Bioassays for coastal water quality: An assessment using the larval development of *Haliotis midae* L

AL Shackleton[1], DS Schoeman[1]* and BK Newman[2]
[1] *Zoology Department, University of Port Elizabeth 6031, South Africa*
[2] *Zoology Department, University of Zululand, Private Bag x 1001, KwaDlangezwa 3886, South Africa*

Abstract

The United States Environmental Protection Agency (USEPA) has established a suite of methods that use coastal invertebrate species as bioassay organisms to test industrial and domestic effluent as well as coastal waters for potential toxicity. Although these methods are used globally, the potential of such toxicity tests has not been adequately explored for South African coastal waters. This study serves to describe a simple, cost-effective and relatively quick testing procedure using the development of *Haliotis midae* larvae as a bioassay of coastal water quality. This test is based on the sensitivity of these larvae to low concentrations of zinc (Zn). Its performance in a field trial demonstrates not only that this test has the potential to identify coastal waters of poor quality, but also that such identification could be of value in attempts to restock natural abalone populations, which are under extreme pressure from legal and illegal exploitation. Further work in this line should focus on the refinement of the methodology for this and other local species and should aim to contribute to the development of suitable criteria for the management of coastal water quality in South Africa.

Introduction

In many regions of the world, aquatic toxicity test data are routinely used to evaluate risks associated with the discharge of effluents from municipal and industrial treatment works into water bodies. This is in fact a legal obligation in many countries (Wells et al., 1998). Such tests can provide an indication of the potential toxicity of an effluent to biological communities inhabiting the receiving waters. Alternatively, toxicity tests can be used to evaluate the status of natural environments that might experience the impacts of other anthropogenic activities, such as harbour dredge sediment disposal and non-point source discharges (MacDonald et al., 1997). The development of scientifically sound protocols for toxicity testing is an extensive process. Not only does it require the identification of suitable candidate organisms, but also the establishment of appropriate and reproducible techniques with which to assess the sensitivity of these organisms to chemicals of anthropogenic origin. Although several workers have described the efficacy of using individual local marine species for toxicity testing purposes (Currie et al., 1974; Greenwood and Brown, 1974; Brown, 1974, 1976, 1982; Brown and Greenwood, 1978; Connell and Airey, 1979, 1982; Brown et al., 1982; Connell et al., 1991), this work focused on a limited number of species that were exposed to a restricted range of toxicants. The development of robust and generally applicable protocols for the assessment of South African marine and estuarine water quality has not received the attention that it deserves in the recent literature.

The most frequently applied procedure for assessing the toxicity of municipal and industrial effluents discharged to coastal waters in South Africa involves the use of gametes of local sea urchin species. This test, the so-called sea urchin fertilisation or sperm cell test, while widely applied throughout the world (Dinnel and Stober, 1987; Chapman, 1995; Beiras et al., 2001), has a major limitation in that it provides only an indication of the short-term, acutely toxic effects of the effluent, thereby failing to consider longer-term, chronic (sublethal) impacts. It is for this reason that a battery of bioassays is usually used to comprehensively assess risks associated with the discharge of an effluent to receiving water biological communities. Such experimental arrays use species from a broad range of taxa and sensitivities, and analyse both acute and chronic effects. South African laboratories are in the process of adapting to this philosophy and currently supplement sea urchin gamete tests with longer-term tests, such as based on estuarine amphipods (Connell and Airey, 1979, 1982). However, there is still a need to expand upon and refine currently applied tests and test organisms used in South African coastal waters by incorporating as wide a range of different taxa as possible as well as by considering longer exposure periods and different test end-points.

Objectively evaluating the suitability of candidate organisms for toxicity testing purposes requires the comparison of biologically measurable responses (end-points) to a range of concentrations of a common reference toxicant. In this manner, the sensitivity of the various organisms can be ranked, and the most suitable species identified (USEPA, 1995). To be of practical use in such bioassays, a candidate species, or at least one of its life history stages, should not only be sensitive to potential contaminants, but should also be relatively easy to collect from the field (*i.e.* abundant) as well as amenable to routine maintenance, culture and rearing in the laboratory (Rand, 1995). If early developmental stages are to be used, spawning should be readily induced; otherwise gametes should be freely available from the natural habitat.

The larvae of the South African abalone, *Haliotis midae* L., meet most of the above criteria. Firstly, sperm and eggs are available at regular intervals from abalone-directed mariculture operations, ensuring a fairly regular supply of test material (although supply to the coast of KwaZulu-Natal might be more difficult than elsewhere). Secondly, *H. midae* larvae are relatively easy to maintain in the laboratory. Finally, larvae of *H. midae* are lecithotrophic (Leighton, 1974; Genade et al., 1988), and can thus be used in tests without having to provide food. This has numerous

* To whom all correspondence should be addressed.
☎ 041 504-2335; fax 041 504-2317; e-mail: zladss@zoo.upe.ac.za
Received 4 March 2002; accepted in revised form 19August 2002.