Report as of FY2006 for 2003TX112G: "Bridging the Gap Between Plankton Dynamics and Spatial Variability in Water Quality in the Guadalupe Estuary (Texas): The Importance of Freshwater Pulses"

Publications

- Conference Proceedings:
  - Davis, S., D. Roelke, G. Gable, H-P. Li, C. Miller. 2005. Physical, chemical, and biological responses to inflow events in Galveston and San Antonio Bays (TX): Bay-wide characterizations. Estuarine Research Federation. Norfolk, VA, USA. October 16-21.
  - Davis, S.E., D. Roelke, J. Pinckney. 2005. Use of high resolution spatial mapping to estimate plankton response to freshwater inflows entering Galveston Bay: Importance of watershed development and ecosystem health. Galveston Bay Estuarine Program meeting. Houston, TX. November 15.
  - Davis, S.E., D. Roelke, D. Slack. 2005. Physical, Chemical, and Biological Responses to Inflow Events in the San Antonio Bay System. Environmental Flows Conference, Texas State University, San Marcos, TX. Oct 31 - Nov 1.
  - Davis, S.E., D. Roelke, et al. Determining the importance of freshwater inflows to ecological structure and function in the bays and marshes of the Guadalupe Estuary (TX). April 1, 2005 at the Gulf Estuarine Research Society Meeting, Pensacola, FL.
  - Li, H.-P., D.L. Roelke, S. Davis, C. Miller, G. Gable, J.V. Montoya, L. Romero. 2005. Biological response during a wet year in San Antonio Bay, TX: Fixed station data. TX Sea Grant Researcher Conference. College Station, TX. October 5.
  - Li, H.-P., D. Roelke, S. Davis, C. Miller, G. Gable, K.-J. Liu, J. V. Montoya, L. Romero. 2006. Freshwater inflow affect in San Antonio Bay, Texas: Preliminary Data. Environmental Protection Agency, Bandera, TX, USA. April 12-14.
  - Roelke, D., S. Davis, H-P. Li, C. Miller, G. Gable, J.V. Montoya, L. Romero. 2005. Biological response during a wet year in San Antonio Bay, TX: Fixed station data. Estuarine Research Federation. Norfolk, VA, USA. October 16-21.
- Other Publications:
  - Davis, S.E.. Understanding the importance of pulsed events in Gulf Coast estuaries. April 20, 2005 Marine Biology Departmental Seminar at Texas A&M University at Galveston, Galveston, TX.
  - Roelke, D.L. 2006. Large-scale disturbances and the predictability of complex aquatic ecosystems. US EPA, Western Ecology Division, Corvallis, Oregon. March 22.
  - Roelke, D.L. 2005. Water issues and research needs in Texas. Brazos Chapter, Texas Master Naturalists, Bryan, TX, USA. November 3.
  - Gable, G., D. Roelke, S. Davis, H-P. Li., K.-J. Liu, C. Miller. 2006. Spatial and Temporal Trends in Physiochemical Water Parameters, Productivity, and Planktonic Community in Mesquite Bay, Texas: Preliminary Data. TAMU, Student Research Week, College Station, TX, USA. April 1.
- unclassified:

- Roelke, D.L. 2005. Regional species richness and supersaturation: The role of migration and disturbance of chaotic communities. University of Oklahoma Seminar Series, OK, USA. October 12.
- Miller, C.M., D.L. Roelke, S.E. Davis. 2005. Hydrologic connectivity of saltwater ponds adjacent to Sundown Bay, Aransas National Wildlife Refuge, TX. TAMU Student Research Symposium, Texas A&M University. College Station, TX. April 23.

Report Follows

Bridging the Gap Between Plankton Dynamics and Spatial Variability in Water Quality in the GuadalupeEstuary (Texas): *The Importance of Freshwater Pulses*

Project Number
2003TX112G

Final Report
September 1, 2003 through August 31, 2006

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Effective Date: June 6, 2007

Project Overview

As decisions regarding freshwater diversions to meet human needs are made, an understanding of the downstream ecological effects is needed. In fact, the primary challenge for water resource managers in coastal states like Texas is to determine how to meet human demands for freshwater, yet maintain critical inflows of freshwater to our nation's estuaries. Therefore, as part of the LGWSP, GBRA, SARA, and SAWS are supporting ongoing ecological and statistical studies of the Guadalupe Estuary by scientists from Texas A&M University and the University of Texas. These studies aim to promote an understanding of the impact of a reduction in freshwater inputs from the Guadalupe River on the marsh ecosystem along the Blackjack Peninsula and commercially important species in the bays (Figure 1).

Section 11.147 (a) of the Texas Water Code defines "beneficial inflows" as those that provide a "salinity, nutrient, and sediment loading regime adequate to maintain an ecologically sound environment in the receiving bay and estuary system that is necessary for the maintenance of productivity of economically important and ecologically characteristic sport or commercial fish and shellfish species and estuarine life upon which such fish and shellfish are dependent." Pulich *et al.* (1998) reported freshwater inflow recommendations for the Guadalupe Estuary based on Texas Estuarine Mathematical Programming (TXEMP) and recommended 1.15 million acre-ft/yr as the "Maximum Harvest (MaxH) target value to fulfill the biological needs of the Guadalupe Estuary System on a seasonal basis." In particular, Pulich *et al*. (1998) found that densities of key harvested species, including both finfish and shellfish, were positively related to inflows that would produce maximum salinity areas of the bay between 5‰ and 20‰. Critical conditions for estuarine health are related to inflows during the wetter months of May and June. Low values of inflows during the drier months (e.g. August) are typical and can be tolerated if adequate inflows occur in earlier months (Pulich *et al*. 1998).

This was a three-year study centered on the San Antonio Bay Estuary (Figure 1) that sought to characterize and map water quality and quantify water column productivity across the entire estuary during different inflow conditions a minimum of 12 times per year (i.e. monthly). Our study also sought to provide a continuous record of materials loading into the bay from the Guadalupe River. This work and all sample analyses have been conducted at Texas A&M University. The synthesis of information collected from this study and concurrent studies in the Galveston Bay Estuary (by Davis and Roelke) will help to provide a more comprehensive understanding of the relationships between the nature (i.e. frequency, magnitude, and mode) of pulsed inflow events and estuarine ecosystem health along the Texas Gulf Coast, thus allowing state water managers to optimize diversions of freshwater (for municipal, agricultural, and industrial uses) while minimizing impact to estuarine ecosystem health. Our results showed strong relationships between nutrient concentrations and location along the estuarine gradient. We also found clear correlations among river inflow and CDOM—an indication of a river source of organic matter possibly fueling net ecosystem production in the upper estuary.

Project objectives, tasks, and schedule of deliverables are described as follows:

Program Element 1: Data Acquisition (Work Plan Objectives, Tasks, and Methods)

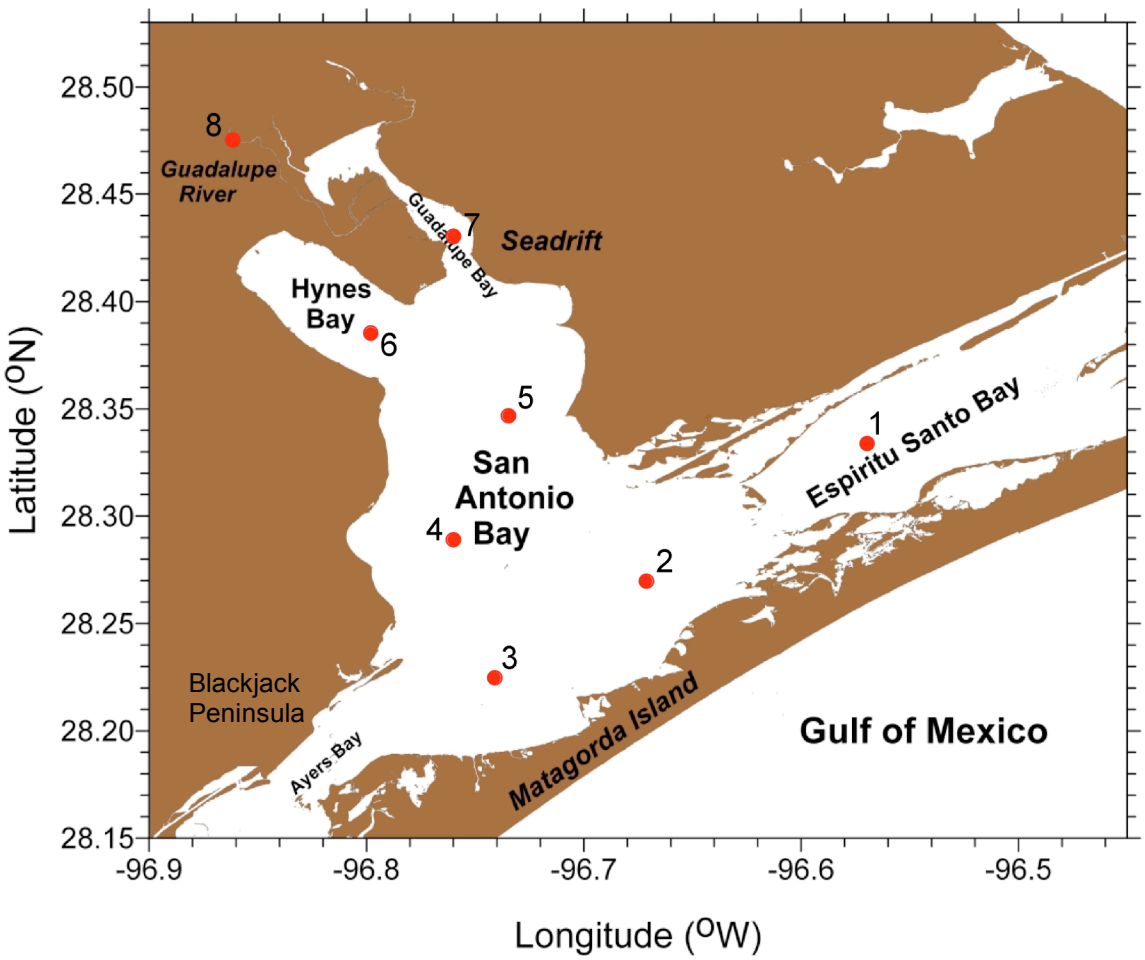


Figure 1: Map of San Antonio Bay/Guadalupe River Estuary and identification of fixed sampling stations.

<u>Objective</u>**:** To collect data on nutrient loading into the San Antonio Bay (i.e., Guadalupe River) Estuary from Guadalupe River and conduct monthly samplings for bay-wide water quality mapping, water column productivity, and plankton community composition.

Task 1 Establish refrigerated water sampler at USGS gauge at Tivoli, TX along the lower Guadalupe River. Run sampling program that will collect tri-daily, composite water samples. These samples will be retrieved every two weeks, processed, and taken to the laboratory for nutrient analyses.

Task 2 Conduct monthly Dataflow runs and measurements of water quality and water column productivity at fixed stations along estuarine salinity axis.

Task 3 Acquire daily flow and stage data from USGS gauge at Tivoli, TX along the lower Guadalupe River and hourly water level and meteorological data from TCOON stations across the estuary.

Progress Report on Program Element 1: The timeline deviated from our original plan as a result of logistical problems encountered with sampling equipment. We finally achieved a successful sampling program along the lower Guadalupe River (Station 8; Figure 1) beginning in late 2005. The site is located near Tivoli, TX and is stationed at the Guadalupe-Blanco River Authority's (GBRA) saltwater barrier site—less than 15 miles from the river's outflow point into Guadalupe Bay (Figure 1). Although there is a USGS gage at the Tivoli, TX site, it only provides reliable measures of gage height (i.e., stage). Discharge values above about 3000 cfs at this site result in over-bank flooding. Since values above this threshold are quite common, we used a combination of discharge values from the San Antonio River (at Goliad, TX), Guadalupe River (at Victoria, TX) and Coleto Creek (near Victoria, TX) to estimate discharge into the estuary. Resource managers at GBRA estimate that this estimate represents approximately 70% of channelized flow into the estuary (Tommy Hill, GBRA personal communication).

With the assistance of staff from GBRA, we installed a refrigerated automated sampler at this site as part of this project. The sampler is programmable and requires a continuous supply of AC electricity. This power was provided by GBRA at no cost to the project and the sampler was secured to anchors set into the concrete bridge at this site. Typically, we programmed the sampler to collect composited samples over a 3-day period of time. The sampling and analysis of nutrients on those samples has continued since the conclusion of this project. In this report, we cover all samples analyzed through August 2006 (Figure 2). However, this Guadalupe River sampling site will continue to operate beyond this project, as long as funds can be secured to maintain its operation. We ran into several equipment-related problems along the way the resulted in several large gaps in the data set. The problems were related to defects in the water detection system in the sampler. Although the problems were corrected at no charge to the project, many of the problems took weeks to months to correct.

Guadalupe River sample data from this period indicates positive correlation between flow magnitude and concentration for most all parameters measured (Figure 2). We saw record inflows prior to the beginning of our field data collection (in late 2004) and most constituents were declining towards the end of this massive pulse. However, smaller, but significant pulses later in the study resulted in noticeable increases in concentrations of most nutrients—especially nitrogen and TSS. DOC and TSS concentrations are reflective of particulate and organic matter loadings to the estuary and often increase under high flows. Concentrations of TN and TP are oftentimes associated with these organic and inorganic constituents and show similar patterns relative to flow magnitude. In terms of dissolved inorganic nitrogen and phosphorus, phosphate, ammonium, and nitrate + nitrite were sensitive to flow magnitude in the Guadalupe River (see fixed station nutrients in appendix). However, a longer, continuous record is needed in order to understand the seasonal dynamics as well as response to flow conditions exhibited by these water column constituents.

We conducted nineteen, monthly Dataflow samplings as a result of USGS/NIWR project funding (**Table 1**). Due to equipment problems, we did not start Dataflow sampling till January 2005. During each of these samplings, we stopped at all fixed stations to collect

water samples for nutrient analysis, TSS, HPLC pigments, and chlorophyll *a*. We also conducted light/dark bottle incubations for measurements of water column productivity.

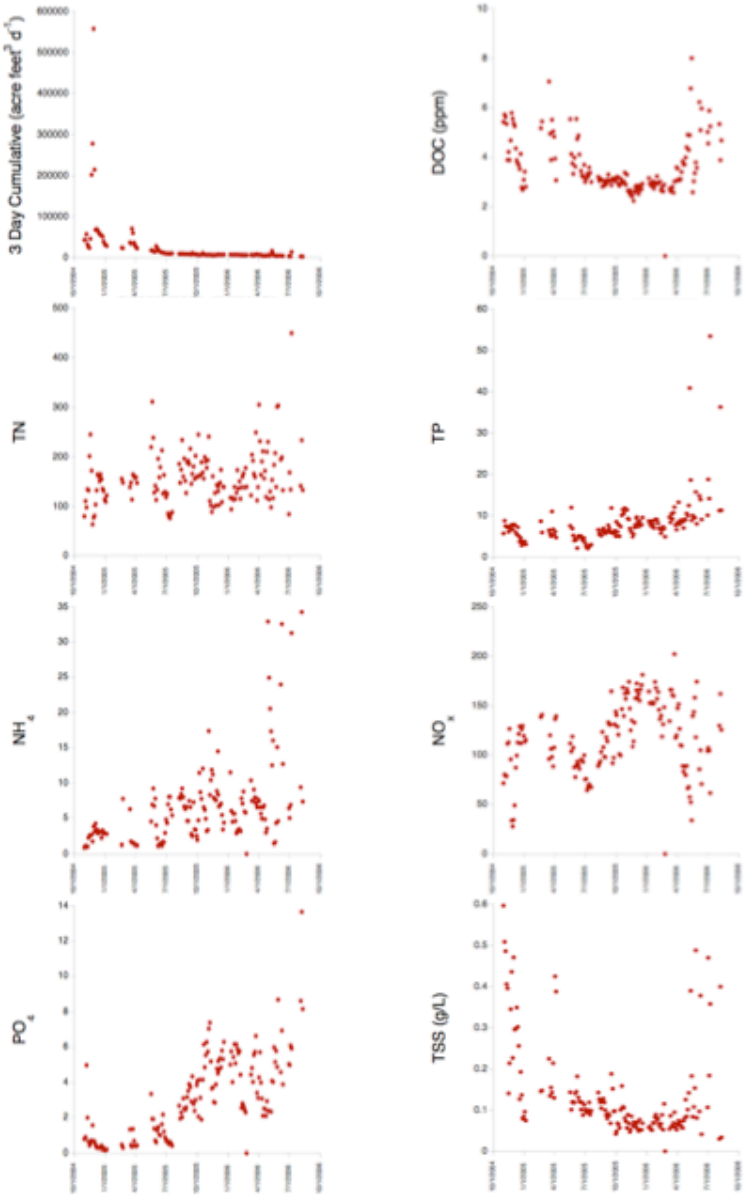


Figure 2: Combined river discharge estimate (upper left) and constituent concentrations (µM unless indicated otherwise) measured at Station 8 throughout the project duration.

Table 1: List of Dataflow sampling dates and parameters measured in San Antonio Bay.
*The September 2005 sampling was delayed as a result of Hurricane Rita.

Dates	**Parameters**
January 25, 2005	transmissivity, chl *a*, DOM, temperature, PAR
February 28, 2005	transmissivity, chl *a*, DOM, temperature, PAR
March 29, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
April 26, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
May 24, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
June 24, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
July 24, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
August 29, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
October 4, 2005*	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
October 27, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
November 19, 20, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
December 20, 2005	transmissivity, chl *a*, DOM, temperature, salinity/conductivity, PAR
January 26, 2006	transmissivity, chl *a*, DOM, temperature, salinity/conductivity
February 22, 2006	transmissivity, chl *a*, DOM, temperature, salinity/conductivity
April 21, 2006	transmissivity, chl *a*, DOM, temperature, salinity/conductivity
May 22, 2006	transmissivity, chl *a*, DOM, temperature, salinity/conductivity
June 23, 2006	transmissivity, chl *a*, DOM, temperature, salinity/conductivity
July 30, 2006	transmissivity, chl *a*, DOM, temperature, salinity/conductivity
August 28, 2006	transmissivity, chl *a*, DOM, temperature, salinity/conductivity

In addition to the station (#8) at the Guadalupe River's saltwater barrier, seven fixed stations were selected to represent the range of salinity/inflow conditions across San Antonio Bay (Figure 1; Table 2). Station 1 was located nearest the Gulf of Mexico in Espiritu Santo Bay and represented our saline end-member. Stations 2 and 3 were located in lower San Antonio Bay. Stations 4 and 5 represented mid-estuary sites. Station 6 was in Hynes Bay and Station 7 represented the freshwater end-member near the mouth of the Guadalupe River (Figure 1; Table 2).

Table 2: Latitude and longitude of fixed sampling stations in San Antonio Bay.

Station	**Latitude**	**Longitude**
1	28°19.00'	93°36.00'
2	28°16.00'	96°41.00'
3	28°14.00'	96°44.00'
4	28°18.00'	96°45.00'
5	28°21.00'	96°44.00'
6	28°23.00'	96°48.00'
7	28°26.00'	96°46.00'

Inflows to the estuary varied considerably over the course of the study. At the beginning of 2005, inflows were high and tapered off through the summer (Figure 2). The drought continued through 2005 and was followed by a series of smaller pulses in early 2006. Low inflows then prevailed for the remainder of the study. Winds in this system are predominantly out of the SE and E—especially during the summer months and represent a significant force in estuarine hydrodynamics.

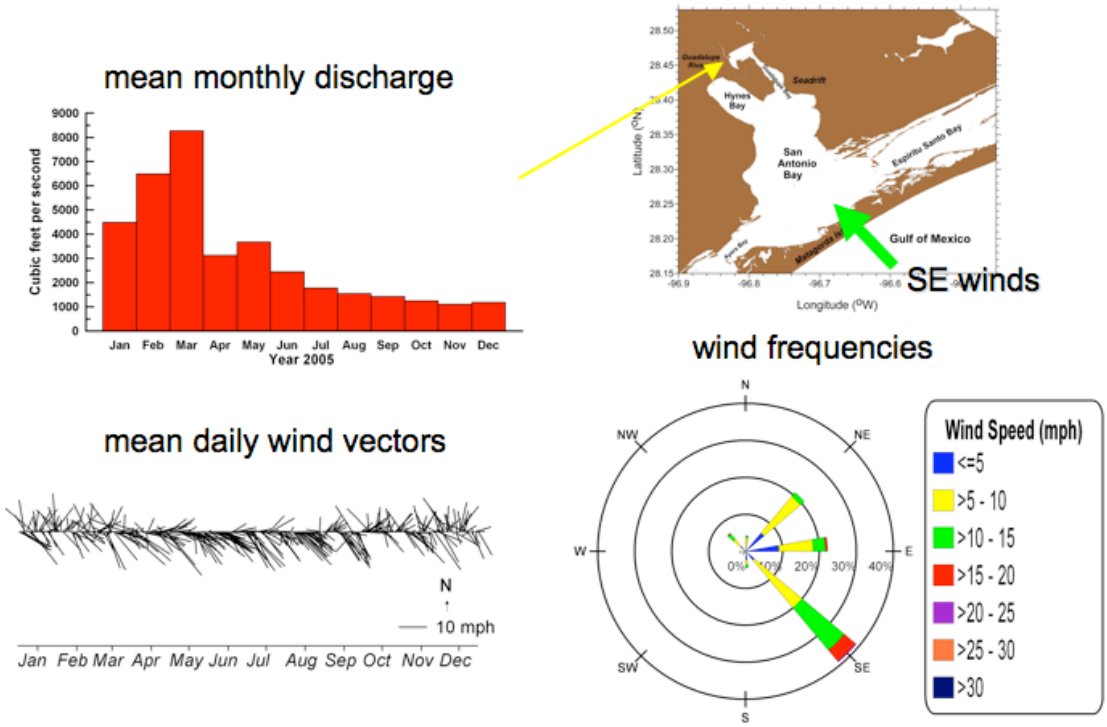


Figure 2: Plots of combined river discharge for 2005 and wind direction, speed (both on lower left) and frequency (lower right) relative to the body of the San Antonio Bay estuary (upper right). Discharge data from USGS and wind data from TX Coastal Ocean Observation Network (http://lighthouse.tamucc.edu/TCOON/HomePage).

Water quality data from the fixed bay stations reflected the relative importance of Gulf of Mexico (GOM) versus river influence (see fixed station data in appendix). Salinity was always lowest in the upper estuary, especially at Station 7 near the Guadalupe River outfall. This was followed by Stations 6, 5, 4, 3, and 2. Station 1 always had the highest salinity. Light attenuation across stations was similar, although Station 1 typically had the lowest attenuation. This site was most influenced by relatively clear GOM waters, but also showed a strong influence of wind mixing. Throughout the bay, light attenuation was largely driven by wind forcing and river inflows.

In general, concentrations of dissolved inorganic nitrogen and phosphorus were lowest in the lower estuarine areas (see fixed station data in appendix). This represents the relative paucity of nutrients in the GOM relative to river sources. Concentrations near the river mouths tended to be highest during high inflow periods.

Concentrations of total nitrogen and total phosphorus showed a similar spatial pattern of river influence and disproportionately higher concentrations near the mouth of the river. However, these constituents were more conservative across the estuarine salinity axis than dissolved inorganic N and P concentrations. This is likely due to the fact that TN and TP concentrations across the bay are likely affected by wind-driven re-suspension. Gross productivity in the water column at these fixed stations often exceeded respiration, resulting in consistent, positive net productivity. Overall, rates of these water column processes indicated more of a seasonal than inflow-related pattern (see fixed station data in appendix).

Obviously, salinity within the estuary is strongly controlled by the relative contributions of river inflow and exchanges with the Gulf of Mexico. We found strong relationships between river discharge and salinity at each site (see plots of concentration vs. salinity in appendix). As expected, this relationship was weakest at Station 1 and only existed as a result of a few high inflows measured early in 2005. Turbidity, DO, and [DOC] were less related to river inflow and were more variable as a result of seasonal variations in wind and temperature. DOC data were lacking for many samplings, but there was evidence of an inverse relationship with inflow. An opposite trend was observed with Dataflow (described below), as CDOM concentrations were positively correlated with river inflows. [TN] and [TP] also were not clearly related to river inflows from the Guadalupe. Despite the lack of a clear trend, the highest concentrations of TN and NH_4^+ measured corresponded with lower inflows, indicating a benthic source of these constituents during periods of high residence times. Likewise, phosphate was typically highest at each fixed station during the lower inflow periods, suggesting a periodic release of this constituent from the sediments. On the other hand, nitrate + nitrite concentrations were positively correlated with river inflows at some sites (especially Stations 4-6; see appendix).

Overall, we found molar ratios of TN:TP were highest in the lower reaches of the estuary and lowest in the mid-upper estuary. However, Station 7 ratios were also high. Given that the rivers seem to represent a significant supply of inorganic N to these areas of the bay, high inflow periods may result in greater productivity in the upper bay. In looking at the spatial patterns of nutrients relative to water column processes, our results are inconclusive in supporting this (see fixed station data and contour plots of nutrients in appendix). Perhaps further work looking at the direct effects of nutrient enrichment on water column processes and benthic exchanges would clarify this.

Dataflow samplings were conducted monthly and required a minimum of 1 day to complete. The technique involved pumping water on board a moving boat and deposited into a de-bubbling reservoir. This water was then pumped into a series of water quality sensors that were connected in-line via tubing. Water quality data were then harvested from these sensors at a fixed time interval (approximately every 4 seconds) and linked with a set of GPS coordinates and stored in a data logger (see Dataflow maps for all samplings and parameters in appendix).

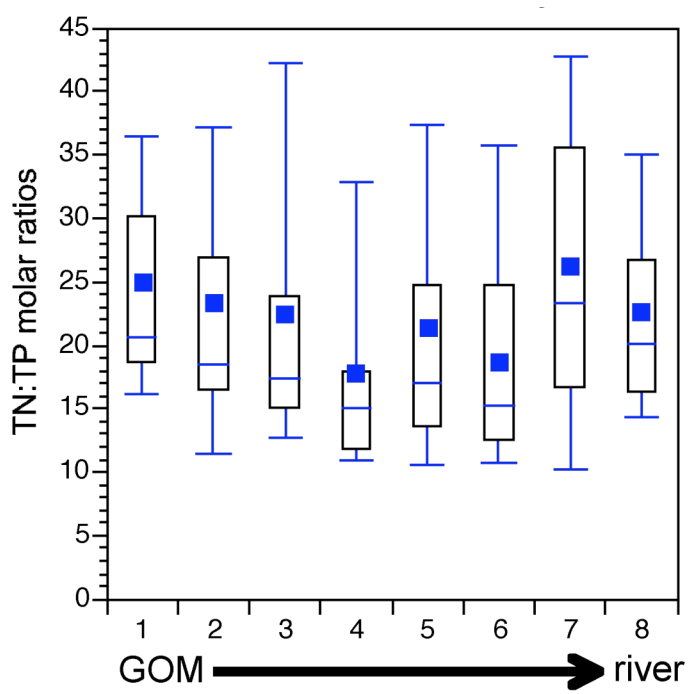


Figure 3: Box plot of molar TN:TP ratios across the salinity gradient of the Guadalupe Estuary throughout the duration of sampling. The boxes in each represent the inter-quartile range of each distribution. The middle line is the mean and the blue square represents the statistical mean. Whiskers indicate the 10th and 90th percentiles.

Dataflow maps were generated for each sampling described in Table 1 (see appendix). These maps provide a powerful illustration of the influence of river inflow relative to marine exchange and even serve to identify general circulation/exchange patterns. They can also help identify areas of management concern (areas of wetland loss, urban development, pollutant loading, etc.). In each map, the transect sampled is indicated by the dashed line.

Program Element 2: Data Analysis

Objective**:** Establish the link between riverine inflows and spatial patterns in water quality and fixed station data.

Task 1	Analyze spatial patterns in water quality parameters using Dataflow information. These data will be synthesized as Surfer-based contour plots (i.e. maps) of bay-wide water quality.
Task 2	Link temporal patterns in inflows and loadings to spatial patterns in estuary-wide water quality and water column productivity through multivariate statistical analyses.

Progress Report on Program Element 2: Although we have estimates of discharge available to us from USGS' Guadalupe River site, the difficulties in sample collection at the SW Barrier site have precluded us from calculating loadings for the period of this study. Still, we have continued to archive data and analyze the link between estimated inflows and patterns we observed throughout the bay during each of our monthly samplings.

Many of these patterns were described in the previous section of this report. However, further analysis of Dataflow data collected in the Galveston Bay and San Antonio Bay estuaries indicates similar trends between river inflows and the loading of dissolved organic matter (Figures 4 and 5). Moving from a period of high inflow to low inflow in each system during 2005 shows the similar spatial patterns for CDOM and conductivity in each estuary (Figure 4 and 5). The statistical distributions for each are quite different though. Likely a result of its smaller size and reduced connection to the Gulf of Mexico, San Antonio Bay had smaller, tighter distributions of CDOM relative to Galveston Bay. For conductivity, distributions were tighter during periods of high inflow in San Antonio Bay relative to Galveston Bay. However, there appeared to be a shift in the distributions as flows decreased in these systems. These patterns reflect differential responses to similar climatic patterns and likely reflect the relative connectivity to the marine end-member and the amount of freshwater inflow relative to estuarine volume. As for relationships among all Dataflow parameters, we saw several instances of correlation among Dataflow parameters—especially between CDOM and conductivity (Figure 6).

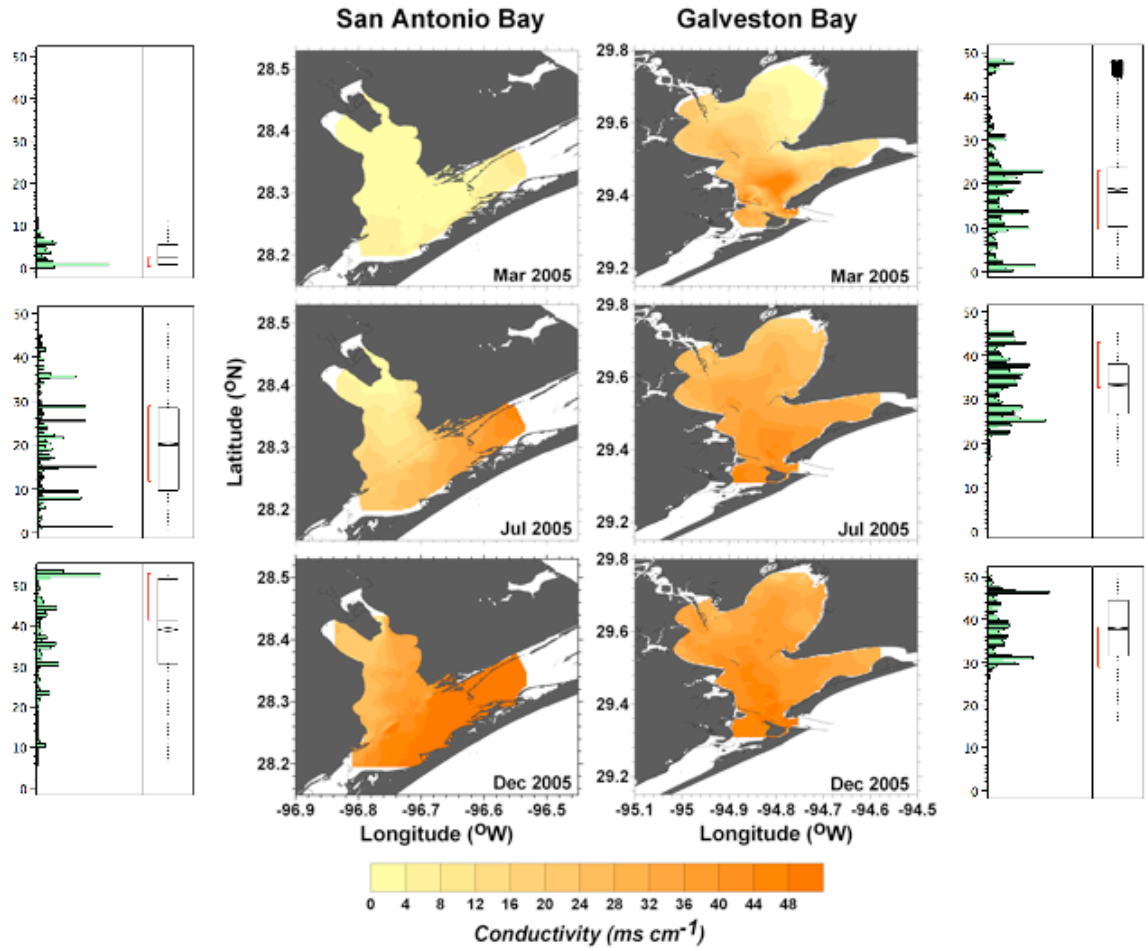


Figure 4: Spatial and Statistical patterns of conductivity in San Antonio and Galveston Bays during the same monthly samplings that went from a period of high inflow (March 2005) to a period of extended low inflow (December 2005).

We used non-metric multi-dimensional scaling to assess the role of estuarine flushing, location along the estuarine gradient, and pulsed nature of inflows on the relationships among fixed station data. PC-ORD 4.25 (MjM Software, Gleneden Beach, OR) was used to run NMS ordination analyses for these data. Dividing the site-specific data by flushing rate (both week^{-1} and month^{-1}) resulted in no distinct separation of clusters except at the highest flushing rate (see NMS results in appendix). This same analysis with two levels of pulsing ("after pulsed inflow" and "not after pulsed inflow") resulted in similar clustering and pulsing during a dry year also indicated some clustering more towards the "no pulse" cluster. However, it should be noted that much of this was driven by differences in site-specific differences in salinity/conductivity, which was the most robust indicator of inflow. And as expected, this pattern was most noticeable at stations nearest the river mouth, where the greatest inflows occurred.

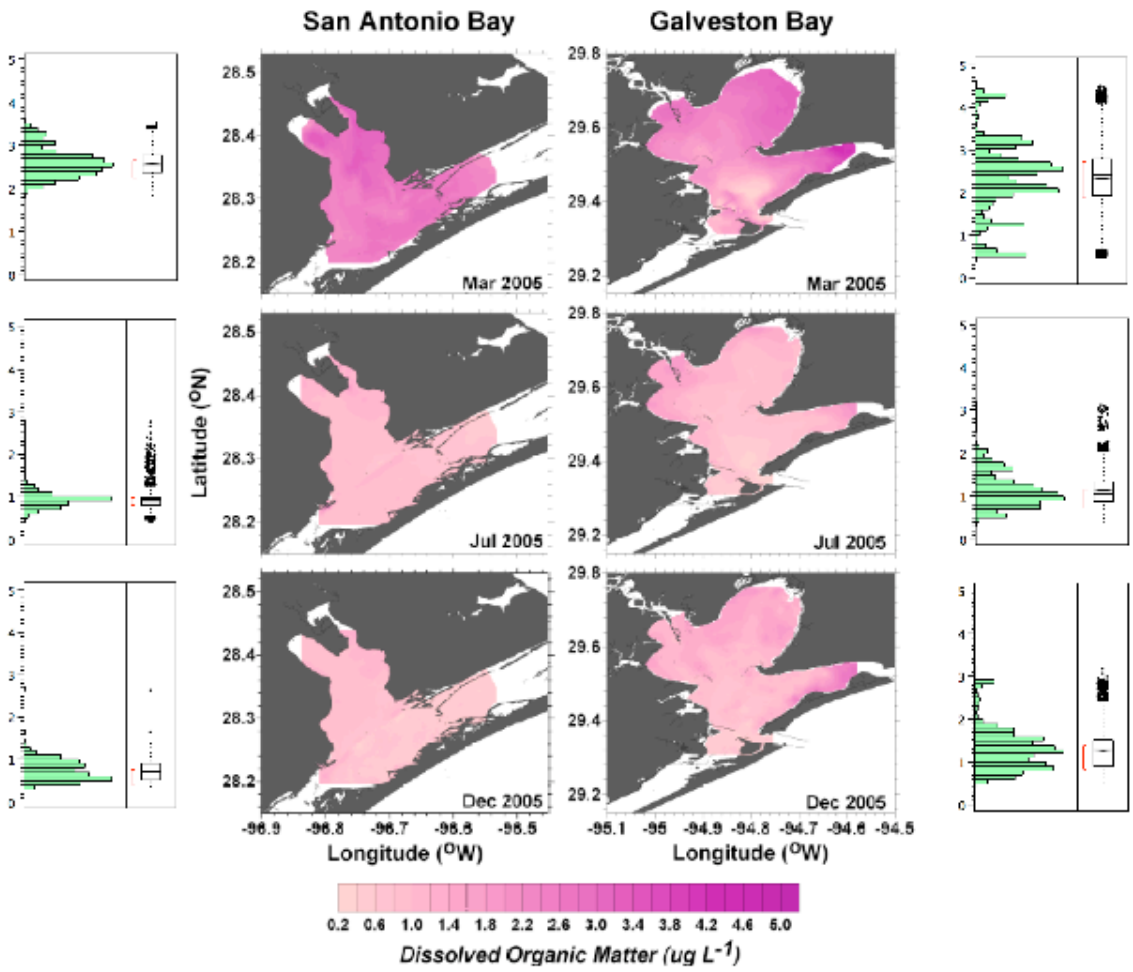
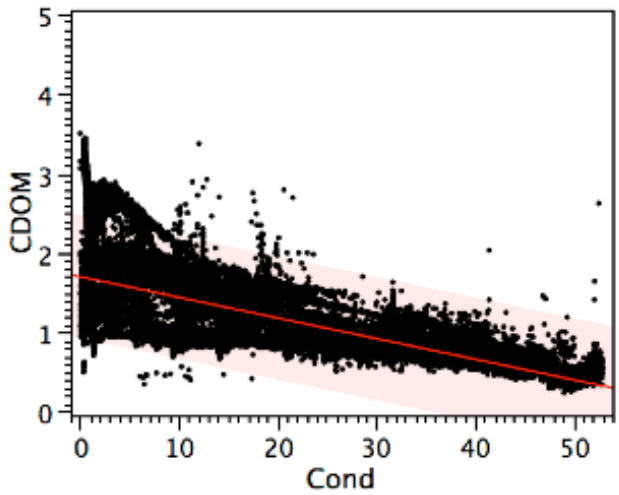


Figure 5: Spatial and statistical patterns of CDOM in San Antonio and Galveston Bays during the same monthly samplings that went from a period of high inflow (March 2005) to a period of extended low inflow (December 2005). CDOM patterns were directly related to river inflows in most all samplings.



CDOM = 1.7009766 - 0.0258825 Cond
RSquare Adj = 0.499

Figure 6: Scatter plot with best fit line showing the relationship between CDOM and conductivity observed across all monthly Dataflow samplings in San Antonio Bay.

Project Impact

This projected supported three graduate students throughout its duration (George Gable, M.S.; Hsiu-Ping Li, Ph.D.; and Carrie Miller, M.S.). Both Carrie and George completed their M.S. degrees in summer 2007 and have publications that are being submitted for review at this time. Hsiu-Ping will finish her dissertation in late 2008 and will also be submitting portions of her dissertation for publication soon. The project also produced 15 presentations, and several other manuscripts that are in preparation. It is also led to sources of additional funding for the Guadalupe and Galveston Bay Estuarine systems that will generate many more peer-reviewed publications and presentations.

As a result of this project, researchers imported a technology from Florida, i.e., Dataflow, that invloves ship-board, flow-through sensors. The technique is relatively inexpensive, rapid and reliable, and invloves the collection of GPS-linked data points collected while the ship runs tight transects across the bay. This technology provides scientists an alternative to remote sensing for data collection in shallow water environments. In addition, this technology is much more accurate and reliable than remote sensing because of the uncertainties associated with remote sensing algorithms targeting shallow type II waters.

Researchers developed a web-based data access system were users can quickly view monthly data being collected in San Antonio Bay, which includes fixed station data and high-resolution spatial maps of the entire bay stsrem (see above for parameters measured). The link for access to these data can be found by visiting the following site: (http://www.wfsc.tamu.edu/roelkelab/SABproj.htm). This service will provide resource managers, scientists, and lay people quick access to system-wide parameters of San Antonio, such as salinity, productivity, etc. This information will be useful to diverse stakeholders in the region, which include commercial and recreational fisherman.

INVITED SEMINARS

Davis, S.E. Understanding the importance of pulsed events in Gulf Coast estuaries. April 20, 2005 Marine Biology Departmental Seminar at **Texas A&M University at Galveston**, Galveston, TX.

Roelke, D.L. 2006. Large-scale disturbances and the predictability of complex aquatic ecosystems. **US EPA, Western Ecology Division**, Corvallis, Oregon. March 22.

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Davis, S.E. 2005. Use of high-resolution spatial mapping to estimate plankton response to freshwater inflows entering Galveston Bay: Importance of watershed development and ecosystem health**. Monitoring & Research Subcommittee of the Galveston Bay Estuary Program**, Houston, TX

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CONTRIBUTED TALKS

Davis, S., D. Roelke, G. Gable, H-P. Li, C. Miller. 2005. Physical, chemical, and biological responses to inflow events in Galveston and San Antonio Bays (TX): Bay-wide characterizations. **Estuarine Research Federation**. Norfolk, VA, USA. October 16-21.

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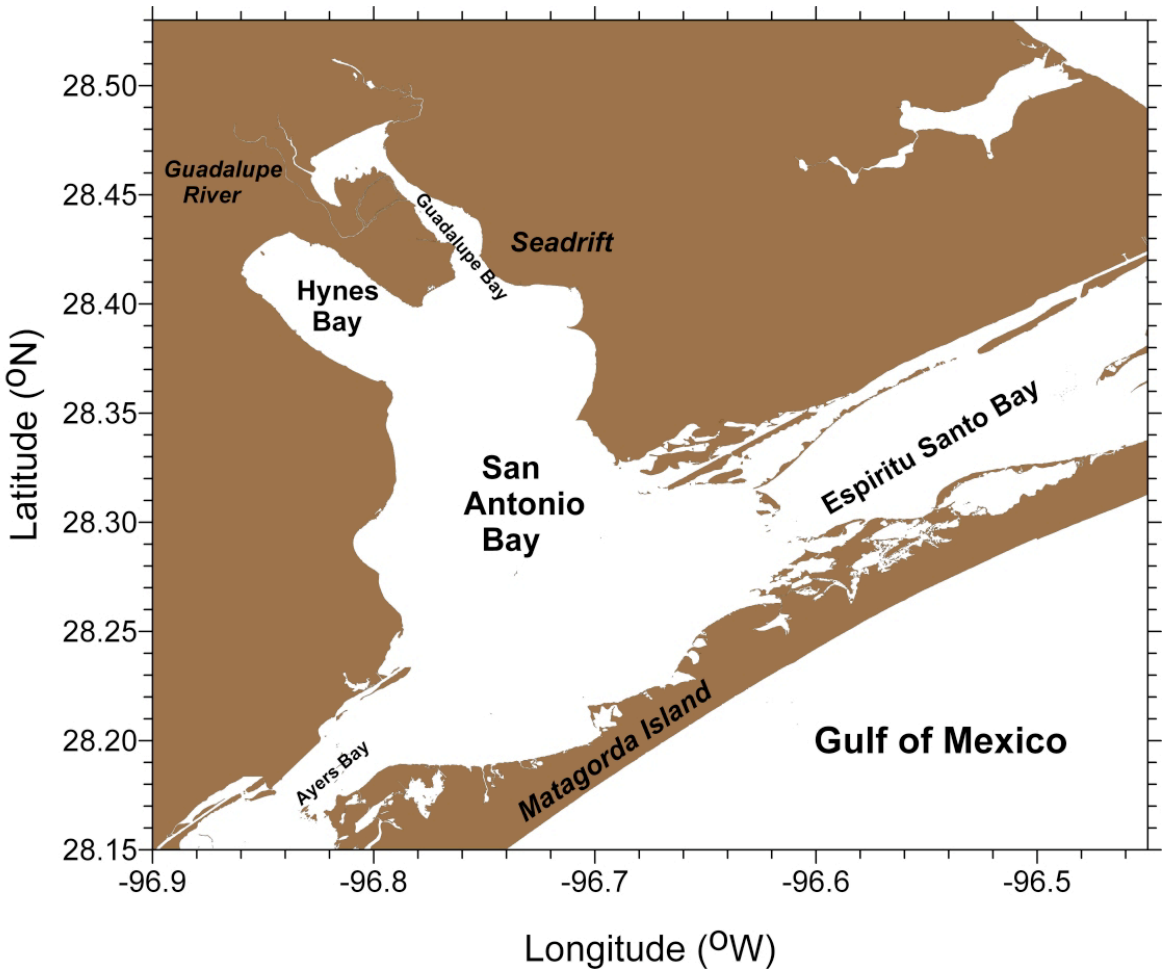
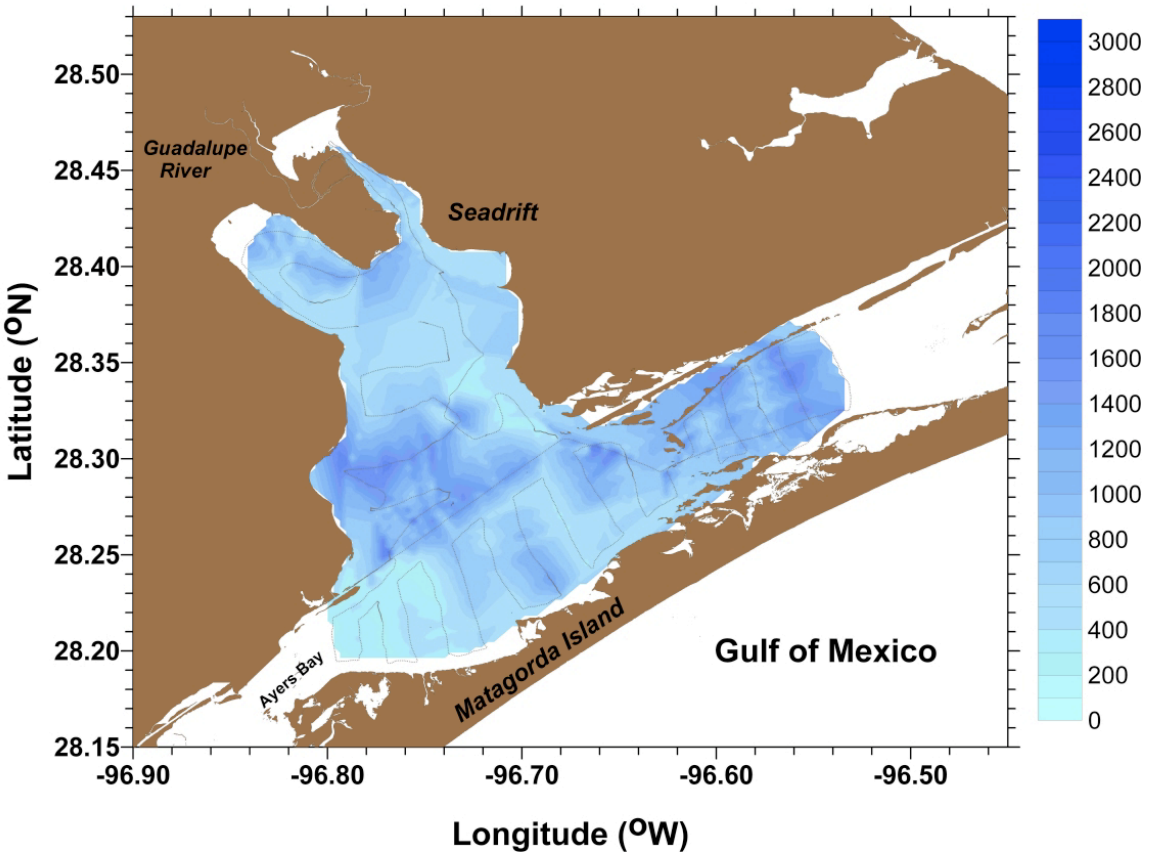
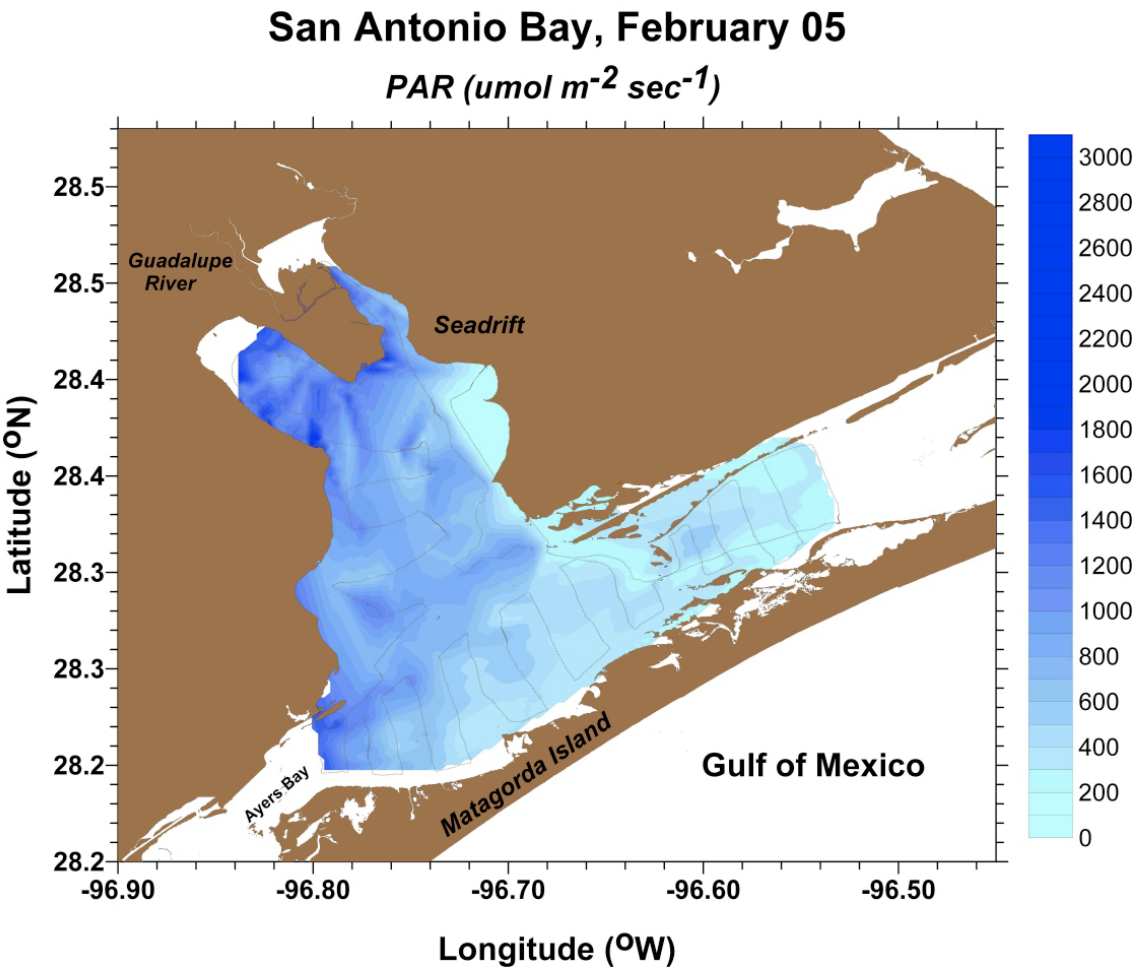
Dataflow Maps from Guadalupe River Estuary



San Antonio Bay, January 05

PAR (umol m^{-2} sec^{-1})




San Antonio Bay, February 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.5
28.5
28.4
28.4
28.3
28.3
28.2
28.2
-96.90
-96.80
-96.70
-96.60
-96.50
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2600
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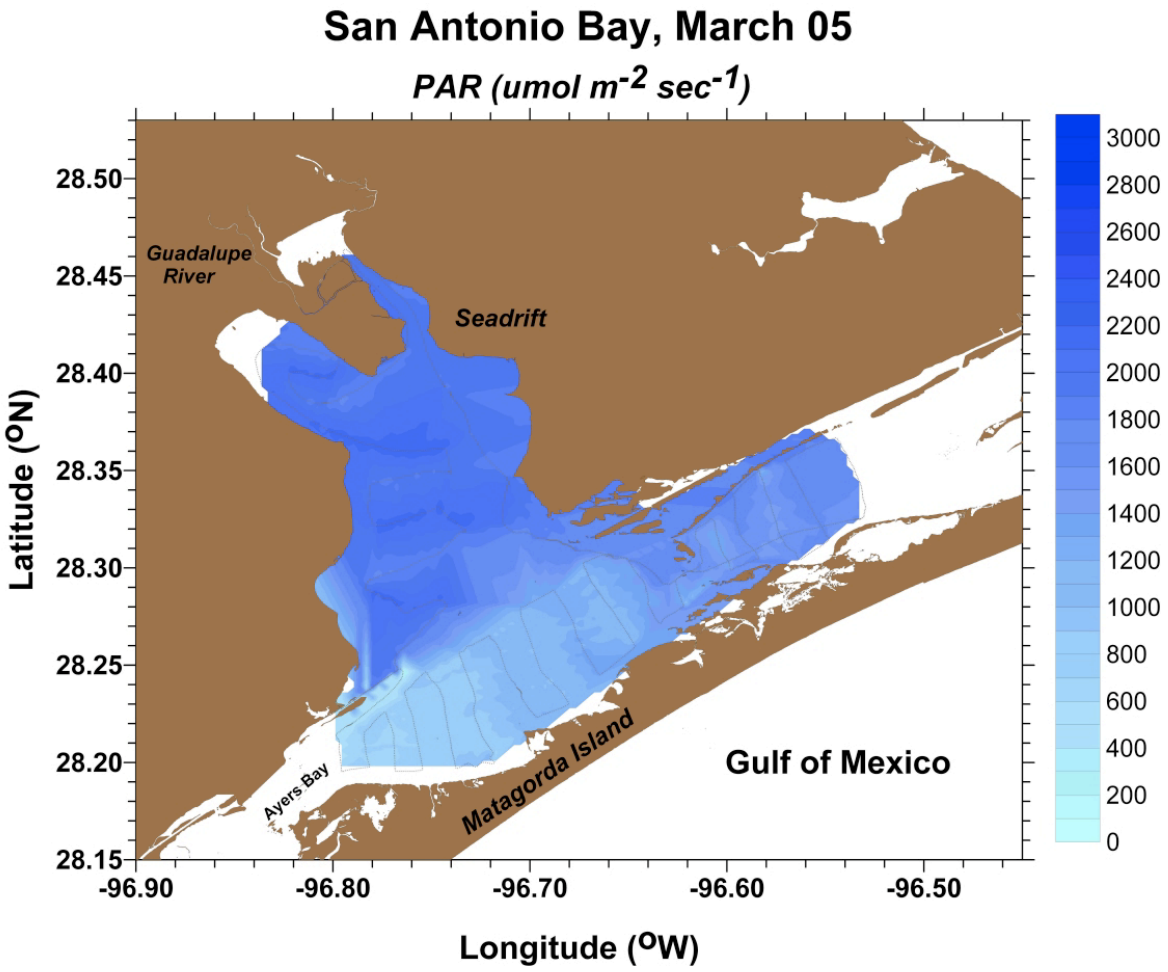
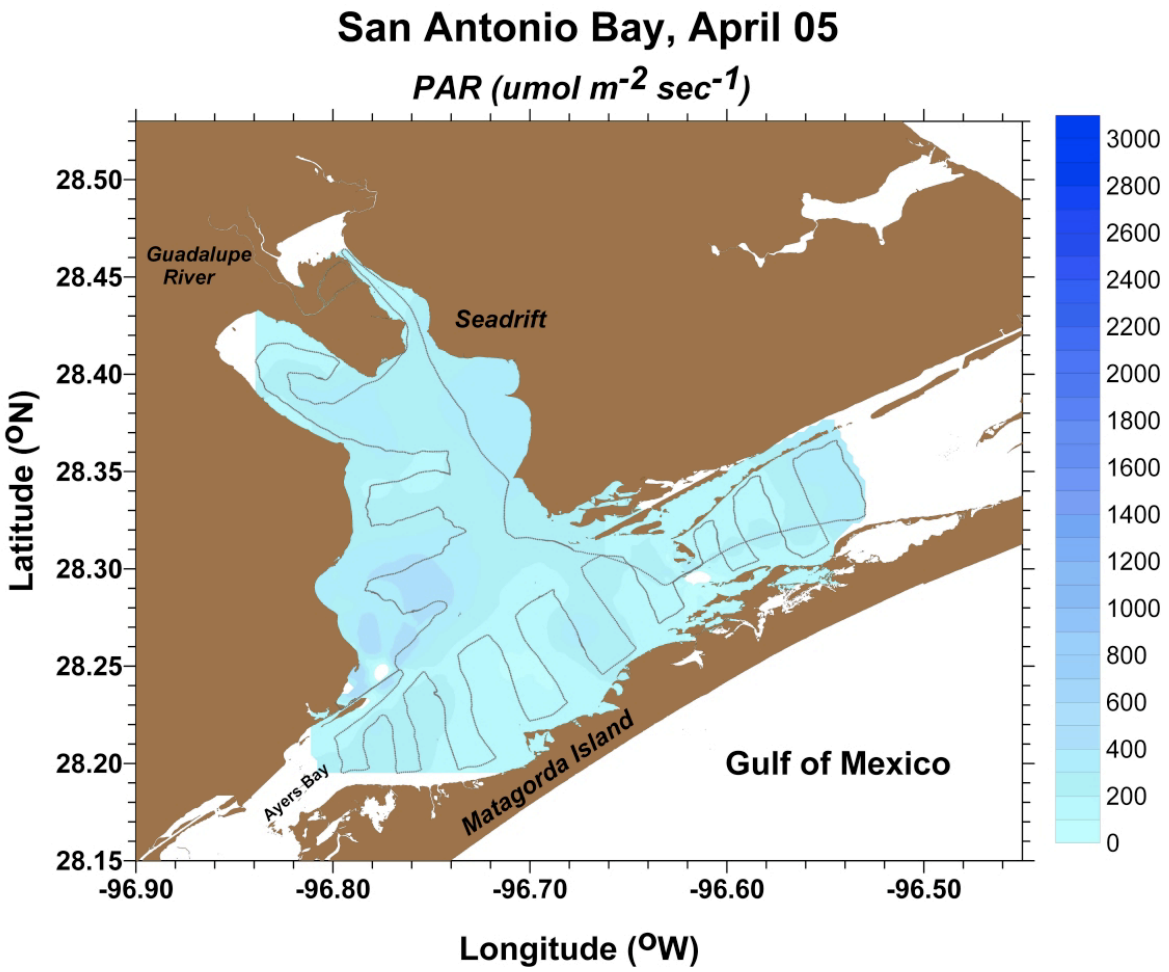
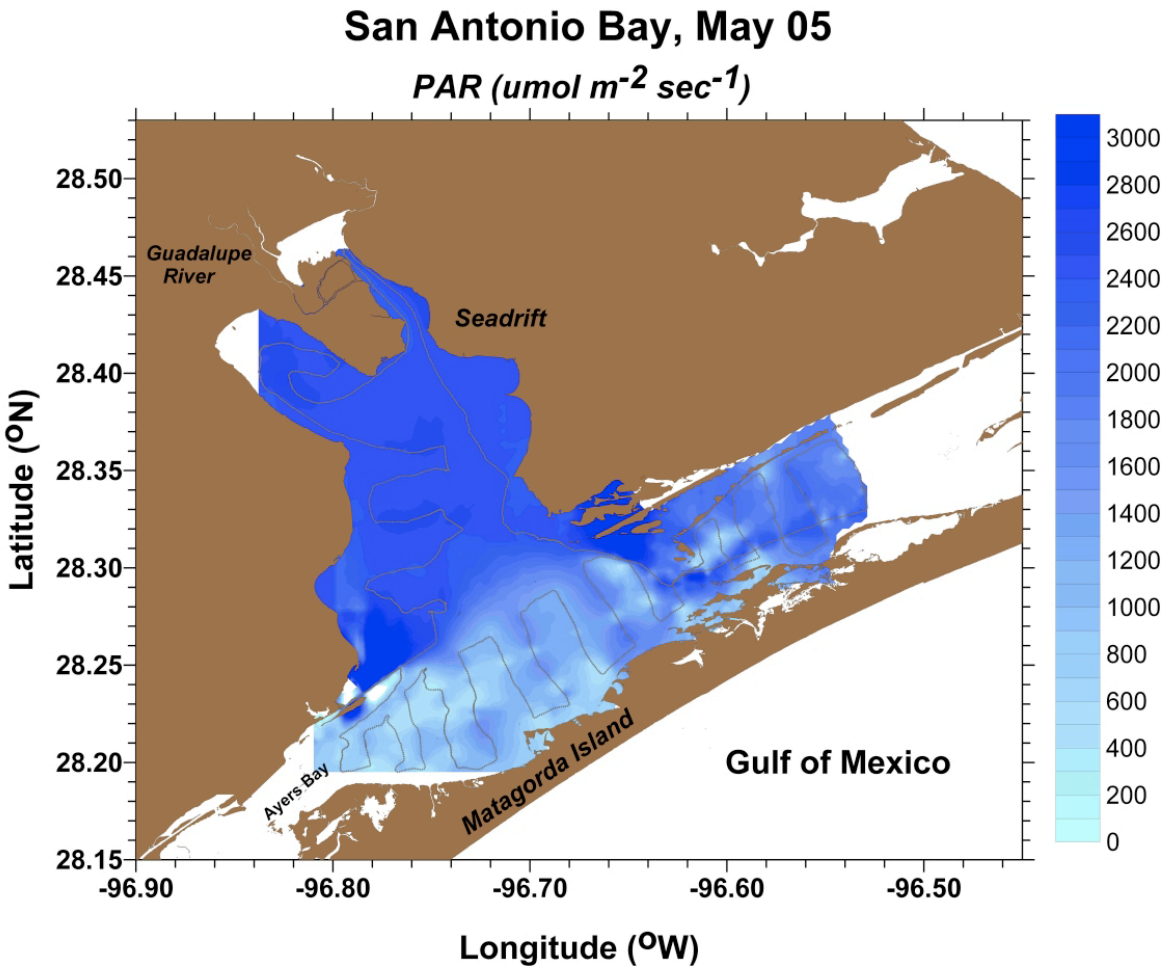
1400
1200
1000
800
600
400
200
0


San Antonio Bay, March 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0


San Antonio Bay, April 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0


San Antonio Bay, May 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
2000
1800
1600
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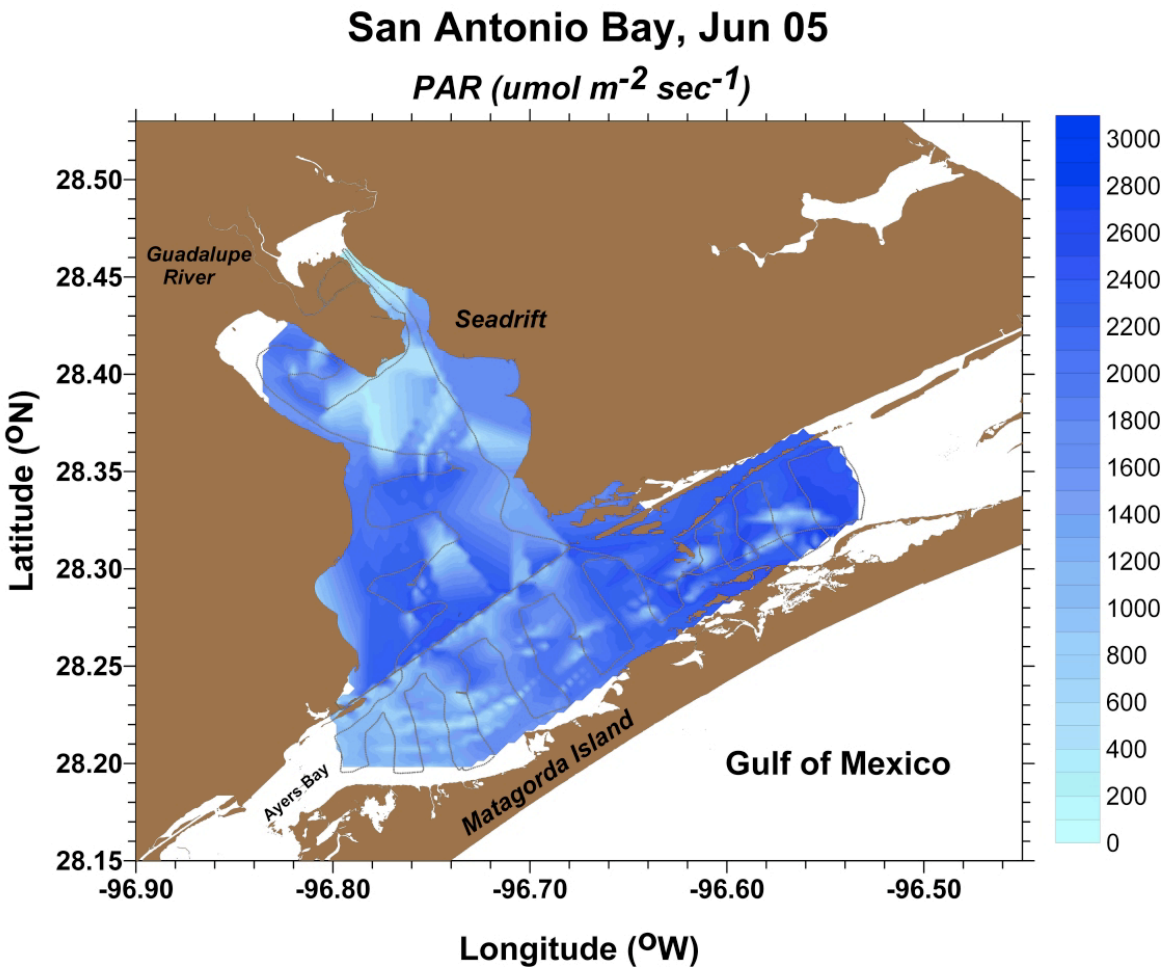
1000
800
600
400
200
0


San Antonio Bay, Jun 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
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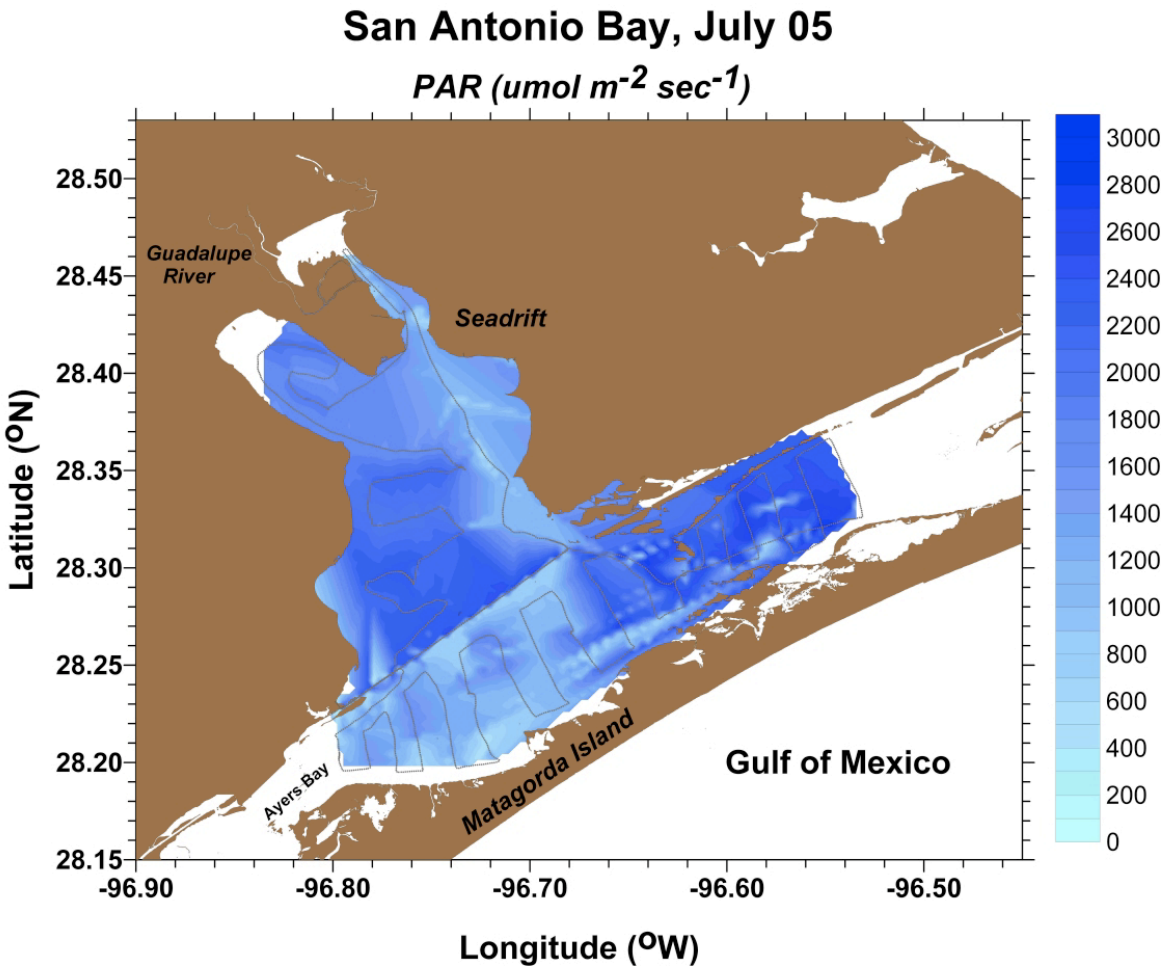
1000
800
600
400
200
0


San Antonio Bay, July 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
2000
1800
1600
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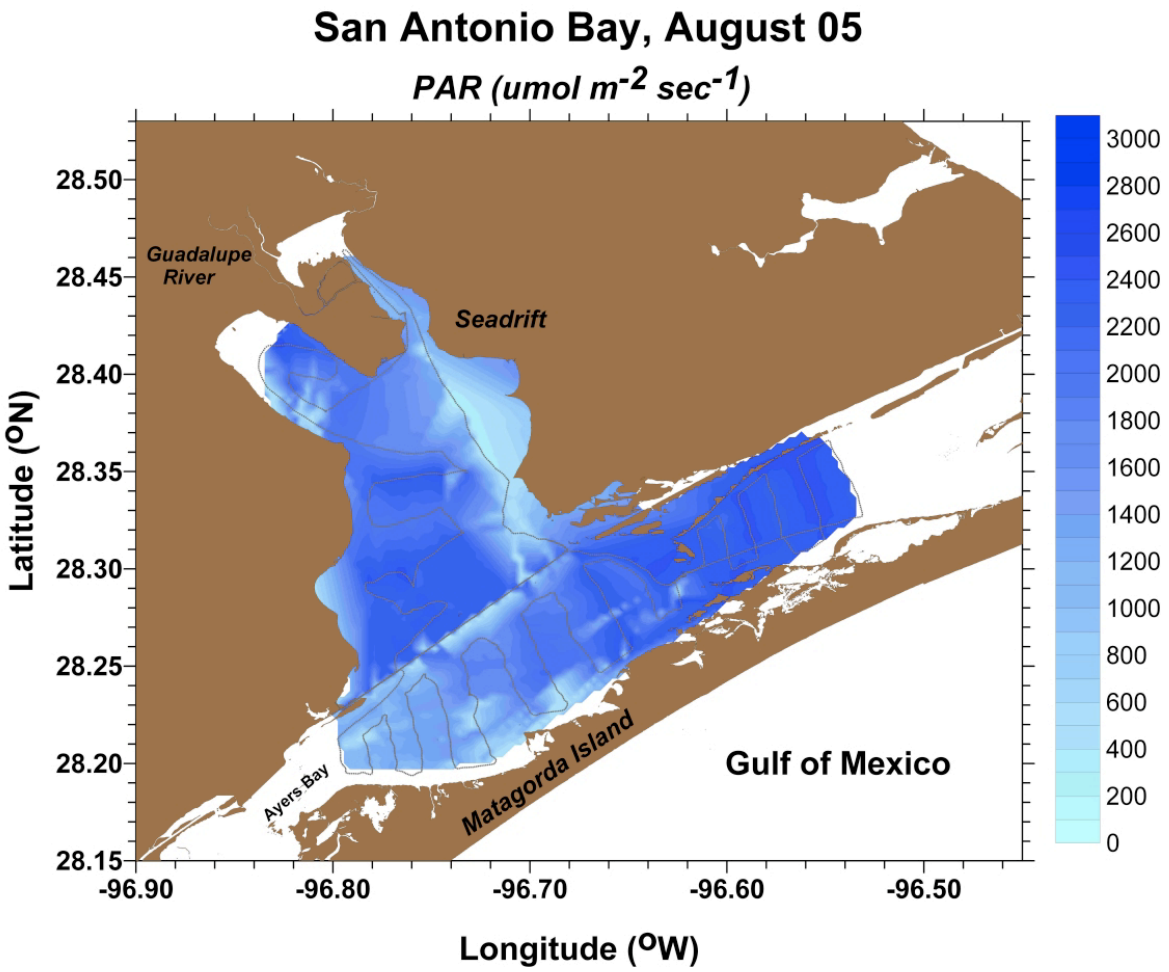
1000
800
600
400
200
0


San Antonio Bay, August 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
2000
1800
1600
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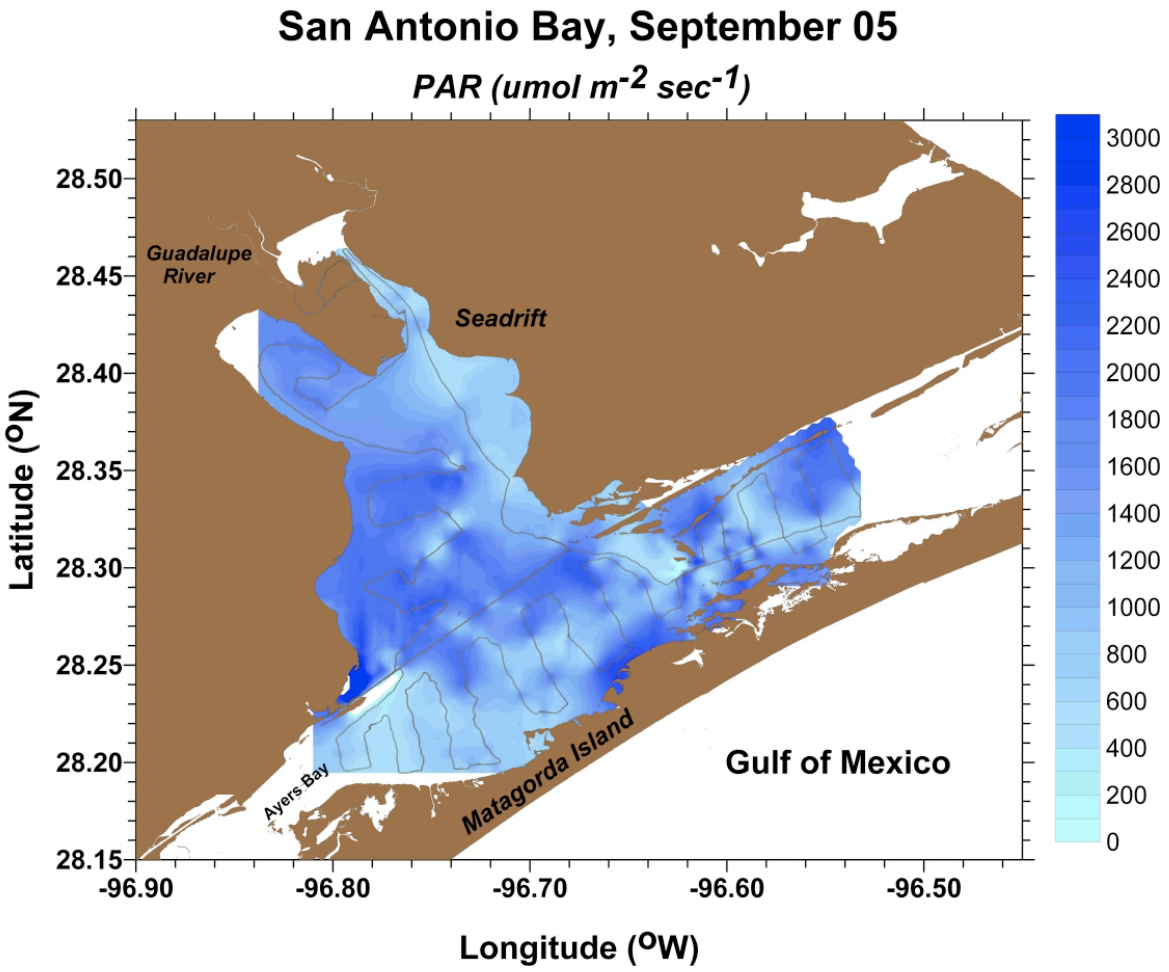
1000
800
600
400
200
0


San Antonio Bay, September 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
2000
1800
1600
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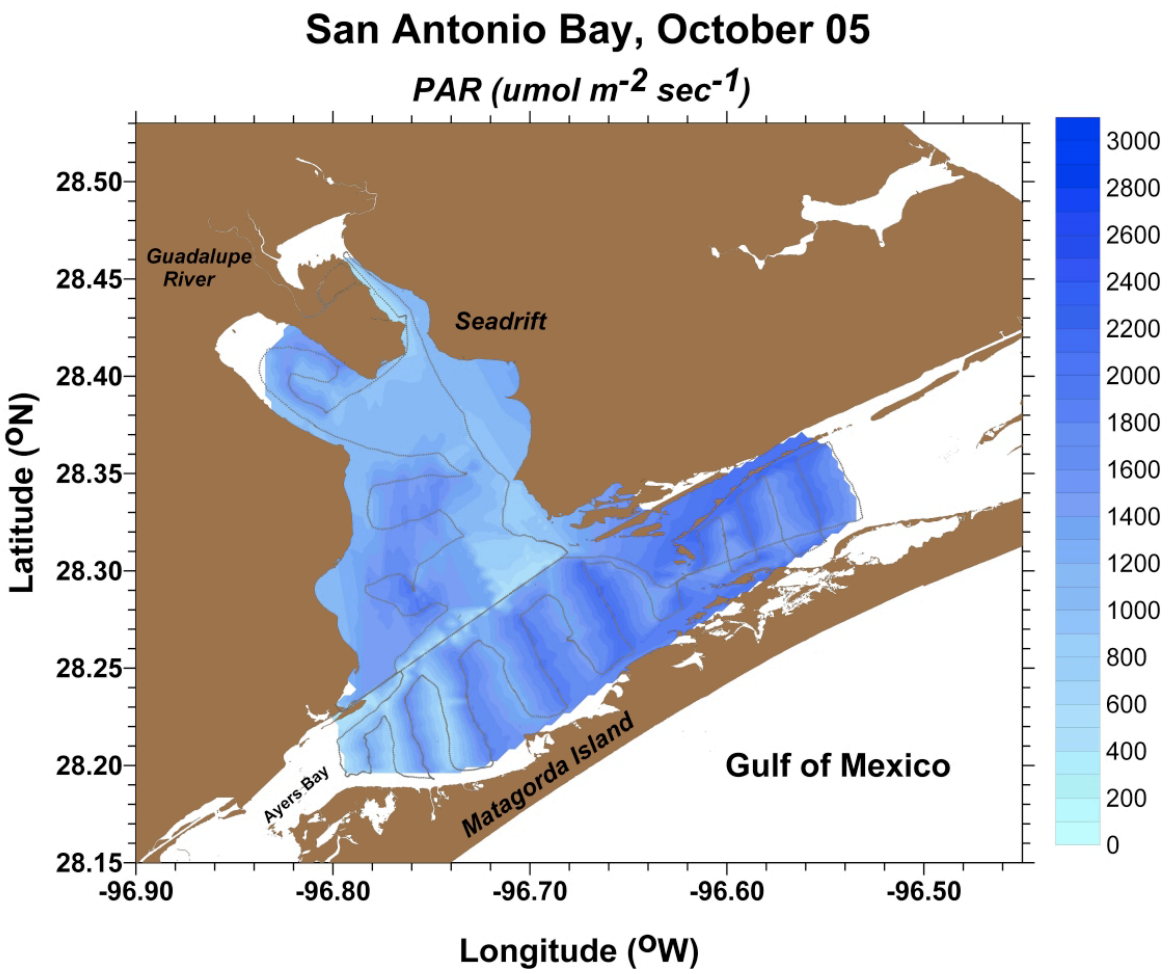
1000
800
600
400
200
0


San Antonio Bay, October 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
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2200
2000
1800
1600
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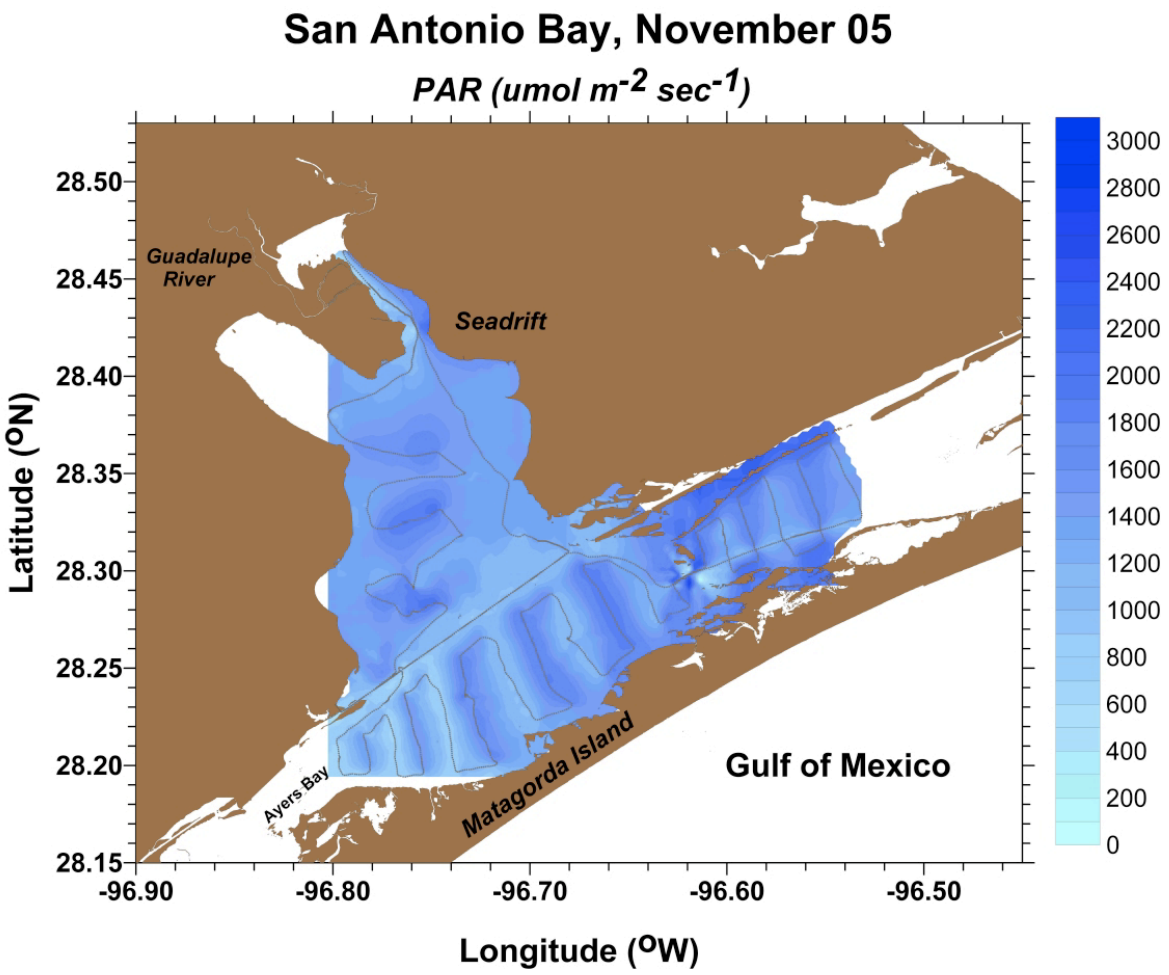
1000
800
600
400
200
0


San Antonio Bay, November 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
2000
1800
1600
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1000
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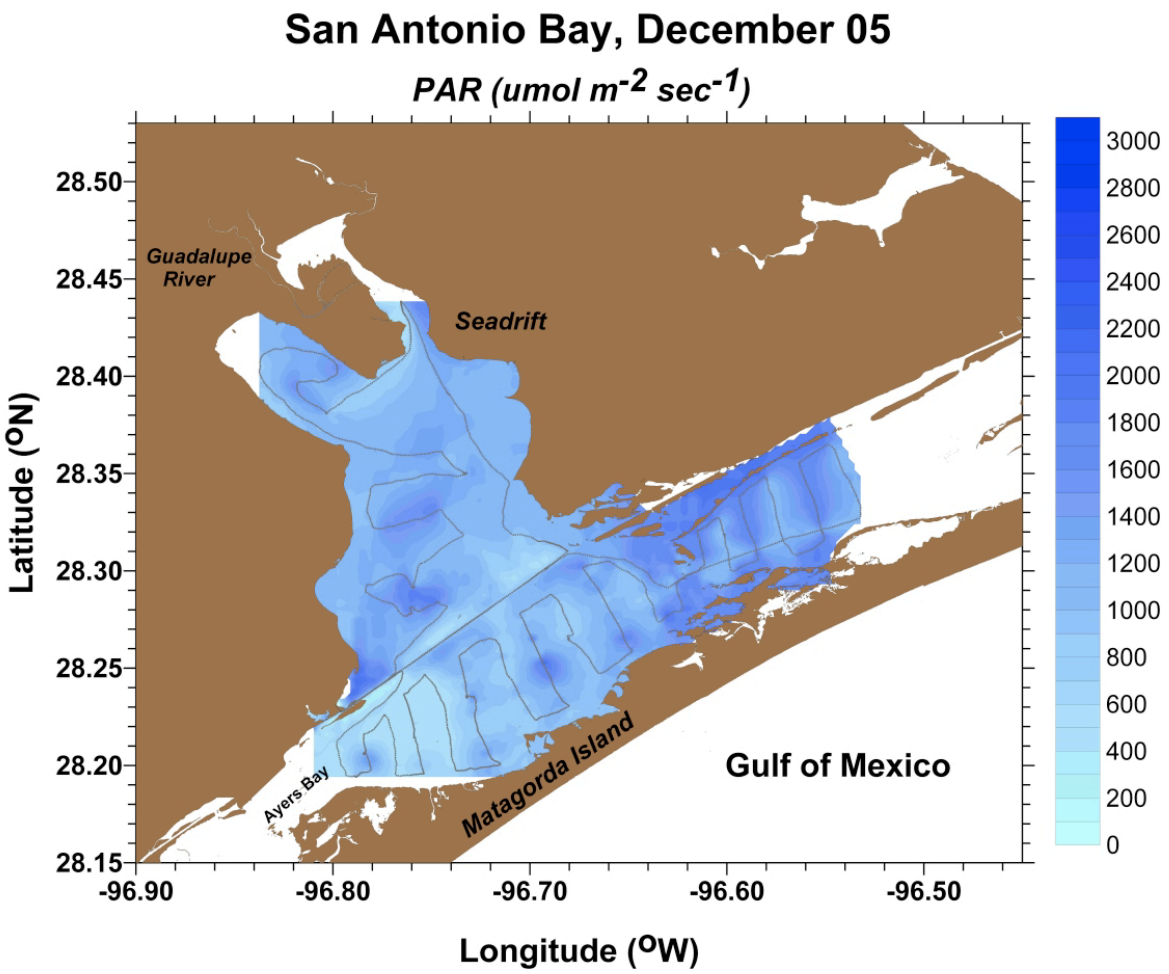
600
400
200
0


San Antonio Bay, December 05
PAR (umol m-2 sec-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
3000
2800
2600
2400
2200
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1800
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1000
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600
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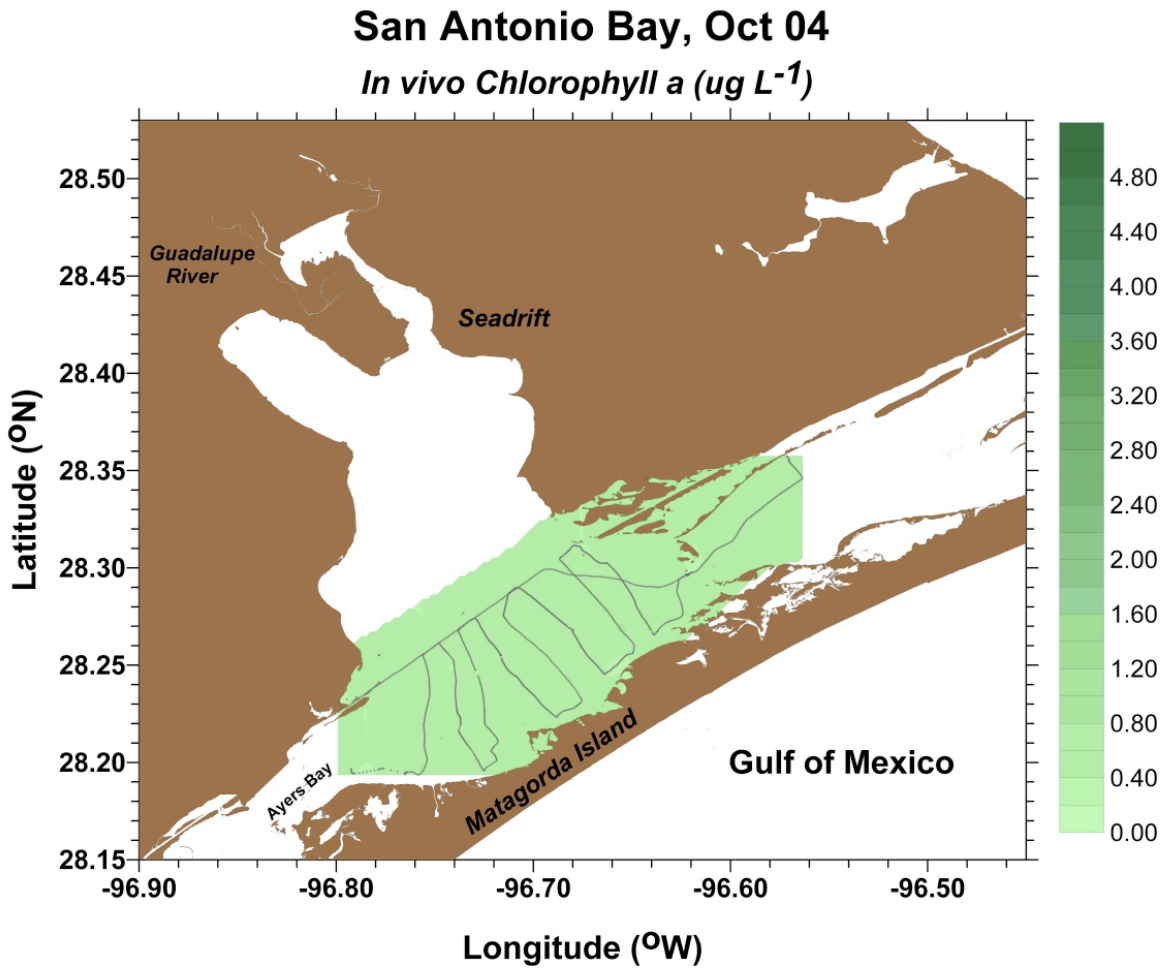
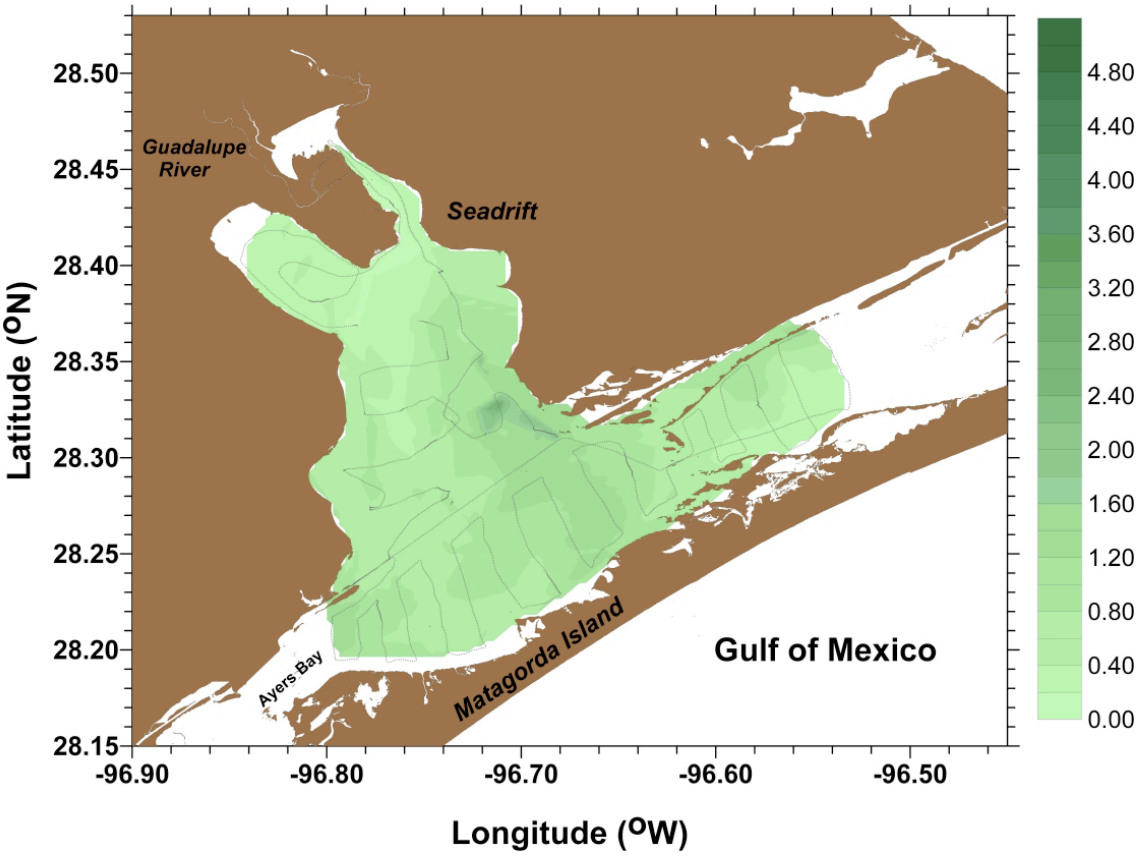
0


San Antonio Bay, Oct 04
In vivo Chlorophyll a (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
4.80
4.40
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00

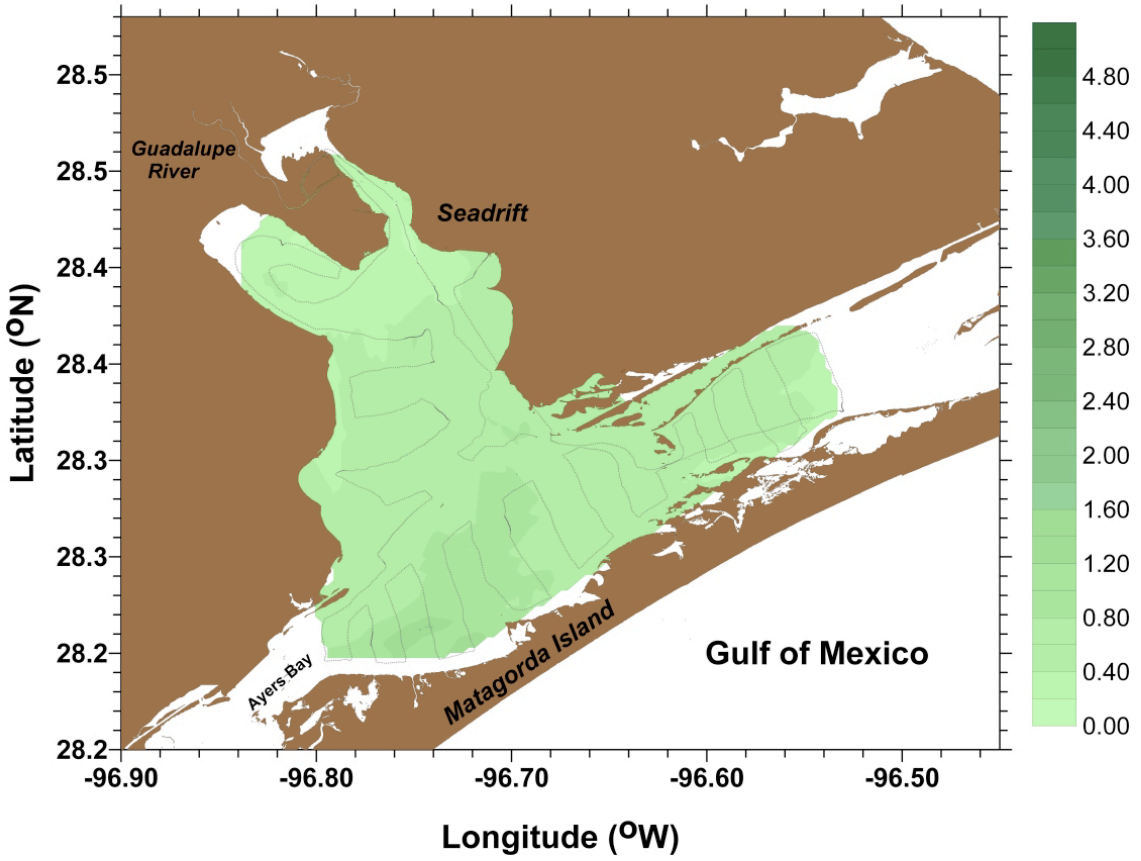
San Antonio Bay, January 05

In vivo Chlorophyll a (ug L^{-1})



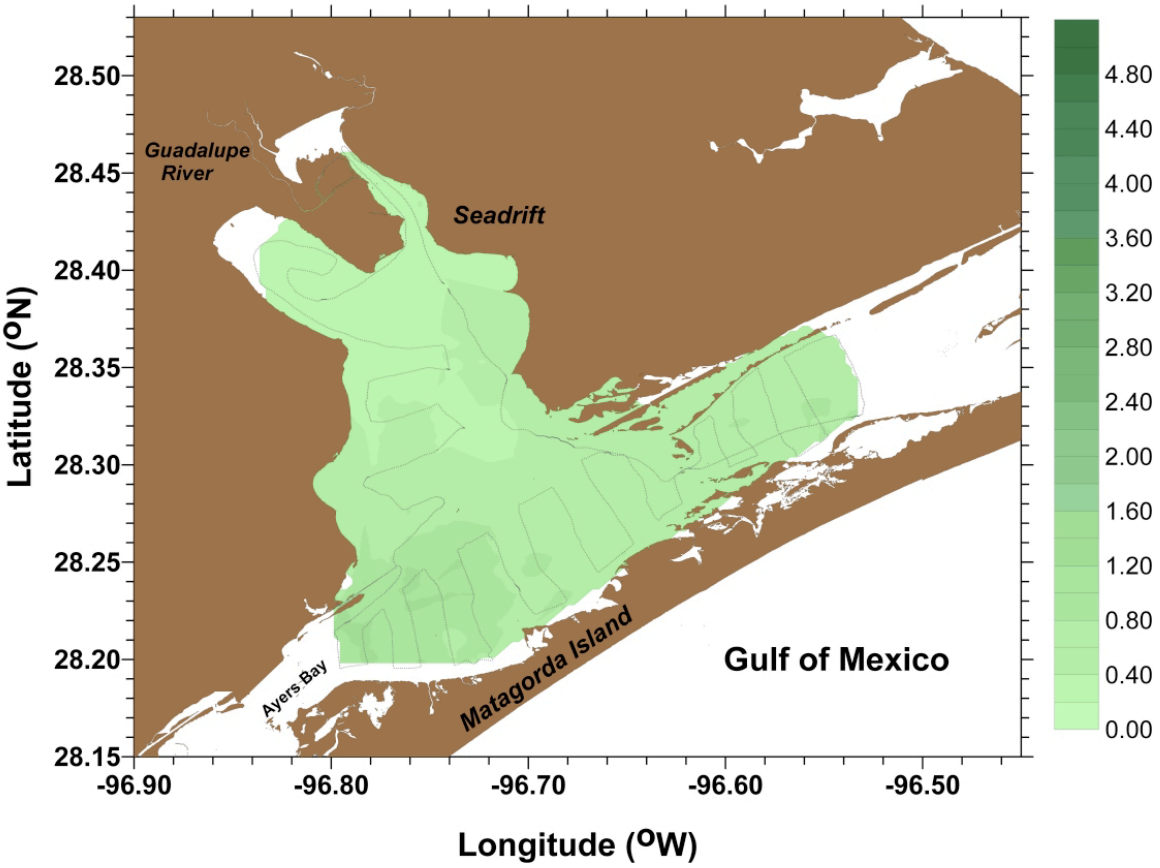
San Antonio Bay, February 05

In vivo Chlorophyll a (ug L^{-1})



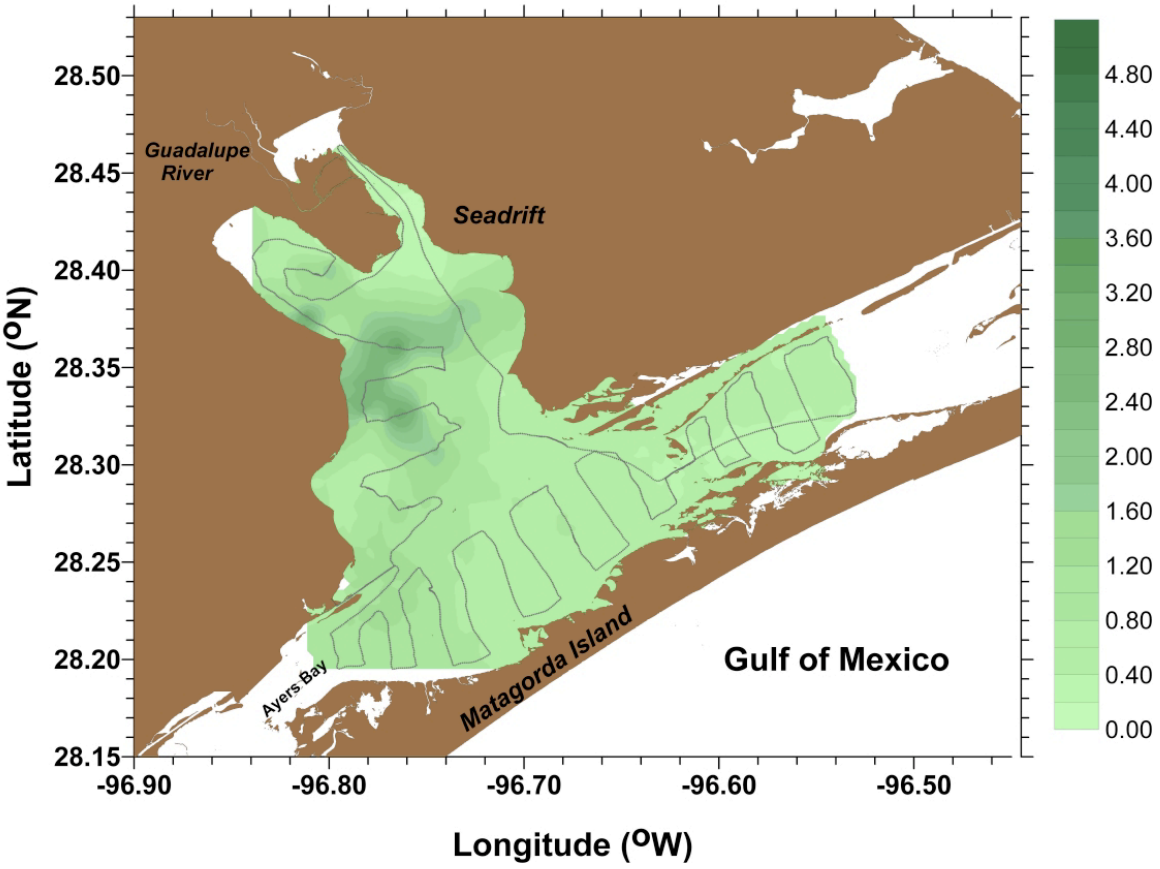
San Antonio Bay, March 05

In vivo Chlorophyll a (ug L^{-1})



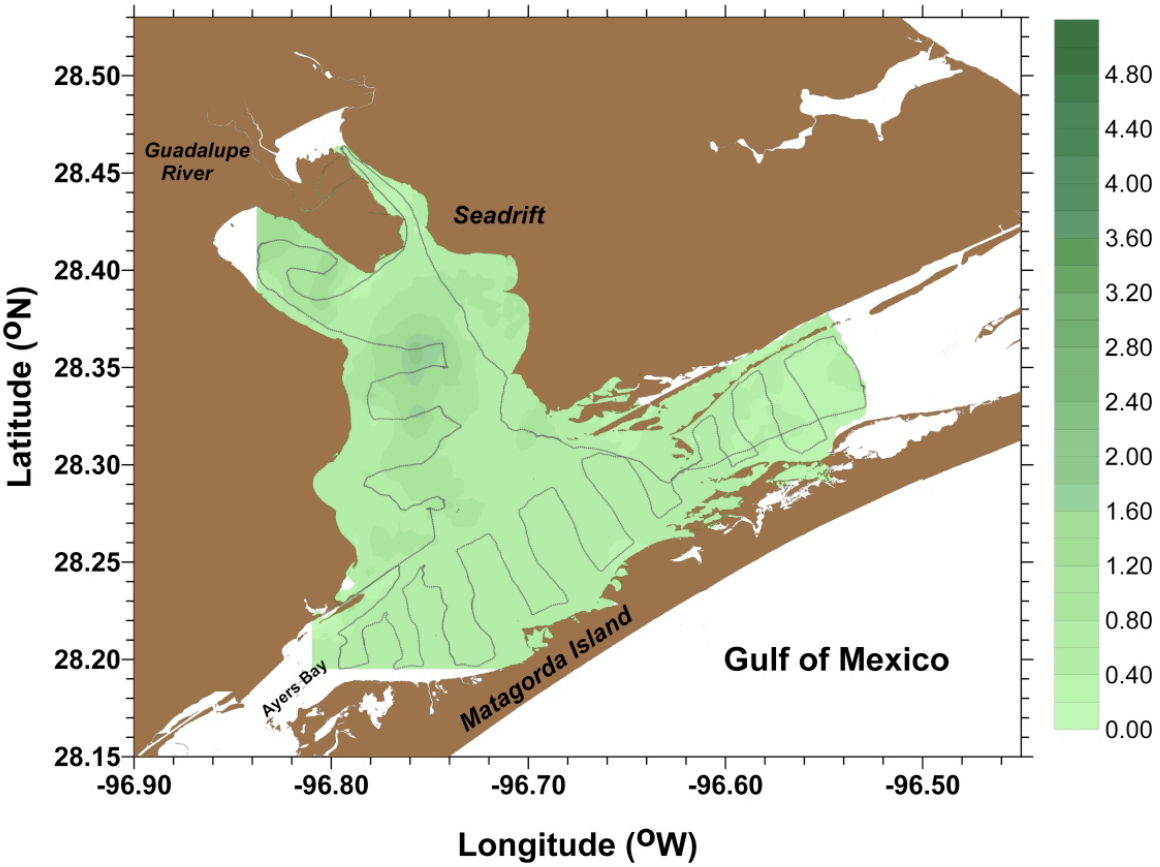
San Antonio Bay, April 05

In vivo Chlorophyll a (ug L^{-1})



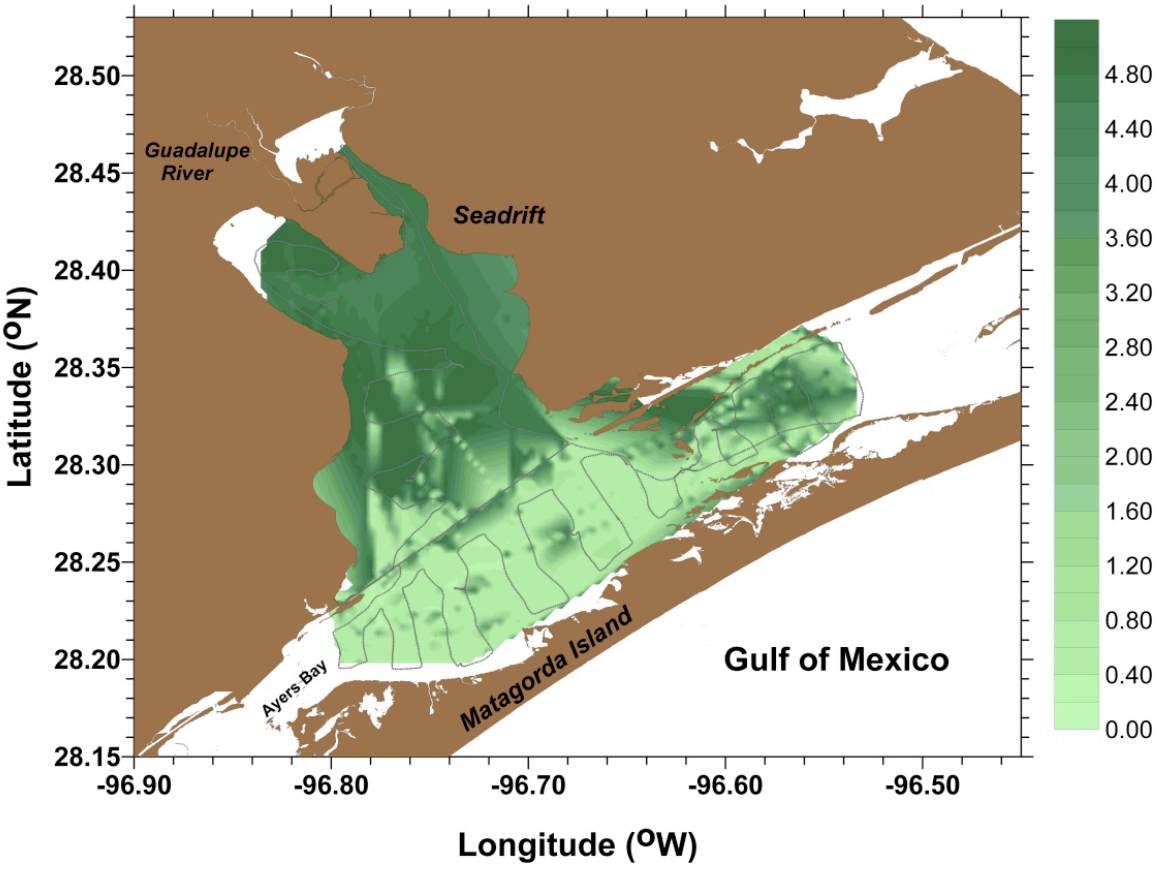
San Antonio Bay, May 05

In vivo Chlorophyll a (ug L^{-1})



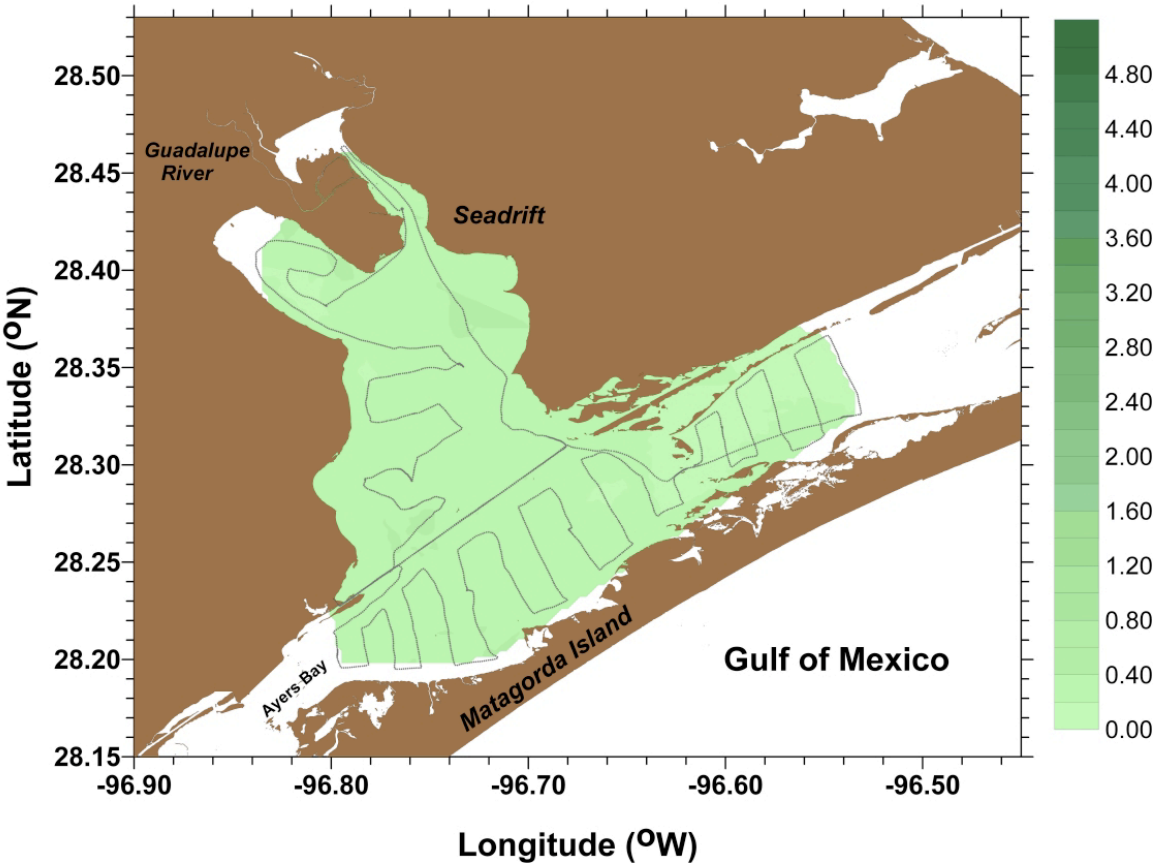
San Antonio Bay, Jun 05

In vivo Chlorophyll a (ug L^{-1})



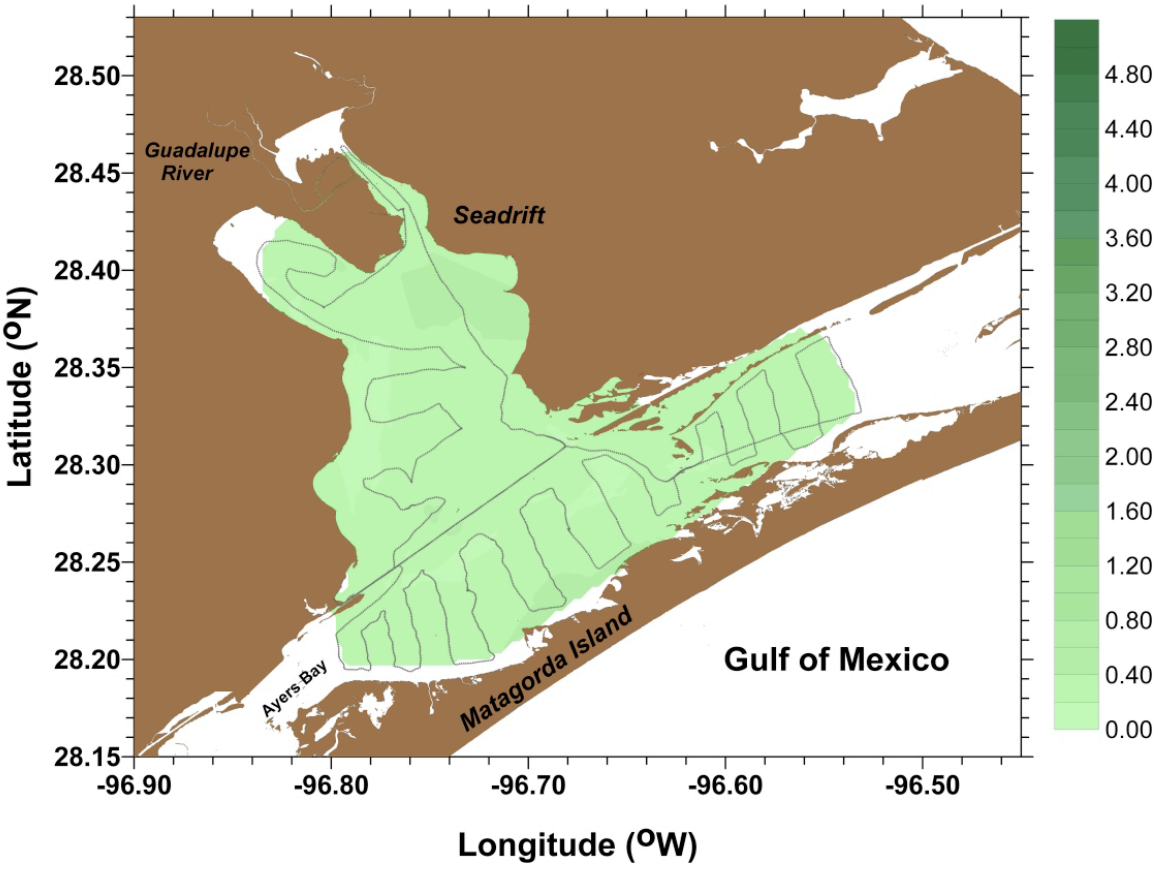
San Antonio Bay, July 05

In vivo Chlorophyll a (ug L^{-1})



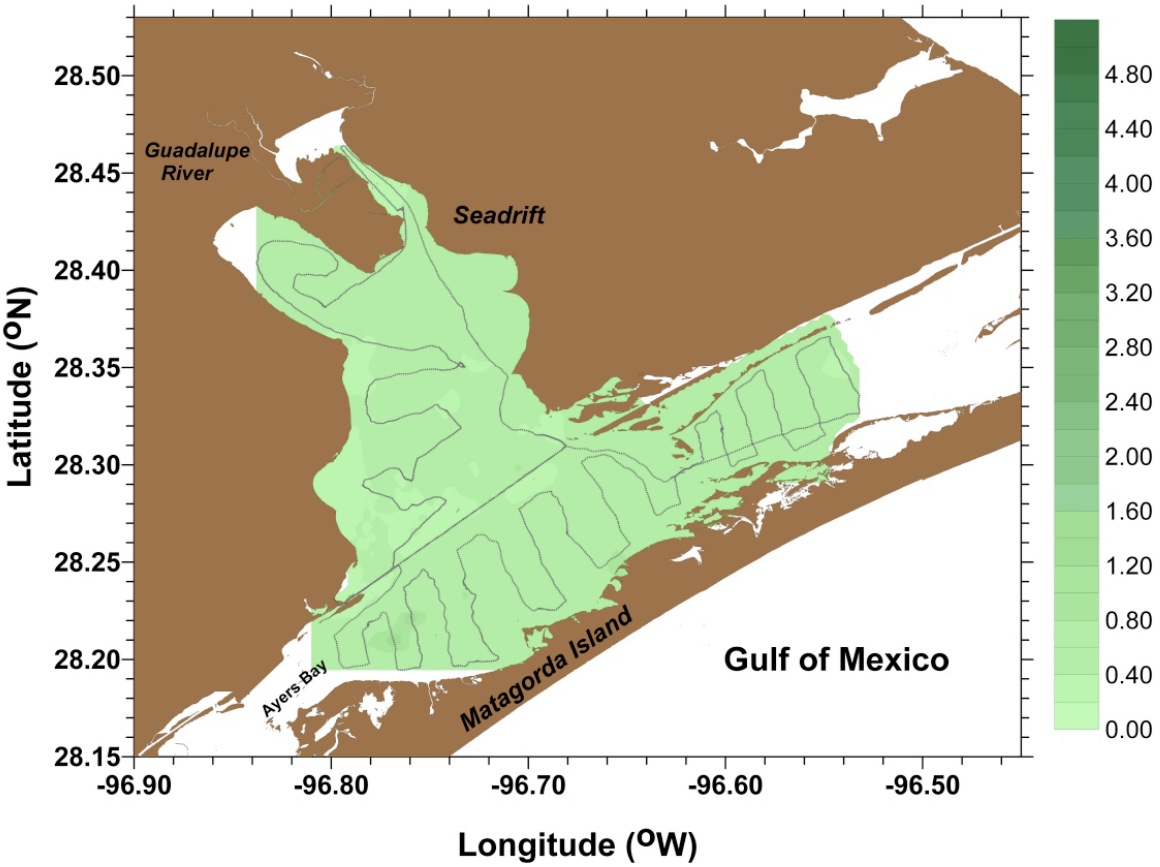
San Antonio Bay, August 05

In vivo Chlorophyll a (ug L^{-1})



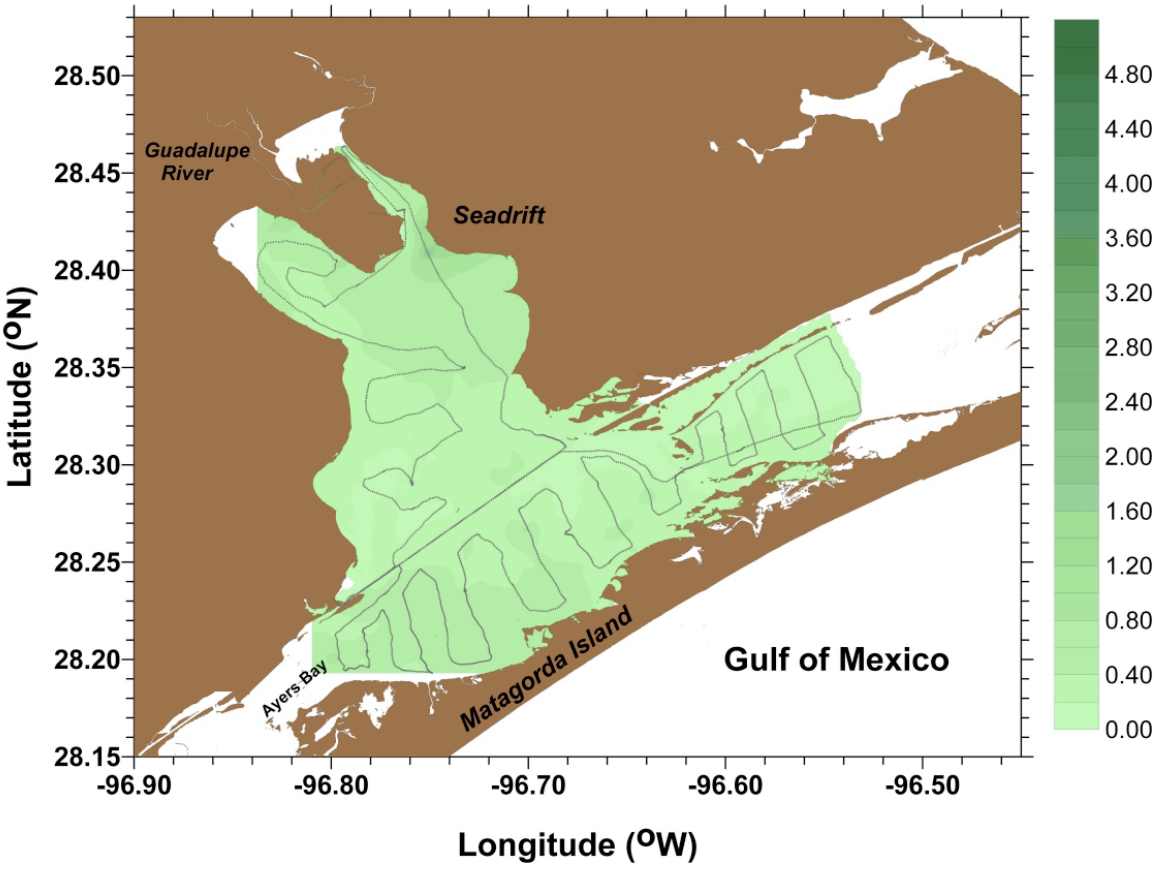
San Antonio Bay, September 05

In vivo Chlorophyll a (ug L^{-1})



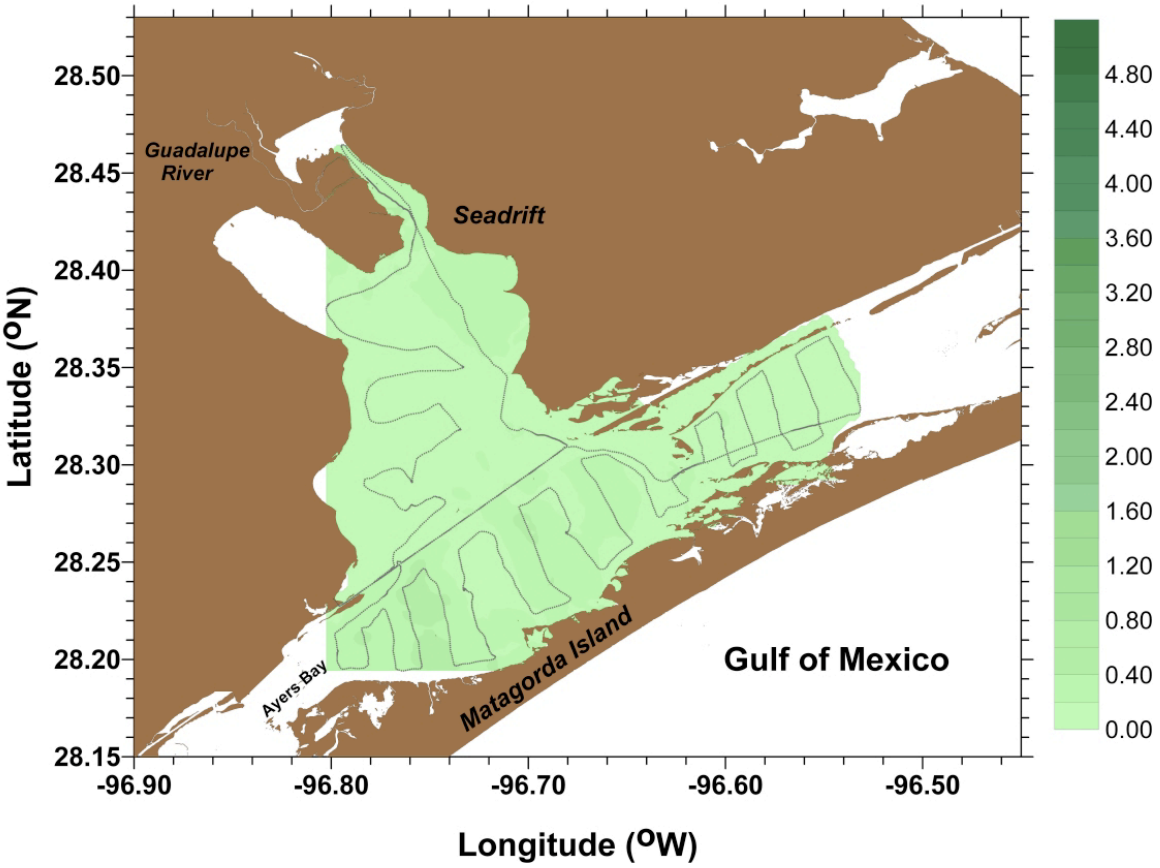
San Antonio Bay, October 05

In vivo Chlorophyll a (ug L^{-1})



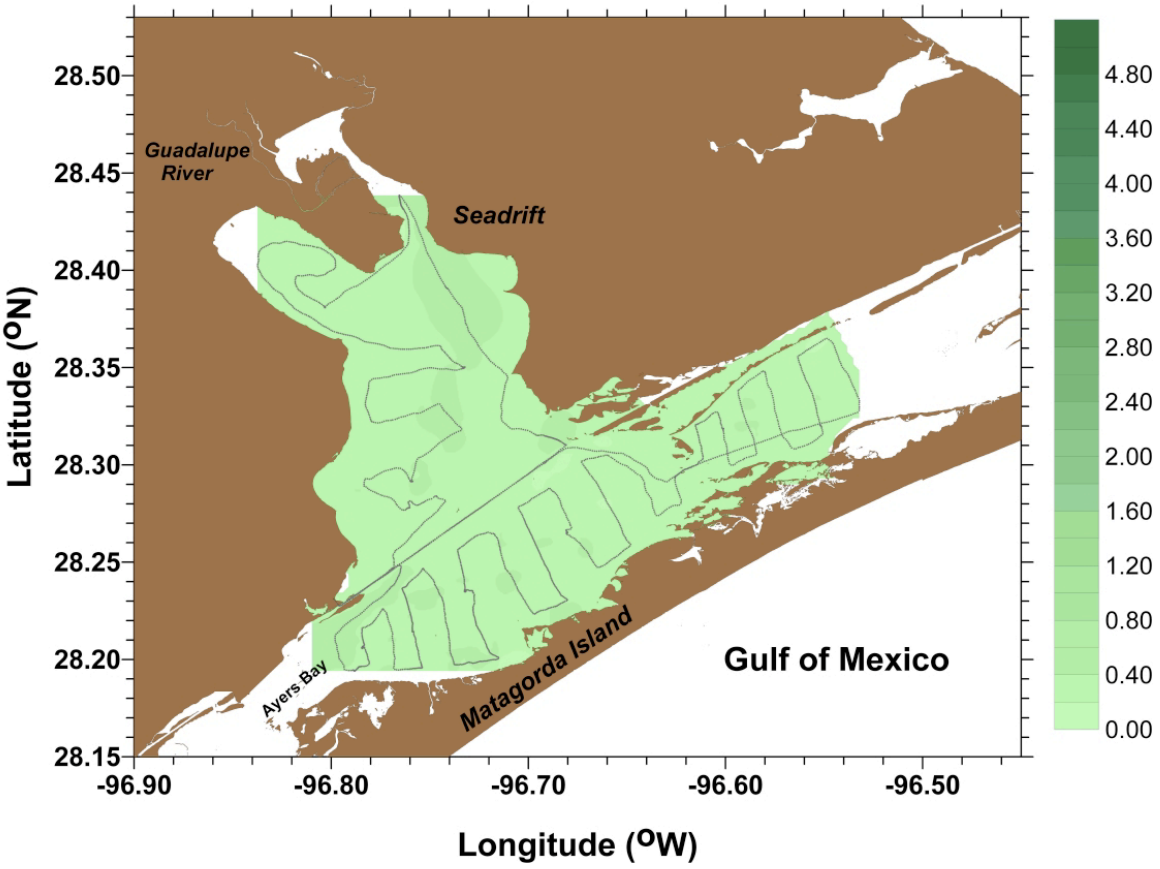
San Antonio Bay, November 05

In vivo Chlorophyll a (ug L^{-1})



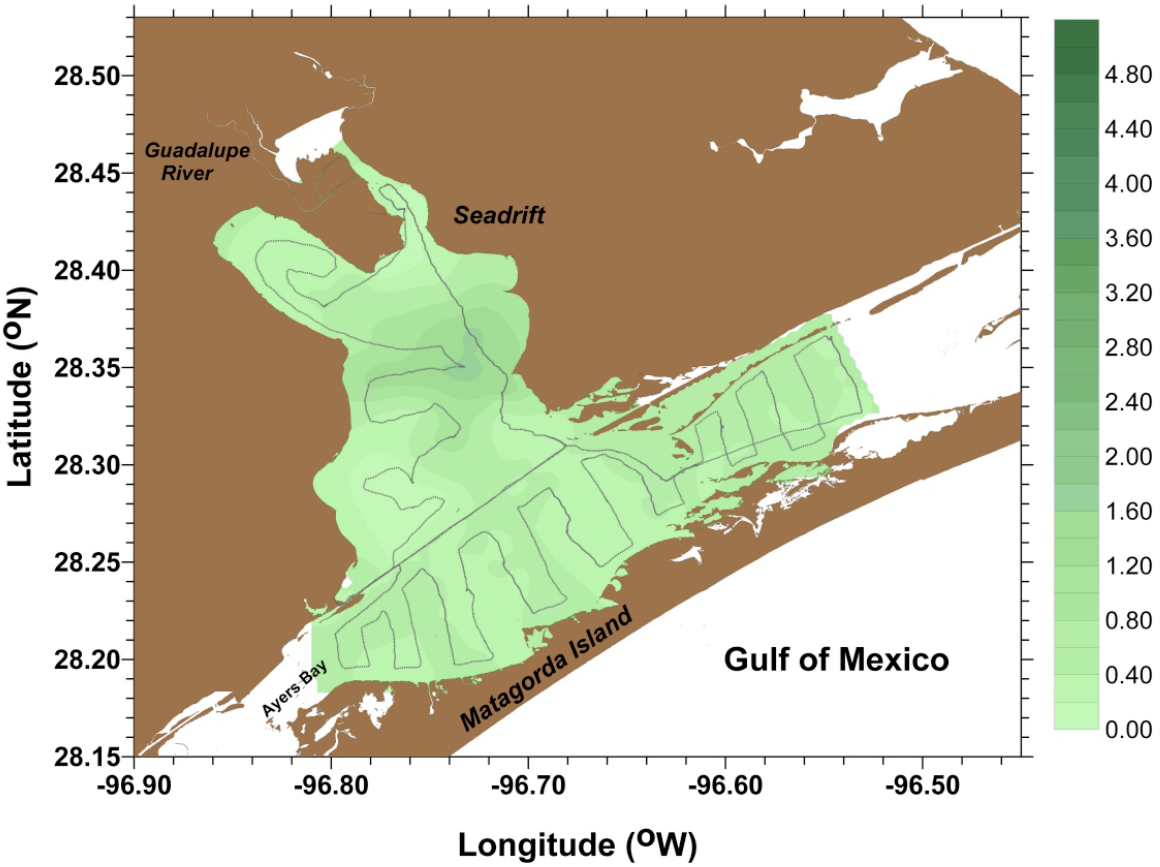
San Antonio Bay, December 05

In vivo Chlorophyll a (ug L^{-1})



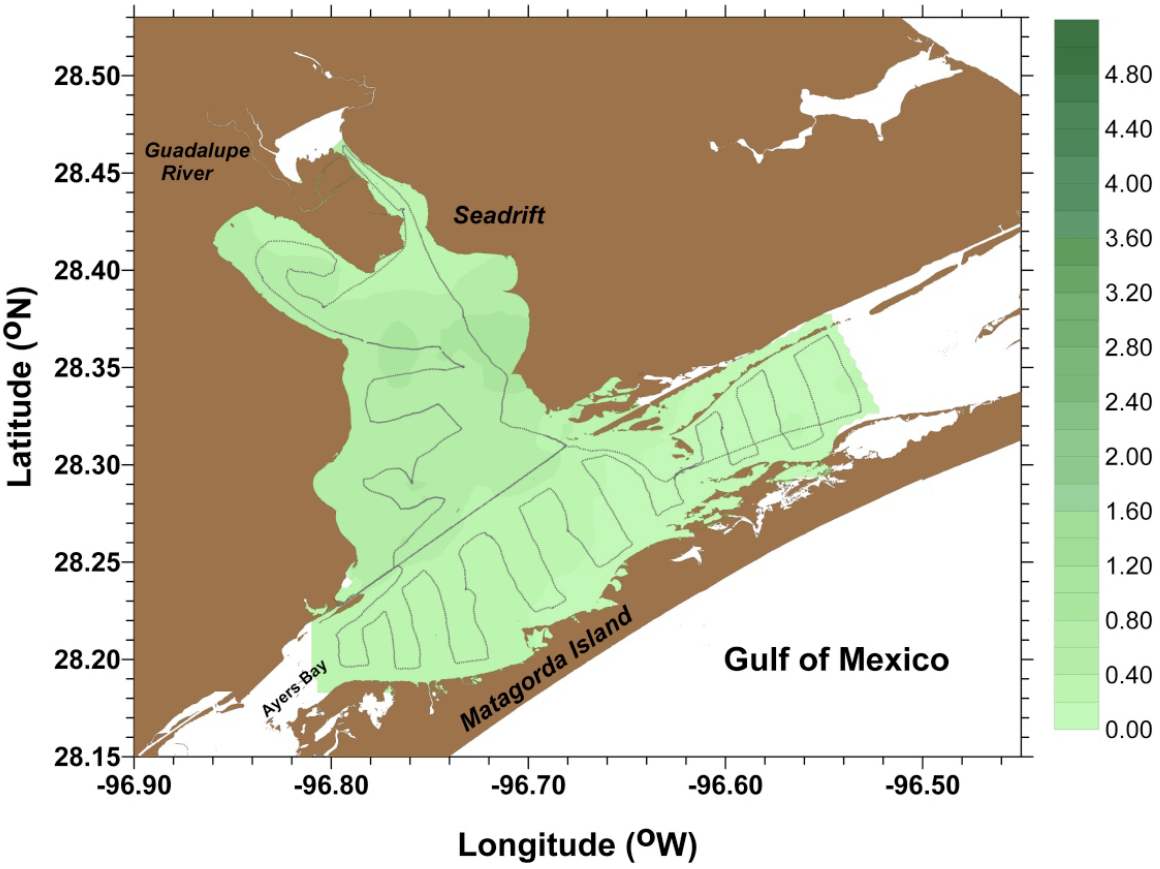
San Antonio Bay, January 06

In vivo Chlorophyll a (ug L^{-1})



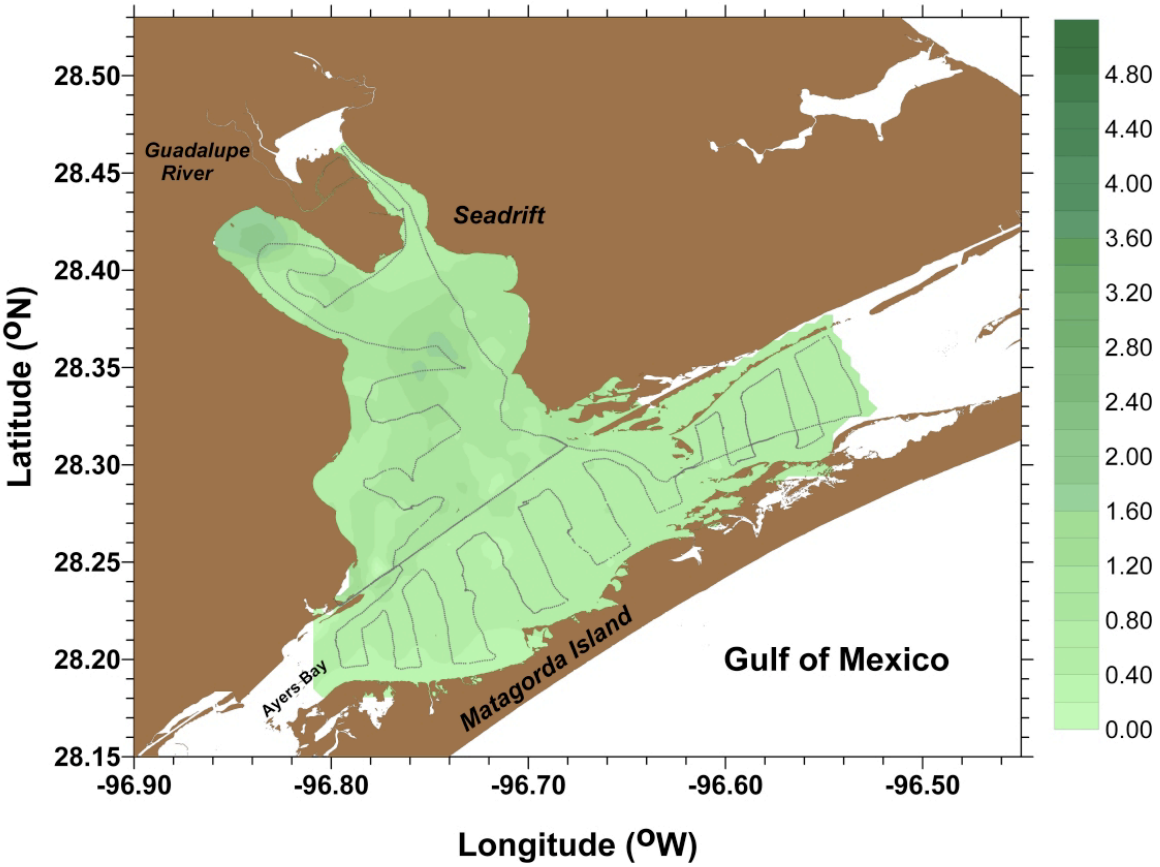
San Antonio Bay, February 06

In vivo Chlorophyll a (ug L^{-1})



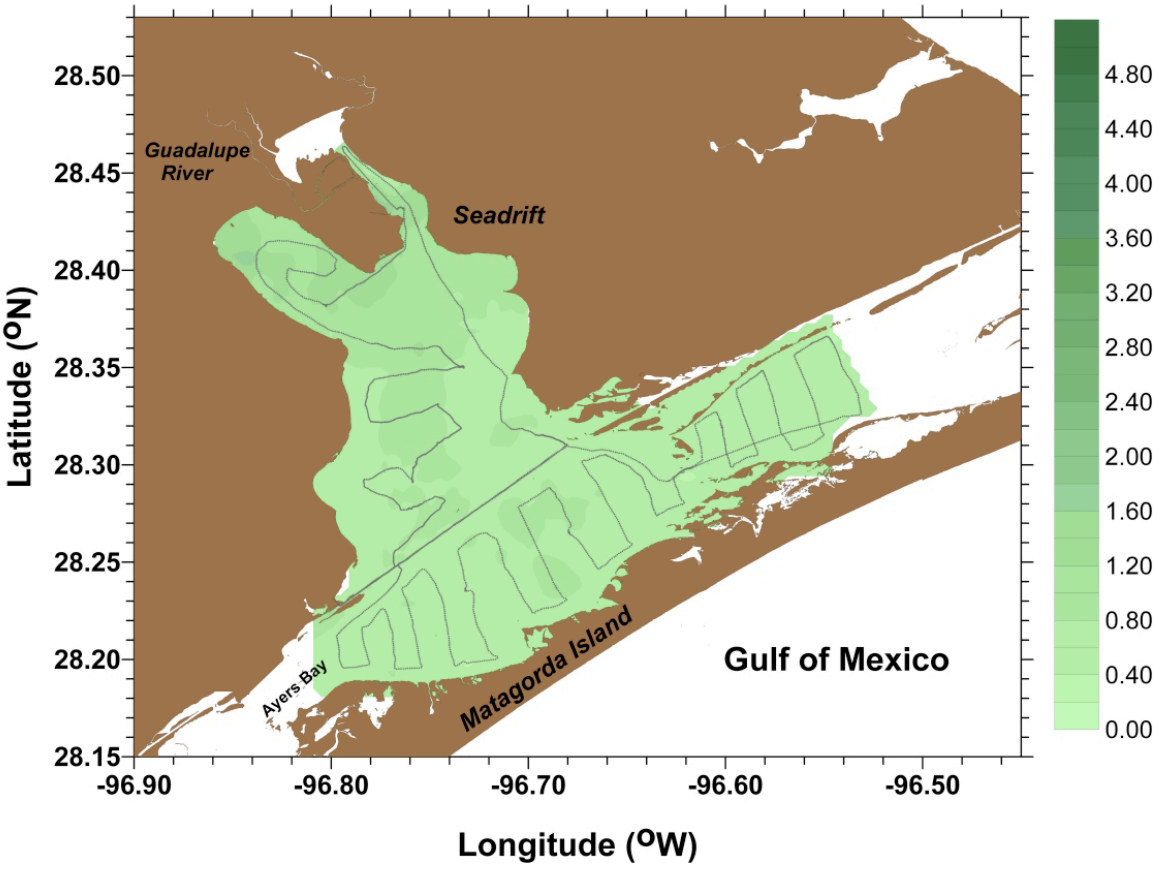
San Antonio Bay, April 06

In vivo Chlorophyll a (ug L^{-1})



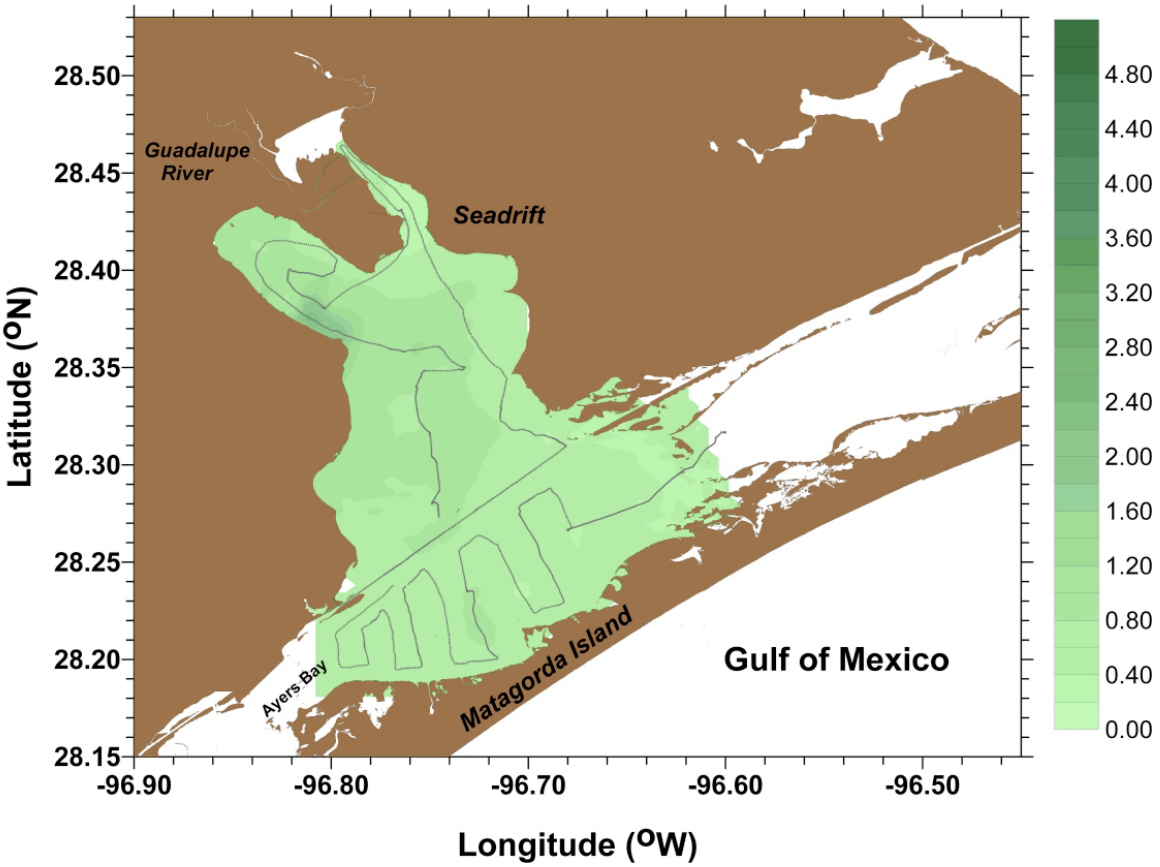
San Antonio Bay, May 06

In vivo Chlorophyll a (ug L^{-1})



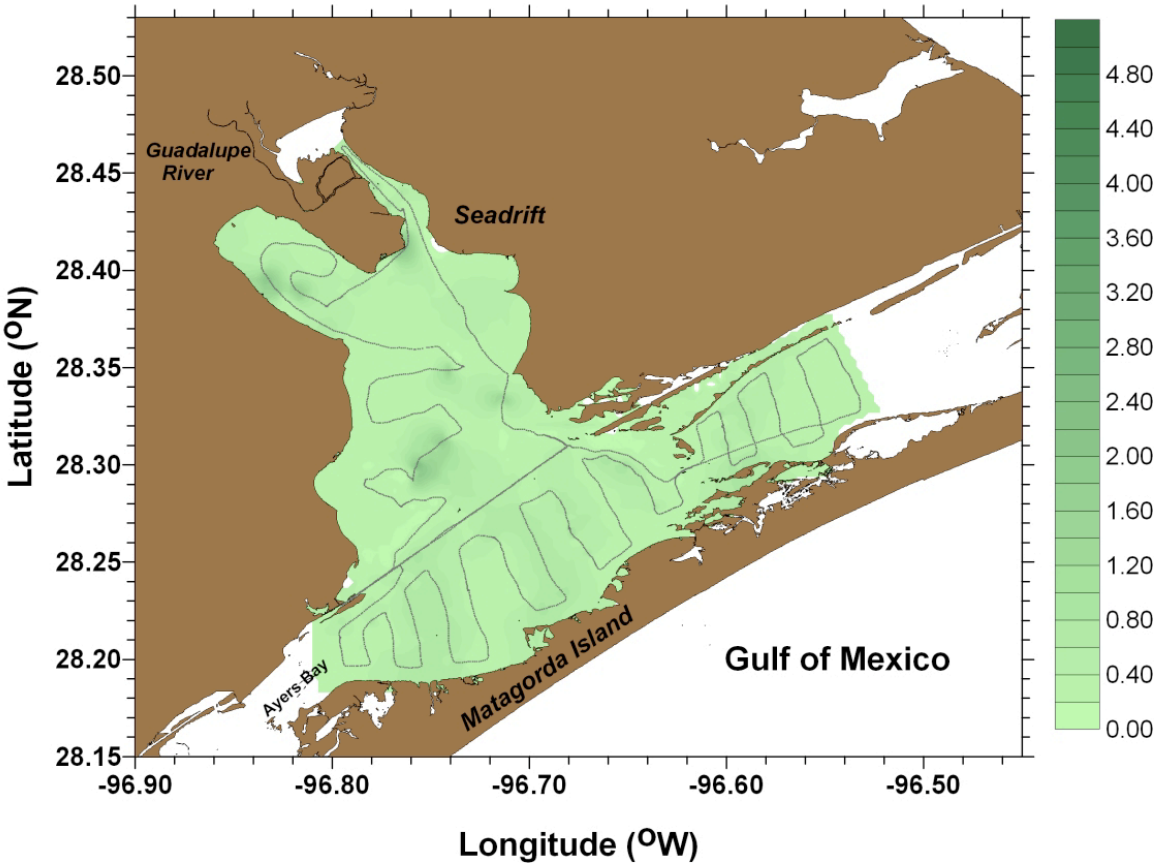
San Antonio Bay, June 06

In vivo Chlorophyll a (ug L^{-1})



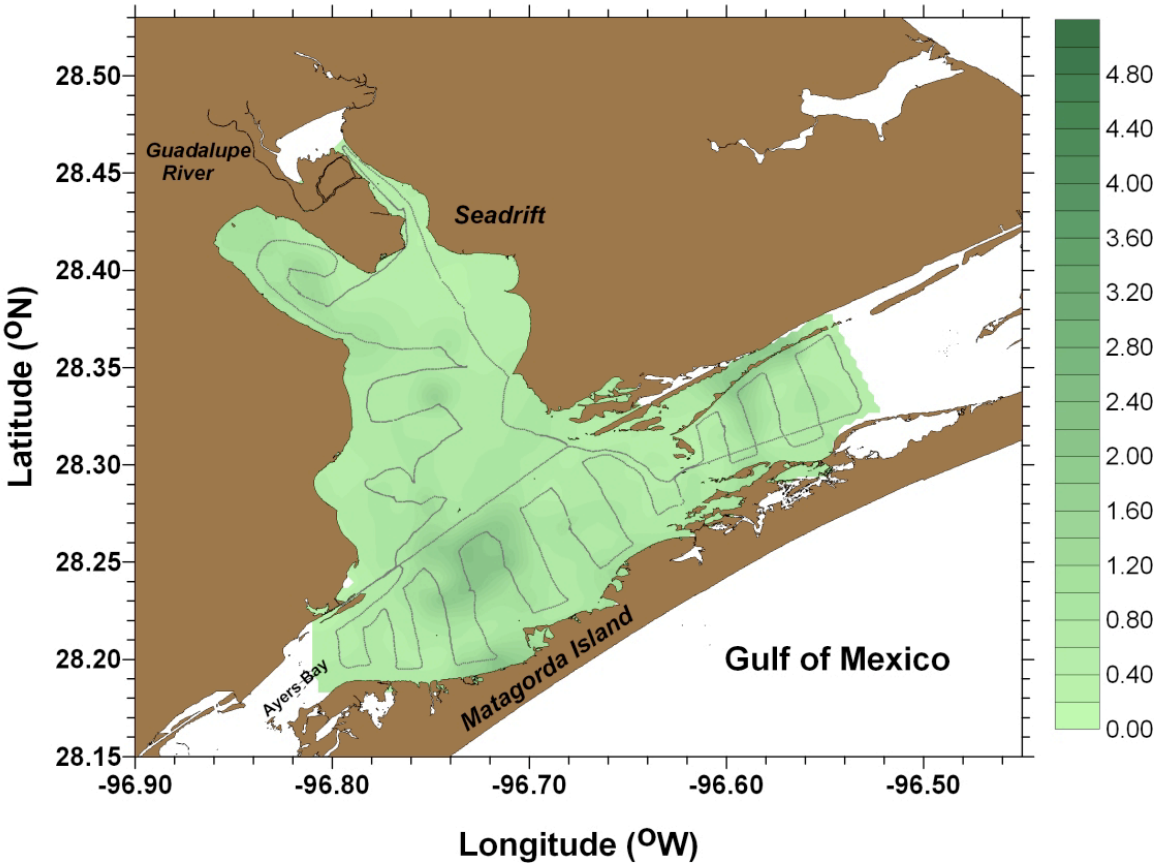
San Antonio Bay, July 06

In vivo Chlorophyll a (ug L^{-1})



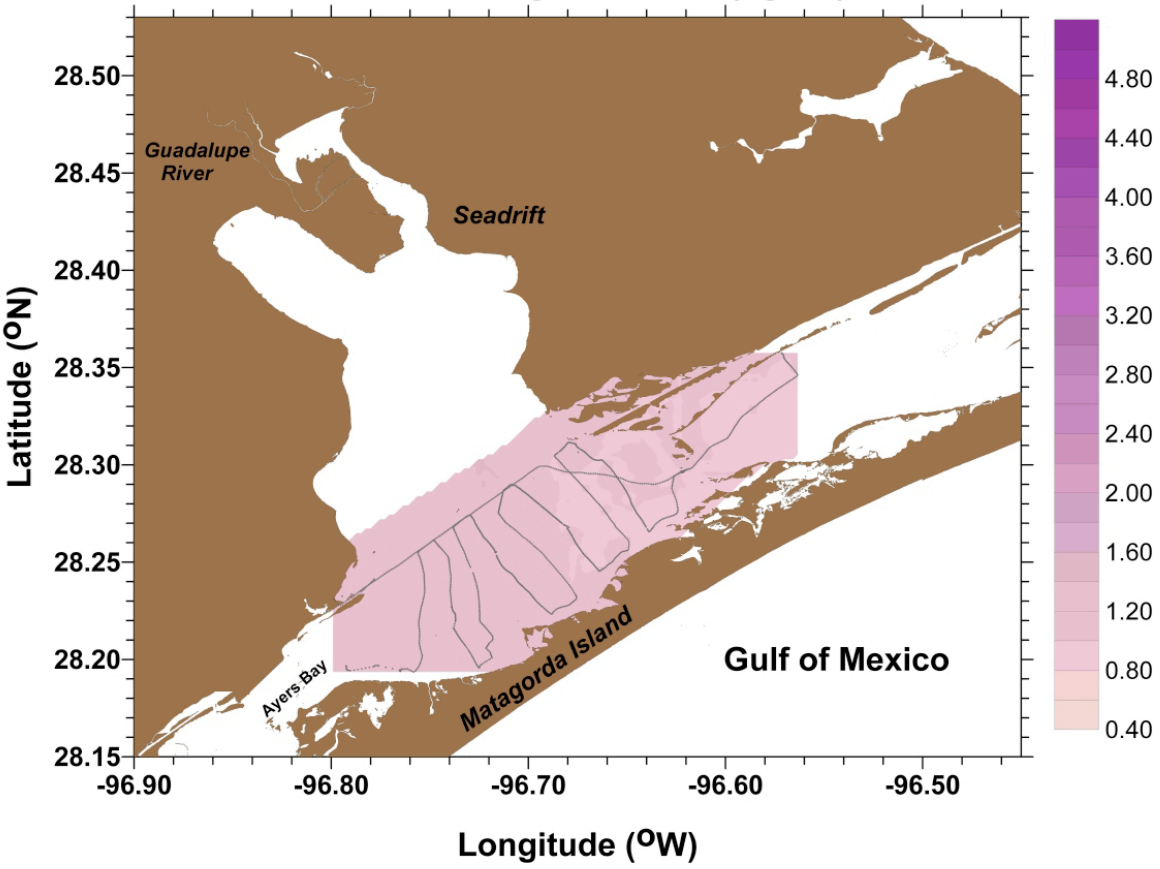
San Antonio Bay, August 06

In vivo Chlorophyll a (ug L^{-1})



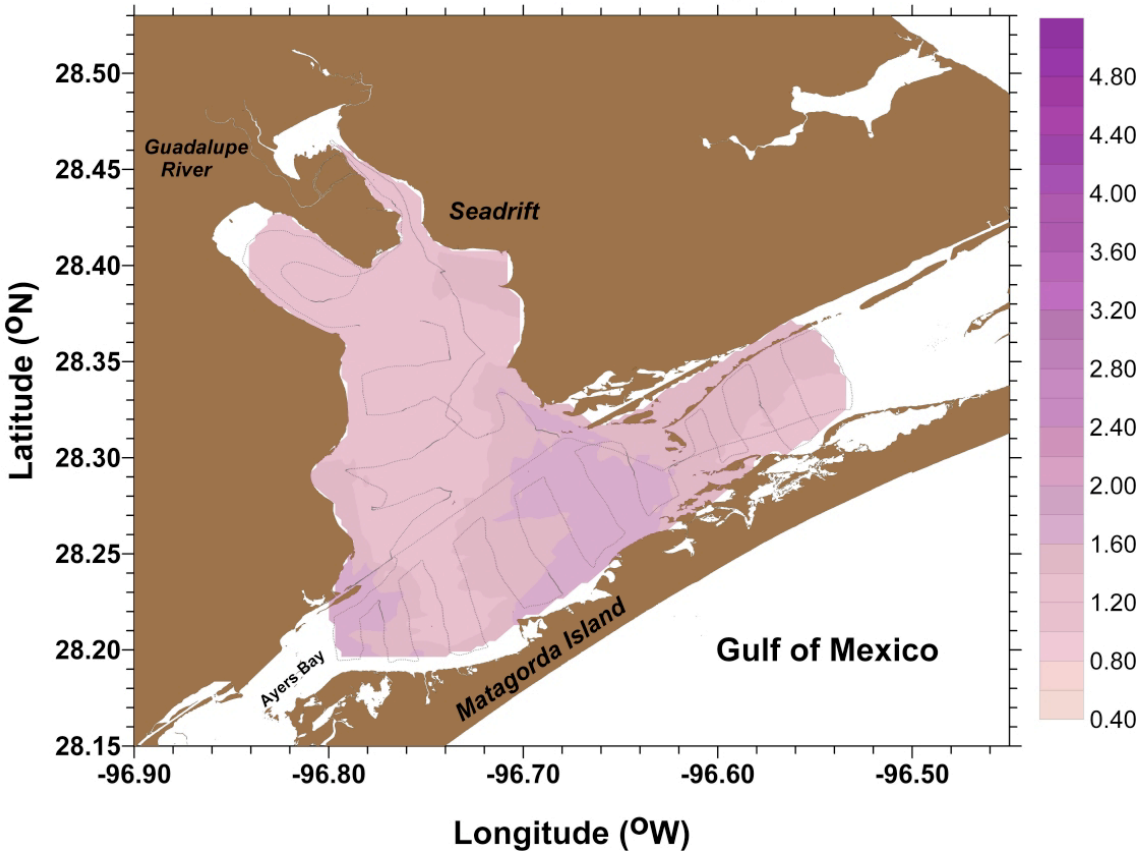
San Antonio Bay, Oct 04

Dissolved Organic Matter (ug L^{-1})



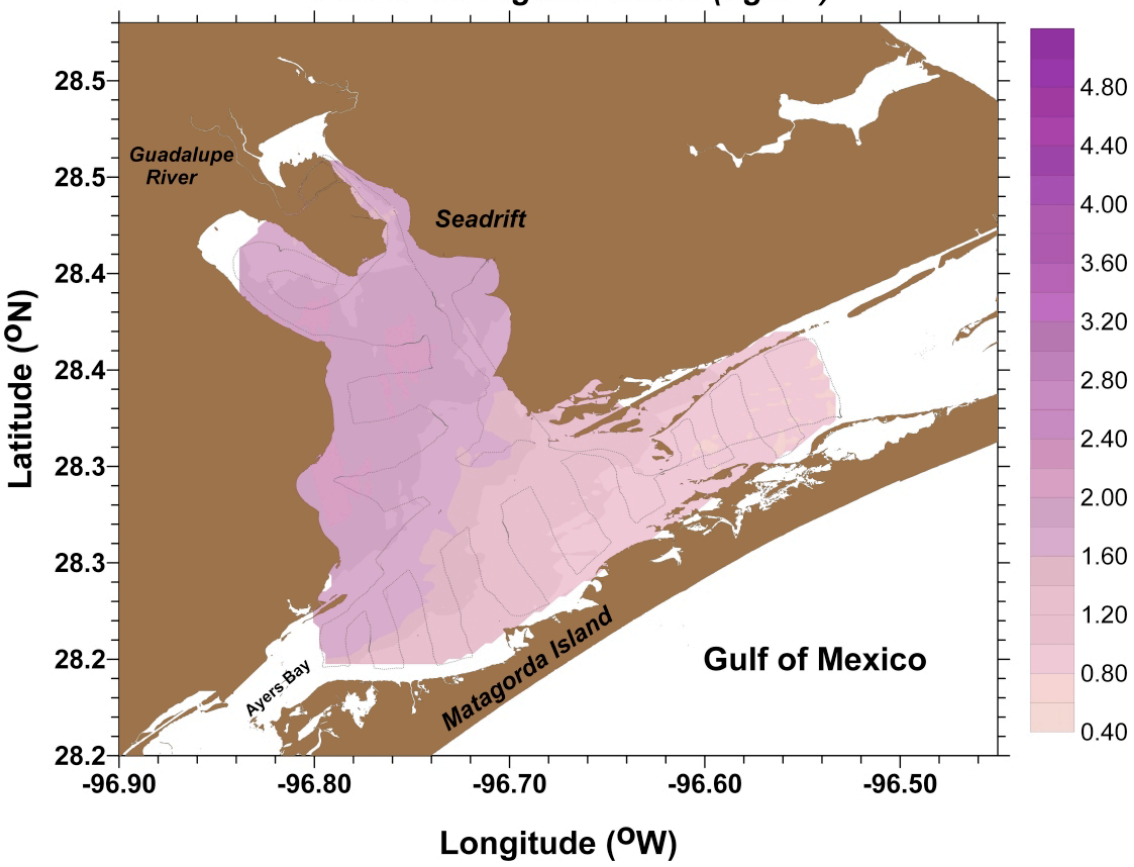
San Antonio Bay, January 05

Dissolved Organic Matter (ug L^{-1})



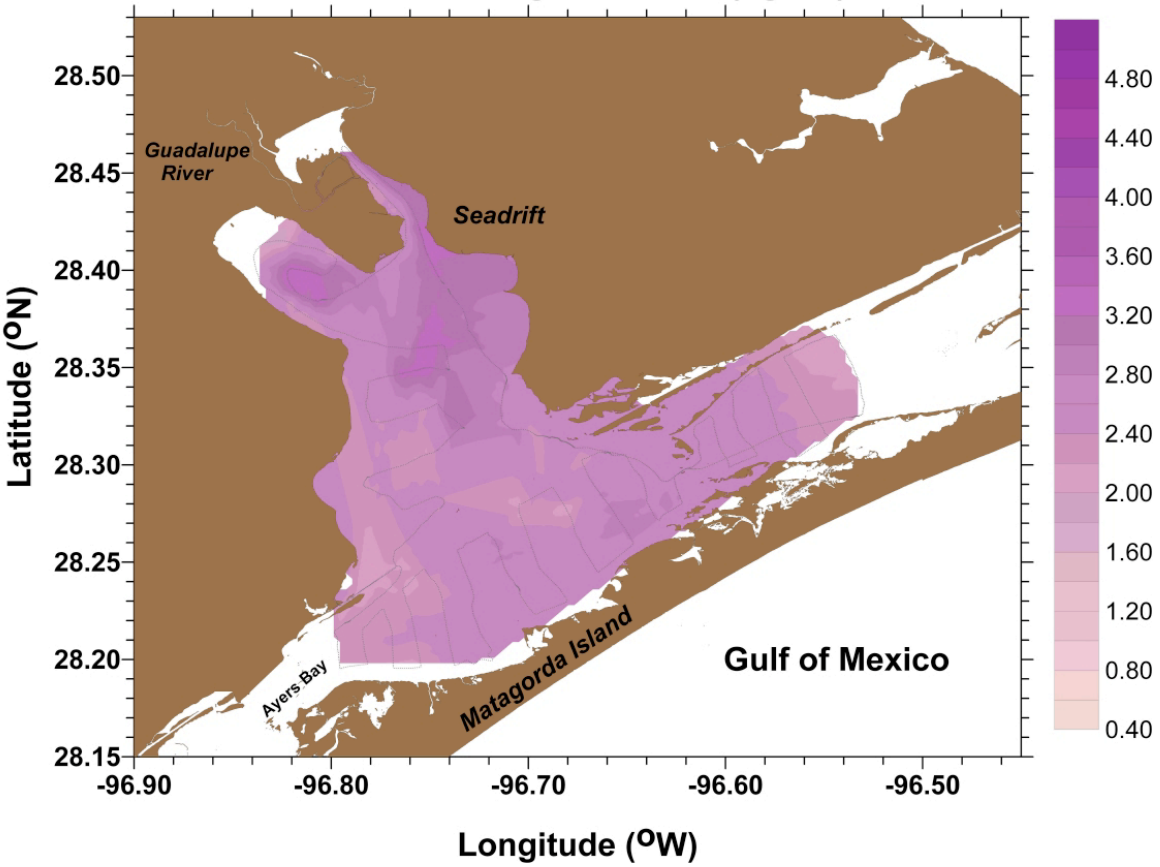
San Antonio Bay, February 05

Dissolved Organic Matter (ug L^{-1})



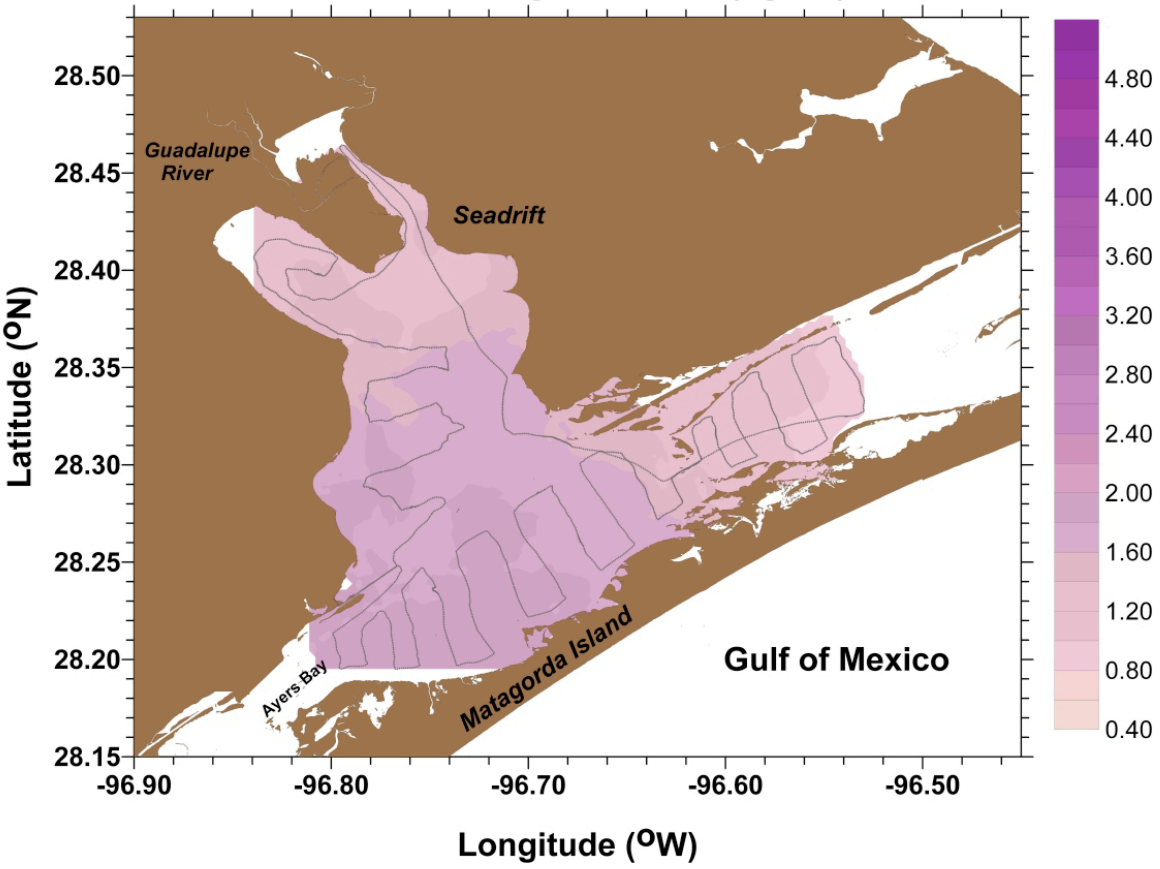
San Antonio Bay, March 05

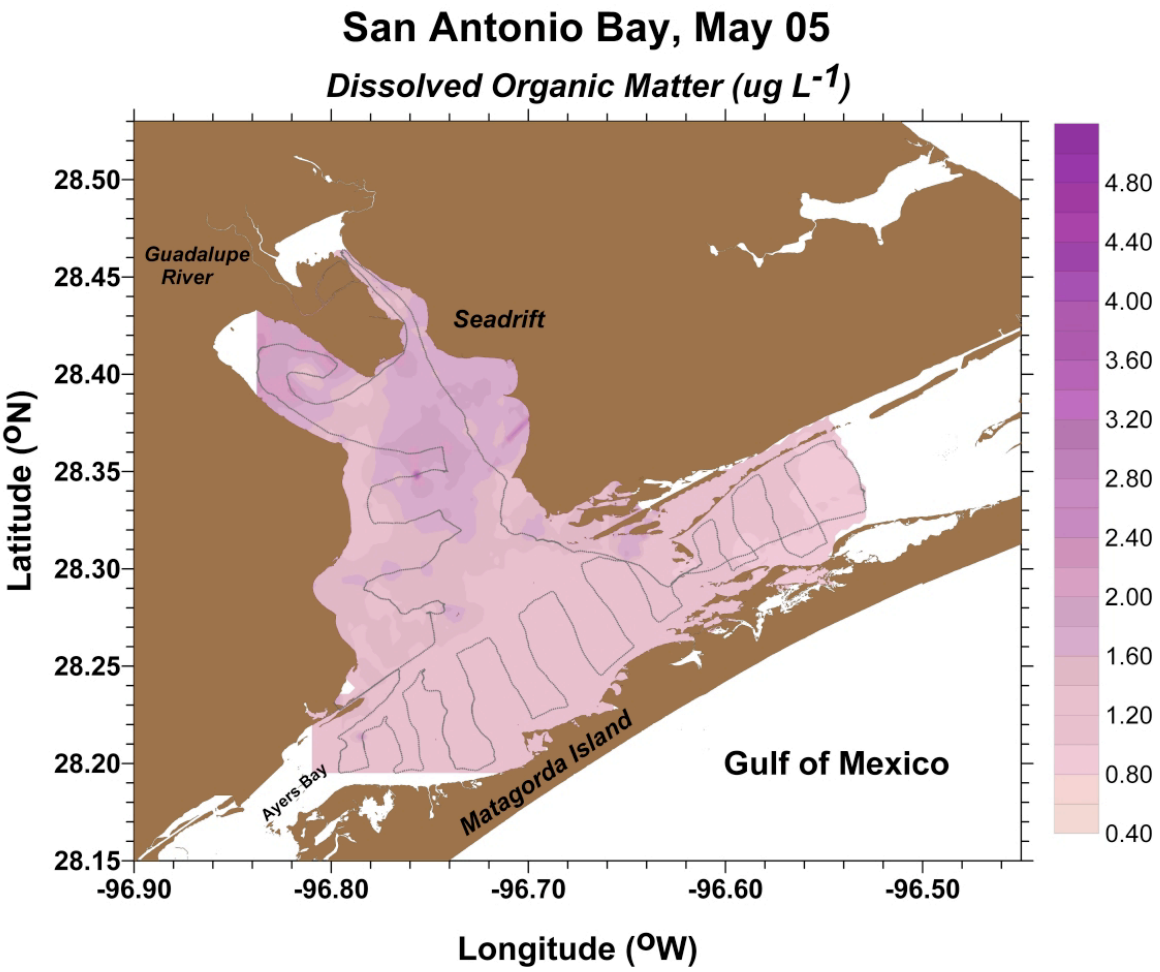
Dissolved Organic Matter (ug L^{-1})



San Antonio Bay, April 05

Dissolved Organic Matter (ug L^{-1})




San Antonio Bay, May 05
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
4.80
4.40
4.00
3.60
3.20
2.80
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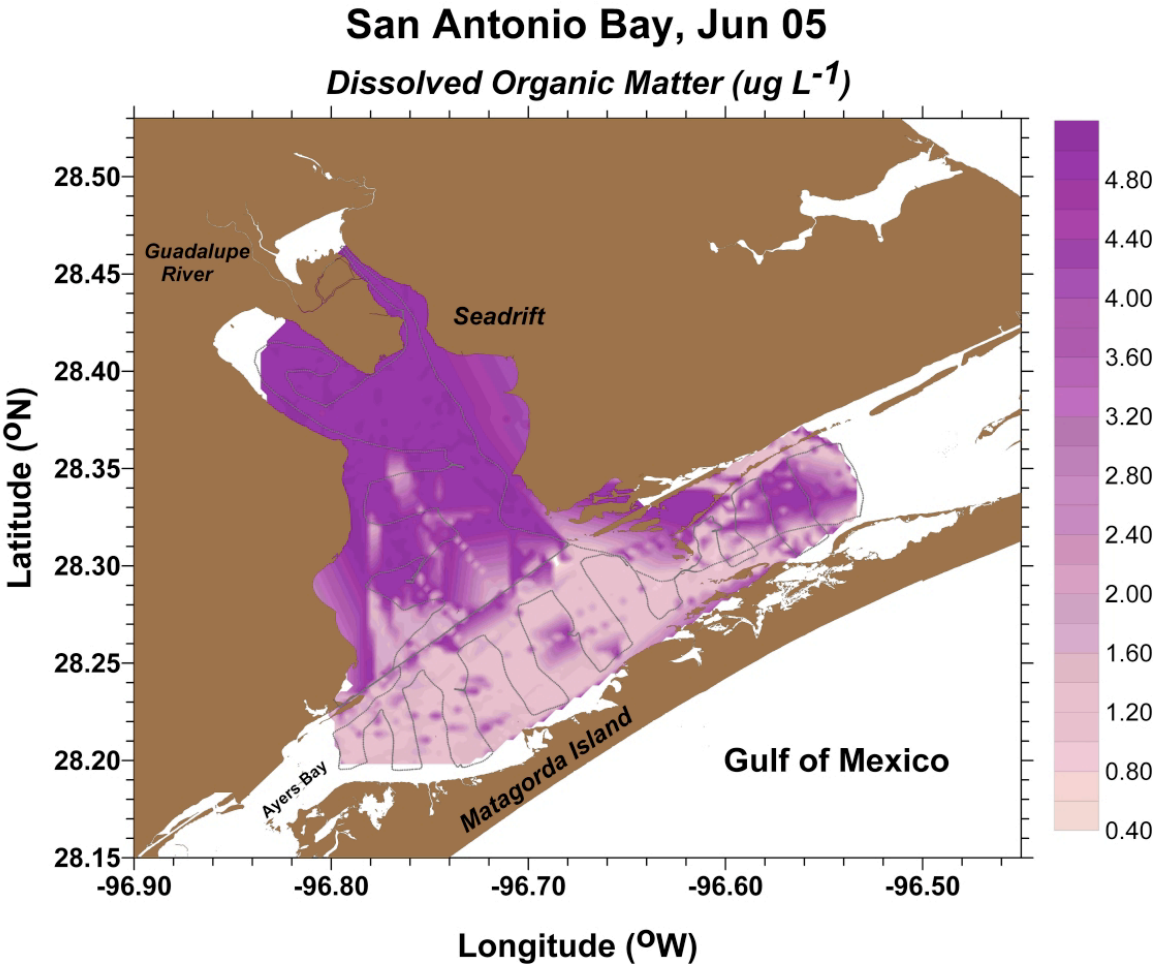
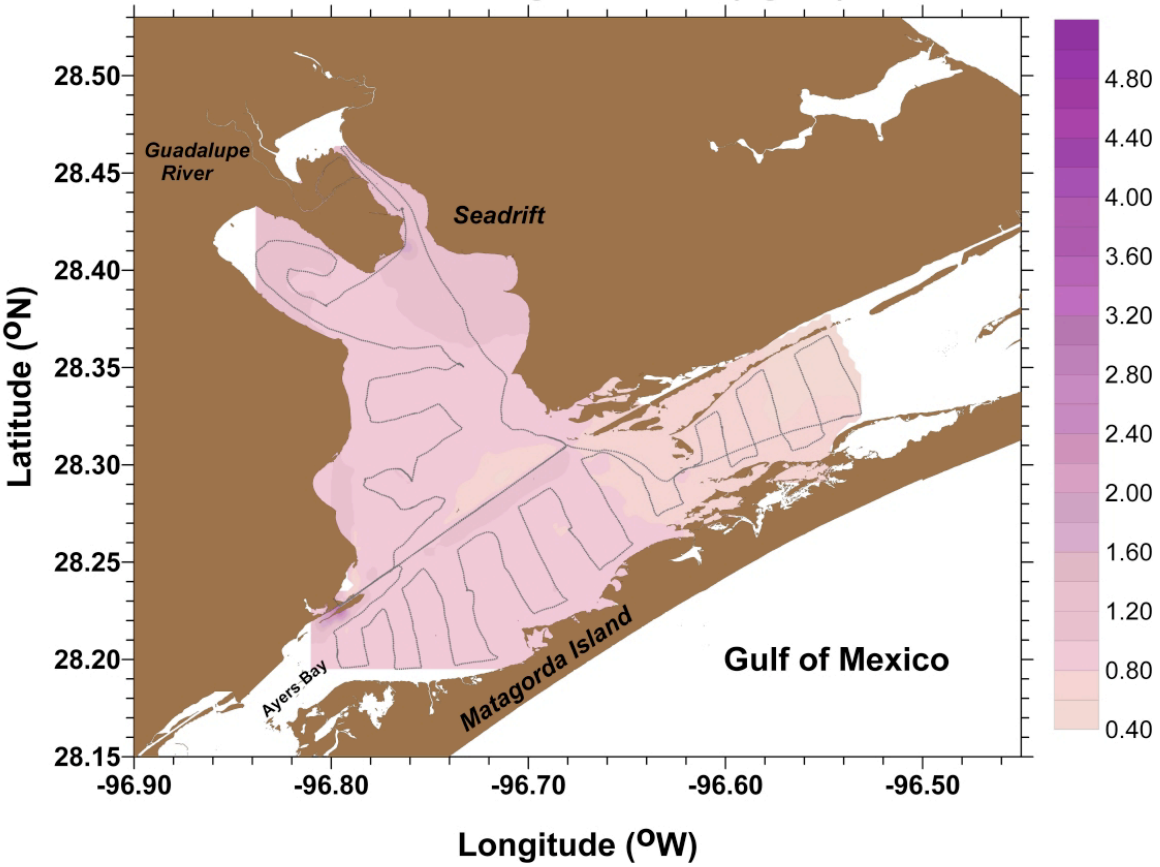
1.60
1.20
0.80
0.40


San Antonio Bay, Jun 05
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
4.80
4.40
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40

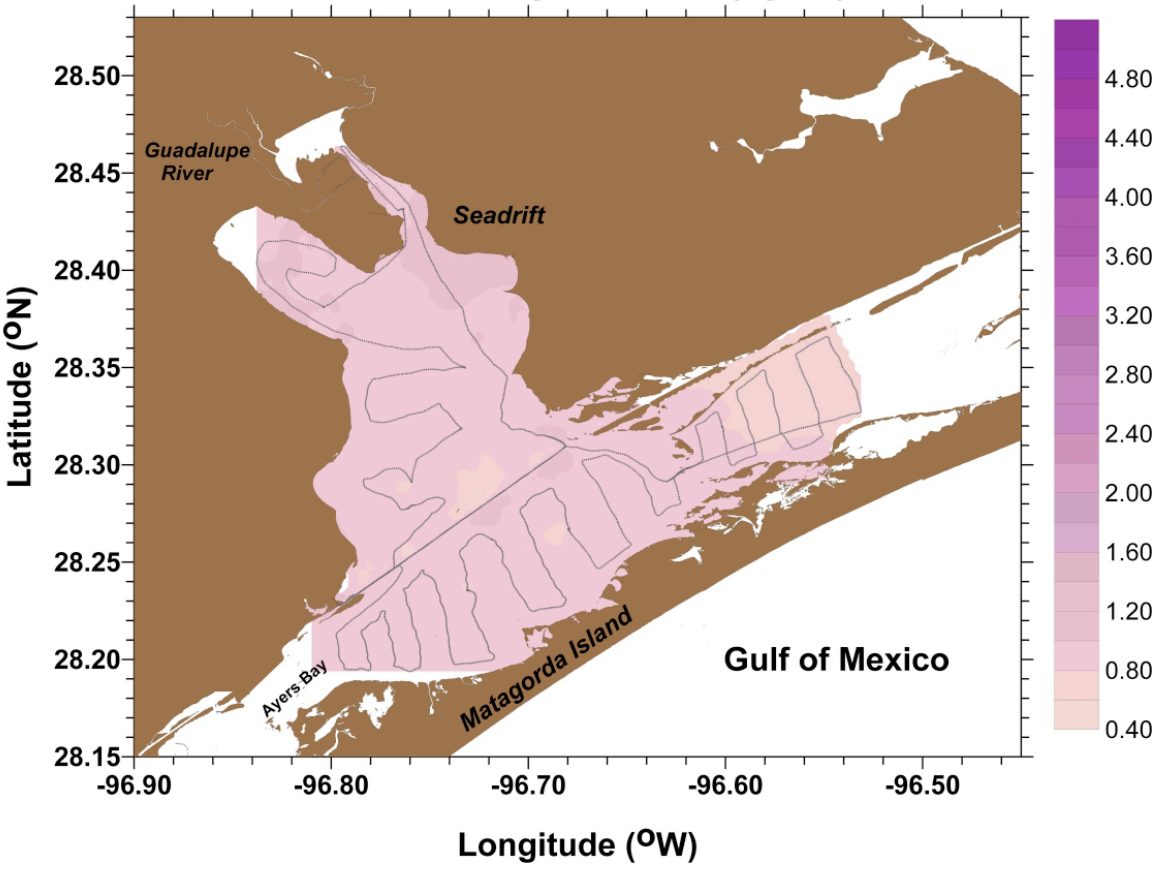
San Antonio Bay, July 05

Dissolved Organic Matter (ug L^{-1})



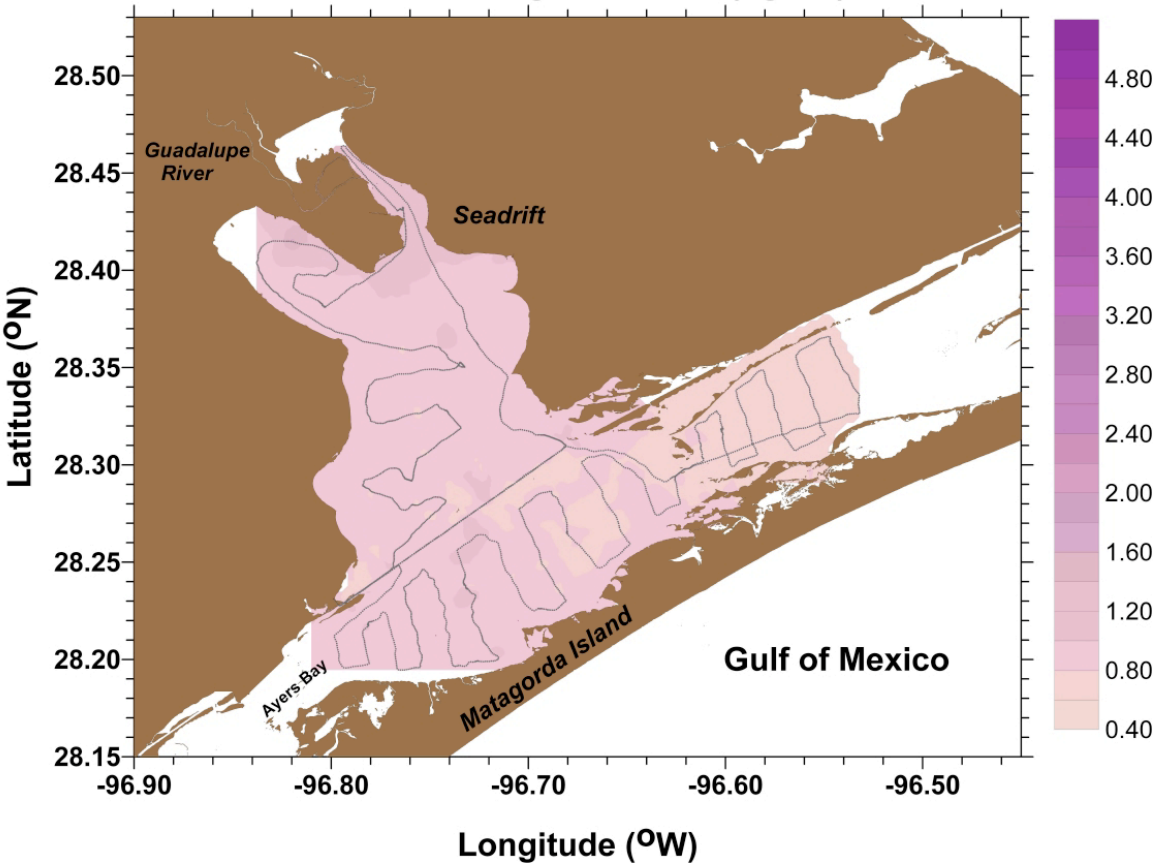
San Antonio Bay, August 05

Dissolved Organic Matter (ug L^{-1})



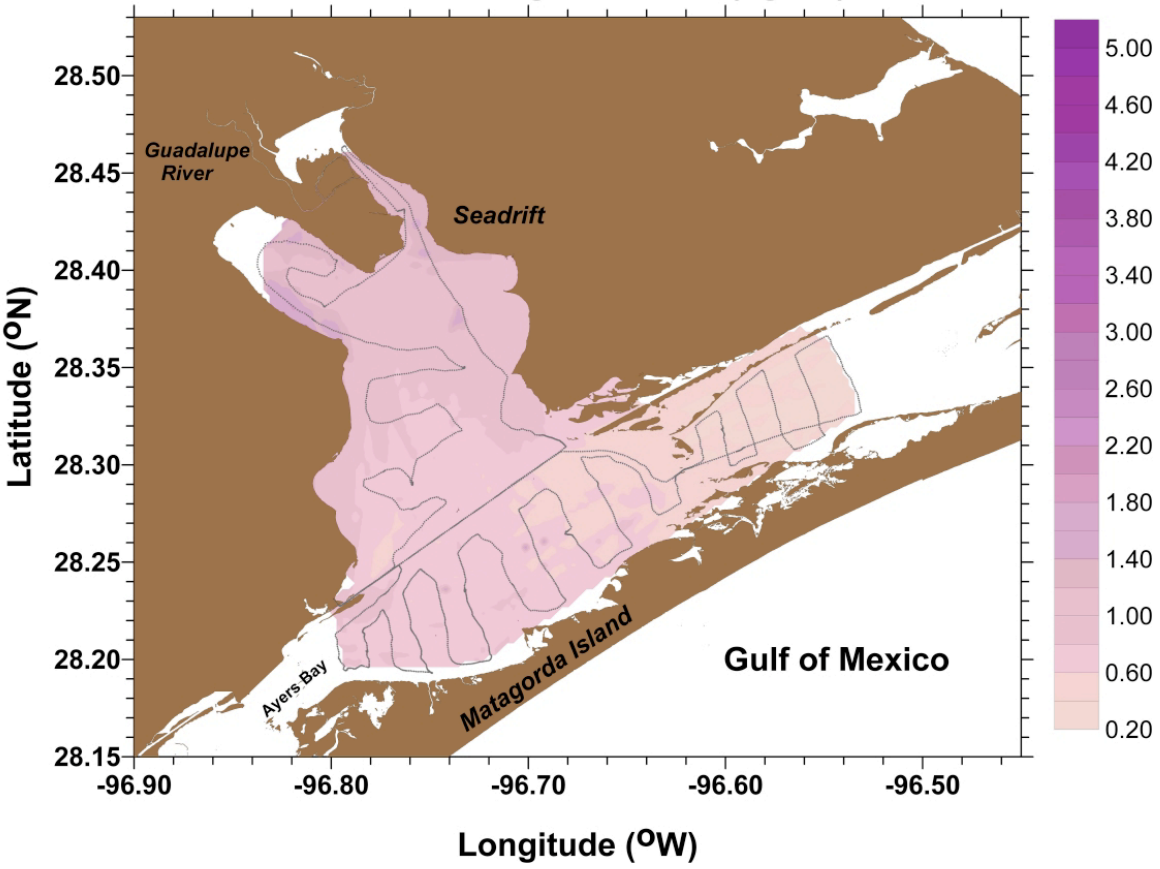
San Antonio Bay, September 05

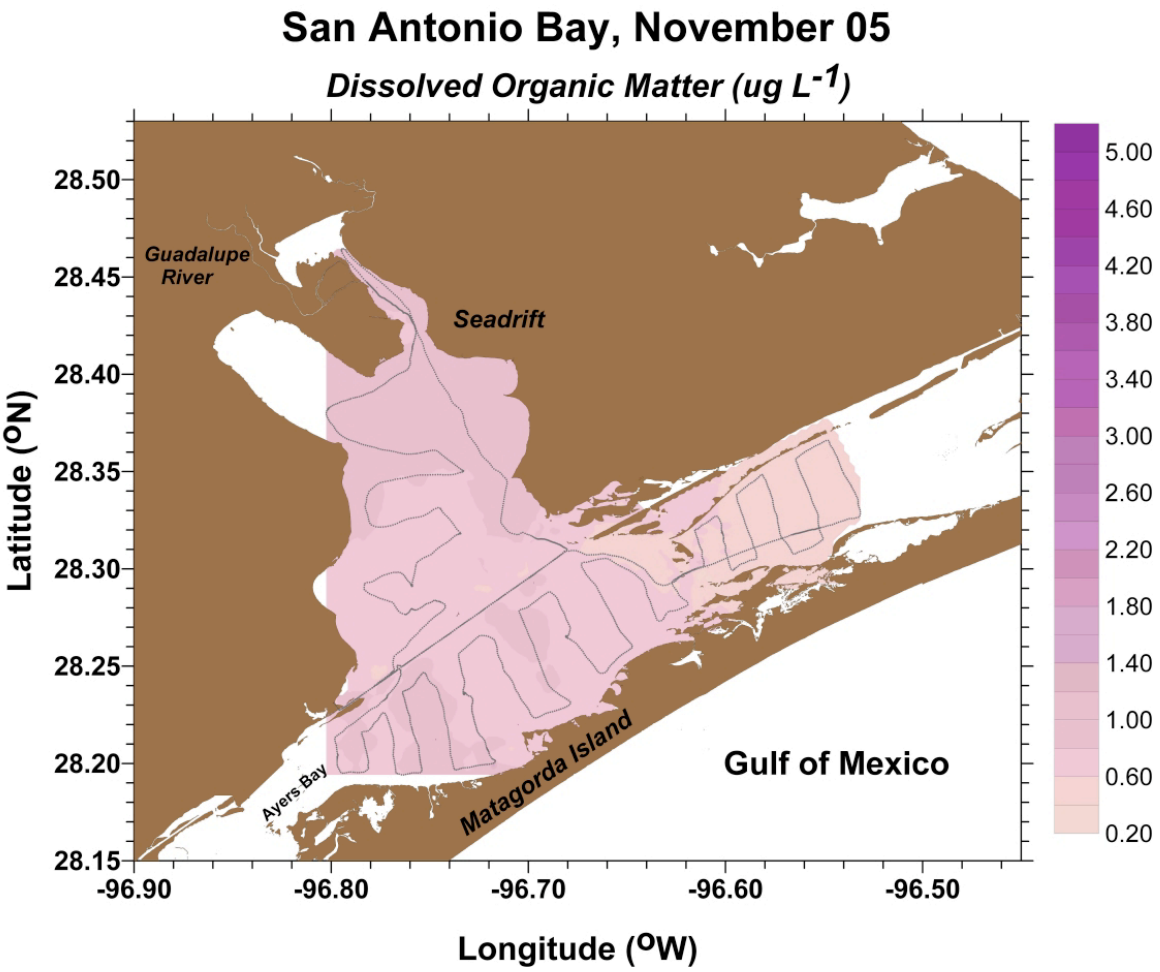
Dissolved Organic Matter (ug L^{-1})

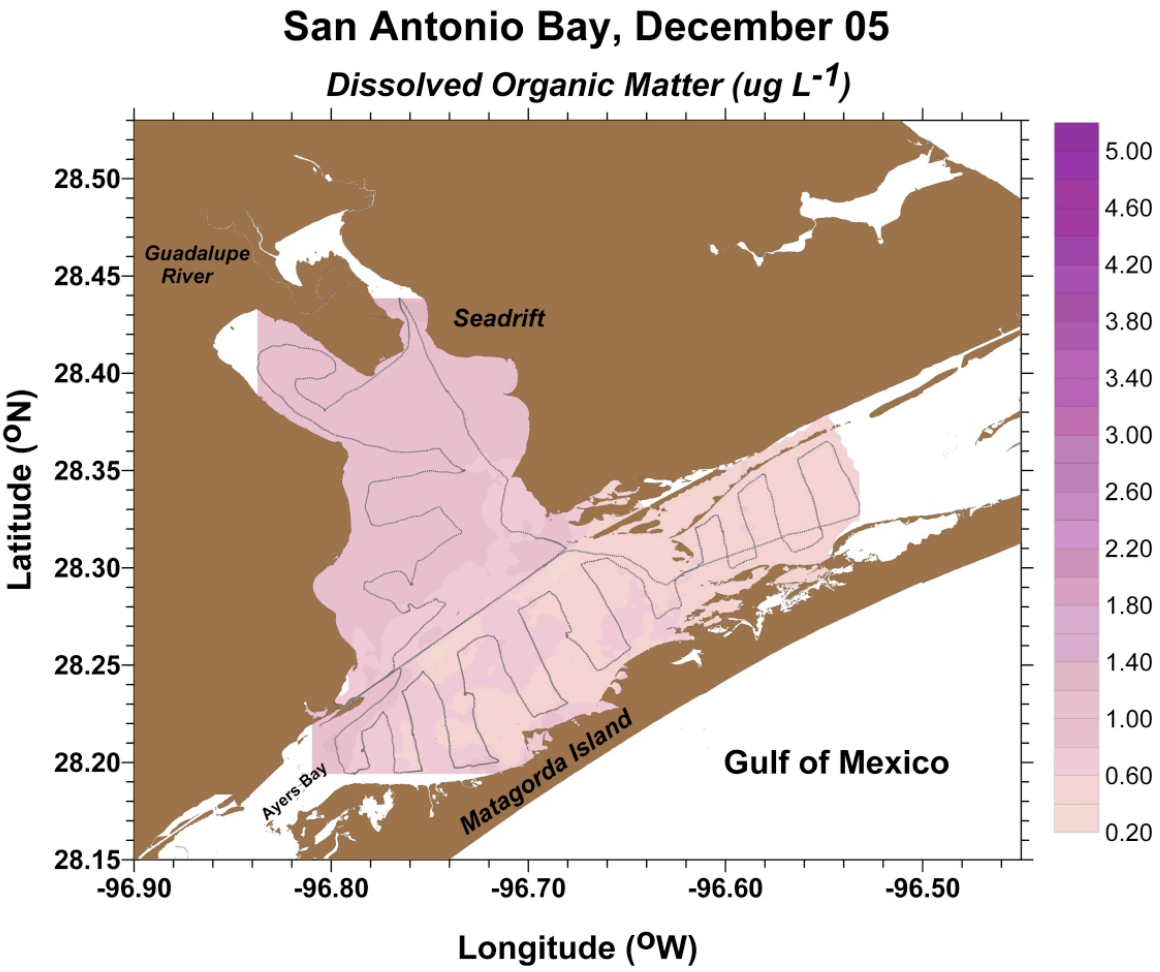


San Antonio Bay, October 05

Dissolved Organic Matter (ug L^{-1})

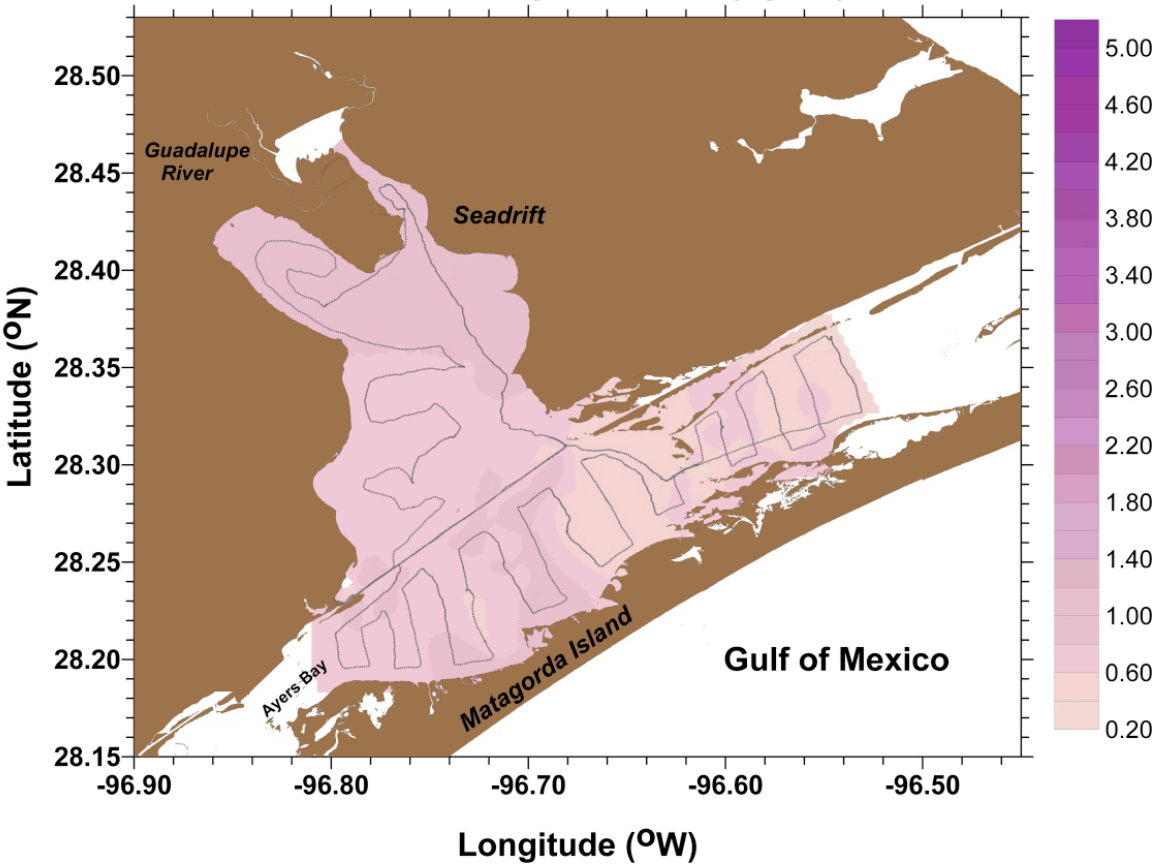



San Antonio Bay, November 05
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
5.00
4.60
4.20
3.80
3.40
3.00
2.60
2.20
1.80
1.40
1.00
0.60
0.20


San Antonio Bay, December 05
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
5.00
4.60
4.20
3.80
3.40
3.00
2.60
2.20
1.80
1.40
1.00
0.60
0.20

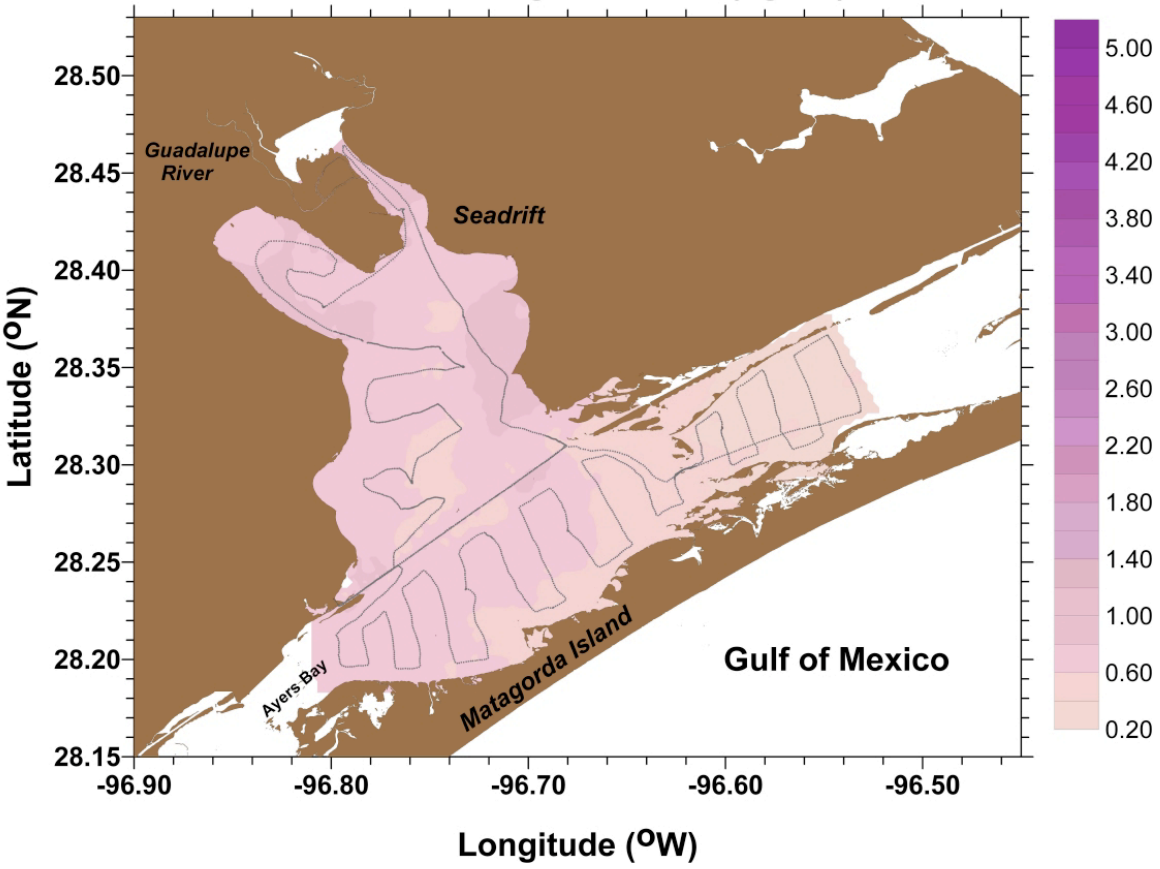
San Antonio Bay, January 06

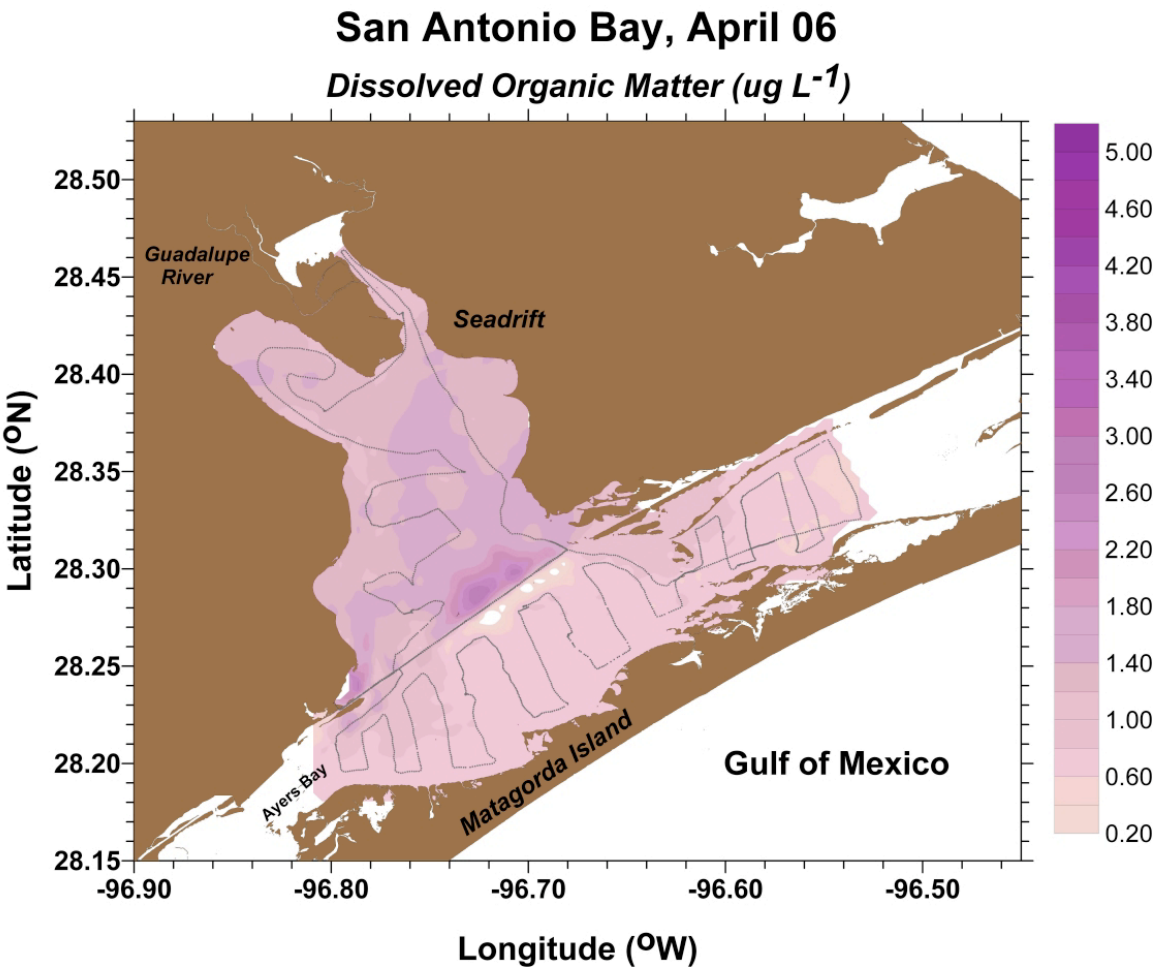
Dissolved Organic Matter (ug L^{-1})

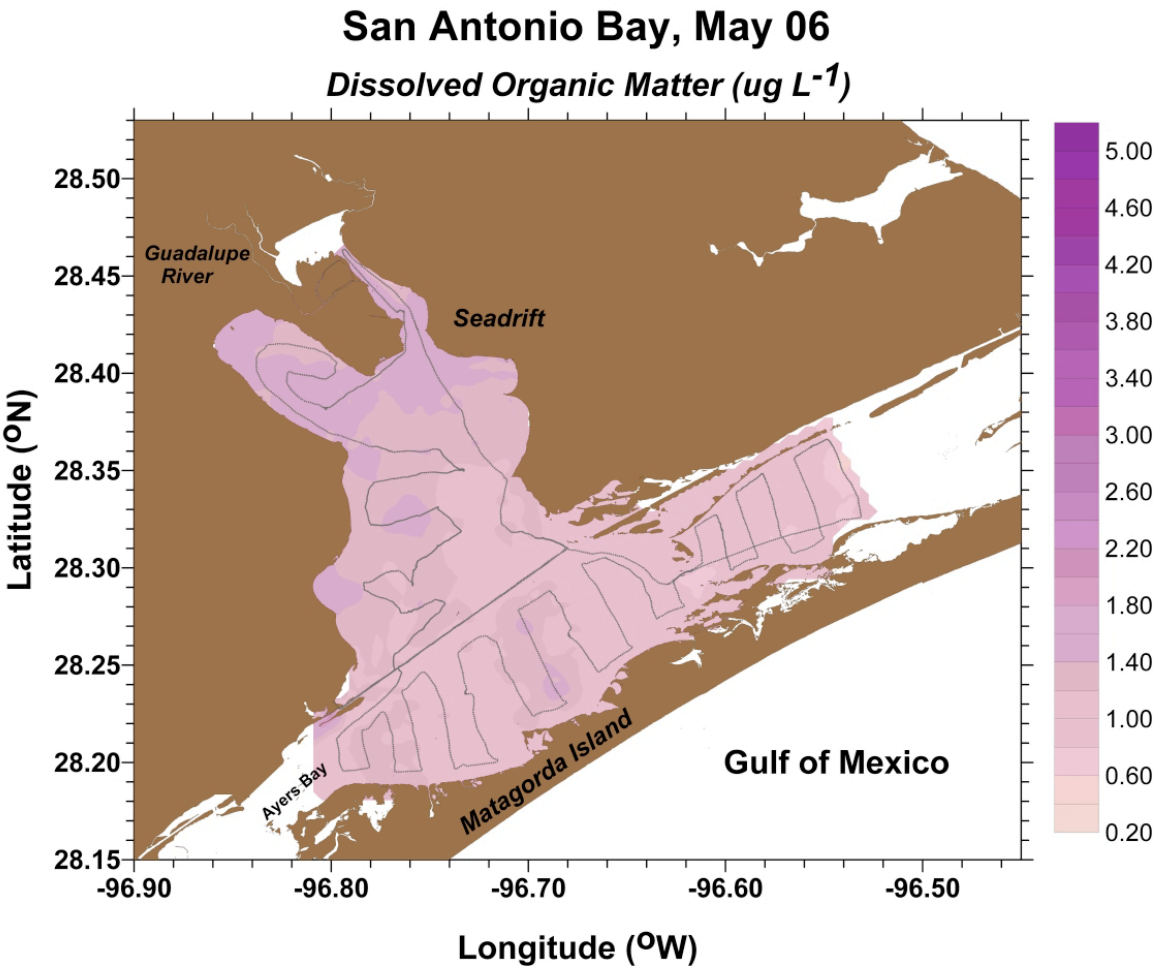


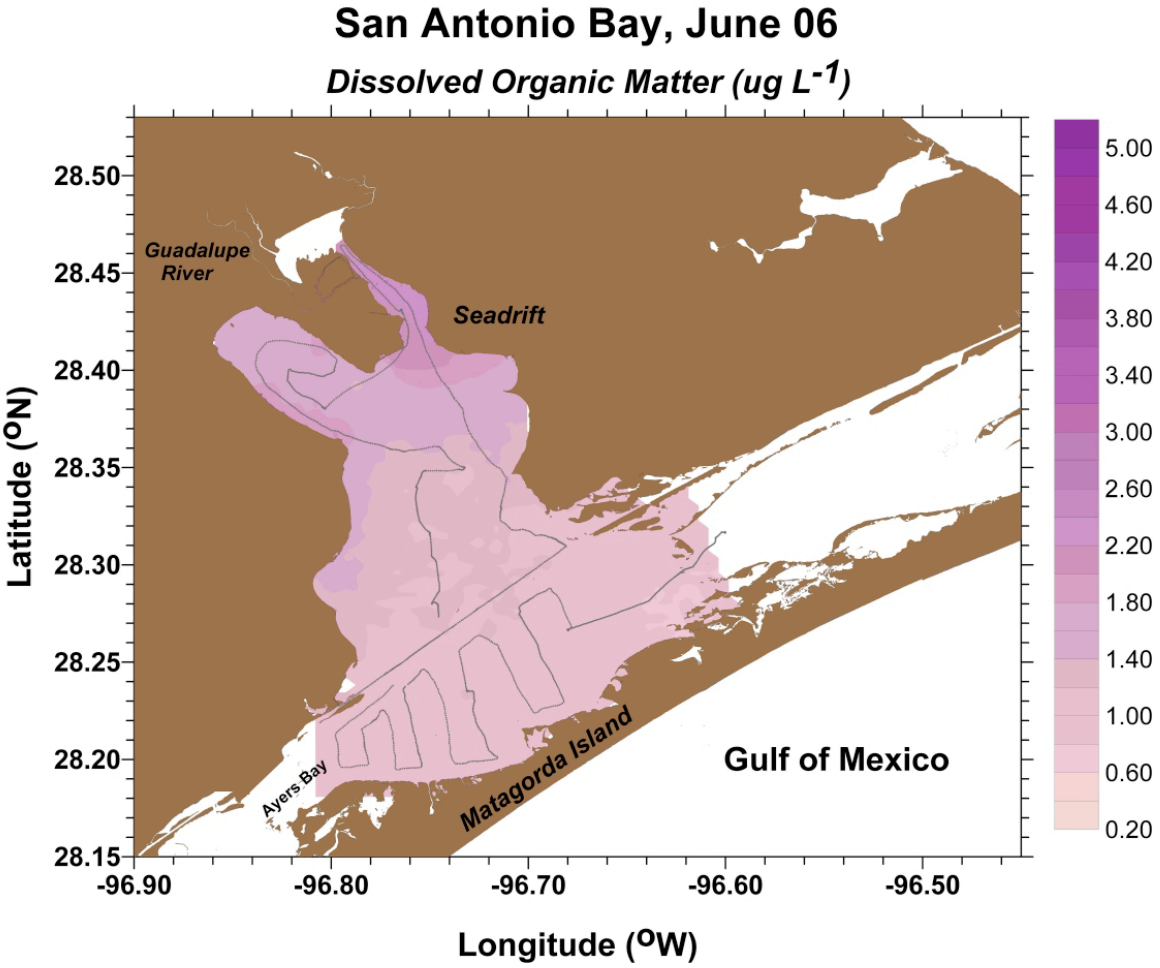
San Antonio Bay, February 06

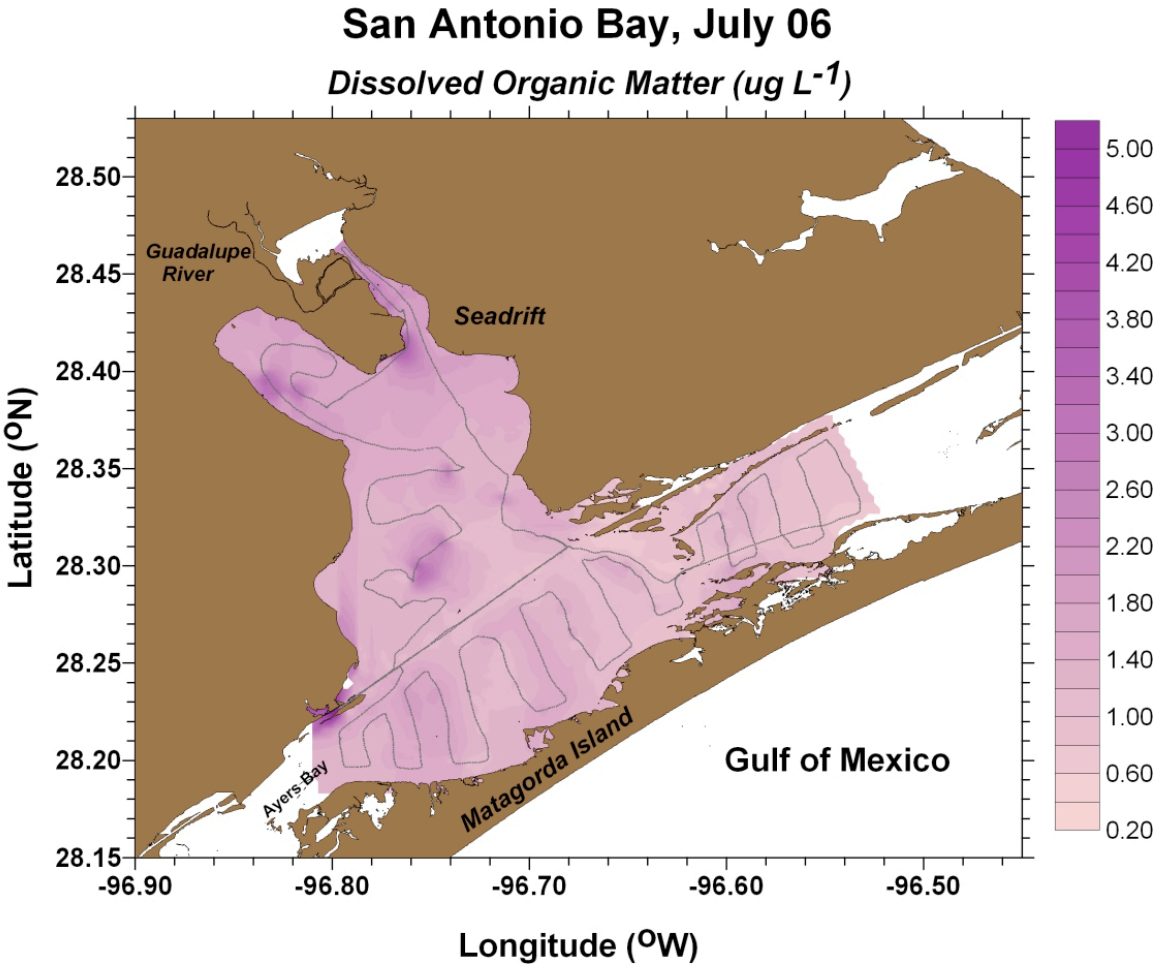
Dissolved Organic Matter (ug L^{-1})




San Antonio Bay, April 06
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
5.00
4.60
4.20
3.80
3.40
3.00
2.60
2.20
1.80
1.40
1.00
0.60
0.20

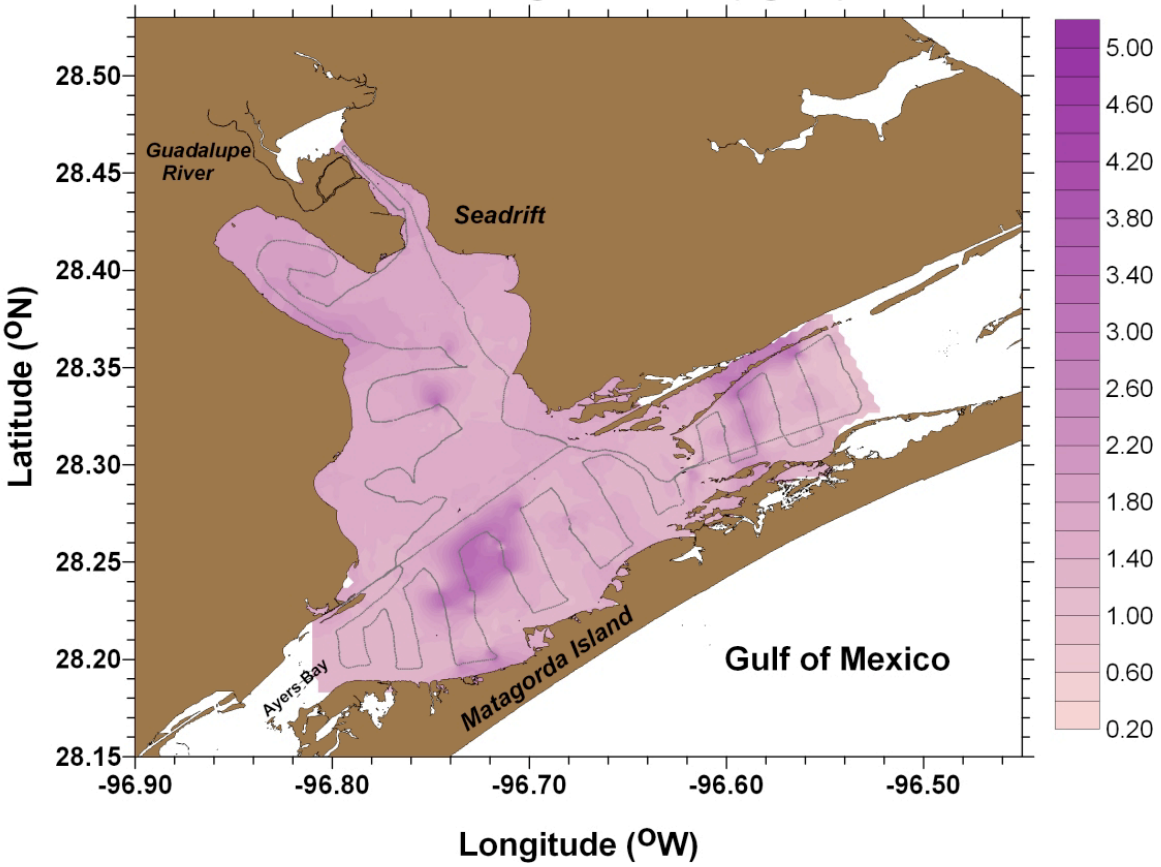

San Antonio Bay, May 06
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
5.00
4.60
4.20
3.80
3.40
3.00
2.60
2.20
1.80
1.40
1.00
0.60
0.20


San Antonio Bay, June 06
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
5.00
4.60
4.20
3.80
3.40
3.00
2.60
2.20
1.80
1.40
1.00
0.60
0.20


San Antonio Bay, July 06
Dissolved Organic Matter (ug L-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (oN)
Longitude (oW)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
5.00
4.60
4.20
3.80
3.40
3.00
2.60
2.20
1.80
1.40
1.00
0.60
0.20

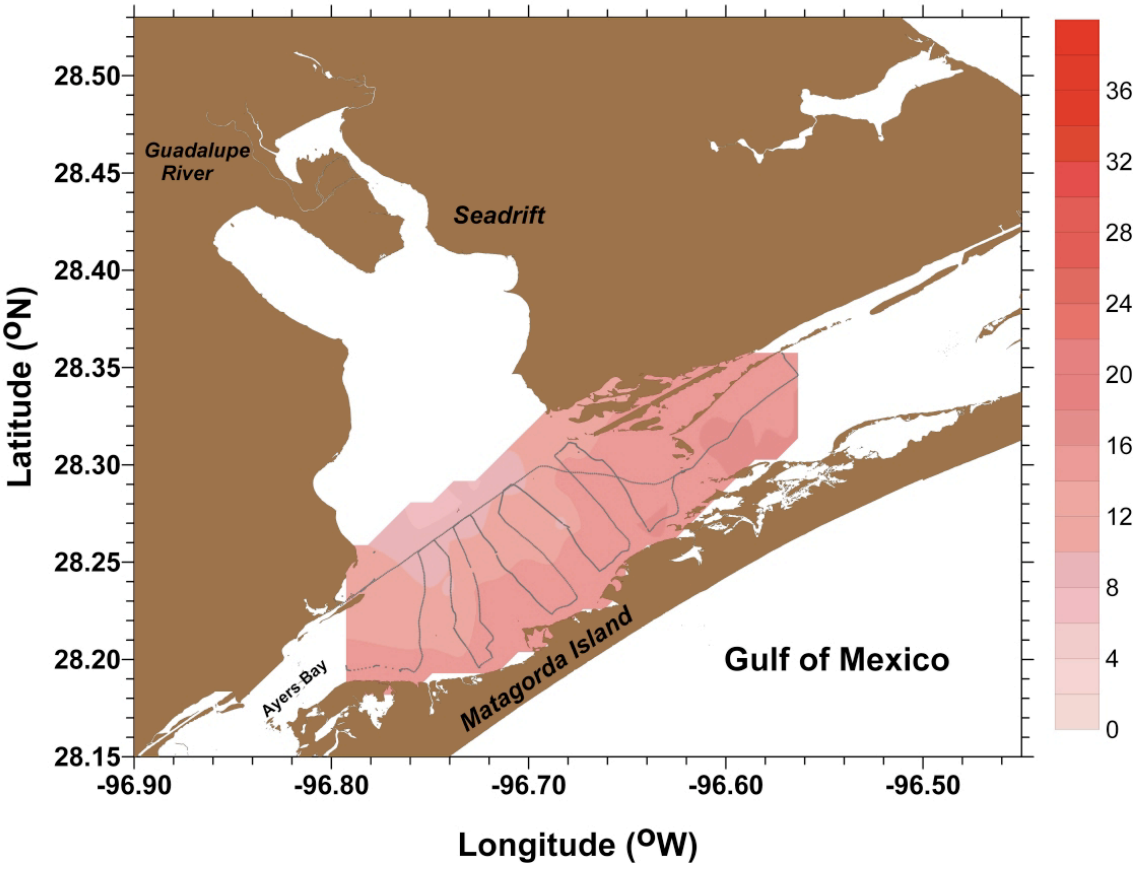
San Antonio Bay, August 06

Dissolved Organic Matter (ug L^{-1})



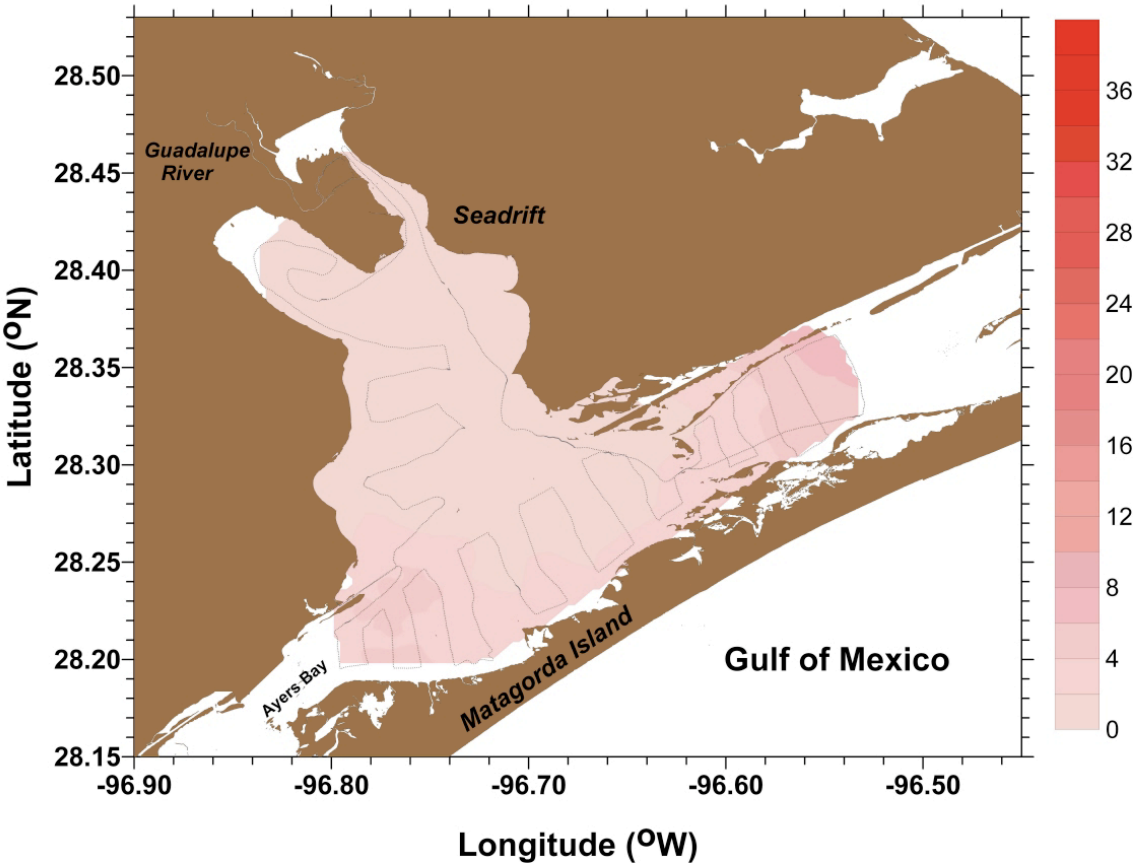
San Antonio Bay, Oct 04

Salinity (PSU)



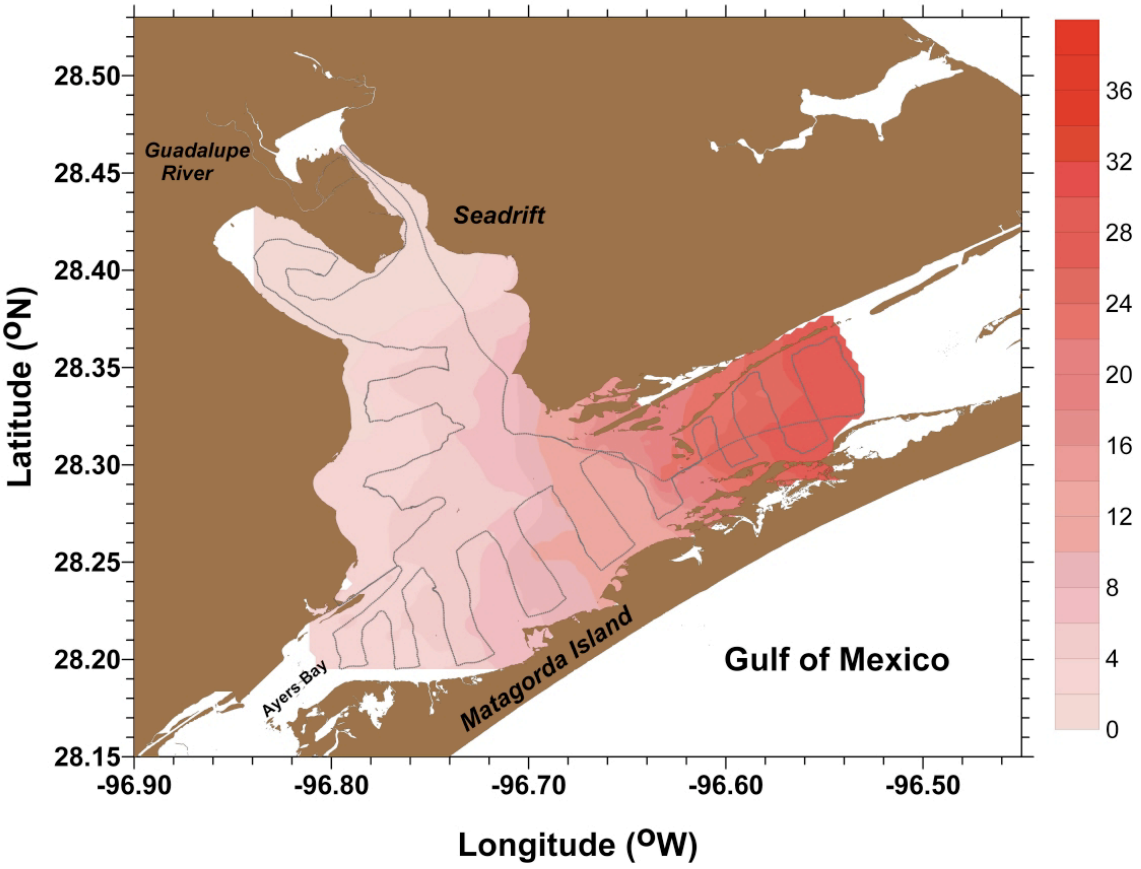
San Antonio Bay, March 05

Salinity (PSU)



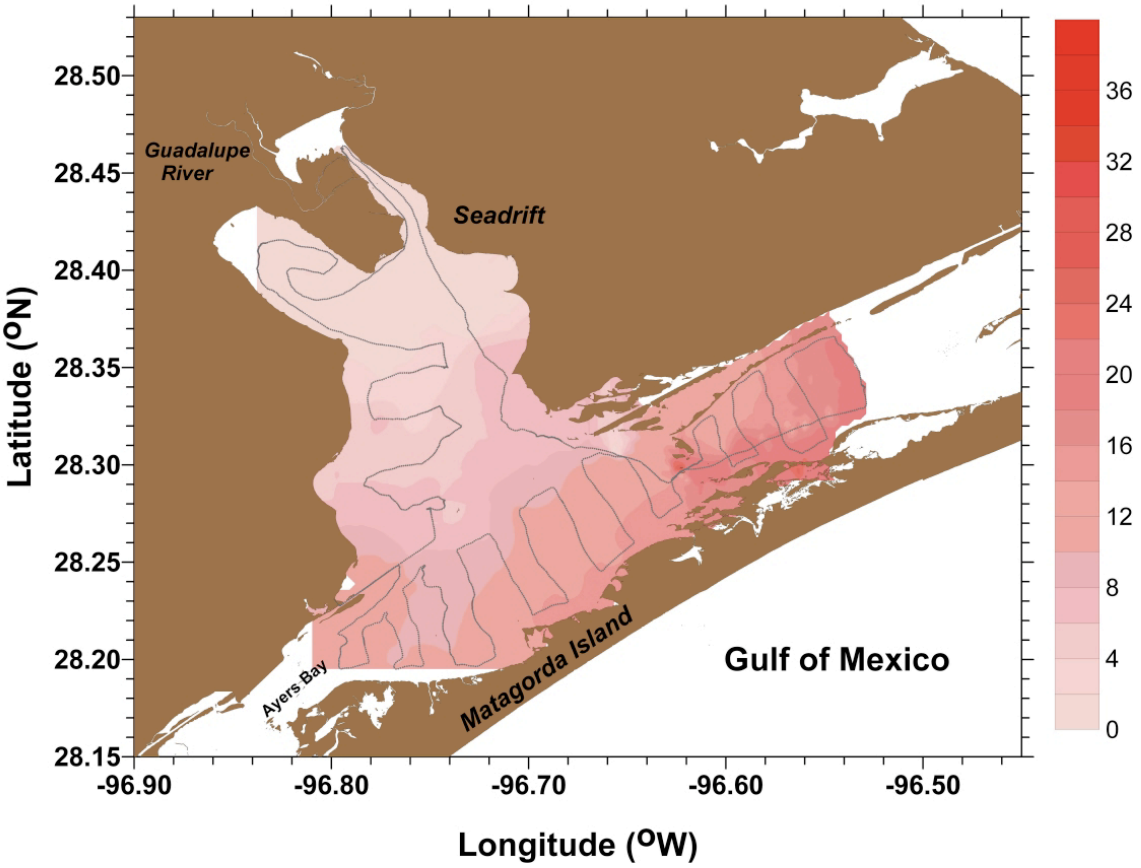
San Antonio Bay, April 05

Salinity (PSU)



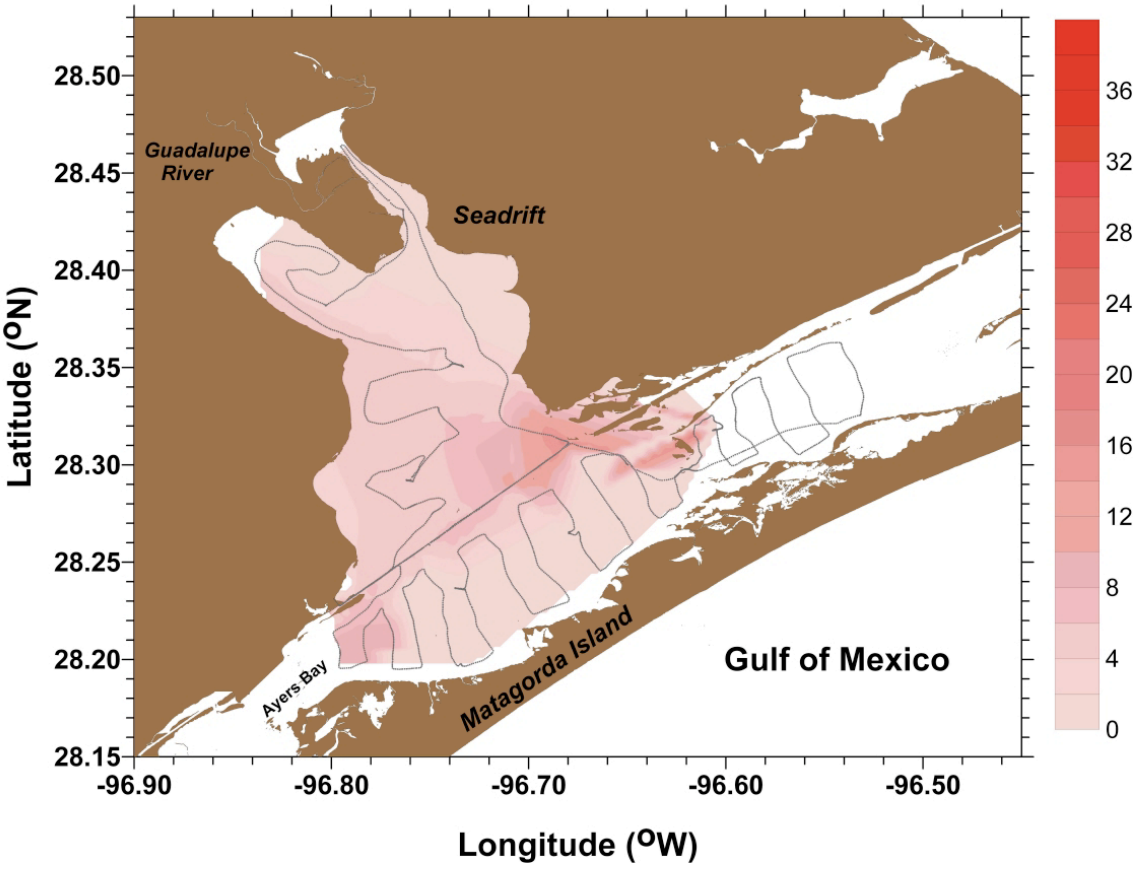
San Antonio Bay, May 05

Salinity (PSU)



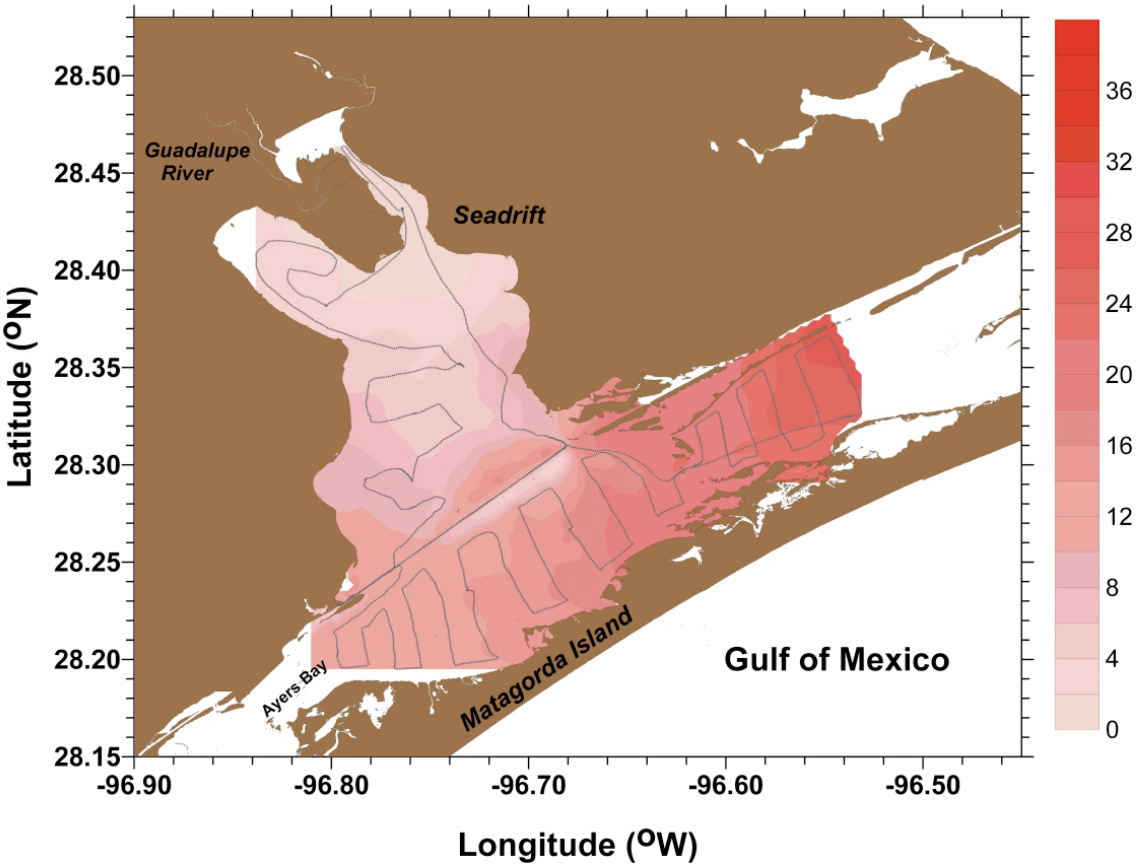
San Antonio Bay, Jun 05

Salinity (PSU)



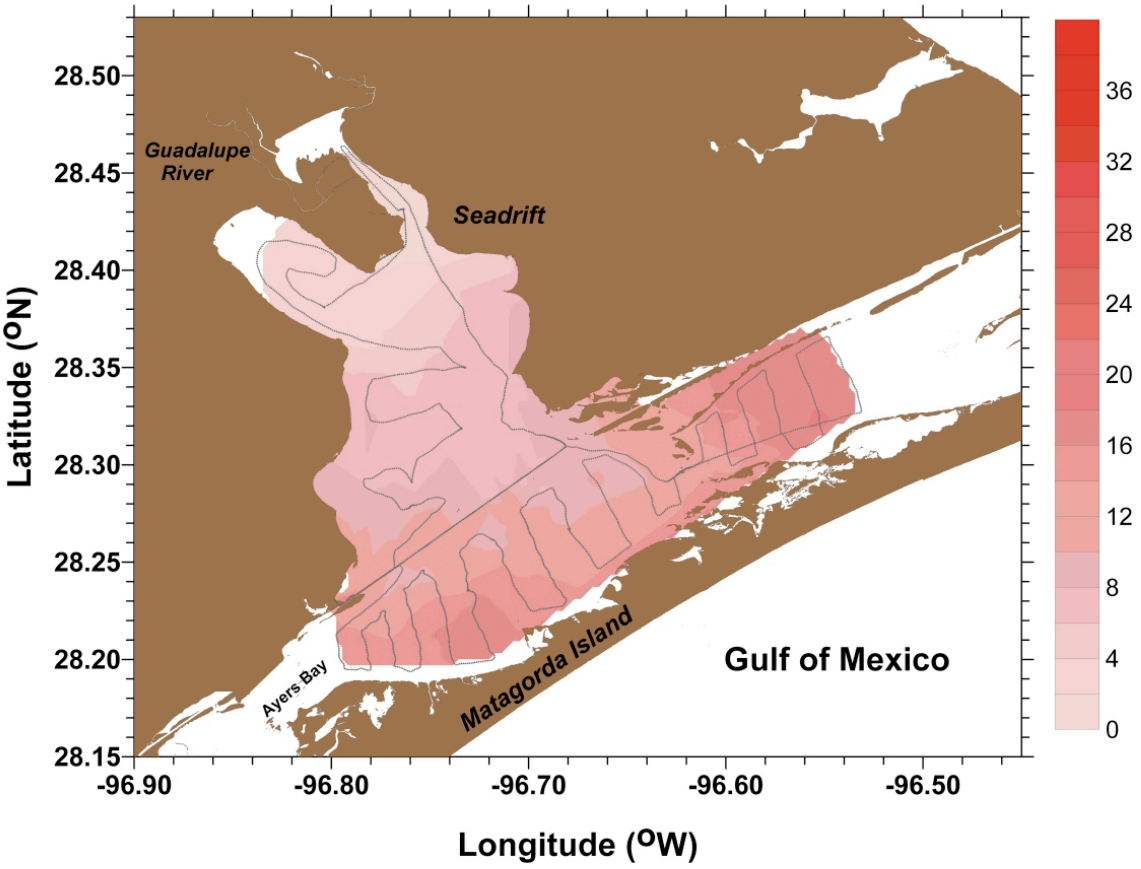
San Antonio Bay, July 05

Salinity (PSU)



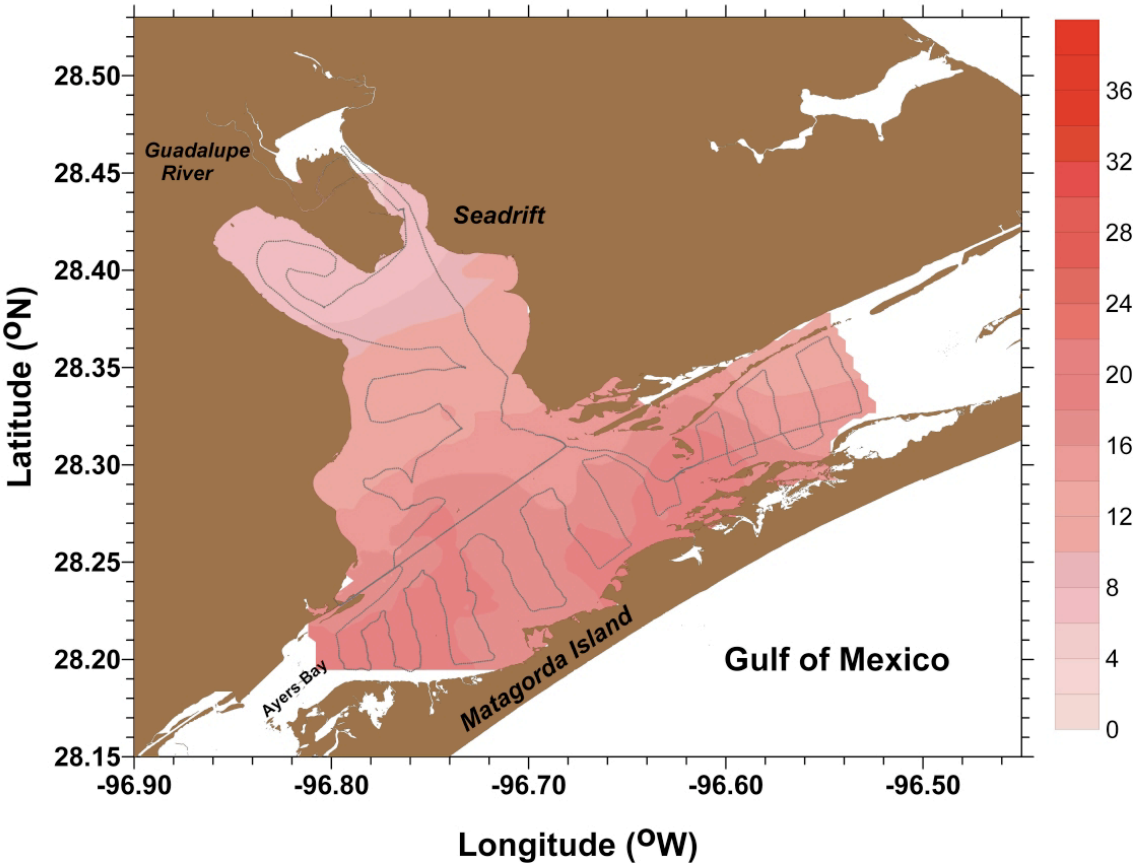
San Antonio Bay, August 05

Salinity (PSU)



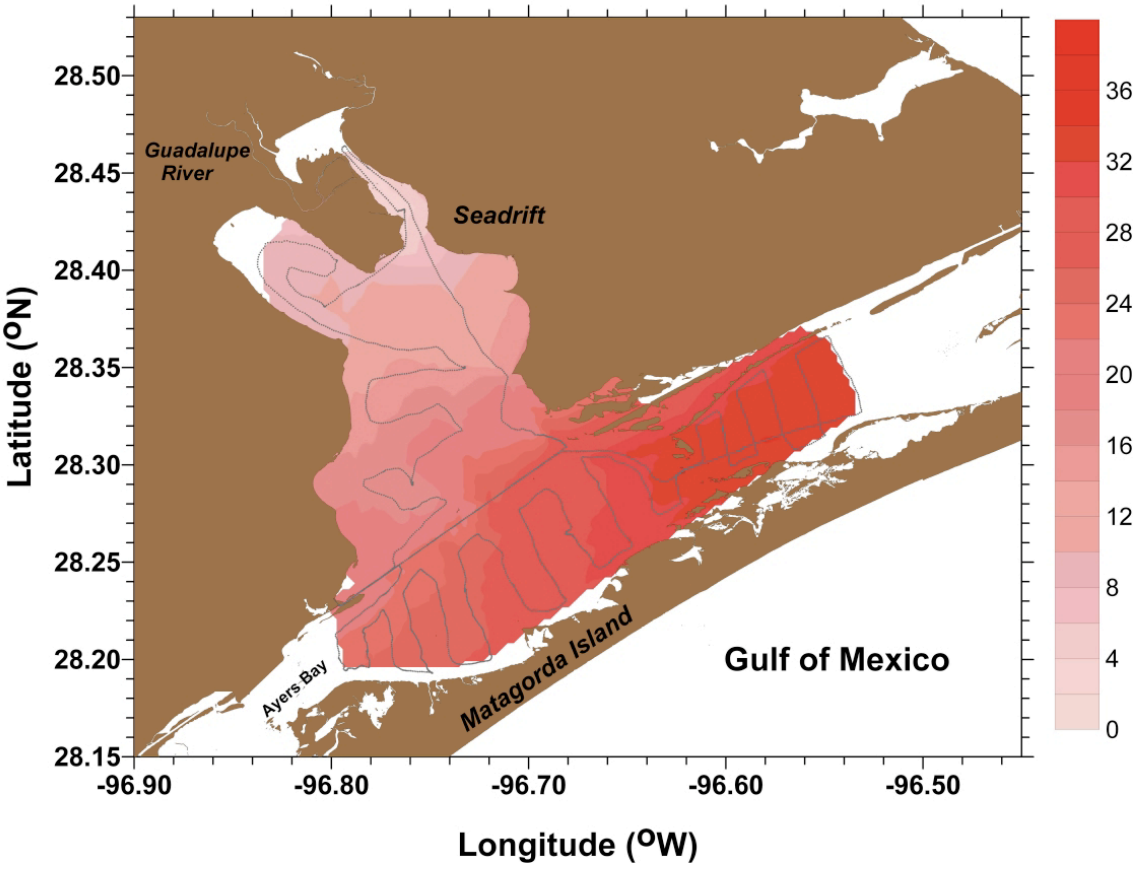
San Antonio Bay, September 05

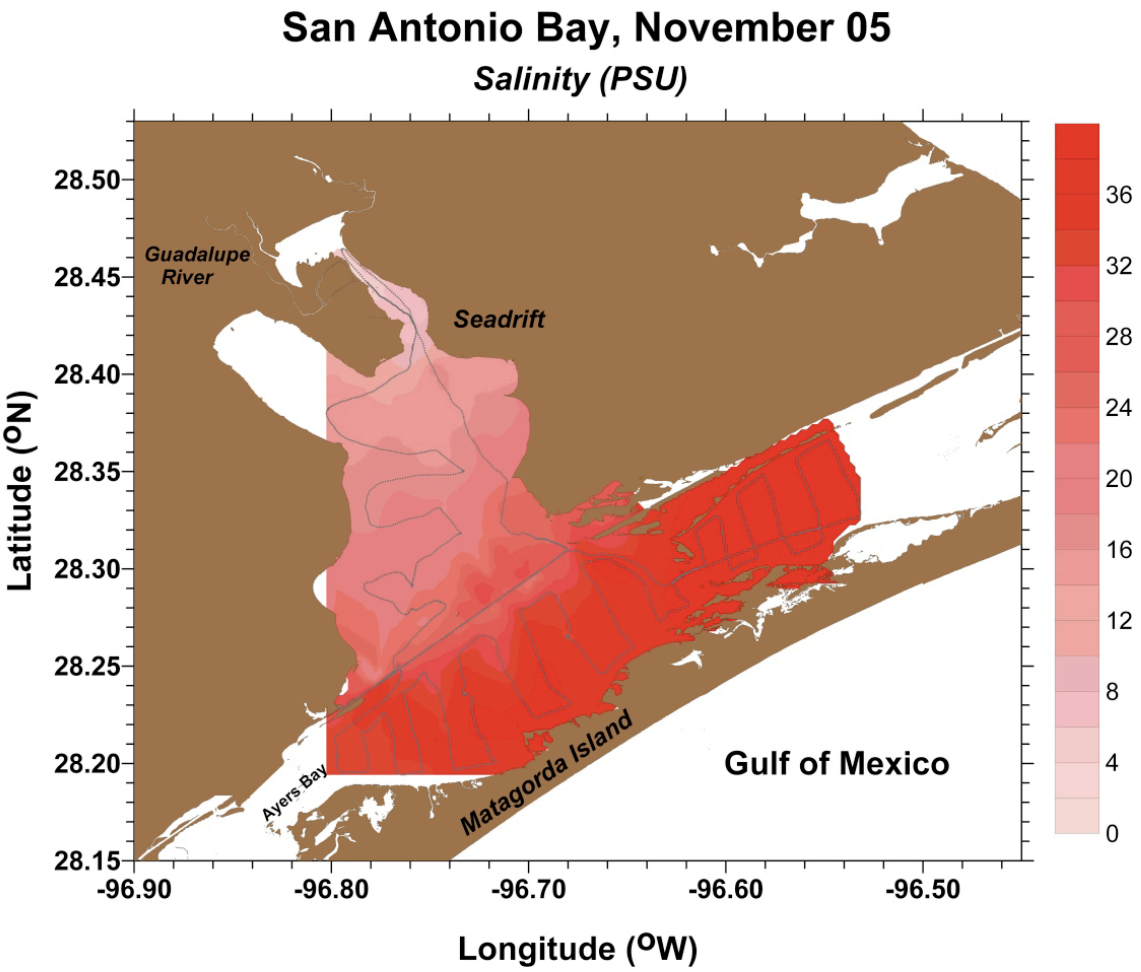
Salinity (PSU)

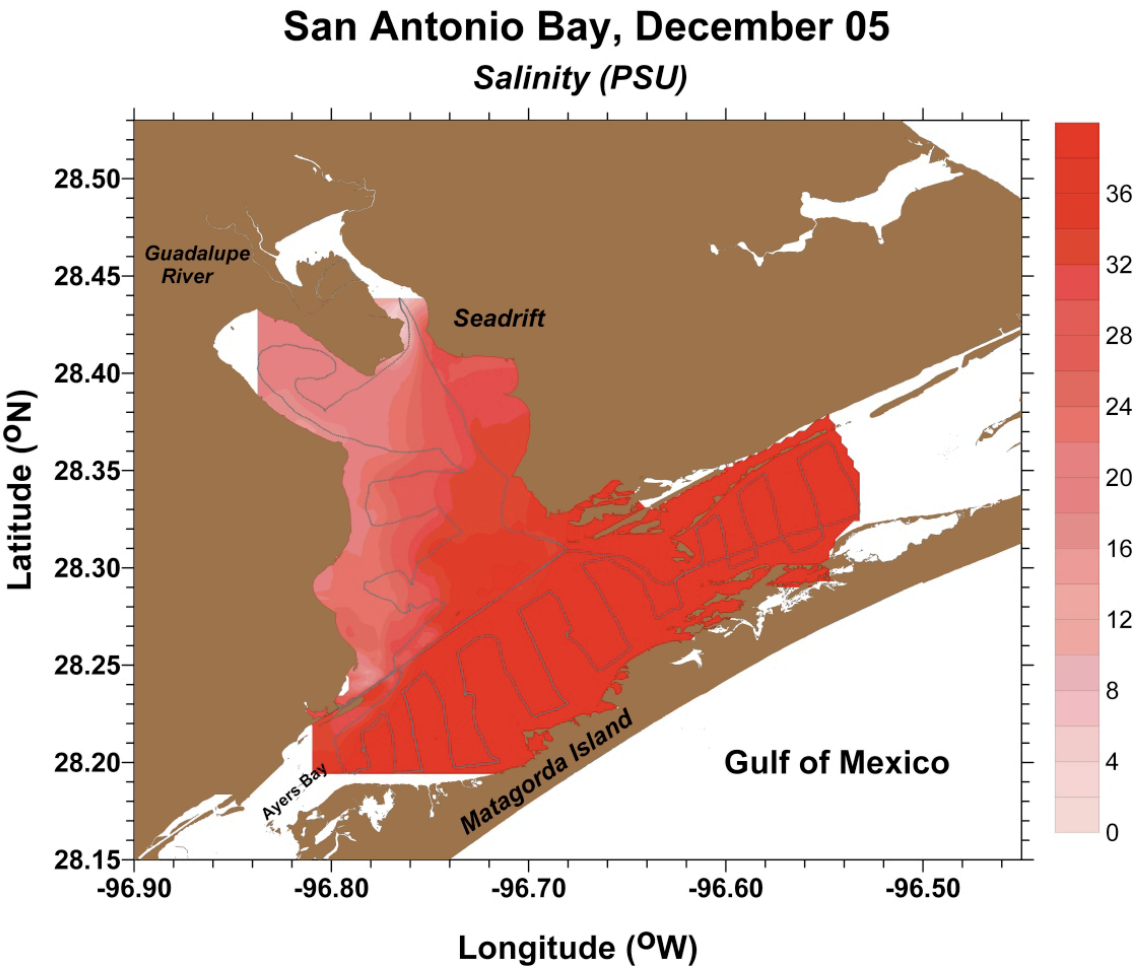


San Antonio Bay, October 05

Salinity (PSU)

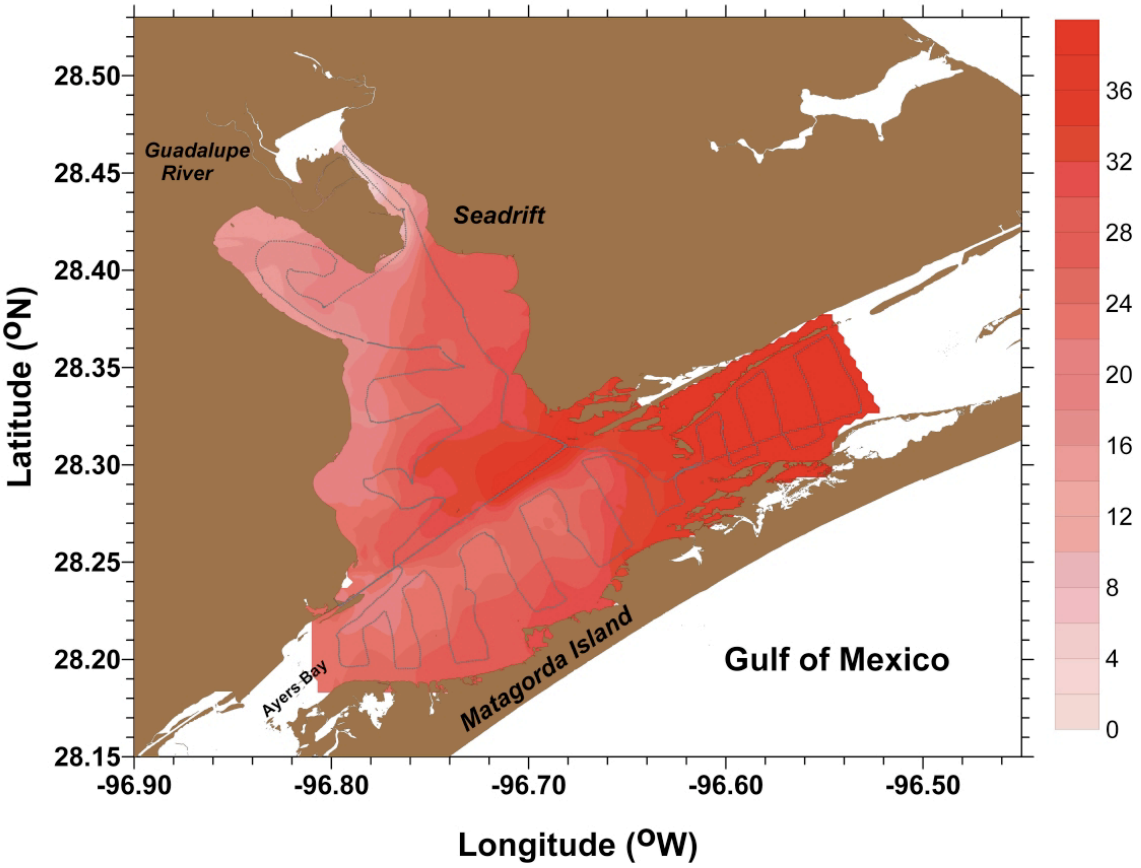



San Antonio Bay, November 05
Salinity (PSU)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
36
32
28
24
20
16
12
8
4
0


San Antonio Bay, December 05
Salinity (PSU)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
36
32
28
24
20
16
12
8
4
0

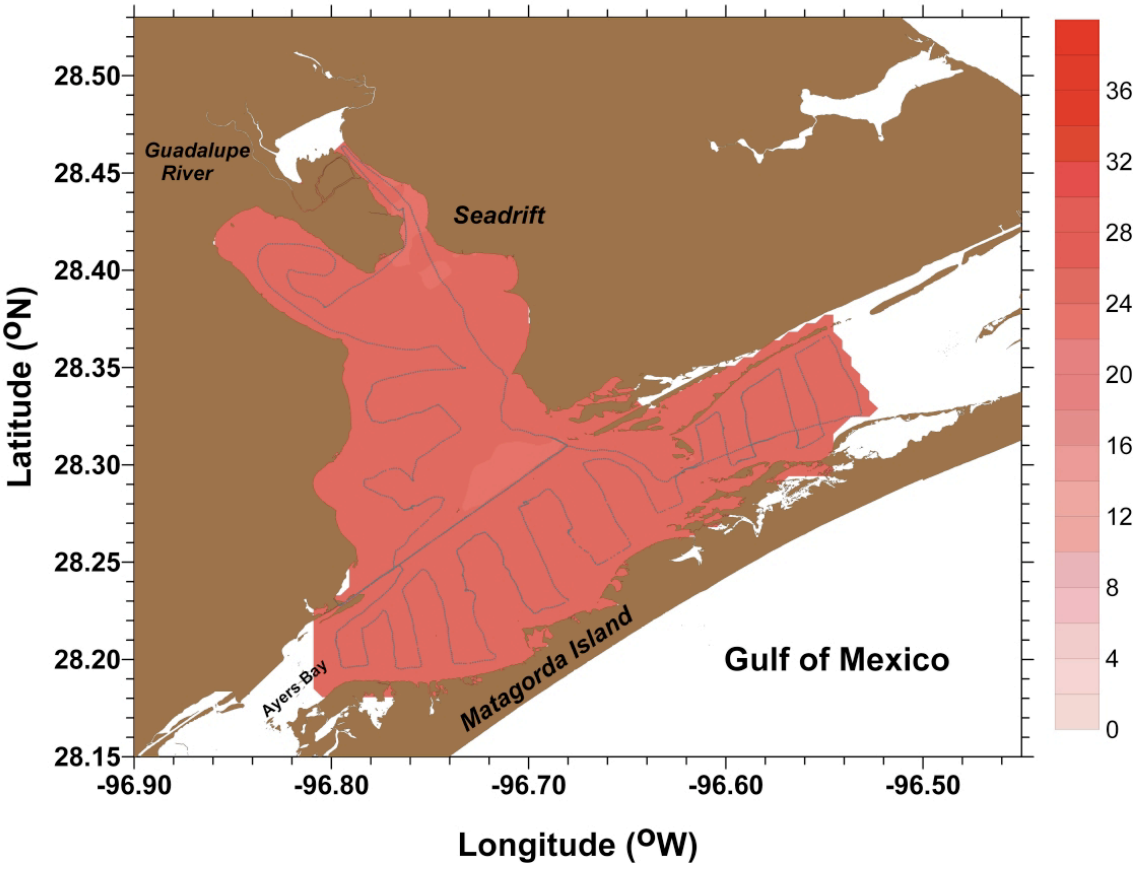
San Antonio Bay, February 06

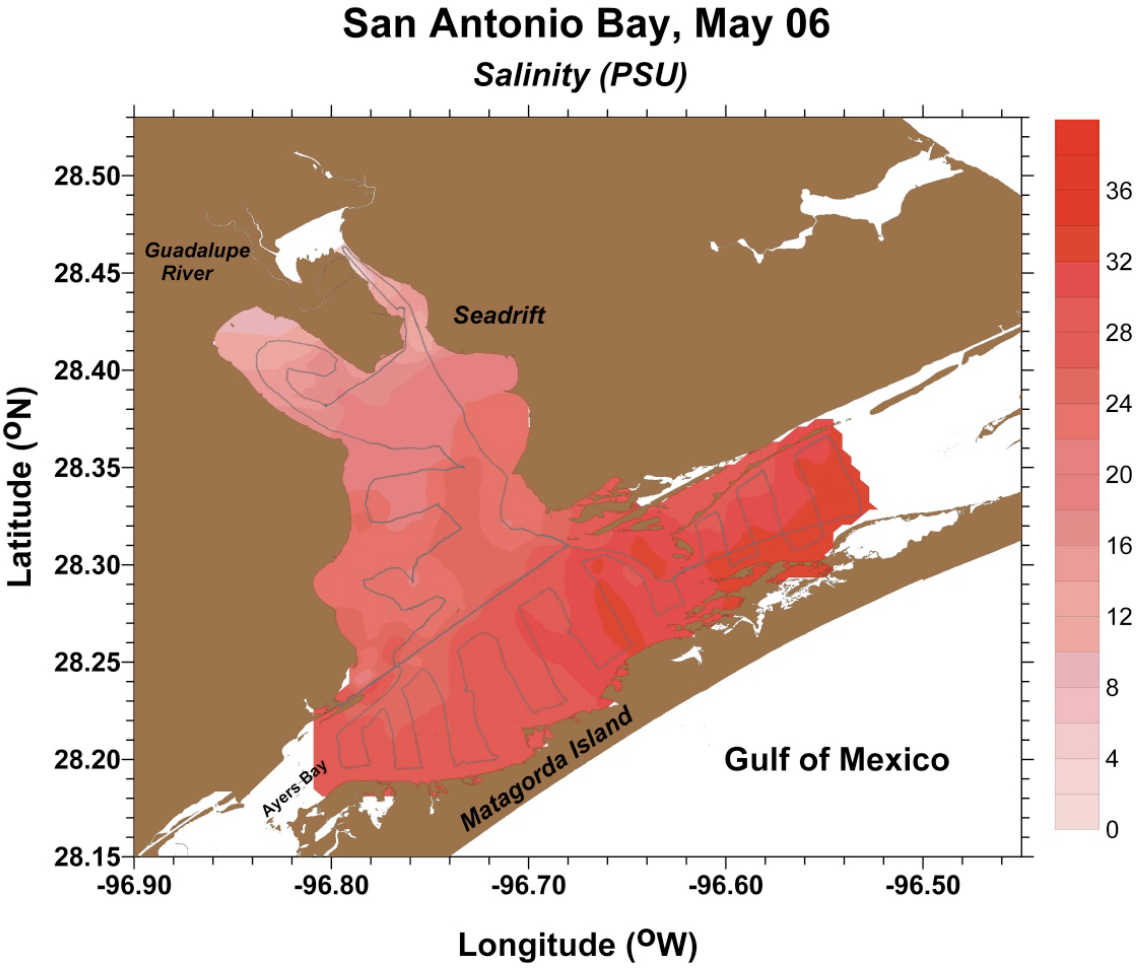
Salinity (PSU)

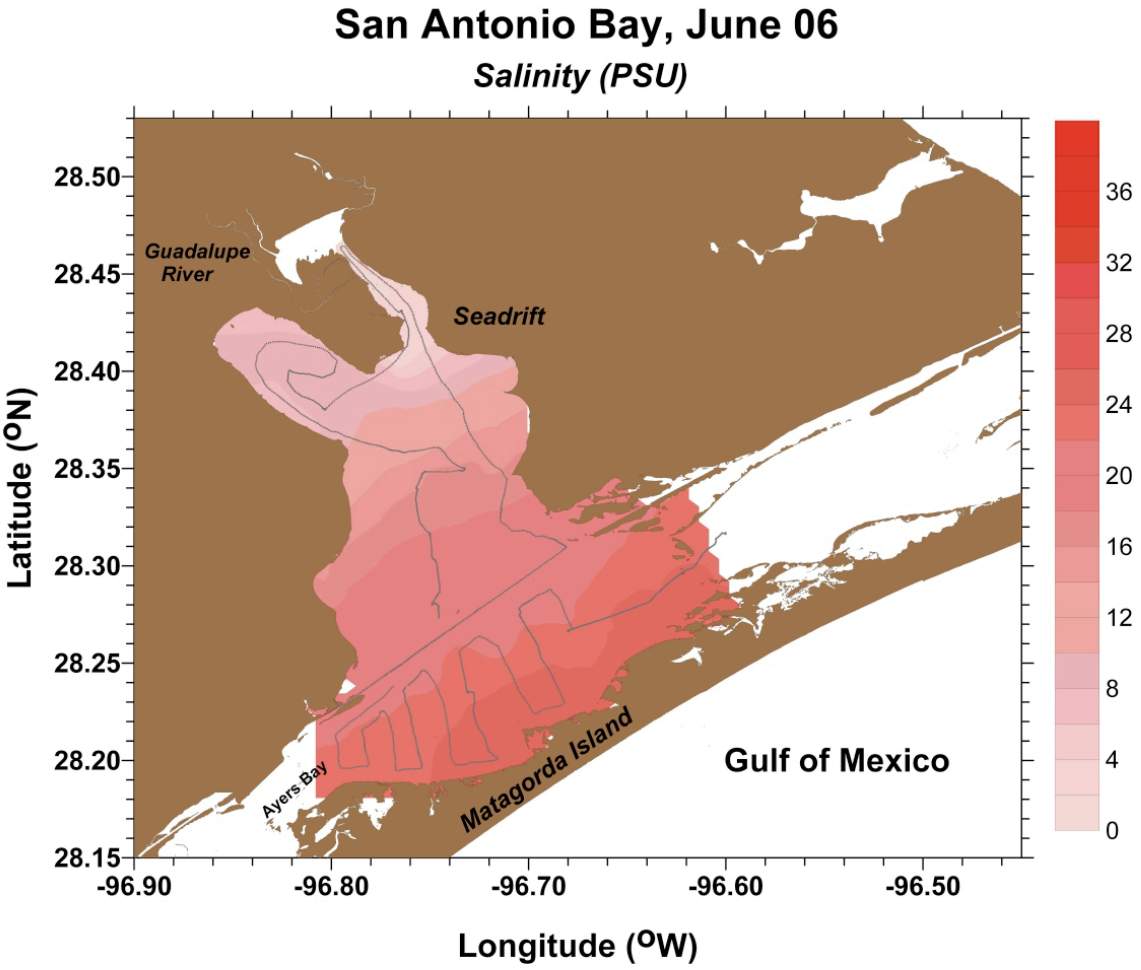


San Antonio Bay, April 06

Salinity (PSU)

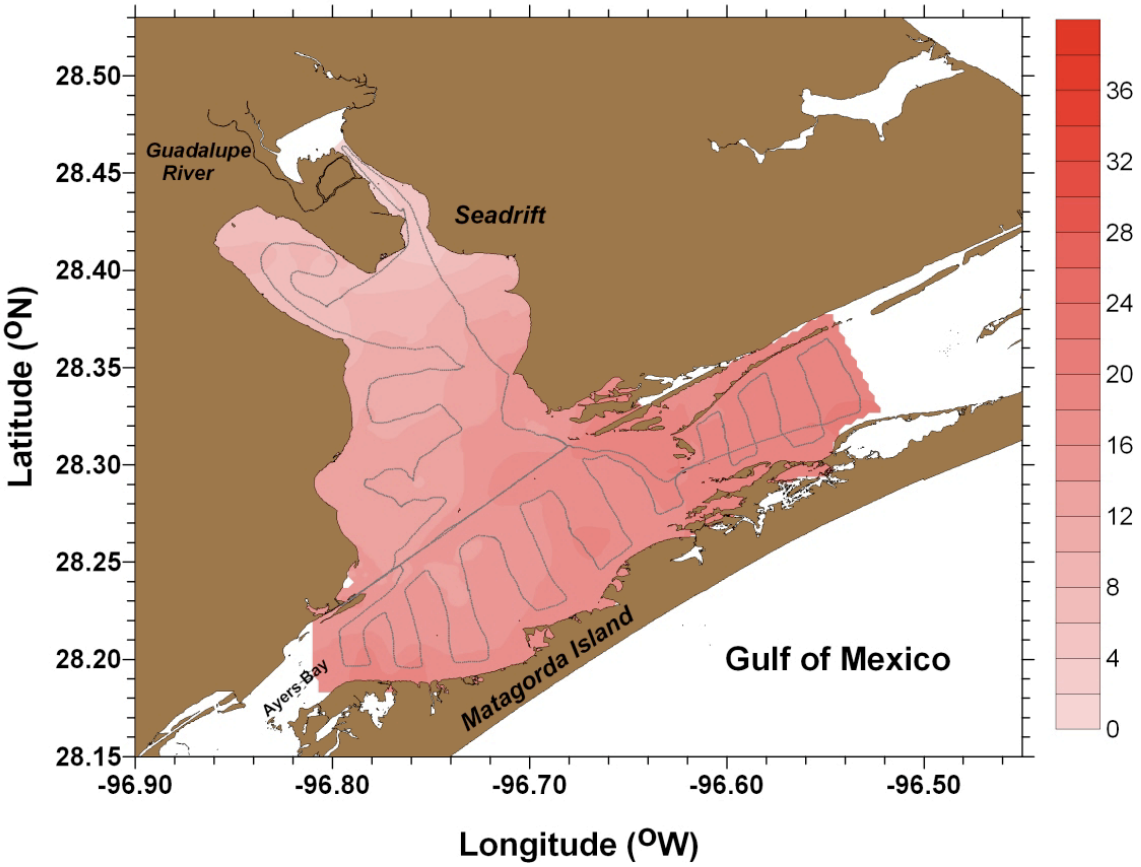



San Antonio Bay, May 06
Salinity (PSU)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
36
32
28
24
20
16
12
8
4
0


San Antonio Bay, June 06
Salinity (PSU)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
36
32
28
24
20
16
12
8
4
0

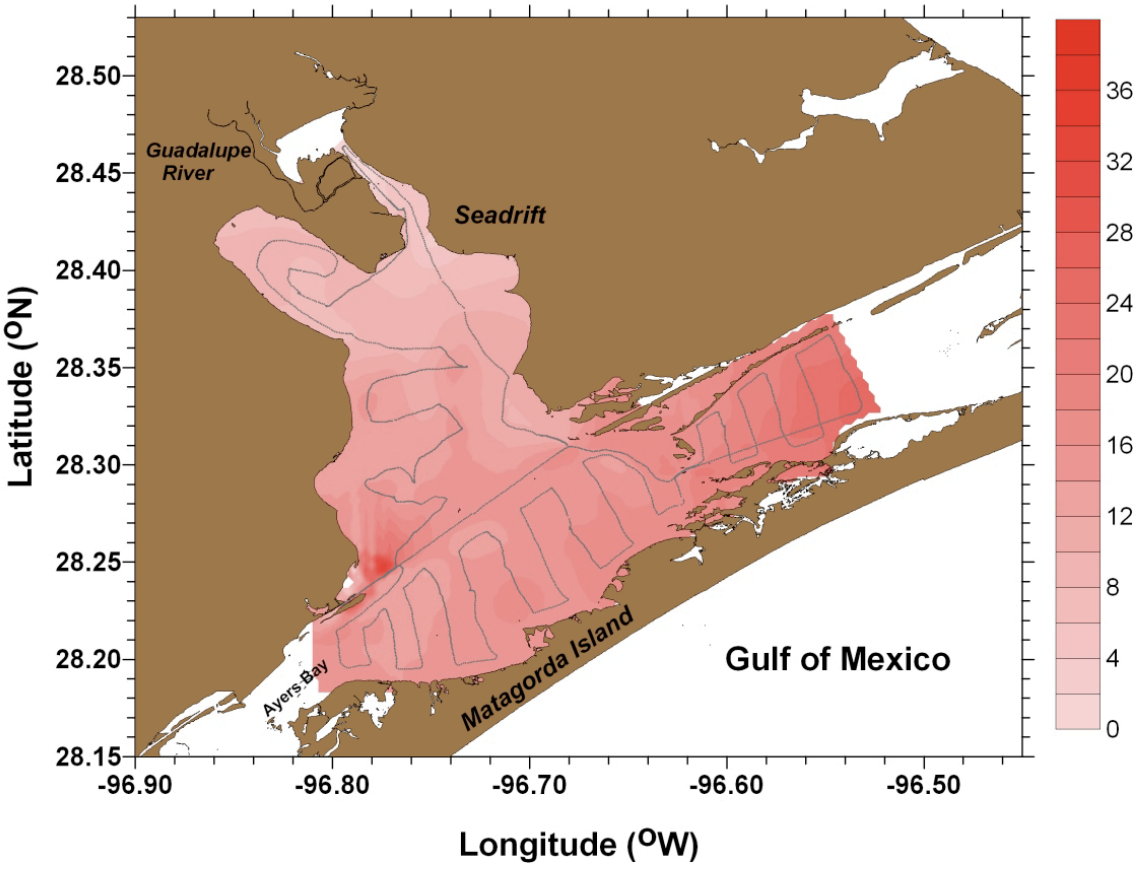
San Antonio Bay, July 06

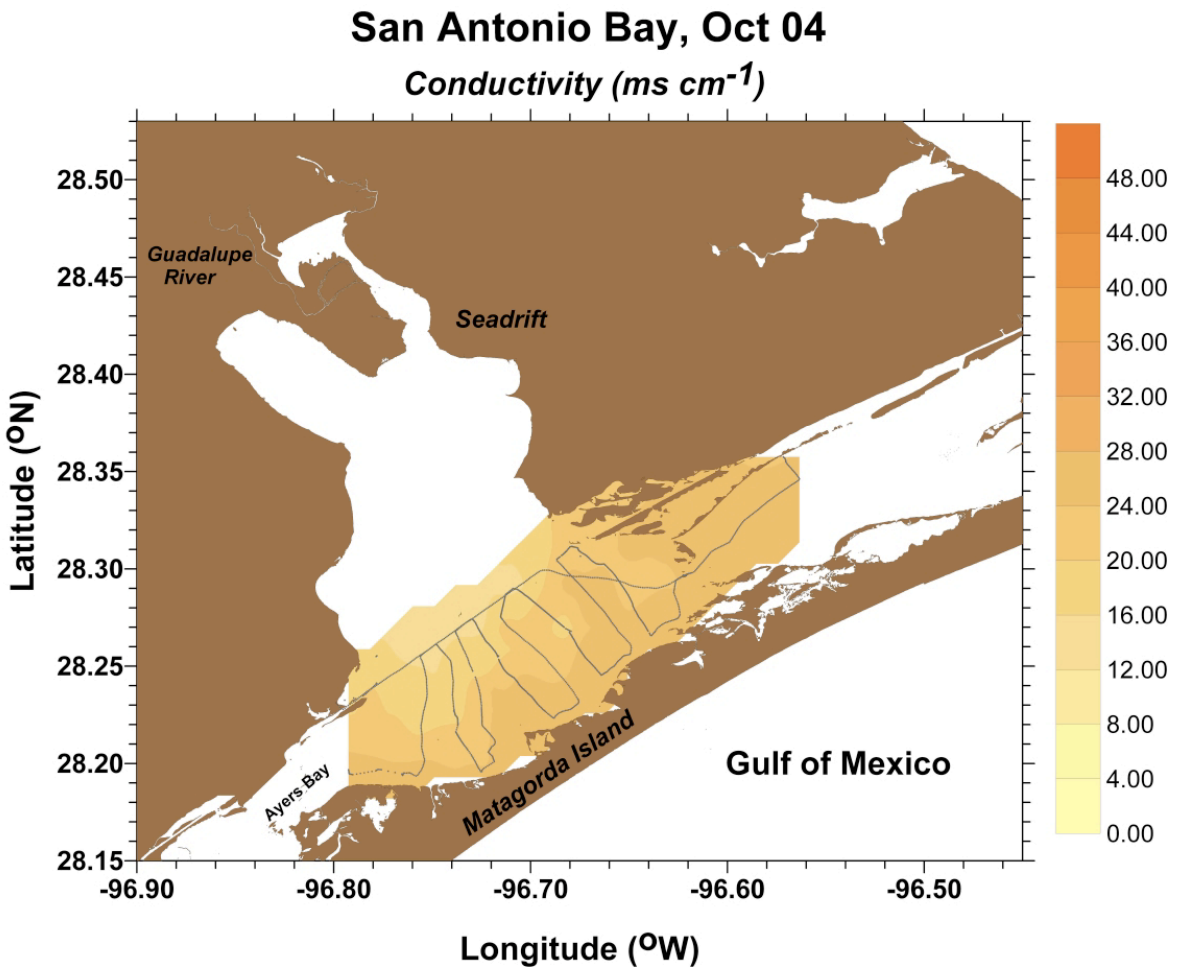
Salinity (PSU)

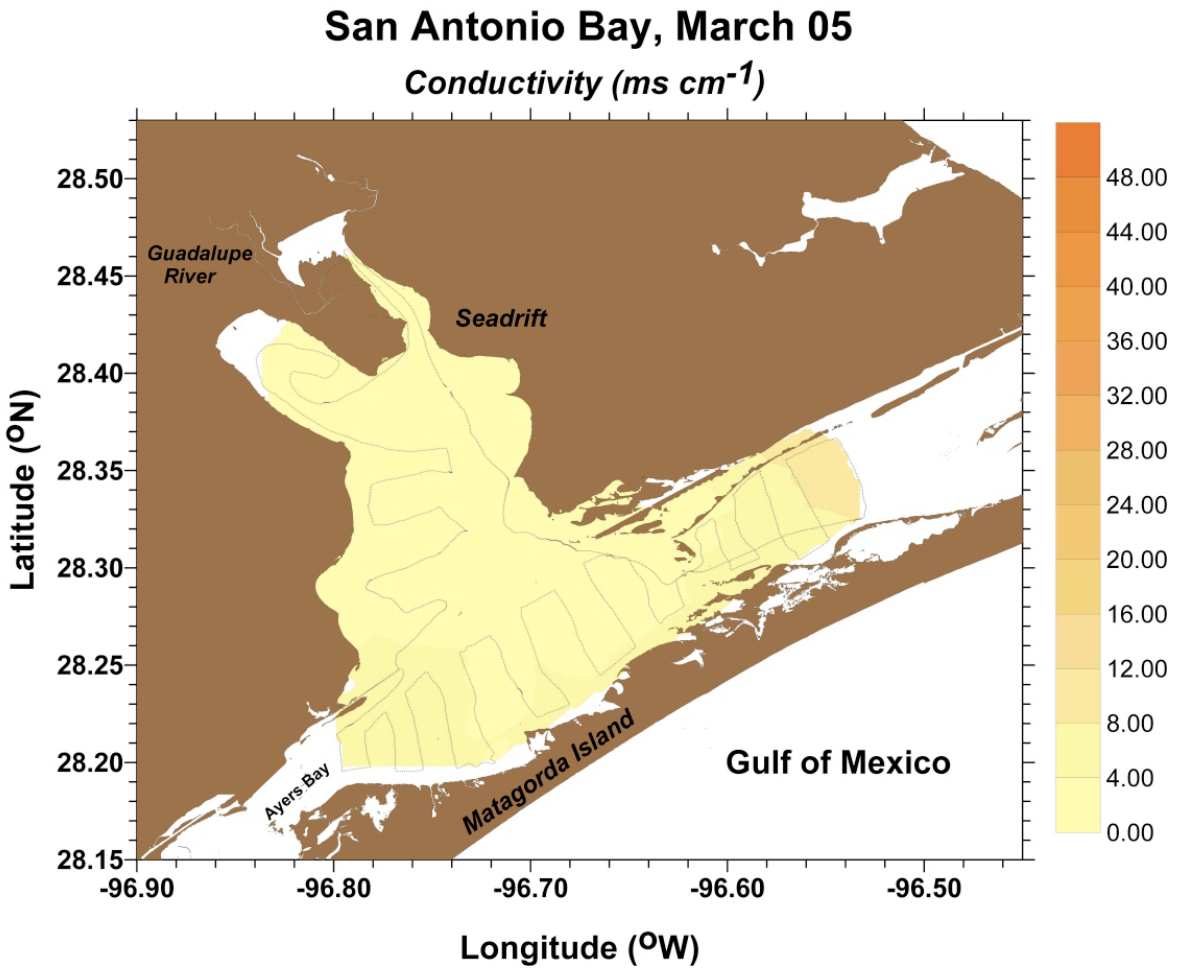


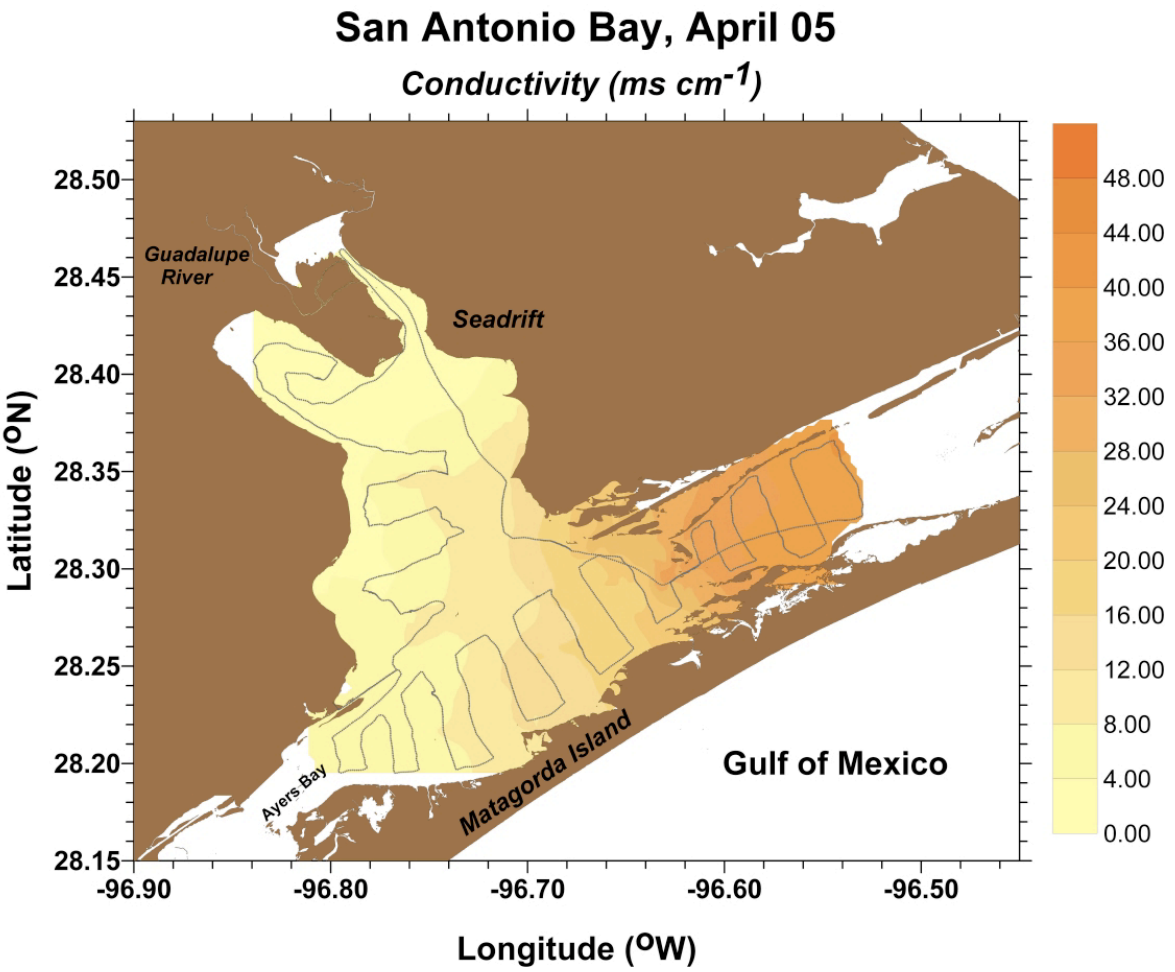
San Antonio Bay, August 06

Salinity (PSU)




San Antonio Bay, Oct 04
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, March 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, April 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
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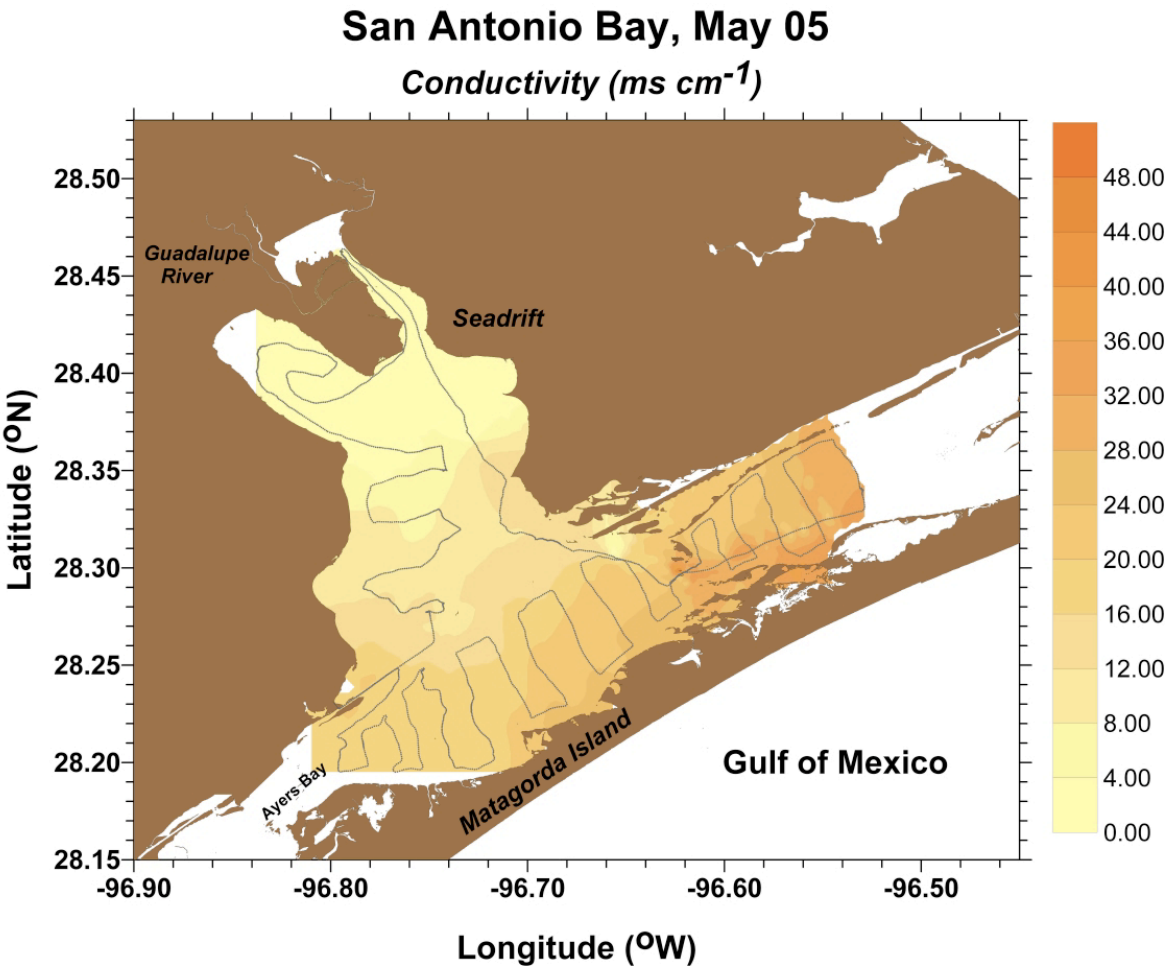
12.00
8.00
4.00
0.00


San Antonio Bay, May 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
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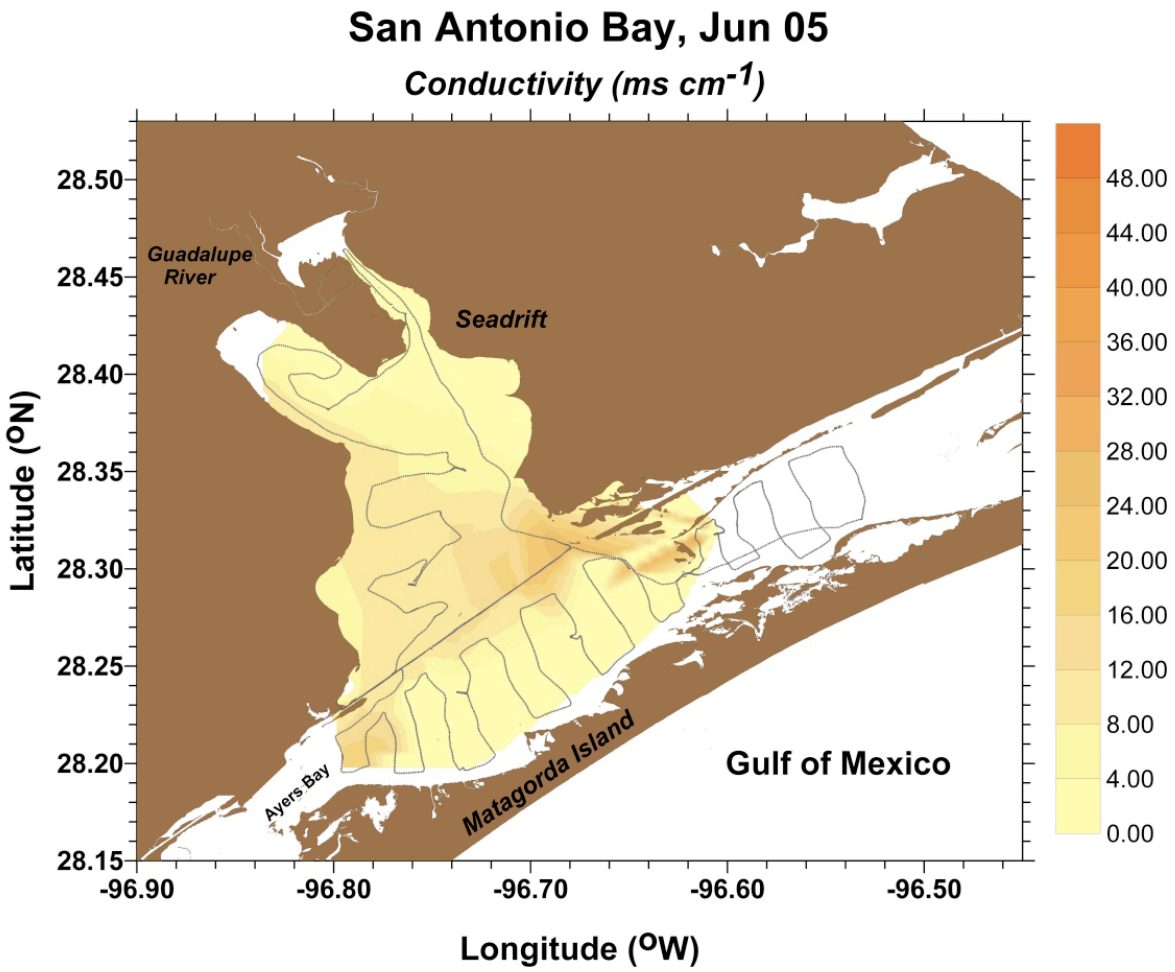
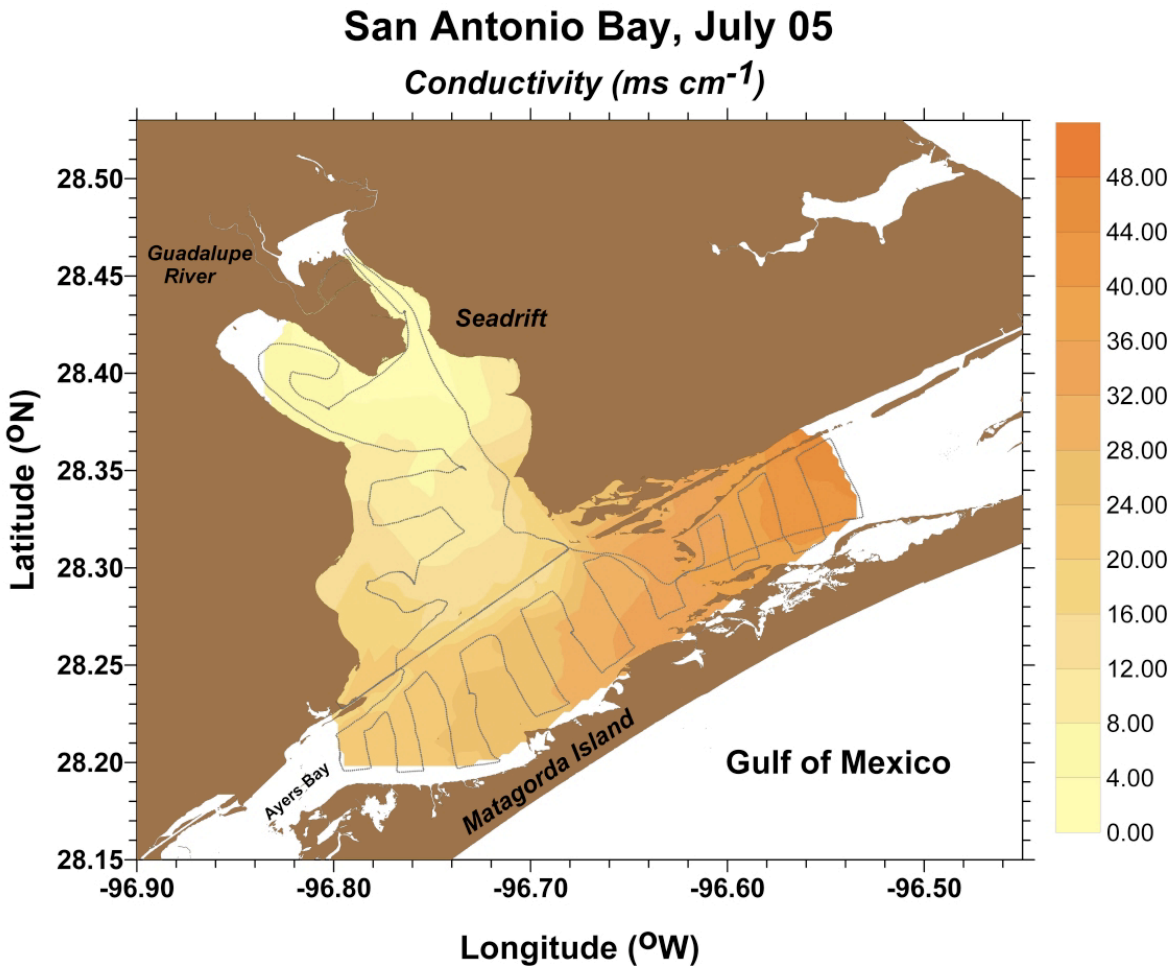
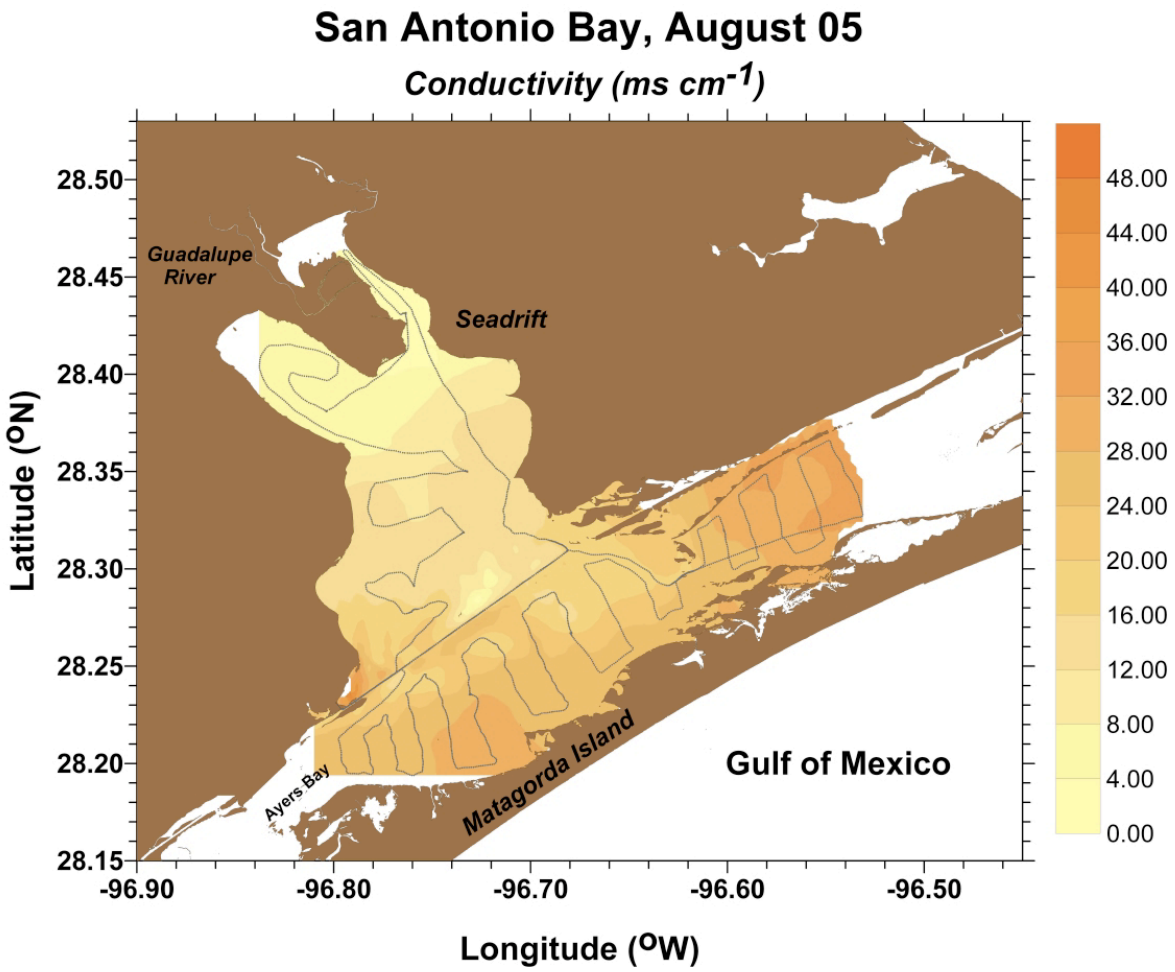
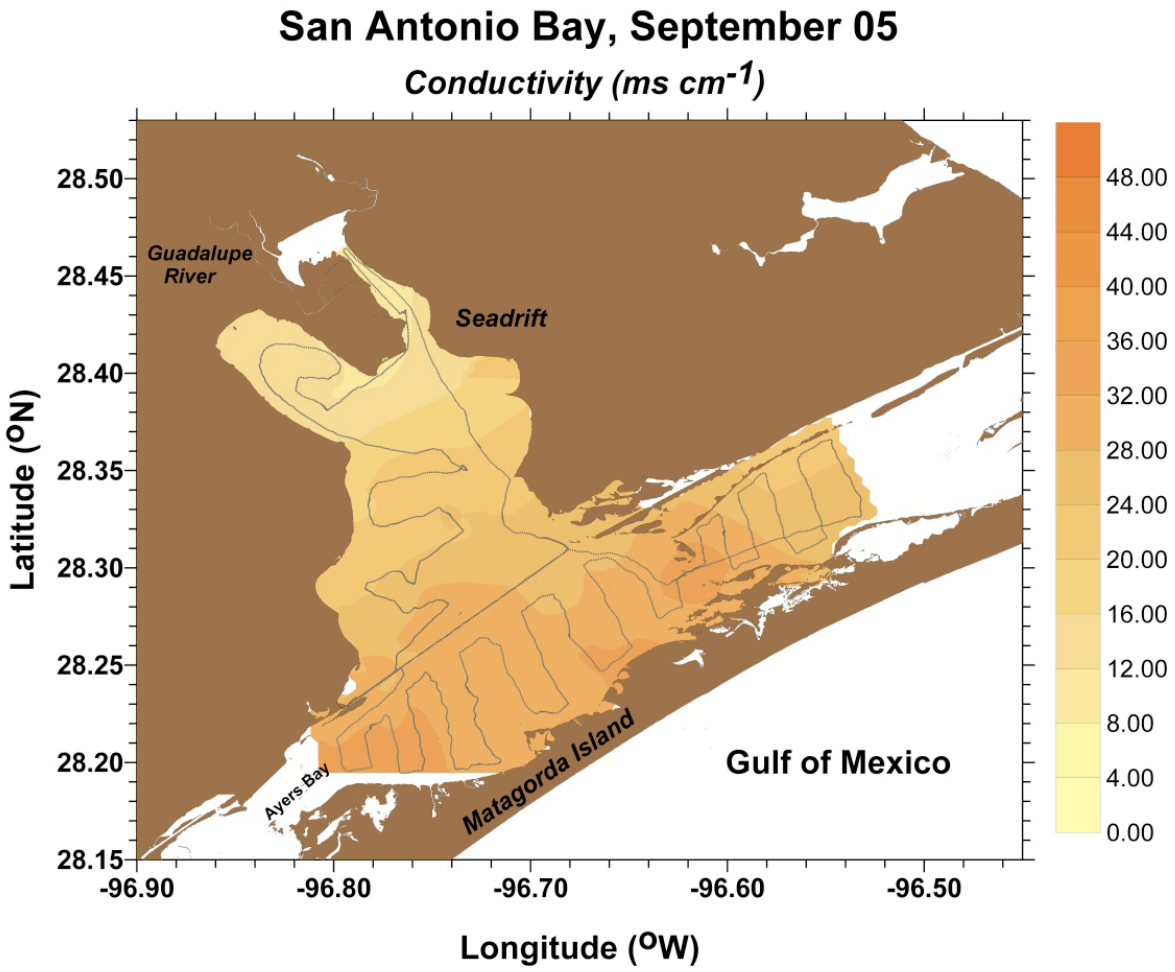
12.00
8.00
4.00
0.00


San Antonio Bay, Jun 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, July 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, August 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, September 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
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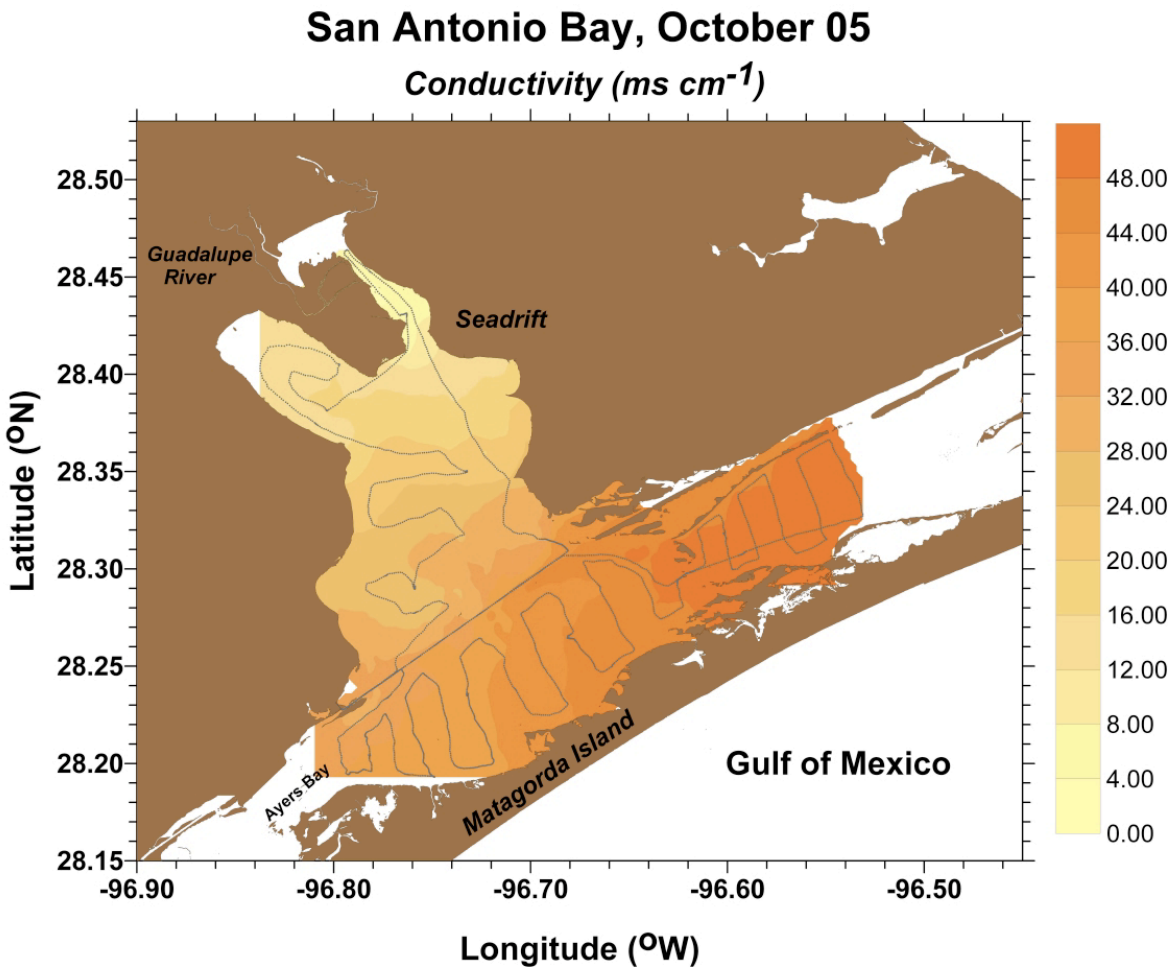
12.00
8.00
4.00
0.00


San Antonio Bay, October 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
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24.00
20.00
16.00
12.00
8.00
4.00
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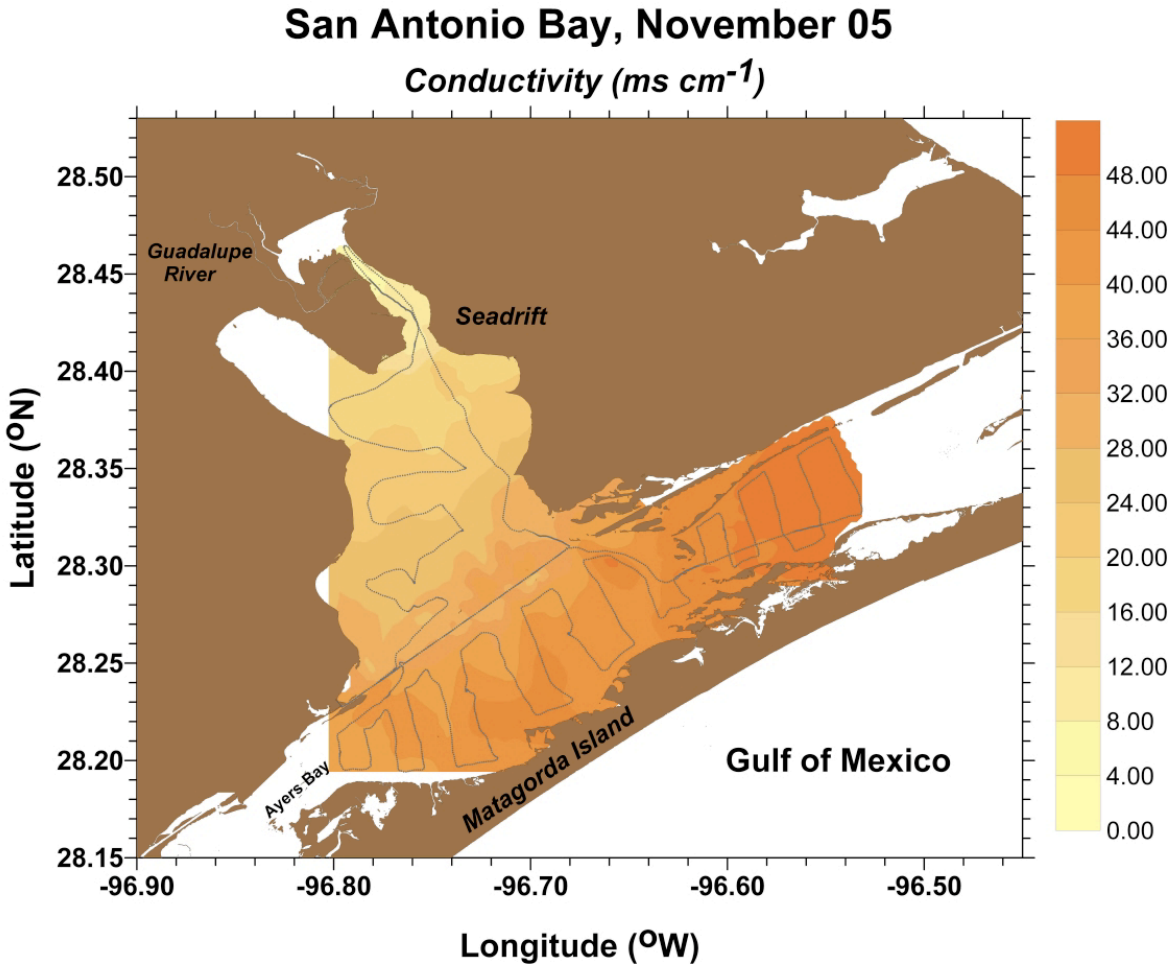
San Antonio Bay, November 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
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24.00
20.00
16.00
12.00
8.00
4.00
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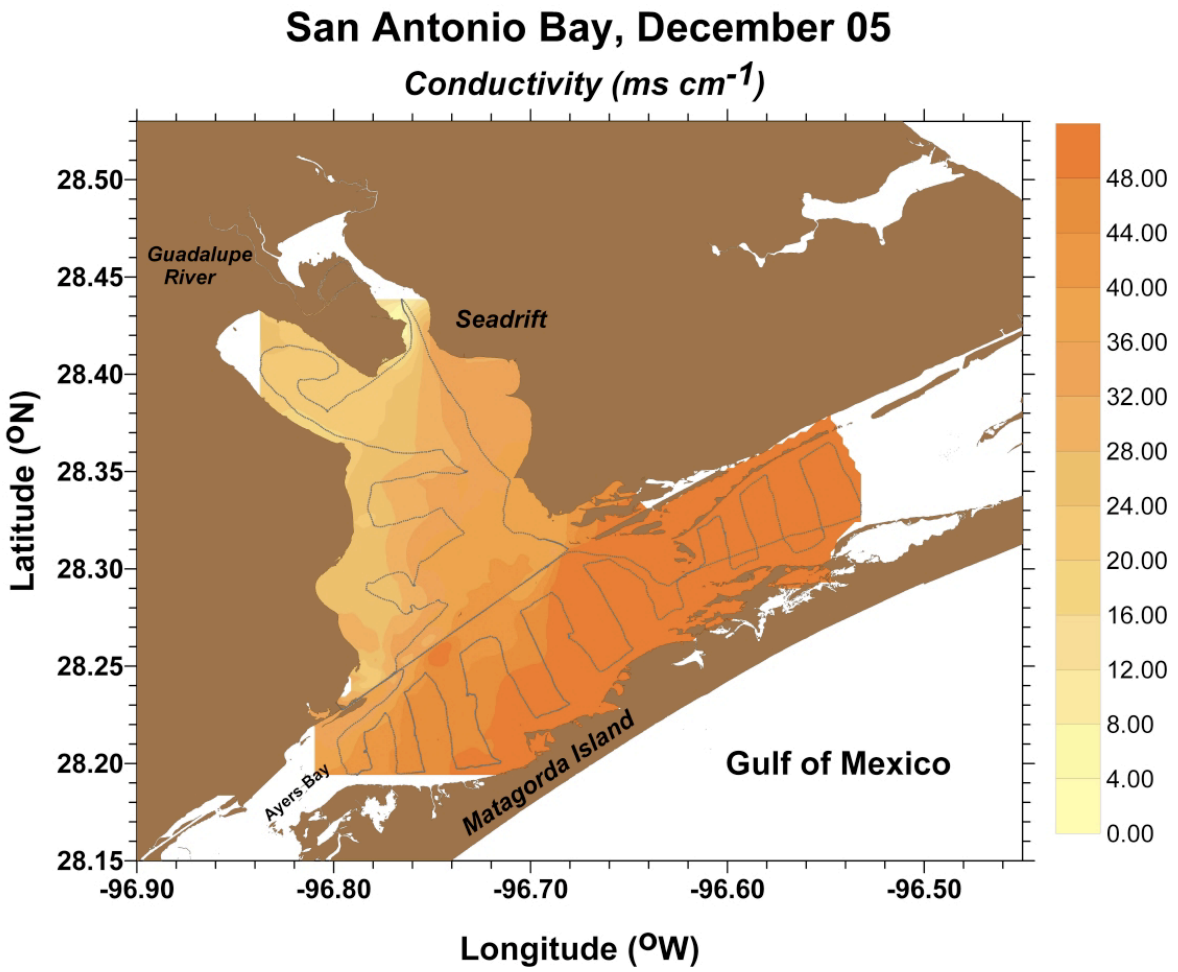
San Antonio Bay, December 05
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
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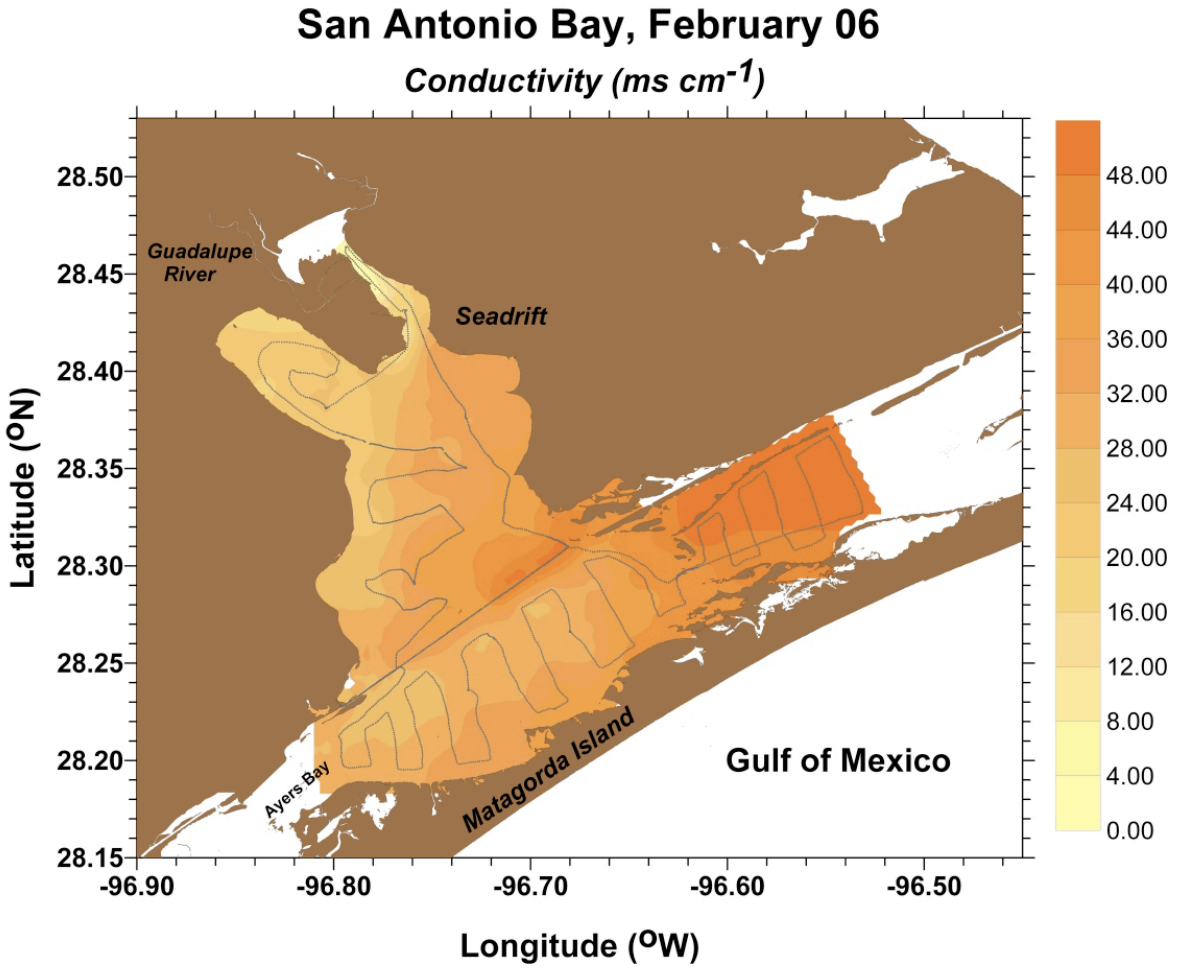
12.00
8.00
4.00
0.00


San Antonio Bay, February 06
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
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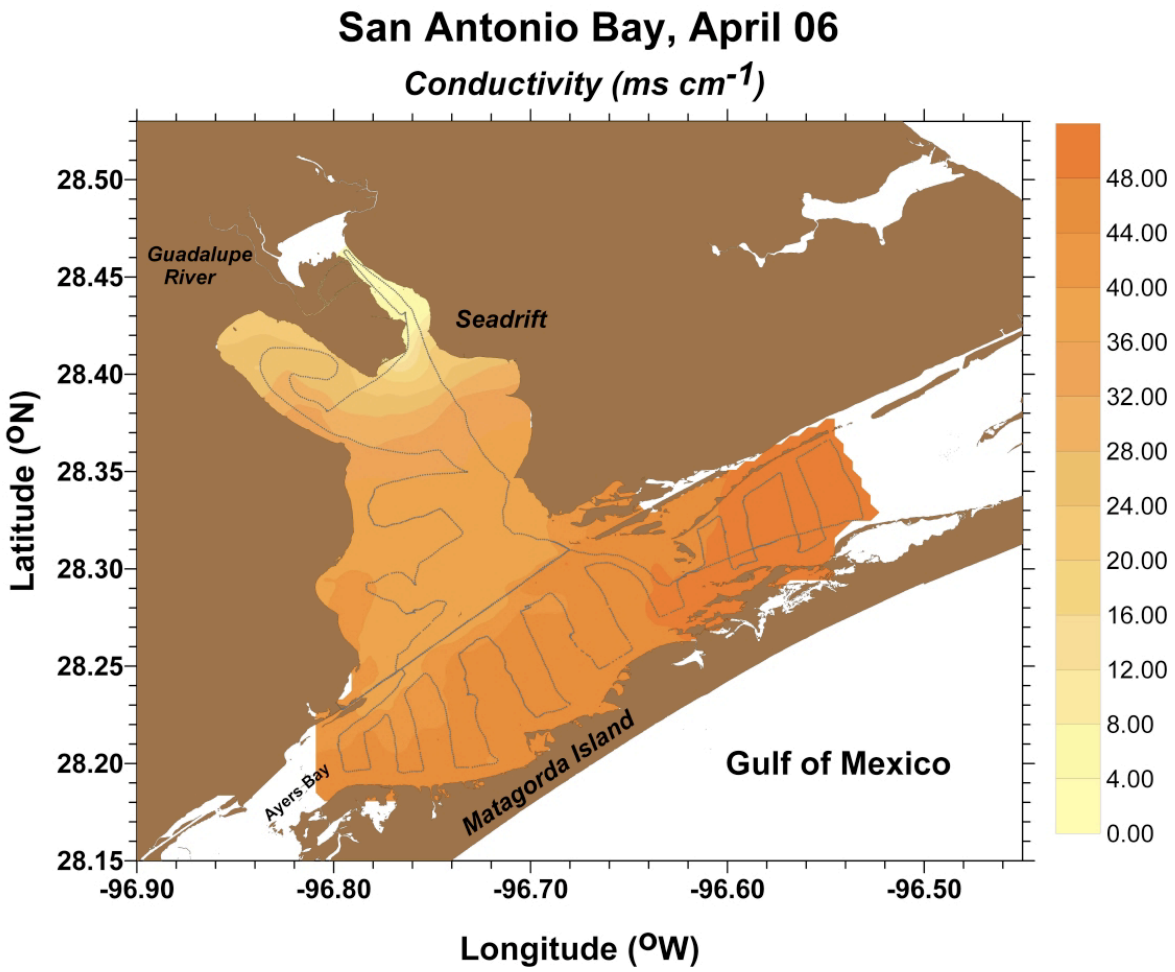
12.00
8.00
4.00
0.00


San Antonio Bay, April 06
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
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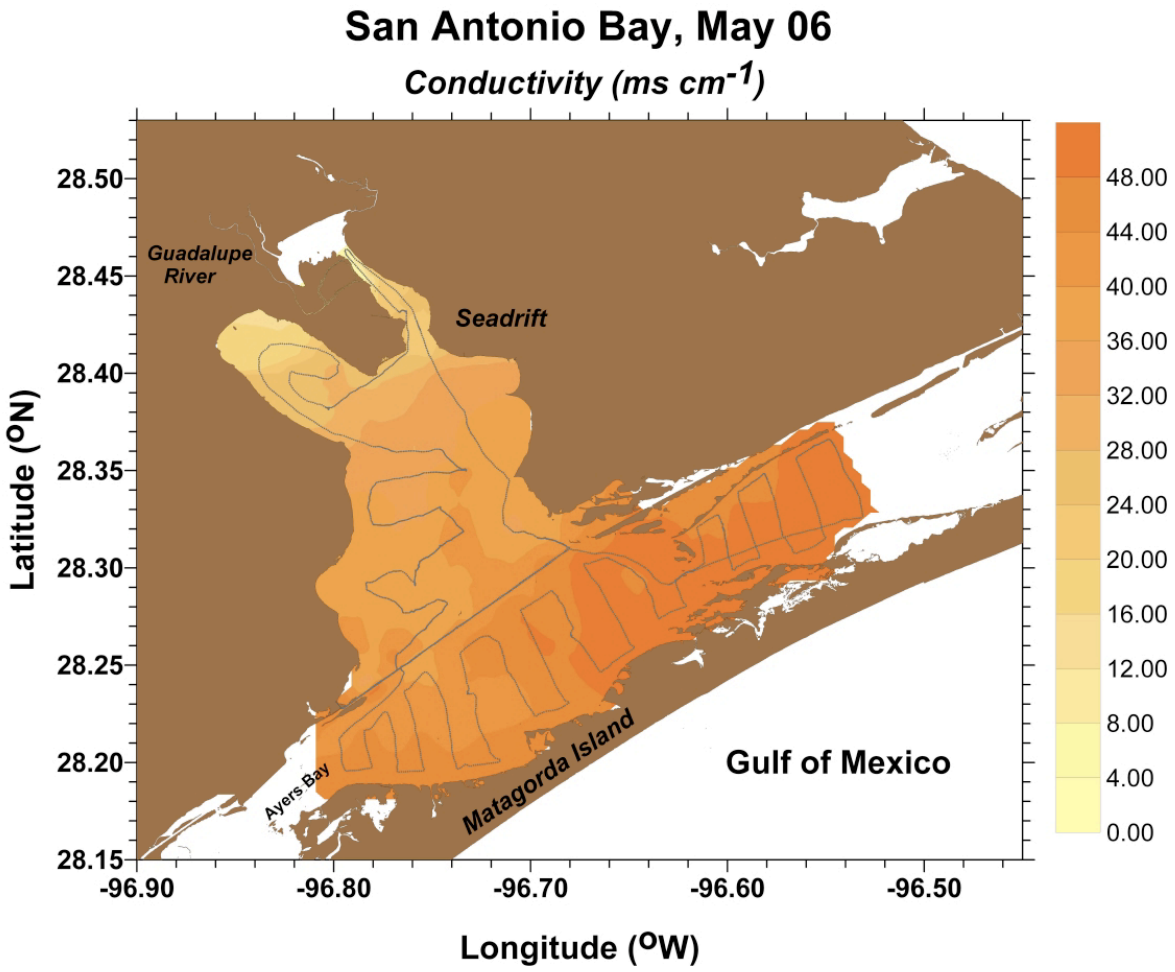
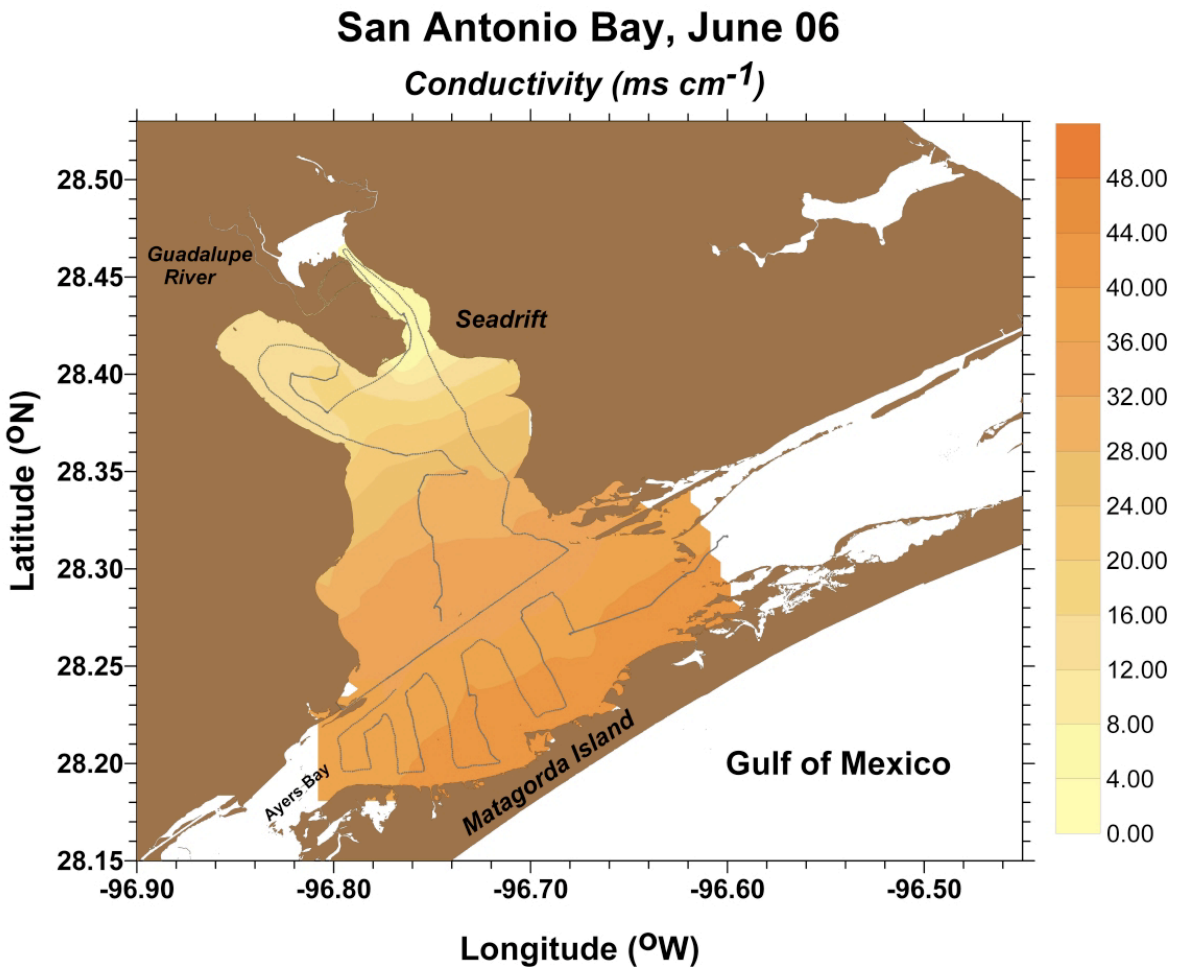
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, May 06
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, June 06
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
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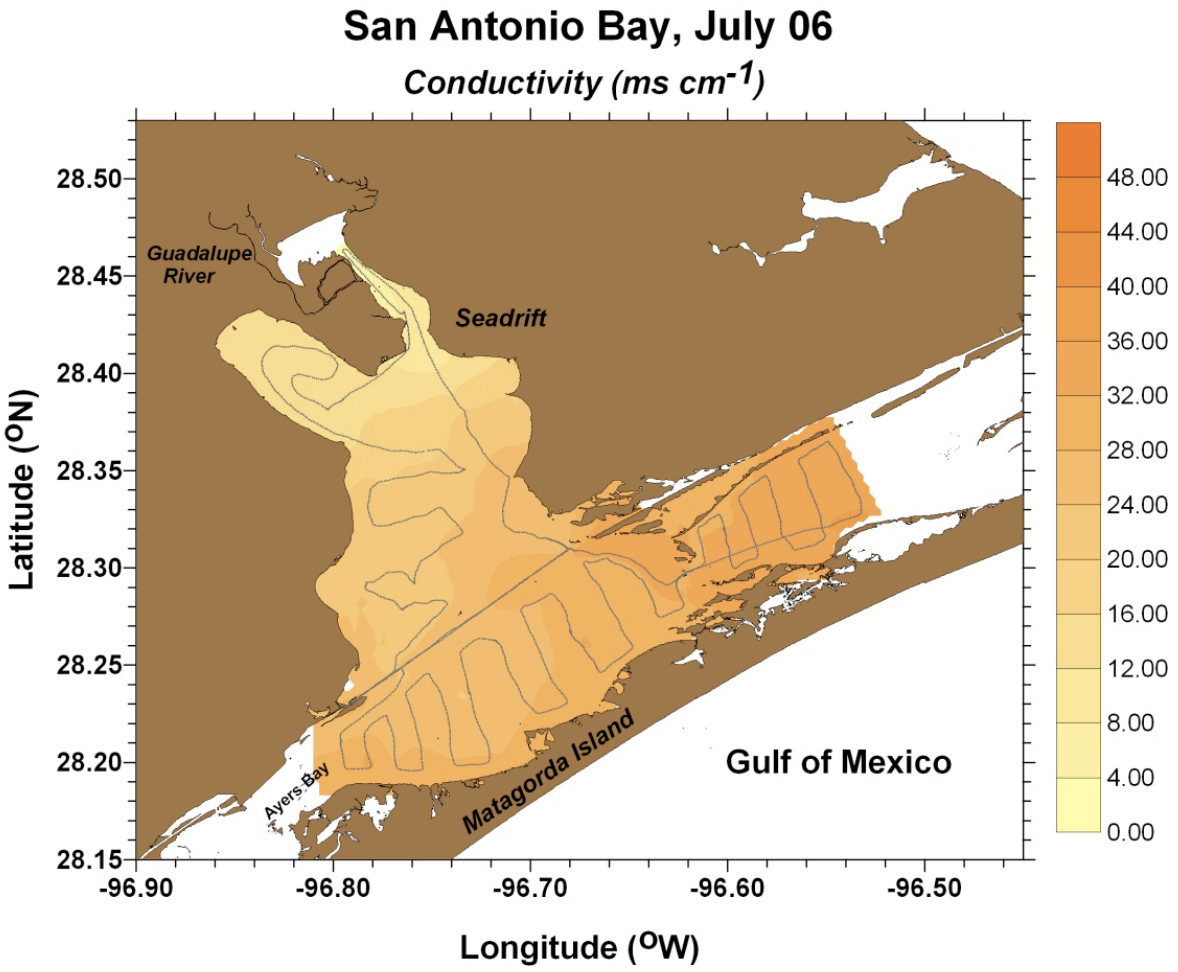
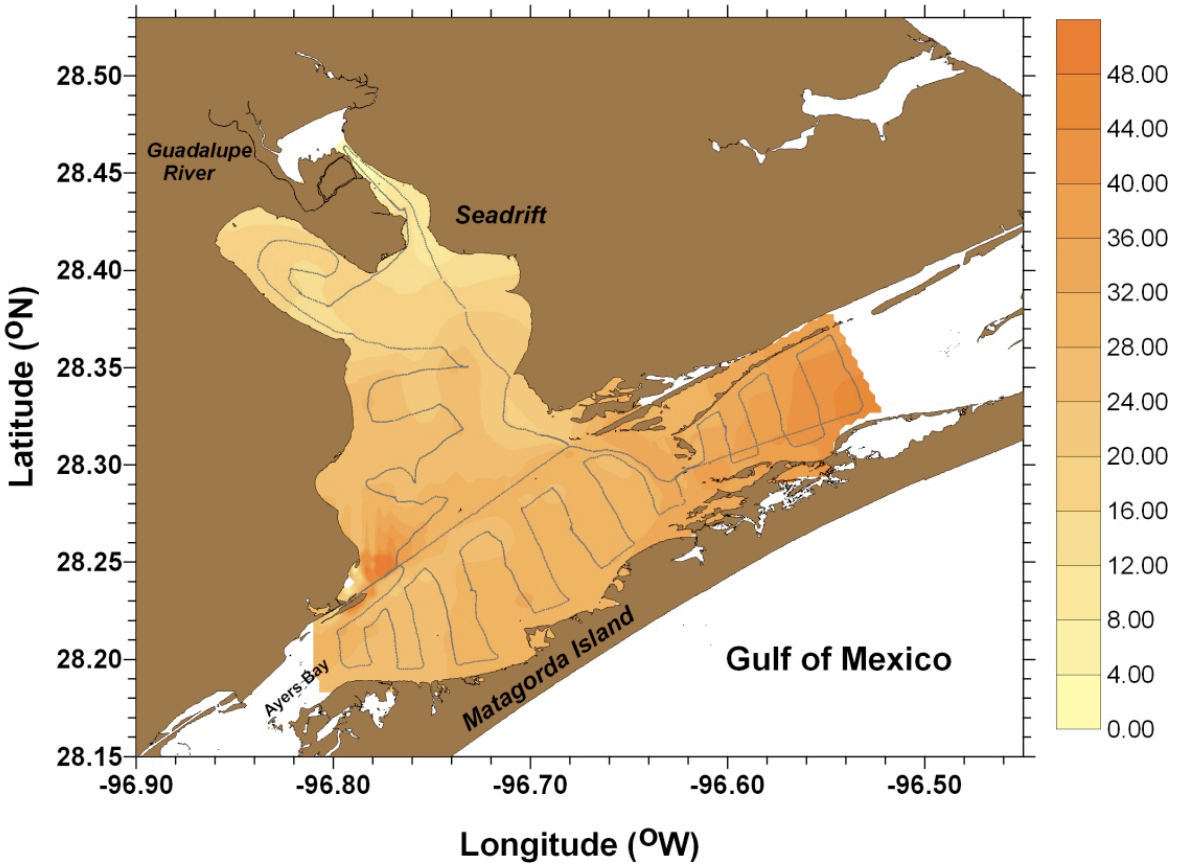
16.00
12.00
8.00
4.00
0.00


San Antonio Bay, July 06
Conductivity (ms cm-1)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
48.00
44.00
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00

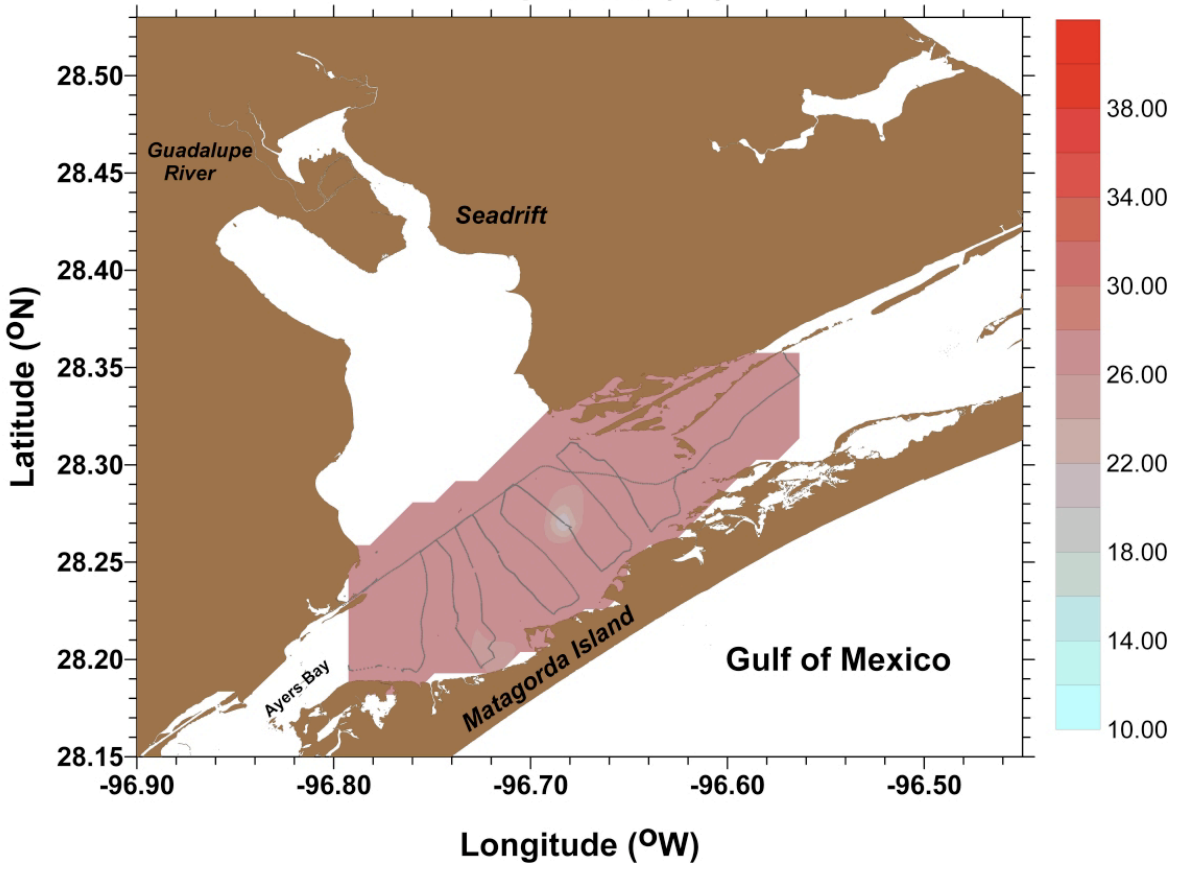
San Antonio Bay, August 06

Conductivity (ms cm^{-1})



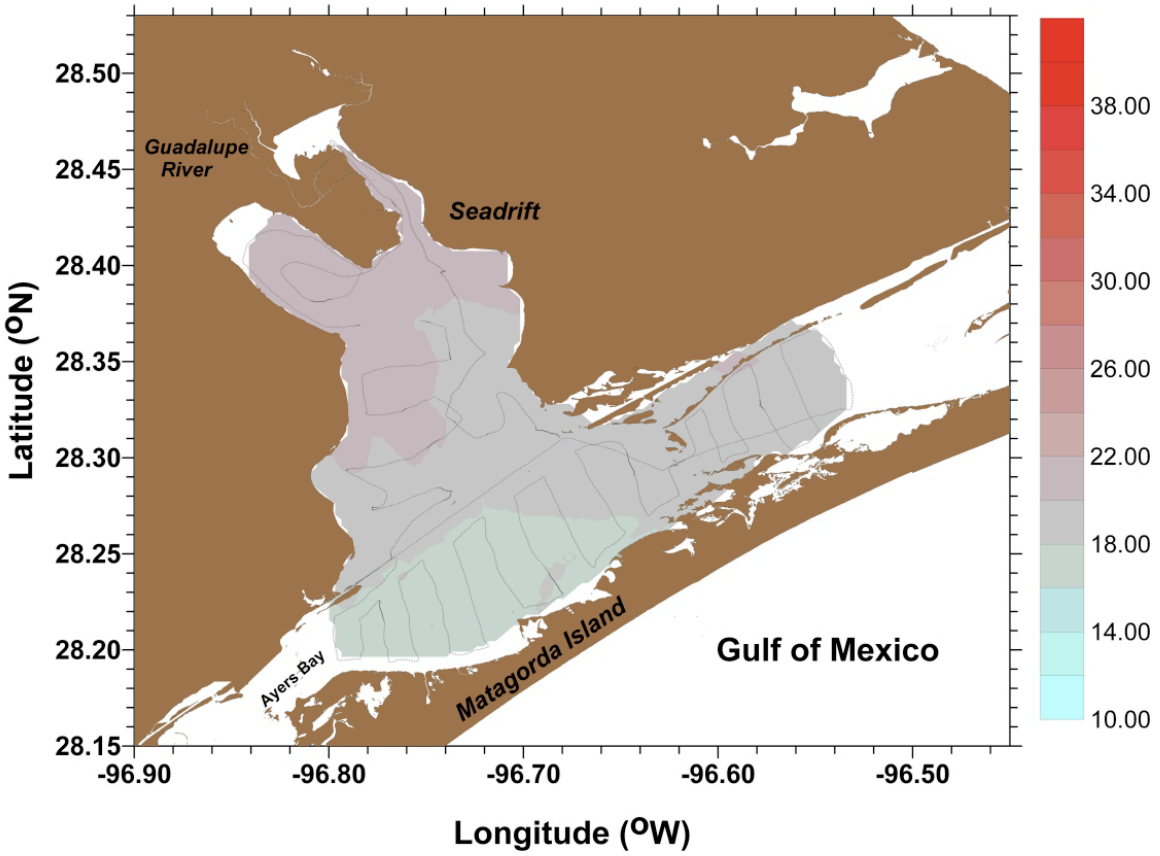
San Antonio Bay, Oct 04

Temperature (°C)



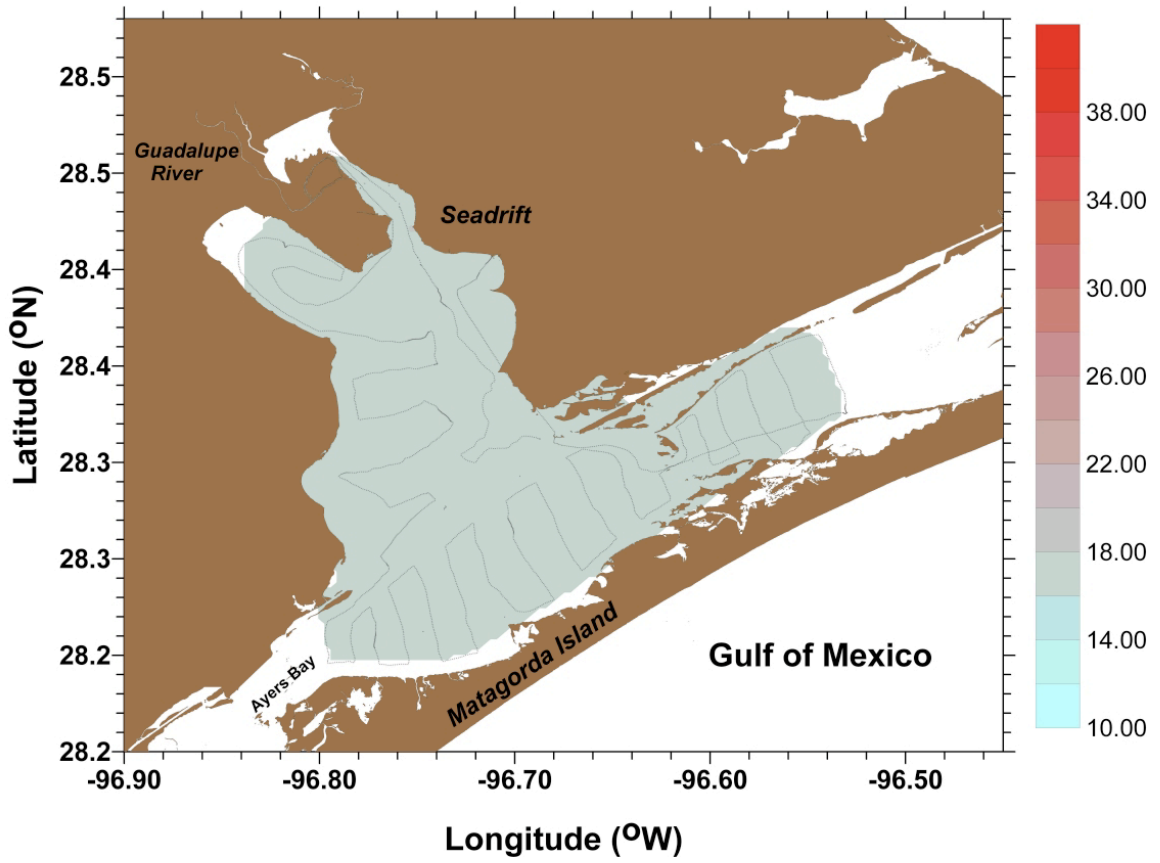
San Antonio Bay, January 05

Temperature (°C)



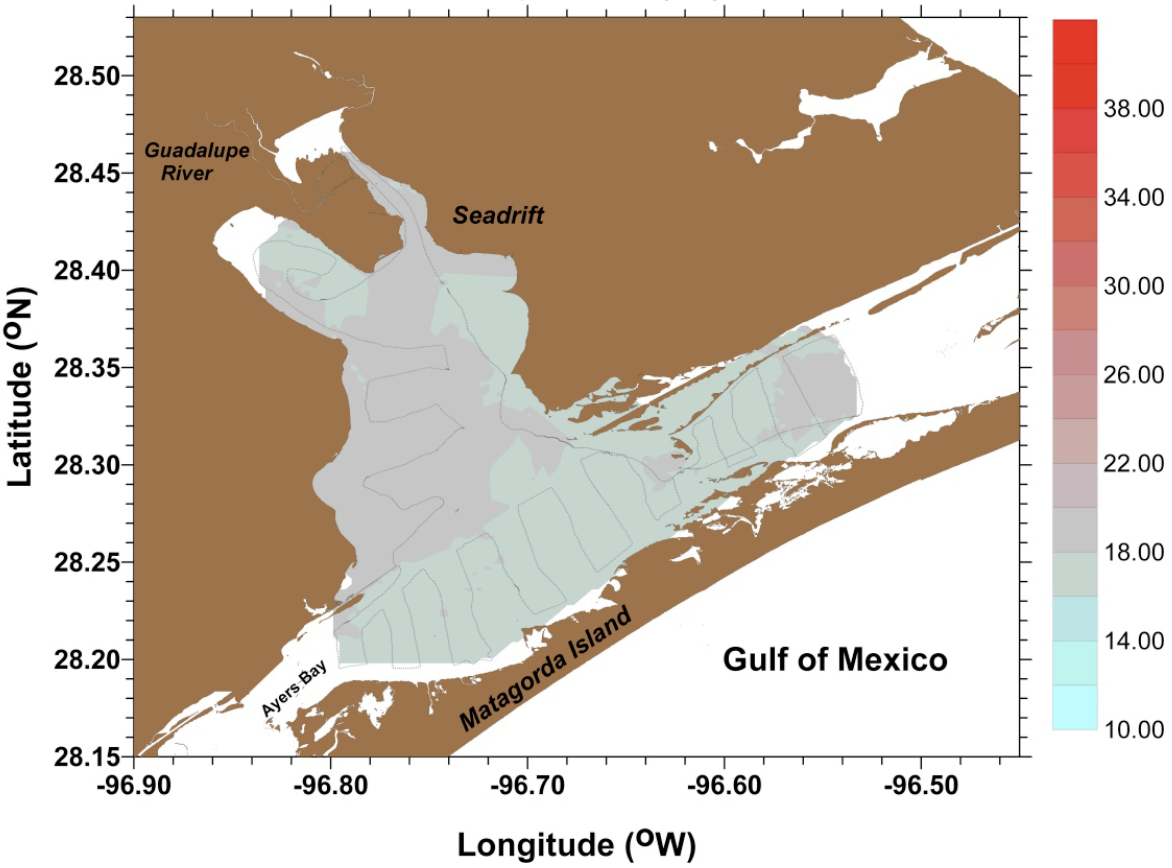
San Antonio Bay, February 05

Temperature (°C)



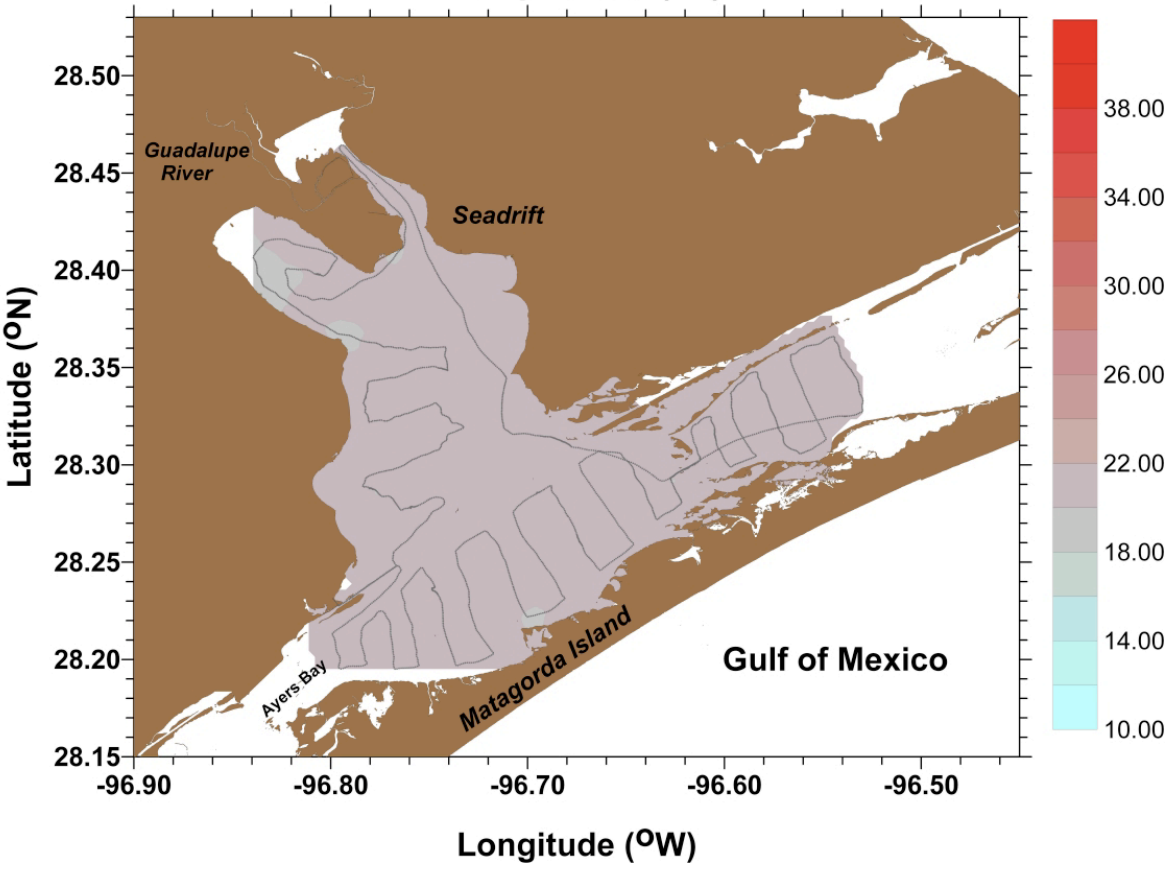
San Antonio Bay, March 05

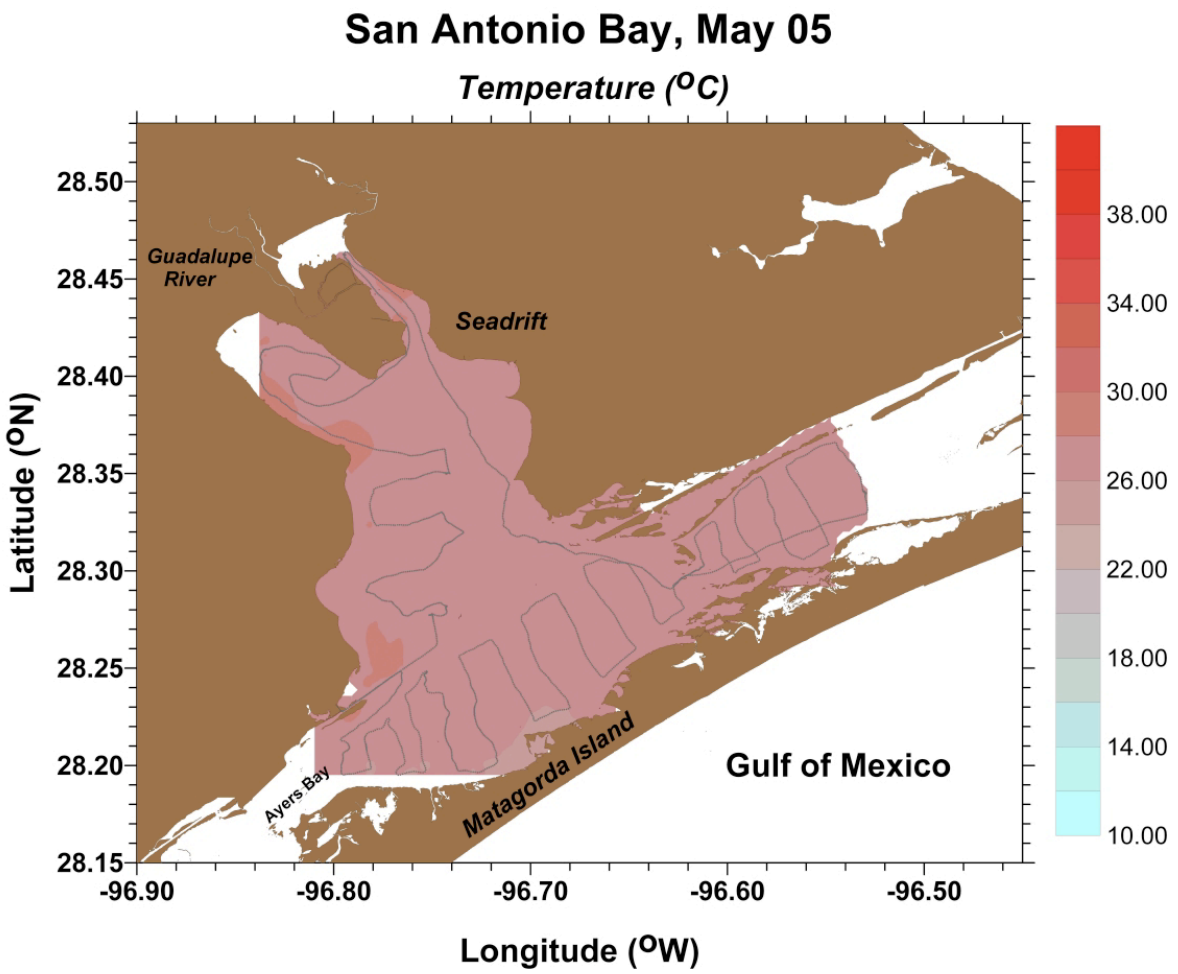
Temperature (°C)

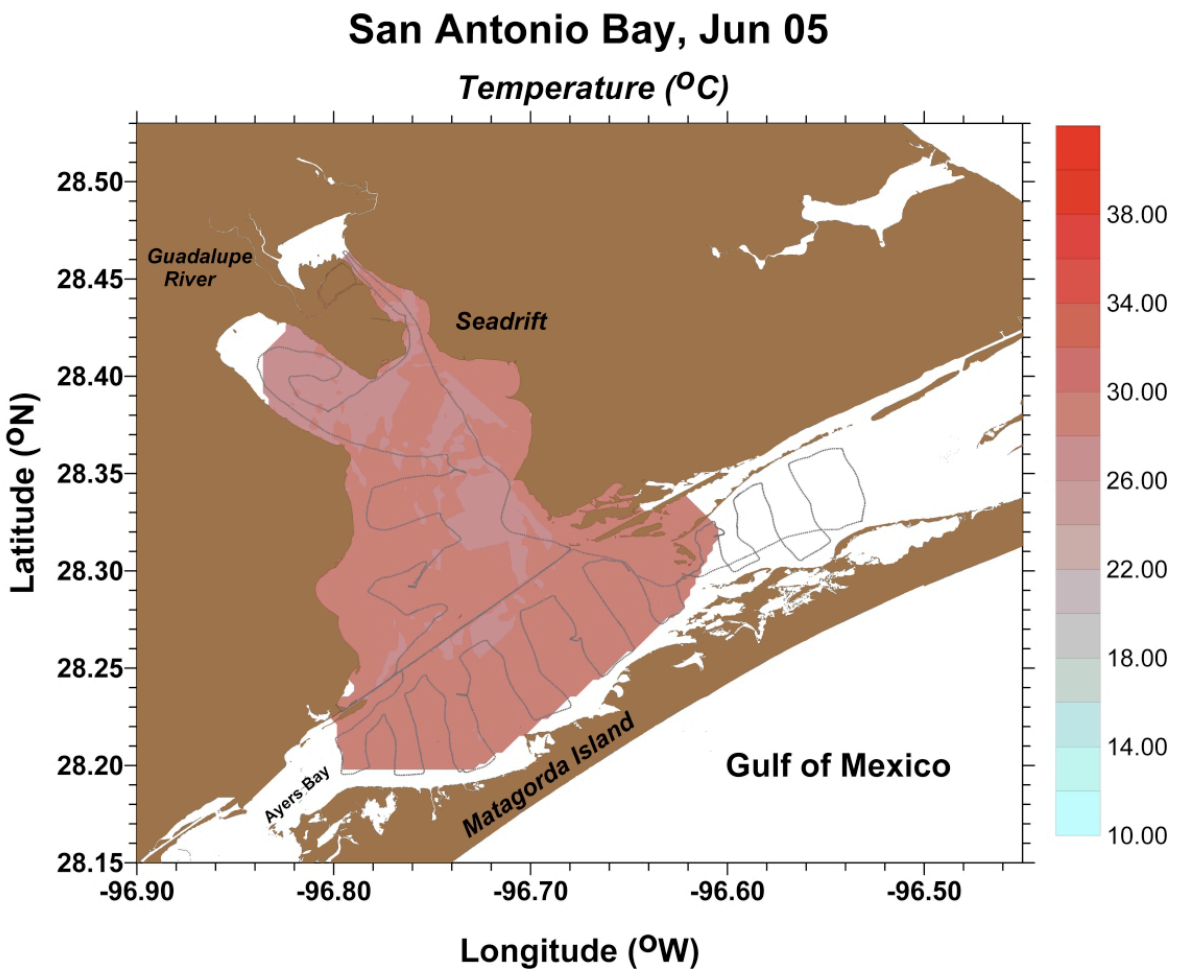


San Antonio Bay, April 05

Temperature (°C)

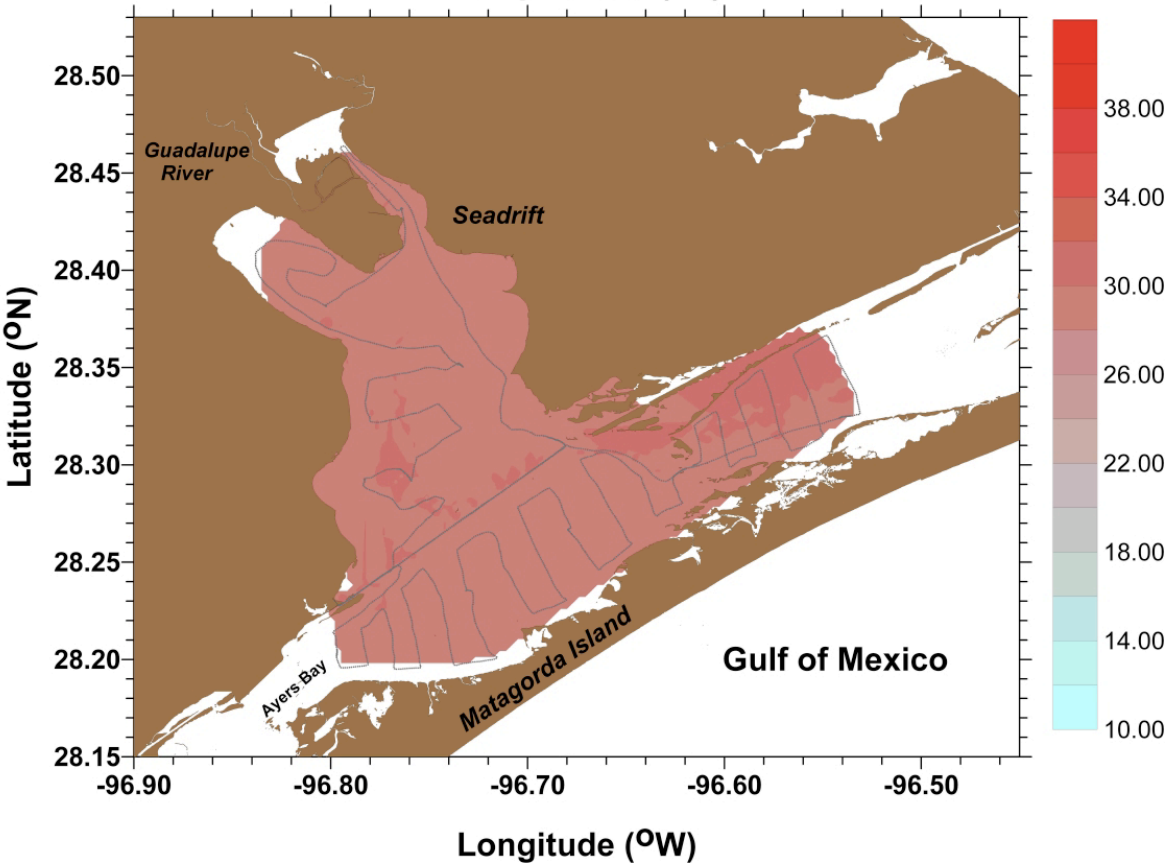



San Antonio Bay, May 05
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
38.00
34.00
30.00
26.00
22.00
18.00
14.00
10.00


San Antonio Bay, Jun 05
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
38.00
34.00
30.00
26.00
22.00
18.00
14.00
10.00

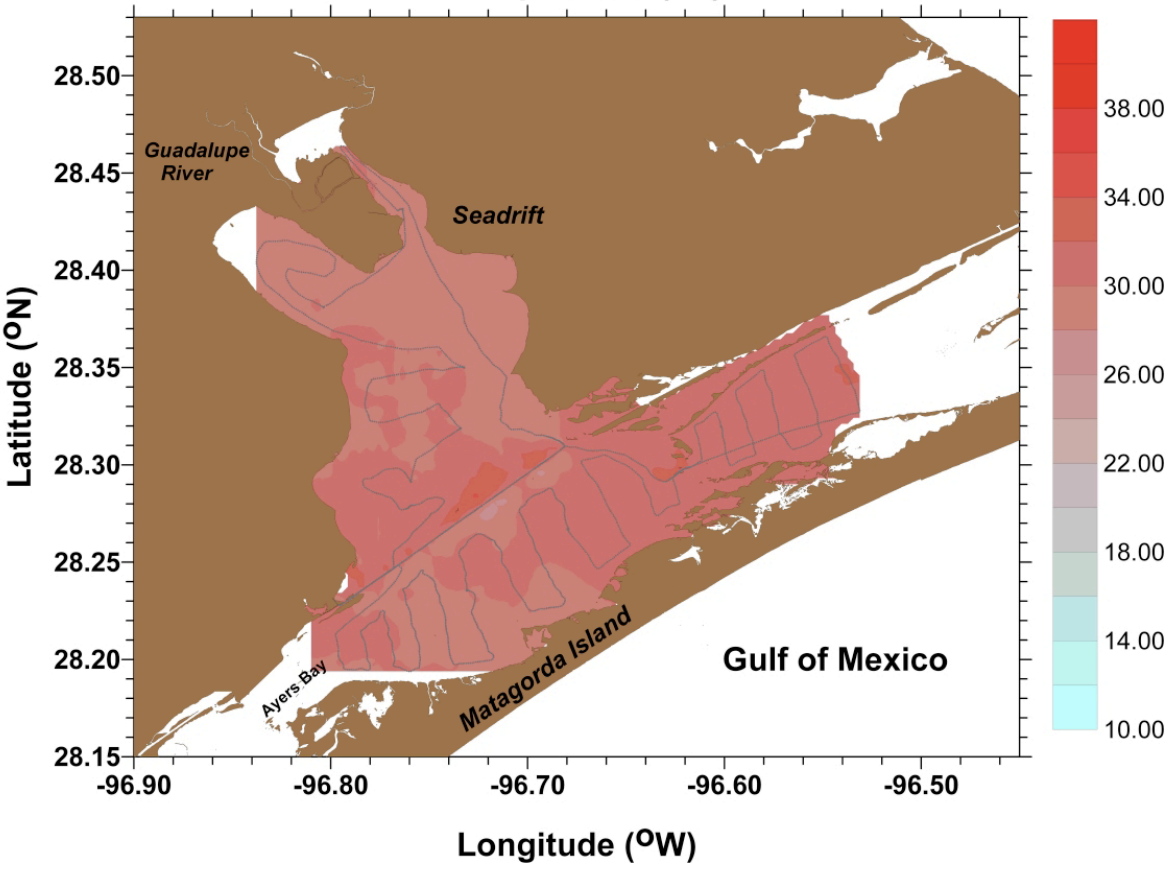
San Antonio Bay, July 05

Temperature (°C)



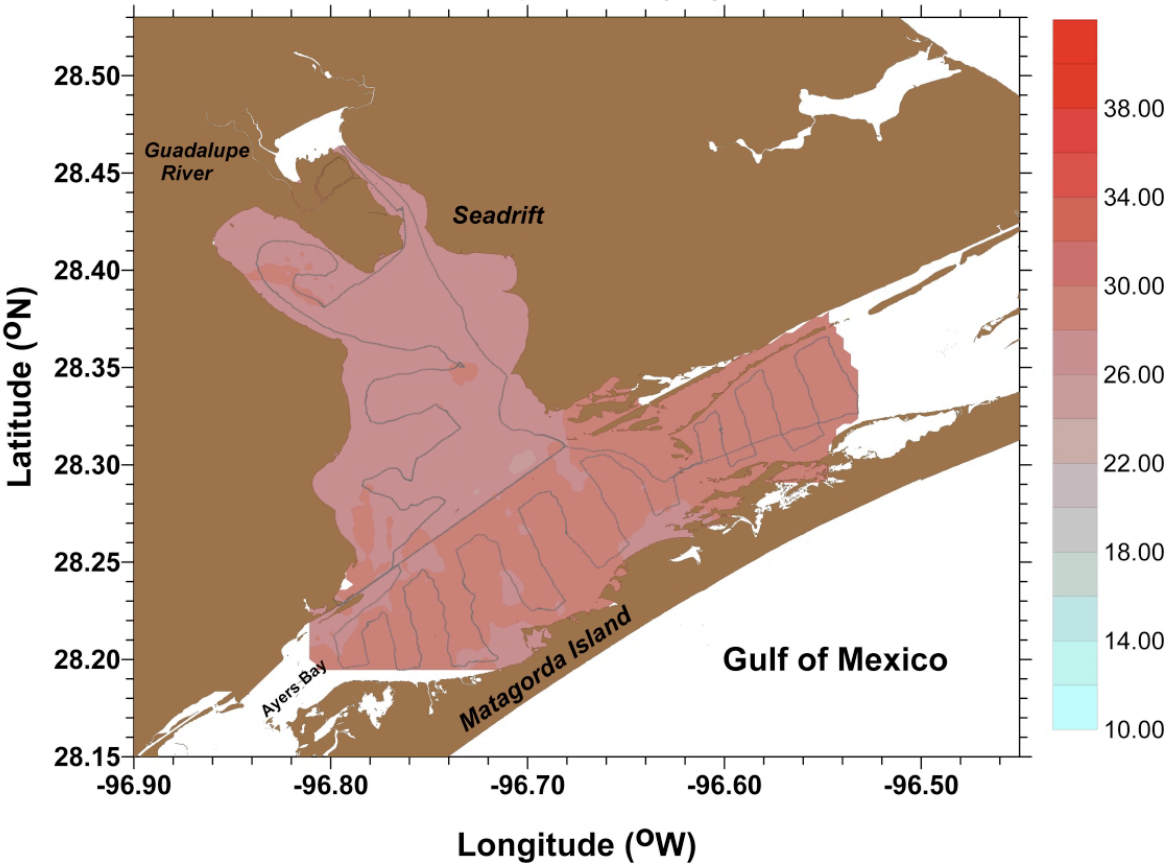
San Antonio Bay, August 05

Temperature (°C)



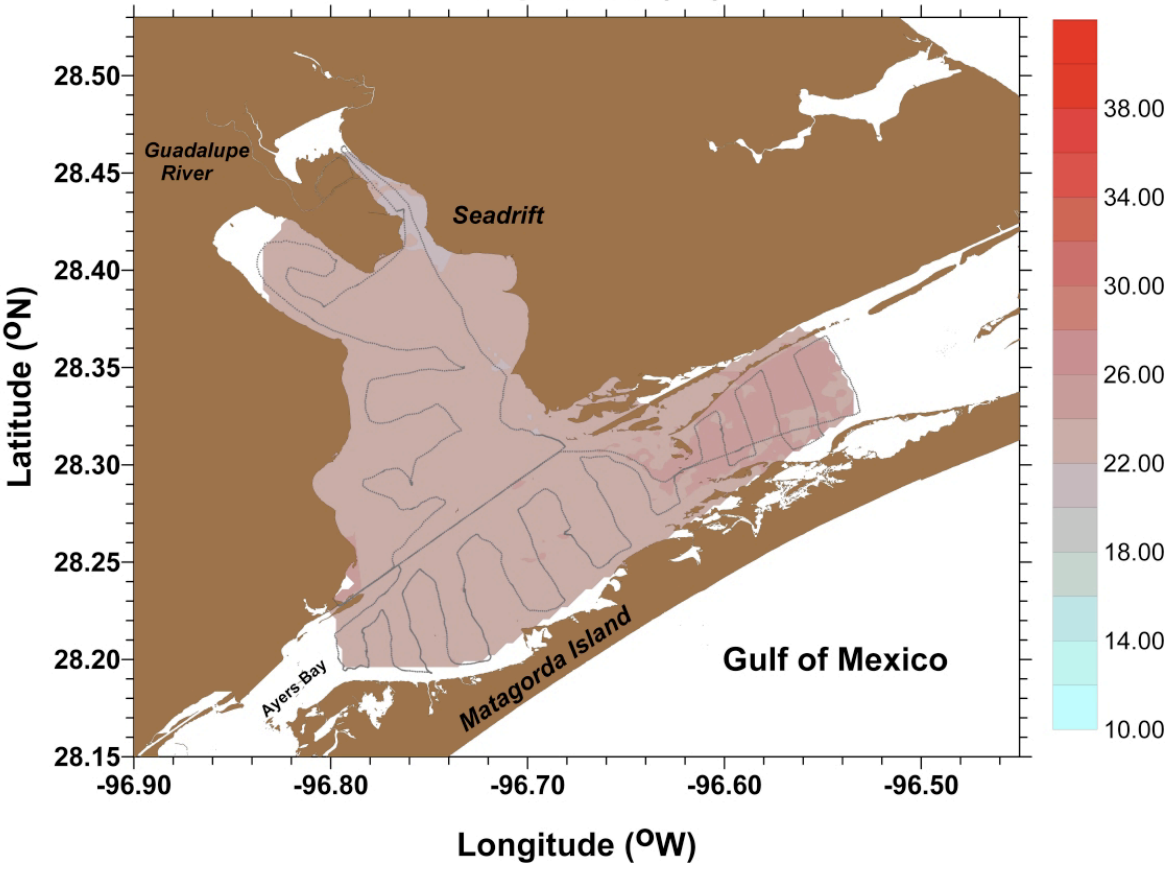
San Antonio Bay, September 05

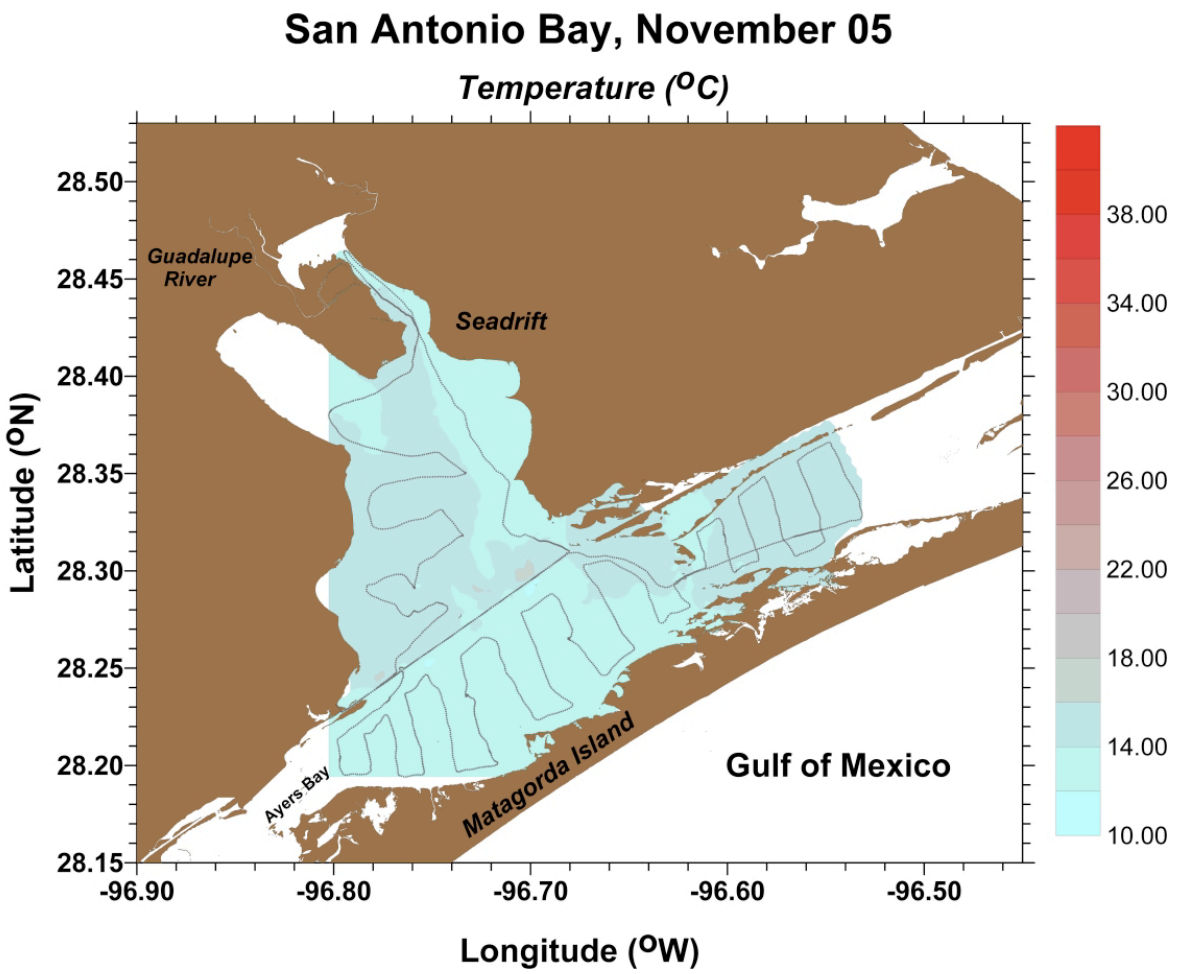
Temperature (°C)



San Antonio Bay, October 05

Temperature (°C)




San Antonio Bay, November 05
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
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-96.50
38.00
34.00
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22.00
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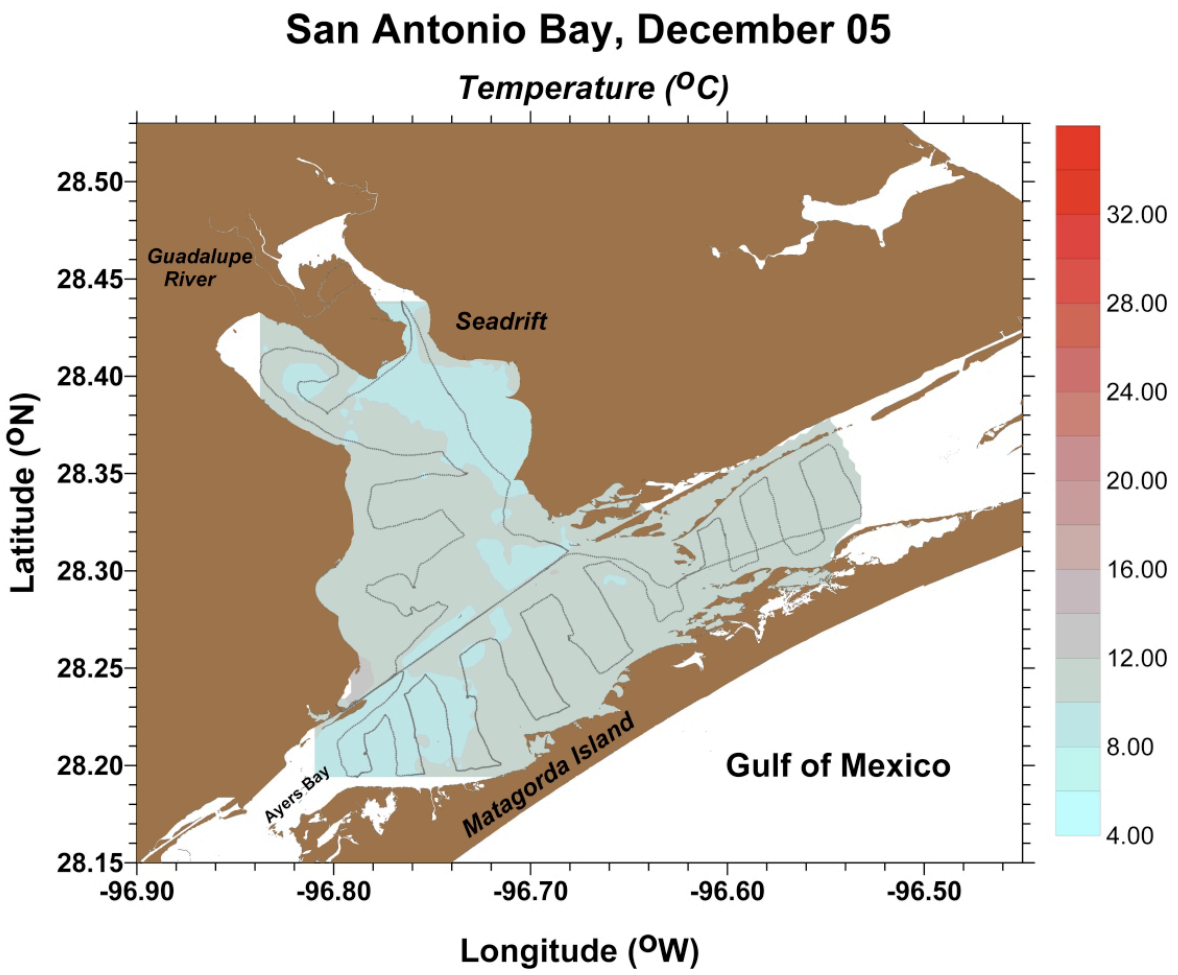
San Antonio Bay, December 05
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
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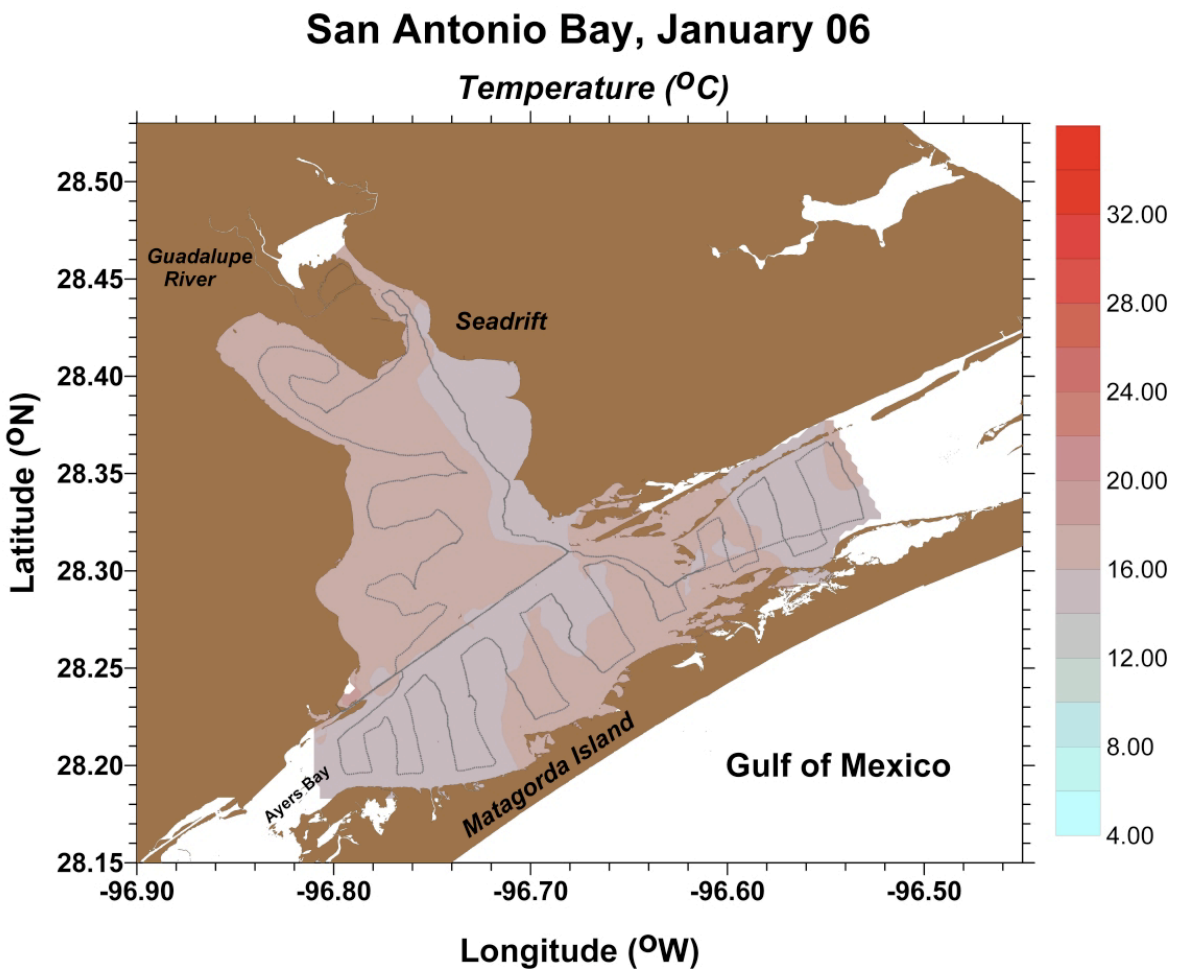
28.00
24.00
20.00
16.00
12.00
8.00
4.00


San Antonio Bay, January 06
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
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-96.50
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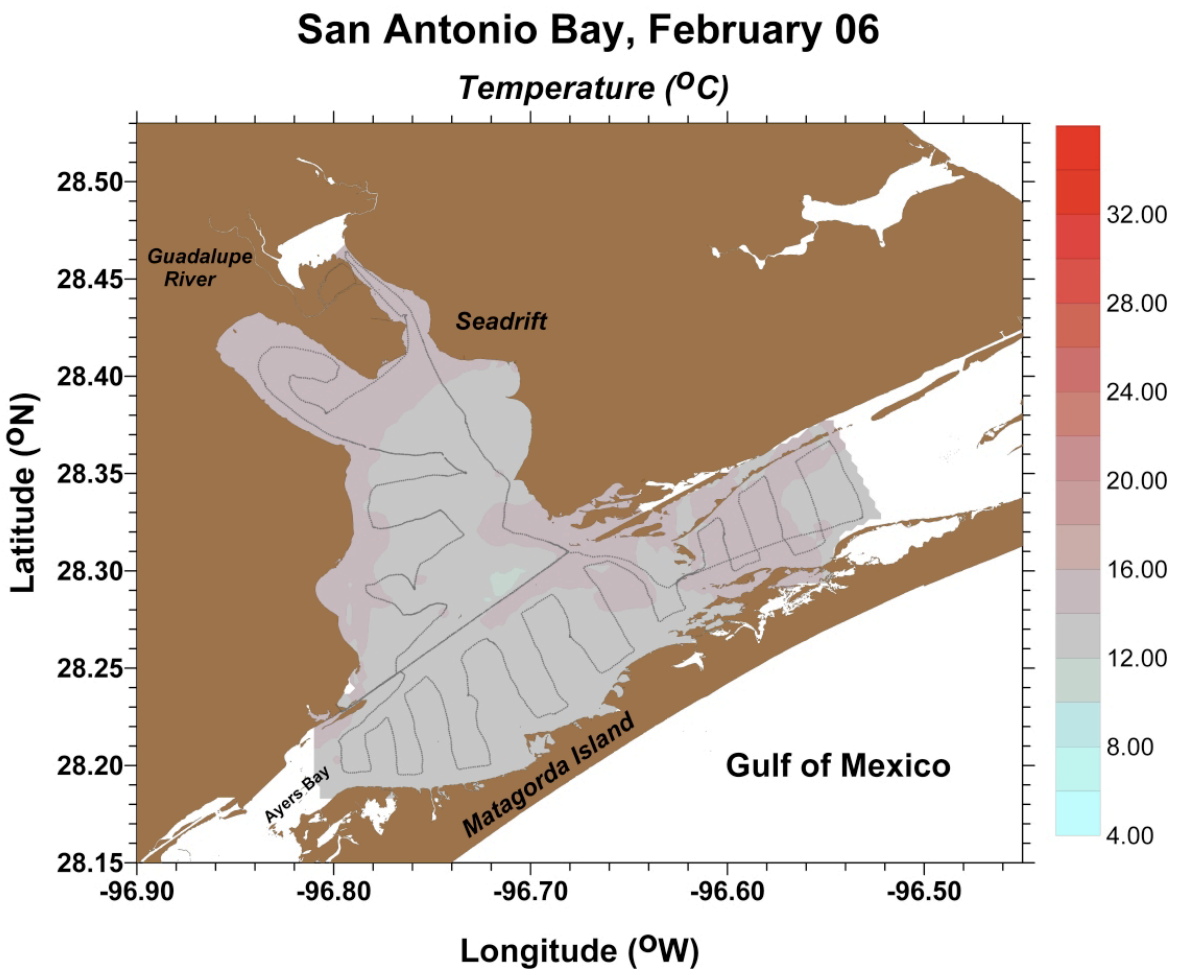
24.00
20.00
16.00
12.00
8.00
4.00


San Antonio Bay, February 06
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
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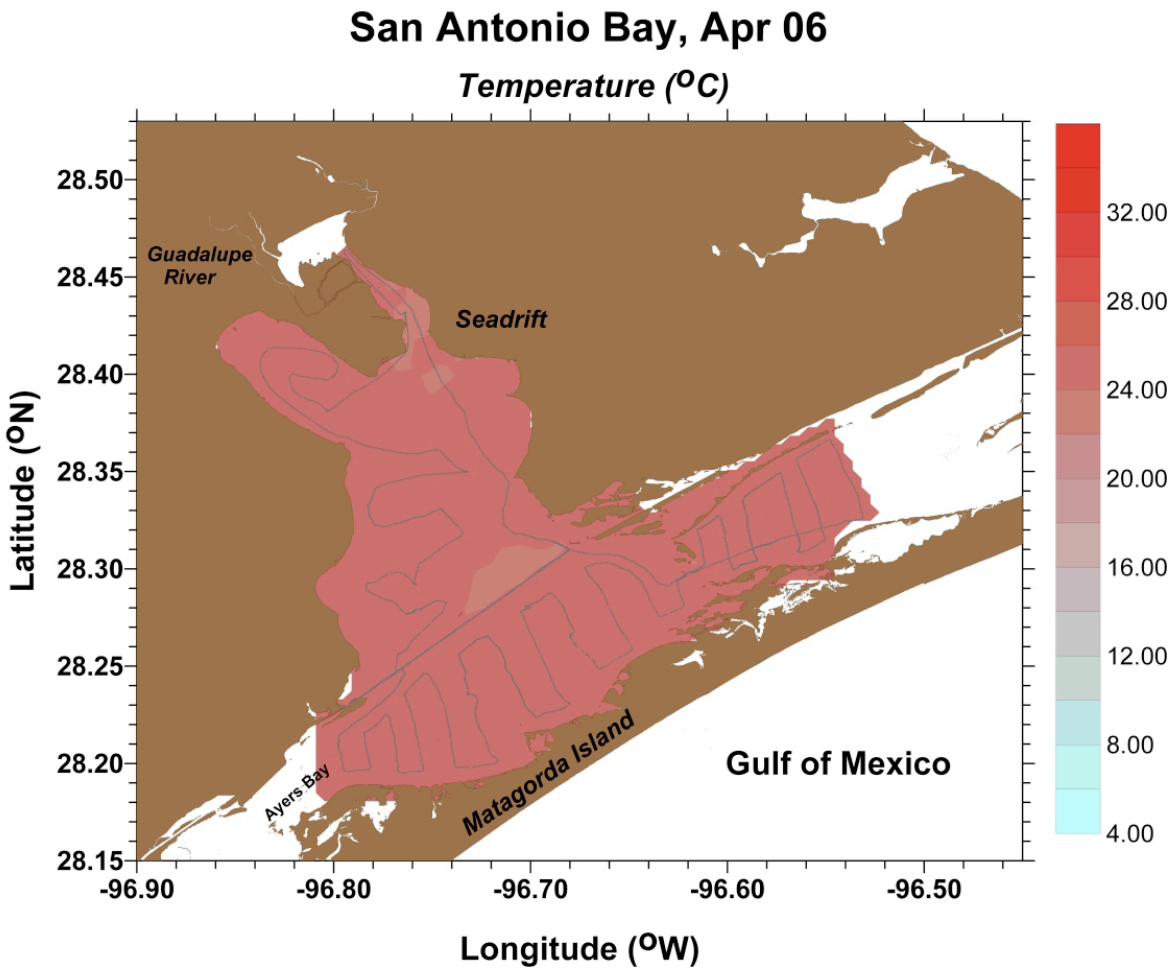
20.00
16.00
12.00
8.00
4.00


San Antonio Bay, Apr 06
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
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24.00
20.00
16.00
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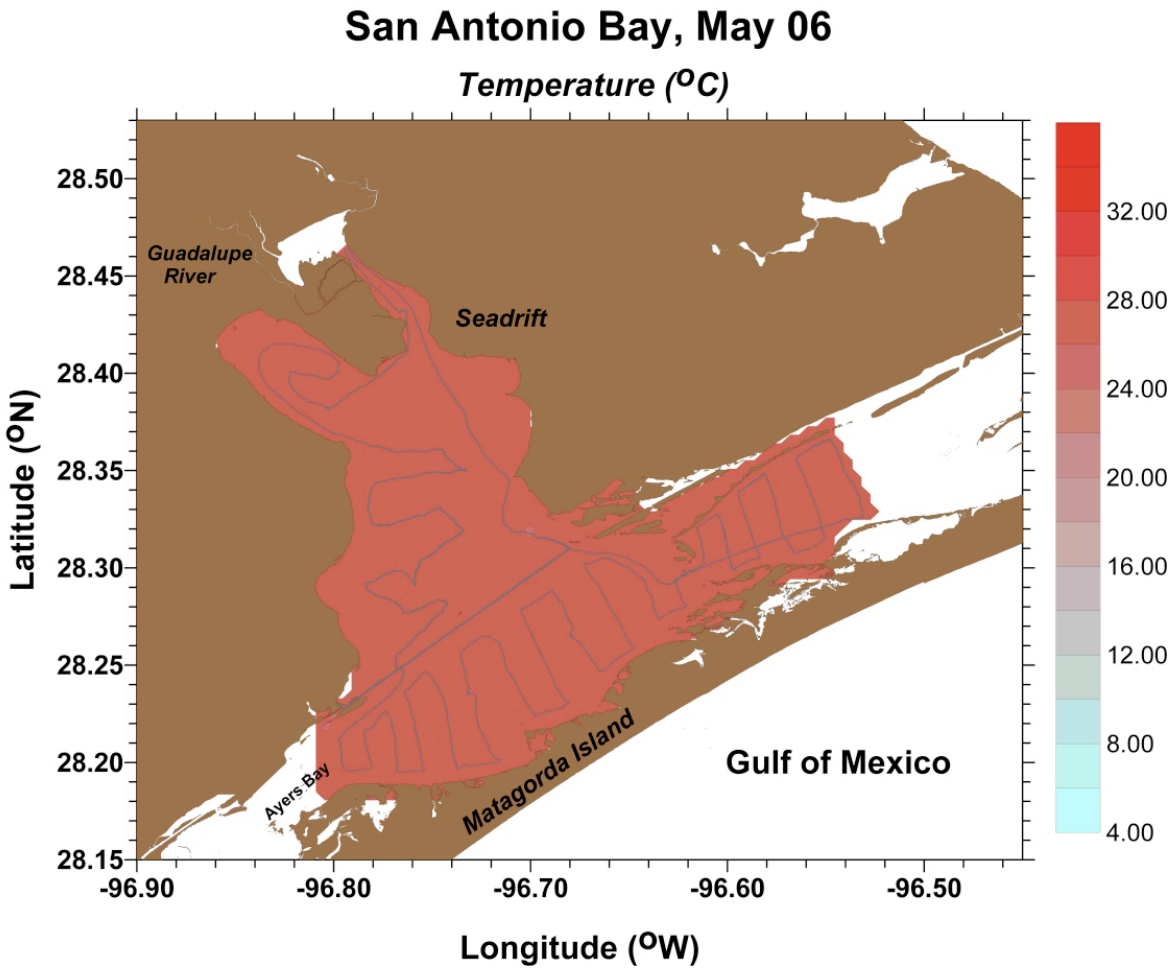
San Antonio Bay, May 06
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
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20.00
16.00
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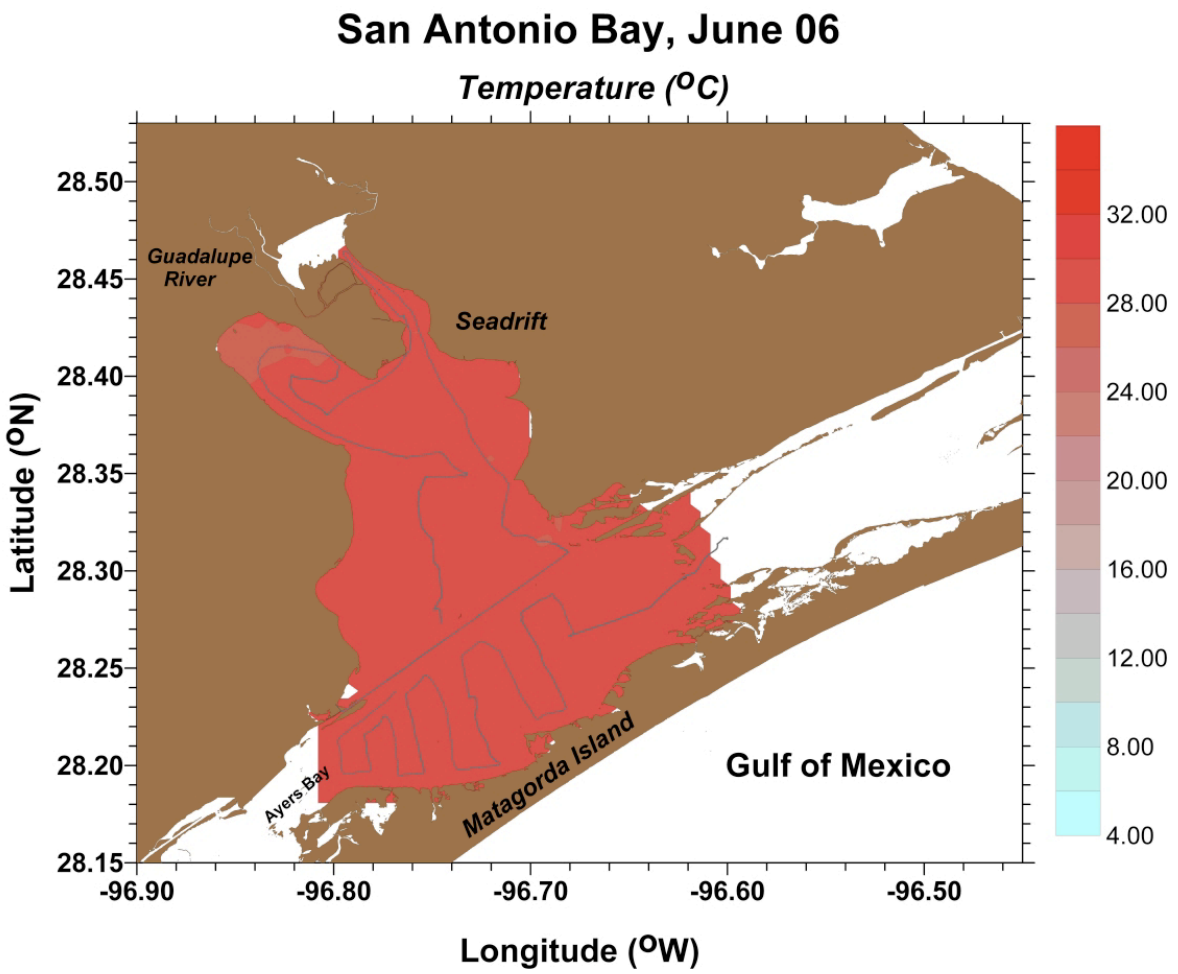
San Antonio Bay, June 06
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
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-96.50
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20.00
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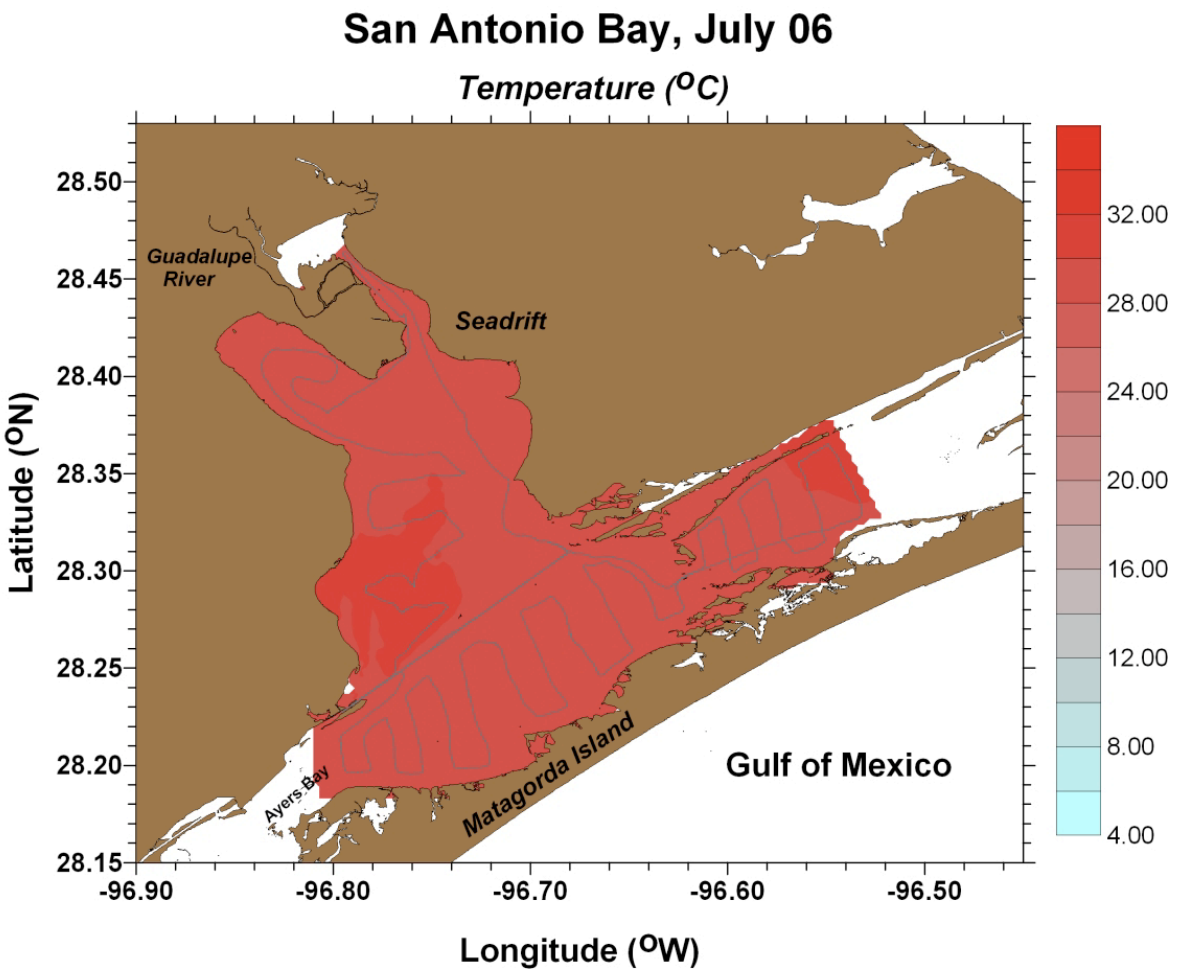
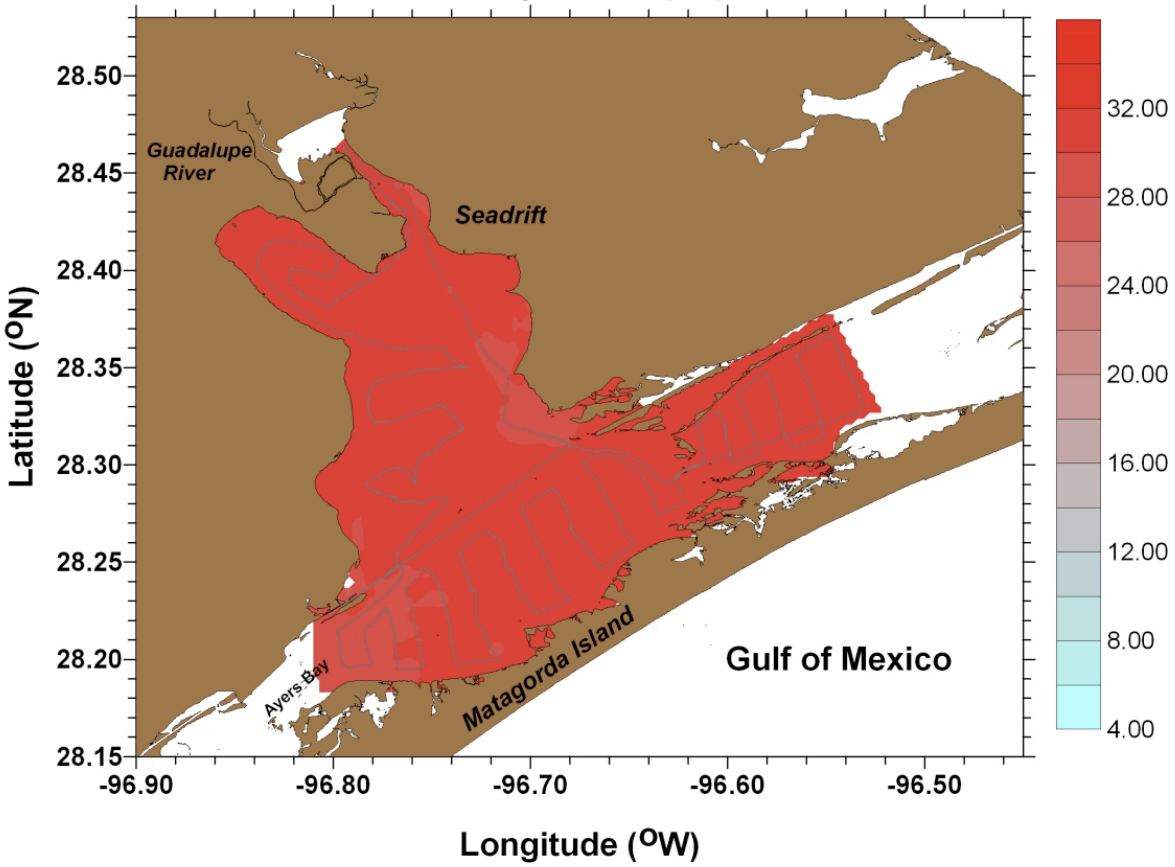

San Antonio Bay, July 06
Temperature (°C)
Guadalupe River
Seadrift
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00

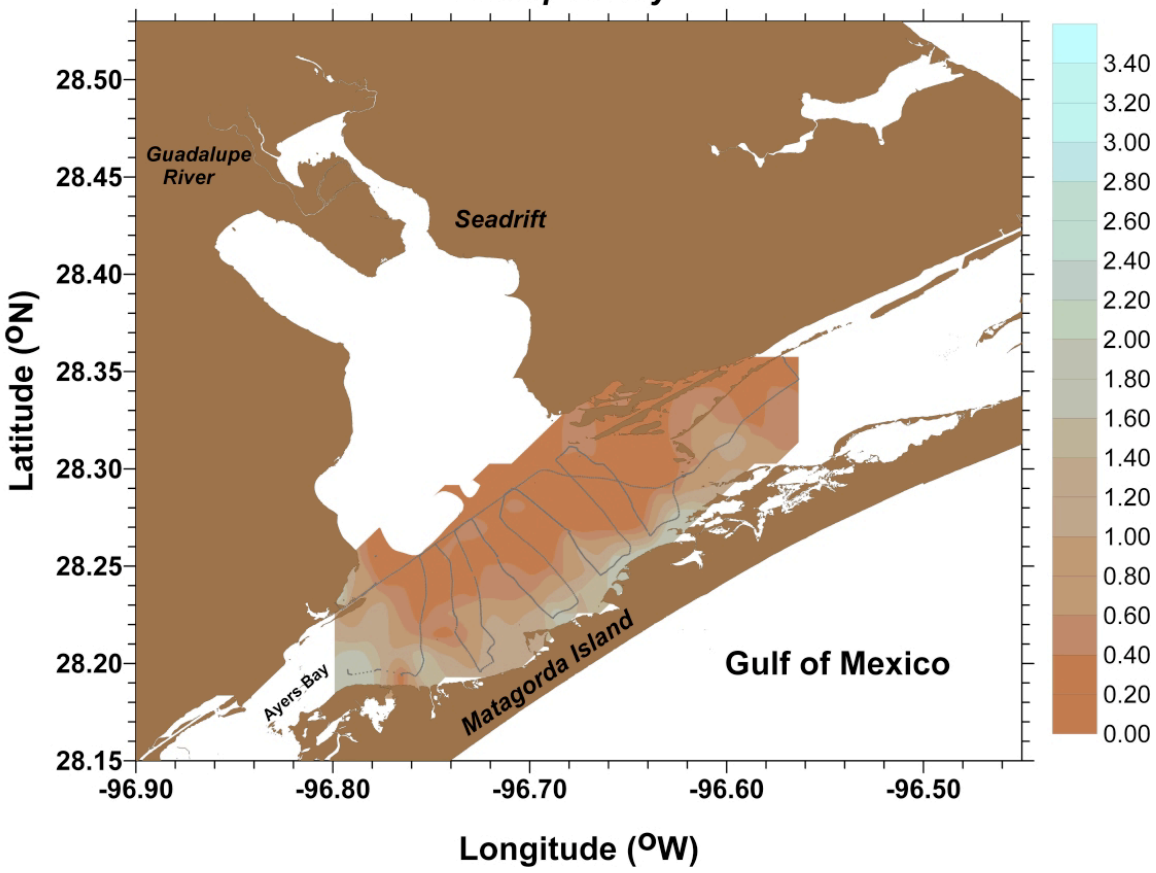
San Antonio Bay, August 06

Temperature (°C)



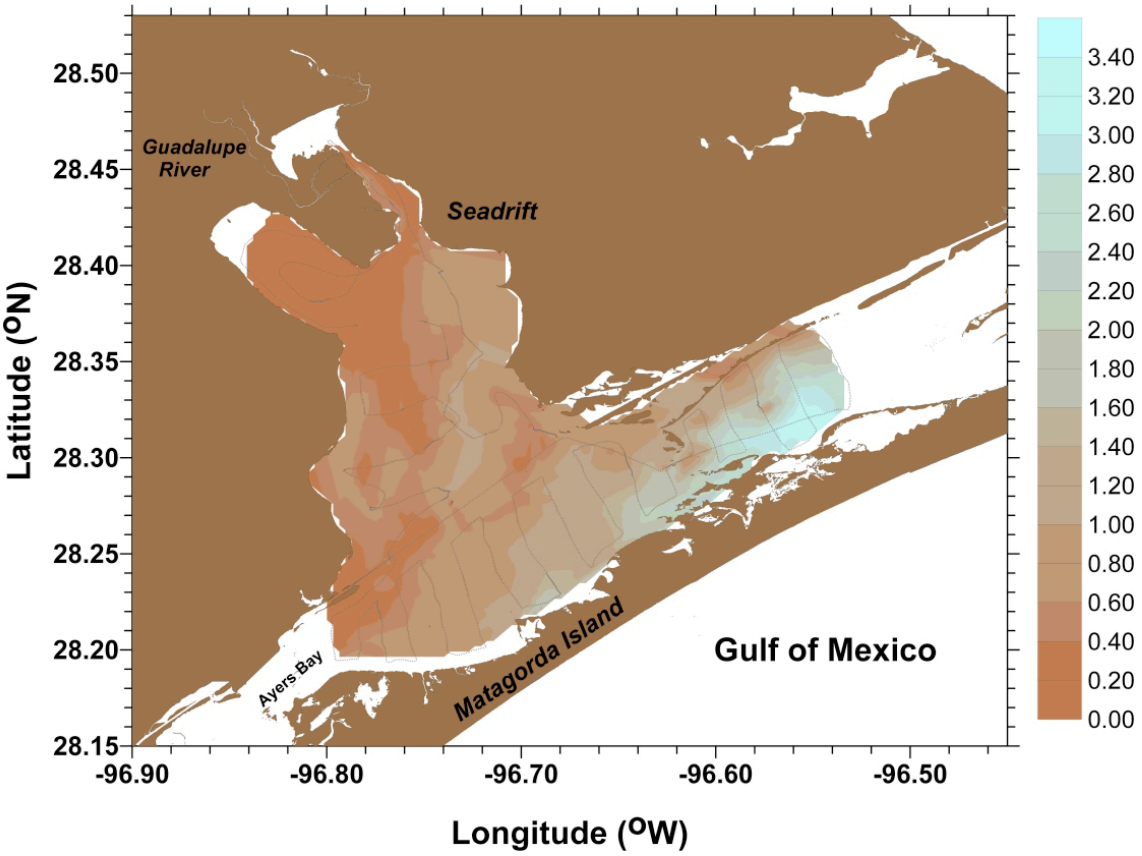
San Antonio Bay, Oct 04

Transparancy



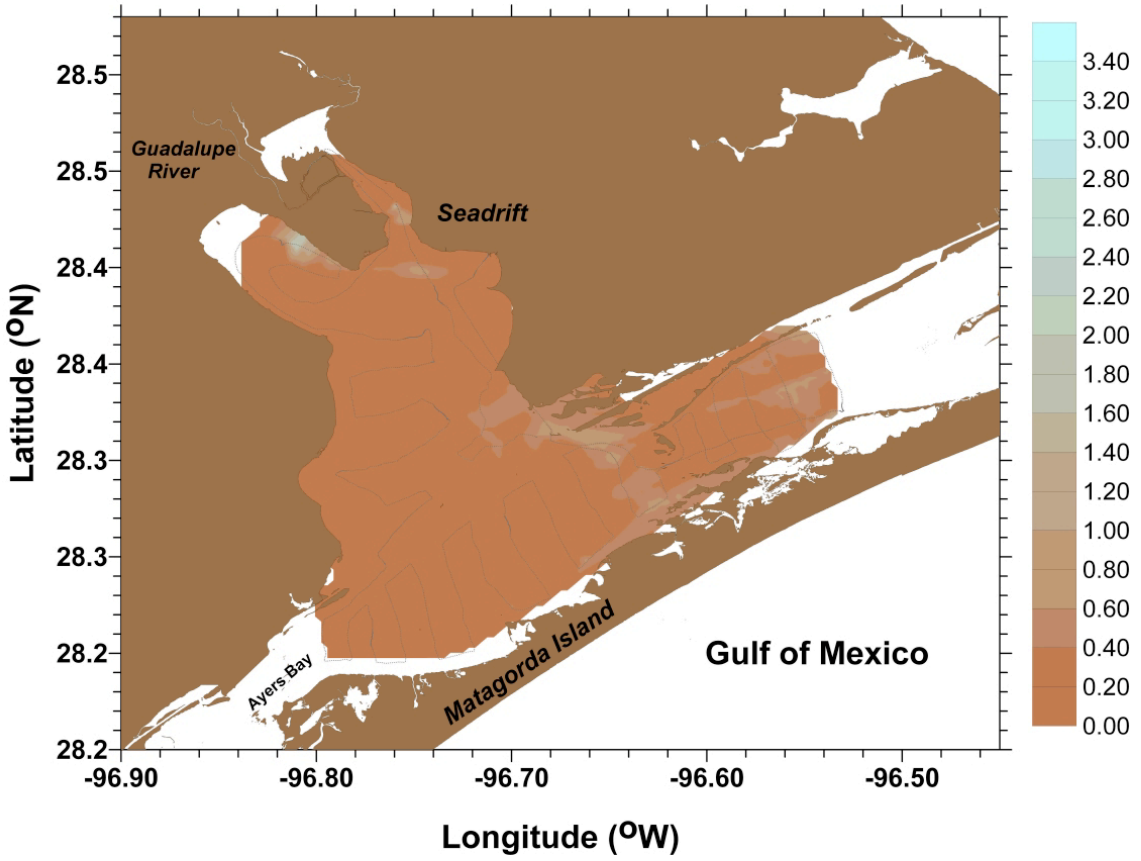
San Antonio Bay, January 05

Transparancy

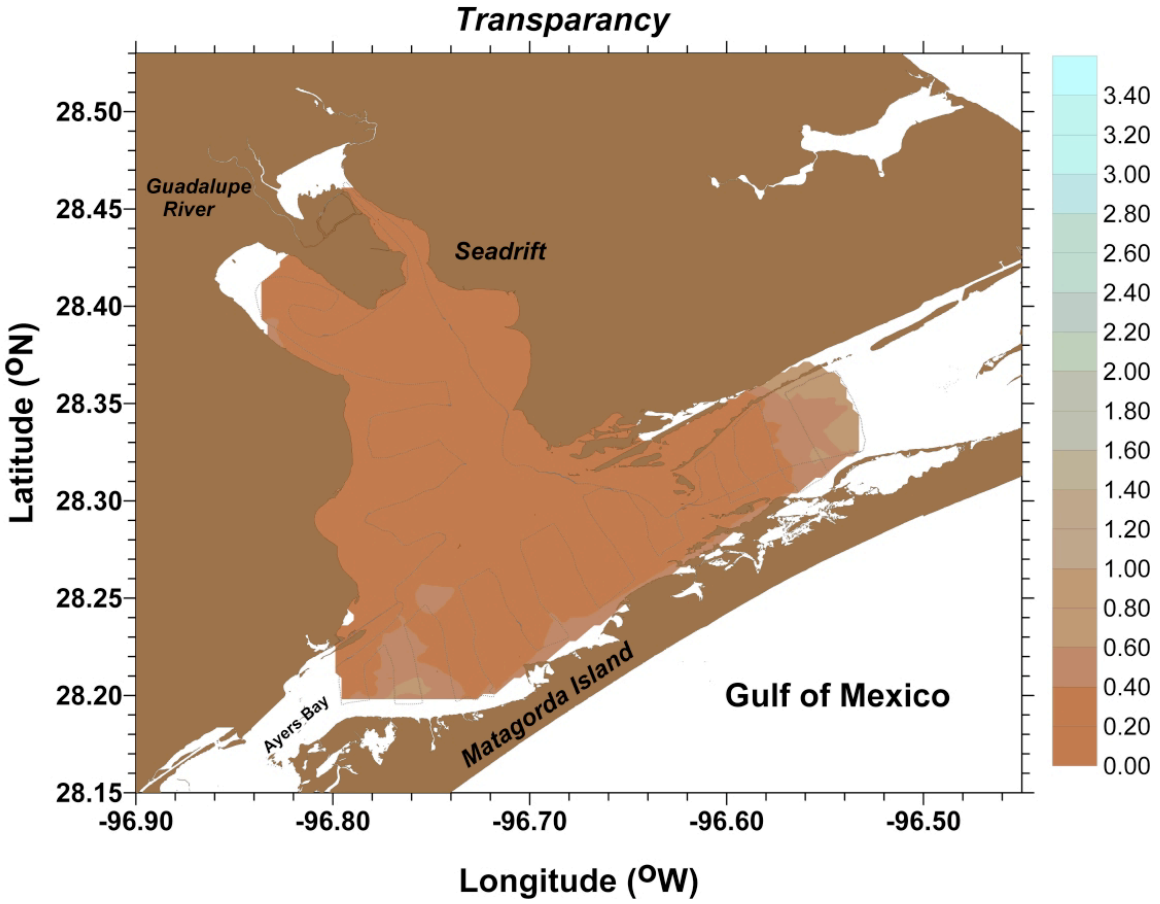


San Antonio Bay, February 05

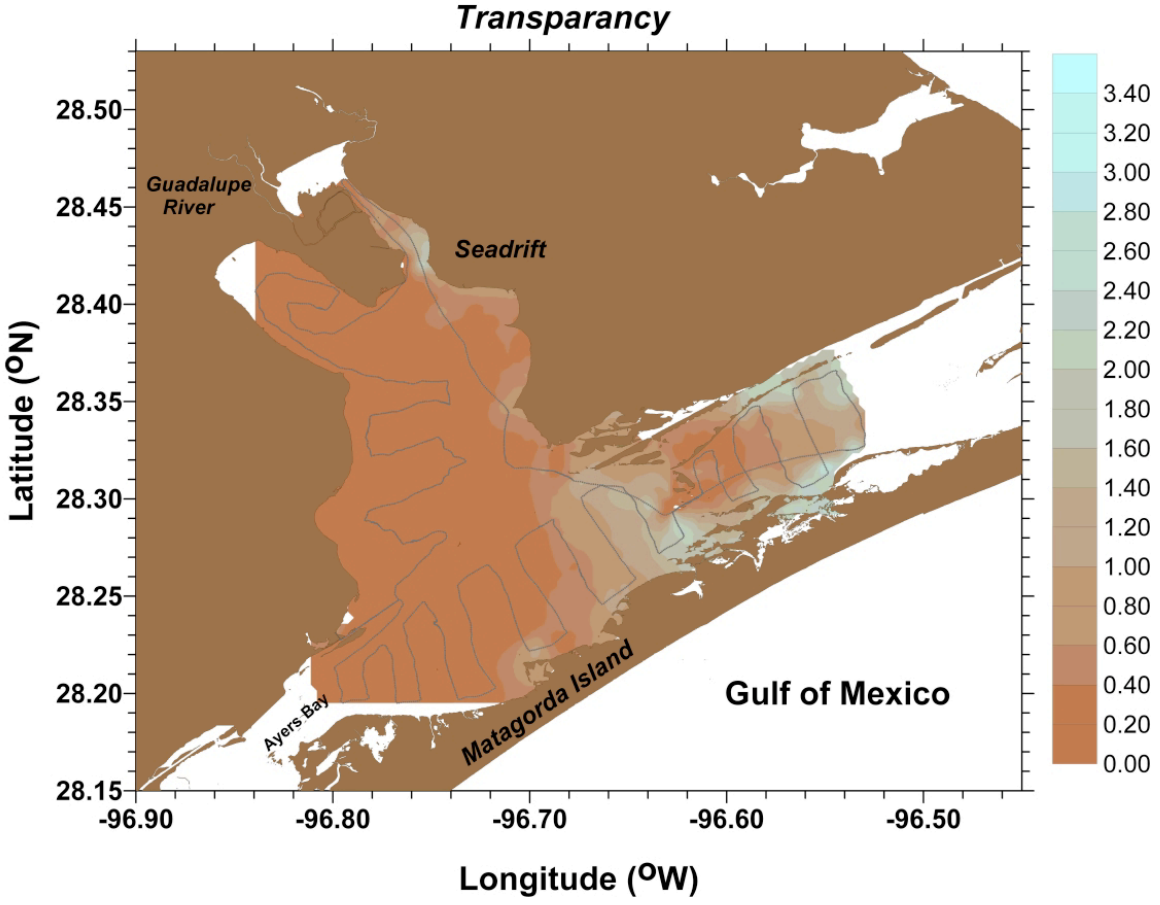
Transparancy



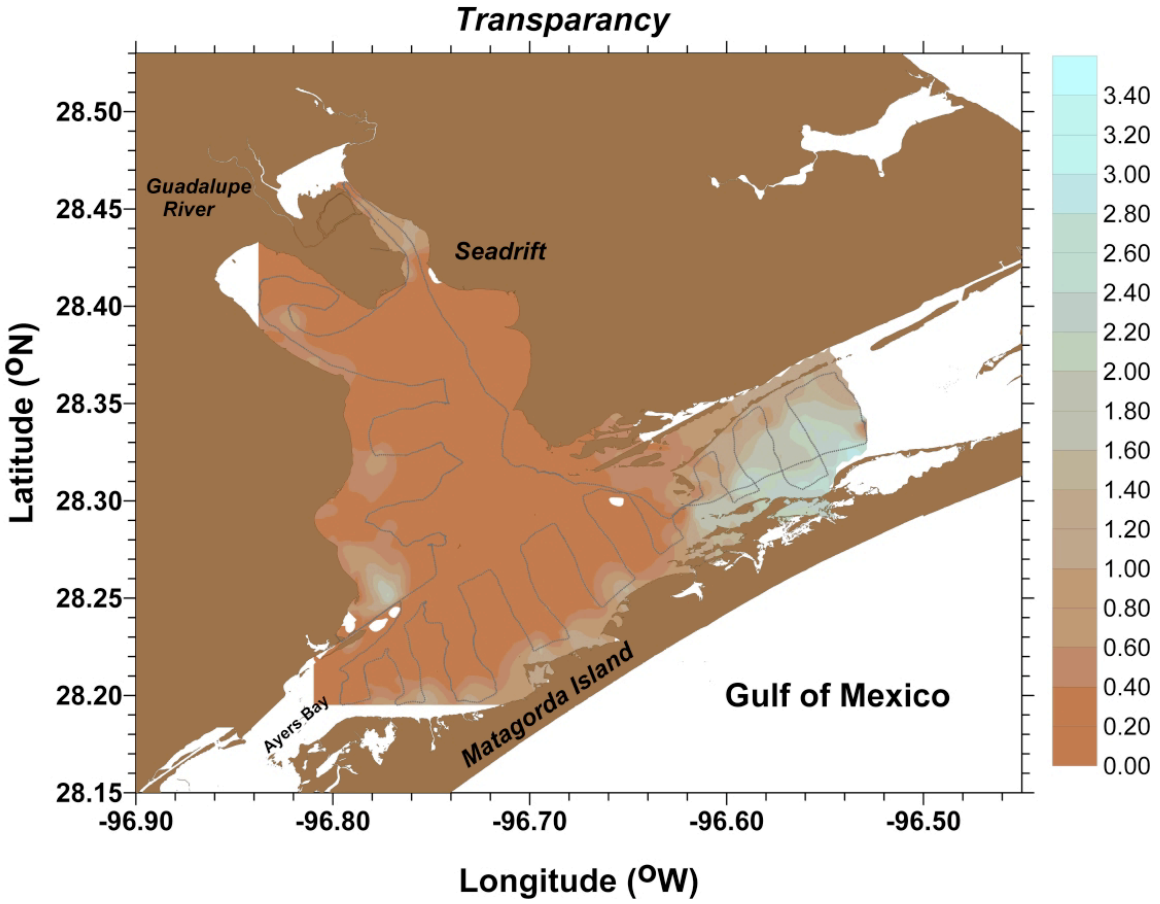
San Antonio Bay, March 05



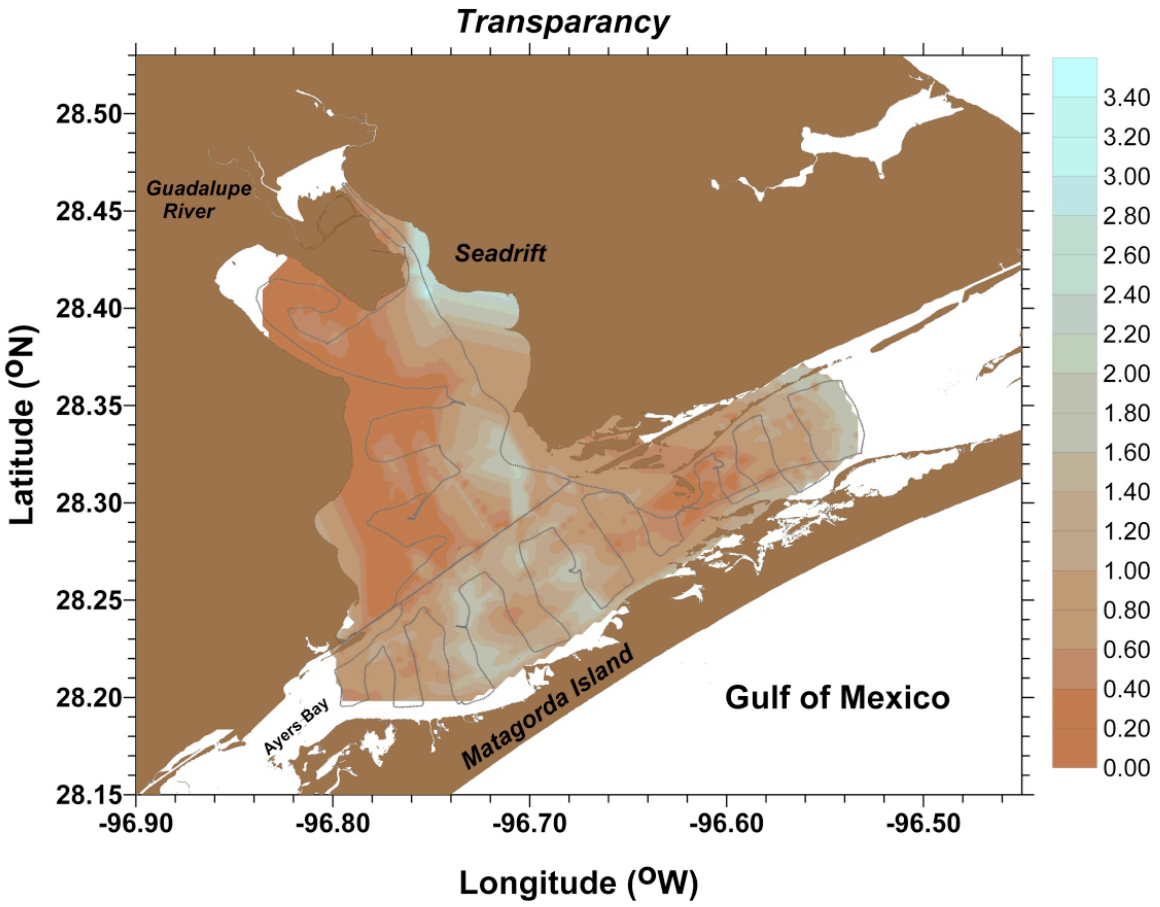
San Antonio Bay, April 05



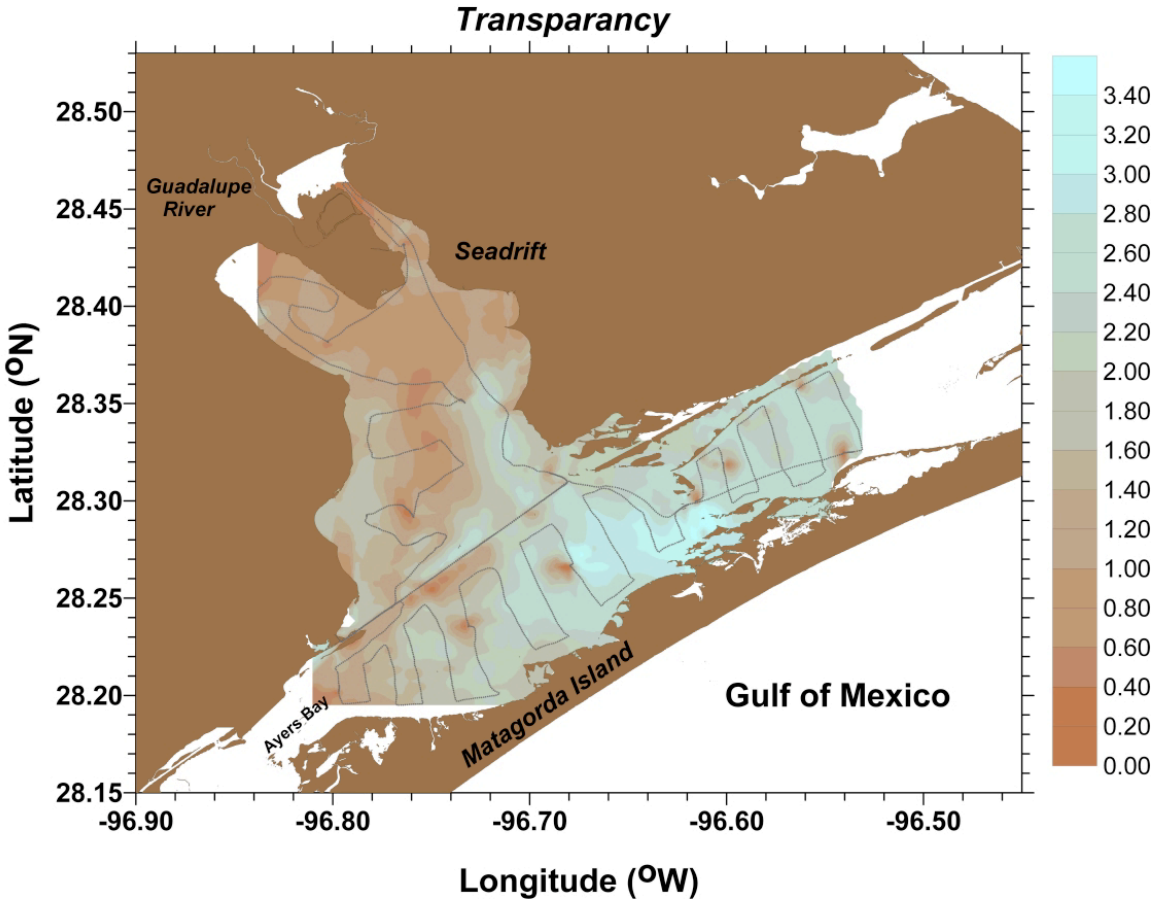
San Antonio Bay, May 05



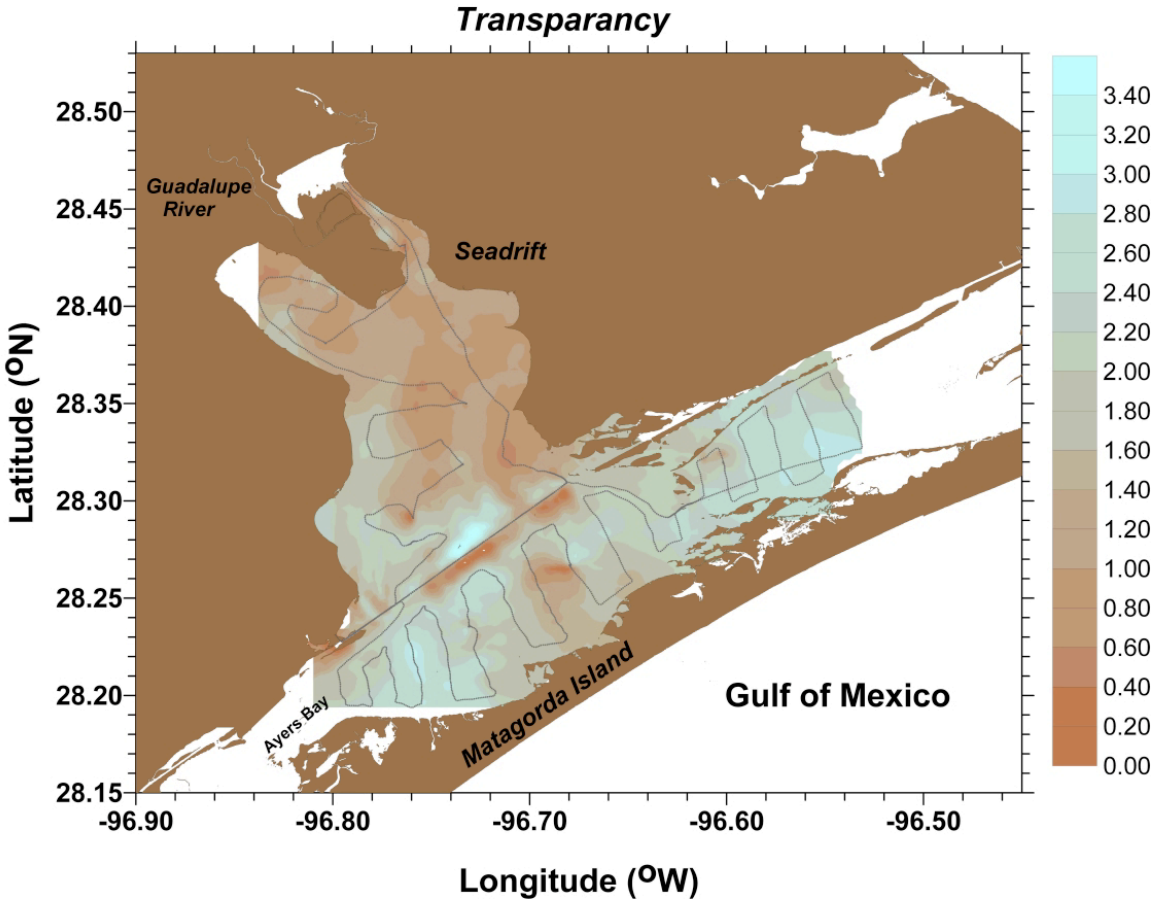
San Antonio Bay, Jun 05



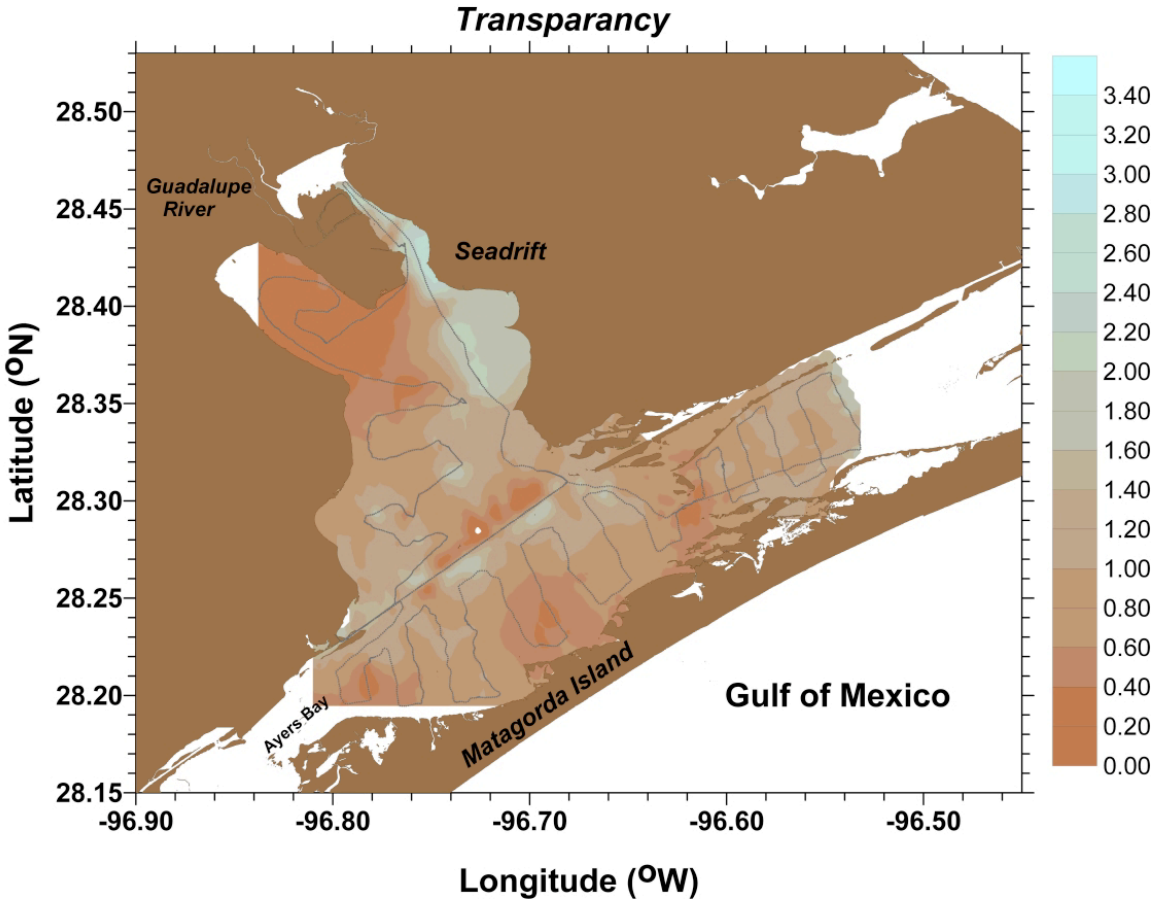
San Antonio Bay, July 05



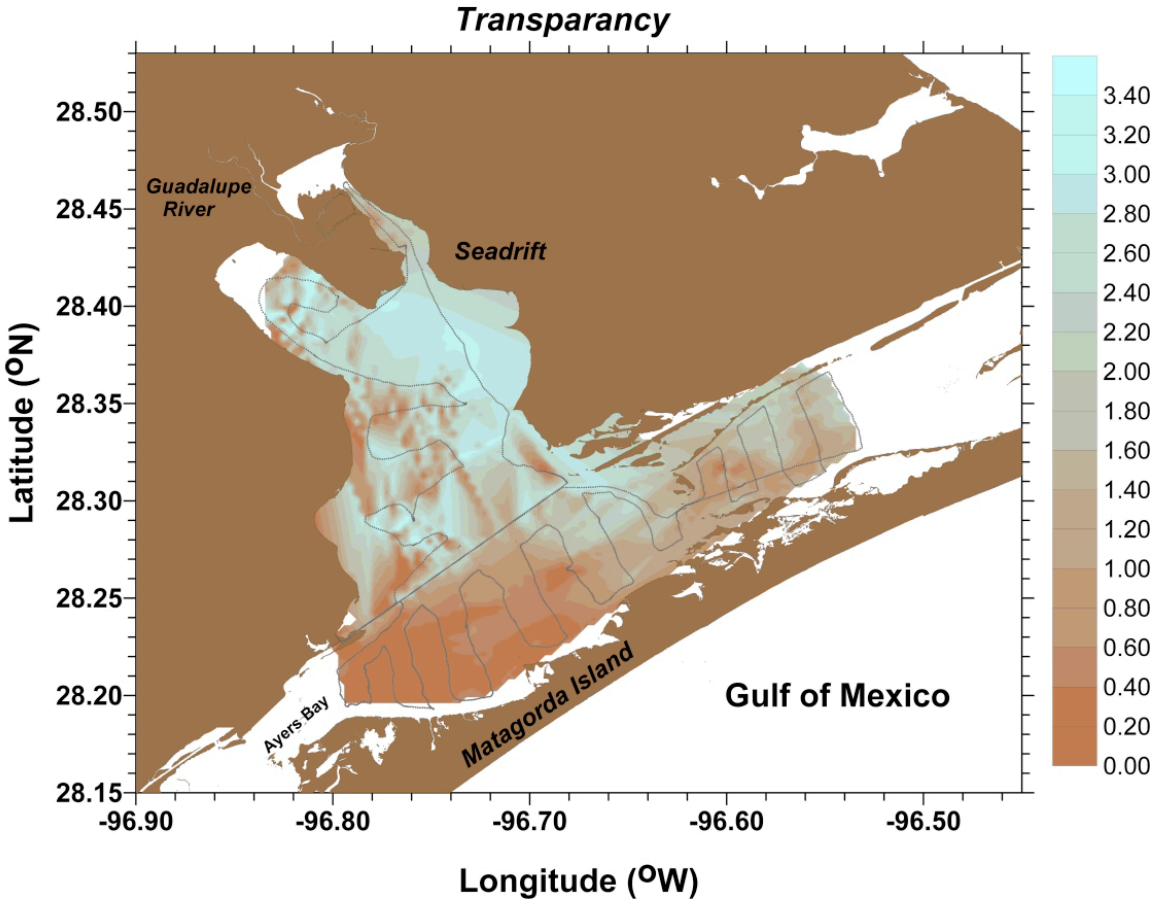
San Antonio Bay, August 05



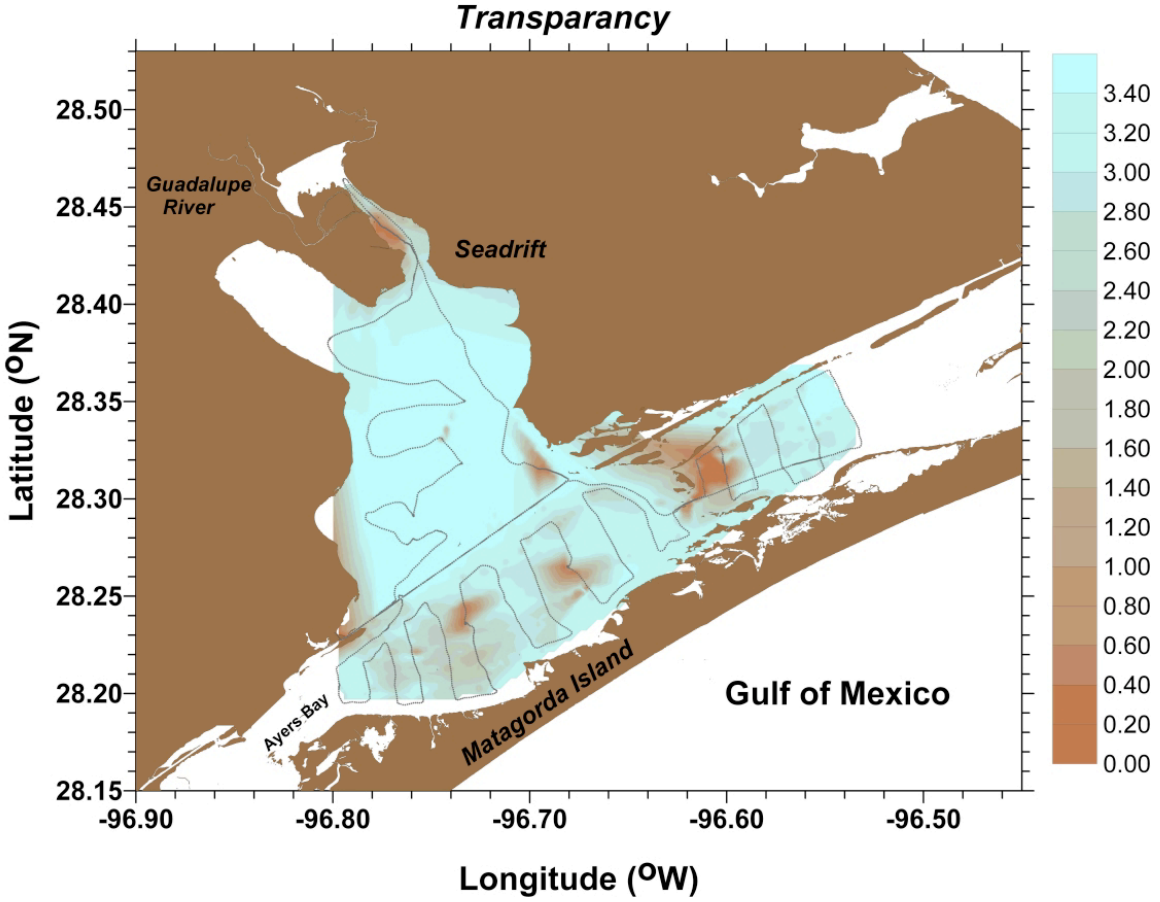
San Antonio Bay, September 05



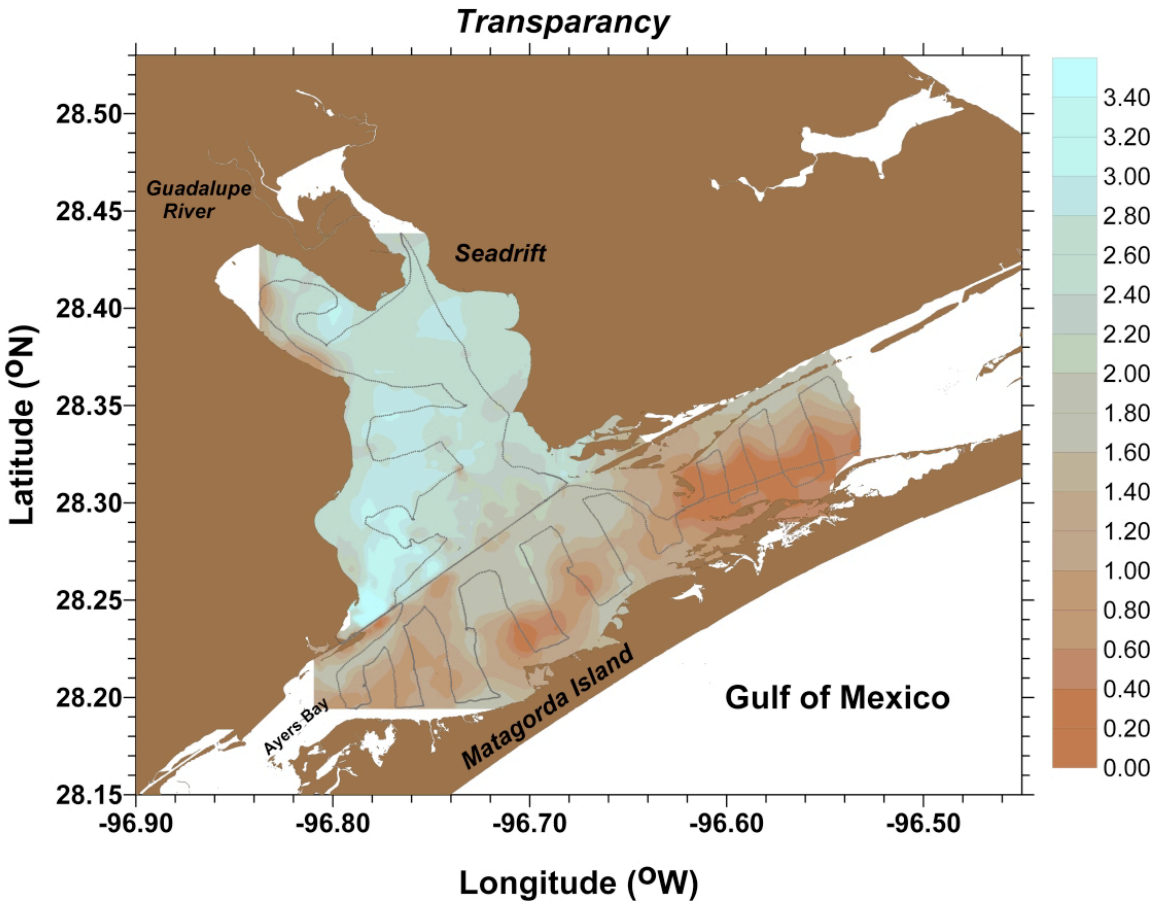
San Antonio Bay, October 05



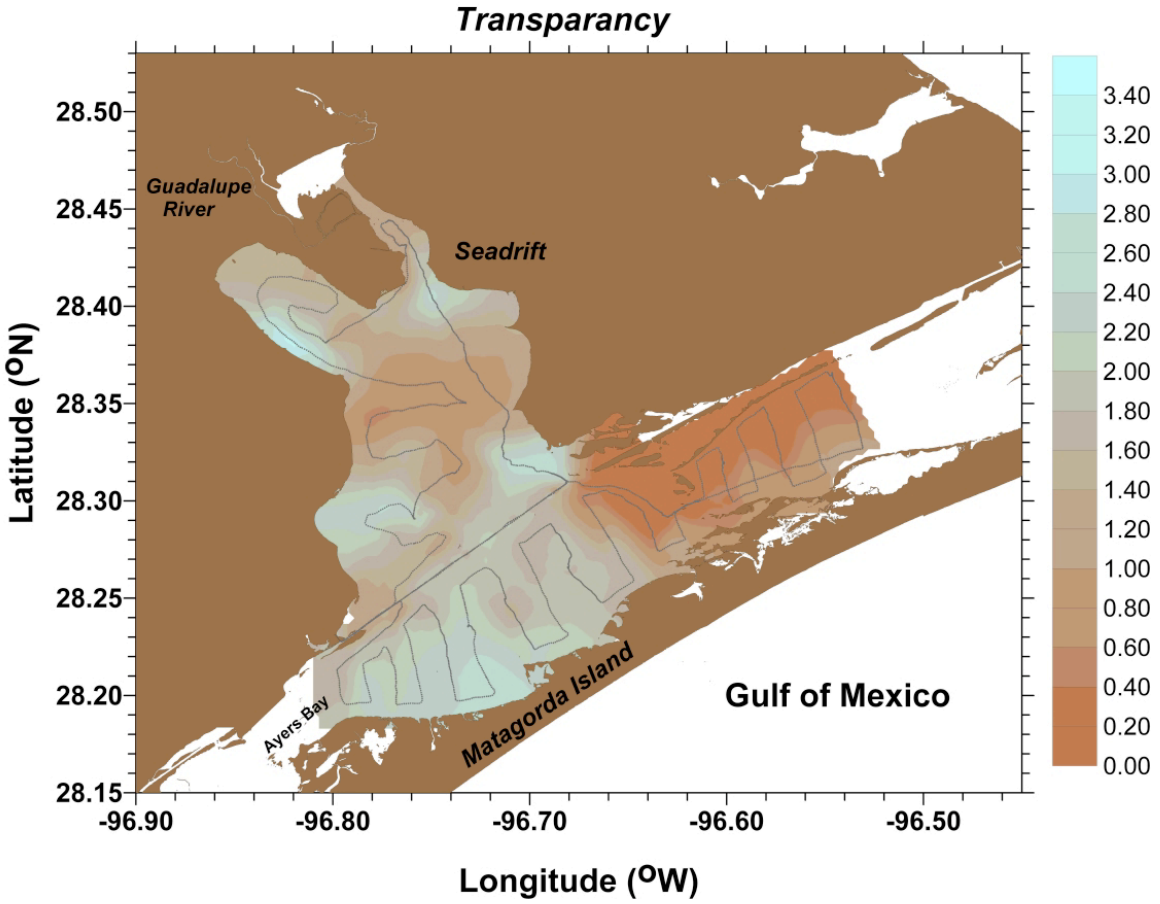
San Antonio Bay, November 05



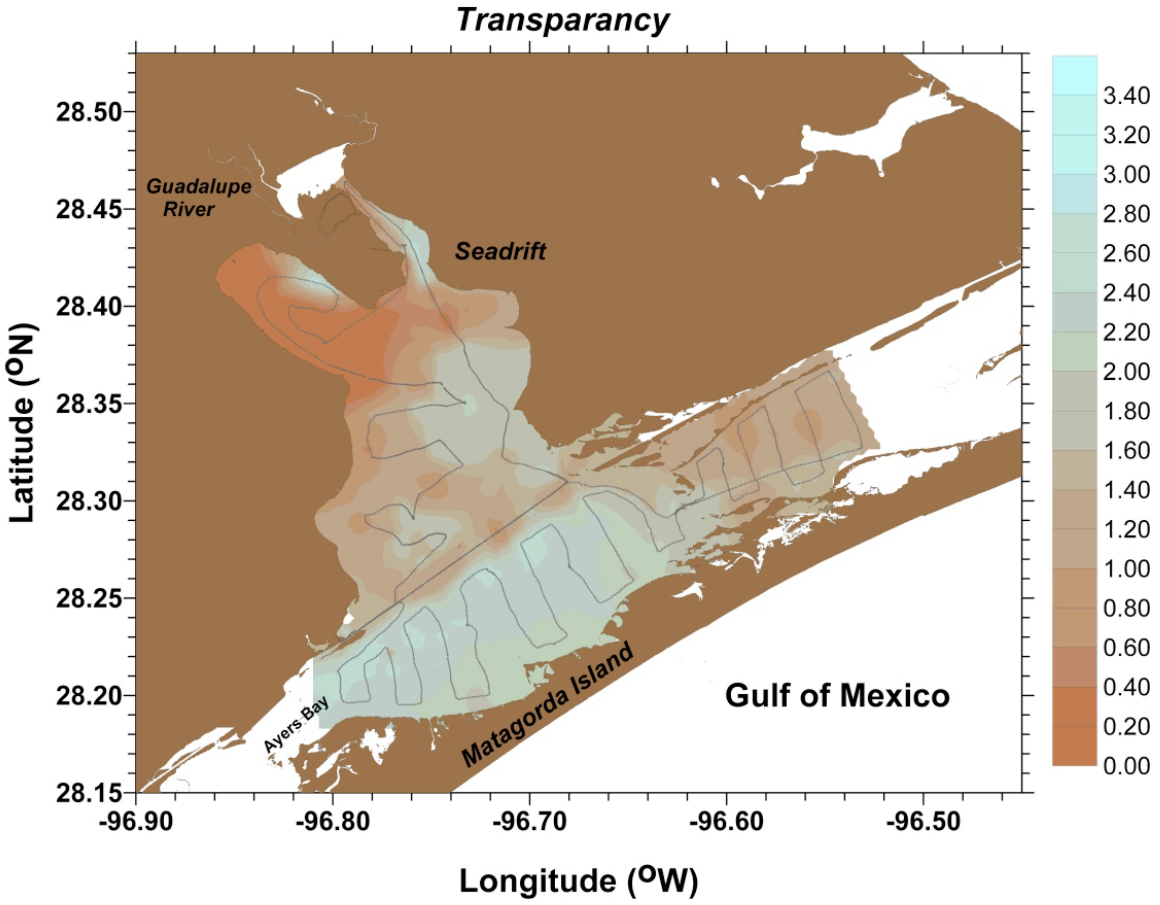
San Antonio Bay, December 05



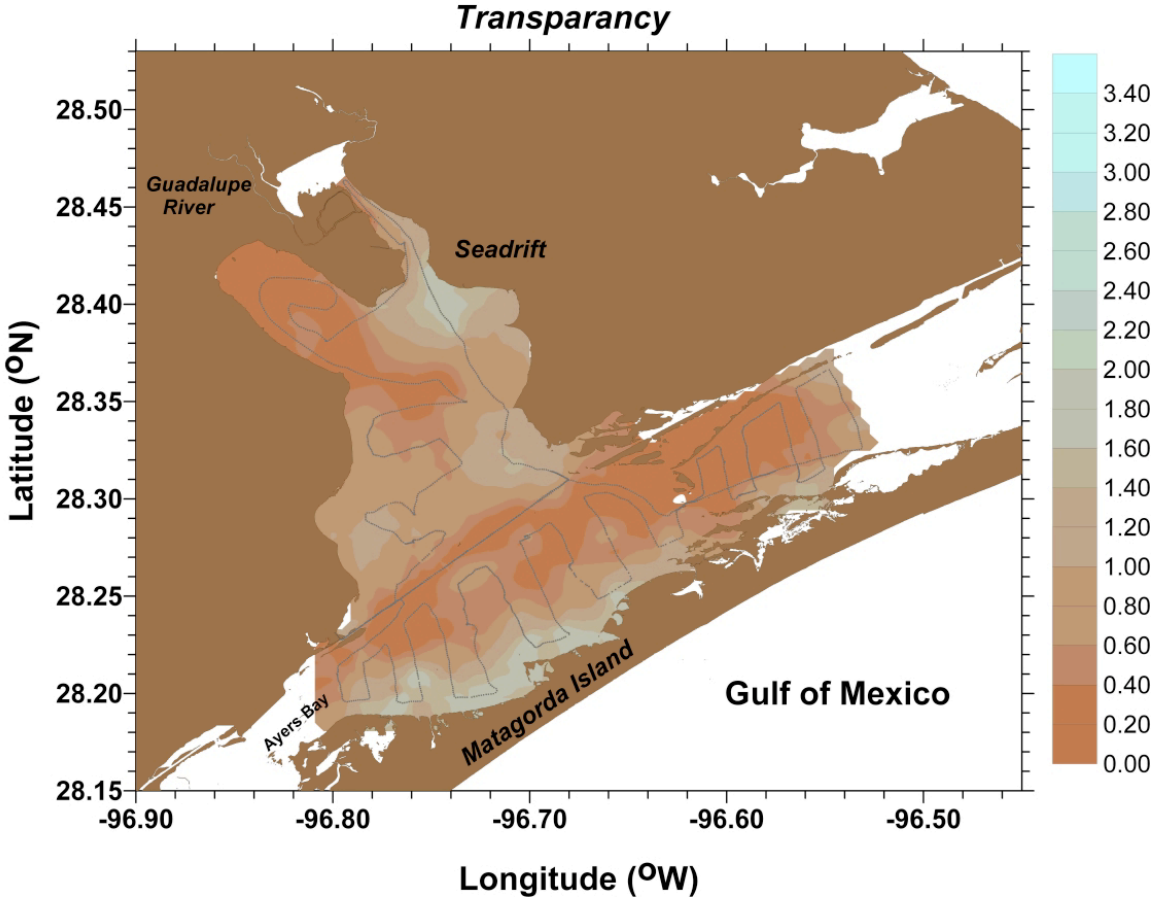
San Antonio Bay, January 06



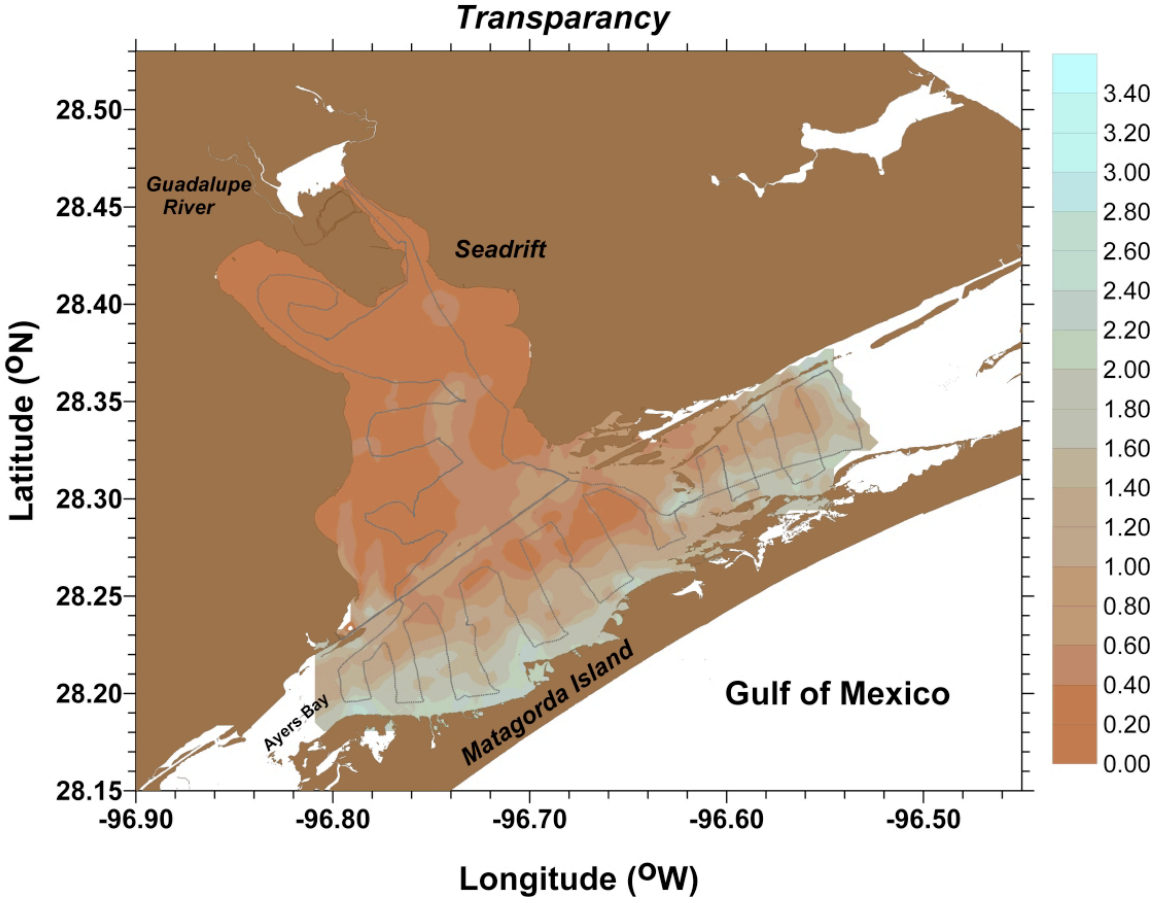
San Antonio Bay, February 06



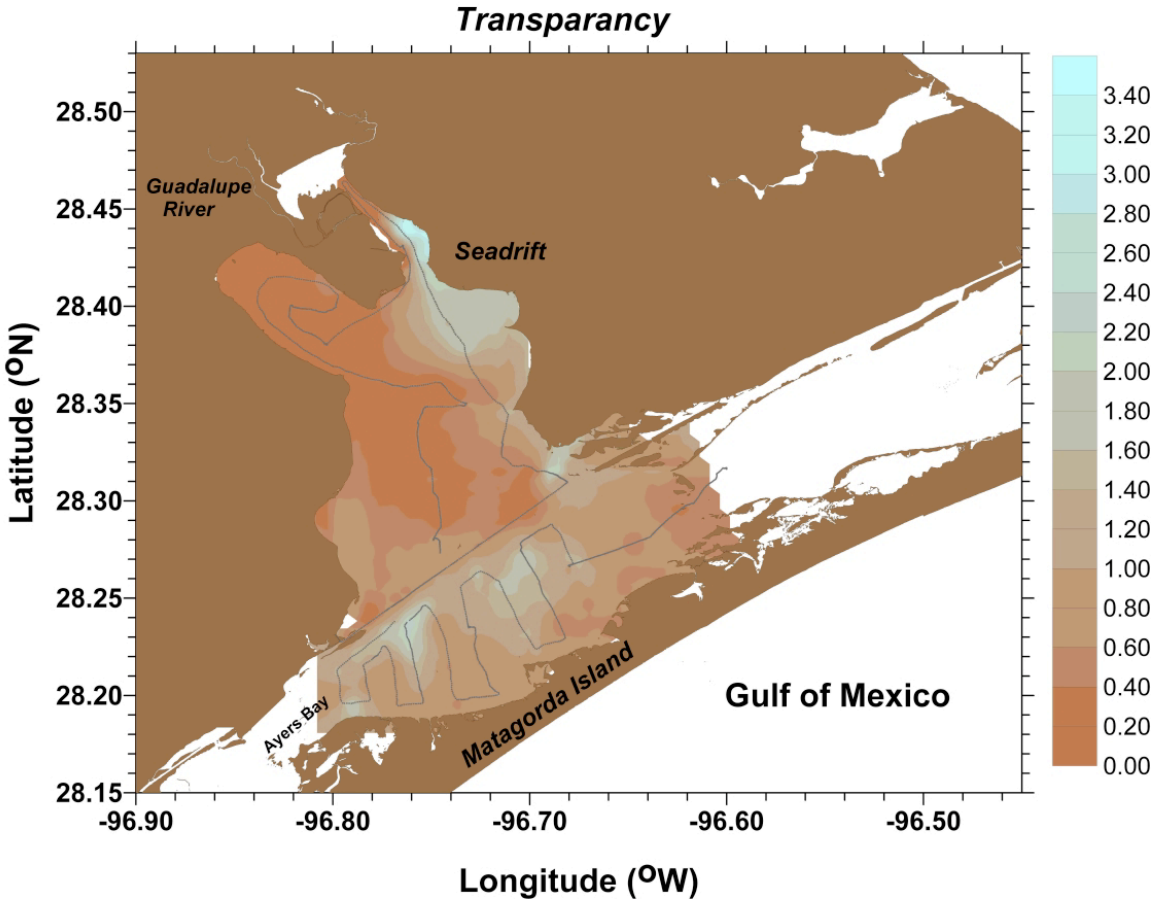
San Antonio Bay, April 06



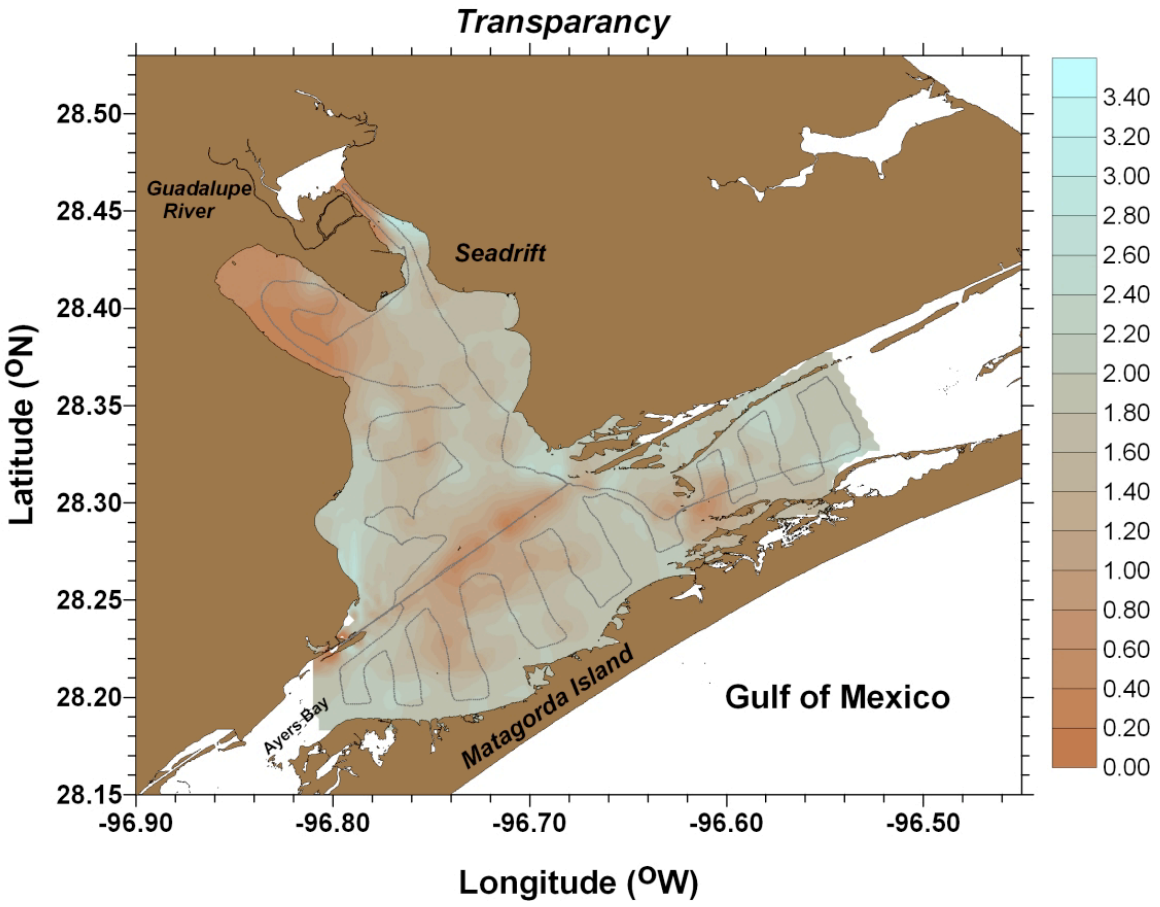
San Antonio Bay, May 06



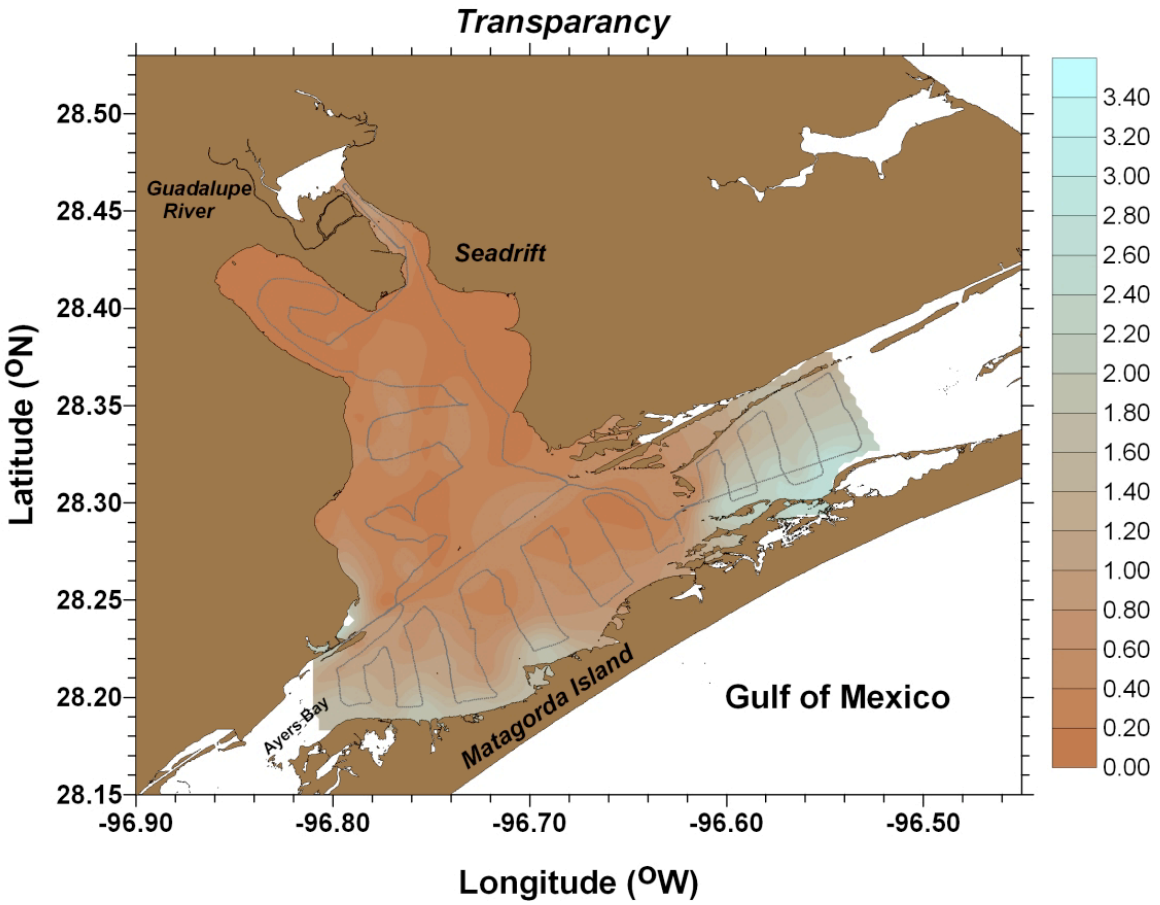
San Antonio Bay, June 06



San Antonio Bay, July 06

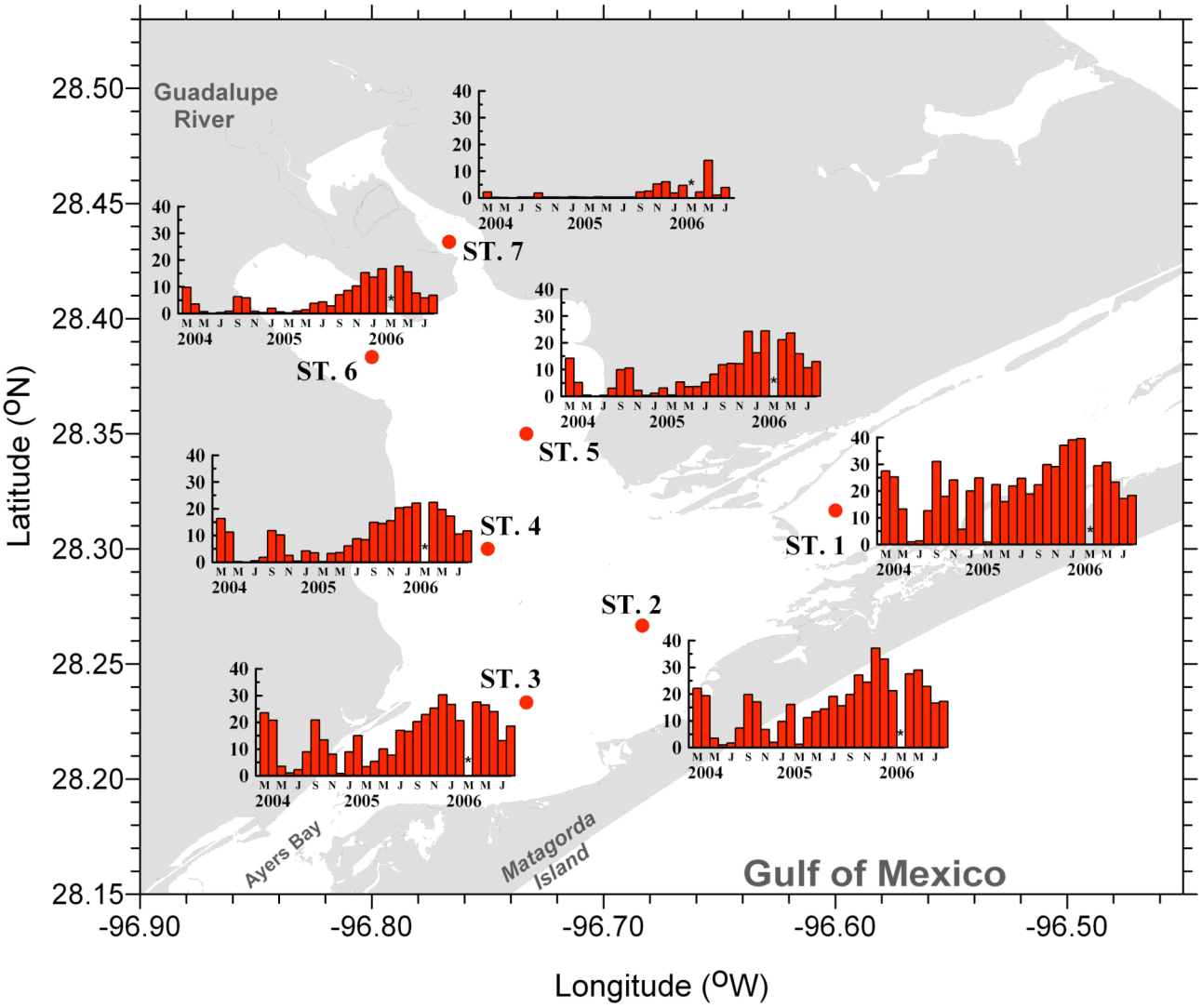


San Antonio Bay, August 06

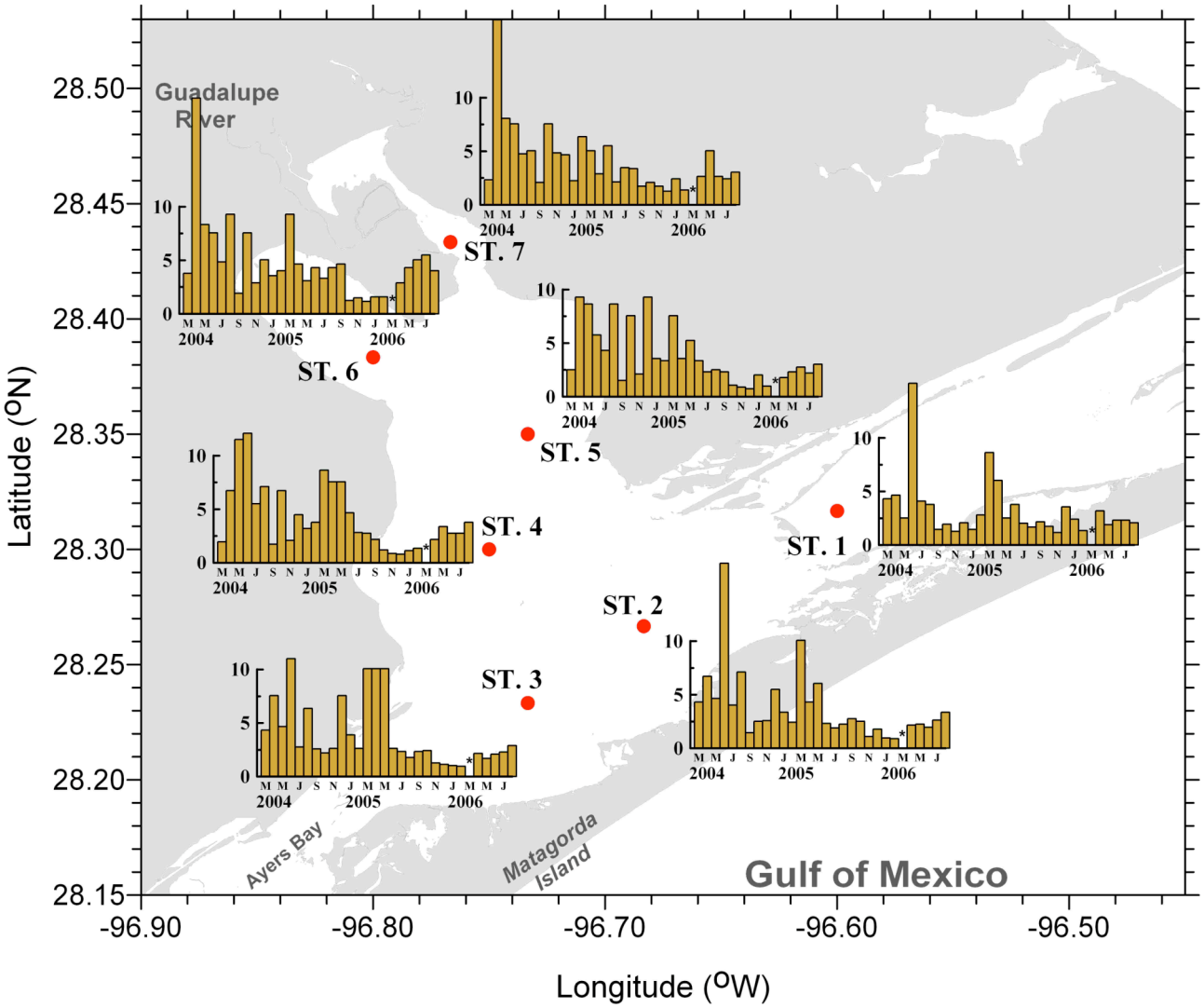


Fixed Station Data across all samplings

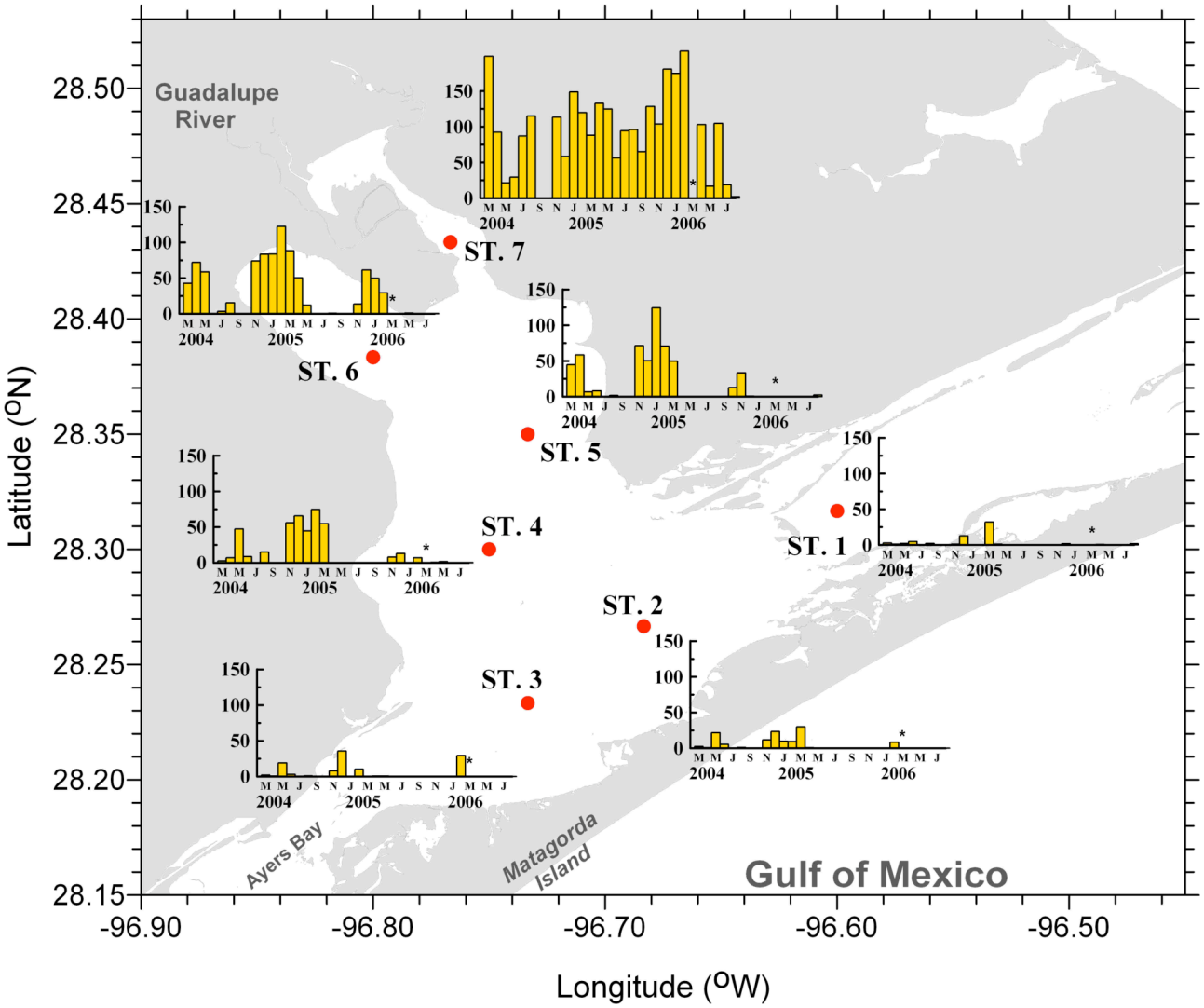
Salinity
(ppt)



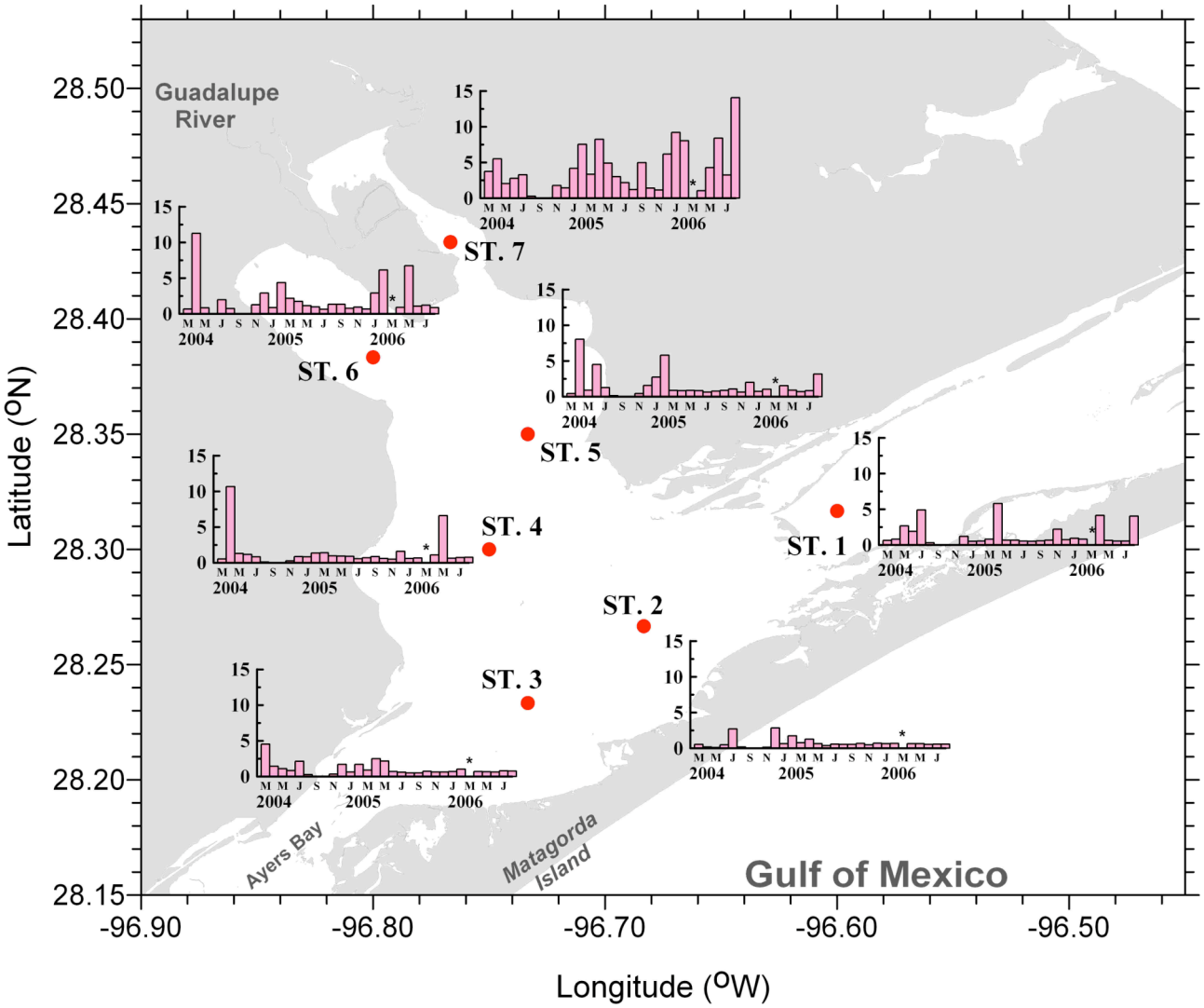
Light Attenuation
(m^{-1})



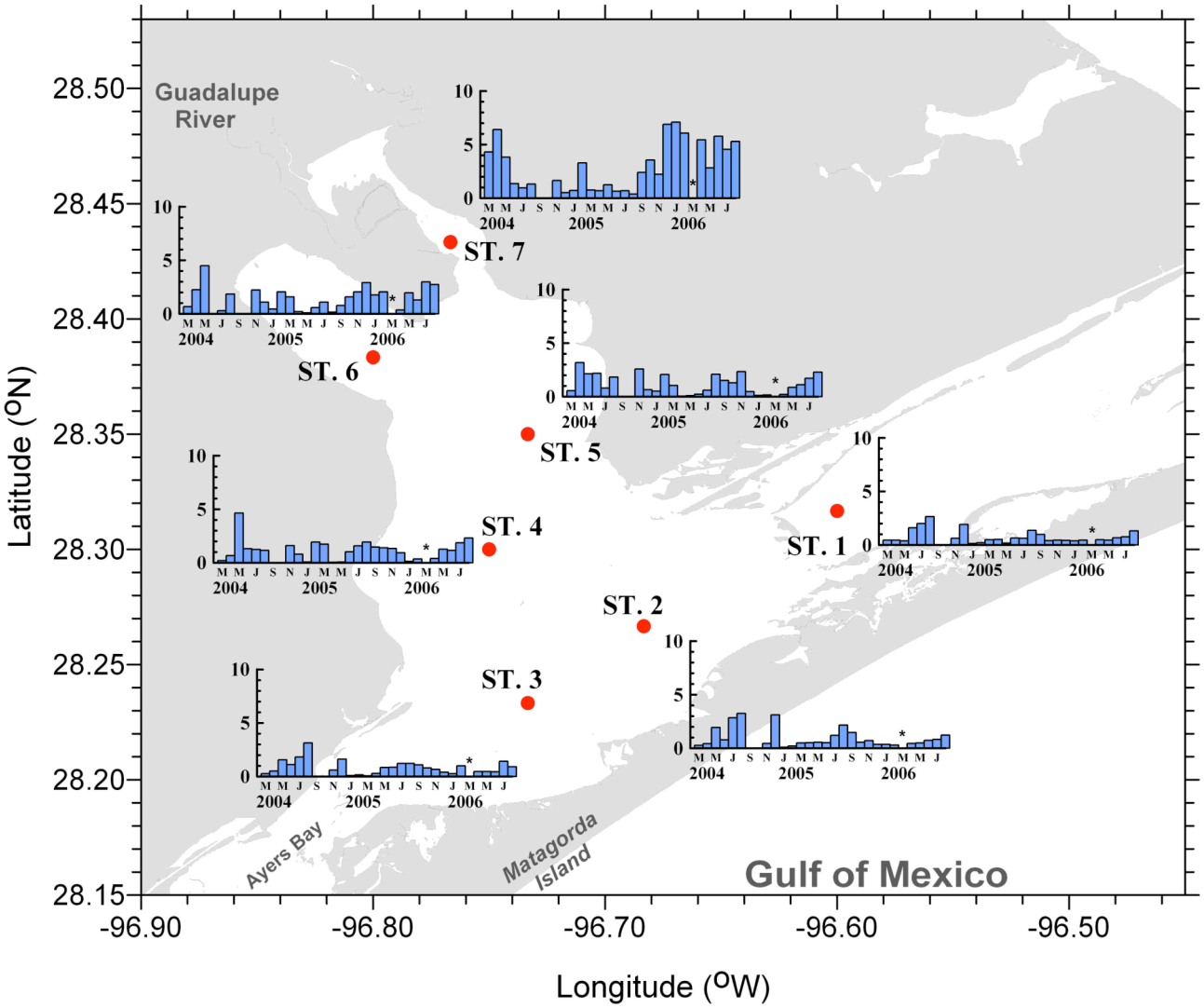
Nitrate *plus* Nitrite
(µM)



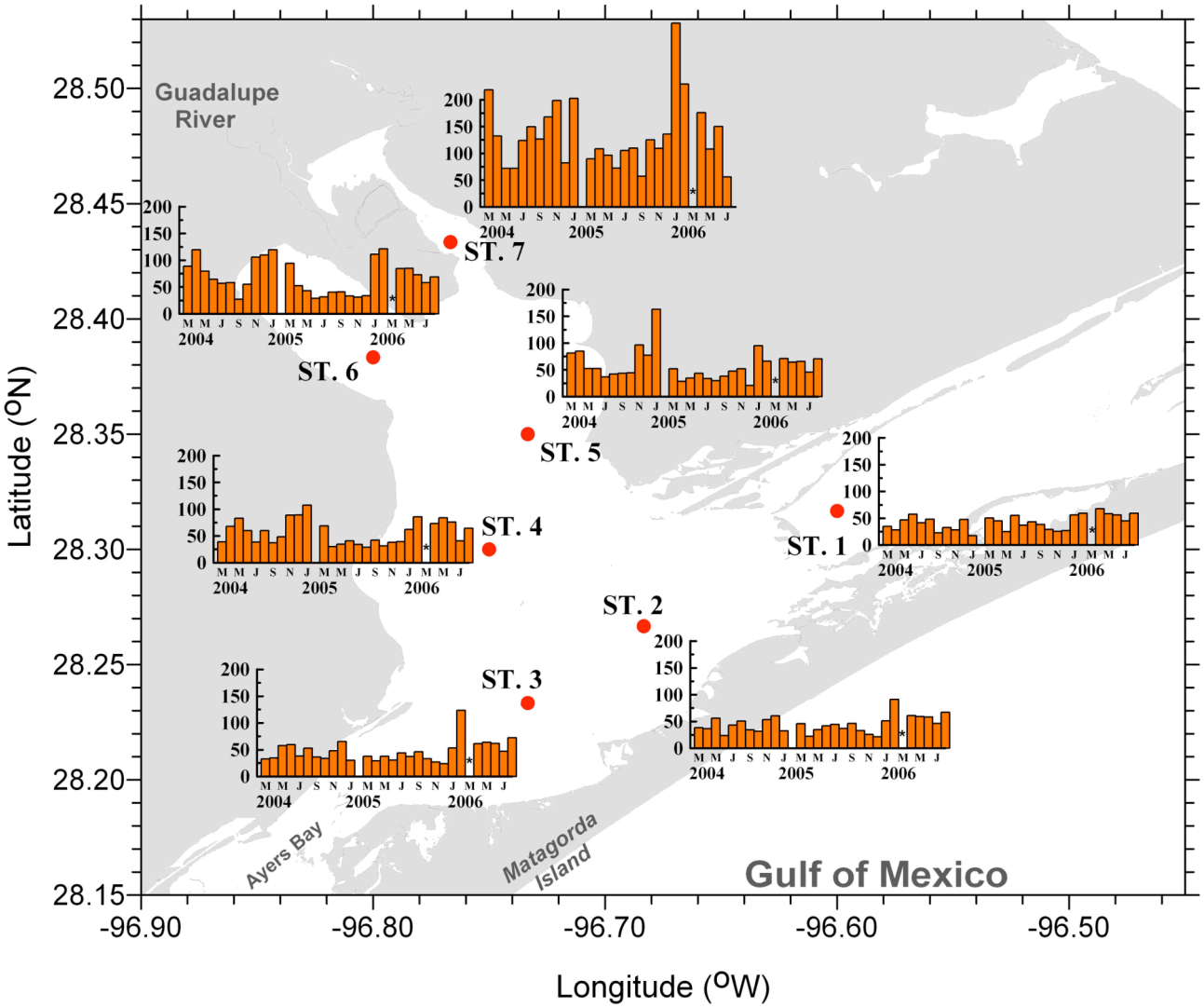
Ammonium
(µM)


Guadalupe River
ST. 7
ST. 6
ST. 5
ST. 4
ST. 3
ST. 2
ST. 1
Ayers Bay
Matagorda Island
Gulf of Mexico
Latitude (°N)
Longitude (°W)
28.50
28.45
28.40
28.35
28.30
28.25
28.20
28.15
-96.90
-96.80
-96.70
-96.60
-96.50
M M J S N J M M J S N J M M J
2004
2005
2006

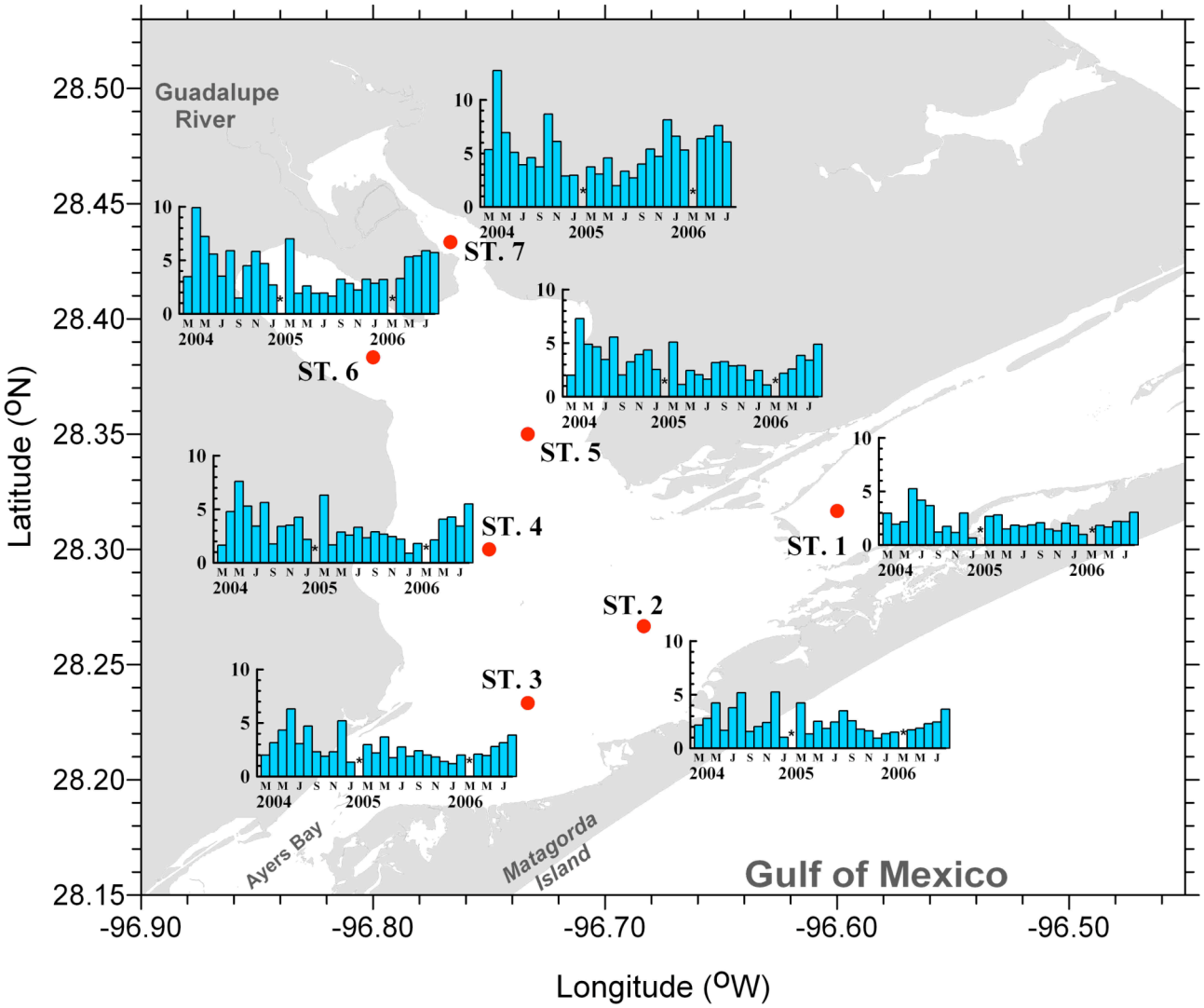
Orthophosphate
(µM)



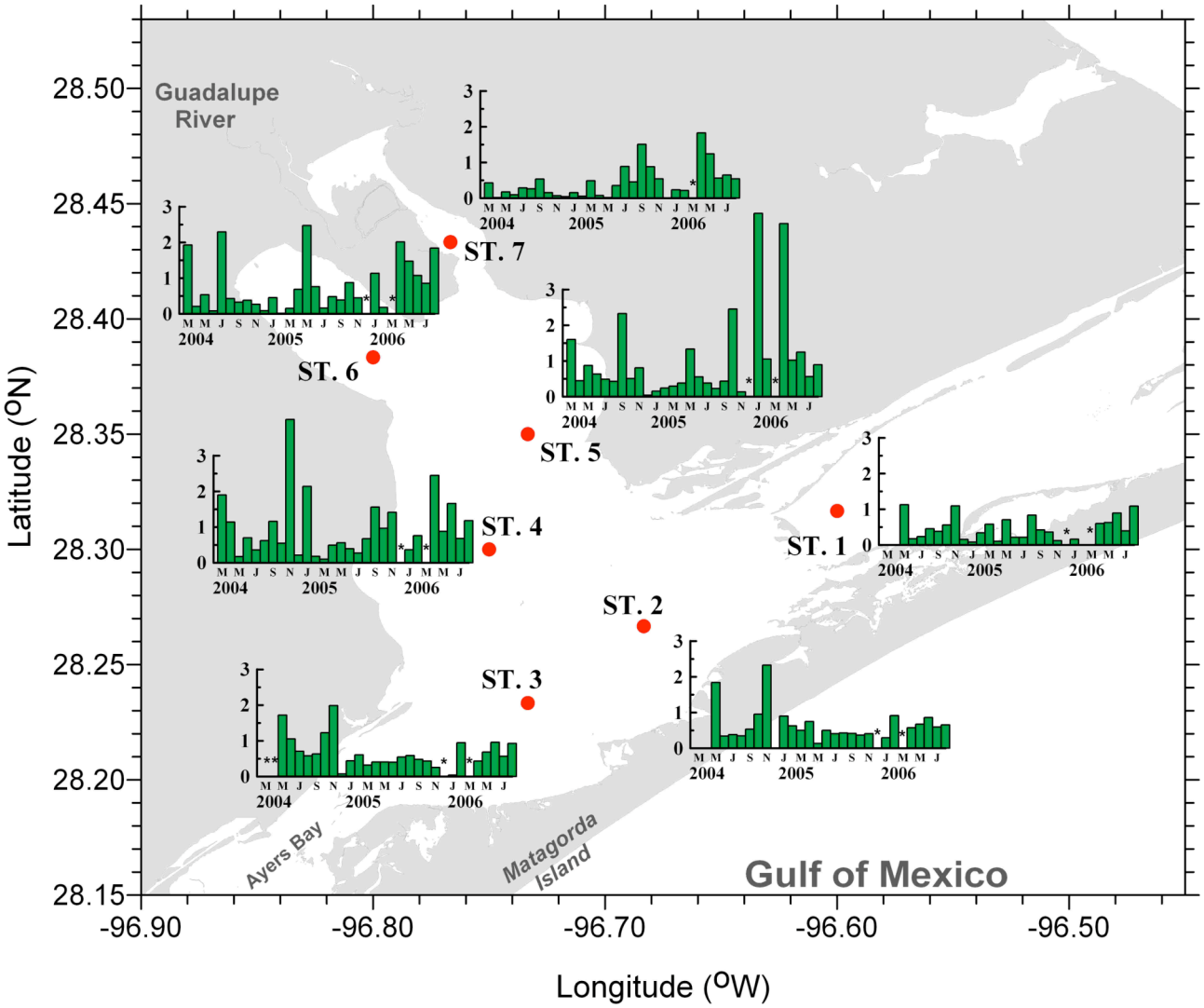
Total Nitrogen
(µM)



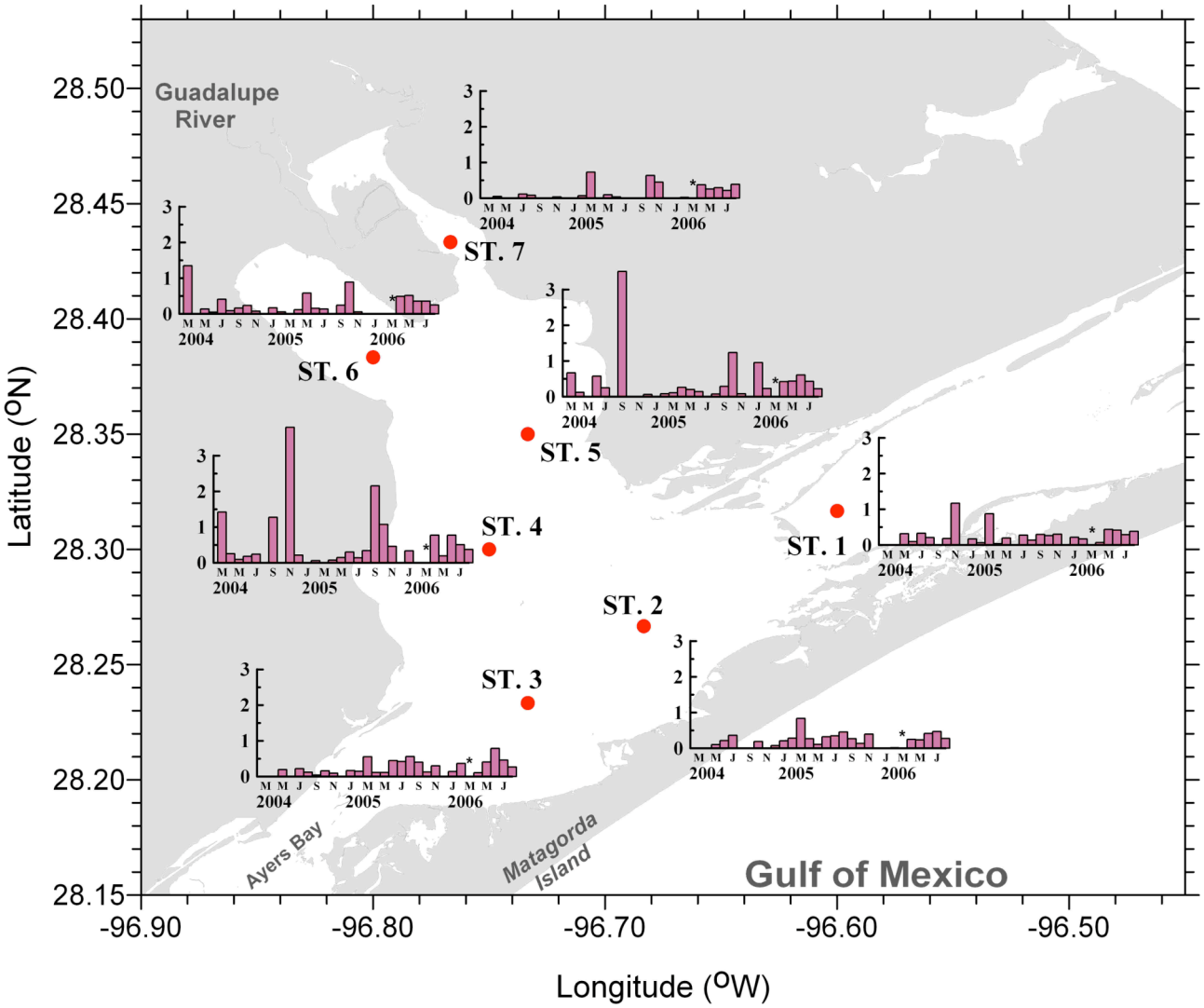
Total Phosphorus
(µM)



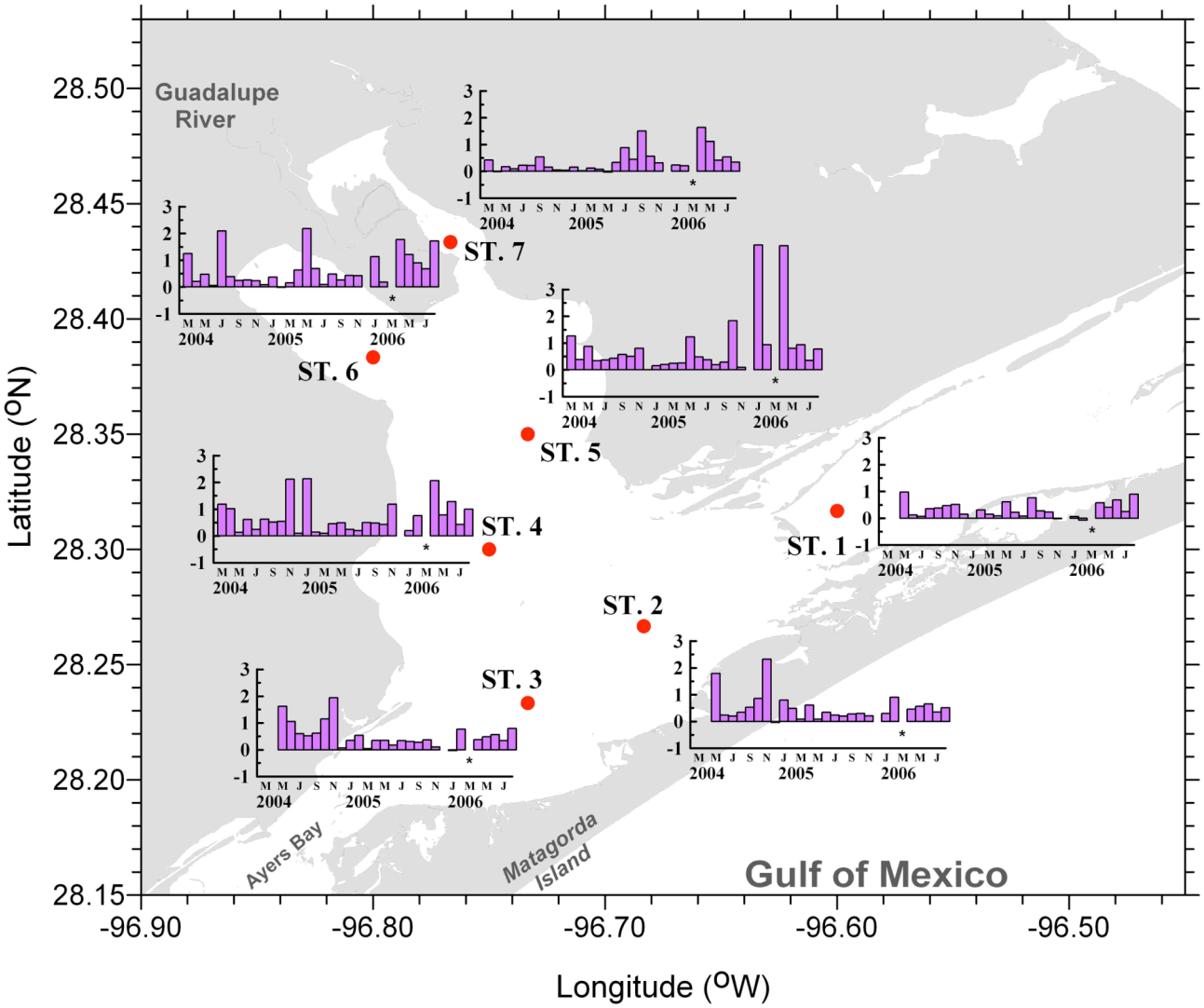
Gross Productivity
(gC m^{-2} d^{-1})



Respiration
(gC m^{-2} d^{-1})



Net Productivity
(gC m^{-2} d^{-1})



Contour Plots of Fixed Station Nutrients

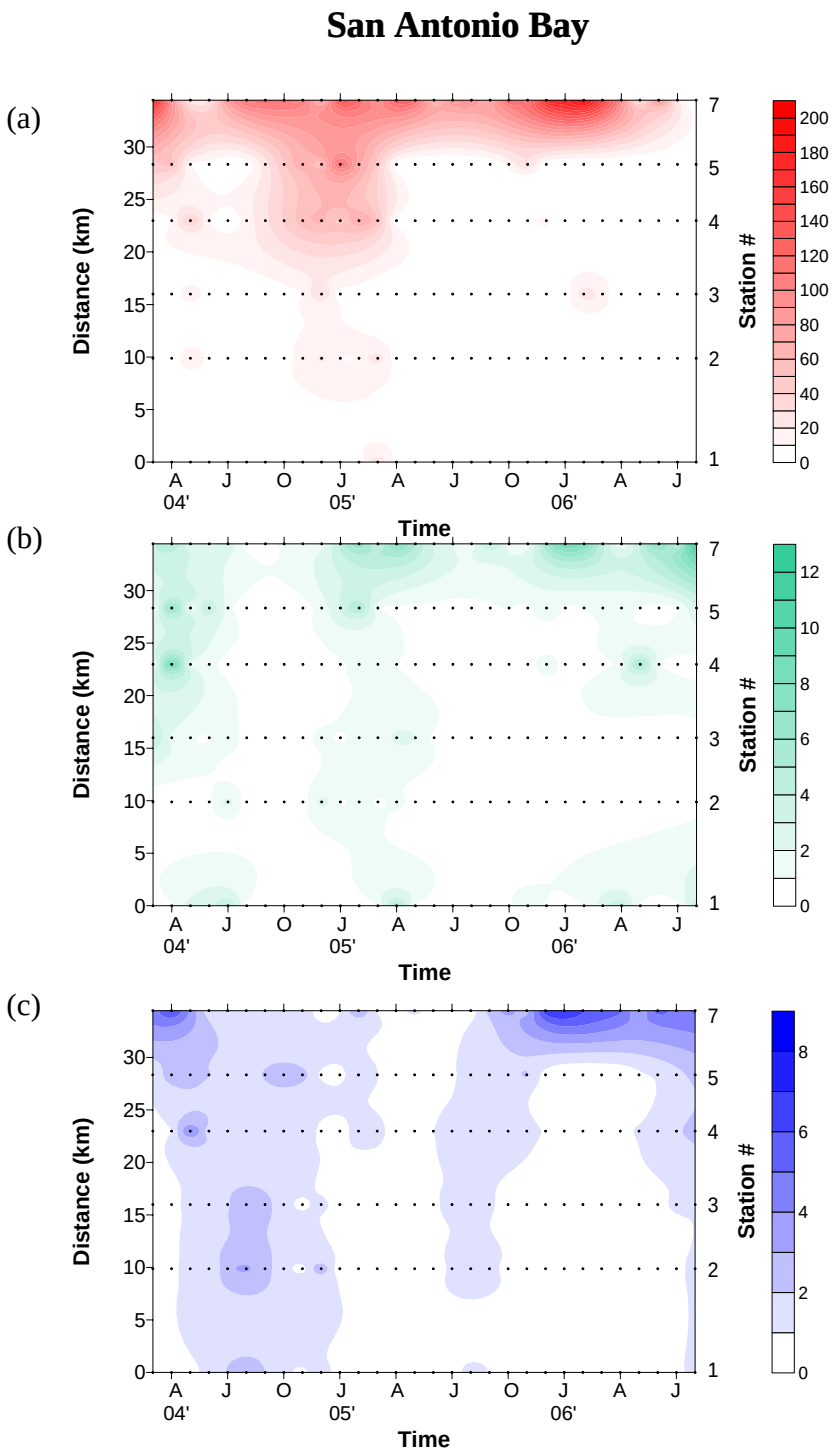


Figure 1 Inorganic nutrient spatial and temporal contour from March, 2004 to Aug, 2006. (a) Nitrate plus nitrite (μM); (b) Ammonium (μM); (c) Orthophosphate (μM).

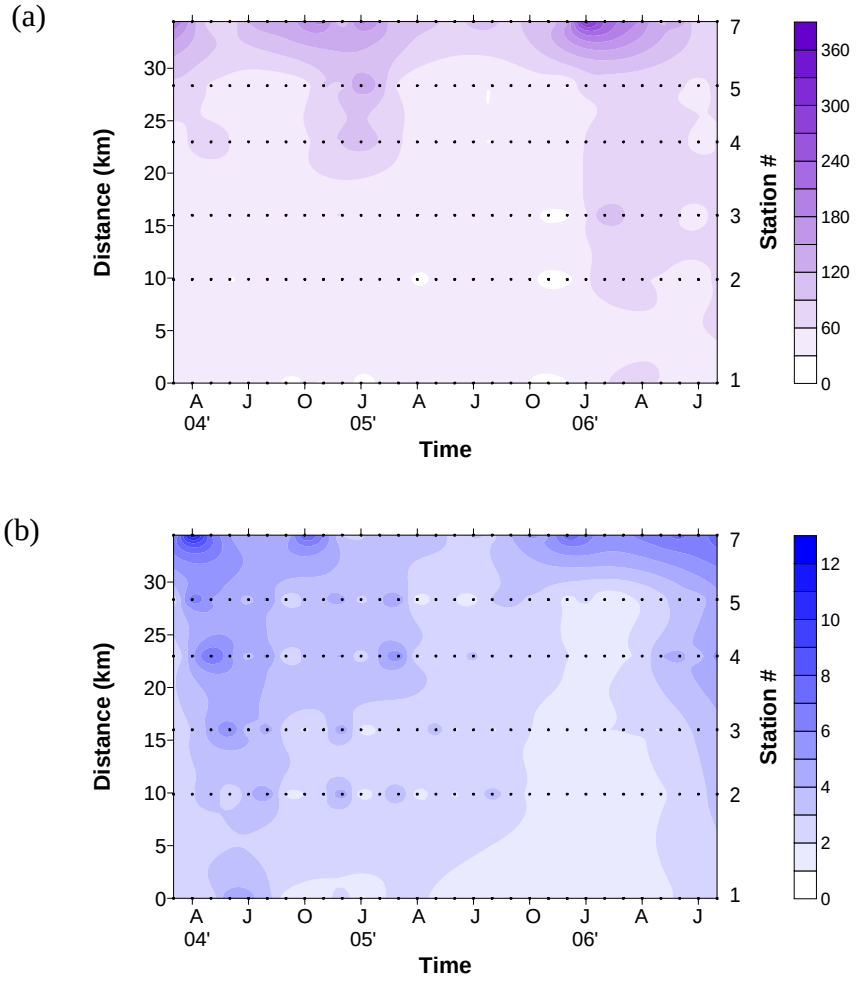


Figure 2 Total Nitrogen (TN) and phosphorous (TP) spatial and temporal contour from March, 2004 to Aug, 2006. (a) TN (μM); (b) TP (μM).

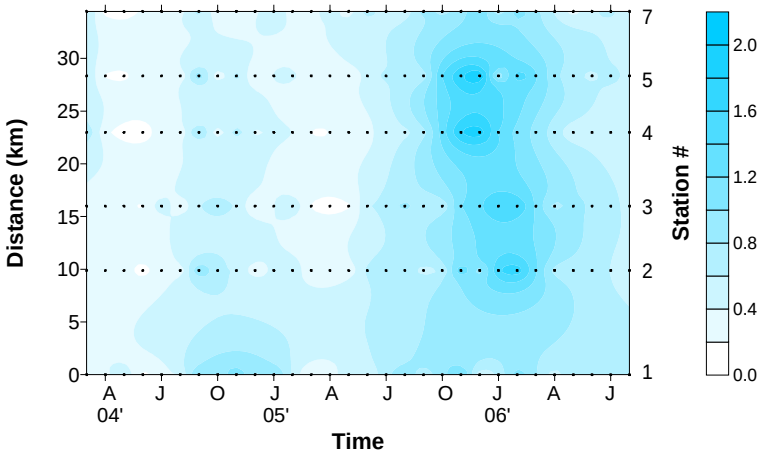


Figure 3 Secchi depth (m) spatial and temporal contour from March, 2004 to Aug, 2006.

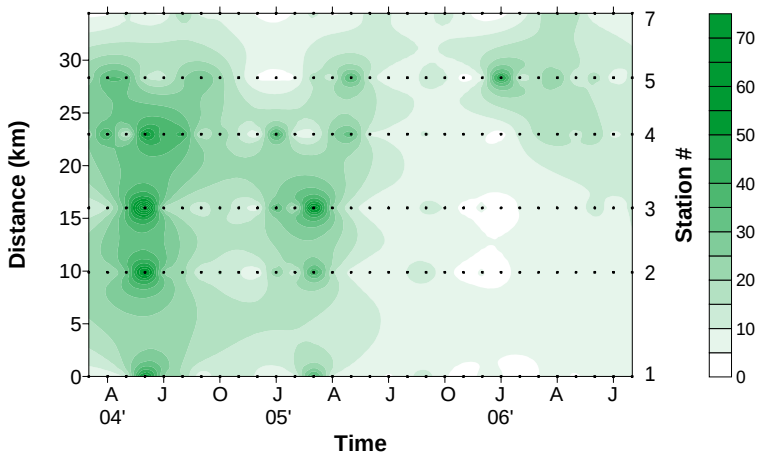


Figure 4 Chlorophyll *a* concentration (μg L^{-1}) spatial and temporal contour from March, 2004 to Aug, 2006.

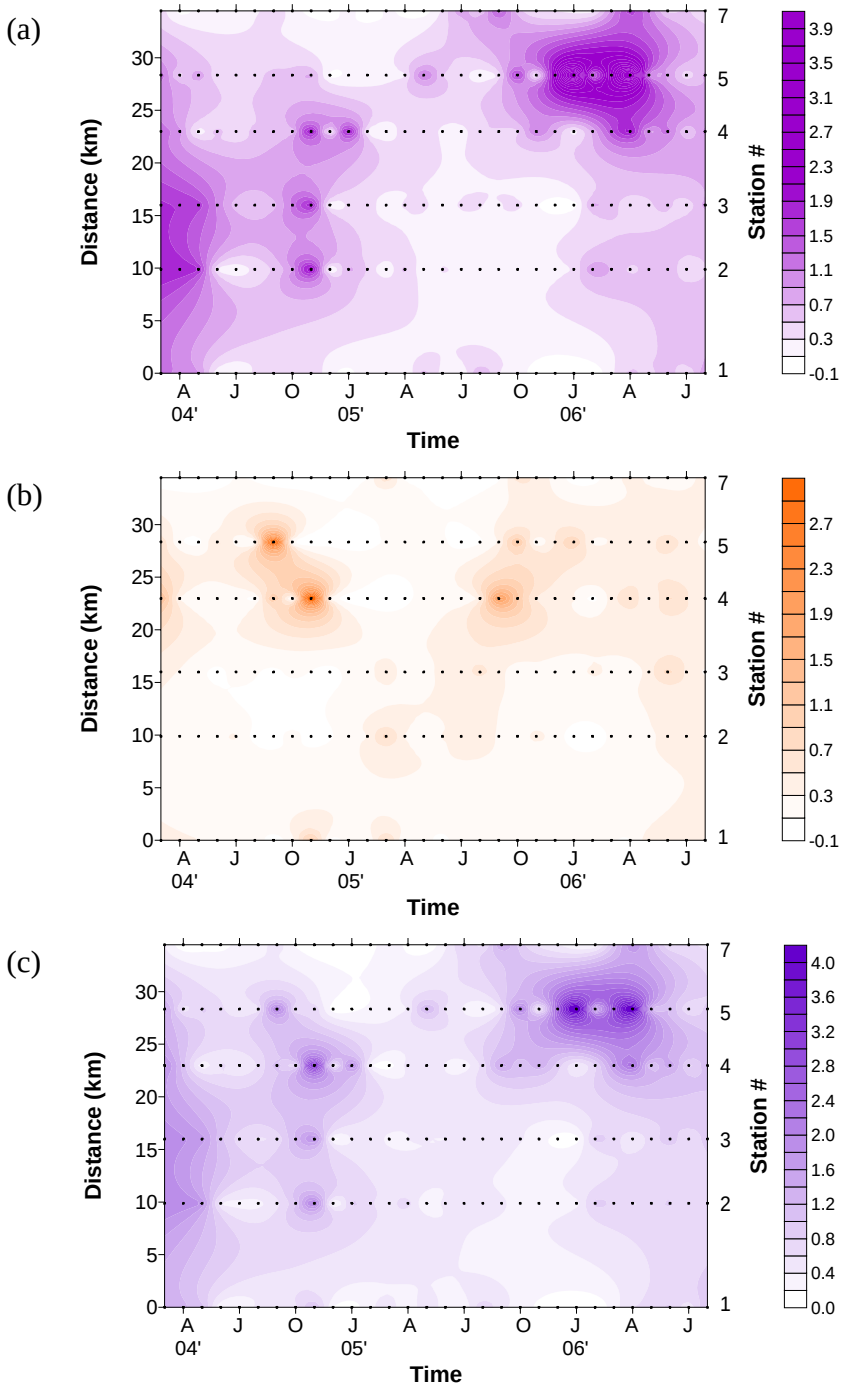


Figure 5 Producutivity (gC m^{-2} d^{-1}) contour from March, 2004 to Aug, 2006. (a) Net productivity; (b) Respiration; (c) Gross Productivity.

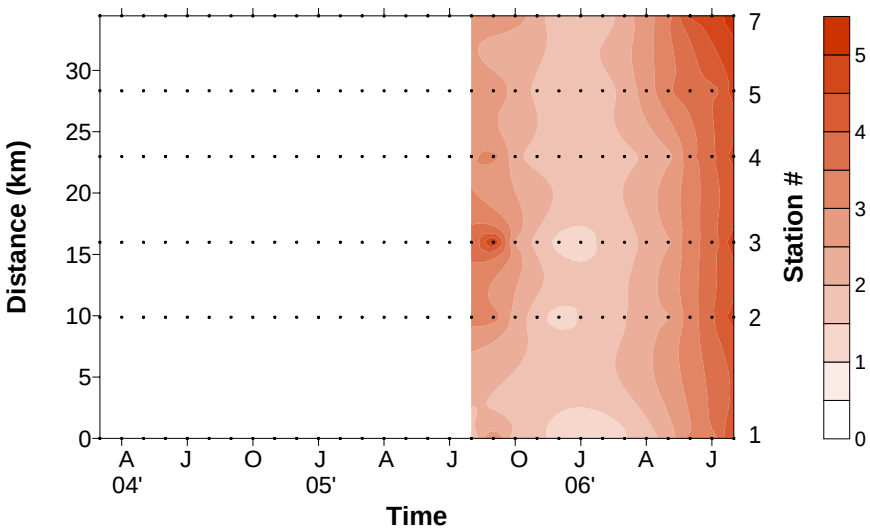


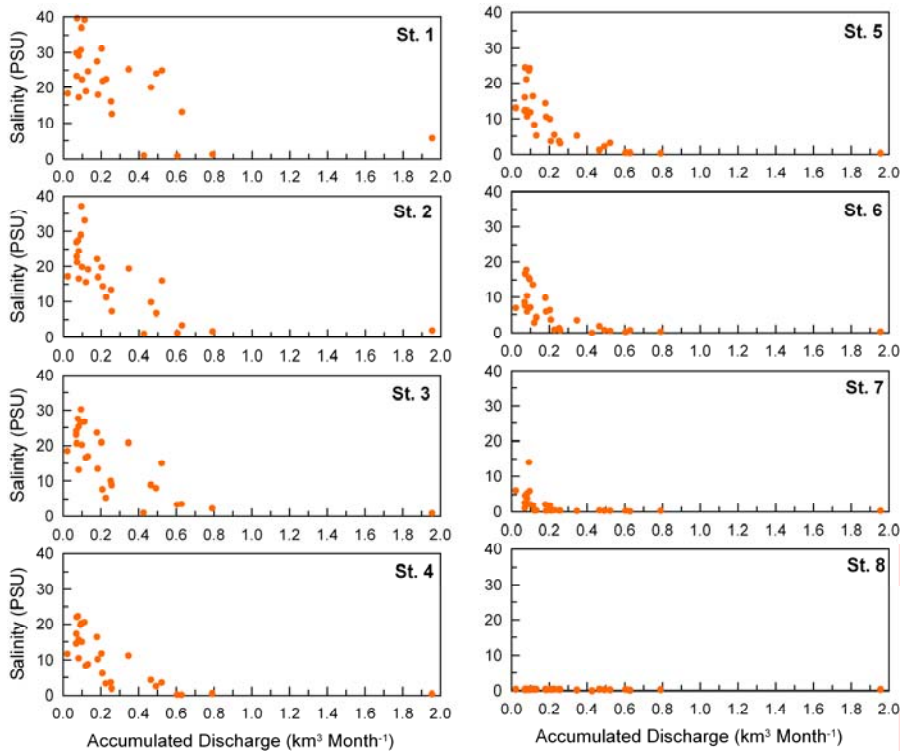
Figure 6 Dissolved organic carbon (mgC L^{-1}) spatial and temporal contour.

Relationships between flow and fixed station data

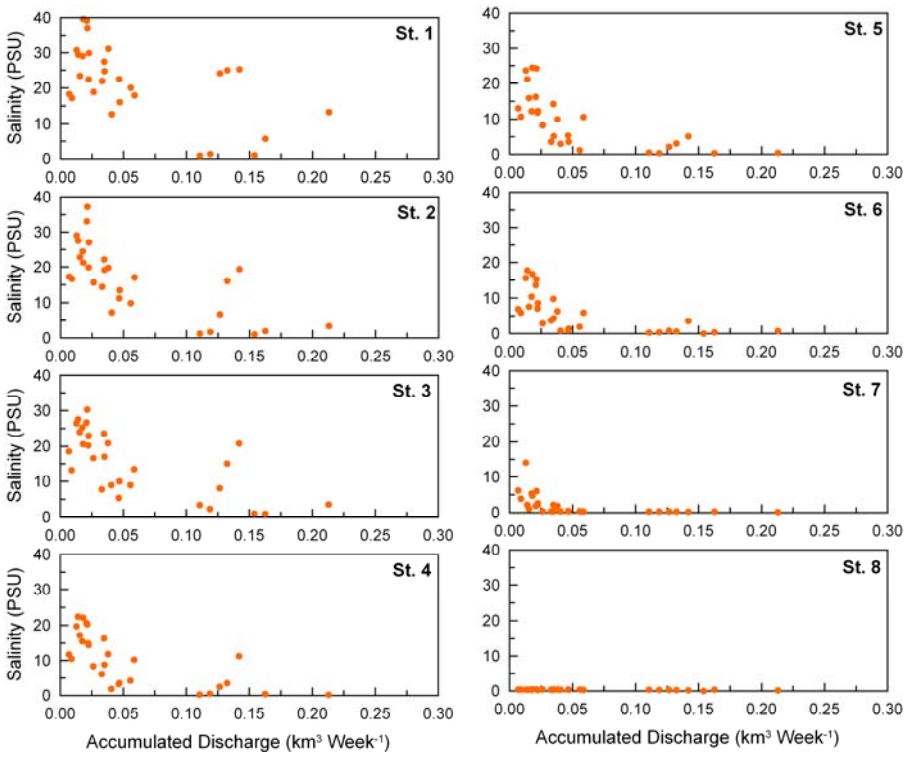
San Antonio Bay

Salinity v.s. Discharge

(A)



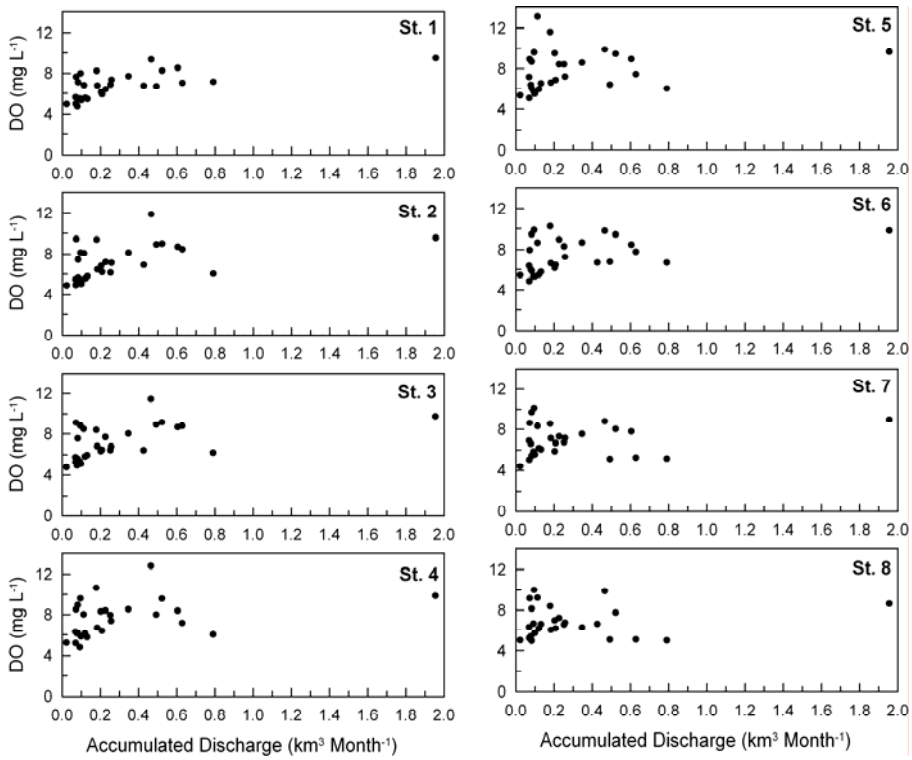
(B)



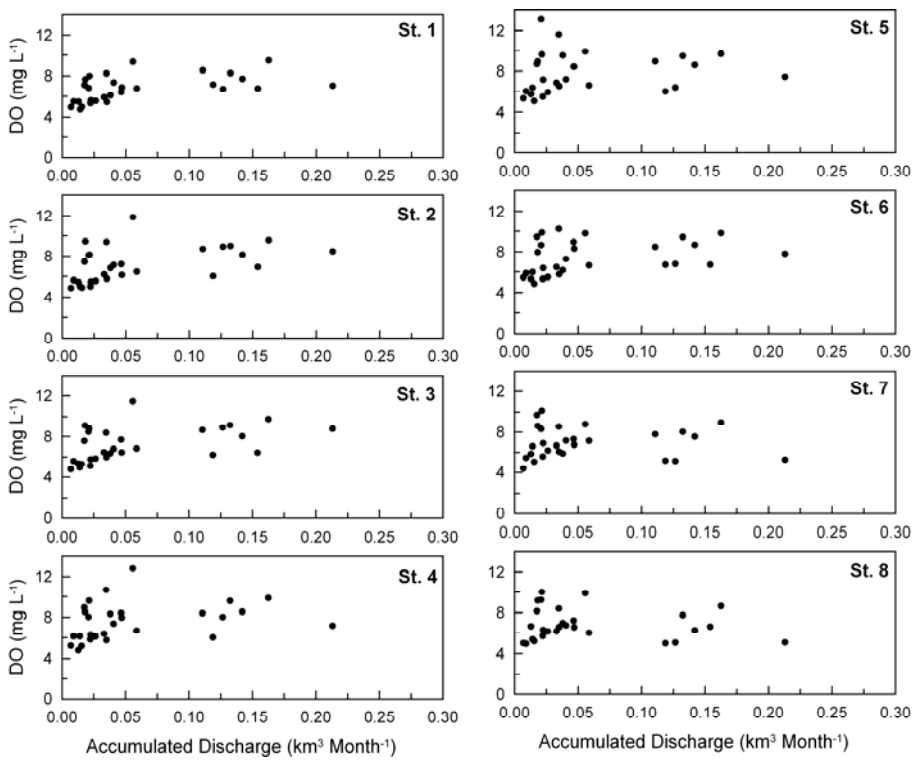
San Antonio Bay

Surface Dissolved Oxygen v.s. Discharge

(A)



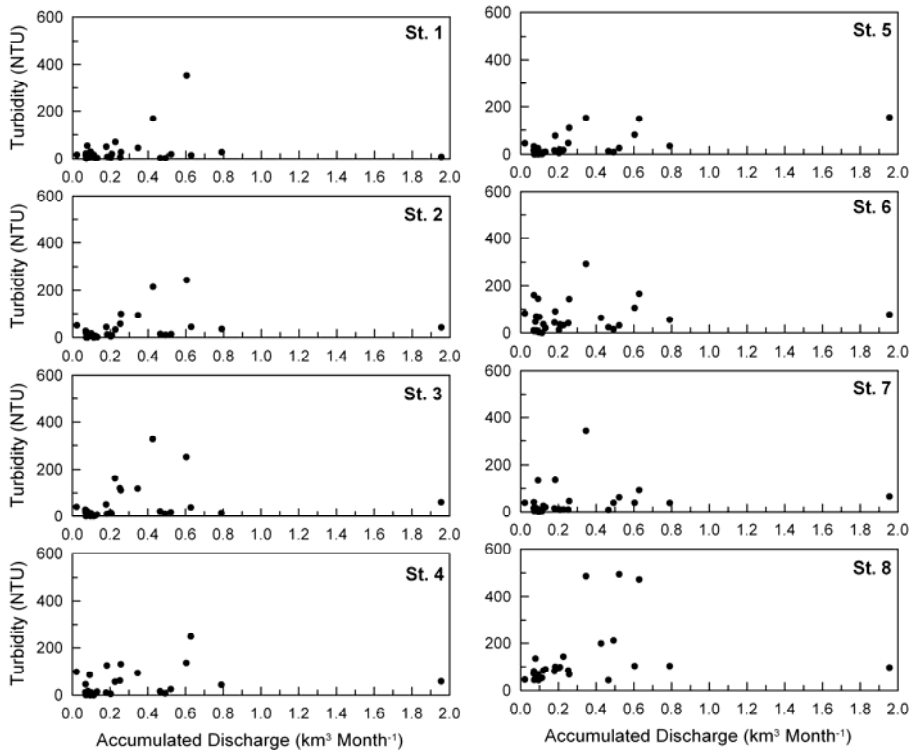
B)



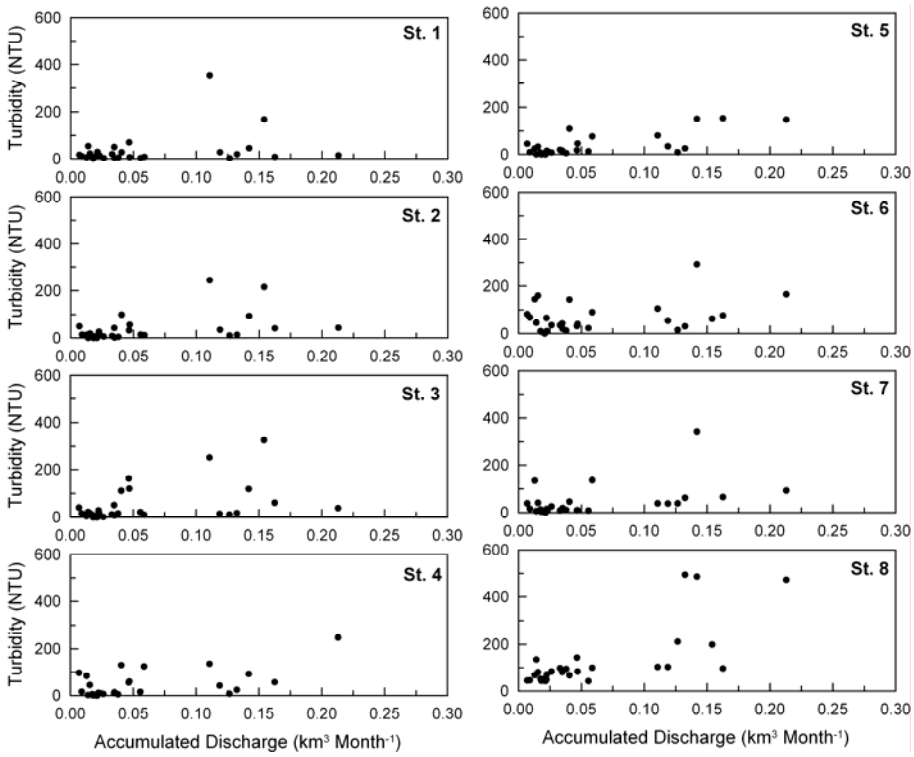
San Antonio Bay

Turbidity v.s. Discharge

(A)



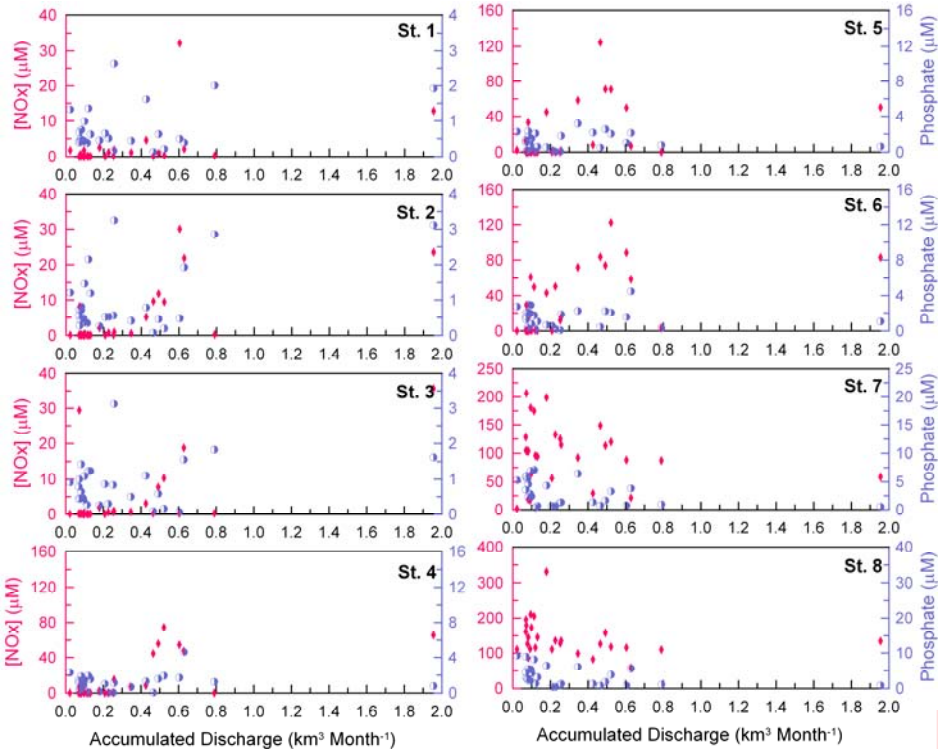
(B)



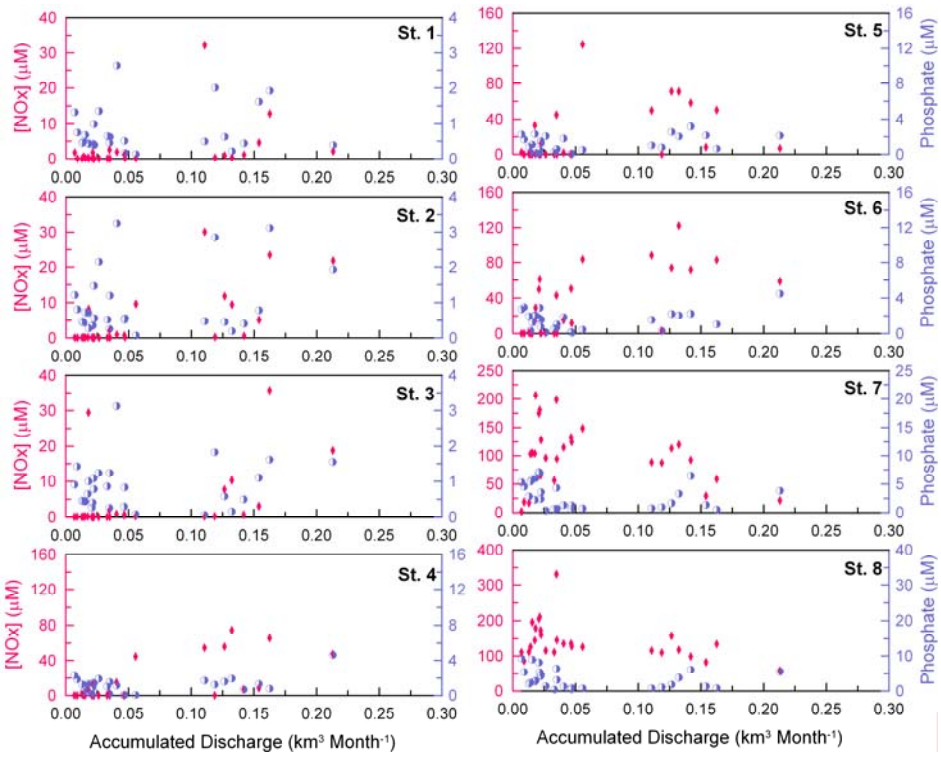
San Antonio Bay

NOx / Phosphate v.s. Discharge

(A)



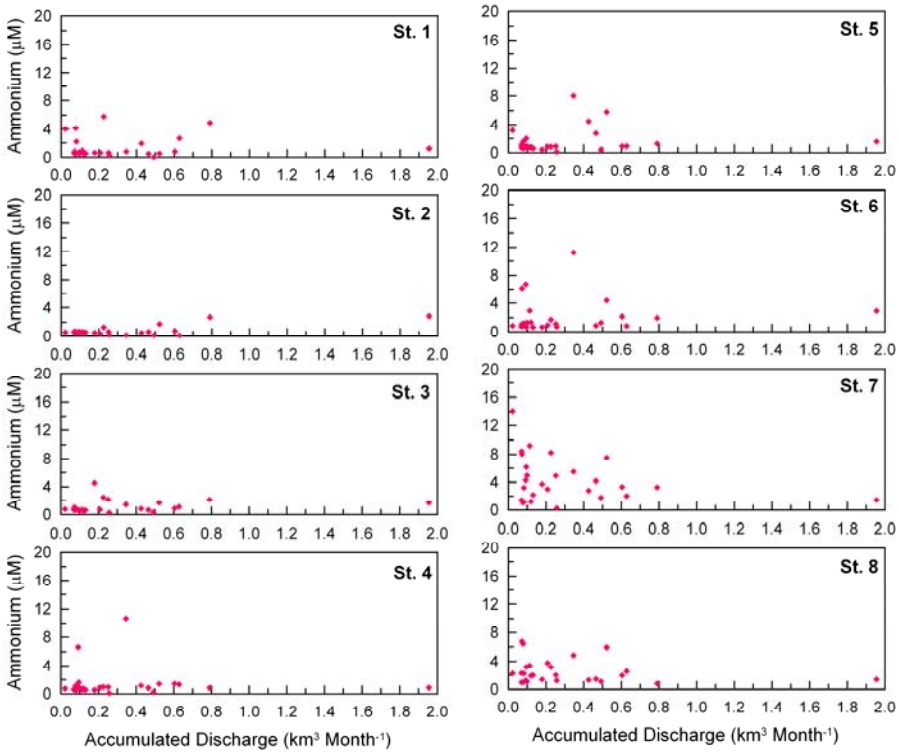
(B)



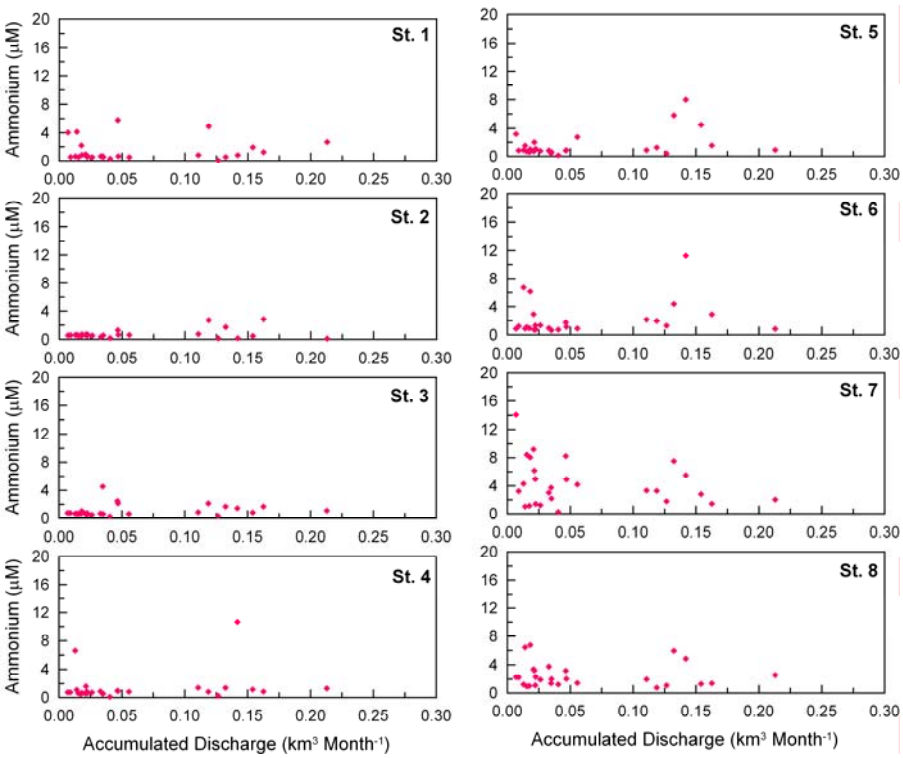
San Antonio Bay

Ammonium v.s. Discharge

(A)



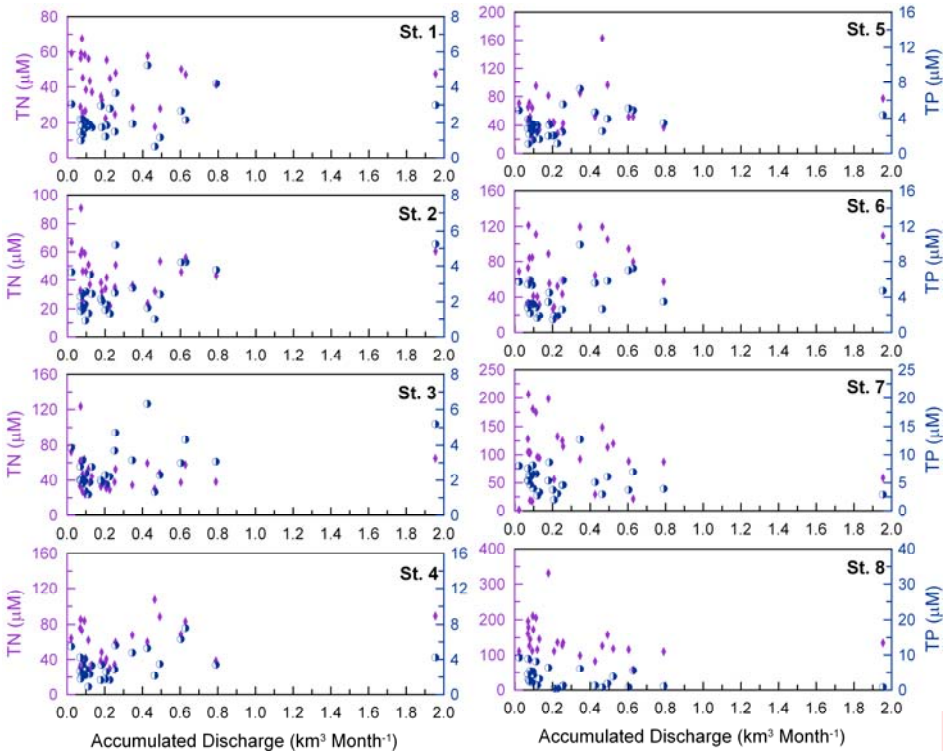
(B)



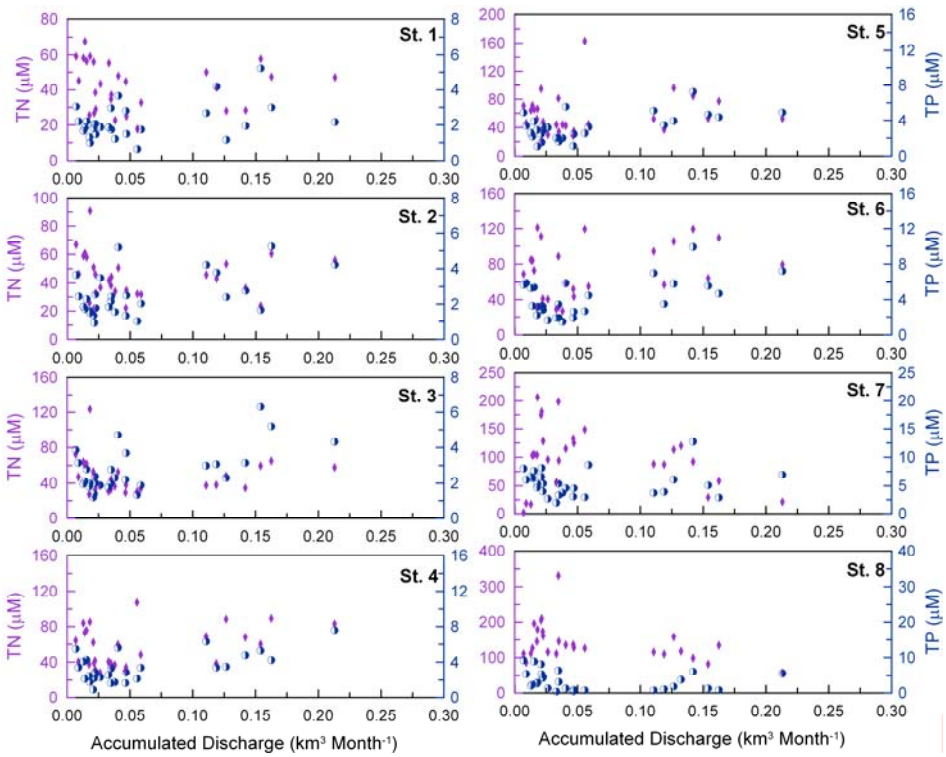
San Antonio Bay

Total Nitrogen/Phosphorus v.s. Discharge

(A)



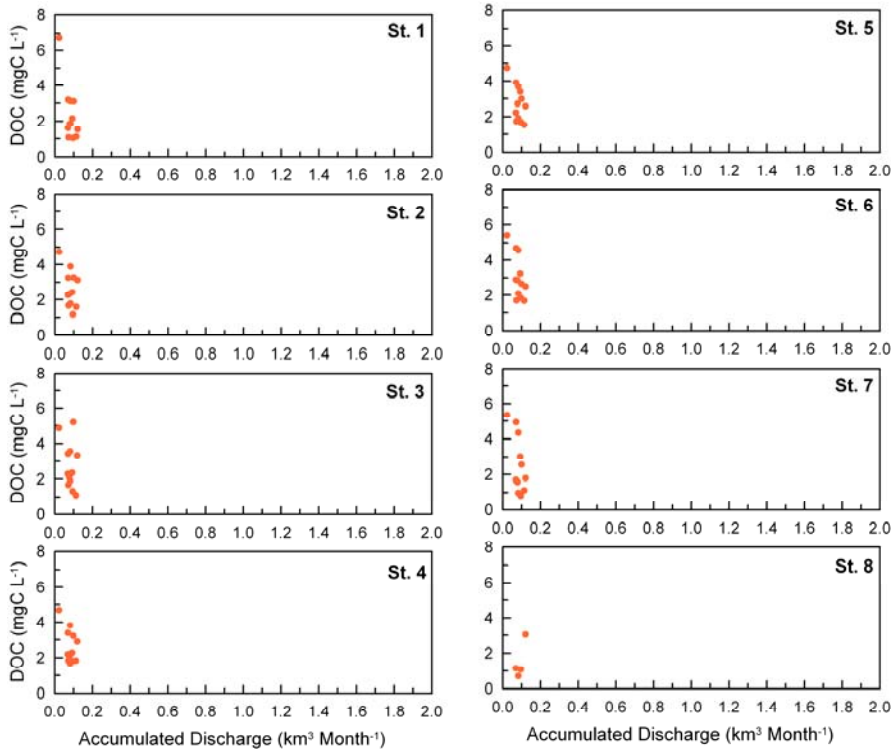
(B)



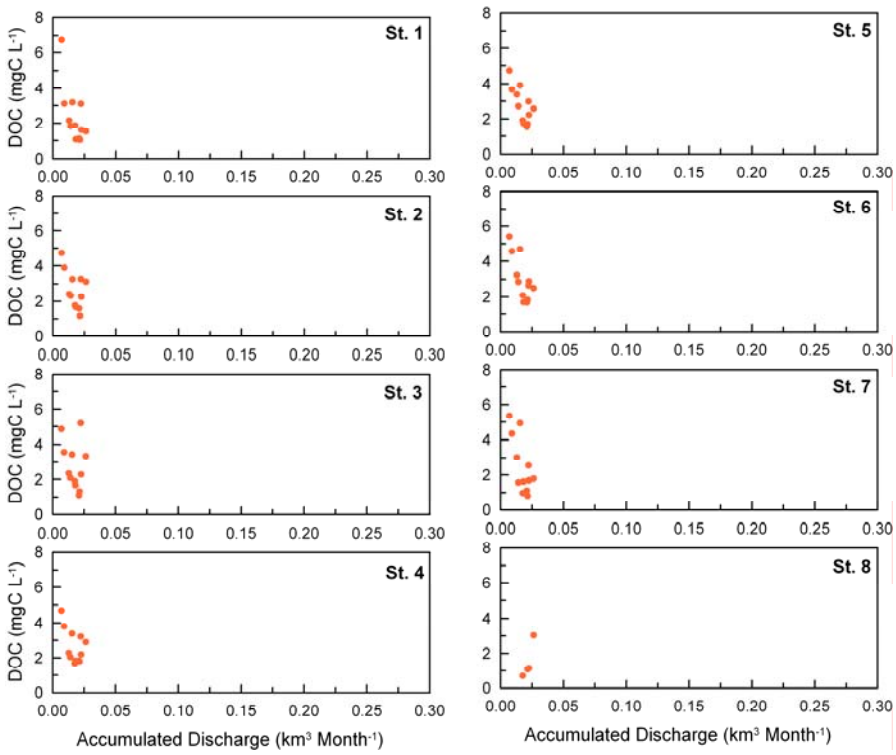
San Antonio Bay

DOC v.s. Discharge

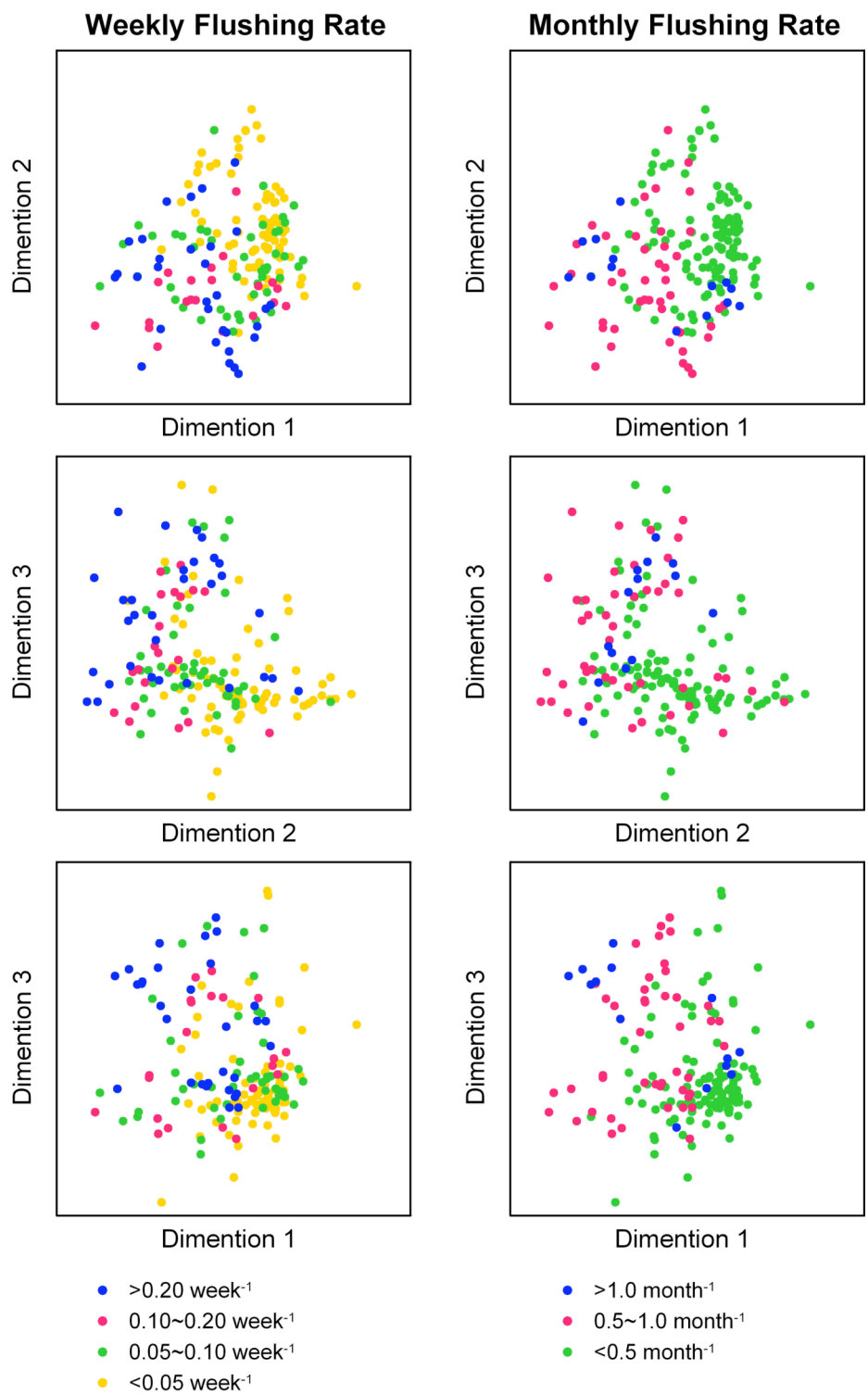
(A)



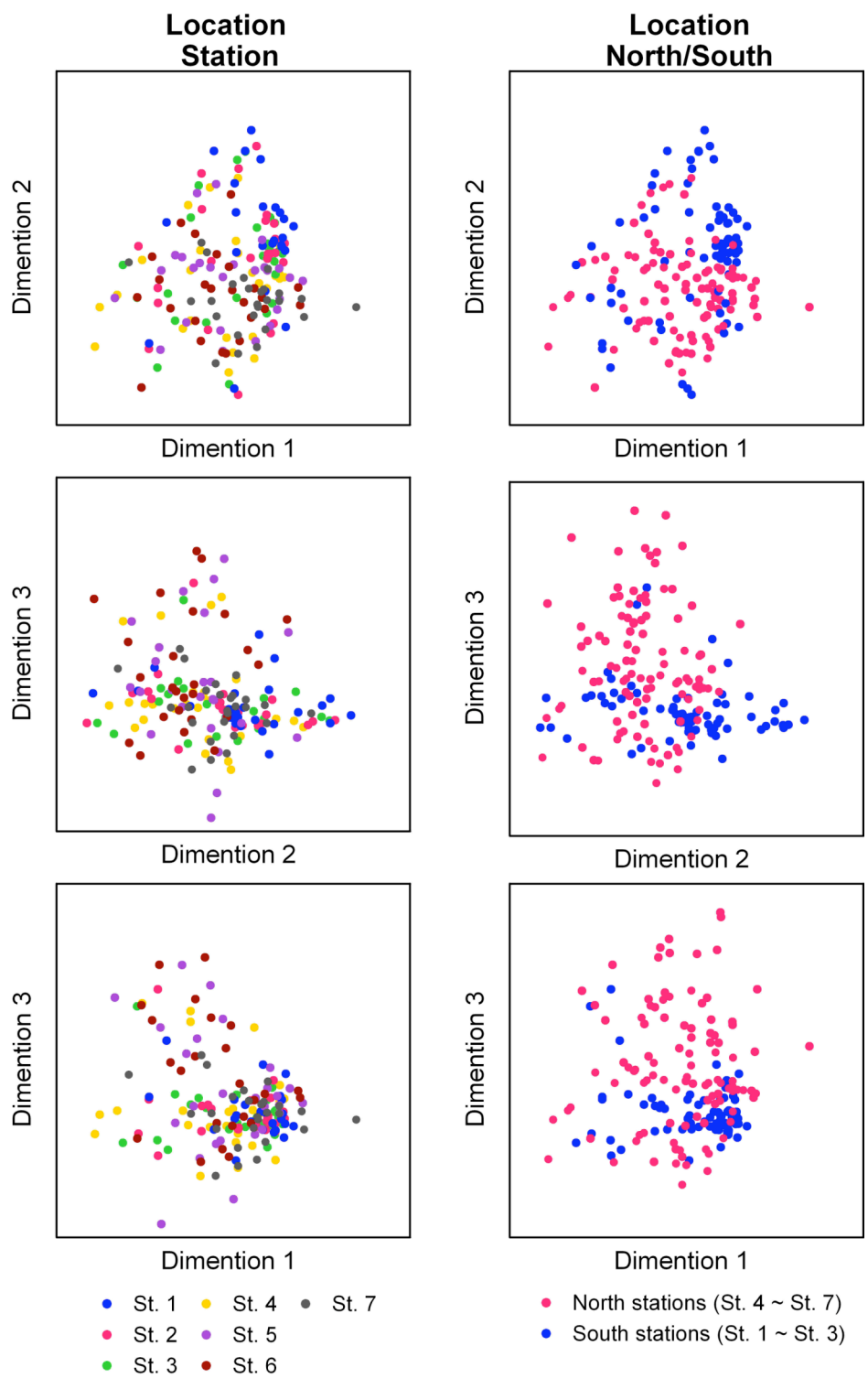
(B)



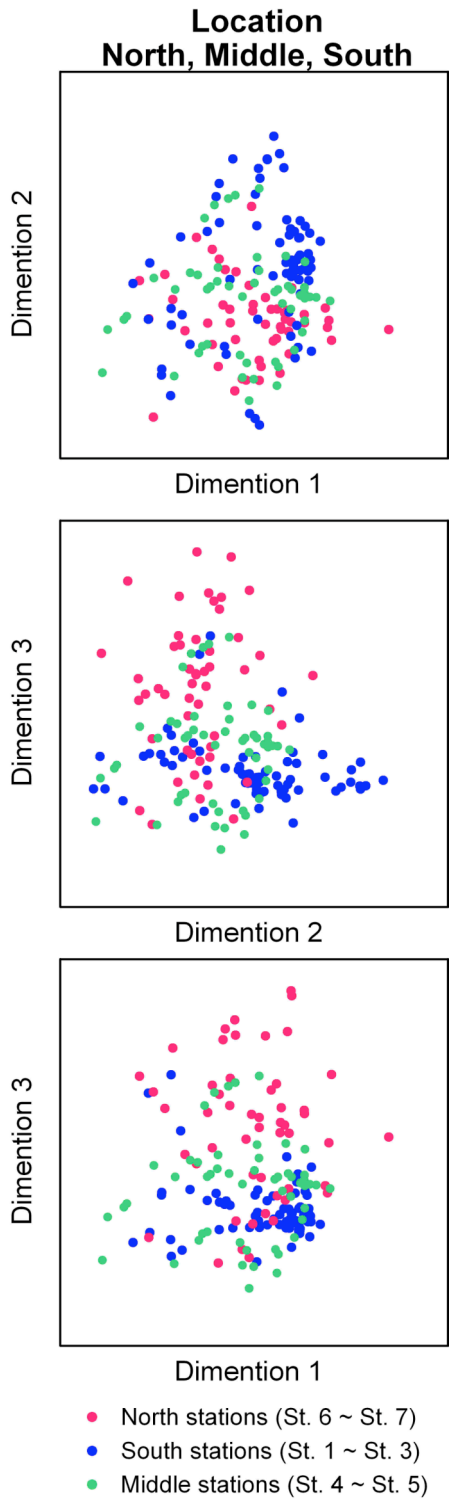
NMS output showing the clustering of sites based on flushing, location, and pulse character



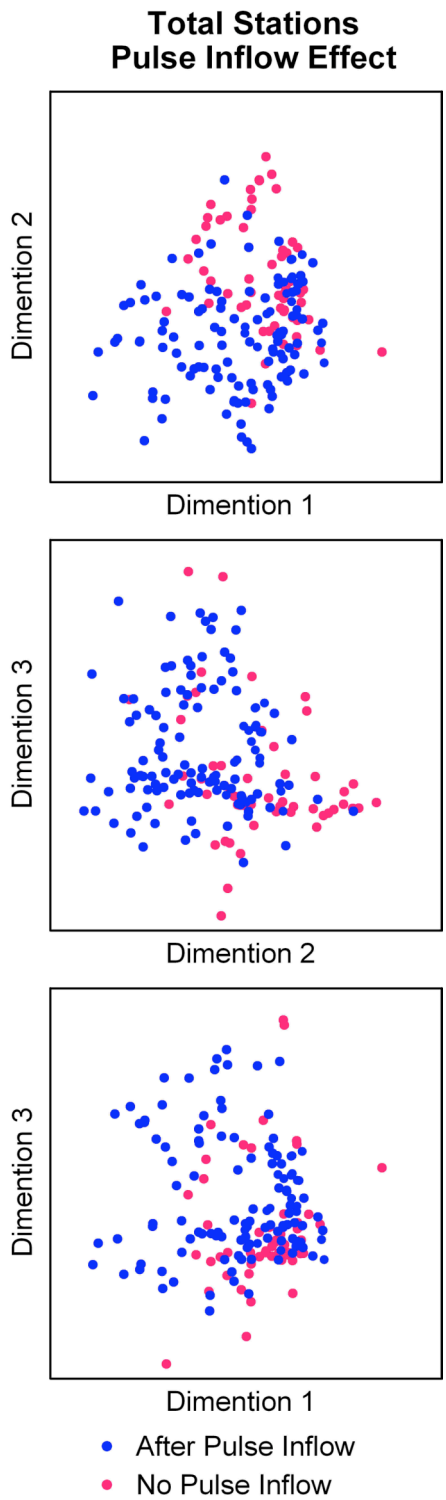
- NMS analysis, 3-D, stress: 12.210.
- Not clearly separation by 4 different flushing rate.
- (Note: dots of <0.05 week^{-1} and <0.5 month^{-1} also indicate dry year, Aug 05 ~ Aug 06.)



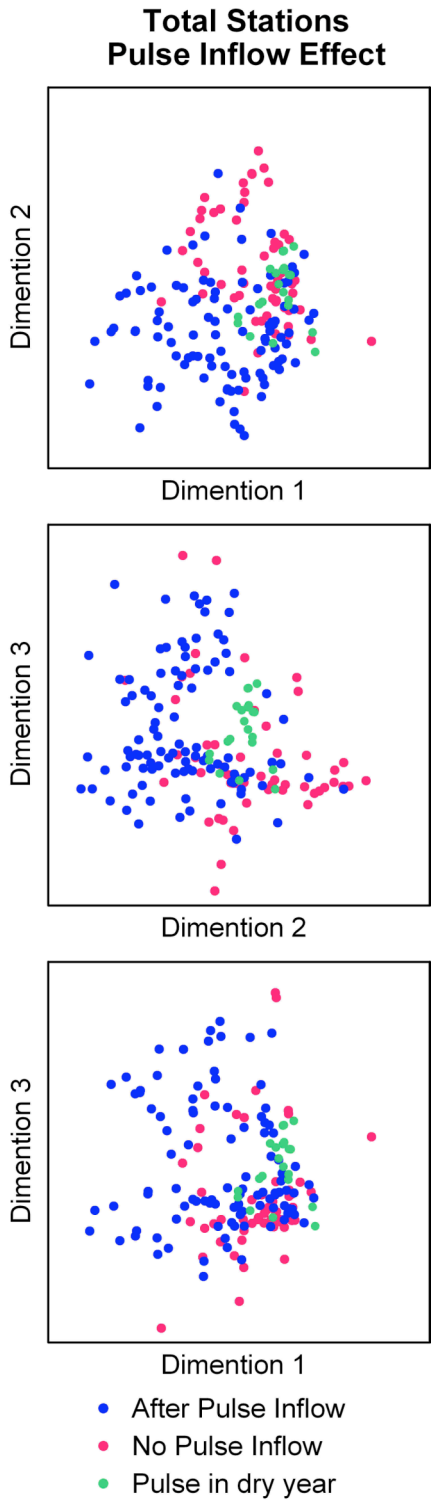
- No distinguish separation can be classified by each station, or just by north/south locations.

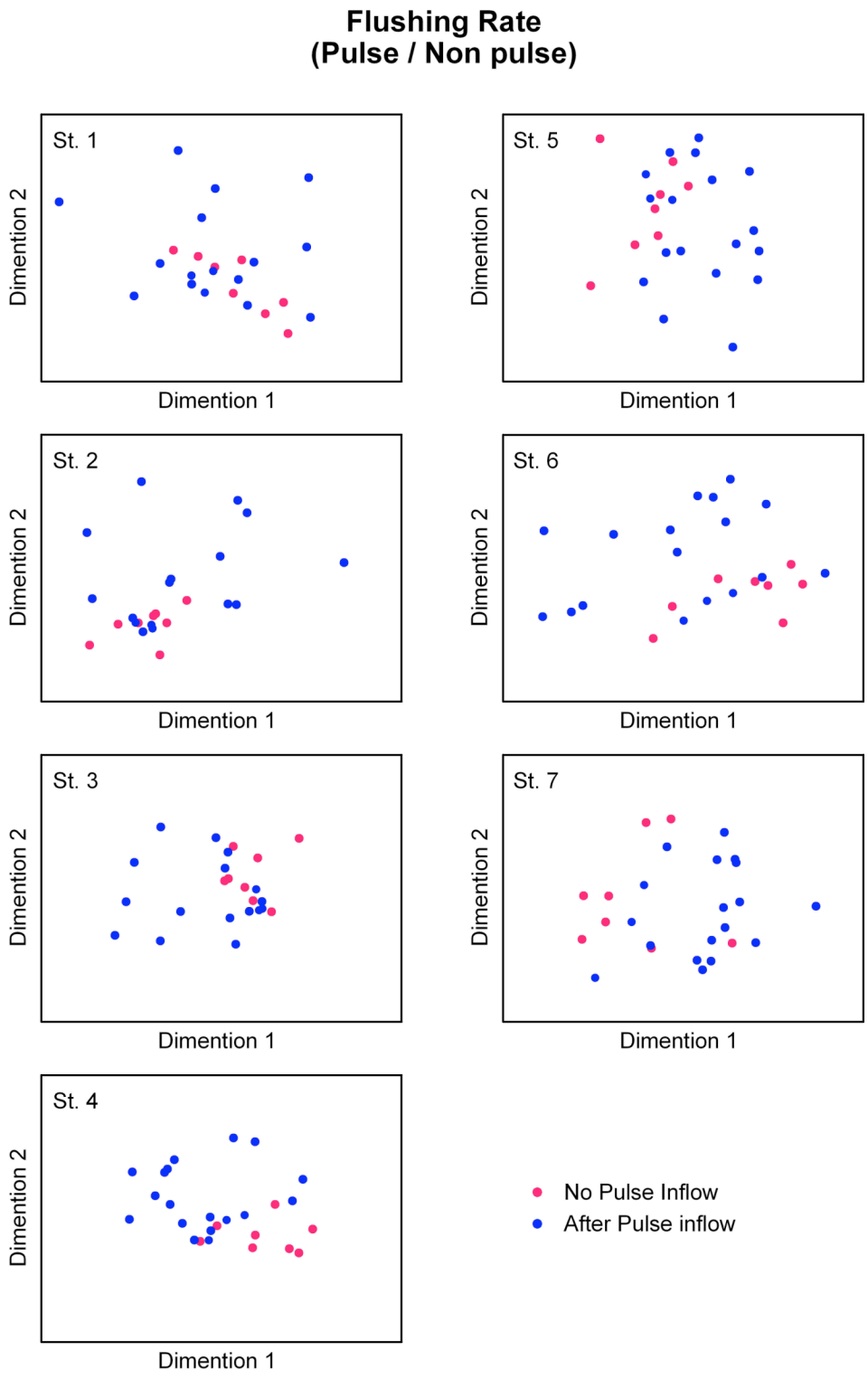


- Classifying stations by three locations, data show that clear separation of north (St. 6~7) and south (St. 1~3) locations, and the middle locations are in between.



• Defined separation of NMS results by pulse and non pulse inflow event shows that the type of inflow could affect the water quality parameters.


Total Stations
Pulse Inflow Effect
Dimention 2
Dimention 1
Dimention 3
Dimention 2
Dimention 3
Dimention 1
After Pulse Inflow
No Pulse Inflow
Pulse in dry year



•All results of these 6 stations can not be divided by different level of flushing rate.

• Pulse inflow could affect whole area of San Antonio Bay based on the clear separation, despite Station 1.