Southeast Florida Coral Reef Initiative (SEFCRI)
Technical Advisory Committee (TAC) Meeting

November 3-4, 2021

Meeting Objectives

1. Update the TAC members on Stony Coral Tissue Loss Disease (SCTLD) status and current research related to environmental cofactors and transmission.
2. Convey status of ongoing and future Coral Protection and Restoration (CPR) grant projects and relevant Local Action Strategy (LAS) projects.
3. Introduce new Coral Reef Conservation Program (CRCP) staff and new SEFCRI Team members.
4. Present new Turbidity research and water quality connections between southeast Florida and the Keys.
5. Hear about and have TAC members provide feedback on updated decision support tools for southeast Florida.

Attendance

Staff

Name	Affiliation	November 3, 2021	November 4, 2021
Alycia Shatters	DEP CRCP	X	X
Mollie Sinnott	DEP CRCP	X	X
Kristi Kerrigan	DEP CRCP	X	X
Jamie Monty	DEP ORCP	X	X
Patrick Connelly	DEP CRCP	X	X
Katie Lizza	DEP CRCP	X	X
Tyler Momminy	DEP CRCP	X	X
Rachel Skubel	DEP CRCP	X	X
Jenn Coley	DEP CRCP	X	X
Jessica Price	DEP CRCP	X	X
Taylor Tucker	DEP CRCP	X	X
Cassie VanWynen	NSU	X	X

TAC Members

Name	Affiliation	November 3, 2021	November 4, 2021
Erick Ault	FWC FWRI	X	X
Ken Banks		X	
Don Berhinger	UF	X	X
Richard Dodge	NSU	X	X
Phil Dustan	College of Charleston SC	X	X
John Fauth	UCF		
Piero Gardinali	FIU Institute of Environment	X	X
Dave Gilliam	NSU	X	X
Lew Gramer	NOAA AOML		
Kurtis Gregg	NMFS	X	X
Dale Griffin	USGS		
Jay Grove	NOAA Fisheries	X	
Judy Lang	AGRRA	X	

Joe Lopez	NSU	X	X
Caitlin Lustic	TNC	X	X
Arthur Mariano	UM RSMAS		
Valerie Paul	Smithsonian Marine Station	X	X
Esther Peters	George Mason University	X	X
Stephanie Schopmeyer	FWC FWRI	X	X
Xaymara Serrano	NMFS	X	X
Manoj Shivlani	University of Miami	X	X
Jack Stamates		X	X
Joshua Voss	FAU Harbor Branch	X	X
Brian Walker	NSU	X	X
Dana Wusinich-Mendez	NOAA CRCP	X	X

Public Attendees

Name	**Affiliation**	**November 3, 2021**	**November 4, 2021**
Alastair Harborne	FIU	X	
Amy Hirons	NSU	X	
Andrew Brandea		X	
Carolin Ciarlariello	DEP OGC	X	X
Christine Hurley	Cummins Cederberg	X	X
Dave Whitall	NOAA NCCOS	X	X
David Vance	FOFR, SEFCRI, Reef Discovery Center	X	
Derek Cox	FWC	X	X
Dimitri Giarikos	NSU	X	X
Dinorah Chacin	NOAA	X	
Emily Dark	DEP IRL AP	X	X
Emily Surmont	DEP IRL AP	X	
Erin Carroll		X	
Greta Aeby	University of Hawaii	X	
Irene Arpayoglou	DEP IRL AP	X	
Jessica Miles	PBC State College	X	
Joanna Walczak	DEP CPR	X	
Jocelyn Karazsia	NMFS	X	
Joey Massa	Callaway Environmental Services	X	X
Kaitlyn …		X	X
Karen Bohnsack	NOAA FKNMS	X	X
Katelyn Armstrong	PBC Reefs	X	
Kirk Dotson	FOFR	X	X
Kirk Fusco	DEP RCP	X	
Laura White		X	
Luke McEachron	FWC FWRI	X	
Maurizio Martinelli	SEAGRANT	X	

Melissa Sathe	FOFR, Coastal Eco-Group Inc.	X	X
Michael Studivan	UM-CIMAS, NOAA-AOML	X	
Natalie Geyer		X	
Nick Jones	NSU	X	
Nicole Sharp	APTIM	X	X
Richard Flamm	FWC FWRI	X	X
Sara Thanner	Miami Dade County DERM	X	
Sarah Noble	DEP DEAR	X	X
Victoria Barker	National Coral Reef Management Fellow	X	
Vladimir Kosmynin	DEP BIPP	X	X
Francesca Fourney	Cummins Cederberg		X
Kathy Fitzpatrick	Martin County		X

Day 1: November 3rd, 2021

Announcements

- Thank you to Friends of Our Coral Reefs for assisting with this meeting
- Introduction of new TAC member – Xaymara Serrano (NMFS, Habitat Division in WPB)

Session I: SCTLD Overview

Update on Stony Coral Tissue Loss Disease (SCTLD) Response – Victoria Barker (NOAA – National Coral Reef Management Fellow)

Current SCTLD Extent

Stony Coral Tissue Loss Disease (SCTLD) is a major disease effecting coral reefs in Florida. It has been observed to effect about half of the species on the reef with high rates of mortality and a high infection rate. It usually affects 2/3 to 100% of susceptible species here in Florida. This disease was first observed in 2014 off the coast of Miami and has spread north and south along the Florida Reef Tract. It has now been observed through the entirety of the Florida Reef Track, including the Dry Tortugas National Park and the Tortugas Ecological Reserve (as of spring 2021). SCTLD has been reported across the Caribbean in 19 different countries/territories/other jurisdictions, including the most recent report in St. Barts. Given the size of the outbreak, we have an increasingly large number of partners who are joining us, including 60-70 state, federal, and local governments, university, and NGOs across Florida.

Research Updates

1. Bacteria and viruses
   We suspect bacteria may be a primary vector because antibiotics has proven to be effective at slowing or stopping lesion progression. New studies suggest both bacteria and viruses have roles in SCLTD, where multiple or co-infections may be occurring, or potentially an opportunistic infection of the symbiont may occur first, with the host cellular destruction occurring later. Studies are underway to characterize the viruses involved and their impact, if there is an impact at all.
2. Algal Symbionts
   Algal symbionts may be the key to understanding SCTLD. Symbionts appear to be infected first within the chloroplasts of the algae, and different species are more resistant than others. Our partners at UM were looking at how algal clades varied in susceptibility, and found that clade D

may be more resistant, while clade B is more susceptible. All the clades are susceptible (none have 100% resistance), and infection can't be ruled out just by looking at the symbiont.

3. Transmission
   Along Florida, currents are likely to spread the disease from reef to reef (from models on smaller spatial scales), but large-scale transmission is likely from human activities. There is no identifiable pattern based on currents alone, and so we are exploring via various partnerships transmission across different scales, including ballast water, sediment transfer, and biofilms as vectors.
4. Environmental Factors
   Generally speaking, we know that sediment is a coral stressor, and we suspect that it may be transporting the SCTLD pathogen(s). Nutrients and large water discharge may also increase disease by decreasing ecosystem and organismal health. Advanced statistical modeling from the Walker and Williams labs has been used to identify possible environmental correlates to coral disease hotspots, both temporally and spatially. For temporal variations, higher coral disease incidence occurred where there were higher water flow rates from inlets over the previous 7 days (>5000 cubic feet/second). For spatial variations, higher coral disease incidence occurred where >7000 septic tanks were found within 21 km, on colonies with <60% live tissue, and in shallower water depths. These are areas we are continuing to explore and have direct management applications for mitigation.

Coral Rescue Progress

This was led by a number of partners, including FWC in partnership with the Association of Zoos and Aquariums (AZA). Researchers collected healthy colonies ahead of the disease margin from the Lower Keys and the Dry Tortugas region, including 1930 corals of 20 high priority species. These colonies are being housed in 24 facilities across 12 states. Some of these corals have been used in outreach with our AZA partners to reach an audience who may have never seen a coral. One of the major goals of this project is genetic marker development for the coral species in holding. Two panels of genetic marker development are also being conducted. Panel 1 had 6 species, with 5 having completed genetic marker development and every colony has been genotyped. We can confidently say we have 50 unique individuals for each of 5 species. Panel 2 is in progress with an additional 5 species. Colonies were also collected as part of endemic zone collections, including both opportunistic collections and targeted collections for species that we need more of. Our partners holding corals span the country, and these corals will be used for propagation and brood stock to breed the next generation of corals that will then be put back out onto Florida's Coral Reef.

Restoration Studies

There are two projects underway focused on restoration. Project 1 is focused on determining what, where, and when we can restore disease susceptible species as the largest coordinated restoration trial underway. Over 6000 corals have been outplanted to develop restoration strategies and a network of connected sites, with the majority of coral having known genotypes. This will also assist in conducting meaningful ecosystem restoration by establishing a network of connected sites. Project 2 is looking at metrics and methods that will enhance outplant survival. The proposal will explore methods for maximizing nursery survival, conditioning outplanting, and predation minimization, and is in the soliciting funding stage.

DTRO Intervention Cruise

SCTLD was first observed in the Dry Tortugas (DRTO) in May 2021. The Dry Tortugas is a very important area, as the gametes from this area will seed a large portion of the rest of Florida reefs. A one-week intervention cruise, funded by NFWF and NOAA CRCP, included 2 teams led by Dr. Karen Neely (NSU) and Dr. Josh Voss (FAU HBOI). On 265 dives along Bird Key Reef, researchers were able to treat 27 different species for an estimated total live tissue area of ~780,000 sq meters. They treated 6,038 coral

every 3 minutes. The park service staff are currently taking over the sites and conducting further intervention as required, with hopes for another cruise in the future.

Questions/Comments

- Manoj Shivlani: Will this presentation be made available online?
    - Allie Shatters: Yes, a pdf of the presentations will be made available for those interested after the meeting.
- Judy Lang: Tori mentioned that last week's list of affected areas was already obsolete, and I have just learned that it has been updated for St. Barth's (attached updated screenshot of Caribbean SCTLD progression to chat)
- Josh Voss: Clarification: a coral was treated every 3 mins.
- JV: We've collected samples from two projects to assess antibiotic resistant but have not yet successfully identified funding to run these samples. To answer Esther Peters, samples were not collected during the DTRO mission, ours are from SE Florida.

Session II: CPR/CRCP and SEFCRI Team Updates

Restoring Resilience of Florida's Coral Reef – Joanna Walczak (DEP CPR)

Background

The Coral Protection and Restoration (CPR) Program has 3 main goals:

1. Guide national coral reef policy and unite Florida state level agencies to ensure effective state-wide coral reef-related authorities, policies, and procedures.
2. Provide leadership for SCTLD for response, restoration of Florida's Coral Reef, and regional water quality priorities with a focus on Biscayne Bay.
3. Effectively administer state funding for Florida's Coral Reef priorities.

National Policy

The US Coral Reef Task Force is the only federal body that deals with national policy about coral reefs and is all the federal agencies and jurisdictions meeting 2 times a year. The US All Island Coral Reef Committee meets separately to communicate with one voice as effectively as we can, recognizing that some island jurisdictions have the same challenges as larger states like Florida and Hawaii. Through the Coral Reef Task Force, we are working to:

- Update the framework for action (2021-2025)
- Include new Disease Response and Restoration working groups. While the focus for the Disease Response group is on SCTLD, there are hopes to broaden this later. This could include ballast water research and BMPs. While a complimentary group, the Coral Disease and Health Consortium, is already in place with a focus on the science, this new working group focuses on the management side of the response. A restoration working group will also be established to address the need to restore at the ecosystem level. At the national level, this group would look at what we can do to address any roadblocks with federal issues. This can include sustainable funding through coral reef insurance. There will be a webinar to look at the feasibility of creating insurance policies to trigger funding for restoring the reef after storm events. These working groups will also look into getting FEMA to define coral reefs as a natural infrastructure, which would allow us to tap into major funding sources to build up the natural systems and their benefits.
- Conduct an EPA coral reef stressor literature review. This task is focused on giving guidance to the jurisdictions, as the current EPA guidelines were not created with corals in mind. The first

step is to figure out the playing field, then focus on the most important priorities for coral specific standards, based on the literature review.

Long Term Goals

In the short term, the CPR is focused on enhancing management and response capacity. In the long term, focus is on reducing local stressors and restoring environmental conditions to improve reef resilience. Long term projects include:

- Developing a resilience action plan for Florida's Coral Reef. This will include participation in Florida's Reef Resilience Programs. While the focus has been on climate issues, we can't ignore all of the other things out there, so we have developed a Resilience Action plan for Florida's Coral Reef. There are 3 goals for this action plan:
    1. Enable resilience-based management of Florida's Coral Reef.
    2. Support public policy that creates the enabling conditions for reef recovery.
    3. Enable stakeholders to support the future of the reef and those who depend on it by bringing in residents and tourists.

  Please visit www.FRRP.org for more information. A subset of these goals includes several management goals as well, such as:
    a. Supporting the passage of Restoring Resilient Reefs Act (S46/HR160), which is the reauthorization of the only Coral Reef Conservation Act in the U.S., providing increased tools and funding for managers and NOAA.
    b. Supporting the connection of Everglades Restoration and unifying our messaging with Florida's Coral Reef efforts - reconnecting these national ecosystems to show how Florida is a global leader in restoration.
    c. Finalizing reef restoration strategy and securing seed funding to jumpstart Florida's 'coral restoration economy'. This strategy would look at the large-scale ecosystem level across the Florida reef and what goals and objectives we want to include in place-based management plans that roll up to the large ecosystem level goals. We also recognize that we need an interconnected network of larvally connected restoration sites, so our goal is to have a workshop on the genetic connectivity of coral and if we can establish criteria for site selection to create a network of sites to help reseed and repopulate the reef.
    d. Supporting increased funding through EPA's South Geographic Initiative. This is the primary funding though the EPA, and we think this is an opportunity to get some water quality specific funding to address bigger issues.
    e. Continuing to support stakeholder engagement and update management plans, ensuring stakeholders have a voice in management.
- Water Quality (WQ)

  There are several goals for this project, including:
    1. Unifying the network of Reef WQ Monitoring Programs. We've funded Phase 1 to look across all the programs that collect WQ across the reef to look at opportunities to stitch these datasets together, spatially and temporally, to look at regional differences and make management decisions.
    2. Inform regional and local management.
    3. Research reef related WQ indicators and standards, in order to develop comparable information for standards.
    4. Implementing and tracking the success of management actions to reduce land-based pollution sources.

FY 20-21 and 21-22 Funding
We've continued to support the efforts that Tori mentioned, in particular opportunities to build partnerships and bringing together cross discipline institutions.

FY 20-21 funding supported (1) Resilient Coastlines and Waste funding and (2) a new Coral Protection and Restoration grant. (1) The Resilient Coastlines and Waste funding is used for mitigating the impacts of coral disease through research, intervention, propagation infrastructure, and restoration trials. This includes building partnerships and bringing together cross discipline institutions, like the SCLTD Resistance Research Consortium. Regional offshore water quality monitoring will continue to establish baseline data for northern reefs. (2) Last year was the first time we had the new Coral Protection and Restoration Grant, with a large portion going toward Miami-Dade County for reducing pollutants in Biscayne Bay, as this area is the heart of Florida's Coral Reefs where water is traveling north and south. This includes septic to sewer conversions, stormwater infrastructure upgrades using innovative technology, and water quality monitoring and modeling. Some of the money also went toward applied research with our partners, including the University of Miami's (UM) collaboration efforts though the Southeast Florida Coral Restoration Hub, the Boy Scouts of America's Florida Sea Base Coral Restoration STEM program, and research and the growing of disease resistant coral at Mote Marine Laboratory in partnership with UM.

FY 21-22 funding is allotted for (1) Phase 2 of the Restoration Trials as part of the Resilient Coastlines and Waste funding and (2) a New Biscayne Bay Water Quality Improvement Grant. (1) Current fund use is stated above for FY 20-21, with plans to continue regional offshore water quality monitoring for northern reefs in FY 21-22. (2) The new Biscayne Bay Water Quality Improvement Grant funds will support local government and non-state entities. We haven't awarded these projects yet but will likely closely align with the Biscayne Bay task force recommendations - conducting septic to sewer conversions, conducting water quality monitoring and modeling, and upgrading stormwater infrastructure.

Florida's Coral Reef Campaign
This is intended to be a collective umbrella campaign. The one-stop-shop that will point to other websites and will highlight all the partnerships and community involved in Florida's Coral Reef Campaign. Please visit FloridasCoralReef.org for more information.

Questions/Comments

- Brian Walker: It will be important to understand when those pollutant reductions come online so their potential effects can be evaluated in the field.

SEFCRI Team and CRCP updates – Kristi Kerrigan (DEP CRCP)

Staff Update – members and titles

Kristi Kerrigan – CRCP Manager and SEFCRI Chair
Mollie Sinnott – promoted to Assistant Manager, continuing as RIPR
Jessica Price – RIPR Technician
Taylor Tucker – RIPR Specialist
Tyler Mominey – Associate Coordinator
Katie Lizza – Fishing, Diving, and Other Uses Coordinator
Patrick Connelly – Marine Industry and Coastal Construction Impacts Coordinator
Allie Shatters – Land-Based Sources of Pollution Coordinator
Rachel Skubel – Awareness and Appreciation Coordinator
Jaime Monty – SE Regional Administrator
Alex Reed – RCP Director

Vacant Reef Resilience Coordinator position

Coral ECA
The Coral Ecosystem Conservation Area (Coral ECA) was established in 2018 under 253.90 F.S. In 2021, the Coral ECA region was renamed the Kristin Jacobs Coral Reef Ecosystem Conservation Area. This includes all the sovereign submerged lands and state waters offshore of Martin, Broward, Palm Beach, and Miami-Dade counties. Signage at marinas and boat ramps in the counties along the ECA will also be updated as part of the new bill.

FDOU 55: Coral ECA Management Plan
A plan is being developed for the Coral ECA for review and approval, following the template of aquatic preserves along with modeling elements from Pennecamp State Park and the Keys National Sanctuary management plans. The University of Miami (UM) was hired to complete a draft by June 2021, followed by an internal review from the CRCP and FWC in July 2021-Septemember 2022, which will incorporate results from the projects under FDOU 51 and 52 into the management plan. The SEFCRI Team and TAC will then review the plan in the Fall of 2022, whose input and comments will be incorporated into the next draft. An Advisory Committee will be formed in the Spring of 2023. Advisory committee meetings will be scheduled, and a final draft will be uploaded for Advisory committee to review. The Advisory Committee will review the final draft in Fall of 2023, and further evaluation and comments will be incorporated. After hiring of public meeting facilitators toward the end of 2023, a public review will be conducted in the Summer of 2024 for further comments. The final management plan aims to be completed by June 2024, with public outreach and engagement throughout the process.

SEFCRI Items
A new Local Action Strategy (LAS) project status tracker is available at https://southeastfloridareefs.net/las-project-status. It is organized by focus area and project completion status and includes a description of the LAS projects and a link to the final project, if applicable. We have also added a new cohort of SEFCRI team members. Members serve a 4-year term which ended in 2020. At the beginning of the year, we solicited applications for non-agency SEFCRI seats in stakeholder groups (academic, diving, fishing, NGO, and other groups). New member onboarding included the history of SEFCRI (including overview, organization, and membership), the importance of Florida's Coral Reef, the DEP Coral Reef Conservation Program, LAS projects, and engagement and participation. We are also aiming for a team meeting just after the new year, so we will be sending out a poll for date options in January/February 2022.

Questions/Comments: None

Session III: SCTLD Environmental Cofactors and Transmission

SCTLD Environmental Cofactors and Transmission – Greta Aeby (University of Hawaii)

Environment and Transmission team

Triad of Disease Causation
The triad of disease causation includes the host, environment, and the pathogen. These components make up disease ecology. Infection depends on immunity, age/condition of the host, and seasonal patterns and environmental conditions. Only under certain conditions can the host get sick, when these three components come together to merge. A lot of the research in Florida is focused on conditions related to the host, including host behavior, genetic susceptibility, and the health state. Conditions for the pathogens

include parthenogenesis, virulence, pathogen source, mode of transmission, and infectious dose. Conditions for the environment include water quality, temperature, colony density, and sedimentation.

Environmental Factors Affecting Other Coral-Disease Systems

Spatial patterns in the field indicate a relationship between a stressor and coral disease prevalence, incidence, or severity. Previous research indicates that diseases such as black band disease, white syndrome (progressive tissue loss disease of unknown etiology), and growth anomalies are more prevalent/severe when sedimentation, physical damage, nutrient stress, sewage pollution, and temperature stress (hot, cold, or bleaching) occur. After getting an idea of spatial patterns in the field, we can go onto more manipulative studies looking at a single or a couple of factors in a controlled manner. Manipulative studies show different environmental factors can affect disease susceptible species or progression. These studies include problems with sedimentation, physical damage, nutrient stress, temperature stress, and hyposalinty stress (ex. after heavy rainfall) in diseases such as black band and white syndrome. The host and symbiont also affect disease resistance or resilience. There are disease and bleaching susceptible species with genetic variability in resistance and resilience to disease. The microbial community on healthy corals may shift in response to stress before disease is a problem. Zooxanthellae clades can affect bleaching and disease resistance. The health of the coral (lipid reserves) may give a coral an edge in being able to fight back. Temporal differences in disease outbreaks may also impact resistance or resilience.

Could Environmental Co-Factors be Influencing SCTLD Dynamics?

We start by looking at spatial patterns and stressors in the area. The initial outbreak in Miami-Dade was near a dredging site and followed by a summer bleaching event (Precht et al. 2016, Miller et al. 2016). This isn't cause and effect, just the relationship between where the disease emerged and other stressors in the region. Field studies show differences in prevalence and virulence among regions along the Florida Reef Tract (FRT) (Aeby et al. 2019, Sharp et al. 2020, Rippe et al. 2018), so we are seeing regional differences. Field studies also show differences in outcome from SCTLD, where the disease arrested sooner in shallow, inshore reefs (Sharp et al. 2020). The Sharp et al. (2020) study mapped out corals before the disease got there on inshore and offshore reefs of the same region in the Keys. Epidemiological models show SCTLD disease hotspots along the FRT, with deeper reefs at greater risk of disease (greater severity) (Muller et al. 2020, Fromuth & Walker et al.). Treated colonies of *Orbicella faveolata* show spatial and temporal patterns of new lesions (Walker et al. 2021). All of this combined indicates a relationship between a stressor and SCTLD occurrence. Prevalence and virulence differ among regions, suggesting that the environment may be influencing SCTLD.

Environment and SCTLD Dynamics Summary

There are four environmental factors to address with SCTLD dynamics.

1. Sedimentation
   This could be the stressor and/or mode of transmission. The origin of the outbreak occurred at dredging sites with a potentially heavy sedimentation load on coral prior to the outbreak (Miller et al. 2016). Hydrodynamic modeling suggests the pathogen is transported via mean depth currents, indicating transmission through neutrally buoyant particles (Dobbelaere et al. 2020), which are likely sediment particles. These are just hypotheses that need to be tested but suggest the sedimentation could be acting as a stressor on the coral leaving it more vulnerable to infection and/or it could be a mechanism by which the pathogen is moving between corals or reef.
2. Temperature
   This factor influence is not clear. We know temperature effects tissue loss diseases and some white syndromes. Temporal patterns of SCTLD prevalence and incidence do occur on reefs in Florida and the Caribbean, but we don't see just a temperature pattern with disease prevalence. There is no clear relationship between sea surface temperature (SST) and disease prevalence in tagged colonies (Aeby et al. 2019, Alvarez-Filip et al. 2019, Thome et al. 2020, Estrada-Saldivar

et al. 2021, Walker et al. 2021), and an epidemiological model found no relationship between disease prevalence and SST (Muller et al. 2020). In both the field and in modeling we are not seeing evidence that suggests that that is an important factor for this disease. There was a significant reduction in transmission rates under high temperatures (not stress, just warmer summer temperatures) or ocean acidification (OA) conditions compared with controls; combined high temperatures and OA conditions showed similar transmission rates compared with controls (Muller et al. 2019 –State of Florida Report).

3. Heat Stress
   Heat stress in this context refers to stress beyond what corals are used to handling. Heat stress reduces virulence on some species, and SCTLD virulence decreases through time. Field observations in Florida saw that the disease halted after bleaching or in corals in excess of 3 Degree Heating Weeks (DHW) (Neely, Muller & Bartels). The slow down in the disease coincided with seasonal bleaching, especially on inshore communities with multiple species (Sharp et al. 2020). For example, in Williams et al. (2021), research was conducted at 3 sites (offshore, mid-channel, and nearshore) with 2, 10x10m plots per site. All coral colonies were mapped, were initially disease free, and were surveyed every 2-3 weeks from May 2018 – December 2019. The disease first emerged in October 2018. They were able to show increased lesion development and high severity in regular temperatures, but lesion development and severity slowed or stopped with increased heat stress (DHW) after SCTLD first emerged. In studies from the USVI, rates of tissue loss in *Orbicella annularis* slowed, but not in *Montastraea cavernosa* following thermal stress (DHW) that lead to bleaching (Meiling et al. 2020). This indicates a species-specific response after DHW. Tagged diseased *M. cavernosa* colonies in the Lower Keys had high mortality in colonies at the onset of SCTLD, but low mortality on colonies in the second year (no heat stress) (Aeby et al. 2021).
4. Water Quality/Nutrient Stress
   Poor water quality is an issue for nearshore coral reefs in Florida. Coral-zooxanthellae symbiosis is sensitive to disruption from excess nitrogen, which stimulates cell division in zooxanthellae. This shifts the balance between nitrogen and phosphate, which results in a destabilization of zooxanthellae integrity (Wiedenmann et al. 2013) visualized at the cellular level (Rosset et al. 2017). This disruption could leave corals less resistant to environmental challenges (lower bleaching threshold) (Wiedenmann et al. 2013), which means corals in water with too much nitrate bleach faster and sooner than corals in clean water. This nutrient stress also could disrupt coral microbiomes, leaving corals more susceptible to bacterial diseases (Zaneveldet al. 2016, Wang et al. 2018).

Manipulative Studies

"Studies on environmental co-factors potentially influencing the disease dynamics of Florida's coral tissue loss diseases." Greta Aeby, Valerie Paul (Smithsonian Marine Station), Jan Landsberg, Yasu Kiryu (FWRI-FWC).

For this research 3 groups investigated healthy vs. diseased colonies for 6 weeks to determine the effect of nitrogen enrichment on zooxanthellae health. These colonies included healthy and diseased *Siderastrea siderea* from the DTRO and the Lower Keys, respectively, and SCLTD diseased *M. cavernosa* from the Lower Keys. Pieces from the same coral were placed in a control group or nitrogen enriched seawater. Zooxanthellae were measured with PAM (as a proxy for photochemical efficiency of the zooxanthellae) two times per week. The nitrate group in healthy *S. siderea* had lower efficiency 2-3 week after exposure than the control corals. For the diseased *S. siderea*, the sensor was placed on a non-lesion section and a lesion section of the coral piece. For non-lesion diseased *S. siderea* after 34 days there was a decrease in efficiency, whereas with lesion diseased tissue there was a decrease around 17 days. Diseased *M. cavernosa* showed the same pattern in non-lesion and lesion tissues between control and excess nitrogen treatments, with no response to exposure. In summary, the effect of nitrogen enrichment differs among

species; lesion and non-lesion tissue and diseased and healthy colonies in *S. siderea* differ. This may indicate a different disease state, or maybe the region where colonies were collected had different histories of exposure to excess nutrients, or there were differences in zooxanthellae clades.

The same corals and methods were used to measure disease progression. In *S. siderea* lesions were either bleaching, had purple pigmentation, or had tissue loss. In *M. cavernosa* lesions had bleaching or tissue loss. 4 out of 7 *S. siderea* colonies had no response to excess nitrate, but the response was not consistent in discoloration/bleaching/tissue loss between the treatment types. In *M. cavernosa*, excess nitrate pieces lost tissue at a faster rate than the control but with greater variability within treatment types. In summary, in *S. siderea*, nitrogen enrichment led to a decrease in zooxanthellae heath, but did not lead to any increases in disease progression. In *M. cavernosa*, nitrogen enrichment had no effect on zooxanthellae health, but did increase the rate of disease progression.

Water Quality and Nutrient Stress Project

For this project, data-driven statistical modeling was used to identify the ecological, abiotic environment, and human drivers of coral disease across scales on Florida's Coral Reef. This included two parts:

1. Part I: Southeast Florida Coral Reef Ecosystem Conservation Area (Coral ECA)
   This part focused on spatial and temporal variation in SCTLD incidence (spatial and temporal models). 51 *Orbicella* spp. colonies were mapped and treated. The area covered the Coral ECA, ~62 km from northern Broward County to Key Biscayne with a timeframe from September 2018 to April 2020. The spatial variations in disease cases used a yearly timescale across the whole area, while the temporal model was on a monthly time scale across the timeseries. The total number of novel SCTLD infections across the entire disease time series was modeled using large corals as replicates against our suite of colony morphometric, human, and abiotic predictors using distance based permutational multiple regression. This included 9 predictor variables: depth, linear size of the colony, surface area of the colony, proportion of live tissue on colony, area of live tissue on colony, nearest distance to outflow, mean total suspended solids (over 3 months prior to survey date), and number of septic tanks within 5 km and 21 km. The spatial model found that septic tanks within 21 km was a primary factor that helped explain where these corals tended to have clusters of diseased colonies. For the temporal model, almost half of the variability was explained by higher flow rates occurring from these areas. Water quality is important when predicting when and where this SCTLD is going to emerge in *Orbicella* spp.
2. Part II: Southeast Florida to Keys (DSD and TLD)
   This portion of the project was part of the Florida Reef Resilience Program and the Disturbance Response Monitoring program survey data, investigating spatial variations in disease cases of dark spot disease (DSD) in *S. siderea* and tissue-loss disease (TLD) in the other coral species. The area of interest was Southeast Florida to the Keys, yearly from 2005-2019. There were 6 core themes: human use of reefs (TNC Ocean Wealth), wastewater treatment, septic/sewer area, land use, in-situ water quality, and human population density. The environmental drivers of regional TLD and DSD were modeled to investigate hotspots and the number of cases across the entire range. For TLD, really only 10% of the variability in the data for the hotspots could explain differences in TLD, so it was not very informative except some variables did not seem important, but hotspots tended to occur in areas of poor habitat. Over half the variability in the data for number of cases could be explained by certain factors, including habitat, year, and host density, where more cases occurred after 2015. It's likely that most cases reported after 2015 may be SCTLD but were labeled as TLD before 2015. For DSD, habitat types and depth mostly explained variability in hotspots, where areas of poor habitat quality and shallower depths had greater number of hotspots. Variability in the number of cases was mostly explained by silica in surface water (which is a proxy for freshwater input), host density, and proximity to septic systems.

We see some consistency among diseases both in freshwater input and proximity to septic systems. Between tagged colonies and surveys, coastal urbanization and water management influence the number of coral disease lesions on the Florida Reef Tract at both large and small temporal and spatial scales.

Overall Summary
Sedimentation is an important co-factor and is likely a stressor and/or mechanism of pathogen transport. There is no clear relationship of SCTLD to temperature. Heat stress reduces SCTLD virulence on some species. Poor water quality reduces zooxanthellae health and increases SCTLD incidence.

Further Research Based on the Disease Triad
Research on these topics will be helpful in further understanding SCTLD incidence and transmission.

- Host: intra- and interspecific differences, is there something innate that differs between and among species, symbiotic partners (zooxanthellae and bacteria), host morphology, feeding strategy
- Pathogen: bacterial co-infections, bacterial infection, waterborne and direct contact, is it a zooxanthellae virus? What are the vectors (butterflyfish, ballast water, fireworms)?
- Environment: excess nitrogen, heat stress, sedimentation

We still have a lot of questions to be answered.

Questions/Comments

- Kirk Dotson: Could it be that the pathogen was buried within the substrate and was released into the water by the dredging activity?
    - Greta Aeby: That is a possibility that we have wondered about!
    - KG: The Miami Central outfall is located approximately 2200 m south of the Miami Harbor entrance channel on the outer reef. Was discharge from this outfall considered in the initial SCTLD work where sedimentation and heat stress were evaluated?
        i. GA: Kurtis I will have to defer that question to Gareth Williams who did the modeling.
        ii. Judith Lang: Kurtis, as you may know, in 2017 that outfall was found to have a leak within a few hundred meters of where the first sick corals were found in 2014 and that leak was soon repaired - as reported in the newspapers. But I have never heard how long it had been leaking, and if there was any chance for long enough to perhaps have a link to the initiation of SCTLD…would be a good question for someone to investigate.
        iii. BW: I think Kurtis is referring to the original SCTLD emergence and not our stats modeling of more recent data. We did not find any relationships to the proximity of outfalls to our large Orbicella lesions.

Can sediment serve as a SCTLD reservoir? – Michael Studivan (NOAA)

Goal and Background
The focus of this project is sediment spreading SCLTD (with hopes to look into whether ballast water is involved in transmission of pathogens and potential ballast water treatments). Several lab-based studies and hydrodynamic models suggest water is the primary vector for spreading SCLTD pathogens, where 25 SCTLD microbial indicator taxa have been found in corals and seawater (Becker et al. 2021). Two taxa, *Rhodobacteraceae* and *Rhizobiales*, have been found in diseased corals and sediment (Rosales et al. 2020). Our question was: can reef sediments also serve as a reservoir and vector of pathogens that may cause SCLTD at local sites?

Methods
To investigate this question, we designed and built an Experimental Reef Lab (https://www.aoml.noaa.gov/experimental-reef-lab/) apparatus for disease exposures to corals, including a

seawater manifold to provide separate seawater sources to half liter independent coral vessels in a raceway, supporting up to 160 replicates per experiment of fully randomized treatments. For the sediment exposure experiment, 3 diseased *M. cavernosa* colonies and 35 L of reef sediment samples were collected from site BC1 in Broward County. These sediment samples were autoclaved then incubated for 2 weeks in independent aquaria, with and without diseased coral colonies. We had 4 treatments: healthy sediment (not exposed to diseased corals), batch disease-inoculated sediment (exposed to three entire diseased colonies), individual disease-inoculated sediment (exposed to ~5 sq. cm disease coral fragments), and a diseased coral contact control. 150 g of sediment was dispensed into each treatment jar, which was then flushed with water for 1 hour (24x volume refresh). Once the disease contact corals showed signs of SCTLD and were removed from the experiment, the sediments from this group were used for individual exposure treatments using apparently healthy corals. We took daily observations and photos. SCTLD appearance was characterized by 4 factors: time to tissue loss (days until a lesion was visible), rate (proportion diseased by species and treatment), health status (SCTLD as confirmed with tissue histology following the experiment), and differential abundance of microbes (sequencing of sediment samples for microbial community profiling from each of the three sediment treatments).

Results

SCTLD signs were elicited in *Orbicella faveolata* within 7 days in the direct contact exposure, and corals treated with batch-inoculated sediments also elicited disease signs in about 7 days. Corals exposed to individual-inoculated sediments demonstrated appearance of tissue loss within 24 hours. Even though there was a strong temporal difference in how soon those individuals were affected following exposure to disease-inoculated sediments, the overall rates remained lower than when diseased corals were in direct contact with apparently health corals. In *M. cavernosa*, it took 2 weeks to observe first signs of tissue loss in the disease contact treatment, with a similar timescale for the batch-inoculated sediment treatment. To note, there was higher tissue loss rates in *M. cavernosa* across all disease treatments compared to *O. faveolata.* There were also differences in how tissue loss was visually occurring between species. *Orbicella faveolata* was more prone to the characteristic white, denuded skeleton lesion, while *M. cavernosa* had more subtle signs like excess mucus production, tissue loss, and tissue retraction forming on the side or undersides of the coral. Using histology, SCTLD was confirmed in all disease samples across treatments, and metrics for symbiont to vacuole ratios for control and disease treatments were established. For the sediment bacterial sequencing, PCoA demonstrated strong differences among sediment treatments, and the sediment incubation type had the largest role in shaping the microbial community. The batch-inoculated sediment treatment samples were distinct from individual-inoculated and healthy sediment samples. A differential abundance analysis was conducted on the sediment samples by associated coral condition (control [no exposure to disease], no visible signs following exposure to disease, and tissue loss), which resulted in 33 different abundant microbial genera among sediment groups, with 16 of these more abundant in the tissue loss associated sediment samples. 15 out of the 25 indicator taxa for SCTLD identified by Becker et al. (2021) were present in the sediment samples, including some *Vibrio* that were more abundant in the tissue loss samples.

Conclusions

1. Reef sediments can serve as a reservoir of potential SCTLD pathogenic microorganisms, which has direct managerial implications for mitigation of further disease spread in coastal zones. This brings to mind the Port Everglades expansion, where these kinds of projects move a lot of sediment and might result in a new flareup of the disease in South Florida. A future question for study is: can pathogen transmission risk be reduced through treatment or other actions? Maybe in how a dredge barge handles or disposes of sediments.
2. Additional factors likely affect the pathogen transmission potential from sediments. Further questions include: how long can sediments remain with potentially infectious pathogenic microorganisms? And are there species-specific interactions? We hope to follow up with some time series experiments.

3. SCLTD-indicator microbes exist in reef sediments, but is this opportunistic growth, or pathogen(s)? As of right now this is unclear, so this question has huge implications for how we can reduce and treat disease-exposed sediment.

Questions/Comments

- Valerie Paul: Can you please explain again the difference between BDS and IDS treatments?
    - MS: They come down to how the disease incubation took place. The batch disease sediment transmission was created during the initial incubation step, where we had the individual 150 L tank and put three entire diseased coral colonies in with autoclaved sediments and let it sit over 2 weeks, with a corresponding healthy sediment tank alongside that was not exposed to disease corals. Following the incubation period, sediments were homogenized and transferred into their respective jars in the transmission apparatus. The disease direct contact control was comprised of an apparently healthy coral fragment on top of apparently healthy sediment, with the disease exposure consisting of a 1x3 cm disease donor fragment cut from one of the larger parent colonies. Once those corals had lesions, we removed them from the experiment and then transferred new apparently healthy corals into those individually-inoculated sediment jars. So, the individual disease sediment treatment had independent small-scale exposures to disease from the donor fragments and the resulting experimental fragments. So that represented a treatment where we had 9 independent disease exposure attempts, but ultimately it started with apparently healthy sediment.
- Vlad Kosmynin: Was ever any signal recorded that disease started after storm, which often causes sedimentation?
    - MS: I'm not clear which storm you're referring to…but I do want to mention that its possible sediment is serving in 2 roles here: as a passive reservoir as residence for the pathogens associated with disease, or as a potential vector both in the transport of sediment to new regions and in causing wounds to corals though sand scouring as a result of storm events or dredging activities. And while our experiment didn't directly test the vector mode of transmission, it is something we would like to look into.
    - VK: any storm, not a specific event.
    - MS: I'm not sure following a storm, I think the some of the groups tracking disease prevalence though time would perhaps have more insight into that question.
    - VK: I think the source of sediments is the key.
    - MS: I agree, and I think there is more investigation that needs to be done.
    - VK: We observed that sediments can cause an injury on coral, and disease starts from this injury later.
    - MS: I agree that synergistic effects could likely play a role with sediments, we're thinking of a way to modify our experimental apparatus to resuspend and deliver sediments to corals!
- VP: Healthy sediment had no healthy coral in it?
    - MS: We made the decisions to not include healthy coral into it because it was hard to find any apparently healthy corals at the time when we conducted the experiment. We were wary to conduct any field collections given that we can't confirm disease status unfortunately.
- Piero Gardinali: Was sequencing done in the sediment microbial populations just after their contamination with the affected corals?
    - MS: Yes, it was a late breaking addition to the experiment. In retrospect I wish that we had some initial sediment samples including some sediment samples from the field. But recognizing that limitation in some of our more recent transmission work, we conducted small scale sampling effort in the field where we took some samples from a coral that

was being harvested for an experiment as well as a linear transect of sediment samples out from the coral. We are hoping that we can get some in situ data for comparison there.

- BW: On a lighter note, EPA provided funding to shut it down: https://www.miamiherald.com/news/local/environment/article244764512.html
  - BW: There's a plan too: https://www.epa.gov/wifia/miami-dade-county-ocean-outfall-discharge-reduction-and-resiliency-enhancement-project
- From Joe Lopez: Did you use the basic universal 16S primers?
  - MS: Yes we did.
- Miles J: In some areas there is dredging, but there are also some recent activities that are involving purchased sand from mines that are being used for renourishment.

Session III cont: SCTLD Environmental Cofactors and Transmission

Analysis of Sediments from Port Everglades Inlet (PEI) for Microbiome Characterization, Phase II- Joe Lopez (NSU)

Project CRCP 13 follow-up on results from once-a-year sampling.

Research Questions

1. What kinds of microbes are in the seawater or marine sediments?
   Here the focus is on un-culturable microbes and using genetics as a tool without having to culture. Bacteria and microbes are prevalent and universal, but most are not pathogenic, so this could be a factor of host health system and the ability to deal with changes in the environment.
2. What are the impacts of human activities on adjacent reef habitats?
3. How different are port vs. reef sediments?

Background

In South Florida, there is a growing population which will continue. Here in Broward County, there is a residency of 2 billion people with just a few outlets to the ocean. Our charge was to characterize the sediments in Port Everglades and on adjacent reefs, as there are plans to deepen the port slated in the next couple years. There are plans to mitigate and monitor activity from this dredging, along with smaller maintenance dredging that occurs every couple of years, with one that happened this year. Our data precedes this O&M regular dredging and then we plan another sampling to occur in March after the dredging. The dredge areas are derived from the June 2019 Port Everglades O&M Spillage Analysis, where you can see where regular dredging occurred. Sediment samples were collected from 18 sites in the port and 22 sites on the adjacent reef.

CRCP 13 Goals (2020-2021)

This is Phase II of this 2-year project. There are 3 goals for CRCP 13 (2020-2021):

1. Generate a comprehensive spatial profile of the microbial communities (and potential pathogens) present in PEI sediments (P) and adjacent Florida Reef Tract (R) sediments
2. Establish a database/dataset that may link environmental sediment parameters with microbiome profiles (of sediments, resuspensions, or water column)
3. Determine if any shifts in microbiome composition can be determined after routine O&M dredging

Preliminary Data Analysis

The analysis was done by a master's student (Campbell et al. 2015) in conjunction with NOAA. We were given water samples also along the reef track and adjacent PEI. This PCoA looked at the 16S data by site-type, or differences in water communities based on location/sampling. The clearest differences were those

water samples obtained near inlets, not just PEI but also Hillsboro. There were no clear differences in water communities based on seasons. The universal 16S gene is a standard for classification of microbial communities and is comprised of 9 variable regions that display enough variation to discern differences between microbes at least down to the family or genus level. Sequencing was carried out with high throughput of the V4 region of the 16S rRNA gene using the Illimina MiSiq (V4 has approximately 254 base pairs and is highly conserved). In 2020, 8.5 million reads were generated across all 118 samples or over 40 sites between the reef and port sites (3 replicates per site). In 2021 we generated 14 million reads across 113 samples. Some samples didn't make it through quality control, but overall, we had an even larger number of reads above the threshold for assessing saturation using the 16S data.

We put it through the standard pipeline looking at variation, relative abundance, and statistics to look at various parameters and patterns in the data. QIME2 was used for procession raw microbiome data and picking Operational Taxonomic Units (OTUs) or Amplified Sequence Variants (ASVs) of the 16S V4 fragment. From a community analysis, all samples were uploaded to the CosmosID pipeline. HT DNA sequencing revealed a rare biosphere of microbial density (Sogin et al., 2006). In general, across most habitats, a set of dominant taxa may appear followed by a long tail of less common taxa that make up that community (rare biosphere). We also took a subset of samples for nutrients (nitrogen, phosphorus, total carbon, 22 trace metals) and chemicals that were analyzed by FIU. Reef sites were close to the port but span across the various depth of the reef and sites also span within the port. Sites P13, P16, and P17 (all in the port) had higher relative abundance of Archaea and Chloroflexi in 2021 (after dredging) relative to 2020.

Results - 16S Data

There was a significant change in 2021 port samples. Alpha diversity is looking at the composition, and we see a shift in the 2021 port dataset. Overall, 1400 species were counted in 2021, with 2600 identified to the genus level. Rosales et al. (2020) found the common presence of Rhodobacterales and Rhizobiales which may be sources of SCTLD. Their abundances vary depending on the site and they were found in the port and reef samples, so may be part of natural flora of sediments. Using the combined 2020 and 2021 datasets, we identified the most abundant 20-30 taxa at the family level as shown on these heat maps, where the Gamma proteobacteria and Desulfobacteriocaeae were common bacteria. The Desulfobacteriocaeae is typically and anerobic sulfate reducing bacteria associated with sludge, which analysis indicated was significantly different and occurs more at the port. Other port enriched orders included a few orders and higher Archaea occurring at sites P13, P16, and P17 the more southern areas of the port. Port sites had 4-5x more fecal bacterial indicating groups. This data is available as a report if you want to see the specific groups identified. The order Desulfobacteriocaeae was also more common in port sites compared to reef sites. Hoc36 was also present on both reef and port sites, which has been previously found in hypersaline soda lakes with a high soluble carbonate alkalinity. At the phylum level, the Proteobacterial were dominant, followed by the Planctomycetes, which were present at both the port and reef sites. The Planctomycetes have a group of pathogenic bacteria. We also look at what could potentially be pathogenic to humans as well, so identified Planctomycetes, Vibrio, etc. are also present in some of this data. There were profile changes between 2020 and 2021 at both the port and reef sites. At the order level, there was a difference in Anaeorlineales between port and reef sites. At the family level, dominant family included Planctomycetaceae, Anaerolinaeaceae, and Desulfobacteriocaeae.

Beta Diversity

This is for the 2021 dataset, analyzed with a NMDS to see if things cluster. There were clear differences in bimodality between port and reef sites, with port sites grouping into 2 groups and reef sites were clustered together. Sites in the middle group (P4-P8) were inlet channel sites, so there is a possible mixing or moving of sediment. In 2020, reef sites clustered in 2 distinct groups, and both were different from the port sites. This shows a shift or change in one year to 2021. When comparing based on depth, that didn't change the overall pattern of having both port and reef communities that were distinct. For the combined

datasets (2020 and 2021), port sites clustered together with a slight partition of 2021, and reef sites clustered together with a slight partition of 2020 reef sites, clearly distinct in their microbial community. This may be driven by just a few large taxa which could be partitioning the sites.

Canonical Correspondence Analysis (CCA) with Respect to Heavy Metal Chemical Analysis
We can superimpose the chemical metadata onto the NMDS with a Canonical Correspondence Analysis (CCA) with respect to heavy metals (cadmium, copper, zinc, mercury, etc.). This shows the partitioning based on the trace metals on the communities. This used a subset of reef and port site sediment samples, 9 port sites and 6 reef sites. In 2021, the port and reef sites clustered apart from one another based on the trace elements compared to 2020, where we saw the same correlation of trace metals to the port sites with lesser correlation to reef sites. From the 2021 trace elements profile, sites P2, P9 and P16 had higher levels of copper, zinc, and mercury. Cadmium didn't show any differences for either year.

Conclusions
We see the same patterns of port and reef sites being partitioned according to their microbial communities. Significant differences appear between sediment microbes in the port and adjacent reef based on 16S amplicon profiles, although similar taxa occur at both site types. This is interesting as these are adjacent and proximal sites with some tidal movement between them, but overall it is one inlet, so there may not be enough flushing of materials/contaminants. Some bacterial taxa identified have the potential to be pathogenic but are not highly abundant and appear in both port and reef habitats. Recent O&M dredging has the potential to shift communities with the potential for the dispersion of microbes in the water column. Deeper metagenomic sequencing of selected samples could provide more information on the functions of the microbes identified. This is just one gene being looked at, and we've carried out some deeper metagenomic sequencing upstream at our Lake Okeechobee project looking at freshwater microbial communities. We get much more information to the function of microbial communities and correlating that to the presence/absence of specific taxa. The best-case scenario in the end would be based on what we do, would we be able to see in 10, 20 years no difference between the port and the reef based on remediation. Some effects are there, we can't pinpoint what they are, but manmade effects have made the partitioning of microbe communities possible, and we should consider what would happened with dredging.

This report is available at the FDEP website: https://floridadep.gov/rcp/coral/content/dep-coral-reef-conservation-program-projects

Questions/Comments

- Phil Dustan: Do you have any data from reef sites in oligotrophic waters away from centers of human populations - like the eastern edge of the Bahamas as controls?
    - JL: That would be great to get. We have samples that haven't been looked at yet, we have sediments. Water is harder to get because you have to filter that on the spot but we can start with the sediment data as a proxy. We have some filtered samples too, it's just a matter of finding funding and designing a study to make the right comparison.
- BW: Interesting that the 2020 reef sites are much more dispersed that the 2021. Any insights on that?
    - JL: On the reef, there's just more ability to move and be affected by currents and storm. What's in the port is likely to stay in the port unless there is some event, so I think the reef sites are more versatile, or likely more subject to natural perturbations.
- BW: Are those heavy metals released and dispersed during dredging?
    - JL: These are trace, so if they are in the sediments, we can likely detect them. What they would do downstream or in the water column I'm not sure what would happen and how they would affect the community. They are going to land somewhere though.

- Dimitri Giarikos: Found any correlation with trace metals?
    - JL: The CCA graph shows that most of port samples were correlated to the presence of trace metals. Now I didn't look at each one, but it looks like most of those had some correlation with the presence of the port microbes.

Potential Environmental Impact from Elemental contaminants found in Port Everglades, Florida U.S. – Dimitri Giarikos & Amy Hirons (NSU)

Background and Research Questions

This came about when talking with Amy Hirons about the Port Everglades dredging project and potential impacts from trace metals as part of that process, especially since the reef is only about 1-1.5 miles away from the port. We teamed up with a geologist, Paul Baldauf at NSU, with the USGS, specifically Andre Daniels, and our graduate student Laura White. The port, inlet, and turning basin were previously call Bay Mabel Harbor from the photo in 1933. In 2019, over 4,000 vessels arrived in the port, bringing in $32 billion in business activity. This is an extremely active and an economically important port to South Florida. So, to find out more about the dredging project, we looked at a draft supplement environmental impact statement (DEIS) from the US Core of Engineers for the Port Everglades dredging project which includes multiple phases. Phase III includes widening and deepening of the channel and dredging of the material to an ocean site located 3.9 miles away from the port. Again, this is a draft, so this site isn't completed yet, but will involve ~257 football fields of dredged material being placed at this area. This disposal site is located away from the outer coral reef area ~1.08 to 1.19 miles away from the reef. The draft statement had to determine the direct impact to the coral, which includes an area of ~29 acres of corals that will be dredged. The indirect impact from sedimentation could influence ~129 acres of coral. Proposed mitigation for this includes reef enhancement through new artificial reef.

Our research questions here are focused on the possible contaminants in the sediment: can they be remobilized, and will they create issues/damage to the coral reef? Our research topics include:

1. Assessing the element concentrations in port sediment over the past century by taking core samples. Core samples will be about 2 m in length, assuming a sedimentation rate of ~1cm/year, and determine different concentrations of trace metals.
2. Compare element concentrations in the port to a control site with limited access/activity to the intracoastal waterway (West Lake) using core samples.
3. Compare element concentration in Port Everglades to surface sediment from the first coral reef tract (N and S of the inlet). All of this is permitted.

Methods

5 factors were compared in the core samples:

1. Threshold effect level (TEL) – at this level or above, a toxic response starts to be observed in benthic organisms
2. Probable effect level (PEL) – where a large percent of benthic population shows a toxic response
3. Geo-accumulation index – verifies the magnitude of contamination of an individual element
4. Potential ecological risk (PER) – considers the cumulative impact of all the elements to the ecological environment, taking into account the different background values of the geography
5. Continental crust (background) – elemental composition (ppm) of the present continental crust as we know it

Core collection occurred in July 2019. Locations included 4 sites in the port (Park HQ, Park Education Center, South Turning Basin, and Dania Cutoff Canal), 1 control (West Lake), 1 North reef and 1 South reef site with 2-3 cores collected per site. The reef cores had 5 cm of top sediment samples collected rather than a larger core due to the density of the reef substrate. Cores were cut longitudinally after

collection at the USGS facility. Visual differences were observed in the cores, and the cores were not same length. The cores contain organic material, and so they are currently being analyzed for organic carbon.

A subsample (1 cm cube) of the sediment in each core was taken at 5 cm intervals along the entire length of the core for a total of 302 sediment samples. Each sample was washed 3 times with ultrapure deionized water (18.2 megohm). These were then pre-dried overnight in a drying oven for 18 hours and then in a vacuum oven for 5 hours, both at 80 deg. C for future processing. The dry weight of each sample was recorded and the EPA method 3050B was then used to digest the samples properly. Inductively Coupled Plasma-Mass Spectrometry analysis for heavy metals was performed using an ThermoFisher Element XR ICP-MS at the University of Southern Mississippi for 14 elements: Arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), molybdenum (Mo), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), tin (Sn), vanadium (V), and zinc (Zn).

Results

Total core samples included 10 from the port sites, 2 from the control (West Lake), and 3 top sediment samples from both the North and South reef sites.

The following compares results from the port (South turning Basin core 1 at 75 cm in length) sites and the West Lake (control) site core (90 cm in length). PEL levels in Cu and As were high in the port site. TEL levels in Zn, Cu, and As were higher in the Port Everglades site compared to West Lake. Molybdenum was higher in the port, with values above background continental crust levels and compared to West Lake. Molybdenum does not have a TEL or PEL value, as no one has looked at it to see if it toxic to organisms. Arsenic was above background levels in every core and has levels above TEL and PEL which is considered toxic. Copper and Zn have spikes in levels closer to the surface sediment. There were also spikes in Sn and Cd above background values. For PER levels, low risk sites included the reef sites and the control site at West Lake, with some low impact at the Park Education Center site. The rest of the sites (port sites) have high to significantly high totals, which is a concern if during the dredging process some of the sediment is distributed to the reef track or if sediments are remobilized at the disposal site. The geo-accumulation index also indicated high contamination of Mo and As in the port sites, with moderate indices at the control and reef sites. A cluster analysis (NMDS) revealed the Mo and As correlated well together, with the highest level of contaminant in the cores. Tin also clustered near Mo and As; it did not directly correlate, but had some contamination in the cores. Copper and Pb are correlated, with spikes but not an overall contamination in all the cores.

When comparing coral reef site levels from the surface sediments, there was none to moderate risk at the reef sites, with moderate As at the North reef site. There was also a high Cu concentration spike at the South reef site for one sediment sample, but not in the rest.

Major concerns with the draft statement include sediment accumulation causing problems for the coral reefs. From reading the statement, it doesn't seem the statement really addresses the possible remobilization of elemental contaminants from the dredged sediments. Arsenic is a big concern that could cause big impacts. Mo is also high, but little is known about the harmful effect on corals, if any. Copper, Zn, Hg, Cd, Pb, and Sn spikes in the cores may also cause issues if the sediment is remobilized. There was a 5-year difference in these samples than from samples collected in 2014 by the USACE. The USACE may be just surface sediments verses core samples. Ranges of values for some elements in 2019 have much higher highs than in 2014, and they go into the TEL and PEL values. For As, the mean levels in all the cores in 2019 were above TEL values except at the reef sites. For Cu, some sites have spikes in in the mean concentration in three cores, but not for West Lake or the reef sites. For Mo, pretty much every core except for the West Lake and reefs sites have way above the background mean values.

Continuing Analysis
Continuing analysis is being conducted by Dr. Kevin M. Yeager (University of Kentucky) who is an expert in sedimentology. This includes high resolution core descriptions and sectioning, bulk density/porosity/POC, and sediment texture (grain sizes). We think the POC values will help us understand how the sediment accumulate these trace metals. Many elements get trapped in organic material, and at a much higher rate than in other sediment types. Radiochemistry with Gamma spectrometry (^{137}Cs) and Alpha spectrometry (^{210} Pb via ^{210}Po) is also being conducted. Current progress has been made on Gamma and Alpha spectrometry, sediment grain sizes to 30 cm, and POC. Preliminary data for the core sample at the Park Education Center 2 (PEC 2) site shows the sediment rate of 0.03 cm/year at this site. This rate indicates that the upper 4-5 cm of the core represents ~133 years of sediment deposition. We were very surprised by this. Most of the first 5-10 cm has the highest concentrations of heavy metals found, included large concentrations of Cu and Zn.

Future Work
Future work includes:

- Determining sedimentation rates, sediment type, and organic composition of current cores to complement the elemental contaminant assessment.
- Analyze the current cores for a suite of pertinent persistent organic pollutants: PCBs (pesticides, can cause serious health risks), PBDEs (flame retardants, can cause neurotoxicity and cancer), and PAHs (petroleum, can cause kidney and liver damage).
- Deploying sediment traps and turbidity monitors at set intervals along the reef tracts (north and south of the inlet) to assess current sediment distribution and contaminant load (including elements and POPs) prior to and during scheduled dredging.
- Deploying acoustic doppler current profilers (ADCP) near reef tracts to quantify current magnitude and direction.
- Determining the PEL values for Molybdenum by spiking corals in the lab. Can we determine TEL and PEL values? This is something to investigate in more detail.

Conclusions
Port Everglades sediment cores have arsenic concentrations above TEL and PEL levels, and very high Mo concentrations (above background levels). Port cores also have large spikes of Cu, Zn, Cd, Pb, Hg, and Sn. The PER in most cores is high to significantly high. The geo-accumulation Index for As and Mo in most cores is strongly to extremely contaminated, and for Sn in Dania Cutoff Canal is strongly to extremely contaminated. Current coral reef sediments have low elemental concentrations except for As and one Cu value that was rechecked. There were correlations between Mo and As, indicated anoxic conditions, sulfidic conditions prone to organic-matter accumulation (high TOC values), as well as Cu and Pb, which tends to correlate with high organic matter.

Questions/Comments

- JL: We saw higher Mo in Port vs reef too, but As was higher on the reef than port at some sites.
    - Dimitri Giarikos: For As, we saw higher concentrations at lower depth in the core (not at the top). Joe I believe you just did top sediments. Just to give you an idea, Arsenic and Mo tend to accumulate in more anoxic conditions, so may be found lower in core.
    - JL: Right we just did grabs at the top.
- PG: I am assuming the USGS did date the cores so we know the sedimentation rates? It does not matter much if they dredge and remove it all but it will help figure out what can be transported without dredging.

    - DG: That (the sedimentation rates) is being done now by Dr. Kevin M Yeager (University of Kentucky) for each core.
    - PD: Mo is a component of grease and other lubricants so it is not too surprising to find it in the basins where there are lots of ships and associated industry.
    - Ken Banks: Cu and Sn are in bottom paint.
    - PD: Zinc is used in automobile tires – wonder if there are tire particles in the cores?
    - JL: Sacrificial zinc is also put on boat hulls to retard biofouling. Sacrificial as it dissolves over time.
    - DG: I agree, I know Cu and Sn have been used as anti-fouling quite a bit, so I'm not surprised to see Cu. Sacrificial zinc is also used for seawater is used to erode parts of the zinc rather than boats.
- BW: How does this compare to what's reported in the EA?
    - DG: The only one I saw was the 2014 table which didn't have every element that we tested but had a few. Our ranges are a lot wider, so we got higher highs. But we did cores, and I believe they only did sediment and water analysis, so our sediment values are higher, likely just because we did the cores.
- Richard Dodge: I don't recall any trace element and sediment information in the DEIS
    - DG: The only information that I could find to compare I found in the USACE 2014 February 2020 Draft ESI, Sediment Metal Concentrations within the Expansion Alternatives. I did mention that this was sediment, I'm assuming surface sediment, and it gave a range for some metals. We did a lot more trace elements, but that's the only information that I found.
    - KG: USEPA analyzed sediment contaminants in their permitting process for the ODMDS.
- PG: If the sedimentation rate is that slow you will not see POPS past the first 2 sections. Something is not right with the sedimentation rates. Plus the port was built more recently that 133 years so you will be dredging natural minerals?
    - DG: That's correct, it seems in all our cores the sediment rate is slow, but we are finding spikes at a meter or even at 1.5 m. But the question is what's going on? I think what's happening is there is a lot of dredging happening over time. There were 2 huge dredging events in that port I think in the late 40's and in the middle of the 1980s. So the sediment is being moved from bottom to top, and a lot of perturbation is occurring. I think it's going to be complicated. I agree, it would make more sense to look at the first 2 cm for POP. I would like to do some testing further down the core to see if during dredging we are bringing top sediment to the bottom, if we find POPs deeper in the core.
- Kristi Kerrigan - It will be extremely helpful to determine the toxicity / threshold limits of these metals for certain coral species! That has significant management implications.
    - DG: I would love to do Mo, I think that will be one of our number one priorities. But I'm not sure how to test that safely with corals in a controlled environment. I know Mo is naturally found in the ocean and in sediment, but it's not naturally found at these concentrations.
- VK: Dimitri, what is getting washed from the sample with ultrapure water?
    - DG: The saltwater. The ICP masspec can't handle a lot of saltwater. We are working on writing grants to get a massspec for in house and not have to worry about washing that out.
- JL: Abby Renegar at the OC could possibly help with a dosing protocol.
- PG: We do have now a triple-quad ICPMS so you can do saltwater at FIU

Closing Remarks

Day 2: November 4th, 2021

Session IV: LAS Project Updates

TAC Meeting: FDOU LAS Project Updates – Katie Lizza (DEP CRCP- FDOU)

FDOU 52: Data Needs for Fisheries Management
Back in 2013 when we were conducting the "Our Florida Reefs" (OFR) process, the fisheries stakeholders disengaged and have voiced opposition to fisheries related Recommended Management Actions (RMAs). This project was developed to re-engage those fishery stakeholders to get their input and knowledge to develop new RMAs in addition to those developed during OFR. Webinars have been conducted to aid the stakeholders' decisions during committee meetings. Webinars included topics such as Coral Reef Ecosystems, Fisheries Status, Addressing Fisheries Information Gaps, Reef Ecology, and Water Quality Updates.

Public Meeting: March 2021
The first public meeting was held on March 11th, 2021. Key input from the public included issues such as: economic impact, artificial reefs installation, MPAs, water quality (WQ) (conversion from septic to sewer), holistic approach to management, engaging fishermen, gathering more information, coral DNA, and community engagement. Some things they wanted us to prioritize were depredation, WQ, and coral disease. Further public comment from the survey website included: establish MPAs, reduce excess nutrients/pollution, mandatory anchor ball field, lack of inshore habitat, large scale introduction of coral, use science to determine closures, bag limits, etc. while allowing state agencies to manage local waters. Questions from the public were provided because they were still unclear on some of these topics, such as:

- Are beach renourishment programs on committee radar?
- Is committee considering providing alternative artificial reef sites?
- How does an MPA help coral reefs grow better?
- If there are closures, what are we trying to accomplish? Improve coral health? Work on fisheries? What fisheries?
- What is the problem you are trying to solve?

This is helpful to managers so we can be aware of the questions the public has and provide answers and increasing engagement with the public.

Committee Meetings 4-8
Since we last met with you all [TAC], we've had numerous committee meetings 4-8. Topic 4 objectives were to build community and trust, which is important for engagement and feeling valued; reflecting on the information for the last 2 webinars; formulating questions that still need to be answered moving forward and developing webinars to answer these questions; and synthesizing thoughts and advancing thinking. Topic 5 objectives included reviewing the public meeting and having the members start identifying potential RMAs and prioritizing the ones they felt were most important. During the stakeholder committee meetings for these two topics, further questions and recommendations were identified. It is important to note that stakeholder committee members' views were diverse, and they differed depending on the topics addressed for RMAs. For example, some support MPAs and some do not, and there are differing opinions on the extent to which they should or should not be used. We also will be diving into MPAs in a later meeting as this topic has differing opinions. There are also topics such as artificial reefs, more data on species, and spawning closures where there was a consensus among the group and thus have been less challenging to tackle during these meetings.
Stakeholder questions arising from these two meetings included:

- Criteria for nursery habitats

- When to prioritize stock assessments?
- What is the best reef structure to restore?

Meeting #6 objectives included introducing the concept of criteria, or under what conditions would an RMA be implemented. We familiarized the committee with the concept of criteria so we could have greater success for future discussion on challenging topics. The stakeholders were divided into 2 groups and assigned one topic to discuss with the purpose of creating a set of criteria for fisheries management. During these groups, RMAs were addressed, specifically spawning closures, more information on species, and anchoring. We used these as they were less challenging topics (had more consensus) and were mentioned by the committee in previous meetings. Example recommended actions were shown to the committee, for example:

Recommendation: Establish buoys (for anchoring)
Goal: reduce anchoring damage
Criteria: Where and when are these buoys placed? Under what conditions? (i.e., establish buoys in x location when y conditions are met).

This meeting also identified criteria for fisheries management and addressed planning for meeting #7.

Meeting #7 objectives included rating the quality of fishing in the Coral ECA, or how important certain issues are to the quality of fishing in the Coral ECA. We followed this rating up by asking how important the following to the quality of fishing are: water quality, coral disease, fishing pressure, shark depredation, and other. Stakeholders provided some feedback from both meetings #6 and #7. They felt it was difficult to answer the quality of fishing as it is a complex question that could not be rated on a simple scale and depended a lot on the location and species. They indicated there are various impacts that affect the Coral ECA, but water quality is the primary impact. Opinions differed on fishing pressure. Similar to meeting #6, members were split into 2 groups to discuss criteria for just more restrictive fisheries restrictions. The stakeholders did not engage on criteria for the modification of fishing regulations. We wanted them to use their knowledge and how they wanted to see their fisheries resources managed going forward, and under what conditions would they recommend modifying fisheries regulations, like bag/size/vessel limits, seasonal closures, or gear restrictions. There was minimal support for modifying fisheries regulations, so as of now we are not focusing on developing RMAs related to fishing pressure. The committee feedback preferred to focus on habitat and water quality with the potential for spawning closure or weight limits, as they felt these were the most important issues impacting the Coral ECA. In part two of committee meeting #7, the focus was shifted to developing RMAs related to habitat loss. As the committee had mentioned artificial reefs before, we had them focus on developing criteria for the installation of artificial reefs. This topic was the best in terms of discussion and moral. Criteria discussed included location, connectivity between artificial and natural reefs, the purpose (for example, increasing habitat for coral recruitment or fisheries population), structure of reef development, and materials used.

Meeting #8 was held on Nov. 2nd and 4th, with the goal of developing recommended criteria for water quality, as this was a topic brought up most by the committee. We plan to show the committee already developed recommendations through the OFR process, but these new criteria will not replace the OFR recommendations that already exist. We would like the stakeholders to have the ability to evaluate existing regulations, and provide input to say which should be prioritized and suggest new RMAs may need to be added to address water quality.

Continued webinars and committee meetings will be held after #8, with surveys being sent to the public and to a randomized sample of fisheries stakeholders who hold fishing licenses in Southeast Florida. What comes out of all of this is a list of recommendations and a list of criteria with input from the wider

fishing community and public. The primary audience will be fishermen, with the reef stakeholders being a secondary audience. The survey aims to survey the wider public and ask them:

- What is the state of the Coral ECA ecosystem including the fisheries?
- What factors are the most important in driving the quality of the ecosystem and fishing in the Coral ECA?
- What is your preference for different possible management responses (WQ, habitat, or fisheries based)?
- What is missing?

FDOU 51: Meta-Analysis of Fish, Water Quality, and Benthic Data

There are ongoing monitoring programs occurring in the Coral ECA, but existing data has been collected separately for each sub-system. SEFCRI has identified a need for a holistic view of the ecosystem and suggested incorporating analysis of spatial and temporal trends and patterns among existing water quality, benthic, and fish data. It was suggested a meta-analysis would accomplish these needs.

I wanted to recap the helpful feedback we've received from the TAC and SEFCRI in the past:

- Narrow the scope of the project.
- Compile info on existing data.
- What question are the data already answering?
- What questions do resource managers want answered?
- What questions can be answered by the existing data?
- Prioritized management questions
- Identifying the gaps in the knowledge of the system
- Is a meta-analysis of the combined data statistics feasible?

Taking this feedback into consideration, we decided to conduct this project in two phases.

Phase I

Phase I involves data compilation and characterization with the following goals:

- Identify existing datasets within the Coral ECA, characterize the data, and identify their limitations.
- Update conceptual models of the Coral ECA subsystems.
- Determine gaps in the knowledge of the system to inform future research and management needs.
- Identify and prioritize resource management questions.
- Develop a proposal for Phase II of this project.

To accomplish this, various participants will be involved in the data compilation process, including data providers, subject matter experts, resource managers, statistical experts, and the project team. The first part of this process involves distributing a questionnaire and conducting interviews. A questionnaire and interviews will be conducted with the data providers, along with a discussion on the data that has already been compiled. Subject matter experts, the project team, and resource managers will also be involved in these discussions on data that has already been compiled so we aren't repeating any data. There will be a Report 1 that compiles the information gathered from the data providers regarding existing data, identifying current and past projects that have already compiled existing data (limitations, spatial/temp scales).

The next step of the process is to evaluate and update existing conceptual models and prioritizing management questions. Models developed in 2013 for the benthic, fish, and water quality data will be

evaluated and updated by subject matter experts, and we will be dividing the working group into subsystems by knowledge expertise. We want to use the updated models to define management priorities and questions for each subsystem, identify required data to address each priority, identify existing datasets that can be used to address each priority, and identify gaps in our knowledge of the systems. This will be done with help from the project team, resource managers, and subject matter experts. There will be a Report 2 that will provide the updated conceptual models for the three subsystems of the Coral ECA, outline prioritized management questions based on the subsystem's conceptualizations and relationships, and address knowledge gaps in our knowledge of the system.

Lastly, there will be a workshop on the data accessibility requirements and statistical feasibility. We will outline data requirements/feasibility of focus areas and management priorities, identify which management priorities can be answered by the data, determine which datasets are comparable, and address what priorities require additional data/what are those requirements. Those involved will include statistical experts, subject matter experts, the project team, and resource managers. Report 3 will combine all the information from data workshops and the facilitated discussions between participants, evaluate scientific and statistical feasibility (to see if meta-analysis is feasible), identify the datasets that are comparable, prioritize management questions that can be answered by existing data, and discuss management priorities that represent data gaps.

Final Report

The final report from Phase I will include the development of a proposal and framework for Phase II Meta-Analysis of Benthic, Fish, and Water Quality Data. The final report will describe the dynamic relationships among the conceptual models developed for each Coral ECA subsystem, address the identified knowledge gaps within the Coral ECA, and make recommendations for coral reef management strategies and protocols, future research, monitoring, and data collection efforts. At the moment we do not know what Phase II will look like, as this first phase will inform the framework for Phase II.

Questions/Comments

- BW: Does the group understand that artificial reefs change the relative abundance of fishes which has an impact on the natural fish communities? They typical attract a lot of predators. If it's a group of fishermen rallying around artificial reefs to somehow improve the fish communities in the region, that action also has an impact on what exists. I don't know if those discussions happen during the meetings but should be brought up.
    - Katie Lizza: Yes, I think they were brought up, I think there is still a question about whether an artificial reef is an attractant or increasing biomass of those fishery populations, so that was definitely brought up as an issue that still needs additional research.
    - Erick Ault: I also think that the committee was looking into ways to supplement for coral reef loss.
- PD: Any thoughts on stopping spearfishing on SCUBA - except for lionfish.
    - Dana Wusinich: In response to Phil's question, that was a draft recommended action during the OFR process, and it was not popular with the same fisherfolk that are also participating in this process, so I don't anticipate there being a lot of support in this process for a management action like that. There was an effort to include a diversity of fishing interests on the group, and there are spear fishers that are participating in the group. There was an effort, I think I drafted the RMA for that during the OFR process, but it got shut down pretty hard.
    - PD: Maybe hook and line fishing yields (especially trophy-sized fish) is negatively impacted by spearfishing on SCUBA? I would like to speak out against spear fishing. I know there are a lot of spear fishers, but when you go to the DEMA meetings the last five years, all you see are spears and fins and teaching people how to go spearfishing. If you can breath-hold dive with a sling that's one thing. I wonder if we can somehow get some questions to the hook and line fisherman to see if they feel spearfishing is taking away their catch potential, because

spear fishers tend to take the biggest trophy sized fish. So, I wonder if there is a way to ask some question to see if spearfishing impact hook and line fishing. With spearfishing on SCUBA, we are one of the only countries in the world that allows that.
    - VK: Phil, I completely agree about SCUBA spearfishing.
    - BW: I'm not for spearing, but I think limiting spearfishing would impact tourism quite a bit.
    - VK: SCUBA spearfishing, not just spearfishing.
    - PD: spearfishing is destructive- period.
    - BW: Agreed.
    - KL: Those are things that we can incorporate this into the survey, so we can have future discussions in the committee
- VK: Was any decision made about not using old boats for making "artificial reefs"?
    - Kristi Kerrigan: They didn't really get into the details of that in terms of types of materials that should or shouldn't be used, but they danced around it a little. We will probably revisit it at future committee meetings.

Awareness and Appreciation Updates – Rachel Skubel (DEP CRCP - AA)

I started as the Awareness and Appreciation Coordinator in September 2021. In this role I'm keen to grow awareness of Florida coral reefs so that more people can gain value from having a relationship with that ecosystem. That includes adapting our ongoing projects so they're more accessible and engaging to the broad and diverse population we have here.

Awareness and Appreciation Focus Area
The goal of the Awareness and Appreciation group is to increase awareness and appreciation of the coral reef ecosystem of the residents and visors of Southeast Florida. Specific LAS projects include:

- AA 35: Coral reef education trunks
- AA 20 and 23: Outreach materials and public events
- AA 5: SEFCRI and FCR websites
- Disease response communications committee

AA35 - Coral Reef Education Trunks
These go out to teachers in the counties bordering the reef. There have been some improvements since the last circulation of the Coral Reef Education Trunks before 2019. We've reimagined lessons and activities by subcontracting teachers who have rewritten lesson plans and expanded the activities. We've also improved non-trunk accessibility for people who can't be shipped a trunk. We've expanded the grades (K-2, 3-5, 6-8, and 9-12) and have more specific and involved activities for each grade. We've been updating the lesson plans, PowerPoints, activities, and resources so they can be used online, which will be available on the SEFCRI website.

AA 20 and 23 – Outreach and Events
We've been pretty busy in the summer and fall and going into winter and have been trying to circulate the great materials we have, trying to have more Spanish material for the large Hispanic community down here as well as developing more VR footage so people can dive into reefs that they may not have in real life. A big thank you to the SEFCRI members who have volunteered with staffing some of these events. Events for the summer included SOS Ocean Conservation Day and the Force Blue Coastal Conservation Cleanup were held. Events for the fall included the Tortuga Music Festival, the Deering Estate 100 Yards of Hope Screening, and the SOS Ocean Conservation Village.

AA5 – SEFCRI and Florida's Coral Reef Websites
We are doing a relaunch of the Florida's Coral Reef website, which will include new content, learning resources, and regular updates to drive long term engagement with the people who visit this site. It will really be a hub and learning pages for all things related to Florida's Coral Reefs. The SEFCRI website will also be updated with the new content we have been working on.

Questions/Comments: None

SEAFAN, BleachWatch, and Marine Debris Update – Tyler Mominey (DEP CRCP - AC)

Southeast Florida Action Network – SEAFAN
We still have lots of reports coming in, and I'm working on outreach to spread the word and get reports in. We are working with FWRI to create a public facing dashboard to present these reports to the public, helping to have the public be involved with sending in reports and seeing reports come in and visually interacting with that. We are also establishing local relationships and outreach events, both in-person and virtual or blended events, such as the Force Blue Coastal Conservation Cleanup in August and Fort Lauderdale by the Sea. We have a few reports from Palm Beach and Broward, and I want to highlight a new healthy elkhorn colony down in Lauderdale by the Sea.

BleachWatch
I'm working on updating a couple things on the current condition of the reports and hope to have more updates soon for this current bleaching season as 2021 wraps up. I'll be connecting with the current BleachWatch instructor network in the beginning of next year and aim to do refresher meetings and trainings.

Marine Debris
The 10th annual reef cleanup was a big success, considering the logistics of this year and getting people back out into the water. We removed over 109 lbs of debris from the reef itself. We were able to partner with Ocean Conservancy using their Clean Swell app, which garnered over 149 participants and estimated a total of 1500 lbs. of trash removed from that do-it-yourself cleanup.

Questions/Comments: None

MICCI 28: Project Update – Patrick Connelly (DEP CRCP - MICCI)

Criterion Concerns and Comments
During the last several months involved in this project, some DEP staff have shifted roles or retired. This also includes our Division of Environmental Assessment and Restoration (DEAR), the agency responsible for revising WQ standards in Florida. So, we've been working on getting new staff up to speed and having DEAR get us up to speed on the revised turbidity criterion. As it stands, the criterion for turbidity is not very protective of corals, and while the goal is a numeric criterion, there are not currently enough studies or data to develop one. The need for more data related to turbidity in Florida is quite apparent, and the MICCI 28 project is intended to develop one or multiple projects that can provide more data that can be used to develop a numeric criterion.

Some concerns and comments include:

- The need for justified numeric criteria – current criteria is not very protective of corals, so we need more data related to turbidity to develop numeric criteria
- The need for more data to validate changes
- Concerns over project cost increases (shutdowns/delays)

- Methods of obtaining natural background do not capture adequate open water conditions and variability

Coral Turbidity Criterion Update

DEAR is undergoing a Triennial Rule Review (as required by U.S. EPA to periodically update water quality standards). One of the standards being updated is turbidity, and the current draft is in narrative form (62-302, F.A.C). The current draft criterion proposes that turbidity shall not be increased above background conditions within areas of the state where coral reef or hardbottom communities are found or have been demonstrated to occur since 1975. The draft rule further provides a method to establish background variability if a particular water body or water segment doesn't have enough historical data. The basic methodology is highlighted in this portion of the draft version of the Impaired Water Rule (IWR) (62-303). It basically says that background turbidity shall be defined as the 90th percentile of the data for a water body between 1975 and 2020, approximately, not including canals or within 200 meters from shore, needing at least 20 temporally independent samples over a 3-year minimum to establish a new background if no data is available. We are currently working with DEAR to understand what water bodies have data or are data deficient.

MICCI 28: Narrowed Project Ideas

Originally there were 9 project ideas developed for the MICCI 28 project. Three project ideas were chosen as the most relevant. They received good comments and thoughts from the TAC team and multiple DEP departments. These include:

1. Design a study to establish regional background turbidity levels.
    - Pros:
        - DEAR recommended this project.
        - This project best informs proposed criterion regardless of sampled area and informs design of dose-response studies (project idea #3).
        - There may also be some existing data, literature, and monitoring data that can be incorporated into this project.
    - Cons
        - Trade off: area covered vs. frequency of sampling in a particular area.
        - This project will have limited utility if sampling isn't frequent or targeted to an area.
    - Other considerations:
      There are 3 possible areas to focus sampling:
        - Healthy reefs to establish 'reference' conditions.
        - Areas with data gaps for the IWR assessment. For example, there is insufficient data for Impaired Waters Rule (IWR) assessment
        - Nearshore areas within 200 m. Based on 62-303, this won't address the IWR assessment, but could be useful if we feel the priority is to understand nearshore turbidity for beach nourishment projects.

      Once we understand where to focus our sampling, we can implement the required sampling methods, which include frequent and continuous sampling, should be targeted to specific locations, at a minimum has 20 samples over three years and ideally are multiyear, seasonal, and capture episodic events. If we do select the offshore sampling reefs to establish a reference turbidity level, sampling should take place far from any construction, major impacts, and ports and outlets. One thing that is stressed in a lot of these projects is that sampling should take place in both the near bottom and surface to include the entire water column.

With respect to recent studies and data mining, Whitall and Bricker 2021 (Examining Ambient Turbidity and TSS Southeast Florida) has some work that can supplement this project idea as well as a lot of the other stuff DEAR has been doing, depending on the sampling area and the scope of work for this project idea. DEAR has some data on water quality sampling that has taken place at certain water bodies in Florida, but the data is still being analyzed. As another benefit, since these requirements have been drafted up like a sample methodology, it may make finding a contractor and developing a scope easier.

2. Compare construction turbidity to background.
    - Pros
        - Most directly relevant to establishing a numeric criterion.
        - This could be an extension of CRCP9, understanding the relationship of biologically relevant data such as PAR and TSS and their relationships to turbidity values as measured in NTUs.
        - Could fill gaps in construction monitoring, including the fact that some bottom sampling in the past seems to be lacking in a lot of projects.
    - Cons
        - Tech could be costly depending on what's used.
        - The data may be vulnerable to shifts in construction timelines, which we know are constantly being modified.
    - Other considerations:
      Some funds or staff time could be dedicated to obtaining dredging company data, if possible. We would also need to ensure sampling is done within the turbidity plume of a project and must include surface and bottom sampling. There should be a minimum of 20 samples take if this information is to be considered in drafting or modifying the turbidity criterion. There was some data collected for 2 studies that monitored maintenance dredging in Port Everglades, GHD and NOAA/USACE/AOML. They both included turbidity and several other parameters. The first one monitored in November 2020-April 2021 (GHD), and the report is complete, but the data has not been fully processed. The other study (NOAA/USACE/AOML) lasted from December 2020-February 2021 – it was supposed to go on for longer but was cut short due to a vessel grounding damaging the sensor equipment. For monitoring of maintenance dredging in general, funding could be utilized for data analysis and more data collection is planned. Also, depending on the gear that we use, other technology should be carefully selected because of the cost. Certain additional sampling equipment or technology should be utilized in a project like this, such as the use of drones.
3. Species and life-stage specific dose response threshold studies related to turbidity.
    - Pros
        - These studies could add species specific threshold numbers for different biological impacts. For example, a pilot study by Cheryl Woodley (NOAA) has provided us with updates on pilot turbidity studies. These pilot studies are testing wound healing capabilities on *O. faveolata* in different turbidity regimes. Results indicate turbidity levels as low as 4 NTUs can impact wound healing capabilities in this species. One of the experimental issues found difficult in the pilot study is maintaining a consistent level of sediment suspension and a constant turbidity level for a full 96-hour period. It tends to fluctuate, either due to sediment getting trapped in the containers being used or due to other factors. Some of you in this meeting may have the potential to help with that. Sediment samples collected from the Port of Miami were milled to a specific size fraction. We're working with Cheryl and the DEAR team to identify ways to move forward with her

research so it can be tailored and used to supplement the revised turbidity criterion. We want to make sure data can be used by DEAR. While we can't provide our state funding directly to Cheryl, I know there are researchers in South Florida who've completed turbidity related studies and who may be interested in more work and funding.

- Cons
    - Difficult to control in field.
    - Difficult to replicate field conditions in the lab.
    - Most expensive project of the three ideas, although Cheryl's work is a great launch point for any other researcher.
    - Substantial time commitment.
- Other considerations
    - In order for the data to supplement the revision of the turbidity criteria, it must be a Florida coral species.

MICCI Project 28: Moving Forward

Our next steps are to continue to identify what agencies are doing what projects and identify what gaps exist and help in developing a scope of work and selecting a project. We will be consulting the TAC, project team, and DEAR staff for project selection and design. Project design will be compliant to DEP SOPs and can inform turbidity criterion. We feel as though there is opportunity for great work here, and it is possible that more than one project can get funded. Thus, we will identify and secure funding sources and contractors or researchers who can complete the work. We've drawn up a list of potential team members, and I welcome anyone volunteering. Please let us know if you would like to be included or taken off the list.

Questions/Comments

- PD: Maybe a "healthy reef" control site should be established where the reefs are in better shape than Southeast Florida- like the southeastern edge of the Bahamas for nutrient and turbidity and water quality in general...
    - VK: Phil, although that would be correct for relatively "healthy reef", it is not applicable to Southeast Florida as a required background. It was not like that even when population of Florida was << 1 mil.
- VK: Cheryl Woodley did a great job with her experiments, demonstrated lethal effects of sedimentation, but it doesn't relate well to making thresholds for turbidity. These are experiments are in small buckets or containers, well imagine now you have, let's say, 12m depth – a) where are you measuring turbidity, b) the same turbidity with a current 1 m/sec vs. 0.1 m/sec… The correlation between turbidity and current has yet to be established or is hard to establish with variable current. It is rather much better to make thresholds in sedimentation rather than trying to judge by turbidity. Turbidity is a good signal for things not going well, but not about the effect on corals and other benthic organisms.
    - Patrick Connelly: I would say that's an important point to make.
    - KK: And that definitely goes back to the cons of those type of studies in a laboratory setting, controlling all the environments verses a field setting that is difficult to control. So yeah, you make a good points Vlad.
- Xaymara Serrano: I wanted to make you all aware that the Great Lakes Environment Research Laboratory working with AOML is planning to do hyperspectral imagery off of Port Everglades, I believe with approval to do it within in 6 months. I know it's not necessarily tied up with these questions, but I know one of the project ideas from earlier is to use remote sensing. I think the plan is to use some of this data, like chlorophyll data, to compare with WQ data that is collected as part of the project, so I just wanted to let you know of that coming.

- XS: The Corps said they are expecting the final report from GHD in the next week or so.
- Jack Stamates: I just want to chime in about sedimentation again and I agree that it's important that there be concurrent sedimentation monitoring. Of course, that can't be done as part of a construction project in real time off the side of a boat, and that's the reason turbidity is so popular is that it's a fairly easy measurement to make. The other comment I wanted to make about studies being done is that we have to consider that during a major dredging operation that the sediment composition will change dramatically as they begin to dig, and typically a much finer sediment shows up and the water color may change (it's a different material). So perhaps some studies might be appropriate if it's possible to access that material.

Session V: Water Quality

South Florida Coral Reef Water Quality: Turbidity and TSS as they relate to criteria development – Dave Whitall (NOAA)

As a note, this is a parallel but independent study with what Patrick talked about, so our approaches are a little different, but it will give some perspective on what the data look like and how they will play into the criteria development.

Background
This is a joint NOAA/DEP effort to assess WQ on coral reefs in South Florida. Federal funding is for 9 locations. Sampling 2 of the 9 Inlet Contributing Areas (ICA) (Government Cut and St. Lucie) began in Sept 2016. DEP secured state funding in 2017 to expand the program to all 9 ICAs. NOAA's involvement ended in 2018 but the project is ongoing led by DEP. We are currently sampling 115 sites across the 9 ICAs, at inlets and outfalls, including three site types: reef, inlet, outfall (the inlet and outfall are targeted, but outfall is surface sampling only). Sites are sampled monthly to capture ambient conditions, as the project didn't set out with specific development or construction projects in mind, so these values would be indicative of the background conditions. Having said that, there is the potential to capture storm events and things like that as a side effect. Statistics used are currently from September 2016 to August 2020. Data includes turbidity (nephelometer) and TSS via standard methods (filtration and mass determination). Nutrient data is also available but will not be discussed today.

Research Questions
1. Are there significant differences between surface and bottom water values?
   This is important to criteria development because bottom water values are likely the most relevant to the reef even though they are harder to measure. However, there may be a situation where you have a nice dataset for only surface water values, so the question becomes is there any utility for surface data, or do we have to stick to bottom water values. It turns out for both turbidity and TSS, there were no significant differences between surface and bottom across the region. There were qualitative differences, where bottom water values were higher, but they were not higher in a statistically meaningful way. I think this difference may be driven by resuspension of existing sediment within the system. What I would conclude from this is that we should still be sampling the bottom water as it is the most relevant, but there is some utility for surface data as well.
2. Are there significant differences between site types (reef vs. inlet vs. outfall)?
   In other words, if you're trying to think about a background value for the region, should you use all the data you can get your hands on, or should you only look at data on the reefs? If there is a difference, we want to make sure to only look at reef data. And in fact, there are significant differences in site types, with reef sites values for turbidity and TSS falling between inlet and outfall sites. This shows us that we have to be reef specific with these data collection efforts, and

that taking samples at the inlets/outfalls, while important, does not have the same impact that the reef data has on criteria development.

3. Are there spatial differences within the study region for TSS and turbidity?
   This is important for a regional standard criterion for protection across the entire region, so we need to know if it varies within the geography. There are significant differences across the Inlet Contributing Areas for turbidity and TSS. There are significant differences between a lot of the inlets, for example, St. Lucie is different to all the others, and Jupiter and Lake Worth are higher than Boynton and Hillsborough. TSS has significant differences, but in a different pattern than the turbidity. This highlights that although we talk about turbidity and TSS together sometimes, they are different measures and don't tell the same story. So, the criteria for the two variables may look very different and they may have different efficacy for protecting corals. Not that we can't talk about them together, but they are different not only in the way they correlate but in the geographic patterns that we can see in the region when comparing the two.
4. Is turbidity or TSS better correlated with the observed biology?
   We want to know what's driving the observed differences in biology, and certainly lots of things go into forcing factors for biological endpoints, not just WQ. Neither TSS or turbidity will be a perfect predictor, and similarly correlation doesn't equal causation, so even if we see nice correlations here that doesn't mean that's what driving the pattern. Having said that, it's important to look for these relationships because if you can't find any relationships between the supposed forcing factors that you are developing criteria for, then you have to ask is this the right criteria to be considering. We looked at NCRMP data as all of our reef sites are co-located with NCRMP sites. This allows us to use the WQ data to look at that biological dataset and see what relationships we may be able to find. We are looking at the benthic habitat classes and rugosity, as rugosity is a broad metric that might be useful to consider. Here are the significant Spearman correlations (Spearman ρ values) for maximum and mean turbidity and TSS, which is a non-parametric rank value, which is why you get the same values for max and mean, just as a digression. Both max and mean turbidity are relatedly strongly correlated with rugosity. Again, that's probably not a perfect metric for reef health because it doesn't measure anything except the vertical complexity of the reef. And I should point out that that's a negative relationship, so as turbidity goes up, rugosity goes down. TSS is correlated with more things. Turf algae is negatively correlated with TSS, and so is the other category. The interesting one is encrusting gorgonians – this has a positive relationship, so as TSS goes up, there is higher prevalence of gorgonians. This may be that gorgonians are more tolerant to TSS, while other species are being forced out by TSS that allows for space for gorgonians to prosper. Or it could be that this isn't a pattern, just noise within the dataset. The take-home here is that TSS is better correlated with more things, but turbidity has higher correlations with an ecosystem level metric. I don't think this is the end of this story, really, we need more biological data because we have a lot of chemistry data in relation to biological data. I think the co-location of chemistry and biological sites is really important to do these kinds of analyses.
5. How do existing criteria compare with observed values of TSS and turbidity?
   This can serve both as an important reality check (are the criteria reasonable based on real world data) was well as give some sense of the extent of the problem. I don't believe Florida is considering a TSS threshold, but it is important to talk about as it is an important metric that may be useful in predicting coral reef health. A study from NOAA NMFS (2020) synthesized TSS data from all over the world both from laboratory and field data. Their proposed TSS value, 3.2mg/L, is specifically protective of corals but is neither species or region specific. Florida may want to think about something that is very specific to Florida, so I'm not saying this is the right

number for Florida, I'm just using it as something we can compare to. So then the question becomes how do you look at this – do you look at summary statistics on a site by site basis? If you do that and look at mean and max all the sites exceed the threshold. If you look at the median, no sites exceed the threshold. Looking at the 75th percentile, there are site both above and below the threshold, so maybe it's more useful to look at individual observations. I think that is the way criteria development is going. If you do that, about a third of the time the observations exceed the threshold. I have no idea if that's "correct" or not, but it seems to pass to me - I think we can all agree that there is a sediment issue on the reef, and if you were to tell me that there was an issue about a third of the time, that seems like a fairly reasonable thing. Again, we're just doing this as an exercise, but this demonstrates the utility of data to evaluate proposed thresholds in terms of ambient conditions. St. Lucie had the most exceedances, and the other ICAs ranged from 43 to 71 exceedances. The existing turbidity standard is 29 NTU above background, which is not specifically protective of corals and not defined particularly well in the original rule. There are different ways to define background data based on the existing dataset. For example, using statistical break points in the data. Logical break points are at the 25, 2.5, and 0.5 percent quartiles, which when using this for reef sites only, yield similar potential criteria of 29.2 or 29.1 NTUs, which is still quite high. These levels are only observed 5 times in the data, suggesting current standards may be much too high. As a take-home point, based on the current criteria the threshold is only exceeded 5 times and 4 are out of St. Lucie, so out of ~2,200 observations. If we agree that there is some turbidity issue in the region, it's just not realistic that it's that rare to have a problem, so it's great the state is revisiting this criterion.

6. What might alternative criteria look like?
   A hypothetical change to 100x more stringent (i.e. 0.29 NTUs above background) and defining the background as the 10% quartile, then exceedances occur ~33% of the time, which is similar to TSS potential criteria. These kinds of datasets will be foundational to any kind of criteria development.

Conclusions

The proposed TSS thresholds may or may not be "correct" for the state of Florida, but they seem to be in the ballpark: exceedances of the threshold occur about 1/3 (33%) of the time. Existing turbidity thresholds appear unlikely to be protective of reefs. A hypothetical standard 100x lower (0.29 NTU) results in a similar number of exceedances to the TSS potential criteria (about 1/3 of the time).

Additional Comments

Reef sites are relatively well mixed. I would still advocate having bottom water data where possible, but there were no significant differences between surface and bottom water samples so there may be some utility in that surface water data. There are differences across the region (between ICAs) for both TSS and turbidity, but they show different patterns. We have to consider regional variability when making criteria, and the way the state is approaching that should capture that nicely. We also need to acknowledge that TSS and turbidity aren't the same thing, so this is key to reinforce. Finally, if we can have more biological data co-located with our chemistry data, we may be able to find some more powerful patterns between the two. We've found some patterns already, but there are some forcing factors that drive biology, not just WQ. So, there are some correlations with benthic cover for each analyte, but more biological data is needed. More experimental/laboratory data would be useful. We do need to be careful about using one species to be representative for the entire reef. There are complexity and potential "bottle" issues when you do experiments in the lab, and we just want to be mindful of how laboratory data relates to broader context and what that means for criteria development. To wrap up, thanks to all the people who have worked on the project. As a final note, there is a new publication reference for this project, cited as: Examining Ambient Turbidity and Total Suspended Solids Data in South Florida Towards Development

of Coral Specific Water Quality Criteria. Whitall and Bricker. 2021 (NOAA Tech Memo). https://repository.library.noaa.gov/view/noaa/32102. doi:10.25923/v35e-cv79.

Questions/Comments

- VP: Encrusting gorgonian would be *Erythropodium*. Are there any others? This species seems to do well in shallow water and under degraded reef conditions. This positive correlation with TSS is interesting.
    - Stephanie Schomeyer: *Briarium*?
    - VL: *Briarium* and *Erythropodium*
    - VP: I have mostly seen upright *Briareum* on the Broward reefs and encrusting one is *Erythropodium*.
    - VK: *Briareum* can be both incrusting and erect form in Broward, but more erect, you are right. But the report said about incrusting forms, so both need to be taken in account, I guess.
    - Dave Whitall: That's really helpful, anybody that can shed light into those patterns that we are seeing is really useful. I thought that was interesting to and may speak to some type of tolerance to higher TSS or opportunistic habitat takeover as other things decline.
- VK: Positive relationship of encrusting octocorals with TSS and NTUs one more time says that turbidity and sediment accumulation are not well correlated.
- VK: 15 NTUs for 2 months can make more harm than 29 NTUs for a week.
- Jack Stamates: Three variables to consider! TSS, turbidity and sedimentation.
    - VK: and time

FKNMS Water Quality Updates – Karen Bohnsack (NOAA)

FKNMS Water Quality Protection Program (WQPP)

The Florida Keys National Marine Sanctuary (FKNMS) has a WQ Protection Program (WQPP) that was mandated as part of the sanctuary's enabling legislation. It's charged with achieving and maintaining water quality conditions that are necessary to protect and restore the sanctuary's habitats, fish, and wildlife, but also the human use and recreational opportunities within our waters. This is done through a series of mechanisms which include corrective action, research, monitoring, and education and outreach. This program is co-chaired by DEP and EPA in coordination with NOAA and is overseen by an interagency steering committee. It's been around for 25 years. Last year, we went through a process of revising the WQPP priorities in an effort to be more strategic and effective in our WQ efforts moving forward. You can find these priorities in greater detail at https://ocean.floridamarine.org/FKNMS_WQPP/steering.htm. These consist of strategies to address 8 WQ issue areas organized into 2 broad themes:

- External issues: South Florida regional influences, tidal flooding and climate
- Internal issues: stormwater, wastewater, canal restoration, sargassum and organic debris, marinas and liveaboards, emerging pollutants of concern

There are also priorities related to WQPP core responsibilities including administration, data collection, analysis, and reporting, and education and outreach.

South Florida Regional Influences

The specific areas of focus include those associated with Everglades Restoration and aging wastewater systems in urbanized South Florida. The WQPP has recognized for a long time that WQ in the Keys is affected by regional factors, but we weren't really doing anything to keep updated with those issues. To address that, last year the 2 advisory bodies, the WQPP and the Sanctuary Advisory Council (SAC), called for a working group to be established and serve as a mechanism to enable better engagement on these regional issues, particularly with a focus on Everglades Restoration. This group is called the Florida

Keys and South Florida Ecosystem Connectivity Team, referred to as the Connectivity Team, which was stood up this past March. The purpose of this group is to provide a voice for downstream resources within the sanctuary by improving understanding of the issues themselves but also allowing opportunity for dialogue between the Keys community and decision makers involved in Everglades Restoration. The objectives of this team are as follows:

- Inform and engage members of the SAC, WQPP and the Florida Keys community in South Florida Ecosystem Restoration.
- Ensure the interests of the FKNMS are represented in South Florida Ecosystem Restoration Task Force and other relevant decision-making processes.
- Facilitate regular participation by the U.S. Army Corps of Engineers and South Florida Water Management District at working group, SAC and WQPP meetings.
- Provide a platform for collaboration on South Florida Ecosystem Restoration and other South Florida regional issues of mutual interest and most urgent importance to the Florida Keys, which includes a mix of interests in member seats, amassed agency advisors.

Everglades Restoration is the primary focus of this group, but they also have the flexibility to redirect attention to other regional issues that may also affect WQ in the Keys as needed. The group has representatives from the WQPP, the Advisory Council, and also includes different interest groups from the Florida Keys community, intentionally designed with a mix of interest including science, policy, industry, etc. In addition to those member seats, we've amassed a number of agency advisors who serve as subject matter experts. This team meets bi-monthly with each team meeting structured to introduce a specific topic related to Everglades Restoration and allow time for questions and discussion. Each topic has been introduced and discussed through a Florida Keys coastal resources lens, in other words, in terms of the ultimate potential downstream implications from any given project. The team will then feed information and recommendations back to the WQPP and the Advisory Council. This group has also shown the potential for Keys stakeholders to have a voice and influence what happens in the Everglades Restoration realm.

To date, the Advisory Council has passed resolutions on 2 topics based on recommendations from the Connectivity Team:

1. The Lake Okeechobee System Operating Manual (LOSOM). This is an ongoing effort from the US Army Corps and the South Florida Water Management District to update Lake Okeechobee operations. This is the playbook on how water is being moved from Lake Okeechobee. This is being updated to account for new features that have come online for Everglades Restoration. At the Connectivity Team's recommendation, the SAC passed a resolution asking for freshwater flows to the southern end of the Everglades to be prioritized. The Corps has since moved forward with a project alternative that aligned with the resolution, although they are still working to optimize that alternative to further improve performance for the ecosystem.
2. Proposed expansion to the Miami-Dade County urban development boundary. Last month during discussion about a key Everglades Restoration project that will improve freshwater flows to Biscayne Bay and the southern coastal system, the team identified a threat to the potential success of this Everglades Restoration Project. That threat is the proposed expansion to the Miami-Dade county urban development boundary to create a nearly 800 acre industrial and hotel complex. The project footprint overlaps with areas being considered for restoration in an area where space is already at a premium. At the recommendation of the Connectivity Team, Advisory Council asked the Miami-Dade County mayor and the Board of County Commissioners to deny the application for the development boundary expansion. The Village of Islamorada and Monroe County also passed similar resolutions, and one is also up for consideration by the city of Marathon. It's interesting that the Florida seagrass die-off in the 80s caused Keys stakeholders to be a resounding voice that pushed for Everglades Restoration in the first place. This group has helped

to again shine more of a spotlight on the connectivity between the Everglades and the Keys, to bring coral reefs back into the picture, and provide a forum for our stakeholders to have a more unified voice.

Advancing Priorities Through Collaboration

We all know that resources, funding, time, and capacity are limited, so we're trying to ensure that the WQPP is being more strategic and working together and directing resources to advance these priorities. We have pleased over the past year to see progress on these priorities both collectively where possible and as individual members. Collectively we have seen improvements in alignment of the priorities with funding opportunities. One of the top priorities identified last year dealt with shallow wastewater injection wells due to concerns that treated effluent disposed into those shallow wells migrates through the limestone and impacts our nearshore waters. "Impact of shallow wastewater injection in the Florida Keys National Marine Sanctuary," was funded by the EPA South Florida Geographic Initiative (SFGI) grant in FY20 and awarded to Penn State which kicked off earlier this summer. The information from that study will be helpful in providing the science necessary to support decision making and efforts underway in Southeast Florida. This year we are also able to weave a number of priorities into the EPA SFGI request for proposals, including further investigating stormwater inputs impacts, and cost-effective management practices, connectivity studies to determine if WQ patterns can be quantitatively linked to upstream inputs, and investigating large vessel WQ impacts in Key West Harbor and adjacent marine ecosystems. EPA has not announced funded projects for this year. This EPA funding is the primary funding mechanism for these types of WQ special studies in the Keys.

Individually agency representatives on the WQPP continue to work within their own spheres. Our WQ priorities have been incorporated into an updated NOAA Office of National Marine Sanctuaries (ONMS) Science Needs Assessment, a tool used throughout ONMS to provide up to date information on priority management issues and science and information needs to address these issues. Within our own agency we are also working to increase awareness about Everglades Restoration and the importance of NOAA's continued presence to help reinforce the connection to our coastal waters. In September we briefed the NOAA Science Council on NOAA's role within the South Florida's Ecosystem Restoration Task Force. For those unfamiliar, the NOAA Science Council is composed of senior scientists from every NOAA line office and they oversee and shape NOAA's research agenda. It was a good opportunity to showcase how line offices can contribute to this work, but to highlight how additional expertise and engagement could potentially be brought to bear to support Everglades Restoration efforts, and specifically ensure that our trust resources within the FKNMS and across South Florida are represented in Everglades Restoration project planning, implementation, and evaluation. Finally, capacity has always been an issue, so we were pleased that this year we were able to fund an intern to help with key communication on behalf of the WQPP. Primary among these tasks is pulling together an updated report to congress to ensure continued support and funding for the WQPP.

Upcoming Efforts

Some upcoming efforts include initiating a review of FKNMS WQ monitoring program by the WQPP Technical Advisory Committee (TAC). The goal is to identify if opportunities exist to improve upon these programs and better meet management needs. This directly ties back to the WQPP priorities (recommendation 19-3) related to the WQPP's core responsibilities of data collection, analysis, and reporting. Those generally recommend that we continue long term monitoring programs but ensure that we are collecting data that meets our needs, make that data available, and appropriately analyze it so it can be used for decision making.

The driving reason for reviewing these water quality monitoring programs is to make sure they are helping inform management decision making. A draft set of management questions include:

- What sources of pollution are causing or contributing to existing or anticipate pollution problems in the sanctuary?
- How effective have management efforts been in reducing or eliminating sources of pollution?
- What is our progress toward achieving and maintaining water quality standards, and toward protecting and restoring coral reefs and other living marine resources of the sanctuary?
- Are current water quality standards sufficient for the protection and restoration of water quality, coral reefs, and other living marine resources of the sanctuary?

These were based on objectives highlighted in the FKNMS Protection Act for the sanctuary's WQ monitoring program. Once agreed upon by the steering committee, the questions will be the basis for an evaluation by the WQPP TAC. This is an opportunity to improve consistency and protocols and build toward that more unified network of WQ monitoring programs and achieve a better understanding of WQ patterns across Florida's Coral Reef. We will be working with DEP and EPA and pulling some of their recent relevant work into this effort.

As the last thing to mention, we will be celebrating the 50th anniversary of the National Marine Sanctuary system in 2022. We've come a long way but are also facing unprecedented challenges; we have a responsibility to save these spectacular places and will keep working toward that with our collaborative efforts.

Questions/Comments

- XS: Can someone remind me what does WQPP stand for again?
  - Allie Shatters: Water Quality Protection Program.
- PD: FYI- the Florida Keys have lost over 95% of its living coral since the first National Marine Sanctuary in the Keys in Key Largo.
  - Karen Bohnsack: It's a depressing trend, and we recognize a need for a paradigm shift in how we manage these resources.

Session VI: Decision Support Tools

Florida's Coral Reef Decision Support Tool – Richard Flamm & Luke McEachron (FWC)

Task 4: The Marine Planner

I'm going to be focusing on Task 4: the Marine Planner. This includes 3 elements:

1. Gathering a list of partners, stakeholders, and managers. If you are involved in fishing or construction and are considered a stakeholder, we would love to hear from you.
2. Gather input on functionality, information needs, and suggested next steps for building a decisions support tool for Florida's Coral Reef.
3. A review of the Marine Planner.
   The Marine Planner falls under the umbrella of the Coral Decision Support System (CDSS). There are 3 parts that the new decision support tool (DST) and the Marine Planner have in common:
   - Data/Knowledge base -
     This is all your maps and other information stored that you could access.
   - A user interface -

This includes analytical availabilities and is customized to access specific kinds of data. It would have widgets (sliders, printing, filters, etc.) and features (opacity, removal, measuring tools, etc.) to manipulate the data relevant to the decision you are making.

- Decision tools – could be used for a whole system of tools, including marine planning, coral restoration, fisheries, and water quality.

About the Marine Planner

The Marine Planner is focused on the Our Florida Reefs process, which was an effort to engage local stakeholders to conserve Southeast Florida reefs. The Marine Planner includes a database structure and user interface relevant to the coral CDSS, so I would not expect any differences with the new rendition of decisions support tools. The Marine Planner was designed for rapid knowledge access in a public setting, with pre-processed data within 200x200m grid cells across the reef tract. This allowed for a real-time display of information for the public. Applications include planning unit filtering and a drawing tool, which allowed the creation of a polygon in the Marine Planner and certain features and values could be selected. For a new CDSS, this could be used for restoration, water quality, and marine planning, and could include a topology/planning unit that could be different for different kinds of problems, like reef zonation, rectangles, and other mapping tools.

What We Are Doing Now

We've been gathering input from researcher/practitioners on an updated version of the planner/decision tool. Interviews have been conducted to understand roles, identify data gaps and how data is used, what other data can be useful, institutional arrangements, and decision tool functionality. These interviews helped inform the survey that will be available later.

We've learned a few things from these interviews and surveys about roles/arrangements and data. Organizations have different roles, expertise, and motivations, and it helps to identify where collaborations can be most efficient. Roles and arrangements include program management, research, field restoration, and permitting/SALS. For the data, recurring data includes benthic information, water current direction and speed (relevant to connectivity), and maps of projects. One concern is that monitoring varies from project to project, as it seems there is no clear standard, which I believe needs to be worked out. We've had many comments about the tool being reef-wide, as all areas are connected.

Additional Thoughts

Here are some additional thoughts about an updated Marine Planner, which will be discussed in the final report we put together:

- The development of the CDSS should be modular. We are not sure how big the design will be or what tools will be included, so it needs to be designed in a modular design so that it can communicate with other parts of the system.
- Maintenance is important for the database and the system. This includes maintenance for the software, which helps fund the updates you get down the road. Updating the database will be a core task.
- Robust monitoring/documenting will prove valuable to learn and share lessons to open machine learning for a more refined analysis.
- It would be helpful to have someone internally as a champion to promote the tool, likely someone who is with the organization most responsible for restoration decisions.
- Who will build and how to build the new tool requires serious consideration.
- The CDSS tool will be valuable to act as a hub for identifying gaps, setting priorities, keeping research and monitoring relevant, and leveraging external funding.

Complementary Efforts

There are some complementary efforts that may assist with development. The South Florida WQ Data Aggregation Project, run by a team from FWC, USF, NOAA, UM, and the sanctuaries, worked on identifying regional WQ programs to understand how to bring data together, advise on programmatic changes that are needed to bring data together easier, and examining trends in the data. This includes goals for Year 1 and 2:

1. Year 1
    - Goals:
        - Compare WQ data across 9 parameters (protocols and programs): Chlorophyll-a, temperature, salinity, nitrate + nitrite (NOx), soluble reactive phosphorus (PO4), silica (Si), turbidity, total nitrogen (TN), and total phosphorus (TP).
        - Examine spatial hotspots and increasing/decreasing trends
        - Integrate remote sensing data - are they tracking the same trends?
    - Results:
        - We were able to determine long term trends for 4 of 80 programs (10 years) and were able to use some remote sensing products to fill in gaps.
        - Preliminary trends did not indicate red flags at first glance.
        - Link for Year 1 story map: https://bit.ly/2XReXwh
2. Year 2
    - Goals
        - Apply lessons from first year to bring together more data, including simple things like naming conventions could be improved to ease comparisons.
        - Examine variability with coordinates (scaling factors). A lot of sites are essentially sampling the same location, but there are issues with geographic coordinates or detection limits, and these compatibility issues add up. By working through them, we think we can more explicitly compare time series from additional programs to see how they are complimenting each other.
        - Create a series of semivariographs to quantify spatial relationships between programs to inform standardized site location and names.
        - Examine correlative relationships between remote sensing and WQ.

    There is more data coming. A DST could incorporate some of these standardized products if there is an interest in WQ parameters at this scale. So, when working through survey, please focus on your needs to better help inform the tools needed. We are still doing some interviews that will help design CDSS, so we would like to talk with more NGO research/field restoration practitioners, regulators, permitters, and engineers. If you feel the survey does not include everything that you think we should consider when developing this tool, we are more than happy to talk to you, you can either put a message in the chat or email me (Richard).

Questions/Comments*:* None

Coral Reef Decision Support Discussion - Brian Walker (NSU)

Introduction

We are hoping to hear from you all to get feedback on considerations for a new tool. Unfortunately, all our old efforts were lost in the old planner, as the old tool was not kept up to date, so a whole re-write would be needed. We liked how the original planner worked for its purpose, we feel it still provided good foundation for a reference for data in the region in one place and to get a quick look at some things spatially that may help answer questions before having to reach out to folks, and to give public access to datasets that have been collected over many years. There were a lot of datasets in the original that were useful, but some not used as much. There have been many new datasets that have come online since then

(original Marine Planner was dated 2014/2015). We want to be able to incorporate the most useful information for the applications for the tool but that can be daunting depending on the task at hand. We would start from scratch to remind people of what the old planner did and see if it is of value to continue to try and develop in this new tool.

Topic 1: Planning Tool Considerations

What type of tool is needed (for the region)?

- Data visualizations
  - Public access for datasets from publicly funded projects.
  - It could be useful for managers, permitters, and other users looking at bathymetry, etc.
- Open real-time data summaries linked to planning units
  - The old tool summary actively calculated as you made decisions for certain aspects of the system, which was a considerable lift in programming (biggest part and cost/time sink).
  - Does this need to be included? Would it be helpful? For context, when you have a management question, you can come up with criteria in a group setting that is brought back to an analyst who runs scenarios, and the results are brought back to people. This process can get derailed by distrust and is done behind the scenes. One of the driving forces of the planner was the open, real time data summary aspect.
- Participatory GIS
  - This could be very valuable – it could include different data layers, summarize landscape, data summaries for certain area. These things were valuable in the OFR process, so if there are application in the future for needing the participatory GIS, that's an aspect to consider.
- Data repository
  - This was not in the old planner in the sense of holding data that could be made available to the public. This aspect would come with a huge maintenance aspect to it, so we are leaning toward avoiding this since there are other database outlets for this in Florida and nationally.

Topic 1 Take-Home Points from the Discussion

What type of tool is needed?

- It would be useful to show how a recommendation was created, including stakeholder feedback.
- It would be useful if it showed data gaps.
- If the tool will be used for restoration planning, there will be feedback to incorporate from public meetings for the Coral ECA restoration plan, and we need to decide how/when to incorporate this.

Questions/Comments

- Don Behringer: I can see a lot of value in a tool, take for example the management recommendations when it came to spearfishing. To be able to have a tool that shows how a recommendation was created and engage stakeholders, and as a tool to see what data is out there and the data gaps would be valuable. In not only creating recommendations but then putting them forth and receiving feedback.
  - BW: We did feel this was helpful in discussions when coming up with management actions or ideas because they could ask questions about certain areas, and we could actively pull up information for them. Does anyone feel the previous marine planner could be changed, or be done better?
  - Jack Stamates: I used the planner before, and it was a useful tool. Having the data to plan things for experiments was a great thing, so I'm sorry the software isn't supported anymore. But having that type of tool was great.

- BW: I guess the real question is putting together a data visualization tool has some challenges but it's easier to do that then to put together a tool that would allow for this real time analysis for this specific application. We felt that was a huge value of the Marine Planner, certainly in the meetings.

Topic 2: Should it be Built to Address Many Applications?

- Coral restoration, fisheries, impact avoidance, resource management support, etc.
- Planning units could be designed and coded for specific purposes.
- How to determine application priority?

Topic 2 Take-Home Points from the Discussion

- What shape should the planning unit be? A square matches NCRMP, but hexagon best fills the plane.
- The NCRMP fish sampling was changed to single dive, which might facilitate change to hexagonal blocks.
- It would be helpful to have info about the tool purpose, the amount of effort to make a switch from square to hexagon, adding new layers, etc. This would help to prioritize what to add now, later, or what is not needed.
- ESRI may have templates for design, which could incorporate Google Earth or a platform that already exists.
- Moving toward pixel based remote sensing, which is scalable.
- Inclusion of a report page on status. This doesn't need values, maybe just includes trends.

Questions/Comments

- BW: Could it be built in a modular way? Where we build the foundation system, then tailer it for different applications. It's hard to see all the application out there, but there are a few examples that came to mind from our discussions in terms of coral restoration ideas, citing fisheries aspects (like what happened in OFR or the new fisheries groups), and impact avoidance. We can do those things, but it comes with tradeoffs – can't build for every application and every need. For example, if someone wanted to cite their specific coral restoration locations and they needed to know to the 10x10m plot scale, that's a very different tool than a participatory GIS for large spatial resource management ideas. Many aspects need to be considered while doing this, and we need to get an understanding of what the application priorities would be. I do know the state is focusing on coral restoration at the moment, but even within the coral restoration framework there could be many applications. Like I mentioned a very specific site for specific restoration, or do we build it to a pretty good answer that can then be explored in finer detail using different methods/more formal analysis. I want people to keep in mind that this is not really a formal statistic tool but are basically presenting informative data layers to show what's there and how it relates in space to one another, but to go further you would need to do more statistical modeling. This type of tool would not be addressing those specific analyses.
    - Kristi Kerrigan: Regarding the restoration strategy, for the Tier 1 strategy, part of that is not going to be any site selection, but what we are doing in that process is developing the criteria. And so that has been identified as a need, a use for this support tool, to basically plug in the x,y, or z criteria and to spit out sites that are recommended that could be used for larval recruitment to achieve a network of sites across the reef.
    - Jack Stamates: Just a thought about the statistical analysis, could the software serve the layers for the user but not do the analysis, that would make that data available, and then if that person is interested they could then look further.

    - Caitlin Lustic: The tier 1 will actually include a site selection process, and I think that will likely be done before this is complete, but it could be a layer in this, like a heat map or another layer as a Tier 1 restoration strategy. Then in the Tier 2 and 3 processes, we may add in other things, like distance from a nursery, so there may still be an application for restoration even if this Tier 1 planning has already developed a map.
- BW: This type of tool won't be appropriate to some of the applications, especially for modeling patterns or temporal data. So, it will have limitations and we want people to know that. One of the considerations that we had would be using square grid vs. hexagonal blocks as a planning unit. Hexagonal units are considered best way to go in spatial planning because they provide full coverage and provide a closer edge to the centroid in all locations than a grid format. In the grid format, from the center of the square to the corner, they are much further away from the center of the square and the nearest edge, so the hexagonal block helps that problem. The issue with this is that the NCRMP are based off of square design, so we used the grid in the past. So, do we consider using hexagonal planning units instead, or do we make a pitch to change survey design/planning unit?
    - Kurtis Gregg: Would the change in the NCRMP fish sampling to a single dive facilitate a change to the hexagonal blocks versus the historical squares?
    - BW: I'm not sure what this change would do for the NCRMP historical data, I believe it would be very challenging to go back and redesign the entire thing for a hexagonal planning unit. But it's worth bringing up now in this discussion. Do we develop the tool to be consistent with the local, historical framework, or do we somehow try to fit this into new planning design? Ideally, they would have used hexagonal blocks from the beginning, but that was back in 90s so it wasn't a consideration back then. We would have to chat with the survey design folks about the possibilities there. I'm not trying to do that, I'm just bringing up to the group, do we stick with what we were doing based on the survey or do we deviate from that?
- Jaime Monty: Thanks for you, Luke, and Richard for moving this forward. Regarding the hexagonal vs. square planning units, maybe it would be helpful to have more info. So, at the end of the day after we get the surveys back and have more information on what everybody thinks we need to use this tool for, we will likely have to prioritize things. If we have a better understanding of what effort it would take to switch to hexagonal units verses just updating existing layers and then adding new layers of the data from after 2014, perhaps that would help us to make these decisions to figure out which things are most important for us to have now verses either adding in later or not at all. Going back to the previous slide, in addition to the utility of using this tool for restoration planning, we also will have upcoming advisory committee and public meetings for the management plan for the Coral ECA, so behind the scenes analysis we should consider whether or not we will need to do analyses for any suggestions that come from the public as a part of the planning process. And is that something that we want to do on the fly or do we want to take information back to do analyses on our own, then come back to a second series of meetings with the results. 2024 seems far away but planning for those needs now is important.
- PD: I think that ESRI may have developed a template for the design, or being able to incorporate Google earth for platform, since some of those platforms are already there. For the hexagonal aspect of this, the original WQ units were hexagonal, but everything from there on used square units due to pixels. So, I would focus on pixels, which you can scale down as needed. And a third idea, we have a patient, an ecosystem wide disease we are dealing with, and a lot of humans may want to see how the patient is doing (how are their systems working). So, there should be a page with as summary of landings, disease, etc. If restoration is going to work, supposedly we should see an uptick in things as well as a continuous downtick. All we've seen for the last 50 years is a series of notches that go down, so I think an overall report on the patient for the average person to view and develop a conscious about taking care of their ecosystem, and that goes all the way

inland, the whole overview of it. That's ambitious, but I think that would be helpful to getting the public involved.

- BW: Last time we tried to avoid any sort of data interpreting, we wanted to present the data as much in raw form as we could. For example, we presented data for ship traffic in the region, and those types of datasets were included but we didn't have specific callout to say this is improving or decreasing.
- PD: I don't think you have to have a value judgment to it, but just showing are things increasing/decrease with respect to a baseline. You look at temperature anomaly now compared to the average temperature between 1890 and 1960, and then show was this year's average higher or lower than that. It's an interpretive tool, not a value judgement. Let people make their own conclusions, but some sort of data summary. And the average public has maybe a seventh-grade level of education, so you can gear this so kids can get a lot out of it as well. So, a landing page that has some summary of the data could be used to justify why we are trying to restore the Florida Keys and the Southeast Florida watershed, or why are we spending money on what we are.
- BW: The original planning page was embedded into the OFR website, and that had supportive information to it. It's a difficult challenge to do that, I don't think it's something we could do real time but information could certainly be prepared to support the tool usage to inform people as they are exploring. The only real summary type data is probably the report card that Karen mentioned or the NCRMP grading system, so it could be a consideration to include that in this.
- PD: The data we heard yesterday on the cores and the trace metals, and how they were presented on color scale, and there are EPA guidelines on the exposure for some of these things. So, some of that could be put in, it's a lot of work.
- BW: When it comes to choosing which data types go in, certainly. It will be an effort depending on what the application is that it's targeting. The way we envision this is that the application will drive the datasets that are going to be programed into it, so coding will be different depending on project (fisheries verses coral restoration).

- AS: I wanted to give Richard a chance to go over survey before it's sent out. We will make sure that if you have any questions, we can go over those now. I'll make sure the survey is sent out with all of the necessary information, and I can gather all the information and pass it along.
- BW: Thank you for your patience with this and let us know if you have any other feedback.
- Comment regarding the survey from Richard – For the survey, include your name so we know you did it. At the bottom there is a text box, there is a question there but also comment on any planning/management unit/shape/size that you think is most appropriate for your needs. If you don't know, just put NA. Just as a reminder, 200x200 m squares were used in Marine Planner, but there have been other suggestions like coral zonation, or ecologically based zonation, so put that in at the end in that comment box. If any of you are interested finding more information on the CDSS, we would love to hear from you and talk about it. When you finish the survey email it to Allie.

Closing Remarks