Nueces Bay Total Maximum Daily Load Project – Year-five Implementation Effectiveness Monitoring Data Report

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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. The listing resulted from zinc in oyster tissue levels being greater than the health assessment comparison value (HAC) of 700 mg/kg as defined by the Texas Department of State Health Services (DSHS 2006) necessary to support the oyster water use in Nueces Bay. In response to this listing, the Texas Commission on Environmental Quality (TCEQ) Total Maximum Daily Load (TMDL) Program, in conjunction with the Coastal Management Program (CMP), funded two projects to: 1) develop a Geographic Information System (GIS) zinc loadings model and 2) verify the zinc impairment in oyster tissue through a sampling program.

The GIS zinc loadings model developed by Mrini *et. al* (2003) provided documentation of zinc loadings and an assessment of possible zinc sources entering into Nueces Bay. Modeling of the data indicated that elevated aqueous total zinc concentrations in Nueces Bay might be due to the discharge of Nueces Bay Power Station (NBPS) once-through cooling water drawn from the Corpus Christi Inner Harbor (Segment 2484). The Corpus Christi Inner Harbor segment includes numerous industrial facilities with TCEQ permitted discharges to Inner Harbor waters.

For the sampling program, the collection of total and dissolved zinc data utilized Ultra-Clean sampling methods and analysis (*EPA 1640–modified*) to augment the TCEQ historical zinc database, reduce data variability, and track the effect of possible reduced zinc loadings resulting from the closure of the NBPS in December 2002. Utilizing EPA method 1640 provides lower detection limits that are necessary since 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 collection 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 field blanks and method blanks sufficiently low enough to allow accurate determinations of ambient zinc concentrations in seawater. Due to analytical interferences caused 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 EPA method 1640. (Batterham et al. 1997; Sohrin et al. 2001).

Historically, as part of the multi-faceted Coastal Bend Bays & Estuaries Program Regional Coastal Assessment Program, the Center for Coastal Studies (CCS) collected water and sediment samples throughout the Coastal Bend region from 2000 through 2004. Aqueous samples were analyzed using EPA method 1640 (and others) for a suite of trace metal parameters. Data from this multiyear study identified dissolved zinc concentrations in Nueces Bay 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 the present study to collect new data, with Year-one data representing zinc concentrations from four sampling events between June 2004 – May 2005 (Nicolau and

Nuñez 2005b). Additional data collected in Year-two represents four sampling events that took place between September 2005 – July 2006 (Nicolau and Nuñez 2006b). Results of the first two years facilitated development of the current TMDL to allocate the allowable zinc load in Nueces Bay (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 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 TCEQ approved the Implementation Plan on 24 October 2007 (TCEQ 2007). As part of determining the Implementation Plan success, sampling occurred biannually for zinc in water, sediment, and tissue in Year-three from April 2008 – August 2008, Year-four from January 2010 – August 2010, and the current Year-five sampling events took place from February 2011 – August 2011.

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 (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 Year-five of the Nueces Bay Zinc TMDL Implementation Effectiveness Monitoring are to continue sampling Nueces Bay (Segment 2482), the Corpus Christi Inner Harbor (Segment 2484), and the Nueces River tidal (Segment 2101) to track water, sediment, and oyster 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, 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 of the TMDL Program required collecting data of sufficient quality to characterize zinc in water and zinc in sediment within Nueces Bay (Segment 2482), Nueces River Tidal (Segment 2101), and the Corpus Christi Inner Harbor (Segment 2484). The design had to be flexible to accommodate possible modifications, such as the addition or deletion of stations or increased sampling frequency, as results from previous sampling years became available.

In Year-one 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 Year-one, sediment was collected from the surficial 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 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 two sediment events conducted in Year-one, and one event conducted in Year-two did yield higher concentrations existing at lower depths (mean surficial = 91.4 mg/kg and mean anaerobic = 110.9 mg/kg). However, no statistically significant difference existed for zinc concentrations between depths (all Stations p = 0.62, Corpus Christi Inner Harbor Stations p = 0.89, Nueces Bay Stations p = 0.70, Nueces River Tidal Stations p = 0.70).

Initially, Year-two sampling protocol was to duplicate that of Year-one. 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 in the TMDL process. The first effort was to investigate the concentration of total and dissolved zinc in water at deeper depths within the Corpus Christi Inner Harbor (Year-two April and July 2006 events). This effort would determine if samples taken at the surface are representative of the NBPS intake pipe located at approximately 7.0 m below the surface and thereby closer to the bottom sediments and possible influence of sediments re-suspended by ship propellers. Data analysis showed no statistical difference between the two depths for total (p = 0.78) or dissolved zinc (p = 0.80) and TCEQ TMDL personnel and CCS agreed surface samples were representative of the water body.

Secondly, TCEQ TMDL personnel and CCS researchers agreed sampling in the western portion of Nueces Bay was necessary since this area lacks current zinc information. This portion of the bay is located adjacent to a historical brine point source discharge facility and is directly downwind from the Inner Harbor industrial complex. 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 Plan for the Nueces Bay TMDL study.

In Year-three, modifications to the sampling plan included a reduction in the number of stations sampled from fifteen to the ten and the number of yearly sampling events was

reduced from four to two. In addition, oyster tissue sampling took place for zinc concentrations 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 Year-four and Year-five, 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.

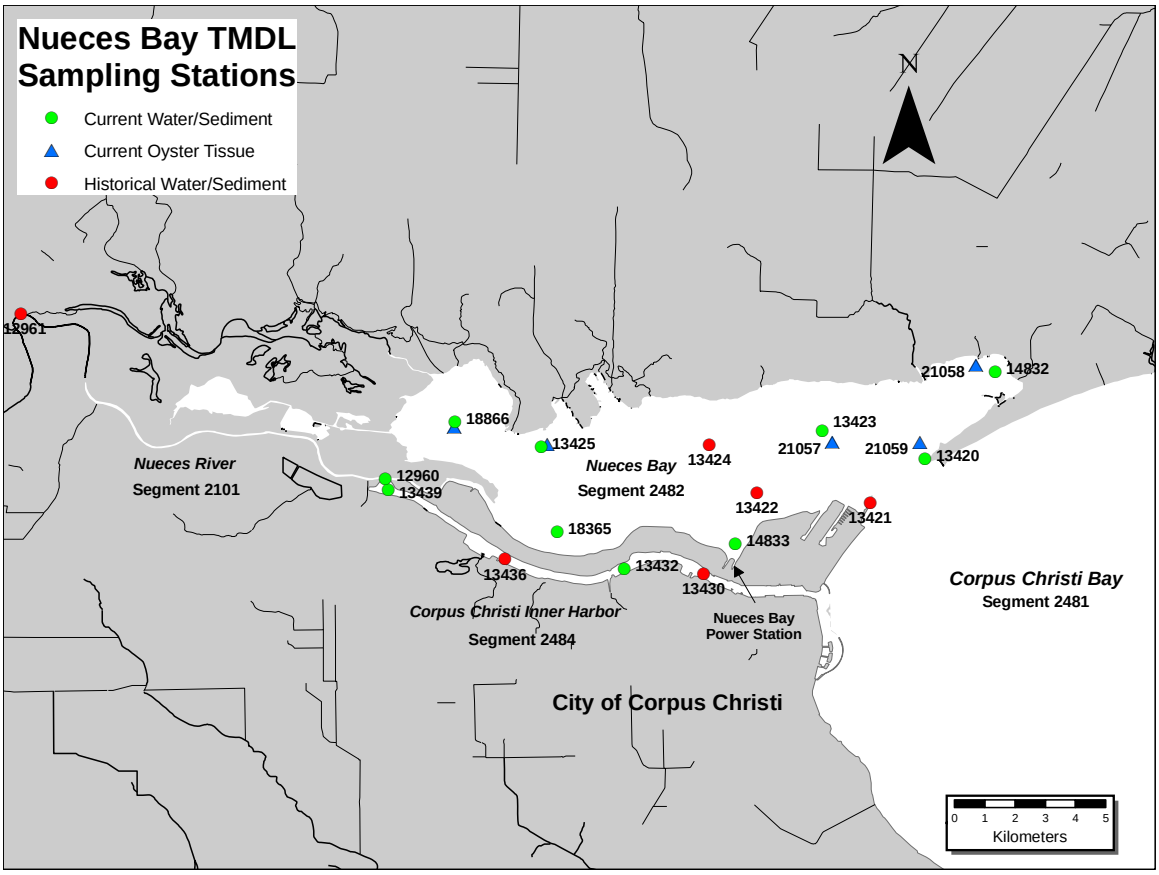

Figure 2.1. Map of current and historical Center for Coastal Studies Nueces Bay TMDL sampling locations.

2.2 Parameters Sampled

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 weight	82009
SGS Silt (0.0039 to 0.0625 mm)	% dry weight	82008
SGS Sand (0.0625 to 2.0 mm)	% dry weight	89991
SGS Gravel (>2.0 mm)	% dry weight	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, 2009, 2010, and 2011). A three-person field crew conducted water and sediment sampling from a 21'fiberglass boat on a quarterly or biannual basis. At each sampling site, field crews collected a core set of data and field samples following methods and protocols 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 specified 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 are requirements for specific 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 year 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 are specific requirements for this TMDL Project and provide additional clarification.

2.3.2. Site Location

As required through TMDL implementation, data collection efforts involved sampling water, sediment, and oyster tissue to monitor and determine effects of zinc loadings to Nueces Bay. Guidelines exist for selecting sampling sites with consideration given to site accessibility and sampling crew safety. Sampling site locations were established prior to field sampling with selection based on 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. See Data Table 7.1.1 for station location information.

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 the sediment. 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 (°C), dissolved oxygen (mg/L), conductivity (µmhos), salinity (Practical Salinity Units or PSU), pH (standard units or su), and turbidity (Nephelometric Turbidity Units or NTU). Water column profiles were conducted when depth was > 1.5 m, and according to TCEQ requirements for vertical depth profiles. Secchi depth measurements were collected at each station using 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 July 2006. TSS samples were collected in 1 L polypropylene bottles and placed on wet ice in the field and 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 sampling methods, the “clean hands – dirty hands” technique, for collecting trace metals samples. Avoiding contamination during field sampling is extremely

important for the accuracy of clean metals data. Reducing potential for contamination is essential 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 sampling 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 came individually bagged and separate from the clean boxes. The actual collection of the water sample took place in a clean box used as a hood to minimize air particulates entering the sample. Certified LDPE sample bottle had a unique identifying number provided by Albion Environmental. Teflon inlet tubing inserted into a particle-free 4.6 m PVC pole allowed for water collection upstream of the sampling boat. Dissolved zinc samples were 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 filter. To verify no contamination occurred during field sampling, one field blank and one field duplicate sample were taken for each sampling event.

Please note that the above description is a simplified version of the sampling process. Additional sampling details can be found 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, a modified 0.04 m^2 Van Veen sampler was used to collect a minimum of three sediment grab samples to ensure enough material for the analyses of total zinc, total organic carbon (TOC), and sediment grain size determinations. A plastic scoop was used to obtain the surficial sediment layer (2 to <5 cm) from each grab sample and composited in a clean, high-grade stainless steel bucket. Continually mixing the sediment from each grab sample ensured a homogenous sample and placement of the bucket containing the sediment material on ice and covering with a lid protected the sample material from contamination. Sub-samples for the various analyses took place as follows:

Inorganic chemical contaminants (Zinc, TOC, and Sediment Grain Size)

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

2.3.7. Oyster Sampling

Oysters were collected at selected sites from shallow reefs using a standard dredge towed behind the boat then placed in Ziploc bags and stored on wet ice. Five samples were collected at each location, yielding 25 samples per sampling event. Each sample consisted of 25 to 30 oysters of market length (2 to 3 inches) to yield >15 g per sample. Upon return to CCS, field staff placed the oysters on fresh wet ice and shipped overnight to GEL laboratories 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 exceedances. 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 2010* (TCEQ 2010) the identification of impairment relates directly to criteria adopted in the *Texas Surface Water Quality Standards* (TSWQS) that protects 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. Typically, areas exhibiting concerns will receive more frequent and possible additional monitoring of the parameter in concern (TCEQ 2010).

To establish whether impairments exist, and if support of aquatic life uses exist, 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 84.20 ppb and a Tidal Water Acute (TWA) criterion of 92.70 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 Year-five appears in Chapter 7-Data Tables 7.2.1 and 7.2.2, and 7.3.1 through 7.3.5, respectively.

During Year-one, salinity ranged from 0.32 to 3.29 PSU in the Nueces River Tidal segment (Table 3.1). Salinity at several Nueces Bay stations was <10.00 PSU for the first two sampling events in 2004 due to precipitation and freshwater river inflows but by the end of Year-one, salinity increased to >20.00 PSU in Nueces Bay. Salinities in the Corpus Christi Inner Harbor remained >20.00 PSU and ranged as high as 30.88 PSU with mean salinity values greatest in the Corpus Christi Inner Harbor for the year. Mean salinity for all stations sampled in Year-one was 18.15 PSU. Lack of significant rainfall during Year-two resulted in salinity ranging from 0.67 to 37.50 PSU in the three segments (Table 3.1). Mean salinity concentrations were greater in the Corpus Christi Inner Harbor, followed by Nueces Bay, and the Nueces River Tidal segment. Overall mean salinity was >30.15 PSU for all stations sampled in Year-two.

Year-three salinity ranged from 4.02 to 36.36 PSU and in Year-four from 4.57 to 32.53 PSU, respectively (Table 3.1). Mean salinity for all stations sampled was higher in Year-three at 28.66 PSU than Year-four at 24.02 PSU. Lower salinity in Year-four was due to increased

precipitation within the region. However, salinity increased in Year-five as drought conditions persisted throughout the region and ranged from 12.43 to 41.34 PSU. Nueces Bay stations had the highest mean salinity at 34.76 PSU, followed by the Corpus Christi Inner Harbor at 32.54 PSU, and the Nueces River Tidal segment at 21.45 PSU (Table 3.1; Data Tables 7.2.1 and 7.3.1). Mean salinity for all stations sampled in Year-five was 32.98 PSU.

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

Year	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
5	2101	Nueces River Tidal	2	12.43	30.46	21.45
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
5	2482	Nueces Bay	14	29.34	41.34	34.76
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
5	2484	Corpus Christi Inner Harbor	4	29.68	35.70	32.54

Dissolved oxygen (DO) concentrations during Year-one were all >5.00 mg/L and ranged from 5.06 to 10.53 mg/L (Table 3.2). In Year-two, DO ranged from 4.63 to 11.06 mg/L. Except for Nueces Bay station 13422 which DO measured 4.63 mg/L during the July 2006 sampling event, all DO measurements were >5.00 mg/L.

Year-three DO concentrations were similar to Year-two, and ranged from 4.77 mg/L recorded at Station 13432 in the Corpus Christi Inner Harbor in August 2008 to 8.99 mg/L at Station 12960 in the Nueces River Tidal segment in April 2008 (Table 3.2). Except for the low DO at Station 13432 all concentrations were >5.00 mg/L. Year-four had similar concentrations and ranged from 4.66 mg/L at Station 12960 in August 2010 to 12.68 mg/L at Station 14833 in Nueces Bay in January 2010. As seen in Year-three, except for the one low value in Year-four all DO values were >5.0 mg/L.

In Year-five, DO ranged from 4.78 mg/L to 11.62 mg/L at Station 12960 in the Nueces River Tidal segment (Table 3.2; Data Tables 7.2.1and 7.3.2). DO concentrations were > 5.00 mg/L

except at Station 12960 (4.78 mg/L) in the Nueces River and Station 13432 (4.90 mg/L) in the Corpus Christi Inner Harbor during the July 2011 sampling event. When compared to Year-four mean DO concentrations decreased in Nueces Bay and the Corpus Christi Inner Harbor.

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

Year	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
5	2101	Nueces River Tidal	2	4.78	11.62	8.20
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
5	2482	Nueces Bay	14	5.67	8.98	7.05
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
5	2484	Corpus Christi Inner Harbor	4	4.90	7.56	6.44

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 recorded during all sampling events, except for Year-four, were higher in Nueces Bay and lowest in the Corpus Christi Inner Harbor (Table 3.3). During the January 2010 sampling event in Year-four, turbidity was 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.

In Year-five, turbidity ranged from 0.00 NTU at Station 13439 in the Corpus Christi Inner Harbor to 102.60 NTU at Station 13423 in Nueces Bay (Table 3.3; Data Tables 7.2.1 and 7.3.4). Over the five-year study, 79.8% of surface water turbidity measurements in Nueces Bay have been <50.0 NTU but some measurements have reached as high as 135.9 NTU. Overall turbidity means for the Corpus Christi Inner Harbor, Nueces River Tidal, and Nueces Bay segments are 3.0, 19.4, and 29.8 NTU, respectively.

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

Year	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
5	2101	Nueces River Tidal	2	8.90	17.90	13.40
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
5	2482	Nueces Bay	14	10.10	102.60	35.86
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
5	2484	Corpus Christi Inner Harbor	4	0.00	1.90	0.95

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

A complete list of individual TSS concentrations for Year-five, along with descriptive statistics, appears in Chapter 7-Data Tables 7.4.1 and 7.5.1.

During the first three years, TSS concentrations were lowest in the Corpus Christi Inner Harbor and highest in Nueces Bay, with concentrations ranging from 5.00 mg/L to 232 mg/L (Table 3.4). In Year-four, TSS concentrations were lower at most stations compared to Year-three due to the exceptional water clarity observed during the January 2010 sampling event. Year-four TSS concentrations ranged from 5.00 to 37.00 mg/L (Table 3.4; Table 7.4.1) and mean concentrations were the lowest recorded for Nueces Bay over the five-year sampling period (Table 3.4; Table 7.5.1). As seen in previous years, TSS concentrations in Year-four were lowest in the Corpus Christi Inner Harbor and highest in Nueces Bay.

In Year-five, mean TSS levels were the highest recorded for all sampling years, most notably in Nueces Bay. TSS concentrations ranged from 12.8 mg/L in the Corpus Christi Inner Harbor to 292 mg/L in Nueces Bay (Table 3.4; Data Tables 7.4.1 and 7.5.1). Figures 3.1 and 3.2 depict individual TSS concentrations for each Year-five sampling event and Figure 3.3 depicts mean TSS concentrations for both sampling events in Year-five.

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

Year	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
5	2101	Nueces River Tidal	2	38.40	59.00	48.70
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
5	2482	Nueces Bay	14	32.00	292.00	110.11
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
5	2484	Corpus Christi Inner Harbor	4	12.80	53.20	28.10

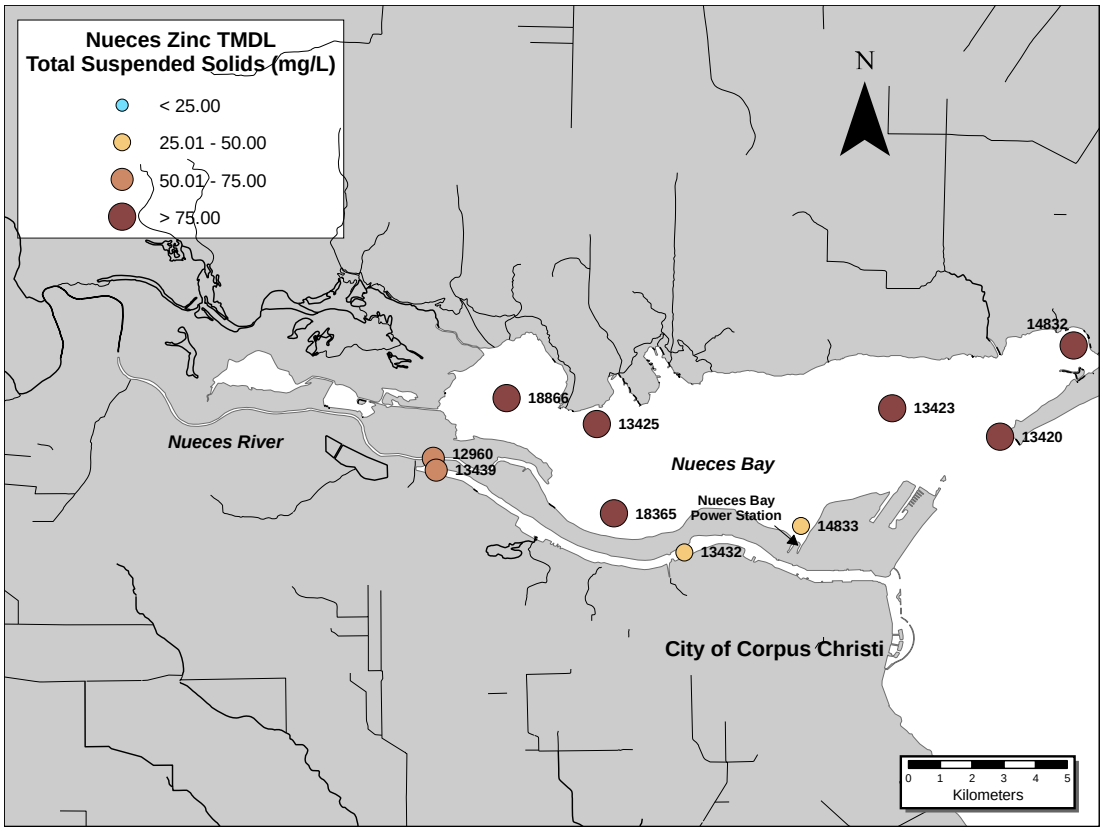

Figure 3.1. TSS concentrations (mg/L) for Year-five February/March 2011 sampling.

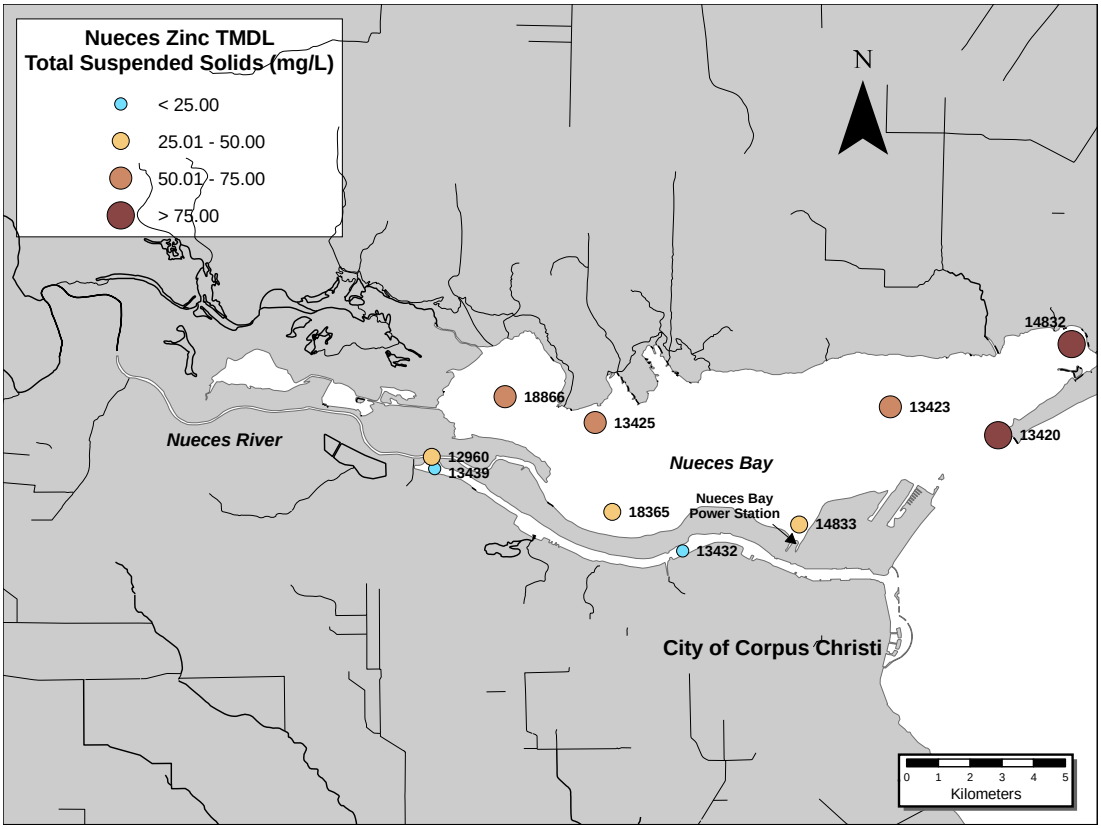

Figure 3.2. TSS concentrations (mg/L) for Year-five July 2011 sampling.

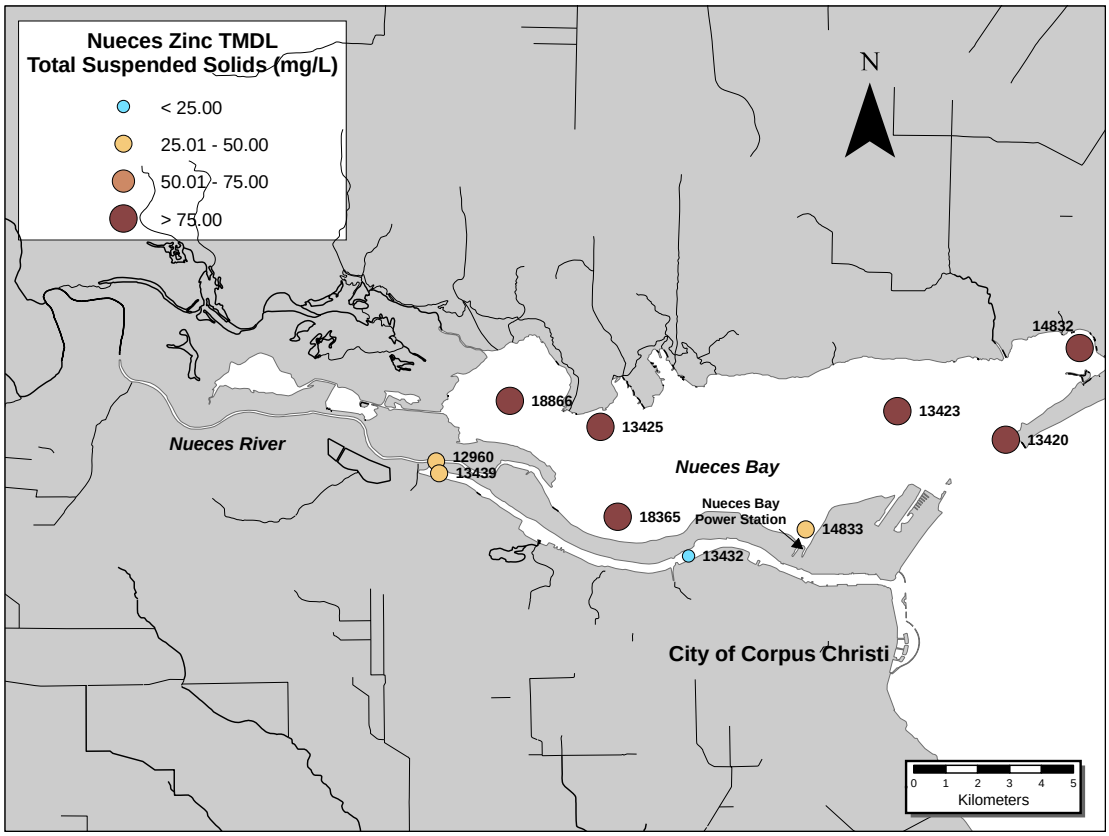

Figure 3.3. Mean TSS concentrations (mg/L) for Year-five sampling.

3.4 Zinc in Water

Dissolved Zinc

A complete list of individual dissolved zinc concentrations for Year-five, along with descriptive statistics, appears in Chapter 7-Data Tables 7.6.1 and 7.7.1.

Since sampling began, individual samples for dissolved zinc in water have not exceeded the TCEQ criterion. Typically, over the five-year study period, highest dissolved zinc concentrations recorded occurred in the Corpus Christi Inner Harbor and lowest concentrations occurred in the Nueces River Tidal segment (Table 3.5). The highest concentration (18.80 ppb) was recorded at Station 13432 in the Corpus Christi Inner Harbor during Year-five and was 4.5 times less than the chronic criterion of 84.20 ppb and 4.9 times less that the acute criterion of 92.70 ppb.

Dissolved zinc concentrations in Year-five ranged from 0.84 ppb at Station 14832 in Nueces Bay to 18.80 ppb at Station 13432 in the Corpus Christi Inner Harbor (Table 3.5; Data Tables 7.6.1 and 7.7.1). Figures 3.4 and 3.5 depict individual dissolved zinc concentrations for each Year-five sampling event and Figure 3.6 depicts mean dissolved zinc concentrations for both sampling events in Year-five.

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

Year	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
5	2101	Nueces River Tidal	2	1.67	1.70	1.69
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
5	2482	Nueces Bay	14	0.84	6.33	2.60
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
5	2484	Corpus Christi Inner Harbor	4	1.74	18.80	9.82

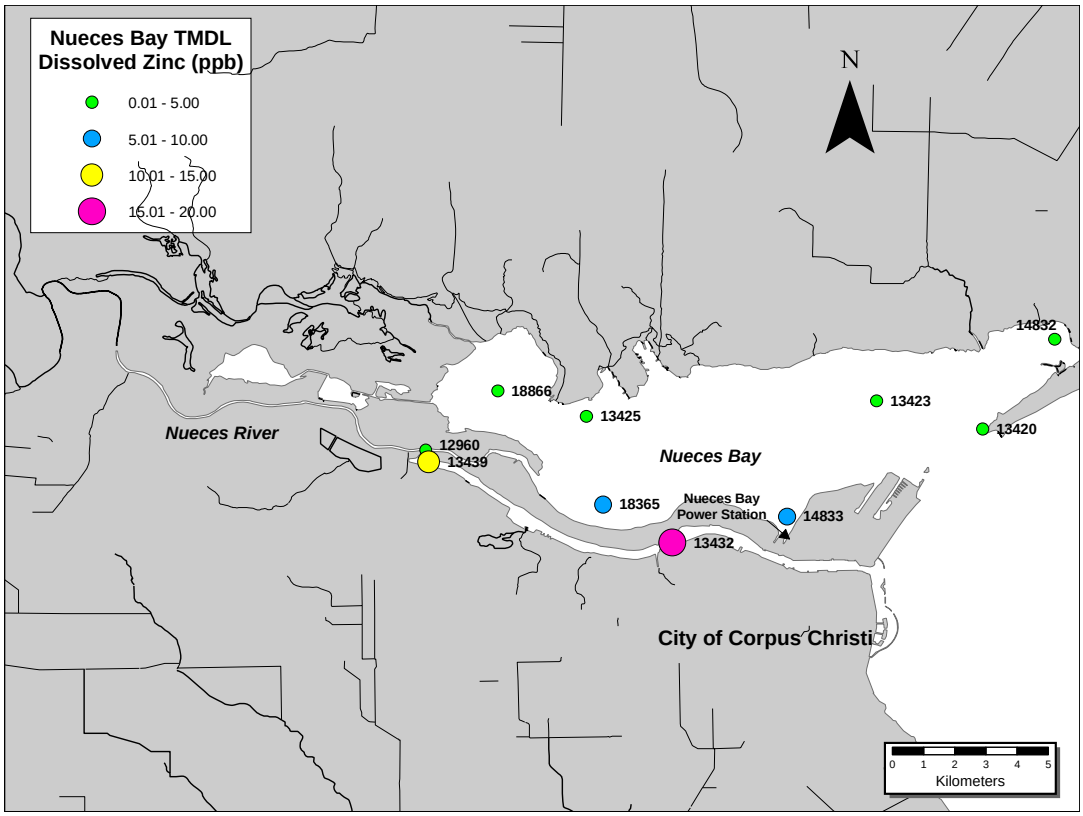

Figure 3.4. Dissolved zinc concentrations (ppb) for Year-five February/March 2011 sampling.

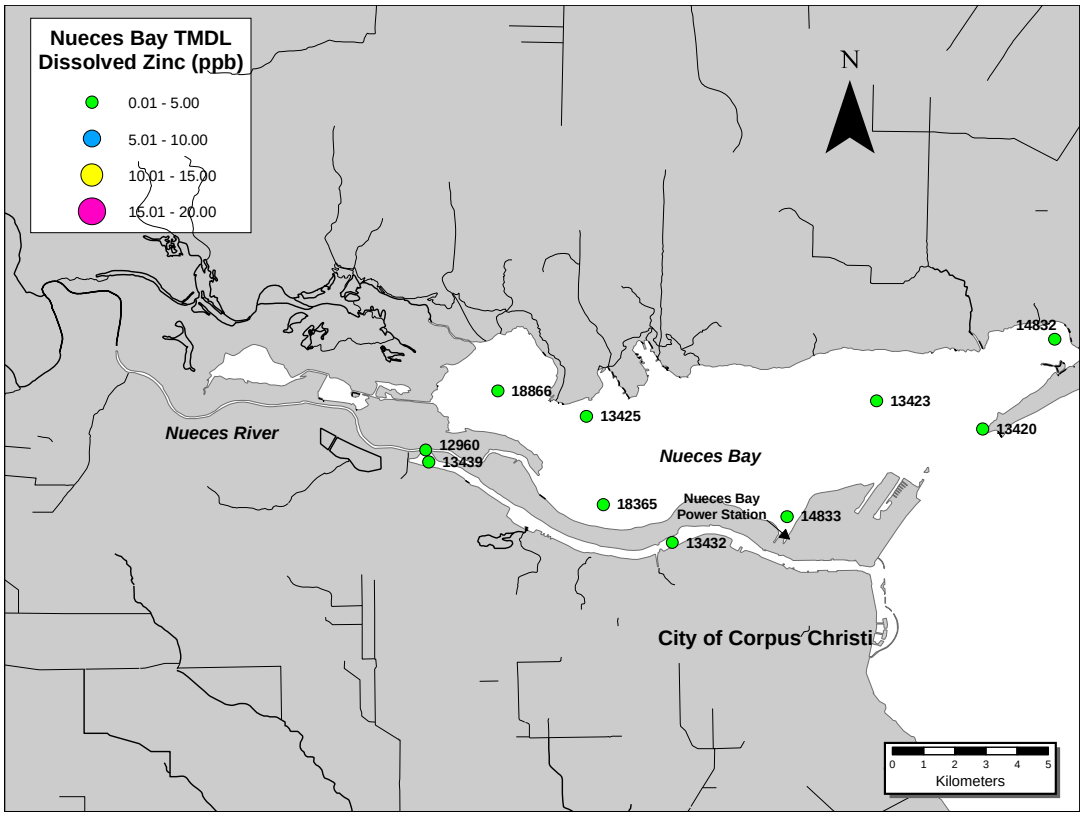

Figure 3.5. Dissolved zinc concentrations (ppb) for Year-five July 2011 sampling.

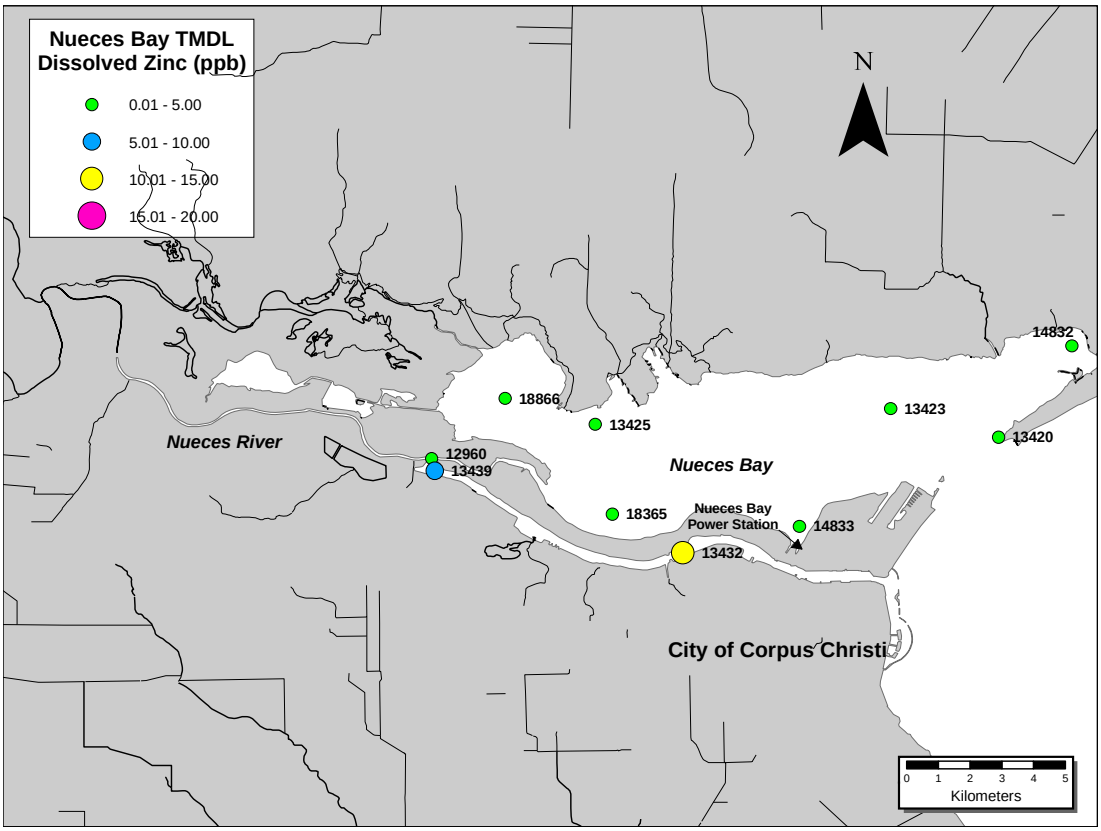

Figure 3.6. Mean dissolved zinc concentrations (ppb) for Year-five sampling.

Total Zinc

A complete list of individual total zinc concentrations in water for Year-five, 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 four times (3.7%) at stations in Nueces Bay. One exceedance occurred in Year-one at Station 13423 in May 2005 with a concentration of 43.40 ppb. TSS concentrations at Station 13423 in May 2005 were 232.00 mg/L, signifying very turbid conditions and high amounts of re-suspended sediments.

In Year-two, two exceedances occurred during the April 2006 sampling event. Total zinc and TSS concentrations at Station 18866 were 36.30 ppb and 178 mg/L and at Station 18365 they were 46.10 ppb and 205 mg/L, respectively. The fourth exceedance occurred during the February/March 2011 sampling event at Station 13423 when the total zinc concentration was 32.70 ppb with a corresponding TSS concentration of 255 mg/L.

Overall, the highest mean total zinc concentrations have varied between Nueces Bay and the Corpus Christi Inner Harbor segments with lowest concentrations in the Nueces River Tidal segment except in Year-four (Table 3.6). Total zinc concentration during Year-five ranged from 3.24 ppb at Station 12960 in the Nueces River to 32.70 ppb at Station 13423 in Nueces

Bay (Data Table 7.6.1). Mean total zinc concentrations were highest in the Corpus Christi Inner Harbor during the February/March 2011 sampling event and in Nueces Bay during the July 2011 sampling event (Data Table 7.7.1).

Due to the shallow nature of Nueces Bay and predominate southeast wind direction, the bay is typically turbid and zinc concentrations are affected by weather conditions preceding sample collection. Because of the turbid nature of Nueces Bay, zinc sequestered in the sediment can be re-suspended with higher total zinc levels typically associated with higher water column TSS concentrations ($r^2 = 0.82$). The largest source of variability in zinc concentrations related to the form of TSS. Specifically, how much of the TSS is phytoplankton or zooplankton (biotic) material and how much is suspended, fine-grained, clay like sediment (abiotic) to which zinc is adsorbed.

While total zinc concentrations in the Corpus Christi Inner Harbor are below the TMDL criteria of 29 ppb, concentrations are still equal or higher than concentrations from the turbid waters of Nueces Bay. The total depth in the Corpus Christi Inner Harbor is >14 m and TSS and turbidity concentrations are low. These data show zinc is clearly entering the inner harbor from sources other than sediment re-suspension and has no association with TSS concentrations. Consequently, inner harbor stations tend to have higher total zinc, but lower TSS levels compared to the other stations sampled in this study. Figures 3.7 and 3.8 depict individual total zinc concentrations for each Year-five sampling event and Figure 3.9 depicts mean total zinc concentrations for both sampling events in Year-five.

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

Year	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
5	2101	Nueces River Tidal	2	3.24	4.64	3.94
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
5	2482	Nueces Bay	14	4.88	32.70	12.26
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
5	2484	Corpus Christi Inner Harbor	4	3.93	23.00	13.14

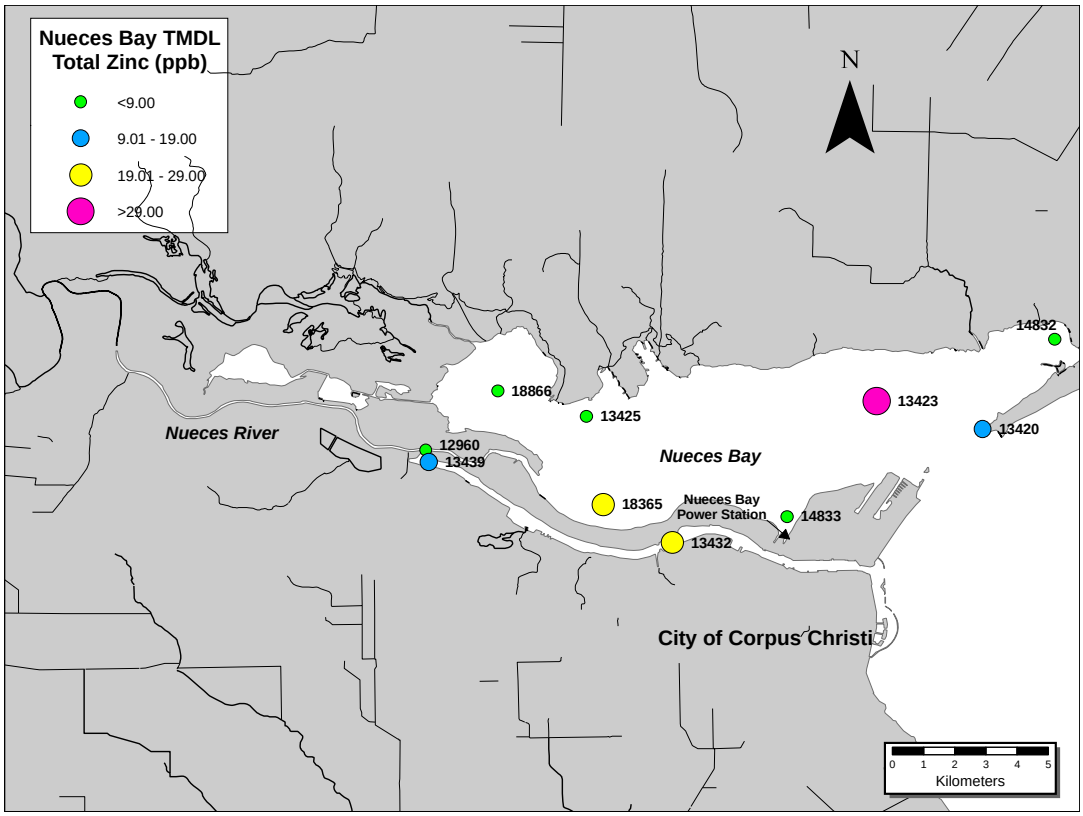

Figure 3.7. Total zinc concentrations (ppb) for Year-five February/March 2011 sampling.

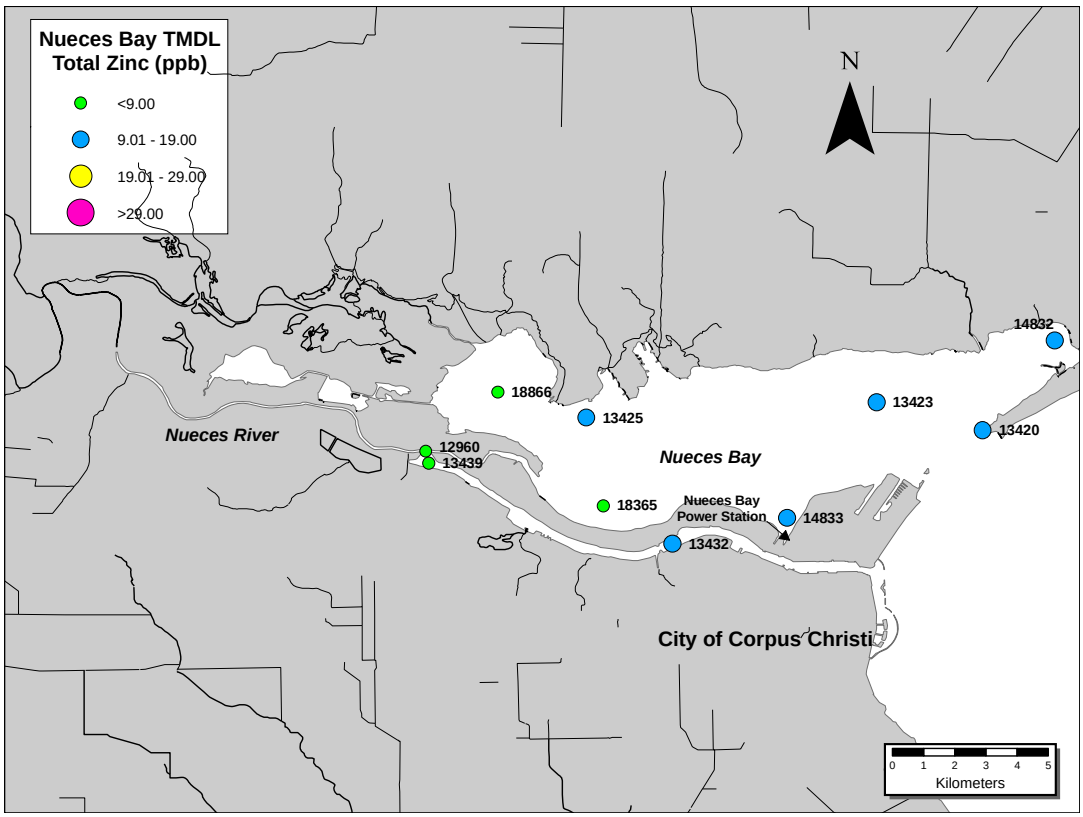

Figure 3.8. Total zinc concentrations (ppb) for Year-five July 2011 sampling.

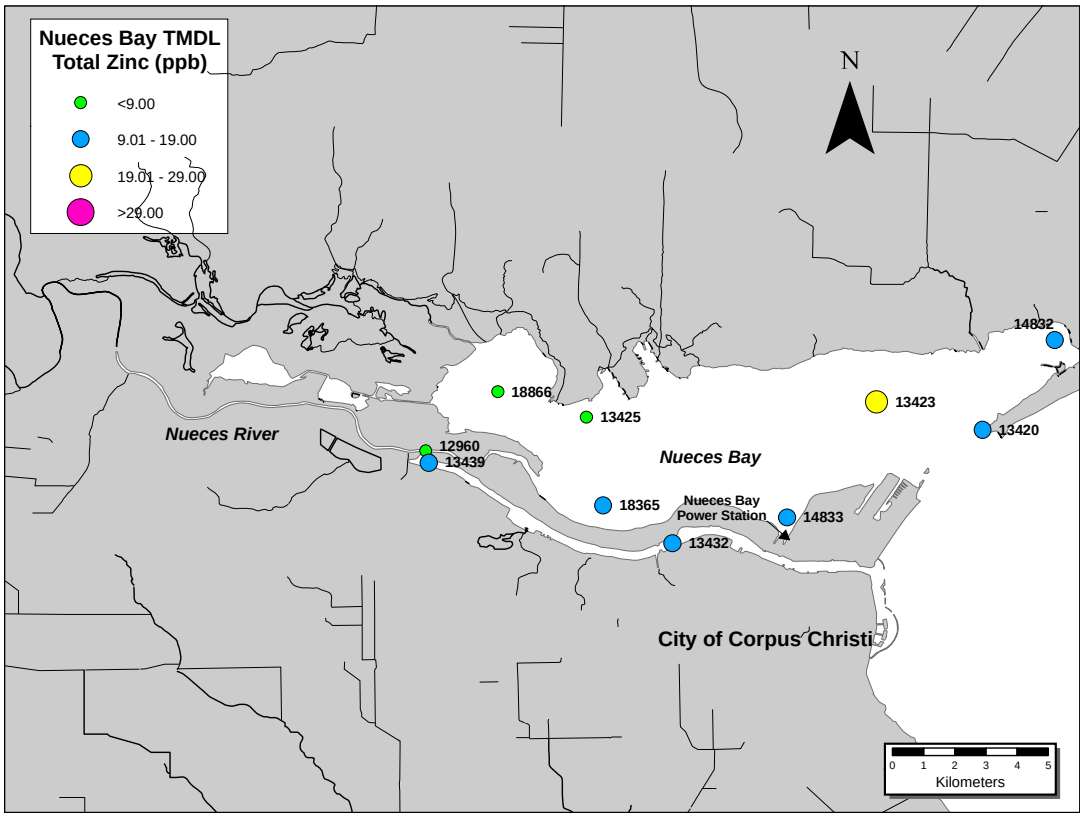

Figure 3.9. Mean total zinc concentrations (ppb) for Year-five sampling.

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4.0 SEDIMENT MONITORING

Two events in Year-one and the first event of Year-two, the upper (2 to <5.0 cm) sediment layer was collected along with the lower (>5 to 9 cm) to determine if increased zinc concentrations could be attributed to legacy deposition. Zinc data was log transformed and subjected to a One-Way ANOVA ($p \leq 0.05$) to compare mean concentrations of upper and lower sediment samples. As previously stated, data showed higher concentrations at lower depths, but data analysis showed no statistically significant difference between sampling depths (all Stations $p = 0.62$, Corpus Christi Inner Harbor Stations $p = 0.89$, Nueces River Tidal Stations $p = 0.70$, and Nueces Bay Stations $p = 0.70$). Since no statistically significant difference existed, we discontinued this portion of the sampling protocol. A complete list of individual sediment characteristics and zinc concentrations, along with descriptive statistics for Year-five, appears in Chapter 7-Data Tables 7.8.1 and 7.9.1 and 7.9.2.

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 proven 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, which is also 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 zinc screening level of 410 mg/kg.

NOAA sediment guidelines are derived from a multitude of nationwide datasets of sediment contamination and corresponding biological effects compiled by Long et al. (1995). 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 applies to 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

The only effects level TCEQ validates on a regulatory basis for zinc in sediment is the Effects Range-Median. While concentrations above the Threshold Effects Level (TEL) do not support TCEQ in identifying concerns, they provide a baseline reference indicating when concentrations have changed. Depending on which of the four effects level is used, a wide range of interpretations is possible. Not considered regulatory criteria or standards, these screening levels and guidelines serve as a non-regulatory interpretive aid for sediment 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 not only serves as a site for bacterial activity, but also 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 but <50,000 mg/kg indicates moderate enrichment, and >50,000 mg/kg indicates high enrichment.

Most Nueces Bay stations have TOC concentrations indicative of low enrichment. Mean concentrations for all stations sampled within the three segments have been <20,000 mg/kg, except Station 12960 in the Nueces River Tidal segment which was 20900 mg/kg in Year-four. In Year-five, TOC values in Nueces Bay ranged from 357 mg/kg at Station 14833 to 7400 mg/kg at Station 13420. In the Nueces River Tidal segment, the range was from 16,000 to 19,600 mg/kg at Station 12960. While in the Corpus Christi Inner Harbor TOC ranged from 5350 mg/kg at Station 13432 to 10,800 mg/kg at Station 13439 (Table 4.1; Data Table 7.8.1 and 7.9.1).

TOC concentrations and spatial distribution patterns were similar during all years, with highest mean concentrations in Nueces River Tidal, followed by Corpus Christi Inner Harbor, and Nueces Bay, respectively (Table 4.1). Figures 4.1 and 4.2 depict individual TOC concentrations in the surficial sediment layer for each Year-five sampling event and Figure 4.3 depicts mean TOC values for both sampling events in Year-five.

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

Year	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
5	2101	Nueces River Tidal	2	16000	19600	17800
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
5	2482	Nueces Bay	14	357	7400	4251
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
5	2484	Corpus Christi Inner Harbor	4	5350	10800	8208

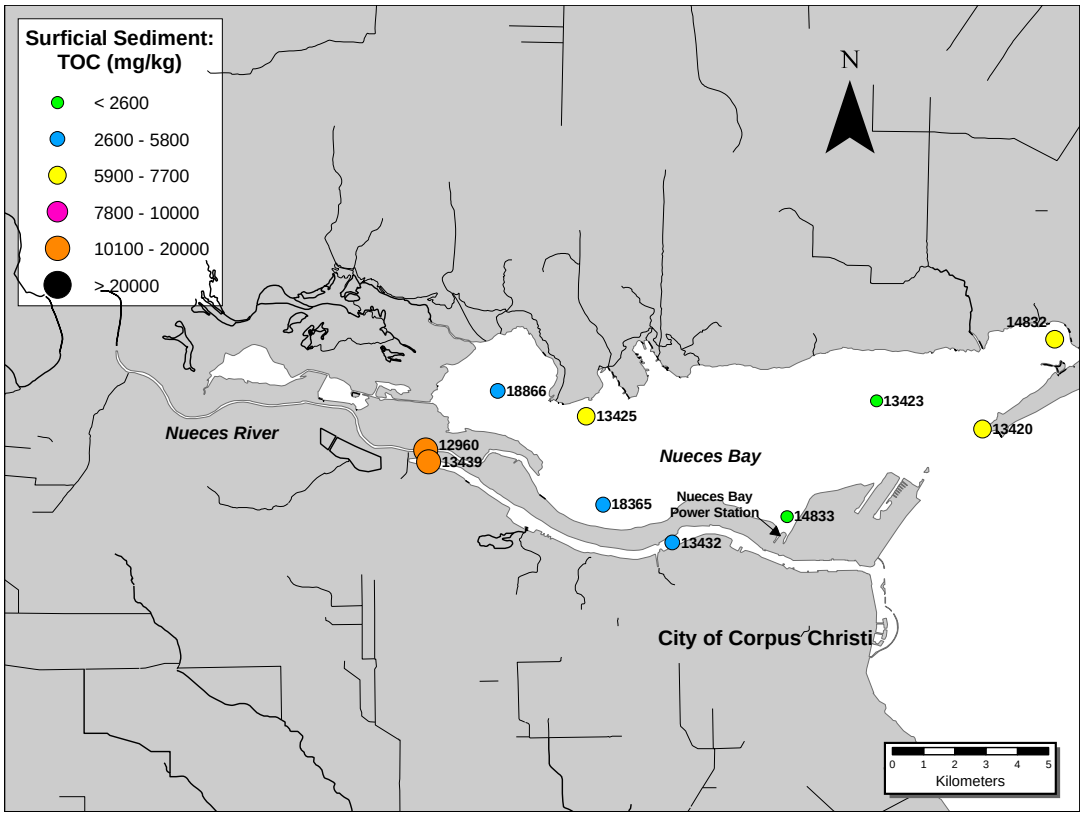

Figure 4.1. Total Organic Carbon concentrations (mg/kg) for Year-five February/March 2011 sampling.

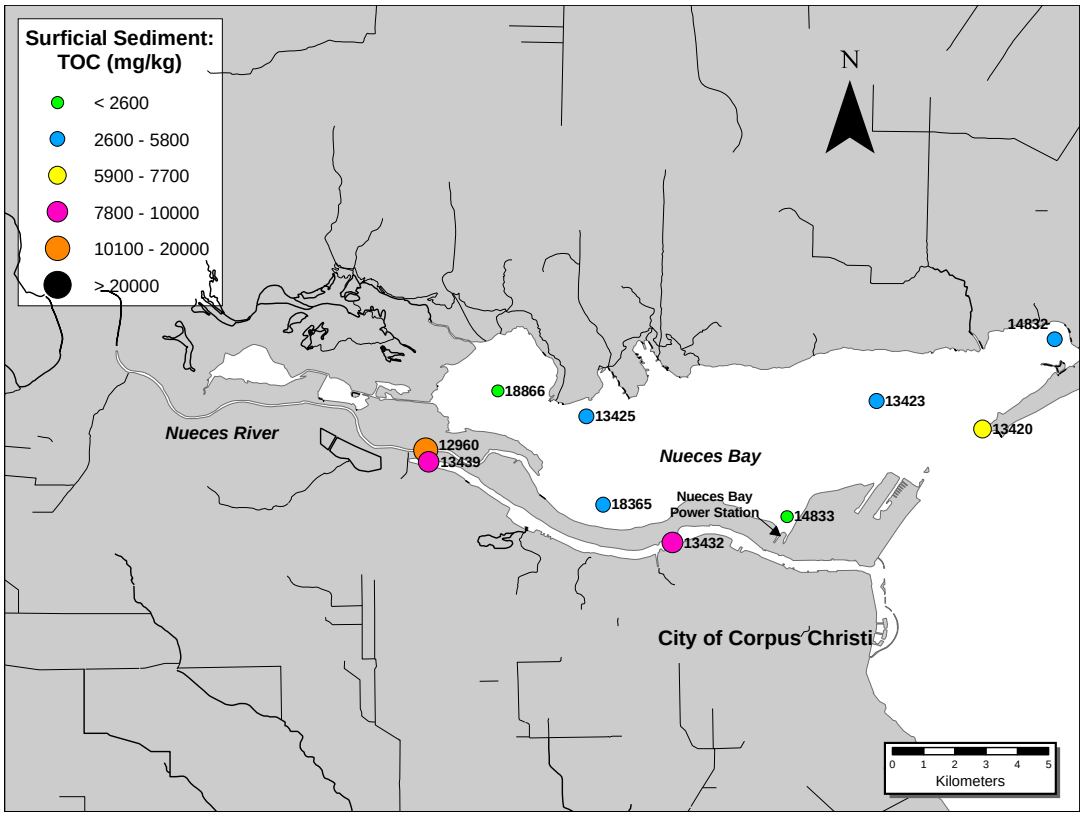

Figure 4.2. Total Organic Carbon concentrations (mg/kg) for Year-five July 2011 sampling.

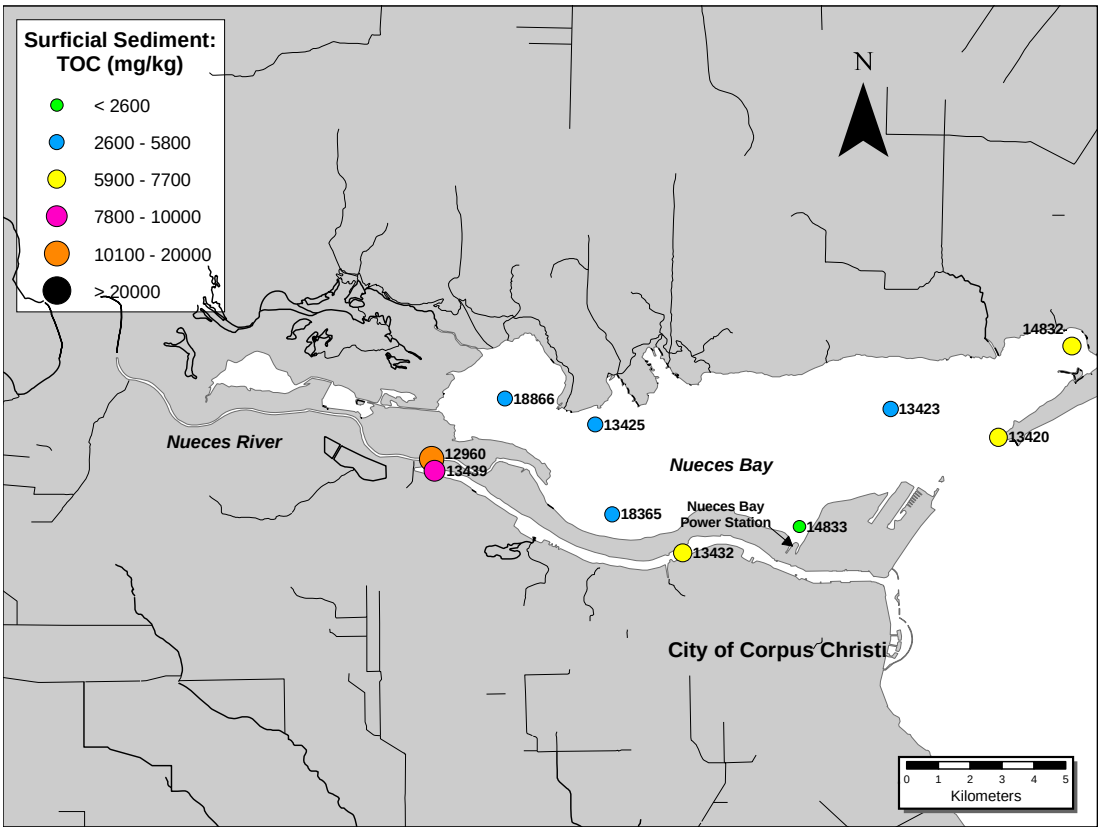

Figure 4.3. Mean Total Organic Carbon concentrations (mg/kg) for Year-five sampling.

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

During Year-five, Silt-Clay values in the surficial sediment layer ranged from 7.12% at Station 14833 in Nueces Bay to 98.30% at Station 12960 in the Nueces River Tidal segment (Table 4.2; Data Table 7.8.1). Silt-Clay values in the Corpus Christi Inner Harbor ranged from 35.90% to 88.10% at Station 13432 and Station 13439, respectively (Data Table 7.8.1). Mean Silt-Clay concentrations were highest in the Nueces River Tidal segment for both sampling events of Year-five (Data Table 7.9.2). Figures 4.4 and 4.5 depict individual Silt-Clay values in the surficial sediment layer for Year-five sampling events and Figure 4.6 depicts mean Silt-Clay values in the surficial sediment layer for both Year-five sampling events.

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

Year	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
5	2101	Nueces River Tidal	2	94.50	98.30	96.40
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
5	2482	Nueces Bay	14	7.12	96.00	52.58
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
5	2484	Corpus Christi Inner Harbor	4	35.90	88.10	61.43

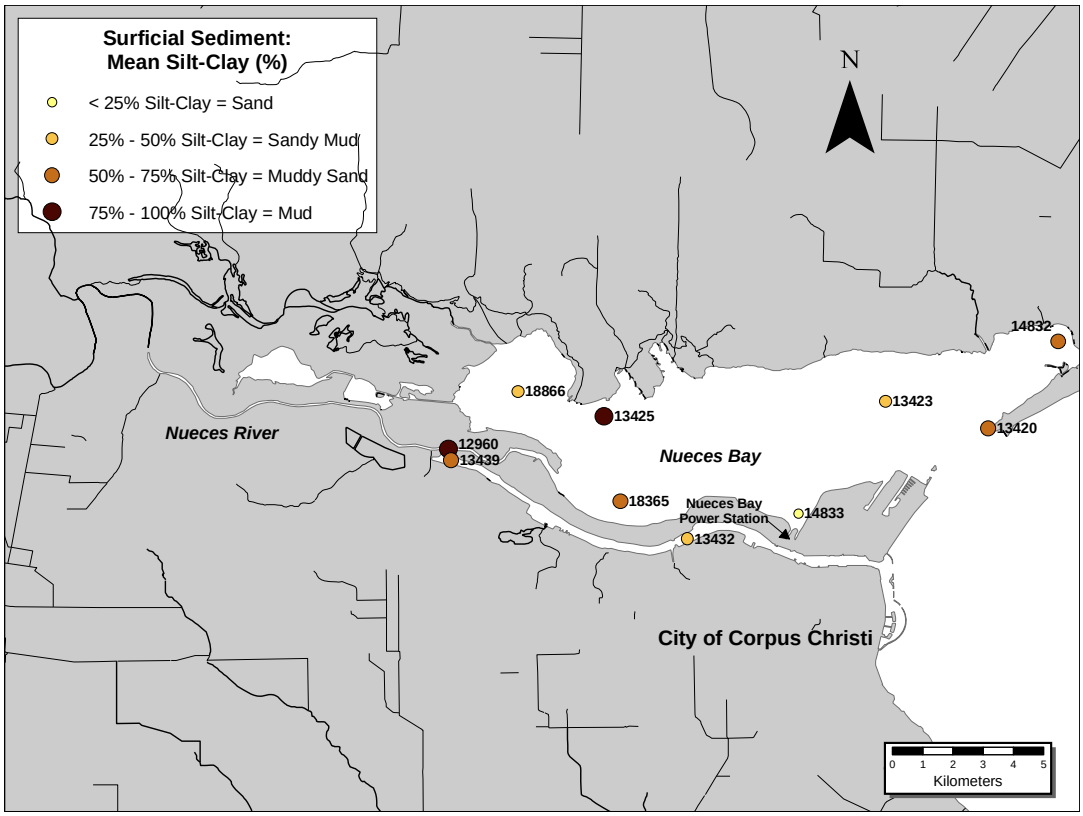

Figure 4.4. Silt-Clay proportions (%) for Year-five February/March 2011 sampling.

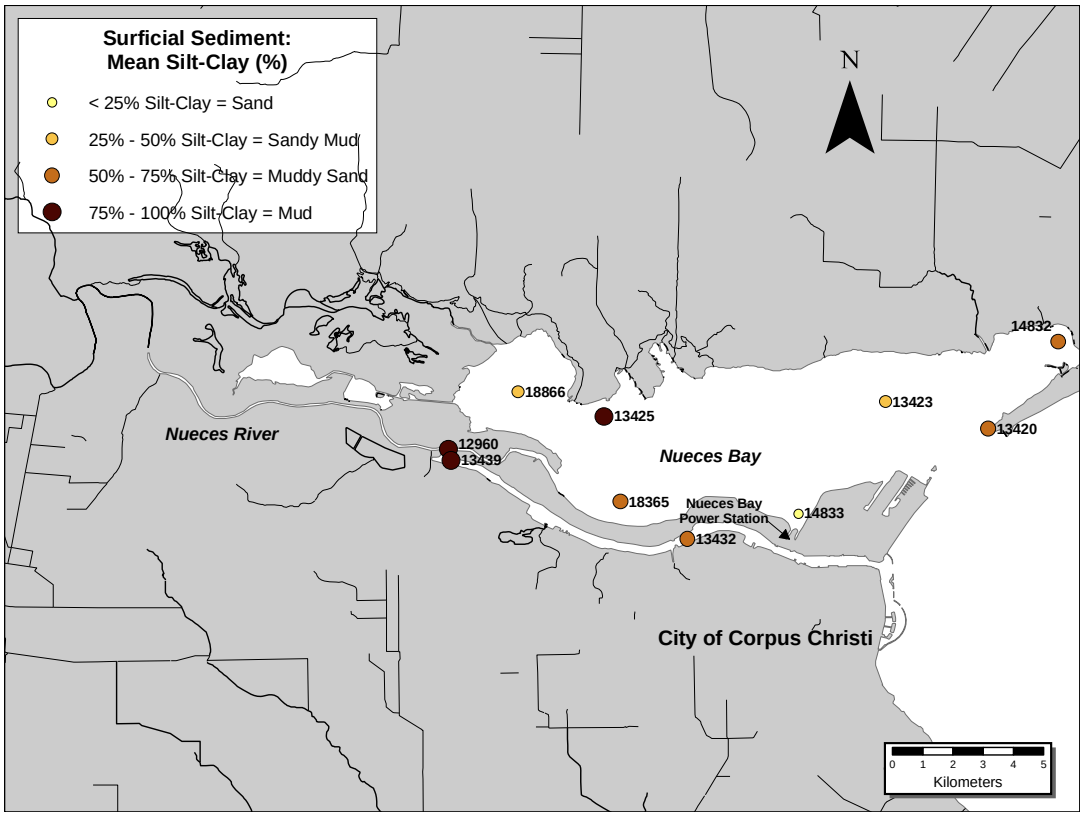

Figure 4.5. Silt-Clay proportions (%) for Year-five July 2011 sampling.

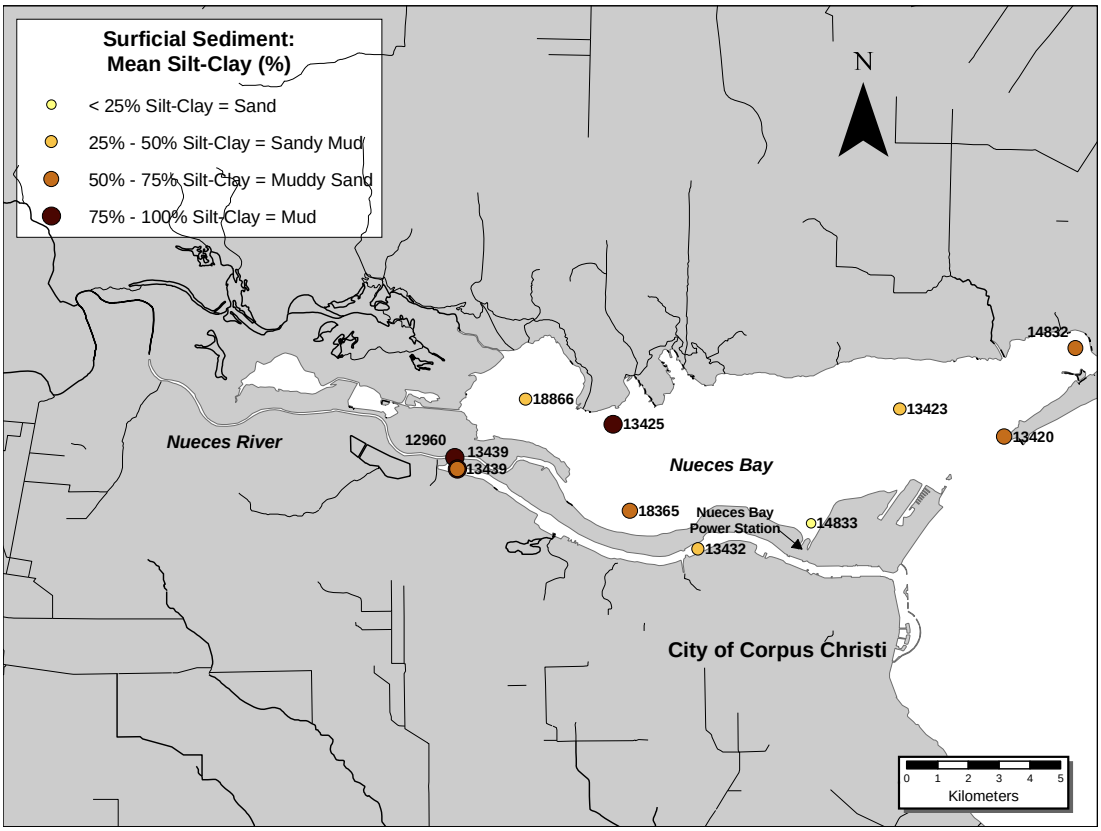

Figure 4.6. Mean Silt-Clay proportions (%) for Year-five sampling.

4.3 Zinc in Sediment

In Year-one, sediment zinc concentrations ranged from 8.00 mg/kg at Station 13421 in Nueces Bay to 485 mg/kg at Station 12961 in the Nueces River Tidal segment. Mean sediment zinc concentrations were highest in the Nueces River Tidal segment followed by the Corpus Christi Inner Harbor and Nueces Bay (Table 4.3). The elevated sediment zinc concentration in September 2004 at the Nueces River Tidal Station 12961was likely due to metal debris recovered from the sampling location. Sediment grabs at 12961 took place downstream of the I-37 Bridge and were adjacent to the area where Corpus Christi Police discovered three submerged cars in July 2005. This large amount of metal may have contributed to the high zinc concentrations recorded. The second event in Year-one took place in May 2005 and sampled upstream of the I-37 Bridge (approximately 300 feet from the September site) and yielded a concentration of 36.90 mg/kg.

For Year-two, sediment zinc concentrations ranged from 13.50 mg/kg at Station 13421 in Nueces Bay to 221.4 mg/kg at Station 13432 in the Corpus Christi Inner Harbor segment and mean concentrations were highest in the Inner Harbor followed by the Nueces River Tidal and Nueces Bay segments, respectively (Table 4.3). Two sampling events in Year-two at Station 12961 yielded sediment zinc concentrations of 34.70 mg/kg and 41.60 mg/kg, respectively. While no longer sampled as part of the current program, the variability in zinc concentrations at Station 12961 shows the patchiness of contaminants often encountered in an urban

watershed. The same spatial distribution pattern for mean sediment zinc concentrations occurred in Year-three and concentrations ranged from 16.20 mg/kg at Station 14833 in Nueces Bay to 201.40 mg/kg at Station 13439 in the Corpus Christi Inner Harbor (Table 4.3). In Year-four the Nueces river Tidal Segment had the highest mean sediment zinc concentrations and zinc concentrations 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 (Table 4.3).

Year-five zinc concentrations in the surficial sediment layer were variable within all three segments and ranged from 13.20 mg/kg at Station 14833 in Nueces Bay to 176.00 mg/kg at Station 13439 in the Corpus Christi Inner Harbor segment. Sediment zinc concentrations in Nueces Bay were the lowest values recorded for the five-year sampling period and ranged from 13.20 to 69.00 mg/kg (Table 4.3; Data Tables 7.8.1 and 7.9.1). Sediment zinc concentrations in the Corpus Christi Inner Harbor ranged from 114.00 to 176.00 mg/kg and mean concentrations were slightly higher in Year-five than Year-four.

Except for one exceedance at Station 12961 in Year-one, 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 exceeded the lowest thresholds of the TEL (124 mg/kg) 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 at the end of the Corpus Christi Inner Harbor channel (See Fig 2.1). Figures 4.7 and 4.8 depict individual zinc concentrations in the surficial sediment layer for each Year-five sampling event and Figure 4.9 depicts mean zinc concentrations in the surficial sediment layer for both sampling events in Year-five.

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

Year	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
5	2101	Nueces River Tidal	2	110.00	121.00	115.50
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
5	2482	Nueces Bay	14	13.20	69.00	37.92
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
5	2484	Corpus Christi Inner Harbor	4	114.00	176.00	143.50

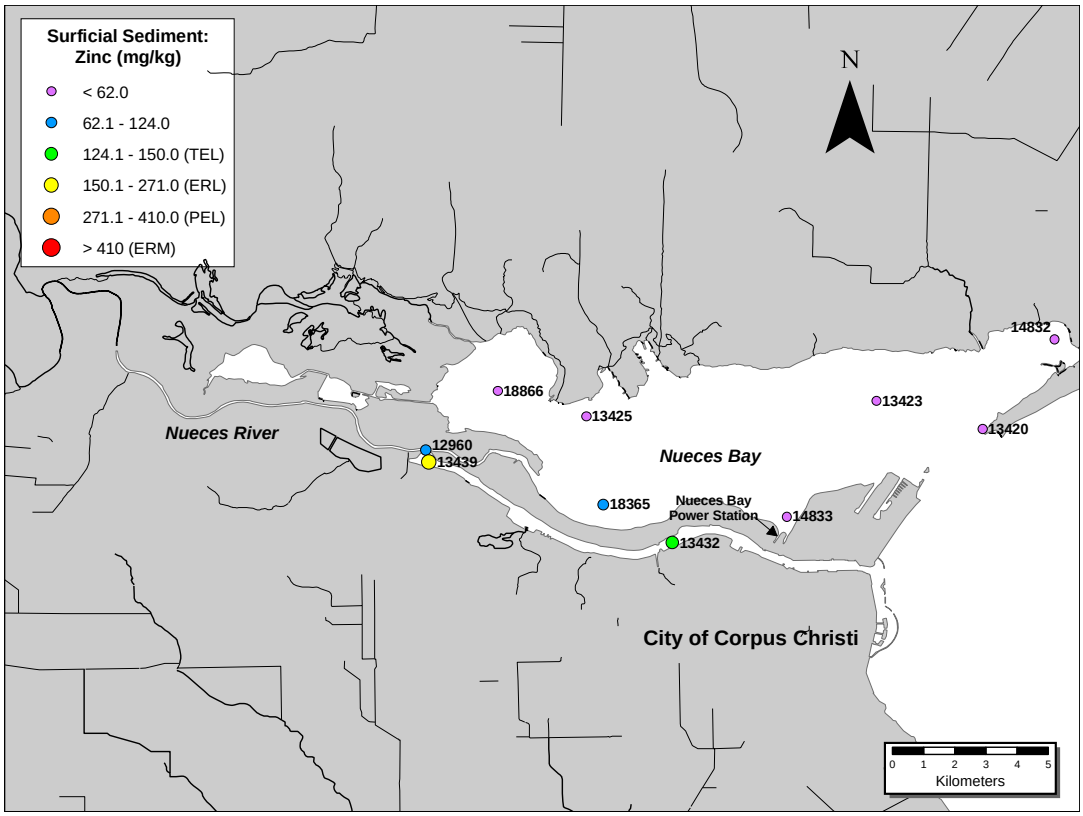

Figure 4.7. Zinc sediment concentrations (mg/kg) for Year-five February/March 2011 sampling.

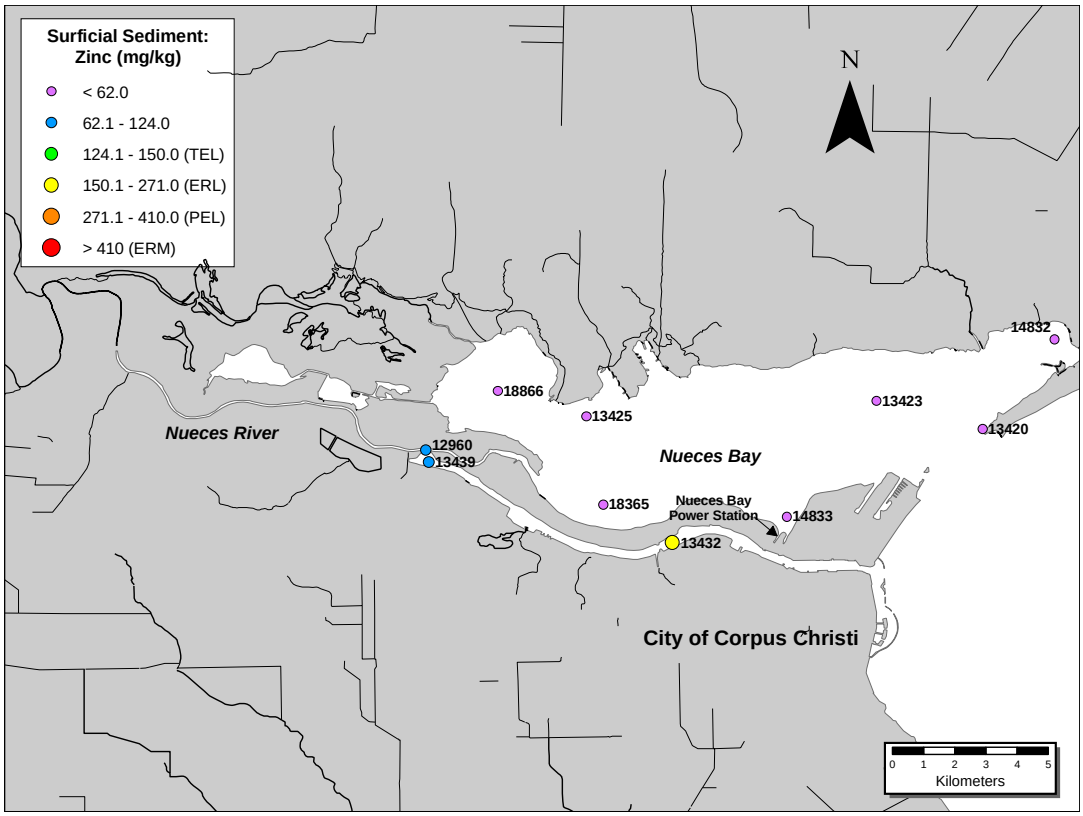

Figure 4.8. Zinc sediment concentrations (mg/kg) for Year-five July 2011 sampling.

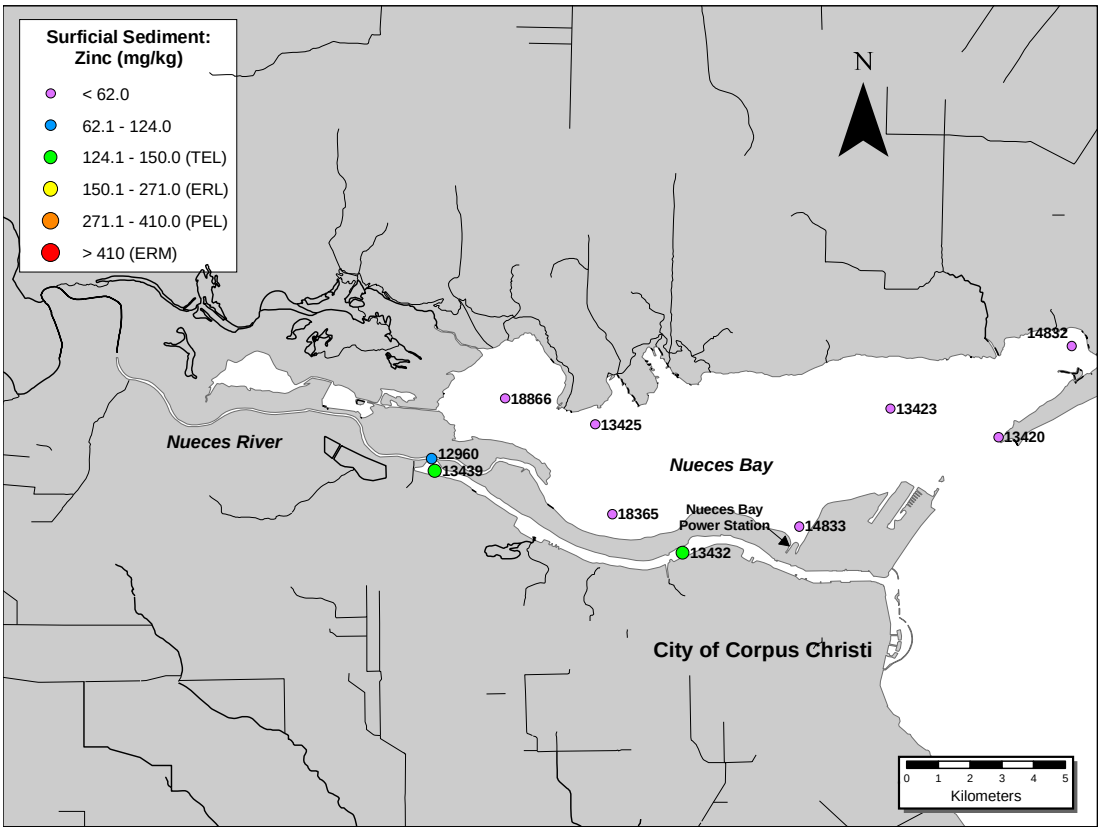

Figure 4.9. Mean zinc sediment concentrations (mg/kg) for Year-five sampling.

5.0 TISSUE SAMPLING

Oysters contain naturally high levels of zinc compared to other food items, such as beef, and they are highly efficient filter feeders and effectively accumulate and sequester zinc and other metals in the environment, often to extremely high concentrations. In general, accumulation of zinc and other trace metals into marine organisms is by the direct uptake of contaminated water, sediment, or through trophic transfer (USEPA 2004; Wang et al 2011). Once an organism absorbs a contaminant, the concentration in animal tissue can increase significantly through subsequent contamination (i.e. bioaccumulation). This same bioaccumulation pattern also happens when humans eat contaminated tissue thereby effecting human health.

5.1 TCEQ Tissue Screening Levels

As stated in TCEQ guidance documentation (TCEQ 2010), the DSHS is the regulatory authority that issues fish and shellfish consumption advisories and aquatic life closures for specific contaminants or classes of chemicals in Texas surface waters. If the health assessment comparison value of <700 mg/kg has not been met in a segment, DSHS issues an advisory and warns the public that consumption of aquatic organisms from the area may be toxic to human health. As these advisories constitute a violation of Texas Surface Water Quality Standards, TCEQ endeavors to ensure that not only the TCEQ segment containing the DSHS sampling site, but also any appropriate connected segments are listed for the contaminant. TCEQ utilizes DSHS Risk Characterization data and advisory sampling information along with TCEQ water body information to determine which segments are impaired.

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. A complete list of individual zinc in oyster tissue concentrations for Year-five appears in Chapter 7-Data Table 7.10.1

During Year-three, multiple attempts to collect oysters occurred during the sampling year. However, high sediment deposition during flooding events on the Nueces River resulted in layers of silt covering many oyster beds in Nueces Bay. This silt and extreme fluctuations in salinity resulted in no viable (alive or market size) oysters available for collection.

In Year-four, an attempt to collect oysters occurred during the January 2010 event. Oysters were found on some reefs but were all <1 inch in size and thereby did meet the required size for collection and analysis. However, a second event in August 2010 yielded adequate size oysters and sampling took place at three of the sampling stations described in the QAPP and at two other stations outside the TCEQ 1250 ft. station site radius of established stations. All sampling locations were geo-located using a Garmin MAP76 GPS.

While the oysters collected during the August 2010 event were market size (2 to 3 inches) when the oysters were being prepared (removed from shell) for analysis at GEL laboratories it was found that the actual oyster tissue was small despite the size of the shell and tissue growth appeared stunted. Rather than yielding the necessary >200 g (weight limit established by DSHS during Risk Characterization studies) of material per sample the typical sample wet weight was approximately 30 g.

Oysters were inspected for possible disease, such as *Perkinsus marinus*, a prevalent oyster pathogen known to occur in Nueces Bay that causes proteolytic degradation of oyster tissues. No visible signs of disease existed and the oysters were characterized as healthy in appearance but extremely small. A possible reason for this small tissue to shell size ratio may have been related to stressful environmental conditions due to sediment deposition from flooding and salinity fluctuations (1.94 to 37.5 PSU) over the last several years, but more investigation is required.

As data from this oyster tissue analysis will not be used for assessment purposes, the decision was made to analyze the oysters regardless of the weight to gather zinc in oyster tissue concentration data. However, the data and station locations were not submitted into TCEQ's Surface Water Quality Monitoring Information System (SWQMIS) database. Tissue analysis revealed high levels of zinc ranging from 675 mg/kg to 3340 mg/kg. Highest mean levels were at Station 21057 in the eastern portion of Nueces Bay and at Station 18866 in the western portion of Nueces Bay. Lowest zinc concentration levels were in the northeastern portion of the bay at Station 21058 (Table 5.1). Zinc concentrations during this study were higher than past DSHS characterization studies where DSHS values ranged from 479 mg/kg to 1405 mg/kg (DSHS 2003; DSHS 2005), but as previously stated the oyster sizes were not representative of that typically sold for human consumption.

One sampling event took place in Year-five on 10 August 2011 for oysters. Mean salinity was greater than Year-four (22.9 PSU vs. 42.4 PSU), and expectations of finding live oysters was low. The individual oysters collected during this event were the largest and healthiest collected thus far for this project. However, the total number of oysters collected was still low with the total weights of the five samples collected at each station <200 g.

The laboratory performing the analysis for this project only required <10 g of tissue material for analysis, so an inquiry was made to DSHS for a clarification on the amount of sample material needed. Results of this inquiry revealed that the >200 g requirement was established based on DSHS analyzing for multiple parameters during their investigations of Nueces Bay. Therefore the QAPP for this project was amended to change the sample amount of oysters for analysis from >200 g to >15 g per composite sample. Combined sample weights ranged from 48.7 g to 108.7 g for Year-five.

During Year-five, zinc in oyster tissue ranged from 293 mg/kg to 3340 mg/kg (Table 5.1 and Data Table 7.10.1). Highest mean levels were at Station 13425 in the western portion of Nueces Bay near Whites Point. Lowest concentration levels observed were in the northeastern portion of the bay at Station 21058 (Table 5.1 and Fig. 5.1). Zinc oyster tissue levels continued to exceed the HAC value of 700 mg/kg but overall mean concentrations have

declined from Year-four. This data continues to be presented for informational purposes and will not be used in the DSHS assessment process. Data collection for zinc in oyster tissue will continue in Year-six since the need to monitor concentrations in oyster tissue still exist.

Table 5.1. Zinc in oyster tissue concentrations (mg/kg) descriptive statistics, listed by sampling year for Nueces Bay TMDL stations sampled. No samples collected during Year-three.

Year	Segment	Segment Name	TCEQ ID	n	Min	Max	Mean
3	2482	Nueces Bay	18866	-	-	-	-
			13425	-	-	-	-
			21057	-	-	-	-
			21058	-	-	-	-
			21059	-	-	-	-
4	2482	Nueces Bay	18866	5	675	3310	2467
			13425	5	1250	3000	2000
			21057	5	2280	3340	2674
			21058	5	1360	1930	1594
			21059	5	821	2470	1802
5	2482	Nueces Bay	18866	5	1060	2810	1710
			13425	5	1140	2550	1950
			21057	5	957	2150	1629
			21058	5	293	1140	732
			21059	5	492	1880	947

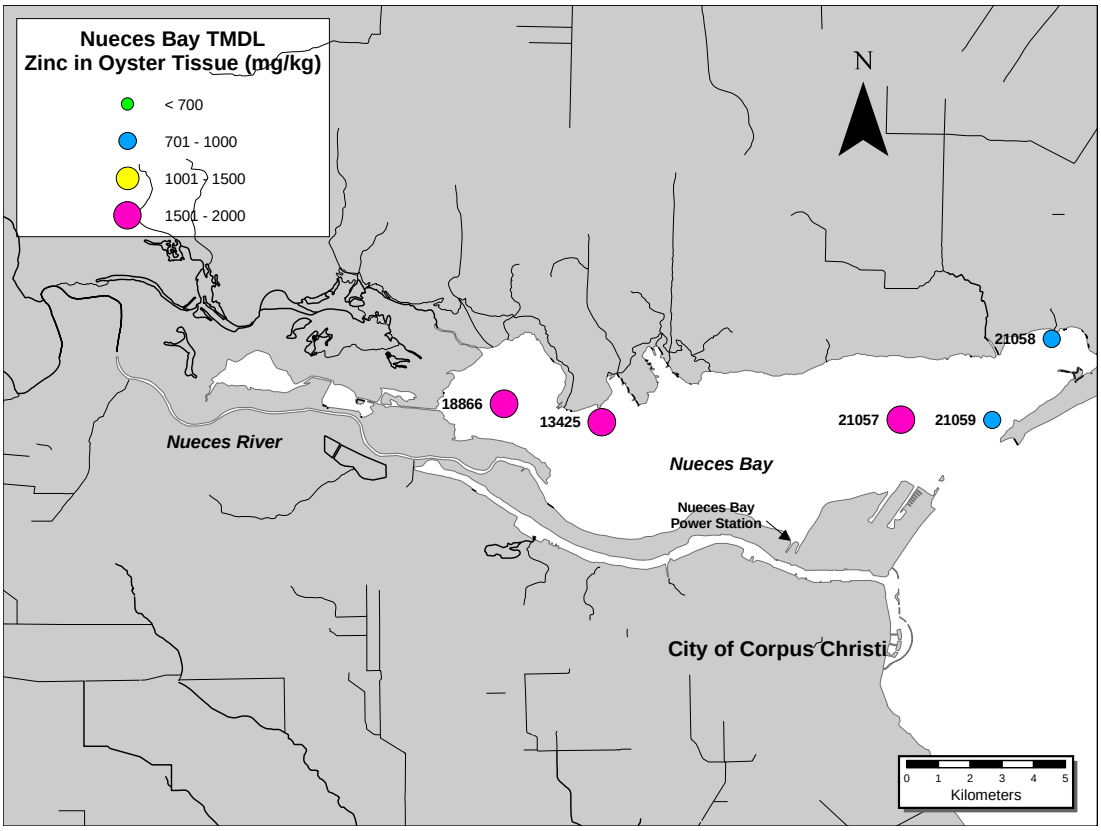

Figure 5.1. Mean zinc in oyster tissue concentrations (mg/kg) for Year-five August 2011 sampling.

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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 (February/March 2011 and July 2011).

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 (February/March 2011) and Sampling Event 2 (July 2011).

Feb/Mar 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)
		Nueces River Tidal	12960	20759	11.62	140.50	8.72	12.43	0.20	0.90	8.90	21.53
2101	2482	Nueces Bay	13420	47491	7.79	108.50	8.03	30.95	0.10	0.60	38.50	22.71
	2482		13423	46078	7.28	99.20	7.76	29.93	0.10	1.45	102.60	21.95
	2482		13425	46197	7.54	102.10	7.83	30.02	0.50	0.90	10.30	21.66
	2482		14832	45715	8.98	123.10	8.16	29.65	0.20	1.00	30.50	22.37
	2482		14833	46523	7.29	98.30	7.82	30.26	0.40	0.68	11.90	21.29
	2482		18365	46450	7.55	102.60	7.97	30.21	0.20	1.25	56.10	21.83
	2482		18866	45226	6.63	89.80	7.79	29.34	0.40	1.00	10.10	21.46
	2484	Corpus Christi Inner Harbor	13432	45156	7.56	97.40	7.84	30.01	1.50	15.30	1.90	19.01
	2484		13439	45701	7.56	96.90	7.81	29.68	1.70	14.00	1.10	18.77
July 2011	**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	47036	4.78	73.30	8.17	30.46	0.30	1.25	17.90	29.14
	2482	Nueces Bay	13420	58813	8.89	151.10	8.24	39.05	0.10	0.30	66.90	32.39
	2482		13423	57932	6.01	98.90	7.98	38.46	0.20	1.70	28.70	30.57
	2482		13425	60092	5.67	92.70	7.91	40.13	0.30	1.20	31.70	29.51
	2482		14832	59353	6.87	114.10	8.26	39.53	0.10	1.20	57.30	30.63
	2482		14833	55315	6.66	111.20	8.03	36.43	0.30	0.85	16.90	31.98
	2482		18365	61672	5.86	97.40	8.00	41.31	3.00	1.45	14.90	30.03
	2482		18866	61666	5.68	93.50	7.98	41.34	0.25	1.10	25.70	29.34
	2484	Corpus Christi Inner Harbor	13432	54224	4.90	79.30	7.94	35.70	1.20	15.50	0.90	30.44
	2484		13439	52977	5.75	93.30	7.97	34.76	0.90	15.00	0.00	30.76

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 (February/March 2011) and Sampling Event 2 (July 2011). **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	-	-	20759
(µmhos)	(Feb/Mar 2011)	2482	Nueces Bay	7	45226	47491	**46240**
		2484	Corpus Christi Inner Harbor	2	45156	45701	45429
	Event 2	2101	Nueces River Tidal	1	-	-	47036
	(July 2011)	2482	Nueces Bay	7	55315	61672	**59263**
		2484	Corpus Christi Inner Harbor	2	52977	54224	53601
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Salinity	Event 1	2101	Nueces River Tidal	1	-	-	12.43
(PSU)	(Feb/Mar 2011)	2482	Nueces Bay	7	29.34	30.95	**30.05**
		2484	Corpus Christi Inner Harbor	2	29.68	30.01	29.85
	Event 2	2101	Nueces River Tidal	1	-	-	30.46
	(July 2011)	2482	Nueces Bay	7	36.43	41.34	**39.46**
		2484	Corpus Christi Inner Harbor	2	34.76	35.70	35.23

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 (February/March 2011) and Sampling Event 2 (July 2011). **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	-	-	**11.62**
(mg/L)	(Feb/Mar 2011)	2482	Nueces Bay	7	6.63	8.98	7.58
		2484	Corpus Christi Inner Harbor	2	7.56	7.56	7.56
	Event 2	2101	Nueces River Tidal	1	-	-	4.78
	(July 2011)	2482	Nueces Bay	7	5.67	8.89	**6.52**
		2484	Corpus Christi Inner Harbor	2	4.90	5.75	5.33
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Dissolved Oxygen	Event 1	2101	Nueces River Tidal	1	-	-	**140.50**
(% Saturation)	(Feb/Mar 2011)	2482	Nueces Bay	7	89.80	123.10	103.37
		2484	Corpus Christi Inner Harbor	2	96.90	97.40	97.15
	Event 2	2101	Nueces River Tidal	1	-	-	73.30
	(July 2011)	2482	Nueces Bay	7	92.70	151.10	**108.41**
		2484	Corpus Christi Inner Harbor	2	79.30	93.30	86.30

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 (February/March 2011) and Sampling Event 2 (July 2011). **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	-	-	**8.72**
(su)	(Feb/Mar 2011)	2482	Nueces Bay	7	7.76	8.16	7.91
		2484	Corpus Christi Inner Harbor	2	7.81	7.84	7.83
	Event 2	2101	Nueces River Tidal	1	-	-	**8.17**
	(July 2011)	2482	Nueces Bay	7	7.91	8.26	8.06
		2484	Corpus Christi Inner Harbor	2	7.94	7.97	7.96
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Water Temperature	Event 1	2101	Nueces River Tidal	1	-	-	21.53
(°C)	(Feb/Mar 2011)	2482	Nueces Bay	7	21.29	22.71	**21.90**
		2484	Corpus Christi Inner Harbor	2	18.77	19.01	18.89
	Event 2	2101	Nueces River Tidal	1	-	-	29.14
	(July 2011)	2482	Nueces Bay	7	29.34	32.39	**30.64**
		2484	Corpus Christi Inner Harbor	2	30.44	30.76	30.60

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 (February/March 2011) and Sampling Event 2 (July 2011). **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	-	-	0.20
(m)	(Feb/Mar 2011)	2482	Nueces Bay	7	0.10	0.50	0.27
		2484	Corpus Christi Inner Harbor	2	1.50	1.70	**1.60**
	Event 2	2101	Nueces River Tidal	1	-	-	0.30
	(July 2011)	2482	Nueces Bay	7	0.10	3.00	0.61
		2484	Corpus Christi Inner Harbor	2	0.90	1.20	**1.05**
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Turbidity	Event 1	2101	Nueces River Tidal	1	-	-	8.90
(NTU)	(Feb/Mar 2011)	2482	Nueces Bay	7	10.10	102.60	**37.14**
		2484	Corpus Christi Inner Harbor	1	1.10	1.90	1.50
	Event 2	2101	Nueces River Tidal	1	-	-	17.90
	(July 2011)	2482	Nueces Bay	7	14.90	66.90	**34.59**
		2484	Corpus Christi Inner Harbor	2	0.00	0.90	0.45

Table 7.3.5. Total Depth (m) descriptive statistics, listed by TCEQ Segment, at Nueces Bay TMDL stations for Sampling Event 1 (February/March 2011) and Sampling Event 2 (July 2011). **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	-	-	0.90
(m)	(Feb/Mar 2011)	2482	Nueces Bay	7	0.60	1.45	0.98
		2484	Corpus Christi Inner Harbor	2	14.00	15.30	**14.65**
	Event 2	2101	Nueces River Tidal	1	-	-	1.25
	(July 2011)	2482	Nueces Bay	7	0.30	1.70	1.11
		2484	Corpus Christi Inner Harbor	2	15.00	15.50	**15.25**

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 (February/March 2011) and Sampling Event 2 (July 2011). **Bold** = highest recorded concentrations for the event.

Segment	Segment Name	TCEQ ID	February/March 2011 (Event 1)	July 2011 (Event 2)	Mean of all Events
2101	Nueces River Tidal	12960	59.00	38.40	48.70
2482	Nueces Bay	13420	144.00	**292.00**	**218.00**
2482		13423	**255.00**	54.40	154.70
2482		13425	122.00	56.80	89.40
2482		14832	98.50	117.00	107.75
2482		14833	42.30	32.00	37.15
2482		18365	134.00	37.60	85.80
2482		18866	95.00	61.00	78.00
2484	Corpus Christi Inner Harbor	13432	31.20	15.20	23.20
2484		13439	53.20	12.80	33.00

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 (February/March 2011) and Sampling Event 2 (July 2011). **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	59.00	59.00	59.00
Suspended	(Feb/Mar 2011)	2482	Nueces Bay	7	42.30	255.00	**127.26**
Solids		2484	Corpus Christi Inner Harbor	2	31.20	53.20	42.20
(TSS)	Event 2	2101	Nueces River Tidal	1	38.40	38.40	38.40
	(July 2011)	2482	Nueces Bay	7	32.00	292.00	**92.97**
		2484	Corpus Christi Inner Harbor	2	12.80	15.20	14.00

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 (February/March 2011) and Sampling Event 2 (July 2011). D = Dissolved Zinc and T = Total Zinc, TWC = Tidal Water Chronic for Dissolved Zinc. Shaded = value exceeded TCEQ Total Zinc Nueces Bay TMDL criteria level. **Bold** = highest recorded concentration for the event.

Parameter	Segment	Segment Name	TCEQ ID	February/March 2011 (Event 1)		July 2011 (Event 2)	
				T	D	T	D
Dissolved Zinc	2101	Nueces River Tidal	12960	4.64	1.70	3.24	1.67
TWC = 84.20	2482	Nueces Bay	13420	9.91	2.00	15.30	1.01
Nueces Bay = NA	2482		13423	32.70	3.83	11.20	2.42
	2482		13425	5.83	2.27	10.10	2.22
	2482		14832	7.24	0.84	13.60	1.10
Total Zinc	2482		14833	8.74	5.05	14.10	2.81
TWC = NA	2482		18365	21.60	6.33	7.67	1.90
Nueces Bay = 29.00	2482		18866	4.88	2.56	8.70	2.11
	2484	Corpus Christi Inner Harbor	13432	23.00	18.80	9.34	4.85
	2484		13439	16.30	13.90	3.93	1.74

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. Shaded = value exceeded Total Zinc Nueces Bay TMDL criteria level. **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	-	-	4.64
	(February/March 2011)	2482	Nueces Bay	7	4.88	32.70	12.99
TWC = NA		2484	Corpus Christi Inner Harbor	2	16.30	23.00	**19.65**
Nueces Bay = 29.00	Event 2	2101	Nueces River Tidal	1	-	-	3.24
	(July 2011)	2482	Nueces Bay	7	7.67	15.30	**11.52**
		2484	Corpus Christi Inner Harbor	2	3.93	9.34	6.64
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Dissolved Zinc	Event 1	2101	Nueces River Tidal	1	-	-	1.70
	(February/March 2011)	2482	Nueces Bay	7	0.84	6.33	3.27
TWC = 84.20		2484	Corpus Christi Inner Harbor	2	13.90	18.80	**16.35**
Nueces Bay = NA	Event 2	2101	Nueces River Tidal	1	-	-	1.67
	(July 2011)	2482	Nueces Bay	7	1.01	2.81	1.94
		2484	Corpus Christi Inner Harbor	2	1.74	4.85	**3.30**

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 (February/March 2011) and Sampling Event 2 (July 2011). Shaded = value exceeded TCEQ ERM screening level. **Bold** = highest recorded concentration for the event.

February/March 2011	Segment	Segment Name	TCEQ ID	Zn	TOC	Gravel/Shell	Sand	Silt-Clay
Zinc (Zn)	2101	Nueces River Tidal	12960	121.00	**19600**	0.00	5.50	**94.50**
ERM = 410.0	2482	Nueces Bay	13420	53.10	6110	0.00	25.70	74.30
	2482		13423	39.20	2480	0.60	57.30	42.10
	2482		13425	51.70	5830	0.00	14.60	85.40
	2482		14832	49.90	6860	0.00	30.60	69.40
	2482		14833	13.20	357	0.00	**92.90**	7.12
	2482		18365	69.00	5080	**1.00**	44.70	54.30
	2482		18866	40.80	4300	0.00	63.80	36.20
	2484	CC Inner Harbor	13432	128.00	5350	0.60	63.50	35.90
	2484		13439	**176.00**	10800	0.00	31.70	68.30
July 2011	**Segment**	**Segment Name**	**TCEQ ID**	**Zn**	**TOC**	**Gravel/Shell**	**Sand**	**Silt-Clay**
Zinc (Zn)	2101	Nueces River Tidal	12960	110.00	**16000**	0.00	1.70	**98.30**
ERM = 410.0	2482	Nueces Bay	13420	33.00	7400	0.00	40.40	59.60
	2482		13423	27.00	3200	**1.10**	59.30	39.60
	2482		13425	42.00	5600	0.00	4.00	96.00
	2482		14832	28.00	5200	0.00	34.90	65.10
	2482		14833	19.00	1900	0.00	**79.10**	20.90
	2482		18365	49.00	3900	1.00	40.80	58.20
	2482		18866	16.00	1300	0.00	72.10	27.90
	2484	CC Inner Harbor	13432	**156.00**	7790	0.00	47.60	53.40
	2484		13439	114.00	8890	0.00	11.90	88.10

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 (February/March 2011) and Sampling Event 2 (July 2011). **Bold** = highest recorded mean concentrations for the event.

Parameter	Date	Segment	Segment Name	n (stations)	Min	Max	Mean
ZINC (mg/kg)	Event 1 (February/March 2011)	2101	Nueces River Tidal	1	-	-	121.00
		2482	Nueces Bay	7	13.20	69.00	45.27
		2484	Corpus Christi Inner Harbor	2	128.00	176.00	**152.00**
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
ZINC (mg/kg)	Event 2 (July 2011)	2101	Nueces River Tidal	1	-	-	110.00
		2482	Nueces Bay	7	16.00	49.00	30.57
		2484	Corpus Christi Inner Harbor	2	114.00	156.00	**135.00**
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
TOC (mg/kg)	Event 1 (February/March 2011)	2101	Nueces River Tidal	1	-	-	**19600**
		2482	Nueces Bay	7	357	6860	4431
		2484	Corpus Christi Inner Harbor	2	5350	10800	8075
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
TOC (mg/kg)	Event 2 (July 2011)	2101	Nueces River Tidal	1	-	-	**16000**
		2482	Nueces Bay	7	1300	7400	4071
		2484	Corpus Christi Inner Harbor	2	7790	8890	8340

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 (February/March 2011)	2101	Nueces River Tidal	1	-	-	5.50
		2482	Nueces Bay	7	14.60	92.90	47.09
		2484	Corpus Christi Inner Harbor	2	31.70	63.50	**47.60**
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Percent Sand (0.0625 - 2.00 mm)	Event 2 (July 2011)	2101	Nueces River Tidal	1	-	-	1.70
		2482	Nueces Bay	7	4.00	79.10	**47.23**
		2484	Corpus Christi Inner Harbor	2	11.90	47.60	29.75
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Percent Silt-Clay (< 0.0625 mm)	Event 1 (February/March 2011)	2101	Nueces River Tidal	1	-	-	**94.50**
		2482	Nueces Bay	7	7.12	85.40	52.89
		2484	Corpus Christi Inner Harbor	2	35.90	68.30	52.10
Parameter	**Date**	**Segment**	**Segment Name**	**n (stations)**	**Min**	**Max**	**Mean**
Percent Silt-Clay (< 0.0625 mm)	Event 2 (July 2011)	2101	Nueces River Tidal	1	-	-	**98.30**
		2482	Nueces Bay	7	20.90	96.00	52.47
		2484	Corpus Christi Inner Harbor	2	53.4	88.10	70.75

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 August 2011 sampling event. **Bold** = highest recorded concentration at each sampling station.

Segment	Segment Name	TCEQ ID*	Sample	August 2011
2482	Nueces Bay	18866	1	**2810**
				1060
				1960
				1130
				1590
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**August 2011**
2482	Nueces Bay	13425	1	**2550**
			2	1710
			3	1140
			4	2230
			5	2120
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**August 2011**
2482	Nueces Bay 2	21057	1	957
	3			2010
	4			1270
	5			**2150**
				1760
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**August 2011**
2482	Nueces Bay	21058	1	**1140**
				645
				627
				293
				958
Segment	**Segment Name**	**TCEQ ID***	**Sample**	**August 2011**
2482	Nueces Bay 2	21059	1	**1880**
	3		2	800
	4		3	492
	5		4	544
			5	1020

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