Supplement to Initial estuarine response to the nutrient dense Piney Point wastewater discharge into Tampa Bay, Florida

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# History of Piney Point

The Piney Point facility in Palmetto, Florida was established in 1966 by the now defunct Borden Chemicals company near Port Manatee on the southeast shore of lower Tampa Bay. Port operations were primarily for export of phosphate production by the plant. Numerous environmental issues were observed in these early years, including suspected wastewater contamination in nearby Bishop Harbor, groundwater contamination from industrial solvents, and air pollution from plant emissions ([Henderson, 2004](#ref-Henderson04)). Ownership of the facility was transferred to different companies over the course of operation and in 1993 the plant was acquired by Mulberry Phosphates, Inc., which also owned a mining facility in Mulberry, Florida to the north. In 1997, 204 million liters of phosphate mining process water from the Mulberry plant spilled into the Alafia River, the second largest tributary to Tampa Bay, killing 1.3 million fishes and impacting 153 hectares of wetland habitat.

The Mulberry corporation filed for bankruptcy in 2001, transferring regulatory oversight of the Piney Point facility to FDEP. Although phosphate production no longer occurred at the site, focus over the next twenty years centered on containment and treatment of wastewater on-site to minimize environmental impacts. Despite these efforts, reduced holding capacities and degraded physical integrity of the holding ponds likely contributed to discharge events to surficial and ground waters. Tropical storm Gabrielle in 2001 produced 33 centimeters of rain, causing over 38 million liters of wastewater to be released into Bishop Harbor, with an estimated 14 metric tons of nitrogen (pers. comm. D. Eckenrod to USEPA, Nov. 28, 2001). Species of phytoplankton associated with harmful algal blooms were observed around this time ([Garrett et al., 2011](#ref-Garrett11)). From November 2003 to October 2004, treated process water from Piney Point was discharged to Bishop Harbor to further reduce the likelihood of an uncontrolled spill. [Switzer et al.](#ref-Switzer11) ([2011](#ref-Switzer11)) reported minimal impacts to nekton communities, although macroalgal blooms of *Ulva spp.* and *Gracilaria spp.* were observed as a potential indication of nutrient eutrophication. Around the same time, 939 million liters of wastewater from Piney Point were barged 193 kilometers offshore to the Gulf of Mexico to reduce strain on the holding capacity of storage ponds ([Hu and Muller-Karger, 2003](#ref-Hu03)). Efforts for onsite treatment were also increased during this period to increase pH, remove heavy metals, and reduce nutrient concentrations to minimize impacts of discharge to local areas.

HRK acquired Piney Point in August 2006 through an administrative agreement with FDEP. This agreement transferred responsibility of the site to HRK with the intention that any future uses must protect and be compatible with the integrity of stack closure and long-term care. In 2011, HRK agreed to the storage of 1.1 million cubic meters of dredged material and seawater from Port Manatee to improve shipping capacity at the port (i.e., Berth 12 construction). This material was added to an existing gypstack at Piney Point. Placement of the dredged material was suspected in compromising the liner integrity which led to an emergency discharge that released 640 million liters of dredged saltwater slurry and 3.2 metric tons of nitrogen to receiving waters leading to Bishop Harbor. The dredging and deposit of slurry at Piney Point continued following structural fortifications to the holding stacks to ensure integrity with additional loadings. HRK maintains ownership and responsibility of the site to present day with oversight by FDEP.

# Sampling methods

Established laboratory and field sample protocols for all survey methods were based on an [Interagency Monitoring Project Plan](https://drive.google.com/drive/u/0/folders/1oBGvjdve-Gpo4Kn3Ovn8a8-yVoP25eec) maintained by the TBEP in agreement with USEPA standards and those of the inter-agency partners. To the extent possible, data quality objectives followed guidelines outlined in the TBEP Data Quality Management Plan ([Sherwood et al., 2020](#ref-tbep1620)). Many of the local partners also participate in the Southwest Florida [Regional Ambient Monitoring Program](https://tbep.org/our-work/boards-committees/technical-advisory-committee/#ramp) that ensures similar standards and protocols are followed in the collection of monitoring data, including routine cross-reference of samples between laboratories to check precision of measured values. Discrete water quality samples were taken primarily from surface grabs by boat and processed by the respective laboratories of each participating agency. For this paper, we focus on parameters related to the Tampa Bay nutrient management paradigm and the expected phytoplankton response from a dense, inorganic nitrogen plume entering the bay. This included evaluation of total nitrogen (mg/L), total ammonia nitrogen (NH + NH, mg/L), nitrate/nitrite (NO + NO, mg/L), total phosphorus (mg/L), orthophosphate (PO, mg/L), and chlorophyll-a (ug/L) concentrations. Samples for pH, salinity (psu), temperature (^o C), and dissolved oxygen saturation (%) were also evaluated given the role these parameters can have as indicators of wastewater contamination (pH), physical drivers of primary production (salinity, temperature), and indicators of primary production and respiration (dissolved oxygen, mg/L). Overall, sample effort was variable given agency resources at the time of the discharge event and over the next few months. As appropriate, water quality data were aggregated at the weekly scale and by major areas of interest (Figure 1a) given the hypothesized impacts adjacent to the discharge site as indicated by the TBCOM tracer model simulated plume patterns. These areas of interest were delineated based on proximity to Piney Point, the main shipping channel in the bay, inflow boundaries (e.g., Little Manatee River), location of the Skyway Bridge at the mouth of Tampa Bay, and major segments of Tampa Bay used by TBEP for assessing programmatic goals.

Phytoplankton samples were also collected by multiple partners and included a mix of quantitative samples enumerating major taxa by cell concentrations and qualitative presence/absence samples. Taxa were aggregated into major groups of interest for Tampa Bay, with a focus on diatoms (Bacillariophyta and other centric taxa), as common primary producers observed throughout the growing season, and species associated with harmful algal blooms (HABs), as a potentially adverse outcome of these species outcompeting others in response to nutrient inputs from Piney Point. Evaluation of HABs data included specific focus on the red tide organism *Karenia brevis* that can occur in the bay depending on salinity and temperature conditions during the growing season. Occurrence of this species has historically been spatially distinct, with blooms originating in subsurface water offshore on the West Florida Shelf ([Liu et al., 2016](#ref-Liu16); [Steidinger, 1975](#ref-Steidinger75); [Weisberg et al., 2019](#ref-Weisberg19), [2014](#ref-Weisberg14)) and occasionally occurring at bloom concentrations in lower and middle Tampa Bay. Data for *K. brevis* were also obtained from event-based monitoring samples collected by FWC and available from a joint FWC-USF short-term red tide tracking product (<http://ocgweb.marine.usf.edu/hab_tracking/wfcom_hab.html>) and from the Harmful Algal BloomS Observing System ([HABSOS](https://habsos.noaa.gov/)). Because of the increased occurrence of red tide in July following the emergency discharge, fish kill reports from FWC were also evaluated in relation to key municipalities (Tampa, St. Petersberg) impacted by the event. Fish kill reports were obtained from the FWC [online database](https://public.myfwc.com/fwri/FishKillReport/searchresults.aspx).

Seagrass and macroalgae transect samples were collected approximately biweekly at locations around Piney Point from April to early October 2021. Each year, the TBEP coordinates inter-agency sampling among regional partners at over sixty fixed locations throughout the bay ([Sherwood et al., 2017](#ref-Sherwood17)). Because of the time-sensitive nature of the potential impacts of wastewater on seagrasses near Piney Point, the sampling protocol used at the routine monitoring locations was modified as a “rapid survey” design to sample seagrasses and macroalgae along fifty meter transects at several of the long-term monitoring sites, as well as new locations selected along the shore and small subembayments (e.g., Bishop Harbor) to provide a more comprehensive coverage of the seagrass community near Piney Point. Seagrasses and macroalgae were identified and abundances were estimated using Braun-Blanquet cover-abundance estimates within a 0.25 m quadrat at 10m distances along each transect. Dominant seagrass species in the bay include *Halodule wrightii*, *Syringodium filiforme*, and *Thalassia testudinum*. Other seagrass species (i.e., *Halophila spp.*, *Ruppia maritima*) were also observed but were present at much lower abundances and were not evaluated herein. Macroalgae taxa were aggregated by major group (i.e., red, green, and cyanobacteria) based on expected responses to nutrient pollution. Seagrasses and macroalgae abundances were converted to frequency of occurrence estimates (i.e., number of locations present divided by total locations sampled) at the transect scale or within major areas (Figure 1a) depending on the analysis described below.

# Figures

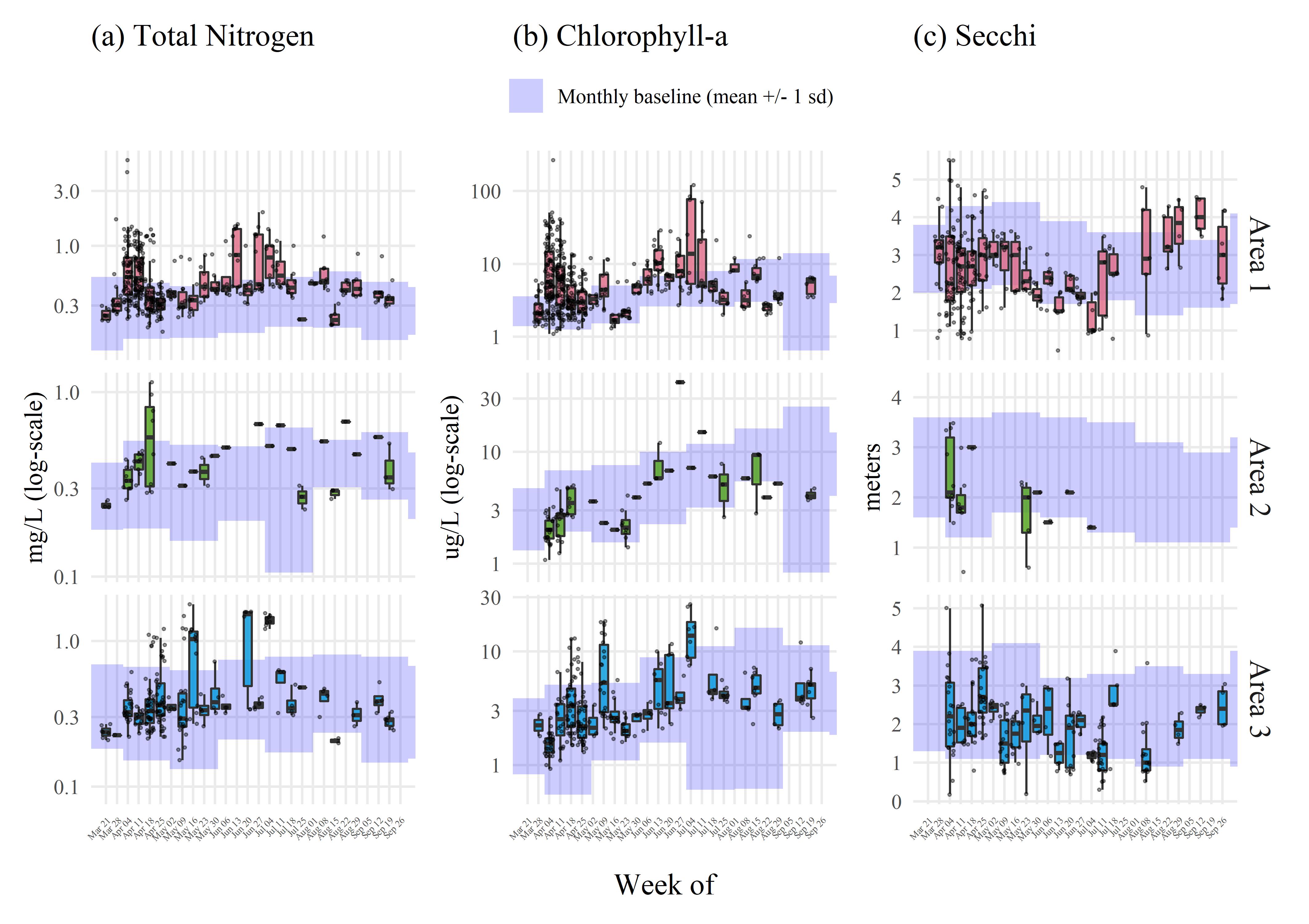


Figure 1: Sampled water quality data by week for April to July 2021 in response to wastewater discharge from Piney Point for (a) total nitrogen (mg/L), (b) chlorophyll-a (ug/L), and (c) secchi disk depth (meters). Observations are aggregated by week and within assessment areas shown in Figure 1a. Normal ranges for the month of observation (monthly baseline) and area are shown by the blue shaded areas. Normal ranges are defined as within +/-1 standard deviation of the mean for the month of observation from 2006 to 2021 for values collected at long-term monitoring sites within each area (Figure 1a).

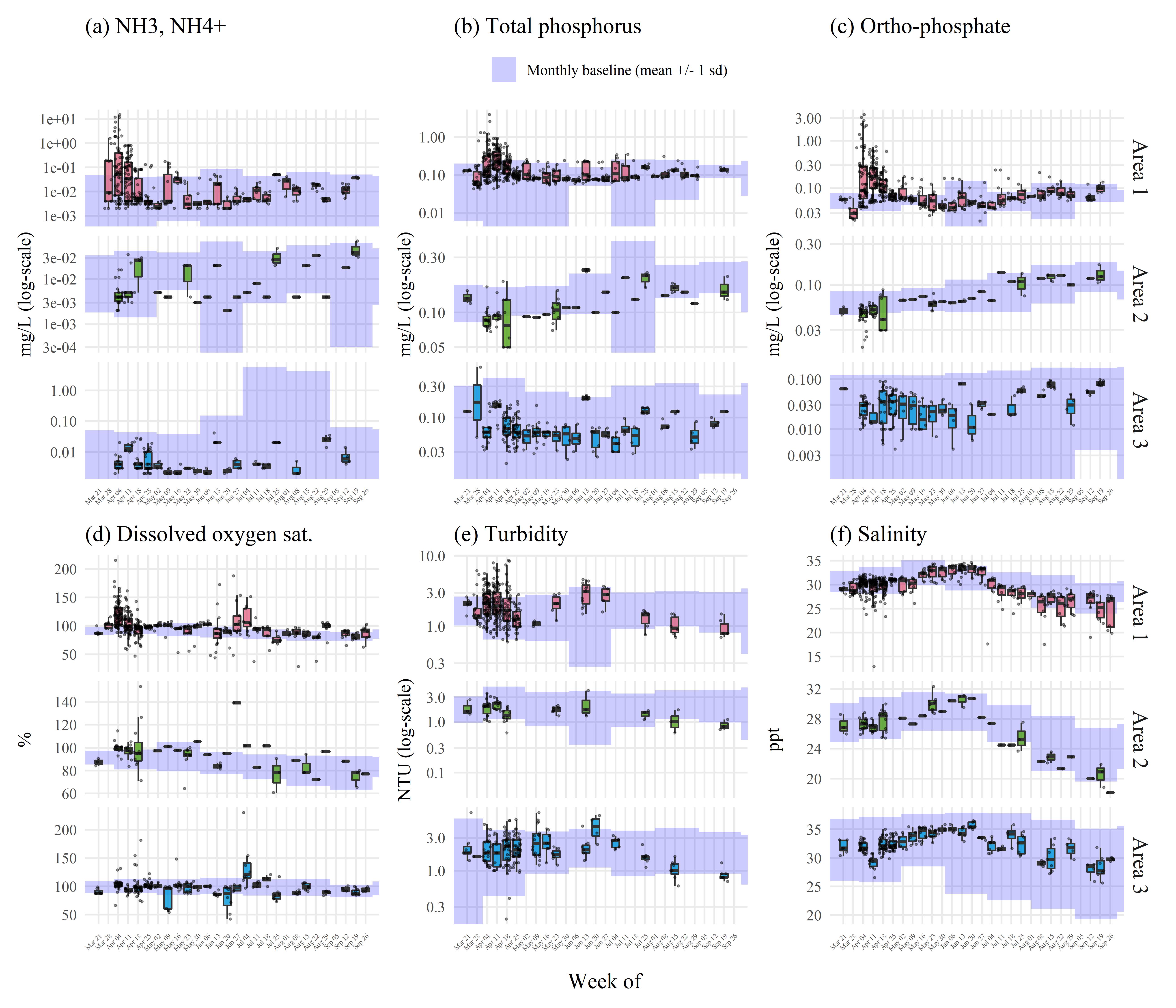


Figure 2: Sampled water quality data by week for April to September 2021 in response to wastewater discharge from Piney Point for (a) total ammonia nitogen (mg/L), (b) orthophosphate (mg/L), (c) total phosphorus (mg/L), (d) dissolved oxygen saturation (%), (e) turbidity (NTU), and (f) salinity (ppt). Observations are aggregated by week and within assessment areas shown in Figure 1a. Normal ranges for the month of observation (monthly baseline) and area are shown by the blue shaded areas. Normal ranges are defined as within +/-1 standard deviation of the mean for the month of observation from 2006 to 2020 for values collected at long-term monitoring sites within each area (Figure 1a).

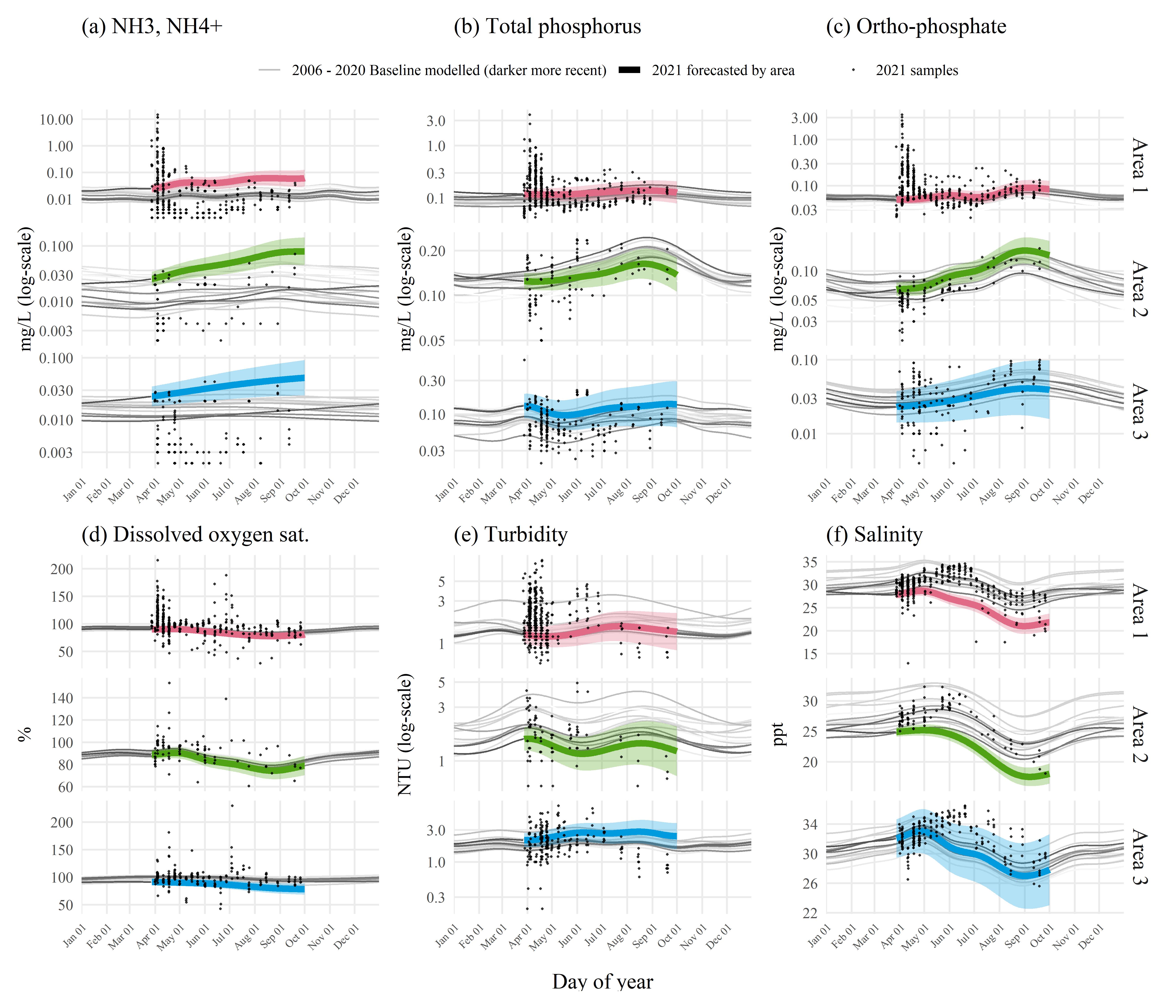


Figure 3: Forecasted 2021 (a) total ammonia nitogen (mg/L), (b) orthophosphate (mg/L), (c) total phosphorus (mg/L), (d) dissolved oxygen saturation (%), (e) turbidity (NTU), and (f) salinity (ppt) by area based on historal seasonal models. Forecasts from the historical models for dates during and after the Piney Point discharge are shown in thick lines (+/- 95% confidence), with observed samples overlaid on the plots to emphasize deviation of 2021 data from historical seasonal estimates. Forecasted values are based on Generalized Additive Models fit to historical baseline data from 2006 to early 2021, with darker lines for more recent years. Results are grouped by assessment areas shown in Figure 1a.

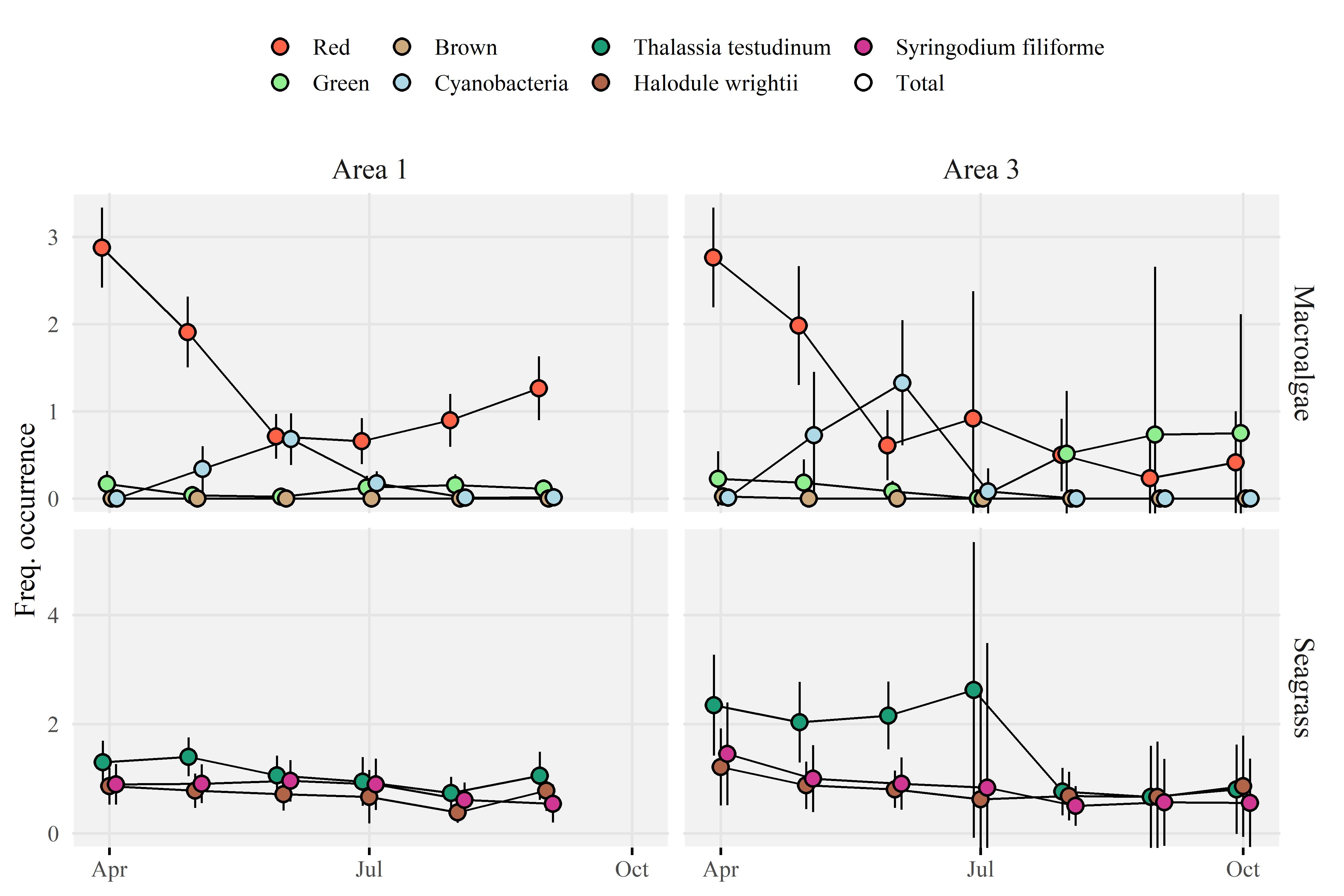


Figure 4: Abundance estimates (+/- 95% confidence) for (a) area 1 and (b) area 3 (Figure 1a) for macroalgae (top) and seagrass (bottom) rapid response transect surveys across all transects (n = 38) near Piney Point. Estimates are grouped by sample months in 2021. Points are offset slightly for readability.



Figure 5: Wind rose plots for 2021 by month. Data are from St. Petersburg, Florida. Wind roses show relative counts of six minute observations in directional (30 degree bins, north is vertical) and speed (m/s) categories.

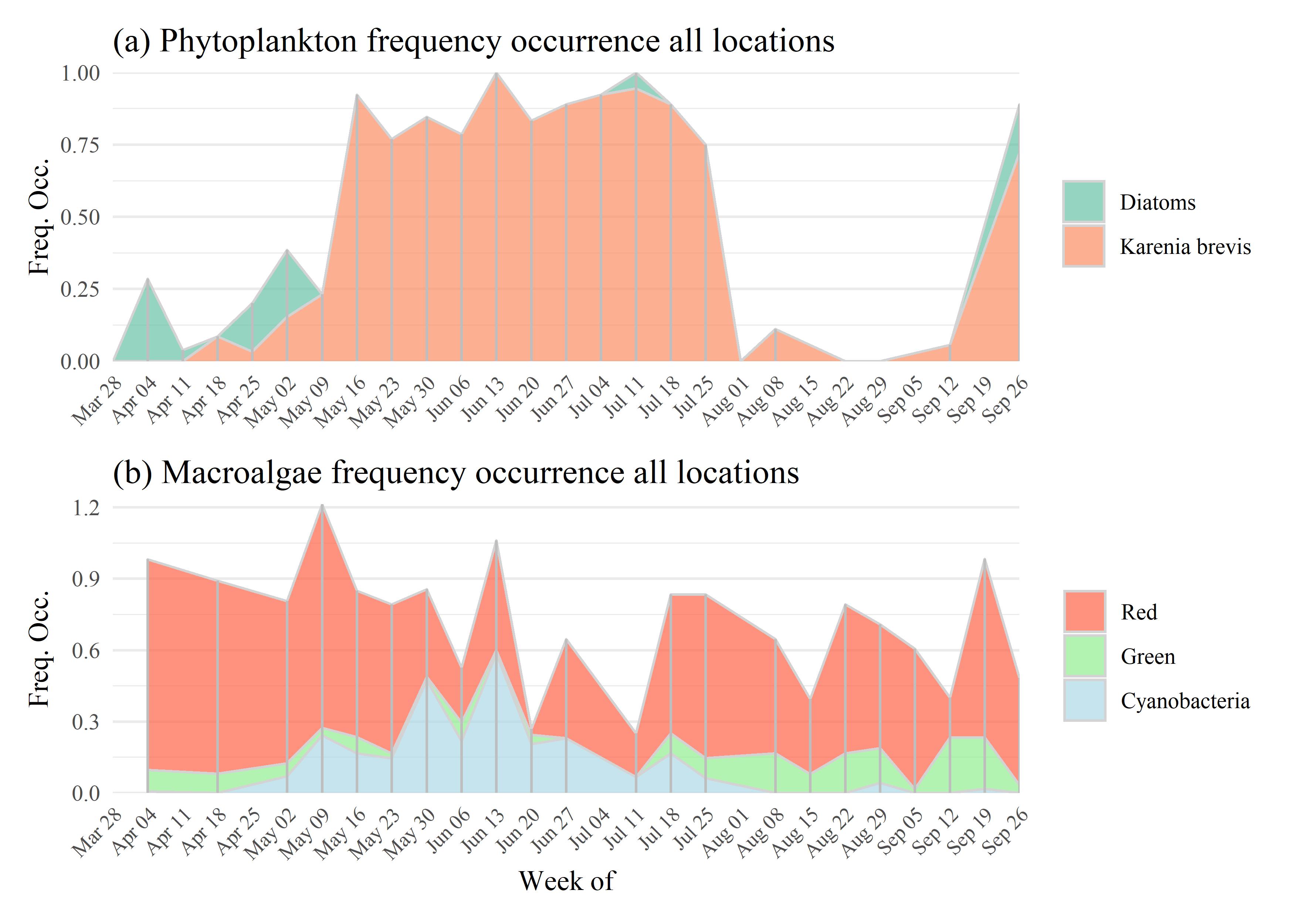


Figure 6: Frequency occurrence estimates for (a) phytoplankton (diatoms and *K. brevis*) and (b) macroalgae groups. Frequency occurrence estimates are aggregated by week of observation based on all sample locations where a phytoplankton or macroalgal taxa was observed divided by all sample locations in a week. Estimates are not additive and are specific to each taxa. Sample dates are noted by vertical grey lines in each plot. Diatoms are based on presence/absense of *Asterionellopsis sp*. and *Skeletonema sp*. Note that frequency occurrence is not a precise measure of cell concentrations.

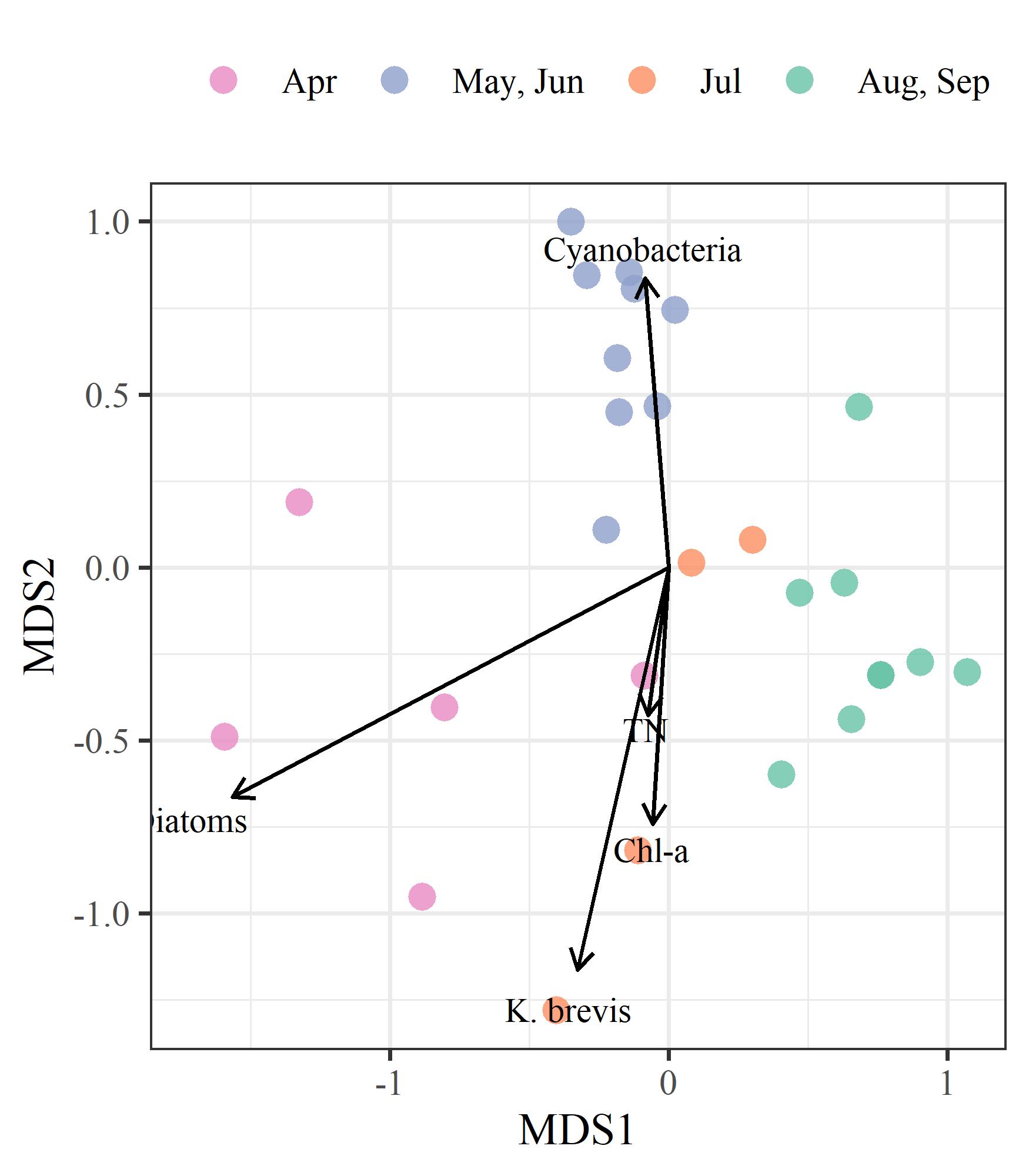


Figure 7: Ordination results comparing weekly summarized observations across all sampled locations for total nitrogen concentrations, chlorophyll-a concentrations, diatom cell concentrations, *Karenia brevis* cell concentrations, and cyanobacteria macroalgal abundances. Ordination results are from non-metric multi-dimensional scaling performed on the 97.5th percentile values of observations in each week for each parameter. Observations are grouped by month periods based on phytoplankton (diatoms or *K. brevis*) or macroalgal dominance.

# Tables

Table 1: Comparison of macroalgae frequency occurrence by areas of interest (Figure 1a) and month. Overall signifance of differences of frequency occurrence between months for macroalgae groups and area combination are shown with Chi-squared statistics based on Kruskall-Wallis rank sum tests. Multiple comparisons with Mann-Whitney U tests (Comp. column) were used to evaluate pairwise monthly frequency occurrences for each macroalgae group in each area. Rows that share a letter within each area and macroalgae group combination have frequency occurrences that are not significantly different between month pairs. Probability values were adjusted for the pairwise comparisons using the Bonferroni method in [Holm](#ref-Holm79) ([1979](#ref-Holm79)). \*\* p < 0.005, \* p < 0.05, blank is not significant at = 0.05.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Area | Macroalgae group | Chi-Sq. | Comp. | Month | N obs. | Med. (Min., Max.) |
| 1 | Red | 23.48\*\* | a | Apr | 23 | 1 (0, 1) |
|  |  |  | ab | May | 24 | 0.708 (0, 1) |
|  |  |  | b | Jun | 23 | 0.389 (0, 1) |
|  |  |  | b | Jul | 14 | 0.321 (0, 0.882) |
|  |  |  | b | Aug | 22 | 0.571 (0, 1) |
|  |  |  | ab | Sep | 20 | 0.732 (0, 1) |
|  | Green | 4.69 | a | Apr | 23 | 0 (0, 0.75) |
|  |  |  | a | May | 24 | 0 (0, 0.429) |
|  |  |  | a | Jun | 23 | 0 (0, 0.167) |
|  |  |  | a | Jul | 14 | 0 (0, 0.333) |
|  |  |  | a | Aug | 22 | 0 (0, 0.833) |
|  |  |  | a | Sep | 20 | 0 (0, 0.833) |
|  | Cyanobacteria | 53.5\*\* | a | Apr | 23 | 0 (0, 0) |
|  |  |  | a | May | 24 | 0 (0, 1) |
|  |  |  | b | Jun | 23 | 0.333 (0, 1) |
|  |  |  | ab | Jul | 14 | 0 (0, 0.417) |
|  |  |  | a | Aug | 22 | 0 (0, 0.333) |
|  |  |  | a | Sep | 20 | 0 (0, 0.167) |
| 3 | Red | 27.57\*\* | a | Apr | 7 | 0.917 (0.917, 1) |
|  |  |  | ab | May | 12 | 0.917 (0.25, 1) |
|  |  |  | c | Jun | 12 | 0.167 (0, 0.75) |
|  |  |  | abc | Jul | 4 | 0.333 (0, 0.833) |
|  |  |  | bc | Aug | 6 | 0.083 (0, 0.833) |
|  |  |  | c | Sep | 5 | 0.167 (0, 0.5) |
|  | Green | 5.42 | a | Apr | 7 | 0 (0, 0.667) |
|  |  |  | a | May | 12 | 0 (0, 0.833) |
|  |  |  | a | Jun | 12 | 0 (0, 0.667) |
|  |  |  | a | Jul | 4 | 0 (0, 0) |
|  |  |  | a | Aug | 6 | 0 (0, 1) |
|  |  |  | a | Sep | 5 | 0 (0, 1) |
|  | Cyanobacteria | 14.33\* | a | Apr | 7 | 0 (0, 0.083) |
|  |  |  | a | May | 12 | 0 (0, 0.833) |
|  |  |  | a | Jun | 12 | 0.292 (0, 1) |
|  |  |  | a | Jul | 4 | 0 (0, 0.333) |
|  |  |  | a | Aug | 6 | 0 (0, 0) |
|  |  |  | a | Sep | 5 | 0 (0, 0) |

Table 2: Comparison of seagrass species frequency occurrence by areas of interest (Figure 1a) and month. Overall signifance of differences of frequency occurrence between months for seagrass species and area combination are shown with Chi-squared statistics based on Kruskall-Wallis rank sum tests. Multiple comparisons with Mann-Whitney U tests (Comp. column) were used to evaluate pairwise monthly frequency occurrences for each seagrass species in each area. Rows that share a letter within each area and seagrass species combination have frequency occurrences that are not significantly different between month pairs. Probability values were adjusted for the pairwise comparisons using the Bonferroni method in [Holm](#ref-Holm79) ([1979](#ref-Holm79)). \*\* p < 0.005, \* p < 0.05, blank is not significant at = 0.05.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Area | Seagrass species | Chi-Sq. | Comp. | Month | N obs. | Med. (Min., Max.) |
| 1 | Thalassia testudinum | 1.4 | a | Apr | 23 | 0.444 (0, 1) |
|  |  |  | a | May | 24 | 0.5 (0, 1) |
|  |  |  | a | Jun | 23 | 0.444 (0, 1) |
|  |  |  | a | Jul | 14 | 0.5 (0, 1) |
|  |  |  | a | Aug | 22 | 0.389 (0, 1) |
|  |  |  | a | Sep | 20 | 0.458 (0, 1) |
|  | Halodule wrightii | 1 | a | Apr | 23 | 0.25 (0, 1) |
|  |  |  | a | May | 24 | 0.167 (0, 1) |
|  |  |  | a | Jun | 23 | 0.25 (0, 1) |
|  |  |  | a | Jul | 14 | 0.25 (0, 1) |
|  |  |  | a | Aug | 22 | 0.167 (0, 1) |
|  |  |  | a | Sep | 20 | 0.167 (0, 1) |
|  | Syringodium filiforme | 0.39 | a | Apr | 23 | 0 (0, 1) |
|  |  |  | a | May | 24 | 0.083 (0, 1) |
|  |  |  | a | Jun | 23 | 0 (0, 1) |
|  |  |  | a | Jul | 14 | 0.083 (0, 1) |
|  |  |  | a | Aug | 22 | 0 (0, 1) |
|  |  |  | a | Sep | 20 | 0 (0, 1) |
| 3 | Thalassia testudinum | 3.56 | a | Apr | 7 | 1 (0, 1) |
|  |  |  | a | May | 12 | 0.875 (0, 1) |
|  |  |  | a | Jun | 12 | 0.875 (0, 1) |
|  |  |  | a | Jul | 4 | 0.583 (0.333, 1) |
|  |  |  | a | Aug | 6 | 0.5 (0, 1) |
|  |  |  | a | Sep | 5 | 0.333 (0, 1) |
|  | Halodule wrightii | 2.82 | a | Apr | 7 | 0.417 (0, 1) |
|  |  |  | a | May | 12 | 0.292 (0, 1) |
|  |  |  | a | Jun | 12 | 0.333 (0, 0.75) |
|  |  |  | a | Jul | 4 | 0 (0, 0.667) |
|  |  |  | a | Aug | 6 | 0.5 (0, 1) |
|  |  |  | a | Sep | 5 | 0.5 (0, 1) |
|  | Syringodium filiforme | 1.75 | a | Apr | 7 | 0.417 (0, 0.833) |
|  |  |  | a | May | 12 | 0 (0, 1) |
|  |  |  | a | Jun | 12 | 0.227 (0, 0.75) |
|  |  |  | a | Jul | 4 | 0 (0, 0.667) |
|  |  |  | a | Aug | 6 | 0.208 (0, 0.917) |
|  |  |  | a | Sep | 5 | 0.333 (0, 1) |

Table 3: Comparison of macroalgae Braun-Blanquet abundances by areas of interest (Figure 1a) and month. Overall signifance of differences of abundances between months for macroalgae groups and area combination are shown with Chi-squared statistics based on Kruskall-Wallis rank sum tests. Multiple comparisons with Mann-Whitney U tests (Comp. column) were used to evaluate pairwise monthly abundances for each macroalgae group in each area. Rows that share a letter within each area and macroalgae group combination have abundances that are not significantly different between month pairs. Probability values were adjusted for the pairwise comparisons using the Bonferroni method in [Holm](#ref-Holm79) ([1979](#ref-Holm79)). \*\* p < 0.005, \* p < 0.05, blank is not significant at = 0.05.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Area | Macroalgae group | Chi-Sq. | Comp. | Month | N obs. | Med. (Min., Max.) |
| 1 | Red | 61.85\*\* | a | Apr | 45 | 3.333 (0, 5) |
|  |  |  | b | May | 46 | 1.833 (0, 4.286) |
|  |  |  | c | Jun | 45 | 0.286 (0, 3) |
|  |  |  | c | Jul | 22 | 0.464 (0, 1.833) |
|  |  |  | c | Aug | 31 | 0.857 (0, 3) |
|  |  |  | bc | Sep | 31 | 1.333 (0, 3.444) |
|  | Green | 6.66 | a | Apr | 45 | 0 (0, 2.167) |
|  |  |  | a | May | 46 | 0 (0, 0.5) |
|  |  |  | a | Jun | 45 | 0 (0, 0.333) |
|  |  |  | a | Jul | 22 | 0 (0, 1) |
|  |  |  | a | Aug | 31 | 0 (0, 1.5) |
|  |  |  | a | Sep | 31 | 0 (0, 1.333) |
|  | Cyanobacteria | 63.56\*\* | a | Apr | 45 | 0 (0, 0) |
|  |  |  | b | May | 46 | 0 (0, 3.667) |
|  |  |  | c | Jun | 45 | 0.167 (0, 4.4) |
|  |  |  | bc | Jul | 22 | 0 (0, 1) |
|  |  |  | ab | Aug | 31 | 0 (0, 0.333) |
|  |  |  | ab | Sep | 31 | 0 (0, 0.5) |
| 3 | Red | 36.16\*\* | a | Apr | 14 | 2.417 (1.667, 4.833) |
|  |  |  | a | May | 19 | 1.667 (0, 4.667) |
|  |  |  | b | Jun | 24 | 0 (0, 2.833) |
|  |  |  | ab | Jul | 4 | 0.833 (0, 2) |
|  |  |  | b | Aug | 12 | 0.167 (0, 1.5) |
|  |  |  | b | Sep | 5 | 0.167 (0, 0.833) |
|  | Green | 5.61 | a | Apr | 14 | 0 (0, 1.667) |
|  |  |  | a | May | 19 | 0 (0, 1.833) |
|  |  |  | a | Jun | 24 | 0 (0, 1.167) |
|  |  |  | a | Jul | 4 | 0 (0, 0) |
|  |  |  | a | Aug | 12 | 0 (0, 3.167) |
|  |  |  | a | Sep | 5 | 0 (0, 3.5) |
|  | Cyanobacteria | 21.31\*\* | a | Apr | 14 | 0 (0, 0.167) |
|  |  |  | ab | May | 19 | 0 (0, 5) |
|  |  |  | b | Jun | 24 | 0.333 (0, 4.833) |
|  |  |  | ab | Jul | 4 | 0 (0, 0.333) |
|  |  |  | a | Aug | 12 | 0 (0, 0) |
|  |  |  | ab | Sep | 5 | 0 (0, 0) |

Table 4: Comparison of seagrass species Braun-Blanquet abundances by areas of interest (Figure 1a) and month. Overall signifance of differences of abundances between months for seagrass species and area combination are shown with Chi-squared statistics based on Kruskall-Wallis rank sum tests. Multiple comparisons with Mann-Whitney U tests (Comp. column) were used to evaluate pairwise monthly abudances for each seagrass species in each area. Rows that share a letter within each area and seagrass species combination have abundances that are not significantly different between month pairs. Probability values were adjusted for the pairwise comparisons using the Bonferroni method in [Holm](#ref-Holm79) ([1979](#ref-Holm79)). \*\* p < 0.005, \* p < 0.05, blank is not significant at = 0.05.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Area | Seagrass species | Chi-Sq. | Comp. | Month | N obs. | Med. (Min., Max.) |
| 1 | Thalassia testudinum | 7.36 | a | Apr | 45 | 1 (0, 4.667) |
|  |  |  | a | May | 46 | 1.083 (0, 4.167) |
|  |  |  | a | Jun | 45 | 0.667 (0, 4) |
|  |  |  | a | Jul | 22 | 0.583 (0, 3.667) |
|  |  |  | a | Aug | 31 | 0.5 (0, 3) |
|  |  |  | a | Sep | 31 | 0.667 (0, 4.333) |
|  | Halodule wrightii | 2.49 | a | Apr | 45 | 0.333 (0, 4.5) |
|  |  |  | a | May | 46 | 0.333 (0, 4.167) |
|  |  |  | a | Jun | 45 | 0.333 (0, 4.833) |
|  |  |  | a | Jul | 22 | 0.25 (0, 5) |
|  |  |  | a | Aug | 31 | 0.167 (0, 2.5) |
|  |  |  | a | Sep | 31 | 0.5 (0, 4.667) |
|  | Syringodium filiforme | 3.53 | a | Apr | 45 | 0 (0, 4.667) |
|  |  |  | a | May | 46 | 0.083 (0, 3.667) |
|  |  |  | a | Jun | 45 | 0 (0, 4) |
|  |  |  | a | Jul | 22 | 0.417 (0, 3.167) |
|  |  |  | a | Aug | 31 | 0 (0, 2.667) |
|  |  |  | a | Sep | 31 | 0 (0, 3.167) |
| 3 | Thalassia testudinum | 12.96\* | a | Apr | 14 | 2.833 (0, 4.5) |
|  |  |  | a | May | 19 | 2.167 (0, 5) |
|  |  |  | a | Jun | 24 | 2.417 (0, 4.833) |
|  |  |  | a | Jul | 4 | 2.167 (1.167, 5) |
|  |  |  | a | Aug | 12 | 0.75 (0, 2) |
|  |  |  | a | Sep | 5 | 0.667 (0, 1.833) |
|  | Halodule wrightii | 2.81 | a | Apr | 14 | 0.75 (0, 3.667) |
|  |  |  | a | May | 19 | 0.667 (0, 3) |
|  |  |  | a | Jun | 24 | 0.75 (0, 2.833) |
|  |  |  | a | Jul | 4 | 0 (0, 2.5) |
|  |  |  | a | Aug | 12 | 0.583 (0, 2) |
|  |  |  | a | Sep | 5 | 0.667 (0, 2) |
|  | Syringodium filiforme | 1.74 | a | Apr | 14 | 0.75 (0, 4.667) |
|  |  |  | a | May | 19 | 0 (0, 3.333) |
|  |  |  | a | Jun | 24 | 0 (0, 3) |
|  |  |  | a | Jul | 4 | 0 (0, 3.333) |
|  |  |  | a | Aug | 12 | 0.167 (0, 1.333) |
|  |  |  | a | Sep | 5 | 0.333 (0, 1.333) |

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