A research and monitoring program to mitigate the impact of harmful algal blooms on the Matagorda Bay and San Antonio Bay ecosystems

Final Report

Submitted by:

Michael S. Wetz
Chair for Coastal Ecosystem Processes
Harte Research Institute
Texas A&M University-Corpus Christi
6300 Ocean Drive, Unit 5869
Corpus Christi, Texas 78412
Phone: 361-825-2132
Fax: 361-825-2050
Email: michael.wetz@tamucc.edu

Laura Beecraft
Assistant Research Scientist
Harte Research Institute
Texas A&M University-Corpus Christi
6300 Ocean Drive, Unit 5869
Corpus Christi, Texas 78412
Phone: 361-825-2042
Fax: 361-825-2050
Email: laura.beecraft@tamucc.edu

Submitted to:

Matagorda Bay Mitigation Trust
Contract No.: 0014

Executive Summary

Since 2008, shellfish harvesting in Matagorda Bay and San Antonio Bay has been closed no less than seven times in each bay due to the presence of harmful algal blooms (HABs). Increasing coastal population and environmental conditions put pressure on coastal water quality, and one symptom of this pressure can be an increasing frequency or intensity of HABs. Yet, our capacity to proactively monitor for and detect HABs has been limited to, at most, three automated sampling instruments (Imaging Flow Cytobot, IFCB) along the Texas coast, with no coverage in Matagorda or San Antonio Bays. This project implemented a dual-approach HAB monitoring program in Matagorda and San Antonio Bays, using a combination of discrete weekly water quality sampling and deployment of an IFCB at a strategic location in Port O'Connor near the connection of Matagorda Bay to the Gulf.

Analysis of water quality data from weekly sampling showed 40% of our observations with chlorophyll *a* concentrations exceeding the TCEQ screening level for possible nutrient impairment. High concentrations of nutrients (nitrogen and phosphorus) were occasionally observed at our three upper estuary sites in Matagorda Bay, despite low annual median concentrations. These were sometimes associated with precipitation events, but not consistently. These observations suggest that the bays may be sensitive to nutrient inputs, in particular nitrogen, and further study is needed to determine if management action is needed to protect water quality. More targeted sampling would provide the necessary data for currently unquantified inflow sources and inform potential management actions to control nutrient inputs and protect the water quality conditions of San Antonio Bay and Matagorda Bay.

Weekly sampling detected a bloom of the toxic species *Karenia selliformis* in 2022. The IFCB detected low levels of HAB species on several occasions, and in particular the presence of *Dinophysis* in February 2025. Importantly, the IFCB was capable of detecting HAB species that were missed by traditional sampling and screening approaches. This, combined with the capacity for continuous automated sampling and rapid AI-assisted identification make this infrastructure invaluable for providing early warning of HAB events. Information on HAB detection was communicated to Texas Parks and Wildlife Department and Department of State Health Services. Both monitoring programs detected the presence of previously undetected HAB species in these bays, albeit in low abundances that pose no risk. Although major HAB events were not observed during the course of this study, the need for past shellfish harvest closures and impacts from past HAB events, as well as detection of novel HAB species in this study, suggest that continued HAB monitoring in the San Antonio Bay and Matagorda Bay complexes is warranted. Maintaining operation of the IFCB at Port O'Connor should be of particular value for protecting local communities and economies that could be adversely impacted by HABs, and may lead to improved ability to predict or forecast HAB events in the future.

Background

Harmful algal blooms (HABs) are caused by the proliferation of phytoplankton species that have harmful effects on marine life, ecosystems, human health and coastal economies. Between 2008 and 2024, shellfish harvesting in Matagorda Bay and San Antonio Bay was closed no less than seven times each bay due to the presence of the HAB species *Karenia brevis* and *Dinophysis ovum*. Fish kills were also reported in response to blooms of the former. Aside from causing fish mortality events and leading to shellfish harvesting closures, a longer-term threat comes from potential impacts on the nascent commercial oyster aquaculture industry in both Matagorda Bay and San Antonio Bay.

In Texas, state agency (Texas Parks & Wildlife Department, TPWD; Texas Department of State Health Services, DSHS) HAB sampling occurs in response to blooms, focusing on assessments of impacts on living resources (TPWD) and/or humans via shellfish (DSHS). Routine monitoring for HABs is not within the mandate of these entities and so they do not have the capacity to provide early warning of HAB events or of identifying environmental conditions leading to blooms.

Past events in Texas, and elsewhere, have demonstrated the value of routine monitoring to provide early warnings of HAB events, enabling more timely and effective responses and reducing both potential illness and economic losses. Currently, the primary tool to achieve this is an automated sampling instrument called an Imaging Flow Cytobot (IFCB; https://mclanelabs.com/imaging-flowcytobot/), that combined with machine learning algorithms, can provide rapid identification of harmful algae. At the time of this study, there were at most three of these instruments active at one time along the Texas coast, and none of these were in or near Matagorda Bay and San Antonio Bay.

The goal for this project was to implement a HAB research and monitoring program in Matagorda Bay and San Antonio Bay to understand risks from HABs and support efforts to mitigate and possibly prevent negative impacts on these ecosystems and their living resources. Specific objectives were to: 1) deploy an IFCB at a strategic location to provide early warning of HAB events, 2) collect data in both bays to understand drivers of HAB events in them, and 3) engage stakeholders to increase awareness of HABs and to seek solutions that will mitigate HAB impacts and potentially limit their future occurrence. These sampling approaches, operating at different time and space scales, are highly complementary and will mitigate risks associated with blooms while also leading to understanding drivers of blooms.

Task 1: IFCB deployment for HAB detection

An IFCB was purchased from McLane Labs at the start of this grant. COVID delayed the initial training of personnel, which began in the spring of 2022. In-house configuration and testing of the IFCB and necessary support equipment was on-going throughout 2022 and 2023. The operation of this IFCB was plagued with component failures, ones that were unusual even to the manufacturers of the instrument. This resulted in substantial delays in configuration, training and deployment testing. An important finding from this study, heretofore unrecognized in the resource management community, was that the depths and conditions of Texas estuaries present additional challenges to the function and longevity of IFCB deployments in them.

Multiple trips were made to the deployment site at Texas Parks and Wildlife Department's Port O'Connor office – referred to as site PO throughout this study (Figure 1, Figure 2). This location was selected for both logistical and environmental reasons: the controlled entry under the supervision of TPWD, availability of electricity connection, and the location enables detection of ocean-derived HABs (such as *K. brevis* and *Dinophysis ovum*) that could affect both Matagorda and San Antonio Bays via Pass Cavallo and the Matagorda Ship Channel, and estuarine HABs affecting Matagorda Bay.

Figure 1. Six weekly sampling locations are indicated by white squares and two-letter site codes. Weather symbols indicate the location of the nearest meteorological stations with available data.


Figure 2. Deployment set up of IFCB175 and supporting equipment at TPWD Port O'Connor.

We achieved multiple successful deployments (Table 1), including detection of a *Karenia* event (*K. selliformis*) that was monitored and reported to TPWD and DSHS (beginning Oct 28, 2024, Table 2, Figure 3) and more detailed detection and monitoring of *Dinophysis* sp. (February 2025,Table 2). Continuous sampling by the IFCB during its deployments captured images of *Karenia brevis* and *Dinophysis* sp. below levels of concern, as well as other species capable of forming HABs (e.g. *Prorocentrum* spp., *Fibrocapsa japonica*, *Chattonella* sp., *Margalefidinium polykrikoides*, *Pseudo-nitzschia* spp.).

An important outcome of the IFCB data collections is that we now have over 167,900 identified and annotated images that are being used to develop a machine-learning based HAB classifier in support of future IFCB deployments at this and other Texas coast location. The operation of the IFCB has also been a tremendous learning opportunity, part of the necessary development and experience that will benefit future instrument deployment efforts, which are already underway at additional locations along the Texas coast: the Texas State Aquarium and tentatively Aransas Bay in Rockport and the Laguna Madre south of Corpus Christi.

Table 1. IFCB175 field deployments at Port O'Connor.

Deployment	**Retrieval**
9/28/2023	9/29/2023
12/20/2023	1/25/2024
7/31/2024	8/6/2024
9/25/2024	10/7/2024
10/17/2024	11/15/2024
2/6/2025	2/19/2025
2/26/2025	3/12/2025
3/18/2025	Present (3/31/2025)

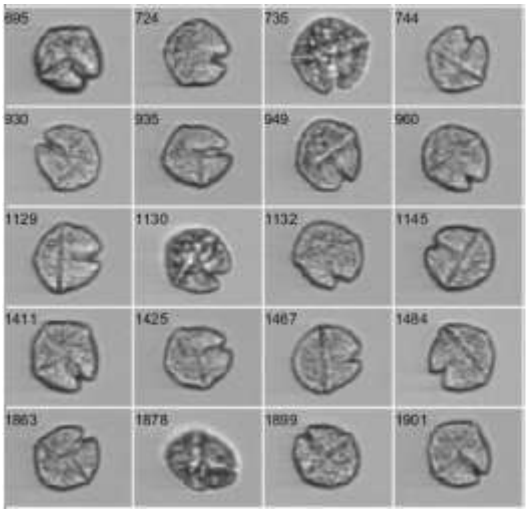

Figure 3. Example IFCB images from 12/15/2022 *Karenia selliformis* bloom. Event detected through weekly field sampling and live screens by microscopy. IFCB images collected in bench-top mode.

Table 2. HAB event communications with Texas Parks & Wildlife Department and Department of State Health Services.

Date	**Samling type**	**Reason**
12/15/2022	Weekly, discrete	*Karenia selliformis* exceeding 150 cells/mL
12/20/2022	Weekly, discrete	Continued monitoring of *K. selliformis* event, cells still present but at lower numbers
10/29/2024	IFCB	*Karenia* -like cells present at low levels, 1-2 cells/mL
10/31/2024	IFCB	Elevated *Karenia* cell numbers (2 to >5 cells/mL), primarily *K. selliformis*
2/10/2025	IFCB	*Dinophysis* sp. present, exceeding 100 cells/L
2/13-2/14/2025	IFCB	Continued observation of *Dinophysis sp.*, numbers not increasing. Also observed elevated numbers of ichthyotoxic *Fibrocapsa japonica*
3/26/2025	IFCB	Reported on disappearance of *Dinophysis sp.* cells in mid-March

Task 2: Water sampling program to quantify HABs and relevant environmental conditions.

Two years of weekly sampling included sample collection and analyses for water chemistry, nutrient concentrations as well as visual examination of live samples to qualitatively assess phytoplankton community composition and monitor for blooms (high numbers) of potentially harmful or toxic species.

Water quality conditions

Weekly water sampling occurred at six near-shore locations, two in San Antonio Bay (AR, SE) and four in Matagorda Bay (BC, PA, PL, PO) (Figure 1). All sites were accessed from shore. There were rare occasions at site PA when prevailing winds altered water levels and the site could not be sampled. Depths averaged 2 m or less at all sites.

Salinity was highest at PO compared to all other sites, and lower at the San Antonio Bay sites (AR, SE) compared to the Matagorda Bay sites – although not significantly in all cases (Table 3). Temperature demonstrated predictable seasonal patterns. Dissolved oxygen (D.O.) levels never indicated hypoxia (<2 mg/L), though it's worth noting we measured surface water at shallow sites, where both air exchange and photosynthesis would make hypoxia less likely. Sites were sampled in a consistent order every week (AR, SE, PO, PL, BC, PA) and we saw predictable differences in D.O. among sites based on sampling time during the day. Those sampled near sunrise were lower (e.g., AR, SE), when all cells in the water would have been using D.O. throughout the night, but phytoplankton had sun exposure to undergo photosynthesis and produce D.O. Sites sampled closer to midday had higher D.O. (BC, PA), due to more time for photosynthesis to increase D.O. in the water column.

Median ammonium concentrations were between 1.7 and 4.1 µM across all sites, and between 0.2 to 3.7 µM for nitrate + nitrite (NO_x). Mean concentrations were higher due to occasional spikes in nutrient concentrations (Table 3). Ammonium was significantly higher at PL compared to most other sites and concentrations at BC were elevated at times. NO_x concentrations were significantly higher at PA compared to the other sites, and spikes were also measured at BC. Orthophosphate median concentrations ranged from 0.5 to 2.3 µM, with the highest levels observed at PA and significantly lower concentrations at PO compared to all other sites. Silicate median concentrations ranged from 35.6 to 115.5 µM, with significantly higher concentrations at AR and SE, and significantly lower concentrations at PO.

Orthophosphate and silicate concentrations showed inverse relationships with salinity across all six sites (R^2 0.33 and 0.46, respectively, Figure 4), with slightly stronger relationships for the sites in Matagorda Bay (PO, PL, BC, PA) compared to San Antonio Bay (AR, SE) (individual plots not shown). This indicates inflow as a source of these nutrients, as lower salinity would often result from precipitation and inflow. It is likely that runoff and inflow events also contribute nitrogen. The ratios of dissolved inorganic nitrogen to dissolved inorganic phosphorus measured in this study averaged 2.3 to 8.3, with median values even lower – indicating strongly nitrogen limiting conditions most of the time. It is likely that any dissolved inorganic nitrogen coming into the bay was rapidly assimilated by bacteria and phytoplankton, making it difficult to detect unless sampling happened to coincide with a large spike.

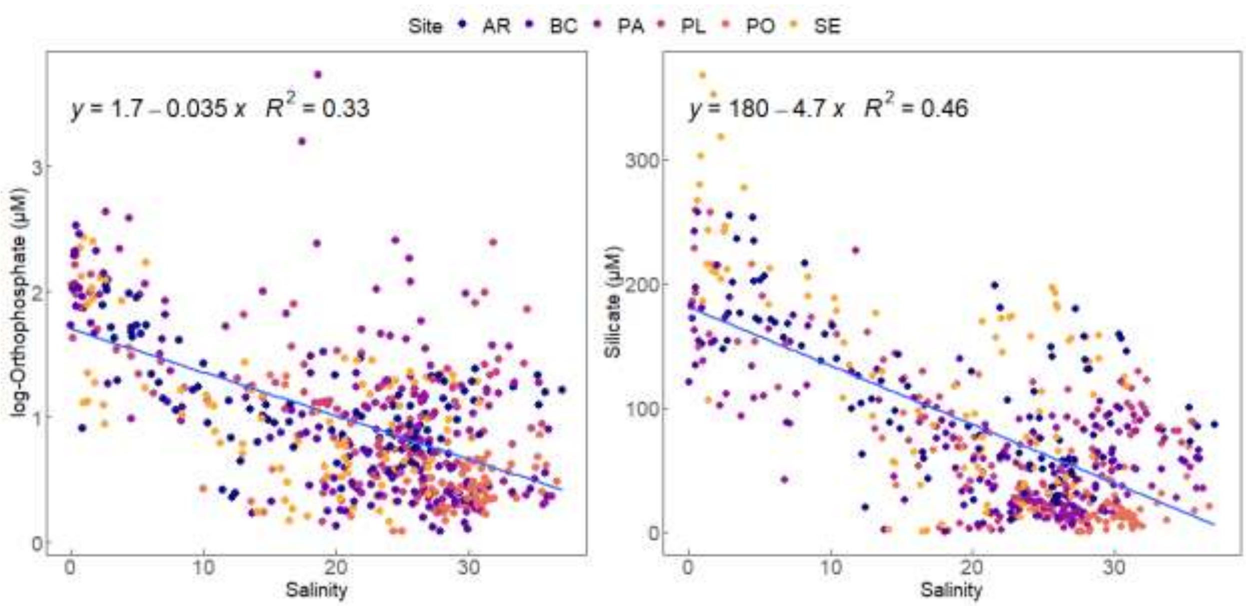

Figure 4. Biplots of (left) log-orthophosphate and (right) silicate concentrations vs. salinity color-coded by site.

Our weekly sampling program was able to capture some of these nutrient pulse events. Port Lavaca site PL experienced peaks in ammonium (exceeding 20 µM) six times during the two-year period (Figure 5). The largest of these coincided with a precipitation event, although other peaks appear to have a delay from a precipitation event or do not relate to one. PL is located very close to an inflow source that is not monitored but likely carries a large influence from both agriculture and urban land use. BC and PA sites also had spikes between 10-20 µM in ammonium several times throughout the sampling period. Similarly, PA had spikes in NO_x (two peaks exceeding 200 µM and 4 more exceeding 100 µM) co-occurring with peaks in orthophosphate (Figure 6). There were a few smaller peaks in NO_x at BC and PL as well. Some of the NO_x peaks at PA aligned with drops in salinity suggesting an inflow event, but others do not, nor do these events correspond to high precipitation or inflow events from the Tres Palacios River. The three sites with the highest dissolved inorganic nitrogen concentrations each have nearby point or diffuse sources of inflow that may be contributing nutrients. Near site PA there is a small unnamed creek that flows past the Palacios Sewage Plant and a wetland area. The shipyard and marina are also much closer to our sampling site compared to the Tres Palacios River. Site BC is located near Five Mile Draw, which appears to bring a collection of channelized inflow sources from the surrounding area. These are possible sources of nutrients that we do not have data for and cannot directly relate to our observations.

Table 3. Water quality conditions at study sites. Pairwise comparisons are based on Welch's one-way comparison of means for samples with unequal variance, and Games-Howell post-hoc comparison of means. Different letters indicate sites with significantly different values.

		AR	**BC**	**PA**	**PL**	**PO**	**SE**
Salinity	mean	18.9	20.5	22.9	20.9	27.8	17.3
	median	21.9	22.6	25.3	23.4	29.6	20.6
	pairwise comparison	a	ab	b	ab	c	a
Dissolved oxygen (mg/L)	mean	5.5	6.9	7.9	6.7	6.0	6.2
	median	5.4	6.5	7.4	6.6	5.9	6.0
	pairwise comparison						
Chlorophyll *a* (µg/L)	mean	9.5	16.6	17.5	10.1	5.6	21.2
	median	7.0	13.3	12.6	7.7	4.9	17.7
	pairwise comparison	a	b	b	a	c	b
Ammonium (µM)	mean	2.3	2.9	4.1	7.8	2.4	2.7
	median	1.8	1.9	3.1	4.1	1.9	1.9
	pairwise comparison	a	ab	b	c	a	a
NO_2+NO_3 (µM)	mean	1.2	8.4	20.1	5.4	0.6	3.4
	median	0.5	0.2	3.7	1.4	0.3	0.6
	pairwise comparison	a	abc	b	c	a	c
Orthophosphate (µM)	mean	2.2	1.8	3.6	2.5	0.7	2.4
	median	1.8	0.7	2.3	2.0	0.5	1.7
	pairwise comparison	ab	a	b	ab	c	ab
Silicate (µM)	mean	110.5	74.9	53.7	82.6	35.1	124.5
	median	100.3	58.4	35.6	70.0	19.1	115.5
	pairwise comparison	a	bc	b	c	d	a
Ratio DIN:DIP	mean	2.3	8.3	5.9	6.7	5.7	4.3
	median	1.5	3.2	5.4	4.4	5.1	2.5
	pairwise comparison	a	ab	b	b	b	ab

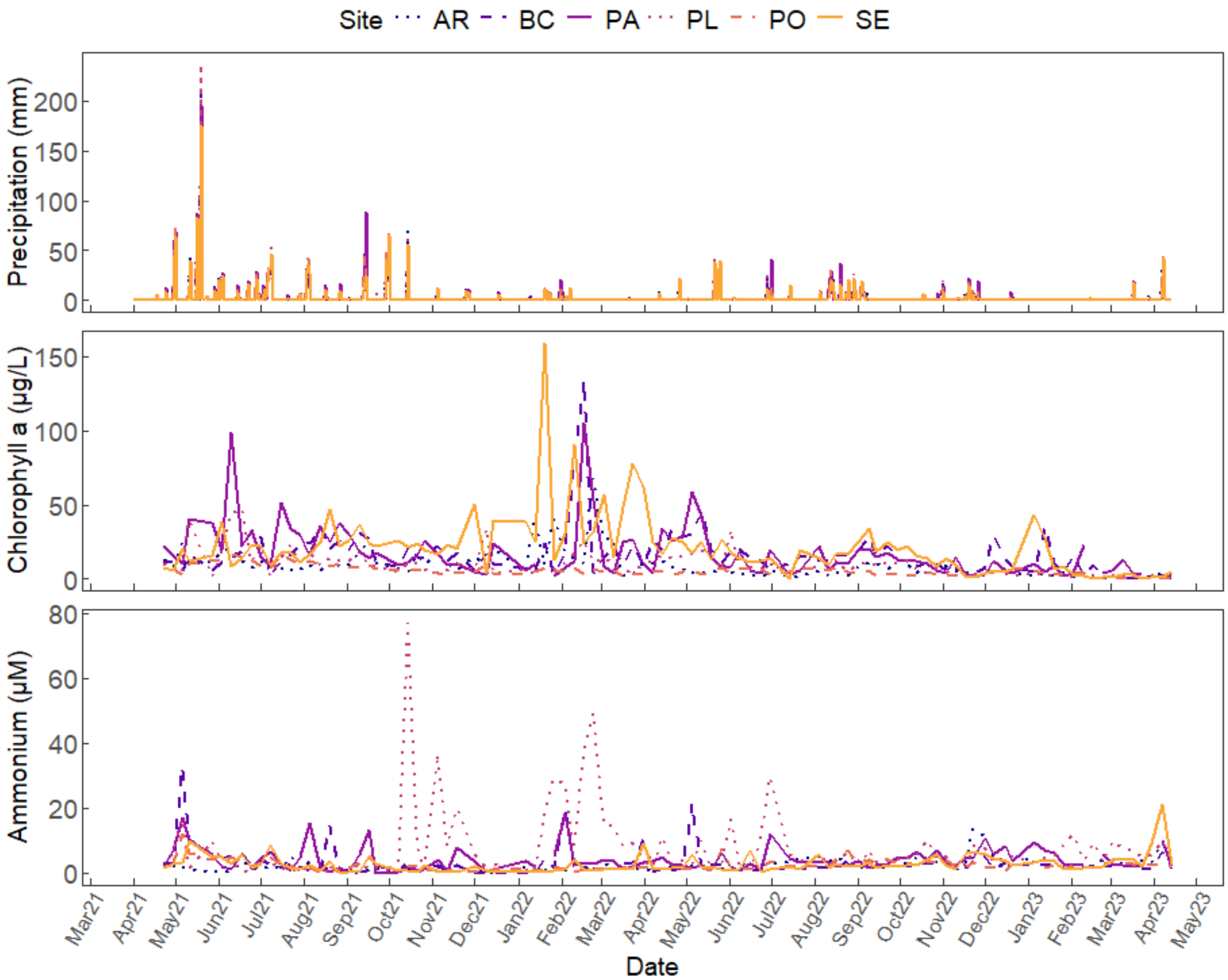

Figure 5. Precipitation (top), chlorophyll a (middle) and ammonium (bottom) concentrations from April 2021 to April 2023, color-coded by site.

Average chlorophyll concentrations across the sites ranged from 5 to 22 µg/L, with PO being statistically lower than the other sites and BC, PA and SE being higher than the other sites. Maximum chlorophyll concentrations exceeding 100 µg/L occurred three times, once each at BC, PA and SE. Concentrations exceeding the TCEQ screening level for nutrient impairment (11.6 µg/L) were observed in almost 40% of the samples collected during the two-year period, occurring at every site, and with the highest frequency at SE and BC (Table 4). Many of the chlorophyll peaks occurred in winter months (Dec, Jan, Feb). Despite this, there was no significant difference in chlorophyll among seasons, nor an interaction between site and season (based on 2-way ANOVA).

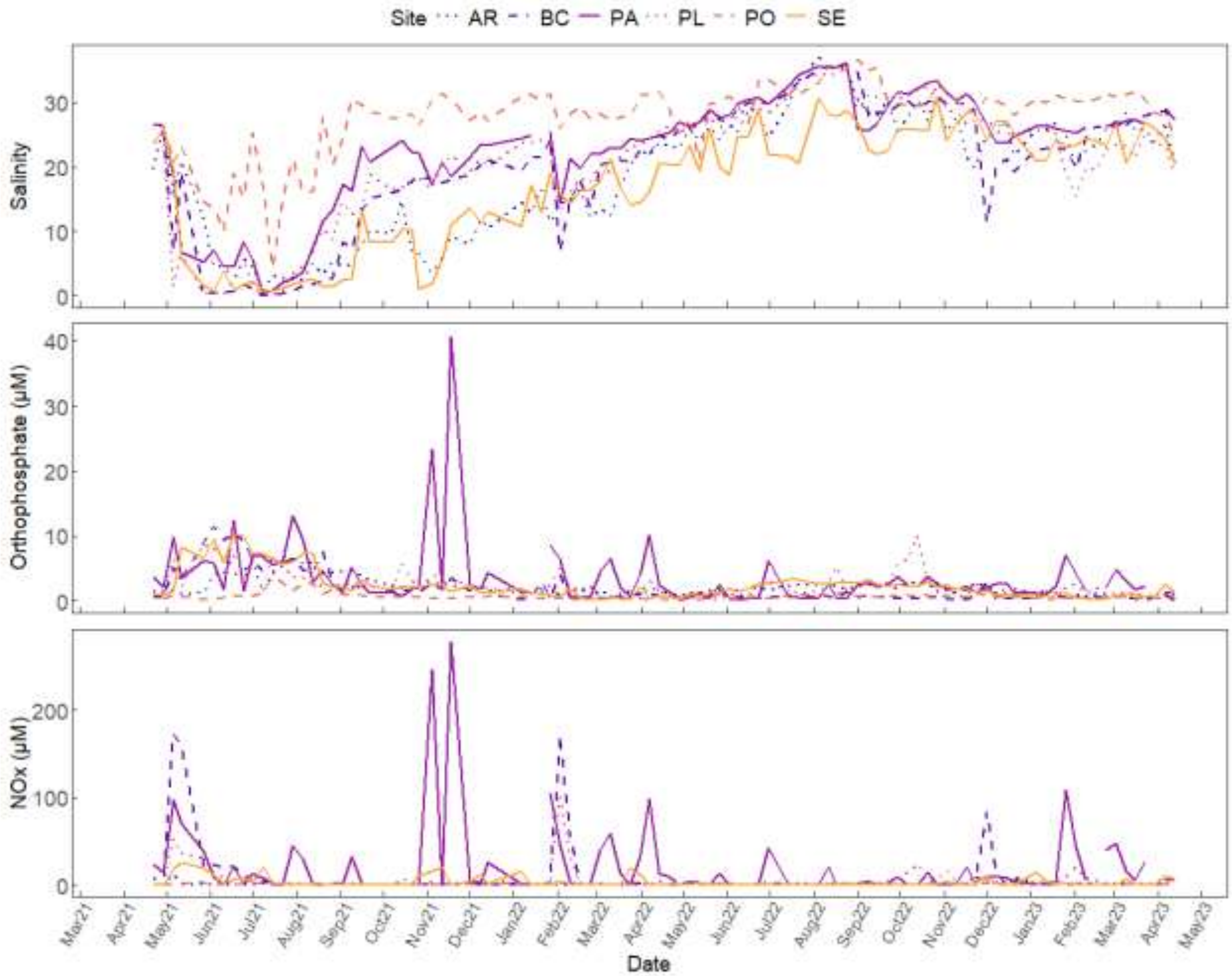

Figure 6. Salinity (top), orthophosphate (middle) and NOx (bottom) concentrations from April 2021 to April 2023, color-coded by site.

Table 4. Number and percentage of chlorophyll samples exceeding the TCEQ threshold for impairment of 11.6 µg/L across the six sampling sites, and overall.

Site	# of samples	Samples exceeding	Percentage exceeding (%)
AR	96	23	24
BC	96	56	58.3
PA	96	49	51
PL	96	27	28.1
PO	96	8	8.3
SE	96	66	68.8
Total	576	229	39.8

Phytoplankton and HABs

Across 96 sampling dates at six sites, we identified 18 different species that can form HABs (Table 5). Generally, these species were observed at low numbers – densities that do not constitute a bloom or risk of harmful effects to other organisms. The most commonly observed potential HAB-forming species were *Kryptoperidinium foliaceum*, *Pseudo-nitzschia* spp. and *Levanderina fissa*. *K. foliaceum* and *L. fissa* are dinoflagellates that are not known to produce toxins but can bloom at high densities resulting in low dissolved oxygen events. Some species of *Pseudo-nitzschia* can produce the toxin domoic acid, which causes amnesic shellfish poisoning. But there are close to sixty species of *Pseudo-nitzschia*, many of which are not easily distinguishable by light microscopy, and only about half of these species produce toxin. There are currently no documented toxic events due to *Pseudo-nitzschia* in Texas waters.

TPWD was notified of high numbers of *Karenia selliformis* at PO on December 15, 2022, with concentrations exceeding 100 cells/mL (Table 2). The DSHS threshold of *Karenia brevis* cells for closing shellfish harvesting is 5 cells/mL (or 5000 cells/L)[1]. The other times *Karenia* spp were observed was at low numbers. Another potent toxin producer is *Dinophysis,* which we observed to be present at PO on 6 out of 96 dates. *Dinophysis* toxins cause diarrheic shellfish poisoning (DSP) when consumed by humans, and cause illness at much lower cell concentrations compared to *Karenia* spp. However, Texas does not currently have an established threshold for this species at which management actions are taken.

There were no clear patterns between the frequency of HAB species presence and water quality (namely salinity and nutrient) conditions. The most frequently observed species (e.g. *K. foliaceum, L. fissa, Akashiwo sanguinea, Prorocentrum cordatum*) were observed at all six sites. *K. foliaceum* was observed less in colder months (Dec, Jan); *L. fissa* was observed more in late summer (Aug, Sept, Oct); *P. cordatum* in late winter (Feb, Mar, Apr). *Pseudo-nitzschia*, *Karenia* spp. and *Dinophysis* were most often observed at PO – the site closest to a connection with the Gulf.

Table 5. Percentage of sampling dates when potential HAB forming species were observed separated by sampling site.

Group	**Genus (species)**	**Toxin/Toxicity**	**Total**	**AR**	**BC**	**PA**	**PL**	**PO**	**SE**
Diatom	*Pseudonitzschia* spp	domoic acid	18	5	10	9	8	67	7
Dinoflagellate	*Akashiwo sanguinea*	surfactants	8	1	10	4	7	7	16
Dinoflagellate	*Cochlodinium* sp	no toxin known	2	0	2	1	4	1	5
Dinoflagellate	*Dinophysis* sp	okadaic acid, DTX-1,PTX-2	1	0	0	0	0	6	1
Dinoflagellate	*Karenia brevis*	brevetoxins	0	0	0	0	0	0	0
Dinoflagellate	*Karenia mikimotoi*	gymnocin-A	0	0	0	0	0	1	0
Dinoflagellate	*Karenia selliformis*	gymnodimine	1	0	0	0	0	4	0
Dinoflagellate	*Karenia* (sp unconfirmed)	brevetoxins, gymnocin-A, ichthyotoxic	3	1	2	1	2	10	1
Dinoflagellate	*Karlodinium* like	*K. veneficum* - cytolysins, karlotoxins	2	0	2	2	2	2	2

Dinoflagellate	*Kryptoperidinium foliaceum*	no toxin known	23	29	10	25	32	15	26
Dinoflagellate	*Levanderina fissa*	no toxin known	15	9	20	8	12	14	26
Dinoflagellate	*Margalefidinium polykrikoides*	ichthyotoxic	1	2	0	0	0	0	2
Dinoflagellate	*Prorocentrum* spp	various toxins/NTK varies by species	5	3	1	4	3	16	4
Dinoflagellate	*Prorocentrum micans*	no toxin known	2	0	2	1	0	6	1
Dinoflagellate	*Prorocentrum cordatum*	haemolytic	11	10	13	8	9	11	14
Dinoflagellate	*Prorocentrum texanum*	okadaic acid	1	1	1	0	0	5	0
Dinoflagellate	*Pyrodinium bahamense*	saxitoxins	0	0	0	0	0	0	0
Raphidophyte	*Chattonella* spp	ichthyotoxic	1	0	1	0	3	0	0
Raphidophyte	*Chattonella subsalsa*	ichthyotoxic	2	2	0	0	4	3	1
Raphidophyte	*Fibrocapsa japonica*	ichthyotoxic	2	0	0	0	0	11	0
Raphidophyte	*Heterosigma* spp	ichthyotoxic	4	2	7	3	4	0	5

[1] Texas Harmful Algal Bloom Response Plan. Harmful Algal Bloom Subcommittee, Toxic Substances Coordinating Committee. 2009. TPWD.

Task 3: Stakeholder engagement

Interim results from the weekly water quality sampling component of this study were shared with community members at the Lavaca Bay Foundation speaker series in a presentation "Assessing the risk to ecosystem health from nutrient pollution in Lavaca Bay" (June 15, 2023, Port Lavaca TX). Combined with long term trend analysis of TCEQ water quality data, it informed a need for a more detailed assessment of water quality conditions in Lavaca Bay and assessment of the potential sensitivity to nutrient enrichment in the system.

Insights gained from this study have helped inform development of a coastal HAB monitoring plan which the research team is leading. To this end, results were incorporated into a presentation "Coastal Harmful Algal Bloom Monitoring in Texas" that was part of a Texas Harmful Algal Bloom Seminar hosted by the Texas State Aquarium and Wildlife Rescue Operation Center (October 23, 2024). Attendees came from a variety of federal, state and research organizations, as well as stakeholders from local communities and businesses. In addition, the draft final report was shared with representatives from two key local stakeholder groups (Lavaca Bay Foundation, Matagorda Bay Foundation). Stakeholders were subsequently given an opportunity to provide insights on HAB-related issues and needs in terms of future monitoring efforts via an online survey conducted by the project team.

Summary

The coast of Texas is anticipated to experience increasing population and impacts from climate and land use changes. These conditions will impact coastal waters, with a risk for degrading water quality if effective monitoring and management strategies are not implemented. One of the potential water quality impacts are increases in harmful algal blooms.

This project used two sampling approaches to monitor for HABs in San Antonio and Matagorda Bay: discrete weekly field sampling at multiple locations and continuous instrument-based (IFCB) sampling at one location. The discrete sampling detected a HAB event of the species *Karenia selliformis* in December 2022. The IFCB detected presence and elevated levels of *Karenia selliformis* and *Dinophysis* sp. in October 2024 and February 2025, respectively. The IFCB captured the presence of toxic species that were missed using traditional sampling and screening methods. For example, we had cases where samples collected by the IFCB on the same day as field sampling showed *Dinophysis* (can cause negative effects at low concentrations) that was not observed in the live screens. This demonstrates the value of this instrument-based sampling to rapidly screen larger sample volumes as well as high frequency sampling for detecting lower abundance HABs and enabling early warning for possible bloom development.

The weekly sampling provided improved spatial and temporal resolution of nearshore water quality in San Antonio and Matagorda Bays. Although nutrient (nitrogen and phosphorus) concentrations were typically low, the detection of large pulse events highlights nutrient pressure on the system and risk for decreasing water quality over time. Current nutrient conditions are characterized by nitrogen limitation of the phytoplankton community, and even small increases in nitrogen concentrations and availability will likely lead to increased chlorophyll and algal biomass. Indeed, this is already visible with chlorophyll concentrations exceeding the TCEQ impairment threshold in almost 40% of our samples, suggesting the system is vulnerable to nutrient pressure. Continued monitoring of water quality, and more targeted sampling of uncharacterized inflow sources will help us to understand nutrient sources to the system and inform management strategies to keep it healthy.

Our observations demonstrate the need for continuing and expanding routine phytoplankton monitoring efforts, as numerous HAB species were identified and present in these bay systems, and IFCB sampling captures these species when traditional sampling cannot. A long-term benefit of this project is the acquisition of the IFCB, development of deployment infrastructure and protocols, and building our capacity for AI-assisted species identification. The time and learning resources put in during this project are already benefiting new deployment efforts and co-development of a dashboard website integrating the AI identification model. This dashboard will be used for multiple IFCBs and a more integrated HAB monitoring network along the Texas coast.