Coordinated monitoring of the Piney Point wastewater discharage into Tampa Bay: Data synthesis and reporting

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From March 30th to April 9th, 2021, an estimated 215 million gallons of wastewater from the Piney Point phosphogypsum stacks were released into Tampa Bay to avoid catastrophic failure of the holding ponds. Ammonium concentrations in the wastewater were measured in excess of 200 mg/L and it was estimated that ~205 tons of total nitrogen were exported to Lower Tampa Bay, exceeding typical annual nitrogen load estimates in a matter of days. In response to these events, a coordinated environmental monitoring effort consisting of multiple government, university, and private sector partners began to assess conditions of surface waters around Piney Point to understand conditions prior to, during, and after the wastewater release. These efforts included sampling of surface water chemistry, surveys of algal community response, assessments of wastewater contaminants, and biological surveys of seagrass, macroalgae, benthic, and nekton communities. This resulted in many disparate data sets coming from multiple sources, which required the use of robust synthesis methods for assessment of current conditions, comparisons with the decades of baseline data available in Tampa Bay, and development of forward-facing reporting products to convey results of field sampling in near real time. This talk will discuss the open-source tools that were used to synthesize the environmental monitoring data, the online dashboard that was developed to report the data, and how these products were used to inform management response to rapidly changing environmental conditions. The specific challenges in combining data, both from a technical and philosophical perspective, will also be discussed as lessons learned from the Piney Point experience to inform future event-based monitoring responses, both in Tampa Bay and elsewhere.

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# Introduction

* Piney Point background
* Monitoring response
* Challenges with data synthesis and need for rapid assessment tools, TBEP commitment to OS

This paper describe the data synthesis and communication tools that were used during the 2021 Piney Point release into Tampa Bay, Florida. We focus specifically on the open science methods and products that were created to organize, contextualize, and communicate these data, including the Piney Point environmental monitoring dashboard developed by the Tampa Bay Estuary Program to rapidly deliver results for data collected in near real-time. A discussion of the technical and philosophical challenges of synthesizing data from multiple disparate sources, as well as the lessons learned, is also provided to inform future response-based monitoring efforts.

# Data collection and synthesis

Monitoring of bay resources in response to release from Piney Point began in late March of 2021 and continued through the summer and early fall. Dozens of local and state institutions conducted monitoring of water quality, phytoplankton (including the red tide organism *Karenia brevis*), seagrasses, macroalgae, and benthic habitats. Monitoring partners included the Florida Department of Environmental Protection (FDEP), Environmental Protection Commission (EPC) of Hillsborough County, Parks and Natural Resources Department of Manatee County, Pinellas County Division of Environmental Management, Fish and Wildlife Research Institute (FWRI) of the Florida Fish and Wildlife Conservation Commission (FWC), City of St. Petersburg, Tampa Bay Estuary Program (TBEP), Sarasota Bay Estuary Program, Environmental Science Associates, University of South Florida, University of Florida, and New College of Florida (Figure 1). Coordination among monitoring agencies was facilitated by the TBEP and under guidance of a plume simulation model run by the Ocean Circulation Lab at the University of South Florida (USF), College of Marine Science ([Chen et al. 2018](#ref-Chen18), [2019](#ref-Chen19)). Initial effort was focused near the release site at Port Manatee (Figure 1), but later expanded throughout middle and lower Tampa Bay, Boca Ciega Bay, Manatee River, and Sarasota Bay as the simulation model predicted dispersal of the plume elsewhere ([Liu et al. 2021](#ref-Liu21)). Sampling effort was most intense in April, with less frequent sampling from May through September, although seagrass and macroalgae sampling was consistent throughout the study period (Table 1).

Water quality monitoring focused on parameters that were expected to indicate a response to elevated nutrient loads from the release from Piney Point. Because Tampa Bay is a nitrogen-limited system ([Wang et al. 1999](#ref-Wang99); [Greening & Janicki 2006](#ref-Greening06); [Greening et al. 2014](#ref-Greening14)), water quality samples were processed for total nitrogen and inorganic forms (i.e., total ammonia nitrogen, nitrate/nitrite), chlorophyll-a as an indication of phytoplankton growth, and additional parameters expected to respond to nutrient loading (e.g., secchi depth, dissolved oxygen). Phytoplankton monitoring included both qualitative (presence/absence) and quantitative (cells/L) summaries of taxa enumerated by microscopy from water samples taken at similar frequency and distribution as the water quality sites. Phytoplankton data also included event-based sampling for *Karenia brevis*. Finally, seagrass and macroalgae data were collected by transect sampling at locations on the southern shore of Tampa Bay near Piney Point. Transect sampling included identification of seagrass species and macroalgae, typically to genus, and Braun-Blanquet abundance estimates at 10 m distances along each 50 m transect. Details on all sampling methods are provided in Beck et al. ([2022](#ref-Beck22)).

The synthesis of data from multiple partners included several challenges that TBEP staff addressed by employing open science principles within the time and resource limitations of the event. First, a centralized location for sharing data was required as a starting location for the synthesis effort. Partner agencies were requested to voluntarily upload their data to a publicly accessible Google Drive folder, or share via email with TBEP staff for upload if access issues to the main drive were encountered. Datasets were also downloaded by TBEP staff from source (e.g., FDEP, <https://floridadep.gov/dear/dear/content/tampa-bay-sampling-response-and-results>) and uploaded to the Google Drive. Although more formal data hosting services that included full metadata

* Synthesis workflow Figure 2
  + Challenges - multiple streams, messy AF
  + Solutions - centralized data uploads, R tools for synthesis (import, testing, app integration)
  + Sorta unified data structure (but see metadata section)
* Repository setup - synthesis and app, Beck ([2021](#ref-Beck21d))

# The Piney Point Dashboard

## Setup

* App creation and hosting, Figure 3, Beck et al. ([2021](#ref-Beck21c))
* App structure - backend
  + R/dat\_proc.R to data folder, logs
  + Testing why and how (testthat, GitHub Actions)
  + Rmarkdown w/ flexdashboard: Dependencies/globals, reactives, UI setup with text descriptions and dynamic inputs
  + CSS styling
  + Google Analytics js
* App structure - frontend
  + Landing page
  + Current data
    - Water quality results
    - Algal surveys
    - Seagrass/macroalgae
    - Contaminants
    - Benthic
  + Baseline data
    - Water quality
    - Seagrasses

## Analytics

* Analytics and where it was linked (e.g., DEP, myfwc), note analytics did not start until May 13th, 2021
  + Average time spent on app, mobile vs desktop (go to analytics to get this)
  + Total users over time (from Google Analytics), Figure 4
  + Users by geographic location (country, state, city), Table 2

# Data Archive

* Rationale, maybe make relative to past PP events (no data) and highlight importance of metadata
* Workflow and GitHub repository
* EML, KNB location, download stats

# Discussion

* Added value of the app
  + analytics speak for themselves, but not the whole picture. How did users get to our dashboard (some of this info is in Analytics, but which of our comms products drove the bus)? How was it used (e.g., screenshots for pres, K. Hubbard pers. comm.)?
  + how can we better assess the value of these tools more holistically? What is the true measure of success in terms of behavior change or driving policy, if any?
* Relevant considerations
  + What worked - use of OS tools, but still very time-consuming (e.g., R/dat\_proc.R is thousands of lines of code)
  + Need for unified datasets, use of tidy principles, etc. Also mention that this relied on partners sending us data/putting data on GDrive, not everyone did that (note issues with the latter, i.e., access from elsewhere can be unreliable, but we also didn’t have all the data). Highly value of partnerships - data collection and sharing.
  + Value of historical data and contextualized summaries
  + Exposure of additional data needs (e.g., macroalgae)
* Future of Piney Point, next steps, etc.

# Figures

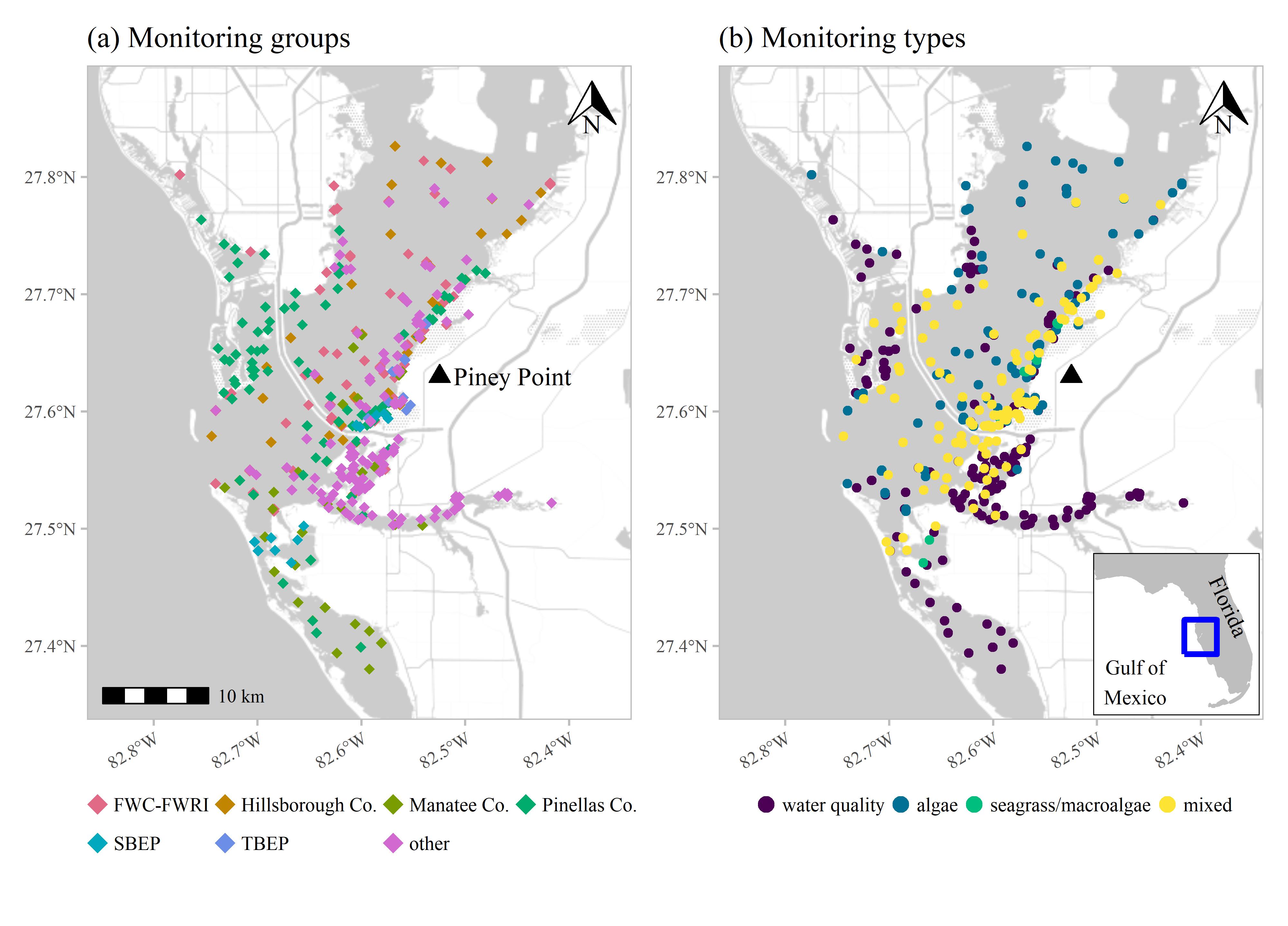


Figure 1: Response-based monitoring effort near Piney Point from March through September 2021 with (a) effort by monitoring group and (b) monitoring data type. Monitoring groups included City of St. Petersburg, Environmental Science Associates, Florida Department of Environmental Protection, Fish and Wildlife Commission, Fisheries and Wildlife Research Institute (FWC-FWRI), Hillsborough Co., Manatee Co., New College of Florida, Pinellas Co., Sarasota Bay Estuary Program (SBEP), Tampa Bay Estuary Program (TBEP), University of Florida, and University of South Florida. Monitoring data included algae sampling, seagrass and macroalgae, water quality (field-based and laboratory samples), and mixed monitoring (algae, seagrass and macroalgae, water quality). Inset shows location of Tampa Bay on the Gulf coast of Florida, USA.

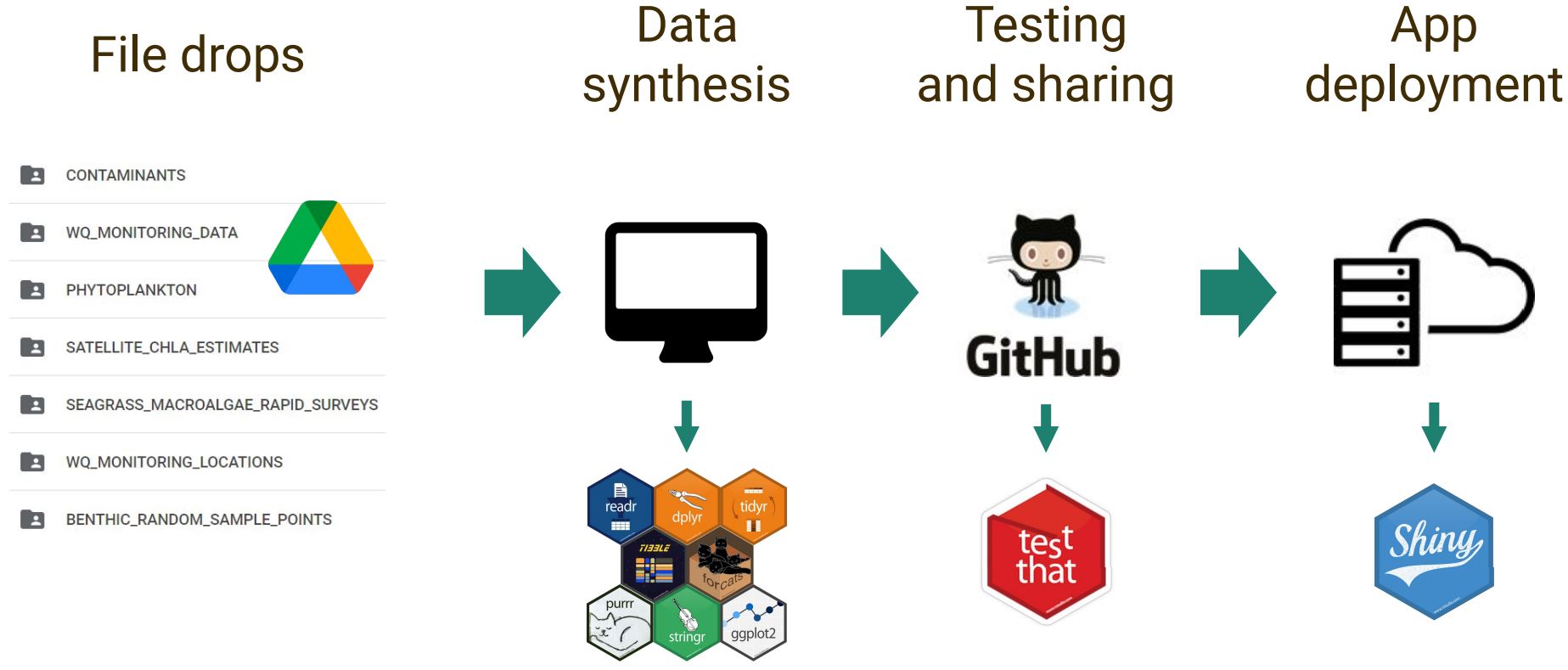


Figure 2: Data synthesis workflow for Piney Point data. Raw data were uploaded by partners to Google Drive, data were synthesized using R-based tools, data and dashboard code were uploaded in a unified format on GitHub that included automated testing, and then the app was deployed using Shiny Server.

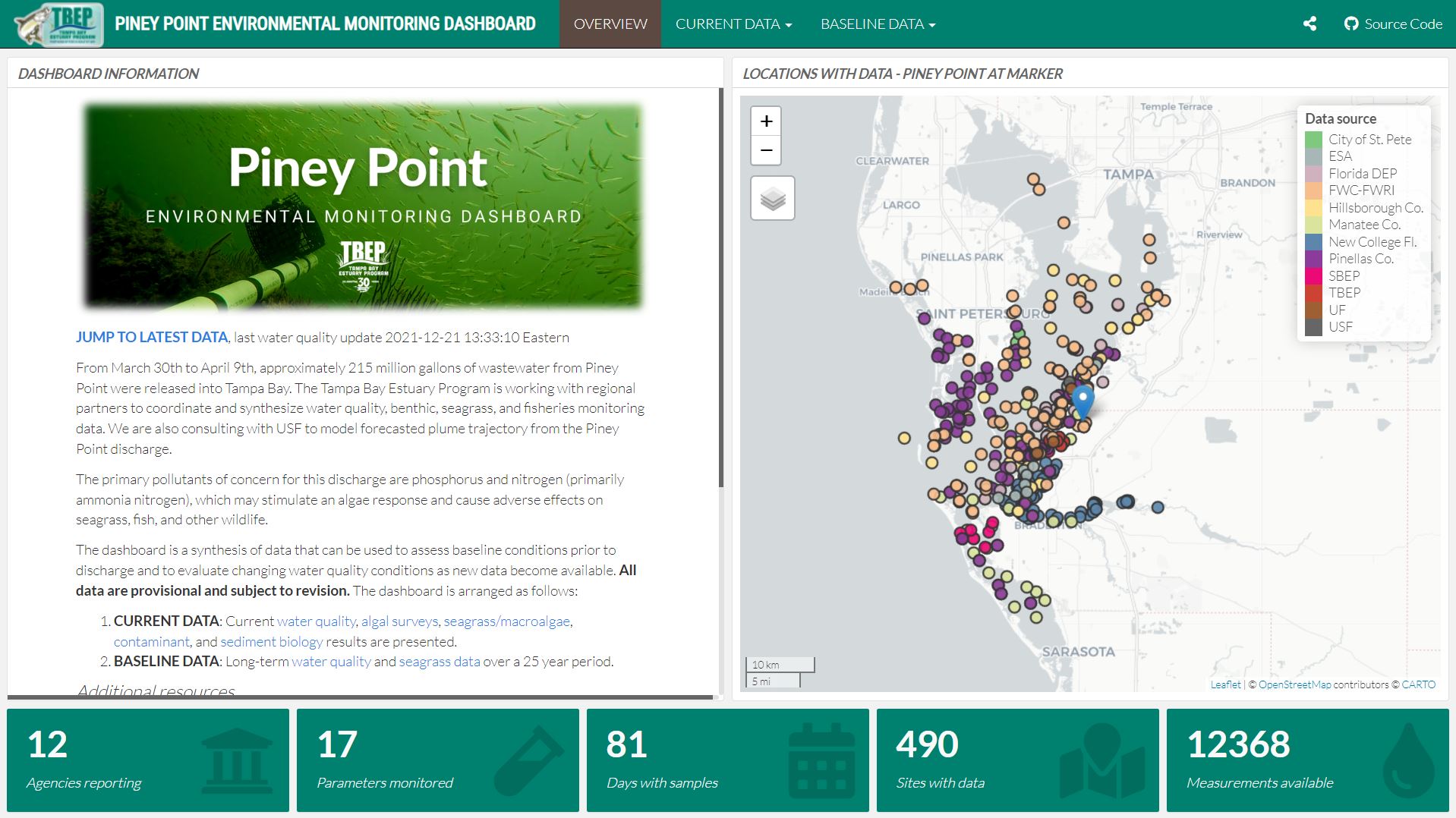


Figure 3: Landing page for the Piney Point dashboard. Users can view a summary of effort to date and access additional tabs to view specific datasets.

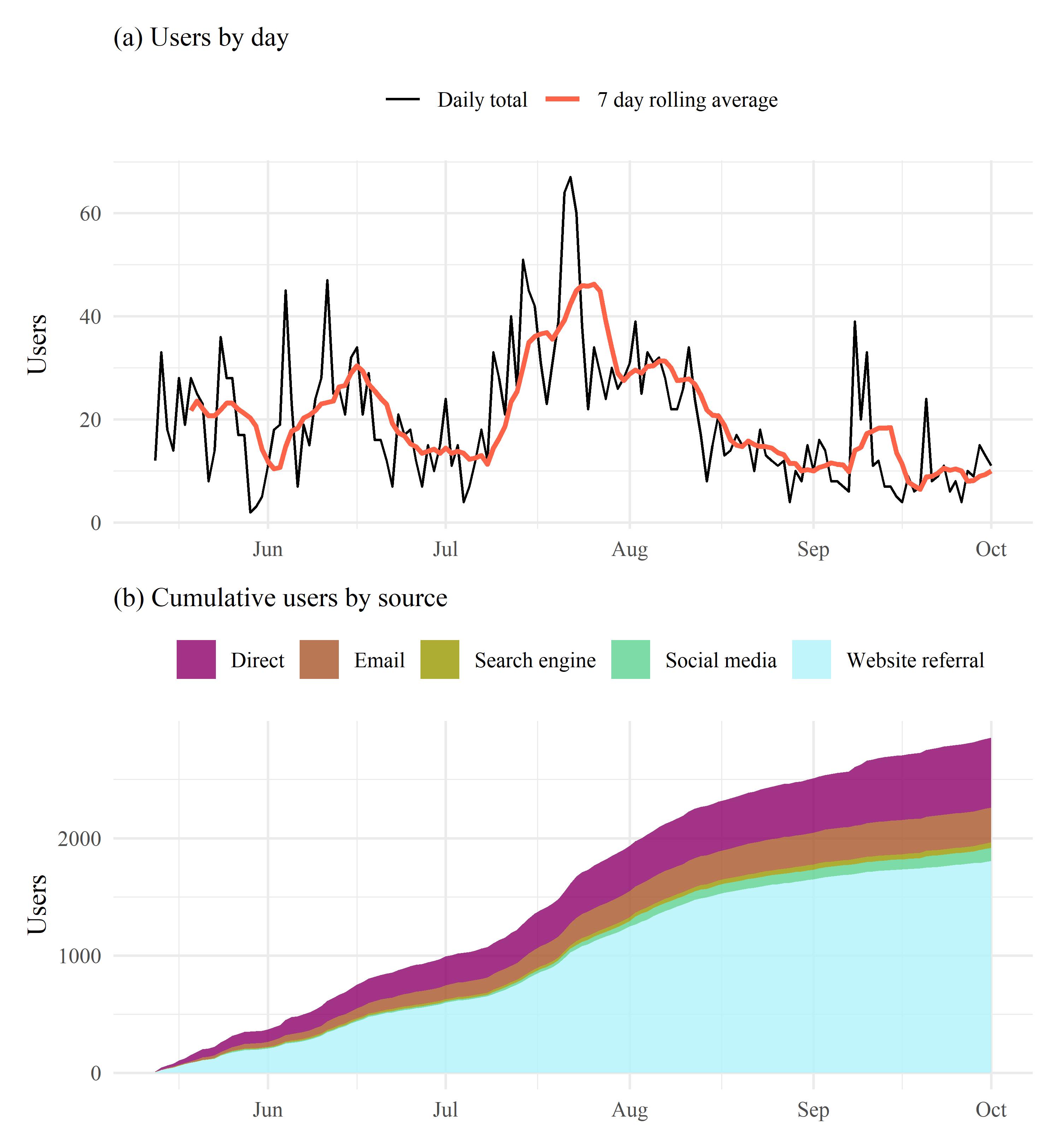


Figure 4: Piney Point dashboard (a) users by day and (b) cumulative users by source. Source refers to how users accessed the dashboard (e.g., direct URL to the dashboard, email links, etc.). Analytics were included in the dashboard beginning on May 13th, 2021.

# Tables

Table 1: Sampling effort for response-based monitoring by partners from April 1st 2021 through September. Values show the total number of unique sites samples for water quality, algae (phytoplankton), and seagrass/macroalgae in Tampa Bay. Values in parentheses show the percentage of the total for each monitoring type.

| Month | Water Quality | Algae | Seagrass/macroalgae |
| --- | --- | --- | --- |
| Apr | 223 (45.1) | 181 (41.8) | 30 (17.4) |
| May | 82 (16.6) | 62 (14.3) | 36 (20.9) |
| Jun | 55 (11.1) | 40 (9.2) | 35 (20.3) |
| Jul | 60 (12.1) | 54 (12.5) | 18 (10.5) |
| Aug | 43 (8.7) | 49 (11.3) | 28 (16.3) |
| Sep | 31 (6.3) | 47 (10.9) | 25 (14.5) |

Table 2: Top ten locations of users by city, state, and country for the Piney Point dashboard. Numbers show the total users and percentages from the total for all locations. Total cities, states, and countries that accessed the dashboard are shown in the column headers in parentheses. Summaries are from May 13th, 2021 when analytics were included in the dashboard to October 1st, 2021.

| City (654) | Users | State (70) | Users | Country (19) | Users |
| --- | --- | --- | --- | --- | --- |
| St. Petersburg | 325 (11.4) | Florida | 2005 (69.9) | United States | 2812 (98.3) |
| Tampa | 282 (9.9) | California | 107 (3.7) | Canada | 11 (0.4) |
| Bradenton | 81 (2.8) | New York | 65 (2.3) | United Kingdom | 9 (0.3) |
| Largo | 68 (2.4) | Texas | 57 (2) | Germany | 8 (0.3) |
| Orlando | 66 (2.3) | Georgia | 56 (2) | Finland | 3 (0.1) |
| Clearwater | 52 (1.8) | Ohio | 44 (1.5) | India | 3 (0.1) |
| Roseville | 49 (1.7) | Illinois | 36 (1.3) | Ireland | 2 (0.1) |
| Pinellas Park | 46 (1.6) | Pennsylvania | 35 (1.2) | Netherlands | 2 (0.1) |
| Sarasota | 43 (1.5) | Indiana | 31 (1.1) | Spain | 2 (0.1) |
| Miami | 42 (1.5) | Virginia | 27 (0.9) | Australia | 1 (0) |

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