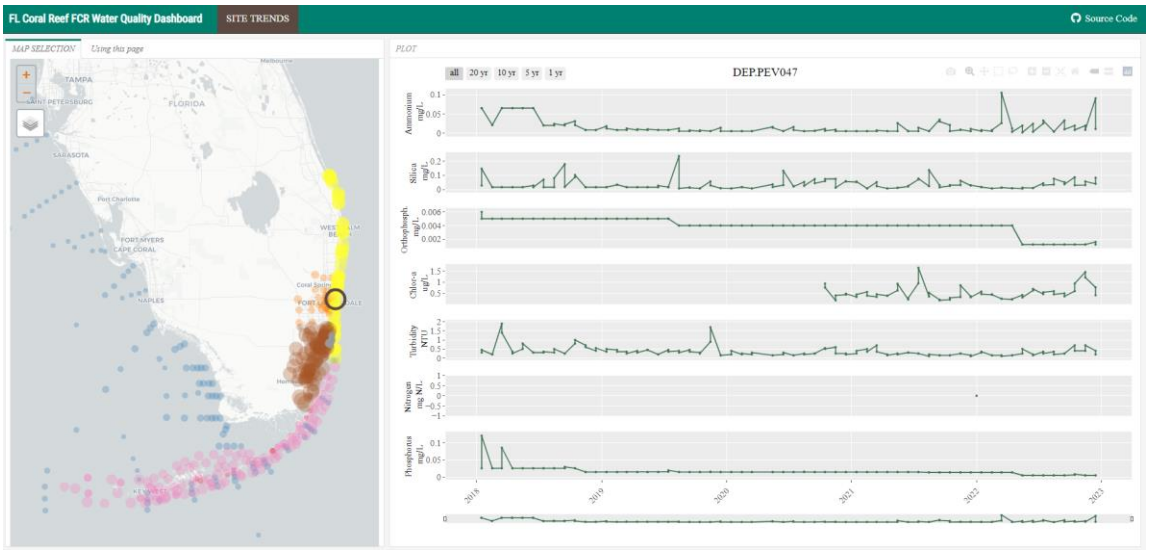
FWC/FWRI File Code # F5530_23-24_F

Florida's Coral Reef Water Quality Data Compilation, Analysis, and Decision Support Year 4



FWC/FWRI File Code # F5530_23-24_F

Florida's Coral Reef Water Quality Data Compilation, Analysis, and Decision Support Year 4

Final Report

Prepared By:
Lucas McEachron[1], Karen Bohnsack[2], Andy Bruckner[2], Alexandra Fine[3], Christopher Kelble[3], David Kochan[1], Kelly Montenero[3], Frank Muller-Karger[4], Tylar Murray[4], Dan Otis[4], Omar Ramzy[3]

[1]Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
[2]Florida Keys National Marine Sanctuary
[3]University of Miami Cooperative Institute for Marine and Atmospheric Studies, NOAA Atlantic Oceanographic and Meteorological Laboratory
[4]University of South Florida

June 2024

Completed in Fulfillment of PO#C1F357
FWC/FWRI File Code # F5530_23-24_F
for

Florida Department of Environmental Protection
Coral Protection and Restoration Program
8000 N Ocean Dr.
Dania Beach, FL 33004

This report should be cited as follows:
McEachron, L., Bohnsack, K., Bruckner, A., Fine, A., Kelble, C., Kochan, D., Montenero, K., Muller-Karger, F., Murray, T., Otis, D, Ramzy, O. 2024. Florida's Coral Reef Water Quality Data Compilation, Analysis, and Decision Support Year 4. Report to Florida Department of Environmental Protection.

This report was funded through a contract agreement from the Florida Department of Environmental Protection's (DEP) Coral Protection and Restoration Program. The views, statements, findings, conclusions, and recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the State of Florida or any of its subagencies.

Acknowledgements
The Florida's Coral Reef unified water quality monitoring database is the aggregation of the data collected by the strenuous field and lab work conducted by a large group of researchers. We'd like to thank NOAA AOML South Florida Ecosystem Restoration Cruise, Florida International University South Florida Estuaries Water Quality Program, the DERM Water Quality Monitoring Program, Broward County Water Quality Monitoring Program, DEP-ECA Coral Ecosystem Conservation Area Water Quality Assessment Program, City of Miami Beach Water Monitoring, North Biscayne Bay Seagrass Loss Water Quality Monitoring Program and Biscayne Bay Aquatic Preserves Continuous Water Quality Monitoring, and Palm Beach County Ambient Water Quality Monitoring Program for collecting and providing these crucial data. We'd especially like to thank Ian Smith from NOAA AOML, Dr. Yan Ding and Dr. Henry Briceno from FIU-SERC, Omar Abdelrahman and Yin Chen from DERM, Lindsey Visser from Broward County, Alycia Shatters from DEP-ECA, Elizabeth Weaton from City of Miami Beach, Griffin Alexander from Biscayne Bay Aquatic Preserve, and Katelyn Armstrong from Palm Beach County for providing these data. We also want to thank Cheryl Clark from Florida DEP for working with us to create a plan to integrate the unified water quality database with the SEACAR Data Discovery Portal. Finally, we'd like to thank our contacts of Florida DEP, Kylie Morgan, Kathleen Czaia, Kristi Kerrigan, and Joanna Walczak, for providing the funding for this project and their continued guidance.

Management Summary
Water quality issues are one of the many natural and anthropogenic stressors facing Florida's Coral Reef. Due to the wide geographical range, variation in biophysical factors, and differing proximity to population centers, many different projects and groups conduct water quality monitoring across the reef. As a result, detecting patterns or analyzing effects of water quality on the reef required finding and combining data from disparate sources. Thus, the water quality data compilation, analysis, and decision support project was tasked with creating a single unified water quality monitoring dataset for Florida's Coral Reef. Initially, the project comprehensively reviewed the available water quality data and programs, compiled comparable datasets, visualized trends, and constructed inclusion criteria to improve data interoperability. Now in year 4, the water quality team updated the database with data from 2023 of the 7 existing programs which met the inclusion criteria and added an 8th, Palm Beach County Ambient Water Quality Monitoring. All data and mapping products, including the trend analyses, web maps, and interactive web applications were updated to include the most recent monitoring data and the new program. The team also developed a new open-source data visualization tool that provides a simple way to examine the time-series trends of water quality on the reef. The team also was involved with both Florida's Coral Reef Coordination Team and the Florida's Coral Reef Resilience Program Water Quality Team meetings to support long-term efforts to identify links between Everglades restoration and reef water quality and the development of a comprehensive reef-wide monitoring program. Finally, the team identified the SEACAR Data Discovery portal as a long-term database solution to host the unified water quality database, mapping products, and visualization tools. Using this database will allow for a streamlined and automated data compilation process while providing a 'one-stop-shop' for data users.

Executive Summary

Florida's Coral Reef (FCR) has been facing a range of anthropogenic and biophysical stressors over the last several decades that have led to widespread declines in coral cover. One of the key concerns for FCR has been the impact of water quality, which is affected by a number of factors that include pollution, land-use change, weather events, and water diversions. However, the large geographic extent of FCR leads to diverse localized and regional pressures that cause significant variation and hotspots in water quality. As a result, efforts to monitor water quality on FCR are made up of a series of discrete regional field sampling programs, continuous sampling with autonomous instruments, and remotely-sensed and satellite-derived analyses. Thus, it is challenging to combine these disparate sources of water quality data to create a comprehensive picture of historical and current water quality trends across FCR. The water quality monitoring data aggregation and analysis project addressed this challenge by developing a unified water quality database ranging from Martin County in the northeast to the Dry Tortugas in the southwest of FCR. During year 4 of this project, the water quality team added an 8th program meeting the compatibility criteria, updated the database and trend analyses, developed new and updated visualization tools and maps, contributed to statewide water quality management teams, and identified a long-term solution for the database and associated products.

The unified water quality database is now updated with data through 2023 for 8 programs that meet the inclusion criteria developed in previous years of the project, with the addition of Palm Beach County for the first time this year. Trend analyses were completed for all of the nutrients monitored by the program, and web maps and applications depicting the data and trends were updated to include the 2023 results. While the existing maps show the spatial patterns of trends well, the need to more clearly visualize temporal trends led the water quality team to develop an open-source data visualization tool (DVT) that allows users to view the time-series data at each individual sampling location. The large number of products associated with the unified database has led to a need for a single 'one-stop-shop' for users to access data and maps. The water quality team identified the Statewide Ecosystem Assessment of Coastal and Aquatic Resources (SEACAR) Data Discovery Interface as a long-term solution. Adding the unified database to SEACAR will allow for a streamlined and automated yearly update of the database while integrating the more rigorous QA/QC processes developed for the water quality project into SEACAR.

The expertise collected during the development of the unified database allowed the team to provide technical advisory support to Florida's Coral Reef Coordination Team (FCRCT) and FCRRP Water Quality team throughout the year. The FCRCT outlined priorities and actions necessary to develop a comprehensive water quality monitoring program to determine the effects of Everglades restoration on FCR. The project team worked with the FCRRP Water Quality team to accomplish action 1, inventorying existing monitoring programs; and supply a framework to accomplish actions 2 and 3, inventorying existing biological and ecological monitoring programs and establishing a list of parameters of interest. In summary, the FCR water quality aggregation project has made it easier for scientists to integrate water quality data into their research, provided critical information to address FCRCT and FCRRP priorities and actions, and developed products for scientists, managers, and the public to visualize spatial and temporal water quality trends across Florida's Coral Reef.

Table of Contents

1. FLORIDA'S CORAL REEF WATER QUALITY DATA COMPILATION, ANALYSIS, AND DECISION SUPPORT YEAR 4

1.1. Background/Introduction

Pressure on marine ecosystems can manifest in the form of localized hotspots in water quality due to discharges of nutrients from human sources, resuspension events from winds, tides, or currents, or from watershed disturbances due to deforestation and other land-use and land-cover change, nutrient pollution, and water diversions. These factors are all compounded by climate change, sea level rise, changing ocean chemistry, species range expansions, soil transport, and erosion. However, few field studies can frequently collect data in dense geographic grids or consider land and adjacent marine systems as part of a continuum within an ecosystem. Often, data from disparate sources (e.g., in situ and satellite derived data) are required to identify patterns in the water quality in Biscayne Bay, Florida Bay, the Florida Keys National Marine Sanctuary, and Florida's Coral Reef. These patterns may be those that occur in response to freshwater delivery or other phenomena that are transported to the reef location at landscape scales.

For the past four years, research scientists from the Florida Fish and Wildlife Conservation Commission, the University of South Florida, the Florida Keys National Marine Sanctuary, the NOAA Atlantic Oceanographic and Meteorological Laboratory, and the University of Miami have comprehensively reviewed the wide array of water quality data collected in southern Florida, compiled comparable datasets, visualized trends in water quality data, and constructed a set of criteria for standards between monitoring programs that would allow for increased interoperability. Additionally, the research team conducted a targeted outreach campaign with the support of DEP to engage with individual water quality program managers to discuss improvements to data provision protocols to reduce bottlenecks. Specifically, discussions were centered on recommendations to improve DEP's Watershed Information Network (WIN) and Statewide Ecosystem Assessment of Coastal and Aquatic Resources (SEACAR) databases for managers uploading data and research team members retrieving aggregated datasets.

While the streamlining and automating of the unified water quality monitoring dataset process continues to be developed and improved, it is necessary to communicate the results and products of the analyses created during the first three project years. The research team released to the public a large number of products including trend analyses, data gap analyses, maps, and other data visualizations. However, the breadth of information provides an opportunity for the research team to support managers and practitioners who wish to incorporate unified water quality information into their decision-making processes. This includes the newly formed Florida's Coral Reef Coordination Team (FCRCT) - a multi-agency team created to "regionally integrate and coordinate management and restoration-related activities to conserve and restore Florida's Coral Reef", which requested technical support to examine datasets, indicators, and map layers created by the WQ research team.

We proposed providing technical support to the FCRCT to aid in the assessment of water quality trends and further streamlining data aggregation and processing. During the 4th year of this project, we updated the existing unified water quality monitoring database, parameter analyses, and web maps with new data and programs. We also informed and provided open-ended technical support at the FCRCT and FCRRP Water Quality team meetings to assist with interpretation of existing data products including GIS layers, data visualization tools, and data analyses. Further, we developed a free and open-source web-based data visualization tool that

allows for rapid, on-demand analysis and visualization of combined time series of water quality monitoring data from all project years. Finally, we provided guidance to identify future solutions to streamline and automate data processing by working with data providers and database managers to identify bottlenecks in data updates and retrievals. We identified a state-wide database to house the unified water quality database to streamline the data aggregation protocol and provide a 'one-stop-shop' for data users.

1.2. Methods

1.2.1. Updating the unified water quality monitoring database

Staff reviewed water quality monitoring programs to determine if previously included programs continued to meet inclusion criteria and if previously excluded programs now meet the same inclusion criteria. The five inclusion criteria were 1) sampled within South Florida 2) sampled at least four water quality parameters of interest 3) contained unique sampling data 4) active sampling and 5) have at least 5 years of continuous data. The water quality parameters of interest include Chlorophyll-a, nitrate (NO3), nitrite (NO2), nitrate + nitrite (NOx), ammonia (NH4), soluble reactive phosphorus (PO4), silica (Si), turbidity, total Kjeldhal nitrogen (TKN), total nitrogen (TN), and total phosphorus (TP). For programs which met these criteria, staff reached out to the contacts to get access to the processed 2023 data for existing programs and full datasets for new programs. These monitoring program partners were: NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML), FIU Southeast Environmental Research Center (SERC), Miami-Dade County Department of Environmental Resource Management (DERM), Florida Department of Environmental Protection (FDEP), Broward County (BC), City of Miami Beach (MB), FDEP Biscayne Bay Aquatic Preserves (BBAP), and Palm Beach County (added this project year for the first time in order to include water quality trends in the Lake Worth Lagoon at FDEP's request).

After the new data were received from each program, data from these monitoring programs along Florida's Coral Reef were processed using R scripts created and refined in years 1 through 4 of the water quality project. These scripts are used to standardize the naming conventions of each analyte, longitude and latitude formats, date format, and units. The R script combined all of the selected monitoring programs' data per analyte, organizing the data into a common format by location and temporally and splitting dates into year/month/day for later summarizing and visualizing manipulations. The scriptwriting process was extensive as many of the compiled programs had markedly different naming conventions for the same analytes, and different date/time formats between each other. Some programs had different data reporting methods depending on the year, so new code had to be written each time changes in reporting were detected. In year 3 script was also written to label sampling sites as active or inactive and programs as continuously sampling or not to help differentiate data to be used in trend analyses. The script allowed for the compiled data to be filtered and extracted from the database by date, source, or analyte for processing. Additional QA/QC was completed to ensure that all data were included in each merged database created per analyte, of all programs which sample each identified project water quality parameter, which include nutrient analytes and water clarity analytes. QA/QC also checked dates, coordinates, and for repeated observations.

Staff then conducted trend analyses on the processed and cleaned data using scripts developed in previous years and updated this project year. To identify "hotspots" and trends where water quality may be worsening over time (e.g., where turbidity is "increasing" over time), time series were extracted from each sampling location for each analyte and assessed

using a seasonal Mann-Kendall test following the methods in Millette et al. 2019. The Mann-Kendall test estimates the Theil-Sen slope, or the rate of change of a parameter over the period that data were collected.

To ease interpretation, we categorized the Theil-Sen slope, or rate of change, as generally increasing or decreasing for each parameter of interest (Chlorophyll-a, nitrate (NO3), nitrite (NO2), nitrate + nitrite (NOx), ammonia (NH4), soluble reactive phosphorous (PO4), silica (Si), turbidity, total Kjeldhal nitrogen (TKN), total nitrogen (TN), and total phosphorus (TP)), at each monitoring site.

Once the database was updated with the processed and cleaned 2023 data from existing programs and data from new programs and subsequent trend analyses, staff updated web maps, mapping applications, and additional visualization tools.

1.2.2. Open-ended technical advisory support for FCRCT and water quality meetings

Staff were asked to attend and provide open-ended technical support for the Florida's Coral Reef Coordination Team meetings during 2023-2024. Staff were on hand to present overviews and results of the water quality aggregation project and contribute to answering questions identified in the Unified Monitoring Framework for Florida's Coral Reef. Staff also attended Florida's Coral Reef Resilience Program Water Quality Team meetings to collaborate with water quality monitoring managers across FCR and contribute to the actions to meet the priorities of the FCRCT.

1.2.3. Data Visualization Tool

Project staff surveyed a suite of potentially useful data visualization tools that could be used as a model for creating the Data Visualization Tool (DVT) for this project. One tool in particular, published by the Tampa Bay Estuary Program, was well suited for the needs of this project and was completely open source, allowing staff to modify the code to create the DVT for this project. The code for the existing tool is written in R/shiny and is publicly available in a Github repository. Staff forked this repository and modified the R/Shiny code to create the tool for this project. In addition to individual water quality parameter files, all parameters in the unified water quality database are merged with all water quality parameters in one large .csv file. This .csv file was used as the input for the data visualization tool. However, prior to ingestion into the DVT, staff created a data report written in R/Quarto to assess the data by parameter and data provider prior to display. This allows users to "preview" the overall dataset and assess data metrics such as the number of observations (per parameter, per data provider and per sampling site) and histograms of all observations per parameter. This data report also informs how best to filter the data that is displayed on the DVT. For example, sampling locations that have less than 20 observations or no observations within the last calendar year are not shown in the initial version of the DVT. Outlier values based on a set of thresholds are also excluded from the DVT. However, these filters can be adjusted based on user needs. After review of the data report and the setting of filters, data was pushed to the DVT, which is described below in section 1.3.3. The DVT is based on the most recent version of the unified water quality database, which includes observations from 2023.

1.2.4. Long-term database solution

To develop a long-term database solution, staff looked at several options. One option is to continue to retrieve water quality data from providers in a manual way by contacting the

providers individually by email. This method has been used so far and has resulted in strong connections with data providers, who have been very accommodating in providing data. However, this is a manual and time-consuming process and project staff would like to move to a more automated approach.

Another option is to use the Watershed Information Network (WIN) database, which is administered by FDEP. The majority of the programs that provide data to the unified water quality database upload their data to WIN. Based on our discussion with data providers and the project team on May 19th, 2023, the WIN database in its current form largely meets the needs of data providers in terms of uploading of data. Data providers upload data to WIN quarterly after QC. Data providers are also able to update their data in the WIN database from time to time based on the subsequent discovery of data quality issues with previously submitted data. However, there are a number of issues with the WIN database, which were outlined in last year's project report on page 11. Most importantly, use of the WIN database is not compatible with our goal of an automated database solution that allows downloads of data via an Application Programming Interface (API) or other automated method. We corresponded with the FDEP's Division of Environmental Assessment and Restoration (DEAR) staff who administer the WIN database on several occasions with the goal of establishing a method to automatically retrieve data. These efforts were not successful, as DEAR staff stated that they were unable to provide an API interface or regular (quarterly) "data dumps" for the purpose of providing data for the unified database.

A third option is to use the Statewide Ecosystem Assessment of Coastal and Aquatic Resources (SEACAR) database, which is funded by FDEP but administered by the University of South Florida Water Institute. SEACAR is a collaborative effort to collect and serve out monitoring data from four habitats, submerged aquatic vegetation, coral reefs, oyster reefs, and coastal wetlands, and the associated water resources across Florida's state managed lands. SEACAR's Data Discovery Interface is the foundation of this effort, which collects, processes, and integrates long-term data from across a large number of monitoring programs. Thus, SEACAR is an invaluable tool for managers to compare habitats and sites across the state, track changes over time, and quickly access critical data for management decisions. Data from the majority of water quality monitoring data providers also goes into the SEACAR database. Staff met with the SEACAR team on February 27, 2024 to investigate the possibility of using SEACAR to access data from the data providers to then be compiled into the unified database. Based on those conversations, it will be possible to use the SEACAR database for a long-term database solution beginning during the next cycle of this project which begins in summer 2024. Further details on this database solution are provided below in section 1.3.4.

1.3. Results

1.3.1. Updates to the unified water quality monitoring database

In this project we compiled, collated, and mapped water quality data for the south Florida coral reef ecosystem by merging the sampling results from different monitoring partners. In FY 4, we added data from Palm Beach County's water quality monitoring program in Lake Worth Lagoon, in order to assess trends in this water body outlet to the reef and fill data gaps. The annually updated unified water quality databases for each analyte include all data collected from all monitoring partners in 2023. This project now included 8 actively sampling monitoring programs- four more than the first year of the project. In this project year, we also updated the

databases and web visualization tools to allow for selection and identification of trends by years within specific periods of time.

Some lessons learned in this year's effort were that it is important to check for changes to the formatting/type of analytes in the individual monitoring partner's yearly updated data, and emphasize to monitoring partners that any changes result in an inability to compare trends in analytes between years and compare with the larger merged and unified South Florida water quality database. It would be helpful to ensure that analyte naming conventions are standardized within WIN itself, perhaps as a drop-down menu option when monitoring partners enter each year's data, since this team has found multiple instances of analytes having slight differences in naming which causes problems when working with data in R. This project effort would benefit from a request by DEP as a funding agency to any funded monitoring partners, to upload their yearly data to WIN in a timely manner each spring, in order to allow for project analysis and tool building. It would also be helpful if DEP as the funding agency could emphasize the need to upload and share all years of current as well as historical data to WIN, rather than splitting it between WIN, SEACAR, and STORET. Future planned work on this project should help to resolve this issue.

The results of the 2023 update to the unified water quality database and trend analysis are available in a publicly accessible web map located at the link here: Water quality trends map

1.3.2 Open-ended technical advisory support for FCRCT and water quality meetings

In addition to the unified water quality databases per analyte, the trends analyses, the interpretation tools and annual reports, we proposed to make presentations to managers and water quality experts to discuss the purpose, tasks, and outcomes of the project.

Our project team was invited to attend and present an overview on our Unified Water Quality Monitoring work thus far to the Florida Coral Reef Coordination team on September 7th, 2023. Alexandra Fine (UM/AOML), Omar Ramzy (UM/AOML), Kelly Montenero (UM/AOML) and Luke McEachron (FWC FWRI) participated and presented. Luke McEachron (FWC FWRI) also presented to the Biscayne Bay Commission Meeting on September 7th, 2023.

Our project team was invited to attend and present at the Development Workshop for the Biscayne Bay and Reef Observation, Interpretation and Prediction System (BBROIPS), on October 25th, 2023. Omar Ramzy (UM/AOML) gave a presentation on our project's goals, background, and outcomes, and shared information on the trend analyses, sampling locations, lessons learned and the capabilities of the water quality web map. The group then discussed similarities, overlap, collaboration points, and differences between the BBROIPS effort and our unified water quality monitoring work. Kelly Montenero (UM/AOML) and David Kochan (FWC FWRI) were also in attendance.

Our project team also was invited to join the FCRRP Research Priority Development Meeting on November 8th, 2023. The focus of our team's participation in this meeting was to discuss incorporating water quality monitoring into coral disease response initiatives and identify research priorities. Alexandra Fine (UM/AOML), Chris Kelble (NOAA AOML), David Kochan (FWC FWRI) joined this meeting.

Our project team also participated in the FCRCT meeting on November 29th, 2023. This virtual meeting discussed and reviewed the final draft of the framework, and our project team members considered where and how our project outcomes and scope of work align with water

quality framework tasks. Alexandra Fine (UM/AOML), Chris Kelble (NOAA AOML), and David Kochan (FWC FWRI) were in attendance.

Our project team was invited to participate in a meeting of the Florida Keys National Marine Sanctuary's Water Quality Protection program also, in the morning of November 29, 2023. David Kochan (FWC FWRI) and Alexandra Fine (UM/AOML) were in attendance.

Our team was invited to attend and present at a meeting of the FCRCT on March 22nd, 2024. David Kochan (FWC FWRI) gave a team presentation on the objectives of our unified water quality monitoring project and gave an overview of the functionality of the project's tools, including the merged water quality database, trend analyses, web maps, story maps, and dashboards from the previous three years of this project effort.

Following the FCRRP Research Priority Development Meeting, bi-weekly to monthly WQ team meetings were established to provide updates and continue developing the action plan document. David Kochan (FWC FWRI) attended meetings on January 12, January 29, February 12, February 23, March 8, and May 17, 2024.

1.3.2. Data Visualization Tool

As described in section 1.2.3, two platforms were developed related to the DVT. One is the data report along with the DVT itself. URL links to both are here:

Data report:
https://usf-imars.github.io/dep-wq-data-report/data_details.html

DVT:
https://7yl4r.shinyapps.io/wq-dash/

The source code for both platforms is also available:

Source code for data report:
https://github.com/USF-IMARS/dep-wq-data-report

Source code for DVT: https://github.com/USF-IMARS/fl-coral-reef-fcr-water-quality-dashboard

An example screenshot of the DVT is shown below in Figure 1.

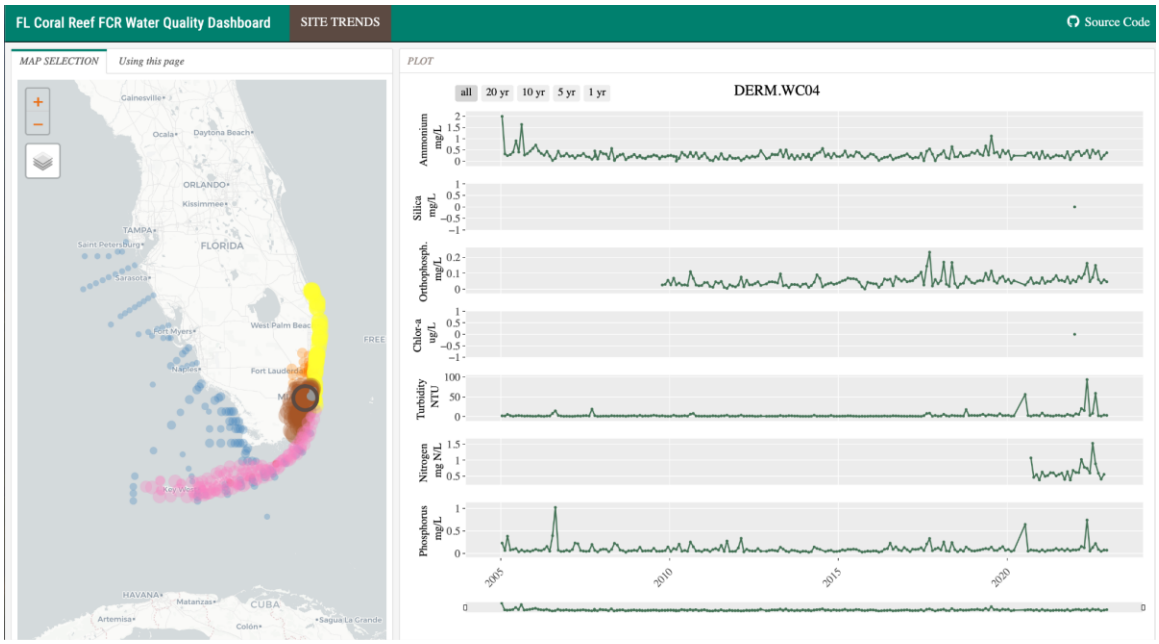


Figure 1. Screenshot of the Data Visualization Tool developed for this project. At left is a map of South Florida with sampling locations from each data provider. Users can zoom and pan the map using the mouse. A particular location is selected by clicking on it and that location is then shown circled in brown. At right is a set of time series from the selected location. Users can hover over a time series to see actual sampled values and adjust the time period shown by selecting a portion of any of the time series. The time range of the x-axis can be adjusted with the time sliders on the bottom reference plot or by clicking and selecting a portion of one of the time series.

The data report shows a set of overall metrics of the unified database related to sampled parameters, sampling sites and data providers. There are six tabs: “Home”, “SitesQC”, “Data Provider Reports”, “WQ Parameter Reports”, “Data Details” and “Source Code on Github”. Users can navigate through these tabs to see information on what fields are in the database, the number of observations (per site, per provider and per parameter), and a histogram of values per water quality parameter.

As shown in Figure 1, the DVT consists of two main parts. There is a map at left which can be panned and zoomed to look closely at a user’s area of interest. Users can select sampling locations by clicking with the mouse to see time series at a particular location. Once the user selects a sampling location, time series at that location will appear to the right of the map. Since not all data providers collect all listed parameters, some time series will not contain data at certain locations. Users can also adjust time ranges on the x-axis, by clicking on any plot and dragging the mouse pointer over the desired time range. The plot on the very bottom is a reference plot for the relative zoom on the x-axis. Time ranges can also be adjusted with the sliders at each end of this plot. The time series are linked, so if the time range is adjusted on one of the time series, all of the time series will show the same time range. There is also a tab with explanatory text and site navigation instructions above the map.

1.3.3. Long-term database solution

Since the SEACAR team and the unified database WQ team collect and process data from similar data streams and SEACAR allows for automated downloads of data, the SEACAR

database is the best long-term option for this project to automate and streamline the process of data compilation and QA/QC. During the next cycle of this project, staff will work with SEACAR to download data from individual providers, run QA/QC checks to remove suspect data and compile the data into a merged format. In turn, the unified water quality database, mapping data, and data visualization tools will be integrated into the data discovery portal. To ensure that data users understand that the unified database is aggregating existing data and not collecting new data, the database and associated products will be placed in a separate 'tab' on the portal with clear documentation and explanation. Currently, the majority of data providers upload data to SEACAR. Staff will work with new data providers or current data providers that do not provide data to SEACAR to move their data into SEACAR on a regular basis, annually at a minimum. Staff will manually compile data from any current or future data providers that do not upload data to SEACAR. The partnership with the SEACAR team will provide two main advantages for this project: the ability to download water quality data in an automated fashion and a publicly accessible repository for the unified water quality database and the suite of tools that have been developed over the course of the project. Further, SEACAR will be able to incorporate the QA/QC processes developed by the WQ team into their data ingestion pipelines for statewide data. By leveraging the WQ QA/QC process, new data uploaded into SEACAR will undergo more rigorous checks while also increasing potential compatibility with other programs. Most importantly, SEACAR is already well known by managers and stakeholders, and integrating the unified database will allow the WQ team to maintain a 'one-stop-shop' for the database and associated products in a location that is already regularly accessed.

1.3.4. Final Deliverables

The following deliverables were provided to Florida DEP for the 2023-2024 Water Quality project:

- Copies of presentations from FCRCT meetings
- Copies of all products produced at the request of the FCRCT and relevant sub-teams.
- Updated water quality database and data products with 2023 monitoring data from every program
- Link to functioning data visualization tool, any relevant scripts, and a summary of capabilities and functions
- Notes, agendas, and participant lists from all meetings. Copies of any presentations provided as PowerPoint or PDF files

Any deliverables not included in this report can be publicly accessed by emailing flcoralfunding@floridadep.gov.

1.4. Discussion and Management Recommendations

This project was motivated by the need to easily understand water quality patterns at different spatial and temporal scales along Florida's Coral Reef, , and to ultimately assess the effect of efforts to improve water quality locally. The need to aggregate and visualize data from different observing programs, and an analysis of water quality hotspots, trends, and data gaps, were identified among the management goals of the Florida Keys National Marine Sanctuary (FKNMS) and as a priority within the sanctuary's Water Quality Protection Program (WQPP), co-chaired by the US Environmental Protection Agency (EPA) and the Florida Department of Environmental Protection (DEP).

The completion of year 4 of the water quality monitoring data aggregation project has continued addressing the need to understand the patterns of water quality across the FCR as well as providing an overview of the spatial and temporal extent of monitoring activities. Using protocols developed in previous project years, the water quality team created updated web maps and new visualization tools to display nutrient trends. Critically, these maps identify areas of the FCR with significant trends, showing hotspots of declining water quality that may result in a localized disturbance to the reef. Further, the development of the new DVT provides a way to examine the time-series data at a single site, which was lacking in visualizations from previous years that were focused on depicting spatial patterns. Researchers and managers now have products that are capable of quickly visualizing spatial and temporal trends. Additionally, with the water quality team identifying the SEACAR Data Discovery Interface as a database solution, the unified water quality database and associated visualization products will have a long-term 'one-stop-shop' for FCR water quality data.

The water quality team was able to use the four years of experience with the unified water quality monitoring database to provide technical advisory support to major initiatives for the management of the FCR. Staff attended meetings of and presented to the FCRCT, which is working to develop a comprehensive framework to monitor water quality on the reef with the specific goal of detecting changes in water quality resulting from Everglades restoration. The unified water quality monitoring database provided critical information on the current extent of comparable water quality monitoring, the challenges of aggregating and integrating different datasets, and the gaps in spatial, temporal, and protocol necessary to detect those types of changes. Staff also worked with the FCRRP Water Quality team, which was tasked with addressing a series of actions identified by the FCRCT priority document. Specifically, the results from the unified water quality monitoring database were a major component of 'Coordinated Action 1: inventory existing water quality monitoring programs along Florida's Coral Reef and nearshore coastal waters of South Florida.' Additionally, the unified water quality monitoring database provided a template and protocol for addressing 'Coordinated Action 2: inventory existing biological or ecological monitoring programs related to FCR and associated resources within the South Florida ecosystem' and critical data for 'Action 3: develop a list of appropriate parameters for monitoring FCR and associated resources within the South Florida ecosystem.'

The unified water quality monitoring database and data visualization products provide crucial information for researchers and managers across Florida's Coral Reef and the nearshore resources of South Florida. Researchers have contacted the water quality team to access the database and requested notification of any updates for projects that include tracking coral health in the ECA and inclusion in a future FCR management decision support system. Staff have been invited to present to the Gulf of Mexico Alliance Data and Monitoring team, who were preparing to contract a project to conduct similar water quality aggregation efforts across the Gulf of Mexico. The lessons learned from this water quality project were helpful in designing a work plan, highlighting priorities, and identifying potential challenges for the Gulf of Mexico water quality project. In summary, the FCR water quality aggregation project has made it easier for scientists to integrate water quality data into their research, provided critical information to address FCRCT and FCRRP priorities and actions, and developed products for scientists, managers, and the public to visualize spatial and temporal water quality trends across Florida's Coral Reef.