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24 March 2006

Patrick Martin
SFWMD
8894 Belvedere Road
West Palm Beach, FL 33411

Re: South Florida Coastal Water Quality Monitoring Network – 10-12/05 Quarterly Report (C-15397)

Dear Mr. Martin:

This letter serves to transmit the South Florida Coastal Water Quality Monitoring Network Quarterly Report as per our SFWMD/SERC Cooperative Agreement #C-15397. This report consists of this letter along with corresponding tables and figures.

Project Background

This report includes water quality data collected monthly during the annual period of record (POR) Oct. – Dec. 2005 from 28 stations in Florida Bay, 22 stations in Whitewater Bay, 25 stations in Ten Thousand Islands, 25 stations in Biscayne Bay, and 28 stations in Cape Romano-Rookery Bay-Pine Island Sound. A total of 49 stations were also collected on the SW Florida Shelf on a quarterly basis. Figure 1 shows the location of the fixed sampling stations.

Water quality parameters monitored at each station include the dissolved nutrients nitrate + nitrite (NO_x), nitrite (NO_2), nitrate (NO_3), ammonium (NH_4), inorganic nitrogen (DIN), and soluble reactive phosphorus (SRP). Silicate ($\text{Si}(\text{OH})_4$) was analyzed at all stations on a quarterly basis in conjunction with SW Shelf sampling. Total concentrations of nitrogen (TN), organic nitrogen (TON), phosphorus (TP), and organic carbon (TOC) were also measured. All concentrations for each of these parameters are reported as parts per million (ppm) except where noted.

Biological parameters monitored included chlorophyll *a* ($\mu\text{g l}^{-1}$) and alkaline phosphatase activity (APA; $\mu\text{M hr}^{-1}$). Field parameters measured at both surface and bottom of the water column include salinity, dissolved oxygen (DO; mg l^{-1}), and temperature ($^{\circ}\text{C}$). Turbidity (NTU) of the surface water was also measured.

Data Results

A previous spatial analysis of data from Florida Bay resulted in the delineation of 3 groups of stations which have robust similarities in water quality (Fig. 2). We have argued that these spatially contiguous groups of stations are the result of similar loading and processing of materials, hence we call them 'zones of similar influence'. The Eastern Bay zone (FBE) acts most like a 'conventional' estuary in that it has a quasi-longitudinal salinity gradient caused by the mixing of freshwater runoff with seawater. In contrast, the Central Bay (FBC) is a hydrographically isolated area with low and infrequent terrestrial freshwater input, a long water residence time, and high evaporative potential. The Western Bay zone (FBW) is the most influenced by the Gulf of Mexico tides and is also isolated from direct overland freshwater sources. Station #7 - Highway Creek did not cluster out with any of the Florida Bay stations and was considered separately.

Using the same statistical approach as above, the TTI-WWB complex was partitioned into 6 distinct zones of similar water quality (Fig. 3). The first cluster was composed of 13 stations in and around the Shark, Harney, Broad, and Lostmans Rivers and is called the Mangrove River (MR) group. This cluster also included a sampling station just off the Faka Union Canal. The second cluster was made up of the 8 stations enclosed within Whitewater Bay proper (WWB). Twelve stations situated mostly in and around the coastal islands of TTI-WWB formed the Gulf Island group (GI). The water quality characteristics at the Coot Bay site were sufficiently different so as to be a cluster of its own. The next cluster contained the northernmost 2 stations in the Blackwater River estuary (BLK). Finally, the Inland Wilderness Waterway zone (IWW) included 11 stations distributed throughout the inside passage as well as the Chatham River and the station off Everglades City.

Biscayne Bay was partitioned into 6 distinct ZSI using the above statistical analysis. The first cluster was composed of 2 stations closest to the shore in the south Bay (Fig. 4); they were called the Alongshore group (AS). These are stations most influenced by the Goulds, Military and Mowry Canals. The second cluster was made up of the 5 stations farther from the coast called Inshore (IS). Thirteen stations situated mostly in the bay proper were called the main Bay (MAIN) group. The next cluster contained 3 stations situated in areas of great tidal exchange (ocean channel, not shown). Two stations in Card Sound grouped together SCARD. For purposes of this report, the stations added to the area north of the Rickenbacker Causeway are defined, a priori, as a distinct cluster, North Bay (NBAY).

The above statistical analysis objectively classified the 49 Shelf sampling sites into 3 zones having similar water quality (Fig. 5). The first cluster was composed of only 2 stations which were closest to the shore off Cape Sable; they were called the SHARK group, after the Shark River, the main source of freshwater to the region. The second cluster was made up of the 7 more northerly stations nearest the coast and called SHOAL. The remaining stations were called the SHELF group.

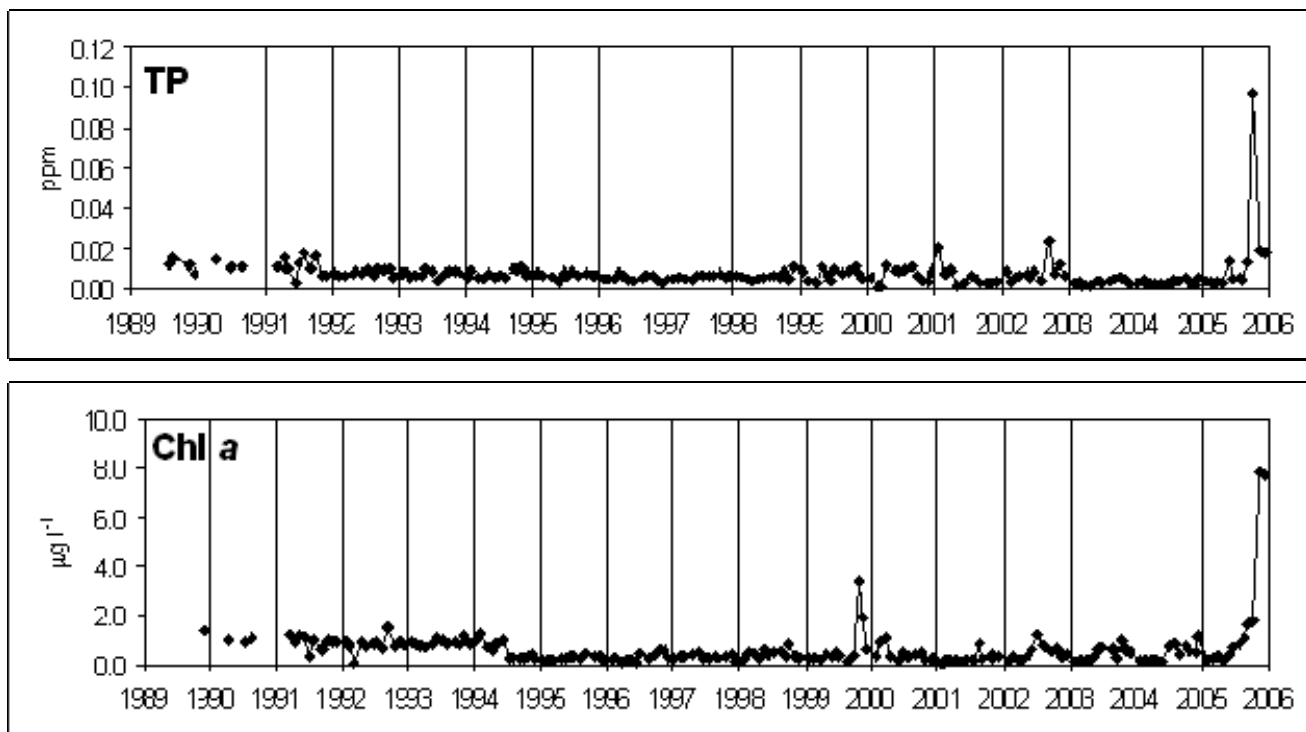
Sampling in the Rookery Bay area began Jan. 1999, so we now have 5 years of data available. But because of the very heterogeneous nature of the area, we will continue to use generally accepted geomorphological characteristics to group the stations (Fig. 6). These groupings are Cocohatchee River (COCO), Estero Bay (EST), Cape Romano-Marco Island (MARC), Naples Bay (NPL), Pine Island Sound (PIS), Rookery Bay (RB), and San Carlos Bay (SCB).

Data are also reported as box-and-whiskers plots (Figs. 7-28). The center horizontal line in the box is the median of the data, the top and bottom of the box are the 25th and 75th percentiles (quartiles), and the ends of the whiskers are the 5th and 95th percentiles.

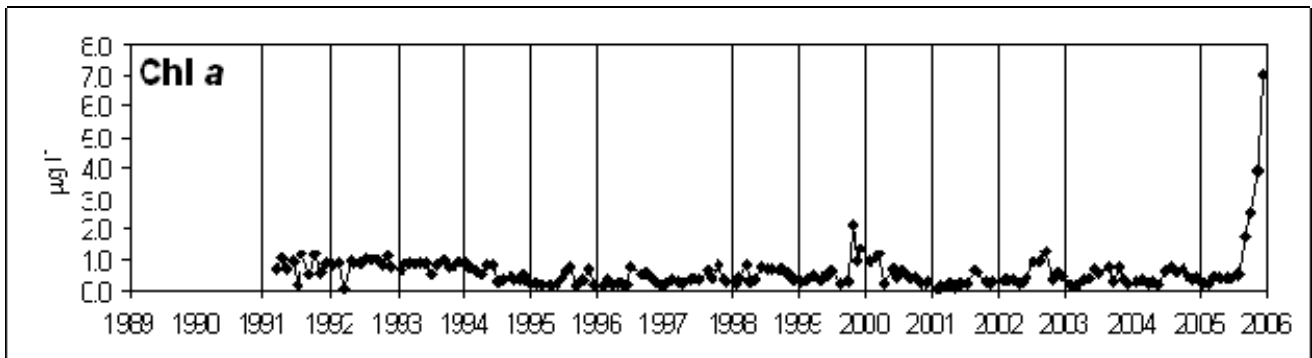
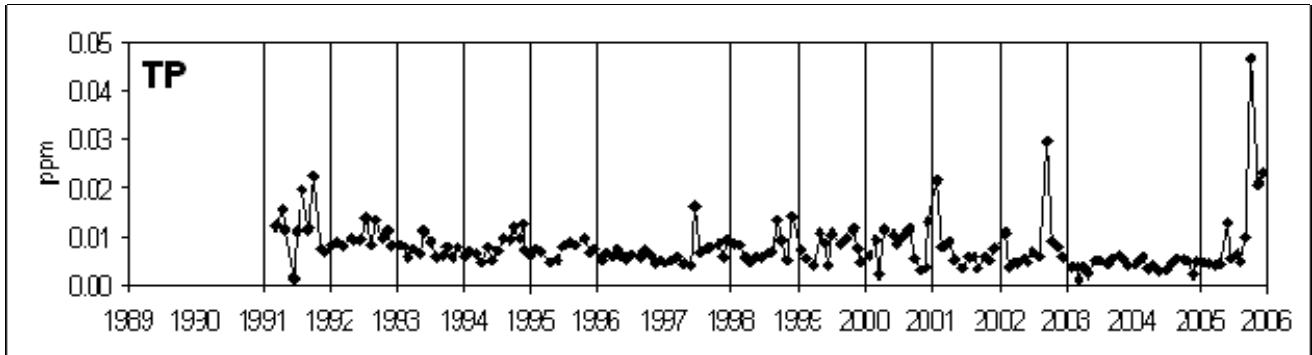
Summary statistics of all water quality parameters by ecosystem are shown in Table 1. The median was chosen because it is a more accurate measure of central tendency in non-normally distributed water quality data. The range is expressed as the minimum (Min.) and maximum (Max.) values for the POR, and *n* is the number of data points used in the analysis.

This and prior sampling periods included the passage of three major hurricanes through the area: Hurricane Katrina 8/26, Hurricane Rita 9/20, and Hurricane Wilma 10/24. In addition, construction on the widening of Route 1 (the Stretch) began in earnest with the cutting of mangroves and stabilizing of soils. Stations in Eastern Florida Bay and South Card Sound experienced a large pulse of TP during October which resulted in some of the highest chlorophyll a values ever recorded. Three examples are shown below which illustrate the problem. We are not sure as to the cause of the TP increase but it was widespread affecting Card Sound, Barnes Sound, Manatee Bay, Blackwater Sound, Little Blackwater Sound, and most of Eastern Florida Bay. We will continue to analyze this and ancillary data and hope to find the cause for inclusion into the FY05 Annual Report in June.

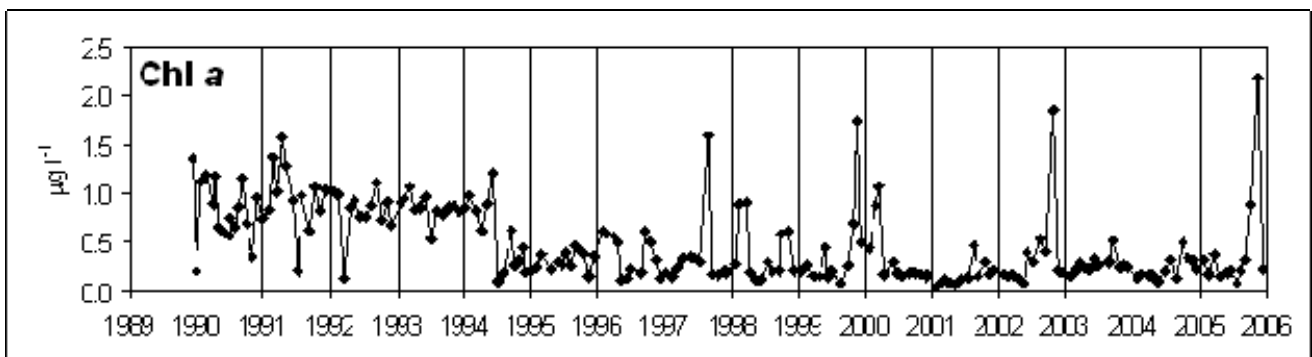
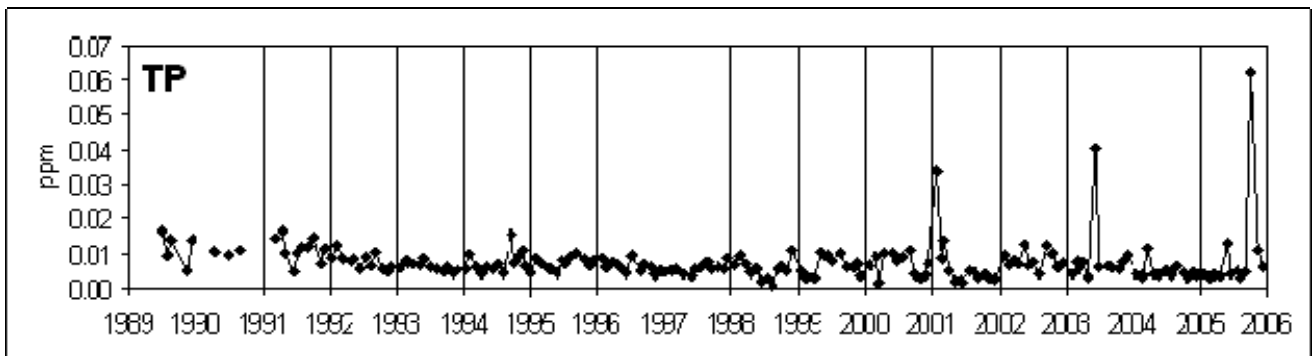
Barnes Sound (Sta. 4)



Manatee Bay (Sta. 3)



Duck Key (Sta. 9)



If you have any questions about the content of this report, please do not hesitate to contact me at 305-348-4076 or boyerj@fiu.edu.

Sincerely,

A handwritten signature in blue ink, reading "Joseph N. Boyer". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Joseph N. Boyer, Ph.D.
Associate Director and Scientist

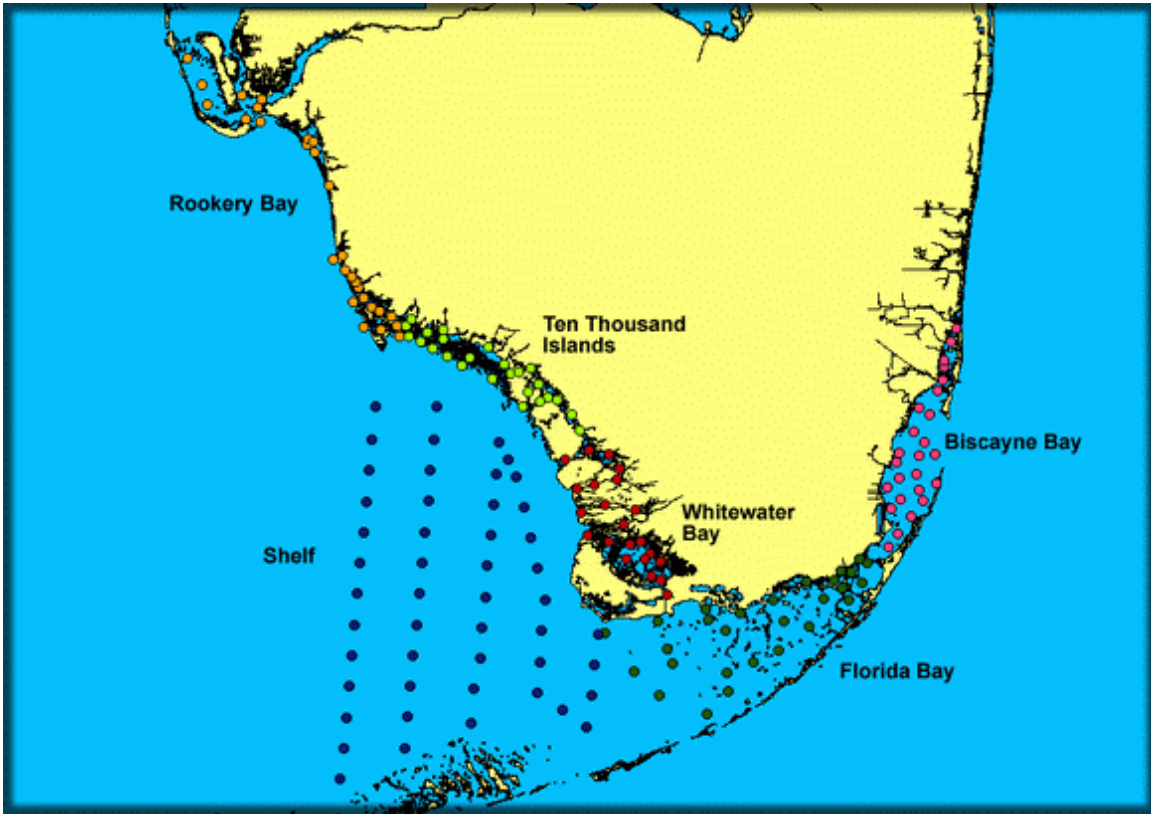
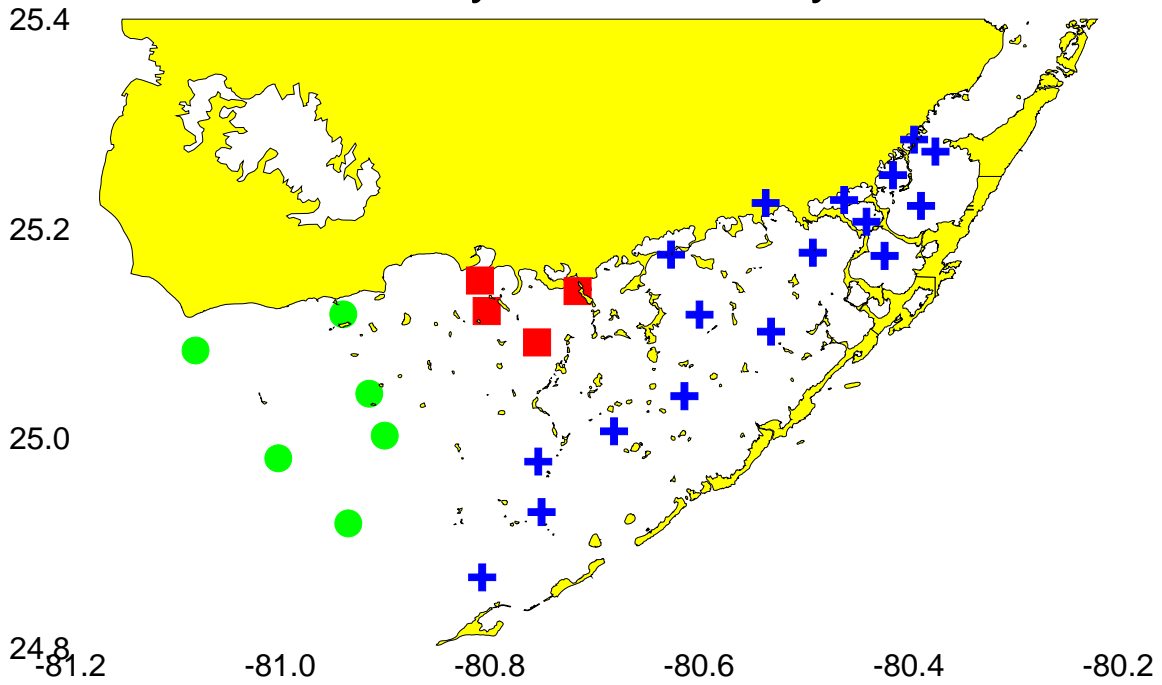


Figure 1: All fixed water quality stations funded by this SFWMD project.

Florida Bay Water Quality Zones



Eastern Bay (+), Central Bay, (■), Western Bay (●)

Figure 2. Florida Bay zones.

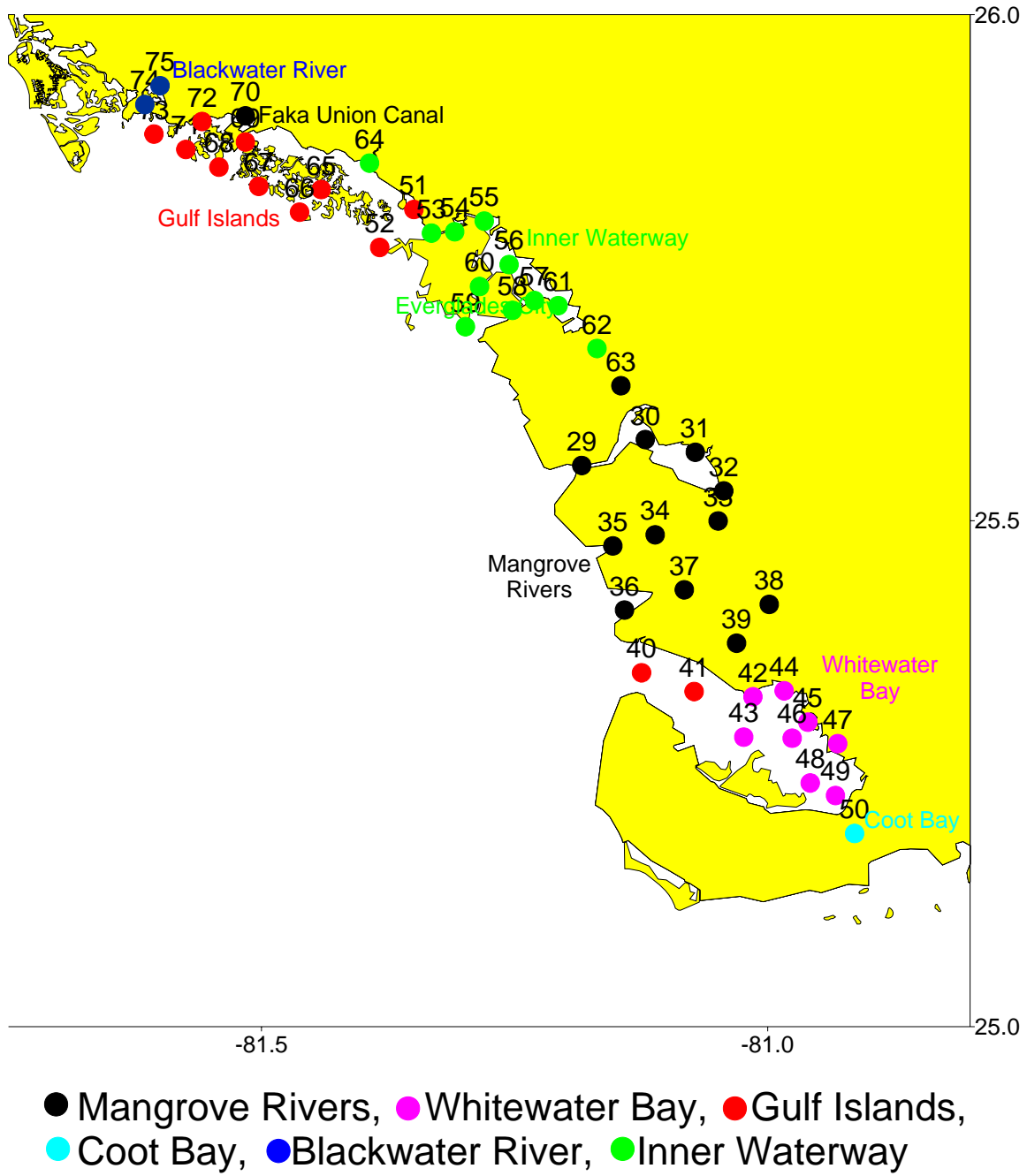


Figure 3. WWB-TTI water quality zones.

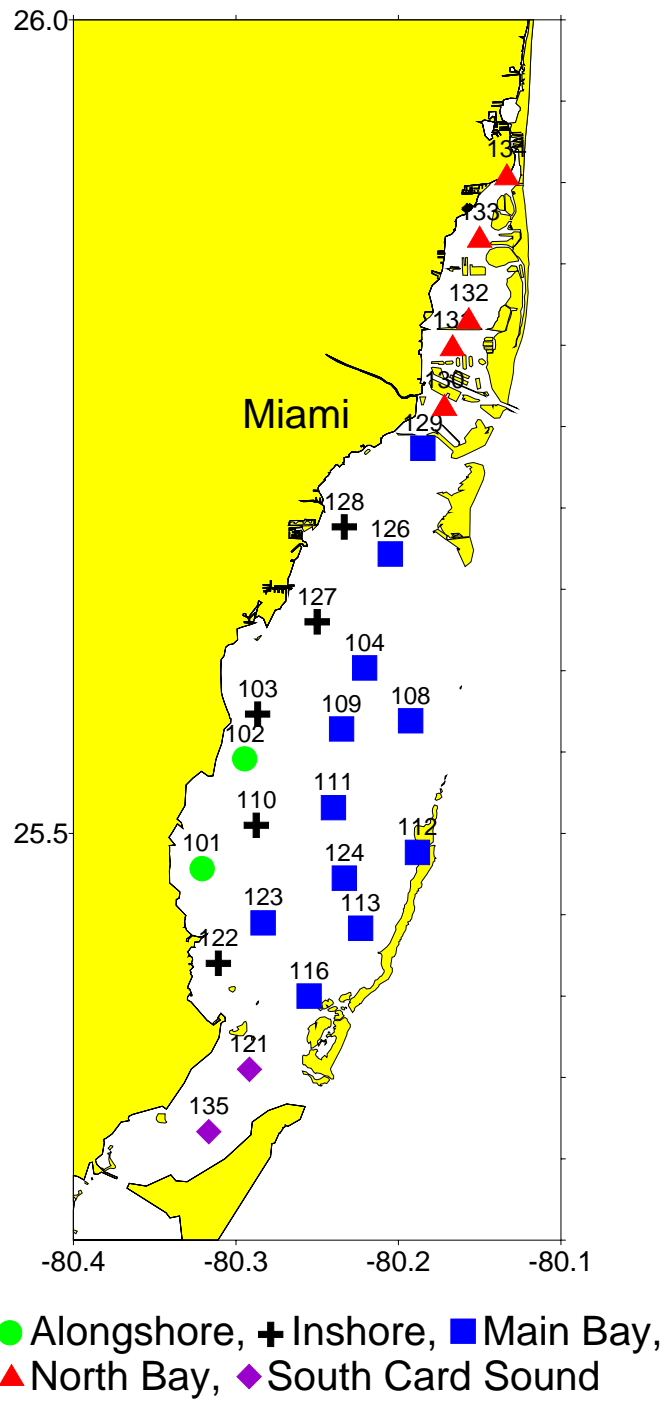


Figure 4. Biscayne Bay water quality zones.

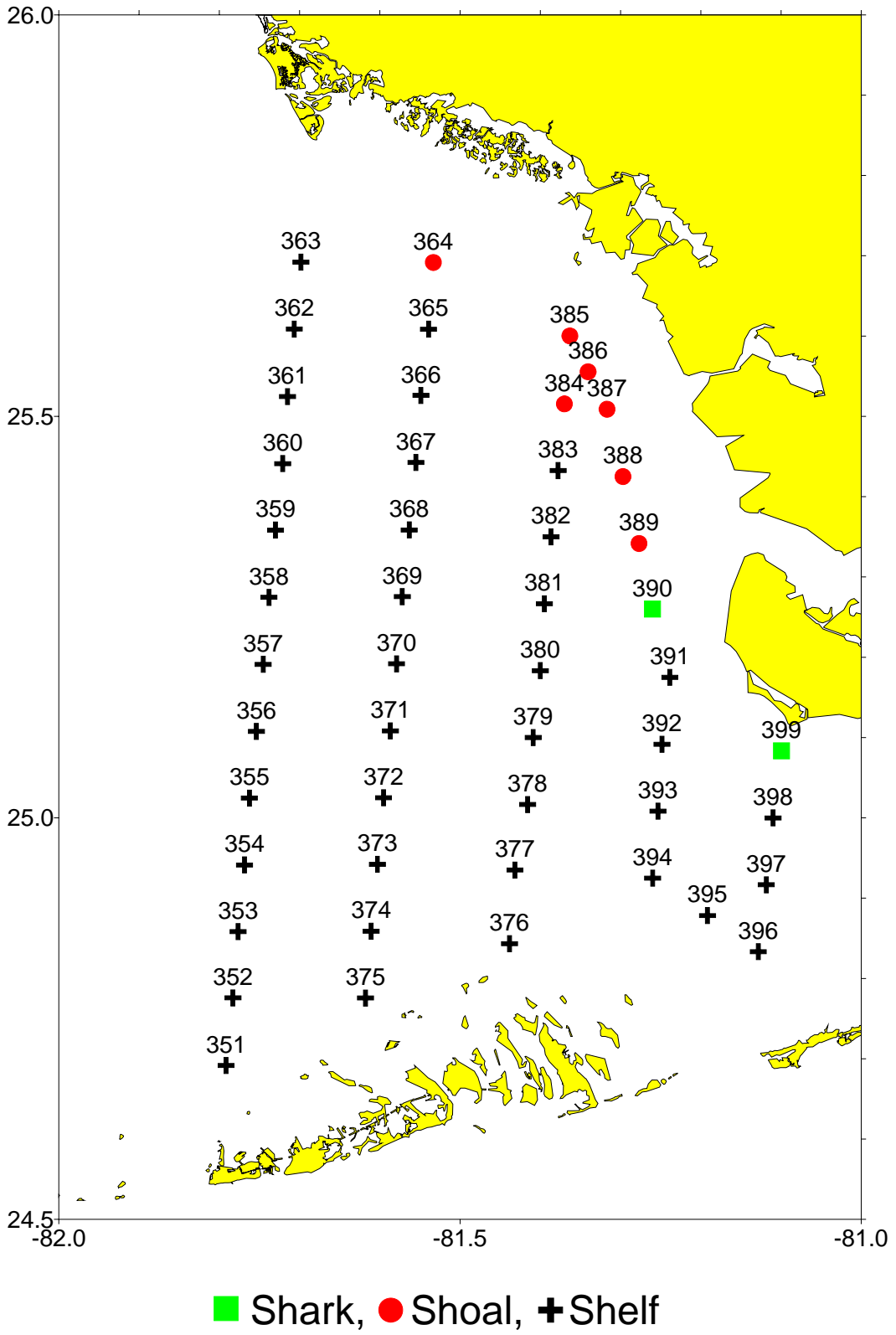


Figure 5. SW Florida Shelf water quality zones.

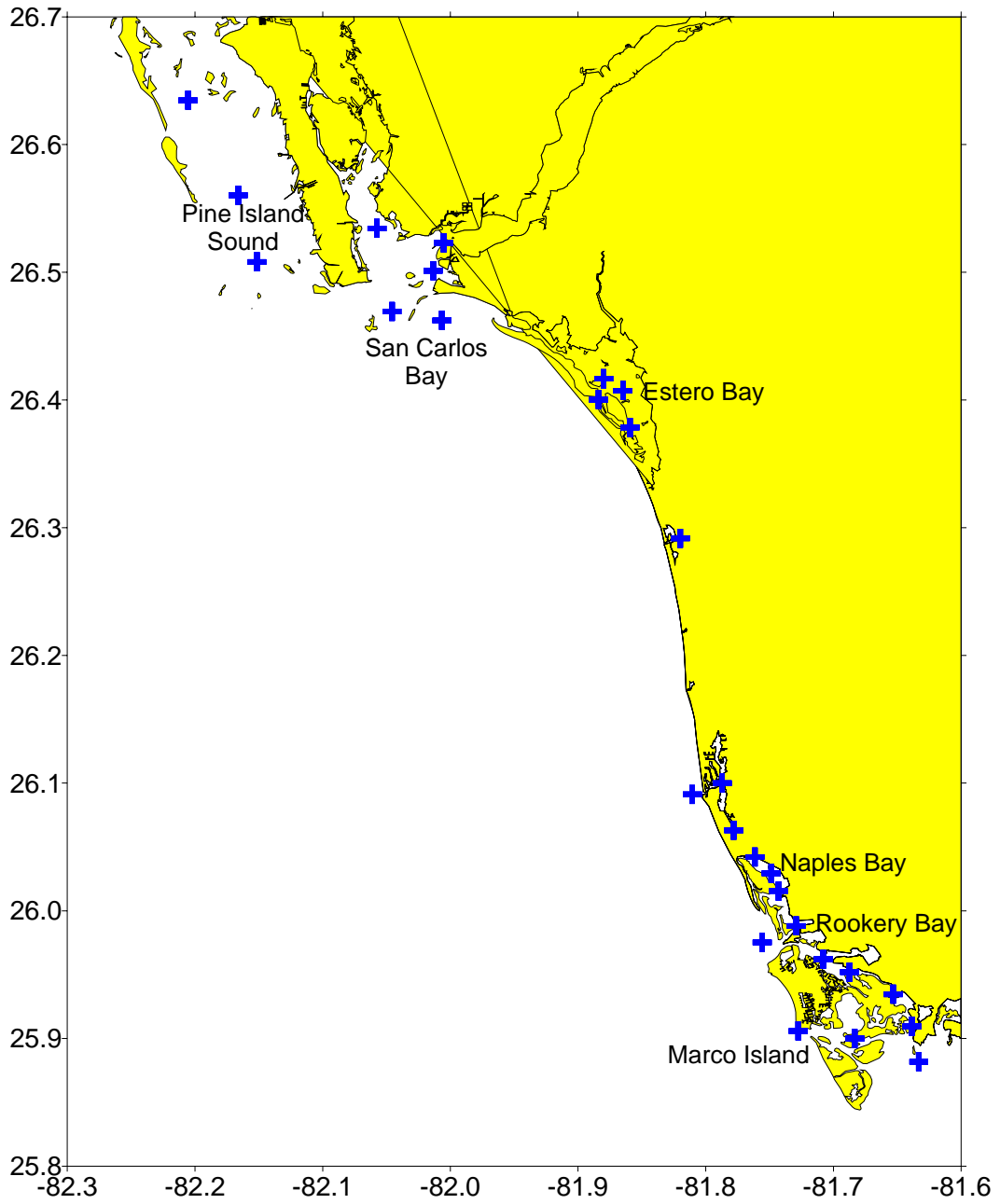


Figure 6. SW estuaries.

Eastern Florida Bay Zone

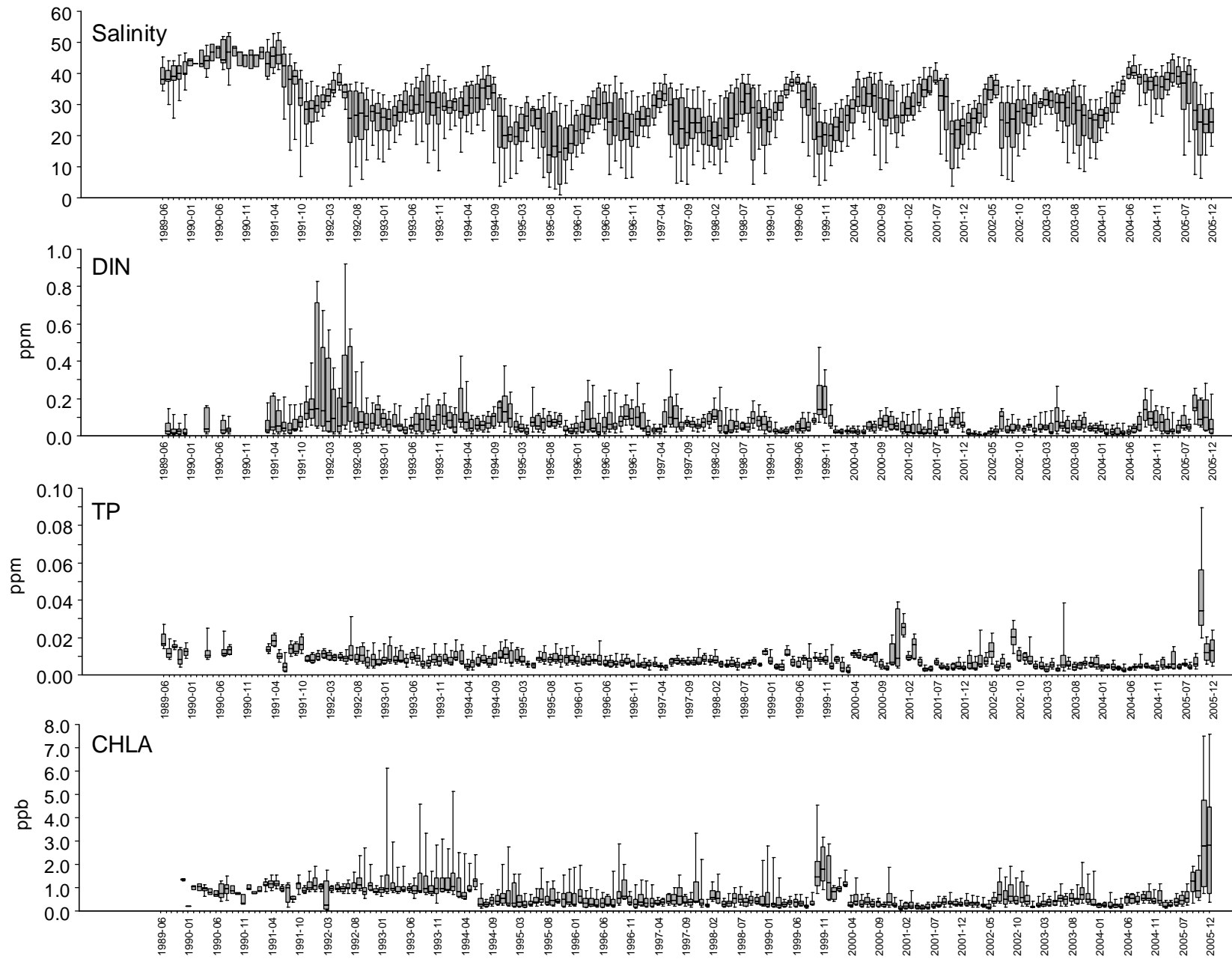


Figure 7. Box-and-whisker plots of water quality in Eastern Florida Bay by survey.

Central Florida Bay Zone

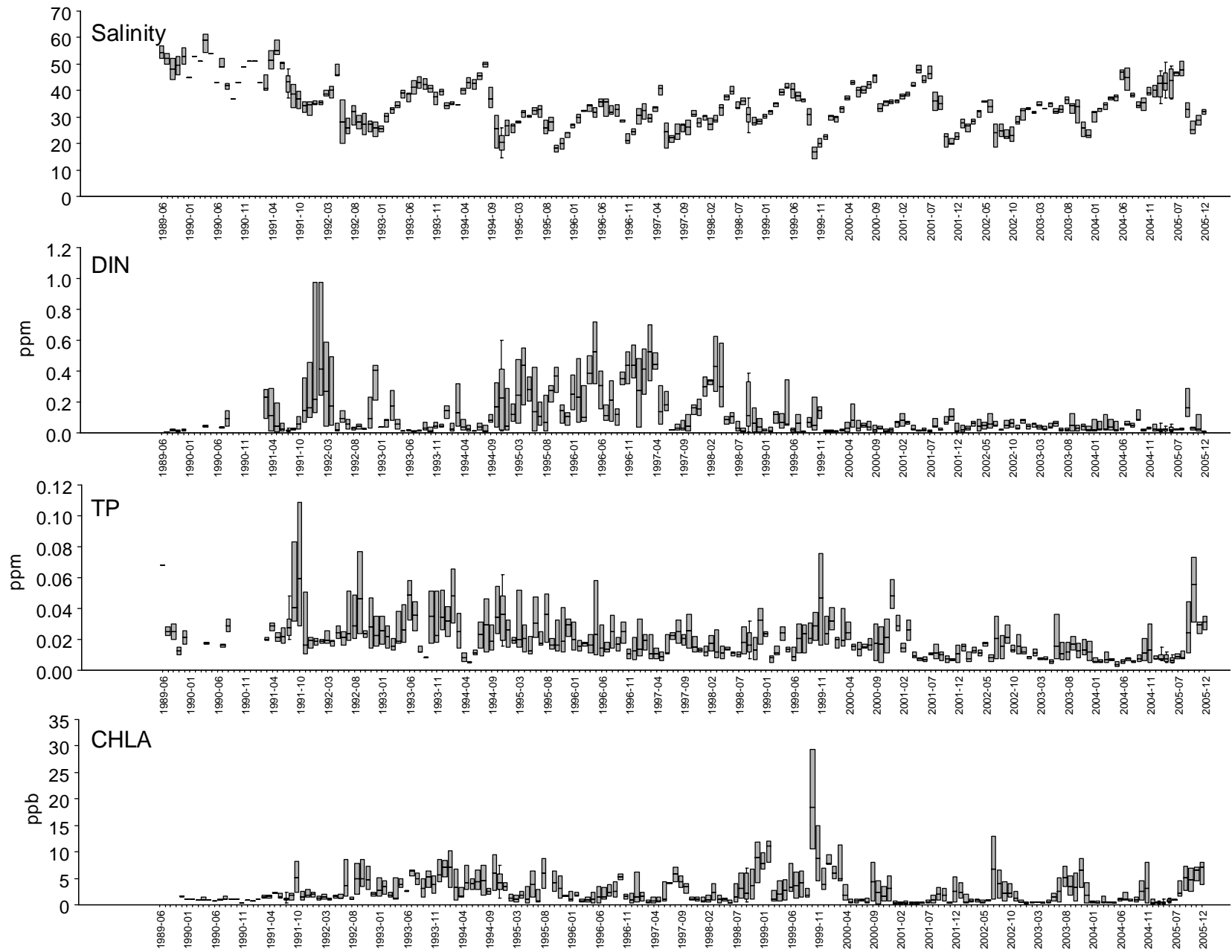


Figure 8. Box-and-whisker plots of water quality in Central Florida Bay by survey.

Western Florida Bay Zone

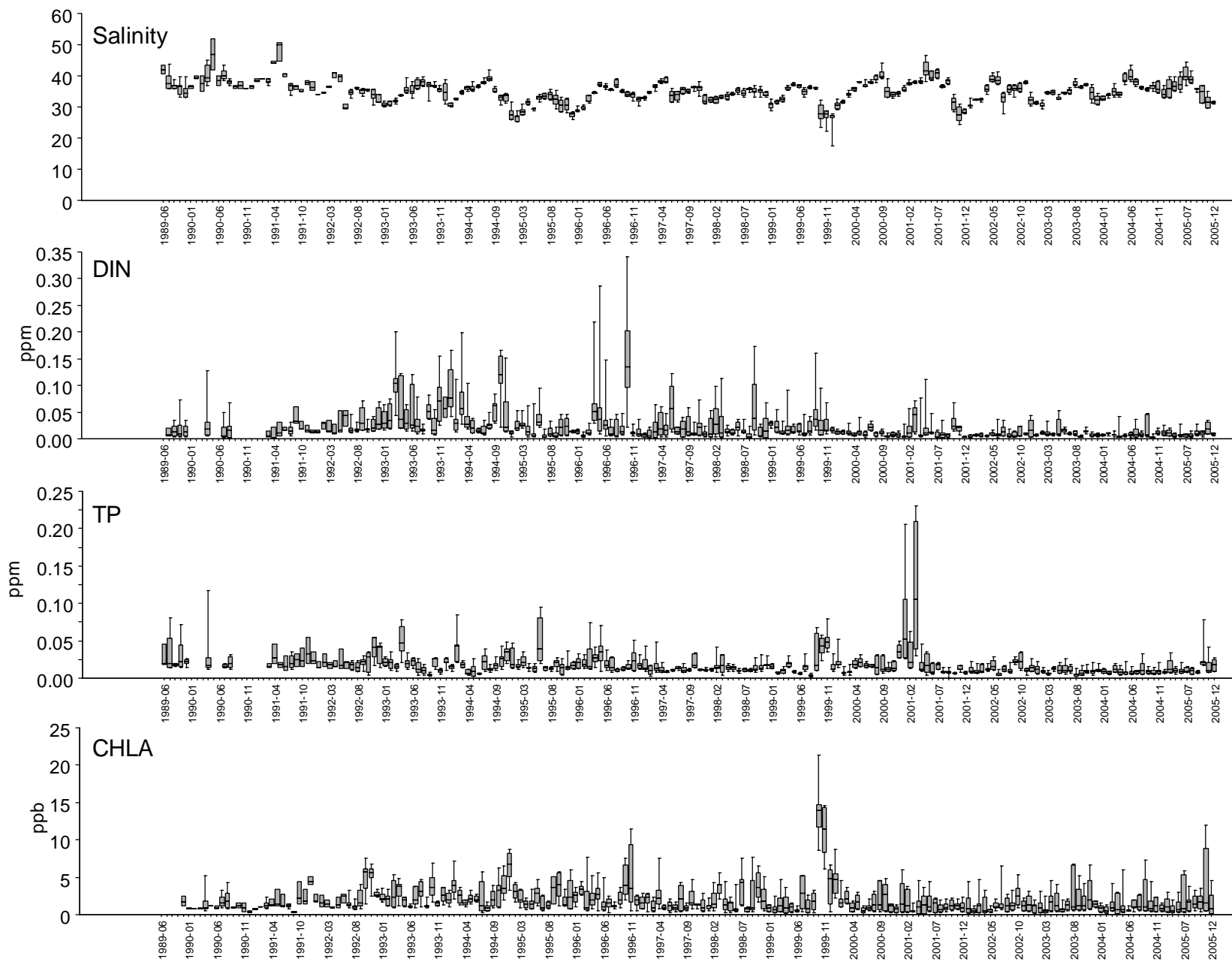


Figure 9. Box-and-whisker plots of water quality in Western Florida Bay by survey.

Whitewater Bay Zone

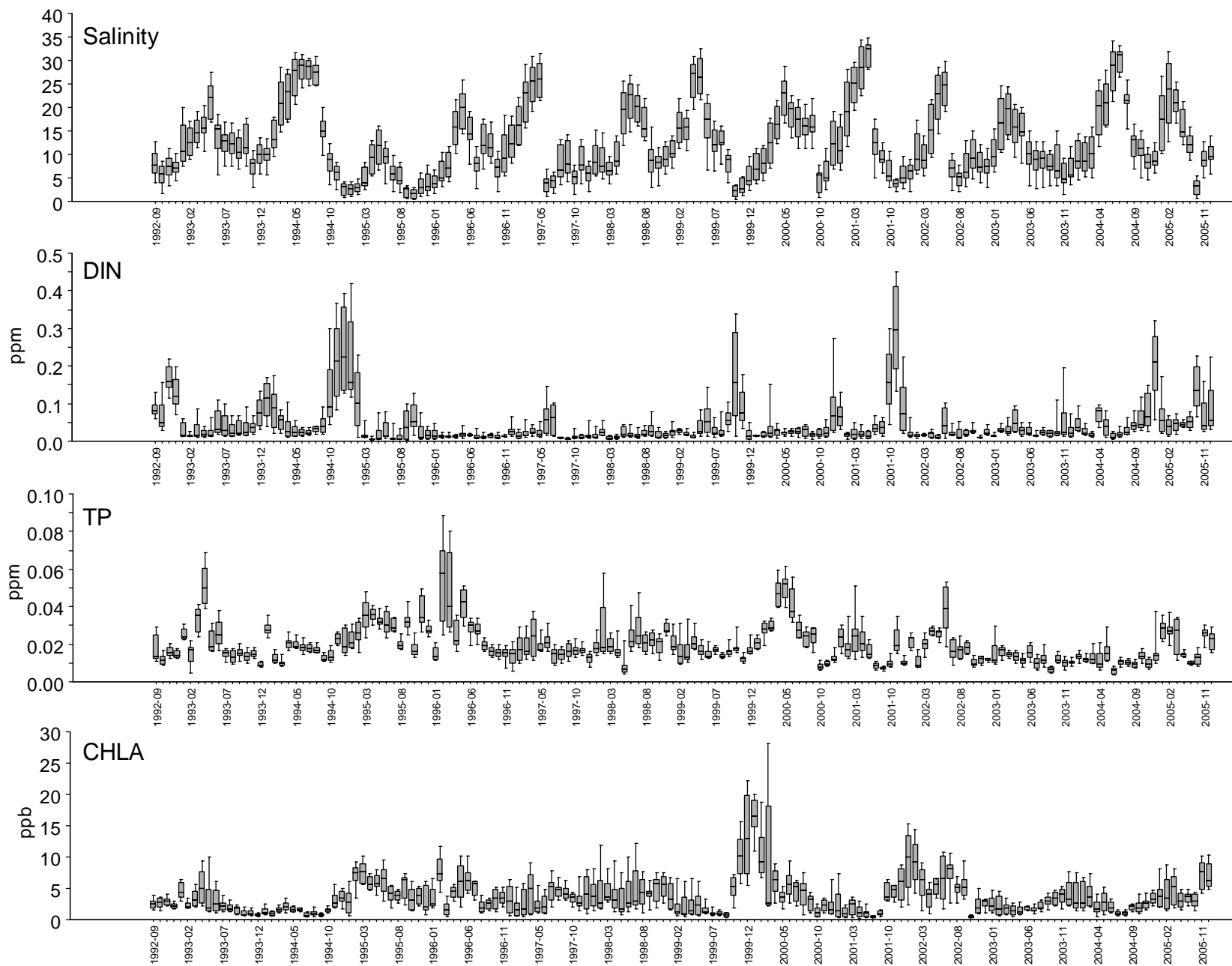


Figure 10. Box-and-whisker plots of water quality in WWB-TTI by survey.

Mangrove Rivers Zone

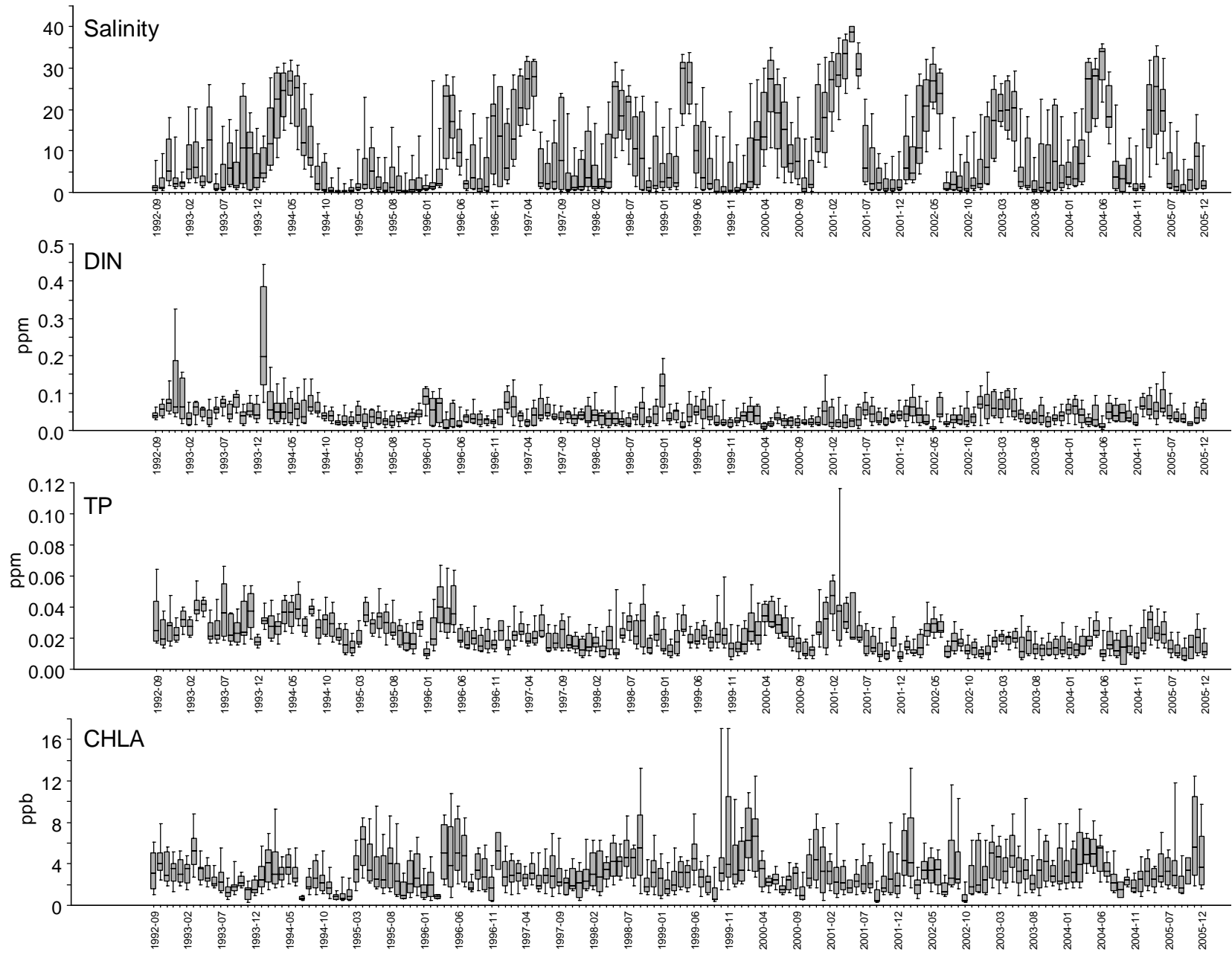


Figure 11. Box-and-whisker plots of water quality in WWB-TTI by survey.

Gulf Islands Zone

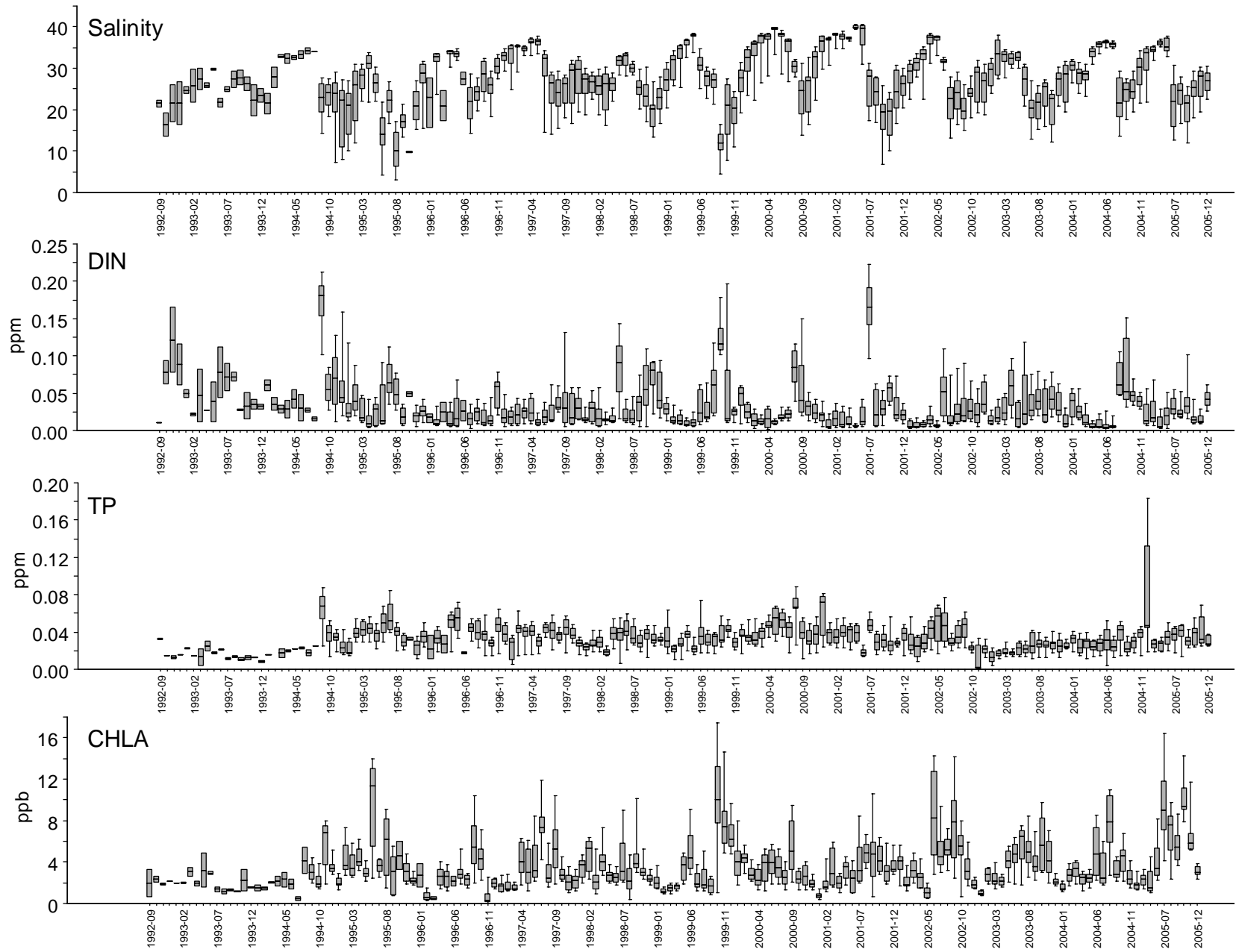


Figure 12. Box-and-whisker plots of water quality in WWB-TTI by survey.

Inner Waterway Zone

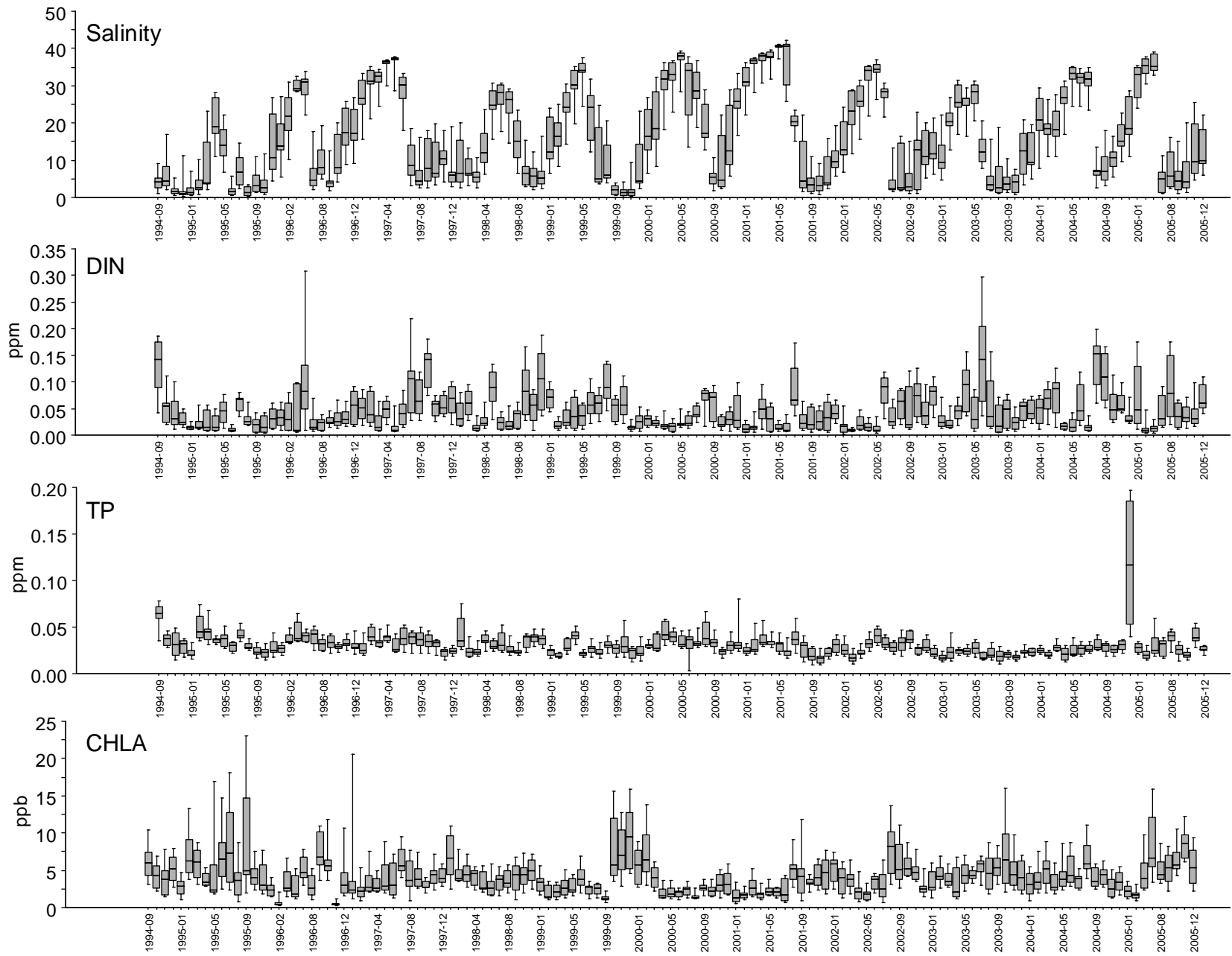


Figure 13. Box-and-whisker plots of water quality in WWB-TTI by survey.

Blackwater River Zone

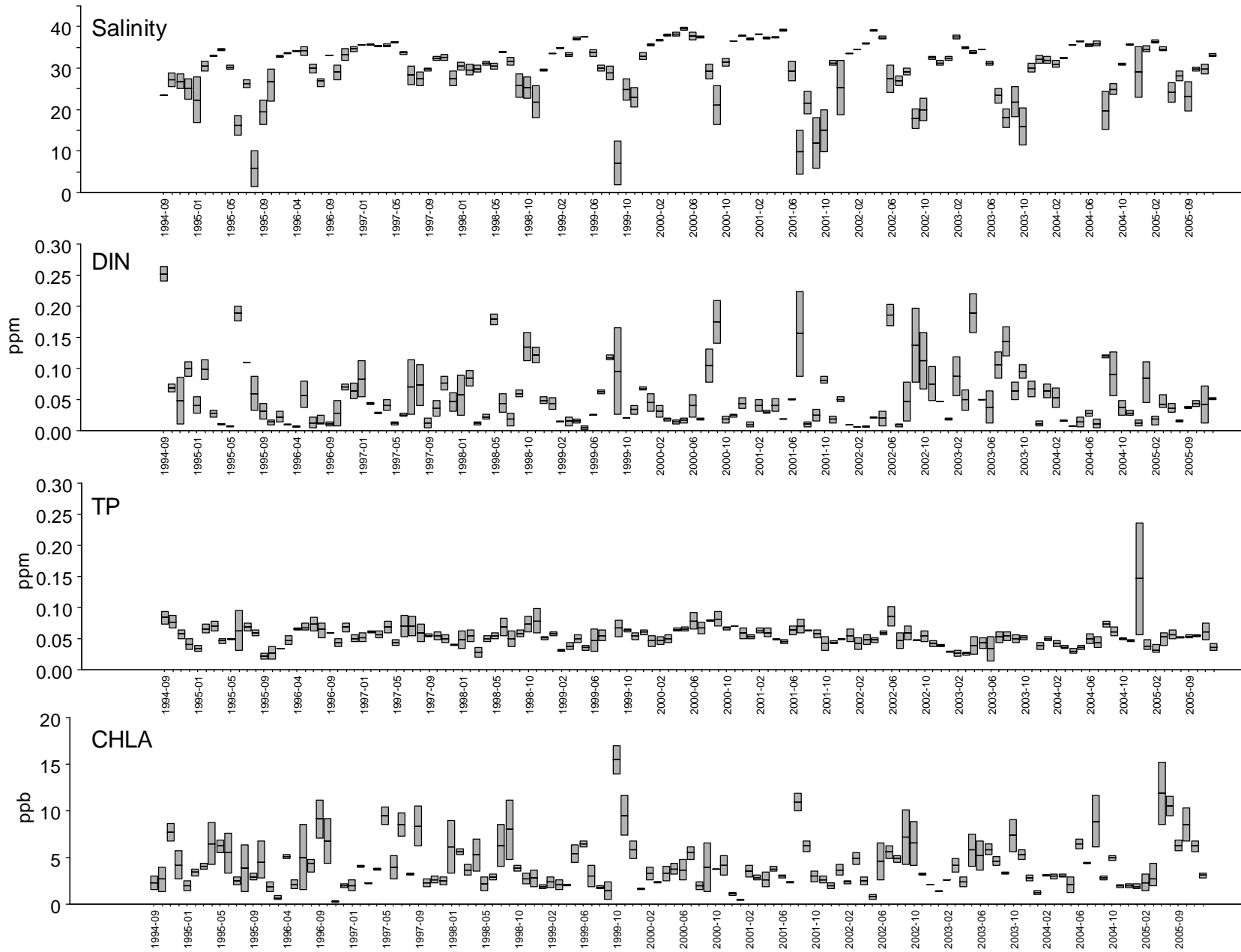


Figure 14. Box-and-whisker plots of water quality in WWB-TTI by survey.

Alongshore Zone

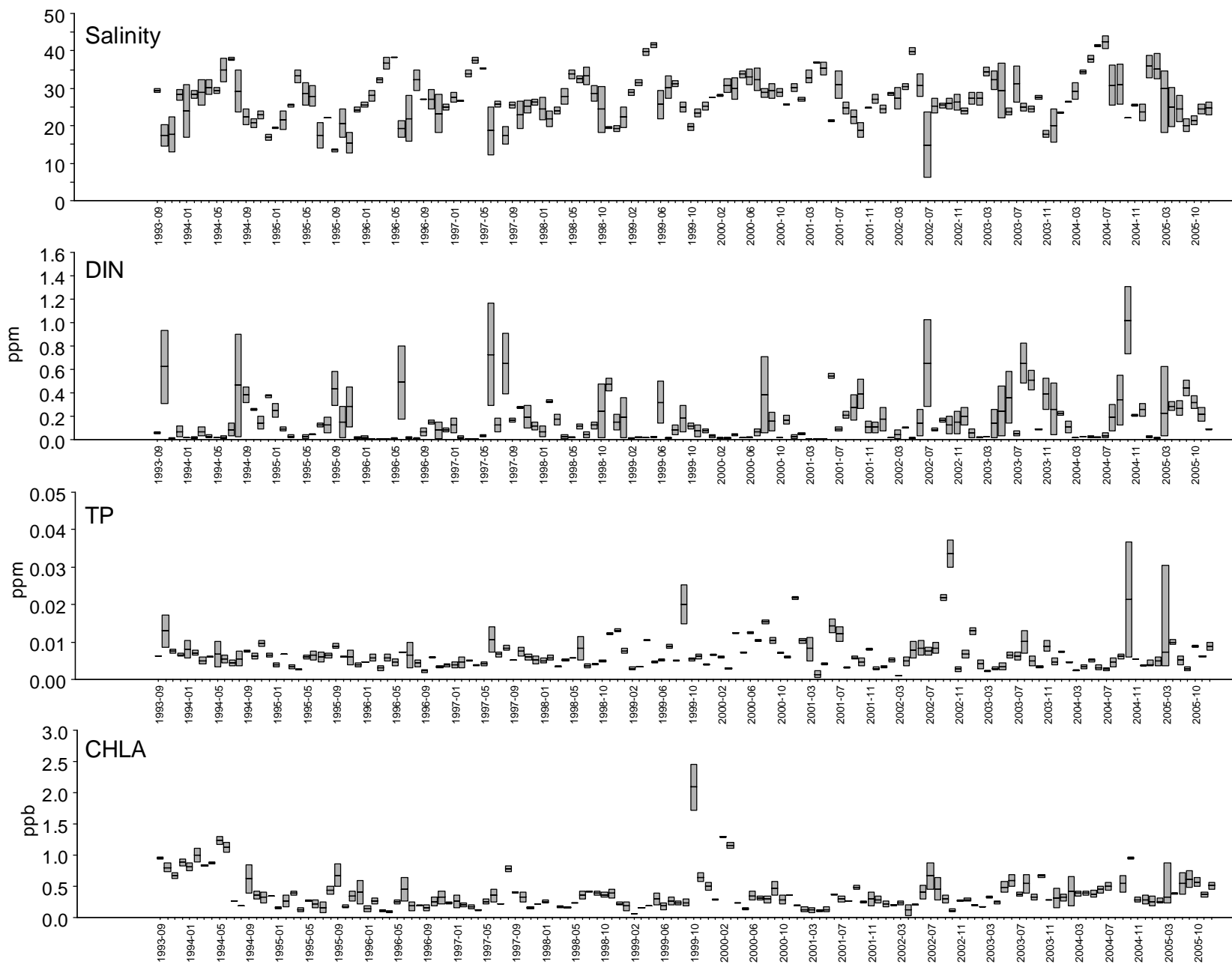


Figure 15. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Inshore Zone

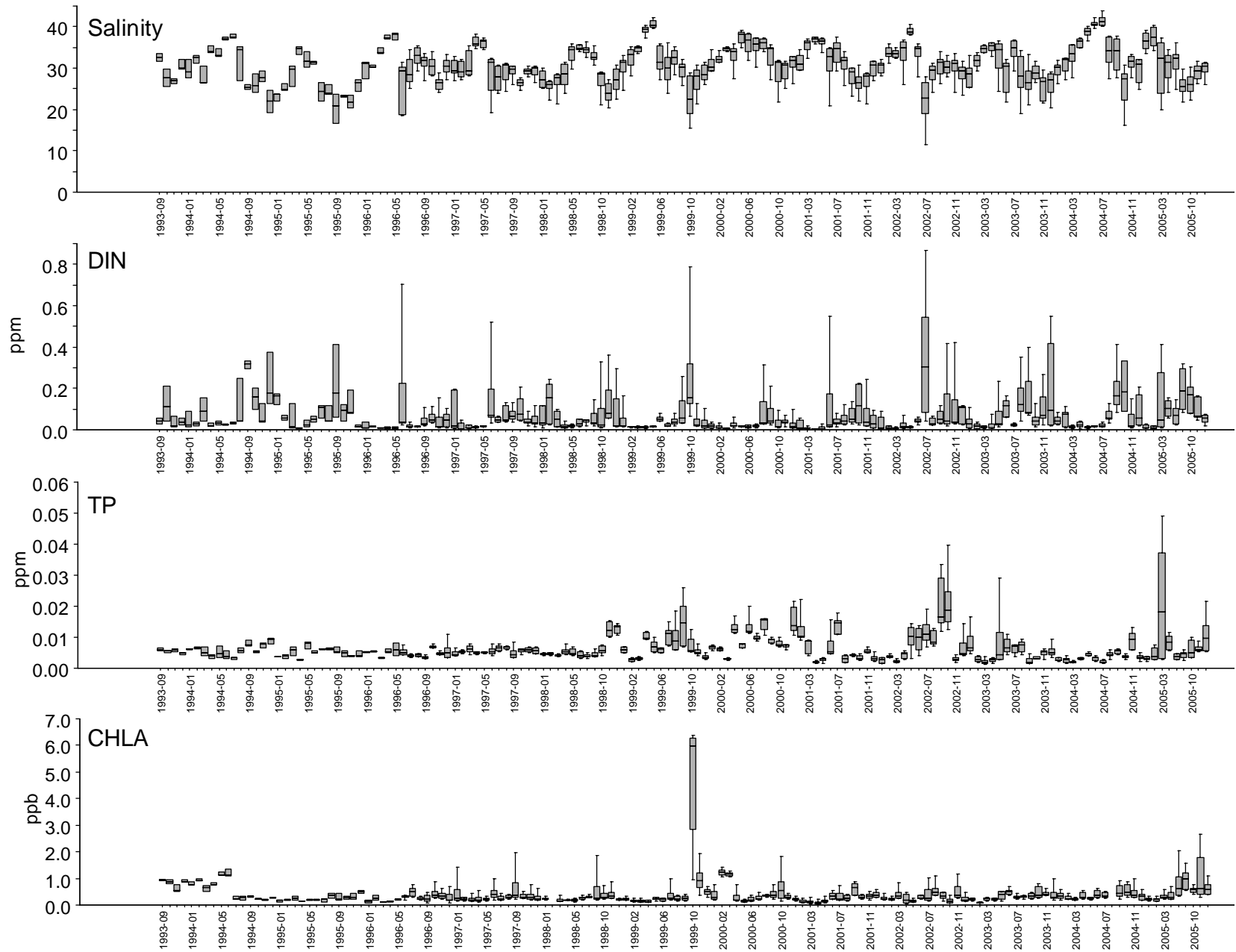


Figure 16. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Main Bay Zone

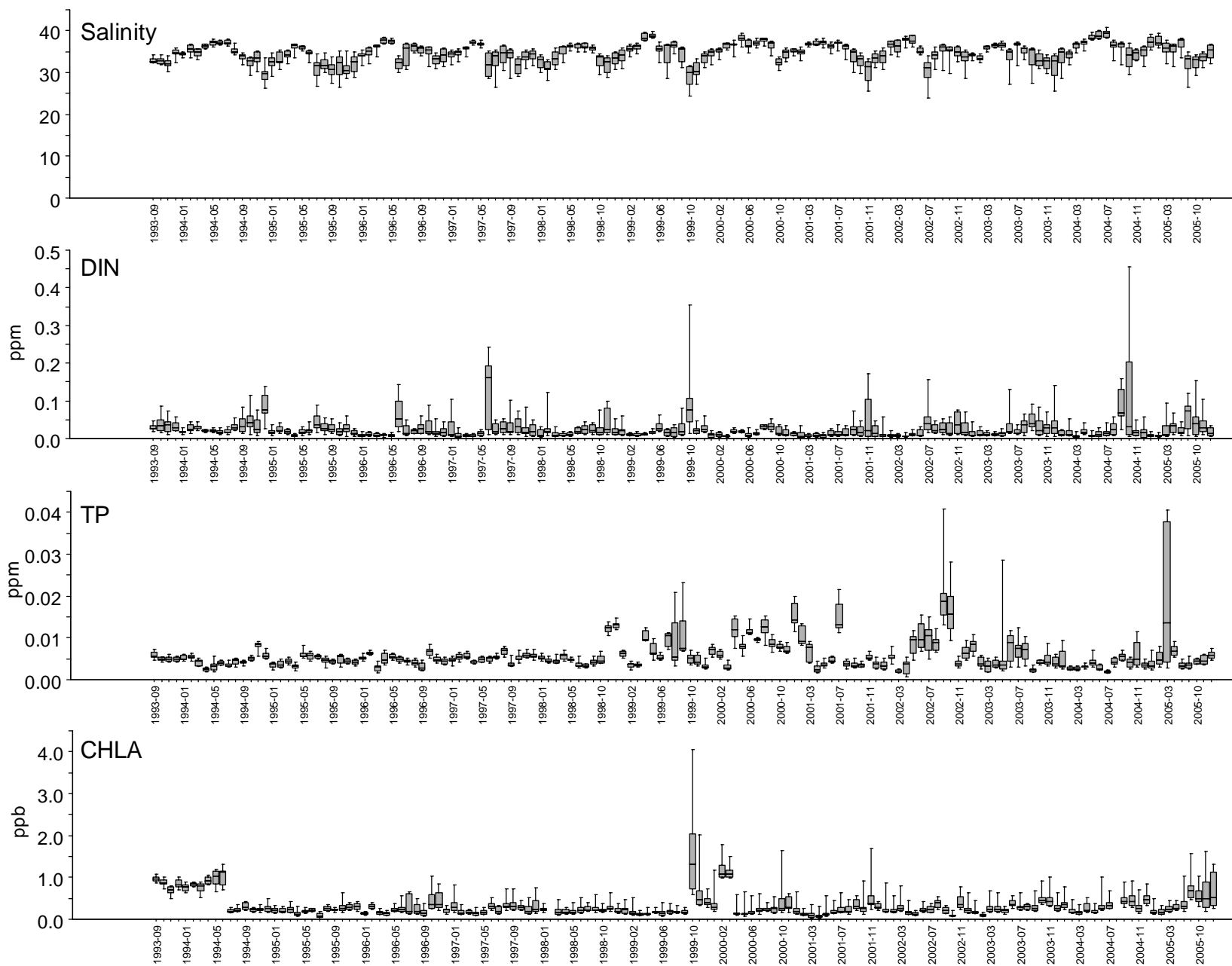


Figure 17. Box-and-whisker plots of water quality in Biscayne Bay by survey.

South Card Sound Zone

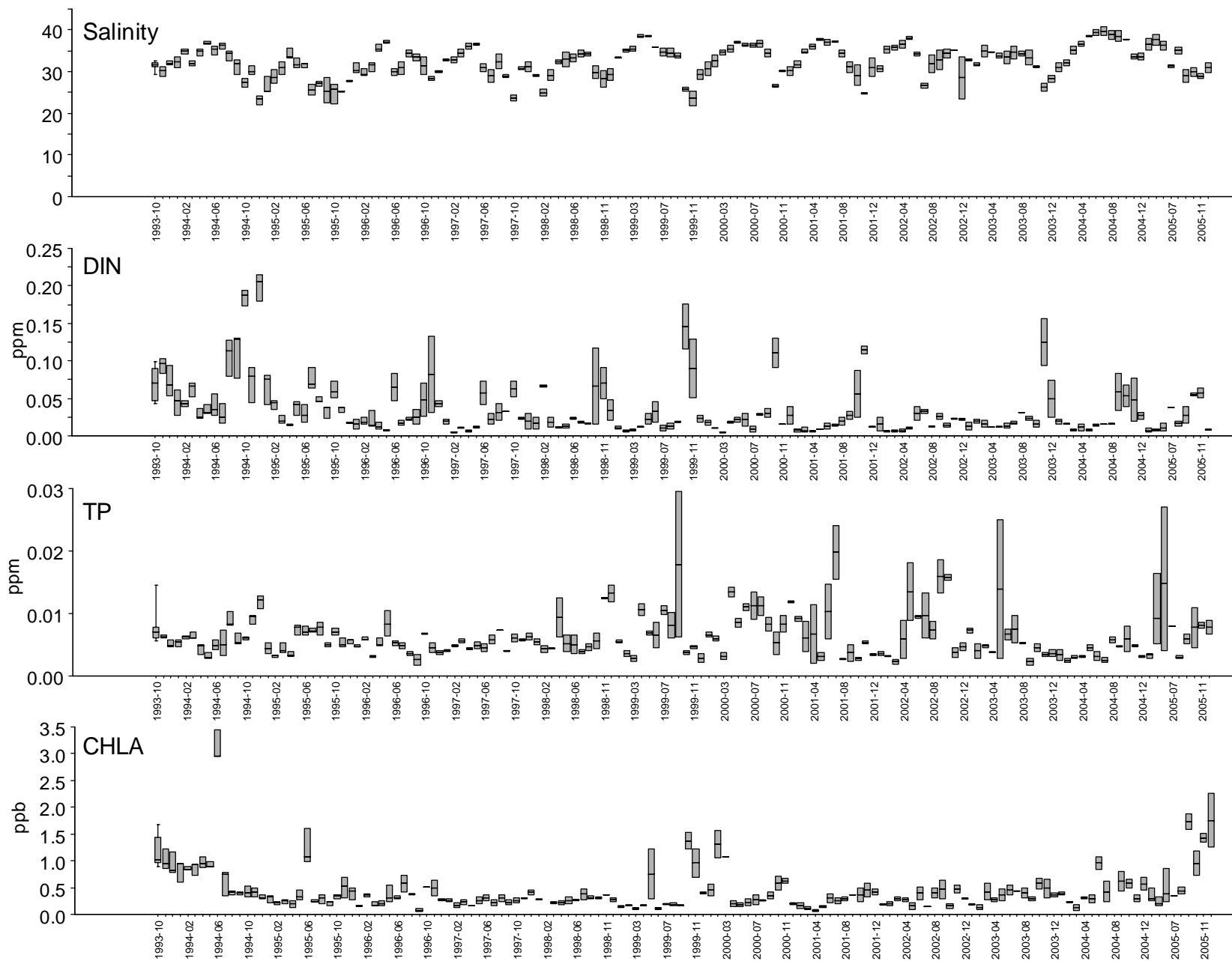


Figure 18. Box-and-whisker plots of water quality in Biscayne Bay by survey.

North Bay Zone

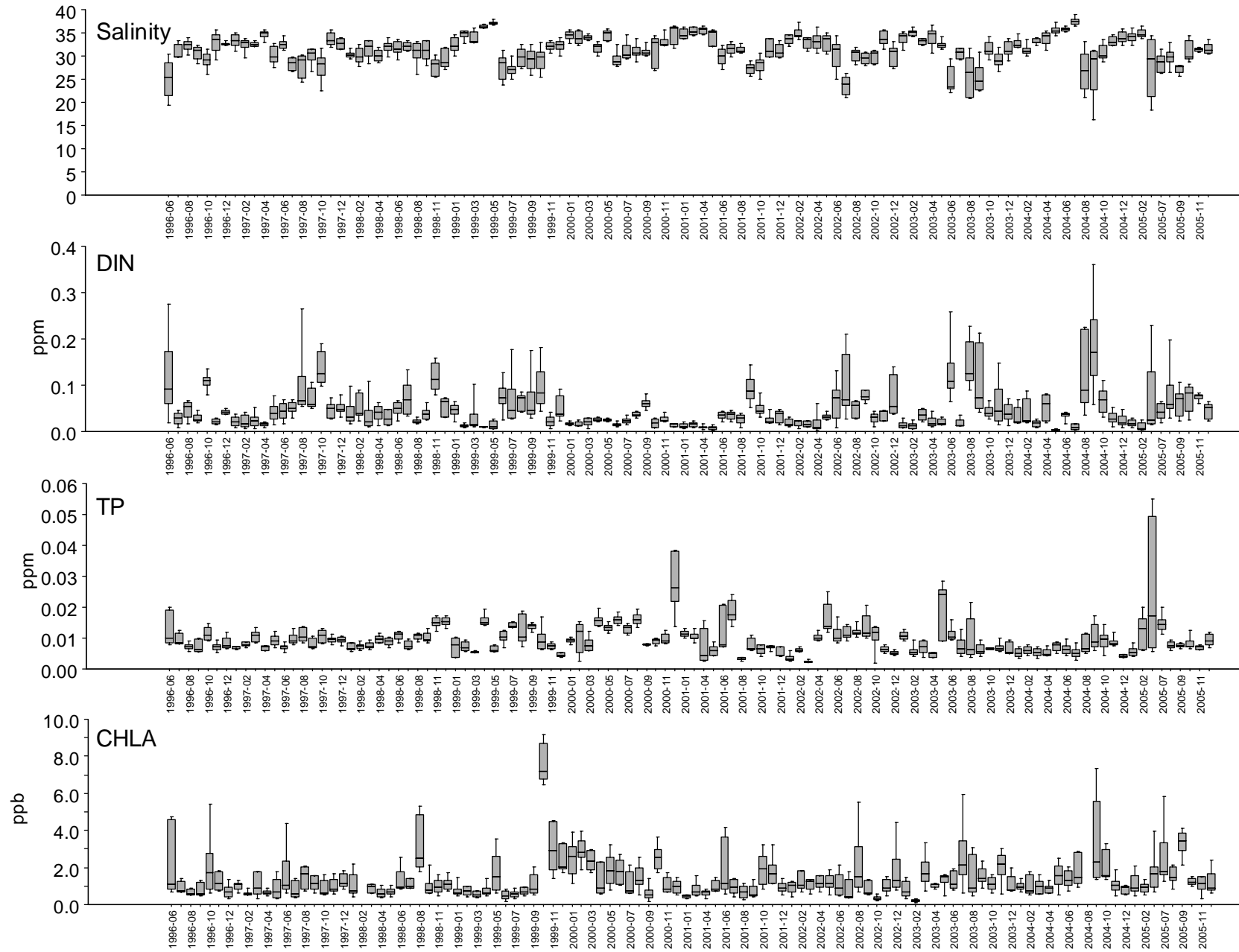


Figure 19. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Shelf Zone

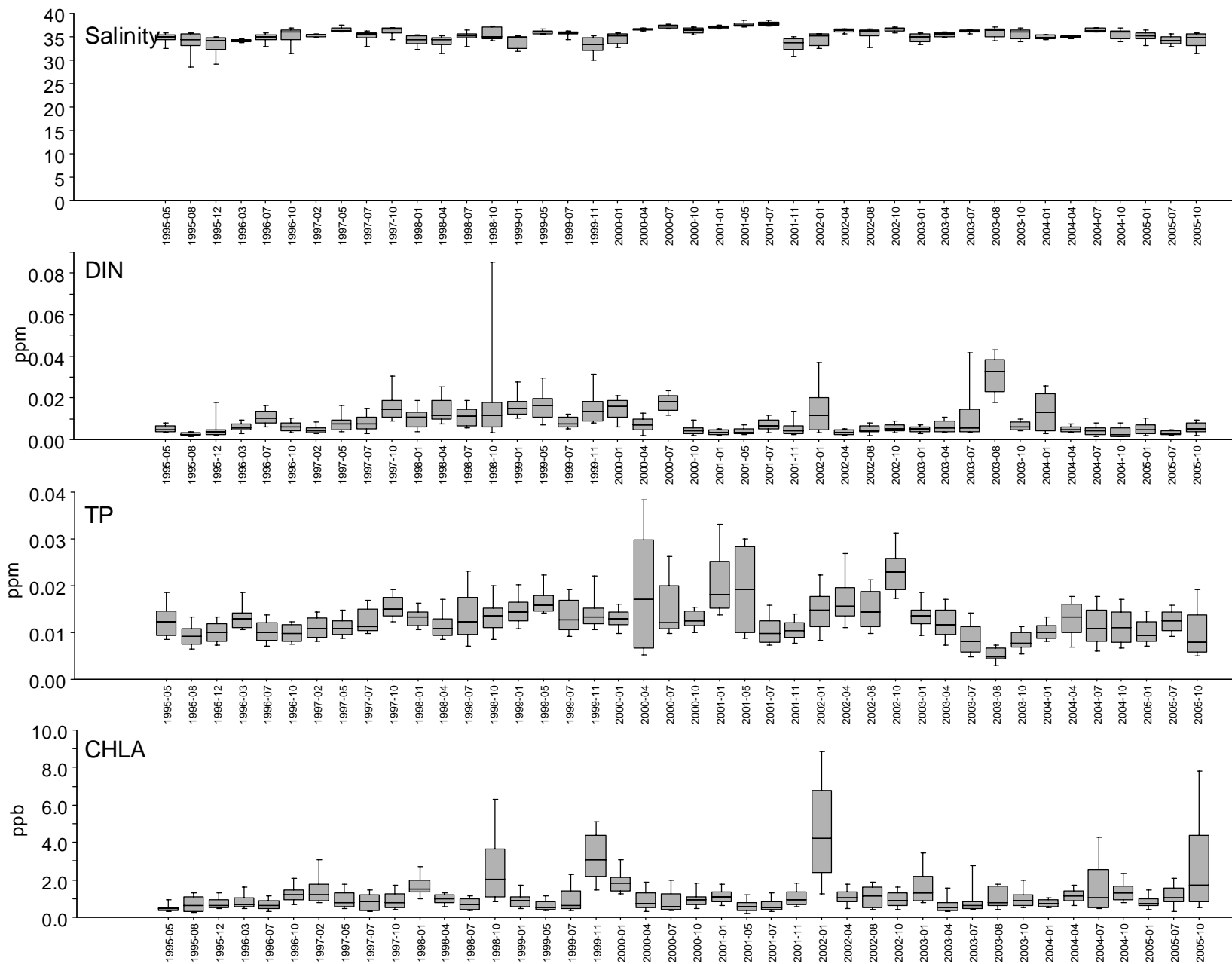


Figure 20. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Shark Zone

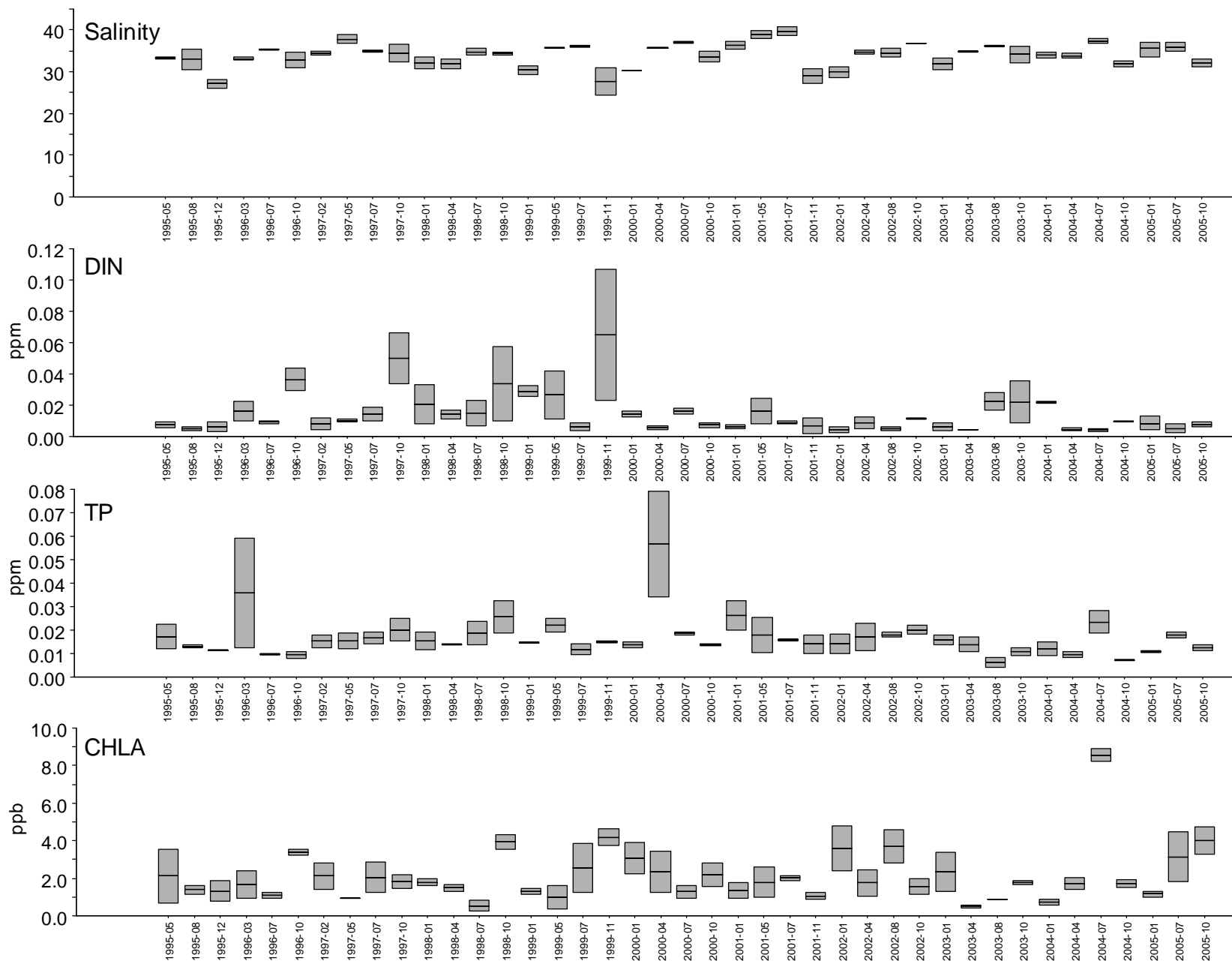


Figure 21. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Shoal Zone

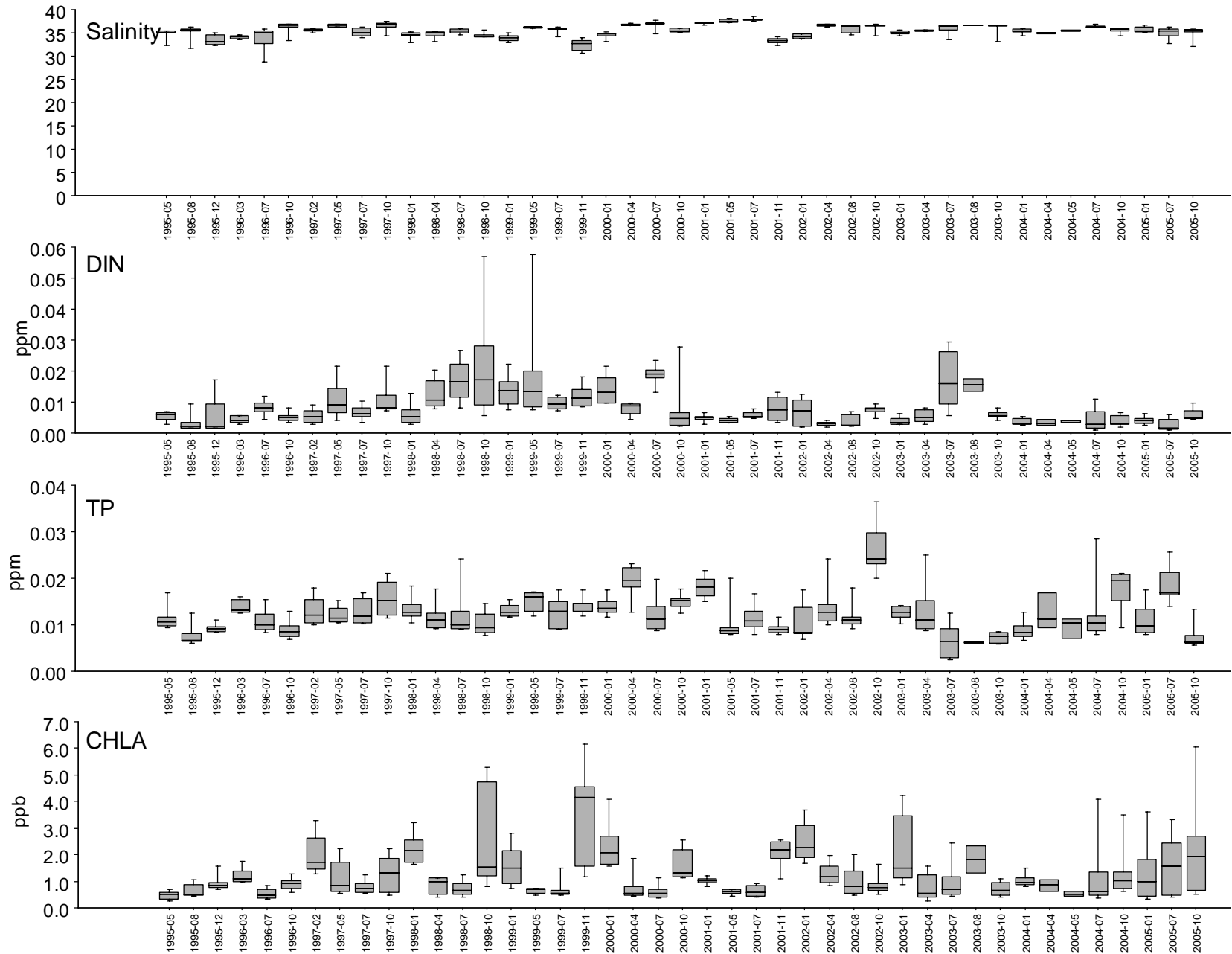


Figure 22. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Marco Zone

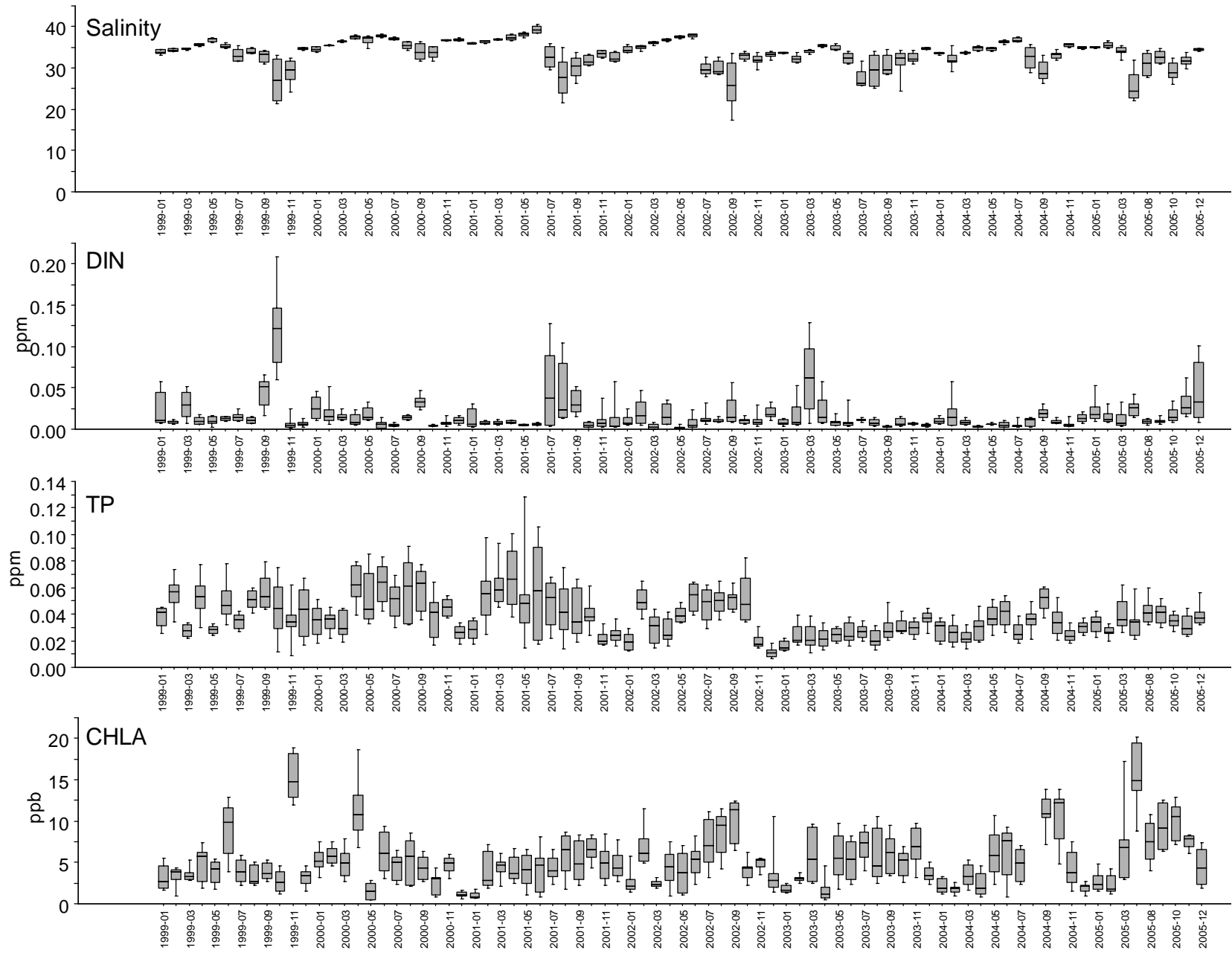


Figure 23. Box-and-whisker plots of water quality in RB-PIS by survey.

Rookery Bay Zone

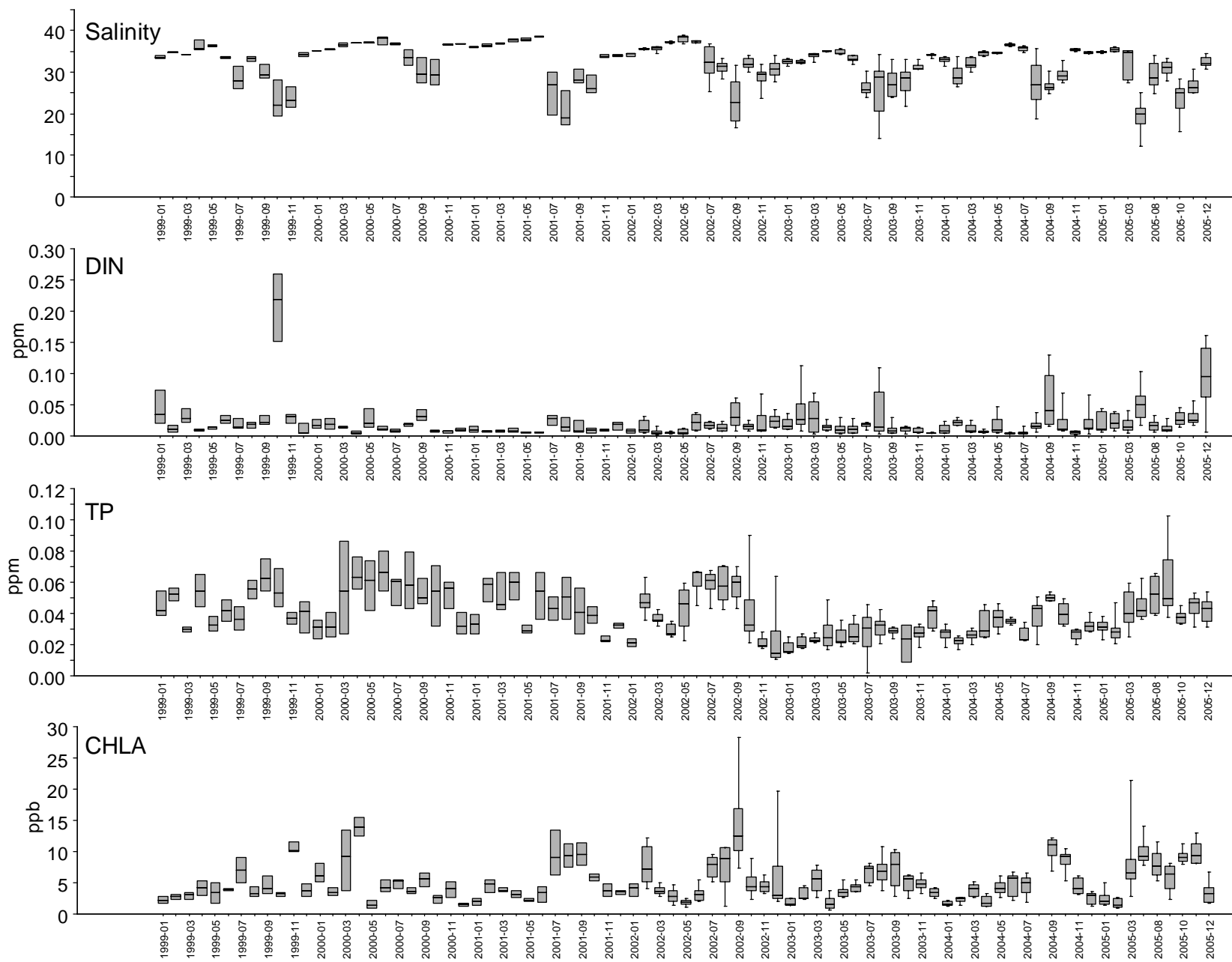


Figure 24. Box-and-whisker plots of water quality in RB-PIS by survey.

Naples Zone

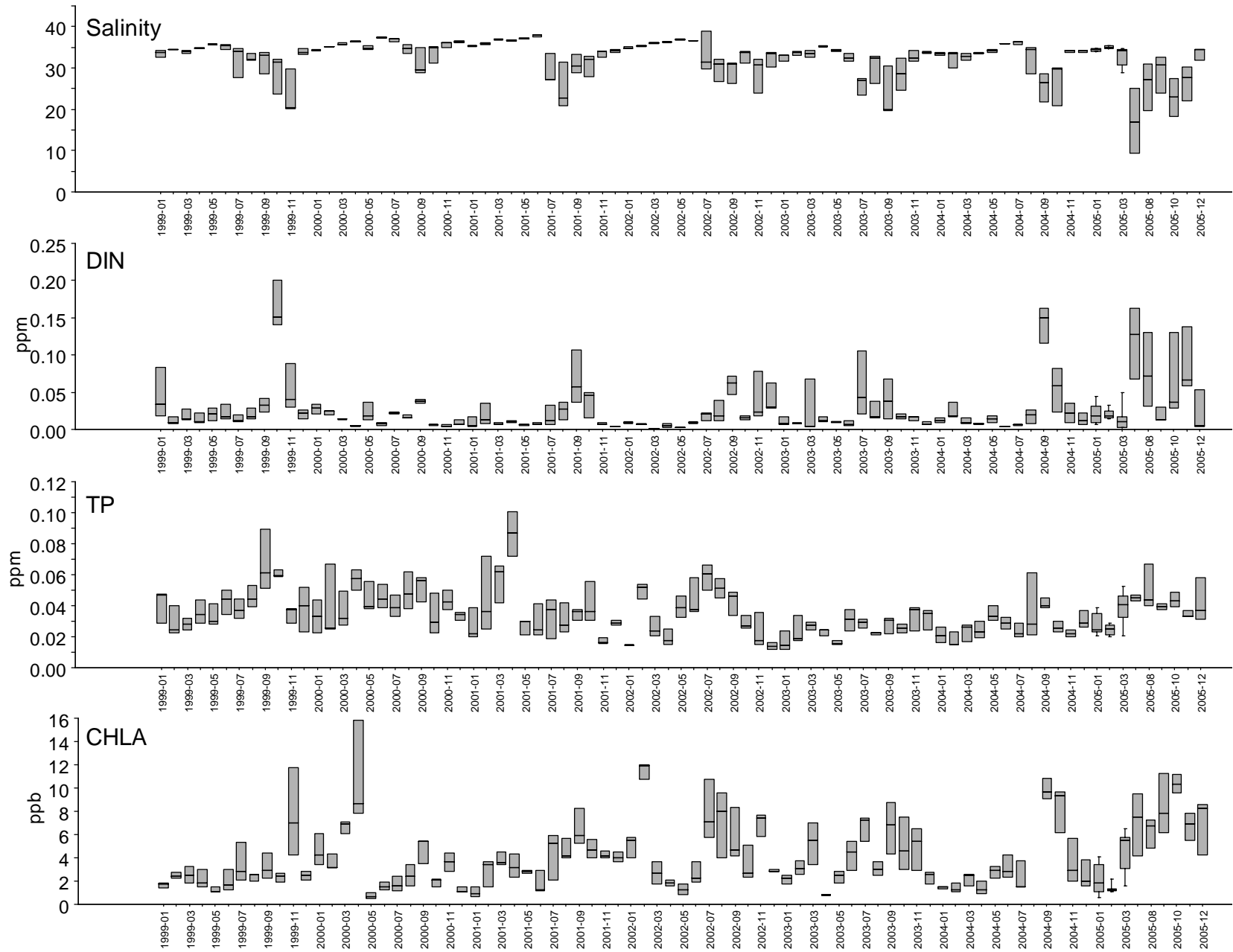


Figure 25. Box-and-whisker plots of water quality in RB-PIS by survey.

San Carlos Bay Zone

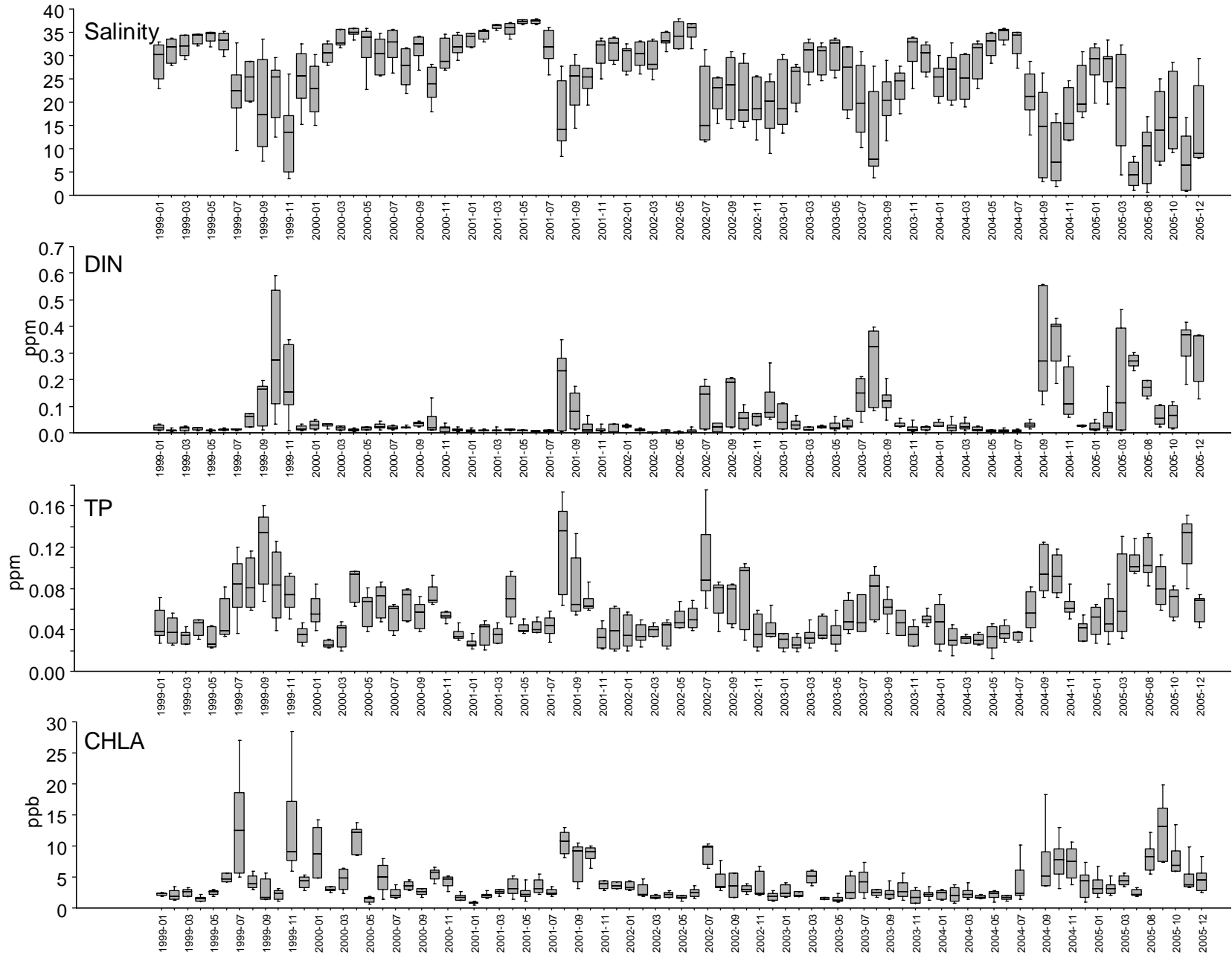


Figure 26. Box-and-whisker plots of water quality in RB-PIS by survey.

Estero Bay Zone

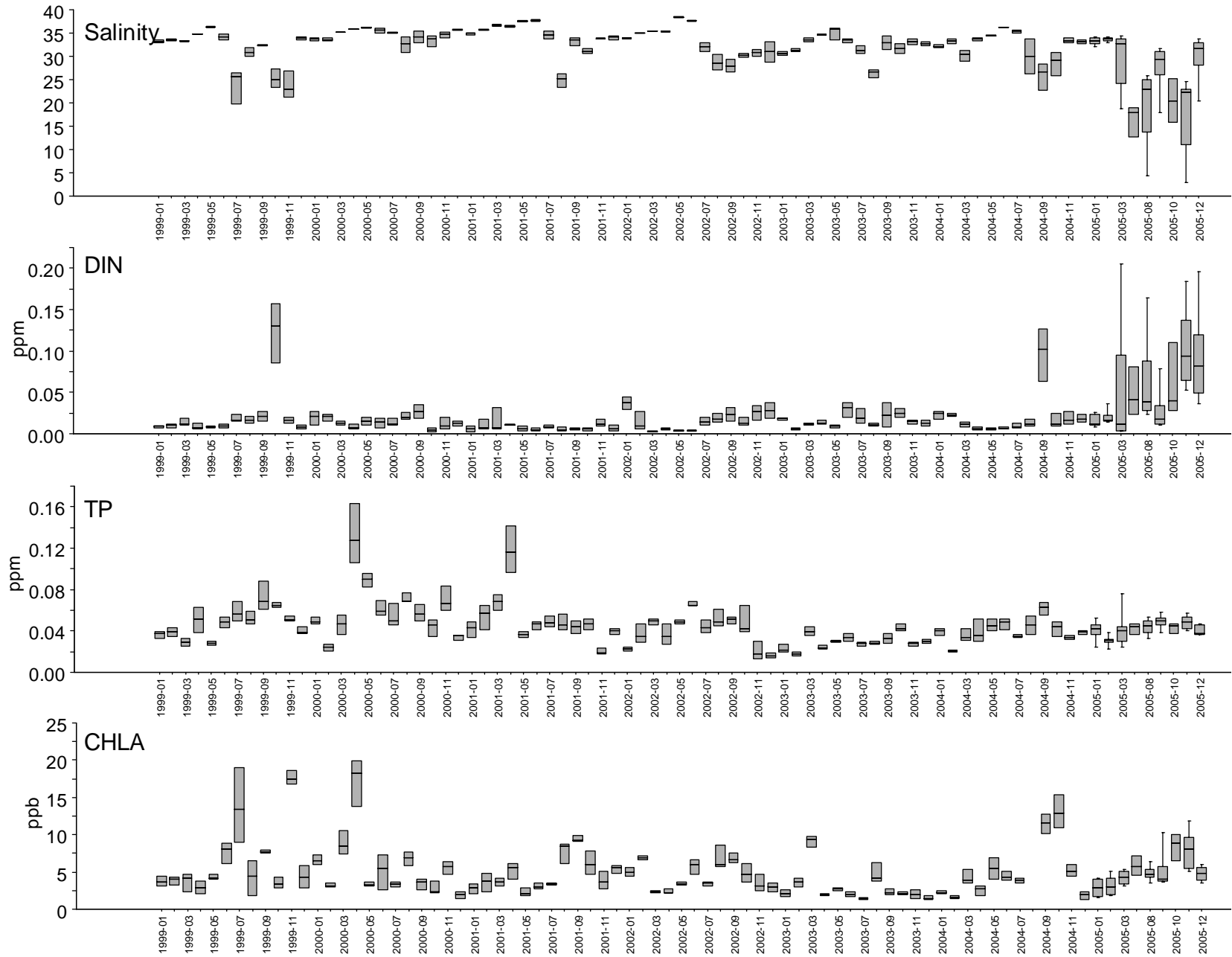


Figure 27. Box-and-whisker plots of water quality in RB-PIS by survey.

Pine Island Sound Zone

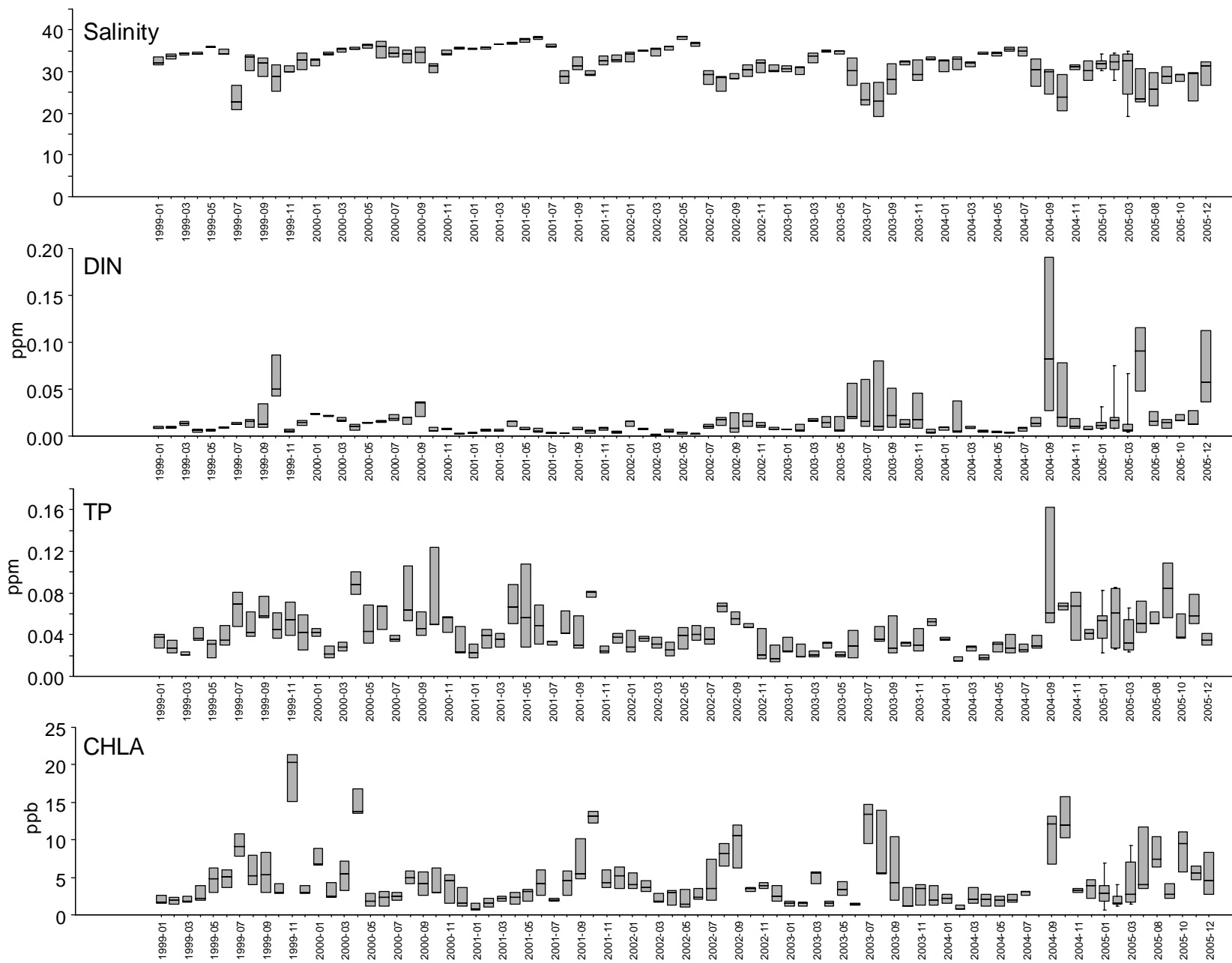


Figure 28. Box-and-whisker plots of water quality in RB-PIS by survey.

Table 1.

Parameter	Zone	Median	Min.	Max.	<i>n</i>
Alkaline	Biscayne Bay	0.139	0.068	1.526	75
Phosphatase Activity ($\mu\text{M h}^{-1}$)	Florida Bay	1.278	0.051	3.565	84
	Rookery Bay	0.062	0.010	0.146	87
	SW Shelf	0.055	0.018	0.439	49
	Ten Thousand Is.	0.059	0.018	1.735	78
	Whitewater Bay	0.582	0.048	3.113	44
Chlorophyll <i>a</i> ($\mu\text{g l}^{-1}$)	Biscayne Bay	0.632	0.187	2.650	75
	Florida Bay	2.258	0.156	12.376	84
	Rookery Bay	7.005	1.679	13.422	87
	SW Shelf	1.835	0.236	11.382	49
	Ten Thousand Is.	5.970	1.746	20.574	78
	Whitewater Bay	6.068	0.984	22.451	44
Surface Dissolved Oxygen (mg l^{-1})	Biscayne Bay	6.97	5.77	8.29	75
	Florida Bay	7.43	3.36	10.31	84
	Rookery Bay	6.18	2.33	8.50	87
	SW Shelf	6.13	3.74	6.84	49
	Ten Thousand Is.	6.44	4.10	11.46	78
	Whitewater Bay	7.62	3.80	9.39	44
Bottom Dissolved Oxygen (mg l^{-1})	Biscayne Bay	7.04	5.86	8.11	75
	Florida Bay	7.49	5.85	10.27	84
	Rookery Bay	6.47	4.38	8.51	87
	SW Shelf	6.41	4.60	12.18	49
	Ten Thousand Is.	6.48	3.65	11.54	78
	Whitewater Bay	7.75	3.90	9.37	44
NH_4^+ (ppm)	Biscayne Bay	0.020	0.002	0.090	75
	Florida Bay	0.019	0.002	0.273	84
	Rookery Bay	0.025	0.001	0.141	87
	SW Shelf	0.002	0.000	0.017	49
	Ten Thousand Is.	0.016	0.001	0.070	78
	Whitewater Bay	0.035	0.002	0.104	44

Parameter	Zone	Median	Min.	Max.	<i>n</i>
NO ₂ ⁻ (ppm)	Biscayne Bay	0.002	0.000	0.010	75
	Florida Bay	0.001	0.000	0.012	84
	Rookery Bay	0.002	0.000	0.027	87
	SW Shelf	0.000	0.000	0.001	49
	Ten Thousand Is.	0.002	0.000	0.007	78
	Whitewater Bay	0.002	0.000	0.022	44
NO ₃ ⁻ (ppm)	Biscayne Bay	0.024	0.001	0.271	75
	Florida Bay	0.011	0.000	0.057	84
	Rookery Bay	0.016	0.002	0.307	87
	SW Shelf	0.002	0.000	0.005	49
	Ten Thousand Is.	0.013	0.000	0.050	78
	Whitewater Bay	0.011	0.000	0.168	44
pH	Biscayne Bay	8.045	7.905	8.235	75
	Florida Bay	8.137	7.825	8.470	84
	Rookery Bay	7.875	7.360	8.050	87
	SW Shelf	7.885	7.675	7.980	49
	Ten Thousand Is.	7.768	7.375	8.200	78
	Whitewater Bay	7.890	7.300	8.355	44
Surface Salinity	Biscayne Bay	31.76	20.31	36.91	75
	Florida Bay	27.26	2.48	38.26	84
	Rookery Bay	29.65	1.27	34.76	87
	SW Shelf	34.96	30.57	36.40	49
	Ten Thousand Is.	22.41	0.38	33.48	78
	Whitewater Bay	9.04	0.47	28.23	44
Bottom Salinity	Biscayne Bay	31.34	20.40	36.84	75
	Florida Bay	27.01	2.47	38.30	84
	Rookery Bay	28.61	0.76	34.66	87
	SW Shelf	34.86	30.07	36.37	49
	Ten Thousand Is.	21.34	0.42	33.47	78
	Whitewater Bay	8.88	0.47	28.16	44
Si(OH) ₄ (ppm)	Biscayne Bay	0.132	0.004	0.684	25
	Florida Bay	0.660	0.026	3.628	28
	Rookery Bay	1.247	0.314	2.940	29
	SW Shelf	0.024	0.000	0.766	49
	Ten Thousand Is.	1.257	0.159	2.283	26
	Whitewater Bay	.	.	.	0

Parameter	Zone	Median	Min.	Max.	<i>n</i>
Soluble	Biscayne Bay	0.001	0.001	0.004	75
Reactive	Florida Bay	0.002	0.000	0.007	84
Phosphorus (ppm)	Rookery Bay	0.011	0.001	0.122	87
	SW Shelf	0.002	0.000	0.003	49
	Ten Thousand Is.	0.005	0.001	0.033	78
	Whitewater Bay	0.001	0.000	0.006	44
Surface Temperature (°C)	Biscayne Bay	25.14	22.52	28.26	75
	Florida Bay	25.00	19.45	30.23	84
	Rookery Bay	25.09	19.19	30.92	87
	SW Shelf	28.85	27.94	29.32	49
	Ten Thousand Is.	25.27	20.79	28.42	78
	Whitewater Bay	23.06	21.09	23.96	44
Bottom Temperature (°C)	Biscayne Bay	25.18	22.52	28.31	75
	Florida Bay	25.02	20.15	30.23	84
	Rookery Bay	25.52	19.24	31.18	87
	SW Shelf	28.74	28.08	29.39	49
	Ten Thousand Is.	25.42	20.77	28.98	78
	Whitewater Bay	23.14	21.11	24.13	44
Total Nitrogen (ppm)	Biscayne Bay	0.243	0.011	0.657	74
	Florida Bay	0.360	0.068	0.736	84
	Rookery Bay	0.222	0.079	0.824	87
	SW Shelf	0.114	0.049	0.219	49
	Ten Thousand Is.	0.328	0.171	1.166	77
	Whitewater Bay	0.416	0.237	0.753	44
Total Organic Carbon (ppm)	Biscayne Bay	2.835	1.506	4.947	75
	Florida Bay	7.726	1.256	17.700	84
	Rookery Bay	5.276	2.631	14.070	87
	SW Shelf	1.663	1.055	2.995	49
	Ten Thousand Is.	7.292	4.289	20.985	78
	Whitewater Bay	13.445	6.044	20.930	44
Total Organic Nitrogen (ppm)	Biscayne Bay	0.180	0.000	0.606	74
	Florida Bay	0.304	0.009	0.706	84
	Rookery Bay	0.162	0.075	0.508	87
	SW Shelf	0.106	0.048	0.210	49
	Ten Thousand Is.	0.290	0.108	1.074	77
	Whitewater Bay	0.356	0.164	0.690	44

Parameter	Zone	Median	Min.	Max.	<i>n</i>
Total	Biscayne Bay	0.006	0.003	0.022	75
Phosphorus (ppm)	Florida Bay	0.020	0.004	0.099	84
	Rookery Bay	0.043	0.023	0.151	87
	SW Shelf	0.008	0.004	0.030	49
	Ten Thousand Is.	0.030	0.007	0.075	78
	Whitewater Bay	0.023	0.008	0.047	44
Turbidity (NTU)	Biscayne Bay	1.17	0.10	8.80	75
	Florida Bay	5.02	0.53	85.80	84
	Rookery Bay	5.57	1.49	17.93	87
	SW Shelf	3.04	0.31	29.00	49
	Ten Thousand Is.	6.65	0.84	28.70	78
	Whitewater Bay	5.15	1.15	15.93	44