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30 September 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) April – June 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 ($\text{Si}(\text{OH})_4$) 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.

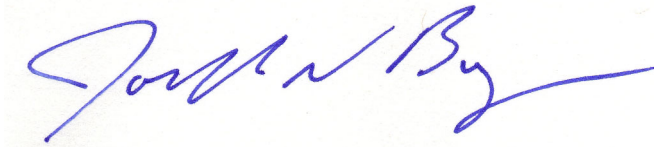
Sampling in the Rookery Bay area began Jan. 1999 so there are less than 5 years of data available. This makes it unfeasible to perform a spatial statistic analysis. Therefore we will use generally accepted geomorphological characteristics to group the stations (Fig. 6). These groupings are Cocohatchee 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
Associate Scientist

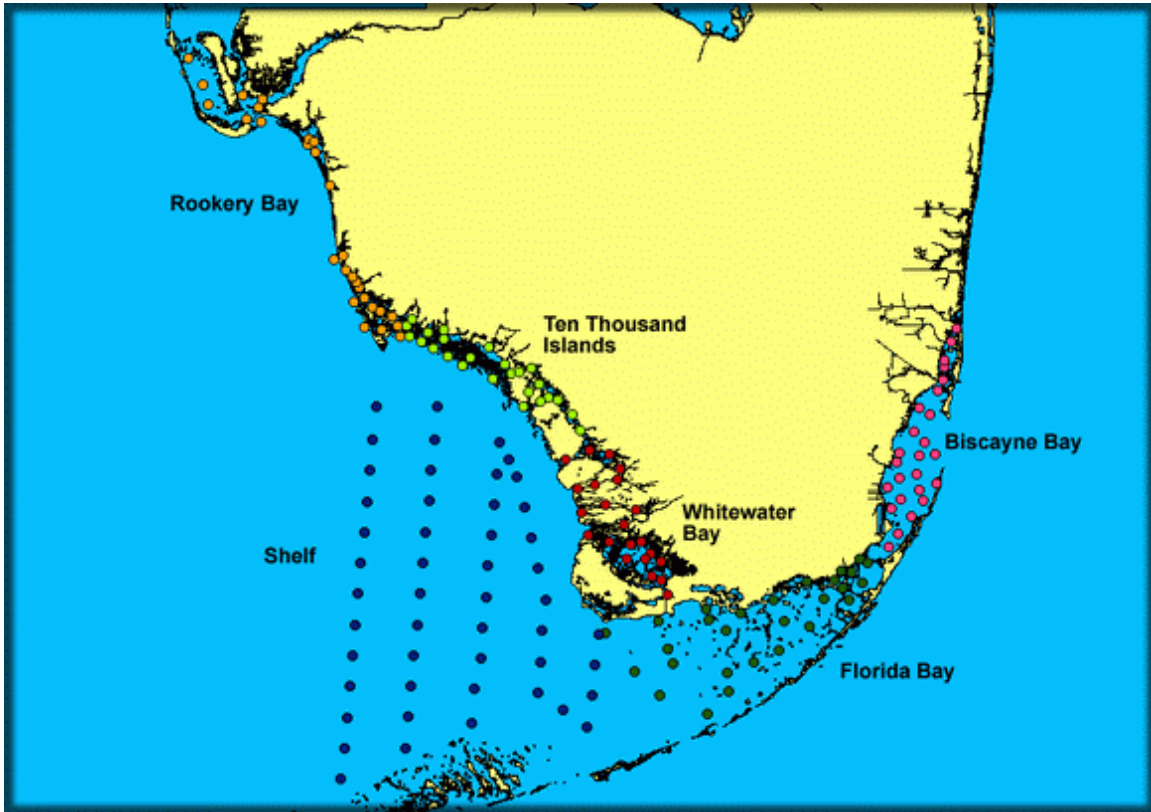
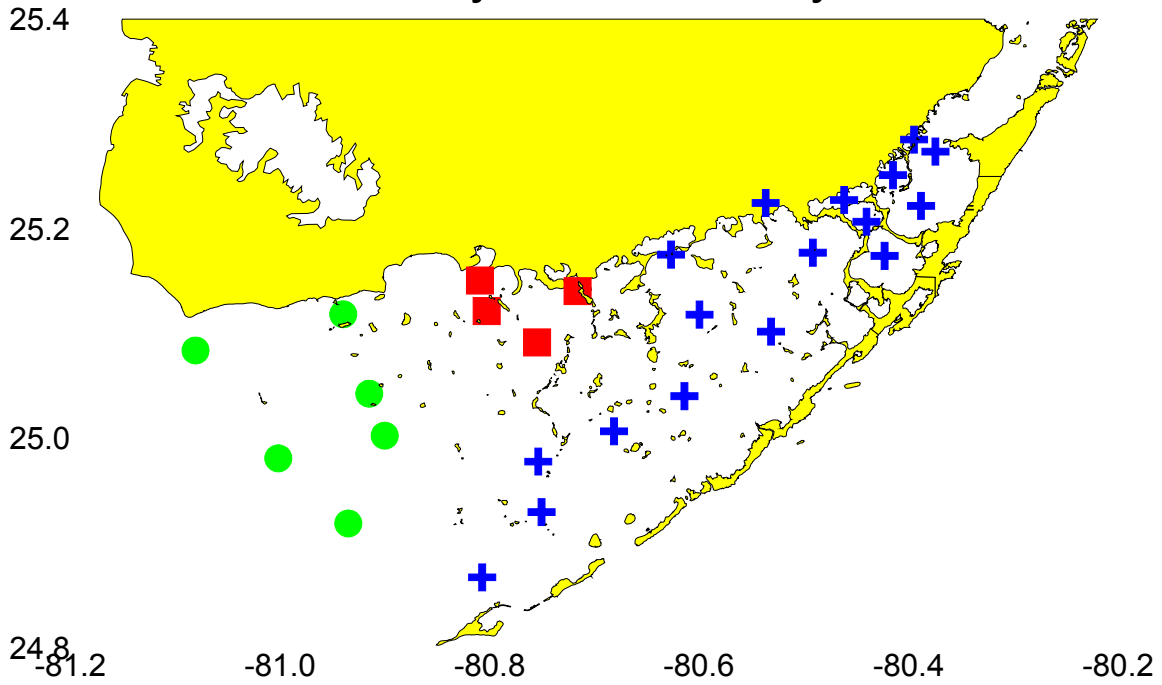


Figure 1: All fixed water quality stations funded by this SFWMD project.

Florida Bay Water Quality Zones



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

Figure 2. Florida Bay zones.

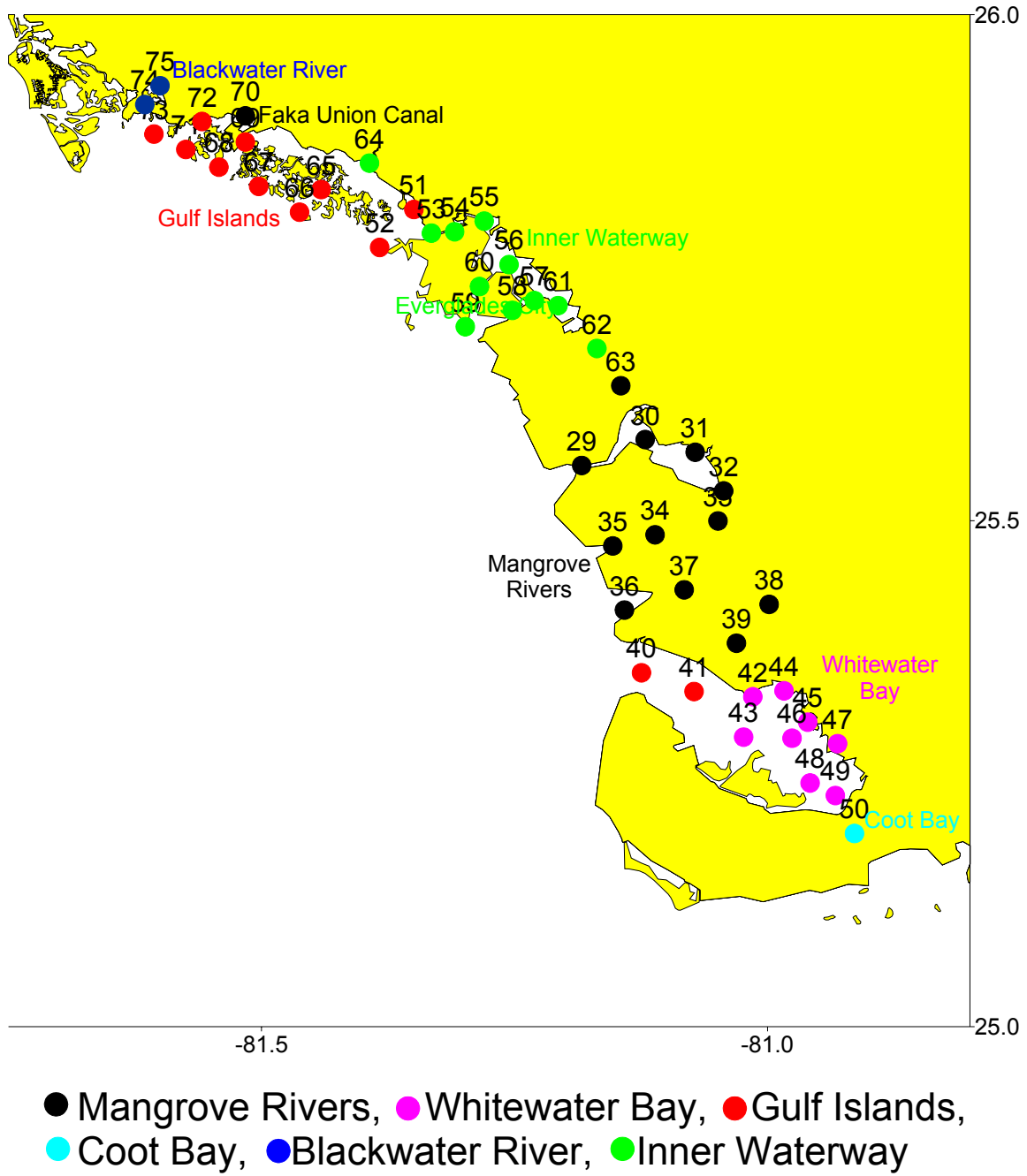


Figure 3. WWB-TTI water quality zones.

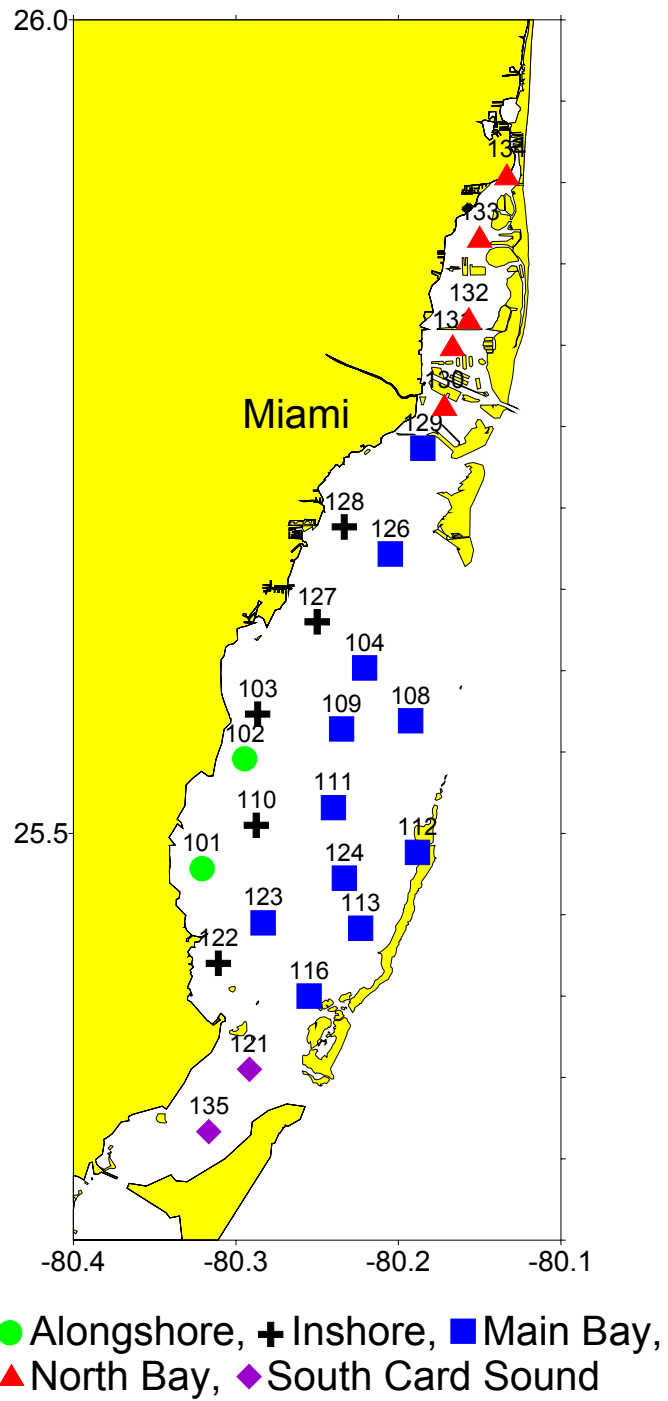


Figure 4. Biscayne Bay water quality zones.

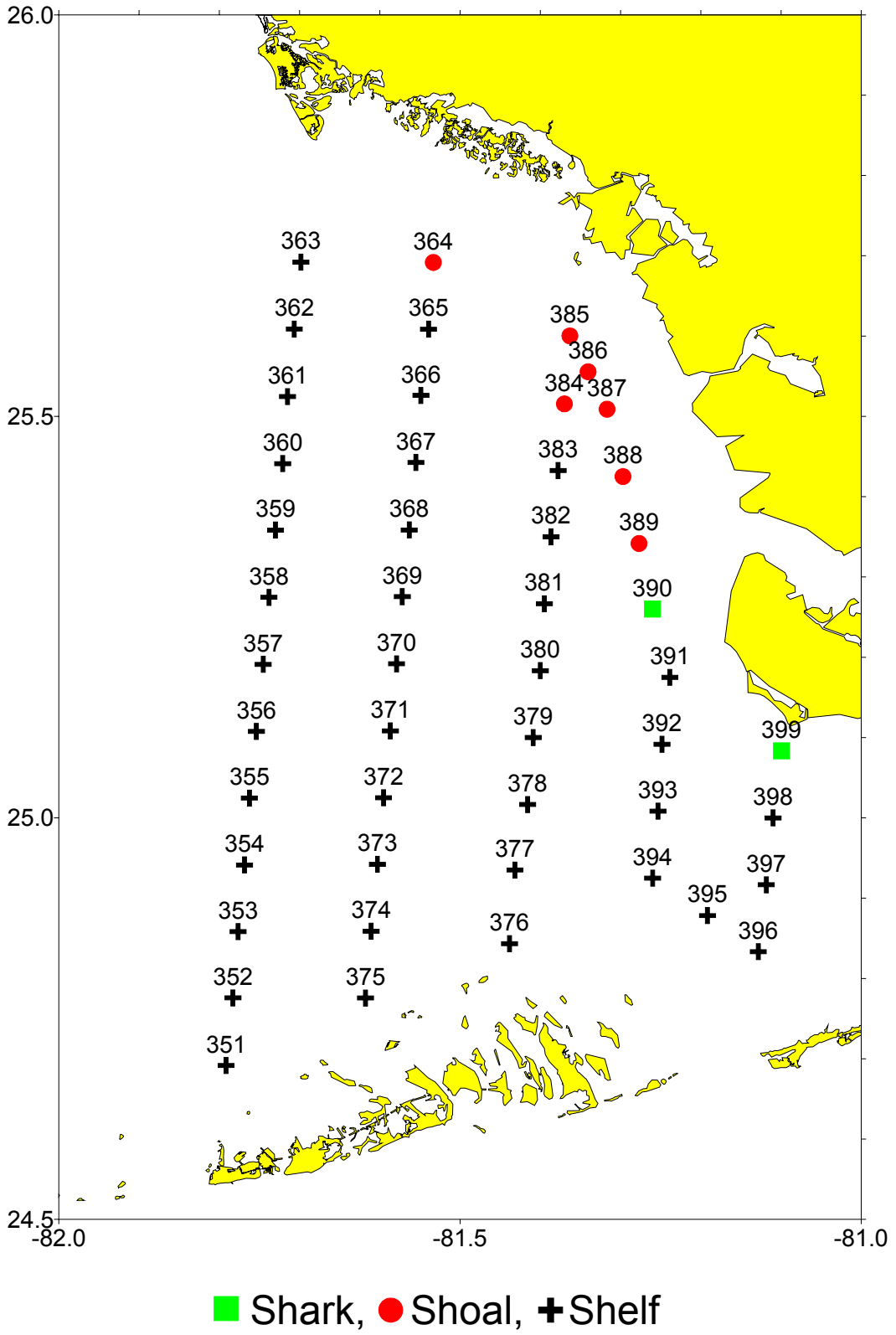


Figure 5. SW Florida Shelf water quality zones.

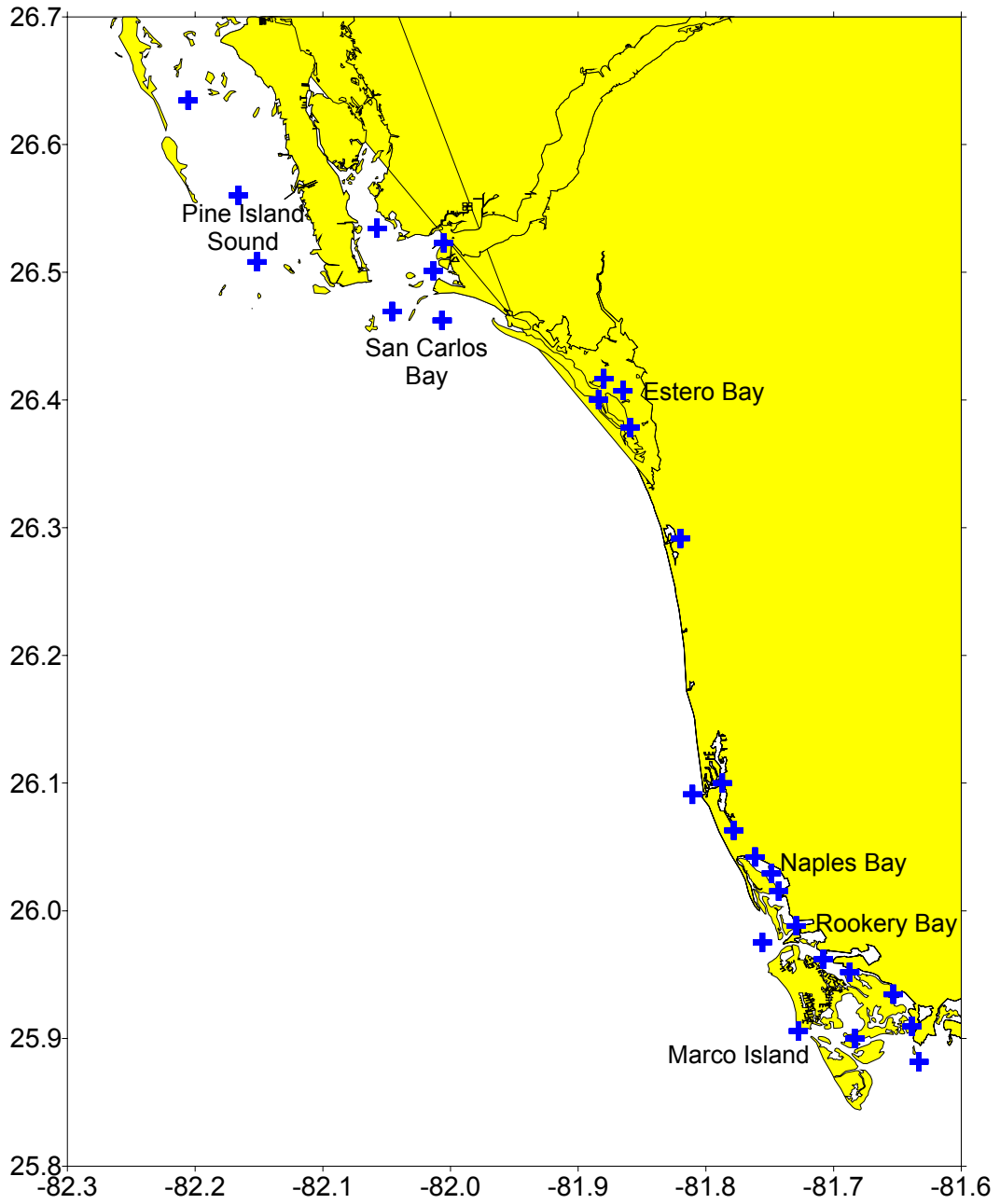


Figure 6. SW estuaries.

Eastern Florida Bay Zone

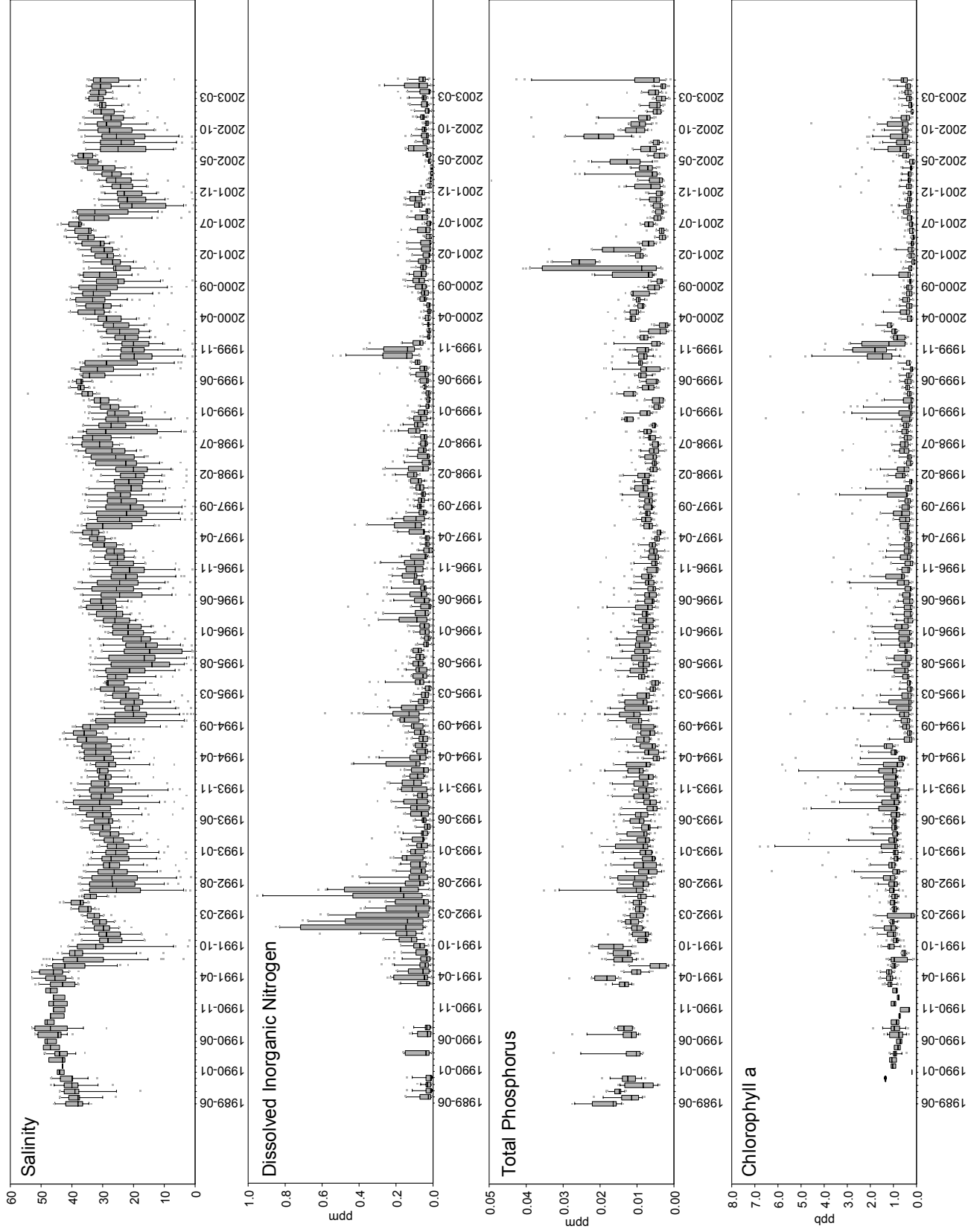


Figure 7. Box-and-whisker plots of water quality in Eastern Florida Bay by survey.

Central Florida Bay Zone

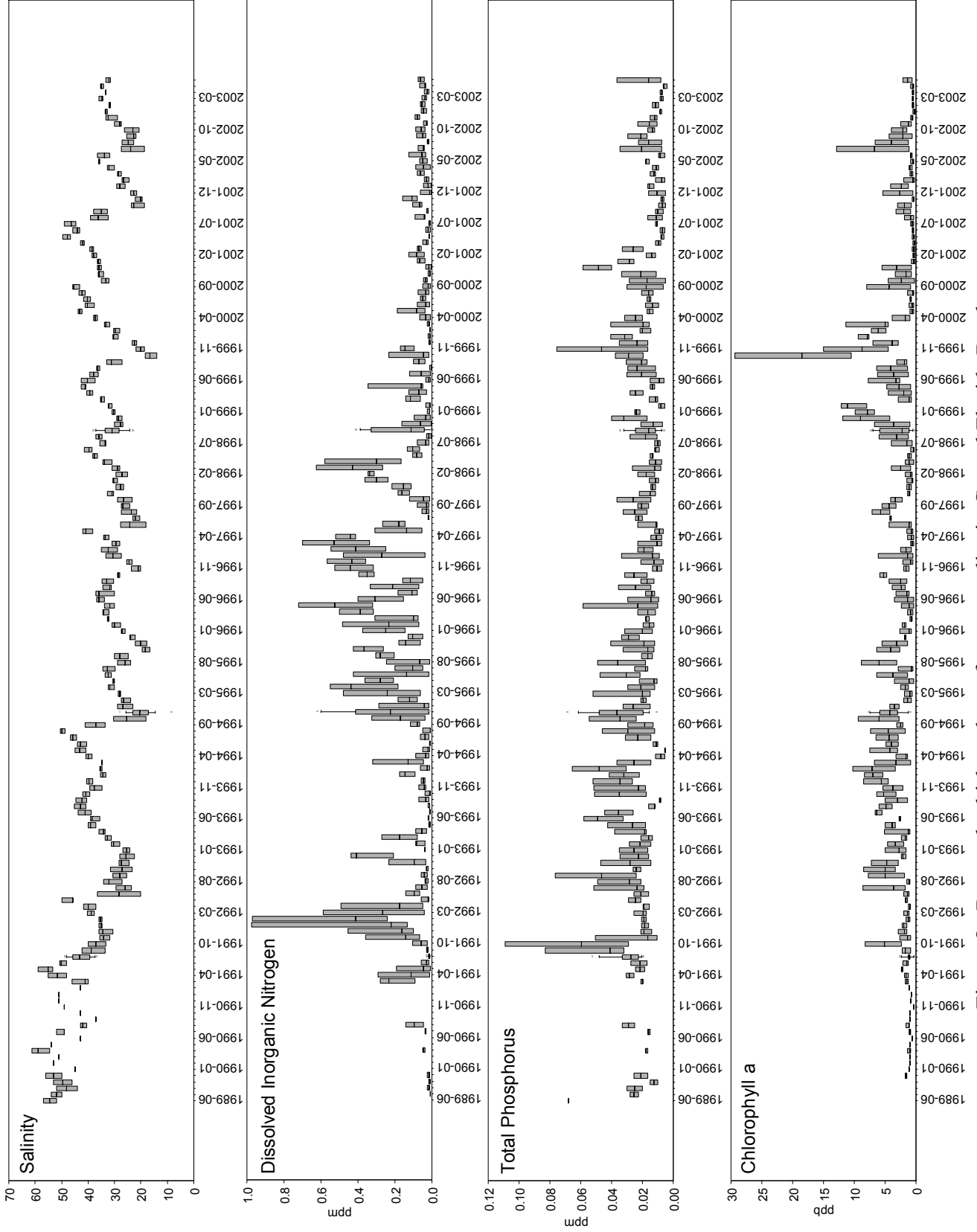


Figure 8. Box-and-whisker plots of water quality in Central Florida Bay by survey.

Western Florida Bay Zone

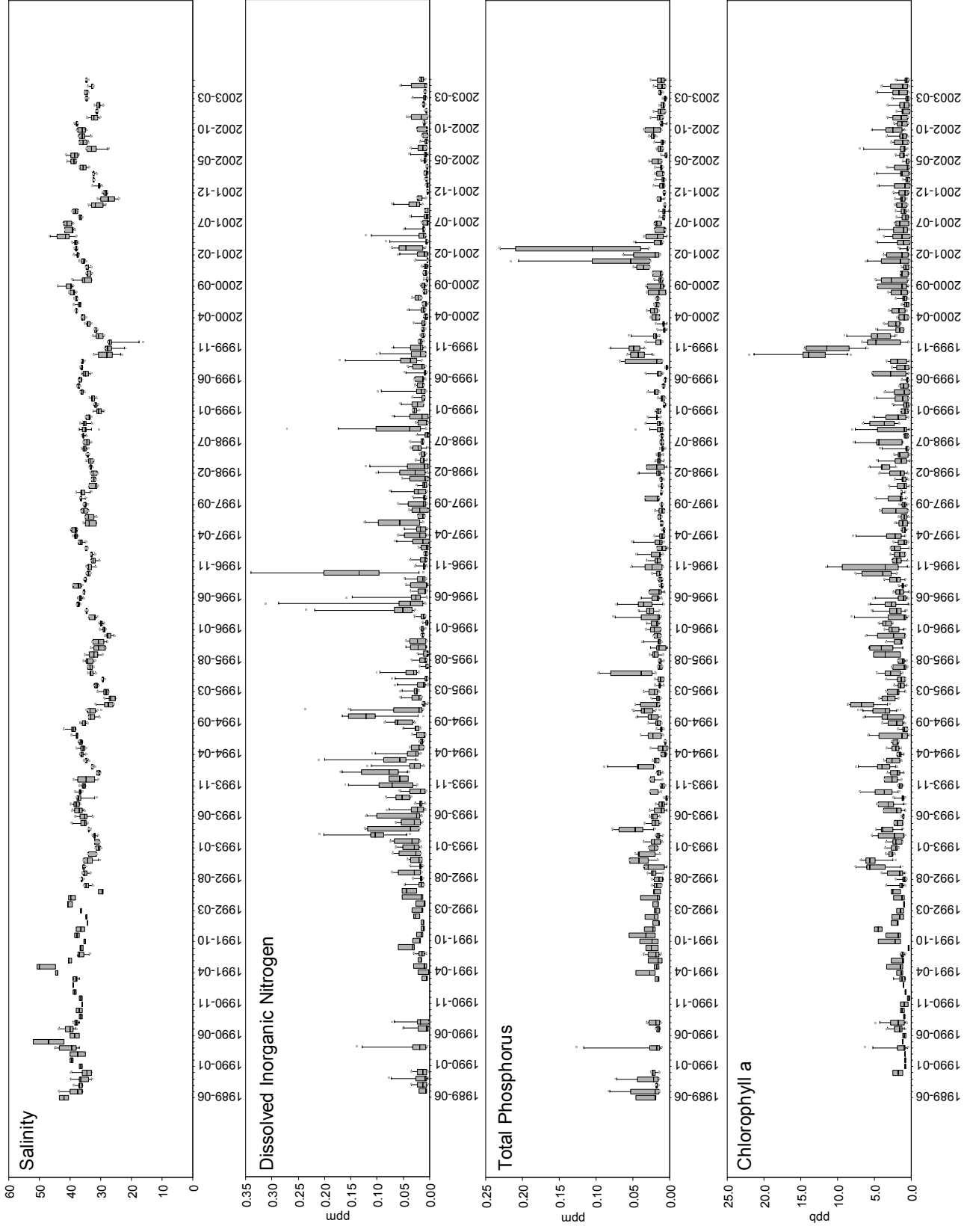


Figure 9. Box-and-whisker plots of water quality in Western Florida Bay by survey.

Whitewater Bay Zone

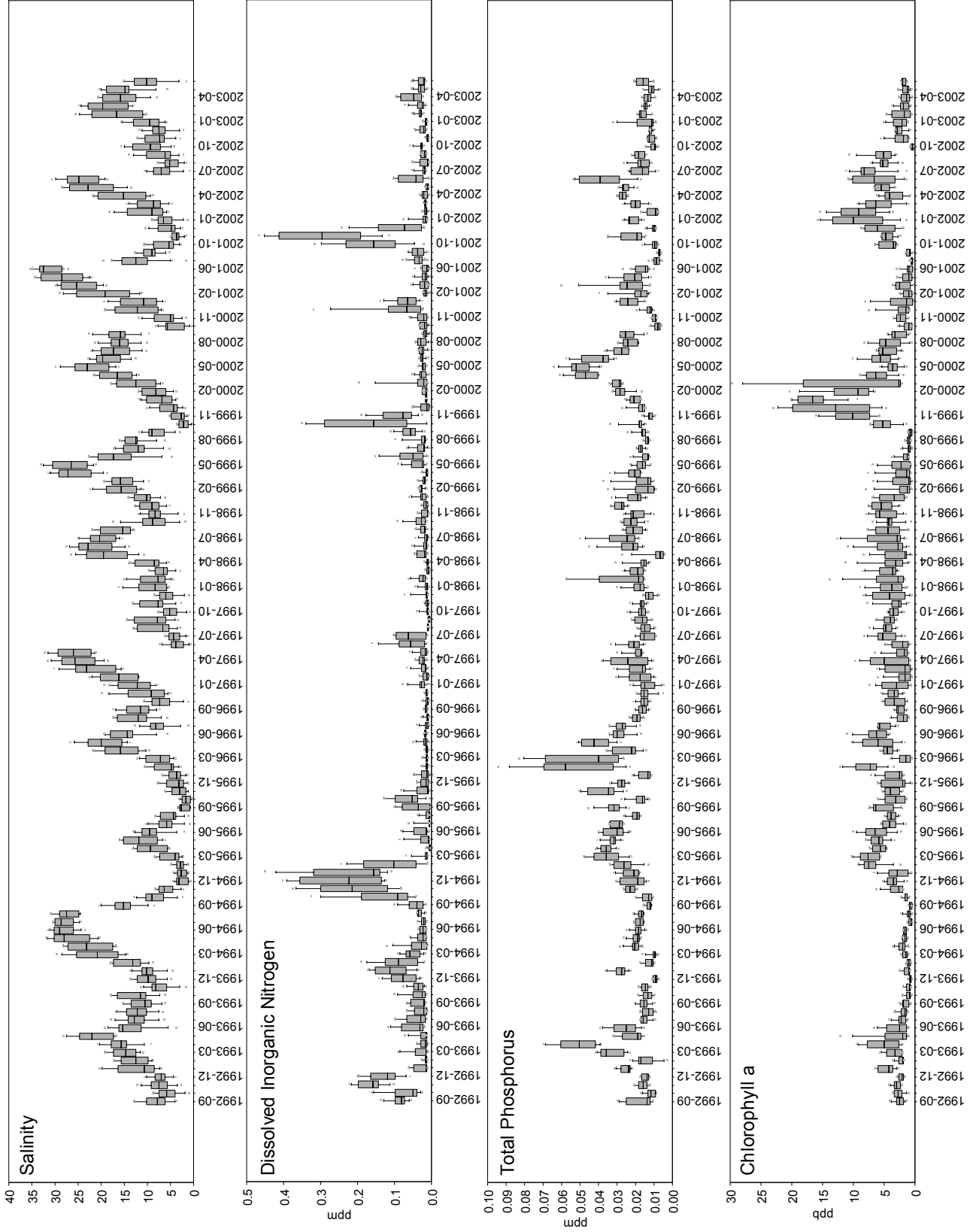


Figure 10. Box-and-whisker plots of water quality in WWB-TTI by survey.

Mangrove Rivers Zone

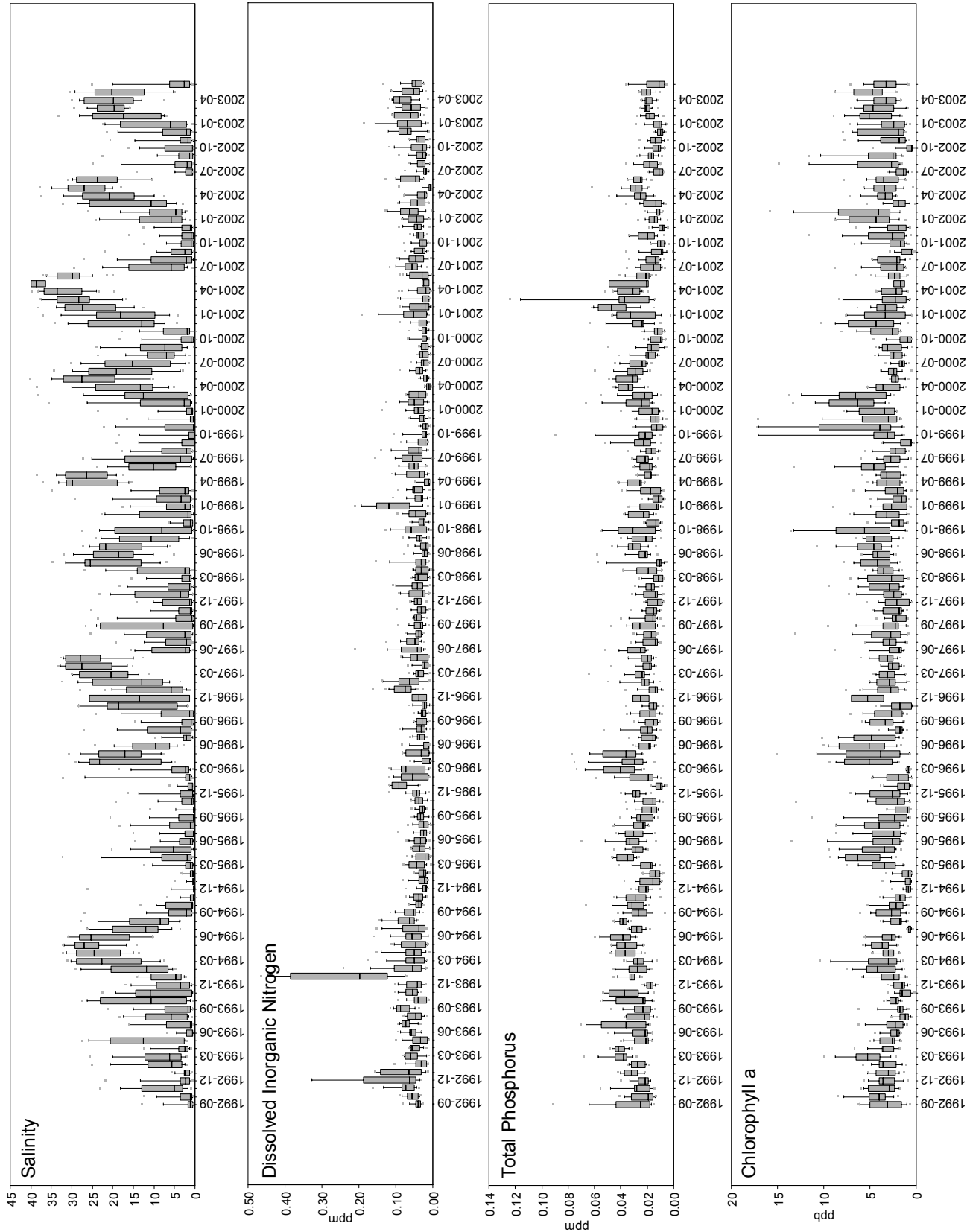


Figure 11. Box-and-whisker plots of water quality in WWB-TTI by survey.

Gulf Islands Zone

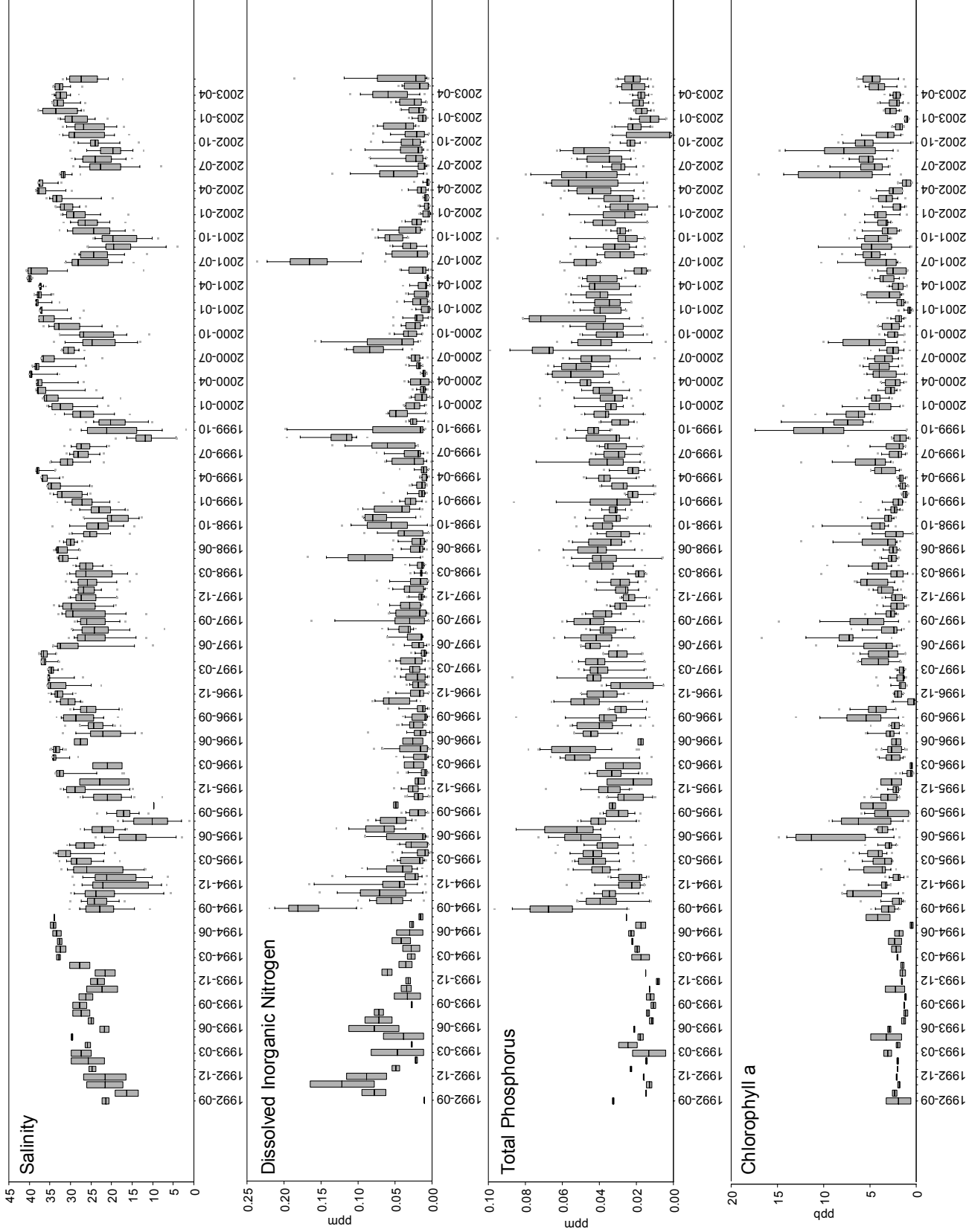


Figure 12. Box-and-whisker plots of water quality in WWB-TTI by survey.

Inner Waterway Zone

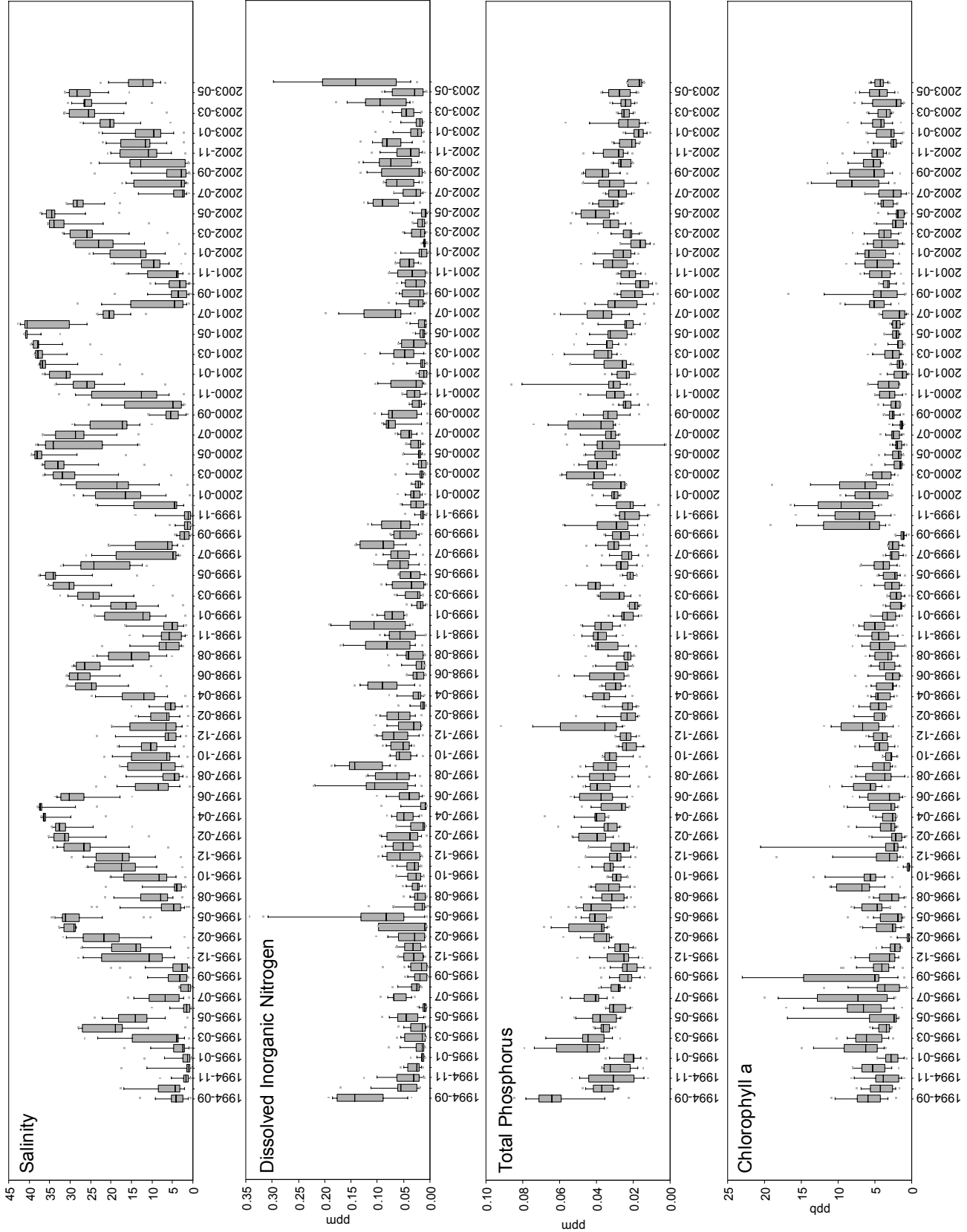


Figure 13. Box-and-whisker plots of water quality in WWB-TTI by survey.

Blackwater River Zone

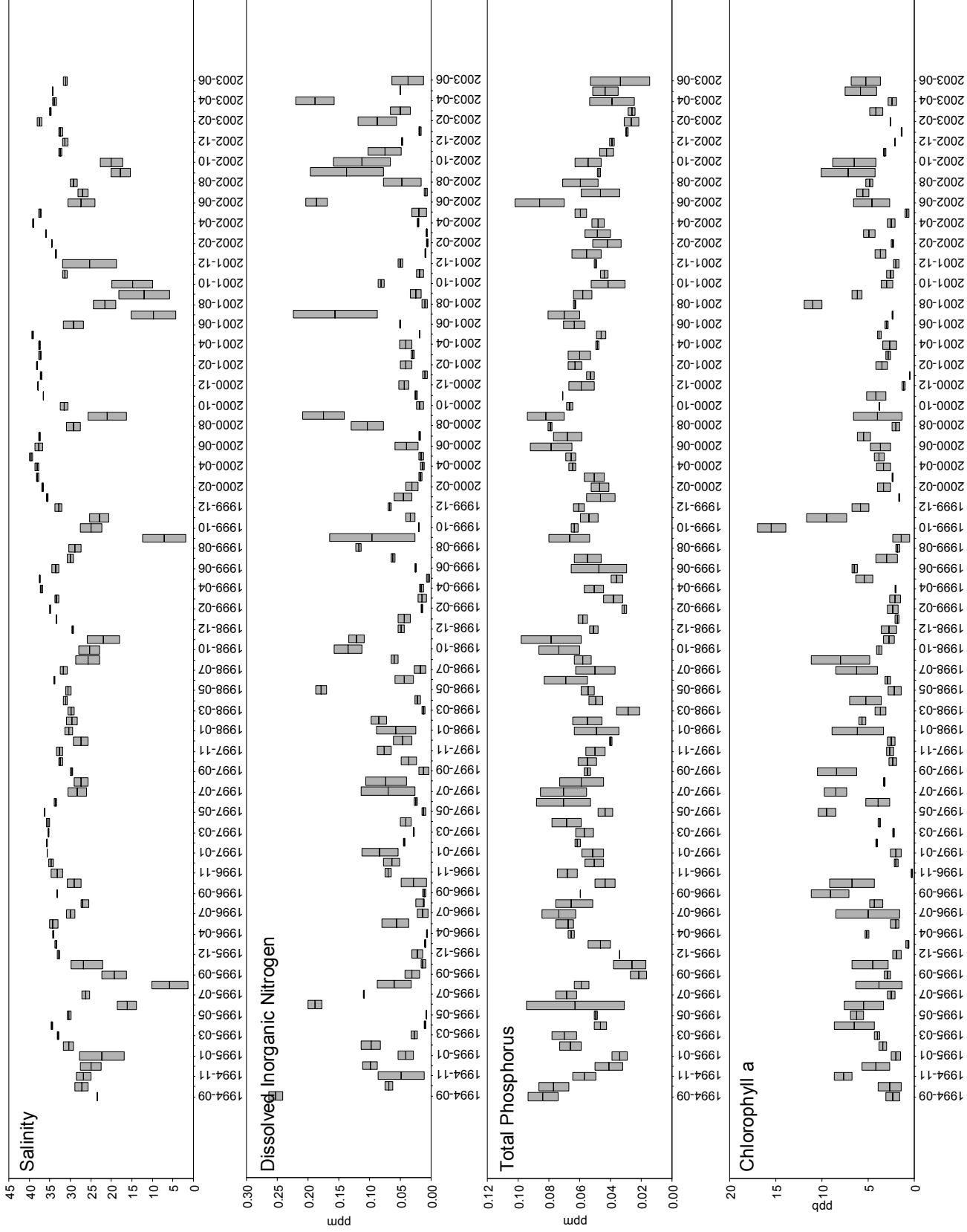


Figure 14. Box-and-whisker plots of water quality in WWB-TTI by survey.

Alongshore Zone

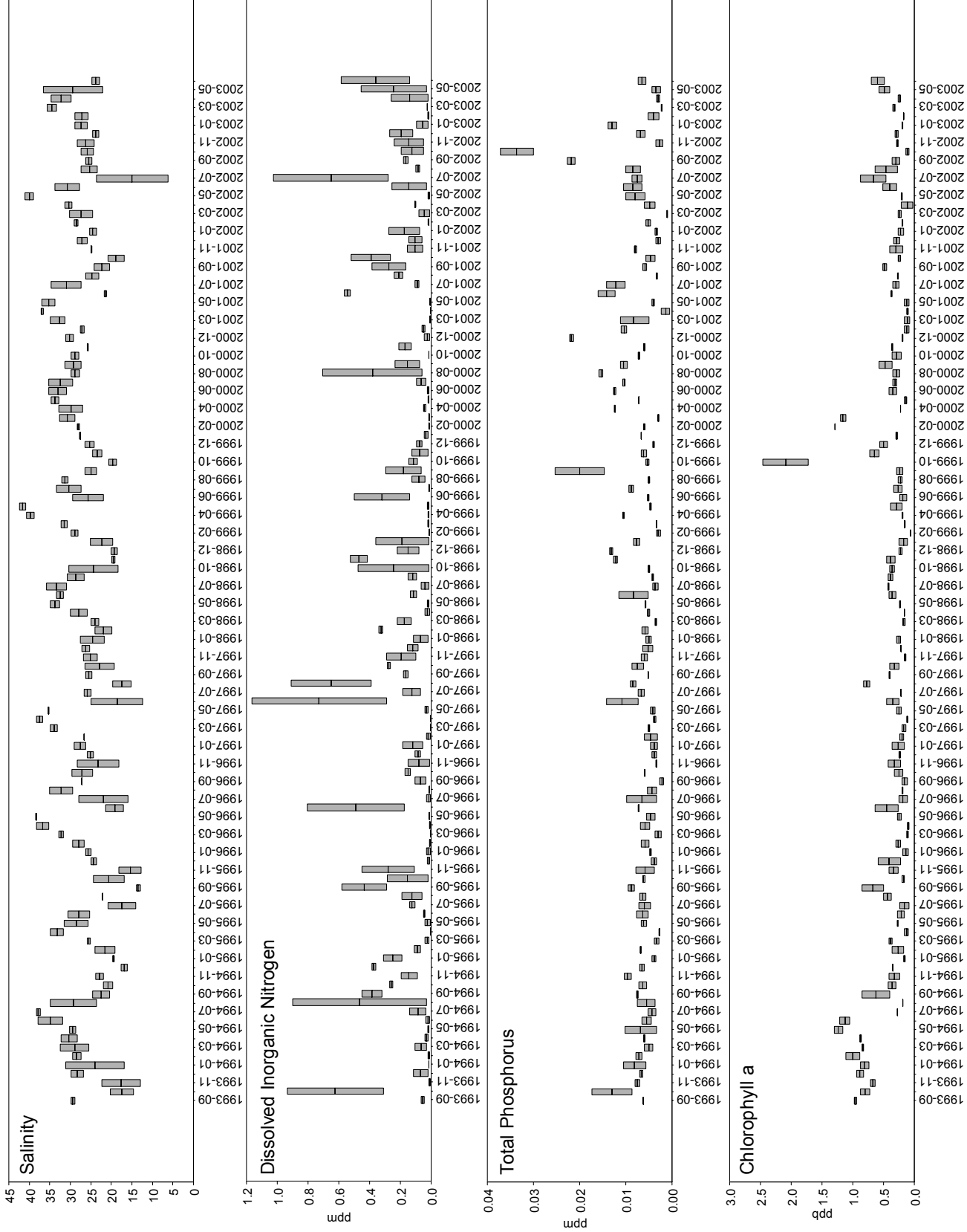


Figure 15. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Inshore Zone

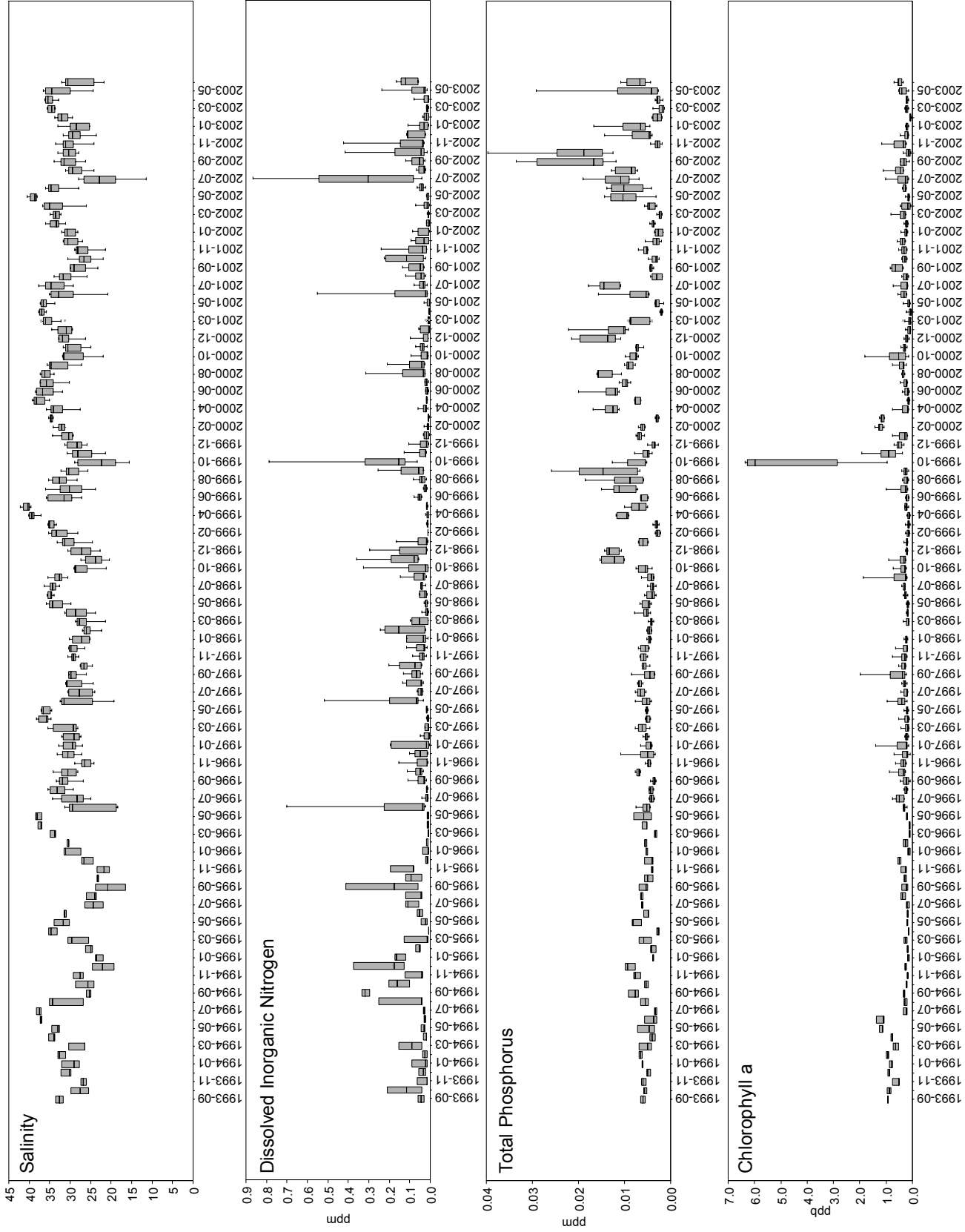


Figure 16. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Main Bay Zone

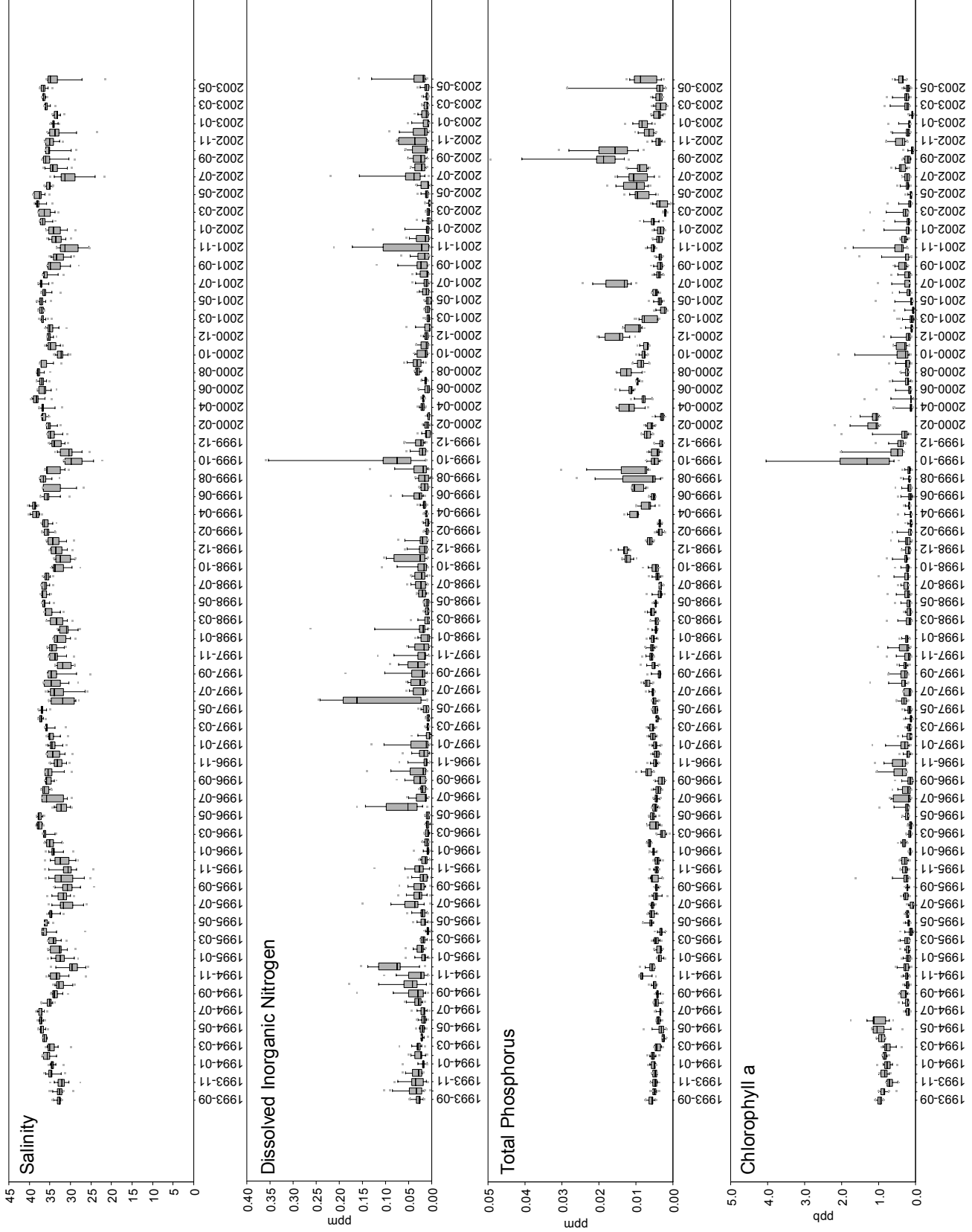


Figure 17. Box-and-whisker plots of water quality in Biscayne Bay by survey.

South Card Sound Zone

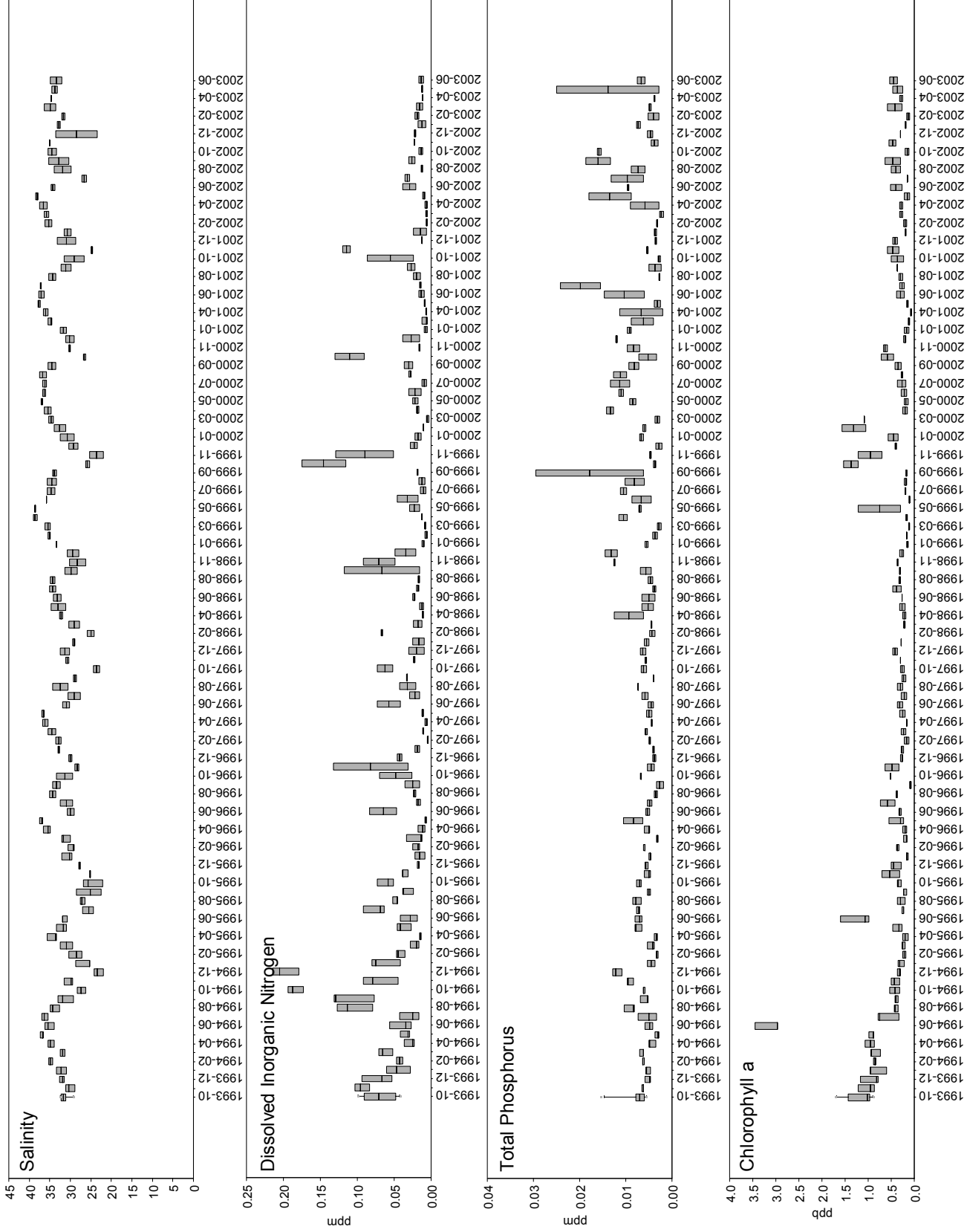


Figure 18. Box-and-whisker plots of water quality in Biscayne Bay by survey.

North Bay Zone

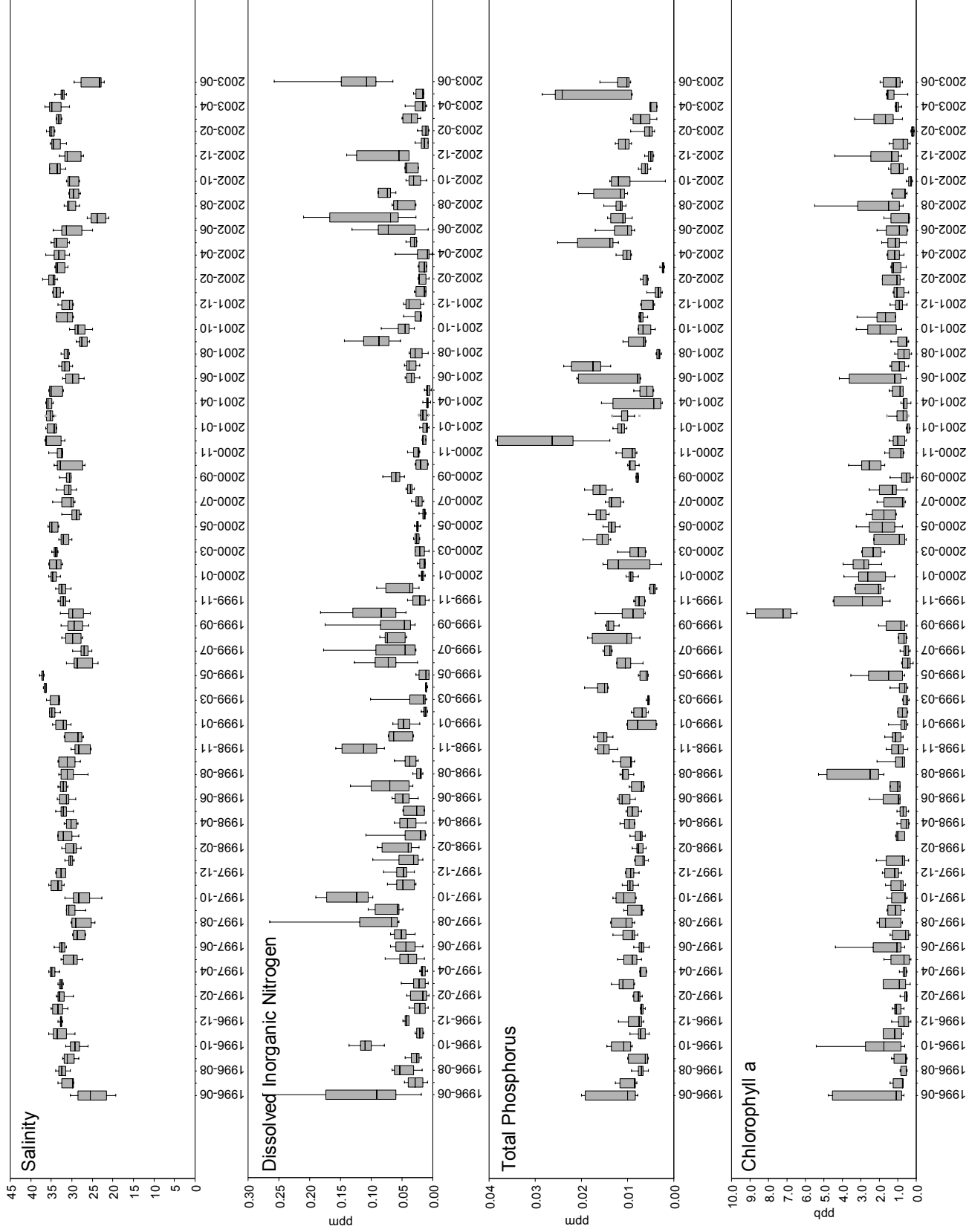


Figure 19. Box-and-whisker plots of water quality in Biscayne Bay by survey.

Shelf Zone

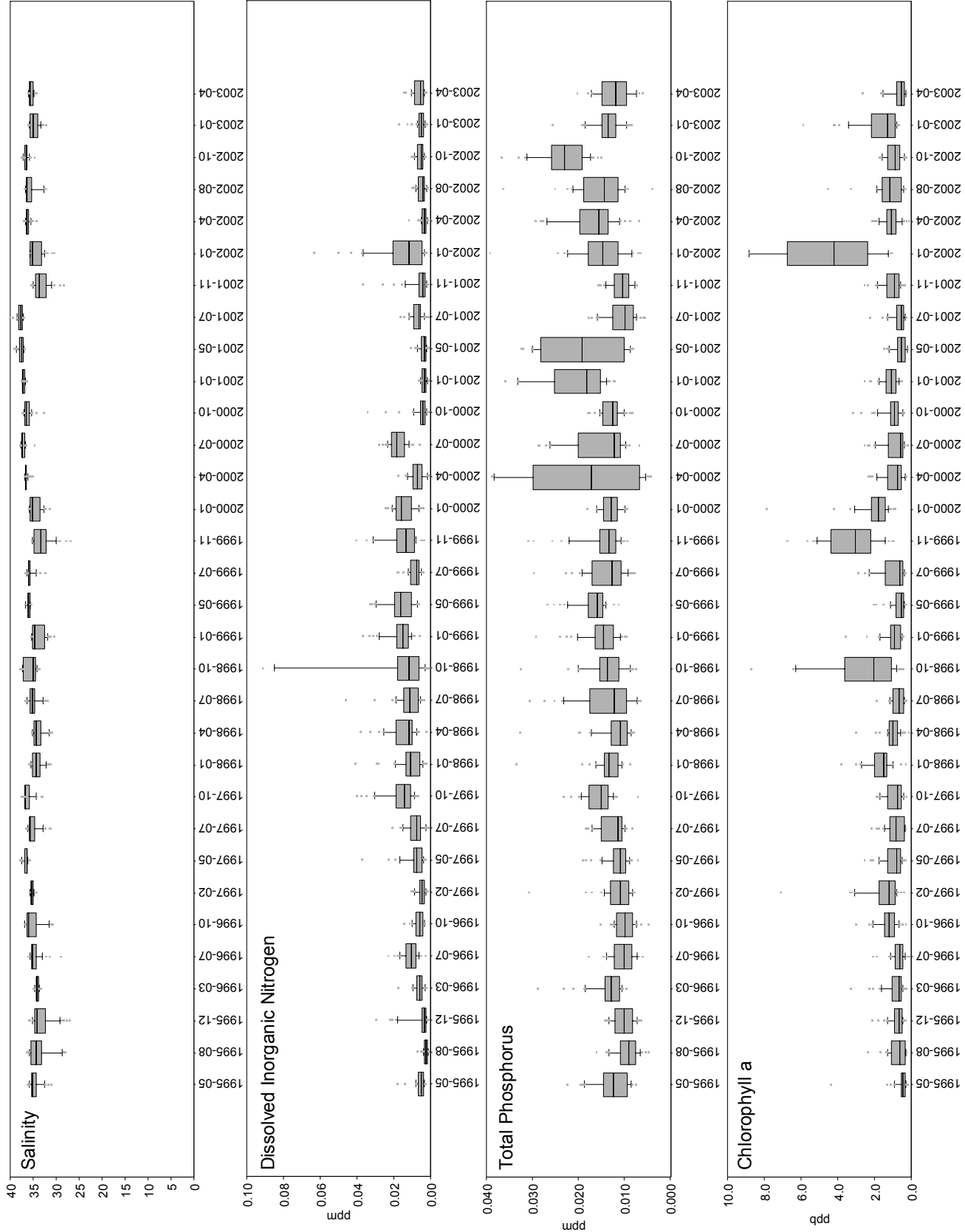


Figure 20. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Shark Zone

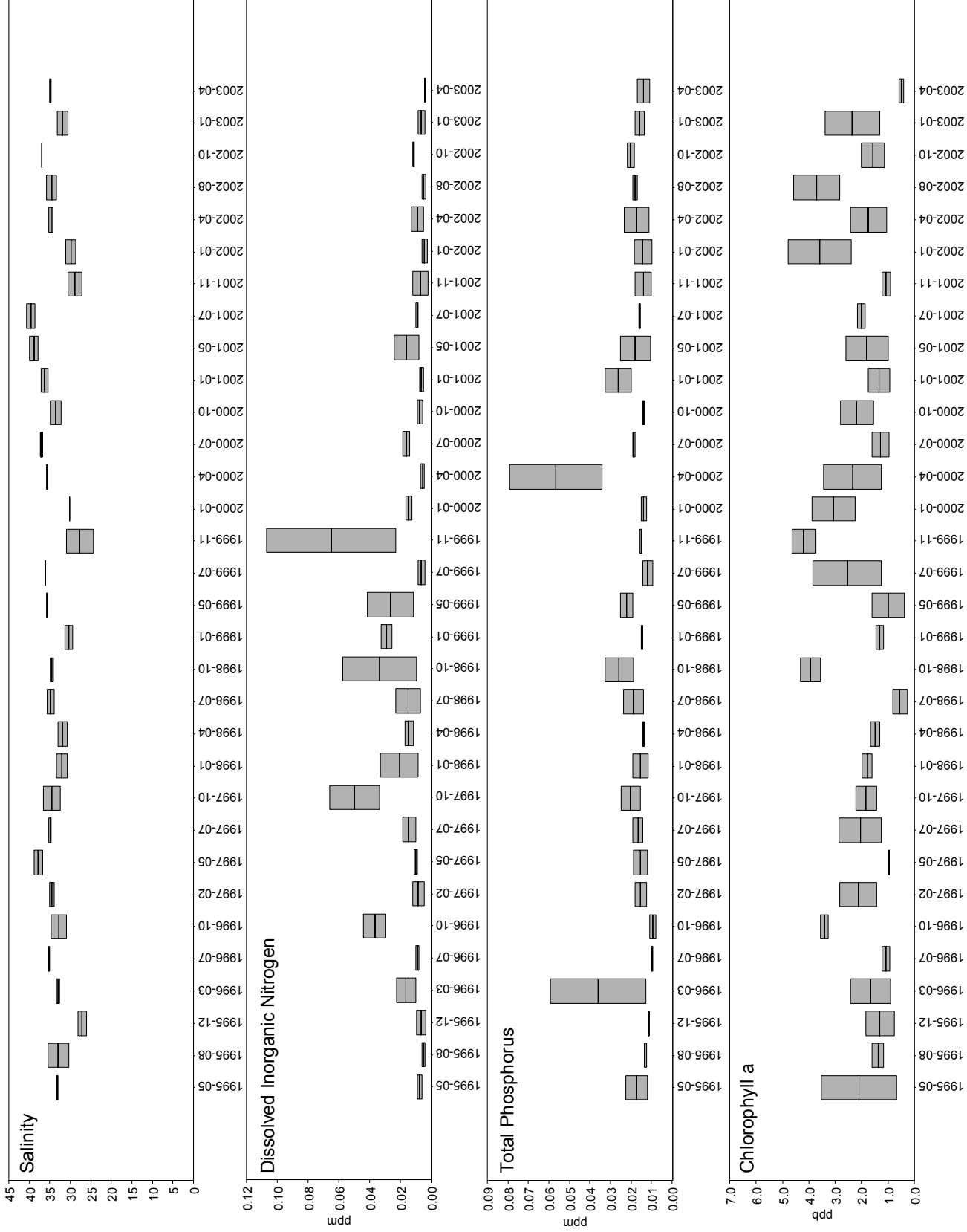


Figure 21. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Shoal Zone

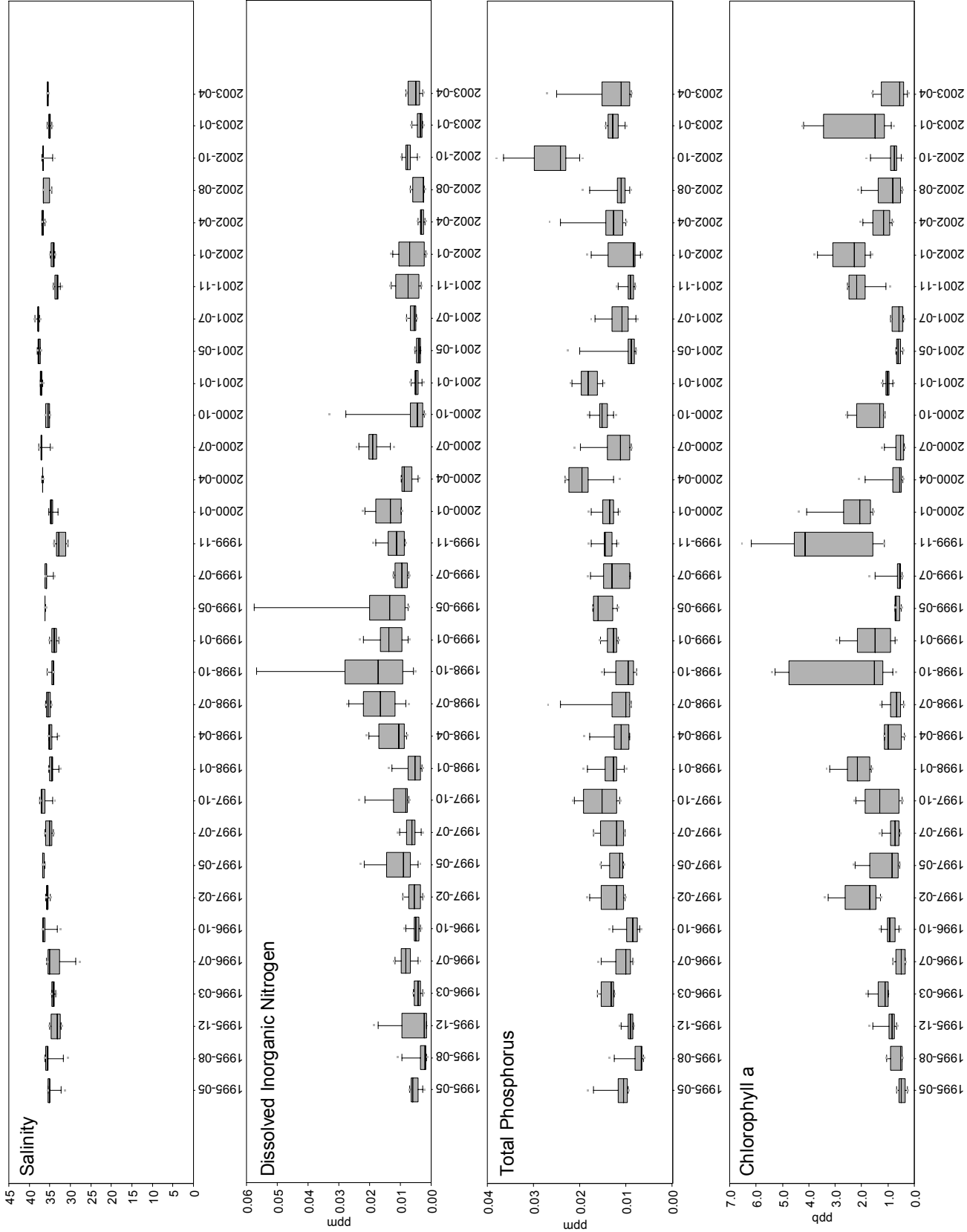


Figure 22. Box-and-whisker plots of water quality in SW Florida Shelf by survey.

Marco Zone

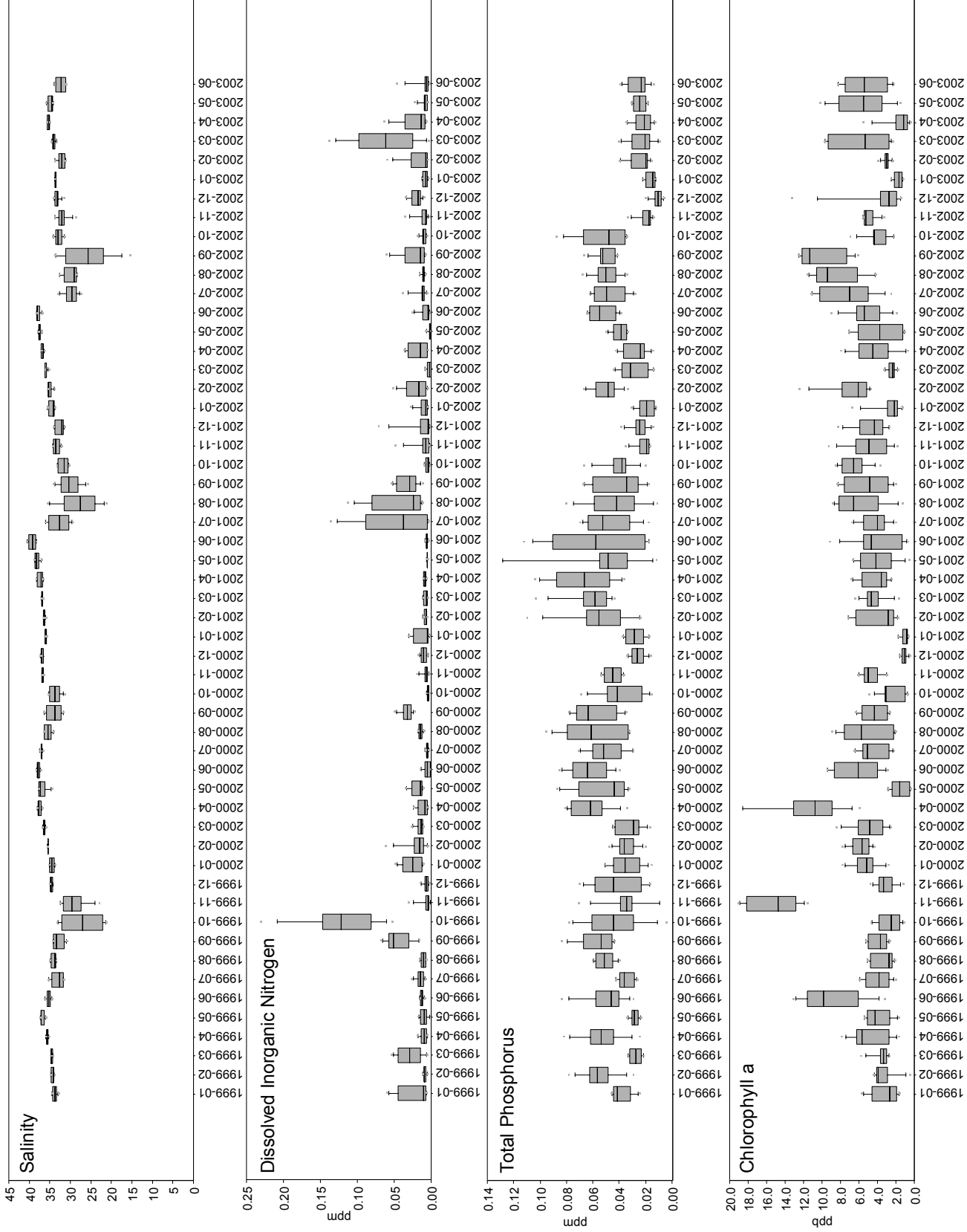


Figure 23. Box-and-whisker plots of water quality in RB-PIS by survey.

Rookery Bay Zone

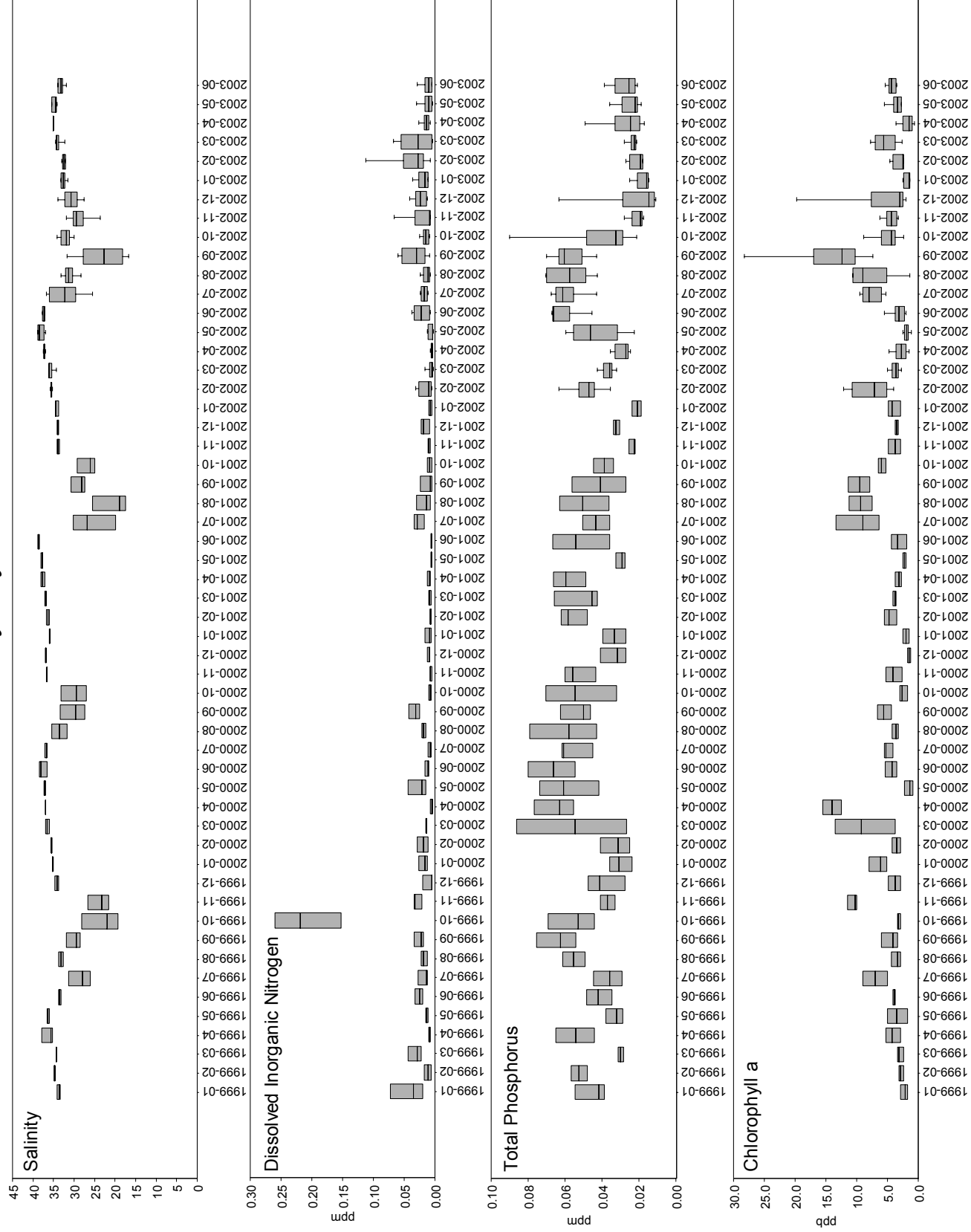


Figure 24. Box-and-whisker plots of water quality in RB-PIS by survey.

Naples Zone

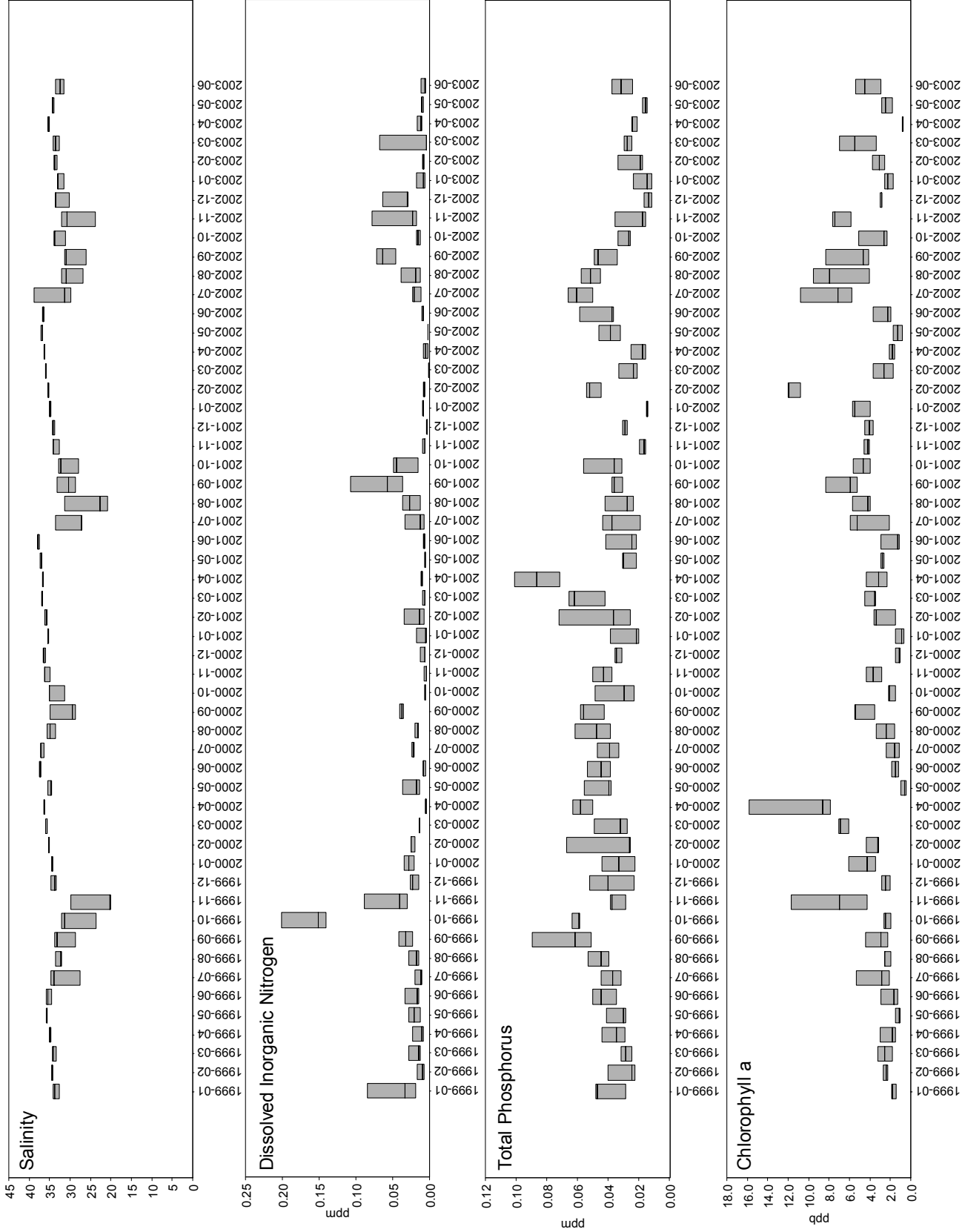


Figure 25. Box-and-whisker plots of water quality in RB-PIS by survey.

San Carlos Bay Zone

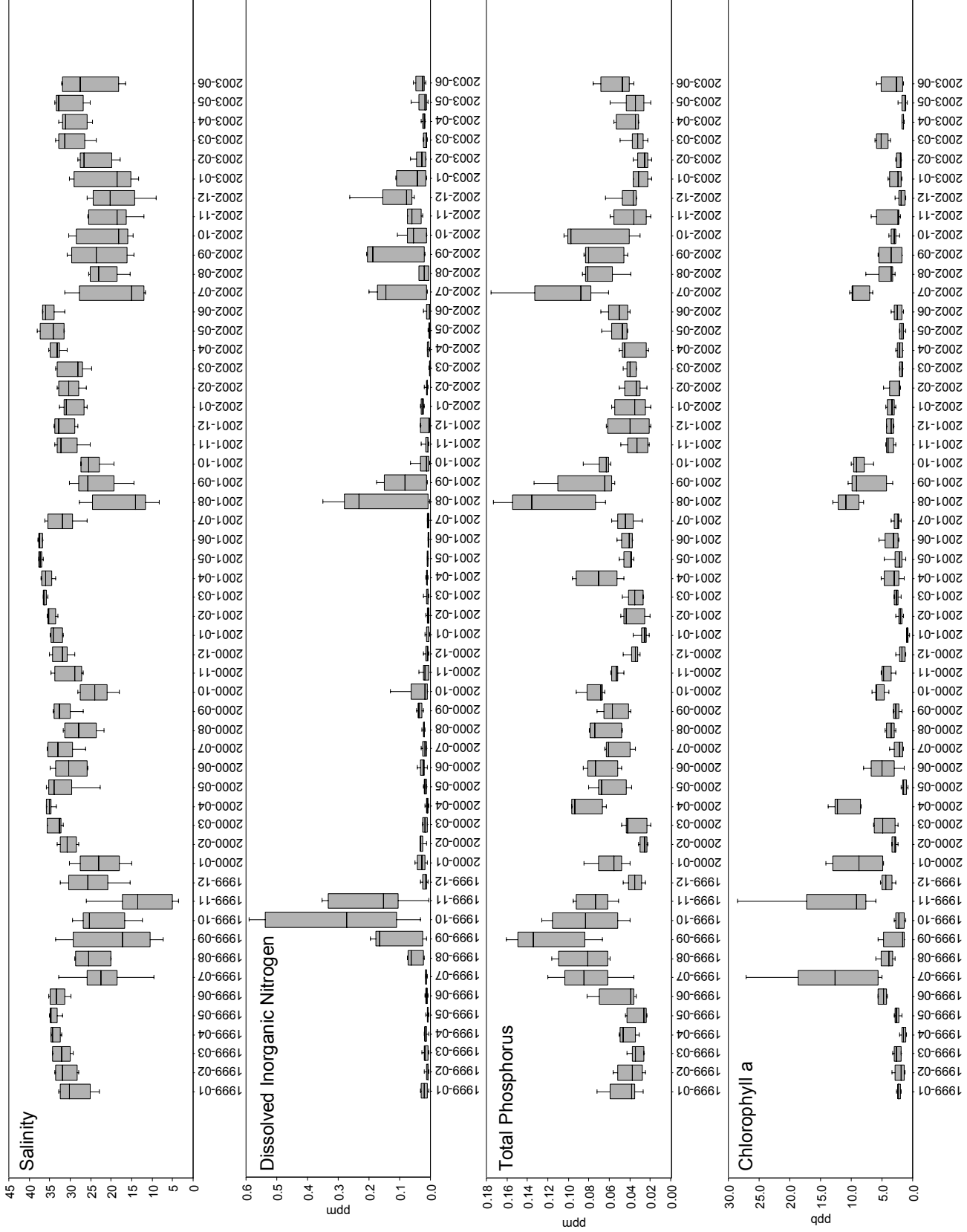


Figure 26. Box-and-whisker plots of water quality in RB-PIS by survey.

Estero Bay Zone

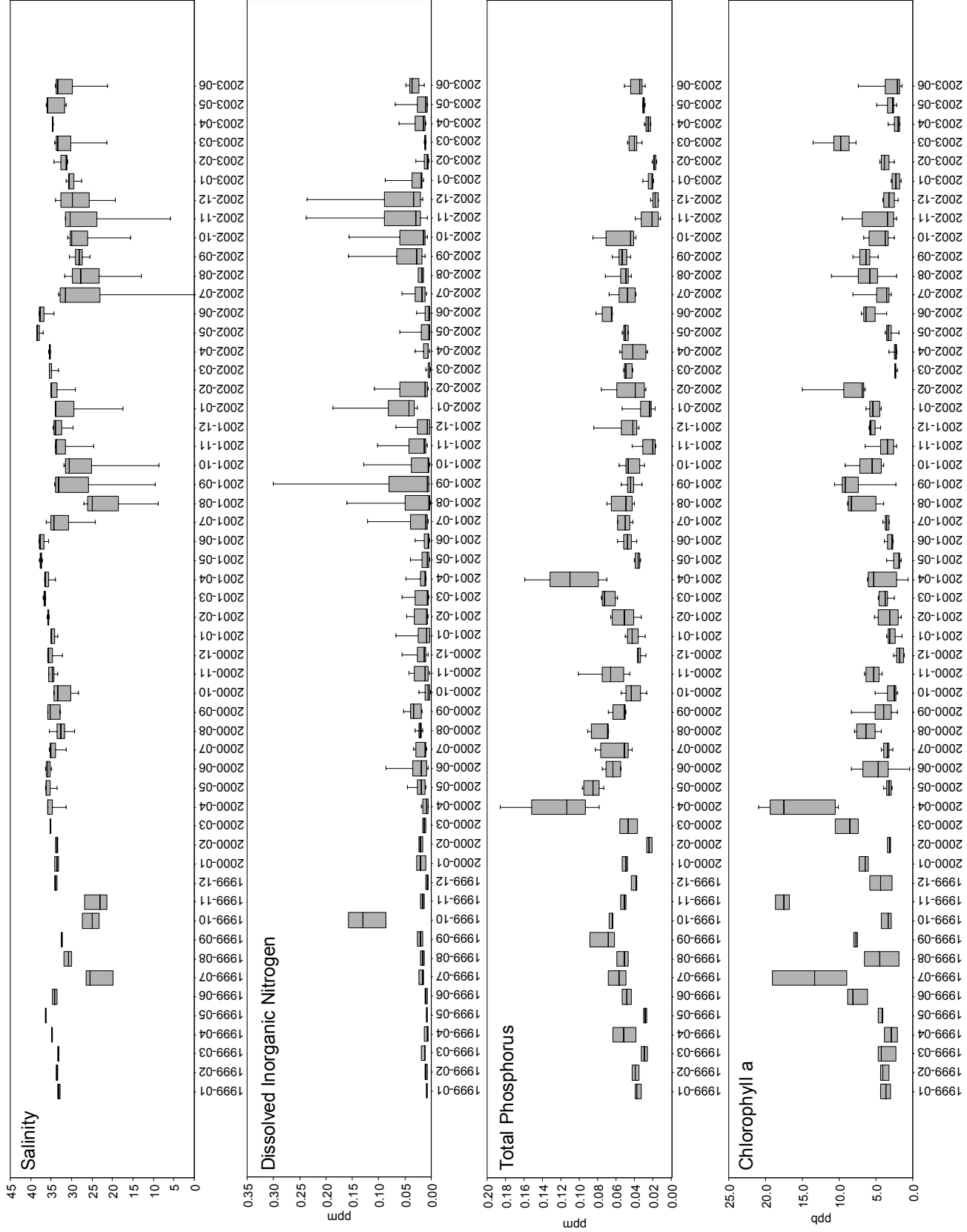


Figure 27. Box-and-whisker plots of water quality in RB-PIS by survey.

Pine Island Sound Zone

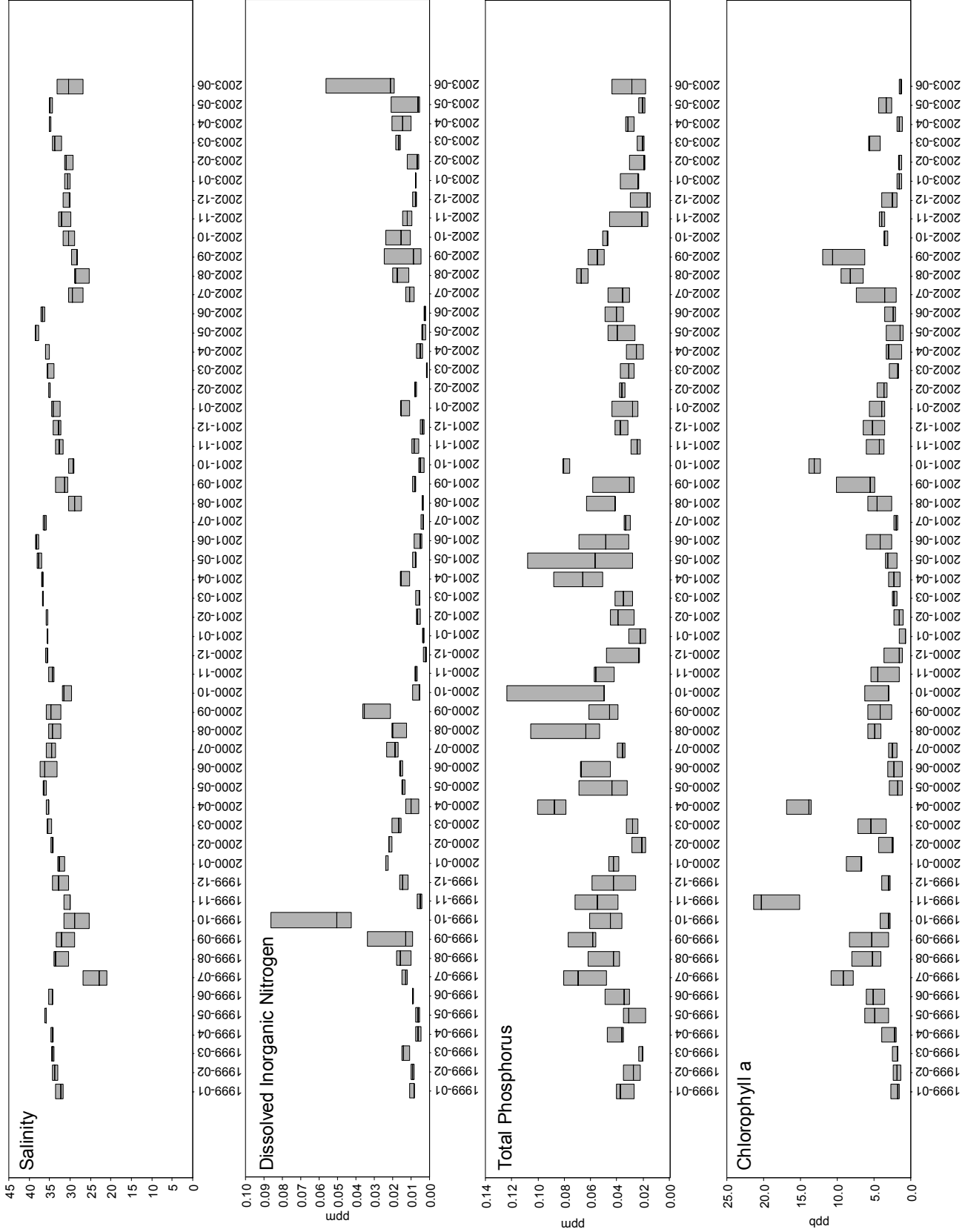


Figure 28. Box-and-whisker plots of water quality in RB-PIS by survey.

Table 1.

Parameter	Zone	Median	Min.	Max.	<i>n</i>
Alkaline	Biscayne Bay	0.144	0.064	0.609	75
Phosphatase	Florida Bay	0.218	0.036	1.558	84
Activity	Rookery Bay	0.045	0.034	0.097	87
($\mu\text{M h}^{-1}$)	SW Shelf	0.025	0.018	0.075	45
	Ten Thousand Is.	0.056	0.028	1.795	78
	Whitewater Bay	0.289	0.032	1.596	66
Chlorophyll a	Biscayne Bay	0.361	0.115	1.938	75
($\mu\text{g l}^{-1}$)	Florida Bay	0.488	0.191	4.819	84
	Rookery Bay	2.375	0.413	10.201	87
	SW Shelf	0.538	0.229	2.625	45
	Ten Thousand Is.	4.043	0.892	8.198	78
	Whitewater Bay	2.298	0.469	8.872	66
Surface	Biscayne Bay	6.29	4.86	7.63	75
Dissolved	Florida Bay	5.94	4.11	7.44	84
Oxygen	Rookery Bay	5.40	3.54	7.26	87
(mg l^{-1})	SW Shelf	5.60	4.03	9.21	45
	Ten Thousand Is.	4.76	2.83	10.23	78
	Whitewater Bay	5.29	2.13	6.77	66
Bottom	Biscayne Bay	6.03	4.38	7.42	75
Dissolved	Florida Bay	5.90	4.07	7.08	84
Oxygen	Rookery Bay	5.22	3.48	7.01	82
(mg l^{-1})	SW Shelf	6.11	4.34	6.80	45
	Ten Thousand Is.	4.58	2.89	9.37	78
	Whitewater Bay	5.00	1.85	6.95	66
NH ₄	Biscayne Bay	0.008	0.003	0.131	75
(ppm)	Florida Bay	0.028	0.002	0.265	83
	Rookery Bay	0.008	0.002	0.063	87
	SW Shelf	0.003	0.001	0.009	45
	Ten Thousand Is.	0.030	0.002	0.314	78
	Whitewater Bay	0.028	0.005	0.081	66
NO ₂	Biscayne Bay	0.001	0.000	0.039	75
(ppm)	Florida Bay	0.001	0.000	0.009	84
	Rookery Bay	0.001	0.000	0.005	87
	SW Shelf	0.001	0.000	0.001	45
	Ten Thousand Is.	0.004	0.000	0.015	78
	Whitewater Bay	0.003	0.000	0.008	66

Parameter	Zone	Median	Min.	Max.	<i>n</i>
NO ₃ (ppm)	Biscayne Bay	0.007	0.000	0.447	75
	Florida Bay	0.007	0.001	0.045	84
	Rookery Bay	0.003	0.000	0.034	87
	SW Shelf	0.002	0.000	0.006	45
	Ten Thousand Is.	0.013	0.001	0.104	78
	Whitewater Bay	0.011	0.000	0.065	66
pH	Biscayne Bay	8.170	7.910	8.695	75
	Florida Bay	8.140	7.935	8.485	84
	Rookery Bay	7.950	7.675	8.190	87
	SW Shelf	8.050	7.890	8.250	45
	Ten Thousand Is.	7.830	7.550	8.370	78
	Whitewater Bay	7.978	6.920	8.900	66
Surface Salinity	Biscayne Bay	34.76	21.59	37.66	75
	Florida Bay	32.48	0.42	35.51	84
	Rookery Bay	34.15	16.50	36.11	87
	SW Shelf	35.55	34.38	36.07	45
	Ten Thousand Is.	28.74	0.69	34.36	78
	Whitewater Bay	15.20	0.86	32.22	66
Bottom Salinity	Biscayne Bay	34.94	22.28	37.66	75
	Florida Bay	32.34	0.40	35.36	84
	Rookery Bay	34.16	17.15	35.82	82
	SW Shelf	35.56	34.74	36.02	45
	Ten Thousand Is.	28.77	0.81	34.38	78
	Whitewater Bay	15.27	0.90	32.55	66
Si(OH) ₄ (ppm)	Biscayne Bay	0.015	0.002	0.429	25
	Florida Bay	0.170	0.014	0.825	28
	Rookery Bay	0.681	0.135	1.734	29
	SW Shelf	0.017	0.001	0.747	45
	Ten Thousand Is.	3.071	1.228	4.493	26
	Whitewater Bay	1.180	0.038	2.826	22
Soluble Reactive Phosphorus (ppm)	Biscayne Bay	0.001	0.000	0.006	75
	Florida Bay	0.002	0.001	0.008	83
	Rookery Bay	0.006	0.000	0.041	87
	SW Shelf	0.001	0.000	0.004	45
	Ten Thousand Is.	0.007	0.000	0.040	78
	Whitewater Bay	0.004	0.001	0.009	66

Parameter	Zone	Median	Min.	Max.	<i>n</i>
Surface Temperature (°C)	Biscayne Bay	28.34	20.02	29.47	75
	Florida Bay	28.36	25.05	30.63	84
	Rookery Bay	29.68	23.09	32.03	87
	SW Shelf	24.33	23.39	24.81	45
	Ten Thousand Is.	30.06	18.86	32.83	78
	Whitewater Bay	28.36	24.84	30.21	66
Bottom Temperature (°C)	Biscayne Bay	28.38	20.02	29.99	75
	Florida Bay	28.35	25.13	30.63	84
	Rookery Bay	29.71	23.62	31.42	82
	SW Shelf	24.33	23.38	24.80	45
	Ten Thousand Is.	29.99	18.47	32.18	78
	Whitewater Bay	28.43	24.47	30.20	66
Total Nitrogen (ppm)	Biscayne Bay	0.356	0.215	1.115	75
	Florida Bay	0.443	0.206	1.370	84
	Rookery Bay	0.274	0.173	0.694	87
	SW Shelf	0.295	0.215	0.542	45
	Ten Thousand Is.	0.440	0.291	0.760	78
	Whitewater Bay	0.482	0.322	0.623	66
Total Organic Carbon (ppm)	Biscayne Bay	2.697	1.692	6.055	75
	Florida Bay	7.047	2.444	15.645	84
	Rookery Bay	4.340	2.796	15.833	87
	SW Shelf	2.534	1.549	16.708	45
	Ten Thousand Is.	8.395	4.243	19.025	78
	Whitewater Bay	12.422	5.132	18.335	66
Total Organic Nitrogen (ppm)	Biscayne Bay	0.310	0.174	1.010	75
	Florida Bay	0.379	0.194	1.163	83
	Rookery Bay	0.259	0.168	0.633	87
	SW Shelf	0.290	0.211	0.538	45
	Ten Thousand Is.	0.368	0.023	0.683	78
	Whitewater Bay	0.412	0.270	0.609	66
Total Phosphorus (ppm)	Biscayne Bay	0.004	0.002	0.029	75
	Florida Bay	0.006	0.001	0.052	84
	Rookery Bay	0.027	0.012	0.076	87
	SW Shelf	0.011	0.006	0.027	45
	Ten Thousand Is.	0.023	0.006	0.054	78
	Whitewater Bay	0.014	0.006	0.034	66
Turbidity (NTU)	Biscayne Bay	0.68	0.15	2.78	75
	Florida Bay	2.03	0.53	18.50	84
	Rookery Bay	2.48	0.76	15.23	87
	SW Shelf	2.49	0.91	19.33	45
	Ten Thousand Is.	4.92	0.60	66.60	78
	Whitewater Bay	2.12	0.72	10.19	66