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MASS STRANDING OF DUGONGS BY A TROPICAL CYCLONE IN NORTHERN AUSTRALIA

The effects of storms on the dugong (*Dugong dugon*) are poorly understood (see Jones 1967). There have been some reports of storms causing both direct and indirect mortality. Animals can die after being stranded by tidal surges (Whittingham 1958, Heinsohn and Marsh 1977). Storms are also known to affect mortality indirectly by destroying the seagrass beds on which dugongs feed (Heinsohn and Spain 1974, see also Kenyon and Poiner 1987). In this paper, I present details of direct mortality to dugongs as result of a cyclone.

Tropical cyclone *Kathy,* accompanied by winds of up to 185 km/h, crossed the coast in the southwest Gulf of Carpentaria, Northern Territory, Australia, near the mouth of the McArthur River, adjacent to the Sir Edward Pellew Group of islands at high tide (3.2 m above datum and only 0.6 m below the highest astronomical tide) on 23 March 1984 (Fig. 1). The cyclone caused considerable damage to the townshiop of Borroloola and to trees in the surrounding countryside. There was an accompanying storm surge which stranded large numbers of marine animals, including 500+ green turtles (*Chelonia mydas*), sharks, rays, fish and at least 27 dugongs on the supratidal mud flats inshore from the coast. This paper describes the stranded dugongs which were rescued by helicopter between 30 March and 1 April 1984. The rescue procedure is described in Marsh *et al.* (1986).

It is impossible to confirm how many dugongs were stranded, but there were almost certainly more than the 27 found as a result of systematic low level helicopter searches. Dugongs were located over an area of about 275 km^2 (Fig. 1) consisting of about 45 km of coastline flanked with supratidal salt mudflats crossed by meandering waterways lined with mangroves. Dugongs (and green turtles, Limpus and Reed 1985) were found stranded up to 9 km inland; some were separated from the nearest waterway by stands of mangroves up to 3 m high.

Only 2 of the 27 dugongs were dead when found. One, photographed from the air on 1 April, but not examined on the ground, appeared to have been dead for a couple of days. The other necropsied on 30 March, had probably been dead for about two days and showed no evidence of injury or disease. Thus all the stranded dugongs examined apparently survived on the mudflats

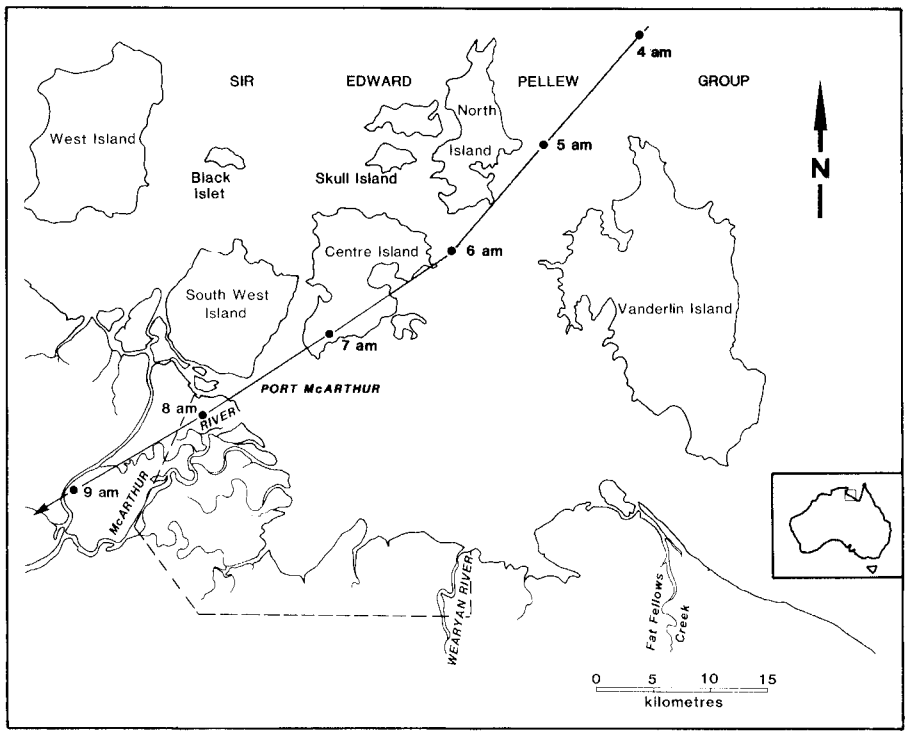

Figure 1. Probable track of cyclone *Kathy* on 23 March 1984, and its hourly positions. The area searched for stranded dugongs is defined by a broken line.

for at least five days. Two dugongs died during attempts to move them by helicopter (Marsh *et al.* 1986). The cause of death was not confirmed but was thought to be stress.

Nineteen of the 27 dugongs were in wallows (Fig. 2) about 3 m in diameter containing water up to about 30 cm deep. Only the backs of these animals were exposed. Even this region was kept moist as the dugongs occasionally spun around their longitudinal axes. This is the same spinning behaviour which renders dugongs particularly susceptible to drowning in nets (Heinsohn *et al.* 1976). This wallow-making behaviour initially appeared to be a remarkably good survival strategy, but it soon became obvious that the wallows were the result of the animals thrashing around in the soft wet mud.

The remaining eight dugongs (including both those found dead) were lying on the mudflats. However, the skin of these animals was coated in mud (Fig. 3) which gave some protection against the drying effects of sun and wind. In general, the animals which were in wallows seemed in much better condition than those that were not. Copious mucous "tears" dribbled from the eyes of all the dugongs once they were out of the water.

Some dugongs had moved up to about 20 m across the mudflats. Such movement seemed to be by rolling. We saw no evidence of dugong flipper marks.

Figure 2. Dugongs in wallows such as this were in surprisingly good condition a week after they had been dumped by the storm surge.

Figure 3. As the wallows dried many of the dugongs were left coated with mud which presumably minimized skin damage.

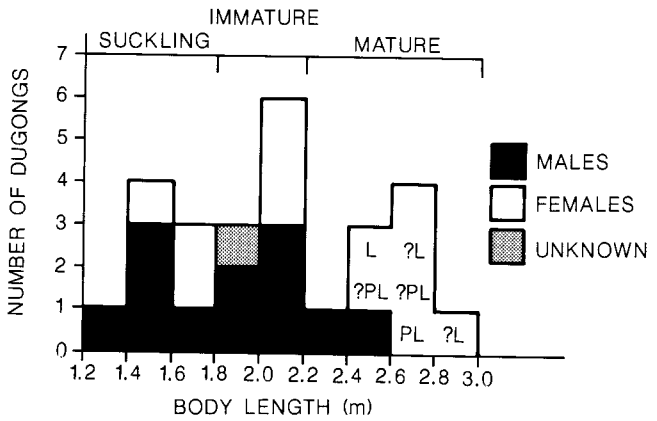

Figure 4. Size, sex and reproductive status of the 26 stranded dugongs which were measured. Animals less than 1.8 m long were classified as suckling; those less than 2.2 m long were classified as immature; males with erupted tusks are mature (Marsh *et al.* 1984*c*). The reproductive status of two of the females was confirmed by dissection (Table 1). The remaining mature females were tentatively classified as lactating if they had elongated nipples and/or pregnant if they had a bulging perineum. Animals were measured as outlined in Heinsohn (1981). Legend: P, pregnant; L, lactating; ?, tentative classification.

On the first day of the rescue (a week after cyclone *Kathy* crossed the coast), we were surprised at the good condition of most of the dugongs; their survival had presumably been facilitated by the moist muddy conditions. There was little evidence of superficial skin damage apart from some slight cracking. The undersides, especially of the larger animals, were extensively bruised. Some of the dugongs had apparently lost weight; the outlines of the spinal processes were visible in several animals, and the large females seemed to have lost condition around the belly area.

By the end of the third day of the rescue, the general condition of the dugongs had deteriorated markedly. Their skin was blistering, cracking and peeling. Some animals were almost moribund in the wallows which were rapidly drying up. The water temperature in one wallow was 35°C at 11 a.m. Rescue efforts were terminated after three days due to funding limitations. It is unlikely, however, that any stranded dugongs were still alive after this time.

We sexed 25 and measured 26 of the stranded dugongs; 12 were male (Fig. 4 and Table 1). All but two males were sexually immature. Six females were also juveniles. Judging by their size (Marsh *et al.* 1984*c*), three of the females and five of the males (including one animal only a few months old) would probably have been suckling. Of the seven adult females examined, three were probably both pregnant and lactating (one confirmed, Table 1), while another three were probably lactating (one confirmed, Table 1). The stranded animals were too scattered to recognize family groupings. In no instance was a small calf found close to an apparently lactating female.

Thus 23 of the 26 stranded animals sexed and/or measured were probably lactating females and young calves. It is not possible to determine whether this sample is representative of the animals which were in the area at the time of

Table 1. Details of the size, age, reproductive status, stomach contents, and heavy metal status of the three necropsied dugongs. The ages were estimated from tusk dentinal layer counts.

Body[a] length (m)	Sex	Age[b] (yr)	Reproductive information[c]		Stomach[d] contents	Heavy metal status[e]				
							Metal (μg/g dry weight)			
			Status	Comments		Tissue	Fe	Cu	Zn	Cd
2.45[f]	♂	17+[h]	mature;[i] inactive testes	mean single testis weight 84 g	*H. univervis*	muscle	76.73	0.95	0.39	<0.16
						kidney	844.00	10.30	164.00	57.00
						liver	25,879.00	107.00	1,928.00	16.40
2.70[f]	♀	39	pregnant/[i] lactating	foetus; length 41 cm, weight 1,600 g; perineum of mother bulging	*H. univervis*	liver	69,377.00	21.93	1,378.00	36.65
2.80[g]	♀	41	lactating[i]	at least 3 placental scars	*H. pinifolia*					

[a] Methodology according to Heinsohn (1981).
[b] Ages estimated from tusk dentinal layer counts as outlined in Marsh (1980).
[c] Methodology according to Marsh *et al.* (1984*a* and *b*).
[d] Methodology according to Marsh *et al.* (1982).
[e] Methodology according to Denton *et al.* (1980). Lead and nickel were below limits of analytical detection. Values are similar to those recorded by Denton *et al.* (1980).
[f] Died during rescue operation.
[g] Dead when found.
[h] Erupted and worn tusks, age estimate a minimum only.
[i] These results are consistent with the pattern of reproduction observed in north-eastern Australia (Marsh *et al.* 1984*c*) except for the occurrence of a female which was simultaneously pregnant and lactating.

the storm, or whether the young animals found it harder to swim against the surge and their mothers followed them in. There is evidence from other areas to support both explanations. Young dugongs are sometimes found stranded on beaches in rough weather (see Marsh *et al.* 1984*c*), and female dugongs are known to congregate in rich feeding grounds near the mouths of rivers (Smith 1987).

The stomachs of the three dugongs necropsied consisted entirely of *Halodule uninervis* and/or *H. pinifolia* (Table 1), the most widespread inshore seagrasses of this region (Dr. I. R. Poiner, CSIRO Cleveland Marine Laboratory, Queensland, 4163). This suggests that, like the stranded turtles (Limpus and Reed 1985), the stranded dugongs had been feeding inshore near the mouth of the McArthur River, where large groups of dugongs have previously been observed (Elliott 1981). All three alimentary canals were packed with seagrasses; the digestive processes had apparentyl ceased since the stranding. The significance of this is unknown. If the rate of passage in dugongs is dependent on the rate of food input, it could be an adaptive strategy to minimize the effects of food shortage.

Acknowledgments

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