Determination of Important Chemical and Nutrient Trends Along an Estuarine Salinity Gradient

Stephanie G. Peart, Jessica A. Baez, Emily A. Peraria, Laura E. Versaggi, and Dr. Gordan Grguric

ABSTRACT

Estuarine waters contain strong chemical gradients [1] due to the characteristic mixing of freshwater and seawater. The salinity gradient is one of the main features of any estuarine ecosystem [2], and can be used to determine the gradients of other chemical and nutrient concentrations that are important for biological activity.

In this study, 16 water samples were collected using a Van Dorn bottle at eight different stations in Great Bay, New Jersey. The station locations varied from Mullica River to the mouth of Great Bay, and were taken at the top of flood tide. The 8 stations were selected based on salinity (ranging 8-31 PSU) as determined in situ using a Sontek CastAway-CD. Water samples were collected both at the surface and near the bottom at each location. Each water sample was analyzed for dissolved ion concentrations using established methodologies.

As the salinity in the samples increased, chlorinity, total alkalinity (T.A.), pH, and dissolved sulfate (SO_4) also increased. A linear relationship for Chlorinity, T.A., and SO_4 was observed with R^2 values of 0.9651, 0.9026, and 0.9404, respectively. While an acceptable linear fit for pH ($R^2 = 0.8207$) was calculated, a second order polynomial fit deemed a better fit ($R^2 = 0.9129$). Dissolved phosphate did not show any clear trend based on salinity. Dissolved silica (SiO_2) concentrations decreased linearly as salinity increased ($R^2 = 0.9595$).
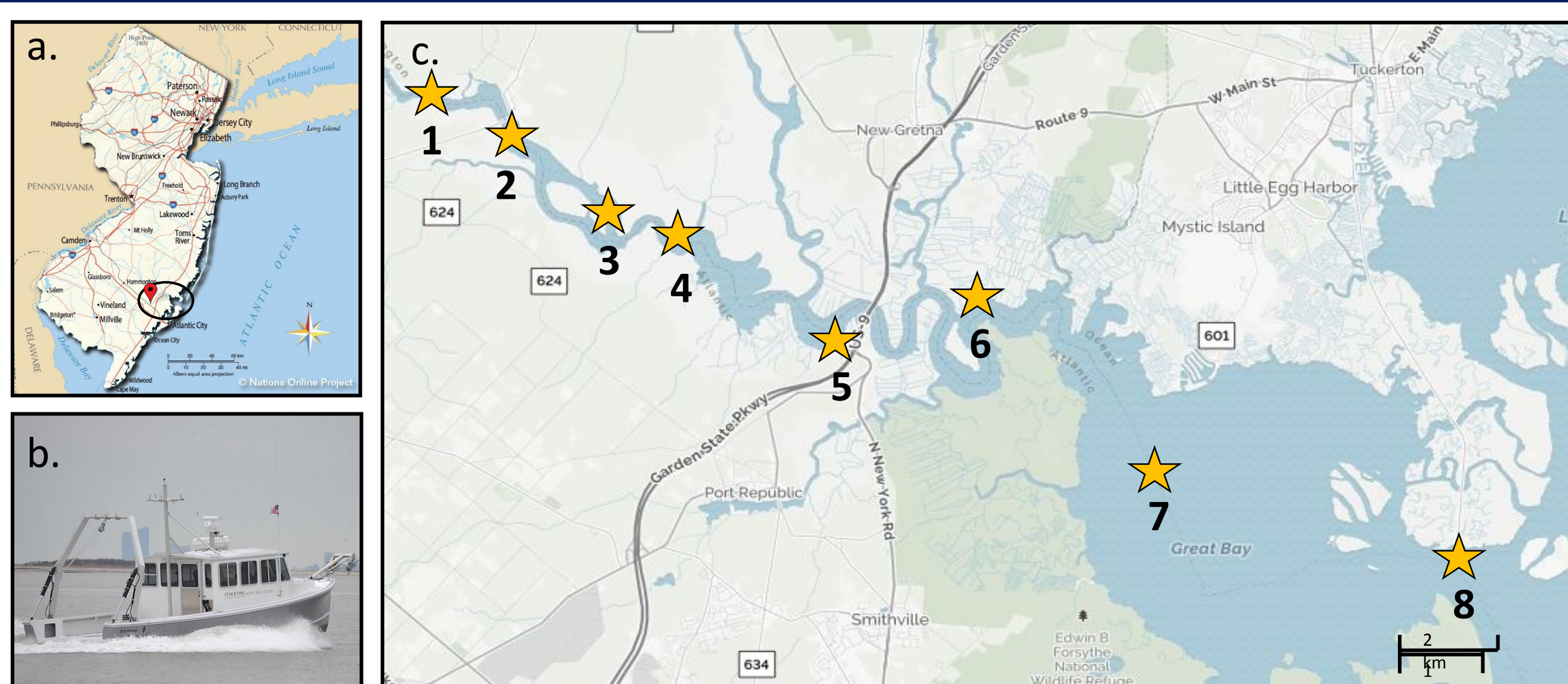
METHODS

Fig. 1 a.) Map of the State of New Jersey with study area indicated. **b.)** Stockton University's R/V Petrel [3]. **c.)** Map of southern New Jersey's Mullica River-Great Bay Estuary [4]. Numbered stars indicate stations where water samples were collected.

Water Sample Collection and In situ Parameters

Water samples were collected by means of a Van Dorn bottle both at the surface and at location's deepest depth at the 8 following locations for a total of 16 samples. GPS and depth were collected by means of R/V Petrel navigation system.

1. **Lower Bank**
   - max depth: **2.74 m**
   - 39°35'42.48 N 74°32'95.72 W

2. **Landing Creek**
   - max depth: **3.96 m**
   - 39°34'86.13 N 74°32'57.03 W

3. **Hog Island**
   - max depth: **6.71 m**
   - 39°34'22.82 N 74°31'27.09 W

4. **Irving's Point**
   - max depth: **6.71 m**
   - 39°34'14.93 N 74°30'32.41 W

5. **Chestnut Neck Hole**
   - max depth: **15.24 m**
   - 39°33'08.63 N 74°27'62.89 W

6. **Akimbo Point**
   - max depth: **12.19 m**
   - 39°33'24.96 N 74°26'00.70 W

7. **Mid-Great Bay**
   - max depth: **2.44 m**
   - 39°31'9.43 N 74°23'18.62 W

8. **Little Egg Inlet**
   - max depth: **15.24 m**
   - 39°30'16.87 N 74°18'65.10 W

Chemical Parameters Analysis

- Dissolved SiO_2 in aqueous solution was measured by the heteropoly blue method [5].
- Dissolved SO_4 was measured by turbidimetric barium chloride method [6].
- Dissolved phosphate was measured by ascorbic acid method [7].
- Chlorinity was measured by a standard Mohr/Knudsen titration with $AgNO_3$, using a automatic RAININ titrator [8].
- T.A. and pH were measured using Orion pH meter. T.A. was computed using the method given in Strickland and Parsons [9].
- Salinity and other field data (temperature etc.) using the Sontek CastAway-CD (US Patent #8272262) system [10].
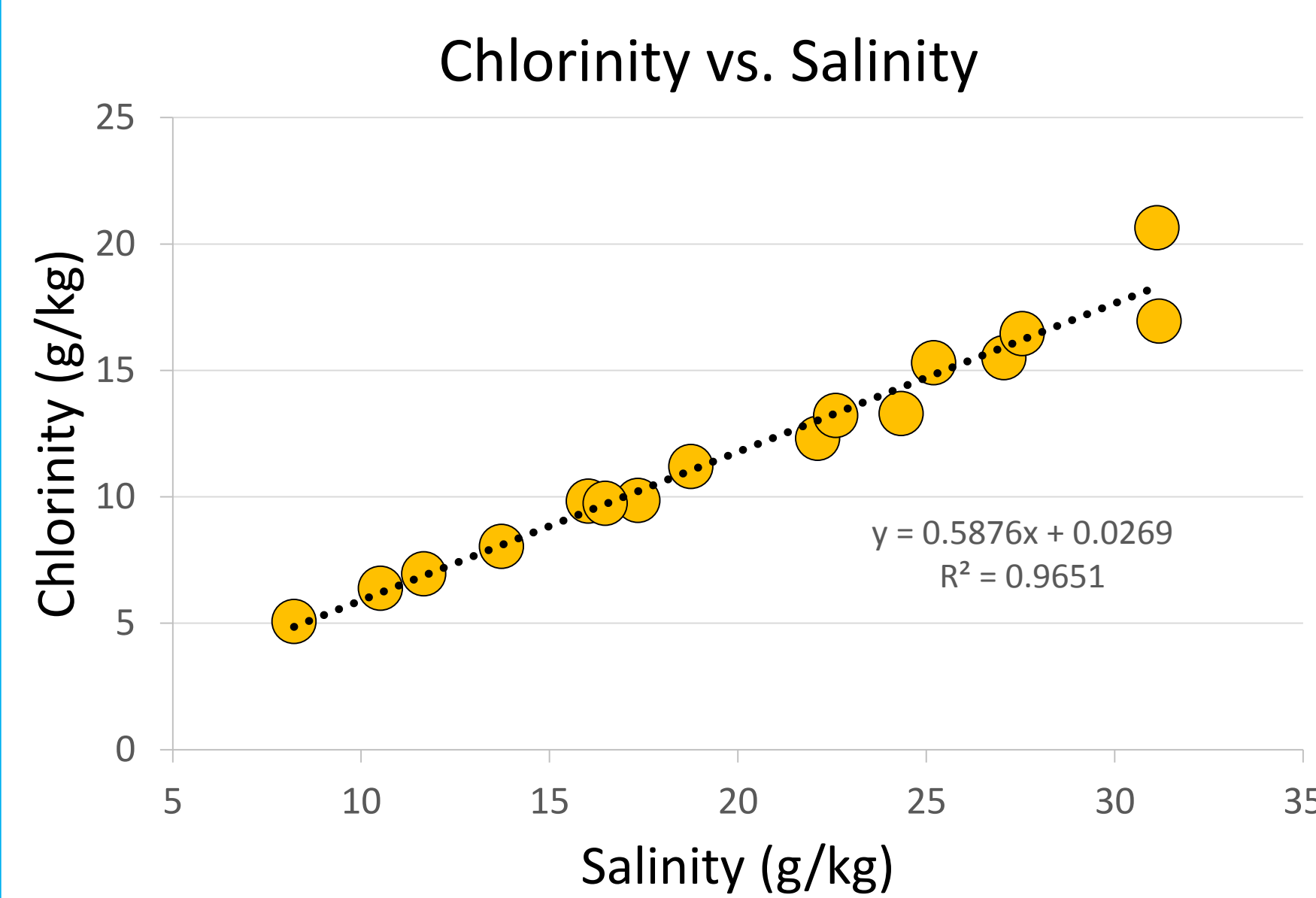
RESULTS

Chlorinity

Fig. 2 Plot showing chlorinity versus salinity in the estuary.

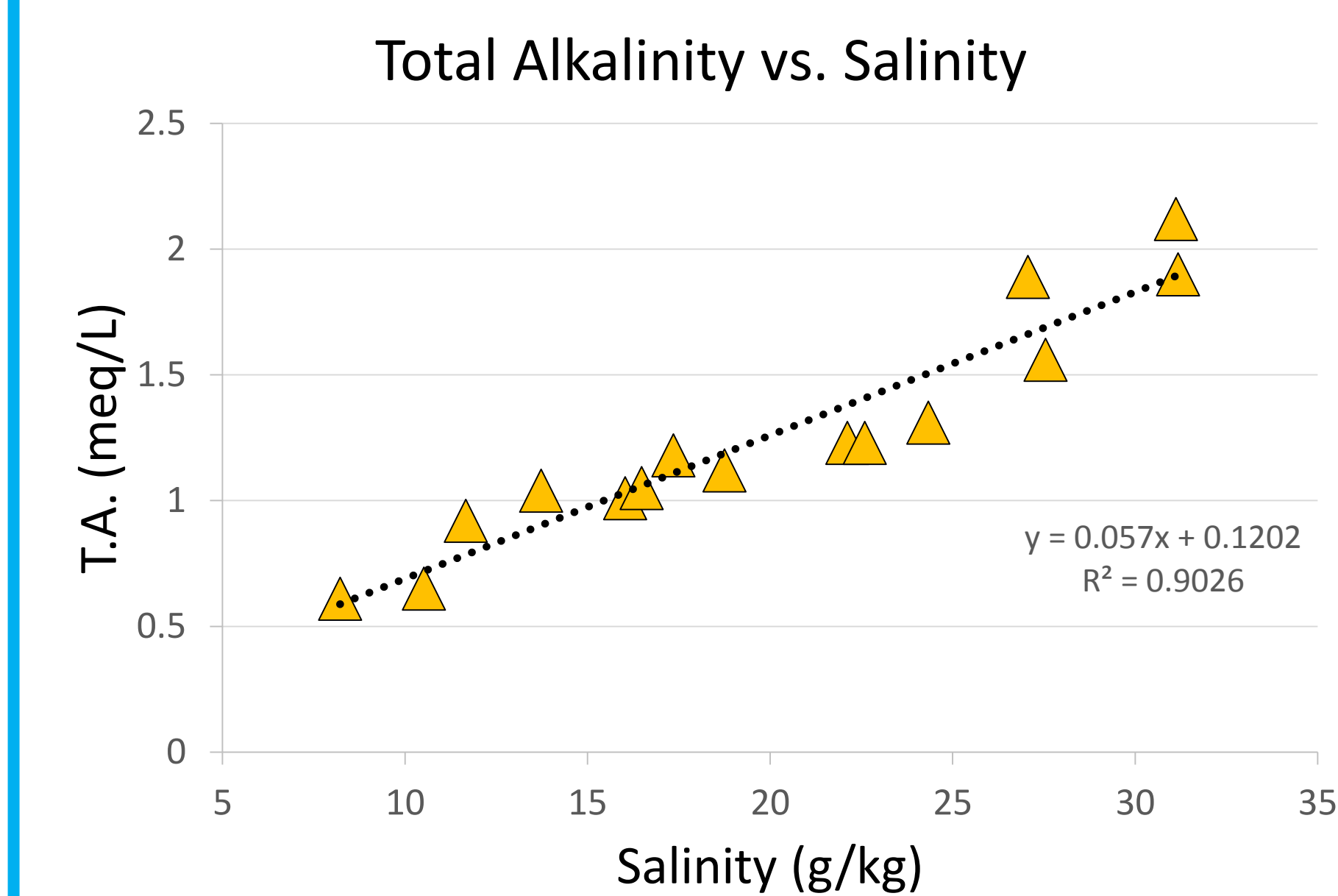### Total Alkalinity (T.A.)

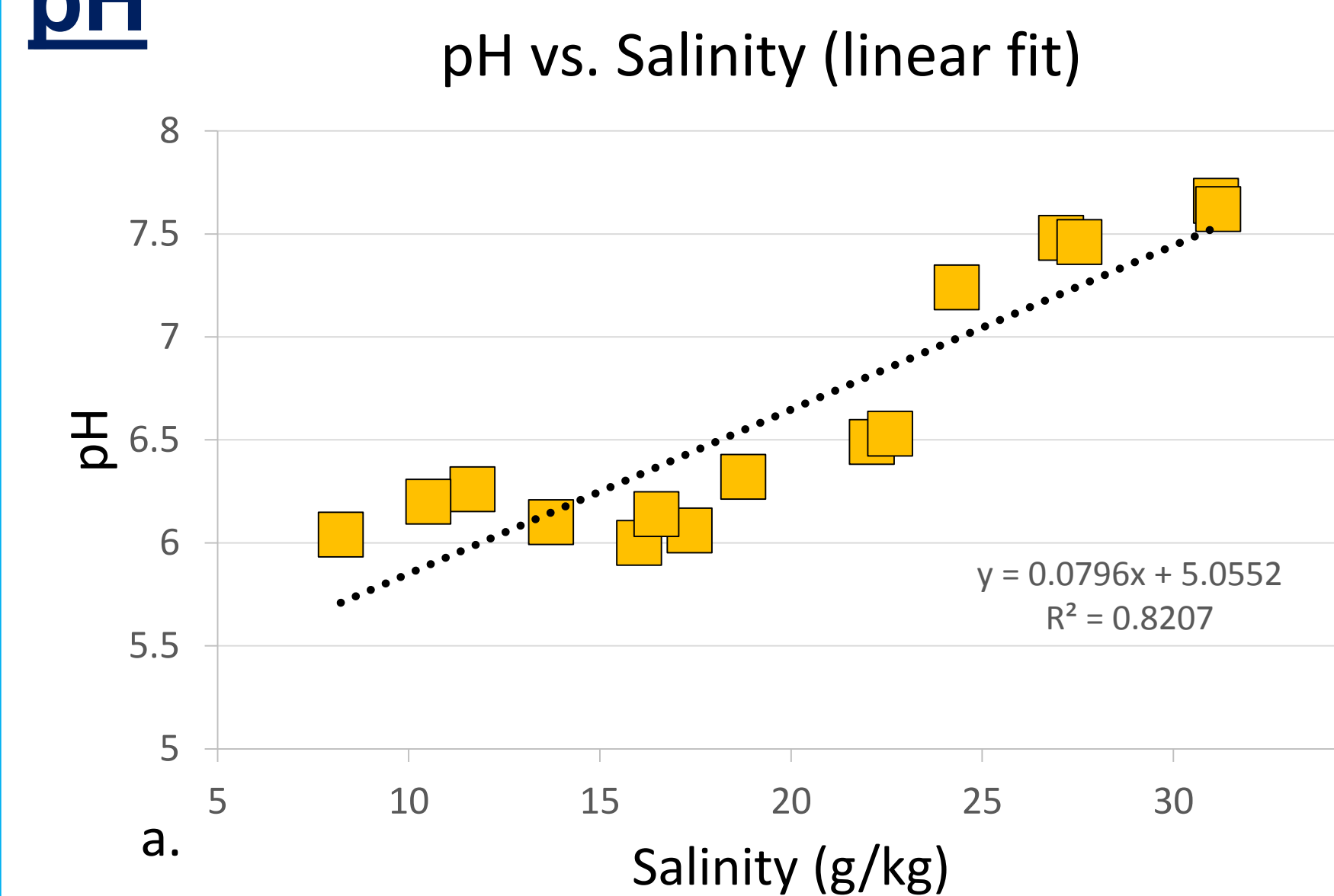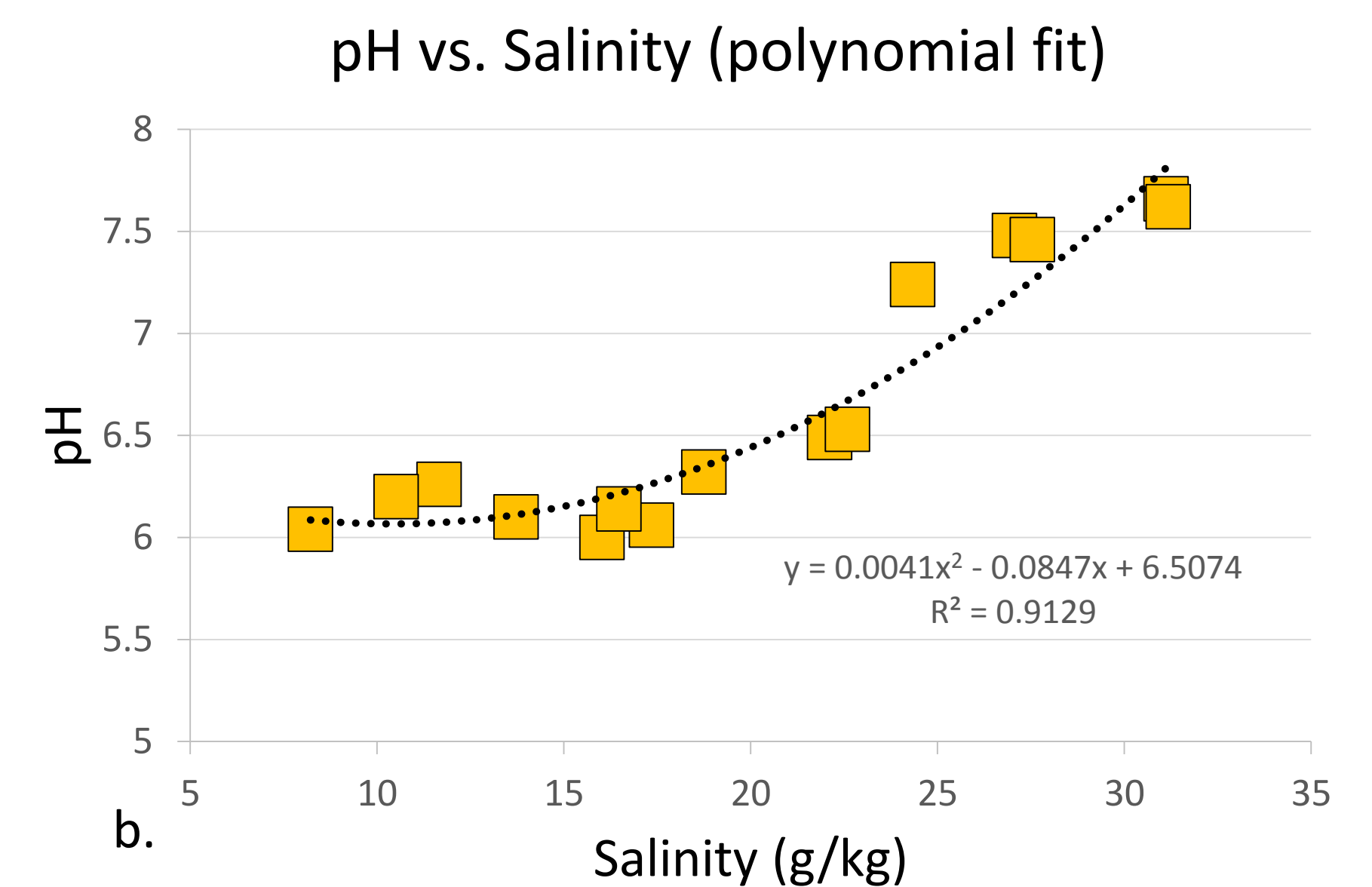**Fig. 3** Plot showing total alkalinity (T.A.) versus salinity in the estuary.

pH

Fig. 4 a.) Plot showing pH versus salinity in the estuary with a linear fit line. **b.)** Plot showing pH versus salinity with a second order polynomial fit line.
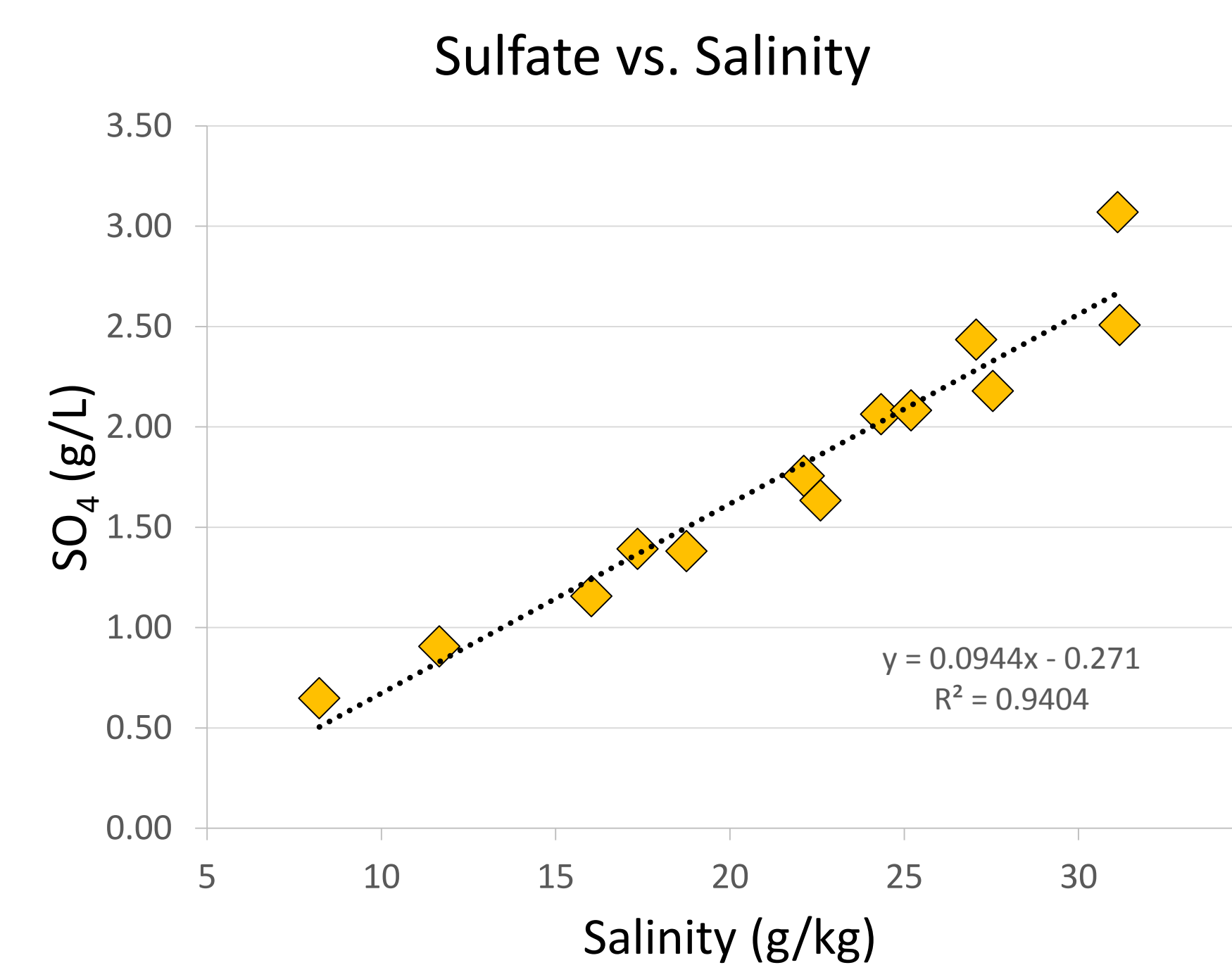
Sulfate (SO₄)

Fig. 5 Plot showing sulfate versus salinity in the estuary.
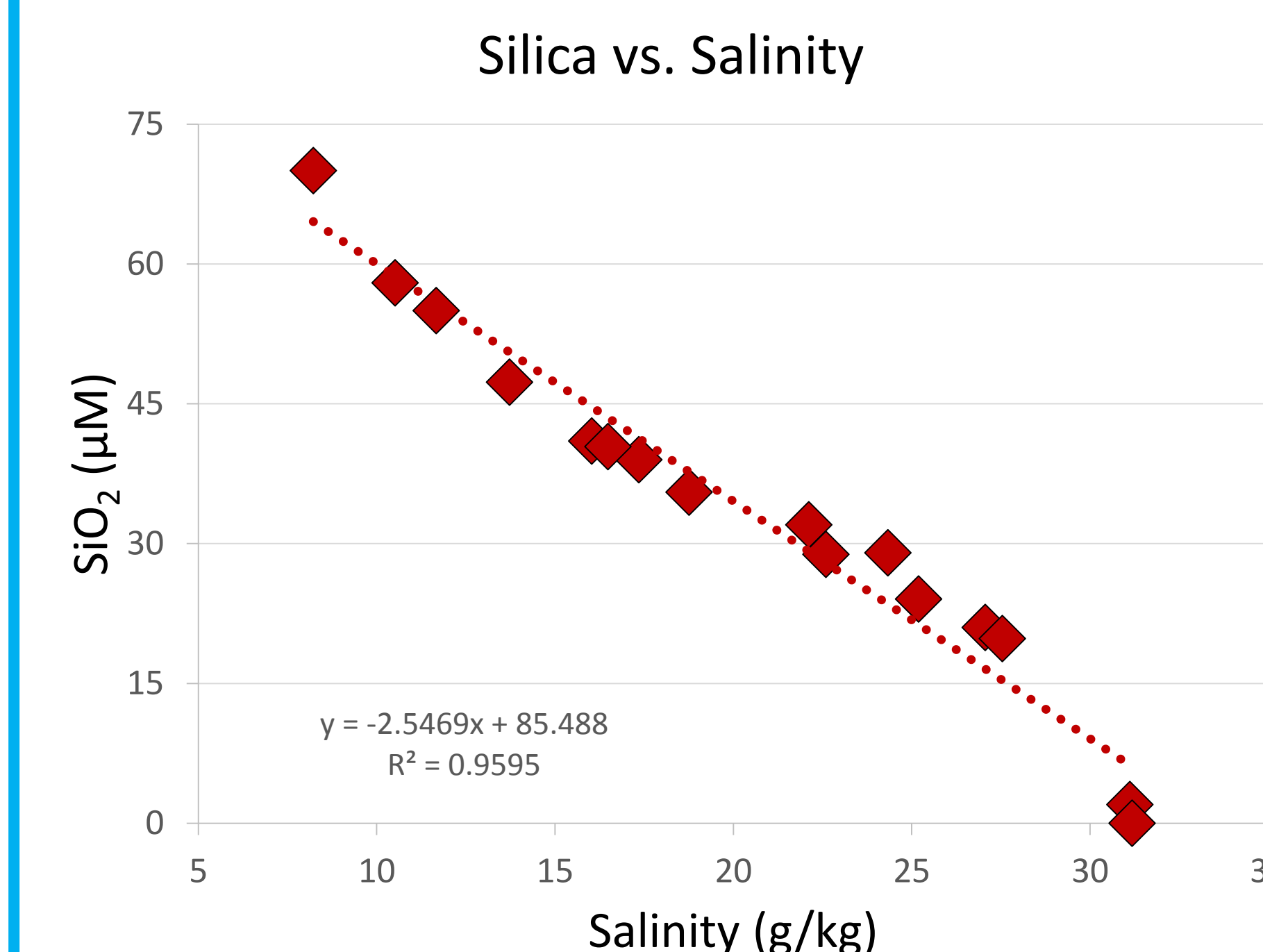
Silica (SiO₂)

Fig. 6 Plot showing silica versus salinity in the estuary.

DISCUSSION

Great Bay is an estuary that receives its freshwater input from the Mullica River and seawater from the Atlantic Ocean. The characteristic mixing of freshwater and seawater generates a saltwater gradient as seen by salinities at our 8 stations (ranging 8-31 PSU) sampled. This range is common amongst similar estuaries.

Chloride ion is one of the major dissolved constituents found in seawater with an empirical relationship (established by the International Commission of Salinity) of salinity = 0.03 + 1.805 x Chlorinity. Therefore, as salinity increases (or decreases), chlorinities should also reflect this. Our chlorinity to salinity linear relationship shows indeed a very small intercept of 0.02, which is mainly the result of residual experimental error, and is very close to the reported residual value. As for the slope of the linear line fit, our value (inverted to read S/Cl) is 1.702. This is within 5.7% of the reported value (1.805). Similarly, sulfate (SO_4) is another major anion found in seawater, and as seen by the data, SO_4 also shows a linear relationship to salinity ($R^2 = 0.9404$).

Total Alkalinity (T.A.) of an aqueous solution is a measurement of the strength of its bases or their ability to neutralize an acid. T.A. is related to pH which is the measurement of the H^+ concentration. There are many natural and biological processes which impact the T.A. and pH, and as seen by the data, both T.A. ($R^2 = 0.9026$) and pH ($R^2 = 0.8207$) increase linearly with salinity. However, the relationship pH to salinity might be better explained with a second order polynomial trend line ($R^2 = 0.9129$).

Silica (SiO_2) is one of the exceptional chemical species insofar as its concentration in surface ocean water is lower than its river concentration. This is because rivers are one of the largest known sources of SiO_2 due to weathering and other geological processes. Many estuarine organisms (i.e. diatoms) rely on SiO_2 as an important nutrient and therefore are known to remove SiO_2 from the water column once it reaches the ocean. As seen in our data, SiO_2 concentrations (range 70 - 0 µM) decreased linearly as salinity increased ($R^2 = 0.9595$). This salinity versus SiO_2 trend is common to many East Coast estuaries. The intercept of our linear line fit shows that predicted SiO_2 in freshwater would be 85 µM. This value is similar to a number of other reported values on East Coast estuaries.

Generally speaking, most of the discovered trends follow those in other similar estuaries. Quantitative analysis of our data is, however, indispensable to determine the specific, numerical values of relevant parameters (e.g. slopes and intercepts) that give each estuary its individual characteristics.

References
(1) Crump, et al. (2004) doi: 10.1128/AEM.70.3.1494–1505
(2) Telesh, et al. (2010) doi:10.1016/j.marpolbul.2010.02.008
(3) www.facebook.com/stocktonfieldstation/photos
(4) www.mapquest.com
(5) Jungreis, Ervin (2000) Encyclopedia of Analytical Chemistry, John Wiley and Sons.
(6) www.epa.gov/sites/production/files/2015-12/documents/9038.pdf
(7) www.epa.gov/sites/production/files/2015-8/documents/method_365-3_1978.pdf
(8) Hong, et al. (2010) doi:10.1155/2010/602939.
(9) Strickland and Parsons (1972) A Practical Handbook of Seawater Analysis
(10) http://www.sontek.com/productsdetail.php?CastAway-CTD-11