Landnote

Department of Conservation & Land Management

1/90

ANALYSIS OF WATER QUALITY IN SHARK BAY AND CORAL BAY: AUGUST-OCTOBER 1989

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SUMMARY

Samples of seawater and beach water were collected from Monkey Mia (Shark Bay) and Coral Bay (Ningaloo Marine Park) in August 1989 and analysed for nutrient and bacterial levels. Monkey Mia samples showed nitrogen levels well below those of a previous survey which was carried out prior to modification of the area's sewage disposal system and which suggested that leaching of sewage was a problem within this area. Nutrient and bacterial levels in Coral Bay showed no indications of pollution. Bacterial levels in beachwater from several sites at Monkey Mia and from one site near Coral Bay were positive for faecal coliforms and/or faecal streptococci. While these levels were generally quite low, two sites returned significant counts for faecal streptococci. Additional samples taken from sites in Shark Bay in October did not detect any significant bacterial levels. The implications of the high temporal variability in bacterial levels are unclear and further sampling is indicated in and around the dolphin visiting area at Monkey Mia.

INTRODUCTION

The maintenance of water quality is integral to the Department of Conservation and Land Management's responsibilities in many marine areas. Within its marine estate the Department has responsibility for managing the effects of water quality on aesthetic, recreation and conservation values. In the wider marine environment, water quality has implications for the conservation of marine wildlife. The Department has a statutory role in these situations under the CALM Act, 1984, and the Wildlife Conservation Act, 1950.

Coral Bay is a major focus for public use within the Ningaloo Marine Park. The mounting human pressures on this area centre around vehicle and boat access and accommodation onshore with boating, swimming and diving in the Bay. These

effects and recommendations for their management have been documented (DCE, 1984; CALM 1988). Both the marine and terrestrial impacts are concentrated in a small sector of the south east corner of the Bay (Fig.1). A number of complaints about water quality have been received from visitors to the beach area around foreshore reserve 37500. These specify unpleasant odours suggestive of decaying organic matter. Further, a study of corals in the area indicated that mortality in the lagoon near the settlement was above that elsewhere, in a pattern suggestive of a water-borne agent emanating from near the beach (C.Simpson, pers. comm., 1989).

A study in February 1989 of water quality at Monkey Mia found evidence from raised nutrient levels to indicate that sewage was leaching into the sea from nearby septic systems (EPA, 1989). That study had been initiated as a result of the deaths or disappearance of several of the dolphins regularly visiting the area. Although it identified sewage contamination of nearshore seawater as a problem, it did not imply a causal link between this pollution and events in the dolphin population. On the recommendation of that study, the area's septic systems were modified to direct effluent further from groundwater sources which interchange with seawater.

The present study was carried out to:

- test for the presence of sewage leaching into Coral Bay around foreshore reserve 37500 which might adversely affect conservation or recreation values;

- monitor the water quality at Monkey Mia to assess whether water quality problems are ongoing or have been alleviated as a result of modifications to the area's septic systems.

METHODS

SAMPLING

Seawater - Samples were taken in sterile bottles held at a distance from the body and moved away from the holder. Samples were taken within 0.2m of the water surface.

Beachwater - Holes from 0.5 to 1.5m deep were dug in the beach sand using a sterilised shovel. Sterile bottles, held using a sterile glove, were immersed in water at the bottom of the hole. Following water sampling, the probe of a Yeo-Kal conductivity meter was immersed in the bottom of the hole to measure salinity and temperature (subsequent equipment problems caused the loss of salinity data).

Bacterial samples - Approximately 25mL of sample was decanted into 75mL of sterile distilled water to produce a subsample near isotonic with body fluid. Four

such subsamples were made up from each seawater and beachwater sample and then cooled on ice packs in an insulated container. Containers were flown to Perth on the day of collection and samples analysed for total coliforms, faecal coliforms, faecal streptococci and salmonella bacteria at the WA State Health Laboratories next morning.

Nutrient samples - Samples of approximately 150mL were stored in Whirlpaks and frozen. Water samples to be analysed for orthophosphate (PO4), ammonium-N (NH4) and nitrate-nitrite-N (NO3-NO2-N) were filtered through Whatman GF/C filters. Samples to be analysed for total nitrogen (TN) and total phosphate (TP) were not filtered. Beachwater samples were analysed for NO3-NO2-N only. All analyses were carried out by the Nutrient Analysis Laboratory in the School of Environmental Science at Murdoch University.

SITES

Coral Bay - All sites in Figure 1 were sampled between 0930 and 1230hrs on 1 August 1989. Control samples were collected first. Seawater samples were collected at BC about 3m from shore in about 1.5m depth, seaward of the breaking of small swells and at S1-S3 from about 2m depth of water in the channel at the beach edge.

Shark Bay - Sites in Figure 2 were sampled between 1000 and 1230hrs on 9 August 1989. Control samples were collected first. Seawater from site S1 was sampled at 1030 hrs (S1-1) before any people or dolphins had passed through the water that morning. It was sampled again at 1145 hrs (S1-2) after the exit of approximately 150 people and 2 dolphins who had been in the water for about 1hr.

Further samples were taken on 4 October 1989 when beachwater sites BW2 and BW8 were sampled for bacteria. Site S1 was sampled 1 and 2hr after the entry of between 100-200 people into the water to view 3 dolphins. In addition to the samples diluted to 1:4, samples of full-stength seawater were returned for analysis.

RESULTS AND DISCUSSION

Coral Bay

Seawater and beachwater from the sites sampled showed no unusually high nutrient or bacterial levels (Table 1) which might have indicated traces of sewage or exogenous nutrient enrichment. Levels of inorganic nutrients were within the range of values typifying unpolluted coral reefs (Crossland 1983). The only remarkable points were the nitrate-nitrite level (100μgL^{-1}) at the seawater control C1 and the high streptococcal count (344/100mL) at beachwater control BC. Given that C1 was approximately 20m from a second seawater control C2 with a nitrate-nitrite level of

4 μgL^{-1} and that other nutrient levels in this sample were not elevated, the high reading was most probably due to contamination during sampling or transport. The high bacterial count is discussed below.

No visual evidence of eutrophication was apparent. Sands around the beach area and at the fringe of the lagoon were the same white colour as those in pristine areas and showed a similar lack of algal growth or dark organic sediments. No unusual densities of phytoplankton were seen or had been reported by local divers or fishermen.

Any past effects of human activities on coral mortality were unable to be assessed as the great majority of the Bay's hard corals had died (reportedly as a result of anoxic conditions caused by entrapment of coral spawn within the Bay in April of this year; C.Simpson, EPA, pers. comm.). Concentrated boating activity observed in this area has the potential to disturb benthic fauna through practices such as tying mooring chains around coral bommies and refuelling at anchor.

Shark Bay

Nutrient levels (Table 2) from beachwater were higher than those at Coral Bay while values from seawater were similar to those at Coral Bay. Sewage contamination results in a large addition of nitrogen and phosphorous to a system. In the nutrient-poor waters of Shark Bay (Smith and Atkinson, 1983) such inputs should be readily detected, although nutrients may be rapidly taken up in primary production by the region's extensive seagrass beds (Walker et al., 1988).

Comparing the results of the present survey with those of February (EPA, 1989) the clearest change was the decrease in nitrogen (nitrate-nitrite) levels in beachwater; approximately two orders of magnitude. A similar, although much lesser, change was seen in seawater nitrogen levels (total, nitrate-nitrite and ammonium). Little change was seen in phosphate levels in seawater. The levels reported for February did not reflect any major exogenous input and it may be that phosphorous is removed from these waters extremely rapidly (Smith and Atkinson, 1983).

In contrast to nitrogen levels, bacterial levels (Table 2) did not show a decrease when compared to the February sampling. The extremely high streptococcus count in sample BW8 in August was well above any of those from the previous samples. In interpreting the bacterial levels it should be borne in mind that -

- salinities above those isotonic with body fluids may increase the mortality rate of bacteria and the dilution technique used in the current study may cause a smaller drop in bacterial numbers during the period between sampling and analysis than the former study, in which samples remained as ambient seawater;

- fresh sewage normally contains more faecal coliforms than faecal streptococci by several orders of magnitude, although faecal streptococci survive better in the environment and passage through ground water will greatly modify this initial ratio;

- guidelines on permissable levels of faecal coliforms specify 150/100mL as a maximum for water used in direct contact recreation and 15/100mL in water from which edible molluscs may be harvested (DCE, 1981), but no specifications have been produced which relate to faecal streptococci.

The origins of faecal streptococci in the BW8 August sample and sample BC near Coral Bay are speculative. Such bacteria are normally indicative of warm-blooded animals and are thus unlikely to be derived from fish-cleaning activities which occur at both sites. Seabirds may carry such bacteria, although it seems unlikely that their droppings could affect a sample from 1-1.5m below the sand surface. Contamination during sampling may be involved, although considerable care was taken with sterile technique. There was no indication of elevated nutrient levels associated with high bacterial counts, although pulses of contamination may have extremely brief effects on dissolved nutrients in these waters and be very difficult to detect.

Bacteria may also have a brief life in the area, giving rise to large temporal variation. Resampling of sites BW2 and BW8 in October showed a much reduced level of faecal streptococci at BW8, although BW2 contained levels of both faecal coliforms and faecal streptococci similar to August (Table 3). Diluted and undiluted samples taken during the October sampling returned very similar results despite a seawater salinity probably above 36ppth.

The occasional low bacterial counts detected are probably of little consequence to the public or wildlife, being within the range of values commonly found on Perth beaches (R.Curtis, pers.comm., State Health Laboratories, 1989). The earlier survey by the EPA, in which sewage leaching was identified through elevated nitrogen levels, did not show the elevated bacterial levels which might be expected from that level of contamination (EPA, 1989). It seems probable that the great majority of bacteria are filtered out, or killed, as sewage percolates through the sand matrix.

The implications of the sporadic high counts may be cause for concern, in either a public health or nature conservation context. Further sampling to determine the frequency of these occurrences, their site specificity, and their origins (including the possibility of sample contamination) is indicated.

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Locality Map

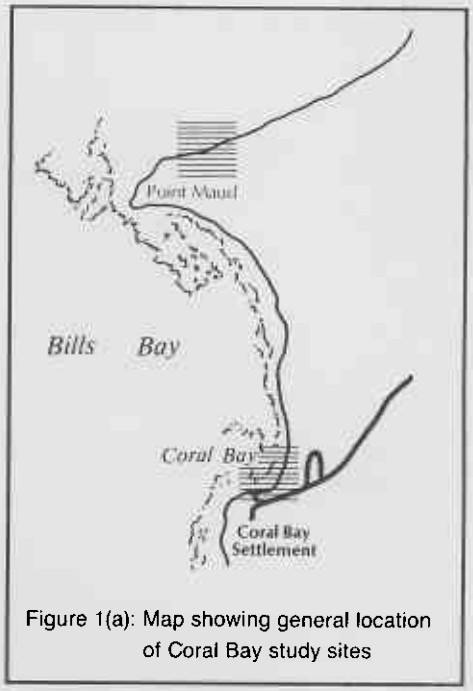

Figure 1(a): Map showing general location of Coral Bay study sites

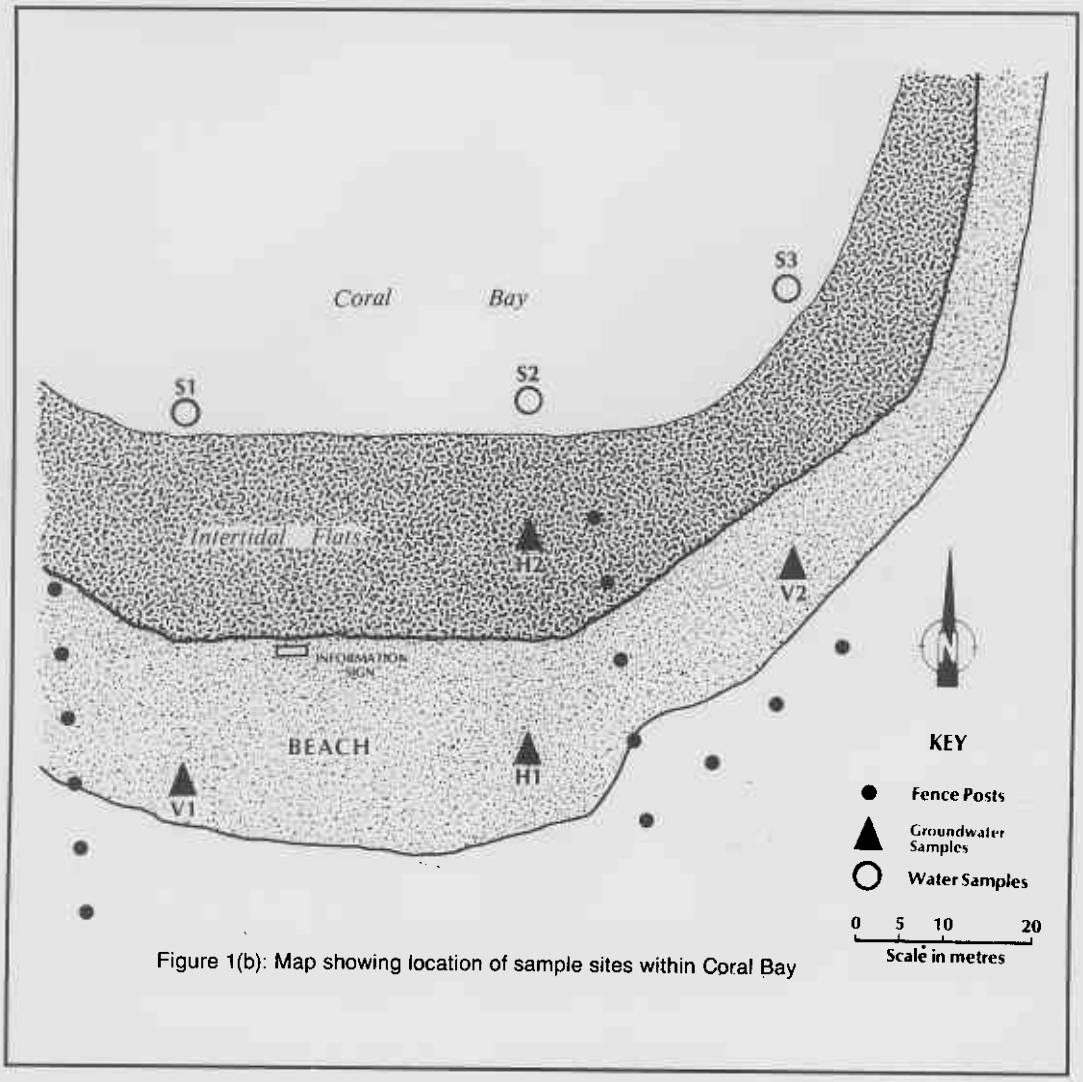

Figure 1(b): Map showing location of sample sites within Coral Bay

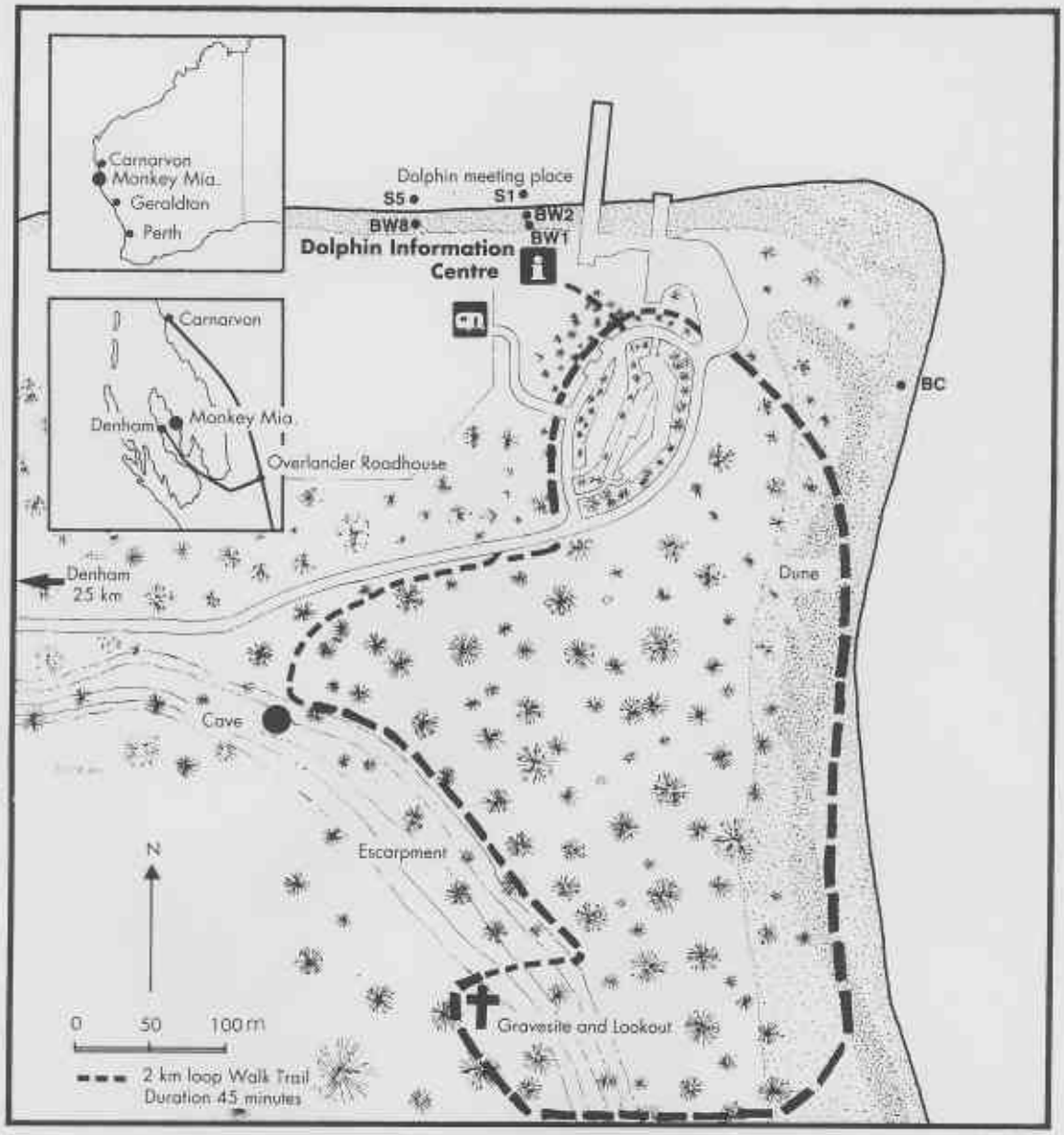

Figure 2: Location map of Monkey Mia showing sampling sites.

TABLE 1: Water quality parameters at Coral Bay. See Fig. 1 for location of sample sites. For the bacterial analyses, total coliforms were identical to faecal coliforms and all Salmonella tests were negative. Nutrients are shown as μgL^{-1} and bacterial counts as bacteria per 100mL.

	Seawater					**Beachwater**				
SAMPLE-	C1	C2	S1	S2	S3	BC1	H1	H2	V1	V2
Temp.^{0}C	19.2	19.2	20.6	20.6	20.6	19.8	20.0	19.8	17.8	20.5
NUTRIENTS										
PO4	11	11	6	6	7					
Total P	35	52	41	34						
NO3-NO2-N	100	4	3	3	2	51	28	85	200	58
NH4-N	1	1	2	1	1					
Total N	156	112	126	126	58					
BACTERIAL										
F.Coli-forms	0	0	0	0	0	0	0	0	0	0
F.Strept-occoci	0	0	0	16	0	344	0	0	10	0

TABLE 2: Water quality parameters at Shark Bay. See Fig. 2 for location of sample sites. For the bacterial analyses, total coliforms were identical to faecal coliforms and all Salmonella tests were negative. Figures in parentheses are from similar sites in February (EPA, 1989) - that study's beachwater control, BW10(C), is used for our BC and seawater site SW2 for our S5. Nutrients are shown as $\mu g L^{-1}$ and bacterial counts as bacteria per 100mL.

	Seawater				**Beachwater**			
SAMPLE-	C1	S1-1	S5	S1-2	BC	BW1	BW2	BW8
Temp.°C	15.6	15.8	15.6		15.2	21.6	20.2	18.6
NUTRIENTS								
PO4	3 (7)	11 (12)	4 (6)					
Total P	42 (19)	42 (35)	33 (22)					
NO3-NO2-N	2 (6)	1 (250)	12 (250)		7 (263)	1250 (110000)	2000 (105000)	1250 (18000)
NH4-N	1 (6)	2 (9)	2 (9)					
Total N	140 (267)	147 (482)	148 (482)					
BACTERIAL								
F.Coli-forms	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	73 (40)	80 (0)
F.Strept-ococci	0 (0)	0 (0)	0 (0)	0	19 (0)	22 (20)	23 (40)	1168 (0)

TABLE 3: Bacterial analyses for October sampling of Shark Bay. Site locations are the same as previously. Sample S1-1 was taken at 1000hr and S1-2 at 1100hr. Figures in parentheses are from water samples taken at the same time, but which were not diluted to isotonic.

	Seawater		Beachwater	
	S1-1	S1-2	BW2	BW8
F.Coli-forms	<4 (2)	<4 (2)	62 (58)	<4 (<2)
F.Strept-ococci	25 (16)	7 (6)	101 (126)	15 (4)

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