Supplementary Material

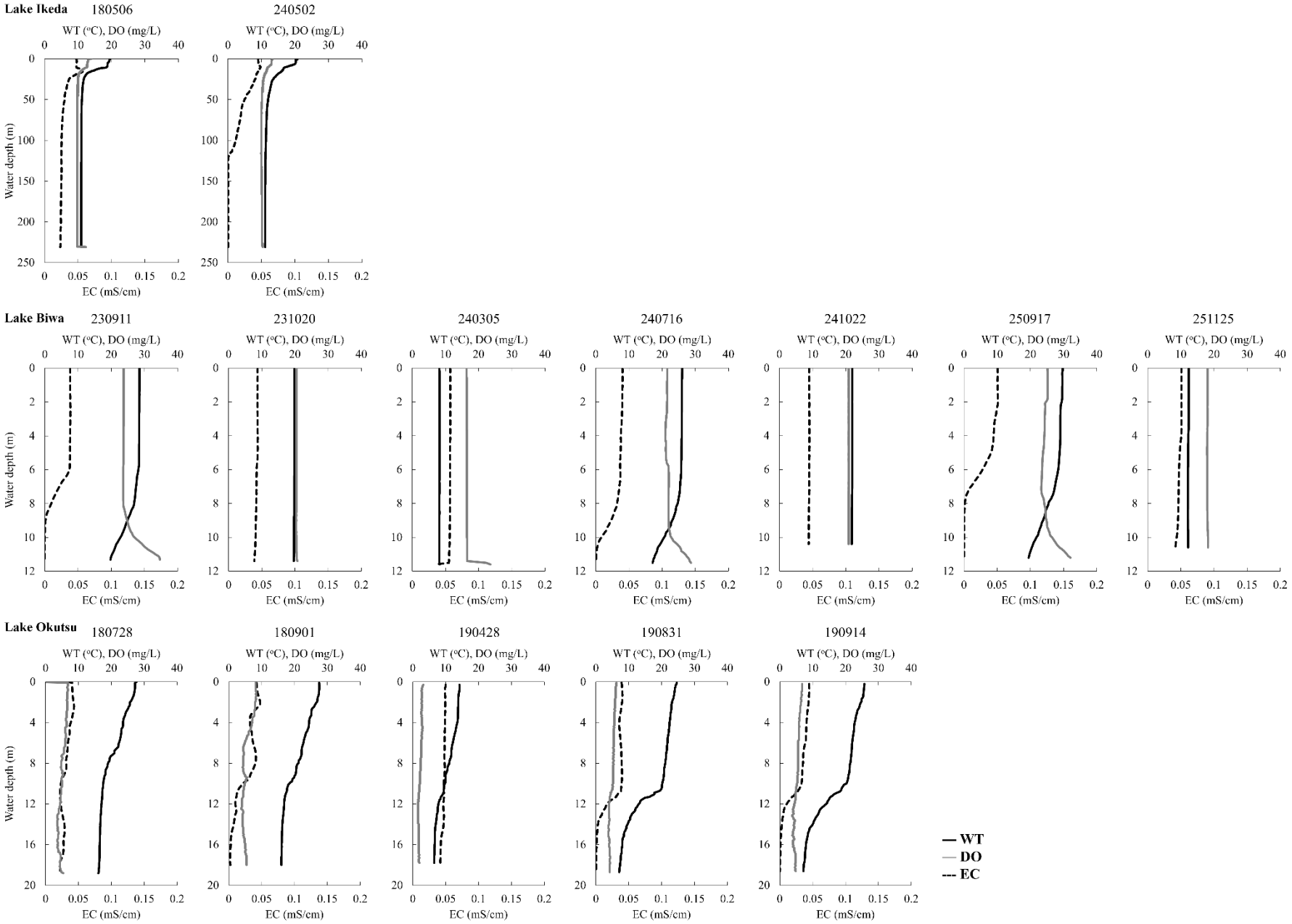

Fig. S1 Vertical profiles of water quality parameters—water temperature (WT), electrical conductivity (EC), and dissolved oxygen (DO)—in the water columns

of Lake Ikeda (May 2018 and May 2024), the South Basin of Lake Biwa (multiple sampling dates, 2023–2025), and Lake Okutsu (2018–2019). Note the development of hypolimnetic anoxia (DO ≈ 0 mg L^{-1}) during stratification periods at all three study sites. These profiles demonstrate the contrasting redox environments associated with circulation and stratification seasons at each lake.

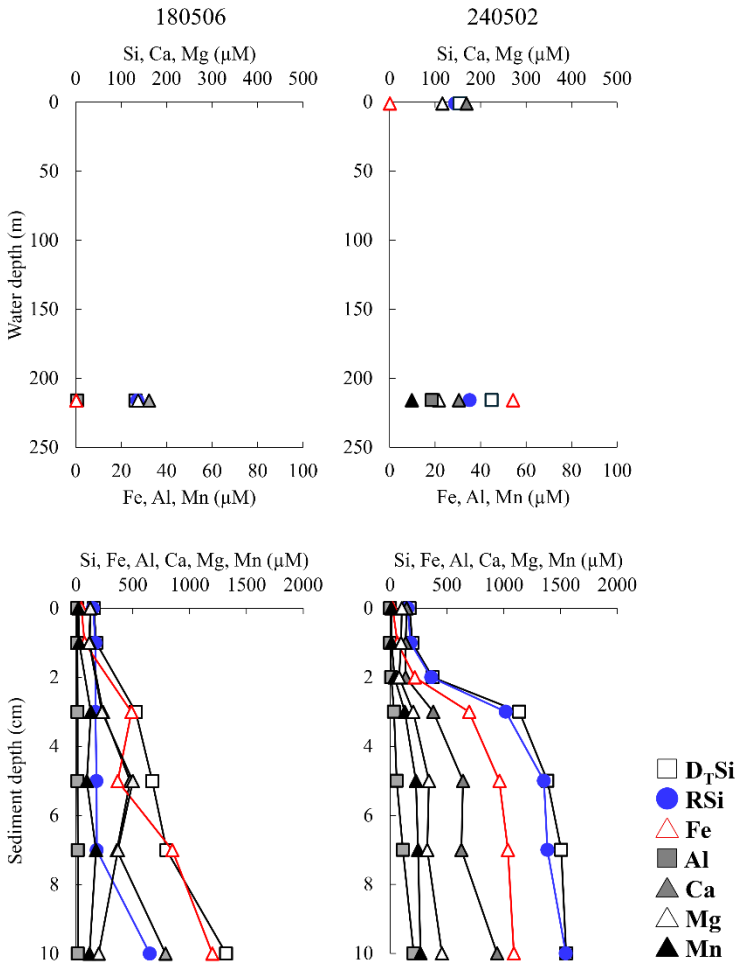

Fig. S2 Vertical profiles of dissolved substances—D_TSi, RSi, iron (Fe), aluminum (Al), calcium (Ca), magnesium (Mg), and manganese (Mn)—in the water column and sediment pore water of Lake Ikeda in May 2018 (oxic) and May 2024 (anoxic). Note the marked increase in all dissolved species, particularly D_TSi, iron, and manganese, in pore water under anoxic conditions in 2024 relative to the uniform, low-concentration profiles observed in 2018. In May 2024, D_TSi in pore water showed a strong positive correlation with iron (R^2 = 0.96) and manganese (R^2 = 0.92; Table S3).

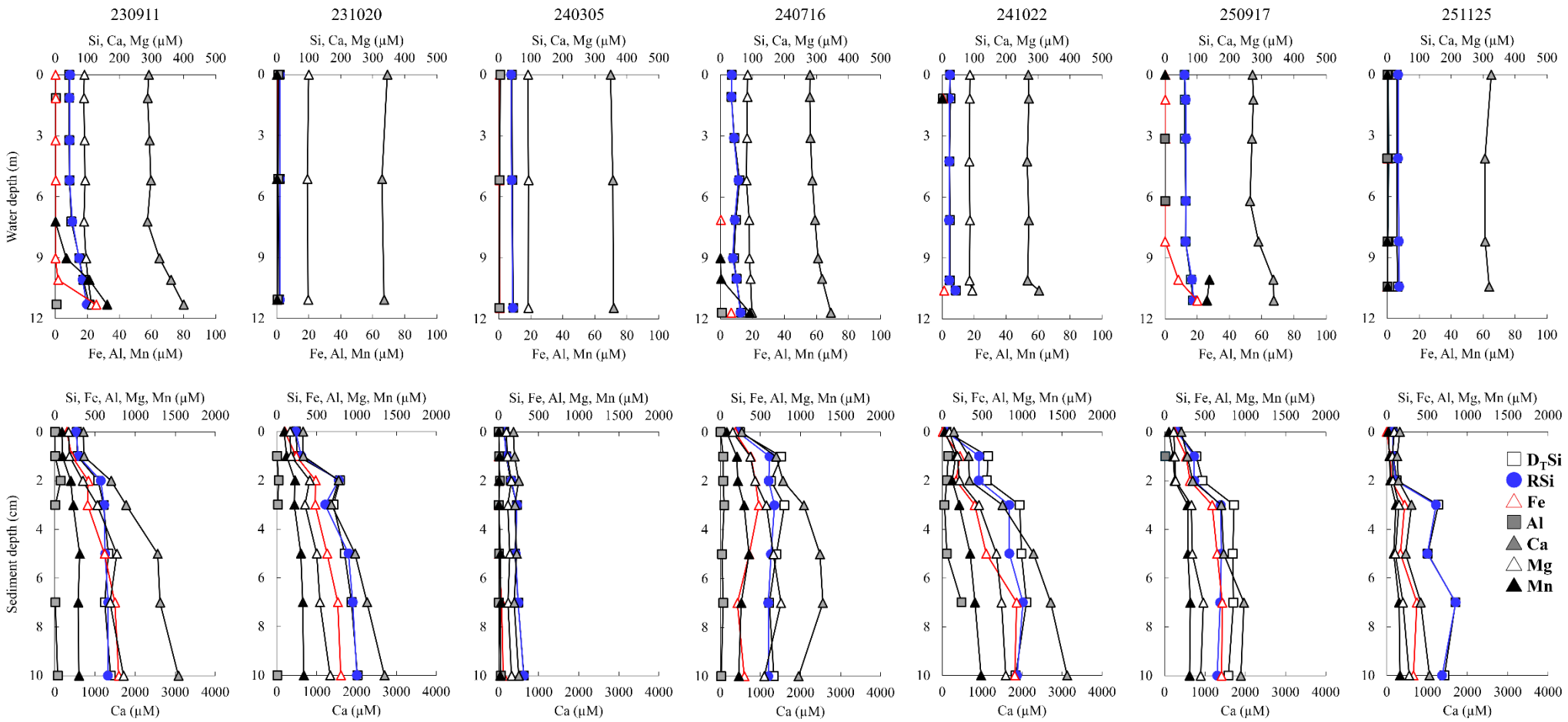

Fig. S3 Vertical profiles of dissolved substances—D_TSi, RSi, iron (Fe), aluminum (Al), calcium (Ca), magnesium (Mg), and manganese (Mn)—in the water column and sediment pore water of the South Basin of Lake Biwa during the study period (2023–2025). Note the seasonal contrast between stratification periods (elevated D_TSi, iron, and manganese; pronounced D_PSi) and circulation periods (suppressed concentrations; near-absence of D_PSi in surface porewater). Correlation coefficients between D_TSi and co-dissolved metals are provided in Table S5.

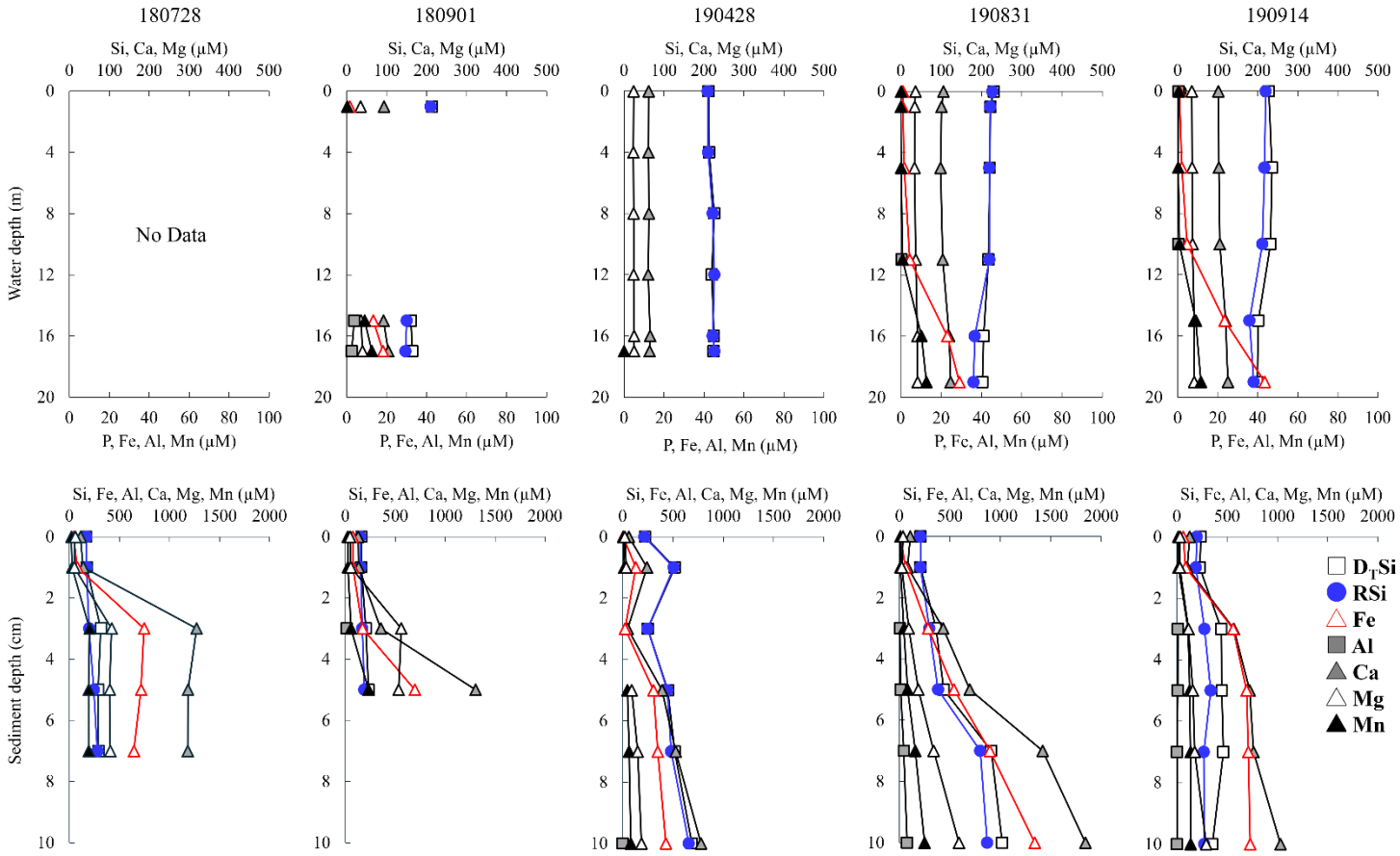

Fig. S4 Vertical profiles of dissolved substances—D_TSi, RSi, iron (Fe), aluminum (Al), calcium (Ca), magnesium (Mg), and manganese (Mn)—in the water column and sediment pore water of Lake Okutsu during the study period (2018–2019). Note the rapid increases in iron and manganese in the anoxic hypolimnion during summer stratification (September 2018, August 2019, September 2019), concurrent with elevated D_TSi concentrations; D_PSi accounted for up to 42% of D_TSi during peak stratification (Table S6). In sediment pore water under anoxic conditions, dissolved iron and manganese reached 12–1341 μM and 9–248 μM, respectively.

Table S1 Dissolved substance data for Lake Ikeda (May 2018 and May 2024), including D_TSi, RSi, D_PSi, and dissolved metal concentrations in water column and sediment pore water.

Lake Ikeda		Depth	RSi	D_TSi	Fe	Al	Ca	Mg	Mn
						($\mu mol\ L^{-1}$)			
May 6, 2018	water depth (m)	1	131.42	123.70	<DL	0.53	159.94	129.02	<DL
		216	135.77	131.53	0.28	0.57	161.40	137.09	0.38
	Sediment depth (cm)	0	148.81	155.36	46.83	<DL	125.70	125.86	20.22
		1	170.54	177.16	76.28	<DL	120.61	115.95	28.24
		3	170.54	525.30	487.85	<DL	237.89	227.30	129.74
		5	179.24	671.04	367.17	<DL	474.75	500.59	95.46
		7	181.84	797.93	847.34	<DL	359.00	367.73	174.89
		10	648.68	1320.46	1200.51	<DL	787.94	199.16	119.11
May 2, 2024	water depth (m)	1	143.74	154.18	0.08	<DL	169.09	115.57	<DL
		231	176.17	224.20	54.27	18.49	152.44	108.26	9.76
	Sediment depth (cm)	0	155.54	171.39	22.49	0.34	145.46	102.96	8.86
		1	180.43	196.54	65.93	0.56	135.47	96.03	13.21
		2	363.47	374.25	218.19	11.10	135.49	79.92	38.16
		3	1017.31	1136.15	695.01	32.93	379.09	202.98	130.06
		5	1353.51	1385.32	961.79	56.78	642.26	340.82	226.58
		7	1384.16	1506.32	1037.51	112.94	628.00	327.72	245.73
		10	1545.74	1548.33	1089.45	207.47	941.70	456.56	266.23

Table S2 Coefficients of determination (R^2) for linear regressions between D_TSi and co-dissolved substances in Lake Ikeda pore water under oxic and anoxic conditions.

Lake Ikeda	RSi	D_TSi	Ca	Fe	Al	Mn	Mg
RSi	1						
D_TSi	0.89	1					
Ca	0.80	0.93	1				
Fe	0.76	0.96	0.91	1			
Al	0.83	0.80	0.94	0.82	1		
Mn	0.83	0.92	0.84	0.89	0.86	1	
Mg	0.47	0.65	0.71	0.62	0.92	0.76	1

Table S3 Dissolved substance data for the South Basin of Lake Biwa (2023–2025), including D_TSi, RSi, D_PSi, and dissolved metal concentrations in water column and sediment pore water.

Lake Biwa		Depth	RSi	D_TSi	Fe	Al	Ca	Mg	Mn
						($\mu mol\ L^{-1}$)			
September 11, 2023	water depth (m)	0	45.87	43.34	0.15	<DL	291.49	90.49	<DL
		1	44.82	42.71	0.16	0.47	287.61	89.33	<DL
		3	44.82	43.09	0.10	<DL	293.65	91.23	<DL
		5	44.29	44.49	0.16	<DL	297.94	93.07	<DL
		7	53.21	50.20	0.15	<DL	287.18	89.50	0.07
		9	74.19	75.10	0.05	<DL	324.43	95.99	6.93
		10	85.20	87.34	1.77	<DL	360.21	102.18	21.22
		11	98.31	106.23	25.54	0.75	400.05	113.36	32.24
	Sediment depth (cm)	0	262.46	273.64	149.84	0.51	707.18	168.45	87.81
		1	294.14	281.51	209.72	4.48	722.21	181.09	92.90
		2	570.05	540.21	415.86	73.77	1400.75	347.63	196.69
		3	614.31	605.71	407.50	4.76	1773.95	528.31	228.35
		5	625.47	666.53	618.67	<DL	2560.88	771.30	309.80
		7	663.23	621.68	746.94	6.02	2618.50	686.94	289.73
		10	659.49	694.05	794.44	34.54	3077.31	855.69	299.93
October 20, 2023	water depth (m)	0	8.35	8.82	0.50	1.09	345.50	99.83	0.09
		5	9.42	9.50	0.65	0.97	328.56	95.28	0.11
		11	7.28	7.78	0.45	0.42	335.22	97.74	0.19
	Sediment depth (cm)	0	236.26	239.66	100.98	<DL	656.11	165.70	93.09
		1	305.98	257.31	240.91	5.03	660.15	176.77	122.62
		2	775.24	791.58	486.14	23.38	1549.74	412.39	227.00
		3	605.90	709.51	480.28	14.07	1367.43	352.88	219.78
		5	898.07	851.14	630.05	<DL	1959.04	499.56	300.90
		7	951.11	936.98	764.75	<DL	2261.59	539.93	325.78
		10	1004.21	1010.82	802.83	6.82	2696.23	668.13	336.61
March 5, 2024	water depth (m)	0	38.71	41.06	0.55	1.05	349.24	91.43	<DL
		5	40.81	42.71	0.42	0.60	355.99	92.91	<DL
		11	43.97	45.52	0.54	0.45	358.86	92.50	<DL
	Sediment depth (cm)	0	68.16	70.72	0.46	0.66	368.35	95.75	0.10
		1	97.30	95.25	1.20	4.51	394.38	110.32	9.69
		2	158.98	151.26	7.32	14.79	502.54	158.14	3.68
		3	226.70	230.29	0.86	1.19	405.27	113.82	2.38
		5	212.12	205.71	1.92	4.78	449.14	137.74	20.89
		7	242.69	244.13	38.04	3.61	387.51	117.58	25.64
		10	312.02	315.45	57.59	29.11	501.97	160.58	19.59
July 16, 2024	water depth (m)	0	35.04	35.47	<DL	<DL	279.94	84.77	<DL
		1	34.55	34.38	<DL	<DL	279.14	84.07	<DL
		3	42.47	43.38	<DL	<DL	280.74	82.67	<DL
		5	56.35	59.82	<DL	<DL	286.95	81.33	<DL
		7	44.95	48.10	0.23	<DL	295.45	90.32	<DL
		9	39.01	42.32	<DL	<DL	304.95	90.56	0.02
		10	49.91	50.19	<DL	<DL	317.45	94.07	0.40
		12	62.79	64.72	6.71	0.86	344.89	98.70	18.44
	Sediment depth (cm)	0	221.30	243.58	185.29	3.04	528.97	152.94	79.19
		1	615.22	762.22	382.69	37.10	1396.07	376.11	206.24
		2	604.61	630.19	437.10	37.64	1565.09	435.34	218.26
		3	676.64	800.06	479.60	48.09	2088.06	576.58	296.76
		5	631.88	699.21	360.05	20.22	2485.58	662.67	358.21
		7	599.21	610.61	213.54	36.05	2559.49	756.53	261.72
		10	599.16	669.20	299.22	9.97	1952.85	549.92	230.83

October 22, 2024	water depth (m)	0	24.51	24.73	<DL	<DL	269.74	87.00	<DL
		1	22.44	25.74	0.55	0.56	271.08	86.50	0.10
		4	22.44	23.20	<DL	<DL	265.89	85.04	<DL
		7	21.92	25.01	<DL	<DL	271.24	86.86	<DL
		10	22.44	24.04	<DL	<DL	267.25	85.75	<DL
		11	41.56	43.47	1.21	<DL	303.11	94.21	<DL
	Sediment depth (cm)	0	50.86	53.94	8.69	<DL	294.31	90.31	31.39
		1	462.58	574.16	223.88	74.81	661.41	192.43	168.48
		2	458.72	561.43	173.85	57.65	682.05	215.20	126.18
		3	839.88	970.61	409.00	30.37	1509.30	461.34	213.04
		5	840.36	990.77	550.53	57.46	2284.20	678.19	350.74
		7	1010.82	1053.59	931.24	241.56	2715.17	742.88	410.21
		10	935.66	919.26	909.14	<DL	3129.20	795.34	486.72
September 17, 2025	water depth (m)	0	60.79	60.97	0.19	<DL	271.44	<DL	0.03
		1	64.43	61.20	0.15	<DL	273.48	<DL	<DL
		3	65.46	61.56	0.15	0.06	269.30	<DL	<DL
		6	64.94	64.28	0.13	0.13	263.79	<DL	<DL
		8	63.91	63.56	0.02	<DL	289.47	<DL	<DL
		10	83.63	80.07	8.24	<DL	336.03	<DL	27.60
		11	88.82	86.93	20.00	<DL	336.85	<DL	26.03
	Sediment depth (cm)	0	159.77	164.53	126.34	<DL	416.70	115.00	54.14
		1	368.07	393.88	268.81	8.87	564.98	129.13	108.25
		2	369.39	471.62	316.26	<DL	699.70	138.85	127.15
		3	698.05	862.29	591.59	<DL	1408.66	333.75	287.59
		5	705.90	848.37	652.63	<DL	1467.59	345.03	288.89
		7	690.87	855.13	716.16	<DL	1967.28	480.91	320.64
		10	653.95	792.36	707.41	<DL	1894.45	449.86	310.31
November 25, 2025	water depth (m)	0	33.80	30.25	0.17	0.19	325.74	3.19	0.05
		4	34.32	29.58	0.12	0.15	305.71	4.64	<DL
		8	36.40	30.77	0.08	0.28	306.71	1.62	0.03
		10	37.95	33.06	0.10	0.20	319.19	0.41	0.34
	Sediment depth (cm)	0	73.94	74.42	1.00	<DL	322.99	91.82	17.89
		1	75.73	79.13	41.61	<DL	258.13	67.65	34.14
		2	108.35	122.56	57.05	<DL	287.24	75.88	43.32
		3	610.58	637.58	220.50	<DL	612.44	150.71	111.97
		5	502.87	508.22	169.62	<DL	467.78	104.19	84.98
		7	853.37	850.72	372.10	<DL	842.00	199.31	152.24
		10	686.09	714.82	329.51	<DL	1056.14	276.52	162.66

Table S4 Coefficients of determination (R^2) for linear regressions between D_TSi and co-dissolved substances in the South Basin of Lake Biwa pore water under oxic and anoxic conditions.

Lake Biwa	RSi	D_TSi	Ca	Fe	Al	Mn	Mg
RSi	1						
D_TSi	0.98	1					
Ca	0.81	0.79	1				
Fe	0.88	0.87	0.87	1			
Al	0.51	0.52	0.37	0.50	1		
Mn	0.89	0.89	0.94	0.93	0.50	1	
Mg	0.78	0.76	0.99	0.82	0.38	0.91	1

Table S5 Dissolved substance data for Lake Okutsu (2018–2019), including D_TSi, RSi, D_PSi, and dissolved metal concentrations in water column and sediment pore water.

Lake Okutsu		Depth	RSi	D_TSi	Fe	Al	Ca	Mg	Mn
						($\mu mol\ L^{-1}$)			
July 28, 2018	water depth (m)					No data			
	Sediment depth (cm)	0	166.99	167.68	44.44	<DL	111.12	57.05	20.16
		1	169.41	172.70	77.43	<DL	136.67	48.51	25.72
		3	197.40	314.15	746.04	<DL	1270.20	421.49	200.97
		5	244.23	287.37	714.98	<DL	1184.66	401.66	192.08
		7	281.07	290.24	642.24	<DL	1182.36	405.95	191.90
September 1, 2018	water depth (m)	1	209.98	213.98	1.54	<DL	93.29	34.83	0.26
		15	150.08	160.93	13.37	3.75	92.14	36.30	9.06
		17	147.05	164.26	18.26	2.60	104.27	39.66	12.55
	Sediment depth (cm)	0	150.67	161.49	72.98	<DL	129.66	47.86	24.65
		1	153.87	160.83	76.91	<DL	134.59	54.18	26.28
		3	170.84	204.62	171.22	13.63	355.26	560.23	57.78
		5	190.72	231.75	696.40	<DL	1304.78	534.64	233.06
April 28, 2019	water depth (m)	0	209.73	212.11	<DL	<DL	61.91	24.24	<DL
		4	210.66	213.31	<DL	<DL	61.02	23.58	<DL
		8	221.86	225.90	<DL	<DL	62.68	23.96	<DL
		12	226.53	219.70	<DL	<DL	60.76	24.14	<DL
		16	221.86	225.25	<DL	<DL	65.43	25.41	<DL
		17	226.53	224.74	<DL	<DL	64.13	25.43	0.06
	Sediment depth (cm)	0	215.61	222.08	4.63	<DL	60.91	21.27	5.28
		1	508.75	518.43	130.46	<DL	242.30	35.35	16.47
		3	245.97	248.27	21.85	<DL	48.15	<DL	<DL
		5	443.47	449.93	305.89	<DL	390.57	89.60	45.38
		7	482.77	516.78	349.72	<DL	528.36	149.38	64.18
		10	658.16	689.74	430.16	1.30	778.73	187.39	80.58
August 31, 2019	water depth (m)	0	227.54	230.97	1.18	<DL	105.97	36.73	0.19
		1	222.36	222.41	1.08	<DL	101.34	35.09	0.16
		5	219.77	220.79	1.80	<DL	98.62	34.27	0.24
		11	219.77	217.44	4.49	0.49	104.30	37.06	0.93
		16	183.48	205.66	23.05	<DL	120.17	41.69	10.35
		19	180.89	202.56	29.20	<DL	123.65	41.93	12.77
	Sediment depth (cm)	0	209.40	209.12	11.94	<DL	107.86	36.05	8.75
		1	209.40	207.85	58.85	<DL	80.34	25.07	10.68
		3	297.52	363.10	285.70	5.76	433.84	92.89	44.10
		5	383.04	438.47	541.11	11.45	696.25	188.58	81.92
		7	800.31	910.49	896.18	44.15	1419.34	338.73	157.20
		10	870.29	1018.31	1340.86	76.86	1844.38	590.51	248.20
September 14, 2019	water depth (m)	0	219.65	227.68	0.86	0.52	101.61	35.24	0.52
		5	216.97	235.57	2.06	<DL	102.95	36.09	0.31
		10	211.61	231.97	4.71	0.43	105.32	36.88	0.88
		15	179.48	201.49	23.42	<DL	119.38	41.15	9.06
		19	190.19	199.09	43.51	<DL	125.31	41.37	11.62
	Sediment depth (cm)	0	198.22	238.93	62.21	<DL	128.02	31.29	12.79
		1	190.19	226.21	87.13	<DL	103.83	30.61	15.25
		3	275.88	440.96	560.80	10.04	567.53	116.45	111.00
		5	337.48	447.44	694.65	9.36	724.03	158.99	127.30
		7	267.85	462.81	710.94	1.59	761.96	176.75	135.78
		10	273.20	354.42	728.63	1.75	1032.69	290.43	137.22

Table S6 Coefficients of determination (R^2) for linear regressions between D_TSi and co-dissolved substances in Lake Okutsu pore water under oxic and anoxic conditions.

Lake Okutsu	RSi	D_TSi	Ca	Fe	Al	Mn	Mg
RSi	1						
D_TSi	0.97	1					
Ca	0.56	0.65	1				
Fe	0.59	0.71	0.96	1			
Al	0.78	0.81	0.84	0.78	1		
Mn	0.36	0.47	0.96	0.93	0.79	1	
Mg	0.30	0.36	0.84	0.75	0.69	0.85	1