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The Abundance and Distribution of the Toxic Dinoflagellate, *Gonyaulax tamarensis*, in Long Island Estuaries

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ABSTRACT: The distribution and abundance of motile cells of the toxic dinoflagellate *Gonyaulax tamarensis* Lebour were monitored in estuarine waters of Long Island, a region with no previous history of shellfish toxicity. The population distribution was patchy, with the species detected in 40% of 115 estuaries examined during the spring bloom season. More detailed studies in four estuaries indicated that the dinoflagellate was most abundant in the headwater regions, with concentrations falling to undetectable levels at the mouths. *G. tamarensis* cell concentrations did not exceed 10^5 cells per l and often remained an order of magnitude lower. In several instances, population growth and accumulation ceased under seemingly favorable environmental and nutritional conditions.

Introduction

Gonyaulax tamarensis Lebour is the dinoflagellate responsible for outbreaks of paralytic shellfish poisoning (PSP) in temperate waters throughout the world. For decades, *G. tamarensis* has been present in the northern New England and eastern Canadian marine environment. Recently, however, dormant cysts of this species were detected in the sediments of six Long Island estuaries (31 examined; Anderson et al. 1982). Since cultures established from these cysts were toxic, the potential for outbreaks of PSP was established in a region with no history of shellfish toxicity. This threat is especially significant in light of the extensive commercial and recreational shellfish industry on Long Island. This study was thus designed to assess the *G. tamarensis* distribution and abundance in Long Island waters.

Methods

Weekly sampling was conducted March through November 1982, at four locations indicated by number in Fig. 1: (1) Centerport Harbor, (2) Mattituck Inlet, (3) Mud Creek at Babylon, and (4) Forge River. Cysts of *G. tamarensis* were previously observed at these four locations (Anderson et al. 1982). Within each location, four separate sites were sampled weekly progressing from the mouth to the head of the estuary. Phytoplankton and nutrient samples were collected by pumping water through 125 mm I. D. Tygon tubing. A vacuum was applied to a collection bottle, and tubing from this bottle was lowered from surface to bottom (deepest sample depth was 3 m) while pumping to provide an integrated sample. Phytoplankton did not pass through a pump and thus were not damaged in collection.

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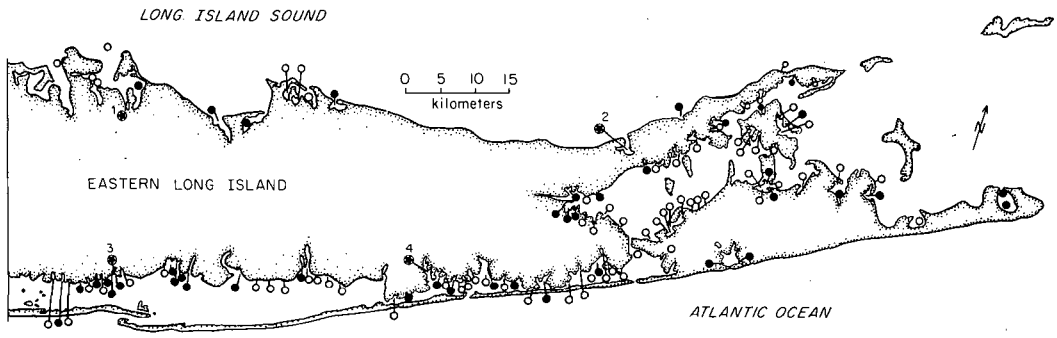

Fig. 1. Sites sampled in 1983. Darkened circles indicate the presence of *G. tamarensis* motile cells.

Phytoplankton samples were concentrated by pouring 500 ml of seawater through 10 μm aperture netting, then backwashing to give a 10 ml sample. Samples were preserved with Lugol's Iodine solution. Salinity and nutrient samples (NO_3^-, NH_4^+, and PO_4^{-3}) were analyzed by the Suffolk County Health Department, using Beckman Instruments model RS7-C salinometer and a Technicon Auto Analyzer II.

Additional phytoplankton samples were collected from surface waters every two weeks at 115 other estuaries throughout Suffolk County, from March through May 1983. These samples were preserved in 10% formalin and concentrated in the laboratory. A one ml aliquot of each sample was counted with a Zeiss standard microscope using a long working distance 40× objective and a Sedgwick-Rafter counting chamber.

Results

Gonyaulax tamarensis vegetative cells were present in 40% of the 115 estuaries and inlets sampled in spring 1983 (Fig. 1). The distribution was patchy, with no apparent clustering or grouping of populations in any one region. Vegetative cells first appeared in late March at the eastern end of the island with concentrations generally remaining below 10^4 cells per l, but concentrations reached 2×10^5 cells per l in the Seatuck Cove area of Moriches Bay.

At the four primary research sites, Mattituck Inlet, Centerport Harbor, Forge River and Mud Creek, several patterns can be observed for the seasonal distribution of motile cells in 1982 (Fig. 2). At two of the four locations, motile cells appeared in March, two weeks after the ice disappeared from the estuaries. Water temperatures were generally 5 °C or higher, except at Mattituck Inlet where the temperature was 4.4 °C. Peak *G. tamarensis* densities occurred from May through mid-June at three research sites, with the highest concentrations at Forge River and Mattituck Inlet (10^4 and 2×10^4 cells per l, respectively). Temperatures were between 17 and 21 °C when populations peaked (Fig. 2). A limited number (4) of mouse bioassays of shellfish from these areas were carried out, and these were negative for PSP (APHA 1970).

Water temperatures rose more rapidly at the south shores sites such that the primary bloom development occurred three weeks earlier than at the north shore sites. Furthermore, vegetative cells were most abundant at the north shore later in the spring (Fig. 2). Thus bloom durations were similar between regions, but the dates of initiation and decline were offset.

Bottom salinities remained relatively constant, between 22–28‰, at the four 1982 locations where *G. tamarensis* was present. Surface salinities ranged between 15–28‰.

Concentrations of nitrogenous nutrients fluctuated widely at all sites (Fig. 2), but in general were present in relatively high concentrations through the study period. Concentrations of NH_4^+ were almost always over 1.0 μg atoms per liter, and at one site, Mud Creek, reached 100 μg atoms per liter. Nitrate concentrations were several fold greater than NH_4^+ at Mattituck and Forge River, ranging from about 5 to 150 μg atoms per liter. Only in summer, when *G. tamarensis* was not present in the water column, did

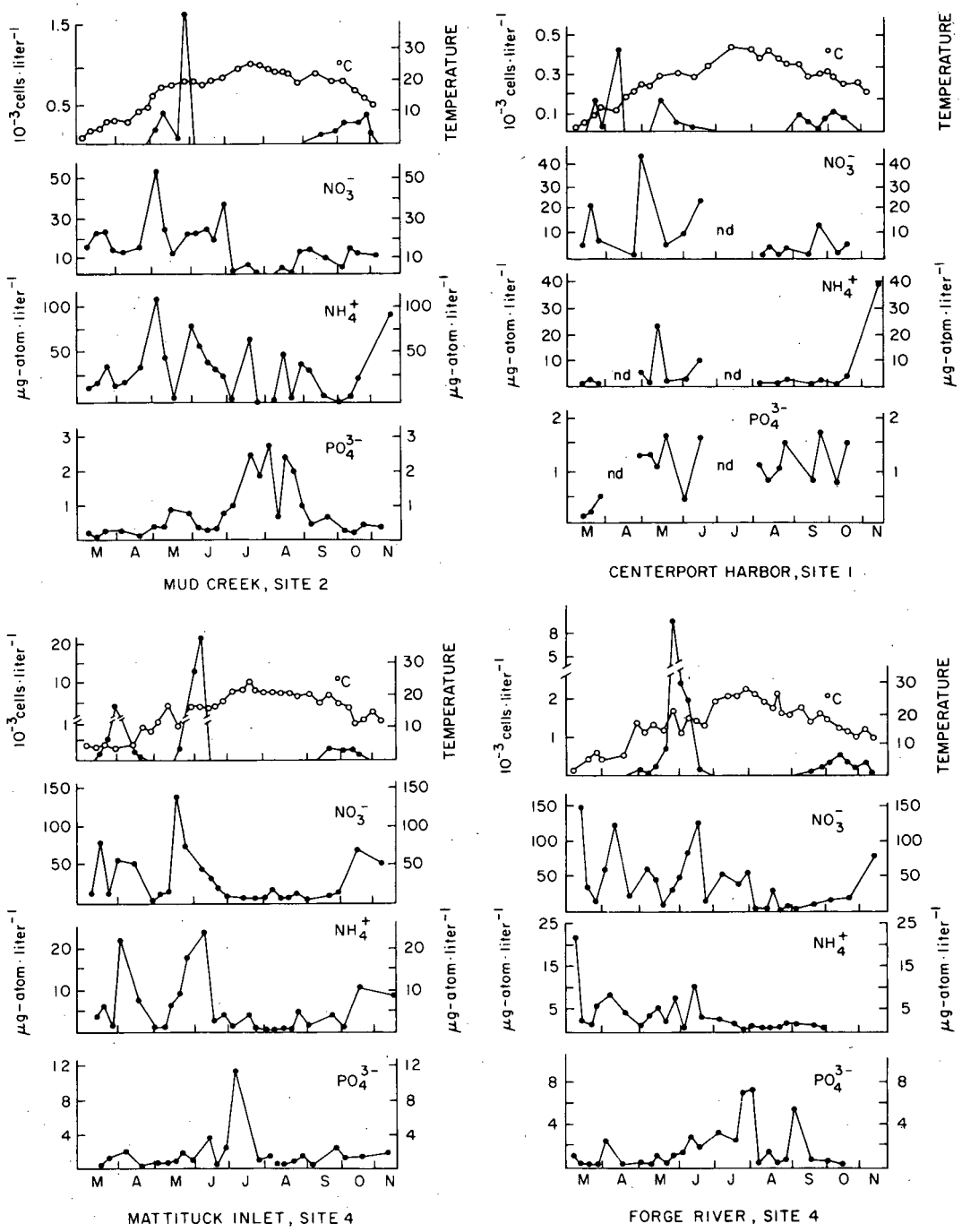

Fig. 2. *G. tamarensis* motile cell concentrations, temperatures, and nitrate, phosphate, and ammonium concentrations for the four primary research locations in 1982.

concentrations of N-nutrients approach zero. It is probable that when *G. tamarensis* is in the vegetative stage, it was not limited by the availability of nitrogenous nutrients.

During the spring, blooms at all four sites were preceded by an increase in NO_3^- concentration. For example, the highest cell concentration at Mud Creek in late May was preceded by an NO_3^- rise to over 50 μg atoms per liter several weeks earlier (Fig. 2). Similarly, the two spring peaks at Mattituck Inlet and the high cell concentrations at Centerport in late April and late May were both heralded by NO_3^- concentration increases two weeks previous. Only at Forge River were there sharp rises in NO_3^- without concommitant population increases. The relationship between these nutrient and cell concentration peaks may be spurious, since there typically occurred a one to two week lag between the nutrient and cell increases. However, these field observations do suggest that bloom development may depend on an increase in nitrogenous nutrient concentrations and in particular that of NO_3^-.

The distribution of *G. tamarensis* populations on Long Island was not uniform within each of the four main study areas. Cell densities were generally confined to the headwaters of the estuaries, falling to undetectable levels at the mouths (Fig. 3). This trend was true throughout all stages of bloom development and decline.

Discussion

Although the region has been historically free from outbreaks of shellfish toxicity, this study documents the presence of motile cells of the toxic dinoflagellate *G. tamarensis* in numerous Long Island estuaries. Vegetative cells of this species were observed in 40% of the 115 estuaries examined. The distribution was patchy, with no large areas totally free of the species. Although the value of this general survey lies more in the overall distribution of *G. tamarensis* than in its quantitative data, it is noteworthy that relatively large motile cell populations (10^5 cells per l) were detected in certain estuaries. Because *G. tamarensis* is so widespread on Long Island, it probably was not introduced via shellfish transplant programs or dredging, which occur at only a few sites around Long Island.

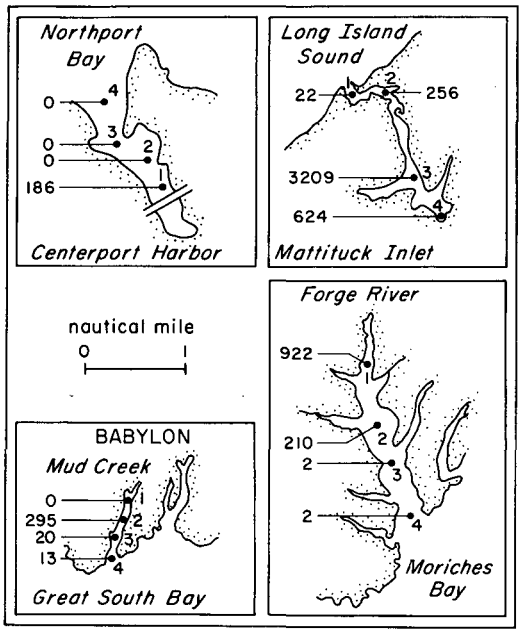

Fig. 3. The mean motile cell concentrations per liter of *G. tamarensis* at each of four sites within the four estuaries investigated in 1982.

The four estuaries that were investigated in greater detail all showed patterns of *G. tamarensis* growth similar to that observed in the Cape Cod region of Massachusetts (Anderson and Morel 1979). Cyst germination apparently seeded the overlying waters (Wall 1975; Steidinger 1975) when water temperatures reached approximately 5 °C in early spring and again as temperatures fell in early fall. It is of note that the timing of these spring blooms is quite similar to those reported for three Cape Cod estuaries (Anderson and Morel 1979). This was true not only in the spring (May, June maxima in cell concentrations) but in the fall as well (small population increases in September and October). This two-bloom sequence is in marked contrast to the timing of PSP outbreaks to the north of Long Island. In eastern Canada, a major bloom typically occurs between July and September (Medcof et al. 1947; Prakash et al. 1971). In Maine, the blooms occur earlier in the year (May–July) but distinct spring and fall events are uncommon (Hurst and Yentsch 1981).

High concentrations of motile cells primarily occurred in headwater regions where

fine-grained sediments are deposited and where currents and tidal flushing are small. Of the four estuaries, Mattituck Inlet and Forge River were the two locations with the largest *G. tamarensis* accumulations. These estuaries exhibit minimum physical disturbances at the stations of maximum concentrations.

Population development of *G. tamarensis* in three of the four study areas seemed to proceed without obvious resource limitation. Salinities of bottom waters remained well within the 20–28‰ optimal range reported for *G. tamarensis* by Yentsch et al. (1975). Temperatures were also suitable for good growth given the broad 12–20 °C optimal range reported by Yentsch et al. (1975) and Watras et al. (1982). With the exception of Centerport Harbor where *G. tamarensis* population size remained relatively small in the presence of low nutrient concentrations, the other major estuaries had relatively high nutrient availability throughout the blooms. In several instances, the *G. tamarensis* population disappeared from the water when nutrients were at or above levels that previously supported growth, as was also observed on Cape Cod by Anderson et al. (1983).

No positive PSP scores were detected in Long Island shellfish. The most logical explanation for the lack of detectable toxicity lies with the apparent low intrinsic toxicities of the Long Island strains of *G. tamarensis*. A recent survey of 35 *G. tamarensis* isolates from the northeastern U.S. and Canada documented toxin contents ranging from 289 m.u. per 10^6 cells to undetectable. Strains isolated from Mattituck, Forge River, and Mud Creek had 34, 18.5 and 16 m.u. per 10^6 cells, respectively (Anderson, unpublished data). As demonstrated by Alam et al. (1979), strains of this species from different regions can have toxin contents that vary by a factor of five or more. It would thus take many more cells of Long Island strains to yield the same level of toxicity found in strains from areas where PSP outbreaks are common.

This study confirmed that motile *G. tamarensis* cells are present in numerous Long Island estuaries during the spring, early summer, and fall. Our data indicate that the populations originate within estuaries and not from advected cells. The highest cell concentrations occurred in headwaters during May or June at temperatures exceeding 13 °C and following periods of heavy rainfall. No vegetative cells were present during the summer, and a small resurgence occurred in early fall. Similarities between these data and those from Massachusetts suggest that the PSP monitoring strategies employed there would be appropriate for Long Island.

Acknowledgments

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