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EXECUTIVE SUMMARY

The Coastal Bend Bays & Estuaries Program, Inc. (CBBEP) initiated the Regional Coastal Assessment Program (RCAP) in 2000 to meet the stated goals of the *Implementation Strategy for the Coastal Bend Bays Plan* (CBBEP 1998). The *Bays Plan* called for a program in which comprehensive water and sediment quality monitoring and assessment is a stated primary goal necessary for understanding local estuarine conditions and providing the tools required for protecting, preserving, and enhancing the unique estuarine and marine resources of the Texas Coastal Bend.

The first Center for Coastal Studies (CCS) RCAP report documented program development and encompassed the initial two years (RCAP 2000 and RCAP 2001) of quarterly baseline-monitoring (Nicolau and Nuñez 2004). Parameters singled out included chlorophyll *a*, dissolved oxygen, salinity, and trace metals in water such as zinc, lead, nickel, mercury, chromium, cadmium, and copper. A significant effort occurred during RCAP 2000 and 2001 monitoring, through the adoption and successful implementation of improved aqueous trace metals sampling and analytical methods, to answer the question, "What are the concentrations of heavy metals in the CBBEP region and are there any significant problems"?

While a few concerns existed for nutrient concentrations and chlorophyll *a* at several locations (Nueces Bay, Corpus Christi Inner Harbor, Oso Bay, Oso Creek, and the Baffin Bay Complex), and metal concentrations in sediment at one location (Corpus Christi Marina), the majority of parameters monitored during RCAP 2000 and 2001 showed good water and sediment quality conditions existed within the CBBEP region. In addition, based on using improved methods the study revealed no aqueous metal concentrations exceeding TCEQ criteria and that concentrations of most metals typically were a significant number of times lower (orders of magnitude in some cases) than all applicable criteria or existing historical data (Nicolau and Nuñez 2004).

Cooperative partnerships developed between CCS, the Texas Parks & Wildlife Department (TPWD), and the United States Environmental Protection Agency (EPA) Office of Research and Development, Environmental Monitoring and Assessment Program (EMAP) - National Coastal Assessment (NCA), lead to a restructuring of the program for RCAP 2002 and all future monitoring events. With baseline monitoring concluded, CCS researchers began conducting one major sampling event during the summer index period (mid July through mid September) for RCAP 2002 that coincided with, and complemented, the EMAP-NCA effort. Sampling within the summer index period represented a "worse case scenario", in which water quality conditions might be stressful and thereby limiting to biota.

RCAP 2002 sampled 50 locations within the CBBEP region, under an approved Quality Assurance Project Plan, for the same parameters as the EMAP-NCA. This cooperative effort allowed TPWD and EPA to increase the original 50 locations designated in the NCA sampling program for the State of Texas to 100 sampling locations. This assured better coverage of the extended Texas coastline and yielded a stronger dataset for assessing coastal conditions on a local and regional level. Parameters measured now included standard routine field data parameters, routine conventional water chemistry, microbiological, inorganic and organic sediment and fish tissue analysis for contaminants, sediment toxicity, and benthic infaunal organisms.

In the absence of established nutrient and sediment criteria, two distinct assessments emerged for RCAP 2002 due to different methods employed by TCEQ and EPA for assessing coastal waters. Data analyzed indicated relatively fair to good water and sediment quality conditions within the CBBEP region depending on the assessment method utilized. (Nicolau and Nuñez 2005). In addition, while the approach for determining fish tissue contaminants differed between TCEQ/Texas Department of State Health Services and EPA guidelines, data indicated very good conditions existed throughout the region.

The RCAP 2002 annual report documented the evolving RCAP program in which CCS researchers began employing alternative methods for investigating cumulative effects of multiple sediment contaminants and used the benthic community assessment as a way to link sediment quality to the biotic environment. Questions raised in RCAP 2002 concerned the more restrictive EPA criteria developed for nutrients as possible estimators of estuarine eutrophication. In addition, the expression of toxic effects in sediment, as determined by the EPA amphipod toxicity test, produced conflicting results, as no straightforward cause-effect relationship appeared to exist, with none of the sites sampled having co-occurring toxicity and elevated sediment contaminants. Questions also arose as to utilization of the EPA's Benthic Condition Index and as to whether the Index accurately characterized all benthic communities within the CBBEP region, suggesting that more data collection and continued refinement of methods and indices is necessary.

In RCAP 2003, budget restrictions and the inclusion of trace metals in water sampling reduced the number of sampling sites from 50 to 32 sites sampled. As sampling for metals in water had not occurred in some water body segments for two years, the CBBEP program management wished to update the state of knowledge concerning this portion of the RCAP program. Data analysis continued to utilize various standard parametric and non-parametric tests dependent on meeting test assumptions of the particular analysis required. Additional data evaluation utilized in the RCAP 2003 report continued to derive from comparisons or evaluations to applicable TCEQ water and sediment quality criteria, or if no criteria existed, then to TCEQ Surface Water Quality Monitoring based screening levels. Further comparison and evaluation of RCAP 2003 data continued to utilize EPA National Coastal Condition Report II (NCCR II) guidelines as a way to provide continuity between locally collected data and the ongoing NCA program for assessing coastal waters and to see if the broad based EPA regional approach is applicable in all estuarine systems. As seen in RCAP 2002, because of different ways that state and federal entities make assessments, the two primary methods (TCEQ and EPA) used for evaluating water and sediment quality within the CBBEP region again produced two distinctly different assessments for RCAP 2003.

WATER MONITORING

Field Data

Field data collected continues to be representative of the CBBEP region, with values recorded during RCAP 2003 typical for the summer index period. In contrast to RCAP 2002, salinity concentrations recorded in RCAP 2003 showed increases within most Segments, as major inflow events ceased towards the end of 2002. Freshwater inflows remain as one of the most critical factors for sustaining long-term estuarine health within the CBBEP region and it is important to continue to document these dramatic short-term shifts in salinity and to assess the conditions created within the region.

Dissolved oxygen continues to represent one of the most essential water quality parameters utilized by both TCEQ and EPA in assessments of aquatic life use and the health of a water body. While a few near-surface dissolved oxygen concentrations fell in the "biologically stressful" range of >2.0 mg/L but <5.0 mg/L, based on one-time grab sampling, overall near-surface dissolved oxygen quality for the CBBEP region can be considered very good.

Routine Conventional Water Chemistry

The continued lack of nutrient criteria, and conflicting methodologies utilized by TCEQ and EPA for assessing coastal waters, once again produced different water quality assessments for the region for RCAP 2003. According to TCEQ screening levels, while some nutrient values exceeded screening levels, based on RCAP 2003 sampling these elevated levels tended to warrant little concern. However, extremely elevated nitrate + nitrite levels in Hynes Bay (Segment 2462), and the clustering of elevated ammonia concentrations in the Baffin Bay Complex (Segment 2492), might possibly indicate areas needing additional temporal and spatial monitoring. Regarding chlorophyll *a* concentrations, possible concerns may exist based on TCEQ screening levels, as elevated concentrations continued for the second straight year. However, elevated concentrations may still be reflective of natural phytoplankton responses to increased nutrients from inflow events prior to sampling, coupled with optimal conditions of high temperatures and increased light levels during the south Texas summer; prime conditions to produce high concentrations of chlorophyll *a*.

Using EPA NCCR II guidance to look at near-surface Dissolved Inorganic Nitrogen (DIN) and Dissolved Inorganic Phosphorus (DIP) concentrations continued to provide a more unfavorable assessment of the region than evaluation using TCEQ Screening Levels. As opposed to RCAP 2002, when DIN concentrations were all <0.10 mg/L at the 50 sites sampled and thereby rated as good for the RCAP sampling region, RCAP 2003 sampling produced 27 sites rated as good, 2 sites as fair, and 3 sites rated as poor. Comparing DIP concentrations for RCAP 2003 with concentrations from RCAP 2002 produced approximately the same percentage of sites exceeding EPA NCCR II guidelines. In addition, many of the sites occurred within the same Segments for both years.

Regarding chlorophyll *a* concentrations, based on EPA guidance 21 sites sampled received a fair ranking in RCAP 2003. As seen in RCAP 2002, the authors still feel the lower end of the fair category (5.00 µg /L) remains too low based on historical concentrations observed for this region. In RCAP 2003, of 32 sites sampled 21 sites received a fair rating, with 10 of those sites having chlorophyll *a* concentrations of <9.00 µg/L and nine sites with concentrations of <6.00 µg/L; suggesting a modified scale for this region of Texas may be in order. Based on analysis of all chlorophyll *a* data collected for RCAP the 75th percentile is 11.47 µg/L. The authors feel that perhaps the new scale should considered <11.50 µg/L as good, 11.50 µg/L to 20.00 µg/L as fair, and >20.00 µg/L as poor.

Overall, the combined EPA Water Quality Index for RCAP 2003 ranked nine sites as good, 22 sites as fair, and one site as poor, with primarily a combination of DIP and chlorophyll *a* concentrations the justification for a fair ranking. On a percentage basis of sites sampled, this was almost identical to RCAP 2002 results. The utility of DIN as an estimator of possible estuarine eutrophication remains questionable because as was seen in RCAP 2002, DIN concentrations did not generally correspond with high chlorophyll *a* concentrations in RCAP 2003. DIN concentrations only corresponded with high levels of chlorophyll *a* in Hynes Bay (Site 295) and relatively moderate levels at two sites (Sites 318 and 322) in the Baffin Bay Complex.

Regarding DIP comparisons, no clear association with high levels of chlorophyll *a* existed for RCAP 2002. Of the 13 sites rated as having poor DIP concentrations (>0.05 mg/L), five had low (good) concentrations of chlorophyll *a*, seven had moderate (fair) concentrations, and only one had poor (high) chlorophyll *a* concentrations. For RCAP 2003, of the eight sites having poor DIP concentrations one had low (good) concentrations of chlorophyll *a*, six had moderate (fair) concentrations and only one had poor (high) chlorophyll *a* concentrations. Additional data assessment of CBBEP and Texas coastal waters is clearly necessary and additional data may provide concentration ranges more applicable within our estuaries. However, it does seem that for RCAP 2003 the association while not definitive, is perhaps becoming a bit clearer.

Microbiological Indicators

Currently, many water body segments in Texas are still undergoing assessment by the TCEQ TMDL group for bacteria impairments related to the Oyster Water Use (Fecal Coliform criteria). The continuation of bacteria sampling in RCAP 2003 provided data using the new criterion, enterococci, in the assessment of the Contact Recreation Use (CRU) for water within the CBBEP region. Analysis of RCAP 2003 data clearly indicates that for the sites sampled, based on the current CRU single sample criteria of 104 CFU/100ml, water quality regarding enterococci concentrations is very good throughout the CBBEP region for the second straight year.

Trace Metals in Water

As the impetus for the entire RCAP monitoring program stemmed from documented historical concerns for possible trace metals in water contamination, and the identification of insufficient and inadequate data with which to make accurate assessments, the results of this portion of the monitoring project continue to be excellent. The authors strongly feel that utilization of ultra-clean sampling and analysis techniques provides the highest quality data available and encourage their use in applicable monitoring programs. As these methods identified no aqueous metal concentrations exceeding chronic TCEQ 2000 Tidal Water Chronic criteria for RCAP 2003, the authors feel that water quality regarding trace metals in water is excellent throughout the region.

However, the authors recommend that if periodic sampling remains cost prohibitive for the entire RCAP area, limited routine sampling should continue in the Baffin Bay Complex (Segment 2492). Even though all sample concentrations fell below applicable criteria, the fact remains that elevated concentrations still look much like those found within, or in close proximity to, the Corpus Christi Inner Harbor. While it is common knowledge that several upstream industrial complexes have permitted discharges into creeks and streams that feed into the Baffin Bay Complex, this region is considered a remote, non-industrialized area. Further analysis of data for these reaches is required to determine if any patterns or sources are discernible and that concentrations continue to remain below acceptable criteria levels.

SEDIMENT MONITORING

Sediment Characteristics and Inorganic/Organic Contaminants

As seen in RCAP 2002, sediment contamination was low for RCAP 2003 and the region rates as good according to TCEQ protocols. However, as seen in RCAP 2002, different methodologies used by TCEQ and EPA produce different assessments.

In contrast to RCAP 2002 sampling results, data analysis showed no cases of high (poor) TOC levels existed at sites sampled for RCAP 2003. While three cases of moderate (fair) levels existed, EPA would consider regional results as good according to NCCR II TOC guidance. Concerning sediment metal and organic contaminants, unlike the RCAP 2002 study, when one site exhibited elevated concentrations of PCBs and Total DDT, no sites had concentrations above respective TCEQ PEL values. However, various sites throughout the region had concentrations above the TCEQ 85^{th} percentile screening level for cadmium, chromium, and zinc. These metals also had concentrations above the 85^{th} percentiles during the RCAP 2002 study. In addition, analytical results for mercury, 4,4’-DDE and Total DDT showed concentrations above TEL screening levels at several sites in Nueces and Corpus Christi Bays during both this and the RCAP 2002 study.

Following the NCCR II assessment guidelines for RCAP 2003 produced no sites with poor sediment quality due to sediment contaminants based on ERL and ERM exceedances. However, sites in five Segments had poor sediment quality due only to the expression of toxic effects. As a fundamental part of the EPA Sediment Quality Index (TOC, Sediment Toxicity, and Sediment Contaminants) used in the EPA NCCR II report, the expression of toxic effects in sediment ranked eight of the 32 RCAP 2003 sites as having poor sediment quality. As was the case in RCAP 2002, the amphipod toxicity test continued to produce the most conflicting results, with no straightforward cause-effect relationship appearing to exist, as none of the sites sampled had co-occurring toxicity and elevated sediment contaminants. While unmeasured chemicals or other confounding factors such as elevated ammonia concentrations, and/or habitat preference of the test organism may have influenced sediment toxicity results, as a result, the lack of co-occurring sediment contamination and toxicity continues to raise questions.

Use of the Sediment Quality Guideline Quotient in RCAP 2003 continued to provide an alternate method of investigating potential contaminant impacts that address cumulative effects of multiple contaminants, as opposed to a single sediment screening level assessment. This process coupled with Factor analysis produced 15 sites with “Moderate” contaminant levels relative to other sites sampled. Although 15 sites had high factor analysis scores, only nine met the criteria for a “Moderate” Sediment Contaminant Distribution (SCD) characterization. Contaminants contributing to variation through factor analysis identified in RCAP 2003 were also similar to those identified during RCAP 2002. Contaminants of interest for RCAP 2003 were metals in the Mission-Aransas estuary, metals and pesticides in the Nueces estuary, and metals in the Baffin Bay complex. Overall PCB's were of little concern with the majority of the concentrations at or near minimum detection limits. Concerning the Guadalupe estuary, based on only one sampling site there are no concerns, but more data collection is required to make a true assessment of this area.

Benthic community characterization for RCAP 2003 resulted in the delineation of five assemblages, and one site classified as an outlier, with many benthic assemblages sharing similar characteristics as those in RCAP 2002. The location of Mid-Depth, Mesohaline, Mud (MMM) and the Mid-Depth, Euhaline, Muddy-Sand (MEMS) assemblages was similar to the Mid-Depth, Mesohaline, Muddy-Sand assemblage of RCAP 2002 and grouped together sites primarily located in naturally stressed areas. These assemblages typically consisted of organisms often characterized as pollution-tolerant species, indicative of environmental stress and organic enrichment. Since both assemblages are located in a dynamic portion of the estuary, other unmeasured factors ought to be considered as possibly having negative impacts on the benthic community. However, as stated for RCAP 2002, co-occurring "moderate" SCD rankings and/or expressions of sediment toxicity at sites exhibiting the greatest evidence of benthic stress, and attaining poor EPA-Benthic Condition Index scores, should not be discounted. The outlying site in Mesquite Bay was located in an area that exhibited expressions of toxicity in addition to reductions of benthic measures. This is the second year such results were observed in this area without increased SCD rankings occurring and could possibly be a result of unmeasured contaminants.

The Shallow-Depth, Euhaline, Sand (SES) assemblage of RCAP 2003 was similar to the RCAP 2002 SES assemblage. As with RCAP 2002, sites within this assemblage expressed toxicity without producing "Moderate" SCD rankings or reductions of benthic measures. Habitat type may exert a stronger influence on the toxicity results, as opposed to contaminant concentrations, in this assemblage. The Deep-Depth, Euhaline, Muddy-Sand (DEMS) assemblage was primarily located in Corpus Christi Bay, and shared the same benthic characteristics and SCD rankings as the Deep-Depth, Polyhaline, Muddy-Sand assemblage of RCAP 2002. This area tends to possess a more complex, or stable, benthic community, with little environmental variability. Similar SQGQ values associated with the SCD rankings for the MMM and MEMS assemblages were observed in the DEMS assemblage. However, the impact to the benthic community in this assemblage was minimal, suggesting that similar contaminant loadings in a dynamic system may have a greater impact on a benthic community than that of a stable system.

The complex process of understanding sediment interactions within the CBBEP region is still evolving and continues to require more data collection and continued refinement of methods and indices. Based on TCEQ guidelines, sediment within the area ranks as good. Using the EPA NCCR II guidelines ranks 8 of the 32 sites sampled (20 of 50 in RCAP 2002) as having degraded sediments due to the expression of toxic effects and 5 of the 32 sites sampled (10 of 50 for RCAP 2002) as having degraded benthic communities. However, the authors believe that based on questionable sediment toxicity results the rankings may not be justified and further monitoring and analysis is necessary for accurately classifying potentially degraded and healthy habitats with the CBBEP area.

TISSUE MONITORING

The approach EPA NCA uses in the collection of data for the NCCR II report continues to make RCAP tissue contaminant data difficult to assess in Texas, as existing standards and methods are not comparable (e.g. whole-body versus edible tissue). EPA is planning to modify this portion of the program and begin analyzing some sites for edible tissue in the RCAP 2004 event.

As observed in RCAP 2002, the concentration of metals in whole-body tissue was lower than all TCEQ/TDSHS applicable screening levels for RCAP 2003. However, three sites sampled during RCAP 2003 fell within the EPA risk based guidance range used in the NCCR II assessment for mercury in fish tissue and one site exceeded the guidance range. Contaminant exceedances were found primarily in catfish and Atlantic Croaker. As seen in RCAP 2002, most sites had low concentrations of aluminum, chromium, and iron. A limited amount of nickel and lead followed by zinc and copper occurred at some locations, with many sites having metals concentration values that were non-detectable.

Detectable PCB concentrations occurred in whole-body tissue at only one site during RCAP 2003 sampling, as opposed to eight sites during RCAP 2002. Detectable concentrations of DDT also occurred at only one site, as opposed to three sites the previous year. As seen with PCB the highest value was well below the screening levels for both years. Total Chlorinated Pesticides, other than DDT, registered in samples at one site in RCAP 2003, as opposed to four sites in RCAP 2002; consisting of small detectable amounts of trans-nonachlor, a major constituent of technical chlordane. At a concentration of 2.58 ppb this small amount of pesticide poses no health problems. As in RCAP 2002, no detectable concentrations of PAHs occurred in any of the sites sampled for RCAP 2003.

Although not applicable, the results of whole-body tissue analysis were compared to screening levels normally used for edible tissue as a basis for determining extent of possible contamination and bioaccumulation in tissue. Based on TCEQ/TDSHS analysis the region ranks as good since most contaminants were non-detectable or well below any applicable screening level. When evaluating the CBBEP region according to EPA guidelines the CBBEP region rated as good. While one site exceeded the maximum concentration range value for mercury, the other three sites fell just above the minimum concentration range value. The presence of mercury in edible fish tissue can be a major concern for public health but more data or studies are necessary to determine if mercury in estuarine fish tissue represents an increasing trend within the area. In addition, as seen in RCAP 2002 no specimens collected in RCAP 2003 showed evidence of lesions or tumors during the external gross pathology examination performed on-board TPWD vessels during sampling.

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1.0 INTRODUCTION

1.1 RCAP Background and Objectives

The Coastal Bend Bays & Estuaries Program, Inc. (CBBEP) initiated the Regional Coastal Assessment Program (RCAP) in 2000 to meet the stated goals of the *Implementation Strategy for the Coastal Bend Bays Plan* (CBBEP 1998). The *Bays Plan* called for a program in which comprehensive water and sediment quality monitoring and assessment is a stated primary goal necessary for understanding local estuarine conditions and providing the tools required for protecting, preserving, and enhancing the unique estuarine and marine resources of the Texas Coastal Bend.

Essential for collection, analysis, and dissemination of the highest quality data to both the public and coastal managers, RCAP allows CBBEP and the communities within the program area, to interact with local, state, and federal entities in the larger goal of protecting and preserving the entire Gulf Coast environment. Established and built first at the local level, these interactions develop highly effective communication lines that provide for data collection, analysis, and improved information transfer that ultimately foster partnerships specifically designed to provide the means for effective coastal monitoring.

The first Center for Coastal Studies (CCS) RCAP report documented program development and encompassed the initial two years (2000 and 2001) of quarterly baseline-monitoring (Nicolau and Nuñez 2004). This intensive monitoring effort wanted to address the numerous historical concerns of the bay system's water quality parameters and metals concentrations that appeared in CBBEP study reports (Ward and Armstrong 1997 CCBNEP-13; Ward and Armstrong 1997 CCBNEP-23). Parameters singled out included chlorophyll *a*, dissolved oxygen, salinity, and trace metals in water such as zinc, lead, nickel, mercury, chromium, cadmium, and copper. Areas of historically elevated trace metals in water concentrations included Redfish Bay (Segment 2483), the Corpus Christi Ship Channel, Nueces Bay (Segment 2482), La Quinta Ship Channel, the Corpus Christi Inner Harbor (Segment 2484), and Corpus Christi Bay (Segment 2481). A significant effort occurred during RCAP 2000 and 2001 monitoring, through the adoption and successful implementation of improved aqueous trace metals sampling and analytical methods, to answer the question, "What are the concentrations of heavy metals in the CBBEP region and are there any significant problems"?

This effort significantly expanded on historical monitoring efforts within the region and yielded accurate and reliable data for initial characterization and assessment of water and sediment quality conditions within the region. While a few concerns existed for nutrient concentrations and chlorophyll *a* at several locations (Nueces Bay, Corpus Christi Inner Harbor, Oso Bay, Oso Creek, and the Baffin Bay Complex), and metal concentrations in sediment at one location (Corpus Christi Marina), the majority of parameters monitored during RCAP 2000 and 2001 showed good water and sediment quality conditions existed within the CBBEP region. In addition, based on using improved methods the study revealed no aqueous metal concentrations exceeding TCEQ criteria and that concentrations of most metals typically were a significant number of times lower (orders of magnitude in some cases) than all applicable criteria or existing historical data (Nicolau and Nuñez 2004).

Cooperative partnerships developed between CCS, the Texas Parks & Wildlife Department (TPWD), and the United States Environmental Protection Agency (EPA) Office of Research and Development, Environmental Monitoring and Assessment Program (EMAP) - National Coastal Assessment (NCA), lead to a restructuring of the program for RCAP 2002. With baseline monitoring concluded, CCS researchers began conducting one major sampling event during the summer index period (mid July through mid September) for RCAP 2002 that coincided with, and complemented, the EMAP NCA effort. Sampling within the summer index period represented a “worse case scenario”, in which water quality conditions might be stressful and thereby limiting to biota.

As a multi-year effort, led by National Health and Environmental Effects Research Laboratory’s Gulf Ecology Division in Gulf Breeze, FL, NCA evaluates assessment methods developed to advance the science of ecosystem condition monitoring by creating an integrated, comprehensive coastal monitoring program among states (USEPA 2001). Integrated sampling programs yield data collected by the same quality assured methods that are directly comparable, easily transferable, and significantly more detailed in scope than individual monitoring programs.

Using a probabilistic design and a common set of survey indicators, each state conducts the survey at a minimum of 50 sites, and assesses the condition of their coastal resources independently; these estimates can then be aggregated to assess conditions at the State, EPA Regional, biogeographical, and National levels. Designed to provide scientifically sound water and sediment quality data, EMAP NCA provides essential spatial and temporal components for monitoring coastal waters; helping to determine resource conditions, providing information to aid in evaluation of environmental policies, and helping to identify emerging environmental problems before they become widespread.

Through the dedication and foresight of the CBBEP, RCAP 2002 sampled 50 locations within the region, at the same time, and for the same parameters (plus additional parameters of local concern) as the EMAP NCA. This cooperative effort allowed TPWD (EPA-EMAP NCA lead agency in Texas) and EPA to sample the original 50 NCA sites in the remaining waters of the state, thereby increasing the NCA sampling program in the State of Texas to 100 sampling locations. These 50 extra sites assured better coverage of the extended coastline of Texas and yielded a stronger dataset for assessing coastal conditions on a local and regional level.

The second RCAP (2002) annual report documented the evolving RCAP program and provided data indicating relatively good conditions within the CBBEP region (Nicolau and Nuñez 2005). However, in the absence of established nutrient and sediment criteria two distinct assessments emerged due to different methods employed by the Texas Commission on Environmental Quality (TCEQ) and EPA for assessing coastal waters.

Using TCEQ guidance, only two sites exceeded nutrient (ammonia, nitrate + nitrite, orthophosphate, and total phosphorus) screening levels (one for ammonia and one for total phosphorus) during RCAP 2002. These results showed little concern for nutrient levels and indicated good conditions throughout the region. In contrast, fourteen sites exhibited elevated levels of chlorophyll *a*. However, these levels may have directly related to natural phytoplankton responses to increased nutrient inflows from flooding events that occurred one month prior to sampling, coupled with the optimal conditions of high temperatures and increased light levels common during the south Texas summer. No concerns existed for bacteria concentrations based on RCAP 2002 monitoring.

Conversely, for RCAP 2002 the combined modified EPA Water Quality Index guidance ranked 15 sites as good, 34 sites as fair, and one site as poor, with a combination of Dissolved Inorganic Phosphorus (DIP) and chlorophyll *a* concentrations the justification for a fair ranking. The more restrictive EPA guidelines for the National Coastal Condition Report II (NCCR II) developed criteria for DIP and Dissolved Inorganic Nitrogen (DIN) as possible estimators of estuarine eutrophication.

However, the utility of DIN as an estimator of possible estuarine eutrophication within the CBBEP region for RCAP 2002 was questionable, as all DIN concentrations were <0.1 mg/L and did not correspond with high chlorophyll *a* concentrations. Regarding DIP comparisons, no clear association with high levels of chlorophyll *a* existed. Of the 13 sites rated as having poor DIP concentrations (>0.05 mg/L), five had low (good) concentrations of chlorophyll *a*, seven had moderate (fair) concentrations, and only one had poor (high) chlorophyll *a* concentrations.

As seen with water quality monitoring, in the absence of established sediment criteria, TCEQ screening levels and EPA NCCR II guidance also produced different assessments. Data analysis showed that while one case of elevated Total Organic Carbon (TOC) levels existed within St. Charles Bay, EPA considered most sites as good according to NCCR II TOC guidance. Concerning sediment metal and organic contaminants, according to TCEQ screening levels, very little concern existed. Only one location, off the town of Bayside in Copano Bay exceeded both the Probable Effects Level and 85th percentile requirements for Total DDT and Total PCB. In addition, this was the only site considered as having poor sediment quality based on EPA NCCR II guidance for sediment metal and organic contaminants.

However, as a fundamental part of the EPA Sediment Quality Index (TOC, Sediment Contaminants, and Sediment Toxicity), the expression of toxic effects in sediment accounted for 18 of 20 sites listed as having poor sediment quality during RCAP 2002. The EPA amphipod toxicity test produced conflicting results, with no straightforward cause-effect relationship appearing to exist, as none of the sites sampled had co-occurring toxicity and elevated sediment contaminants, a fact that raised questions concerning the amphipod testing method currently used by EPA in the NCCR.

For RCAP 2002, CCS researchers also used alternative methods for investigating potential contaminant impacts with a Sediment Contaminant Distribution (SCD) approach. This approach utilized the Sediment Quality Guideline Quotient method to address cumulative effects of multiple contaminants. This process, coupled with Factor analysis, aided in identifying patterns of potential environmental contamination. Analysis produced 16 sites with moderate contaminant levels (relative to all other RCAP 2002 sites sampled) and only one site with high contaminant levels exceeding established screening levels. Contaminants of interest for the 50 sites sampled were pesticides in the Mission-Aransas estuary, metals within the Nueces Estuary, particularly Arsenic, Chromium, Copper, Nickel, Lead and Zinc. The aforementioned metals along with some PCBs also existed in greater concentrations within the Baffin Bay complex.

The benthic community assessment for RCAP 2002 provided a way to link sediment quality to the biotic environment. Similarity analysis based on community composition and structure resulted in the classification of four benthic community assemblages. Of the four benthic assemblages defined, the Mid-Depth, Mesohaline, Muddy-Sand assemblage grouped together sites consisting of characteristics indicative of a stressed benthic community. The locations of the sites suggests the stress might have been brought upon by natural occurring events, such as the major flooding seen one month prior to RCAP 2002 sampling. However, sites within the assemblage that exhibited the greatest evidence of benthic stress, and low EPA Benthic Condition Index scores, also had moderate SCD rankings that cannot be ignored.

The Shallow-Depth, Euhaline, Sand assemblage grouped together 15 sites, primarily in the Upper Laguna Madre, and consisted of characteristics typically not associated with degraded sediment. However, the EPA's Benthic Condition Index characterized many of the sites as fair or poor. Although this index may be applicable in the other RCAP 2002 assemblages, the authors feel that the index misrepresented this type of benthic community, and requires more data collection and continued refinement of methods and indices.

In summary, for RCAP 2002, based on TCEQ guidelines sediment quality ranked as good, with only one site exceeding screening level concentrations. Conversely, using EPA NCCR II guidelines ranked 20 of the 50 sites as having degraded sediments and 10 of the 50 sites as having degraded benthic communities. However, based on questionable sediment toxicity results the EPA rankings may not be justified and further analysis is necessary to provide a more accurate classification of potentially degraded and healthy habitats.

Concerning tissue contaminants for RCAP 2002, due to the approach EPA-NCA uses in the collection of data for the NCCR II report makes tissue contaminant data difficult to assess in Texas, as existing standards and methods are not comparable (e.g. whole-body versus edible tissue). While not applicable, results of whole-body tissue analysis for RCAP 2002 were compared to screening levels normally used for edible tissue as a basis for determining the extent of possible contamination and bioaccumulation.

According to TCEQ/TSDHS and EPA guidelines, the concentration of metals in whole-body tissue was lower than all applicable screening levels. Detectable concentrations of PCBs occurred in whole-body tissue at eight locations within the RCAP 2002 sampling area, DDT occurred at three sites, and Total Chlorinated Pesticides other than DDT registered in whole-body tissue samples at four sampling sites. All detected concentrations were far below any applicable screening level. No detectable concentrations of PAHs occurred in any of the sites sampled. In addition, no specimens showed evidence of lesions or tumors during external gross pathology examinations performed on-board TPWD vessels during RCAP 2002 sampling. Based on this analysis, the region ranked as very good concerning tissue contaminants. Future events and reevaluation of sampling and analysis protocols may produce results that are comparable to existing state guidelines and /or federal guidelines.

The continued goal of the CBBEP in establishing the RCAP is to protect, preserve, and enhance the natural resources of our coastal environment by providing descriptive and quantitative data and developing diagnostic procedures to characterize the physical, chemical, and biological dynamics of the CBBEP coastal environment. A comprehensive RCAP addressing these goals and objectives has the unique ability to interact with many of the other Action Plans as described in the *Bays Plan* in an overall adaptive management structure. Therefore, the continued objectives of this project are to build upon the current RCAP while interfacing with the broader NCA that assesses all coastal waters of the United States.

1.2 Regional Coastal Assessment Program Participants and Contractors

RCAP 2003 involved partnership efforts of the federal, state, local agencies, and stakeholder groups listed in Table 1.1. These groups were instrumental in providing funding, in-kind services, and/or expertise. CBBEP and CCS are grateful for their continued support. Table 1.2 lists participating RCAP 2003 contractors and primary personnel.

Table 1.1. Regional Coastal Assessment Program 2003 participants.

Institution

- **Coastal Bend Bays & Estuaries Program**
- **Gulf of México Program**
- **Texas Commission on Environmental Quality (TCEQ)**
- **Texas Parks and Wildlife Department**
  - Coastal Ecology
  - Coastal Fisheries
- **U.S. Environmental Protection Agency (USEPA)**
  - Region 4 – Atlanta, Georgia
    - Gulf of México Program
  - Region 6 – Dallas, Texas
  - National Health and Environmental Effects Research Laboratory - Gulf Ecology Division

Table 1.2. Regional Coastal Assessment Program 2003 contractors.

	Contractor/Institution	Primary Personnel
Principal Contractor	Center for Coastal Studies (CCS)	Mr. Brien A. Nicolau Mr. Alex X. Nuñez
Water Chemistry		
Nutrients	Texas A&M University Department of Oceanography	Mr. Christopher Schmidt
Chlorophyll *a*	University of Texas Marine Science Institute (UTMSI)	Dr. Tracy Villareal
Trace Metals	Albion Environmental	Dr. Paul N. Boothe
Sediment/Tissue		
Trace Element Chemistry Organic Chemistry	Texas Parks and Wildlife Department Environmental Contaminants Laboratory (TPWD – ECL)	Dr. David Klein Mr. Gary Steinmetz Ms. Pamela Hamlett
Sediment/Water Chemistry		
Grain Size Total Organic Carbon Total Suspended Solids	FUGRO South, Inc (FSI)	Mr. Steve DeGregorio
Sediment Toxicity Testing	HESS, Inc.	Mr. Neal Huebotter
Microbiological	Texas A&M University-Corpus Christi (TAMUCC)	Dr. Joanna Mott

1.3 References

CBBEP. 1998. Implementation Strategy for the Coastal Bend Bays Plan. CBBEP-2. 179 pp.

Nicolau, B. A. and Alex X. Nuñez. 2004. Coastal Bend Bays & Estuaries Program, Regional Coastal Assessment Program (RCAP): RCAP 2000 and RCAP 2001 Annual Report. Center for Coastal Studies, Texas A&M University-Corpus Christi. TAMUCC-CC-0406-CCS. 246 pp.

Nicolau, B. A. and Alex X. Nuñez. 2005. Coastal Bend Bays & Estuaries Program, Regional Coastal Assessment Program (RCAP): RCAP 2002 Annual Report. Center for Coastal Studies, Texas A&M University-Corpus Christi. TAMUCC-CC-0502-CCS. 198 pp.

USEPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan 2001-2004. USEPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002.

Ward, G. H. and N. E. Armstrong. 1997a. Current Status and Historical Trends of Ambient Water, Sediment, Fish and Shellfish Tissue Quality in the Corpus Christi Bay National Estuary Program Study Area. Summary Report. CBBNEP-13. 270 p.

Ward, G. H. and N. E. Armstrong. 1997b. Ambient Water, Sediment, Fish, and Shellfish Tissue Quality of the Corpus Christi Bay Study Area: Present Status and Historical Trends. CCBNEP-23. 807 p.

2.0 METHODS

2.1 Sampling Process Design

RCAP development originally consisted of a three-phase process based on providing data that would characterize water and sediment quality conditions in the CBBEP region (Fig 2.1) and begin to identify significant long-term trends. In addition, RCAP would provide support for the TCEQ Surface Water Quality Monitoring Program (SWQM) and Total Maximum Daily Load (TMDL) process. Input from local, state, and federal representatives, facilitated stakeholder workgroup consensus regarding appropriate and effective sampling and analytical protocols for monitoring the region. As part of the initial process, coordination with TCEQ ensured a comprehensive monitoring strategy that determined effective methods of identifying water and sediment quality concerns for the CBBEP area. This included the Upper Laguna Madre and Baffin Bay; an area determined to be deficient in recent data collection. With attaining achievable water and sediment quality objectives as the goal, development of the work plan attempted to balance objectives with available resources.

Baseline quarterly monitoring for RCAP 2000 consisted of 120 (30 per quarter) randomly selected sites sampled in the northern and central portions of the CBBEP area. In addition, sampling occurred at 10 targeted fixed TCEQ sites each quarter, and 8 fixed sites in Oso Creek and Oso Bay for two quarters; bringing the total number of sites sampled to 176 for RCAP 2000. During RCAP 2001, sampling took place in the Upper Laguna Madre and Baffin Bay complex at 31 randomly selected sites per quarter for a total number of 124 sites sampled (Nicolau and Nuñez 2004). For RCAP 2002, sampling occurred once during the summer index period and consisted of 50 randomly selected sites located within 11 of the 13 TCEQ defined Segments in the CBBEP region (Nicolau and Nuñez 2005).

RCAP 2003 sampling consisted of 32 randomly selected sites (Fig. 2.2), located within 10 of 13 possible TCEQ defined Segments in the CBBEP region. Site selection continued to utilize the EPA-EMAP sampling design in which each sampling site becomes a statistically valid probability-based sample (Stevens 1997; Stevens and Olsen 1999). Selection of sites by the EPA-NCA team involved placement of multiple hexagonal grids, of predetermined size, over the study areas with sites then selected by a systematic random approach. The uniform spatial coverage provided by a grid ensured sampling of parameters was proportional to geographical location.

The following Segments contained the 32 sites selected for sampling: San Antonio Bay/Hynes Bay/Guadalupe Bay (Segment 2462), Mesquite Bay/Carlos Bay/Ayers Bay (Segment 2463), Aransas Bay (Segment 2471), Copano Bay/Mission Bay/Port Bay (Segment 2472), Corpus Christi Bay (Segment 2481), Nueces Bay (Segment 2482), Redfish Bay (Segment 2483), Oso Bay (Segment 2485), Laguna Madre (Segment 2491), and Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) (Fig. 2.1). The random sampling design did not generate any sites to be sampled in either St. Charles Bay (Segment 2473), Corpus Christi Inner Harbor (Segment 2484), or Oso Creek (Segment 2485A-TCEQ unclassified Tidal Stream segment).

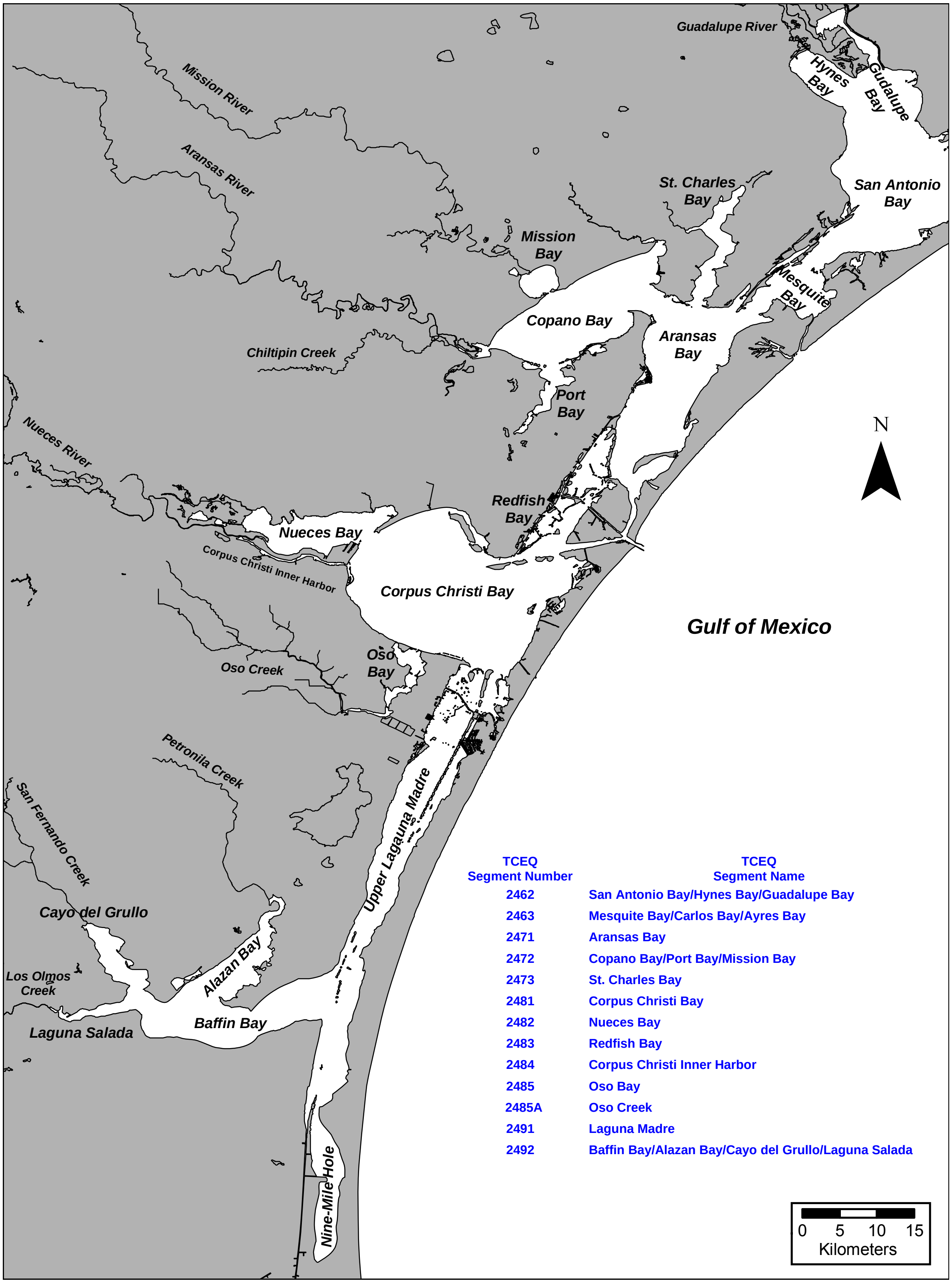

Fig. 2.1. Map depicting CBBEP RCAP sampling area with listing of TCEQ Segment Numbers and Segment Names.

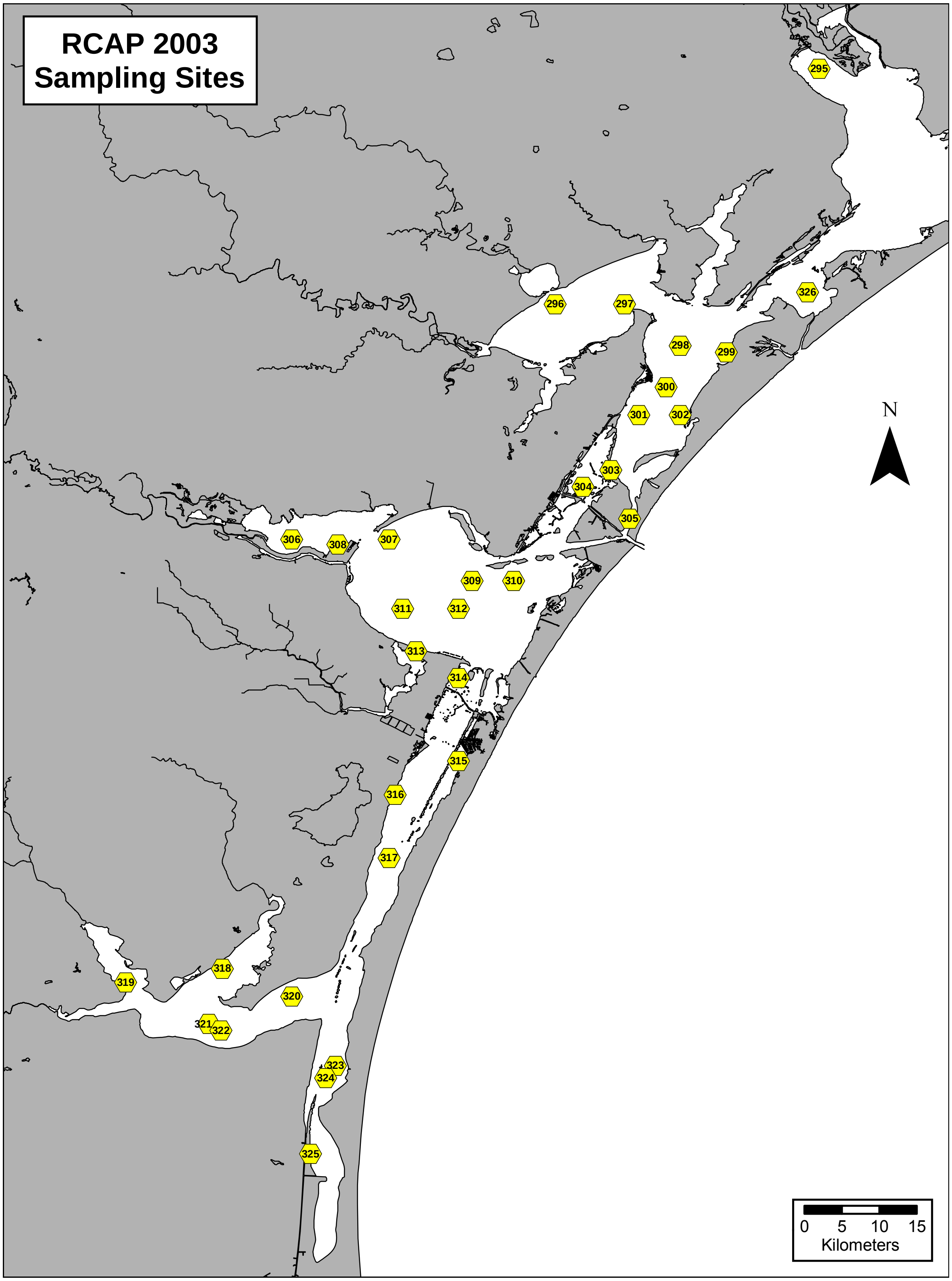

Fig. 2.2. Distribution of RCAP 2003 sampling sites (32) with corresponding CCS Site ID number. See Table 6.1.1 for corresponding TCEQ Station ID numbers and other pertinent information.

2.2 Parameters Sampled

Table 2.1 lists all parameters measured for RCAP 2003. Parameters measured but not presented within the scope of this report are available upon request to the CBBEP and CCS Project Managers.

Table 2.1. Parameters collected and analyzed for RCAP 2003.

FIELD PARAMETERS (Water)	Units	Lab
Conductivity	µS/cm	CCS
Depth Sample Collected	Meters	CCS
Dissolved Oxygen	mg/L	CCS
Dissolved Oxygen	% Saturation	CCS
Habitat Type	Description	CCS
Marine Debris	Description	CCS
PAR – Terrestrial	$\mu mol\ s^{-1}\ m^{-2}$	CCS
PAR – Flat Cosine	$\mu mol\ s^{-1}\ m^{-2}$	CCS
PAR –- Spherical	$\mu mol\ s^{-1}\ m^{-2}$	CCS
pH	su	CCS
Salinity	PSU	CCS
Seagrass Type (Species)	Scientific name	CCS
Seagrass Percent Cover	%	CCS
Secchi Depth	Meters	CCS
Tide Stage	DNR Tide Gauge	CCS
Total Depth	Meters	CCS
Turbidity	Visual assessment	CCS
Turbidity	NTU	CCS
Water Color	Visual assessment	CCS
Water Odor	Olfactory assessment	CCS
Water Surface	Visual assessment	CCS
Water Temperature	°C	CCS
FIELD PARAMETERS (Weather)	**Units**	**Lab**
Air Temperature	°C	CCS
Barometric Pressure	mm/Hg	CCS
Cloud Cover	%	CCS
Dew Point	°C	CCS
Heat Index	°C	CCS
Present Weather	Visual assessment	CCS
Rainfall (Days since last)	Days	CCS
Rainfall (Inches past 1 day)	Inches	CCS
Rainfall (Inches past 7 days)	Inches	CCS
Relative Humidity	%	CCS
Wind Chill	°C	CCS
Wind Direction	Compass Direction	CCS
Wind Speed	MPH	CCS

Table 2.1. (continued).

ROUTINE CONVENTIONAL CHEMISTRY (Water)	Units	Lab
Ammonia	mg/L	TAMU
Nitrate	mg/L	TAMU
Nitrite	mg/L	TAMU
Nitrate/Nitrite	mg/L	TAMU
Orthophosphate	mg/L	TAMU
Total Phosphorus	mg/L	TAMU
Total Suspended Solids (TSS)	mg/L	FSI
Chlorophyll *a*	µg/L	UTMSI

MICROBIOLOGICAL (Water)	Units	Lab
Enterococci (IDEXX 51, IDEXX 97, and EPA Method 1600)	CFU/100ml	TAMUCC

TRACE METALS (Water)	Units	Lab
Arsenic (Dissolved)	µg/L	ALBION
Cadmium (Dissolved)	µg/L	ALBION
Copper (Dissolved)	µg/L	ALBION
Lead (Dissolved)	µg/L	ALBION
Mercury (Total)	µg/L	ALBION
Nickel (Dissolved)	µg/L	ALBION
Selenium (Total)	µg/L	ALBION
Zinc (Dissolved)	µg/L	ALBION

SEDIMENT QUALITY PARAMETERS	Units	Lab
SGS Clay (<0.0039 mm)	% dry wt.	FSI
SGS Silt (0.0039 to 0.0625 mm)	% dry wt.	FSI
SGS Sand (0.0625 to 2.0 mm)	% dry wt.	FSI
SGS Gravel + shell hash (>2.0 mm)	% dry wt.	FSI
Total Organic Carbon (TOC)	mg/kg (% dry wt)	FSI

INORGANICS – SEDIMENT and TISSUE TRACE METALS	Units	Lab
Aluminum (Al)	mg/kg (dry and wet wt.)	TPWD ECL
Antimony (Sb) (Sediment only)	mg/kg (dry wt.)	TPWD ECL
Arsenic (As)	mg/kg (dry and wet wt.)	TPWD ECL
Cadmium (Cd)	mg/kg (dry and wet wt.)	TPWD ECL
Chromium (Cr)	mg/kg (dry and wet wt.)	TPWD ECL
Copper (Cu)	mg/kg (dry and wet wt.)	TPWD ECL
Iron (Fe)	mg/kg (dry and wet wt.)	TPWD ECL

Table 2.1. (continued).

Lead (Pb)	mg/kg (dry and wet wt.)	TPWD ECL
Manganese (Mn) (Sediment only)	mg/kg (dry wt.)	TPWD ECL
Mercury (Hg)	mg/kg (dry and wet wt.)	TPWD ECL
Nickel (Ni)	mg/kg (dry and wet wt.)	TPWD ECL
Selenium (Se)	mg/kg (dry and wet wt.)	TPWD ECL
Silver (Ag)	mg/kg (dry and wet wt.)	TPWD ECL
Tin (Sn)	mg/kg (dry and wet wt.)	TPWD ECL
Zinc (Sn)	mg/kg (dry and wet wt.)	TPWD ECL
ORGANICS – SEDIMENT AND TISSUE PAHs	**Units**	**Lab**
1-Methylnaphthalene	ng/g (dry and wet wt.)	TPWD ECL
1-Methylphenanthrene	ng/g (dry and wet wt.)	TPWD ECL
2,3,5-Trimethylnaphthalene	ng/g (dry and wet wt.)	TPWD ECL
2,6-Dimethylnaphthalene	ng/g (dry and wet wt.)	TPWD ECL
2-Methylnaphthalene	ng/g (dry and wet wt.)	TPWD ECL
Acenaphthene	ng/g (dry and wet wt.)	TPWD ECL
Acenaphthylene	ng/g (dry and wet wt.)	TPWD ECL
Anthracene	ng/g (dry and wet wt.)	TPWD ECL
Benzo(a)anthracene	ng/g (dry and wet wt.)	TPWD ECL
Benzo(a)pyrene	ng/g (dry and wet wt.)	TPWD ECL
Benzo(b)fluoranthene	ng/g (dry and wet wt.)	TPWD ECL
Benzo(g,h,i)perylene	ng/g (dry and wet wt.)	TPWD ECL
Benzo(k)fluoranthene	ng/g (dry and wet wt.)	TPWD ECL
Biphenyl	ng/g (dry and wet wt.)	TPWD ECL
Chrysene	ng/g (dry and wet wt.)	TPWD ECL
Dibenz(a,h)anthracene	ng/g (dry and wet wt.)	TPWD ECL
Dibenzothiophene	ng/g (dry and wet wt.)	TPWD ECL
Fluoranthene	ng/g (dry and wet wt.)	TPWD ECL
Fluorene	ng/g (dry and wet wt.)	TPWD ECL
Indeno(1,2,3-cd)pyrene	ng/g (dry and wet wt.)	TPWD ECL
Naphthalene	ng/g (dry and wet wt.)	TPWD ECL
Phenanthrene	ng/g (dry and wet wt.)	TPWD ECL
Pyrene	ng/g (dry and wet wt.)	TPWD ECL
ORGANICS – SEDIMENT AND TISSUE PCB CONGENERS		
PCB Nos. 8, 18, 28, 44, 52, 66, 77, 101,105, 118, 126, 128, 138, 153, 170, 180, 187, 195, 206, 209	ng/g (dry and wet wt.)	TPWD ECL

Table 2.1. (continued).

ORGANICS – SEDIMENT AND TISSUE DDTs		
2,4'-DDD	ng/g (dry and wet wt.)	TPWD ECL
4,4'-DDD	ng/g (dry and wet wt.)	TPWD ECL
2,4'-DDE	ng/g (dry and wet wt.)	TPWD ECL
4,4'-DDE	ng/g (dry and wet wt.)	TPWD ECL
2,4'-DDT	ng/g (dry and wet wt.)	TPWD ECL
4,4'-DDT	ng/g (dry and wet wt.)	TPWD ECL
ORGANICS – SEDIMENT AND TISSUE CHLORINATED PESTICIDES		
Aldrin	ng/g (dry and wet wt.)	TPWD ECL
Alpha-Chlordane	ng/g (dry and wet wt.)	TPWD ECL
Dieldrin	ng/g (dry and wet wt.)	TPWD ECL
Endosulfan I	ng/g (dry and wet wt.)	TPWD ECL
Endosulfan sulfate	ng/g (dry and wet wt.)	TPWD ECL
Endrin	ng/g (dry and wet wt.)	TPWD ECL
Heptachlor	ng/g (dry and wet wt.)	TPWD ECL
Heptachlor epoxide	ng/g (dry and wet wt.)	TPWD ECL
Hexachlorobenzene	ng/g (dry and wet wt.)	TPWD ECL
Lindane (gamma-BHC)	ng/g (dry and wet wt.)	TPWD ECL
Mirex	ng/g (dry and wet wt.)	TPWD ECL
Toxaphene	ng/g (dry and wet wt.)	TPWD ECL
Trans-Nonachlor	ng/g (dry and wet wt.)	TPWD ECL
SEDIMENT TOXICITY		
Sediment Toxicity Amphipods; *Ampelisca abdita*, *Leptocheirus plumulosus*	% Survival	HESS
BENTHIC SPECIES COMPOSITION		
Sorting	Number of vials	CCS
Counting	Integer	CCS
Biomass	mg (dry wt.)	CCS
Taxonomy	Classification	CCS
FISH COMMUNITY COMPOSITION *		
Counting	Integer	TPWD CF
Taxonomy	Classification	TPWD CF
Gross Pathology	Various	TPWD CF

* RCAP is providing additional funding for the tissue analysis and will eventually receive the community data from this sampling activity; however, the CCS RCAP Field Team did not conduct the actual trawl sampling. This is an integral aspect of the NCA and the TPWD-Coastal Fisheries branch has conducted the sampling in Texas since August 2000. The information provided is for documentation purposes only since the CBBEP receives the data collected.

2.3 Sampling Methods

The RCAP 2000/2001 and 2002 annual reports (Nicolau and Nuñez 2004; Nicolau and Nuñez 2005) previously described sampling methods employed by CCS personnel during monitoring. These methods, along with any changes and/or additions, appear again in this annual report to document modifications associated with any revisions to the RCAP monitoring design. In general, RCAP follows methods consistent with the *USEPA National Coastal Assessment–Coastal 2001-2004 Quality Assurance Project Plan* and the *TCEQ Surface Water Quality Monitoring Procedures Manual (1999).*

Unique conditions differentiate EMAP Provinces or geographic regions (e.g., climate, depth, bottom type, tidal influence, biota, etc.), therefore, on occasions; it is necessary to modify standard EMAP field procedures to meet the needs particular to a region or sub region. Such modifications generally gain approval as long as the altered procedures meet the general guidelines of established protocol and adhere to the spirit of the Quality Assurance/Quality Control (QA/QC) established for EMAP so that the resultant data remain comparable to that collected by standard procedures.

During RCAP 2003, a 3 to 4-person CCS field crew conducted sampling from a shallow draft bay skiff. Utilizing this craft facilitated sampling in areas often encountered on a daily basis in which water depth typically averaged <1 meter, a common occurrence throughout the Coastal Bend. Field activities performed at each site required approximately 1 to 2 hours per site; therefore, a team sampled 4 to 6 sites in a normal day. Of course, this was subject to factors such as weather, seas, travel distance, and holding times for microbiological samples; with some microbiological samples actually passed to waiting shore personnel for direct transport to the lab, so that the field crews could continue sampling.

At each sampling site, CCS field crews uniformly collected a core set of data and samples according to defined methods and protocols. Core field data and samples included those specifically detailed in applicable QAPPs and listed previously in Table 2.1. CCS field crews had the option of gathering additional environmental information for other researchers or agencies, as long as those activities did not take precedence over core activities. Samples collected from the field arrived back at the CCS facilities the afternoon of sampling to be properly stored, or immediately shipped, to the appropriate laboratories for analysis. Applicable QAPPs list sample handling and storage guidelines.

Additional aspects outlined in the following sections reflect specific requirements for RCAP sampling parameters and/or provide additional clarification. Field crews adhered to these methods as closely as possible during the course of this program.

2.3.1. Field Sampling Procedures

RCAP procedures for field collection of environmental samples and data follow methods developed by the TCEQ SWQM program and EMAP-Estuaries over long-term experience with large-scale, regional monitoring projects (e.g., EPA National Coastal Assessment, EMAP-E Province Monitoring, the Mid-Atlantic Integrated Assessment, and the Western Pilot Coastal Monitoring).

Full documentation of RCAP procedures utilized exists in the following approved QAPPs, state, and federal documents:

1. *Quality Assurance Project Plan for the Coastal Bend Bays Project – Surface Water Quality Monitoring and Assessment, 2000.*
2. *Quality Assurance Project Plan for the Coastal Bend Bays Project – Surface Water Quality Monitoring and Assessment, Amendment 2 – Sediment Collection, 2000.*
3. *Quality Assurance Project Plan for the Coastal Bend Bays Project – Phase III, Surface Water and Sediment Quality Monitoring and Assessment, Upper Laguna Madre and Baffin Bay, 2001.*
4. *Quality Assurance Project Plan for the Coastal Bend Bays & Estuaries Program, Regional Coastal Assessment Program (RCAP), 2002.*
5. *Quality Assurance Project Plan for the Coastal Bend Bays & Estuaries Program, Regional Coastal Assessment Program (RCAP), 2003.*
6. *TCEQ Surface Water Quality Monitoring Procedures Manual. 1999.*
7. *USEPA National Coastal Assessment-Coastal 2001-2004 Quality Assurance Project Plan – 2001.*

2.3.2. Site Location

EPA provided CCS field crews with randomly selected RCAP sampling locations as coordinates of latitude/longitude in degrees-minutes, expressed to the nearest 0.01 minute (i.e., 00° 00.00'). CCS crews used GPS to locate the site. The acceptable tolerance goal was that the sampling site be within 0.02 nautical miles (nm), or ±120-ft, of the given coordinates. This reflects the accuracy expected from a properly functioning GPS unit of the caliber used for the study. Verification of GPS's performance occurred on a daily basis.

CCS field crews strictly adhered to site positioning guidelines, unless substantiated reasons prevented sampling within that defined area. Because EMAPs probabilistic sampling design is unbiased, potentially, some of the generated sites fell in locations not always conducive to sampling (e.g., shallow conditions, inaccessible due to oyster reefs, shallow conditions over protected seagrass beds, etc.). Prior planning by CCS personnel helped resolve potential problems before the actual sampling day, with substitute sites selected from a list of alternative randomly generated sampling sites.

To ascertain spatial distribution of sites required plotting coordinates of random locations on NOAA nautical charts, or other acceptable charts, to reconnoiter on paper obvious problem situations (e.g., water depth, hazards to navigation, etc.). If suspect sites appeared in this exercise, CCS field crews conducted a field reconnaissance to determine actual site conditions. If an intended site location presented an obvious problem, then depending on the situation, the CCS Project Manager, in consultation with the EPA, elected to relocate the site within an acceptable range of the original location. The CCS Project Manager and EPA made decisions on this level (i.e., significant changes to the sampling design), not the CCS field crews.

Field teams, however, had a limited degree of onsite flexibility to relocate sampling sites when confronted with unexpected obstacles or impediments associated with locating within the ±0.02 nm guideline (e.g., shallow conditions, danger, or risk, to crew from ship traffic, man-made obstructions, etc.). CCS field crews then moved the site to the nearest location from the intended site amenable to conduct sampling; making every effort to relocate to an area that appeared similar in character to that of the intended site.

When necessary to relocate the site >0.02 nm the reason for the shift became part of the documented field record. Document records for any site relocation, >0.05 nm (300 ft), required review before data collected from the site would be acceptable for inclusion in the study database. At times, crews might have trouble in obtaining a "good grab" when collecting sediment due to the nature of the bottom at the established site. In these situations, even after collecting the water quality samples and data, it was permissible to move around within a 120-ft radius to locate more favorable sediment conditions without having to resample the water quality indicators.

2.3.3. Water Column Measurements

The first activities conducted upon arriving onsite involved water sampling and water column measurements; as these data and samples strictly required collection before disturbing bottom sediments. If upon arrival at the site, CCS field crews ascertained that sediments had been disturbed (e.g. shallow depth or other disturbance creating turbid conditions) then field crews allowed adequate time so that the disturbance dissipated before sample collection began.

Instantaneous water column profiles and visual assessments performed at each site by CCS field crews measured basic water quality parameters (Table 2.1) and ambient conditions utilizing hand-held multiparameter water quality probes (e.g., YSI Sondes). Water column profiling followed EPA protocols. Instantaneous near-surface measurements occurred 0.5 m below the surface (near-surface) and bottom condition measurements took place at 0.5 m off the bottom (near-bottom). To obtain undisturbed near-bottom readings required ascertaining bottom depth, pulling up the probe approximately 0.5 m, and then allowing 2-3 minutes for disturbed conditions to settle before taking the near-bottom measurements.

At least one measurement of light attenuation (Photosynthetically Active Radiation or PAR) occurred, with secchi depth also measured at each site. Measurements of light penetration, taken by hand-held light meters, occurred at discrete depth intervals in a manner similar to that for profiling water quality parameters. The underwater sensors are hand lowered slowly with the deck reading and underwater readings recorded at each discrete interval. If light measurements become negative before reaching bottom, the measurement terminates at that depth. Secchi depth determination used a standard 20-cm diameter black and white secchi disc lowered to the depth at which it no longer discernable; and then slowly retrieved until it just reappears; depth is marked and recorded as secchi depth (rounded to nearest 0.1 m).

2.3.4. Routine Conventional Water Chemistry

Due to different methods used by EPA (samples field filtered from 3 depths) and TCEQ (typically one whole water unfiltered sample collected at near-surface but for RCAP 2003 water collection occurred at the same depths as EPA samples) in the NCA and SWQM programs, respectively, required CCS field crews to collect two individual sets of samples where methods differed. This ensured that data collected would be comparable to historical TCEQ near-surface data used in the assessment of Texas coastal waters and to data from TPWD/EPA-NCA Texas sites and other states.

CCS field crews collected water samples for the determination of dissolved and total nutrients (see Table 2.1), chlorophyll *a*, and total suspended solids by using a Van Doren sampler. Depending on depth at the sampling site, water sample collection followed EPA-NCA protocols as follows:

Shallow sites (<2 m) - sample at 0.5 m (near-surface) and 0.5 m off-bottom;[1]

Standard site (>2 m) - sample at 0.5 m (near-surface), mid-depth, and 0.5 m off-bottom;[1]

[1]Unless the depth is so shallow that near-surface and near-bottom overlap; then sample mid-depth, only.

For EPA-NCA samples, an approximate 3 L sub-sample was drawn into a clean, wide-mouth Nalgene container from each applicable water depth at the site. This provided enough water for the remainder of the sample processing which essentially was filtration; with the filtrate becoming the dissolved nutrient sample and the filters retained for chlorophyll *a* analysis. Total Suspended Solids (TSS) and total nutrient samples required unfiltered water collection. TCEQ sample collection took place in the same manner except that nutrient samples (except orthophosphate) were not field filtered.

2.3.4.1. Chlorophyll *a*

At each site, a new sampling pack consisting of a disposable, graduated 60 ml polypropylene syringe, fitted with a polypropylene filtering assembly, filtered the site water from applicable water depths, through a 25 mm GF/F filter. If conditions allowed (low suspended solids load) then field crews filtered 100 ml of site water for each chlorophyll sample. If another filter was required then field crews carefully detached the filter assembly, replaced the filter, and continued with the filtration until the desired volume was processed. Field crews used tweezers to carefully remove the filter from its holder and fold once upon the pigment side, and then placed it onto a pre-labeled aluminum sheet, wrapped and folded the sheet, and then placed the contents into a pre-labeled, disposable whirl-pak bag. CCS field crews recorded the volume of water filtered on all sample containers, and the field form, and then placed the whirl-pak bag into a small instant-freeze chamber (small ice chest with several pounds of dry ice). Samples remained frozen until time of analysis.

2.3.4.2. Dissolved and Total Nutrients

For dissolved nutrients, CCS field crews collected approximately 30 ml of filtrate from the above chlorophyll filtration into a pre-labeled, clean 30 ml Nalgene screw-capped bottle, which was also stored in the dry ice freezing chamber. Before placing sample in the freezer, they recorded the approximate salinity (±2 ppt) on the container, a convenience for the analyst who performs the nutrient analysis. Depending on the analytical instrumentation used, matrix matching of solutions (e.g., standards or wash solutions) was necessary for certain analytes.

The nutrient samples remained frozen until time on analysis. For TCEQ total nutrient samples, crews collected 30 ml of unfiltered seawater from each applicable depth. The samples were held on wet ice in the field and stored at 4ºC to await laboratory determinations.

2.3.4.3. Total Suspended Solids (TSS)

After chlorophyll and nutrient sample collection, CCS field crews vigorously shook the remaining water in one 3 L sub-sample to re-suspend the particles and collected 1 L into a pre-labeled Nalgene container. The samples were held on wet ice in the field and stored at 4ºC to await laboratory determinations.

2.3.5. Trace Metals in Water

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.

The usual approach was to attach the Teflon inlet tubing to a particle-free 15-foot PVC pole using metal-free cable ties. PVC pole placement into the water body required the inlet tubing be upstream of the sampling vessel. Dissolved metal samples required filtering the sample through a twice pre-cleaned (first at the manufacturer and second at Albion Environmental) Gelman 0.45μm large capacity capsule filter; with a new filter used for each dissolved sample taken at a site. Total metals samples followed the same procedures but without the use of the filter. To verify that no contamination occurred during sampling required taking a Field Blank sample at the beginning and end of each sampling day. Field Duplicate samples verified laboratory analysis and occurred once for each 10 samples collected.

Please note that the above description is a simplified version of the sampling process. The proper way to perform trace metals sampling in estuarine waters, which eliminates field contamination and obtains the best sample possible, is complex and beyond the scope of this section. Please see Nicolau and Nuñez 2004 for more details concerning the trace metals in water sampling portion of the RCAP. In addition, considerably more detailed documentation exists in EPA Method 1669 *Sampling ambient water for trace metals at EPA water quality criteria levels* 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 Surficial Sediment

At each site, CCS field crews utilized a modified 0.04 m^2 Van Veen sampler to obtain multiple grabs; collecting the surficial sediment layer (top 2-3 cm) by spatula or scoop. The sample was then composited to provide sediment for the analyses of trace metal and organic contaminants, total organic carbon (TOC), and sediment grain size. The number of grabs required to yield an adequate volume of composited sediment depended on the surface area obtained by the particular grab; however, surficial sediment from a minimum of eight grabs usually yielded enough quality material for the final sample. Sediment sampling followed established TCEQ and EPA protocols (TCEQ 1999; EPA 2001)

CCS field crews combined the surficial sediment from the individual grabs in a clean, high-grade stainless steel or Teflon vessel. To protect the sample from contamination between grabs, CCS field crews covered the sample bucket with a lid and placed the sample on ice. Stirring action blended in each addition of sediment to the composite, with the final mixture stirred consistently to ensure a homogenous sample before taking required sub-samples.

2.3.6.1. Organic chemical contaminants

The collection of composited sediment for organic contaminants analysis required placing approximately 500 cc into a clean, pre-labeled, glass wide-mouth, I-Chem jar with jars filled to approximately 75% of capacity to allow for expansion during freezing. The sample was held on wet ice aboard and upon transfer to shore storage was frozen, unless it was scheduled for extraction within 7 days; in that case, the sample was held at 4ºC to await processing.

2.3.6.2. Inorganic chemical contaminants

The collection of composited sediment for inorganic contaminants analysis required placing approximately 125 cc into a clean, pre-labeled, wide-mouth Nalgene bottle with bottles filled to approximately 75% of capacity to allow for expansion during freezing. The sample was held on wet ice while aboard and upon transfer to shore storage was frozen, unless it was scheduled for digestion within 7 days; in that case, the sample was held at 4ºC to await processing.

2.3.6.3. Total Organic Carbon (TOC)

The collection of composited sediment for TOC analysis required placing approximately 250 cc of composited sediment into a small, clean, pre-labeled amber glass jar with jars filled to approximately 75% of capacity to allow for expansion during freezing. The sample was held on wet ice aboard and upon transfer to shore storage was frozen, unless it was scheduled for extraction within 7 days; in that case, the sample was held at 4ºC to await processing.

2.3.6.4. Sediment Grain Size

The collection of composited sediment for Sediment Grain Size analysis required placing approximately 500 cc of composited sediment into a clean, pre-labeled, wide-mouth polypropylene jar. The sample was held on wet ice aboard and upon transfer to shore storage, the sample was held at 4ºC to await laboratory processing.

2.3.6.5. Toxicity testing

The collection of composited sediment for toxicity analysis required placing approximately 4000 cc into a clean, pre-labeled, wide- mouth Nalgene jar. The sample was held on wet ice aboard and upon transfer to shore storage was held at 4ºC to await further processing and initiation of testing within 30 days of collection.

2.3.7. Benthic Infaunal Community

Biological sampling procedures and methods had prior approval by TCEQ and EPA. CCS field crews sampling benthic biota in this region have historically utilized these methods to provide characterizations and quantify benthic habitat. Sampling protocols and CCS benthic laboratory Quality Assurance/Quality Control procedures are adapted from the Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses (1995) and are maintained and available upon request from the CCS Project Manager.

The method employed by CCS field crews for benthic macroinvertebrate infauna sampling involved using a PVC cylindrical (10.16 cm diameter) push corer to sample benthic infauna to a depth of 10 cm in the sediment. Multiple extensions extended the corer to reach bottom sediments in deeper waters. A minimum of five (5) replicate samples (81.1 cm^2) taken at each site yielded a total area of 405.4 cm^2. Each sample was then placed in a 0.5 mm mesh biobag and field washed by gently homogenizing the sample by hand. Following this procedure, sediment sample storage on ice occurred to preserve samples for transport to CCS facilities before sample placement in a 10% formalin and seawater mixture. All benthic samples required a minimum of one (1) week for fixation. Sample transfer to 45% isopropyl alcohol took place approximately seven days later. Laboratory analysis consisted of washing samples through nested sieves (minimum mesh size = 0.5 mm), with organisms sorted, counted, and identified to the lowest possible taxon. Biomass determination required drying all specimens, for a minimum of two days, at 90°C in a standard drying oven before weighing to the nearest 0.0001 g.

2.3.8. Habitat Evaluation

Several observations took place in the field to document certain attributes or conditions of the site to help characterize overall ecological site health. Observations made by CCS field crews included the occurrence of submerged aquatic vegetation (SAV), the occurrence of macro algae beds/mats, the presence of marine debris (litter), and if there was obvious evidence of disruptive anthropogenic activities (e.g., dredging or prop scouring or scarring), these observations, and a brief description, became part of the permanent field record.

2.3.9. Fish Trawls

Fish trawls are an integral aspect of EMAP-NCA and TPWD-Coastal Fisheries (TPWD-CF) branch has conducted the sampling in Texas since August 2000. While CCS will not be doing this sampling, the data will eventually become a part of the RCAP data record. The information provided below is for documentation purposes.

Using standard agency protocols, TPWD-Coastal Fisheries conducts fish trawls, where possible, at each site to collect fish and shellfish for community structure and abundance estimates; target species for contaminant analyses, and specimens for histopathological examination. Additional trawls supplemented the sample, if needed, to obtain enough target species for contaminant analyses. Trawling should be the last field activity that the crew performs while onsite because of their disturbance to conditions at the site.

2.3.9.1. Community Structure

TPWD-CF personnel sorted and identified to the lowest taxonomic level possible all fish and invertebrates from a successful trawl (fulltime on bottom with no hangs or other interruptions). The first nineteen individuals per species required measuring to the nearest centimeter (fork length when tail forked, otherwise overall length - snout to tip of caudal). TPWD-CF personnel recorded lengths on a field form, made a total count for each species, and returned fish to the estuary if not retained for histopathology or chemistry.

2.3.9.2. Gross Pathology

All fish were field screened for external gross pathologies while being measured and counted for the community structure evaluation. A brief examination of each fish documented any obvious external conditions such as lesions, lumps, tumors, and fin erosion. In addition, an examination of the gills took place for discoloration or erosion. Any fish exhibiting a pathological condition required saving for further laboratory histopathological evaluation. Field personnel on the Fish Data form recorded a generic description of the observed condition, and then tagged the specimen before immediately preserving in Dietrich's solution to await shipment to the laboratory.

Each fish preserved had its body cavity opened to expose internal tissues to the fixative. Stainless steel surgical scissors were used to open the body starting at the anal pore and cutting anteriorly through the body wall, taking care not to cause undue damage to the internal organs; the cut continued through the thoracic region and over to the gill slits. The body cavity was then be spread apart (popped open) by hand to further ensure the fixative flooded the internal organs. An appropriate container (e.g., a 1-2 gallon plastic bucket), with enough Dietrich's solution to completely cover the specimen, served as storage for each tagged fish, with multiple samples held in a common container provided fish were appropriately tagged.

2.3.9.3. Tissue Contaminant Analyses

Several species designated as target samples for analyses of chemical contaminants in whole-body tissue were: Spot (*Leiostomus xanthurus*), Atlantic Croaker (*Micropogonias undulatus*), Catfish (*Arius felis*, *Bagre marinus*, *Ictalurus punctatus*, *Ictalurus furcatus*), Brown Shrimp (*Farfantepenaeus aztecus*), White Shrimp (*Litopenaeus setiferus*), and Pink Shrimp (*Farfantepenaeus duorarum*). In the Laguna Madre, the following species were acceptable surrogates: Pinfish (*Lagodon rhomboides*), Pigfish (*Orthopristis chrysoptera*), and Toadfish (*Opsanus beta*). Five to ten individuals (minimum total wet weight of 300 g) of a species comprised a composited sample at sites where target species collection was sufficient. After measurement and recording on the sampling form as chemistry fish, TPWD-CF personnel rinsed the fish with site water and individually wrapped the fish with heavy-duty aluminum foil before placing samples together in a plastic, Ziploc bag, labeled with Site ID and a Species ID Code (e.g., the first four letters of both the genus and species). Sample placement on wet ice in the field maintained samples until the samples were transferred to shore and frozen to await laboratory analysis.

2.3.10. Microbiological

To collect additional tidal water data for evaluation of the IDEXX (chromogenic substrate, or enzyme specific) method used by TCEQ for microbiological analysis required collection of two near-surface water samples from each site. Collection involved directly immersing the inverted polypropylene screw cap, 125 ml sterile plastic bottles beneath the water surface to the appropriate depth, quickly turning the bottle upright, and filling the container at that depth. The samples were held on wet ice in the field at 4ºC. Depending on holding times (six hours), sample delivery involved passing the samples to waiting shore personnel for direct transport to the lab, or involved delivery by the field crews within the appropriate holding times for applicable analysis.

2.4 Analytical Laboratories and Methods

Analytical procedures for RCAP ranged from straightforward determinations such as percent gravel/silt/sand/clay to comprehensive analyses of trace metal and organic contaminants in complex environmental matrices. Laboratory Directors/Scientists/Managers were responsible for overseeing laboratory sample analyses, and data processing duties related to the parameters as defined in, and according to guidelines included in, the QAPPs.

Analyses were in accordance with the most recently published edition of *Standard Methods for the Examination of Water and Wastewater*, the TCEQ *Surface Water Quality Monitoring Procedures Manual 1999*, alternate TCEQ approved methods, or EPA approved methods. Many procedures for various analyses derive from those developed for the EMAP-Estuaries Program, which documents specific analytical processes details (USEPA 1995). Additional information is contained in Section B4 of the National Coastal Assessment Program QAPP (USEPA 2001). Trace metals in water analysis utilized the EPA 1600 series of new clean chemistry methods. These methods include guidance for both the collection (EPA 1669) and analysis (e.g. EPA 1631, 1632, 1638, 1640) of water samples to determine priority pollutant metal levels in the sub part per billion range. Method 1669 describes procedures for collection and filtration of ambient water and wastewater samples, without contamination.

The Laboratory Director/Manager/Scientist of all contract laboratories and the CCS Project Manager retain copies of all documentation, raw data, and calibration data that are applicable. The CCS Project Manager retains custody of all project records for perpetuity except laboratory calibration and equipment maintenance records, which will remain with the laboratories. Copies of laboratory SOPs are available for review by CBBEP, TCEQ, and EPA. All laboratory SOPs were consistent with EPA requirements as specified in the method.

2.5 Quality Assurance

RCAP monitoring took place under an approved Quality Assurance Project Plan (QAPP). The purpose of the QAPP, which includes sample sites and a sampling plan, is to provide a clear delineation of the CCS Quality Assurance (QA) policy, management structure, and policies used to implement the extensive QA requirements necessary to document reliability, quality, precision, accuracy, completeness, and validity of the data. All participants used Standard Operating Procedures and maintained QA records. QA documentation accompanied all data report submissions. The Laboratory Manager of all contract laboratories and the CCS Project Manager retain copies of all documentation, raw data, and calibration data that is applicable.

QAPP review by the CBBEP, TCEQ, and EPA ensured that data generated for the purposes described above are scientifically valid and legally defensible. A process insured that data collected, analyzed, and submitted to the statewide database guaranteed reliability and therefore use of the data in possible TMDL development, permit decisions, water quality assessments, and other programs deemed appropriate. The individual QAPPs for the all RCAP events are available from CCS upon request.

2.6 Data Analyses

Data analysis utilized various standard parametric and non-parametric tests dependent on meeting test assumptions of the particular analysis required. Additional data evaluation utilized in this report derives from comparisons or evaluations to applicable TCEQ water and sediment quality criteria obtained the Texas Surface Water Quality Standards (TSWQS) adopted by the TCEQ on July 26, 2000. The TSWQS provide a quantitative basis for evaluating use support by identifing *Primary Concerns*, or if no criteria exist, then to TCEQ SWQM based screening levels that identify *Secondary Concerns* (e.g. Tidal Water Chronic criteria for Toxic Substance in Water vs. Nutrients and Chlorophyll *a* Screening Levels). Further comparison and evaluation of RCAP 2003 data used EPA National Coastal Condition Report II (NCCR II) guidelines (USEPA 2004). Use of this evaluation technique was to provide continuity between locally collected data and the ongoing NCA program for assessing coastal waters and to see if the broad based EPA regional approach is applicable in all estuarine systems. More details concerning these approaches, and the particular methods utilized, are available within the individual chapters of this document.

2.7 References

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3.0 WATER MONITORING

3.1 Introduction

As significant components of coastal watersheds, estuaries are vital natural and economic resources. In fact, our local bays and estuaries either directly, or indirectly, relate in some way to almost 70% of the Coastal Bend economy and coastal communities such as ours depend on having pristine estuarine conditions (CBBEP 2005). As extremely productive systems, estuaries are highly vulnerable to human impacts (Mann 2000). With more than 50% of the nation's population residing along coastal margins, population increases place demands on our natural resources; often producing deleterious effects on an estuary that directly affect the livelihood of people living and working in coastal areas (USEPA 2004).

While many factors, such as reduced freshwater inflow, habitat modification/destruction, and climate change, can affect estuarine system health, the fundamental health of an estuarine system depends on the type and quantity of pollutants, such as heavy metals, excessive nutrients, and disease causing microorganisms, or pathogens, (viruses, bacteria, and parasites) that may enter the water column. The process of eutrophication, caused by the addition of excessive nutrients into an estuarine system, may result in accelerated production of organic matter and produce undesirable effects (Rabalais 1992; Bricker et al. 1999; CENR 2003). While elevated concentrations of priority pollutants in the water column, sediments, and tissues of aquatic animals may affect diverse groups of species, either through direct exposure or indirectly through the food chain, and eventually be harmful to humans.

The ability to predict definitive water quality trends for all estuaries remains hampered by scarce trend data and large gaps in data and information (Bricker et al. 1999). However, local programs (RCAP), state programs (TCEQ-SWQM), and national programs (EMAP-NCA), are attempting to address the national goal of improving and protecting water quality through comprehensive monitoring, interpretation, modeling, and research. The mission of protecting coastal regions is too daunting a task for one entity alone. Only through cooperative partnerships will we achieve maximum effectiveness in creating an adaptive management framework that aids in protecting our watershed and estuarine systems (Bricker et al. 1999; CENR 2003). Therefore, sampling and analysis of water quality parameters remains a primary focus of the RCAP program in assessing status and trends within the CBBEP area.

3.2 Sampling Design and Data Evaluation

Water quality sampling for RCAP 2003 took place from July 23rd through August 20th 2003 at 32 randomly selected sites throughout the CBBEP region as described in Chapter 2.0. Table 6.1.1 in the *Data Tables* chapter and Fig. 2.2 provide site information and location. Table 2.1 provides a complete list of parameters measured during RCAP 2003 sampling.

In addition to EMAP-NCA parameters sampled, the CBBEP decided to incorporate trace metals in water sampling back into RCAP as an update to data collected during RCAP 2000 and RCAP 2001. This one-time event collected a reduced set of parameters; eight out of the original 11 metals as aluminum, chromium, and silver were all non-detects in the first RCAP events. Monitoring occurred within each Segment, but at a reduced number of sites (19 of 32); to build upon the numerous RCAP data previously collected utilizing the improved sampling and analytical techniques.

The *Data Tables* in Chapter 6.0 provide individual concentration values for near-surface and near-bottom Field Parameters measured (Table 6.2.1 and 6.2.2), with summary statistics by TCEQ segments (Table 6.3.1 through 6.3.8). In the case of near-bottom measurements the total number of sites with data collected was 24, as water depth at 8 of the sites was too shallow (e.g. near-surface and near-bottom depths are equal) to obtain multiple measurements.

For Routine Conventional Water Chemistry, the *Data Tables* in Chapter 6.0 present individual parameter concentrations (Tables 6.4.1 through 6.4.7) according to each sampling method, with summary statistics by TCEQ segments (Table 6.5.1 through 6.5.12). Individual microbiological concentrations are in Table 6.6.1. Trace metal in water concentrations are in Table 6.7.1. While information exists for multiple parameters at additional depths, presently TCEQ and EPA only use near-surface data for assessment. Additional data provided in the *Data Tables* serves only as a reference.

If a criterion, screening level, or concentration range existed, then data evaluation followed two different approaches; 1) the TCEQ regulatory approach and 2) according to guidelines utilized in the EPA NCCR II (USEPA 2004). Where no criteria or screening level exists, data presentation considers how the parameter compares between segments or applies to water quality within the CBBEP region in general.

3.2.1. 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, or 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 official designated use. Similar exceedances of numerical screening levels identify segments with no concerns or concerns for impairment. As defined in the *Texas Surface Water Quality Standards* (TSWQS) the identification of *Primary Concerns*" relates directly to criteria adopted in the TSWQS that protect the designated use of a water body. *Secondary Concerns* are parameters for which there are no existing standards adopted but that have elevated concentrations exceeding screening levels.

Results of the assessment appear in the *Texas Water Quality Inventory and 303(d) List*, as required by Sections 305(*b*) and 303(*d*) of the federal Clean Water Act on a periodic basis. Section 305(*b*) requires states to report the extent to which water bodies attain designated water quality standards while Section 303(*d*) of the act requires states to identify water bodies for which constituent loadings are not stringent enough to attain water quality standards. Therefore, the 303(*d*) list contains Segments with *Primary Concerns* and while water bodies with *Secondary Concerns* appear on the 305(*b*) report, they are not included on the 303(*d*) list. Typically, areas exhibiting *Secondary Concerns* will receive more frequent and possible additional parameter monitoring (TCEQ 2003).

To establish whether *Primary Concerns* exist, and if a segment supports the Aquatic Life Use, TCEQ assesses dissolved oxygen (DO) and toxic substances in water criteria, among others. Contact Recreation Use assessment utilizes the Enterococci criterion as an indicator of concern and support for bacterial pathogens in Tidal Waters. TCEQ uses methodologies for assessing *Secondary Concerns* for nutrients and chlorophyll *a* in water, as no water quality criteria exists on a national or state level. However, EPA, state regulatory agencies, and a multitude of researchers are working to address this situation to better protect and restore the waters of the country. Individual criteria and screening levels for the various parameters sampled for RCAP 2003 appear in the following applicable sections.

At the time of RCAP 2003 sampling, the following segments within the CBBEP area appeared on the 2002 303(d) list for *Primary Concerns*:

Bacteria in Oyster Waters
Segment 2462 – San Antonio Bay/Hynes Bay/Guadalupe Bay
Segment 2472 – Copano Bay/Port Bay/Mission Bay

Bacteria (Contact Recreation)
Segment 2485A – Oso Creek (unclassified water body)

Depressed Dissolved Oxygen Levels
Segment 2483A – Conn Brown Harbor (unclassified water body)
Segment 2485 – Oso Bay
Segment 2491 – Laguna Madre

Zinc in Oyster Tissue
Segment 2482 – Nueces Bay

At the time of RCAP 2003 sampling, the following segments within the CBBEP area appeared on the 2002 305(b) list for S*econdary Concerns*:

Ammonia
Segment 2484 – Corpus Christi Inner Harbor

Nitrate + Nitrite Nitrogen
Segment 2462 – San Antonio Bay/Hynes Bay/Guadalupe Bay
Segment 2484 – Corpus Christi Inner Harbor
Segment 2485A – Oso Creek (unclassified water body)

Orthophosphorus
Segment 2462 – San Antonio Bay/Hynes Bay/Guadalupe Bay
Segment 2485A – Oso Creek (unclassified water body)

Total Phosphorus
Segment 2462 – San Antonio Bay/Hynes Bay/Guadalupe Bay
Segment 2472 – Copano Bay/Port Bay/Mission Bay
Segment 2485A – Oso Creek (unclassified water body)

Excessive Algal Growth (Chlorophyll *a*)
Segment 2485 – Oso Bay
Segment 2491 – Laguna Madre (near mouth of Baffin Bay)
Segment 2492 – Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Upper Baffin)

3.2.2. EPA NCCR II Guidelines

RCAP 2003 data evaluation used a subset of the EPA NCCR II guidelines for assessing water quality at individual sites (Table 3.1). Use of this evaluation approach continues to provide continuity between locally collected data and the ongoing NCA program for assessing coastal waters and to see if the broad based EPA regional approach is applicable in all estuarine systems. As in RCAP 2002, evaluation of RCAP 2003 sites utilized four of the five parameters comprising the overall EPA Water Quality Index (DO, DIN, DIP, Chlorophyll *a*), as questions of applicability of the fifth parameter, the Water Clarity criteria, still exist for this region.

Table 3.1. EPA NCA guidelines for assessing Dissolved Oxygen, Dissolved Inorganic Nitrogen, Dissolved Inorganic Phosphorus, Chlorophyll *a*, and the modified Water Quality Index by site (USEPA 2004).

Rating		**Dissolved Oxygen (DO)**
Good	(green)	DO concentration >5.0 mg/L.
Fair	(yellow)	DO concentration between 2.0 mg/L and 5.0 mg/L.
Poor	(red)	DO concentration <2.0 mg/L.
Rating		**Dissolved Inorganic Nitrogen (DIN)**
Good	(green)	DIN concentration <0.1 mg/L.
Fair	(yellow)	DIN concentration between 0.1 mg/L and 0.5 mg/L.
Poor	(red)	DIN concentration >0.5 mg/L.
Rating		**Dissolved Inorganic Phosphorus (DIP)**
Good	(green)	DIP concentration <0.01 mg/L.
Fair	(yellow)	DIP concentration between 0.01 mg/L and 0.05 mg/L.
Poor	(red)	DIP concentration >0.05 mg/L.
Rating		**Chlorophyll *a***
Good	(green)	Chlorophyll *a* concentration <5.0 µg/L.
Fair	(yellow)	Chlorophyll *a* concentration between 5.0 µg/L and 20 µg/L.
Poor	(red)	Chlorophyll *a* concentration >20.0 µg/L.
Rating		**Water Quality Index (WQI)**
Good	(green)	A maximum of one indicator is rated fair, and no indicators are poor.
Fair	(yellow)	One of the indicators is rated poor, or two or more indicators are rated fair.
Poor	(red)	Two or more of the four indicators are rated poor.

3.3 Results and Discussion

3.3.1. Field Data

A complete list of instantaneous core field parameters, along with summary statistics, appears in Chapter 6-*Data Tables* 6.2.1 and 6.2.2 and 6.3.1 through 6.3.8, respectively. For many parameters no established state or federal criteria exists. However, data collected serves as initial descriptors of a water body, or segment, and aid as indicators when making determinations of whether unusual or stressful conditions exist. As standard protocol in most monitoring programs, collection of multi-year datasets may allow for future status and trends analysis and be useful in ascertaining changing conditions within the CBBEP region.

3.3.1.1. Precipitation and Gauged Inflows

Precipitation recorded at Corpus Christi International Airport (CRP) totaled 32.92 cm/yr from January 1st through August 31st 2003; representing an increase of 7.22 cm/yr for the same period preceding RCAP 2002 sampling (NOAA 2002; NOAA 2003). As opposed to RCAP 2002, when a slow moving tropical wave produced enough rainfall in the upper Nueces River watershed to pass-through approximately 1,000,000 ac-ft of water from Lake Corpus Christi to the Nueces River, substantial declines in inflows preceded RCAP 2003 sampling, with only 80,000 ac-ft of recorded pass-throughs recorded at the Calallen USGS Gauge No. 08211500 (Fig. 3.1). While still a considered a substantial amount of inflow for this region, it did not have the same effect of dramatically lowering salinity concentrations as seen in RCAP 2002 (Nicolau and Nuñez 2005).

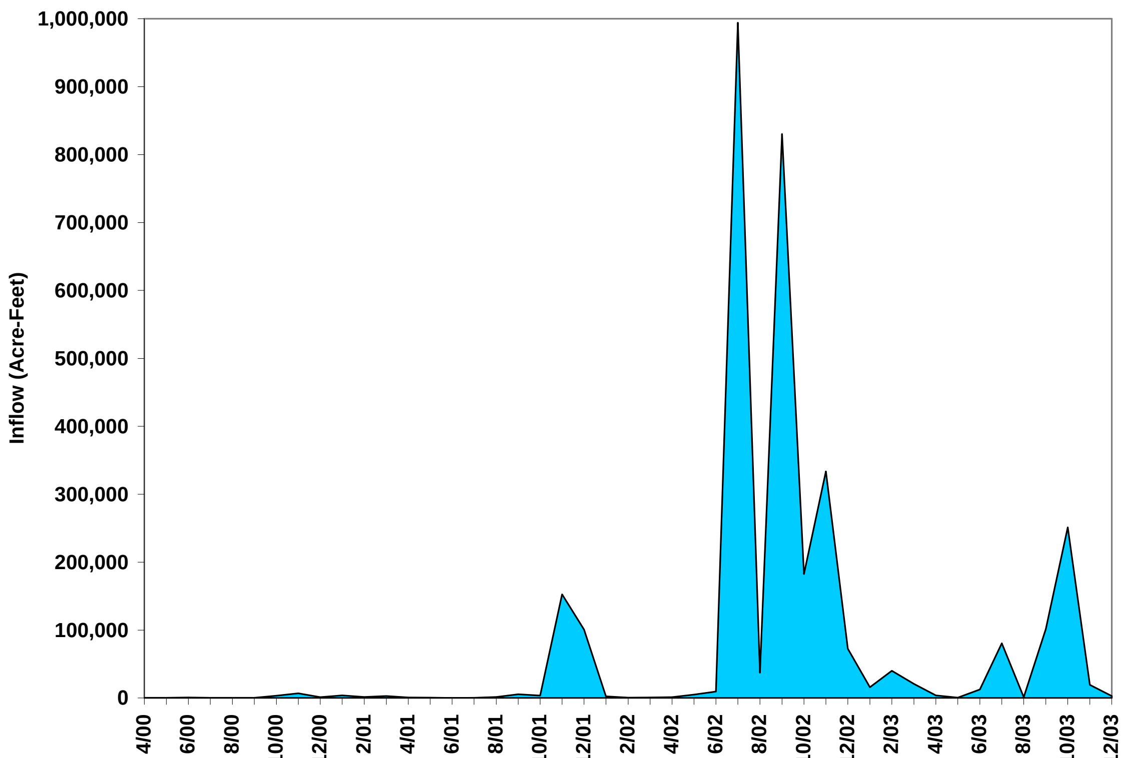

Fig. 3.1. Total monthly inflow (acre-feet) on the Nueces River recorded at the Saltwater Diversion Dam in Calallen, Texas from April 2000 through December 2003 (USGS Gauge No. 08211500).

3.3.1.2. Total Depth

For all 32 RCAP 2003 sampling sites Total Depth ranged from 0.80 m in the Upper Laguna Madre (Segment 2491) to 4.55 m in Corpus Christi Bay (Segment 2481) (Table 6.2.1). Mean Total Depth was greatest in Corpus Christi Bay at 3.66 m and shallowest in Oso Bay (Segment 2485) at 0.90 m (Table 6.2.8). Mean Total Depth in all other Segments ranged from 0.97 m to 2.33 m. Water depths were representative of all water bodies sampled. However, mean Total Depth of sites sampled in the Upper Laguna Madre tended to be 0.50 m greater than those sampled for RCAP 2002.

3.3.1.3. Water Temperature

Water temperature ranged from 28.44°C to 31.77°C (Tables 6.2.1 and 6.2.2) at sites sampled during the summer index period. Comparison of all sites ($n = 24$) where multiple-depth sampling occurred showed no statistically significant differences ($p = 0.70$) between near-surface and near-bottom water temperatures. Within Segments, mean near-surface water temperature ranged from 29.12°C in the Baffin Bay Complex (Segment 2492) to 31.77°C in Oso Bay (Segment 2485), respectively (Table 6.3.7). At sites where multiple depth sampling occurred mean near-bottom water temperature ranged from 29.12°C in the Baffin Bay Complex to 30.51°C in the Copano/Port/Mission Bay complex (Segment 2472) (Table 6.3.7). Mean difference between near-surface and near-bottom measurements was <0.14°C during RCAP 2003. Recorded temperatures were typical of summer months in this area and were below the established TCEQ standard of 35.0°C and consistent with temperatures recorded in past RCAP events (Nicolau and Nuñez 2004; Nicolau and Nuñez 2005).

3.3.1.4. pH

pH values for RCAP 2003 fell within the bounds of established TCEQ standard (6.5 - 9.5); ranging from 7.75 at Site 318 in the Baffin Bay Complex (Segment 2492) to a high of 8.54 at Site 295 located in Hynes Bay (Segment 2462) (Tables 6.2.1 and 6.2.2). No significant statistical differences ($p = 0.57$) existed between near-surface and near-bottom pH at sites ($n = 24$) where multiple-depth sampling occurred. Mean near-surface pH concentrations ranged from 7.94 in the Baffin Bay Complex to 8.54 in Hynes Bay (Table 6.3.5). At sites where multiple depth sampling occurred mean near-bottom pH ranged from 7.93 in the Baffin Bay Complex to 8.15 in the Upper Laguna Madre (Segment 2491) (Table 6.3.5). The mean difference between near-surface and near-bottom pH was <0.06, with many segments exhibiting no mean difference between depths. Mean near-surface pH values tended to be slightly lower than values recorded for RCAP 2002 sites and all but one value fell in the range (7.5 to 8.5) typical of estuarine waters.

3.3.1.5. Secchi Depth

While highly subjective, Secchi depth data provides a visual method to ascertain some relative measure of water clarity. Bay systems, or water body segments, within the CBBEP region are typically turbid and Secchi Depth measurements for RCAP 2003 tended to validate readings recorded from earlier RCAP sampling events. Secchi Depth ranged from 0.15 m in the Baffin Bay Complex (Segment 2492) to 1.2 m in Aransas Bay (Segment 2471) (Table 6.2.1). Mean Secchi Depth for all segments averaged <1.00 m with Oso Bay (Segment 2485) Mesquite Bay (Segment 2462), and the Baffin Bay Complex once again being the most turbid. Mean Secchi Depth readings were <1.00 m (Table 6.3.8) for all segments sampled.

3.3.1.6. Turbidity

Turbidity also serves as a measurement of water clarity by measuring the amount of suspended particles resulting from such sources as natural erosion, organic decay, and algae in the water. No criteria or screening level exists in Texas for turbidity, but the addition of reliable instrument data that removes the visual subjectivity of the person recording Secchi Depth may aid TCEQ in the establishment of applicable screening levels for the naturally turbid bay systems of Texas.

Turbidity values during RCAP 2003 ranged from 0.90 NTU in the Upper Laguna Madre (Segment 2491) to 121.30 NTU in the Baffin Bay Complex (Segment 2492) (Table 6.2.1 and 6.22). Comparison of all sites (n = 24) where multiple-depth sampling occurred showed no statistically significant differences (p = <0.12) existed between near-surface and near-bottom turbidities. Mean near-surface turbidity ranged from 3.12 NTU in the Upper Laguna Madre to 53.88 NTU in the Baffin Bay Complex while at sites where multiple depth sampling occurred mean near-bottom turbidity ranged from 3.45 in the Upper Laguna Madre to 59.30 NTU in the Baffin Bay Complex (Table 6.3.6). The mean difference between near-surface and near-bottom turbidity was greatest in the Copano/Port/Mission Bay complex (Segment 2472) at 8.40 NTU (Tables 6.2.1 and 6.2.2 and 6.3.6).

3.3.1.7. Salinity

CCS researchers previously stated aspects of the CBBEP regional salinity regime in earlier RCAP reports (Nicolau and Nuñez 2004). In summary, salinity concentrations typically are quite high due to natural conditions, reduced freshwater inflows, and the hypersaline Upper Laguna Madre. However, many species in the region are adapted to stressful conditions of hypersaline waters and are also able to adjust to wide salinity fluctuations that often occur when significant amounts of freshwater flows into the system.

The previous year saw sampling for RCAP 2002 recording the impact of significant amounts of freshwater inflow to the system. Substantial inflow amounts recorded in July 2002 (see Fig. 3.1), one month prior to sampling, resulted in dramatic changes in salinity regimes throughout most of the region. The greatest reduction (-84.8%) observed in mean salinity concentrations occurred in Nueces Bay (Segment 2482), followed by St. Charles Bay (Segment 2473) and the Copano/Port/Mission Bay complex (Segment 2472) (Table 3.2). Mean concentrations actually increased in the Upper Laguna Madre, once again demonstrating the variability in regional freshwater inflows, with location being as important as volume.

Despite the approximately 80,000 ac-ft of freshwater passed-through to Nueces Bay in July 2003, and the approximate 16,000 ac-ft of recorded inflows to the Mission-Aransas estuary from the Aransas and Mission Rivers, overall declines in inflows between RCAP 2002 and RCAP 2003 sampling events allowed salinities to increase throughout most of the region (Fig. 3.1; Table 3.2). The greatest increases in PSU occurred in Aransas Bay (Segment 2471), Redfish Bay (Segment 2483), and Nueces Bay (Segment 2482). However, the largest percent change occurred in Nueces Bay (Table 3.2). In contrast, both the Upper Laguna Madre (Segment 2491) and the Baffin Bay Complex (Segment 2492) actually showed declines in salinities; reinforcing the highly variable nature of the CBBEP region. Most segments still recorded salinity values in RCAP 2003 lower then first RCAP events used in this comparison.

For RCAP 2003, salinity values ranged from 0.49 PSU at Site 295 in Hynes Bay to 44.79 PSU at Site 323 located in the southern reach of the Upper Laguna Madre (Segment 2491) (Fig. 2.1; Figs. 3.2 and 3.3; Tables 6.2.1 and 6.2.2). Comparison of all sites (n = 24) where multiple-depth sampling occurred showed no statistically significant differences ($p = 0.67$) between near-surface and near-bottom salinities. Mean near-surface salinity within Segments ranged from 0.49 PSU in Hynes Bay to 37.71 PSU in the Baffin Bay complex (Segment 2492) (Table 6.3.2). At sites where multiple depth sampling occurred mean near-bottom salinity ranged from 0.49 PSU in Hynes Bay to 38.78 PSU in the Upper Laguna Madre (Table 6.3.2). The mean difference between near-surface and near-bottom salinity was <1.07 PSU for most Segments, except the Copano/Port/Mission Bay complex (Segment 2472) where the mean difference was 2.15 PSU (Tables 6.2.1 and 6.2.2 and 6.3.2).

Table 3.2. Mean near-surface salinity concentrations recorded for the same Segments during RCAP 2000 and RCAP 2001 summer sampling events, RCAP 2002, and RCAP 2003, with changes in PSU and percent decrease or increase (in parentheses) for mean concentrations for RCAP 2000/2001 versus RCAP 2002 and RCAP 2002 versus RCAP 2003.

Segment	2000/2001* Mean PSU	2002 Mean PSU	PSU and % Change 2002 vs. 2000/2001	2003 Mean PSU	PSU and % Change 2003 vs. 2002
2471	37.40	18.82	-18.58 (-49.7%)	32.51	+13.69 (+72.4%)
2472	29.30	10.83	-18.47 (-63.0%)	10.00	-0.83 (-7.7%)
2481	39.51	21.15	-18.36 (-46.5%)	32.49	+11.34 (+53.6%)
2482	37.96	5.76	-32.20 (-84.8%)	17.84	+12.08 (+209.7%)
2483	37.43	24.57	-12.86 (-34.4%)	37.60	+13.03 (+53.0%)
2485	37.67	30.60	-7.07 (-18.8%)	36.02	+5.42 (+17.7%)
2491	42.30	46.78	+4.48 (+10.6%)	37.71	-9.07 (-19.4%)
2492	53.61	48.67	-4.94 (-9.2%)	36.75	-11.9 (-24.5%)

2471 - Aransas Bay
2472 - Copano Bay/Port Bay/Mission Bay
2481 - Corpus Christi Bay
2482 - Nueces Bay
2483 - Redfish Bay
2485 - Oso Bay
2491 - Laguna Madre (Upper)
2492 - Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada

*Segments 2471 through 2485 sampled Summer 2000 and Segments 2491 and 2492 sampled summer 2001

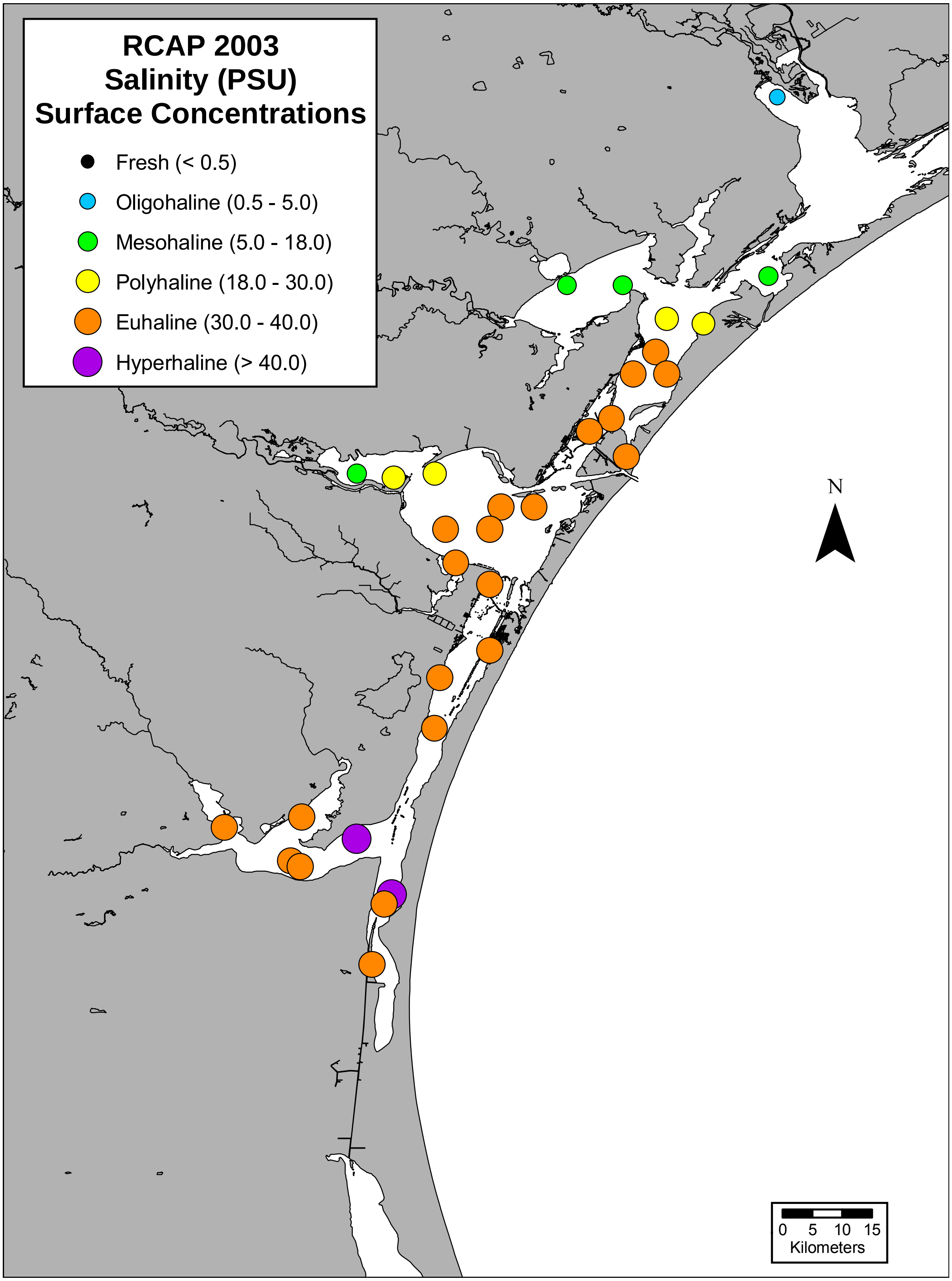

Fig. 3.2. Surface salinity concentrations (PSU) at RCAP 2003 sampling sites.

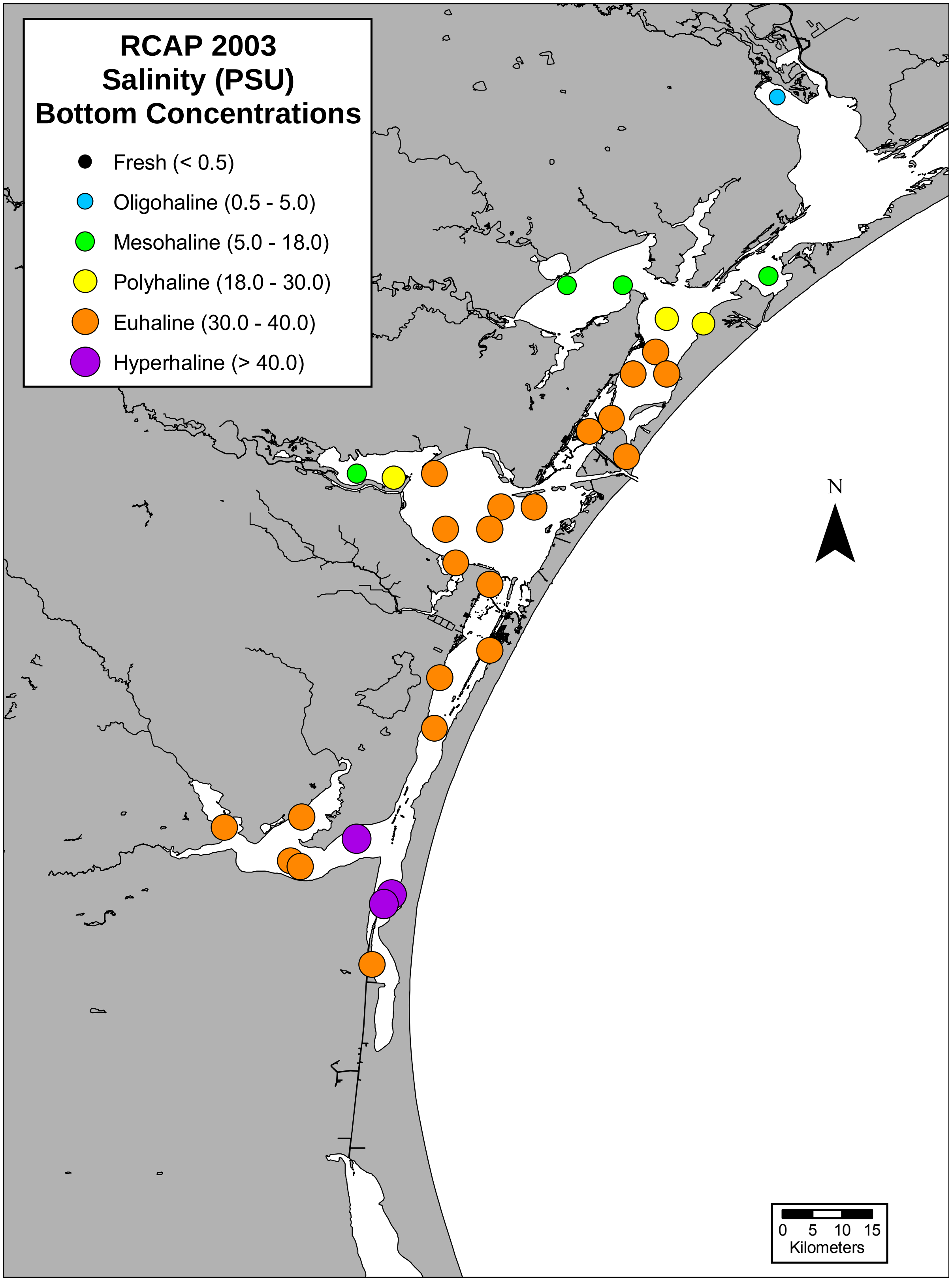

Fig. 3.3. Bottom salinity concentrations (PSU) at RCAP 2003 sampling sites.

3.3.1.8. Dissolved Oxygen

Based on sites sampled for RCAP 2003, near-surface Dissolved Oxygen (DO) quality continues to be extremely good throughout the CBBEP region. As the primary water quality parameter TCEQ utilizes in assessing Aquatic Life Use (ALU) and health of a water body the importance of this criterion cannot be overstated.

As previously stated in past RCAP reports, Segments in Texas classify as *exceptional, high,* or *intermediate,* with criteria based on meeting 24-hour near-surface (0.30 m below) average concentrations of 5.0, 4.0, and 3.0 mg/L, respectively. In addition, absolute minimum criteria to protect the range of ALUs in tidal waters are 1.0 mg/L less for all categories (TCEQ 2003). All segments monitored for RCAP 2003 carry a 24-hour surface DO criterion of 5.0 mg/L for *exceptional* habitat, except the Baffin Bay complex; classified as *high* habitat with a 4.0 mg/L criterion.

It is important to note that while many monitoring programs, Texas included, routinely measures DO (grab sample) throughout the water column on a quarterly basis, assessments are made only on 24-hour near-surface DO measurements, which in many cases may incorrectly interpret actual DO conditions and resultant aquatic health. Discounting the effect of low DO concentrations over the bottom sediments can affect numerous estuarine aquatic species and have varying detrimental effects (USEPA 2001).

RCAP 2003 instantaneous grab sampling (entire water column) took place during the most critical part of the summer index period when expected DO levels are routinely low. Specifically chosen because warmer water temperatures hold less DO than colder waters, the summer index period provides periods in which water quality conditions might be stressful and thereby limiting to biota. The combined effect of warmer waters and higher salinities can further depress DO concentrations as high salinity waters also hold less DO. While instantaneous grab sampling within a Segment does not warrant using the 24-hour criterion to evaluate DO conditions, RCAP DO data serves as a valuable tool to assess if conditions perhaps warrant further monitoring due to depressed DO concentrations at near-surface and near-bottom depths.

During RCAP 2003, no recorded instances of near-surface hypoxia (<2.0 mg/L) occurred at any site sampled (Fig. 3.4; Tables 6.2.1 and 6.3.3). While four sites recorded near-surface DO concentrations in the "biologically stressful" range (>2.0 mg/L but <5.0 mg/L), two were sites sampled in the early morning in shallow water and the concentrations at one site (Site 299 in Aransas Bay) was just below the criterion (4.96 mg/L). Regarding segment criterion, this represents two sites, or 6.3% of the sites sampled, that failed to meet the respective criteria (Site 299 in Aransas Bay and Site 316 in the Upper Laguna Madre as Sites 321 and 322 in the Baffin Bay Complex did meet the 4.0 mg/L TCEQ criterion established for Segment 2492). In addition to the two shallow water (<1.0 m) sites (Sites 299 and 316), the evaluation of near-bottom DO concentrations recorded only one additional site (Site 314 in Corpus Christi Bay – Segment 2481) which fell below the 5.0 mg/L criterion (Fig. 3.5).

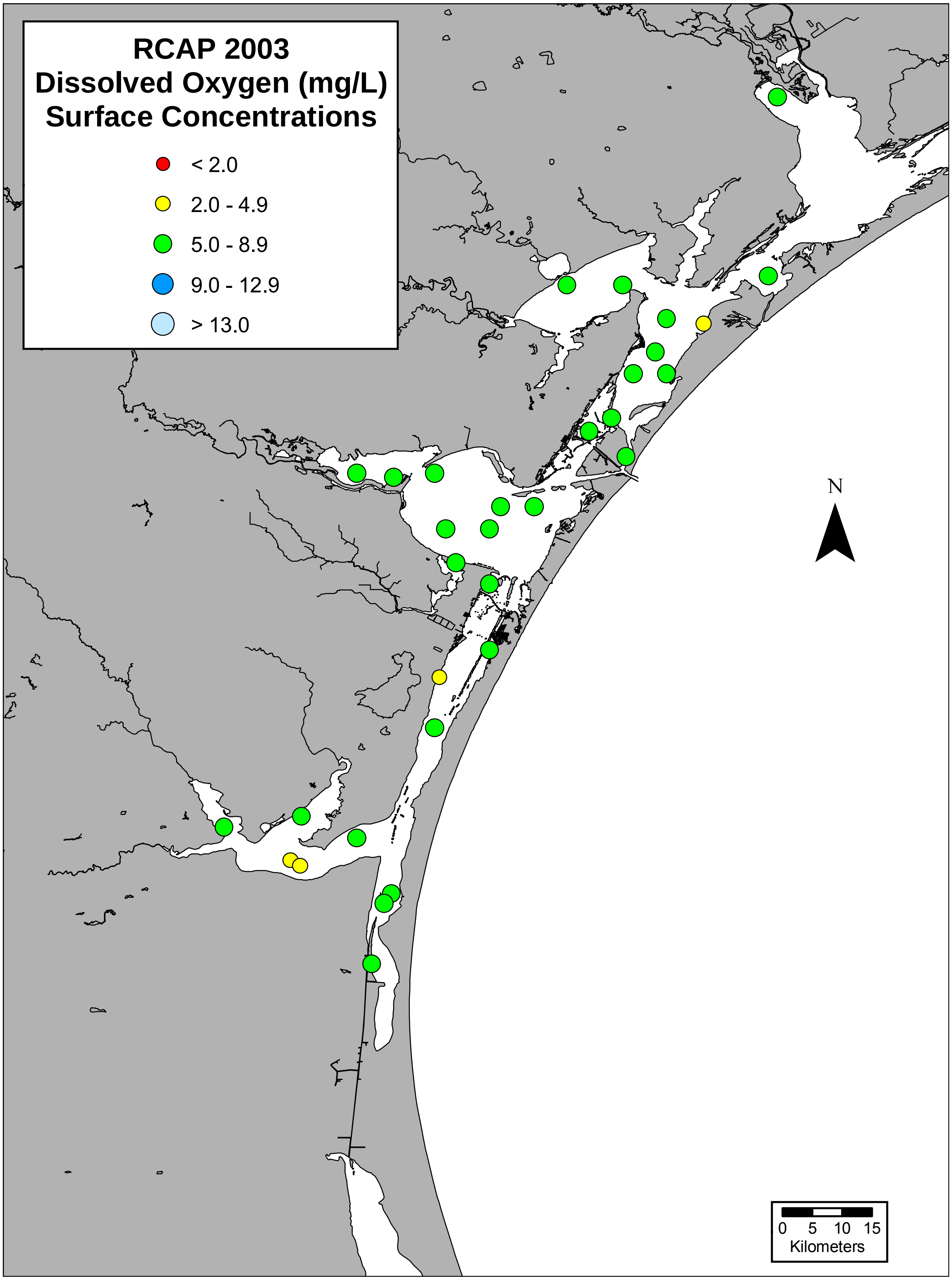

Fig. 3.4. Surface dissolved oxygen concentrations (mg/L) at RCAP 2003 sampling sites (sites in Baffin Bay coded as yellow while <5.0 mg/L did meet the TCEQ established criterion of 4.0 mg/L for this Segment).

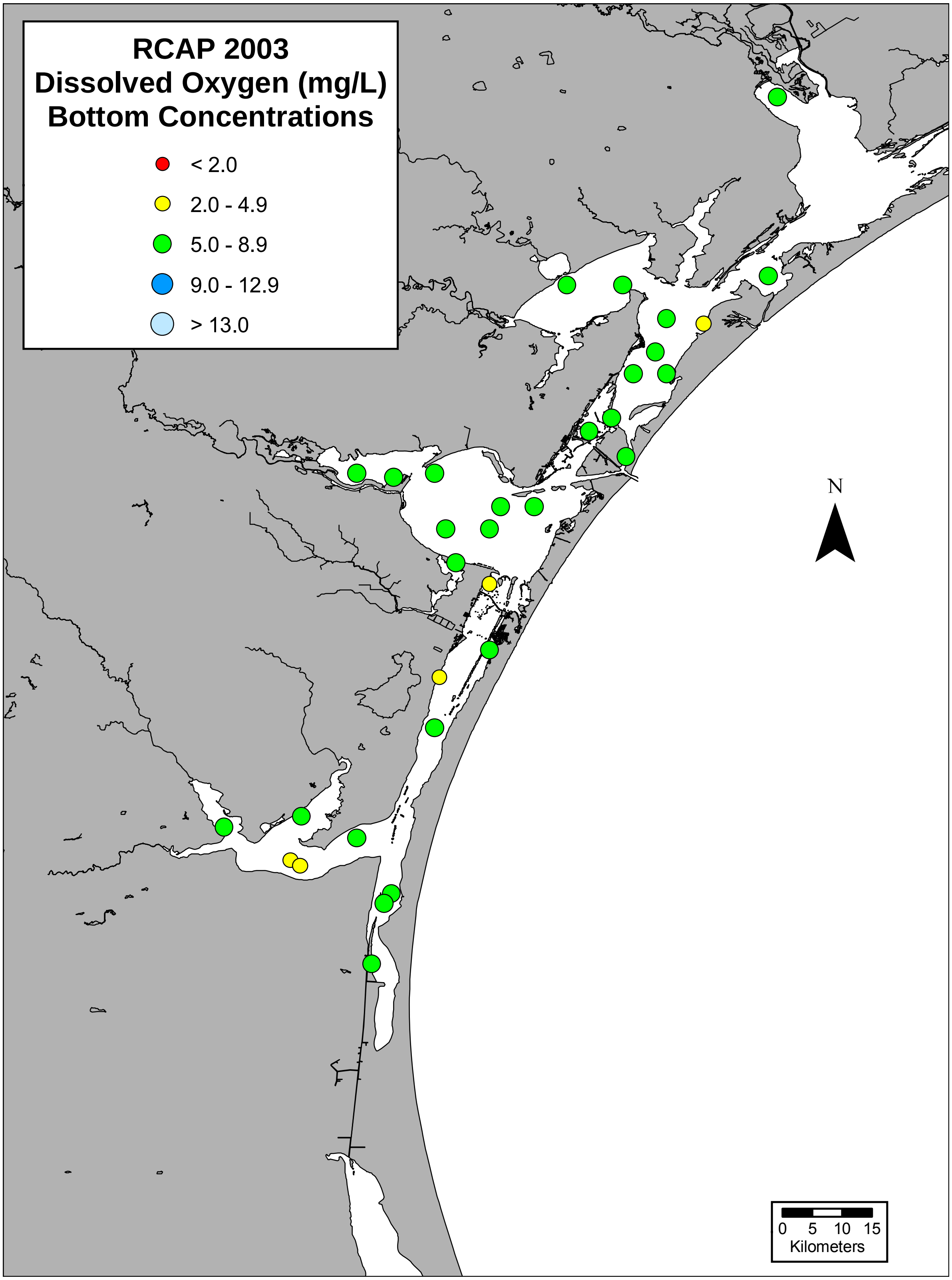

Fig. 3.5. Bottom dissolved oxygen concentrations (mg/L) at RCAP 2003 sampling sites (sites in Baffin Bay coded as yellow while <5.0 mg/L did meet the TCEQ established criterion of 4.0 mg/L for this Segment).

Individual near-surface DO concentrations ranged from 3.51 mg/L at Site 316 in the Upper Laguna Madre (Segment 2491) to 8.89 mg/L at Site 304 located in Redfish Bay (Segment 2483) (Fig. 3.4; Tables 6.2.2 and 6.3.3). Mean near-surface DO ranged from 5.29 mg/L in the Upper Laguna Madre to 8.89 mg/L in Redfish Bay (Table 6.3.3). Mean near-bottom salinity at sites where multiple depth sampling occurred ranged from 5.22 mg/L in the Upper Laguna Madre to 7.07 mg/L in Nueces Bay (Table 6.3.3). Comparison of all sites (n = 24) where multiple-depth sampling occurred showed statistically significant differences (p = <0.02) between near-surface and near-bottom DO concentrations. The mean difference between near-surface and near-bottom DO concentrations was <0.18 mg/L for all Segments where multiple depth sampling occurred, except the Copano/Port/Mission Bay complex (Segment 2472) and Corpus Christ Bay (Segment 2481), where the differences were 0.88 mg/L and 1.03 mg/L, respectively (Tables 6.2.1 and 6.2.2 and 6.3.3).

3.3.2. TCEQ Routine Conventional Water Chemistry

Excessive nutrient concentrations remain a major concern in estuarine waters throughout the United States as persistent high nutrient levels may result in estuarine eutrophication and produce undesirable effects, such as increased incidents of algal blooms, which often result in low dissolved oxygen levels and harmful biotic conditions (Bricker et al. 1999; CENR 2003). In the absence of established criteria, TCEQ continues to utilize screening levels for nutrients (ammonia, nitrate + nitrite, orthophosphate, total phosphorus), and chlorophyll *a*. These screening levels aid in identifying aquatic life use concerns within a segment based on percent exceedance derived from long-term SWQM data. Screening Level Estuary 2002 (SLE 2002) concentrations apply to all sites sampled in RCAP 2003.

3.3.2.1. Nitrogen

A primary limiting nutrient in estuarine systems, nitrogen levels control rates of primary production, with high input levels often producing significant increases in phytoplankton and macrophyte production. Some limits suggested for avoiding algal blooms and for maintaining designated aquatic life uses in estuaries range between 0.10 mg/L for maximum diversity, to 1.00 mg/L for moderate diversity (NOAA/EPA 1988; AWWA 1990; Rabalais 1992; Bricker et al. 1999).

Applying the applicable TCEQ screening level for ammonia of 0.10 mg/L, showed relatively low near-surface ammonia concentrations recorded during RCAP 2003 for all but four sites located in the Baffin Bay Complex (Segment 2492). Concentrations at all 32 sites ranged from <0.001 mg/L to 0.537 mg/L; with a mean of 0.057 mg/L (Fig. 3.6; Tables 6.4.1 and 6.5.1). Table 3.3 lists the number of sampling sites exceeding the screening level during RCAP 2003. The high concentrations in the Baffin Bay Complex resulted in mean ammonia concentrations exceeding the screening level for this segment. Mean concentrations in other segments sampled were typically <0.02 mg/L (Table 6.5.1).

Individual near-surface concentrations of nitrate + nitrite ranged from 0.022 mg/L to a extreme high of 3.105 mg/L at Site 295 in Hynes Bay (Segment 2462). The overall mean for all 32 sites was 0.132 mg/L and there were two sites exceeding the screening level in RCAP 2003, as opposed to no screening level exceedances in RCAP 2002 (Fig.3.7; Table 3.3; Tables 6.4.4 and 6.5.7). Mean concentrations of nitrate + nitrite were highest in Hynes Bay due to one extremely elevated concentration, which may relate to inflows received from the San

Antonio and Guadalupe Rivers. All other segments typically reported mean nitrate + nitrite concentrations of <0.05 mg/L except for the Baffin Bay Complex, which had a mean concentration of 0.157 mg/L (Table 6.5.7).

Table 3.3. Total number of sampling sites (n) and the number of applicable TCEQ screening level exceedances seen for nutrients and chlorophyll *a* within each TCEQ Segment sampled for RCAP 2003. No value indicated by – means no exceedances existed for this parameter.

Segment Number	Segment Name	n	Ammonia	Nitrate + Nitrite	Ortho P	Total P	Ch *a*
2462	San Antonio/Hynes/Guadalupe Bay	1	-	1	1	-	1
2463	Mesquite/Carlos/Ayers Bay	1	-	-	-	-	-
2471	Aransas Bay	7	-	-	-	-	-
2472	Copano/Port/Mission Bays	2	-	-	2	-	-
2481	Corpus Christi Bay	6	-	-	-	-	-
2482	Nueces Bay	2	-	-	-	-	1
2483	Redfish Bay	1	-	-	-	-	-
2485	Oso Bay	1	-	-	-	-	-
2491	Laguna Madre	6	-	-	-	-	1
2492	Baffin Bay/Alazan Bay/ Cayo del Grullo/Laguna Salada	5	4	1	-	-	5

3.3.2.2. Phosphorus

Total phosphorous measures the various forms of phosphorus (particulate and dissolved) found in water. Particulate phosphorus is bound to mineral and organic sediment while dissolved phosphorus exists in the water solution. Particulate phosphorus availability to plants and algae varies from 10% to 90% of total phosphorus inputs where as the dissolved portion is 100% bioavailable. Combined, the bioavailable portion of particulate and dissolved phosphorus represents the phosphorus that promotes surface water eutrophication (NRCS 1994). Recommended levels of phosphorus to avoid algal blooms are 0.01 mg/L to 0.10 mg/L or a 10:1 N:P ratio (NOAA 1998; Bricker et al. 1999).

Total Phosphorus (TP) near-surface concentrations for RCAP 2003 ranged from 0.003 mg/L to 0.177 mg/L, with an overall mean of 0.032 mg/L. There were no sites exceeding the TCEQ screening level of 0.22 mg/L in RCAP 2003, as opposed to one site in RCAP 2002 (Table 3.3). Mean concentrations for all segments were <0.080 mg/L, except in Hynes Bay (Segment 2462), which had a mean value of 0.177 mg/L (Fig. 3.8; Tables 6.4.5 and 6.5.9).

Ortho-Phosphate (OP), or dissolved inorganic phosphate, near-surface concentrations ranged from <0.009 mg/L to 0.234 mg/L. The overall mean for sites sampled was 0.054 mg/L and there were three sites exceeding the TCEQ screening level of 0.16 mg/L in RCAP 2003, as opposed to no sites in RCAP 2002 (Table 3.3). Mean concentrations for all segments were typically <0.050 mg/L, except in Hynes Bay (Segment 2462), which had a mean value of 0.210 mg/L and the Copano/Port/Mission Bay complex (Segment 2472) where the mean value was 0.204 mg/L (Fig. 3.9; Tables 6.4.6 and 6.5.10).

3.3.2.3. Chlorophyll *a*

Chlorophyll *a* concentrations are an indicator of phytoplankton biomass in estuarine waters. Due to the rapid response of phytoplankton to nutrient level increases, high concentrations may possibly indicate poor water quality. Therefore, many monitoring programs utilize chlorophyll *a* concentrations to evaluate water quality. However, it is important to remember that short-term elevated levels do not necessarily indicate poor water quality as much as persistent long-term elevated levels. Long-term elevated levels of chlorophyll *a* may reflect increased nutrient inputs, with increasing trends being a strong indicator of estuarine eutrophication (Bricker et al. 1999; CENR 2003).

From the data collected for RCAP 2003, persistent elevated chlorophyll *a* concentrations, relative to TCEQ screening levels, continue to indicate possible concerns. When compared to the 11.50 µg/L TCEQ screening level, individual concentrations produced eight sites exceeding the screening level in three of ten segments sampled (Table 3.3). In contrast to RCAP 2002, where the distribution of sites exceeding the screening level existed in Nueces Bay (Segment 2482) and Corpus Christi Bay (Segment 2481), for RCAP 2003 the majority of the sites exceeding the screening level occurred in the Baffin Bay Complex (Segment 2492) (Fig. 3.10; Tables 6.4.7 and 6.5.11).

Chlorophyll *a* concentrations ranged from a low of 1.58 µg/L to a high of 35.00 µg/L and the overall mean concentration for all 32 sites was 8.76 µg/L. This was down slightly from RCAP 2002 when the mean concentration for all 50 sites sampled was 9.24 µg/L. The one high value recorded at Site 295 in Hynes Bay (Segment 2462) exceeded the screening level by threefold and the five sites exceeding the screening level in the Baffin Bay Complex resulted in a mean segment concentration of 15.21 µg/L. (Table 6.5.11).

Comparison of historical RCAP data continues to indicate that elevated chlorophyll *a* concentrations may be short-term and possibly correspond with increased nutrient inputs from inflow events. During all four RCAP 2000 sampling events, elevated chlorophyll *a* concentrations occurred in known areas of historical concern; the Corpus Christi Inner Harbor (Segment 2484), which was not sampled during RCAP 2002 and RCAP 2003, and Oso Bay (Segment 2485). During the four RCAP 2001 events, the majority of elevated concentrations occurred primarily in the Baffin Bay Complex (Segment 2492) during the Summer and Fall 2001 sampling events, with the Fall 2001 event coinciding with increased inflows to the system (Nicolau and Nuñez 2004). RCAP 2002 chlorophyll *a* data also indicated a majority of the sites exceeding the screening level in areas receiving greater amounts of freshwater inflow (Nicolau and Nuñez 2005). For RCAP 2003, the majority of the sites exceeding the screening levels in the Baffin Bay Complex also coincided with decreases in salinity that indicate some form of freshwater inputs to the system. Additional data collected through this and other sources may help establish whether possible *Secondary Concerns* do exist for persistent elevated chlorophyll *a* concentrations.

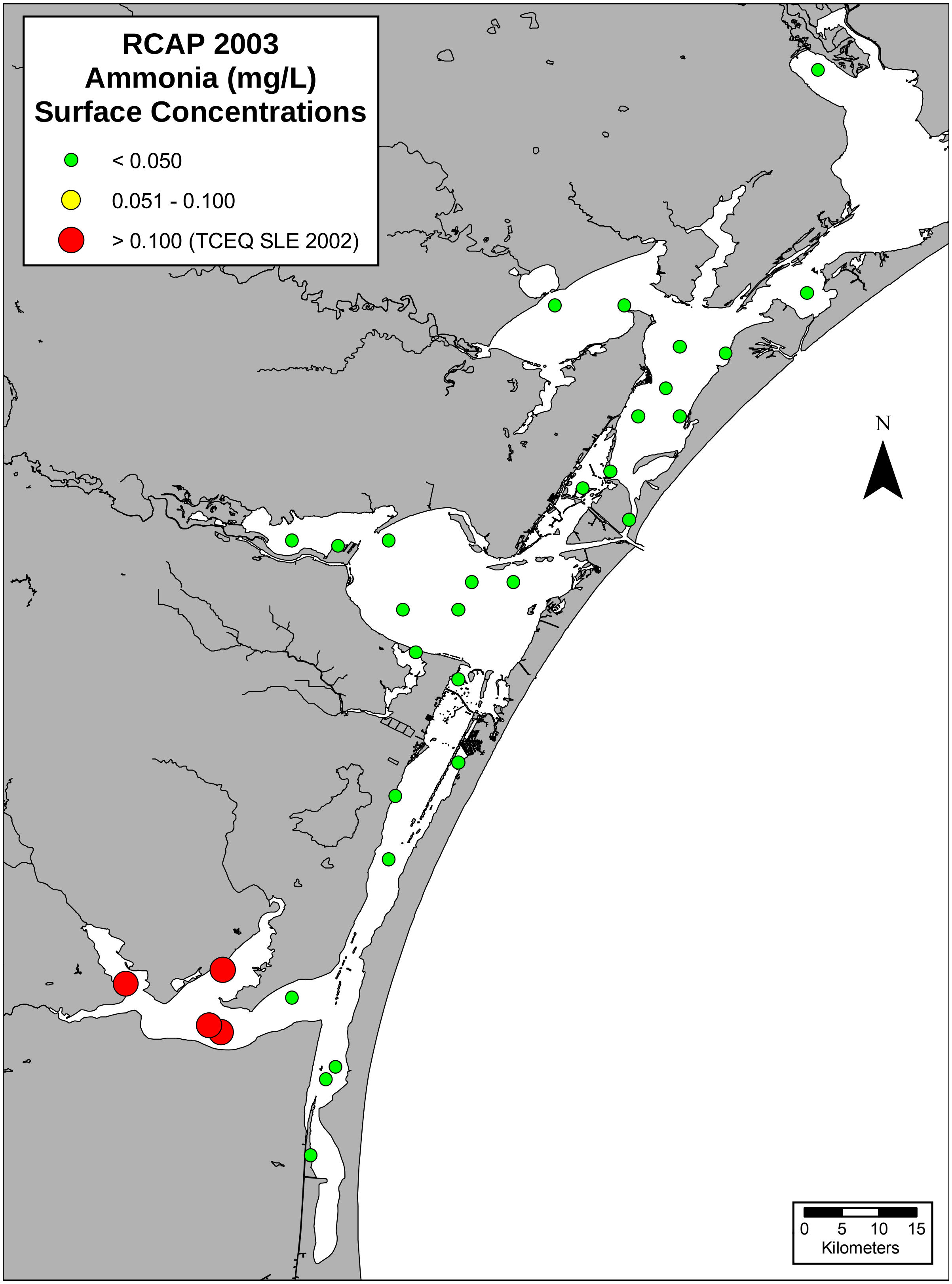

Fig. 3.6. Ammonia surface concentrations (mg/L) at RCAP 2003 sampling sites as evaluated according to TCEQ Screening Level Estuary 2002 (SLE 2002) guidelines.

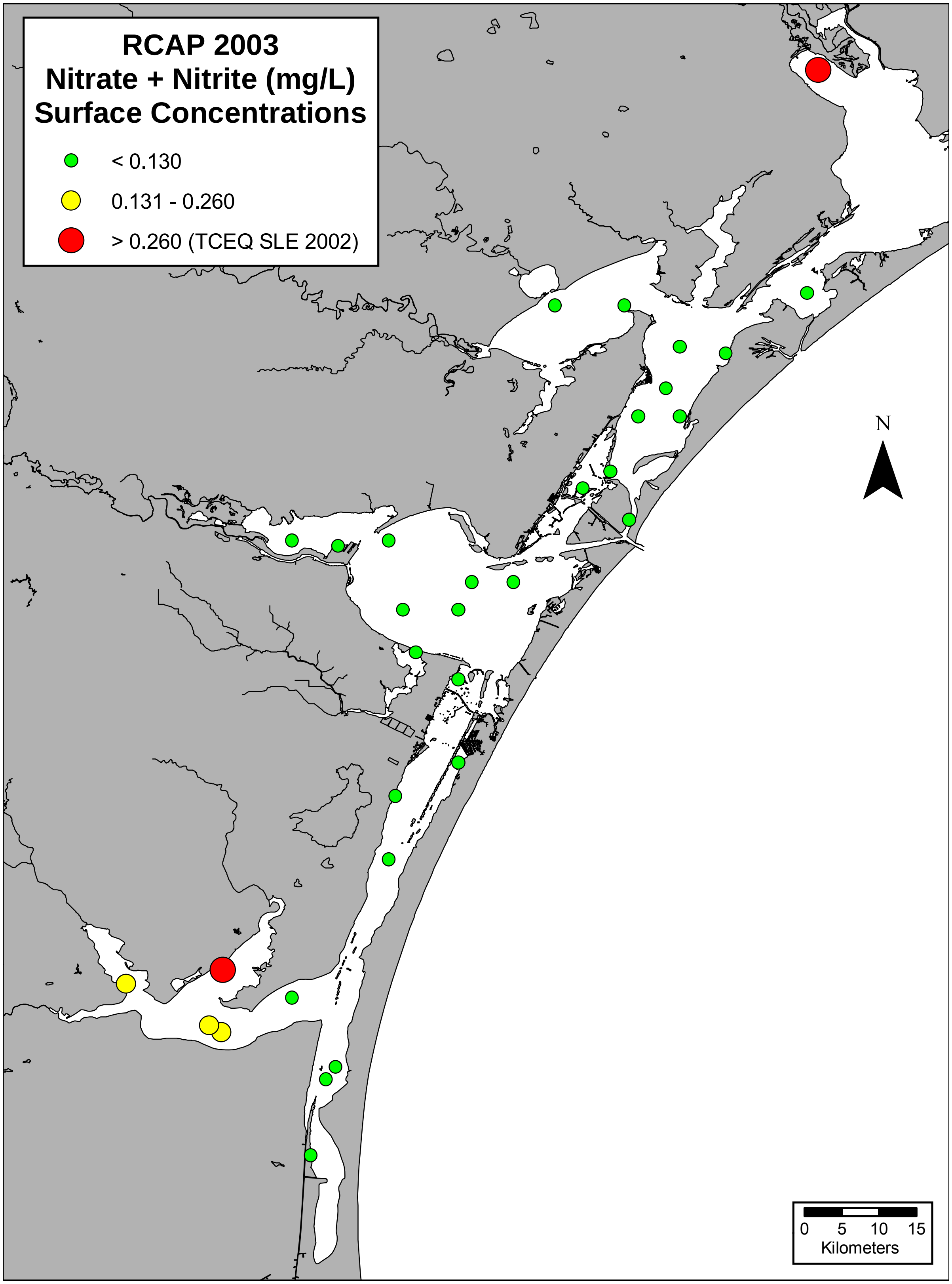

Fig. 3.7. Nitrate + Nitrite surface concentrations (mg/L) at RCAP 2003 sampling sites evaluated according to TCEQ Screening Level Estuary 2002 (SLE 2002) guidelines.

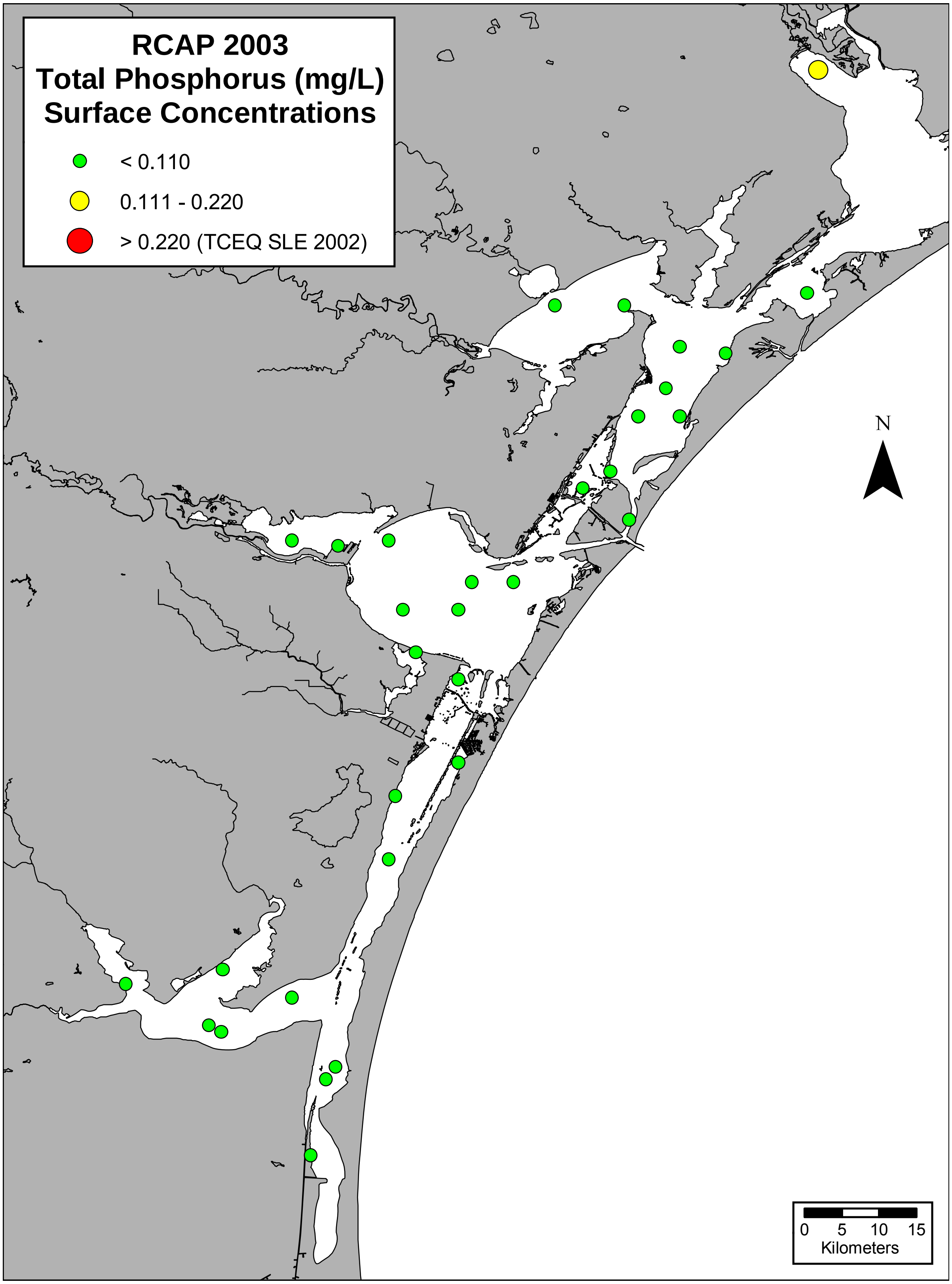

Fig. 3.8. Total Phosphorus surface concentrations (mg/L) at RCAP 2003 sampling sites evaluated according to TCEQ Screening Level Estuary 2002 (SLE 2002) guidelines.

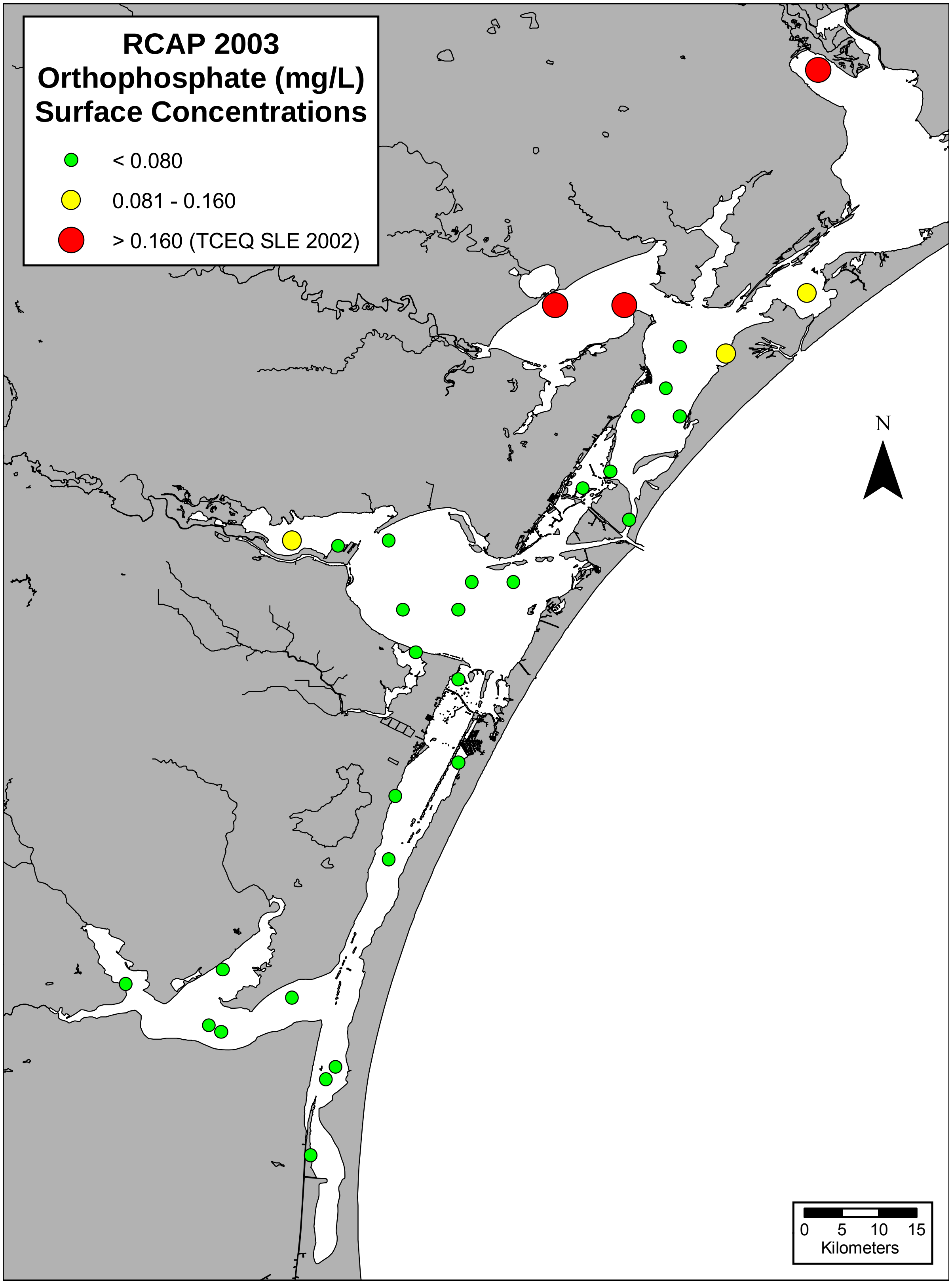

Fig. 3.9. Orthophosphate surface concentrations (mg/L) at RCAP 2003 sampling sites evaluated according to TCEQ Screening Level Estuary 2002 (SLE 2002) guidelines.

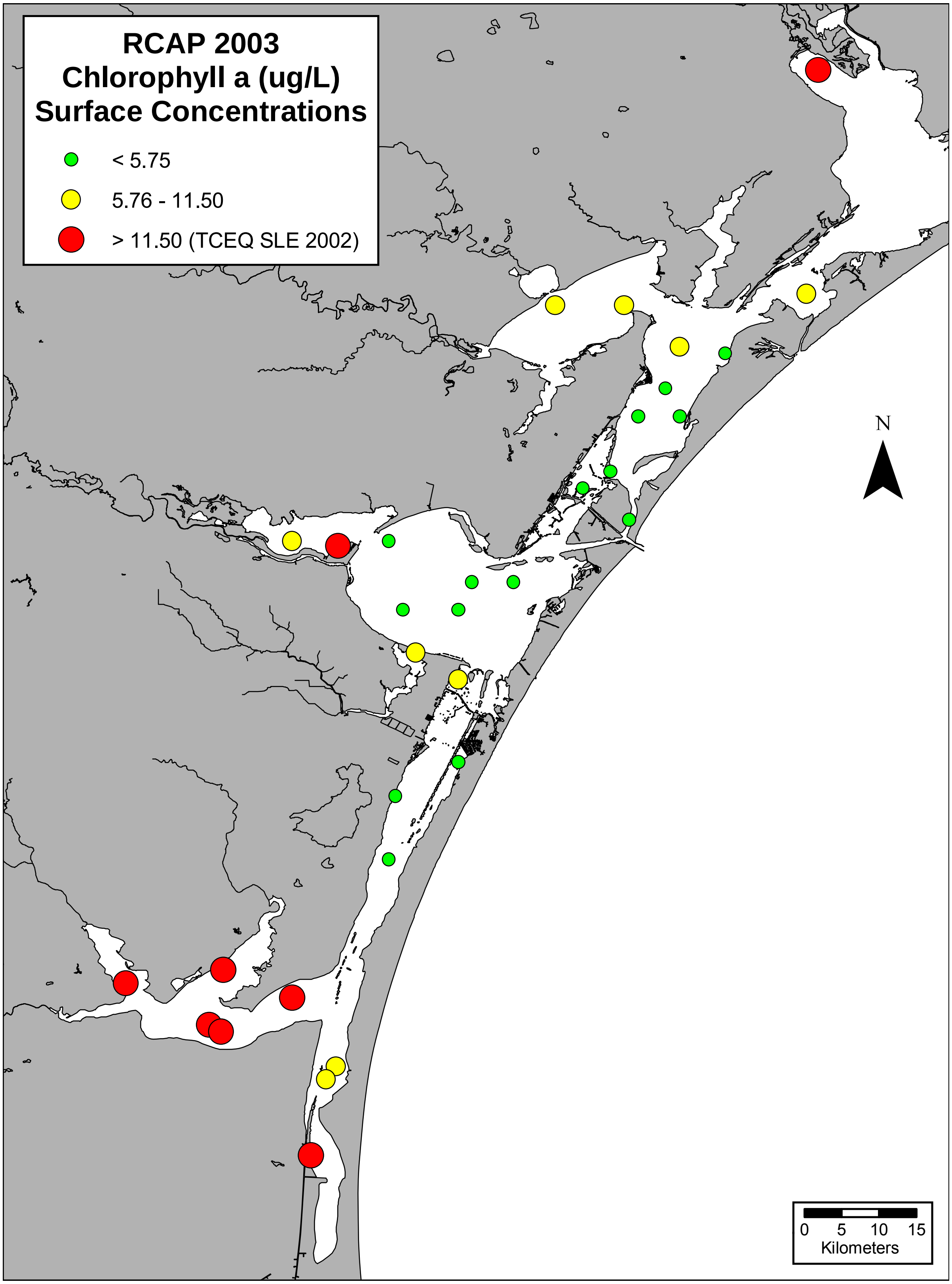

Fig. 3.10. Chlorophyll *a* surface concentrations (µg/L) at RCAP 2003 sampling sites evaluated according to TCEQ Screening Level Estuary 2002 (SLE 2002) guidelines.

3.3.3. EPA NCCR II Water Quality Index

According to EPA, the NCCR II Water Quality Index (WQI) only intends to characterize acutely degraded water quality conditions and does not identify sites that may experience infrequent hypoxic events or nutrient enrichment on a consistent basis (USEPA 2004). Therefore, the EPA position is that, "a rating of a poor WQI means that the site is likely to have consistently poor condition during the monitoring period. If designated fair or good, the site did not experience poor condition on the date sampled, but could be characterized by poor condition for short time periods". In addition, to assess WQI variability at a specific site will require increased or supplemental sampling (USEPA 2004).

3.3.3.1. Dissolved Oxygen

While a limited number of TCEQ defined segments (Baffin Bay Complex - Segment 2492) carry a <5.0 mg/L dissolved oxygen criterion, EPA and TCEQ generally evaluate near-surface DO along the same guidelines. As seen in Section 3.3.1.8, near-surface DO concentrations within the RCAP 2003 area rank as very good with no recorded instances of hypoxia. Three sites (Sites 299, 321, and 322) recorded near-surface DO concentrations between 4.0 mg/L and 5.0 mg/L (lowest concentration was 4.73 mg/L) and one site (Site 316) recorded a DO concentration of 3.51 mg/L (Fig. 3.4; Tables 6.2.1 and 6.3.3). Evaluation of near-bottom DO concentrations only added one additional site (Site 314) with a DO concentration that was 4.27 mg/L (Table 6.2.2).

Based on EPA NCCR II guidelines listed in Table 3.1, for the 32 sites sampled in RCAP 2003, DO was rated as good at 87.5% and fair at 12.5% of the sites sampled (Table 3.4). In contrast to RCAP 2002, where for the 50 sites sampled DO rated as good at 95% and fair at 5% of the sites sampled.

3.3.3.2. Dissolved Inorganic Nitrogen

EPA NCCR II guidelines (Table 3.1) evaluate near-surface Dissolved Inorganic Nitrogen (DIN) based on the combined concentrations of ammonia, nitrate, and nitrite samples collected and filtered in the field. EPA considers DIN as one of the estuarine eutrophication indicators. However, reference concentrations used in Gulf Coast and East Coast evaluations are lower than NOAA concentrations reported in Bricker et al. (1999) as EPA believes that summer does not represent a period when nutrient values would reach a maximum due to phytoplankton uptake from spring to summer for chlorophyll production.

Based on these guidelines, RCAP 2003 sampling shows that 27 sites achieved a rating of good (84.4%), 2 sites fair (6.2%), and 3 sites poor (9.4%) (Table 3.4; Fig. 3.11). DIN concentrations ranged from <0.001 mg/L to 3.302 mg/L. Due to the extremely high concentrations recorded at Site 295 in Hynes Bay (Segment 2462) the mean for all sites sampled was 0.168 mg/L. These values are considerably higher than the DIN concentrations recorded in RCAP 2002 when the range was 0.002 mg/L to 0.281 mg/L and the mean was 0.025 mg/L for the 49 sites sampled (one site had missing data). Discounting the Site 295 sample produces a mean of 0.067 mg/L, which while higher than RCAP 2002 sampling, is probably more representative. One possible note of concern would be that the 2 remaining sites listed as poor, and the 2 listed as fair, were all located in the Baffin Bay Complex (Segment 2492) (Fig. 3.11).

3.3.3.3. Dissolved Inorganic Phosphorus

EPA NCCR II guidelines (Table 3.1) evaluate near-surface Dissolved Inorganic Phosphorus at considerably lower concentrations then TCEQ. Along with DIN, EPA also considers DIP as an estimator of eutrophication and gives the same reasoning for reference concentrations being lower than reported in Bricker et al. (1999).

Based on these guidelines, only one site (3.1%) achieved a rating of good, 23 (71.9%) sites ranked as fair, and eight (25.0%) sites ranked as poor (Table 3.4; Fig. 3.12). DIP concentrations ranged from 0.009 mg/L to 0.234 mg/L, with an overall mean of 0.054 mg/L. When compared to the 49 sites (one site had missing data) sampled for RCAP 2002, DIP concentrations ranged from <0.001 mg/L to 0.137 mg/L, with an overall mean of 0.031 mg/L. Of the RCAP 2002 sites sampled, 16 (32.7%) achieved a rating of good, 20 (40.8%) ranked as fair, and 13 (26.5%) ranked as poor. Percentage comparison shows increases in DIP concentrations effectively moved most sites, primarily located in the Upper Laguna Madre and Baffin Bay Complex that ranked as good in RCAP 2002, to a rank of fair for RCAP 2003; percentages of poor sites and locations remained relatively the same.

Sites ranked as poor occurred in the same areas that typically received the majority of freshwater inflows prior to sampling for both RCAP 2002 and RCAP 2003 (Fig. 3.1; Fig. 3.12). While not as dramatic in RCAP 2003, Nueces Bay did receive a considerable, relative to this area, amount of inflow. Sites ranked as poor in the Copano/Mission Bay area also received increased inflows during this period relative to the months prior to sampling. Steady inflows from the Guadalupe River (approximately 80,000 ac-ft prior to sampling) may influence those sites ranked as poor in Hynes Bay, Mesquite Bay, and northern Aransas Bay. Therefore, elevated DIP concentrations recorded during RCAP 2002 and RCAP 2003 may still be indicative of short-term nutrient inputs from freshwater inflow events and not reflective of long-term eutrophication within the system. However, based on limited sampling events more data collection and comparison is necessary to make an effective determination.

3.3.3.4. Chlorophyll *a*

In the absence of established criteria, TCEQ uses a screening level of >11.50 µg/L to indicate *Secondary Concerns* for elevated chlorophyll *a* concentrations. Based on this screening level, *Secondary Concerns* may be justified for some areas in RCAP 2003. However, elevated concentrations may continue to represent short-term influences from freshwater inflow events prior to sampling in which nutrient inputs influence phytoplankton responses.

EPA NCCR II guidelines evaluate near-surface chlorophyll *a* concentrations based on recommendations proposed in Bricker et al. (1999), with the poor, or concerned, range being concentrations >20.0 µg/L (Table 3.1). For the 32 sites sampled in RCAP 2003, 10 (31.3%) achieved a good rating, 21 (65.6%) ranked as fair, and 1 (3.1%) ranked as poor (Table 3.4; Fig. 3.13). Near-surface chlorophyll *a* concentrations ranged from 1.58 µg/L to 35.00 µg/L. Overall mean concentration for all sites was 8.76 µg/L (Tables 6.4.7 and 6.5.11). Maximum and mean values recorded for RCAP 2003 were lower than RCAP 2002, but on a percentage basis, the ranking values were relatively similar. For 49 sites sampled in RCAP 2002 (one site had missing data), 16 (32.7%) sites achieved a good rating, 30 (61.2%) sites ranked as fair, and 3 (6.1%) sites ranked as poor. Near-surface chlorophyll *a* concentrations ranged from <0.22 µg/L to 45.42 µg/L; overall mean concentration for all sites of 9.24 µg/L.

Table 3.4. Results of the individual parameter and combined EPA Water Quality Index by site for RCAP 2003. DO= Dissolved Oxygen, DIN= Dissolved Inorganic Nitrogen, DIP= Dissolved Inorganic Phosphorus, Ch *a* = Chlorophyll *a*, WQI= Water Quality Index.

Segment	Site	DO	DIN	DIP	Ch *a*	EPA WQI
2462	295	Green	Red	Red	Red	Red
2463	326	Green	Green	Red	Yellow	Yellow
2471	298	Green	Green	Red	Yellow	Yellow
2471	299	Yellow	Green	Red	Green	Yellow
2471	300	Green	Green	Yellow	Yellow	Yellow
2471	301	Green	Green	Yellow	Green	Green
2471	302	Green	Green	Yellow	Yellow	Yellow
2471	303	Green	Green	Yellow	Green	Green
2471	305	Green	Green	Yellow	Green	Green
2472	296	Green	Green	Red	Yellow	Yellow
2472	297	Green	Green	Red	Yellow	Yellow
2481	307	Green	Green	Yellow	Yellow	Yellow
2481	309	Green	Green	Yellow	Yellow	Yellow
2481	310	Green	Green	Yellow	Green	Green
2481	311	Green	Green	Yellow	Green	Green
2481	312	Green	Green	Yellow	Green	Green
2481	314	Green	Green	Yellow	Yellow	Yellow
2482	306	Green	Green	Red	Yellow	Yellow
2482	308	Green	Green	Red	Yellow	Yellow
2483	304	Green	Green	Yellow	Green	Green
2485	313	Green	Green	Yellow	Yellow	Yellow
2491	315	Green	Green	Yellow	Green	Green
2491	316	Yellow	Green	Green	Yellow	Yellow
2491	317	Green	Green	Yellow	Green	Green
2491	323	Green	Green	Yellow	Yellow	Yellow
2491	324	Green	Green	Yellow	Yellow	Yellow
2491	325	Green	Green	Yellow	Yellow	Yellow
2492	318	Green	Red	Yellow	Yellow	Yellow
2492	319	Green	Yellow	Yellow	Yellow	Yellow
2492	320	Green	Green	Yellow	Yellow	Yellow
2492	321	Yellow	Yellow	Yellow	Yellow	Yellow
2492	322	Yellow	Red	Yellow	Yellow	Yellow

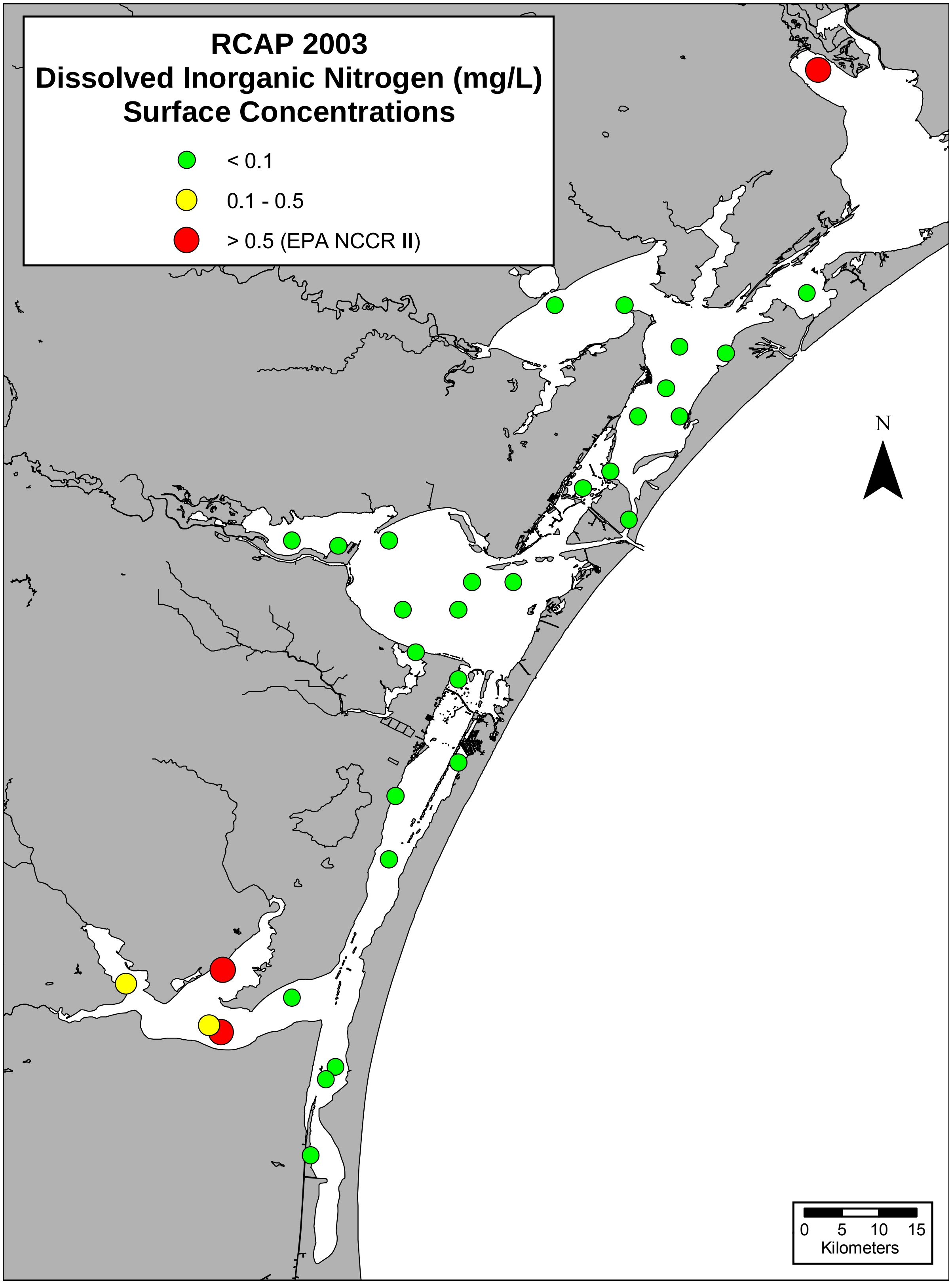

Fig. 3.11. Dissolved Inorganic Nitrogen surface concentrations (mg/L) at RCAP 2003 sampling sites evaluated according to EPA NCCR II guidelines.

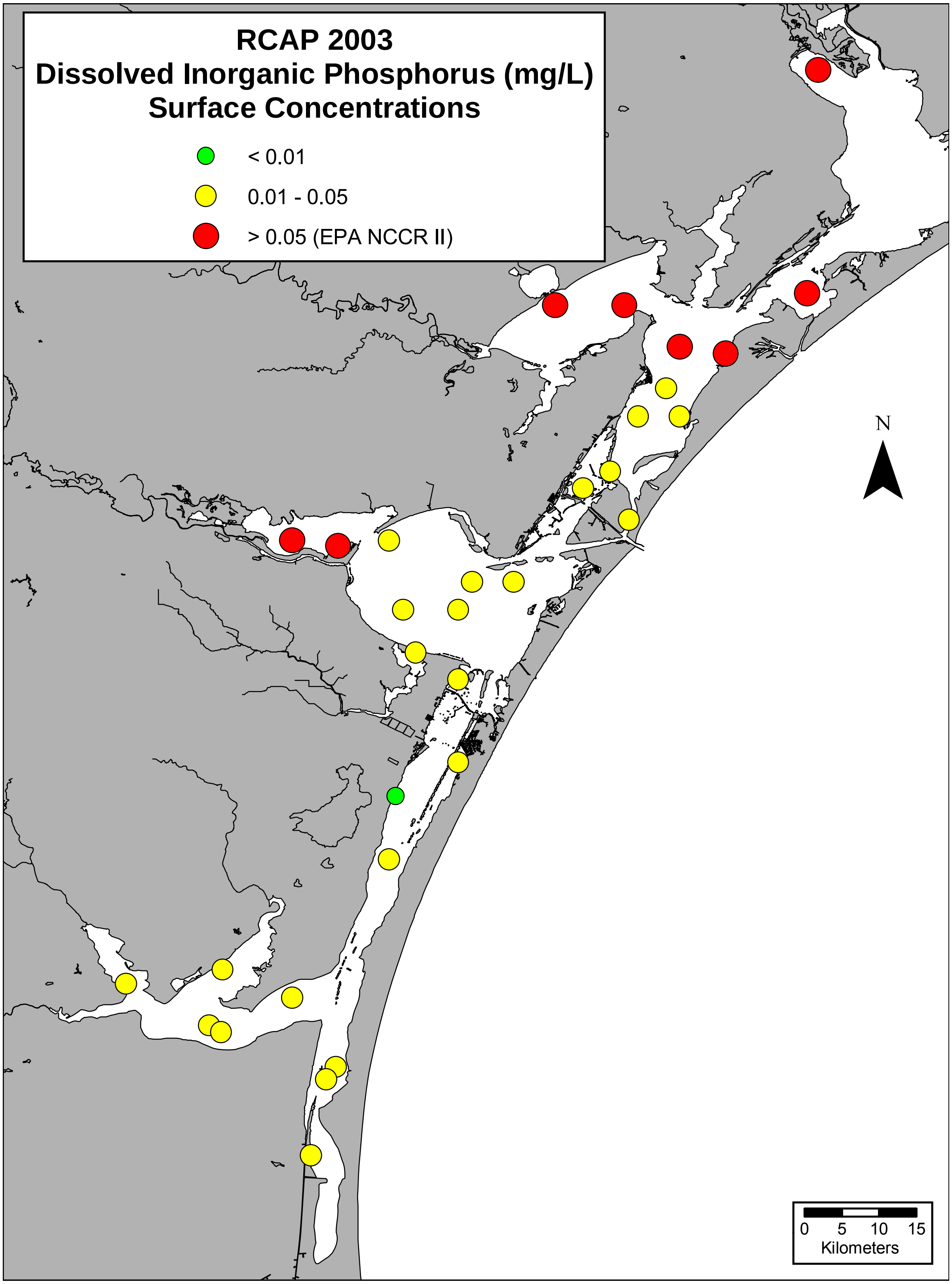

Fig. 3.12. Dissolved Inorganic Phosphorus surface concentrations (mg/L) at RCAP 2003 sampling sites evaluated according to EPA NCCR II guidelines.

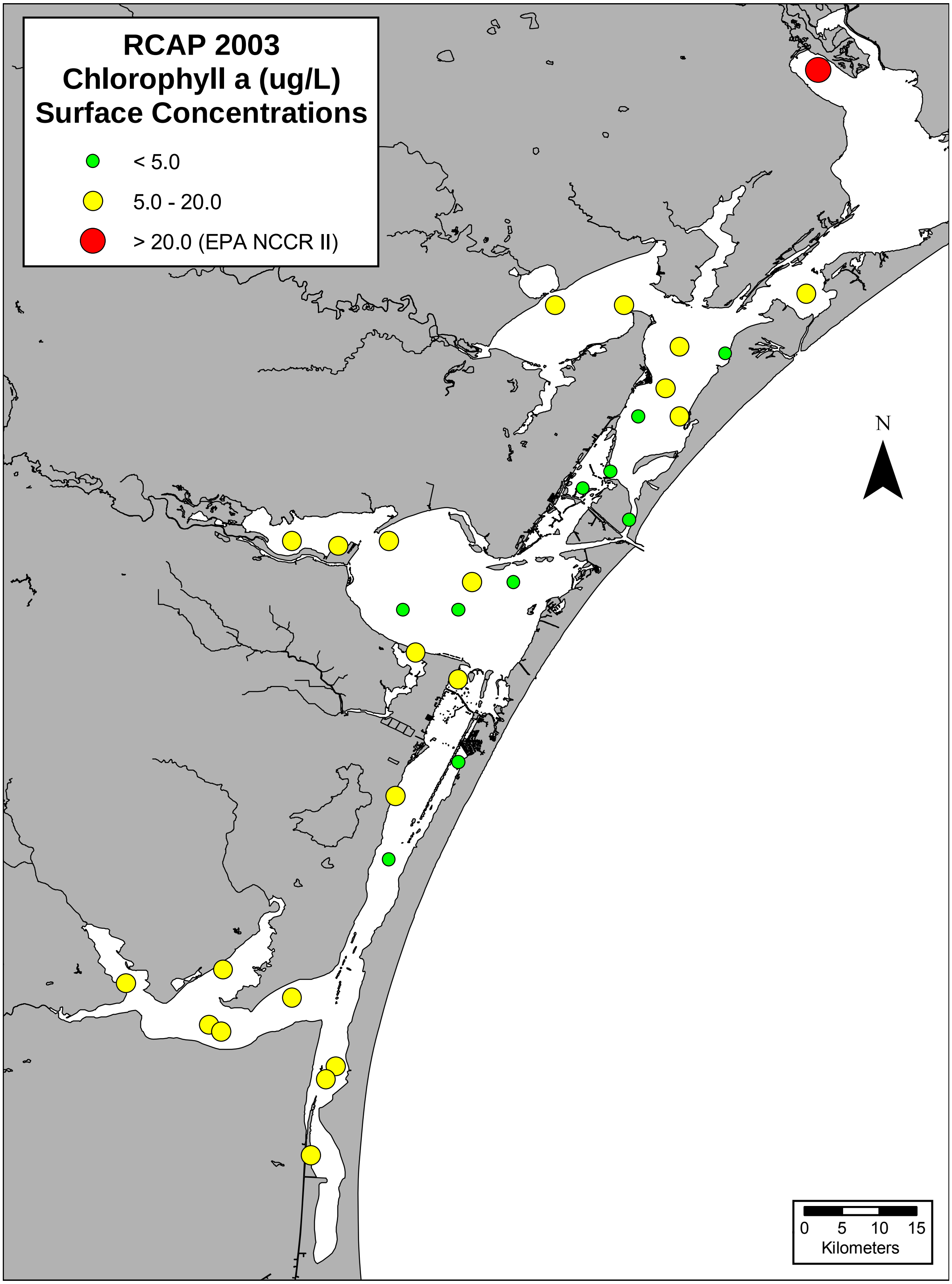

Fig. 3.13. Chlorophyll *a* surface concentrations (µg/L) at RCAP 2003 sampling sites evaluated according to EPA NCCR II guidelines.

3.3.4. Microbiological Indicators

Disease causing microorganisms, or pathogens, can adversely affect estuarine systems; resulting in restrictions of shellfish harvesting areas, fish kills, and adverse effects on human health during recreational use involving primary contact (i.e., wading, swimming, fishing, etc) with water (Heilman 2000; USEPA 2002).

TCEQ analyzes concentrations of *Escherichia coli* and fecal coliform in freshwater, and enterococci in marine or tidal water to determine Contact Recreation Use (CRU) support. Existence of these naturally occurring organisms in high numbers within the water column indicates contamination by fecal matter originating from warm-blooded animals, including humans. TCEQ guidance stresses that full CRU support does not necessarily guarantee that waters are completely free of disease causing organisms (TCEQ 2003). In addition, the national EPA Beachwatch Program monitors Texas beaches for enterococci concentrations to determine closures based on elevated bacterial concentrations.

Support of the TCEQ CRU utilizes a 10-sample minimum per individual site. For routinely monitored bacteria data, the long-term geometric average for enterococci is 35-colony forming units/100 ml (CFU/100ml) in tidal water. Due to various interpretations, an enterococci criterion of 89 CFU/100ml applies to individual samples under the TCEQ SWQM program. However, the TCEQ TMDL program uses the same criteria as the EPA Beachwatch program, which is 104 CFU/100ml. The CRU is not supported if the geometric average of samples collected exceeds the mean criterion or if the criteria for individual samples are exceeded >25% of the time. As RCAP 2003 sampling only occurred one time and at random locations, determination of CRU support is not applicable. However, data collected still continues to provide CBBEP and TCEQ information for assessing conditions over the region.

For comparative purposes, RCAP 2003 sampling utilized the recently approved TCEQ IDEXX method (SWQM monitoring) for the determination of enterococci concentrations. TCEQ adopted IDEXX for simplicity and ease of use by field personnel, as opposed to the more labor-intensive EPA 1600 laboratory filtration method. While some concerns exist as to the possibility that IDEXX may under or over report actual bacterial concentrations present, from a TCEQ regulatory perspective the method tends to provide adequate concentration determinations and would only cause concern when concentrations were located closely to the criteria values.

Based on the sites and areas sampled for RCAP 2003, bacterial conditions continue to be rated as very good. RCAP 2003 sampling utilized both the IDEXX 51 method, that provides accuracy of 1 to 200 CFU/100 ml, or when concentrations are low, and the IDEXX 97 method that provides accuracy of 1 to 2149 CFU/100 ml, or when concentrations are high, since no knowledge existed as to what current concentrations might be during sampling. Results revealed very little differences between methods as enterococci concentrations were relatively low with the majority of the 31 sites (one site had missing data) yielding concentrations of <10 CFU/100 ml (Fig. 3.14; Table 6.6.1). No sites exceeded either the individual 89 CFU/100ml or 104 CFU/100 ml criterion. In RCAP 2002, one site in Nueces Bay and one site in Corpus Christi Bay at the confluence with Nueces Bay exceeded the criterion. The high concentrations in RCAP 2002 related directly to the extremely large inflow amounts received during the flooding event prior to sampling.

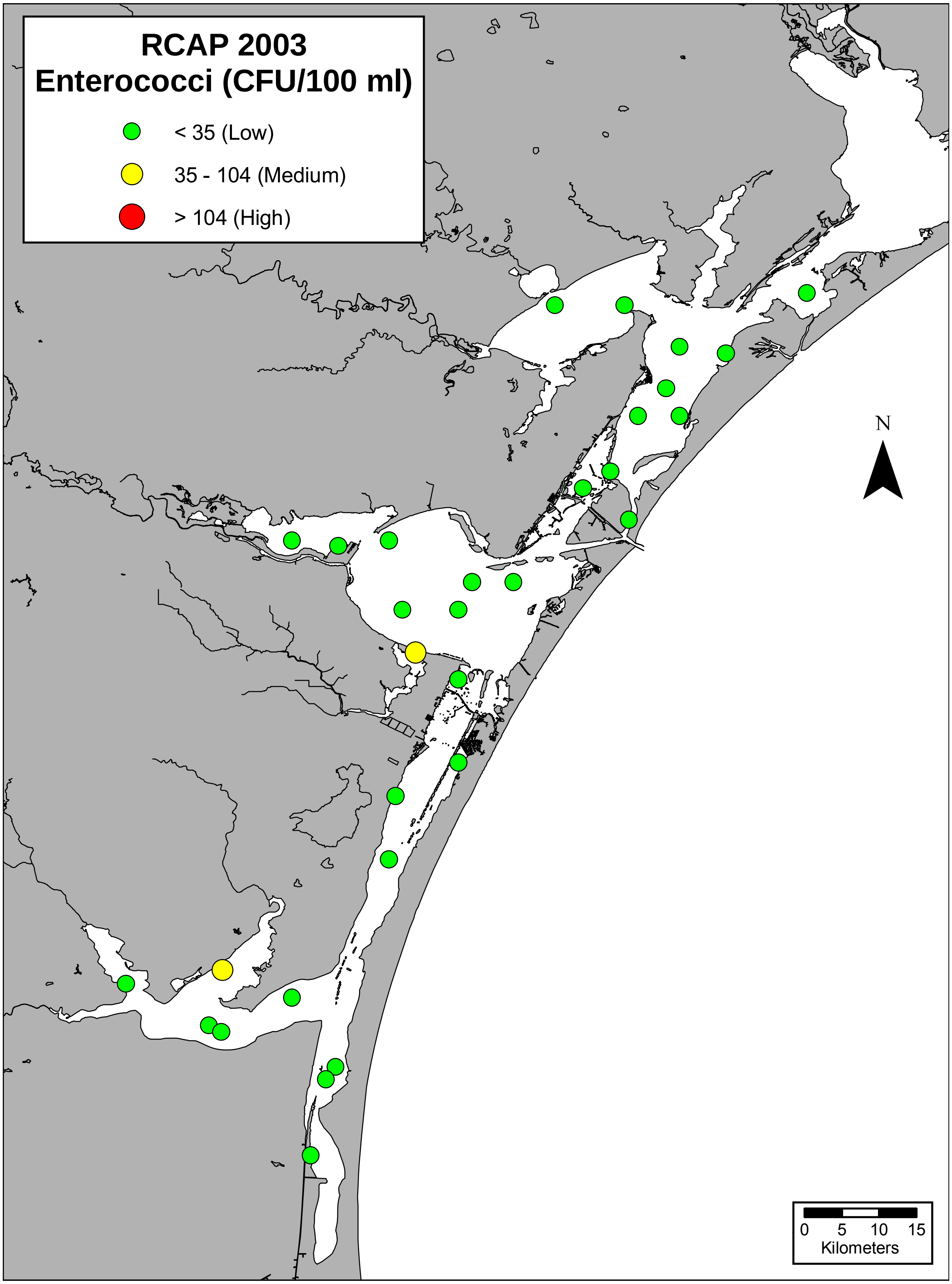

Fig. 3.14. Enterococci concentrations (CFU/100 ml) at RCAP 2003 sampling sites evaluated according to TCEQ TMDL and EPA Beachwatch Criteria guidelines.

3.3.5. Trace Metals in Water

Support of basic life processes requires trace amounts of many heavy metals. However, in higher concentrations they are toxic to aquatic organisms. Historically, elevated metal concentrations are responsible for creating widespread problems within many coastal and estuarine systems (Kennish 1992). Significant portions of these metals directly relate to domestic and industrial discharges but substantial amounts of heavy metals found in estuaries also come from river inputs or the atmosphere (Kennish 1992). In natural water, metals exist in many phases, although dissolved concentrations are relatively low. While many coastal areas did successfully remediate past degradation, the prevalence of heavy metals in industrial and domestic processes and the extreme toxic nature of heavy metal contamination require continued vigilance to protect our estuarine systems (Kennish 1992; Mann 2000). As historical concerns once documented potential problems for the CBBEP region, continued monitoring for heavy metals remains an essential part of the RCAP monitoring effort.

As previously stated, many trace metals serve as micronutrients critical for supporting basic life processes but are lethal in higher concentrations and toxic to aquatic organisms. Many problems in coastal and estuarine systems correlate to pollution directly related to excessive trace metal inputs. Therefore, TCEQ developed criteria for toxic substances in water to assess aquatic life use support that include 26 organic substances and a suite of 12 metals in dissolved and total forms. Table 3.5 lists criteria for the eight metals sampled in RCAP 2003.

As was found in RCAP 2000 and RCAP 2001 and from sites sampled for RCAP 2003, there are no concerns for trace metal concentrations within the CBBEP region. When compared to TCEQ criteria, individual concentrations produced no exceedances in any of the segments sampled and many of the highest concentrations recorded were 95.0% less than the criteria (Table 3.5). As also observed in RCAP 2000 and RCAP 2001, during RCAP 2003 the greatest numbers of highest concentrations recorded occurred in Nueces Bay (Segment 2482) and the Baffin Bay Complex (Segment 2492). As somewhat expected, concentrations of trace metals would tend to be relatively higher in Nueces Bay than the other segments due to proximity of the Corpus Christi Inner Harbor (Segment 2484); the primary industrial complex for the region. However, relatively higher concentrations in the Baffin Bay Complex still require further data collection and analysis to understand the complete nature of inputs to that area.

Table 3.5. Trace metals collected during RCAP 2003 showing Segment recording the highest concentration, with range of concentrations, Tidal Water Chronic (TWC 2000) criteria, and the percent that the highest individual concentration attained of applicable criteria.

Parameter	Segment	Range (µg/L)	TWC 2000	% < TWC 2000
Arsenic	2492 (Baffin Bay Complex)	1.33 – 9.04	78.00	11.60
Cadmium	2482 (Nueces Bay)	<0.020 – 0.086	10.00	0.86
Copper	2492 (Baffin Bay Complex)	0.204 – 1.378	3.60	38.30
Lead	2492 (Baffin Bay Complex)	<0.020 – 0.114	5.30	2.20
Mercury	2482 (Nueces Bay)	0.0005 – 0.0052	1.10	0.47
Nickel	2492 (Baffin Bay Complex)	0.0448 – 1.251	13.10	9.55
Selenium	2482 (Nueces Bay)	<0.100 – 0.569	136.00	0.42
Zinc	2482 (Nueces Bay)	<0.200 – 1.344	84.20	1.60

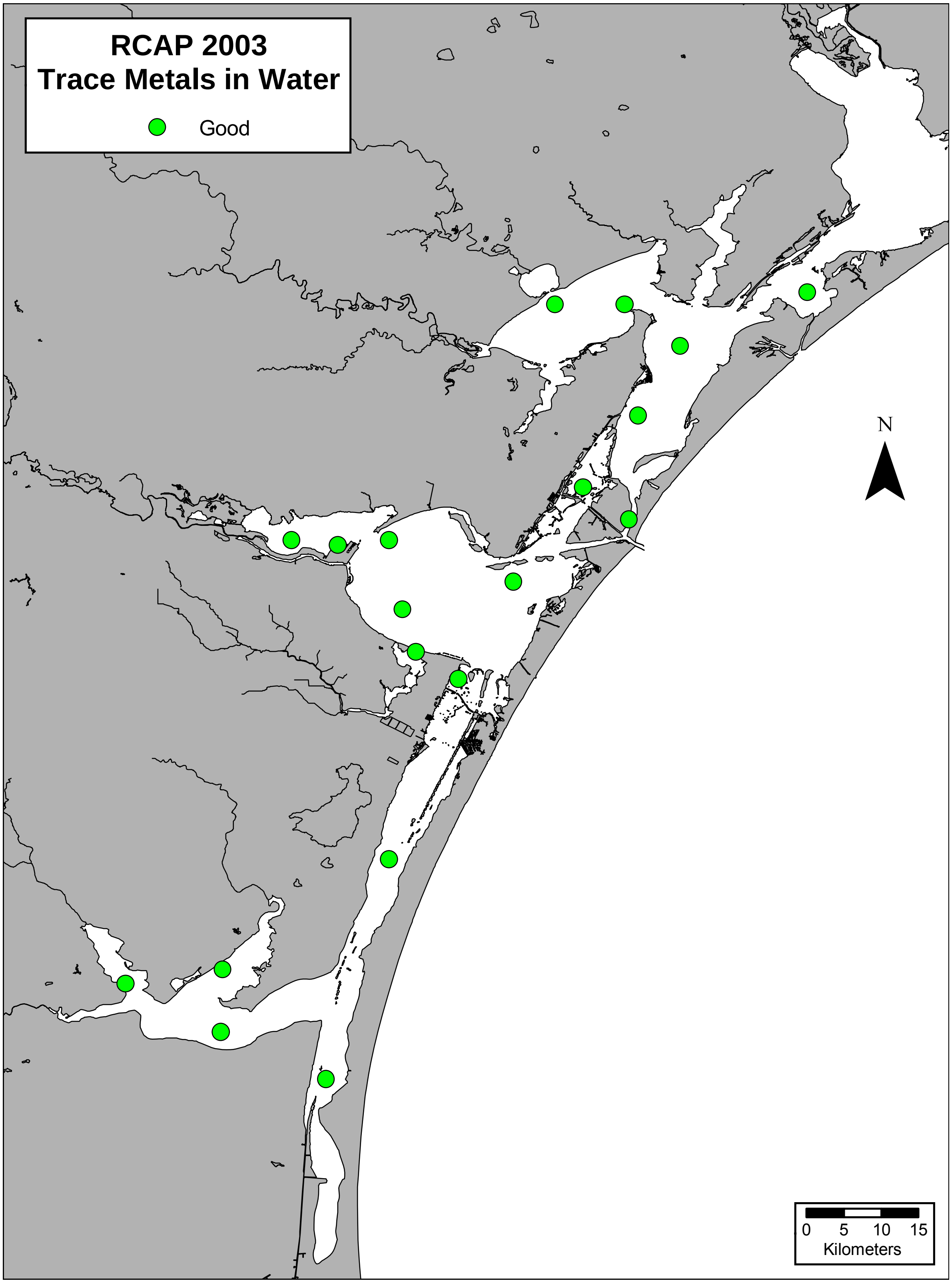

Fig. 3.15. Results of trace metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, and zinc) evaluation at 19 RCAP 2003 sampling sites. All trace metals concentrations were below established criteria.

3.4 Summary

The initial attempt at providing data for comparisons on a local, regional, and national level began with the RCAP 2002 assessment and continued for RCAP 2003. Unfortunately, the same problem in making a standardized assessment still exists because of the different ways that TCEQ and EPA evaluate water quality within the CBBEP region. As an evolving process, the collection and assimilation of additional RCAP data is aiding in developing indicators that will give us a better picture as to what may represent healthy or degraded conditions or habitat within the CBBEP region.

Field data collected continues to be representative of the CBBEP region, with values recorded during RCAP 2003 typical for the summer index period. In contrast to RCAP 2002, salinity concentrations recorded in RCAP 2003 showed increases within most Segments, as major inflow events ceased towards the end of 2002 (see Fig. 3.2). Freshwater inflows remain as one of the most critical factors for sustaining long-term estuarine health within the CBBEP region but it is important to document the stress to aquatic organisms that these dramatic short-term shifts in salinity can create (Montagna et al. 2002).

Dissolved oxygen continues to represent one of the most essential water quality parameters utilized by both TCEQ and EPA in assessments of aquatic life use and the health of a water body. While a few near-surface dissolved oxygen concentrations fell in the “biologically stressful” range of >2.0 mg/L but <5.0 mg/L, based on one-time grab sampling, overall near-surface dissolved oxygen quality for the CBBEP region can be considered very good (see Fig. 3.4). As opposed to RCAP 2002 when salinity stratification in the water column due to increased inflows produced one instance of hypoxia, and caused depressed DO concentrations at five sampling sites within Corpus Christi Bay, data collected in RCAP 2003 showed no signs of hypoxia at the sites sampled (see Fig. 3.5). Future events will continue to monitor near-bottom DO concentrations to provide a complete picture of the system.

In the continued absence of established nutrient criteria, state and federal monitoring entities employ screening levels based on different methodologies. According to TCEQ screening levels, while some nutrient values exceeded screening levels (see Figs. 3.6 through 3.9 and Table 3.3), based on RCAP 2003 sampling, these elevated levels tend to warrant little concern. However, the extremely elevated nitrate + nitrite levels in Hynes Bay (Segment 2462), and the clustering of ammonia exceedances in the Baffin Bay Complex (Segment 2492), may possibly indicate areas needing additional temporal and spatial monitoring. Elevated Total Phosphorus levels recorded in Nueces Bay during RCAP 2002, which were also elevated in all RCAP 2000 sampling events, did not present a concern in RCAP 2003, as all levels were <0.05 mg/L.

Regarding chlorophyll *a* concentrations, possible *Secondary Concerns* may exist based on TCEQ screening levels (see Fig. 3.10). Elevated concentrations may relate to natural phytoplankton responses to increased nutrients from inflow events prior to sampling, coupled with the optimal conditions of high temperatures and increased light levels during the south Texas summer; conditions that often produce high concentrations of chlorophyll *a* (Monbet 1992). While higher primary productivity levels may be beneficial for some estuarine organisms in the short-term, if elevated concentrations continue to persist in future RCAP events, or in the assessment of regional TCEQ SWQM and other data sources, then long-term elevated levels of chlorophyll *a* may be a strong indicator of possible estuarine eutrophication.

Using EPA NCCR II guidance, which looks at near-surface Dissolved Inorganic Nitrogen (DIN) and Dissolved Inorganic Phosphorus (DIP) concentrations, still provides a more unfavorable assessment of the region than evaluation using TCEQ Screening Levels. As opposed to RCAP 2002, when DIN concentrations were all <0.10 mg/L and thereby rated as good for the RCAP sampling region, RCAP 2003 sampling produced 27 sites rated as good (84.4%), 2 sites fair (6.2%), and 3 sites rated as poor (9.4%) (see Fig. 3.11 and Table 3.4). As expected, the three sites rated as poor occurred in the same Segments (Hynes Bay and the Baffin Bay Complex) identified using TCEQ Screening Levels for ammonia and nitrate + nitrite.

EPA guidance concerning DIP concentrations is more restrictive than TCEQ methodologies used to establish criteria ranges. While the point may be debatable, as to which concentration range to use, EPA is attempting to use a range for all Gulf Coast states so that conditions are comparable throughout the region. Comparing DIP concentrations for RCAP 2002 with concentrations from RCAP 2003 shows that approximately the same percentage (26.5% versus 25.0%) of sites exceeded EPA NCCR II guidelines for DIP and were rated as poor (see Fig. 3.12 and Table 3.4). In addition, many of the sites occurred within the same Segments for both years. Overall, the mean value of DIP concentrations for the region increased from 0.031 mg/L to 0.054 mg/L mainly due to four elevated concentrations from Hynes Bay, Mesquite Bay, and Copano Bay (see Table 6.4.6).

Regarding RCAP 2003 chlorophyll *a* concentrations, based on EPA guidance the majority, 21 or 65.6% of sites sampled received a fair ranking (see Fig. 3.13 and Table 3.4). While the upper end of the EPA range is higher than the TCEQ screening levels (>20.00 µg/L versus 11.50 µg/L) the lower end of the fair category is still considered as too low based on historical concentrations observed for this region. In RCAP 2002, 39 sites or 79.6% of the sites sampled received a fair rating (5.00 µg/L to 20.00 µg/L). However, 17 of the sites had chlorophyll *a* concentrations of <9.00 µg/L and five sites had concentrations <6.00 µg/L. The same picture was evident in RCAP 2003 as 21 sites received a fair rating, with 10 of those sites having chlorophyll *a* concentrations of <9.00 µg/L and nine sites with concentrations of <6.00 µg/L suggesting a modified scale for this region of Texas may be in order. Based on analysis of all chlorophyll *a* data collected for RCAP, the 75th percentile is 11.47 µg/L. The authors feel that perhaps the new scale should be <11.50 µg/L would be considered as good, 11.50 µg/L to 20.00 µg/L would be rated as fair, and >20.00 µg/L would be considered as poor.

Overall, the combined EPA Water Quality Index (not including the Water Clarity Index) ranked nine sites as good, 22 sites as fair, and one site as poor, with primarily a combination of DIP and chlorophyll *a* concentrations the justification for a fair ranking (see Table 3.4). EPA guidelines for NCCR II developed criteria for DIP and DIN as possible estimators of eutrophication. However, the utility of DIN as an estimator of possible eutrophication within the CBBEP region was judged questionable for RCAP 2002, as all DIN concentrations were <0.10 mg/L and did not correspond with high chlorophyll *a* concentrations. For RCAP 2003 high levels of DIN did correspond with high levels of chlorophyll *a* in Hynes Bay (Site 295) and relatively moderate levels at two sites (Sites 318 and 322) in the Baffin Bay Complex.

Regarding DIP comparisons, no clear association with high levels of chlorophyll *a* existed for RCAP 2002. Of the 13 sites rated as having poor DIP concentrations (>0.05 mg/L), five had low (good) concentrations of chlorophyll *a*, seven had moderate (fair) concentrations, and only one had poor (high) chlorophyll *a* concentrations. For RCAP 2003, of the eight sites having poor DIP concentrations one had low (good) concentrations of chlorophyll *a*, six had moderate (fair) concentrations and only one had poor (high) chlorophyll *a* concentrations. Of six sites listed as fair, only one site would have exceeded the TCEQ standard of 11.50 µg/L, with three sites having chlorophyll *a* concentrations <8.00 µg/L, two sites <10.00 µg/L, and one site was 12.80 µg/L.

Van Dolah et al. (2004) also questioned the effectiveness of DIN and DIP as indicators of high phytoplankton concentrations indicative of possible eutrophication for South Carolina sites monitored for the NCA program in 2001 and 2002. Additional data assessment of CBBEP and Texas coastal waters is clearly necessary and additional data may provide concentration ranges more applicable within our estuaries.

Currently, many water body segments in Texas are still undergoing assessment by the TCEQ TMDL group for bacteria impairments related to the Oyster Water Use (Fecal Coliform criteria). The continuation of bacteria sampling in RCAP 2003 provided data using the new criterion, enterococci, in the assessment of the Contact Recreation Use (CRU) for water within the CBBEP region. Analysis of RCAP 2003 data clearly indicates that for the sites sampled, based on the current CRU single sample criteria of 104 CFU/100ml, water quality regarding enterococci concentrations is very good throughout the CBBEP region.

As previously stated, the prevalence of trace metals in industrial and domestic processes and the extreme toxic nature of metal contamination require continued monitoring to protect all water bodies. As the impetus for the entire RCAP monitoring program stemmed from documented historical concerns, and the identification of insufficient and inadequate data with which to make accurate assessments, the results of this portion of the monitoring project continue to be excellent. The authors strongly feel that utilization of ultra-clean sampling and analysis techniques provides the highest quality data available and encourage their use in applicable monitoring programs. As these methods identified no aqueous metal concentrations exceeding chronic TCEQ 2000 Tidal Water Chronic criteria for RCAP 2003, the authors feel that water quality regarding trace metals in water is excellent throughout the region.

However, the authors recommend that if periodic sampling remains cost prohibitive for the entire RCAP area, limited routine sampling should continue in the Baffin Bay Complex (Segment 2492). Even though all sample concentrations fell below applicable criteria, the fact remains that elevated concentrations still look much like those found within, or in close proximity to, the Corpus Christi Inner Harbor. While it is common knowledge that several upstream industrial complexes have permitted discharges into creeks and streams that feed into the Baffin Bay Complex, this region is considered a remote, non-industrialized area. Further analysis of data for these reaches is required to determine if any patterns or sources are discernible and that concentrations continue to remain below acceptable criteria levels.

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4.0 SEDIMENT MONITORING

4.1 Introduction

Although natural processes may provide low-level environmental inputs of certain trace metals, anthropogenic activities affect the estuarine environment through the discharge of a wide variety of metal and organic substances, and environmental concerns always exist in estuaries regarding the potential for contamination of sediments with toxic chemicals (Nicolau and Nuñez 2004; Nicolau and Nuñez 2005). Therefore, sediment and biological monitoring constitute a major portion of RCAP by providing data for long-term status and trends analysis.

When contaminants enter estuarine systems, they bind to suspended particulates in the water column then settle out, or sink, to the underlying sediments. When found, most contaminants usually occur in elevated concentrations in the upper few centimeters of sediments. Sediments consisting of fine grains (Silt-Clay) or enriched with organic matter (Total Organic Carbon or TOC) may influence the degree of contamination. Concerns also exist regarding the possible re-suspension and transport of sediment contaminants across wide areas (Kennish 1992; GBEP 2002; USEPA 2004; SFEI 2004). As sediments also provide biological habitat, potential effects may result when benthic deposit-feeding organisms ingest sediment particles. While not all sediment contaminants are biologically available, some have the potential to yield possibly harmful effects to humans through bioaccumulation and possible biomagnification through the food web (Kennish 1992).

Therefore, regulatory agencies, and informed citizens, consider contaminated sediments as a primary indicator reflecting poor conditions in a water body. Researchers, resource managers, and regulatory officials utilize a multitude of methodologies for assessing coastal sediments, which often yield differing results so the need for accurate, reliable, and substantial amounts of data, utilizing multiple evaluation techniques, is necessary to make informed decisions that will help to protect and enhance the estuarine environment of the CBBEP region.

4.2 Sampling Design and Data Evaluation

Sediment sampling for RCAP 2003 took place from July 27th through August 20th 2003 at 32 randomly selected sites throughout the CBBEP region as described in Chapter 2.0. Table 6.1.1 in the *Data Tables* chapter and Fig. 2.2 provide site information and location.

RCAP 2003 sediment contaminant analysis consisted of 15 trace metals, 20 Polychlorinated Biphenyls (PCBs), 6 DDT metabolites and 13 chlorinated pesticides other than DDT, and 23 Polycyclic Aromatic Hydrocarbons (PAHs) (Table 2.1). The *Data Tables* in Chapter 6.0 provide actual concentration values for each contaminant recorded at an individual site location (Metals-Table 6.8.1; PCB–Table 6.10.1; DDT-Table 6.10.2; Chlorinated Pesticides–Table 6.10.3; PAHs–Table 6.10.4) and summary descriptive results for metals in sediments for each TCEQ Segment (Table 6.9.1 through 6.9.6).

Data analysis and evaluation utilized all, or a subset, of contaminants and employed three different methods: 1) the TCEQ Sediment Quality Screening Level regulatory approach, 2) according to guidelines utilized in the EPA NCCR II (USEPA 2004), and 3) the Sediment Contaminant Distribution approach utilizing the Sediment Quality Guideline Quotient (SQGQ) method with Factor Analysis.

4.2.1. TCEQ Sediment Quality Screening Levels

Currently, regulatory criteria still does not exist for the majority of sediment contaminants. However, TCEQ continues to employ sediment-screening levels to assess *Secondary Concerns*; previously defined as parameters for which no adopted standard exists that exhibit elevated concentrations exceeding these screening levels.

Screening levels established by TCEQ utilize long-term data based on the 85th percentiles of all TCEQ Surface Water Quality Monitoring (SWQM) data and the Probable Effects Level (PEL) guidelines developed by NOAA through its National Status and Trends Program. TCEQ revises the sediment 85th percentiles on an annual basis while NOAA sediment guidelines derive from a multitude of nationwide datasets of sediment contamination and corresponding biological effects compiled by Long et al. (1995). A *Secondary Concern* is identified by TCEQ if the 85th percentiles and PELs are exceeded greater than 25% of the time based on the number of exceedances for a given sample size (TCEQ 2003).

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	*Rare* adverse effects observed
Effects Range Low	ERL	Effects begin to occur in sensitive species
Probable Effects Level	PEL	*Frequent* adverse effects observed
Effects Range-Median	ERM	Median concentration of the compiled toxic data

4.2.2. EPA NCCR II Sediment Quality Index

Evaluation of RCAP 2003 sediment data used the EPA NCCR II guidelines for assessing individual sites (Table 4.1) to provide continuity between locally collected data and the ongoing EMAP-NCA program for assessing coastal waters and to see if the broad based EPA regional approach is applicable in all estuarine systems. The EPA Sediment Quality Index (SQI) utilizes a combined approach (Sediment TOC, Sediment Contaminants, and Sediment Toxicity) to assess sediment conditions, with sediment toxicity from organic matter enrichment assessed by measuring TOC, and Sediment Contaminants assessed in relation to ERL and ERM values as previously defined in Section 4.2.1 and listed in Table 4.2.

4.2.2.1. Sediment Toxicity Test Methods

Sediment toxicity analysis followed EPA procedures for ten-day solid phase tests conducted with the amphipod, *Ampelisca abdita*, with test organisms collected from Dillon Beach, California (USEPA 1995). Tests were conducted at 20°C and water quality in the test chambers was measured periodically. Salinity was maintained at 30±3 PSU, by addition of deionized water if necessary. Total ammonia concentrations were measured on days 1, 4 and 10 of the experiments, and pH was measured daily. Total ammonia (expressed as nitrogen), pH, salinity and temperature data were used to calculate the concentrations of unionized ammonia (NH_3). Twenty animals were added to each experimental chamber at test start. Test sediments were sieved after 10-day exposure and the number live amphipods was counted.

Three toxicity test series were performed as sediments were collected and arrived at the laboratory. Each batch of sediments included a duplicate sample for one of the sites, and reference and control sediments were used concurrently to each test. Christmas Bay, Galveston Island, TX, was used as a reference site and the sediment from the organisms' collection site (Dillon Beach, CA) was used as control. In addition, 96-h reference toxicant tests using potassium chloride (KCl) in aqueous phase were conducted periodically during the experimental period with *A. abdita*. Results of the reference toxicant tests performed were used to prepare a control chart (Environment Canada 1990).

Toxicity tests with three sediment samples (Sites 298, 304, and 306) were also performed using the amphipod *Leptocheirus plumulosus*, for comparison of sensitivity with *A. abdita*. The same reference sediment from Christmas Bay was used in this test, and the control consisted of the sediment in which the animals were cultured. Whereas *A. abdita* constructs tubes that tend to stay intact when sieved, *L. plumulosus* builds U-shaped burrows in the sediment, which have little cohesive structure to them and tend to disintegrate when the sediment is sieved (DeWitt et al. 1992).

Table 4.1. EPA NCA guidelines for assessing Sediment TOC (% dry weight), Sediment Toxicity, and Sediment Contaminants for determining the Sediment Quality Index (SQI), by site (USEPA 2004).

Rating		TOC (% dry weight) Guidelines
Good (Low)	(green)	TOC concentration <2.0%.
Fair (Moderate)	(yellow)	TOC concentration between 2.0% and 5.0%.
Poor (High)	(red)	TOC concentration >5.0%.
Rating		**Sediment Toxicity Guidelines**
Good	(green)	The amphipod survival rate is greater than or equal to 80%.
Poor	(red)	The amphipod survival rate is less than 80%.
Rating		**Sediment Contaminant Guidelines**
Good	(green)	No ERM concentrations are exceeded, and less than five ERL concentrations are exceeded.
Fair	(yellow)	Five or more ERL concentrations are exceeded.
Poor	(red)	An ERM concentration is exceeded for one or more contaminants.
Rating		**Sediment Quality Index (SQI) Guidelines**
Good	(green)	None of the individual components are poor, and sediment contaminants indicator is good.
Fair	(yellow)	No measures are poor, and the sediment contaminants indicator is fair.
Poor	(red)	One or more of the of the component indicators is poor.

Table 4.2. List of metal concentrations in parts per million (ppm) and organic contaminant concentrations in parts per billion (ppb) along with corresponding ERL and ERM, values used in the NCCR II analysis and the PEL values used in SQGQ analysis.

Metals (ppm)	ERL	ERM	PEL
Arsenic	8.2	70.0	41.60
Cadmium	1.2	9.6	4.21
Chromium	81.0	370.0	160.40
Copper	34.0	270.0	108.20
Lead	46.7	218.0	112.18
Mercury	0.15	0.71	0.70
Nickel	20.9	51.6	42.4
Silver	1.0	3.7	1.77
Zinc	150	410.0	271.00
Organics (ppb)			
Acenaphthene	16.0	500.0	88.90
Acenapthylene	44.0	640.0	127.87
Anthracene	85.3	1,100.0	245.00
Flourene	19.0	540.0	144.35
2-Methyl naphthalene	70.0	670.0	201.00
Napthalene	160.0	2,100.0	390.64
Phenanthrene	240.0	1,500.0	543.53
Benz(a)anthracene	261.0	1,600.0	692.53
Benzo(a)pyrene	430.0	1,600.0	763.22
Chrysene	384.0	2,800.0	845.98
Dibenzo(a,h)anthracene	63.4	260.0	1,34.61
Fluoranthene	600.0	5,100.0	1,493.54
Pyrene	665.0	2,600.0	1,397.60
Low molecular weight PAH*	552.0	3,160.0	1,442.00
High molecular weight PAH**	1,700.0	9,600.0	6,676.14
Total PAH	4,020.0	44,800.0	16,770.40
4,4'-DDE	2.2	27.0	374.00
Total DDT	1.6	46.1	51.70
Total PCBs	22.7	180.0	188.79

*Low Molecular weight: acenaphthene, acenapthylene, anthracene, flourene, naphthalene, phenanthrene

**High Molecular weight: benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, pyrene

One-tailed paired T-tests were run among duplicate samples. If duplicates were not significantly different (p=0.05), the sample named as duplicate was removed from the dataset. Using this criterion, no pair of duplicates was kept in the dataset. A GLM (general linear model) and Duncan test were run with all controls and all references separately. No significant differences were detected among the four controls or among the four reference samples from the four different sets of experiments. A GLM and Duncan test run with all controls and references combined indicated significant difference among some of the controls and references. Therefore, further comparisons were done separately for each test date.

Data from each test, analyzed for normality and homogeneity of variances, used SAS/LAB® Software (SAS 1992). The datasets from samples analyzed for toxicity on August 27^{th} 2003 did not meet the homogeneity of variances assumption and were, therefore, square root transformed prior to further analyses. No transformation took place on the remaining datasets. Statistical comparisons among treatments used ANOVA and Dunnett's one-tailed t-test (which controls the experimentwise error rate) performed with SAS (SAS 1989). Dunnett's comparisons occurred separately towards the performance control (Dillon Beach, California) and reference (Christmas Bay, Galveston Island, Texas) samples as two different datasets. Differences from both control and reference samples required analysis at $\alpha = 0.05$ and 0.01, and a minimum significant difference (MSD) from the control of 15% supplied an additional criterion (Thursby et al. 1997).

A Spearman correlation analysis took place between amphipod survival data and concentrations of all measured chemicals above detection limits in at least one sample, Total Organic Carbon (TOC) and sediment grain size distribution. PCB data for the correlation analysis required reduction to Total PCBs and all concentrations below detection limits equaled zero for the correlation analysis. Correlations between Silt-Clay and sediment chemistry were also analyzed. Application of a Bonferroni adjustment for analysis of significance of correlations used the following formula: p/√# variables, where p = 0.05 or 0.01 and # variables = 43. Correlations with a Bonferroni adjusted $p \leq 0.0076$ or 0.0015 were significant at 5 and 1% levels, respectively.

4.2.3. Sediment Contaminant Distribution

RCAP 2003 sediment contaminant characterization utilized both Sediment Quality Guideline Quotient (SQGQ) and factor analysis in order to determine the Sediment Contaminant Distribution (SCD) for the region. The purpose of this method is to identify the distribution patterns of the sediment contaminant and associated loadings within the CBBEP.

The SQGQ is a method increasingly utilized to quantify potentially harmful mixtures of contaminants present in varying concentrations (Hyland et al. 1999). The purpose of this method is to identify sites that may not necessarily have individual contaminant exceedances, but could cumulatively have concentrations that may negatively affect the biota of the system. This approach follows methods described in Long et al. (2003) and incorporates multiple RCAP 2003 contaminants also used in EPA NCCR II sediment assessments (Table 4.2). Calculating the SQGQ for each individual site involved first obtaining the ratio for each contaminant variable by dividing the variable concentration by its respective PEL (Texas screening value), then summing up the individual quotients and dividing by the total number of contaminant variables to arrive at a final collective quotient.

RCAP 2002 acted as the "baseline" year for determining the three SQGQ categories used for future RCAP sampling events. For RCAP 2002 the upper and lower bound of the 95% Confidence Interval (CI) resulted in SQGQ breaks occurring at 0.029 for the lower bound CI and 0.045 for the upper bound CI. However, due to the relatively low contaminant concentrations seen at most RCAP 2002 sites, those sites with contaminants above the 85^{th} percentile were not observed until SQGQ values were above the Upper Bound CI. This resulted in characterizing sites with SQGQ values above the Upper Bound CI as "Moderately" contaminated and sites below the Upper Bound CI as exhibiting "Low" contamination. Site 258 in RCAP 2002 was the only extreme outlier identified and was characterized with "High" sediment contamination.

Factor analysis, using Varimax rotation, aided in identifying what components were potentially responsible for elevated SQGQs (i.e. metals, PAH's, pesticides, etc.). This is a data reduction technique, which consolidates and transforms data sharing similar characteristics into a new variable. The newly generated data matrix contains variables, which are orthogonal (i.e. non-correlating or covarying) and ordered in decreasing variance (Long et al. 2003). Varimax rotation maximizes the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix. This has the effect of differentiating the original variables by extracted factor by minimizing the number of variables that have high loadings on any one given factor. A Varimax solution yields results that make it as easy as possible to identify each variable with a single factor.

4.2.4. Benthic Community

Benthic analysis included common measures of community composition such as richness, density, biomass, and diversity. In addition, benthic community evaluation utilized the EPA Benthic Condition Index (EPA-BCI) for Gulf of Mexico Estuaries (Engle and Summers 1999) according to the guidelines in Table 4.3. Development of the index aids in assessing the health of the macrobenthic community. The purpose of the index is to reflect conditions of both water and sediment quality and serves as an independent variable used for the assessment of estuarine condition by EPA in NCCR II. If calculated correctly, a poor benthic condition should often co-occur with poor sediment or water quality (USEPA 2004). Community characterizations also included mean community measures for TCEQ designated segments and benthic community assemblages.

Table 4.3. EPA NCA guidelines for determining the Benthic Index (Gulf Coast), by site (USEPA 2004).

Rating		Benthic Index (Gulf Coast) Guidelines
Good	(green)	Benthic Index score is >5.0
Fair	(yellow)	Benthic Index score is between 3.0 and 5.0
Poor	(red)	Benthic Index score is <3.0

Identification of benthic community assemblages utilized the PRIMER v5.0 (Plymouth Routines in Multivariate Ecological Research) software program developed by Clark and Warwick (2001). Community characterization begins with the Bray-Curtis Similarity Matrix, which replaces the original data with pairwise similarity coefficients that reflect aspects of similarity (species composition and densities) in a community. Delineation of Benthic Assemblages and Species Groups from this matrix incorporated hierarchical clustering and the ordination technique referred to as Non-metric Multidimensional Scaling (MDS). The two techniques are then compared in order to cross check for adequacy and mutual consistency of both representations.

Cluster analysis aims to find the "natural groupings" of sites by describing the patterns of occurrences of each species across a given set of samples with a dendrogram constructed for graphic illustration of the clustering. MDS constructs a configuration of the samples in an attempt to satisfy all the conditions imposed by the rank similarity matrix (Clark and Warwick, 2001).

The BIOENV procedure identified factors distinguishing Benthic Assemblages from each other. This program selects the environmental variables that best explain community patterns, by maximizing the rank correlation between biological (Bray-Curtis Similarity Matrix) and physiochemical (Euclidean Similarity Matrix) similarity matrices (Clarke and Warwick 2001). The SIMPER procedure identified the top contributing species for both the TCEQ Segments and the Benthic Assemblages. This procedure indicates which species are responsible for the observed clustering pattern (Benthic Assemblage), or the differences between sets of samples defined *a priori* (TCEQ Segments) (Clarke and Warwick 2001).

4.3 Results and Discussion

4.3.1. Sediment Characteristics

Total Organic Carbon (TOC) is one of three components (TOC, Sediment Toxicity, and Sediment Contaminants) utilized by EPA in assessing estuarine sediment quality for the National Coastal Condition Report (USEPA 2004). TOC provides a relative measure of organic matter contained in sediments and typically, elevated TOC percentages are associated with sediments high in slit/clay content. Unlike RCAP 2002, no correlation existed between TOC and Silt-Clay content for sites sampled in RCAP 2003.

TOC concentrations ranged from the lowest TOC values of <0.10% at Site 313 in Oso Bay (Segment 2485) and Sites 303 and 305 in Aransas Bay (Segment 2471) to a high of 2.74% at Site 322 in the Baffin Bay Complex (Segment 2492) (Fig. 4.1; Fig. 4.2; Table 6.8.1). As in RCAP 2002, the lowest mean TOC enrichment per segment value of 0.03% occurred in Oso Bay (Segment 2485) (Table 6.9.1). While several sites exhibited moderate enrichment, unlike RCAP 2002, no Segment in RCAP 2003 was characterized as moderately enriched, as all mean Segment values were <2.0% (Table 4.4; Table 6.9.1). The CBBEP region rates as very good concerning TOC enrichment as the overall mean TOC concentration for the 32 sites sampled in RCAP 2003 was 0.95%.

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 expected with a randomized sampling design, considerable variability occurred in most Segments (Fig. 4.3; Fig 4.4).

For RCAP 2003, individual Silt-Clay proportions ranged from 4.98% to 98.69% (Fig. 4.3; Fig. 4.4; Table 6.8.1).While Corpus Christ Bay (Segment 2481) had the greatest number of sites (Table 4.4) characterized with mud (>75% Silt-Clay), Copano Bay/Port Bay/Mission Bay (Segment 2472) had the highest mud content percentages (>93%) (Table 6.8.1). Aransas Bay (Segment 2471) had the greatest number of sites characterized as muddy sand (50% - 75% Silt-Clay) and the Upper Laguna Madre (Segment 2491) contained the greatest number of sites characterized with a low Silt-Clay content (<25%) (Table 4.4). Mean Silt-Clay proportions for Segments ranged from 4.98% to 96.32% with highest and lowest mean values recorded in Copano Bay and the Upper Laguna Madre, respectively (Table 6.9.1).

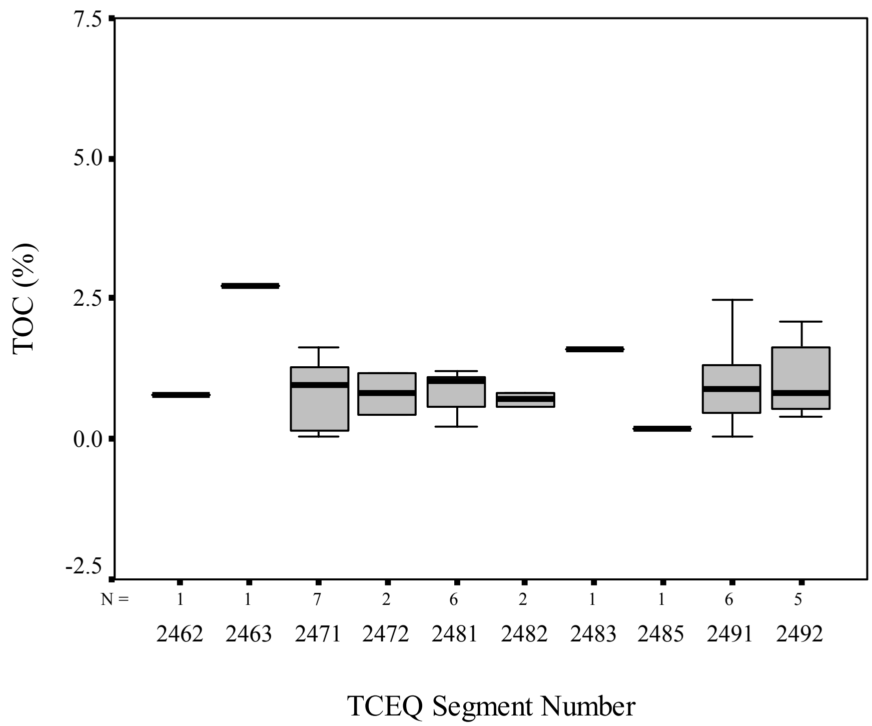


Fig. 4.1. Box and whisker plots of TOC (%) for TCEQ segments during RCAP 2003. Boxes are interquartile ranges; horizontal lines within boxes are medians; whisker endpoints are high and low extremes.

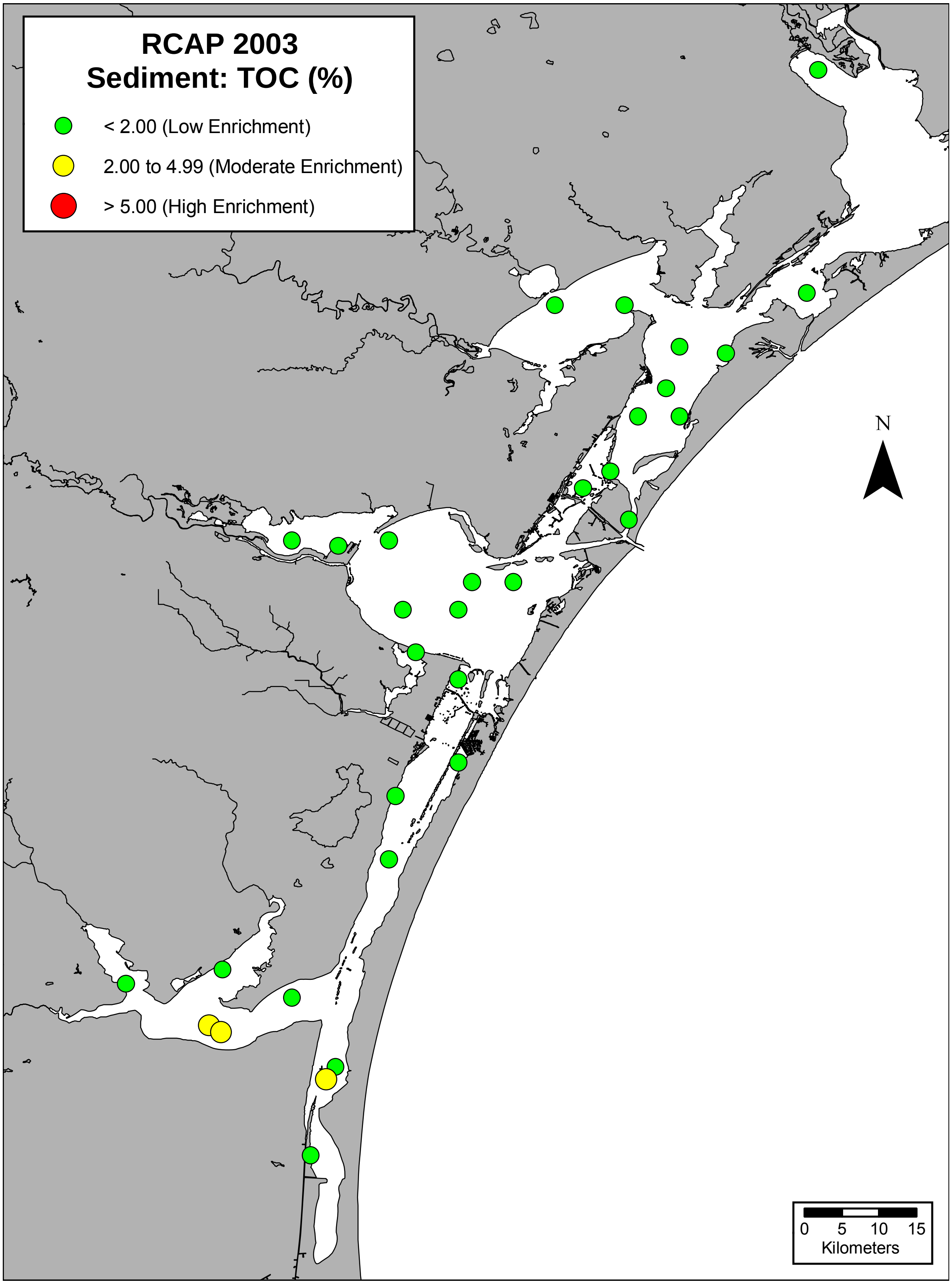


Fig. 4.2. Total Organic Carbon sediment concentrations (% dry weight) for RCAP 2003 sampling sites.

Table 4.4. Sediment characteristics distribution listing total number of sampling sites within TCEQ designated Segments and number of sites associated with % TOC and % Silt-Clay categories.

Segment	Segment Name	n	% TOC			% Silt-Clay			
			<2% (Low)	2% - 5% (Mod)	>5% (High)	<25% (Sand)	25% – 50% (Sand-Mud)	50% – 75% (Mud-Sand)	>75% (Mud)
2462	San Antonio/Hynes/ Guadalupe Bay	1	1	-	-	-	-	-	1
2463	Mesquite/Carlos/Ayers Bay	1	1	-	-	-	1	-	-
2471	Aransas Bay	7	7	-	-	3	-	3	1
2472	Copano Bay/Port Bay/ Mission Bay	2	2	-	-		-	-	2
2481	Corpus Christi Bay	6	6	-	-	1	1	1	3
2482	Nueces Bay	2	2	-	-	1	-	-	1
2483	Redfish Bay	1	1	-	-	1	-	-	-
2485	Oso Bay	1	1	-	-	1	-	-	-
2491	Laguna Madre	6	5	1	-	5	-	1	-
2492	Baffin Bay/Alazan Bay/ Cayo del Grullo/Laguna Salada	5	3	2	-	-	1	1	3

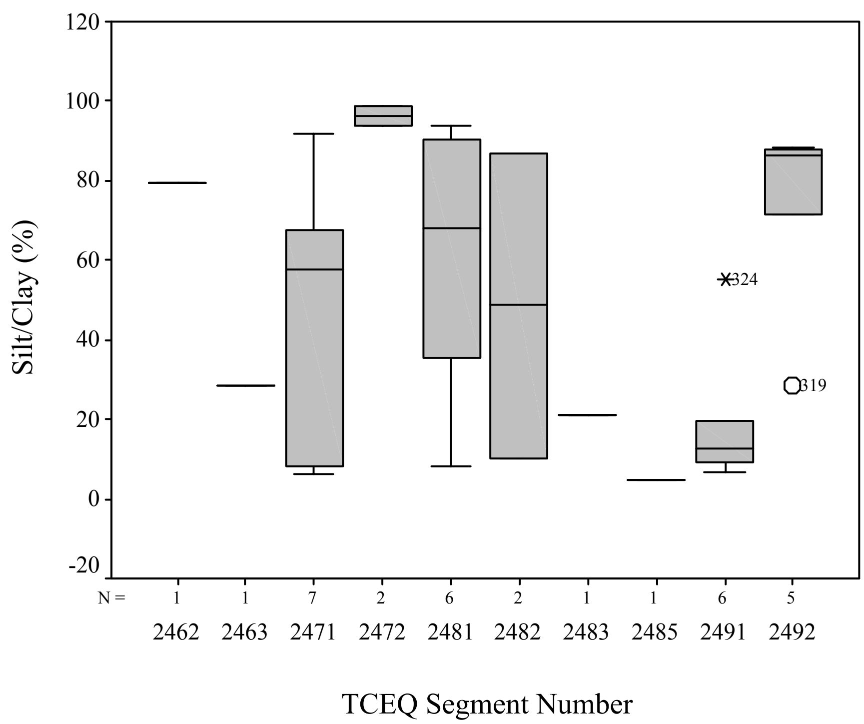


Fig. 4.3. Box and whisker plots of Silt-Clay (%) for TCEQ segments during RCAP 2003. Boxes are interquartile ranges; horizontal lines within boxes are medians; whisker endpoints are high and low extremes.

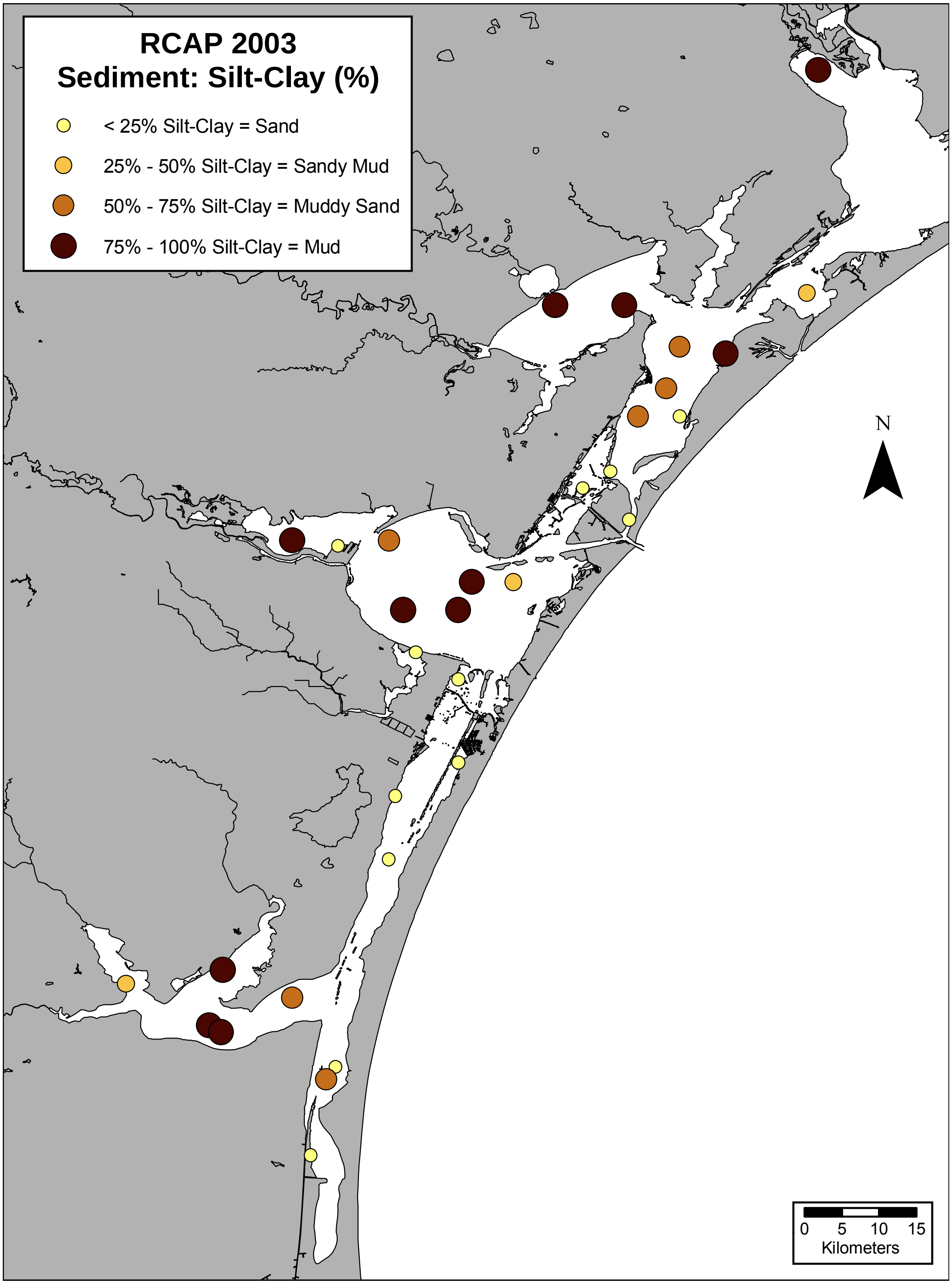


Fig. 4.4. Silt-Clay sediment concentrations for RCAP 2003 sampling sites.

4.3.2. TCEQ Sediment Quality Screening Levels

As previously stated, a *Secondary Concern* is identified by TCEQ if the 85th percentiles and PELs are exceeded greater than 25% of the time based on the number of exceedances for a given sample size (TCEQ 2003). Table 4.5 lists RCAP 2003 sites whose contaminant concentrations exceeded the 85th percentile and/or PEL levels, along with sites above the Threshold Effects Levels (TEL). While TCEQ does not use concentrations above TEL values in identifying *Secondary Concerns*, TEL values aid in providing a baseline reference indicating that possible harmful concentrations may be occurring.

TCEQ requires a minimum of 10 samples within a Segment in order to apply the 25% temporal exceedance of the screening level necessary to justify a *Secondary Concern*. While not applicable to this one-time sampling event, as no Segment had 10 sites sampled, no Segment had *Secondary Concerns* based on exceedances of the 85th percentiles and PELs. Unlike RCAP 2002, no sites had concentrations above respective PEL values. However, some minor concerns may exist as cadmium, chromium, and zinc had concentrations above TCEQ 85th percentile screening levels. These metals also had concentrations above the 85th percentiles during RCAP 2002. In addition mercury, 4,4'-DDE and total DDT had concentrations above TEL screening levels during both this and the RCAP 2002 study.

Table 4.5. RCAP 2003 sampling sites with sediment contaminants exceeding respective screening levels..

	Contaminant	Screening Level	Site (s)
Metals	Arsenic	TEL	296, 297, 301, 306, 309, 312, 321 322
	Cadmium	85th Percentile	307
	Chromium	TEL and/or 85th Percentile	296, 297, 300, 301, 302, 309, 312, 318, 321, 322,
	Mercury	TEL	307
	Zinc	85th Percentile	307, 312
Organics	4,4'-DDE	TEL	306, 313
	Total DDT	TEL	306

4.3.3. EPA NCCR II Sediment Quality Index

Following the NCCR II assessment guidelines (Table 4.1) for RCAP 2003 produced no sites with poor sediment quality due to TOC enrichment or sediment contaminants based on ERL and ERM exceedances. However, eight sites in five Segments had poor sediment quality due to the expression of toxic effects (Fig 4.5, Table 4.6).

Amphipod (*Ampelisca abdita*) survival in sediments collected for RCAP 2003 ranged from 63% to 93%, with control and reference sediment survival ranging from 90% to 94% and 72% to 87%, respectively, in the three experiments performed (Table 6.11.1). Survival was only significantly different from reference sediments in two samples (Sites 315 and 316) located in the Upper Laguna Madre (Segment 2491) at $\alpha = 0.05$, but not at $\alpha = 0.01$. Please note that EPA criteria for toxic determination only applies if significantly different from control and not reference sediment. Both samples were also described as having a large amount of debris, which made survival counts difficult.

Similar to RCAP 2002 experiments, a larger number of samples had significantly lower survival than the control at $\alpha = 0.05$. Those sites included Site 326 in Mesquite Bay (segment 2463), Sites 298 and 300 in Aransas Bay (Segment 2471), Site 297 in Copano/Mission/Port Bay (Segment 2472), Site 304 in Redfish Bay (Segment 2483), and Sites 315, 316, and 325 in the Upper Laguna Madre (Segment 2491) (Fig. 4.5; Table 6.11.1). Of those, samples Sites 297, 298, 315 and 316 were also significantly different from the control at $\alpha = 0.01$.

None of the sediment samples from Sites 298, 304 and 306 tested with *Leptocheirus plumulosus* was toxic to this species. The reason for the discrepancy of toxicity results between the species is not clear. It does not seem to be related to grain size distribution, since the three samples tested with *L. plumulosus* covered a broad range of grain sizes, with 36% gravel and only 21% Silt-Clay in the sample from Site 304 and 64% and 87% of Silt-Clay in samples from Sites 298 and 306, respectively (Table 6.8.1). *A. abdita*, which exhibited significantly elevated mortality in samples from Sites 304 and 306, had high survival in several other sediment samples with similar grain size distribution.

As seen in RCAP 2002, the northern end of Upper Laguna Madre exhibited some of the strongest effects, with 63% amphipod survival at Site 315 and 69% at Site 316. Sites 297 and 298, in Copano Bay and northern Aransas Bay, respectively, were also responsible for some of the strongest effects, both with 68% amphipod survival (Fig. 4.5; Table 6.11.1). Milder effects, significant at $\alpha = 0.05$, were exhibited in some sites in Mesquite Bay, mid Aransas Bay, Redfish Bay, and the southern end of the Upper Laguna Madre (Sites 326, 300, 304 and 325, respectively).

The pH of the overlying water in all *A. abdita* toxicity tests, measured on days 0 through 10, ranged from 7.9 to 8.4. The unionized ammonia (NH_3 - as ammonia N) levels in the reference samples were among the highest measured on day 10, ranging from 35.5 to 59.1 µg/L in the three different experiments (Table 6.11.1). Ammonia reached higher levels than the reference on day 10 in samples from Sites 315, 316, 321, 322 and 324, with concentrations ranging from 92 to 167 µg/L. Amphipod mortality in samples from Sites 315 and 316 was higher than in their respective reference, but this cannot be attributed to ammonia alone, since samples from Sites 321 and 322 had even higher concentrations of unionized ammonia (Table 6.11.1) and exhibited elevated survival. Kohn et al. (1994) found a 96-h LC50 of 830 µg NH_3/L for *A. abdita* in aqueous phase tests. Therefore, ammonia is unlikely to be responsible for the toxicity observed in any of the samples from this study, although it is cannot be ruled out as a potential contributing factor for amphipod mortality in samples from Sites 315 and 316.

Reference toxicant tests conducted with KCl in aqueous phase during the experimental seasons of RCAP 2002 and RCAP 2003 resulted in 96-h LC50 values ranging from 534 to 1120 mg/L. All tests had overlapping 95% confidence intervals, indicating that there was no significant difference among the LC50 values (Reish and Oshida 1987). LC50 values from tests conducted in both years were within the acceptable limits established by a control chart (Environment Canada 1990).

None of the 32 tested sediments had concentrations of any of the measured chemicals above the Effects Range Median (ERM) and/or the Probable Effect Level (PEL) (NOAA 1999) (see Table 4.2) which represent concentrations above which adverse biological effects are expected to occur frequently (Long et al. 1995; MacDonald et al. 1996). A few chemicals, in a few sediments, exhibited concentrations between the Effects Range Low (ERL) and ERM, and/or between the threshold effect level (TEL) and PEL, which represent the range at which adverse effects are possible but only expected to occur occasionally. However, the only toxic sediment with any chemical above TEL and ERL was the sample from Site 297 in Copano Bay (Segment 2472), with only slightly elevated arsenic.

Grain size distribution and organic matter content does not seem to explain the observed *A. abdita* mortality either: total organic carbon (TOC) in the sediments that caused an adverse effect ranged from 0.44% to 1.63%; percent gravel ranged from 0% to 36%, sand from 6% to 83%, and fine particles (Silt-Clay) from 9% to 94% (Table 6.8.1). There were several samples, which exhibited elevated *A. abdita* survival in this same range of natural sediment features, with the exception of the amount of gravel in the sample from Site 304, which may have either contributed to *A. abdita* mortality in that sample or prevented accurate counts of amphipods at test termination.

Significant positive Spearman rank correlations were identified between metals, except silver and selenium, and silt and clay (Table 6.11.2), but no significant correlations occurred between *A. abdita* survival and sediment chemistry, organic matter content, or grain size distribution. While concentrations of some contaminants (measured or unmeasured), grain size distribution and confounding factors (e.g., ammonia), may have contributed to adverse effects in one or more samples, overall, and as seen in RCAP 2002, toxicity tests performed with sediments from RCAP 2003 did not discern any straightforward cause-effect relationships.

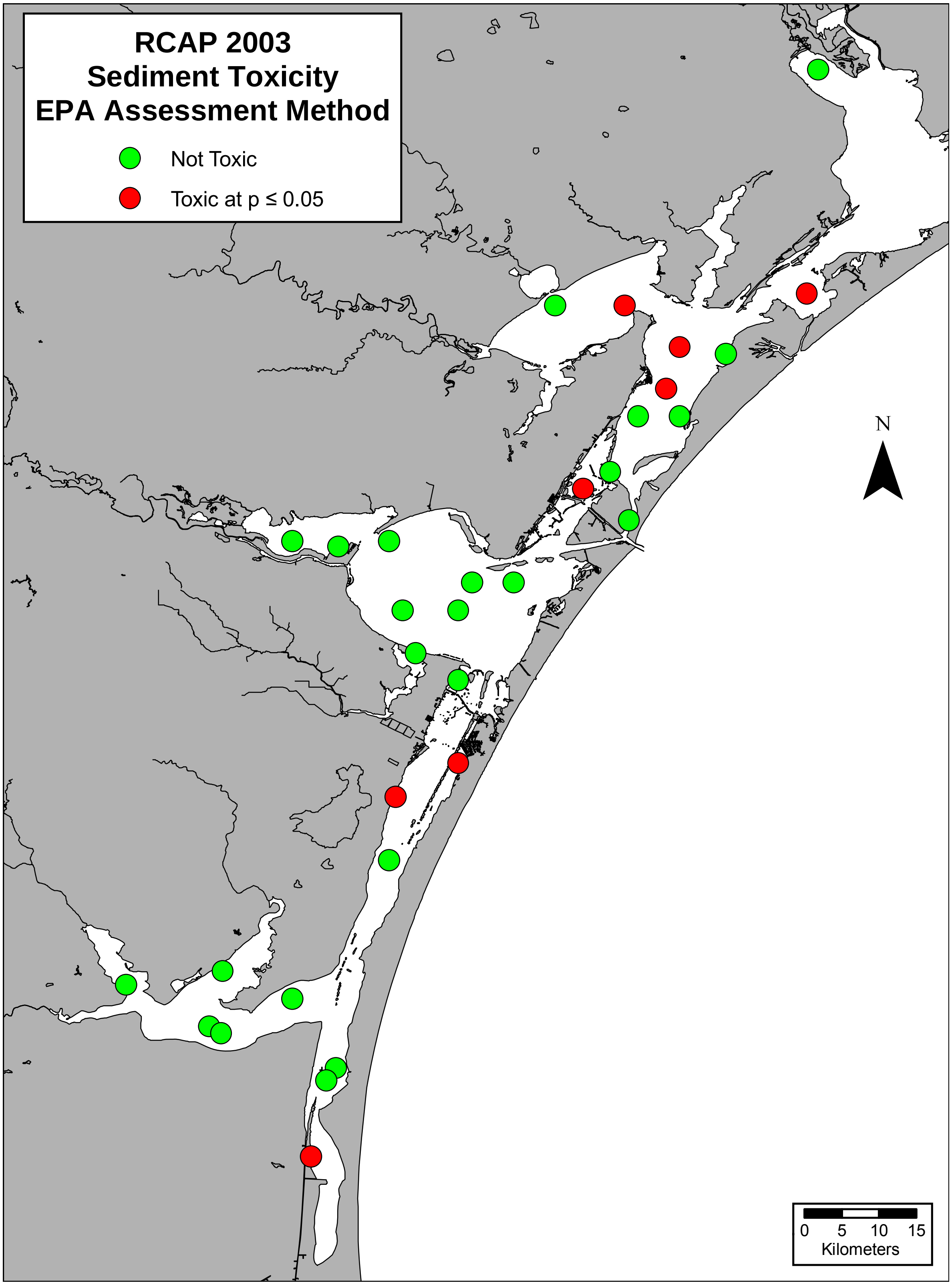


Fig. 4.5. RCAP 2003 sampling sites exhibiting toxic effects based on EPA assessment methods.

Table 4.6. Results of individual parameter and combined EPA Sediment Quality Index (SQI) by site for RCAP 2003, as defined by guidelines in Table 4.1.

Segment *	Site	TOC	Sediment Toxicity	Sediment Contaminant	EPA SQI
2462	295	[green]	[green]	[green]	[green]
2463	326	[green]	[red]	[green]	[red]
2471	298	[green]	[red]	[green]	[red]
2471	299	[green]	[green]	[green]	[green]
2471	300	[green]	[red]	[green]	[red]
2471	301	[green]	[green]	[green]	[green]
2471	302	[green]	[green]	[green]	[green]
2471	303	[green]	[green]	[green]	[green]
2471	305	[green]	[green]	[green]	[green]
2472	296	[green]	[green]	[green]	[green]
2472	297	[green]	[red]	[green]	[red]
2481	307	[green]	[green]	[green]	[green]
2482	306	[green]	[green]	[green]	[green]
2482	308	[green]	[green]	[green]	[green]
2482	309	[green]	[green]	[green]	[green]
2482	310	[green]	[green]	[green]	[green]
2482	311	[green]	[green]	[green]	[green]
2482	312	[green]	[green]	[green]	[green]
2482	314	[green]	[green]	[green]	[green]
2483	304	[green]	[red]	[green]	[red]
2485	313	[green]	[green]	[green]	[green]
2491	315	[green]	[red]	[green]	[red]
2491	316	[green]	[red]	[green]	[red]
2491	317	[green]	[green]	[green]	[green]
2491	323	[green]	[green]	[green]	[green]
2491	324	[yellow]	[green]	[green]	[green]
2491	325	[green]	[red]	[green]	[red]
2492	318	[green]	[green]	[green]	[green]
2492	319	[green]	[green]	[green]	[green]
2492	320	[green]	[green]	[green]	[green]
2492	321	[yellow]	[green]	[green]	[green]
2492	322	[yellow]	[green]	[green]	[green]

* 2462 (San Antonio Bay/Hynes Bay/Guadalupe Bay), 2463 (Mesquite Bay/Carlos Bay/Ayers Bay), 2471 (Aransas Bay), 2472 (Copano Bay/Port Bay/Mission Bay), 2481 (Corpus Christi Bay), 2482 (Nueces Bay), 2483 (Redfish Bay), 2485 (Oso Bay), 2491 (Laguna Madre), 2492 (Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada).

4.3.4. Sediment Contaminant Distribution

As seen in RCAP 2002, sediment contamination throughout the region was generally low for sites sampled in RCAP 2003. SQGQ analysis for RCAP 2003 incorporated the same subset of contaminants analyzed for RCAP 2002. The subset consisted of the 28 contaminants (see Table 4.2) used in the EPA NCCR II sediment contaminant assessment (see guidelines in Table 4.1) (EPA 2004). As previously stated, calculating the SQGQ sites involved first obtaining the ratio for each of the 28 contaminants at a site by dividing the variable concentration by its respective PEL value, then summing up the individual quotients and dividing by 28 to arrive at a final collective quotient for that site.

For RCAP 2003, individual SQGQ site values ranged from 0.006 to 0.059 with a mean of 0.031. The highest individual quotient value occurred at Site 312 in Corpus Christi Bay (Segment 2481) and the lowest at Site 303 in Aransas Bay (Segment 2471). Overall, higher individual SQGQ values occurred at sites located in Copano Bay (Segment 2472).

Mean SQGQ values within TCEQ segments ranged from 0.014 and 0.056 (Table 4.7) with four segments only represented by one site. In those instances, we reported the individual SQGQ value for that site as the mean in Table 4.7. As found in RCAP 2002 data analysis, for RCAP 2003 the highest mean SQGQ value was in Copano Bay (Segment 2474) and the lowest in the Upper Laguna Madre (Segment 2491). However, mean values recorded in RCAP 2003 were lower for all segments than RCAP 2002. Box-plots in Fig. 4.6 indicate the variability seen within some segments.

Table 4.7. Mean SQGQ values for TCEQ designated segments during the RCAP 2003.

Segment	Segment Name	n	Min	Max	Mean
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.024
2463	Mesquite Bay/Carlos Bay/ Ayers Bay	1	-	-	0.022
2471	Aransas Bay	7	0.006	0.050	0027
2472	Copano Bay/Port Bay/Mission Bay	2	0.055	0.057	0.056
2481	Corpus Christi Bay	6	0.011	0.059	0.042
2482	Nueces Bay	2	0.015	0.058	0.037
2483	Redfish Bay	1	-	-	0.018
2485	Oso Bay	1	-	-	0.013
2491	Laguna Madre	6	0.007	0.029	0.014
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.010	0.053	0.037

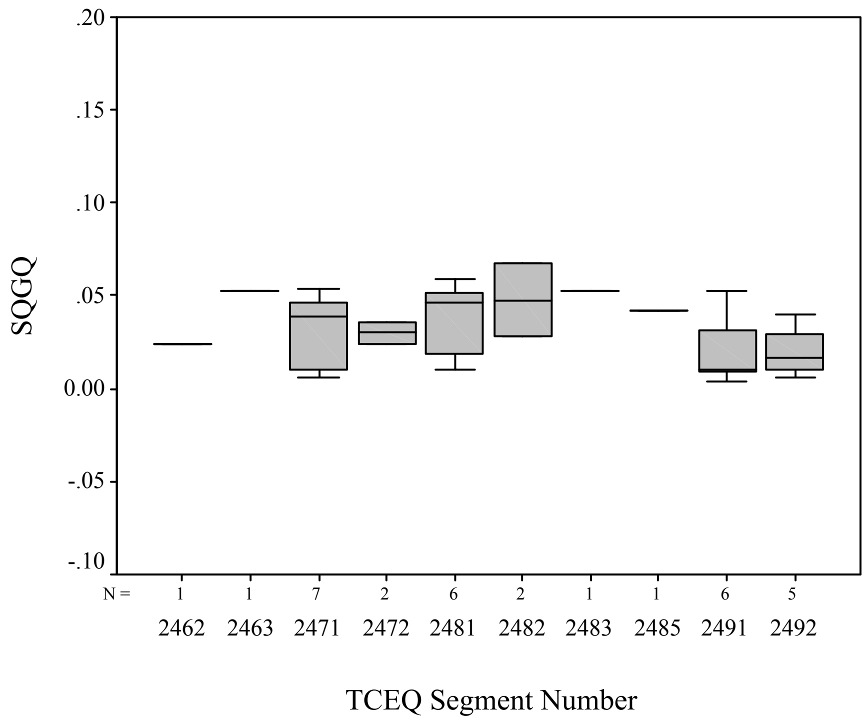


Fig. 4.6. Box and whisker plots of SQGQ values for TCEQ segments during RCAP 2003. Boxes are interquartile ranges; horizontal lines within boxes are medians; whisker endpoints are high and low extremes.

Factor analysis identified the variables primarily contributing to sediment loadings. Prior to analysis, 23 PAHs, 20 PCB's, 6 DDT metabolites and 13 Chlorinated Pesticides were reduced to four variables consisting of Total PAHs, Total PCB's, Total DDT's, and Total Chlorinated Pesticides. These variables, along with nine of the 15 metals (see Table 4.2), and the abiotic factors TOC, Sand, Silt-Clay, Salinity, and Dissolved Oxygen (DO) were combined into one data matrix.

Characterization of the sediment through ordination resulted in two PC axes accounting for 83.4% of the cumulative variation. The first axis (Contaminant PC1) represented 49.8% of the variation with Arsenic, Chromium, Copper, Nickel, Lead, Zinc, Silt-Clay and TOC accounting for much of the variation. Positive PC1 factor values exhibited elevated metal concentrations and higher percentages of Silt-Clay and TOC. The PC1 metals were also listed as the metals contributing the greatest to sediment contamination during RCAP 2002 study (Nicolau and Nuñez 2005). TOC percentages were low and do not appear to have as much of an influence on the factor scores as the metals or Silt-Clay.

The second PC axis (Contaminant PC2) represented 33.6% of the variation and was attributed to Total DDT and Total PAH. Although concentrations of Total PAHs were low, factor analysis identified this variable as part of the second PC possibly due to the linear trend of increasing Total PAHs as observed in RCAP 2002 (Nicolau and Nuñez 2005). This suggests that factor scores may be more attributable to Total DDT concentrations and the low concentrations associated with Total PAH that co-varies with this contaminant. Both contaminants contributed to sediment contamination during the RCAP 2002 study.

Sites located in Quadrant I (Fig. 4.7) had increased concentrations of PC1 designated metals, Silt-Clay, and TOC. Quadrant II also contained sites characterized with increased concentrations of PC1 metals, Silt-Clay, and TOC plus the addition of Total DDT and Total PAH concentrations. Quadrant III had low contaminant concentrations, while Quadrant IV had elevated Total DDT and Total PAH concentrations.

The sites in Quadrant I (Fig. 4.7) are primarily located in Corpus Christi Bay (Segment 2481) and Aransas Bay (Segment 2471). Four sites plotted in Quadrants II and IV had high PC2 scores. However, only two of the four sites had concentrations above any screening levels. These included Site 306 in Nueces Bay (Segment 2482) and Site 313 in Oso Bay (Segment 2485) with concentrations of DDT above TEL screening levels. Sites characterized with high factor analysis scores are listed in Table 4.8.

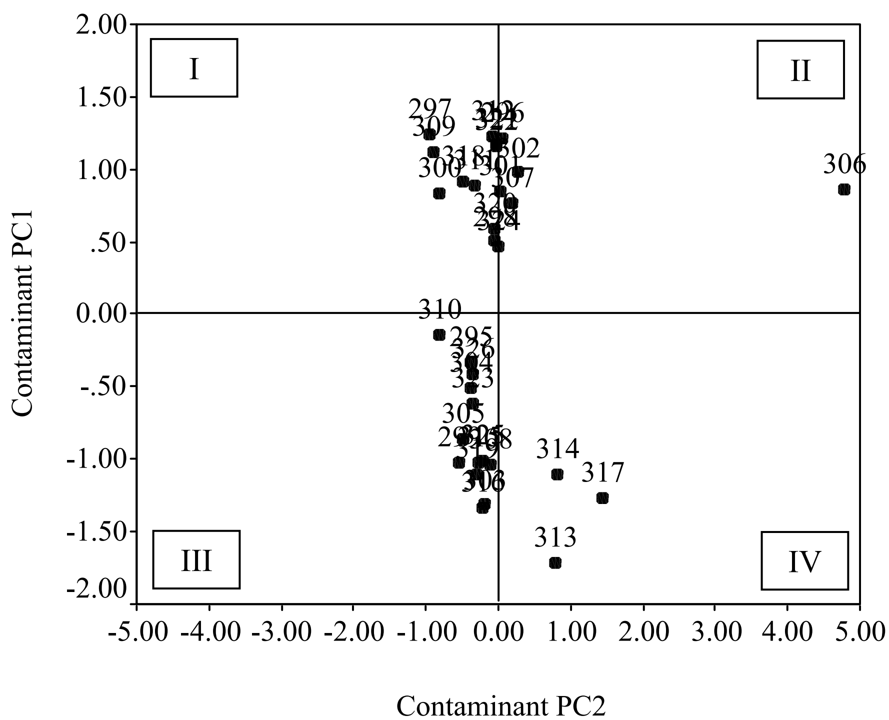


Fig. 4.7. Factor-loading scores for RCAP 2002 based on physical-chemical and contaminant variables. Sites found on the third PC axis are designated in bold red.

Table 4.8. Sites within TCEQ designated segments identified through factor analysis as having higher contamination relative to all other RCAP 2003 sampling sites.

Segment	Bay	Site	PC1 (Metals)	PC2 (Total DDT and PAH)
2472	Copano Bay/ Port Bay/ Mission Bay	296	*	
		297	*	
2471	Aransas Bay	300	*	
		301	*	
		302	*	
2485	Oso Bay	313		*
2482	Nueces Bay	306	*	*
2481	Corpus Christi Bay	309	*	
		311	*	
		312	*	
		314		*
2492	Baffin Bay/ Alazan Bay/	318	*	
	Cayo del Grullo/ Laguna Salada	321	*	
		322	*	
2491	Laguna Madre	317		*

RCAP 2003 Sediment Contaminant Distribution (SCD) rankings utilized the same breaks as defined for the RCAP 2002 sediment assessment (Nicolau and Nuñez 2005), and as previously mentioned, the SCD determination included SQGQ values aided by factor analysis. Results from factor analysis in Table 4.8 aided in determining what components were potentially responsible for the SCD classification of “Low”, “Moderate”, or “High” (i.e. metals, PAH’s, pesticides, etc.). As opposed to RCAP 2002, no sites during RCAP 2003 classified as “High”. Although 15 sites had been identified with high factor analysis scores, only nine met the criteria for a “Moderate” SCD characterization. Site 307 was not identified through factor analysis, however met the SQGQ criteria and was characterized with a “Moderate” SCD classification. These moderately contaminated sites occurred in five of the ten TCEQ segments sampled during RCAP 2003 (Table 4.8; Fig 4.8). Sites delineated as having increased contaminant concentration through factor analysis, but not meeting the SQGQ criteria included Site 314 in Corpus Christi Bay, Site 300 and 301 in Aransas Bay, Site 317 in the Upper Laguna Madre, Site 318 in Alazan Bay within the Baffin Bay Complex and Site 313 in Oso Bay.

Sites ranked with “Moderate” contamination in the Mission-Aransas estuary are primarily due to metals. These sites were typically located near freshwater inflow sources or near shore. Copano/Port/Mission Bay (Segment 2472) had two sites characterized with moderate SCD rankings (Table 4; Fig. 4.8).

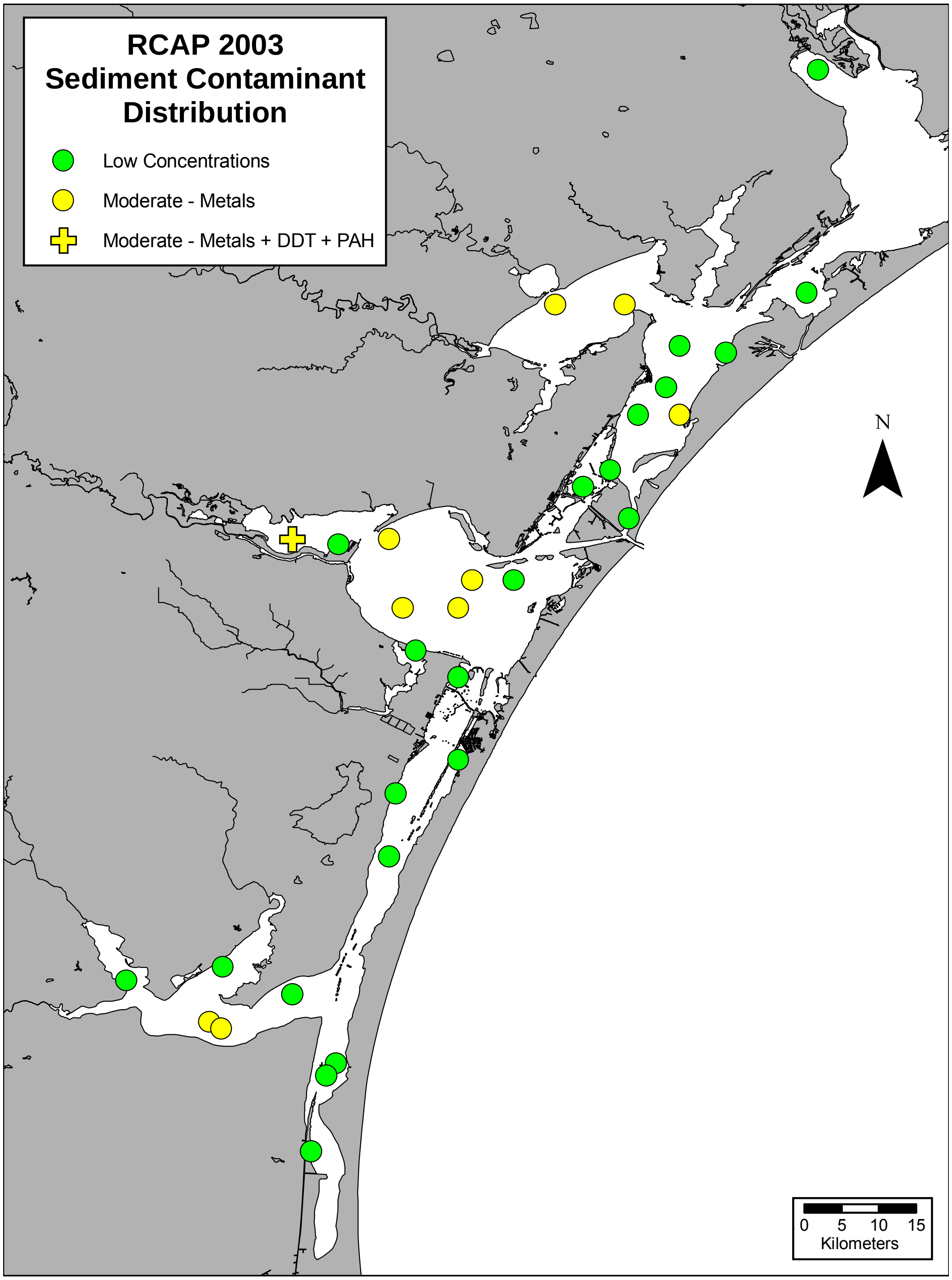


Fig. 4.8. Sediment contaminant distribution for RCAP 2003 sampling sites derived by SQGQ and Factor analysis. Metals consisted of Arsenic, Chromium, Copper, Nickel, Lead, and Zinc.

Based on factor analysis increased contaminant loads at Sites 296 and 297 are due to metal contaminants, as this segment had the highest mean concentrations for 10 of the 15 metals sampled, and the second and third highest mean concentrations for 4 of the 15 metals sampled (Table 6.9.1 through 6.9.6). While no concentrations exceeded PEL screening values there were concentrations above 85th percentile screening values for Chromium and TEL screening levels for Arsenic (Table 4.5). Chromium concentrations also exceeded 85th percentile screening levels in this Segment during RCAP 2002. Aransas Bay (Segment 2471) had one site ranked with a “Moderate” SCD (Table 4.8; Fig. 4.8). Site 302, located in the eastern portion of the bay had an SQGQ of 0.050, attributed to increased metal concentrations, including a concentration above the 85th percentile for Chromium. Other sites in Aransas Bay (Sites 300 and 301) had low SCD values, but had concentrations above the 85th percentile for Chromium. In addition, Site 301 had a concentration above the respective Arsenic TEL.

Within the Nueces Estuary, factor analysis attributed moderate SCD rankings to metal contaminants, with the majority of sites located in Quadrant I of the Principle Component plot (Fig. 4.7). Nueces Bay (Segment 2482) exhibited a moderate SCD ranking at Site 306, while moderate SCD rankings in Corpus Christi Bay (Segment 2481), occurred at sites 307, 309, 311 and 312 (Table 4.8; Fig. 4.8). Site 306 in Nueces Bay had concentrations above TEL’s for Arsenic, 4,4’- DDE and Total DDT (Table 4.5). However, no concentration exceeded respective PEL or 85th percentile concentrations. Although factor analysis identified Site 313 in Oso Bay (Segment 2485) with a high PC2 score, it did not meet criteria necessary for characterizing it as having a moderate SCD ranking. However, this is the second year that a site in this bay has had DDT concentration above TEL screening levels. Overall, metal concentrations resulted in moderate SCD rankings for Corpus Christi Bay. Sites with a moderate SCD rank included 307, 309, 311, and 312. Site 307 did not have a high PC score co-occurring with an elevated SQGQ value; typically observed with moderate SCD ranked sites. The high SQGQ value resulted from an elevated, when compared to other sites, Mercury concentration (>TEL screening level), a contaminant that did not contribute to PC variation. This site also had concentrations above the 85th Percentile for Zinc and Cadmium. Sites 309 and 312 had concentrations above TEL screening level for Arsenic and 85th Percentile for Chromium. In addition, Site 312 was above the 85th Percentile for Zinc (Table 4.5).

Within the Baffin Bay complex (Segment 2492), Sites 321 and 322 had moderate SCD rankings (Table 4.8; Fig. 4.8). Factor analysis delineated metal concentrations as the primary source. Both sites had concentrations above the 85th percentile screening level for Arsenic and Chromium (Table 4.5). Site 318 had concentrations above the 85th percentile for Chromium (Table 4.5). However, cumulatively, sediment contaminant concentrations were low.

In general, as in RCAP 2002, sediment contamination throughout the region was low for RCAP 2003. Sites exhibiting any form of sediment contamination were at most characterized as “moderate” relative to other sites sampled. These sites typically had one or more contaminant above respective 85th percentile or TEL screening levels. Similar contaminants had increased concentrations in the same segments during RCAP 2002. As observed during RCAP 2002, increased contaminant deposition occurred in Nueces Bay, Copano Bay, and Baffin Bay. Contaminants contributing to variation through factor analysis identified in RCAP 2003 were also similar to those identified during RCAP 2002. Breaking the CBBEP region into four estuarine systems, contaminants of interest for RCAP 2003 were metals in the Mission-Aransas estuary, metals and pesticides in the Nueces estuary, and metals in the Baffin Bay complex (Fig. 4.8). Overall PCB’s were of little concern with the majority of the concentrations at or near minimum detection limits. Concerning the Guadalupe estuary, based on only one sampling site there are no concerns, but more data collection is required to make a true assessment of this area.

4.3.5. Benthic Community

Benthic analysis for RCAP 2003 identified 114 species totaling 3000 individuals within the sampling area as opposed to 173 species totaling 4775 individuals in RCAP 2002. As seen in RCAP 2002, the most abundant group was annelids, which comprised 61.9% of all organisms collected in RCAP 2003. Polychaetes represented 99.6% of the annelids and no one particular species numerically dominated this group. As opposed to RCAP 2002, when molluscs were the second most abundant group collected, in RCAP 2003 arthropods accounted for 18.2% of all organisms collected; dominated by the amphipod crustacean, *Cerapus tubularis*, which accounted for 44.0% of all crustaceans collected. Molluscs represented 15.5% of all organism collected with the bivalve, *Mulinia lateralis*, yielding 46.3% of all molluscs collected. Collectively these three groups represented 95.6% of all organisms during RCAP 2003. The remaining 4.4% of organisms collected primarily included representatives from the phyla Cnidaria, Echinodermata, Nemertea, Sipuncula, and Hemichordata.

Across the region at all 32 RCAP 2003 sites, richness ranged from 1 to 39 (mean = 13) species collected and was negatively correlated with Silt-Clay (-0.566, $p<0.001$) and positively correlated with SAV (0.467, $p=0.007$). Density ranged from 74 to 12,927 individuals m^{-2} (mean = 2313 individuals m^{-2}), and was positively correlated with SAV (0.516, $p=0.002$). Biomass ranged from 0.01 g m^{-2} to 10.86 g m^{-2} (mean = 2.44 g m^{-2}). The EPA-BCI resulted in values ranging from 0.36 to 7.43 (mean = 4.76). Table 4.9 list benthic community characteristics by TCEQ Segment.

Benthic community assemblage grouped together sites into clusters by constructing a dendrogram using a Bray-Curtis similarity matrix that reflected aspects of similarity (species composition and densities). Groups were super-imposed over an MDS plot to cross-check the adequacy and consistency of both representations (Fig. 4.9). Both cluster analysis (at 13.8%) and the MDS plot (Stress = 0.18) revealed that 31 of the 32 sites sampled during RCAP 2003 could be attributed to five assemblages. The remaining site, which did not group within any assemblage, classified as an outlier (Site 326 located in Mesquite Bay) (Fig. 4.9). Mean similarities of sites within each assemblage ranged from 14% to 56.9%. Box-plots for richness, density, and biomass in Fig. 4.10 show the spread within the assemblages.

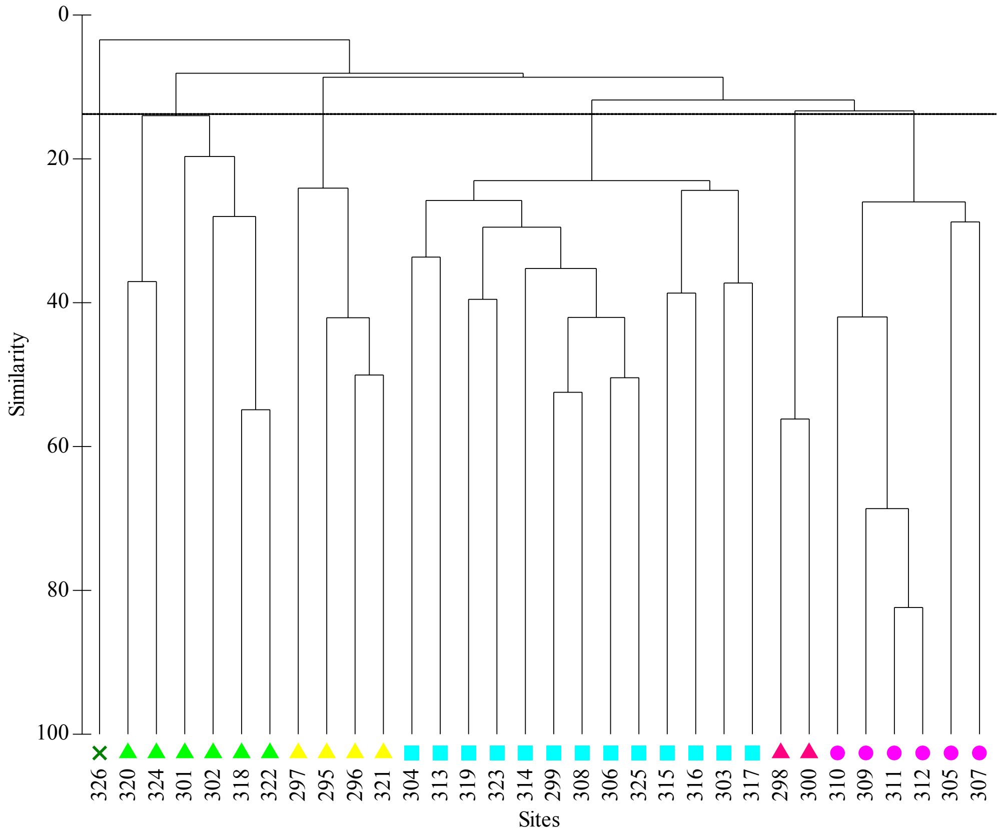
The BIOENV analysis indicated the best correlation between abiotic and biotic data was the combination of depth, salinity, and Silt-Clay ($r_w = 0.297$). Although significant, the relatively low correlation suggests that some unmeasured variable is effecting the benthic distribution in addition to the aforementioned variables. Box-plots in Fig. 4.11 show the spread of the abiotic factors within the assemblages. Factors that the BIOENV procedure identified as affecting assemblage distribution resulted in classifications five assemblages listed below, with Fig. 4.12 providing a geographical distribution of these assemblages:

1. **M**id-Depth **M**esohaline **M**uddy Assemblage (**MMM**),
2. **S**hallow-Depth **E**uhaline **S**and Assemblage (**SES**),
3. **M**id Depth **E**uhaline **M**uddy-**S**and Assemblage (**MEMS**)
4. **M**id Depth **P**olyhaline **M**uddy-**S**and Assemblage (**MPMS**)
5. **D**eep Depth **E**uhaline **M**uddy-**S**and (**DEMS**)

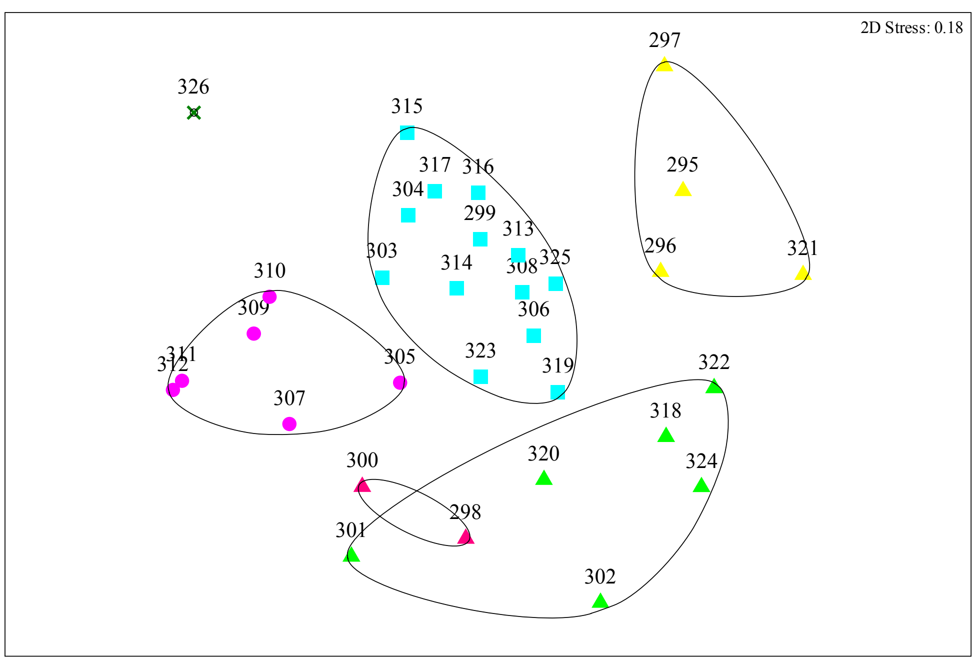
Table 4.9. Benthic community characteristics, EPA Benthic Condition Index, and dominant species percent contribution as related to density and distribution, listed by TCEQ Segment. Numbers for community characteristics are ranges with mean values in parentheses. AC =Arthropod Crustacean, AP =Annelid Polychaete, MB =Mollusc Bivalve, and N =Nemertean.

Segment *	Species Richness	Density (m^{-2})	Biomass ($g\ m^{-2}$)	Species Diversity	EPA Benthic Index	Dominant Species and Percent Contribution (Density and Distribution)	
2462 (n=1)	– (4)	– (1900)	– (0.19)	– (1.73)	– (5.35)	*Melinnia maculata* (AP) *Capitella capitata* (AP) *Streblospio benedicti* (AP)	90.0
2463 (n=1)	- (2)	– (74)	– (0.74)	– (0.92)	– (3.52)	*Parandalia fauveli* (AP) *Diopatra cuprea* (AP)	100.0
2471 (n=7)	2 – 28 (12)	74 – 10,978 (2139)	0.01 – 3.16 (1.04)	0.92 – 3.97 (2.39)	3.01 – 7.43 (5.13)	Nemertean (N) *Aricidea fragilis* (AP) *Glycinde solitaria* (AP)	59.4
2472 (n=2)	2 – 3 (3)	123 – 222 (173)	– (0.02)	0.72 – 1.39 (1.06)	0.36 – 3.64 (2.00)	*Capitella capitata* (AP)	100.0
2481 (n=6)	10 - 29 (17)	370 – 3133 (2146)	0.76 – 7.04 (3.35)	2.34 – 4.12 (3.20)	4.89 – 7.13 (5.88)	*Aricidea fragilis* (AP) *Naineris* sp. (AP) *Lumbrineris* sp. (AP)	43.3
2482 (n=2)	11 – 17 (14)	4835 – 9128 (6982)	5.33 – 5.76 (5.55)	1.16 – 2.58 (1.87)	2.29 – 5.08 (3.68)	*Mediomastus* sp. (AP) *Mulinia lateralis* (MB) Nemertean (N)	54.0
2483 (n=1)	- (18)	- (1924)	- (0.80)	- (3.56)	- (6.26)	*Cymadusa compta* (AC) *Prionospio heterobranchia* (AP) *Tharyx cf. annulosus* (AP)	49.0
2485 (n=1)	– (33)	– (2590)	– (4.85)	– (4.33)	– (6.74)	*Brachidontes exustus* (MB) *Marphysa sanguinea* (AP) *Capitella capitata* (AP)	33.8
2491 (n=6)	3 – 39 (20)	74 – 12,927 (3425)	0.17 – 10.86 (4.96)	1.58 – 3.82 (3.23)	3.12 – 6.89 (5.18)	*Acteocina canaliculata* (MG) *Ericthonius brasiliensis* (AC) *Mulinia lateralis* (MB)	32.0
2492 (n=5)	1 – 12 (6)	271 – 2196 (962)	0.03 – 1.34 (0.68)	0.00 – 3.37 (1.56)	1.82 – 5.29 (3.38)	*Mulinia lateralis* (MB) *Streblospio benedicti* (AP) *Paraprionospio pinnata* (AP)	85.0

* 2462 (San Antonio Bay/Hynes Bay/Guadalupe Bay), 2463 (Mesquite Bay/Carlos Bay/Ayers Bay), 2471 (Aransas Bay), 2472 (Copano Bay/Port Bay/Mission Bay), 2481 (Corpus Christi Bay), 2482 (Nueces Bay), 2483 (Redfish Bay), 2485 (Oso Bay), 2491 (Laguna Madre), 2492 (Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada).



a)



b)

Fig. 4.9. Benthic assemblages determined by a) cluster analysis with results super-imposed onto a b) MDS plot to cross check for adequacy and mutual consistency of both representations.

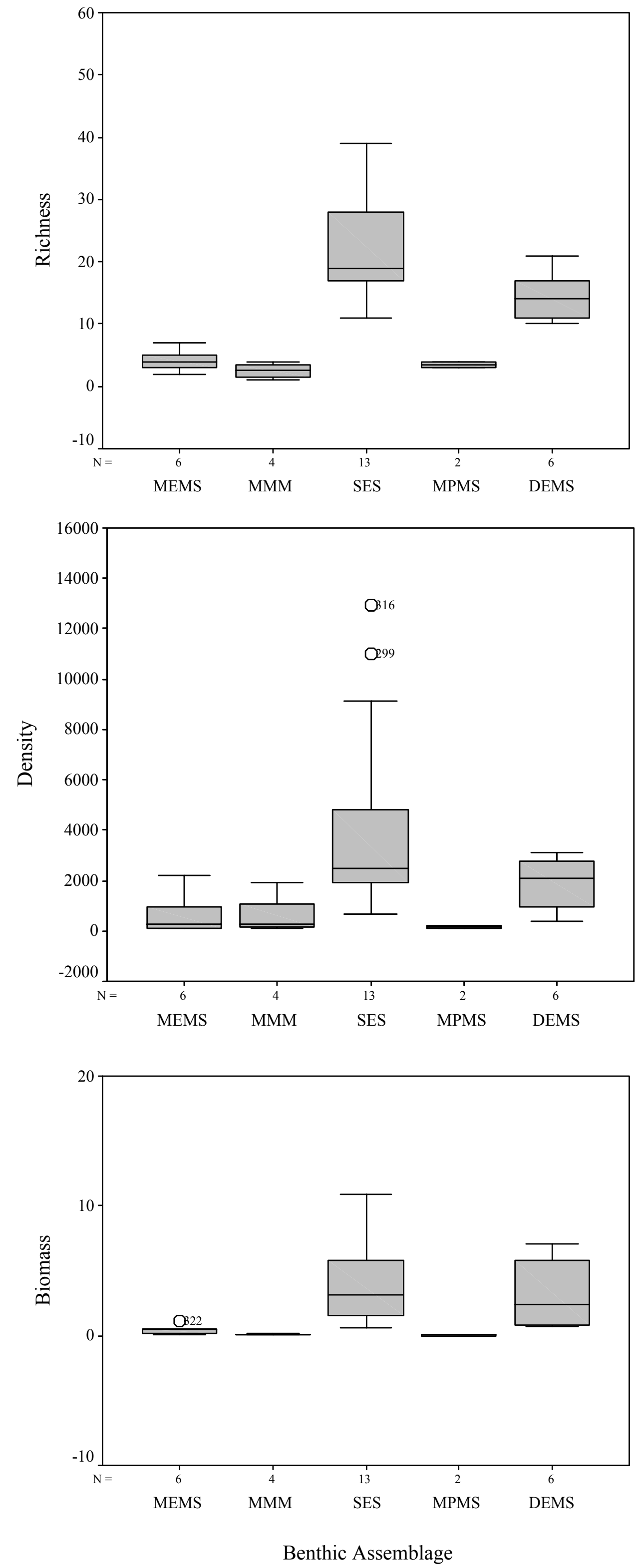


Fig. 4.10. Box and whiskers plots of biotic factors a) Richness, b) Density, and c) Biomass by benthic assemblage. Boxes are interquartile ranges; horizontal lines within boxes are medians; whisker endpoints are high and low extremes.

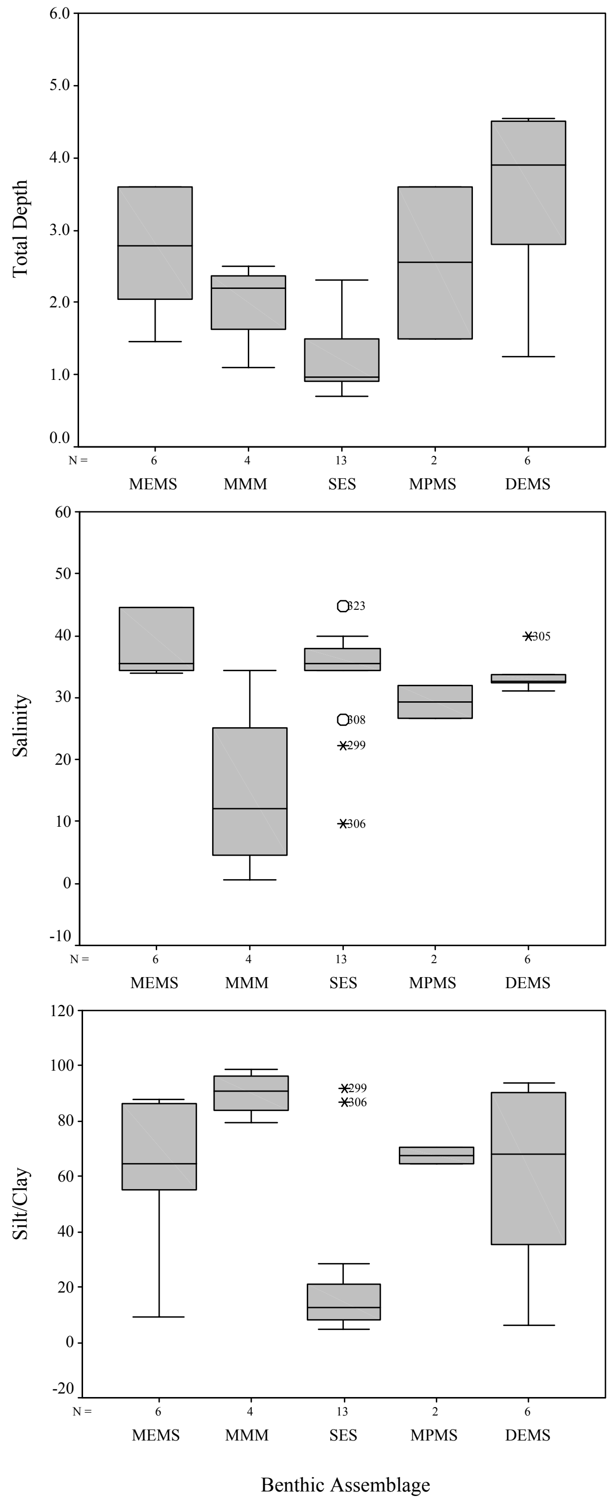


Fig. 4.11. Box and whisker plots of abiotic factors a) Total Depth, b) Salinity, and c) Silt-Clay content by benthic assemblage. Boxes are interquartile ranges; horizontal lines within boxes are medians; whisker endpoints are high and low extremes.

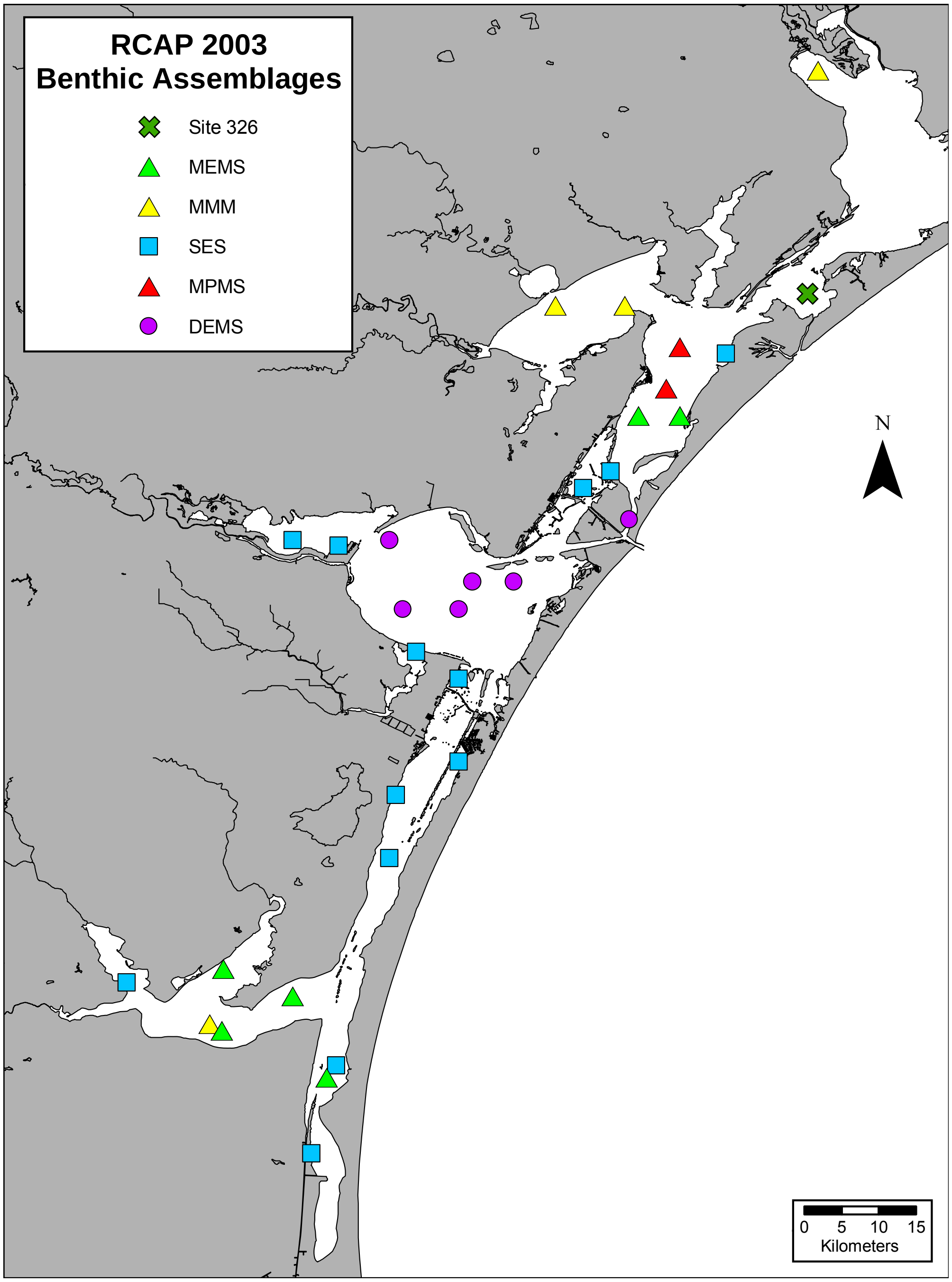
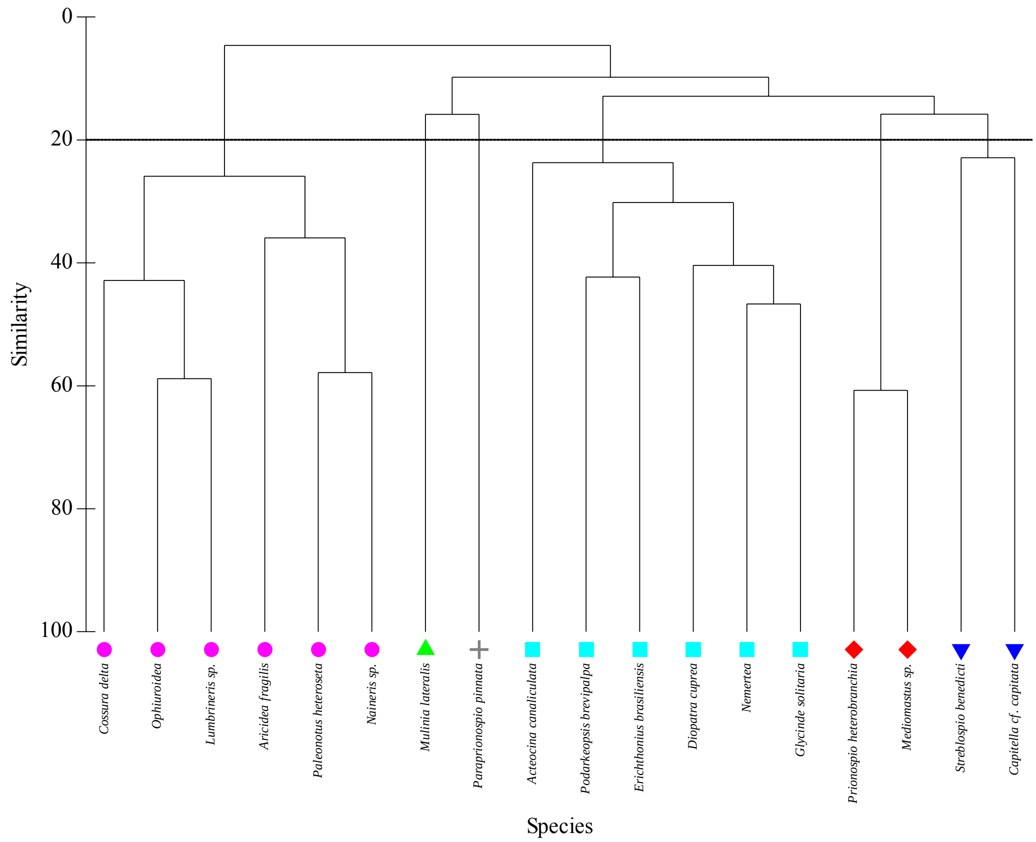
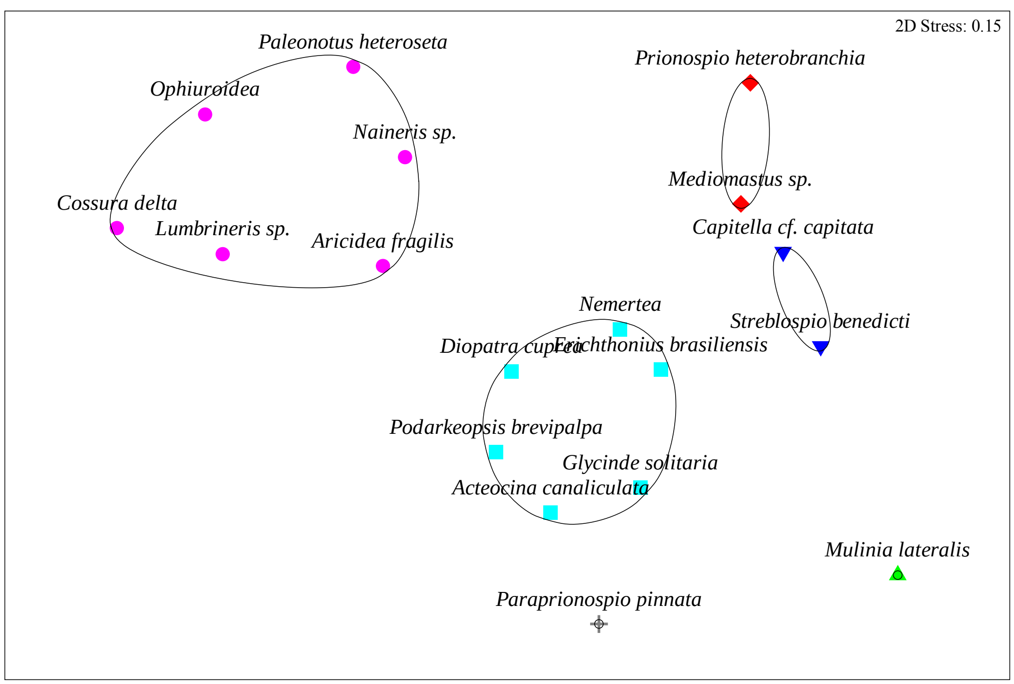


Fig. 4.12. Benthic assemblage distribution for RCAP 2003.

The SIMPER procedure identified species contributing the greatest to similarity within an assemblage and dissimilarity between assemblages. The species contributing > 70% of inter-group similarity within the benthic assemblages reduced the matrix from 114 species to 18 species. Inverse cluster analysis performed on the reduced matrix identified species that were most representative of the benthic assemblages. Cluster analysis and the MDS plot (Stress = 0.15) revealed the 18 species could be attributed to six Species Groups represented by four groups containing multiple species and two groups containing a single species (Fig. 4.13; Table 4.10).



a)



b)

Fig. 4.13. Species groups determined by a) cluster analysis with results super-imposed onto a b) MDS plot.

Table 4.10. Total density (individuals m^{-2}) of taxa within each benthic assemblage by species group. Numbers in parentheses denote the percentage of occurrence within the benthic assemblage groups. Species contributing to over 70% of inter-group similarity within the benthic assemblages are in bold.

Species	Benthic Assemblage				
	MMM (n=4)	MPMS (n=2)	SES (n=13)	MEMS (n=6)	DEMS (n=6)
Species Group 1					
Cossura delta	-	-	-	-	**222.0 (67)**
Ophiuroidea	-	-	-	-	**468.7 (67)**
Lumbrineris sp.	-	-	-	-	**370.1 (100)**
Aricidea fragilis	-	98.7 (50)	394.72 (15)	74.0 (17)	**863.5 (100)**
Paleonotus heteroseta	-	-	74.0 (8)	24.7 (17)	**3305.8 (83)**
Naineris sp.	-	24.7 (50)	271.4 (15)	-	**1504.9 (67)**
Species Group 2					
Mulinia lateralis	-	-	**4539.3 (46)**	**715.4 (67)**	-
Species Group 3					
Paraprionospio pinnata	-	-	222.0 (31)	**419.4 (67)**	24.7 (17)
Species Group 4					
Acteocina canaliculata	-	-	**616.8 (54)**	172.7 (50)	-
Podarkeopsis brevipalpa	-	-	**345.4 (69)**	-	49.3 (33)
Erichthonius brasiliensis	-	-	**888.1 (69)**	-	-
Diopatra cuprea	-	-	**567.4 (69)**	-	197.4 (33)
Nemertea	24.6 (25)	**49.3 (100)**	**1258.2 (92)**	-	123.4 (33)
Glycinde solitaria	-	**98.7 (100)**	**616.8 (54)**	24.7 (17)	24.7 (17)
Species Group 5					
Prionospio heterobranchia	-	-	**4095.2 (54)**	-	-
Mediomastus sp.	-	-	**5402.7 (69)**	-	172.7 (33)
Species Group 6					
Streblospio benedicti	**690.8 (75)**	-	**1134.8 (62)**	2097.0 (33)	24.7 (17)
Capitella cf. capitata	**592.1 (75)**	-	**6192.2 (77)**	-	49.3 (17)

MMM (Mid Depth, Mesohaline, Muddy)
MPMS (Mid Depth, Polyhaline, Muddy Sand)
SES (Shallow, Euhaline, Sand)
MEMS (Mid Depth, Euhaline, Muddy Sand)
DEMS (Deep Depth, Euhaline, Muddy Sand)

Based on a weight-of-evidence approach, biotic measures of richness, density, biomass, and the EPA Benthic Condition Index were combined with SCD rankings and sediment toxicity within the assemblages to assess sediment quality. Using RCAP 2002 as a benthic assessment baseline, sites characterized as having low richness, density, and biomass if measures fell below the 25th percentile and high if measures were above the 75th percentile. Sites with low benthic measures, moderate to high SCD rankings and/or expressing toxic effects, were evaluated and reported within the assemblages.

Mid Depth, Mesohaline, Mud (MMM)

The MMM assemblage grouped together four sites, typically near sources of freshwater inflows (see Fig. 4.9 and Fig. 4.12), in Hynes Bay (Segment 2462), Copano Bay/Port Bay/Mission Bay (Segment 2472), and Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492). Depths ranged from 1.10 m to 2.50 m with a mean of 2.00 m. Due to the broad geographic location of sites, this assemblage had the greatest bottom salinity variability. Concentrations ranged from 0.49 PSU to 34.33 PSU with a mean of 14.78 PSU, classifying this as a mesohaline assemblage. Silt-Clay ranged from 79.32% to 98.69% with a mean of 90.02%, classifying this as a mud assemblage (see Fig. 4.11).

Mean benthic density was 629 individuals m^{-2} and ranged from 123 individuals m^{-2} to 1900 individuals m^{-2}. Biomass ranged from 0.02 g m^{-2} to 0.19 g m^{-2}. Mean species richness was 3 species collected and ranged from 1 to 4 species collected (see Fig. 4.10). Species diversity ranged from 0.00 to 1.73. The EPA-BCI ranged from good to poor, with the majority of the sites characterized as poor. The inverse cluster analysis identified the ubiquitous group, Species Group 6, as the primary species contributing the greatest similarity within the MMM assemblage (see Fig. 4.13 and Table 4.10). This group consists of organisms characterized as pollution-tolerant species indicative of environmental stress and organic enrichment. As a result this assemblage as a whole, exhibited characteristics of a stressed community.

Sites in the MMM assemblage were located in areas where dramatic salinity shifts commonly occur. Northern sites are located near freshwater inputs, subjecting these communities to salinity reductions during significant freshwater inflows while the Baffin Bay site is located in an area where evaporation typically exceeds precipitation, creating a hypersaline environment, with both conditions resulting in stressful environments for benthic communities. As a result, the possibility that the bioeffects are partially due to co-varying stressors, other than anthropogenic inputs, deserves consideration (Hyland et al. 2003).

Three of the four sites within the MMM assemblage, characterized with moderate sediment contaminants (SCD), also exhibited characteristics of a stressed benthic community consisting of low richness, densities, and biomass (Table 4.11). The EPA-BCI at the three sites ranged from fair to poor. The moderate SCD characterization at these sites is attributed to increased metal loadings (see Fig 4.8). As previously mentioned, Sites 296, 297 and 321 had concentrations above the 85th percentile screening value for Chromium and above the TEL for Arsenic (see Table 4.5). In addition, Site 297 exhibited characteristics of toxicity and Site 321 was ranked with medium TOC enrichment.

Table 4.11. Benthic community characterization in relation to sediment contaminant characteristics within the MMM assemblage. Bold represents sites characterized with reduced benthic community measures. SAV indicates presence or absence of submerged aquatic vegetation.

Segment*	Site	Richness	Density	Biomass	EPA-BCI	Toxic	TOC	SCD	SAV	Silt-Clay
2462	**295**	**Low**	**Moderate**	**Low**						**Mud**
2472	**296**	**Low**	**Low**	**Low**						**Mud**
2472	**297**	**Low**	**Low**	**Low**						**Mud**
2492	**321**	**Low**	**Low**	**Low**						**Mud**

* 2462 (San Antonio Bay/Hynes Bay/Guadalupe Bay, 2472 (Copano Bay/Port Bay/Mission Bay), 2492 (Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada).

Mid Depth, Polyhaline, Muddy Sand (MPMS)

The MPMS assemblage grouped together two sites located in Aransas Bay (Segment 2471) (see Fig. 4.9 and Fig. 4.12). Depths ranged from 1.50 m to 3.60 m with a mean of 2.55 m. Salinities ranged from 26.57 PSU to 31.99 PSU with a mean of 29.28 PSU, classifying it as a polyhaline assemblage. Sediments ranged from 64.42% Silt-Clay to 70.59% with a mean of 67.51%, classifying this assemblage as a muddy-sand assemblage (see Fig. 4.11).

Mean benthic density was 148 individuals m^{-2}. Density ranged from 99 individuals m^{-2} to 197 individuals m^{-2} and a biomass range of 0.01 g m^{-2} to 0.11 g m^{-2}. Species richness ranged from 3 to 4 species collected and diversity ranged from 1.50 to 1.75 (see Fig. 4.10). The benthic condition at the sites was classified as fair. No species group contributed primarily to this assemblage. However, the top contributing species associated with this assemblage were the species in Species Group 4 (see Fig. 4.13 and Table 4.10).

The MPMS assemblage was located in the open waters of Aransas Bay (see Fig. 4.12) and sites exhibited reductions of richness, densities and biomass in addition to fair EPA-BCI values (Table 4.12). Reduced benthic measures could be attributed to geographic location. At the time of sampling heavy shrimp trawling activity was observed. This activity often disturbs the bottom sediments resulting in a stressed community. Expressions of toxicity are exhibited at both sites (see Fig. 4.5) with a concentration above the 85th percentile screening level for Chromium at Site 300 (see Table 4.5).

Table 4.12. Benthic community characterization in relation to sediment contaminant characteristics within the MPSM assemblage. Bold represents sites characterized with reduced benthic community measures. SAV indicates presence or absence of submerged aquatic vegetation.

Segment*	Site	Richness	Density	Biomass	EPA-BCI	Toxic	TOC	SCD	SAV	Silt-Clay
2471	**298**	**Low**	**Low**	**Low**						**Muddy Sand**
2471	**300**	**Low**	**Low**	**Low**						**Muddy Sand**

Shallow Depths, Euhaline, Sand (SES)

The SES assemblage grouped together 13 sites with the majority (six) of sites located in the Upper Laguna Madre (Segment 2491) (see Fig. 4.9 and Fig. 4.12). Sites in this assemblage were typically shallow, ranging from 0.70 m to 2.30 m, with a mean of 1.27 m. Salinities ranged from 9.59 PSU to 44.79 PSU with a mean of 33.26 PSU, classifying it as a euhaline assemblage. Sediments in this assemblage ranged from 4.98 % to 91.70 % Silt-Clay, with a mean of 24.60%; classifying this assemblage as a sand assemblage (Fig. 4.11).

Mean benthic density was 4306 individuals m^{-2}. Density ranged from 666 individuals m^{-2} to 12,927 individuals m^{-2} and a biomass ranged from 0.62 g m^{-2} to 10.86 g m^{-2}. Mean species richness was 22 species collected and ranged from 11 to 39 species collected (see Fig. 4.10). Species diversity ranged from 1.16 to 4.33. Benthic condition ranged from poor to good with the majority characterized as good (Table 4.13). The SES assemblage also had the greatest number of top contributing species, in addition to the most diverse species groups; with three species groups primarily associated with this assemblage (see Table 4.10). Species Group 4 consisted of a large number of organisms (see Fig. 4.13 and Table 4.10). Species Group 2 and 5 contained organisms found almost exclusively in this assemblage. Although not exclusive to this assemblage, Species Group 6 had higher densities and frequencies of occurrences within this assemblage.

Site 306 in Nueces Bay was the only site in this assemblage characterized with a moderate SCD ranking due to metals and DDT concentrations (Table 4.13; see Figure 4.8). Although characterized with moderate richness, high density, and moderate biomass, this site ranked as poor for the EPA-BCI. This was primarily due to the dominance of the bivalve *Mulinia lateralis*, which accounted for 81% of the total density at this site. Although richness was moderate, densities associated with the other organisms were low. The dominance of this single, pollution tolerant organism suggests that this may be a disturbed community (Hyland et al. 2000; Carr et al. 1998, Gray 1981). Site 306 is located in a portion of Nueces Bay along the south shoreline where "over the crest" disposal of sediments from the Corpus Christi Inner Harbor once occurred. This fact, combined with past discharges from a smelting plant operation, may contribute to the overall higher metals concentrations found in these sediments and possibly to the elevated levels (zinc) currently being found in oyster tissue. While no one individual metal concentration was extremely elevated, the cumulative effect of all metals concentrations singles out this site with a moderate SCD ranking.

Four sites exhibited expressions of toxicity. However, at three of the sites, no significant reductions in benthic community measures or elevated SCD values were observed (Table 4.13). Poor toxicity rankings may be a result of possible problems associated with the testing process as opposed to actual toxic effects within this assemblage. Site 304 contained a large amount of algal material while Sites 315 and 316 contained large amounts of seagrass material making survival counts difficult. Site 325 also exhibited reductions of benthic community measures. However, the reduction of the measures maybe due to natural effects as opposed to toxic effects. This site is located in the northern portion of "Nine-Mile or Dead Mans Hole". This area has been described as potentially a naturally stressed environment for the benthic community, due to its shallow depth (<0.5), limited circulation, and high salinities (Nicolau and Nuñez 2005).

Table 4.13. Benthic community characterization in relation to sediment contaminant characteristics within the SES assemblage. Bold represents sites characterized with reduced benthic community measures. SAV indicates presence or absence of submerged aquatic vegetation.

Segment*	Site	Richness	Density	Biomass	EPA-BCI	Toxic	TOC	SCD	SAV	Silt-Clay
2471	299	High	High	Moderate					*	Mud
2471	303	High	Moderate	Moderate					*	Sand
2481	314	High	High	Moderate						Sand
2482	306	Moderate	High	Moderate						Mud
2482	308	Moderate	High	Moderate					*	Sand
2483	304	Moderate	Moderate	Moderate						Sand
2485	313	High	High	Moderate						Sand
2491	315	Moderate	Moderate	Moderate					*	Sand
2491	316	High	Moderate	High					*	Sand
2491	317	High	Moderate	High						Sand
2491	323	Moderate	High	Low						Sand
2491	325	Moderate	Low	Moderate						Sand
2492	319	Moderate	High	Moderate						Sandy Mud

* 2471 (Aransas Bay), 2472 (Copano Bay/Port Bay/Mission Bay), 2481 (Corpus Christi Bay), 2482 (Nueces Bay), 2483 (Redfish Bay), 2485 (Oso Bay), 2491 (Laguna Madre), 2492 (Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada).

Mid Depth, Euhaline, Muddy Sand (MEMS)

The MEMS assemblage grouped together six sites (see Fig. 4.9 and Fig. 4.12), located in the open waters of Aransas Bay (Segment 2471), Laguna Madre (Segment 2491), and Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492). Depths ranged from 1.45 m to 3.60 m with a mean of 2.70 m. Geographic location of the sites was broad, with bottom salinity concentrations ranging from 34.04 PSU to 44.64 PSU with a mean of 38.13 PSU, classifying this as a euhaline assemblage. Low Silt-Clay content at Site 302 skewed Silt-Clay content within this assemblage which ranged from 9.09% to 87.86% and a produced a mean of 61.26%, classifying this as a muddy-sand assemblage (see Fig. 4.11).

Mean benthic density was 637 individuals m^{-2} and ranged from 74 individuals m^{-2} to 2196 individuals m^{-2}. Biomass ranged from 0.02 g m^{-2} to 1.12 g m^{-2}. Mean species richness was 4 species collected and ranged from 2 to 7 species collected (see Fig. 4.10). Species diversity ranged from 0.37 to 2.58. Benthic condition ranged from good to poor, with the majority of the six sites characterized as fair (Table 4.14). Inverse cluster analysis identified two groups, Species Group 2 and 3, as containing the primary species contributing the greatest similarity within the MEMS assemblage (see Fig. 4.13 and Table 4.10). Species Group 2 occurred at the three sites in Baffin Bay (Segment 2492) but not at the northern sites in Aransas Bay.

As seen with the MMM and MPMS assemblages, characteristics of a stressed community were observed for this assemblage (Table 4.14). Like the MMM assemblage, MEMS sites in the Laguna Madre and Baffin Bay are in areas where evaporation typically exceeds precipitation, resulting in a hypersaline environment, stressful to benthic communities. The two northern sites (301 and 302) in Aransas Bay are located near the sites in the MPMS assemblage, an area heavily trawled for shrimp.

Two of the six sites within the MEMS assemblage, characterized with moderate SCD rankings exhibited characteristics of a stressed benthic community consisting of low to moderate richness, densities, and biomass (Table 4.14). The benthic condition at these seven sites ranged from good to poor. However, all sites exhibited characteristics of a stressed community. Site 301, ranked with a medium EPA-BCI value and observed reductions of benthic measures, was classified with low, or good, SCD values but concentrations above the TEL for Arsenic and the 85th percentile for Chromium were observed at this site (see Table 4.5). Site 302 also displayed characteristics associated with a stressed community and was classified as having a moderate SCD value, attributed to increased metal concentrations (see Fig. 4.8) including Chromium, which was above the 85th percentile screening level (see Table 4.5).

Table 4.14. Benthic community characterization in relation to sediment contaminant characteristics within the MEMS assemblage. Bold represents sites characterized with reduced benthic community measures. SAV indicates presence or absence of submerged aquatic vegetation.

Segment*	Site	Richness	Density	Biomass	EPA-BCI	Toxic	TOC	SCD	SAV	Silt-Clay
2471	**301**	**Low**	**Low**	**Low**						**Muddy Sand**
2471	**302**	**Low**	**Low**	**Low**						**Sand**
2491	**324**	**Low**	**Low**	**Low**						**Muddy Sand**
2492	**318**	**Low**	**Moderate**	**Low**						**Mud**
2492	320	Moderate	Low	Low						Muddy Sand
2492	**322**	**Low**	**Moderate**	**Moderate**						**Mud**

* 2471 (Aransas Bay), 2491 (Laguna Madre), 2492 (Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada).

Site 318, characterized with low richness, moderate densities and low biomass, was dominated by the bivalve *Mulinia lateralis* and the annelid *Paraprionospio pinnata*. The dominance of a single or group of organisms in a community has often been described as a characteristic of a disturbed community (Hyland et al. 2000; Gray 1981). In addition, these organisms have been characterized as a pollution tolerant species within the CBBEP region (Carr et al. 1998). This site also had a poor EPA-BCI score. Although classified with a low (good) SCD ranking, this site was identified as having concentrations above the 85^{th} percentile for Chromium (see Table 4.5). Site 322 exhibited similar benthic characteristics and was dominated by the pollution tolerant annelid *Streblospio benedicti*. This site was located near Site 321 in the MMM assemblage and exhibited similar sediment characteristics, such as concentrations above the 85^{th} percentile screening value for Chromium, above the TEL for Arsenic, and ranked with a medium TOC (see Table 4.5 and Fig. 4.2).

Deep Depth, Euhaline, Muddy Sand (DEMS)

The DEMS assemblage grouped together six sites primarily located in Corpus Christi Bay (Segment 2841), with one site in Lydia Ann Channel (Segment 2471) (see Fig. 4.9 and Fig. 4.12). Sites in this assemblage were typically deeper than the other sites, ranging from 1.25 m to 4.55 m with a mean of 3.48 m. Salinities ranged from 30.97 PSU to 39.95 PSU with a mean of 33.69 PSU, classifying it as a euhaline assemblage. Sediments in this assemblage ranged from 6.46% to 93.87% Silt-Clay with a mean of 60.36%, classifying this assemblage as a muddy-sand assemblage (see Fig. 4.11).

Mean benthic density was 1887 individuals m^{-2}. Density ranged from 370 individuals m^{-2} to 3133 individuals m^{-2} and biomass ranged from 0.68 g m^{-2} to 7.04 g m^{-2}. Mean species richness was 15 species collected and ranged from 10 to 21 species collected (see Fig 4.10). Species diversity ranged from 2.34 to 3.83. The benthic condition ranged from good to fair with the majority of the sites being classified as good (Table 4.15). One species group was associated with this assemblage. Species Group 1 consisted of ubiquitous, large-bodied organisms (see Fig. 4.13 and Table 4.10). The DEMS assemblage is a relatively stable community with sites primarily located in Corpus Christi Bay. Salinities were euhaline with minimal variability. No evidence of significant benthic impairment existed where increased SCD values occurred.

Table 4.15. Benthic community characterization in relation to sediment contaminant characteristics within the DEMS assemblage. Bold represents sites characterized with reduced benthic community measures. SAV indicates presence or absence of submerged aquatic vegetation.

Segment*	Site	Richness	Density	Biomass	EPA-BCI	Toxic	TOC	SCD	SAV	Silt-Clay
2471	305	Moderate	Moderate	Moderate						Sand
2481	307	Moderate	Low	Moderate						Muddy Sand
2481	309	Moderate	Moderate	Moderate						Mud
2481	310	Moderate	High	Moderate						Sandy Mud
2481	311	Moderate	Moderate	Moderate						Mud
2481	312	Moderate	High	High						Mud

* 2471 (Aransas Bay), 2481 (Corpus Christi Bay).

One outlying site was distinct from the other assemblages due to differing species composition. Site 326 was located in Mesquite Bay (Segment 2463). Although there was only one site sampled in this segment, this is the second year that a site in this segment exhibited expressions of toxicity in addition to reductions of benthic measures (Table 4.16).

Table 4.16. Benthic community characterization in relation to sediment contaminant characteristics for three outlier sites. Bold represents sites characterized with reduced benthic community measures. SAV indicates presence or absence of submerged aquatic vegetation.

Segment*	Site	Richness	Density	Biomass	EPA-BCI	Toxic	TOC	SCD	SAV	Silt-Clay
2463	**326**	**Low**	**Low**	**Moderate**						**Sandy Mud**

* 2463 (Mesquite Bay/Carlos Bay/Ayers Bay).

As previously stated, the benthic community characterization resulted in the delineation of five assemblages and one outlier, with the BIOENV procedure identifing salinity, depth, and sediment grain-size as the primary natural factors responsible for benthic community distribution. As suggested, the poor correlation associated with the BIO-ENV test may indicate that there may be other unmeasured factors effecting benthic distribution. During the RCAP 2003 study, patterns of stress occurred within the benthic assemblages where elevated contamination and/or expressions of toxic effects existed, but not where both conditions existed. Researchers suggest that observations like this could be due to under-sensitivity of assays; or field and lab bioeffects caused by unmeasured stressors (Carr et. al 1998; Hyland et al. 2000; Balthis et al. 2002; Hyland 2003).

Many benthic assemblages for the RCAP 2003 shared similar characteristics as those of the RCAP 2002 assemblages. The location of MMM and MEMS assemblages was similar to the MMMS assemblage of the RCAP 2002 study (Nicolau and Nunez 2005). These assemblages grouped together sites located in naturally stressed areas, as reflected in the benthic community. Both assemblages consisted of organisms characterized as pollution-tolerant species indicative of environmental stress and organic enrichment. Since both assemblages are located in a dynamic portion of the estuary, other unmeasured factors ought to be considered as negatively impacting the benthic community, such as biological interactions and/or physical factors; including upwelling of bottom waters due to high winds, bottom water currents, and/or storm events (Balthis et al. 2002; Hyland et al. 2003). However, co-occurring moderate SCD rankings and/or expressions of sediment toxicity at sites exhibiting the greatest evidence of benthic stress and poor EPA-BCI scores should not be ignored. The outlying site (Site 326) in Mesquite Bay (Segment 2463) was located in an area that exhibited expressions of toxicity in addition to reductions of benthic measures. This is the second year such results are observed in the area without increased SCD rankings and could be a result of unmeasured contaminants (Balthis et al. 2002; Hyland et al. 2003).

The MPMS assemblage included two sites located in the open waters of Aransas Bay (Segment 2471). These sites exhibited characteristics of a stressed community that potentially attributed to physical impacts as opposed to contaminant loadings. At the time of sampling, heavy shrimp trawling activity occurred with the area. This activity often disturbs the bottom sediments resulting in stressed community characteristics for a short time. However, potential problems with the test used to identify expressions of toxicity should not be overlooked. As previously mentioned, such conditions could also be a result of unmeasured contaminants (Balthis et al. 2002; Hyland et al. 2003).

The SES assemblage of RCAP 2003 was similar to the SES assemblage in RCAP 2002 with regard to benthic community characteristics. As with RCAP 2002, within this assemblage numerous sites expressed toxicity without moderate SCD rankings or reductions of benthic measures. Habitat type may influence the toxicity results as opposed to contaminant concentrations in this assemblage (Nicolau and Nuñez 2005). Based on RCAP 2003 and historical RCAP data, *Ampelisca abdita* rarely occurred within Upper Laguna Madre benthic samples and was completely absent where seagrass was present. In addition, the sites sampled in this habitat contained large amounts seagrass detrital material making survival counts difficult, once again suggesting this habitat may not be conducive to this species (Nicolau and Nuñez 2005).

The DEMS assemblage was primarily located in Corpus Christi Bay (Segment 2481), and shared the same benthic characteristics and SCD rankings as the DPMS assemblage of the RCAP 2002 study. This system has been identified as a stable environment with little environmental variability resulting in a more complex benthic community (Nuñez 2004; Nicolau and Nuñez 2004; Nicolau and Nuñez 2005). Similar SQGQ values associated with SCD rankings for the MMM and MEMS assemblages were observed in the DEMS assemblage. However, the impact to the benthic community in the DEMS assemblage was minimal. This suggests that similar contaminant loadings in a dynamic system may have a greater impact on a benthic community than that of a stable system.

4.4 Summary

As seen in RCAP 2002, sediment contamination was low for RCAP 2003 and the region rates as good according to TCEQ protocols. However, as was the case in RCAP 2002, different methodologies used by TCEQ and EPA produced different assessments. In contrast to RCAP 2002 sampling results, data analysis showed no cases of high (poor) TOC levels existed at sites sampled for RCAP 2003. While three cases of moderate (fair) levels existed, EPA would consider the results for the region as good according to NCCR II guidance (see Table 4.1; Fig. 4.1; Fig. 4.2; Table 4.4). Percentage of Silt-Clay conformed to expected values for sites sampled, although within some TCEQ Segments there was considerable variability (see Table 4.4; Fig. 4.3; Fig. 4.4).

Concerning sediment metal and organic contaminants, according to TCEQ screening levels, no *Secondary Concerns* exists. Unlike RCAP 2002, when one site exhibited elevated concentrations of PCBs and Total DDT, no sites had concentrations above respective PEL values. However, some concerns may exist as various sites throughout the region had concentrations above the TCEQ 85th percentile screening levels for cadmium, chromium, and zinc. These metals also had concentrations above the 85th percentiles during the RCAP 2002 study. In addition, analytical results for mercury, 4,4'-DDE and Total DDT showed concentrations above TEL screening levels at several sites in Nueces and Corpus Christi Bays during both RCAP 2002 and RCAP 2003.

Following NCCR II assessment guidelines (Table 4.1) for RCAP 2003 produced no sites with poor sediment quality due to sediment contaminants based on ERL and ERM exceedances. However, sites in five Segments had poor sediment quality due to the expression of toxic effects. As a fundamental part of the EPA Sediment Quality Index (TOC, Sediment Toxicity, and Sediment Contaminants) used in the EPA NCCR II report, the expression of toxic effects in sediment ranked eight of the 32 RCAP 2003 sites as having poor sediment quality. As was the case in RCAP 2002, the amphipod toxicity test continued to produce the most conflicting results, with no straightforward cause-effect relationship appearing to exist, as none of the sites sampled had co-occurring toxicity and elevated sediment contaminants. While unmeasured chemicals or other confounding factors such as elevated ammonia concentrations during the testing process, and/or habitat preference of the test organism may have influenced sediment toxicity results, as a result, the lack of co-occurring sediment contamination and toxicity continues to raise questions.

Use of the Sediment Quality Guideline Quotient (SQGQ) in RCAP 2003 continues to provide an alternate method of investigating potential contaminant impacts that address cumulative effects of multiple contaminants, as opposed to a single sediment screening level assessment. This process coupled with Factor analysis produced 15 sites with “Moderate” contaminant levels relative to the other RCAP 2003 sites sampled. Although 15 sites had high factor analysis scores, only nine met the criteria for a “Moderate” Sediment Contaminant Distribution characterization.

These “moderately” contaminated sites occurred in five of the ten TCEQ segments sampled during RCAP 2003. These sites typically had one or more contaminant above respective the TCEQ 85^{th} percentile or TEL (TELs not used by TCEQ) screening levels. Similar contaminants had increased concentrations in the same segments during RCAP 2002. As observed during RCAP 2002, increased contaminant deposition occurred in Nueces Bay, Copano Bay, and Baffin Bay. Contaminants contributing to variation through factor analysis identified in RCAP 2003 were also similar to those identified during RCAP 2002. Contaminants of interest for RCAP 2003 were metals in the Mission-Aransas estuary, metals and pesticides in the Nueces estuary, and metals in the Baffin Bay complex. Overall PCB’s were of little concern with the majority of the concentrations at or near minimum detection limits. Concerning the Guadalupe estuary, based on only one sampling site there are no concerns, but more data collection is required to make a true assessment of this area.

Benthic community characterization for RCAP 2003 resulted in the delineation of five assemblages, and one site classified as an outlier, with many benthic assemblages sharing similar characteristics as those in RCAP 2002. The location of MMM and MEMS assemblages was similar to the MMMS assemblage of RCAP 2002 and grouped together sites primarily located in naturally stressed areas. These assemblages typically consisted of organisms often characterized as pollution-tolerant species, indicative of environmental stress and organic enrichment. Since both assemblages are located in a dynamic portion of the estuary, other unmeasured factors ought to be considered as possibly having negative impacts on the benthic community. However, as stated for RCAP 2002, co-occurring “moderate” SCD rankings and/or expressions of sediment toxicity at sites exhibiting the greatest evidence of benthic stress, and attaining poor EPA-BCI scores, should not be discounted. The outlying site (Site 326) in Mesquite Bay was located in an area that exhibited expressions of toxicity in addition to reductions of benthic measures. This is the second year such results are observed in the area without increased SCD rankings and could possibly be a result of unmeasured contaminants.

Regarding benthic community characteristics, the SES assemblage of RCAP 2003 was similar to the RCAP 2002 SES assemblage. As with RCAP 2002, sites within this assemblage expressed toxicity without producing “Moderate” SCD rankings or reductions of benthic measures. Habitat type may exert a stronger influence on the toxicity results, as opposed to contaminant concentrations, in this assemblage. As based on historical RCAP data, *Ampelisca abdita* rarely occurred within Upper Laguna Madre samples; being completely absent where seagrass was present. The DEMS assemblage was primarily located in Corpus Christi Bay, and shared the same benthic characteristics and SCD rankings as the DPMS assemblage of RCAP 2002. This area tends to possess a more complex, or stable, benthic community; with little environmental variability. Similar SQGQ values associated with the SCD rankings for the MMM and MEMS were observed in the DEMS assemblage. However, the impact to the benthic community in this assemblage was minimal, suggesting that similar contaminant loadings in a dynamic system may have a greater impact on a benthic community than that of a stable system.

The complex process of understanding sediment interactions within the CBBEP region is still evolving and continues to require more data collection and continued refinement of methods and indices. Based on TCEQ guidelines, sediment within the area ranks as good. Using the EPA NCCR II guidelines ranks 8 of the 32 sites sampled (20 of 50 in RCAP 2002) as having degraded sediments due to the expression of toxic effects and 5 of the 32 sites sampled (10 of 50 for RCAP 2002) as having degraded benthic communities. However, the authors believe that based on questionable sediment toxicity results the rankings may not be justified and further monitoring and analysis is necessary for accurately classifying potentially degraded and healthy habitats with the CBBEP area.

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5.0 TISSUE MONITORING

5.1 Introduction

According to EPA, 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 theses contaminants, 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. Contaminants of concern consist of Mercury (methyl-mercury), metals such as copper, chromium, or zinc (currently found in elevated levels in oyster tissue in Nueces Bay), PAHs, PCBs, and DDT and other pesticides.

5.2 Sampling Design and Data Evaluation

Tissue sampling (whole-body) for RCAP 2003 took place from July 23rd through August 20th 2003 at 27 (5 sites not sampled due to shallow water or no specimens collected) randomly selected sites throughout the CBBEP region as described in Chapter 2.0. Table 6.1.1 in the *Data Tables* chapter and Fig. 2.2 provide site information and location. A complete list of parameters measured during the RCAP 2003 sampling event is in Table 2.1. The *Data Tables* in Chapter 6.0 provide the type of fish analyzed at each site (Table 6.12.1) and individual concentration values for tissue metals and tissue organic parameters measured (Table 6.13.1 and 6.14.1 through 6.14.4). Tissue analysis involved processed whole-body tissue rather than fillets to provide a better idea of possible bioaccumulation. If a screening level or concentration range existed, then data evaluation followed two different approaches; 1) the TCEQ regulatory approach and 2) according to guidelines utilized in the EPA NCCR II (USEPA 2004).

5.2.1. TCEQ Criteria and Screening Levels

Currently, regulatory criteria do not exist for the majority of tissue contaminants. However, TCEQ does employ screening levels developed from human health criteria in the TSWQS for lead and 31 organic substances to assess the concentration of toxicants in edible fish tissue. Screening levels for an additional six metals include arsenic (inorganic arsenic screen is based on 10% of total arsenic value), cadmium, chromium, copper, mercury, and selenium which come from Texas Department of State Health Services (TDSHS) screening levels used to issue consumption advisories. Screening levels aid in identifying *Secondary Concerns* for those parameters for which no adopted standard exists that exhibit elevated concentrations greater than 25% of the time based on the number of exceedances for a given sample size (TCEQ 2003). TCEQ and TDSHS do not screen or issue advisories based on whole-body fish tissue. Results presented serve as a point of reference for comparison of possible tissue contamination within the CBBEP region.

5.2.2. EPA NCCR II Guidelines

Evaluation of RCAP 2003 tissue contaminant data used the EPA NCCR II guidelines for assessing individual sites as listed in Table 5.1 and based on the risk guidelines for recreational fishers provided in Table 5.2. EPA recognizes that these assessments do not often involve widely consumed fish species of market length. However, if the fish contaminant data exceeds the risk-based concentrations ranges in Table 5.2 for consumption of four 8-ounce meals per month for any contaminant then the site is assessed as impaired for human use (USEPA 2004). Furthermore, no guidance exists to asses the ecological risk of whole-body contaminants, but EPA Advisory Guidance often serves as a basis for estimating consumption advisories even when data are based on whole-fish or organ-specific body burdens. Use of this evaluation approach in the RCAP is to provide continuity between locally collected data and the ongoing NCA program for assessing coastal waters.

Table 5.1. EPA NCA guidelines for assessing fish tissue contaminants, by site (USEPA 2004).

Rating		Fish Tissue Contaminant Guidelines
Good	(green)	The index score falls below the range of the guidance criteria for a risk-based consumption associated with four 8-ounce meals per month.
Fair	(yellow)	The index score falls within the range of the guidance criteria for a risk-based consumption associated with four 8-ounce meals per month
Poor	(red)	The index score exceeds the maximum value of the range of the guidance criteria for a risk-based consumption associated with four 8-ounce meals per month

Table 5.2. EPA NCA risk guidelines for recreational fishers. Multiple screening values are for noncancer health endpoints, respectively (USEPA 2004). Metals are in parts per million (ppm) and organics are in parts per billion (ppb).

Metals	Screening Value (ppm)	Concentration Range (ppm) (noncancer)
Arsenic (Inorganic)[a]	1.2	3.5 – 7.0
Cadmium	4.0	0.35 – 0.70
Mercury	0.4	0.12 – 0.23
Selenium	20.0	5.9 – 12.0
Organics	**Screening Value (ppb)**	**Concentration Range (ppb) (noncancer)**
Chlordane	2000	590 - 1200
DDT (Total)	2000	59 - 120
Dieldrin	200	59 - 120
Endosulfan	24000	7000 - 14000
Endrin	1200	350 - 700
Heptachlor epoxide	52	15 - 31
Hexachlorobenzene	3200	940 - 1900
Lindane	1200	350 - 700
Mirex	800	230 - 470
Toxaphene	100	290 - 590
PAH (Total)	5.47	-
PCB (Total)	80	23 - 47

[a] EPA estimates inorganic arsenic at 2% of total arsenic as opposed to TCEQ/TDSHS using 10% of total arsenic.

5.3 Results and Discussion

The approach EPA NCA uses in the collection of data for the NCCR II report continues to make RCAP tissue contaminant data difficult to assess in Texas, as existing standards and methods are not comparable (e.g. whole-body versus edible tissue). EPA is planning to modify this portion of the program and begin analyzing some sites for edible tissue in the RCAP 2004 event.

As observed in RCAP 2002 (Nicolau and Nuñez 2005), the concentration of metals in whole-body tissue was lower than all TCEQ/TDSHS applicable screening levels for RCAP 2003. However, three sites sampled during RCAP 2003 fell within the EPA risk based guidance range used in the NCCR II assessment for mercury in fish tissue and one site exceeded the guidance range (Table 6.13.1; Fig.5.1). Contaminant exceedances were found primarily in catfish and Atlantic Croaker. As seen in RCAP 2002, most sites had low concentrations of aluminum, chromium, and iron. A limited amount of nickel and lead followed by zinc and copper occurred at some locations, with many sites having metals concentration values that were non-detectable.

Detectable PCB concentrations occurred in whole-body tissue at only one site (Site 297 in Copano Bay-Segment 2472) during RCAP 2003 sampling (6.14.1), as opposed to eight sites during RCAP 2002. As was observed in RCAP 2002, all concentrations for RCAP 2003 were far below any screening level. Detectable concentrations of DDT also occurred at only one site; located in Aransas Bay (Segment 2471) (Table 6.14.2) as opposed to three sites in RCAP 2002. As seen with PCB the highest value was well below screening levels. Total Chlorinated Pesticides other than DDT registered in whole-body tissue samples at one site (Site 297 in Copano Bay-Segment 2472) in RCAP 2003, as opposed to four sites in RCAP 2002 and consisted of small detectable amounts of trans-nonachlor, a major constituent of chlordane (Table 6.14.3). Monitoring of chlordane and its constituents is important as high levels of chlordane can cause damage to the nervous system or liver. At a concentration of 2.58 ppb this small amount of pesticide poses no health problems. No detectable concentrations of PAHs occurred in any of the 27 sites sampled (Table 6.14.4).

5.4 Summary

Although not applicable, the results of whole-body tissue analysis were compared to screening levels normally used for edible tissue as a basis for determining extent of possible contamination and bioaccumulation in tissue. Based on TCEQ/TDSHS screening levels the region ranks as good, since most contaminants were non-detectable or well below any applicable screening level. When evaluating the CBBEP region according to EPA guidelines the CBBEP region also rated as good. While one site exceeded the maximum concentration range value (>0.23 ppm) for mercury, the other three sites fell just slightly above the minimum concentration range value (>0.12 ppm). The presence of mercury in edible fish tissue can be a major concern for public health but more data or studies are necessary to determine if mercury in estuarine fish tissue represents an increasing trend within the area.

As seen in RCAP 2002 no specimens collected in RCAP 2003 showed evidence of lesions or tumors during the external gross pathology examination performed on-board TPWD vessels during sampling. Future events and reevaluation of sampling and analysis protocols may produce results that are comparable to existing state guidelines and /or federal guidelines.

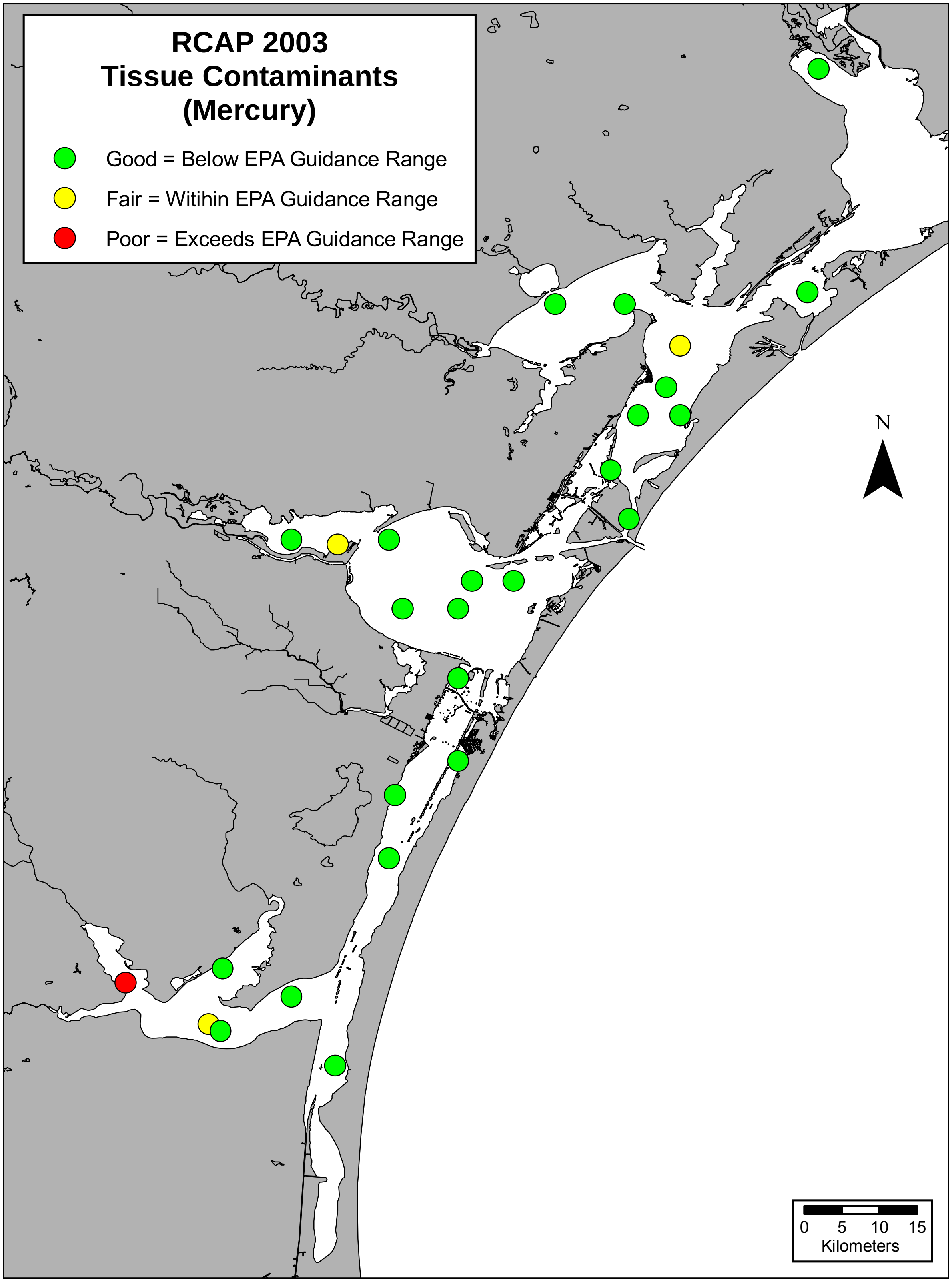

Fig. 5.1. Results of mercury tissue contaminant evaluation according to EPA guidance ranges (see Table 5.2) at 27 of 32 RCAP 2003 sampling sites.

5.5 References

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6.0 DATA TABLES

6.1 Sampling Site Information

Table 6.1.1. RCAP 2003 sampling site (32) information, sample type, and sampling date. **Sample Types:** FD = Field Data, RC = Routine Conventional Water Chemistry, M = Microbiological, TM = Trace Metals-Water, TMSED = Trace Metals-Sediment, SEDORG = Sediment Organics, SEDTOX = Sediment Toxicology, TISORG = Tissue Organics, TMTIS = Trace Metals-Tissue, BEN = Benthic Cores.

Segment Number	Segment Name	CCS ID	TCEQ ID	Sample Type	Sampling Date	Latitude (dd)	Longitude (dd)	Depth (m)
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/23/2003	28.40833	96.82500	1.10
2463	Mesquite/Carlos/Ayres Bays	326	18296	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/05/2003	28.13934	96.83861	1.42
2471	Aransas Bay	298	18268	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/11/2003	28.07500	96.99167	1.50
2471		299	18269	FD, RC, M. TMSED, SEDORG, SEDTOX, BEN	08/05/2003	28.06707	96.93630	0.90
2471		300	18270	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/19/2003	28.02500	97.00833	3.60
2471		301	18271	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/19/2003	27.99167	97.04167	3.60
2471		302	18272	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/19/2003	27.99167	96.99167	3.60
2471		303	18273	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/19/2003	27.92500	97.07500	1.50
2471		305	18275	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/19/2003	27.86690	97.05267	1.25
2472	Copano/Port/Mission Bays	296	18226	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/11/2003	28.12500	97.14167	2.16
2472		297	18267	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/11/2003	28.12500	97.05833	2.50
2481	Corpus Christi Bay	307	18277	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/23/2003	27.84167	97.34167	3.50
2481		309	18279	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/06/2003	27.79167	97.24167	4.30
2481		310	18280	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/06/2003	27.79167	97.19167	2.80
2481		311	18281	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/06/2003	27.75833	97.32500	4.50
2481		312	18282	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/06/2003	27.75833	97.25833	4.55
2481		314	18284	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/24/2003	27.67500	97.25833	2.30
2482	Nueces Bay	306	18276	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/23/2003	27.84167	97.45833	1.44
2482		308	18278	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/23/2003	27.83541	97.40306	0.70
2483	Redfish Bay	304	18274	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, BEN	08/19/2003	27.90501	97.10814	0.97
2485	Oso Bay	313	18283	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, BEN	08/06/2003	27.70720	97.30958	0.90
2491	Laguna Madre	315	18285	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/24/2003	27.57500	97.25833	0.85
2491		316	18286	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/24/2003	27.53446	97.33412	0.80
2491		317	18287	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/24/2003	27.45833	97.34167	1.75
2491		323	18293	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/18/2003	27.20828	97.40591	2.10
2491		324	18294	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, BEN	08/20/2003	27.19342	97.41742	2.65
2491		325	18295	FD, RC, M. TMSED, SEDORG, SEDTOX, BEN	08/20/2003	27.10190	97.43572	0.97
2492	Baffin Bay/Alazan Bay	318	18288	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2003	27.32500	97.54167	1.45
2492	Cayo del Grullo/Laguna Salada	319	18289	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2003	27.30833	97.65833	1.32
2492		320	18290	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/18/2003	27.29167	97.45833	2.91
2492		321	18291	FD, RC, M. TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2003	27.25833	97.55833	2.25
2492		322	18292	FD, RC, M. TM, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2003	27.25035	97.54390	2.05

6.2 Field Parameters – Individual Concentrations (Near-Surface and Near-Bottom Grab Samples)

Table 6.2.1. Near-surface Field Parameter concentrations recorded 0.50 m below surface at RCAP 2003 sampling sites. Shaded = value below TCEQ 24-Hour DO average criteria. Value is not applicable to grab samples but provides a reference. All Segments have a 5.0 mg/L DO criteria except Segment 2492 where the criterion is 4.0 mg/L. ND = No Data collected.

Segment	Segment Name	CCS ID	TCEQ ID	Cond. (µmhos)	DO (mg/L)	DO Sat. (%)	pH (su)	Salinity (psu)	Secchi Depth (m)	Total Depth (m)	Turbidity (NTU)	Water Temp (°C)
2462	San Antonio/Hynes/Guadalupe Bay	295	18266	ND	7.56	ND	8.54	0.49	ND	1.10	ND	29.69
2463	Mesquite/Carlos/Ayres Bay	326	18296	27962	6.13	88.40	8.15	17.11	0.30	1.42	29.20	29.52
2471	Aransas Bay	298	18268	41513	6.09	93.50	8.23	26.51	0.85	1.50	6.00	30.25
2471		299	18269	35347	4.96	72.80	8.03	22.17	> 0.90	0.90	3.70	28.89
2471		300	18270	49143	5.85	92.10	8.21	31.97	0.90	3.60	6.40	29.92
2471		301	18271	52793	6.09	97.22	8.19	34.66	1.10	3.60	4.10	29.73
2471		302	18272	49906	6.15	96.30	8.24	32.55	1.10	3.60	4.00	29.36
2471		303	18273	59549	6.44	105.30	7.89	39.74	1.20	1.50	2.70	29.62
2471		305	18275	59886	7.52	124.90	8.00	39.94	0.90	1.25	7.40	30.37
2472	Copano/Port/Mission Bay	296	18226	14905	7.84	111.10	8.19	8.59	0.50	2.16	10.60	31.00
2472		297	18267	19301	7.05	99.20	8.16	11.40	0.95	2.50	4.50	29.91
2481	Corpus Christi Bay	307	18277	45795	6.32	98.20	8.06	29.54	0.40	3.50	16.50	29.85
2481		309	18279	51154	6.84	108.10	8.04	33.44	0.85	4.30	5.00	29.43
2481		310	18280	49727	6.32	99.90	8.12	32.39	0.65	2.80	10.40	29.52
2481		311	18281	49544	7.71	122.10	7.99	32.25	0.80	4.50	4.60	30.19
2481		312	18282	50007	7.43	117.40	7.98	32.60	0.95	4.55	4.70	29.95
2481		314	18284	52863	6.33	101.20	8.20	34.72	0.75	2.30	8.30	29.52
2482	Nueces Bay	306	18276	15828	7.65	105.50	8.08	9.19	0.65	1.44	8.00	29.40
2482		308	18278	41492	6.74	101.80	8.06	26.48	0.50	0.70	11.80	29.25
2483	Redfish Bay	304	18274	56801	8.89	148.10	8.22	37.60	0.90	0.97	6.80	31.16
2485	Oso Bay	313	18283	54733	8.53	141.40	8.25	36.02	0.25	0.90	22.40	31.77
2491	Laguna Madre	315	18285	52764	5.03	78.60	8.23	34.69	> 0.85	0.85	1.60	28.44
2491		316	18286	52325	3.51	54.90	7.89	34.39	> 0.80	0.80	0.90	28.61
2491		317	18287	54003	5.22	82.50	8.14	35.59	0.98	1.75	3.40	28.86
2491		323	18293	64353	6.18	103.10	8.25	43.39	0.95	2.10	2.70	29.55
2491		324	18294	59425	6.10	101.20	8.16	39.62	1.00	2.65	2.70	30.54
2491		325	18295	58075	5.69	93.40	8.31	38.59	0.70	0.97	7.40	30.04
2492	Baffin Bay/Alazan Bay	318	18288	54405	6.01	95.50	7.75	35.89	0.15	1.45	112.80	28.86
2492	Cayo del Grullo/Laguna Salada	319	18289	53194	6.66	106.70	7.92	34.97	0.20	1.32	59.50	29.41
2492		320	18290	65836	5.90	99.00	8.26	44.54	0.60	2.91	7.00	29.50
2492		321	18291	52307	4.84	76.30	7.89	34.33	0.25	2.25	58.50	28.91
2492		322	18292	51904	4.73	74.50	7.88	34.03	0.45	2.05	31.60	28.93

Table 6.2.2. Near-bottom Field Parameter concentrations recorded 0.50 m off-bottom at RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. Shaded = value below TCEQ 24-Hour DO average criteria. Value is not applicable to grab or bottom samples but provides a reference. All Segments have a 5.0 mg/L DO criteria except Segment 2492 where the criterion is 4.0 mg/L. ND = No Data collected.

Segment	Segment Name	CCS ID	TCEQ ID	Cond. (µmhos)	DO (mg/L)	DO Sat. (%)	pH (su)	Salinity (psu)	Total Depth (m)	Turbidity (NTU)	Water Temp (°C)
2462	San Antonio/Hynes/Guadalupe Bay	295	18266	ND	7.56	ND	8.54	0.49	1.10	ND	29.69
2463	Mesquite/Carlos/Ayres Bay	326	18296	27962	6.09	87.70	8.15	17.12	1.42	29.40	29.52
2471	Aransas Bay	298	18268	41659	5.93	91.40	8.23	26.57	1.50	7.50	30.31
2471		299	18269	35347	4.96	72.80	8.03	22.17	0.90	3.70	28.89
2471		300	18270	49171	5.81	91.50	8.22	31.99	3.60	6.40	29.92
2471		301	18271	53616	5.68	90.80	8.17	35.27	3.60	6.30	29.71
2471		302	18272	52355	5.73	90.50	8.24	34.36	3.60	13.10	29.29
2471		303	18273	59653	6.38	104.40	7.89	39.80	1.50	2.60	29.59
2471		305	18275	59878	7.42	123.20	7.99	39.95	1.25	8.30	30.29
2472	Copano/Port/Mission Bay	296	18226	14879	7.46	104.10	8.16	8.58	2.16	13.00	30.28
2472		297	18267	25908	5.67	82.90	8.07	15.71	2.50	18.90	30.74
2481	Corpus Christi Bay	307	18277	47767	5.84	91.50	8.06	30.97	3.50	32.70	29.91
2481		309	18279	51519	6.22	98.10	8.00	33.73	4.30	10.20	29.45
2481		310	18280	49666	6.19	92.70	8.12	32.36	2.80	11.10	29.77
2481		311	18281	49946	5.83	92.50	7.94	32.57	4.50	10.70	29.66
2481		312	18282	49986	6.41	101.50	7.93	32.57	4.55	15.80	29.74
2481		314	18284	52811	4.27	68.00	8.07	34.71	2.30	10.00	29.08
2482	Nueces Bay	306	18276	16472	7.39	102.10	8.07	9.59	1.44	8.50	29.39
2482		308	18278	41492	6.74	101.80	8.06	26.48	0.70	11.80	29.25
2483	Redfish Bay	304	18274	56801	8.89	148.10	8.22	37.60	0.97	6.80	31.16
2485	Oso Bay	313	18283	54733	8.53	141.40	8.25	36.02	0.90	22.40	31.77
2491	Laguna Madre	315	18285	52764	5.03	78.60	8.23	34.69	0.85	1.60	28.44
2491		316	18286	52325	3.51	54.90	7.89	34.39	0.80	0.90	28.61
2491		317	18287	54010	5.11	80.70	8.16	35.59	1.75	4.00	28.86
2491		323	18293	66130	5.97	99.90	8.20	44.79	2.10	3.50	29.34
2491		324	18294	66002	6.00	101.70	8.12	44.64	2.65	3.30	30.22
2491		325	18295	58075	5.69	93.40	8.31	38.59	0.97	7.40	30.04
2492	Baffin Bay/Alazan Bay	318	18288	54395	5.80	92.10	7.73	35.88	1.45	121.30	28.85
2492	Cayo del Grullo/Laguna Salada	319	18289	53196	6.41	101.90	7.90	37.97	1.32	61.00	29.42
2492		320	18290	65863	5.78	97.00	8.27	44.56	2.91	6.90	29.49
2492		321	18291	52306	4.63	72.80	7.88	34.33	2.25	73.60	28.92
2492		322	18292	51914	4.63	72.60	7.88	34.04	2.05	33.70	28.94

6.3 Field Parameters – Summary Statistics (Near-Surface and Near-Bottom grab samples)

Table 6.3.1. Conductivity (μmhos) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. **Bold** = highest recorded mean concentration. ND = No Data collected.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Conductivity	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	ND	ND	ND
(μmhos)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	27962
	2471	Aransas Bay	7	35347	59886	49734
	2472	Copano Bay/Port Bay/Mission Bay	2	14905	19301	17103
Near-Surface	2481	Corpus Christi Bay	6	45795	52863	49848
(0.50 m below)	2482	Nueces Bay	2	15828	41492	28660
	2483	Redfish Bay	1	-	-	56801
	2485	Oso Bay	1	-	-	54733
	2491	Laguna Madre	6	52325	64353	**56824**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	51904	65836	55529
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Conductivity	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	ND	ND	ND
(μmhos)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	27976
	2471	Aransas Bay	7	35347	59878	50240
	2472	Copano Bay/Port Bay/Mission Bay	2	14879	25908	20394
Near-Bottom	2481	Corpus Christi Bay	6	47767	52811	50283
(0.50 above)	2482	Nueces Bay	2	16472	41492	28982
	2483	Redfish Bay	1	-	-	56801
	2485	Oso Bay	1	-	-	54733
	2491	Laguna Madre	6	52325	66130	**58218**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	51914	65863	55535

Table 6.3.2. Salinity (PSU) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. **Bold** = highest recorded mean concentration.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Salinity	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.49
(PSU)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	17.11
	2471	Aransas Bay	7	22.17	39.94	32.51
	2472	Copano Bay/Port Bay/Mission Bay	2	8.59	11.40	10.00
Near-Surface	2481	Corpus Christi Bay	6	29.54	34.72	32.49
(0.50 m below)	2482	Nueces Bay	2	9.19	26.48	17.84
	2483	Redfish Bay	1	-	-	37.60
	2485	Oso Bay	1	-	-	36.02
	2491	Laguna Madre	6	34.39	43.39	**37.71**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	34.03	44.54	36.75
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Salinity	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.49
(PSU)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	17.12
	2471	Aransas Bay	7	22.17	39.95	32.87
	2472	Copano Bay/Port Bay/Mission Bay	2	8.58	15.71	12.15
Near-Bottom	2481	Corpus Christi Bay	6	30.97	34.71	32.82
(0.50 above)	2482	Nueces Bay	2	9.59	26.48	18.04
	2483	Redfish Bay	1	-	-	37.60
	2485	Oso Bay	1	-	-	36.02
	2491	Laguna Madre	6	34.39	44.79	**38.78**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	34.04	44.56	37.36

Table 6.3.3. Dissolved Oxygen (mg/L) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. Shaded = value below TCEQ 24-Hour DO average criteria. Value is not applicable to grab or bottom samples but provides a reference. All Segments have a 5.0 mg/L DO criteria except Segment 2492 where the criterion is 4.0 mg/L. **Bold** = highest recorded mean concentration.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Dissolved Oxygen	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	7.56
(mg/L)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	6.13
	2471	Aransas Bay	7	4.96	7.52	6.16
	2472	Copano Bay/Port Bay/Mission Bay	2	7.05	7.84	7.45
Near-Surface	2481	Corpus Christi Bay	6	6.32	7.71	6.83
(0.50 m below)	2482	Nueces Bay	2	6.74	7.65	7.20
	2483	Redfish Bay	1	-	-	**8.89**
	2485	Oso Bay	1	-	-	8.53
	2491	Laguna Madre	6	3.51	6.18	5.29
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	4.73	6.66	5.63

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Dissolved Oxygen	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	7.56
(mg/L)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	6.09
	2471	Aransas Bay	7	4.96	7.42	5.99
	2472	Copano Bay/Port Bay/Mission Bay	2	5.67	7.46	6.57
Near-Bottom	2481	Corpus Christi Bay	6	4.27	6.41	5.79
(0.50 above)	2482	Nueces Bay	2	6.74	7.39	7.07
	2483	Redfish Bay	1	-	-	**8.89**
	2485	Oso Bay	1	-	-	8.53
	2491	Laguna Madre	6	3.51	6.00	5.22
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	4.63	6.41	5.45

Table 6.3.4. Dissolved Oxygen (% saturation) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. **Bold** = highest recorded mean concentration. ND = No Data Collected.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Dissolved Oxygen	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	ND	ND	ND
(% Saturation)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	88.40
	2471	Aransas Bay	7	72.80	124.90	97.45
	2472	Copano Bay/Port Bay/Mission Bay	2	99.20	111.10	105.15
Near-Surface	2481	Corpus Christi Bay	6	98.20	122.10	107.82
(0.50 m below)	2482	Nueces Bay	2	101.80	105.50	103.65
	2483	Redfish Bay	1	-	-	**148.10**
	2485	Oso Bay	1	-	-	141.40
	2491	Laguna Madre	6	54.90	103.10	85.62
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	74.50	106.70	90.40
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Dissolved Oxygen	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	ND	ND	ND
(% Saturation)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	87.70
	2471	Aransas Bay	7	72.80	123.20	94.94
	2472	Copano Bay/Port Bay/Mission Bay	2	82.90	104.10	93.50
Near-Bottom	2481	Corpus Christi Bay	6	68.00	101.50	90.72
(0.50 above)	2482	Nueces Bay	2	101.80	102.10	101.95
	2483	Redfish Bay	1	-	-	**148.10**
	2485	Oso Bay	1	-	-	141.40
	2491	Laguna Madre	6	54.90	101.70	84.87
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	72.60	101.90	87.28

Table 6.3.5. pH (su) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. **Bold** = highest recorded mean concentration.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
pH	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**8.54**
(su)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	8.15
	2471	Aransas Bay	7	7.89	8.24	8.11
	2472	Copano Bay/Port Bay/Mission Bay	2	8.16	8.19	8.18
Near-Surface	2481	Corpus Christi Bay	6	7.98	8.20	8.07
(0.50 m below)	2482	Nueces Bay	2	8.06	8.08	8.07
	2483	Redfish Bay	1	-	-	8.22
	2485	Oso Bay	1	-	-	8.25
	2491	Laguna Madre	6	7.89	8.31	8.16
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	7.75	8.26	7.94
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
pH	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**8.54**
(su)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	8.15
	2471	Aransas Bay	7	7.89	8.24	8.11
	2472	Copano Bay/Port Bay/Mission Bay	2	8.07	8.16	8.12
Near-Bottom	2481	Corpus Christi Bay	6	7.93	8.12	8.02
(0.50 m above)	2482	Nueces Bay	2	8.06	8.07	8.07
	2483	Redfish Bay	1	-	-	8.22
	2485	Oso Bay	1	-	-	8.25
	2491	Laguna Madre	6	7.89	8.31	8.15
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	7.73	8.27	7.93

Table 6.3.6. Turbidity (NTU) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. **Bold** = highest recorded mean concentration. ND = No Data collected.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Turbidity	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	ND	ND	ND
(NTU)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	29.20
	2471	Aransas Bay	7	2.70	7.40	4.90
	2472	Copano Bay/Port Bay/Mission Bay	2	4.50	10.60	7.55
Near-Surface	2481	Corpus Christi Bay	6	4.60	16.50	8.25
(0.50 m below)	2482	Nueces Bay	2	8.00	11.80	9.90
	2483	Redfish Bay	1	-	-	6.80
	2485	Oso Bay	1	-	-	22.40
	2491	Laguna Madre	6	0.90	7.40	3.12
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	7.00	112.80	**53.88**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Turbidity	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	ND	ND	ND
(NTU)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	29.40
	2471	Aransas Bay	7	2.60	13.10	6.84
	2472	Copano Bay/Port Bay/Mission Bay	2	13.00	18.90	15.95
Near-Bottom	2481	Corpus Christi Bay	6	10.00	32.70	15.08
(0.50 m above)	2482	Nueces Bay	2	8.50	11.80	10.15
	2483	Redfish Bay	1	-	-	6.80
	2485	Oso Bay	1	-	-	22.40
	2491	Laguna Madre	6	0.90	7.40	3.45
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	6.90	121.30	**59.30**

Table 6.3.7. Water Temperature (°C) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. At sites where water depth is shallow, the near-surface and near-bottom values are the same. **Bold** = highest recorded mean concentration.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Water Temperature	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	29.69
(°C)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	29.52
	2471	Aransas Bay	7	28.89	30.37	29.73
	2472	Copano Bay/Port Bay/Mission Bay	2	29.91	31.00	30.46
Near-Surface	2481	Corpus Christi Bay	6	29.43	30.19	29.74
(0.50 m below)	2482	Nueces Bay	2	29.25	29.40	29.33
	2483	Redfish Bay	1	-	-	31.16
	2485	Oso Bay	1	-	-	**31.77**
	2491	Laguna Madre	6	28.44	30.54	29.34
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	28.86	29.50	29.12
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Water Temperature	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	29.69
(°C)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	29.52
	2471	Aransas Bay	7	28.89	30.31	29.71
	2472	Copano Bay/Port Bay/Mission Bay	2	30.28	30.74	30.51
Near-Bottom	2481	Corpus Christi Bay	6	29.08	29.91	29.60
(0.50 m above)	2482	Nueces Bay	2	29.25	29.39	29.32
	2483	Redfish Bay	1	-	-	31.16
	2485	Oso Bay	1	-	-	**31.77**
	2491	Laguna Madre	6	28.44	30.22	29.25
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	28.85	29.49	29.12

Table 6.3.8. Secchi Depth (m) and Total Depth (m) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites. **Bold** = highest recorded mean concentration. ND = No Data Collected.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Secchi Depth	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	ND	ND	ND
(m)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.30
	2471	Aransas Bay	7	0.85	1.20	**0.99**
	2472	Copano Bay/Port Bay/Mission Bay	2	0.50	0.95	0.73
	2481	Corpus Christi Bay	6	0.40	0.95	0.73
	2482	Nueces Bay	2	0.50	0.65	0.58
	2483	Redfish Bay	1	-	-	0.90
	2485	Oso Bay	1	-	-	0.25
	2491	Laguna Madre	6	0.70	1.00	0.88
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.15	0.60	0.33
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Total Depth	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	1.10
(m)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	1.42
	2471	Aransas Bay	7	0.90	3.60	2.28
	2472	Copano Bay/Port Bay/Mission Bay	2	2.16	2.50	2.33
	2481	Corpus Christi Bay	6	2.30	4.55	**3.66**
	2482	Nueces Bay	2	0.70	1.44	1.07
	2483	Redfish Bay	1	-	-	0.97
	2485	Oso Bay	1	-	-	0.90
	2491	Laguna Madre	6	0.80	2.65	1.52
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	1.32	2.91	2.00

6.4 Routine Conventional Water Chemistry – Individual Concentrations (mg/L or ppm, chlorophyll *a* µg/L or ppb)

Table 6.4.1. Ammonia concentrations (mg/L or ppm) at RCAP 2003 sampling sites. TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated in parentheses below parameter and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded concentration.* = indicates sample not collected due to depth requirements.

Segment	Segment Name	CCS ID	TCEQ ID	Ammonia SNU (SLE 0.10)	Ammonia MNU	Ammonia BNU	Ammonia SN	Ammonia MN	Ammonia BN
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	0.021	*	*	0.014	*	*
2463	Mesquite/Carlos/Ayres Bays	326	18296	0.014	*	*	<0.001	*	0.002
2471	Aransas Bay	298	18268	0.018	*	*	0.020	*	0.015
2471		299	18269	<0.001	*	*	<0.001	*	*
2471		300	18270	0.001	0.002	0.002	<0.001	<0.001	<0.001
2471		301	18271	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
2471		302	18272	0.002	<0.001	<0.001	<0.001	0.001	0.004
2471		303	18273	<0.001	*	<0.001	<0.001	*	<0.001
2471		305	18275	0.002	*	0.002	0.001	*	0.002
2472	Copano/Port/Mission Bays	296	18226	0.007	0.009	0.010	0.003	0.004	0.003
2472		297	18267	0.007	0.009	0.011	0.007	0.005	0.010
2481	Corpus Christi Bay	307	18277	0.008	0.012	0.022	0.016	0.018	0.027
2481		309	18279	0.012	<0.001	0.019	<0.001	0.018	0.016
2481		310	18280	0.007	0.009	0.003	<0.001	<0.001	<0.001
2481		311	18281	0.001	0.002	0.015	<0.001	<0.001	0.010
2481		312	18282	0.002	0.002	0.009	<0.001	<0.001	0.001
2481		314	18284	0.022	0.021	0.020	0.020	0.036	0.012
2482	Nueces Bay	306	18276	<0.001	*	0.016	<0.001	*	<0.001
2482		308	18278	<0.001	*	*	0.003	*	*
2483	Redfish Bay	304	18274	0.003	*	*	0.003	*	*
2485	Oso Bay	313	18283	0.010	*	*	0.005	*	*
2491	Laguna Madre	315	18285	<0.001	*	*	<0.001	*	*
2491		316	18286	<0.001	*	*	0.003	*	*
2491		317	18287	0.007	*	<0.001	<0.001	*	0.013
2491		323	18293	0.037	0.037	0.031	0.036	0.026	0.028
2491		324	18294	0.026	0.016	0.026	0.020	0.032	0.013
2491		325	18295	0.019	*	*	0.014	*	*
2492	Baffin Bay/Alazan Bay	318	18288	0.396	*	0.038	0.318	*	0.284
2492	Cayo del Grullo/Laguna Salada	319	18289	0.252	*	0.253	0.205	*	0.206
2492		320	18290	0.023	0.020	0.020	0.012	0.013	0.024
2492		321	18291	0.380	0.372	0.382	0.342	0.319	0.304
2492		322	18292	**0.537**	**0.525**	**0.497**	**0.513**	**0.504**	**0.326**

Table 6.4.2. Nitrate concentrations (mg/L or ppm) at RCAP 2003 sampling sites. TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). **Bold** = highest recorded concentration.* = indicates sample not collected due to depth requirements.

Segment	Segment Name	CCS ID	TCEQ ID	Nitrate SNU	Nitrate MNU	Nitrate BNU	Nitrate SN	Nitrate MN	Nitrate BN
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	**3.037**	*	*	**3.245**	*	*
2463	Mesquite/Carlos/Ayres Bays	326	18296	<0.010	*	<0.010	<0.010	*	<0.001
2471	Aransas Bay	298	18268	<0.010	*	<0.010	<0.010	*	<0.001
2471		299	18269	<0.010	*	*	<0.001	*	*
2471		300	18270	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2471		301	18271	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2471		302	18272	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2471		303	18273	<0.010	*	<0.010	<0.010	*	<0.010
2471		305	18275	<0.010	*	<0.010	<0.010	*	<0.010
2472	Copano/Port/Mission Bays	296	18226	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2472		297	18267	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2481	Corpus Christi Bay	307	18277	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2481		309	18279	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2481		310	18280	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2481		311	18281	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2481		312	18282	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2481		314	18284	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2482	Nueces Bay	306	18276	<0.010	*	<0.010	<0.010	*	<0.010
2482		308	18278	<0.010	*	*	<0.001	*	*
2483	Redfish Bay	304	18274	<0.010	*	*	<0.001	*	*
2485	Oso Bay	313	18283	<0.010	*	*	<0.010	*	*
2491	Laguna Madre	315	18285	<0.010	*	*	<0.010	*	*
2491		316	18286	<0.010	*	*	<0.010	*	*
2491		317	18287	<0.010	*	<0.010	<0.010	*	<0.010
2491		323	18293	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2491		324	18294	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2491		325	18295	<0.010	*	*	<0.010	*	*
2492	Baffin Bay/Alazan Bay	318	18288	<0.010	*	<0.010	0.152	*	0.081
2492	Cayo del Grullo/Laguna Salada	319	18289	0.045	*	0.033	<0.010	*	<0.010
2492		320	18290	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2492		321	18291	0.068	0.053	0.042	<0.010	<0.010	<0.010
2492		322	18292	0.095	**0.114**	**0.062**	0.149	**0.151**	**0.140**

Table 6.4.3. Nitrite concentrations (mg/L or ppm) at RCAP 2003 sampling sites. TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). **Bold** = highest recorded concentration.* = indicates sample not collected due to depth requirements.

Segment	Segment Name	CCS ID	TCEQ ID	Nitrite SNU	Nitrite MNU	Nitrite BNU	Nitrite SN	Nitrite MN	Nitrite BN
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	0.068	*	*	0.043	*	*
2463	Mesquite/Carlos/Ayres Bays	326	18296	0.036	*	0.038	0.003	*	0.002
2471	Aransas Bay	298	18268	0.014	*	0.015	0.002	*	0.003
2471		299	18269	0.010	*	*	0.003	*	*
2471		300	18270	0.009	0.007	0.008	<0.001	<0.001	0.001
2471		301	18271	0.008	0.008	0.010	0.002	0.001	<0.001
2471		302	18272	0.007	0.007	0.009	0.001	0.005	0.003
2471		303	18273	0.005	*	0.007	0.003	*	0.003
2471		305	18275	0.010	*	0.010	0.001	*	0.002
2472	Copano/Port/Mission Bays	296	18226	0.016	0.018	0.020	0.004	0.005	0.006
2472		297	18267	0.014	0.014	0.023	0.005	0.008	0.015
2481	Corpus Christi Bay	307	18277	0.020	0.019	0.045	<0.001	0.003	0.033
2481		309	18279	0.008	0.010	0.016	0.001	0.004	0.003
2481		310	18280	0.011	0.012	0.012	0.001	0.001	0.010
2481		311	18281	0.009	0.009	0.019	<0.001	<0.001	0.004
2481		312	18282	0.008	0.008	0.020	0.005	<0.001	0.001
2481		314	18284	0.017	0.017	0.015	0.002	<0.001	0.002
2482	Nueces Bay	306	18276	0.012	*	0.013	0.001	*	0.001
2482		308	18278	0.023	*	*	0.003	*	*
2483	Redfish Bay	304	18274	0.010	*	*	0.003	*	*
2485	Oso Bay	313	18283	0.039	*	*	0.001	*	*
2491	Laguna Madre	315	18285	0.003	*	*	0.001	*	*
2491		316	18286	0.002	*	*	0.001	*	*
2491		317	18287	0.005	*	0.006	0.001	*	<0.001
2491		323	18293	0.014	0.014	0.012	0.005	0.010	0.003
2491		324	18294	0.009	0.012	0.011	0.005	0.004	0.005
2491		325	18295	0.013	*	*	0.004	*	*
2492	Baffin Bay/Alazan Bay	318	18288	**0.260**	*	**0.236**	**0.100**	*	**0.082**
2492	Cayo del Grullo/Laguna Salada	319	18289	0.119	*	0.126	0.027	*	0.025
2492		320	18290	0.022	0.023	0.021	0.006	0.006	0.005
2492		321	18291	0.098	**0.100**	0.118	0.012	0.016	0.019
2492		322	18292	0.080	0.066	0.108	0.031	**0.032**	0.046

Table 6.4.4. Nitrate + Nitrite (N + N) concentrations (mg/L or ppm) at RCAP 2003 sampling sites. TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated in parentheses below parameter and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded concentration.* = indicates sample not collected due to depth requirements.

Segment	Segment Name	CCS ID	TCEQ ID	N + N SNU (SLE 0.26)	N + N MNU	N + N BNU	N + N SN	N + N MN	N + N BN
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	**3.105**	*	*	**3.288**	*	*
2463	Mesquite/Carlos/Ayres Bays	326	18296	0.036	*	0.038	0.003	*	0.002
2471	Aransas Bay	298	18268	0.014	*	0.015	0.002	*	0.003
2471		299	18269	0.010	*	*	0.008	*	*
2471		300	18270	0.009	0.007	0.008	<0.001	<0.001	0.001
2471		301	18271	0.008	0.008	0.010	0.001	0.001	<0.001
2471		302	18272	0.007	0.007	0.009	0.001	0.005	0.003
2471		303	18273	0.005	*	0.007	0.003	*	0.003
2471		305	18275	0.010	*	0.010	0.001	*	0.002
2472	Copano/Port/Mission Bays	296	18226	0.016	0.018	0.020	0.004	0.005	0.006
2472		297	18267	0.014	0.014	0.023	0.005	0.008	0.015
2481	Corpus Christi Bay	307	18277	0.028	0.019	0.064	<0.001	0.003	0.033
2481		309	18279	0.008	0.010	0.016	0.001	0.004	0.003
2481		310	18280	0.011	0.012	0.012	0.001	0.001	0.010
2481		311	18281	0.009	0.009	0.019	<0.001	<0.001	0.004
2481		312	18282	0.008	0.008	0.020	0.005	<0.001	0.001
2481		314	18284	0.017	0.017	0.015	0.002	<0.001	0.002
2482	Nueces Bay	306	18276	0.012	*	0.013	0.001	*	0.001
2482		308	18278	0.023	*	*	0.006	*	*
2483	Redfish Bay	304	18274	0.010	*	*	0.008	*	*
2485	Oso Bay	313	18283	0.039	*	*	0.001	*	*
2491	Laguna Madre	315	18285	0.003	*	*	0.001	*	*
2491		316	18286	0.002	*	*	0.001	*	*
2491		317	18287	0.005	*	0.006	0.001	*	<0.001
2491		323	18293	0.014	0.014	0.012	0.005	0.010	0.003
2491		324	18294	0.009	0.018	0.011	0.005	0.004	0.005
2491		325	18295	0.013	*	*	0.004	*	*
2492	Baffin Bay/Alazan Bay	318	18288	0.260	*	**0.236**	0.252	*	0.163
2492	Cayo del Grullo/Laguna Salada	319	18289	0.163	*	0.159	0.027	*	0.025
2492		320	18290	0.022	0.023	0.021	0.006	0.006	0.005
2492		321	18291	0.166	0.153	0.160	0.012	0.016	0.019
2492		322	18292	0.174	**0.180**	0.169	0.180	**0.183**	**0.186**

Table 6.4.5. Total Phosphorus (TP) concentrations (mg/L or ppm) at RCAP 2003 sampling sites. TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated in parentheses below parameter and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded concentration.* = indicates sample not collected due to depth requirements.

Segment	Segment Name	CCS ID	TCEQ ID	TP SNU (0.22)	TP MNU	TP BNU
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	**0.177**	*	*
2463	Mesquite/Carlos/Ayres Bays	326	18296	0.026	*	0.026
2471	Aransas Bay	298	18268	0.059	*	0.059
2471		299	18269	0.018	*	*
2471		300	18270	0.042	0.042	0.051
2471		301	18271	0.042	0.033	0.045
2471		302	18272	0.047	0.045	0.048
2471		303	18273	0.033	*	0.031
2471		305	18275	0.033	*	0.030
2472	Copano/Port/Mission Bays	296	18226	0.088	0.075	**0.091**
2472		297	18267	0.071	0.068	0.069
2481	Corpus Christi Bay	307	18277	0.011	0.010	0.032
2481		309	18279	0.006	0.007	0.007
2481		310	18280	0.012	0.012	0.021
2481		311	18281	0.012	0.012	0.014
2481		312	18282	0.014	0.009	0.011
2481		314	18284	0.004	0.003	0.006
2482	Nueces Bay	306	18276	0.047	*	0.039
2482		308	18278	0.027	*	*
2483	Redfish Bay	304	18274	0.034	*	*
2485	Oso Bay	313	18283	0.005	*	*
2491	Laguna Madre	315	18285	0.005	*	*
2491		316	18286	0.003	*	*
2491		317	18287	0.005	*	0.015
2491		323	18293	0.035	0.038	0.039
2491		324	18294	0.033	**0.514**	0.035
2491		325	18295	0.038	*	*
2492	Baffin Bay/Alazan Bay	318	18288	0.012	*	0.025
2492	Cayo del Grullo/Laguna Salada	319	18289	0.013	*	0.011
2492		320	18290	0.060	0.056	0.051
2492		321	18291	0.014	0.014	0.017
2492		322	18292	0.011	0.010	0.024

Table 6.4.6. Orthophosphorus (OP), or Dissolved Inorganic Phosphorus, concentrations (mg/L or ppm) at RCAP 2003 sampling sites. TCEQ and EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated in parentheses below parameter and is only applicable to SN samples. Other exceedances provided for reference. **Bold** = highest recorded concentration.* = indicates sample not collected due to depth requirements.

Segment	Segment Name	CCS ID	TCEQ ID	OP SN (SLE 0.16)	OP MN	OP BN
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	0.210	*	*
2463	Mesquite/Carlos/Ayres Bays	326	18296	0.113	*	0.099
2471	Aransas Bay	298	18268	0.058	*	0.064
2471		299	18269	0.085	*	*
2471		300	18270	0.022	0.044	0.045
2471		301	18271	0.034	0.034	0.025
2471		302	18272	0.045	0.058	0.042
2471		303	18273	0.022	*	0.026
2471		305	18275	0.021	*	0.017
2472	Copano/Port/Mission Bays	296	18226	**0.234**	**0.185**	**0.235**
2472		297	18267	0.175	0.180	0.196
2481	Corpus Christi Bay	307	18277	0.035	0.032	0.100
2481		309	18279	0.018	0.022	0.022
2481		310	18280	0.038	0.037	0.066
2481		311	18281	0.037	0.036	0.044
2481		312	18282	0.044	0.026	0.033
2481		314	18284	0.013	0.008	0.017
2482	Nueces Bay	306	18276	0.100	*	0.118
2482		308	18278	0.079	*	*
2483	Redfish Bay	304	18274	0.019	*	*
2485	Oso Bay	313	18283	0.015	*	*
2491	Laguna Madre	315	18285	0.014	*	*
2491		316	18286	0.009	*	*
2491		317	18287	0.016	*	0.046
2491		323	18293	0.027	0.056	0.023
2491		324	18294	0.025	0.024	0.031
2491		325	18295	0.024	*	*
2492	Baffin Bay/Alazan Bay	318	18288	0.038	*	0.077
2492	Cayo del Grullo/Laguna Salada	319	18289	0.039	*	0.033
2492		320	18290	0.039	0.039	0.032
2492		321	18291	0.043	0.043	0.052
2492		322	18292	0.034	0.032	0.074

Table 6.4.7. Chlorophyll *a* (Ch *a*) and Total Suspended Solid (TSS) concentrations (µg/L or ppb and mg/L or ppm) at RCAP 2003 sampling sites. TCEQ and EPA Method (SCL = Surface Ch *a* Field Filtered, MCL = Mid-Depth Ch *a* Field Filtered, BCL = Bottom Ch *a* Field Filtered), SS = Surface sample, MS = Mid-depth sample, and BS = Bottom sample. Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated in parentheses below parameter and is applicable only to SCL samples. Other exceedances provided for reference. **Bold** = highest recorded concentration.*= indicates sample not collected due to depth requirements.

Segment	Segment Name	CCS ID	TCEQ ID	Ch *a* SCL (SLE 11.50)	Ch *a* MCL	Ch *a* BCL	TSS SS	TSS MS	TSS BS
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	**35.00**	*	*	162.00	*	*
2463	Mesquite/Carlos/Ayres Bays	326	18296	7.75	*	5.97	17.00	*	21.00
2471	Aransas Bay	298	18268	6.96	*	6.70	10.00	*	12.00
2471		299	18269	3.15	*	*	6.00	*	*
2471		300	18270	5.34	5.60	5.71	10.00	11.00	11.00
2471		301	18271	4.47	4.64	5.57	8.00	9.00	15.00
2471		302	18272	5.37	2.70	4.02	7.00	6.00	8.00
2471		303	18273	4.10	*	3.45	16.00	*	6.00
2471		305	18275	3.55	*	3.11	14.00	*	17.00
2472	Copano/Port/Mission Bays	296	18226	9.29	7.17	8.62	11.00	15.00	17.00
2472		297	18267	7.94	8.46	8.41	5.00	7.00	18.00
2481	Corpus Christi Bay	307	18277	5.08	5.41	1.36	10.00	13.00	23.00
2481		309	18279	5.60	2.26	5.65	14.00	10.00	15.00
2481		310	18280	3.77	4.25	1.97	13.00	16.00	16.00
2481		311	18281	3.74	4.42	4.11	10.00	10.00	16.00
2481		312	18282	1.58	5.16	4.40	12.00	9.00	22.00
2481		314	18284	7.92	7.99	8.65	16.00	18.00	17.00
2482	Nueces Bay	306	18276	9.26	*	8.45	37.00	*	69.00
2482		308	18278	12.80	*	*	21.00	*	*
2483	Redfish Bay	304	18274	2.75	*	*	11.00	*	*
2485	Oso Bay	313	18283	10.20	*	*	47.00	*	*
2491	Laguna Madre	315	18285	4.93	*	*	5.00	*	*
2491		316	18286	5.39	*	*	3.00	*	*
2491		317	18287	3.58	*	13.10	9.00	*	8.00
2491		323	18293	11.00	5.60	13.20	7.00	8.00	9.00
2491		324	18294	8.84	9.48	12.90	7.00	7.00	12.00
2491		325	18295	14.80	*	*	13.00	*	*
2492	Baffin Bay/Alazan Bay	318	18288	14.80	*	13.33	**176.00**	*	**177.00**
2492	Cayo del Grullo/Laguna Salada	319	18289	15.17	*	16.57	87.00	*	111.00
2492		320	18290	18.90	**20.90**	**19.50**	15.00	17.00	16.00
2492		321	18291	14.62	14.43	10.67	78.00	**73.00**	133.00
2492		322	18292	12.55	11.85	8.30	48.00	50.00	148.00

6.5 Routine Conventional Water Chemistry –Summary Statistics

Table 6.5.1. Ammonia (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Ammonia	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.021
SNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.014
TCEQ	2471	Aransas Bay	7	<0.001	0.018	0.003
SLE 2000	2472	Copano Bay/Port Bay/Mission Bay	2	0.007	0.007	0.007
0.10 mg/L	2481	Corpus Christi Bay	6	0.001	0.022	0.008
	2482	Nueces Bay	2	<0.001	<0.001	<0.001
	2483	Redfish Bay	1	-	-	0.003
	2485	Oso Bay	1	-	-	0.010
	2491	Laguna Madre	6	<0.001	0.037	0.015
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.023	0.537	**0.318**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	<0.001	0.002	0.001
	2472	Copano Bay/Port Bay/Mission Bay	2	0.009	0.009	0.009
	2481	Corpus Christi Bay	6	<0.000	0.021	0.008
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.016	0.037	0.027
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.020	0.525	**0.306**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.016
	2471	Aransas Bay	6	<0.001	0.020	0.004
	2472	Copano Bay/Port Bay/Mission Bay	2	0.010	0.011	0.011
	2481	Corpus Christi Bay	6	0.003	0.022	0.015
	2482	Nueces Bay	1	-	-	0.016
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	<0.001	0.031	0.019
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.020	0.497	**0.238**

Table 6.5.2. Ammonia (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Ammonia	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.014
SN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	<0.001
	2471	Aransas Bay	7	<0.001	0.020	0.003
	2472	Copano Bay/Port Bay/Mission Bay	2	0.003	0.007	0.005
	2481	Corpus Christi Bay	6	<0.001	0.020	0.006
	2482	Nueces Bay	2	<0.001	0.003	0.002
	2483	Redfish Bay	1	-	-	0.003
	2485	Oso Bay	1	-	-	0.005
	2491	Laguna Madre	6	<0.001	0.036	0.012
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.012	0.513	**0.278**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	<0.001	0.001	<0.001
	2472	Copano Bay/Port Bay/Mission Bay	2	0.004	0.005	0.004
	2481	Corpus Christi Bay	6	<0.001	0.036	0.012
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.026	0.032	0.029
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.013	0.504	**0.279**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.002
	2471	Aransas Bay	6	<0.001	0.015	0.004
	2472	Copano Bay/Port Bay/Mission Bay	2	0.003	0.010	0.007
	2481	Corpus Christi Bay	6	<0.001	0.027	0.011
	2482	Nueces Bay	1	-	-	<0.001
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	0.013	0.028	0.018
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.024	0.326	**0.229**

Table 6.5.3. Nitrate (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nitrate	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**3.037**
SNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	<0.010
	2471	Aransas Bay	7	<0.010	<0.010	<0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	<0.010	<0.010	<0.010
	2481	Corpus Christi Bay	6	<0.010	<0.010	<0.010
	2482	Nueces Bay	2	<0.010	<0.010	<0.010
	2483	Redfish Bay	1	-	-	<0.010
	2485	Oso Bay	1	-	-	<0.010
	2491	Laguna Madre	6	<0.010	<0.010	<0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<0.010	0.095	0.041
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	<0.010	<0.010	<0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	<0.010	<0.010	<0.010
	2481	Corpus Christi Bay	6	<0.010	<0.010	<0.010
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	<0.010	<0.010	<0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	<0.010	0.114	**0.055**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	<0.010
	2471	Aransas Bay	6	<0.010	<0.010	<0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	<0.010	<0.010	<0.010
	2481	Corpus Christi Bay	6	<0.010	0.020	0.003
	2482	Nueces Bay	1	-	-	<0.010
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	<0.010	<0.010	<0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<0.010	0.062	**0.027**

Table 6.5.4. Nitrate (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nitrate	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**3.245**
SN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	<0.010
	2471	Aransas Bay	7	<0.010	<0.010	<0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	<0.010	<0.010	<0.010
	2481	Corpus Christi Bay	6	<0.010	<0.010	<0.010
	2482	Nueces Bay	2	<0.010	<0.010	<0.010
	2483	Redfish Bay	1	-	-	<0.010
	2485	Oso Bay	1	-	-	<0.010
	2491	Laguna Madre	6	<0.010	<0.010	<0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<0.010	0.152	0.060
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	<0.010	<0.010	<0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	<0.010	<0.010	<0.010
	2481	Corpus Christi Bay	6	<0.010	<0.010	<0.010
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	<0.010	<0.010	<0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	<0.010	0.151	**0.050**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	<0.010
	2471	Aransas Bay	6	<0.010	<0.010	<0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	<0.010	<0.010	<0.010
	2481	Corpus Christi Bay	6	<0.010	<0.010	<0.010
	2482	Nueces Bay	1	-	-	<0.010
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	<0.010	<0.010	<0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<0.010	0.140	**0.044**

Table 6.5.5. Nitrite (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.068
SNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.036
	2471	Aransas Bay	7	0.005	0.014	0.009
	2472	Copano Bay/Port Bay/Mission Bay	2	0.014	0.016	0.015
	2481	Corpus Christi Bay	6	0.008	0.020	0.012
	2482	Nueces Bay	2	0.012	0.023	0.017
	2483	Redfish Bay	1	-	-	0.010
	2485	Oso Bay	1	-	-	0.039
	2491	Laguna Madre	6	0.002	0.014	0.008
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.022	0.260	**0.116**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	0.007	0.008	0.007
	2472	Copano Bay/Port Bay/Mission Bay	2	0.014	0.018	0.016
	2481	Corpus Christi Bay	6	0.008	0.019	0.012
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.012	0.014	0.013
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.023	0.100	**0.063**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.038
	2471	Aransas Bay	6	0.007	0.015	0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	0.020	0.023	0.021
	2481	Corpus Christi Bay	6	0.012	0.045	0.021
	2482	Nueces Bay	1	-	-	0.013
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	0.006	0.012	0.009
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.021	0.236	**0.122**

Table 6.5.6. Nitrite (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**0.043**
SN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.003
	2471	Aransas Bay	7	<0.001	0.003	0.002
	2472	Copano Bay/Port Bay/Mission Bay	2	0.004	0.005	0.004
	2481	Corpus Christi Bay	6	<0.001	0.005	0.002
	2482	Nueces Bay	2	0.001	0.003	0.002
	2483	Redfish Bay	1	-	-	0.003
	2485	Oso Bay	1	-	-	0.001
	2491	Laguna Madre	6	<0.001	0.005	0.003
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.006	0.100	0.035
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	<0.001	0.005	0.002
	2472	Copano Bay/Port Bay/Mission Bay	2	0.005	0.008	0.007
	2481	Corpus Christi Bay	6	<0.001	0.004	0.001
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.004	0.010	0.007
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.006	0.032	**0.018**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.002
	2471	Aransas Bay	6	<0.001	0.003	0.002
	2472	Copano Bay/Port Bay/Mission Bay	2	0.006	0.015	0.010
	2481	Corpus Christi Bay	6	0.001	0.033	0.009
	2482	Nueces Bay	1	-	-	0.001
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	<0.001	0.005	0.003
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.005	0.082	**0.035**

Table 6.5.7. Nitrate + Nitrite (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nitrate + Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**3.105**
SNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.036
TCEQ	2471	Aransas Bay	7	0.005	0.014	0.009
SLE 2000	2472	Copano Bay/Port Bay/Mission Bay	2	0.014	0.016	0.015
0.26 mg/L	2481	Corpus Christi Bay	6	0.008	0.028	0.013
	2482	Nueces Bay	2	0.012	0.023	0.017
	2483	Redfish Bay	1	-	-	0.010
	2485	Oso Bay	1	-	-	0.039
	2491	Laguna Madre	6	0.002	0.014	0.008
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.022	0.260	0.157
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	0.007	0.008	0.007
	2472	Copano Bay/Port Bay/Mission Bay	2	0.014	0.018	0.016
	2481	Corpus Christi Bay	6	0.008	0.019	0.012
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.014	0.018	0.016
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.023	0.180	**0.119**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.038
	2471	Aransas Bay	6	0.007	0.015	0.010
	2472	Copano Bay/Port Bay/Mission Bay	2	0.020	0.023	0.021
	2481	Corpus Christi Bay	6	0.012	0.064	0.024
	2482	Nueces Bay	1	-	-	0.013
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	0.006	0.012	0.009
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.021	0.236	**0.149**

Table 6.5.8. Nitrate + Nitrite (mg/L) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by EPA Method (SN = Surface Nutrient Field Filtered, MN = Mid-Depth Nutrient Field Filtered, BN = Bottom Nutrient Field Filtered). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nitrate + Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**3.288**
SN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.003
	2471	Aransas Bay	7	<0.001	0.008	0.002
	2472	Copano Bay/Port Bay/Mission Bay	2	0.004	0.005	0.004
	2481	Corpus Christi Bay	6	<0.001	0.005	0.002
	2482	Nueces Bay	2	0.001	0.006	0.004
	2483	Redfish Bay	1	-	-	0.008
	2485	Oso Bay	1	-	-	0.001
	2491	Laguna Madre	6	0.001	0.005	0.003
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.006	0.252	0.095
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	<0.001	0.005	0.002
	2472	Copano Bay/Port Bay/Mission Bay	2	0.005	0.008	0.007
	2481	Corpus Christi Bay	6	<0.001	0.004	0.001
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.004	0.010	0.007
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.006	0.183	**0.068**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.002
	2471	Aransas Bay	6	<0.001	0.003	0.002
	2472	Copano Bay/Port Bay/Mission Bay	2	0.006	0.015	0.010
	2481	Corpus Christi Bay	6	0.001	0.033	0.009
	2482	Nueces Bay	1	-	-	0.001
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	<0.001	0.005	0.003
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.005	0.186	**0.079**

Table 6.5.9. Total Phosphorus (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ Method (SNU = Surface Nutrient Unfiltered in Field, MNU = Mid-Depth Nutrient Unfiltered in Field, BNU = Bottom Nutrient Unfiltered in Field). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated and is only applicable to SNU samples. Other exceedances provided for reference. **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Total Phosphorus	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**0.177**
SNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.026
TCEQ	2471	Aransas Bay	7	0.018	0.059	0.039
SLE 2000	2472	Copano Bay/Port Bay/Mission Bay	2	0.071	0.088	0.080
0.22 mg/L	2481	Corpus Christi Bay	6	0.004	0.014	0.010
	2482	Nueces Bay	2	0.027	0.047	0.037
	2483	Redfish Bay	1	-	-	0.034
	2485	Oso Bay	1	-	-	0.005
	2491	Laguna Madre	6	0.003	0.038	0.020
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.011	0.060	0.022
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Total Phosphorus	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	0.033	0.045	0.040
	2472	Copano Bay/Port Bay/Mission Bay	2	0.068	0.075	0.071
	2481	Corpus Christi Bay	6	0.003	0.012	0.009
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.038	0.514	**0.276**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.010	0.056	0.027
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Total Phosphorus	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BNU	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.026
	2471	Aransas Bay	6	0.030	0.059	0.044
	2472	Copano Bay/Port Bay/Mission Bay	2	0.069	0.091	**0.080**
	2481	Corpus Christi Bay	6	0.006	0.032	0.015
	2482	Nueces Bay	1	-	-	0.039
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	0.015	0.039	0.030
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.011	0.051	0.025

Table 6.5.10. Orthophosphorus, or Dissolved Inorganic Phosphorus, (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ and EPA Method (SN = Surface Nutrient Field Filtered, MNU = Mid-Depth Nutrient Field Filtered, BNU = Bottom Nutrient Field Filtered). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated and is only applicable to SN samples. Other exceedances provided for reference. **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Orthophosphorus	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**0.210**
SN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.113
TCEQ	2471	Aransas Bay	7	0.021	0.085	0.041
SLE 2000	2472	Copano Bay/Port Bay/Mission Bay	2	0.175	0.234	0.204
0.16 mg/L	2481	Corpus Christi Bay	6	0.013	0.044	0.031
	2482	Nueces Bay	2	0.079	0.100	0.090
	2483	Redfish Bay	1	-	-	0.019
	2485	Oso Bay	1	-	-	0.015
	2491	Laguna Madre	6	0.009	0.027	0.019
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.034	0.043	0.038
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Orthophosphorus	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	0.034	0.058	0.045
	2472	Copano Bay/Port Bay/Mission Bay	2	0.180	0.185	0.183
	2481	Corpus Christi Bay	6	0.008	0.037	0.027
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.024	0.056	0.040
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.032	0.043	0.038
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Orthophosphorus	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BN	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.099
	2471	Aransas Bay	6	0.017	0.064	0.036
	2472	Copano Bay/Port Bay/Mission Bay	2	0.196	0.235	0.216
	2481	Corpus Christi Bay	6	0.017	0.100	0.047
	2482	Nueces Bay	1	-	-	0.118
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	0.023	0.046	0.033
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.032	0.077	0.053

Table 6.5.11. Chlorophyll *a* (µg/L or ppb) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ and EPA Method (SCL = Surface Ch *a* Field Filtered, MCL = Mid-Depth Ch *a* Field Filtered, BCL = Bottom Ch *a* Field Filtered). Shaded value exceeded TCEQ Screening Level Estuary (SLE) indicated and is only applicable to SN samples. Other exceedances provided for reference. **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Chlorophyll *a*	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**35.00**
SCL	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	7.75
TCEQ	2471	Aransas Bay	7	3.15	6.96	4.71
SLE 2000	2472	Copano Bay/Port Bay/Mission Bay	2	7.94	9.29	8.62
11.50 µg/L	2481	Corpus Christi Bay	6	1.58	7.92	4.62
	2482	Nueces Bay	2	9.26	12.80	11.03
	2483	Redfish Bay	1	-	-	2.75
	2485	Oso Bay	1	-	-	10.20
	2491	Laguna Madre	6	3.58	14.80	8.09
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	12.55	18.90	15.21
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Chlorophyll *a*	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MCL	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	2.70	5.60	4.31
	2472	Copano Bay/Port Bay/Mission Bay	2	7.17	8.46	7.82
	2481	Corpus Christi Bay	6	2.26	7.99	4.92
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	5.60	9.48	7.54
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	11.85	20.90	**15.73**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Chlorophyll *a*	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BCL	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	5.97
	2471	Aransas Bay	6	3.11	6.70	4.76
	2472	Copano Bay/Port Bay/Mission Bay	2	8.41	8.62	8.52
	2481	Corpus Christi Bay	6	1.36	8.65	4.36
	2482	Nueces Bay	1	-	-	8.45
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	12.90	13.20	13.07
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	8.30	19.50	**13.67**

Table 6.5.12. Total Suspended Solids (TSS) concentrations (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2003 sampling sites, by TCEQ and EPA Method (SS = Surface Sample, MS = Mid-Depth Sample, BS = Bottom Sample). **Bold** = highest recorded mean concentrations. *= indicates sample not collected due to depth requirements.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
TSS	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	**162.0**
SS	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	17.0
	2471	Aransas Bay	7	6.0	16.0	10.1
	2472	Copano Bay/Port Bay/Mission Bay	2	5.0	11.0	8.0
	2481	Corpus Christi Bay	6	10.0	16.0	12.5
	2482	Nueces Bay	2	21.0	37.0	29.0
	2483	Redfish Bay	1	-	-	11.0
	2485	Oso Bay	1	-	-	47.0
	2491	Laguna Madre	6	3.0	13.0	7.3
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	15.0	176.0	80.8
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
TSS	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
MS	2463	Mesquite Bay/Carlos Bay/Ayres Bay	*	*	*	*
	2471	Aransas Bay	3	6.0	11.0	8.7
	2472	Copano Bay/Port Bay/Mission Bay	2	7.0	15.0	11.0
	2481	Corpus Christi Bay	6	9.0	18.0	12.7
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	7.0	8.0	7.5
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	17.0	73.0	**46.7**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
TSS	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	*	*	*	*
BS	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	21.0
	2471	Aransas Bay	6	6.0	17.0	11.5
	2472	Copano Bay/Port Bay/Mission Bay	2	17.0	18.0	17.5
	2481	Corpus Christi Bay	6	15.0	23.0	18.2
	2482	Nueces Bay	1	-	-	69.0
	2483	Redfish Bay	*	*	*	*
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	3	8.0	12.0	9.7
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	16.0	177.0	**117.0**

6.6 Microbiological – Individual Concentrations (CFU/100 ml)

Table 6.6.1. Enterococci concentrations comparing two different IDEXX methods recorded at RCAP 2003 sampling sites. Shaded value exceeded TCEQ criteria level of 104 CFU/100 ml. **Bold** = highest recorded concentration. ND = no data collected.

Segment	Segment Name	CCS_ID	TCEQ_ID	IDEXX 51	IDEXX 97
2462	San Antonio/Hynes/Guadalupe Bay	295	18266	ND	ND
2463	Mesquite/Carlos/Ayres Bay	326	18296	10.00	<10.00
2471	Aransas Bay	298	18268	<10.00	<10.00
2471		299	18269	<10.00	<10.00
2471		300	18270	<10.00	<10.00
2471		301	18271	<10.00	<10.00
2471		302	18272	<10.00	<10.00
2471		303	18273	<10.00	10.00
2471		305	18275	<10.00	<10.00
2472	Copano/Port/Mission Bay	296	18226	<10.00	<10.00
2472		297	18267	<10.00	10.00
2481	Corpus Christi Bay	307	18277	<10.00	<10.00
2481		309	18279	10.00	<10.00
2481		310	18280	<10.00	<10.00
2481		311	18281	<10.00	<10.00
2481		312	18282	<10.00	<10.00
2481		314	18284	<10.00	<10.00
2482	Nueces Bay	306	18276	20.00	**41.00**
2482		308	18278	<10.00	<10.00
2483	Redfish Bay	304	18274	<10.00	<10.00
2485	Oso Bay	313	18283	42.00	20.00
2491	Laguna Madre	315	18285	<10.00	<10.00
2491		316	18286	<10.00	<10.00
2491		317	18287	<10.00	<10.00
2491		323	18293	<10.00	<10.00
2491		324	18294	<10.00	<10.00
2491		325	18295	<10.00	<10.00
2492	Baffin Bay/Alazan Bay	318	18288	**75.00**	**41.00**
2492	Cayo del Grullo/Laguna Salada	319	18289	31.00	10.00
2492		320	18290	<10.00	<10.00
2492		321	18291	31.00	20.00
2492		322	18292	<10.00	<10.00

6.7 Trace Metals in Water– Individual Concentrations (µg/L or ppb)

Table 6.7.1. Trace metals in water concentrations (µg/L or ppb) at 19 of 32 RCAP 2003 sampling sites. D = Dissolved and T = Total. All values fell well below applicable TCEQ criteria levels. No value (-) indicates concentration below the detection limit listed in parentheses below chemical symbol. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS_ID	TCEQ_ID	As (D) (0.5)	Cd (D) (0.02)	Cu (D) (0.1)	Hg (T) (0.0005)	Ni (D) (0.1)	Pb (D) (0.02)	Se (T) (0.1)	Zn (D) (0.2)
2463	Mesquite/Carlos/Ayres Bays	18296	326	2.99	-	0.875	0.0012	1.042	-	0.183	-
2471	Aransas Bay	18268	298	2.14	-	0.605	0.0005	0.691	-	0.124	-
2471		18271	301	2.04	-	0.469	0.0005	0.494	0.032	-	-
2471		18275	305	1.33	-	0.239	0.0006	0.448	0.021	-	-
2472	Copano/Port/Mission Bays	18226	296	5.34	-	1.136	0.0009	1.024	-	0.181	-
2472		18267	297	4.35	-	0.973	0.0006	0.969	0.057	0.199	-
2481	Corpus Christi Bay	18277	307	2.11	0.072	0.804	0.0043	0.751	0.024	0.196	0.854
2481		18284	314	2.38	-	0.227	0.0014	0.575	0.057	-	-
2481		18280	310	1.99	0.052	0.709	0.0015	0.670	0.033	0.132	0.449
2481		18281	311	1.87	0.057	0.774	0.0012	0.732	0.022	0.184	0.618
2482	Nueces Bay	18276	306	3.82	0.035	0.994	0.0040	1.049	0.030	0.202	0.694
2482		18278	308	2.23	**0.086**	0.959	**0.0052**	0.951	-	**0.569**	**1.344**
2483	Redfish Bay	18274	304	1.94	-	0.312	0.0005	0.549	0.029	-	-
2485	Oso Bay	18283	313	2.68	0.024	0.613	0.0022	0.804	0.113	-	0.250
2491	Laguna Madre	18287	317	2.88	-	0.204	0.0010	0.540	0.028	-	-
2491		18294	324	1.80	-	0.352	0.0007	0.550	0.034	-	-
2492	Baffin Bay/Alazan Bay/	18288	318	**9.04**	0.037	**1.378**	0.0050	**1.251**	0.066	0.134	-
2492	Cayo del Grullo/Laguna Salada	18289	319	7.97	0.020	1.183	0.0034	1.206	**0.114**	0.161	0.918
2492		18292	322	7.89	-	0.875	0.0020	0.991	0.081	0.112	0.282

TCEQ Tidal Water Chronic Criteria Levels (ppb): As (78.00), Cd (10.00), Cu (3.60), Pb (5.30), Ni (13.10), Hg (1.10), Se (136.00), Zn (84.20).

6.8 Trace Metals in Sediment and Sediment Characteristics– Individual Concentrations (mg/kg or ppm dry weight)

Table 6.8.1. Trace metal (mg/kg or ppm dry weight) and sediment characteristic (%) concentrations for RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. No value (-) indicates concentration below the detection limit listed in parentheses below chemical symbol. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	Ag (0.05)	Al (1300)	As (1.5)	Cd (0.05)	Cr (4.0)	Cu (5.0)	Fe (500)	Hg (0.01)	Mn (2.0)	Ni (1.0)	Pb (1.0)	Sb (0.2)	Se (0.1)	Sn (0.1)	Zn (2.0)	% TOC	% Silt-Clay	% Sand	% Gravel
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-	30476	4.7	0.18	27.8	-	12367	0.028	221	3.3	10.1	0.37	0.40	-	34.5	0.77	79.32	20.40	0.28
2463	Mesquite/Carlos/Ayres Bays	326	18296	0.06	28036	4.9	0.06	17.3	-	9289	0.013	175	6.5	9.6	0.50	0.10	0.30	26.8	0.45	28.51	71.49	0.00
2471	Aransas Bay	298	18268	0.05	5933	6.8	0.12	27.6	5.7	14347	0.031	306	5.3	12.9	0.47	0.29	-	44.2	1.18	64.42	34.42	1.16
2471		299	18269	-	16042	2.4	-	7.0	-	3747	0.017	68	-	6.5	0.27	-	0.40	13.3	0.25	91.70	8.30	0.00
2471		300	18270	-	34883	7.0	0.18	38.1	8.5	21350	0.041	354	6.4	14.3	0.49	-	0.20	62.5	0.98	70.59	29.29	0.12
2471		301	18271	-	44279	7.3	0.14	38.1	9.6	20299	0.039	335	7.8	16.2	0.43	0.27	0.20	57.2	0.95	57.84	39.89	2.27
2471		302	18272	-	39624	6.8	0.19	**53.8**	11.1	**31687**	0.033	**663**	9.8	17.3	0.51	-	0.70	84.8	1.61	9.09	90.81	0.11
2471		303	18273	-	9816	1.8	-	6.2	-	1851	-	25	-	5.8	0.26	-	-	8.4	0.04	7.17	90.47	2.36
2471		305	18275	-	13758	2.4	-	16.9	-	3387	0.014	69	1.4	6.8	0.27	-	-	13.5	0.06	6.46	**93.47**	0.08
2472	Copano/Port/Mission Bays	296	18226	-	60994	**9.5**	0.25	48.4	11.6	28682	0.043	408	**11.7**	20.1	**0.79**	0.25	0.90	77.6	1.59	**98.69**	1.17	0.14
2472		297	18267	-	65827	9.2	0.24	49.0	12.0	29129	0.043	380	11.5	19.8	0.66	0.66	0.70	81.0	1.63	93.95	6.06	0.00
2481	Corpus Christi Bay	307	18277	-	38068	5.9	**0.93**	30.3	7.9	15408	**0.172**	198	7.1	8.1	0.56	**0.97**	0.20	109.5	0.82	52.29	42.43	5.28
2481		309	18279	-	51146	8.0	0.28	40.4	9.9	22867	0.074	335	10.0	18.2	0.59	0.70	0.60	92.9	1.11	90.40	9.23	0.37
2481		310	18280	-	13683	4.0	0.21	22.8	-	12674	0.013	312	8.3	9.8	0.60	-	0.10	54.7	0.58	35.61	42.09	22.29
2481		311	18281	-	46088	6.5	0.28	34.4	8.3	21298	0.092	284	5.5	18.3	0.60	0.24	0.60	93.3	1.06	83.54	15.09	1.37
2481		312	18282	-	57524	7.3	0.34	43.9	11.4	26096	0.091	321	11.6	**21.5**	0.64	0.74	1.00	**112.8**	1.20	93.87	5.80	0.33
2481		314	18284	-	11097	2.0	0.09	8.8	-	2536	0.022	30	-	5.6	0.30	0.42	0.10	17.7	0.22	8.16	91.36	0.48
2482	Nueces Bay	306	18276	-	42014	7.4	0.39	33.6	9.0	18241	0.083	261	5.0	16.7	0.50	0.58	0.50	86.2	0.98	86.94	12.96	0.43
2482		308	18278	**0.10**	13779	2.5	0.23	8.0	-	3214	0.037	43	-	6.4	0.32	0.46	-	24.6	0.17	10.41	89.26	0.34
2483	Redfish Bay	304	18274	-	22829	3.2	0.13	18.5	-	8243	0.019	153	3.4	8.1	0.29	-	-	29.0	0.57	21.18	42.75	**36.07**
2485	Oso Bay	313	18283	-	4596	1.6	0.09	0.0	-	1221	-	74	-	3.7	0.59	-	-	7.2	0.03	4.98	77.50	17.52
2491	Laguna Madre	315	18285	-	11240	2.5	0.10	15.0	-	3745	0.019	75	-	5.8	0.32	0.39	-	13.7	1.12	12.87	76.70	10.43
2491		316	18286	-	9001	2.5	0.06	4.2	-	2107	0.016	29	-	4.9	0.39	0.36	-	8.9	0.64	9.00	75.15	15.85
2491		317	18287	-	9682	1.7	-	5.6	-	1958	-	41	1.4	2.6	0.00	-	-	8.6	0.38	6.84	85.79	7.37
2491		323	18293	-	19999	5.2	0.08	11.9	-	6800	0.022	173	2.7	8.9	0.27	0.27	-	23.3	0.83	19.45	73.15	7.40
2491		324	18294	-	34146	6.7	0.16	23.8	6.9	13731	0.027	447	4.2	11.6	0.45	0.23	-	43.1	2.10	55.04	43.32	1.64
2491		325	18295	-	16198	2.8	0.10	6.3	-	4094	0.015	90	1.2	6.3	0.26	-	-	14.5	0.53	12.62	82.75	4.63
2492	Baffin Bay/Alazan Bay	318	18288	-	57987	6.6	0.19	41.2	9.2	24765	0.034	420	6.3	14.6	0.60	0.21	0.80	69.4	1.65	87.86	11.92	0.21
2492	Cayo del Grullo/Laguna Salada	319	18289	-	11488	2.4	0.08	7.4	-	4192	0.025	58	-	6.1	0.36	0.51	-	14.6	0.48	28.49	59.77	11.74
2492		320	18290	-	37290	6.4	0.19	25.1	7.7	13304	0.027	275	5.3	13.9	0.40	0.13	0.10	42.0	1.31	71.42	28.58	0.00
2492		321	18291	0.07	**69891**	8.1	0.30	47.7	13.2	31089	0.048	569	8.7	18.5	0.76	0.43	0.90	89.9	2.49	88.10	11.90	0.00
2492		322	18292	0.08	64143	8.7	0.31	45.3	**13.6**	28872	0.047	556	8.4	18.5	0.73	0.43	**1.10**	83.2	**2.74**	86.29	13.71	0.00

6.9 Trace Metals in Sediment and Sediment Characteristics – Summary Statistics (mg/kg or ppm dry weight)

Table 6.9.1. Total Organic Carbon (%), Sand (%), and Silt-Clay (%) summary statistics, listed by TCEQ Segment, for RCAP 2003 sampling sites. **Bold** = highest recorded mean concentrations.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Total Organic Carbon (%)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.77
	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.45
	2471	Aransas Bay	7	0.04	1.61	0.72
	2472	Copano Bay/Port Bay/Mission Bay	2	1.59	1.63	1.61
	2481	Corpus Christi Bay	6	0.22	1.20	0.83
	2482	Nueces Bay	2	0.17	0.98	0.58
	2483	Redfish Bay	1	-	-	0.57
	2485	Oso Bay	1	-	-	0.03
	2491	Laguna Madre	6	0.38	2.10	0.93
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.48	2.74	**1.73**

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Percent Sand	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	20.40
(0.0625 - 2.00 mm)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	71.49
	2471	Aransas Bay	7	8.30	93.47	55.24
	2472	Copano Bay/Port Bay/Mission Bay	2	1.17	6.06	3.62
	2481	Corpus Christi Bay	6	5.80	91.36	34.33
	2482	Nueces Bay	2	12.96	89.26	51.11
	2483	Redfish Bay	1	-	-	42.75
	2485	Oso Bay	1	-	-	**77.50**
	2491	Laguna Madre	6	43.32	85.79	72.81
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	11.90	59.77	25.18

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Percent Silt-Clay	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	79.32
(< 0.0625 mm)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	28.51
	2471	Aransas Bay	7	6.46	91.70	43.90
	2472	Copano Bay/Port Bay/Mission Bay	2	93.95	98.69	**96.32**
	2481	Corpus Christi Bay	6	8.16	93.87	60.65
	2482	Nueces Bay	2	10.41	86.94	48.68
	2483	Redfish Bay	1	-	-	21.18
	2485	Oso Bay	1	-	-	4.98
	2491	Laguna Madre	6	6.84	55.04	19.30
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	28.49	88.10	72.43

Table 6.9.2. Aluminum, Antimony, and Arsenic (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. **Bold** = highest recorded mean concentrations.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Aluminum (Al)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	30476
PEL (NA)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	28036
85th Percentile (NA)	2471	Aransas Bay	7	5933	44279	23476
	2472	Copano Bay/Port Bay/Mission Bay	2	60994	65827	**63411**
	2481	Corpus Christi Bay	6	11097	57524	36268
	2482	Nueces Bay	2	13779	42014	27897
	2483	Redfish Bay	1	-	-	22829
	2485	Oso Bay	1	-	-	4596
	2491	Laguna Madre	6	9001	34146	16711
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	11488	69891	48160

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Antimony (Sb)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.37
PEL (NA)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.50
85th Percentile (NA)	2471	Aransas Bay	7	0.26	0.51	0.39
	2472	Copano Bay/Port Bay/Mission Bay	2	0.66	0.79	**0.73**
	2481	Corpus Christi Bay	6	0.30	0.64	0.55
	2482	Nueces Bay	2	0.32	0.50	0.41
	2483	Redfish Bay	1	-	-	0.29
	2485	Oso Bay	1	-	-	0.59
	2491	Laguna Madre	6	<0.20	0.45	0.28
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.36	0.76	0.57

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Arsenic (As)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	4.70
PEL = 41.60	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	4.87
85th Percentile = 9.61	2471	Aransas Bay	7	1.77	7.30	4.92
	2472	Copano Bay/Port Bay/Mission Bay	2	9.20	9.48	**9.34**
	2481	Corpus Christi Bay	6	1.96	8.01	5.61
	2482	Nueces Bay	2	2.51	7.36	4.94
	2483	Redfish Bay	1	-	-	3.24
	2485	Oso Bay	1	-	-	1.63
	2491	Laguna Madre	6	1.74	6.66	3.59
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	2.37	8.74	6.44

Table 6.9.3. Cadmium, Chromium, and Copper (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. **Bold** = highest recorded mean concentrations.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Cadmium (Cd)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.18
PEL = 4.21	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.06
85th Percentile = 0.663	2471	Aransas Bay	7	<0.05	0.19	0.09
	2472	Copano Bay/Port Bay/Mission Bay	2	0.24	0.25	0.25
	2481	Corpus Christi Bay	6	0.09	0.93	**0.36**
	2482	Nueces Bay	2	0.23	0.39	0.31
	2483	Redfish Bay	1	-	-	0.13
	2485	Oso Bay	1	-	-	0.09
	2491	Laguna Madre	6	<0.05	0.16	0.08
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.08	0.31	0.21

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Chromium (Cr)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	27.80
PEL = 160.40	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	17.30
85th Percentile = 36.90	2471	Aransas Bay	7	6.20	53.80	26.81
	2472	Copano Bay/Port Bay/Mission Bay	2	48.40	49.00	**48.70**
	2481	Corpus Christi Bay	6	8.80	43.90	30.10
	2482	Nueces Bay	2	8.00	33.60	20.80
	2483	Redfish Bay	1	-	-	18.50
	2485	Oso Bay	1	-	-	<4.00
	2491	Laguna Madre	6	4.20	23.80	11.13
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	7.40	47.70	33.34

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Copper (Cu)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	<5.00
PEL = 108.20	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	<5.00
85th Percentile = 19.90	2471	Aransas Bay	7	<5.00	11.10	4.99
	2472	Copano Bay/Port Bay/Mission Bay	2	11.60	12.00	**11.80**
	2481	Corpus Christi Bay	6	<5.00	11.40	6.25
	2482	Nueces Bay	2	<5.00	9.00	4.50
	2483	Redfish Bay	1	-	-	<5.00
	2485	Oso Bay	1	-	-	<5.00
	2491	Laguna Madre	6	<5.00	6.90	1.15
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<5.00	13.60	8.74

Table 6.9.4. Iron, Lead, and Manganese (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. **Bold** = highest recorded mean concentrations.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Iron (Fe)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	12367
PEL (NA)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	9289
85th Percentile (NA)	2471	Aransas Bay	7	1851	31687	13810
	2472	Copano Bay/Port Bay/Mission Bay	2	28682	29129	**28906**
	2481	Corpus Christi Bay	6	2536	26096	16813
	2482	Nueces Bay	2	3214	18241	10728
	2483	Redfish Bay	1	-	-	8243
	2485	Oso Bay	1	-	-	1221
	2491	Laguna Madre	6	1958	13731	5406
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	4192	31089	20444

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Lead (Pb)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	10.13
PEL = 112.18	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	9.62
85th Percentile = 21.90	2471	Aransas Bay	7	5.75	17.26	11.38
	2472	Copano Bay/Port Bay/Mission Bay	2	19.80	20.05	**19.93**
	2481	Corpus Christi Bay	6	5.63	21.54	13.58
	2482	Nueces Bay	2	6.37	16.73	11.55
	2483	Redfish Bay	1	-	-	8.08
	2485	Oso Bay	1	-	-	3.66
	2491	Laguna Madre	6	2.61	11.57	6.68
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	6.06	18.54	14.31

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Manganese (Mn)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	221
PEL (NA)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	175
85th Percentile (NA)	2471	Aransas Bay	7	25	663	260
	2472	Copano Bay/Port Bay/Mission Bay	2	380	408	**394**
	2481	Corpus Christi Bay	6	30	335	247
	2482	Nueces Bay	2	43	261	152
	2483	Redfish Bay	1	-	-	153
	2485	Oso Bay	1	-	-	74
	2491	Laguna Madre	6	29	447	142
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	58	569	376

Table 6.9.5. Mercury, Nickel, and Selenium (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. **Bold** = highest recorded mean concentrations.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Mercury (Hg)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.028
PEL = 0.696	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.013
85th Percentile = 0.230	2471	Aransas Bay	7	<0.010	0.041	0.025
	2472	Copano Bay/Port Bay/Mission Bay	2	0.043	0.043	0.043
	2481	Corpus Christi Bay	6	0.013	0.172	**0.077**
	2482	Nueces Bay	2	0.037	0.083	0.060
	2483	Redfish Bay	1	-	-	0.019
	2485	Oso Bay	1	-	-	<0.010
	2491	Laguna Madre	6	<0.010	0.027	0.017
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.025	0.048	0.036

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nickel (Ni)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	3.32
PEL = 42.80	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	6.52
85th Percentile = 21.40	2471	Aransas Bay	7	<1.00	9.82	4.38
	2472	Copano Bay/Port Bay/Mission Bay	2	11.47	11.73	**11.60**
	2481	Corpus Christi Bay	6	<1.00	11.64	7.09
	2482	Nueces Bay	2	<1.00	5.00	2.50
	2483	Redfish Bay	1	-	-	3.43
	2485	Oso Bay	1	-	-	<1.00
	2491	Laguna Madre	6	<1.00	4.15	1.56
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<1.00	8.66	5.73

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Selenium (Se)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	0.40
PEL = NA	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.10
85th Percentile = 1.70	2471	Aransas Bay	7	<0.10	0.29	0.08
	2472	Copano Bay/Port Bay/Mission Bay	2	0.25	0.66	0.46
	2481	Corpus Christi Bay	6	<0.10	0.97	0.51
	2482	Nueces Bay	2	0.46	0.58	**0.52**
	2483	Redfish Bay	1	-	-	<0.10
	2485	Oso Bay	1	-	-	<0.10
	2491	Laguna Madre	6	<0.10	0.39	0.21
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	0.13	0.51	0.34

Table 6.9.6. Silver, Tin, and Zinc (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85^{th} percentile screening level. Shaded value exceeded TCEQ 85^{th} percentile only. **Bold** = highest recorded mean concentrations.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Silver (Ag)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	<0.05
PEL = 1.77	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	**0.06**
85^{th} Percentile = 0.600	2471	Aransas Bay	7	<0.05	0.05	0.01
	2472	Copano Bay/Port Bay/Mission Bay	2	<0.05	<0.05	<0.05
	2481	Corpus Christi Bay	6	<0.05	<0.05	<0.05
	2482	Nueces Bay	2	<0.05	0.10	0.05
	2483	Redfish Bay	1	-	-	<0.05
	2485	Oso Bay	1	-	-	<0.05
	2491	Laguna Madre	6	<0.05	<0.05	<0.05
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<0.05	0.08	0.03

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Tin (Sn)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	<0.10
PEL (NA)	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	0.30
85^{th} Percentile (NA)	2471	Aransas Bay	7	<0.10	0.70	0.21
	2472	Copano Bay/Port Bay/Mission Bay	2	0.70	0.90	**0.80**
	2481	Corpus Christi Bay	6	0.10	1.00	0.43
	2482	Nueces Bay	2	<0.10	0.50	0.25
	2483	Redfish Bay	1	-	-	<0.10
	2485	Oso Bay	1	-	-	<0.10
	2491	Laguna Madre	6	<0.10	<0.10	<0.10
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	<0.10	1.10	0.58

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Zinc (Zn)	2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	1	-	-	34.50
PEL = 271.0	2463	Mesquite Bay/Carlos Bay/Ayres Bay	1	-	-	26.80
85^{th} Percentile = 107.0	2471	Aransas Bay	7	8.40	84.80	40.56
	2472	Copano Bay/Port Bay/Mission Bay	2	77.60	81.00	79.30
	2481	Corpus Christi Bay	6	17.70	112.80	**80.15**
	2482	Nueces Bay	2	24.60	86.20	55.40
	2483	Redfish Bay	1	-	-	29.00
	2485	Oso Bay	1	-	-	7.20
	2491	Laguna Madre	6	8.60	43.10	18.68
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	5	14.60	89.90	59.82

6.10 Sediment Organics – Individual Concentrations (ng/g or ppb Dry Weight)

Table 6.10.1. Sediment concentrations (ng/g or ppb) of 2 out of 20 PCB congeners (all other PCBs < reporting limit) at RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. No value (-) indicates concentration below the reporting limit. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	101	105	Total PCB
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-	-	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-	-	-
2471	Aransas Bay	298	18268	-	-	-
2471		299	18269	-	-	-
2471		300	18270	-	-	-
2471		301	18271	-	-	-
2471		302	18272	-	-	-
2471		303	18273	-	-	-
2471		305	18275	-	-	-
2472	Copano/Port/Mission Bays	296	18226	-	-	-
2472		297	18267	-	-	-
2481	Corpus Christi Bay	307	18277	-	-	-
2481		309	18279	-	-	-
2481		310	18280	-	-	-
2481		311	18281	-	-	-
2481		312	18282	-	-	-
2481		314	18284		1.81	1.81
2482	Nueces Bay	306	18276	5.27		**5.27**
2482		308	18278	-	-	-
2483	Redfish Bay	304	18274	-	-	-
2485	Oso Bay	313	18283	-	-	-
2491	Laguna Madre	315	18285	-	-	-
2491		316	18286	-	-	-
2491		317	18287	-	-	-
2491		323	18293	-	-	-
2491		324	18294	-	-	-
2491		325	18295	-	-	-
2492	Baffin Bay/Alazan Bay	318	18288	-	-	-
2492	Cayo del Grullo/Laguna Salada	319	18289	-	-	-
2492		320	18290	-	-	-
2492		321	18291	-	-	-
2492		322	18292	-	-	-

Table 6.10.2. Sediment concentrations of DDD, DDE, and DDT (ng/g or ppb) at RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. No value (-) indicates concentration below the reporting limit. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	2,4'-DDD	4,4'-DDD	2,4'-DDE	4,4'-DDE	2,4'-DDT	4,4'-DDT	Total DDT (DDD + DDE + DDT)
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-	-	-	-	-	-	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-	-	-	-	-	-	-
2471	Aransas Bay	298	18268	-	-	-	-	-	-	-
2471		299	18269	-	-	-	-	-	-	-
2471		300	18270	-	-	-	-	-	-	-
2471		301	18271	-	-	-	-	-	-	-
2471		302	18272	-	-	-	-	-	-	-
2471		303	18273	-	-	-	-	-	-	-
2471		305	18275	-	-	-	-	-	-	-
2472	Copano/Port/Mission Bays	296	18226	-	-	-	-	-	-	-
2472		297	18267	-	-	-	-	-	-	-
2481	Corpus Christi Bay	307	18277	-	-	-	-	-	-	-
2481		309	18279	-	-	-	-	-	-	-
2481		310	18280	-	-	-	-	-	-	-
2481		311	18281	-	-	-	-	-	-	-
2481		312	18282	-	-	-	-	-	-	-
2481		314	18284	-	-	-	-	-	-	-
2482	Nueces Bay	306	18276	-	-	-	-	**14.19**	-	**14.19**
2482		308	18278	-	-	-	-	-	-	-
2483	Redfish Bay	304	18274	-	-	-	-	-	-	-
2485	Oso Bay	313	18283	-	-	-	-	3.43	-	3.43
2491	Laguna Madre	315	18285	-	-	-	-	-	-	-
2491		316	18286	-	-	-	-	-	-	-
2491		317	18287	-	-	**0.78**	**1.21**	-	-	1.99
2491		323	18293	-	-	-	-	-	-	-
2491		324	18294	-	-	-	-	-	-	-
2491		325	18295	-	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	318	18288	-	-	-	-	-	-	-
2492	Cayo del Grullo/Laguna Salada	319	18289	-	-	-	-	-	-	-
2492		320	18290	-	-	-	-	-	-	-
2492		321	18291	-	-	-	-	-	-	-
2492		322	18292	-	-	-	-	-	-	-

Table 6.10.3. Sediment concentrations (ng/g or ppb) of 13 Chlorinated Pesticides (Aldrin, Alpha-Chlordane, Dieldrin, Endosulfan I, Endosulfan sulfate, Endrin, Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Lindane (gamma-BHC), Mirex, Toxaphene, and Trans-Nonachlor) other than DDT at RCAP 2003 sampling sites were all below detectable reporting limits.

Segment	Segment Name	CCS ID	TCEQ ID	Chlorinated Pesticides
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-
2471	Aransas Bay	298	18268	-
2471		299	18269	-
2471		300	18270	-
2471		301	18271	-
2471		302	18272	-
2471		303	18273	-
2471		305	18275	-
2472	Copano/Port/Mission Bays	296	18226	-
2472		297	18267	-
2481	Corpus Christi Bay	307	18277	-
2481		309	18279	-
2481		310	18280	-
2481		311	18281	-
2481		312	18282	-
2481		314	18284	-
2482	Nueces Bay	306	18276	-
2482		308	18278	-
2483	Redfish Bay	304	18274	-
2485	Oso Bay	313	18283	-
2491	Laguna Madre	315	18285	-
2491		316	18286	-
2491		317	18287	-
2491		323	18293	-
2491		324	18294	-
2491		325	18295	-
2492	Baffin Bay/Alazan Bay	318	18288	-
2492	Cayo del Grullo/Laguna Salada	319	18289	-
2492		320	18290	-
2492		321	18291	-
2492		322	18292	-

Table 6.10.4. Sediment concentrations (ng/g or ppb) of 23 PAH's at RCAP 2003 sampling sites. Shaded value exceeded TCEQ PEL and 85th percentile screening level. Shaded value exceeded TCEQ 85th percentile only. No value (-) indicates concentration below reporting limit. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	acenaphthene	acenaphthylene	anthracene	benzo(a)anthracene	dibenz(a,h)anthracene	biphenyl	chrysene
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-	-	-	-	-	-	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-	-	-	-	-	-	-
2471	Aransas Bay	298	18268	-	-	-	-	-	-	-
2471		299	18269	-	-	-	-	-	-	-
2471		300	18270	-	-	-	17.96	-	-	17.55
2471		301	18271	-	-	-	-	-	-	-
2471		302	18272	-	-	-	-	-	-	-
2471		303	18273	-	-	-	-	-	-	-
2471		305	18275	-	-	-	-	-	-	-
2472	Copano/Port/Mission Bays	296	18226	-	-	0.98	-	-	-	-
2472		297	18267	-	-	5.46	5.43	-	-	10.05
2481	Corpus Christi Bay	307	18277	-	-	-	-	-	-	-
2481		309	18279	-	-	-	6.67	-	-	8.64
2481		310	18280	-	-	-	-	-	-	-
2481		311	18281	-	-	-	-	-	-	-
2481		312	18282	-	-	-	-	-	-	-
2481		314	18284	-	-	-	-	-	-	-
2482	Nueces Bay	306	18276	-	-	-	-	-	-	-
2482		308	18278	-	-	-	-	-	-	-
2483	Redfish Bay	304	18274	-	-	-	-	-	-	-
2485	Oso Bay	313	18283	-	-	**25.85**	**48.06**	**6.14**	-	**44.74**
2491	Laguna Madre	315	18285	-	-	-	-	-	-	-
2491		316	18286	-	-	-	-	-	-	-
2491		317	18287	-	-	-	-	-	-	-
2491		323	18293	-	-	-	-	-	-	-
2491		324	18294	-	-	-	-	-	-	-
2491		325	18295	-	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	318	18288	-	-	-	-	-	-	-
2492	Cayo del Grullo/Laguna Salada	319	18289	-	-	-	-	-	-	-
2492		320	18290	-	-	-	-	-	-	-
2492		321	18291	-	-	-	-	-	-	-
2492		322	18292	-	-	-	-	-	-	-

Table 6.10.4. (continued).

Segment	Segment Name	CCS ID	TCEQ ID	fluoranthene	benzo(b)fluoranthene	benzo(k)fluoranthene	fluorene	naphthalene	1-methylnaphthalene
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-	-	-	-	-	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-	-	-	-	-	-
2471	Aransas Bay	298	18268	-	-	-	-	-	-
2471		299	18269	-	-	-	-	-	-
2471		300	18270	-	-	-	-	-	-
2471		301	18271	-	-	-	-	-	-
2471		302	18272	-	-	-	-	-	-
2471		303	18273	-	-	-	-	-	-
2471		305	18275	-	-	-	-	**1.87**	
2472	Copano/Port/Mission Bays	296	18226	1.26	-	-	-	1.09	**1.76**
2472		297	18267	14.94	-	-	-	-	-
2481	Corpus Christi Bay	307	18277	-	-	-	-	-	-
2481		309	18279	10.66	-	-	-	-	-
2481		310	18280	3.52	-	-	-	-	-
2481		311	18281	1.05	-	-	-	-	-
2481		312	18282	-	-	-	-	-	-
2481		314	18284	3.70	-	-	-	-	-
2482	Nueces Bay	306	18276	11.72	-	-	-	-	-
2482		308	18278	-	-	-	-	-	-
2483	Redfish Bay	304	18274	-	-	-	-	-	-
2485	Oso Bay	313	18283	**111.04**	**43.93**	**31.73**	-	-	-
2491	Laguna Madre	315	18285	-	-	-	-	-	-
2491		316	18286	-	-	-	-	-	-
2491		317	18287	-	-	-	-	-	-
2491		323	18293	-	-	-	-	-	-
2491		324	18294	-	-	-	-	-	-
2491		325	18295	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	318	18288	5.58	-	-	-	-	-
2492	Cayo del Grullo/Laguna Salada	319	18289	-	-	-	-	-	-
2492		320	18290	-	-	-	-	-	-
2492		321	18291	-	-	-	-	-	-
2492		322	18292	-	-	-	-	-	-

Table 6.10.4. (continued).

Segment	Segment Name	CCS ID	TCEQ ID	2-methylnaphthalene	2,6-dimethylnaphthalene	2,3,5-trimethylnaphthalene	phenanthrene	1-methylphenanthrene
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-	-	-	-	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-	-	-	-	-
2471	Aransas Bay	298	18268	-	-	-	-	-
2471		299	18269	-	-	-	-	-
2471		300	18270	-	-	-	-	-
2471		301	18271	-	-	-	-	-
2471		302	18272	-	-	-	-	-
2471		303	18273	-	-	-	-	-
2471		305	18275	-	-	-	-	-
2472	Copano/Port/Mission Bays	296	18226	1.19	-	-	1.51	-
2472		297	18267	**2.95**	-	-	8.21	-
2481	Corpus Christi Bay	307	18277	-	-	-	-	-
2481		309	18279	-	-	-	3.78	-
2481		310	18280	-	-	-	-	-
2481		311	18281	-	-	-	-	-
2481		312	18282	-	-	-	-	-
2481		314	18284	1.38	-	-	2.21	-
2482	Nueces Bay	306	18276	-	-	-	-	-
2482		308	18278	-	-	-	-	-
2483	Redfish Bay	304	18274	-	-	-	-	-
2485	Oso Bay	313	18283	-	-	-	**61.26**	-
2491	Laguna Madre	315	18285	-	-	-	-	-
2491		316	18286	-	-	-	-	-
2491		317	18287	-	-	-	-	-
2491		323	18293	-	-	-	-	-
2491		324	18294	-	-	-	-	-
2491		325	18295	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	318	18288	-	-	-	-	-
2492	Cayo del Grullo/Laguna Salada	319	18289	-	-	-	-	-
2492		320	18290	-	-	-	-	-
2492		321	18291	-	-	-	-	-
2492		322	18292	-	-	-	-	-

Table 6.10.4. (continued).

Segment	Segment Name	CCS ID	TCEQ ID	benzo(g,h,i)perylene	pyrene	benzo(a)pyrene	indeno(1,2,3-cd)pyrene	dibenzothiophene	Total PAH
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-	-	-	-	-	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-	-	-	-	-	-
2471	Aransas Bay	298	18268	-	-	-	-	-	-
2471		299	18269	-	-	-	-	-	-
2471		300	18270	-	-	-	-	-	35.51
2471		301	18271	-	-	-	-	-	-
2471		302	18272	-	-	-	-	-	-
2471		303	18273	-	-	-	-	-	-
2471		305	18275	-	-	-	-	-	1.87
2472	Copano/Port/Mission Bays	296	18226	-	-	2.67	-	-	10.46
2472		297	18267	-	9.55	-	-	-	56.59
2481	Corpus Christi Bay	307	18277	-	-	-	-	-	-
2481		309	18279	-	10.06	-	-	-	39.81
2481		310	18280	-	2.22	-	-	-	5.74
2481		311	18281	-	1.14	-	-	-	2.19
2481		312	18282	-	-	-	-	-	-
2481		314	18284	-	2.82	-	-	-	10.11
2482	Nueces Bay	306	18276	-	14.34	-	-	-	26.06
2482		308	18278	-	-	-	-	-	-
2483	Redfish Bay	304	18274	-	-	-	-	-	-
2485	Oso Bay	313	18283	**24.56**	**68.07**	**26.20**	**21.70**	-	**513.28**
2491	Laguna Madre	315	18285	-	-	-	-	-	-
2491		316	18286	-	-	-	-	-	-
2491		317	18287	-	-	-	-	-	-
2491		323	18293	-	-	-	-	-	-
2491		324	18294	-	-	-	-	-	-
2491		325	18295	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	318	18288	-	-	-	-	-	5.58
2492	Cayo del Grullo/Laguna Salada	319	18289	-	-	-	-	-	-
2492		320	18290	-	-	-	-	-	-
2492		321	18291	-	-	-	-	-	-
2492		322	18292	-	-	-	-	-	-

6.11 Sediment Toxicity

Table 6.11.1. RCAP 2003 toxicity results and unionized ammonia concentrations in sediment toxicity tests conducted with the amphipods, *Ampelisca abdita* and *Leptocheirus plumulosus*.

Ampelisca abdita

Sample ID	Rep Number (Alive Amphipods) 1	2	3	4	5	Mean Number Alive	Mean % Survival	% of Cont.	% of Ref.	Significantly different Cont.	Ref.	Day 10 NH_3
Control	20	18	17	17	18	18.0	90.0					7.9
Control	16	20	20	19	19	18.8	94.0					6.3
Control [b]	16	20	18	19	17	18.0	90.0					5.0
Reference	18	17	17	18	17	17.4	87.0					47.3
Reference	12	19	13	14	14	14.4	72.0					35.5
Reference [b]	16	19	17	17	16	17.0	85.0					59.1
295 [b]	15	14	18	14	18	15.8	79.0	87.8	92.9			6.3
296	16	18	12	17	17	16.0	80.0	85.1	111.1			5.0
297	17	15	15	12	9	13.6	68.0	72.3	94.4	***		5.0
298	13	13	13	13	14	13.2	66.0	70.2	91.7	***		6.3
299	19	19	17	20	18	18.6	93.0	103.3	106.9			12.2
300	14	14	14	17	15	14.8	74.0	78.7	102.8	**		6.3
301	20	12	16	14	15	15.4	77.0	81.9	106.9			7.9
302	18	18	14	19	16	17.0	85.0	90.4	118.1			12.2
303	12	15	18	19	17	16.2	81.0	86.2	112.5			18.3
304	9	18	15	14	16	14.4	72.0	76.6	100.0	**		12.2
305	19	14	14	17	15	15.8	79.0	84.0	109.7			9.8
306 b	19	17	16	18	20	18.0	90.0	100.0	105.9			9.8
307 b	17	20	17	19	17	18.0	90.0	100.0	105.9			6.3
308 b	13	18	15	13	17.3[b]	14.8	73.8	81.9	86.8			79.4
309	16	17	17	17	17	16.8	84.0	93.3	96.6			6.3
310	18	14	17	16	15	16.0	80.0	88.9	92.0			7.9
311	14	15	17	18	14	15.6	78.0	86.7	89.7			6.3
312	19	15	18	18	17	17.4	87.0	96.7	100.0			6.3
313	12	18	17	17	14	15.6	78.0	86.7	89.7			36.6
314 b	16	17	18	17	17	17.0	85.0	94.4	100.0			9.8

Table 6.11.1. (continued).

Ampelisca abdita

Sample ID	Rep Number (Alive Amphipods) 1	2	3	4	5	Mean Number Alive	Mean % Survival	% of Cont.	% of Ref.	Significantly different Cont.	Ref.	Day 10 NH_3
315 b	17	15	12	12	7	12.6	63.0	70.0	74.1	***	**	134.0
316 b	17	14	15	10	13	13.8	69.0	76.7	81.2	***	**	106.4
317 b	15	17	17	18	17	16.8	84.0	93.3	98.8			7.9
318	17	14	13	19	12	15.0	75.0	83.3	86.2			6.3
319	20	18	20	17	18	18.6	93.0	103.3	106.9			7.9
320	16	15	20	19	18	17.6	88.0	93.6	122.2			7.9
321	20	14	18	13	17	16.4	82.0	91.1	94.3			152.2
322	18	18	15	14	17	16.4	82.0	91.1	94.3			167.0
323	18	19	17	18	18	18.0	90.0	95.7	125.0			44.2
324	19	15	17	16	19	17.2	86.0	91.5	119.4			91.6
325	13	16	14	16	14	14.6	73.0	77.7	101.4	**		67.2
326	16	12	14	17	14	14.6	73.0	81.1	83.9	**		6.3

Leptocheirus plumulosus

Sample ID	Rep Number (Alive Amphipods) 1	2	3	4	5	Mean Number Alive	Mean % Survival	% of Cont.	% of Ref.	Significantly different Cont.	Ref.	Day 10 NH_3
Control	20	20	20	20	20	20.0	100.0					
Reference	20	19	19	20	20	19.6	98.0					
298	20	19	19	20	19	19.4	97.0	97.0	99.0			
304	20	20	20	20	17	19.4	97.0	97.0	99.0			
306	20	20	19	20	20	19.8	99.0	99.0	101.0			

* Indicates significant difference at $p \leq 0.05$ but does not meet MSD requirement
** Indicates significant difference at $p \leq 0.05$ and < MSD
*** Indicates significantly different at $p \leq 0.01$ and < MSD
[a] Test on Site 295 was a rerun of an earlier test performed due to poor control survival
[b] Replicate 5 of Site 308 started with 30 organisms. Final number was normalized to an initial 20 for comparability.

Table 6.11.2. Spearman rank correlation coefficients between concentrations of chemicals in the sediment and amphipod survival, or chemicals and % Silt-Clay. Only chemicals for which at least one sediment sample had a value above detection are included. Shaded = significant correlations at $p \leq 0.05$ and ≤ 0.01, respectively, with Bonferroni adjustment for multiple comparisons. Negative values indicate an inverse correlation.

Chemical	Toxicity r^2	p	Silt/Clay r^2	p
2,4'-DDE	0.000	1.0000	0.301	0.0935
4,4'-DDE	0.126	0.4915	-0.087	0.6345
4,4'-DDD	0.097	0.5960	-0.263	0.1465
2,4'-DDT	0.097	0.5960	-0.263	0.1465
Total DDT	0.147	0.4220	-0.058	0.7510
Total PCB	0.275	0.1274	-0.033	0.8569
naphthalene	-0.029	0.8754	0.001	0.9962
1-methylnaphthalene	0.000	1.0000	0.302	0.0935
2-methylnaphthalene	-0.085	0.6427	0.214	0.2400
phenanthrene	-0.068	0.7130	0.114	0.5356
anthracene	-0.206	0.2579	0.146	0.4263
fluoranthene	-0.034	0.8534	0.255	0.1588
Pyrene	0.036	0.8449	0.090	0.6255
benzo(a)anthracene	-0.199	0.2743	0.112	0.5430
Chrysene	-0.211	0.2463	0.114	0.5430
benzo(b)fluoranthene	-0.078	0.6717	-0.302	0.0935
benzo(k)fluoranthene	-0.078	0.6717	-0.302	0.0935
benzo(a)pyrene	-0.058	0.7537	-0.014	0.9414
benzo(g,h,i)perylene	-0.078	0.6717	-0.302	0.0935
dibenz(a,h)anthracene	-0.078	0.6717	-0.302	0.0935
indeno(1,2,3-cd)pyrene	-0.078	0.6717	-0.302	0.0935
Total PAH	-0.100	0.5858	0.211	0.2470
Ag	-0.236	0.1929	0.081	0.6587
Al	0.154	0.3997	0.784	<0.0001
As	0.004	0.9825	0.780	<0.0001
Cd	0.138	0.4521	0.650	<0.0001
Cr	0.035	0.8497	0.727	<0.0001
Cu	0.118	0.5213	0.714	<0.0001

Table 6.11.2. (continued).

Chemical	Toxicity r^2	p	Silt-Clay r^2	p
Fe	0.084	0.6496	0.765	<0.0001
Hg	0.195	0.2841	0.706	<0.0001
Mn	0.020	0.9151	0.658	<0.0001
Ni	0.036	0.8431	0.668	<0.0001
Pb	0.081	0.6583	0.821	<0.0001
Sb	-0.024	0.8968	0.645	<0.0001
Se	0.178	0.3301	0.438	0.0123
Sn	0.208	0.2531	0.739	<0.0001
Zn	0.172	0.3452	0.714	<0.0001
% TOC	0.019	0.9190	0.672	<0.0001
% Gravel	-0.100	0.5842	-0.533	0.0017
% Sand	-0.125	0.4963	-0.974	<0.0001
% Clay	0.120	0.5110	-	-
% Silt	0.198	0.2760	-	-
% Silt-Clay	0.149	0.4157	-	-

6.12 Fish species analyzed for Trace Metals and Organics in Tissue Monitoring

Table 6.12.1. List of fish species analyzed for whole body tissue monitoring at 27 of 32 RCAP 2003 sampling sites. Missing sites (5) reflect no trawls taken due to shallow water or no specimens collected as indicated in Table 6.1.1.

Segment	Segment Name	CCS ID	TCEQ ID	*Micropogonias undulatus* (Atlantic Croaker)	*Leiostomus xanthurus* (Spot)	*Arius felis* (Hardhead Catfish)	*Lagodon rhomboides)* (Pinfish)
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	295	18266	■			
2463	Mesquite Bay/Carlos Bay/Ayres Bay	326	18296	■			
2471	Aransas Bay	298	18268			■	
2471		300	18270		■		
2471		301	18271			■	
2471		302	18272	■			
2471		303	18273			■	
2471		305	18275			■	
2472	Copano Bay/Port Bay/Mission Bay	296	18226			■	
2472		297	18267			■	
2481	Corpus Christi Bay	307	18277		■		
2481		309	18279	■			
2481		310	18280		■		
2481		311	18281	■			
2481		312	18282			■	
2481		314	18284				■
2482	Nueces Bay	306	18276		■		
2482		308	18278			■	
2491	Laguna Madre	315	18285				■
2491		316	18286				■
2491		317	18287				■
2491		323	18293				■
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	318	18288	■			
2492		319	18289			■	
2492		320	18290	■			
2492		321	18291			■	
2492		322	18292	■			

6.13 Trace Metals in Tissue – Individual Concentrations (mg/kg or ppm wet weight)

Table 6.13.1. Trace metal concentrations (mg/kg or ppm wet weight) in tissue (whole body) for 27 of 32 RCAP 2003 sampling sites. Missing sites (5) reflect no trawls taken due to shallow water or no specimens collected as indicated in Table 6.1.1. Shaded value exceeded applicable TCEQ/TDSHS Tidal Water screening levels for: As = 3.00 (inorganic arsenic estimated as 10% of total arsenic), Cd = 0.50, Cr = 100.00, Cu = 40.00, Hg = 0.70, Pb = 8.33 and Se = 2.0. Shaded value exceeded EPA NCCR II screening values (inorganic arsenic estimated at 2.0% of total arsenic) or fell within the noncancer concentration range (see Table 5.2). No value (-) indicates concentration below the reporting limit indicated below the chemical symbol. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	Ag (0.02)	Al (10.0)	As (2.0)	Cd (0.07)	Cr (0.1)	Cu (1.0)	Fe (25.0)	Hg (0.01)	Ni (0.2)	Pb (0.1)	Se (1.0)	Sn (0.05)	Zn (20.0)
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	295	18266	-	44	-	-	0.40	-	38	0.01	-	-	-	-	-
2463	Mesquite Bay/Carlos Bay/Ayres Bay	326	18296	-	107	-	-	0.50	-	61	0.01	-	-	-	-	-
2471	Aransas Bay	298	18268	-	53	-	-	0.50	-	45	0.12	-	0.51	-	-	-
2471		300	18270	-	126	-	-	1.10	-	105	0.01	0.44	0.22	-	-	-
2471		301	18271	-	112	6.90	-	**18.90**	1.06	**173**	0.04	**8.26**	0.25	1.14	-	177
2471		302	18272	-	103	-	-	0.80	-	64	0.01	-	-	-	-	-
2471		303	18273	-	-	4.50	-	5.80	-	47	0.10	2.53	0.15	-	-	148
2471		305	18275	-	20	3.10	-	2.30	-	37	0.08	1.37	0.26	-	-	100
2472	Copano Bay/Port Bay/Mission Bay	296	18226	-	39	5.20	-	0.70	**1.51**	35	0.03	0.22	-	-	-	101
2472		297	18267	-	16	-	-	0.60	-	-	0.03	-	-	-	0.10	107
2481	Corpus Christi Bay	307	18277	-	92	-	-	0.40	-	60	0.01	-	0.51	-	-	-
2481		309	18279	-	77	4.40	0.07	1.50	-	77	0.03	0.41	0.36	1.11	-	**239**
2481		310	18280	-	**193**	-	-	0.70	-	118	0.03	0.23	0.29	-	-	-
2481		311	18281	-	14	-	-	1.70	-	41	0.02	0.48	-	**1.17**	-	158
2481		312	18282	-	29	6.10	-	2.90	-	48	0.04	1.15	0.12	1.03	-	154
2481		314	18284	-	158	-	-	2.00	1.10	94	0.03	0.73	0.21	-	-	21
2482	Nueces Bay	306	18276	-	61	-	-	3.60	-	60	0.05	1.57	0.33	-	-	-
2482		308	18278	-	12	5.50	-	4.00	-	39	0.12	1.72	0.28	-	-	161
2491	Laguna Madre	315	18285	-	43	2.50	-	1.00	-	39	0.03	0.30	0.18	-	-	22
2491		316	18286	-	21	-	-	2.30	1.19	-	0.04	0.97	0.41	-	-	21
2491		317	18287	-	55	2.50	-	1.00	-	35	0.02	0.29	0.10	-	-	24
2491		323	18293	-	61	2.50	-	1.50	-	47	0.03	0.67	-	-	-	20
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	318	18288	-	73	2.90	-	0.90	-	51	0.02	0.21	-	-	-	-
2492		319	18289	-	16	4.90	-	0.80	-	44	0.46	-	**1.74**	-	-	140
2492		320	18290	-	48	3.00	-	0.80	-	32	0.01	0.30	-	-	-	-
2492		321	18291	-	25	**15.60**	-	0.60	-	30	0.13	-	0.56	-	-	83
2492		322	18292	-	47	-	-	0.50	-	31	0.01	-	-	-	-	13

6.14 Tissue Organics – Individual Concentrations (ng/g or ppb wet weight)

Table 6.14.1. Tissue concentrations (ng/g or ppb) of 5 of 20 PCB congeners (PCB's 18, 18, 28, 44, 66, 77, 101, 105, 118, 126, 128, 138, 170, 195, and 206 values were < reporting limit) at 27 of 32 RCAP 2003 sampling sites. Missing sites (5) reflect no trawls taken due to shallow water or no specimens collected as indicated in Table 6.1.1. Shaded value exceeded TCEQ screening level. No value (-) indicates concentration below the reporting limit. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	52	153	180	187	209	Total PCB
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	295	18266	-	-	-	-	-	-
2463	Mesquite Bay/Carlos Bay/Ayres Bay	326	18296	-	-	-	-	-	-
2471	Aransas Bay	298	18268	-	-	-	-	-	-
2471		300	18270	-	-	-	-	-	-
2471		301	18271	-	-	-	-	-	-
2471		302	18272	-	-	-	-	-	-
2471		303	18273	-	-	-	-	-	-
2471		305	18275	-	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	296	18226	-	-	-	-	-	-
2472		297	18267	**4.51**	**9.07**	**3.29**	**1.71**	**0.95**	**19.53**
2481	Corpus Christi Bay	307	18277	-	-	-	-	-	-
2481		309	18279	-	-	-	-	-	-
2481		310	18280	-	-	-	-	-	-
2481		311	18281	-	-	-	-	-	-
2481		312	18282	-	-	-	-	-	-
2481		314	18284	-	-	-	-	-	-
2482	Nueces Bay	306	18276	-	-	-	-	-	-
2482		308	18278	-	-	-	-	-	-
2491	Laguna Madre	315	18285	-	-	-	-	-	-
2491		316	18286	-	-	-	-	-	-
2491		317	18287	-	-	-	-	-	-
2491		323	18293	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	318	18288	-	-	-	-	-	-
2492		319	18289	-	-	-	-	-	-
2492		320	18290	-	-	-	-	-	-
2492		321	18291	-	-	-	-	-	-
2492		322	18292	-	-	-	-	-	-

Table 6.14.2. Tissue concentrations of DDD, DDE, and DDT (ng/g or ppb) at 27 of 32 RCAP 2003 sampling sites. Missing sites (5) reflect no trawls taken due to shallow water or no specimens collected as indicated in Table 6.1.1. Shaded value exceeded TCEQ screening level. No value (-) indicates concentration below the reporting limit. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	2,4'-DDD	4,4'-DDD	2,4'-DDE	4,4'-DDE	2,4'-DDT	4,4'-DDT	Total DDT
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	295	18266	-	-	-	-	-	-	-
2463	Mesquite Bay/Carlos Bay/Ayres Bay	326	18296	-	-	-	-	-	-	-
2471	Aransas Bay	298	18268	-	-	-	**6.84**	-	-	**6.84**
2471		300	18270	-	-	-	-	-	-	-
2471		301	18271	-	-	-	-	-	-	-
2471		302	18272	-	-	-	-	-	-	-
2471		303	18273	-	-	-	-	-	-	-
2471		305	18275	-	-	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	296	18226	-	-	-	-	-	-	-
2472		297	18267	-	-	-	-	-	-	-
2481	Corpus Christi Bay	307	18277	-	-	-	-	-	-	-
2481		309	18279	-	-	-	-	-	-	-
2481		310	18280	-	-	-	-	-	-	-
2481		311	18281	-	-	-	-	-	-	-
2481		312	18282	-	-	-	-	-	-	-
2481		314	18284	-	-	-	-	-	-	-
2482	Nueces Bay	306	18276	-	-	-	-	-	-	-
2482		308	18278	-	-	-	-	-	-	-
2491	Laguna Madre	315	18285	-	-	-	-	-	-	-
2491		316	18286	-	-	-	-	-	-	-
2491		317	18287	-	-	-	-	-	-	-
2491		323	18293	-	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	318	18288	-	-	-	-	-	-	-
2492		319	18289	-	-	-	-	-	-	-
2492		320	18290	-	-	-	-	-	-	-
2492		321	18291	-	-	-	-	-	-	-
2492		322	18292	-	-	-	-	-	-	-

Table 6.14.3. Tissue concentrations (ng/g or ppb) of 12 of 13 Chlorinated Pesticides (Aldrin, Alpha-Chlordane, Dieldrin, Endosulfan I, Endosulfan sulfate, Endrin, Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Lindane (gamma-BHC), Mirex, and Toxaphene, other than DDT at 27 of 32 RCAP 2003 sampling sites were all below the reporting limit. Missing sites (5) reflect no trawls taken due to shallow water or no specimens collected as indicated in Table 6.1.1. Shaded value exceeded screening level. No value (-) indicates concentration below the reporting limit. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	Trans-nonachlor	Total Chlorinated Pesticides
2462	San Antonio Bay/Hynes Bay/Guadalupe Bay	295	18266	-	-
2463	Mesquite Bay/Carlos Bay/Ayres Bay	326	18296	-	-
2471	Aransas Bay	298	18268	-	-
2471		300	18270	-	-
2471		301	18271	-	-
2471		302	18272	-	-
2471		303	18273	-	-
2471		305	18275	-	-
2472	Copano Bay/Port Bay/Mission Bay	296	18226	-	-
2472		297	18267	**2.58**	**2.58**
2481	Corpus Christi Bay	307	18277	-	-
2481		309	18279	-	-
2481		310	18280	-	-
2481		311	18281	-	-
2481		312	18282	-	-
2481		314	18284	-	-
2482	Nueces Bay	306	18276	-	-
2482		308	18278	-	-
2491	Laguna Madre	315	18285	-	-
2491		316	18286	-	-
2491		317	18287	-	-
2491		323	18293	-	-
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	318	18288	-	-
2492		319	18289	-	-
2492		320	18290	-	-
2492		321	18291	-	-
2492		322	18292	-	-

Table 6.14.4. Tissue concentrations (ng/g or ppb) of 23 PAH's at 27 of 32 RCAP 2003 sampling sites were all below detectable reporting limits. Missing sites (5) reflect no trawls taken due to shallow water or no specimens collected as indicated in Table 6.1.1

Segment	Segment Name	CCS ID	TCEQ ID	PAH's
2462	San Antonio/Hynes/Guadalupe Bays	295	18266	-
2463	Mesquite/Carlos/Ayres Bays	326	18296	-
2471	Aransas Bay	298	18268	-
2471		299	18269	-
2471		300	18270	-
2471		301	18271	-
2471		302	18272	-
2471		303	18273	-
2471		305	18275	-
2472	Copano/Port/Mission Bays	296	18226	-
2472		297	18267	-
2481	Corpus Christi Bay	307	18277	-
2481		309	18279	-
2481		310	18280	-
2481		311	18281	-
2481		312	18282	-
2481		314	18284	-
2482	Nueces Bay	306	18276	-
2482		308	18278	-
2483	Redfish Bay	304	18274	-
2485	Oso Bay	313	18283	-
2491	Laguna Madre	315	18285	-
2491		316	18286	-
2491		317	18287	-
2491		323	18293	-
2491		324	18294	-
2491		325	18295	-
2492	Baffin Bay/Alazan Bay	318	18288	-
2492	Cayo del Grullo/Laguna Salada	319	18289	-
2492		320	18290	-
2492		321	18291	-
2492		322	18292	-