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Estuarine, Coastal and Shelf Science 63 (2005) 619–632
ESTUARINE COASTAL AND SHELF SCIENCE
www.elsevier.com/locate/ECSS

Short-term consequences of a benthic cyanobacterial bloom (*Lyngbya majuscula* Gomont) for fish and penaeid prawns in Moreton Bay (Queensland, Australia)

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Received 16 August 2004; accepted 17 January 2005

Abstract

This study examined the phenology and ecological consequences of a benthic filamentous cyanobacterial bloom (*Lyngbya majuscula*) in Deception Bay (Moreton Bay, Queensland, Australia). Bloom initiation occurred in mid December 1999 and expanded to encompass an 8 km^2 area by April 2000. Small fish and penaeid prawns (<25 cm total length) were quantitatively sampled through periods designated as before, during and after the bloom using a combination of pop-netting within mangroves and beam trawling over adjacent seagrass beds. Data on larger-bodied fish were compiled from daily fishing logs provided by local commercial fishers. Changes in dry mass of bloom material caught in nets and changes in water chemistry were also measured. Mean concentrations of ammonia-N in residual water within mangroves were several orders of magnitude higher in the affected area than in the control and dissolved oxygen was markedly lower in affected areas. Across the study area, mean density, live mass and number of species declined during the bloom, with fish assemblages using mangroves showing greater decline than assemblages using seagrasses. Response at the species level was highly variable; generally, epibenthic species showed a more sustained decline than demersals. Mean monthly fish catch was significantly lower in bloom than non-bloom years. This study has also demonstrated that throughout the bloom, the affected area continued to support a highly diverse and abundant fish and prawn assemblage, and probably maintained its function as an important nursery habitat for many species.

Keywords: cyanobacteria; algal bloom; *Lyngbya majuscula*; mangroves; seagrasses; Moreton Bay

1. Introduction

The localised and periodic rapid proliferation of cyanobacteria and eukaryotic algae in the marine environment has been occurring for millions of years (McGowan et al., 1999). It is now evident, however, that the frequency, magnitude and persistence of bloom events is increasing worldwide due to eutrophication associated with urban, industrial and agricultural expansion (Hallegraeff, 1993; Paerl, 1997; Smayda, 1997; Valiela et al., 1997; Raffaelli et al., 1998; Fogg, 2002). Blooms exert a pulse disturbance by rapidly altering the biophysical structure of the environment and causing extreme fluctuations in the chemical composition of water and sediments, often with severe consequences for a wide range of species (Hull, 1987; Paerl, 1988; Raffaelli et al., 1998; Millie et al., 1999; Castaldelli et al., 2003; Chan et al., 2003). Bloom events often occur in shallow and sheltered inshore waters such as bays and estuaries, which also support diverse assemblages of marine animals and large populations exploited by fisheries (Beck et al., 2001; Pittman and McAlpine, 2003). Many fish and crustacean life cycles

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0272-7714/$ - see front matter
doi:10.1016/j.ecss.2005.01.007

have evolved to utilise inshore areas as nursery habitat, particularly during the warmest and most biologically productive months of the year. Typically, it is the warmest months (with high irradiance) in which optimal conditions exist for the initiation and rapid proliferation of blooms. This co-occurrence may affect the quality of nursery habitat and future patterns of marine animal abundance in bloom affected areas.

Traditionally, research on bloom events have focussed on examining changes in water quality, detecting and characterising toxins, identifying causative factors and developing monitoring programmes to protect human health (Anderson and Garrison, 1997). In contrast, relatively little is known about the ecological consequences for marine animals, particularly highly mobile animals such as fish and crustaceans that use inshore areas for all or part of their life cycle (Holmquist, 1997). The dearth of information is primarily a result of the ephemeral and often unpredictable nature of the bloom phenomenon and the difficulty in adequately sampling mobile marine animals in spatially heterogeneous inshore areas. Studies on the ecological impact of blooms, particularly macroalgal blooms, have indicated that animal–bloom relations are complex (e.g., Raffaelli et al., 1998; Chan et al., 2003). The type and magnitude of animal response is a function of the morphology, physiology, behaviour (including feeding behaviour) and life-history strategies of individual animal species, as well as the biological characteristics of the bloom-forming organism and the bloom biomass, density and spatio-temporal extent.

Lyngbya majuscula Gomont (=*Microcoleus lynbyaceus* (Kützing) Crouan) is a cyanobacterium (Family: Oscillatoriaceae) that grows as long filaments and can form benthic mats and detached floating masses (Rippka et al., 1981; Moore, 1984). Some strains produce compounds that are toxic to marine animals, including molluscs, fish and crustaceans (e.g., Milligan et al., 2000; Osborne et al., 2001) and a number of metabolites isolated from *L. majuscula* have been demonstrated to deter grazers (Cardellina et al., 1979; Wylie and Paul, 1988; Pennings et al., 1996; Thacker et al., 1997; Nagle and Paul, 1998, 1999). *Lyngbya majuscula* is widely distributed in tropical and subtropical shallow coastal waters (reviewed by Osborne et al., 2001) and extensive blooms have been recorded in Hawaii (Moore, 1984), Guam (Nagle and Paul, 1998), Caribbean (Gerwick et al., 1994), Florida (Blair and Meyer, 1986) and Australia (Dennison et al., 1999). In Queensland, Australia, blooms of *L. majuscula* have been reported at several locations including Hervey Bay, Fraser Island, Whitsundays, Shoalwater Bay and Hinchinbrook Island and at several sites within Moreton Bay, South-East Queensland (Dennison et al., 1999).

This study was an unanticipated component of a broader study in Moreton Bay examining the spatial ecology of fish and prawn assemblages. The objective was to determine the ecological consequences of a *Lyngbya majuscula* bloom on juvenile fish and penaeid prawn species.

2. Study site

Moreton Bay (Fig. 1) is a shallow-water (<40 m) semi-enclosed bay. The climate is subtropical, with mean sea surface temperatures ranging from 16 °C in July (winter) to 29 °C in January (summer). Broad-scale water movement is driven by mixed diurnal and semi-diurnal tidal incursions and hydrodynamic transport models predict an overall residence time of 45 days (Dennison and Abal, 1999). Field sampling took place in northern Deception Bay, a shallow water embayment within Moreton Bay (Fig. 1) characterised by fringing mangroves and adjacent vegetated tidal flats composed of mixed-species seagrass-algal beds.

3. Materials and methods

3.1. Sampling nekton

A stratified-random sampling strategy was used to quantify juvenile and small-bodied (<25 cm) adult fish and penaeid prawns using mangroves and adjacent tidal flats on daytime high tides. Assemblages within

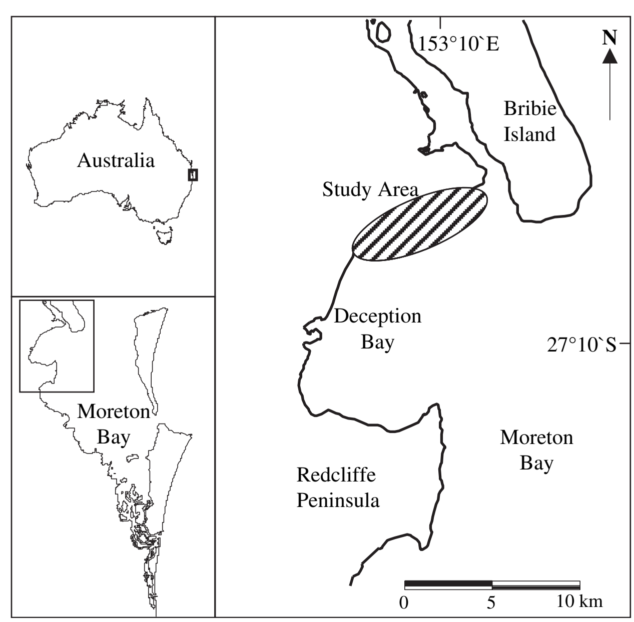

Fig. 1. Map showing the location of the study area at northern Deception Bay, within Moreton Bay. Inset shows the location of Moreton Bay within Queensland, Australia.