POST-RED TIDE RECOVERY OF SARASOTA BAY FISH COMMUNITIES

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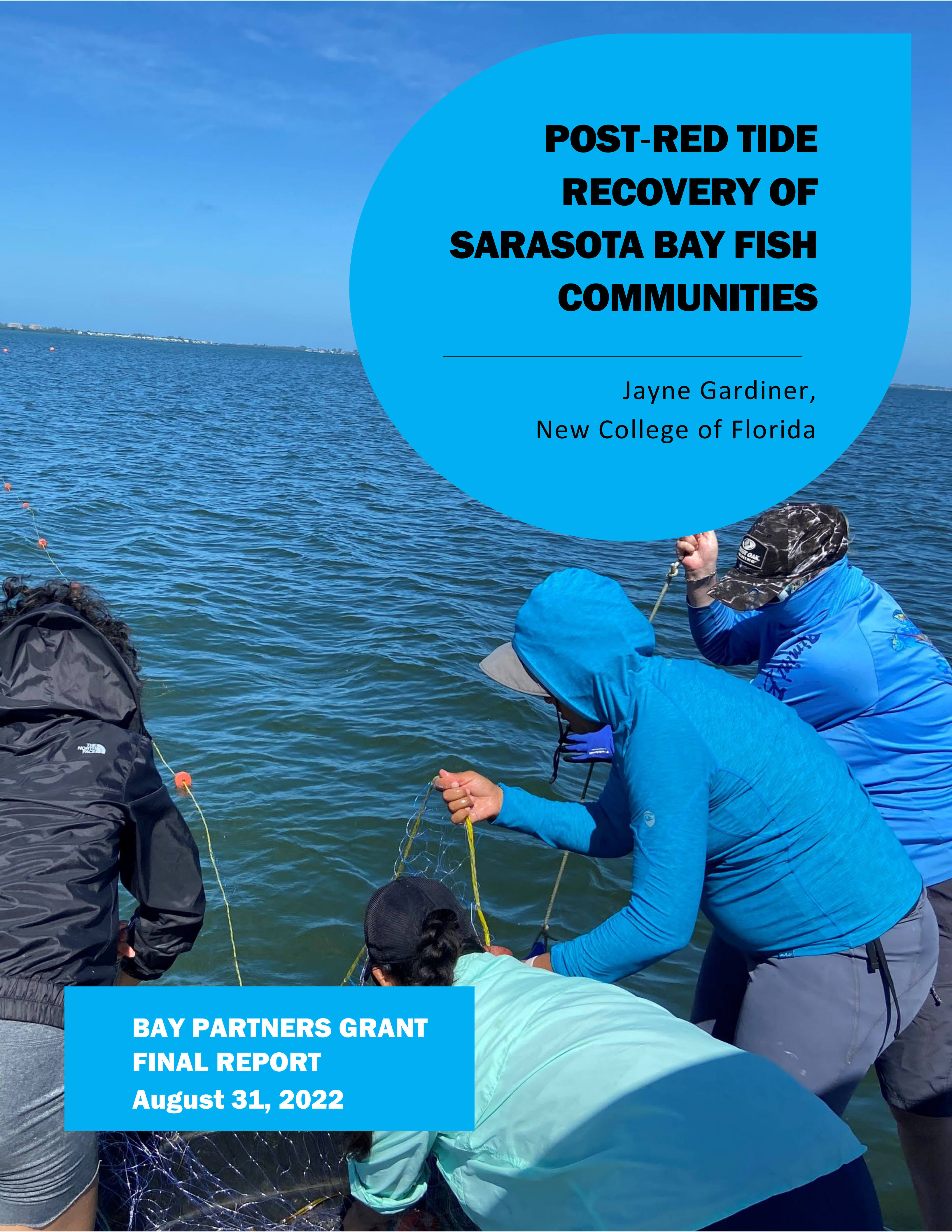

BAY PARTNERS GRANT FINAL REPORT
August 31, 2022

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Final Report

Prepared by: Jayne Gardiner, New College of Florida

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1. Detailed description of work completed

We completed monthly standardized gillnet and longline sampling in Terra Ceia Bay and Sarasota Bay from April to October, 2021 (Figure 1). All fish were identified to the species level, measured, and released. Elasmobranchs were tagged with individually-numbered dart tags (sharks) or cinch-loop tags (batoids) to facilitate identification of any individuals who were subsequently recaptured. We computed catch-per-unit-effort (gillnet: animals/net hour, longline: animals/100 hooks) by species and trophic guild. Data within each bay were pooled monthly. Each sampling period was designated as "red tide" (defined as a period of 30 days after a *Karenia brevis* sample within the embayment exceeded 10^5 cells/L; Gannon et al., 2009) or "non-red tide" based on cell count data obtained from the FWRI-FWC HAB Monitoring Database. The bloom in southwest Florida, which occurred from late October 2017 through early 2019 and is thus referred to as the 2017-2019 red tide event, began in the south and moved progressively north. High *K. brevis* cell counts were recorded in Sarasota Bay from June 2018 through January 2019 and thus the period of "red tide" in Sarasota Bay, based on the above definition, was from June 2018 through February 2019. A Before-After Control-Impact with temporal pairing (BACI-P) analysis (Smith, 2002) was conducted to examine the effects of red tide on Sarasota Bay (impacted) vs Terra Ceia Bay (unimpacted). Generalized linear mixed models were used to test the effect of period (before, during, and after the 2017-2019 red tide), site type (control vs. impact), and period by site interaction on abundance, species richness, and Shannon-Wiener diversity index. During summer 2021, both Sarasota Bay and Terra Ceia Bay were impacted by red tide. Because the onset and duration of the event differed between the two embayments, data from the 2021 red tide period (July – October) were excluded from the BACI analyses. We are exploring other analyses for this portion of the dataset – incorporating datasets from other GULFSPAN sampling locations that can serve as additional control sites may allow us to examine the effects of the second red tide event, however, those data were not yet available at the time of this report.

Our results demonstrate negative effects of the 2017-2019 red tide on Sarasota Bay fish communities. Total abundance of fish in Sarasota Bay was reduced during the red tide event and species richness and diversity were significantly lower, however all of these recovered during the approximately 2-year post-red tide period (Figs 2-4). We also examined effects of red tide on abundance by trophic guild (following the methods of Gannon et al, 2009) and by species (for the 10 most numerous species). Here, we observed differential effects. No significant effects of the red tide event were observed for demersal herbivores (primarily represented by filefish and parrotfish in this study), demersal omnivores (primarily represented by striped pinfish), demersal piscivores (primarily represented by catfish, flatfish, drums, and snappers), pelagic filter feeders (menhaden, herring, and sardines), and pelagic omnivores (mullet species), however, sample sizes for demersal herbivores, pelagic filter feeders, and pelagic omnivores were small (Fig 5). Significant effects were observed for demersal invertivores (primarily comprised of benthic stingrays, pelagic stingrays, bonnetheads, spadefish, and mojarras) and pelagic piscivores (primarily comprised of sharks, jacks, pompanos, ladyfish, and mackerels). Recovery for both of these guilds was observed within 2 years (Fig 6).

At the species level, significant effects were observed for hardhead catfish, bonnetheads, and permit. Recovery within 2 years was observed for hardhead catfish and bonnetheads, however, the abundance of permit remained lower than in the pre-red tide period at the time of the 2021 red tide event. No significant effects were observed for gafftopsail catfish, cownose rays, yellowfin menhaden, striped pinfish, crevalle jacks, Florida pompano, or Spanish mackerel.

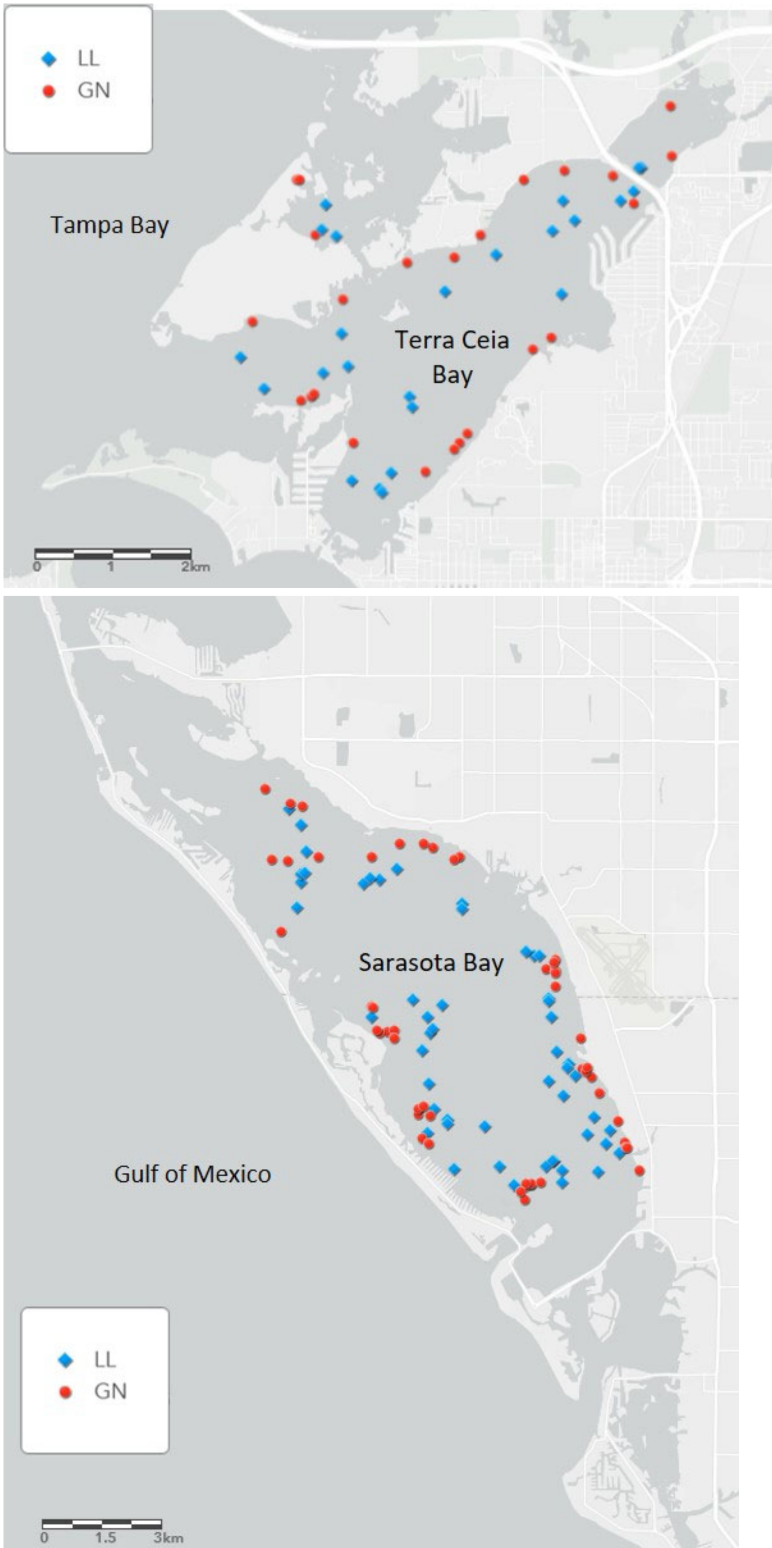


Figure 1. Locations of gillnet and longline sets made in Terra Ceia Bay (gillnet: n=24, longline: n = 24) and Sarasota Bay gillnet (n = 51) and longline (n = 52) in 2021.

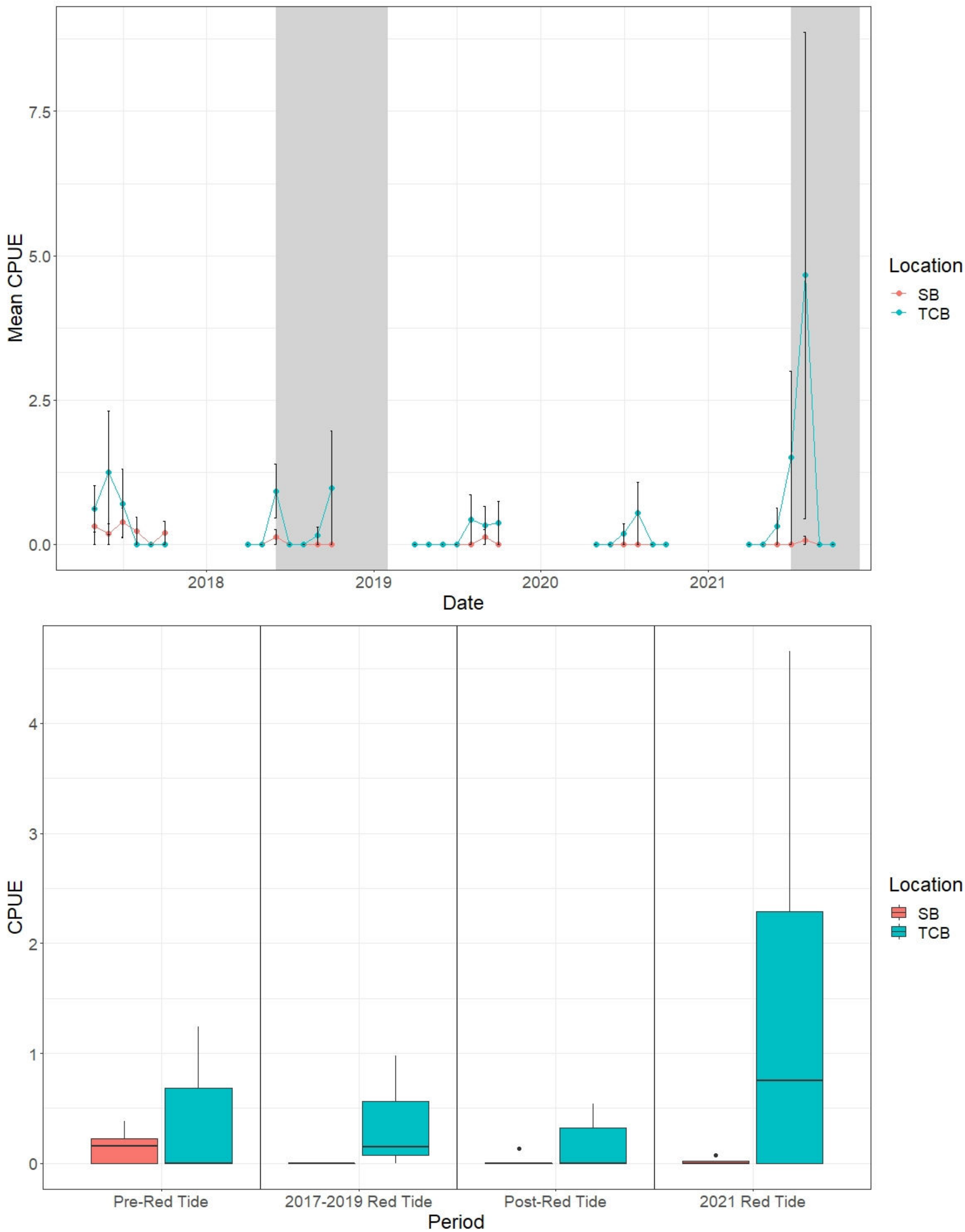


Figure 2. Total fish abundance. A) BACI (time series) plot: areas shaded in gray represent periods of red tide in Sarasota Bay. B) Boxplots by period. BACI contrasts indicate a significant change in total fish abundance (period x location interaction, $F = 6.05$, $p = 0.004$). Data from the 2021 red tide event were excluded from the BACI analysis as both bays were impacted.

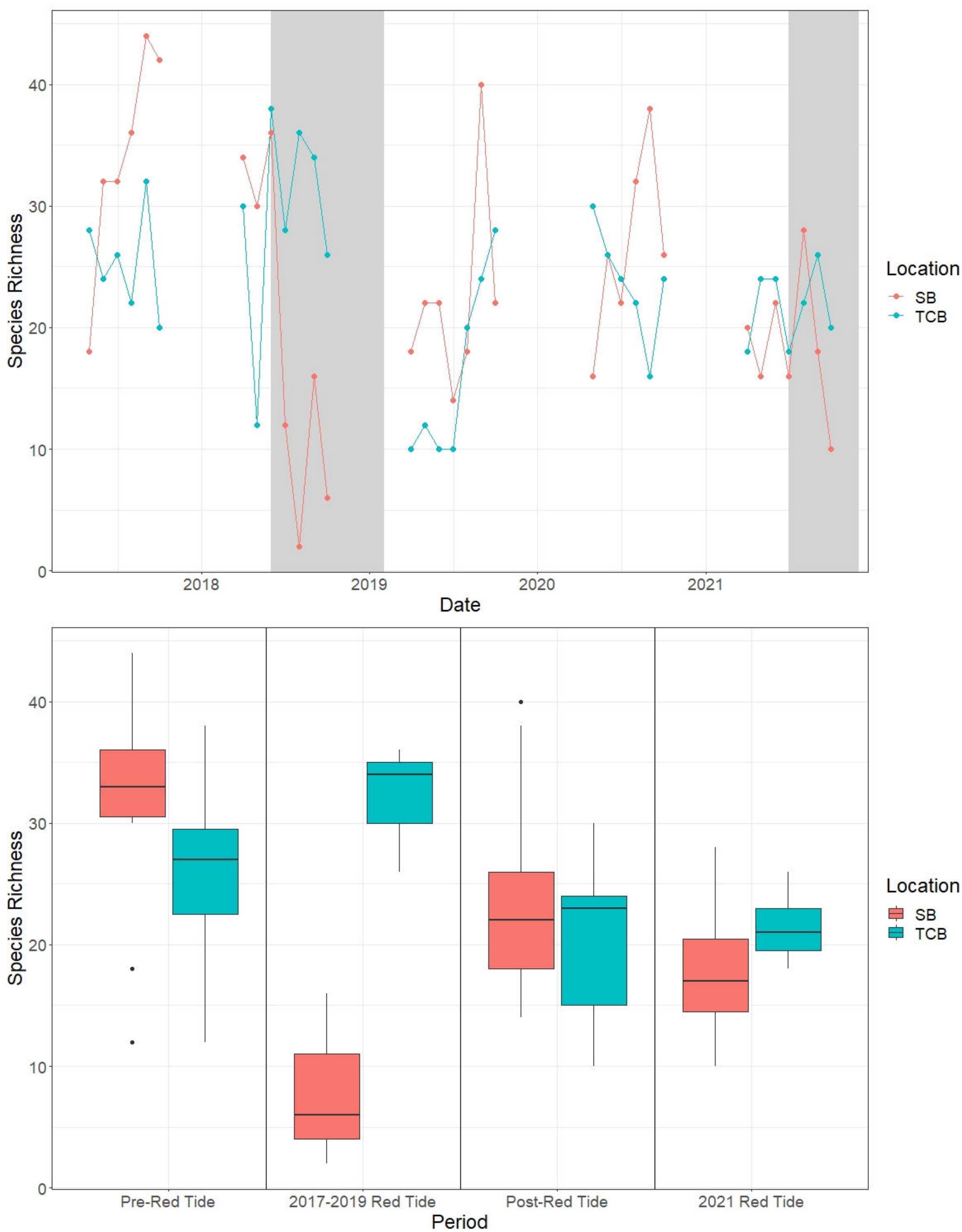


Figure 3. Total fish species richness. A) BACI (time series) plot: areas shaded in gray represent periods of red tide in Sarasota Bay. B) Boxplots by period. BACI contrasts indicate a significant change in species richness (period x location interaction, $F = 10.25$, $p = 0.0005$). Data from the 2021 red tide event were excluded from the BACI analysis as both bays were impacted.

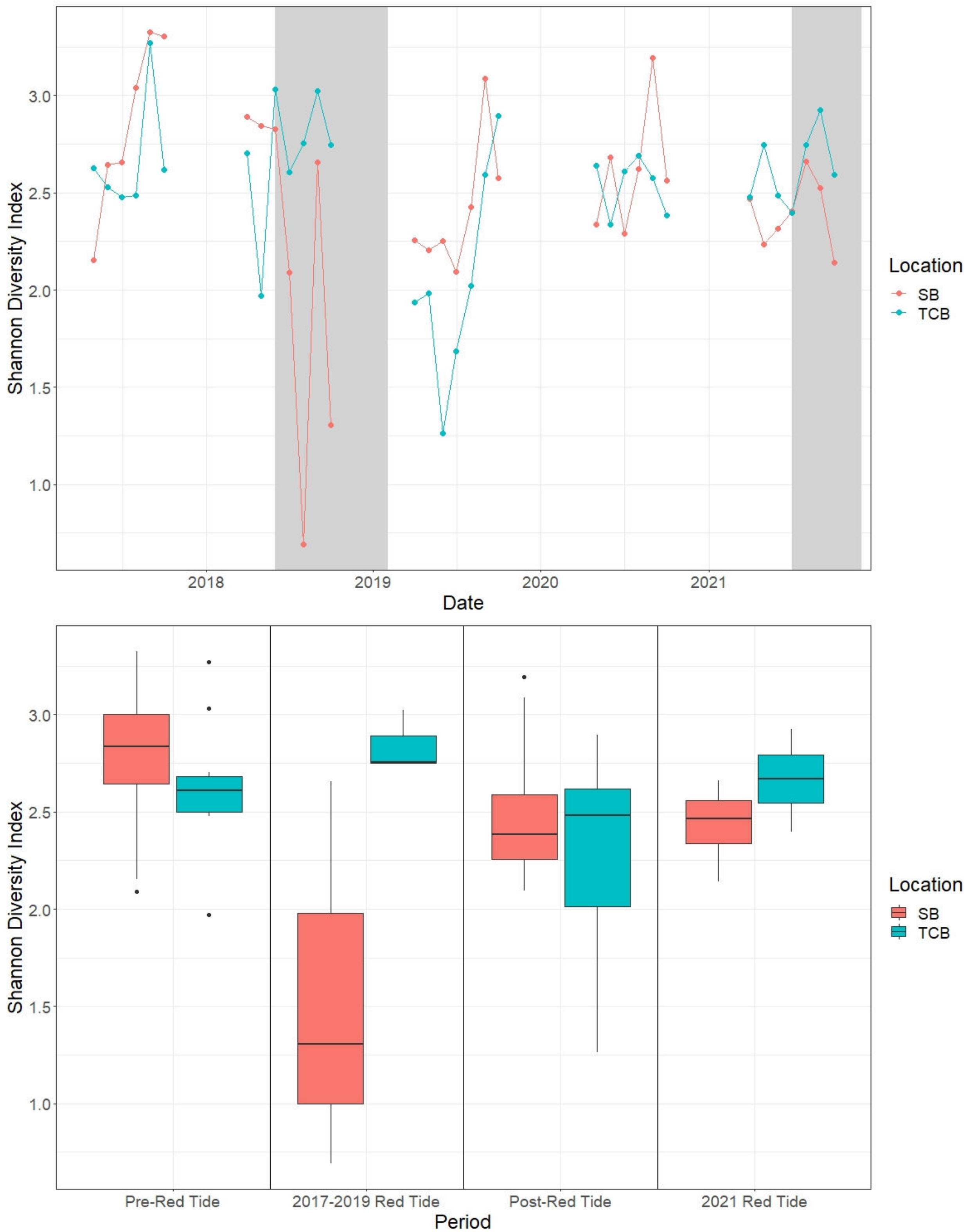
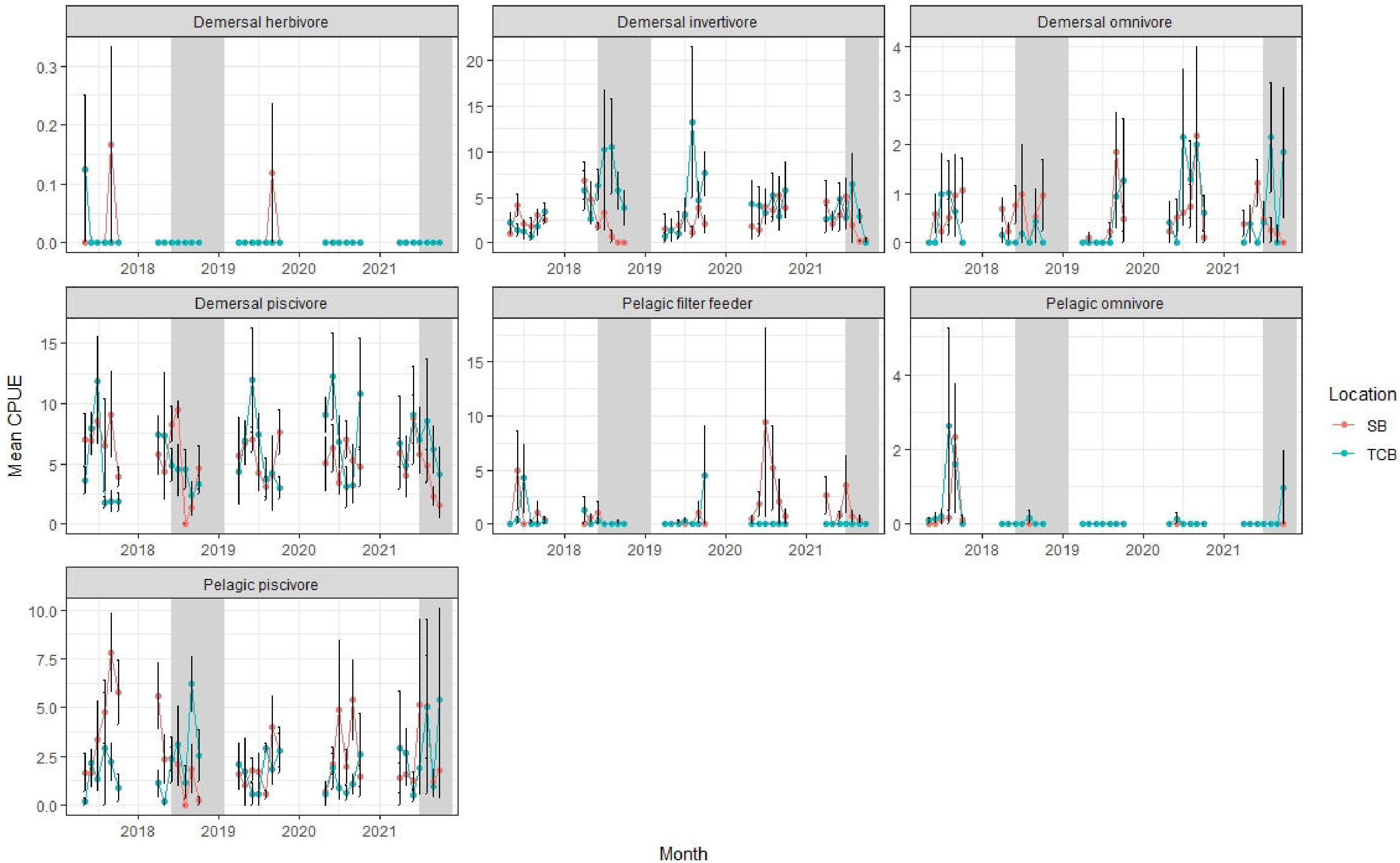


Figure 4. Total fish species diversity. A) BACI (time series) plot: areas shaded in gray represent periods of red tide in Sarasota Bay. B) Boxplots by period. BACI contrasts indicate a significant change in total fish diversity (period x location interaction, $F = 12.11$, $p = 0.0002$). Data from the 2021 red tide event were excluded from the BACI analysis as both bays were impacted.



Demersal herbivore
Demersal invertivore
Demersal omnivore
Demersal piscivore
Pelagic filter feeder
Pelagic omnivore
Pelagic piscivore
Mean CPUE
Month
2018
2019
2020
2021
Location
SB
TCB

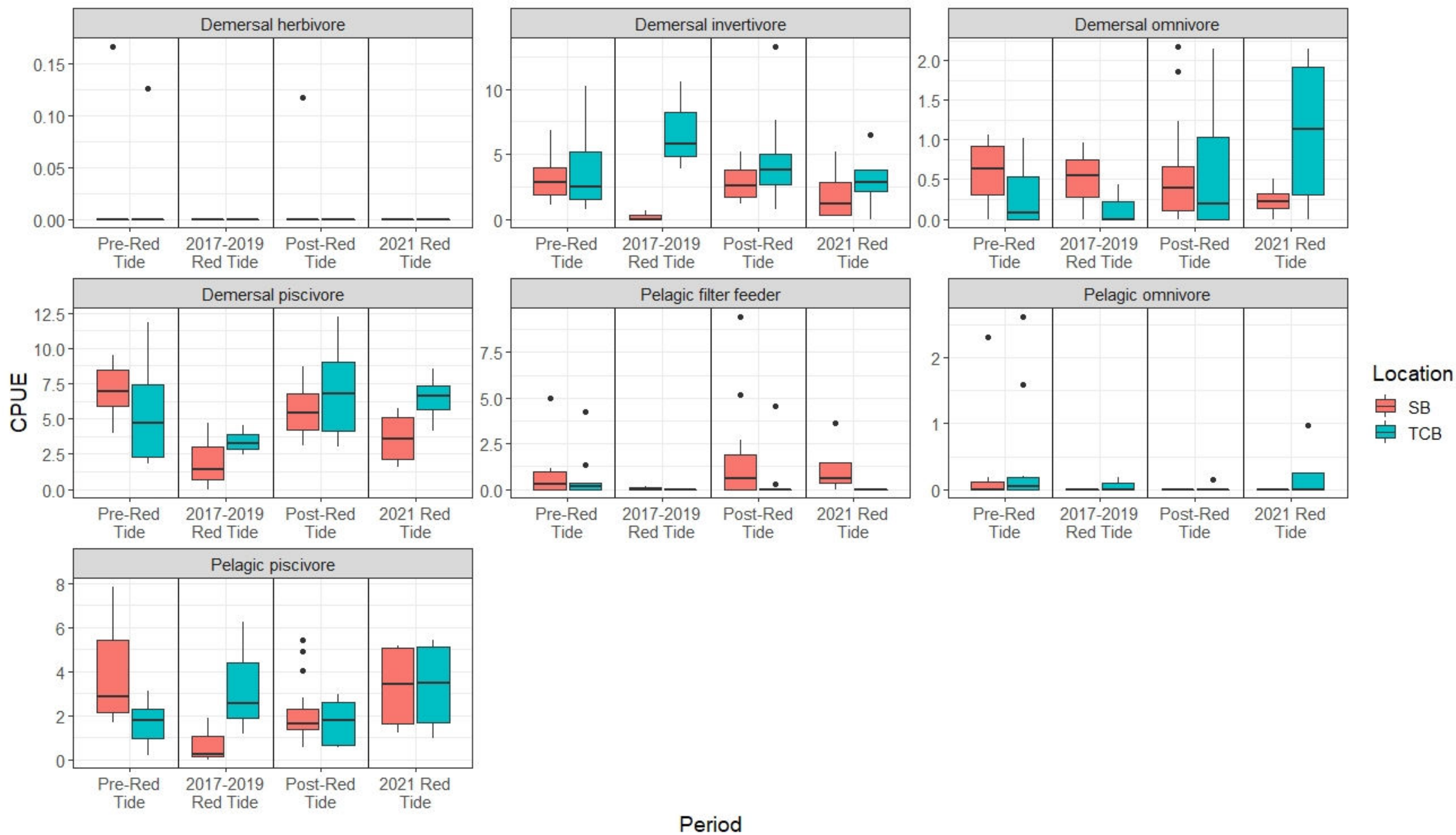
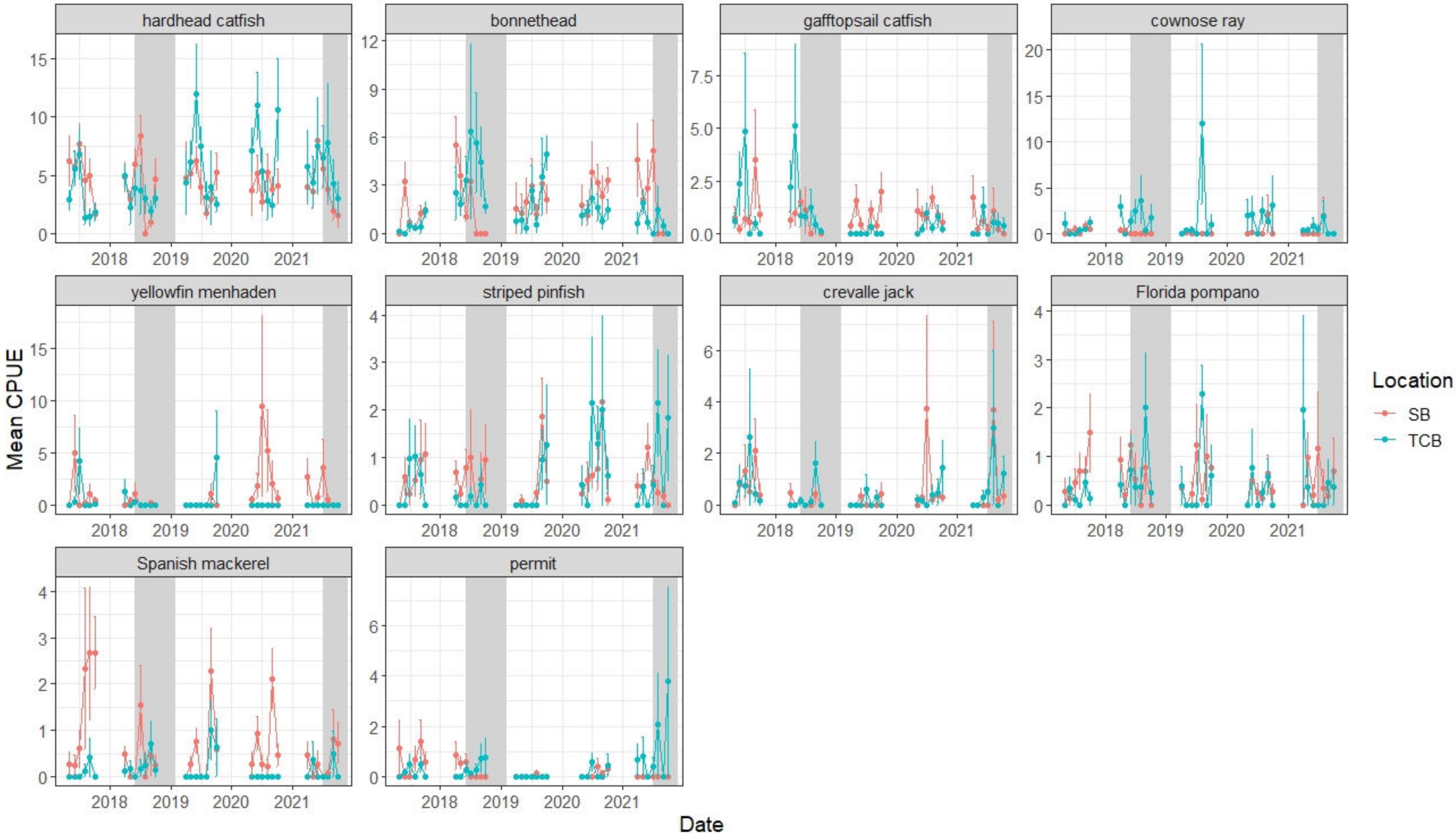


Fig 5. Abundance by trophic guild. A) BACI (time series) plot: areas shaded in gray represent periods of red tide in Sarasota Bay. B) Boxplots by period. BACI contrasts indicate a significant change in abundance (period x location interaction) for demersal invertivores ($F = 3.94$, $p = 0.03$) and pelagic piscivores ($F = 6.67$, $p = 0.005$). No significant effects were observed for demersal herbivores ($F = 0.041$, $p = 0.9$), demersal omnivores ($F = 0.94$, $p = 0.4$), demersal piscivores ($F = 2.38$, $p = 0.1$), pelagic filter feeders ($F = 0.71$, $p = 0.5$) or pelagic omnivores ($F = 0.44$, $p = 0.7$). Data from the 2021 red tide event were excluded from the BACI analysis as both bays were impacted.


hardhead catfish
bonnethead
gafftopsail catfish
cownose ray
yellowfin menhaden
striped pinfish
crevalle jack
Florida pompano
Spanish mackerel
permit
Mean CPUE
Date
Location
SB
TCB

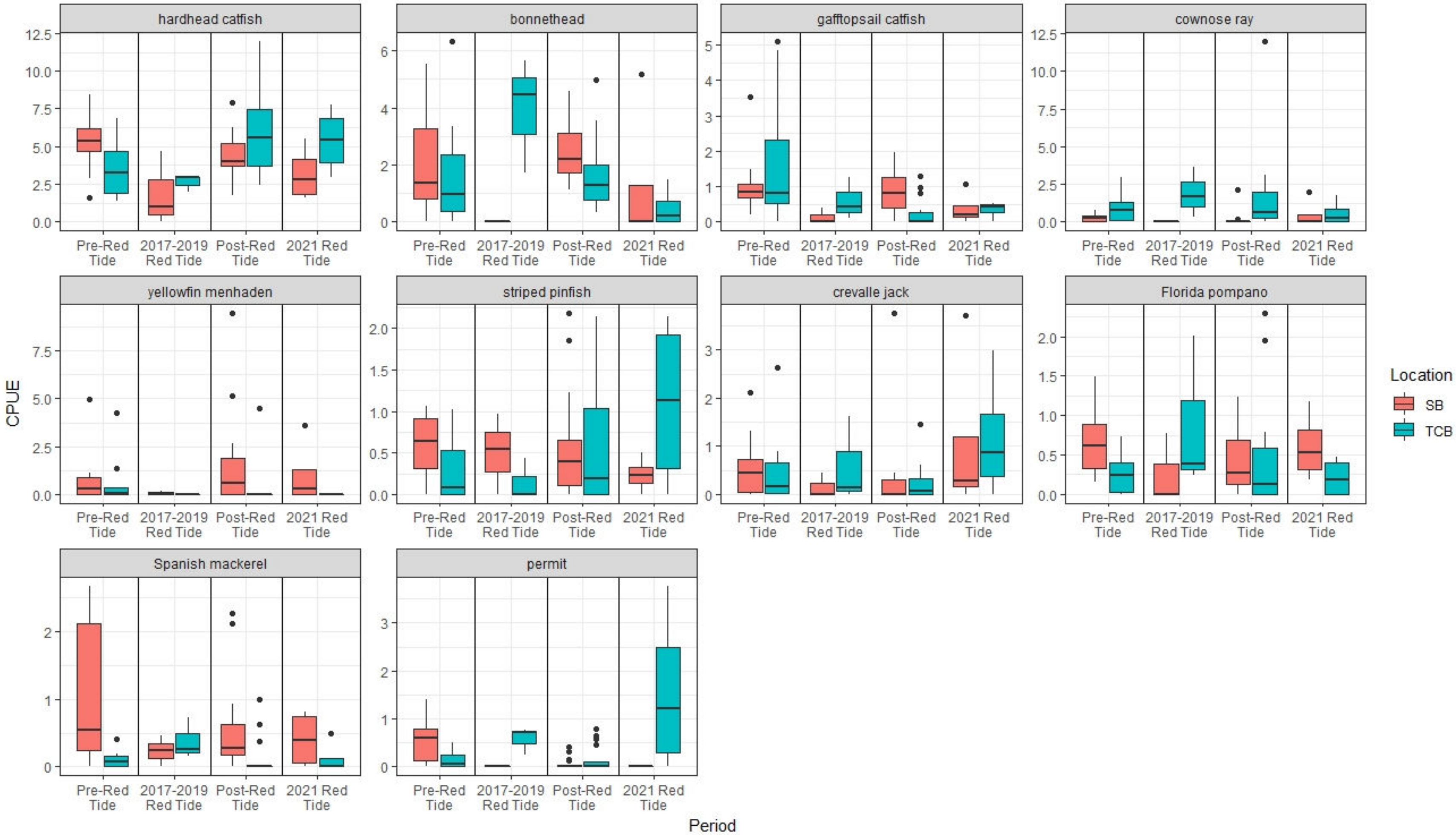


Fig 6. Abundance by species for the 10 most numerous species. A) BACI (time series) plot: areas shaded in gray represent periods of red tide in Sarasota Bay. B) Boxplots by period. BACI contrasts indicate a significant change in abundance (period x location interaction) for hardhead catfish (F = 6.05, p = 0.007), bonnetheads (F = 9.78, p = 0.0007), and permit (F = 9.45, p = 0.0008). No significant effects were observed for gafftopsail catfish (F = 2.92, p = 0.07), cownose rays (F = 0.43 p = 0.7), yellowfin menhaden (F = 0.72 p = 0.5), striped pinfish (F = 0.94, p = 0.4), crevalle jack (F = 0.41, p = 0.7), Florida pompano (F = 2.61, p = 0.09) or Spanish mackerel (F = 2.91, p =0.07). Data from the 2021 red tide event were excluded from the BACI analysis as both bays were impacted.

2. Photographs and/or videos of the completed project (attached).

3. A description of how the project met the goals outlined in the application

The research goal of this project was to examine the long-term effects of red tide on Sarasota Bay fish communities. We leveraged seasonal, monthly, standardized fishery-independent survey data (NOAA GULFSPAN) from our prior efforts in 2017-2020. Funds from SBEP (plus match from the Mote Scientific Foundation) allowed us to continue this sampling through 2021. We completed monthly sampling, April through October, in Sarasota Bay and Terra Ceia Bay (goal: 98 sets, actual: 151 sets). We contributed data to NOAA, which will be used for Essential Fish Habitat assessments and SouthEast Data Assessment and Review (SEDAR) stock assessments:
Carlson, J.K., Kroetz, A., Hoover, A., Higgs, J., Hendon, J.M., Hamilton, B., Peterson, C., Dawdy, A., Grubbs, R.D., **Gardiner, J.M.**, Beaver, J.A., and **Wiley, T.R.** In Review. Shark nursery grounds and essential fish habitat studies. The GULFSPAN survey. The Gulf of Mexico Shark Pupping and Nursery Survey FY-2021. Report to NOAA Fisheries, Highly Migratory Species Division. National Marine Fisheries Service, Panama City Laboratory Contribution 2022-xx, 64pp.

We also contributed water quality data to the Tampa Bay Estuary Program as part of their response to the Piney Point disaster (https://shiny.tbep.org/piney-point/?_ga=2.143167671.361279435.1660761663-1243523709.1660761663); these data were also published in the peer-reviewed literature:
Beck, M.W., Altieri, A., C. Angelini, Burke, M.C., Chen, J., Chin, D.W., **Gardiner, J.M.**, Hu, C., Hubbard, K.A., Liu, Y., Lopez, C., Medina, M., Morrison, E., Phlips, E.H., Raulerson, G.E., Scolaro, S., Sherwood, E.T., Tomasko, D., Weisberg, B., Whalen, J. 2022. Initial estuarine response to inorganic nutrient inputs from a legacy mining facility adjacent to Tampa Bay, Florida. *Marine Pollution Bulletin* 178:113598. https://doi.org/10.1016/j.marpolbul.2022.113598).

A second manuscript on the effects of red tide on Sarasota Bay fish communities is currently in preparation for submission to a peer-reviewed journal.

4. A description of community benefits achieved

The community benefits goal of this project was to increase diversity in marine STEM. More specifically, we sought to provide hands-on learning opportunities for students by engaging 2 paid interns and 30 undergraduate students in the research. We surpassed this goal, with 4 paid interns (two Environmental Discovery Awards Program interns and two NCF Shark Research Internship interns), 22 undergraduate students, 4 post-bachelor's students (who were unemployed or underemployed at the time), 1 postdoctoral student, and 3 early career professionals. We have already observed positive impacts of our work: all of the post-bachelor's students are now pursuing graduate degrees, one of the interns landed her dream job (as a fisheries biologist with FWC), one is pursuing a graduate degree in marine science and the other two are pursuing undergraduate thesis research projects that leverage the skills they developed during their internships. Additionally, biological samples were obtained during this project to support student research activities at 13 different institutions.