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Spatial variability of phytoplankton specific growth rate in the coastal waters.

by

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Summary

Factors responsible for the spatial structure of phytoplankton turnover (*P/B*) were examined in a coastal environment. During strong winds, the wind stress accounted for all the variance in the spatial structure of *P/B*. In calmer periods, biological influences were manifested.

Summaire

On a examiné, dans un milieu côtier, les facteurs responsables de la structure spatiale du taux de renouvellement (*P/B*) du phytoplancton. Pendant les périodes de vent fort, la force du vent expliquait toute la variance dans la structure spatiale de *P/B*. Dans les périodes plus calmes, les influences biologiques étaient manifestes.

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In a previous study (Platt, Dickie and Trites, 1970) we have examined the variance between-stations of phytoplankton biomass estimates (using chlorophyll as an index) in coastal waters. We report here some recent results on environmental factors correlated with the variance between-stations in the productivity:biomass (*P/B*) ratio for phytoplankton in the same coastal area, St. Margaret's Bay, Nova Scotia.

Full experimental details are given in Therriault (1977). Briefly, six stations chosen randomly to lie within an area of a few square kilometers were occupied on thirty occasions throughout the year. On each occasion, replicate samples were taken for ^{14}C uptake, chlorophyll *a* and phaeopigment concentration, C/N ratio of the particulate matter, NO_3, SiO_3, NH_3 , PO_4. The design was such that the between-station component of the variance of each quantity measured could be separated by analysis of variance. Wind speed and direction were measured continuously in two sites on the shore of the Bay, and averaged every hour.

Figure 1 shows the daily means of wind stress and direction together with the between-station variance and mean value of *P/B* for each sampling day. Appreciable seasonal differences in wind stress can be seen, with generally lower values during summer and a short period in the winter: during these calm periods, mean *P/B* ratios were generally higher.

In Table 1, the spatial components of the variances of *P/B* and its biological and chemical covariates are listed. Significant spatial inhomogeneities could be detected at all times of the year for most quantities measured. No consistent relationships could be found between the spatial structure of the *P/B* ratio to those of its covariates.

The relative importance of the different covariates has been evaluated by stepwise regression using the spatial variance in *P/B* as dependent variable. For this analysis, the results have been separated into those corresponding to winds greater than 5 ms^{-1} (average of 72 h prior to sampling) and those corresponding to winds less than 5 ms^{-1}. This threshold was chosen as that corresponding to the wind stress above which increasing wind stress has a measurable effect on near surface turbulence (Kullenberg, 1971, 1972).

Table 2a shows the result of regression analysis for all data, pooled regardless of wind speed. Several factors, of roughly equal importance, combined to explain the observed spatial variance of *P/B*. These were wind stress (accounted for 13% of variance in *P/B*), variance of C/N ratio (14%), and NH_4(13%). In all, 64% of the variance in *P/B* could be accounted for.

Differences in C/N are interpreted as reflecting differences in chemical composition of phytoplankton due to local differences in species composition or in the physiological state of the population (Antia et al., 1963; Strickland et al., 1969; Caperon and Meyer, 1972). Differences in NH_3 are interpreted as reflecting variations in grazing activity of zooplankton.

Table 2b is for the regression analysis using data for winds <5 ms^{-1}. Our previous work (Platt and Filion, 1973) has suggested that calm periods would be more conducive to the finding of stronger horizontal gradients in species-related characteristics of the phytoplankton community. In Table 2b we see that spatial variances in C/N ratio alone could account for 43% of the spatial structure in *P/B*. Phaeopigments (20%) are also important during calm periods. These are interpreted as another index of grazing activity. In all, 85% of the variance in *P/B* could be accounted for.

Table 2c is for winds $\geq$5 ms^{-1}. Here, only one factor, wind stress is significant; accounting for 41% of the variance in *P/B*. In a non-linear regression, Table 2d, reflecting the non-linear nature of the relationship between wind stress and near-surface turbulence, 80% of the variance in *P/B* could be explained. Periods of high winds leading to stronger turbulent mixing are thus responsible for damping out biological differences between stations such that phytoplankton turnover at adjacent stations becomes more similar.

References

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Table 1. Comparison of the between-station components of the variance for the various biological and chemical factors measured in St. Margaret's Bay.

Day	Day/Month	*P/B*	Phaeo.	C/N	PO_4^{3-}	NO_3^-	SiO_3^{2-}	NH_3
1	(14/01)	0.0569	3.009	0.331	0.437	1.404	0.115	3.387
2	(29/01)	112.9588	0.171	0.600	0.103	0.577	0.091	1.073
3	(11/02)	0.0000	0.007	0.358	0.000	0.026	0.021	1.201
4	(18/02)	21.5194	0.004	0.000	0.010	0.567	0.000	0.731
5	(26/02)	9.9766	0.019	0.000	0.027	----	0.046	1.441
6	(04/03)	0.0000	0.000	2.740	0.073	1.237	12.988	1.420
7	(11/03)	0.1331	0.000	0.392	0.006	0.048	1.368	0.881
8	(18/03)	0.0000	0.000	1.775	0.178	0.059	0.563	2.212
9	(03/04)	0.0791	0.000	3.187	0.066	17.471	1.438	0.199
10	(08/04)	0.0214	0.000	0.453	0.140	11.057	0.096	0.295
11	(22/04)	0.0953	0.393	0.000	0.026	0.000	1.108	0.502
12	(30/04)	0.7594	0.225	2.626	0.007	0.033	0.627	4.900
13	(14/05)	0.7709	0.009	0.975	0.006	0.005	1.051	0.204
14	(21/05)	4.0847	0.021	0.088	0.013	0.163	0.446	1.916
15	(03/06)	0.6395	0.176	0.064	0.039	0.042	1.494	0.194
16	(11/06)	3.3368	0.055	0.336	0.001	0.022	0.348	0.140
17	(17/06)	5.6191	0.208	0.148	0.037	0.007	0.302	0.161
[illegible]	(02/07)	15.7691	0.019	0.000	0.112	0.147	1.498	0.657
19	(16/07)	19.9218	0.175	0.193	0.024	0.064	0.060	0.632
20	(23/07)	9.4763	0.030	0.748	0.217	0.001	0.444	0.330
21	(07/08)	19.4665	0.014	0.281	0.017	0.015	1.989	0.145
22	(13/08)	356.3272	0.065	4.042	0.052	0.005	0.087	0.131
23	(02/09)	18.1306	0.214	0.319	0.162	0.069	2.704	0.024
24	(09/09)	316.3335	17.224	1.037	0.004	0.024	0.023	1.234
25	(23/09)	2.1530	0.106	0.929	0.063	0.006	0.691	0.083
26	(08/10)	0.5852	0.095	3.177	0.025	1.194	0.424	1.583
27	(22/10)	1.5913	0.192	0.243	0.019	0.148	0.577	0.352
28	(05/11)	2.2422	0.000	0.000	0.013	0.150	0.453	0.000
29	(19/11)	4.1834	25.334	0.836	0.182	3.358	6.339	4.258
30	(16/12)	0.0447	0.000	0.039	0.011	0.000	0.193	0.829

Table 2. Summary of the stepwise linear regression analyses using data for a) all sampling days (30 cruises); b) the sampling days characterized by a previous wind velocity (previous 72 h) <5 ms^{-1}; c) the sampling days with previous wind velocity ≥ 5 ms^{-1}. The quantity R is the cumulative multiple correlation coefficient. $\overline{\Delta R^2}$ is the increase in the amount of the variance in the independent variable which is explained by including a particular variable in the regression.

Dependent Variable	Independent Variables	Regress. Coeff.	s.e. of Regress. Coeff.	Cumulative R	ΔR^2
a) Variance *P/B*	Var. C/N	53.675	10.750	0.3799	0.1443
	Wind stress	- 0.077	0.067	0.5219	0.1280
	Var. Phaeo.	9.588	2.365	0.5844	0.0692
	Var. NH_3	-33.797	10.336	0.6851	0.1278
	Var. NO_3^-	- 7.997	3.200	0.7420	0.0812
	Var. SiO_3^{2-}	-11.370	4.765	0.7998	0.0892
	Constant	54.510			
b) Variance *P/B*	Var. C/N	67.886	11.669	0.6529	0.4263
	Var. NH_3	-33.572	9.122	0.7110	0.0792
	Var. Phaeo.	12.819	2.343	0.8387	0.1979
	Var. SiO_3^{2-}	-39.156	10.906	0.9225	0.1476
	Constant	36.699			
c) Variance *P/B*	Wind stress	- 0.039	0.016	0.6425	0.4128
	Constant	25.230			
d) Variance *P/B* (log)	Wind stress (log)	- 6.821	1.145	0.8930	0.7980
	Constant	18.579			

Analysis of Variances

		df	Sum of Squares	F_s
a)	Regression	6	136452.864	6.807
	Residual	23	76839.841	
b)	Regression	4	167074.918	18.575
	Residual	13	29231.826	
c)	Regression	1	258.919	6.327
	Residual	9	368.289	
d)	Regression	1	5.291	35.459
	Residual	9	1.343	