**Performance Progress Report--Final**
**Coral Reef Conservation Program**
**Training the next generation in protected species assessment and management using geospatial technology**
**C. Hunter and L. Wedding**

## Overview:

This grant supported innovative research and training to monitor, assess, and map coral reef habitat critical to the persistence and preservation of Hawaii's two NOAA Species of Concern (SOC; *Lingula reevii* and *Montipora dilatata*) in the face of climate change. Conducted by professionals-in-training, the efficacy of targeted biocontrol and removal of invasive algae was tested in collaboration with local resource management staff in Kāneʻohe Bay, Hawaii. The research was carried out as part of a capstone marine field curriculum at University of Hawaii to provide undergraduate students with hands-on training and experience in addressing real-world coral reef resource management challenges. Final deliverables (e.g., GIS database, maps, and final reports) are currently being used to support coral reef management in Hawaii.

## Summary of Results:

The goal of facilitating undergraduate training in protected species assessment and management using geospatial technology was successfully met during field courses in 2013 and 2014. Undergraduates in the course engaged with local resource management staff and UH researchers to address the monitoring, assessment, and mapping of coral reef habitat critical to the persistence and preservation of Hawaii's two NOAA Species of Concern. The 2013 field course (BIOL 403: Field Problems in Marine Biology) was conducted from July 8$^{th}$ through August 2$^{nd}$, 2013, by Drs. Cynthia Hunter and Lisa Wedding, with the assistance of three UH graduate students (Keisha Bahr, Lauren Van Heukelem, and Ryan Logan). Fourteen students took the class, and worked in teams to develop and conduct directed research on two NOAA Species of Concern--*Lingula reevii* and *Montipora dilatata*. The 2014 field course, with 12 students, was held July 14$^{th}$-August 8$^{th}$, and taught by Drs. Lisa Wedding and Ku'ulei Rodgers, with the assistance of three UH graduate students (Keisha Bahr, Lauren Van Heukelem, and Charley Westbrook).

During the summer courses, *Lingula reevii* abundance and environmental characteristics (temperature, salinity, pH, and sediment grain size) were assessed at eleven sites in Kaneohe Bay. GPS locations were recorded for all *L. reevii* burrows observed. Abundance was significantly correlated with all parameters; most *Lingula reevii* were found at sites with sand substrates, specifically between 0.25 and 0.5 mm in size. Although there has been no statistically significant change in the distributional abundance of *L. reevii* since 2011, burrows are notoriously difficult to find; GPS locations of individual burrows may aid in future studies. The COI gene was sequenced from a single individual and compared to published sequences of three *Lingula* species from Japan, China, and South Korea. The Hawaii *L. reevii* was genetically distinct from these three other species, but there is a need for genetic comparison with *L. reevii* populations reported from Japan and Indonesia. There is also an ecological difference between the Japanese and Hawaiian *L. reevii*: the Japanese populations burrow in mud flats, while the Hawaiian populations are found burrowed in the sand (Goto et al., 2014). During these research efforts, undergraduate students at

UH learned highly technical geospatial and genetic methodologies in work on this species of management concern, adding to metrics of success for the project.

In addition, advanced ecological survey field methods were transferred while students collected environmental parameters (depth, temperature, salinity, pH, light intensity, and water flow) were assessed along with community structure and spatial complexity on three reefs on which *Montipora dilatata* has been identified in Kaneohe Bay. The perimeter and morphology (encrusting, plating, branching) of nine confirmed *M. dilatata* colonies were compared to those identified by DeParte et al. (2011). Perimeter size ranged from 3.0-8.8 m, and all colony morphologies were found on all three reefs. There has been no statistically significant change in *M. dilatata* size and morphology since 2011.

We worked closely with the Hawaii Department of Land and Natural Resources (DLNR)-Division of Aquatic Resources (DAR) during this project. The direct engagement with the state coral reef management agency in Hawaii was an important learning opportunity and additional metric of success during this course. Undergraduate students learned how to engage local management agencies to ensure their field research addressed on-the-ground questions and concerns in Hawaii. Teaching students how to foster these critical partnerships was a key learning opportunity from this CRCP grant. DAR provided our course with 1,400 aquacultured sea urchins, *Tripneustes gratilla*, in July 2013. Deployment of the herbivorous urchins in the vicinity of *Montipora dilatata* (Colony 12) on a patch reef (#44) in Kaneohe Bay was done in cooperation with the DAR Aquatic Invasive Species Team. One of the students in the 2013 course, Ryan Rautureau, gained additional research experience by examining feeding strategies in this sea urchin species. In addition, three graduate assistants (Keisha Bahr, Tayler Massey, and Lauren Van Heukelem) and three undergraduates (Ryan Rautureau, Rebecca Weible and Karen Bryan) continued to assist with urchin surveys from September 2013 through December 2014.
The overall learning outcome and lesson of engaging local management agencies to frame their research questions with clear implications was significant for the class as a whole. In addition, several students were motivated beyond the classroom experience to carry out further research on the herbivorous urchins to support the state of Hawaii's Aquatic Invasive Species Team.

The NOAA grant provided the opportunity and funds to support the next generation of marine scientists to engage and carry out relevant research and support the local invasive species management efforts. More specifically, on May 3, 2014, we recovered 73 of the original 1400 urchins deployed in July 2013. Average test diameter was 60.4 mm. This is in comparison to the November 2013 survey in which 215 urchins were found, with an average test diameter of 56.7 mm, indicating a slower rate of growth than in the first six months after deployment (Rautureau 2014). The collector urchins showed signs of stress--short spines (few had "collected" anything) and several had lesions on their tests. We also found 11 dead tests of unknown age of demise. After counting and measuring, we returned all live collector urchins to the vicinity of Colony 12, placing them in remaining areas with *Kappaphycus sp.* or coralline algae, since they seem to avoid direct contact with living coral. We observed small patches of *Kappaphycus sp.* and unattached fragments of the invasive algae in holes between *Porites compressa* colonies. There was almost no *Kappaphycus sp.* in the vicinity of the target *Montipora dilatata* colony indicating that the biocontrol grazers had been effective.

Based on our report of urchin stress indicators and lesions on Patch Reef 44, and their own observations on a reef several kilometers south, the Hawaii Department of Land and Natural Resources Division of Aquatic Resources, Aquatic Invasive Team (DLNR; DAR-AIS) initiated

bay-wide surveys of urchin disease and halted all movement and transplanting of urchins. As of June 18, 2014, the AIS team determined that the disease outbreak had declined and transplanting began again. This management action demonstrates the successful and iterative process of research and engagement between UH undergraduate students and the state coral reef management agency that NOAA facilitated through this grant. Students and local managers benefited from this learning opportunity and the research outcomes that were swiftly communicated by the BIOL 403 instructors.

Our next steps involved working with DLNR DAR-AIS we deployed a new "crop" of 2,000 aquacultured sea urchins around *Montipora dilatata* Colony 12 on Patch Reef #44 on July 30, 2014. *Kappaphycus sp*. abundance and numbers of urchins were monitored on July 24 (before the 2014 deployment) and again on November 1 (3 months after deployment). On July 24, 26 urchins were located with an average test size of 72 mm (min.=55 mm, max.=110 mm). On November 1, 199 urchins were located with an average test size of 52 mm (min.=32 mm, max.=79 mm). Overall, there was no significant change in the percent cover of *Kappaphycus sp.* between July and November 2014 (one-way ANOVA; p=0.4524). In July, the average percent cover was ~5.5% and in November it was ~6.7%. Although we saw no significant decline in *Kappaphycus sp.* between survey periods in 2014, the average abundance was significantly lower than what was measured on this reef in 2012 (24%). This confirms that the urchins are effectively controlling *Kappaphycus sp.*, particularly in the area of vulnerable *Montipora dilatata*; importantly, all urchins appeared healthy.

Student reports on *in situ* oceanographic and geospatial habitat assessment of *Lingula reevii* and *Montipora dilatata*, and of grazing by *Tripneustes gratilla* on invasive seaweed in Kāneʻohe Bay, are listed below, along with a published note in Reef Encounters (Bahr, et al. 2015). These reports have also been shared with colleagues at DLNR-DAR.

Butcher, Elizabeth, Kelsey Dockter, Tiffany Nicole Gutlay, Troy Maeda, Ryan Rautureau, Tiara Stark, Kaela Stender. 2013. Observing and mapping the effects of microclimates on the presence and persistence of *Montipora dilatata* coral colonies in Kāneʻohe Bay, Oʻahu, Hawaiʻi. Report submitted to NOAA Coral Reef Conservation Program. 34 pgs.

Adams, Katherine, Megan Bargerhuff, Chris Guo, Megan Russell. 2014. Characterizing the unique habitat of *Montipora dilatata*. Report submitted to NOAA Coral Reef Conservation Program. 26 pgs.

Nesbit, Katherine, Taylor Scofield, Aly Tanaka, Jesse Wywadis, Micheal Davis, Dan Delago, Kyleena Lamadrid. 2013. A survey of environmental factors potentially contributing to abundance and distribution of *Lingula reevii* in Kāneʻohe Bay, Oʻahu, Hawaiʻi. Report submitted to NOAA Coral Reef Conservation Program. 33 pgs.

Giffen, Kyle, Justine Sheu, Josie Streiffert, Sarah Rodeghero. 2014. A taxonomic study of *Lingula reevii* and survey of abundance in relation to varying environmental parameters in South Kāneʻohe Bay. Report submitted to NOAA Coral Reef Conservation Program. 31 pgs.

Burns, Echelle, Erin Day, Ryan Sirota, and Alison Williams Teaching. 2014. Mapping distributional changes of *Lingula reevii* and temporal changes of *Montipora dilatata*

Kāneʻohe Bay, Oahu. Report submitted to NOAA Coral Reef Conservation Program. 28 pgs.

Rautureau, Ryan. 2013. Examining differences in feeding strategies in *Tripneustes gratilla*, with a focus on management implications. Report submitted to NOAA Coral Reef Conservation Program. 25 pgs.

Bahr, Keisha, Kuʻulei Rodgers, and Paul Jokiel. 2015. Recent freshwater kill event in Kāneʻohe Bay, Hawaiʻi. Reef Encounters 30(1): 42-43.

**Outreach:**

Outreach and public engagement was a key component of this work and was conducted at several levels. In order to reach the broader community, we communicated our findings to the public by highlighting our research efforts in Kāneʻohe Bay through the UH Sea Grant Hanauma Bay invited speaker series. This presentation engaged the interested community on Oahu and shared our efforts to monitor, assess, and map coral reef habitat critical to preserve Hawaii's two NOAA Species of Concern (SOC; *Lingula reevii* and *Montipora dilatata*) in the face of climate change. This was an excellent opportunity for our graduate teaching assistants to gain professional skills and communicate our research findings in timely manner to the broader public. Both Keisha Bahr and Charley Westbrook synthesized our work and learned how to summarize scientific findings in a manner that the public can resonate with. The UH Sea Grant Hanauma Bay speaker series draws a broad group of community members interested in locally relevant research and was a excellent outreach venue to highlight our research findings.

We also were committed to communicating our research in a manner that could reach a wider audience and apply technology. We set up a daily blog (http://uhbiology.kahikai.org/) that was (and remains) posted online to engage the public through text, pictures and video of undergraduates conducting field research on *Lingula reevii* and *Montipora dilatata*. We were able to archive 2013 daily research logs and continued to add updated text and images during 2014 field work. In addition, our research efforts were featured on a NOAA "storymap" highlighting our contribution to mapping America's coral reefs (Figure B). This storymap is linked to a NOAA CCMA website; it serves to communicate to the public our work assisting managers in understanding the distribution of Species of Concern and includes links to our UH website and blog. The storymap has been a great communication and outreach tool that links our project directly to NOAA and highlights the unique approaches we applied to teach technology to undergraduate students.

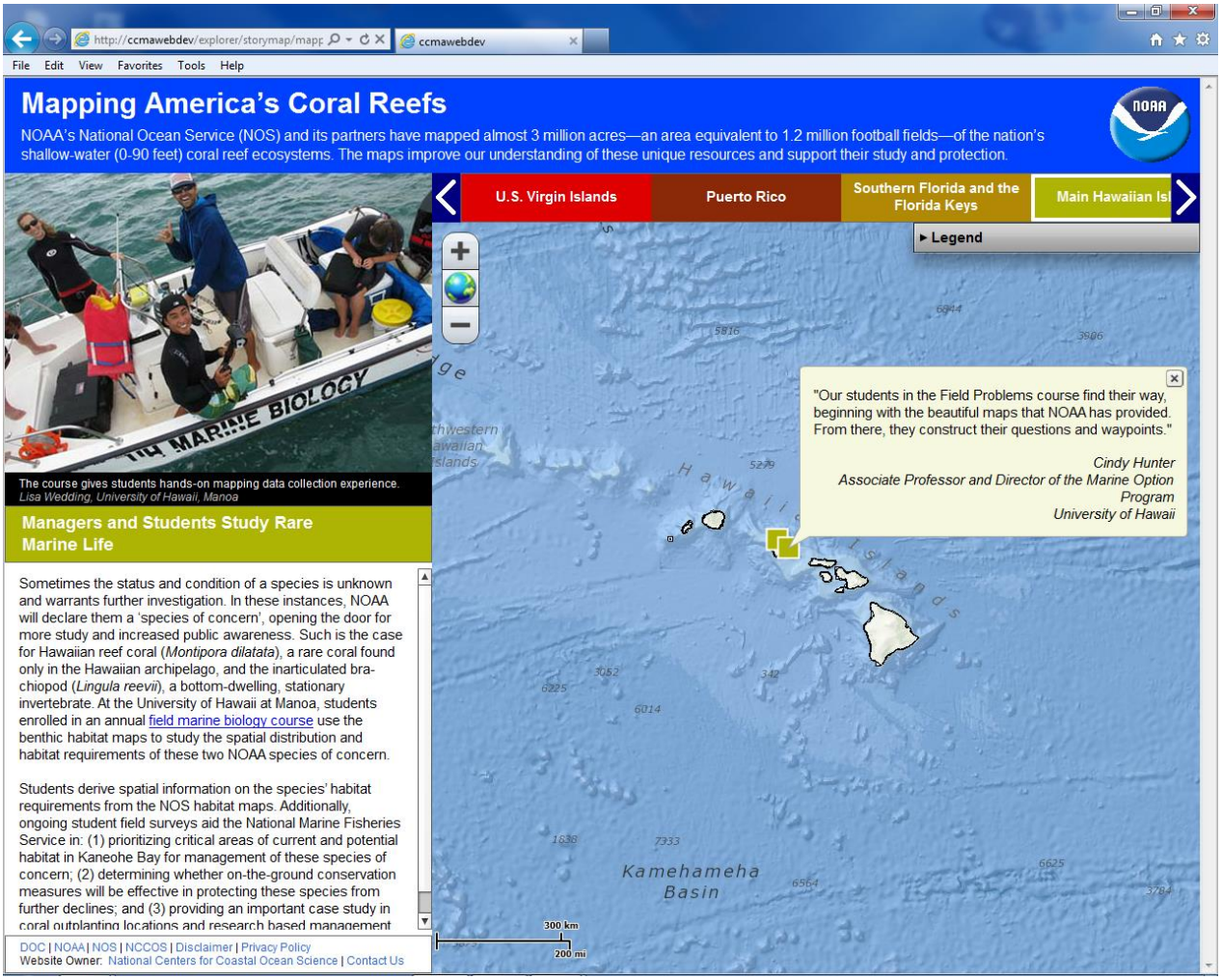


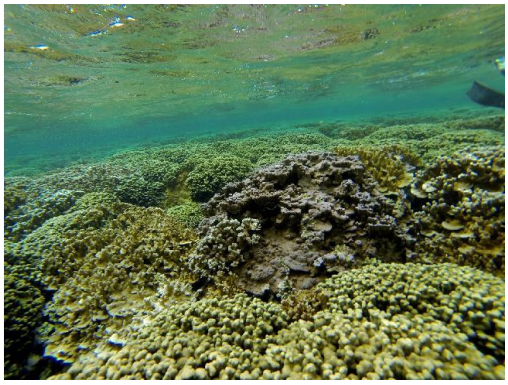

Figure B. NOAA featured our field work online to communicate to the public how students worked with managers to map and understand the distribution of species of concern.

**Next Steps**

Two major natural disturbances to coral reefs in Kāneʻohe Bay, Oʻahu, Hawaiʻi, occurred in Summer/Fall, 2014—a fresh-water kill resulting from lowered salinity as a result of a heavy rainfall event on July 19-20 (Bahr et al. in review), and widely-distributed coral bleaching resulting from elevated seawater temperatures (continuous degree-heating weeks peaking at a maximum of 30°C on September 20). The Hawaiʻi State Division of Aquatic Resources estimates an average of 87% of corals bleached in Kāneʻohe Bay (Neilson 2014). Total mortality of corals has been reported in some regions (Rodgers pers. obs.). This event is more severe in magnitude and geographic scale than the only previously observed major bleaching event in Hawaii in 1996 and is anticipated to lead to significant levels of coral mortality in the next few years. Both of these events further threaten Pacific Islands Region Species of Concern (SOC), *Montipora dilatata* and *Lingula reevii*, as well as other common corals and invertebrates (particularly sea urchins) in Kāneʻohe Bay.

In light of the recent low salinity and high temperature disturbances, there is a critical need to understand the current spatial distribution of *Montipora dilatata* and *Lingula reevii*, and identify potential land-based threats to their survival in order to support well-informed decisions with respect to habitat conservation and management. We will apply new approaches to identifying potential sources of land-based pollution in the adjacent watershed and in the face of climate change. By understanding the current patterns of species distribution we can use this information to forecast predicted distribution of key species under different climate change scenarios. Ecological monitoring and mapping will be conducted to define the species distribution patterns and assess critical reef habitat for SOC. In addition, we will couple the spatially explicit land-based threats and species distributions data sets to identify areas of the land-sea interface that are hotspots for future natural disturbances.

As has been so successful in previous years, this study will be carried out as part of a capstone marine field curriculum to provide students with hands-on training and experience in addressing real-world coral reef resource management challenges. University of Hawaiʻi undergraduate students will likely advance to jobs at local, federal agencies and NGOs in Hawaiʻi upon graduation and this cutting edge geospatial training will ensure our next generation of coral reef managers will be well equipped to address the issues facing our coral reef ecosystems. The expected outcomes of this project will provide: 1) maps and prioritization of critical areas of current and potential habitat in Kāneʻohe Bay for management of two NOAA Species of Concern; and 2) determination of which land-sea links can be precisely determined so that managers might develop effective mitigations in protecting reefs from further declines in Kāneʻohe Bay. We hope to use the novel applications of GIS and aerial imagery in the Hawaiʻi marine college curriculum to provide students (the next generation of potential Pacific resource managers) with hands-on training and experiences in appropriate technology.



*Montipora dilatata, Lingula reevii, and Tripneustes gratilla in* Kaneohe Bay

Next-gen coral reef managers