

## Harmful Dinoflagellates in the Gulf Stream and Atlantic Barrier Coral Reef, Belize

Maria A. Faust<sup>1</sup> and Patricia A. Tester<sup>2</sup>

<sup>1</sup>Department of Systematic Biology–Botany, NMNH, Smithsonian Institution, 4210 Silver Hill Road, Suitland, MD 20746, USA, faust.maria@nmnh.si.edu; <sup>2</sup>Center for Coastal Fisheries and Habitat Research, National Ocean Service, NOAA, 101 Pivers Island Road, Beaufort, NC 28516, USA

### Abstract

Dinoflagellates from two locations in Gulf Stream waters of the US South Atlantic Bight are reported and compared with dinoflagellates from the tropical Atlantic Barrier Coral Reef, Belize. There is limited information on HAB species in the two areas. A total of 45 tropical oceanic warm-water species, and 16 benthic, potentially harmful species were present.

### Introduction

This report presents information on the distribution of harmful dinoflagellates in the Gulf Stream along the southeastern coast of the United States where expatriate *Karenia brevis* blooms have occurred (Tester and Steidinger, 1997). The aim of this paper is to report the harmful algal bloom (HAB) species composition and oceanic dinoflagellates in the Gulf Stream and compare these with the species composition found in Belizean coral reef-mangrove habitats (Faust 2000). In the continental shelf waters of the US South Atlantic Bight, phytoplankton distribution is highly variable and dinoflagellates represent 46% of total phytoplankton biomass (Marshall, 1971, 1982). The tropical oceanic dinoflagellates are major components in the plankton. The entry of tropical assemblages of dinoflagellates into the Gulf Stream is from the Gulf of Mexico via the Florida Current (Tester and Steidinger 1997), the Caribbean Sea (Marshall, 1978), or the Sargasso Sea (Parker, 1971). Inshore habitats may also contribute organisms to the Gulf Stream (Richardson, 1976).

In the waters off Carrie Bow Cay and Douglas Cay, Belize, distribution of dinoflagellates revealed countless surprises. This coral reef-mangrove ecosystem is characterized by great diversity, showing distinct characteristics relative to adjacent oceanic water from those in lagoonal shallow mangrove cays (Macintyre and Ruetzler, 2000) where harmful and oceanic dinoflagellate species co-exist (Faust, 2000). HAB dinoflagellates are abundant inside protected cays, maintaining blooms in naturally enriched shallow water (Morton and Villareal, 2000), with different species from those in adjacent pelagic waters (Faust, 2000). Information, however, is limited on the species of HAB di-

noflagellates in the swift-moving current of the Gulf Stream compared with the oceanic regime of the fore reef of Carrie Bow Cay and deep channel waters outside of Douglas Cay, Belize.

### Materials and Methods

The samples include eight integrated water column net tows (20 and 35 mm pore size net) in the Gulf Stream and Atlantic Barrier Reef, Belize (Table 1). Sample origin: 1) Gulf Stream—27 nm offshore from Cape Lookout, NC, and 6 km offshore from the Indian River Inlet, FL; and 2) Belize—50 m offshore from Carrie Bow Cay, and in the channel outside Douglas Cay. Cells were preserved in 2% glutaraldehyde final concentration and processed for scanning electron microscopy following Faust (1990). Species identifications were made from 685 SEM micrographs of alike oceanic and HAB dinoflagellate species.

### Results

A total of 53 dinoflagellate species, 45 oceanic, and 17 HAB species were identified from eight plankton collections. The number of oceanic species ranged from 41 to 45 per collection (Table 2). Cell size was generally large (<100 µm). The diversity of species varied in each collection. The worldwide-distributed tropical oceanic species were the most abundant—e.g., *Ceratium trichoceros*, *C. vultur*, *C. macroceros*, and *C. concilians*, *C. horridum*, *C. tripos*, *C. massiliense*, *C. lunula*, *C. declinatum*, and *C. candelabrum*—whereas *C. furca* was cosmopolitan. The *Protoperidinium* spp. identified were *P. curtipes*, *P. depressum*, *P. divergens*, *P. elegans*, *P. globulosus*, *P. grande*, *P. obtusum*, and *P. steinii*. Frequently the following species were included: *Diplopetla*

**Table 1** Station location, date, sample depth (m), temperature (°C), salinity (psu) of collections.

Site	Date	Location	Depth (m)	Temperature	Salinity
Cape Lookout, NC	4-Jun-02	34°23'N 79°56'W	10	28	36
	18-Jun-02	34°36'N 76°06'W	15	27	36
Indian River Inlet, FL	2-Feb-02	27°30'N 79°56'W	114	22.5	36
	22-Apr-02	27°31'N 79°55'W	100	22.5	36
Carrie Bow Cay, Belize	17-May-00	16°48'N 88°05'W	10	26	35
	1-Jun-01	16°53'N 88°13'W	10	27	35
Douglas Cay, Belize	22-May-01	16°43'N 88°13'W	10	31	35
	29-May-01	16°43'N 88°10'W	10	29	35

**Table 2** Number of oceanic and HAB dinoflagellates in collections.

Dinoflagellates	Cape Lookout	Indian River	Carrie Bow Cay	Douglas Cay
Oceanic species	45	41	44	43
HAB species	7	8	9	9
Total numbers	52	51	53	52
% HAB spp.	13	16	17	17

*bomba*, *Prorocentrum micans*, *P. compressum*, and *P. gracile*, *Goniodoma sphaericum*, and *G. polyedricum*. Ornamented oceanic species were *Ornithocercus quadratus*, *O. magnificus*, *O. steinii*, and *O. thumii*, *Ceratocorys horrida*, and *Podolampas bipes*, while the rare species included *Blepharocysta hermosiliai* and *B. splendor-maris*, *Diplopsalopsis orbicularis*, *Lissodinium taylora*, and *Spiraulax kofoidii*.

Distribution of HAB species varies from 7 to 9 in the collections (Table 2). Cell size of autotrophic species are relatively small (<100 µm). Red tide-forming HAB species were *Gonyaulax grindleyi*, *G. polygramma*, and *G. spinifera*; benthic HAB species were *Coolia monotis*, *Gambierdiscus toxicus*, *G. pacificus*, and *G. australes*, *Ostreopsis siamensis*, *Prorocentrum belizeanum*, *P. borbonicum*, *P. emarginatum*, *P. lima*, and *P. mexicanum*; and planktonic HAB species were *Dinophysis caudata*, *D. rotundata*, and *D. rapa*. The full listing of the sixteen HAB species representing planktonic and benthic tropical warm-water species is shown in Table 3, below.

### Discussion

Our study reports the distribution of HAB species in the recent collections at four geographically distant sites and locations collected in the Gulf Stream and the Atlantic Barrier Reef, Belize. A total of 53 dinoflagellate species were present in the eight samples, separated into oceanic, benthic HAB and red tide-forming HAB species. Dinoflagellate taxa were representative of tropical oceanic species. Coral reef-mangrove HAB dinoflagellates enter southeastern waters of the United States in Gulf Stream warm-core rings (Gould, 1988). These rings carry water of distinct quality and composition (Parker, 1971, Richardson, 1976) and have a stabilizing influence on planktonic organisms of the Gulf Stream (Wiebe, 1976). The Gulf Stream, with its eddy formation, provides the entry of the tropical and subtropical species into waters north of Cape Hatteras (Marshall, 1978). Warm-core ring protection and survival offers a possible explanation to findings of 45 warm water oceanic and 16 HAB species as far north as Cape Lookout, NC (Marshall, 1978). The dinoflagellate assemblages are diverse in both shelf and coral reef waters, in association with chain-forming and planktonic diatoms. Marshall (1982) examined dinoflagellate distribution in southeastern shelf waters south of Cape Lookout, NC. He found that of the 72 specimens, 46% of the species were present at far-off shelf

**Table 3** HAB dinoflagellate species in collections. Values are yes (present), no (absent).

Dinoflagellate	Cape Lookout	Indian River	Carrie Bow Cay	Douglas Cay
<i>Coolia monotis</i>	no	yes	no	no
<i>Dinophysis caudata</i>	yes	no	yes	yes
<i>Dinophysis rotundata</i>	no	no	no	no
<i>Dinophysis rapa</i>	yes	no	yes	no
<i>Gambierdiscus toxicus</i>	yes	yes	yes	yes
<i>G. australes</i>	yes	yes	no	no
<i>G. pacificus</i>	no	no	yes	no
<i>Gonyaulax grindleyi</i>	no	no	yes	no
<i>G. polygramma</i>	no	no	yes	yes
<i>G. spinifera</i>	yes	yes	yes	yes
<i>Ostreopsis siamensis</i>	no	yes	no	yes
<i>Prorocentrum lima</i>	yes	yes	no	yes
<i>P. emarginatum</i>	no	yes	yes	yes
<i>P. mexicanum</i>	no	yes	no	yes
<i>P. borbonicum</i>	no	no	yes	no
<i>P. belizeanum</i>	no	no	no	yes

stations, where highest species concentrations of *Ceratium furca*, *C. lineatum*, and *C. trichoceros*, *Dinophysis caudata*, and *Prorocentrum micans* occurred. Comparison of our studies with those of Marshall (1982) is not possible. He did not report any HAB dinoflagellate species in his collections south of Cape Lookout. In our studies, four genera represent the highest number of tropical oceanic species: 33% *Ceratium*, 8% *Dinophysis*, 19% *Protopectinidium*, and 19% *Prorocentrum*. Similarly, four genera depicted 16% benthic HAB taxa: *Dinophysis*, *Gonyaulax*, *Gambierdiscus*, and *Prorocentrum*.

The study provides new knowledge on tropical benthic HAB species associations and distributions within tropical oceanic taxa in Gulf Stream and Belizean reef-mangrove habitats. The discovery of the presence of tropical benthic HAB species in Gulf Stream waters in the South Atlantic Bight is considered significant new information. We report benthic HAB dinoflagellate assemblages in Gulf Stream water that represent potentially harmful species distributed worldwide (Steidinger and Tangen, 1997) and HAB dinoflagellate species described from the Belizean coral reef mangroves (Faust 1996, 2000). The distribution pattern of tropical HAB species exhibited a long geographical distance from Cape Lookout, NC, to Douglas Cay, Belize. Our data showing HAB specimens in the Gulf Stream's fast-moving current suggests that this is a possible mechanism for the dispersal of HAB species. However, the relationship of broad hydrographic events, and dispersal of HAB species, and phytoplankton dynamics in the Gulf Stream need further investigation.

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