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# PHYTOPLANKTON ECOLOGY AND DISTRIBUTION AT MANATEE CAY, PELICAN CAYS, BELIZE

BY

STEVE L. MORTON

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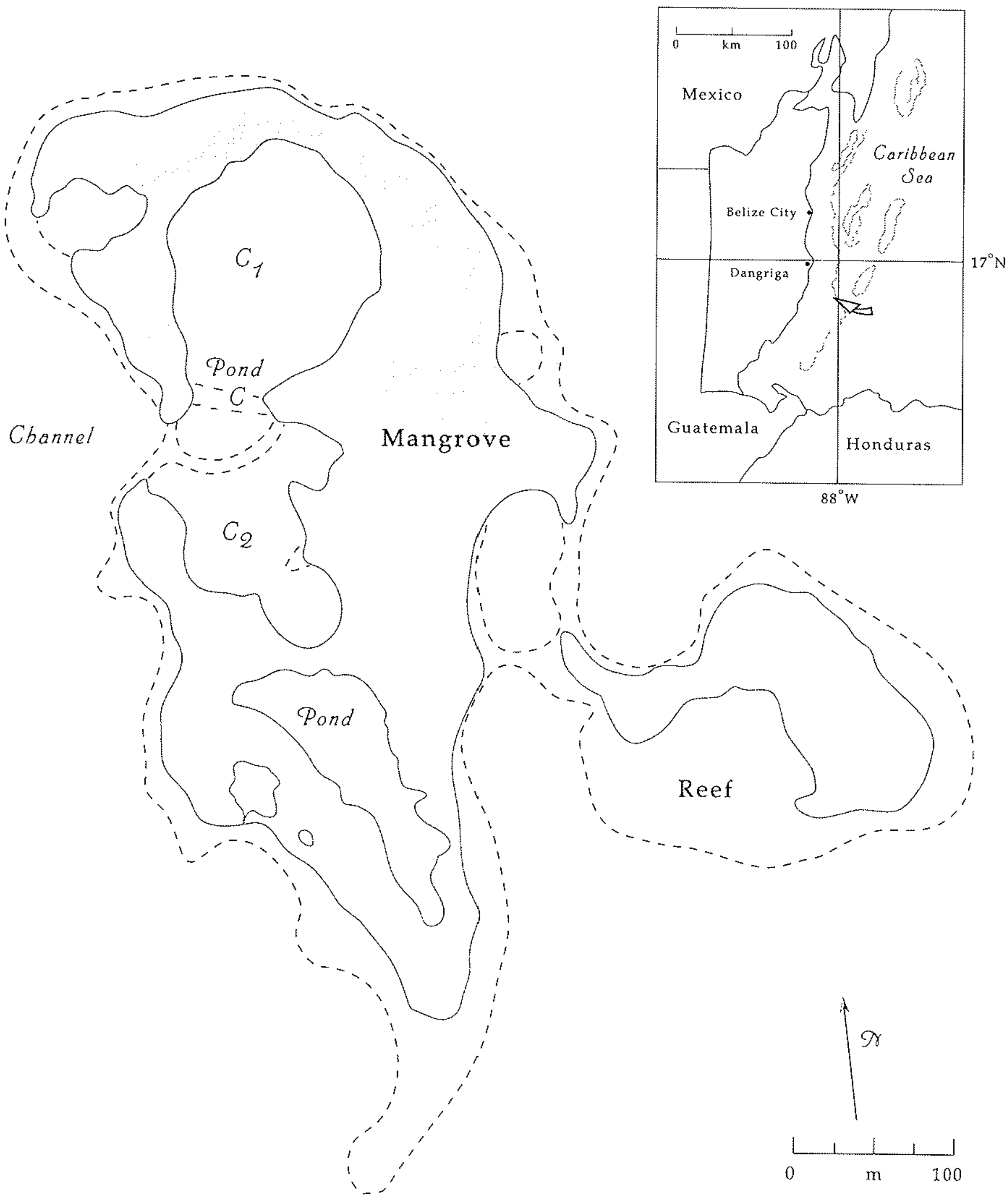


Figure 1. Sample sites in Pond C of Manatee Cay.

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## ABSTRACT

The phytoplankton population of Manatee Cay Pond C in the Pelican Cays of Belize differs from the population in the channel directly outside the cay in both biomass and species diversity. Significant differences also occur between the two large, semi-enclosed lobes of Pond C, $C_1$ and $C_2$. An ecological survey demonstrated that the phytoplankton population in the pond is dominated by the mixotrophic dinoflagellate *Ceratium furca*. Surprisingly, diatoms common in the channel are in low abundance or absent in the Manatee pond. A large vertical migrating biomass of *Gymnodinium sanguinium* was found in the larger northern pond lobe known as $C_1$.

## INTRODUCTION

The Belize Barrier Reef system is the largest in the Western Hemisphere, extending approximately 250 km from the Yucatan Peninsula to the Gulf of Honduras (Rützler and Macintyre, 1982; James and Ginsburg, 1979). The entire barrier reef can be separated into two distinct systems. North of Belize City the shelf is shallow and has a series of islands with a discontinuous reef lacking a well-defined reef flat. South of Belize City, the reef flat is well-developed with a continuous reef. In the southern reaches of this platform the reef is cut by deep channels that form a number of shelf atolls (James and Ginsburg, 1979). The Pelican Cays group is located in this region, which is where shallow mangrove cays are immediately adjacent to channels up to 30 m deep. Several cays of this group contain central ponds separated by shallow coral ridges. These ponds, which may be 10 to 12 m deep, are characterized by a rich benthic community, primarily tunicates and sponges overgrowing mangrove substrates (Rützler and Feller, 1996; Rützler et al., this volume; Goodbody, this volume). Three of these cays with semi-enclosed ponds—Fisherman's Cay, Manatee Cay, and Cat Cay—are the largest examples. Because of the shallow coral ridges, the ponds are almost completely enclosed during periods of low tide.

The 30-cm tide and wind-driven circulation allow only limited exchange between the semi-enclosed ponds. Villareal et al. (this volume) recently studied the complex hydrography of Manatee Cay. In this study, the water inside the pond is treated as separate water mass because

[1]Bigelow Laboratory for Ocean Sciences, McKown Point, West Boothbay Harbor, ME 04575. Present address: National Ocean Service NOAA, 219 Ft. Johnson Rd., Charleston, SC 29412.

there is little or no exchange with the water outside the pond. The pond water is warmer and more saline than water outside the cay. Thus the hydrographic conditions in Manatee pond appear to respond rapidly to local heating. Villareal et al. (this volume) hypothesize that a thin layer of surface water may advect into the pond, possibly by tidal or wind-driven circulation and then become modified by local heating and evaporation to create surface water that is completely different from the adjacent water separated by the shallow coral ridge This survey reports on the phytoplankton population in two areas of the large Manatee Cay pond. This population is compared with that from the adjacent water outside Manatee Cay.

## MATERIALS AND METHODS

During May 1996 surveys were conducted from small boats in Pond C of Manatee Cay. Samples were collected from two pond sites and one channel site (Fig. 1). The first pond site is located in the largest, northern lobe of the pond, $C_1$ (16o40.05'N 88o11.50'W). This lobe is approximately 230 m north to south and 130 m east to west. It is 35 feet deep (Urish, this volume). The second pond site is in the southern lobe of the pond, $C_2$ (16°39.95'N 88°11.51'W). This smaller lobe is approximately 120 m north to south and 100 m east to west. It has a maximum measured depth of 50 feet (Urish, this volume). The channel site outside Manatee Cay is approximately 200 m from the entrance to the ponds (16°39.93'N 88,45°11.51'W).

Phytoplankton tows were made at each site using a 10-µm-mesh net fitted with a calibrated flow meter. To reduce error caused by net clogging, only short tows of less than 2 minutes were taken. Tows were taken at three different times during the day. Samples were concentrated to a volume of 250-ml and fixed with 1% glutaraldehyde. Phytoplankton was enumerated using a 1-ml Sedwick-Rafter counting chamber. Each sample was counted three times.

## RESULTS

Channel Site Outside Manatee Cay

Seven species of centric diatoms dominated the net phytoplankton of the channel site adjacent to Manatee Cay (Table 1). The average biomass of these species was 4,512 cells • $L^{-1}$ with *Rhizosolenia calcaravis* and *Bacteriastrum furcatum* making up approximately 82% of the total biomass. The three species of pennate diatoms were in much lower abundance than the centric diatoms. No significant differences in species composition were noted between tows taken during the three sampling periods.

Eleven species of dinoflagellates were collected from this site. The total dinoflagellate population was approximately half the diatom population, ranging from 27,700 cells • $L^{-1}$ to 21,800 cells • $L^{-1}$. The dominant type was heterotrophic dinoflagellates, *Protoperidinium*. No significant change in species composition or biomass was observed during the three sample times.

Table 1. Phytoplankton population from the channel outside the ponds of Manatee Cay Pond C (16°39.93'N 88°11.51'W). (Each count is the mean of four separate phytoplankton tows.)

| Species | Sample 1 (9:00 a.m.) | Sample 2 (12:00 a.m.) | Sample 3 (2:00 a.m.) |
|---|---|---|---|
| Centric Diatom | | | |
| *Coscinodiscus* sp. | 110 | 120 | 115 |
| *Asterionellopsis glacialis* | 250 | 300 | 180 |
| *Rhizosolenia calcaravis* | 2,800 | 2,500 | 2,400 |
| *Bacteriastrum cf. furcatum* | 1,190 | 1,000 | 1,150 |
| *Thalassiothrix* sp. | 160 | 140 | 160 |
| *Thallasiosiria* sp. | 270 | 280 | 250 |
| *Hemialus hauckii* | 57 | 40 | 64 |
| Pennate Diatoms | | | |
| *Pleurosigma normannii* | 80 | 75 | 90 |
| *Pleurosigma simonsenii* | 40 | 43 | 30 |
| *Navicula* sp. | 30 | 40 | 35 |
| Autotrophic Dinoflagellates | | | |
| *Ceratocorys armata* | 70 | 50 | 80 |
| *Dinophysis caudata* | 540 | 600 | 560 |
| *Prorocentrum micans* | 30 | 20 | 50 |
| *Gymnodinium* sp. | 30 | 20 | 15 |
| Mixotrophic Dinoflagellates | | | |
| *Ceratium tripos* | 430 | 420 | 400 |
| *Ceratium fusus* | 110 | 120 | 110 |
| *Ceratium furca* | 460 | 500 | 430 |
| *Ceratium trichoceros* | 110 | 120 | 110 |
| Heterotrophic Dinoflagellates | | | |
| *Protoperidinium divergens* | 540 | 550 | 600 |
| *Protoperidinium depressum* | 490 | 300 | 450 |
| *Protoperidinium pentagonum* | 80 | 70 | 50 |

Manatee Cay Pond, Northern Lobe $C_1$

Eleven species were collected at this site (Table 2). The phytoplankton community was dominated by dinoflagellates. *Ceratium furca* was the dominant dinoflagellate with densities ranging from 73,790 cells • $L^{-1}$ to 60,000 cells • $L^{-1}$. Two species, *Prorocentrum hoffmannianum* and *Gymnodinium sanguineum*, were present at this site but absent from all other sites. The centric diatoms, *Cosinodiscus* sp. and *Rhizosolenia calcaravis*, along with the cyanophyte, *Oscillatoria* sp., were present but in very low abundance.

Table 2. Phytoplankton population from Manatee Cay Pond C, northern lobe $C_1$ (16°40.05'N 88°11.50'W). (Each count is the mean of four separate phytoplankton tows.)

| Species | Sample 1 (9:00 a.m.) | Sample (12:00 a.m.) | Sample 3 (2:00 a.m.) |
|---|---|---|---|
| Diatoms | | | |
| *Cosinodiscus* sp. | 15 | 30 | 9 |
| *Rhizosolenia* sp. | 8 | 5 | 2 |
| Autotrophic Dinoflagellates | | | |
| *Dinophysis caudata* | 670 | 450 | 550 |
| *Pyrophacus stenii* | 330 | 200 | 260 |
| *Prorocentrum hoffmannianum* | 35 | 20 | 30 |
| *Gymnodinium sanguineum* | 30 | 50 | 3,200 |
| Mixotrophic Dinoflagellates | | | |
| *Ceratium furca* | 73,790 | 64,000 | 60,000 |
| *Ceratium tripos* | 70 | 50 | 65 |
| Heterotrophic Dinoflagellates | | | |
| *Protoperidinium divergens* | 670 | 500 | 700 |
| *Protoperidinium pentagonum* | 80 | 50 | 20 |
| Other | | | |
| *Oscillatoria* sp. | 33 | 10 | 20 |

The population of *Gymnodinium sanguineum* was the only species of phytoplankton that displayed a significant change during the three sampling times. *Gymnodinium sanguineum* increased from 30 cells • $L^{-1}$ during the 10:00 a.m. collection to 3,200 cells • $L^{-1}$ during the 2:00 p.m. collection.

Manatee Cay Pond, Southern Lobe $C_2$

Seven species of dinoflagellates were the only group of phytoplankton found at this site (Table 3). Diatoms were completely absent in all samples. *Ceratium furca* was the dominant species, ranging from 90,000 cells • $L^{-1}$ to 107,980 cells • $L^{-1}$. Two species, *Scrippsiella* sp. and *Protoceratium reticulatum,* were present at this site but absent from all other sites. Diatoms were completely absent from the phytoplankton community. No significant changes in species composition and number was displayed during the three separate sampling times.

Table 3. Phytoplankton population from Manatee Cay Pond C, southern lobe $C_2$ (16°39.95'N, 88°11.51'W). (Each count is the mean of four separate phytoplankton tows.)

| Species | Sample 1 (9:00 a.m.) | Sample (12:00 a.m.) | Sample 3 (2:00 a.m.) |
|---|---|---|---|
| Autotrophic Dinoflagellates | | | |
| *Dinophysis caudata* | 2,010 | 1,900 | 1,500 |
| *Scrippsiella* sp. | 2,610 | 1,600 | 2,840 |
| *Pyrophacus stenii* | 1,004 | 850 | 1,300 |
| Mixotrophic Dinoflagellates | | | |
| *Ceratium furca* | 107,980 | 98,000 | 90,000 |
| Heterotrophic Dinoflagellates | | | |
| *Protoperidinium divergens* | 1,040 | 900 | 1,070 |
| *Protoperidinium pentagonum* | 1,570 | 2,400 | 1,300 |

## DISCUSSION

The phytoplankton community in the channel site is typical of a tropical oceanic community (Villareal, 1994, 1995 ; Morton, unpublished). Both the diatom and dinoflagellate species that dominate this community are commonly found throughout the Caribbean. The high dinoflagellate biomass inside the pond is remarkable, and is probably due to the unique nature of these mangrove cays. Large dinoflagellate populations have also been observed within semi-enclosed mangrove-lined lagoons north of the Pelican System. These cays include Twin Cays, Tobacco Range, and Douglas Cay (Faust and Gulledge, 1996; Morton and Villareal, in press; Morton, unpublished). At these locations, the dinoflagellate community in the mangrove-fringed lagoon is quite different from that in the adjacent water mass outside.

Both the northern and southern lagoons and ponds have a dinoflagellate-dominated community without any significant diatom population. There are notable differences in the composition and numbers of dinoflagellates in the two lobes of Manatee Cay Pond C. The larger northern lobe ($C_1$) has 11 species (8 dinoflagellate species, 2 diatom species, and 1 cyanophyte species) and a total phytoplankton population ranging from 64,856 to 75,731 cells • $L^{-1}$. The southern lobe ($C_2$) has 7 species of dinoflagellates and a total phytoplankton population ranging from 98,010 to 116,214 cells • $L^{-1}$. Both the northern and southern lobes are dominated by *Ceratium fusus*; this species contributes 92 to 97% of the total phytoplankton population. Large populations of *Ceratium fusus* are known to cause mortalities of benthic animals due to oxygen depletion and to cause acute toxicity of oyster larval stages (Cardwell et al., 1979; Mahoney and Steimle, 1979).

These three phytoplankton populations did have a few species in common (*Dinophysis caudata*, *Ceratium furca*, *Protoperidinium divergens*, and *P. depressum*). In all cases, the two pond sites had a larger biomass than the channel site outside. The extreme example is *Ceratium furca*. Within the pond the population examined ranged from 60,000 to 107,980 cells • $L^{-1}$ while the outside population ranged from 100 to 120 cells • $L^{-1}$.

Three species of toxic dinoflagellates—*Dinophysis caudata*, *Prorocentrum hoffmannianum*, and *Protoceratium reticulatum*—were found in high numbers in both Pond C locations. *Dinophysis caudata* and *Prorocentrum hoffmannianum* produce okadaic acid and related derivatives, while *Protoceratium reticulatum* produces yessotoxin (Lee et al., 1987; Aikman et al., 1993; Morton et al., 1994; Satake et al., 1997). Both these lipid soluble polyether toxins have been implicated in ciguatera fish poisoning (see review by Tindall and Morton, 1998). Thus, juvenile fishes feeding inside the pond have a greater chance of accumulating toxins than fishes feeding outside. The greatest numbers of toxic dinoflagellates associated with ciguatera fish poisoning are epiphytic and not planktonic. An ecological survey of epiphytic dinoflagellates by Morton and Faust (1997) has shown a low abundance of these dinoflagellates outside Fisherman's Cay. However, no determination of the epiphytic flora was conducted within the different ponds of the Pelican Cays. Additional sampling will be required to determine if the epiphytic dinoflagellates follow a similar trend as the planktonic dinoflagellates.

The only species to display a significant variation in cell number during the three sampling periods was *Gymnodinium sanguineum*. This species displayed a 100-fold increase in population density between the 9:00 a.m. tow and the 2:00 p.m. tow. *Gymnodinium sanguineum* is a classic example of a dinoflagellate known for diurnal vertical migration and for rapid swimming. Cullen and Horrigan (1981) showed that this species can swim up to 1.1 $m \cdot h^{-1}$. Villareal et al. (this volume) show that a vertically migrating chlorophyll *a* maximum is caused by this dinoflagellate in the northern lobe of Manatee Cay Pond C.

A hydrographic survey of Manatee Cay (Villeareal et al., this volume) has shown that the water mass within the pond has a distinct temperature-salinity structure suggesting little or no exchange with the water outside the pond. This hydrographic profile would retain biomass and nutrients within the pond. The differences in the phytoplankton populations between the two sampling locations of the pond also coincide with the hydrographic survey. Each of these pond sections could be considered a different ecosystem. This survey only collected phytoplankton greater than 10 µm. However, Villareal et al. (this volume) show that this fraction accounts for approximately 50 to 80% of the total chlorophyll *a* content. Thus, the size fraction less than 10 µm makes up a significant portion of the biomass within these ponds. Additional surveys are required to determine if the species composition of the nanoplankton and picoplankton shows similar trends as the net phytoplankton. Semi-enclosed ponds such as that of Manatee Cay appear to be prime locations for dinoflagellate blooms in traditionally nutrient-poor tropical waters. Similar Belizean mangrove-lined lagoons, Douglas Cay, Twin Cay, and Tobacco Range, also display large dinoflagellate blooms. In the red tide observed at Douglas Cay, maximum cell counts of *Gonyaulax polygramma* reach $3.6 \times 10^6$ cells $\cdot$ $L^{-1}$ (Morton and Villareal, in press). These blooms appear to be persistent and occur independent of human activity.

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