MEMORANDUM

TO:	ROBERT SACKELLARES, GEORGIA-PACIFIC MIKE MARKEY, GULF POWER	DATE:	JUNE 23, 2010
		RE:	APALACHICOLA RIVER NUTRIENT LOADINGS
FROM:	ANDREW J. THUMAN, P.E.	FILE:	GPCO.035

INTRODUCTION

This memorandum summarizes the analyses performed to assist in the development of total nitrogen (TN) and total phosphorus (TP) loads for the Apalachicola River to support nutrient criteria development in Apalachicola Bay. While these analyses may not result in specific nutrient criteria values, it is the objective to present an approach and corresponding results that can be used for the development of final values. Existing TN, TP and flow data was analyzed and, considering flow to be an explanatory variable, long term nutrient loads were estimated. In addition, Apalachicola Bay water quality data were analyzed.

DATA USED

Available water quality and flow data were obtained from the following sources: USGS for flow and water quality; and Florida DEP (FDEP) STORET for water quality. The locations where river data were available are presented in Figure 1 with the stations at the Lake Seminole outlet (FDEP STORET at Hwy 90 and USGS gage #02358000) and Sumatra (USGS gage #02359170) containing the most data. These two stations (Lake Seminole and Sumatra) were used to complete the river loading analyses. The period of record for data at these stations is presented in Table 1.

Table 1. Data Station Information

Location/Source	Drainage Area (mi^2)	Data Type	Period of Record
Lake Seminole/FDEP	17,200	Nutrients	1998-2005
Lake Seminole/USGS	17,200	Nutrients Flow	1971-1995 1922-2009
Sumatra/USGS	19,200	Nutrients Flow	1979-2009 1977-2009

These data were used to develop concentration relationships to flow so that the daily flow record could be used to develop long term estimates of river concentrations and loads for TN and TP. Ultimately, annual geometric mean loads were developed to be used in developing protective loads to Apalachicola Bay.

LOADING ANALYSES

The data obtained are presented in Figures 2 and 3 for flow, TN and TP at Lake Seminole and Sumatra from 1975-2009 along with the proposed EPA instream protective values (IPV) for TN (0.824 mg/L) and TP (0.043 mg/L) as horizontal dashed lines. The flow data range from about 5,000-200,000 cfs; the TN data range from about 0.3-1.5 mg/L; and the TP data range from about 0.01-0.1 mg/L. These data were used to develop concentration relationships to flow using the data from 1990-2009 (Figure 4). This time period was chosen since pre-1990 TN data at Lake Seminole seemed higher and more variable than the post-1990 data. Although strong correlations between concentration and flow were not observed, generally increasing trends in concentration were observed with increasing flow. Log-log regressions were completed on the data and the resulting equations are presented in Table 2 and on Figure 4.

Table 2. Concentration-Flow Regression Equations

Location/Source	TN Equation	TP Equation
Lake Seminole	$0.244Q^{0.116}$	$0.0038Q^{0.223}$
Sumatra	$0.675Q^{0.005}$	$0.0008Q^{0.379}$

Figures 5 and 6 present the calculated daily loads based on the concentration-flow regression equations and the daily flows at Lake Seminole and Sumatra from 1975-2009. The solid blue horizontal lines in each panel represent annual geometric means of flow, TN load and TP load. In general, the calculated TN and TP loads compare well with the observed loads. The TN loads range from about 10,000-1,000,000 lb/d and the TP loads range from about 500-70,000 lb/d.

Since the concentration-flow relationships are not very strong (little variation with flow), much of the load variation to Apalachicola Bay is due to the hydrology of the river. In order to incorporate the hydrology (flow) variation into developing nutrient criteria or protective nutrient loads, probability distributions of TN and TP loads were developed. Figure 7 presents log probability distributions of calculated annual geometric means for TN and TP loads for the time period 1975-2009 at Lake Seminole and 1978-2009 at Sumatra. The data are log-normally distributed and lend themselves to selecting a protective nutrient load from the Apalachicola River to the bay.

The proposed EPA IPVs are based on annual geometric means that are not to be exceeded more than once in a three year period. In addition, the long term average of annual geometric means shall not be greater than the IPVs. Since the Apalachicola Bay system is considered to be in good ecological health, existing loads to the bay should be maintained until a more comprehensive study is completed to determine the true nutrient assimilative capacity of the bay. Given that existing loads should be maintained and that an annual geometric mean load should not be exceeded more than once in a three year period, it is desirable to select an upper percentile load from the probability distributions presented in Figure 7. For example, a one in three year exceedance would correlate to the 67th percentile on these distributions but this would only allow an assessment to be completed after a three year period is completed or based on a moving three year assessment period. Alternately, a never to exceed load (95th, 99th, or maximum) would allow the regulatory agencies to establish compliance with the criteria each year rather that waiting many years to establish a long term average and a specific number of years (e.g., three) to determine if there is more than one exceedance of the annual geometric mean. In addition, a never to exceed load would also allow the existing load variability due to the hydrology of the river to be accounted for in setting a protective nutrient load to the bay.

Table 3 presents a few of the statistical annual geometric mean loads from the probability distributions in order to provide examples of potential protective nutrient loads to the bay.

Table 3. Apalachicola River Statistical Nutrient Loads

	Lake Seminole	Sumatra
TN Load (lb/d)	67% - 81,633 95% - 116,509 99% - 130,085 Max – 130,112	67% - 93,582 95% - 116,971 99% - 118,274 Max - 118,301
TP Load (lb/d)	67% - 3,639 95% - 5,375 99% - 6,064 Max – 6,065	67% - 4,755 95% - 6,459 99% - 6,558 Max – 6,560

APALACHICOLA BAY DATA

Apalachicola Bay data was provided by FDEP from the Apalachicola National Estuarine Research Reserve (ANERR) from 2002-2008. The database contained data at 10 stations for the following parameters: chlorophyll-a (chl-a); dissolved inorganic nitrogen ($DIN=NH_4+NO_2+NO_3$); orthophosphate (PO_4); salinity; temperature; and dissolved oxygen (DO). Figure 8 presents a map of the ANERR station locations with surface and bottom data available at the East Bay station. All of the ANERR data is presented in Attachment 1 as time-series at each station. The annual average chl-a in the bay ranged from about 1.2-10.7 µg/L with an average of 4.8 µg/L (excluding the East Bay and River stations). The East Bay station was excluded because it is potentially impacted by local sources or restricted circulation and had an annual average chl-a of 11.3 µg/L with a range of 2.1-17.9 µg/L.

An analysis was completed to determine whether any relationships existed between bay annual average chl-a data, river flow and nutrient loads. Figure 9 presents the bay annual average chl-a data versus annual average flow, TN load and TP load for the years 2002-2008. The data do not suggest any strong relationships between the variables and almost no relationships if the 2005 data are excluded. The high flow year of 2005 exhibited very low chl-a levels throughout the bay system but a similar high flow year of 2003 had almost double the chl-a levels. The cause for this difference in chl-a levels between similar high flow years is not known but potential causes could be related to larger scale Gulf of Mexico impacts on chl-a levels in 2005 as opposed to 2003, or a number of relatively low flow years prior to 2003. Based on the weak relationships observed in the data, bay chl-a levels do not seem to be strongly influenced by river inputs and are probably more controlled by bay circulation and light levels as opposed to nutrient loading and freshwater flow.

SUMMARY

Apalachicola River nutrient loads were developed based on the USGS daily flow records and relationships between nutrient concentration and flow. These nutrient loads were determined to aid in determining a protective nutrient load to Apalachicola Bay given that the current ecological health of the bay is good. In addition, Apalachicola Bay water quality data was analyzed and it was determined that there was little relationship to annual average chl-a levels in the bay and river nutrient loads. The weak relationships observed suggest that bay chl-a levels are probably more controlled by bay circulation and light levels as opposed to nutrient loading and freshwater flow. One option for developing a protective nutrient load to the bay is to develop a never to exceed load (95^{th}, 99^{th}, or maximum). This would allow the regulatory agencies to establish compliance with the criteria each year rather that waiting many years to establish a long term average and a specific number of years (e.g., three) to determine if there is more than one exceedance of the annual geometric mean. In addition, a never to exceed load would also allow the existing load variability due to the hydrology of the river to be accounted for in setting a protective nutrient load to the bay.

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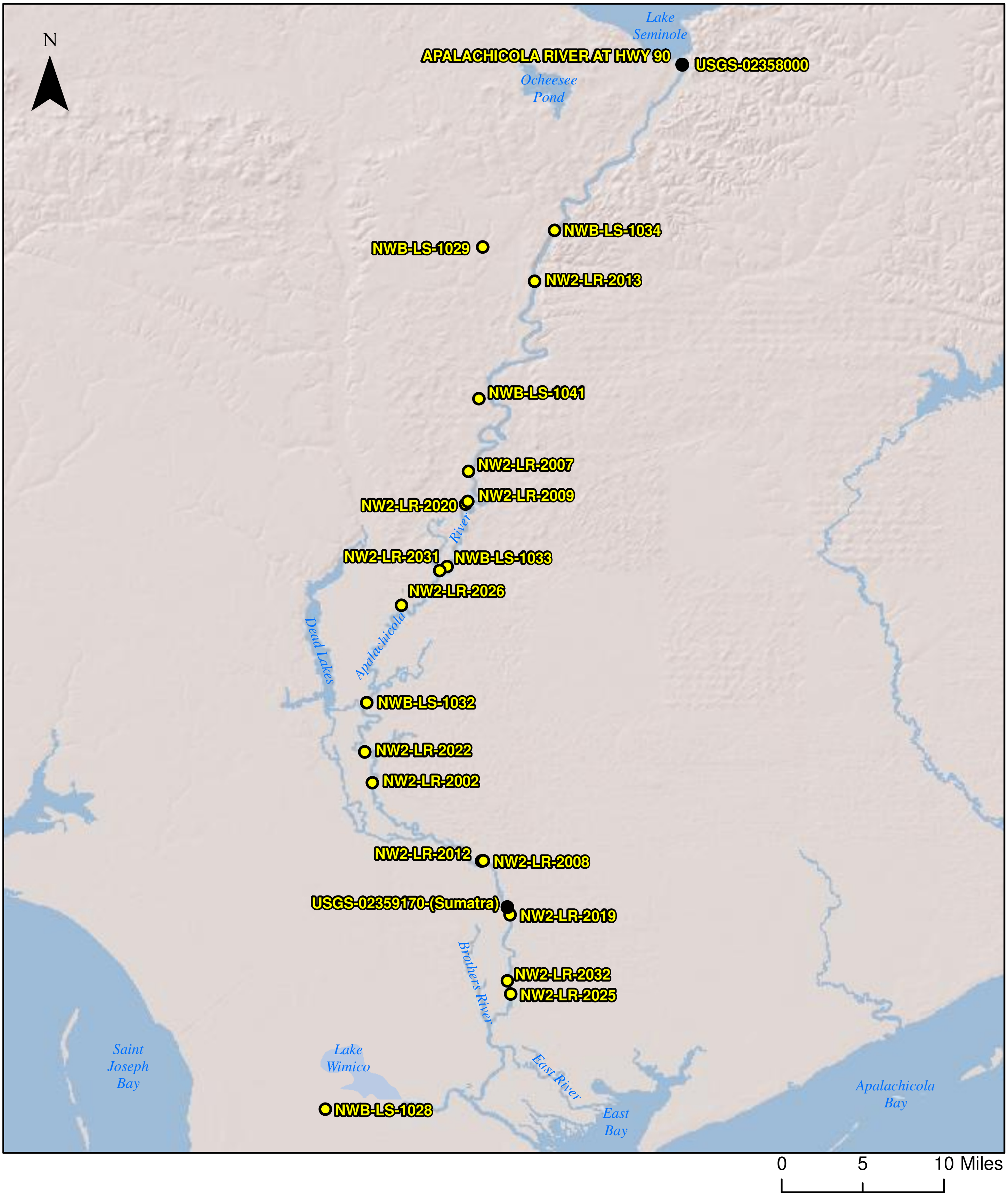

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Figure 1. Apalachicola River Station Locations

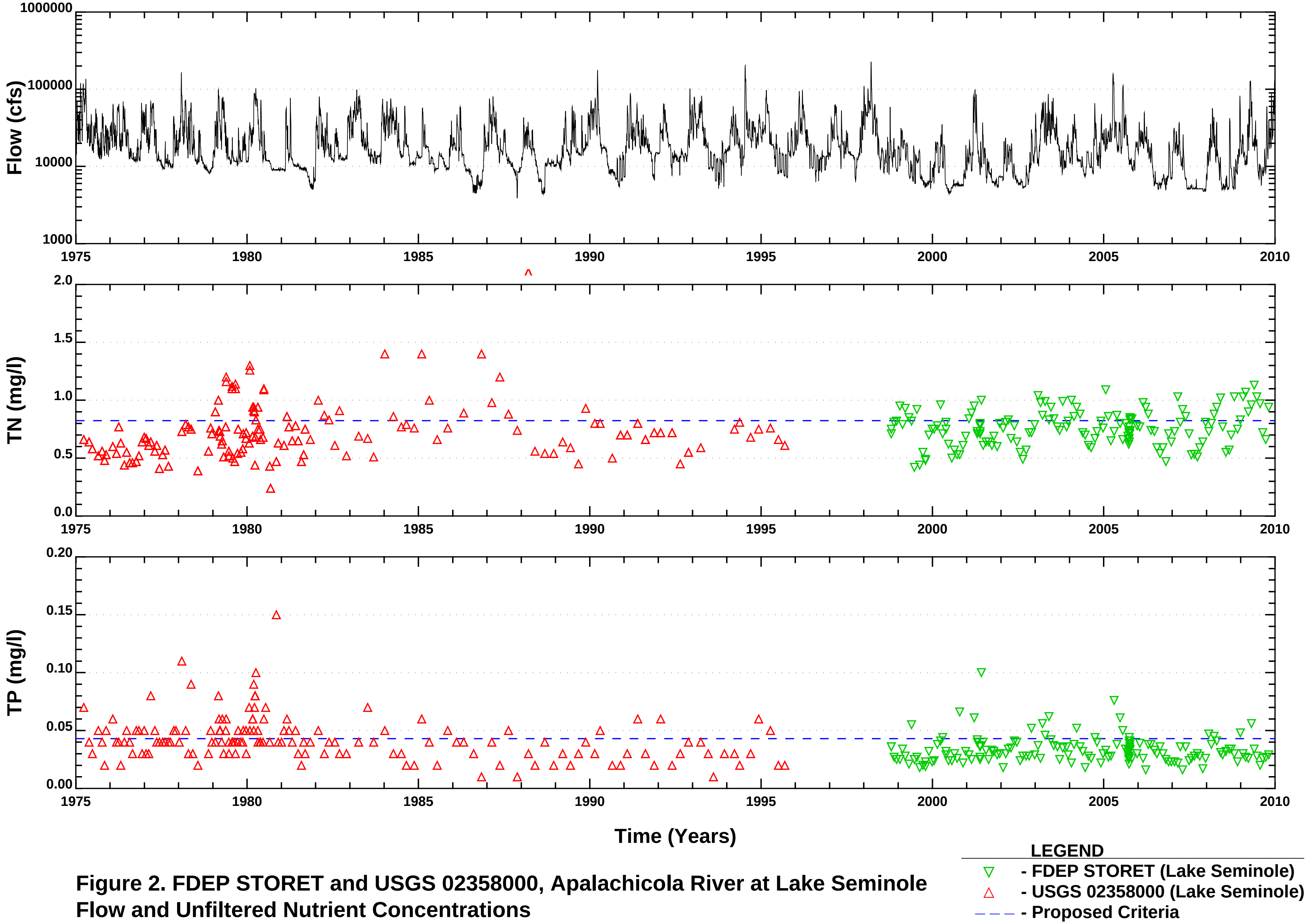


Figure 2. FDEP STORET and USGS 02358000, Apalachicola River at Lake Seminole Flow and Unfiltered Nutrient Concentrations

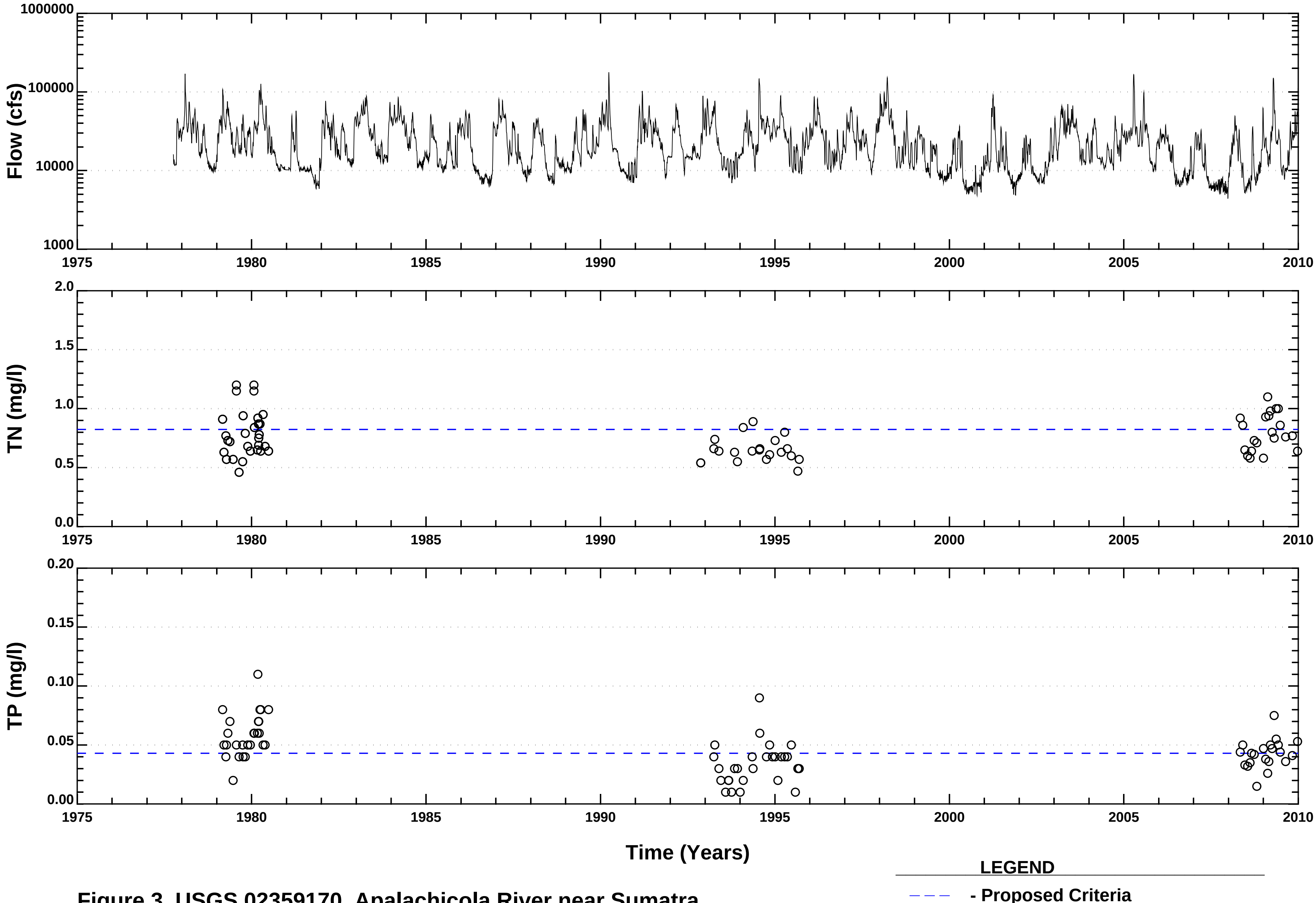


Figure 3. USGS 02359170, Apalachicola River near Sumatra Flow and Unfiltered Nutrient Concentrations

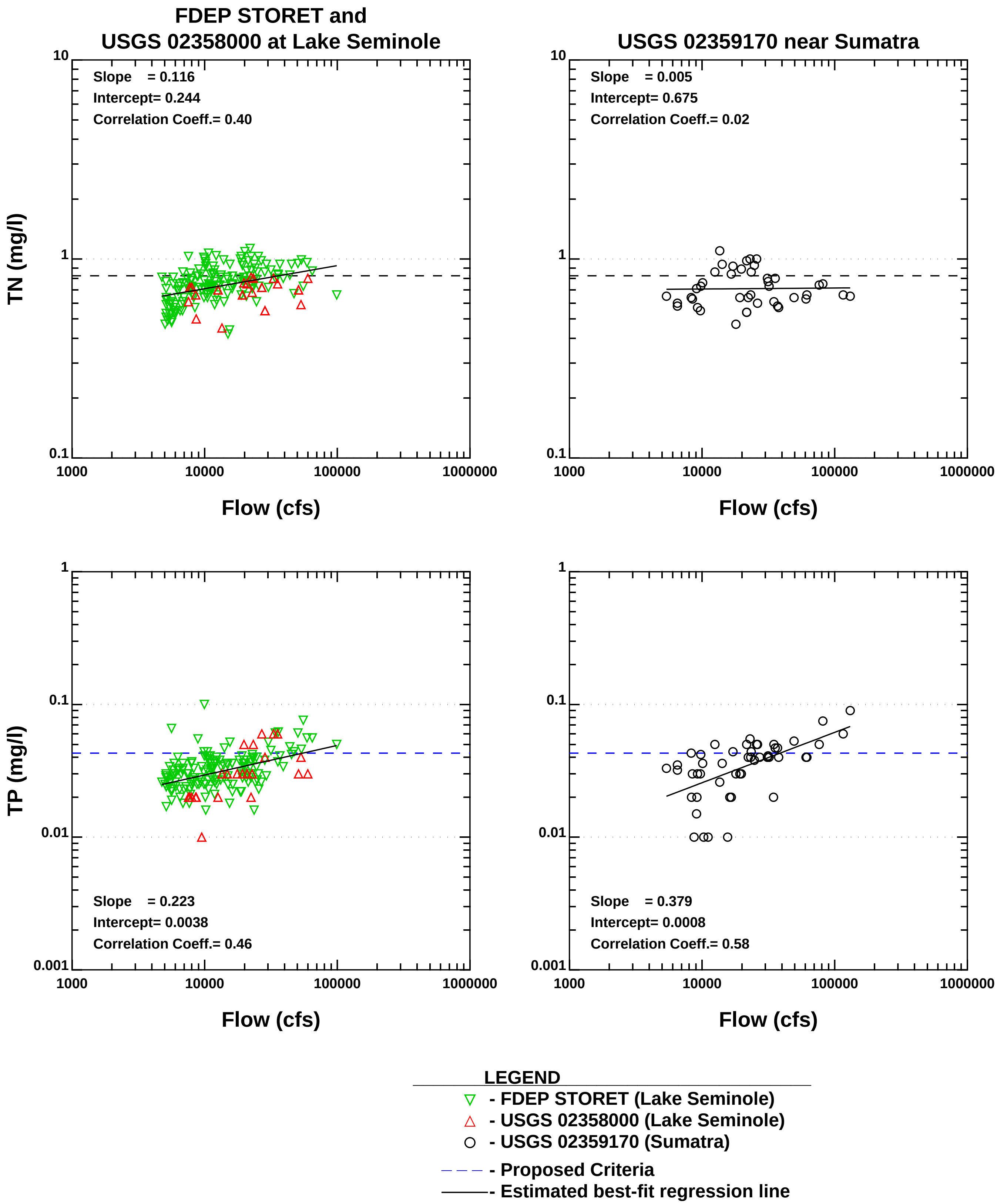


Figure 4. Apalachicola River at Lake Seminole and near Sumatra (Post 1990) Unfiltererd Nutrient Concentration vs Flow

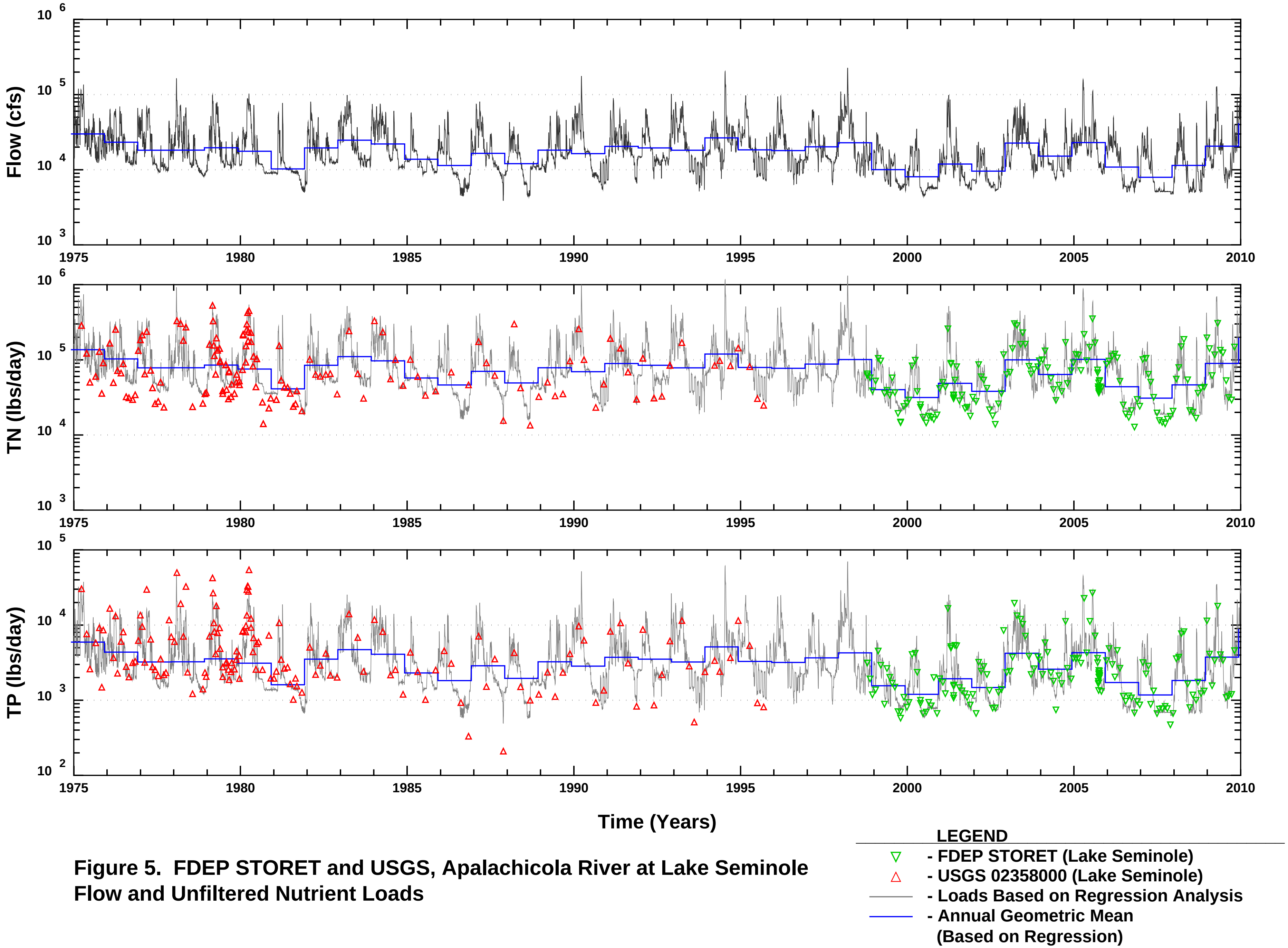


Figure 5. FDEP STORET and USGS, Apalachicola River at Lake Seminole Flow and Unfiltered Nutrient Loads

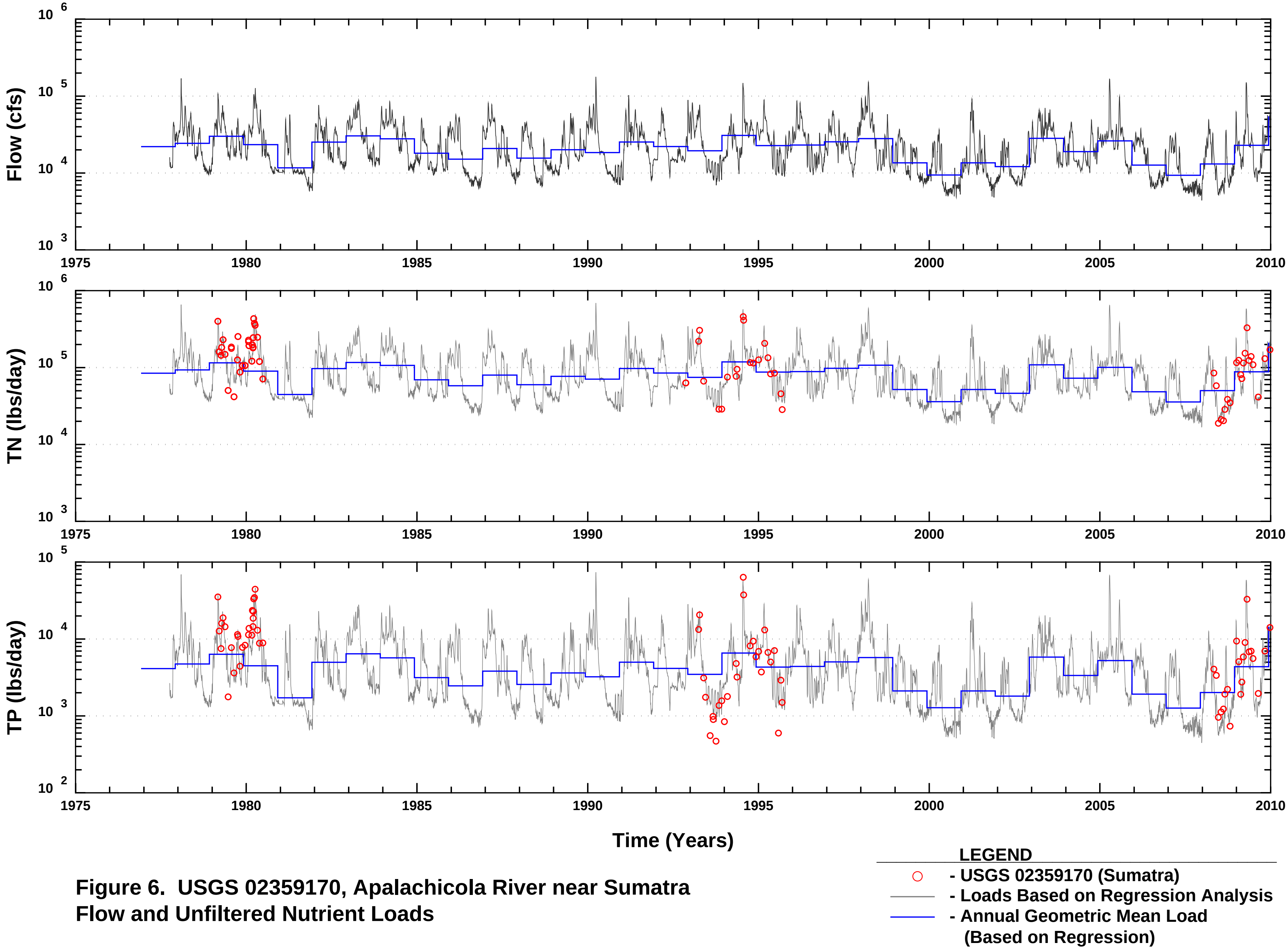


Figure 6. USGS 02359170, Apalachicola River near Sumatra Flow and Unfiltered Nutrient Loads

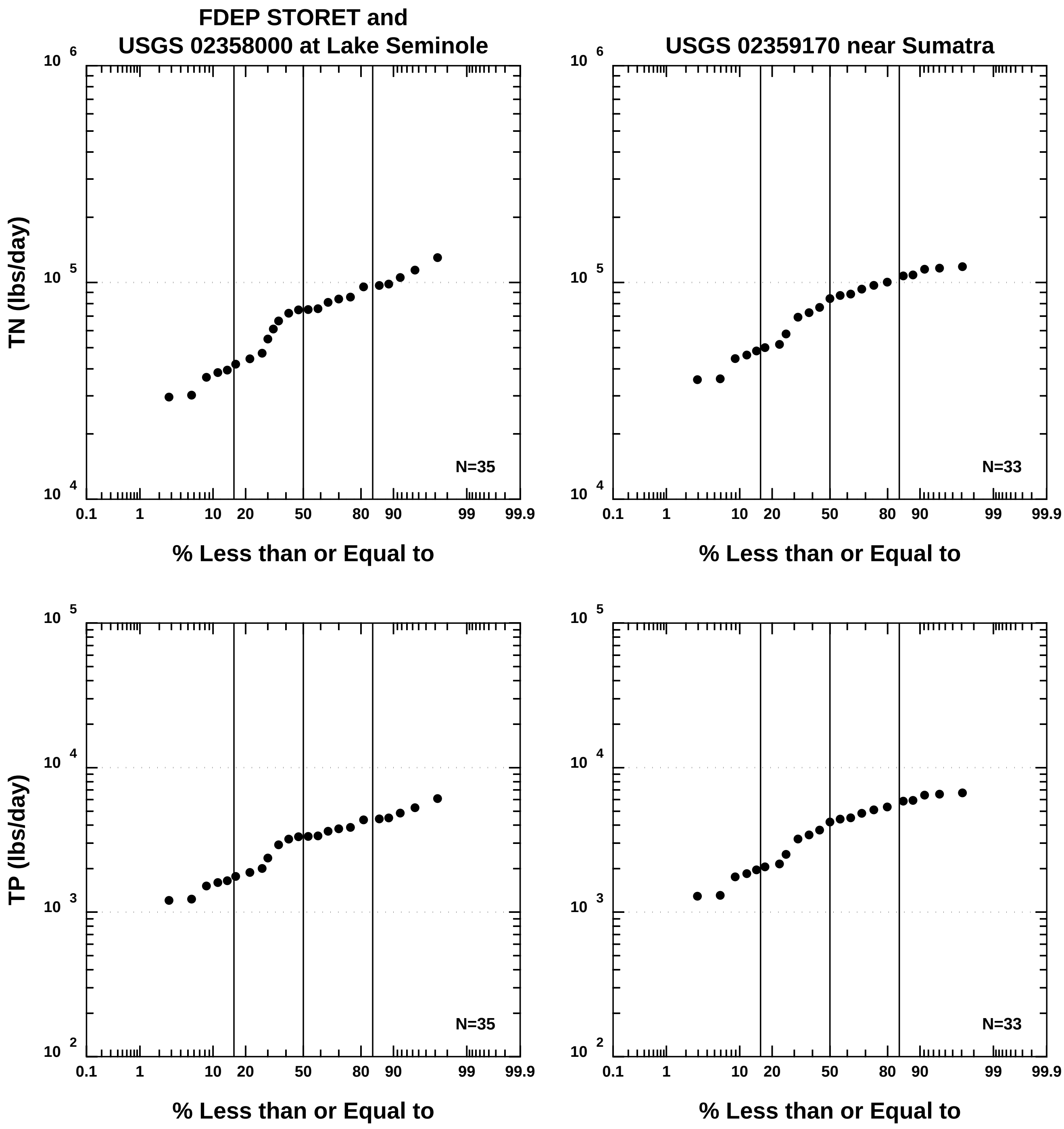


**Figure 7. Apalachicola River at Lake Seminole and near Sumatra
Probability of Annual Geometric Mean Estimated Unfiltered Nutrient Loads**

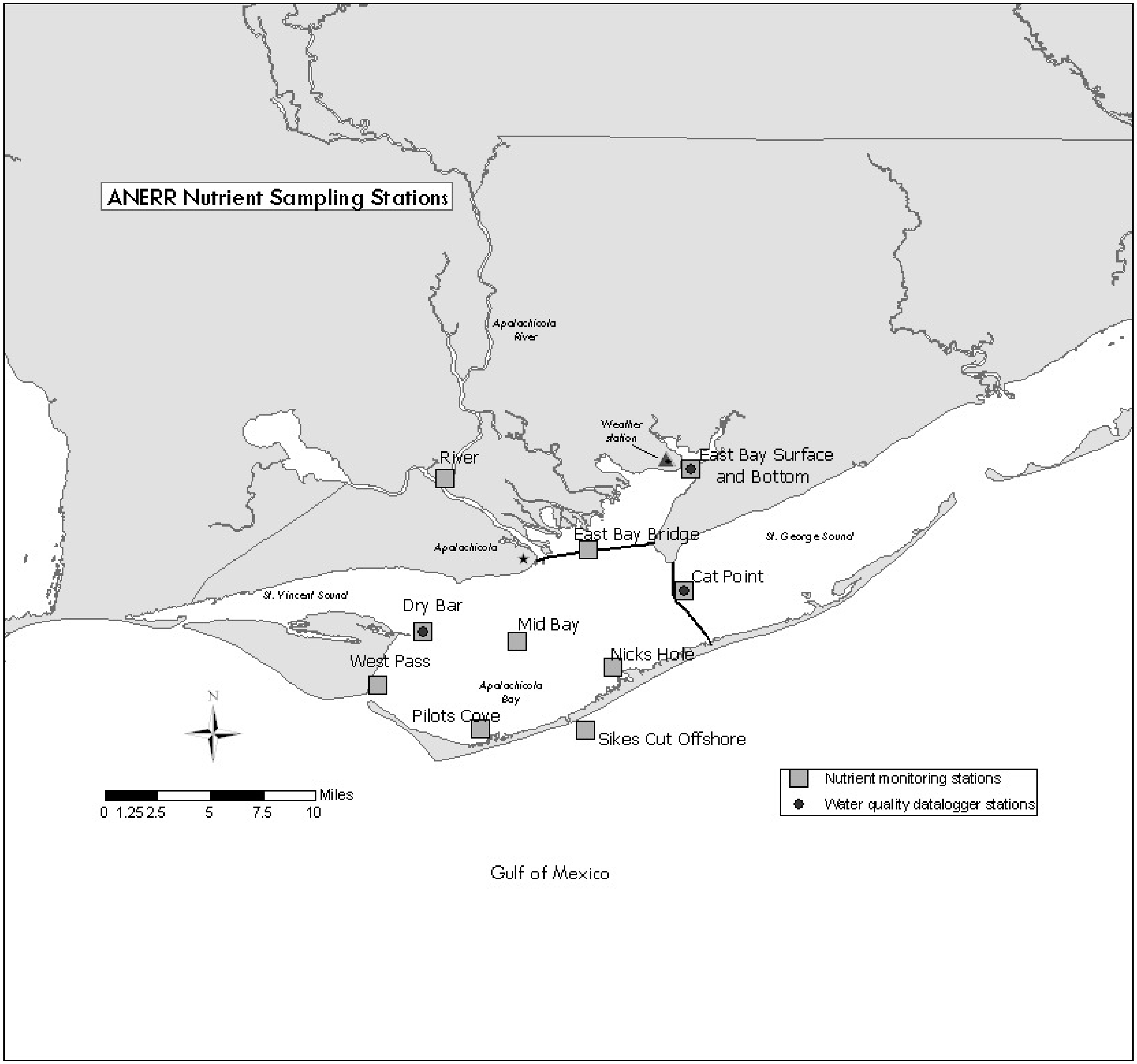


Figure 8. ANERR Monitoring Station Locations

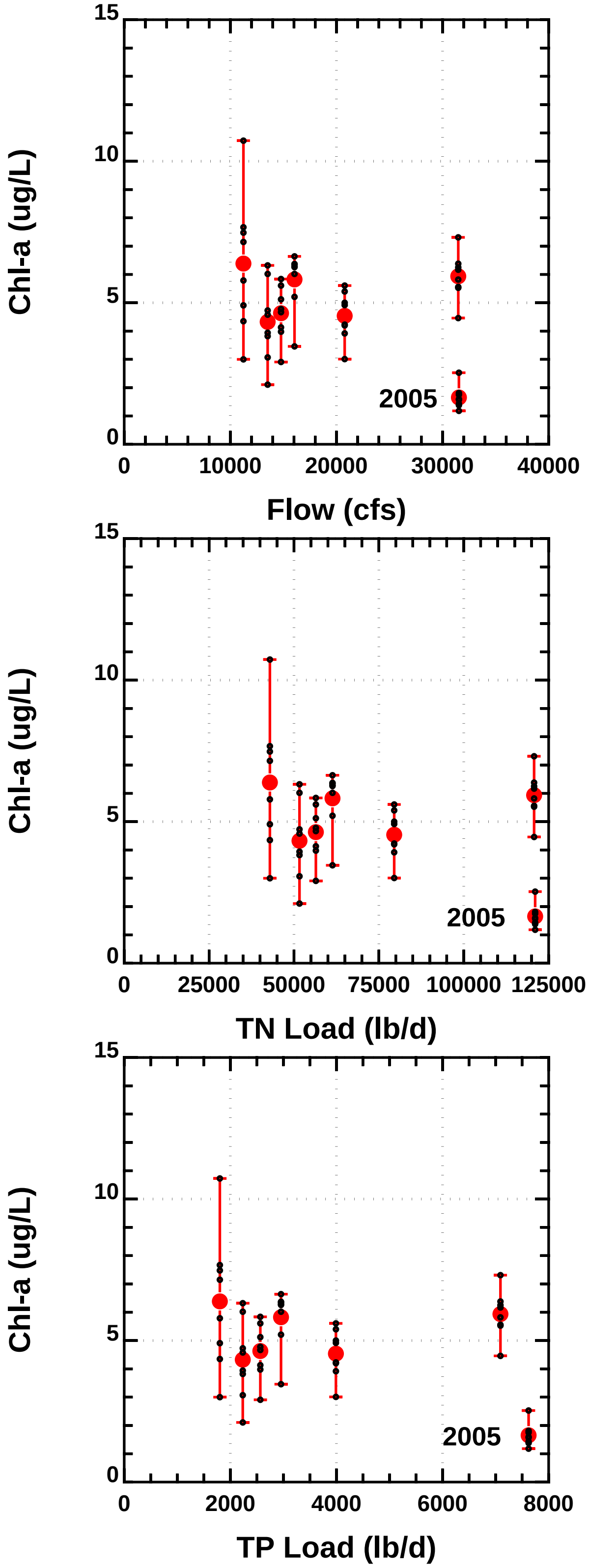
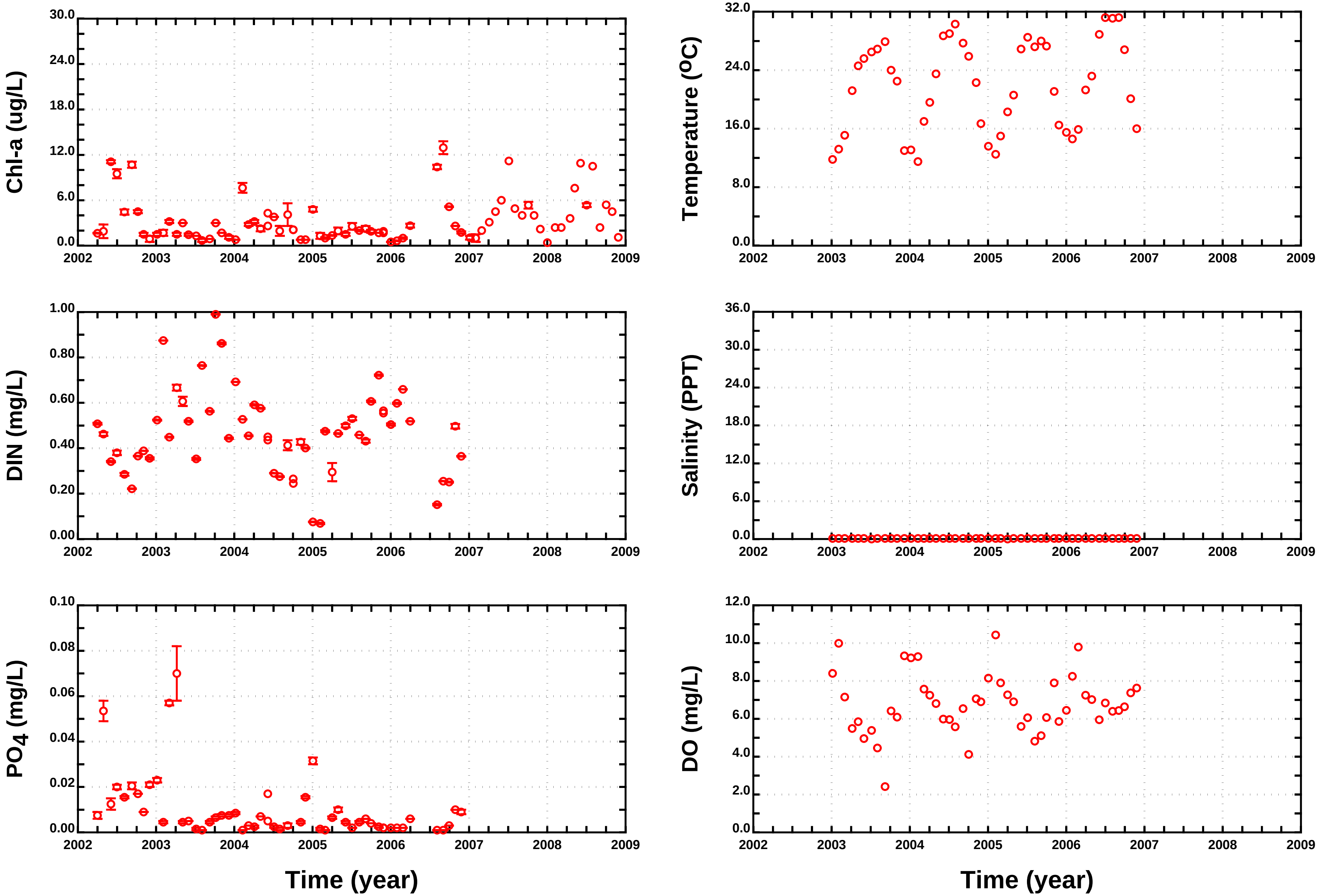


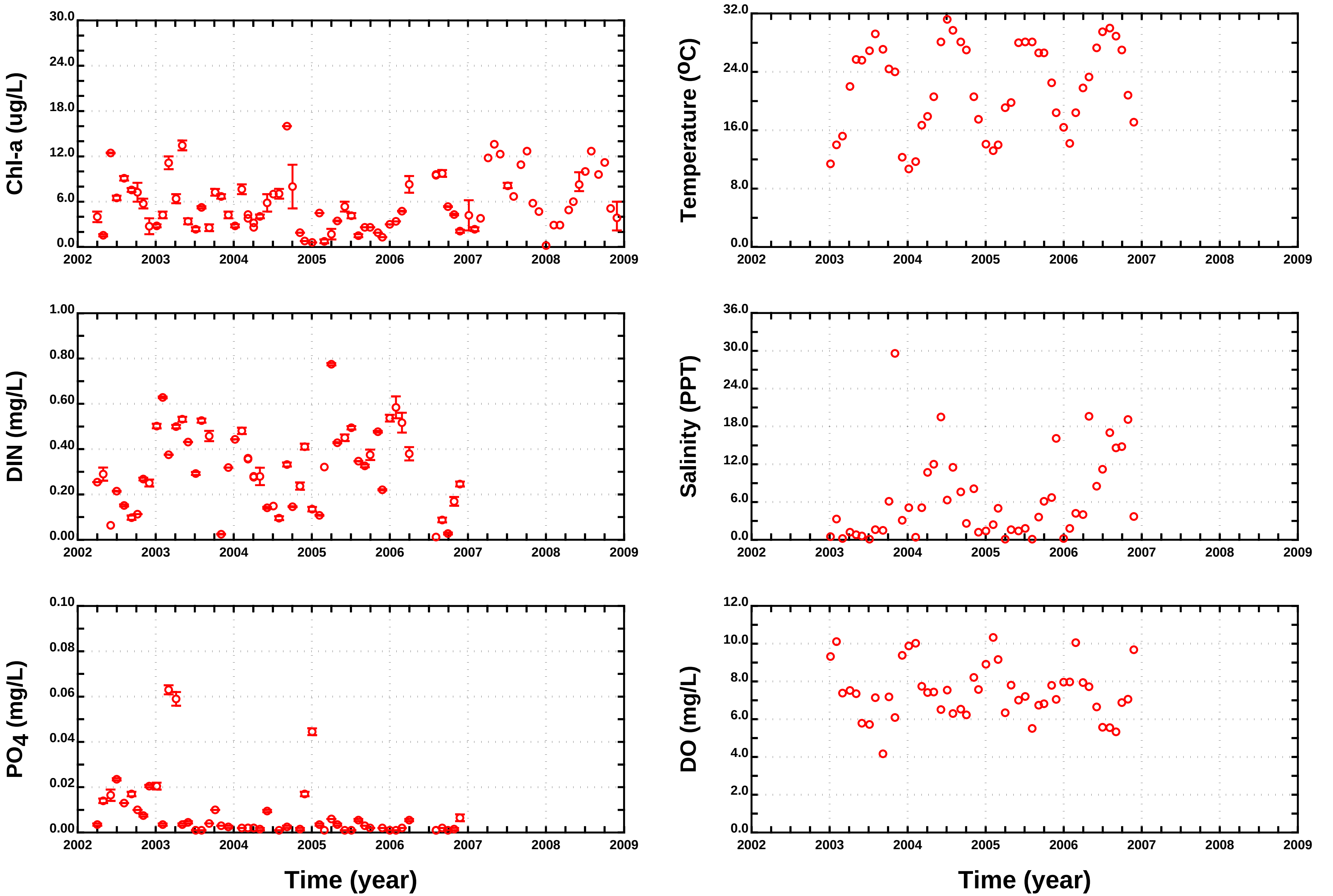
Figure 9. Apalachicola Bay Chl-a Relationships

ATTACHMENT 1

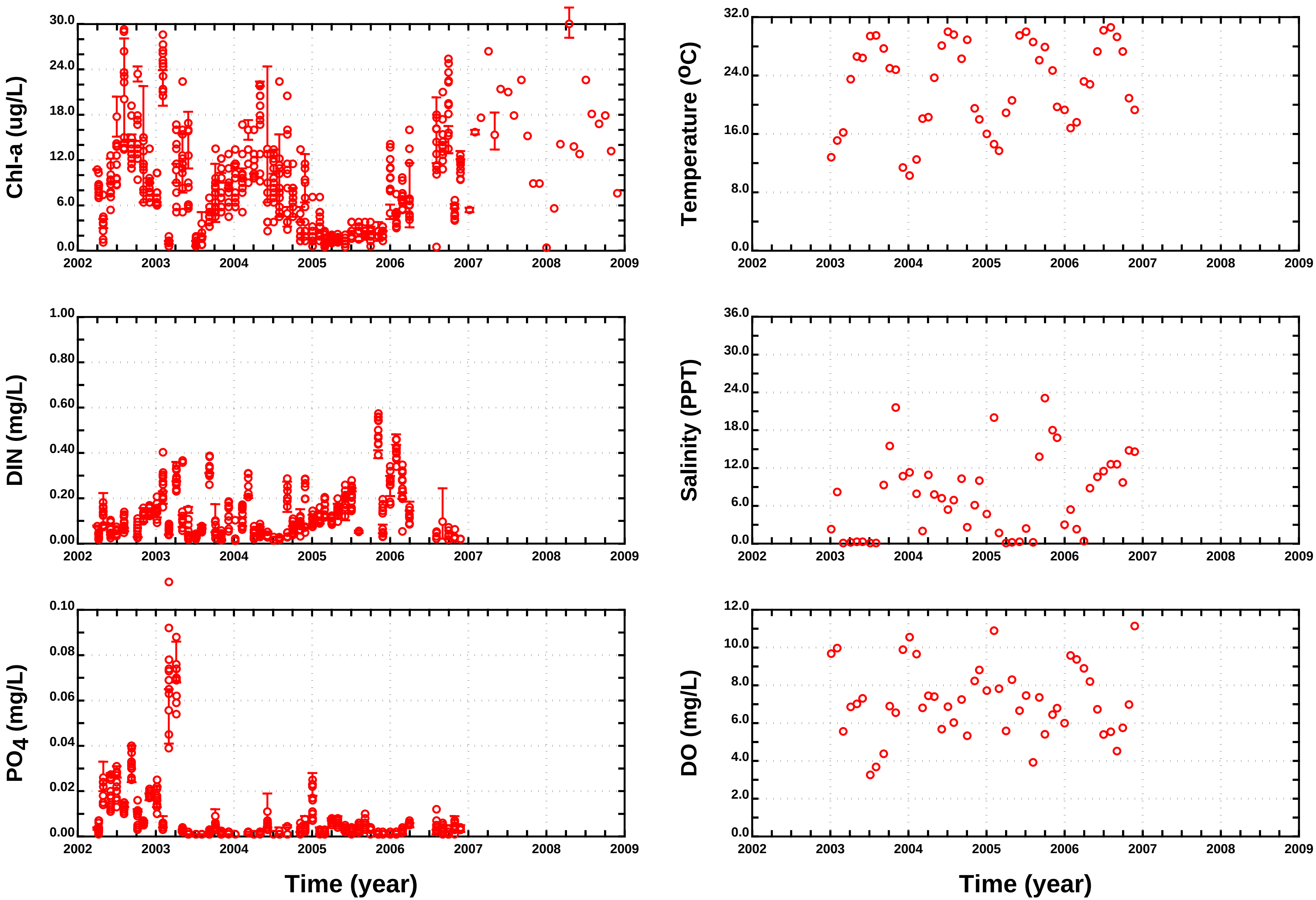
ANERRS APALACHICOLA BAY
WATER QUALITY DATA
TIME-SERIES FIGURES



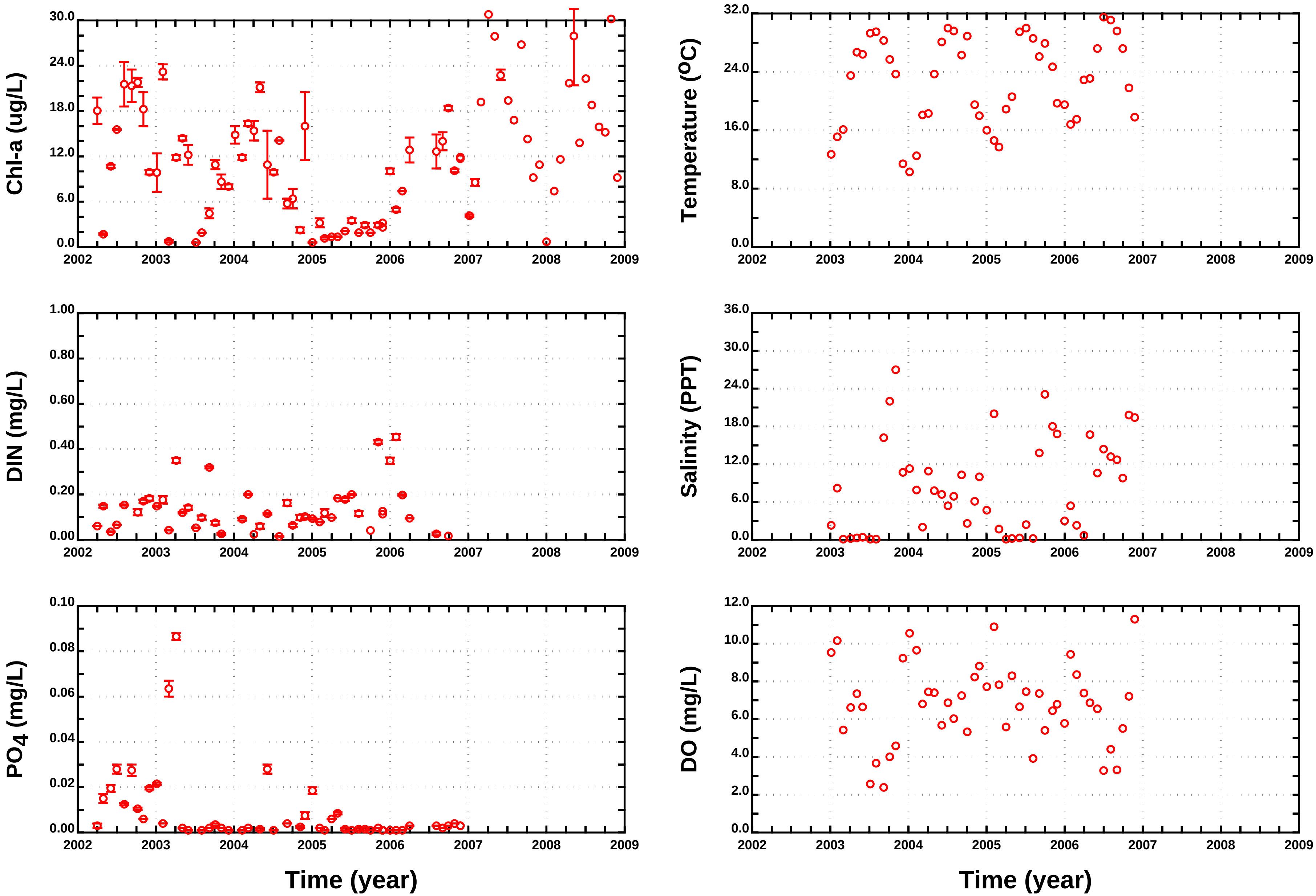
Apalachicola Bay Station "River", 2002-2009



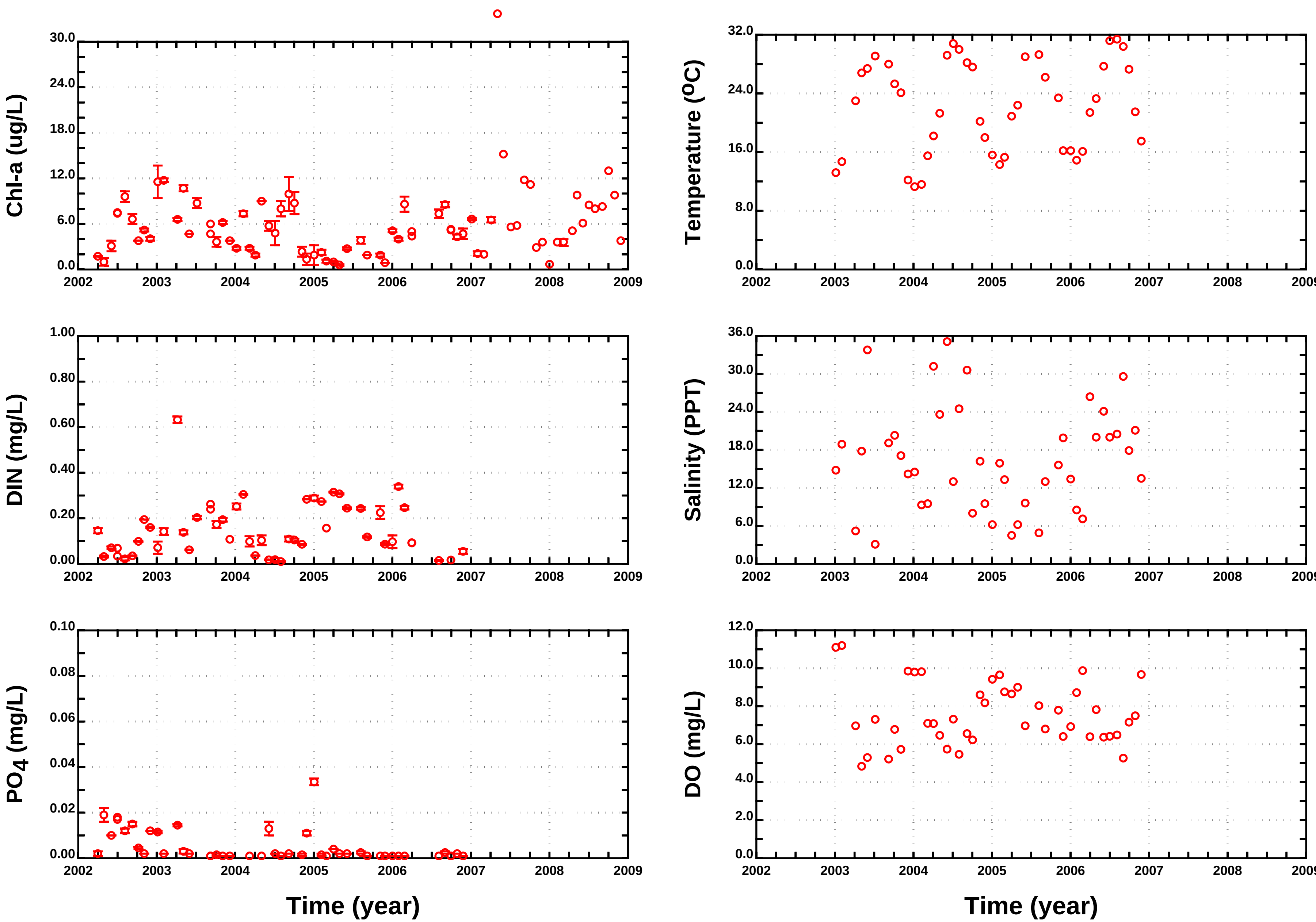
Apalachicola Bay Station "East Bay Bridge", 2002-2009



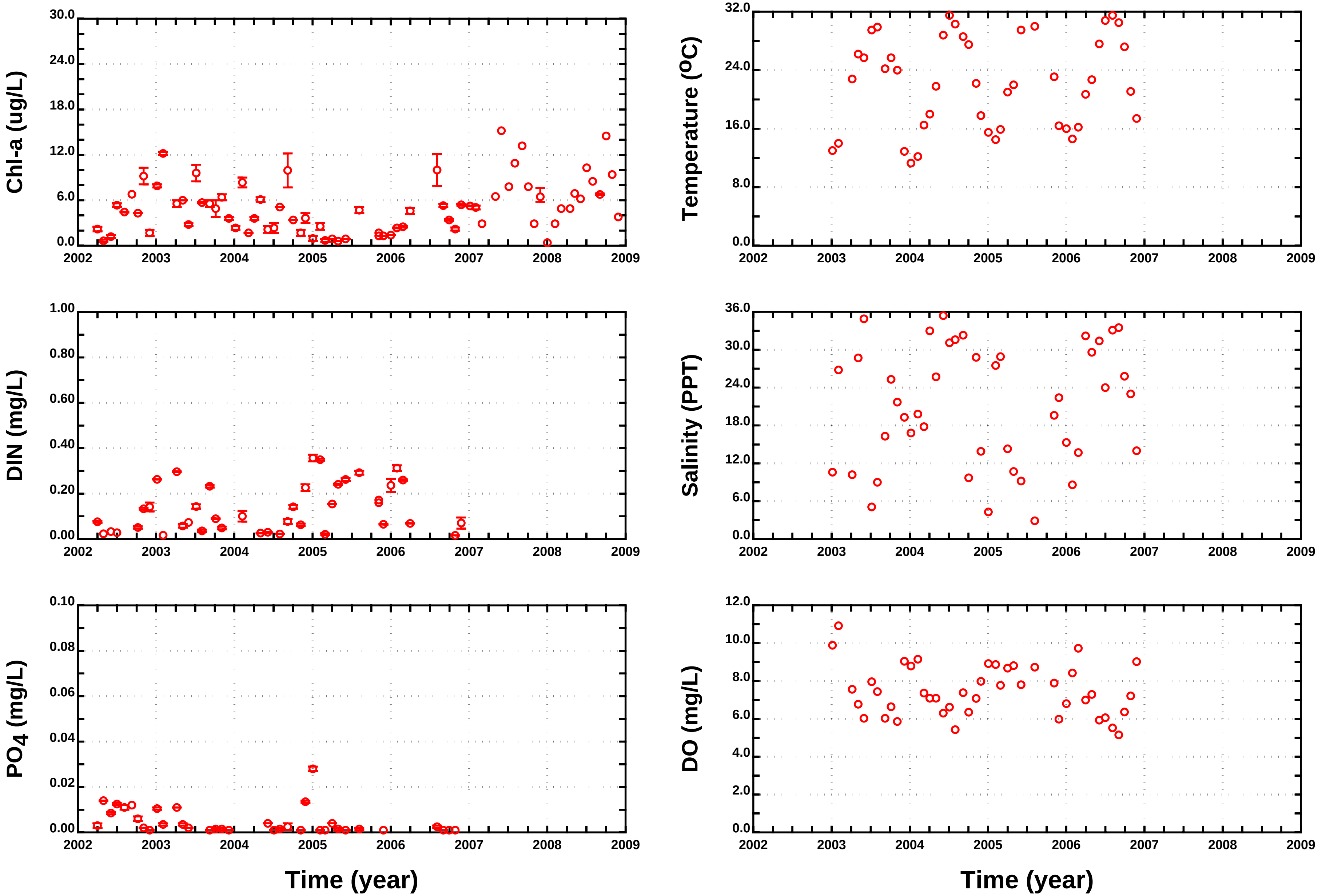
Apalachicola Bay Station "East Bay Surface", 2002-2009



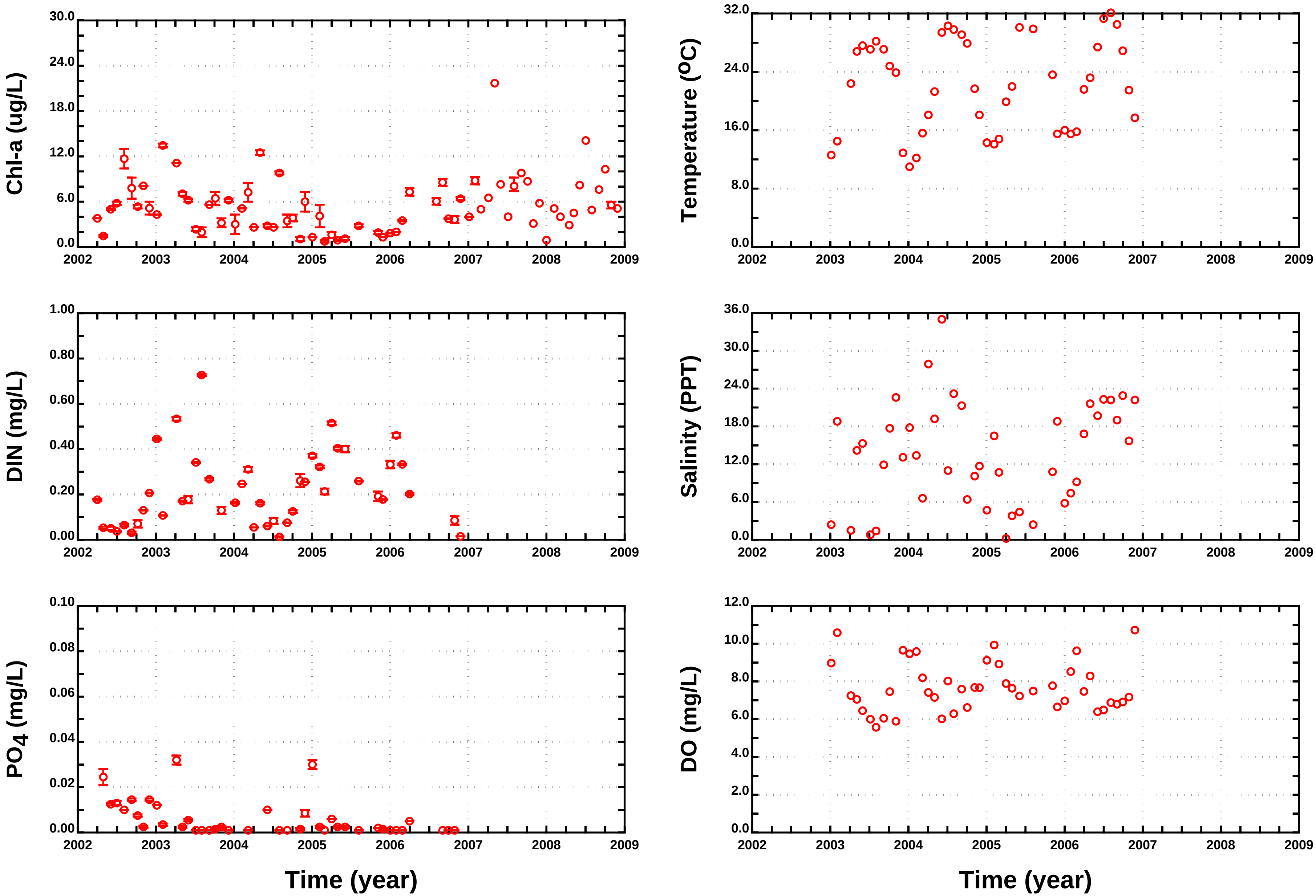
Apalachicola Bay Station "East Bay Bottom", 2002-2009



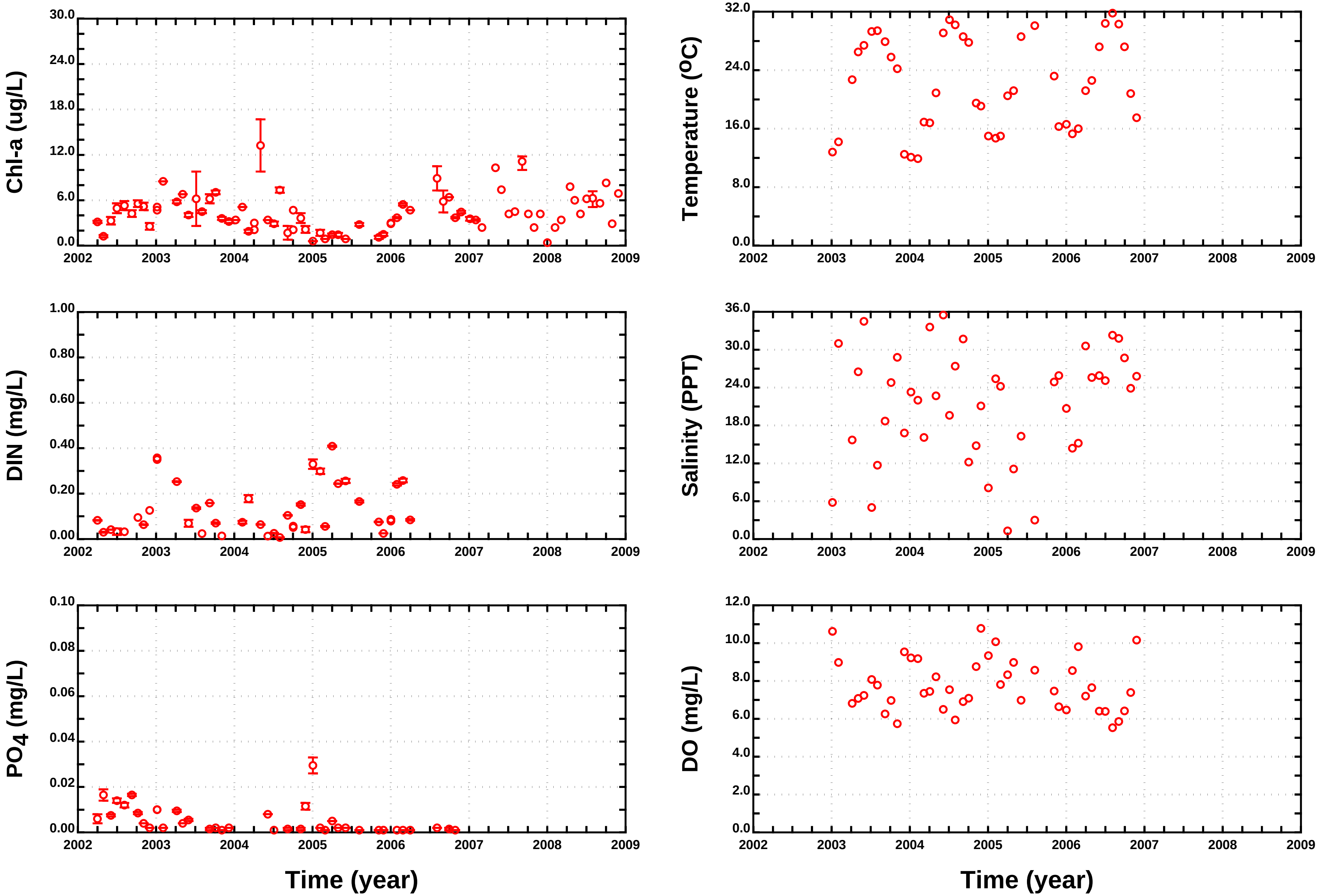
Apalachicola Bay Station "Dry Bar", 2002-2009



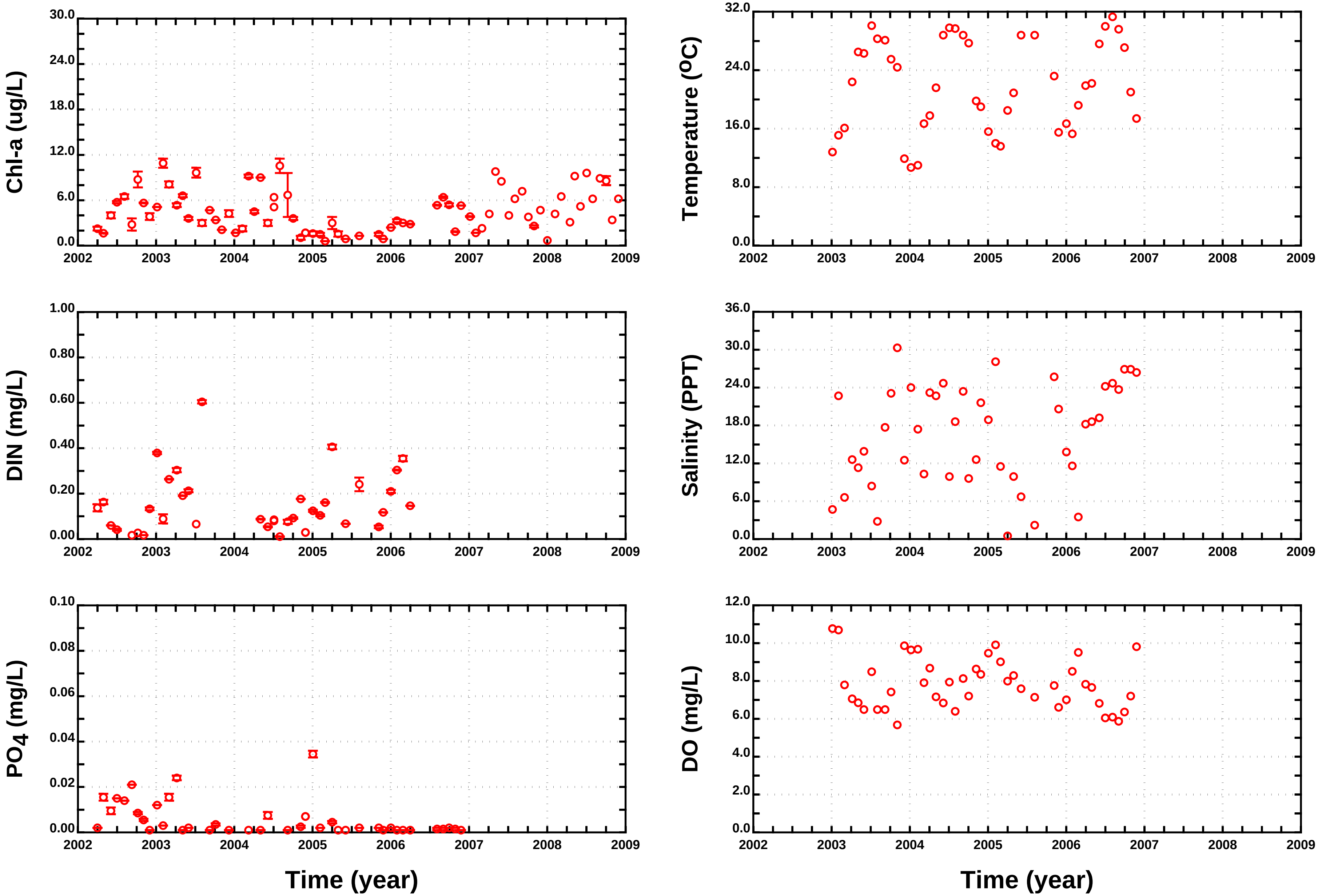
Apalachicola Bay Station "West Pass", 2002-2009



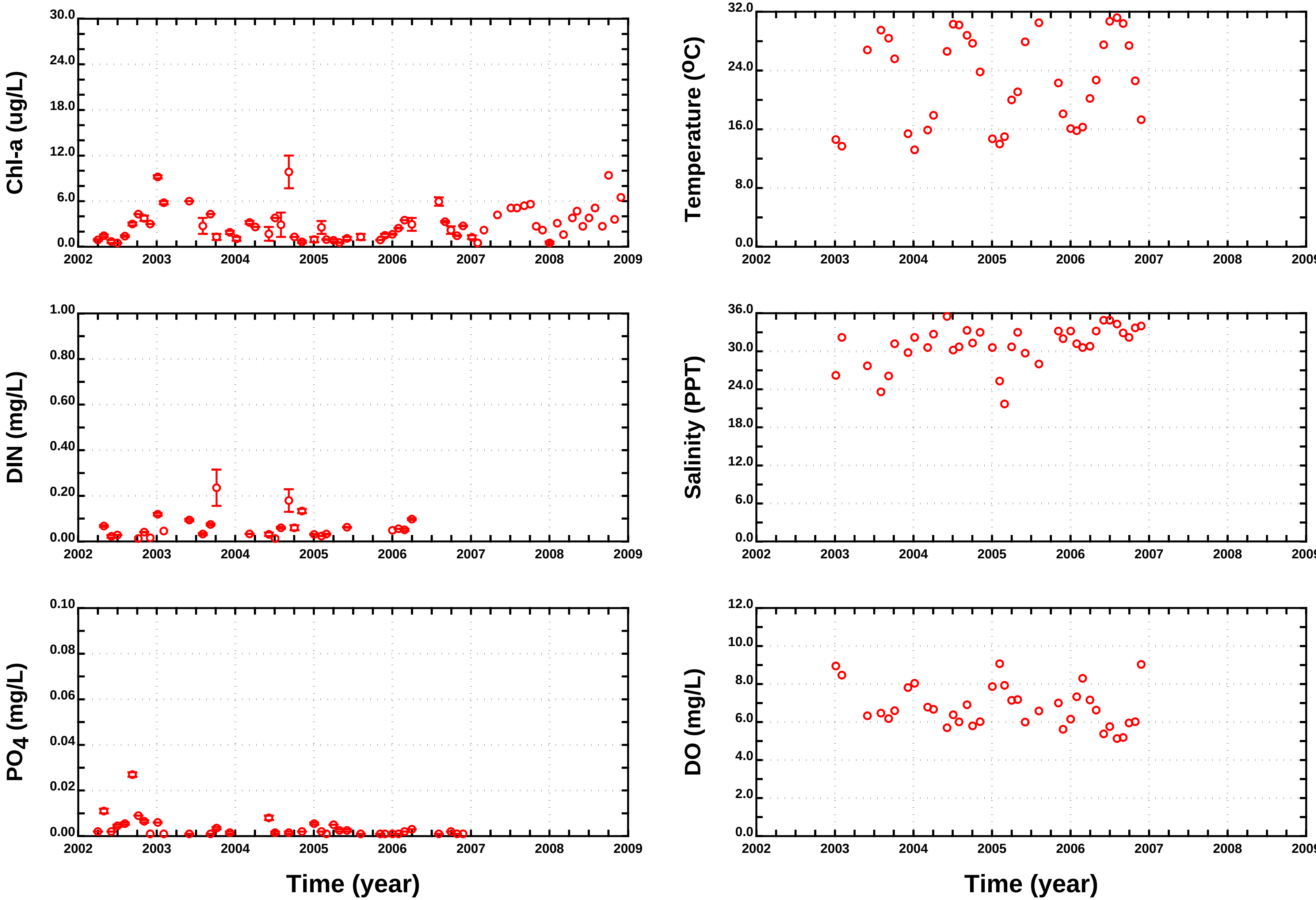
Apalachicola Bay Station "Mid Bay", 2002-2009



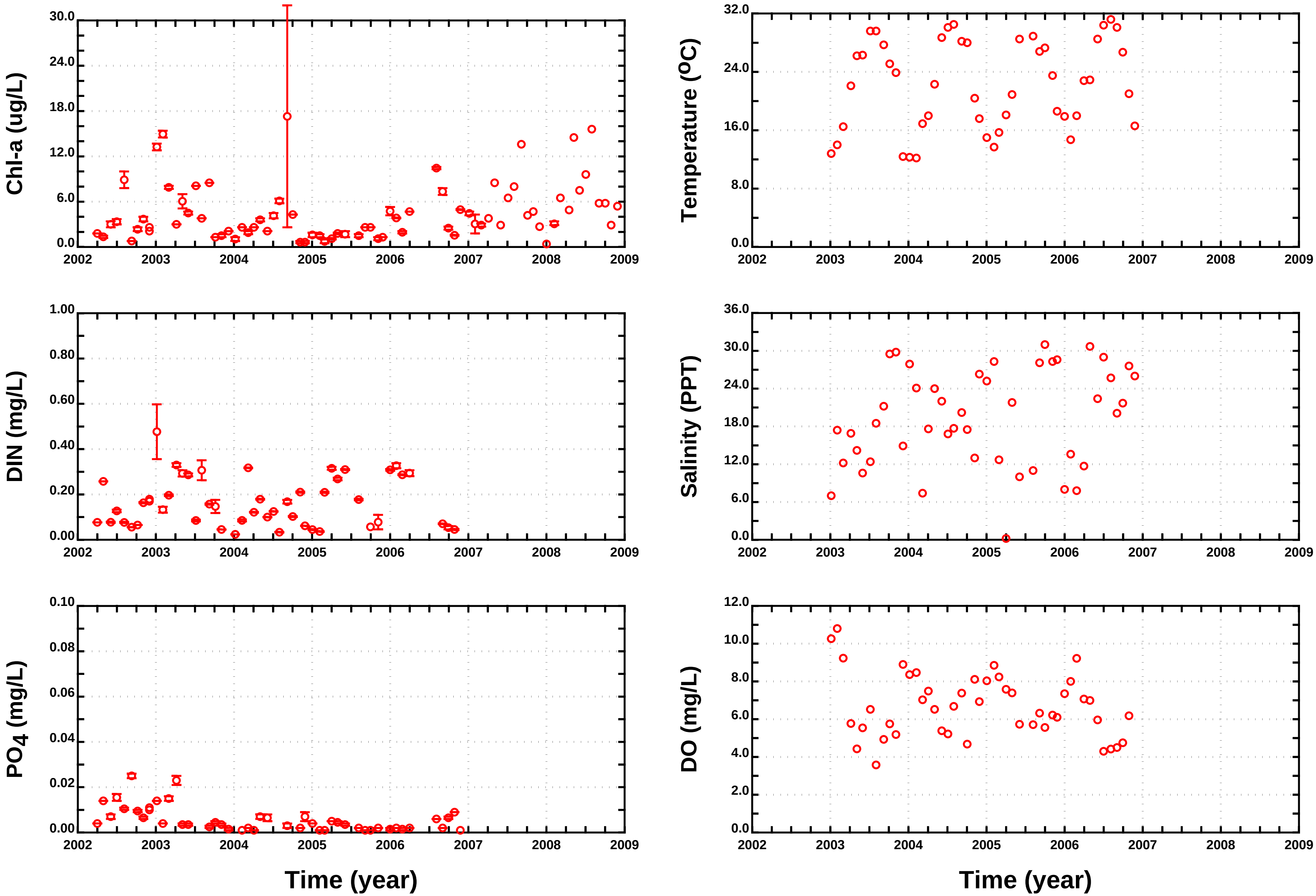
Apalachicola Bay Station "Pilots Cove", 2002-2009



Apalachicola Bay Station "Nicks Hole", 2002-2009



Apalachicola Bay Station "Sikes Cut", 2002-2009



Apalachicola Bay Station "Cat Point", 2002-2009