

PHYTOPLANKTON AND WATER QUALITY OF THE COASTAL WATERS OF NEW BRUNSWICK AND ADJACENT AREAS

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This paper gives the results of investigations during 1971 to 1984 on the phytoplankton of the coastal and marine waters of New Brunswick and Soctia-Fundy-Cody and Georges Bank regions. The phytoplankton composition, distribution and seasonal succession in relation to water quality are presented.

Le présent travail rapporte les résultats des études sur le phytoplancton des eaux côtières et marines du Nouveau-Brunswick ainsi que des régions de Scotia-Fundy-Cody et du Banc Georges entre 1971 et 1984. La composition, distribution et succession saisonnière du phytoplancton en relation avec la qualité de l'eau sont présentées.

Introduction

The coast of New Brunswick, Nova Scotia, and Prince Edward Island is long and its coastal waters are productive. Part of this productivity is related to the phytoplankton which sustains, in part, an important shellfish industry. Thus estimations of the phytoplankton populations of these waters provide some understanding of this fishery. The purpose of this paper is to report the phytoplankton populations collected in the period during 1971-84.

Methods

Collection areas. In the study area several phytoplankton samples were collected during investigations on water quality, nutrients and biomass. The results on water quality have been reported (Gordon and Dadswell, 1984; Gordon et al., 1985; Jonnavithula, 1980; Lakshminarayana, 1976, 1983; Lakshminarayana and Bourque, 1979; Lakshminarayana and Jean-Pierre, 1975; Lakshminarayana and Jonnavithula, 1989). For convenience, based on the period and duration of investigation, the study area is divided into six regions. Five of these regions and the time and locations of collections are given in Table I. Data for the sixth region (Malpeque Bay, P.E.I.) have been published (Sita Devi and Lakshminarayana, 1989).

Methods of collection and identification. Phytoplankton samples were collected by both water bottles and 64 μm mesh net. The samples were preserved in Lugol's iodine-formalin neutralized with sodium tetraborate (pH 7.0-7.3). Methods of study and identification are given in Lakshminarayana (1983). Physico-chemical analyses were by the methods described by Sita Devi and Lakshminarayana, (1989).

Results and Discussion

Analyses of the coastal and marine waters are summarized in Table I. General distribution patterns of pH, temperature, salinity, nitrate and phosphate were variable but within the ranges reported (Tait and De Santo, 1975) for coastal and marine waters. These waters were well oxygenated. Higher concentrations of trace metals were noted

Table I Mean values of acidity, temperature and chemical constituents of marine waters off the coast of New Brunswick

Collection Areas	Year	pH	Temp. °C	Dissolved Oxygen mg mL ⁻¹	Salinity 0/00	Nitrate mg mL ⁻¹	Phosphate mg mL ⁻¹	No. of analyses
CHALEUR								
66°W 48°N to 65°W 47°N								
Jacquet R. to Lower Caraquez:								
1. June	1973	8.0	19.5	8.3	10.0	0.7	0.3	57
2. July	1973	7.9	21.5	8.0	14.6	0.9	0.15	57
BATHURST HARBOUR:								
3. July-September	1971	N.D.	16.6	6.7	23.6	N.D.	N.D.	12
4. June-November	1972	N.D.	15.5	8.6	10.7	N.D.	N.D.	9
Caraqet to Baie du Vin:								
5. June-November	1982	8.0	19.6	N.D.	19.9	N.D.	N.D.	72
Caraqet Bay:								
6. June-November	1982	8.0	13.6	8.1	27.4	N.D.	N.D.	48
NORTHUMBERLAND STRAIT								
65°W 47°N to 62°W 46°N								
Shediac Bay:								
1. May	1972	7.6	9.9	9.0	11.0	N.D.	N.D.	180
Bouctouche Bay:								
2. June-August	1973	7.5	20.8	8.5	21.0	N.D.	N.D.	54
Northumberland Strait:								
3. June-August	1975	8.1	17.0	N.D.	23.7	0.03	0.02	95
4. May-October	1976	7.9	13.4	6.2	24.6	0.02	0.03	185
5. May-October	1977	8.1	11.6	6.9	25.7	0.06	0.01	185
GEORGES BANK*								
Shelf area of Nova Scotia & Georges Bank								
1. August	1974	N.D.	14.8	N.D.	32.8	0.7	0.3	47
BAY OF FUNDY*								
1. August	1978	N.D.	14.2	9.5	30.8	0.3	1.05	N.K.
Cumberland Basin:								
2. March	1979	N.D.	1.8	N.D.	29.6	12.7	1.2	N.K.
3. October	1979	N.D.	10.9	N.D.	33.6	5.3	1.1	N.K.
4. February	1980	N.D.	2.0	N.D.	30.5	12.7	1.2	N.K.
PASSAMOQUODDY BAY								
1. August	1977	8.0	N.D.	11.2	32.5	N.D.	N.D.	12
2. May	1978	8.1	4.7	12.3	26.8	N.D.	N.D.	14
3. February	1979	N.D.	1.3	N.D.	30.7	N.D.	N.D.	4
4. November	1979	8.2	9.3	3.5	32.5	0.01	0.9	18
5. November	1980	8.1	7.8	5.6	32.7	0.1	0.1	18
6. February	1981	8.0	6.8	8.5	31.9	N.D.	N.D.	18
7. November	1981	8.0	6.8	5.6	32.7	0.1	0.1	18
8. April	1983	8.1	1.5	12.0	33.3	0.1	1.1	18

* Subba Rao, 1975; * Keizer *et al.*, 1984; N.D. Not determined N.K. Not known.

Table II Bacillariophyceae collected in marine waters off the coast of New Brunswick and adjacent areas.

Genus ^a	Species	Chaleur	Northumberland Strait	Scotian Shelf & Georges Bank	Bay of Fundy	Passamaquoddy Bay
<i>Achnanthes</i>	<i>longipes</i>		4			2
	<i>taeniata</i>	5,6	4			1
<i>Actinocyclus</i>	<i>oceanarius</i>	5,6	4		2,3	
<i>Actinoptychus</i>	<i>senarius</i>	5,6	4*		2,3*	4,5,7
<i>Amphipleura</i>	<i>rutilans</i>	1,2,3				
<i>Amphiprora</i>	<i>alata</i>	5,6	4			1,2
	<i>ornata</i>		4			
<i>Amphora</i>	<i>aungusta</i>		4			
	<i>coffeaeformis</i>	5,6				
	<i>ovalis</i>					1,2
<i>Asterionella</i>	<i>glacialis</i>	5,6	2,4,5	1	2,3,4	
<i>Auliscus</i>	<i>incertus</i>					3,4,5
<i>Bacillaria</i>	<i>paxillifer</i>				3,4	6
<i>Bacteriastrum</i>	<i>hyalinum</i>	1,2				
<i>Bacteriosira</i>	<i>fragilis</i>		2,5			2
<i>Bellerochea</i>	<i>malleus</i>	2				
<i>Biddulphia</i>	<i>alternans</i>		4*		2	8
	<i>aurita</i>	5,6	4*		2*	3,4,6,7
	<i>mobiliensis</i>				2,3*	3,4,6,7
	<i>obtusa</i>	2				
	<i>pulchella</i>		4	1		1
	<i>regia</i>					1
<i>Brebissonia</i>	<i>boeckii</i>					1,2
<i>Caloneis</i>	<i>thuretii</i>					1
	<i>westii</i>					4
<i>Ceratulina</i>	<i>pelagica</i>		4			1
<i>Cerataulus</i>	<i>turgidus</i>					1
<i>Campylodiscus</i>	<i>fastuosus</i>	2				
<i>Chaetoceros</i>	<i>affine</i>	5	4	1	2,3	
	<i>atlanticum</i>	5,6	4*	1*		2,1
	<i>breve</i>		2,4			
	<i>boreale</i>					3
	<i>compressus</i>	5,6*	4,5*	1	1	1,2
	<i>conconvicorne</i>	1,2				8
	<i>coronatum</i>				2,3	
	<i>constrictum</i>		2,4			1,2*
	<i>convolutum</i>					3,8
	<i>curvisetum</i>					3,4,6,7
	<i>danicum</i>		2			3-8
	<i>debile</i>	5,6	2,4*			3-8*
	<i>decipiens</i>	5*	2-5*		1	1-7
	<i>diadema</i>	5	2		1,3,4	1,2*
	<i>didymum</i>	5	5		1	1
<i>furcellatum</i>		2			1	
	<i>gracile</i>				2,3	
	<i>lacinosum</i>	5,6	2,4			1
	<i>lorenzianum</i>	5,6	1,2			1

Table II (cont'd)

Genus†	Species	Chaleur	Northumberland Strait	Scotian Shelf & Georges Bank	Bay of Fundy	Passamaquoddy Bay
<i>Chaetoceros</i>	<i>peruvianum</i>				2	
	<i>radians</i>				2,3	8
	<i>septentrionale</i>	5	2,4,5			
	<i>sociale</i>	5,6	2,4*			1*
	<i>subtile</i>				2	
	<i>teres</i>	5,6	2,45			1
	<i>wighamii</i>	5,6				
<i>Cocconeis</i>	<i>willei</i>	5,6	1,2			
	<i>disculoides</i>	5,6				
<i>Corethron</i>	<i>scutellum</i>	5,6*	4,5			
	<i>criophilum</i>					6,7,8
<i>Coscinodiscus</i>	<i>asteromphalus</i>		4*		2,3,4	6,7,8
	<i>centralis</i>	1,2,4*		1,4*	5,7*	
	<i>concinus</i>	5	4*		2,4*	5,7*
	<i>eccentricus</i>		4*		2,3*	1,2
	<i>lineatus</i>				2,3	
	<i>marginatus</i>				2,3	2-7
	<i>normani</i>				2	3-7
	<i>oculus-iridis</i>				2	8
	<i>radiatus</i>	5,6*	1,2,4*	2,3,4	8	
<i>Coscosira</i>	<i>polychorda</i>	6	4			
<i>Cyclotella</i>	<i>compta</i>		4			1
	<i>meneghiniana</i>				4	
	<i>striata</i>		4		2,3,4	
<i>Detonula</i>	<i>confervacea</i>		1,2			1,2
<i>Diploneis</i>	<i>crabro</i>	5,6				
	<i>didyma</i>				4	3-7
	<i>sithii</i> var. <i>smithii</i>				2,3	1
<i>Ditylum</i>	<i>brightwellii</i>				2,3	5,6,7
<i>Endictya</i>	<i>oceanica</i>					1,2,3
<i>Epithemia</i>	<i>musculus</i>					1,2,3
<i>Eucampia</i>	<i>radiatus</i>		2,4		2,3	
	<i>zodiacus</i>				2,3*	3-7
<i>Eupodiscus</i>	<i>radiatus</i>				2,3	1,2
<i>Fragilaria</i>	<i>capucina</i>		4			2
	<i>crotonensis</i>	5,6	5		2,3	
	<i>oceanica</i>	5,6	4		2,3*	
<i>Gomphonema</i>	<i>acuminatum</i>					1,2
	<i>marinum</i>					1,2
<i>Grammatophora</i>	<i>marina</i>	5,6	4,5			3-7
	<i>oceanica</i>		4			
	<i>serpentina</i>					3-7
<i>Guinardia</i>	<i>flaccida</i>					8
<i>Gyrosigma</i>	<i>balticum</i>	5	2,4,5			
	<i>fasciola</i> var. <i>fasciola</i>					2,3* 3
	<i>hippocampus</i>	5,6				
	<i>wansbeckii</i>				2,3	
<i>Hyalodiscus</i>	<i>scoticus</i>	5,6				3-7
<i>Isthmia</i>	<i>enervis</i>					1,2
	<i>nervosa</i>					1,2

Table II (cont'd)

Genus [†]	Species	Chaleur	Northumberland Strait	Scotian Shelf & Georges Bank	Bay of Fundy	Passamaquoddy Bay
<i>Leptocylindrus</i>	<i>danicus</i>	5,6		1*	3	1,2*
<i>Lauderia</i>	<i>borealis</i>	5,6				
<i>Licmophora</i>	<i>baileyi</i>		4,5			
	<i>flabellata</i>		4,5		4	
	<i>gracilis</i>				4	8
	<i>lyngbyei</i>		4,5			
	<i>paradoxa</i>	5,6				
<i>Mastogloia</i>	<i>elliptica</i>		4			
	<i>smithii</i>					1,2
<i>Melosira</i>	<i>artica</i>	5,6	4			
	<i>crenulata</i>					1,2
	<i>juergensii</i>				2,3	3-7
	<i>moniliformis</i>	1	4,5*		2,3,4	1,2*
	<i>nummuloides</i>		2,4		2,3,4*	3-7
	<i>subflexilis</i>					1,2
	<i>sulcata</i>		2,4		4	
	<i>varians</i>		4*			1,2
	<i>westii</i>				4	
	<i>Navicula</i>	<i>abrupta</i>		4		
<i>bahusiensis</i>					2,3,4	3-7
<i>crucifera</i>						3
<i>cryptocephala</i> var. <i>Grunow</i>						3
<i>distans</i>					2,3	1,2
<i>inclementis</i>						1,2
<i>inflexa</i>						1,2
<i>maculosa</i>						1,2
<i>marina</i>						1,2
<i>membranacea</i>						2
<i>perigrina</i>						2,3
<i>scopulorum</i>		5,6				
<i>vanhoffeni</i>		5,6				2,3
<i>Navicula</i> sp.		5,6				
<i>Nitzschia</i> sp.	<i>acuminata</i>		4			
	<i>angularis</i>		4		4	
	<i>bilobata</i>					1
	<i>closterium</i>	5,6*	1-5*		2,3,4	307
	<i>delicatissima</i>				2,3	
	<i>dubia</i>				2,3	
	<i>frigida</i>	5,6				
	<i>lanceolata</i>	5,6				
	<i>longissima</i>	5,6*	4,5*	1	2	
	<i>paradoxa</i>	5,6				
	<i>panduriformis</i>	5,6				
	<i>plana</i>	5,6				
	<i>punctata</i>	5,6				
	<i>sigmoidea</i>		45			
	<i>seriata</i>	5,6	2,4*	1*	2,3*	1-7
	<i>sigma</i> var. <i>intercedens</i>	5,6*	5			

Table II (cont'd)

Genus*	Species	Chaleur	Northumberland Strait	Scotian Shelf & Georges Bank	Bay of Fundy	Passamaquoddy Bay
<i>Phaeodactylum</i>	<i>tricornutum</i>		4			
<i>Paralia</i>	<i>sulcata</i>	1,2-6	4*		3,4*	3-7
<i>Pinnularia</i>	<i>ambigua</i>	5,6				
	<i>cruciformis</i>				2,3	
	<i>major</i>					1-7
	<i>rectangulata</i>	5,6				
<i>Planktoniella</i>	<i>sol</i>				3*	
	<i>sol</i>					3-7
<i>Pleurosigma</i>	<i>aestuarii</i>		4*	1	2,3	
	<i>angulatum</i>					1,2
	<i>attenuatum</i>					1,2
	<i>balticum</i>					1,2
	<i>decorum</i>					8
	<i>delicatulum</i>					3-7
	<i>elongatum</i>	5,6				1,2
	<i>fasciola</i>		4			1,2
	<i>formosum</i>		1,2			1,2
	<i>intermedium</i>					3-7
	<i>normani</i>					2,3*
	<i>obscurum</i>		4			
	<i>spenceri</i>					
<i>Porosira</i>	<i>strigosum</i>				3	7
	<i>glacialis</i>		1,2			
<i>Raphoneis</i>	<i>amphiceros</i>					7
<i>Rhabdonema</i>	<i>arcuatum</i>					3-7
<i>Rhizosolenia</i>	<i>alata</i>	5,6	4		3*	1,2
	<i>alata forma gracillima</i>					1,2
	<i>delicatula</i>					8
	<i>fragilissima</i>		2,4			
	<i>hebetata</i>		4	1	2,3,4	3-7
	<i>hebetata forma semispina</i>			2		2,3,4
	<i>imbricata</i>		4			
	<i>pungens</i>	5,6*	2,5			
	<i>robusta</i>				4	
	<i>setigera</i>		2,4	1	2,3	1,2*
	<i>stolterforthii</i>				1	3
	<i>shrubsolei</i>					1,2
	<i>styliiformis</i>	5,6	4	1	2,3*	3-7
<i>Rhopalodia</i>	<i>gibba</i>					1,2
<i>Schroederella</i>	<i>delicatula</i>			1		
<i>Schroederella</i>	sp.			1		
<i>Skeletonema</i>	<i>costatum</i>	5,6	2,4,5	1*	2,3	3-7*
	<i>subsalum</i>		4			
<i>Stauroneis</i>	<i>anceps</i>		4			
	<i>salina</i>		4			
	<i>sp.</i>	4				
<i>Stephanodiscus</i>	<i>dubius</i>		4			
<i>Stephanopyxis</i>	<i>turris</i>		4			
<i>Streptotheca</i>	<i>tamesis</i>				2,3	
<i>Striatella</i>	<i>unipunctata</i>		4			1

Table II (cont'd)

Genus [†]	Species	Chaleur	Northumberland Strait	Scotian Shelf & Georges Bank	Bay of Fundy	Passamaquoddy Bay
<i>Surirella</i>	<i>fastuosa</i>		4		2,3,4*	
	<i>gemma</i>		4			1,2
	<i>ovalis</i>		4			3-7
	<i>ovata</i>				2,3*	
	<i>smithii</i>					3-7
<i>Synedra</i>	<i>affinis</i>	1,3,5,6*	4		2,3*	
	<i>crystallina</i>	4,5				
	<i>fulgens</i>	4,5				
	<i>gallionii</i>	4,5				
	<i>investiens</i>					3-7
	<i>puchella</i>				2,3	3-7
	<i>radians</i>					7
	<i>ulna</i>		4			
	<i>undulata</i>					3,7
	<i>Thalassionema</i>	<i>nitzschoides</i>				1,2,3
<i>Thalassiosira</i>	<i>baltica</i>		4,5			
	<i>decipiens</i>		4*		2,3	
	<i>gravida</i>	5,6	2		2,3	1,2
	<i>hyalina</i>		4*			
	<i>nordenskioldii</i>	5,6	2,3,4		2	1,2
<i>Thalassiothrix</i>	<i>subtilis</i>		4			
	<i>frauenfeldii</i>			1	2,3	
	<i>longissima</i>	5,6	4		3,4*	7
<i>Thalassiothrix</i>	<i>nitzschoides</i>	5,6	4			1,2
	<i>favus</i>					3-7
<i>Triceratium</i> sp.						3-7

[†] Names of genera are quoted only on first occurrence and are implied thereafter.

in the nearshore waters than the offshore waters (Lakshminarayana and Jonnavithula, 1989).

A total of 339 species representing 111 genera of phytoplankton were identified in this study, and are listed in Tables II and III. Fifty of these species were found in Malpeque Bay and not elsewhere, and 161 of the 339 species were not found in Malpeque Bay. The species reported were divided among Bacillariophyceae - 267, Dinophyceae - 50, Chrysophyceae - 5, Cryptophyceae - 2, Haptophyceae - 6, Euglenophyceae - 1, Prasinophyceae - 1, Cyanophyceae - 5, and Chlorophyceae - 2. Ultraplankton (< 2 µm) in the samples were generally abundant and this group of algae which were not identified, needs further study.

Phytoplankton of Chaleur (Fleuve du Jacquet to Baie du Vin). A total of 55 species were identified from 252 samples. The most commonly collected phytoplankton (given in Tables II and III) consisted primarily of diatoms. *Skeletonema costatum*, *Asterionella glacialis*, *Bacillaria paradoxa*, *Chaetoceros marina* and *Melosira moniliformis* were noted in October. *Peridinium ovatum*, *P. depressum*, *P. longipes* and *Dinophysis* sp. occurred in small numbers in October and July and *P. depressum* was also observed in August. *Oscillatoria* sp. was seen in July in a few samples.

Table III Chrysophyceae, Dinophyceae, Haptophyceae and other phytoplankton collected off the coast of New Brunswick and adjacent areas.

Genus*	Species	Chaleur	Northumberland Strait	Scotian Shelf & Georges Bank	Bay of Fundy	Passamaquoddy Bay
<i>Distephanus</i>	<i>speculum</i>		4,5			8
	<i>speculum</i> var. <i>setenarius</i>					8
<i>Dinobryon</i>	<i>balticum</i>					3-7
<i>Amphidinium</i>						3-7
<i>Ceratium</i>	<i>arcticum</i>	5,6	1,2			
	<i>bucephalum</i>	5,6				
	<i>extensum</i>				2,3	
	<i>furca</i>				2,3	3-7*
	<i>fuscus</i>	5,6	2,4	1	2,3	3-7*
	<i>hirundinelle</i>	1,2				
	<i>lineatum</i>		4		2,3	
	<i>longipes</i>	5,6	2,4*	1	3	
	<i>macroceros</i>	4*			2,3	
	<i>symmetricum</i>	5,6				
	<i>tripos</i>		4		3*	3,5*
<i>Dinophysis</i>	<i>acuminata</i>	5,6	4*			
	<i>catenata</i>					3-7
	<i>caudata</i>			1		
	<i>ellipsoides</i>		2			
	<i>norvegica</i>	5,6	2,4	1		1,2
	<i>ovum</i>			1		
	<i>rotundata</i>	5,6				
<i>Diplosalis</i>	<i>lenticula</i>	5,6				
<i>Goniodoma</i>	<i>depressum</i>	5,6				
<i>Alexandrium</i>	<i>tamarense</i>					1,2*
<i>Gonyaulax</i>	<i>spiniifera</i>		4			
<i>Protogonyaulax</i>	<i>tamarensis</i>		4	1	2,3*	
<i>Gymnodinium</i>	<i>lohmanii</i>	5,6				
<i>Gymnodinium</i> sp.				1		
<i>Oxytoxum</i> sp.			4	1		
<i>Peridinium</i>	<i>achromaticum</i>	5,6				
	<i>brevipes</i>	1,2				
	<i>crassipes</i>	5,6	4*			
	<i>depressum</i>		2,4	1	1	1,2*
	<i>longipes</i>	5,6				
	<i>ovatum</i>	5,6				
	<i>pallidum</i>	5,6	1,2			
<i>Phodolampas</i>	<i>spiniifera</i>	5,6				
<i>Prorocentrum</i>	<i>micans</i>	5,6	4	1		
<i>Phalacroma</i> sp.			4	1		
<i>Halosphaera</i>	<i>viridis</i>	5,6				
<i>Anacystis</i> sp.	5,6					

* Names of genera are quoted only on first occurrence and are implied thereafter.

Phytoplankton of the Northumberland Strait. The 100 species of phytoplankton noted in 699 samples from the Northumberland Strait were distributed among 68 genera and as six classes: Bacillariophyceae - 46; Dinophyceae - 11; Cryptophyceae - 2; Hepatophyceae - 6; Chrysophyceae - 2; and Euglenophyceae - 1. Frequent species found in this area are given in Tables II and III. During the spring, cold water species e.g. *Coscinodiscus asteromphalus*, *C. centralis*, *C. eccentricus*, *C. radiatus*, *Pleurosigma aestuarii*, *Thalassionema nitzischioides*, *Dinophysis acuminata*, *Chilomonas marina* were abundant. From May to June and briefly in September and October diatoms were dominant. The following species were only observed in May to October 1976: *Dictyocha fibula*, *Amphidinium longum*, *Dinophysis acuta*, *D. borealis*, *Exuviaella baltica*, *Glenodinium danicum*, *Gymnodinium gracile*, *Peridinium conicum*, *P. excentricum*, *P. pellucidum*, *Pyrocystis lunula*, *Prorocentrum rostratum*, *Protoceratium reticulatum*, *Chilomonas marina*, *Rhodomonas* sp., *Acanthoica acanthos*, *Phaeocystis* sp., *Pontosphaera huxleyi*, *Syracosphaera* sp., *Cocolithus pelagicus*, and *Euglena* sp. After August dinoflagellates were important.

Phytoplankton of the Scotian Shelf and Georges Bank In this region during August 1974 (Subba Rao, 1975) 109 samples from several sampling stations showed many microflagellates and several species of dinoflagellates, although the latter were not in large numbers. The diatoms *Skeletonema costatum*, *Leptocylindrus danicus*, *Nitzschia seriata*, *Chaetoceros atlanticum* and *Chaetoceros* sp. were frequent in the samples.

Phytoplankton of the Bay of Fundy. Examination of 1077 water samples collected on four cruises throughout the Bay at Pecks Cove and Cumberland Basin (Gordon and Dadswell, 1984) revealed 40 genera consisting of 119 species representing diatoms (34 genera or 105 species), dinoflagellates (4 genera or 12 species), silicoflagellate - 1 and green algae - 1. The benthic diatom *Paralia sulcata* was very common as was *Actinoptychus senarius*, an oceanic diatom. There appears to be a definite seasonal distribution of phytoplankton typical of a temperate coastal region having winter, spring, summer and autumn populations. Several species described by Marshall (1978), as occurring in the Gulf of Maine and surrounding Atlantic waters were represented among the species recorded from the Bay of Fundy (Tables II and III). The areas Chignecto Bay, Cumberland Basin, Minas Basin were rich or diverse in diatoms, the greatest diversity appearing in mid June. The dominant species found in Cumberland Basin are given in Tables II and III. These species were found in Chignecto Bay where *Coscinodiscus centralis*, *Cyclotella meneghiniana*, *Eucampia zodiacus*, *Thalassiosira decipiens* and *Ceratium tripos* were also common. Similar species were found in the Minas Basin, hence differences between the inner and outer Bay of Fundy were apparent.

Phytoplankton of Passamaquoddy Bay. The phytoplankton of the Quoddy region resembles that of the coastal margin of the Gulf of Maine. A checklist of 127 species of phytoplankton consisting of 120 diatoms, six dinoflagellates and one Chrysophyte has been published (Lakshminarayana, 1983). Species of *Chaetoceros* lead both in diversity and numbers in the Passamaquoddy Bay waters, and the diatoms increased with the onset of spring. *Thalassiosira nordenskioldii*, *Rhizosolenia setigera*, *R. styliformis* were most frequent in March and April. *Thalassiosira gravida*, *Chaetoceros debile*, *Ch. diadema*, *Ch. constrictum*, *Ch. sociale*, *Coscinodiscus concinnus* and *C. centralis* were common in summer while at the end of summer *Skeletonema costatum*, *Leptocylindrus danicus* and *Rhizosolenia setigera* appeared in these waters. In general, the dinophycean members were few and they infrequently occurred in autumn and summer. These species were *Ceratium tripos*, *C. fusus*, *C. furca*,

Peridinium depressum, *Dinophysis norvegica* and *Alexandrium tamarense* (*Gonyaulax excavata*). A reported herring kill in the Bay of Fundy was attributed to the toxins of *A. tamarense* (White, 1977) during blooms of this species in the Atlantic coastal waters of northeastern America. During the winter *Skeletonema costatum* and *Melosira moniliformis* were common.

Water quality and phytoplankton distribution To understand phytoplankton distribution it is necessary to consider water quality characteristics as well as geographic, hydrographic and topographic parameters. Culture studies (Guillard and Kilham, 1977) on *Phaeocystis* and *Skeletonema* from tropical and northern coastal waters of the Atlantic Ocean show that the optimum temperatures of growth of these species depends on where they were collected. By contrast some authors (Braarud, 1945; Smayda, 1958) consider that the latitudinal distribution of phytoplankton (arctic, boreal, temperate, tropical) is regulated by temperature.

In the case of *Thalassiosira nordenskioldii* it was found that this species grew well at 10-11°C in culture, and our observations (Sita Devi and Lakshminarayana, 1989) showed that it was a dominant species in Malpeque Bay when the water temperature was 18-21°C. In the surveys reported in this paper (Table II) it was also found during the summer months when the water temperature was in the range 13-21°C. By contrast it has been reported (Gran and Braarud, 1935; Smayda, 1957) to achieve its maximum population density in the temperature range 2-3°C. This apparent anomaly may be due to the presence of high nutrient levels for Braarud (1945, 1945a) found that boreal diatoms grew actively at 20°C in polluted waters, whereas growth was negligible in non-polluted waters. Though our studies (Sita Devi and Lakshminarayana, 1989) indicated that the waters of Malpeque Bay were of good quality, there may still have been sufficient nutrient in spring and summer to account for the bloom of this organism. Hence, at the moment there are insufficient reasons to reclassify this organism from an arctic boreal neritic species (Davidson, 1931).

The optimum conditions of temperature and salinity for growth and reproduction of dinoflagellates and coccolithophorids remain obscure, though Raymont (1963) has reported that some species reproduce most actively at low salinities. Smayda (1958) quoted high temperature optima (20-25°C) for *Prorocentrum micans*, *Ceratium fusus* and *C. furca*, and our studies (Table III), in agreement, indicated that maximum populations of the first two organisms occurred during the summer (temperature range 13-21°C). However, *C. furca* was isolated only during the winter months when water temperatures were in the range 1-11°C. *Dinophysis acuminata* was also found predominantly (Table III) in the summer months at ~14°C and salinity ~25‰ and these results agree with those of Lassus et al. (1985) who found that though blooms of this organism occurred between 30-35‰ salinity at 15-21°C, its preferred habitat lay in colder waters.

In summary the most common phytoplankton of the marine waters surveyed in this work were *Thalassiosira gravida*, *T. nordenskioldii*, *T. decipiens*, *Skeletonema costatum*, *Chaetoceros dicipiens*, *C. boreale*, *C. atlanticum*, *C. diadema*, *Rhizosolenia setigera*, *R. styliiformis*, *Thalassionema nitzschoides*, *Thalassiothrix longissima*, *Distephanus speculum*, *Peridinium ovatum*, *Ceratium articum*, *C. fusus*, *C. longipes*, *C. tripos*, and *C. macroceros*. These species were found in a wide range of water temperatures and salinities.

Bacon (1977) observed that the spring phytoplankton of the Northumberland Strait probably forms an important food source for oyster (*Ostrea edulis*) populations. Of the 128 phytoplankton species recorded in British coastal waters, 33 were found in the

stomach contents of marine animals (Hendey, 1964) and hence were part of their food supply. Thus certain species might well be useful as nutrients in pisciculture (Maestrini et al., 1984) or as assay organisms to measure specific pollutants. Phytoplankton identification will also help the selection and culture of specific algal ecotypes.

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