

6. NUTRIENT STOCKS

Sampling in the Cairns box was carried out between February 1989 and July 1991 (CNS series). Two series of water samples were available for the Tully box, an initial series collected during February, 1987 (COT series) and a second series collected between October 1988 and November 1989 (FAM series). Depth-weighted mean water column concentrations of dissolved and particulate nutrients, plant pigments and suspended solids concentrations (where measured) in the two study boxes are summarized in Tables 5-8. As the water column was generally well mixed at most stations, the depth-weighted mean concentration is usually similar to both a simple arithmetic mean of station concentration data and near-surface concentrations. The station data are grouped by bathymetric depth bands and season.

The summer season (October-April) corresponds to the period of greatest rainfall, river runoff, shelfbreak upwelling activity and the occurrence of cyclones. South-easterly trade winds, which typify the winter (May-September) period, suppress shelfbreak upwelling activity and lead to active mixing of the water column at all locations across the shelf. South-easterly trade winds occur throughout the year, but are generally most intense during the July-September period.

The four depth bands selected roughly correspond to: inshore waters (< 10 m); the inshore-lagoon transition zone (10-20 m); the central GBR lagoon (20-30 m); and the outer-shelf reef matrix (> 40 m). Because of horizontal mixing, the segregation of individual stations into defined depth bands is somewhat arbitrary. Stations from the 31 to 40 m depth band were not included in the statistical calculations as this band encompasses a poorly defined transition between the open waters of the GBR lagoon and the outer-shelf reef matrix. Shelf stations located in depths exceeding 40 m are all clearly within the reef matrix and therefore provide a clearer contrast between the two hydrographic settings. To discount the importance of a small number of stations with high, outlying concentration values, the medians of the depth-averaged concentrations for each season and depth band are given as well.

The presence or absence of cross-shelf gradients (Figures 20-23) in nutrient and particulate concentrations varied between nutrient species, season and location. For the larger data set available for the Cairns box, statistically significant (1-way ANOVA, $p \leq 0.05$), season-independent cross-shelf gradients in depth-averaged water column concentrations were found for particulate nitrogen (PN), particulate phosphorus (PP), silicate, phytoplankton pigments (chlorophyll and phaeophytin) and suspended solids. Although concentrations were very low, a statistically significant cross-shelf gradient for nitrite was also found in winter samples. Ammonia, phosphate, DON and DOP, the principal pools of dissolved nitrogen and phosphorus did not show significant cross-shelf gradients.

In the case of the Tully box, fewer stations were occupied and for some nutrient or particulate species, data is not available for all depth bands in both of the seasonal periods. No suspended solids data is available for Tully box stations. Silicate was the only dissolved nutrient species in the Tully box data to have a statistically significant cross shelf concentration gradient in both seasons. Significant cross-shelf nitrite and DOP gradients were found in the summer, while significant cross-shelf ammonium, nitrite, PON, phosphate and PP gradients occurred during the winter.

It is not surprising that higher PN, PP and suspended solids concentrations occurred at shallow stations, given the inputs of sediment and wind-driven resuspension near the coast. Low suspended solid and particulate nutrient concentrations within the outer-shelf reef matrix reflect the greater importance of lateral exchange with adjacent low-nutrient oceanic waters.

Table 5. Summary statistics for dissolved and particulate water column nutrient concentrations in the Cairns box for the summer (October - April) season. Values are given as depth-weighted average concentrations over the full depth of the water column sampled. *Italics* = significant difference between winter-summer mean ($p < 0.05$). **Bold** = significant difference between Cairns-Tully box means ($p < 0.05$)

	NH ₄	NO ₂	NO ₃	TDN	DON	PON μmol l ⁻¹	PO ₄	TDP	DOP	POP	SiO	Chl μg l ⁻¹	Phaeo μg l ⁻¹	S.S. mg l ⁻¹
CNS - <=10 m Summer														
Mean	0.28	0.001	<i>0.03</i>	6.79	6.49	1.80	0.10	0.19	<i>0.09</i>	<i>0.13</i>	5.23	<i>0.61</i>	<i>0.25</i>	2.00
Std Dev	0.28	0.003	0.03	3.08	2.91	0.63	0.11	0.22	0.13	0.04	2.64	0.14	0.05	1.10
Coeff. Var.	98.6	282.3	75.3	45.3	44.9	35.0	109.1	120.0	133.8	33.7	50.5	22.1	20.7	54.8
n	17	17	17	16	16	17	17	16	16	17	17	17	17	16
Median	0.21	0.000	0.04	5.75	5.45	1.60	0.08	0.09	0.03	0.14	4.48	0.58	0.23	1.80
Maximum	0.81	0.010	0.08	14.50	13.64	3.66	0.50	0.87	0.37	0.19	12.55	0.84	0.35	5.39
Minimum	0.00	0.000	0.00	3.53	3.16	1.20	0.01	0.02	0.00	0.05	2.08	0.41	0.18	0.45
CNS - 11 to 20 m Summer														
Mean	<i>0.36</i>	0.004	0.04	6.40	5.99	1.15	<i>0.06</i>	0.18	0.13	<i>0.09</i>	3.73	<i>0.42</i>	0.20	<i>1.07</i>
Std Dev	0.29	0.008	0.04	3.50	3.40	0.38	0.03	0.20	0.19	0.03	2.13	0.13	0.08	0.50
Coeff. Var.	82.2	205.2	90.4	54.7	56.7	33.0	42.5	106.1	150.9	36.5	57.1	30.8	40.3	46.3
n	20	20	20	18	18	19	20	18	18	19	20	19	19	15
Median	0.29	0.000	0.04	5.14	4.69	1.10	0.07	0.13	0.06	0.08	3.86	0.40	0.18	1.06
Maximum	0.92	0.030	0.16	16.67	16.25	2.23	0.11	0.73	0.67	0.14	6.99	0.83	0.46	1.90
Minimum	0.04	0.000	0.00	3.18	3.07	0.44	0.02	0.03	0.00	0.04	0.53	0.19	0.09	0.27
CNS - 21 to 30 m Summer														
Mean	0.35	<i>0.000</i>	<i>0.04</i>	6.61	6.26	1.13	0.08	<i>0.14</i>	0.07	0.09	2.12	<i>0.38</i>	<i>0.19</i>	0.64
Std Dev	0.40	0.000	0.04	2.49	2.29	0.45	0.04	0.06	0.05	0.03	1.48	0.15	0.09	0.34
Coeff. Var.	114.7		100.2	37.6	36.5	39.7	52.4	40.3	77.3	32.5	69.9	39.2	45.9	52.2
n	20	20	20	18	18	19	20	18	18	20	20	20	20	9
Median	0.17	0.000	0.03	6.36	6.14	0.99	0.07	0.13	0.05	0.09	1.89	0.33	0.19	0.62
Maximum	1.22	0.000	0.20	10.03	9.71	2.73	0.17	0.28	0.20	0.15	4.58	0.68	0.38	1.28
Minimum	0.01	0.000	0.01	2.87	2.69	0.68	0.02	0.04	0.00	0.05	0.52	0.20	0.08	0.32
CNS - > 41 m Summer														
Mean	0.33	0.018	0.05	6.11	5.88	0.83	0.08	0.14	0.07	<i>0.06</i>	1.70	<i>0.34</i>	<i>0.19</i>	0.16
Std Dev	0.30	0.042	0.04	2.93	2.91	0.22	0.04	0.03	0.03	0.02	0.91	0.13	0.08	0.08
Coeff. Var.	90.4	235.8	75.2	48.0	49.4	26.3	51.7	22.1	48.2	35.9	53.5	38.5	41.7	50.1
n	17	17	17	11	11	17	17	11	11	17	17	17	17	4
Median	0.18	0.000	0.03	6.77	6.17	0.80	0.07	0.15	0.07	0.05	1.64	0.36	0.19	0.16
Maximum	0.95	0.170	0.13	12.25	11.93	1.19	0.17	0.18	0.12	0.10	3.61	0.56	0.36	0.25
Minimum	0.04	0.000	0.02	2.64	2.46	0.49	0.02	0.07	0.02	0.03	0.45	0.13	0.08	0.07

Table 6. Summary statistics for dissolved and particulate water column nutrient concentrations in the Cairns box for the winter (May - September) season. Values are given as the depth-weighted average concentrations over the full depth of the water column sampled. Bold means = significant difference between Cairns-Tully box means ($p < 0.05$)

	NH ₄	NO ₂	NO ₃	TDN	DON	PON μmol l ⁻¹	PO ₄	TDP	DOP	POP	SiO	Chl μg l ⁻¹	Phaeo μg l ⁻¹	S.S. mg l ⁻¹
CNS - ≤10 m Winter														
Mean	0.40	0.003	0.06	6.34	5.87	1.67	0.10	0.15	0.06	0.19	6.69	0.77	0.34	3.47
Std Dev	0.31	0.009	0.05	2.86	2.83	0.54	0.03	0.07	0.06	0.09	3.31	0.33	0.18	1.98
Coeff. Var.	78.0	281.3	92.2	45.1	48.1	32.3	27.9	44.8	93.2	49.6	49.5	42.9	53.6	57.1
n	25	25	25	25	25	25	25	25	25	25	25	17	17	18
Median	0.26	0.000	0.04	5.87	5.00	1.63	0.10	0.13	0.05	0.17	4.94	0.70	0.28	2.99
Maximum	1.31	0.040	0.22	11.91	11.44	3.41	0.13	0.31	0.19	0.50	15.02	1.57	0.70	7.20
Minimum	0.11	0.000	0.00	2.90	2.62	0.73	0.04	0.03	0.00	0.06	3.42	0.35	0.11	0.59
CNS - 11 to 20 m Winter														
Mean	0.56	0.004	0.04	6.42	5.83	1.22	0.09	0.16	0.09	0.13	5.80	0.58	0.28	1.43
Std Dev	0.47	0.009	0.03	2.42	2.46	0.61	0.04	0.14	0.13	0.08	3.35	0.26	0.21	0.69
Coeff. Var.	83.6	224.9	87.3	37.7	42.3	49.9	43.2	85.8	149.3	64.3	57.8	44.7	75.5	48.4
n	50	50	50	49	49	50	50	49	49	50	50	36	36	32
Median	0.33	0.000	0.03	6.21	5.21	1.12	0.09	0.12	0.04	0.10	5.08	0.48	0.23	1.26
Maximum	1.80	0.050	0.16	12.21	12.01	4.43	0.25	0.57	0.50	0.43	17.78	1.68	1.38	3.29
Minimum	0.10	0.000	0.00	2.20	1.77	0.56	0.02	0.02	0.00	0.04	0.58	0.33	0.11	0.39
CNS - 21 to 30 m Winter														
Mean	0.39	0.006	0.08	5.24	4.73	1.09	0.09	0.10	0.03	0.08	3.79	0.59	0.27	0.88
Std Dev	0.28	0.007	0.08	1.40	1.33	0.27	0.03	0.06	0.05	0.02	3.27	0.21	0.11	0.28
Coeff. Var.	71.5	129.3	103.9	26.7	28.2	24.5	27.1	58.1	167.0	23.3	86.2	35.1	39.9	31.8
n	16	16	16	14	14	16	16	14	14	16	16	14	14	8
Median	0.33	0.000	0.06	5.69	4.99	1.06	0.10	0.08	0.01	0.08	2.62	0.58	0.26	0.86
Maximum	1.24	0.020	0.29	7.45	7.07	1.63	0.13	0.23	0.18	0.11	9.90	1.02	0.50	1.35
Minimum	0.11	0.000	0.00	2.97	2.66	0.74	0.05	0.03	0.00	0.05	0.71	0.30	0.11	0.60
CNS - >41 m Winter														
Mean	0.51	0.006	0.05	5.33	4.70	0.75	0.09	0.14	0.06	0.05	1.36	0.48	0.27	0.23
Std Dev	0.41	0.009	0.03	1.24	1.00	0.20	0.02	0.08	0.06	0.02	0.78	0.25	0.14	0.17
Coeff. Var.	80.6	162.0	72.1	23.3	21.2	27.0	19.9	54.8	108.5	42.0	56.9	53.4	52.0	70.9
n	21	21	21	19	18	20	21	19	18	21	21	11	11	10
Median	0.23	0.000	0.04	5.44	4.97	0.72	0.09	0.11	0.04	0.04	1.18	0.45	0.21	0.21
Maximum	1.27	0.030	0.14	7.49	6.18	1.20	0.12	0.27	0.19	0.08	3.76	1.11	0.63	0.52
Minimum	0.16	0.000	0.01	2.96	2.70	0.45	0.04	0.04	0.00	0.01	0.38	0.24	0.13	0.02

Table 7. Summary statistics for dissolved and particulate water column nutrient concentrations in the Tully box for the summer (October - April) season. Values are given as depth-weighted average concentrations over the full depth of the water column sampled. Italics = significant difference between winter-summer means ($p < 0.05$)

	NH ₄	NO ₂	NO ₃	TDN	DON	PON μmol l ⁻¹	PO ₄	TDP	DOP	POP	SiO	Chl μg l ⁻¹	Phaeo μg l ⁻¹	S.S. mg l ⁻¹
COT/FAM - ≤10 m Summer														
Mean	0.16	0.050	0.10	0.31			0.10				9.71			
Std Dev	0.09	0.058	0.14	0.24			0.03				10.75			
Coeff. Var.	59.9	115.5	141.4	78.5			27.9				110.7			
n	4	4	4	4			4				4			
Median	0.17	0.050	0.05	0.32			0.10				5.49			
Maximum	0.24	0.100	0.30	0.53			0.12				25.34			
Minimum	0.04	0.000	0.00	0.06			0.06				2.53			
COT/FAM - 11-20 m Summer														
Mean	<i>0.19</i>	<i>0.006</i>	<i>0.04</i>	<i>0.23</i>	4.00	<i>1.37</i>	0.12		0.27	<i>0.10</i>	3.57	0.38	0.70	
Std Dev	0.25	0.025	0.06	0.28	0.49	0.27	0.05		0.06	0.03	1.60	0.16	0.95	
Coeff. Var.	134.3	400.0	165.1	118.6	12.3	19.6	41.6		20.7	31.6	44.9	41.5	136.1	
n	16	16	16	16	3	10	16		3	10	16	10	10	
Median	0.10	0.000	0.00	0.13	4.21	1.37	0.11		0.27	0.10	3.19	0.38	0.24	
Maximum	0.94	0.100	0.20	0.99	4.35	1.94	0.21		0.32	0.15	8.78	0.60	3.09	
Minimum	0.00	0.000	0.00	0.01	3.44	0.95	0.06		0.21	0.06	2.11	0.17	0.02	
COT/FAM - 21 to 30 m Summer														
Mean	0.19	0.000	0.03	0.22	3.70	1.21	0.12		0.22	<i>0.07</i>	<i>2.09</i>	0.35	<i>0.99</i>	
Std Dev	0.32	0.000	0.05	0.33	0.30	0.35	0.06		0.04	0.03	0.96	0.20	1.29	
Coeff. Var.	170.6		164.1	148.8	8.0	28.8	52.0		15.7	39.0	46.0	57.9	129.4	
n	14	14	14	14	3	10	14		3	10	14	10	10	
Median	0.05	0.000	0.00	0.08	3.68	1.16	0.11		0.22	0.07	1.63	0.32	0.41	
Maximum	1.12	0.000	0.10	1.19	4.00	1.88	0.26		0.26	0.12	4.02	0.70	3.97	
Minimum	0.00	0.000	0.00	0.01	3.41	0.68	0.06		0.19	0.04	0.84	0.14	0.02	
COT/FAM - > 41 m Summer														
Mean	<i>0.16</i>	<i>0.032</i>	0.09	<i>0.29</i>	4.55	<i>1.32</i>	<i>0.13</i>		0.35	0.08	<i>1.87</i>	0.38	0.90	
Std Dev	0.24	0.048	0.14	0.33	0.53	0.44	0.06		0.15	0.03	1.05	0.18	0.95	
Coeff. Var.	151.7	148.0	154.9	111.4	11.7	33.3	42.6		43.8	41.2	56.2	46.6	106.1	
n	28	28	28	28	6	21	28		6	21	28	21	21	
Median	0.09	0.000	0.00	0.14	4.65	1.20	0.12		0.31	0.08	1.50	0.36	0.51	
Maximum	1.02	0.100	0.60	1.13	5.29	2.59	0.23		0.64	0.13	4.26	0.70	3.32	
Minimum	0.00	0.000	0.00	0.06	3.79	0.90	0.06		0.23	0.04	0.75	0.15	0.11	

Table 8. Summary statistics for dissolved and particulate water column nutrient concentrations in the Tully box for the winter (May - September) season. Values are given as depth-weighted average concentrations over the full depth of the water column sampled.

	NH ₄	NO ₂	NO ₃	TDN	DON	PON μmol l ⁻¹	PO ₄	TDP	DOP	POP	SiO	Chl μg l ⁻¹	Phaeo μg l ⁻¹	S.S. mg l ⁻¹
COT/FAM - <= 10 m Winter														
Mean	1.17	0.175	0.35	1.71		2.46	0.14			0.30	29.26		0.02	
Std Dev	1.09	0.206	0.57	1.54		0.61	0.09			0.12	24.41		0.02	
Coeff. Var.	93.2	117.8	164.1	90.1		24.8	62.3			41.8	83.4		88.7	
n	4	4	4	4		4	4			4	4		4	
Median	0.89	0.150	0.10	1.70		2.19	0.13			0.27	18.80		0.02	
Maximum	2.61	0.400	1.20	3.08		3.37	0.25			0.46	65.53		0.03	
Minimum	0.30	0.000	0.00	0.35		2.08	0.06			0.20	13.91		0.00	
COT/FAM - 11 to 20 m Winter														
Mean	0.77	0.075	0.53	1.37		2.69	0.13			0.19	29.48		0.01	
Std Dev	0.65	0.096	0.61	1.40		0.18	0.07			0.06	11.49		0.01	
Coeff. Var.	83.9	127.7	116.8	102.1		6.5	57.1			34.9	39.0		102.9	
n	4	4	4	4		4	4			4	4		4	
Median	0.56	0.050	0.30	0.88		2.69	0.10			0.21	24.61		0.01	
Maximum	1.69	0.200	1.40	3.36		2.89	0.23			0.23	46.46		0.03	
Minimum	0.29	0.000	0.10	0.36		2.49	0.08			0.09	22.26		0.00	
COT/FAM - 21 to 30 m Winter														
Mean	0.32	0.000	0.06	0.38		1.18	0.11			0.11	4.74	0.26	0.00	
Std Dev	0.11	0.000	0.05	0.11		0.31	0.03			0.03	2.73	0.04	0.00	
Coeff. Var.	33.5		82.8	27.9		26.5	26.9			24.0	57.7	14.7	27.6	
n	8	8	8	8		12	8			12	8	4	8	
Median	0.30	0.000	0.10	0.36		1.27	0.11			0.11	4.75	0.27	0.00	
Maximum	0.49	0.000	0.10	0.54		1.69	0.15			0.15	7.62	0.30	0.01	
Minimum	0.16	0.000	0.00	0.21		0.70	0.07			0.07	1.89	0.22	0.00	
COT/FAM - > 41 m Winter														
Mean	0.42	0.000	0.07	0.51		0.89	0.08			0.07	1.29	0.25	0.74	
Std Dev	0.22	0.000	0.07	0.21		0.24	0.01			0.02	1.35	0.04	1.56	
Coeff. Var.	53.5		96.4	41.4		26.5	17.1			23.9	104.3	17.6	211.1	
n	10	10	10	10		16	10			16	10	8	10	
Median	0.32	0.000	0.10	0.44		0.91	0.08			0.07	0.98	0.25	0.00	
Maximum	0.92	0.000	0.20	0.98		1.18	0.11			0.10	5.09	0.31	4.08	
Minimum	0.27	0.000	0.00	0.33		0.57	0.07			0.04	0.44	0.16	0.00	

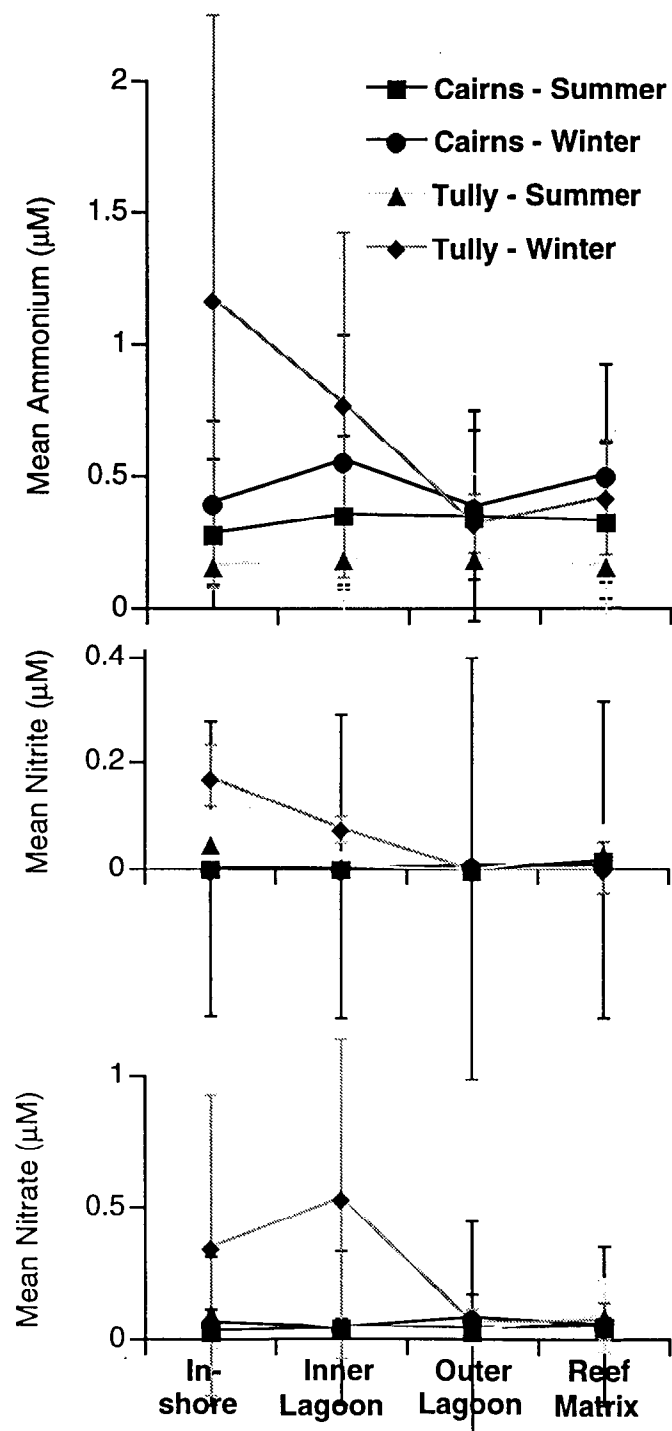


Figure 20. Cross-shelf gradients and seasonal changes in depth-weighted mean water column concentrations (± 1 standard deviation) of ammonium (Top), nitrite (Middle) and nitrate (Bottom) in the Cairns and Tully boxes.

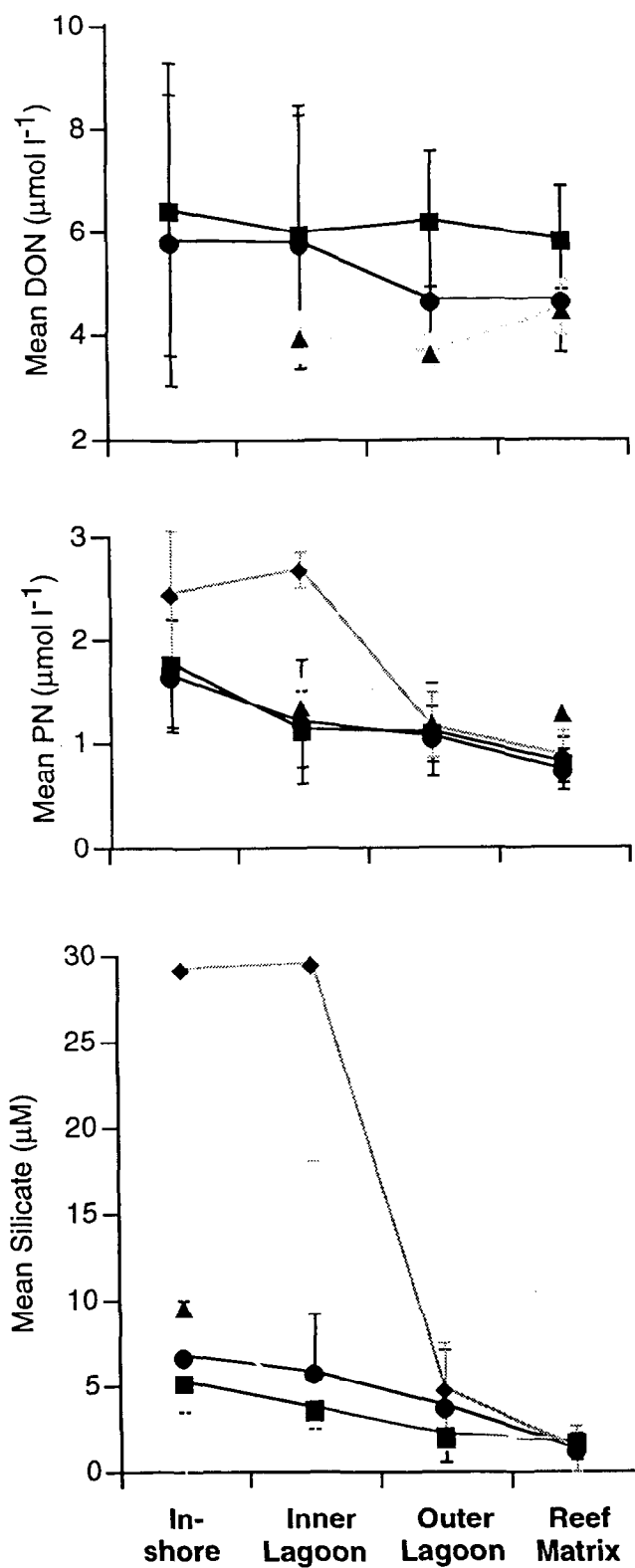


Figure 21. Cross-shelf gradients and seasonal changes in depth-weighted mean water column concentrations (± 1 standard deviation) of DON (Top), PN (Middle) and silicate (Bottom) in the Cairns and Tully boxes. Symbols are as given in Figure 20.

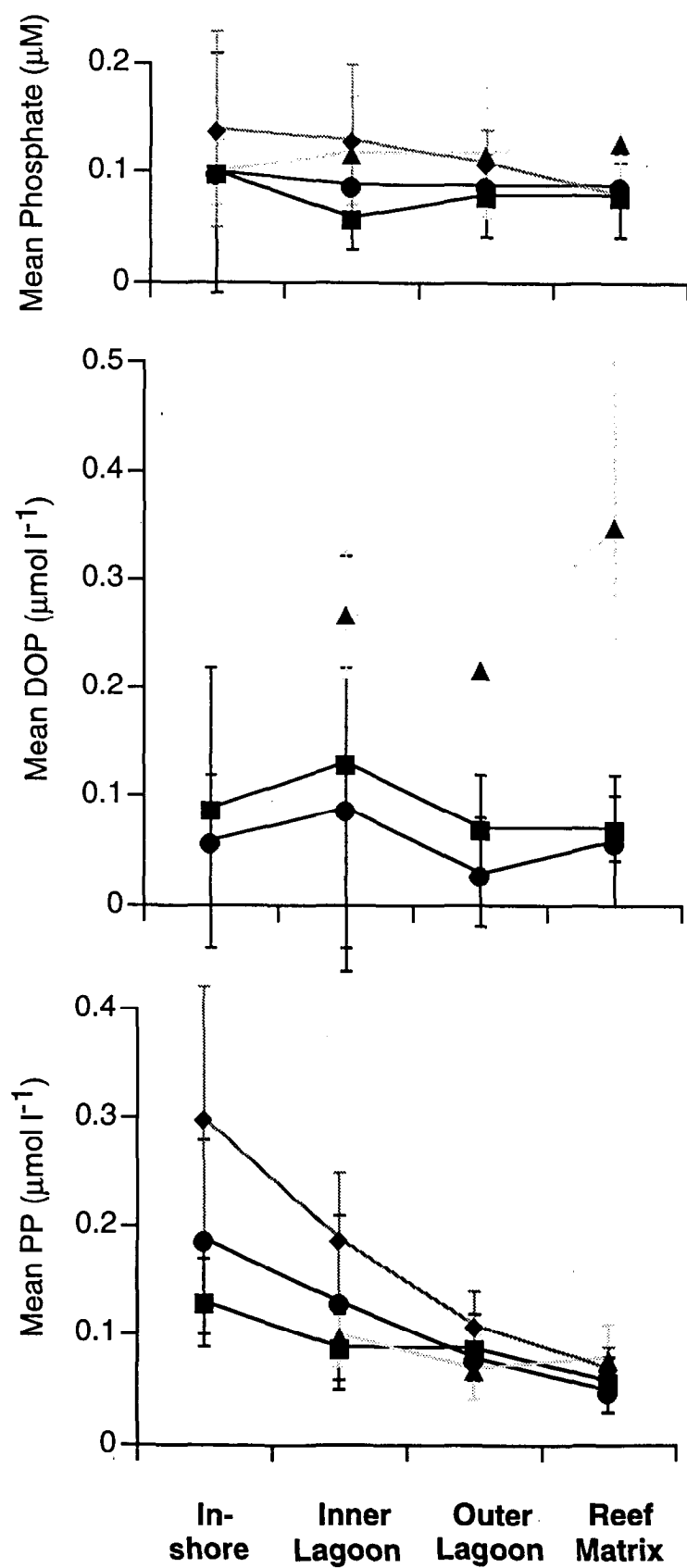


Figure 22. Cross-shelf gradients and seasonal changes in depth-weighted mean water column concentrations (± 1 standard deviation) of phosphate (Top), DOP (Middle) and PP (Bottom) in the Cairns and Tully boxes. Symbols are as given in Figure 20.

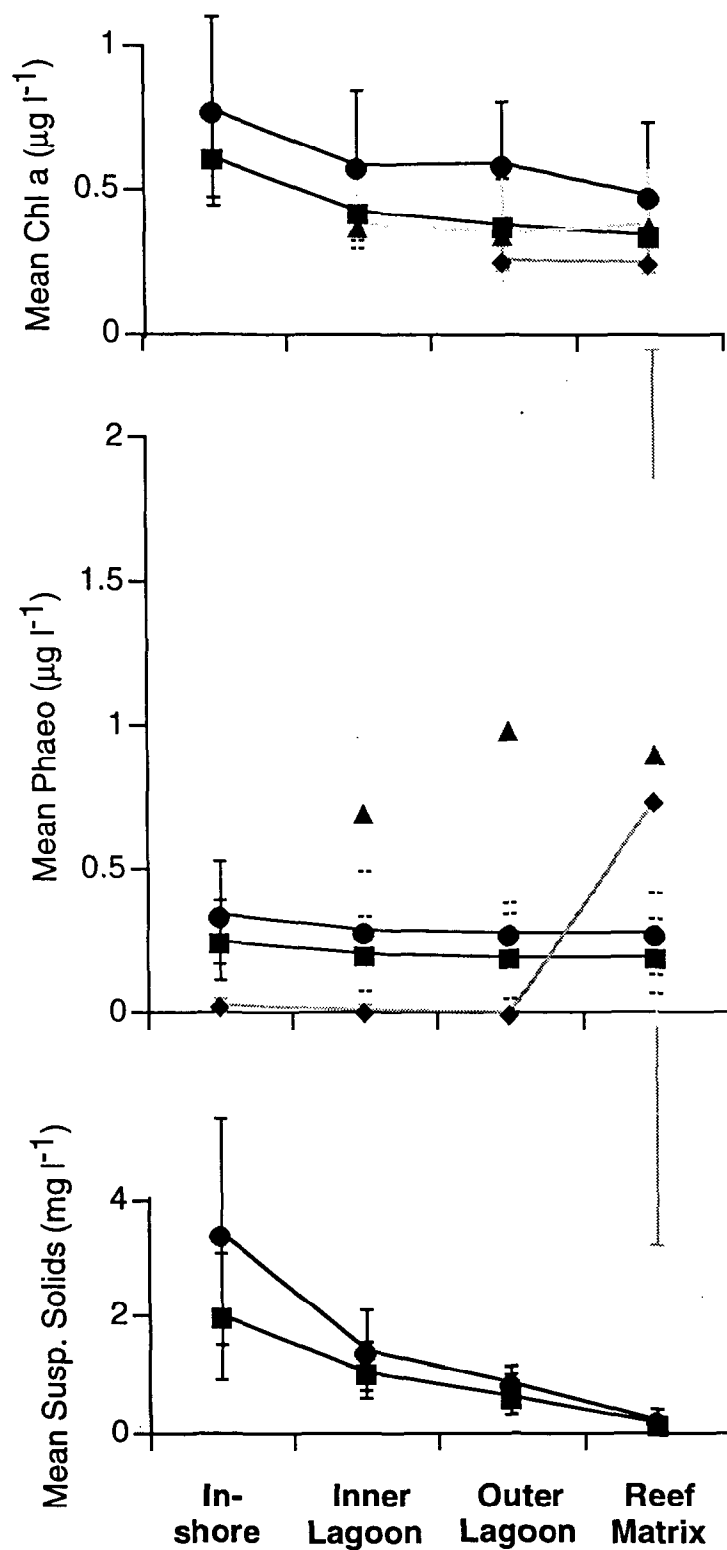


Figure 23. Cross-shelf gradients and seasonal changes in depth-weighted mean water column concentrations (± 1 standard deviation) of chlorophyll *a* (Top), phaeophytin (Middle) and suspended solids (Bottom) in the Cairns and Tully boxes. Symbols are as given in Figure 20.

Tables 9-12 present calculated seasonal estimates of integrated stocks of individual nutrient species within each of the depth bands, total stocks within each of the two boxes and the distributions of nutrient stocks between the four depth bands. Despite the general occurrence of higher concentrations of most nutrient species in the two shallowest depth bands, most of the nutrient, suspended particle and pigment stocks, resided in the larger volumes of water seaward of the 30 m isobath. This trend was least pronounced in the case of suspended solids, where resuspension processes near the coast result in elevated nearshore concentrations.

Tables 13-16 give the estimates of total shelf nutrient stocks per linear metre of coastline within each of the two boxes. With the exception of DON and suspended solids, shelf stocks of most nutrient species were on the order of several 1's to several 10's of kilomoles per metre of coastline. These estimates provide a basis for normalizing inputs and sinks of nutrients which must be averaged over longer sections of the coast.

Dissolved organic nitrogen (DON) was, by a large margin, the largest pool of water column nitrogen, comprising 78-81 percent of the total water column stock. The composition and activity of this heterogeneous pool of nitrogen is virtually unknown. Particulate nitrogen (PN) is the next largest pool, ranging between 14 and 21 percent of total water column nitrogen. Ammonium was the principal form of inorganic nitrogen in central GBR waters, with contributions to total shelf stocks ranging between 1.5 and 6.3 percent. Nitrate and nitrite were, in all cases, trivial contributors to total shelf nitrogen stocks.

Phosphorus was more equally divided between dissolved inorganic, dissolved organic and particulate pools in both the Cairns and Tully boxes. Dissolved inorganic stocks ranged between 23 and 49 percent of total phosphorus. Dissolved organic phosphorus ranged between 15 and 60 percent of total phosphorus, while particulate phosphorus varied between 16 and 36 percent of total phosphorus. The greatest discrepancy from this general pattern occurred during summer in the samples collected off Dunk Island, where 60 percent of the total water column phosphorus was apparently present as DOP and only 16 percent as PP. Unfortunately, insufficient winter data is available to assess whether this distribution between phosphorus species is a persistent feature in the Tully box or is ephemeral.

The relationship of measured PN and PP concentrations to phytoplankton biomass (as chlorophyll) was highly variable (Figure 24). In both cases, statistical correlations between either PN or PP and chlorophyll were weak. The intercepts of geometrical mean slope functional regressions (Ricker, 1973, hereafter GM regression) of PN on chlorophyll were not statistically different from zero, indicating that most of the particulate nitrogen in the water column was associated with, or derived from, algal material. However, the slopes of both the PN-chl and PP-chl functional regressions (1.9 and 0.21 mmol mg⁻¹, respectively) are considerably higher than the ratios expected for living phytoplankton (0.5 to 1 and 0.01-0.1 mmol mg⁻¹; Perry, 1976; Goldman, 1980), clearly indicating that most of the PN and PP in GBR shelf waters is in the form of detritus.

Correlations between PN or PP and suspended solids were less well defined (Figure 25). In the case of PN, the intercept of the GM regression was considerably greater than zero, clearly indicating a poor association between PN and inorganic suspended materials. The intercept of the functional PP vs. suspended solids relationship did not greatly differ from zero, suggesting that most of the PP not tied up in phytoplankton biomass is bound to inorganic particles. Phosphorus is known to be strongly bound to regional soil (Moody and Chapman, 1991) and marine sediment particles (Entsch et al., 1983; Alongi, 1989) and to be enriched in carbonate sediments in particular (Entsch et al., 1983). Step-wise regressions of PN and PP on suspended solids and chlorophyll concentrations indicate that fluctuations in these two variables collectively account for only 44 and 33 percent of the variances in PN and PP concentrations, respectively. In single variable regressions, fluctuations in suspended solids concentrations

account for 30 and 18 percent of the variance in PN and PP, respectively, with chlorophyll alone accounting for 31 and 16 percent. The high level of scatter in the individual relationships precludes the use of functional relationships between PN, PP, chlorophyll and suspended solids based on field data for predicting phytoplankton biomass.

The mean N/P ratio in pooled particulate matter taken from the GM regressions slope (7.53) is approximately half of the value expected for phytoplankton with a Redfield composition ($N/P = 16$) (Figure 26). Collectively, the high P/chl ratio (from the GM regression slope) and low particulate N/P ratio are indicative of dilution of the water column particulate phosphorus pool with phosphorus adsorbed to or incorporated in inorganic particles.

Table 9. Distribution of shelf nutrient stocks within long-shelf depth bands in the Cairns box during summer (October - April). Concentrations used are median concentrations from Table 5.

Depth Band Volume (km ³)	Median concentration (μM)*				Stock in depth band (kmol)				Total Stock	Percentage of total stock in depth bands			
	<10 m	10-20 m	20-30 m	30+ m	<10 m	10-20 m	20-30 m	30+ m		<10 m	10-20 m	20-30 m	30+ m
	1.9	10.9	20.4	149									
NH ₄	0.21	0.29	0.17	0.18	399.0	3106.5	3366.0	26820.0	33692	1.2	9.2	10.0	79.6
NO ₂	0.000	0.000	0.000	0.000	0.0	0.0	0.0	0.0	0	0	0	0	0
NO ₃	0.04	0.04	0.03	0.03	76.0	436.0	612.0	4470.0	5594	1.4	7.8	10.9	79.9
TDN	5.75	5.14	6.36	4.81	10915.5	55971.5	129642.0	715945.0	912474	1.2	6.1	14.2	78.5
DON	5.45	4.69	6.14	4.68	10355.0	51121.0	125154.0	696575.0	883205	1.2	5.8	14.2	78.9
PON	1.60	1.10	0.99	0.91	3040.0	11990.0	20196.0	135590.0	170816	1.8	7.0	11.8	79.4
PO ₄	0.08	0.07	0.07	0.06	152.0	708.5	1428.0	8940.0	11229	1.4	6.3	12.7	79.6
TDP	0.09	0.13	0.13	0.15	171.0	1362.5	2652.0	22350.0	26536	0.6	5.1	10.0	84.2
DOP	0.03	0.06	0.05	0.07	57.0	599.5	1020.0	10430.0	12107	0.5	5.0	8.4	86.2
POP	0.14	0.08	0.09	0.06	266.0	872.0	1734.0	8940.0	11812	2.3	7.4	14.7	75.7
SiO	4.48	3.86	1.89	2.06	8512.0	42019.5	38454.0	306940.0	395926	2.1	10.6	9.7	77.5
Chlorophyll	0.58	0.40	0.33	0.31	1102.0	4360.0	6732.0	46190.0	58384	1.9	7.5	11.5	79.1
Phaeophytin	0.23	0.18	0.19	0.17	437.0	1962.0	3774.0	25330.0	31503	1.4	6.2	12.0	80.4
Susp. Solids	1.80	1.06	0.62	0.25	3420.0	11554.0	12648.0	37250.0	64872	5.3	17.8	19.5	57.4
Total dissolved N					475.0	3542.5	3978.0	31290.0					
Total N					13870.0	66653.5	149328.0	863455.0					
Total dissolved P					323.0	2071.0	4080.0	31290.0					
Total P					589.0	2943.0	5814.0	40230.0					

* Pigment concentrations are in μg per litre and suspended solids concentrations are in mg per litre

Table 10. Distribution of shelf nutrient stocks within long-shelf depth bands in the Cairns box during winter (May - September). Concentrations used are median concentrations from Table 6.

Depth Band Volume (km ³)	Median concentration (μM)*				Stock in depth band (kmol)				kmol	Percentage of total stock in depth bands			
	<10 m	10-20 m	20-30 m	30+ m	<10 m	10-20 m	20-30 m	30+ m		<10 m	10-20 m	20-30 m	30+ m
	1.9	10.9	20.4	149									
NH ₄	0.26	0.33	0.33	0.44	494.0	3542.5	6630.0	65560.0	76227	0.6	4.6	8.7	86.0
NO ₂	0.000	0.000	0.000	0.000	0.0	0.0	0.0	0.0	0	0	0	0	0
NO ₃	0.04	0.03	0.06	0.07	76.0	327.0	1122.0	10430.0	11955	0.6	2.7	9.4	87.2
TDN	5.87	6.21	5.69	6.26	11153.0	67689.0	116076.0	932740.0	1127658	1.0	6.0	10.3	82.7
DON	5.00	5.21	4.99	5.29	9500.0	56789.0	101796.0	787465.0	955550	1.0	5.9	10.7	82.4
PON	1.63	1.12	1.06	0.86	3097.0	12153.5	21624.0	128140.0	165015	1.9	7.4	13.1	77.7
PO ₄	0.10	0.09	0.10	0.09	190.0	981.0	1938.0	13410.0	16519	1.2	5.9	11.7	81.2
TDP	0.13	0.12	0.08	0.12	247.0	1308.0	1530.0	17880.0	20965	1.2	6.2	7.3	85.3
DOP	0.05	0.04	0.01	0.03	95.0	436.0	204.0	4470.0	5205	1.8	8.4	3.9	85.9
POP	0.17	0.10	0.08	0.06	323.0	1090.0	1632.0	8940.0	11985	2.7	9.1	13.6	74.6
SiO	4.94	5.08	2.62	1.41	9386.0	55317.5	53346.0	210090.0	328140	2.9	16.9	16.3	64.0
Chlorophyll	0.70	0.48	0.58	0.35	1330.0	5232.0	11730.0	52150.0	70442	1.9	7.4	16.7	74.0
Phaeophytin	0.28	0.23	0.26	0.20	532.0	2452.5	5202.0	29800.0	37987	1.4	6.5	13.7	78.4
Susp. Solids	2.99	1.26	0.86	0.36	5671.5	13734.0	17442.0	53640.0	90488	6.3	15.2	19.3	59.3
Total dissolved N					570.0	3869.5	7752.0	75990.0					
Total N					13167.0	72812.0	131172.0	991595.0					
Total dissolved P					437.0	2289.0	3468.0	31290.0					
Total P					760.0	3379.0	5100.0	40230.0					

* Pigment concentrations are in μg per litre and suspended solids concentrations are in mg per litre

Table 11. Distribution of shelf nutrient stocks within long-shelf depth bands in the Tully box during summer (October - April). Concentrations used are median concentrations from Table 7.

Depth Band	Median concentration (μM)*				Stock in depth band (kmol)				kmol	Percentage of total stock in depth bands			
	<10 m	10-20 m	20-30 m	30+ m	<10 m	10-20 m	20-30 m	30+ m		<10 m	10-20 m	20-30 m	30+ m
Volume (km^3)	1.5	8.5	31	267									
NH ₄	0.17	0.10	0.05	0.09	255.0	807.5	1395.0	24030.0	26488	1.0	3.0	5.3	90.7
NO ₂	0.050	0.000	0.000	0.000	75.0	0.0	0.0	0.0	75	100.0	0.0	0.0	0.0
NO ₃	0.05	0.00	0.00	0.00	75.0	0.0	0.0	0.0	75	100.0	0.0	0.0	0.0
TDN	0.32	0.13	0.08	0.14	472.5	1062.5	2480.0	37380.0	41395	1.1	2.6	6.0	90.3
DON		4.21	3.68	4.65	0.0	35785.0	114080.0	1240215.0	1390080	0.0	2.6	8.2	89.2
PON		1.37	1.16	1.20	0.0	11602.5	35960.0	320400.0	367963	0.0	3.2	9.8	87.1
PO ₄	0.10	0.11	0.11	0.12	150.0	935.0	3410.0	30705.0	35200	0.4	2.7	9.7	87.2
TDP													
DOP		0.27	0.22	0.31	0.0	2295.0	6820.0	81435.0	90550	0.0	2.5	7.5	89.9
POP		0.10	0.07	0.08	0.0	807.5	2015.0	21360.0	24183	0.0	3.3	8.3	88.3
SiO	5.49	3.19	1.63	1.45	8235.0	27072.5	50375.0	385815.0	471498	1.7	5.7	10.7	81.8
Chlorophyll		0.38	0.32	0.36	0.0	3187.5	9765.0	96120.0	109073	0.0	2.9	9.0	88.1
Phaeophytin		0.24	0.41	0.51	0.0	2044.3	12679.0	136437.0	151160	0.0	1.4	8.4	90.3
Susp. Solids													
Total dissolved N					405.0	807.5	1395.0	24030.0					
Total N					405.0	48195.0	151435.0	1584645.0					
Total dissolved P					150.0	935.0	3410.0	30705.0					
Total P					150.0	1742.5	5425.0	52065.0					

* Pigment concentrations are in μg per litre and suspended solids concentrations are in mg per litre

Table 12. Distribution of shelf nutrient stocks within long-shelf depth bands in the Tully box during winter (May - September). Concentrations used are median concentrations from Table 6.

Depth Band Volume (km ³)	Median concentration (μM)*				Stock in depth band (kmol)				kmol	Percentage of total stock in depth bands			
	<10 m 1.9	10-20 m 10.9	20-30 m 20.4	30+ m 149	<10 m	10-20 m	20-30 m	30+ m		<10 m	10-20 m	20-30 m	30+ m
NH ₄	0.89	0.56	0.30	0.32	1681.5	6049.5	6120.0	47680.0	61531	2.7	9.8	9.9	77.5
NO ₂	0.150	0.050	0.000	0.000	285.0	545.0	0.0	0.0	830	34.3	65.7	0.0	0.0
NO ₃	0.10	0.30	0.10	0.10	190.0	3270.0	2040.0	14900.0	20400	0.9	16.0	10.0	73.0
TDN													
DON													
PON	2.19	2.69	1.27	0.91	4161.0	29321.0	25806.0	134845.0	194133	2.1	15.1	13.3	69.5
PO ₄	0.13	0.10	0.11	0.08	247.0	1035.5	2142.0	11920.0	15345	1.6	6.7	14.0	77.7
TDP													
DOP													
POP	0.27	0.21	0.11	0.07	503.5	2289.0	2142.0	10430.0	15365	3.3	14.9	13.9	67.9
SiO	18.80	24.61	4.75	0.98	35710.5	268194.5	96798.0	145275.0	545978	6.5	49.1	17.7	26.6
Chlorophyll			0.27	0.25									
Phaeophytin	0.02	0.01	0.00	0.00	32.3	92.7	81.6	596.0	803	4.0	11.5	10.2	74.3
Susp. Solids													
Total dissolved N					2156.5	9864.5	8160.0	62580.0					
Total N					6317.5	39185.5	33966.0	197425.0					
Total dissolved P					247.0	1035.5	2142.0	11920.0					
Total P					750.5	3324.5	4284.0	22350.0					

* Pigment concentrations are in μg per litre and suspended solids concentrations are in mg per litre

Table 13. Calculated stocks of nutrients per metre of coastline within the Cairns box during summer. Linear distance along coast (16° 5'S - 16° 52.5'S) - 88 km.

	kmol	kmol m ⁻¹	Metric tons	Metric tons per metre of Coastline
NH ₄	33692	0.383	472.02	0.0054
NO ₂	0	0.000	0.00	0.0000
NO ₃	5594	0.064	78.37	0.0009
TDN	912474	10.369	12783.76	0.1453
DON	883205	10.036	12373.70	0.1406
PON	170816	1.941	2393.13	0.0272
PO ₄	11229	0.128	157.31	0.0018
TDP	26536	0.302	371.76	0.0042
DOP	12107	0.138	169.61	0.0019
POP	11812	0.134	165.49	0.0019
SiO	395926	4.499	5546.92	0.0630
	kg	kg m ⁻¹	Metric tons	Metric tons per metre of Coastline
Chlorophyll	58384	0.663	58.38	0.0007
Phaeophytin	31503	0.358	31.50	0.0004
Susp. Solids	64872	0.737	64872.00	0.7372

Table 14. Calculated stocks of nutrients per metre of coastline within the Cairns box during winter. Linear distance along coast (16° 5'S - 16° 52.5'S) - 88 km.

	kmol	kmol m ⁻¹	Metric tons	Metric tons per metre of Coastline
NH ₄	76227	0.866	1067.93	0.0121
NO ₂	0	0.000	0.00	0.0000
NO ₃	11955	0.136	167.49	0.0019
TDN	1127658	12.814	15798.49	0.1795
DON	955550	10.859	13387.26	0.1521
PON	165015	1.875	2311.85	0.0263
PO ₄	16519	0.188	231.43	0.0026
TDP	20965	0.238	293.72	0.0033
DOP	5205	0.059	72.92	0.0008
POP	11985	0.136	167.91	0.0019
SiO	328140	3.729	4597.23	0.0522
	kg	kg m ⁻¹	Metric tons	Metric tons per metre of Coastline
Chlorophyll	70442	0.800	70.44	0.0008
Phaeophytin	37987	0.432	37.99	0.0004
Susp. Solids	90488	1.028	90487.50	1.0283

Table 15. Calculated stocks of nutrients per metre of coastline within the Tully box during summer. Linear distance along coast (16° 52.5'S - 17° 55'S) - 116 km.

	kmol	kmol m ⁻¹	Metric tons	Metric tons per metre of Coastline
NH ₄	26488	0.228	371.09	0.0032
NO ₂	75	0.001	1.05	0.0000
NO ₃	75	0.001	1.05	0.0000
TDN				
DON	1390080	11.983	19475.02	0.1679
PON	367963	3.172	5155.15	0.0444
PO ₄	35200	0.303	493.15	0.0043
TDP				
DOP	90550	0.781	1268.61	0.0109
POP	24183	0.208	338.80	0.0029
SiO	471498	4.065	6605.68	0.0569
	kg	kg m ⁻¹	Metric tons	Metric tons per metre of Coastline
Chlorophyll	109073	0.940	109.07	0.0012
Phaeophytin	151160	1.303	151.16	0.0017
Susp. Solids				

Table 16. Calculated stocks of nutrients per metre of coastline within the Tully box during winter. Linear distance along coast (16° 52.5'S - 17° 55'S) - 116 km.

	kmol	kmol m ⁻¹	Metric tons	Metric tons per metre of Coastline
NH ₄	61531	0.530	862.05	0.0074
NO ₂	830	0.007	11.63	0.0001
NO ₃	20400	0.176	285.80	0.0025
TDN				
DON				
PON	194133	1.674	2719.80	0.0234
PO ₄	15345	0.132	214.98	0.0019
TDP				
DOP				
POP	15365	0.132	215.26	0.0019
SiO	545978	4.707	7649.15	0.0659
	kg	kg m ⁻¹	Metric tons	Metric tons per metre of Coastline
Chlorophyll	803	0.007	0.80	0.0000
Phaeophytin		0.000	0.00	0.0000
Susp. Solids				

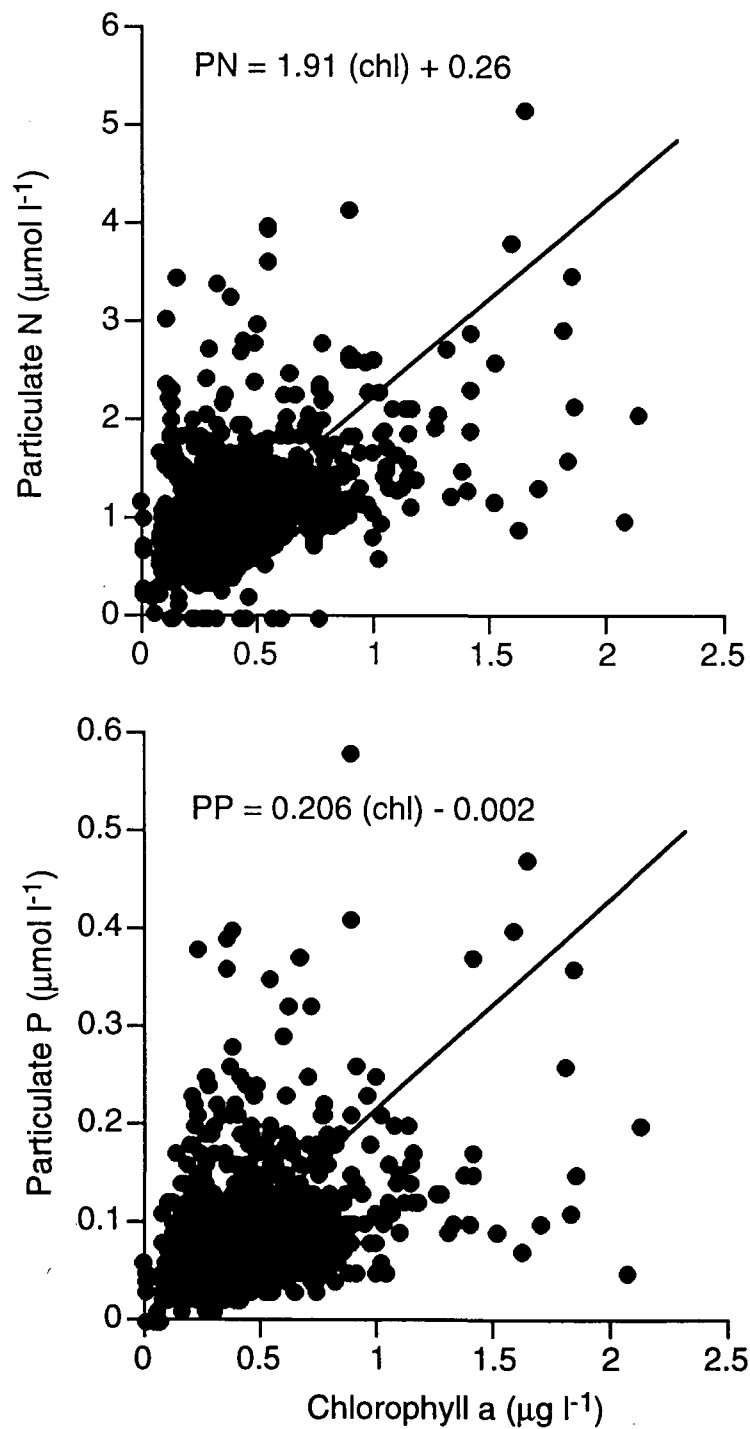


Figure 24. Relationships between depth-weighted mean water column stocks of PN and PP and stocks of chlorophyll *a* in waters of the Cairns and Tully boxes. The regression lines shown are GM functional regressions (Ricker, 1973).

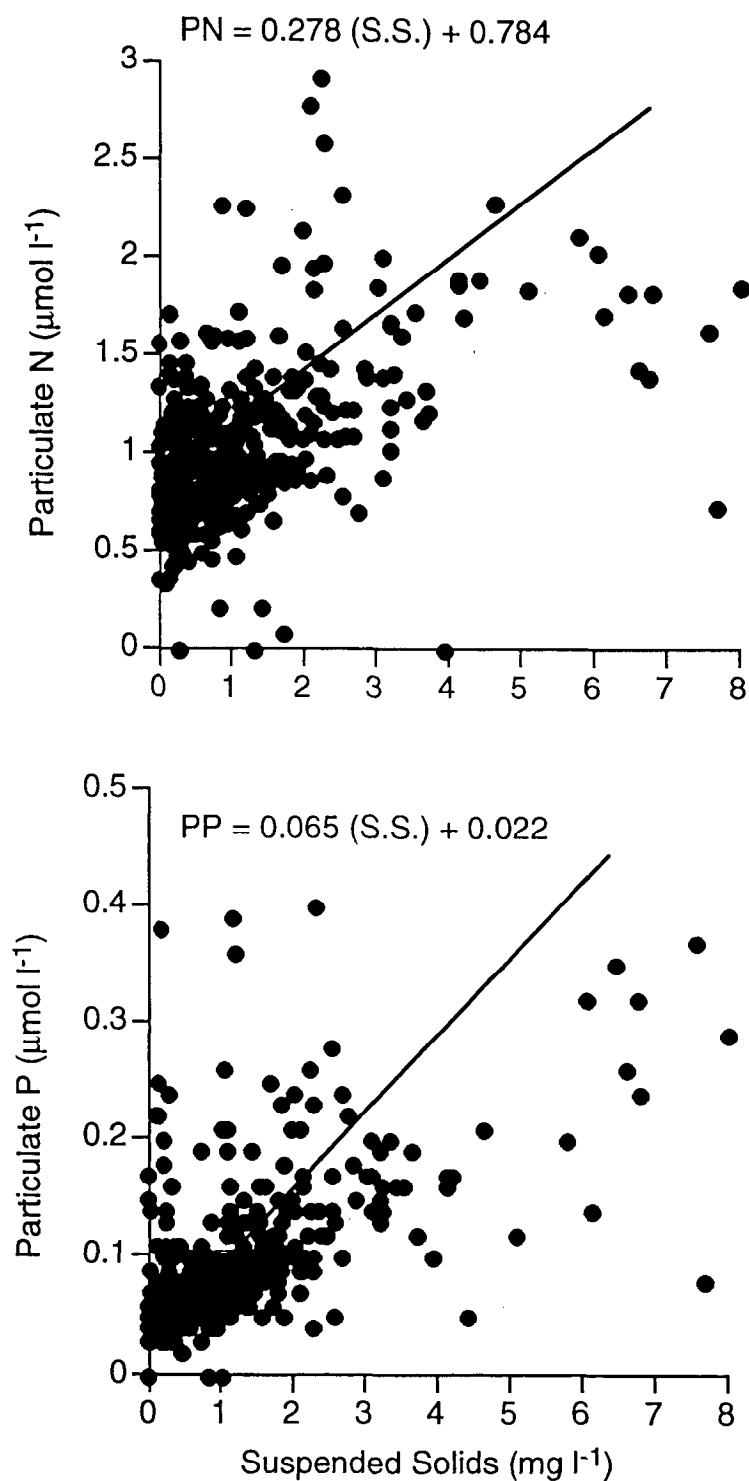


Figure 25. Relationships between depth-weighted mean water column stocks of PN and PP and stocks of suspended solids in waters of the Cairns and Tully boxes. The regression lines shown are GM functional regressions (Ricker, 1973).

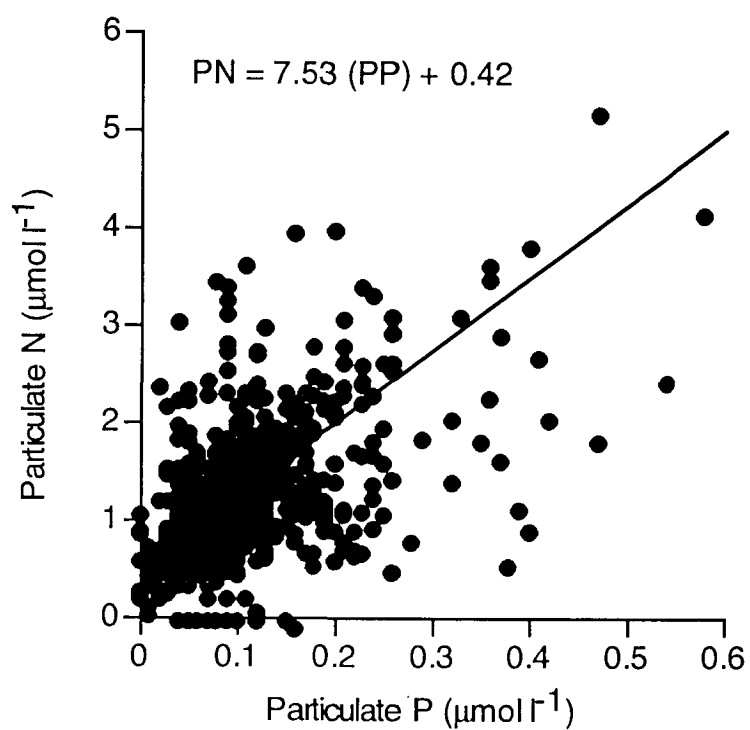


Figure 26. Relationships between depth-weighted mean water column stocks of PN and PP in the Cairns and Tully boxes. The regression lines shown are GM functional regressions (Ricker, 1973).