

Section 5 Results - Plankton

Phytoplankton

Phytoplankton abundance and diversity consistently were highest at Ventura Point and lowest at the Rose Creek inlet through the first 15 months of sampling (Figure 13). Abundance varied with time and peaks were evident at all sites, but timing of peaks varied considerably among sites. Diatoms typically were more abundant than dinoflagellates at all sites, especially during the summer months, although dinoflagellates tended to dominate during the winter. Silicoflagellates were present at most sites but represented a minor component of the phytoplankton in Mission Bay. Four different temporal patterns were apparent at the six sites.

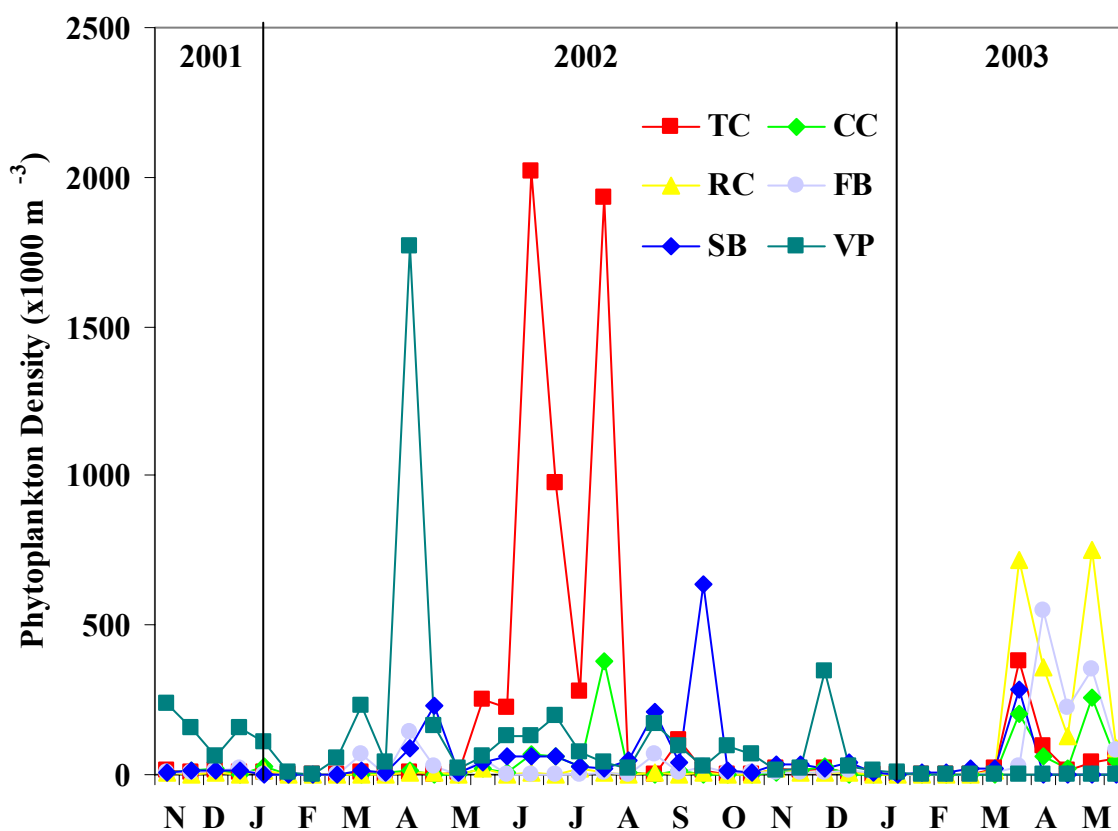


Figure 13. Phytoplankton density from horizontal plankton net tows conducted at six sites in Mission Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations: TC – Tecolote Creek inlet, CC – Cudahy Creek inlet, RC – Rose Creek inlet, FB – Fiesta Bay, SB – Sail Bay, VP – Ventura Point.

Tecolote Creek

Summer diatom blooms seemed to dominate the back bay sites near the inlet of Tecolote Creek (Figure 14). Between May and July 2002, a bloom of the chain-forming diatom *Chaetoceros decipiens* produced cell densities of approximately 2×10^6 cells m^{-3} in early June and again in mid July. Diatom densities were relatively low during the winter months when the phytoplankton assemblage was made up primarily of dinoflagellates. An early spring bloom of *C. decipiens* developed in the back bay during late February and early March 2003, following a large rainfall event that deposited more than 2.5" of rain at Sea World over a three day period. The diatom bloom lasted only a short time and was followed by lower density blooms of three dinoflagellate species, *Ceratium lineatum*, *C. macroceros* and *C. tripos*. Spring blooms of this type were not observed during the winter of 2001-2002 when rainfall was relatively scarce.

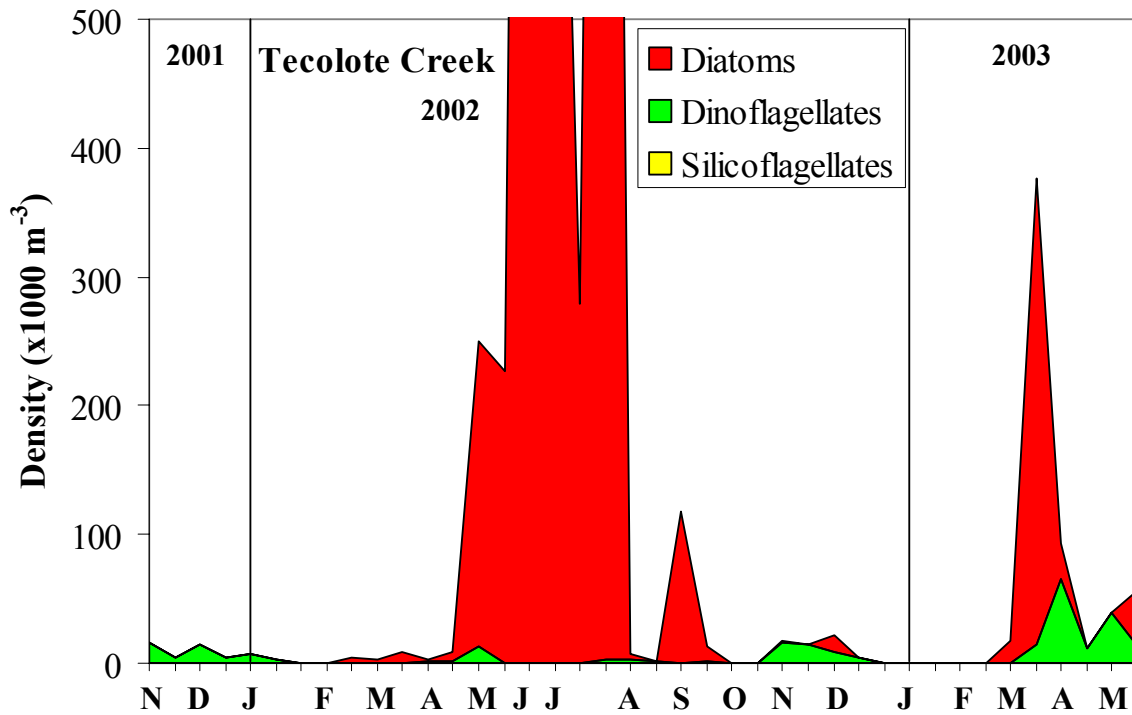


Figure 14. Phytoplankton density from horizontal plankton net tows conducted near the mouth of Tecolote Creek between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figure 13.

Cudahy Creek

Temporal patterns in phytoplankton abundance and community composition near the Cudahy Creek inlet were similar to those observed near the Tecolote Creek inlet (Figure 15). Diatoms (*Chaetoceros decipiens*) dominated the phytoplankton during the summer, while dinoflagellates were more common during the winter. Typically, phytoplankton densities at Cudahy Creek were lower than at Tecolote Creek, however peak cell densities at Cudahy Creek during the dinoflagellate bloom in March-April 2003 were nearly four times higher than the peak densities measured at Tecolote Creek. The dinoflagellate bloom at Cudahy Creek in spring 2003 was composed primarily of *Ceratium lineatum*.

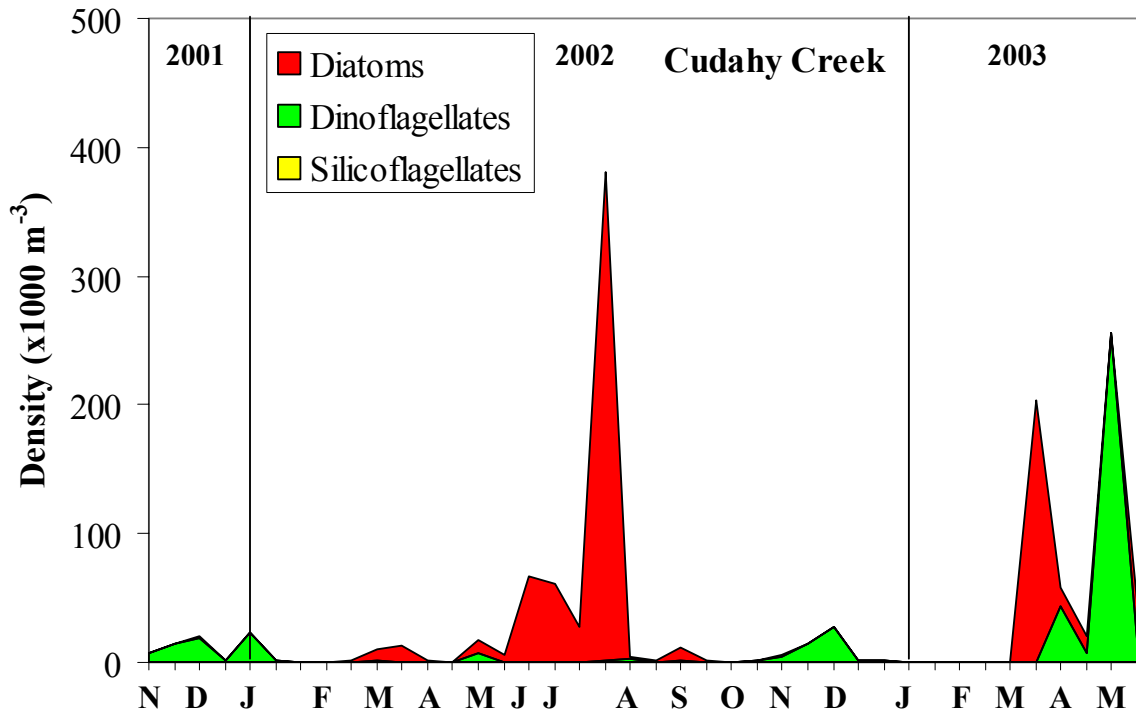


Figure 15. Phytoplankton density from horizontal plankton net tows conducted near the mouth of Cudahy Creek between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-14.

Rose Creek

Phytoplankton densities near the Rose Creek inlet were consistently low from November 2001 until February 2003 (Figure 16). As at Tecolote Creek and Cudahy Creek, a bloom of *C. decipiens* was observed during late February and early March 2003. The diatom bloom lasted only a short time and was followed by blooms of three different dinoflagellates: *Akashiwo sanguinea* (also known as *Lingulodinium polyedrum* and *Gonyaulax polyedra*) in mid March then *Ceratium macroceros* and *C. lineatum* in mid and late April, respectively. Peak densities during the *Ceratium* blooms exceeded 7×10^5 cells m^{-3} , far higher than densities at either Tecolote Creek or Cudahy Creek during the same time period.

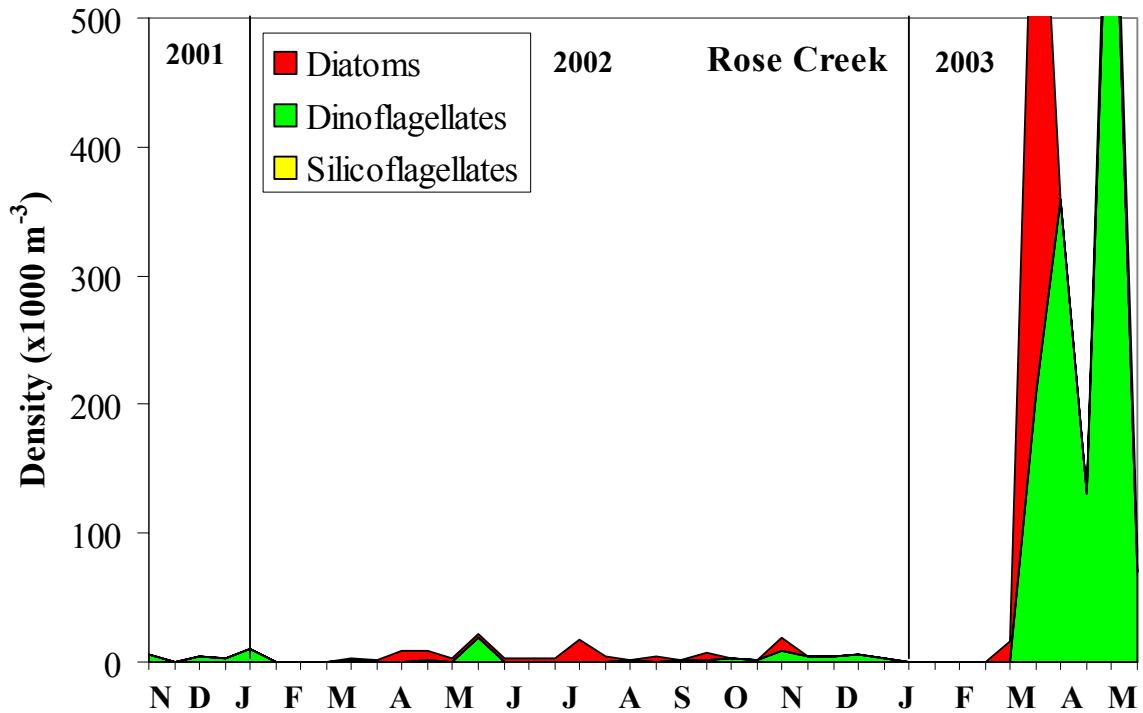


Figure 16. Phytoplankton density from horizontal plankton net tows conducted near the mouth of Rose Creek between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-15.

Fiesta Bay

In Fiesta Bay, phytoplankton populations exhibited distinct peaks in spring and fall 2002 (Figure 17). These abundance maxima were composed primarily of diatoms: *Pseudonitzschia* sp. in the spring and several chain-forming species of *Chaetoceros* in the spring and fall. The spring peak in diatoms was followed in the summer by an increase in the density of the dinoflagellate, *Ceratium lineatum*. The *Chaetoceros* bloom that was evident at the back bay sites during spring 2003 was not evident in Fiesta Bay, however populations of *Ceratium lineatum* exhibited two pronounced abundance peaks during March and April 2003.

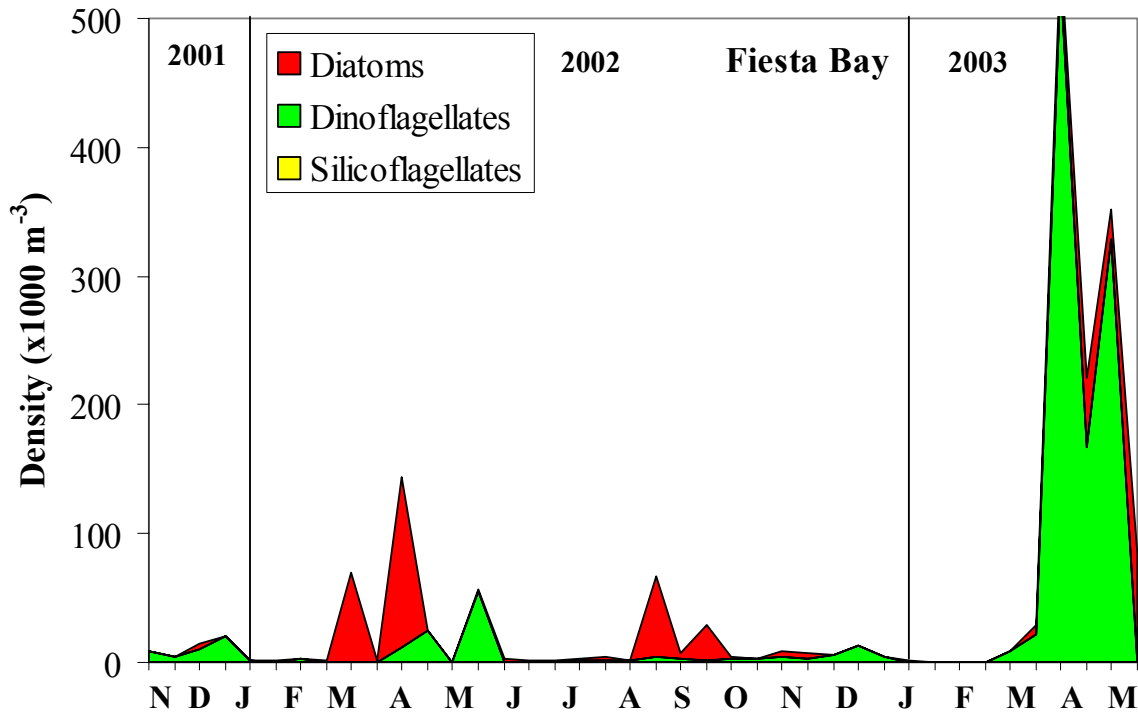


Figure 17. Phytoplankton density from horizontal plankton net tows conducted in Fiesta Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-16.

Sail Bay

As in Fiesta Bay, phytoplankton populations exhibited distinct peaks in spring and fall 2002 and spring 2003. However, unlike Fiesta Bay, secondary abundance maxima also were observed, in summer and winter 2002 (Figure 18). Diatom blooms typically were composed of chain-forming *Chaetoceros* species, primarily *C. debilis* and *C. decipiens*. However, the diatom density peak at this site in early September 2002 was the result of a short-lived bloom of *Asterionella japonica*. Dinoflagellate abundance peaks in Sail Bay were due almost exclusively to high densities of *Ceratium lineatum*. Although other dinoflagellate species were present, *C. lineatum* was the numerically dominant dinoflagellate throughout most of the year.

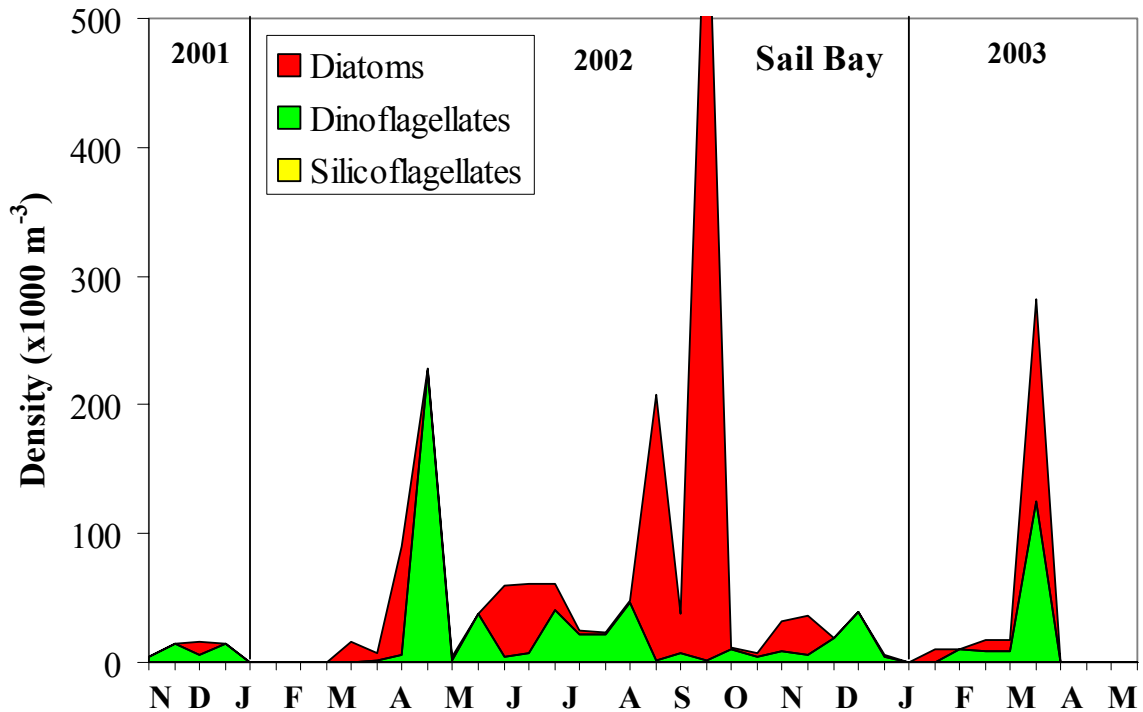


Figure 18. Phytoplankton density from horizontal plankton net tows conducted in Sail Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-17.

Ventura Point

At Ventura Point, the phytoplankton community seemed to reflect abundance and composition trends from the coastal environment more than Mission Bay. Abundance varied throughout the year, with peaks during all seasons (Figure 19). Diatom abundance maxima were made up of several species in addition to the *Chaetoceros* spp. that were prevalent throughout the rest of the bay. Near Ventura Point, the peak diatom density was observed in late March 2002 at 1.7×10^6 cells m^{-3} . This abundance peak was diverse, consisting of large numbers of *Chaetoceros debilis* as well as *Pseudonitzschia* sp., *Nitzschia longissima*, and *Skeletonema costatum*. Aside from *Chaetoceros debilis*, none of the other species were present in large numbers at the other five sites. Dinoflagellate abundance also varied throughout the year at Ventura Point. Density peaks in the spring and winter were composed primarily of *Akashiwo sanguinea* and *Ceratium lineatum*, the former more dominant during most of the year. Samples from this site have not yet been processed for 2003.

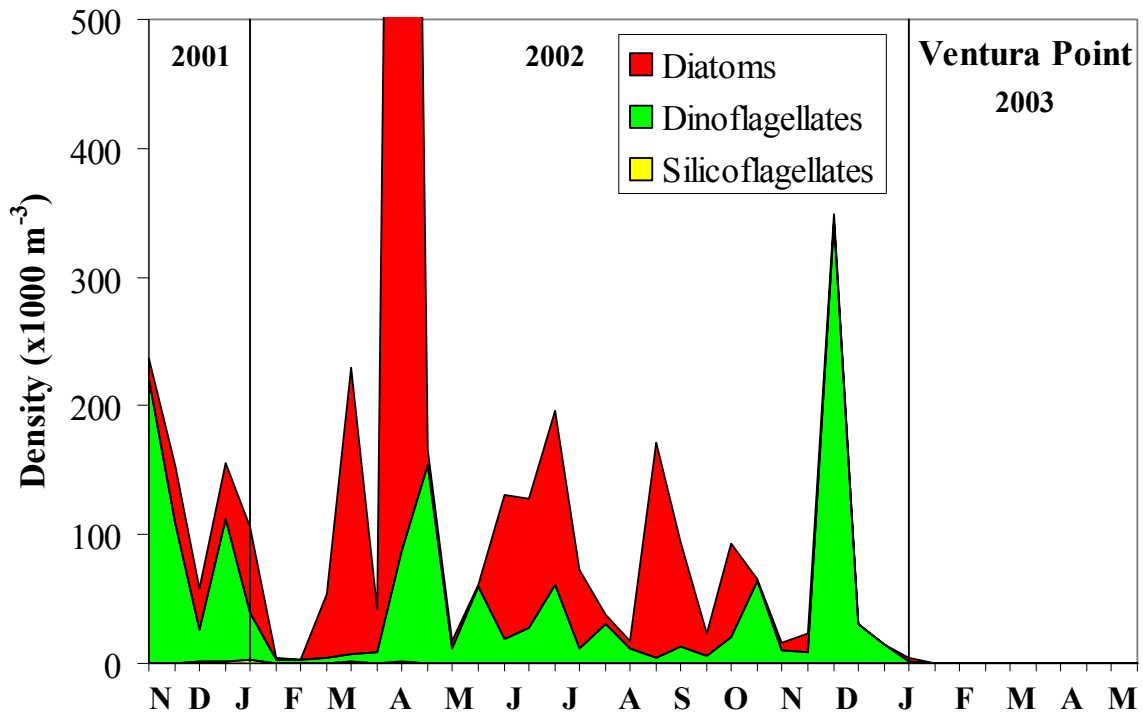


Figure 19. Phytoplankton density from horizontal plankton net tows conducted near Ventura Point between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-18.

Phytoplankton Diversity

The diversity of phytoplankton was evaluated by calculating the Shannon-Wiener diversity index (H') using the following formula

$$H' = - \sum_{i=1}^n p_i \ln p_i$$

Diversity of phytoplankton was highest throughout the bay during the winter and early spring of 2001-2002. Diversity at all sites declined sharply at about the same time as the onset of the first spring phytoplankton blooms at Sail Bay and Ventura Point. Relatively low diversity values (0.5-1.0) were observed at all sites during summer and fall 2002. A second drop in diversity values occurred in concert with blooms that developed shortly after large rain events in winter 2002-2003, and no diversity values greater than 1.0 were observed from January through May 2003.

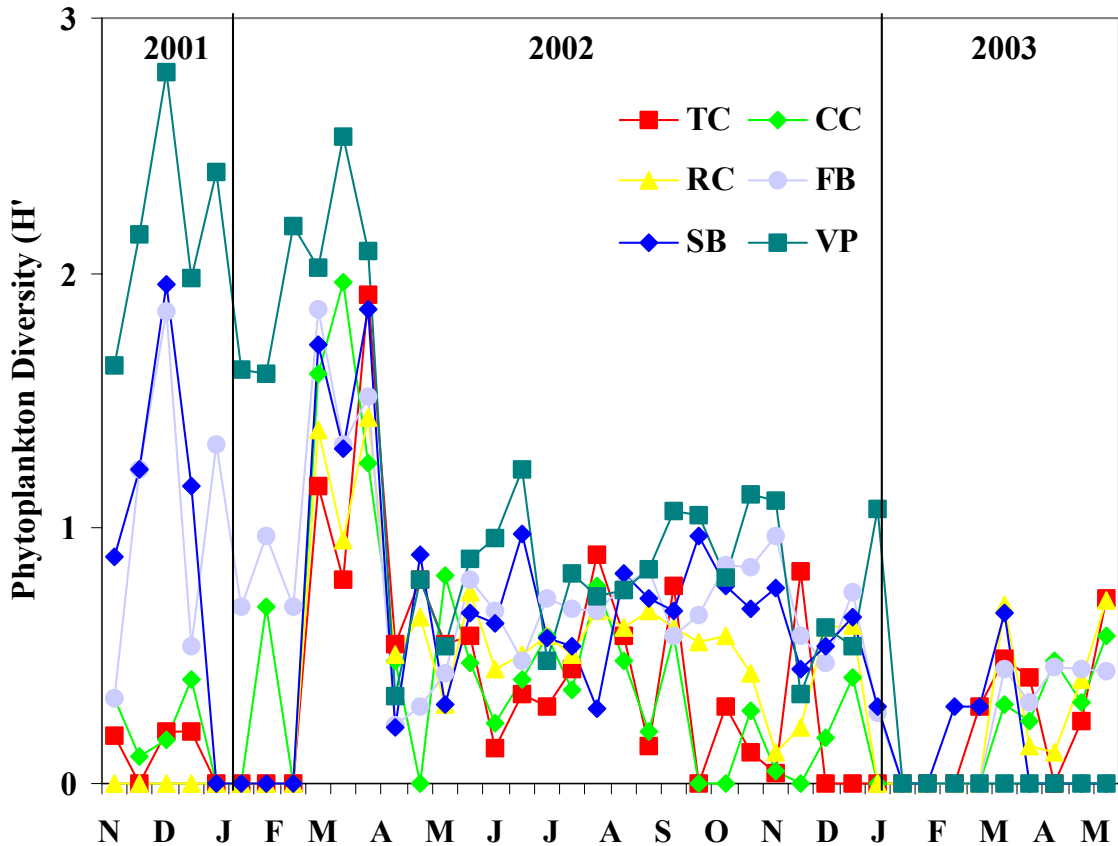


Figure 20. Phytoplankton diversity from horizontal plankton net tows conducted at six sites in Mission Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-19.

Phytoplankton diversity displayed an inverse relationship to the concentrations of phosphate (Figure 21) and silica (Figure 22) across all sites during the study period. Maximum phytoplankton diversity typically was associated with periods of low nutrient concentrations, and the reverse was true when nutrient concentrations were high.

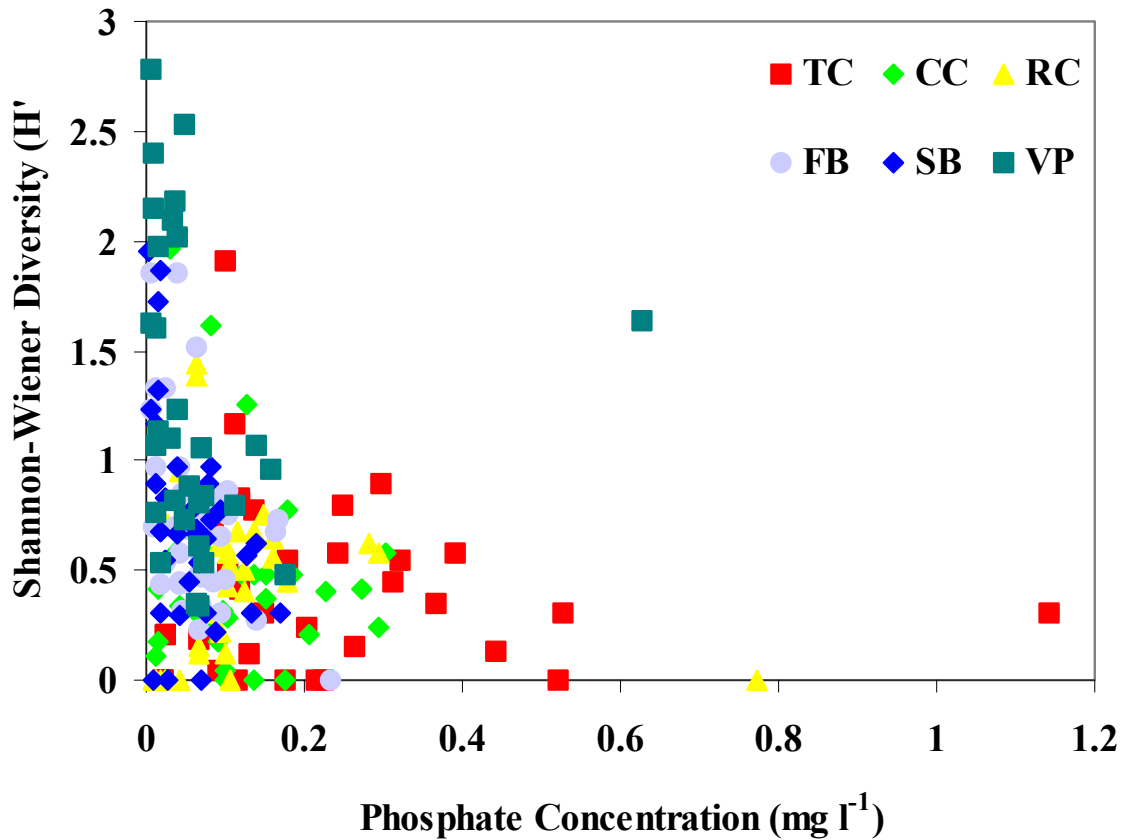


Figure 21. Phytoplankton diversity in relation to concentration of phosphate-phosphorus at six sites in Mission Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Site abbreviations are the same as for Figures 13-20.

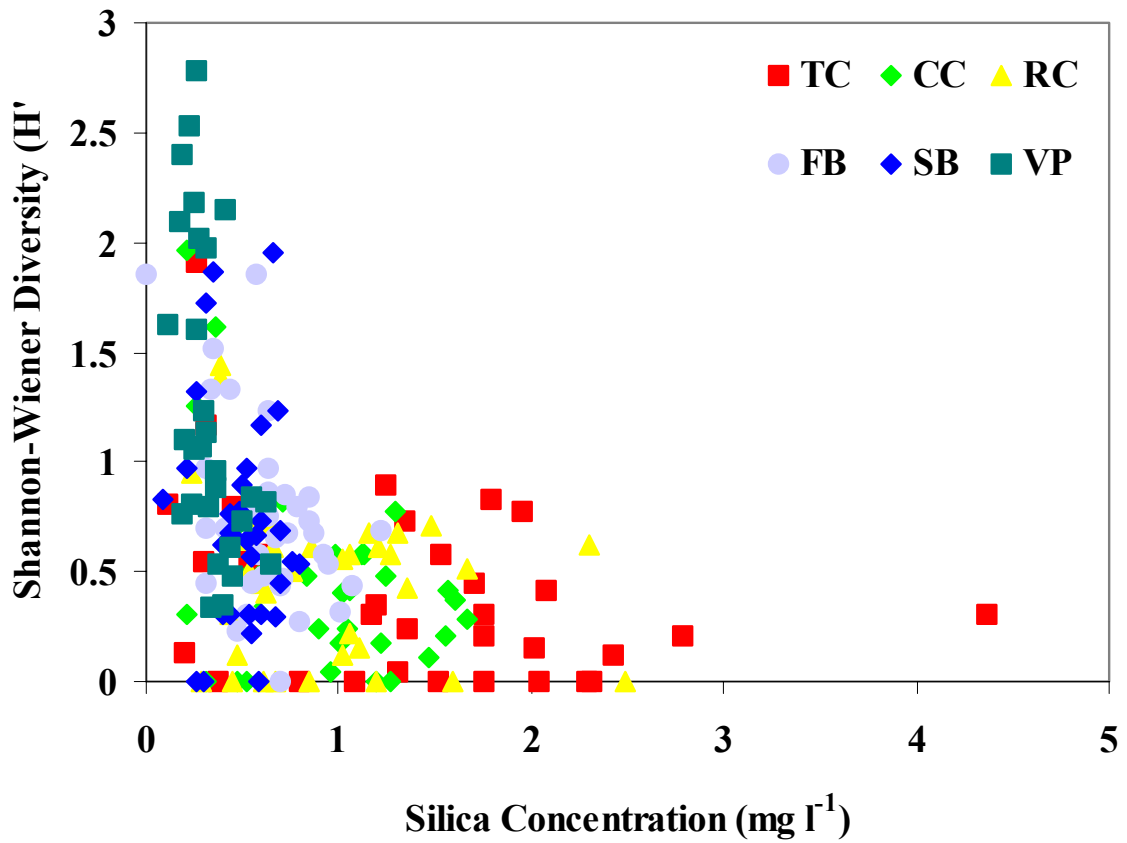


Figure 22. Phytoplankton diversity in relation to concentration of silica at six sites in Mission Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Site abbreviations are the same as for Figures 13-21.

Zooplankton

Zooplankton abundance was highest at Tecolote Creek and lowest in Fiesta Bay during 2002 (Figure 23). Densities were highest during the summer at all sites, with a secondary abundance peak in the fall. No spring peak in zooplankton was observed during 2002, following an unusually dry winter, however spring zooplankton peaks were seen at all sites in 2003, following a wetter winter. These patterns are similar to those exhibited by phytoplankton in Mission Bay (Figure 13).

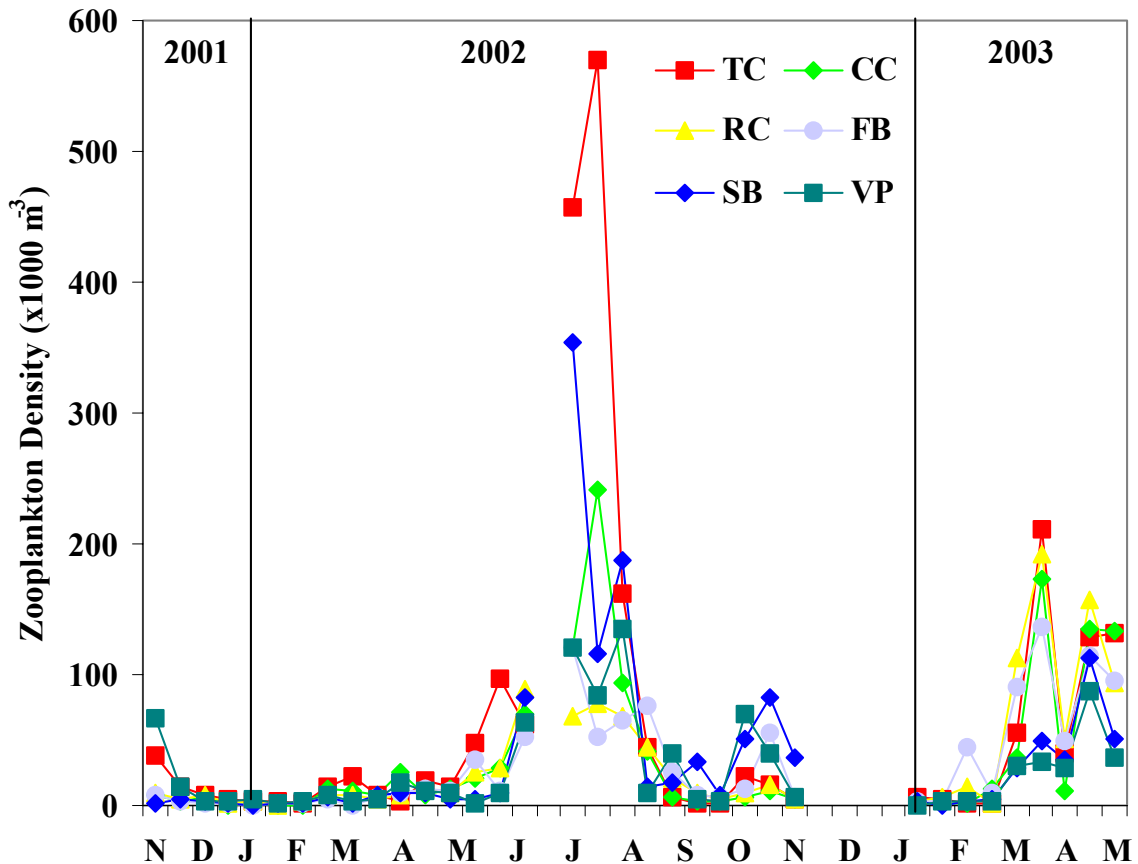


Figure 23. Zooplankton density from horizontal plankton net tows conducted at six sites in Mission Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-22

Ciliates dominated the zooplankton at Tecolote Creek during summer 2002 (Figure 24). The majority of these ciliates were tintinnids (*Tintinnopsis* spp.). Copepods were present as well, primarily *Acartia tonsa* and *Oithona oculata*. Crustacean nauplius larvae were evident throughout the year and dominated the zooplankton in this area during the winter and spring before the onset of the spring zooplankton bloom.

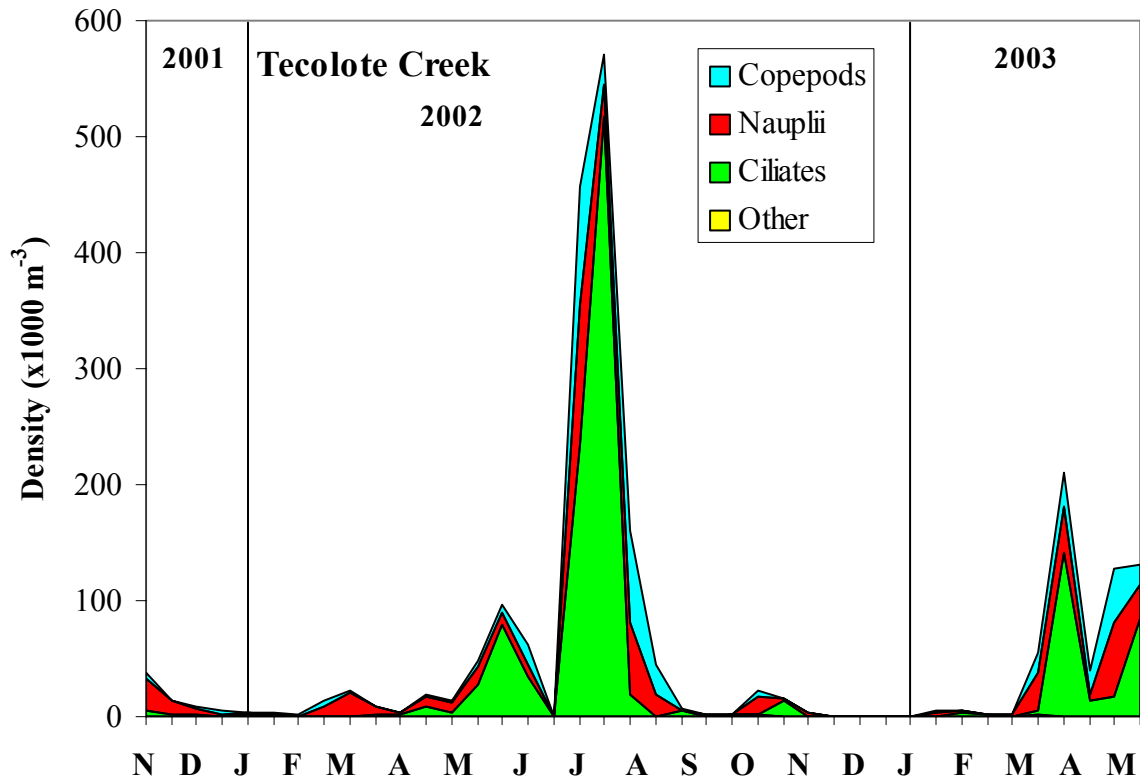


Figure 24. Zooplankton density from horizontal plankton net tows conducted near the mouth of Tecolote Creek between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-23.

Ciliates were the most abundant group of zooplankton at Cudahy Creek during summer 2002 and spring 2003 (Figure 25). The taxonomic composition of the zooplankton in this area was similar to that at Tecolote Creek. Copepods were conspicuous during the late spring and summer, following elevated populations of nauplius larvae.

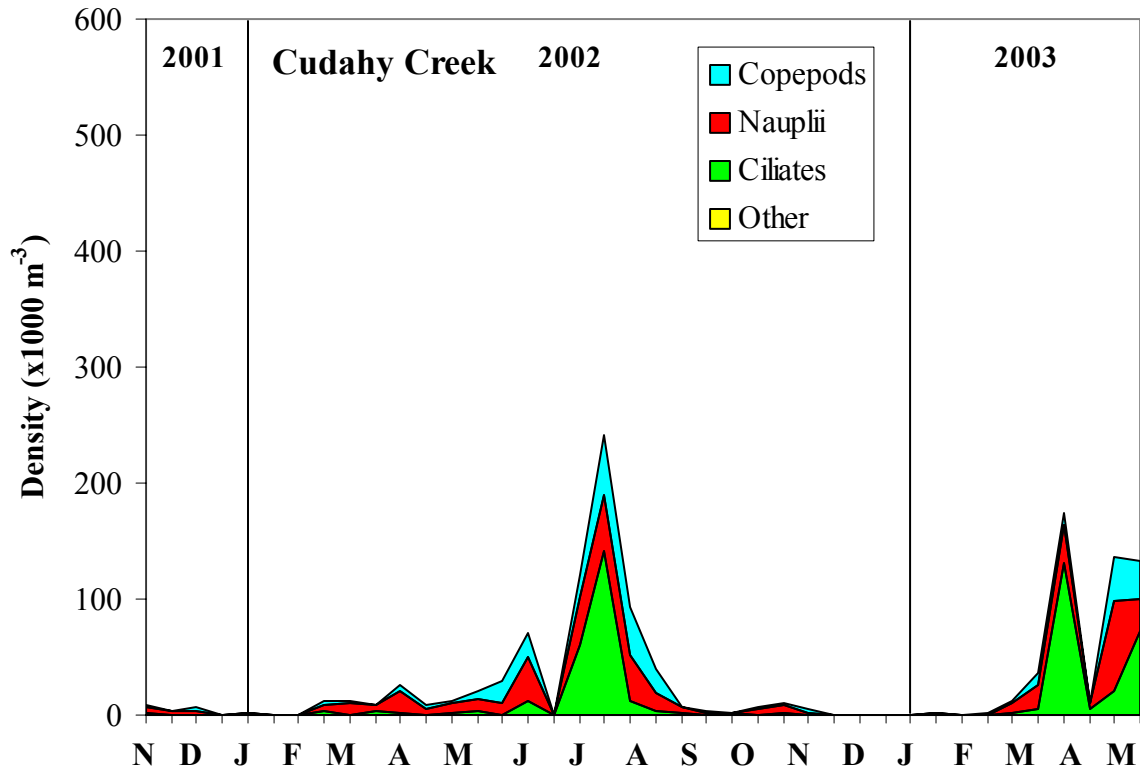


Figure 25. Zooplankton density from horizontal plankton net tows conducted near the mouth of Cudahy Creek between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-24.

Copepods and nauplii dominated the zooplankton at Rose Creek during spring and summer 2002 (Figure 26). In spring 2003, ciliates and nauplii made up a large proportion of zooplankton in early spring, giving way to larger numbers of copepods in late spring. The taxonomic composition of the zooplankton in this area was similar to that at Tecolote Creek and Cudahy Creek.

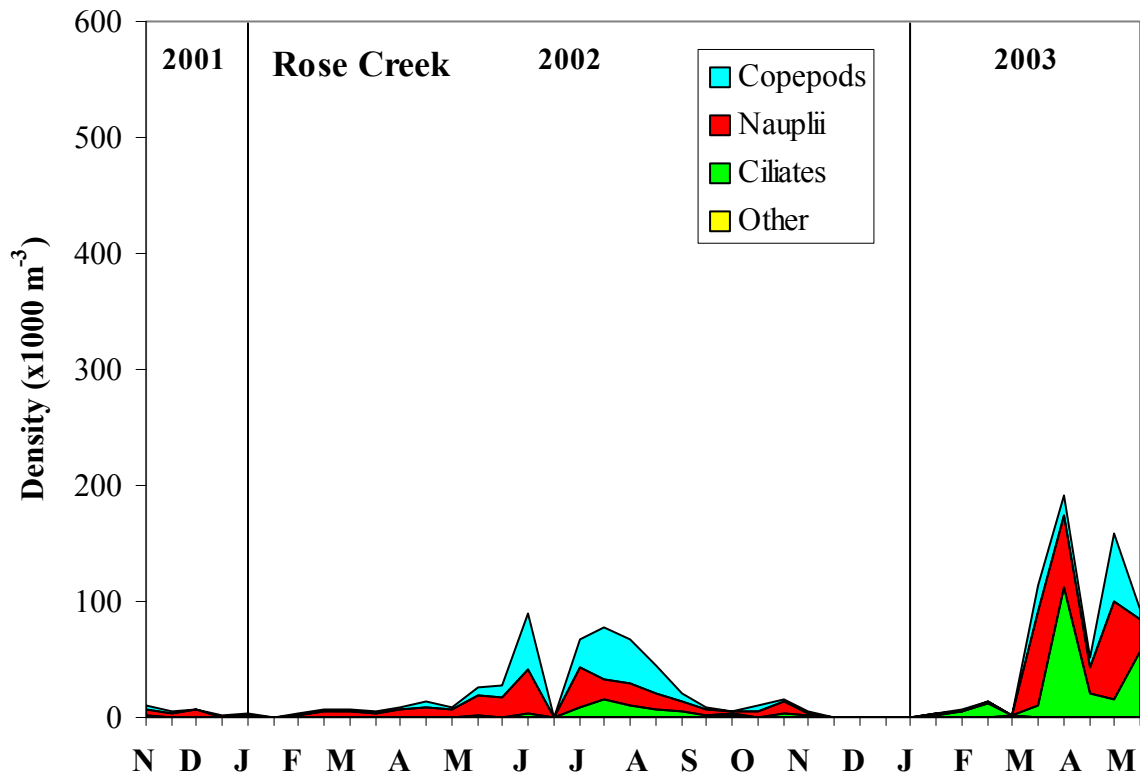


Figure 26. Zooplankton density from horizontal plankton net tows conducted near the mouth of Tecolote Creek between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-25.

Temporal patterns of zooplankton abundance in Fiesta Bay resembled those near the mouth of Rose Creek. Ciliates and nauplii were abundant during the spring in 2002 and 2003, with highest densities of copepods during late spring and early summer (Figure 27).

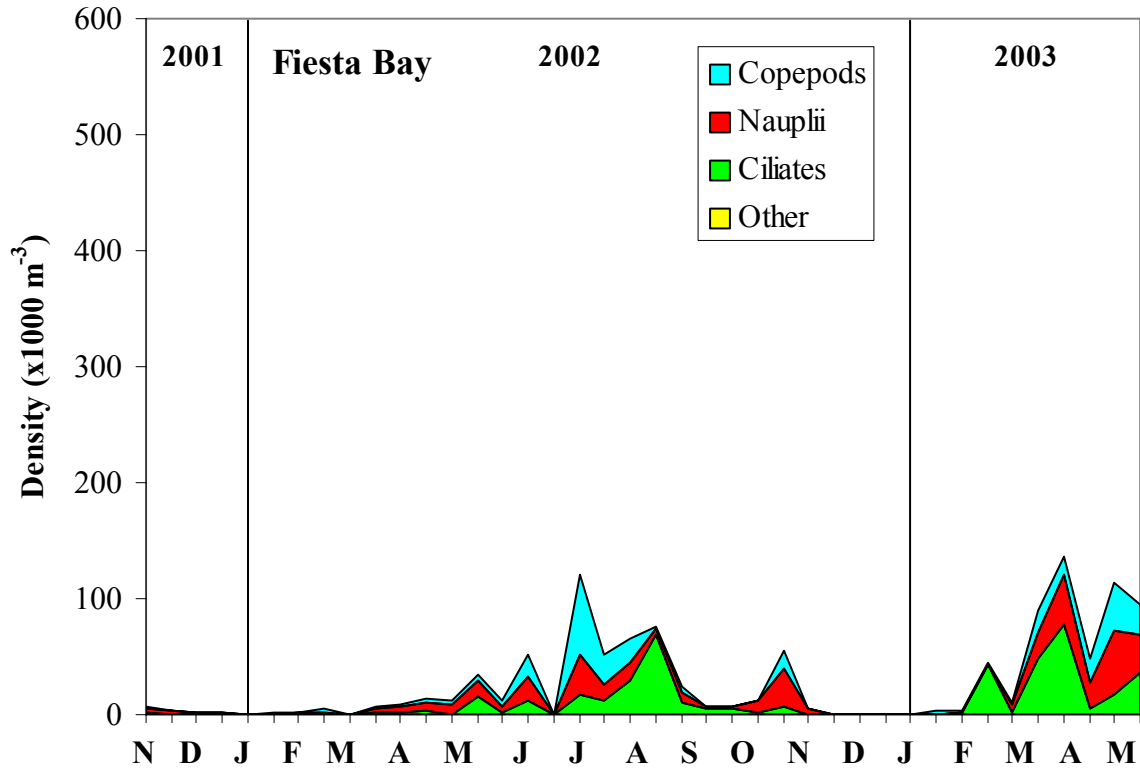


Figure 27. Zooplankton density from horizontal plankton net tows conducted in Fiesta Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-26.

Relatively few zooplankton were collected in Sail Bay during the winter and spring of 2001-2002 (Figure 28). Ciliates made up the overwhelming majority of the zooplankton community during summer 2002 but were almost completely absent in the fall when copepods and nauplii predominated.

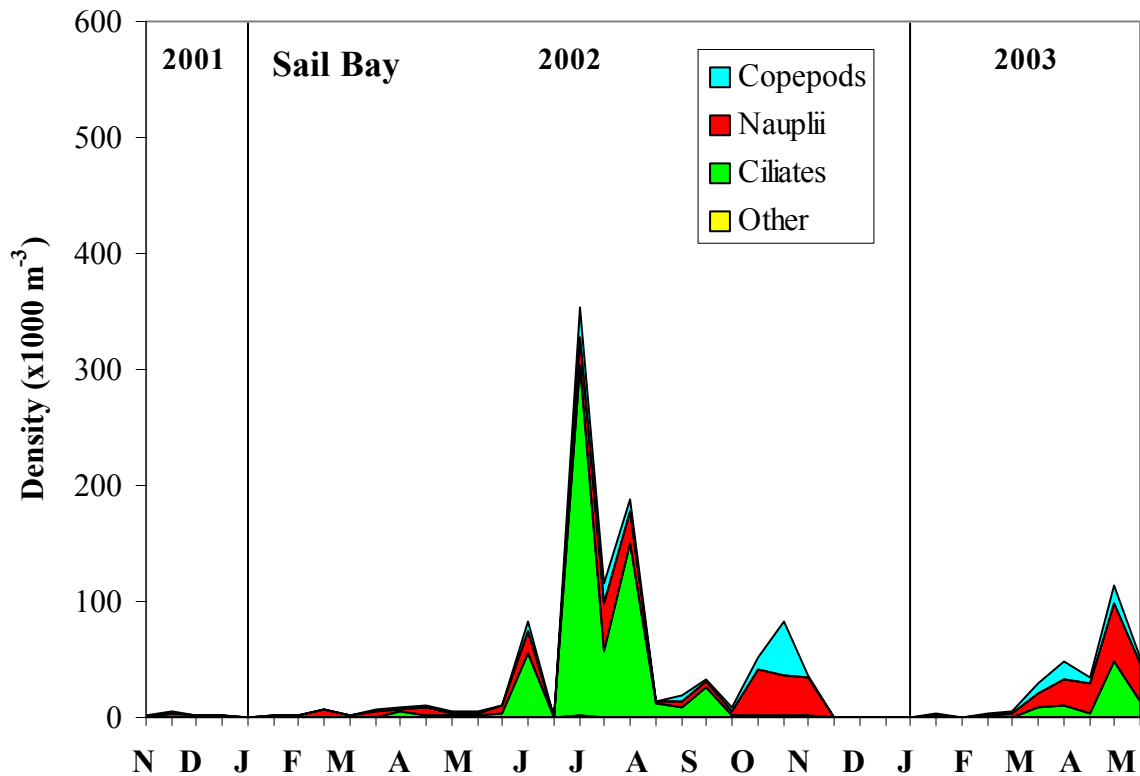


Figure 28. Zooplankton density from horizontal plankton net tows conducted in Sail Bay between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-27.

Copepods were scarce near Ventura Point, compared to ciliates and nauplii (Figure 29). As in Sail Bay, ciliates made up the majority of the zooplankton community during summer 2002 but were almost completely absent in the fall. Nauplii dominated the zooplankton assemblage during fall 2001 and fall 2002, whereas ciliates were most abundant in the spring.

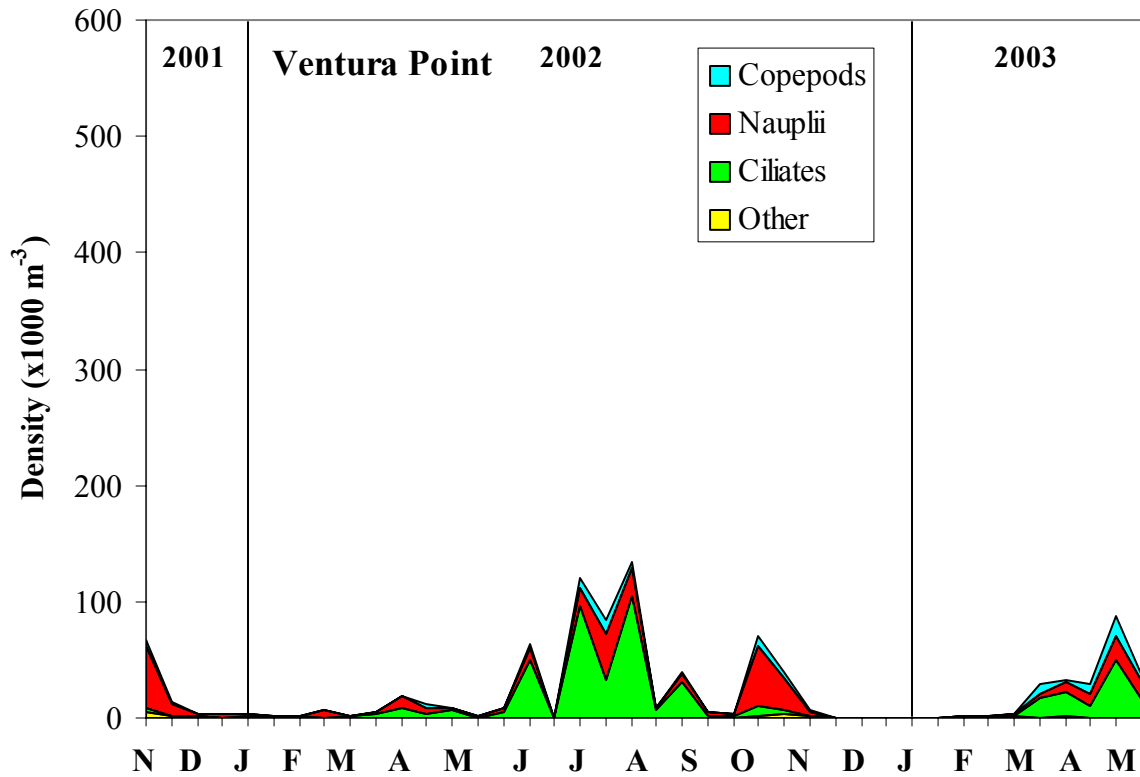


Figure 29. Zooplankton density from horizontal plankton net tows conducted near Ventura Point between November 2001 and May 2003. Each data point represents a single biweekly sample. Letters on the X-axis indicate the first sampling date within a calendar month. Site abbreviations are the same as for Figures 13-28.