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Dinoflagellate cysts from surface sediments of Saldanha Bay, South Africa: an indication of the potential risk of harmful algal blooms

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Abstract

The distribution and abundance of dinoflagellate cysts from recent coastal sediments in Saldanha Bay, was investigated, and compared to the cyst assemblages of the adjacent coastal upwelling system as reflected in the sediments off Lambert's Bay on the southern Namaqua shelf. Twenty-two cyst types were identified from three sample sites off Lambert's Bay with recorded abundances between 1726 and 1863 cysts ml^{-1} wet sediment. At least 21 distinctive cyst types were identified from 32 sample sites within Saldanha Bay. Cyst abundance in Saldanha Bay was relatively low, averaging 116 cysts ml^{-1} wet sediment. The region off Lambert's Bay is especially susceptible to the formation of harmful algal blooms attributed to high biomass dinoflagellate blooms. Owing to these blooms and the retentive circulation characteristics of this area, cyst formation and deposition is high. Blooms can be advected into Saldanha Bay, but their development and duration in the Bay is restricted by the system of exchange that operates between the Bay and the coastal upwelling system, in that there is a net export of surface waters from the Bay. Consequently, fewer cysts are formed and deposited within the Bay thereby reducing the likelihood of in situ bloom development initiated from the excystment of cysts.

Keywords: Dinoflagellate cysts; Harmful algal bloom; Saldanha Bay; Upwelling

1. Introduction

Some 200 of the approximate 2000 existing species of marine dinoflagellates are known to form resting cysts as part of their life history (Head, 1996). These life history stages form an important component of the ecology and biogeography of these dinoflagellates (Wall et al., 1977; Dale, 1983; Ellegaard et al., 1994). Functions attributed to cysts include species dispersal (Anderson et al., 1995), survival through unfavourable conditions (Dale, 1983; Nehring, 1993) and bloom initialisation (Anderson et al., 1983; Cembella et al.,

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1988; Ishikawa and Taniguchi, 1996). Cysts are typically preserved in sediments (Head, 1996; Dale, 2001), thereby providing an integrated record over time of the presence of cyst-producing dinoflagellates. Surveys of cyst assemblages in sediments are also useful in that they may reveal species seldom observed in the plankton, owing to rare, short-lived, or difficult to identify vegetative stages (Hesse et al., 1996). Cyst surveys also provide a history of harmful species in a given area thereby providing an indication of the potential for future blooms.

The Benguela Current on the west coast of southern Africa is one of four major upwelling systems in the world. In the southern Benguela, three upwelling centres can be distinguished (Fig. 1A): the Namaqua (30°S), Cape Columbine (33°S) and Cape Peninsula (34°S), with upwelling most common during spring and summer (Nelson and Hutchings, 1983). The shelf is broad downstream of the Cape Columbine upwelling cell favouring stratification conducive to the development of a range of harmful and toxic dinoflagellate species (Pitcher et al., 1998; Pitcher and Calder, 2000).

Saldanha Bay is a semi-enclosed embayment situated upstream of the Cape Columbine upwelling cell (Fig. 1). With a maximum depth of 30 m Saldanha Bay is protected from the high-energy coastline, but remains a highly productive system owing to its link on its western side to the Benguela upwelling system (Pitcher and Calder, 1998). At the coastal-bay interface, upwelling processes on the shelf determine the advective transport of phytoplankton and the input of nutrients from the coastal upwelling system. These horizontal exchanges are dictated by event-scale fluctuations in wind stress and barotropic shelf waves (Pitcher and Calder, 1998).

Despite the recognition that cysts play an important role in the life history of many dinoflagellates, and in particular several harmful dinoflagellates, few studies of the composition, abundance and distribution of dinoflagellate cysts in the bottom sediments of South African coastal waters have been carried out. This paper provides the first description of the species composition, distribution and abundance of recent dinoflagellate cysts in the sediments of Saldanha Bay. These observations are compared to investigations of cyst composition and abundance in the adjacent coastal upwelling system as reflected by cyst assemblages off Lambert's Bay, located downstream of the Cape Columbine upwelling centre, on the southern Namaqua shelf. An explanation of the underlying mechanisms that control cyst distribution and abundance in each of these areas is provided. This knowledge and understanding provides an indication of the potential risk of harmful blooms in these respective areas.

2. Methods

2.1. Sediment collection and preparation

To determine the species composition, distribution and abundance of cysts, surface sediments were collected from three sites off Lambert's Bay (Fig. 1A), one in March 2001 and two in March 2003, and from 32 sites in Saldanha Bay (Fig. 1B) in September 2001, by means of a small Van Veen grab. Samples were stored in the dark at 4 °C, to prevent cyst germination, until further examination. For cyst identification and enumeration, samples were processed as described by Wall and Dale (1968), and Matsuoka and Fukuyo (2000). A small volume of sediment was removed from each sample to which a known volume of filtered seawater (FSW) was added prior to sonicating for 2 min to separate any cysts from detrital particles. From this, a 2 ml subsample was removed and filtered through a 125 μm and 20 μm mesh. The slurry remaining on the 20 μm mesh was thoroughly washed with FSW, before backwashing into a beaker and recording the final volume. From this, 1 ml of sample was removed by pipette, placed on a Sedgewick-Rafter chamber and cysts were enumerated using an Olympus BX-60 light microscope. Photographs were taken using a digital camera attachment. Cyst concentrations are presented as the number of cysts ml^{-1} wet sediment. Cyst diversity was estimated using the Shannon–Weaver index.

Mud and organic carbon distributions in Saldanha Bay were determined from sediment samples collected by diver operated PVC cores, in February 1995. The mud content was defined as the fraction of sediment that could be wet sieved through <63 μm mesh. Particulate organic carbon was determined by CHN analysis (Grasshoff, 1976), using a Carlo Erba analyser. The carbonate fraction was removed from