7.7 Patterns of Nutrient Enrichment and Depletion in Jamaica Bay, Summer 2000

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7.7.1 INTRODUCTION

Large inputs of the nutrients nitrogen and phosphorus into Jamaica Bay from waste water treatment plants, sewage outflows, and in runoff are serious concerns because they fuel phytoplankton blooms, which in turn may lead to eutrophication and hypoxic (low oxygen) conditions in the lower water column. Dissolved nutrient concentrations were measured throughout the summer (June-September 2000) in Jamaica Bay in order to determine spatial and temporal patterns of nutrient enrichments as well as the role of biological productivity and tidal flushing as nutrient sinks content of Jamaica Bay.

7.7.2 METHODS

Surface water samples were collected in de-ionized water-rinsed polyethylene bottles mounted on a plexiglas holder attached to a 10 foot-long fiberglass pole. Waters were sampled upstream of the boat's wake and as far off the side as possible to avoid contamination. Mid-depth and bottom water samples were drawn from a 1.7 L Niskin bottle. Immediately after collection, a 60 ml aliquot was filtered though a 0.45 µm pore size polypropylene syringe-tip filter and preserved with 0.1% by volume hydrochloric acid.

The nutrients nitrate+nitrite ($N_{NO2+NO3}$), phosphate (PO_4), and silicate (Si) were measured at the Lamont-Doherty Earth Observatory by standard colorimetric methods (Strickland and Parsons, 1965; Grasshoff, 1976) using a QuikChem 8000 flow-injection analyzer (Lachat Instruments). Detection limits, calculated as three times the standard deviation of a NaCl blank measured every 10 samples, were 0.1, 0.1, and 0.2 µmol kg^{-1} for $N_{NO2+NO3}$, PO_4, and Si, respectively. Measurement precisions for 15 µmol kg^{-1} $N_{NO2+NO3}$, 1.5 µmol kg^{-1} PO_4, and 40 µmol kg^{-1} Si standards were ±2%, ±1%, and ±1%, respectively.

7.7.3 RESULTS

In general, Jamaica Bay waters were enriched in phosphate (~5 µM) relative to coastal waters but $N_{NO2+NO3}$ and Si concentrations ($N_{NO2+NO3}$, Si ~20 µM) did not appear to be anomalously high (Duedall et al., 1977; NYDEP, 1999). All nutrient levels were higher in the northern regions of Jamaica Bay than in the well-mixed southern channel.

Over the four sampling dates throughout the summer, surface dissolved inorganic $N_{NO2+NO3}$ concentrations were highest throughout Jamaica Bay on June 1 (up to 30 µmol/L or 0.4 mg/L), were at intermediate levels on June 28, and on July 18 had were almost totally depleted, presumably by the extreme phytoplankton bloom observed in surface waters (Figure 7.7-1, Table 7.7-1). By mid-September $N_{NO2+NO3}$ levels had returned to intermediate levels. PO_4 in surface waters generally followed the same pattern as $N_{NO2+NO3}$, but reached maximum concentrations (up to 6 µmol/L or 0.2 mg/L) on June 28 and did not experience the degree of depletion shown by $N_{NO2+NO3}$except in Grassy Bay (Figure 7.7-1, Table 7.7-1). Nutrient profiles show very little variability with depth except in Grassy Bay, where circulation is restricted (Figure 7.7-2; Table 7.7-1). In June and July surface waters were depleted in $N_{NO2+NO3}$ and PO_4, likely due to consumption by plankton. Bottom waters were depleted in $N_{NO2+NO3}$ but not PO_4.

In the northern region, Bergen Basin was extremely enriched in PO_4 (26 µM) and Si (69 µM) relative to bay waters, and Paerdegat Basin in Si (65 µM) (Table 7.7-2). Some indication of mixing with these fresher, PO_4 and Si-enriched waters may be apparent in the observed surface enrichments of P and Si in Grassy Bay and Fresh Creek. An anomalously high $N_{NO2+NO3}$ concentration (39 µM) was measured only near the Rockaway Treatment Plant outfall, 9 ft below the surface (Table 7.7-2)

Over half a tidal cycle, nutrient concentrations showed the greatest variability near the mouth of Jamaica Bay. All nutrients were lowest at high tide and highest at low tide, consistent with the pattern of nutrient-enriched bay waters flushing through Rockaway inlet during ebb tide. The opposite relation between nutrient enrichments and tidal stage was observed in Grassy Bay, where tidal flushing appeared to have a somewhat smaller effect on the range of nutrient concentrations, likely due to the restricted circulation in Grassy Bay.

7.7.4 CONCLUSIONS

Patterns of nutrient depletions throughout the summer suggest that surface concentrations of $N_{NO2+NO3}$, PO_4, and Si were regulated by biological productivity in the early to mid-summer: depletions of Si in late June suggest a diatom-dominated plankton assemblage and the recovery of N and Si in September may suggest a shift to smaller algae that utilize a different nitrogen source. Depletions in bottom water $N_{NO2+NO3}$ in Grassy Bay relative to surface waters may have resulted from denitrification under low oxygen conditions. From early to late summer there was an overall increase in P and decrease in $N_{NO2+NO3}$ throughout the water column of Jamaica Bay.

Dissimilar trends of $N_{NO2+NO3}$ and PO_4 with depth in Grassy Bay suggest that different processes affect surface and bottom water $N_{NO2+NO3}$ and PO_4 concentrations. While low nutrient concentrations in surface waters are likely due to phytoplankton uptake of $N_{NO2+NO3}$ and PO_4, low $N_{NO2+NO3}$ levels measured in the bottom waters of Grassy Bay may be the result of water column denitrification, which occurs under low oxygen conditions. Elevated PO_4 levels in the bottom waters of Grassy Bay are the highest observed anywhere in Jamaica Bay and suggest that either phosphorus is sequestered in Grassy Bay or that there may be a sedimentary source of dissolved phosphorus to the overlying water column, since under low oxygen conditions phosphate is released from iron-hydroxide phases in the sediments.

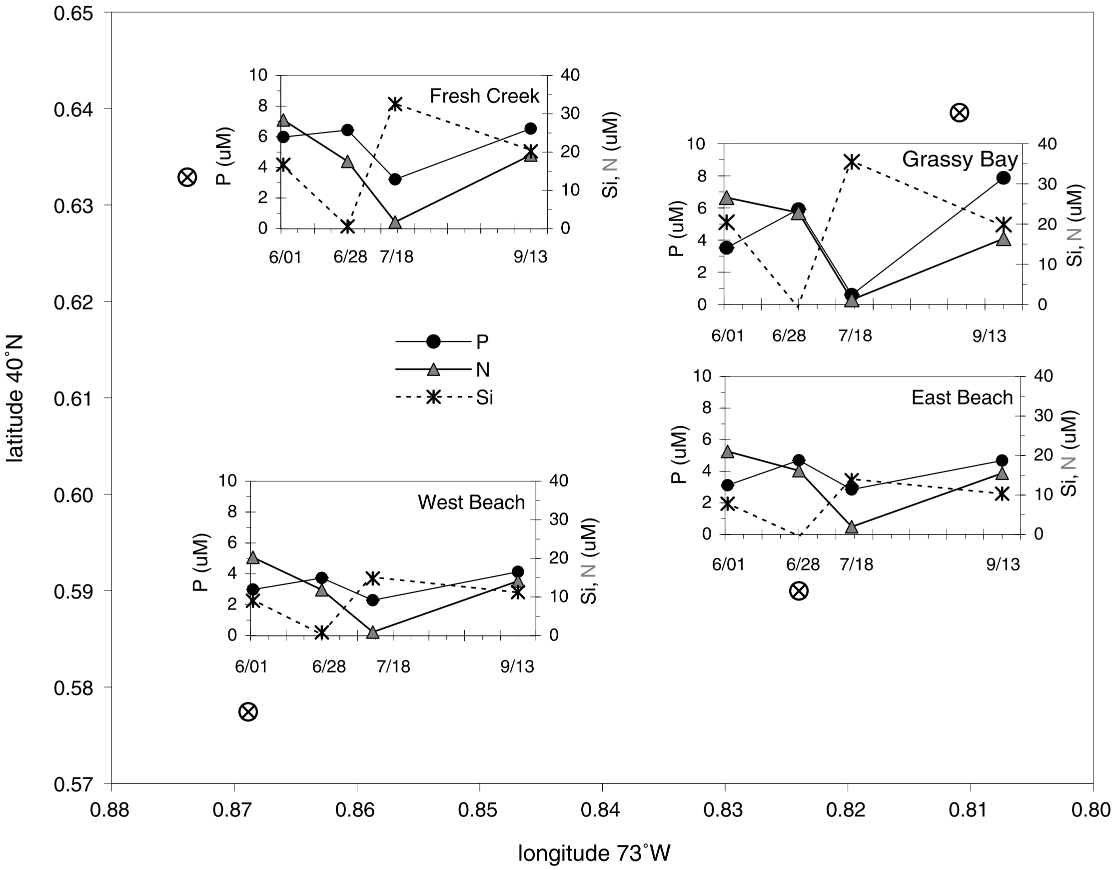

Figure 7.7-1. Summer time series of surface dissolved inorganic phosphate (P; circles), nitrate (N; triangles), and silicate (Si; asterisks) plotted at the latitude and longitude (decimal degrees) of each station in Jamaica Bay. Note that nitrate and silicate are on the same scale.

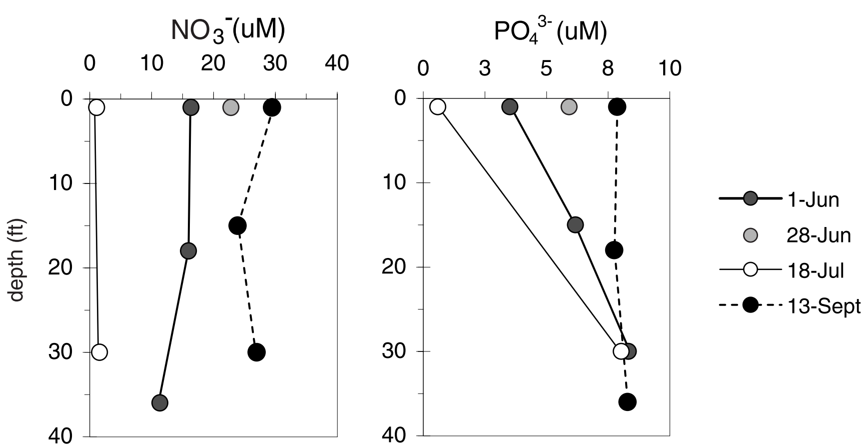

Figure 7.7-2. Changes in water column concentrations of nitrate and phosphate throughout the summer in Grassy Bay.

Table 7.7-1. Summer time series of surface and water column nutrient concentrations in West Beach Channel (WB), at the mouth of Fresh Creek (FC), in Grassy Bay (GB), and in the East Beach Channel (EB). n.d. indicates concentrations were below the measurable detection limit.

	depth	P (µM)	N (µM)	Si (µM)
1 June 2000				
WB	surface	2.97	20.32	8.84
	mid	2.91	19.93	12.54
	bottom	2.40	16.70	8.27
FC	surface	6.14	28.64	15.89
	mid	5.38	27.61	15.47
	bottom	5.06	26.09	13.11
GB	surface	3.52	29.46	20.41
	mid	6.18	23.91	15.36
	bottom	7.75	26.99	20.17
EB	surface	3.11	21.02	6.74
	mid	3.12	21.03	7.53
	bottom	3.04	20.66	7.37
28 June 2000				
WB	surface	3.73	11.86	0.82
FC	surface	6.44	17.58	0.60
GB	surface	5.92	22.83	n.d.
EB	surface	4.69	16.16	n.d.
18 July 2000				
WB	surface	2.29	0.92	14.80
FC	surface	3.22	1.72	32.52
GB	surface	0.59	1.14	35.47
	bottom	8.04	1.60	40.56
EB	surface	2.85	1.96	13.75
13 September 2000				
WB	surface	4.13	14.12	11.25
	mid	3.46	12.02	10.92
FC	surface	6.53	19.23	20.19
	mid	5.16	16.65	22.20
GB	surface	7.87	16.37	19.86
	mid	7.75	15.97	19.60
	bottom	8.29	11.35	24.96
EB	surface	4.68	15.50	10.33
	mid	4.65	14.55	10.54

Table 7.7-2. ***September 11, 2000:*** **high resolution depth profile in Grassy Bay.** ***September 12, 2000:*** **changes in nutrient concentrations in Grassy Bay (GB), Fresh Creek (FC), and the West Beach Channel (WB) over half a tidal-cycle (high-low-slack tide).** ***September 13, 2000:*** **nutrient concentrations in Bergen Basin (BB), Paerdegat Basin (PB), Broad Channel (BC), Grass Hassock Channel (B19), and at the Rockaway Treatment Plant (RTP).**

	time	depth (ft)	P (µM)	N (µM)	Si (µM)
September 11, 2000					
GB	16:30	27	10.23	9.39	31.88
		24	8.98	13.55	24.14
	16:37	21	8.74	14.29	22.61
	16:41	18	8.77	14.56	22.68
	16:45	15	8.67	15.63	22.89
	16:49	12	8.69	15.76	24.22
	16:57	12	8.95	16.51	23.37
	17:01	9	9.63	16.48	23.36
	17:04	6	10.17	17.62	25.29
	17:08	3	11.08	17.64	27.55
	17:13	1.5	9.58	16.55	25.11
GB	17:51	36	8.06	12.20	23.36
	17:55	1	6.94	15.70	18.02
September 12, 2000					
GB	8:09	36	9.32	9.38	30.21
	8:14	18	7.82	14.68	19.62
	8:19	1	8.11	15.51	19.10
GB	8:15	33	8.62	11.80	24.42
		15	7.47	14.77	17.32
	8:28	1	9.42	17.45	22.67
		0	10.20	18.02	25.56
GB	11:10	36	8.29	11.35	24.96
	11:13	18	7.75	15.97	19.60
	11:19	1	7.87	16.37	19.86
GB	14:30	30	9.03	8.50	29.49
	14:38	27	8.28	11.34	24.10
	14:44	15	7.72	15.79	18.84
	14:47	0	7.37	16.41	17.04
GB	16:13	30	8.64	9.65	26.35
	16:22	10	7.63	15.45	18.67
	16:26	0	8.01	18.76	22.33
FC	11:59	0	6.61	30.37	11.11
FC	9:04	9	5.21	17.01	15.40
	9:10	1	6.68	24.21	17.03
FC	11:45	6	5.16	16.65	22.20
	11:50	1	6.53	19.23	20.19

FC	15:12	3	6.48	22.24	16.28
FC	16:48	5	6.95	21.86	17.52
WB	10:05	24	1.84	4.34	3.25
	10:11	0	3.13	8.86	7.50
WB	12:10	24	3.46	12.02	10.92
	12:21	0	4.13	14.12	11.25
WB	15:38	27	4.09	13.43	10.63
	15:45	0	4.82	16.04	12.91
WB	17:12	24	3.68	11.69	9.34
	17:18	0	3.68	11.89	9.44
September 13, 2000					
BB	9:00	0.5	9.90	25.44	12.50
BB	9:07	1	26.13	68.53	18.77
BB	9:17	2	19.00	49.56	14.83
BB		1	8.87	21.83	16.85
BB	9:43	7	9.97	24.97	12.51
BB	9:52	0	14.89	38.40	15.16
BB		15	9.14	24.74	11.28
PB		1	5.30	64.96	24.34
PB	12:53	8	6.28	22.04	17.28
PB		1	2.92	66.37	28.12
PB	13:32	1	3.89	21.56	19.30
PB	13:32	1	5.10	21.19	19.86
BC	15:35	27	6.79	16.30	14.97
BC		1	6.85	14.24	15.01
BC	16:13	17	4.65	10.54	14.55
BC		1	4.68	10.33	15.50
BC		1	4.66	10.17	15.60
B19	16:34	36	4.94	14.12	14.68
B19		1	3.84	7.53	13.14
RTP	10:45	9	6.56	16.37	38.55
RTP		0	4.57	12.02	14.81