Marine Micropaleontology 76 (2010) 104–123

Contents lists available at ScienceDirect

Marine Micropaleontology

journal homepage: www.elsevier.com/locate/marmicro

Research paper

Dinoflagellate cyst distribution in surface sediments along the south-western Mexican coast (14.76° N to 24.75°N)

Audrey Limoges [a,*], Jean-François Kielt [a], Taoufik Radi [a], Ana Carolina Ruíz-Fernandez [b], Anne de Vernal [a]

[a] GEOTOP-UQAM C.P. 8888, succ. Centre ville, Montréal, Québec, Canada H3C 3P8
[b] Universidad Nacional Autónoma de México, A.P. 811, Centro, 82 000 Mazatlán, Sinaloa, México

ARTICLE INFO

Article history:
Received 28 August 2009
Received in revised form 15 June 2010
Accepted 22 June 2010

Keywords:
Mexico
Cysts
Environmental parameters
Upwelling
Primary productivity

ABSTRACT

In this study, we explore the relationship between the modern assemblages of organic-walled dinoflagellate cysts and sea-surface conditions (temperature, salinity, primary productivity) and water depth and distance to the coast. Statistical treatments were performed on 95 surface sediment samples from sites located along the south-western Mexican coast (14.76° N to 24.75°N). Redundancy analysis (RDA) illustrates that the principal parameters correlated with the regional cyst distribution are the distance to the coast and the productivity in the upper water column, which is closely related to upwelling intensity. Empirical observations coupled with RDA provide insight into the spatial coverage of some cyst taxa produced by dinoflagellate species potentially responsible for harmful algal blooms along the coast. They also allow the recognition of four zones of assemblages, which are linked to the upwelling intensity and the productivity and characterize La Paz Bay, the south-western Mexican margin (from 15.95° N to 23.11° N), the northern part of the Gulf of Tehuantepec and the southern part of the Gulf of Tehuantepec.

1. Introduction

During recent decades, some areas along the western Mexican coast, notably Bahía Mazatlán and Baja California, were affected by periodic and relatively frequent red tide events (Ramírez-Camarena et al., 1999; Alonso-Rodríguez and Ochoa, 2003; Mee et al., 2003; Hernández-Becerril et al., 2007). In Bahía Mazatlán, seventeen harmful algal blooms (HABs) have been reported in a period of 4 months during the year 2000 (Alonso-Rodríguez and Ochoa, 2004). Primary productivity is stimulated by upwelling, terrestrially derived nutrient enrichment and by various biotic and abiotic factors (Mee et al., 1985; Alonso-Rodríguez and Ochoa, 2004). Massive proliferation of toxic dinoflagellates is the major cause of harmful algal blooms (HABs). When high density of toxic species occurs, the toxins are ingested by organisms and transferred to higher trophic levels through the food chain, which may extend to human poisoning. Due to the environmental and human health impacts, HABs represent a big threat for the national tourism and fishing industries.

Dinoflagellates constitute one of the major groups of marine plankton, which include both phototrophic, heterotrophic and mixotrophic species (e.g. Gaines and Elbraechter, 1987; Taylor and Pollingher, 1987). The presence of specific dinoflagellate species in marine environments depends on their respective feeding behaviours: while phototrophic growth is supported mostly by the nutrient availability and sunlight penetration, heterotrophic species are dependent upon diatoms and other micro-organisms on which they prey (Jacobson and Anderson, 1986). During reproduction, as part of their life-cycle, 10% to 20% of dinoflagellates produce a cyst to protect their cell for a variable period of time (e.g. Dale, 1976; Taylor and Pollingher, 1987; Head, 1996). Unlike siliceous or carbonates microfossils, which are sensitive to dissolution processes, the cysts of most dinoflagellates are composed of very resistant organic material and are generally well-preserved in sediment. Therefore, chemical and physical treatments easily allow their extraction from sediments.

In coastal environments, close relationships exist between the modern assemblages of organic-walled dinoflagellate cysts in sediment and biotic and abiotic conditions in the upper water column. Cyst distribution depends upon sea-surface parameters including salinity, temperature, sea-ice cover and primary productivity (Wall et al, 1977; Matsuoka, 1985; Mudie, 1992; Ellegaard et al., 1994; Marret, 1994; Matthiessen, 1994; de Vernal et al., 1997, 2001, 2005; Zonneveld, 1997; Rochon et al., 1999; de Vernal and Marret, 2007; Radi and de Vernal, 2008). Cyst assemblages have also been used as tracers of pollution related to human activities (urbanization and industrialization) (Pospelova et al., 2002) and development of eutrophication (Dale and Fjellså, 1994; Dale, 1996).

Because cyst assemblages from sediments represent a valuable tool for paleoceanographic and paleoenvironmental reconstructions, several studies were undertaken for the establishment of databases (Wall et al. 1977; de Vernal and Giroux, 1991; Dale and Fjellså, 1994; Marret, 1994; Devillers and de Vernal, 2000; Vink et al., 2000; Radi and de Vernal, 2004, 2008; Radi et al., 2007; Pospelova et al., 2008; Zonneveld, 1997). Comprehensive modern reference databases are

* Corresponding author. Tel.: +1 514 987 3000x1554; fax: +1 514 987 3635.
E-mail address: limoges.audrey@courrier.uqam.ca (A. Limoges).

0377-8398/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.marmicro.2010.06.003

available for middle to high latitudes (North Atlantic Ocean, Arctic Ocean and North Pacific Ocean) (cf. de Vernal and Marret, 2007). However, the distribution of dinoflagellate cysts at low latitudes is still poorly documented. Therefore, in order to improve the spatial coverage of the modern cyst databases, notably in areas susceptible to record HABs, palynological analyses have been performed in surface sediment from the south-western Mexican coast.

Here, we present the analyses of 47 surface sediment samples collected on the B/O *El Puma* during the TEHUA V oceanographic cruise, in September 2007. Sampling sites were located along the south-western Mexican coast between 15.95° N and 23.11° N and correspond to the area where human activities are developing. The results of the samples analyzed here were combined with data from La Paz Bay and the Gulf of Tehuantepec (cf. Kielt, 2006) to develop a database including a total of 95 sites (Fig. 1) (Tables 1 and 2).

2. Regional setting

2.1. Oceanographic circulation

Primary productivity in the eastern tropical Pacific is related to the dynamics of water masses, which are determined by atmospheric circulation patterns. The study area is characterized by three important zones showing particular oceanographic features: the Gulf of California, its transitional zone and the Gulf of Tehuantepec (Fig. 2).

- Gulf of California and its transition zone

  The Gulf of California is a marginal sea of the Pacific Ocean also called the Sea of Cortés. La Paz Bay (24.15°N to 24.97°N) is located in the southernmost portion of the Gulf of California, along the eastern margin of the Peninsula of Baja California. The surface water masses in the south of the Gulf of California are characterized by temperatures between 22 and 25 °C and salinities higher than 34.9 (Alvarez-Sanchez et al., 1978; Lávin and Marinone, 2003). During summer, the south-easterly winds induce surface circulation responsible for upwelling in La Paz Bay (Molina-Cruz, 1986; Barron et al., 2004). In winter, the north-westerly winds are prevailing and define an upwelling zone off the coast of Guaymas City (Molina-Cruz, 1986).

  Off the western coast of Baja California, the California Current (CC) flows south in winter and spring and to southwest in summer and fall. When reaching 20°N, the water masses of the CC shift seaward to form the southern branch of the North Pacific subtropical gyre (Wyrtki, 1965; Kessler, 2006). The CC results in relatively cold (17 to 20 °C) and low-saline (34.5) surface waters (Fiedler and Talley, 2006).

  The area comprised between the southern end of Baja California (23°N) and the Corrientes Cape (20°N) corresponds to a transitional

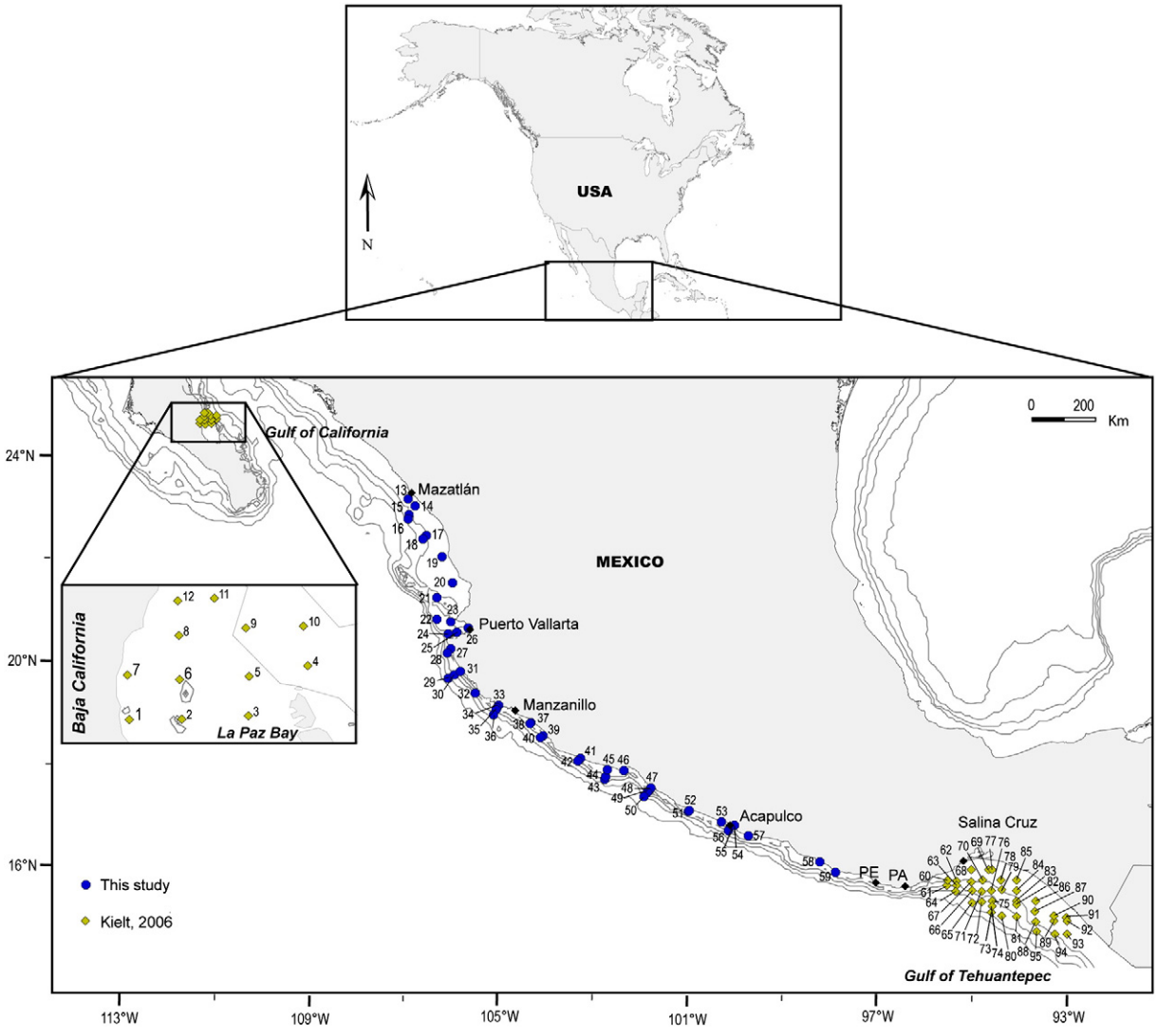

Fig. 1. Map of the study area showing the location of the principal cities (PE: Puerto Escondido and PA: Puerto Angel) and the 95 surface-sediment samples used to develop the dinoflagellate cyst database. The database includes results from this study and from the thesis of Kielt (2006). Isobath contours correspond to 200, 500, 1000 and 2000 m.