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ScienceDirect
Ecotoxicology and Environmental Safety 70 (2008) 469–474
Ecotoxicology and Environmental Safety
www.elsevier.com/locate/ecoenv

Toxicity of estuarine sediments using a full life-cycle bioassay with the marine copepod *Robertsonia propinqua*☆

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Received 9 December 2006; received in revised form 10 October 2007; accepted 9 December 2007
Available online 1 February 2008

Abstract

Estuarine sediment contamination is a growing significant ecological issue in New Zealand. Methods of assessing toxicity and ecological impacts in a cost effective way are currently limited. Further to that is a need to develop bioassays that generate data quickly and cost effectively and have ecological relevance to the wider community. A chronic full life-cycle bioassay to assess the toxicity of New Zealand estuarine sediments using the marine harpacticoid copepod *Robertsonia propinqua* has been investigated. Sediment samples were collected from the Bay of Plenty region and included two polluted and one reference site. Sources of pollutants in the contaminated field sites originated from a variety of sources and generally include nutrients, pesticides and herbicides and the pollutants zinc, copper, lead and polycyclic aromatic hydrocarbons (PAHs). Conversely, the reference site was exposed to low levels of contaminants due to the relatively undeveloped catchment. Adult male and female copepods were exposed to field collected sediments for 24 days under flow-through conditions at 21 °C and 12 h L:D cycles. Five endpoints were recorded: male and female survival, fecundity (number of gravid females per replicate at the end of the test), clutch size per female, number of eggs per sample and juvenile survival (number of nauplii and copepodites per replicate at the end of the test). Adult mortality was observed in all sediment samples but the number of males, gravid females, clutch size per female and number of eggs produced were not affected by either the contaminated or reference sediment samples. However, the contaminated sediments did reduce reproductive output (i.e. nauplii and copepodite production). Therefore, we conclude that reproductive endpoints provide a good measure of sediment-associated contaminant effects compared with adult *R. propinqua* survivorship. It may be that a change in focus from chemical thresholds without ecological relevance or lethal dose threshold methods, to more subtle but ecologically significant elements of faunal life, such as reproductive success, are a more sensitive and a long term ecologically informative method.

Keywords: Urbanisation; Contaminant exposure; New Zealand; Estuarine; Sediment bioassay; Copepods

1. Introduction

New Zealand has the fourth largest maritime area in the world, with an exclusive economic zone (EEZ) of some 483 million hectares, with only the United States, French Polynesia and Indonesia having larger areas (Ministry for the Environment, 1997). The coastal marine environment of New Zealand is mainly made up of river-fed estuaries that cover a total area of at least 100,000 ha, providing nurseries for commercially valuable fisheries as well as nesting, feeding and resting areas for migratory birds (Ministry for the Environment, 1997). Over the last 100 years these areas have become sinks for human-related contaminants. Many of New Zealand's main cities are

☆This work was done in accordance with the requirements of the New Zealand Animal Welfare Act 1999.

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0147-6513/$ - see front matter © 2007 Elsevier Inc. All rights reserved.
doi:10.1016/j.ecoenv.2007.12.008

situated within estuarine catchments (i.e. Auckland, Whangarei, Tauranga, Napier, Nelson, Christchurch and Invercargill). Over the last 40 years the pressure on the coastal environment has dramatically increased as a result of rapidly increasing urbanisation as people choose the coastal life. With urbanisation comes an increase in impervious surfaces (e.g., roads and housing developments) causing increased stormwater runoff containing contaminants from non-point sources that discharge largely untreated into coastal and estuarine environments. The primary stormwater contaminants of concern in New Zealand estuaries are zinc (e.g., from galvanised steel, tyres), copper (vehicle wiring), lead (street runoff, industrial and municipal wastewater discharges), and polycyclic aromatic hydrocarbons (PAHs) (also originating from vehicle emissions). These have accumulated in estuarine sediments over the past decades (ANZECC, 2000; ARC, 2003; Williamson and Wilcock, 1994). Studies are beginning to indicate that these contaminants are affecting the fauna, particularly sediment-dwelling organisms (infauna), by reducing species abundance, increasing contaminant accumulation in shellfish and crustaceans, and causing changes in growth and reproductive rates (Ministry for the Environment, 1997, and references therein).

Sediments are an integral component of all aquatic ecosystems, providing food and habitat to many infaunal organisms. Contaminants typically bind to the finer silty material of estuarine sediments, creating a reservoir of contaminants that become a source of pollution to the water column and organisms (Oberholster et al., 2005).

Acute (short term, 24–96 h exposure) and chronic (long term—full life-cycle of an organism) sediment toxicity bioassays have been used in a number of studies to investigate the effects of contaminated estuarine sediment on a variety of benthic dwelling organisms (Chandler and Green, 1996; Kovatch et al., 1999; Stronkhorst et al., 2003; Bejarano et al., 2004; Oberholster et al., 2005; Castro et al., 2006). These tests have used a variety of organisms such as amphipods (Costa et al., 2005; King et al., 2006; Manyin and Rowe, 2006), midge (Soares et al., 2005), water louse (De Lange et al., 2005), mayfly nymph (De Lange et al., 2005), heart urchin (Stronkhorst et al., 1999), copepods (Willis, 1999) and oysters (Geffard et al., 2001, 2004) to assess the effects of contamination. These tests have proven to be successful in identifying sediments with potential toxicological effects to the organisms inhabiting the test sediment. The aim of this study was to develop a test using the marine benthic copepod *Robertsonia propinqua* to assess reproductive, survival and developmental effects of chemical pollution present within field-collected sediments in the Bay of Plenty region, New Zealand. The use of *R. propinqua* is relevant as it is found throughout New Zealand estuarine and intertidal environments and is ecologically important as a food source to juvenile benthic feeding fish. In addition, it is sensitive to sediment associated contaminants, can be cultured in the laboratory and can complete an entire life cycle from juvenile to reproductive adult in 24 days (Hack et al., unpublished data). The full life-cycle of *R. propinqua* was investigated to ascertain the acute effects of sediment associated contaminants and identify potential chronic effects resulting from continued exposure to contaminated sediment.

2. Material and methods

2.1. Field site locations

2.1.1. Bay of Plenty region (Fig. 1)

The Tauranga harbour is located on New Zealand's northeast coast in the Bay of Plenty. The harbour catchment covers an area of approximately 200 km^2 and is well developed with extensive horticultural, agricultural, urban and commercial uses. Tauranga city supports a population around 110,000 (Statistics New Zealand, 2006). Ohiwa harbour (the reference site) is located in the Whakatane region, south of Tauranga city, with a population around 33,000 (Statistics New Zealand, 2006). The harbour catchment covers an area of approximately 27 km^2 and is surrounded by rural pastures and low density housing, mainly in the northern Whakatane town area (Environment Bay of Plenty, 2003).

2.2. Field site classification (Fig. 1)

Sites within the smaller metropolitan Tauranga region included two polluted sites, Waikareao Foreshore Reserve (2788350E, 6384875N,

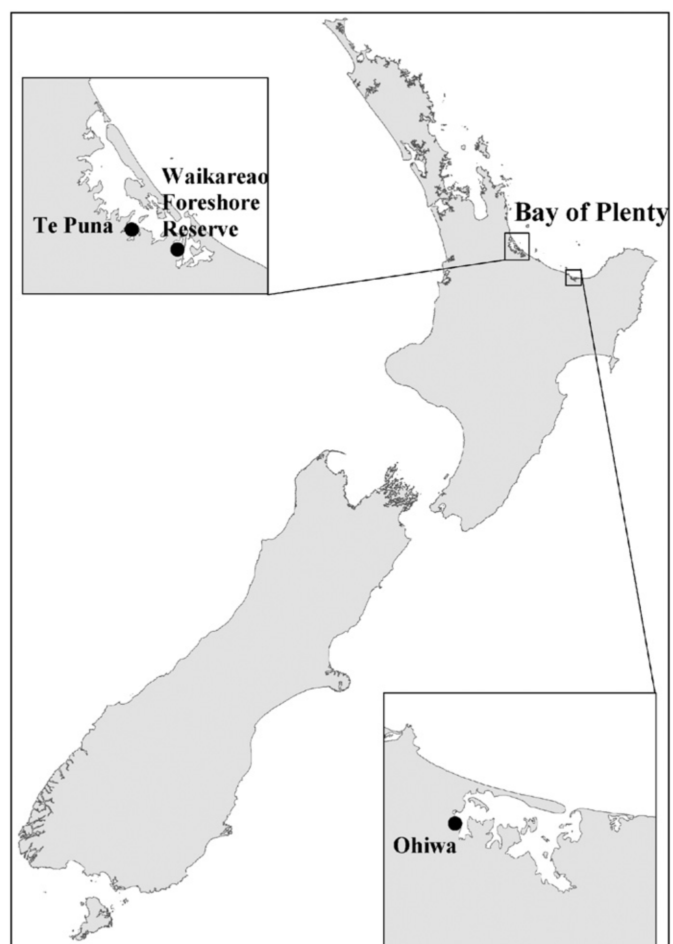

Fig. 1. Map of New Zealand indicating location of field sites within the Bay of Plenty region.