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RCAP 2000 and RCAP 2001
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COASTAL BEND BAYS & ESTUARIES PROGRAM

REGIONAL COASTAL ASSESSMENT PROGRAM (RCAP)

RCAP 2000 and RCAP 2001

ANNUAL REPORT

Prepared for:

Coastal Bend Bays & Estuaries Program, Inc.
1305 N. Shoreline Boulevard, Suite 205
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EXECUTIVE SUMMARY

According to the *Implementation Strategy for the Coastal Bend Bays Plan*, maintaining and or enhancing the quality of water and sediment within the Coastal Bend is a primary goal in protecting the natural resources of our region. The *Bays Plan* called for the Coastal Bend Bays & Estuaries Program (CBBEP) to initiate a comprehensive monitoring and assessment program to meet this stated objective.

As the first in a series of reports, this annual report provides monitoring data for the first two years (2000 and 2001) of the CBBEP Regional Coastal Assessment Program (RCAP). This baseline-monitoring program addresses numerous historical water quality and trace metal concentration concerns and the lack of adequate available historical data with which to make management decisions. By significantly expanding on present monitoring efforts within the region, and focusing on providing water, sediment, and biological data characterizing conditions of the regions coastal waters, the CBBEP intends to meet, and exceed, the stated objectives of the *Bays Plan*.

RCAP 2000 and 2001 included implementation of an intensive probabilistic sampling design, provided by the EPA Environmental Monitoring and Assessment Program (EMAP), for monitoring estuarine systems. Selection of EMAP sites involved a systematic random approach to provide for uniform spatial coverage, ensuring sampling of parameters was proportional to geographical location. Selection of a different site for each of the eight events (four per year) yielded 120 sites for RCAP 2000 and 124 sites for RCAP 2001. During RCAP 2000, the monitoring plan also included 10 targeted Texas Commission on Environmental Quality (TCEQ) sites sampled for four events and 8 fixed TCEQ sites in Oso Bay and Oso Creek, sampled for two events. Reporting of data adhered to TCEQ procedures by placing stations within defined water bodies, or “segments”.

The RCAP 2000 study area included stations located within Copano Bay/Mission Bay/Port Bay (Segment 2472), St. Charles Bay (Segment 2473), Aransas Bay (Segment 2471), Redfish Bay (Segment 2483), Corpus Christi Bay (Segment 2481), Nueces Bay (Segment 2482), Corpus Christi Inner Harbor (Segment 2484), Oso Bay (Segment 2485), and Oso Creek (Segment 2485A-TCEQ unclassified Tidal Stream segment). RCAP 2001, completed the second year effort for the southern CBBEP area, and included the Upper Laguna Madre (Segment 2491), Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492), and a small portion of southern Corpus Christ Bay (Segment 2481) just north of the J.F.K. Causeway.

Measurements of routine field data parameters, routine conventional water chemistry, trace metal contaminants in water, and benthic biological organisms took place over eight sampling events. Microbiological sampling occurred over four events during RCAP 2001 and Trace metal contaminants in sediment took place for one event during RCAP 2000 and RCAP 2001. Data reported within this document adhered to TCEQ procedures by assessing the segment on an individual basis and then evaluating segments within the region as a whole.

WATER MONITORING

Field Data

During RCAP 2000 and 2001, values recorded for basic field data parameters reported (Total Depth, Water Temperature, pH, secchi depth, salinity, and dissolved oxygen) were typical for the region or indicative of the particular sampling area, as random selection of stations allowed for equal chances of sampling characteristically different locations.

Total Depth for RCAP 2000 ranged from 0.30 m within many segments, typically at randomly selected stations along shorelines, to >15.00 m in the Corpus Christi Ship Channel (Segment 2481) or Corpus Christi Inner Harbor (Segment 2484). During RCAP 2001 Total Depth ranged from 0.26 m to 2.77 m and typically was highest in Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492). Generally, mean Total Depth for all segments in RCAP 2000 and RCAP 2001 were indicative of the particular segment, as random selection of stations allowed for equal chances of sampling relatively deep and shallow locations.

Water temperature for RCAP 2000 tended to be higher in the shallower segments such as St. Charles Bay (Segment 2473), Oso Bay (Segment 2485), and Nueces Bay (Segment-2482) and temperatures recorded exhibited typical seasonal variations seen in the CBBEP region. RCAP 2001 water temperature readings followed expected variations. Mean water temperature remained relatively consistent between all three segments, with mean water temperatures usually slightly higher in the shallow waters of the Upper Laguna Madre (Segment 2491).

Typically, pH of estuarine and coastal waters ranges from 7.5 to 8.5, with occasional deviations above 9.0 or below 7.0. pH values remained consistent for all segments sampled in RCAP 2000 and averaged around 8.00. Some deviations above 8.5 occurred in Oso Bay but never ranged above 8.75. For RCAP 2001, mean pH values averaged around 8.40 for most sampling events, and while relatively consistent between segments, tended to be higher in the Upper Laguna Madre and higher than most segments sampled for RCAP 2000.

Bay systems, or water body segments, within the CBBEP region are typically turbid and Secchi Depth measurements for RCAP 2000 tended to validate this fact. Mean Secchi Depth for most segments tended to average <1.0 m with Nueces Bay (Segment 2482), Oso Bay (Segment 2485), and Oso Creek (Segment 2485A) being the most turbid; average yearly Secchi Depth reading of <0.40 m. Mean Secchi Depth during RCAP 2001 averaged around 0.60 m in the Upper Laguna Madre to 0.50 m in the Baffin Bay Complex. Drawbacks to using Secchi Depth as an indicator of water clarity in shallow locations such as the Upper Laguna Madre were noted, as Secchi Depth readings of >0.30 m, >0.4, or >1.30 m (actual RCAP 2001 values) represents the secchi disk sitting on the bottom. Actual water clarity conditions may then be significantly higher but are unquantifiable using this method. In actuality, RCAP 2001 saw > a certain Secchi Depth for 53.8% of the Upper Laguna Madre readings, as opposed to representing only 9.3% of the readings for the Baffin Bay Complex signifying that water clarity may be considerably better than Secchi Depth numbers alone reveal.

Salinity concentrations typically are quite high within the CBBEP region due to natural semi-arid conditions, reduced of freshwater inflows, and the unique hypersaline Laguna Madre, which comprises the southern half of the CBBEP region. For RCAP 2000, sampling events recorded the typical salinity variability seen throughout the CBBEP region. Salinity values ranged from <2.00 PSU on Oso Creek (Segment 2485A), to a high of 52.15 PSU in Oso Bay (Segment 2485). Mean salinity values tended to be highest in Corpus Christi Bay (Segment 2481) and Nueces Bay (Segment 2482) and lowest in the northern bays.

RCAP 2001, sampling events captured the influence of increased freshwater inputs into the system. Salinity concentrations ranged from 59.04 PSU during sampling Event 1 (Summer 2001) to 22.36 PSU in Event 2 (Fall 2001) at stations located in the Laguna Salada in the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492. Lack of sustained freshwater inputs saw salinity concentrations rise back up to hypersaline conditions in Event 4 (Spring 2002). Mean salinity concentrations tended to be higher in Segment 2492 and in particular, the western most reaches of the Baffin Bay complex in the Laguna Salada and Cayo del Grullo.

Dissolved oxygen (DO) represents the most essential water quality parameter that TCEQ utilizes in assessing the aquatic life use (ALU) and thereby the health of the water body, or segment. As RCAP 2000 and RCAP 2001 only collected instantaneous grab sample DO readings, it does not warrant using the 24-hour DO criterion to evaluate conditions within the segments. However, DO sampling to meet compliance routinely targets segments where low instantaneous DO concentrations indicate partial or nonsupport of the designated ALU making the data collected useful in assisting the assessment process.

During RCAP 2000, we recorded no instances of hypoxia (<2.0 mg/l^{-1}) for all stations sampled. For the entire year, only 4.0% of the measurements recorded fell below respective criterion. For RCAP 2001 we recorded only one instance of hypoxia (1.65 mg/l^{-1}) at one station located in Baffin Bay (Segment 2492). For the 124 stations sampled, 10% of the measurements recorded fell below respective criterion. While there were a small amount of DO concentrations that fell in the "biologically stressful" range of >2.0 mg/l^{-1} but <5.0 mg/l^{-1}, these were stations sampled in the summer and in the early morning. Except for two stations sampled in RCAP 2001, mean DO measurements for all segments monitored for RCAP 200 and RCAP 2001 were >5.0 mg/l^{-1}. Therefore, we evaluate overall DO quality as very good throughout the entire CBBEP region sampled.

Routine Conventional Water Chemistry

Due to the lack of established nutrient criteria, TCEQ utilizes four nutrients (Ammonia, Nitrate + Nitrite, Total Phosphorus, and Orthophosphate) and chlorophyll *a* to assess and identify secondary concerns for aquatic life uses when evaluating the condition of waters in the Texas. Unfortunately, the first year (RCAP 2000) of this program did not produce what we consider as viable results for two parameters (Nitrate + Nitrite and Orthophosphate) due to possible analytical and data reporting problems.

Nutrient concerns identified during RCAP 2000 tended to occur in areas historically known to have problems and cited on the *Texas Water Quality Inventory and 303(d) List* compiled by TCEQ. Data analysis confirmed those concerns in the Corpus Christi Inner Harbor (Segment 2484) for Ammonia and Chlorophyll *a*, Oso Bay (Segment 2485) for Ammonia and Total

Phosphorus, and Oso Creek (Segment 2485A) for Total phosphorus and Chlorophyll *a.* With the exception of Nueces Bay, which had a 41.6% exceedance of the Total Phosphorus screening level, and discounting the problems addressed with Nitrate + Nitrite and Orthophosphate, the majority of segments sampled in RCAP 2000 did not show concerns for nutrient enrichment or elevated chlorophyll *a* concentrations. Therefore, we evaluate nutrient and chlorophyll a conditions in the CBBEP region as relatively good, but needing some improvement.

For RCAP 2001, while there were some instances of nutrient exceedances none was above the 25% level used by TCEQ to list a segment with Secondary Concerns. However, chlorophyll *a* did exceed the screening level for the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) area 51.9% of the time. While the Laguna Madre (Segment 2491) did not cross the 25% threshold, it did come close, exceeding the screening level 21.5% of the time.

Residence times and mixing may play a role in chlorophyll *a* concentrations seen in the Baffin Bay complex during RCAP 2001. Typically enclosed bays systems or coastal lagoons, such as Baffin Bay and the Upper Laguna Madre, experience limited flushing, allowing nutrients to remain within the system for long periods. In addition, temperature and light levels optimal for phytoplankton production tend to be high within the area and nutrient runoff from adjacent agricultural lands is possible during increased precipitation events.

We found that many of these conditions existed during RCAP 2001. Typically, this system experiences poor flushing and long residence times. During RCAP 2001, chlorophyll *a* exceeded the screening level 42.9% of the time in summer, when the highest mean water temperatures occurred, and 46.4% of the time in fall, when increased inflows to the system lowered salinities and inputs to the system produced 88.9% of the Total Phosphorus exceedances.

While some of these exceedances may be part of natural hydrodynamics within the system, they also indicated the presence of nutrient pulses to the system that require additional monitoring to assess trends within this segment. Within the Laguna Madre (Segment 2491), the only discernible pattern observed were 64.3% of the chlorophyll *a* exceedances occurred at stations located at the mouth of Baffin Bay or south of Baffin Bay in the Land Cut and Nine-Mile Hole area.

Microbiological Indicators

The addition of bacteria sampling in RCAP 2001 provided data using the new criterion, Enterococci, in the assessment of the TCEQ Contact Recreation Use (CRU) for water within the CBBEP region. Although sampling took place at random station locations, and is therefore not acceptable in evaluating the CRU under current TCEQ guidelines, data collected serves as a tool for CBBEP and TCEQ to assess conditions over a broad area. RCAP 2001 data showed three exceedances, or <5.0%, of the CRU in the Laguna Madre (Segment 2491) at stations located close to bird rookery islands. Therefore, we evaluate water quality as very good within the southern CBBEP region for bacteria.

Trace Metals in Water

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 of aqueous trace metals concentrations within the CBBEP region, the results of this portion of the monitoring project are excellent. We strongly feel that utilization of ultra-clean sampling and analysis techniques provided the highest quality data available and encourage their use in applicable monitoring programs. Applying TCEQ criteria to evaluate RCAP 2000 and 2001 results identified **no** metal concentrations exceeding chronic criteria, and typically concentrations of most metals were **a significant number of times lower (orders of magnitude in some cases)** than all applicable criteria and existing historical data. As a result, we evaluate water quality regarding trace metals as very good to excellent within the CBBEP region.

During RCAP 2000 elevated metals concentrations often occurred at Oso Creek stations or at Station 13441 in Oso Bay. Elevated concentrations result from the effluent discharges dominating flow in Oso Creek and the location of Station 13441 in the dilution zone of the Oso Wastewater Treatment Plant. Highest mean arsenic concentrations tended to occur in areas with freshwater inputs (Aransas, Mission, and Nueces Rivers), and highly reflect the natural background levels typically found in freshwater. However, sources may also relate to runoff from unknown nonpoint sources. As expected, most concentrations of trace metals tended to be highest in relation to proximity to the Corpus Christi Inner Harbor (Segment 2484). As the primary industrial complex for the region, this area would exhibit elevated concentrations on a more frequent basis. Except for elevated copper concentrations (still below criteria) in the Corpus Christi Inner Harbor, all other trace metal concentrations fell far below the TCEQ criteria.

During RCAP 2001, data analysis found the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) exhibited elevated metal concentrations 71.8% of the time. However, all concentrations, except copper, which was elevated but did not exceed, fell far below TCEQ criteria. As seen in RCAP 2000, mean arsenic concentrations were higher relative to station proximity to freshwater inputs. Mean arsenic concentrations tended to be highest in the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492), most notably in Alazan Bay and the main stem of Baffin Bay. As increased arsenic levels coincided with decreased salinity from increased precipitation and subsequent inflows, it would be safe to assume that discharges into Alazan Bay may point to Petronila Creek and unknown inputs as the source.

Higher metals concentrations occurred within the Corpus Christi Inner Harbor (Segment 2484) as expected, but in general, the picture looks very good. We suggest implementation of continued ultra-clean sampling and analysis to track trends within this segment, especially for copper. In addition, copper monitoring is highly recommended within Baffin Bay (Segment 2492). Even though all sample concentrations fell below applicable criteria, the fact that elevated concentrations similar to those in the Corpus Christi Inner Harbor occurred in this remote, non-industrialized area, requires additional analysis. Several upstream industrial complexes exist that have permitted discharges into creeks and streams that feed into Baffin Bay. Further data analysis is required to see if any patterns or sources are discernible.

SEDIMENT MONITORING

Sediment Characteristics

For RCAP 2000, highest individual Total Organic Carbon (TOC) concentrations occurred in Copano Bay/Port Bay/Mission Bay (Segment 2472). This segment produced the highest mean TOC enrichment values, with 29% of the stations yielding values of >5% TOC and 43% of the stations yielding moderate TOC enrichment values of 2 to 5%. Corpus Christi Bay (Segment 2481), exhibited moderate and high enrichment values for 38% and 8% of the stations sampled, respectively. RCAP 2001 stations in the Laguna Madre (Segment 2491) and Baffin Bay (Segment 2492) consisted of low to moderate TOC enrichment values.

The percentage of mud (silt/clay) within sediments is an important aspect in determining which benthic organisms might exist within an area and the possible bioavailability of some contaminants to the biological community. Silt/Clay proportions for RCAP 2000 stations showed Copano Bay/Port Bay/Mission Bay (Segment 2472) had the highest mud content with Corpus Christi Bay (Segment 2481) yielding the highest muddy sand content. Aransas Bay (Segment 2471) contained higher percentage of stations with sand. During RCAP 2001, proportions of Silt/Clay showed the Laguna Madre (Segment 2491) to be predominantly muddy sand while Baffin Bay was primarily composed of stations with high mud content.

Sediment Trace Metals

Like water quality, evaluating complexity of sediment contaminants is a process requiring analysis of multiple datasets over long periods. In addition, for a complete examination it will be necessary to consider more parameters such as sediment organics (PCBs, DDT, pesticides, PAHs, etc) and toxicity. As the first in a series of monitoring efforts planned by CBBEP, excepting one station, RCAP 2000 and RCAP 2001 sampling events showed that sediment quality within the CBBEP region concerning trace metals is very good.

Applying applicable TCEQ screening level procedures, identified only one station as a secondary concern. Located within the City of Corpus Christi Municipal Marina; this was the only station with a metal concentration (mercury) above both applicable screening levels. In addition, exceedances of one screening level (TCEQ 85th percentile) also occurred at this station for copper, lead, and zinc.

With the exception of four metals (aluminum, arsenic, nickel, and silver), higher sediment metal concentrations occurred during RCAP 2000 compared to RCAP 2001, with minimal variability in concentrations observed during both years. Highest mean trace metal concentrations in RCAP 2000 occurred in Corpus Christi Bay (Segment 2481) followed by Copano Bay/Port Bay/Mission Bay (Segment 2472). During RCAP 2001, higher concentrations occurred in Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492). Most metals were highly correlated with aluminum and thereby were not indicative of anthropogenic enrichment. However, regression analysis did indicate some possible anthropogenic enriched stations in Corpus Christi Bay (Segment 2481) for lead and for nickel and in Redfish Bay (Segment 2483) for nickel. RCAP 2001 analysis indicated some locations in the Upper Laguna Madre (Segment 2491) having high aluminum:metal ratios for either cadmium, chromium, copper, and zinc individual

BIOLOGICAL MONITORING

The primary goal of the RCAP 2000 and RCAP 2001 benthic component was to begin a baseline characterization of the benthic communities within segments of the CBBEP region in the process of establishing biocriteria applicable to this unique region.

During RCAP 2000, benthic analysis identified 254 species totaling 18,413 individuals within the Mission-Aransas Estuary (Copano Bay Complex and Aransas Bay) and the Nueces Estuary (Nueces Bay, Corpus Christi Bay, and Redfish Bay). The most abundant group was annelids (67.1%), followed by arthropods (16.0%), and molluscs (11.7%), which collectively represented 94.8% of all organisms collected during RCAP 2000. During RCAP 2001, benthic analysis identified 162 species totaling 32,399 individuals within the Upper Laguna Madre and Baffin Bay Complex. Annelids dominated collections (46.3%), followed by molluscs (30.4%), and arthropods (21.5%). Collectively these three groups represented 98.2% of all organism collected during RCAP 2001.

A basic analysis of the RCAP 2000 baseline data indicates varying degrees of complexity within the areas sampled. Within the Mission-Aransas and Nueces Estuaries, observed differences in biological and physiochemical attributes existed with salinity, depth, overall benthic density, species richness, and diversity being significantly greater in the Nueces Estuary. In the Mission-Aransas Estuary, dissolved oxygen and species dominance (influence of one or two species) typically were higher, most notably in the Copano Bay area. The Mission-Aransas Estuary typically exhibited salinity gradients more reflective of a characteristic estuary and salinity tended to be more variable as opposed to the relatively stable high salinity observed in the Nueces Estuary, which is a strong indicator of reduced freshwater inflow from the Nueces River.

Species collected during RCAP 2000 were representative of past research, with many species historically found throughout this region. While some species collected, classify as pollution tolerant, or pollution sensitive, these same species also occur in extremely stressful environments where fluctuating physical or environmental conditions cause areas to undergo sudden and abrupt changes in their immediate surroundings (i.e., extreme fluctuations in salinity). This may signify that the benthic communities are comprised of “hearty” species that can tolerate constantly changing conditions and that “pollution” is not the reason they tend to occur. Additional data collection over time, which captures these changing conditions, will aid in future assessments.

During RCAP 2001, two distinct benthic communities existed within the areas sampled all related to the presence or absence of Submerged Aquatic Vegetation (SAV), or seagrass beds. Such factors as salinity, dissolved oxygen, water depth and circulation, sediment type, and turbidity played a role in influencing the benthic community composition and the presence, quality, and quantity of SAV.

As seen with RCAP 2000, species collected during RCAP 2001 were representative of past research, with many species historically found throughout the area sampled. As previously discussed, aspects of stress are applicable for RCAP 2001, as monitoring for this area occurred in a mostly shallow depth, warm water, hypersaline environment, where only the most adaptable species tend to survive. The intent is not to dismiss the possible influence of environmentally damaging inputs to the system; but is a cautious reminder that natural conditions may have as much, or more, of an influence on the health of a system.

As the first in a series of long-term monitoring events, it is not possible to make definitive conclusions as to how the health of the benthic community relates to sediment quality as sampling only occurred for sediment metals during one quarter of each monitoring year. As future sampling events become more complex, with analysis done for sediment inorganic and sediment organic contaminants and sediment toxicity, we hope to establish an index of unique indicator species and parameters. This index will allow future monitoring events the ability to assess the overall health of the system and identify areas that may or may not warrant further attention.

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In addition, we wish also to thank the individual laboratories that provided analytical assistance over the course of two years (see Section 1.3 for details). Without their funding commitment, active support, and hard work, this project would not have been possible. We extend a special thanks to Dr. Paul N. Boothe at Albion Environmental for instruction in the art of "Ultra-Clean" metal sampling techniques and extended guidance throughout the project.

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For RCAP 2001 we wish again to thank Erin M Albert, who stepped up and took over the field supervisor responsibility when Alex X. Nuñez felt his age coming on and Jennifer Pearce for field and benthic laboratory assistance while in pursuit of her Masters Degree. In addition, we thank Dr. Kim Withers for field and laboratory assistance in identifying benthic organisms, Fred Ruiz for assistance in the field and laboratory and his undying mantra, "it is all about the data", and Amy Thurlkill and Adam Cochran for graciously bouncing around the waters of the Coastal Bend.

For both projects, we also thank the numerous undergraduate and graduate students, who assisted in the field sampling and who learned the art of "picking and grinning" as they cleaned, sorted, and picked their way through benthic samples. In addition, we also thank the staff at the Center for Coastal Studies for administrative support, encouragement, and patience.

1.0 INTRODUCTION

1.1 Background

According to the *Implementation Strategy for the Coastal Bend Bays Plan* (CBBEP 1998), maintaining and or enhancing the quality of water and sediment within the Coastal Bend is a primary goal in protecting the natural resources of our region. The *Bays Plan* called for the Coastal Bend Bays & Estuaries Program, Inc. (CBBEP) to initiate a comprehensive monitoring and assessment program to meet this stated objective.

This report encompasses the initial two years (2000 and 2001) of the CBBEP Regional Coastal Assessment Program (RCAP). This baseline-monitoring program, conducted by the Center for Coastal Studies (CCS) at Texas A&M University-Corpus Christi, significantly expands on present monitoring efforts within the region and focuses on providing scientifically sound water quality, sediment quality, and biological data describing conditions of the coastal waters of the CBBEP region. As the first in a series of RCAP reports, we provide the following essential information, which describes the assessment of water quality in the State of Texas and documents the ongoing development and implementation of this program.

Through their statewide monitoring program, the Texas Commission on Environmental Quality (TCEQ) compares conditions in Texas surface waters to established standards and screening criteria. Results 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 (CWA) 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*) act requires states to identify water bodies for which effluent limitations are not stringent enough to implement water quality standards.

The 303(*d*) list identifies water bodies (Segments) not meeting, or not expected to meet, standards set for their use. The list identifies which pollutants or conditions are responsible for the failure to meet standards; and those impaired water bodies targeted for clean-up activities. The list is thereby an overview of the status of surface waters of the state; including public health concerns, fitness for use by aquatic species and other wildlife, and specific pollutants and their possible sources (TCEQ 2002). As stated in the *TCEQ Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2002*, the TCEQ is required by the CWA, and federal regulations, to consider “all existing and readily available water quality-related data and information” in development of the *Texas Water Quality Inventory and 303(d) List*.

Therefore, TCEQ collaboratively works with federal, state, regional, and local partners to collect and assess Texas water quality data. Conditions utilized to strengthen the scientific foundation of 303(*d*) listing decisions include; time limits (data collected within the last 5 years), geographic focus (data from an area targeted for assessment), and data quality (data collected under a TCEQ approved Quality Assurance Project Plan or QAPP). Utilization of this reliable data verifies partial or non-support of designated uses, determines priority ranking of water bodies, and directs future water quality monitoring within defined or classified water body segments.

To remediate identified impairments, TCEQ must develop action plans, which often involve extensive monetary resources. Restoring quality within an impaired water body then makes it essential to be relatively certain of pollution sources and causes. A primary tool utilized to gain this understanding is development of a total maximum daily load (TMDL) model. If successful, a TMDL helps determines the maximum pollutant amount that a water body can receive and still both attain and maintain its water quality standards. Typically, the TMDL allocates this allowable amount (load) to both point and nonpoint sources in the watershed and is normally prepared for each pollutant in every impaired water body. The United States Environmental Protection Agency (EPA) requires submission of TMDLs for review and approval (TCEQ 2002).

Upon TMDL finalization, the development of an implementation plan then describes activities necessary to achieve the pollutant reductions identified. Incorporating both non-regulatory and regulatory mechanisms, the implementation plan details items such as permit effluent limits and recommendations, nonpoint source pollution best management practices, possible stream standard revisions, special projects, pollution prevention, public education, and watershed-specific rule recommendations. In cooperation with regional and local stakeholders the best strategies for the watershed/water body are developed. The implementation plan should describe activities, schedules, define legal authority, provide assurances of voluntary practices, identify possible funding sources, define performance results, and require follow-up monitoring plans to determine implementation plan success (TCEQ 2002).

As stated in TCEQ (2002) documentation, attainment of the water quality standard is the ultimate goal, but evaluation of interim results to assess progress need consideration, as accurately predicting how long improvements may take to occur, or how much improvement might occur, is difficult. To achieve these interim evaluations often requires a phasing in of implementation activities, especially those that address nonpoint sources of pollution, and implementing cost effective and time-tested activities first.

After initial assessment, if non-attainment of water quality standards exists, then the next round of implementation begins. By using an adaptive management approach, water body assessment is continual, with adjustments in implementation activities made when needed for ultimately attaining water quality standards.

With these goals in mind, the CBBEP initiated the first in a series of data collection monitoring events to assess water and sediment quality of the region. Historically viewed as an under sampled region, the CBBEP area nonetheless continued to experience temporal and spatial declines in intense water and sediment quality monitoring since the mid-1970s (Ward and Armstrong 1997 CCBNEP-13; Ward and Armstrong 1997 CCBNEP-23).

Insufficient monitoring in the Copano/Port/Mission Bay complex (Segment 2472), Aransas Bay (Segment 2471), Upper Laguna Madre (Segment 2491), and the Baffin Bay complex (Segment 2492) was viewed as unsatisfactory. Although various programs studied the bay systems, collective historical data lacked a consistent monitoring of specific parameters throughout the expansive area encompassed by the Coastal Bend Bay System (Ward and Armstrong 1997 CCBNEP-13; Ward and Armstrong 1997 CCBNEP-23).

Numerous historical concerns of the bay system's water quality parameters and metals concentrations appeared in CBBEP study reports (Ward and Armstrong 1997 CCBNEP-13; Ward and Armstrong 1997 CCBNEP-23). Parameters included chlorophyll *a*, dissolved oxygen, salinity, and trace metals such as zinc, lead, nickel, mercury, chromium, cadmium, and copper. Areas of historically elevated metals 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). In CCBNEP-23, Ward and Armstrong (1997) stated that the solution to the lack of available historical data was to "sample at more locations, more frequently, for more parameters" and to take advantage of the costs of sampling the bay system waters by monitoring for as many constituents as possible.

In 1999, due to elevated dissolved copper concentrations, and other incidents of water quality standards exceedances; including dissolved oxygen, zinc, and fecal coliform in portions of Corpus Christi Bay (Segment 2481), Nueces Bay (Segment 2482), Conn Brown Harbor (Segment 2483A), and Oso Bay (Segment 2485), placed the segments on the Draft State of Texas 1999 CWA Section 303(*d*) List.

However, an anomaly in copper data results indicated that several dissolved copper values were higher than total copper values. This resulted in Corpus Christi Bay's removal from the Final 1999 303(d) list for exceeding acceptable copper standards until further evaluation and additional data was available. This incident, and the listing of other concerns, which may or may not indicate the possibility of ongoing TMDLs, prompted the CBBEP and local stakeholders to take a proactive approach in assessing the water and sediment quality conditions within our area.

1.2 Regional Coastal Assessment Program Objectives and Philosophy

Primary RCAP objectives are to establish and implement a program that conducts intensive monitoring yielding accurate and reliable data. This data should accurately characterize and assess the status and trends of water and sediment quality within the CBBEP area, be superior to historical monitoring data, address areas and parameters of historic concern, and provide a solid basis for future management decisions. This data should allow for precise localization of anthropogenic and natural influences within the CBBEP region with a greater resolution than previously seen through historical monitoring programs.

Some methods to achieve these goals are conducting the RCAP under state and federally approved QAPPs and using the most advanced methods. An example of this would be the determination of Trace Metal concentrations in water that use "Ultra-Clean" sampling methods and laboratory techniques which focus on yielding improved data accuracy. Project objectives support the comprehensive CBBEP conservation and management plan goals, as stated in the *Bays Plan*.

Comprehensive understanding provides the tools required to protect, preserve, and enhance the unique estuarine and marine resources of our area. A principal component for developing this understanding is the development and implementation of a sound regional water and sediment quality monitoring program, consisting of the collection, analysis, and dissemination of the highest quality data.

A comprehensive RCAP allows the CBBEP and 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. These interactions, established and built first at the local level, develop highly effective communication lines that provide for data sharing and improved information transfer that ultimately fosters partnerships specifically designed to provide the means for effective coastal monitoring.

A key component in establishing RCAP is continued association and partnership development with TCEQ and EPA for water and sediment quality projects currently conducted within the program area. The rationale of using the EPA Office of Research and Development—Environmental Monitoring and Assessment Program (EMAP) probability-based sampling design is to determine the status, extent, changes, and trends in the water and sediment quality, and the ecological communities of an area, with a scientifically sound monitoring plan. EMAP designs determine the condition of resources, provide information to aid in the evaluation of environmental policies, and help identify emerging environmental problems before they become widespread.

The goal the RCAP is to protect, preserve, and enhance the natural resources of our coastal environment by providing descriptive and quantitative data to aid in the development of diagnostic procedures. These procedures will help characterize physical, chemical, and biological dynamics of our coastal environment in evaluating habitat conditions within the CBBEP region.

A comprehensive RCAP, addressing these goals and objectives, has the unique ability to interact with most, if not all, of the other Action Plans as described in the *Bays Plan*. As the program matures, the CBBEP's intent is to utilize an adaptive management process in evaluating conditions relative to regulatory criteria, guidelines, or screening levels. The selection of random station locations throughout the CBBEP region will provide for an unbiased analysis in a variety of estuarine habitats. In addition, the modification of sampling parameters and criteria, to develop meaningful indicators, will be possible under this program, in the ultimate goal of gaining a better understanding of our estuarine system health.

1.3 Regional Coastal Assessment Program Participants and Contractors

RCAP 2000 and 2001 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 support. Table 1.2 lists participating RCAP 2000 and RCAP 2001 contractors and primary personnel.

Table 1.1. Regional Coastal Assessment Program (RCAP) 2000 and 2001 participants.

Institution

- **Coastal Bend Bays & Estuaries Program**
- **National Oceanic and Atmospheric Administration (NOAA)**
  - Coastal Zone Management Program
- **Nueces River Authority (NRA)**
- **Port Industries of Corpus Christi (PICC)**
- **Texas Commission on Environmental Quality (TCEQ)**
  - Houston Analytical Laboratory
- **Texas General Land Office**
  Coastal Coordination Council (CCC) - Coastal Management Program (CMP)
- **U.S. Environmental Protection Agency (USEPA)**
  - Region 6 – Dallas, Texas
  - National Health and Environmental Effects Research Laboratory - Gulf Ecology Division

Table 1.2. Regional Coastal Assessment Program (RCAP) 2000 and 2001 contractors.

	Contractor/Institution	Primary Personnel
Principal Contractor	Center for Coastal Studies	Mr. Brien A. Nicolau Mr. Alex X. Nuñez Mr. Jefferson N. Childs Ms. Erin M. Albert Ms. Jennifer Pearce
Routine Chemistry – Water	Texas Commission on Environmental Quality and FUGRO South, Inc.	Houston Analytical Laboratory and Mr. Steve DeGregorio
Trace Metals - Water	Albion Environmental	Dr. Paul N. Boothe
Trace Metals - Sediment	FUGRO South, Inc.	Mr. Steve DeGregorio
Microbiological	Texas A&M University-Corpus Christi	Dr. Joanna Mott

1.4 References

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

TCEQ. 2002. Guidance for Screening and Assessing Texas Surface and Finished Drinking Water Quality Data (FY 2002). Revised 2/11/02. 87 p.

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 consisted of a three-phase process based on providing scientifically sound data that characterized water and sediment quality conditions, identified significant long-term trends, and supported the TCEQ TMDL process.

Input from local, state, and federal representatives, facilitated stakeholder workgroup consensus regarding appropriate and effective sampling and analytical protocols for monitoring the CBBEP area. 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 Coastal Bend Bay System. 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.

Collectively referred to as RCAP 2000, Phase I included development, design, and initial implementation of the monitoring plan, while Phase II completed the first year monitoring effort for the northern and central CBBEP area. The RCAP 2000 study area included stations located within Copano Bay/Mission Bay/Port Bay (Segment 2472), St. Charles Bay (Segment 2473), Aransas Bay (Segment 2471), Redfish Bay (Segment 2483), Corpus Christi Bay (Segment 2481), Nueces Bay (Segment 2482), Corpus Christi Inner Harbor (Segment 2484), Oso Bay (Segment 2485), and Oso Creek (Segment 2485A-TCEQ unclassified Tidal Stream segment). As an effluent dominated stream that feeds Oso Bay, the individual characteristics of the two water bodies are quite different. TCEQ continues to investigate the possibility of assigning Oso Creek a separate Segment Number but has not done so at this time. Phase III, or RCAP 2001, completed the second year effort for the southern CBBEP area, and included the Upper Laguna Madre (Segment 2491) and Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) (Fig. 2.1).

RCAP 2000 and 2001 included implementation of an intensive probabilistic sampling design, provided by EPA EMAP, for monitoring estuarine systems. Selection of EMAP sites involved placement of multiple hexagonal grids, of predetermined size, over the study areas with grids then selected by a systematic random approach. The uniform spatial coverage provided by a grid ensured sampling of parameters was proportional to geographical location. For RCAP 2000 and 2001, selection involved 30 and 31 random grids, respectively, with one randomly selected site per grid sampled each event. Selection of a different site for each of four events yielded 120 sites for RCAP 2000 and 124 sites for RCAP 2001 (Fig 2.2). During RCAP 2000, the monitoring plan included 10 targeted TCEQ sites sampled for four events and 8 fixed TCEQ sites in the "Oso Bay/Oso Creek" project, sampled for two events (Fig. 2.2).

Selection of TCEQ locations came from the project steering committee, with site selection based on the need to provide adequate coverage of the project area and on areas of committee concerns. The additional sites chosen from the "Oso Creek/Oso Bay Project" represented an opportunity to include sites from an area with an ongoing project addressing TMDL concerns.

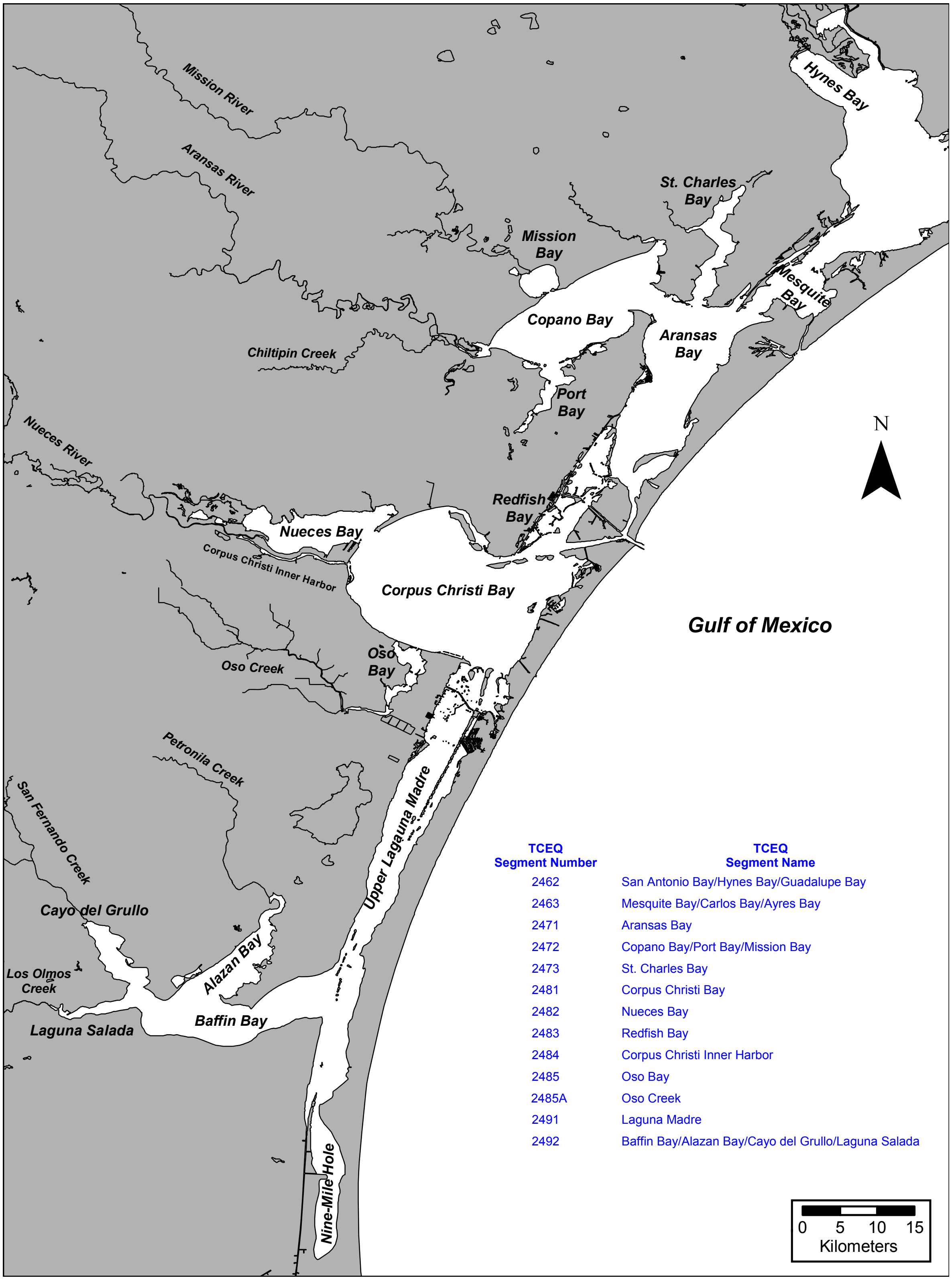

Fig. 2.1. Map depicting CBBEP RCAP sampling area with listing of TCEQ Segment Numbers and Segment Names.

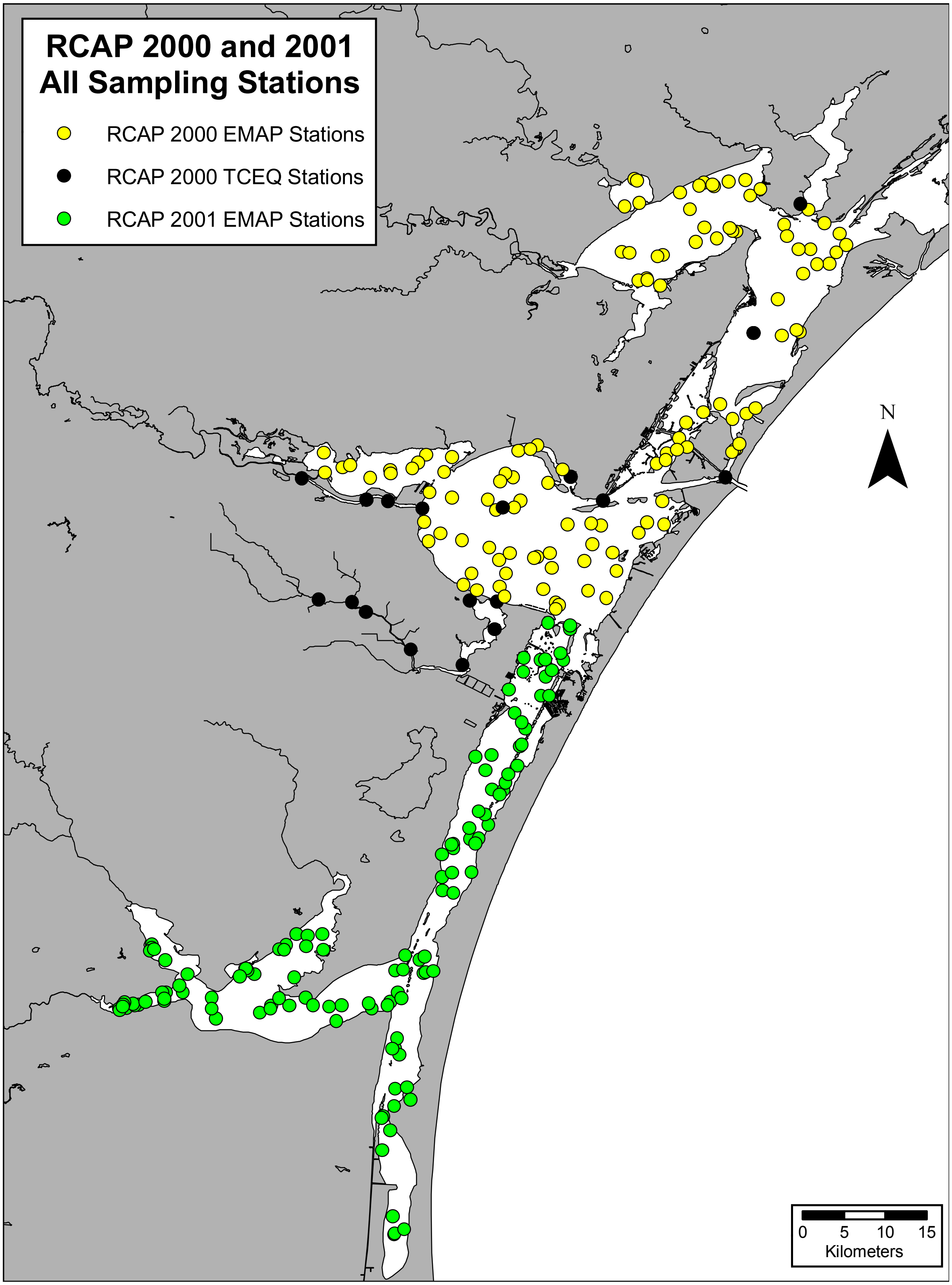

Fig. 2.2. Map of RCAP 2000 and RCAP 2001 EMAP and TCEQ sampling locations.

2.2 Parameters Sampled

Table 2.1 lists all parameters measured for RCAP 2000 and RCAP 2001. 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 analyzed for the Regional Coastal Assessment Program (RCAP) 2000 and 2001.

FIELD PARAMETERS (Water)	Units	Contractor	Program Year
Total Depth	Meters	CCS	2000/2001
Depth Sample Collected	Meters	CCS	2000/2001
Water Temperature	°C	CCS	2000/2001
Dissolved Oxygen	mg/l^{-1}	CCS	2000/2001
Dissolved Oxygen	% Saturation	CCS	2000/2001
Conductivity	μS/cm	CCS	2000/2001
Salinity	PSU	CCS	2000/2001
pH	su	CCS	2000/2001
Turbidity	Visual assessment	CCS	2000/2001
Turbidity	NTU	CCS	2001
Secchi Depth	Meters	CCS	2000/2001
PAR – Terrestrial	$\mu mol\ s^{-1}\ m^{-2}$	CCS	2001
PAR – Flat Cosine	$\mu mol\ s^{-1}\ m^{-2}$	CCS	2001
PAR – Spherical	$\mu mol\ s^{-1}\ m^{-2}$	CCS	2001
Seagrass Percent Cover	%	CCS	2001
Tide Stage	DNR Tide Gauge	CCS	2000/2001
Water Color	Visual assessment	CCS	2000/2001
Water Odor	Olfactory assessment	CCS	2000/2001
Water Surface	Visual assessment	CCS	2000/2001
FIELD PARAMETERS (Weather)	**Units**	**Contractor**	**Program Year**
Air Temperature	°C	CCS	2000/2001
Barometric Pressure	mm/Hg	CCS	2001
Cloud Cover	%	CCS	2000/2001
Dew Point	°C	CCS	2001
Heat Index	°C	CCS	2001
Present Weather	Visual assessment	CCS	2000/2001
Rainfall (Days since last)	Days	CCS	2000/2001
Rainfall (Inches past 1 day)	Inches	CCS	2000/2001
Rainfall (Inches past 7 days)	Inches	CCS	2000/2001
Relative Humidity	%	CCS	2001
Wind Chill	°C	CCS	2001
Wind Direction	Compass Direction	CCS	2000/2001
Wind Speed	MPH	CCS	2000/2001

Table 2.1. (continued) Parameters analyzed for the Regional Coastal Assessment Program (RCAP) 2000 and 2001.

ROUTINE CHEMISTRY (Water)	Units	Contractor	Program Year
Alkalinity (Total)	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Ammonia-Nitrogen	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Nitrate/Nitrite-Nitrogen	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Total Kjeldahl Nitrogen (TKN)	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Chloride	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Sulfate	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Orthophosphate	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Total Phosphorus	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Total Organic Carbon (TOC)	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Total Dissolved Solids (TDS)	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Total Suspended Solids (TSS)	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Volatile Suspended Solids (VSS)	mg/l^{-1}	TCEQ/FUGRO	2000/2001
Chlorophyll *a*	$\mu g/l^{-1}$	TCEQ/CCS	2000/2001
Pheophytin *a*	$\mu g/l^{-1}$	TCEQ/CCS	2000/2001
MICROBIOLOGICAL (Water)	**Units**	**Contractor**	**Program Year**
Enterococci	CFU/100ml	TAMUCC	2001
TRACE METALS (Water)	**Units**	**Contractor**	**Program Year**
Aluminum (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Arsenic (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Cadmium (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Chromium (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Copper (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Lead (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Mercury (Total)	$\mu g/l^{-1}$	ALBION	2000/2001
Nickel (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Selenium (Total)	$\mu g/l^{-1}$	ALBION	2000/2001
Silver (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
Zinc (Dissolved)	$\mu g/l^{-1}$	ALBION	2000/2001
TRACE METALS (Sediment)	**Units**	**Contractor**	**Program Year**
Aluminum	mg/kg dry wt.	FSI	2000/2001
Arsenic	mg/kg dry wt.	FSI	2000/2001
Cadmium	mg/kg dry wt.	FSI	2000/2001
Chromium	mg/kg dry wt.	FSI	2000/2001
Copper	mg/kg dry wt.	FSI	2000/2001
Lead	mg/kg dry wt.	FSI	2000/2001
Mercury	mg/kg dry wt.	FSI	2000/2001
Nickel	mg/kg dry wt.	FSI	2000/2001
Selenium	mg/kg dry wt.	FSI	2000/2001
Silver	mg/kg dry wt.	FSI	2000/2001
Zinc	mg/kg dry wt.	FSI	2000/2001

Table 2.1. (continued) Parameters analyzed for the Regional Coastal Assessment Program (RCAP) 2000 and 2001.

SEDIMENT QUALITY PARAMETERS	Units	Contractor	Program Year
SGS Clay (<0.0039 mm)	%	FSI	2000/2001
SGS Silt (0.0039 to 0.0625 mm)	%	FSI	2000/2001
SGS Sand (0.0625 to 2.0 mm)	%	FSI	2000/2001
SGS Gravel + shell hash (>2.0 mm)	%	FSI	2000/2001
Total Organic Carbon	mg/kg and % dry wt	FSI	2000/2001
BENTHIC SPECIES COMPOSITION	**Units**	**Contractor**	**Program Year**
Density	No./ m^{-2}	CCS	2000/2001
Biomass	mg (dry wt.)	CCS	2000/2001
Taxonomy	Classification	CCS	2000/2001

2.3 Sampling Methods

During RCAP 2000 and 2001, a 3 to 4-person primary CCS field crew conducted sampling from a 19-ft shallow draft bay skiff. Use of this craft facilitated sampling in areas, often encountered on a daily basis, in which water depth typically averaged less than 1 meter; a common occurrence throughout the Coastal Bend. Field activities performed at each site required approximately 1-2 hours per site; therefore, a team sampled 4 to 6 stations 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 samples actually passed to waiting shore personnel for direct transport to the lab during RCAP 2001

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 the 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 TCEQ for the Surface Water Quality Monitoring Program (SWQM) and EMAP-Estuaries over long-term experience with large-scale, regional monitoring projects (e.g., SWQM, 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. *TCEQ Surface Water Quality Monitoring Procedures Manual. 1999.*
5. *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 station 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 station 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 stations 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 TCEQ or EPA, elected to relocate the site within an acceptable range of the original location. The CCS Project Manager, TCEQ, 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 station 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 station 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 station, CCS field crews ascertained that sediments had been disturbed (e.g. shallow depth or other disturbance creating turbid conditions) then adequate time allowed 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 conditions utilizing hand-held multiparameter water quality probes (e.g., Hydrolab Surveyor or YSI Sondes). Water column profiling followed TCEQ protocols as defined in the TCEQ *Surface Water Quality Monitoring Procedures Manual* (1999). Instantaneous surface measurements occurred 0.3 m below the surface and near-bottom condition measurements took place at 0.3 m off the bottom. To obtain undisturbed bottom readings required ascertaining bottom depth, pulling up the probe approximately 0.3 m, and then allowing 2-3 minutes for disturbed conditions to settle before taking the near-bottom measurements.

During RCAP 2001 at least one measurement of light attenuation (Photosynthetically Active Radiation or PAR) occurred, with secchi depth measured at each station during both sampling years. 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. At each discrete interval, the deck reading and underwater readings recorded. 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

CCS field crews collected a full suite of water quality parameters as listed in Table 2.1, collectively referred to by TCEQ as Routine Conventionals. Sample collection, handling, preservation, and transport followed TCEQ protocols (TCEQ 1999). Collection required using three (3) new, 1-liter pre-cleaned polyethylene water bottles (amber colored for Chlorophyll *a*), directly immersed beneath the water surface to a depth of 0.3 m; a depth considered representative of the water mass. Placement of samples on ice and temperature maintenance at 4°C ± 2° ensured sample integrity until delivered to the laboratories for analysis. At all times during sample collection, handling, preservation, and transport CCS field crews exercised care to prevent exposure of samples to direct sunlight for extended periods (>1 minute).

2.3.5. Trace Metals

A significant expense incurred during RCAP 2000 and 2001 monitoring resulted from the adoption and successful implementation of improved sampling and analytical methods that would finally answer the question, “What are the concentrations of heavy metals in the CBBEP region and do we have any significant problems”? The following provides some background information and clarification of this choice of methods (adapted from Albion Environmental SOPs and personnel and written communication with Dr. Paul N. Boothe).

This question is growing in importance because of the increasing emphasis, by both the EPA and many states, on water-quality based permitting including the use of dissolved metal measurements. This emphasis means that in the near future dischargers will have to measure trace metals in their effluents and receiving waters at levels much lower than currently required by existing technology-based effluent limits. In some cases, water quality criteria are as much as 280 times lower than those achievable using existing conventional EPA methods required to support technology-based permits. In addition, accurate low-level metals data are becoming increasingly important in environmental risk assessment studies. The ease of contaminating ambient water, or treated wastewater, samples with the metals of interest and interfering substances cannot be overemphasized. There is consensus that much of the aqueous metals data determined using existing conventional EPA methods is inaccurate (biased high) due to sampling and analytical contamination and other artifacts.

To address this methodological shortfall, EPA developed the 1600 series of new clean chemistry methods to facilitate the implementation of water quality based effluent limits. 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 analytical methods EPA 1631, 1632, and 1638 are not intended for determination of metals at elevated concentrations normally found in treated or untreated discharges from industrial facilities. Existing regulations (40*CFR* Parts 400-500) typically limit concentrations in industrial discharges to the mid to high part-per-billion (ppb) range. The new 1600 series methods designed, measure ambient metals concentrations in receiving waters and treated discharges, which are normally in the low part-per-trillion (pptr) to low ppb range. Actual concentration ranges to which this guidance is applicable will be dependent on the sample matrix, dilution levels, and other laboratory operating conditions.

The ultra-clean mercury method (EPA 1631) was the first new method approved for compliance monitoring under the Clean Water Act. Method 1631 corrects the situation faced by regulated dischargers who had permit limits for mercury in the 1-20 $\mu g/l^{-1}$ (ppb) range and an approved method (e.g. EPA 245) with a detection limit of 200 ppb. Method 1638 is for direct multi-element analysis of freshwater samples (i.e. total dissolved solids, TDS, <2,000 ppm) by inductively-coupled plasma mass spectrometry. Detection limits by this method range from 0.03 ppb for lead to 1 ppb for selenium. Due to uncorrectable interferences from elevated dissolved solid levels in high Total Dissolved Solid (TDS) samples (e.g. seawater, some terrestrial surface waters, some groundwater and some industrial discharges) method 1638 is not useful to analyze these matrices. To address this situation, EPA developed preconcentration techniques (EPA 1640) that remove interfering dissolved solids from samples before analysis. Preconcentration techniques are labor intensive and tedious to perform but are the only analytical approaches that can provide accurate trace element data in elevated TDS aqueous samples.

A consistent and overwhelming conclusion is that below ~ 50-100 $\mu g/l^{-1}$ (ppb), clean metals data are always more accurate and precise than comparable metals data obtained using conventional procedures. The difference ranges from 25-50% to several hundred fold. The difference in accuracy is observable for virtually all dissolved measurements as well as the majority of total recoverable determinations. Without comparable clean data, it is difficult to detect inaccuracies in conventional data. For example, most conventional data observed often passes the limited Quality Assurance (QA) required, but the data are still wrong.

While the cost of obtaining clean metals data is higher than conventional procedures (i.e. typically ~50%). Cost comparison on a per sample basis shows clean chemistry costs are similar, or even cheaper, than conventional methods. For example, clean chemistry procedures require more QA samples to validate sample collection occurred without contamination and to confirm data accuracy. These include both field (bottle blanks, sampler blanks, field blanks, field duplicates) and laboratory (certified reference material, duplicates, matrix spikes, blank spikes, method blanks). The rigorous QA is an important reason why clean metals data are more accurate and readily accepted and defensible to regulators.

Failure to meet QA under old conventional methods necessitates discarding data or completely re-sampling and incurring the costs for a second time; hoping to meet QA once again. The long-term cost of using clean chemistry is usually lower due to savings from reduced monitoring requirements, as the data obtained is accurate the first time around; providing successful fulfillment of all QA requirements occurs. Clean metals data are defensible because of the comprehensive quality assurance (QA) approach employed. This data validation aspect (defensibility) of clean metals data is crucial since clean data are usually always significantly lower than the historical conventional data.

As expected, avoiding contamination during sampling is an important contributor to the enhanced accuracy of clean metals data and all CCS personnel received training from Dr. Paul N. Boothe of Albion Environmental in the appropriate method, using the "clean hands – dirty hands" approach, for collecting trace metals samples. Successful implementation of this approach is paramount in reducing contamination during sampling events, as the primary sources of sample contamination during clean metals sampling comes from airborne particulates and sample contact of contaminated surfaces.

CCS field crews used specialized sampling kits developed by Albion Environmental and a peristaltic pump to obtain grab samples because accurate measurement of trace metals in saline waters requires large sample volumes. 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 sampling event.

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. Additional 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 an Ekman dredge sampler (22.86 cm x 22.86 cm), 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 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 five 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.

2.3.7. Benthic Infaunal Community

Biological sampling procedures and methods had 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 primary method employed by CCS field crews for benthic macroinvertebrate infauna sampling involved using a PVC cylindrical (10.16 cm diameter) push corer with multiple extensions to sample benthic infauna to a depth of 10 cm. A minimum of five (5) replicate samples (81.1 cm^2) taken at each station 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 containing the protein stain Rose Bengal.

Where water depth prohibited using the PVC coring device, CCS field crews employed the following method for collecting marine benthic macroinvertebrates. Using an Ekman dredge (22.86 cm x 22.86 cm), two replicate grab samples collected at each station yielded a total area sampled of 522.6 cm^2. Before dredging, all sediments adhering to the dredge required removal, before lowering the dredge in a controlled descent to penetrate the bottom. CCS field crews then slowly pulled the dredge to the surface, brought it aboard, and emptied the contents into a plastic tub. Each sample was then placed in a 0.5 mm mesh biobag and field washed by gently homogenizing the sample by hand before sample storage on ice for transport to the CCS facilities.

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.

2.4 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 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 for the two sampling years 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 as cited in the 40 CFR 136, Appendix B revision 1.11. Many procedures for various analyses derive from those developed for the EMAP-Estuaries Program, which documents specific analytical processes details. Additional information is contained in Section B4 of the National Coastal Assessment Program QAPP (USEPA 2001). Trace metals analysis followed EPA 1600 (e.g. EPA 1631, 1632, 1638, 1640) series as previously described in Section 2.3.5.

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 in possible TMDL development, permit decisions, water quality assessments, and other programs deemed appropriate. The individual QAPPs for the first two RCAP events are available from CCS upon request.

2.6 Analysis and Data Evaluation Methods (DEMs)

Data analysis utilized various standard parametric and non-parametric tests dependent on meeting test assumptions or the particular analysis required. Data Evaluation Methods, or DEMs, utilized in this report derive from comparisons or evaluations to applicable TCEQ water and sediment quality criteria identifying *Primary Concerns*, or if no criteria exist, then to TCEQ SWQM based screening levels that identify *Secondary Concerns* (e.g. Tidal Water Criteria for Toxic Substance in Water vs. Nutrients and Chlorophyll *a* Screening Levels). More details concerning these approaches, and the particular DEMs utilized, are available within the individual chapters of this document.

2.7 References

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3.0 WATER MONITORING RESULTS

3.1 Introduction

Coastal regions are extremely productive systems and conversely highly vulnerable to human impacts (Mann 2000). As a significant component of the coastal watershed, estuaries are vital natural and economic resources, with coastal economies often dependent on having pristine estuarine conditions. Typically, estuaries serve as nursery grounds for two-thirds of the nation's commercial fish and shellfish and provide recreational activities such as boating, swimming, fishing, windsurfing, and support one of the fastest growing global ecotourism businesses; bird watching. As population expansion continues, increased demands on our natural resources can have deleterious effects on the estuary and directly affect the livelihood of the people living and working in coastal areas (EPA 1998).

Many factors affect estuarine system health (i.e., reduced freshwater inflow, habitat modification/destruction, climate change) but the fundamental health of an estuarine system depends on the type and quantity of pollutants that may be entering the water column. Historical degradation of the marine environment includes such point source inputs as; direct industrial pipeline discharges, thermal power plant discharges, and wastewater treatment discharges. Nonpoint sources include; urban and agricultural runoff, leaky septic systems, and improperly disposed waste material (medical, boat/marina, pets). Collectively these sources are the most recognizable transport mechanisms that often produce inputs of harmful toxic chemicals, nutrients, pesticides, and pathogens (Kennish 1992; Bricker et al. 1999; Mann 2000). Marine debris is another widespread pollution problem threatening estuarine/coastal systems, with material entering estuaries from storm sewers and other sources (EPA 1998).

Estuaries are vulnerable to the inputs of various substances. Some of those substances such as heavy metals, excessive nutrients, and disease causing microorganisms, or pathogens, (viruses, bacteria, and parasites) can adversely affect estuarine systems. Elevated concentrations 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.

Support of basic life processes requires trace amounts of many heavy metals. However, in higher concentrations they are toxic to aquatic organisms and historically been responsible for creating widespread problems within a many coastal and estuarine systems (Kennish 1992). Significant portions of these metals directly relate to domestic and industrial discharges. Excluding anthropogenic inputs, 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 successfully remediated 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 for the CBBEP region documented potential problems, monitoring for heavy metals became an essential part of the RCAP monitoring effort.

Excessive nutrients may result in accelerated eutrophication. Eutrophication results from increased rates of supply of organic matter entering an ecosystem. While organic matter is beneficial to an extent, to supply diverse food webs with materials needed to support commercial and recreational fisheries, excessive amounts often produce undesirable effects (Rabalais 1992; Bricker et al. 1999; CENR 2003). Bricker et al. (1999), in the *National Estuarine Eutrophication Assessment* conducted by NOAA, stated that nitrogen is the driving force behind estuarine eutrophication and that of 44 estuaries surveyed having significantly high eutrophic conditions, nonpoint sources of nitrogen accounted for >75% of total nitrogen inputs. Agriculture accounted for >50% of nonpoint inputs to 17 of these 44 estuaries while urban sources accounted for >50% for seven estuaries. Expressions of eutrophic conditions, as listed by Bricker et al. (1999) are Primary Symptoms: *High Chlorophyll a levels*, *Increases in Epiphytic Algae*, and *Macroalgae Blooms*. Secondary Symptoms classify as *Low Dissolved Oxygen*, *Loss of Submerged Aquatic Vegetation*, and *Harmful Algal Blooms*. The Gulf of Mexico, and more specifically the Texas Gulf coast, appear as identifiable areas with moderate to high expression levels.

One secondary symptom is that of Harmful Algal Blooms (HABs). When HABs occur, they may result in the prevention of sunlight from penetrating the water, thereby depriving seagrass beds the light needed for survival. HABs also may produce extensive fish kills and noxious conditions harmful to human respiratory systems. As seagrass die off accelerates, food and shelter once provided to animals living within the seagrass beds disappears, and the organisms leave or die. As these organism die, and alga decays, the water column suffers declines in the most essential aquatic life constituent necessary for survival, oxygen. As more organisms die, the process accelerates and may lead to eventual system collapse.

However, symptoms may sometimes relate to natural causes that give expressions of these symptoms. A case in point would be the persistent Texas brown tide organism (*Aureoumbra lagunensis*), which lasted for nearly ten years in areas of the Upper Laguna Madre since first appearing in December of 1989. Following a severe freeze, that induced massive fish kills, the excessive nutrients provided by decaying organisms, when combined with increased salinities and low flushing rates due to drought, allowed the organism to dominate the ecosystem (Buskey et al. 1998, 2001).

While the *National Estuarine Eutrophication Assessment* was a comprehensive status report, the ability to predict definitive trends for all estuaries remains hampered by scarce trend data and large gaps in data and information. Bricker et al. 1999 and CENR 2003, point out that in some cases high chlorophyll *a* concentrations may be natural and that we lack complete knowledge for all but the most widely study estuarine systems. Our knowledge base concerning all the factors influencing an estuary and a particular estuary's susceptibility to eutrophication are limited. Recommendations by all groups involved with this assessment called for comprehensive monitoring, interpretation, modeling, and research for maximum effectiveness in assembling an adaptive management framework that would aid in protecting our watershed and estuarine systems (Bricker et al. 1999; CENR 2003).

Therefore, the productivity of our estuary and the protection of critical habitat for wildlife and humans alike, along with aesthetic appeal of bays in the Coastal Bend, are dependent on our continued maintenance and future enhancement of water quality within the CBBEP region. Protection of our natural aquatic resources is paramount if we wish to have a healthy and vital estuarine ecosystem (CBBEP 1998). As previously stated in Chapter 1, the expansive area of CBBEP region historically lacked consistent monitoring of a broad range of parameters and that sufficient monitoring needed to take place over much of the system to begin to produce an accurate characterization of the CBBEP area. The development of the RCAP is the first step in correcting this shortcoming and supplying the necessary data to achieve the ultimate goal of protecting and enhancing the diverse estuarine systems found within the Coastal Bend.

3.2 Sampling Design and Data Evaluation

Sampling for RCAP 2000 began late April 2000 and concluded May of 2001 (four major events) for field parameters, routine water chemistry, and trace metals in water at 176 stations. Table 6.1.1 through 6.1.4 in the *Data Tables* chapter and Figs. 3.1 through 3.4 provide station information. Sampling for RCAP 2001 ran from summer (late July, August, and early September) 2001 through May 2002 (four major events) for field parameters, routine water chemistry, microbiological, and trace metals at 124 stations. Table 6.1.5 through 6.1.8 in the *Data Tables* chapter and Fig. 3.5 provide station information. Sampling extending over the three-month period in summer 2001 resulted from weather related disruptions in the sampling program. However, as this period fell within the critical index period, as defined by TCEQ, of July 15th through September 15th we feel the extended event highly reflects typical summer conditions within the CBBEP region.

3.2.1. Water Quality Criteria and Screening Levels

TCEQ uses many physical, chemical, and biological characteristics in assessing support of designated uses and criteria of a water body (Segment). Primarily, comparison of individual parameter values to either numerical criteria or screening levels determines the number of values exceeded. Based on number of exceedances, the assessment classifies a segment as either being in full support, partial support, or not supportive of the 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 that have elevated concentrations exceeding screening levels. 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 the dissolved oxygen criteria 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 (EPA 2003). Individual criteria and screening levels for the various parameters sampled for RCAP 2000 and 2001 appear in the following applicable sections.

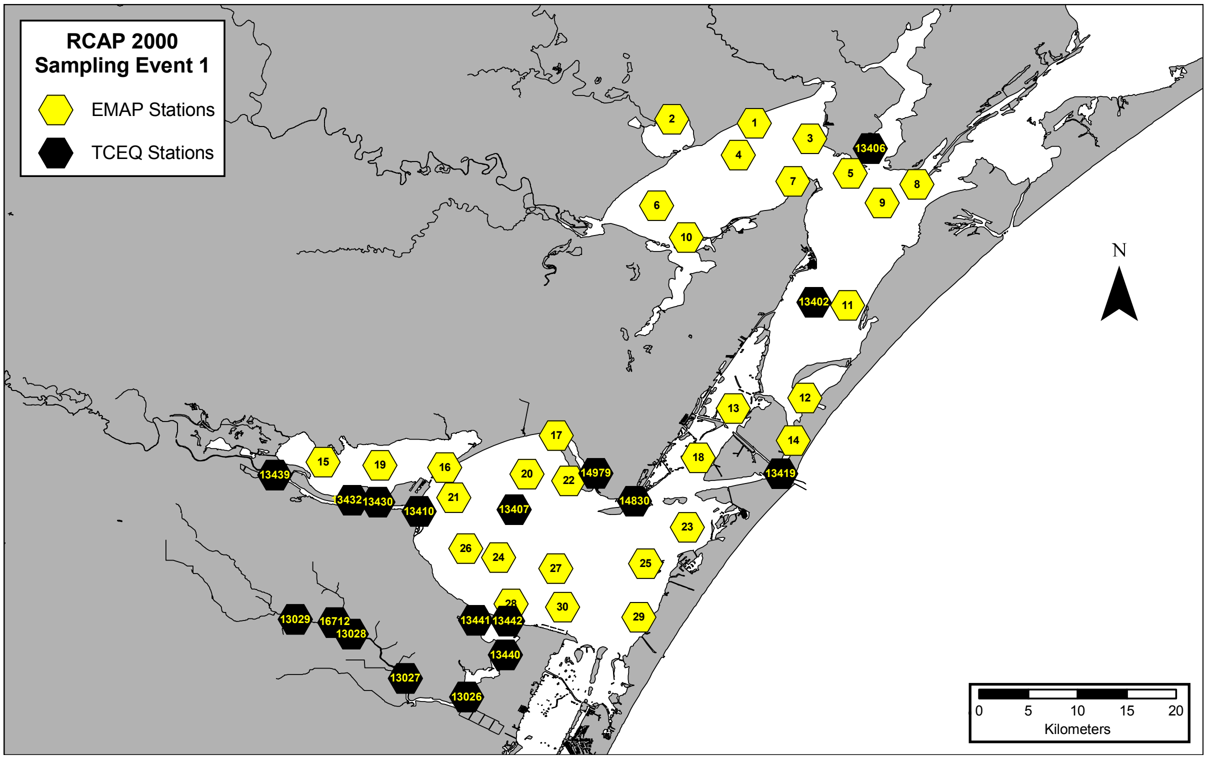

Fig. 3.1. Map of RCAP 2000 sampling stations depicting 48 stations sampled during Event 1 (Spring 2000).

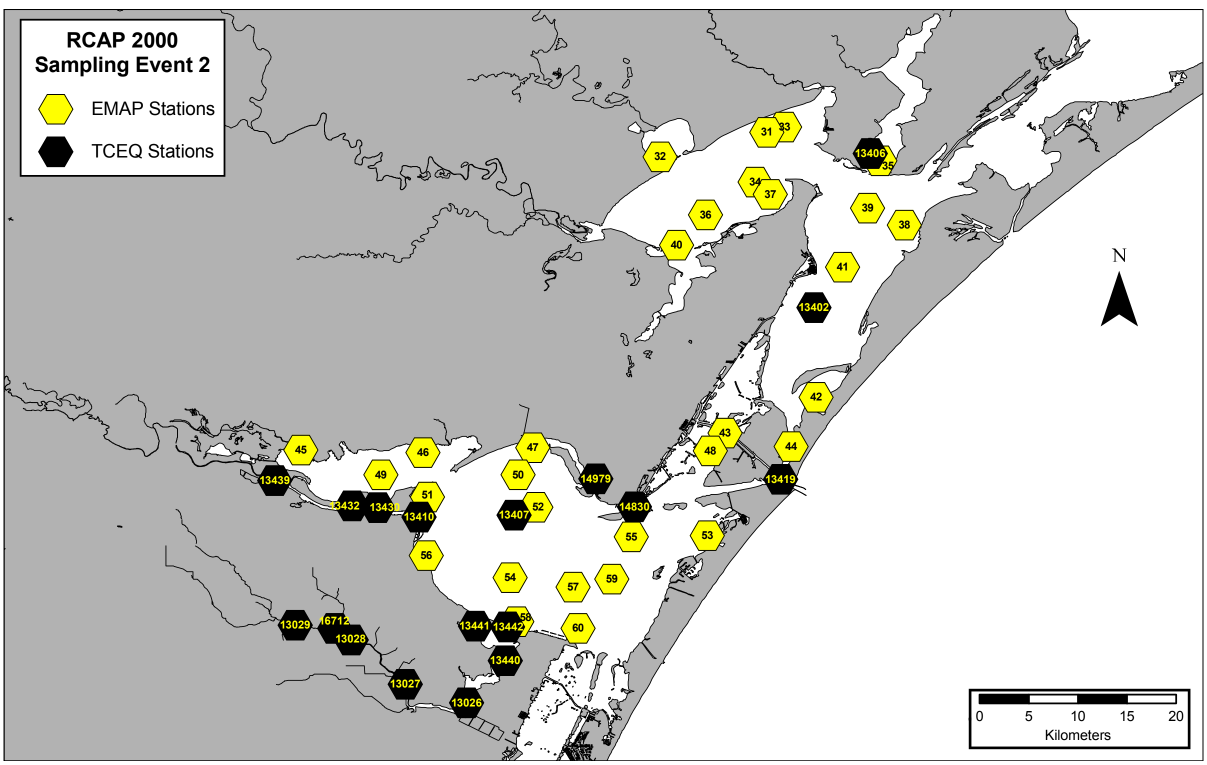

Fig. 3.2. Map of RCAP 2000 sampling stations depicting 48 stations sampled during Sampling Event 2 (Summer 2000).

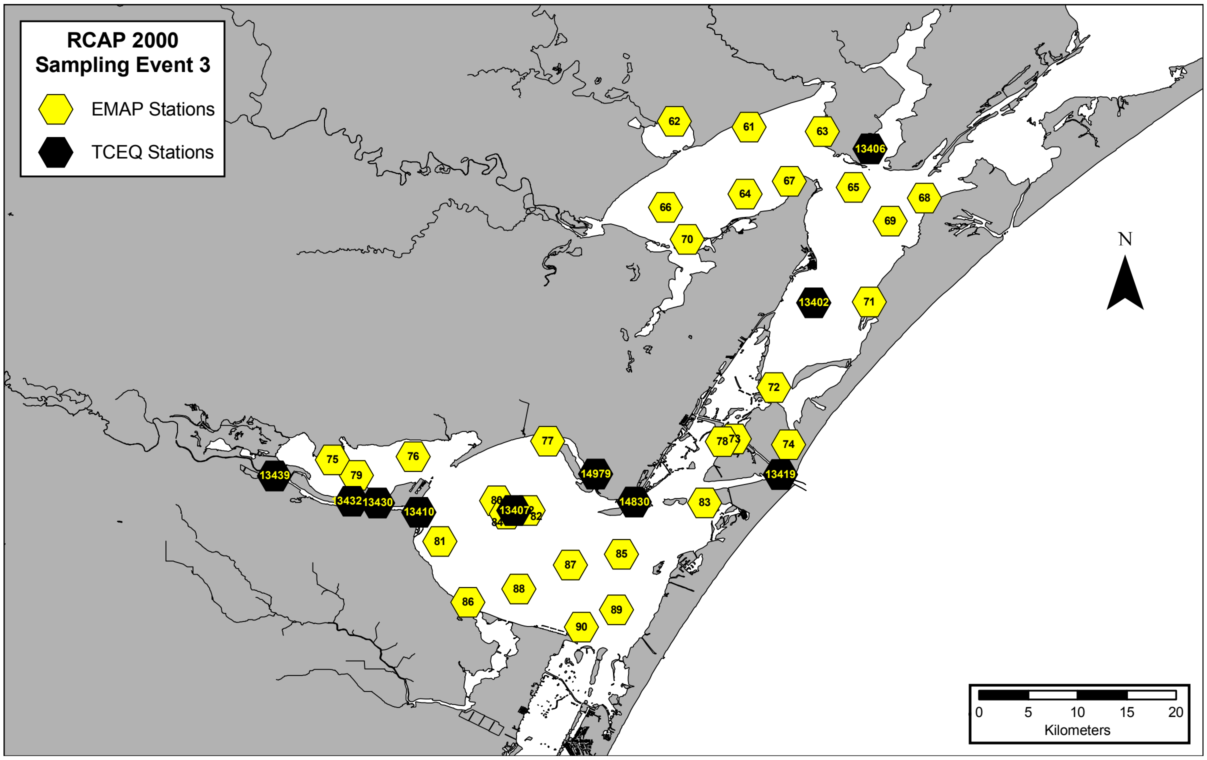

Fig. 3.3. Map of RCAP 2000 sampling stations depicting 40 stations sampled during Sampling Event 3 (Fall 2000).

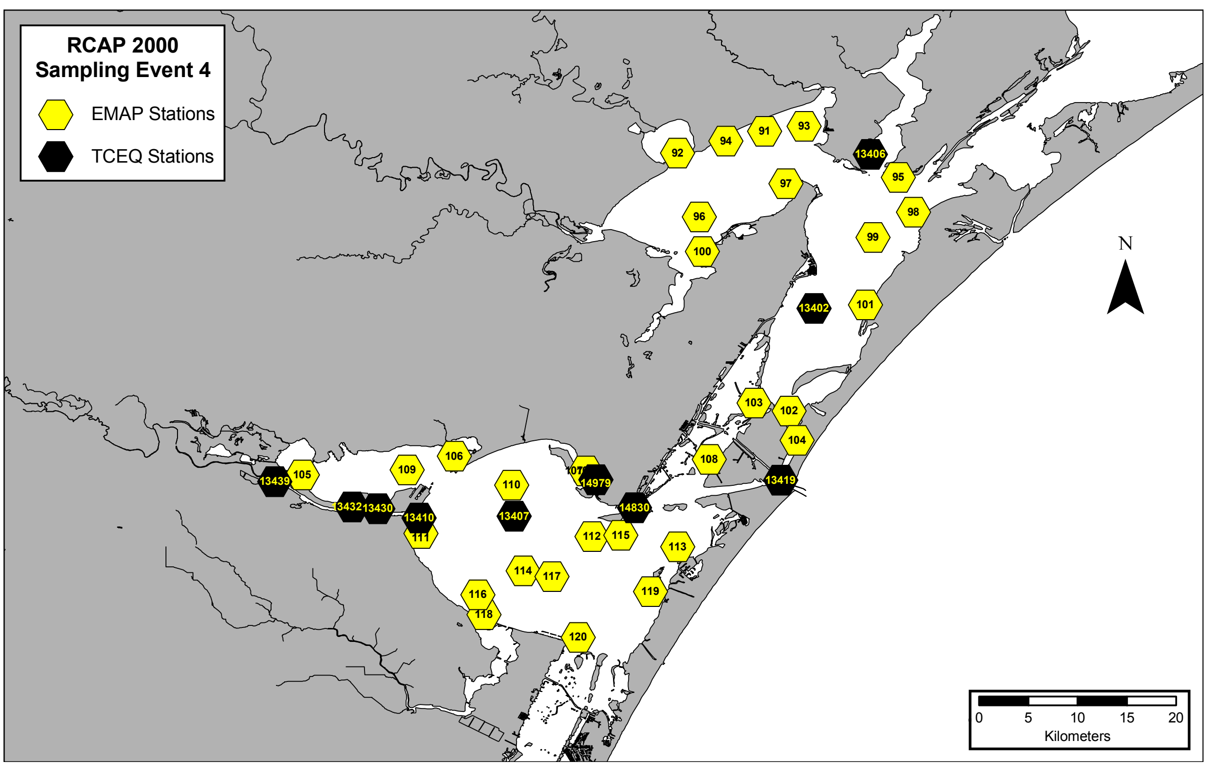

Fig. 3.4. Map of RCAP 2000 sampling stations depicting 40 stations sampled during Sampling Event 4 (Winter 2001).

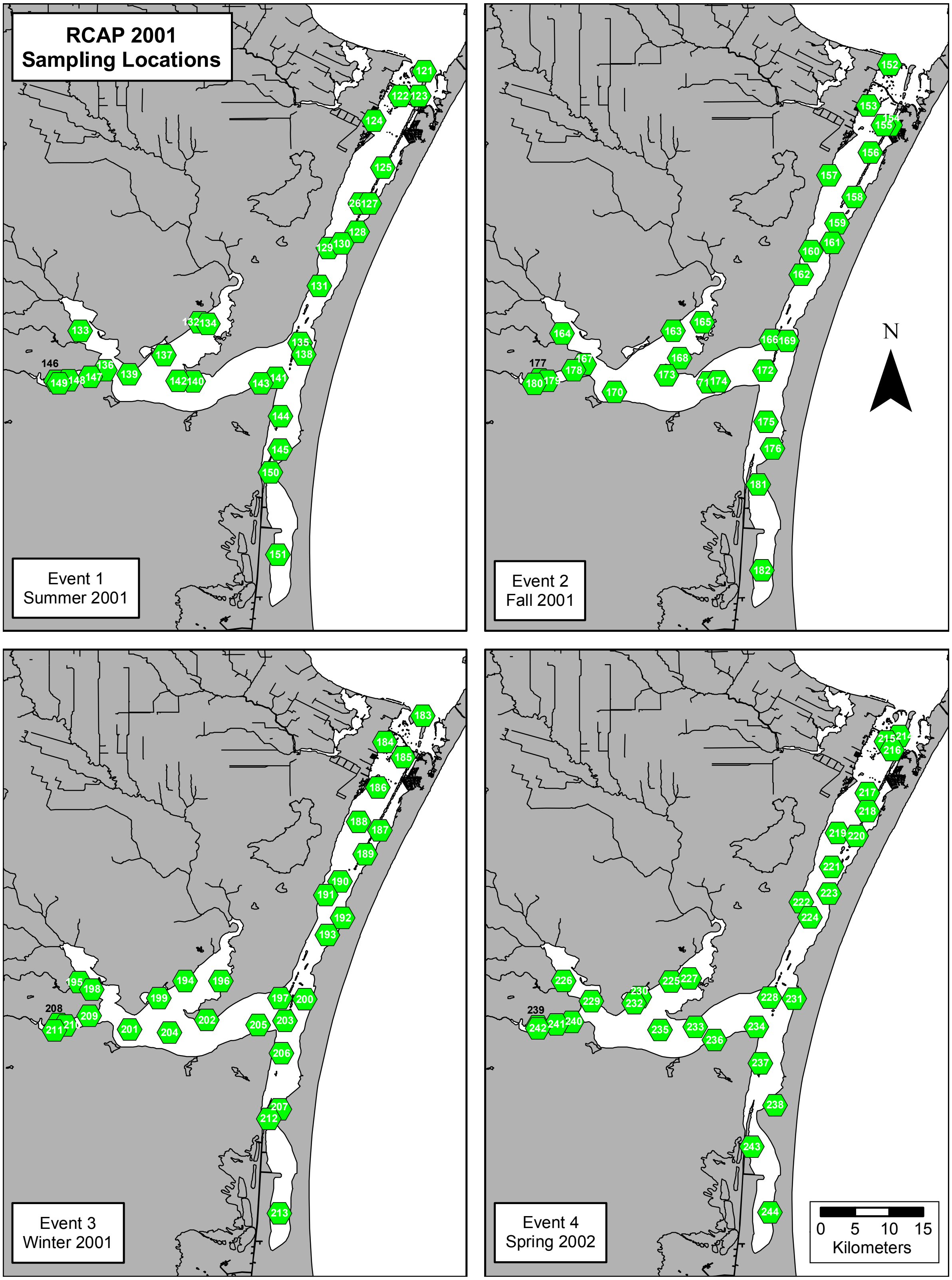

Fig. 3.5. Map of RCAP 2001 sampling stations depicting 124 stations (31 stations sampled each event).

3.2.2. Data Evaluation Methods (DEM)

A complete list of parameters measured during the RCAP 2000 and 2001 sampling events are contained in Table 2.2 in Chapter 2, *Sampling Design and Approach*. *Data Tables* in Chapter 6.0 provide individual concentration values and summary statistics for each parameter recorded at an individual station, or for individual segments, respectively. We analyzed and evaluated the data by TCEQ Segments and present summary descriptive results for minimum, maximum, and mean values for Field Parameters, Routine Conventional Water Chemistry Parameters, Microbiological Parameters (RCAP 2001 only), and Trace Metals in Water Parameters.

We would like to stress that the use of “high” or “elevated” concentrations within the Trace Metals in Water results section (Section 3.3.4) pertains to the relationships between stations sampled than to concentrations found above a certain detrimental level, as most trace metal concentrations within the water column sampled during RCAP 2000 and RCAP 2001 were extremely low.

We used two Data Evaluation Methods (DEM 1 and 2) to assess concentrations of the above listed parameters sampled for RCAP 2000 and 2001. If a criterion or screening level exists, then DEM 1 followed regulatory procedures used by TCEQ and evaluated concentrations by the stated criteria or applicable screening levels. 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.

DEM 2 utilized PRIMER v5.0 (Plymouth Routines in Multivariate Ecological Research) software program developed by Clark and Warwick (2001) for analysis of data using multivariate non-metric Multidimensional Scaling (MDS). Building on similarity (Normalized Euclidean Distance) matrix rankings of metal species and concentrations, procedures compute spatial coordinates for a set of points (i.e. concentrations) where distances between pairs of points fit as closely as possible to the measured similarity between a corresponding set of objects (i.e. Stations) (Tolan and Newstead 2004). This identifies station groupings based on similar concentrations, with the MDS plot providing a graphical representation of those groupings.

3.3 Results and Discussion

3.3.1. Field Data

A complete list of instantaneous core field parameters, along with summary statistics, collected for RCAP 2000 and RCAP 2001 appears in Chapter 6-*Data Tables* 6.2.1 through 6.2.8 and 6.3.1 through 6.3.12, respectively. For many of the parameters no established state or federal criteria exist. They nonetheless serve as initial descriptors of a water body, or segment, and aid as indicators of healthy water quality, when making determinations of whether unusual or stressful conditions exist. As standard protocol for most monitoring programs, collection of multi-year datasets will allow for future status and trends predictions and may be useful in ascertaining changing conditions within the CBBEP region.

3.3.1.1. Total Depth

Total Depth for RCAP 2000 ranged from 0.30 m within many segments, typically at randomly selected stations along shorelines, to 15.61 m in the Corpus Christi Ship Channel. Mean Total Depth was deepest in the Corpus Christi Inner Harbor (Segment 2484) and shallowest in St. Charles Bay (Segment 2473), Oso Bay (Segment 2485), and Nueces Bay (Segment-2482) (Tables 6.2.1 through 6.2.4 and 6.3.7). Mean Total Depth as reported in Table 6.3.7 is high (approximately 6.0 m) for Corpus Christi Bay (Segment 2481), as several stations fell within the Corpus Christi Ship Channel. Discounting these stations gives a more typical depth of 3.5 to 4.0 m for stations sampled within this segment.

RCAP 2001 Total Depth ranged from 0.26 m to 2.77 m; both stations located in the Upper Laguna Madre (Segment 2491). Typically, mean Total Depth recorded was highest in Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) with a mean Total Depth of approximately 1.5 m as opposed to 1.0 m in the Upper Laguna Madre (Segment 2491) (Tables 6.2.5 through 6.2.8 and 6.3.13). Generally, mean Total Depth for all segments in RCAP 2000 and RCAP 2001 were indicative of the particular segment, as random selection of stations allowed for equal chances of sampling relatively deep and shallow locations.

3.3.1.2. Water Temperature

Collection of surface water temperature data relates to how this parameter may affect other water quality indicators, such as dissolved oxygen; collected as part of the RCAP. Water temperature during RCAP 2000 ranged from 15.95°C in Copano Bay/Port Bay/Mission Bay (Segment 2472) during Event 4 (Winter 2001) to 33.24°C in Oso Bay (Segment 2485) during Event 2 (Summer 2000). Mean water temperature for RCAP 2000 tended to be higher in the shallower segments such as St. Charles Bay (Segment 2473), Oso Bay (Segment 2485), and Nueces Bay (Segment-2482) and temperatures recorded exhibited typical seasonal variations seen in the CBBEP region (Tables 6.2.1 through 6.2.4 and 6.3.8).

RCAP 2001 water temperature readings followed expected variations and ranged from 13.02°C during sampling Event 3 (Winter 2002) to 32.33°C during sampling Event 1 (Summer 2001). Mean water temperature remained relatively consistent between all three segments, with mean water temperatures usually slightly higher in the Upper Laguna Madre (Segment 2491) (Tables 6.2.5 through 6.2.8 and 6.3.11).

3.3.1.3. pH

Another indicator of possible stressful estuarine conditions is pH. Based on a logarithmic scale, significant stress may result from small changes in pH values. Extremely low or high pH values are often indicative of possible pollutants to the water body (Van Dolah et al. 2002). Typically, the pH of estuarine and coastal waters ranges from 7.5 to 8.5 with occasional deviations above 9.0 or below 7.0.

pH values for RCAP 2000 ranged from 7.45 to a high of 8.75 at Station 13441 located near the Oso Wastewater Treatment Plant in Oso Bay (Segment 2485). A high value of 8.75 also occurred during sampling Event 2 (Summer 2000) at Station 13027 in Oso Creek (Segment 2485A) (Tables 6.2.1 through 6.2.4 and 6.3.5). Mean pH values remained consistent for all segments sampled in RCAP 2000 (Table 6.3.5). For RCAP 2001 pH values ranged from 8.10

to 9.01 at stations located within the Upper Laguna Madre (Segment 2491) and mean pH values for most sampling events, while relatively consistent between segments, tended to be higher in the Upper Laguna Madre and higher than most segments sampled for RCAP 2000 (Table 6.2.5 through 6.2.8 and 6.3.11).

3.3.1.4. Secchi Depth

TCEQ uses secchi depth data as a visual way to measure eutrophication in lakes, reservoirs, and surrounding watersheds (TCEQ 2003). While commonly used in these waters as a qualitative measure, along with other quantitative measurements such as Chlorophyll *a* and Total Phosphorus concentrations, for the evaluation of eutrophic states and subsequent classification to a trophic state index, TCEQ does not use it for this purpose in estuarine systems. However, it still provides a historically used 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 2000 tended to validate this fact. Secchi Depth ranged from 0.10 m in Oso Bay (Segment 2485) to 4.5 m in Corpus Christi Bay (Segment 2481). This unusually deep reading for Corpus Christi Bay was observed at Station 13419, located in the Corpus Christi Ship Channel near Aransas Pass, and reflected the movement into the system of a large mass of cooler, clear, open gulf waters during sampling Event 4 (March 2001). Typically, Secchi Depth for Corpus Christ Bay averaged around 1.2 m during RCAP 2000 (Tables 6.2.1 through 6.2.4 and 6.3.6). Mean Secchi Depth for most segments tended to average <1.0 m with Nueces Bay (Segment 2482), Oso Bay (Segment 2485), and Oso Creek (Segment 2485A) being the most turbid; average yearly Secchi Depth reading of <0.40 m.

For RCAP 2001 mean Secchi Depth readings ranged from 0.30 m to 1.35 m. The limited number of stations in the Corpus Christi Bay (Segment 2481), located above the J.F.K. Causeway, tended to have higher Secchi Depth readings than either the Upper Laguna Madre (Segment 2491) or the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492). Mean Secchi Depth for these two segments tended to average around 0.60 m in the Upper Laguna Madre to 0.50 m in the Baffin Bay Complex (Table 6.2.5 through 6.2.8 and 6.3.12).

However, one often overlooked drawback to this method is that when using Secchi Depth as an indicator of water clarity in shallow locations (e.g. Upper Laguna Madre); a Secchi Depth reading of >0.30 m, >0.4, or >1.30 m (actual RCAP 2001 values) represents the secchi disk sitting on the bottom. Actual water clarity conditions may then be significantly higher but are unquantifiable using this method. In actuality, RCAP 2001 saw > a certain Secchi Depth for 53.8% of the Upper Laguna Madre readings, as opposed to representing only 9.3% of the readings for the Baffin Bay Complex (Tables 6.2.5 through 6.2.8) signifying that water clarity may be considerably better than Secchi Depth numbers alone reveal.

3.3.1.5. Salinity

Salinity concentrations typically are quite high within the CBBEP region due to natural semi-arid conditions, reduction of freshwater inflows on the Nueces River due to reservoir impoundments, and the unique hypersaline Laguna Madre, which comprises the southern half of the CBBEP region (Jones 1975; Tunnel 2002). While justly used as a measure of habitat stress in estuarine systems, because of salinities influence on species distribution and diversity, careful interpretation of salinity values for the CBBEP region is often necessary.

Many species found within the region are clearly adapted to the short-term stressful conditions of hypersaline waters, and are able to accommodate wide salinity fluctuations that occur when significant amounts of freshwater inputs flow into the system. However, recent studies do indicate that restrictions in freshwater inflows, coupled with natural climactic conditions, may be affecting biotic conditions, especially in the area of the Nueces Delta (Montagna et al. 2002, Palmer et al. 2002). While the City of Corpus Christi is currently involved in projects to augment natural freshwater inflows, through beneficial reuse of wastewater diverted to the Nueces Delta, under typical conditions the Nueces Delta classifies as a reverse estuary, with salinity concentrations often higher in the Nueces Delta and Nueces Bay than in Corpus Christi Bay and the Gulf of Mexico.

As no current restrictions exist on the Aransas and Mission Rivers, such as the dams and reservoirs existing on the Nueces River (a small dam once existed on the lower reach of the Aransas River), salinity concentrations typically are lower in the Copano Bay/Port Bay/ Mission Bay (Segment 2472). Increasing salinity concentrations typical of a positive estuary is the normal condition as you proceed down Aransas Bay (Segment 2471) and approach the gulf pass at Port Aransas, just east of Redfish Bay (Segment 2483). From there as one proceeds westward through Corpus Christi Bay (Segment 2481) salinities may increase to values >36.0 PSU, indicative of open Gulf of Mexico waters, and often culminate in hypersaline (>40.0 PSU) conditions in the Nueces Delta (Fig. 3.6; Tables 6.2.1 through 6.2.4 and 6.3.2). Higher salinities often recorded in Oso Bay (Segment 2485), and which feed into Corpus Christi Bay, are directly related to the influence of the AEP-CP&L Barney Davis Power Plant which uses hypersaline waters of the Upper Laguna Madre (Segment 2491) in a once pass-through cooling process discharged at the head of Oso Bay.

For RCAP 2000, sampling events recorded the typical variability in salinity seen throughout the CBBEP region. Salinity values ranged from 1.93 PSU on Oso Creek (Segment 2485A), for the two events sampling occurred, and from 8.16 PSU in Copano Bay/Port Bay/ Mission Bay (Segment 2472) to a high of 52.15 PSU in Oso Bay (Segment 2485) and 42.20 PSU in Corpus Christi Bay (Segment 2481). Lower mean salinities seen in Event 1 (Spring 2000) rose to higher levels in sampling Event 2 (Summer 2000) with some segments declining slightly in Event 3 (Fall 2000) and further declines recorded in Event 4 (Winter 2001). Mean salinity values tended to be highest in Corpus Christi and Nueces Bays and lowest in the northern bays as described above (Fig. 3.6; Tables 6.2.1 through 6.2.5 and 6.3.)

For RCAP 2001, sampling events captured the influence of increased freshwater inputs from precipitation into the system. Salinity concentrations ranged from 59.04 PSU during sampling Event 1 (Summer 2001) to 22.36 PSU in Event 2 (Fall 2001) at stations located in the Laguna Salada in the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) (Fig. 3.7; Tables 6.2.5 through 6.2.8 and 6.3.9). During sampling Event 3 (Winter 2002), salinity values increased slightly in Segment 2492 but continued to decline in the Upper Laguna Madre (Segment 2491) from approximately Bird Island Basin to the entrance to Corpus Christi Bay. Lack of sustained freshwater inputs then saw salinity concentrations rise back up to hypersaline conditions in Event 4 (Spring 2002). Mean salinity concentrations tended to be higher in Segment 2492 and in particular, the western most reaches of the Baffin Bay complex in the Laguna Salada and Cayo del Grullo.

3.3.1.6. Dissolved Oxygen

Dissolved oxygen (DO) represents the most essential water quality parameter that TCEQ utilizes in assessing the aquatic life use and thereby the health of the water body, or segment. Each TCEQ classified, tidally-influenced, segment receives an Aquatic Life Use (ALU) based on physical, chemical, and biological characteristics of the segment; *exceptional, high,* or *intermediate use,* with DO criteria based on meeting 24-hour average concentrations of 5.0, 4.0, and 3.0 mg/l^{-1}, respectively. In addition, the absolute minimum criteria to protect the range of ALUs in tidal waters are 1.0 mg/l^{-1} less for all categories (TCEQ 2003). All segments monitored during RCAP 2000 and RCAP 2001 carry a 24-hour DO criterion of 5.0 mg/l^{-1} for *exceptional* habitat, except for Baffin Bay (Segment 2492) and the four stations (13029, 16712, 13028, and 13027) located on the unclassified portion of Oso Creek (Segment 2485A), which carry a 4.0 mg/l^{-1} classification for *high* habitat. In addition, the Corpus Christi Inner Harbor (Segment 2484) carries an *intermediate* use classification and a 3.0 mg/l^{-1} criterion.

As RCAP 2000 and RCAP 2001 only collected instantaneous grab sample DO readings, it does not warrant using the 24-hour criterion to evaluate conditions within the segments. However, DO sampling to meet compliance of the designated ALUs described, routinely targets segments where low instantaneous DO concentrations indicate partial or nonsupport of the designated ALU. In this case, DO data collected serves as a valuable tool for the CBBEP and the TCEQ to assess if conditions perhaps warrant further monitoring.

During RCAP 2000, we recorded no instances of hypoxia (<2.0 mg/l^{-1}) for all stations sampled (Fig. 3.8; Tables 6.2.1 through 6.2.4 and 6.3.3). While a small amount of DO concentrations fell in the "biologically stressful" range of >2.0 mg/l^{-1} but <5.0 mg/l^{-1}, these were stations sampled in the summer and in the early morning; concentrations tended to be >4.0 mg/l^{-1} at those stations. Therefore, we evaluate overall DO quality for RCAP 2000 as very good throughout the CBBEP region sampled.

For RCAP 2000, DO concentrations ranged from 3.31 mg/l^{-1} at Station 13440 in Oso Bay (Segment 2485) to 13.42 mg/l^{-1} at Station 13441, also located in Oso Bay adjacent to the Oso Wastewater Treatment Plant (Fig. 3.8; Tables 6.2.1 through 6.2.4). Since sampling only occurred for two Events at these locations, if we discount these stations DO shows a range of 4.72 mg/l^{-1} for Station 59 (Event 2, Summer 2000) in Corpus Christi Bay (Segment 2481) to 12.87 mg/l^{-1} for Station 98 (Event 4, Winter 2001) in Aransas Bay (Segment 2471). For stations sampled for all four Events, mean DO levels in all segments exceeded the 5.0 mg/l^{-1} criterion (Table 6.3.3). For the entire year, only 7 out of 176 stations sampled, or 4.0%, fell below respective criterion. Six of the lower readings occurred during Event 2 (Summer 2000) falling between 4.0 and 5.0 mg/l^{-1}; values typically expected during this season.

For RCAP 2001 we recorded only one instance of hypoxia (1.65 mg/l^{-1}) at one station (Station 236) sampled during Event 4 (Spring 2002). This station is located in Baffin Bay (Segment 2492) along the southern shoreline in an area of extensive seagrass beds. With a Total Depth at station of 0.61 m and the value recorded at 0845 hours, the low DO concentration was not surprising (Fig. 3.9; Tables 6.2.5 through 6.2.8 and 6.3.10). During RCAP 2001 DO ranged to a high of 11.72 mg/l^{-1} recorded during Event 3 (Winter 2002) in Baffin Bay (Segment 2492). Except for two stations in Corpus Christi Bay (Segment 2481) sampled during Event 1 (Summer 2001), mean DO concentrations recorded were >5.0 mg/l^{-1} (Fig. 3.9; Tables 6.2.5 through 6.2.8 and 6.3.10). As was seen in RCAP 2000, we evaluate overall DO quality for RCAP 2001 as very good throughout the southern area of the CBBEP region.

Over the course of the sampling year, Event 1 (Summer 2001) saw eight (2 in Corpus Christi Bay-Segment 2481) and 6 in Upper Laguna Madre (Segment 2491) DO readings that fell below the 5.0 mg/l^{-1} criteria. Typically, these readings took place at early morning, and/or in shallow depths, and often over seagrass beds. These conditions, and the fact that it was summer, indicate a possible worst-case scenario when DO concentrations are typically low. The remainder of the year saw only three more occurrences (DO concentrations >4.0 mg/l^{-1}) in the Upper Laguna Madre and the one previously mentioned hypoxic reading in Baffin Bay, all of which occurred in Event 4 (Spring 2002) under the same situations as previously described; early morning, shallow depth, and over seagrass beds (Fig. 3.9).

The shallow nature of our bays often plays a large part in naturally occurring and wide diurnal DO fluctuations recorded. Warmer temperatures, higher salinities, and increased biological activity through the breakdown of organic matter, from natural and point and non-point sources, all contribute to possible DO depletion. High emphasis remains on the fact that relatively shallow, warm water, high salinity bays, typical of the South Texas region, exert a strong influence on DO, and that collectively all these factors may produce water quality conditions that can lead to depressed DO levels (Nicolau et al. 2001).

The exceptional habitat designation for a great number of our bays is justifiable, but it is clear that natural conditions may play a critical part when low DO levels occur. These are often natural fluctuations within the water body segments of the region and the possibility exists that the DO criteria for exceptional habitat may not always be attainable within all parts of the CBBEP region based on the present fixed numerical values (Nicolau et al. 2001).

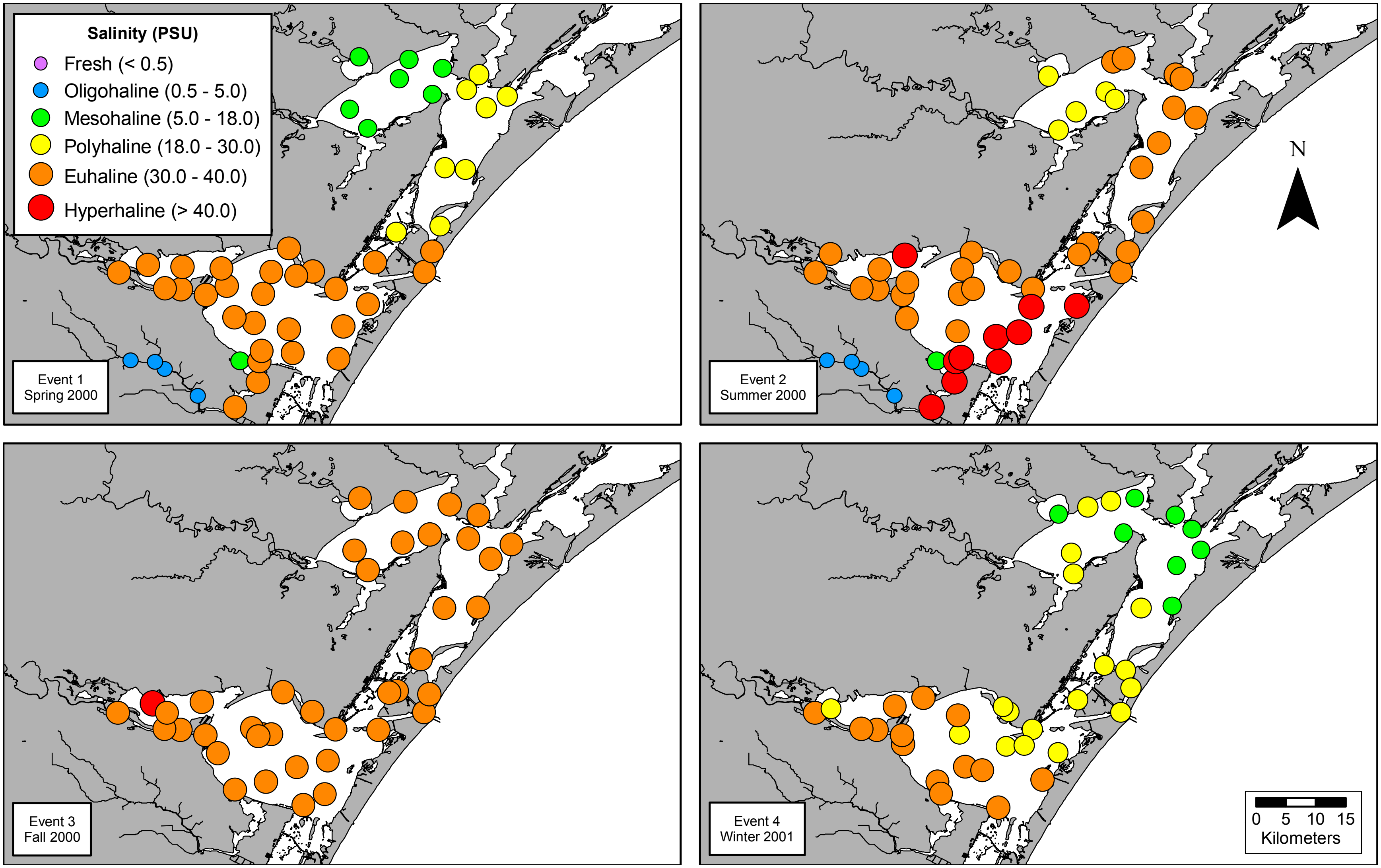

Fig. 3.6. Salinity concentrations (PSU) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

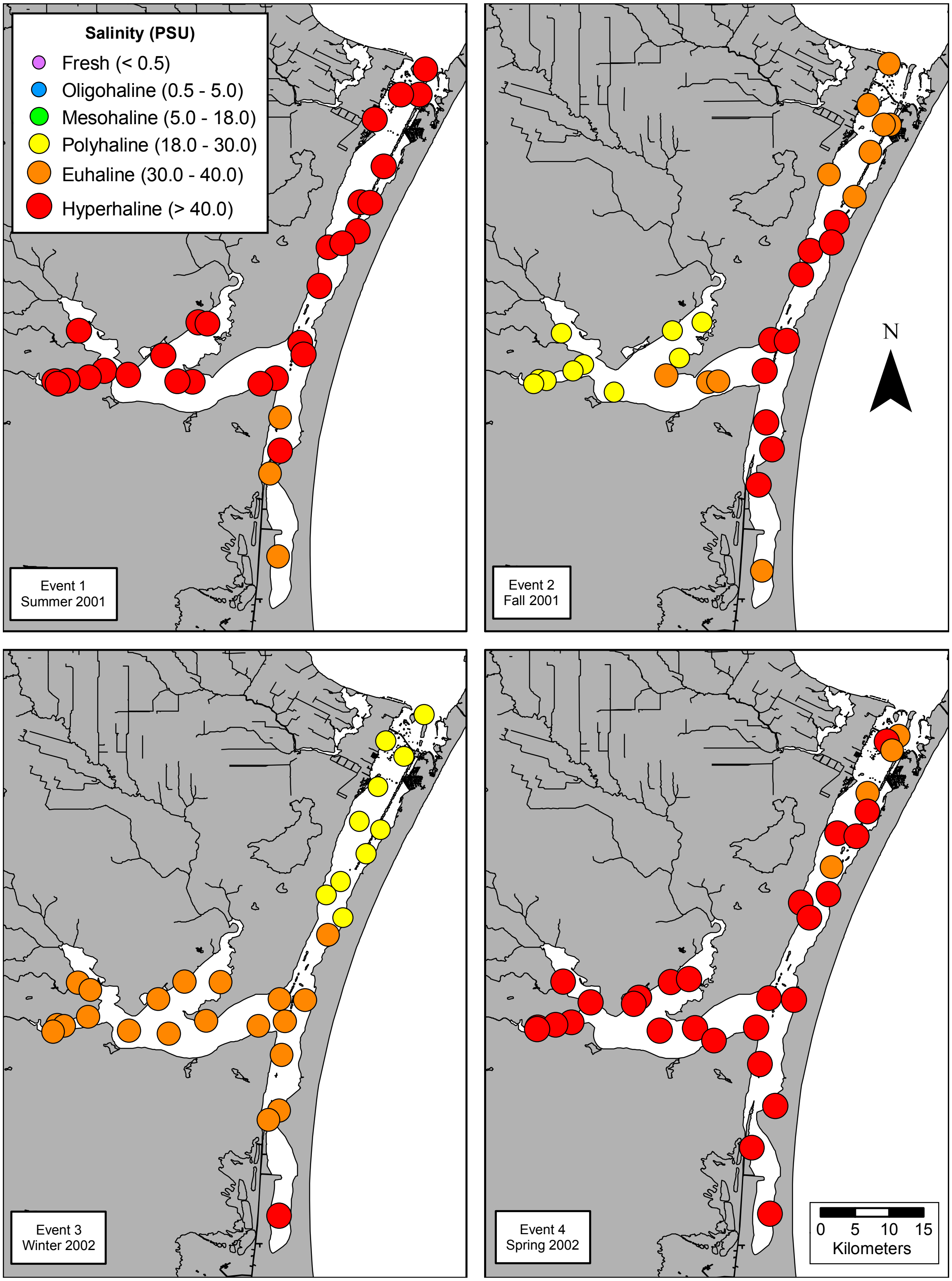

Fig. 3.7. Salinity concentrations (PSU) at randomly selected EMAP stations for RCAP 2001.

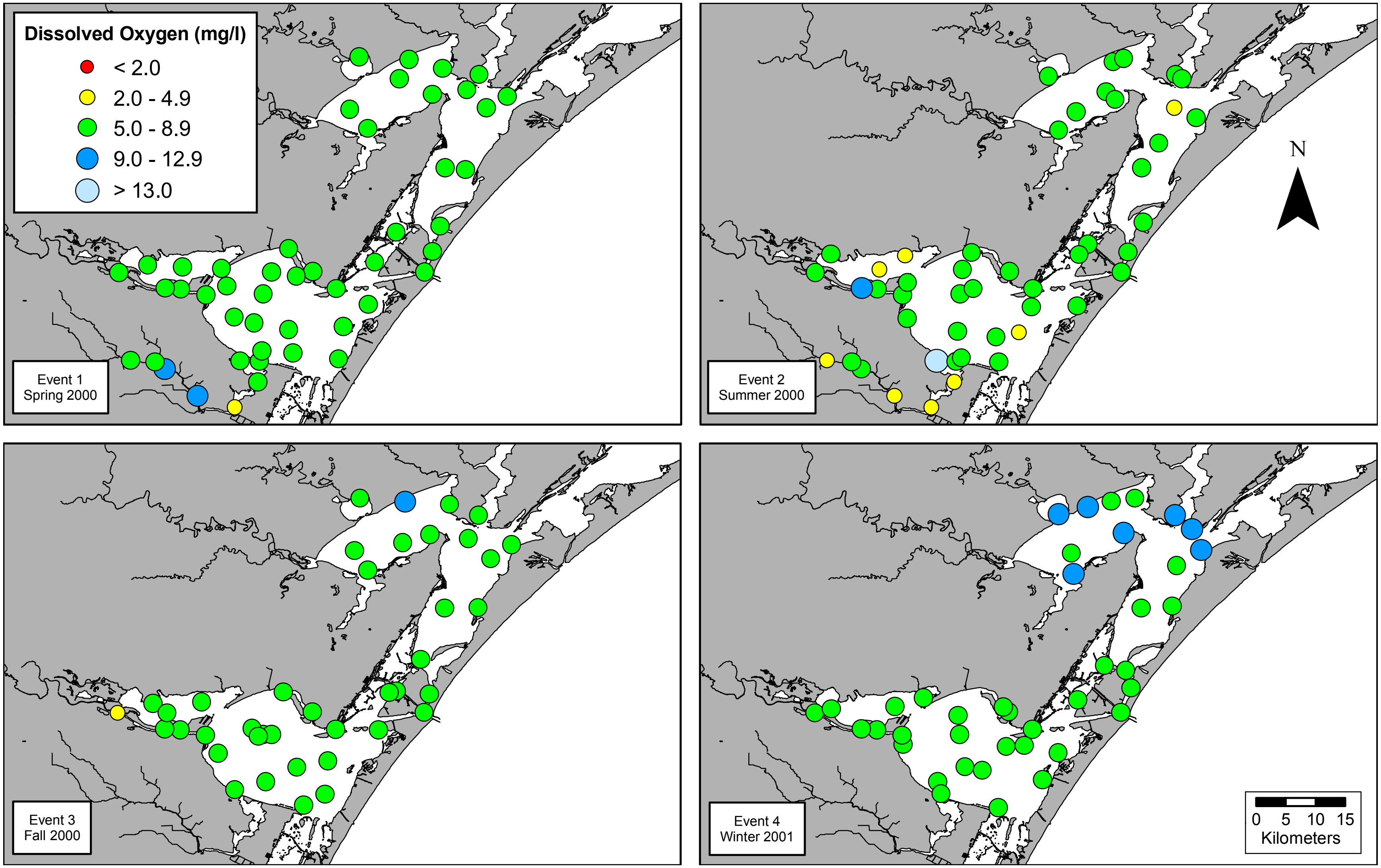

Fig. 3.8. Dissolved oxygen concentrations (mg/l^{-1}) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

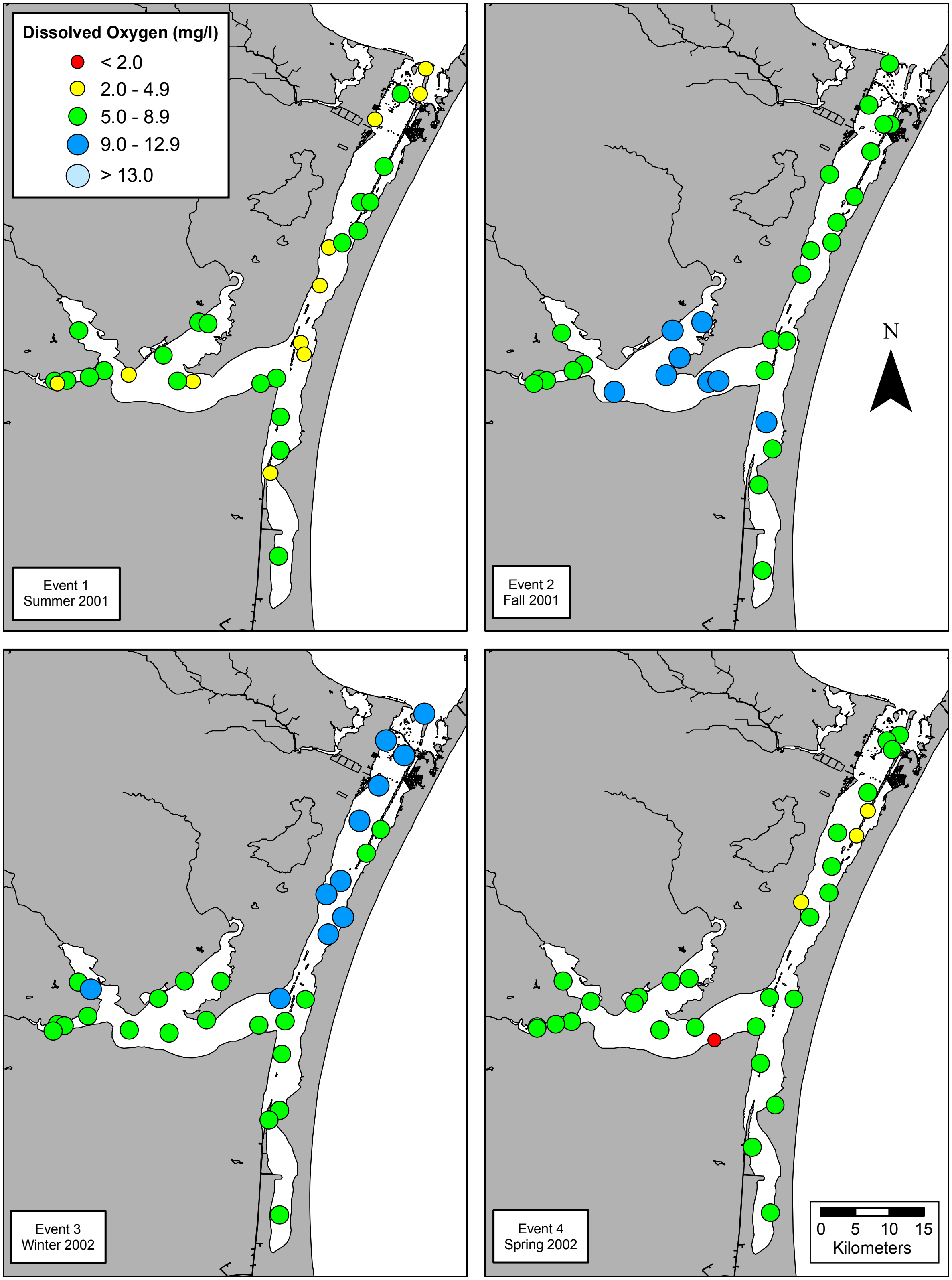

Fig. 3.9. Dissolved oxygen concentrations (mg/l^{-1}) at randomly selected EMAP stations for RCAP 2001.

3.3.2. Routine Conventional Water Chemistry

Adoption of the TSWQS allows TCEQ to direct water quality programs that protect, maintain, and restore the state waters of Texas. As previously mentioned, the quantitative basis for evaluating use support, and management of point and non-point, surface water loadings within Texas, derive from numerical concentrations, or criteria, established in the TSWQS. Utilization of these criteria as maximum or minimum concentrations that may result from permitted discharges, or originating from non-point sources within the receiving stream, allows for detailed assessments.

In the absence of criteria, TCEQ established screening levels for nutrients (ammonia, nitrate + nitrite, orthophosphate, total phosphorus), and chlorophyll *a*. These screening levels aid in determining concerns for aquatic life use, within a segment, based on percent exceedance derived from long-term SWQM data. The following discussion centers on those nutrients and screening levels, and presents an opportunity to aid in those determinations. Screening Level Estuary 2000 (SLE 2000) applies to all stations except those on Oso Creek (Segment 2485A) where Screening Level Tidal Stream 2000 (SLTS 2000) is applicable. Additional parameters collected, but not reported here (Table 2.1; Tables 6.4.1 through 6.4.8; Tables 6.5.1 through 6.5.21) may further serve in assessing the water body through interpretation of the individual constituents analyzed.

3.3.2.1. Ammonia Nitrogen (SLE 2000 = 0.10 mg/l^{-1} and SLTS 2000 = 0.58 mg/l^{-1})

Ammonia is an essential nutrient required for life, but high levels may harm aquatic organisms. Extreme amounts alter metabolism or increase body pH. Moderately elevated levels can affect hatching success, reduce growth rate, and impair morphological development in fish. Typical transport modes to a surface water body are overland flow following rainfall or irrigation events, direct industry or municipal source discharges, or airborne particulate deposition (Kennish 1992). Primarily, water quality managers must be concerned with the toxicity of ammonia to aquatic life. Water temperature, pH, DO, carbon dioxide concentrations, toxic compound existence, and prior acclimation to ammonia may directly affect ammonia toxicity (USEPA 1991). Typically, experiments show that a variety of fish species suffers lethal effects when ammonia ranges from 0.2 to 2.0 mg l^{-1} (USEPA 1987).

Using DEM 1, or applying applicable TCEQ Screening Levels for evaluation, showed relatively low concentrations of this parameter recorded during RCAP 2000 (Fig. 3.10; Table 6.4.1 through 6.4.4; Table 6.5.2). Table 3.1 indicates percentage of exceedances during RCAP 2000 and shows concerns in areas historically known, and listed, as exhibiting moderate to high levels of ammonia (Corpus Christi Inner Harbor -Segment 2848 and Oso Bay-Segment 2485). Mean concentrations of ammonia were always highest in these segments (Table 6.5.2). Range of ammonia was from <0.05 mg/l^{-1} to a high of 9.73 mg/l^{-1} found at Station 13441 in Oso Bay (Tables 6.4.1 through 6.4.4; Table 6.5.2).

For RCAP 2001 little variability existed in ammonia concentration levels when compared to RCAP 2000. The Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) exhibited exceedance of the screening level 7.4% of the time (Table 3.2; Fig. 3.15; Tables 6.4.5 through 6.5.8). Overall, ammonia concentrations were low and ranged from <0.02 mg/l^{-1} to 0.14 mg/l^{-1} with mean concentrations typically higher in Segment 2492.

Table 3.1. Percentage of applicable TCEQ Screening Level exceedances seen for nutrients and chlorophyll *a* within each segment sampled for RCAP 2000. * = did not meet QA/QC criteria. ** Provisional assessment only (see Section 3.3.2.2 and 3.3.2.4).

Segment Number	Segment Name	n	Ammonia	Nitrate Nitrite	Ortho Phosphate	Total Phosphorous	Chlorophyll *a*
2471	Aransas Bay	27	-	*	*	-	-
2472	Copano/Port/Mission Bays	28	-	*	*	-	-
2473	St. Charles Bay	5	-	*	*	-	-
2481	Corpus Christi Bay	68	-	*	*	-	1.5
2482	Nueces Bay	12	-	*	*	41.6	8.3
2483	Redfish Bay	8	-	*	*	-	-
2484	Corpus Christi Inner Harbor	12	50.0	75.0**	*	8.3	25.0
2485	Oso Bay	8	25.0	37.5**	*	37.5	-
2485A	Oso Creek	8	-	62.5**	62.5**	75.0	62.5

Table 3.2. Percentage of applicable TCEQ Screening Level exceedances seen for nutrients and chlorophyll a within each segment sampled for RCAP 2001.

Segment Number	Segment Name	n	Ammonia	Nitrate Nitrite	Ortho Phosphate	Total Phosphorous	Chlorophyll *a*
2481	Corpus Christi Bay	5	-	-	-	-	-
2491	Laguna Madre	65	-	-	-	3.1	21.5
2492	Baffin Bay/ Alazan Bay/ Cayo del Grullo/ Laguna Salada	54	7.4	-	-	16.6	51.9

3.3.2.2. Nitrate + Nitrite Nitrogen (SLE 2000 = 0.26 mg/l^{-1} and SLTS 2000 = 1.83 mg/l^{-1})

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 0.1 mg l^{-1} for maximum diversity, to 1.0 mg l^{-1} for moderate diversity (NOAA/EPA 1988; AWWA 1990; Rabalais 1992). Increased inputs of nitrogen can further cause depressed DO concentrations within a system, as increased aquatic vegetation result in increased plant respiration at night. In addition, dead macrophyte and phytoplankton serve to stimulate decomposer organisms and microbial breakdown of organic matter requiring oxygen. Additional problems result in the aesthetic interpretation of the water body as decaying algal mats and other vegetation can produce noxious odors and discoloration of the water.

Using DEM 1, or applying applicable TCEQ Screening Levels for data evaluation, proved unsuccessful for RCAP 2000. Multiple questions arose as to the usefulness and validity of the data as reported in the lab analysis as many reported results were simply <0.25 mg/l^{-1} (Table 6.4.1 through 6.4.4). While just below the SLE 2000 limit of 0.26 mg/l^{-1}, which satisfies assessment from a regulatory perspective, it fails to provide actual values that would be more useful in understanding concentration gradients within the CBBEP region. In addition to this shortcoming, we feel that most of the elevated concentrations reported might not be valid and offer the following explanation on a sampling event basis. Table 3.1 provides on a provisional basis the percentage of exceedances observed for nitrate + nitrite during RCAP 2000.

RCAP 2000 – Sampling Event 1 (Spring 2000, March 29 through April 19)

Many of the values for this event fell <0.25 mg/l^{-1} or <0.15 mg/l^{-1} (Fig. 3.11; Table 6.4.1) and for reasons listed above failed to provide actual concentration gradients. We do feel that results reported for the Corpus Christi Inner Harbor (Segment 2484) may be accurate as this is an area of historical concern. Concentrations reported in the TCEQ TRACS database for a TCEQ sampling event that occurred one week after our sampling event support the values reported. We are also in agreement with the values reported for Station 13441 in Oso Bay (Segment 2485). This station is located downstream from the Oso Wastewater Treatment Plant and historical data supports the value recorded. We are also in agreement with the values reported for all stations on Oso Creek (Segment 2485A). This area remains a concern for various nutrients, as flow within Oso Creek is predominately effluent from various wastewater treatment plants. In addition, there is a distinct pattern in the values, with highest values at upstream stations decreasing downstream, a pattern often seen in the historical data.

RCAP 2000 – Sampling Event 2 (Summer 2000, August 21 through August 30)

As opposed to the Sampling Event 1, very few of the values reported were <0.25 mg/l^{-1} (Fig. 3.11; Table 6.4.2). We are again in agreement with the values reported for the Corpus Christi Inner Harbor (Segment 2484) as TCEQ Region 14 personnel sampled one day after we sampled and recorded similar values. We are also in support of the values recorded at Station 13441 in Oso Bay (Segment 2485) and all stations in Oso Creek (Segment 2485A). At this point, we disagree with the reported values for the remaining stations. While values reported are not impossible to attain, we do not find historical evidence to validate the elevated concentrations.

A search of the historical data (TCEQ TRACS database) shows many values of <0.25 mg/l^{-1} and <0.10 mg/l^{-1} for summer sampling events. Although TCEQ did not sample in late August (some samples taken in mid to late July) typical values reported agreed with the data from historical summer sampling events. The most compelling evidence for our concern is that when we compared our data to data collected for the EPA National Coastal Assessment Program we found that on August 29, 2000 both TPWD (NCA lead agency) and CCS were sampling Corpus Christ Bay (Segment 2481) on the same day and often in close proximity to each other. Looking at Table 6.4.2 one sees our values ranged from 0.42 mg/l^{-1} to 1.20 mg/l^{-1}. NCA data on the other hand was all <0.05 mg/l^{-1}.

We are concerned about the elevated values but remain cautious as to the complete accuracy of the concentrations reported. We find no compelling evidence to invalidate the data (i.e., sample contamination, lab contamination, inaccurate analysis, etc.) except for the reasons we have stated. We therefore provide the data on a provisional basis and await future sampling events that validate or invalidate the elevated concentrations recorded for the region.

RCAP 2000 – Sampling Event 3 (Fall 2000, October 16 through October 25)

All values reported for this period were <0.25 mg/l^{-1} (Fig. 3.11; Table 6.4.3). While we would have like to have seen actual concentrations reported, we are in agreement with these values as TCEQ historical data is in support of the data at many locations over the CBBEP region.

RCAP 2000 – Sampling Event 4 (Winter 2000, March 5 through March 14)

Data reported during this sampling event gives us the most concern due to the extremely elevated concentrations within the water column (Fig. 3.11; Table 6.4.4). Search of historical data does not yield any concentrations even approaching these values, except in the Corpus Christi Inner Harbor (Segment 2484), or in areas dominated by wastewater effluent. Unfortunately, TCEQ Region 14 did not sample in March, but rather in February and April (some areas sampled in January and May), so the actual time sampling occurred is different. However, concentrations in the Corpus Christi Inner Harbor may be possible as the TCEQ sampling event that occurred February 13, 2001 recorded values of 1.11 mg/l^{-1} to 1.48 mg/l^{-1} at the same three stations CCS sampled in March (Table 6.4.4). When one looks at the TCEQ data for the region as a whole for February and April, most values are <0.25 mg/l^{-1}. Speculation as to whether our 10-day sampling event captured a dramatic turnover in the system does not seem possible, as we could not find any historical supporting evidence of past events. This is not to say that it is not possible, just improbable. Concentrations as elevated as the ones recorded do not appear in the TCEQ data record for this region and we remain generally suspect of the values reported but are unable to explain any problems in the collection or analysis of the samples. We therefore provide the data on a provisional basis and await future sampling events that validate or invalidate the elevated concentrations recorded for the region.

As opposed to RCAP 2000, there were no concerns for RCAP 2001 sample analysis. For RCAP 2001, concentrations of Nitrate + Nitrite were below the detection limit of 0.05 mg/l^{-1} for all sampling events, and did not exceed TCEQ SLE 2000 limits (Fig. 3.16; Table 3.2; Tables 6.4.5 through 6.4.8 and Table 6.5.17) and are similar to data found in the TCEQ TRACS database.

3.3.2.3. Total Phosphorus (SLE 2000 = 0.22 mg/l^{-1} and SLTS 2000 = 0.71 mg/l^{-1})

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).

Phosphorus inputs to freshwater and estuarine systems typically come from either agricultural and/or urban-residential runoff, and from treatment or lack of wastewater treatment. As with nitrogen, phosphorus stimulates macrophyte and phytoplankton growth. Typically, phosphorus is a limiting nutrient in freshwater systems but may become limited in estuarine systems where nitrogen concentrations are elevated and N:P ratios are >16:1 (Jawaorski 1981). Recommended levels of phosphorus to avoid algal blooms are 0.01 mg l^{-1} to 0.1 mg l^{-1} or a 10:1 N:P ratio (NOAA/EPA 1988). Earlier comments, concerning deleterious effects stated for nitrogen, apply equally to phosphorus.

Using DEM 1, or applying applicable TCEQ Screening Levels for evaluation of the data, indicated some of the same areas of historical concern as seen with ammonia. Table 3.1 provides the percentage of exceedances of the parameter for Oso Creek, Oso Bay, and the Corpus Christi Inner Harbor. However, exceedances in the Corpus Christi Inner Harbor (Segment 2484) are quite low when compared to the Oso Creek and Oso Bay area. However, Nueces Bay (Segment 2482) exceeded the SLE 2000 value 41.6% of the time samples were collected, which was not the case with ammonia in which there were no exceedances recorded. Range of total phosphorus for RCAP 2000 was from <0.05 mg/l^{-1} to 2.00 mg/l^{-1}. Mean concentrations tended to be higher in Nueces Bay when Oso Creek was not included in the analysis (Fig. 3.12; Table 6.4.1 through 6.4.4; Table 6.5.12)

For RCAP 2001 the same picture appears as that seen for ammonia, with more variability in the concentrations of total phosphorus than that seen for RCAP 2000, and with a greater number of exceedances seen in the Baffin Bay Complex (Segment 2492) (Fig. 3.17; Table 3.2; Tables 6.4.5 through 6.4.8; Table 6.5.20. Range was from <0.04 mg/l^{-1} to 0.26 mg/l^{-1} and mean concentrations were higher in Segment 2492 for all but sampling Event 1 (Summer 2001).

3.3.2.4. Ortho-phosphate (SLE 2000 = 0.16 mg/l^{-1} and SLTS 2000 = 0.55 mg/l^{-1})

As previously, stated, dissolved phosphorus is readily available for plants, and consists of inorganic orthophosphate and organic phosphorus-containing compounds. Used in fertilizers and as animal feed supplements phosphates are highly nutritious to plants and animals. Typically, elevated phosphate concentrations may indicate fertilizer runoff, waste discharges, or the presence of industrial effluents or detergents in surface water. Although organically bound, phosphates from these sources degrade over time to "ortho" or reactive phosphates. If elevated phosphate levels persist, aquatic plant life production increases dramatically and often leads to eutrophication of the system.

Using DEM 1, or applying applicable TCEQ Screening Levels for evaluation of the data, proved unsuccessful for RCAP 2000. As with Nitrate + Nitrite, questions arose as to the usefulness of the orthophosphate data as reported. A majority (91.5%) of the results reported were above the TCEQ SLE 2000 assessment levels (Table 6.4.1 through 6.4.4) which failed to provide useful values for assessment or that would be helpful in understanding concentration gradients within the CBBEP region.

The only useful values reported were in the areas of historical and documented concerns, Oso Creek (Segment 2485A) or Station 13441 in Oso Bay (Segment 2485). Values reported tended to exceed the applicable screening levels the majority of the time (Fig. 3.13; Table 3.1; Table 6.4.1 through 6.4.4). As these areas typically experienced lower salinities, it would appear that sample analysis suffered from matrix interferences due to high salinities. Investigation of historical TCEQ data indicates that this condition is not an isolated incident, as many values recorded in the database are less than some number that is higher than the SLE 2000 assessment level. Therefore, Total Phosphorus serves as a better indicator of phosphorus levels within the segments for the RCAP 2000 sampling events.

For RCAP 2001 no concerns existed for sample analysis and orthophosphate concentrations were typically <0.05 mg/l^{-1} for all sampling events (Fig. 3.18; Tables 6.4.5 through 6.4.8; Table 6.5.17).

3.3.2.5. Chlorophyll a (SLE 2000 = 11.50 μg/l^{-1} and SLTS 2000 = 19.2 μg/l^{-1})

Chlorophyll *a* concentrations serve as an indicator of phytoplankton abundance and biomass in estuarine waters and are a commonly used measure of water quality within many monitoring programs. Typically, high levels relate to the overproduction of algae and may indicate poor water quality while low levels are indicative of good water quality. However, short-term elevated levels do not necessarily indicate poor water quality as much as the persistence of elevated levels over the long-term. Long-term elevated levels of chlorophyll *a* may reflect increased nutrients, with increasing trends a strong indicator of eutrophication (Bricker et al. 1999; CENR 2003).

As seen with ammonia and total phosphorus, DEM 1 analysis of chlorophyll *a* data continued to indicate areas of historical concern. Table 3.1 provides the percentage of exceedances of the parameter for Oso Creek and the Corpus Christi Inner Harbor. A small number of exceedances also occurred in Nueces Bay and Corpus Christi Bay. Range of Chlorophyll *a* for RCAP 2000 was from <1.00 μg/l^{-1} to a high of 63.70 μg/l^{-1} found at Station 13028 on Oso Creek. Mean concentrations tended to be higher in the Corpus Christi Inner Harbor (Segment 2484) or Nueces Bay (Segment 2482) when Oso Creek was not included in the analysis (Fig. 3.14; Table 6.4.1 through 6.4.4; Table 6.5.4)

For RCAP 2001 more variability in the concentrations of chlorophyll *a* occurred than that seen for RCAP 2000, and with a greater number of exceedances seen in Segment 2492 within the Baffin Bay Complex (Fig. 3.19; Table 3.2; Tables 6.4.5 through 6.4.8; Table 6.5.16. Range was from <0.34 μg/l^{-1} to 26.33 μg/l^{-1}. Excluding Segment 2481, which typically only had one station sampled each quarter, mean concentrations were higher in Segment 2492 for all sampling events.

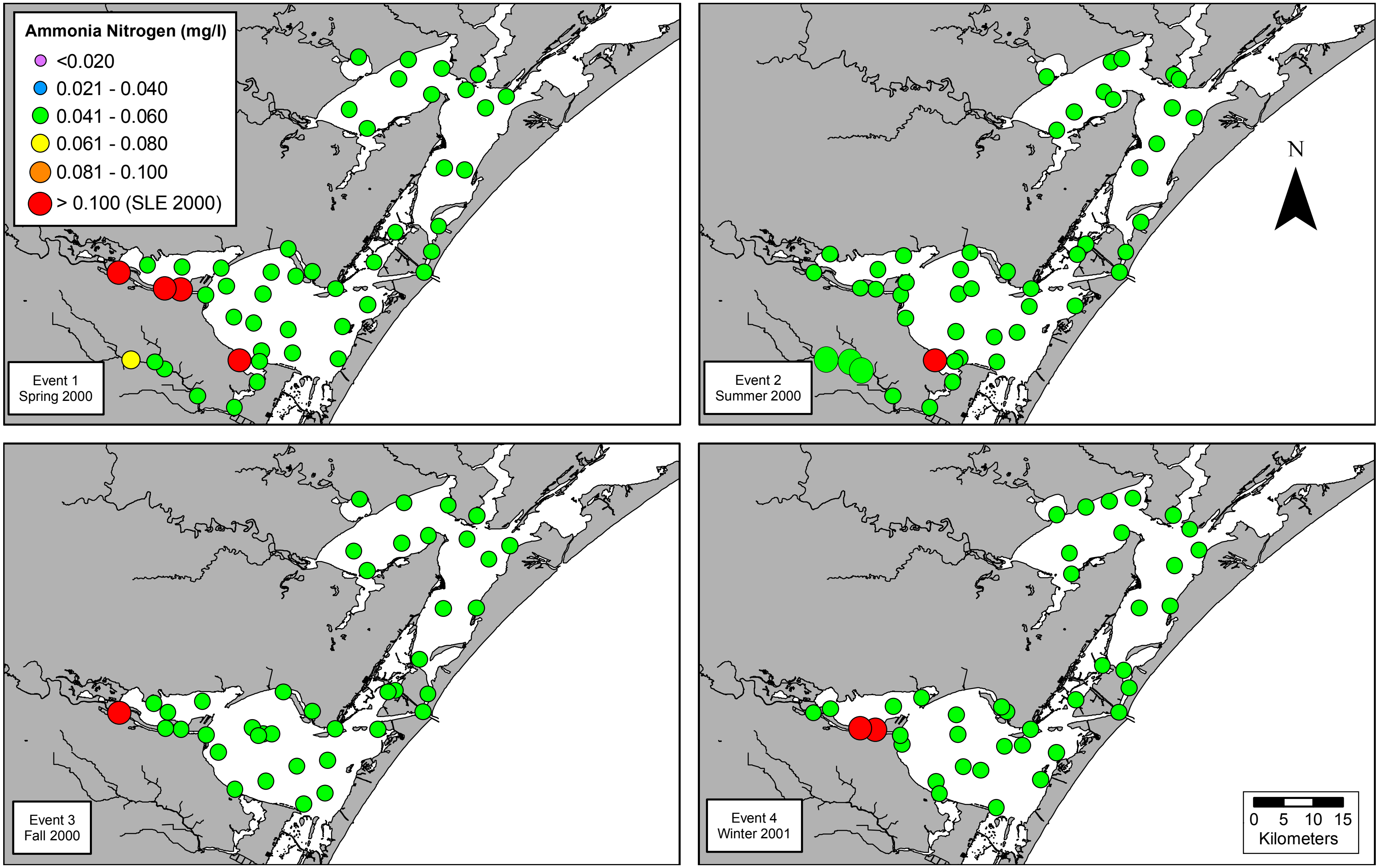

Fig. 3.10. Ammonia Nitrogen concentrations (mg/l^{-1}) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000. (Note: SLTS 2000 for Oso Creek = 0.58 mg/l^{-1})

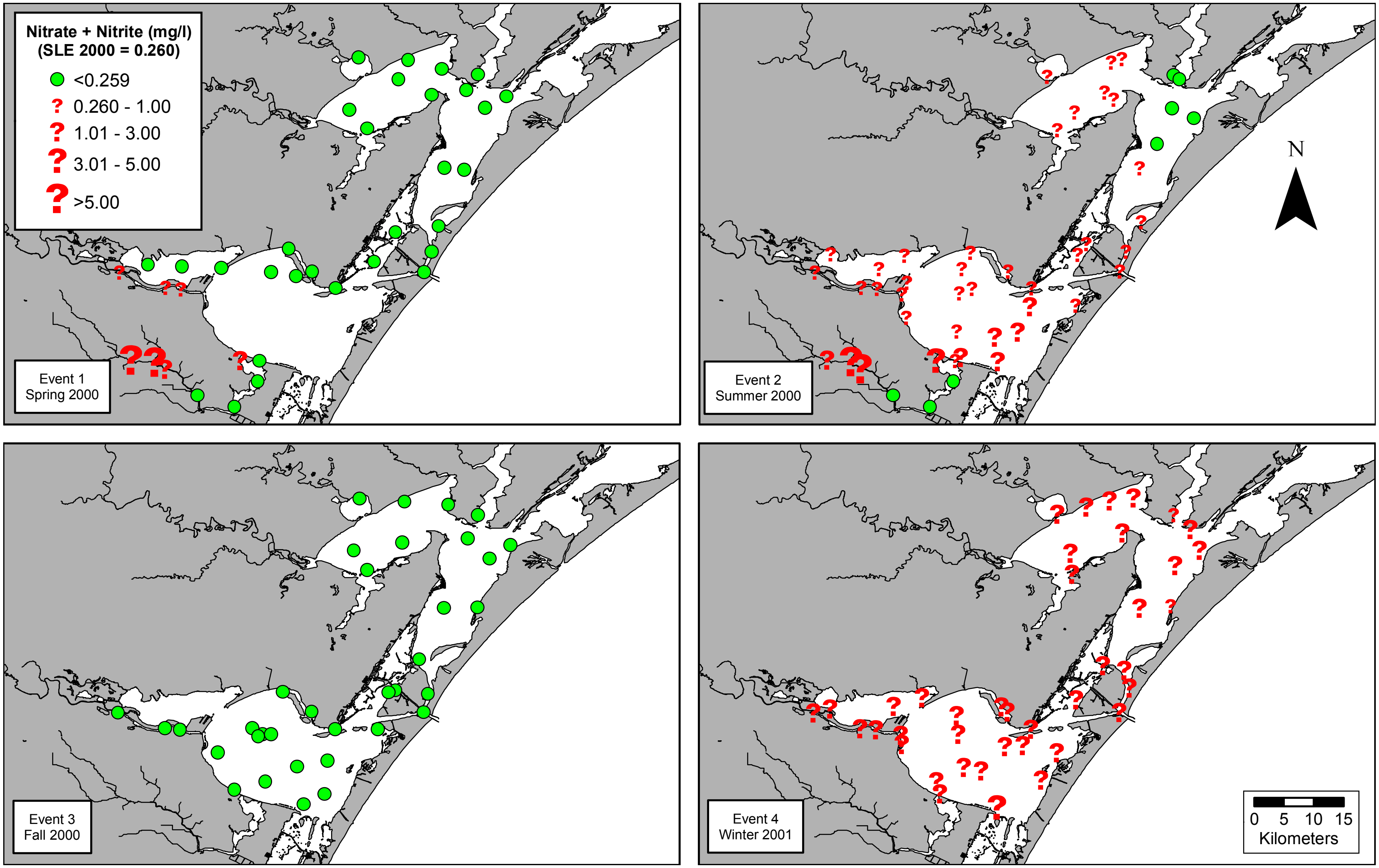

Fig. 3.11. Nitrate + Nitrite concentrations (mg/l^{-1}) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000. **NOTE**: Some data is questionable (see Section 3.3.2.2) due to extremely high concentrations which conflict with samples analyzed by other agencies during the same period and potential analytical problems. Data presentation is on a provisional basis only. (Note: SLTS 2000 for Oso Creek = 1.83 mg/l^{-1})

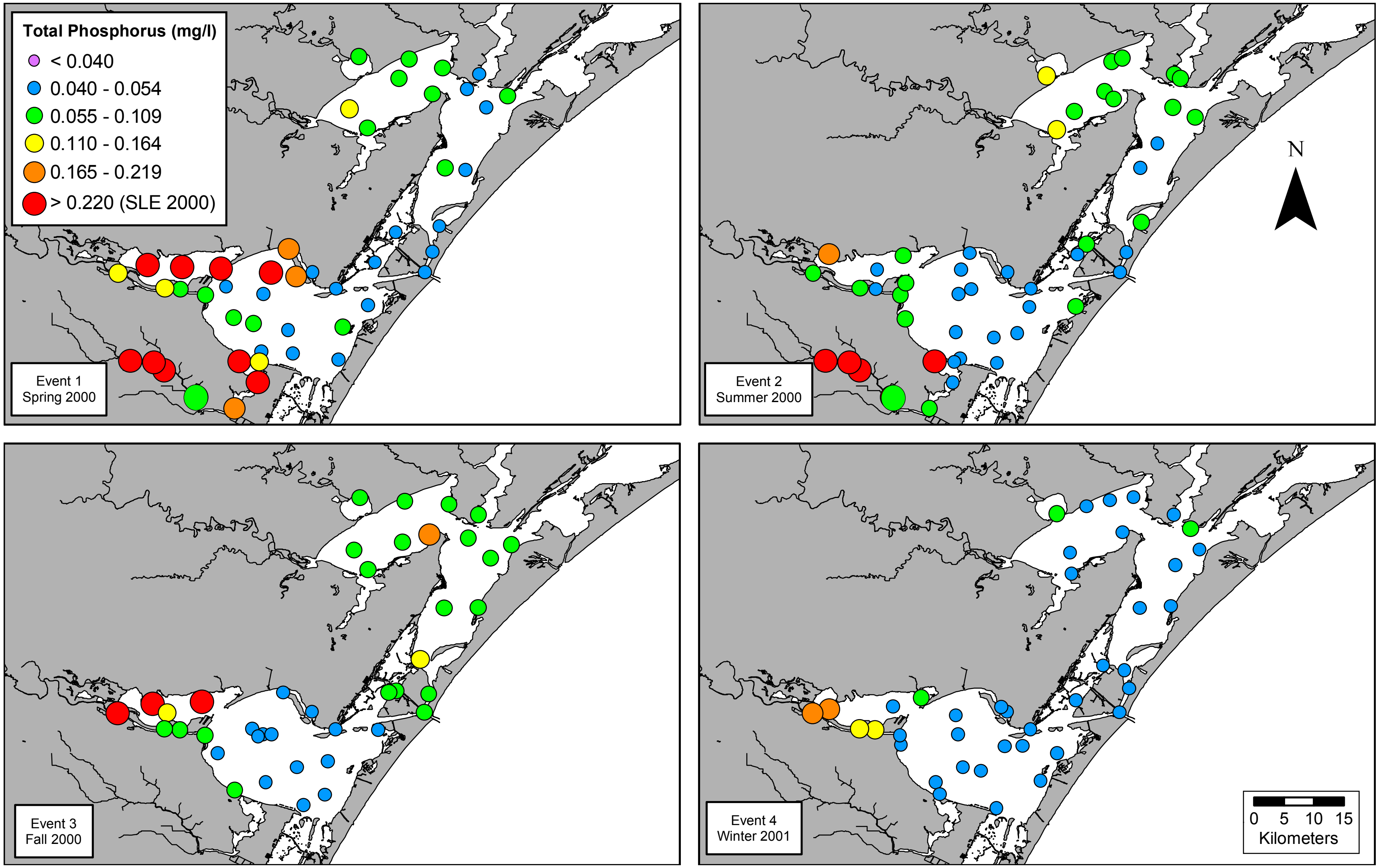

Fig. 3.12. Total Phosphorus concentrations (mg/l^{-1}) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000. (Note: SLTS 2000 for Oso Creek = 0.71 mg/l^{-1})

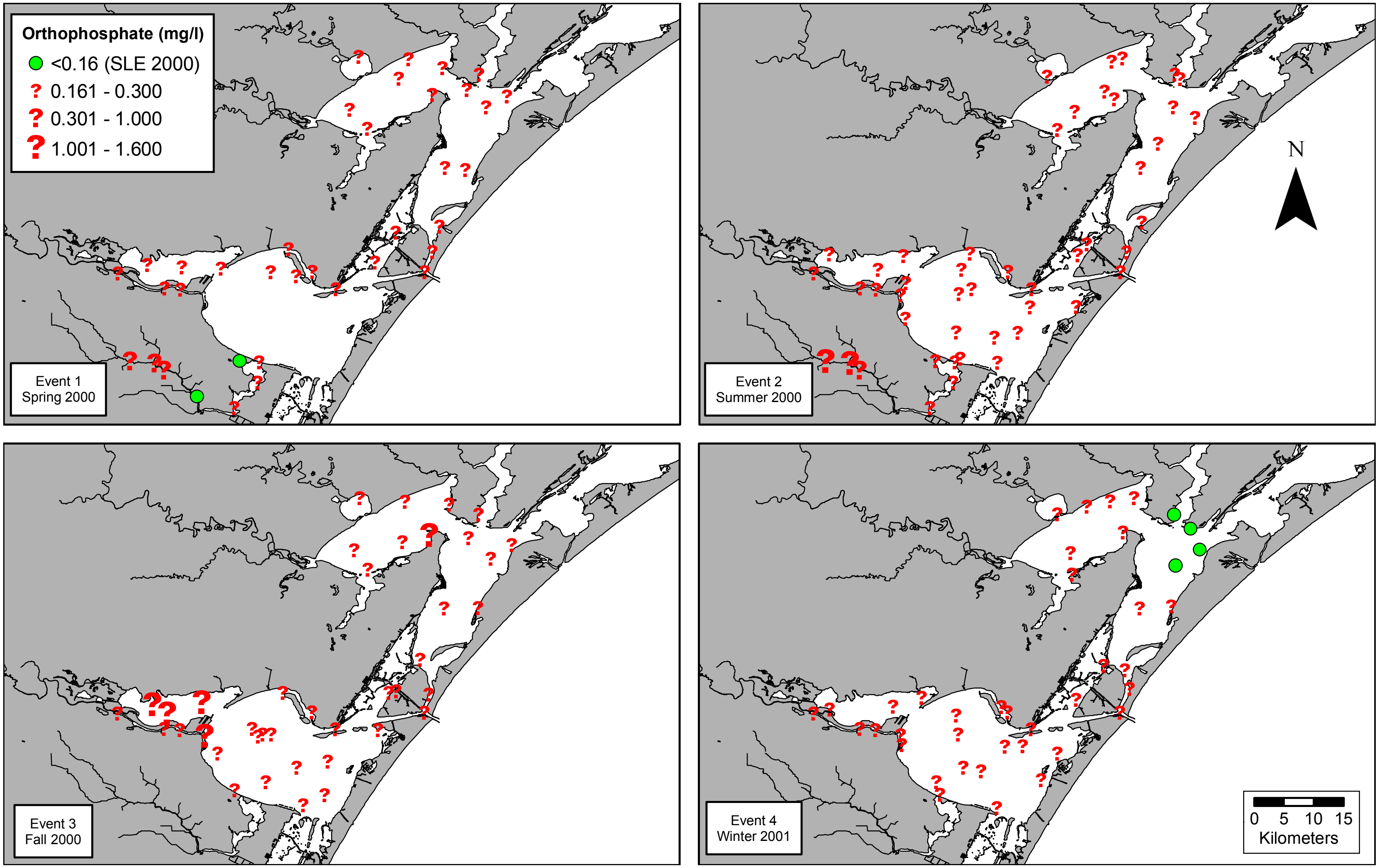

Fig. 3.13. Orthophosphate concentrations (mg/l^{-1}) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000. **NOTE**: All data except on Oso Creek and at Station 13441 in Oso Bay is questionable (see Section 3.3.2.4) due to potential analytical problems. Data presentation is on a provisional basis only. (Note: SLTS 2000 for Oso Creek = 0.55 mg/l^{-1})

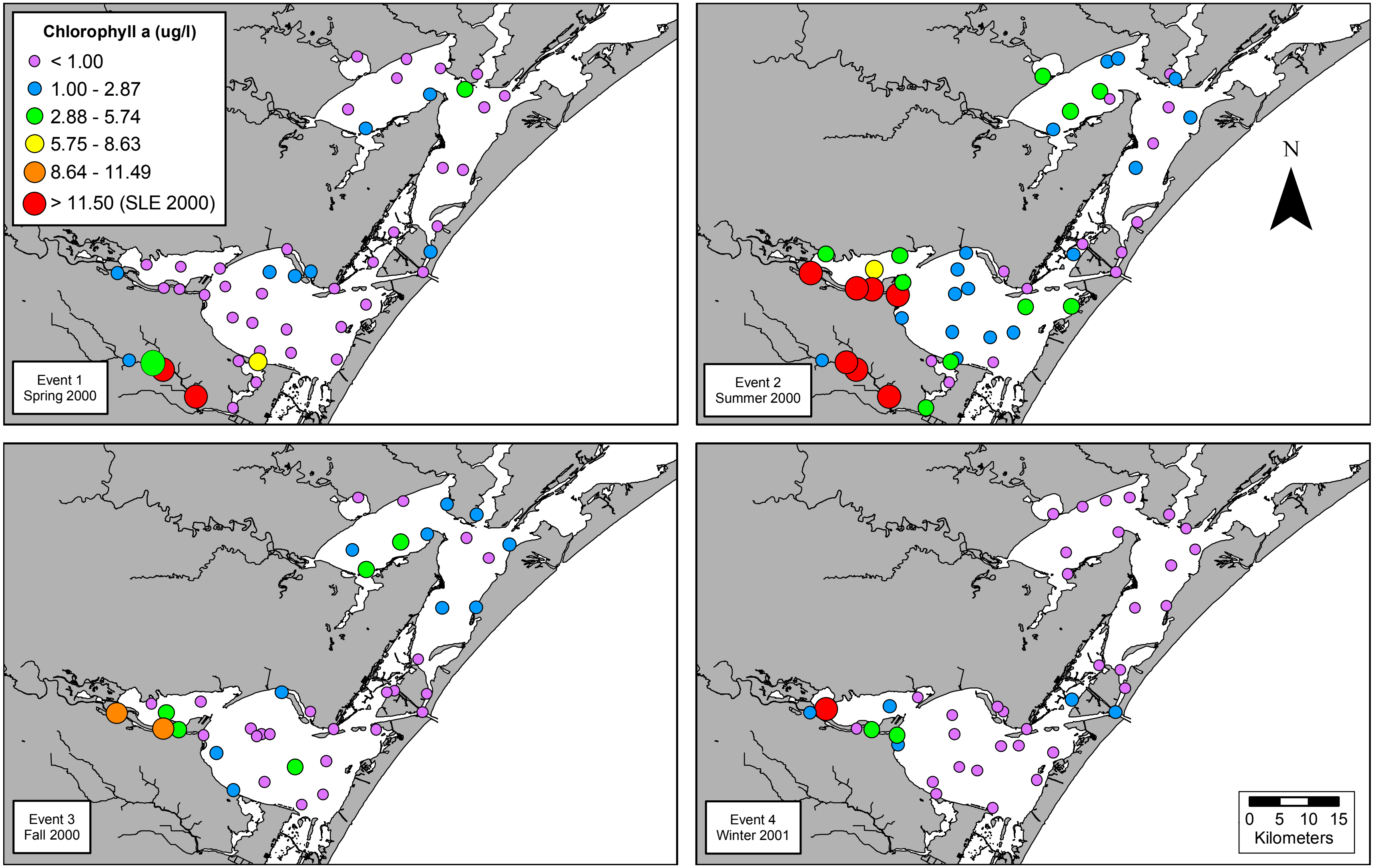

Fig. 3.14. Chlorophyll *a* concentrations ($\mu g/l^{-1}$) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000. (Note: SLTS 2000 for Oso Creek = 19.2 $\mu g/l^{-1}$)

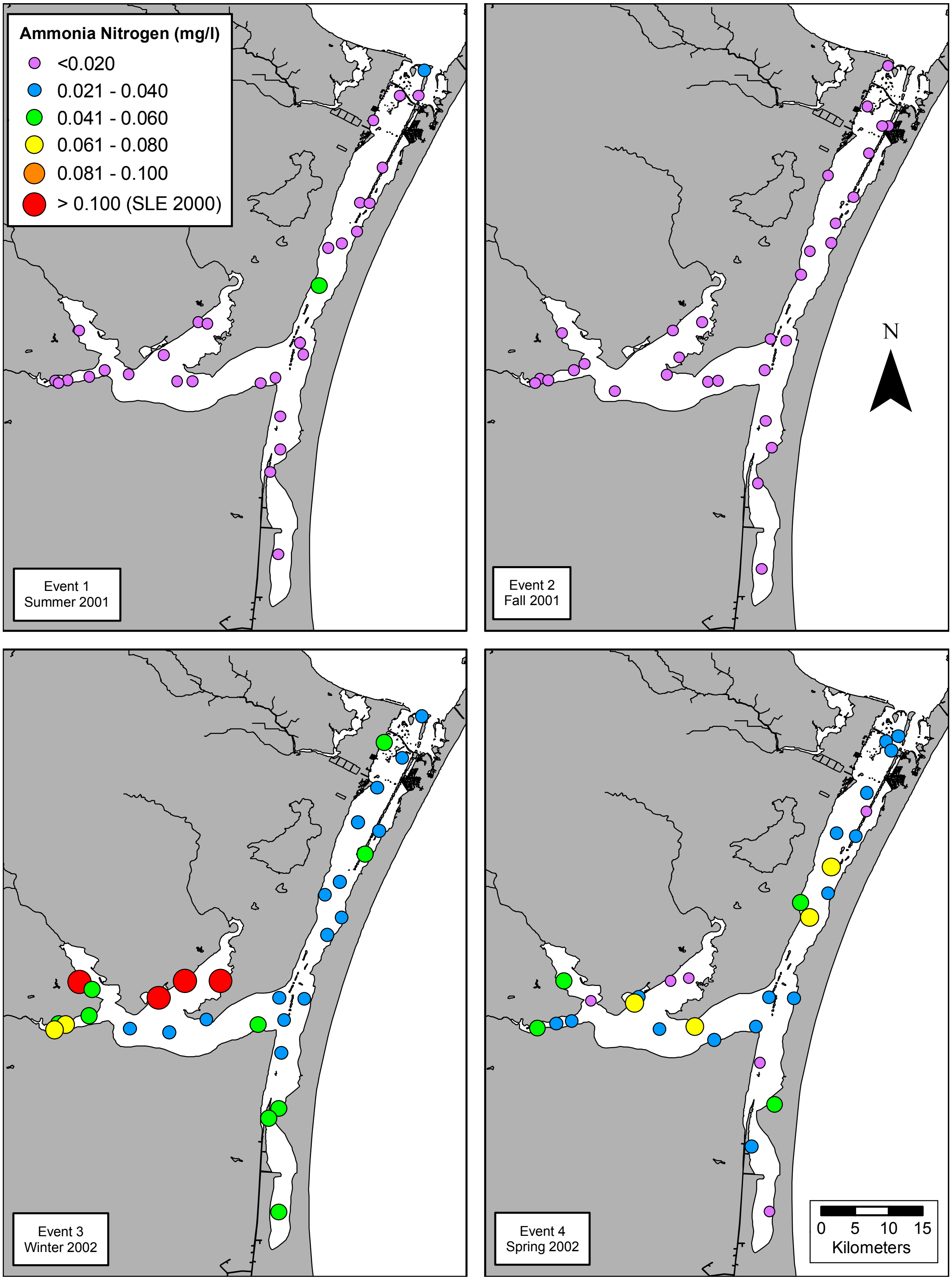

Fig. 3.15. Ammonia Nitrogen concentrations (mg/l^{-1}) at randomly selected EMAP stations for RCAP 2001.

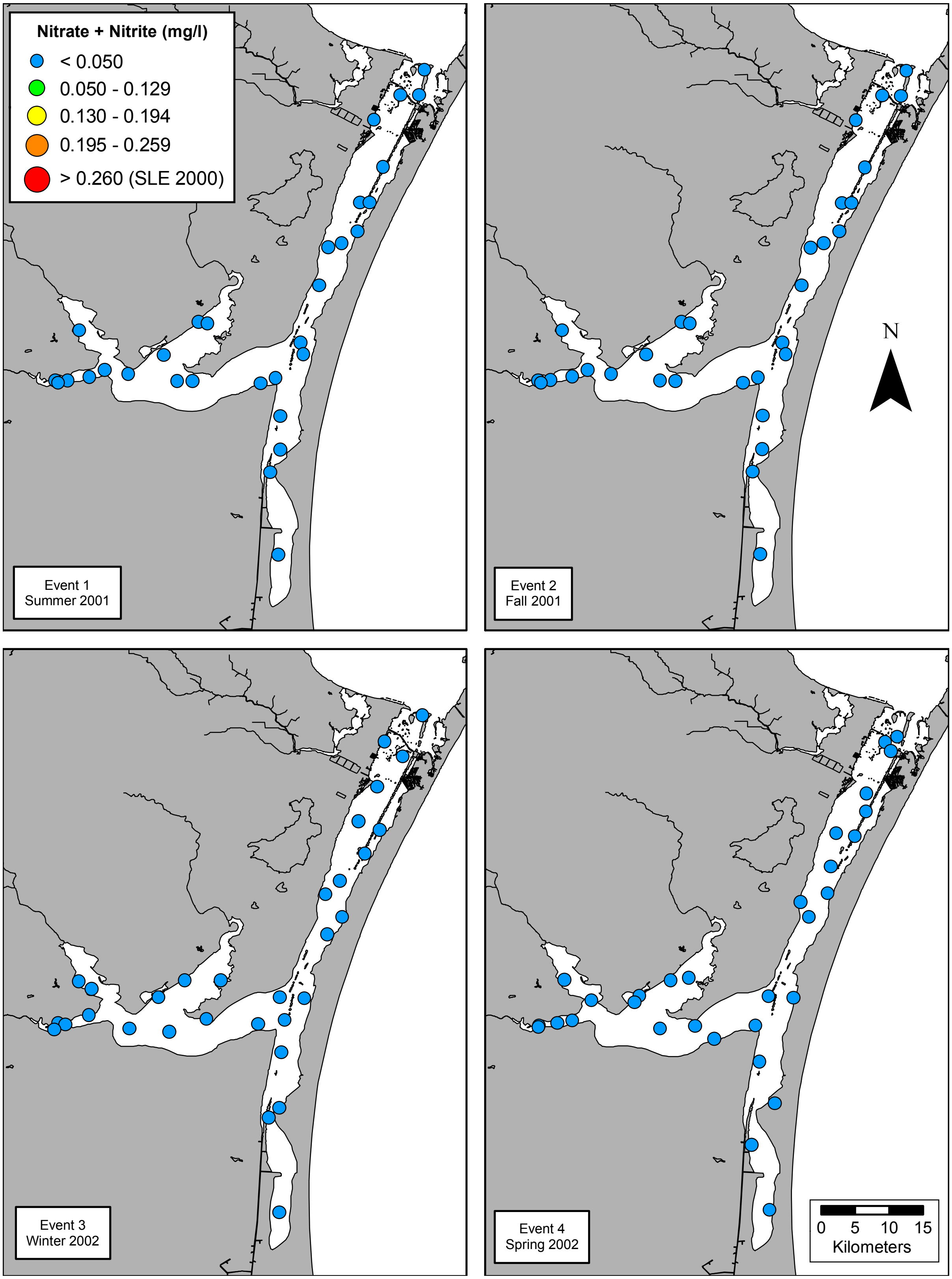

Fig. 3.16. Nitrate + Nitrite concentrations (mg/l^{-1}) at randomly selected EMAP stations for RCAP 2001.

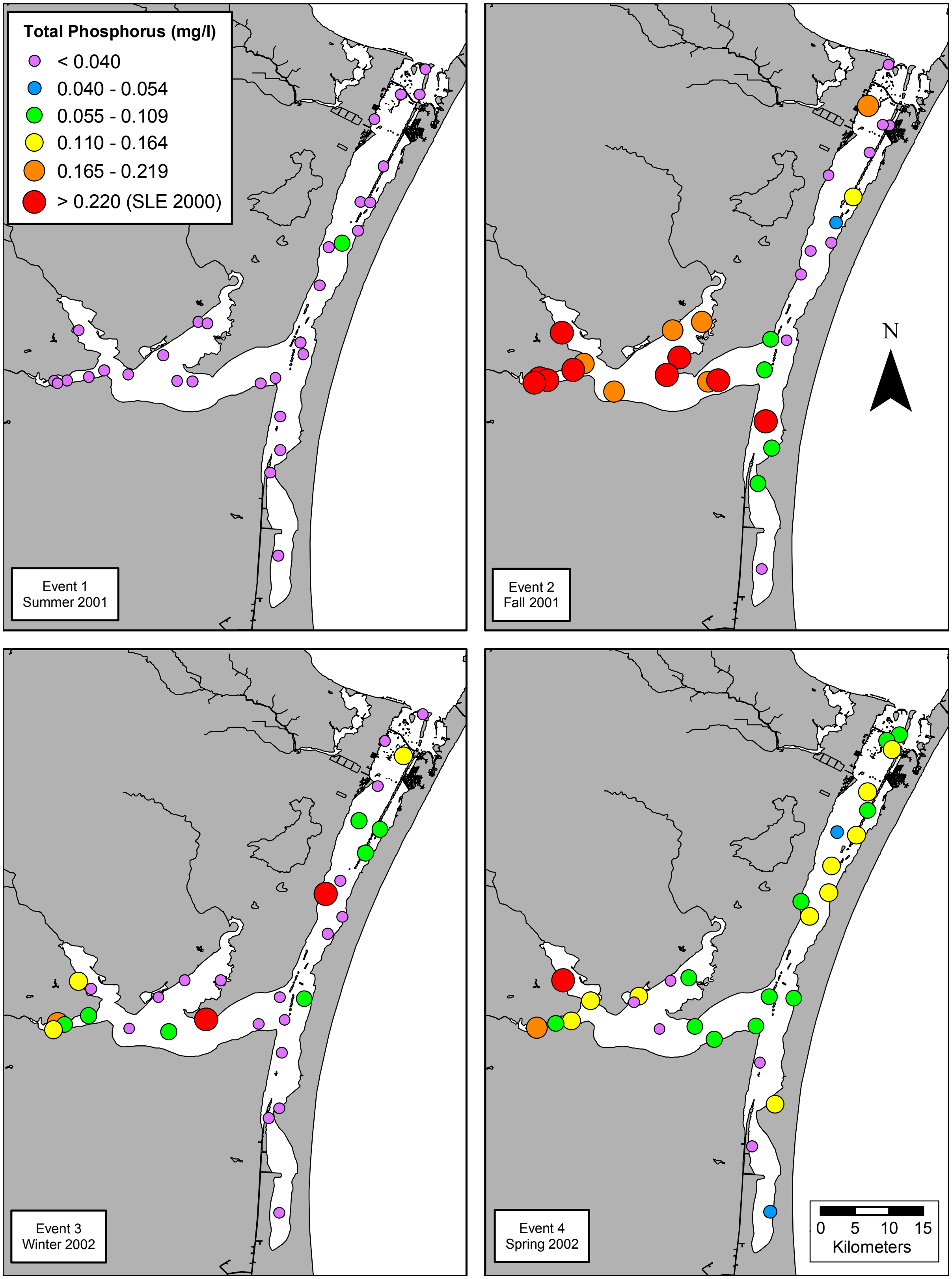

Fig. 3.17. Total Phosphorus concentrations (mg/l^{-1}) at randomly selected EMAP stations for RCAP 2001.

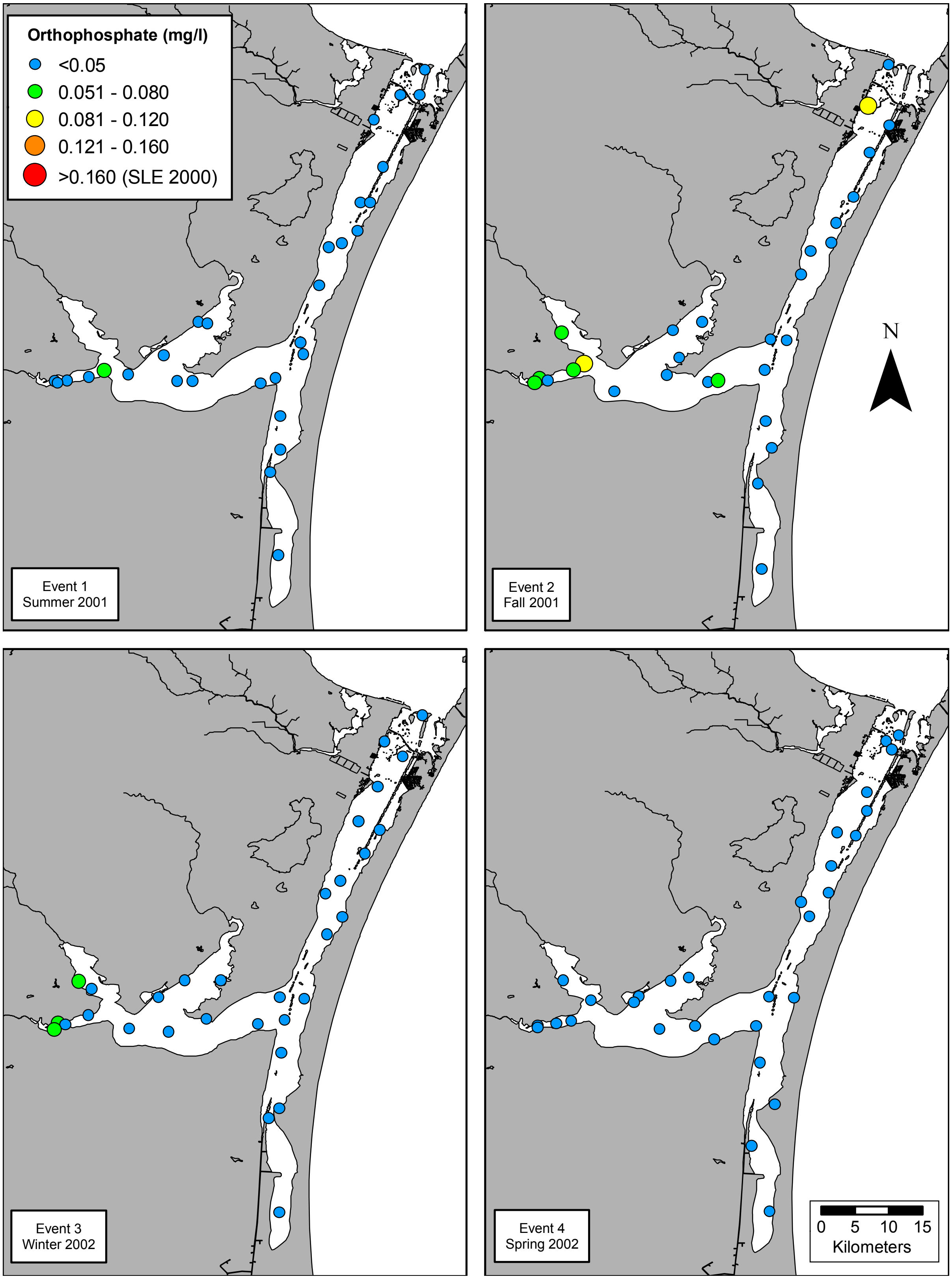

Fig. 3.18. Orthophosphate concentrations (mg/l^{-1}) at randomly selected EMAP stations for RCAP 2001.

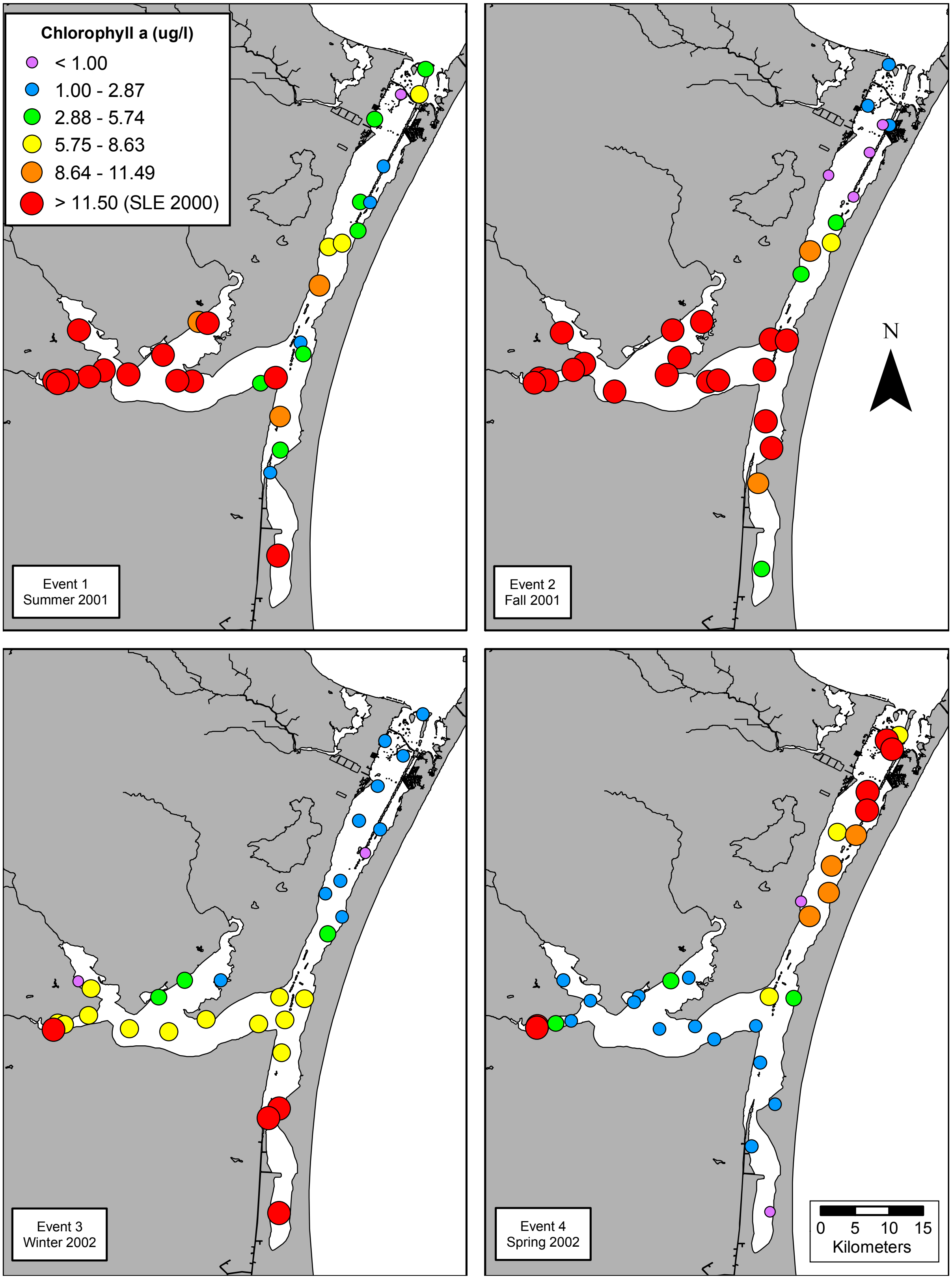

Fig. 3.19. Chlorophyll *a* concentrations ($\mu g/l^{-1}$) at randomly selected EMAP stations for RCAP 2001.

3.3.3. Microbiological Indicators

Disease causing microorganisms, or pathogens, can adversely affect estuarine systems. Densities considered unsafe often result in closer or restrictions of shellfish harvesting areas, produce fish kills, and can have adverse effects on human health. Transmittal of microbial pathogens to humans may occur during recreational use involving primary contact (i.e., wading, swimming, fishing, etc) with water (Heilman 2000; USEPA 2002). Typically, high pathogen concentrations in the water column may result from such possible sources as polluted stormwater runoff, wastewater overflows, boating wastes, and malfunctioning septic systems that carry microorganisms from fecal material into the environment.

Since it is not possible to monitor all pathogens present in the water, TCEQ analyzes concentrations of three organisms to determine support of the Contact Recreation Use (CRU): fecal coliform and *Escherichia coli* in freshwater, and Enterococci in tidal water. 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 support of the CRU does not necessarily guarantee that freshwater or tidal waters are completely free of disease causing organisms (TCEQ 2003).

Support of the CRU utilizes a 10-sample minimum per individual station. For routinely monitored bacteria data, the long-term geometric average for Enterococci is 35-colony forming units/100 ml (CFU/100ml) in tidal water. An Enterococci criterion of 104 CFU/100ml also applies to individual samples. The CRU is not supported if the geometric average of samples collected exceeds the mean criterion of if the criteria for individual samples are exceeded >25% of the time. Although sampling took place at random station locations, and is therefore not acceptable in evaluating the CRU under current guidelines, data collected serves as a tool for CBBEP and TCEQ to assess conditions over a broad area.

Using DEM 1, or applying TCEQ criteria to evaluate RCAP 2001 (bacteria not sampled in RCAP 2000) results, identified only three (2.4%) out of 124 samples where Enterococci concentrations exceeded the individual 104 CFU/100ml criteria. Distribution of Enterococci concentrations in water for RCAP 2001, along with applicable CRU 2000 criteria, appears on Figs. 3.20. Actual concentration values appear in *Data Tables* 6.6.1 through 6.6.4.

During RCAP 2001, 67.7% of all Enterococci samples analyzed produced concentrations of <10 CFU/100ml. Samples analyzed during Event 2 (Fall 2001) revealed greater variability in the Cayo del Grullo and Laguna Salada area of Segment 2492. This area is sparsely populated but homes within the area are dependent on septic systems for waste disposal, which may be a possible explanation for the variability seen in the samples collected. All three exceedances of the criteria occurred in the Upper Laguna Madre (Segment 2491) (Fig 3.20). The two exceedances observed during Event 3 (Winter 2002) and the one exceedance observed in Event 4 (Spring 2002) came from samples collected in close proximity to bird rookery islands (Fig. 3.20). While it is often difficult to quantify the relationship of bird populations to fecal loadings, there are studies indicating it as an important source that bears consideration in making regulatory determinations (Anderson et al. 1997: Alderisio and DeLuca 1999; Heilman 2000). Based on the current criteria of 104 CFU/100ml, water quality, regarding bacterial indicators, evaluates as very good within the southern CBBEP region.

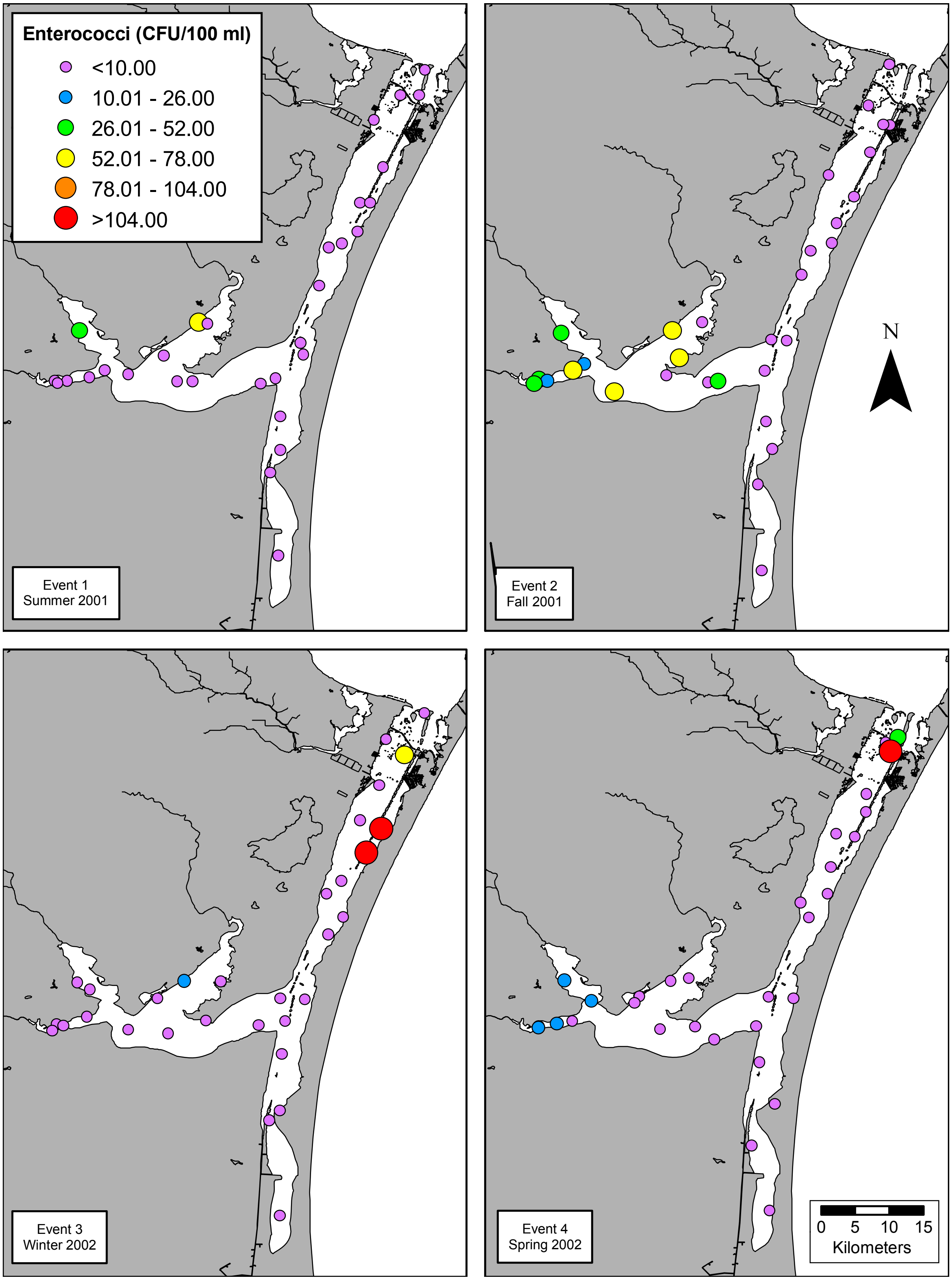

Fig. 3.20. Enterococci concentrations (CFU/100 ml) at randomly selected EMAP stations for RCAP 2001.

3.3.4. Trace Metals in Water

As previously stated, many trace metals serve as micronutrients that are critical in supporting basic life processes but are lethal in higher concentrations and toxic to aquatic organisms. Historically 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. Criteria developed include 26 organic substances (not presently monitored in RCAP) and a suite of 12 metals in dissolved and total forms. Of the 11 metals collected (Cyanide not collected) for this program: dissolved metals included; aluminum, arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc; and total metals consisted of mercury and selenium.

Using DEM 1, or applying TCEQ criteria to evaluate RCAP 2000 and 2001 results, identified **no** metal concentrations exceeding chronic TCEQ 2000 Tidal Water Criteria (TWC 2000) and water quality, regarding trace metals, evaluates as very good within the CBBEP region. Since no Primary Concerns existed, data presentation considers how the mean values of a particular parameter compares between segments or applies to water quality within the CBBEP region in general. As previously stated, segments reported as **"high" or "elevated"** pertain to relationships between stations sampled and not to concentrations found above a certain detrimental level, or the established criteria, as concentrations of most metals typically were **a significant number of times lower (orders of magnitude in some cases)** than all applicable TWC 2000 criteria or existing historical data.

Distribution of trace metal concentrations in water for RCAP 2000, along with applicable TWC 2000 criteria, appears on Figs. 3.23 through 3.30. Actual concentration values appear in *Data Tables* 6.7.1 through 6.7.4 and summary statistics appear in *Data Tables* 6.8.1 through 6.8.11. No narrative or graphical presentation is presented for aluminum, chromium, or silver (except *Data Tables* in Chapter 6) as all values, except 3 aluminum samples (<35.00 ppb), fell below the respective detection limits of <20.00 ppb, <5.00 ppb, and <0.449 ppb.

Evaluation of data for stations in Oso Bay (Segment 2485) and Oso Creek (Segment 2485A) is limited in this discussion due to sampling only occurring for two events (see Section 2.1). Elevated individual, and mean, concentrations often occurred at Oso Creek stations or at Station 13441 in Oso Bay during these first two events. Expectation of elevated concentration results from the fact that effluent discharges dominate flow in Oso Creek and Station 13441 is located in the dilution zone at the Oso Wastewater Treatment Plant. Sites sampled in Oso Creek during the first and second events resulted in the highest individual and mean concentrations for dissolved arsenic, lead, and nickel (Table 3.3; Figs. 23, 26, and 28; and *Data Table* Section 6.7 and 6.8). Highest mean dissolved zinc concentrations occurred for Oso Bay (Segment 2485) due to consistently higher levels recorded at Station 13441 (Fig. 30; *Data Table* Section 6.7 and 6.8). In addition, both areas exhibited elevated levels of copper similar to those seen in the Corpus Christi Inner Harbor (Segment 2484) and Nueces Bay (Segment 2482). However, for the four parameters listed as having highest mean concentrations within Oso Creek and Oso Bay, all values remained well below applicable TWC 2000 criteria (Table 3.3)

Removal of Oso Creek and Oso Bay from the evaluation of trace metals data for RCAP 2000 showed highest mean concentrations consistently occurred in the Corpus Christi Inner Harbor

(Segment 2484) or Nueces Bay (Segment 2482) areas (Table 3.3). The exception would be for arsenic, which had higher mean concentrations recorded for sampling Events 1 and 3 in the Copano Bay/Port Bay/Mission Bay (Segment 2472) (Table 3.3). Highest mean arsenic concentrations tended to occur in areas with freshwater inputs (Aransas, Mission, and Nueces Rivers), and highly reflect the natural background levels typically found in freshwater. However, sources may also relate to runoff from unknown nonpoint sources.

As expected, examination of the data shows that most concentrations of trace metals tended to be highest in relation to proximity to the Corpus Christi Inner Harbor (Segment 2484). As the primary industrial complex for the region, this area would exhibit elevated concentrations on a more frequent basis. Except for elevated copper concentrations (still below criteria) in the Corpus Christi Inner Harbor (Segment 2484, all trace metal concentrations fell far below the TWC 2000 criteria (Table 3.3; Figs. 3.23 through 3.30).

Table 3.3. Section 1 lists trace metals (except aluminum, chromium, or silver) collected during RCAP 2000 showing sampling Event and Segment (excluding Oso Creek and Oso Bay) scoring the highest mean concentration, with applicable TWC 2000 criteria, highest individual concentration, and percent highest individual concentration attained of TWC 2000 criteria; Section 2 lists number of trace metals a particular Segment in Section 1 scored the highest mean concentration by event, total number for all events, and percent of total time Segment recorded highest mean concentration; Section 3 lists trace metals scoring highest mean concentration in Oso Bay (Segment 2485) or Oso Creek (Segment 2485A) during first two sampling events, applicable TWC 2000 criteria, highest individual concentration recorded, and percent highest individual concentration attained of TWC 2000 criteria.

1 Parameter	E1	E2	E3	E4	TWC 2000	Highest Concentration	% of TWC 2000
Arsenic	2472	2482	2472	2484	78.0	6.61	8.5
Cadmium	2482	2482	2482	2484	10.0	0.574	5.7
Copper	2484	2484	2482	2484	3.6	3.378	93.8
Lead	2484	2484	2484	2484	5.3	0.622	11.7
Mercury	-	2482	2482	2482	1.1	0.054	4.9
Nickel	2484	2482	2482	2484	13.1	2.06	15.7
Selenium	2484	2484	2484	2484	136.0	8.52	6.3
Zinc	2484	2484	2482	2484	84.2	19.9	23.6
2 Segment	**E1**	**E2**	**E3**	**E4**	**Total**	**% of time**	
2484 (CC Inner Harbor)	5	4	2	7	18	58.0	
2482 (Nueces Bay)	1	4	5	1	11	35.5	
2472 (Copano/Port/Mission Bay)	1		1		2	6.5	
3 Parameter	**E1**	**E2**	**E3**	**E4**	**TWC 2000**	**Highest Concentration**	**% of TWC 2000**
Arsenic	2485A	2485A	-	-	78.0	11.45	14.7
Lead	2485A	2485A	-	-	5.3	0.377	7.1
Nickel	2485A	2485A	-	-	13.1	8.68	66.3
Zinc	2485	2485	-	-	84.2	21.47	25.5

As stated, elevated individual and mean concentrations often occurred in Oso Creek or at Station 13441 in Oso Bay thereby creating a masking effect. This masking effect, brackish water differences, and the fact that sampling only occurred for two events, did not allow for clear groupings of similar trace metal concentrations at other stations. Therefore, stations within this area required removal from the Similarity Matrix and MDS plot analysis.

Using DEM 2 (Similarity Matrix) the MDS plot identified seven distinct groups (Fig 3.21). Group 1 consisted of one station (42), located in Aransas Bay-Segment 2471 sampled during Event 2; characterized as having low trace metal concentrations with the exception of lead. This particular lead concentration was the highest recorded during RCAP 2000 but well below the criteria (Table 3.3; Fig. 3.26.). Group 2 contained stations from every segment that all exhibited similarly low trace metal concentrations (Fig. 3.21).

Groups 3 and 4 contained stations with similar elevated concentrations of cadmium and nickel (Figs. 3.24 and 3.28). Factors separating these two groups included elevated concentrations of arsenic (Fig. 3.23) in Group 3 and elevated concentrations of mercury (Fig. 3.27) in Group 4. Stations in Group 3 included one station (32) in Copano Bay/Port Bay/Mission Bay (Segment 2472) and two stations (45 and 49) in Nueces Bay (Segment 2482), all collected during sampling Event 2. Group 4 stations were located in the upper portion of Nueces Bay (Segment 2482) with samples collected during Events 3 and 4.

Groups 5 through 7 contained similar elevated concentrations of cadmium, copper, nickel, and Zinc (Fig. 3.21 and Figs. 3.24, 3.25, 3.28, and 3.30). Group 5 primarily consisted of stations located in the Corpus Christi Inner Harbor (Segment 2484) and Nueces Bay (Segment 2484), with samples collected during all sampling events except Event 3. Divergence of Groups 6 and 7 resulted from Group 6 contained an elevated concentration of mercury (Fig. 3.27) and Group 7 had an elevated concentration of selenium. Both groups consisted of one station located in the Corpus Christi Inner Harbor (Segment 2482), sampled during Event 4.

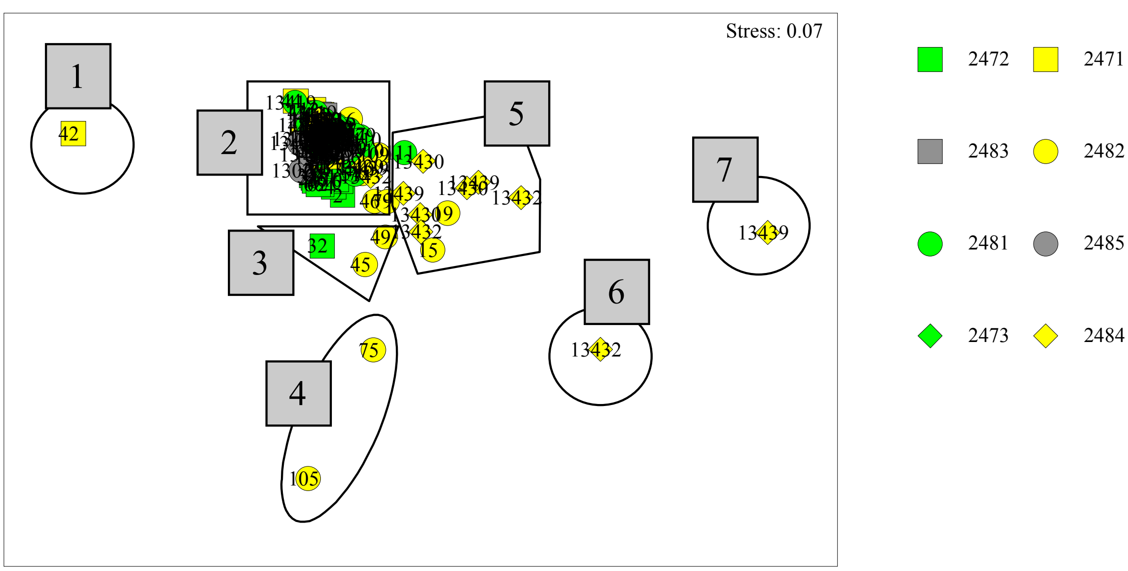

Fig. 3.21. MDS plots grouping stations together based on similar trace metal concentrations in water during RCAP 2000. Numbers in grey boxes define Groups.

Distribution of trace metal concentrations in water for RCAP 2001, along with applicable TWC 2000 criteria, appears on Figs. 3.31 through 3.38. Actual concentration values appear in *Data Tables* 6.7.5 through 6.7.8 and summary statistics appear in *Data Tables* 6.8.12 through 6.8.17. No narrative or graphical presentation is presented for aluminum, chromium, or silver (except *Data Tables* in Chapter 6) as all values, except 3 aluminum samples (<133.00 ppb), fell below the respective detection limits of <20.00 ppb, <5.00 ppb, and <0.449 ppb, respectively.

Examination of the data shows Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) exhibited elevated metal concentrations 71.8% of the time (Table 3.4). In comparison, the limited number of stations sampled in Corpus Christi Bay (Segment 2481), just north of the J.F.K. Causeway, were elevated 18.8%, and the Upper Laguna Madre (Segment 2491) elevated 9.4% of the time, respectively (Table 3.4 and Figs. 3.31 through 3.38). However, as was the case for RCAP 2000 all concentrations, except copper, which was elevated but did not exceed, fell far below TWC 2000 criteria (Table 3.4).

As was also seen in RCAP 2000, mean arsenic concentrations (Fig. 3.31) in RCAP 2001 were higher relative to station proximity to freshwater inputs. Except for sampling Event 1, mean arsenic concentrations were highest in the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492), most notably in Alazan Bay and the main stem of Baffin Bay during sampling Event 2 in Fall 2001. As increased arsenic levels coincided with decreased salinity (Fig. 3.9) from increased precipitation and subsequent inflows, it would be safe to assume that discharges into Alazan Bay may point to Petronila Creek and unknown inputs as the source.

Table 3.4. Section 1 lists trace metals (except aluminum, chromium, or silver) collected during RCAP 2001 showing sampling Event and Segment scoring the highest mean concentration, applicable TWC 2000 criteria, highest individual concentration, and percent highest individual concentration attained of TWC 2000 criteria; Section 2 lists number of trace metals a particular Segment scored the highest mean concentration by event, total number for all events, and percent of total time Segment recorded highest mean concentration.

1	Parameter	E1	E2	E3	E4	TWC 2000	Highest Concentration	% of TWC 2000
	Arsenic	2491	2492	2492	2492	78.0	10.2	13.1
	Cadmium	2492	2491	2492	2492	10.0	0.135	1.4
	Copper	2492	2492	2492	2492	3.6	2.90	80.6
	Lead	2492	2492	2492	2491	5.3	0.551	10.4
	Mercury	2492	2492	2492	2481	1.1	0.0054	0.5
	Nickel	2492	2492	2492	2492	13.1	1.662	12.7
	Selenium	2481	2492	2492	2481	136.0	0.440	0.3
	Zinc	2492	2481	2481	2481	84.2	1.428	1.7

2	Segment	E1	E2	E3	E4	Total	% of time	
	2481 (Corpus Christi Bay)	1	1	1	3	6	18.8	
	2491 (Upper Laguna Madre)	1	1		1	3	9.4	
	2492 (Baffin Bay/Alazan Bay Cayo del Grullo/Laguna Salada)	6	6	7	4	23	71.8	

Using DEM 2 (Similarity Matrix) the MDS plot delineated nine distinct groups based on similar metals concentrations (Fig 3.22). Group 1 contained stations with similarly low metals concentrations primarily located in the Upper Laguna Madre (Segment 2491) (*Data Tables* 6.7.5 through 6.7.8). Groups 2, 3, 4, and 6 characteristically had elevated arsenic (Fig. 3.31), copper (Fig. 3.33), and nickel (Fig. 3.36), at varying concentrations, and contained stations predominantly located in the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492). Group 2 diverged from other groups due to typically higher cadmium concentrations, while Group 3 had one station in Baffin Bay (174) with the highest arsenic concentrations recorded for RCAP 2001. These two groups contained stations sampled during Events 2, 3, and 4 during periods of reduced or increasing salinities (Figs. 3.9 and 3.31).

Groups 4 and 6 contained stations, sampled during Event 1, during a period of high salinities, resulting from reduced freshwater inflows. Group 4 included stations that contained moderately elevated concentrations of arsenic, cadmium, copper, and nickel, with elevated zinc concentrations setting this station apart from the other groups. Group 6 had moderate concentrations of arsenic, copper, and nickel with relatively elevated concentrations of mercury grouping the stations together.

Groups 5, 7, 8, and 9 typically had low metal concentrations and were located predominately in the Upper Laguna Madre (Segment 2491). Group 5 had slightly elevated concentrations of mercury and nickel and contained stations in the northern portion of the Upper Laguna Madre while Group 7 contained stations with higher concentrations of Selenium. Group 8 consisted of just one station (153) with the highest zinc concentration and Group 9 consisted of one station (237) with elevated lead concentrations.

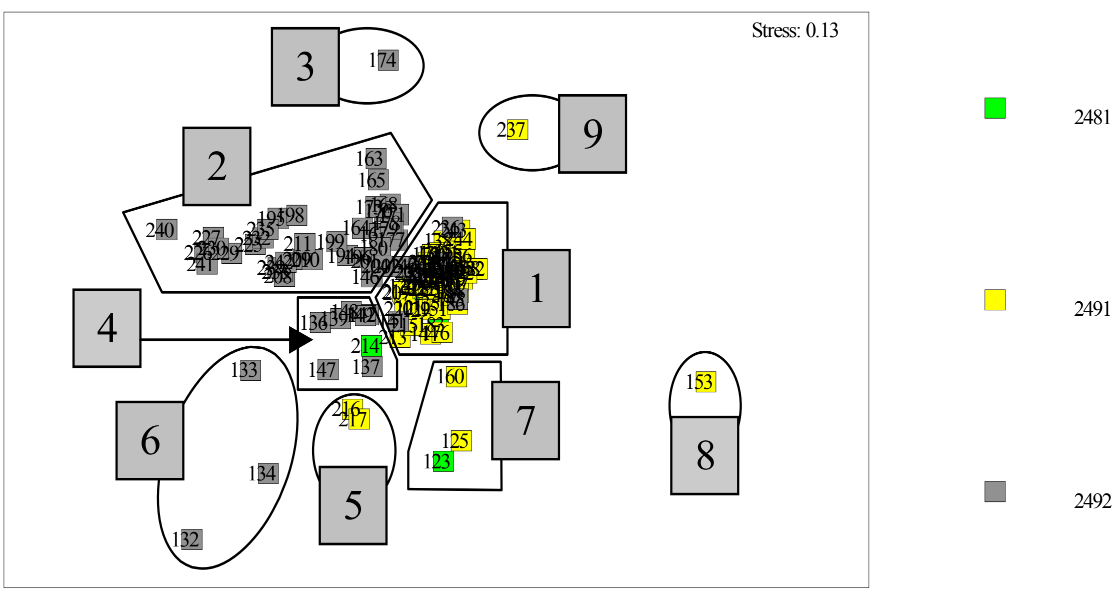

Fig. 3.22. MDS plots grouping stations together based on similar trace metal concentrations in water during RCAP 2001. Numbers in grey boxes define Groups.

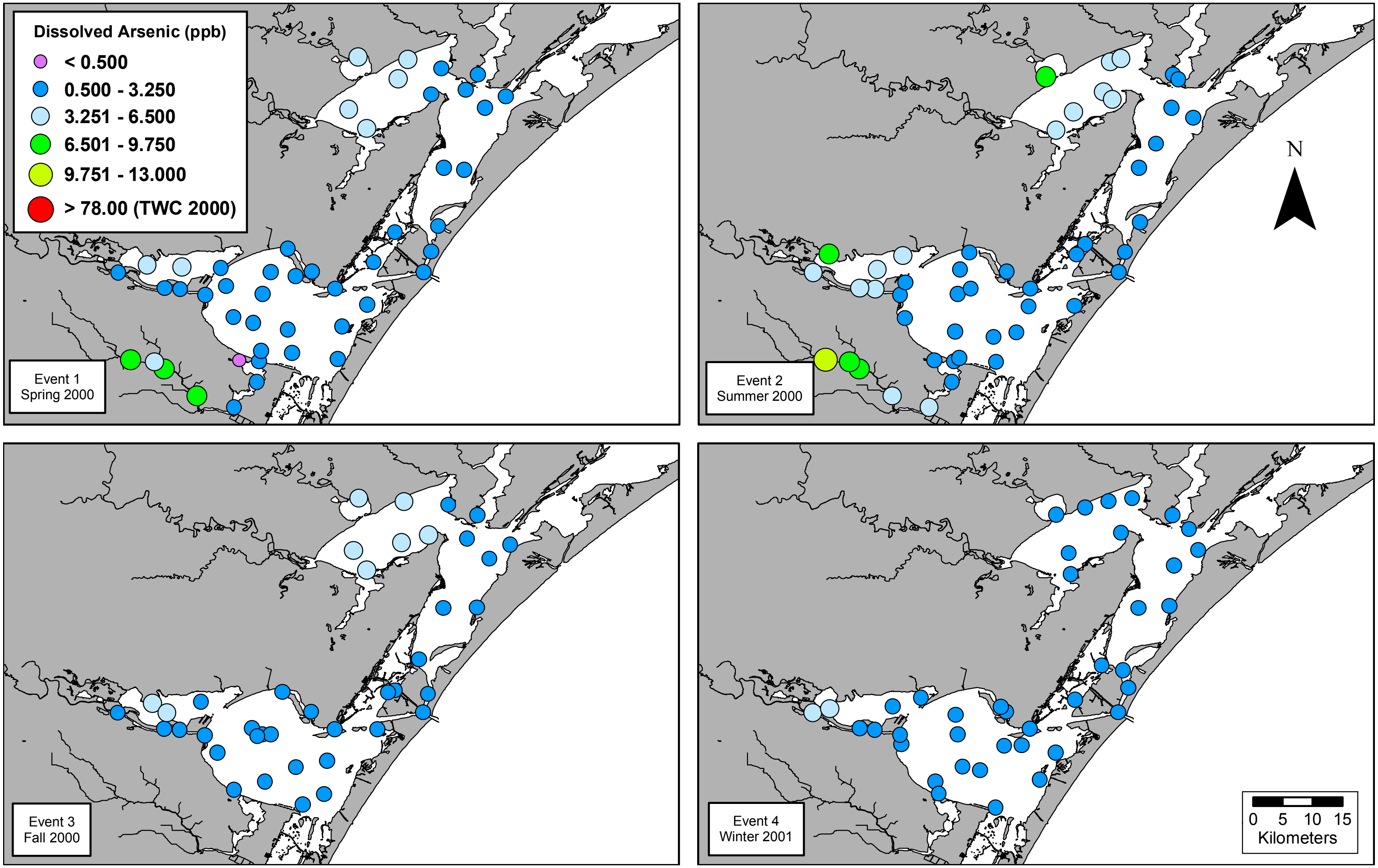

Fig. 3.23. Dissolved Arsenic concentrations ($\mu g/l^{-1}$ or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

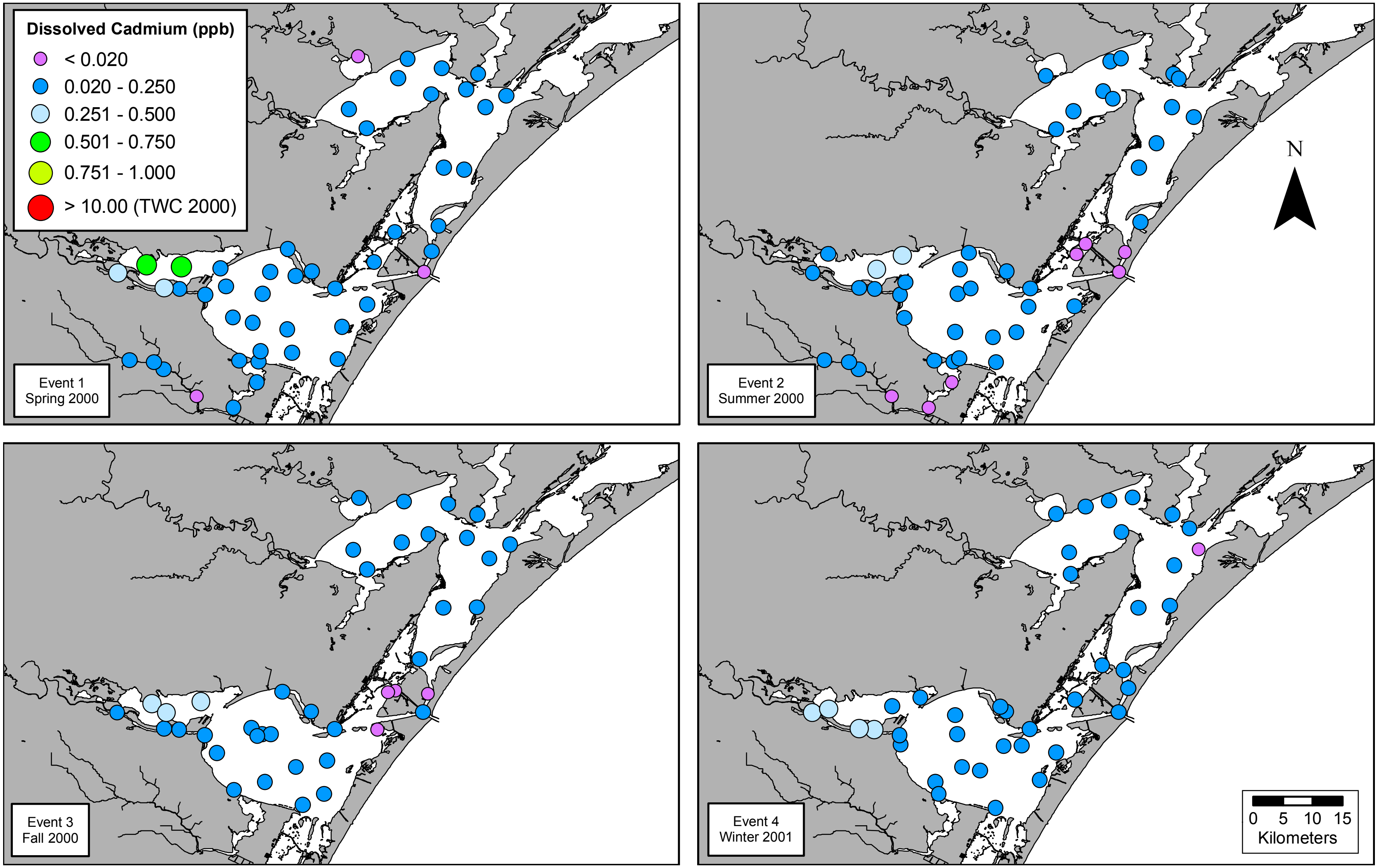

Fig. 3.24. Dissolved Cadmium concentrations (μg/l[-1] or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

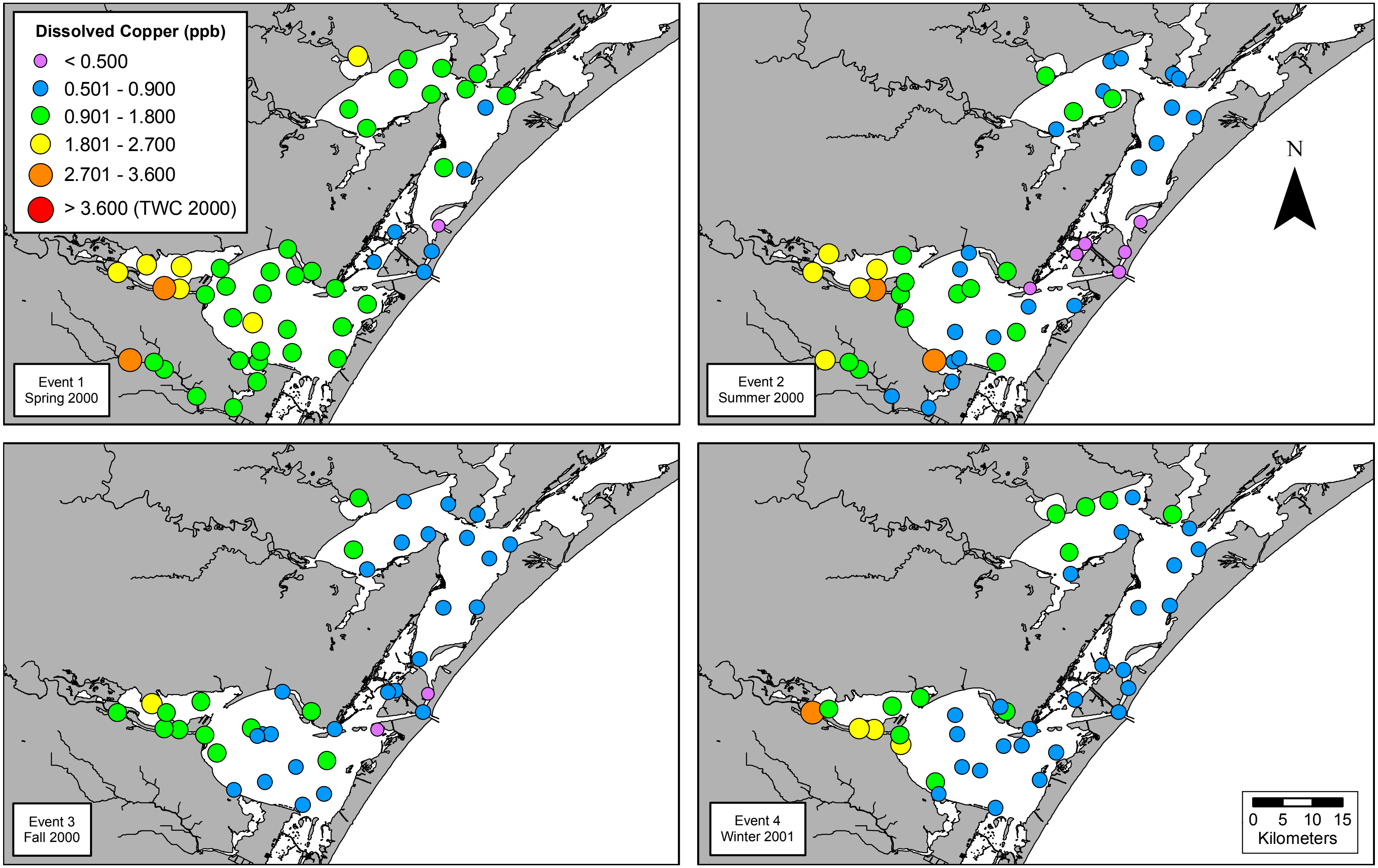

Fig. 3.25. Dissolved Copper concentrations ($\mu g/l^{-1}$ or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

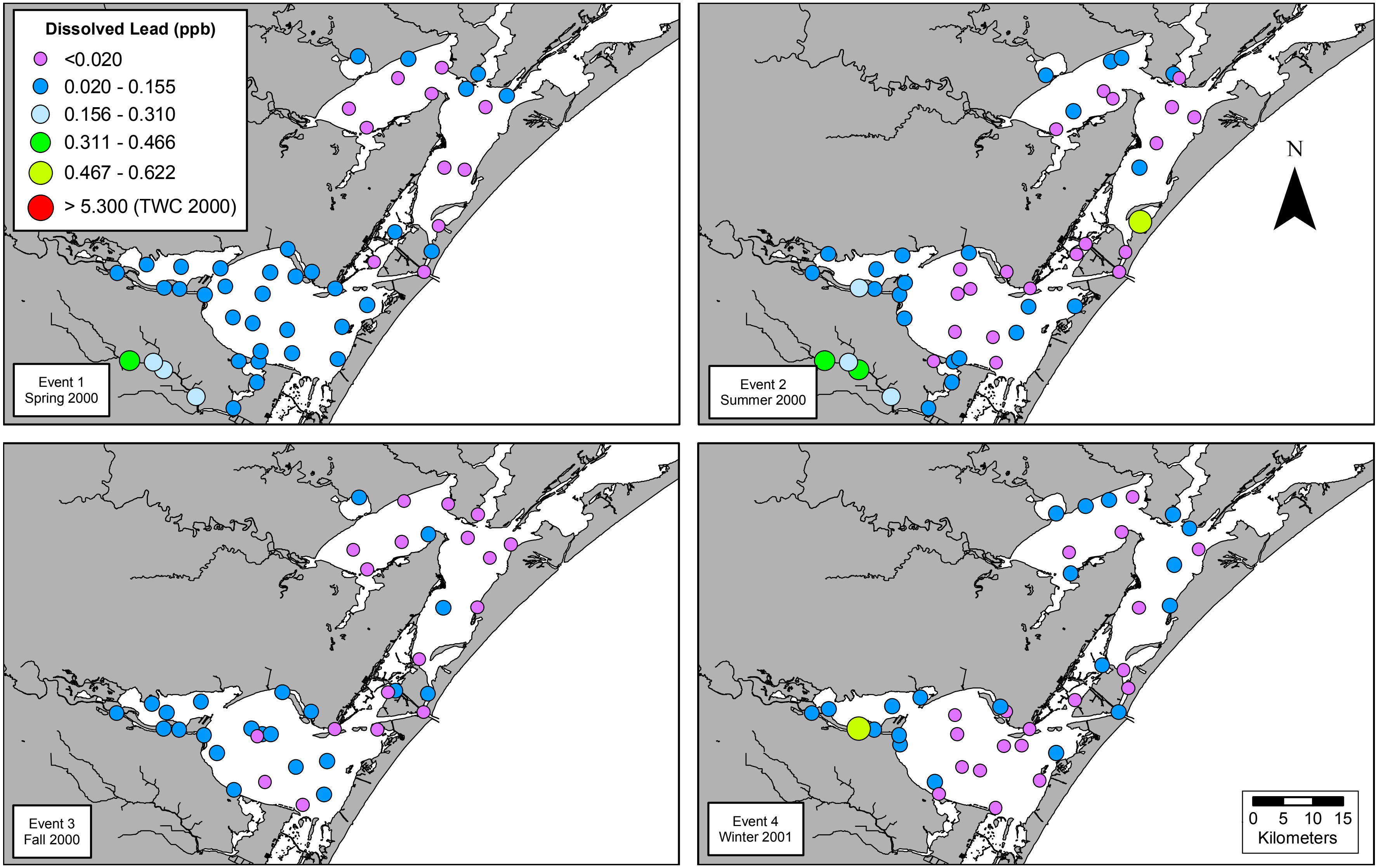

Fig. 3.26. Dissolved Lead concentrations (μg/l^{-1} or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

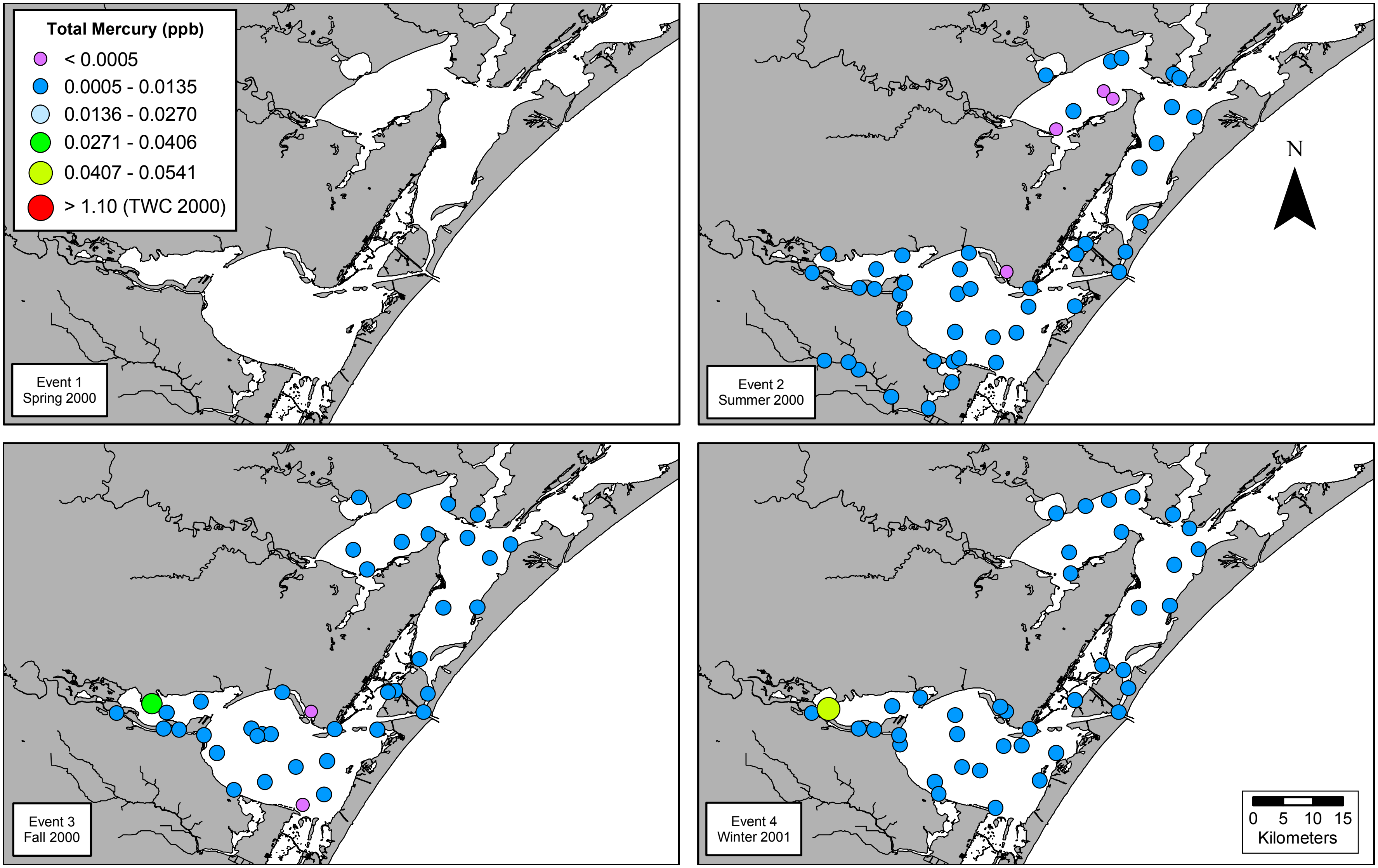

Fig. 3.27. Total Mercury concentrations ($\mu g/l^{-1}$ or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

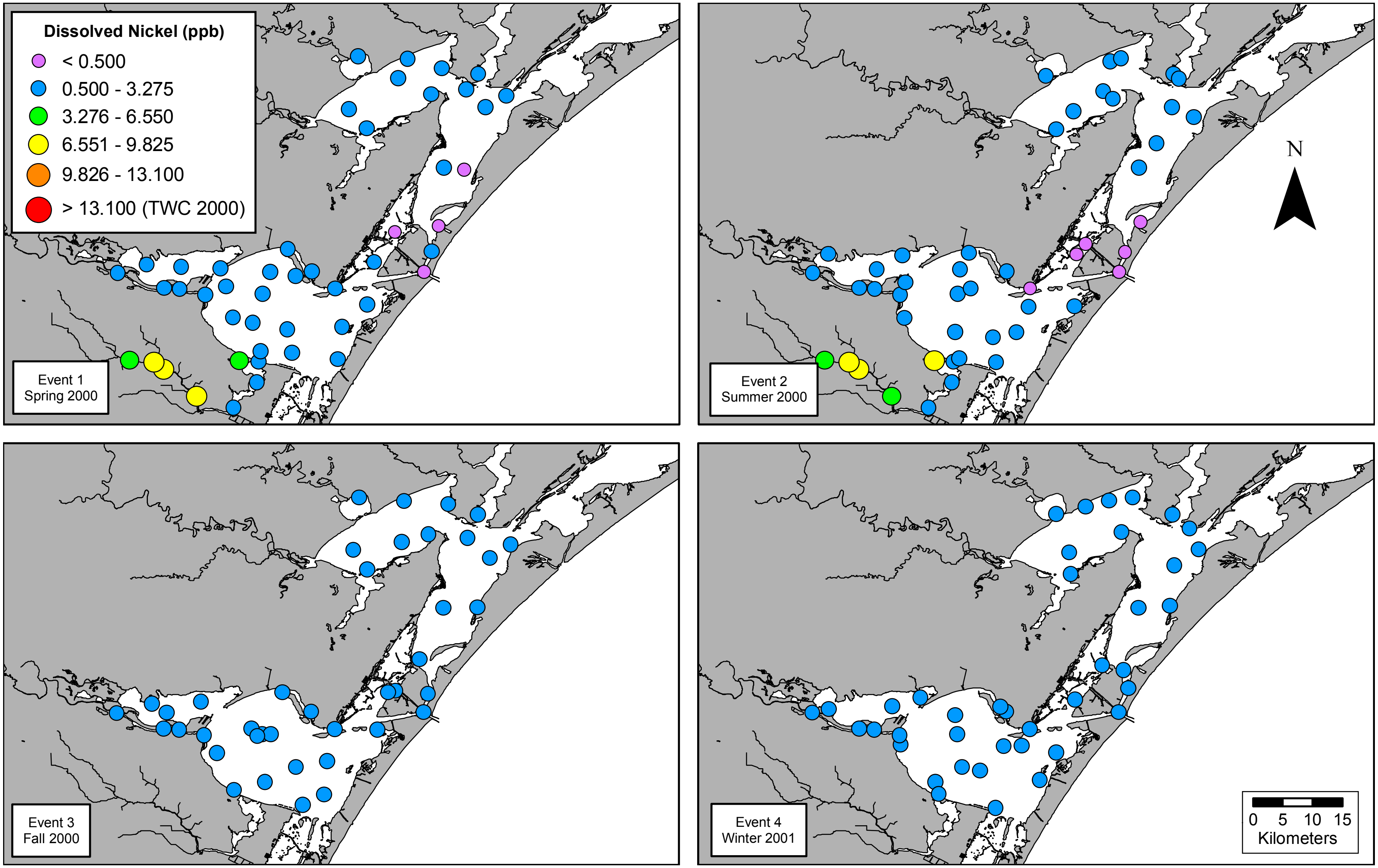

Fig. 3.28. Dissolved Nickel concentrations ($\mu g/l^{-1}$ or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

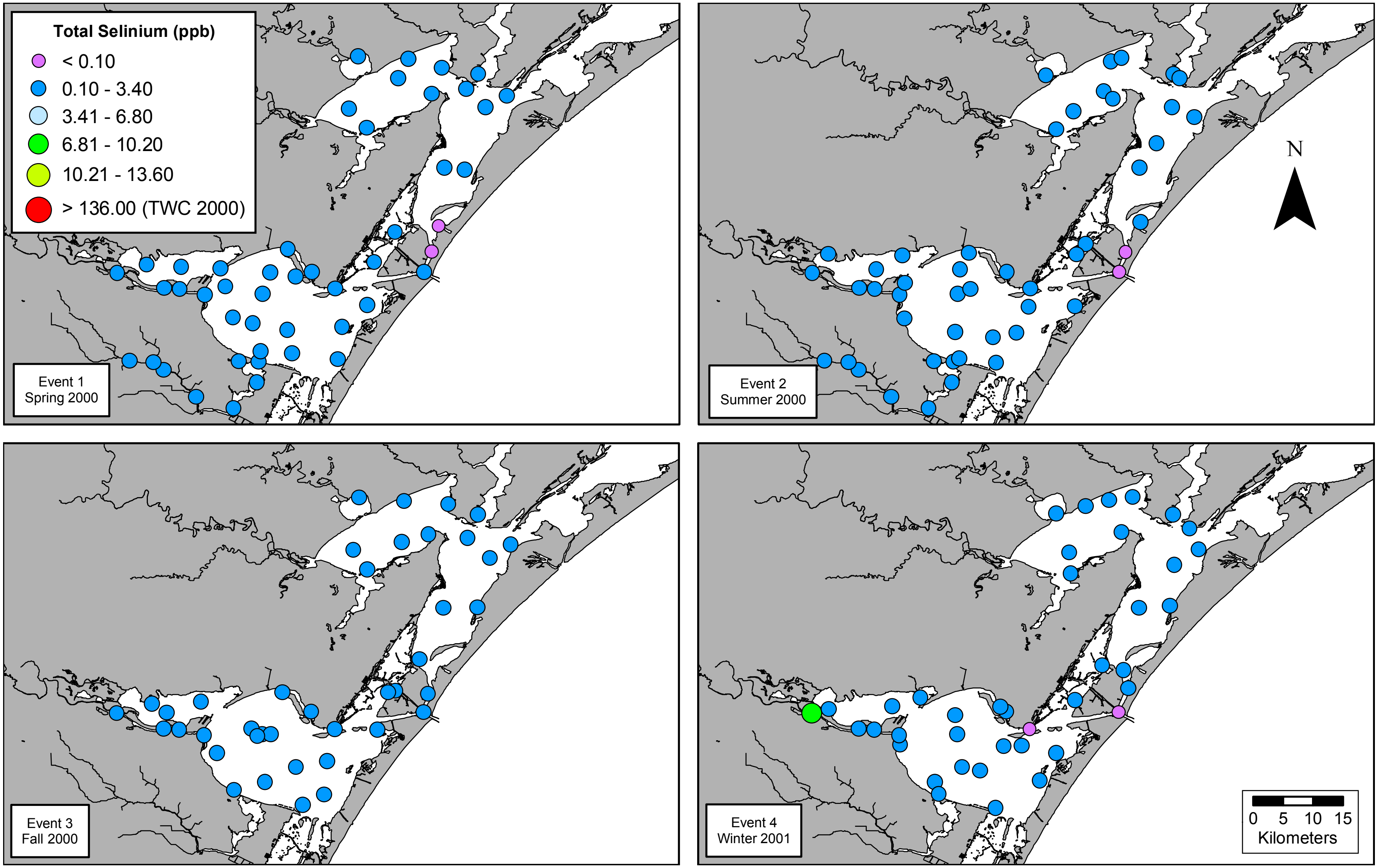

Fig. 3.29. Total Selenium concentrations (µg/l^{-1} or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

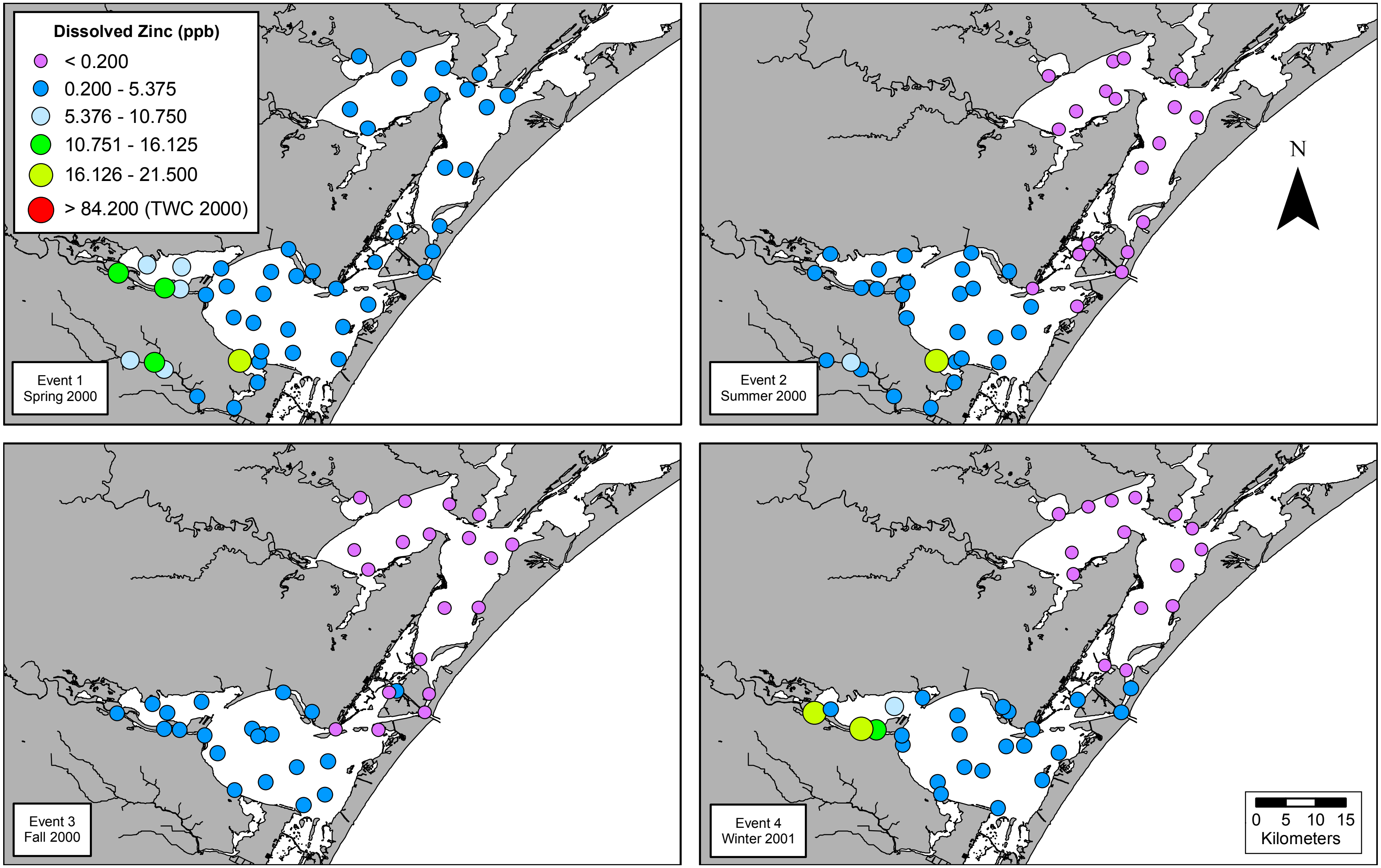

Fig. 3.30. Dissolved Zinc concentrations ($\mu g/l^{-1}$ or ppb) at both randomly selected EMAP and fixed TCEQ stations for RCAP 2000.

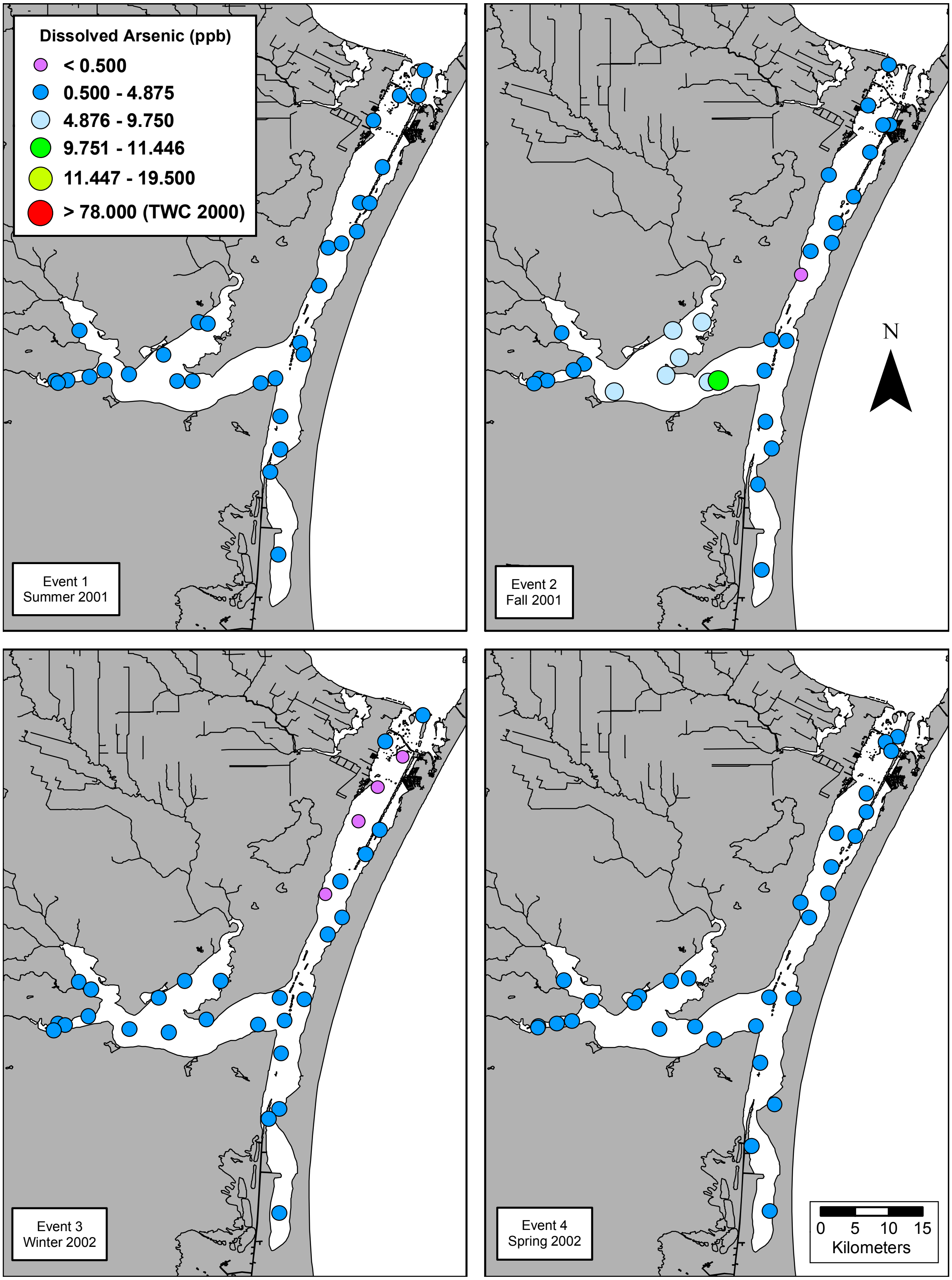

Fig. 3.31. Dissolved Arsenic concentrations ($\mu g/l^{-1}$ or ppb) at randomly selected EMAP stations for RCAP 2001.

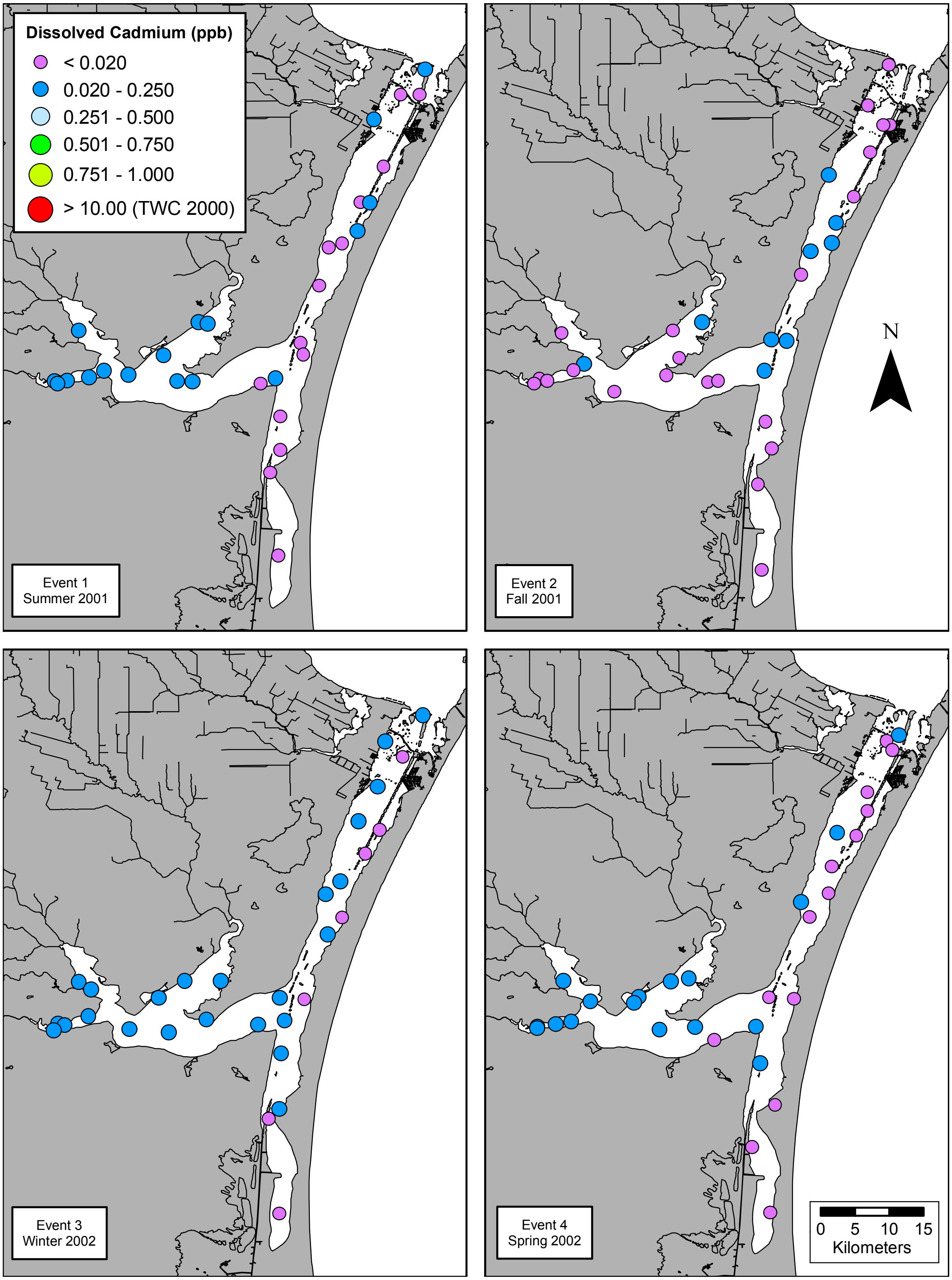

Fig. 3.32. Dissolved Cadmium concentrations ($\mu g/l^{-1}$ or ppb) at randomly selected EMAP stations for RCAP 2001.

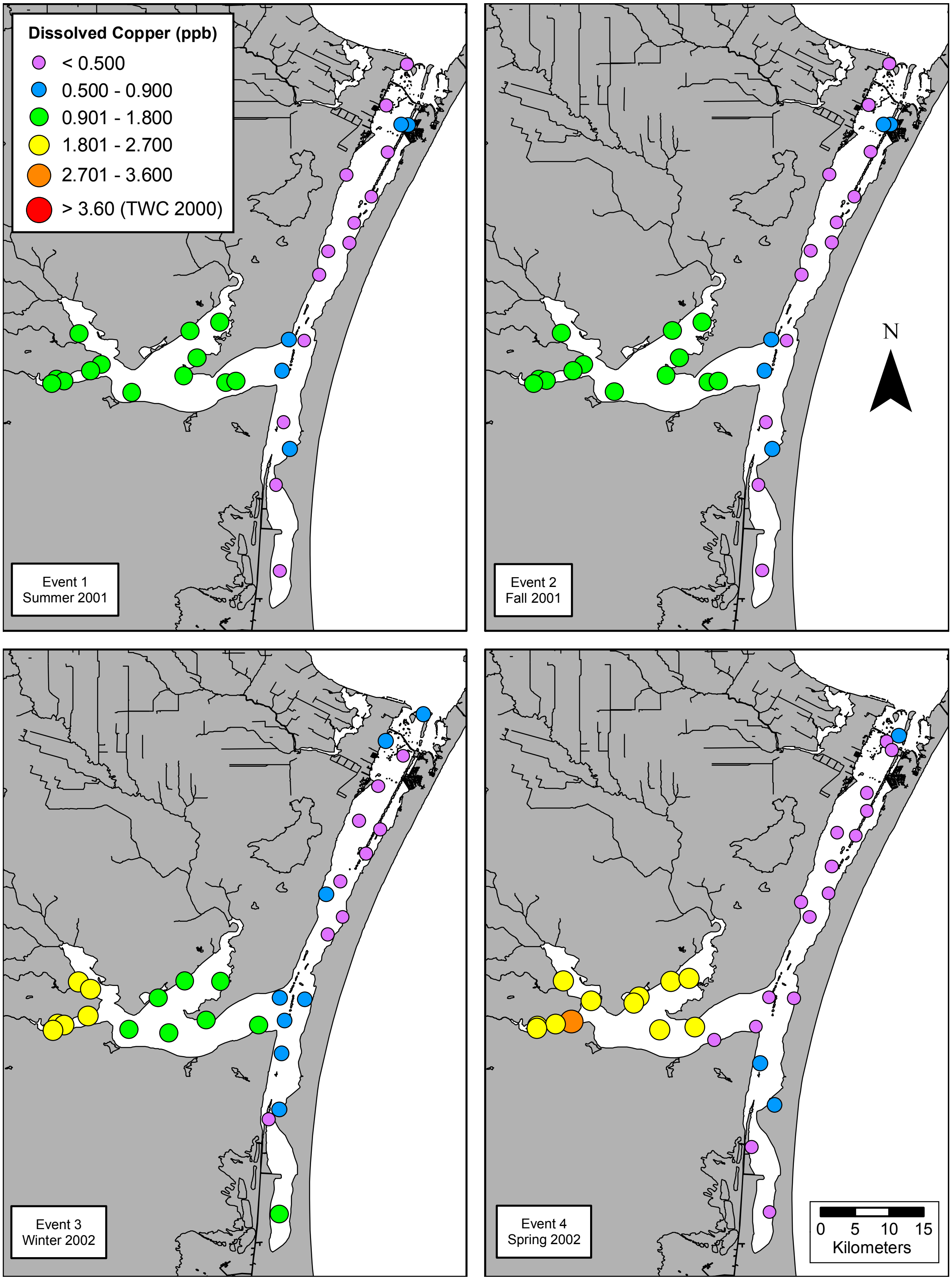

Fig. 3.33. Dissolved Copper concentrations (µg/l^{-1} or ppb) at randomly selected EMAP stations for RCAP 2001.

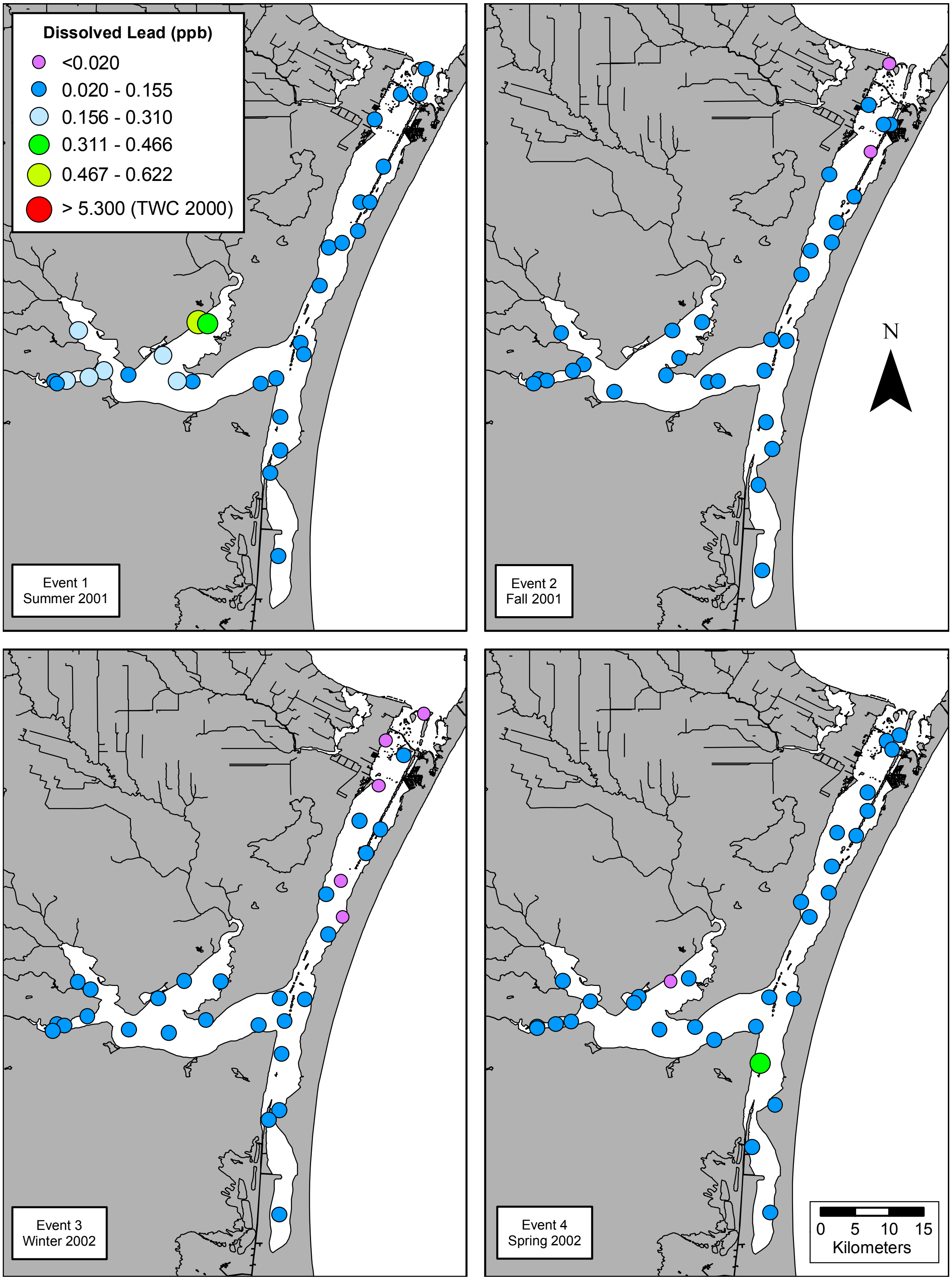

Fig. 3.34. Dissolved Lead concentrations ($\mu g/l^{-1}$ or ppb) at randomly selected EMAP stations for RCAP 2001.

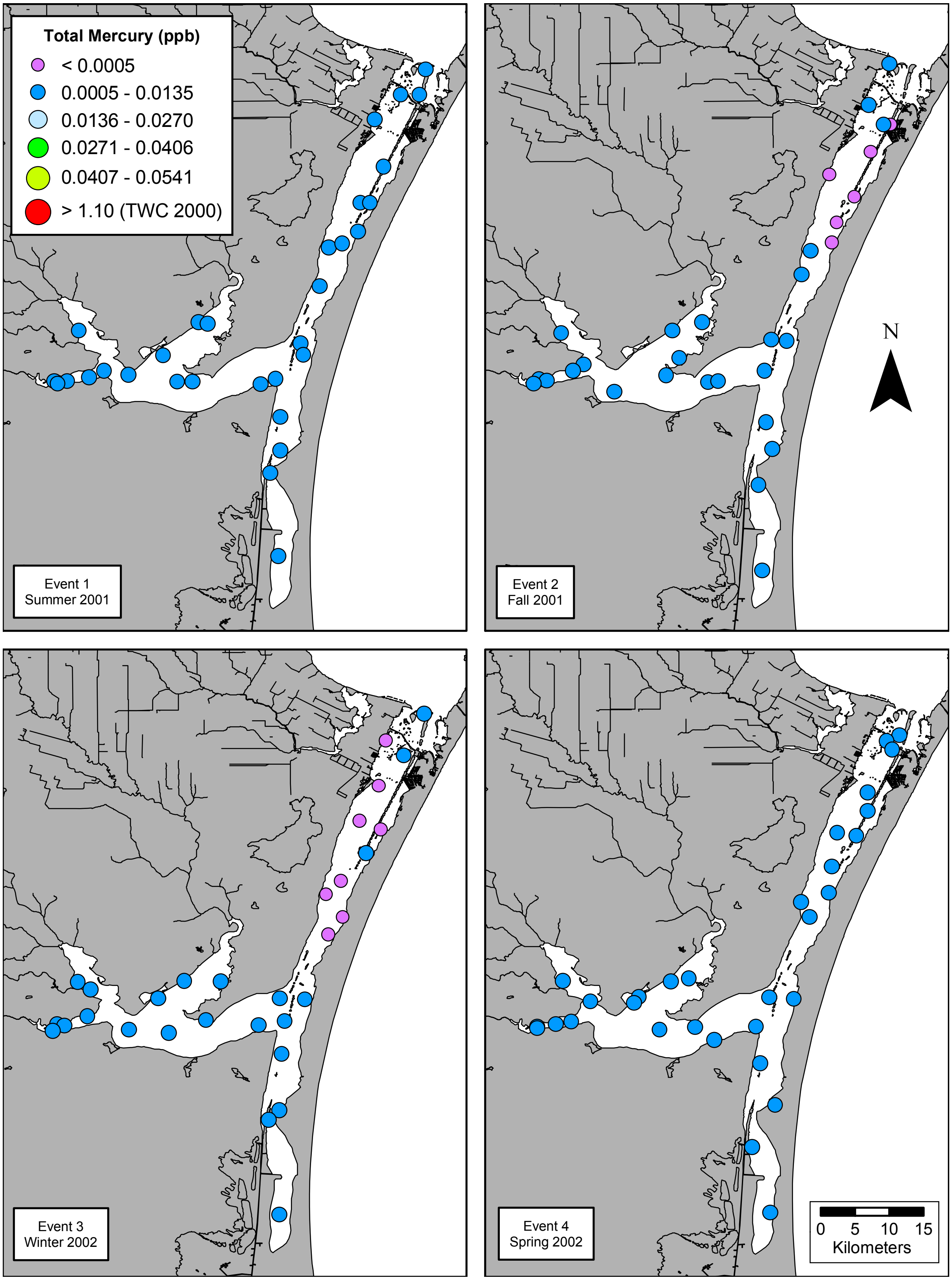

Fig. 3.35. Total Mercury concentrations ($\mu g/l^{-1}$ or ppb) at randomly selected EMAP stations for RCAP 2001.

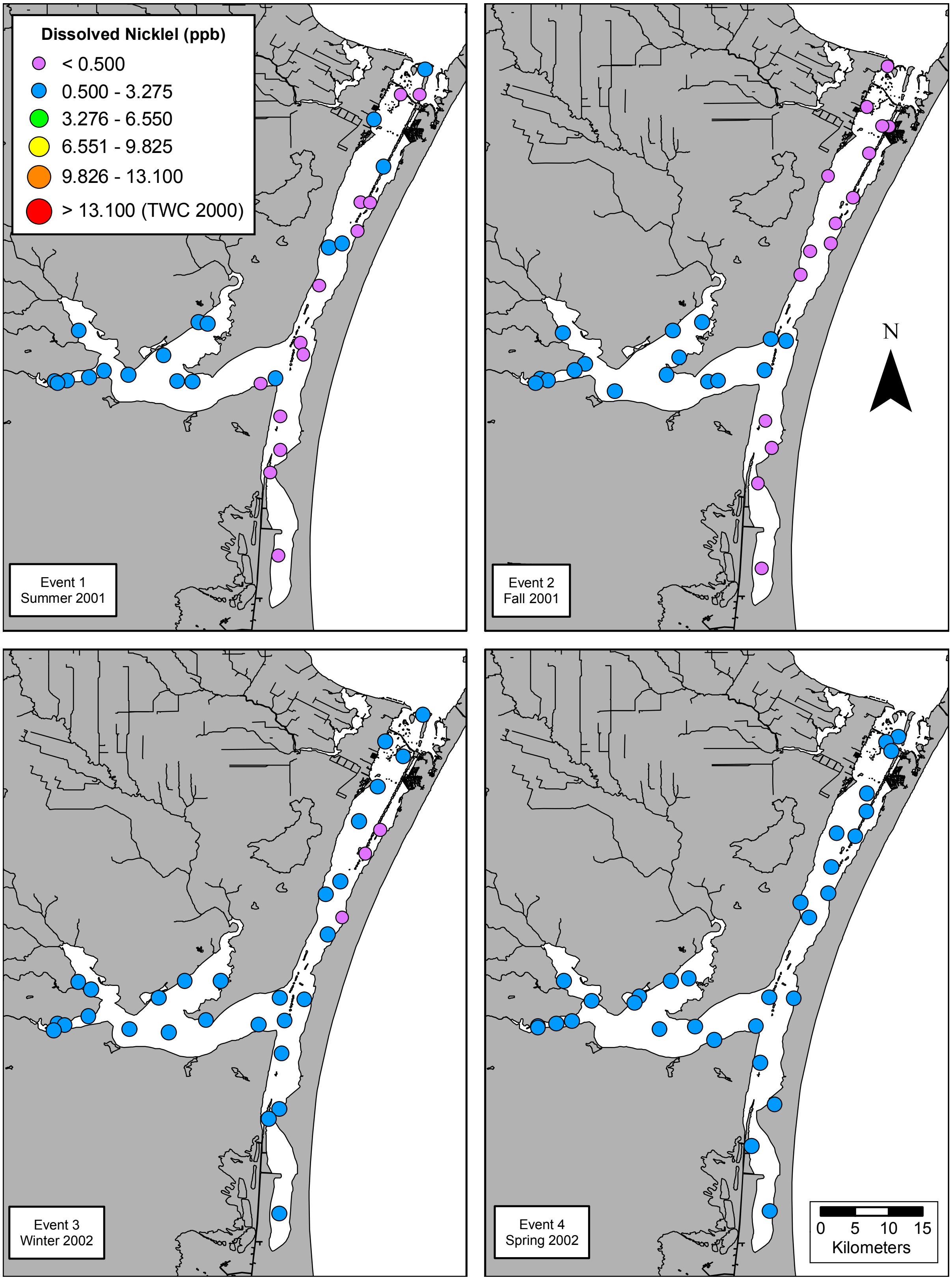

Fig. 3.36. Dissolved Nickel concentrations ($\mu g/l^{-1}$ or ppb) at randomly selected EMAP stations for RCAP 2001.

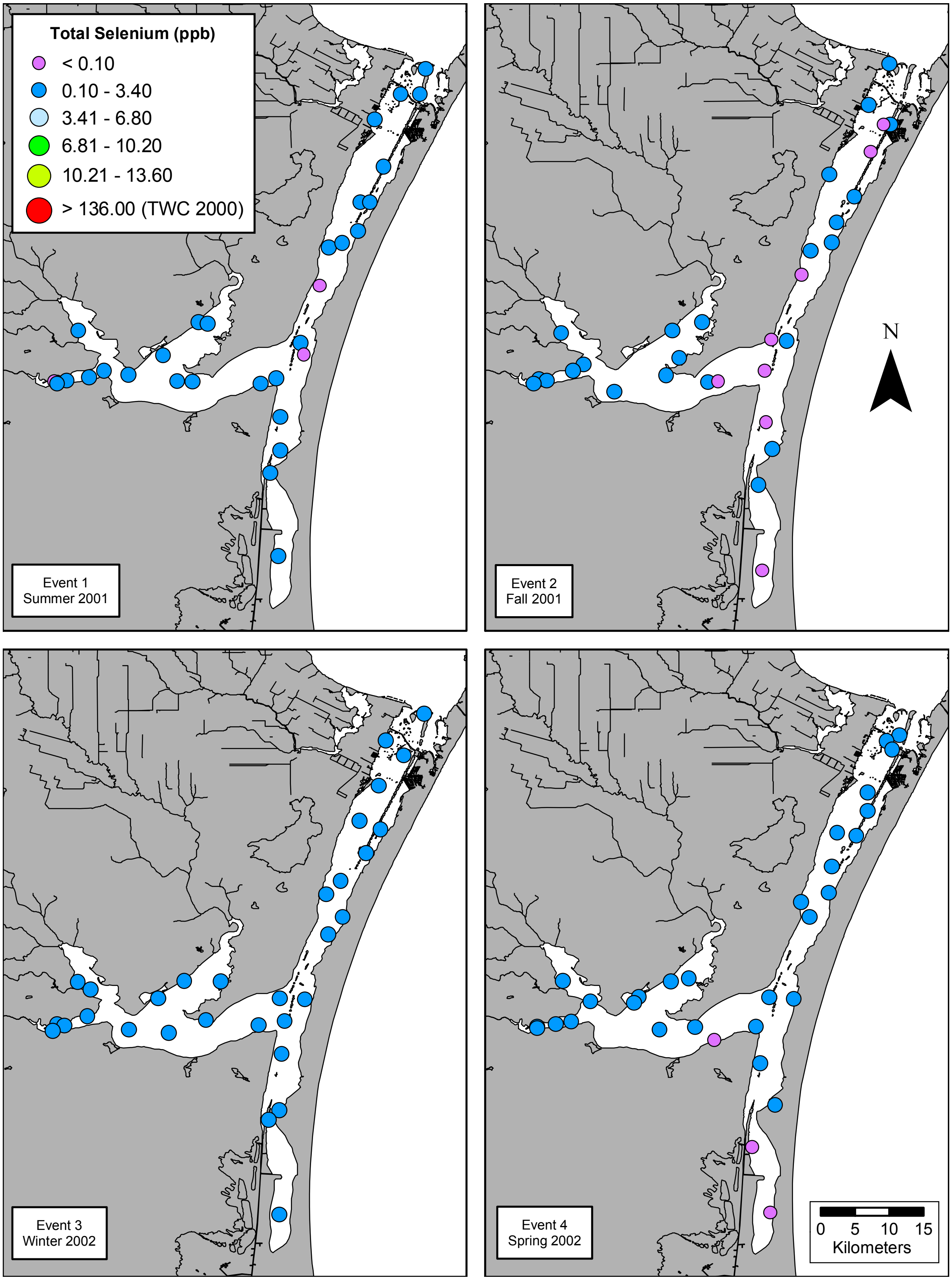

Fig. 3.37. Total Selenium concentrations (µg/l^{-1} or ppb) at randomly selected EMAP stations for RCAP 2001.

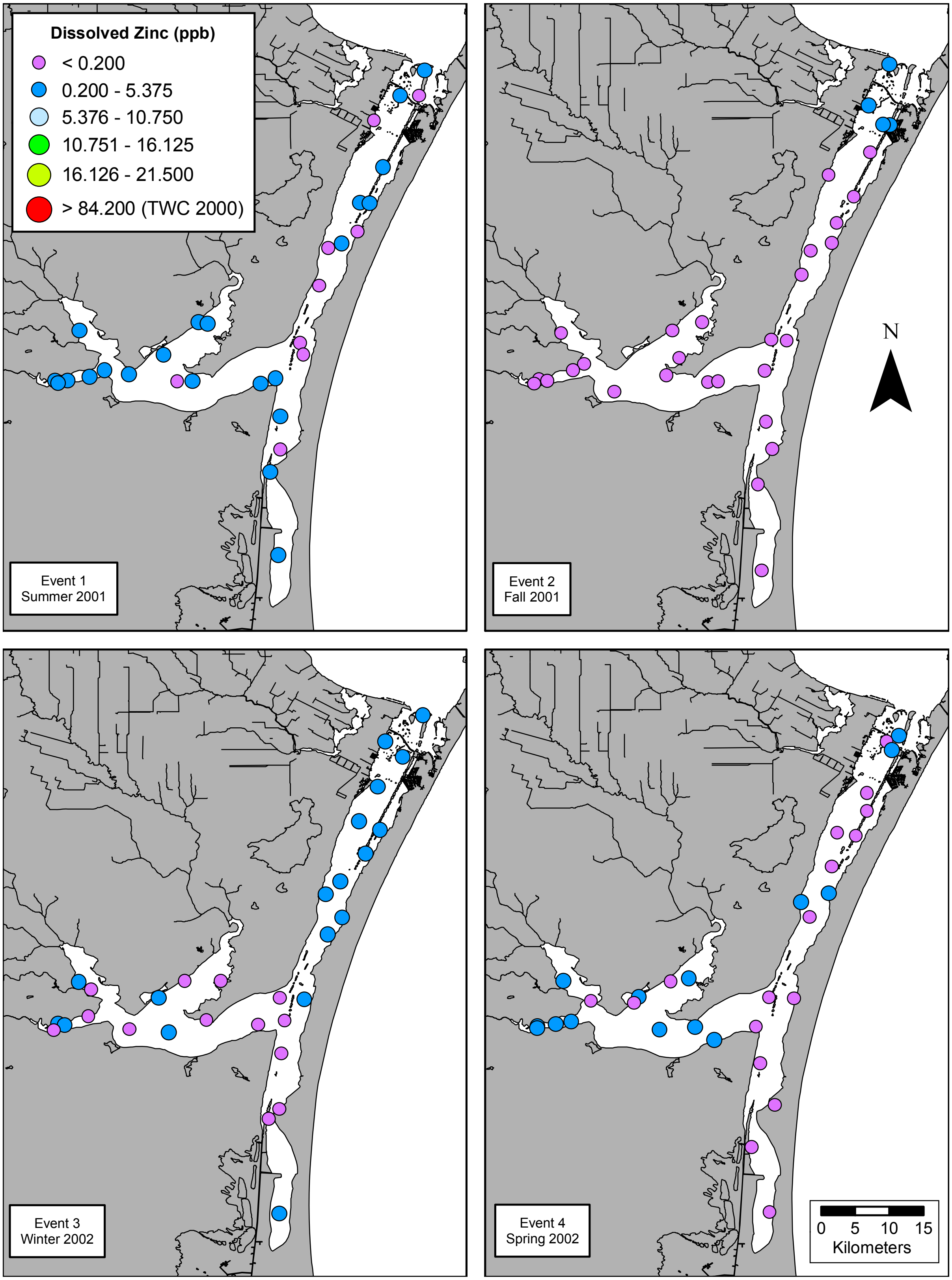

Fig. 3.38. Dissolved Zinc concentrations (µg/l^{-1} or ppb) at randomly selected EMAP stations for RCAP 2001.

3.4 Summary

Initial evaluation of water quality within the CBBEP region shows while concerns exist in areas historically known to have nutrient problems, overall, conditions are good. Monitoring and assessing water quality conditions within the Coastal Bend region is a high priority for the CBBEP. In cooperation with state and federal authorities, the CBBEP intends to augment ongoing compliance (TCEQ) and ambient (EPA EMAP) monitoring, as historically this monitoring occurs in separate and often dissimilar sampling programs (USGS 1995).

The goal of improving national water quality is an enormous task, and far too big for one entity to accomplish. Dwindling monetary resources will require cooperative partnerships on all levels. Accurate characterization requires comprehensive monitoring to address resources at risk and programs must evolve to use integrated measures of water and sediment quality, along with biological community health, to achieve the best conditions possible. Most importantly, the commitment must be long term, as typically the amount of comprehensive data available is not sufficient to determine trends in overall quality within a system (Rabalais 1992; USGS 1995; Bricker et al. 1999; CENR 2003; Sanger et al. 2003).

Field Data

Regarding temperature, which along with salinity directly influences the amount of dissolved oxygen in the water column and plays an important part in habitat conditions for living resources, values were typical for our region. Another indicator of possible stressful estuarine conditions is pH, a principal factor controlling contaminant and nutrient availability to living resources. While pH varies with dissolved oxygen levels and salinity, typically, the pH of estuarine and coastal waters ranges from 7.5 to 8.5. During the course of RCAP 2000 and RCAP 2001 pH concentrations remained within this range except for areas within Oso Creek (Segment 2485A) and Oso Bay (Segment 2484) where values ranged slightly, but not dramatically, higher (8.75) downstream of wastewater treatment plants.

As previously stated, salinity serves as a measure of habitat stress in estuarine systems due to its influence on distribution, abundance, and diversity of biological resources. Within the CBBEP region, concentrations typically are quite high due to natural climate conditions, limitations on freshwater inflow, and the hypersaline characteristics of the Laguna Madre. During RCAP 2000, values were typical for the region during what characterizes as a period of reduced freshwater inflows. However, characteristic salinity gradient patterns did exist during portions of the study when freshwater inflows increased (see Fig. 3.6). During RCAP 2001, salinity concentrations were typically higher since sampling occurred in the Laguna Madre and Baffin Bay area, but the influence of increased freshwater inflows was also apparent (see Fig. 3.7). In general, salinity patterns observed appeared “normal” for the region but the influence of reduced, or lack of, freshwater inflows remains a critical factor for sustaining the health of the estuarine systems within the CBBEP region.

Dissolved oxygen represents the most essential water quality parameter utilized in assessing aquatic life use and the health of a water body. Strongly influenced by temperature and salinity (e.g. freshwater inflows) along with point and non-point discharges it is the fundamental parameter used by regulatory agencies and researchers in evaluating the health of the system (Sanger et al. 2003). While some dissolved oxygen concentrations in RCAP 2000 and RCAP 2001 fell in the “biologically stressful” range of >2.0 mg/l^{-1} but <5.0 mg/l^{-1} (one hypoxic value of <2.0 mg/l^{-1}) overall conditions indicated that based on one-time grab sampling overall dissolved oxygen quality for the CBBEP region can be considered very good (see Figs. 3.8 and 3.9).

Routine Conventional Water Chemistry

Due to the lack of established nutrient criteria, TCEQ utilizes four nutrients (Ammonia, Nitrate + Nitrite, Total Phosphorus, and Orthophosphate) and chlorophyll *a* to assess and identify secondary concerns for aquatic life uses when evaluating the condition of waters in the Texas. As nutrient impacts, and resulting eutrophication often reflected in elevated chlorophyll *a* concentrations, can have profound effects on estuarine waters, knowledge gained from these parameters is vital.

Unfortunately for RCAP 2000, and as explained in Section 3.3.2.2 and 3.3.2.4, the first year of this program did not produce what we consider as viable results for two parameters (Nitrate + Nitrite and Orthophosphate). Changes in program procedures should yield data that are more viable in future years. Concerns identified for nutrients tended to occur in areas historically known to have problems and cited on the *Texas Water Quality Inventory and 303(d) List* compiled by TCEQ. With the exception of Nueces Bay, which had a 41.6% exceedance of the Total Phosphorus screening level, and discounting the problems addressed with Nitrate + Nitrite and Orthophosphate, the majority of the segments sampled in RCAP 2000 did not show concerns for nutrient enrichment or elevated chlorophyll *a* concentrations. Therefore, we evaluate nutrient and chlorophyll *a* conditions in the CBBEP region as relatively good, but needing some improvement.

For RCAP 2001, while there were some instances of nutrient exceedances none was above the 25% exceedance level used by TCEQ to list a segment with Secondary Concerns. However, chlorophyll *a* did exceed the SLE 2000 for the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) 51.9% of the time. While the Laguna Madre (Segment 2491) did not cross the 25% threshold, it did come close, exceeding the SLE 2000 21.5% of the time.

Hinga et al. (1995) suggest that chlorophyll *a* may be a better immediate indicator of water quality conditions than nutrient concentrations. Affected by biological uptake capabilities, grazer interactions, temperature, turbulence, and turbidity levels, concentrations of nitrogen or phosphorus occurring in water column samples may underestimate nutrient availability because of the large nutrient reserves existing in sediments.

Hydrodynamics related to residence times and mixing may play a role in chlorophyll *a* concentrations seen in RCAP 2001. Typically enclosed bays systems or coastal lagoons, such as the Baffin Bay complex and Upper Laguna Madre, experience limited flushing. Limits to flushing and increased residence times often produce elevated chlorophyll *a* concentrations. As opposed to well-flushed systems that tend to dilute nutrients and transport them out of the system making them unavailable. High flushing also produces high turbidity levels that limit light available for photosynthesis (Monbet 1992).

Monbet (1992) also noted that increased rainfall, especially when nutrients cascade into a system, results in higher chlorophyll *a* levels and that elevated levels occur when temperature and light levels are high because these conditions are optimal and typically produce increased phytoplankton concentrations.

Regarding the SLE 2000 exceedances for chlorophyll *a* in the Baffin Bay complex, we find that many of these conditions existed during RCAP 2001. Typically, this system experiences poor flushing and long residence times. During RCAP 2001, chlorophyll *a* exceeded the screening level 42.9% of the time in summer, when the highest mean water temperatures occurred, and 46.4% of the time in fall, when increased inflows to the system lowered salinities and inputs to the system produced 88.9% of the Total Phosphorus exceedances.

While some of these exceedances may be part of natural hydrodynamics within the system, they also indicated the presence of nutrient pulses to the system that require additional monitoring to assess trends within this segment. Within the Laguna Madre (Segment 2491), the only discernible pattern observed was that 64.3% of the chlorophyll *a* exceedances occurred at stations located at the mouth of Baffin Bay or south of Baffin Bay in the Land Cut and Nine-Mile Hole area; occurring during each sampling event.

Microbiological Indicators

Currently, 14 coastal water body segments in Texas, including the Copano/Mission/Port Bay (Segment 2472) area are undergoing assessment by the TCEQ TMDL group for bacteria impairments related to the Oyster Water Use (Fecal Coliform criteria). The addition of bacteria sampling in RCAP 2001 is to provide data using the new criterion, Enterococci, in the assessment of the Contact Recreation Use (CRU) for water within the CBBEP. At present, only Oso Creek (Segment 2485A) and Oso Bay (Segment 2485) show impairment for this use. While sampling did not occur in these segments during RCAP 2001, some sampling will occur in future events. Analysis of RCAP 2001 data showed that even with three exceedances for the CRU in the Laguna Madre (Segment 2491), based on the current criteria of 104 CFU/100ml, water quality can be considered very good within the southern CBBEP region.

Trace Metals

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. There have been tremendous gains in reducing inputs and reversing problems associated with trace metal contamination nationwide (Kennish 1992; Mann 2000). 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 of aqueous trace metals concentrations within the CBBEP region, the results of this portion of the monitoring project are excellent. We strongly feel that utilization of ultra-clean sampling and analysis techniques provided the highest quality data available and encourage their use in applicable monitoring programs.

Many people associated with the natural resources of our area did not believe that a problem existed but lacked the necessary data to assess the nature of aqueous trace metal concentrations within the area. The two DEM methods applied served as an approach to view the data from different perspectives but the primary method, using DEM 1, or applying TCEQ criteria to evaluate RCAP 2000 and 2001 results was the most critical. As this method identified **no** aqueous metal concentrations exceeding chronic TCEQ 2000 Tidal Water

Criteria for the entire area, we feel that water quality regarding trace metals in water is very good to excellent. Increased metals concentrations occurred within the Corpus Christi Inner Harbor as expected, but in general, the picture looks good. We suggest implementation of continued monitoring, perhaps on a reduced scale, to track trends within this segment, especially for copper.

In addition, copper monitoring is highly recommended within the Baffin Bay complex (Segment 2492). Even though all sample concentrations fell below the applicable criteria, the fact that elevated concentrations like those seen in the Corpus Christi Inner Harbor occurred in this remote, non-industrialized area, requires additional analysis. Several upstream industrial complexes exist that have permitted discharges into creeks and streams that feed into the Baffin Bay complex. Further analysis of data for these reaches is required to see if any patterns or sources are discernible.

3.5 References

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4.0 SEDIMENT MONITORING

4.1 Introduction

When contaminants enter estuarine systems, they bind to suspended particulates in the water column. Suspended particulates settle out, or sink, to the underlying sediments at varying rates dependent on particle size, metrological, and hydrological conditions (i.e. high wind speed and wave height). Typically, highest contaminant concentrations occur in the top 5 centimeters of estuarine bottom sediments. As trace metals do not degrade into other substances, high trace metal concentrations may result in permanent sediment contamination. Contaminated sediments may now act as sources for additional sediment contamination. Sediment re-suspension caused by disturbances from excessive wind and wave conditions, boat traffic, or dredging operations can transport sediment contaminants across wide areas (Kennish 1992, GBEP 2002, SFEI 2004).

In addition, since sediments provide biological habitat, potential effects may result when deposit-feeding organisms ingest sediment particles and accumulate sediment contaminants into body tissue. While not all sediment contaminants are biologically available, some may yield potentially harmful effects through bioaccumulation and possible biomagnification through the food web (Kennish 1992).

For these reasons, water column assessment for trace metal contaminants provides a snapshot of metal inputs into the aquatic environment where as sediments provide information to assess metal enrichment over a temporal scale (Schropp et al. 1990). As the RCAP program will provide yearly sampling for five years, sediment monitoring is an important component for assessing long-term status and trends.

Natural processes typically can provide low-level environmental inputs of certain trace metals. However, wide varieties of anthropogenic activities tend to produce excessive inputs and may result in potential metal contamination within the estuarine environment. These activities include point and non-point sources from agriculture, automobiles and boats, wastewater treatment plants, urban runoff, and numerous industrial activities (USEPA 1998). Metals often associated with agriculture include arsenic, copper, and lead. Automobiles and boats are sources of cadmium, chromium, copper, lead, nickel, and zinc. Pollutants associated with industrial activities include, cadmium, copper, lead, mercury, nickel, zinc, and other metals (USEPA 1998). Therefore, regulatory agencies, and informed citizens, often consider contaminated sediments as a primary indicator of poor estuarine conditions. Accurate, reliable, and substantial amounts of sediment contamination data is necessary to make decisions ensuring best management practices that protect and enhance the estuarine environment of the CBBEP region.

4.2 Sampling Design and Data Evaluation

Monitoring for trace metals in sediment occurred at 30 EMAP stations during Sampling Event 4 (March 2001) of RCAP 2000 and 31 EMAP stations during the Sampling Event 1 (August 2001) of RCAP 2001. Table 6.1.4 and 6.1.5 in the *Data Tables* chapter and Figure 4.1 provide pertinent station information.

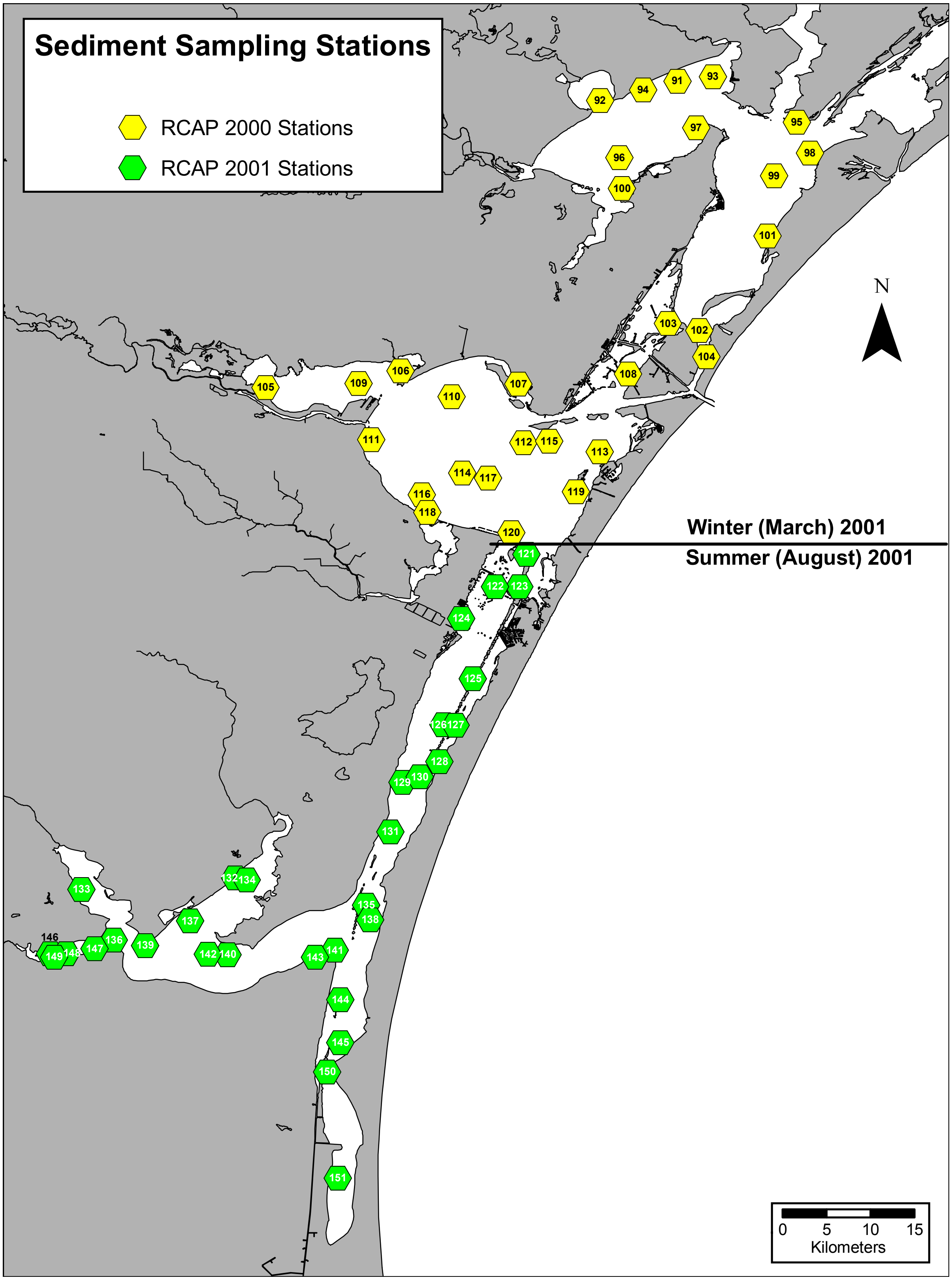

Fig. 4.1. Map of RCAP sediment sampling stations. 30 stations sampled during RCAP 2000 (March 2001) and 31 stations sampled during RCAP 2001 (August 2001).

4.2.1. Sediment Quality Guidelines and Screening Levels

The TCEQ utilizes various approaches for assessing sediment quality in the State of Texas. Currently, regulatory criteria do not exist for the majority of sediment contaminants. However, TCEQ does 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 85^{th} percentiles of all Surface Water Quality Monitoring (SWQM) data and the Probable Effects Levels (PELs) guidelines developed by NOAA through its National Status and Trends Program. TCEQ revises the sediment 85^{th} 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 both the 85^{th} percentiles and PELs should be 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 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. Data Evaluation Methods (DEM)

A complete list of parameters measured during the RCAP 2000 and 2001 sampling events are contained in Table 2.2 of the *Sampling Design and Approach* chapter. The *Data Tables* in Chapter 6.0 provide actual concentration values for each metal recorded at an individual station location (Table 6.9.1). We analyzed and evaluated the data by TCEQ Segments and present summary descriptive results in Table 6.10.1 through 6.10.5, providing both mean and geometric mean values for sediment data. Using a geometric mean tends to dampen the influence of the highest and lowest concentrations and may provide a more realistic mean value for the segment.

As previously stated for Trace Metals in Water (Section 3.2.2), we continue to stress that the use of **"high"** or **"elevated"** concentrations within this section pertains, in most cases, to relationships between stations sampled than to concentrations found above a certain detrimental level; **as most trace metal concentrations within sediments** sampled during RCAP 2000 and RCAP 2001 **were relatively low**.

We used three methods (DEM 1, 2, and 3) to assess metal concentrations in sediment for RCAP 2000 and 2001. DEM 1 followed regulatory procedures used by TCEQ and evaluated metal concentrations by PEL and 85th percentile screening levels. DEM 2 utilized the PRIMER v5.0 (Plymouth Routines in Multivariate Ecological Research) software program developed by Clark and Warwick (2001) for analysis of metal data using multivariate non-metric Multidimensional Scaling (MDS). Building on similarity (Normalized Euclidean Distance) matrix rankings of metal species and concentrations, procedures compute spatial coordinates for a set of points (i.e. metal concentrations) where distances between pairs of points fit as closely as possible to the measured similarity between a corresponding set of objects (i.e. Stations) (Tolan and Newstead 2004). This identifies station groupings based on similar concentrations, with the MDS plot providing a graphical representation of those groupings.

DEM 3 identified stations characterized as metal enriched through anthropogenic activities. A common procedure is normalizing metal concentrations to grain size differences, but this approach cannot successfully compensate for metal variability because determination of natural trace metal concentrations, and their variability in sediments, relates not only to grain size, but also to composition of minerals and secondary compounds (Aloupi and Angelidis 2001). However, utilization of aluminum is common because it is an abundant element in the earths crust; and metal:aluminum ratios characteristically remain relatively constant, and there are typically no significant anthropogenic sources (Summers et al. 1996).

Aluminum was the normalization factor we choose because both sampling events had highly correlated Aluminum: Silt-Clay ratios with exhibiting strong linear relationships: RCAP 2000 (n = 30, Pearson's correlation = 0.958, R^2 = 0.919) and RCAP 2001 (n = 31, Pearson's Correlation = 0.966, R_2 = 0.934). We used mathematical relationships between aluminum concentrations and concentrations of the other elements sampled to determine enrichment by using a regression equation for each metal against corresponding aluminum concentrations found in the sediment (Summer et al. 1996; Aloupi and Angelidis 2001). Regression analysis was significant when slope coefficients ($ß_1$) were positive and significantly different from zero ($p<0.001$).

4.3 Results and Discussion

4.3.1. Sediment Characteristics

Total Organic Carbon (TOC) provides a relative measure of the organic matter contained in sediments. For RCAP 2000, the highest individual TOC concentration of 11.4% TOC occurred at Station 91 in Copano Bay/Port Bay/Mission Bay (Segment 2472). Segment 2472 had the highest mean TOC enrichment value of 4.21% TOC (Table 6.10.1). Within the segment, 29% the stations sampled yielded high enrichment values of >5% TOC, 43% of the stations yielded moderate enrichment values of 2 to 5%, and 29% of the stations yielded low enrichment values of <2.0% TOC (Table 4.1).

Lowest individual TOC values of 0.03% occurred at Station 107 in the La Quinta Channel area of Corpus Christi Bay (Segment 2481). Within Segment 2481, 54% of the stations showed low enrichment, 38% moderate enrichment, and 8% high enrichment (Table 4.1), yielding a mean TOC enrichment value of 2.03% for the entire segment (Table 6.10.1).

Geographical distribution of sediment TOC appears on Figs. 4.2 and actual RCAP 2000 values are in Table 6.9.1.

The percentage of mud (silt/clay) within sediments is an important aspect in determining which benthic organisms might exist within an area and the possible bioavailability of some contaminants to the local biological community. Silt/Clay proportions for RCAP 2000 stations showed Segment 2472 had the highest mud (>80%) content with Segment 2481 yielding the highest muddy sand (20-80%) content (Table 4.1). Both segments produced highest mean Silt/Clay values (Table 6.10.1). Aransas Bay (Segment 2471) contained higher percentage of stations with sand (<20%). Geographical distribution of Silt/Clay proportions appear on Fig. 4.3 and actual values are in Table 6.9.1.

RCAP 2001 stations in the Laguna Madre (Segment 2491) consisted of low to moderate TOC enrichment 80% and 20% of the time, respectively (Table 4.1) and produced a mean TOC concentration of 1.35% for the segment (Table 6.10.1). TOC concentrations ranged from 0.02% at Station 124 to a high of 3.21% at Station 129 (Fig. 4.2). Segment 2492 in the Baffin Bay complex also exhibited low to moderate enrichment at 86% and 14% of the stations sampled, respectively. Geographical distribution of sediment TOC appears on Figs. 4.2 and actual RCAP 2001 values are in Table 6.9.2.

Proportions of Silt/Clay for RCAP 2001 stations showed Segment 2491 to be predominantly muddy sand (20-80%) while Segment 2492 in the Baffin Bay complex was primarily composed of stations with high mud content (Tables 4.1 and 6.10.1 and Fig. 4.3). Geographical distribution of Silt/Clay proportions appears on Fig. 4.3 and actual values are in Table 6.9.2.

Table 4.1. Sediment characteristics distribution listed by TCEQ Segment.

RCAP	Segment	Segment Name	n	% TOC			% Silt/Clay		
				<2% (Low)	2-5 (Med)	>5% (High)	<20% (Sand)	20 - 80 (Mud-Sand)	>80% (Mud)
2000	2471	Aransas Bay	6	100	-	-	50	50	-
	2472	Copano Bay/Port Bay/ Mission Bay	7	29	43	29	14	43	43
	2481	Corpus Christi Bay	12	54	38	8	8	58	34
	2482	Nueces Bay	3	100	-	-	-	100	-
	2483	Redfish Bay	2	100	-	-	-	100	-
2001	2481	Corpus Christi Bay	2	100	-	-	100	-	-
	2491	Laguna Madre	15	80	20	-	7	93	-
	2492	Baffin Bay/Alazan Bay/ Cayo del Grullo/Laguna Salada	14	86	14	-	7	36	57

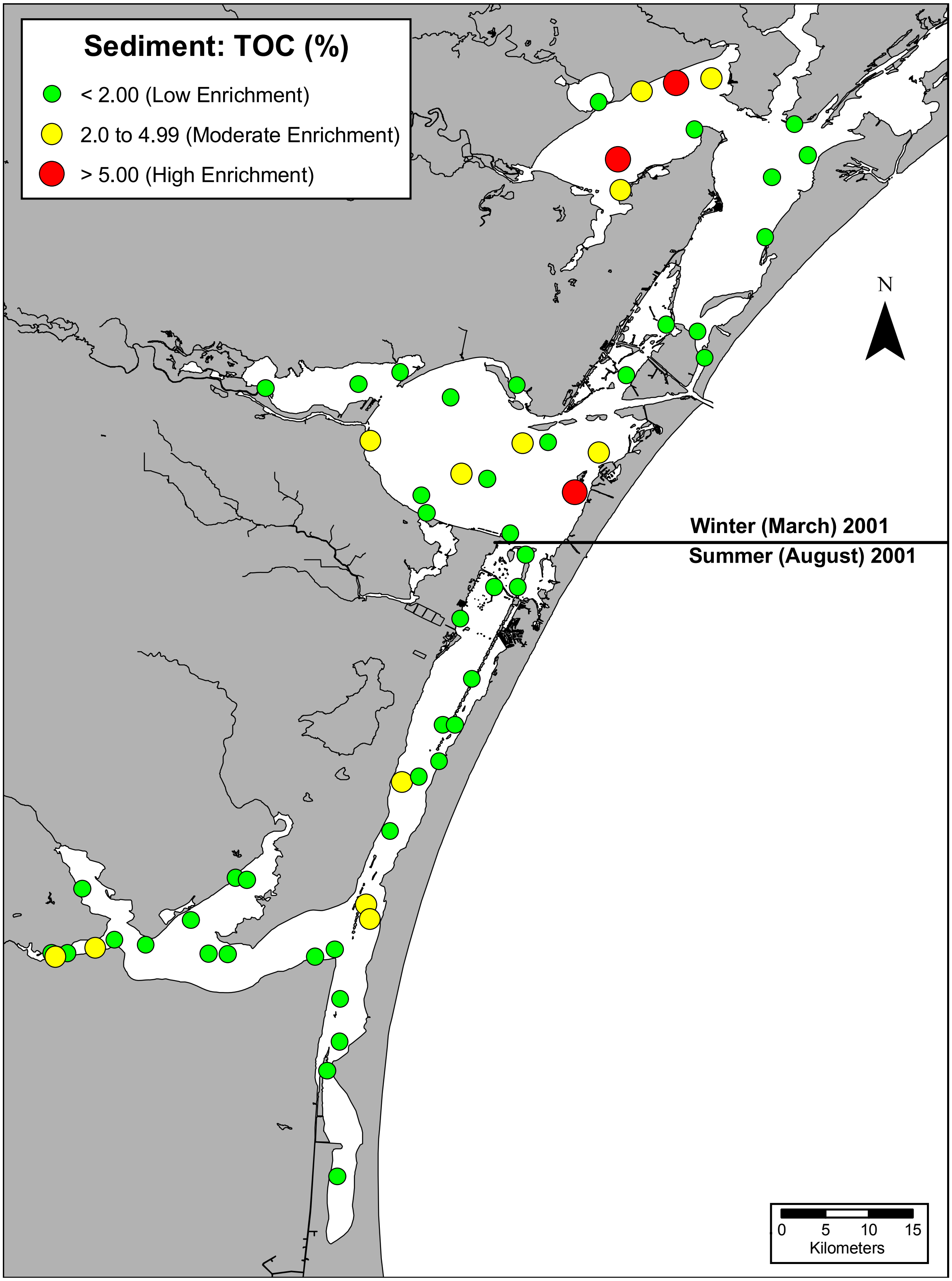

Fig. 4.2. Total Organic Carbon sediment concentrations (% dry weight) for 30 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

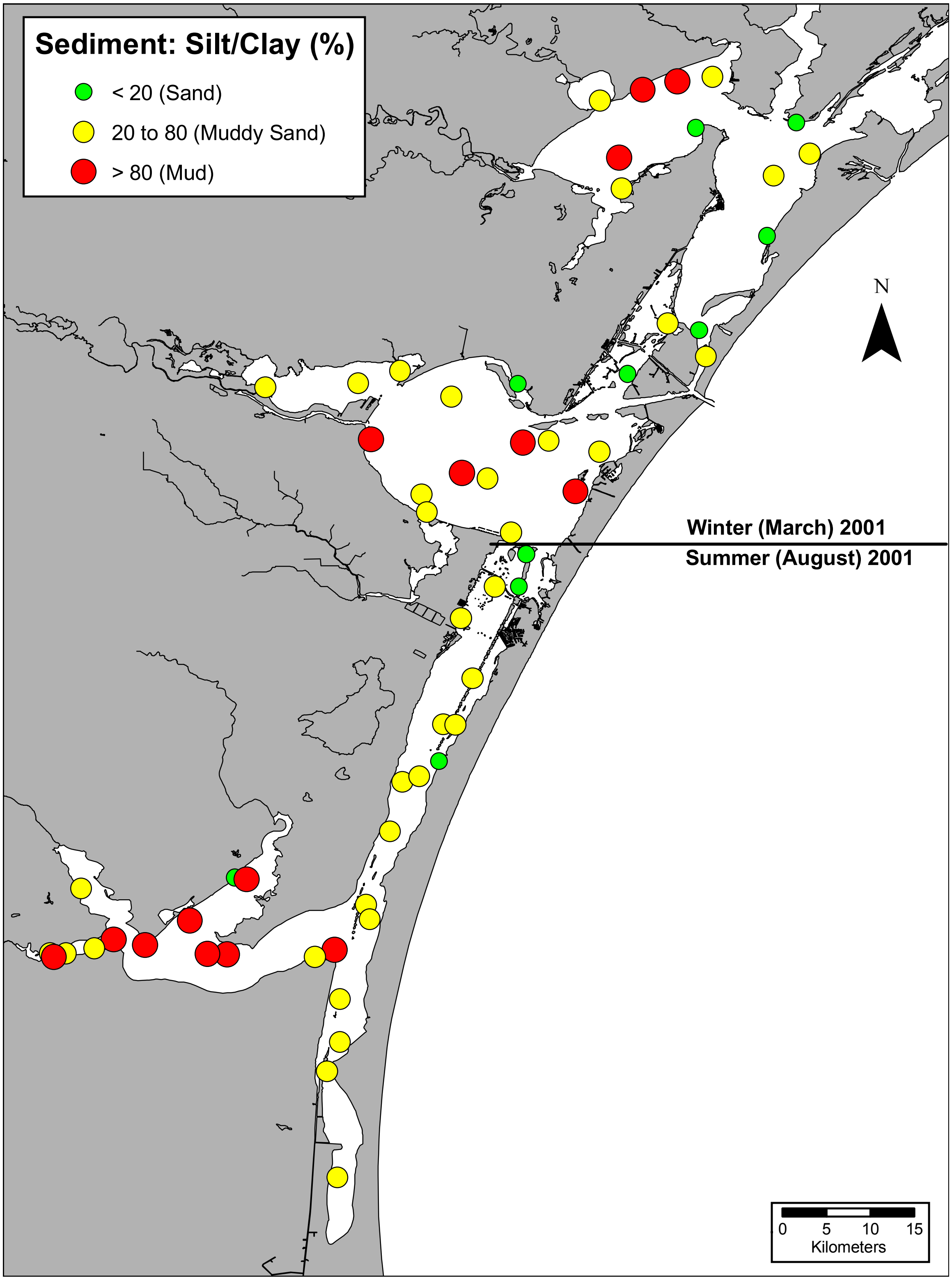

Fig. 4.3. Silt/Clay sediment concentrations (%) for 30 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

4.3.2. Sediment Metals

With the exception of four metals (aluminum, arsenic, nickel, and silver), higher sediment metal concentrations occurred during RCAP 2000 compared to RCAP 2001, with minimal variability in concentrations observed during both years. Highest mean trace metal concentrations in RCAP 2000 occurred in Corpus Christi Bay (Segment 2481) followed by Copano Bay/Port Bay/Mission Bay (Segment 2472). During RCAP 2001, higher concentrations occurred in Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) (Table 6.10.1 through 6.10.5). Distribution of the full suite of sediment metals along with applicable TEL and PEL levels appear on Figs. 4.6 – 4.16 and actual individual concentrations appear in Table 6.9.1 and 6.9.2.

Applying TCEQ screening level procedures (DEM 1), for both RCAP 2000 and 2001, identified Station 111 as a secondary concern. Located within the City of Corpus Christi Municipal Marina; Station 111 was the only station with a metal concentration (mercury) above the PEL and 85th percentile screening levels. In addition, while concentrations did not exceed PELs, exceedance of TELs and the 85th percentile occurred for copper, lead, and zinc at Station 111.

Using DEM 2 (Similarity Matrix) the MDS plot identified eight distinct groups (Fig 4.4). As discussed, Station 111 had elevated levels of four trace metals (copper, lead, mercury, and zinc), which skewed the original DEM 2 analysis by producing a masking effect. This masking effect did not reveal relationships of trace metal concentrations at all other stations. Therefore, this station required removal from the Similarity Matrix and MDS plot.

Group 1 consisted of one station located in Aransas Bay (Segment 2471) that was low in all metal concentrations except mercury (Fig. 4.4). While elevated, in comparison to other stations, this concentration was approximately 75% and 24% lower than the PEL and 85th percentile, respectively. If any concern exists, it would be that this station is located along the southern shores of Blackjack Peninsula, adjacent to the Aransas National Wildlife refugee, which is the winter home of the endangered Whooping Crane. Field crews did observe Whooping Cranes actively feeding near this station during sampling Event 3 (March 2001).

Characterization of Groups 2 and 3 identified stations also with low metal concentrations. However, in relation to Group 2, Group 3 separated due to slightly elevated concentrations of mercury and nickel. Group 2 consisted of stations primarily located in Aransas Bay (Segment 2471) and Nueces Bay (Segment 2482) while Group 3 consisted of stations in Copano Bay/Port Bay/ Mission Bay (Segment 2472) and Aransas Bay (Fig. 4.4).

When compared to all RCAP 2000 stations, Groups 4 through 8 contained stations with similar elevated concentrations of cadmium and chromium. However, Group 4 diverged from the other Groups due to elevated arsenic concentrations. Group 4 consisted of stations located in Corpus Christi Bay (Segment 2481) and one station in Nueces Bay (Segment 2482) (Fig 4.4). Groups 5 diverged from other groups due to elevated concentrations of lead, nickel, and zinc and consisted of stations found exclusively in the Copano Bay/Port Bay/Mission Bay area (Segment 2472) while Group 6, which had elevated concentrations of nickel and zinc, comprised stations found in Corpus Christi Bay.

Group 7 contained stations located in Corpus Christi Bay (Segment 2481), which exhibited in relation to all other RCAP 2000 stations, the highest concentrations, of arsenic, lead, nickel, and zinc. Group 8 contained one station (119), located southwest of Shamrock Island in Corpus Christi Bay (Fig 4.4). Station 119 contained the highest relative concentrations of more individual metals (cadmium, chromium, copper, nickel, silver, and zinc), than any other RCAP 2000 station.

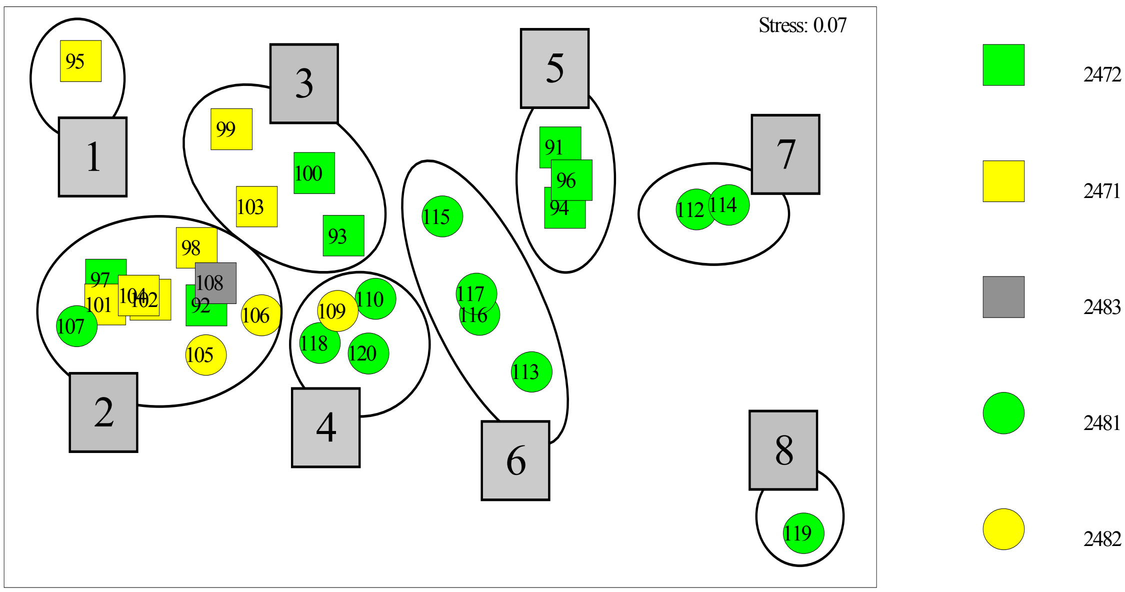

Fig. 4.4. MDS plots grouping stations together based on similar sediment metal concentrations during RCAP 2000. Numbers in grey boxes define Groups.

For RCAP 2001, Similarity Matrix results and the corresponding MDS plot identified six groups (Fig 4.5) for the August 2001 sampling event. Group 1 consisted of stations from all segments and had low trace metal concentrations. Group 1 did not have elevated levels of copper characteristic of Groups 2 through 6.

Group 2 contained stations located in the Laguna Madre (Segment 2491) and Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) (Fig 4.5) that exhibited elevated levels of cadmium. However, cadmium levels remained from 63% to 88% below the PELs and 85th percentile screening levels, respectively. Group 3 contained one station (135) having elevated concentrations of Silver. Concentration levels remained 59% and 86% below 85th percentile and PEL screening levels, respectively (Fig 4.5).

Group 4 consisted of stations located in the Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492) (Fig 4.5). The highest relative concentrations of aluminum, chromium, copper, mercury, nickel, lead, and zinc found during the RCAP 2001 sampling occurred in this group. All concentrations were below the PEL screening levels. However, nickel did exceed the 85th percentile screening level at all stations.

Group 5 contained stations in the Upper Laguna Madre (Segment 2491) near urbanized areas, characterized by elevated sediment metal concentrations of cadmium, lead, nickel, and zinc. All levels were below both screening criteria. Group 6 had one station (129) in the Upper Laguna Madre (Segment 2491), characterized in relation to all other RCAP 2001 stations, with elevated concentrations of arsenic (Fig 4.5). While concentrations of arsenic at this station exceeded the 85th percentile screening value, the concentration was approximately 77% below the PEL screen.

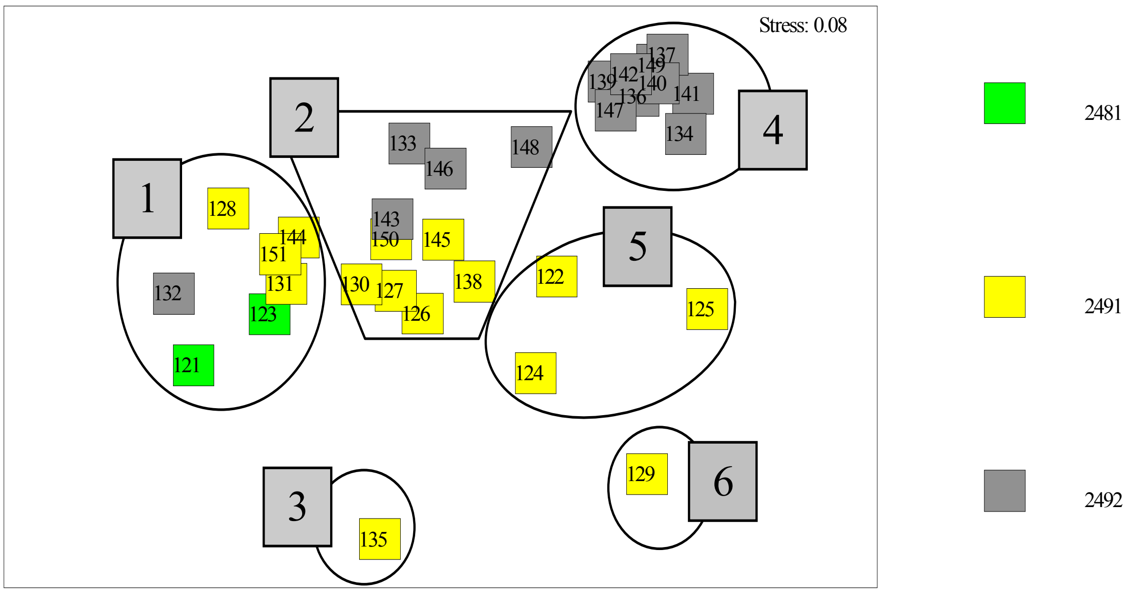

Fig. 4.5. MDS plots grouping stations together based on similar sediment metal concentrations during RCAP 2001. Numbers in grey boxes define Groups.

For DEM 3, the normalization of metals for regression analysis followed procedures outlined in Summers et al. (1996) which requires removal of all statistical outliers and values exceeding ERL guidelines. Outliers, falling above the potential regression, represented possible sediment metal enrichment and required removal before final regression analysis. Removal of the outliers is necessary so that the weight of the outlier does not dampen the remaining values. Definition of enrichment was any station whose metal concentration fell above a particular slopes associated 95% confidence interval.

We omitted selenium and silver from regression analysis because selenium concentrations were all below detection limits, while silver had only three stations in RCAP 2000, and six stations in RCAP 2001, with concentrations above detection limits (Tables 6.9.1 and 6.9.2). Transformation of sediment metal concentrations occurred, if needed, in order to achieve approximate normality before being regressed against aluminum. Using Pearson's correlation coefficient, significant correlations existed with aluminum ($p<0.001$). Table 4.2 lists regression analysis results for RCAP 2000 and 2001.

Table 4.2. Transformations and results of regressions applied to RCAP aluminum versus metal data. * no transformation necessary.

RCAP	Element	Transformation	n	R^2	b0	b1
2000	As	*	30	0.567	0.8767	0.8968
	Cd	*	30	0.487	0.0420	0.0910
	Cr	*	30	0.965	2.2787	8.5094
	Cu	*	29	0.859	3.7310	3.1452
	Pb	*	27	0.669	2.6542	2.4200
	Hg	√	28	0.297	0.1635	0.3880
	Ni	*	28	0.807	3.7342	3.2848
	Se	Omitted	-	-	-	-
	Ag	Omitted	-	-	-	-
	Zn	*	29	0.782	10.8979	21.9878
2001	As	Omitted	-	-	-	-
	Cd	*	26	0.437	0.5870	0.0304
	Cr	*	30	0.967	-0.7227	6.2355
	Cu	*	29	0.848	1.5906	1.2416
	Pb	*	30	0.641	2.8511	0.9652
	Hg	*	30	0.815	0.0045	0.0091
	Ni	*	30	0.611	12.1526	3.0723
	Se	Omitted	-	-	-	-
	Ag	Omitted	-	-	-	-
	Zn	*	30	0.909	10.7594	12.7837

All slope coefficients ($ß_1$) were positive and significantly different from zero ($p<0.001$) except for mercury in RCAP 2000 and arsenic in RCAP 2001. For RCAP 2000, regression analysis utilized in DEM 3 confirmed the DEM 1 analysis using TCEQ PELs and 85th percentile screening levels. High aluminum:metal ratios at Station 111 in Corpus Christi Bay (Segment 2481) for copper, lead, mercury, and zinc suggested anthropogenic enrichment for these sediment metals.

Most metals were highly correlated with aluminum and thereby were not indicative of anthropogenic enrichment. However, regression analysis did indicate some possibly anthropogenic enriched stations in Corpus Christi Bay at Stations 112 and 114 for lead and at Station 115 for nickel and in Redfish Bay (Segment 2483) at Station 103 for nickel. RCAP 2001 analysis indicated Station 125 having high aluminum:metal ratios for cadmium, chromium, copper, and zinc while Station 124 had high ratios for cadmium and copper. Additional stations with high ratios for cadmium included Stations 122, 126, and 129.

4.4 Summary

Like water quality, evaluating the complexity of sediment contaminants is a process requiring analysis of multiple data over longer periods than one or two sampling events. In addition, for a complete examination it will be necessary to consider more parameters such as sediment organics (PCBs, DDT, pesticides, PAHs, etc) and toxicity. As the first in a series of monitoring efforts planned by CBBEP, excepting Station 111, RCAP 2000 and RCAP 2001 sampling events showed that sediment quality within the CBBEP region concerning trace metals is very good.

Possible reasons for Station 111 having multiple metals with concentrations exceeding screening levels may directly relate to the station's location in the City of Corpus Christi Municipal Marina. Antifouling paint found on boat hulls could be a significant source of copper, with trace amounts of copper leached out over time to protect against marine fouling organisms (Kennish 1992). For example, the Norwegian Defense Research Establishment Division for Environmental Toxicology concluded that Norwegian marine paint factories and shipyards were responsible for a large part of the organic and heavy metal pollutants presently found along their coastline (Johnsen and Engøy 1999). Another element is zinc, which boat owners use to protect against galvanic corrosion of propeller shafts and thru-hull fittings. Like copper bottom paint, zinc anodes are slowly leached out over time, with the precipitate falling to the sediments. In addition, mercury once served as a biocide to prevent the buildup of marine fouling organisms and lead functioned as a pigment and as a biocide.

The three DEM methods employed served as an approach to view the data from different perspectives. In lieu of established criteria, DEM 1 is the primary method of evaluation used by TCEQ to identify secondary concerns, and as such, serves as the benchmark for assessing sediment quality. Utilization of this method found only one station (Station 111) out of 61 stations sampled that merits closer investigation (Figs. 4.10 – 4.12, and 4.16).

DEM 2 provided a method grouping stations based on similar sediment metal characteristics, thereby giving slightly better resolution to metal concentrations in the bay segments. While DEM 2 showed possible concerns for Station 95 (Figs. 4.4 and 4.12) due elevated mercury concentrations adjacent to the Aransas National Wildlife Refugee, conclusions based on only one sample point would be premature. Interestingly, one other station in Aransas Bay (Station 99), located south of Station 95, had a similarly elevated concentration. The only common discernable characteristic is proximity of these stations to the Intracoastal Waterway. In addition to these stations, there was one station (100) in the Copano Bay/Port Bay/Mission Bay area (Segment 2472) that also exceeded the TEL level but was well below the applicable screening levels for mercury. DEM 2 also identified Station 119 as being distinct from other RCAP 2000 stations due to elevated concentrations of multiple metals, as well as identifying Group 4 in the Baffin Bay complex that had the highest concentrations of multiple metals found in RCAP 2001 (Figs. 4.4 and 4.5).

Finally, DEM 3 provided a standard way in which EPA and many other agencies and researchers investigate sediment contaminants and try to make determinations as to whether sources of contamination may be potentially anthropogenic in origin or simply natural background levels. This method confirmed the findings of DEM 1 regarding Station 111; suggesting elevated concentrations at this station are due to anthropogenic inputs. Furthermore, DEM 3 identified the possibility also exists that several other stations (103, 112, 114, 115 in RCAP 2000, and 122, 124, 125, 129 in RCAP 2001) may have concentrations of certain elements slightly higher than background levels. DEM 3 also identified that due to low aluminum:metals ratios, elevated concentrations of multiple metals at RCAP 2000 Station 119 are most likely background rather than anthropogenic in nature.

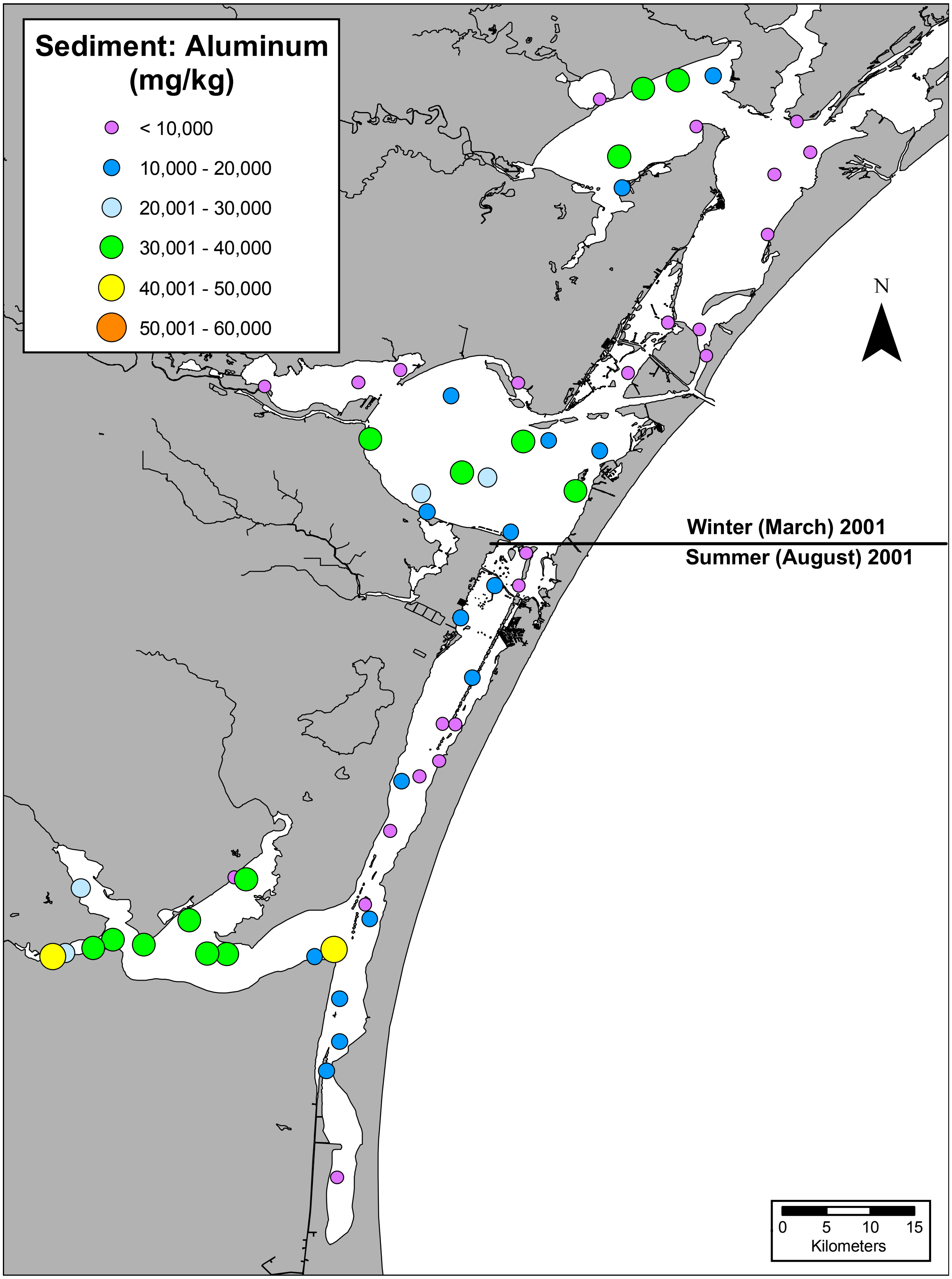

Fig. 4.6. Aluminum sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

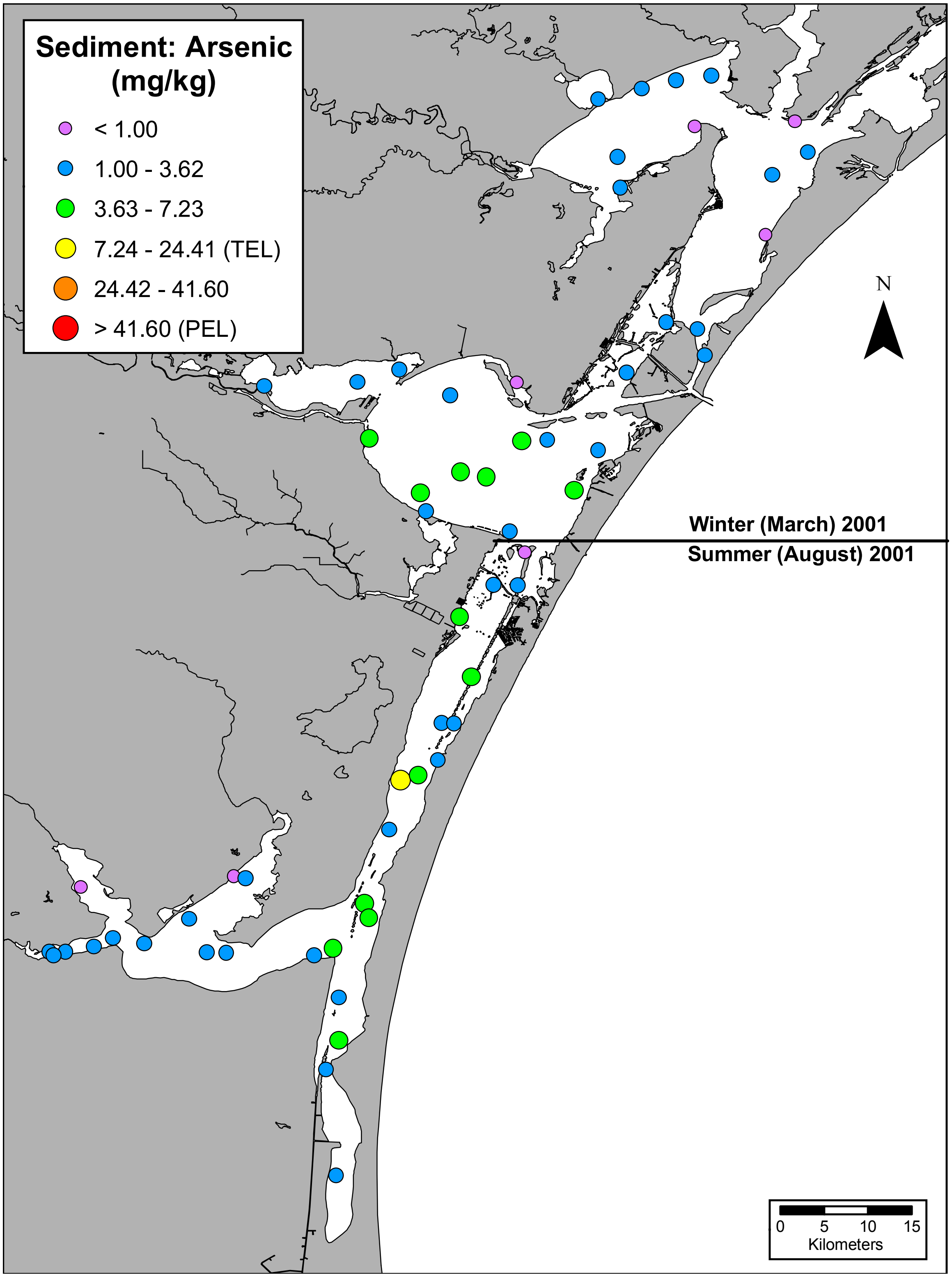

Fig. 4.7. Arsenic sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

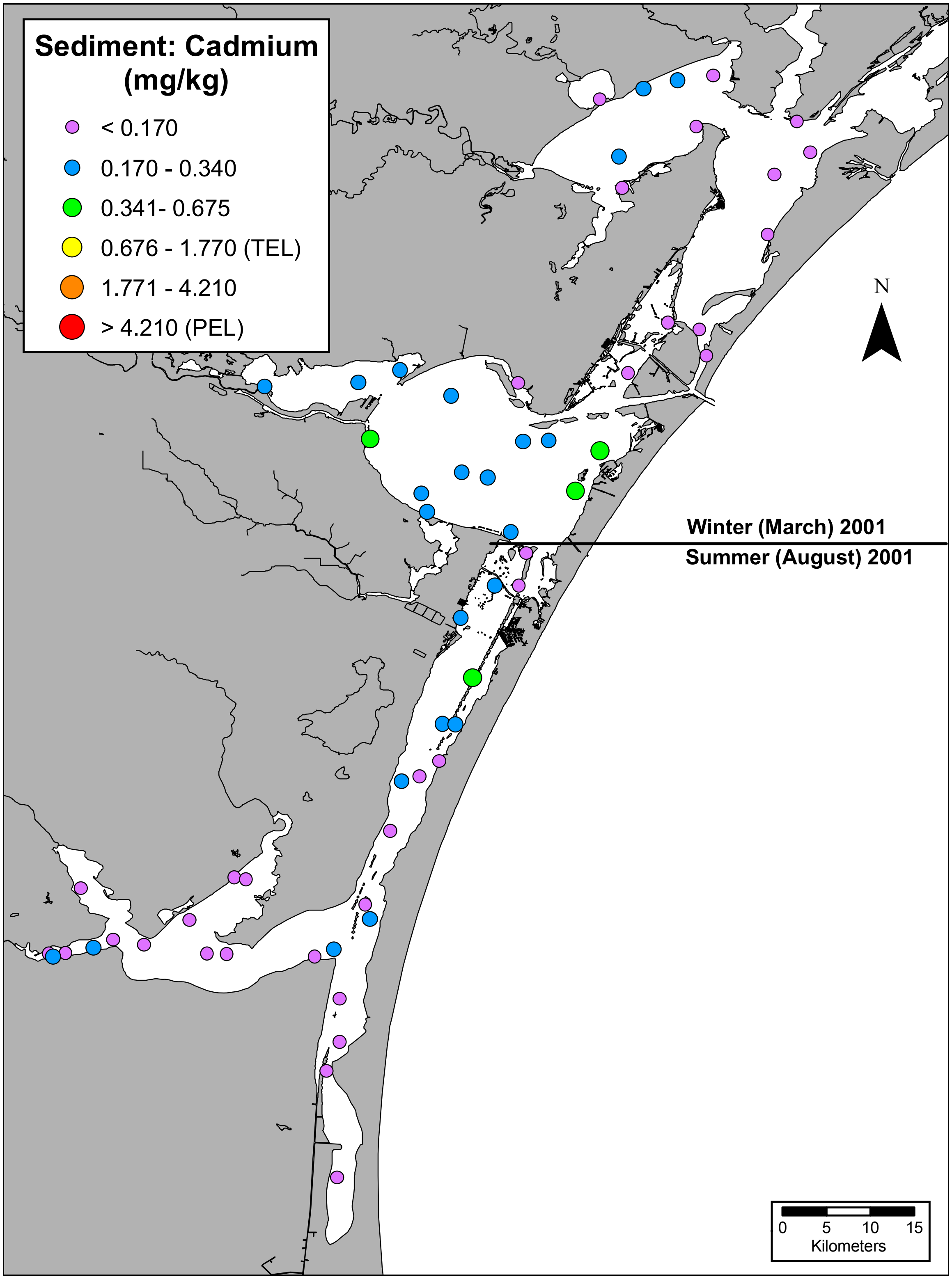

Fig. 4.8. Cadmium sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

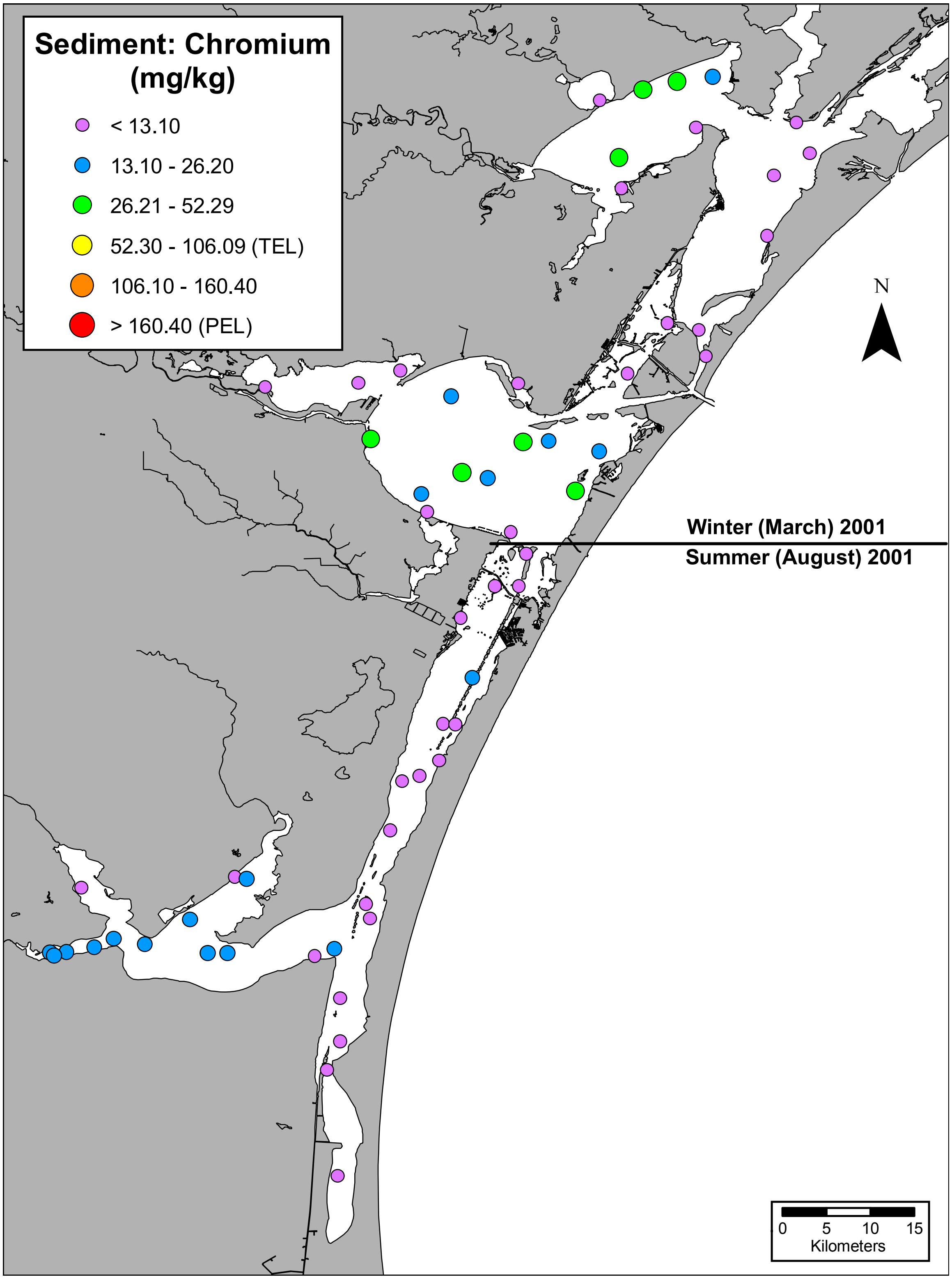

Fig. 4.9. Chromium sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

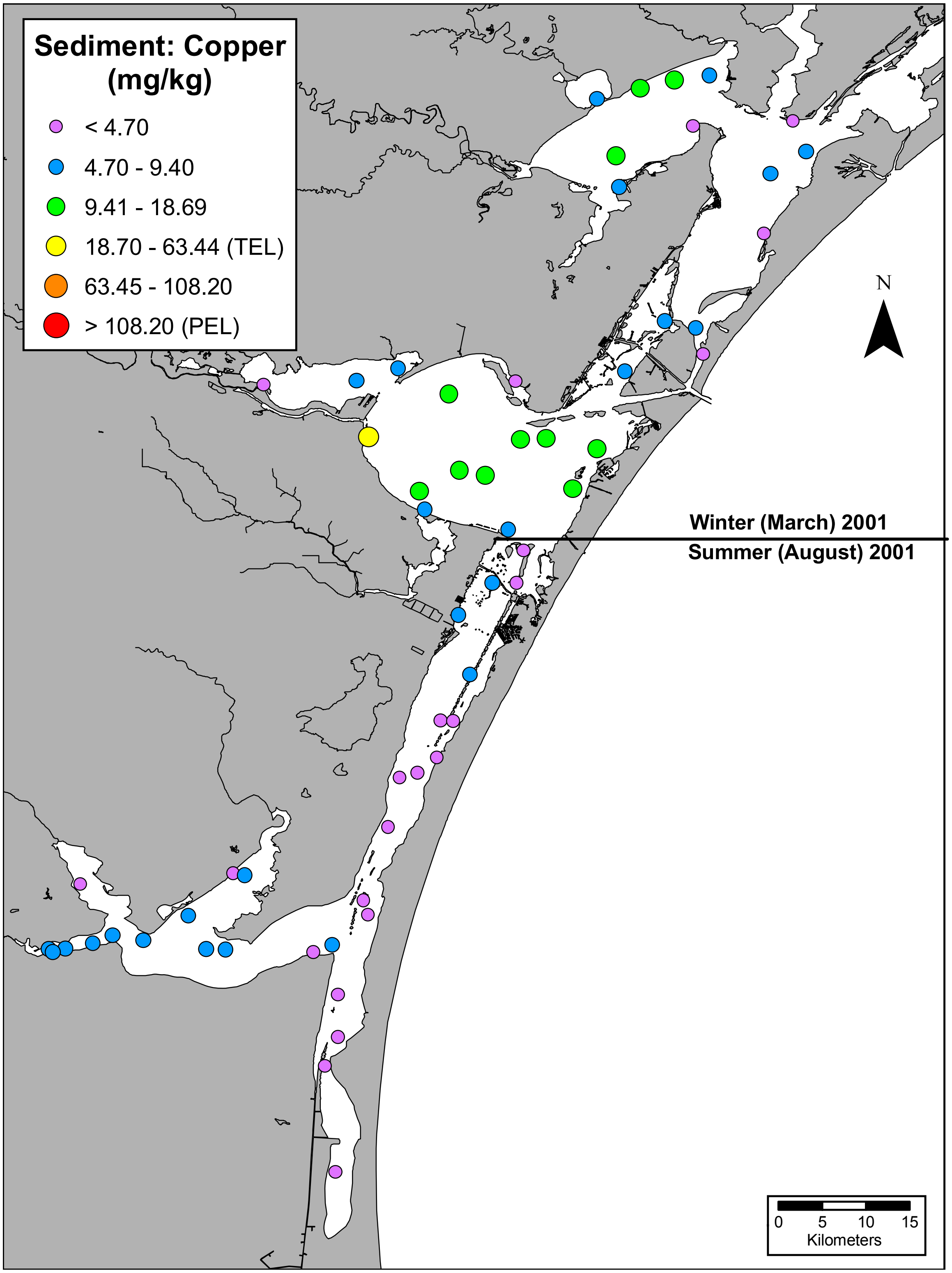

Fig. 4.10. Copper sediment concentrations (mg/kg, dry weight) 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

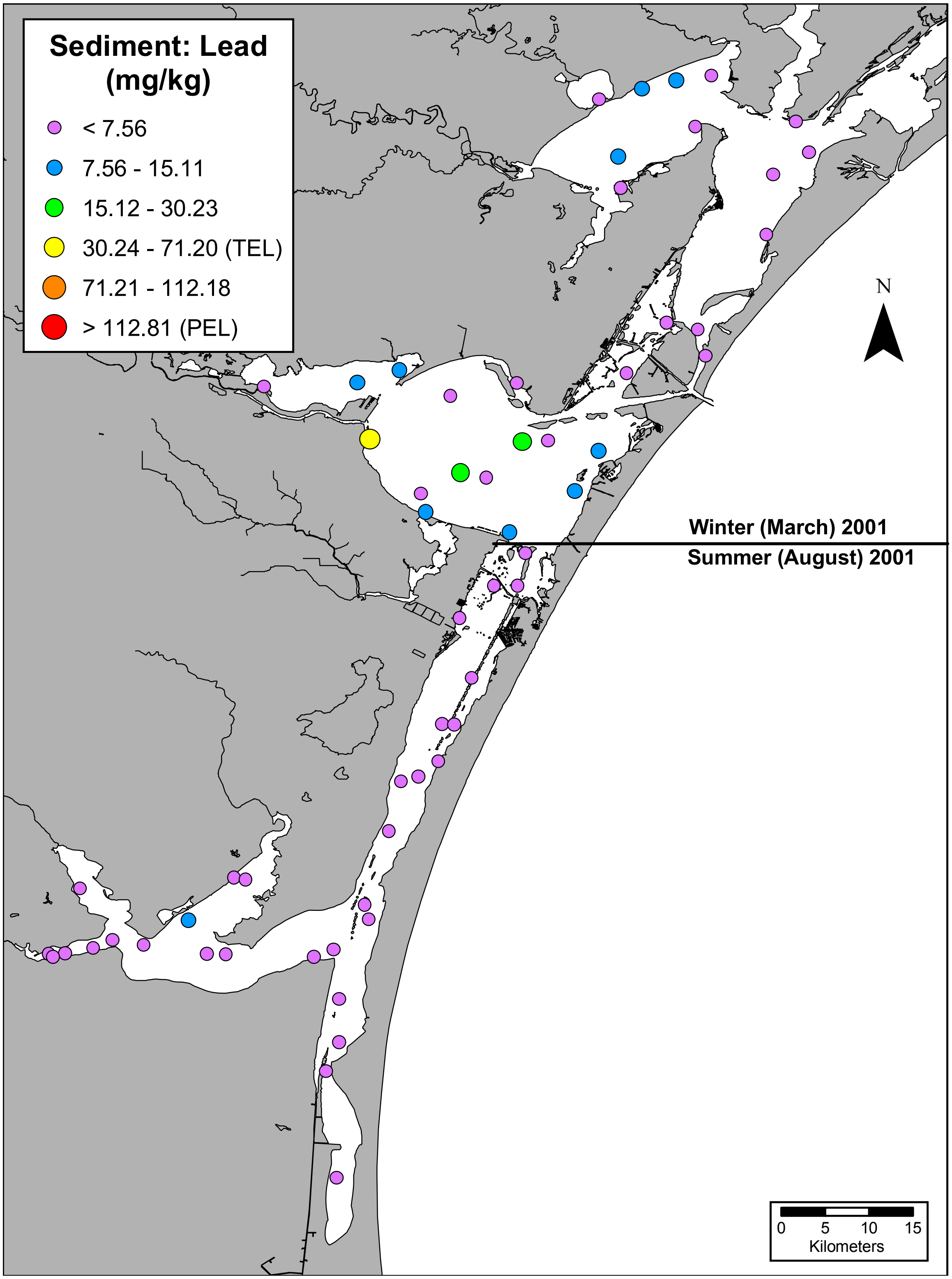

Fig. 4.11. Lead sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

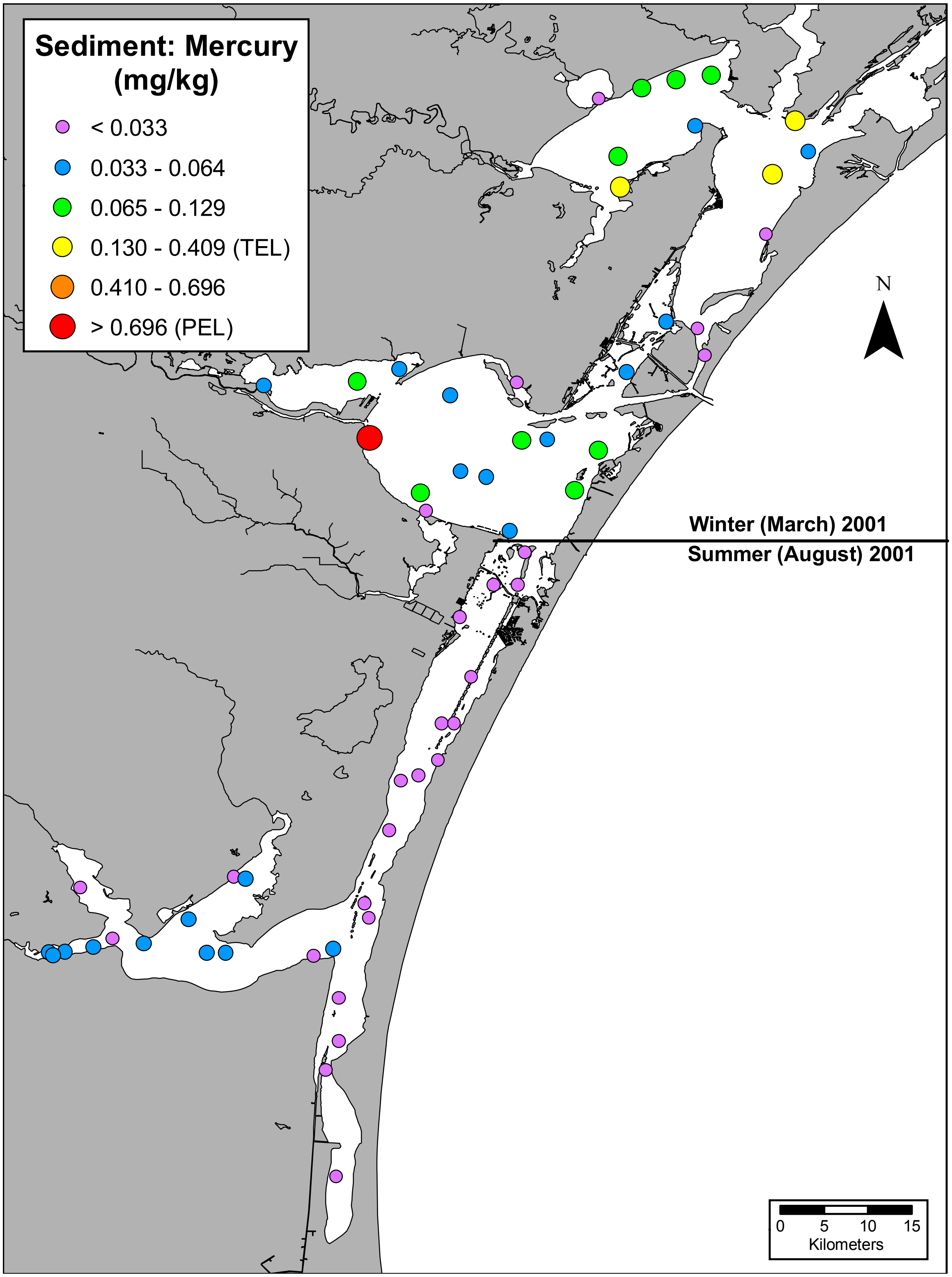

Fig. 4.12. Mercury sediment concentrations (mg/kg, dry weight) 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

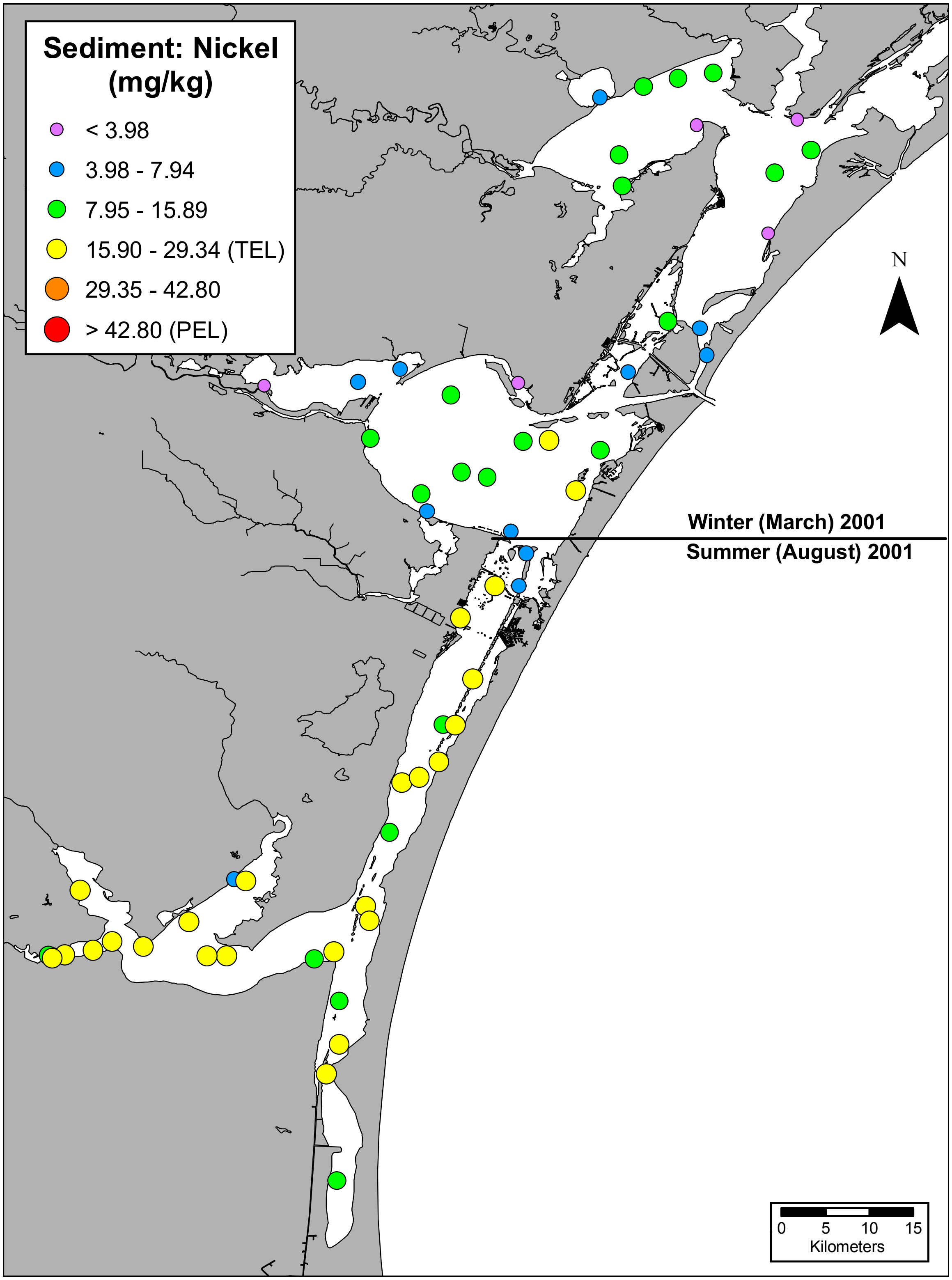

Fig. 4.13. Nickel sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

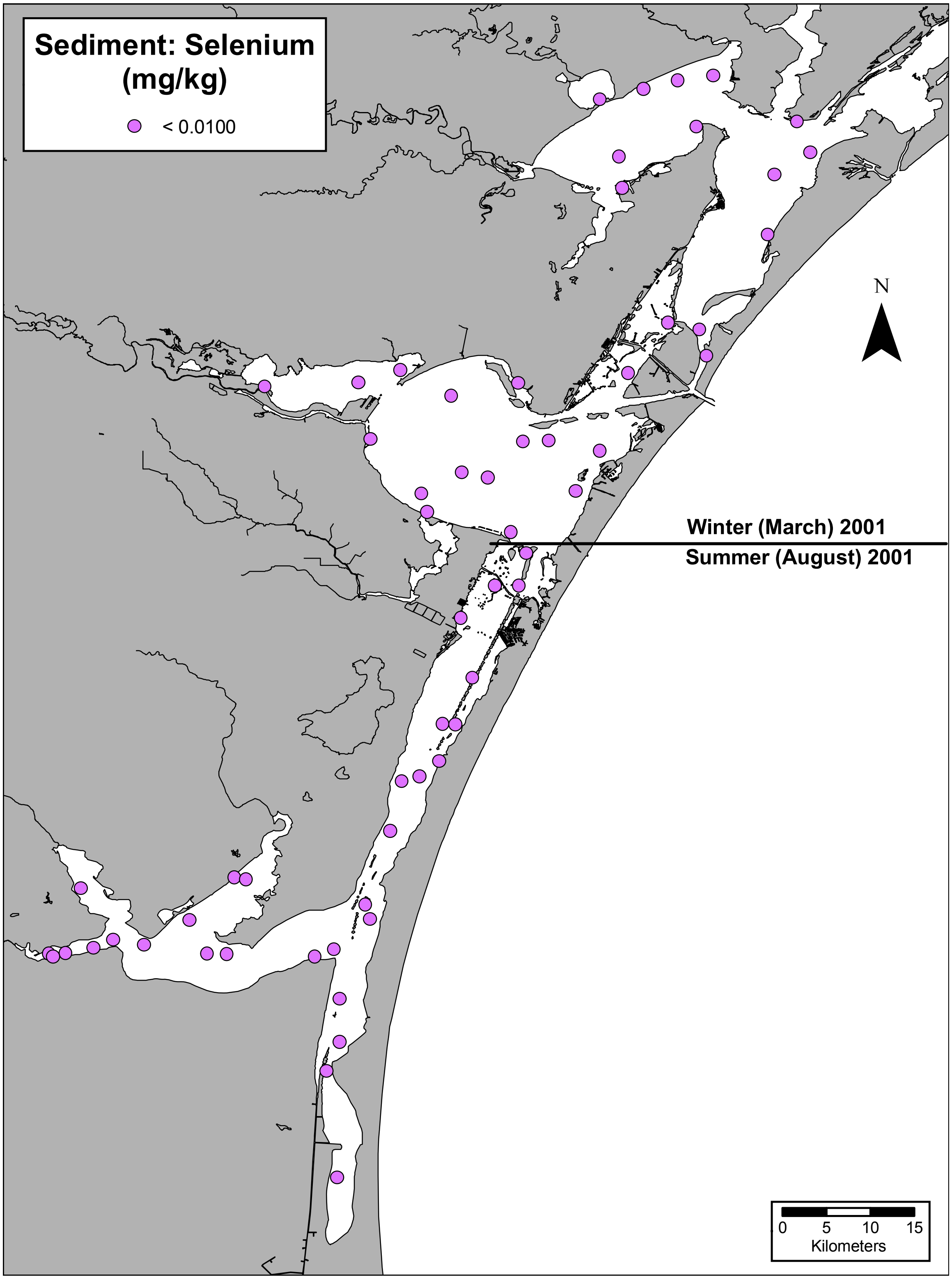

Fig. 4.14. Selenium sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

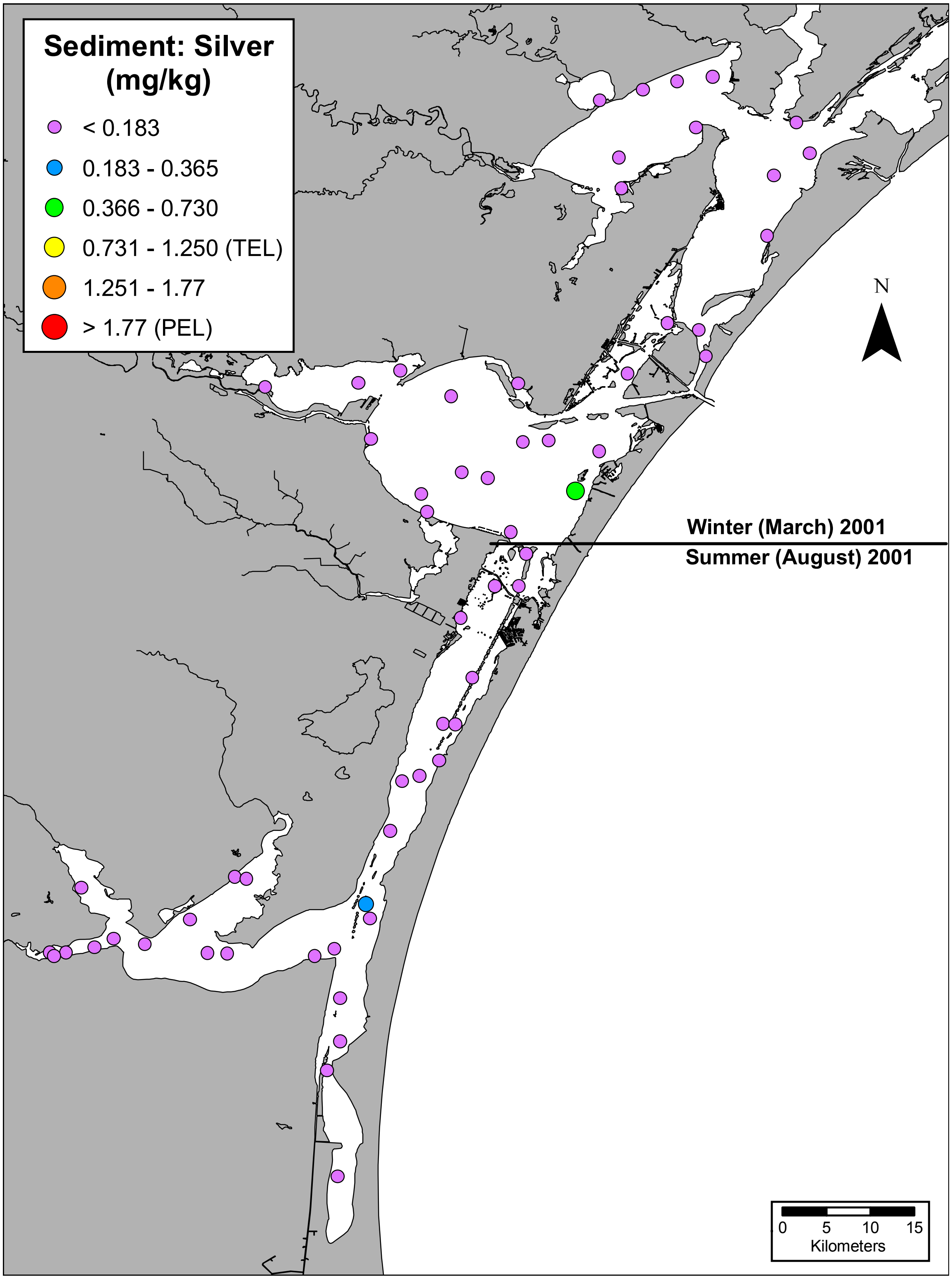

Fig. 4.15. Silver sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

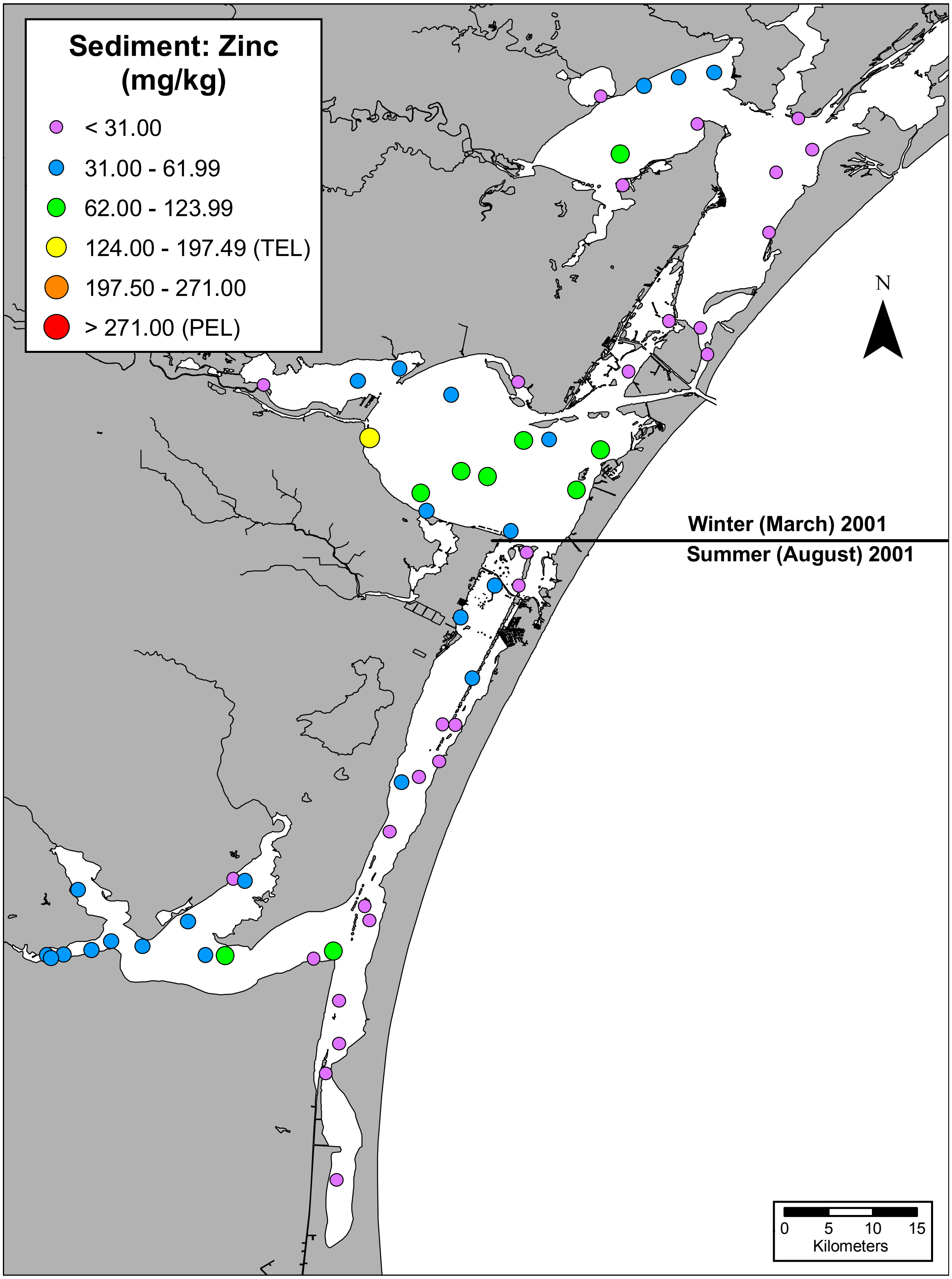

Fig. 4.16. Zinc sediment concentrations (mg/kg, dry weight) for 31 stations sampled RCAP 2000 (March 2001) and 31 stations sampled RCAP 2001 (August 2001).

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5.0 BIOLOGICAL MONITORING

5.1 Introduction

The recognition that chemical water quality analyses alone do not adequately predict or reflect the condition of all aquatic resources has lead to the implementation of biological surveys and the establishment of biocriteria for water quality monitoring programs. A biological component is important because it provides a direct measure of the condition of the biota, which may be undetected or underestimated by other methods (Borja et al. 2000). Benthic communities are an integral component of the estuarine system. They break down deposited organic material, are important to nutrient cycling, and provide a source of food for higher trophic organisms such as commercial and recreational fish.

The study of benthic communities as an integral component for assessing sediment and water quality in estuaries occurs for multiple reasons. Benthic organisms are relatively limited in their mobility. Unlike fish, these organisms cannot flee an area during periodic environmental changes. In many instances, benthic communities impacted by environmental changes will show alterations in community composition. The ability for the community to return to its original composition depends on the severity and duration of the impact. These measured shifts in community composition in relation to water and sediment data provides information needed to fulfill the biological component of a water and sediment-monitoring program. Researchers identify many benthic organisms as pollution tolerant or sensitive or on the ability to withstand extremely stressful environments. Sensitivity to pollutants, or stressful conditions, determines the overall diversity of organisms in a community, making benthic organisms a good indicator of the environmental fitness of the system (Dauer et al. 2000).

The purpose of the RCAP 2000 and RCAP 2001 benthic component was to gather information to characterize the existing benthic community. This information, along with data collected from future monitoring events, when sediment organics and toxicity sampling is incorporated in the program, will aid in characterization of the benthic community and identification of factors affecting biological health. From this additional data, we hope to develop "indicator species" unique to our estuarine system that will allow us to monitor the general health of the system and identify areas perhaps warranting further attention.

5.2 Sampling Design and Data Evaluation

Sampling for benthic organisms in RCAP 2000 began April 2000 and concluded May 2001 (four events) at 120 stations. Table 6.1.1 through 6.1.4 in the *Data Tables* chapter and Figs. 5.1 through 5.4 provide station information. Sampling in RCAP 2001 ran from summer (late July, August, and early September) 2001 through May 2002 (four events) at 124 stations. Table 6.1.5 through 6.1.8 in the *Data Tables* chapter and Fig. 5.5 provide station information.

5.2.1. Data Evaluation Methods (DEM)

Benthic community analysis included measures of richness, density, and diversity. *Data Tables* in Chapter 6.0 (Tables 6.11.1 through 6.11.5) provide summary descriptive statistics for those measures. We utilized the similarity percentage analysis (SIMPER) program in the PRIMER v5.0 (Plymouth Routines in Multivariate Ecological Research) software program developed by Clark and Warwick (2001) to identify the dominant species that had the greatest densities and distribution within the segment.

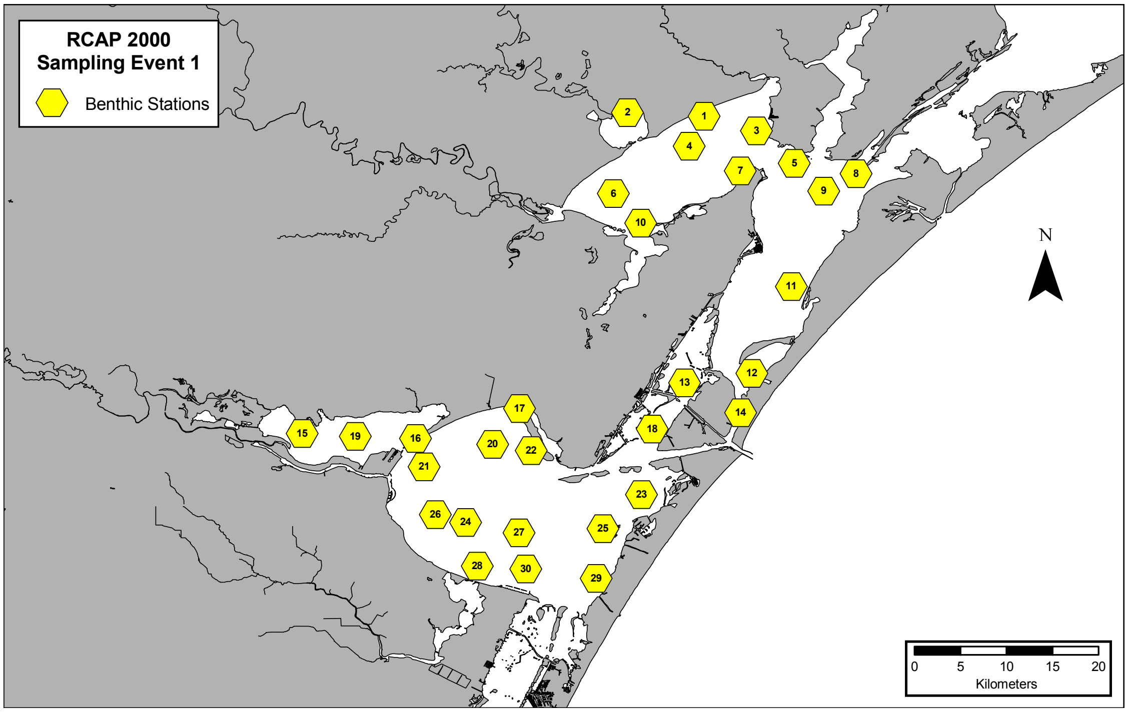

Fig. 5.1. Map of RCAP 2000 sampling stations depicting 30 stations sampled for benthic organisms during Event 1 (Spring 2000).

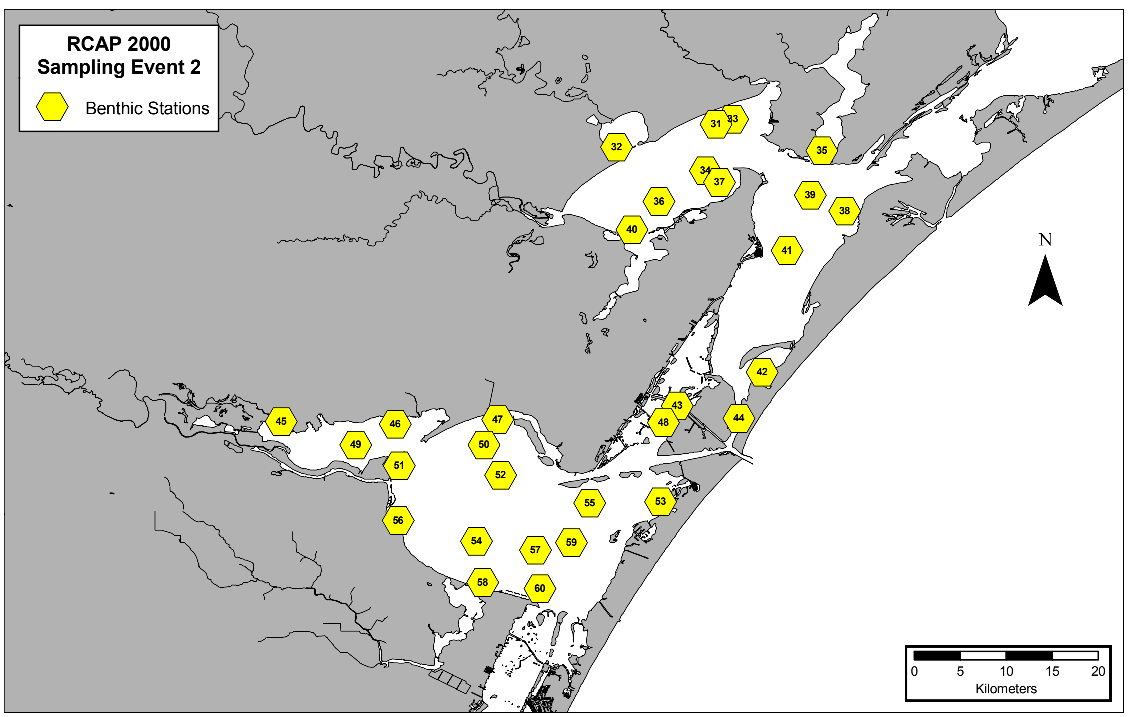

Fig. 5.2. Map of RCAP 2000 sampling stations depicting 30 stations sampled for benthic organisms during Sampling Event 2 (Summer 2000).

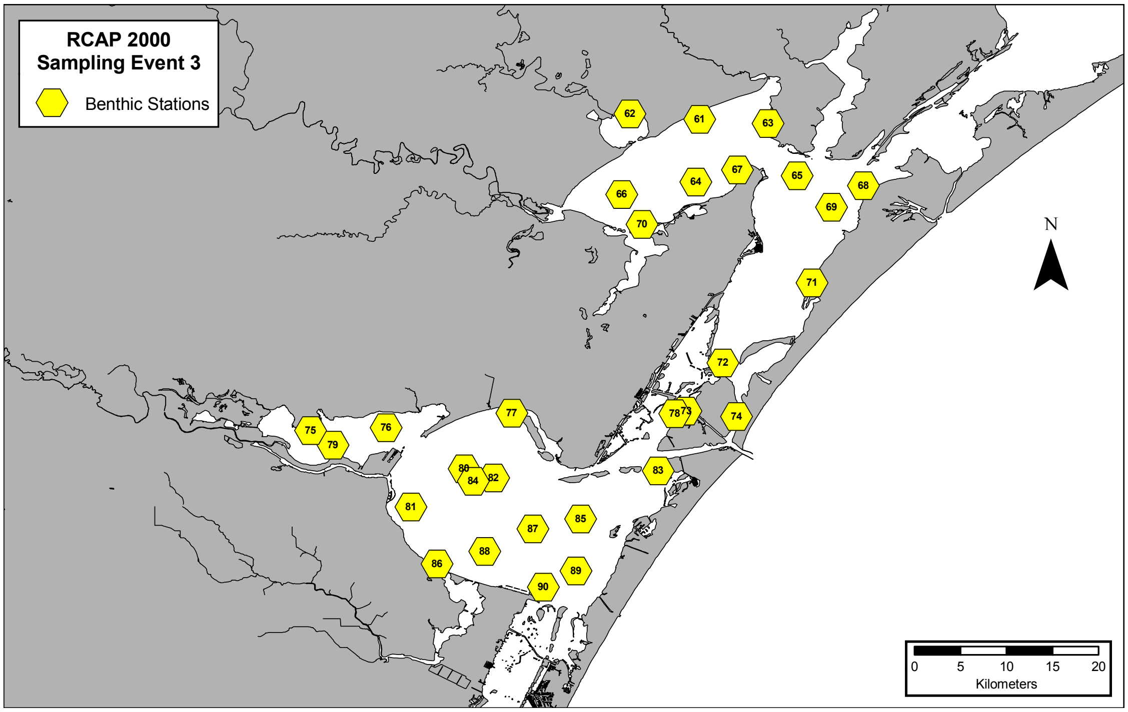

Fig. 5.3. Map of RCAP 2000 sampling stations depicting 30 stations sampled for benthic organisms during Sampling Event 3 (Fall 2000).

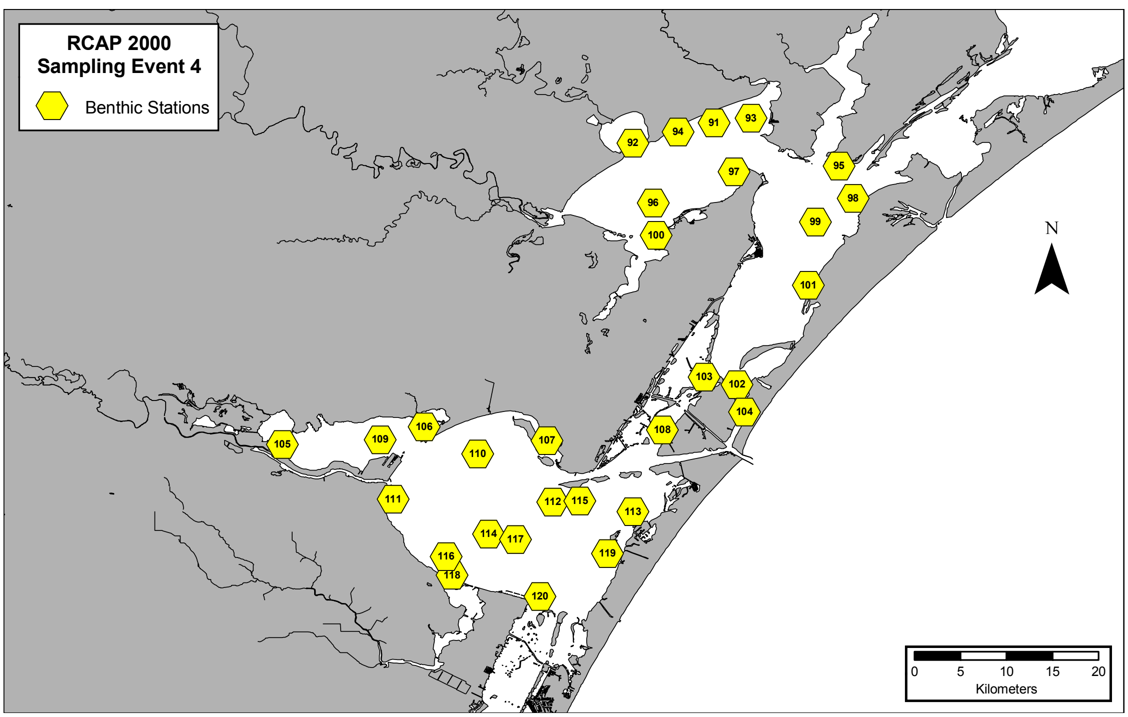

Fig. 5.4. Map of RCAP 2000 sampling stations depicting 30 stations sampled for benthic organisms during Sampling Event 4 (Winter 2001).

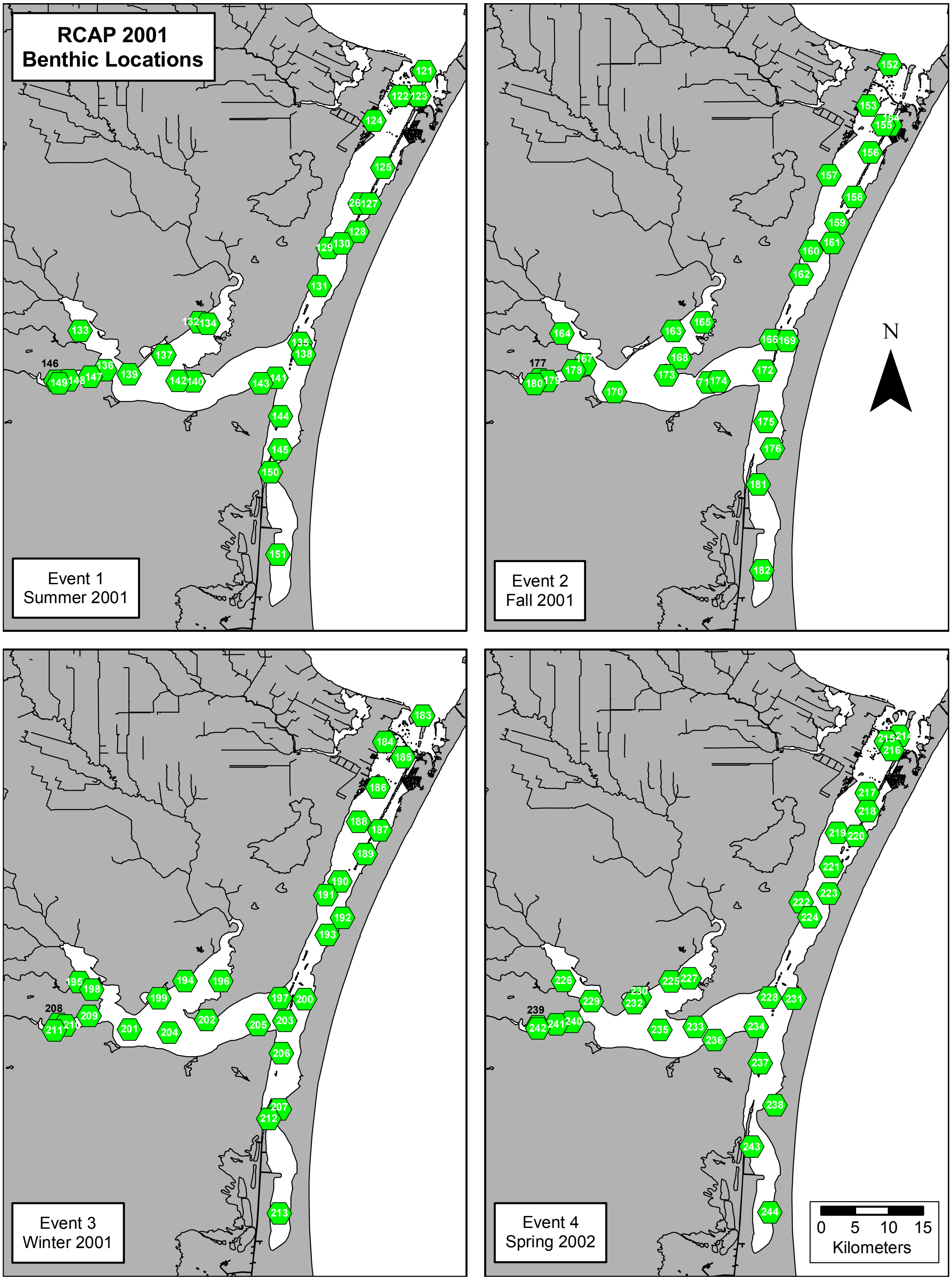

Fig. 5.5. Map of RCAP 2001 sampling stations depicting 124 stations sampled for benthic organisms (31 stations sampled each event).

5.3 Results and Discussion

During RCAP 2000, benthic analysis by Nuñez (2004) identified 254 species totaling 18,413 individuals within the Mission-Aransas and Nueces estuary systems. Since only one benthic sampling event occurred in St. Charles Bay (Segment 2473), and because the station location was at the confluence with Aransas Bay (Segment 2471), all data for this analysis grouped the St. Charles Bay station data with the Aransas Bay data.

The most abundant group was annelids, which comprised 67.1% of all organisms collected. Polychaetes represented 66.2% of the annelids, with the polychaete *Mediomastus ambiseta* dominating the group, accounting for 14.8% of all annelids collected. The second most abundant group was arthropods, which accounted for 16.0% of all organisms collected, dominated by the amphipod crustacean, *Ampelisca abdita*, representing 51.3% of all arthropods collected. Molluscs represented 11.7% of all organism collected with the dwarf surf calm, *Mulinia lateralis*, representing 42.0% of all molluscs collected. Collectively these three groups represented 94.8% of all organism collected during RCAP 2000. The remaining 5.2% of organisms collected included representatives from the phyla Chaetognatha, Cnidaria, Echinodermata, Nemertea, Nemata, Sipuncula, and Hemichordata.

Mission-Aransas Estuary

Copano Bay/Port Bay/ Mission Bay (Segment 2472)

Mean benthic density, all sampling events combined, was 1869 individuals m^{-2} (SD = 2550). Density ranged from 74 individuals m^{-2} in Event 2 (Summer 2000) to 11,052 individuals m^{-2} in Event 4 (Winter 2001) (Fig. 5.6 and Table 6.11.1). Mean species richness was 10 species collected (SD = 7). Species richness ranged from 2 to 25 species collected and typically mean species richness was lowest in this segment when compared to all segments sampled (Fig. 5.7 and Table 6.11.2). Species diversity ranged from 0.73 to 3.78 and mean species diversity was lowest in this segment for all sampling events (Fig. 5.8 and Table 6.11.3).

Density, richness, and diversity (Figs. 5.6 through 5.8 and Tables 6.11.1 through 6.11.3) typically were greatest near the confluence of Copano Bay and Aransas Bay (Segment 2471). Characterization of Segment 2472 is one of a relatively simple community composition and trophic structure, with stations in the segment typically dominated by one or two species. Overall, the dominant species was the polychaete, *Mediomastus ambiseta*, a pollution sensitive species (Carr 1998). Studies in estuarine systems within the Gulf of Mexico found increasing salinity and sediment grain-size (sand) were two of the main environmental factors effecting benthic distribution, typically producing more diverse benthic communities (White et al. 1983; Longley 1994; Engle and Summers 1998; Engle and Summers 1999. Opposite conditions existed in this study. Salinity was lower and more variable (Figs 3.6 and 3.7) and sediment grain-size decreased (high mud content) (Fig. 4.3); perhaps playing a part in the simpler community structure observed.

Aransas Bay (Segment 2471)

Mean benthic density, for all sampling events, was 4984 individuals m^{-2} (SD = 7742). Density ranged from 370 individuals m^{-2} in Event 2 (Summer 2000) to 35,229 individuals m^{-2} in Event

4 (Winter 2001) (Fig. 5.6 and Table 6.11.1). Mean Species richness was 21 species collected (SD = 13). Species richness ranged from 4 to 51 species collected and highest number of species being collected in Event 4 (Winter 2001) (Fig. 5.7 and Table 6.11.2). Species diversity ranged from 1.53 to 4.59 and mean species diversity was highest in this segment during Event 3 (Fall 2000) (Fig. 5.8 and Table 6.11.3).

Density, richness and diversity (Figs. 5.6 through 5.8 and Tables 6.11.1 through 6.11.3) were typically greatest in Lydia Ann Channel and in the northern portion of the bay, north of the Long Reef complex (Long, Half-Moon, and Grassy Island reefs), while simpler community structures were found at locations in the middle of the bay. Density, richness, and diversity were similar to that of Nueces, Redfish, and Corpus Christi bays. A slightly more complex community structure existed at most locations in Aransas Bay, with the polychaetes *Mediomastus ambiseta*, *Paraprionospio pinnata,* and *Clymenella torquata* dominating collections. Like Copano Bay, the Aransas Bay segment had lower salinities throughout the year, ranging from mesohaline to euhaline (Fig. 3.6). In addition, there was also a more definitive salinity concentration gradient seen, with lower salinities to the north increasing as you approached the gulf pass at Port Aransas.

Nueces Estuary

Nueces Bay (Segment 2482)

Mean benthic density, for all sampling events, was 3690 individuals m^{-2} (SD = 4291). Density ranged from 173 individuals m^{-2} in Event 1 (Spring 2000) to 13,223 individuals m^{-2} in Event 4 (Winter 2001) (Fig. 5.6 and Table 6.11.1). Mean species richness was 19 species collected (SD = 9). Species richness ranged from 3 to 34 species collected with highest number of species being collected in Event 2 (Summer 2000) (Fig. 5.7 and Table 6.11.2). Species diversity ranged from 1.38 to 4.48 and mean species diversity was highest in this segment during Event 2 (Summer 2000) (Fig. 5.8 and Table 6.11.3).

Density, richness, and diversity (Figs. 5.6 through 5.8 and Tables 6.11.1 through 6.11.3) were typically greatest in the eastern portion of the bay near the confluence between Nueces Bay and Corpus Christi Bay (Segment 2481). Community composition and complexity was similar to that of Corpus Christi Bay, suggesting encroachment of benthic organisms typically associated with Corpus Christi Bay. Minimal variability in salinity resulted in a relatively stable environment indicative of the open bay waters of Corpus Christi Bay, as salinity concentrations were high (euhaline) most of the year due to reductions in freshwater inflow. Dominant species, in Nueces Bay were the bivalve mollusc, *Mulinia lateralis*, and the polychaetes *Tharyx* cf. *annulosus* and *Podarkeopsis brevipalpa*. When compared to the other two secondary bays (Copano Bay in RCAP 2000 and Baffin Bay in RCAP 2001), this bay was more complex (i.e. no one dominant species, greater richness, and diversity).

Corpus Christi Bay (Segment 2481)

Mean benthic density, for all sampling events, was 3693 individuals m^{-2} (SD = 2520). Density ranged from 321 individuals m^{-2} in Event 3 (Fall 2000) to 10,361 individuals m^{-2} in Event 2 (Summer 2000) (Fig. 5.6 and Table 6.11.1). Mean species richness was 23 species collected (SD = 9). Species richness ranged from 6 to 41 species collected with highest number of species being collected in Event 2 (Summer 2000) (Fig. 5.7 and Table 6.11.2). Species diversity ranged from 2.22 to 4.92 and mean species diversity was highest in this segment during Event 2 (Summer 2000) (Fig. 5.8 and Table 6.11.3).

Overall, density was greatest near the Gulf pass and species richness was lowest in the southern portion of the bay near the mouth of the Laguna Madre. Diversity was relatively homogeneous with the exception of sites located near the mouth on the Laguna Madre and Stations in the La Quinta Channel turning basin. As with Nueces and Redfish bays, there was no one species that dominated the bay. Dominant species in Corpus Christi Bay consisted of the polychaetes *Paleanotus heteroseta*, *Polydora caulleryi*, *Aricidea fragilis*, and *Tharyx* cf. *annulosus*.

Corpus Christi Bay characterizes as a stable environment that had little environmental variability, producing a more complex system with minimal variability observed in richness, density, and diversity. This minimal variability could be due to the previously mentioned reduction in freshwater inflows. Water quality is marine influenced, with mean salinity concentrations more euhaline throughout the year. The reduction of richness and diversity observed in Corpus Christi Bay near the confluences of Oso Bay and Laguna Madre may result from the seasonal hypoxic zone identified by Montagna and Kalke (1992). This hypoxic zone results from salinity stratification due to a combined effect of high evaporation and minimal water circulation (Montagna and Kalke 1992). Although RCAP 2000 sampling recorded no hypoxic conditions (data collected primarily mid-day), low bottom dissolved oxygen concentrations did occur during Event 2 (Summer 2000).

Redfish Bay (Segment 2483)

Mean benthic density, for all sampling events, was 7000 individuals m^{-2} (SD = 4480). Density ranged from 395 individuals m^{-2} in Event 3 (Fall 2000) to 13,667 individuals m^{-2} in Event 4 (Winter 2001) (Fig. 5.6 and Table 6.11.1). Mean species richness was 31 species collected (SD = 13). Species richness ranged from 10 to 46 species collected with highest number of species collected in Event 1 (Spring 2000) and Event 4 (Winter 2001) (Fig. 5.7 and Table 6.11.2). Species diversity ranged from 2.67 to 4.43 and mean species diversity was highest in this segment during Event 1 (Spring 2000) (Fig. 5.8 and Table 6.11.3).

Density, richness, and diversity (Figs. 5.6 through 5.8 and Tables 6.11.1 through 6.11.3) were greatest in the southern open waters of the bay near the junction to Corpus Christi Bay. Species dominating Redfish Bay included the polychaetes, *Mediomastus ambiseta*, *Capitella capitata, Streblospio benedicti*, *Tharyx* cf. *annulosus,* and *Clymenella torquata*. Although random sampling occurred at a limited number of stations (n = 8), this area appeared to have the most complex benthic community. This bay exists as an ecotone, or a transitional zone between the two estuaries (Mission-Aransas and Nueces), possessing a highly complex community structure containing characteristic species associated with each individual estuary.

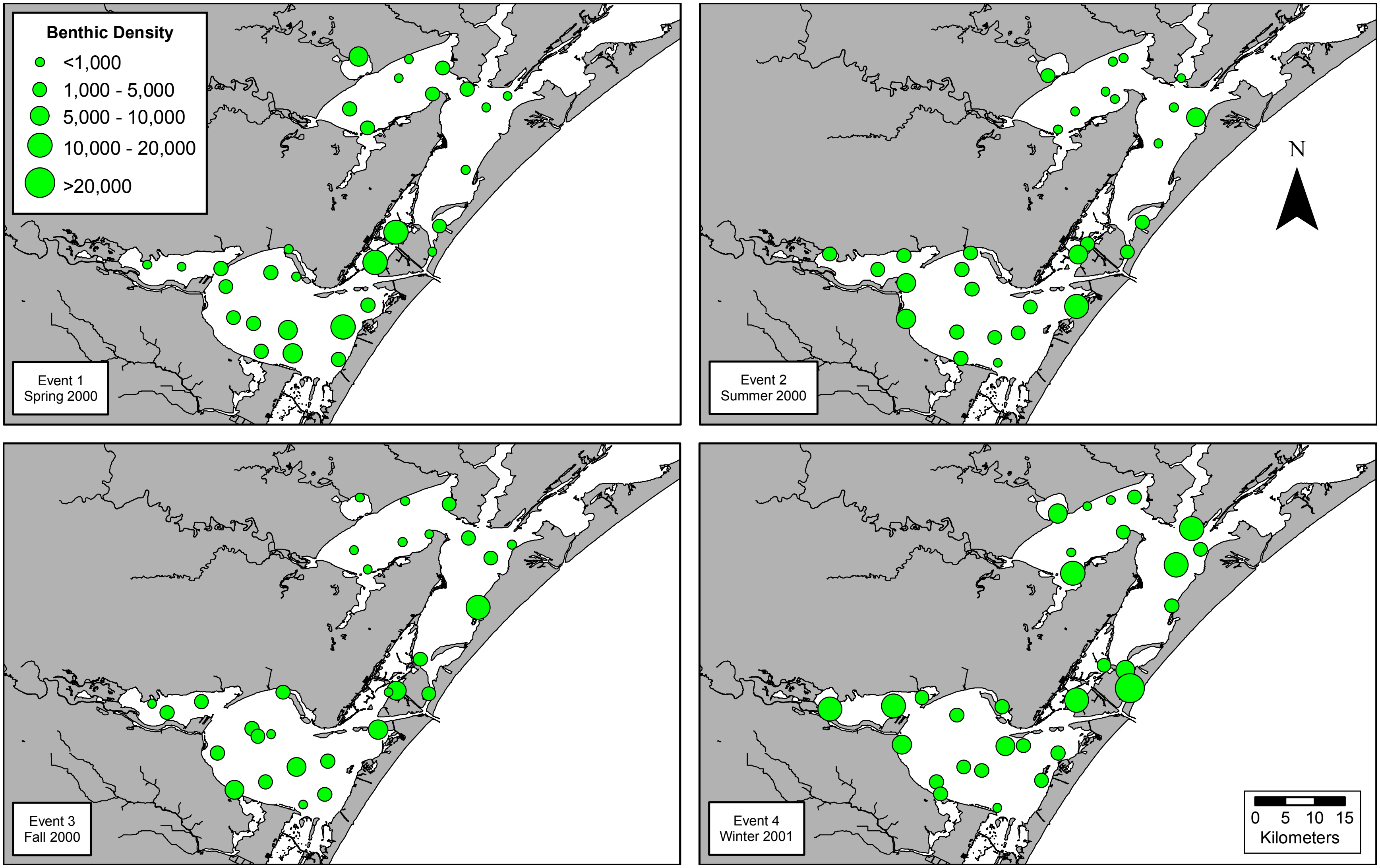

Fig. 5.6. Mean benthic density (number of individuals m^{-2}) at randomly selected EMAP stations (30) for RCAP 2000.

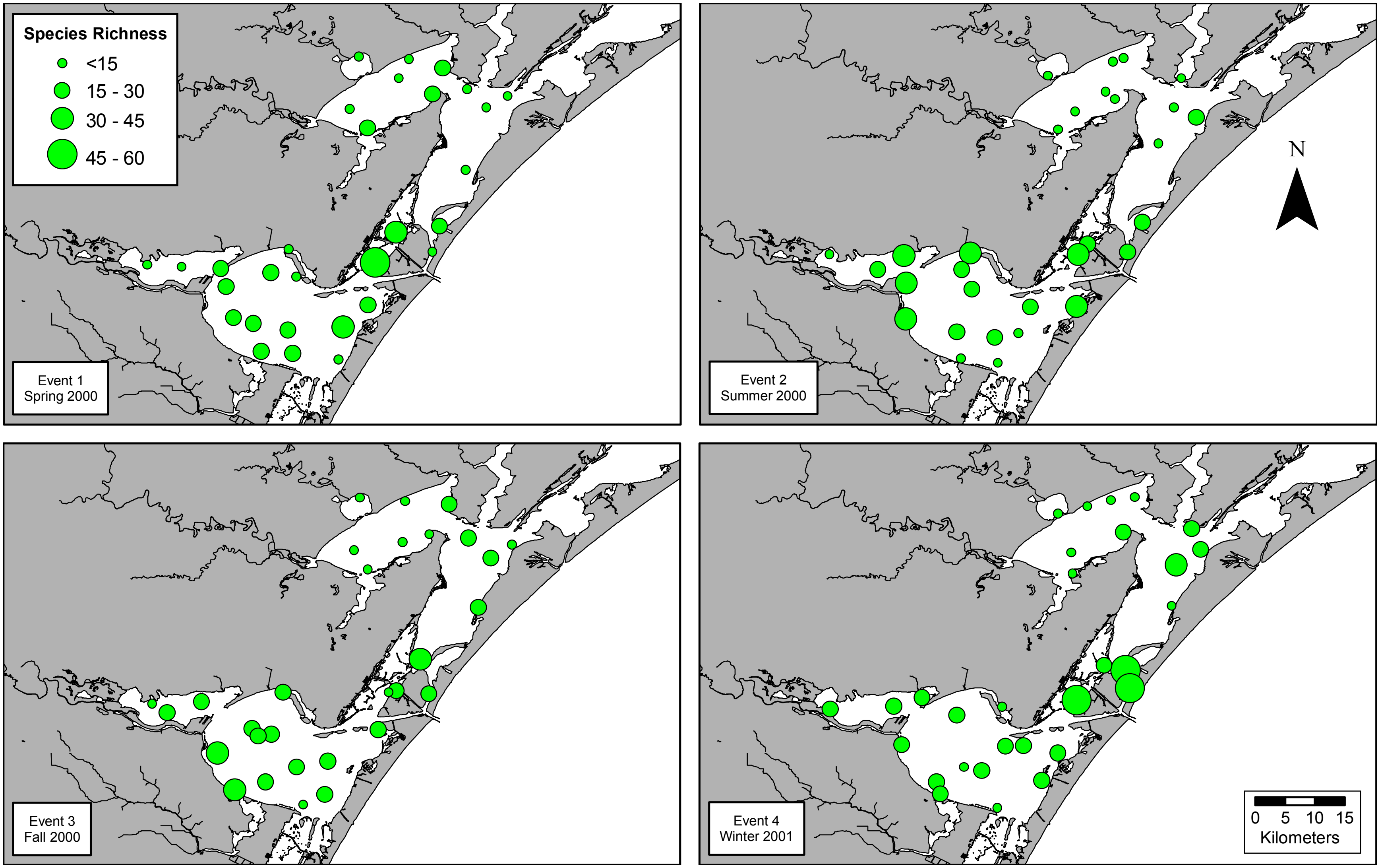

Fig. 5.7. Benthic species richness (number of individual species) at randomly selected EMAP stations (30) for RCAP 2000.

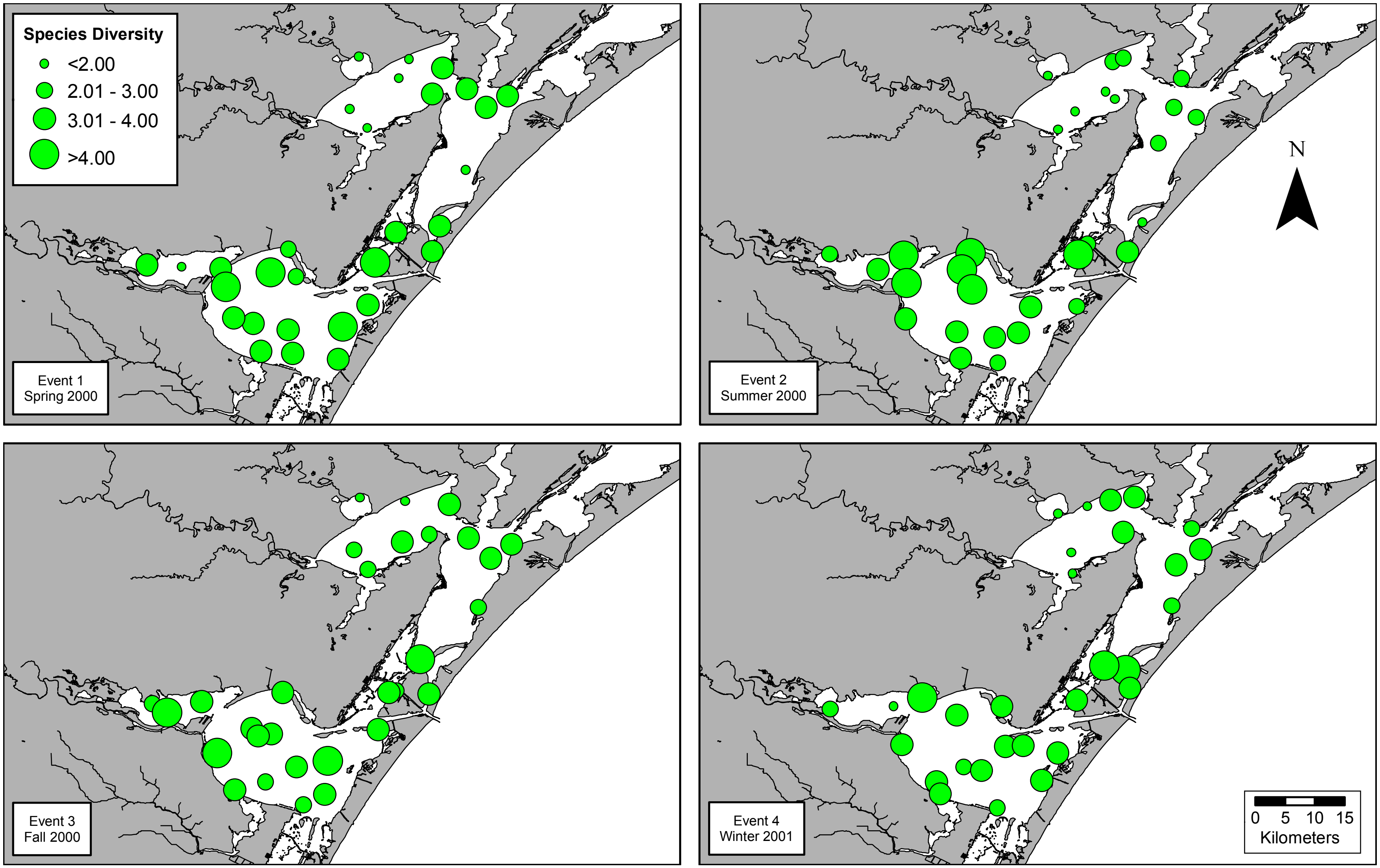

Fig. 5.8. Benthic species diversity (Shannon-Weiner $H'_{\log 2}$) at randomly selected EMAP stations (30) for RCAP 2000.

During RCAP 2001, benthic analysis by Pearce (2003) identified 162 species totaling 32,399 individuals. The most abundant group was annelids, which comprised 46.3% of all organisms collected. Polychaetes represented 87.7% of the annelids, with the polychaete *Prionospio heterobranchia* dominating the group, accounting for 33.8% of all annelids collected. The second most abundant group was molluscs, which accounted for 30.4% of all organisms collected, dominated by the dwarf surf clam, *Mulinia lateralis*, representing 53.1% of all molluscs collected. Arthropods represented 21.5% of all organism collected with the amphipod crustacean, *Erichthonius brasiliensis*, representing 46.9% of all arthropods collected. Collectively these three groups represented 98.2% of all organism collected during RCAP 2001. The remaining 1.8% of organisms collected included representatives from the phyla Cnidaria, Echinodermata, Nemertea, Nemata, Phoronida, and Platyhelminthes.

Upper Laguna Madre and Baffin Bay Complex

Corpus Christ Bay (Segment 2481)

Mean benthic density, for all sampling events, was 4855 individuals m^{-2} (SD = 2109). Density ranged from 2738 individuals m^{-2} in Event 1 (Summer 2001) to 8289 individuals m^{-2} in Event 4 (Spring 2002) (Fig. 5.9 and Table 6.11.4). Mean species richness was 30 species collected (SD = 5). Species richness ranged from 24 to 35 species collected with highest number of species being collected in Event 1 (Summer 2001) (Fig. 5.10 and Table 6.11.4). Species diversity ranged from 1.92 to 4.58 (Fig. 5.11 and Table 6.11.5) and mean species diversity was highest in this segment during Event 1 (Summer 2001).

Dominant species consisted of the polychaete, *Prionospio heterobranchia*, oligochaetes, nemerteans, and the gastropod mollusc, *Cerithium lutosum.* Density, richness, and diversity were greatest at the sites associated with Submerged Aquatic Vegetation (SAV) or seagrass beds. Although classified as part of Corpus Christi Bay by TCEQ, this portion of the bay located south of Corpus Christi Bay proper and north of the J.F.K. Causeway, is more characteristic of the Laguna Madre regarding benthic community composition. Of the total number of sites located in this segment (5), 80% were located within SAV beds.

Laguna Madre (Segment 2491)

Mean benthic density, for all sampling events, was 8576 individuals m^{-2} (SD = 6424). Density ranged from 173 individuals m^{-2} in Event 1 (Summer 2001) to 32,737 individuals m^{-2} in Event 3 (Winter 2002) (Fig. 5.9 and Table 6.11.4). Mean species richness was 26 species collected (SD = 13). Species richness ranged from 3 to 59 species collected with highest number of species collected in Event 3 (Winter 2002) (Fig. 5.10 and Table 6.11.4). Species diversity ranged from 0.36 to 4.48 (Fig. 5.11 and Table 6.11.5) and mean species diversity was highest in this segment during Event 4 (Spring 2002). Excluding the limited number of stations in the Corpus Christi Bay segment the Laguna Madre had the highest mean diversity values for all sampling events in RCAP 2001.

The polychaetes, *Prionospio heterbranchia* and *Syllis cornuta* and the bivalve *Anomalocardia auberiana* were the dominant species. As seen in the Corpus Christi Bay segment, higher

density, richness, and diversity occurred in SAV beds. Of the 65 sites sampled in RCAP 2001 57% of those sites occurred within SAV beds.
Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada (Segment 2492)

Mean benthic density, for all sampling events, was 4029 individuals m^{-2} (SD = 7112). Density ranged from 25 individuals m^{-2} in Event 2 (Fall 2001) to 42,309 individuals m^{-2} in Event 3 (Winter 2002) (Fig. 5.9 and Table 6.11.4). Mean species richness was 6 species collected (SD = 5). Species richness ranged from 1 to 24 species collected with highest number of species being collected in Event 3 (Winter 2002) (Fig. 5.10 and Table 6.11.4). Species diversity ranged from 0.00 to 3.19 (Fig. 5.11 and Table 6.11.5) and mean species diversity was highest in this segment during Event 3 (Winter 2002).

The dominant species collected was the bivalve *Mulinia lateralis*. Two significantly different benthic communities existed within this segment depending on the presence of SAV. Sites located in SAV beds (16.7%) typically produced greater species richness, density, and diversity. Average species richness for stations located in SAV beds was 10 species collected, while the average species richness at stations not located in SAV beds was 3 species collected. Pearce (2000) identified two distinct benthic groups during RCAP 2001. The species associated with sites located in SAV beds consisted of “climax” community species, while the species associated with unvegetated sites typically consisted of early colonizing species.

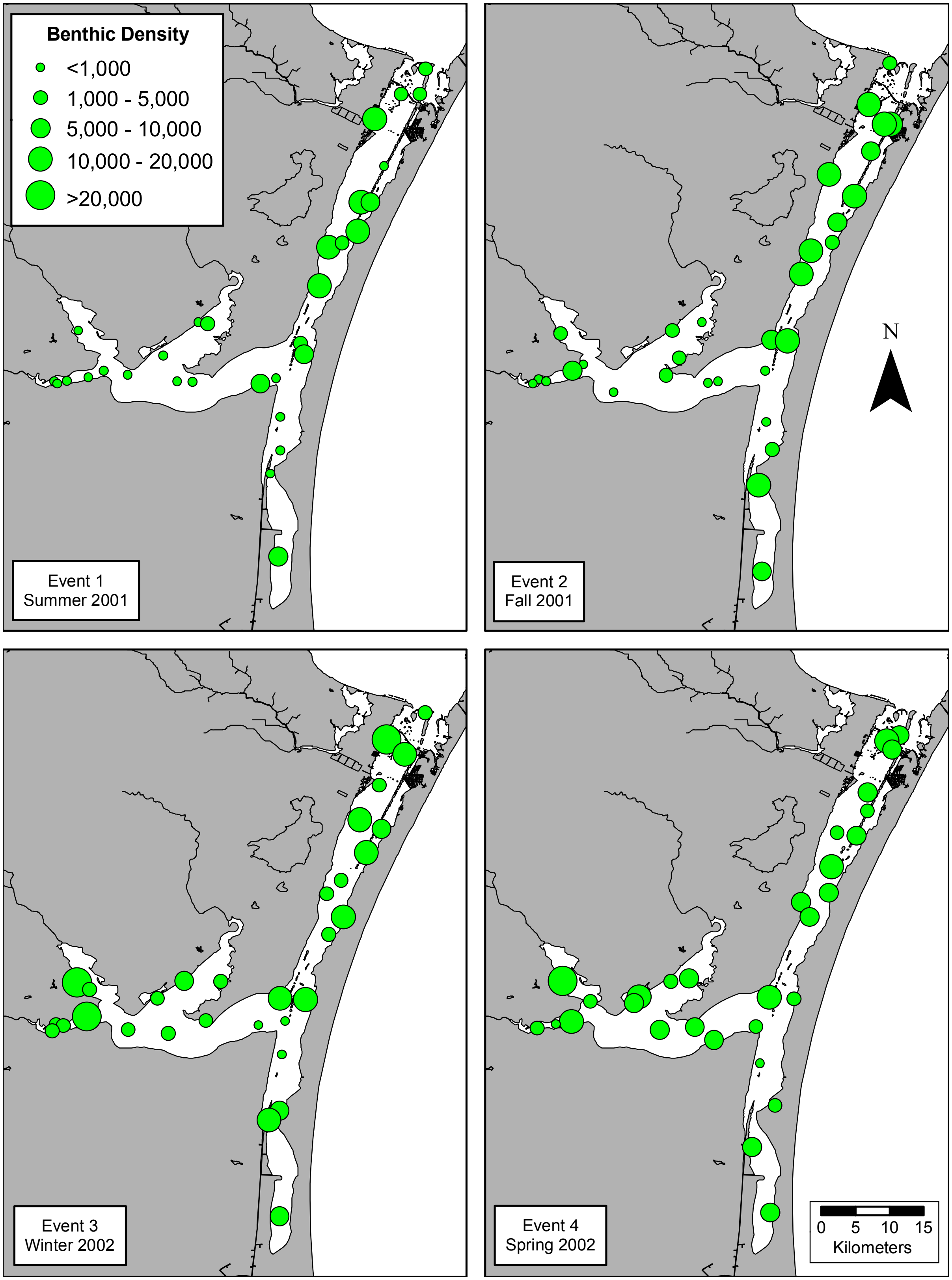

Fig. 5.9. Mean benthic density (number of individual m^{-2}) at randomly selected EMAP stations (31) for RCAP 2001.

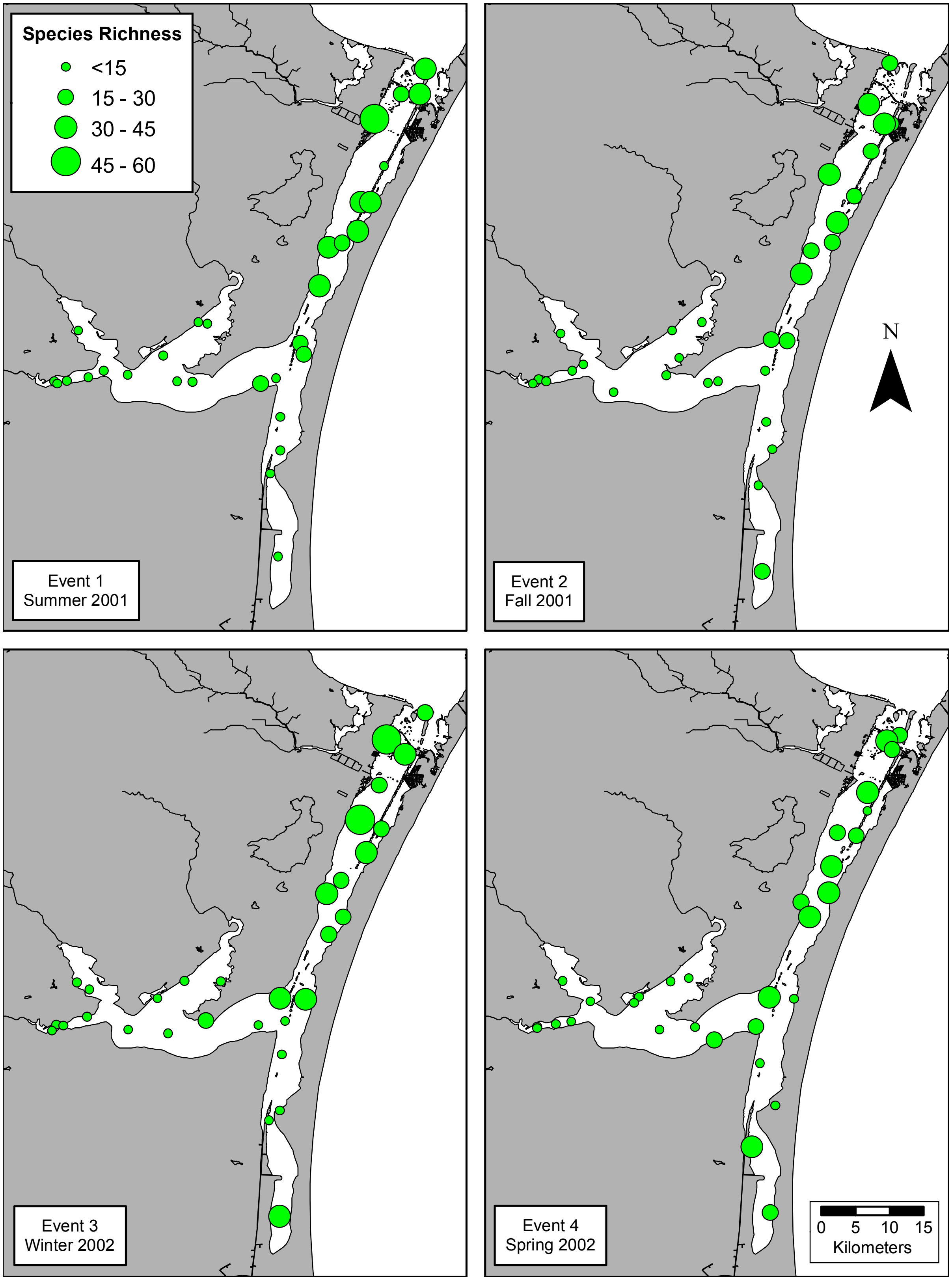

Fig. 5.10. Benthic species richness (number of individual species) at randomly selected EMAP stations (31) for RCAP 2001.

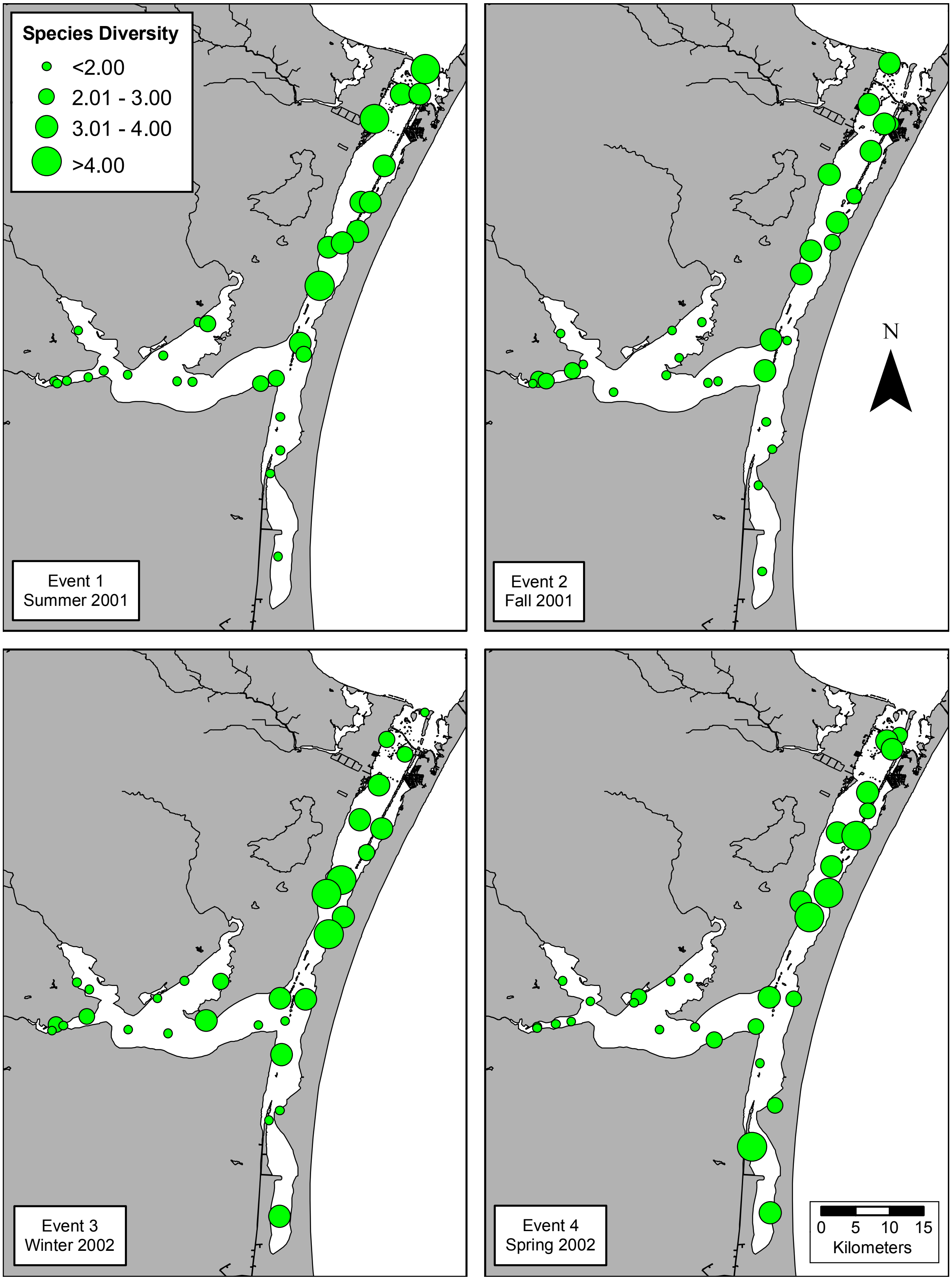

Fig. 5.11. Benthic species diversity (Shannon-Weiner H'_{log2}) at randomly selected EMAP stations (31) for RCAP 2001.

5.4 Summary

The primary goal of the RCAP 2000 and RCAP 2001 benthic component was to begin a baseline characterization of the benthic communities within segments of the CBBEP region. Both Nuñez (2004) and Pearce (2003) used this opportunity to complete M.S. thesis degrees while assisting on this project, and the reader is encouraged to read their results for more detailed analysis of benthic community composition for the respective regions. As the first in a series of long-term monitoring events, it is not possible to make definitive conclusions as to how the health of the benthic community relates to sediment quality as sampling only occurred for sediment metals during one quarter of each monitoring year.

As previously stated, as future sampling events become more complex, with analysis done during each sampling event for sediment inorganic and sediment organic contaminants and sediment toxicity, we hope to establish an index of unique indicator species and parameters. This index will allow future monitoring events the ability to assess the overall health of the system and identify areas that may or may not warrant further attention.

A basic analysis of the RCAP 2000 baseline data indicates varying degrees of complexity within the areas sampled. Within the Mission-Aransas (Segment 2471 and 2472) and Nueces estuaries (Segment 2483, 2481, and 2482), observed differences in biological and physiochemical attributes existed. Nuñez (2004) concluded that specifically, salinity, depth, overall benthic density, species richness, and diversity were significantly greater in the Nueces Estuary. In the Mission-Aransas Estuary, dissolved oxygen and species dominance (influence of one or two species) typically were higher, most notably in the Copano Bay area.

The Mission-Aransas estuary typically exhibited salinity gradients more reflective of a characteristic estuary, with lower salinities in the upper regions near freshwater inputs grading to higher salinities as one approached the gulf pass at Port Aransas. Salinity also tended to be more variable the Mission-Aransas Estuary as opposed to the relatively stable high salinity observed in the Nueces Estuary, which for Nueces Bay is a strong indicator of reduced freshwater inflow from the Nueces River.

Species collected during RCAP 2000 were representative of past research, with many species historically found throughout this region (see Nuñez 2004 for more detail). While some species collected, classify as pollution tolerant, or pollution sensitive, these same species also occur in extremely stressful environments. Stresses commonly relate to fluctuating physical or environmental conditions that cause these areas to undergo sudden and abrupt changes in their immediate surroundings. If environmental conditions are conducive to producing stable faunal communities, high species diversity and richness values typically tend to occur; regardless of whether the population abundance is high or low. However, communities under extreme environmental stress, regardless of the stressor, exhibit lower diversity and richness values with large populations of one or two species dominating the community (Pearson and Rosenberg 1978; Bowman and Jennings 1992; Hall et al. 1997; Rakocinski et al. 1997).

While conditions during RCAP 2000 indicated relatively stable, although high salinity, it is only a matter of time before the region once again experiences a major inflow event. Historical information for this region shows periodic episodes when salinities will decline dramatically before rising again to levels observed during RCAP 2000; making salinity a major stressor on the benthic communities within the area. This may signify that the benthic communities are comprised of "hearty" species that can tolerate these constantly changing conditions and that "pollution" is not the reason they tend to occur. Additional data collection over time, which captures these changing conditions, will aid in future assessments.

During RCAP 2001, Pearce (2003) identified two distinct benthic communities within the three segments (Segments 2481, 2491, and 2492) sampled and within the Baffin Bay complex (Segment 2492), all related to the presence or absence of SAV, or seagrass beds. As seen in RCAP 2000 factors such as salinity, dissolved oxygen, water depth and circulation, sediment type, and turbidity played a role in influencing benthic community composition and the presence, quality, and quantity of SAV.

Pearce (2003) attributed the lack of seagrass within the Baffin Bay complex most likely related to greater water depth, lack of circulation and inflow, wind driven turbidity, and sediment type, while salinity and dissolved oxygen were primary factors, along with shallow water depth and sandier substrates, for SAV,

The species collected during RCAP 2001 were representative of past research, with many species historically found throughout the area sampled (see Pearce 2003 for more detail). As previously discussed, aspects of stress are applicable for RCAP 2001, as monitoring for this area occurred in a mostly shallow depth, warm water, hypersaline environment, where only the most adaptable species tend to survive. While this is not to dismiss the possible influence of environmentally damaging inputs to the system, it is a cautious reminder that natural conditions may have as much, or more, of an influence on the health of a system.

5.5 References

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6.0 DATA TABLES

6.1 Sampling Site Information

Table 6.1.1. RCAP 2004 sampling site (32) information, sample type, and sampling date. **Sample Types:** FD = Field Data, RC = Routine Conventional Water Chemistry, M = Microbiological, 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)
2471	Aransas Bay	337	18607	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/27/2004	28.07500	97.00833	2.85
		340	18610	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/27/2004	27.92500	97.02500	2.30
		341	18270	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/27/2004	28.02500	97.00833	3.50
		344	18613	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/27/2004	28.04167	96.95833	3.10
		353	18620	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/27/2004	27.97500	97.00833	3.50
2472	Copano Bay/Port Bay/Mission Bay	332	18602	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/26/2004	28.04167	97.15833	1.55
		338	18608	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/26/2004	28.12926	97.13891	2.10
		343	18612	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/26/2004	28.12500	97.15833	1.75
		356	18623	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/26/2004	28.17500	97.02500	2.20
		357	18624	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/26/2004	28.09167	97.09167	2.40
2481	Corpus Christi Bay	333	18603	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.72500	97.25833	4.50
		339	18609	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.70833	97.29167	1.00
		346	18614	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.80833	97.19167	2.75
		348	18616	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.72500	97.20833	4.45
		350	18618	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.75496	97.33736	4.50
		351	17758	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.80833	97.30833	4.50
		354	18621	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.79167	97.35833	4.15
		355	18622	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/04/2004	27.74167	97.17500	3.85
2482	Nueces Bay	331	18601	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/03/2004	27.87983	97.49577	1.05
		349	18617	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/03/2004	27.86563	97.42309	1.72
		352	18619	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/03/2004	27.84167	97.44167	1.72
2483	Redfish Bay	328	18236	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/03/2004	27.85833	97.12500	2.55
2485	Oso Bay	330	18600	FD, RC, M, TMSED, SEDORG, SEDTOX, BEN	08/11/2004	27.69000	97.29997	0.70
2491	Laguna Madre	335	18605	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/09/2004	27.52500	97.32500	1.55
		347	18615	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	08/09/2004	27.47500	97.34167	1.55
2492	Baffin Bay/Alazan Bay	327	18598	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/21/2004	27.27130	97.70459	1.35
	Cayo del Grullo/Laguna Salada	329	18599	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/21/2004	27.27500	97.64167	1.10
		334	18604	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/20/2004	27.32231	97.55703	1.10
		336	18606	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/21/2004	27.35084	97.69093	1.10
		342	18611	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/20/2004	27.27500	97.55833	2.20
		345	18260	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/20/2004	27.25833	97.49167	2.10
		358	18625	FD, RC, M, TMSED, SEDORG, SEDTOX, TISORG, TMTIS, BEN	07/21/2004	27.33771	97.67424	1.65

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 2004 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.

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)
2471	Aransas Bay	337	18607	16297	6.75	94.70	8.41	9.47	0.60	2.85	7.61	30.38
		340	18610	41751	7.05	110.00	8.23	26.60	0.65	2.30	5.65	30.97
		341	18270	23310	6.90	99.60	8.27	13.99	0.70	3.50	8.03	30.51
		344	18613	25268	6.57	94.30	8.25	15.29	0.70	3.10	6.56	29.84
		353	18620	26362	7.37	108.80	8.37	16.01	0.85	3.50	4.19	30.83
2472	Copano Bay/Port Bay/Mission Bay	332	18602	4647	6.55	87.80	8.62	2.46	0.20	1.55	50.89	29.38
		338	18608	3952	7.46	101.70	8.47	2.63	0.25	2.10	43.25	30.91
		343	18612	3479	6.91	92.50	8.37	1.81	0.20	1.75	66.47	30.12
		356	18623	8779	7.54	104.90	8.39	4.85	0.30	2.20	28.65	31.35
		357	18624	4569	6.92	93.60	8.43	2.42	0.25	2.40	49.57	30.42
2481	Corpus Christi Bay	333	18603	42546	5.31	83.40	8.26	27.16	0.85	4.50	3.91	31.32
		339	18609	42486	6.27	99.10	8.27	27.08	0.55	1.00	7.26	31.62
		346	18614	46097	5.78	91.90	8.21	29.71	0.65	2.75	7.82	31.26
		348	18616	44769	5.17	81.60	8.18	28.76	1.00	4.45	3.42	31.14
		350	18618	40322	6.39	100.60	8.29	25.56	0.95	4.50	3.56	32.15
		351	17758	38112	6.78	106.20	8.33	24.19	0.65	4.50	4.96	32.06
		354	18621	38101	6.89	107.90	8.33	23.98	0.90	4.15	4.40	32.31
		355	18622	45118	5.58	88.20	8.18	29.02	0.95	3.85	3.21	30.97
2482	Nueces Bay	331	18601	5359	7.72	105.10	9.00	2.86	0.30	1.05	25.17	30.75
		349	18617	17735	6.63	93.70	8.38	10.38	0.45	1.72	10.75	30.33
		352	18619	7789	7.78	107.10	8.80	4.27	0.35	1.72	16.81	30.98
2483	Redfish Bay	328	18236	47860	5.46	87.50	8.36	30.99	0.75	2.55	6.42	31.26
2485	Oso Bay	330	18600	49008	4.55	71.20	8.19	31.91	0.20	0.70	56.78	29.85
2491	Laguna Madre	335	18605	50825	5.83	94.20	8.47	33.16	0.90	1.55	3.98	31.07
		347	18615	51251	6.00	96.40	8.78	33.49	1.00	1.55	4.33	30.62
2492	Baffin Bay/Alazan Bay	327	18598	24758	4.47	65.10	8.52	14.96	0.25	1.35	19.11	30.46
	Cayo del Grullo/Laguna Salada	329	18599	26346	4.51	64.90	8.00	16.03	0.40	1.10	16.18	29.32
		334	18604	26487	6.51	95.80	8.42	16.09	0.30	1.10	43.53	31.12
		336	18606	22808	6.05	86.50	8.17	13.67	0.30	1.10	36.30	30.03
		342	18611	29696	6.22	91.60	8.41	18.26	0.50	2.20	8.93	30.42
		345	18260	33047	5.69	84.10	8.41	20.55	0.70	2.10	6.35	29.84
		358	18625	24222	6.08	88.20	8.24	14.59	0.25	1.65	25.73	30.56

Table 6.2.2. Near-bottom Field Parameter concentrations recorded 0.50 m off-bottom at RCAP 2004 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.

Segment	Segment Name	CCS ID	TCEQ ID	Cond. (µmhos)	DO (mg/L)	DO Sat. (%)	pH (su)	Salinity	Total Depth (m)	Turbidity (NTU)	Water Temp (°C)
2471	Aransas Bay	337	18607	31829	2.09	32.40	7.99	19.85	2.85	16.88	30.86
		340	18610	53546	5.33	86.70	8.01	35.17	2.30	32.83	30.82
		341	18270	34322	2.63	39.70	8.05	21.45	3.50	24.20	30.92
		344	18613	33545	2.94	43.80	8.06	20.88	3.10	38.11	30.34
		353	18620	34212	5.35	80.60	8.21	21.36	3.50	36.02	30.49
2472	Copano Bay/Port Bay/Mission Bay	332	18602	4647	6.55	87.60	8.63	2.46	1.55	47.14	29.89
		338	18608	4948	7.32	99.70	8.47	2.63	2.10	67.37	30.84
		343	18612	3478	6.89	92.30	8.38	1.81	1.75	66.95	30.14
		356	18623	8818	7.21	100.00	8.41	4.88	2.20	32.90	31.27
		357	18624	4568	6.91	93.20	8.57	2.41	2.40	47.21	30.44
2481	Corpus Christi Bay	333	18603	45138	1.44	23.50	7.92	29.02	4.50	7.12	31.32
		339	18609	42486	6.27	99.10	8.27	27.08	1.00	7.26	31.62
		346	18614	46111	5.74	91.40	8.22	29.73	2.75	8.10	31.28
		348	18616	46298	1.98	31.80	7.95	29.95	4.45	9.91	31.29
		350	18618	42994	5.40	85.40	8.22	27.48	4.50	14.79	31.38
		351	17758	46001	5.63	90.60	8.22	29.67	4.50	4.75	31.24
		354	18621	43373	5.49	86.40	8.22	27.77	4.15	7.54	31.36
		355	18622	45180	5.53	84.00	8.16	29.05	3.85	5.51	30.97
2482	Nueces Bay	331	18601	5359	7.72	105.10	9.00	2.86	1.05	25.17	30.75
		349	18617	19272	5.87	84.30	8.31	11.22	1.72	13.88	30.41
		352	18619	8144	7.43	102.10	8.73	4.50	1.72	17.65	30.64
2483	Redfish Bay	328	18236	51336	3.90	63.20	8.24	33.53	2.55	8.44	31.19
2485	Oso Bay	330	18600	49008	4.55	71.20	8.19	31.91	0.70	56.78	29.85
2491	Laguna Madre	335	18605	50901	5.69	91.50	8.43	33.23	1.55	6.91	30.83
		347	18615	51250	5.91	94.80	8.78	33.50	1.55	4.26	30.58
2492	Baffin Bay/Alazan Bay	327	18598	24758	4.47	65.10	8.52	14.96	1.35	19.11	30.46
	Cayo del Grullo/Laguna Salada	329	18599	26346	4.51	64.90	8.00	16.03	1.10	16.18	29.32
		334	18604	26487	6.51	95.80	8.42	16.09	1.10	43.53	31.12
		336	18606	22808	6.05	86.50	8.17	13.67	1.10	36.30	30.03
		342	18611	29701	5.93	87.40	8.40	18.26	2.20	13.67	30.34
		345	18260	35230	5.01	75.40	8.42	22.10	2.10	33.10	30.67
		358	18625	24197	6.01	87.30	8.24	14.58	1.65	25.38	30.70

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 2004 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	2471	Aransas Bay	5	16297	41751	26598
(µmhos)	2472	Copano Bay/Port Bay/Mission Bay	5	3479	8779	5085
	2481	Corpus Christi Bay	8	38101	46097	42194
Near-Surface	2482	Nueces Bay	3	5359	17735	10294
(0.50 m below)	2483	Redfish Bay	1	-	-	47860
	2485	Oso Bay	1	-	-	49008
	2491	Laguna Madre	2	50825	51251	**51038**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	22808	33047	26766
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Conductivity	2471	Aransas Bay	5	31829	53546	37491
(µmhos)	2472	Copano Bay/Port Bay/Mission Bay	5	3478	8818	5292
	2481	Corpus Christi Bay	8	42486	46298	44698
Near-Bottom	2482	Nueces Bay	3	5359	19272	10925
(0.50 above)	2483	Redfish Bay	1	-	-	**51336**
	2485	Oso Bay	1	-	-	49008
	2491	Laguna Madre	2	50901	51250	51076
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	22808	35230	27075

Table 6.3.2. Salinity near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	9.47	26.60	16.27
	2472	Copano Bay/Port Bay/Mission Bay	5	1.81	4.85	2.83
	2481	Corpus Christi Bay	8	23.98	29.71	26.93
Near-Surface	2482	Nueces Bay	3	2.86	10.38	5.84
(0.50 m below)	2483	Redfish Bay	1	-	-	30.99
	2485	Oso Bay	1	-	-	31.91
	2491	Laguna Madre	2	33.16	33.49	**33.33**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	13.67	20.55	16.31
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Salinity	2471	Aransas Bay	5	19.85	35.17	23.74
	2472	Copano Bay/Port Bay/Mission Bay	5	1.81	4.88	2.84
	2481	Corpus Christi Bay	8	27.08	29.95	28.72
Near-Bottom	2482	Nueces Bay	3	2.86	11.22	6.19
(0.50 above)	2483	Redfish Bay	1	-	-	**33.53**
	2485	Oso Bay	1	-	-	31.91
	2491	Laguna Madre	2	33.23	33.50	33.37
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	13.67	22.10	16.53

Table 6.3.3. Dissolved Oxygen (mg/L) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	6.57	7.37	6.93
(mg/L)	2472	Copano Bay/Port Bay/Mission Bay	5	6.55	7.54	7.08
	2481	Corpus Christi Bay	8	5.17	6.89	6.02
Near-Surface	2482	Nueces Bay	3	6.63	7.78	**7.38**
(0.50 m below)	2483	Redfish Bay	1	-	-	5.46
	2485	Oso Bay	1	-	-	4.55
	2491	Laguna Madre	2	5.83	6.00	5.92
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	4.47	6.51	5.65
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Dissolved Oxygen	2471	Aransas Bay	5	2.09	5.35	3.67
(mg/L)	2472	Copano Bay/Port Bay/Mission Bay	5	6.55	7.32	6.98
	2481	Corpus Christi Bay	8	1.44	6.27	4.69
Near-Bottom	2482	Nueces Bay	3	5.87	7.72	**7.01**
(0.50 above)	2483	Redfish Bay	1	-	-	3.90
	2485	Oso Bay	1	-	-	4.55
	2491	Laguna Madre	2	5.69	5.91	5.80
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	4.47	6.51	5.50

Table 6.3.4. Dissolved Oxygen (% saturation) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2004 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
Dissolved Oxygen	2471	Aransas Bay	5	94.30	110.00	101.48
(% Saturation)	2472	Copano Bay/Port Bay/Mission Bay	5	87.80	104.90	96.10
	2481	Corpus Christi Bay	8	81.60	107.90	94.86
Near-Surface	2482	Nueces Bay	3	93.70	107.10	**101.97**
(0.50 m below)	2483	Redfish Bay	1	-	-	87.50
	2485	Oso Bay	1	-	-	71.20
	2491	Laguna Madre	2	94.20	96.40	95.30
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	64.90	95.80	82.31
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Dissolved Oxygen	2471	Aransas Bay	5	32.40	86.70	56.64
(% Saturation)	2472	Copano Bay/Port Bay/Mission Bay	5	87.60	100.00	94.56
	2481	Corpus Christi Bay	8	23.50	99.10	74.03
Near-Bottom	2482	Nueces Bay	3	84.30	105.10	**97.17**
(0.50 above)	2483	Redfish Bay	1	-	-	63.20
	2485	Oso Bay	1	-	-	71.20
	2491	Laguna Madre	2	91.50	94.80	93.15
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	64.90	95.80	80.34

Table 6.3.5. pH (su) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	8.23	8.41	8.31
(su)	2472	Copano Bay/Port Bay/Mission Bay	5	8.37	8.62	8.46
	2481	Corpus Christi Bay	8	8.18	8.33	8.26
Near-Surface	2482	Nueces Bay	3	8.38	9.00	**8.73**
(0.50 m below)	2483	Redfish Bay	1	-	-	8.36
	2485	Oso Bay	1	-	-	8.19
	2491	Laguna Madre	2	8.47	8.78	8.63
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	8.00	8.52	8.31

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
pH	2471	Aransas Bay	5	7.99	8.21	8.06
(su)	2472	Copano Bay/Port Bay/Mission Bay	5	8.38	8.63	8.49
	2481	Corpus Christi Bay	8	7.92	8.27	8.15
Near-Bottom	2482	Nueces Bay	3	8.31	9.00	**8.68**
(0.50 m above)	2483	Redfish Bay	1	-	-	8.24
	2485	Oso Bay	1	-	-	8.19
	2491	Laguna Madre	2	8.43	8.78	8.61
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	8.00	8.52	8.31

Table 6.3.6. Turbidity (NTU) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2004 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
Turbidity	2471	Aransas Bay	5	4.19	8.03	6.41
(NTU)	2472	Copano Bay/Port Bay/Mission Bay	5	28.65	66.47	47.77
	2481	Corpus Christi Bay	8	3.21	7.82	4.82
Near-Surface	2482	Nueces Bay	3	10.75	25.17	17.58
(0.50 m below)	2483	Redfish Bay	1	-	-	6.42
	2485	Oso Bay	1	-	-	**56.78**
	2491	Laguna Madre	2	3.98	4.33	4.16
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	6.35	43.53	22.30
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Turbidity	2471	Aransas Bay	5	16.88	38.11	29.61
(NTU)	2472	Copano Bay/Port Bay/Mission Bay	5	32.90	67.37	52.31
	2481	Corpus Christi Bay	8	4.75	14.79	8.12
Near-Bottom	2482	Nueces Bay	3	13.88	25.17	18.90
(0.50 m above)	2483	Redfish Bay	1	-	-	8.44
	2485	Oso Bay	1	-	-	**56.78**
	2491	Laguna Madre	2	4.26	6.91	5.59
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	13.67	43.53	26.75

Table 6.3.7. Water Temperature (°C) near-surface and near-bottom summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	29.84	30.97	30.51
(°C)	2472	Copano Bay/Port Bay/Mission Bay	5	29.38	31.35	30.44
	2481	Corpus Christi Bay	8	30.97	32.31	**31.60**
Near-Surface	2482	Nueces Bay	3	30.33	30.98	30.69
(0.50 m below)	2483	Redfish Bay	1	-	-	31.26
	2485	Oso Bay	1	-	-	29.85
	2491	Laguna Madre	2	30.62	31.07	30.85
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	29.32	31.12	30.25
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Water Temperature	2471	Aransas Bay	5	30.34	30.92	30.69
(°C)	2472	Copano Bay/Port Bay/Mission Bay	5	29.89	31.27	30.52
	2481	Corpus Christi Bay	8	30.97	31.62	**31.31**
Near-Bottom	2482	Nueces Bay	3	30.41	30.75	30.60
(0.50 m above)	2483	Redfish Bay	1	-	-	31.19
	2485	Oso Bay	1	-	-	29.85
	2491	Laguna Madre	2	30.58	30.83	30.71
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	29.32	31.12	30.38

Table 6.3.8. Secchi Depth (m) and Total Depth (m) summary statistics, listed by TCEQ Segment for RCAP 2004 sampling sites. **Bold** = highest recorded mean concentration.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Secchi Depth	2471	Aransas Bay	5	0.60	0.85	0.70
(m)	2472	Copano Bay/Port Bay/Mission Bay	5	0.20	0.30	0.24
	2481	Corpus Christi Bay	8	0.55	1.00	0.81
	2482	Nueces Bay	3	0.30	0.45	0.37
	2483	Redfish Bay	1	-	-	0.75
	2485	Oso Bay	1	-	-	0.20
	2491	Laguna Madre	2	0.90	1.00	**0.95**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.25	0.70	0.39
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Total Depth	2471	Aransas Bay	5	2.30	3.50	3.05
(m)	2472	Copano Bay/Port Bay/Mission Bay	5	1.55	2.40	2.00
	2481	Corpus Christi Bay	8	1.00	4.50	**3.71**
	2482	Nueces Bay	3	1.05	1.72	1.50
	2483	Redfish Bay	1	-	-	2.55
	2485	Oso Bay	1	-	-	0.70
	2491	Laguna Madre	2	1.55	1.55	1.55
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	1.10	2.20	1.51

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 2004 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. **Bold** = highest recorded concentration.* = indicates sample not collected due to depth requirements. ND = No Data Collected.

Segment	Segment Name	CCS ID	TCEQ ID	Ammonia SNU (SLE 0.10)	Ammonia MNU	Ammonia BNU	Ammonia SN	Ammonia MN	Ammonia BN
2471	Aransas Bay	337	18607	0.002	0.003	0.007	0.003	0.002	0.001
		340	18610	0.008	0.006	0.008	0.003	0.001	0.003
		341	18270	0.003	0.006	0.009	0.003	**0.016**	0.007
		344	18613	0.008	0.005	0.015	0.002	0.003	0.008
		353	18620	0.002	0.002	0.034	0.002	0.002	0.004
2472	Copano Bay/Port Bay/Mission Bay	332	18602	0.014	*	0.015	0.004	*	0.002
		338	18608	0.011	0.015	0.015	0.005	0.003	0.004
		343	18612	0.017	*	ND	0.007	*	0.005
		356	18623	0.020	0.012	0.010	0.005	0.004	0.005
		357	18624	0.015	0.009	0.015	0.006	0.003	0.004
2481	Corpus Christi Bay	333	18603	0.016	0.002	**0.084**	0.001	0.002	0.064
		339	18609	0.004	*	*	0.003	*	*
		346	18614	0.002	0.003	0.003	0.005	0.002	0.004
		348	18616	0.003	0.012	0.056	0.003	0.003	**0.070**
		350	18618	0.008	0.003	0.007	0.011	0.002	0.004
		351	17758	0.003	0.001	0.002	0.001	0.003	0.002
		354	18621	0.003	0.003	0.006	0.001	0.004	0.004
		355	18622	0.002	0.009	0.005	0.004	0.002	0.004
2482	Nueces Bay	331	18601	0.016	*	*	0.002	*	*
		349	18617	0.005	*	0.017	0.009	*	0.005
		352	18619	0.010	*	0.014	0.006	*	0.005
2483	Redfish Bay	328	18236	0.004	0.001	0.008	0.002	0.004	0.007
2485	Oso Bay	330	18600	0.021	*	*	0.002	*	*
2491	Laguna Madre	335	18605	0.012	*	0.014	0.013	*	0.012
		347	18615	0.018	*	0.037	0.019	*	0.011
2492	Baffin Bay/Alazan Bay	327	18598	0.018	*	*	0.008	*	*
	Cayo del Grullo/Laguna Salada	329	18599	**0.143**	*	*	**0.133**	*	*
		334	18604	0.014	*	*	0.005	*	*
		336	18606	0.020	*	*	0.002	*	*
		342	18611	0.005	0.005	0.012	0.005	0.003	0.006
		345	18260	0.005	**0.016**	0.017	0.005	0.012	0.005
		358	18625	0.007	*	0.013	0.005	*	0.007

Table 6.4.2. Nitrate concentrations (mg/L or ppm) at RCAP 2004 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. ND = No Data Collected.

Segment	Segment Name	CCS ID	TCEQ ID	Nitrate SNU	Nitrate MNU	Nitrate BNU	Nitrate SN	Nitrate MN	Nitrate BN
2471	Aransas Bay	337	18607	<0.005	<0.005	<0.005	0.006	0.005	0.009
		340	18610	<0.005	<0.005	<0.005	0.011	0.005	0.003
		341	18270	<0.005	<0.005	<0.005	<0.005	<0.005	0.005
		344	18613	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
		353	18620	<0.005	<0.005	<0.005	0.006	0.006	0.006
2472	Copano Bay/Port Bay/Mission Bay	332	18602	<0.005	*	<0.005	0.003	*	0.007
		338	18608	<0.005	<0.005	<0.005	<0.005	<0.005	0.003
		343	18612	<0.005	*	ND	<0.005	*	<0.005
		356	18623	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
		357	18624	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2481	Corpus Christi Bay	333	18603	<0.005	<0.005	**0.016**	0.018	**0.018**	**0.017**
		339	18609	0.006	*	*	0.004	*	*
		346	18614	<0.005	<0.005	0.007	0.004	0.005	0.004
		348	18616	<0.005	<0.005	<0.005	0.005	0.004	0.006
		350	18618	<0.005	<0.005	<0.005	0.006	0.005	0.005
		351	17758	<0.005	<0.005	0.005	0.005	0.005	0.008
		354	18621	**0.007**	<0.005	<0.005	0.005	0.005	0.005
		355	18622	<0.005	**0.006**	0.006	0.004	<0.005	0.005
2482	Nueces Bay	331	18601	<0.005	*	*	<0.005	*	*
		349	18617	<0.005	*	<0.005	<0.005	*	0.003
		352	18619	<0.005	*	<0.005	0.005	*	0.005
2483	Redfish Bay	328	18236	0.006	<0.005	0.007	0.010	0.013	0.011
2485	Oso Bay	330	18600	<0.005	*	*	0.016	*	*
2491	Laguna Madre	335	18605	<0.005	*	<0.005	0.022	*	0.014
		347	18615	<0.005	*	<0.005	0.008	*	0.005
2492	Baffin Bay/Alazan Bay	327	18598	<0.005	*	*	0.005	*	*
	Cayo del Grullo/Laguna Salada	329	18599	0.060	*	*	**0.083**	*	*
		334	18604	<0.005	*	*	0.006	*	*
		336	18606	<0.005	*	*	0.015	*	*
		342	18611	<0.005	<0.005	<0.005	0.010	0.004	0.011
		345	18260	<0.005	<0.005	<0.005	0.003	0.004	0.004
		358	18625	<0.005	*	<0.005	0.011	*	0.010

Table 6.4.3. Nitrite concentrations (mg/L or ppm) at RCAP 2004 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. ND = No Data Collected.

Segment	Segment Name	CCS ID	TCEQ ID	Nitrite SNU	Nitrite MNU	Nitrite BNU	Nitrite SN	Nitrite MN	Nitrite BN
2471	Aransas Bay	337	18607	0.005	0.003	0.011	0.001	0.001	0.003
		340	18610	0.011	0.010	0.010	0.001	0.001	0.003
		341	18270	0.014	0.006	0.024	0.001	**0.022**	0.001
		344	18613	0.018	**0.046**	**0.051**	0.001	0.001	0.001
		353	18620	0.011	0.012	0.018	0.001	<0.001	<0.001
2472	Copano Bay/Port Bay/Mission Bay	332	18602	0.016	*	0.018	0.002	*	0.002
		338	18608	0.018	0.023	0.025	0.001	0.001	0.003
		343	18612	**0.053**	*	ND	0.003	*	0.002
		356	18623	0.017	0.019	0.014	0.002	0.002	0.001
		357	18624	0.017	0.015	0.024	0.002	0.002	0.002
2481	Corpus Christi Bay	333	18603	0.004	0.008	0.017	0.001	0.001	0.006
		339	18609	0.006	*	*	0.002	*	*
		346	18614	0.006	0.008	0.008	0.002	0.001	0.002
		348	18616	0.008	0.007	0.014	0.001	0.002	**0.010**
		350	18618	0.006	0.005	0.008	<0.001	0.001	0.001
		351	17758	0.008	0.006	0.010	0.001	0.001	0.004
		354	18621	0.005	0.007	0.008	0.001	0.001	0.001
		355	18622	0.005	0.005	0.005	0.002	0.001	0.001
2482	Nueces Bay	331	18601	0.013	*	*	0.002	*	*
		349	18617	0.009	*	0.013	0.001	*	0.003
		352	18619	0.013	*	0.013	0.001	*	0.001
2483	Redfish Bay	328	18236	0.005	0.007	0.009	0.001	0.003	0.003
2485	Oso Bay	330	18600	**0.053**	*	*	0.003	*	*
2491	Laguna Madre	335	18605	0.007	*	0.016	0.003	*	0.004
		347	18615	0.012	*	0.013	0.004	*	0.001
2492	Baffin Bay/Alazan Bay	327	18598	0.020	*	*	0.002	*	*
	Cayo del Grullo/Laguna Salada	329	18599	0.043	*	*	**0.044**	*	*
		334	18604	0.013	*	*	0.001	*	*
		336	18606	0.014	*	*	0.008	*	*
		342	18611	0.035	0.035	0.035	0.002	0.002	0.001
		345	18260	0.013	0.015	0.021	0.002	0.002	0.002
		358	18625	0.009	*	0.014	0.002	*	0.002

Table 6.4.4. Nitrate + Nitrite (N + N) concentrations (mg/L or ppm) at RCAP 2004 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. ND = No Data Collected.

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
2471	Aransas Bay	337	18607	0.005	0.003	0.011	0.006	0.006	0.012
		340	18610	0.011	0.010	0.010	0.013	0.006	0.006
		341	18270	0.014	0.006	0.024	0.006	**0.022**	0.006
		344	18613	0.018	**0.046**	**0.051**	0.001	0.001	0.001
		353	18620	0.011	0.012	0.018	0.006	0.006	0.006
2472	Copano Bay/Port Bay/Mission Bay	332	18602	0.016	*	0.018	0.005	*	0.010
		338	18608	0.018	0.023	0.025	0.001	0.001	0.006
		343	18612	0.053	*	ND	0.003	*	0.002
		356	18623	0.017	0.019	0.014	0.002	0.002	0.001
		357	18624	0.017	0.015	0.024	0.002	0.002	0.002
2481	Corpus Christi Bay	333	18603	0.004	0.010	0.033	0.019	0.019	**0.024**
		339	18609	0.012	*	*	0.006	*	*
		346	18614	0.007	0.008	0.015	0.006	0.006	0.006
		348	18616	0.008	0.007	0.014	0.006	0.006	0.016
		350	18618	0.006	0.005	0.008	0.006	0.006	0.006
		351	17758	0.008	0.006	0.015	0.006	0.006	0.012
		354	18621	0.012	0.007	0.008	0.006	0.006	0.006
		355	18622	0.005	0.011	0.011	0.006	0.001	0.006
2482	Nueces Bay	331	18601	0.013	*	*	0.002	*	*
		349	18617	0.009	*	0.013	0.001	*	0.005
		352	18619	0.013	*	0.013	0.006	*	0.006
2483	Redfish Bay	328	18236	0.011	0.011	0.016	0.011	0.016	0.014
2485	Oso Bay	330	18600	0.053	*	*	0.020	*	*
2491	Laguna Madre	335	18605	0.009	*	0.016	0.025	*	0.018
		347	18615	0.012	*	0.013	0.012	*	0.006
2492	Baffin Bay/Alazan Bay	327	18598	0.020	*	*	0.007	*	*
	Cayo del Grullo/Laguna Salada	329	18599	**0.103**	*	*	**0.127**	*	*
		334	18604	0.013	*	*	0.006	*	*
		336	18606	0.014	*	*	0.023	*	*
		342	18611	0.035	0.035	0.035	0.012	0.006	0.012
		345	18260	0.013	0.015	0.021	0.006	0.006	0.006
		358	18625	0.010	*	0.014	0.012	*	0.011

Table 6.4.5. Total Phosphorus (TP) concentrations (mg/L or ppm) at RCAP 2004 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. ND = No Data Collected.

Segment	Segment Name	CCS ID	TCEQ ID	TP SNU (0.22)	TP MNU	TP BNU
2471	Aransas Bay	337	18607	0.079	0.076	0.072
		340	18610	0.039	0.041	0.036
		341	18270	0.064	0.068	0.074
		344	18613	0.069	0.071	0.065
		353	18620	0.061	0.057	0.084
2472	Copano Bay/Port Bay/Mission Bay	332	18602	**0.157**	*	**0.155**
		338	18608	0.119	0.118	0.130
		343	18612	0.156	*	ND
		356	18623	0.116	0.108	0.123
		357	18624	0.144	**0.148**	0.145
2481	Corpus Christi Bay	333	18603	0.035	0.044	0.056
		339	18609	0.052	*	*
		346	18614	0.037	0.030	0.039
		348	18616	0.041	0.046	0.055
		350	18618	0.040	0.041	0.040
		351	17758	0.041	0.040	0.034
		354	18621	0.050	0.035	0.047
		355	18622	0.038	0.038	0.034
2482	Nueces Bay	331	18601	0.154	*	*
		349	18617	0.074	*	0.093
		352	18619	0.134	*	0.130
2483	Redfish Bay	328	18236	0.024	0.024	0.027
2485	Oso Bay	330	18600	0.102	*	*
2491	Laguna Madre	335	18605	0.027	*	0.028
		347	18615	0.027	*	0.022
2492	Baffin Bay/Alazan Bay	327	18598	0.077	*	*
	Cayo del Grullo/Laguna Salada	329	18599	0.071	*	*
		334	18604	0.075	*	*
		336	18606	0.092	*	*
		342	18611	0.073	0.075	0.084
		345	18260	0.062	0.066	0.072
		358	18625	0.083	*	0.094

Table 6.4.6. Orthophosphorus (OP), or Dissolved Inorganic Phosphorus, concentrations (mg/L or ppm) at RCAP 2004 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
2471	Aransas Bay	337	18607	0.127	0.164	0.143
		340	18610	0.058	0.042	0.060
		341	18270	0.104	0.126	0.085
		344	18613	0.110	0.134	0.095
		353	18620	0.091	0.064	0.061
2472	Copano Bay/Port Bay/Mission Bay	332	18602	0.117	*	0.111
		338	18608	0.141	0.102	0.100
		343	18612	0.135	*	0.106
		356	18623	0.223	**0.224**	0.218
		357	18624	0.186	0.103	0.173
2481	Corpus Christi Bay	333	18603	0.089	0.091	0.118
		339	18609	0.099	*	*
		346	18614	0.063	0.055	0.061
		348	18616	0.063	0.064	0.151
		350	18618	0.074	0.091	0.080
		351	17758	0.101	0.068	0.082
		354	18621	0.100	0.094	0.096
		355	18622	0.077	0.067	0.068
2482	Nueces Bay	331	18601	0.069	*	*
		349	18617	0.167	*	**0.255**
		352	18619	**0.228**	*	0.223
2483	Redfish Bay	328	18236	0.015	0.032	0.032
2485	Oso Bay	330	18600	0.036	*	*
2491	Laguna Madre	335	18605	0.025	*	0.023
		347	18615	0.022	*	0.016
2492	Baffin Bay/Alazan Bay	327	18598	0.026	*	*
	Cayo del Grullo/Laguna Salada	329	18599	0.028	*	*
		334	18604	0.023	*	*
		336	18606	0.063	*	*
		342	18611	0.040	0.040	0.039
		345	18260	0.034	0.035	0.037
		358	18625	0.053	*	0.054

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 2004 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
2471	Aransas Bay	337	18607	8.00	7.95	11.35	8.00	10.00	17.00
		340	18610	8.55	8.00	6.65	13.00	10.00	25.00
		341	18270	9.50	10.30	13.70	16.00	10.00	35.00
		344	18613	9.70	9.55	10.45	12.00	13.00	23.00
		353	18620	6.10	5.70	10.70	8.00	10.00	**50.00**
2472	Copano Bay/Port Bay/Mission Bay	332	18602	11.70	*	16.05	56.00	*	41.00
		338	18608	7.40	6.35	7.15	29.00	**39.00**	21.00
		343	18612	8.45	*	7.35	35.00	*	32.00
		356	18623	7.85	9.10	6.85	24.00	23.00	26.00
		357	18624	9.75	12.75	9.45	31.00	36.00	37.00
2481	Corpus Christi Bay	333	18603	3.78	5.15	2.52	12.00	11.00	15.00
		339	18609	6.40	*	*	21.00	*	*
		346	18614	2.96	2.73	2.96	15.00	24.00	22.00
		348	18616	5.25	4.76	2.90	14.00	10.00	28.00
		350	18618	2.84	3.04	3.08	9.00	12.00	12.00
		351	17758	3.80	2.83	3.60	13.00	13.00	9.00
		354	18621	3.51	4.26	3.13	13.00	20.00	13.00
		355	18622	3.30	4.01	3.57	19.00	20.00	6.00
2482	Nueces Bay	331	18601	20.95	*	*	29.00	*	*
		349	18617	6.20	*	6.40	13.00	*	18.00
		352	18619	15.70	*	16.55	17.00	*	24.00
2483	Redfish Bay	328	18236	5.20	5.25	5.80	14.00	13.00	12.00
2485	Oso Bay	330	18600	15.05	*	*	**58.00**	*	*
2491	Laguna Madre	335	18605	4.88	*	6.20	15.00	*	19.00
		347	18615	3.88	*	3.98	20.00	*	21.00
2492	Baffin Bay/Alazan Bay	327	18598	**31.60**	*	*	29.00	*	*
	Cayo del Grullo/Laguna Salada	329	18599	8.75	*	*	15.00	*	*
		334	18604	8.55	*	*	31.00	*	*
		336	18606	9.58	*	*	32.00	*	*
		342	18611	13.60	14.05	14.35	14.00	19.00	35.00
		345	18260	17.65	**18.05**	**17.95**	15.00	15.00	34.00
		358	18625	9.75	*	12.70	38.00	*	38.00

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 2004 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	2471	Aransas Bay	5	0.002	0.008	0.005
SNU	2472	Copano Bay/Port Bay/Mission Bay	5	0.011	0.020	0.015
TCEQ	2481	Corpus Christi Bay	8	0.002	0.016	0.005
SLE 2000	2482	Nueces Bay	3	0.005	0.016	0.010
0.10 mg/L	2483	Redfish Bay	1	-	-	0.004
	2485	Oso Bay	1	-	-	0.021
	2491	Laguna Madre	2	0.012	0.018	0.015
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.005	0.143	**0.030**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2471	Aransas Bay	5	0.002	0.006	0.004
MNU	2472	Copano Bay/Port Bay/Mission Bay	3	0.009	0.015	**0.012**
	2481	Corpus Christi Bay	7	0.001	0.012	0.005
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.001
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.005	0.016	0.011
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2471	Aransas Bay	5	0.007	0.034	0.015
BNU	2472	Copano Bay/Port Bay/Mission Bay	4	0.010	0.015	0.014
	2481	Corpus Christi Bay	7	0.002	0.084	0.023
	2482	Nueces Bay	2	0.014	0.017	0.016
	2483	Redfish Bay	1	0.008	0.008	0.008
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.014	0.037	**0.026**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.012	0.017	0.014

Table 6.5.2. Ammonia (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.002	0.003	0.003
SN	2472	Copano Bay/Port Bay/Mission Bay	5	0.004	0.007	0.005
	2481	Corpus Christi Bay	8	0.001	0.011	0.004
	2482	Nueces Bay	3	0.002	0.009	0.006
	2483	Redfish Bay	1	-	-	0.002
	2485	Oso Bay	1	-	-	0.002
	2491	Laguna Madre	2	0.013	0.019	0.016
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.002	0.133	**0.023**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2471	Aransas Bay	5	0.001	0.016	0.005
MN	2472	Copano Bay/Port Bay/Mission Bay	3	0.003	0.004	0.003
	2481	Corpus Christi Bay	7	0.002	0.004	0.003
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.004
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.003	0.012	**0.008**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Ammonia	2471	Aransas Bay	5	0.001	0.008	0.005
BN	2472	Copano Bay/Port Bay/Mission Bay	4	0.002	0.005	0.004
	2481	Corpus Christi Bay	7	0.002	0.070	**0.022**
	2482	Nueces Bay	2	0.005	0.005	0.005
	2483	Redfish Bay	1	-	-	0.007
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.011	0.012	0.012
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.005	0.007	0.006

Table 6.5.3. Nitrate (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	<0.001	<0.001	<0.001
SNU	2472	Copano Bay/Port Bay/Mission Bay	5	<0.001	<0.001	<0.001
	2481	Corpus Christi Bay	8	<0.001	0.007	0.002
	2482	Nueces Bay	3	<0.001	<0.001	<0.001
	2483	Redfish Bay	1	-	-	0.006
	2485	Oso Bay	1	-	-	<0.001
	2491	Laguna Madre	2	<0.001	0.002	0.001
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<0.001	0.060	**0.009**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2471	Aransas Bay	5	<0.001	<0.001	<0.001
MNU	2472	Copano Bay/Port Bay/Mission Bay	3	<0.001	<0.001	<0.001
	2481	Corpus Christi Bay	7	<0.001	0.006	0.001
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	**0.004**
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	<0.001	<0.001	<0.001
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2471	Aransas Bay	5	<0.001	<0.001	<0.001
BNU	2472	Copano Bay/Port Bay/Mission Bay	4	<0.001	<0.001	<0.001
	2481	Corpus Christi Bay	7	<0.001	0.016	0.005
	2482	Nueces Bay	2	<0.001	<0.001	<0.001
	2483	Redfish Bay	1	-	-	**0.007**
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	<0.001	<0.001	<0.001
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	<0.001	<0.001	<0.001

Table 6.5.4. Nitrate (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.001	0.001	0.001
SN	2472	Copano Bay/Port Bay/Mission Bay	5	0.001	0.003	0.002
	2481	Corpus Christi Bay	8	<0.001	0.002	0.001
	2482	Nueces Bay	3	0.001	0.002	0.001
	2483	Redfish Bay	1	-	-	0.001
	2485	Oso Bay	1	-	-	0.003
	2491	Laguna Madre	2	0.003	0.004	0.004
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.001	0.044	**0.009**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2471	Aransas Bay	5	<0.001	0.022	**0.005**
MN	2472	Copano Bay/Port Bay/Mission Bay	3	0.001	0.002	0.002
	2481	Corpus Christi Bay	7	0.001	0.002	0.001
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.003
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.002	0.002	0.002
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate	2471	Aransas Bay	5	<0.001	0.003	0.002
BN	2472	Copano Bay/Port Bay/Mission Bay	4	0.001	0.003	0.002
	2481	Corpus Christi Bay	7	0.001	0.010	**0.004**
	2482	Nueces Bay	2	0.001	0.003	0.002
	2483	Redfish Bay	1	-	-	0.003
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.001	0.004	0.003
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.001	0.002	0.002

Table 6.5.5. Nitrite (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.005	0.018	0.012
SNU	2472	Copano Bay/Port Bay/Mission Bay	5	0.016	0.053	0.024
	2481	Corpus Christi Bay	8	0.004	0.008	0.006
	2482	Nueces Bay	3	0.009	0.013	0.012
	2483	Redfish Bay	1	-	-	0.005
	2485	Oso Bay	1	-	-	**0.053**
	2491	Laguna Madre	2	0.007	0.012	0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.009	0.043	0.021
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2471	Aransas Bay	5	0.003	0.046	0.015
MNU	2472	Copano Bay/Port Bay/Mission Bay	3	0.015	0.023	0.019
	2481	Corpus Christi Bay	7	0.005	0.008	0.007
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.007
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.015	0.035	**0.025**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2471	Aransas Bay	5	0.010	0.051	**0.023**
BNU	2472	Copano Bay/Port Bay/Mission Bay	4	0.014	0.025	0.020
	2481	Corpus Christi Bay	7	0.005	0.017	0.010
	2482	Nueces Bay	2	0.013	0.013	0.013
	2483	Redfish Bay	1	-	-	0.009
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.013	0.016	0.015
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.014	0.035	**0.023**

Table 6.5.6. Nitrite (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.001	0.001	0.001
SN	2472	Copano Bay/Port Bay/Mission Bay	5	0.001	0.003	0.002
	2481	Corpus Christi Bay	8	<0.001	0.002	0.001
	2482	Nueces Bay	3	0.001	0.002	0.001
	2483	Redfish Bay	1	-	-	0.001
	2485	Oso Bay	1	-	-	0.003
	2491	Laguna Madre	2	0.003	0.004	0.004
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.001	0.044	**0.009**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2471	Aransas Bay	5	<0.001	0.022	**0.005**
MN	2472	Copano Bay/Port Bay/Mission Bay	3	0.001	0.002	0.002
	2481	Corpus Christi Bay	7	0.001	0.002	0.001
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.003
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.002	0.002	0.002
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrite	2471	Aransas Bay	5	<0.001	0.003	0.002
BN	2472	Copano Bay/Port Bay/Mission Bay	4	0.001	0.003	0.002
	2481	Corpus Christi Bay	7	0.001	0.010	**0.004**
	2482	Nueces Bay	2	0.001	0.003	0.002
	2483	Redfish Bay	1	-	-	0.003
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.001	0.004	0.003
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.001	0.002	0.002

Table 6.5.7. Nitrate + Nitrite (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.005	0.018	0.012
SNU	2472	Copano Bay/Port Bay/Mission Bay	5	0.016	0.053	0.024
TCEQ	2481	Corpus Christi Bay	8	0.004	0.012	0.008
SLE 2000	2482	Nueces Bay	3	0.009	0.013	0.012
0.26 mg/L	2483	Redfish Bay	1	-	-	0.011
	2485	Oso Bay	1	-	-	**0.053**
	2491	Laguna Madre	2	0.009	0.012	0.011
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.010	0.103	0.030
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2471	Aransas Bay	5	0.003	0.046	0.015
MNU	2472	Copano Bay/Port Bay/Mission Bay	3	0.015	0.023	0.019
	2481	Corpus Christi Bay	7	0.005	0.011	0.008
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.011
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.015	0.035	**0.025**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2471	Aransas Bay	5	0.010	0.051	**0.023**
BNU	2472	Copano Bay/Port Bay/Mission Bay	4	<0.001	0.025	0.016
	2481	Corpus Christi Bay	7	0.008	0.033	0.015
	2482	Nueces Bay	2	0.013	0.013	0.013
	2483	Redfish Bay	1	-	-	0.016
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.013	0.016	0.015
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.014	0.035	**0.023**

Table 6.5.8. Nitrate + Nitrite (mg/L) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.001	0.013	0.006
SN	2472	Copano Bay/Port Bay/Mission Bay	5	0.001	0.005	0.003
	2481	Corpus Christi Bay	8	0.006	0.019	0.008
	2482	Nueces Bay	3	0.001	0.006	0.003
	2483	Redfish Bay	1	-	-	0.011
	2485	Oso Bay	1	-	-	0.020
	2491	Laguna Madre	2	0.012	0.025	0.019
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.006	0.127	**0.028**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2471	Aransas Bay	5	0.001	0.022	0.008
MN	2472	Copano Bay/Port Bay/Mission Bay	3	0.001	0.002	0.002
	2481	Corpus Christi Bay	7	0.001	0.019	0.007
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	**0.016**
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.006	0.006	0.006
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Nitrate + Nitrite	2471	Aransas Bay	5	0.001	0.012	0.006
BN	2472	Copano Bay/Port Bay/Mission Bay	4	0.001	0.010	0.004
	2481	Corpus Christi Bay	7	0.006	0.024	0.011
	2482	Nueces Bay	2	0.005	0.006	0.006
	2483	Redfish Bay	1	-	-	**0.014**
	2485	Oso Bay		*	*	*
	2491	Laguna Madre	2	0.006	0.018	0.012
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.006	0.012	0.010

Table 6.5.9. Total Phosphorus (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.039	0.079	0.062
SNU	2472	Copano Bay/Port Bay/Mission Bay	5	0.116	0.157	**0.139**
TCEQ	2481	Corpus Christi Bay	8	0.035	0.052	0.042
SLE 2000	2482	Nueces Bay	3	0.074	0.154	0.121
0.22 mg/L	2483	Redfish Bay	1	-	-	0.024
	2485	Oso Bay	1	-	-	0.102
	2491	Laguna Madre	2	0.027	0.027	0.027
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.062	0.092	0.076
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Total Phosphorus	2471	Aransas Bay	5	0.041	0.076	0.062
MNU	2472	Copano Bay/Port Bay/Mission Bay	3	0.108	0.148	**0.125**
	2481	Corpus Christi Bay	7	0.030	0.046	0.039
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.024
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.066	0.075	0.070
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Total Phosphorus	2471	Aransas Bay	5	0.036	0.084	0.066
BNU	2472	Copano Bay/Port Bay/Mission Bay	4	0.123	0.155	**0.138**
	2481	Corpus Christi Bay	7	0.034	0.056	0.044
	2482	Nueces Bay	2	0.093	0.130	0.111
	2483	Redfish Bay	1	-	-	0.027
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.022	0.028	0.025
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.072	0.094	0.083

Table 6.5.10. Orthophosphorus, or Dissolved Inorganic Phosphorus, (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	0.058	0.127	0.098
SN	2472	Copano Bay/Port Bay/Mission Bay	5	0.117	0.223	**0.160**
TCEQ	2481	Corpus Christi Bay	8	0.063	0.101	0.083
SLE 2000	2482	Nueces Bay	3	0.069	0.228	0.155
0.16 mg/L	2483	Redfish Bay	1	-	-	0.015
	2485	Oso Bay	1	-	-	0.036
	2491	Laguna Madre	2	0.022	0.025	0.024
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.023	0.063	0.038
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Orthophosphorus	2471	Aransas Bay	5	0.042	0.164	0.106
MN	2472	Copano Bay/Port Bay/Mission Bay	3	0.102	0.224	**0.143**
	2481	Corpus Christi Bay	7	0.055	0.094	0.076
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	0.032
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	0.035	0.040	0.038
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Orthophosphorus	2471	Aransas Bay	5	0.060	0.143	0.089
BN	2472	Copano Bay/Port Bay/Mission Bay	4	0.100	0.218	0.142
	2481	Corpus Christi Bay	7	0.061	0.151	0.094
	2482	Nueces Bay	2	0.223	0.255	**0.239**
	2483	Redfish Bay	1	-	-	0.032
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	0.016	0.023	0.020
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	0.037	0.054	0.043

Table 6.5.11. Chlorophyll *a* (µg/L or ppb) summary statistics, listed by TCEQ Segment for RCAP 2004 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*	2471	Aransas Bay	5	6.10	9.70	8.37
SCL	2472	Copano Bay/Port Bay/Mission Bay	5	7.40	11.70	9.03
TCEQ	2481	Corpus Christi Bay	8	2.84	6.40	3.98
SLE 2000	2482	Nueces Bay	3	6.20	20.95	14.28
11.50 µg/L	2483	Redfish Bay	1	-	-	5.20
	2485	Oso Bay	1	-	-	**15.05**
	2491	Laguna Madre	2	3.88	4.88	4.38
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	8.55	31.60	14.21
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Chlorophyll *a*	2471	Aransas Bay	5	5.70	10.30	8.30
MCL	2472	Copano Bay/Port Bay/Mission Bay	3	6.35	12.75	9.40
	2481	Corpus Christi Bay	7	2.73	5.15	3.83
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	5.25
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	14.05	18.05	**16.05**
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
Chlorophyll *a*	2471	Aransas Bay	5	6.65	13.70	10.57
BCL	2472	Copano Bay/Port Bay/Mission Bay	4	6.85	16.05	9.37
	2481	Corpus Christi Bay	7	2.52	3.60	3.11
	2482	Nueces Bay	2	6.40	16.55	11.48
	2483	Redfish Bay	1	-	-	5.80
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	3.98	6.20	5.09
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	12.70	17.95	**15.00**

Table 6.5.12. Total Suspended Solids (TSS) concentrations (mg/L or ppm) summary statistics, listed by TCEQ Segment for RCAP 2004 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	2471	Aransas Bay	5	8.0	16.0	11.4
SS	2472	Copano Bay/Port Bay/Mission Bay	5	24.0	56.0	35.0
	2481	Corpus Christi Bay	8	9.0	21.0	14.5
	2482	Nueces Bay	3	13.0	29.0	19.7
	2483	Redfish Bay	1	-	-	14.0
	2485	Oso Bay	1	-	-	**58.0**
	2491	Laguna Madre	2	15.0	20.0	17.5
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	14.0	38.0	24.9
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
TSS	2471	Aransas Bay	5	10.0	13.0	10.6
MS	2472	Copano Bay/Port Bay/Mission Bay	3	23.0	39.0	**32.7**
	2481	Corpus Christi Bay	7	10.0	24.0	15.7
	2482	Nueces Bay	*	*	*	*
	2483	Redfish Bay	1	-	-	13.0
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	*	*	*	*
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	2	15.0	19.0	17.0
Parameter	**Segment**	**Segment Name**	**n (sites)**	**Min**	**Max**	**Mean**
TSS	2471	Aransas Bay	5	17.0	50.0	30.0
BS	2472	Copano Bay/Port Bay/Mission Bay	4	21.0	41.0	31.4
	2481	Corpus Christi Bay	7	6.0	28.0	15.0
	2482	Nueces Bay	2	18.0	24.0	21.0
	2483	Redfish Bay	1	-	-	12.0
	2485	Oso Bay	*	*	*	*
	2491	Laguna Madre	2	19.0	21.0	20.0
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	3	34.0	38.0	**35.7**

6.6 Microbiological – Individual Concentrations (CFU/100 ml)

Table 6.6.1. Enterococci concentrations (IDEXX method) recorded at RCAP 2004 sampling sites. Shaded value exceeded TCEQ criteria level of 104 CFU/100 ml. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS_ID	TCEQ_ID	IDEXX 97
2471	Aransas Bay	337	18607	<10.00
		340	18610	<10.00
		341	18270	<10.00
		344	18613	<10.00
		353	18620	<10.00
2472	Copano Bay/Port Bay/Mission Bay	332	18602	10.00
		338	18608	<10.00
		343	18612	<10.00
		356	18623	<10.00
		357	18624	<10.00
2481	Corpus Christi Bay	333	18603	20.00
		339	18609	20.00
		346	18614	<10.00
		348	18616	<10.00
		350	18618	<10.00
		351	17758	<10.00
		354	18621	<10.00
		355	18622	<10.00
2482	Nueces Bay	331	18601	<10.00
		349	18617	10.00
		352	18619	<10.00
2483	Redfish Bay	328	18236	<10.00
2485	Oso Bay	330	18600	121.00
2491	Laguna Madre	335	18605	<10.00
		347	18615	<10.00
2492	Baffin Bay/Alazan Bay	327	18598	10.00
	Cayo del Grullo/Laguna Salada	329	18599	<10.00
		334	18604	10.00
		336	18606	<10.00
		342	18611	<10.00
		345	18260	<10.00
		358	18625	20.00

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

Table 6.7.1. Trace metal (mg/kg or ppm dry weight) and sediment characteristic (%) concentrations for RCAP 2004 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. MS = Missing Sample.

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 (0.010)	Mn (2.0)	Ni (1.0)	Pb (1.0)	Sb (0.20)	Se (0.10)	Sn (0.10)	Zn (2.0)	% TOC	% Silt-Clay	% Sand	% Gravel
2471	Aransas Bay	337	18607	0.05	79100	5.9	0.25	41.3	13.3	25800	0.030	504	18.9	16.7	0.20	0.59	0.60	76.5	0.57	**95.69**	3.65	0.66
		340	18610	-	70200	6.4	0.17	31.2	11.9	21700	0.033	412	14.3	13.5	-	0.47	0.70	66.6	1.16	63.56	36.44	0.00
		341	18270	0.15	75300	6.2	0.68	34.3	14.4	22800	0.047	465	15.0	20.0	0.30	0.52	0.50	150.7	1.05	74.12	25.38	0.49
		344	18613	-	70600	6.2	0.19	28.7	11.3	20200	0.030	310	12.6	14.2	0.20	0.51	0.50	64.2	0.95	68.12	30.49	1.39
		353	18620	0.07	81900	6.5	0.21	**48.5**	15.9	31600	0.030	**523**	19.8	19.4	0.20	0.67	0.70	93.7	1.55	90.49	9.50	0.00
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	46400	2.2	0.11	9.5	5.6	6700	0.010	101	4.3	4.4	-	0.13	0.70	19.4	0.28	27.56	72.34	0.10
		338	18608	0.06	81700	5.5	0.24	36.4	12.9	24700	0.030	375	14.2	16.2	0.30	0.53	0.90	67.7	1.44	90.80	9.20	0.00
		343	18612	-	53200	2.5	0.09	15.2	6.2	9000	0.014	157	5.0	7.3	-	0.22	0.50	25.4	0.16	43.21	56.79	0.00
		356	18623	0.05	84900	6.7	0.17	32.5	11.3	21700	0.022	272	14.4	14.6	0.30	0.59	1.10	60.5	0.86	83.69	16.31	0.00
		357	18624	0.07	**87400**	9.1	0.29	47.1	16.0	**33100**	0.033	492	**20.5**	21.3	0.40	0.74	**2.80**	93.2	**3.14**	MS	MS	MS
2481	Corpus Christi Bay	333	18603	0.11	84000	6.5	0.48	44.1	16.4	29900	0.068	417	18.4	22.3	0.40	0.70	1.60	129.7	2.66	90.37	9.32	0.31
		339	18609	-	34700	-	0.10	10.7	2.8	3600	-	76	-	4.2	-	-	0.40	11.4	0.03	8.52	90.91	0.82
		346	18614	0.15	45100	2.4	0.06	14.3	5.0	5500	0.018	130	3.0	5.2	-	0.11	0.20	22.9	0.09	15.23	79.20	5.56
		348	18616	0.15	86200	6.9	0.49	44.4	17.4	30500	0.078	387	18.8	**24.1**	**0.60**	**0.85**	1.20	130.8	1.81	90.89	8.25	0.86
		350	18618	0.13	85700	7.1	0.40	40.2	16.6	29200	0.070	370	16.3	21.9	0.50	0.64	0.80	132.0	1.32	73.72	25.41	0.88
		351	17758	0.06	60400	5.1	0.23	19.2	12.8	19200	0.050	226	10.9	13.4	0.30	0.52	-	69.2	0.36	32.91	52.97	**14.12**
		354	18621	0.11	78100	7.1	0.49	37.4	14.8	24400	0.096	327	12.9	21.8	0.40	0.51	0.90	121.1	1.10	83.71	14.27	2.02
		355	18622	0.12	79800	8.9	0.50	41.1	16.2	27200	0.071	428	17.1	22.7	0.40	0.63	1.20	119.7	2.16	89.62	10.38	0.00
2482	Nueces Bay	331	18601	-	54600	2.1	0.49	15.3	7.0	7000	0.034	116	3.7	6.8	-	-	0.90	38.5	0.03	56.12	43.72	0.16
		349	18617	0.11	68700	4.6	0.63	26.6	11.3	18600	0.098	229	9.1	15.1	0.50	0.50	1.00	101.5	0.22	71.72	27.55	0.73
		352	18619	0.14	81600	6.3	**0.98**	44.2	**19.0**	25300	**0.167**	344	12.6	22.2	0.30	0.66	1.00	**154.6**	0.26	92.48	7.52	0.00
2483	Redfish Bay	328	18236	**0.33**	65200	4.4	0.23	21.1	12.6	14900	0.036	252	10.2	11.0	0.20	0.32	0.30	57.0	0.04	39.52	54.34	6.14
2485	Oso Bay	330	18600	0.11	68100	3.9	0.34	25.3	11.9	17200	0.024	246	9.1	12.9	0.30	0.38	1.30	60.0	0.36	63.24	36.57	0.19
2491	Laguna Madre	335	18605	-	30000	1.2	0.09	-	-	2100	-	38	-	2.4	-	-	0.30	9.4	0.03	4.82	93.44	0.85
		347	18615	-	25800	1.1	-	-	-	1300	-	28	-	1.7	-	-	-	5.6	0.03	2.72	93.05	4.23
2492	Baffin Bay/Alazan Bay	327	18598	0.07	72100	4.0	0.26	24.6	13.2	15400	0.024	214	8.7	10.7	0.20	0.36	1.00	49.8	0.69	58.30	41.26	0.44
	Cayo del Grullo/Laguna Salada	329	18599	-	28900	1.3	-	-	-	2000	0.010	44	-	2.2	-	-	0.30	7.6	0.10	4.80	**94.20**	1.42
		334	18604	0.05	64900	6.6	0.19	26.3	8.9	16700	0.013	200	8.6	10.4	0.40	0.50	0.70	44.4	0.34	64.87	29.14	6.00
		336	18606	-	45100	1.4	0.09	6.7	5.2	6400	-	110	2.7	5.0	0.20	0.17	0.30	20.1	0.25	24.15	71.00	4.84
		342	18611	0.10	79100	**10.1**	0.32	43.1	16.1	29400	0.039	502	18.2	20.0	0.30	0.75	0.80	91.2	0.69	90.66	9.34	0.00
		345	18260	0.09	81900	8.6	0.38	41.8	17.0	29300	0.038	493	18.2	21.6	0.30	0.83	0.50	91.1	0.97	93.37	6.63	0.00
		358	18625	0.07	77200	4.9	0.23	28.9	12.4	19700	0.023	306	11.4	14.6	0.30	0.56	0.90	62.6	0.56	71.56	27.70	0.73

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

Table 6.8.1. Total Organic Carbon (%), Sand (%), and Silt-Clay (%) summary statistics, listed by TCEQ Segment, for RCAP 2004 sampling sites. **Bold** = highest recorded mean concentrations.

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Total Organic Carbon (%)	2471	Aransas Bay	5	0.57	1.55	1.06
	2472	Copano Bay/Port Bay/Mission Bay	5	0.16	3.14	1.18
	2481	Corpus Christi Bay	8	0.03	2.66	**1.19**
	2482	Nueces Bay	3	0.03	0.26	0.17
	2483	Redfish Bay	1	-	-	0.04
	2485	Oso Bay	1	-	-	0.36
	2491	Laguna Madre	2	0.03	0.03	0.03
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.10	0.97	0.51

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Percent Sand	2471	Aransas Bay	5	3.65	36.44	21.09
(0.0625 - 2.00 mm)	2472	Copano Bay/Port Bay/Mission Bay	4	9.20	72.34	38.66
	2481	Corpus Christi Bay	8	8.25	90.91	36.34
	2482	Nueces Bay	3	7.52	43.72	26.26
	2483	Redfish Bay	1	-	-	54.34
	2485	Oso Bay	1	-	-	36.57
	2491	Laguna Madre	2	93.05	93.44	**93.25**
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	6.63	94.20	39.90

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Percent Silt-Clay	2471	Aransas Bay	5	63.56	95.69	**78.40**
(< 0.0625 mm)	2472	Copano Bay/Port Bay/Mission Bay	4	27.56	90.80	61.32
	2481	Corpus Christi Bay	8	8.52	90.89	60.62
	2482	Nueces Bay	3	56.12	92.48	73.44
	2483	Redfish Bay	1	-	-	39.52
	2485	Oso Bay	1	-	-	63.24
	2491	Laguna Madre	2	2.72	4.82	3.77
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	4.80	93.37	58.24

Table 6.8.2. Aluminum, Antimony, and Arsenic (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2004 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)	2471	Aransas Bay	5	70200	81900	**75420**
PEL (NA)	2472	Copano Bay/Port Bay/Mission Bay	5	46400	87400	70720
85th Percentile (NA)	2481	Corpus Christi Bay	8	34700	86200	69250
	2482	Nueces Bay	3	54600	81600	68300
	2483	Redfish Bay	1	-	-	65200
	2485	Oso Bay	1	-	-	68100
	2491	Laguna Madre	2	25800	30000	27900
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	28900	81900	64171

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Antimony (Sb)	2471	Aransas Bay	5	<0.20	0.30	0.18
PEL (NA)	2472	Copano Bay/Port Bay/Mission Bay	5	<0.20	0.40	0.20
85th Percentile (NA)	2481	Corpus Christi Bay	8	<0.20	0.60	**0.33**
	2482	Nueces Bay	3	<0.20	0.50	0.27
	2483	Redfish Bay	1	-	-	0.20
	2485	Oso Bay	1	-	-	0.30
	2491	Laguna Madre	2	<0.20	<0.20	<0.20
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<0.20	0.40	0.24

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Arsenic (As)	2471	Aransas Bay	5	5.86	6.50	**6.21**
PEL = 41.60	2472	Copano Bay/Port Bay/Mission Bay	5	2.22	9.08	5.19
85th Percentile = 9.61	2481	Corpus Christi Bay	8	<1.00	8.92	5.49
	2482	Nueces Bay	3	2.14	6.27	4.34
	2483	Redfish Bay	1	-	-	4.43
	2485	Oso Bay	1	-	-	3.85
	2491	Laguna Madre	2	1.14	1.16	1.15
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	1.27	10.09	5.26

Table 6.8.3. Cadmium, Chromium, and Copper (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2004 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)	2471	Aransas Bay	5	0.17	0.68	0.30
PEL = 4.21	2472	Copano Bay/Port Bay/Mission Bay	5	0.09	0.29	0.18
85th Percentile = 0.663	2481	Corpus Christi Bay	8	0.06	0.50	0.34
	2482	Nueces Bay	3	0.49	0.98	**0.70**
	2483	Redfish Bay	1	-	-	0.23
	2485	Oso Bay	1	-	-	0.34
	2491	Laguna Madre	2	<0.05	0.09	0.04
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<0.05	0.38	0.21

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Chromium (Cr)	2471	Aransas Bay	5	28.70	48.50	**36.80**
PEL = 160.40	2472	Copano Bay/Port Bay/Mission Bay	5	9.50	47.10	28.14
85th Percentile = 36.90	2481	Corpus Christi Bay	8	10.70	44.40	31.43
	2482	Nueces Bay	3	15.30	44.20	28.70
	2483	Redfish Bay	1	-	-	21.10
	2485	Oso Bay	1	-	-	25.30
	2491	Laguna Madre	2	<4.00	<4.00	<4.00
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<4.00	43.10	24.49

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Copper (Cu)	2471	Aransas Bay	5	11.30	15.90	**13.36**
PEL = 108.20	2472	Copano Bay/Port Bay/Mission Bay	5	5.60	16.00	10.40
85th Percentile = 19.90	2481	Corpus Christi Bay	8	2.80	17.40	12.75
	2482	Nueces Bay	3	7.00	19.00	12.43
	2483	Redfish Bay	1	-	-	12.60
	2485	Oso Bay	1	-	-	11.90
	2491	Laguna Madre	2	<5.00	<5.00	<5.00
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<5.00	17.00	10.40

Table 6.8.4. Iron, Lead, and Manganese (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2004 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)	2471	Aransas Bay	5	20200	31600	**24420**
PEL (NA)	2472	Copano Bay/Port Bay/Mission Bay	5	6700	33100	19040
85th Percentile (NA)	2481	Corpus Christi Bay	8	3600	30500	21188
	2482	Nueces Bay	3	7000	25300	16967
	2483	Redfish Bay	1	-	-	14900
	2485	Oso Bay	1	-	-	17200
	2491	Laguna Madre	2	1300	2100	1700
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	2000	29400	16986

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Lead (Pb)	2471	Aransas Bay	5	13.50	20.00	16.76
PEL = 112.18	2472	Copano Bay/Port Bay/Mission Bay	5	4.40	21.30	12.76
85th Percentile = 21.90	2481	Corpus Christi Bay	8	4.20	24.10	**16.95**
	2482	Nueces Bay	3	6.80	22.20	14.70
	2483	Redfish Bay	1	-	-	11.00
	2485	Oso Bay	1	-	-	12.90
	2491	Laguna Madre	2	1.70	2.40	2.05
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	2.20	21.60	12.07

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Manganese (Mn)	2471	Aransas Bay	5	310	523	**442**
PEL (NA)	2472	Copano Bay/Port Bay/Mission Bay	5	101	492	279
85th Percentile (NA)	2481	Corpus Christi Bay	8	76	428	295
	2482	Nueces Bay	3	116	344	230
	2483	Redfish Bay	1	-	-	252
	2485	Oso Bay	1	-	-	246
	2491	Laguna Madre	2	28	38	33
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	44	502	267

Table 6.8.5. Mercury, Nickel, and Selenium (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2004 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)	2471	Aransas Bay	5	0.030	0.047	0.034
PEL = 0.696	2472	Copano Bay/Port Bay/Mission Bay	5	0.010	0.033	0.022
85th Percentile = 0.230	2481	Corpus Christi Bay	8	<0.010	0.096	0.056
	2482	Nueces Bay	3	0.034	0.167	**0.100**
	2483	Redfish Bay	1	-	-	0.036
	2485	Oso Bay	1	-	-	0.024
	2491	Laguna Madre	2	<0.010	<0.010	<0.010
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<0.010	0.039	0.021

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Nickel (Ni)	2471	Aransas Bay	5	12.60	19.80	**16.12**
PEL = 42.80	2472	Copano Bay/Port Bay/Mission Bay	5	4.30	20.50	11.68
85th Percentile = 21.40	2481	Corpus Christi Bay	8	0.00	18.80	12.18
	2482	Nueces Bay	3	3.70	12.60	8.47
	2483	Redfish Bay	1	-	-	10.20
	2485	Oso Bay	1	-	-	9.10
	2491	Laguna Madre	2	<1.00	<1.00	<1.00
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<1.00	18.20	9.69

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Selenium (Se)	2471	Aransas Bay	5	0.47	0.67	**0.55**
PEL = NA	2472	Copano Bay/Port Bay/Mission Bay	5	0.13	0.74	0.44
85th Percentile = 1.70	2481	Corpus Christi Bay	8	<0.10	0.85	0.50
	2482	Nueces Bay	3	<0.10	0.66	0.39
	2483	Redfish Bay	1	-	-	0.32
	2485	Oso Bay	1	-	-	0.38
	2491	Laguna Madre	2	<0.10	<0.10	<0.10
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<0.10	0.83	0.45

Table 6.8.6. Silver, Tin, and Zinc (mg/kg or ppm) summary statistics, listed by TCEQ Segment, for RCAP 2004 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
Silver (Ag)	2471	Aransas Bay	5	<0.05	0.15	0.05
PEL = 1.77	2472	Copano Bay/Port Bay/Mission Bay	5	<0.05	0.07	0.04
85th Percentile = 0.600	2481	Corpus Christi Bay	8	<0.05	0.15	0.10
	2482	Nueces Bay	3	<0.05	0.14	0.08
	2483	Redfish Bay	1	-	-	**0.33**
	2485	Oso Bay	1	-	-	0.11
	2491	Laguna Madre	2	<0.05	<0.05	0.00
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	<0.05	0.10	0.05

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Tin (Sn)	2471	Aransas Bay	5	0.50	0.70	0.60
PEL (NA)	2472	Copano Bay/Port Bay/Mission Bay	5	0.50	2.80	1.20
85th Percentile (NA)	2481	Corpus Christi Bay	8	<0.10	1.60	0.79
	2482	Nueces Bay	3	0.90	1.00	0.97
	2483	Redfish Bay	1	-	-	0.30
	2485	Oso Bay	1	-	-	**1.30**
	2491	Laguna Madre	2	<0.10	0.30	0.15
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	0.30	1.00	0.64

Parameter	Segment	Segment Name	n (sites)	Min	Max	Mean
Zinc (Zn)	2471	Aransas Bay	5	64.20	150.70	90.34
PEL = 271.0	2472	Copano Bay/Port Bay/Mission Bay	5	19.40	93.20	53.24
85th Percentile = 107.0	2481	Corpus Christi Bay	8	11.40	132.00	92.10
	2482	Nueces Bay	3	38.50	154.60	**98.20**
	2483	Redfish Bay	1	-	-	57.00
	2485	Oso Bay	1	-	-	60.00
	2491	Laguna Madre	2	5.60	9.40	7.50
	2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	7	7.60	91.20	52.40

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

Table 6.9.1. Sediment concentrations (ng/g or ppb) of 4 out of 20 PCB congeners (all other PCBs < reporting limit) at RCAP 2004 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	130	170	Total PCB
2471	Aransas Bay	337	18607	-	-	-	-	-
		340	18610	-	-	-	-	-
		341	18270	-	-	-	-	-
		344	18613	-	-	-	-	-
		353	18620	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	**5.05**	-	-	-	5.05
		338	18608	-	3.98	-	**5.20**	**9.18**
		343	18612	-	**7.14**	-	-	7.14
		356	18623	-	-	-	-	-
		357	18624	-	-	-	-	-
2481	Corpus Christi Bay	333	18603	-	1.98	**1.21**	-	3.19
		339	18609	-	1.08	-	-	1.08
		346	18614	-	-	-	-	-
		348	18616	-	-	-	-	-
		350	18618	-	-	-	-	-
		351	17758	-	-	-	-	-
		354	18621	-	-	-	-	-
		355	18622	-	-	-	-	-
2482	Nueces Bay	331	18601	-	-	-	-	-
		349	18617	-	-	-	-	-
		352	18619	-	4.26	-	-	4.26
2483	Redfish Bay	328	18236	-	-	-	-	-
2485	Oso Bay	330	18600	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-
		347	18615	-	1.41	-	-	1.41
2492	Baffin Bay/Alazan Bay	327	18598	-	-	-	-	-
	Cayo del Grullo/Laguna Salada	329	18599	-	-	-	-	-
		334	18604	-	-	-	-	-
		336	18606	-	-	-	-	-
		342	18611	-	-	-	-	-
		345	18260	-	-	-	-	-
		358	18625	-	-	-	-	-

Table 6.9.2. Sediment concentrations of DDD, DDE, and DDT (ng/g or ppb) at RCAP 2004 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)
2471	Aransas Bay	337	18607	-	-	-	-	-	-	-
		340	18610	-	-	-	-	-	-	-
		341	18270	-	-	-	-	-	-	-
		344	18613	-	-	**1.30**	-	-	-	1.30
		353	18620	-	-	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-	-	-	-	-
		338	18608	**8.23**	-	-	-	-	-	**8.23**
		343	18612	2.56	-	-	-	-	**1.49**	4.06
		356	18623	-	-	-	-	-	-	-
		357	18624	-	-	-	-	-	-	-
2481	Corpus Christi Bay	333	18603	-	-	-	-	-	-	-
		339	18609	0.33	-	-	-	**0.58**	-	0.91
		346	18614	-	-	-	-	-	-	-
		348	18616	-	-	-	-	-	-	-
		350	18618	-	-	-	-	-	-	-
		351	17758	-	-	-	-	-	-	-
		354	18621	-	-	-	-	-	-	-
		355	18622	-	-	-	-	-	-	-
2482	Nueces Bay	331	18601	-	-	-	-	-	-	-
		349	18617	-	-	-	-	-	-	-
		352	18619	-	-	-	-	-	-	-
2483	Redfish Bay	328	18236	-	-	-	-	-	-	-
2485	Oso Bay	330	18600	-	-	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-	-	-
		347	18615	-	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	327	18598	-	-	-	-	-	-	-
	Cayo del Grullo/Laguna Salada	329	18599	-	-	-	-	-	-	-
		334	18604	-	-	-	-	-	-	-
		336	18606	-	-	-	-	-	-	-
		342	18611	-	-	-	-	-	-	-
		345	18260	-	-	-	-	-	-	-
		358	18625	-	-	-	-	-	-	-

Table 6.9.3. Sediment concentrations (ng/g or ppb) of 2 of 13 Chlorinated Pesticides other than DDT (all other chlorinated pesticides < reporting limit) at RCAP 2004 sampling sites. No value (-) indicates concentration below the reporting limit. **Bold** = highest recorded concentration.

Segment	Segment Name	CCS ID	TCEQ ID	alpha-chlordane	t-nonachlor	Total Chlorinated Pesticides
2471	Aransas Bay	337	18607	-	-	-
		340	18610	-	-	-
		341	18270	-	-	-
		344	18613	-	-	-
		353	18620	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-
		338	18608	**3.74**	**3.64**	**7.38**
		343	18612	-	-	-
		356	18623	-	-	-
		357	18624	-	-	-
2481	Corpus Christi Bay	333	18603	-	-	-
		339	18609	-	-	-
		346	18614	3.26	-	3.26
		348	18616	-	-	-
		350	18618	-	-	-
		351	17758	-	-	-
		354	18621	-	-	-
		355	18622	-	-	-
2482	Nueces Bay	331	18601	-	-	-
		349	18617	-	-	-
		352	18619	-	-	-
2483	Redfish Bay	328	18236	-	-	-
2485	Oso Bay	330	18600	-	-	-
2491	Laguna Madre	335	18605	-	-	-
		347	18615	-	-	-
2492	Baffin Bay/Alazan Bay	327	18598	-	-	-
	Cayo del Grullo/Laguna Salada	329	18599	-	-	-
		334	18604	-	-	-
		336	18606	-	-	-
		342	18611	-	-	-
		345	18260	-	-	-
		358	18625	-	-	-

Table 6.9.4. Sediment concentrations (ng/g or ppb) of 23 PAH's at RCAP 2004 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
2471	Aransas Bay	337	18607	-	-	-	1.82	-	-	6.03
		340	18610	-	-	-	-	-	-	-
		341	18270	-	-	-	-	-	-	-
		344	18613	-	-	-	-	-	-	-
		353	18620	-	-	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-	-	-	-	-
		338	18608	-	-	-	-	-	-	-
		343	18612	-	-	-	-	-	-	-
		356	18623	-	-	-	-	-	-	-
		357	18624	-	-	-	-	-	-	-
2481	Corpus Christi Bay	333	18603	-	-	-	-	-	-	-
		339	18609	-	-	-	-	-	-	-
		346	18614	-	-	-	-	-	-	-
		348	18616	-	-	-	-	-	-	-
		350	18618	-	-	-	-	-	-	-
		351	17758	-	-	-	-	-	-	-
		354	18621	-	-	-	-	-	-	-
		355	18622	-	-	**4.63**	**10.58**	-	-	**9.26**
2482	Nueces Bay	331	18601	-	-	-	-	-	-	-
		349	18617	-	-	-	-	-	-	-
		352	18619	-	-	-	-	-	-	-
2483	Redfish Bay	328	18236	-	-	-	-	-	-	-
2485	Oso Bay	330	18600	-	-	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-	-	-
		347	18615	-	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	327	18598	-	-	-	-	-	-	-
	Cayo del Grullo/Laguna Salada	329	18599	-	-	-	-	-	-	-
		334	18604	-	-	-	-	-	-	-
		336	18606	-	-	-	-	-	-	-
		342	18611	-	-	-	-	-	-	-
		345	18260	-	-	-	-	-	-	-
		358	18625	-	-	-	-	-	-	-

Table 6.9.4. (continued).

Segment	Segment Name	CCS ID	TCEQ ID	fluoranthene	benzo(b)fluoranthene	benzo(k)fluoranthene	fluorene	naphthalene	1-methylnaphthalene
2471	Aransas Bay	337	18607	-	-	**1.54**	-	-	-
		340	18610	-	-	-	-	-	-
		341	18270	-	-	-	-	-	-
		344	18613	-	-	-	-	-	-
		353	18620	-	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-	-	-	-
		338	18608	-	-	-	-	-	-
		343	18612	-	-	-	-	-	-
		356	18623	-	-	-	-	-	-
		357	18624	-	-	-	-	-	-
2481	Corpus Christi Bay	333	18603	-	-	-	-	-	-
		339	18609	-	-	-	-	-	-
		346	18614	-	-	-	-	-	-
		348	18616	5.08	-	-	-	-	-
		350	18618	7.27	-	-	-	-	-
		351	17758	-	-	-	-	-	-
		354	18621	-	-	-	-	-	-
		355	18622	**24.27**	-	-	-	-	-
2482	Nueces Bay	331	18601	-	-	-	-	-	-
		349	18617	13.84	-	-	-	-	-
		352	18619	15.70	-	-	-	-	-
2483	Redfish Bay	328	18236	-	-	-	-	-	-
2485	Oso Bay	330	18600	-	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-	-
		347	18615	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	327	18598	-	-	-	-	-	-
	Cayo del Grullo/Laguna Salada	329	18599	-	-	-	-	-	-
		334	18604	-	-	-	-	-	-
		336	18606	-	-	-	-	-	-
		342	18611	-	-	-	-	-	-
		345	18260	-	-	-	-	-	-
		358	18625	-	-	-	-	-	-

Table 6.9.4. (continued).

Segment	Segment Name	CCS ID	TCEQ ID	2-methylnaphthalene	2,6-dimethylnaphthalene	2,3,5-trimethylnaphthalene	phenanthrene	1-methylphenanthrene
2471	Aransas Bay	337	18607	-	-	-	-	-
		340	18610	-	-	-	-	-
		341	18270	-	-	-	-	-
		344	18613	-	-	-	-	-
		353	18620	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-	-	-
		338	18608	-	-	-	-	-
		343	18612	-	-	-	-	-
		356	18623	-	-	-	-	-
		357	18624	-	-	-	-	-
2481	Corpus Christi Bay	333	18603	-	-	-	-	-
		339	18609	-	-	-	-	-
		346	18614	-	-	-	-	-
		348	18616	-	-	-	-	-
		350	18618	-	-	-	-	-
		351	17758	-	-	-	-	-
		354	18621	-	-	-	-	-
		355	18622	-	-	-	**9.35**	-
2482	Nueces Bay	331	18601	-	-	-	-	-
		349	18617	-	-	-	-	-
		352	18619	-	-	-	-	-
2483	Redfish Bay	328	18236	-	-	-	-	-
2485	Oso Bay	330	18600	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-
		347	18615	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	327	18598	-	-	-	-	-
	Cayo del Grullo/Laguna Salada	329	18599	-	-	-	-	-
		334	18604	-	-	-	-	-
		336	18606	-	-	-	-	-
		342	18611	-	-	-	-	-
		345	18260	-	-	-	-	-
		358	18625	-	-	-	-	-

Table 6.9.4. (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
2471	Aransas Bay	337	18607	-	-	-	-	-	9.39
		340	18610	-	-	-	-	-	-
		341	18270	-	-	-	-	-	-
		344	18613	-	2.66	-	-	-	2.66
		353	18620	-	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-	-	-	-
		338	18608	-	8.33	-	-	-	8.33
		343	18612	-	-	-	-	-	-
		356	18623	-	-	-	-	-	-
		357	18624	-	-	-	-	-	-
2481	Corpus Christi Bay	333	18603	-	-	-	-	-	-
		339	18609	-	-	-	-	-	-
		346	18614	-	-	-	-	-	-
		348	18616	-	4.82	-	-	-	9.90
		350	18618	-	6.50	-	-	-	13.77
		351	17758	-	-	-	-	-	-
		354	18621	-	-	-	-	-	-
		355	18622	-	**27.86**	-	-	-	**85.95**
2482	Nueces Bay	331	18601	-	-	-	-	-	-
		349	18617	-	10.89	-	-	-	24.73
		352	18619	-	16.41	-	-	-	32.11
2483	Redfish Bay	328	18236	-	-	-	-	-	-
2485	Oso Bay	330	18600	-	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-	-
		347	18615	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay	327	18598	-	-	-	-	-	-
	Cayo del Grullo/Laguna Salada	329	18599	-	-	-	-	-	-
		334	18604	-	-	-	-	-	-
		336	18606	-	-	-	-	-	-
		342	18611	-	-	-	-	-	-
		345	18260	-	-	-	-	-	-
		358	18625	-	-	-	-	-	-

6.10 Sediment Toxicity

Table 6.10.1. RCAP 2004 toxicity results in sediment toxicity tests conducted with the amphipod *Ampelisca abdita*.

Segment	Segment Name	CCS ID	TCEQ ID	Rep Number (Alive Amphipods) 1	2	3	4	5	Mean % Survival
		Control	Control	90	95	85	95	100	93
		Reference	Reference	95	95	100	80	90	92
2471	Aransas Bay	337	18607	90	75	100	100	90	91
		340	18610	85	95	95	95	90	92
		341	18270	80	100	95	95	100	94
		344	18613	80	90	100	95	90	91
		353	18620	80	90	95	80	95	88
2472	Copano Bay/Port Bay/Mission Bay	332	18602	90	100	70	90	95	89
		338	18608	90	95	95	100	95	95
		343	18612	85	100	100	95	100	96
		356	18623	100	95	100	90	90	95
		357	18624	80	90	85	90	90	87
2481	Corpus Christi Bay	333	18603	80	90	95	90	100	91
		339	18609	95	95	95	90	75	90
		346	18614	95	85	90	95	85	90
		348	18616	85	95	100	85	95	92
		350	18618	100	85	100	100	100	97
		351	17758	85	100	95	100	95	95
		354	18621	75	80	95	90	95	87
		355	18622	90	85	85	95	95	90
2482	Nueces Bay	331	18601	90	95	85	75	95	88
		349	18617	80	80	95	95	90	88
		352	18619	90	70	100	80	90	86
2483	Redfish Bay	328	18236	90	95	90	80	100	91
2485	Oso Bay	330	18600	80	85	95	100	85	89
2491	Laguna Madre	335	18605	65	90	85	90	90	84
		347	18615	75	100	95	65	90	85
2492	Baffin Bay/Alazan Bay	327	18598	85	100	100	80	95	92
	Cayo del Grullo/Laguna Salada	329	18599	85	65	85	95	95	85
		334	18604	100	95	100	95	100	98
		336	18606	95	95	70	80	85	85
		342	18611	95	95	90	95	100	95
		345	18260	100	95	95	95	100	97
		358	18625	90	90	95	90	95	92

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

Table 6.11.1. List of fish species analyzed for whole body tissue monitoring at 31 of 32 RCAP 2004 sampling sites. Missing site (1) reflects 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)	*Pogonias cromis* (Black Drum)
2471	Aransas Bay	337	18607	■				
		340	18610		■			
		341	18270			■		
		344	18613		■			
		353	18620		■			
2472	Copano Bay/Port Bay/Mission Bay	332	18602	■				
		338	18608			■		
		343	18612			■		
		356	18623	■				
		357	18624			■		
2481	Corpus Christi Bay	333	18603			■		
		339	18609	■				
		346	18614	■				
		348	18616	■				
		350	18618	■				
		351	17758		■			
		354	18621	■				
		355	18622	■				
2482	Nueces Bay	331	18601			■		
		349	18617		■			
		352	18619		■			
2483	Redfish Bay	328	18236	■				
2491	Laguna Madre	335	18605				■	
		347	18615				■	
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	327	18598			■		
		329	18599			■		
		334	18604			■		
		336	18606					■
		342	18611			■		
		345	18260			■		
		358	18625			■		

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

Table 6.12.1. Trace metal concentrations (mg/kg or ppm wet weight) in tissue (whole body) for 31 of 32 RCAP 2004 sampling sites. Missing site (1) reflects 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 (or exceeded) 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)
2471	Aransas Bay	337	18607	-	100	-	-	-	-	61	0.01	-	0.10	-	-	-
		340	18610	-	**231**	-	-	0.28	-	**163**	0.02	-	0.21	-	-	-
		341	18270	-	141	-	-	-	-	86	0.01	-	0.14	-	-	-
		344	18613	-	126	-	-	0.11	-	68	-	-	-	-	-	-
		353	18620	-	118	-	-	0.10	-	66	-	-	-	1.04	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	11	-	-	-	-	-	0.02	-	-	-	-	-
		338	18608	-	33	-	**0.07**	-	-	-	0.07	-	-	-	-	158
		343	18612	-	32	-	-	-	1.00	28	0.09	-	-	-	-	181
		356	18623	-	100	-	-	-	-	55	0.02	-	-	-	-	-
		357	18624	-	23	-	-	-	**2.30**	26	**0.61**	-	-	-	-	110
2481	Corpus Christi Bay	333	18603	-	207	2.30	-	1.22	-	149	0.12	0.30	0.22	**1.82**	-	**237**
		339	18609	-	30	-	-	-	-	19	0.01	-	-	-	-	-
		346	18614	-	45	-	-	-	-	41	0.03	-	-	1.61	-	-
		348	18616	-	34	-	-	-	-	27	0.02	-	-	1.50	-	-
		350	18618	-	33	-	-	-	-	27	0.03	-	-	1.77	-	-
		351	17758	-	69	-	-	-	-	58	0.04	-	0.16	1.06	-	-
		354	18621	-	64	-	-	-	-	46	0.06	-	-	1.72	-	-
		355	18622	-	60	-	-	0.22	-	40	-	-	-	1.50	-	-
2482	Nueces Bay	331	18601	-	29	-	-	-	-	-	0.06	-	-	-	-	-
		349	18617	-	40	-	-	-	-	37	0.06	-	0.13	-	-	-
		352	18619	-	89	-	-	0.90	-	71	0.04	0.20	0.19	-	-	-
2483	Redfish Bay	328	18236	-	41	-	-	-	-	35	0.02	-	-	1.54	-	-
2491	Laguna Madre	335	18605	-	36	2.50	-	1.39	1.10	36	0.06	0.30	-	1.20	-	-
		347	18615	-	11	-	-	-	1.40	-	0.03	-	**0.39**	-	-	-
2492	Baffin Bay/Alazan Bay/	327	18598	-	29	4.70	-	-	-	53	0.06	-	0.29	-	-	174
	Cayo del Grullo/Laguna Salada	329	18599	-	49	7.30	-	-	1.00	48	0.06	-	-	-	-	147
		334	18604	-	74	**8.00**	-	-	1.00	46	0.04	-	0.10	1.01	-	117
		336	18606	-	49	-	-	-	-	31	0.08	-	-	-	-	-
		342	18611	-	18	4.90	-	**2.44**	-	44	0.05	**0.80**	0.24	-	-	178
		345	18260	-	73	5.10	-	0.16	-	54	0.04	-	0.16	-	-	186
		358	18625	-	22	4.70	-	0.20	-	44	0.06	-	0.15	-	-	119

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

Table 6.13.1. Tissue concentrations (ng/g or ppb) of 4 of 20 PCB congeners (all other PCBs < reporting limit) at 31 of 32 RCAP 2004 sampling sites. Missing site (1) reflects 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	44	105	153	170	Total PCB
2471	Aransas Bay	337	18607	-	-	-	-	-
		340	18610	-	-	-	-	-
		341	18270	-	-	-	-	-
		344	18613	-	-	-	-	-
		353	18620	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-	-	-
		338	18608	-	-	-	-	-
		343	18612	-	-	-	-	-
		356	18623	-	-	-	-	-
		357	18624	-	-	-	-	-
2481	Corpus Christi Bay	333	18603	-	-	-	-	-
		339	18609	-	-	-	-	-
		346	18614	-	-	-	-	-
		348	18616	-	-	-	-	-
		350	18618	-	-	-	-	-
		351	17758	-	-	-	-	-
		354	18621	-	-	-	-	-
		355	18622	-	-	-	-	-
2482	Nueces Bay	331	18601	-	-	-	-	-
		349	18617	-	-	-	-	-
		352	18619	-	-	-	-	-
2483	Redfish Bay	328	18236	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-
		347	18615	-	-	-	-	-
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	327	18598	-	-	-	-	-
		329	18599	-	-	-	-	-
		334	18604	-	-	-	-	-
		336	18606	**13.48**	**29.22**	**11.38**	**6.69**	**60.77**
		342	18611	-	-	-	-	-
		345	18260	-	-	-	-	-
		358	18625	-	-	-	-	-

Table 6.13.2. Tissue concentrations of DDD, DDE, and DDT (ng/g or ppb) at 31 of 32 RCAP 2004 sampling sites. Missing site (1) reflects 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
2471	Aransas Bay	337	18607	-	-	-	-	-	-	-
		340	18610	-	-	-	-	-	-	-
		341	18270	-	-	-	-	-	-	-
		344	18613	-	-	-	-	-	-	-
		353	18620	-	-	-	-	-	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-	-	-	-	-	-
		338	18608	-	-	-	-	-	-	-
		343	18612	-	-	-	-	-	-	-
		356	18623	-	-	-	-	-	-	-
		357	18624	-	-	-	8.82	-	-	8.82
2481	Corpus Christi Bay	333	18603	-	-	-	-	-	-	-
		339	18609	-	-	-	-	-	-	-
		346	18614	-	-	-	-	-	-	-
		348	18616	-	-	-	-	-	-	-
		350	18618	-	-	-	-	-	-	-
		351	17758	-	-	-	-	-	-	-
		354	18621	-	-	-	-	-	-	-
		355	18622	-	-	-	-	-	-	-
2482	Nueces Bay	331	18601	-	-	-	-	-	-	-
		349	18617	-	-	-	-	-	-	-
		352	18619	-	-	-	-	-	-	-
2483	Redfish Bay	328	18236	-	-	-	-	-	-	-
2491	Laguna Madre	335	18605	-	-	-	-	-	-	-
		347	18615	-	-	-	-	-	-	-
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	327	18598	-	-	-	-	-	-	-
		329	18599	-	-	-	-	-	-	-
		334	18604	-	-	-	-	-	-	-
		336	18606	-	-	-	5.84	-	-	5.84
		342	18611	-	-	-	-	-	-	-
		345	18260	-	-	-	**11.96**	-	-	**11.96**
		358	18625	-	-	-	-	-	-	-

Table 6.13.3. Tissue concentrations (ng/g or ppb) of 12 of 13 Chlorinated Pesticides other than DDT (all other chlorinated pesticides < reporting limit) at 31 of 32 RCAP 2004 sampling sites were all below the reporting limit. Missing site (1) reflects 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	gamma-BHC-Lindane	Total Chlorinated Pesticides
2471	Aransas Bay	337	18607	-	-
		340	18610	-	-
		341	18270	-	-
		344	18613	-	-
		353	18620	-	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-	-
		338	18608	-	-
		343	18612	-	-
		356	18623	-	-
		357	18624	-	-
2481	Corpus Christi Bay	333	18603	-	-
		339	18609	-	-
		346	18614	-	-
		348	18616	-	-
		350	18618	-	-
		351	17758	-	-
		354	18621	-	-
		355	18622	-	-
2482	Nueces Bay	331	18601	-	-
		349	18617	-	-
		352	18619	-	-
2483	Redfish Bay	328	18236	-	-
2491	Laguna Madre	335	18605	-	-
		347	18615	-	-
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	327	18598	-	-
		329	18599	-	-
		334	18604	-	-
		336	18606	-	-
		342	18611	**3.03**	**3.03**
		345	18260	-	-
		358	18625	-	-

Table 6.13.4. Tissue concentrations (ng/g or ppb) of 23 PAH's at 31 of 32 RCAP 2004 sampling sites were all below detectable reporting limits. Missing site (1) reflects 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
2471	Aransas Bay	337	18607	-
		340	18610	-
		341	18270	-
		344	18613	-
		353	18620	-
2472	Copano Bay/Port Bay/Mission Bay	332	18602	-
		338	18608	-
		343	18612	-
		356	18623	-
		357	18624	-
2481	Corpus Christi Bay	333	18603	-
		339	18609	-
		346	18614	-
		348	18616	-
		350	18618	-
		351	17758	-
		354	18621	-
		355	18622	-
2482	Nueces Bay	331	18601	-
		349	18617	-
		352	18619	-
2483	Redfish Bay	328	18236	-
2491	Laguna Madre	335	18605	-
		347	18615	-
2492	Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada	327	18598	-
		329	18599	-
		334	18604	-
		336	18606	-
		342	18611	-
		345	18260	-
		358	18625	-