

**Final Report prepared for
Florida Department of Environmental Protection (DEP)**

Project Title: Florida Disease Response Coral Rescue - NSU

Principal Investigator(s):

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Project Dates:

Final Report date: 06/15/2022

Project dates: 07/01/2021 - 06/30/2022

Project Goals and Objectives:

During the first two years of this project, approximately 980 rescue corals have been housed at NSU in the land-based SEACOR system (which consists of 30 individual tanks, each with fully independent filtration and life support systems). While primarily acting as a receiving and quarantine facility for newly rescued corals, NSU also has filled the role of both a treatment center and overstock holding for some corals previously held by other project partners. The NSU team has also assisted with logistics issues regarding both rescue and non-rescue coral transportation as needed.

As the rescue project progresses to include endemic corals, we have increased our capabilities to hold (temporary and long-term) other corals beyond the scope of the non-endemic coral field collections. This effort includes both the SEACOR rescue tanks and the 4,000 gallon main onshore nursery at NSU, and includes providing both short-term and long-term housing for corals that are, for example, rescued as part of building and maintenance projects (i.e. Port Everglades maintenance dredging and bulkhead replacements) or corals quarantined before transfer to other facilities. The available facilities are unique in terms of the capability to provide short-term quarantine care and long-term life support.

The scope has also been expanded, in collaboration with Dr. Joana Figueiredo's efforts in coral propagation, to include the microfragmentation of key reef-building species. Asexually reproducing corals through fragmentation has the advantage of quickly increasing coral biomass available to restoration efforts, but it does not contribute to increased genetic diversity. Fragmentation consists of breaking adult colonies into multiple smaller pieces, which are then grown in land-based and/or offshore nurseries. Smaller fragments present faster growth rates than larger colonies. This has been hypothesized to be because smaller corals allocate more energy towards growth and away from reproduction, or simply because the perimeter to area ratio is more advantageous for the growth of modular organisms. Microfragmentation of reef-building species impacted by the SCTLD outbreak needs to be optimized and intensified in land-

based and offshore nurseries to significantly enhance their density on the reef, enhance fertilization success, and ultimately promote recruitment success. To meet this objective, we will microfragment and grow out multiple species in the onshore nursery, then transfer these corals as needed to the offshore nursery to support outplanting efforts.

Project Tasks:

- **Task 1: Care and maintenance of existing and new rescue corals**

One senior and two staff aquarists are responsible for the care and maintenance of existing and new rescue corals, overseen by the project PI. This task includes maintenance of water quality via weekly water changes in the NSU Building Nursery and SEACOR coral rescue holding systems, daily equipment checks and repairs as necessary to ensure that all systems are operating normally. Regular health inspections are conducted on all colonies in holding. The corals are fed three times weekly. Pests, epiphytes, and algae are removed from coral colonies when observed. Any damaged, bleached, or diseased corals are maintained in a separate system(s) for quarantine care and treatment. A daily log of coral care and maintenance activities is maintained. This task also includes acclimation of incoming corals to nursery conditions, as well as preparation and packaging of corals for transport between intermediate facilities and long-term holders. Monthly updates of the number of corals maintained in the NSU Building Nursery and the SEACOR systems are provided to DEP.

Completed tasks:

- NSU currently no longer holds any naive rescue corals, as they have all been transported to Association of Zoos & Aquariums (AZA) facilities or other approved holders, where they will be held long term.
- NSU now holds a large selection of endemic corals from mitigation efforts, such as the Port Everglades Jetty Collections (Special Activity License # SAL-21-2306-R) as well as corals that have been removed thus far for the beach renourishment project (Special Activity License # SAL-21-2375-R & SAL-21-2383-R). “Corals of opportunity” as well as corals that have been held here at NSU continue to be residents in the onshore nursery and contribute to our propagation efforts. We have provided monthly reports to DEP on the numbers of corals held at NSU.
- NSU has held, and out planted, all of the ACER specimens brought in by Dial Cordy (On behalf of the Army Corps of Engineering) from a region known as “Reach 2.”. All corals received clearance from a veterinarian prior to transplanting and were handled in such a way that biosecurity was always maintained.
- In March of 2022, NSU provided temporary holding for an FWC Endemic coral rescue that totaled 102 colonies from Broward County. All corals from this collection were documented, tissue-sampled, and inventoried by FWC before being distributed to project partners.
- A summary of all incoming and outgoing coral activity is provided in Table 1.

Table 1. Summary of incoming and outgoing endemic rescue corals.

| Batch Name/# | Event Type (Arrival/Internal Transfer/Shipme nt or Transplanting) | Date | # Of Corals | Destination or Current System |
|---------------------------|-------------------------------------------------------------------------------|-------------------------------------|----------------|----------------------------------|
| LIRMAN-01-2021 | ARRIVAL | 6/14/2021 & 6/21/2021 | 3 | NSU - Building Nursery |
| N/A | ARRIVAL | 7/9/2021 | 6 | NSU - SEACOR |
| N/A | ARRIVAL | 7/19/2021 | 5 | NSU - Building Nursery |
| N/A | SHIPMENT | 7/28/2021 | 31 | UNC Wilmington - Dr. Fogarty |
| LIRMAN-02-2021 | ARRIVAL | 7/29/2021 | 2 | NSU - Building Nursery |
| WALKER-01-2022 | ARRIVAL | 10/20/2021 | 2 | NSU - SEACOR |
| ARMYFRAGS-01-2021 | ARRIVAL | 12/01/2021 through 12/11/2021 | 731 | NSU - SEACOR |
| GILLIAM-01-2022 | ARRIVAL | 1/26/2022 | 19 | NSU - SEACOR |
| GILLIAM-01-2022 | ARRIVAL | 1/27/2022 | 11 | NSU - SEACOR |
| N/A | TRANSPLANT ED | 1/30/2022 | 676 | The Ocean |
| GILLIAM-01-2022 | SHIPMENT | 2/3/2022 | 30 | MOTE |
| WALKER-01-2022 | ARRIVAL | 2/8/2022 | 1 | NSU - SEACOR |
| WALKER-01-2022 | ARRIVAL | 2/10/2022 | 4 | NSU - SEACOR |
| GILLIAM-02-2022 | ARRIVAL | 2/11/2022 | 1 | NSU - SEACOR |
| GILLIAM-ARMYFRAGS-01-2021 | TRANSPLANT ED | 2/28/2022 | 270 | The Ocean |
| GILLIAM-ARMYFRAGS-01-2021 | SHIPMENT | 2/28/2022 | 283 | University of Miami |
| GILLIAM-03-2022 | ARRIVAL | 3/1/2022 | 22 | NSU - SEACOR |
| GILLIAM-FRAGS-02-2022 | TRANSPLANT ED | 3/18/2022 | 38 | The Ocean |
| FWC-01-2022 | ARRIVAL | 3/28/2022 | 55 | NSU - SEACOR |
| FWC-01-2022 | ARRIVAL | 3/29/2022 | 47 | NSU - SEACOR |
| FWC-01-2022 | SHIPMENT | 3/30/2022 | 94 | MOTE |
| GILLIAM-03-2022 | INTERNAL TRANSFER | 4/1/2022 | 22 | NSU - Building Nursery |
| FWC-01-2022 | INTERNAL TRANSFER | 5/3/2022 | 8 | NSU - Dr. Figueredo |
| WALKER-02-2022 | ARRIVAL | 5/18/2022 | 5 | NSU - SEACOR |

Next steps:

- As NSU no longer holds naïve colonies, our purpose has shifted to acting as a hub for coral nursery activities; hosting corals for grow-out/micro-fragmentation, holding corals for out planting, holding endemic corals that are pending shipment to other holders, providing support for nearby coral holders, and quarantining worker animals.

- NSU's onshore nursery operations continue to provide a biosecure space for the care of new colonies, diseased/agitated colonies, as well as growing fragments. This facilitates not only our own specified goals but also other labs such as Dr. Gilliam (NSU), Dr. Walker (NSU), Dr. Figueiredo (NSU), and outside labs such as Dr. Lirman (RSMAS). Additionally, we also provide essential support to government agencies such as the Army Core of Engineers and Florida Fish & Wildlife (FWC). We have also begun to take in coral from environmental contractors, such as Dial Cordy, when corals moved for mitigation cannot be immediately transplanted.
- NSU will continue to provide care and maintenance for the endemic corals in our systems. Specifically:
 - Corals are visually assessed for general health condition daily and fed amino acids and powdered sterilized foods 3 times per week.
 - Maintenance of water quality via weekly water changes on all coral holding systems, daily equipment checks and repairs as necessary to ensure that all systems are operating normally.
 - Algal growth is maintained at a minimum via cleaning and herbivores to prevent competition or overgrowth.
 - Any damaged, bleached, and diseased corals are maintained in a separate system(s) for quarantine care and treatment, consistent with veterinary guidance.
- NSU will continue to provide support for ongoing coral transfer activities, including:
 - Acclimation of incoming corals to nursery conditions, and preparation and packaging of corals.
 - Facilitating direct transportation from collection to other project partners when needed.
 - Provide short-term housing for corals that are pending out planting.
- **Task 2: Inter-organization and public communication**

This task includes interactions with other intermediate holding and AZA facilities, including participation by the senior aquarist in weekly conference calls, and troubleshooting and problem-solving through email and telephone conferences with AZA partners. Many of the corals involved in the rescue project have rarely been held in captivity. Sharing observations with holding partners about the behaviors and needs of each of these species has been essential to the success of the project thus far. Public outreach interactions and education about Florida's Coral Reef and the rescue project are also a part of this task.

Completed Tasks:

- The team continues to participate in public outreach interactions and education regarding the rescue project. This includes communication with aquaculture industry partners, 3rd party environmental contractors, and participating in weekly conference calls with the AZA and our partners in FWC and NOAA.
- The NSU husbandry team is continuing to accept master's program level volunteers once or twice a week (under direct supervision of the husbandry team) to provide

- opportunities to learn about the coral rescue effort and coral husbandry. Volunteers assist in cleaning systems, re-mounting coral on tiles, and target feeding.
- NSU's husbandry team is also making contributions to the Caribbean Coral Aquarist Training (CCAT) program, making written contributions to the "Coral Systems Design and Construction" chapter which is currently being reviewed and edited by the AZA.
 - 6 Month evaluation of the water quality of the NSU Building Nursery conducted by Aqua Medic, courtesy of FWC & AZA, providing comprehensive measurements of the elements in our artificial seawater.
 - Visitation of the corals under the care of SeaWorld & Disney held at FCRC as well as a tour of the facility in Orlando.
 - NSU provided coral nursery tours for a visiting, conservation-minded, US Navy Admiral and his team of advisors.
 - The Nature Conservancy's Julia Rose, from their Hawaii team, came for a comprehensive coral nursery and filtration tour.
 - The NSU Nursery Team visited University of Miami's RSMAS campus for the summer coral spawning hub meeting; strengthening relations between our program here at NSU and our partners down at UM, as well as the Smithsonian, and The Florida Aquarium.
 - The NSU team continues to nurture relationships with our existing partners but also forge new relationships with the Army Core of Engineers as well as Environmental Contractors/Advisors such as Dial Cordy, and Non-profits such as the Reef Discovery Center.

Next steps:

- NSU will continue to maintain inter-organization and public communication. This includes interactions with other intermediate holding and AZA facilities, participation in weekly conference calls, and troubleshooting and problem solving through email and telephone conferences with partners.
 - FWC & NSU are continuing to use some of the SEACOR systems as quarantine space for working-animals (such as sea urchins, shrimps, snails, etc.) that can be sent to Coral Rescue facilities nation-wide. NSU accepted a single batch of Peppermint shrimp (*Lysmata wurdemanni*) that completed the quarantine process in late January of 2022 and were distributed to project partners through FWC. NSU has since quarantined another batch of Peppermint shrimp, various sea urchins, crabs, and snails on behalf of FWC that is currently being distributed to coral rescue partners.
 - NSU plans to accept more quarantine requests for the coral rescue project in order to alleviate the space/capability restrictions of the coral rescue project partners.
- **Task 3: Microfragmentation and grow-out of microfragments in land-based nursery**
Corals of several species which have been affected by the STCLD will be microfragmented and grown in a land-based nursery. This includes corals collected for

research purposes in previous years and corals of opportunity which have been collected and brought to NSU. Based on existing stock of corals, a minimum of 500 microfrags will be made with up to 750 total microfragments; if additional corals of opportunity become available for microfragmenting then this target number may be increased. A portion of the microfragments will be moved to the offshore nursery (collaboratively with Dr. Joana Figueiredo).

Completed tasks:

- The onshore nursery currently holds a large number of coral fragments from multiple species (see graphs below for species numbers).
- NSU has produced 3,605 coral fragments since June of 2021, of which 1,267 have been outplanted. Our inventory is actively growing, and we are poised to continue to increase our production capability.
- Four corals of opportunity (three colonies of *Siderastrea siderea* and one colony of *Montastraea cavernosa*) were fragmented on 04/08/2021 and we have monitored the growth rate in these corals. To measure size and growth of the fragments, scale referenced photographs were processed using ImageJ's polygon selection and measurement features, using the metric ruler in each image for scale. The difference in amount of living tissue on each fragment was used to calculate a daily growth rate (in cm²/day).
 - All three colonies of *S. siderea* responded well to microfragmentation, with an overall 95% survivorship over 14 months (Figure 1A). For colony 1, all 36 fragments survived (100% survivorship), with limited (11%) tissue loss in only one fragment (Figure 2B). Five fragments of the 32 made from colony 2 did not survive (84.4% survivorship), and 2 of surviving fragments had minimal tissue loss (6.5-7.9%). One fragment of the 31 made from colony 3 did not survive (96.9% survivorship), and 4 fragments had some tissue loss (5.3-24.7%) by December 2021. However, by June 2022, 80 of the 93 surviving SSID fragments have gained tissue area. In contrast, fragments of NSU-MCAV1 fell to a 0% survivorship shortly after December 2021. The parent colony continues to do well, indicating that the starting size of our fragments were too small. NSU-MCAV2 cut in the beginning of January 2022, producing 11 fragments of an average size of 9.7 cm². These fragments have maintained a 100% survivorship through June 2022. Three fragments have lost tissue (1.5%-3.5%) with other specimens gaining as much as 18% over their original size. NSU-OFAV1 and NSU-OFAV2 both responded well to fragmentation. Both colonies maintained a 100% survivorship, 2 fragments of OFAV1 and 21 fragments of OFAV2, from January 2022 through June 2022 (Figure 1C). All fragments gained tissue over the 152-day monitoring period (Figure 2A) with an average total tissue area increase of 49.9% over their original size.
 - Mean growth rate of the surviving microfragments for both species is shown in Figure 3. Overall growth rate was higher *O. faveolata* as compared to *S. siderea* and *M. cavernosa* (Figure 3D), and substantial variability was

observed in growth rate of microfragments from different *S. siderea* colonies (Figure 2B).

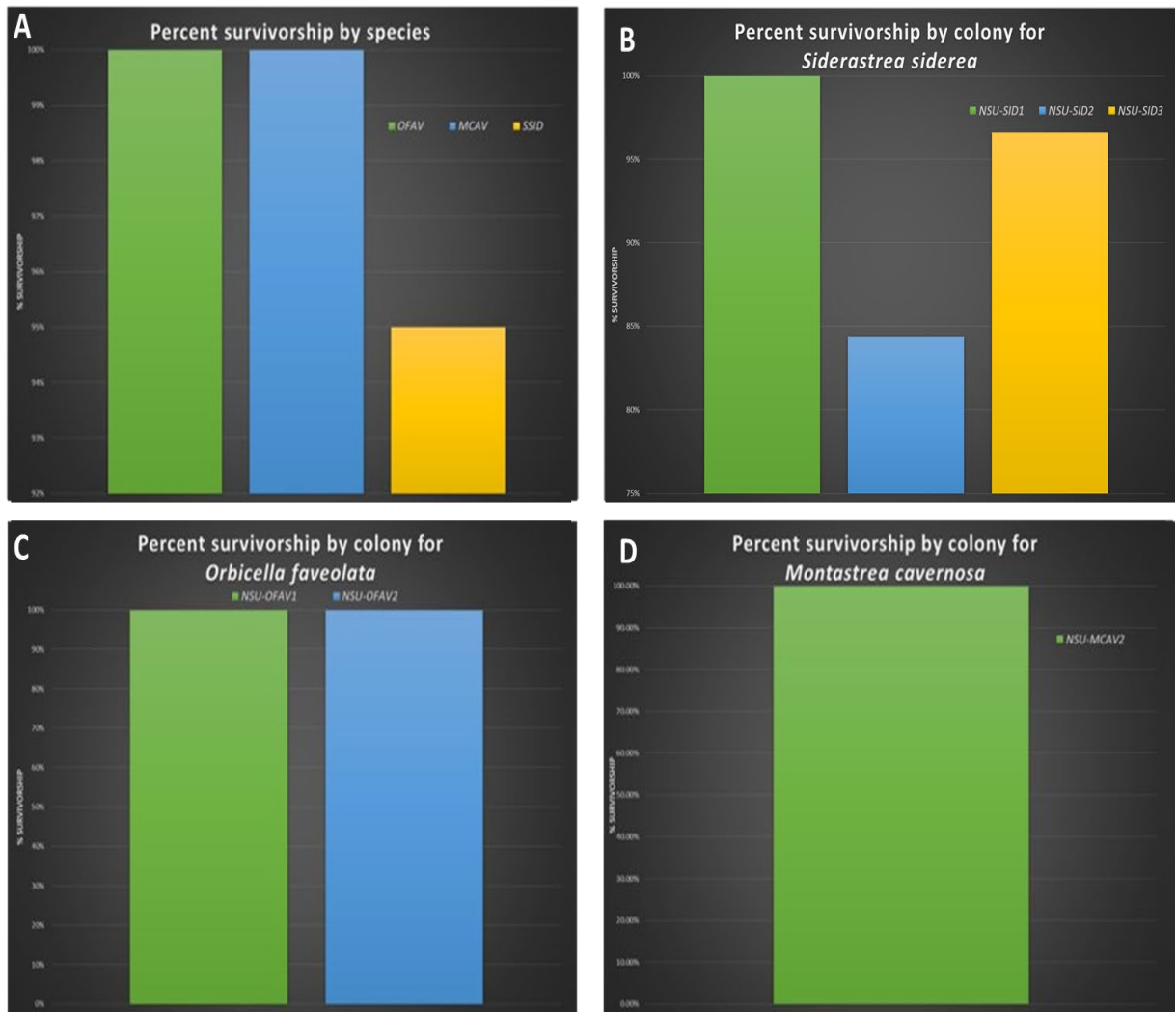


Figure 1. A) Overall % survivorship for microfragments of *Orbicella faveolata*, *Montastraea cavernosa* and *Siderastrea siderea*; B) % survivorship by colony for *Siderastrea siderea* microfragments; C) % survivorship by colony for *Orbicella faveolata* microfragments; D) % survivorship by colony for *Montastraea cavernosa* microfragments.

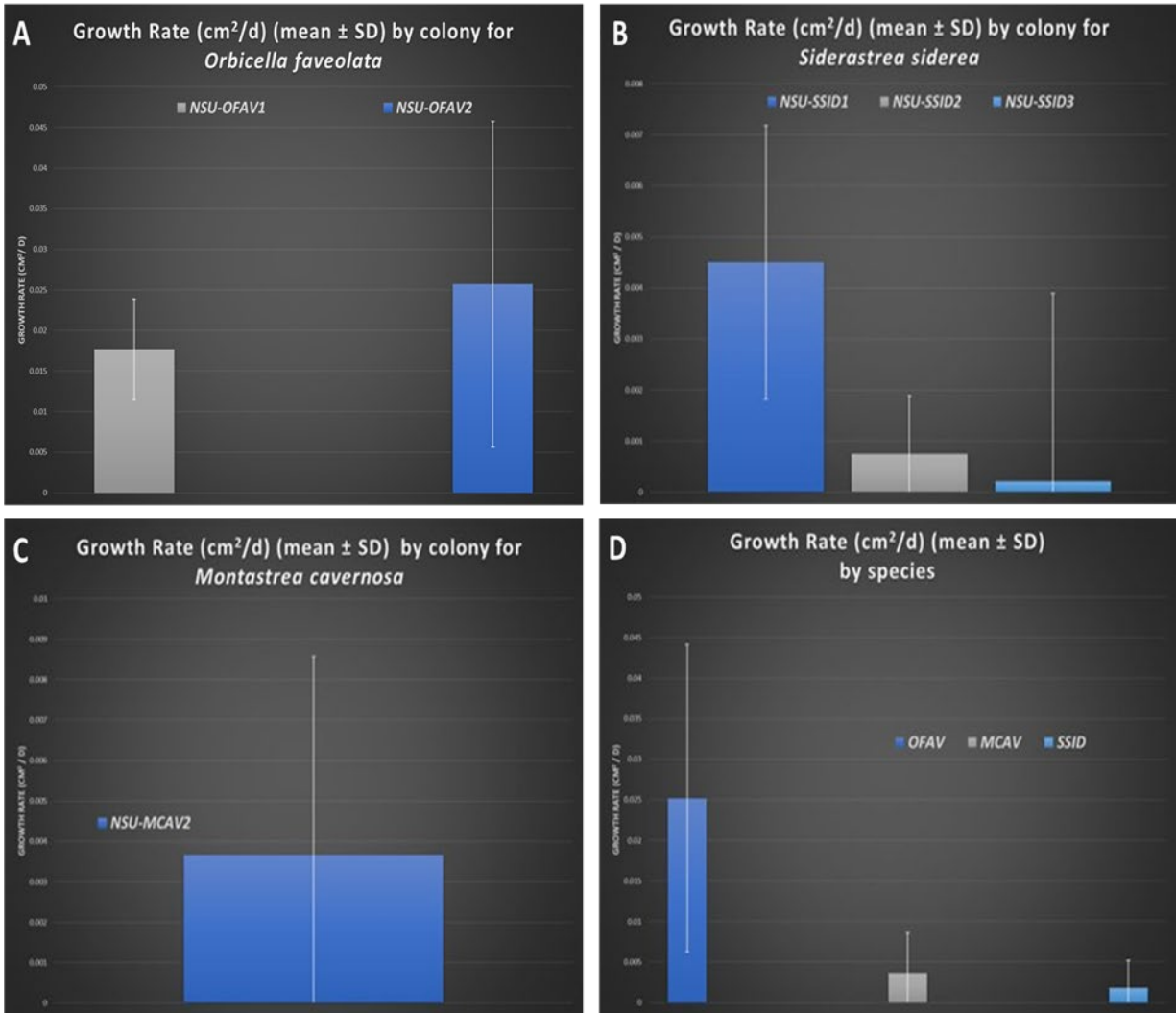


Figure 2. A) Growth rate (mean ± SD, in cm²/day) by colony for microfragments of *Orbicella faveolata*. B) Growth rate (mean ± SD, in cm²/day) by colony for microfragments of *Siderastrea siderea*. C) Growth rate (mean ± SD, in cm²/day) by colony for microfragments of *Montastrea cavernosa*. D) Growth rate (mean ± SD, in cm²/day) by species.

Next steps:

- Several additional corals of opportunity have been collected and added to the coral nursery stock in the time since this initial group of fragments was produced. We will be using these corals to expand the microfragment program by increasing the number of species represented as well as the number of unique colonies per species.
- NSU will continue to make improvements to our onshore nursery facilities, such as enhancing filtration and system water volume, to improve our overall utility and improve husbandry.
- NSU will continue to conduct microfragmentation and grow-out of coral fragments in onshore coral nursery.

Current Inventory:

Cumulative Inventory: 263 colonies, 2,376 fragments

Indoor Systems

Colonies: 6 (Endemic)

Fragments: 1,472 (Endemic)

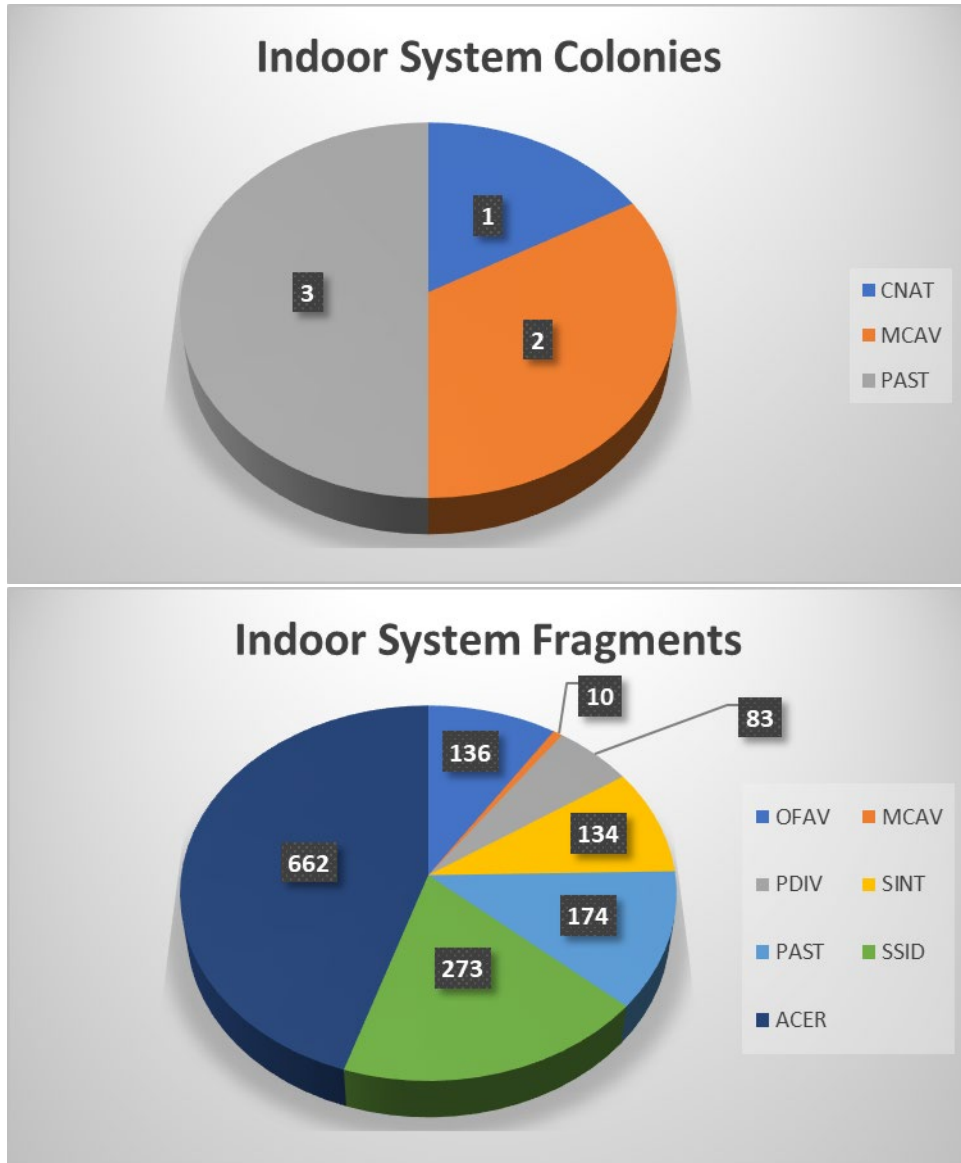


Figure 3: Standing inventory of the Indoor Systems as of June 15th, 2022.

Building Nursery

Colonies: 164 (Endemic)

Fragments: 842 (Endemic)

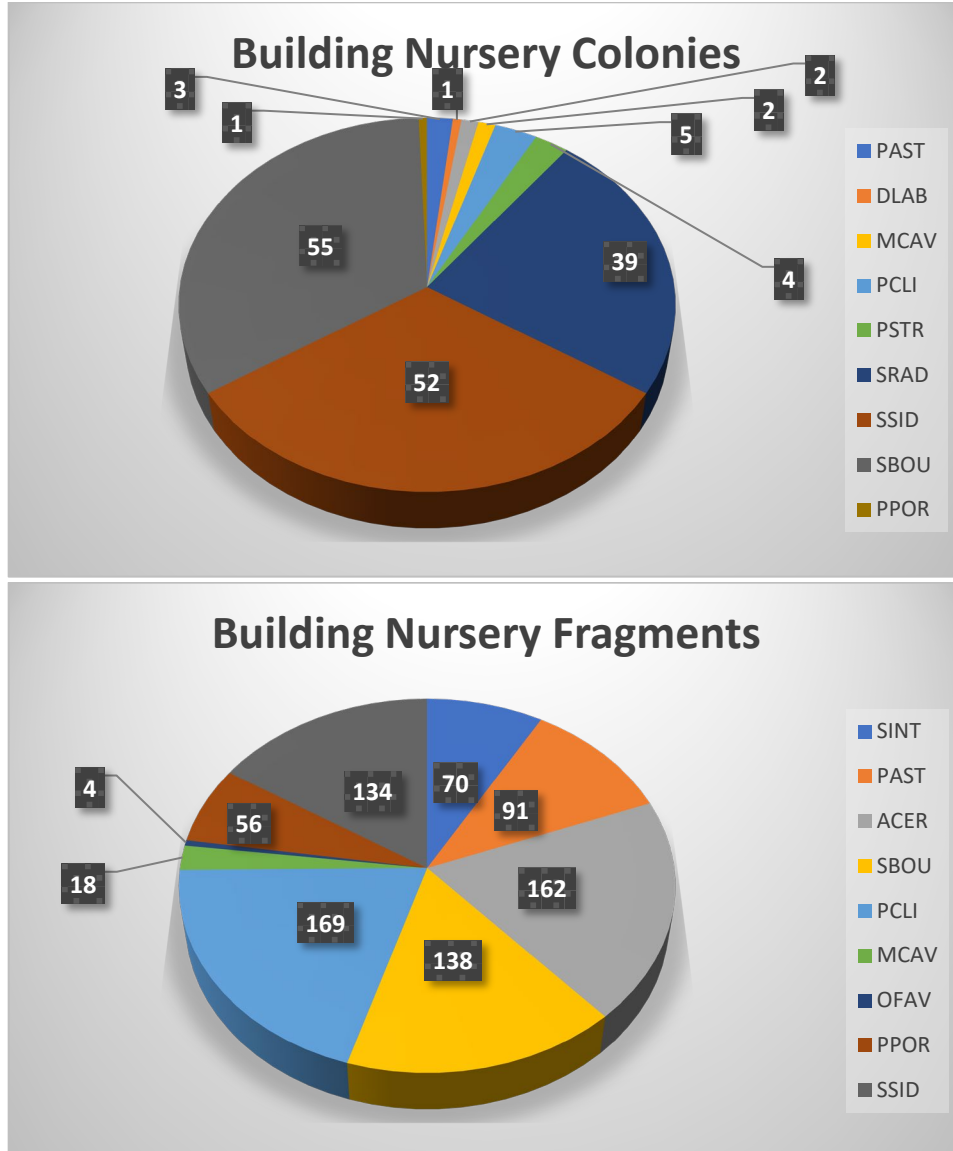


Figure 4: Standing inventory of the Building Nursery as of June 15th, 2022.

SEACOR Systems

Colonies: 93 (Endemic)

Fragments: 262 (Endemic)

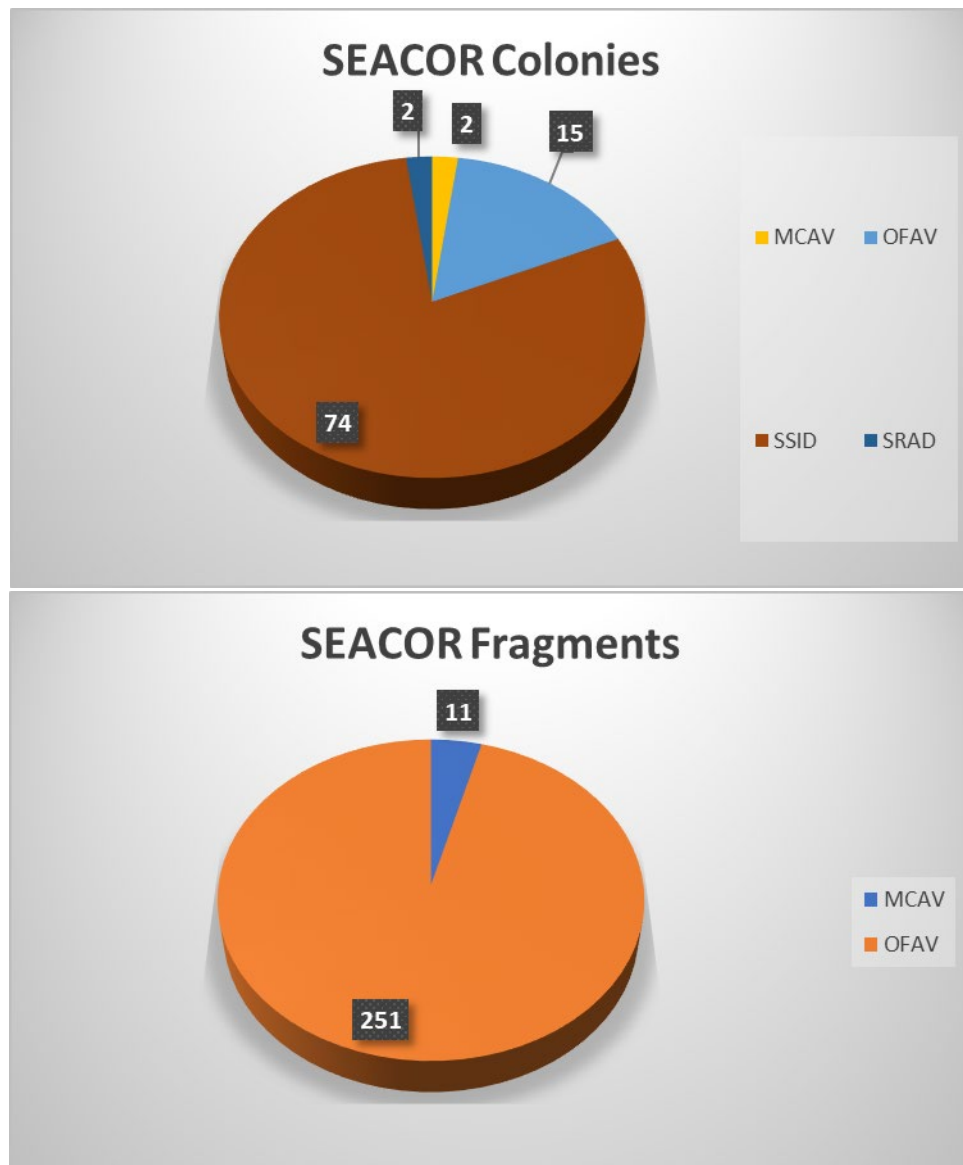


Figure 5: Standing inventory of the SEACOR Systems as of June 15th, 2022.

Supplemental Images:

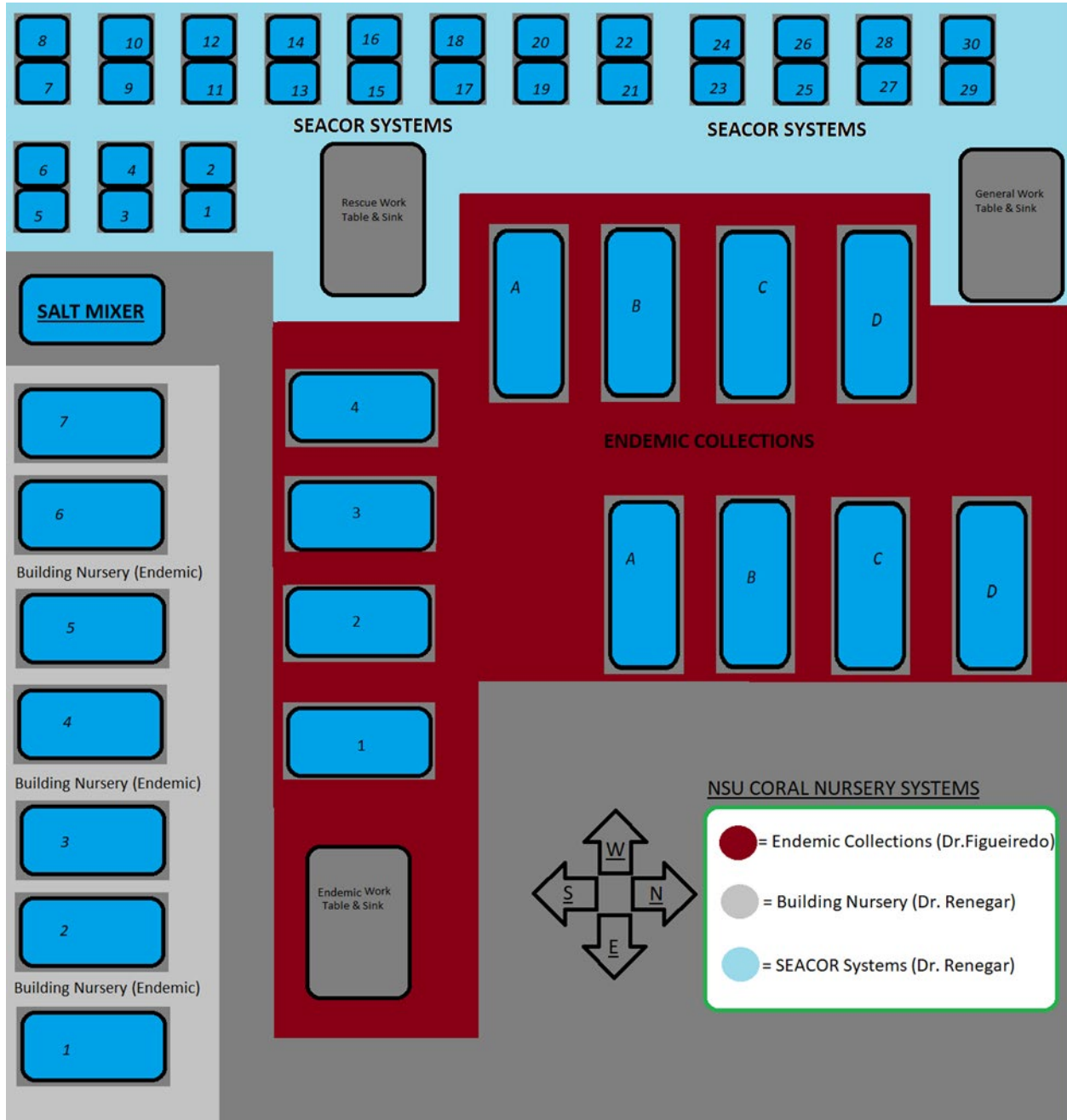


Figure 6: A general map of the NSU onshore coral nursery area.

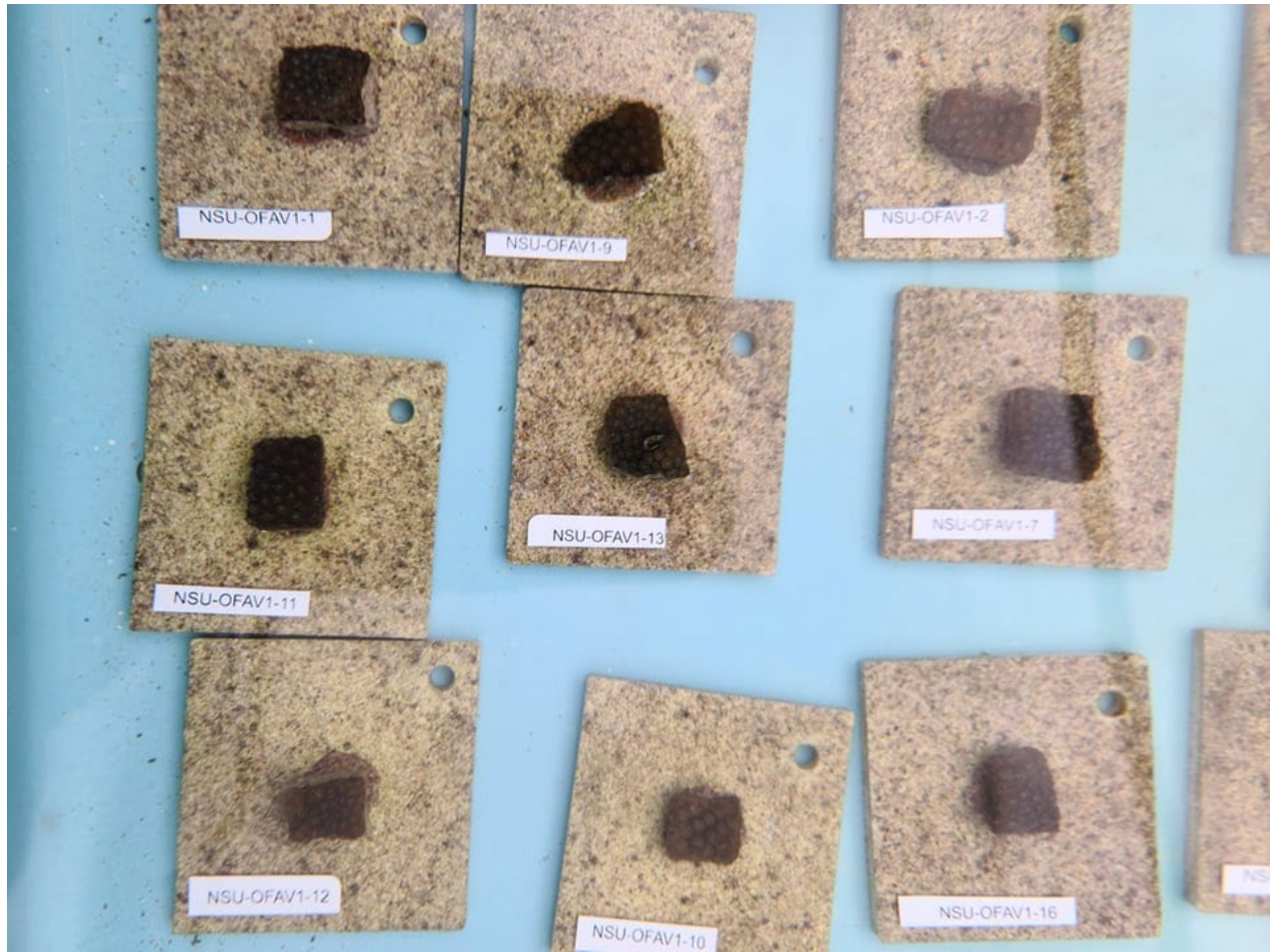


Figure 7: Fragments of OFAV which are measured on the 14th of each month using ImageJ.

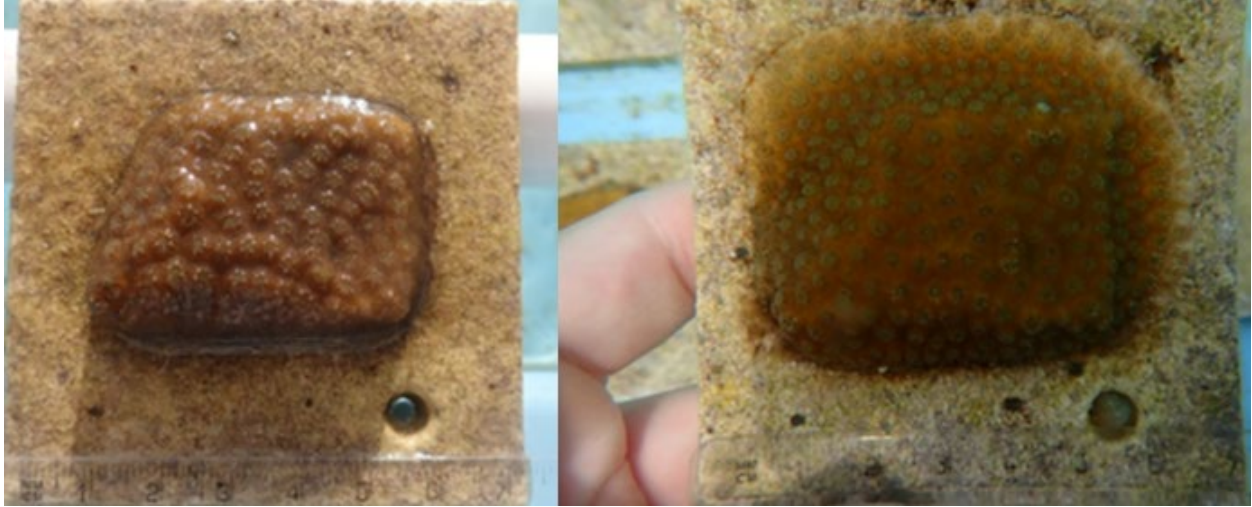


Figure 8: A fragment of NSU-OFAV2. There is a notable amount of growth from January 2022 (Left) when compared to June 2022 (Right).

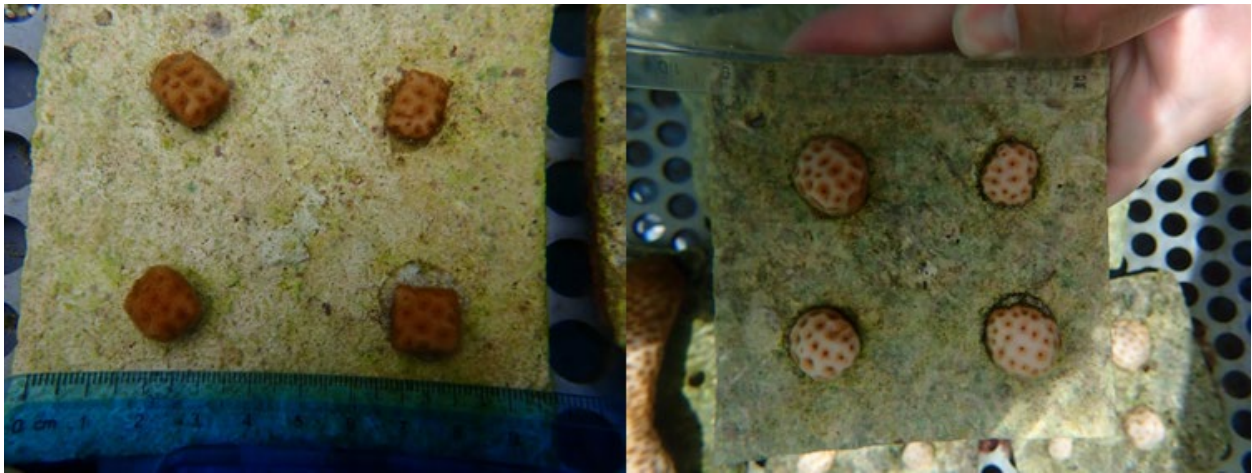


Figure 9: Fragments of SSID in January 2022 (left) as compared to June 2022 (right).

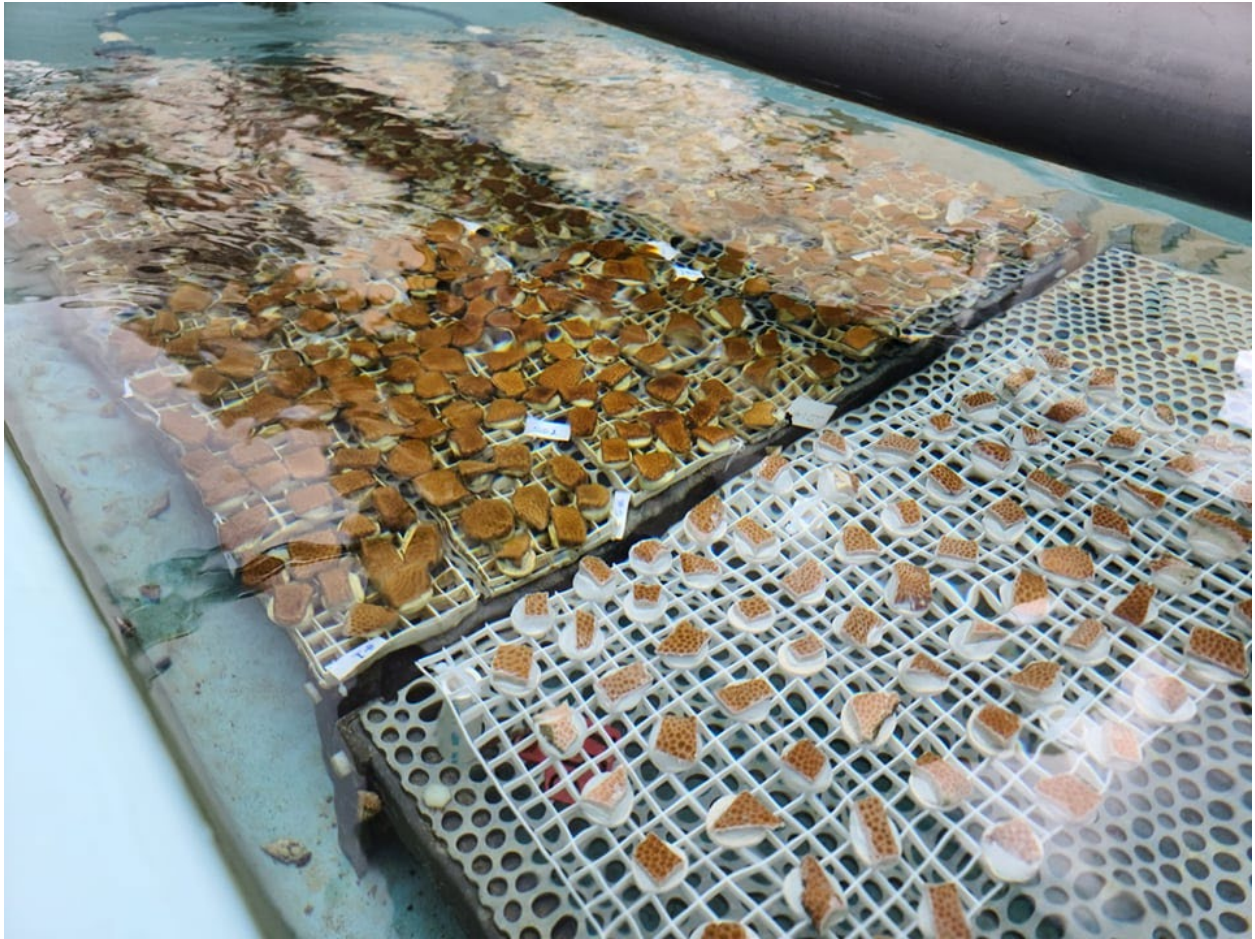


Figure 10: Fragments in the grow-out process in the NSU building nursery. These fragments were outplanted by the CRRAM Lab.



Figure 11: More fragments in the grow-out process. These fragments were outplanted by the CRRAM Lab.



Figure 12: Project aquarist Matthew Rojano caring for some of the corals in NSU's onshore Building Nursery.



Figure 13: NSU students from Dr. Gilliam's CRRAM Lab fragmenting corals for grow-out in the onshore nursery.



Figure 14: ACER brought in by Dial Cordy on behalf of the Army Corps of Engineers for the beach renourishment project. These corals have since been transplanted offshore by the CRRAM Lab.



Figure 15: The FWV Coral Rescue Team coming into the NSU marina to offload corals on the first day of the 2022 Endemic rescue operation.



Figure 16: NSU coral aquarists Katrina Smith (Left) and Mathew Rojano (Right) care for newly arrived Rescue Corals from FWC. Pest organisms and excess algae are carefully removed. A general health assessment is also conducted at this time.



Figure 17: The FWC Rescue Team preparing to ship Rescue Corals with the assistance of NSU.