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Mercury Concentrations in Oysters from the Coastline of Northern Territory, Australia

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Mercury has been found in the fat of penguin and glacial ice from Antarctica, indicating a global contamination of mercury through atmospheric circulation and other natural processes. Globally, 10,500 tons of mercury are mined and processed for industry (Adriano 1986). It is released into the atmosphere via burning of fossil fuel and roasting of ores (Mitra 1986). About fifty percent of the mercury finds its way into the marine environment and similar amounts are transferred annually into the ocean via weathering processes (Klein & Goldberg 1970). The ratio of the natural input to the anthropogenic input is about 4:1 (Mitra 1986). Biotransformation of inorganic mercury to the more toxic alkylated form is either very slow or relatively inefficient in bivalves (Jackson *et al* 1986). Little information is available about mercury speciation in bivalves, except that dissolved inorganic mercury is quickly taken up in the gills and concentrated in the inorganic form in the gills prior to gradual transport to other organs (Cunningham & Tripp 1975; Wrench 1975; Roesijadi 1982). After the tragic incident of mercury poisoning at Minamata (Tsubaki & Irukayama 1977; Fujiki 1980) attention was focused towards mercury pollution throughout the world and major monitoring programs of mercury in fish, shellfish, birds, seals and mammals are carried out today. A wealth of knowledge now exists for mercury in marine organisms in many areas of the world. Comparatively little information is available for Australian species (Hussain & Bleiler 1973; Williams et al. 1976; Denton & Breck 1981; and Jackson et al. 1986) and nothing is known of the levels of mercury in marine species from the tropical coastal regions of the Northern Territory.

The Northern Territory has a coastline of about 5000 kilometres bordered by the Timor and Arafura Seas and the Gulf of Carpentaria (Fig 1). Mudflats, mangrove swamps and sand beaches dominate the coastline which is uninhabited in most places. Coastal population centers include Darwin, the capital with a population of approximately 76,000, the bauxite mining town of Nhulunbuy (5,000) on Gove Peninsula and Alyangula (2,000) a manganese mining town on Groote Eylandt. The township of Galiwinku, on Elcho Island (5,000) is the largest aboriginal center. There are several other small aboriginal communities spread along the coastline, particularly in Arnhem Land where, prior to entry, special permission from the Aboriginal Land Council of the Northern Territory is required. Oyster beds are common on rocky substrats throughout the coastline of the Northern Territory and many provide food for aboriginal communities. The concentration

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of metals in oysters and other bivalve molluscs can increase by many orders of magnitude above background levels (Furness & Rainbow 1990; Förstner & Wittmann 1983), thus demonstrating the potential of oysters as sentinel accumulators of heavy metals (Soule & Kleppel 1988). The Northern Territory provides an ideal situation to study baseline information on mercury concentrations in coastal environments which are free from anthropogenic as well as industrial pollution. These data make useful comparisons with those from other industrialized locations in Australia (Williams et al. 1976; Jackson et al.1986). In this paper we report preliminary results of an ongoing baseline study of heavy metals in oysters (Peerzada & Dickinson 1989; Peerzada et al. 1990). Results of mercury concentrations in oysters from ten localities along the coastline of the Northern Territory are described.

With respect to climate, the Northern Territory lies well within the tropics and is subjected to two weather systems. The dry season extends from April to October, approximately, when southeast trade winds prevail, and the wet season extends from November to April, when the northwest monsoon prevails. During the latter period, cyclones can be experienced, particularly in the months of February and March. The annual rainfall in 1989 measured at Darwin Airport was 1481 mm, of which 98% fell during the period December to April. Sea-surface temperatures at Darwin Harbor are virtually constant throughout the year with minimum temperature in the dry season (about 25-28 °C) and maximum in the wet season (28-29 °C) (Reynolds 1983). Salinity ranges from 27.8 to 35.5 ppt between the months of February and September, respectively.

METHODS AND MATERIALS

Oysters (*Saccostrea cucullata* and *S. echinata*) from the coastline of the Northern Territory were collected during the dry season of 1987 and from Darwin Harbor at the end of the dry season of 1990. Specimens of *S. cucullata* were small (3-4 cm in length; 2-3 cm in width), therefore 4-6 oysters were pooled in one sample while *S. echinata* were large (8-12 cm in length; 6-8 cm in width), therefore each sample contained an individual oyster. Six replicates of both oysters (36 *S. echinata* and 6 *S. cucullata*) were prepared for analysis from each of ten sites in the study.

The determination of mercury in marine organisms has been the subject of many studies (Denton & Breck 1981; Collett et al. 1981; Evans et al. 1986). For the purpose of the present investigation the method of Lovie (1983) was used. Approximately 2g of oyster flesh was initially left in 5 mL of concentrated nitric acid (Analar), 2.5 mL of sulfuric acid (Analar) and 1 mL of hydrochloric acid (Analar) at room temperature for fifteen minutes and then digested by steam bath for forty minutes. After cooling the digest was made up to 50 mL in a volumetric flask with deionized water. A 1-5 mL aliquot was diluted with 20 mL distilled water and the mercury present reduced to elemental form with 3 mL of 20 % (w/v) stannous chloride (Analar) in 10 % hydrochloric acid. Mercury was determined by flameless atomic absorption spectrophotometery using a Varian 875 instrument. The detection limit for mercury was 0.01 μgg^{-1}. Blanks were treated similarly and the accuracy of the method used was established by periodic determination of mercury in albacore tuna (NBS Research Material 50). A triplicate analyses of mercury in Albacore tuna (NBS RM 50) gave a value of $0.85 \pm 0.02\ \mu gg^{-1}$ against the Certified Value of $0.95 \pm 0.1\ \mu gg^{-1}$.

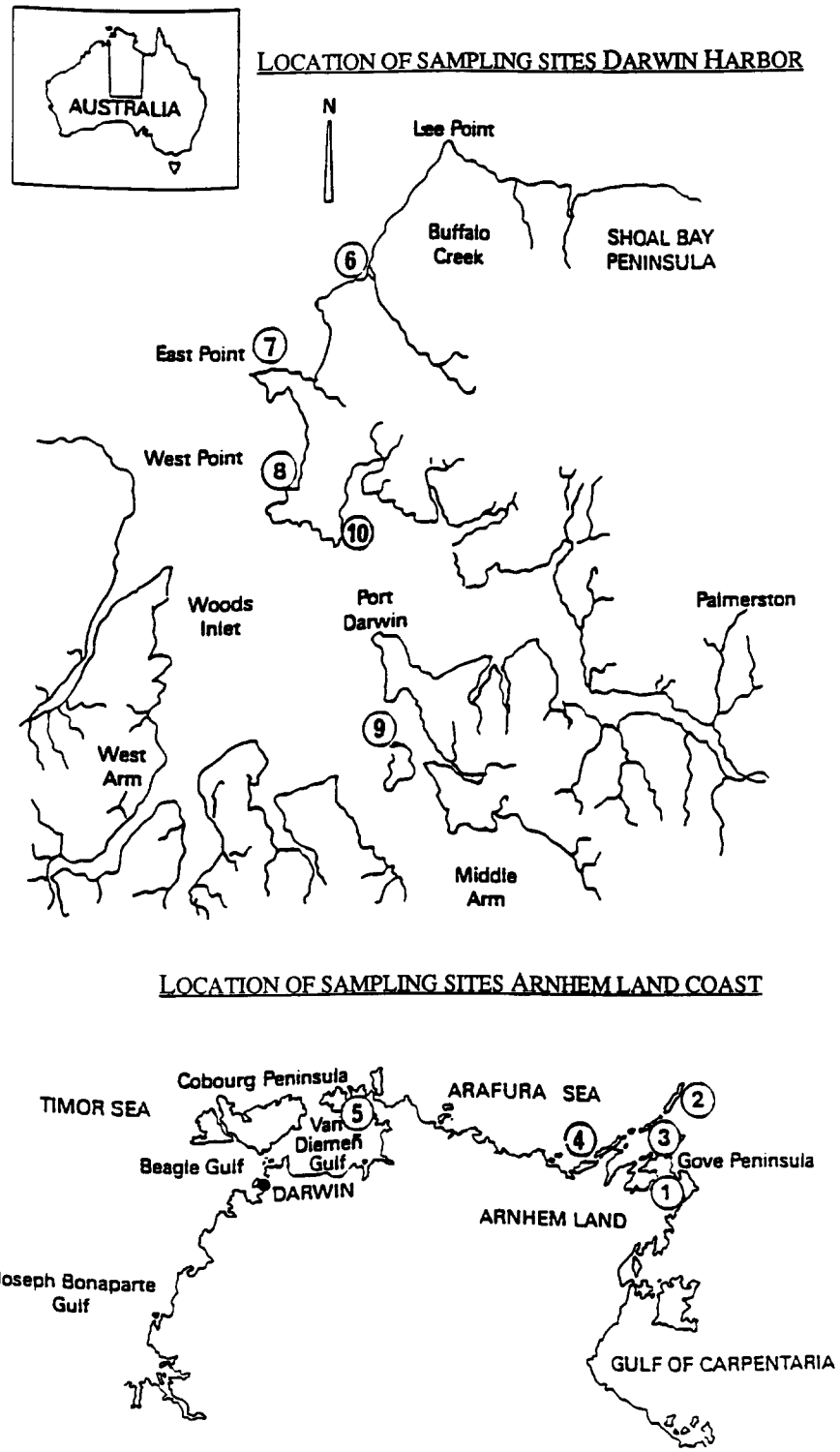

Figure 1. Oyster collection sites in Darwin Harbor and from the coastline of the Northern Territory

Table 1: Mean concentrations of mercury (μgg^{-1} wet weight) in oyster species from the Northern Territory coastline given as the range and the average value ± Standard deviation X ± SD, between brackets. Locations 5,7,8,9 and 10 are within Darwin Harbor (Fig. 1)

Location		Oyster	Mercury
1.	Raragala Island	*Saccostrea echinata*	0.018-0.034 (0.027 ± 0.006)
2.	Marchinbar	*Saccostrea echinata*	0.016-0.027 (0.024±0.004)
3.	Coburg Peninsula	*Saccostrea echinata*	0.019-0.032 (0.027 ±0.009)
4.	Elcho Island	*Saccostrea cucullata*	0.010-0.020 (0.013 ± 0.005)
5.	Rapid Creek	*Saccostrea cucullata*	0.044-0.053 (0.050 ± 0.005)
6.	Gove Harbor	*Saccostrea echinata*	0.077-0.125 (0.099 ± 0.020)
7.	East Point	*Saccostrea cucullata*	0.029-0.073 (0.061 ± 0.018)
8.	Channel Island	*Saccostrea cucullata*	0.040-0.049 (0.043 ± 0.005)
9.	Ski Club	*Saccostrea cucullata*	0.031-0.040 (0.035 ± 0.004)
10.	Darwin Wharf	*Saccostrea cucullata*	0.024-0.033 (0.029 ± 0.006)

RESULTS AND DISCUSSION

Mercury levels in oysters from most sites from the Northern Territory coastline were low but slightly higher than the range of 0.003 - 0.017 μgg^{-1} (wet weight), found in cultivated and noncultivated oysters (*Crassostrea commercialis*) from non-mercury contaminated waters along the northeast coast of Sydney in New South Wales (Hussain & Bleiler 1973). A higher concentration of mercury (0.069 μgg^{-1} wet weight) was reported in oysters from a similar temperate region of the George River, Botany Bay (Williams et al. 1976). A low level of mercury was found in most oysters sampled from the Northern Territory with Gove Harbor being the exception where levels reached 0.099 μgg^{-1} (wet weight) but were still within the recommended guidelines (0.5 μgg^{-1} wet weight) of the National Heath and Medical Research Council (NHMRC), for human consumption. Samples of oysters from the vicinity of the alumina plant at Gove Harbor have consistently shown higher concentrations of heavy metals when compared to Darwin Harbor (Peerzada & Dickinson 1989; Peerzada et al. 1990). At Gove, bauxite is mined 20 km inland and carried on a partly open conveyor belt to the refinery where, by the historic "Bayer Process", the alumina (aluminium oxide) is produced. The bauxite ore contains 0.05 μgg^{-1} of mercury and concentrations of 200 μgL^{-1} in the spent liquor (sodium aluminate solution) from the refinery and 0.2 μgL^{-1} in the sea water of Gove Harbor have been reported (Noller 1990). Mercury concentrations (in μgg^{-1} wet weight) in oysters from Cleveland Bay, Queensland vary with species, e.g., jewel-box oyster (*Chama iostoma*) 0.08; milky oyster (*Saccostrea*

cucullata) 0.06; black-lip oyster (*Saccostrea echinata*) 0.03 and no mercury was detected in thorny oyster (*Spondylus ducalis*) (Denton & Breck 1981). The highest level of contamination by mercury in an Australian bivalve is reported from Princess Royal Harbor, Albany, Western Australia where near old diffuser sites of a fertilizer plant concentrations varied from 2.2 to 26 μgg^{-1} in cockles (*Katelysia scalarina*), exceeding the NHMRC guidelines (see above). Concentrations of mercury in the water and effluent in the vicinity of the fertilizer plant were between 0.2 and 0.4 μgL^{-1} but in the scrubber effluent pit before discharge to Princess Royal Harbor concentrations were between 600 and 920 μgL^{-1} (Jackson et al. 1986).

In Darwin Harbor, mean concentrations of mercury in black-lip oysters (*S. cucullata*) were 0.050 μgg^{-1} at Rapid Creek (Table 1, Location 5) and 0.061 μgg^{-1} at East Point (Table 1, Location 7) and were of a similar value for mercury in oysters from Cleveland Bay in tropical Queensland. Concentrations of heavy metals at Rapid Creek and East Point have always been relatively higher when compared to the other sites in Darwin Harbor (Peerzada & Dickinson 1989). These two locations receive macerated sewage from most of Darwin's suburbs. Levels of mercury in oysters (*Saccostrea echinata*) at Raragala (Fig. 1, Location 1), Marchinbar Island (Fig. 1, Location 2) and Coburg Peninsula (Fig. 1, Location 3) were similar (Table 1). The lowest levels of mercury in oysters (*Saccostrea cucullata)* were found at Elcho Island (Fig. 1, Location 4; Table 1).

The low levels of mercury found in this study indicate minor contamination of parts of the Northern Territory coastline which we presume to be associated with human settlement and industry. As there are no known natural sources of mercury contamination in the area, elevated levels in Darwin Harbor could be attributed to domestic waste discharge, use of mercury containing anti-fouling marine paints, atmospheric input and general harbor activities.

A great difference in metal concentrations from site-to-site has been observed, however other factors must be considered, e.g., size variations in organisms, geographical and genetic differences, individual differences in metal uptake ability, ingestion of sediment particles and induction of metal binding protein. In order to assess the role of metals in the aquatic environment, there is no real substitute for chemical analysis of tissues of organisms exposed to metals in various forms in a particular situation (Waldichuk 1985).

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