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19 December 2003

Chad Kennedy
SFWMD
3301 Gun Club Road
West Palm Beach, FL 33416

Re: Estuarine Water Quality Monitoring Network Quarterly Report (C-15397)

Dear Mr. Kennedy:

This letter serves to transmit the Estuarine 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) July – Sep. 2003 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 ($Si(OH)_4$) 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 ($\mu g\ l^{-1}$) and alkaline phosphatase activity (APA; $\mu M\ hr^{-1}$). Field parameters measured at both surface and bottom of the water column include salinity, dissolved oxygen (DO; $mg\ l^{-1}$), and temperature (^oC). 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 there are less than 5 years of data available. This makes it unfeasible to perform a spatial statistic analysis. Therefore we will 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.

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,

Joseph N. Boyer, Ph.D.
Associate Director

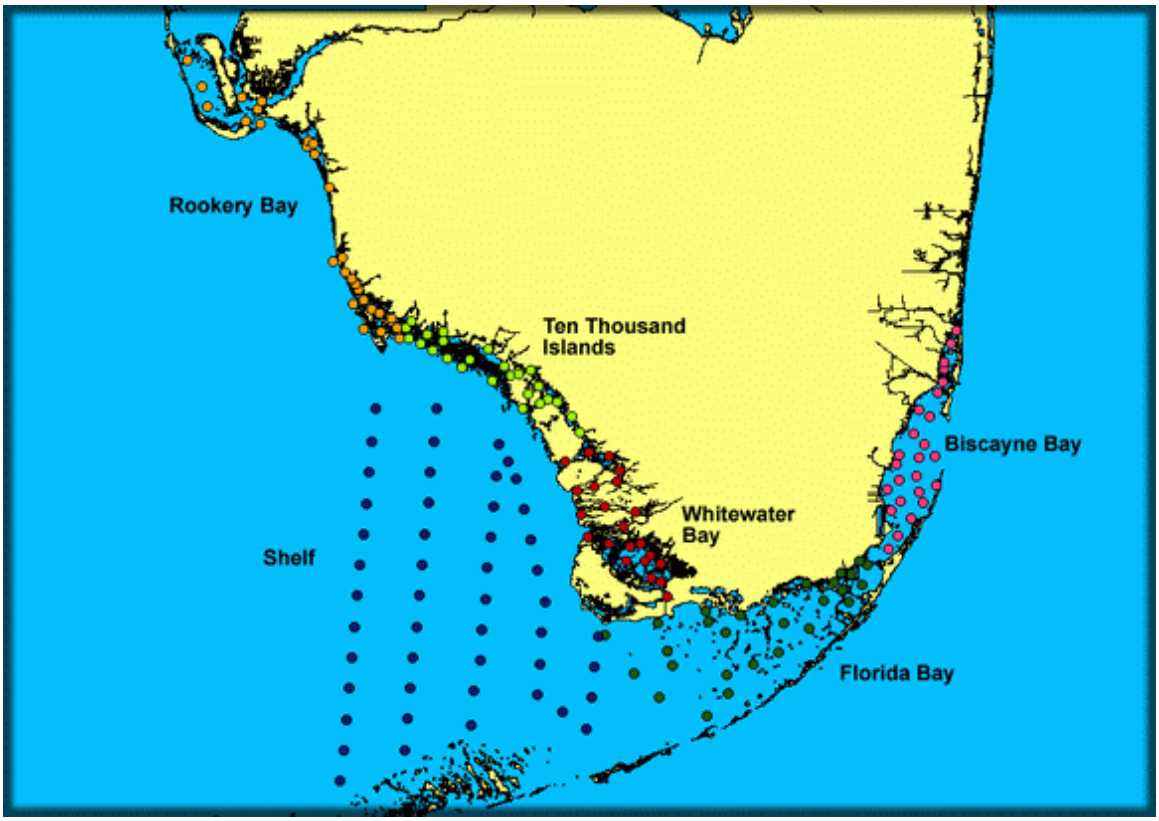

Figure 1: All fixed water quality stations funded by this SFWMD project.

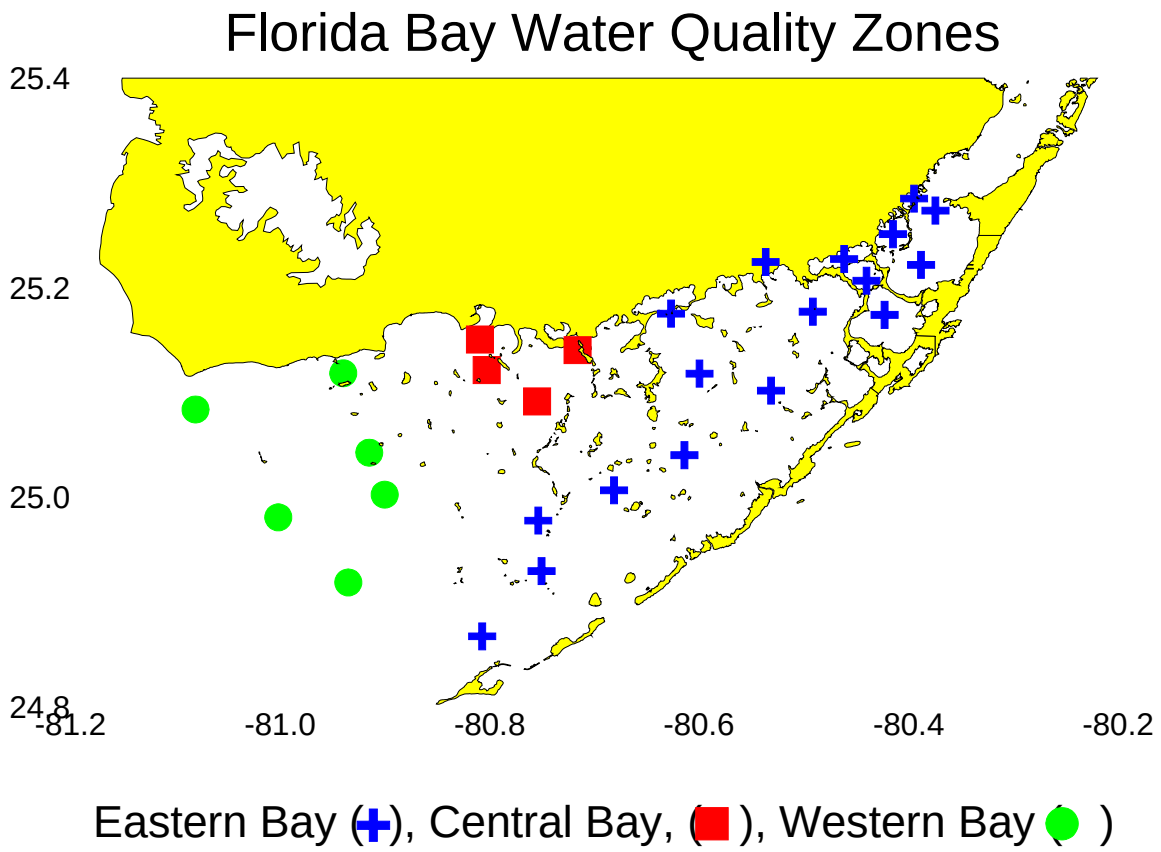

Figure 2. Florida Bay zones.

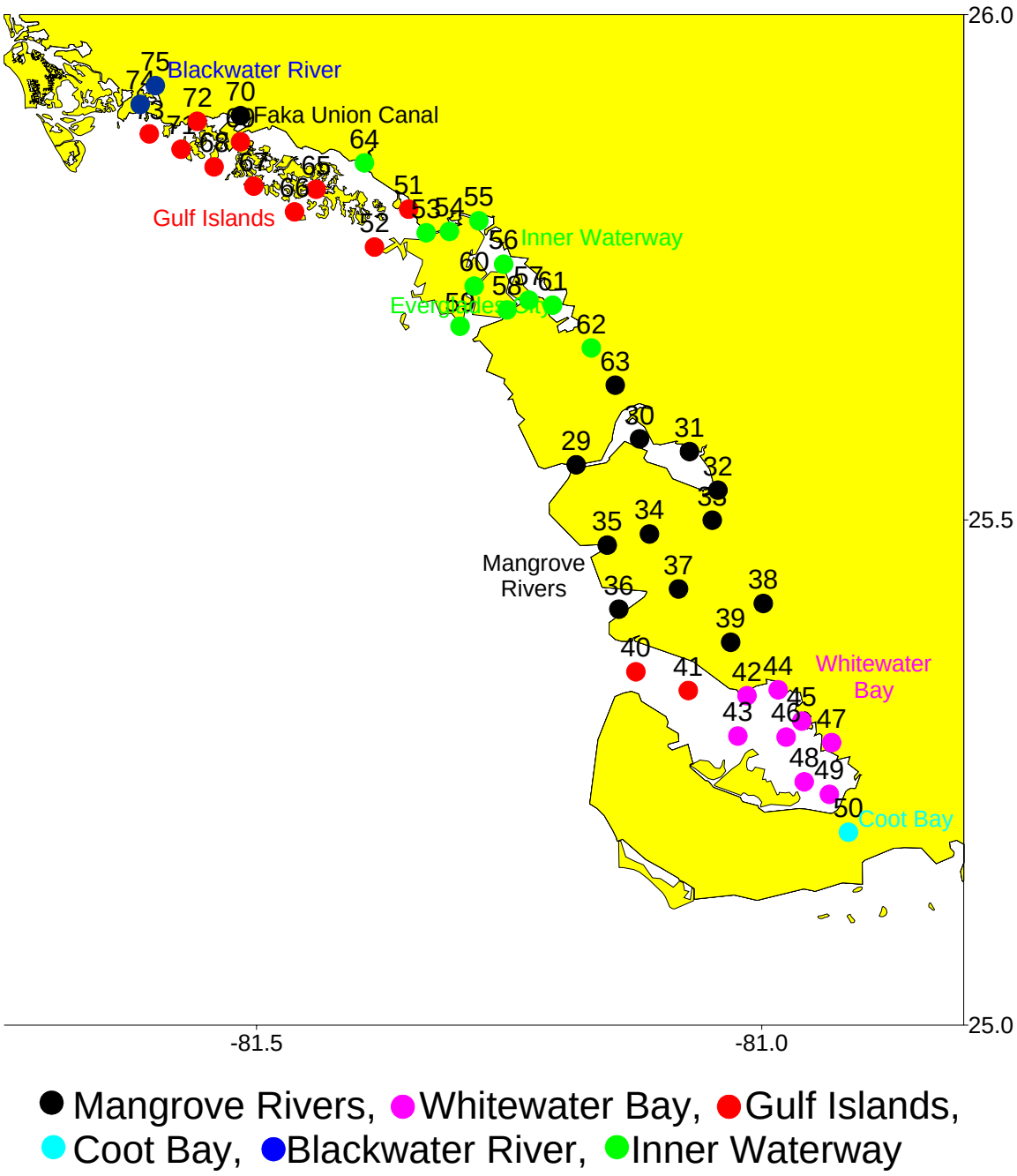

Figure 3. WWB-TTI water quality zones.

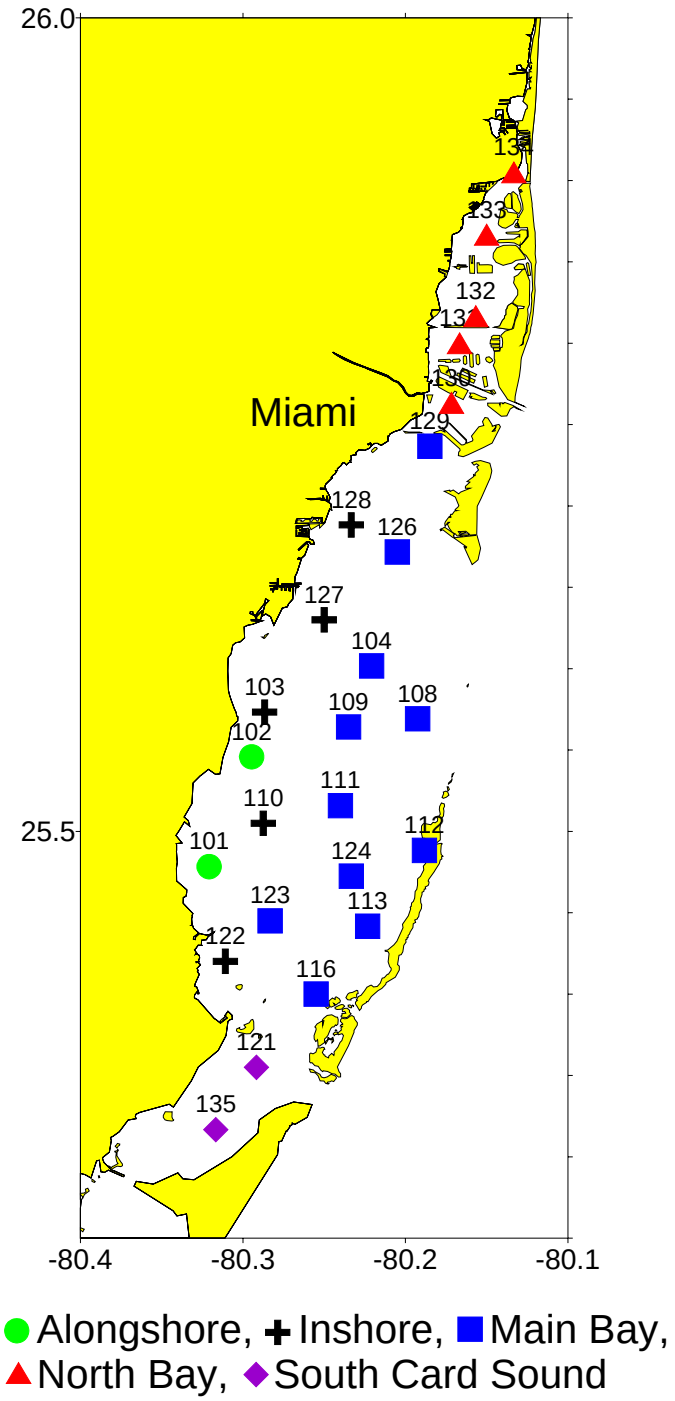

Figure 4. Biscayne Bay water quality zones.

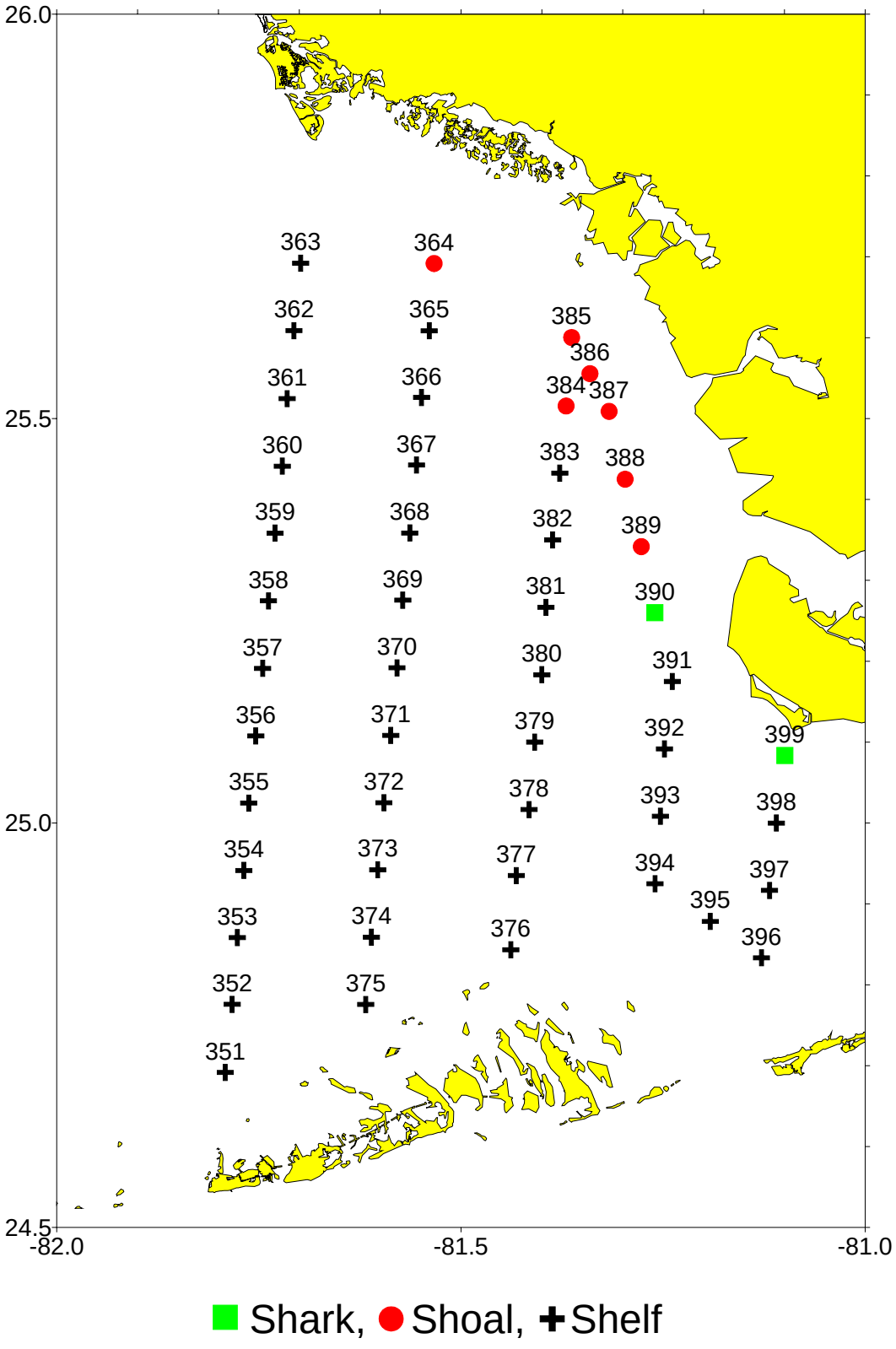

Figure 5. SW Florida Shelf water quality zones.

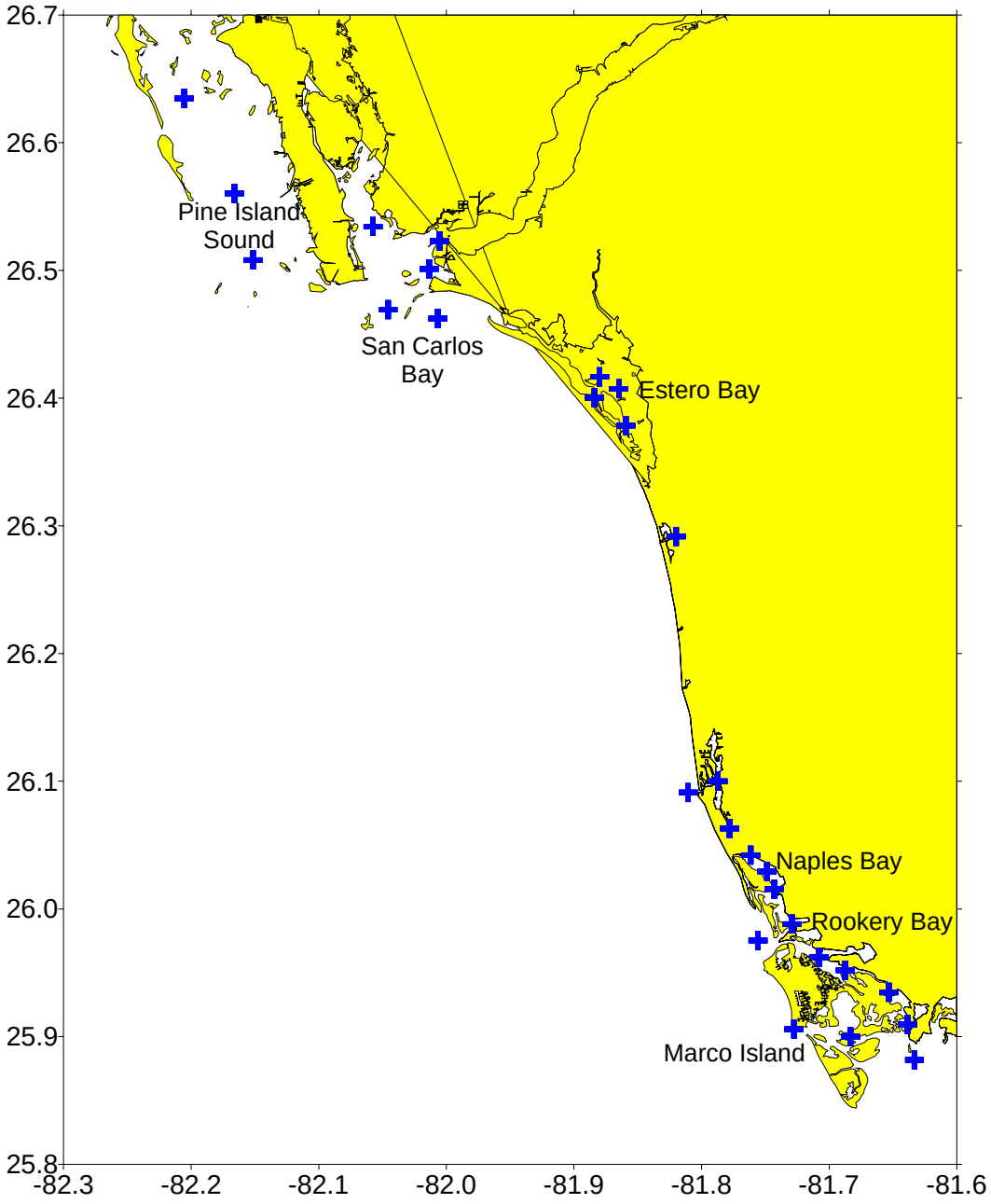

Figure 6. SW estuaries.

Eastern Florida Bay Zone

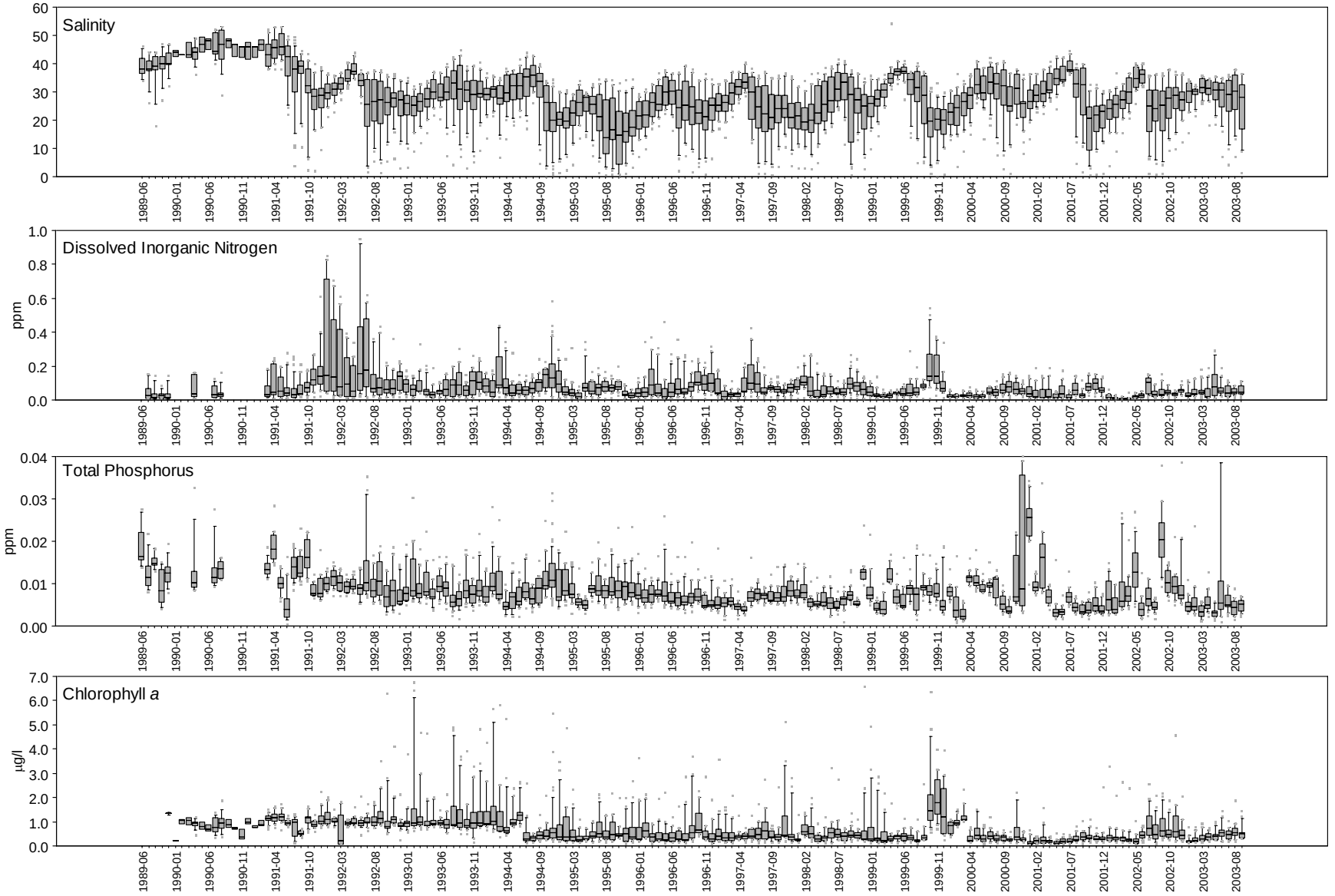

Figure 7. Box-and-whisker plots of water quality in Eastern Florida Bay by survey.

Central Florida Bay Zone

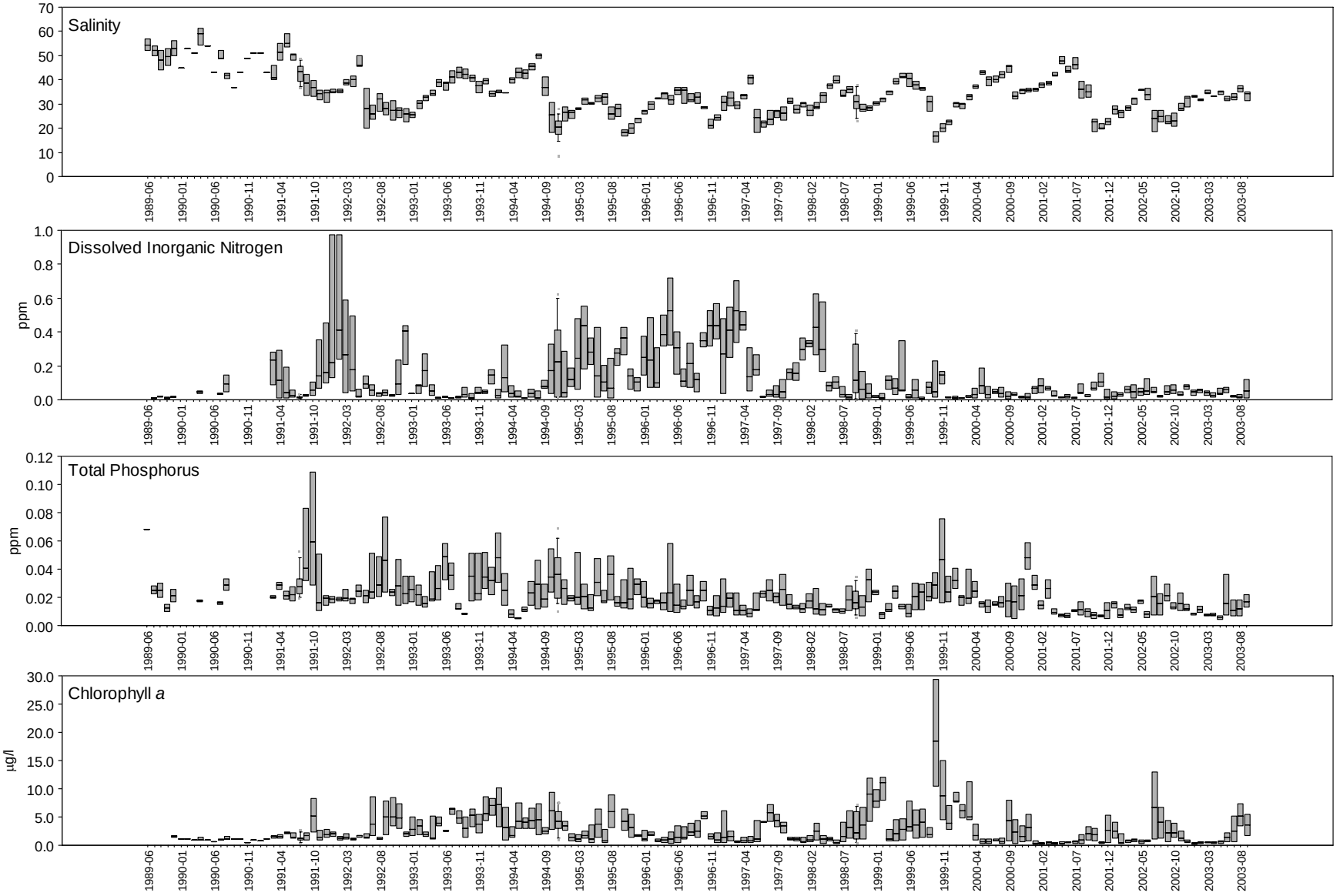

Figure 8. Box-and-whisker plots of water quality in Central Florida Bay by survey.

Western Florida Bay Zone

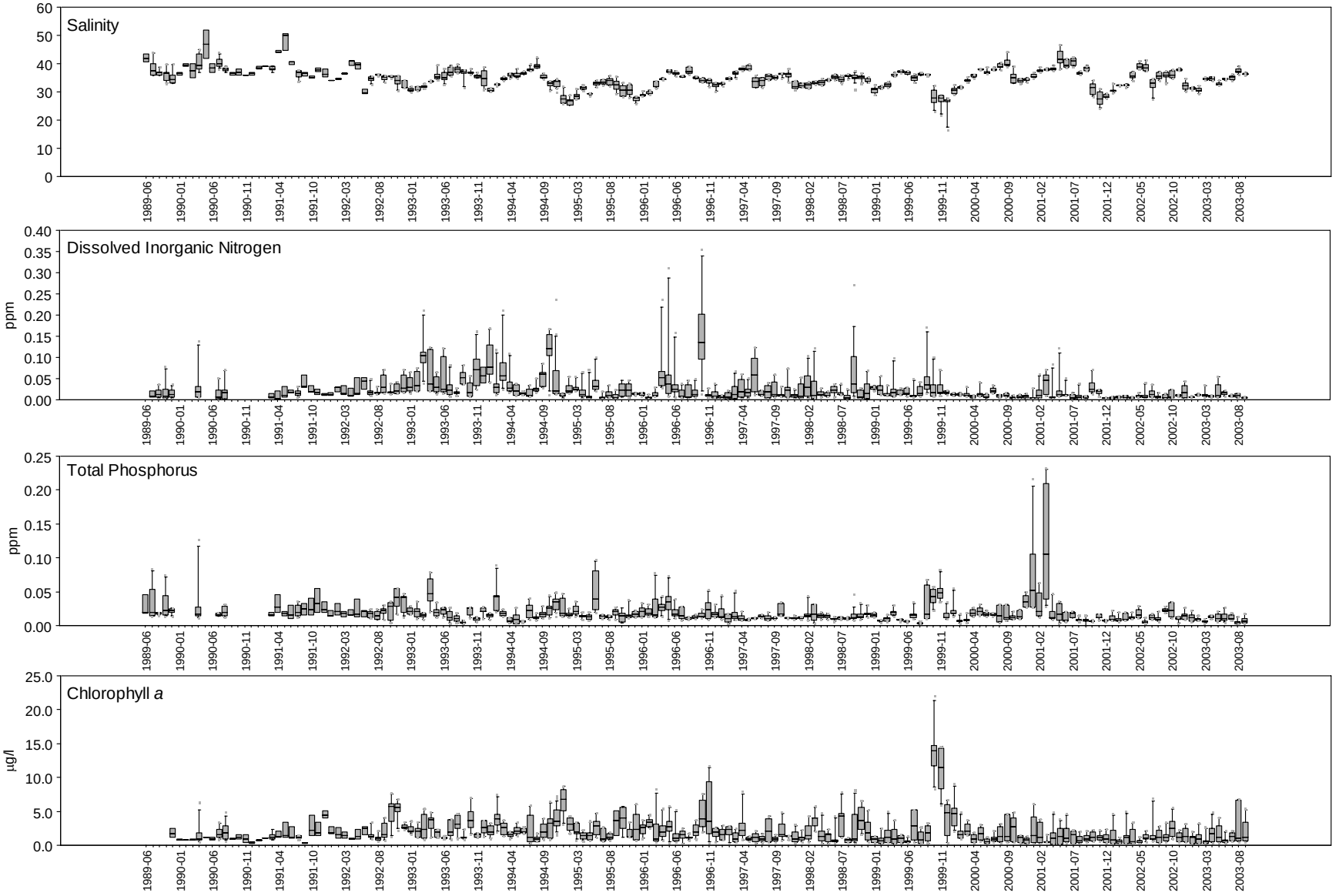

Figure 9. Box-and-whisker plots of water quality in Western Florida Bay by survey.

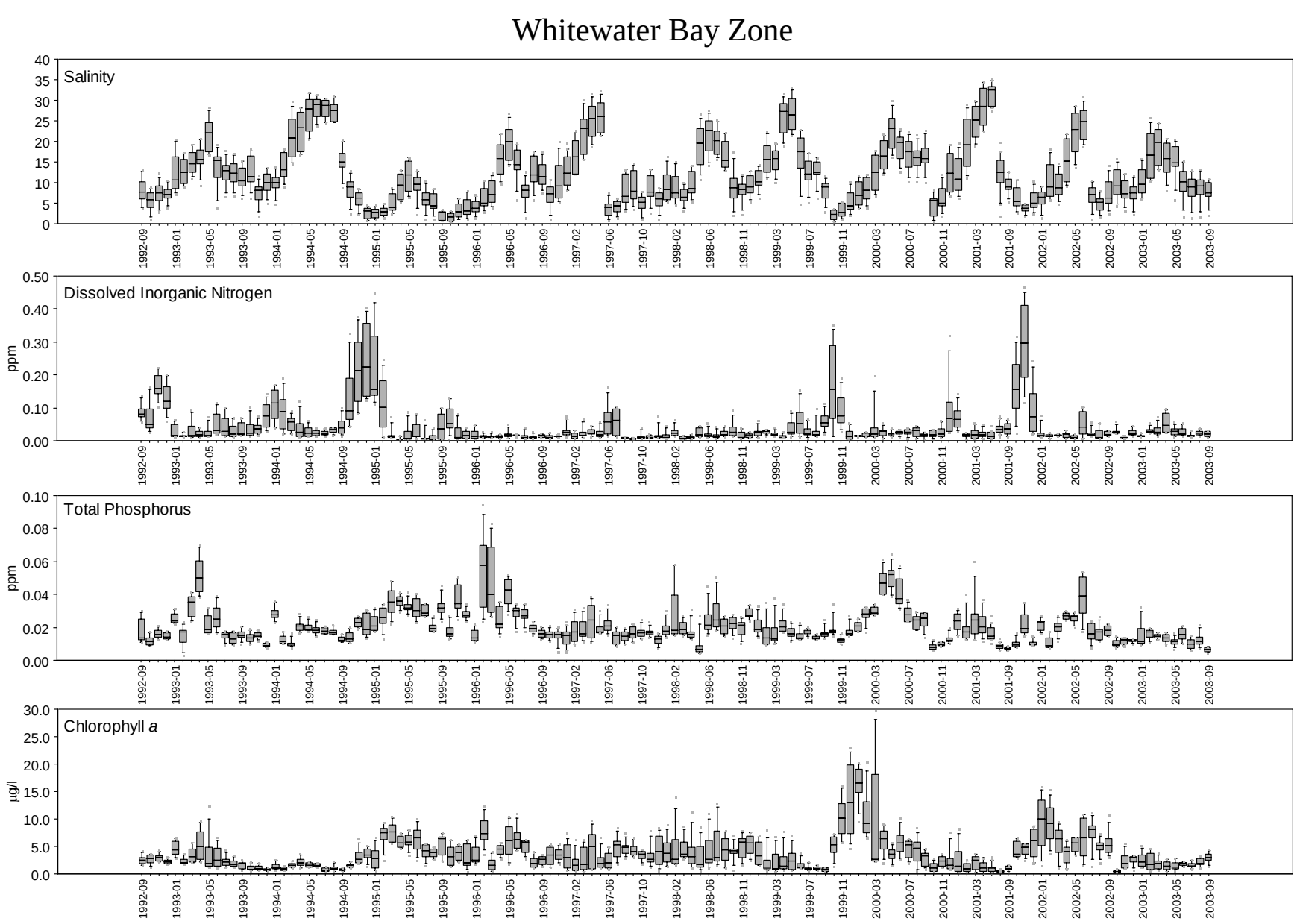

Figure 10. Box-and-whisker plots of water quality in WWB-TTI by survey.

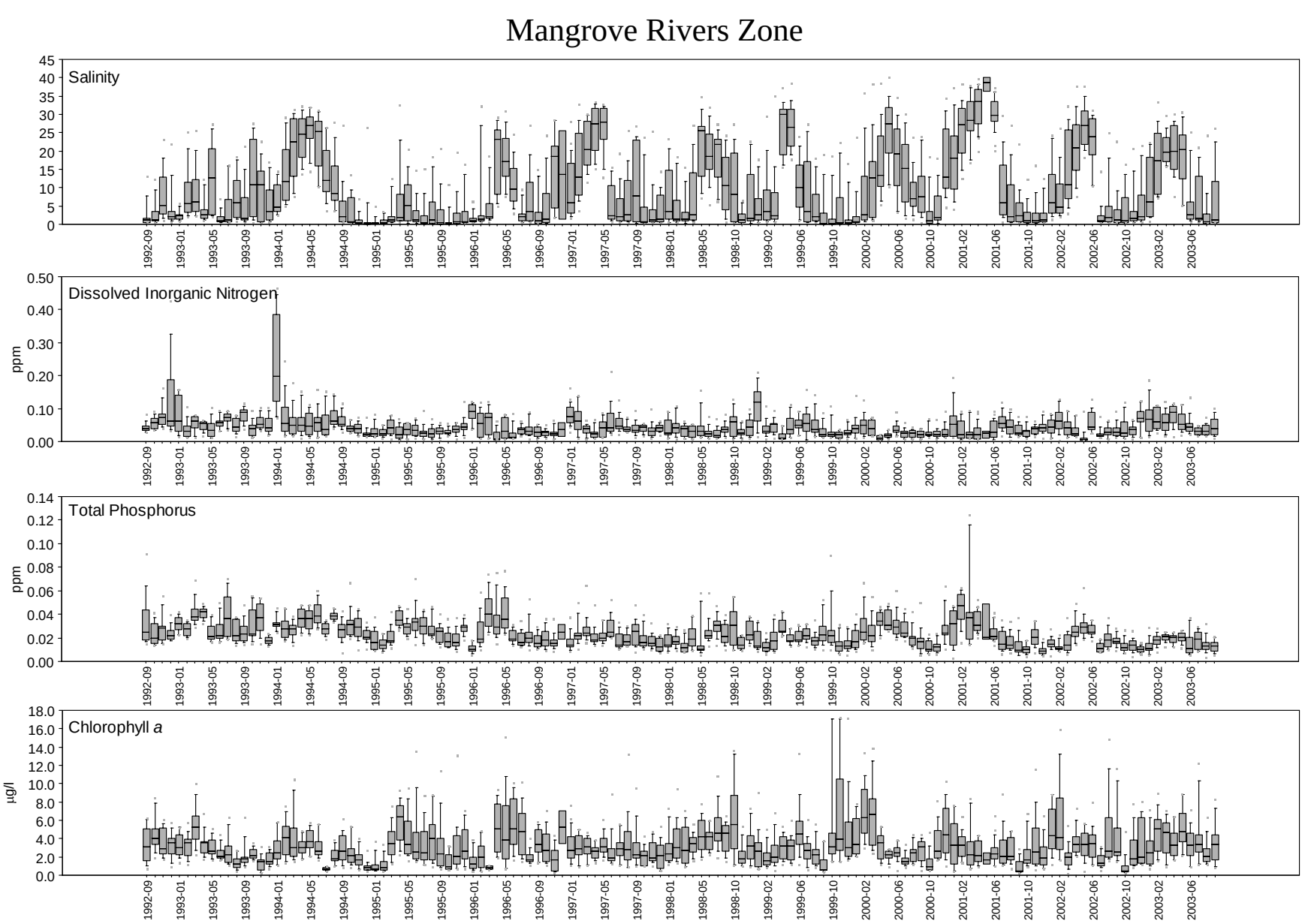

Figure 11. Box-and-whisker plots of water quality in WWB-TTI by survey.

Gulf Islands Zone

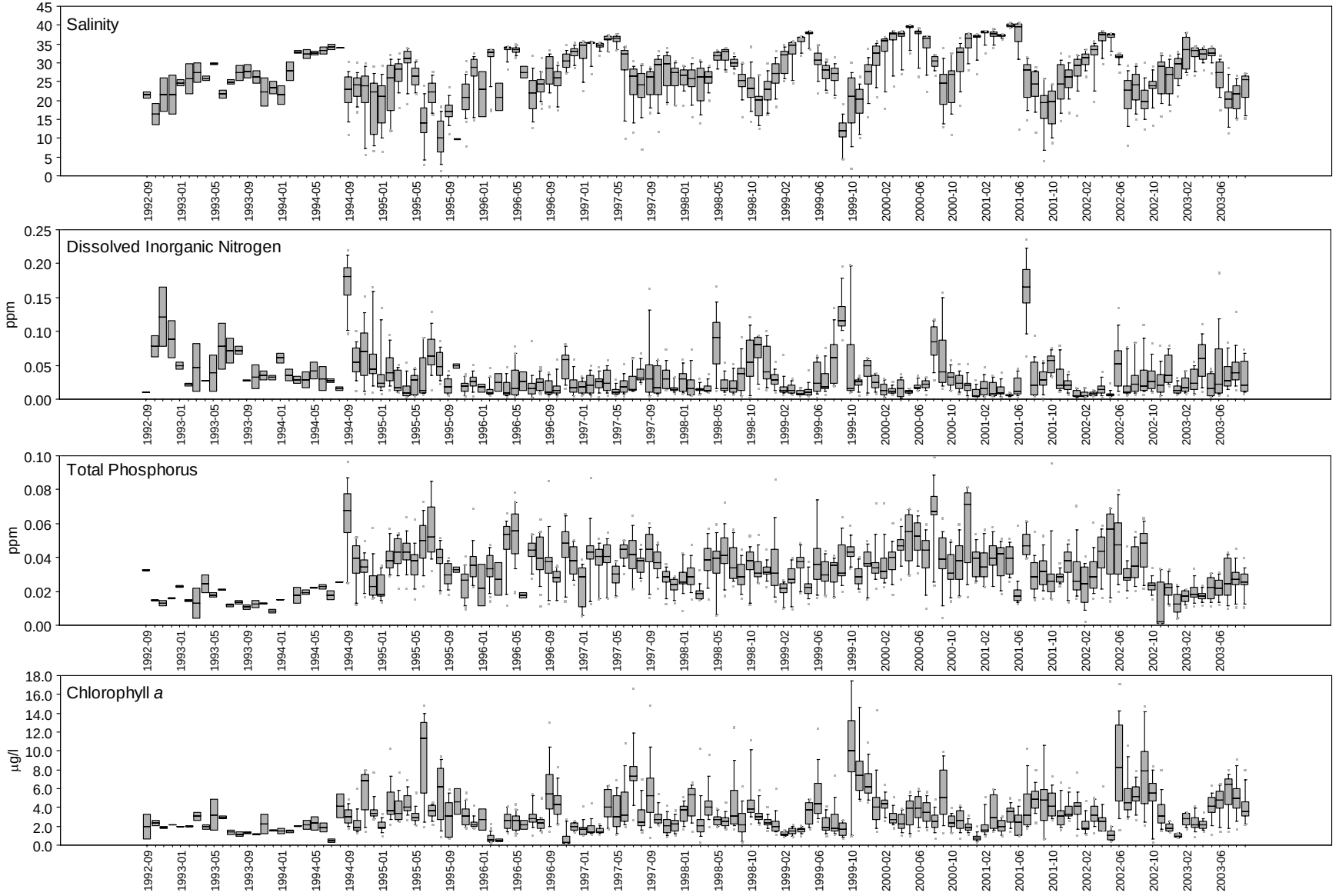

Figure 12. Box-and-whisker plots of water quality in WWB-TTI by survey.

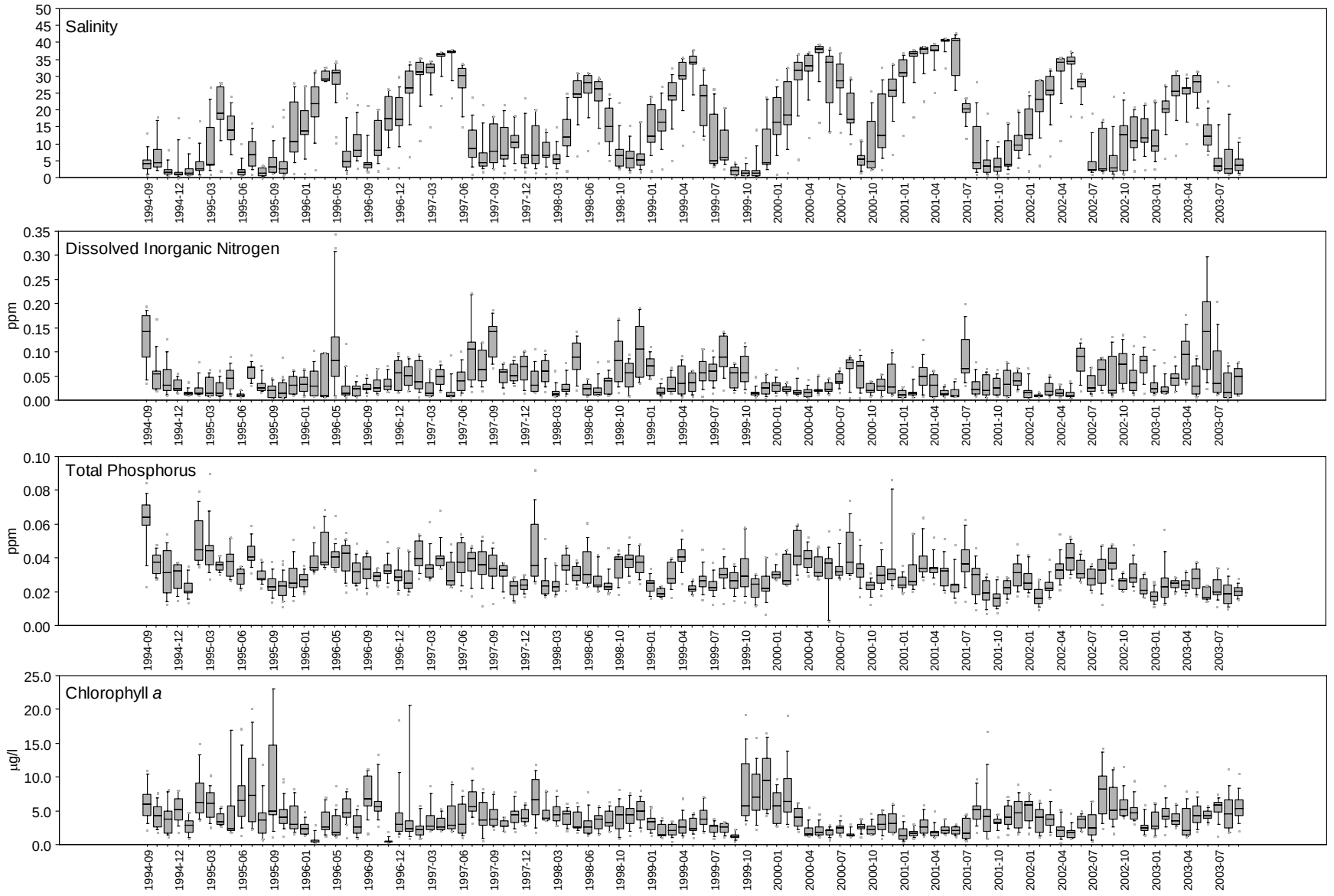

Figure 13. Box-and-whisker plots of water quality in WWB-TTI by survey.

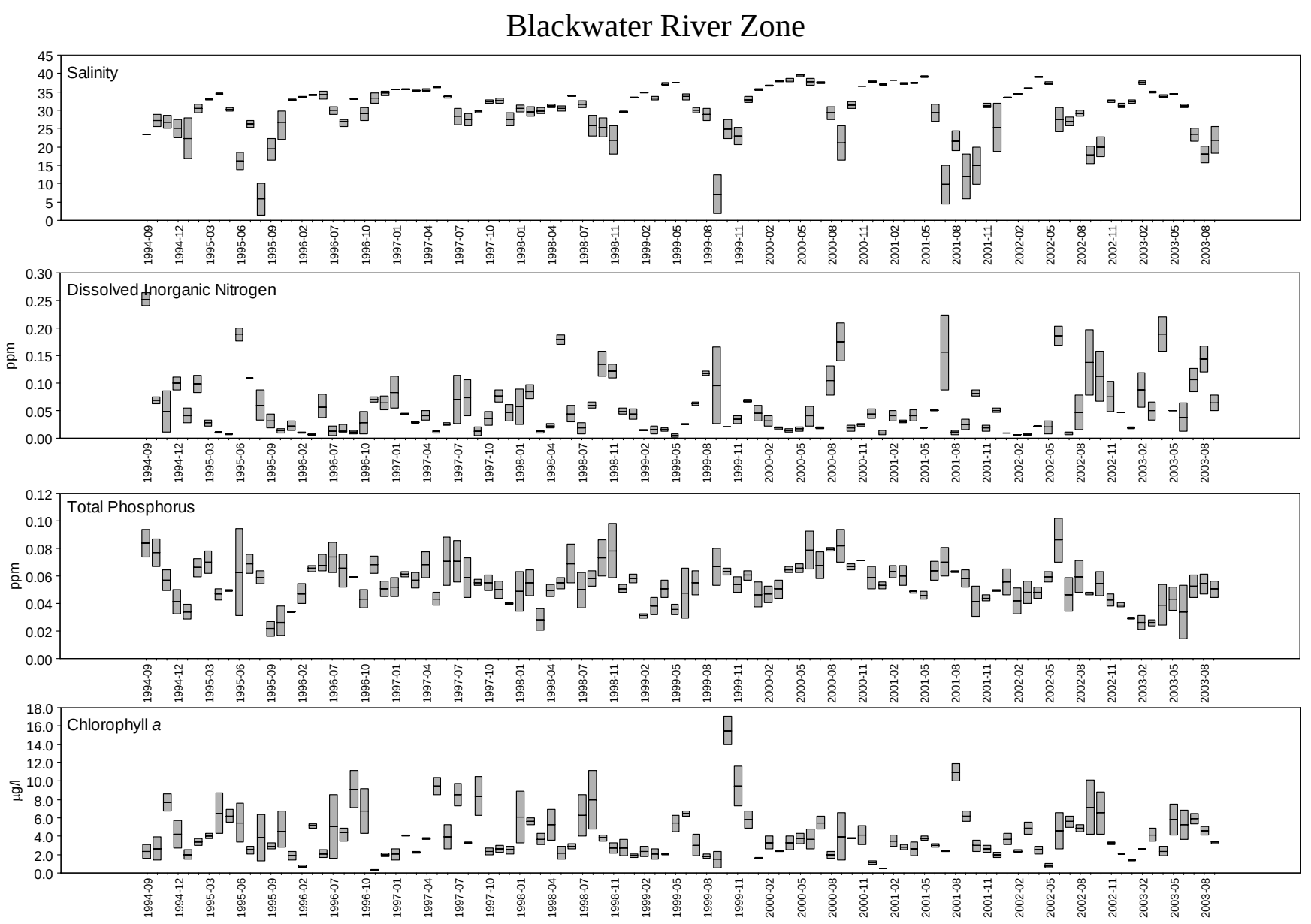

Figure 14. Box-and-whisker plots of water quality in WWB-TTI by survey.

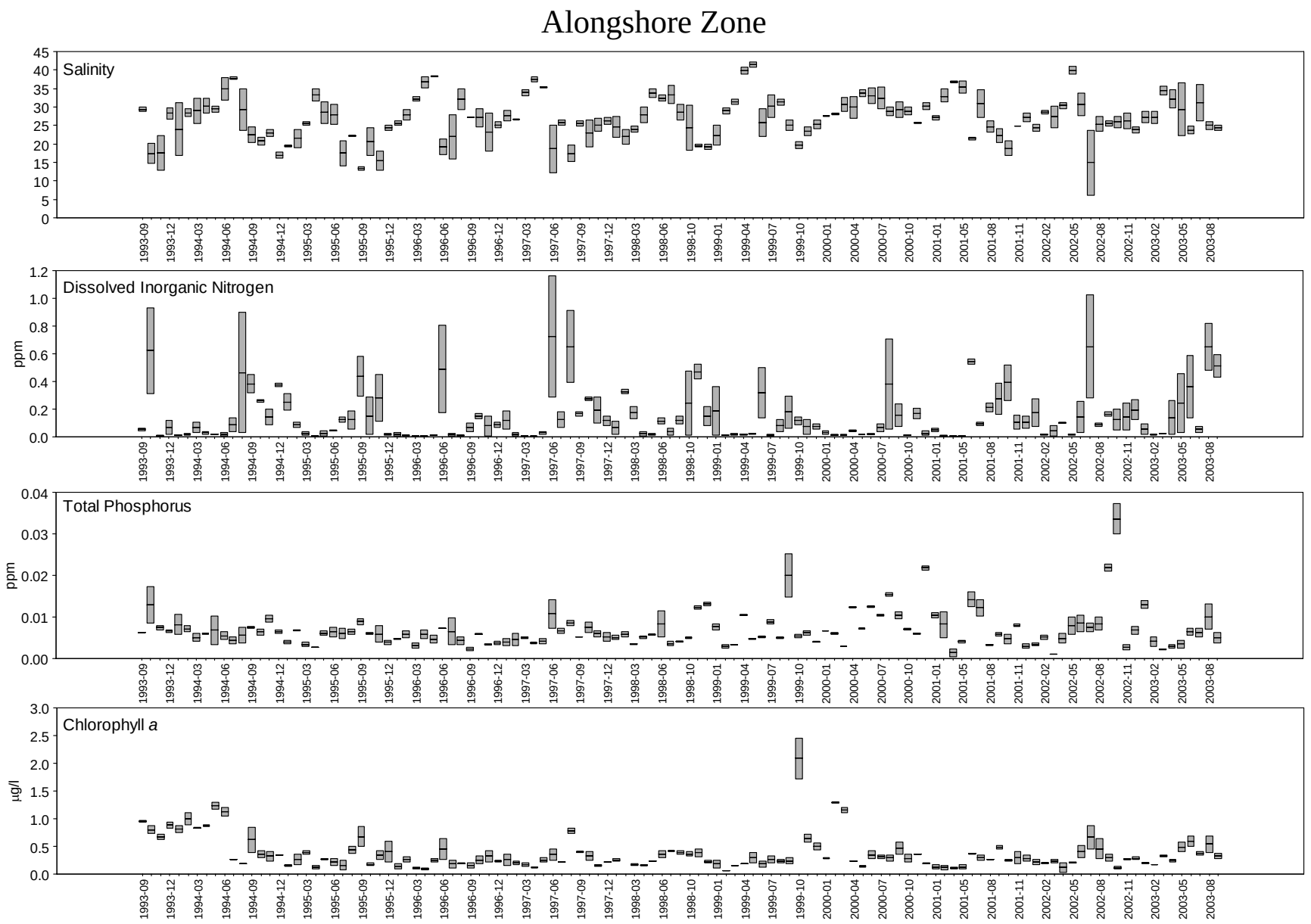

Figure 15. Box-and-whisker plots of water quality in Biscayne Bay by survey.

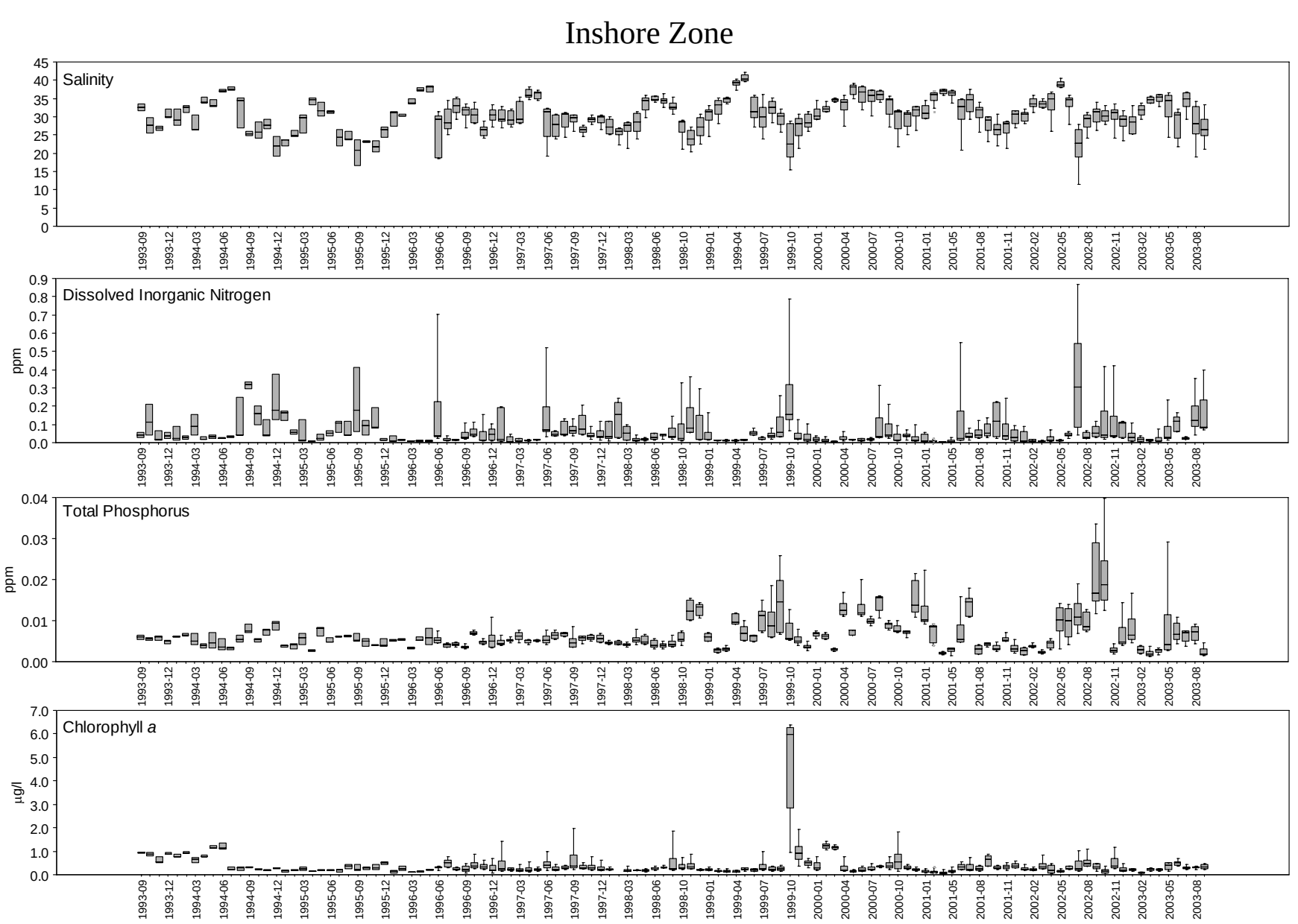

Figure 16. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Main Bay Zone

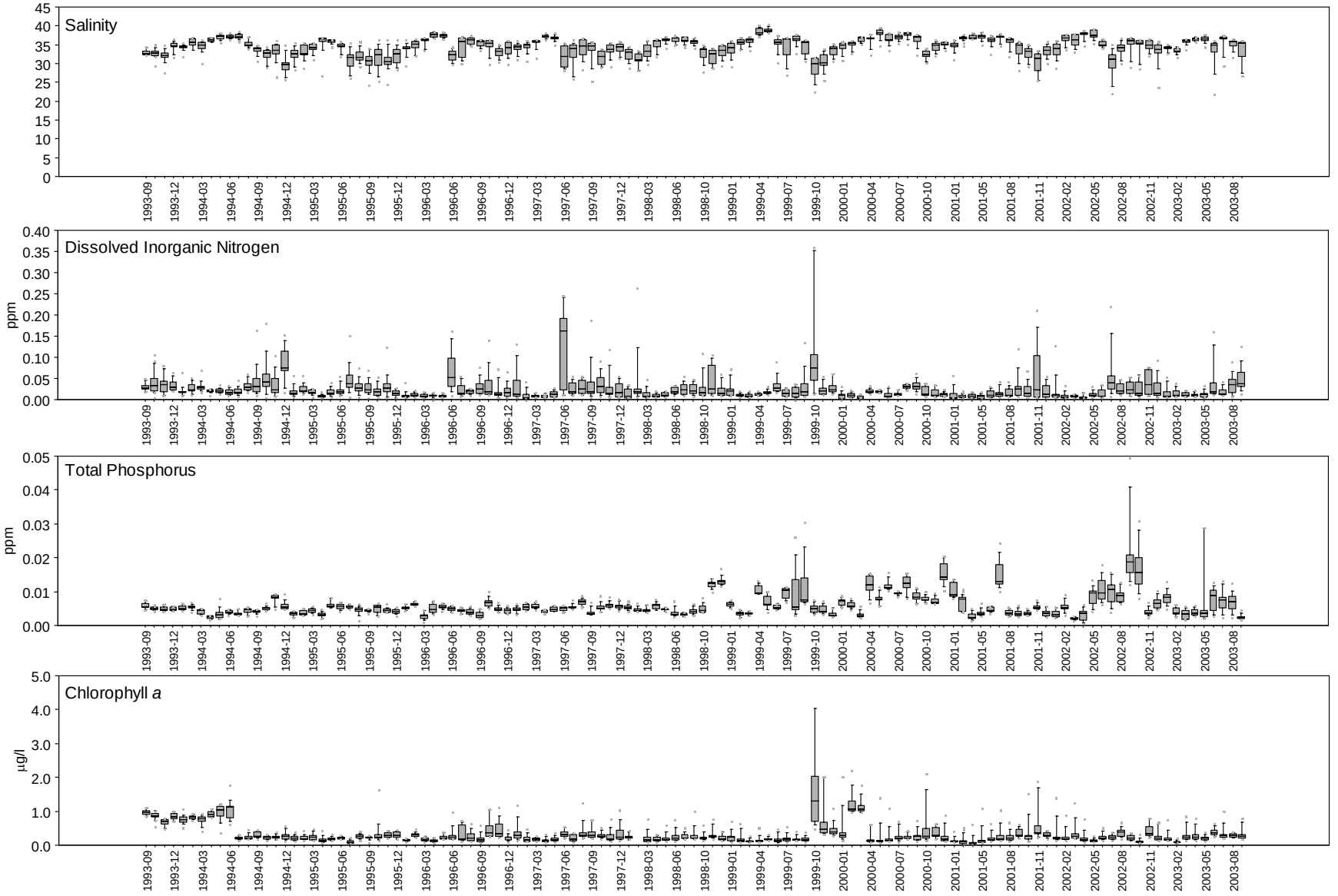

Figure 17. Box-and-whisker plots of water quality in Biscayne Bay by survey.

South Card Sound Zone

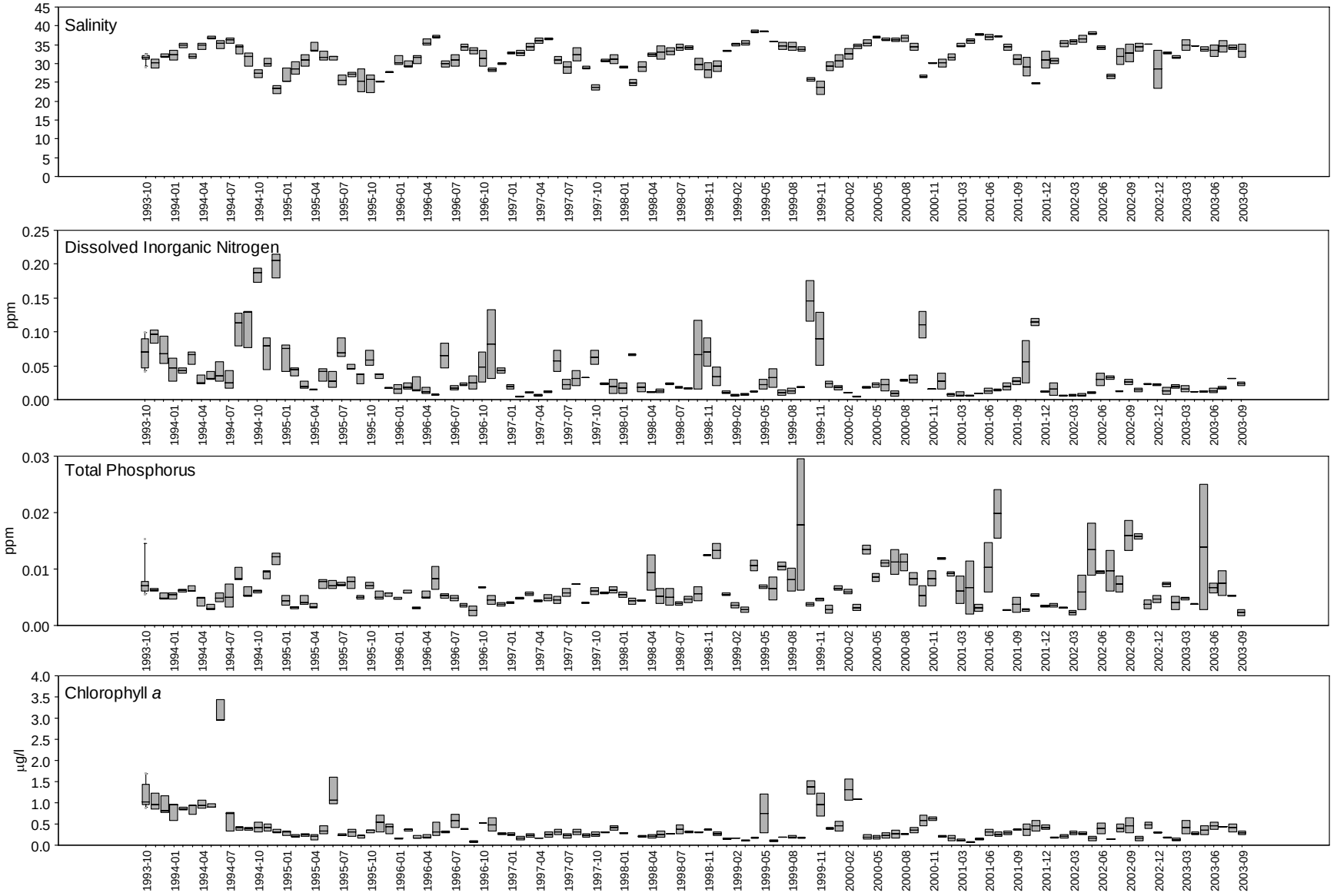

Figure 18. Box-and-whisker plots of water quality in Biscayne Bay by survey.

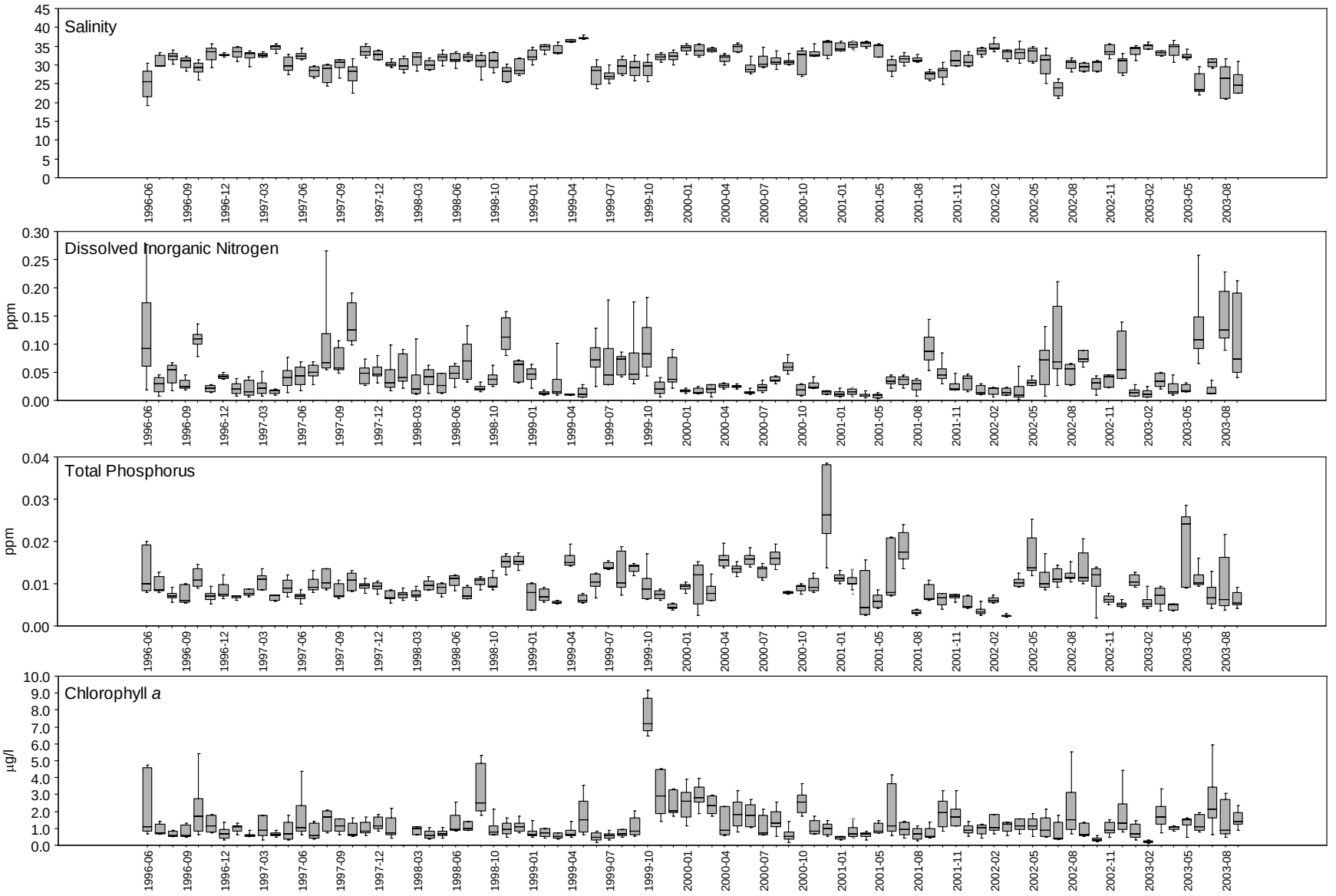

Figure 19. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Shelf Zone

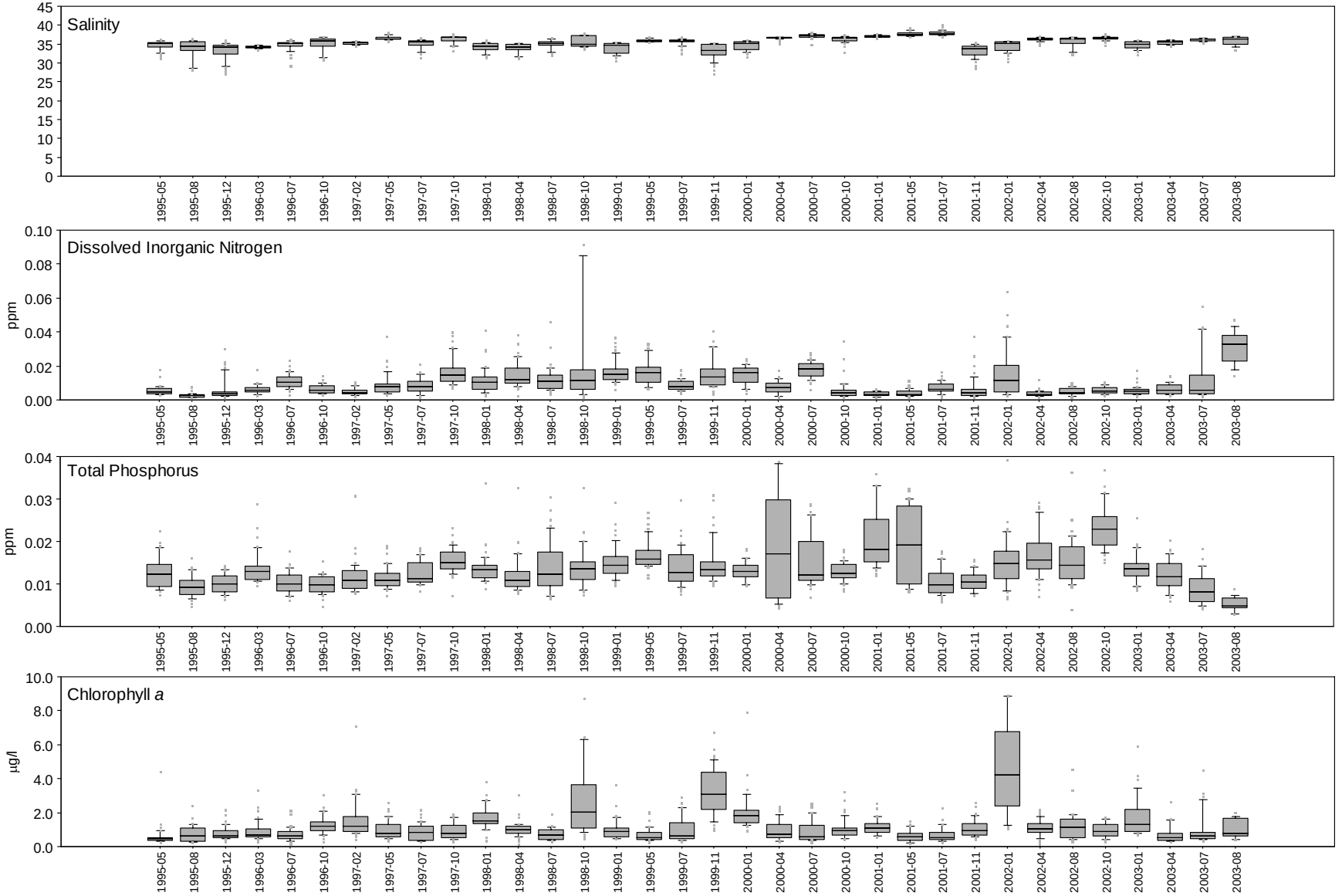

Figure 20. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Shark Zone

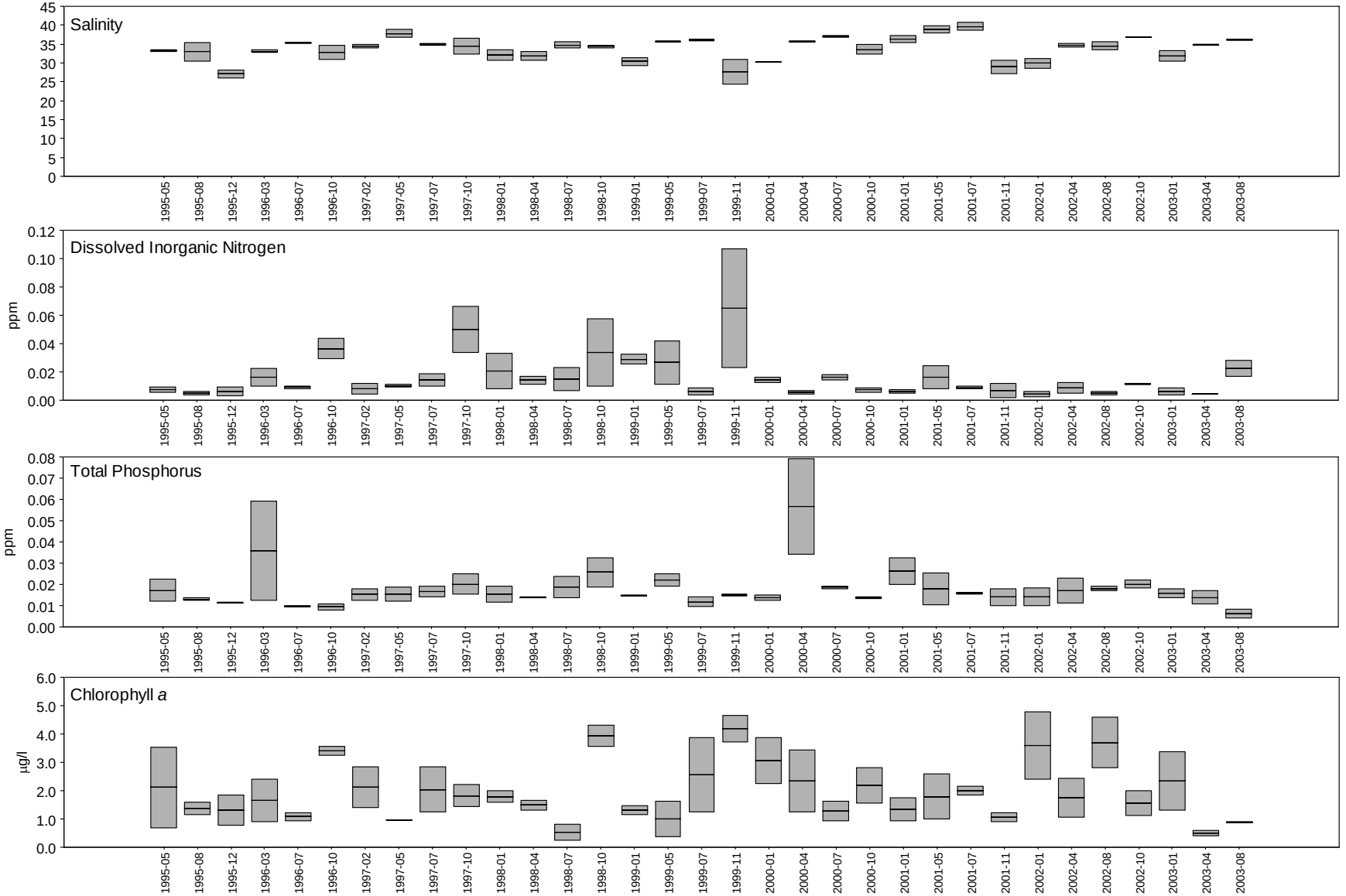

Figure 21. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Shoal Zone

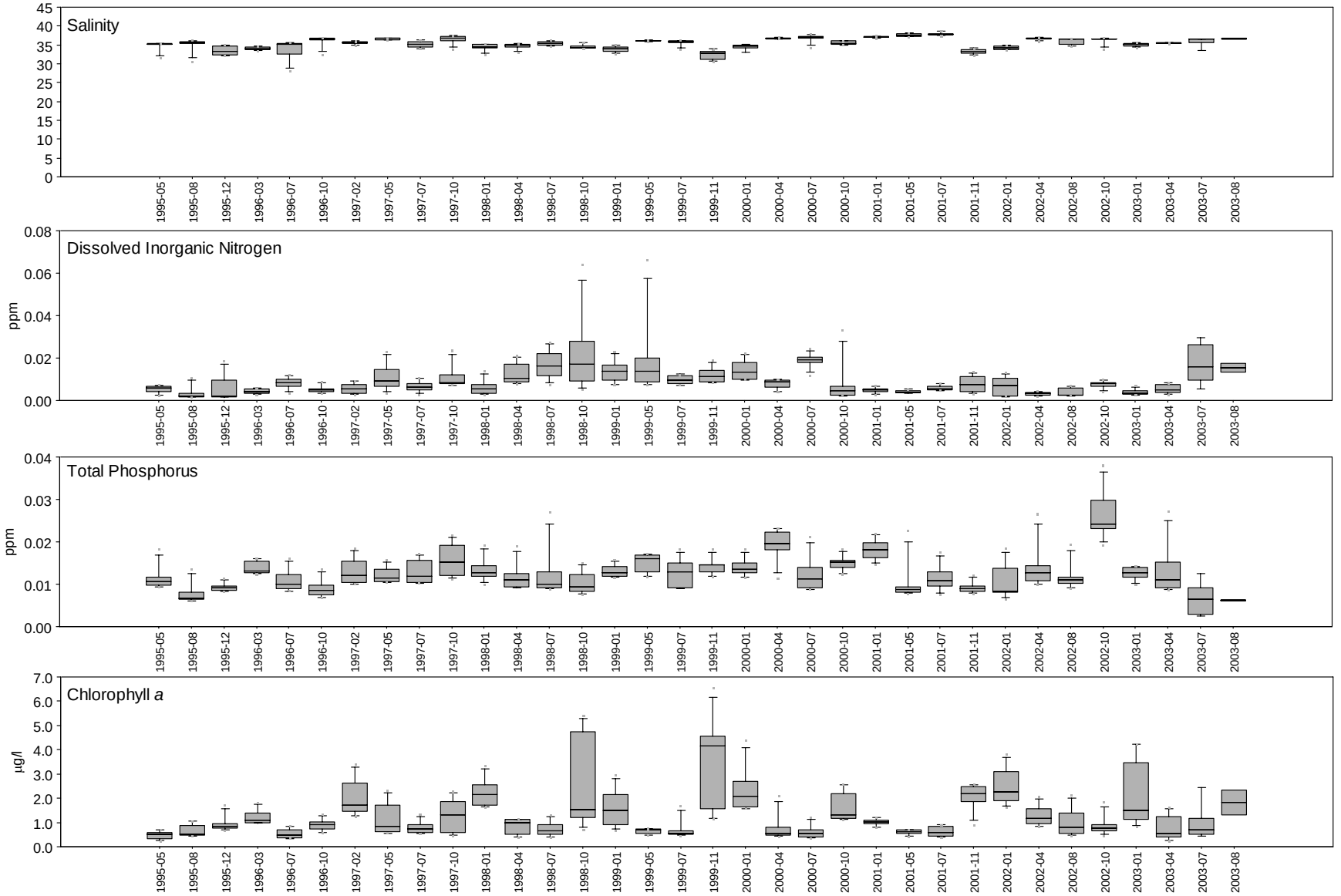

Figure 22. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Marco Zone

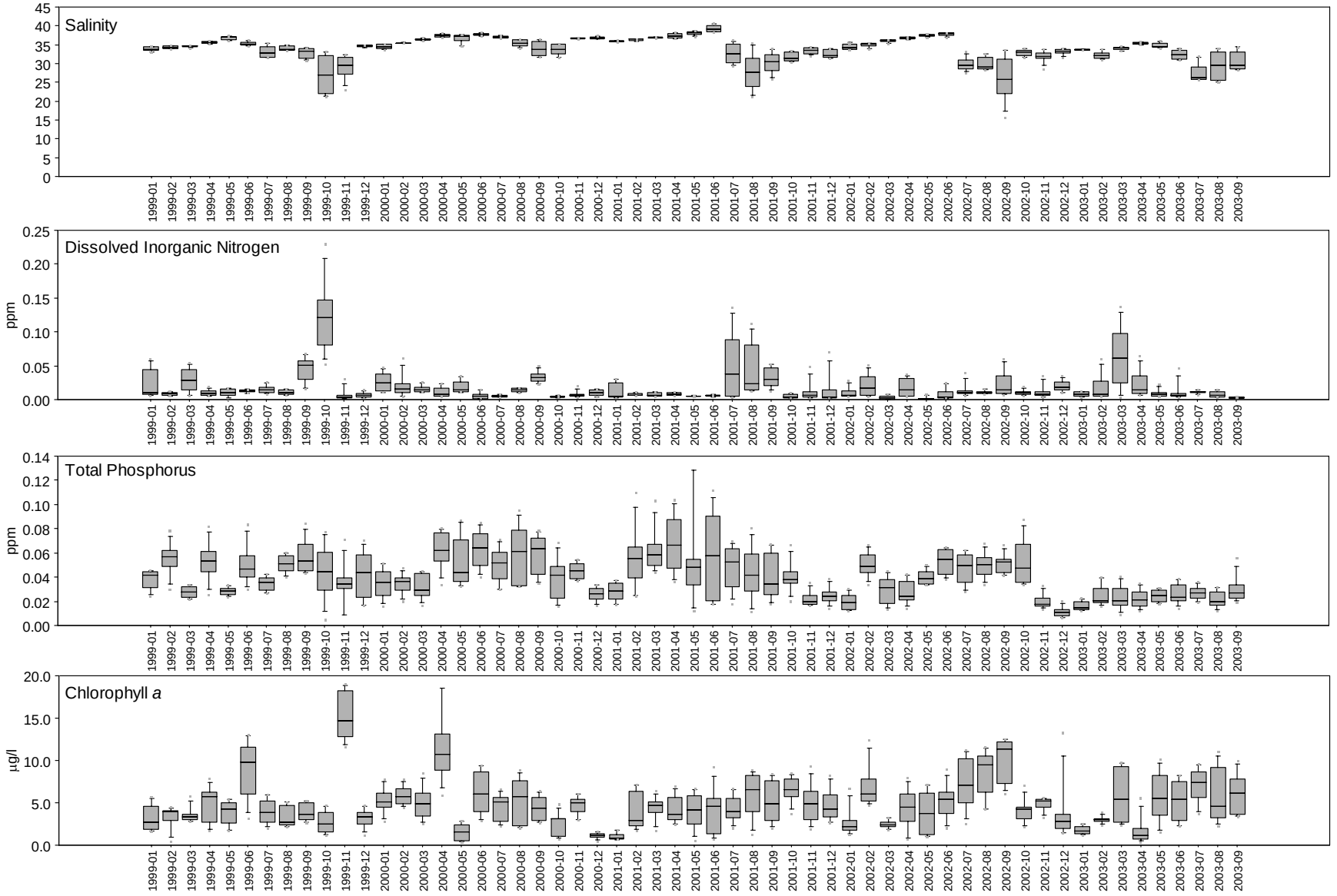

Figure 23. Box-and-whisker plots of water quality in RB-PIS by survey.

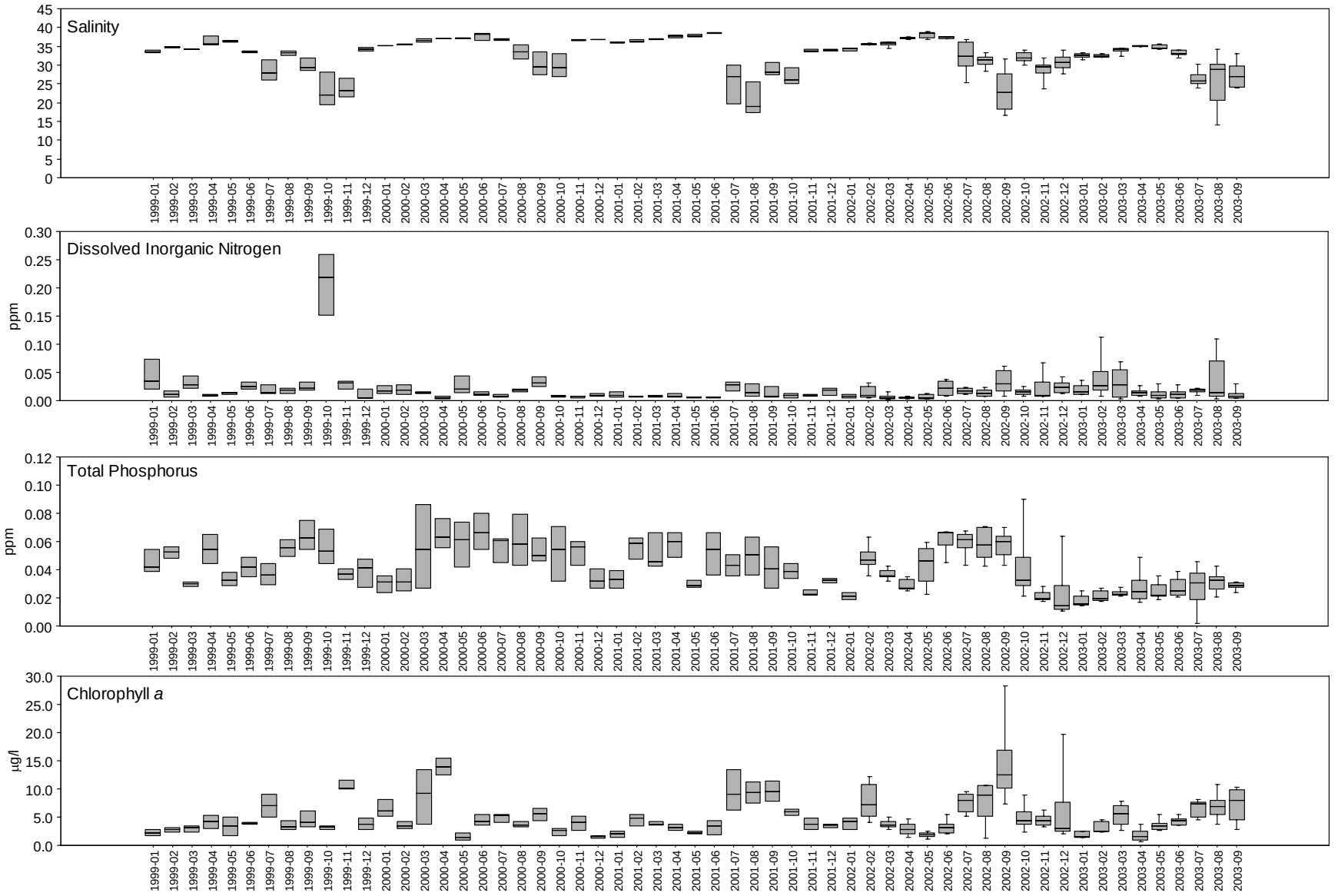

Figure 24. Box-and-whisker plots of water quality in RB-PIS by survey.

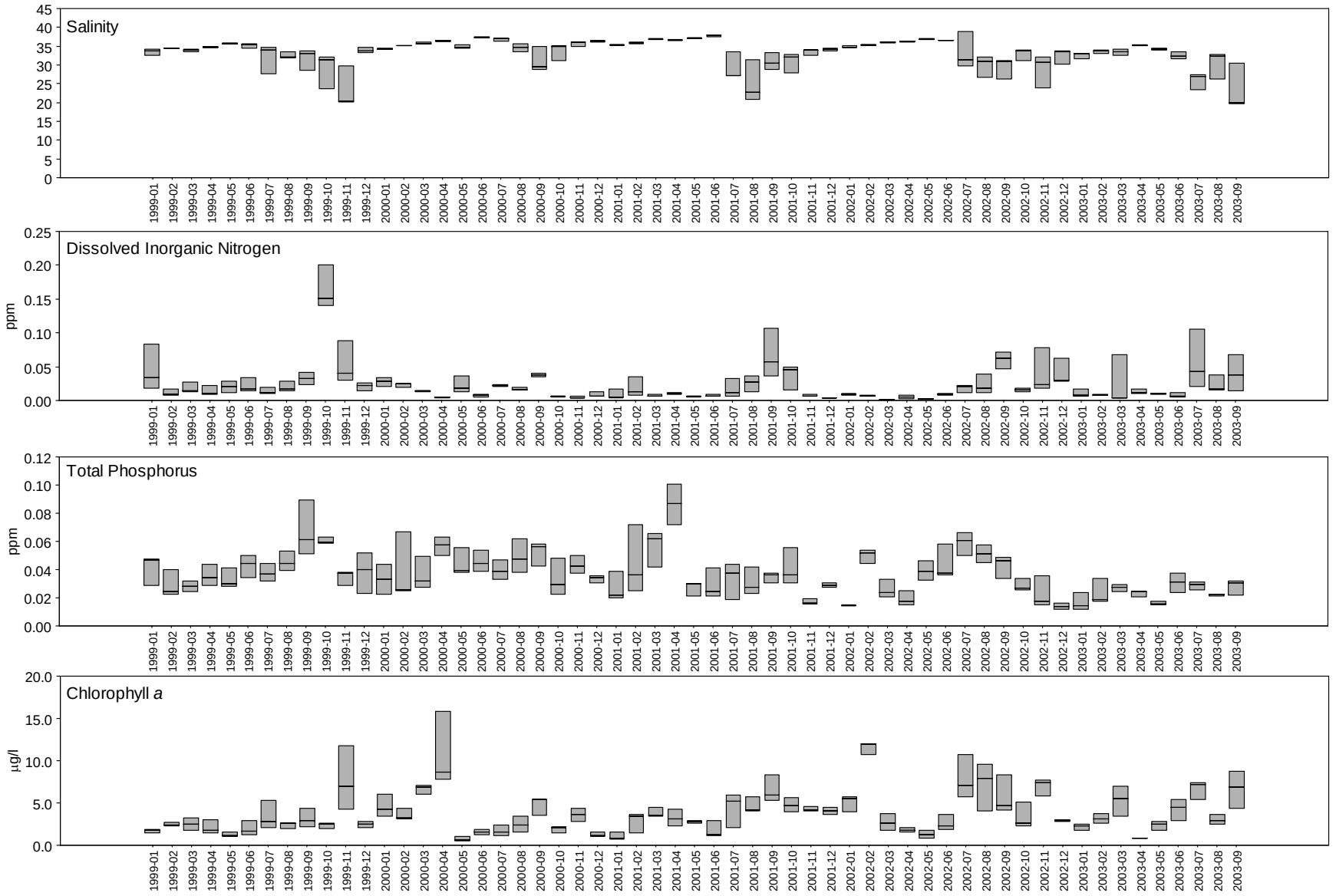

Figure 25. Box-and-whisker plots of water quality in RB-PIS by survey.

San Carlos Bay Zone

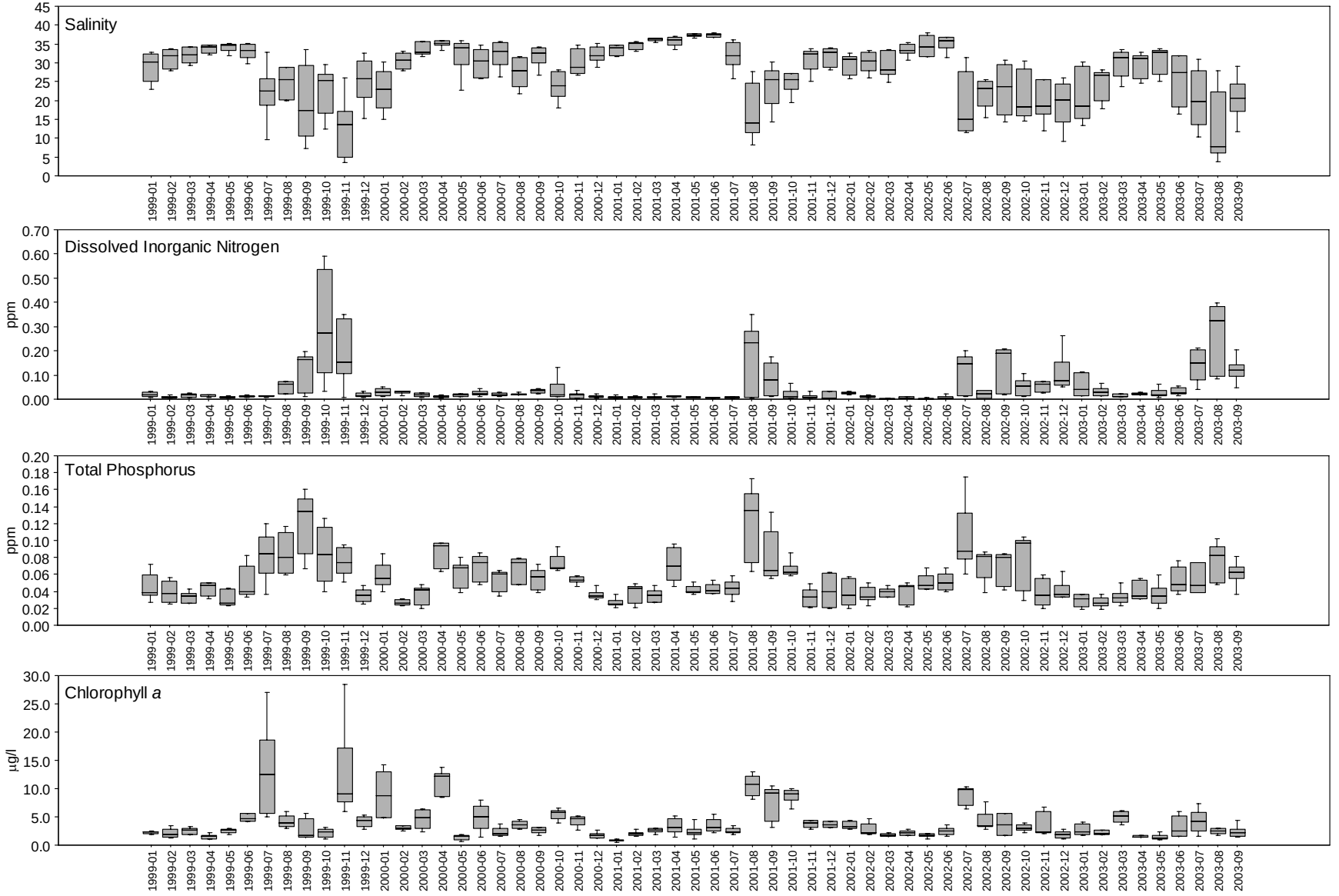

Figure 26. Box-and-whisker plots of water quality in RB-PIS by survey.

Estero Bay Zone

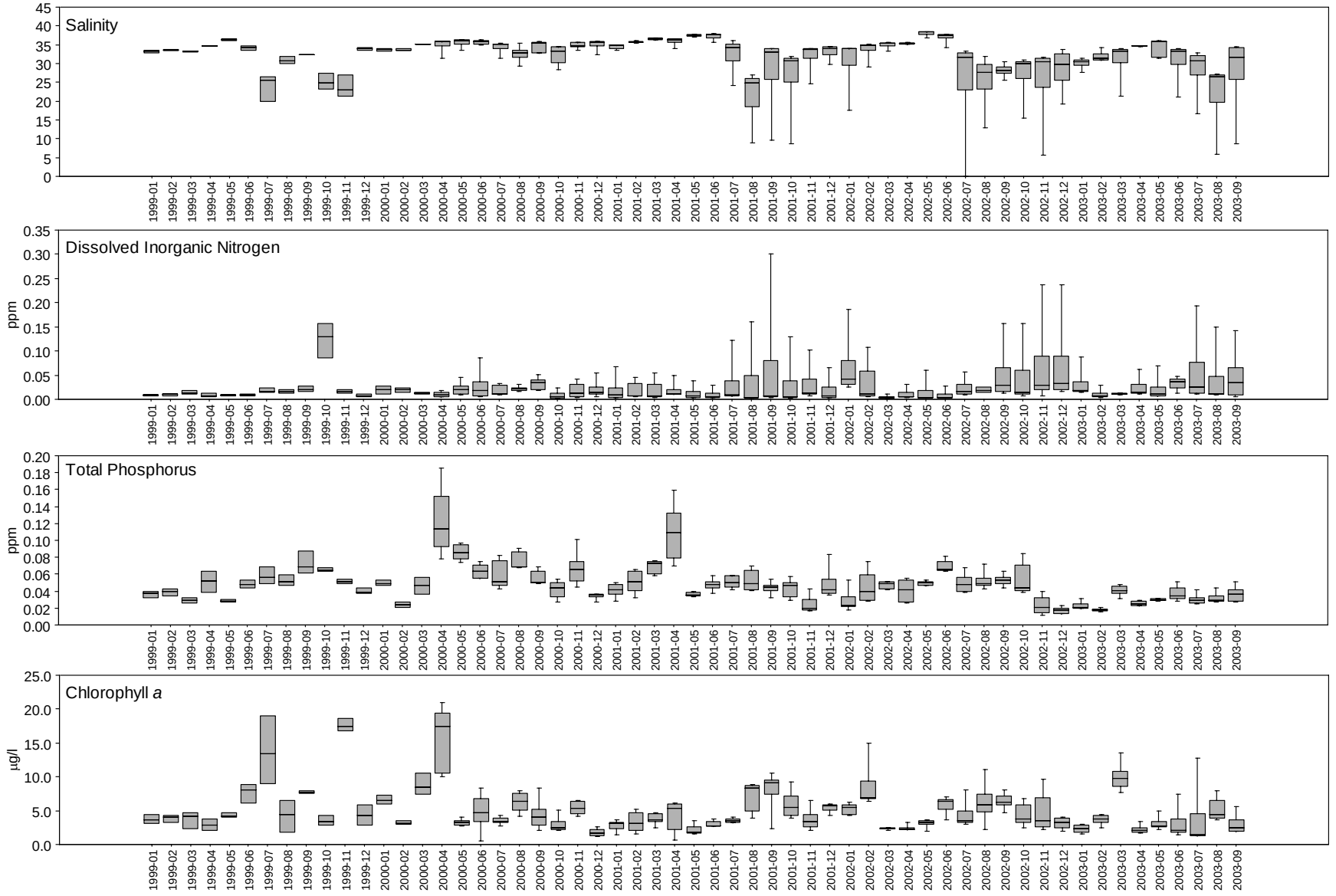

Figure 27. Box-and-whisker plots of water quality in RB-PIS by survey.

Pine Island Sound Zone

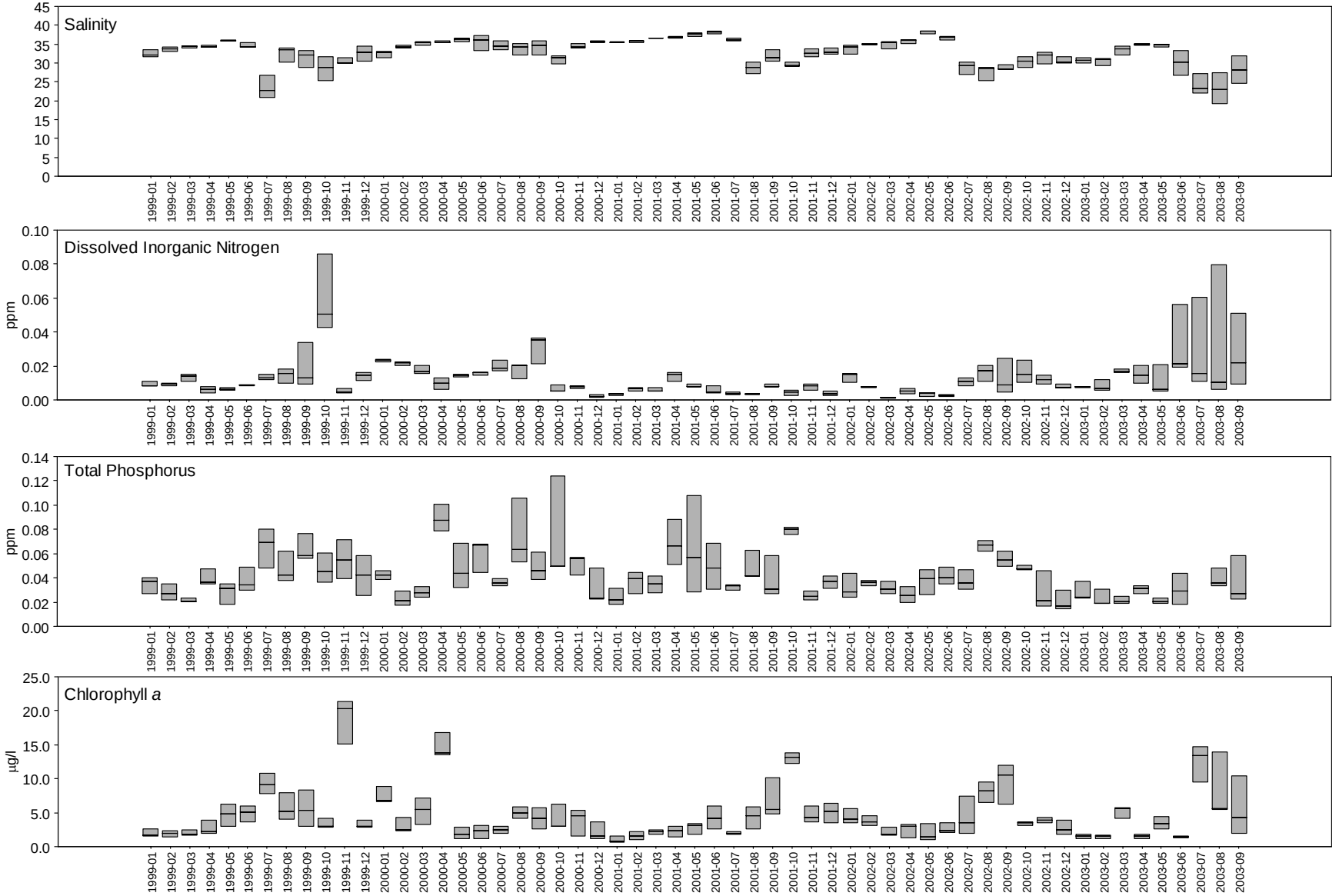

Figure 28. Box-and-whisker plots of water quality in RB-PIS by survey.

Table 1.

Parameter	Zone	Median	Min.	Max.	*n*
Alkaline Phosphatase Activity ($\mu M\ h^{-1}$)	Biscayne Bay	0.157	0.022	1.000	75
	Florida Bay	0.374	0.086	6.900	84
	Rookery Bay	0.047	0.031	0.110	87
	SW Shelf	0.039	0.020	0.315	49
	Ten Thousand Is.	0.097	0.033	0.985	78
	Whitewater Bay	0.352	0.049	3.565	66
Chlorophyll a ($\mu g\ l^{-1}$)	Biscayne Bay	0.326	0.177	5.924	75
	Florida Bay	0.616	0.188	9.604	84
	Rookery Bay	5.153	1.198	16.667	87
	SW Shelf	0.736	0.319	4.528	49
	Ten Thousand Is.	5.040	1.017	11.188	78
	Whitewater Bay	2.554	0.778	12.247	66
Surface Dissolved Oxygen ($mg\ l^{-1}$)	Biscayne Bay	5.02	4.01	7.00	75
	Florida Bay	5.61	4.17	7.05	84
	Rookery Bay	5.26	2.81	7.91	87
	SW Shelf	4.19	2.26	7.37	49
	Ten Thousand Is.	5.05	2.75	8.11	78
	Whitewater Bay	5.22	2.41	8.66	66
Bottom Dissolved Oxygen ($mg\ l^{-1}$)	Biscayne Bay	5.00	3.20	7.82	75
	Florida Bay	5.69	3.64	9.78	84
	Rookery Bay	4.87	3.50	7.14	84
	SW Shelf	4.78	2.68	5.59	49
	Ten Thousand Is.	4.72	2.77	8.26	78
	Whitewater Bay	4.98	2.38	8.43	66
NH_4 (ppm)	Biscayne Bay	0.021	0.004	0.221	75
	Florida Bay	0.027	0.003	0.154	84
	Rookery Bay	0.008	0.001	0.087	87
	SW Shelf	0.013	0.001	0.042	49
	Ten Thousand Is.	0.017	0.003	0.135	78
	Whitewater Bay	0.014	0.002	0.058	66
NO_2 (ppm)	Biscayne Bay	0.002	0.000	0.039	75
	Florida Bay	0.001	0.000	0.008	84
	Rookery Bay	0.001	0.000	0.017	87
	SW Shelf	0.000	0.000	0.001	49
	Ten Thousand Is.	0.003	0.000	0.013	78
	Whitewater Bay	0.002	0.001	0.005	66
NO_3 (ppm)	Biscayne Bay	0.012	0.001	0.561	75
	Florida Bay	0.004	0.000	0.040	84
	Rookery Bay	0.006	0.001	0.352	87
	SW Shelf	0.001	0.000	0.013	49
	Ten Thousand Is.	0.009	0.000	0.079	78
	Whitewater Bay	0.006	0.001	0.049	66

Parameter	Zone	Median	Min.	Max.	*n*
pH	Biscayne Bay	8.055	7.880	8.550	75
	Florida Bay	8.137	7.825	9.115	84
	Rookery Bay	7.910	7.400	8.435	87
	SW Shelf	8.185	8.085	8.320	49
	Ten Thousand Is.	7.818	7.185	8.195	78
	Whitewater Bay	7.775	7.125	8.800	66
Surface Salinity	Biscayne Bay	33.26	19.07	37.28	75
	Florida Bay	33.51	0.26	39.06	84
	Rookery Bay	26.92	3.70	34.47	87
	SW Shelf	36.32	33.46	37.08	49
	Ten Thousand Is.	12.43	0.24	28.28	78
	Whitewater Bay	8.73	0.27	28.62	66
Bottom Salinity	Biscayne Bay	34.23	19.68	37.25	75
	Florida Bay	33.40	0.27	39.88	84
	Rookery Bay	28.80	5.83	34.94	84
	SW Shelf	36.34	33.48	37.07	49
	Ten Thousand Is.	14.77	0.23	29.75	78
	Whitewater Bay	8.93	0.22	30.78	66
$Si(OH)_4$ (ppm)	Biscayne Bay	0.084	0.029	0.430	25
	Florida Bay	0.633	0.059	4.339	28
	Rookery Bay	1.614	0.318	3.068	29
	SW Shelf	0.103	0.006	0.600	49
	Ten Thousand Is.	2.687	0.533	4.110	26
	Whitewater Bay	1.253	0.047	3.904	22
Soluble Reactive Phosphorus (ppm)	Biscayne Bay	0.002	0.000	0.006	75
	Florida Bay	0.001	0.000	0.009	84
	Rookery Bay	0.007	0.001	0.090	84
	SW Shelf	0.001	0.000	0.002	49
	Ten Thousand Is.	0.003	0.001	0.030	78
	Whitewater Bay	0.002	0.000	0.006	66
Surface Temperature (^oC)	Biscayne Bay	29.77	27.28	31.46	75
	Florida Bay	29.87	28.60	32.03	84
	Rookery Bay	30.18	27.89	32.07	87
	SW Shelf	30.77	30.47	31.72	49
	Ten Thousand Is.	30.49	28.46	31.67	78
	Whitewater Bay	29.86	28.45	31.65	66
Bottom Temperature (^oC)	Biscayne Bay	29.78	27.39	31.65	75
	Florida Bay	29.84	28.60	31.84	84
	Rookery Bay	29.95	27.97	32.14	84
	SW Shelf	30.74	30.37	31.35	49
	Ten Thousand Is.	30.38	29.02	31.32	78
	Whitewater Bay	29.60	28.43	31.50	66

Parameter	Zone	Median	Min.	Max.	*n*
Total Nitrogen (ppm)	Biscayne Bay	0.302	0.192	1.049	75
	Florida Bay	0.465	0.197	1.538	84
	Rookery Bay	0.337	0.142	0.784	87
	SW Shelf	0.241	0.149	0.409	49
	Ten Thousand Is.	0.459	0.247	0.707	78
	Whitewater Bay	0.477	0.260	1.129	66
Total Organic Carbon (ppm)	Biscayne Bay	3.230	1.570	6.951	75
	Florida Bay	7.836	1.724	15.608	84
	Rookery Bay	5.729	2.366	15.425	87
	SW Shelf	2.033	1.543	3.399	45
	Ten Thousand Is.	9.908	4.966	19.817	78
	Whitewater Bay	12.331	5.878	20.698	64
Total Organic Nitrogen (ppm)	Biscayne Bay	0.241	0.000	0.374	75
	Florida Bay	0.434	0.186	1.534	84
	Rookery Bay	0.314	0.053	0.520	87
	SW Shelf	0.213	0.107	0.406	49
	Ten Thousand Is.	0.410	0.235	0.654	78
	Whitewater Bay	0.445	0.213	1.111	66
Total Phosphorus (ppm)	Biscayne Bay	0.005	0.002	0.022	75
	Florida Bay	0.005	0.001	0.024	84
	Rookery Bay	0.030	0.002	0.102	82
	SW Shelf	0.006	0.003	0.018	49
	Ten Thousand Is.	0.024	0.003	0.061	77
	Whitewater Bay	0.011	0.004	0.031	66
Turbidity (NTU)	Biscayne Bay	0.55	0.15	2.02	75
	Florida Bay	1.91	0.32	16.26	84
	Rookery Bay	2.28	0.64	9.50	87
	SW Shelf	2.07	0.38	8.58	49
	Ten Thousand Is.	4.78	0.50	11.87	78
	Whitewater Bay	1.84	0.59	10.44	66