Vŏnē Research Inc. and Cry of the Water

Diving to Make a Difference!

In partnership with
Palm Beach County Reef Rescue

Site Lauderdale-by-the-Sea Elkhorn Coral Reattachment Broward County, FL

One-Year Monitoring Report

Report to Florida Fish & Wildlife Conservation Commission
Re: SAL# 08SRP-1091 (Site Lauderdale-By-The-Sea)

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Cover Photo: Elkhorn Fragment in sand nearshore to Lauderdale-By-The-Sea
© Cry of the Water

Report Photographs: © Vŏnē Research Inc., Cry of the Water and Palm Beach County Reef Rescue

Acknowledgements
The authors would like to acknowledge support of Vŏnē Research Inc., in particular, Stephen Attis for training and technical support required for permitting and implementation of coral reattachment projects. We would also like to thank Palm Beach County Reef Rescue for logistical support during the pre-restoration and monitoring dives and the reporting process. Further thanks is extended to Danielle Morley for the literature research and reporting she provided for the introduction of this report.

Furthermore, all parties involved would like to thank Esther Peters for her rapid response to the coral disease threat present on the reattachment site and to Tom Bartlett of NOAA for providing us with the results of the disease testing.

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EXECUTIVE SUMMARY

Vŏnē Research Inc. was informed by Dan and Stephanie Clark from Cry of the Water about a fragment of *Acropora palmata* lying on the hardbottom and sand offshore of Lauderdale-By-The-Sea in June 2008. Cry of the Water and Ed Tichenor from Palm Beach County Reef Rescue (PBCRR) asked Vŏnē Research to apply for a permit to re-attach the fragment to hardbottom reef. On July 11, 2008, Vŏnē Research received the permit. On July 17, 2008, Stephen Attis and Kristen Hoss of Vŏnē Research trained Dan and Stephanie Clark, Ed Tichenor and Terry St. Jean on methods used to reattached coral. Following the training, permitees reattached the *Acropora palmata* fragment to the reef and established an adjacent reference coral for survivability comparison.

The fragment was discovered and re-attached offshore of Lauderdale-By-The-Sea, FL, thus the site is named after the town (Figure 1). Site Lauderdale-By-The-Sea is herein referred to as the reattachment site. Repairs included reattaching the fragment of coral to the hard reef substrate. Furthermore, Vŏnē Research and Cry of the Water photographed the reattachment site. Cry of the Water performed and will continue to complete monitoring dives in order to document changes of the reattached coral over time and compare those changes to an ecologically similar reference coral (Figures 2 and 3). Due to evident disease on the fragment and adjacent colony (Appendix A), Cry of the Water monitored the colony at three days, two weeks, one month, four months, six months and one year post attachment to determine disease progression and to help collect tissue samples of the colony as well as to determine reattachment success. Diseased tissue was collected by Ester Peters, using FWCC permit SAL #08SRP-1096, who collected mucus, water and sediment samples on and around the reattachment site for use in disease identification. The samples were tested by NOAA and *A. coralicida,* which is often associated with coral disease, was present in the sample (Appendix C). The one year survey revealed that the fragment remains attached, however only three small patches of living tissue remain, the rest of the skeleton is covered by macroalgae, and epifauna such as poriferans (sponges). In July 2008, the fragment and reference had an estimated 90% live tissue coverage; a year later, visual estimations revealed that the fragment had 1% to 5% and the reference coral had 20% to 40% tissue coverage remaining. Further monitoring dives will be performed two years from the re-attachment date.

Vŏnē Research Inc. found through numerous reattachment projects (Vŏnē Research 2003-2008) that reattachment efforts such as the one performed at Lauderdale-By-The-Sea are viable restoration methods when performed by trained divers in a timely manner. In the past, restoration efforts have shown significant success and coral survivability. However, previous reattachment sites were located further out to sea and were not between two wastewater discharge pipes. Moreover, the previously reattached corals did not show known signs of disease prior to reattachment.

INTRODUCTION

Coral reefs and associated habitats are characterized by their high species diversity supporting up to one-quarter of all marine fish species (Chabanet et al. 2005; Jameson et al. in press; McAllister 1988), which is correlated to their high gross productivity (Chabanet et al. 2005; Jameson et al. in press). Over half of the fisheries species which are managed in the United States spend a stage of their life on or around coral reefs (Jameson et al. in press). The role of coral reefs in cultivating biodiversity, fisheries, coastal protection through diffusing the intensity of waves, aesthetics, and its increasing importance for tourism revenue make this ecosystem an extremely valuable natural resource providing numerous benefits to humans. Coral reefs contribute to economic benefits estimated at $375 billion per year worldwide (Jameson et al. in press). In Florida, recreational use of coral reefs generated approximately $1.6 billion US dollars in 1990 (Jameson et al. in press). In the year 2001, a report entitled: Socioeconomic Study of Reefs in Southeast Florida (Johns, Leeworthy, Bell and Bonn, p ES-5-6) revealed the following:

> Reef-related expenditures generated $505 million in sales in Palm Beach County, $2.1 billion in sales in Broward County, $1.3 billion in sales in Miami Dade County and $490 million in sales in Monroe County during the 12-month period from June 2000 to May 2001. These sales resulted in $194 million in income to Palm Beach County residents, $1.1 billion in income to Broward County residents, $614 million in income to Miami-Dade County residents and $139 million in income to Monroe County residents during the same time period. Reef related expenditures provided 6,300 jobs in Palm Beach County, 36,000 jobs in Broward County, 19,000 jobs in Miami-Dade County and 10,000 jobs in Monroe County.

However, despite their economic, environmental and aesthetic importance, the conditions and health of coral reefs in southeast Florida have been, and continue to be, negatively impacted by both natural and anthropogenic variables (SFCRI 2006, Collier 2006) which will eventually reverse the positive effects that coral reefs have on the economy of Florida, commercial fisheries, and the quality of life of Florida residents and visitors. The current rate of degradation of natural habitats worldwide due to human impact is unprecedented in history (Vitousek 1997). These systems are deteriorating far beyond the level where simple conservation methods, such as setting aside an area for preservation, can correct the situation.

Anthropogenic impacts include but are not limited to coastal development, beach renourishment, increased nutrient load and sedimentation due to runoff and discharge, dredging activities, cable drags, anchor damage, Carbon Dioxide build-up in the atmosphere and groundings. Coral growth rates are very slow thus coral ecosystems may take decades to recover from such activities if they can recover at all. Corals are colonial organisms that house themselves in a calcareous structure and host an endosymbiotic alga (zooxanthellae), which assists with primary production on the reef. Coral reefs increase at the gradual rate of 1 to 5 meters per 1000 years (Jaap 2000). Due to this growth rate, damaged reefs may not naturally recover in our lifetime. A more aggressive approach involving actively restoring damaged sites is needed if this ecosystem is to be saved. As our reefs continue to disappear at an alarming rate, the act of reef restoration may become the dominant conservation act (Rinkevich 2005). Reef restoration efforts such as coral transplants and coral reattachment can help to reverse some anthropogenic impacts

such as cable drags, anchor damage and groundings. Vŏnē Research Inc. with assistance from Cry of the Water has been permitted by the State of Florida to respond to such events that impact reefs in Broward County in order to document damage, stabilize and repair reefs.

STUDY SITE

Site Lauderdale-By-The-Sea and the reference site are characterized by the presence of hexacorals, octocorals and poriferans (sponges) that are significant constituents of the macrofauna growing on a hardbottom reef which parallels the coast (Figure 1).

The reattachment site is located at an approximate depth of 3 meters at GPS coordinates N 26° 10.910' and W 80 ° 05.593' (Figure 1 and 2). An adjacent undamaged *A. palmata* colony was chosen as a reference site a (Figure 1 and 2) to be used as a control for monitor the progress of the reattachment. Depth at this site is approximately 3 meters, and contains similar coral types and ecological parameters as those of the reattachment site. The reference site is located adjacent to the reattached fragment on the same portion of reef.

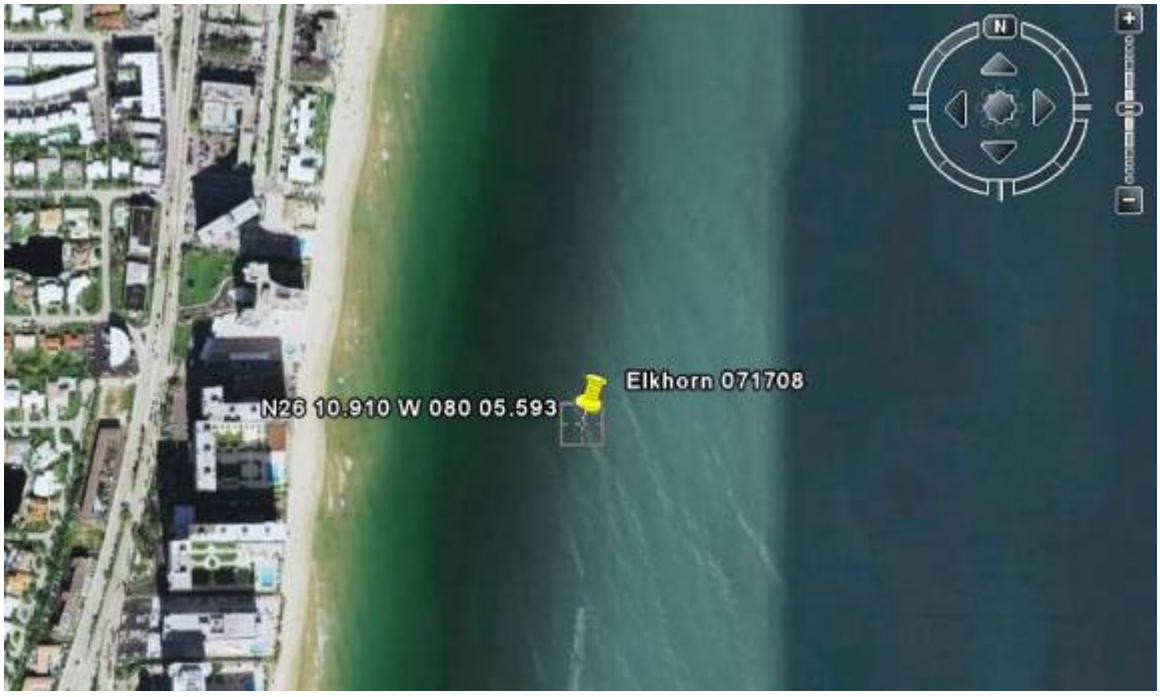

Figure1. Aerial photographs showing Lauderdale-By-The-Sea Elkhorn Coral # 071708 reattachment site and GPS coordinates offshore.

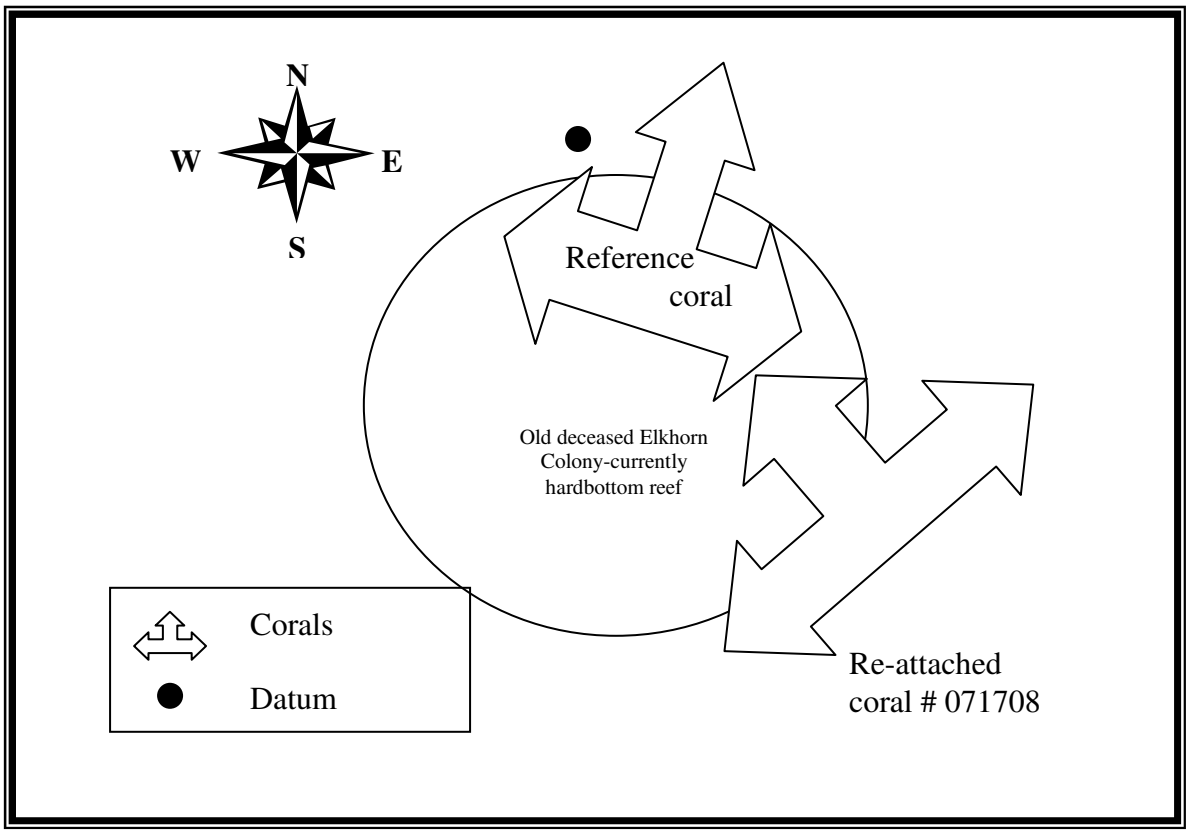

Figure 2. Map of the Re-attachment Site and Reference Site Lauderdale-By-The-Sea.

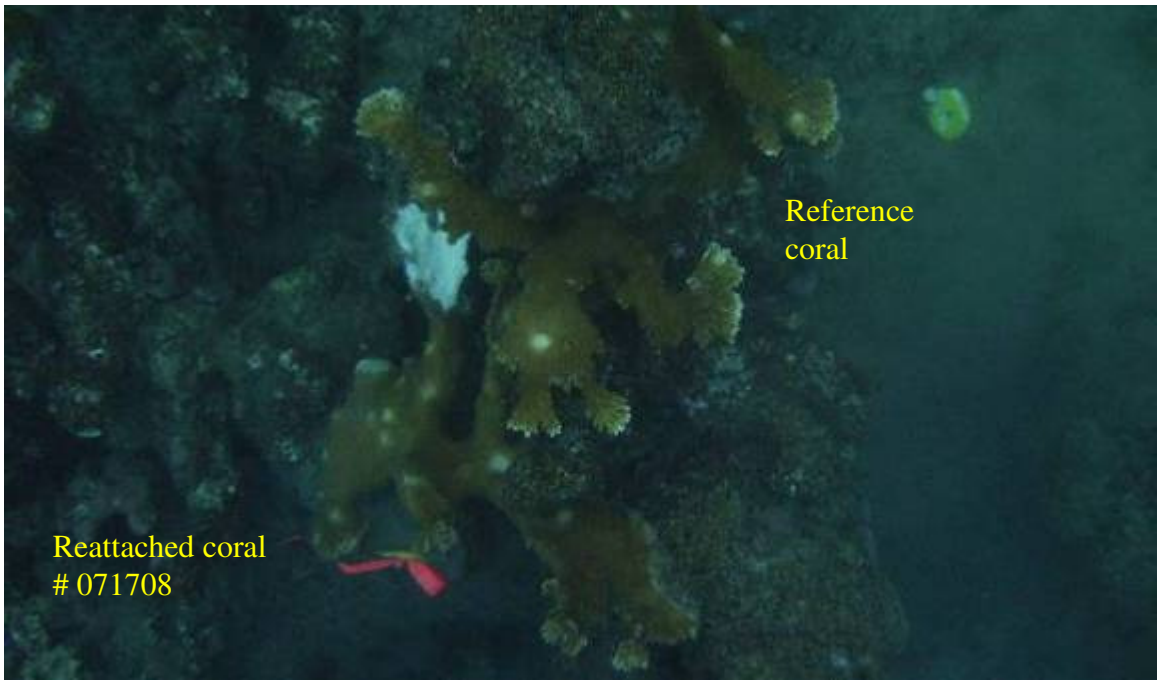

Figure 3. Reattachment and reference sites adjacent to each other on existing elkhorn coral colony, now part of the hardbottom reef.

SITE AND COLONY HISTORY

Cry of the Water first documented the *Acropora palmata* colony in the summer of 2006 returning to the site periodically using landmarks as navigational aids. The colony appears to be a remnant of a larger colony. The *A. palmata* colony is located within 244 meters of two active discharge air conditioning cooling tower pipes just off the surf zone. The pipes, named Drainage Struture ID # 16 and 17 (Olson & CP&E 2001) are discharging warm water (Appendix B). A file review found that no NPDES discharge permits exist for either point source; thus the discharge pipes appear to be a violation of the Federal Clean Water Act.

In the nearshore area of Broward County, *Acropora palmata* and *Acropora cervicornis* is concentrated between Port Everglades and Lauderdale-by-the-Sea. This reach of Broward beach has never had a large scale dredge and fill project and has not been subjected to the long term siltation, sedimentation and turbidity problems seen from these projects. The absence of large scale beach renourishment may account for the density of *Acroporids* along this stretch of Broward coastline.

Dan Clark photographed the colony in January of 2007 (Appendix A). In November of 2007 the location of the *A. palmata* colony was reported to Jennifer Moore, *Acropora* Coordinator for NOAA Fisheries Service, Protected Resources Division.

On June 11, 2008 Dan Clark escorted PBCRR divers Ed Tichenor and Terry St. Jean to the site where they discovered the *A. palmata* fragment on the hardbottom and sand. The colony did not show signs of disease or bleaching. Ed Tichenor videotaped the colony and fragment on June 11, 2008 (Cover and Appendix A) and again on July 17, 2008 (Appendix A) during the fragment reattachment.

Cry of the Water divers returned to the site on June 20, 2008, three days after reattachment and performed a follow-up site inspection. Surge in the area caused some of the cement to slide off the attachment site but the majority of the cement held in place. The Portland cement was firmly cured and the attached fragment was securely held in place. Divers observed that one of the white spots that was visible on the reference coral, had increased in size from the July 17, 2008 dive. White spots were not visible on the June 11, 2008 site inspection (Appendix A).

During the 2 week site inspection on July 26, 2008, Ester Peters, permitted by FWCC SAL #08SRP-1096, collected mucus samples from the reattached fragment and the reference corals, water and sediment samples on and around the reattachment site for use in disease identification (Appendix C). Dan and Stephanie Clark assisted Ester with the sampling.

During a one month observation dive it was discover that the disease that appeared to be white pox, had spread over more of the control and reattachment site. Moreover, it was also noted that Broward County installed a concrete marker labeled 331. Broward is currently attempting to locate and mark all Elkhorn coral reported to them.

During the four month monitoring survey, datum identification tags for both the control and reattachment sites were scraped clean by Cry of the Water. Digital photographs were taken along with visual observations.

During the six month and one year monitoring surveys, photographs were taken and a visual area survey was performed. Moreover, air conditioning discharge pipes were inspected for operation status.

METHODS & MATERIALS

Multiple dive teams performed initial survey and reef restoration dives in June and July 2008. Initial survey dives were performed by Cry of the Water and PBCRR, the broken fragment was discovered during a June 11, 2008 site inspection. On July 17, 2008 Vŏnē Research Inc. trained Cry of the Water and PBCRR personnel on coral reattachment methods. Following the training, the combined teams performed the reef restoration procedure. Portland cement was mixed with ocean water and formed into balls. The cement was then placed into zip-lock baggies for transport to the reattachment site. SCUBA teams were deployed onto the damaged reef from the beach, to perform coral reattachment. The SCUBA divers scrubbed the reattachment site on hardbottom clean of algae and loose sediment. Then a cement ball was firmly pressed onto the cleaned area and the coral fragment was firmly pressed onto the cement. Initial reef restoration monitoring included comparing the reattached coral to that of a colony of *A. palmata* that was not broken from the reef. The reference and reattachment sites will be revisited within six months, one year and two years after the initial reattachment date. The two sites were photographed and corals were measured. Yellow, Plexiglas datum tags embedded with identification markings were fixed to the reattachment and reference sites to ensure proper identification of corals for future monitoring efforts.

The site was located from shore using underwater navigational aids such as landmarks and reef ledges. Garmain GPS marks are available. One team of scuba divers was deployed and focused on digitally photographing coral health and site conditions. Photographs and video were then taken using a Reefmaster digital camera and a Sony HDV camera secured in a Sea View underwater housing. Visual observations of the attached fragment and controlled sites were also taken.

RESULTS

The coral was successfully reattached; however the cement did not set as quickly as desired. The surge in the area caused some of the cement to slide off of the attachment site yet the majority of the cement did hold. Multiple site visits ensured that the reattachment effort was successful. The one-year monitoring visit verified that the fragment remained anchored at the reattachment site.

Initially, the reattached *A. palmata* had a bleached area on it that was dead. Moreover, the proximal end of the fragment which was on the sand was also dead. Both the fragment and the reference colony had white splotches on them (Appendix A). When reattached, the fragment and reference corals had an estimated 90% live tissue coverage; a year later, visual estimations revealed that the fragment had 1% to 5% and the reference coral had 20% to 40% tissue coverage remaining. The tissue did not regenerate at either site and macroalgae and macrofauna continued to settle upon the exposed coral skeleton between the August and one year monitoring visits.

On July 26, 2008 the white spots that were observed on the control and the reattached colony on July 17, expanded in area and appeared as large white patches (Appendix A). The coral tissue was sampled by Ester Peters and test results are summarized in this report in Appendix C.

On August 8, 2008 a site visit revealed that the disease had progressed significantly. The majority of the control colony was affected. The disease had not progressed as rapidly on the attached fragment as it did on the control site (Appendix A, Peters 2008 and Smith 2008).

On November 25, a site visit revealed that the reattachment and control colonies showed signs of the disease. A greater percentage of the control site was affected than that of the reattachment site. Also a greater percentage of the control site was dead and covered with algae as compared to the reattachment site. The colony did not grow in size, assumedly because of the disease. Visual area observations revealed that the adjacent bottom was covered with short red algae (Figure 4) that had not been as prevalent on other dives.

On February 12, 2009, the six month survey revealed that green algal coverage dominated the reattachment and control corals. The green filamentous algae were not the same as and had excluded the red algae seen on prior dives. Moreover, it covered the adjacent reef. Increased surface area of the reattachment and control were impacted by the disease. Three small patches of the reattached fragment continue to be covered with living coral tissue, each portion being less than 19.35 sq centimeters. Several patches on the control site remain living. The largest of these patches was on the back side of the control, the datum side.

On June 13, 2009, the one year monitoring survey revealed that the coral fragment remained attached. Both the reattachment and control corals were dominated by algal coverage; however, the green algae were displaced mainly by encrusting algal forms. Increased surface area of the reattachment and control were impacted by the disease. Three small patches of the reattached fragment continue to be covered with living coral tissue, one being approximately 19.35 sq centimeters as reported in February; the other two have decreased in area. Several patches on the control site remain covered with living coral tissue and have also decreased in area. The largest of these patches remains on the north datum side of the control.

During visual surveys of the area, damsel fish were seen around this coral on almost every dive, this included fish nibbling on the live tissue. Also sea slugs and a large hermit crab inside a conch shell perched on top of the attached fragment were observed at the site.

A large *Montastrea cavernosa* coral within 15 meters of the Elkhorn colony was being competitively excluded by *Cleona* and *Palythoa*. Upon the one-year survey, portions of the colony remain living.

Coral disease, *Cleona* and *Palythoa* outbreaks are often bioindicators of degraded water quality; therefore, water quality in the area is still a concern. As of February 2009, air conditioning cooling tower pipes were still discharging in the surf zone at the adjacent beach and may be a point source which could affect water quality (Appendix B). However, initial inspection of several of the air conditioning cooling tower pipe discharges in June 2009, revealed that some of the discharges may have stopped although the discharge pipe behind the Fountainhead Condo (north pipe, Appendix B) was still pumping.

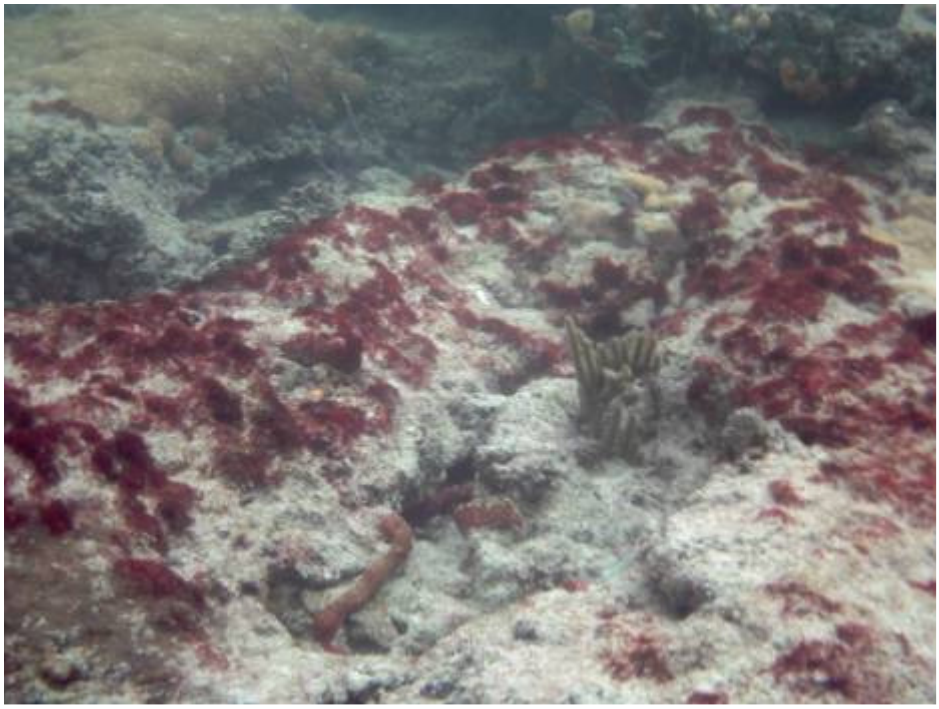

Figure 4. Red algae which appeared around reattachment site.

DISCUSSION

Vŏnē Research Inc. found through numerous reattachment efforts (Vŏnē Research 2003-2008) that reattachment efforts such as the one performed at Lauderdale-By-The-Sea are viable restoration methods when performed by trained divers in a timely manner. In the past, restoration efforts have shown significant success and coral survivability. However, other reattachment sites were located further out to sea and were not between two wastewater discharge pipes. Moreover the previously reattached corals did not show known signs of disease prior to reattachment.

RECOMMENDATIONS

Based on the evaluation of the initial reattachment effort, Vŏnē Research and Cry of the Water recommend the following actions:

1) Continue to monitor the site for disease and survivability of reattached *Acropora palmata*.
2) Continue monitoring water quality and bioindicators surrounding the reattachment area.
3) Reduce the response time to reef damage events to promote higher survivability and reef recovery. Historically, this resulted in a higher success of coral restoration projects (Jaap 2000).

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APPENDIX A
PHOTOGRAPHS OF CORAL AT THE REFERENCE AND REATTACHMENT SITES

Appendix A. Photographs of coral at reference and reattachment site

Original Elkhorn Colony on January 2007 prior to fragmentation

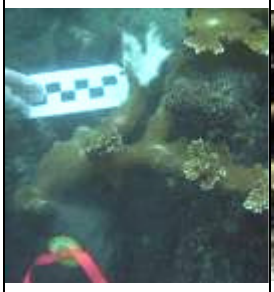
Fragment on June 11, 2008. Note non-diseased appearance.

Appendix A cont…. Photographs of coral at reference and reattachment site

Mother colony on June 11, 2008 missing fragment

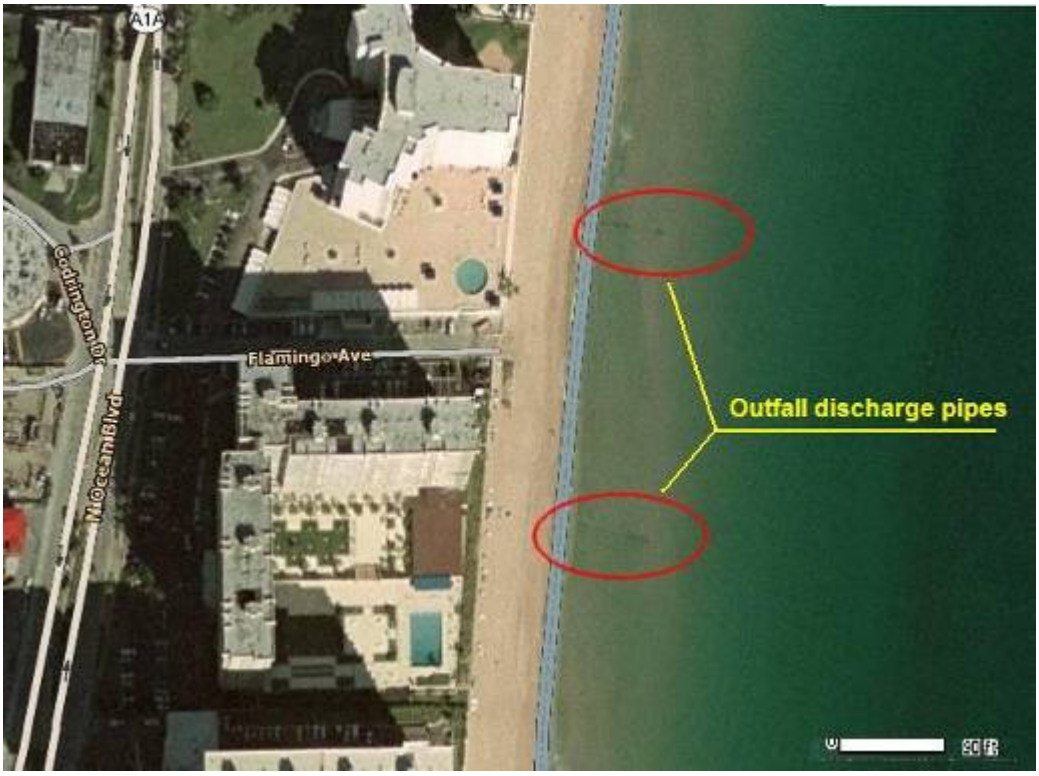
Fragment July 17, 2008 showing signs of disease and stress.

Reference coral, June 11, 2008

Reattachment and Reference Sites post attachment					
Coral	**July 2008**	**August 2008**	**November 2008**	**February 2009**	**June 2009**
071708: Elkhorn Coral *Acropora palmata*					
REF: Elkhorn Coral *Acropora palmata*					

APPENDIX B
LOCATION OF WASTEWATER DISCHARGE PIPES COMPARED TO LOCATION OF ELKHORN COLONY

Appendix B. Location of Wastewater Discharge Pipes compared to Location of Elkhorn Colony



Location of wastewater discharge pipes.

Aerial photographs showing Lauderdale-By-The-Sea Elkhorn Coral # 071708 reattachment site and GPS coordinates offshore.

APPENDIX C
E-MAIL REPORT ON STATUS OF DISEASE SAMPLES

Appendix C. E-mail Report on Status of Disease Samples

--- On **Wed, 1/21/09, Thomas Bartlett <*Thomas.Bartlett@noaa.gov*>** wrote:
From: Thomas Bartlett <Thomas.Bartlett@noaa.gov>
Subject: Re: Samples from Lauderdale-by-the-Sea
To: reefteam4@yahoo.com
Cc: "Cheryl Woodley" <Cheryl.Woodley@noaa.gov>, "Esther Peters" <esther.peters@verizon.net>, epeters2@gmu.edu
Date: Wednesday, January 21, 2009, 12:16 PM

Greetings all,

Allow me to summarize our results.

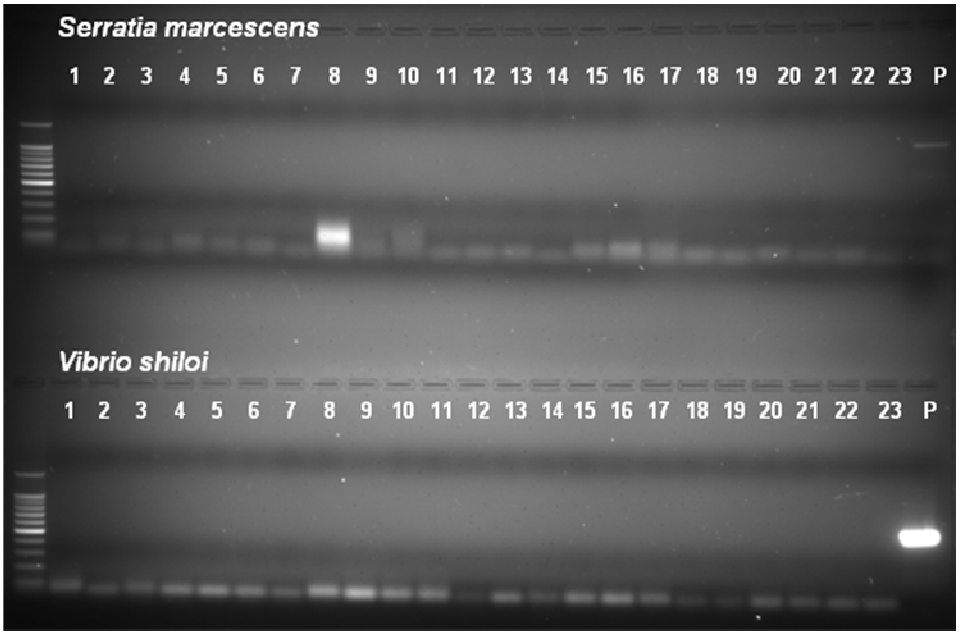
The DNA from the Ft. Lauderdale samples of water, sediment, algae, and coral mucus was extracted using a FastDNA Spin Kit for Soil. Known quantities of sample DNA (approximately 4.5ng each) were added to a PCR reaction with primers
specific to known bacteria species.

The first slide shows the resulting agarose gels after screening the Ft. Lauderdale DNA extracts with primers specific to known coral pathogens. There were no positive hits for S. marcescens or V. shiloi, one positive for V. coralliilyticus (marked by an "X"; sample #13), and 5 positives with A. coralicida. Out of all these, only one (#13) was representative of a diseased
coral sample. We were planning to re-extract and screen the samples again (at least the positives) to verify the results.

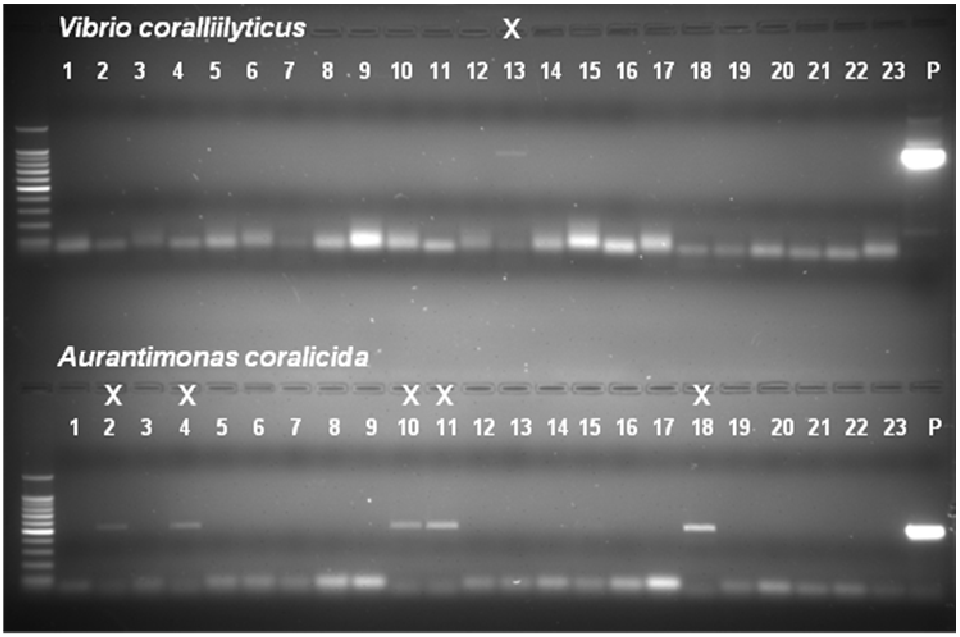
The second slide shows the resulting agarose gel after screening the DNA extracts with primers specific to Staphylococcus aureus. Although this bacteria
has not yet been shown to be associated with corals, there was a positive hit in
one of the sediment samples (#2).

If there are any questions or requests, please do not hesitate to ask. Thanks.

Tom Bartlett



Well	Sample
1	1.W.1.H-W
2	1.S.2.H-S
3	1.A.1.H-A
4	1.Acer.1.H-M
5	1.Acer.2.H-M
6	1.W.3.UD
7	1.S.5.UD
8	1.A.4.UD
9	1.Acer.3.U-M
10	1.Acer.4.U-M
11	1.Acer.5.U-M
12	1.Acer.6.U-M
13	1.Acer.3.D-M
14	1.Acer.4.D-M
15	1.Acer.5.D-M
16	1.Acer.6.D-M
17	2.W.1.W
18	2.S.2.S
19	2.A.1.A
20	2.Apal.1.U-M
21	2.Apal.2.U-M
22	2.Apal.1.D-M
23	2.Apal.2.D-M
P	Positive



X – Positive hit