LITTLE BAY AND TULE CREEK DATA REPORT: ROCKPORT, TEXAS

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THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY
TEXAS STREAM TEAM

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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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The rising STAR of Texas

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ACKNOWLEDGEMENTS

The Texas Stream Team encourages life-long learning about the environment and people's relationship to the environment through its multidisciplinary community science programs. We also provide hands-on opportunities for Texas State University students and inspire future careers and studies in natural resource related fields. Preparation of this report fulfills a contract deliverable for the granting entity, but it also serves as a valuable educational experience for the students that assisted in preparing the report. The Texas Stream Team staff values the student contributions and recognizes each individual for their role. The following staff and student workers assisted in the preparation of this report and are acknowledged for their contributions:

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INTRODUCTION

Texas Stream Team

Texas Stream Team is a volunteer community science water quality monitoring program. Community scientist water quality monitoring occurs at predetermined monitoring sites, at approximately the same time of day each month. Information collected by Texas Stream Team community scientists is covered by a Texas Commission on Environmental Quality-approved Quality Assurance Project Plan to ensure a standard set of methods is used. Community scientist data may be used to identify surface water quality trends, target additional data collection needs, identify potential pollution events and sources of pollution, and to test the effectiveness of water quality management measures. Texas Stream Team community scientist data are not used by the state to assess whether water bodies are meeting the designated surface water quality uses and standards. Data collected by Texas Stream Team provide valuable information, often collected in water bodies professionals are not able to monitor frequently or monitor at all.

For additional information about water quality monitoring methods and procedures, including the differences between professional and volunteer community science monitoring, please refer to the following sources:

- Texas Stream Team Core Water Quality Community Scientist Manual
- Texas Stream Team Advanced Water Quality Community Scientist Manual
- Texas Stream Team Program Volunteer Water Quality Monitoring Program Quality Assurance Project Plan
- Texas Commission on Environmental Quality Surface Water Quality Monitoring Procedures

The purpose of this report is to provide a summary of the data collected by Texas Stream Team community scientists. The data presented in this report should be considered in conjunction with other relevant water quality reports for a holistic view of water quality in Little Bay and Tule Creek in Rockport within the San Antonio-Nueces Coastal Basin. Such sources may include, but are not limited to, the following:

- Texas Surface Water Quality Standards
- Texas Water Quality Inventory and 303(d) List (Integrated Report)
- Texas Clean Rivers Program partner reports, such as Basin Summary and Highlight Reports
- Texas Commission on Environmental Quality Total Maximum Daily Load reports
- Texas Commission on Environmental Quality and Texas State Soil and Water Conservation Board Nonpoint Source Program funded reports, including watershed protection plans

To get involved with Texas Stream Team or for questions regarding this watershed data report contact us at TxStreamTeam@txstate.edu or at (512) 245-1346. Visit our website for more information on our programs at www.TexasStreamTeam.org.

WATERSHED DESCRIPTION

Location and Climate

The Little Bay and Tule Creek waterbodies in Rockport span approximately 16-square miles and are part of the larger San Antonio-Nueces Coastal Basin (Figure 1). The Tule Creek watershed extends approximately 2,340 acres, is located within the northeastern portion of the Live Oak Peninsula, and drains to Little Bay (Aransas County, 2010). The Tule Creek watershed encompasses the City of Rockport, the county seat of Aransas County. This area is important locally for aesthetics, recreation, and for the ecosystem it supports, but it is also historically significant and provides a variety of activities for tourists (City of Rockport, 2023).

Early history about Little Bay is scarce, but the area was used by the Karankawa people for generations as a coastal fishing camp before Anglo settlement in the early 19th century (Jasinski, 2004; and Lipscomb, 2020). Irish and Mexican immigrants began arriving to the area in the 1820s. Beginning in the mid-19th century, cattle processing and shipping were the dominant industry. Shrimping and shipbuilding would quickly become top industries throughout the 20th century with 51 million pounds of shrimp being produced by 1950 and many ships being built and repaired for the United States Navy during the World Wars (Long, 2020). In the late 20th and early 21st centuries, Key Allegro Real Estate developed Little Bay into a resort area, and it is now an affluent community (Jasinski, 2004).

The Texas Commission on Environmental Quality designates classifications for streams, rivers, lakes, and bays in the San Antonio-Nueces Coastal Basin and throughout Texas (Table 1). Aransas Bay (Segment 2471) borders the eastern mainland near Rockport and Fulton, while Copano Bay (Segment 2472) borders the northwestern mainland near Copano Village. Little Bay (Segment 2471A) is located between Aransas Bay, Rockport Beach, and Key Allegro. The two bay segments (2471 and 2472) are classified segments, while Little Bay (2471A) is an unclassified segment. Tule Creek is not recognized as a classified or unclassified segment but serves as drainage for Rockport and flows into Little Bay.

The climate in this part of the state is described as subtropical-humid with mild winters and warm summers (Long, 2020). National Oceanic and Atmospheric Administration climate data from a weather station at Rockport, Texas was acquired from the National Data Center (National Oceanic and Atmospheric Administration, 2021). Average annual precipitation at Rockport is 36.4 inches and occurs year-round (Figure 2). Long-term monthly average precipitation has a unimodal distribution with a peak occurring in September and October. Average rainfall during these months is 5.7 and 4.0 inches each month, respectively. The least amount of rainfall (1.9 inches) occurs in December. The warmest and coldest months of the year are August (29.94°C) and January (13.28°C), respectively.

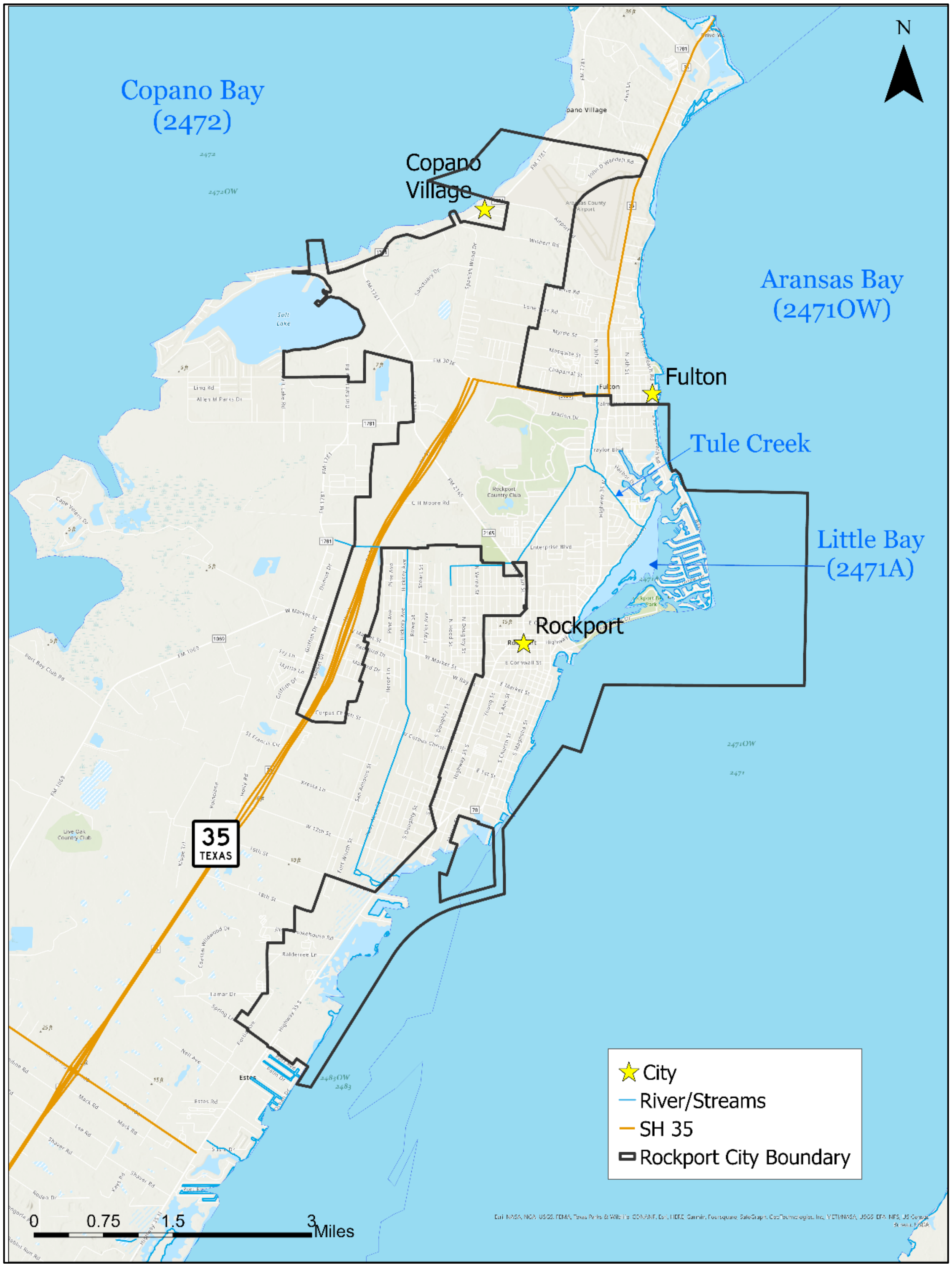

Figure 1. Little Bay and Tule Creek in Rockport within Aransas County, Texas.

Table 1. Texas Commission on Environmental Quality segment classifications (Texas Commission on Environmental Quality, 2022).

Segment Number	Unclassified Segment Name	Segment Description
2471	Aransas Bay	Boundaries of bay and estuary segments have not been precisely defined.
2471A	Little Bay	Located between Aransas Bay (Segment 2471) on the east side and Broadway Street in Rockport on the west side and Rockport Beach on the south side in Aransas County.
2472	Copano Bay/Port Bay/Mission Bay	Boundaries of bay and estuary segments have not been precisely defined.

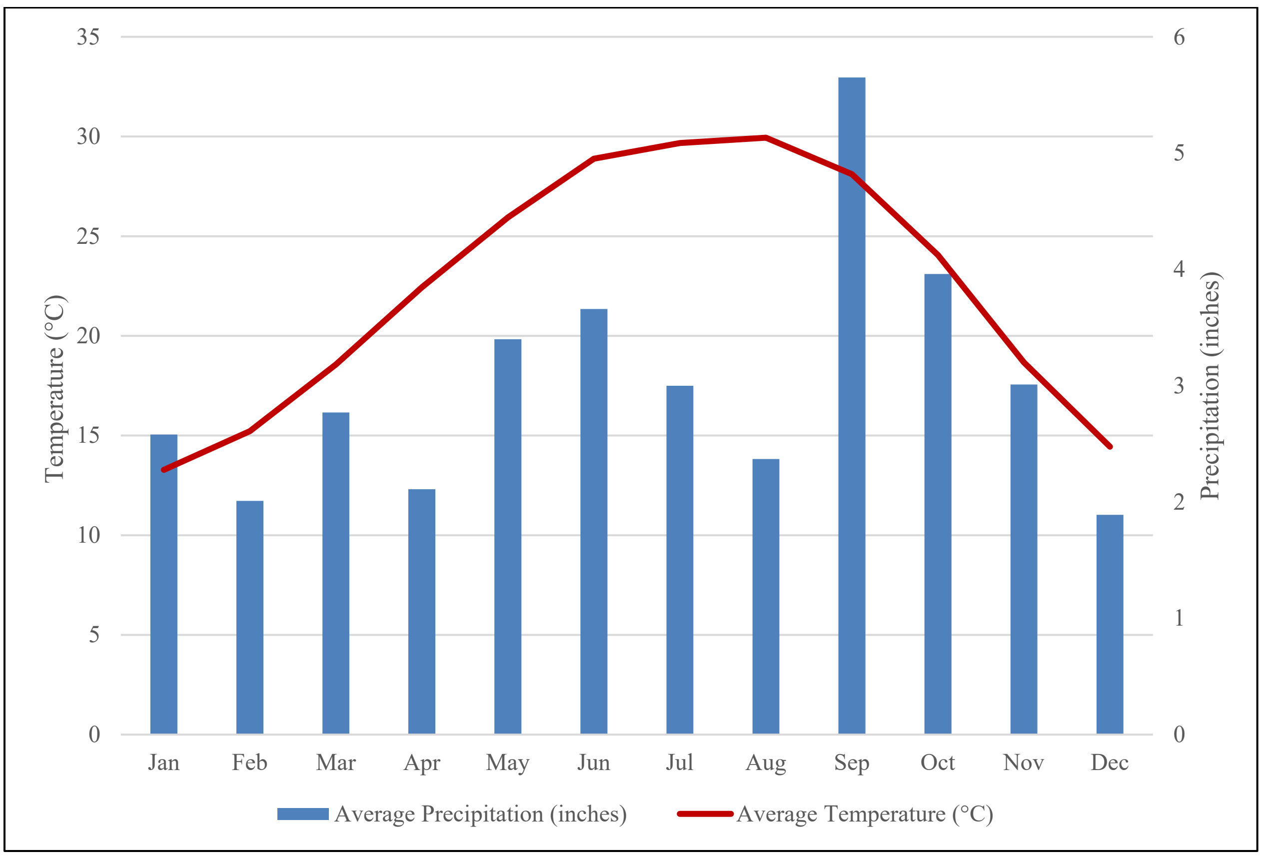

Figure 2. Long-term (1991-2020) monthly average precipitation (inches) and air temperature (°C) from Rockport, Texas (National Oceanic and Atmospheric Administration Climate Data, 2021).

Physical Description

Little Bay and Tule Creek in Rockport are completely contained in Aransas County. Located just below the midpoint along the Texas Gulf Coast, the landscape is described as nearly level. The Gulf prairies and marsh vegetation is comprised of tallgrass prairies, live oak woodlands, mesquite, and acacias (Texas Parks and Wildlife Department, 2023). Soils that support the landscape include acidic sands, sandy loams, and clayey subsoils (Long, 2020).

This area supports diverse wildlife including turtles, alligators, eels, and numerous of birds including whooping cranes, bald eagles, pelicans, wood storks, and many more (United States Fish and Wildlife Service, 2023).

Land Use

Land cover types were determined from spatial data sets processed in geographic information systems for the Little Bay and Tule Creek areas in Rockport (Figure 3). Ninety-one percent of the land cover in the area consists of developed land (42%), open water (26%), forest (14%), and emergent herbaceous wetlands (9%) (Table 2). The remaining land use types, grassland (5%), shrub (2%), woody wetlands (1%), bare (0.8%), and planted/cultivated (0.3%) comprise approximately 9% of the area.

Table 2. Land use in the Little Bay Rockport Watershed in Aransas County, Texas (National Land Cover Data, 2016).

Land Use Type	Acres (ac)	Hectares (ha)	Percent (%)
Developed	4,455.80	1,803.2	41.59%
Open Water	2,804.65	1,135	26.18%
Forest	1,449.57	586.62	13.53%
Emergent Herbaceous Wetlands	940.19	380.48	8.78%
Grassland	547.65	221.63	5.11%
Shrub	241.41	97.7	2.25%
Woody Wetlands	150.02	60.71	1.4%
Bare	87.40	35.37	0.816%
Planted/Cultivated	37.17	15.04	0.347%
Total	**10,713.87**	**4,335.75**	**100**

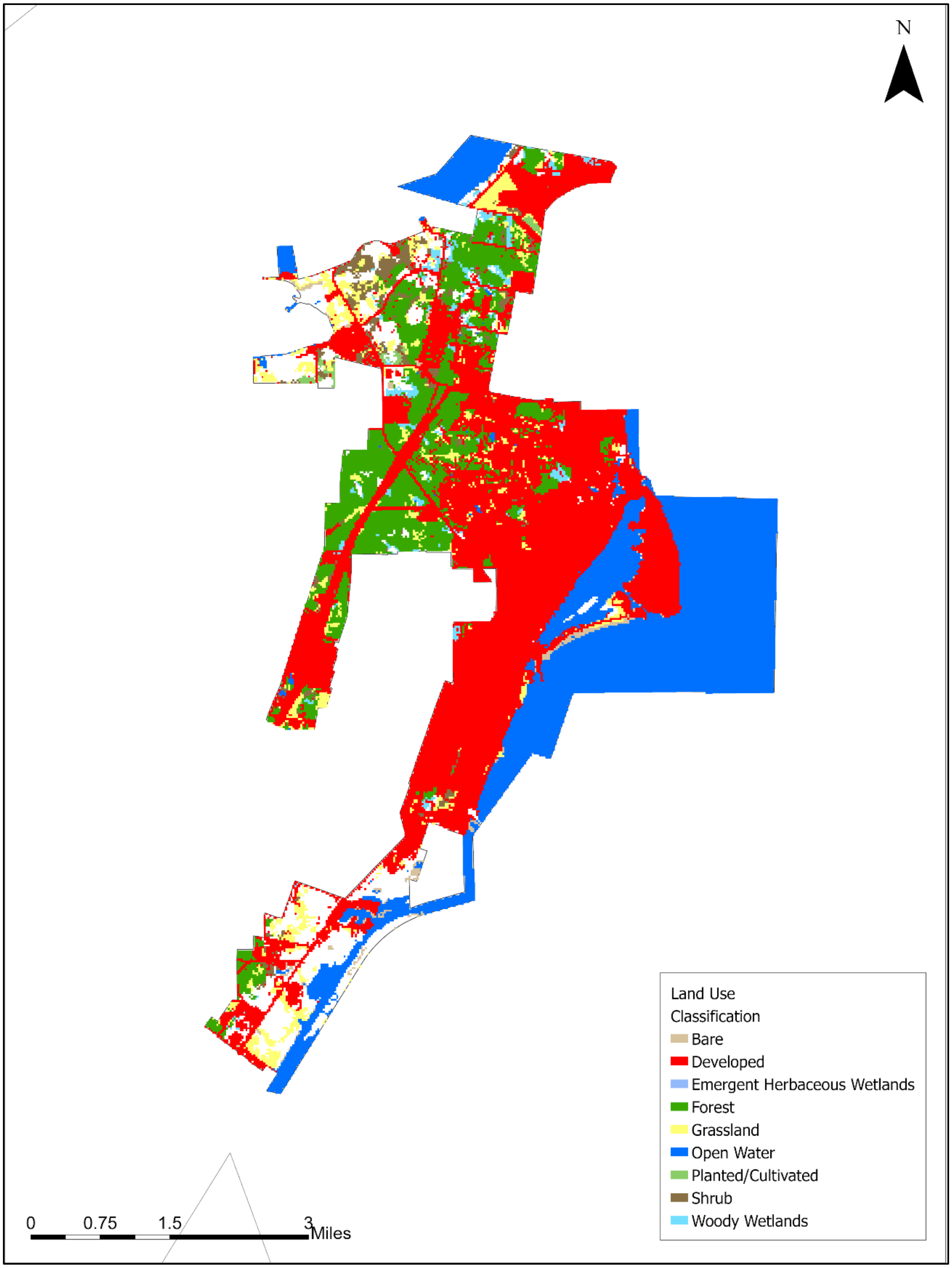

Figure 3. Land cover for the City of Rockport including Tule Creek and Little Bay in Aransas County, Texas (National Land Cover Data, 2016).

History

Aransas County was established by hunter-gatherer communities more than 6,000 – 8,000 years ago and was occupied by Aransas, Karankawa, and Coahuiltecan indigenous peoples (Long, 2020). Spanish explorers arrived in the area in the early 16th century but failed to settle over the years due to numerous attacks by the natives. Colonization of the area would not occur until the early 19th century by Irish and Mexican settlers (Long, 2020). Farming and fishing communities would sparsely populate the land.

After the Civil War, local port towns were crucial in cattle slaughtering, packing, shipping, and boat building (City of Rockport, 2023). The construction of railroads would promote these industries, including tourism. The area experienced population growth and prosperity throughout the 20th century, primarily because of the shrimping industry and development of the Gulf Intracoastal Waterway (Long, 2020). Despite these industries being crucial to the local economy today, the area is known for its vacation attractions and recreational opportunities (City of Rockport, 2023).

Endangered Species and Conservation Needs

The common names of 31 species listed as threatened or endangered (under the authority of Texas state law and/or under the United States Endangered Species Act) within Little Bay and Tule Creek areas in Rockport are included in Appendix A. A summary of the number of species per taxonomic group listed as state or federally endangered, threatened, G1 or G2 (critically imperiled or imperiled), species of greatest conservation need, and/or endemic are provided in Table 3.

Table 3. State and federally listed species in the Little Bay and Tule Creek areas of Rockport in Aransas County, Texas (Texas Parks and Wildlife Department, 2021).

Taxon	**Endangered (Federal or State)**	**Threatened (Federal or State)**	**G1 or G2 (Critically imperiled or imperiled)**	**Species of Greatest Conservation Need (NPWD) (S1 or S2)**	**Endemic Total Count**
Amphibians	0	2	0	0	2
Birds	2	8	1	11	22
Fish	0	2	0	3	5
Mammals	7	2	3	9	21
Reptiles	3	5	3	6	17
Insects	0	0	1	1	2
Mollusks	0	0	1	1	2
Plants	0	0	6	7	13
Total Count	**12**	**19**	**15**	**38**	**84**

Texas Water Quality Standards

The Texas Surface Water Quality Standards establish explicit goals for the quality of streams, rivers, lakes, and bays throughout the state. The standards are developed to maintain the quality of surface waters in Texas to support public health and protect aquatic life, consistent with the sustainable economic development of the state. Water quality standards identify appropriate uses for the state's surface waters, including aquatic life, recreation, and sources of public water supply as drinking water. The criteria for evaluating support of those uses in Aransas Bay (Segment 2471), Copano Bay (Segment 2472), and Little Bay (2471A) included in this report are provided in Table 4. The dissolved oxygen criteria are for dissolved oxygen means at any site within the segment, the minimum and maximum values for pH apply to any site within the segment, the Enterococci indicator bacteria for saltwater is a geometric mean, and the temperature criteria is a maximum value at any site within the segment.

The Texas Surface Water Quality Standards also contain narrative criteria (verbal descriptions) that apply to all waters of the state and are used to evaluate support of applicable uses. Narrative criteria include general descriptions such as the existence of excessive aquatic plant growth, foaming of surface waters, taste- and odor-producing substances, sediment build-up, and toxic materials. Narrative criteria are evaluated by using screening levels, if they are available, and other information, including water quality studies, existence of fish kills or contaminant spills, photographic evidence, and local knowledge. Screening levels serve as a reference to indicate when water quality parameters may be approaching levels of concern.

Table 4. State water quality criteria for Aransas, Copano and Little Bays in Rockport, Aransas County, Texas (Texas Commission on Environmental Quality, 2022).

Segment	Dissolved Oxygen (mg/L)	pH Range (s.u.)	Enterococci Bacteria (#/100 mL)	Temperature (°C)
2471 – Aransas Bay	Grab screening level: 5.0 Grab min.: 4.0	6.5-9.0	Primary Contact Recreation 1: 35 geomean, 130 single sample	35
2471A – Little Bay	Grab screening level: 4.0 Grab min.: 3.0	NA	Primary Contact Recreation 1: 35 geomean, 130 single sample	NA
2472 – Copano Bay/Port Bay/Mission Bay	Grab screening level: 5.0 Grab min.: 4.0	6.5-9.0	Primary Contact Recreation 1: 35 geomean, 130 single sample	35

Water Quality Impairments

The *2022 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (Integrated Report) includes an index of water quality impairments. The classified segment, Copano Bay (Segment 2472), has impairments for bacteria in oyster waters. This segment is designated as Category 5C. Additional data and information will be collected or evaluated before a management strategy is selected.

WATER QUALITY PARAMETERS

Water Temperature

Water temperature influences the physiological processes of aquatic organisms, and each species has an optimum temperature for survival. High water temperatures increase oxygen-demand for aquatic communities and can become stressful for fish and aquatic insects. Water temperature variations are most detrimental when they occur rapidly, leaving the aquatic community no time to adjust. Additionally, the ability of water to hold oxygen in solution (solubility) decreases as temperature increases. This effect is exacerbated in coastal water bodies influenced by tidal, saline waters.

Warm water temperatures occur naturally with seasonal variation, as water temperatures tend to increase during summer and decrease in winter in the Northern Hemisphere. Daily (diurnal) water temperature changes occur during normal heating and cooling patterns. Man-made sources of warm water include power plant effluent after it has been used for cooling or hydroelectric plants that discharge warm water. Community scientist monitoring may not identify fluctuating patterns due to diurnal changes or events such as power plant releases because of the monthly sampling frequency. While community scientist data may not show diurnal temperature fluctuations, they could demonstrate the fluctuations over seasons and years when collected consistently at predetermined monitoring sites and monthly frequencies.

Specific Conductance and Salinity

Specific conductance is a measure of the ability of a body of water to conduct electricity. It is measured in microsiemens per centimeter (µS/cm). A body of water is more conductive if it has more total dissolved solids such as nutrients and salts, which indicates poor water quality if they are overly abundant. High concentrations of nutrients can lead to eutrophication, which results in lower levels of dissolved oxygen. High concentrations of salt can inhibit water absorption and limit root growth for vegetation, leading to an abundance of more drought tolerant plants, and can cause dehydration of fish and amphibians. Sources of total dissolved solids can include agricultural runoff, domestic runoff, or discharges from wastewater treatment plants.

Salinity is a measure of the saltiness or the dissolved inorganic salt concentration in water. Salinity is often measured in ocean, estuarine, or tidally-influenced waters, but in Texas there are some inland streams that have a high salt content due to the local geology and require salinity measurements. Some common ions measured as salinity include sodium, chloride, magnesium, sulfate, calcium, and potassium. Seawater typically has a salt content of 35 parts per thousand (ppt or ‰). Like other water quality parameters, salinity affects the homeostasis or the balance of water and solutes within both plants and animals. Too much or too little salt can affect plant and animal cell survival and growth, therefore salinity is an important measurement.

Dissolved Oxygen

Oxygen is necessary for the survival of organisms like fish and aquatic insects. The amount of oxygen needed for survival and reproduction of aquatic communities varies according to species composition and adaptations to watershed characteristics like stream gradient, habitat, and available streamflow.

The dissolved oxygen concentrations can be influenced by other water quality parameters such as nutrients and temperature. High concentrations of nutrients can lead to excessive surface vegetation and algae growth, which may starve subsurface vegetation of sunlight and, therefore, reduce the amount of oxygen they produce via photosynthesis. This process is known as eutrophication. Low dissolved oxygen can also result from high groundwater inflows (which have low dissolved oxygen due to minimal aeration), high temperatures, or water releases from deeper portions of dams where dissolved oxygen stratification occurs. Supersaturation typically occurs underneath waterfalls or dams with water flowing over the top where aeration is abundant.

pH

The pH scale measures the concentration of hydrogen ions in a range from zero to 14 and is reported in standard units (s.u.). The pH of water can provide information regarding acidity or alkalinity. The range is logarithmic; therefore, every one-unit change is representative of a 10-fold increase or decrease in acidity or alkalinity. Acidic sources, indicated by a low pH level, can include acid rain and runoff from acid-laden soils. Acid rain is predominantly caused by coal powered plants with minimal contributions from the burning of other fossil fuels and other natural processes, such as volcanic emissions. Soil-acidity can be caused by excessive rainfall leaching alkaline materials out of soils, acidic parent material, crop decomposition creating hydrogen ions, or high-yielding fields that have drained the soil of all alkalinity. Sources of high pH (alkaline) include geologic composition, as in the case of limestone increasing alkalinity and the dissolving of carbon dioxide in water. Carbon dioxide is water soluble, and as it dissolves it forms carbonic acid. A suitable pH range for healthy organisms is between 6.5 and 9.0 s.u.

Water Transparency and Total Depth

Two instruments can be used by Texas Stream Team community scientists to measure water transparency, a Secchi disc or a transparency tube. Both instruments are used to measure water transparency or to determine the clarity of the water, a condition known as turbidity. The Secchi disc is lowered into the water until it is no longer visible, then raised until it becomes visible, and the average of the two depth measurements is recorded. A transparency tube is filled with sample water and water is released until the Secchi pattern at the bottom of the tube can be seen. The tube is marked with two-millimeter increments and is used to measure water transparency. Transparency measurements less than the total depth of the monitoring site are indicative of turbid water. Readings that are equal to total depth indicate clear water. Highly turbid waters pose a risk to wildlife by clogging the gills of fish, reducing visibility, and carrying contaminants. Reduced visibility can harm predatory fish or birds that depend on good visibility to find their prey. Turbid waters allow less light to penetrate deep into the water, which, in turn, decreases the density of phytoplankton, algae, and other aquatic plants. This reduces the dissolved oxygen in the water due to reduced photosynthesis. Contaminants are mostly transported in sediment rather than in the water. Turbid waters can result from sediment runoff from construction sites, erosion of farms, or mining operations.

E. coli and Enterococci Bacteria

E. coli bacteria originate in the digestive tract of endothermic organisms. The United States Environmental Protection Agency has determined *E. coli* to be the best indicator of the degree of pathogens in a freshwater system. A pathogen is a biological agent that causes disease.

Enterococci bacteria are a subgroup of fecal streptococci bacteria (mainly *Streptococcus faecalis* and *Streptococcus faecium*) that are present in the intestinal tracts and feces of warm-blooded animals. It is used by the Texas Commission on Environmental Quality as an indicator of the potential presence of pathogens in tidally-influenced saltwater along the Texas Gulf Coast.

Little Bay in Rockport is designated a primary contact recreation 1 use. This means that recreation activities are presumed to involve a significant risk of ingestion of water (e.g., wading by children, swimming, water skiing, diving, tubing, surfing, hand fishing as defined by Texas Parks and Wildlife Code, §66.115, and the following whitewater activities: kayaking, canoeing, and rafting).

The standard for a bacteria impairment is based on the geometric mean (geomean) of the bacteria measurements collected. A geometric mean is a type of average that incorporates the high variability found in parameters such as *E. coli* and enterococci which can vary from zero to tens of thousands of colony forming units per 100 milliliters (CFU/100 mL). The standard for contact recreational use of a water body is 126 CFU/100 mL for *E. coli* in freshwater or 35

CFU/100 mL for enterococci in saltwater. A water body is considered impaired if the geometric mean is higher than the corresponding water quality standard.

Texas Stream Team does not currently monitor water quality for enterococci in coastal waters. Instead, community scientists can get certified in *E. coli* bacteria monitoring, the indicator used by the Texas Commission on Environmental Quality for freshwater streams.

Nitrate-Nitrogen

Nitrogen is present in terrestrial or aquatic environments as nitrate-nitrogen, nitrites, and ammonia. Nitrate-nitrogen tests are conducted for maximum data compatibility with the Texas Commission on Environmental Quality and other partners. Just like phosphorus, nitrogen is a nutrient necessary for the growth of most living organisms. Nitrogen inputs into a water body may be from livestock and pet waste, excessive fertilizer use, failing septic systems, and industrial discharges that contain corrosion inhibitors. The effect excess nitrogen has on a water body is known as eutrophication and is described previously in the “Dissolved Oxygen” section. Nitrate-nitrogen dissolves more readily than orthophosphate, which tend to be attached to sediment, and, therefore, can serve as a better indicator of possible sewage or manure pollution during dry weather.

Phosphate

Phosphorus almost always exists in the natural environment as phosphate and continually cycles through the ecosystem as a nutrient necessary for the growth of most organisms. Testing for phosphate in the water excludes the phosphate bound up in plant and animal tissue. There are other methods to retrieve phosphate from the material to which it is bound, but they are too complicated and expensive to be conducted by community scientists. Testing for phosphate provides an idea of the degree of phosphorus in a water body. It can be used for problem identification, which can be followed up with more detailed professional monitoring, if necessary. Phosphorus inputs into a water body may be caused by the weathering of soils and rocks, discharge from wastewater treatment plants, excessive fertilizer use, failing septic systems, livestock and pet waste, disturbed land areas, drained wetlands, water treatment, and some commercial cleaning products. The effect excess phosphate has on a water body is known as eutrophication and is described above in the “Dissolved Oxygen” section.

DATA COLLECTION, MANAGEMENT AND ANALYSIS

Data Collection

The field sampling procedures implemented by trained community scientists are documented in the Texas Stream Team Core Water Quality Community Scientist Manual and the Texas Stream Team Advanced Water Quality Community Scientist Manual. The sampling protocols in the manuals adhere closely to the Texas Commission on Environmental Quality Surface Water Quality Monitoring Procedures Manual, Volume 1 (August 2012). Additionally, all data collection adheres to Texas Stream Team's Texas Commission on Environmental Quality-approved Quality Assurance Project Plan.

Procedures documented in Texas Stream Team Water Quality Community Scientist Manuals or the Texas Commission on Environmental Quality Surface Water Quality Monitoring Procedures Manual, Volume 1 (August 2012) outline the necessary steps to prevent contamination of samples, including direct collection into sample containers, when possible. Field quality control samples are collected and analyzed to detect whether contamination has occurred and to ensure data accuracy and precision.

Field sampling activities are documented on Environmental Monitoring Forms. The following items are recorded for each field sampling event: station ID, location, sampling time, date, depth, sample collector's name/signature, group identification number, meter calibration information, and reagent expiration dates. Specific conductance values are converted to total dissolved solids using a conversion factor of 0.65 and are reported as mg/L.

Values for measured parameters are recorded. If reagents or media are expired, it is noted, and data are flagged and communicated to Texas Stream Team staff. Sampling is not permitted with expired reagents or bacteria media; the corresponding values will be flagged in the database and excluded from data reports. Detailed observational data recorded include water appearance, weather, field observations (biological activity and stream uses), algae cover, unusual odors, days since last significant rainfall, and flow severity. Comments related to field measurements, number of participants, total time spent sampling, and total round-trip distance traveled to the sampling site are also recorded for grant reporting and administrative purposes.

Data Management

The community scientists collect field data and report the measurement results to Texas Stream Team, by submitting a hard copy of the Environmental Monitoring Form, entering the data directly into the online Waterways Dataviewer, or by using the electronic Environmental Monitoring Form. All data are reviewed to ensure they are representative of the samples analyzed and locations where measurements were made. The measurements and associated quality control data are also reviewed to ensure they conform to specified monitoring procedures and project specifications as stated in the approved Quality Assurance Project Plan.

Data review and verification is performed using a quality control checklist and self-assessments, as appropriate to the project task, followed by automated database functions that validate data as the information is entered into the database. The data are verified and evaluated against project specifications and are checked for errors, especially errors in transcription, calculations, and data input. Potential errors are identified by examination of documentation and by manual and computer-assisted examination of corollary or unreasonable data. Issues that can be corrected are corrected and documented. Once entered, the data can be accessed publicly through the online Texas Stream Team Datamap.

Data Analysis

Data were compiled, analyzed, summarized, and compared to state water quality standards and/or criteria to provide readers with a reference point for parameters that may be of concern. The statewide, biennial assessment performed by the Texas Commission on Environmental Quality involves more stringent monitoring methods and oversight than those used by community scientists and staff in this report. The Texas Stream Team community scientist water quality monitoring data are not currently used in the Texas Commission on Environmental Quality assessments mentioned above. However, the Texas Stream Team data is intended to inform stakeholders about general characteristics and assist professionals in identifying areas of potential concern to plan future monitoring efforts.

All data collected by community scientists in the study watersheds were exported from the Texas Stream Team database and grouped by site. Sites with 10 or more monitoring events were maintained in the dataset for analysis. Sites with fewer than 10 monitoring events were excluded from the analysis for this report but may be used in future data summary reports. Once compiled, data were sorted, summary statistics were generated and reviewed, and results were graphed in JMP Pro 14.0.0 (SAS Institute Inc., 2018) using standard methods. Best professional judgement was used to verify outliers. Outlier box or scatter plots were prepared to provide a compact view of the distribution of the data for each parameter and site(s). The horizontal line within the box plot represents the median sample value, while the ends of the box represent the 25th and 75th quantiles or the interquartile range. The lines extending from each end of the box, or whiskers, are computed using the 25th/75th quartiles ± 1.5 x (interquartile range). Outliers are plotted as points outside the box plot.

DATA RESULTS

Water quality data from 10 Texas Stream Team monitoring sites in Little Bay and Tule Creek in Rockport were acquired for this report (Figure 4). The 10 sites were monitored sporadically during the past 27 years from October 1997 through March 2023. Trained community scientists conducted between four and 38 sampling events at each site, for a total of 160 monitoring events (Table 5). The period of record for the sampling events ranged from October 1997 through March 2023, with all sites experiencing temporal intermittent sampling. Only sites with 10 or more sampling events were included in the analysis to prevent seasonal bias in the results.

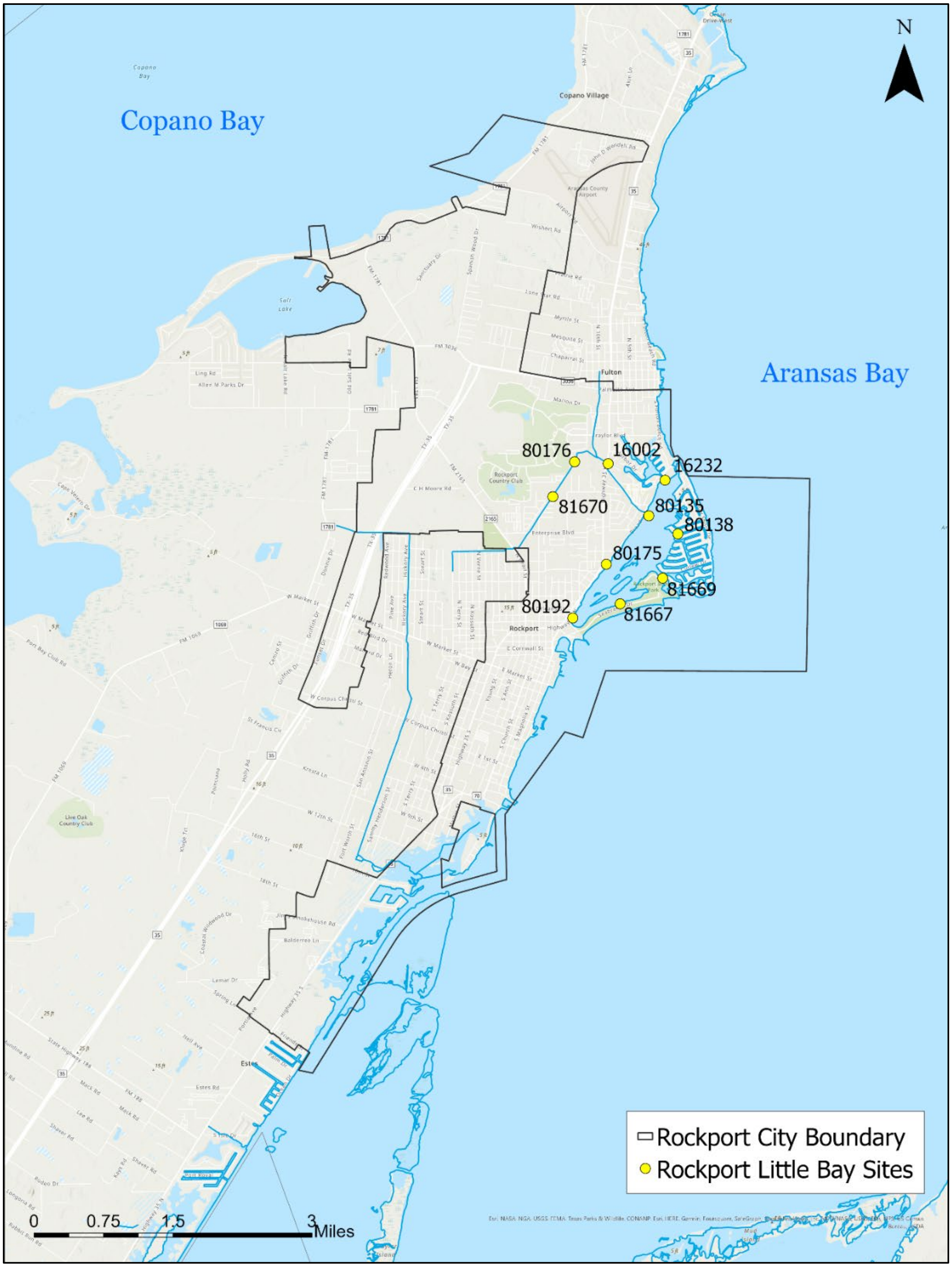

Figure 4. Texas Stream Team monitoring sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas.

Table 5. Texas Stream Team monitoring sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas.

Site ID	Description	Number of Monitoring Events (n)	Period of Record
81670	Tule Creek off Service Road from Stadium Dr	6	1/12/2022 – 9/14/2022
80176	WWTP Effluent Ditch @ Cherry Hills	14	1/10/2002 – 6/13/2002 1/12/2022 – 6/8/2022 1/11/2023 – 3/8/2023
16002	Wetland @ SH 35 Near Tule Creek in Rockport	17	11/21/1997- 6/29/1998 1/12/2022 – 3/8/2023
80135	Little Bay @ Effluent Site	38	7/13/2000 – 7/8/2003 2/8/2005 – 4/24/2007 3/9/2022
16232	Little Bay @ Broadway	14	10/16/1997 – 5/21/1998 1/12/2022 – 6/8/2022 12/14/2022 – 3/8/2023
80175	Little Bay Near Intersection of SH 35 and Broadway St	28	7/13/2002 – 4/24/2007 1/12/2022 – 6/8/2022
80138	Little Bay @ Melcher Dock	27	7/13/2000 – 11/8/2001 1/12/2022 – 4/13/2022
80192	Little Bay @ The Spirit Column Site Near SH 35	6	1/12/2022 – 6/8/2022
81667	Boat ramp at Rockport Beach	6	1/12/2022 – 6/8/2022
81669	Key Allegro in Little Bay off Blue Heron Dr	4	1/12/2022 – 4/13/2022
	TOTAL	**160**	

Site Analysis

Water quality monitoring data from six sites with 10 or more sampling events were analyzed and summarized including the number of samples, mean, standard deviation, and range of values (Table 6). Community scientists monitored the sites for standard core parameters, including air and water temperature, specific conductance, total dissolved solids, salinity, dissolved oxygen, pH, Secchi disc/tube transparency, and total depth.

Table 6. Texas Stream Team data summary for sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas. (Oct 1997 to Mar 2023).

Parameter	**Tule Creek Sites**		**Little Bay Sites**			
	80176	**16002**	**80135**	**16232**	**80175**	**80138**
Number of events	n =14	n =17	n = 38	n = 14	n =28	n =27
Air Temperature (°C)	22.2±5.6 (16.2)	22.6±5.9 (23)	24.7±4.7 (20.3)	22.6±4.7 (16.7)	23.3±6.2 (25.5)	21.0±5.8 (19.5)
Water Temperature (°C)	22.4±4.4 (13)	22.1±6.4 (22)	23.9±4.7 (18.6)	21.9±5.2 (18)	22.8±6.4 (26.2)	21.9±6.4 (20)
Specific Conductance (µS/cm)	ND	792±551 (1838)	ND	ND	ND	ND
***Total Dissolved Solids (mg/L)**	ND	515±358 (1195)	ND	ND	ND	ND
Salinity (ppt)	0.8±1.0 (2)	0.67±1.2 (2)	13.7±10.0 (35.1)	14.3±8.1 (25.5)	14.0±8.4 (28.8)	21.1±11.4 (38.4)
Dissolved Oxygen (mg/L)	5.7±2.8 (9.4)	5.5±1.5 (3.8)	4.1±2.8 (12.9)	7.5±2.3 (7.3)	6.2±3.0 (11)	6.3±2.1 (6)
pH (s.u.)	7.8±0.4 (1.5)	7.7±0.4 (1.4)	7.8±0.5 (2.4)	8.8±0.2 (0.7)	8.2±0.6 (2.3)	8.2±0.2 (0.6)
Secchi Disk (m)	ND	0.3±0.2 (0.4)	0.5±0.3 (1.5)	0.7±0.1 (0.3)	0.6±0.4 (1.5)	0.9±0.5 (2.3)
Transparency Tube (m)	0.5±0.2 (0.5)	0.4±0.1 (0.4)	ND	0.4±0.2 (0.5)	ND	ND
Total Depth (m)	0.5±0.3 (0.8)	0.3±0.1 (0.4)	0.6±0.3 (1.5)	0.7±0.4 (1.3)	0.5±0.3 (1.3)	1.4±0.5 (2.8)

*Total dissolved solids were calculated from specific conductance (TDS = specific conductance * 0.65).
ND = no data available.

Air and Water Temperature

Average air temperature for all sites ranged from 21.0 to 24.7°C (Table 6). The lowest mean air temperature (21.0°C) was observed at Melcher Dock (site 80138), while the highest mean air temperature (24.7°C) was observed at the Tule Creek confluence with Little Bay referred to as the effluent site (site 80135).

Average water temperature for all sites ranged from 21.9 to 23.9°C (Table 6). The lowest mean water temperature (21.9°C) was observed at the site on Broadway (site 16232), while the highest mean water temperature (23.9°C) was observed at the Tule Creek confluence with Little Bay (site 80135). Discreet water temperature measurements from two sites (16002 and 16232) included in this report did not meet the water quality standard (35°C) during the period of record for this report (Figure 5). Measurements for the remaining four sites (80135, 80138, 80175, and 80176) met the water quality standard throughout the period of record for this report.

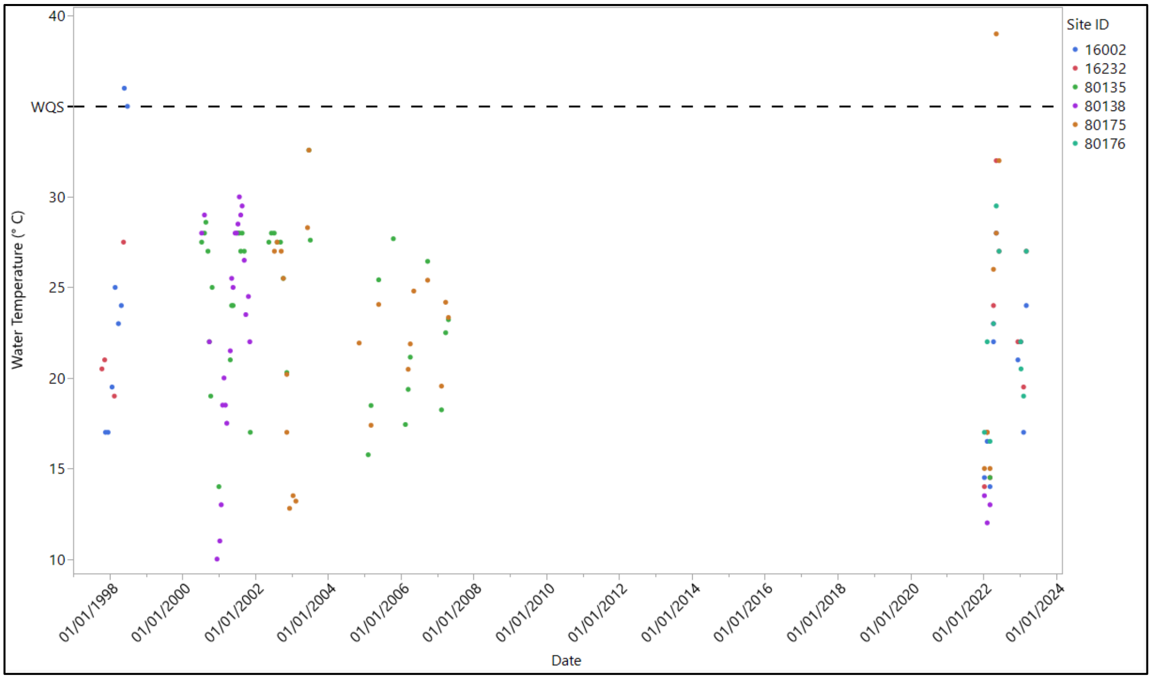

Figure 5. Water temperature for Texas Stream Team sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas. (Oct 1997 to Mar 2023). WQS = Water Quality Standard.

Specific Conductance and Salinity

Total dissolved solid values were calculated from specific conductance measurements when more than 10 measurements were available. Only one site (16002) had more than 10 specific conductance measurements. The average total dissolved solids for the wetland site near Tule Creek (16002) was 515 mg/L (Table 6). Water quality criteria for total dissolved solids are not available for Tule Creek.

Salinity measurements were collected for all six sites and average values ranged from 0.7 to 21.1 ppt (Table 6). The site with the lowest average salinity was the wetland site near Tule Creek (16002), while the site with the highest salinity was Melcher Dock in Little Bay (80138) (Figure 6). A salinity gradient from freshwater in Tule Creek in the west towards saltier water in Little Bay toward the east was observed.

Dissolved Oxygen

The range of average dissolved oxygen values for all sites spanned from 4.1 to 7.5 mg/L (Table 6). The average dissolved oxygen value at five sites was above the average water quality standard of 4.0 mg/L and below the standard at one site (80135) (Figure 7). However, there were discreet measurements at five of the six sites that fell below the average water quality standard at varying times throughout the period of record of this report. The minimum water quality standard of 3.0 was observed to extend to or below that value at three sites (80176, 80135, and 80175) (Figure 7).

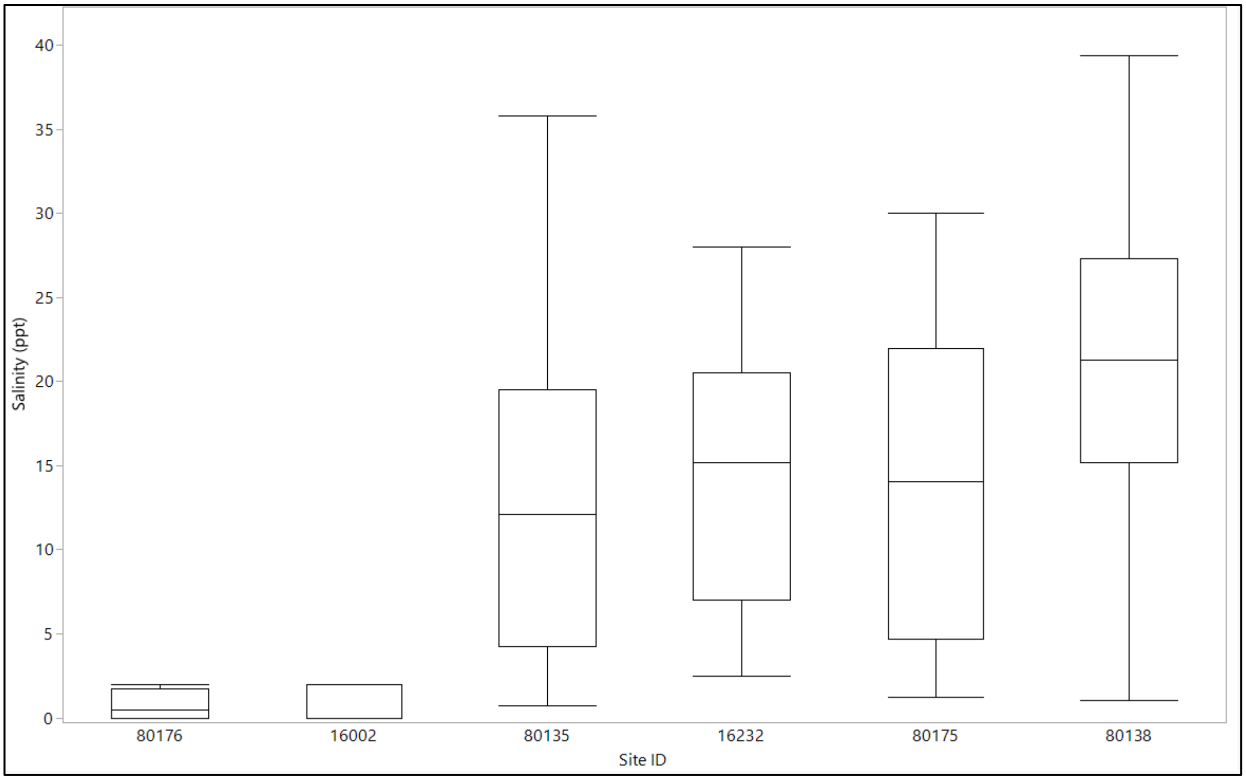

Figure 6. Salinity (ppt) for Texas Stream Team sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas. (Oct 1997 to Mar 2023).

pH

Average pH values at all sites are within the range of the water quality standards (6.5 to 9.0 s.u.) (Table 6). The average range of values at all sites was between 7.7 and 8.8 s.u. Three sites (80135, 16232, and 80175) had discreet values at or slightly above the upper limit of the pH water quality standard (Figure 8).

Transparency and Total Depth

Secchi disks and transparency tubes were used to measure transparency at the sites monitored in Little Bay and Tule Creek (Table 6). The average transparency values measured with a Secchi disk reported at all sites ranged from 0.3 to 0.9 m, while the average transparency tube values ranged from 0.4 to 0.5 m (Table 6). More variability in the Secchi disk measurements was observed than the measurements collected with a transparency tube (Figure 9).

Total depth was measured at all sites monitored (Table 6). The average range of depths from all six sites was from 1.4 m at Melcher Dock (site 80138) to 0.3 m at the Tule Creek wetland on SH35 (site 16002).

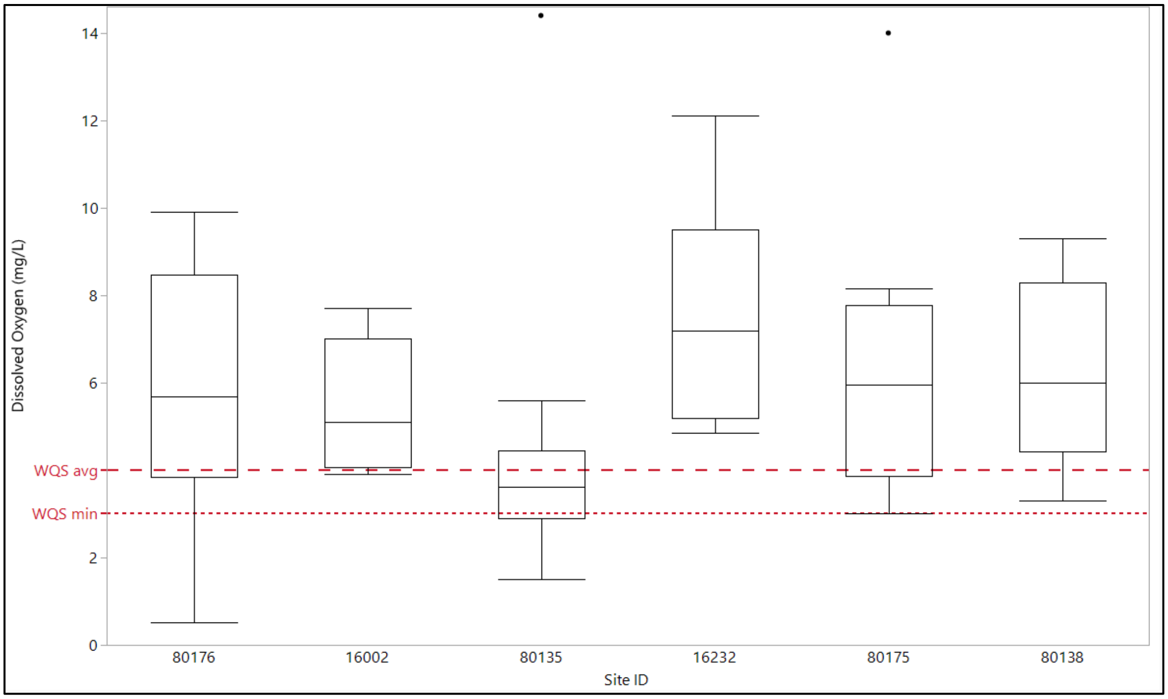

Figure 7. Dissolved oxygen in water for Texas Stream Team sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas. (Oct 1997 to Mar 2023). WQS avg= average water quality standard; WQS min = minimum water quality standard.

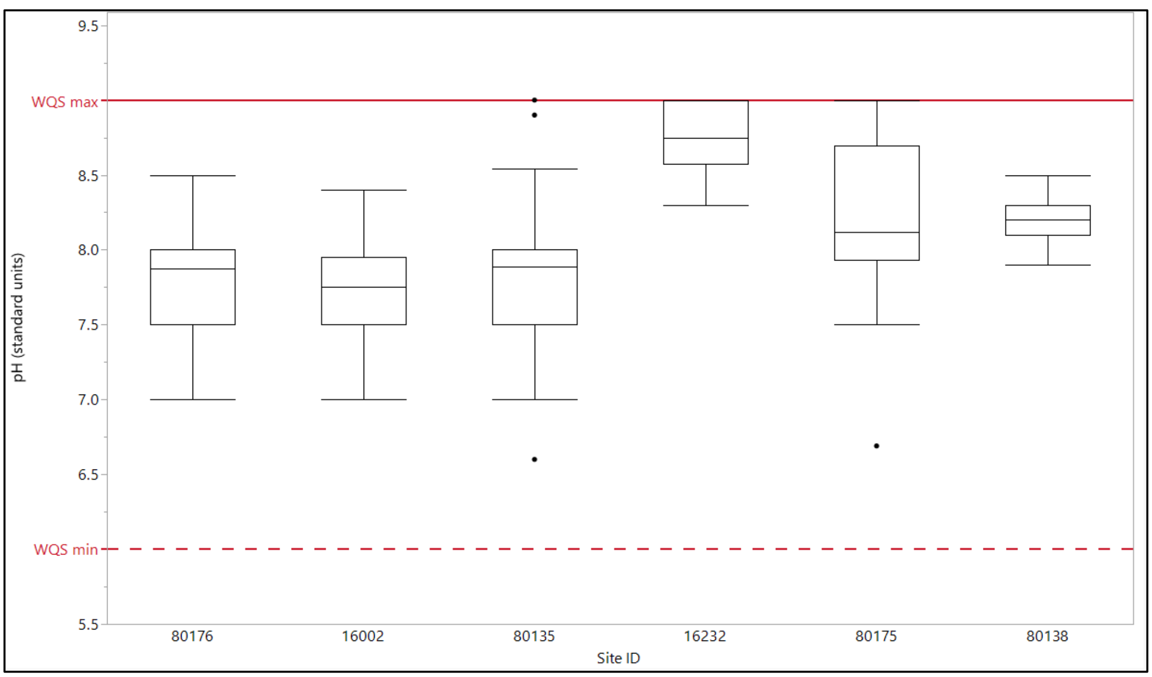

Figure 8. pH (s.u.) for Texas Stream Team sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas. (Oct 1997 to Mar 2023). WQS max= maximum pH water quality standard; WQS min = minimum pH water quality standard.

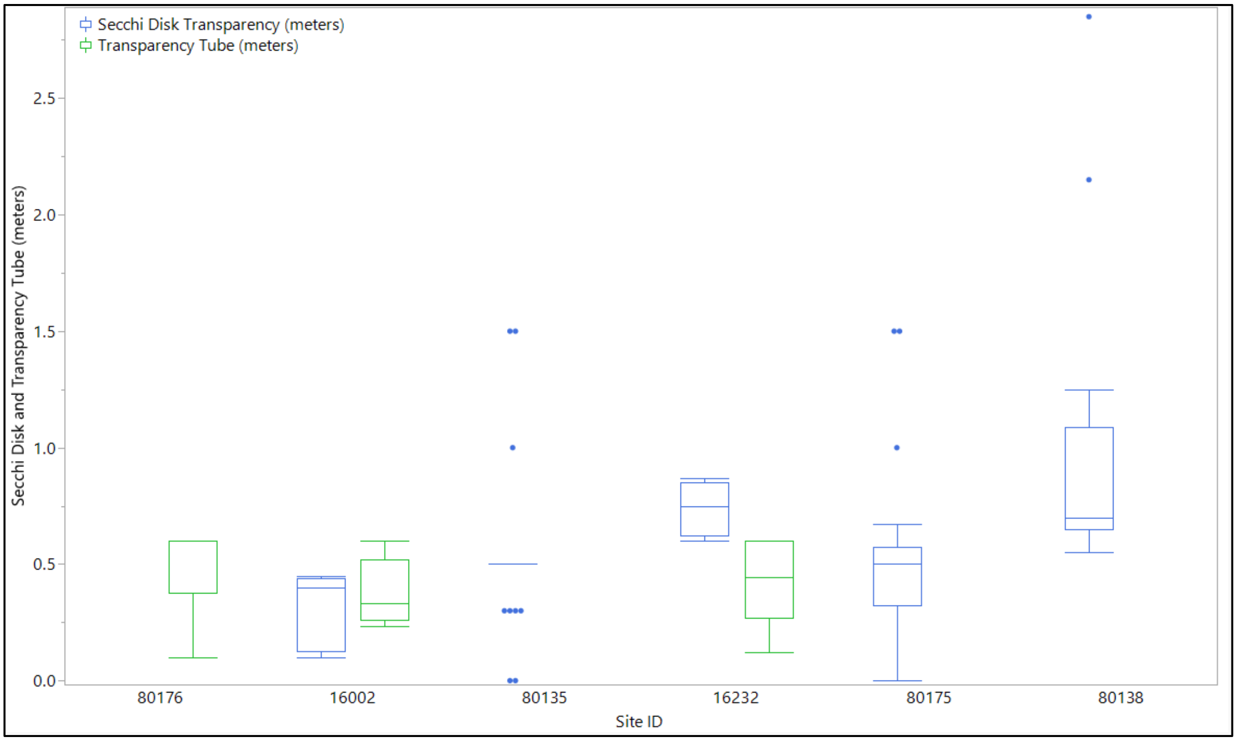

Figure 9. Secchi disk and transparency tube measurements for Texas Stream Team sites in Little Bay and Tule Creek in Rockport, Aransas County, Texas. (Oct 1997 to Mar 2023).

WATERSHED SUMMARY

Texas Stream Team community scientists monitored standard core parameters at 10 sites in Little Bay and Tule Creek in Rockport, Texas, from October 1997 to March 2023. Of the 10 sites monitored, six sites had 10 or more monitoring events and were included in this data summary report. Of the six sites included in the report, two are on Tule Creek while the remaining four sites are on Little Bay. Little Bay is an unclassified segment and Tule Creek is not recognized as either classified or unclassified but serves to convey wastewater and stormwater from Rockport to Little Bay. Collectively the six sites included in this summary report were monitored for the Texas Stream Team by trained community scientists.

Parameters monitored by Texas Stream Team community scientists included water and air temperature, specific conductance, total dissolved solids, salinity, dissolved oxygen, pH, transparency, and total depth. No advanced nutrient or bacteria parameters were monitored as part of this effort. Available data from the six monitoring sites were analyzed and summarized in this report.

The 2022 Integrated Report (IR) identified a bacteria impairment for the oyster water use in Copano Bay (Segment 2472). Although Company Bay is adjacent to the project area included in this report, no bacteria data was collected by the community scientists monitoring water quality, and Copano Bay was not in the scope of this report. No impairments were identified in the IR for Little Bay or Tule Creek.

The water quality standard associated with the uses in Little Bay were applied to the results of this analysis to evaluate overall water quality. Discreet water temperature measurements from two sites, one on Tule Creek (site 16002) and one on Little Bay (site 16232), did not meet the water quality standard (35°C) during the period of record for this report. A salinity gradient from freshwater in Tule Creek in the west towards saltier water in Little Bay towards the east was observed. The warmer and saltier water becomes, the less oxygen it is capable of absorbing therefore lower concentrations are measured.

The range of average dissolved oxygen values for all sites in Tule Creek and Little Bay spanned from 4.1 to 7.5 mg/L. The average dissolved oxygen value at the site located at the confluence of Tule Creek and Little Bay (site 80135) did not meet the average water quality standard of 4.0 mg/L. In addition, there were discreet measurements at five of the six sites that fell below the average water quality standard at varying times throughout the period of record of this report. Three of those sites (80176, 80135, and 80175) also had values at or below the minimum water quality standard of 3.0 mg/L at some point during the period of record. Although Little Bay is not listed as impaired for dissolved oxygen, the system is showing signs of concern based on these results. With the growing human population and increased development in the Rockport area, these findings should be of concern to residents and decision-makers alike.

The Texas Stream Team community scientists monitoring standard core water quality parameters in Tule Creek and Little Bay are encouraged to continue monitoring. Continuation of the ongoing monitoring is crucial due to the results presented here and the potential for increased development in Rockport and the surrounding area. Continued water quality monitoring is important for the development of long-term data sets that describe current water quality conditions and for historical and future trends to capture changes in water quality as the area grows. Texas Stream Team will continue to support community scientists by providing technical support, creating new monitoring sites, and re-activating existing sites. We look forward to training new community scientists to expand, grow, and sustain the water quality monitoring efforts in this area and beyond. For more information about Texas Stream Team and upcoming trainings contact us at TxStreamTeam@txstate.edu or visit the calendar of events on our website at www.TexasStreamTeam.org.

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Appendix A.

Table 7. Endangered species located within the Little Bay Rockport Watershed.

Species Type	Common Name	Federal/State Listing
Birds	Northern aplomado falcon	Federally Listed as Endangered, State Listed as Endangered
	Whooping crane	Federally Listed as Endangered, State Listed as Endangered
Mammals	Sperm whale	Federally Listed as Endangered, State Listed as Endangered
	Sei whale	Federally Listed as Endangered, State Listed as Endangered
	Blue whale	Federally Listed as Endangered, State Listed as Endangered
	Gulf of Mexico Bryde's whale	Federally Listed as Endangered, State Listed as Endangered
	Humpback whale	Federally Listed as Endangered
	North Atlantic right whale	Federally Listed as Endangered, State Listed as Endangered
	Ocelot	Federally Listed as Endangered, State Listed as Endangered
Reptiles	Atlantic hawksbill sea turtle	Federally Listed as Endangered, State Listed as Endangered
	Kemp's Ridley sea turtle	Federally Listed as Endangered, State Listed as Endangered
	Leatherback sea turtle	Federally Listed as Endangered, State Listed as Endangered

Table 8. Threatened species located within the Little Bay Rockport Watershed.

Species Type	Common Name	Federal/State Listing
Amphibian	Black-spotted newt	State Listed as Threatened
Birds	Sheep frog	State Listed as Threatened
	Reddish egret	State Listed as Threatened
	White-faced ibis	State Listed as Threatened
	Wood stork	State Listed as Threatened
	Swallow-tailed kite	State Listed as Threatened
	White-tailed hawk	State Listed as Threatened
	Black rail	Federally Listed as Threatened, State Listed as Threatened
	Piping plover	Federally Listed as Threatened, State Listed as Threatened
	Rufa red knot	Federally Listed as Threatened, State Listed as Threatened
Fish	Shortfin mako shark	State Listed as Threatened
	Oceanic whitetip shark	Federally Listed as Threatened, State Listed as Threatened
Mammals	White-nosed coati	State Listed as Threatened
	West Indian manatee	Federally Listed as Threatened, State Listed as Threatened
Reptiles	Loggerhead sea turtle	Federally Listed as Threatened, State Listed as Threatened
	Green sea turtle	Federally Listed as Threatened, State Listed as Threatened
	Texas tortoise	State Listed as Threatened
	Texas horned lizard	State Listed as Threatened
	Texas scarlet snake	State Listed as Threatened

Table 9. State and federally listed species in the Little Bay Rockport Watershed in Aransas County, Texas.

Taxon	**Endangered (Federal or State)**	**Threatened (Federal or State)**	**G1 or G2 (Critically imperiled or imperiled)**	**Species of Greatest Conservation Need (NPWD) (S1 or S2)**	**Endemic Total Count**
Amphibians	0	2	0	0	2
Birds	2	8	1	11	22
Fish	0	2	0	3	5
Mammals	7	2	3	9	21
Reptiles	3	5	3	6	17
Insects	0	0	1	1	2
Mollusks	0	0	1	1	2
Plants	0	0	6	7	13
Total Count	**12**	**19**	**15**	**38**	**84**