. The crest breaks the surface in some places at low tide. The Reef crest further north towards Yalku is less apparent since the lagoon is not a bay but an eroded channel, and corals grow on an extension of the rocky headland. Within the bays lie lagoonal and patch reef systems (the back reef) which were not included in the study. Seaward of the reef crest lie fore reef structures at approximately 10 m (the inner reef), 11-14m (the middle reef) and at 15-18m (the outer reef). The reefs are separated by sand channels approximately 40-50m wide.

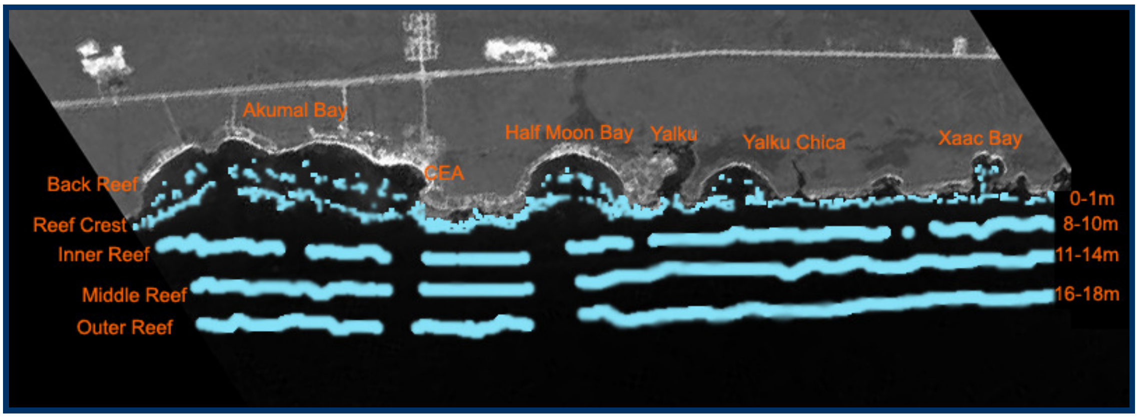

Figure 4: An aerial photograph of Akumal and the surrounding area where transects were laid. Blue colour represents an approximation of the reef structure in the studied region from the southern tip of Akumal Bay and Xaac bay.

Methods:

In collaboration with the UCD group, 39 linear transects of 30m length were decided upon, using m^2 quadrats to measure community composition.

In keeping with recent similar studies, radial transects were attempted during a week of training but this method was deemed destructive due to the abundance of sea fans and other soft corals, protruding above the substrate.

Sites were chosen by random stratification of 6 km of coast line around Akumal. An attempt was made to survey the inner, middle and outer sections of the fore reef at 12 sites, chosen by equally dividing the survey region into adjacent segments.

Results:

The community data can be summarized by the following statistics:

Mean Live Cover:	0.333394	SE 0.0207	range 9-59%
Mean Pilou' s index:	0.838314	SE 0.0134	range 0.65-0.96
Mean Simpson's index:	0.186401	SE 0.0138	range 8.24E-02 - 0.562222
Mean Shannon Wiener's index:	0.878755	SE 0.0233	range 0.683192- 1.156322
Mean # spp per transect:	11.39474	SE 0.436	range 5-18
Total # coral species observed:	35		

Discussion:

At a Nature Concervancy Conference in Cancun, attended by representatives from CINVESTSAV University, Merida, Q. Roo, and Amigos de Saan Ka'an of the Siaan Ka'an Biosphere reserve (and Lucy Jack), the reefs at Akumal were proposed as a priority for conservation due to their high diversity, unique, well developed spur and groove reef structure and increasing risk from anthropogenic impacts.
Muňoz –Chargrin & La Cruz Aguera measured live coral cover in Akumal using an area based approach in 1993 and published an average of 23% (Muňoz –Chargrin & La Cruz Aguera,1993). A survey in 1999 using the AAGRA survey technique (Steneck & Lang, 2003) recorded live stoney coral cover over 9 transects at Akumal to be 18%. The ACE team recorded a total of 35 observed species whilst Steneck & Lang, 2003 reported 18 species.

Our higher estimates may indicate reef recovery after two events of 1998, the mass bleaching of corals due to El Niño and sea temperature rise and the destruction of reef structure due to hurricane Mitch. However, it must also be noted that although hopefully comparative, methodologies between studies were not standardized and so these differences may be an artifact of that.

Geology and Hydrology:

Introduction:

The Karst system consists of a series of interlinking subterraneous water passages eroded into the limestone rock defining a hydrology which is distinctive of the Yucatan. Surface flows of fresh water are characteristically absent and precipitation either evaporates or enters underground cave systems, known as cenotes. Seven out of 10 of the worlds longest cave systems are found in the Yucatan peninsular between Puerto Morelos and Tulum, Akumal lying between these points.

Fresh water flows from the land out towards the ocean in the upper layers of this system and salt water flows inland in the lower layer (see Figure 4). The significant movement of water creates a dynamic interchange of salt and fresh water from the land and sea.

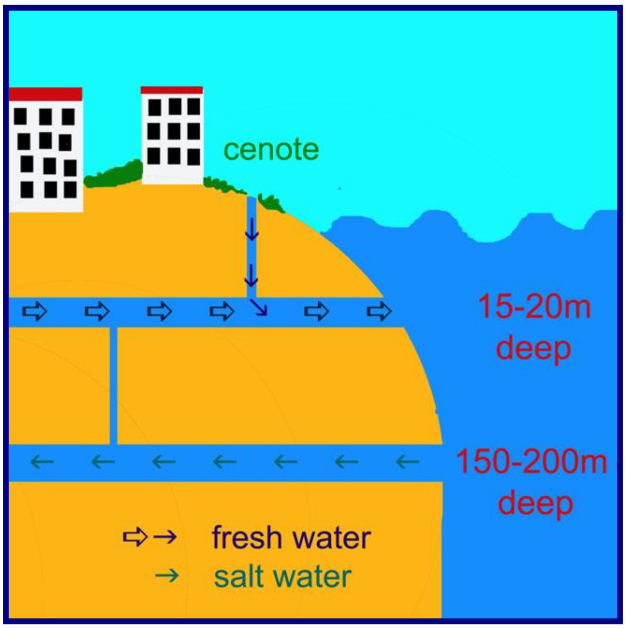

Figure 4: A schematic diagram of the Yucatan Cenote systems. Fresh water fills the upper cave system and generally is thought to flow out to sea. The lower cave system is filled with salt water and flow is thought to move in a landward direction.

The affect of calettas (out-flows of water from the cenote system into the sea) was of great interest to the ACE project. Yalku and Yalku chika, calettas in Akumal, release a high volume of water of terrestrial origin into Akumal's coastal waters. The most current attitude of developers in the region, that it is easier to ask for forgiveness than for permission, has lead to the gross mismanagement of both solid waste and human waste in the region including unlined dumps and inadequate waste treatment plants. Treated and untreated human waste is injected for disposal at a recommended depth of 50-100m into the karst system, which is in range of all cenote systems and therefore essentially flows directly into coastal waters. Human waste that is treated with fresh water is injected into the dense, deep salt water layer. It then rises into the fresh-water layer due to its density and flows either into the mangroves or directly out onto the reef through calettas on the reef floor, thereby potentially contaminating all systems.

The relationship between increased eutrophication of coastal waters and reef degradation has been well documented. Studies have linked increases in organic nutrients with microalgal blooms, increased macroalgal coverage of hard corals and experimentally induced increases in coral diseases. However, the affect of untreated pathogens of human origin on the reef community is also of interest. Aspergilosis, a fungal infection killing soft corals especially sea fans, has been linked to African Dust and so possibly, other diseases may also be linked to alien disease vectors of non-marine origin.

Methods:

ACE has aimed to glean as much knowledge from the local and cave diving community in order to assess the potential impacts of this situation and examine any potential association between it and Yellow Band Disease distribution or any other measured parameters of reef health in Akumal. ACE worked in collaboration with cave explorer, Gregory Brown, to produce maps of cenotes in the area and to postulate flow direction (See Figure 6 and Figure 7).

A short documentary was also produced in collaboration with Damon Hope and Gregory Brown, to record the discovery, exploration and potential significance of this newly mapped cave system. This will be produced on CD for submission with the final report.

Water was taken from the reef for analysis in collaboration with Dr Rebecca Ferrell and Drew Davidson, Microbiologists from the Metropolitan State College of Denver, who tested samples for the abundance of human fecal contaminants in the CEA laboratory.

Water samples were also taken using a remotely operated device to control for diver contamination or disturbance. These samples were tested for organic nutrients using a field photometer in the CEA laboratory. Samples were also analysed for pH and salinity. Sediment traps were laid on each transect and their retrieval attempted after 2 weeks for calculation of sedimentation rate. Temperature and horizontal turbidity were also measured by divers on each transect.

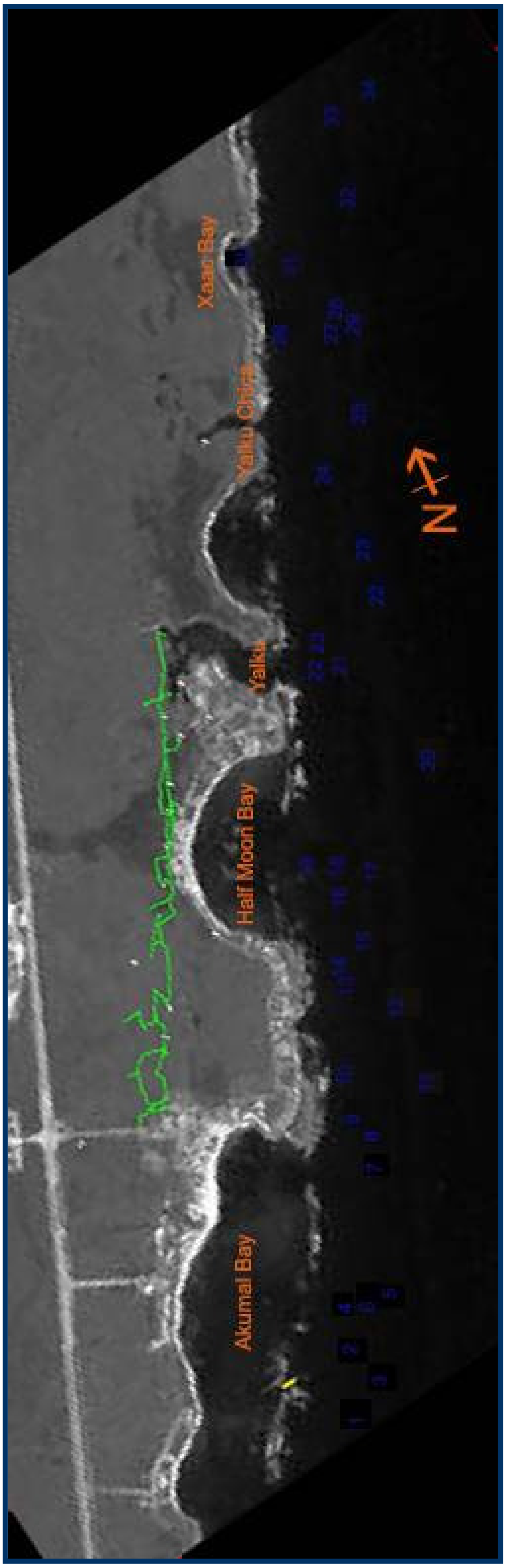

Figure 5: An aerial photograph of Akumal and the surrounding study sites. The green line shows the position of the cave system Ak Kimin, behind Akumal Bay. Blue numbers show transects where data was collected by ACE.

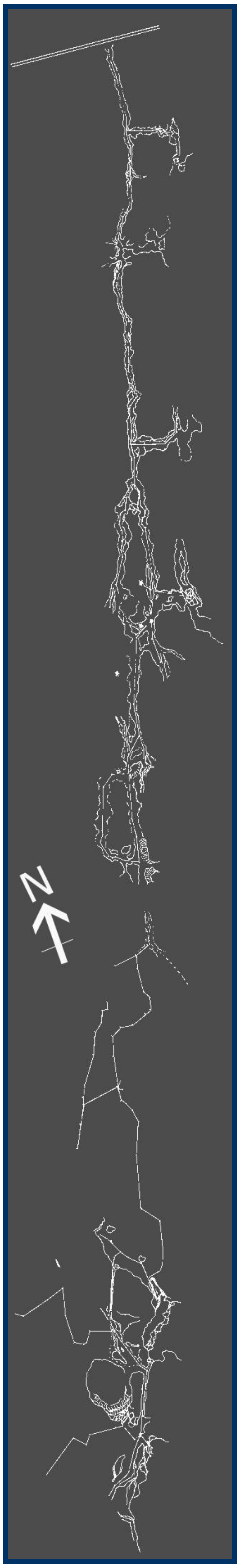

Figure 6: Line drawing maps of the cave system Ak kimin, which runs behind Akumal and into the calettas Yalku and Yalku chica. This map can be fitted on top of the green line in Figure 5

Results:

The results can be summarized as follows:

Abiotic factors:

Mean temp °C	29.3	SE 0.12	range 28-31
Mean Turbidity (m)	22.33	SE 1.04	range 13-35
Mean sedimentation (g/day)	2.6224	SE 0.0442	range 2.51-2.71
Mean salinity ‰	36.97	SE 0.105	range 36 - 38
Mean pH	8.0216	SE 0.0352	range 7.5-8.35

Water Quality:

Mean Nitrite (m mol/l)	0.5900	SE 0.301	range 0 - 3.05
Mean Nitrate (µ mol/l)	0.0201	SE 0.00462	range 0 – 1.83
Mean Phosphate (m mol/l)	3.7229	SE 2.74	range 0 – 130.35
Mean Ammonia (m mol/l)	101.32	SE19.4	range 1.5 - 442.75

Discussion:

An experimental manipulation of nutrient levels on Akumals coral reefs (6-15 m depth), Bruno et al, (2003) recorded mean ambient levels of Nitrate, Ammonium and Phosphorous before manipulation as 0.6, 0.485 and 1.46 µ mol/l.
Our investigation shows a high variance in some of the nutrients measured but lower levels than those recorded in previous experiments.
Bruno et al (2003) froze water samples which were then processed at a Nutrient Analysis Laboratory at the University of North Carolina, USA. We used a field spectrophotometer in the Centro Ecologico Laboratory and recorded much lower levels, which may be an artefact of nutrient degradation during sampling or differences in equipment.
The UC Davis team also took water samples for nutrient testing in a US facility, and so our results can be compared for the final report and disease analysis.

Faecal contamination:

(Colonies/100 ml)

Mean mENDO_LES (Faecal Coliform)	28.8	SE 14.2	range 1 – 192
Mean KF-STREP (Faecal Enterococcus)	172	SE 71.8	range 1 -800

Discussion:

E. coli is an infectious species of the coliform group of bacteria that may cause gastrointestinal problems and diarrhoea. They originate in the human gut and, therefore, can be used as an indicator of faecal contamination. Both the US and Mexican standards for drinking water allow no more than 2 faecal coliform (*E. coli*) per 100ml sample. Categories used in the Programme for Clean Beaches, SEMARNAT; (www.semarnat.gob.mx/playas) are as follows:

Contaminant colonies/100ml	Clean	Acceptable	Not recommended	Not Clean
Faecal Coliform	>200	2001-500	5001-1000	>1000
Faecal Enterococcus	>40	41-200	2001-500	>500

It can be seen that using this data reef water in Akumal is highly contaminated due to high levels of Faecal Enterococci and unsuitable for drinking and bathing, even at depths of 12m.

However, due to the extreme nature of these results, questions need to be asked about the reliability of the data and the potential for laboratory derived mistakes such as electrical surges and powercuts affecting fridges and therefore plate sterility. ACE feels it is important to publish these results but to do with a caveat until the data has been more fully analyzed and explored.

Yellow Band Disease prevalence:

Disease was categorised in two ways; as definite cases of disease and as suspected cases. Definite cases included *Montastrea* corals colonies showing a clear yellow band of brightened individuals and a circle of dead coral inside the ring. Possible cases included circular discolouration of *Montastrea* corals in the same yellow colour seen in rings, which had not yet developed into the typical band. Using these two definitions of disease: diseased, and possibly diseased, the data can be analysed using a the more precise or more generally inclusive case definitions when looking for trends in disease prevalence (mean number of *Montastrea* corals affected by Yellow Band Disease/number of *Montastrea* corals per transect).

Case 1 (Diseased):
Mean Disease Prevalence: 6.942019917 SE: 1.25 Range: 0 – 36.36
Case 2 (Diseased and possibly diseased):
Mean Disease Prevalence: 19.56455715 SE: 2.41 Range: 0 – 54.54

Under both case definitions, *M. annularis* was the most commonly affected species, followed by *M. faveolata* and then by M. *Franksii*. *M. cavernosis* was not seen to be affected be disease.

Environmental Education:

The reef team conducted two environmental education workshops for children in Akumal. The first took place in the CEA Visitor Centre and consisted of a PowerPoint show, introducing the concept of water quality and conservation of Mangroves, Seagrasses and Coral Reef ecosystems. Children took part in a quiz for prizes and a volunteer was dressed in full SCUBA gear whilst we explained our work with the help of photos and video clips. A second crafts workshop took place in the Akumal Library where children made environmental awareness posters for display in the CEA visitor centre.

Figure 7 a & b: Lucy jack and Loic Lhopitallier give an environmental eductaion class in the CEA Vistor centre to local children.

Publications:

During our stay, the ACE team wrote several articles for the CEA website detailing their involvement and progress. Please see www.ceakumal.org

Health and Safety:

During the expedition, care was taken to avoid contaminated food and water. Team members covered up to minimize risks of contracting malaria and dengue fever and to avoid over exposure to the sun.

One team member contracted Otitis (divers ear) in both ears and required antibiotics. Another suffered minor Barotitis in both ears which was treated with anti-inflammatory drugs, decongestants and by proscribing diving. A prevalent problem was sea sickness which was treated by taking Dramamine before disembarkation.

Dive safety:

All diving was conducted conservatively by qualified and experienced divers (minimum qualification PADI Rescue Diver) under the supervision of a BS-AC Advanced diver and the Boat Captain. No divers suffered from any kind of decompression illness or other diving related injury. Diving was performed for a maximum of five days per week and four days rest was taken half way through the expedition period.

Contributors:

Lucy Jack, Loïc Lhopitallier, Marion Perutz.

Aknowledgements:

For their help, ACE would like to thank:

Akumal Dive Shop
Andy McLean
Bryanston School
Centro Ecológico Akumal
Canadian Amy
Chris Burbidge
Damon Hope
Gregory Brown
Ivan Cavallero
Janet Foley and Susanne Sokolow
John Deag
Lois Moriel
Lucy Gallagher
Rebecca Ferrell and Drew Davidson
The Albert Reckit Charitable Trust
Selena Kaffer
The Barnston Bequest
The British Association
The Davis Fund
The Edinburgh #2 Trust
The Keasby Memorial Bursary Foundation
The Royal Geographical Society
The Student Travel Fund
The Swann Travel Fund
The Weir Fund
Zack from Tenessee