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OBSERVATIONS ON "RED TIDE" ORGANISMS IN COASTAL WATERS OF SOUTHWESTERN LOUISIANA

Florida red tides are predominantly blooms of *Ptychodiscus brevis* (*Gymnodinium*), a toxic unarmored dinoflagellate (Steidinger and Haddad 1981). Red tides in the northern Gulf are more often associated with blooms of *Gonyaulax monilata*, a toxic, armored dinoflagellate (Connel and Cross 1950, Wardel *et al.* 1975, Perry *et al.* 1979, Perry 1980, Perry and McLelland 1981a,) *Oscillatoria erythraea*, a blue-green alga (Eleuterius *et al.* 1981) and *Prorocentrum minimum*, an armored, perhaps toxic, dinoflagellate (Perry and McLelland 1981 a & b).

The purpose of this paper is to report the common occurrence of four species of red tide producing organisms in local marine and estuarine waters and that blooms may occur when environmental conditions are favorable.

MATERIALS AND METHODS

During 1981 monthly water samples were collected at five estuarine stations associated with Calcasieu Lake and seven marine stations in the Gulf of Mexico (Figure 1 and Table 1). Each collection consisted of three one liter samples taken at a depth of one meter with a van Dorn sampler. Samples were preserved with Lugol's iodine at a final concentration of 1 part/100 parts sample. Routine analysis of species composition and cell counts followed the method described by Maples (1982). Salinity, dissolved oxygen, pH, and temperature were measured *in situ* with a Kahlscico Hydrolab Series 8000. Nutrients, $\text{NO}_3\text{-N}$, $\text{NH}_4\text{-N}$, and total PO_4 , were determined by the methods of Strickland and Parsons (1972).

RESULTS AND DISCUSSION

Four red tide producing species, *Noctiluca millaris* Surirey, *Oscillatoria erythraea* (Ehren.) Kutz., *Gonyaulax monilata* Howell and *Prorocentrum minimum* (Par.) Schiller were identified from our samples. Other dinoflagellate species observed in the coastal waters of southwestern Louisiana during this study were: *Ceratium furca* (Ehren.) Calp. and Lack., *C. fusus* (Ehren.) Dujardin, *C. massiliensis* (Gourret) Jörg., *C. trichoceros* (Ehren.) Kofoid, *C. tripos* var. *atlanticum* Ostenfield, *Cochlodinium* sp., *Dinophysis caudata* Saville-Kent, *D. caudata* var. *acuminiformis* Jörg., *Gonyaulax polygramma* Stein, *Glenodinium splendens* Lebour, *Oxytoxum milneri* Murray & Whiting, *O. scolopax* Stein, *Peridinium divergens* Ehren., *Prorocentrum compressum* (Ostenfield) Abbé, *P. gracile* Schutt and

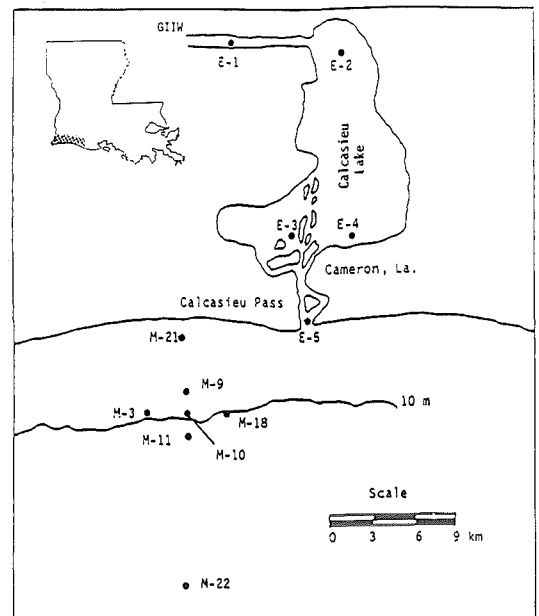


Figure 1. Location of sampling stations in coastal waters of southwestern Louisiana. M — Marine; E — Estuarine; GIWW — Gulf Intracoastal Waterway; map insert shows location of study area.

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Table 1. Sample station locations in southwestern Louisiana. Marine stations are designated 'M' and estuarine stations 'E'.

Station	Latitude	Longitude	Depth (m)
M-3	29°39.5' N	93°30.3' W	9.4
M-9	29°40.5' N	93°28.4' W	9.1
M-10	29°39.5' N	93°28.3' W	9.8
M-11	29°38.5' N	93°28.3' W	10.4
M-18	29°39.5' N	93°26.3' W	9.8
M-21	29°43.5' N	93°28.3' W	5.5
M-22	29°31.5' N	93°28.3' W	11.3
E-1	30°03.3' N	93°26.1' W	4.0
E-2	30°03.1' N	93°18.4' W	1.3
E-3	29°51.3' N	93°22.0' W	1.2
E-4	29°51.2' N	93°18.5' W	1.5
E-5	29°46.1' N	93°20.4' W	6.0

Pyrophacus horologium Stein.

Noctiluca miliaris was recorded from all marine stations but was never seen in samples collected from Calcasieu Lake (Figure 1). This species was present from early spring through mid-summer (April-July), with cell counts never exceeding $200 \cdot 1^{-1}$. The environmental conditions during this period are presented in Table 2.

Prorocentrum minimum was recorded from all marine stations except M-22 and at estuarine stations E-3, E-4 & E-5 from mid-summer through late fall (July-October). The environmental conditions during this period are presented in Table 2. Cell counts never exceeded $3000 \cdot 1^{-1}$. Perry and McLelland (1981b) reported blooms of this dinoflagellate in Mississippi Sound. Our observation is the first of this organism from coastal waters of Louisiana. *Prorocentrum minimum* has been suspected of causing mussel poisoning in coastal waters of Holland (Kat 1979).

Oscillatoria erythraea (*Trichodesmium*) was recorded only from the marine stations (Figure 1). This species was first observed at offshore station M-22 in May. By the month of August it was observed at all the other marine stations except M-21, and had disap-

peared from all stations by October. This bloom pattern suggests a coastal movement (offshore to coast) for this species. Housley (1976) also noted higher concentrations of this alga in deep offshore waters (35-50 fathoms) of Mississippi and Louisiana. The largest population in our study was recorded on August 14, 1982 at station M-22 with counts of 1048 trichomes $\cdot 1^{-1}$. Environmental conditions prior to this bloom were: low rainfall, stratified water column, low nitrate-nitrogen, high water temperature, high salinity and basic pH (Table 2). Similar conditions preceded a bloom of this alga in Mississippi Sound (Eleuterius *et al.* 1981).

Gonyaulax monilata is a toxic dinoflagellate, however, it does not cause shellfish poisoning because bivalves do not filter in its presence (Tufts 1979, Steidinger & Haddad 1981). No fish kills, jubilees or discolored waters were associated with its presence in the estuarine and marine waters of

Table 2. Environmental data for coastal marine waters of southwestern Louisiana during the phytoplankton bloom months of 1981.*

Month	Temperature (°C)	Salinity (‰)	Dissolved Oxygen (ml \cdot l $^{-1}$)	NO $_3^-$ -N (mg \cdot l $^{-1}$)
April	22.0	28.0	5.41	0.086
May	24.0	27.4	5.06	0.120
June	29.6	17.0	5.08	0.030
July	29.6	26.3	4.74	0.015
August	30.5	32.3	4.19	0.010
September	28.5	26.4	4.56	0.010
October	27.2	25.8	4.30	0.010

	NH $_4^+$ -N (mg \cdot l $^{-1}$)	Total Phosphates (mg \cdot l $^{-1}$)	pH
April	0.097	0.018	8.2
May	0.150	0.020	8.2
June	0.025	0.016	8.1
July	0.020	0.015	8.3
August	0.010	0.012	8.3
September	0.020	0.010	8.4
October	0.025	0.011	8.2

*All values are means.

southwestern Louisiana. This organism first appeared at estuarine station E-4 in June and at marine station M-18 in August. This would suggest a seaward movement (estuary to sea) of the bloom during the sample period. Such a movement could have been accomplished by both river runoff and tidal transport.

The cell counts at station E-4 in June were low, $150-200 \cdot 1^{-1}$. On September 9, 1981 there was a localized bloom of 5.0×10^3 cells $\cdot 1^{-1}$ near the oyster reef in the south end of Calcasieu Lake. By October 1, 1981 this species was no longer observed in samples from the estuary. The initial appearance of *Gonyaulax* in the estuary followed by seaward movement of the population would suggest the presence of "seed beds" (hypnozygotes) in Calcasieu Lake. Walker and Steidinger (1979) described "seed beds" as dormant cysts in the sediments. Certain unknown environmental interactions cause a resuspension and/or excystment, creating a mobile population of asexually reproducing cells which can become a bloom (Steidinger and Haddad 1981).

Gonyaulax monilata first appeared at marine stations in August, disappearing by November. The largest population occurred at station M-18 on August 14, 1981. Counts of 2.6×10^4 cells $\cdot 1^{-1}$ were recorded. Environmental conditions at the time of sample collections are presented in Table 2. A pronounced stratification of the water column was also evident during the month of August. Perry *et al.* (1979) reported a large bloom of this dinoflagellate in the coastal waters of Mississippi, Florida, Alabama and Louisiana.

Most of the other species of dinoflagellates observed in this study were seasonal, occurring from July through October, however, *P. compressum* may be considered a resident

species since it could be found during any month in our samples. No species of dinoflagellate was found only in the estuary. *Gonyaulax polygramma*, *Glenodinium splendens*, *Prorocentrum compressum* and *P. gracile* were observed in samples from both marine and estuarine waters. *Dinophysis caudata* was observed occasionally at station E-5, but this is not unexpected because E-5 is near marine waters (Figure 1).

The other species reported earlier in this paper were found only in marine waters and at all stations except *Ceratium massiliense*, *C. trichoceros* and *Pyrophacus horologium* which were found only in samples from station M-22.

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