Nueces Bay Total Maximum Daily Load Project – Phase IV
Implementation Effectiveness Monitoring Data Report

Prepared for:

Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

Prepared by:

Brien A. Nicolau and Erin M. Hill

Center for Coastal Studies
Texas A&M University-Corpus Christi
6300 Ocean Drive, Suite 3200
Corpus Christi, Texas 78412

November 2010

TAMU-CC-1101-CCS

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Page

ACKNOWLEDGEMENTS

The Texas Commission on Environmental Quality - Total Maximum Daily Load Program provided funding for this project through Umbrella Contract Number 582-5-72503 Work Order Number 007, with funding coming through state funds # 24260.

We want to thank Aaron S. Baxter and Robert "Bobby" Duke from the Center for Coastal Studies for field assistance. We appreciate their enthusiasm and energy in assisting with all aspects of the project. Without their dedication and strong work ethic, this project would not have been possible. In addition, we also want to thank the entire staff at the Center for Coastal Studies for administrative support.

1.0 INTRODUCTION

1.1 Background

The 1998 *Texas Water Quality Inventory and Clean Water Act 303(d) List* of impaired waters initially listed Nueces Bay (Segment 2482) for not meeting the oyster water use due to elevated zinc levels in oyster tissue. In response to this listing, the Total Maximum Daily Load (TMDL) Program at the Texas Commission on Environmental Quality (TCEQ), in conjunction with the Coastal Management Program (CMP), funded two projects to: 1) develop a Geographic Information System zinc loadings model and 2) verify the zinc impairment in oyster tissue through a sampling program

Mrini *et. al* 2003 provides documentation of source assessment and zinc loadings into Nueces Bay. Modeling of information compiled and analyzed possibly indicated that elevated Total Zinc concentrations in Nueces Bay might be due to the discharge of once-through cooling water from the Nueces Bay Power Station (NBPS) obtained from the Corpus Christi Inner Harbor (Segment 2484). This Segment includes numerous industrial users with TCEQ permitted discharges to Inner Harbor waters.

To augment the historical database, reduce data variability, and track the effect of reduced loadings due to the closure of the NBPS in December 2002, there was a necessity to gather both total and dissolved zinc data using Ultra-Clean sampling methods and analysis (*EPA 1640–modified*). Use of this sophisticated method provides lower detection limits that are necessary because zinc is ubiquitous in the environment and is one of the most difficult trace metals to collect and analyze accurately without contamination. The ease of contaminating samples during sampling or analysis cannot be overestimated as ambient zinc concentrations in seawater or brackish waters can typically be below one part per billion (µg/L or ppb) making it difficult to get required field blanks and method blanks sufficiently low to permit accurate determinations of low ambient seawater zinc concentrations. Due to severe analytical interferences for direct analysis methods, posed by the high salt content of seawater, universal consensus exists in the oceanographic research community that many ambient trace metals (including zinc) can only be accurately determined in seawater using sophisticated analytical techniques such as the pre-concentration techniques described in method 1640. (Batterham et al. 1997; Sohrin et al. 2001).

Using this method, results of recent dissolved zinc concentrations measured in the study area by the Center for Coastal Studies (CCS), as part of the Coastal Bend Bays & Estuaries Program Regional Coastal Assessment Program, ranged from 0.69 ppb to 19.90 ppb, with a mean concentration of 6.40 ppb (Nicolau and Nuñez 2004; Nicolau and Nuñez 2005a; Nicolau and Nuñez 2005b; Nicolau 2006a).

TCEQ initiated Phase I of the study to begin collecting new data and sampling took place from June 2004 – May 2005 (Nicolau and Nuñez 2005b) and was followed by Phase II sampling which provided additional data and took place from September 2005 – July 2006 (Nicolau and Nuñez 2006b). Results of the above mentioned projects aided in the development of a TMDL to allocate the allowable zinc load (TCEQ 2006).

On 1 November 2006, TCEQ approved one TMDL for Nueces Bay (segment 2482) to address the zinc impairment associated with the oyster waters use as listed on the draft 2004 State of Texas Clean Water Act 303(d) list (TCEQ 2006). The U.S. Environmental Protection Agency (EPA) approved the TMDL on 15 December 2006 and the TCEQ approved the Implementation Plan on 24 October 2007 (TCEQ 2007). As part of determining Implementation Plan success, sampling for zinc in water, sediment, and tissue continued for Phase III from April 2008 – August 2008 and the current Phase IV sampling events, which took place from January 2010 – August 2010.

1.2 Project Objectives

As stated in the Implementation Plan (TCEQ 2007) the ultimate goals are to:

- Ensure levels of zinc in oyster tissue attenuate to levels below the health assessment comparison value (HAC) of 700 mg/kg that supports the oyster water use in Nueces Bay (Texas Department of State Health Services (DSHS) 2006).

- Adopt a criterion for zinc in water that is more appropriate and protective of human health via the pathway of ingestion of oysters. Zinc concentrations in the surface water of Nueces Bay are below the current criterion; however, zinc resulting from legacy sources exists in oyster tissue at levels that could result in adverse health effects from regular or long-term consumption (DSHS, 2006). For this reason, a revised criterion for total zinc of 29 μg/L (ppb) was calculated to ensure the protection of human health.

Project objectives for Phase IV of the Nueces Bay Zinc TMDL Implementation Effectiveness Monitoring was to sample Nueces Bay (Segment 2482), the Corpus Christi Inner Harbor (Segment 2484), and the Nueces River tidal (Segment 2101) and track water, sediment, and tissue zinc levels. This report summarizes the data collected during this multi-year sampling program. The goal is to provide TCEQ with sufficient data to address the zinc questions in Nueces Bay and to determine if the designated uses are being met and to track zinc loadings to Nueces Bay (i.e. TMDL implementation) and the effect these loadings have on water and sediment quality and ultimately in oyster tissue.

2.0 METHODS

2.1 Sampling Process Design and Modifications

The original sample design resulted from TMDL Program requirements that required collecting data of sufficient quality to characterize zinc in water and zinc in sediment within Nueces Bay (Segment 2482), Nueces River (Segment 2101), and the Corpus Christi Inner Harbor (Segment 2484) for TMDL related decisions. The design also had to be flexible in order to accommodate possible modifications as results from previous sampling years became available.

In Phase I the CCS sampled eight (8) sites in Nueces Bay, two (2) sites in the Nueces River, and four (4) sites in the Corpus Christi Inner Harbor for four (4) water and two (2) sediment sampling events (Figure 2.1). In Phase I, sediment was collected from the surficial sediment layer (2 to <5 cm) and anaerobic layer (>5 to 9 cm) and analyzed for total zinc, total organic carbon (TOC), and sediment grain size. Sampling of the deeper, anaerobic sediment layer would possibly determine if lower or higher sediment zinc concentrations existed and possibly identify a "legacy" layer with higher concentrations providing a source of zinc from re-suspension (i.e. wind and wave, boat/ship activity, scouring). Data analysis of the two sediment events conducted in Phase I, and one event conducted in Phase II, yielded slightly higher concentrations existing at lower depths. However, there was no statistically significant difference between the two sampling depths (all Stations $p = .676$, Inner Harbor Stations $p = .965$, Nueces Bay Stations $p = .624$).

Initially, the Phase II sampling protocol was to be identical to Phase I. However, after meeting with TCEQ TMDL personnel on 18 January 2006, the decision was to discontinue sampling the anaerobic sediment layer portion and redirect resources towards two new sampling efforts identified as important aspects of the TMDL. The first effort was to investigate the concentration of total and dissolved zinc in water at deeper depths within the Corpus Christi Inner Harbor (Phase II April and July 2006 events). This addressed if samples taken at the surface are representative of the NBPS intake pipe depth (≈ 7.0 m) located closer to the sediment. Data analysis showed no discernible differences existed and TCEQ TMDL personnel and CCS agreed surface samples were representative of the water body.

Secondly, consensus existed among TCEQ TMDL personnel and CCS researchers that sampling was not occurring in a major portion of western Nueces Bay, an area lacking in current sampling information. This portion of the bay is located adjacent to known historical point source brine discharges and is directly downwind from the industrial complex of the Inner Harbor. Station 18866 (Figure 2.1) was added to the sampling program in April 2006 after agreement this station would be beneficial to the project. Sampling continues at Station 18866 as part of the Implementation and Effectiveness Monitoring for the Nueces Bay TMDL study.

In Phase III, reduction in the number of stations sampled from fifteen (15) to the current ten (10) and the number of sampling events from four (4) to two (2) occurred. In addition, sampling for zinc concentrations in oyster tissue took place at five (5) stations in Nueces Bay. Please note that DSHS, not TCEQ, has the administrative and assessment authority for the National Shellfish Sanitation Program for Texas, zinc in oyster tissue data collected for the Implementation Effectiveness Monitoring Program is for informational purposes and TCEQ does not intend for it to be included for assessment purposes.

For Phase IV, sampling occurred for all parameters described in the Quality Assurance Project Plan (QAPP) and listed in Table 2.1. All data collected underwent quality assurance and is compliant with TCEQ Data Management protocols.

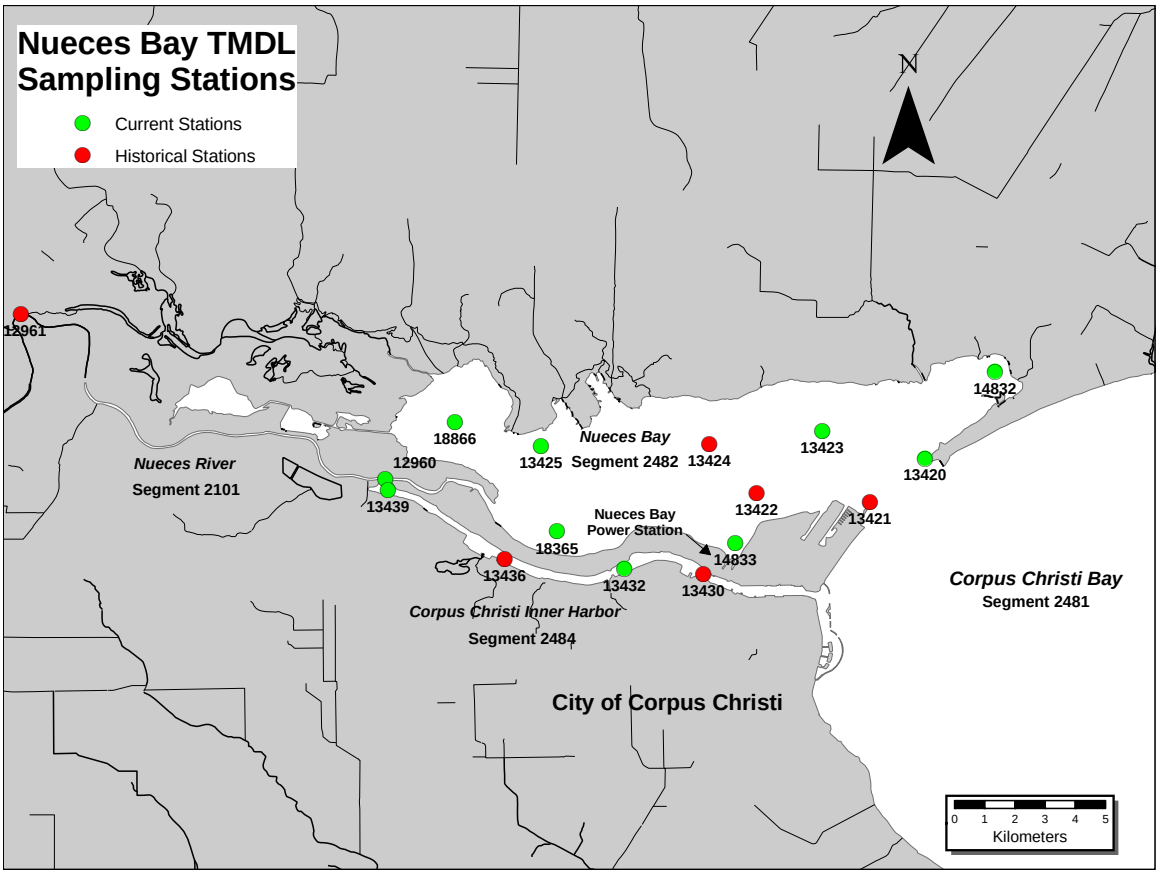

Figure 2.1. Map depicting current and historical Nueces Bay TMDL sampling locations.

2.2 Parameters Sampled

Table 2.1 lists all parameters measured for the Nueces Bay TMDL project.

Table 2.1. Parameters analyzed for the Nueces Bay TMDL project.

FIELD PARAMETERS (Water)	Units	TCEQ Parameter Codes
Total Depth	Meters	82903
Depth Sample Collected (Grab)	Meters	13850
Water Temperature (Grab)	°C	00010
Dissolved Oxygen Saturation (Grab)	%	00301
Dissolved Oxygen (Grab)	mg/L	00300
Conductivity (Grab)	µS/cm	00094
Salinity (Grab)	Practical Salinity Units	00480
pH (Grab)	su	00400
Turbidity	Visual assessment	88842
Turbidity	NTU	82078
Secchi Depth	Meters	00078
Tide Stage	DNR Tide Gauge	89972
Water Color	Visual assessment	89969
Water Odor	Olfactory assessment	89971
Water Surface	Visual assessment	89968
FIELD PARAMETERS (Weather)	**Units**	**TCEQ Parameter Codes**
Air Temperature	°C	00020
Barometric Pressure	mm/Hg	NA
Cloud Cover	%	NA
Dew Point	°C	NA
Heat Index	°C	NA
Present Weather	Visual assessment	89966
Rainfall (Days since last)	Days	72053
Rainfall (Inches past 1 day)	Inches	82553
Rainfall (Inches past 7days)	Inches	82554
Relative Humidity	%	NA
Wind Chill	°C	NA
Wind Direction	Compass Direction	89010
Wind Speed	MPH	NA

Table 2.1. (continued).

TRACE METALS IN WATER	Units	TCEQ Parameter Codes
Zinc (Dissolved)	µg/L or ppb	01090
Zinc (Total)	µg/L or ppb	01092
TRACE METALS IN SEDIMENT	**Units**	**TCEQ Parameter Codes**
Zinc	mg/kg dry weight	01093
ORGANICS	**Units**	**TCEQ Parameter Codes**
Total Organic Carbon (TOC)	mg/kg dry weight	81951
Total Solids	%	81373
SEDIMENT GRAIN SIZE	**Units**	**TCEQ Parameter Codes**
SGS Clay (<0.0039 mm)	% dry wt	82009
SGS Silt (0.0039 to 0.0625 mm)	% dry wt	82008
SGS Sand (0.0625 to 2.0 mm)	% dry wt	89991
SGS Gravel (>2.0 mm)	% dry wt	80256
ROUTINE CHEMISTRY (Water)	**Units**	**TCEQ Parameter Codes**
Total Suspended Solids (TSS)	mg/L	00530

2.3 Sampling Methods

The CCS followed sampling procedures for all parameters documented in the TCEQ-approved QAPPs for this project (CCS 2004, 2005, 2007, and 2009). A 3-person field crew conducted sampling from small craft (typically, 20-25 ft.) on a biannual basis for water and sediment quality. At each sampling site, field crews collected a core set of data and samples following methods and protocols as described in the TCEQ *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue* (TCEQ RG-415) or the CCS QAPP applicable for that sampling year. Core field data/samples included those specifically detailed in Table 2.1 and listed below, with further detail provided in the chapters of this document.

1. Routine field parameters such as ambient weather conditions (air temperature, wind speed and direction, cloud cover, etc.).
2. Instantaneous water column profile (dissolved oxygen, pH, salinity, temperature, depth, etc.).
3. Routine chemical parameters (total suspended solids).
4. Total and dissolved zinc in water.
5. Zinc, total organic carbon, and grain size in sediment.

Note: Zinc in oyster tissue sampling is conducted separate from water and sediment sampling events.

Additional aspects outlined below reflect specific requirements for sampling parameters and/or provide additional clarification. The following sections describe the general methods and procedures for each core sampling activity that occurred at the sampling sites.

2.3.1. Field Sampling Procedures

The CCS followed sampling procedures documented in the current TCEQ *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue* available for that Phase of sampling (see TCEQ 2008 for most current reference). For trace element sampling, EPA Method 1669: *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* (EPA 1999) provides additional sampling guidance. Additional procedures for field sampling outlined in this section reflect specific sampling requirements for this TMDL Project and/or provide additional clarification.

2.3.2. Site Location

As required through TMDL implementation, data collection efforts involve monitoring water, sediment, and oyster tissue data to determine effects of reduced zinc loadings to Nueces Bay. To this end, some general guidelines existed for selecting sampling sites, with overall consideration given for accessibility and safety. Establishment of sampling locations occurred prior to commencement of sampling and site selection determination utilized criteria described in the TCEQ *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue* (TCEQ RG-415). Development of all monitoring activities was coordinated with the TCEQ TMDL Project Manager.

2.3.3. Water Column Measurements

Routine field observations, ambient weather and water conditions, were conducted first upon arriving at each station. Water column measurements followed, as these data/samples require collection before disturbing sediments. Water column measurements were taken using a multiparameter sonde (e.g., YSI 6920 Multiprobe) connected by cable to a display unit and included: water temperature, dissolved oxygen (DO), conductivity, salinity, pH, and turbidity. Water column profiles, when required, were conducted according to TCEQ requirements for vertical depth profiles. Secchi depth measurements collected at each station utilized a standard 20-cm diameter black and white secchi disc.

2.3.4. Routine Conventional Chemistry

Total Suspended Solids.

One (1) L of unfiltered seawater was collected at 0.3 m at each station during all sampling years with additional water samples collected at ≈ 7.0 m at the four (4) Corpus Christi Inner Harbor stations in July 2006. TSS samples were collected in 1 L polypropylene bottles and put on wet ice in the field, Samples were then stored at 4ºC before laboratory analysis commenced.

2.3.5. Trace Metals in Water (Total and Dissolved Zinc)

All CCS personnel received prior field training from Dr. Paul N. Boothe of Albion Environmental on EPA method 1640-modified, the “clean hands – dirty hands” approach, for

collecting trace metals samples. Avoiding contamination during field sampling is extremely important for the accuracy of clean metals data. It is paramount to reduce the possibility of sample contamination during sampling events, as the primary sources of sample contamination comes from airborne particulates and sample contact of contaminated surfaces. CCS personnel have been successfully performing these procedures since March 2000 (Nicolau and Nuñez 2004; Nicolau and Nuñez 2005a; Nicolau and Nuñez 2005b; Nicolau 2006a).

CCS field crews used specialized sampling kits developed by Albion Environmental and a peristaltic pump to obtain grab samples. Each sampling kit configuration came individually bagged and separate from the clean boxes in which the actual collection of the water sample took place. Sample bottles within each kit had a unique identifying number and utilized certified LDPE bottles provided by Albion Environmental. Teflon inlet tubing inserted into a particle-free 4.6 m PVC pole allows for placement of the inlet tubing into the water upstream of the sampling vessel. Dissolved zinc samples are filtered through a pre-cleaned (Albion) Single Sample 0.45 µm large capacity capsule filter; with a new filter used for each dissolved sample taken. Samples collected for total zinc followed the same procedures as dissolved zinc but without the use of a filter. To verify no contamination occurred during field sampling, one field blank and one field duplicate sample were taken for each sampling event for laboratory analysis.

Please note that the above description is a simplified version of the sampling process. Additional detailed documentation exists in EPA Method 1669 *Sampling ambient water for trace metals at EPA water quality criteria levels* (USEPA 1999) and Albion Environmental Standard Operating Procedures modified after EPA Method 1669. Both documents are available upon request to the CCS Project Manager.

2.3.6. Composited Sediments

At each site, we used a modified 0.04 m^2 Van Veen sampler to collect multiple sediment grab samples. The surficial sediment layer (2 to <5 cm) was then sampled by spatula or scoop and composited separately to provide sediment for the analyses of total zinc, total organic carbon (TOC), and grain size determinations. A minimum of three grabs were composited for the final sample and combined into a clean, high-grade stainless steel or Teflon vessel. Between grabs, we placed the container of composited sediment on ice and covered with a lid to protect the sample from contamination. Stirring blended in each addition of sediment to the composite, with the final mixture stirred well to ensure a homogenous sample. Sub-samples for the various analyses took place as follows:

Inorganic chemical contaminants (Zinc)

Approximately 500 g of composited sediment was placed in a clean, pre-labeled, wide-mouth LDPE bottle and held on wet ice while aboard. Upon transfer from field to lab, the sample was held at 4ºC until laboratory processing commenced.

TOC

Approximately 500 g of composited sediment was placed in a small, clean, pre-labeled amber glass bottle/jar and held on wet ice aboard. Upon transfer from field to lab, the sample was held at 4ºC until laboratory processing commenced.

Grain size determination

Approximately 500 g of composited sediment was placed in a clean, pre-labeled, wide-mouth LDPE bottle and held on wet ice while aboard. Upon transfer from field to lab, the sample was held at 4ºC until laboratory processing commenced.

2.3.7. Oyster Sampling

At each site chosen for sampling, oysters were collected from shallow reefs using a standard dredge towed behind the boat then placed in Ziploc bags and stored on wet ice. Five samples, taken at each location, yield 25 samples per sampling event. Each sample consisted of enough oysters (25 to 30) of market length (2 to 3 inches) to yield >200 g per sample. Upon return to CCS, field staff placed the oysters on fresh wet ice and shipped overnight to the lab for analysis.

3.0 WATER MONITORING

3.1 TCEQ Criteria and Screening Levels

TCEQ uses many physical, chemical, and biological characteristics in assessing support of designated uses and criteria of a water body (Segment). Primarily, comparison of individual parameter values to either numerical criteria or screening levels determines the number of values exceeded. Based on number of exceedances, the assessment classifies a segment as either being in full support, partial support, or not supportive of the designated use. Similar exceedances of numerical screening levels identify segments with no concerns or concerns for impairment.

As defined in the *Guidance for Assessing and Reporting Surface Water Quality in Texas 2008* (TCEQ 2008) the identification of impairment relates directly to criteria adopted in the *Texas Surface Water Quality Standards* (TSWQS) that protect the designated use of a water body. The 303(*d*) list contains Segments with impairments; while water bodies with concerns appear on the 305(*b*) report they are not included on the 303(*d*) list. Typically, areas exhibiting concerns will receive more frequent and possible additional parameter monitoring (TCEQ 2008).

To establish whether impairment exists, and if support of aquatic life uses exists, TCEQ developed criteria for toxic substances in water. TCEQ developed criteria for 26 organic substances and a suite of 12 metals in dissolved and total forms with zinc concentrations based on a dissolved Tidal Water Chronic (TWC) criterion of 84.2 ppb and a Tidal Water Acute (TWA) criterion of 92.7 ppb. TCEQ has no criterion or screening level to evaluate total zinc concentrations in water, except in Nueces Bay where under this TMDL a revised criterion of 29 ppb calculated for total zinc ensures protection of human health.

3.2 Field Data

A select list of individual field parameter concentrations and descriptive statistics for stations sampled during Phase IV appears in Chapter 7-Data Tables 7.2.1 and 7.2.2, and 7.3.1 through 7.3.5, respectively.

During Phase I, salinity at several Nueces Bay stations was <10.00 PSU for the first two sampling events in 2004 due to continued precipitation and freshwater river inflows. By the end of Phase I, salinity rose to >20.00 PSU in Nueces Bay. Lack of significant rainfall during Phase II resulted in salinity ranging from 22.44 to 37.50 PSU at Nueces Bay and Corpus Christi Inner Harbor stations (Table 3.1). Overall mean salinity was >32.00 PSU for all Phase II sampling events.

Phase III salinity levels for Nueces Bay and Corpus Christi Inner Harbor stations ranged from 27.10 to 36.36 PSU and in Phase IV from 13.45 to 32.53 PSU, respectively. Mean concentrations were lower in Phase IV than Phase III for Nueces Bay and the Corpus Christi Inner Harbor stations due to increased precipitation within the region.

Table 3.1. Salinity (PSU) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	8	0.32	3.29	0.81
2	2101	Nueces River Tidal	8	0.67	14.01	6.57
3	2101	Nueces River Tidal	2	4.02	8.56	6.29
4	2101	Nueces River Tidal	2	4.57	6.18	5.38
1	2482	Nueces Bay	32	1.94	28.85	17.57
2	2482	Nueces Bay	34	22.44	37.50	33.40
3	2482	Nueces Bay	14	27.10	36.36	30.87
4	2482	Nueces Bay	14	13.45	30.58	23.18
1	2484	Corpus Christi Inner Harbor	16	22.73	30.88	28.00
2	2484	Corpus Christi Inner Harbor	16	32.51	37.41	35.03
3	2484	Corpus Christi Inner Harbor	4	29.53	34.95	32.09
4	2484	Corpus Christi Inner Harbor	4	28.03	32.53	30.19

Dissolved oxygen (DO) concentrations during Phase I were all >5.00 mg/L and ranged from 5.06 to 10.53 mg/L. In Phase II, except for Station 13422 in Nueces Bay during the July 2006 sampling event when DO measured 4.63 mg/L, all DO measurements were >5.00 mg/L with DO ranging from 4.63 to 11.06 mg/L.

Phase III DO concentrations were similar to Phase II, with a low of 4.77 mg/L recorded at Station 13432 in the Inner Harbor in August 2008 to a high of 8.99 mg/L at Station 12960 in the Nueces River Tidal segment in April 2008. Except for the low DO at Station 13432 all concentrations were >5.00 mg/L. Phase IV had similar concentrations with a low of 4.66 mg/L at Station 12960 recorded in August 2010 and a high of 12.68 mg/L at Station 14833 in Nueces Bay in January 2010. Again, except for the one low value all other DO values were >5.0 mg/L. Phase IV has yielded the highest mean DO concentrations of the four years sampling has occurred (Table 3.2).

Water depth, typically <1.50 m, coupled with high wind speeds, define the usual turbid nature of Nueces Bay, where visibility is often <0.5 m. Mean turbidity levels recorded during all sampling events were higher in Nueces Bay and lowest in the Corpus Christi Inner Harbor (Table 3.3). Although 93% of surface water measurements have been <50.0 NTU, measurements in previous years have reached 135.9 NTU in Nueces Bay. Long-term means for this project are 3.2, 20.0, and 26.8 NTU for the Corpus Christi Inner Harbor, Nueces River Tidal, and Nueces Bay segments, respectively. During the January 2010 sampling event in Phase IV, turbidity concentrations were low due to a winter “norther” passing through the area, which was followed by several days of calm to no winds. These conditions allowed suspended sediment to drop out of the water column thereby producing exceptional water clarity, >1.5 m at some stations.

Table 3.2. Dissolved Oxygen (mg/L) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	8	5.65	9.08	7.70
2	2101	Nueces River Tidal	8	7.08	11.06	9.15
3	2101	Nueces River Tidal	2	6.63	8.99	7.81
4	2101	Nueces River Tidal	2	4.66	11.35	8.01
1	2482	Nueces Bay	32	7.15	9.51	8.02
2	2482	Nueces Bay	34	4.63	10.37	7.40
3	2482	Nueces Bay	14	5.16	8.67	6.82
4	2482	Nueces Bay	14	4.66	12.68	8.95
1	2484	Corpus Christi Inner Harbor	16	5.06	10.53	7.48
2	2484	Corpus Christi Inner Harbor	16	5.28	9.71	7.22
3	2484	Corpus Christi Inner Harbor	4	4.77	7.44	6.28
4	2484	Corpus Christi Inner Harbor	4	5.29	9.84	7.58

Table 3.3. Turbidity (NTU) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	6	16.10	44.00	27.47
2	2101	Nueces River Tidal	8	3.90	38.30	15.71
3	2101	Nueces River Tidal	2	15.90	17.70	16.80
4	2101	Nueces River Tidal	2	10.10	26.00	18.05
1	2482	Nueces Bay	24	6.10	135.90	36.18
2	2482	Nueces Bay	28	2.00	121.00	26.89
3	2482	Nueces Bay	14	8.40	112.60	31.39
4	2482	Nueces Bay	14	0.10	33.30	6.87
1	2484	Corpus Christi Inner Harbor	15	0.09	13.40	3.57
2	2484	Corpus Christi Inner Harbor	12	0.00	9.00	3.89
3	2484	Corpus Christi Inner Harbor	4	1.10	2.80	1.68
4	2484	Corpus Christi Inner Harbor	4	0.70	2.60	1.10

3.3 TCEQ Routine Conventional Water Chemistry – Total Suspended Solids (TSS)

A complete list of individual TSS concentrations for Phase IV, along with descriptive statistics, appears in Chapter 7-Data Tables 7.4.1 and 7.5.1. Mean TSS levels in Phase IV were lower than levels seen in previous years (Table 3.1), most notably in Nueces Bay.

In previous years, lower concentrations occurred in the Corpus Christi Inner Harbor and higher concentrations occurred in Nueces Bay; however during Phase IV while the pattern remained the same, low TSS concentrations existed at most locations. TSS concentrations in Phase IV ranged from 5.00 to 37.00 mg/L at Station 13420 in Nueces Bay (Table 3.1; Table 7.4.1) and mean concentrations were the lowest recorded for Nueces Bay over the four-year sampling period (Table 3.1; Table 7.5.1). Figs. 3.1, 3.2, and 3.3 depict individual TSS concentrations for each Phase IV sampling event and mean TSS concentrations for both sampling events in Phase IV, respectively.

Table 3.4. Total Suspended Solids (mg/L) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	8	10.00	80.00	30.75
2	2101	Nueces River Tidal	8	7.00	77.00	23.63
3	2101	Nueces River Tidal	2	20.00	29.00	24.50
4	2101	Nueces River Tidal	2	13.00	25.00	19.00
1	2482	Nueces Bay	32	12.00	232.00	46.69
2	2482	Nueces Bay	34	5.00	205.00	41.00
3	2482	Nueces Bay	14	11.00	200.00	50.86
4	2482	Nueces Bay	14	5.00	37.00	12.21
1	2484	Corpus Christi Inner Harbor	16	9.00	28.00	16.38
2	2484	Corpus Christi Inner Harbor	16	4.00	22.00	10.88
2	2484	Corpus Christi Inner Harbor (Mid-depth)	4	3.00	9.00	6.50
3	2484	Corpus Christi Inner Harbor	4	6.00	25.00	11.25
4	2484	Corpus Christi Inner Harbor	4	6.00	10.00	8.50

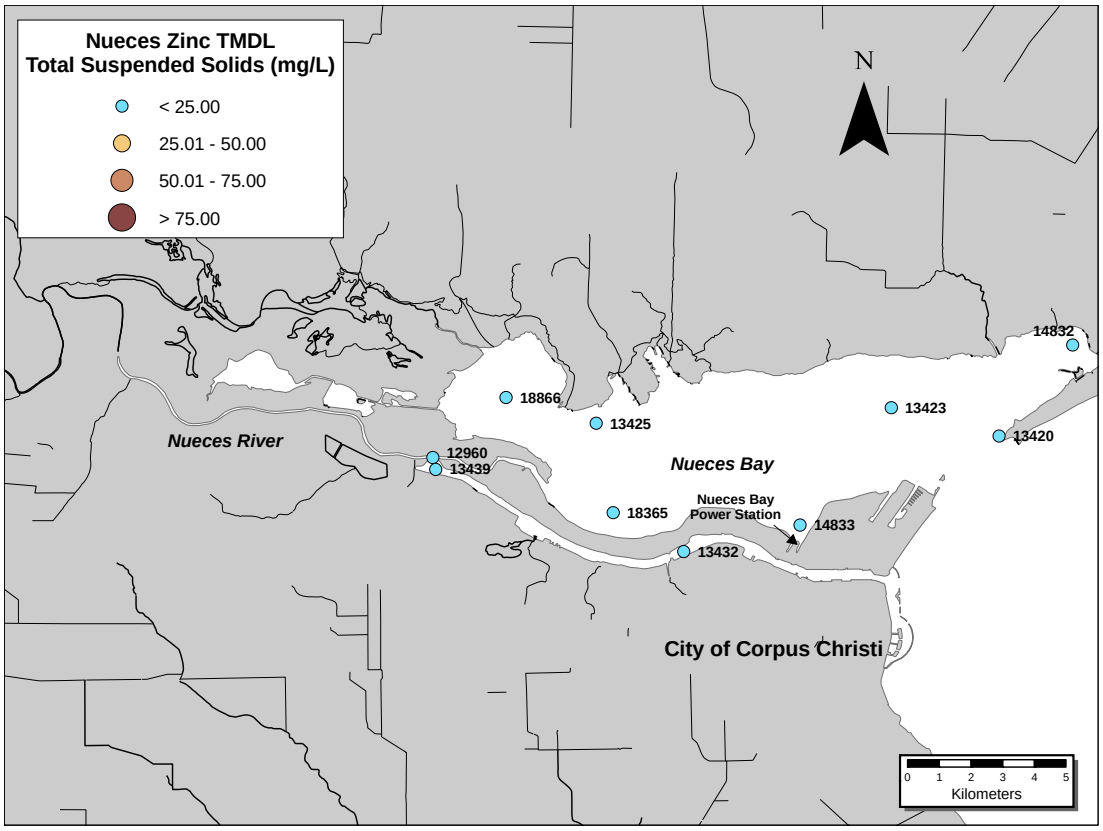

Figure 3.1. TSS concentrations (mg/L) for January 2010.

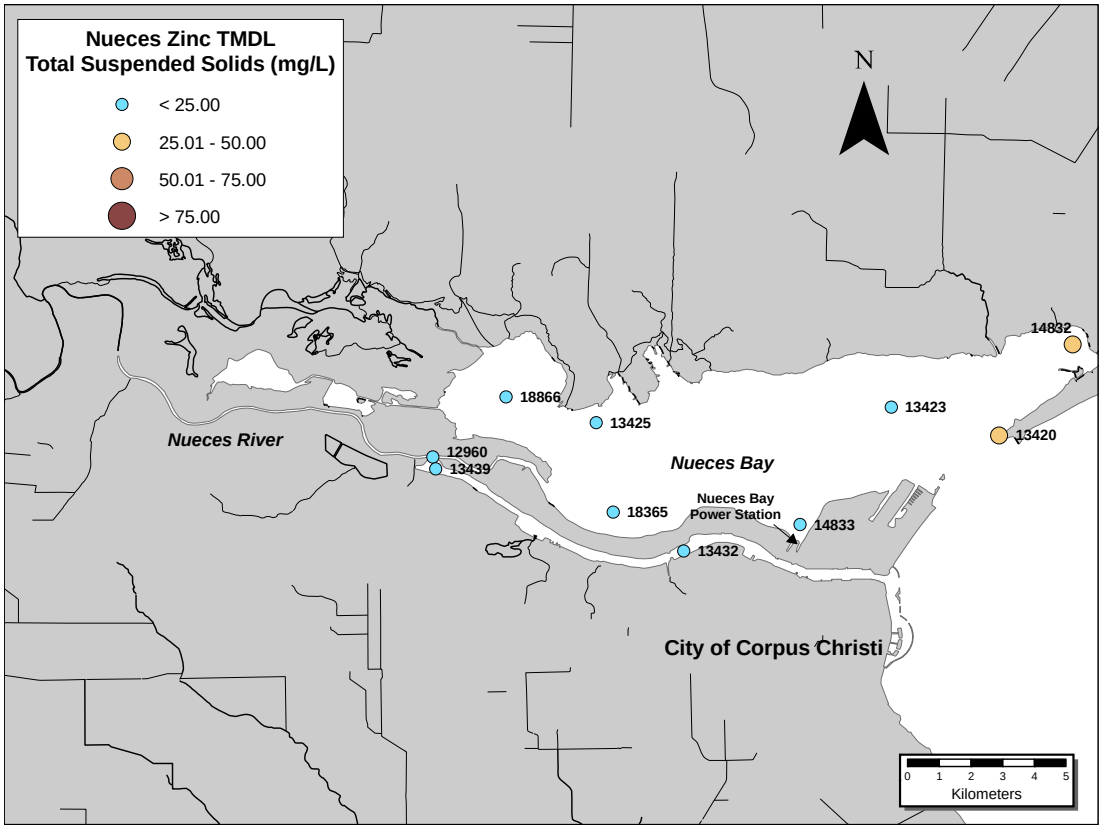

Figure 3.2. TSS concentrations (mg/L) for August 2010.

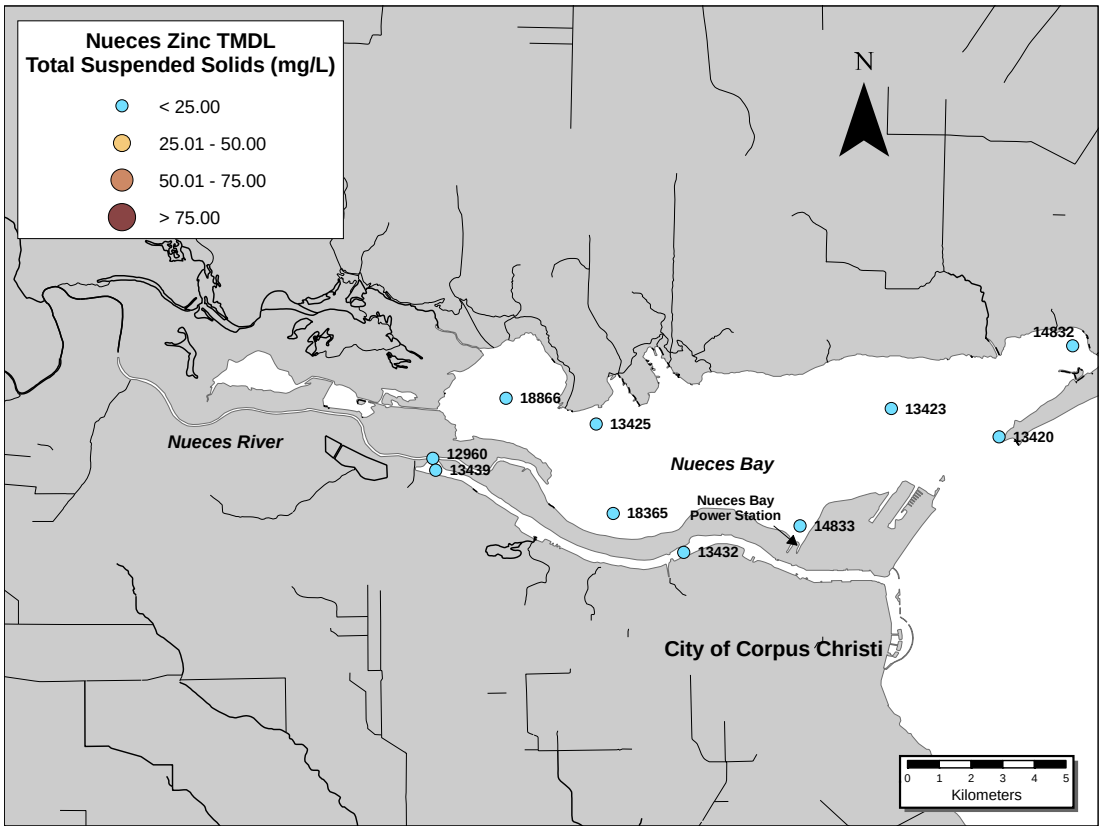

Figure 3.3. Mean Total Suspended Solids concentrations (mg/L) for Phase IV.

3.4 Zinc in Water

Dissolved Zinc

A complete list of individual dissolved zinc concentrations for Phase IV, along with descriptive statistics, appears in Chapter 6-Data Tables 6.6.1 and 6.7.1. Since sampling began, individual dissolved zinc concentrations have not exceeded the TCEQ criterion for dissolved zinc. The highest concentration (12.90 ppb) recorded occurred at Station 13432 in the Corpus Christi Inner Harbor during Phase II and was 6.5 times less than the chronic criterion of 84.20 ppb and 7.1 times less that the acute criterion of 92.70 ppb. While considerably lower than the criterion, highest individual and mean concentrations occur in the Corpus Christi Inner Harbor and lowest mean concentrations tend to occur in the Nueces River Tidal segment. However, in Phase IV the lowest mean concentration recorded was in Nueces Bay (Table 3.5; Table 7.6.1; Table 7.7.1). Dissolved zinc concentrations in Phase IV ranged from 0.64 ppb at Station 18866 in Nueces Bay to 8.44 ppb at Station 13439 in the Inner Harbor (Table 3.5; Table 7.6.1). Figs. 3.4, 3.5, and 3.6 depict individual dissolved zinc concentrations for each Phase IV sampling event and mean dissolved zinc concentrations for both sampling events in Phase IV, respectively.

Table 3.5. Dissolved zinc (ppb) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	8	0.10	0.40	0.21
2	2101	Nueces River Tidal	8	0.20	0.72	0.37
3	2101	Nueces River Tidal	2	0.23	0.24	0.23
4	2101	Nueces River Tidal	2	0.89	1.72	1.31
1	2482	Nueces Bay	32	0.34	2.40	1.11
2	2482	Nueces Bay	34	0.61	4.88	2.38
3	2482	Nueces Bay	14	0.77	2.63	1.70
4	2482	Nueces Bay	14	0.64	2.95	1.26
1	2484	Corpus Christi Inner Harbor	16	1.67	10.80	5.12
2	2484	Corpus Christi Inner Harbor	16	2.69	12.90	7.42
2	2484	Corpus Christi Inner Harbor (Mid-depth)	8	4.35	12.20	8.13
3	2484	Corpus Christi Inner Harbor	4	2.59	7.73	5.24
4	2484	Corpus Christi Inner Harbor	4	2.08	8.44	5.66

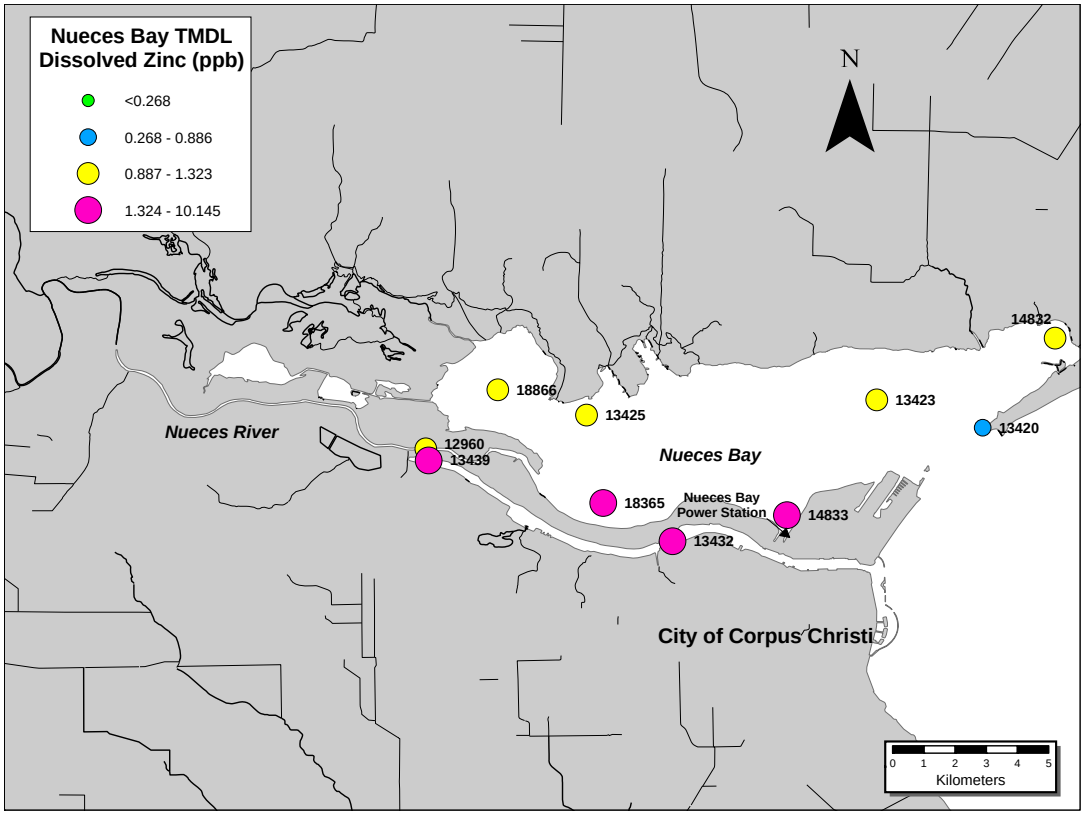

Figure 3.4. Dissolved zinc concentrations (ppb) for January 2010.

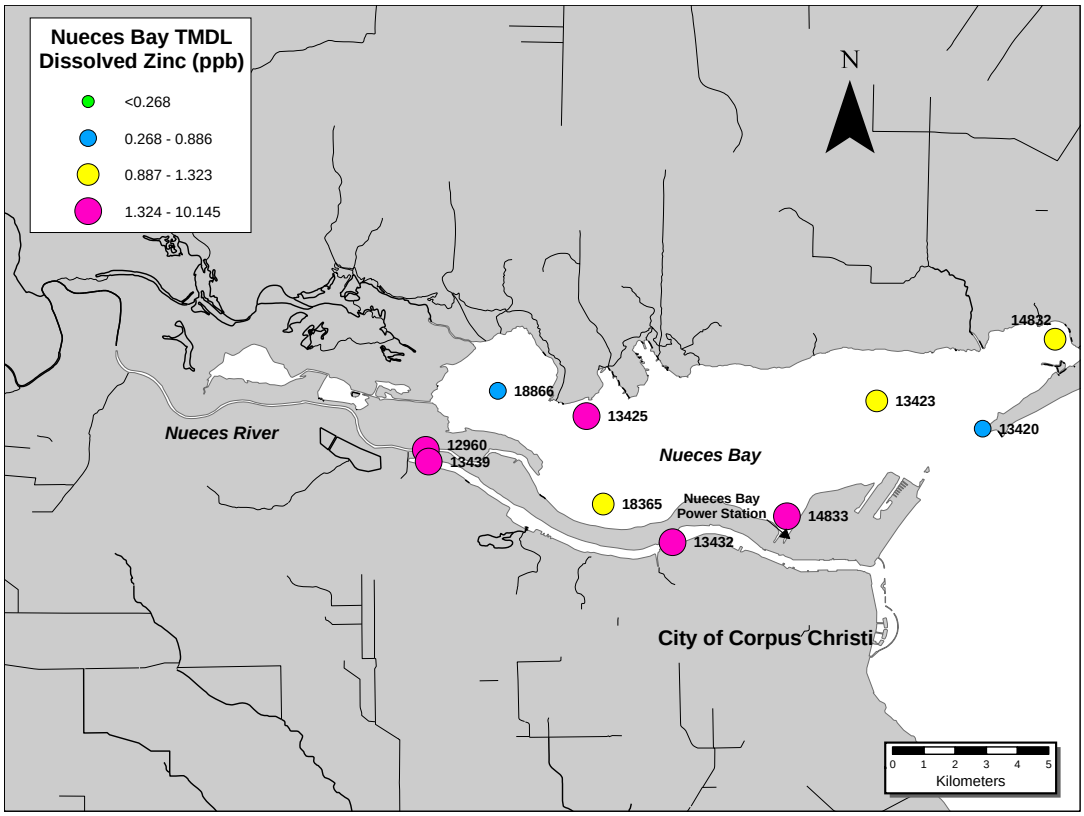

Figure 3.5. Dissolved zinc concentrations (ppb) for August 2010.

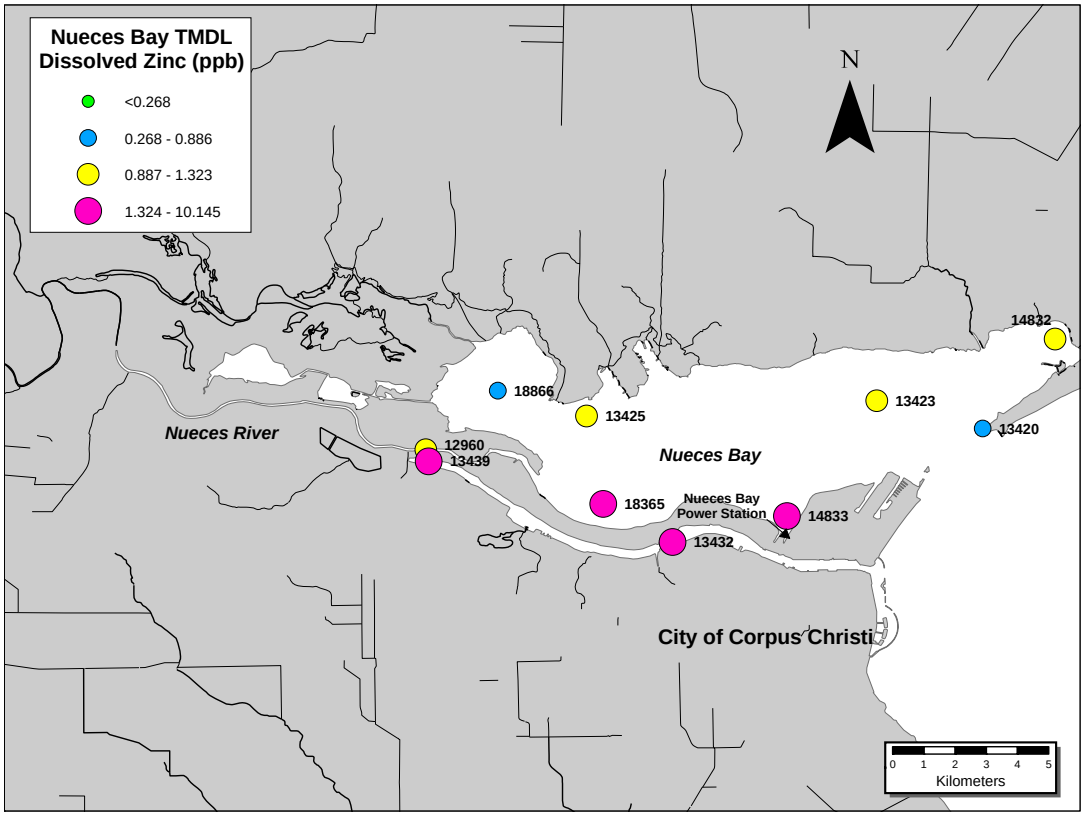

Figure 3.6. Mean dissolved zinc concentrations (ppb) for Phase IV.

Total Zinc

A complete list of individual total zinc concentrations for Phase IV, along with descriptive statistics, appears in Chapter 7-Data Tables 7.6.1 and 7.7.1. Since 2004, individual total zinc concentrations have exceeded the TCEQ TMDL criterion for total zinc three times at stations in Nueces Bay. One exceedance occurred in Phase I at Station 13423 during the May 2005 sampling event, with a concentration of 43.40 ppb. Corresponding TSS concentrations were 232.00 mg/L, signifying very turbid conditions and high amounts of re-suspended sediments. Phase II saw two exceedances, once at Station 18866 and Station 18365 during the April 2006 sampling event. Again, corresponding TSS concentrations were 178.00 mg/L and 205.00 mg/L at Station 18866 and Station 18365, respectively.

Since sampling began, the highest mean total zinc concentrations have alternated between Nueces Bay and the Corpus Christi Inner Harbor segments with lowest concentrations observed in the Nueces River Tidal segment in all but Phase IV (Table 3.6). Total zinc concentration during Phase IV ranged from a low of 0.87 ppb at Station 13420 in Nueces Bay to 9.73 ppb at Station 13439 in the Corpus Christi Inner Harbor (Data Table 7.6.1). During January 2010 sampling, when TSS levels were low, the Corpus Christi Inner Harbor had values that although far below the criterion, were two to three times higher than any other values recorded (Data Table 7.6.1). While the highest concentration of 8.65 ppb, recorded at Station 13439 in the Corpus Christi Inner Harbor during August 2010 sampling, was also well below the criterion, all other stations showed increased total zinc concentrations compared to January 2010 sampling. While TSS values were elevated at some stations during this event, many stations showed relatively similar values as those reported for the January 2010 sampling event (Data Table 7.4.1).

Due to the shallow nature of Nueces Bay and predominate southeast windy conditions, the waters of Nueces Bay are typically turbid. Because of the bays turbid nature, zinc sequestered in the sediment is re-suspended and higher total zinc levels appear to be associated with water column TSS. As previously stated, weather conditions observed during this sampling year tended to yield the lowest total zinc values recorded of all sampling years as TSS values were low.

Despite zinc concentrations being low in the Corpus Christi Inner Harbor, concentrations often remain equal or higher than concentrations from the turbid waters of Nueces Bay. As total depth in the Corpus Christi Inner Harbor is >14 m and total suspended solids (turbidity) concentrations are low, zinc is clearly entering the inner harbor from sources other than sediment re-suspension (most likely from industrial discharges) and has no association with TSS. Consequently, inner harbor stations tend to have higher total zinc, but lower TSS levels than other stations sampled as part of this study. Figs. 3.7, 3.8, and 3.9 depict individual total zinc concentrations for each Phase IV sampling event and mean total zinc concentrations for both sampling events in Phase IV, respectively.

Table 3.6. Total zinc (ppb) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	8	1.30	8.79	4.63
2	2101	Nueces River Tidal	8	0.97	17.70	3.97
3	2101	Nueces River Tidal	2	2.74	5.38	4.06
4	2101	Nueces River Tidal	2	2.48	5.45	3.97
1	2482	Nueces Bay	32	3.00	43.40	10.15
2	2482	Nueces Bay	34	1.78	46.10	10.17
3	2482	Nueces Bay	14	4.16	24.00	9.57
4	2482	Nueces Bay	14	0.87	7.28	3.02
1	2484	Corpus Christi Inner Harbor	16	3.68	12.40	7.93
2	2484	Corpus Christi Inner Harbor	16	4.66	23.40	10.71
2	2484	Corpus Christi Inner Harbor (Mid-depth)	8	4.66	23.60	12.33
3	2484	Corpus Christi Inner Harbor	4	4.78	9.07	7.03
4	2484	Corpus Christi Inner Harbor	4	4.36	9.73	7.60

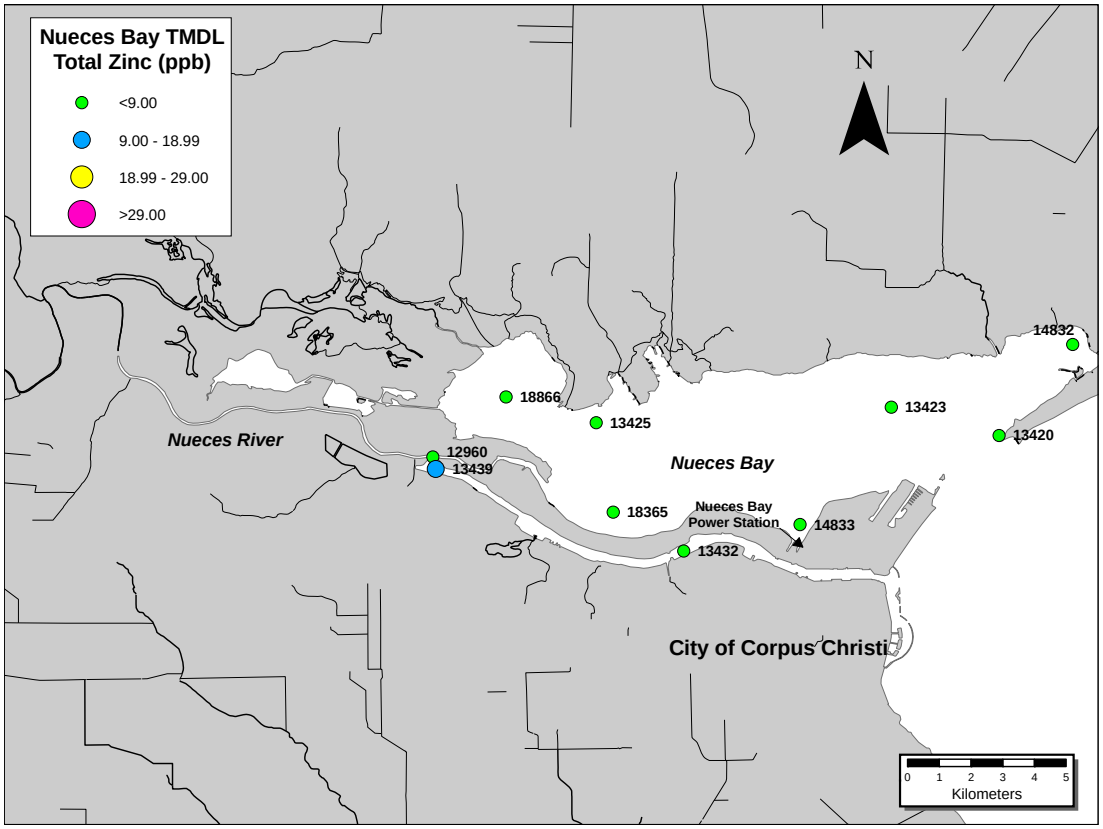

Figure 3.7. Total zinc concentrations (ppb) for Phase IV January 2010.

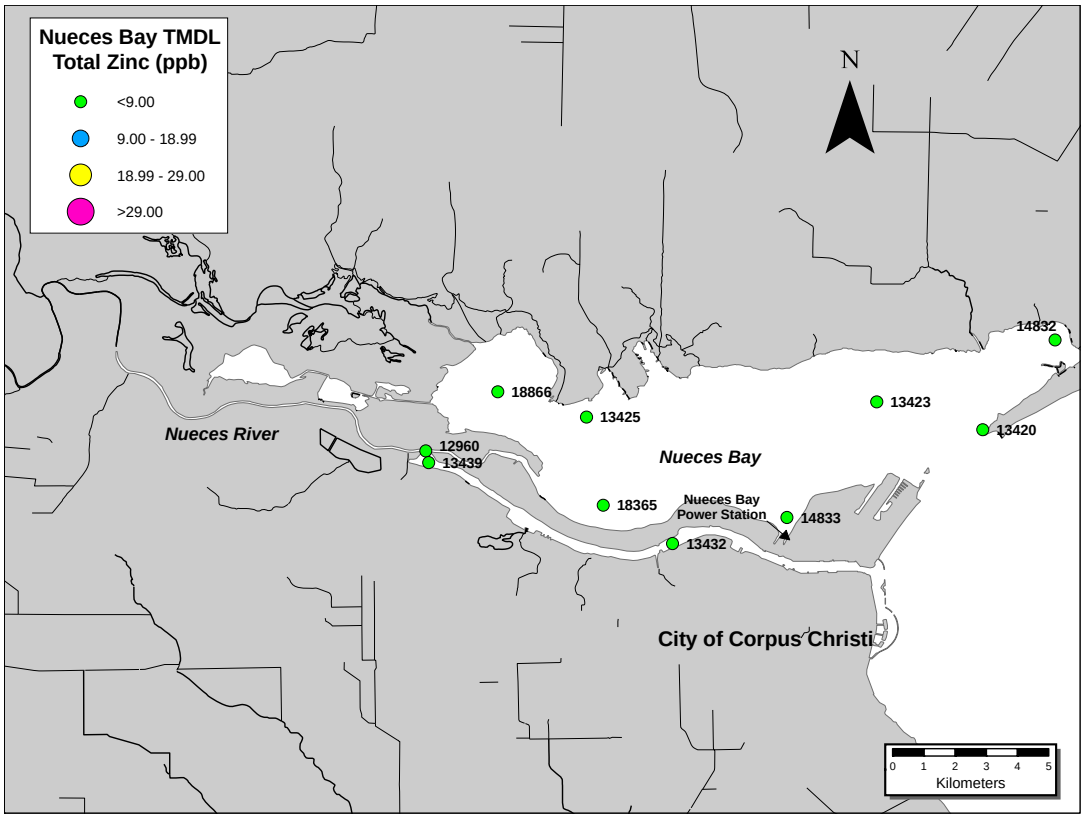

Figure 3.8. Total zinc concentrations (ppb) for August 2010.

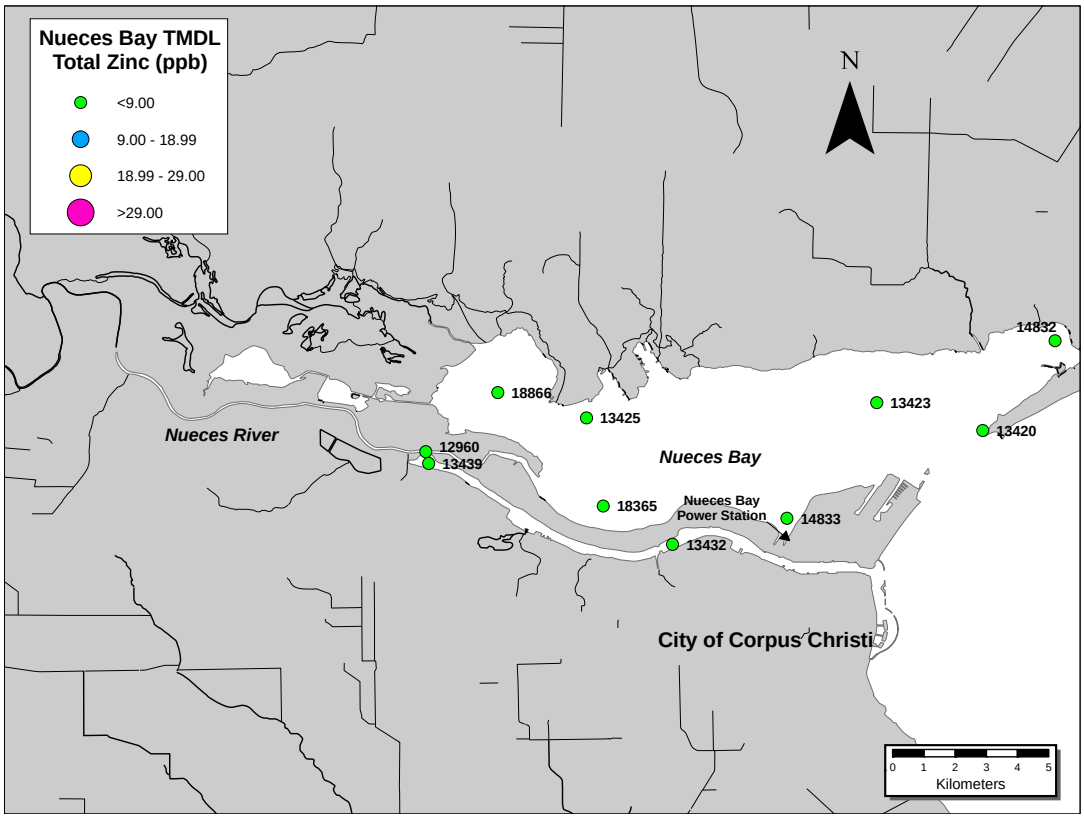

Figure 3.9. Mean total zinc concentrations (ppb) for Phase IV.

4.0 SEDIMENT MONITORING

For two events in Phase I, and the first event of Phase II, the upper (2 to <5.0 cm) sediment layer was collected along with the lower (>5 to 9 cm), or slightly deeper sediment to determine if increased zinc concentrations could be attributed to legacy deposition. Zinc data was log transformed and subjected to a One-Way ANOVA ($p \leq 0.05$) between mean concentrations of upper and lower sediment samples. As previously stated, while data analysis yielded slightly higher concentrations at lower depths, there was no statistically significant difference between the two sampling depths (all Stations $p = .68$, Corpus Christi Inner Harbor Stations $p = .97$, Nueces Tidal and Bay Stations $p = .62$). Since no statistically significant difference existed, we discontinued this portion of the sampling program. A complete list of individual sediment characteristics and zinc concentrations, along with descriptive statistics for Phase IV, appears in Chapter 6-Data Tables 6.8.1 and 6.9.1 and 6.9.2.

4.1 TCEQ Sediment Quality Screening Levels

Currently, there are no regulatory criteria for the majority of sediment contaminants. However, TCEQ does employ sediment-screening levels for metal and organic substances demonstrated to have adverse ecological effects. Comparison of sample contaminant concentrations are compared to screening levels developed by TCEQs Ecological Assessment Program and based on guidelines developed by the National Oceanic and Atmospheric Administration (NOAA) through its National Status and Trends Program. Currently the established TCEQ screening level for zinc in sediment is 410 mg/kg or the Effects Range Median (ERM) as defined by NOAA. A concern for aquatic life exists if more than 20 percent of the contaminant samples exceed the screening level.

NOAA sediment guidelines derive from a multitude of nationwide datasets of sediment contamination and corresponding biological effects compiled by Long et al. (1995). While concentrations above Threshold Effects Level (TEL) values do not aid TCEQ in identifying concerns, they provide a baseline reference indicating increasing concentrations. Depending on the effects level used, a wide range of interpretations is possible using these guidelines. Not considered regulatory criteria or standards, these screening levels and guidelines serve as a non-regulatory interpretive aid for sediment chemical data. Based on comparable datasets, but calculated differently (Long et al. 1995; MacDonald et al. 1996), the classification of these levels and their corresponding increasing effect thresholds employs the following terminology:

Threshold Effects Level	TEL (124 mg/kg)	*Rare* adverse effects observed
Effects Range Low	ERL (150 mg/kg)	Effects begin to occur in sensitive species
Probable Effects Level	PEL (271 mg/kg)	*Frequent* adverse effects observed
Effects Range-Median	ERM (410 mg/kg)	Median concentration of compiled toxic data

4.2 Sediment Characteristics

Total organic carbon (TOC) provides a relative measure of organic matter contained in sediments and is the sum of particulate organic carbon and dissolved organic carbon. Decaying detrital particulate organic material serves as a site for bacterial activity, which in turn provides binding sites for both metal and organic contaminants (Simpson et al. 2005). Typically, elevated TOC concentrations are associated with sediments high in Silt-Clay content. Generally, TOC values <20,000 mg/kg indicate low enrichment, >20,000 mg/kg and <50,000 mg/kg indicates moderate enrichment, and >50,000 mg/kg indicates high enrichment.

While some individual stations exhibited concentrations indicative of moderate enrichment, mean concentrations for all stations sampled in the segment are <20,000 mg/kg except at Station 12960 in the Nueces River Tidal segment (Table 4.1). Lowest mean concentrations occurred in Nueces Bay all four sampling years, with the mean concentrations in Phase IV being the highest recorded of all events (Table 4.1). TOC values ranged from 1710 mg/kg at Station 14833 to 23,400 mg/kg at Station 13420 in Nueces Bay, 20,100 to 21,700 mg/kg at Station 12961 in the Nueces River Tidal, and 4980 mg/kg at Station 13432 to 20,000 mg/kg at Station 13439 in the Corpus Christi Inner Harbor (Table 4.1; Table 7.8.1).

Similar concentrations and distribution patterns occurred during all years, with highest mean concentrations in Nueces River Tidal, followed by Corpus Christi Inner Harbor, and Nueces Bay, respectively (Table 4.1). Figs. 4.1, 4.2, and 4.3 depict individual TOC concentrations in the surficial sediment layer for each Phase IV sampling event and mean TOC values in the for both sampling events in Phase IV.

Table 4.1. Total Organic Carbon (mg/kg) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	4	6500	12000	8075
2	2101	Nueces River Tidal	4	5930	25200	15683
3	2101	Nueces River Tidal	2	19100	20400	19750
4	2101	Nueces River Tidal	2	20100	21700	20900
1	2482	Nueces Bay	16	270	10000	4519
2	2482	Nueces Bay	17	1320	10400	5554
3	2482	Nueces Bay	14	3670	14700	8003
4	2482	Nueces Bay	14	1710	23400	8206
1	2484	Corpus Christi Inner Harbor	8	1500	12000	7850
2	2484	Corpus Christi Inner Harbor	8	2990	17400	11275
3	2484	Corpus Christi Inner Harbor	4	13100	22900	16950
4	2484	Corpus Christi Inner Harbor	4	4980	20000	12545

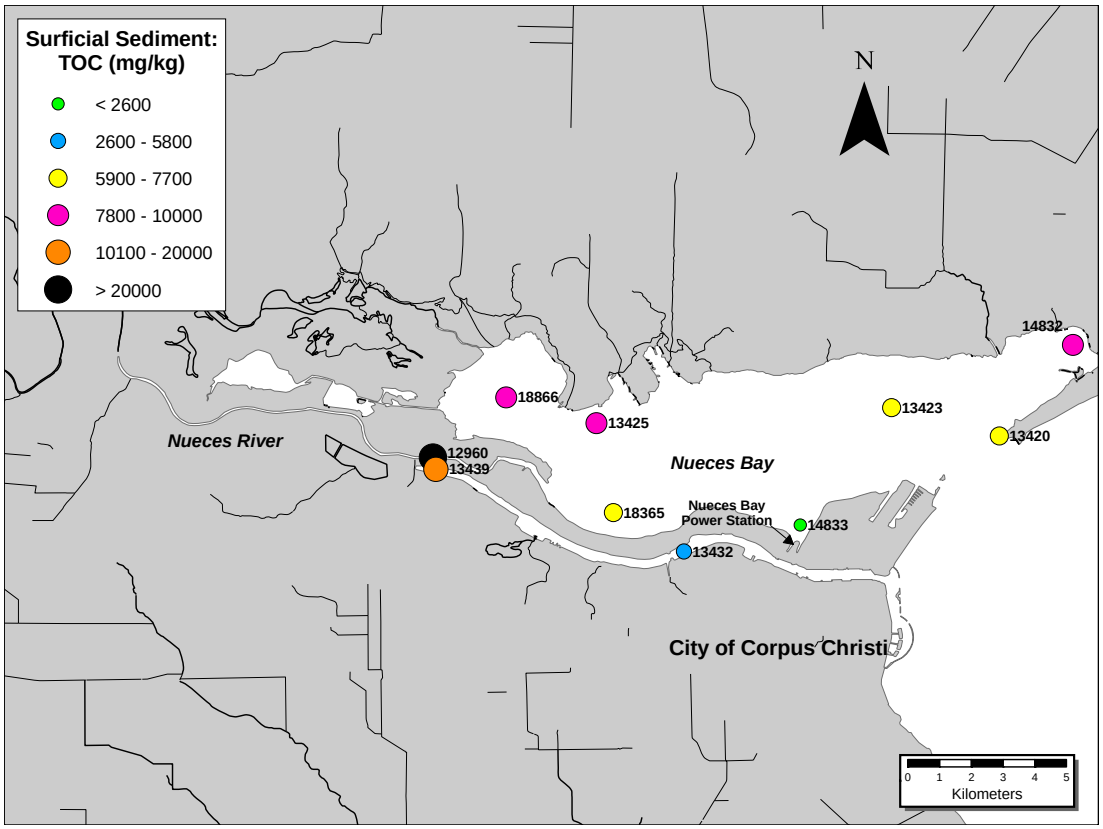

Figure 4.1. Total Organic Carbon concentrations (mg/kg) for January 2010.

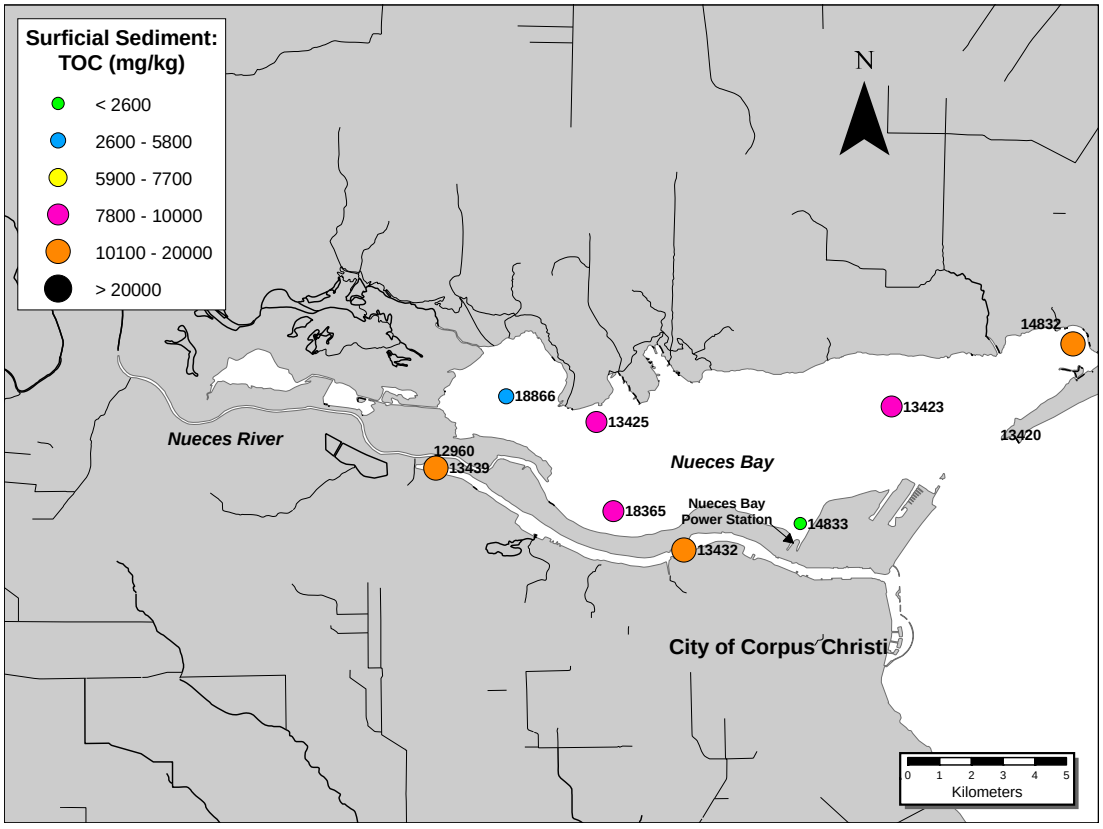

Figure 4.2. Total Organic Carbon concentrations (mg/kg) for August 2010.

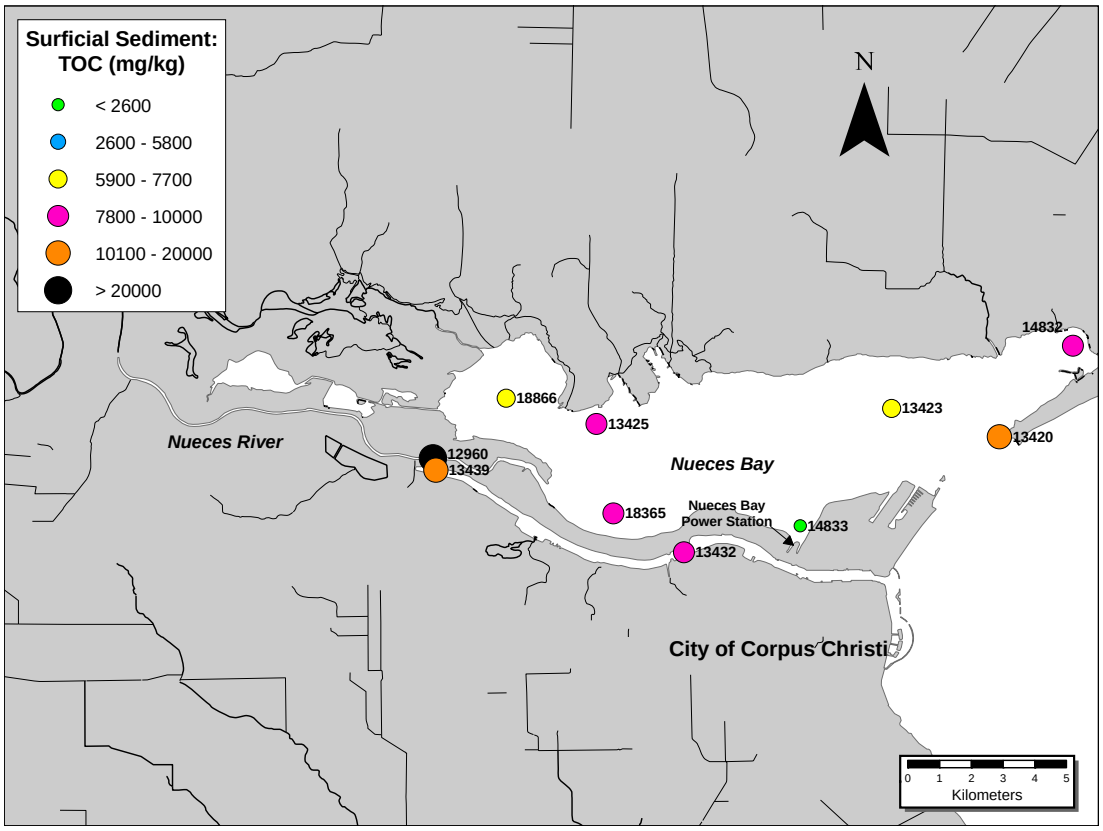

Figure 4.3. Mean Total Organic Carbon concentrations (mg/kg) for Phase IV.

The percentage of mud (Silt-Clay) within sediments is also an important aspect in the assessments of estuarine condition. Typically, as sediment grain size decreases, the risk of contamination increases due to the strong affinity metals have to adsorb to Silt-Clay particles. Sediment grain size is also a contributing factor effecting the distribution of marine benthic organisms. As stated previously elevated TOC concentrations are typically associated with sediments high in Silt-Clay content and the distribution pattern of Silt-Clay was the same as TOC, with highest mean concentrations in Nueces River Tidal, followed by the Corpus Christi Inner Harbor, and Nueces Bay, respectively (Table 4.2).

During Phase IV, Silt-Clay values in the surficial sediment layer ranged from 5.86% at Station 14833 in Nueces Bay to 94.44% at Station 12961 in the Nueces River Tidal segment (Table 4.2; Table 7.8.1). Silt-Clay values in the Corpus Christi Inner Harbor ranged from 39.63% to 74.13% at Station 13432 and Station 13439, respectively. Mean concentrations increased at all segments between the January and August 2010 sampling events in Phase IV (Table 7.9.1). Figs. 4.4, 4.5, and 4.6 depict individual Silt-Clay values in the surficial sediment layer for each Phase IV sampling event and mean Silt-Clay values in the surficial sediment layer for both sampling events in Phase IV, respectively.

Table 4.2. Silt-Clay (%) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	4	62.34	95.09	76.45
2	2101	Nueces River Tidal	4	45.94	78.13	65.43
3	2101	Nueces River Tidal	2	68.46	96.08	82.27
4	2101	Nueces River Tidal	2	83.29	94.44	88.87
1	2482	Nueces Bay	16	4.61	93.71	41.98
2	2482	Nueces Bay	17	2.53	88.36	37.79
3	2482	Nueces Bay	14	8.11	70.11	41.85
4	2482	Nueces Bay	14	5.86	74.43	41.95
1	2484	Corpus Christi Inner Harbor	8	12.80	87.49	57.03
2	2484	Corpus Christi Inner Harbor	8	19.44	90.82	59.24
3	2484	Corpus Christi Inner Harbor	4	59.28	88.46	68.54
4	2484	Corpus Christi Inner Harbor	4	39.63	74.13	59.52

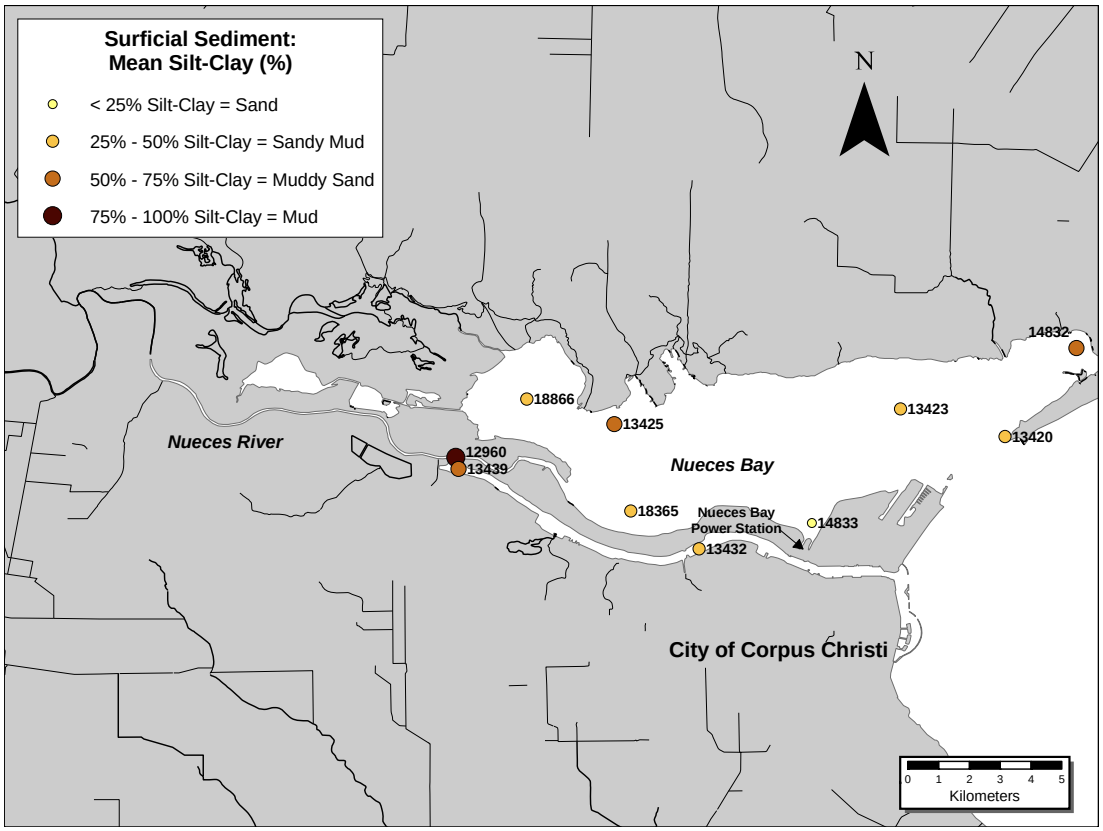

Figure 4.4. Silt-Clay proportions (%) for Phase IV January 2010.

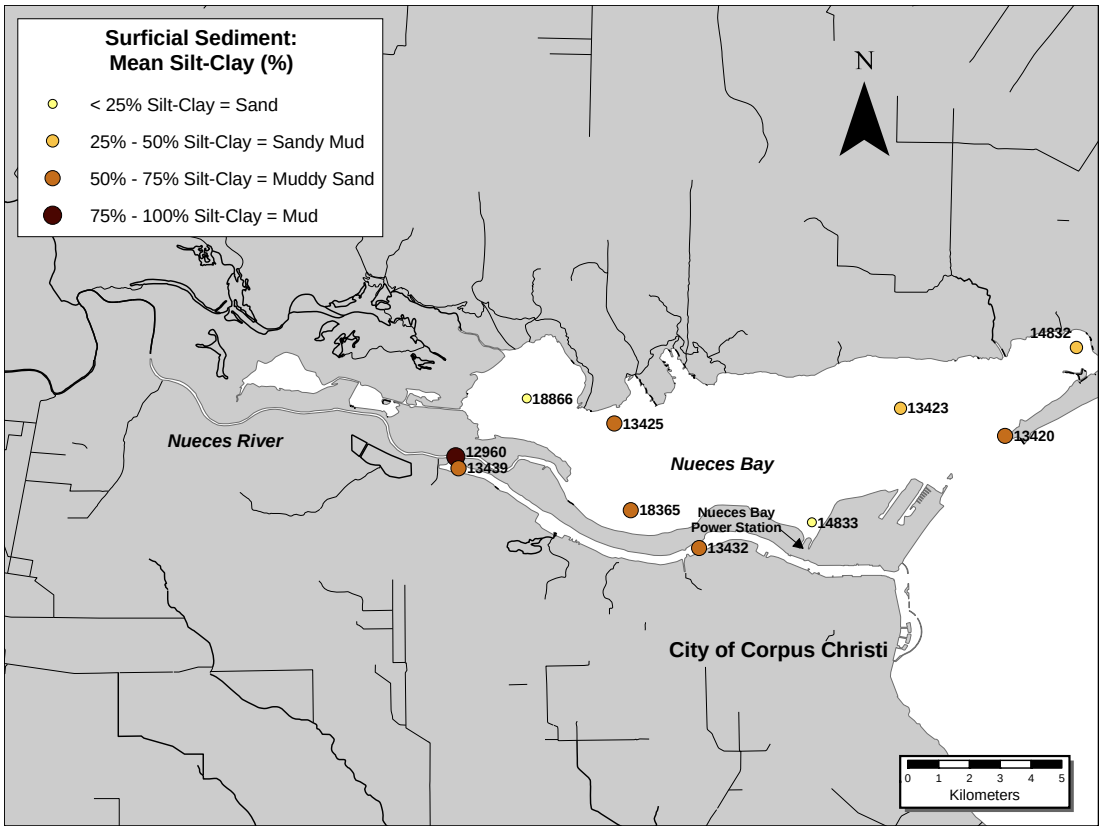

Figure 4.5. Silt-Clay proportions (%) for Phase IV August 2010.

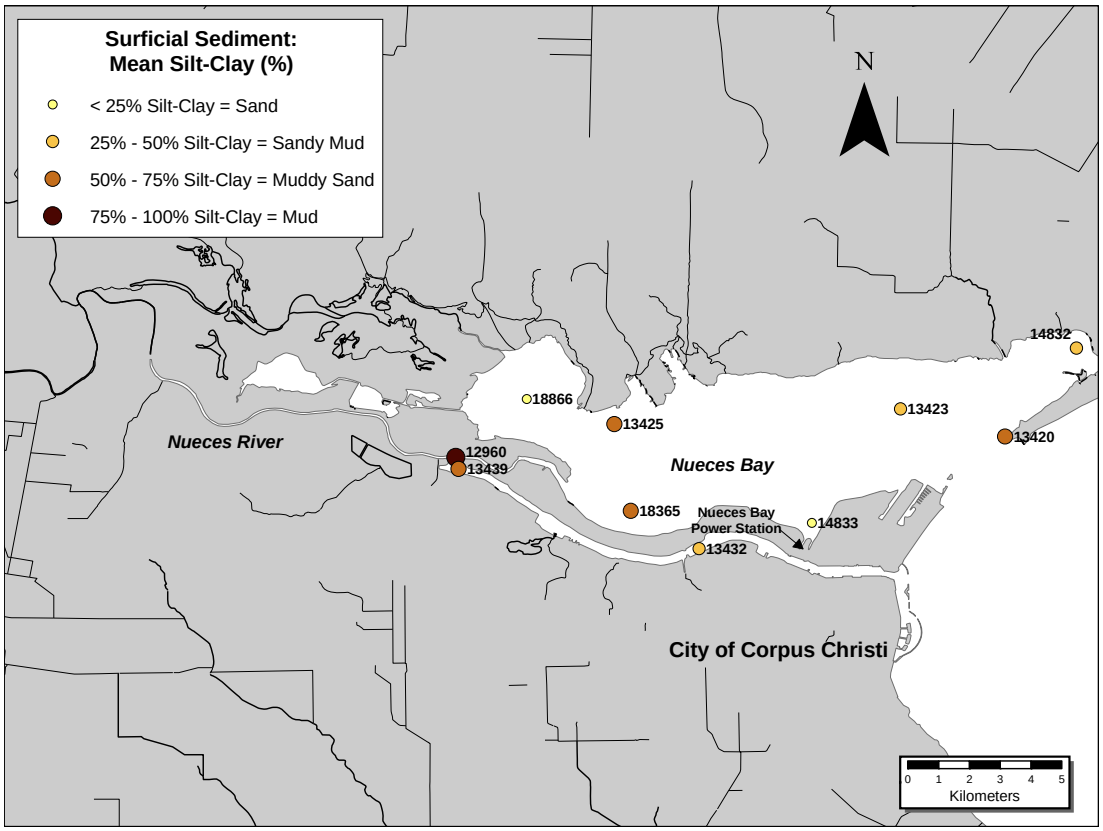

Figure 4.6. Mean Silt-Clay proportions (%) for Phase IV.

4.3 Zinc in Sediment

As detailed in Phase I, elevated sediment zinc concentrations (485 mg/kg) at Nueces River Tidal Station 12961 may be due to the circumstances encountered at the sampling location (Table 4.1). For the September 2004 event, sediment grabs took place downstream of the I-37 Bridge due to anchoring difficulties upstream caused by excessive river currents. This sampling point was adjacent to an area where in July 2005 police discovered three submerged cars. The presence of this large amount of metal may have contributed to the high concentrations recorded. The second Phase I event in May 2005 sampled upstream of the bridge (approximately 300 feet from the September site) and yielded a concentration of 36.90 mg/kg. Two sampling events in Phase II yielded 34.70 mg/kg and 41.60 mg/kg, respectively and collectively these results perhaps are more representative of this location. While no longer sampled, the situation at Station 12961 points to the variability often encountered when sampling within an urban watershed.

Phase IV individual zinc concentrations in the surficial sediment layer were variable and ranged from 12.10 mg/kg at Station 14833 in Nueces Bay to 185.00 mg/kg at Station 13439 in the Corpus Christi Inner Harbor segment (Data Table 7.8.1). Sediment zinc concentrations ranged from 12.10 to 92.40 mg/kg in Nueces Bay with mean concentrations in Nueces Bay slightly higher during Phase IV when compared to Phase III, and slightly lower than seen in the first two Phases (Table 4.1). Sediment zinc concentrations in the Corpus Christi Inner Harbor ranged from 72.70 to 185.00 mg/kg. Mean concentrations were lower than those observed in Phase III and similar to concentrations seen in Phase I sampling.

Except for the one elevated reading at Station 12961, all sediment zinc concentrations for this project remain below the ERM screening value of 410 mg/kg and below the PEL value of 271 mg/kg. Values that have exceed the lowest thresholds (TEL) are in the Corpus Christi Inner Harbor segment and at Station 12960 in the Nueces River Tidal segment, which is adjacent to Station 13439 located in the Viola Turning Basin portion at the end of the Inner Harbor channel (See Fig 2.1). Figs. 4.7, 4.8, and 4.9 depict individual zinc concentrations in the surficial sediment layer for each Phase IV sampling event and mean zinc concentrations in the surficial sediment layer for both sampling events in Phase IV.

Table 4.3. Zinc in surficial sediment (mg/kg) descriptive statistics, listed by sampling year (Phase) and TCEQ segment for all Nueces Bay TMDL stations sampled.

Phase	Segment	Segment Name	n	Min	Max	Mean
1	2101	Nueces River Tidal	4	36.90	485.00	180.20
2	2101	Nueces River Tidal	4	34.70	161.40	70.78
3	2101	Nueces River Tidal	2	19.60	106.80	63.20
4	2101	Nueces River Tidal	2	151.00	166.00	158.50
1	2482	Nueces Bay	16	8.00	115.80	55.29
2	2482	Nueces Bay	17	13.50	120.80	53.68
3	2482	Nueces Bay	14	16.20	75.90	42.61
4	2482	Nueces Bay	14	12.10	92.20	45.81
1	2484	Corpus Christi Inner Harbor	8	63.40	164.80	129.78
2	2484	Corpus Christi Inner Harbor	8	51.10	221.40	166.01
3	2484	Corpus Christi Inner Harbor	4	158.30	201.50	183.55
4	2484	Corpus Christi Inner Harbor	4	72.70	185.00	134.68

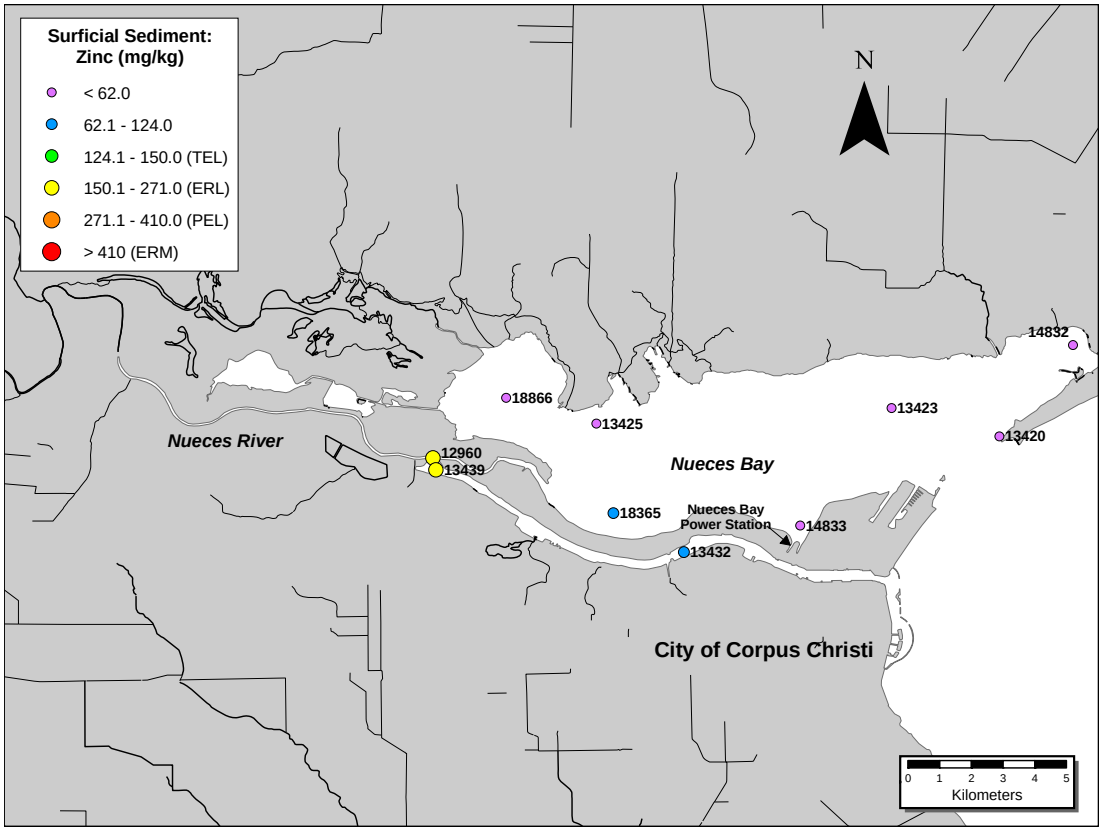

Figure 4.7. Zinc sediment concentrations (mg/kg) for January 2010.

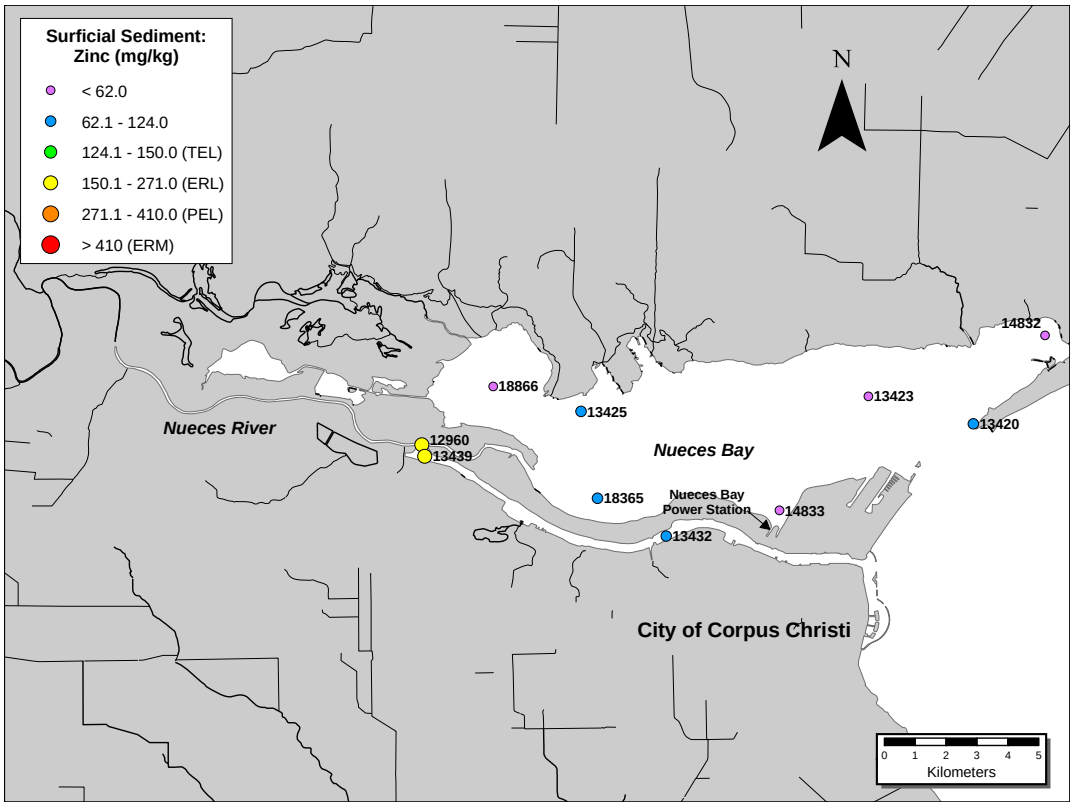

Figure 4.8. Zinc sediment concentrations (mg/kg) for August 2010.

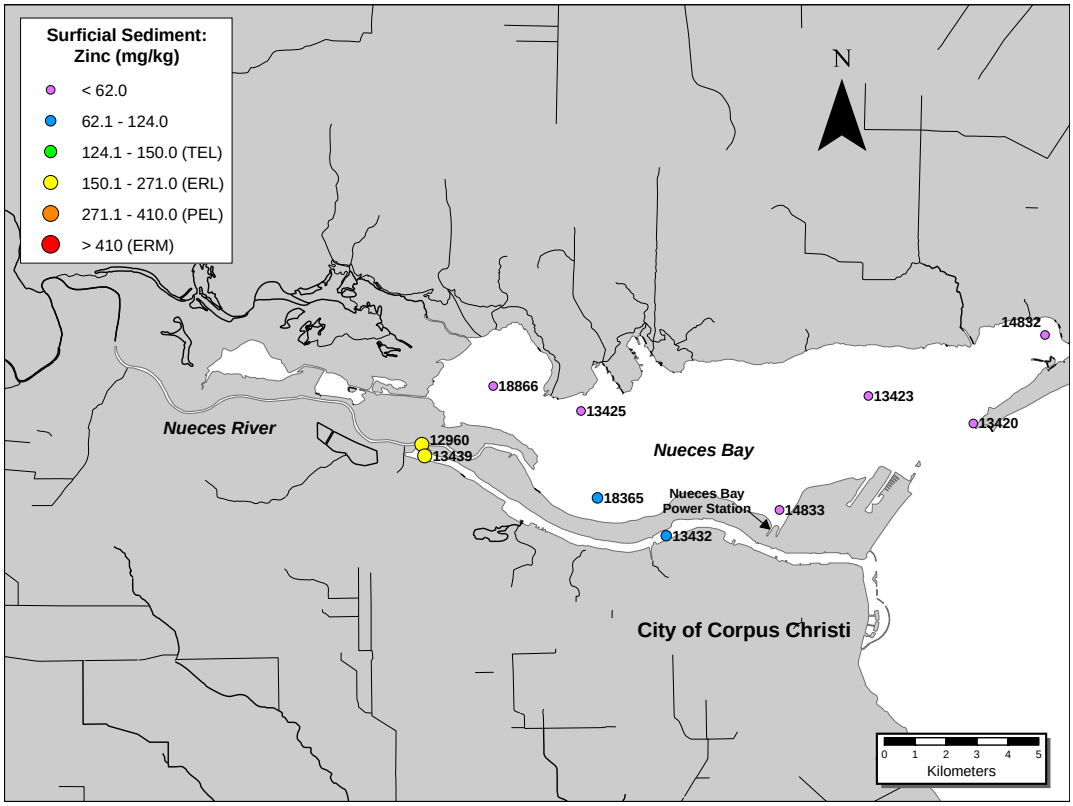

Figure 4.9. Mean zinc sediment concentrations (mg/kg) for Phase IV.

5.0 TISSUE SAMPLING

Pathways that contaminants may enter into marine organisms involve direct uptake from contaminated waters and/or sediments or consumption of already contaminated organisms (USEPA 2004). Once an organism acquires a contaminant, the tendency to remain in the animal tissues or increase through subsequent contamination can be significant. This same bioaccumulation pattern can also happen when humans eat contaminated tissue thereby effecting human health. Concerning oysters, they provide a natural high source of zinc compared to other sources, such as beef, they are highly efficient filter feeders and effectively concentrate and sequester zinc in the environment.

5.1 TCEQ Tissue Screening Levels

As stated in TCEQ guidance documentation (TCEQ 2008), the DSHS will issue fish and shellfish consumption advisories and aquatic life closures for specific contaminants and/or classes of chemicals in areas of Texas surface waters. If DSHS issues such advisories or orders, this indicates a Texas Surface Water Quality Standards violation, specifically of the narrative criterion that surface waters not be toxic to humans from the consumption of aquatic organisms. TCEQ utilizes sampling site information provided in DSHS risk characterizations and advisories, along with TCEQ water body segment information to determine which segments are impaired. TCEQ also will strive to ensure that not only the TCEQ segment containing the DSHS sampling site, but also any appropriate connected segments are listed for the appropriate contaminant.

5.2 Zinc in Oyster Tissue

As previously stated, as TCEQ does not have the administrative and assessment authority for the National Shellfish Sanitation Program for Texas, zinc in oyster tissue data presented here is for informational and not assessment purposes.

During Phase III, multiple attempts to collect oysters took place during the sampling year. However, layers of silt covered many oyster beds in Nueces Bay, which resulted from high sediment loads and deposition during flooding events on the Nueces River. This silt and extreme fluctuations in salinity resulted in no viable (alive or market size) oysters available for collection.

In Phase IV an attempt to collect oysters was made during the January 2010 event. Oysters were found on some reefs but were all <1 inch in size and thereby not adequate for collection and analysis. An expedited amendment to the QAPP, issued in August 2010, allowed for an additional sampling event in an attempt to find market size oysters. Oyster samples were collected at three of the sampling stations described in the QAPP and at two other stations outside the TCEQ 1250' station site radius. All sampling locations were geo-located using a Garmin MAP76 GPS. Oysters collected during the August 2010 event were in the market size category of 2 to 3 inches. However, when oysters arrived at the laboratory and were prepared for analysis it was found that all the actual oyster tissue was extremely small despite the size of the shell. Rather than yielding the necessary >200 g (weight limit established by DSHS during the initial sampling phase) of material per sample the typical sample wet weight was

approximately 30 g. Given the small size of the material per sample, this data and the station locations were not submitted into TCEQ's Surface Water Quality Monitoring Information System (SWQMIS).

Oysters were inspected for possible disease, such as *Perkinsus marinus*; a prevalent oyster pathogen known to occur in Nueces Bay that is characterized by proteolytic degradation of oyster tissues. No visible signs of disease existed and the oysters were best characterized as being healthy in appearance but extremely small. It is our contention that stressful environmental conditions due to sediment deposition from flooding and salinity fluctuations (1.94 to 37.5 PSU) over the last several years may have resulted in this small tissue to shell size condition, but more investigation is required. As data from this analysis is not used for assessment purposes, the decision was made to analyze the oysters regardless of the weight to gather zinc in oyster tissue concentration data. A complete list of individual zinc in oyster tissue concentrations for Phase IV appears in Chapter 7-Data Table 7.10.1.

During Phase IV, oyster tissue analysis revealed high levels of zinc that ranged from 675 mg/kg to 3340 mg/kg (Table 5.1). Highest mean levels were at Station NB3 in the eastern portion and at Station NB1 in the western portion of Nueces Bay. Lowest concentration levels observed were in the northeastern portion of the bay at Station NB4 (Table 5.1 and Fig. 5.1). While most zinc concentrations recorded were higher than past DSHS studies, due to the various reasons previously stated these oysters are not representative of oysters typically sold for human consumption. Therefore, presentation of this data is for informational purposes only. The need for more collection and analysis is necessary to address the question of zinc concentrations in oyster tissue with future events scheduled to occur in Phase V.

Table 5.1. Zinc in oyster tissue concentrations (mg/kg) descriptive statistics, listed by sampling year (Phase) for Nueces Bay TMDL stations sampled. No samples collected during Phase III and the first sampling event of Phase IV. TCEQ Station IDs pending.

Phase	Segment	Segment Name	TCEQ ID	n	Min	Max	Mean
3	2482	Nueces Bay	NB1	-	-	-	-
			NB2	-	-	-	-
			NB3	-	-	-	-
			NB4	-	-	-	-
			NB5	-	-	-	-
4	2482	Nueces Bay	NB1	5	675	3310	2467
			NB2	5	1250	3000	2000
			NB3	5	2280	3340	2674
			NB4	5	1360	1930	1594
			NB5	5	821	2470	1802

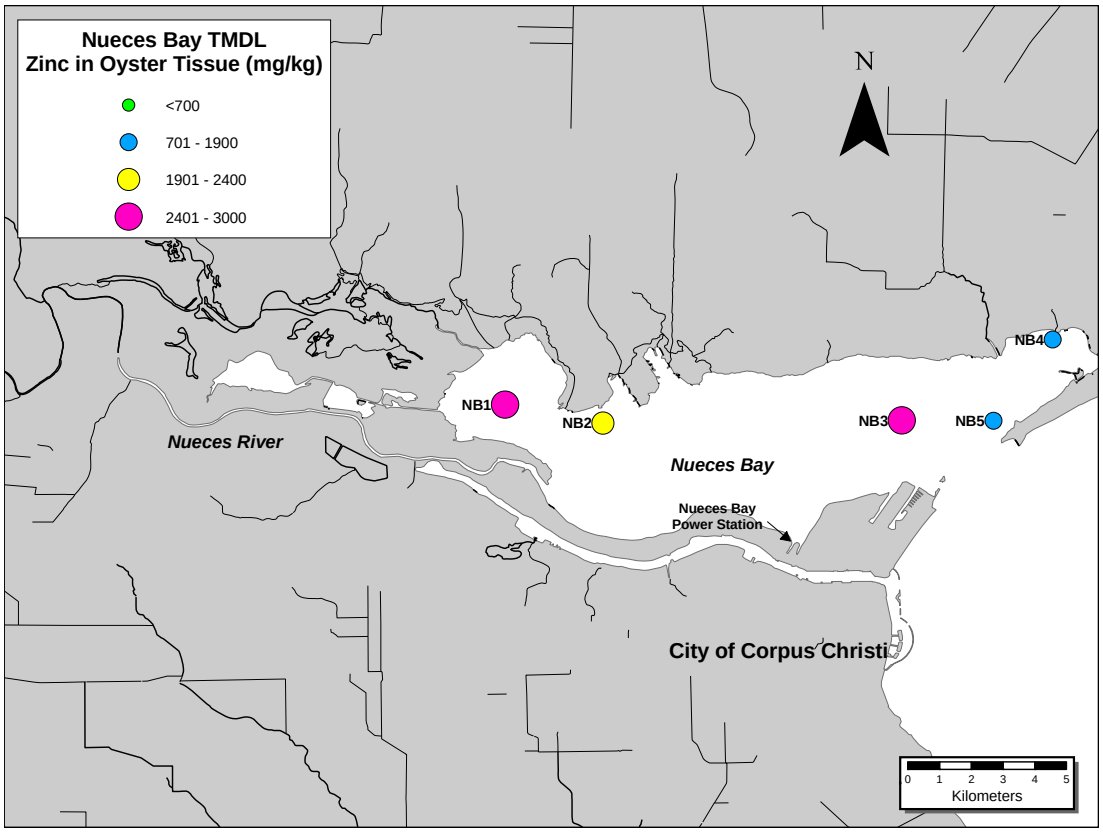

Figure 5.1. Mean zinc in oyster tissue concentrations (mg/kg) for Phase IV.

6.0 REFERENCES

Batterham, G.J., N.C. Munksgaard and D.L. Parry. 1997. Determination of Trace Metals in Seawater by Inductively Coupled Plasma Mass Spectrometry after Off-line Dithiocarbamate Solvent Extraction. Journal of Analytical Atomic Spectrometry 12:1277–1280.

Center for Coastal Studies. 2004. Quality Assurance Project Plan for the Nueces Bay Total Maximum Daily Load Project. Revision 1. 67 pp.

Center for Coastal Studies. 2005. Quality Assurance Project Plan for the Nueces Bay Total Maximum Daily Load Project. Revision 0. 65 pp.

Center for Coastal Studies. 2007. Quality Assurance Project Plan for the Nueces Bay Zinc Total Maximum Daily Load Implementation and Effectiveness Monitoring. Revision 0. 73 pp.

Center for Coastal Studies. 2009. Quality Assurance Project Plan for the Nueces Bay Zinc Total Maximum Daily Load Implementation and Effectiveness Monitoring. Revision 0. 75 pp.

DSHS 2006. Texas Department of State Health Services. Characterization of Potential Health Risks Associated with Consumption of Fish and Shellfish from Nueces Bay, Nueces County, TX. August 2005. 30pp.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environ. Manage. 19(1):81-97.

MacDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long and C.G. Ingersoll. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology. 5: 253-278.

Nicolau, B.A. and A.X. Nuñez. 2004. Coastal Bend Bays and Estuaries Program Regional Coastal Assessment Program (RCAP): RCAP 2001 and RCAP 2002 annual report. Texas A&M University-Corpus Christi, Center for Coastal Studies Technical Report No. TAMU-CC-0406-CCS, Corpus Christi, Texas, USA. 246 pp.

Nicolau, B.A. and A.X. Nuñez. 2005a. Coastal Bend Bays and Estuaries Program Regional Coastal Assessment Program (RCAP): RCAP 2003 annual report. Texas A&M University-Corpus Christi, Center for Coastal Studies Technical Report No. TAMU-CC-0503-CCS, Corpus Christi, Texas, USA. 187 pp.

Nicolau, B.A. and A.X. Nuñez. 2005b. Nueces Bay Total Maximum Daily Load Project – Phase I Interim Data Report. Texas A&M University-Corpus Christi, Center for Coastal Studies Technical Report No. TAMU-CC-0508-CCS, Corpus Christi, Texas, USA. 38 pp.

Nicolau, B.A. 2006a. Coastal Bend Bays and Estuaries Program Regional Coastal Assessment Program (RCAP): RCAP 2004 annual report. Texas A&M University-Corpus Christi, Center for Coastal Studies Technical Report No. TAMU-CC-0603-CCS, Corpus Christi, Texas, USA. 171 pp.

Nicolau, B.A. 2006b. Nueces Bay Total Maximum Daily Load Project – Phase II Data Report. Texas A&M University-Corpus Christi, Center for Coastal Studies Technical Report No. TAMU-CC-0604-CCS, Corpus Christi, Texas, USA. 46 pp.

Simpson, S.L. G.E. Bately, A.A. Chariton, J.L. Stauber, C.K. King, J.C. Chapman, R.V. Hyne, S.A. Gale, A.C. Roach, and W.A. Maher. 2005. Handbook for Sediment Quality Assessment. Centre for Environmental Contaminants Research, Bangor, New South Wales, Australia. 117 pp.

Sohrin, Y., M. Kinugasa, K. Okamura, K. Norisuye, T. Ishita, Y. Fujishima, H. Hasegawa and K. Ueda. 2001. Determination of Trace Metals in the Ocean by MAF-8HQ Column Extraction-ICP-MS. Analytical Sciences 17:49-52.

TCEQ. 2006. One Total Maximum Daily Load for Zinc in Oyster Tissue in Nueces Bay Segment 2482. Chief Engineer's Office, Water Programs, TMDL Section, Austin, Texas. 39 pp.

TCEQ. 2007. Implementation Plan for Zinc in Oyster Tissue in Nueces Bay Segment 2482. Chief Engineer's Office, Water Programs, TMDL Section, Austin, Texas. 12 pp.

TCEQ. 2008. Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue. TCEQ, Monitoring Operations Division, Austin, Texas. 210 pp.

TCEQ. 2008. Guidance for assessing and reporting surface water quality data in Texas, 2008. TCEQ, Monitoring Operations Division, Austin, Texas. 170 pp.

USEPA. 1999. Method 1669 "Sampling ambient water for trace metals at EPA water quality criteria levels". EPA 821-R-95-034. Office of Water, Washington, DC.

USEPA. 2004. National Coastal Condition Report II. EPA/620/R-03/002. Office of Research and Development and Office of Water, Washington D. C. 285 pp.

7.0 DATA TABLES

7.1 Station Information

Table 7.1.1. Segment designation, TCEQ Station ID, sample type, and station location coordinates for Nueces Bay TMDL stations. Sampling took place for FD = Field Data, RC = Routine Conventional Water Chemistry, and TM = Trace Metals-Water, TMSED = Trace Metals-Sediment for two events (January 2010 and August 2010).

Segment Number	Segment Name	TCEQ ID	Latitude (dd)	Longitude (dd)
2101	Nueces River Tidal	12960	27.84667	-97.52084
2482	Nueces Bay	13420	27.85278	-97.36028
		13423	27.86083	-97.39083
		13425	27.85639	-97.47450
		14832	27.87861	-97.33944
		14833	27.82750	-97.41670
		18365	27.83104	-97.46967
		18866	27.86372	-97.50007
2484	Corpus Christi Inner Harbor	13432	27.82000	-97.44972
		13439	27.84333	-97.52000

7.2 Field Parameters – Individual Concentrations for grab samples taken at surface (0.30 m)

Table 7.2.1. Field Parameter concentrations at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 12 (August 2010). * = no data collected.

January 2010	Segment	Segment Name	TCEQ_ID	Cond. (µmhos)	DO (mg/L)	DO Sat. (%)	pH (su)	Salinity (PSU)	Secchi Depth (m)	Total Depth (m)	Turbidity (NTU)	Water Temp (°C)
	2101	Nueces River Tidal	12960	10825	11.35	116.50	8.12	6.18	0.40	0.80	10.10	14.46
	2482	Nueces Bay	13420	41505	11.87	148.10	8.34	26.31	> 0.60	0.60	0.10	18.17
	2482		13423	40569	11.76	142.90	8.24	26.20	> 1.30	1.30	0.70	16.34
	2482		13425	35517	10.06	113.10	8.04	21.05	> 0.90	0.90	0.60	14.93
	2482		14832	40544	12.46	151.30	8.35	25.95	> 0.90	0.90	1.00	16.53
	2482		14833	44212	12.68	156.80	8.30	28.60	> 0.40	0.40	0.30	17.14
	2482		18365	34912	10.27	117.80	8.01	22.02	> 1.00	1.00	0.40	15.35
	2482		18866	30567	9.93	110.40	8.05	19.02	> 0.90	0.90	4.60	14.70
	2484	Corpus Christi Inner Harbor	13432	43950	9.84	116.20	7.85	28.38	1.30	15.30	*	15.03
	2484		13439	43447	9.58	113.80	7.76	28.03	1.00	13.80	2.60	15.44
August 2010	**Segment**	**Segment Name**	**TCEQ_ID**	**Cond. (µmhos)**	**DO (mg/L)**	**DO Sat. (%)**	**pH (su)**	**Salinity (PSU)**	**Secchi Depth (m)**	**Total Depth (m)**	**Turbidity (NTU)**	**Water Temp (°C)**
	2101	Nueces River Tidal	12960	8360	4.66	63.50	8.61	4.57	0.20	0.70	26.00	30.41
	2482	Nueces Bay	13420	47377	8.35	139.10	8.35	30.58	0.20	0.60	33.30	33.63
	2482		13423	42834	6.59	104.60	8.06	27.43	0.80	1.70	1.90	31.70
	2482		13425	28030	6.04	88.40	7.86	17.15	0.65	1.10	4.20	30.11
	2482		14832	45577	7.53	117.30	8.39	29.33	0.35	1.20	14.10	31.66
	2482		14833	33745	6.62	100.70	8.04	21.00	0.70	0.80	3.70	31.46
	2482		18365	26911	6.47	95.60	7.99	16.37	0.50	1.45	5.30	31.03
	2482		18866	22381	6.06	87.4	8.05	13.45	0.40	1.2	9.90	30.23
	2484	Corpus Christi Inner Harbor	13432	49832	5.29	84.80	7.94	32.53	1.25	15.40	1.40	30.82
	2484		13439	48950	5.60	38.90	7.93	31.83	1.10	15.80	0.70	31.03

7.3 Field Parameters – Descriptive Statistics based on grab samples taken at surface (0.30 m)

Table 7.3.1 Conductivity (µmhos) and Salinity (PSU) descriptive statistics, listed by TCEQ Segment, at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
Conductivity	Event 1	2101	Nueces River Tidal	1	-	-	10825
(µmhos)	(January 2010)	2482	Nueces Bay	7	30567	44212	38261
		2484	Corpus Christi Inner Harbor	2	43447	43950	**43699**
	Event 2	2101	Nueces River Tidal	1	-	-	8360
	(August 2010)	2482	Nueces Bay	7	22381	47377	35265
		2484	Corpus Christi Inner Harbor	2	48950	49832	**49391**
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Salinity	Event 1	2101	Nueces River Tidal	1	-	-	6.18
(PSU)	(January 2010)	2482	Nueces Bay	7	19.02	28.60	24.16
		2484	Corpus Christi Inner Harbor	2	28.03	28.38	**28.21**
	Event 2	2101	Nueces River Tidal	1	-	-	4.57
	(August 2010)	2482	Nueces Bay	7	13.45	30.58	22.19
		2484	Corpus Christi Inner Harbor	2	31.83	32.53	**32.18**

Table 7.3.2. Dissolved Oxygen (mg/L and % Saturation) descriptive statistics, listed by TCEQ Segment, at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
Dissolved Oxygen	Event 1	2101	Nueces River Tidal	1	-	-	**11.35**
(mg/L)	(January 2010)	2482	Nueces Bay	7	9.93	12.68	11.29
		2484	Corpus Christi Inner Harbor	2	9.58	9.84	9.71
	Event 2	2101	Nueces River Tidal	1	-	-	4.66
	(August 2010)	2482	Nueces Bay	7	6.04	8.35	**6.81**
		2484	Corpus Christi Inner Harbor	2	5.29	5.60	5.45
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Dissolved Oxygen	Event 1	2101	Nueces River Tidal	1	-	-	116.50
(% Saturation)	(January 2010)	2482	Nueces Bay	7	110.40	156.80	**134.34**
		2484	Corpus Christi Inner Harbor	2	113.80	116.20	115.00
	Event 2	2101	Nueces River Tidal	1	-	-	63.50
	(August 2010)	2482	Nueces Bay	7	87.40	139.10	**104.73**
		2484	Corpus Christi Inner Harbor	2	38.90	84.80	61.85

Table 7.3.3. pH (su) and Water Temperature (°C) descriptive statistics, listed by TCEQ Segment, at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
pH	Event 1	2101	Nueces River Tidal	1	-	-	8.12
(su)	(January 2010)	2482	Nueces Bay	7	8.01	8.35	**8.19**
		2484	Corpus Christi Inner Harbor	2	7.76	7.85	7.81
	Event 2	2101	Nueces River Tidal	1	-	-	**8.61**
	(August 2010)	2482	Nueces Bay	7	7.86	8.39	8.11
		2484	Corpus Christi Inner Harbor	2	7.93	7.94	7.94
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Water Temperature	Event 1	2101	Nueces River Tidal	1	-	-	14.46
(°C)	(January 2010)	2482	Nueces Bay	7	14.70	18.17	**16.17**
		2484	Corpus Christi Inner Harbor	2	15.03	15.44	15.24
	Event 2	2101	Nueces River Tidal	1	-	-	30.41
	(August 2010)	2482	Nueces Bay	7	30.11	33.63	**31.40**
		2484	Corpus Christi Inner Harbor	2	30.82	31.03	30.93

Table 7.3.4. Secchi Depth (m) and Turbidity (NTU) descriptive statistics, listed by TCEQ Segment, at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
Secchi Depth	Event 1	2101	Nueces River Tidal	1	-	-	0.40
(m)	(January 2010)	2482	Nueces Bay	7	> 0.40	> 1.30	> 0.86
		2484	Corpus Christi Inner Harbor	2	1.00	1.30	**1.15**
	Event 2	2101	Nueces River Tidal	1	-	-	0.20
	(August 2010)	2482	Nueces Bay	7	0.20	0.80	0.51
		2484	Corpus Christi Inner Harbor	2	1.10	1.25	**1.18**
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Turbidity	Event 1	2101	Nueces River Tidal	1	-	-	**10.10**
(NTU)	(January 2010)	2482	Nueces Bay	7	0.10	4.60	1.10
		2484	Corpus Christi Inner Harbor	1	-	-	2.60
	Event 2	2101	Nueces River Tidal	1	-	-	**26.00**
	(August 2010)	2482	Nueces Bay	7	1.90	33.30	12.64
		2484	Corpus Christi Inner Harbor	2	0.70	1.40	1.05

Table 7.3.5. Total Depth (m) descriptive statistics, listed by TCEQ Segment, at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
Total Depth	Event 1	2101	Nueces River Tidal	1	-	-	0.80
(m)	(January 2010)	2482	Nueces Bay	7	0.40	1.30	0.86
		2484	Corpus Christi Inner Harbor	2	13.80	15.30	**14.55**
	Event 2	2101	Nueces River Tidal	1	-	-	0.70
	(August 2010)	2482	Nueces Bay	7	0.60	1.70	1.15
		2484	Corpus Christi Inner Harbor	2	15.40	15.80	**15.60**

7.4 Routine Conventional Water Chemistry – Individual Concentrations for grab samples taken at surface (0.30 m)

Table 7.4.1. Total Suspended Solid concentrations (mg/L or ppm) at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded concentrations for the event.

Segment	Segment Name	TCEQ ID	January 2010 (Event 1)	August 2010 (Event 2)	Mean of all Events
2101	Nueces River Tidal	12960	**13.00**	25.00	19.00
2482	Nueces Bay	13420	5.00	**37.00**	**21.00**
2482		13423	6.00	9.00	7.50
2482		13425	7.00	8.00	7.50
2482		14832	9.00	31.00	20.00
2482		14833	8.00	9.00	8.50
2482		18365	6.00	10.00	8.00
2482		18866	12.00	14.00	13.00
2484	Corpus Christi Inner Harbor	13432	6.00	9.00	7.50
2484		13439	10.00	9.00	9.50

7.5 Routine Conventional Water Chemistry –Descriptive Statistics based on grab samples taken at surface (0.30 m)

Table 7.5.1. Total Suspended Solids (mg/L) descriptive statistics, listed by TCEQ Segment, at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
Total	Event 1	2101	Nueces River Tidal	1	-	-	**13.00**
Suspended	(January 2010)	2482	Nueces Bay	7	5.00	12.00	7.57
Solids		2484	Corpus Christi Inner Harbor	2	6.00	10.00	8.00
(TSS)	Event 2	2101	Nueces River Tidal	1	-	-	**25.00**
	(August 2010)	2482	Nueces Bay	7	8.00	37.00	16.86
		2484	Corpus Christi Inner Harbor	2	9.00	9.00	9.00

7.6 Trace Metals in Water – Individual Concentrations for pumped grab samples taken at surface (0.30 m)

Table 7.6.1. Individual zinc concentrations (ppb) at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). D = Dissolved Zinc and T = Total Zinc, TWC = Tidal Water Chronic for Dissolved Zinc.

Parameter	Segment	Segment Name	TCEQ ID	January 2010 (Event 1)		August 2010 (Event 2)	
				T	D	T	D
Dissolved Zinc	2101	Nueces River Tidal	12960	2.48	0.89	5.45	1.72
TWC = 84.20	2482	Nueces Bay	13420	0.87	0.79	7.28	0.65
Nueces Bay = NA	2482		13423	1.65	1.14	2.82	1.24
	2482		13425	1.41	1.00	3.21	1.57
	2482		14832	1.70	1.32	4.17	0.92
Total Zinc	2482		14833	3.13	2.95	4.08	1.46
TWC = NA	2482		18365	2.51	1.97	3.40	1.07
Nueces Bay = 29.00	2482		18866	2.70	0.95	3.41	0.64
	2484	Corpus Christi Inner Harbor	13432	7.66	6.61	8.65	5.51
	2484		13439	9.73	8.44	4.36	2.08

7.7 Trace Metals in Water – Descriptive Statistics based on pumped grab samples taken at surface (0.30 m)

Table 7.7.1. Total and Dissolved Zinc (ppb) descriptive statistics, listed by TCEQ Segment, for Nueces Bay TMDL stations. **Bold** = highest recorded mean concentrations for the event. TWC = Tidal Water Chronic.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
Total Zinc	Event 1	2101	Nueces River Tidal	1	-	-	2.48
	(January 201)	2482	Nueces Bay	7	0.87	3.13	2.00
TWC = NA		2484	Corpus Christi Inner Harbor	2	7.66	9.73	**8.70**
Nueces Bay = 29.00	Event 2	2101	Nueces River Tidal	1	-	-	5.45
	(August 2010)	2482	Nueces Bay	7	2.82	7.28	4.05
		2484	Corpus Christi Inner Harbor	2	4.36	8.65	**6.51**
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Dissolved Zinc	Event 1	2101	Nueces River Tidal	1	-	-	0.89
	(January 2010)	2482	Nueces Bay	7	0.79	2.95	1.45
TWC = 84.20		2484	Corpus Christi Inner Harbor	2	6.61	8.44	**7.53**
Nueces Bay = NA	Event 2	2101	Nueces River Tidal	1	-	-	1.72
	(August 2010)	2482	Nueces Bay	7	0.64	1.57	1.08
	Event 1	2484	Corpus Christi Inner Harbor	2	2.08	5.51	**3.80**

7.8 Trace Metals in Sediment and Sediment Characteristics – Individual Concentrations

Table 7.8.1. Zinc, Total Organic Carbon (TOC) concentration (mg/kg), and sediment characteristic concentrations (%) at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010).

January 2010	Segment	Segment Name	TCEQ ID	Zn	TOC	Gravel/Shell	Sand	Silt-Clay
Zinc (Zn)	2101	Nueces River Tidal	12960	151.00	20100	0.00	16.71	83.29
ERM = 410.0	2482	Nueces Bay	13420	24.80	6700	0.08	67.84	32.08
	2482		13423	43.30	5950	0.82	56.67	42.51
	2482		13425	47.50	8990	0.03	34.00	65.96
	2482		14832	36.40	7960	0.00	49.87	50.13
	2482		14833	12.10	1710	0.07	94.08	5.86
	2482		18365	66.40	6750	9.25	46.60	44.15
	2482		18866	25.40	8330	0.03	73.59	26.38
	2484	CC Inner Harbor	13432	72.70	4980	2.51	57.86	39.63
	2484		13439	185.00	13400	0.00	25.87	74.13
August 2010	**Segment**	**Segment Name**	**TCEQ ID**	**Zn**	**TOC**	**Gravel/Shell**	**Sand**	**Silt-Clay**
Zinc (Zn)	2101	Nueces River Tidal	12960	166.00	21700	0.00	5.56	94.44
ERM = 410.0	2482	Nueces Bay	13420	75.40	23400	0.00	24.94	74.43
	2482		13423	49.20	8860	3.05	60.20	36.75
	2482		13425	65.30	9700	0.07	28.28	71.64
	2482		14832	38.90	10100	0.25	51.30	48.46
	2482		14833	20.70	2200	0.10	91.78	8.11
	2482		18365	92.20	9890	2.06	39.62	58.31
	2482		18866	43.70	4340	0.09	77.44	22.47
	2484	CC Inner Harbor	13432	103.00	11800	1.32	44.25	54.34
	2484		13439	178.00	20000	0.00	30.01	69.98

7.9 Trace Metals in Sediment – Descriptive Statistics

Table 7.9.1. Zinc and Total Organic Carbon (mg/kg), in sediment descriptive statistics, listed by TCEQ Segments, for Nueces Bay TMDL Stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
ZINC (mg/kg)	Event 1 (January 2010)	2101	Nueces River Tidal	1	-	-	**151.00**
		2482	Nueces Bay	7	12.10	66.40	36.56
		2484	Corpus Christi Inner Harbor	2	72.70	185.00	128.85
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
ZINC (mg/kg)	Event 2 (August 2010)	2101	Nueces River Tidal	1	-	-	**166.00**
		2482	Nueces Bay	7	20.70	92.20	55.06
		2484	Corpus Christi Inner Harbor	2	103.00	178.00	140.50
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
TOC (mg/kg)	Event 1 (January 2010)	2101	Nueces River Tidal	1	-	-	**20100**
		2482	Nueces Bay	7	1710	8990	6627
		2484	Corpus Christi Inner Harbor	2	4980	13400	9190
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
TOC (mg/kg)	Event 2 (August 2010)	2101	Nueces River Tidal	1	-	-	**21700**
		2482	Nueces Bay	7	2200	23400	9784
		2484	Corpus Christi Inner Harbor	2	11800	20000	15900

Table 7.9.2. Percent Sand and Percent Silt-Clay in sediment descriptive statistics listed by TCEQ Segments, for Nueces Bay TMDL Stations for Sampling Event 1 (January 2010) and for Sampling Event 2 (August 2010). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
Percent Sand (0.0625 - 2.00 mm)	Event 1 (January 2010)	2101	Nueces River Tidal	1	-	-	16.71
		2482	Nueces Bay	7	34.00	94.08	**60.38**
		2484	Corpus Christi Inner Harbor	2	25.87	57.86	41.87
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Percent Sand (0.0625 - 2.00 mm)	Event 2 (August 2010)	2101	Nueces River Tidal	1	-	-	5.56
		2482	Nueces Bay	7	24.94	91.78	**53.37**
		2484	Corpus Christi Inner Harbor	2	30.01	44.25	37.13
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Percent Silt-Clay (< 0.0625 mm)	Event 1 (January 2010)	2101	Nueces River Tidal	1	-	-	**83.29**
		2482	Nueces Bay	7	5.86	65.96	38.15
		2484	Corpus Christi Inner Harbor	2	39.63	74.13	56.88
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Percent Silt-Clay (< 0.0625 mm)	Event 2 (August 2010)	2101	Nueces River Tidal	1	-	-	**94.44**
		2482	Nueces Bay	7	8.11	74.43	45.74
		2484	Corpus Christi Inner Harbor	2	54.34	69.98	62.16

7.10 Trace Metals in Oyster Tissue – Individual Concentrations

Table 7.10.1. Zinc in oyster tissue concentrations (mg/kg) at Nueces Bay TMDL stations for Sampling Event 1 (January 2010) and Sampling Event 2 (August 2010). **Bold** = highest recorded concentration for the event.: No samples collected during January 2010 event. TCEQ Station IDs pending.

Segment	Segment Name	TCEQ ID*	Sample	January 2010 (Event 1)	August 2010 (Event 2)
2482	Nueces Bay	CCS_NB1	1	-	675
			2	-	3310
			3	-	3260
			4	-	2800
			5	-	2290
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**January 2010 (Event 1)**	**August 2010 (Event 2)**
2482	Nueces Bay	CCS_NB2	1	-	1770
			2	-	2670
			3	-	1310
			4	-	3000
			5	-	1250
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**January 2010 (Event 1)**	**August 2010 (Event 2)**
2482	Nueces Bay	CCS_NB3	1	-	2480
			2	-	2910
			3	-	**3340**
			4	-	2280
			5	-	2360
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**January 2010 (Event 1)**	**August 2010 (Event 2)**
2482	Nueces Bay	CCS_NB4	1	-	1660
			2	-	1530
			3	-	1360
			4	-	1930
			5	-	1490
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**January 2010 (Event 1)**	**August 2010 (Event 2)**
2482	Nueces Bay	CCS_NB5	1	-	1800
			2	-	821
			3	-	1630
			4	-	2470
			5	-	2290