

Florida Disease Response Coral Rescue and Propagation - NSU



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Final Report

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Management Summary

The NSU Onshore Coral nursery is a multipurpose, *ex-situ* onshore coral nursery dedicated to support the preservation and restoration of Florida’s Coral Reef. The nursery is a hub for coral nursery activities; housing corals for grow-out/microfragmentation and out planting and providing logistical support for a variety of other reef restoration activities through close collaborations and communication with restoration partners. The onshore nursery currently holds 4,684 corals of 15 species: 337 colonies and 4,347 fragments. Overall, 2,093 corals have been out planted from the NSU Onshore nursery systems since the start of 2023.

Executive Summary

The mission of the NSU Onshore Coral nursery is to serve as a multipurpose, *ex-situ* onshore coral nursery dedicated to support the preservation and restoration of the Florida's Coral Reef. The nursery is a hub for coral nursery activities, providing a biosecure space for the care of new colonies, diseased/agitated colonies, and fragment grow-out. The nursery facilities support the restoration activities of other NSU researchers including Dr. Gilliam (NSU), Dr. Walker (NSU), and Dr. Figueiredo (NSU). Additionally, we also provide essential support to agencies such as the Army Core of Engineers & Florida Fish & Wildlife (FWC). The nursery husbandry team also maintains inter-organization and public communication activities, including 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 utilize the SEACOR system as quarantine space for maintenance animals (such as sea urchins, shrimps, snails, etc.) that are distributed to other coral rescue facilities.

Our primary focus continues to be the care and maintenance for the endemic corals in our systems and support for ongoing coral outplant and transport activities, including acclimation of incoming corals to nursery conditions, direct transportation from collection to other project partners when needed, and short-term housing for corals that are pending transplantation. We 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.

The onshore nursery currently holds 4,684 corals in total; 337 colonies and 4,347 fragments. A total of 2,093 corals have been outplanted from the onshore nursery systems since the start of 2023, more than double 2022-2023 target number. As additional corals of opportunity are added to the coral nursery stock, these corals are used to expand the microfragment program by increasing the number of species represented as well as the number of unique colonies per species.

Acknowledgements

The NSU husbandry team consists of a dedicated group of NSU students and employees who ensure the well-being of corals in the nursery, including Onshore Nursery manager Kyle Pisano; current staff aquarists Austin Blakeslee, Ellen Skelton, Amanda Travers; and recently graduated staff aquarists Matt Rojano and Katrina Smith.

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List of Acronyms

AAGA	<i>Agaricia agaricites</i>
AZA	Association of Zoos and Aquariums
DEP	Florida Department of Environmental Protection
FWC	Florida Fish & Wildlife
MCAV	<i>Montastraea cavernosa</i>
NSU	Nova Southeastern University
OFAV	<i>Orbicella faveolata</i>
PSTR	<i>Pseudodiploria strigosa</i>
SCTLD	Stony Coral Tissue Loss Disease
SINT	<i>Stephanocoenia intersepta</i>
SSID	<i>Siderastrea siderea</i>

1. DESCRIPTION

During the first three years of this project, naïve and endemic rescue corals were housed at NSU in the land-based main building nursery (eight 400-gallon raceways and a comprehensive life support system), the SEACOR system (30 individual tanks, each with fully independent filtration and life support systems) and two indoor propagation systems (each with two 200-gallon raceways and independent life support systems).

NSU's role in broader coral rescue and reef restoration efforts has been multifaceted. While primarily acting as a receiving and quarantine facility for incoming corals, NSU has also assisted with logistics issues regarding both rescue and non-rescue coral transportation, shipping supply storage needs, and has provided volunteers support for coral receiving, coral shipping, and other miscellaneous tasks and preparations as needed. During year 3 of the project, as the rescue project progressed to include endemic corals, we have increased our capabilities to hold other corals beyond the scope of the original non-endemic coral field collections. This effort has included both the SEACOR system and the 4,000-gallon main onshore building nursery at NSU, providing both short-term and long-term housing for corals which 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 ample short-term quarantine care and long-term life support.

The project scope was also expanded in Year 3, in collaboration with Dr. Figueiredo, Dr. Walker, and Dr. Gilliam's efforts in coral propagation, to include micro-fragmentation 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.

The overall goals of this project are to provide continuing support for ongoing coral rescue and propagation (via fragments and microfragments). This proposal therefore requests support for continuing housing and care of present and future rescue corals and grow out of coral fragments and microfragments for outplanting. This effort utilizes four dedicated personnel for care of corals and supplies for holding and maintenance of >1000 rescue corals and coral fragments during Year 4 of this project. To meet this objective, we will fragment or micro-fragment and grow out multiple species in in the onshore nursery, then transfer these corals as needed to the offshore nursery to support restoration efforts.

The outcomes of this project will be incorporated into an ongoing coral disease response effort which seeks to improve understanding of the scale and severity of the coral disease outbreak on Florida's Coral Reef, identify primary and secondary causes, identify management actions to remediate disease impacts, restore affected resources, and ultimately prevent future outbreaks. As such, collaboration amongst partners is encouraged when appropriate to avoid duplication of efforts and ensure alignment of needs. Coordination with other Principal Investigators is recommended and required, as appropriate.

2. METHODS

2.1. 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. Corals receive regular health inspections on all colonies in holding, are fed three times weekly, and pests, epiphytes, and algae are removed from coral colonies. 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.

2.2. 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.

2.3. Task 3: Microfragmentation and grow-out of microfragments in land-based nursery

One senior and one staff aquarist are responsible for generating coral fragments and their care and maintenance, overseen by the project PI. Corals of several species which have been affected by STCLD have been fragmented or microfragmented; this includes corals collected for research purposes in previous years and corals of opportunity which have been collected and brought to NSU. Coral fragments and microfragments are maintained in the NSU Building nursery, Temperature is maintained with a heat exchanger and process chilled water. Filtration consists of a protein skimmer with

ozonation, a UV sterilizer, and a media/carbon reactor. A calcium reactor is used to maintain calcium levels and facilitate coral growth. In-tank circulation is provided by submersible powerheads and wave timers. Coral fragments and microfragments are also maintained in two indoor propagation systems (each with two 200-gallon raceways and independent life support systems). For the indoor systems, temperature is maintained with in-line chillers and submersible heaters. Filtration consists of protein skimmers and media/carbon reactors. Calcium reactors are used to maintain calcium levels and facilitate coral growth. In-tank circulation is provided by submersible powerheads and wave timers, and lighting is provided by Ecotech Radion XR30 Pro LED lights. Corals are visually assessed for general health condition daily and fed three times weekly ad libitum to promote growth and enhance survival rates. Water quality is maintained via weekly water changes, with daily equipment checks and maintenance as necessary to ensure that the system is operating normally.

Thirteen corals of opportunity have been fragmented and are being monitored monthly for growth. The colonies consist of two *Agaricia agaricites* (AAGA), one *Montastraea cavernosa* (MCAV), three *Orbicella faveolata* (OFAV), one *Pseudodiploria strigosa* (PSTR), three *Stephanocoenia intersepta* (SINT), and three *Siderastrea siderea* (SSID). To measure size and growth of the fragments, scale referenced photographs were processed using Image J's polygon selection and measurement features, using the metric ruler in each image for scale. The change in amount of living tissue on each fragment is tracked and shown as the average cm² for each colony's fragments, the parent colony's surface area is also shown if the whole colony was not used to make fragments.

2.4. Task 4: Upgrade of seawater mixing and distribution system

This task includes modifications and reconfiguration of the existing seawater well and distribution system to support the use of artificial seawater in the onshore coral nursery. These modifications include disconnection of the 5,000 gallon mixing tank from the seawater wells, installation of a 5,000 GPD RO/DI Skid Unit and installation of a slurry mixing system to facilitate the production of artificial seawater, and reconfiguration of associated piping and valves. Modifications to the distribution system include relocation of the existing protein skimmer and connection to the distribution system, and reconfiguration of piping and valves to accommodate the skimmer. Design and installation work will be completed by Tenji, Inc. in cooperation with NSU facilities and Onshore nursery staff and management.

3. RESULTS

3.1. Task 1: Care and maintenance of existing and new rescue corals

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 are held long term. NSU's onshore nursery operations continue to facilitate not only our goals but also other labs such as Dr. Gilliam (NSU), Dr. Walker (NSU), and Dr. Figueiredo (NSU), and we continue to provide a biosecure space for the care of new colonies brought in as corals of opportunity, diseased/agitated colonies,

as well as growing fragments, and providing a secure, reliable and flexible space for emergency storage of corals from other facilities. The onshore nursery currently holds 4,684 corals in total; 337 colonies and 4,347 fragments. This includes a variety of corals comprised of corals of opportunity, endemic rescue corals, corals propagated from within the nursery, and a number of recruits from other facilities. Additionally, we also provide essential support to government agencies such as the Army Core of Engineers & Florida Fish & Wildlife (FWC), taking in coral from environmental contractors when corals moved for mitigation cannot be immediately transplanted. A summary of the current coral inventory is provided in Table 1, and detailed inventory of colonies and fragments in the nursery system is provided in Figure 1.

Table 1 Current coral inventory in the NSU On-Shore Coral Nursery

	Colonies	Fragments	Total
Building Nursery			
<i>Acropora cervicornis</i>		300	300
<i>Diploria labyrinthiformis</i>	1		1
<i>Montastraea cavernosa</i>		226	226
<i>Orbicella faveolata</i>		4	4
<i>Porites astreoides</i>	3	8	11
<i>Porites porites</i>	1	19	20
<i>Pseudodiploria clivosa</i>	3	466	469
<i>Pseudodiploria strigosa</i>	3	8	11
<i>Siderastrea radians</i>	39		39
<i>Siderastrea siderea</i>	49	231	280
<i>Solenastrea bournoni</i>	55	138	193
<i>Stephanocoenia intersepta</i>		22	22
Total	154	1422	1576
SEACOR Systems			
<i>Agaricia agaricites</i>	2	20	22
<i>Colpophyllia natans</i>		44	44
<i>Diploria labyrinthiformis</i>	1	208	209
<i>Montastraea cavernosa</i>	8	31	39
<i>Orbicella faveolata</i>	63	792	855
<i>Orbicella franksi</i>	2	132	134
<i>Porites astreoides</i>	4		4
<i>Pseudodiploria clivosa</i>	5	260	265
<i>Pseudodiploria strigosa</i>	2	7	9
<i>Siderastrea radians</i>	2		2
<i>Siderastrea siderea</i>	84	9	93
<i>Solenastrea bournoni</i>	1		1
<i>Stephanocoenia intersepta</i>	3	30	33
Total	177	1533	1710
Indoor Systems			
<i>Acropora cervicornis</i>		662	662
<i>Colpophyllia natans</i>	1		1
<i>Montastraea cavernosa</i>	2	10	12
<i>Orbicella faveolata</i>		56	56
<i>Porites astreoides</i>	3	174	177
<i>Porites divaricata</i>		83	83
<i>Siderastrea siderea</i>		273	273
<i>Stephanocoenia intersepta</i>		134	134

Total	6	1392	1398
Overall Total	337	4347	4684

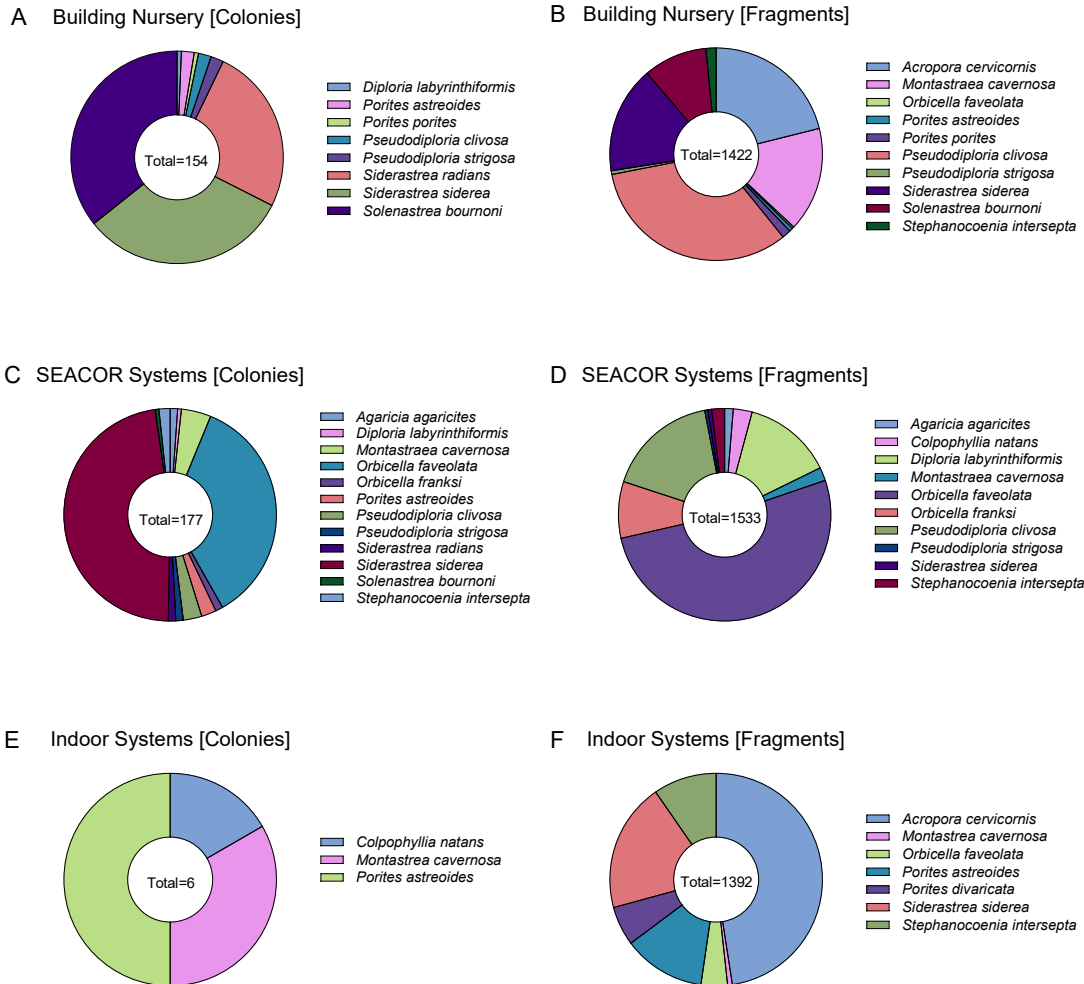


Figure 1 A) Species colony inventory in the Building Nursery, B) species fragment inventory in the Building Nursery, C) species colony inventory in the SEACOR Systems, D) Species fragment inventory in the SEACOR Systems, E) species colony inventory in the Indoor Systems, and F) species fragment inventory in the Indoor Systems.

3.2. Task 2: Inter-organization and public communication

The NSU 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. We 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 welcomed the management team from John Pennekamp State Park for a consultation on coral nursery development at Pennekamp State Park. NSU hosted a press conference for Debbie Wasserman-Schultz and provided coral nursery tours for the congresswoman and other VIPs. We continue to nurture relationships with our existing partners and forge new relationships with the Army Core of Engineers, Environmental Contractors/Advisors such as Dial Cordy, and non-profits such as the Reef Discovery Center.

3.3. Task 3: Microfragmentation and grow-out of microfragments in land-based nursery

The onshore nursery currently holds a large number of coral fragments from multiple species. Thirteen corals of opportunity have been fragmented and are being monitored monthly for growth. The survivorship and growth rate by species is shown in Figure 2, and the survivorship and growth rate by colony is shown in Figure 3 and Figure 4 respectively. All colonies, except for two of the SSID colonies, that were part of the growth monitoring study had a 100% survivorship. The two SSID colonies with reduced survivorship were of smaller fragment size, and were slow to recover tissue. Similar to the MCAV fragments that were lost in the 2021-2022 project year, this indicates that starting with a larger fragment size for this species allows them to better tolerate on-shore conditions.

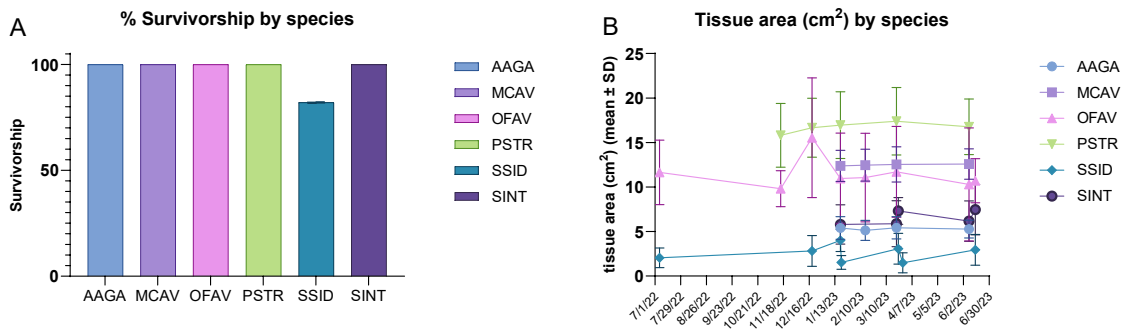


Figure 2 A) % survivorship by species, and B) growth rate by species from 07/01/22 to 06/15/23.

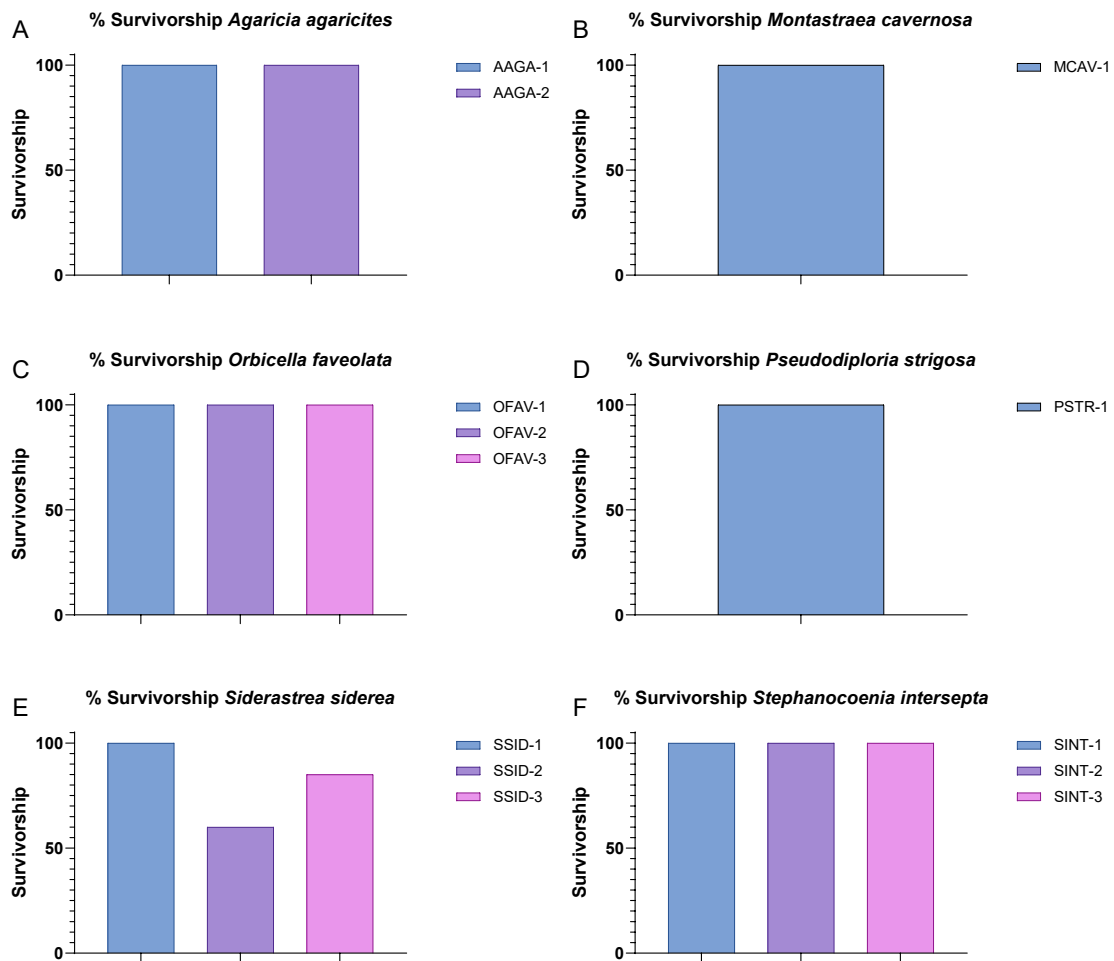


Figure 3 A) % survivorship for fragments of *Agaricia agaricites* colonies, B) % survivorship for fragments of *Montastraea cavernosa* colonies, C) % survivorship for fragments of *Orbicella faveolata* colonies, D) % survivorship for fragments of *Pseudodiploria strigosa* colonies, E) % survivorship for fragments of *Siderastrea siderea* colonies, and F) % survivorship for fragments of *Stephanocoenia intersepta* colonies.

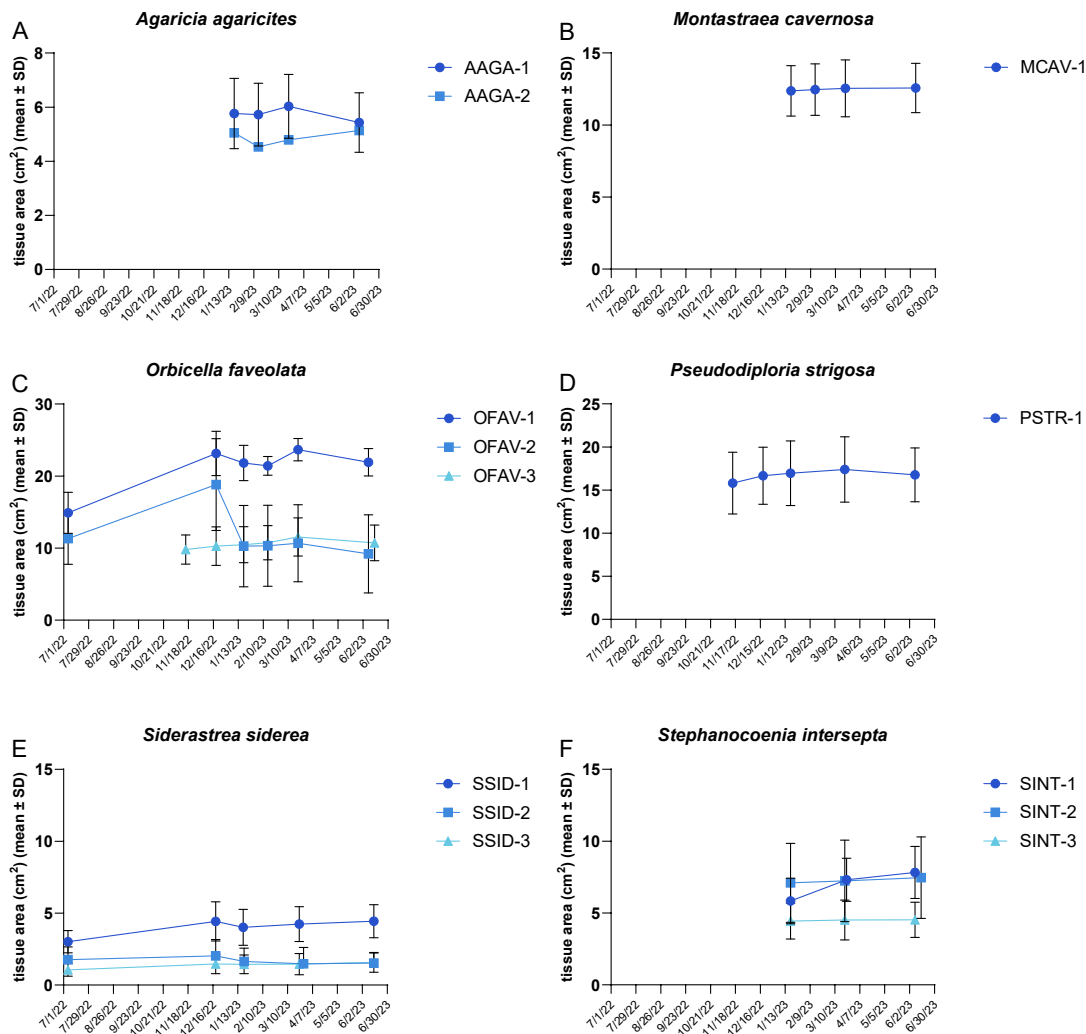


Figure 4 A) Growth rate for fragments of *Agaricia agaricites* colonies, B) growth rate for fragments of *Montastraea cavernosa* colonies, C) growth rate for fragments of *Orbicella faveolata* colonies, D) growth rate for fragments of *Pseudodiploria strigosa* colonies, E) growth rate for fragments of *Siderastrea siderea* colonies, and F) growth rate for fragments of *Stephanocoenia intersepta* colonies.

3.4. Task 4: Upgrade of seawater mixing and distribution system

Initial contracting delays were resolved; the delivery of RO/DI system has been scheduled for early July and final installation will be completed by 8/31/23. Ed Seidel of Tenji, Inc. visited NSU in May 2023 to finalize layout of system upgrades and installation plan.

4. DISCUSSION

The mission of the NSU Onshore Coral nursery is to serve as a multipurpose, *ex-situ* onshore coral nursery dedicated to support the preservation and restoration of the Florida

reef tract. The nursery is 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 maintenance animals. The nursery provides a biosecure space for the care of new colonies, diseased/agitated colonies, and fragment grow-out. This facilitates not only our own specified goals but also other labs such as Dr. Gilliam (NSU), Dr. Walker (NSU), and Dr. Figueiredo (NSU). Additionally, we also provide essential support to government agencies such as the Army Core of Engineers & Florida Fish & Wildlife (FWC), taking in coral from environmental contractors when corals moved for mitigation cannot be immediately transplanted. Going forward, our focus continues to be the care and maintenance for the endemic corals in our systems and support for ongoing coral transfer activities, including acclimation of incoming corals to nursery conditions, and preparation and packaging of corals, direct transportation from collection to other project partners when needed, and short-term housing for corals that are pending transplantation. We 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.

The nursery husbandry team maintains inter-organization and public communication activities, including 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 utilize the SEACOR system as quarantine space for maintenance animals (Such as sea urchins, shrimps, snails, etc.) that can be distributed to other coral rescue facilities.

The onshore nursery currently holds 4,684 corals in total: 337 colonies and 4,347 fragments. A total of 2,093 corals have been outplanted from the onshore nursery systems since the start of 2023, more than double our target number. Additional corals of opportunity are continually added to the coral nursery stock and 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.