Chapter 8.1

Analysis of phytoplankton populations in the Maryland Coastal Bays

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Abstract

Phytoplankton populations were analyzed for current status (2001-2003) as well as long-term trend (1983-2003) at several Coastal Bays water monitoring stations. Status was assessed for the winter, spring, summer, and fall seasons, while trends were assessed for July, August, and September only. For the Coastal Bays overall, phytoflagellates, diatoms, and dinoflagellates dominated spring and summer seasons from 2001 through 2003. The fall was strongly dominated by phytoflagellates, with diatoms and cryptophytes also appearing at relatively high levels. Highest diversity was observed during winter when samples were dominated by phytoflagellates and diatoms. Status at individual stations varied. Trend analyses indicated an overall reduction in phytoplankton abundance in the St. Martin River, while phytoplankton density increased in tributaries of the Isle of Wight Bay. Blue-green algae declined, while raphidophyte populations increased, in Newport Bay and the upper tributaries of the St. Martin River.

Introduction

Phytoplankton**,** or algae, are a natural and critical part of aquatic ecosystems. Algae, like terrestrial plants, capture the sun's energy and support the food web that leads to fish and shellfish. They occur in a size range from tiny microscopic cells floating in the water column (phytoplankton) to large mats of visible macroalgae that grow on bottom sediments.

Presently, there are fourteen stations sampled for phytoplankton in the Coastal Bays (Figure 8.1.1). Phytoplankton sampling in the Coastal Bays began in 1983 as part of an intensive survey to assess nutrient loading to the St. Martin River. This survey was performed in the summer on slack tide. In 1992, the survey was repeated to assess the expansion of the Ocean Pines sewage treatment plant (STP) on the St. Martin River. In 1998, tributaries considered to have similar chemistry to those where *Pfiesteria* was found in 1997 were sampled, including the St. Martin River and Trappe/Ayer's Creek watersheds in the Coastal Bays. There were three phytoplankton stations in each of the watersheds. In 2001, routine Coastal Bays sampling began and that initiative added seven stations for phytoplankton identification. There were two stations in Isle of Wight Bay, two in Chincoteague Bay, and one in each of Turville Creek, Manklin Creek, and Marshall Creek. All of these stations were sampled monthly throughout the entire year. In 2003, six of these stations were sampled weekly from May until the end of October. The subset included DNR fixed-monitoring stations TRC0043, AYR0017, NPC0012, MSL0011, TUV0011, and XDM4486 (Figure 8.1.1). This sampling was initiated to track harmful algal species in the Coastal Bays.

Indicator: None (*draft*: presence/ dominance of bluegreens)

Data sets

Data for phytoplankton trends were restricted to samples collected from July, August, and September. The data for Marshall Creek (MSL0011) was limited to three years with 16 samples collected, but 88 percent of those samples (14) were collected in 2003. Data from Turville Creek (TUV0011) and Manklin Creek (MKL0010) were collected over four years with 22 and 10 samples collected, respectively. Seventy percent of those samples that were collected in Turville Creek were collected in 2003. Data for Isle of Wight Bay (XDN3445), Assawoman Bay (XDN6454), and Chincoteague Bay (XDN5932 and XBM1301) were limited, starting in 2001 with nine samples for each location over three years. Data for Trappe Creek (TRC0043) and Ayers Creek (AYR0017) spanned six years with 30 samples collected. Data for the St. Martin River spanned eight years with 72 samples collected from five stations. The data record was not continuous over the eight years of sampling. Samples were collected in 1983 and 1992 at the same stations, then 1998 through 2003 at another set of stations. In addition, phytoplankton counts were conducted seasonally from 2001 through 2003 on samples collected from selected fixed-station water quality monitoring stations (see Section 4 and Figure 8.1.1). These counts were reviewed to assess three-year status of phytoplankton populations at the station and segment levels.

Analyses

Samples collected in plastic liter bottles were analyzed within 48 hours following sampling. One-milliliter (ml.) aliquots of the unpreserved (i.e. live), mixed samples were placed in a Sedgewick-Rafter plankton counting cell and allowed to settle for 15 minutes. Identification and counting were done with an Olympus phase-contrast compound microscope at 200X magnification. A single strip count was made. The perimeters and diagonals of the counting cell were then examined for any additional plankton forms not encountered in the strip count. These were recorded as present at cell densities of one. When necessary for identification of smaller forms, samples were examined under higher magnification. Significant blooms may have been treated with preservative on the counting chamber after identification from the live material to better estimate the densities.

Status of phytoplankton populations

Results of phytoplankton analyses for each bay segment by station follow:

Assawoman Bay

XDN6454 - Chrysophytes dominated the community in spring and declined through the remainder of the year. Diatoms made their greatest contribution in winter and remained present at about ten to fifteen percent of the community the rest of the year. Phytoflagellates were dominant in summer and fall and were then significant community components of the winter and spring. Cryptophytes achieved their greatest contributions in fall, though they were not the dominant phytoplankton. *Chrysocromulina* contributed similarly in the fall. Cyanophytes were approximately five percent of the community in winter and were rare in other seasons (Figure 8.1.3).

XDN3445 – Chrysophytes represented 31 percent of the spring community with co-dominant phytoflagellates and moderate diatom contributions. Chrysophytes declined in importance through the remainder of the year. Diatoms achieved dominance (more than half of the community) in winter. *Chrysocromulina* was present during summer, fall, and winter, with greatest importance in autumn (29 percent). Cryptophytes and dinoflagellates were present at low importance from summer into winter (Figure 8.1.4).

St. Martin River

XDN4797 – Diatoms were the winter and spring dominant plankton with persistent presence in summer and fall. Phytoflagellates dominated the summer. Cryptophytes were the dominant form of algae in the fall with nearly even contributions of chrysophytes, diatoms, and phytoflagellates comprising most of the rest of the autumn community. Cyanophytes contributed small proportions to the community in all seasons with greatest abundance in the summer (roughly five percent) (Figure 8.1.5).

XDM4486 – Diatoms were the winter and spring dominants, declining in importance in summer and fall. Phtyoflagellates comprised more than half of the summer community. Cryptophytes dominated in fall with significant contributions from the chrysophytes and phytoflagellates. Cryptophytes remained important in the winter. Cyanophytes were present in summer less than five percent at the same time raphidophytes (at roughly two percent of the time) were the most abundant (Figure 8.1.6).

XDN4312 - Diatoms were the winter and spring dominant plankton with persistent presence in summer and fall. Phytoflagellates dominated the summer. Cryptophytes were the dominant form of phytoplankton in the fall with nearly even contributions of chrysophytes, diatoms, and phytoflagellates comprising most of the rest of the fall community. Cyanophytes contributed small proportions to the community in all seasons with greatest abundance in the winter (roughly five percent). Winter showed greater representation of more rare components of the community (e.g., *Pyramimonas, Chrysochromulina,* Dinoflagellates) (Figure 8.1.7).

Isle of Wight Bay

TUV0016 – No winter data was collected at this station. Chrysophytes were dominant in spring (greater than fifty percent) with diatoms and phytoflagellates evenly contributing to the remainder of the community. Phytoflagellates dominated in summer with diatoms and chrysophytes evenly contributing the remainder of the summer community. Phytoflagellates comprised approximately 80 percent of the fall community at this location (Figure 8.1.8).

TUV0011 – Chrysophytes dominated the spring followed by phytoflagellates and diatoms in abundance as well. Phytoflagellates dominated in summer (62 percent) with important contributions from diatoms, chrysophytes, and, to a lesser degree, dinoflagellates. Phytoflagellates remained dominant in the fall with important contributions from diatoms, cryptophytes, and *Chrysocromulina*. Winter was dominated by phytoflagellates, but diatoms reached their greatest contribution of the year as co-dominants. Cyanophytes and chrysophytes were well represented in winter (Figure 8.1.9).

Newport Bay

TRC0043 – Diatoms dominated the spring with important contributions from cyanophytes and phytoflagellates and minor contributions from greens and chrysophytes. Phytoflagellates dominated in summer with diatoms and lesser contributions from chrysophytes and cyanophytes. Phytoflagellates dominated the fall but cryptophytes made their greatest contribution of the year. *Chrysocromulina* and dinoflagellates were common, though small, components of the community. Winter was co-dominated by diatoms and phytoflagellates, and greens were a small but significant component (Figure 8.1.10).

NPC0012 – This station was dominated by phytoflagellates year-round. Diatoms contributed their greatest percentage during winter, but varied little in their relative contribution across all seasons at this location. Chrysophytes had their greatest presence in spring and summer and were represented at lower levels in fall and winter. Cryptophytes and *Chrysocromulina* were best represented in autumn but were relatively minor with respect to dominance. Dinoflagellates were also relatively small contributors to the community in fall and winter. Cyanophytes were notably abundant during winter, nearly co-dominant with phytoflagellates. Cyanophytes remained persistent in the community, though as relatively minor contributors, during spring, summer, and fall (Figure 8.1.11).

MSL0010 – Cyanophytes made their strongest presence year-round at this site, but were never greater than 19 percent (spring). Phytoflagellates dominated the summer and fall, diatoms co-dominated with phytoflagellates in winter. Raphidophytes were best represented among the surveyed sites in this analysis; they were small components (two to three percent) of the spring and summer communities. Chrysocromulina were also important in the spring (the only site where this was evident) and to a lesser degree in the fall. Cryptophytes and greens were among the lesser representatives in the community during fall, winter, and spring. Chrysophytes were best represented in the summer but vary relatively little across seasons in the contribution to the overall community (Figure 8.1.12).

MKL0010 – Diatoms co-dominated with phytoflagellates in winter and were important during spring along with phtyoflagellates and chrysophytes. Diatoms were common to the summer and fall seasons. Cryptophytes made their strongest appearance in the fall, though only eight percent, and smaller contributions in summer and winter. Dinoflagellates were minor components of the summer, fall, and winter seasons. Cyanophytes made their greatest contributions in winter, though they were only seven percent of the community (Figure 8.1.13).

Chincoteague Bay

XBM5932 – Chrysophytes dominated in the spring, making up nearly half of the community and declining in importance through the remainder of the year. Winter season was the most diverse, with diatoms co-dominant with phytoflagellates and *Chrysocromulina*. Cyanophytes were strongest contributors in the winter making up about 12 percent of the community. Cryptophytes made their greatest contribution in the fall, but only contributed three to four percent and were lesser contributors in winter (Figure 8.1.14).

XBM1301 – Phytoflagellates co-dominated with diatoms in summer and fall. Spring was dominated by phytoflagellates, with secondary dominance divided between chrysophtes and diatoms. Cryptophytes made their greatest contribution in the fall, but only contributed three to four percent and were lesser contributors in summer and winter. Winter was again the most diverse season, with important contributions from *Chrysocromulina* and cyanophytes (Figure 8.1.15).

Trends in phytoplankton populations

The analysis of the phytoplankton community included data from July, August, and September. Variables for each station included abundance of cells per milliliter for Cyanophyta, Chlorophyta, Bacillariophyta, Pyrophyta, Raphidophyceae, Chrysophyceae, Cryptophyceae, Prymnesiaceae, Prasinophyceae, and total number. Results of the analysis by segment are described below.

St. Martin River

Phytoplankton data from the St. Martin River based primarily on cell densities showed an enriched condition in the upper river with gradually diminishing enrichment downriver. This was apparent for all years. The upper most station (Table 8.1.1) was more affected by high flow then downstream stations (Tables 8.1.2 and 8.1.3).

There was an average overall reduction of 85% in total phytoplankton cell counts from 1983-2003 (Tables 8.1.1-8.1.3).

Major groups of phytoplankton for the seven years of sampling were similar. Five taxonomic groups dominated 88 percent of the samples (72). They were, unidentified microflagellates (45%), *Paulinella ovalis* (24%), *Cyclotella* (8%), *Cylindrotheca closterium* (8%), and *Oscillatoriaceae* (4%).

The data suggested blue-greens were reducing at stations XDM4486 (Figure 8.1.16). The data also suggested Raphidophyceae were increasing at stations XDM4486 (Figure 8.1.19).

<u>Isle of Wight Bay</u>

The data suggested phytoplankton density was increasing in both Manklin and Turville Creeks (Figures 8.1.22 and 8.1.23). This strength of the trend was limited by the small amount of data.

<u>Newport Bay</u>

The data suggested blue-greens were declining at stations TRC0043 (Figure 8.1.17) and AYR0017 (Figure 8.1.18). Raphidophyceae were increasing at stations NPC0012 (Figure 8.1.20) and MSL0011 (Figure 8.1.21).

Summary

Seasonal patterns in phytoplankton community dynamics of the Coastal Bays were investigated from community composition data (Figure 8.1.6). Diatoms achieved their greatest contributions most often during winter, their next greatest contribution in spring, and were less common components of the community in summer and fall. Chrysophytes made their greatest contributions in the spring and were at times and locations dominant before declining through summer, fall, and winter.

Chrysochromulina and phytoflagellates were strong, consistent components of the year-round Coastal Bays community, typically comprising 50 percent or more of the plankton in the summer season. These taxa made lesser but significant contributions throughout the remainder of the year.

Cryptophytes, a desirable food source for many dinoflagellates, were most frequently encountered in the fall, but rarely composed more than 8-10 percent of the community. Secondarily, they contributed around two percent of the summer and winter communities when present. Their low contributions overall may be a function of grazing pressures rather than low productivity.

Raphidophytes, involving species with the potential for toxin production and blooms that could affect living resources or occasionally human health, made their strongest showing and Marshall Creek during spring and summer and were otherwise rare. Cyanophytes were most commonly winter contributors to the plankton community and rarely made up greater than five percent of the community in any season. Common potentially toxic, summer bloom-forming cyanophytes such as *Microcystis*, *Anabaena* and *Aphanizomenon* appeared rarely, not unexpectedly since they prefer largely freshwater habitats that are uncommon to the Coastal Bays tributaries. Remaining groups (i.e., Greens, Ebria+, Pyramimosa+ groups) comprised infrequent and small contributions to the community. Unclassified cells occurred most frequently during the spring. Seasonally, winter tended to show the greatest diversity of groups represented in the analysis.

Table 8.1.1: Raw phytoplankton cell counts and percent change over time for one St. Martin River station.

St. Martin River - Total Count Per Ml.

XDM4486 - July

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	1,386,271			*Cyclotella*	Low
1992	20,271	-98.5377318		*Perdinium*	Average
1998	9,966	-99.28109295	0.491638301	*Nitzschia*	High
1999	15,529	-98.87980056	1.558197873	*Nitzschia*	Low
2000	19,769	-98.57394406	1.273037543	*Oscillatoriaceae*	Low
2001	38,479	-97.2242801	1.946431281	*Paulinella ovalis*	Low
2002	258,985	-81.31786642	6.730554328	Unidentified Flagellates	Low*
2003	41,965	-96.97281412	0.162036411	Unidentified Flagellates	High*
					*- Record

XDM4486 - August

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	1,228,441			Oscillatoriaceae	Low
1992	2,912	-99.76295158		Oscillatoriaceae	Average
1998	22,949	-98.13185981	7.880837912	*Paulinella ovalis*	High
1999	25,599	-97.91613924	1.115473441	*Paulinella ovalis*	Low
2000	10,815	-99.11961584	0.422477441	*Cyclotella*	Low
2001	150,310	-87.76416613	13.89828941	*Cyclotella*	Low
2002	345,322	-71.88941105	2.297398709	Unidentified Flagellates	Low*
2003	48,635	-96.0409169	0.140839564	Unidentified Flagellates	High*
					*- Record

XDM4486 - September

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	2,001,762			*Cyclotella*	Low
1992	18,536	-99.07401579		*Gyrodinium uncatenum*	Average
1998	17,225	-99.13950809	0.929272767	*Paulinella ovalis*	High
1999	107,060	-94.65171184	6.215384615	*Skeletonema*	Low
2000	63,813	-96.81215849	0.596048945	Unidentified Flagellates	Low
2001	6,148	-99.69287058	0.096344005	Unidentified Flagellates	Low
2002	112,399	-94.38499682	18.2822056	Unidentified Flagellates	Low*
2003	20,135	-98.99413617	0.179138604	*Gyrodinium uncatenum*	High*
					*- Record

Table 8.1.2: Raw phytoplankton cell counts and percent change over time for two St. Martin River stations.

St. Martin River - Total Count Per Ml.

XDN4506 + XDN4797 - July

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	280,340			*Cyclotella*	Low
1992	249,046	-11.16287365		Unidentified Flagellates	Average
1998	13,568	-95.16016266	0.054479895	*Nitzschia*	High
1999	12,296	-95.61389741	0.90625	*Pennales*	Low
2000	20,671	-92.62645359	1.68111581	*Paulinella ovalis*	Low
2001	4,082	-98.54391097	0.197474723	Unidentified Flagellates	Low
2002	112,908	-59.7246201	27.6599706	Unidentified Flagellates	Low*
2003	239,258	-14.65434829	2.11905268	Unidentified Flagellates	High*
					*- Record

XDN4506 + XDN4797 - August

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	256,039			Unidentified Flagellates	Low
1992	8,362	-96.73409129		*Katodinium rotundatum*	Average
1998	14,893	-94.18330801	1.781033246	*Nitzschia*	High
1999	18,391	-92.81710989	1.234875445	*Paulinella ovalis*	Low
2000	18,497	-92.77570995	1.005763689	*Paulinella ovalis*	Low
2001	16,749	-93.45841844	0.905498189	*Cyclotella*	Low
2002	43,938	-82.83933307	2.623320795	Unidentified Flagellates	Low*
2003	194,881	-23.88620484	4.435363467	Unidentified Flagellates	High*
					*- Record

XDN4506 + XDN4797 - September

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	134,085			Unidentified Flagellates	Low
1992	9,648	-92.80456427		*Paulinella ovalis*	Average
1998	19,133	-85.73069322	1.983105307	*Paulinella ovalis*	High
1999	27,348	-79.60398255	1.429362881	*Paulinella ovalis*	Low
2000	6,785	-94.93977701	0.248098581	*Paulinella ovalis*	Low
2001	6,890	-94.86146847	1.015475313	Unidentified Flagellates	Low
2002	5,777	-95.69153895	0.838461538	Unidentified Flagellates	Low*
2003	309,202	130.6014841	53.52293578	Unidentified Flagellates	High*
					*- Record

Table 8.1.3: Raw phytoplankton cell counts and percent change over time for two St. Martin River stations.

St. Martin River - Total Count Per Ml.

XDN4312+ XDN4118 - July

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	160,620			*Rhizosolenia*	Low
1992	179,287	11.62184037		Unidentified Flagellates	Average
1998	8,109	-94.95143818	0.045229158	*Nitzschia*	High
1999	8,056	-94.98443531	0.993464052	*Paulinella ovalis*	Low
2000	8,799	-94.52185282	1.092229394	*Paulinella ovalis*	Low
2001	2,120	-98.68011456	0.24093647	*Paulinella ovalis*	Low
2002	29,892	-81.38961524	14.1	Unidentified Flagellates	Low*
2003	130,645	-18.66205952	4.370567376	Unidentified Flagellates	High*
					*- Record

XDN4312+ XDN4118 - August

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	112,463			Unidentified Flagellates	Low
1992	7,145	-93.64679939		*Katodinium rotundatum*	Average
1998	13,303	-88.17122076	1.861861442	*Nitzschia*	High
1999	14,840	-86.80454905	1.115537849	*Paulinella ovalis*	Low
2000	17,543	-84.40109191	1.182142857	Unidentified Flagellates	Low
2001	13,568	-87.9355877	0.773413897	Unidentified Flagellates	Low
2002	14,893	-86.75742244	1.09765625	Unidentified Flagellates	Low*
2003	86,743	-22.86974383	5.824414154	Unidentified Flagellates	High*
					*- Record

XDN4312+ XDN4118 - September

DATE	COUNT	% CHANGE from 1983	CHANGE from Year to Year	DOMINANT TAXA	Rainfall
1983	121,676			Unidentified Flagellates	Low
1992	6,105	-94.98257668		*Paulinella ovalis*	Average
1998	11,448	-90.59140669	1.875184275	*Paulinella ovalis*	High
1999	19,879	-83.66234919	1.736460517	*Skeletonema*	Low
2000	8,109	-93.33557974	0.407917903	Unidentified Flagellates	Low
2001	5,777	-95.25214504	0.712418301	Unidentified Flagellates	Low
2002	7,526	-93.81472106	1.302752294	Unidentified Flagellates	Low*
2003	99,640	-18.11039153	13.23943662	Unidentified Flagellates	High*
					*- Record

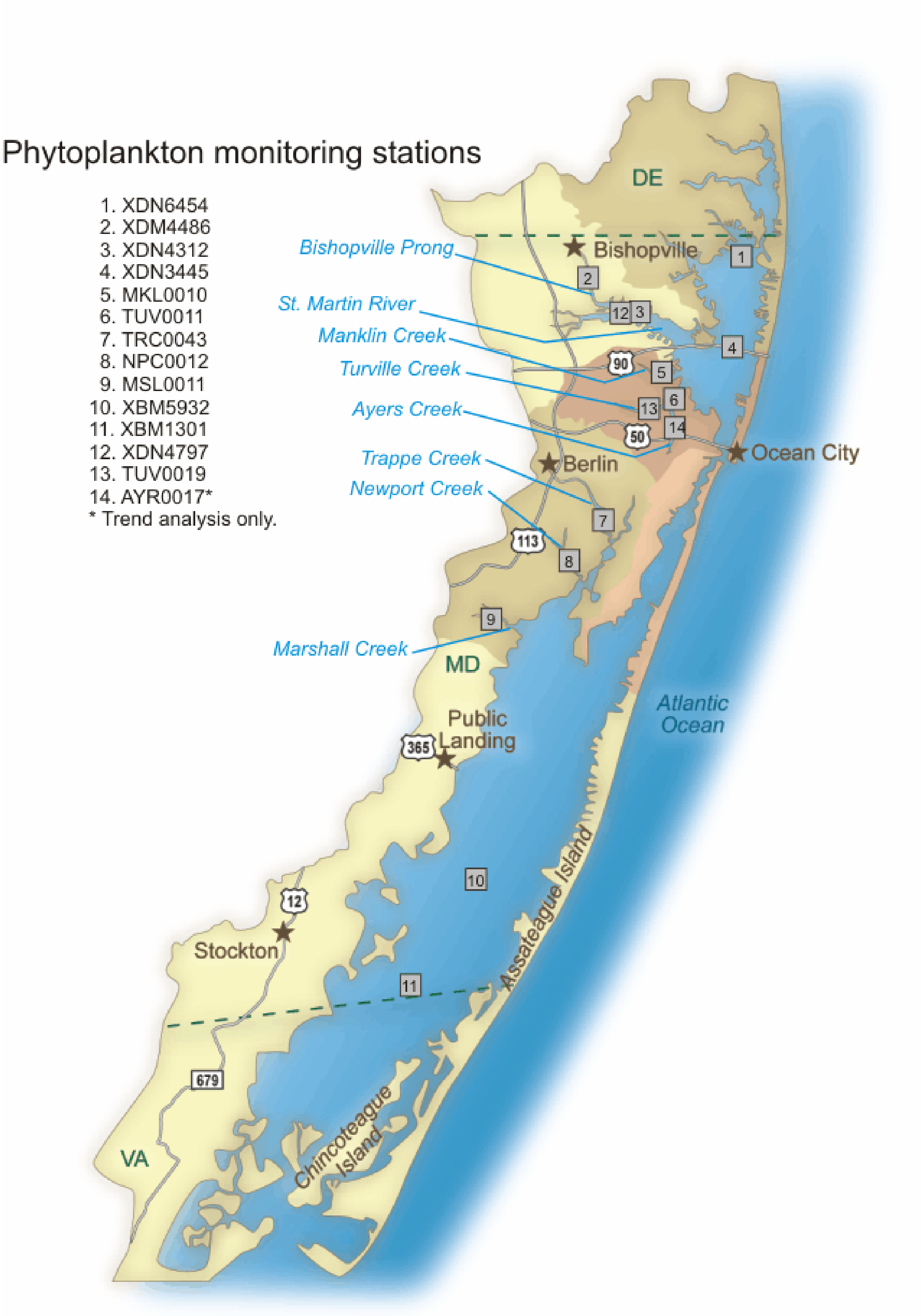

Figure 8.1.1: Location of Maryland Department of Natural Resources phytoplankton monitoring stations in the Maryland Coastal Bays.

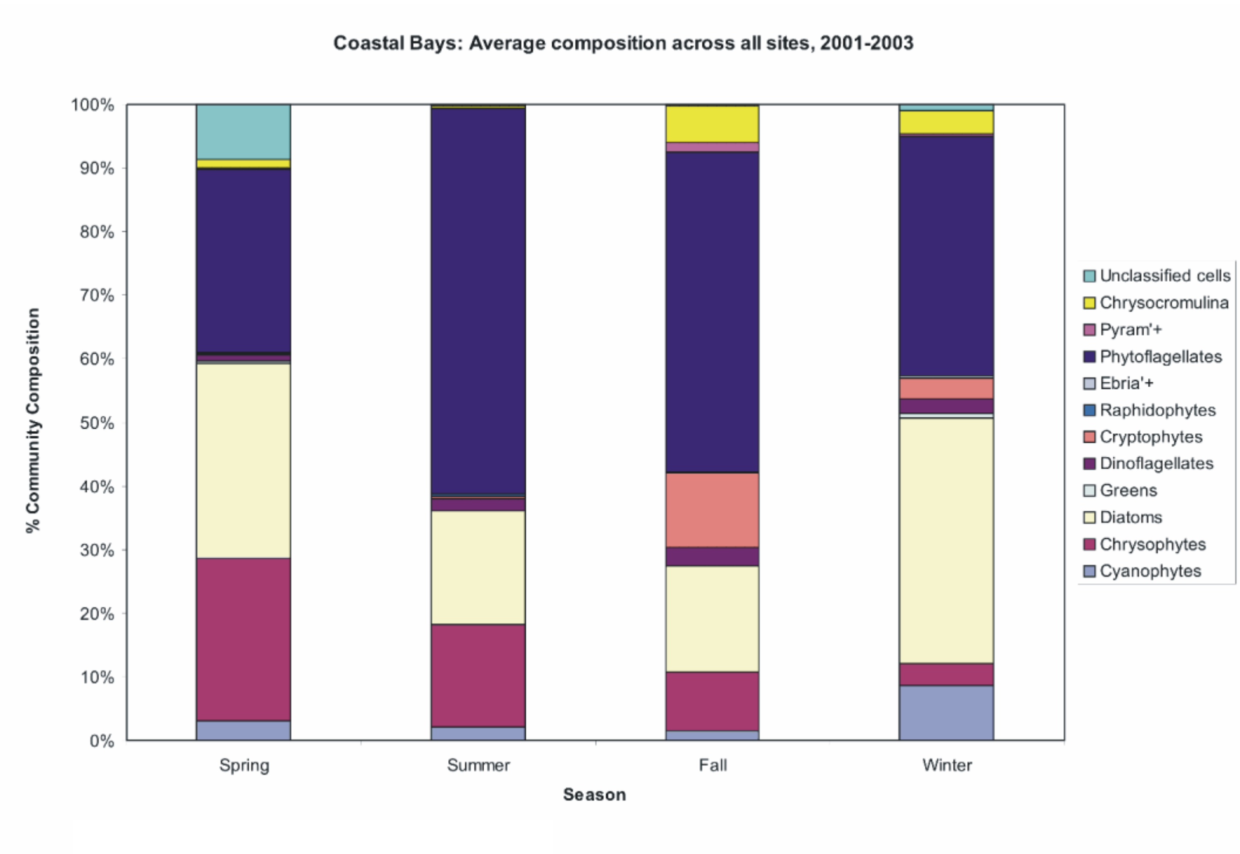

Figure 8.1.2: Total phytoplankton community over seasons.

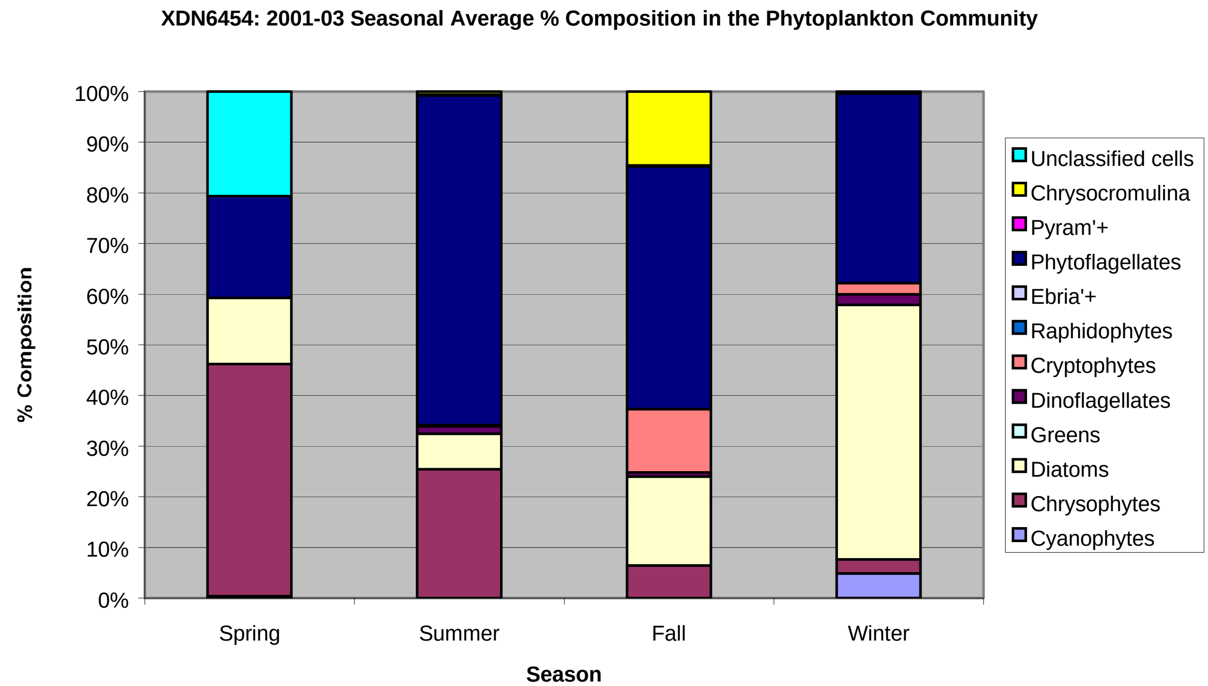

Figure 8.1.3. Phytoplankton community composition at station XDN6454 (Assawoman Bay).

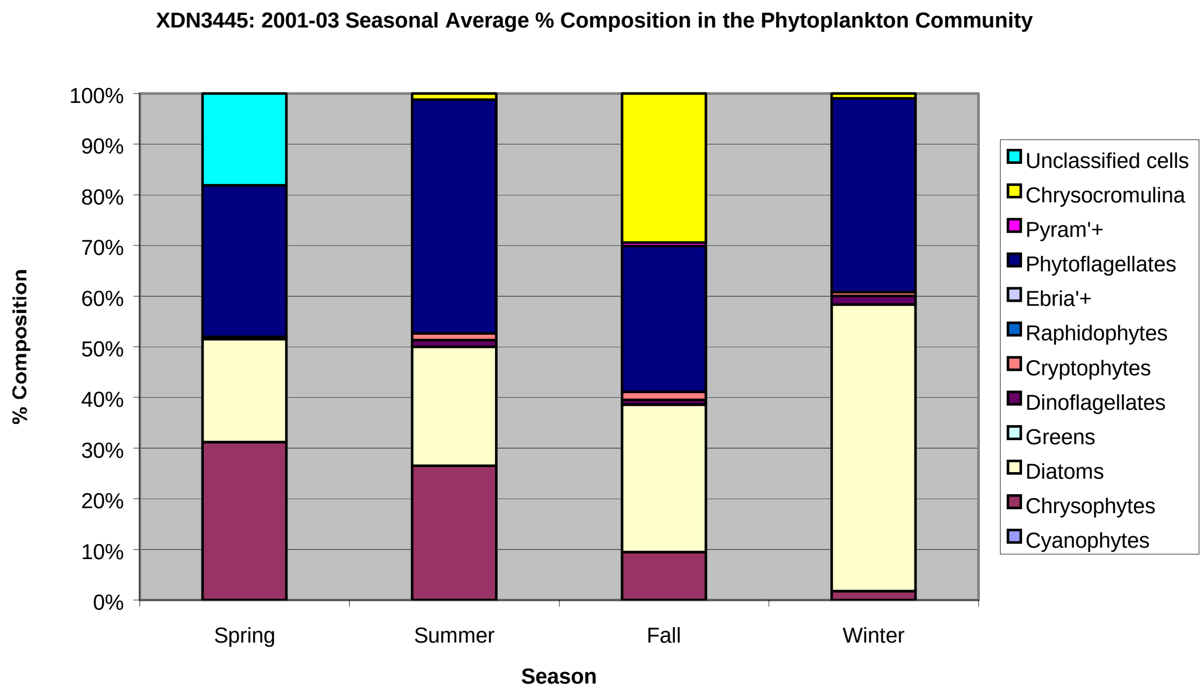

Figure 8.1.4. Phytoplankton community composition at station XDN3445 (Assawoman Bay).

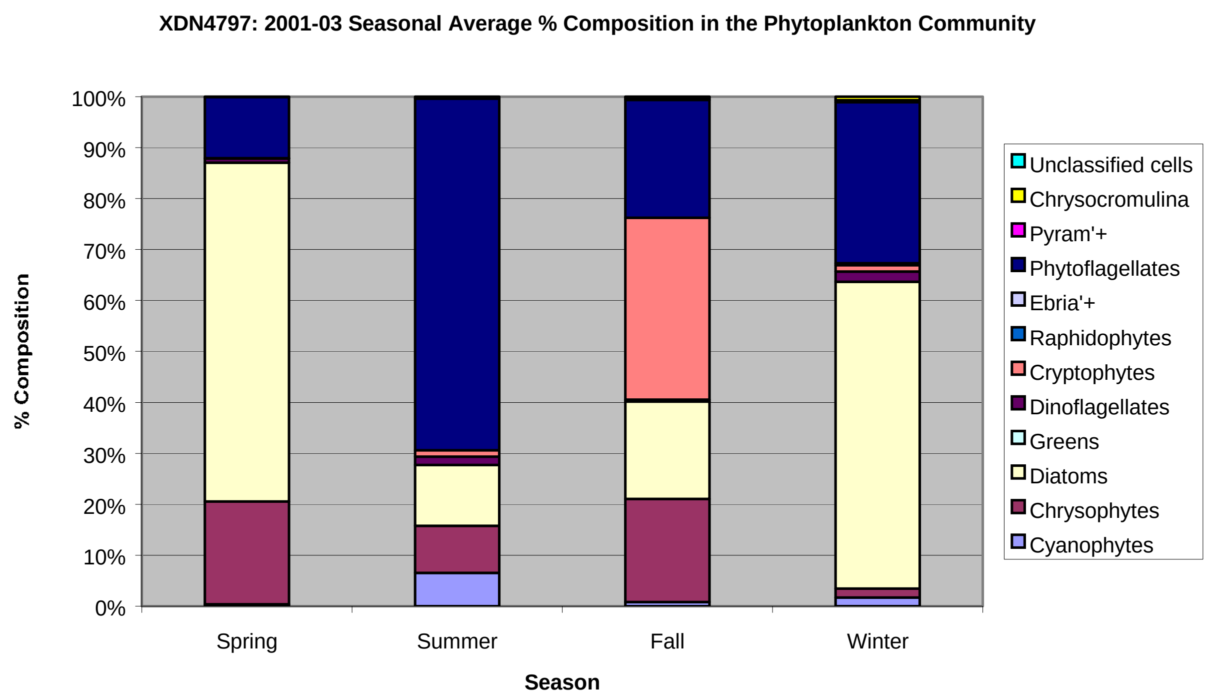

Figure 8.1.5. Phytoplankton community composition at station XDN4797 (St. Martin River).

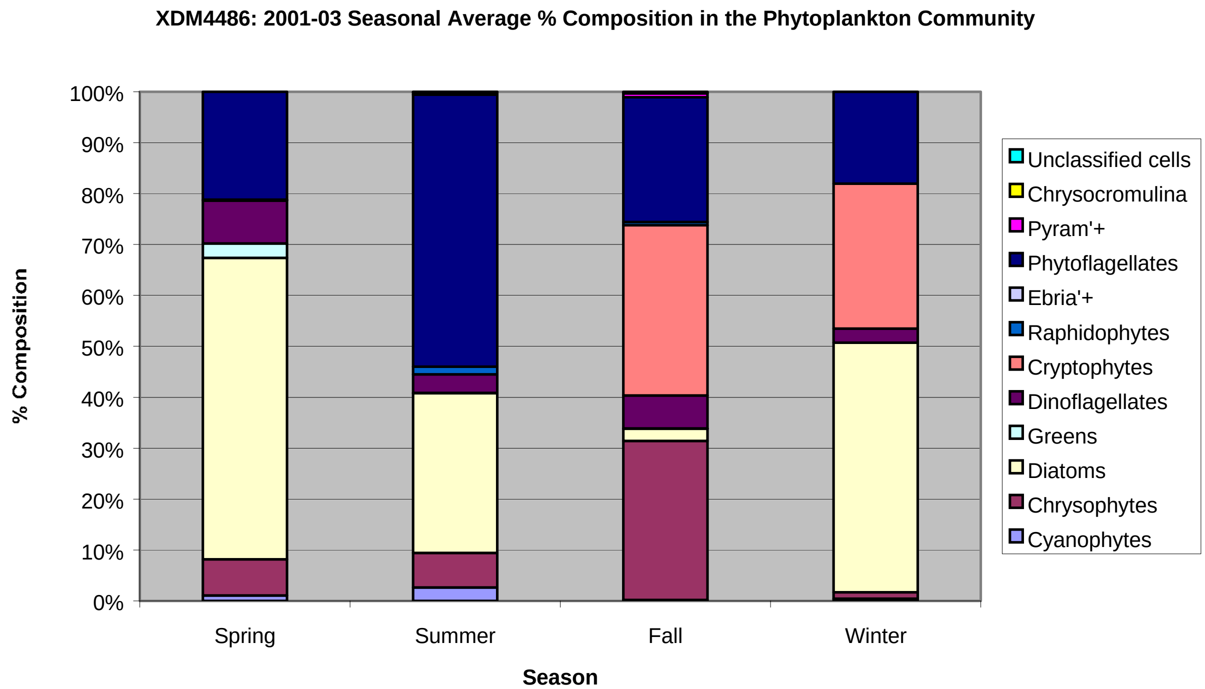

Figure 8.1.6. Phytoplankton community composition at station XDM4486 (St. Martin River).

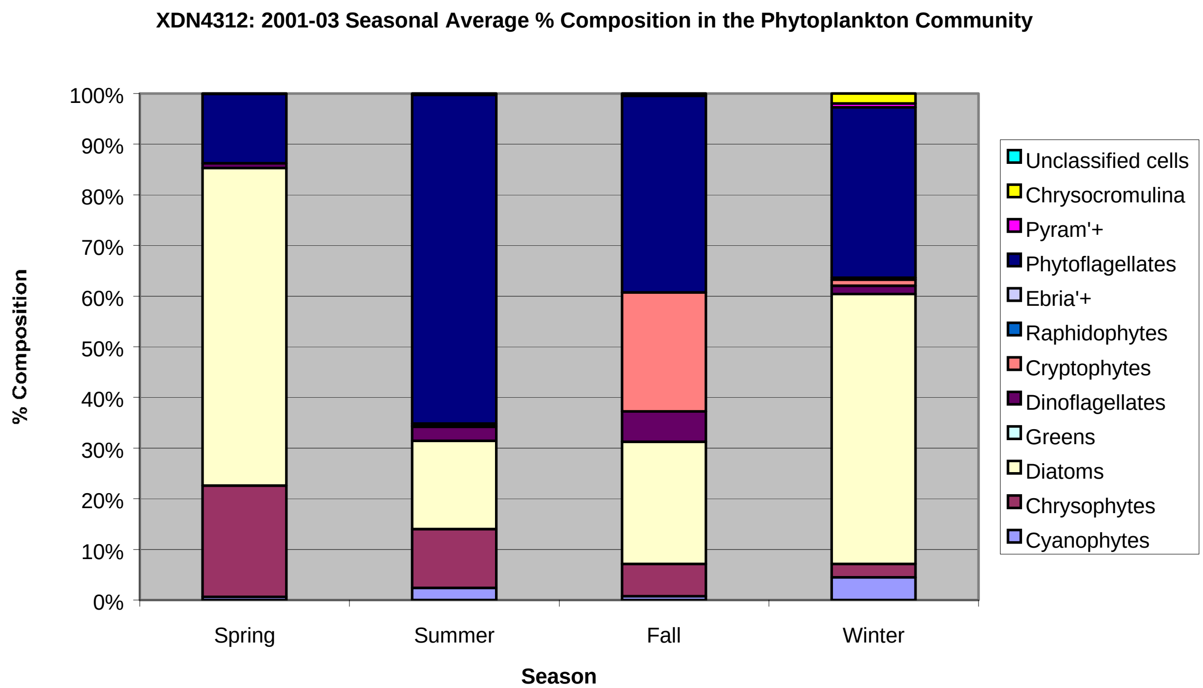

Figure 8.1.7. Phytoplankton community composition at station XDN4312 (St. Martin River).

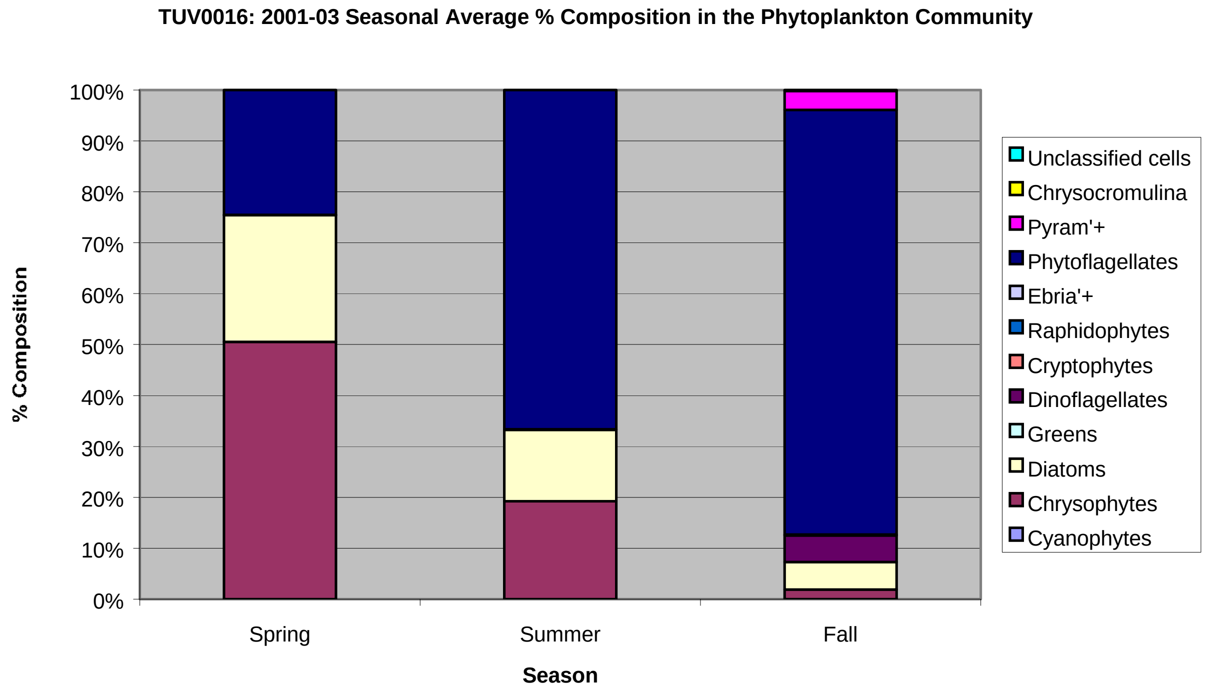

Figure 8.1.8. Phytoplankton community composition at station TUV0016 (Isle of Wight Bay).

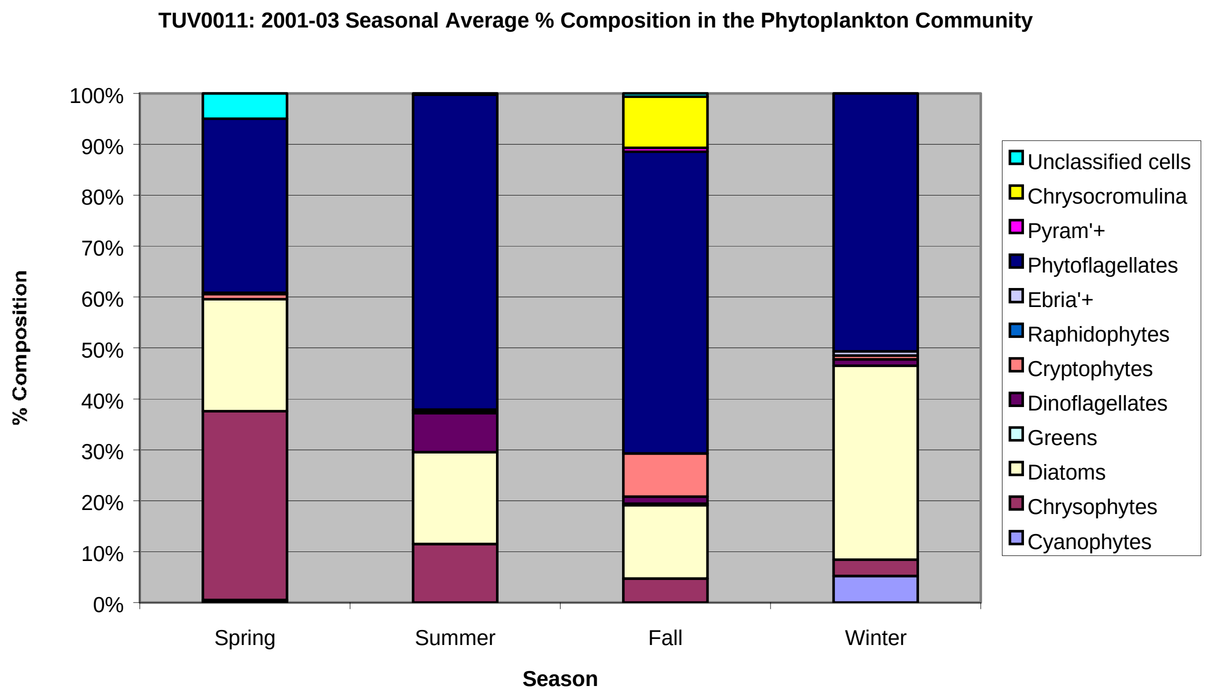

Figure 8.1.9. Phytoplankton community composition at station TUV0011 (Isle of Wight Bay).

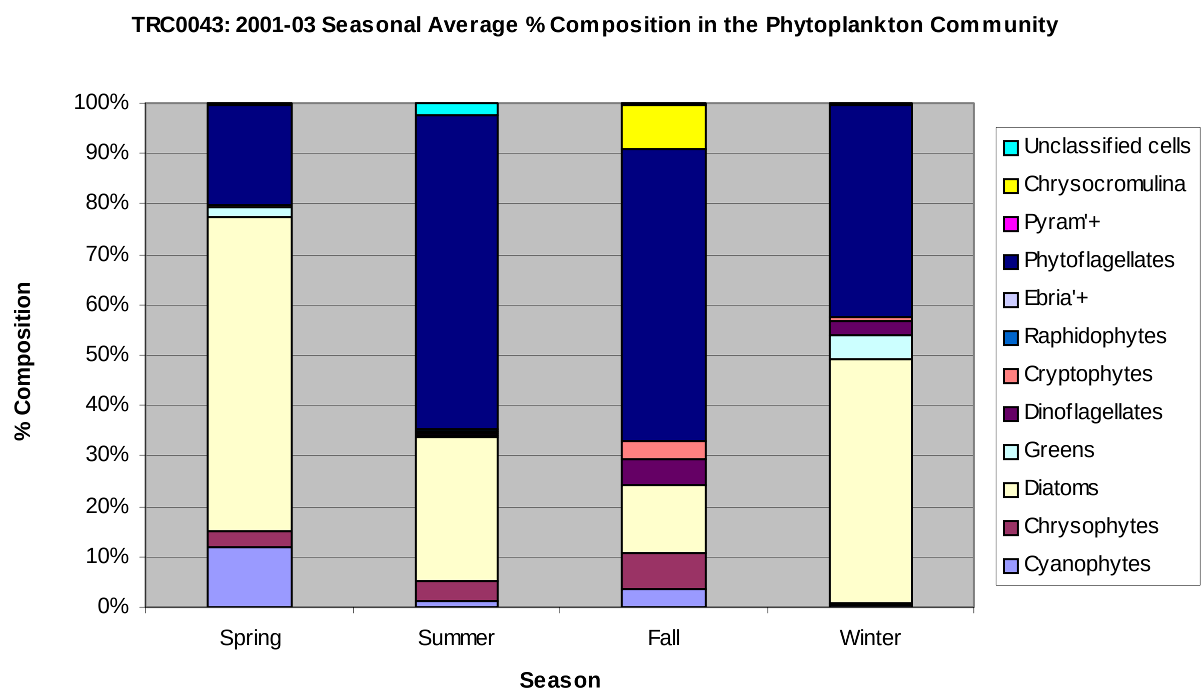

Figure 8.1.10. Phytoplankton community composition at station TRC0043 (Newport Bay).

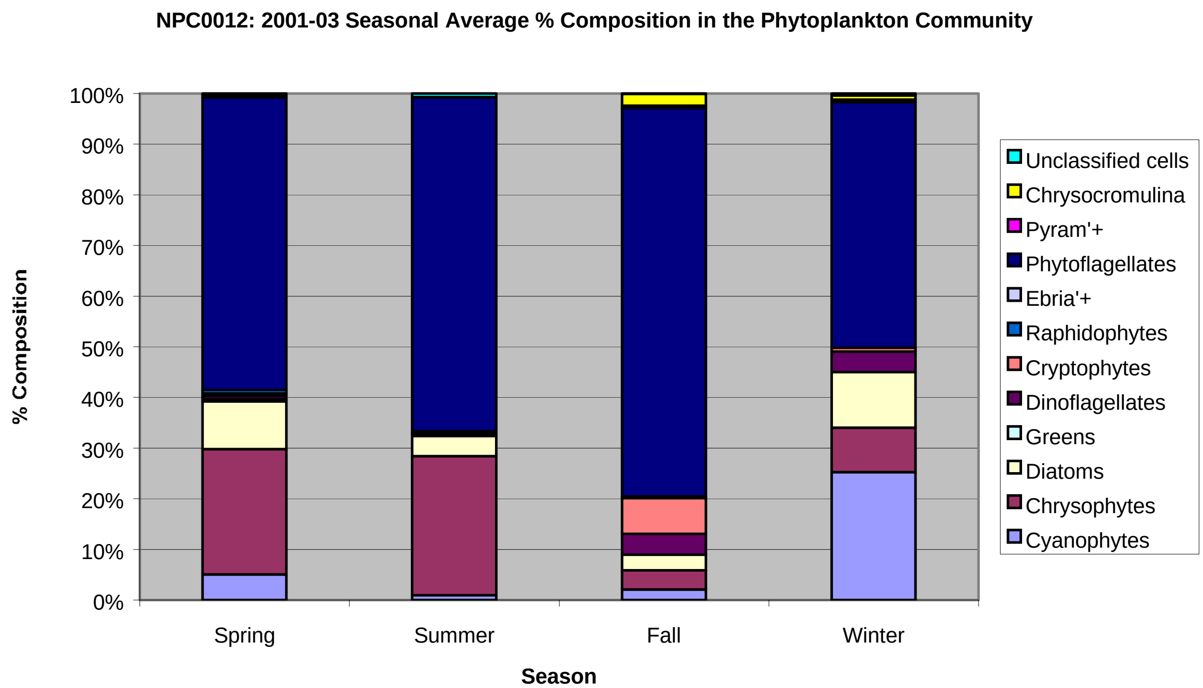

Figure 8.1.11. Phytoplankton community composition at station NPC0012 (Newport Bay).

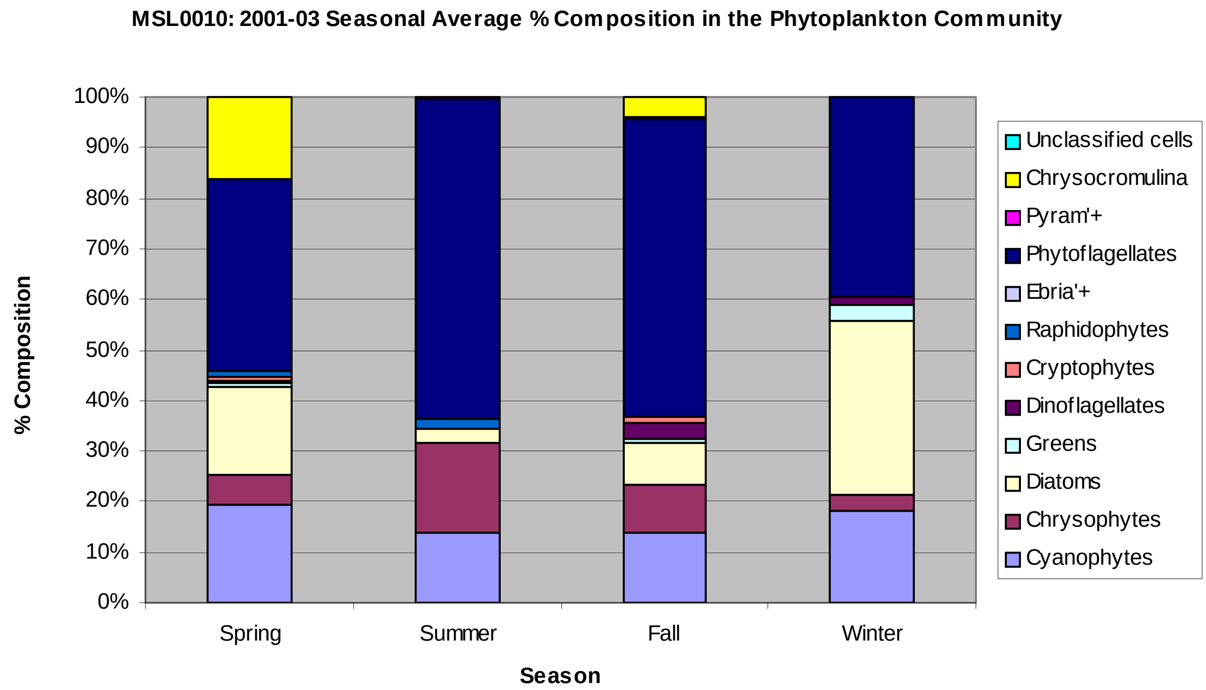

Figure 8.1.12. Phytoplankton community composition at station MSL0010 (Newport Bay).

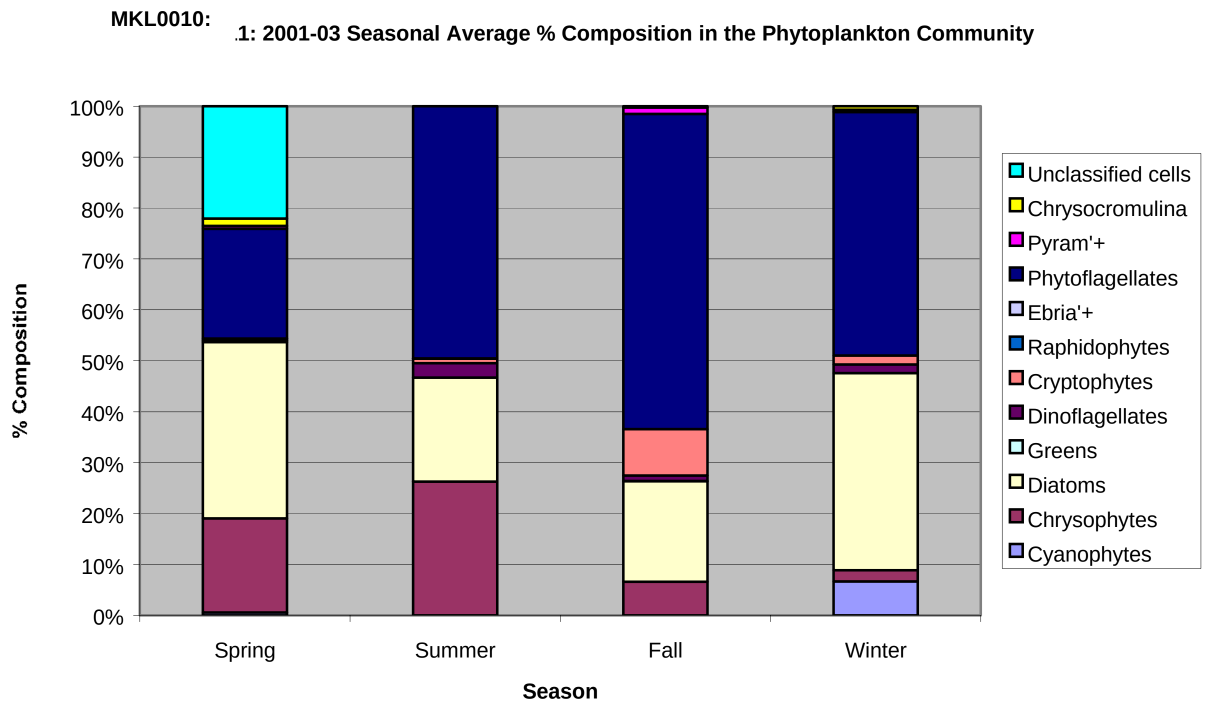

Figure 8.1.13. Phytoplankton community composition at station MKL0010 (Newport Bay).

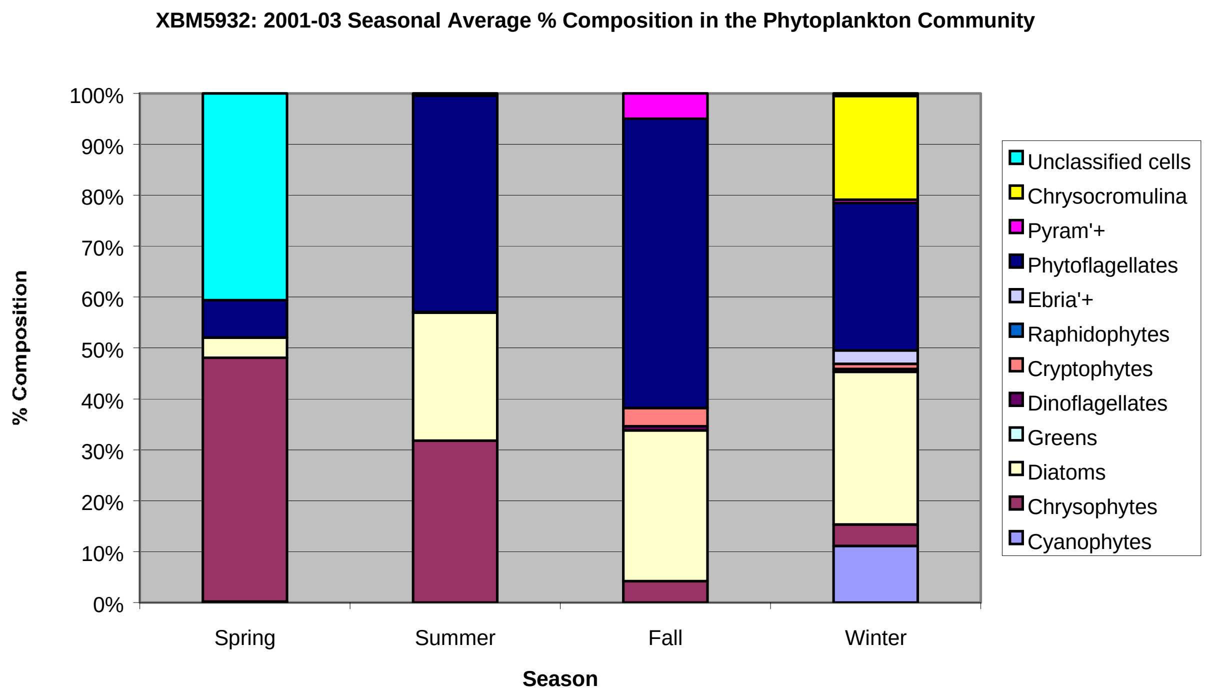

Figure 8.1.14. Phytoplankton community composition at station XBM5932 (Chincoteague Bay).

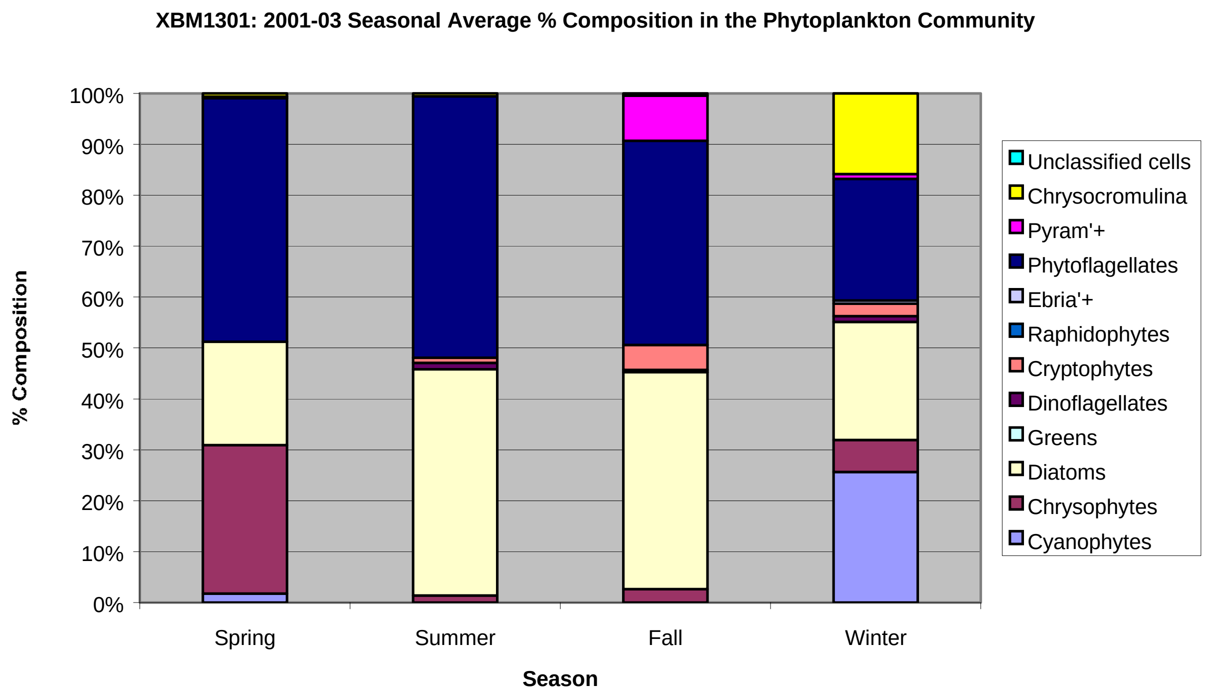

Figure 8.1.15. Phytoplankton community composition at station XBM1301 (Chincoteague Bay).

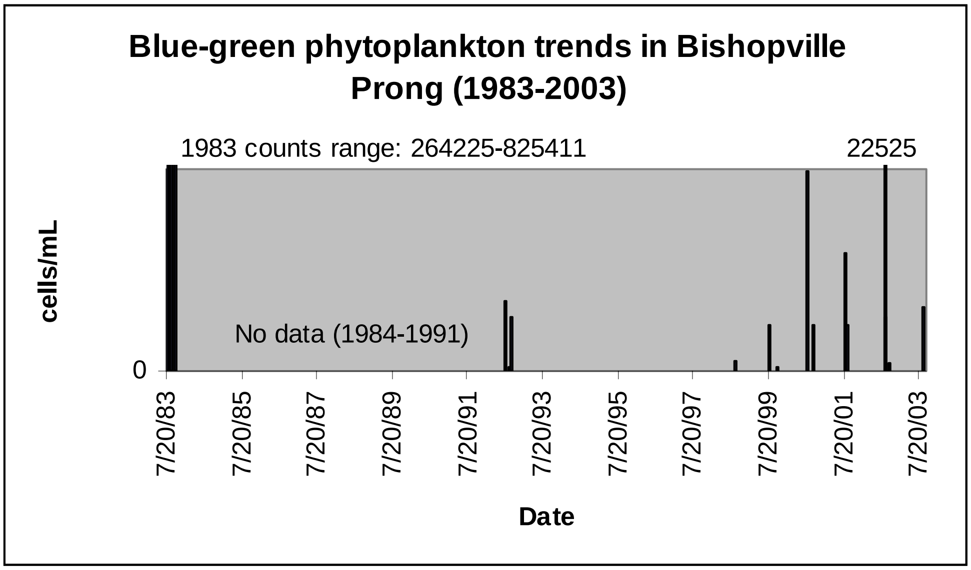

Figure 8.1.16: Trends in blue-green phytoplankton population (1983 and then 1992-2003) on Bishopville Prong (XDM4486). Counts exceeding 15000 cells/mL are shown next to corresponding bar.

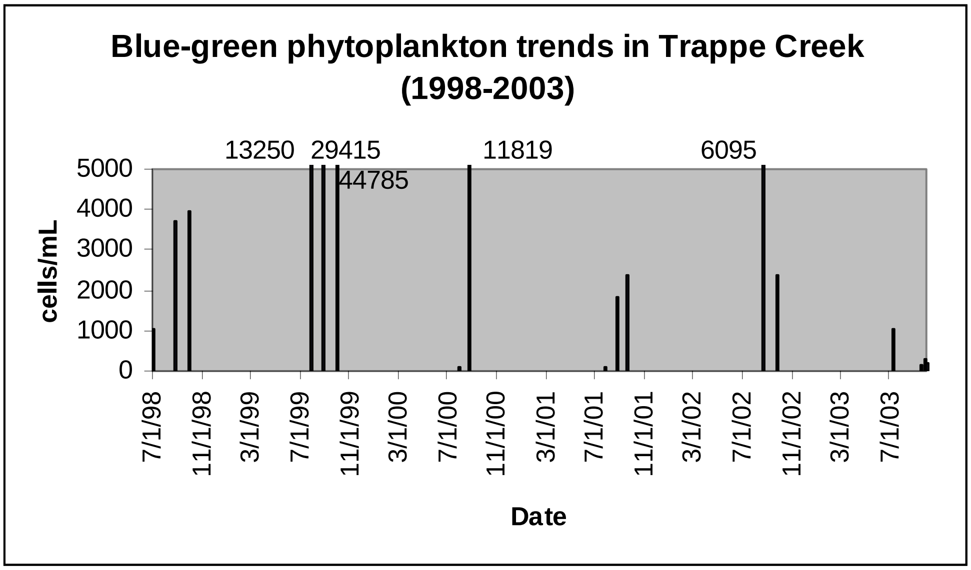

Figure 8.1.17: Trends in blue-green phytoplankton population (1998 – 2003) on Trappe Creek. Counts exceeding 5000 cells/mL are shown next to corresponding bar.

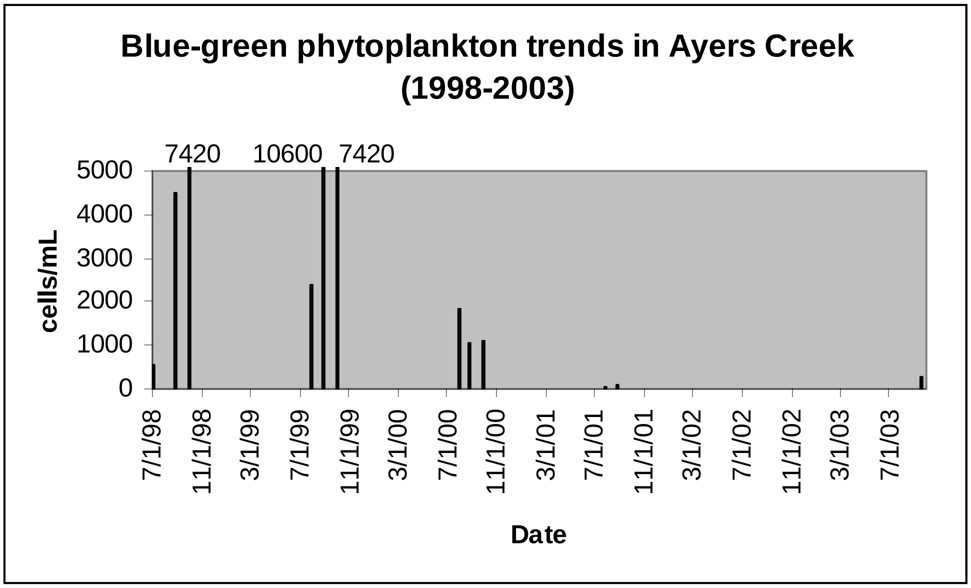

Figure 8.1.18: Trends in blue-green phytoplankton population (1998 – 2003) on Ayers Creek. Counts exceeding 5000 cells/mL are shown next to corresponding bar.

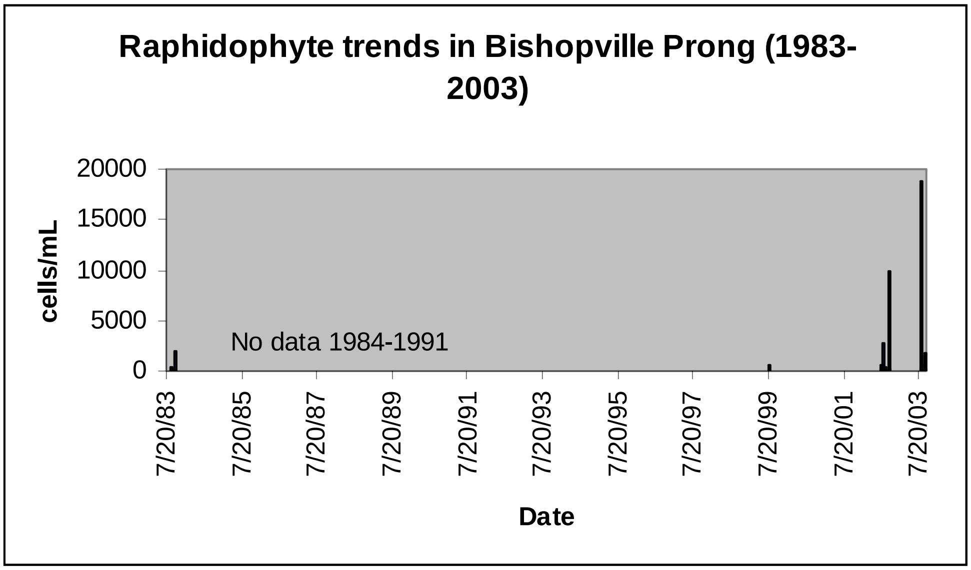

Figure 8.1.19: Trends in Raphidophyte population (1983 – 2003) on Bishopville Prong (XDM4486).

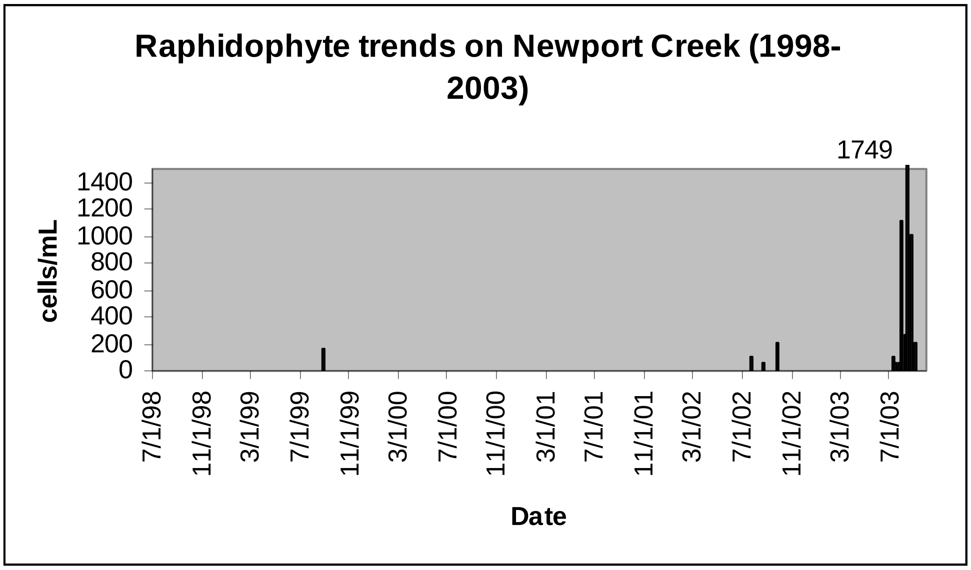

Figure 8.1.20: Trends in Raphidophyte population (1998 – 2003) on Newport Creek. Counts exceeding 1500 cells/mL are shown next to corresponding bar.

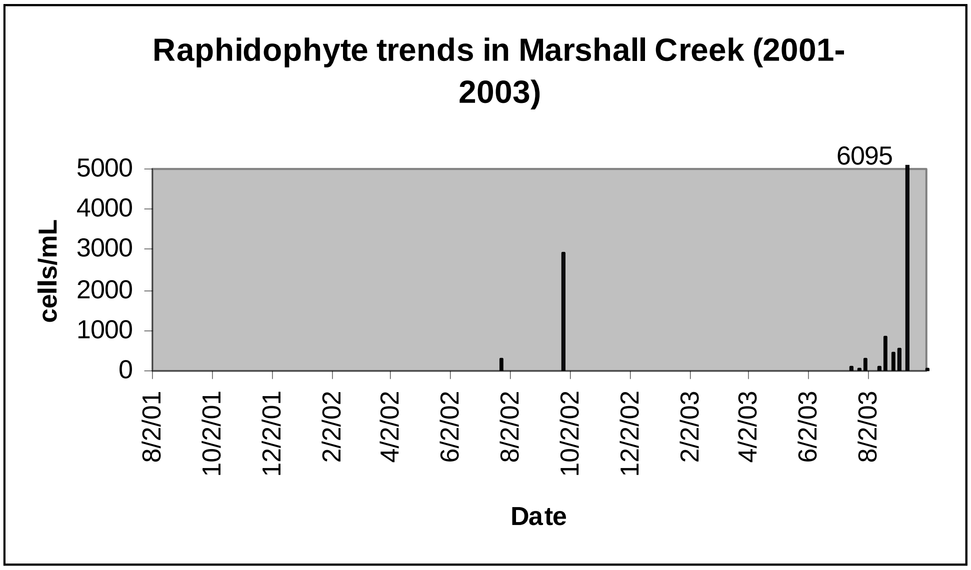

Figure 8.1.21: Trends in Raphidophyte population (2001 – 2003) on Marshall Creek. Counts exceeding 5000 cells/mL are shown next to corresponding bar.

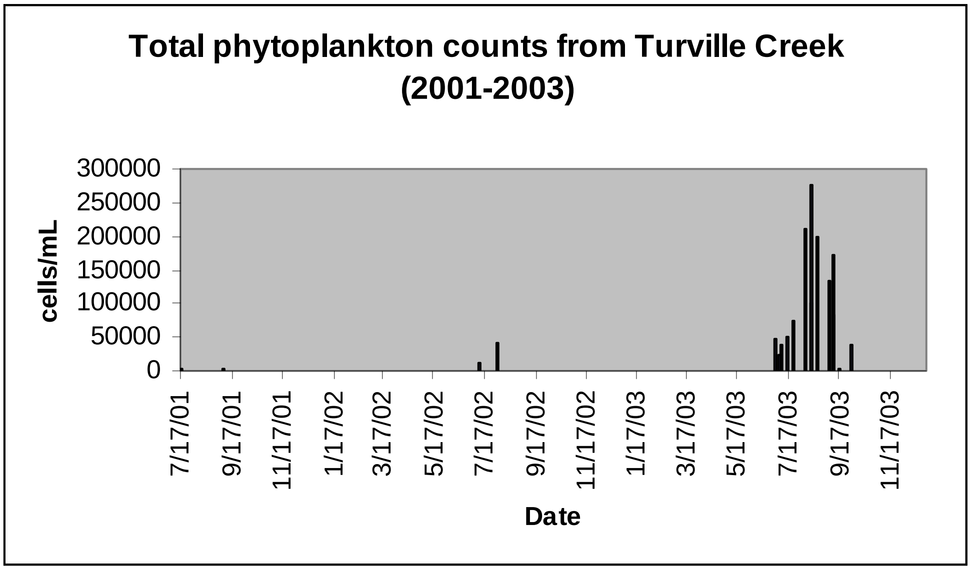

Figure 8.1.22: Trends in total phytoplankton population (2001 – 2003) on Turville Creek.

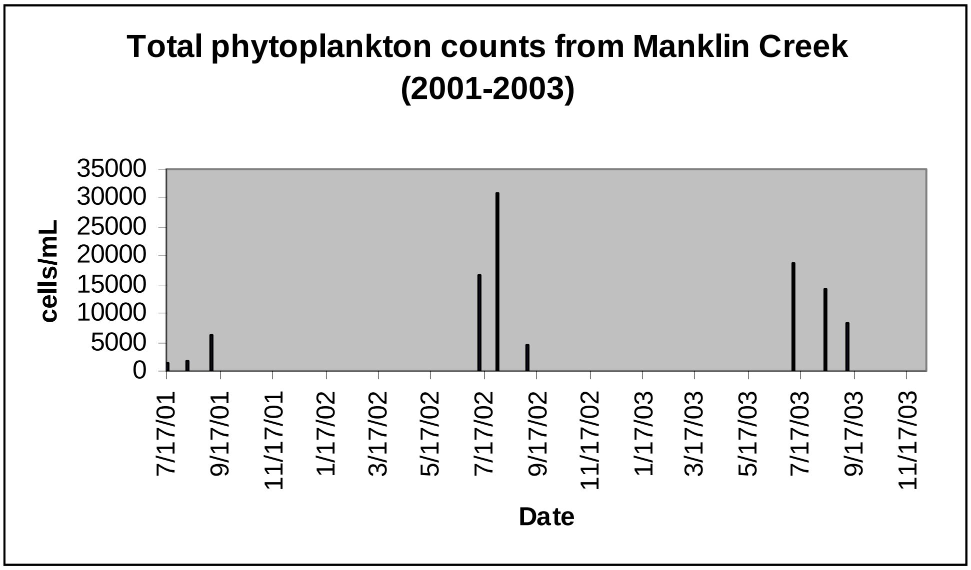

Figure 8.1.23: Trends in total phytoplankton population (1992 – 2003) on Manklin Creek.