6. RESULTS

Detailed hydrographic data from the stations are presented in the appendix tables. Depth-weighted mean water temperatures, nutrient, chlorophyll and suspended solid concentrations for all stations are summarised in table 1. Integrations for these mean values were extended to the bottom or fifty metres, whichever was shallower to minimise biases introduced by integrating enhanced sub-thermocline nutrient concentrations. Sediment characteristics are given in table 2. For comparative purposes, the water column averaged nutrient, chlorophyll and suspended solid concentrations are also presented in summary tables grouped geographically within the study area (tables 3-9). The allocation of individual stations to these groups is not exclusive. Means of depth-weighted average nutrient concentrations for Torres Strait and Cooktown stations are presented in table 10.

Shelf waters were reasonably well mixed by wind and tidal action. At most on-shelf stations, vertical gradients of all parameters measured were small. The one prominent exception to this general trend occurred at the shelfbreak station immediately inshore of Raine Island inlet (28), where a well-defined near-bottom intrusion (< 24°C in bottom water) was identified. Cooler near-bottom water was also detected at two shelfbreak stations (15, 16) just inside of the barrier and at one station (14) in the channel just outside a gap between two reefs, suggesting shelfbreak mixing of subthermocline waters.

Surface salinities at outer-shell stations (mean = 34.58 ppt) were significantly higher than at Coral Sea (34.47 ppt) and inner-shelf stations (34.44 ppt), although reasons for this were not resolved. Surface salinities at stations on the two northern transects (mean = 34.60 ppt) were higher than the two southern transects (34.44 ppt). Variability in water temperatures, particularly surface temperatures, was directly related to solar heating and the time of day for sampling. As a result, geographical variability in temperatures could not be established. On individual days, surface temperatures varied by as much as one to two degrees Celsius.

Slightly elevated concentrations of inorganic nutrient species were sporadically observed in near-bottom samples, but not on a consistent basis. The variability observed in water column concentrations of nutrient species at non-shelfbreak stations was of the order expected for sampling and analytical variability (Furnas et al. 1990).

Ammonium was the principal inorganic nitrogen species measured in shelf water column or Coral Sea mixed-layer water samples (table 1). Nitrate and nitrite concentrations were very low in the mixed layer at all stations, in many cases, at concentrations below detection limits. Collectively, inorganic nitrogen species (NH_4+NO_2+NO_3) were a relatively small component of total water column nitrogen (TN), averaging only 2.7±1.9 (1 s.d.) and 3.5±1.2 percent of TN, respectively at inner- (depth < 20 m) and outer-shelf depth (depth > 20 m) stations. Particulate (PON) and dissolved organic (DON) nitrogen comprised the major pools of water column nitrogen. PON averaged 49±14 and 48±13 percent, at inner- and outer-shelf stations, respectively.

The situation was somewhat different for phosphorus. Phosphate (PO_4) averaged 24±12 and 33±13 percent of total water column phosphorus (TP) stocks (depth-weighted) at inner- and outer-shelf stations, respectively. Depth-weighted dissolved organic phosphorus (DOP) concentrations averaged 16±8 (inner-shelf) and 10±10 (outer-shelf) percent of TP, respectively. Particulate phosphorus (POP) comprised the major water column phosphorus pool, averaging 61±10 (inner-shelf) and 57±12 (outer-shelf) percent of TP.

Table 1. Depth-weighted mean water column concentrations at far northern Great Barrier Reef stations, February 1990. Integrations were calculated out to fifty metres or the bottom, whichever was shallower.

Station	Depth m	NH_4	NO_2	NO_3	DON	PON µmol/l	PO_4	DOP	POP	Si	Chl µg/l	Pha µg/l	S.S mg/l
SHL01	20	0.07	0.00	0.03	7.13	5.11	0.00	0.10	0.28	1.13	0.48	0.17	
SHL02	300	0.29	0.05	0.18	4.33	3.23	0.09	0.00	0.05	0.78	0.28	0.25	0.70
SHL03	35	0.15	0.00	0.06	3.25	3.75	0.06	0.02	0.08	0.63	0.57	0.36	0.88
SHL04	16	0.19	0.00	0.50	3.24	2.21	0.05	0.00	0.09	1.54	0.27	0.27	0.93
SHL05	28	0.18	0.00	0.04	3.90	4.63	0.05	0.00	0.09	2.34	0.70	0.42	1.40
SHL06	16	0.16	0.00	0.05	3.47	4.15	0.04	0.03	0.09	1.46	0.34	0.22	1.15
SHL07	6	0.17	0.00	0.04	4.43	2.76	0.04	0.02	0.10	7.87	0.30	0.13	1.55
SHL08	8	0.14	0.00	0.05	3.39	4.19	0.04	0.02	0.13	2.59	0.42	0.22	1.80
SHL09	28	0.12	0.00	0.04	3.36	3.92	0.04	0.01	0.09	2.99	0.59	0.37	1.48
SHL10	38	0.18	0.00	0.03	3.48	4.04	0.05	0.01	0.09	1.50	0.46	0.27	1.16
SHL11	44	0.21	0.00	0.04	3.36	2.87	0.06	0.01	0.11	2.23	1.05	0.60	0.89
SHL12	43	0.18	0.00	0.18	3.70	3.19	0.07	0.01	0.10	2.43	1.07	0.55	
SHL13	300	0.18	0.00	0.05	4.48	3.54	0.08	0.00	0.09	0.02	1.17	0.59	0.74
SHL14	57	0.25	0.00	0.34	4.41	4.39	0.06	0.05	0.10	0.10	0.90	0.52	
SHL15	21	0.42	0.00	0.00	4.71	3.39	0.02	0.06	0.10	0.01	0.65	0.43	0.96
SHL16	28	0.41	0.01	0.10	4.72	2.56	0.06	0.02	0.07	0.21	0.85	0.48	0.76
SHL17	40	0.26	0.00	0.02	4.86	4.59	0.04	0.03	0.09	0.12	0.51	0.30	1.08
SHL18	40	0.30	0.00	0.02	5.00	2.39	0.04	0.02	0.09	0.02	0.66	0.40	0.88
SHL19	32	0.28	0.00	0.03	4.99	2.35	0.05	0.02	0.07	0.19	0.45	0.33	0.88
SHL20	34	0.19	0.00	0.08	5.25	3.53	0.05	0.06	0.09	0.21	0.82	0.45	0.84
SHL21	40	0.20	0.00	0.06	5.67	3.58	0.06	0.01	0.09	0.29	1.42	0.61	0.81
SHL22	40	0.17	0.00	0.04	5.04	3.98	0.05	0.01	0.09	0.13	1.17	1.03	1.08
SHL23	40	0.20	0.00	0.02	3.41	4.14	0.06	0.01	0.09	0.04	1.30	0.58	0.75
SHL24	40	0.23	0.00	0.01	3.30	1.04	0.06	0.03	0.02	1.08	0.20	0.10	0.41
SHL25	40	0.22	0.00	0.02	3.64	0.82	0.06	0.01	0.02	0.91	0.14	0.08	0.43
SHL26	40	0.16	0.00	0.02	3.89	1.55	0.05	0.02	0.03	1.04	0.14	0.10	0.46
SHL27	300	0.17	0.01	0.01	3.91	4.59	0.04	0.03	0.12	0.00	0.85	0.56	1.13
SHL28	34	0.08	0.05	2.91	1.10	2.87	0.30	0.00	0.08	0.76	1.45	0.96	0.84
SHL29	34	0.16	0.01	0.02	2.17	5.23	0.07	0.00	0.12	0.04	1.71	1.18	1.13
SHL30	18	0.14	0.02	0.01	2.60	5.79	0.05	0.00	0.13	0.39	0.79	0.64	1.67
SHL31	300	0.15	0.00	0.03	2.37	3.16	0.04	0.00	0.11	1.26	0.51	0.28	1.29
SHL32	26	0.15	0.00	0.01	2.71	2.96	0.04	0.03	0.09	1.02	0.46	0.18	1.04
SHL33	10	0.30	0.00	0.03	2.59	6.37	0.03	0.04	0.15	0.22	0.63	0.31	1.90
SHL34	6	0.45	0.00	0.04	2.63	6.98	0.03	0.01	0.16	0.00	0.57	0.37	2.24
SHL35	16	0.50	0.01	0.02	1.71	4.23	0.05		0.13	0.55	0.48	0.18	1.26
SHL36	36	0.19	0.00	0.03		3.34	0.05		0.10	0.97	0.58	0.21	0.96
SHL37	34	0.18	0.00	0.05		3.32	0.05		0.10	0.78	0.77	0.38	1.34
SHL38	18	0.15	0.00	0.03		3.77	0.02		0.12	0.21	0.89	0.46	0.96
SHL39	18	0.21	0.00	0.02		3.78	0.06		0.11	0.14	0.98	0.51	0.96
SHL40	300	0.18	0.02	0.02		3.98	0.05		0.11	0.00	0.89	0.52	0.75
SHL41	300	0.17	0.01	0.10		4.97	0.05		0.11	0.10	1.19	0.79	0.69
SHL42	20	0.08	0.00	0.06		5.41	0.06		0.12	0.44	1.59	0.88	0.77
SHL43	44	0.09	0.00	0.04		3.88	0.03		0.09	0.54	0.24	0.14	0.99
SHL44	27	0.09	0.00	0.05		2.88	0.03		0.10	1.62	0.30	0.18	1.24
SHL45	9	0.09	0.00	0.04		4.11	0.04		0.11	2.28	0.30	0.14	1.41
SHL46	10	0.14	0.00	0.04	6.64	6.23	0.04	0.04	0.12	3.03	0.49	0.28	1.23
SHL47	7	0.15	0.00	0.04	5.38	4.05	0.04	0.02	0.09	2.84	0.43	0.20	0.87
SHL48	6	0.10	0.00	0.05	5.36	3.95	0.05	0.03	0.08	3.41	0.41	0.17	0.99
SHL49	16	0.11	0.00	0.04	5.69	2.35	0.03	0.04	0.07	1.57	0.34	0.16	0.78
SHL50	16	0.12	0.00	0.03	5.15	3.18	0.04	0.01	0.07	1.30	0.34	0.14	0.87
SHL51	14	0.13	0.00	0.03	5.22	3.58	0.12	0.01	0.09	1.97	0.44	0.17	1.32
SHL52	9	0.09	0.00	0.03	4.57	4.32	0.02	0.06	0.13	1.72	0.52	0.21	1.54
SHL53	6	0.09	0.00	0.02	4.91	4.83	0.02	0.03	0.12	1.38	0.50	0.23	2.09
SHL54	6	0.12	0.00	0.04		4.85	0.02		0.12	1.31	0.48	0.25	1.76
SHL55	12	0.13	0.00	0.02		0.00	0.04		0.00	0.83	0.31	0.15	0.73
mean		0.19	0.00	0.10	4.07	3.72	0.05	0.02	0.10	1.14	0.66	0.38	1.09
std dev		0.09	0.01	0.39	1.27	1.31	0.04	0.02	0.04	1.31	0.38	0.25	0.40
n		55	55	55	43	55	55	42	55	55	55	55	52

Table 2. Characteristics of shelf sediments in the far northern Great Barrier Reef

Station	Depth m	Offshore km	% gravel	% sand w/w	% mud	clay % of mud fraction	$CaCO_3$ % of mud fraction	%N w/w	%P w/w	Gravel composition (% of particles) % mollusc	% echino.	% foram.	% Halimeda	% terrigen.
Lloyd Bay transect														
3	35	33	95.2	3.1	1.8	35.6	97.7	0.031	0.028	1.4	0.0	0.6	96.2	0.0
4	16	28	45.6	31.6	22.8	26.5	83.2	0.048	0.025	2.5	0.0	0.7	96.3	0.0
5	30	19	6.6	35.6	57.8	7.9	65.2	0.069	0.040	49.4	34.5	1.5	3.4	0.0
6	16	10	2.6	21.0	76.4	8.3	39.7	0.089	0.034	75.9	22.6	0.0	0.0	0.0
7	7	7	3.4	9.8	86.8	6.9	32.1	0.110	0.031	92.6	6.5	0.0	0.0	0.0
Lloyd Bay transect														
8	7	3	7.6	20.8	71.6	10.2	33.6	0.097	0.016	87.9	9.5	0.5	0.0	0.5
9	29	10	8.5	55.1	36.4	12.5	30.5	0.074	0.023	44.1	10.0	0.4	0.0	39.7
10	38	14	3.6	49.1	47.3	10.3	51.2	0.078	0.032	73.3	14.4	0.0	0.0	10.7
11	44	24	4.9	47.6	47.5	7.8	68.1	0.066	0.037	56.7	8.5	1.1	28.3	0.0
12	43	34	35.4	59.0	5.6	57.1	93.1	0.037	0.031	5.5	0.0	8.5	82.9	0.0
16	38	59	39.3	59.3	1.4	22.0	97.1	0.063	0.025	3.1	0.0	20.7	73.6	0.0
17	30	46	64.6	35.1	0.3	40.9	94.7	0.051	0.034	23.1	0.4	20.7	28.2	0.0
Shelburne Bay transect														
28	32	111	53.3	46.1	0.6	35.3	93.8	0.029	0.028	5.7	0.0	6.5	79.0	0.0
29	31	93	22.7	76.5	0.8	48.6	87.6	0.021	0.025	23.0	0.4	4.9	64.0	0.0
30	18	76	18.7	80.2	1.1	32.9	82.6	0.041	0.030	19.3	0.2	1.6	66.4	0.0
31	27	51	8.4	65.4	26.2	15.0	75.8	0.052	0.040	74.9	17.6	1.7	0.0	0.0
32	27	30	2.1	31.2	66.7	7.7	62.2	0.074	0.033	70.8	27.0	0.0	0.0	0.0
33	10	2	2.5	88.0	9.5	26.2	40.9	0.037	0.010	69.7	10.2	13.6	0.3	1.5

Table 2 continued

Station	Depth m	Offshore km	% gravel	% sand w/w	% mud	clay % of mud fraction	$CaCo_3$ % of mud fraction	%N w/w	%P w/w	Gravel composition (% of particles) % mollusc	% echino.	% foram.	% Halimeda	% terrigen.
Shelburne Bay transect														
34	7	7	3.1	78.7	18.2	15.1	43.7	0.038	0.017	69.0	9.3	16.8	0.0	0.8
35	18	6	2.4	76.3	21.3	15.3	43.0	0.041	0.018	76.9	14.7	0.8	0.2	2.7
36	36	8	5.5	63.1	31.4	11.8	47.3	0.056	0.029	63.8	22.7	0.0	0.0	5.2
37	38	15	19.0	53.7	27.3	10.2	69.5	0.065	0.042	74.7	6.4	0.5	0.2	1.2
38	20	45	28.7	68.6	2.7	41.3	94.3	0.157	0.030	4.3	0.2	1.1	93.2	0.0
39	20	59	66.2	24.8	9.0	17.6	96.6	0.031	0.028	6.2	0.2	1.2	85.9	0.0
Temple Bay transect														
42	22	73	36.2	52.7	11.0	48.8	93.2	0.041	0.020	2.5	0.0	1.4	94.2	0.0
43	45	44	8.7	65.6	25.8	16.7	76.3	0.057	0.041	71.3	11.9	0.0	0.0	0.8
44	27	28	7.3	29.0	63.7	7.5	42.0	0.088	0.033	89.4	7.2	0.0	0.0	0.0
45	10	5	2.9	16.1	81.0	8.9	32.6	0.098	0.037	76.7	18.7	0.0	0.0	0.0
Temple Bay - Inshore														
46	11		4.6	16.8	78.6	7.7	35.9	0.094	0.035	77.0	17.2	0.3	0.0	0.5
47	7		7.5	74.6	17.9	18.1	30.0	0.055	0.022	62.7	17.9	2.0	0.7	8.5
48	8		3.3	73.6	23.1	12.4	32.6	0.070	0.026	44.1	13.6	1.3	0.0	37.8
49	18		5.0	25.0	70.0	10.2	38.8	0.090	0.036	74.6	14.8	0.0	0.0	0.0
50	17		4.6	23.4	72.0	9.1	44.9	0.090	0.036	79.7	17.6	0.0	0.0	0.0
51	15		5.8	53.5	40.7	12.4	36.6	0.068	0.031	81.9	14.1	0.0	0.0	2.5
52	10		14.6	34.5	50.9	10.6	39.6	0.081	0.033	84.4	14.1	0.2	0.0	0.0
53	7		8.2	50.0	41.8	10.9	34.9	0.077	0.028	84.7	8.8	5.1	0.0	0.5
54	7		13.7	66.6	19.7	16.0	32.6	0.068	0.026	72.9	5.0	4.3	0.1	15.2

Table 3. Depth-weighted mean water column concentrations for depths < 50 m at Coral Sea stations, February 1990

Station	Depth	NH_4	NO_2	NO_3	DON	PON	PO_4	DOP	POP	Si	Chl	Pha	S.S.
	m					µmol/l					µg/l	µg/l	mg/l
SHL02	300	0.29	0.05	0.18	4.3	3.2	0.09	0	0.05	0.78	0.28	0.25	0.70
SHL13	300	0.18	0	0.05	4.5	3.5	0.08	0	0.09	0.02	1.17	0.59	0.74
SHL14	57	0.25	0	0.34	4.4	4.4	0.06	0.05	0.10	0.10	0.90	0.52	
SHL21	40	0.20	0	0.06	5.7	3.6	0.06	0.01	0.09	0.29	1.42	0.61	0.81
SHL22	40	0.17	0	0.04	5.0	4.0	0.05	0.01	0.09	0.13	1.17	1.03	1.08
SHL23	40	0.20	0	0.02	3.4	4.1	0.06	0.01	0.09	0.04	1.30	0.58	0.75
SHL24	40	0.23	0	0.01	3.3	1.0	0.06	0.03	0.02	1.08	0.20	0.10	0.41
SHL25	40	0.22	0	0.02	3.6	0.8	0.06	0.01	0.02	0.91	0.14	0.08	0.43
SHL26	40	0.16	0	0.02	3.9	1.6	0.05	0.02	0.03	1.04	0.14	0.10	0.46
SHL27	300	0.17	0.01	0.01	3.9	4.6	0.04	0.03	0.12	0	0.85	0.56	1.13
SHL40	300	0.18	0.02	0.02		4.0	0.05		0.11	0	0.89	0.52	0.75
SHL41	300	0.17	0.01	0.10		5.0	0.05		0.11	0.10	1.19	0.79	0.69
mean		0.20	0.01	0.07	4.2	3.3	0.06	0.02	0.08	0.37	0.8	0.48	0.72
std dev		0.039	0.015	0.097	0.74	1.41	0.014	0.016	0.037	0.440	0.485	0.294	0.236
n		12	12	12	10	12	12	10	12	12	12	12	11

Table 4. Depth weighted mean water column concentrations at inshore stations (depth < 20 m), February 1990

Station	Depth	NH_4	NO_2	NO_3	DON	PON	PO_4	DOP	POP	Si	Chl	Pha	S.S.
	m					µmol/l					µg/l	µg/l	mg/l
SHL06	16	0.16	0	0.05	3.5	4.2	0.04	0.03	0.09	1.46	0.34	0.22	1.15
SHL07	6	0.17	0	0.04	4.4	2.8	0.04	0.02	0.1	7.87	0.3	0.13	1.55
SHL08	8	0.14	0	0.05	3.4	4.2	0.04	0.02	0.13	2.59	0.42	0.22	1.8
SHL33	10	0.30	0	0.03	2.6	6.4	0.03	0.04	0.15	0.22	0.63	0.31	1.9
SHL34	6	0.45	0	0.04	2.6	7.0	0.03	0.01	0.16	0	0.57	0.37	2.24
SHL35	16	0.50	0.01	0.02	1.7	4.2	0.05		0.13	0.55	0.48	0.18	1.26
SHL36	36	0.19	0	0.03		3.3	0.05		0.1	0.97	0.58	0.21	0.96
SHL45	9	0.09	0	0.04		4.1	0.04		0.11	2.28	0.3	0.14	1.41
SHL46	10	0.14	0	0.04	6.6	6.2	0.04	0.04	0.12	3.03	0.49	0.28	1.23
SHL47	7	0.15	0	0.04	5.4	4.1	0.04	0.02	0.09	2.84	0.43	0.2	0.87
SHL48	6	0.10	0	0.05	5.4	4.0	0.05	0.03	0.08	3.41	0.41	0.17	0.99
SHL49	16	0.11	0	0.04	5.7	2.4	0.03	0.04	0.07	1.57	0.34	0.16	0.78
SHL50	16	0.12	0	0.03	5.2	3.2	0.04	0.01	0.07	1.3	0.34	0.14	0.87
SHL51	14	0.13	0	0.03	5.2	3.6	0.12	0.01	0.09	1.97	0.44	0.17	1.32
SHL52	9	0.09	0	0.03	4.6	4.3	0.02	0.06	0.13	1.72	0.52	0.21	1.54
SHL53	6	0.09	0	0.02	4.9	4.8	0.02	0.03	0.12	1.38	0.5	0.23	2.09
SHL54	6	0.12	0	0.04		4.9	0.02		0.12	1.31	0.48	0.25	1.76
mean		0.18	0	0.04	4.4	4.3	0.04	0.03	0.11	2.03	0.45	0.21	1.4
std dev		0.122	0.002	0.009	1.4	1.2	0.023	0.015	0.026	1.783	0.100	0.064	0.446
n		17	17	17	14	17	17	13	17	17	17	17	17

Table 5. Depth-weighted mean water column concentrations at outer shelf stations (depth > 20 m), February 1990

Station	Depth	NH_4	NO_2	NO_3	DON	PON	PO_4	DOP	POP	Si	Chl	Pha	S.S.
	m					µmol/l					µg/l	µg/l	mg/l
SHL03	35	0.15	0	0.06	3.3	3.8	0.06	0.02	0.08	0.63	0.57	0.36	0.88
SHL04	16	0.19	0	0.05	3.2	2.2	0.05	0	0.09	1.54	0.27	0.27	0.93
SHL05	28	0.18	0	0.04	3.9	4.6	0.05	0	0.09	2.34	0.70	0.42	1.40
SHL09	28	0.12	0	0.04	3.4	3.9	0.04	0.01	0.09	2.99	0.59	0.37	1.48
SHL10	38	0.18	0	0.03	3.5	4.0	0.05	0.01	0.09	1.50	0.46	0.27	1.16
SHL11	44	0.21	0	0.04	3.4	2.9	0.06	0.01	0.11	2.23	1.05	0.60	0.89
SHL12	43	0.18	0	0.18	3.7	3.2	0.07	0.01	0.10	2.43	1.07	0.55	
SHL15	21	0.42	0	0	4.7	3.4	0.02	0.06	0.10	0.01	0.65	0.43	0.96
SHL16	28	0.41	0.01	0.10	4.7	2.6	0.06	0.02	0.07	0.21	0.85	0.48	0.76
SHL17	40	0.26	0	0.02	4.9	4.6	0.04	0.03	0.09	0.12	0.51	0.30	1.08
SHL18	40	0.30	0	0.02	5.0	2.4	0.04	0.02	0.09	0.02	0.66	0.40	0.88
SHL19	32	0.28	0	0.03	5.0	2.4	0.05	0.02	0.07	0.19	0.45	0.33	0.88
SHL20	34	0.19	0	0.08	5.3	3.5	0.05	0.06	0.09	0.21	0.82	0.45	0.84
SHL28	34	0.18	0.05	2.91	1.1	2.9	0.30	0	0.08	0.76	1.45	0.96	0.84
SHL29	34	0.16	0.01	0.02	2.2	5.2	0.07	0	0.12	0.04	1.71	1.18	1.13
SHL30	18	0.14	0.02	0.01	2.6	5.8	0.05	0	0.13	0.39	0.79	0.64	1.67
SHL31	300	0.15	0	0.03	2.4	3.2	0.04	0	0.11	1.26	0.51	0.28	1.29
SHL32	26	0.15	0	0.01	2.7	3.0	0.04	0.03	0.09	1.02	0.46	0.18	1.04
SHL36	36	0.19	0	0.03		3.3	0.05		0.10	0.97	0.58	0.21	0.96
SHL37	34	0.18	0	0.05		3.3	0.05		0.10	0.78	0.77	0.38	1.34
SHL38	18	0.15	0	0.03		3.8	0.02		0.12	0.21	0.89	0.46	0.96
SHL39	18	0.21	0	0.02		3.8	0.06		0.11	0.14	0.98	0.51	0.96
SHL42	20	0.08	0	0.06		5.4	0.06		0.12	0.44	1.59	0.88	0.77
SHL43	44	0.09	0	0.04		3.9	0.03		0.09	0.54	0.24	0.14	0.99
SHL44	27	0.09	0	0.05		2.9	0.03		0.10	1.62	0.30	0.18	1.24
mean		0.19	0	0.16	3.6	3.6	0.06	0.02	0.10	0.90	0.76	0.45	1.06
std dev		0.085	0.011	0.574	1.2	1.0	0.052	0.019	0.015	0.869	0.386	0.25	0.238
n		25	25	25	18	25	25	18	25	25	25	25	24

Table 6. Depth-weighted mean water column concentrations at shelf stations on the two northern transects, February 1990

Station	Depth	NH_4	NO_2	NO_3	DON	PON	PO_4	DOP	POP	Si	Chl	Pha	S.S.
	m					µmol/l					µg/l	µg/l	mg/l
SHL28	34	0.18	0.05	2.91	1.1	2.9	0.30	0	0.08	0.76	1.45	0.96	0.84
SHL29	34	0.16	0.01	0.02	2.2	5.2	0.07	0	0.12	0.04	1.71	1.18	1.13
SHL30	18	0.14	0.02	0.01	2.6	5.8	0.05	0	0.13	0.39	0.79	0.64	1.67
SHL31	300	0.15	0	0.03	2.4	3.2	0.04	0	0.11	1.26	0.51	0.28	1.29
SHL32	26	0.15	0	0.01	2.7	3.0	0.04	0.03	0.09	1.02	0.46	0.18	1.04
SHL33	10	0.30	0	0.03	2.6	6.4	0.03	0.04	0.15	0.22	0.63	0.31	1.90
SHL34	6	0.45	0	0.04	2.6	7.0	0.03	0.01	0.16	0	0.57	0.37	2.24
SHL35	16	0.50	0.01	0.02	1.7	4.2	0.05		0.13	0.55	0.48	0.18	1.26
SHL36	36	0.19	0	0.03		3.3	0.05		0.10	0.97	0.58	0.21	0.96
SHL37	34	0.18	0	0.05		3.3	0.05		0.10	0.78	0.77	0.38	1.34
SHL38	18	0.15	0	0.03		3.8	0.02		0.12	0.21	0.89	0.46	0.96
SHL39	18	0.21	0	0.02		3.8	0.06		0.11	0.14	0.98	0.51	0.96
mean		0.23	0.01	0.27	2.2	4.3	0.07	0.01	0.12	0.53	0.82	0.47	1.30
std dev		0.123	0.015	0.833	0.6	1.4	0.0775	0.017	0.023	0.424	0.395	0.315	0.431
n		12	12	12	8	12	12	7	12	12	12	12	12

Table 7. Depth-weighted mean water column concentrations at stations on the southern transects, February 1990

Station	Depth	NH_4	NO_2	NO_3	DON	PON	PO_4	DOP	POP	Si	Chl	Pha	S.S.
	m					µmol/l					µg/l	µg/l	mg/l
SHL03	35	0.15	0	0.06	3.3	3.8	0.06	0.02	0.08	0.63	0.57	0.36	0.88
SHL04	16	0.19	0	0.05	3.2	2.2	0.05	0	0.09	1.54	0.27	0.27	0.93
SHL05	28	0.18	0	0.04	3.9	4.6	0.05	0	0.09	2.34	0.70	0.42	1.40
SHL06	16	0.16	0	0.05	3.5	4.2	0.04	0.03	0.09	1.46	0.34	0.22	1.15
SHL07	6	0.17	0	0.04	4.4	2.8	0.04	0.02	0.10	7.87	0.30	0.13	1.55
SHL08	8	0.14	0	0.05	3.4	4.2	0.04	0.02	0.13	2.59	0.42	0.22	1.80
SHL09	28	0.12	0	0.04	3.4	3.9	0.04	0.01	0.09	2.99	0.59	0.37	1.48
SHL10	38	0.18	0	0.03	3.5	4.0	0.05	0.01	0.09	1.50	0.46	0.27	1.16
SHL11	44	0.21	0	0.04	3.4	2.9	0.06	0.01	0.11	2.23	1.05	0.60	0.89
SHL12	43	0.18	0	0.18	3.7	3.2	0.07	0.01	0.10	2.43	1.07	0.55	
SHL15	21	0.42	0	0	4.7	3.4	0.02	0.06	0.10	0.01	0.65	0.43	0.96
mean		0.19	0.00	0.05	3.7	3.6	0.05	0.02	0.10	2.33	0.58	0.35	1.22
std dev		0.080	0.000	0.045	0.5	0.7	0.013	0.017	0.013	2.039	0.274	0.145	0.321
n		11	11	11	11	11	11	11	11	11	11	11	10

Table 8. Depth-weighted mean water column concentrations at stations within Temple Bay, February 1990

Station	Depth	NH_4	NO_2	NO_3	DON	PON	PO_4	DOP	POP	Si	Chl	Pha	S.S.
	m					µmol/l					µg/l	µg/l	µg/l
SHL45	9	0.09	0	0.04		4.1	0.04		0.11	2.28	0.30	0:14	1.41
SHL46	10	0.14	0	0.04	6.6	6.2	0.04	0.04	0.12	3.03	0.49	0.28	1.23
SHL47	7	0.15	0	0.04	5.4	4.1	0.04	0.02	0.09	2.84	0.43	0.20	0.87
SHL48	6	0.10	0	0.05	5.4	4.0	0.05	0.03	0.08	3.41	0.41	0.17	0.99
SHL49	16	0.11	0	0.04	5.7	2.4	0.03	0.04	0.07	1.57	0.34	0.16	0.78
SHL50	16	0.12	0	0.03	5.2	3.2	0.04	0.01	0.07	1.30	0.34	0.14	0.87
SHL51	14	0.13	0	0.03	5.2	3.6	0.12	0.01	0.09	1.97	0.44	0.17	1.32
SHL52	9	0.09	0	0.03	4.6	4.3	0.02	0.06	0.13	1.72	0.52	0.21	1.54
SHL53	6	0.09	0	0.02	4.9	4.8	0.02	0.03	0.12	1.38	0.50	0.23	2.09
SHL54	6	0.12	0	0.04		4.9	0.02		0.12	1.31	0.48	0.25	1.76
mean		0.11	0	0.036	5.4	4.1	0.04	0.03	0.10	2.08	0.43	0.20	1.29
std dev		0.02	0	0.008	0.6	1.0	0.029	0.017	0.023	0.773	0.076	0.047	0.428
n		10	10	10	8	10	10	8	10	10	10	10	10

Table 9. Depth-weighted mean water column concentrations at inshore stations in Shelburne and Lloyd Bays, February 1990

Station	Depth m	NH_4	NO_2	NO_3	DON	PON µmol/l	PO_4	DOP	POP	Si	Chl µg/l	Pha µg/l	S.S. mg/l
SHL06	16	0.16	0	0.05	3.5	4.2	0.04	0.03	0.09	1.46	0.34	0.22	1.15
SHL07	6	0.17	0	0.04	4.4	2.8	0.04	0.02	0.10	7.87	0.30	0.13	1.55
SHL08	8	0.14	0	0.05	3.4	4.2	0.04	0.02	0.13	2.59	0.42	0.22	1.80
SHL33	10	0.30	0	0.03	2.6	6.4	0.03	0.04	0.15	0.22	0.63	0.31	1.90
SHL34	6	0.45	0	0.04	2.6	7.0	0.03	0.01	0.16	0	0.57	0.37	2.24
SHL35	16	0.50	0.01	0.02	1.7	4.2	0.05		0.13	0.55	0.48	0.18	1.26
SHL36	36	0.19	0	0.03		3.3	0.05		0.10	0.97	0.58	0.21	0.96
mean		0.27	0	0.04	3.0	4.6	0.04	0.02	0.12	1.95	0.47	0.23	1.55
std dev		0.148	0.004	0.011	0.9	1.5	0.008	0.011	0.027	2.751	0.126	0.081	0.457
n		7	7	7	6	7	7	5	7	7	7	7	7

Table 10. Means and standard deviations of depth-weighted mean mixed-layer nutrient and chlorophyll concentrations in the Torres Strait and the Ribbon Reefs

	NH_4	NO_2	NO_3	DON µmol/l	PO_4	DOP	$Si(OH)_4$	Chlorophyll µg/l
Torres Strait and far northern GBR - November/December 1979								
mean	0.58	0.05	0.33*	4.20	0.1*	0.13	3.36	0.41
std. dev	0.34	0.04	0.13*	1.08	0.03*	0.05	1.82	0.22
no. stations	19	20	19*	19	19*	19	20	20
Ribbon Reefs (Cooktown - Lizard Island - Princess Charolette Bay) - October 1987								
mean	0.02	< 0.01	0.06		0.01		0.06	0.31
std. dev	0.03	< 0.01	0.09		0.02		0.07	0.13
no. stations	63	63	63		63		63	52

* One Torres Strait Station (10) excluded: mean NO_3=4.93 µM, mean PO_4=2.71 µM

The degree of horizontal spatial variability of individual nutrient species and water column parameters within the defined sub-areas was assessed in a pair-wise comparison between sub-areas using one-way analyses of variance (Sokal and Rohlf 1981). Because of the complex bathymetry and current patterns within the region and because transects were only occupied once, a more detailed spatial analysis would be unwarranted. As mixed-layer concentrations of all parameters fluctuated within relatively small ranges and individual values were smoothed by the depth weighting process, the data were not transformed. One outlying nitrate water column mean (station 34) was deleted from the working data set. Results of the pairwise comparisons are given in table 11.

Coherent spatial distributions of nutrient species within the study area are not readily apparent. Statistically significant differences between mean concentrations of individual nutrient species were found between geographically defined groups of stations. In most cases, these differences between group means are relatively small and the apparent spatial gradients do not apply to all species of a particular nutrient element. For most dissolved nutrient species, standard deviations for group means are of similar order to analytical precision of individual analyses. In the absence of more detailed information on circulation and nutrient process rates within the area, it would appear that spatial trends in concentrations of nutrients were very weak, if they existed at all, during the period of the survey.

Table 11. Pairwise comparisons (one-way ANOVA) between depth-weighted mean water column nutrient concentrations in the far northern Great Barrier Reef and adjoining waters. Values shows are probabilities < 0.1 for incorrect rejection of the hypothesis that the means of the grouped stations are equal. Gaps indicate the lack of a significant difference (p > 0.1)

		NH_4	NO_2	NO_3	DON	PON	PO_4	DOP	POP	Si	Chl a	S.S
	vs.											
Coral Sea	Inshore (< 20 m)		0.001			0.050	0.004		0.009	0.004	0.006	<.001
Coral Sea	Outer-shelf (> 20 m)	0.004							0.020	0.055		0.001
Inshore (< 20 m)	Outer-shelf (> 20 m)					0.037		0.097	0.069	0.010	0.002	0.003
Temple Bay	Outer bays inshore	0.004	0.010	0.029	<.001				0.079			
North transects	Southern transects				<.001				0.023	0.007		
North transects	Torres Strait	0.002	0.001					<.001		<.001	0.001	
All Shelburne	Torres Strait	<.001	<.001	0.014			0.036	<.001		<.001	0.009	
All Shelburne	Ribbon Reefs	<.001	0.067				<.001			<.001	<.001	

Some comparisons between groups of stations are worthy of note, however. Not surprisingly, suspended solids concentrations at shelf stations were significantly higher than in the Coral Sea. Chlorophyll concentrations at both inshore and Coral Sea stations were higher than in the Coral Sea. Chlorophyll concentrations at both inshore and Coral Sea stations were higher than on the outer shelf. Higher concentrations of chlorophyll might be expected inshore. The higher Coral Sea chlorophyll concentrations, measured at stations immediately outside of the reef, appear due to exchange through gaps between shelfbreak reefs (Wolanski et al. 1988) which pulls sub-thermocline nutrients into the surface mixed layer. Alternative mechanisms for nutrient mixing in the reef-ocean boundary include geostrophically forced transport through reef gaps (Nof and Middleton 1989) or tidal pumping due to internal waves (Thompson and Wolanski 1984).

Mean water column concentrations of dissolved nutrients within the study area were generally lower than concentrations of the same species within the Torres Strait (sampled in November 1979) and higher than concentrations in the Lizard Island-Ribbon Reef region (sampled in October 1987; table 10). Chlorophyll concentrations in the study area were, on the whole, higher than to the north and south. Inferences about a north-south gradient of nutrient levels within the far northern Great Barrier Reef, however, should be tempered with caution. Subtle, but significant evolution has occurred since 1979 with regard to the handling and analysis of dissolved nutrient samples by the Australian Institute of Marine Science Laboratory Services group, which generally has led to a drop in measured concentrations as contamination sources have been controlled. The Ribbon Reef nutrient samples were analysed at sea directly after sample collection, which is likely to have reduced sources of contamination arising from sample storage. These systematic differences are believed to be small in absolute magnitude, but nonetheless, are of similar order to the apparent differences between data sets.

Primary production rates in the study area (table 12) were high relative to areal rates measured in the central Great Barrier Reef (Furnas and Mitchell 1987, 1990). The bulk of standing crop and primary production was attributable to picoplankton (> 2 µm size fraction). Production rates within the study area were higher than rates measured within the Great Barrier Reef

lagoon immediately prior to and following the sampling period (SHL001 - 15.5°S, SHL005 - 14.5°S). The highest areal production rates, surprisingly, were measured at the two production stations (SHL027 - Raine Island, SHL041 - Wreck Bay) occupied outside of the reef. The high production rates at these stations appear due to three factors: higher phytoplankton standing crops (chlorophyll concentrations) at these stations, deeper euphotic zones at offshore stations (75-90 m vs. 15-35 m) and occurrence of high production rates to deeper depths within the euphotic zone. Production rates at these two stations were the highest non-cyclone affected production rates measured to date by the Biological Oceanography group in Great Barrier Reef waters. Lower areal production rates in inshore waters largely reflect the shallower depth of the water column (euphotic zone). At all stations, appreciable levels of irradiance penetrated to the sea floor (figures 3-6). In no case did near-bottom scalar irradiance at near-shore stations fall below 20% of surface irradiance during the cruise.

Table 12. Chlorophyll standing crops (mg/m^2) and mid-day hourly water column primary production rates ($mg\ C/m^2/hr$) in the far northern Great Barrier Reef and adjacent waters of the Coral Sea. Mean chlorophyll concentrations will differ from hydrographic stations due to different sampling depths used. Daily primary production can be estimated by multiplying the mid-day hourly rates by eight.

Station		Total	> 10 µm fraction	10-2 µm fraction	< 2 µm fraction
Shl 01 (GBR lagoon ca. 15°S)					
	Chlorophyll	9.5	1.8	1.2	6.5
	Production	89.6	3.5	8.8	78.9
Shl 03	Chlorophyll	18.3	7.8	1.6	9.0
	Production	381.3	61.1	44.2	276.0
Shl 09	Chlorophyll	15.1	7.5	3.3	4.2
	Production	215.5			
Shl 16	Chlorophyll	21.0	9.2	8.8	2.9
	Production	185.6			
Shl 19	Chlorophyll	19.3	6.3	6.7	6.3
	Production	284.7	40.0	36.4	208.3
Shl 27	Chlorophyll	65.9			15.8
	Production	1001.9	129.9	157.2	714.8
Shl 35	Chlorophyll	7.1	2.1	0.9	4.1
	Production	133.6	9.9	6.2	117.5
Shl 41	Chlorophyll				
	Production	957.5	40.8	206.5	710.3
Shl 55 (GBR lagoon ca. 14°S)					
	Chlorophyll	3.7	2.7	0.3	0.8
	Production	75.0	5.5	5.3	64.2

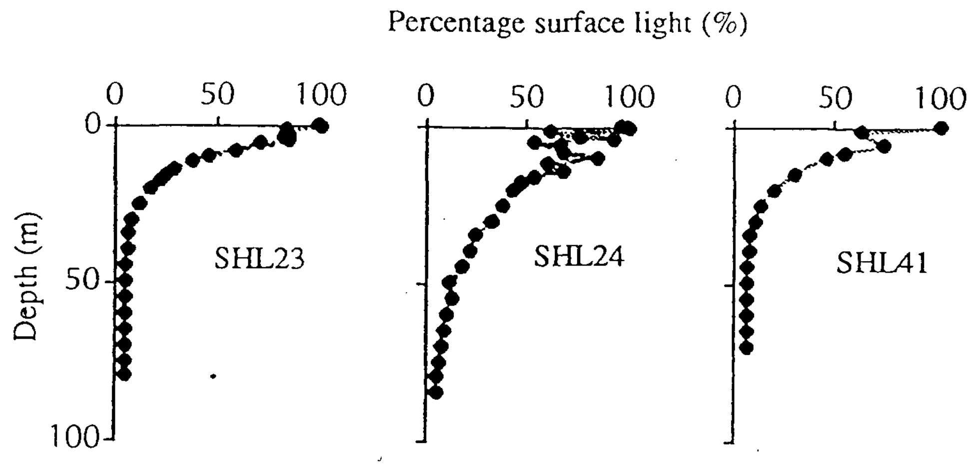

Figure 6. Light profiles from stations, 50-100 m depth

Near bottom irradiance levels at mid- and outer-shelf stations ranged from > 25 to < 5 percent of surface irradiance. In all cases, readily measurable light was reaching the bottom and accounted for the growth of benthic algae.

Zooplankton standing crop (mg m^{-3} dry weight) exhibited a distinct inshore (mean = 26.3) - outer shelf (18.7) - Coral Sea (8.9) gradient. No significant north-south or Temple Bay-other bays differences were observed. A taxonomic analysis of the populations collected has not been made.

Not surprisingly, clear onshore-offshore gradients were observed in sediment grain size and particle characteristics (figure 7). Nearshore sediments had higher contents of terrigenous minerals and lower carbonate contents than offshore sediments. The carbonate content of sediments ranged from > 90 percent by weight at the shelfbreak to 30-40 percent at nearshore stations. The gravel sizer fraction dominated surficial sediments at outer-shelf stations. At inshore stations, this fraction was largely comprised of mollusc fragments, while degraded fragments of the calcareous green alga, *Halimeda*, were more important on the outer shelf. In contrast, muds were relatively more important at nearshore sediments.

The phosphorus content of sediments (figure 8 Top) generally peaked at mid-shelf stations. The lower phosphorus content of inshore sediments was probably due to the lower carbonate content and hence phosphorus binding capacity of the sediments. With one exception, the nitrogen content of sediments declined with distance from shore. The high nitrogen content of that one sample was most likely due to the inadvertent inclusion of an organism in the material analysed. Otherwise, differences between transects were slight, if any.

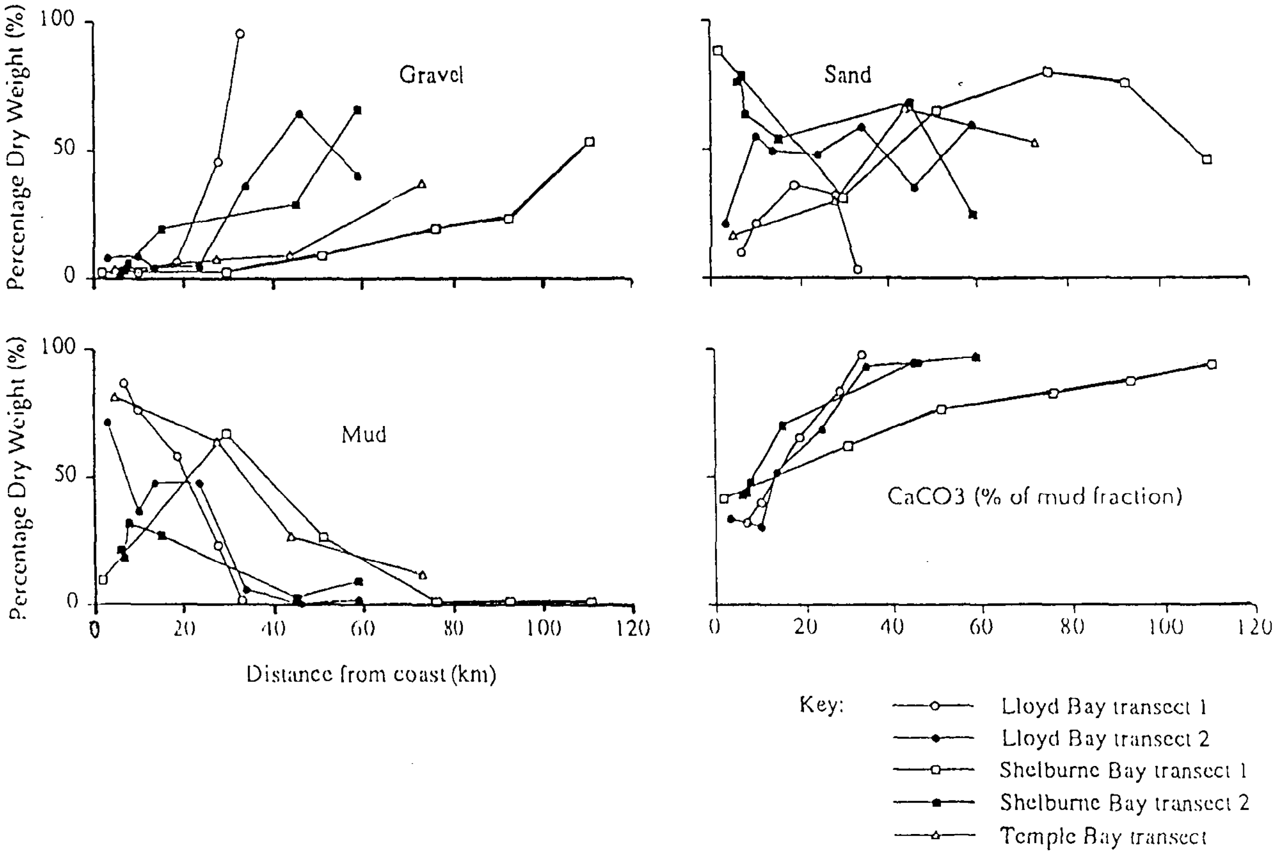

Figure 7. Grain size characteristics and $CaCO_3$ (as % of mud fraction) of shelf sediments in relation to distance from coast

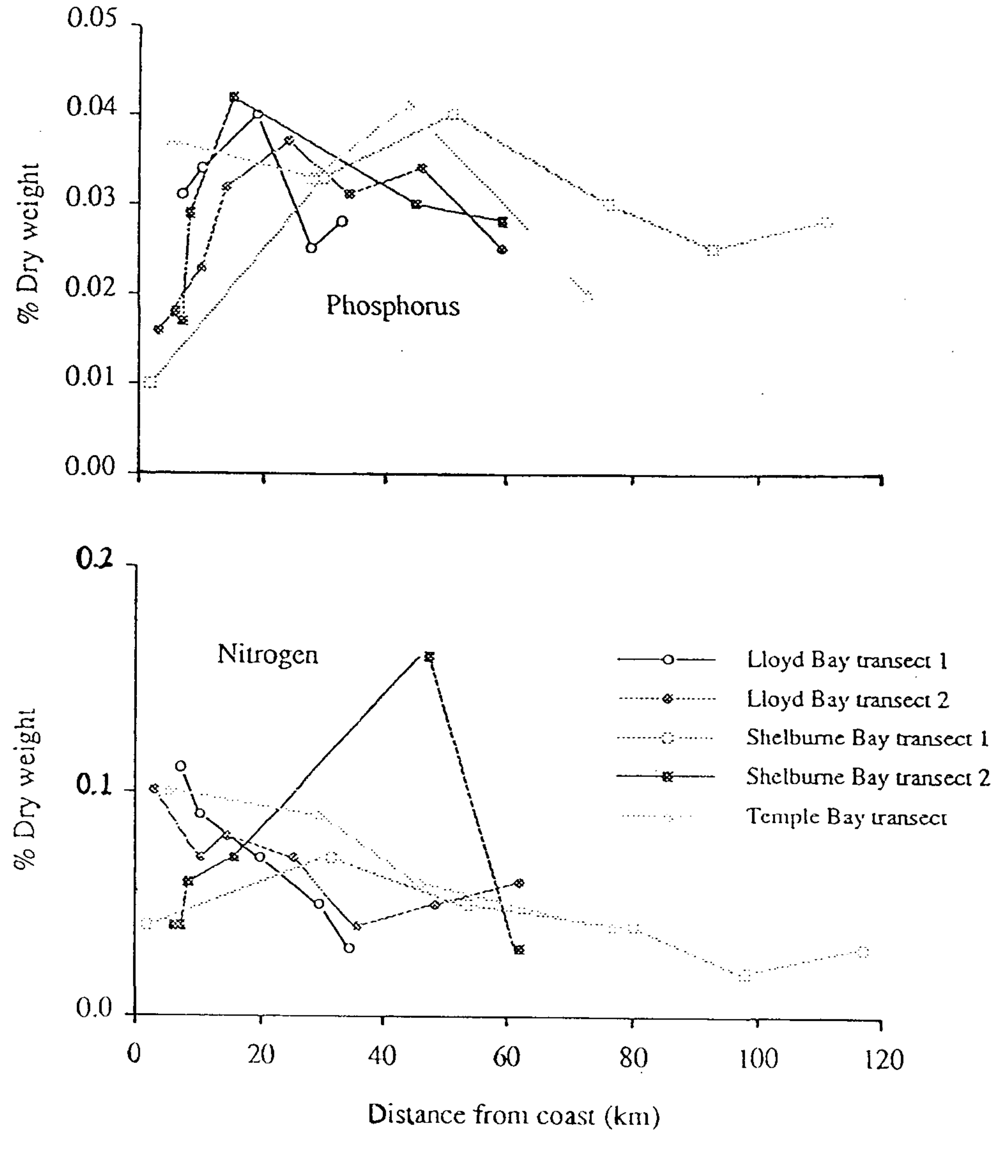

Figure 8. Nitrogen and phosphorus content of surficial sediments in relation to distance from coast