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FIRST DRAFT

HURRICANE ANDREW CORAL REEF AND WATER QUALITY ASSESSMENT

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INTRODUCTION

On September 16th, the marine section (Szmant, Curry) of the Resource Damage Assessment team started surveying the coral reef resources of Biscayne National Park and continued through the 22 nd of September. The team started at the southern end of the park moving northward along the seaward margin of the reef platform. The reefs evaluated were Ball Buoy reef on the southern boundary, moving north through Rubicon, Elkhorn, Alina's, Pacific, Ajax, Long, Triumph ending at the Kavorkian Memorial reef site on the northern boundary. An east west component was defined by evaluating the reefs at Bache Shoals, the Fowey wreck site and ending at Triumph reef.

The short term purpose of this assessment was to obtain a simple, qualitative, "snapshot" of the damage done on the coral reef platform by the storm. At each of the sites, the team specifically looked for signs of breakage, abrasion, out of place or new rubble piles, an excessive or unusual silt cover, tissue loss, excessive abrasion and finally, sediment structure.

In addition, samples were collected for water quality and sediment analyses because of a concern that a major impact of the hurricane on both Biscayne Bay and offshore marine communities would be a longer term deterioration of water quality caused by sediment resuspension and decaying organic matter.

METHODS

Damage assessment of coral reefs

Water quality measurements

Water and sediment samples were collected from two areas: The first was within Biscayne Bay, from six stations extending from south of Convoy Pt. to NE of Black Pt. Stations were ca. 500 yards offshore (we had no Loran or GPS). These stations were selected because they approximated sample locations used in a 1985 study of Biscayne Bay. The second set of samples was collected along a transect from Caesar's Creek to Pacific Reef, re-occupying the same stations that have been used in 1990/91 during the SEAKEYS project.

Water samples were collected with Niskin bottles deployed on a hand-held line. Samples were taken 1 m below the surface and 1

meter above the bottom when water depth exceeded 3 m, or at mid-depth if water depth was 3 m or less. Water samples were transferred to 1 liter polyethylene bottles and kept on ice in the dark until returned to the RSMAS campus for analysis (within 4 hr). In the laboratory, subsamples were filtered for chlorophyll and particulate C, N and P; the filtrate was analyzed for dissolved inorganic nutrients (ammonium, nitrate and soluble reactive phosphorus) and total dissolved N and P. Additional filtered water was saved for total organic C analysis (to be done by Dr. R. Jones, FIU). Unfiltered subsamples were analyzed for total N and P (includes less refractory particulate organic forms as well as the dissolved organic), and for sulfide and sulfate (only Biscayne Bay samples).

Sediment cores were taken by SCUBA divers using 7.5 cm diameter x 30 cm long plastic corers. Cores were kept vertical submerged in a bucket of seawater until they were processed at RSMAS. The cores were extruded in air at 2-cm intervals. A volumetric subsample was removed from each section to be dried for porosity measurements. The rest of the section sediment was packed into filter funnels with GF/A filters and porewaters extracted under vacuum. Subsamples of porewater were analyzed for dissolved inorganic nutrients, total N and P, and sulfide and sulfate. The remaining sediment was wrapped in aluminum foil and frozen for later analysis of extractable ammonium and phosphate, and for grain size analysis.

Not all of the analyses have been completed at the time of this report being prepared. All of the sediment results will be forthcoming.

OBSERVATIONS AND RESULTS

Damage to Coral Reefs

The major types of damage observed to corals were detachment and overturning (both small and large coral heads), and breakage (elkhorn coral). Abrasion and gouges were also evident on some corals. Damage types to soft corals and sponges, two of the major reef organisms on BNP reefs, were also mainly detachment and burial, and partial breakage (chunks missing). Damage severity varied greatly among and within reefs, with more severe damage to corals and soft corals observed on Bache Shoals and to sponges on the deeper off-shore reefs. A brief description of each reef visited (from South to North) follows.

Ball Buoy (mid-shore): This reef is dominated by large stands of the elkhorn coral *Acropora palmata*, a species known to be sensitive to storm damage. Some colonies had broken branch tips and in some cases whole branches had broken off and were laying amidst large colonies of this species. Some colonies had abraded fronds. Recently exposed skeletons (where branches broken off or tissues abraded) of *A. palmata* were covered with a green filamentous alga,

possibly *Cladophora*. Older lesions on the same or adjacent colonies had a totally different algal colonization. This infection with the filamentous green was not observed on any of the other reefs observed. Roughly 10 to 20 % of the elkhorn colonies had breakage. Soft corals, sponges and other reef organisms did not show any sign of recent hurricane damage. Overall, damage was slight, concentrated on one major species. The fate of broken elkhorn with the green algal infestation should be monitored.

Rubicon (mid-shore): This reef is characterized by a large rubble field on the reef flat with few large corals. The rubble field had large numbers of recently broken and killed corals (cobbles with some tissue remaining), mostly elkhorn but also some head corals, and generally looked disturbed. A grass bed on the southern side of the reef crest was undercut, but grasses just south of this feature did not appear to be affected or buried. Overall, damage was moderate but the source of the fresh rubble was not apparent. This reef should be surveyed more extensively.

Elkhorn (mid-shore): This reef has dense patches of elkhorn coral on the northeastern quadrant, much of which was broken up; large colonies were overturned, and many of the smaller pieces were reduced to rubble. However, there were still other colonies that were not physically impacted. Interestingly, the broken and abraded elkhorn pieces showed no evidence of the filamentous green alga observed on Ball Buoy Reef. Head corals on the eastern side of the reef showed minimal signs of damage. Some soft corals were detached. The reef flat looked abraded and disturbed. Overall, the damage was moderate to the elkhorn, slight to moderate to the remaining organisms; reef should be surveyed in more detail.

Ajax (offshore): Area visited was at 80 ft. depth where there was some deep spur and groove. Area was characterized by small colonies of the star corals *Montastrea annularis* (morph type III) and *M. cavernosa*, the barrel sponge *Xestospongia* and smaller colonies of other corals (*Siderastrea*, *Stephanocoenia*, *Agaricia* spp.). Much of the deep reef and corals was covered by silt, but it appeared that some corals that had previously been partially covered by silt has been exposed during or following the storm. This was evidenced by dead white area in along the edge or middle of a colony, usually in a depression. Other colonies with silt on them had similar dead white areas under accumulations of silt. Some of the large *Xestospongia* colonies had upper portions missing, especially on their seaward sides; these were in the process of healing. These light colored lesions were similar in shape to older totally heals lesions on some of the colonies. A few gorgonians and tube sponges were detached and accumulated in reef depressions. It is not know where the silty condition on this reef was normal or related to the storm. The bottom around and seaward of the deep reef was composed of fine rich sediments which had burrows and algal films. Thus, if the deep sediments were disturbed by the storm they had already returned to some degree of normalcy. Even though there was a strong current at the surface, the deeper water was calm, possibly allowing for the accumulation

of silt.

Pacific (off-shore):

Alina's (mid-shore): This reef has many large head corals, especially *Montastrea annularis* and *Diploria spp.*, but very little elkhorn. Several of the large coral heads on the reef flat, especially toward the middle and south of the reef, were dislodged and overturned; examination of the exposed attachment sides indicates that the colonies that overturned were heavily bioeroded. Other large and better attached coral heads were not affected. There were many detached soft corals on the back (western) side of the reef, lodged in depressions among the large star corals. The northern end of the reef appeared unaffected, as did parts of the southern end. Overall, damage was slight to moderate; recruitment to the newly exposed coral framework, and the fate of the overturned corals, should be monitored.

Long Reef (off-shore): We examined a deep spur than ranged from 50 to 80 ft depth. There was a strong current at the surface but no current at depth. The reef was silty and had a very low coverage by hard corals. As on Ajax, many of the barrel sponges had pieces missing from their seaward sides, but there was little evidence of damage to hard or soft corals. Some corals showed evidence of detachment from earlier storms. There were many heavy ropes (lobster pots) draped over the sponges and corals; some of these animals showed evidence of recent abrasion from these lines. We recommend that these lines should be removed so as to prevent further damage to the reef fauna. Overall, storm damage was minimal.

Ledges (off-shore): This small formation at 20 to 40 ft. has high topography filled with schools of fish. The benthic community is characterized by a dense soft coral community, with some head corals. On the seaward side of the formation there were a few overturned corals partially buried in the sand, and a few detached soft corals. Overall, however, there was only slight evidence of hurricane damage. This site has a fair number of small recruits of *Montastrea cavernosa* that could serve as a resource for a study of juvenile coral survival.

Triumph (deep off-shore): We examined a deep reef ridge at 80 ft depth. There was a strong current at the surface and a slight current at depth. This reef was less silty than either Ajax or Long reefs. There is little hard coral at this site, similar to the aforementioned reefs. Barrel sponges showed evidence of breakage, with large pieces missing. There were large masses of sponges of numerous species accumulated in depressions at the base of the reef ridges; some large soft corals were mixed in with the sponges. There were a few overturned pieces of coral rock along the margin of the reef, and evidence of coral blocks overturned during previous storms. The sediment around the reef looked more or less normal, and did not look disturbed. Overall, there was

significant damage to the sponge community but it was not clear whether the sponge accumulations derived from the shallower reef inshore of the deep reef or from sponge populations further offshore. The source of the damaged sponges should be determined.

Triumph (shallow off-shore): At the southern end of Triumph reef Dr. Jim Porter has a photographic documentation site that he and his team have been sampling for the past several years. The site is visited by Dr. Porter annually and by Park personnel every three weeks to deploy and recover an Hydrolab DataSonde water quality monitoring unit measuring Dissolved oxygen, ph, salinity, conductivity and temperature at hourly intervals. The unit was in place and running during the storm. The unit was collected three weeks after the storm and the data collected during the storm event will be made available. Early reports by Porter and the park staff indicated that the reef was destroyed. In reality, there was some minor damage and a large coral head (2 m diameter) was displaced several hundred feet from Porter's study site. The clearest indication of the passing of the storm was the large accumulation of broken lobster traps, sea fans and plumes rope and other debris in hollows and other protected areas of the reef complex. There was no evidence of abrasion, breakage or excessive siltation

Bache (mid-shore): On the western side of the coral reef platform is a small complex of reefs (5) known as Bache Shoal. The area is a popular snorkeling and recreational site because of the very high faunal diversity and the availability of mooring buoys. Early reports also indicated severe damage to the reefs in the complex. Although no mooring buoys were lost, there was a significant amount of damage. A number of heads of *Montastrea annularis* were displaced and turned over. Sea fans and plumes were displaced, dislodged and buried and many sponges had nicks and cuts resulting from impacts with moving debris. The pavement rock of the reef appeared to be very broken compared to the highly cemented and smooth pavement extant prior to the storm. The process that would cause this type of damage without the total loss of the benthic community is unknown. About 30% of the benthic community was lost by displacement, covering and breakage. There was no evidence of tissue abrasion (sand blasting), excessive siltation nor was there any development of rubble piles.

Kavorkian (northern eastern boundary of BNP): The Kavorkian Wreck was a 75 foot coastal Fishing vessel that was sunk adjacent seaward of the National Park boundary as an artificial reef memorial to a local dive shop operator. The vessel was originally placed in 68 feet of water, showed very little deterioration since it was sunk in 1984 and was located about 70 meters from a healthy natural reef. It was last evaluated by Park personnel approximately one week prior to the storm. The post storm evaluation confirmed post storm reports, the vessel was completely destroyed and thrown against the reef by natural reef. The total relief of the vessel after the storm was less than 1-1.5 meters compared to its 5 meter profile prior to the storm. The Wreck was almost completely turned inside

out and the wreckage was reshaped to conform to the shape of the reef. Survey of the reef itself indicated very little damage to the rock substrate of the reef. The reef was almost totally devoid of macro fauna and probably died long before the storm event. The sediment around the site was a very fine, easily disturbed marl but there was very little deposition of this material on the wreck itself or in the numerous depressions on the reef. At the time of the survey there was a noticeable current, sufficient to scour areas of high relief such as the reef and wreck.

Water Quality Studies

Dissolved inorganic nitrogen (nitrate and ammonium) were high within Biscayne Bay, approximating or exceeding the maximum values measured during a twelve year study from 1972 to 1984. Dissolved inorganic phosphate was, however, very low. Organic, especially particulate organic, nutrient concentrations were high, especially POP (particulate organic phosphorus) which in some samples exceeded $2 \mu\text{M}$. Chlorophyll and phaeophytin concentrations were also high, but we have no pre-hurricane data with which to compare the results. Fazel, Clarke and Ortnier have several years of data, as does Dade County ERM, that would be useful to examine. Salinities were moderately low (14 to 16 ppt.) at stations off of Moody Canal and Black Pt. Salinities measured two days after the storm by Fazel et al. were only depressed by 1 ppt. over pre-storm values; temperatures were about 2°C lower after the storm and were still depressed 1°C four weeks after the storm. Overall, the Bay appears to be experiencing a phytoplankton bloom promoted by the recent influx of runoff and debris. This bloom should be monitored since it could seriously affect benthic macrophytes, especially turtle grass, and benthic filter feeders such as sponges. On the other hand, increased concentrations of suspended bacteria would favor the sponges.

Nutrients and chlorophyll values along the Caesar's Creek to Pacific Reef transect were within the normal range previously measured for this area. There was no indication of nutrient and chlorophyll enriched waters exiting the Bay to the reef areas through Caesar's Creek during our sampling period. Sampling was during the ebbing tide and thus should have reflected such enrichment if it was occurring.

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by
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Large blow out located on ^{the} northeastern corner was located with a debris field clearly to the west. Within the debris field the rubble varied in size from large coral heads (1-1.5m) to a fine silt. The source of this material was clearly evident on the reef and along the reef margin.

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