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Red-tide–associated Mass Mortality in 2005 of the Sand Dollars *Encope aberrans, Encope michelini,* and *Mellita tenuis* (Echinodermata: Echinoidea) on the Central Florida Gulf Coast Shelf

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In March 2005, populations of *Encope aberrans* and *E. michelini* found at 20-m depth (ca. 27 km west of Captiva Island) and of *Mellita tenuis* at 6.5-m depth (ca. 7 km west of Egmont Key) were studied to calculate density and size frequency distribution. All individuals were alive. A red tide occurred on the central Florida Gulf Coast shelf during the summer. In Sept., all individuals in these populations were dead. Dead individuals had lost their spines and were gray but intact, indicating recent death. On the same date, all *E. michelini* and *E. aberrans* were alive in a population at 20-m depth (ca. 26 km north of the site off Captiva Island and ca. 23 km west of Gasparilla Island). All individuals in a population of *M. tenuis* at 2-m depth immediately offshore Fort De Soto Park were alive 1 mo after the observation of complete mortality off Egmont Key. All *E. aberrans* at a site 28 km southwest of Egmont Key were dead in Oct. In May 2006, live *E. michelini* occurred at the Captiva site at the same density as in March and Sept. 2005. Their large size indicates their origin was by migration from nearby areas unaffected by the red tide.

Red tides are prominent features of shallow waters of the eastern (Kusek et al., 1999; Kirkpatrick et al., 2004) and western (Magaña et al., 2003) Gulf of Mexico. Reports of red-tide–associated mass mortalities usually concern fish and harvestable bivalves because of their conspicuousness and economic impact. Reports of red-tide–associated mass mortalities of other benthic marine invertebrates on the Gulf of Mexico shelf are less common (Gunter et al., 1948; Smith, 1975; Wardle et al., 1975; Tiffany and Heyl, 1978; Serafy, 1979). These reports provide no quantitative data. Quantitative data are necessary to understand the potential impact of the red tide. The report of Simon and Dauer (1972), with quantitative documentation of mortality of benthic invertebrates resulting from a rare incursion of red tide into Tampa Bay in 1971, seems unique.

Reports of mass mortalities of fish and other reef animals from Tarpon Springs to Sarasota, Florida associated with a red tide of *Karenia brevis* appeared during the first week of August 2005 (Harmful Algal Bloom Group, 2005a, 2005b). Here we quantify the mass mortality of three species of sand dollars associated with that red tide.

MATERIALS AND METHODS

Populations were observed by SCUBA off the central Florida gulf coast shelf in March, Sept., and Oct. 2005, and May 2006 (Fig. 1, Table 1). Densities were calculated by counting the number of individuals within 30 1-m^2 sequential quadrats along two parallel transects. Sizes were measured to the nearest millimeter with calipers as the width of the test at the anterior lateral notches for *E. aberrans* and *E. michelini* and the anterior lateral lunules for *M. tenuis*. This measurement was done instead of the more usual greatest width of the test because the test is often damaged (Lawrence and Tan, 2001) and positioning of calipers for measurement is more exact. Salinity, temperature, and oxygen concentration were measured by sensor (Seabird Electronics) in Sept. Physical parameter measurements were not taken on all dates because of logistics.

RESULTS

Densities, size frequency distributions, and condition of the populations are given in Table 2. In March 2005, all individuals in populations of *E. aberrans* and *E. michelini* ca. 27 km west of Captiva Island (Captiva East) and of *M. tenuis* ca. 7 km west of Egmont Key (Egmont East) were alive. In Sept. 2005, all individuals in these populations were dead. Dead individuals had no spines and were gray but the tests were intact, validating their inclusion in density measurements. On the same date, all *E. michelini* and *E. aberrans* were alive in a population ca. 26 km north ca. 23 km west of Gasparilla Island (Gasparilla). All individuals in a population of *M. tenuis* at 2-m depth immediately offshore Fort De Soto were alive before and

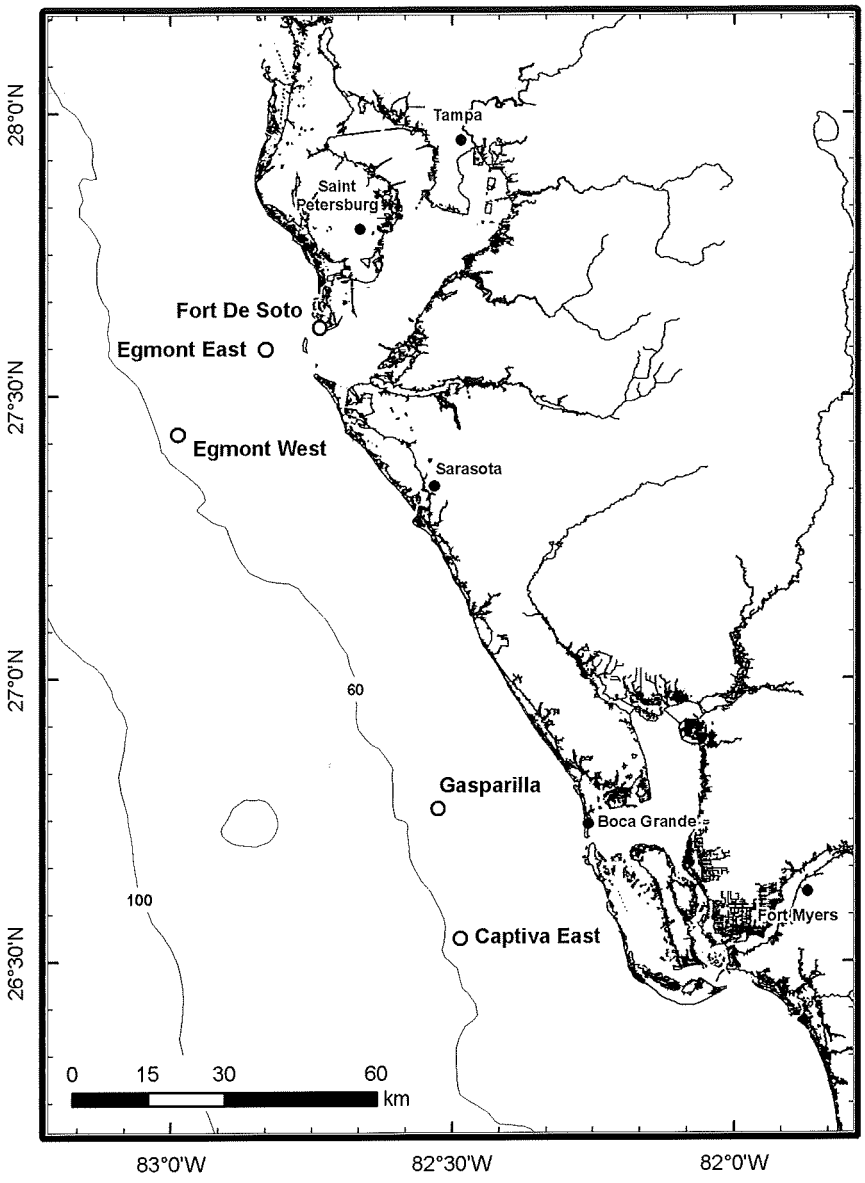

Fig. 1. Location of sites off the central Florida gulf coast shelf.

after the complete mortality of *M. tenuis* at Egmont East, ca. 11 km to the southwest. All *E. aberrans* ca. 28 km southwest of Egmont Key (Egmont West) were dead on 13 Oct.

Salinity, temperature, and oxygen concentration in Sept. 2005 are given in Table 1. Surface and bottom temperatures (ca. 28 C) and salinities (ca. 35‰) were similar in both surface and bottom waters at all sites. Surface and bottom oxygen concentrations ranged from 6.2 to 7.6 mg/l at all sites except at Gasparilla, where bottom oxygen concentration was 4.6 mg/l.

In May 2006, 7 mo after the observation of the mass mortalities, large *E. michelini* were found at Captiva East at a density and size like those in Sept. 2005; 33% of these were intact dead individuals. *Encope michelini* and a few *E. aberrans*, all alive as in Sept. 2005, were found at Gasparilla. No live sand dollars were found at either Egmont East or West.

Discussion

Documentation of mass mortalities associated with red tides in the Gulf of Mexico has been limited primarily to qualitative statements

TABLE 1. Observation sites and dates, and temperature, salinity and oxygen concentration in September 2005.

Site	Date	Depth (m)	Temperature (C)	Salinity (‰)	Oxygen concentration (mg/l)
Captiva East	19 Mar 05	18.3	16.7		
26°32.45′N	17 Sept 05	1.5	28.7	35.5	7.6
82°29.14′W		20.1	28.7	35.5	7.2
26°34.36′N	4 May 06				
82°29.73′W					
Gasparilla					
26°46.20′N	17 Sept 05	1.5	29.3	35.1	6.3
82°31.52′W		18.1	28.0	35.4	4.6
26°46.14′N	4 May 06				
82°31.51′W					
Egmont West	13 Oct 05	18.6	27.2		
27°25.92′N					
82°59.20′W	5 May 06				
27°25.44′N					
82°58.61′W					
Egmont East					
27°34.98′N	20 Mar 05	1.5	28.8	34.2	6.5
82°50.09′W	18 Sept 05	6.5	28.7	34.6	6.2
27°31.97′N	5 May 06				
82°53.17′W					
Fort De Soto					
27°37.31′N	10 Sept 05	ca. 2			
82°59.00′W	21 Oct 05				

TABLE 2. Density and size (mean ± SD) and condition of *E. aberrans, E. michelini,* and *M. tenuis* on the central Florida gulf coast shelf in 2005 and 2006. The size of *E. michelini* in May 2006 are for alive and dead individuals separately.

	Site	Date	Density (individuals · m^{-2})	Size (cm)	Condition
E. aberrans	Captiva East	19 Mar 05	0		
		17 Sept 05	0.3 ± 1.0	10.5 ± 1.0	Dead
		4 May 06	0		
	Gasparilla	17 Sept 05	0.0 ± 0.2	10.3 ± 0.0	Alive
		4 May 06	0		
	Egmont East	20 Mar 05	0.2 ± 0.5	10.5 ± 0.7	Alive
		18 Sept 05		10.7 ± 0.4	Dead
		5 May 06	0		
	Egmont West	13 Oct 05	0		
		5 May 06	0		
E. michelini	Captiva East	19 Mar 05	0.9 ± 1.0	8.2 ± 0.5	Alive
		17 Sept 05	0.4 ± 0.8	7.4 ± 0.8	Dead
		4 May 06	0.2 ± 0.4	8.5 ± 0.6	Alive
				8.3 ± 0.5	Dead
	Gasparilla	17 Sept 05	0.3 ± 0.8	7.2 ± 0.6	Alive
		4 May 06	0.1 ± 0.4	8.4 ± 0.6	Alive
M. tenuis	Egmont East	20 Mar 05	4.1 ± 2.5	7.1 ± 0.6	Alive
		18 Sept 05		7.3 ± 0.9	Dead
		5 May 06	0		
	Fort De Soto	10 Sept 05	20.3 ± 6.6	6.4 ± 0.8	Alive
		21 Oct 05	18.3 ± 3.2		Alive

about fish and reef-associated invertebrates (review by Kusek et al., 1999). The data in this article are the first to report and quantify red-tide–associated mass mortality of benthic marine invertebrates in deeper waters, including pre- and postcondition characteristics of the populations.

Reports of red-tide–associated mortality of fish and reef-associated invertebrates off the central Florida gulf coast shelf appeared in Aug. 2005 (Harmful Algal Bloom Group, 2005a, 2005b). *Karenia brevis* were present in benthic water samples taken at the sites where dead sand dollars were found in the present study on the date of observation in Sept. (C. Heil, Fish and Wildlife Research Institute, St. Petersburg, pers. comm.). Oxygen concentrations at the sites were not low, except for bottom water at Gasparilla, where both *E. aberrans* and *E. michelini* were alive. These measurements were made after the mass mortality of the sand dollars and the antecedent conditions are not known.

Although the mass mortality of sand dollars found here was extensive, it was also patchy, as indicated by complete mortality and no mortality of populations of *E. aberrans* and *E. michelini* only ca. 26 km apart and of *M. tenuis* only ca. 11 km apart. Steidinger (1975) noted blooms of *Gymnodinum* (*Karenia*) *brevis* on the Florida Gulf Coast shelf may be localized. The repopulation of Captiva East by *E. michelini* by May 2006 also indicates mass mortality can be very localized. The large size of these individuals precludes the possibility of their being recruits and suggests migration from nearby areas. In contrast, no *M. tenuis* were found at Egmont East in May 2006. This suggests a more extensive mortality there and failure of repopulation by either migration or recruitment.

Sand dollars are conspicuous macroinvertebrates on the Florida gulf coast shelf (Salsman and Tolbert, 1965; Bell and Frey, 1969; Lane and Lawrence, 1980; Frazer et al., 1991, Kurz, 1995; Pomory, 2004). Their mass mortality represents a major, abrupt change in local community composition and could have considerable ecological consequences. The widespread distribution of the sand dollars on the shelf indicates they constitute a metapopulation from which repopulation by migration or recruitment could occur.

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