Results of a Survey of the Plankton Communities Located Offshore of a Proposed Quarry Site at Whites Cove, Digby Neck, Nova Scotia

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Results of a Survey of the Plankton Communities Located Offshore of a Proposed Quarry Site at Whites Cove, Digby Neck, Nova Scotia

1. Introduction

A seasonal survey of the plankton community located offshore of Whites Cove, Digby Neck, Nova Scotia was carried out during the spring, summer and fall of 2004. The primary objectives of the survey were to: (1) document the phytoplankton and zooplankton communities present in term of species composition and abundance; (2) collect and archive a permanent reference collection of phytoplankton and zooplankton and; (3) carry out a literature review of plankton studies previously carried out within the Bay of Fundy/Gulf of Maine ecosystem with emphasis on the area in and around Digby Neck.

2. Approach

The survey was carried out during three time periods (29 April, 28 July, and 21 October) at three sites offshore of the property on which the proposed quarry site is located. The three sample sites were located approximately one kilometre offshore of the northern, central and southern boundaries of the property (Figure 2.1). In addition to collection of quantitative and qualitative samples of phytoplankton and zooplankton, measurements of water column stratification (based on temperature and salinity profiles), water transparency (as Secchi Disk depth) and phytoplankton chlorophyll *a* concentration were measured at each site.

3. Methodology

Water column stratification was measured using a Yellow Springs Instrument Salinity-Conductivity-Temperature Meter. Secchi Disk depths were determined using a standard 20 cm diameter Secchi Disk.

The methodology for collection of phytoplankton and zooplankton was based on the protocols established by Environment Canada's Ecological Monitoring and Assessment Network (EMAN)[*].

Since there was never any indication of water column stratification, phytoplankton samples were collected as composite water samples taken at depths of 2, 15 and 25 meters from surface to bottom using a Van Dorn water sampler. The samples were stored in glass containers and preserved using 5 ml of a formalin-acetic acid solution for each 250 ml of water sample. Enumeration and species composition was carried out using the

[*] http://www.eman-rese.ca/eman/ecotools/protocols/marine/introduc.html

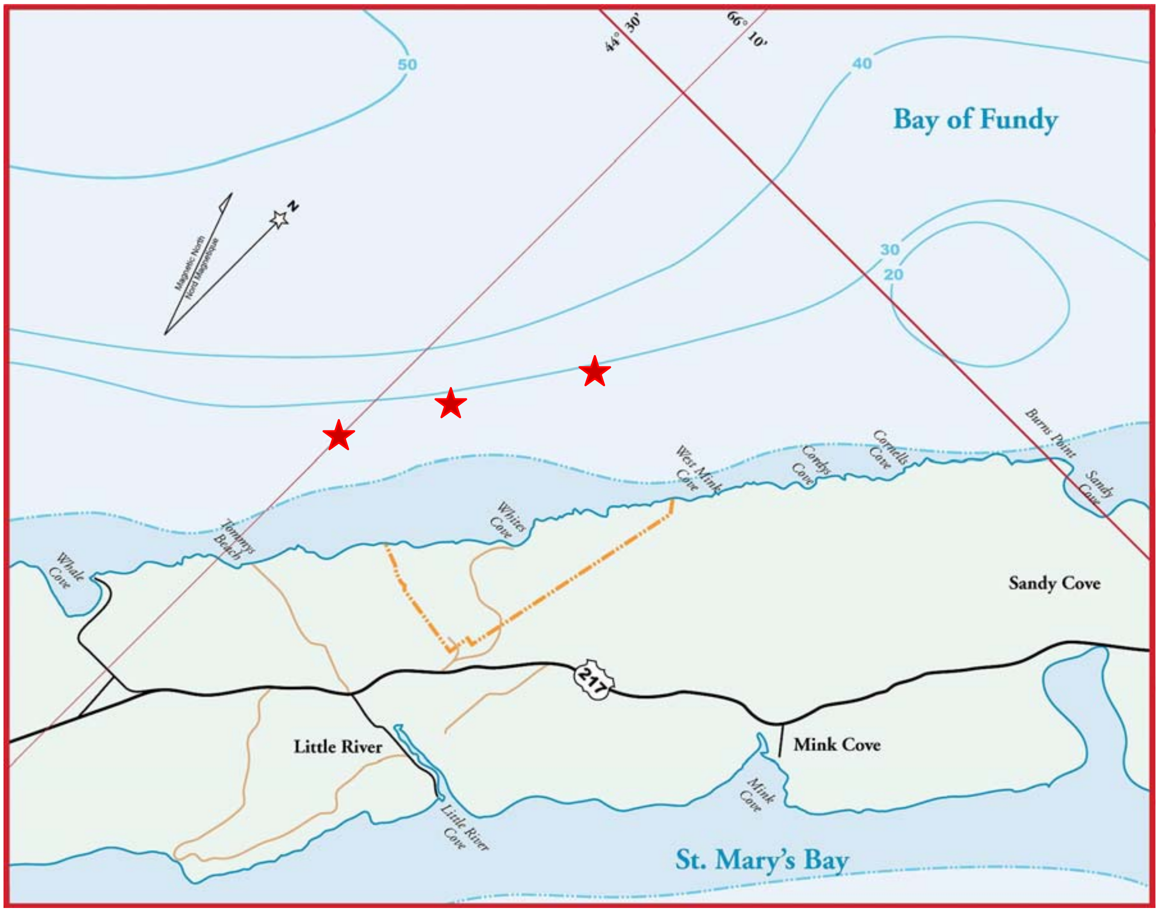

Fig. 2.1 Location of sample stations.

standard settling chamber and inverted microscope technique by personnel of the Department of Fisheries and Oceans Biological Laboratory in St. Andrew's, N.B.

Zooplankton samples were collected using a 200 micron mesh, 30 cm diameter, one meter long, conical Nitex net. The samples for quantitative analyses were collected using vertical water column tows starting at a depth of 30 m. In order to assure a sufficient number of organisms were collected to provide a complete assessment of the species present, qualitative samples were also collected using an oblique tow in which the zooplankton net was allowed to settle to 25 m and then slowly retrieved to the surface over a period of 10 minutes while the boat moved forward at a speed of 1 to 2 knots. The zooplankton samples were preserved using an equal volume of 10 % buffered formalin and were stored in glass jars. Quantitative analysis was carried out using standard dissecting microscope and sub-sampling procedures by Dr. John Roff of Acadia University, Wolfville, Nova Scotia.

Chlorophyll *a* measurements were made by filtering one litre composite water samples, collected using the same procedure as for phytoplankton samples, through Watman GF/C glass fibre filters and extracting the chlorophyll from the filters using 20 ml of 95 %

acetone. The extraction of chlorophyll was carried out in a dark refrigerator for 24 hours, after which the samples were decanted, centrifuged and the absorption measured spectrophotometrically and chlorophyll *a* concentration calculated according the procedure described in Strickland and Parsons (1972).

4. Results

Details of sample dates, times, and locations are contained in Table 4.1 and the results of measurements of water temperature, salinity and water transparency are contained in Table 4.2. There was never any indication of water column stratification at any of the stations or during any of the sampling periods. Salinity varied little as did Secchi Disk depth which was quite high indicating relatively clear water.

4.1 Phytoplankton

Appendix I lists the phytoplankton species present and their abundance at each sample site during each sampling period. A total of 61 species were observed. Of these, 51 species were diatoms, 10 species were dinoflagellates and 6 species were either euglenoids or silicoflagellates. There were also numerous species of tintinnid protozoans and one species of a foraminiferan protozoan present.

Figure 4.1 illustrates the abundance of diatoms and dinoflagellates at each sample site during each sampling period. The greatest numbers of diatoms were present during late April which is probably indicative of the occurrence of the spring phytoplankton bloom. The numbers of dinoflagellates were about an order of magnitude less than the numbers of diatoms.

Table 4.1. Sample times, locations and station depths.

Station	Date	Time	Location		Depth (m)	Tide State
			Latitude	Longitude		
South	04 April 2004	12:37	44° 27’ 33”	66° 10’ 07”	32	Low
“	28 July 2004	10:45	44° 27’ 30”	66° 10’ 00”	34	1/3 Ebb
“	21 October 2004	12:45	44° 27’ 29”	66° 10’ 05”	32	Low
Central	04 April 2004	13:10	44° 28’ 10”	66° 09’ 18”	31	Low
“	28 July 2004	11:15	44° 28’ 13”	66° 09’ 12”	38	1/2 Ebb
“	21 October 2004	11:30	44° 28’ 12”	66° 09’ 13”	31	Low
North	04 April 2004	13:48	44° 28’ 44”	66° 08’ 43”	32	Low
“	28 July 2004	11:45	44° 28’ 46”	66° 08’ 40”	40	2/3 Ebb
“	21 October 2004	10:45	44° 28’ 42”	66° 08’ 47”	32	Low

Table 4.2 Water temperature, salinity and Secchi Disk depth values at each sample station.				
Station	**Date**	**Temp. (°C)**	**Salinity (ppt)**	**Secchi Depth (m)**
South	04 April 2004	3.2	31.3	7.2
"	28 July 2004	9.5	32.3	7.0
"	21 October 2004	7.4	32.0	7.1
Central	04 April 2005	3.3	31.1	7.0
"	28 July 2004	9.3	32. 2	7.2
"	21 October 2004	7.3	32.1	7.3
North	04 April 2005	3.3	31.3	7.0
"	28 July 2004	8.8	32.2	7.1
"	21 October 2004	7.4	30.0	7.2

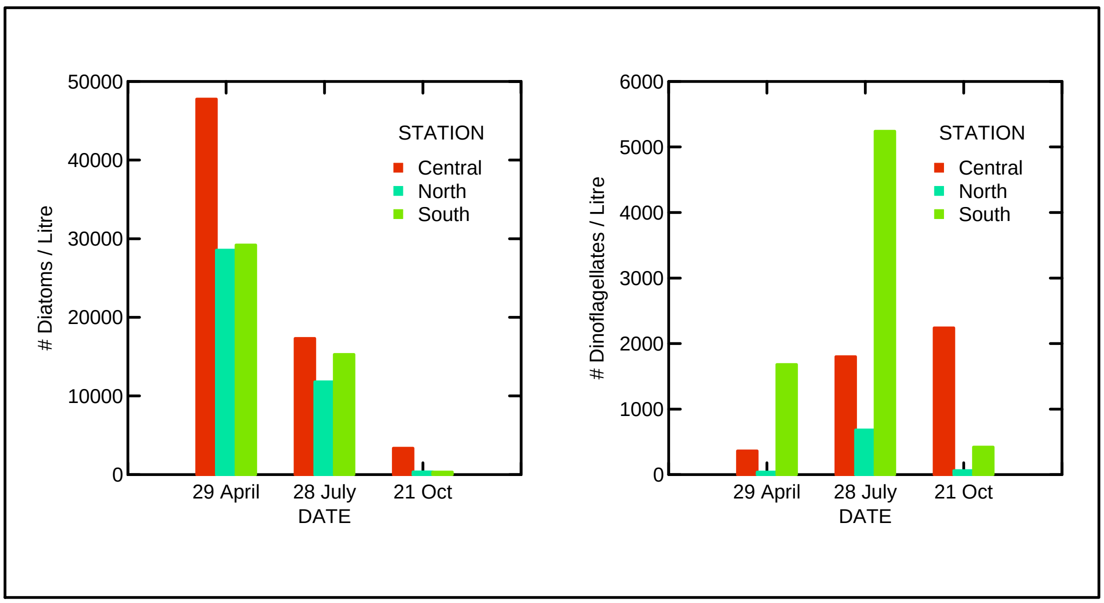

Figure 4.1 Abundance of diatoms and dinoflagellates at each site during each sample period.

4.1.1 Diatoms

The phytoplankton community was dominated by diatoms, in terms of both number of species and abundance, as is typical of unstratified strongly mixed water masses. A total of 51 species were identified. *Chaetoceros* was the most dominant genus present. Two species of *Pseudo-nitzschia* were present during the July sampling period. Both of these species are known to produce domoic acid, a toxin that causes amnesic shellfish poisoning (ASP).

4.1.2 Dinoflagellates

A number of dinoflagellate species were also present. Dinoflagettes are the phytoplankton species most often responsible for producing red and brown tides as well as various toxins that can pose health risks to numerous marine organisms and, in some cases humans, if ingested. A total of 10 dinoflagettes species were observed, but none were present in concentrations great enough[*] to be considered problematic. Only 4 of the 10 species present are known to produce toxins. These included *Alexandrium sp*., *Amphidinium carterae*, *Dinophysis norvegica* and *Heterocapsa triquerta*.

4.1.3 Other Phytoplankton Species

Other phytoplankton species observed includes the silicoflagellates *Dictyocha speculum*, *Notholca sp*. and *Mesodimium ruben*. The latter was one of the most abundant of all phytoplankton species, particularly during the July sampling period. Three groups of euglenoids, *Eutreptia*/*Eutreptiella* and *Laboea sp*., were also present.

4.1.4 Phytoplankton Chlorophyll a Concentrations

Table 4.3 lists the concentration of phytoplankton chlorophyll *a* measured for each sample station and time. Chlorophyll *a* concentrations were quite high in April, ranging between 3.4 and 3.6 μg/L, and indicative of spring bloom levels. During July and October, they were much lower. The seasonal variation in chlorophyll *a* levels followed that of phytoplankton numbers (Appendix I).

4.2 Protozoa

One species of foraminifera, *Phaeocystis pouchetii* was observed in the phytoplankton samples but was present in only two of the nine samples collected. Tintinnids (ciliate protozoans) were present at most sample times and sites.

[*] Although it varies with species, concentrations less than 1000 per liter are not usually considered to be great enough to cause either red and brown tide or toxicity problems.

Table 4.3 Phytoplankton chlorophyll *a* concentrations measured at each station.

Station	Date	Phytoplankton Chlorophyll *a* (µg/L)
South	04 April 2004	3.6
"	28 July 2004	0.8
"	21 October 2004	0.1
Central	04 April 2005	3.7
"	28 July 2004	1.0
"	21 October 2004	0.3
North	04 April 2005	3.4
"	28 July 2004	0.6
"	21 October 2004	0.1

4.3 Zooplankton

Appendix IIA lists the zooplankton species present and their abundance at each sample site during each sampling period. Calanoid copepods dominated the zooplankton at all times. Numbers were relatively high[*] ranging from a low of a low of 23 per m^3 during April, to a high of 762 per m^3 during July. The abundance of immature copepods (copepodites and nauplii) followed that of the adult copepods. There was no evidence of a consistent difference in abundance between the three sample stations. A total of nine species of calanoid copepods were observed. Of these, *Pseudocalanus sp*., *Paracalanus sp*. and *Temora longicornis* were most abundant.

Two species of cladocerans, *Evadne sp. and Podon sp*., were also present, but abundant only during July. Other zooplankton species present included *Limacina sp.*, a pteropod, and *Oikopleura sp*., a tunicate. Both were abundant during July. A number of larvae were also observed of which *Balanus* nauplii (a barnacle) were the most common and abundant.

The only difference observed between the quantitative vertical tows (Appendix IIA) and the qualitative oblique tows (Appendix IIB) was that the latter included two additional species: *Obelia sp*., a gelatinous zooplankton, and *Tomopteris sp*. a pelagic polycheate, both of which were present in low numbers.

[*] Although there is considerable regional and interannual variability, copepod zooplankton numbers within the Bay of Fundy/Gulf of Maine system typically range from a low of about 50 per m^3, to a high of about 1000 m^3 (Durbin 1996).

Figure 4.2 illustrates the variation in the abundance of copepods and larvae among site and sample times.

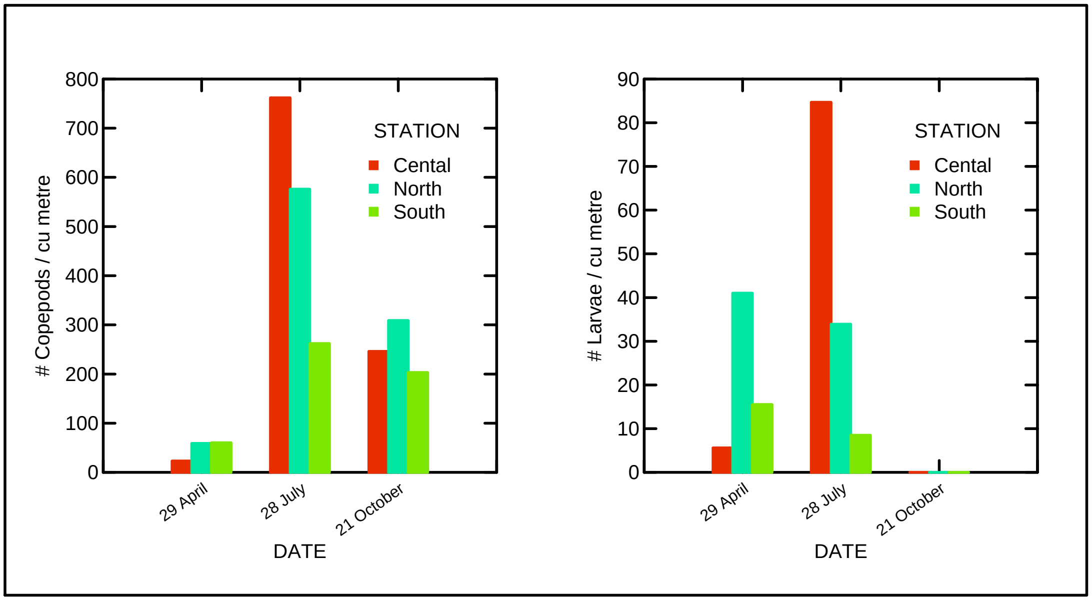

Figure 4.2 Abundance of copepods and larvae at each site during each sample period.

5. Discussion

The Gulf of Maine/Outer Bay of Fundy* is a very dynamic system characterized by high mixing rates and strong currents. Durbin (1996) characterized the area as having four hydrographically distinct regions: the Central Gulf region; shallow offshore banks such as Georges Bank; well-mixed coastal regions; and estuarine regions where freshwater inputs reduce salinities. Each of these regions contains a distinct plankton community. The Whites Point area falls within Durbin's well-mixed coastal region which is transitional between the estuarine and central Gulf areas.

Early studies of zooplankton abundance and distribution within the Bay of Fundy have been carried out by Fish and Johnson (1937) and Sameoto (1977). A number of other zooplankton surveys within the Bay have been carried out as part of larger surveys that have focused on larval fish (Daborn 1996). Two more recent surveys (Corey and Milne 1987; Brown and Gaskin 1989) within the Bay have included the region along the shoreline of Digby Neck and reported results very similar to the present survey.

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* The outer Bay of Fundy is typically defined as the area southwest of a transect from Digby, N.S to St. John, N.B.

Estuarine species, as well as the species most prominent in the central Gulf of Maine, are present but occur in low numbers. The zooplankton community along the Digby Neck shoreline is dominated by species that are common to the southwest Nova Scotia shoreline, such as *Acartia sp*., *Calanus finmarchicus, Oithona sp*., *Pseudocalanus sp*., and *Temora longicornis* and it is likely that many of these species are transported to this area by tidal currents. This region also tends to have higher concentrations of zooplankton than the central Gulf area as a result of upwelling systems that bring in nutrient rich waters (Townsend 1991). This is reflected in this survey by the high chlorophyll *a* concentrations observed during the spring survey and the corresponding relatively high zooplankton numbers observed.

Populations of euphausiids, a major food item of whales, are common within the Bay of Fundy, but are typically located in areas where depths range between 125-200 metres. They are not commonly found in large numbers along the Southwest Nova Scotia shelf (Kulka et al. 1982), but there have been some reports of populations being present during summer off Briar Island, just south of Digby Neck (Brown and Gaskin 1989). No euphausiid species were observed in this survey and it is unlikely that they would be abundant or common to the Whites Point area because of the shallow water depths.

Gelatinous zooplankton, particularly the ctenophore *Pleurobrachia pileus*, are common within the Gulf of Maine/Bay of Fundy system, but few were observed in this survey. Milne and Corey (1986), in a survey of ctenophore distribution carried out over an 8-year period, found that the centre of abundance for ctenophores in this region is located over the southwest Nova Scotia shelf, and that an area of secondary abundance, maintained by immigration from the shelf region, occurs within the Grand Manan region. The area along the Whites Point shoreline is on the very outer fringe of the Grand Manan which may explain the absence of ctenophores observed in this survey.

The Bay of Fundy has been long known as an area in which a number of harmful algal species are common. The most common species are the dinoflagellate *Alexandrium sp*. and the diatom *Pseudo-nitzschia sp*., both of which were observed in this survey. Blooms of *Alexandrium sp*., which produces a PSP toxin, are common and on numerous occasions blooms of this species have reached cell concentrations as high as 10,000 per litre (Martin et al. 2001). *Mesodinium rubren* is another dinoflagellate that is also common within the Bay of Fundy and was observed in this survey. Although this species is not known to produce toxins, it can produce red tides that result in depletion of dissolved oxygen in areas where tidal mixing is weak and flushing rates are low. This has occurred in areas within Passamaquoddy Bay and resulted in mortality of cage-reared salmon.

The phytoplankton and zooplankton community along the Whites Point shoreline appears to be typical of what has been observed in other plankton surveys carried out in this region. In terms of species composition, none of the species present were unexpected. In terms of abundance, numbers were similar to that reported for other surveys. Based on comparisons with the results of other plankton surveys, there does not appear to be any unique characteristics associated with the plankton community along this shoreline.

6. Acknowledgements

The competent help of Captain Gregg Tidd, from whose boat the plankton survey was carried out, is gratefully acknowledged.

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APPENDIX I
Phytoplankton Species Composition and Abundance
(numbers are per litre)

Species	29-Apr-05			28-Jul-05			21-Oct-05		
	South	Central	North	South	Central	North	South	Central	North
Dinoflagellates									
Alexandrium sp.				200	40				
Amphidinium carterae								40	
Amphidinium sphenoides	40				40				
Ceratium longipes						80			
Ceratium tripos				400	440	240		80	
Dinophysis norvegica							20		
Gyrodinium spp.				80					
Heterocapsa triquetra				40		80			
Minuscula bipes				40					
Protoperidinium sp.				40					
Total No Dinoflagellates	**40**	**0**	**0**	**800**	**520**	**400**	**20**	**120**	**0**
Diatoms									
Actinoptychus senarius				80				160	
Asterionellopsis kariana	240	480	240						
Attheya spp.	40	120	40			40			
Chaetoceros affinis									
Chaetoceros borealis									20
Chaetoceros compressus	560	1440	480						
Chaetoceros convolutus	40	160	40						
Chaetoceros convolutus		80	80	120	80	40			
Chaetoceros danicus				40					
Chaetoceros debilis	960	1200	1440	360	600	200			
Chaetoceros decipiens	40	120	80	40					
Chaetoceros didymus				160	360	200			
Chaetoceros filiformis					80				
Chaetoceros ingolfianus		240	240		40				
Chaetoceros laciniosus					40				
Chaetoceros lorenzianus					40				
Chaetoceros radicans	160	40		160	440	80			
Chaetoceros similis					160	120			
Chaetoceros simplex		40		80	240				
Chaetoceros socialis	7520	9080	4960						
Chaetoceros spp.	5320	16560	9160	4680	3360	1920			
Chaetoceros spp.				80	40				
Chaetoceros subtilis		80	40	80	80	40			
Chaetoceros teres				80		160			
Corethron criophilum					80	40	20		20
Coscinodiscus sp.								120	
Cylindrotheca closterium		80	120	440	1120	360	220	280	140
Dactyliosolen fragilissimus				440	520	480			

Eucampia zodiacus				40	40	80			
Guinardia delicatula				40	40				
Helicotheca tamesis								1360	
Leptocylindrus danicus		80		960	280	200			
Leptocylindrus minimus				120	40	200			
Licmophora abbreviata	40		40						
Navicula sp.				40		40			
Odontella aurita									
Paralia marina								400	
Pleurosigma strigosum									
Porosira glacialis	4760	4440	1960						
Pseudo-nitzschia delicatissima	40	160	40	5800	7880	6640		160	
Pseudo-nitzschia seriata				400	520	120			
Rhizosolenia hebetata	80	360	400	440	440	360			
Skeletonema costatum	7160	9440	6000	320	400	240	60		120
Thalassionema nitzschioides	40	40					40	880	60
Thalassionema nitzschioides				280	400	240			
Thalassiosira auguste-lineata	40								
Thalassiosira gravida	120	240	40						
Thalassiosira nordenskioeldii	1120	1160	2080						
Thalassiosira spp.	880	1720	760						
Thalassiosira spp. (tiny)	40	400	320						
Total No Diatoms	**29200**	**47760**	**28560**	**15280**	**17320**	**11800**	**340**	**3360**	**360**
Others									
Dictyocha speculum	40	80	40	80	40		240	1040	60
Eutreptia / Eutreptiella				80	80			40	
Laboea sp.	40			440	40	40		160	
Mesodinium rubrum	1240	160		4520	1360	600	100	400	
Notholca sp.	80				40	40		40	
Phaeocystis pouchetii		40						200	
Tintinnids	280	80		120	240		80	360	
Total No Others	**1680**	**360**	**40**	**5240**	**1800**	**680**	**420**	**2240**	**60**
Total Number of All Species	**30920**	**48120**	**28600**	**21320**	**19640**	**12880**	**780**	**5720**	**420**

APPENDIX IIA
Zooplankton Species Composition and Abundance Collected in the Vertical Tows
(numbers are individuals per cubic metre)

SPECIES	29-Apr-04			28-Jul-05			21-Oct-05		
	Station			Station			Station		
	S1	C1	N1	S2	C2	N2	S3	C3	N3
Adult Calanoid Copepods									
Acartia	21.2		8.5	12.7	50.8	25.4	12.7	19.1	45.1
Calanus finmarchicus	1.5	0.9	4.2	8.5	59.4	59.3	19.1	6.4	1.4
Centropages	12.0			8.5		25.4	38.1	36.0	50.8
Eurytemora				8.5	42.4	59.3			
Microsetella			1.4					4.2	4.2
Oithona	14.1	9.4	32.5	63.5	118.5	67.8	127.1	55.1	77.6
Pseudo/ Paracalanus	11.3	2.8	12.7	29.6	160.9	177.9	112,2	118.6	118.6
Temora longicornis				131.3	330.4	160.9	2.1	6.4	8.5
Tortanus		9.4					4.2		2.8
Total Adult Copepods	**60.1**	**23.4**	**59.3**	**262.6**	**762.4**	**576.0**	**203.3**	**245.8**	**309.0**
Immature Copepods				567.5	1194.4	1168.9	122.8	103.8	118.6
Cladocerans									
Evadne				4.3	33.9	8.5	4.2	2.1	
Podon				216.0	465.0	185.4		2.1	4.2
Total Cladocerans	**0.0**	**0.0**	**0.0**	**220.3**	**498.9**	**193.9**	**4.2**	**4.2**	**4.2**
Others									
Limacina				12.7		50.8	2.1		
Oikopleura				63.5		186.4			1.4
Parasagitta	1.4								
Total Others	**1.4**	**0.0**	**0.0**	**76.2**	**0.0**	**237.2**	**2.1**	**0.0**	**1.4**
Larvae									
Balanus nauplii	11.3	3.8	31.1	8.5	33.9	25.4			
Crab zoea					8.5				
Decapod larvae		0.9			25.4	8.5			
Polychaete larvae	4.2	0.9	9.9		16.9				
Total Larvae	**15.5**	**5.6**	**41.0**	**8.5**	**84.7**	**33.9**	**0.0**	**0.0**	**0.0**

APPENDIX IIB
Zooplankton Species Composition Collected in the Oblique Tows

SPECIES	29-Apr-04			28-Jul-05			21-Oct-05		
	Station			Station			Station		
	S1	C1	N1	S2	C2	N2	S3	C3	N3
Calanoid Copepods									
Acartia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Calanus finmarchicus	✓	✓	✓	✓	✓	✓	✓	✓	✓
Centropages							✓	✓	✓
Eurytemora				✓	✓	✓			
Microstella								✓	
Oithona	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pseudo/ Paracalanus	✓	✓	✓	✓	✓	✓	✓	✓	✓
Temora longicornis				✓	✓	✓	✓	✓	✓
Tortanus									✓
Cladocerans									
Evadne				✓	✓	✓			✓
Podon				✓	✓	✓			✓
Others									
Limacina				✓	✓	✓			✓
Obelia							✓		✓
Oikopleura				✓	✓	✓			
Tomopteris				✓	✓	✓	✓		✓
Larvae									
Balanus nauplii	✓	✓	✓		✓	✓			
Crab zoea					✓	✓	✓		