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ScienceDirect
Estuarine, Coastal and Shelf Science 73 (2007) 630–638
ESTUARINE COASTAL AND SHELF SCIENCE
www.elsevier.com/locate/ecss

Spatio-temporal variability in faunal assemblages surrounding the discharge of secondary treated sewage

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Received 20 March 2006; accepted 1 March 2007
Available online 7 May 2007

Abstract

Macrofaunal assemblages inhabiting the intertidal zone surrounding an input of secondary treated effluent were sampled in order to determine how the pollution impact varied temporally and spatially. Assemblages varied along the pollution gradient formed by the Bolivar Wastewater Treatment Plant outfall in Gulf St Vincent, South Australia. While the abundance of some species did not vary, the abundance of juvenile western king prawns (*Melicertus latisulcatus*) and blue crabs (*Portunus pelagicus*) progressively decreased with proximity to the outfall. Species richness and diversity also decreased towards the outfall. An increase in nutrient content in the water adjacent to the outfall is likely to explain these changes. At distances of 4 and 5 km away, species diversity increased and the abundance of *M. latisulcatus* decreased, possibly due to a change in habitat from sand to seagrass. The occurrence of a storm prior to sampling on one occasion masked the effects of pollution and habitat changes. The results of this study suggest that the disposal of treated effluent into Gulf St Vincent is having a localised effect on the faunal assemblages surrounding the discharge point.

Keywords: *Melicertus latisulcatus*; *Portunus pelagicus*; South Australia; Adelaide; Bolivar Wastewater Treatment Plant; effluent

1. Introduction

Sewage effluent is considered one of the most common anthropogenic disturbances of marine benthic communities and has long been recognised as one of the principal causes of faunal change in near-shore benthic environments (Pearson and Rosenberg, 1978). Sewage effluent is released into the environment in a variety of treated forms, volumes, and in areas of vastly different environmental conditions. Gradients in contaminants, such as nutrients, are commonly found with distance from point source discharges. Such gradients, which result from the dissipation of contaminants by waves and their dilution with seawater, have been widely documented as affecting faunal communities. There are some general patterns in ecological responses to organic enrichment, with fauna and flora showing opposing but overlapping gradients of opportunistic and disturbance intolerant species (Littler and Murray, 1975; Pearson and Rosenberg, 1978; López Gappa et al., 1990; Roberts, 1996; Díez et al., 1999). At points of high organic input, opportunistic species dominate the community while less tolerant species become increasingly rare or disappear. With increasing distance from the most organically enriched area, there is a decline in the abundance of opportunistic species and an increase in species richness (Pearson and Rosenberg, 1978).

While there is an extensive literature investigating the impacts of organic enrichment, in some cases the highly variable nature of the marine environment has been more influential than the source of impact in shaping benthic communities (e.g. Smith, 1994; Roberts, 1996; Lardicci et al., 1999). To ensure that human impacts can be differentiated from natural variability, the beyond BACI (before/after-control/impact) experimental design was developed (Underwood, 1991), whereby multiple control locations are compared with a single disturbed location. In many instances, however, a lack of

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doi:10.1016/j.ecss.2007.03.008

baseline data from outfall sites prior to the commencement of effluent disposal has meant that researchers are unable to implement a beyond BACI experimental design, and instead they compare environmental variables around a discharge area to one or a few supposedly pristine sites located many kilometres away (e.g. Roberts et al., 1998; Stark et al., 2003; Terlizzi et al., 2005). While these studies provide some evidence of the effects of effluent discharge, they are far from conclusive. Stronger evidence would be provided by the demonstration of a gradient response away from the discharge site, especially when the gradient occurs in two spatially opposing directions. Studies examining such gradient responses also have the advantage of determining the spatial extent of any impact, rather than just its magnitude at or near the discharge point (López Gappa et al., 1990; Ferraro et al., 1991; Ellis et al., 2000; Soltan et al., 2001).

It has been well established that sewage discharge can lead to severe habitat degradation in marine environments, especially when discharge occurs into relatively shallow and sheltered coastal areas (López Gappa et al., 1990; Hunter and Evans, 1995). Many of these areas are dominated by seagrasses, which can undergo substantial decline in the presence of elevated nutrients and resultant increased epiphyte growth (e.g. Cambridge et al., 1986; Neverauskas, 1987; Shepherd et al., 1989). An example of such a decline is in Gulf St Vincent, South Australia, where more than 1100 ha of seagrass has been lost adjacent to the intertidal discharge of treated effluent from the Bolivar Wastewater Treatment Plant (Bolivar WWTP; Shepherd et al., 1989; Cameron, 1999; Seddon, 2002). Here, we examine the extent of spatial and temporal variation in the macrofaunal assemblage around the Bolivar WWTP outfall, with a particular focus on juveniles of commercially important species such as western king prawns (*Melicertus latisulcatus*) and blue crabs (*Portunus pelagicus*), which use the intertidal and shallow subtidal habitats as nursery areas (Connolly, 1994; Kangas and Jackson, 1998; Bloomfield and Gillanders, 2005).

2. Materials and methods

2.1. Study site

Spatial and temporal variation in marine macrofauna was investigated around the Bolivar WWTP outfall in Gulf St Vincent, South Australia. The Bolivar WWTP was commissioned in 1967 and is one of three wastewater treatment plants that currently service Adelaide, which has a population of 1.08 million. Between 1991 and 2000 the Bolivar WWTP accounted for 57.6% of the daily effluent discharged into Gulf St Vincent (Wilkinson et al., 2003), which in 2001 was approximately 96 ML/day. The outfall is situated approximately 28 km north of Adelaide (138°35′55″E, 34°55′42″S), and discharges secondary treated sewage into the intertidal zone of Gulf St Vincent (Fig. 1). The receiving low energy environment that was once inhabited by extensive *Zostera*, *Heterozostera*, and *Posidonia* seagrass beds (Shepherd et al., 1989; Cameron, 1999), is currently dominated by several kilometres of intertidal mud flats (grain size 65% <250 μm; Nayar et al., 2006) up to 1.5 km wide, and is adjacent to grey mangroves, *Avicennia marina*, which border the coastline. Sampling sites within 2 km of the Bolivar WWTP outfall were devoid of seagrass, although aerial photographs reveal the presence of seagrass meadows at more distant sites.

2.2. Assessment of faunal assemblage

Macrofauna were sampled adjacent to the outfall (site 0), and 1, 2, and 5 km north and 1, 2, and 4 km south of the outfall using a water-jet net (Kangas and Jackson, 1998). Samples were collected on 3 days during a 5-day period in both March and May 2001, when mean daily volume of effluent entering the gulf was 95.2 and 98.4 ML, respectively. To further investigate temporal variability, faunal samples were also collected

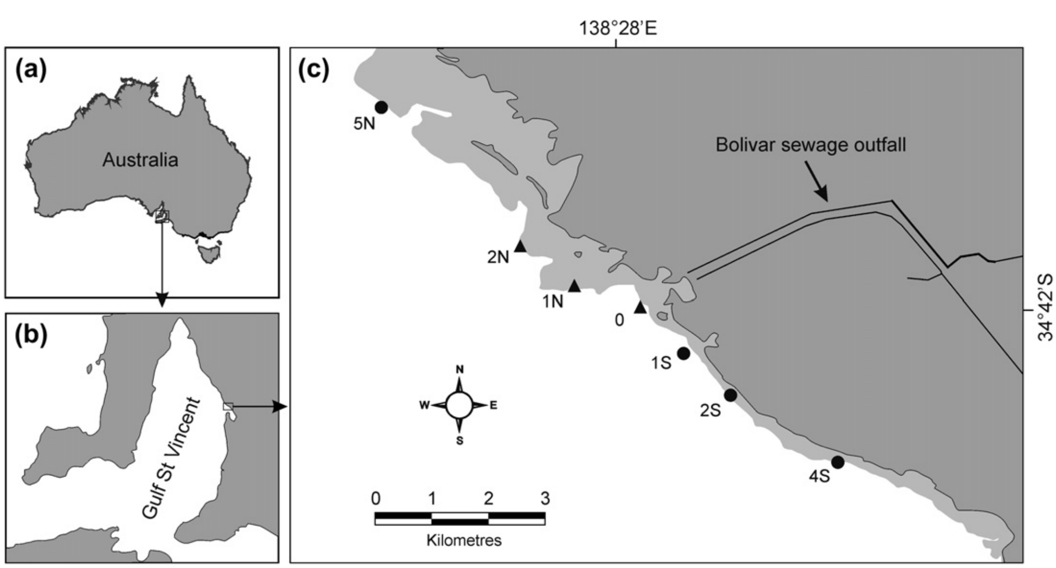

Fig. 1. Map of (a) Australia, (b) Gulf St Vincent and (c) location of sampling sites surrounding the Bolivar WWTP outfall. ●, sites sampled in March and May only; ▲, sites sampled in February, March, May and August. The light grey area on the map represents the mangrove distribution.