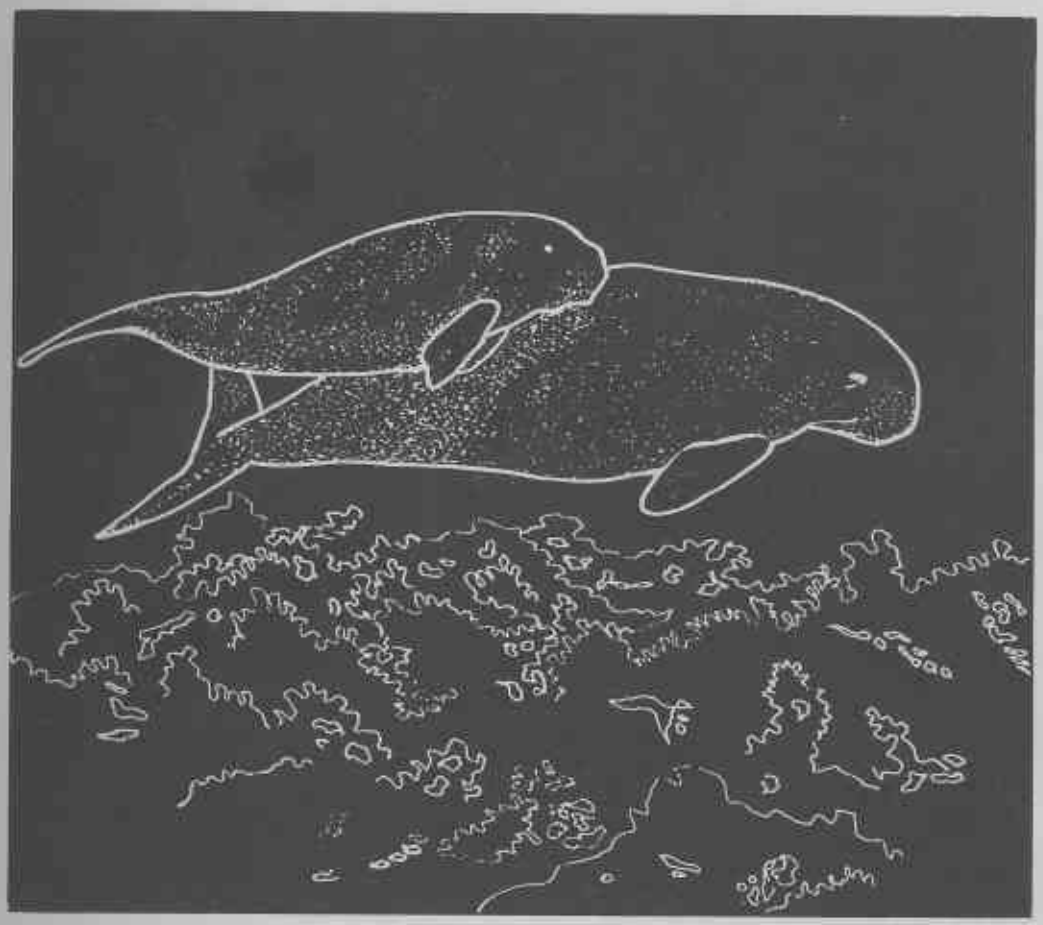
Dugong in Northern Waters of Western Australia 1984

by R.I.T. Prince



Technical Report No 7

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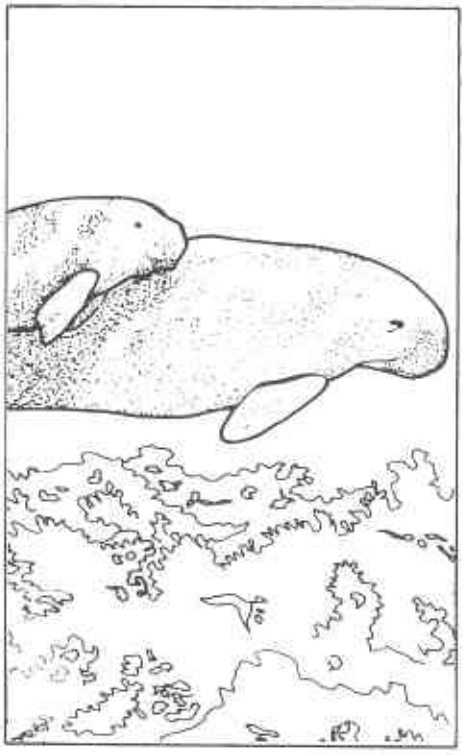

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PREFACE

The Dugong (Dugong dugon (Muller)) is included in the IUCN Mammal Red Data Book, Part 1, as a species vulnerable to extinction, and in Western Australia it is similarly placed in accord with provisions of the Western Australian Wildlife Conservation Act, 1950, within the special category of fauna considered "likely to become extinct, or is rare or otherwise in need of special protection" (WCA section 14 (2) (ba)).

Despite the apparently vulnerable status of the remaining presumed relict dugong populations in many parts of the species range, the Australian region is known to hold sizeable populations in a number of widely dispersed localities, and thus offers the best prospects for future conservation of the dugong. Knowledge of dugong populations in Australian waters is, however, incomplete.

In Western Australian waters an ongoing research program is extending our knowledge of the Shark Bay dugong population, but only limited contemporary information on populations in more northern waters has previously been available. Exmouth Gulf had been shown in 1977-78 to provide an important refuge. It was also demonstrated that dugong probably did occur in reasonable abundance in different places along the coastline and among the off-shore islands of the coastal sector from the eastern head of Exmouth Gulf up to the Port Hedland area, but no follow up work to confirm and/or extend these observations had been possible to 1984. Data on the populations northward from Port Hedland were generally not available.

The provision of funding by the Australian National Parks and Wildlife Service in mid 1984 and the co-operation of the Australian Coastal Surveillance Organisation (COASTWATCH) facilitated a reconnaissance aerial survey of the coastal waters of northern Western Australia in July/August 1984 and the associated preliminary investigations into the possible distribution and abundance of dugong and dugong habitat in these areas, and the possible role of traditional subsistence hunting as a factor affecting these dugong populations.

This publication is a printing incorporating minor editorial revisions of the original unpublished report submitted to the Australian National Parks and Wildlife Service, Canberra, in October 1984 as required by the contract of 7 June 1984.

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DUGONG IN NORTHERN WATERS OF WESTERN AUSTRALIA - 1984

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ABSTRACT

Aerial reconnaissance surveys of Western Australian coastal waters in the northern half of the State flown during the period late June-early August 1984 have confirmed the importance of Exmouth Gulf as a major dugong refuge and supported previous conclusions regarding the presence and distribution of dugongs in the area extending from Exmouth Gulf northwards to the DeGrey River.

The initial surveys of the Kimberley coast have also demonstrated the widespread occurrence of dugongs in the Dampier Land area, but major concentrations similar to those found in Shark Bay and Exmouth Gulf were not found at this time. Further work on the far north Kimberly coastline is required before more useful data for this area are obtained, but some of the larger bays and gulfs do appear suitable for dugongs and worthy of closer study.

Seagrass collections made in the inter-tidal area in the course of this work have added one species (Enhalus acoroides) to collections for Western Australia, and further material to the limited collections of Thalassia hemprichii, as well as adding to knowledge of this marine flora and potential dugong food source in northern Western Australia.

Enquiries directed to the Aboriginal community groups in the Dampier Land area have indicated close traditional links between the coastal people and dugongs. Traditional capture of dugongs and turtles was by hand, rather than by use of a spear or harpoon. This latter technological innovation was introduced by Europeans, and harpooning is now the common method used in taking dugongs. Outboard powered dinghies are used, and allow greater flexibility in movement of hunters in search of dugong, but are of little use for the final approach to within harpoon range when attempting to take a dugong.

The taking of dugong may still be a seasonal activity in some areas such as One Arm Point, but appears to be less restricted in the vicinity of Broome, where 25-30 dugongs per annum may be the present catch rate.

The total dugong catch in the Dampier Land area could presently be of the order of 50-80 animals per annum on the basis of data to hand. In total, the apparent dugong harvest in this area could be of major impact on the local dugong stocks. The Roebuck Bay harvest certainly appears to be much greater than that which could be supported by the dugong thought to be present around 7-8 August 1984 (i.e. an estimated 50-100 individuals). The need for harvest monitoring and careful management of this apparent conservation problem with the cooperative involvement of the Aboriginal communities concerned has been noted.

INTRODUCTION

Prince, Anderson and Blackman (1981) reported on the abundance and distribution of dugong in the coastal waters of Western Australia between Shark Bay and the DeGrey River (Port Hedland area) as determined by aerial surveys during the period February 1977 and April 1979, and emphasized the need for similar information being obtained for dugong populations inhabiting the more northern waters of the State.

Since April 1979 an ongoing research program (e.g. Anderson 1982a, 1982b, 1984; Anderson and Prince, in press) has added to our knowledge of the Shark Bay population, but no further work on the Exmouth Gulf to DeGrey River coastal sector (Fig. 1) had been done to 1984, and the complete lack of recent documented information pertaining to dugong populations in more northern areas had not been corrected. Growing public concern regarding the potential impact of a considered increase in the take of dugong in the Broome area (Roebuck Bay) by Aboriginal people was however brought to the attention of the Western Australian Department of Fisheries and Wildlife during 1983. This development pointed to an even more pressing need for information on the Kimberley (Fig. 2) dugong populations.

Letters were written to the coastal Aboriginal community groups in the Kimberley region of Western Australia in November 1983 advising them of the Department's need to obtain information and desire to have their co-operation as required in any investigations that might subsequently be undertaken. Funding to permit necessary investigation of the problem was also sought.

Because of the isolated and poorly accessible character of most of the extensive Kimberley coastline it was considered wise to plan a reconnaissance survey of as much of this coast as possible by the most cost efficient means available as the first step in the proposed investigation of dugong distribution and abundance in this area. Co-operation of the Australian Coastal Surveillance Organisation (COASTWATCH) for this purpose was sought and obtained with the assistance of the Australian National Parks and Wildlife Service (ANPWS), which service also provided major funding support for this project.

This paper reports the results of work undertaken in July-August 1984 aimed at:

i) making a pilot assessment of dugong distribution and

abundance in the waters of northern Western Australia from Port Hedland northwards to Broome and Derby thence around to the Western Australian-Northern Territory border; and

ii) providing an assessment of survey design requirements and costing of a program to establish current distribution and abundance of dugong in this area and the levels and possible impact of traditional hunting.

II ENVIRONMENT

Coastal areas of the Kimberley can be separated into two broad zones:

i) that from the W.A./N.T. border to Cape Leveque (Fig. 2), generally characterized by a rugged broken coastline with numerous offshore islands that reflects the geology and geomorphological processes that have affected this area. Seasonally there is a high runoff from the well vegetated hinterland, but there is no exposure to heavy oceanic swell (see Burbidge et al. 1978; and Ride and Serventy 1974); and

ii) that from Cape Leveque to southward of Broome along the Eighty Mile Beach (Figs. 1 & 2). Typically, this area receives little runoff from the sandy inland areas, and the coastline comprises low sandy beaches with the occasional line of low cliffs. Offshore, the inner Rowley Shelf slopes gently to the 60 fathom (110 m) line which is some 160 km to seaward in the Cape Bossut-Cape Jaubert area (Carrigy and Fairbridge 1954).

These northern coasts of Western Australia are subject to an extremely rigorous tidal regime, which combines a high amplitude variation between high and low water with a dominant semidiurnal flow. This regime is at its most extreme along the north western Kimberley coast. Here the maximum range of high spring tides can exceed 11 m whereas the range at low neaps can fall to as little as 1 m. On average the range of spring tides is c. 8-10 m, and of neaps, c. 2 m. The range of the spring tides in particular falls away both to the north and south of the King Sound-Buccaneer Archipelago area, averaging c. 6 m at Port Hedland to the south and $\leq$ 5 m on the far north coast (Australian National Tide Tables 1984).

Climatically, the tropical Kimberley region experiences a short rainy summer period followed by a prolonged winter drought, with transitional periods between, during which daytime temperatures are elevated. Most rainfall is received during the period December-March, and much of this comes from thunderstorms and about one quarter from monsoonal systems. Tropical cyclones are however responsible for the most widespread and heavy falls (see Gentilli 1972). Rainfall on the north west Kimberley coast in the vicinity of the Prince Regent River (Fig. 2) exceeds 1 200 mm per annum. Southward of Broome annual rainfall declines to less than 600 mm, while the

far northern coastal areas from Kalumburu to the W.A./N.T. border receive 800-1000 mm. Average annual maximum and minimum air temperatures exceed 30°C and 20°C respectively (W.A. Year Book 1974). Sea temperatures off the Eighty Mile Beach may vary between 20-22°C in July-August and from 28°C to as high as 31-32°C in late summer. There is little variation between surface and bottom temperatures in waters <30 m deep. Northward of King Sound sea temperatures generally exceed 25°C throughout the year (Rand Dybdahl, pers. comm.; see also NOAA GOSSTCOMP Sea Surface Temperature data).

The general environment of the Port Hedland to Exmouth Gulf and Shark Bay coast is as discussed by Prince, Anderson and Blackman (1981; pp. 81-2).

Localities mentioned in the text are shown in Figs. 1-3.

III METHODS

AERIAL SURVEY AND RECONNAISSANCE

The preliminary reconnaissance inspections were made from the Aero Commander 500 aircraft routinely used by COASTWATCH when travelling along their normal flight paths at the usual altitude and speed combinations designated for the different sectors of each flight. These flights are generally conducted at heights of either 1500' (457 m) or 500' (152 m) depending on the task, and at speeds in the range 130-140 knots (240-260 km/hr). Observations were made from either the port or starboard rear seat positions, depending on circumstances.

Special purpose surveys were done from a Cessna 210 aircraft flown at c. 800' (245 m) and a speed of c. 85 knots (160 km/hr). Observations were made from the co-pilot's seat (starboard front). Neutral (light grey) tinted polaroid sunglasses were worn on all flights to reduce glare.

SEAGRASS COLLECTION

All collecting was done at or above the low water mark during this work. Because of the dearth of specimens in Western Australian herbarium collections from areas northward of Port Hedland I endeavoured to search as many accessible areas as possible for the presence of seagrass(es). Special searches were also made in areas where direct aerial observations and/or other information suggested that seagrass was present, e.g. Roebuck Bay and Sunday Island. Species collected were dry pressed, and the specimens were identified by Dr Diana Walker, Botany Department, University of Western Australia.

INVESTIGATION OF HUNTING METHODS, IMPACT OF HUNTING, AND PERCEPTIONS OF ABUNDANCE, ETC.

Enquiries in the Broome area were made after initial discussions with local National Aboriginal Conference (NAC) staff. One four day trip to visit the One Arm Point group was also

included. Other Aboriginal community groups have yet to be visited.

IV RESULTS

SURVEYS

Flights with COASTWATCH early July 1984 permitted further observations being made along the coast and among the offshore islands between the DeGrey River and Coolgra Point, north east of Onslow (Fig. 1). In addition, colleagues based at Karratha were able, with cooperation of CUSTOMS authorities, to reinspect the Exmouth Gulf area late June 1984. (Flight paths). Dugong data from these COASTWATCH flights are summarized in Table 1.

Further flights with COASTWATCH, the first on July 6, and the remainder over the period July 25 to August 2, covered the coast from Broome northwards into King Sound and then around the coast to Darwin. Island groups and offshore reefs were inspected as operations permitted. Results for the Western Australian coasts are summarized in Tables 2-4.

In addition to the COASTWATCH flights, two flights using charter aircraft were made on August 7 and 8. The first of these involved a grid survey of the Roebuck Bay area down to Cape Villaret (Fig. 2) commencing c. 3 hours after low neap tide and was designed to detect groups of feeding dugongs. The survey pattern flown is shown in Fig. 3.

The second flight on August 8 included a 1 hour close survey of the reef edge and adjacent waters in the Montgomery Islands area (Collier Bay) on a falling tide, plus a close inspection of Dugong Bay and the eastern sector of Talbot Bay (Fig. 2) in the same general area, and close inspection of Pender and Beagle Bays and the remaining coast southwards to Broome on the return leg. A brief reexamination of the northern sector of Roebuck Bay where feeding dugong had been noted the previous day (Fig. 3, tracks 12-14) was also made prior to landing at Broome.

Results from these charter flights are summarized in Tables 5 and 6.

SEAGRASS COLLECTION

Extensive seagrass banks are found in Roebuck Bay adjacent to Broome (Fig. 4). Halophila ovalis appears to be the major species present in the inter-tidal area, but Halodule uninervis also occurs in reasonable abundance. The upper inter-tidal limits to the most vigorous stands appear to be determined by the length of time of exposure and degree of drying of the tidal flats occupied by these seagrasses at low tide. The broad soft-leaved Halophila ovalis appears to do best in situations where some standing water remains. Halodule uninervis is the more prominent species in the mixed stands in

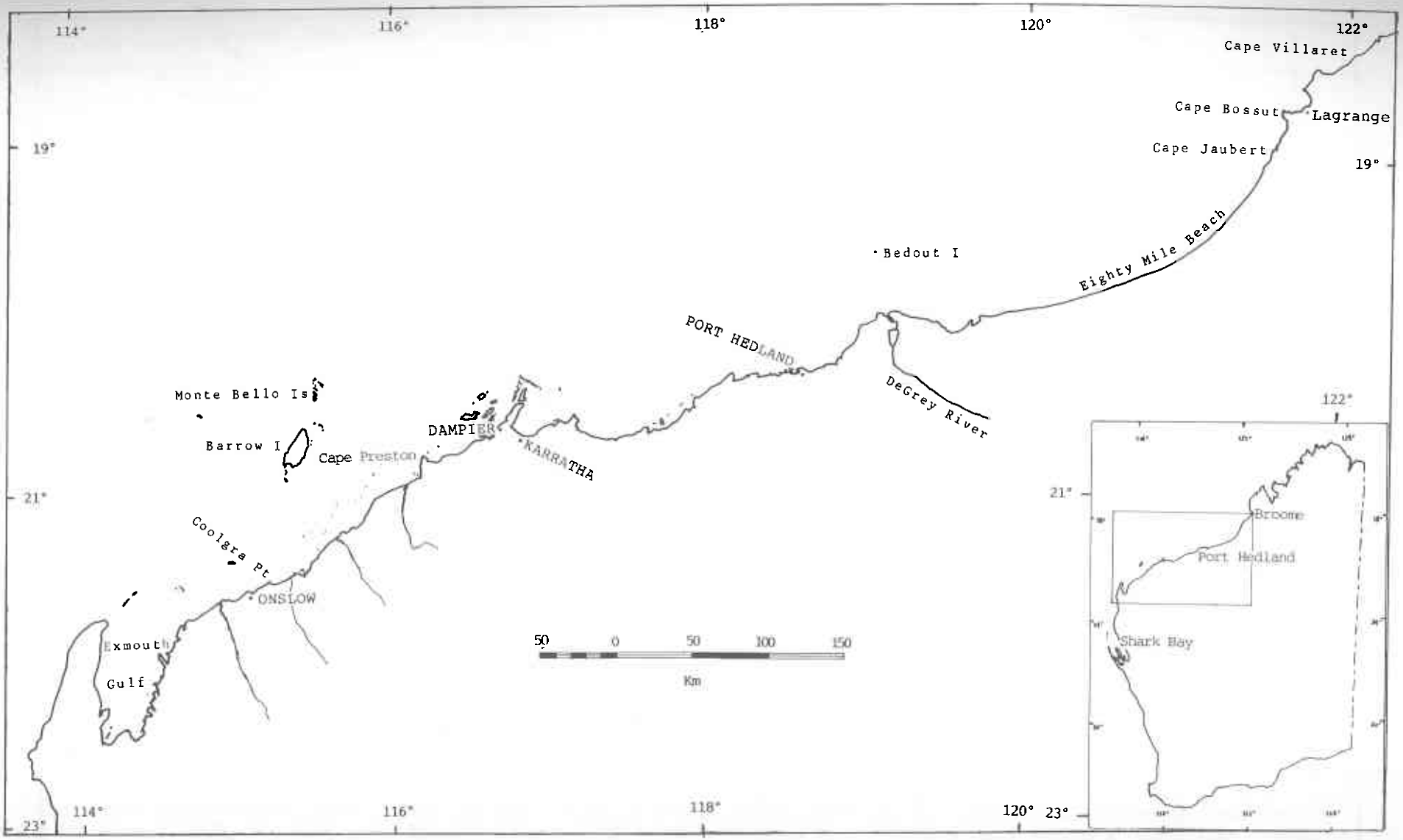

Fig 1. Localities - North West Coastline, Western Australia.

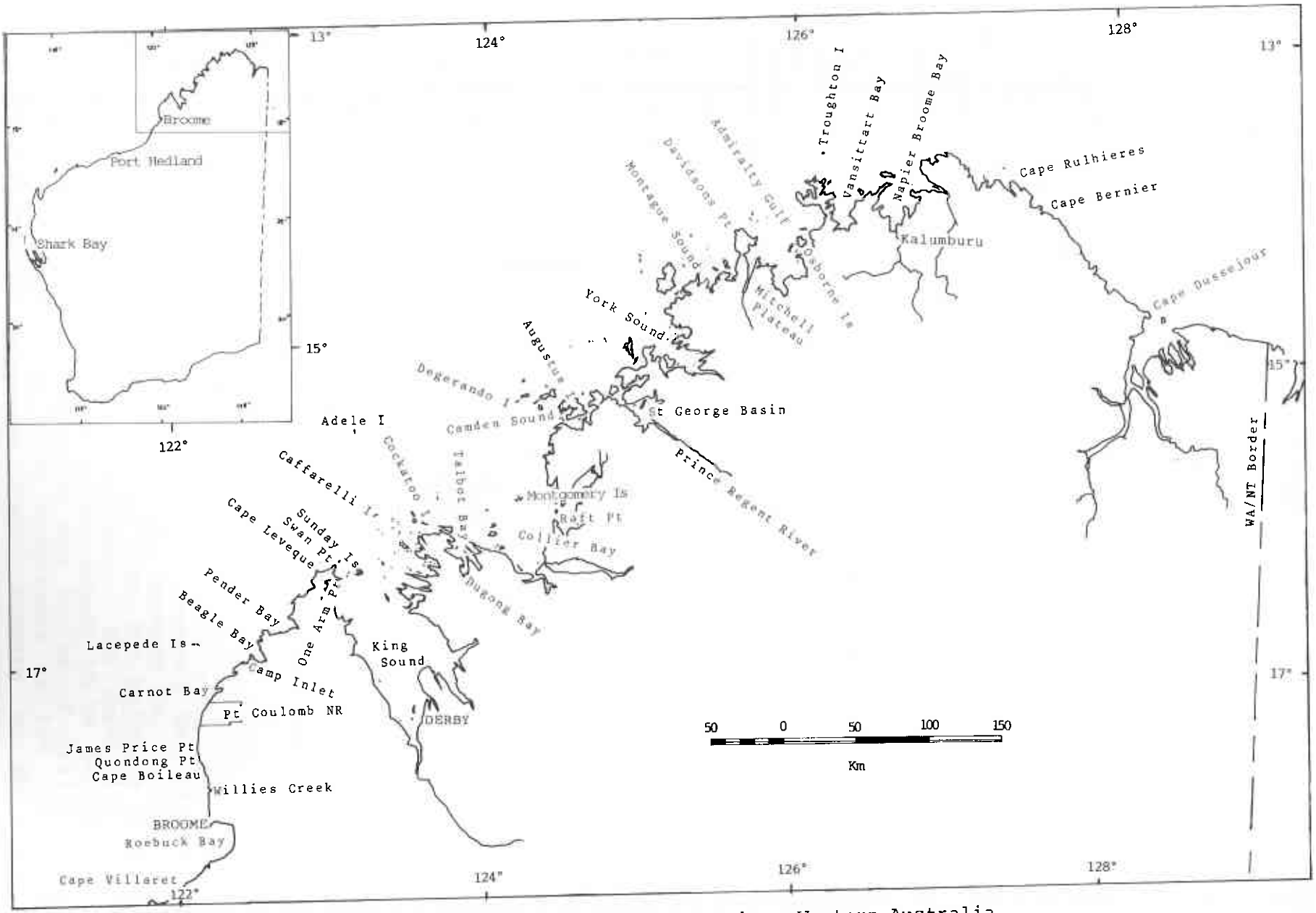

Fig 2. Localities - Kimberley and Dampier Land Coastline, Northern Western Australia.

Table 1. Summary of Dugong Observations made while on COASTWATCH Flights along the North West Coast of Western Australia, 4 and 7 July, 1984.

	Bedout Island & DeGrey River area to Dampier		Dampier to Onslow - offshore sector		Dampier to Onslow - onshore sector	
	4-vii-84	7-vii-84	4-vii-84	7-vii-84	4-vii-84	7-vii-84
Flight time (hours)	0.6†	2.0	1.1	1.2	Nil	0.7
Survey time (hours)*	0.5	1.6	0.9	1.0	-	0.7
Dugong sightings	1	2	5	5	-	9
Total Dugongs seen	4	2	7	5	-	16
Largest aggregation sighted	4	1	2	1	-	7
Dugongs/100 km coastline	2.9	0.6	4.1	2.6	-	9.1
Viewing conditions	good-fair	fair-poor	good-fair	poor	-	poor-fair
Tide state	mid, rising	low-mid	mid, rising	low-mid	-	mid, rising
Tidal amplitude (m)	~4	2	3	2	-	2

*This time represents that part of the total flight time spent over potential dugong habitat.
†Part sector only surveyed. Flown along different tracks on outward and return legs of flight.

Table 2. Summary of Dugong Observations made while on COASTWATCH Flights along the Dampier Land Coasts of Northern Western Australia, July-August 1984.
(Dampier Land refers in this instance to the Area from Cape Bossut, c. 60 nm South-West of Broome, to the eastern side of and including King Sound).

A. Observations made to South of Broome

	Broome to Cape Bossut sector		Broome - approaches from S.W.	Broome - offshore	Roebuck Bay - western side
	6-vii-84	7-vii-84	4-vii-84	7-vii-84	4-vii-84
Flight time (hours)	0.4	0.35	0.15	0.15	0.05
Survey time (hours)*	0.4	0.3	0.15	0.15	0.05
Dugong sightings	2	3	1	Nil	2
Total Dugongs seen	2	3	2	-	4
Largest aggregation sighted	1	1	2	-	3
Dugongs/100 km coastline	2.0	3.0	5.7	Nil	N/A
Viewing conditions	good	good	good	good	good
Tide State	low -mid	mid, falling	high, falling	high, rising	high, falling
Tidal amplitude (m)	4.5	3.5	6	3.5	6

*This time represents that part of the total flight time spent over potential dugong habitat.

B. To Northward of Broome - Western coastal traverses from Cable Beach to Cape Leveque

	6-vii-84	27-vii-84	30-vii-84†	31-vii-84†	2-viii-84†
Flight time (hours)	0.7	0.75	0.8	0.9	0.9
Survey time (hours)*	0.7	0.65	0.7	0.8	0.75
Dugong Sightings	8	18	9	4	1
Total Dugongs seen[c]	9(1)	22(2)	9(2)	4(2)	2
Largest Aggregation sighted	2	3	1	1	2
Dugongs/100 km coastline	5.0	12.9	5.0	2.1	1.1
Viewing conditions	good	fair-good	good excellent	good -fair	good
Tide state	high, rising	mid, falling	high, falling	high	high, rising
Tidal amplitude (m)	4.5-5.5	5-5.5	8-9	8-8.5	7.5-8.5

* This time represents that part of the total flight time spent over potential dugong habitat.
† Author only observer for dugongs. c Indicates number of calves present in addition to the adult dugongs seen.

C. Observations of Dugongs and other species made in the King Sound area.

	The King Sound Islands and Buccaneer Archipelago		Across and Inside Entrance of King Sound	
	6-vii-84	31-vii-84†	30-vii-84†	2-viii-84†
Flight time (hours)	1.55	1.05	0.5 + 0.1	0.3
Survey time (hours)*	1.15	1.0	0.4 + 0.1	0.3
Dugongs	3^{n} (3)^{s}	-	-	-
Dolphins	8 (1)	5 (4)	1+2 (1+2)	3 (1)
Turtles	8 (7)	7 (5)	1+3 (1+1)	-
Viewing Conditions	good-fair	good	good	good
Tide State	mid, rising	high, falling	high-mid/mid-low	high
Tidal amplitude (m)	5.5	8	8.5	8

* This time represents that part of the total flight time spent over potential dugong habitat.
† Author only observer for dugongs. n Indicates total numbers of individual animals seen; s the total sightings of that type of animal.

Table 3. Observations of other species (besides Dugongs) made while on COASTWATCH flights in the Dampier Land area, July-August 1984.

A. To Northward of Broome - Western coastal traverses from Cable Beach to Cape Leveque.

	6-vii-84	27-vii-84	30-vii-84†	31-vii-84†	2-viii-84†
Flight time (hours)	0.7	0.75	0.8	0.9	0.9
Uncertain I/d[q] Mammals	-	$^{2}/_{1}{}^{n}$ ($^{1}/_{1}$)^{s}	$^{3}/_{-}$ ($^{1}/_{-}$)	-	-
Dolphins	-	3 (2)	13 (8)	8 (2)	20 (4)
Whales	-	-	-	-	1 (1)
Turtles	45 (26)	32 (22)	46 (23)	44 (22)	17 (8)
Mantas	-	-	2 (2)	1 (1)	1 (1)
Large Sharks	1 (1)	2 (2)	-	-	2 (2)
Viewing conditions	good	fair-good	good-excellent	good-fair	good
Tide state	high, rising	mid, falling	high, falling	high	high, rising
Tidal amplitude (m)	4.5-5.5	5-5.5	8-9	8-8.5	7.5-8.5

† Author only observer for dugongs and other species. q Data as presented show observations classed as possible Dugongs/possible Dolphins when recorded. n Indicates total numbers of individual animals seen; s the total sightings of that type of animal.

B. Offshore tracks from northward of Broome up to entrance of King Sound

	6-vii-84	30-vii-84†	31-vii-84†	2-viii-84†
Flight time (hours)	1.1	0.8	0.75	0.9
Uncertain I/d Mammals[q]	-	$-/_4{}^n$ $(-/_4)^s$	-	-
Dolphins	30 (1)	17 (8)	1 (1)	2 (2)
Whales	-	2* (1)	1 (1)	1 (1)
Turtles	-	2 (1)	7 (4)	2 (1)
Mantas	-	-	1 (1)	-
Large Sharks	-	1 (1)	2 (2)	-
Viewing conditions	good	fair	fair	fair
Tide State	mid, rising	mid -low	mid -low	high -mid
Tidal amplitude (m)	~5	8.5	8.5	8

† Author only observer for dugongs and other species. q Data as presented show observations classed as possible Dugongs/possible Dolphins when recorded. n Indicates total number of individual animals seen; s the total sightings of that type of animal. * Voucher photo of animals seen.

Table 4. Summary of Observations of Dugongs and other species made while on COASTWATCH Flights around the Northern Kimberley coastline of Western Australia, 26 July to 2 August 1984.

A. Coastal traverses from the W.A./N.T. Border to the western head of Admiralty Gulf.

	WA/NT Border - C. Dussejour 26-vii-84	C. Dussejour - C. Rulhieres 27-vii-84	Napier Broome Bay area 27-vii-84	Vansittart Bay area 27-vii-84	Admiralty Gulf area 27-vii-84
Flight time (hours)	0.3	0.45	0.5	0.35	0.4
Dugongs sighted	-	-	-	-	-
Mud plumes	-	-	4^{n} (2)^{s}	5 (3)*	2 (1)
Uncertain I/d Mammals[q]	-	-	-	$^{3}/_{-}$ ($^{1}/_{-}$)	$^{1}/_{6}$ ($^{1}/_{1}$)
Dolphins	-	-	-	-	8 (3)
Whales	-	-	-	-	-
Turtles	1 (1)	2 (1)	11 (4)	3 (1)	2 (2)
Mantas	-	-	-	-	-
Viewing Conditions	poor	poor	fair	fair	fair
Tide state	low, -mid	mid, falling	mid, rising	mid, -high	high, rising
Tidal amplitude (m)	2.5	3	3.5	4	4.5

n Indicates total number of individual animals seen; s the total sightings of that type of animal.
* Voucher photo of one observation obtained. q Data as presented show observations classed as possible Dugongs/possible Dolphins when recorded.

B. Offshore tracks from Westward of Admiralty Gulf to King Sound area.

	Davidsons Point - Degerando Island 27-vii-84	Degerando Island - Swan Point area 27-vii-84	30-vii-84	Raft Point - Adele Island 31-vii-84	2-viii-84
Flight time (hours)	0.65	0.4	0.5	0.65	0.65
Dugongs sighted	-	-	-	-	-
Mud plumes	-	-	-	-	-
Uncertain I/d Mammals	-	-	-	-	-
Dolphins	8[n] (3)[s]	1 (1)	1 (1)	-	4 (2)
Whales	-	-	1 (1)	-	5 (3)
Turtles	3 (1)	1 (1)	-	2 (1)	5 (3)
Mantas	1 (1)	-	-	-	-
Viewing Conditions	fair -good	fair -poor	fair	good	good
Tide state	high, falling	mid, falling	mid, falling	high, falling	high
Tidal amplitude (m)	4 to 6	6	9	10	9.5

n Indicates total number of individual animals seen; s the total sightings of that type of animal.

C. Traverses from the Adele Island - Caffarelli Island area to north of Augustus Island.

	Caffarelli Island - Adele Island 31-vii-84	Cockatoo Island - Raft Point 30-vii-84	Cockatoo Island - Raft Point 31-vii-84	Raft Point-New Island (Camden Sound) 30-vii-84	Augustus Island area 30-vii-84
Flight time (hours)	0.3	0.4	0.5	0.25	0.25
Dugongs sighted	1[n] (1)[s]	-	-	-	-
Dolphins	16 (2)	-	-	-	-
Whales	3 (2)	-	-	-	-
Turtles	3 (3)	-	-	1 (1)	-
Viewing conditions	good	good	good	good	good
Tide state	high, falling	high, falling	mid, falling	mid, falling	mid, falling
Tidal Amplitude (m)	11	10	10	10	10

n Indicates total number of individual animals seen; s the total sightings of that type of animal.

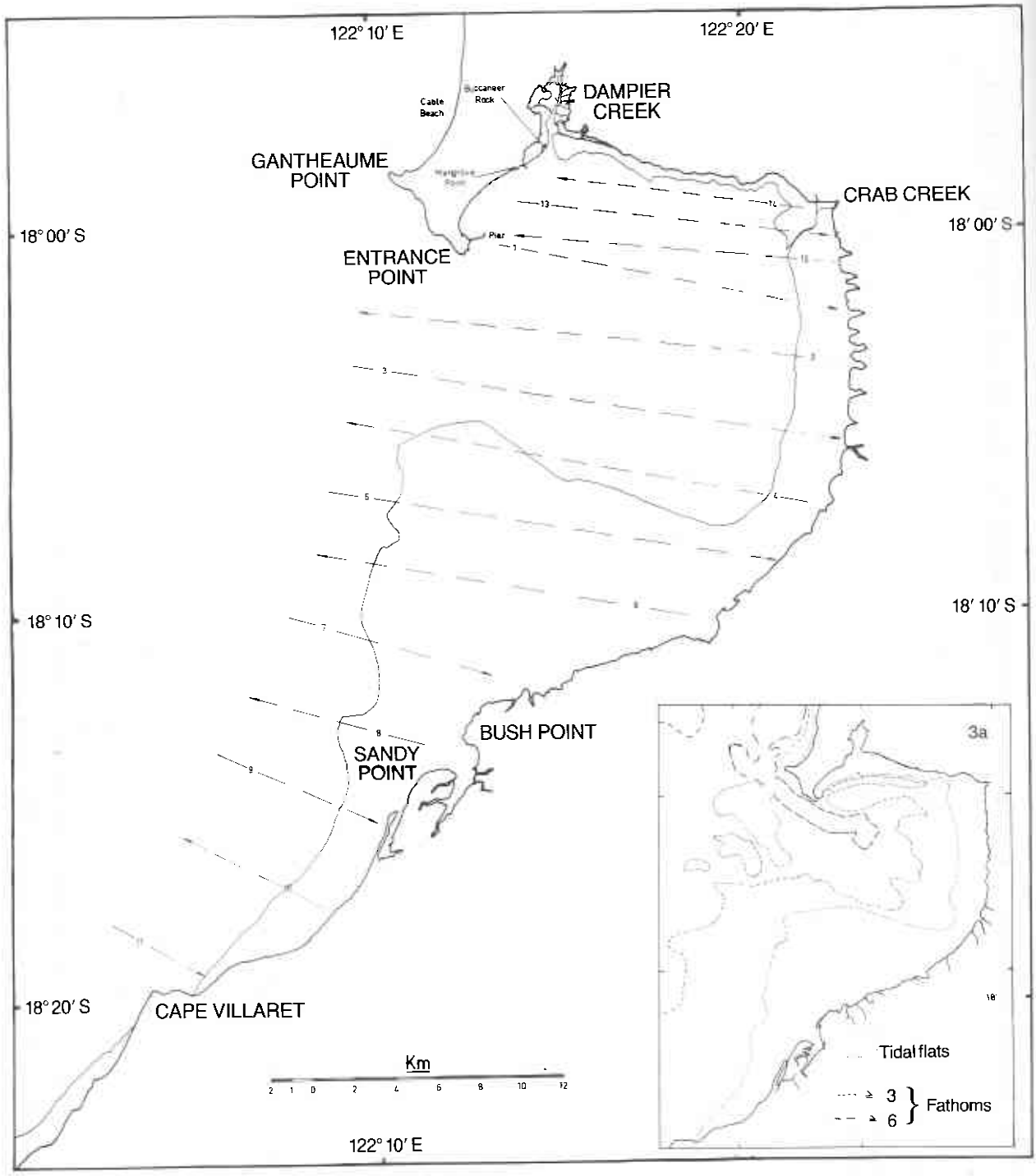

Fig. 3. Dugong survey flight lines in Roebuck Bay, 7-viii-84. Numerals indicate order in which tracks were flown, arrowheads the direction of travel. "X" indicates approximate location of small group of dugongs. The original flight plan commenced with the Dampier Creek-Crab Creek track (14) and proceeded southward as for tracks 1-11. Traffic approaching the Broome airport circuit forced the change. Track 1 was commenced at 1608 hrs. and track 11 was completed at 1709 hrs. Tracks 12-14 were flown between 1720 and 1740 hrs. Low tide (2.9 m) was at 1250 hrs. Expected high tide (5.2 m) was 1907 hrs. **Inset, 3a.** Bathymetry relevant to dugong distribution and survey grid.

Table 5. Summary of Observations made in the Roebuck Bay Area - Charter Surveys, 7 and 8 August, 1984

	Southward of Entrance Point 7-viii-84		Northwards of Entrance Point 7-viii-84		Northward of Entrance Point 8-viii-84	
Flight time (hours)	1.0		0.45		0.15	
Survey time (hours)*	0.85		0.3		0.15	
	Numbers	Sightings	Numbers	Sightings	Numbers	Sightings
Dugongs[c]	11[(1)]	6	7†	3	11[(1)]†	3
Mud plumes	-		16†	4	14†	3
Uncertain I/d Mammals[q]	-		-/5	-/4	-	
Dolphins	34	5	-		-	
Turtles	29	19	5	4	3	3
Mantas	-		-		-	
Large Sharks	-		-		-	
Viewing conditions	good		good-fair		fair	
Tide state	mid, rising		mid-high		mid, rising	
Tidal amplitude (m)	2.5		2.5		3	

*This time is that spent on survey grid legs. c Indicates the number of calves present in addition to the adult dugongs seen. † Some of the dugongs seen were individuals responsible for mud plumes also counted separately. q These data as presented show observations classed as possible Dugongs/possible Dolphins when recorded.

Table 6. Summary of Observations made while on Charter Surveys Northward of Broome, 8 August 1984.

	Montgomery Islands area	Pender Bay	Beagle Bay	Camp Inlet - Cape Boileau
Flight time (hours)	1.15	0.15	0.15	0.65
Dugongs[c]	3(1)n (2)s	-	-	6(2) (4)
Mud Plumes	-	-	-	-
Uncertain I/d Mammals	-	-	-	-
Dolphins	-	-	-	-
Turtles	160+ (N/A)	1 (1)	7 (5)	8 (8)
Mantas	-	-	-	-
Large Sharks	1 (1)	-	-	-
Viewing conditions	good	good -fair	good -fair	good -fair
Tide state	mid, falling	low	low, rising	low -mid
Tidal amplitude (m)	6.5	4	3.5	3.5

c Indicates the number of calves present in addition to the adult dugongs seen. n Indicates total numbers of individual animals seen; s the total sightings of that type of animal.

places where the substrate is fully exposed at low tide (see Fig. 5). The upper limits of the general distribution of these seagrass stands appear to lie within an area that is drained and then reflooded within an hour or two on either side of low tide. The substrate in Roebuck Bay is a fine greyish mud and the seagrass rhizomes here generally grow within the first 3 to 5 cm. Dugong feeding trails can be seen (Fig. 6, Pl. 1).

Apart from the extensive mixed vigorous stands mentioned above, some apparently less vigorous, isolated seagrass stands were also found in Roebuck Bay. Halophila ovata was found on the more exposed mudflat area on the north side of Buccaneer Rock (Fig. 6, Pl. 2, and Fig. 7), and also collected along with Halophila ovalis from the seaward edge of the mangrove (Avicennia marina) stands in the Crab Creek area. Standing water was present at low tide in both situations. Halodule uninervis was also found in similar situations in the Crab Creek area.

A few isolated stands of Halodule uninervis only were found above the low tide mark at Barred Creek (Cape Boileau), while Syringodium isoetifolium was the only species found and collected in the inter-tidal zone at Quondong Point (see Figs. 8 & 9). In each case the seagrass was found in rock pools, where the substrate was a fairly coarse shelly sand which could potentially be extremely abrasive if not stabilized. The presence of extensive apparently mobile shell and shell-sand banks within the inter-tidal area of Willie's Creek appeared to be the reason why no seagrass was found in this particular locality.

Five seagrass species were collected in the One Arm Point - Sunday Island area of King Sound. Of these, one (Enhalus acoroides) is a new record for the State (Keighery 1981), and another (Thalassia hemprichii) had hitherto been poorly collected (Di Walker and Hugh Kirkman, pers. comms.) Isolated clumps of Enhalus acoroides were present on the north side of One Arm Point and also in the Sunday Islands channel (Fig. 10). Thalassia hemprichii was much more abundant in each instance, and formed an extensive stabilizing mat of vegetation on the raised reef platform in the Sunday Islands channel (see Fig. 11). In addition to the above species records, Halophila ovalis and Halodule uninervis were found in association with Thalassia hemprichii at One Arm Point, and Halophila ovata alone was found in "blow out" type openings in the extensive Thalassia hemprichii beds and also mixed with this latter species where only a sparse cover existed in the Sunday Islands channel area (Figs. 12 & 13).

Searches for seagrass and the collection of specimens were limited to the above mentioned sites during the course of this project. On ground inspections elsewhere could not be accommodated. Nevertheless, areas covered during the aerial inspections were viewed with an eye to their being capable of providing good dugong habitat, and hence seagrass beds.

The identification of probable seagrass communities from the air was possible, e.g. the Sunday Islands site, and the areas

within Roebuck Bay near Broome, as proven by the subsequent on ground inspections, but few such good opportunities were presented. The closer surveillance of the reefs around the Montgomery Islands and in the north eastern sector of Talbot Bay during the charter work on 8 August in fact suggested that the plant cover here was predominantly algae with little if any areas of seagrass. In contrast, the common observation of numbers of feeding dugong in the deeper water offshore along the coastal sector from about James Price Point northwards to Carnot Bay can be taken to indicate the presence of seagrass beds below the low water mark.

Apart from the above observations, examination of reef and bay areas elsewhere was extremely brief (dictated by circumstances). Parts of some of the larger north Kimberley bays and gulfs, etc., e.g. Napier Broome and Vansittart Bays, and Admiralty Gulf and Montague Sound (Fig. 2), appeared likely to be favourable for the growth of seagrass communities, but water conditions and operational requirements did not favour more positive identification of particular sites on this occasion.

IMPACT OF HUNTING, PERCEPTIONS OF ABUNDANCE, AND HARVEST TECHNOLOGY, ETC.

Direct enquiries were made around Broome and at One Arm Point. Follow up discussions were pursued on returning to Perth with other researchers who have been studying the domestic economy of Kimberley Aboriginal communities.

Many of the people who have a present active involvement in exploitation of dugong on the Dampier Land coasts have links with the One Arm Point-Sunday Island area. My enquiries at One Arm Point provided sufficient evidence to demonstrate a strong traditional association between these people and the dugong. The language has specific words for different dugong and groupings of dugongs; there are words for the different parts of the dugong and ritual for butchering and protocol for distributing the meat of captured dugong; and at least one site on Sunday Island which is of significance in the Aboriginal law. This summary of information gleaned by me while at One Arm Point has been corroborated by others of greater experience in this area than myself. The most interesting finding was that capture of dugong and turtles prior to the settlement of Europeans on this coast was done by hand only.

Hunting of dugong in the One Arm Point area is generally restricted to the period from about March-April through to August-September, with availability of dugong in the area apparently being the controlling factor, both now and in pre-European times. There appear from my enquiries to have been no traditional limits to the number of dugong that might be taken in any year, but this is not exceptional when the limited availability of dugong and the method of capture prior to the coming of Europeans is taken into account.

One dugong was taken during my visit to One Arm Point. It was apparently a male and was the fourth obtained by the particular hunter during 1984. I did not see the whole animal itself, and

was unable to obtain any specimens or measurements. One other hunter in this community had succeeded in taking two animals for 1984; total 6 taken to 5 August 1984. Eleven animals were taken at One Arm Point during 1983 (Nick Green, pers. comm.).

Dugong hunting in Roebuck Bay now may be attempted at any time of the year. One family group in particular appears to account for the major part of the hunting effort, but further enquiries are needed to fill in gaps in the information obtained. At least one dugong had been taken about the time of my initial visit to Broome in early July, and an unsuccessful attempt to take a dugong was made on the night of 31 July while I was engaged in the main part of this project. Another dugong also was taken several days after I returned to Perth on completion of the project work (Joe Bornman, pers. comm.). This information is indicative of a fairly concerted hunting pressure being applied to the Roebuck Bay dugong stock and suggests that 20-30 animals may presently be being taken per annum and consumed by people in the Broome area (it appears possible that not all these animals are being taken from within Roebuck Bay). The Broome District Fisheries Officer, Mr John Looby, previously estimated that the 1983 take of dugong in this area would be of the order of 25-35 animals (Report of 19 May 1983).

Other Aboriginal communities in the Dampier Land area also take dugong. The people at Lagrange (south west of Broome) are probably taking 4-5 per annum (Nick Green, pers. comm.). Those at Beagle Bay and Lombadina (near Cape Leveque) possibly account for numbers similar to those taken by the One Arm Point group. Taken together these data suggest that the present take of dugong by Aboriginal people of the Dampier Land area could be in the range of 50-80 animals per annum. A harvest of this order could potentially have a major impact on the local dugong population(s) (see Marsh 1983).

Enquiries directed at finding out whether dugong hunting might now have affected the abundance of dugong, or that the local abundance of dugong might have changed, produced two types of responses. There is a generally held opinion that the use of outboard powered craft has affected the behaviour of dugong such that it is now extremely difficult to get within range of a dugong when hunting if the motor is used while attempting to spear the animal. The final approach must be made by quietly sculling the dinghy to the spot where the feeding dugong is expected to surface. This suggests that surviving dugong have modified their behaviour in response to continued hunting from powered craft. The second type of response was that it was now much more difficult to see dugong during daylight hours than in times past. Hunting by moonlight at times of the neap tides appears to be favoured.

In total, the common belief held is that dugong are still present in reasonable numbers and that the reported behavioural changes adequately account for their apparent scarcity during daylight hours (cf. Jarman 1966; Anderson 1981). The question that must of course then be asked is where (if at all) these wary dugong are taking refuge during the day. There is nothing

that can be offered in this regard from local sources, and I have yet to do sufficiently intensive surveys in each locality. However, the observation that dugong might be more readily seen along the less accessible part of the Dampier Land coastline between James Price Point and Carnot Bay (the middle section of which includes the Point Coulomb Nature Reserve), rather than along parts to the north or south could be significant in this context.

Further enquiries were directed to ascertaining the possible impact of changes in harvest technology on hunting practices, and trying to obtain some appreciation of maximum harvest pressure in the past.

The One Arm Point situation requires further investigation, but indications are that the present levels of hunting may quantitatively be of similar magnitude to that expected in the distant past when traditional hand capture was the norm, and fewer people were present. Hunting in the more recent past (10-15 years ago) may however have accounted for much larger numbers per annum.

In the vicinity of Broome changes in harvest technology have potentially increased the "fishing power" of those wishing to take dugong. Apart from the initial advent of the spear or harpoon, the availability of the outboard motor in more recent times has freed the hunter from some environmental constraints. Pre-World War II, access to the favoured hunting areas in Roebuck Bay was dependent on the tides. The intending hunter rowed his dinghy out into the main channel of Dampier Creek on the falling tide and was then carried further out into Roebuck Bay. He achieved what he could around the period of the change of tide and then re-positioned himself to catch the incoming tide to return home. He was thus compelled to be at sea for a period of 5-6 hours on each trip and was also effectively prevented from ranging over to the eastern sector of Roebuck Bay by the pattern of tidal flow. Use of an outboard powered dinghy now frees the hunter to go where he desires and also increases the effectiveness of time that may be spent in the hunting area. A comprehensive assessment of the net impact of these changes on the hunting of dugong in Roebuck Bay cannot be made on present information, but it is apparent that the risk to dugong may now be greater than in the past.

Up to seven parties have been noted hunting dugong at one time in the past and a maximum of four animals has been known to have been taken on one day in Roebuck Bay. The time frame for these observations has not yet been established, but my informant did mention that only small numbers of dugong (6-8 individuals) may now be seen at one time and that it was much easier to see numbers of dugong in daylight hours prior to the advent of outboard motors. Harpoons with detachable heads were first used in the late 1940s period.

Plate 1

Plate 2

Fig. 4. Showing the extent of the mixed-species (Halophila ovalis and Halodule uninervis) seagrass beds in the Mangrove Point-Inner Anchorage area of Roebuck Bay at morning low tide on 1-viii-84. Low water was 0.3 m. **Pl. 1.** Beds to the eastward of Mangrove Point (on right hand side of photo on shoreline). **Pl. 2.** View of same beds to southward over the Inner Anchorage area (deep-water pier in middle of photo).

Plate 1

Plate 2

Fig. 5. Habit of seagrass species found in Mangrove Point area, Roebuck Bay, at low tide on 1-viii-84 (cf. Fig. 4). **Pl. 1.** Habit of Halophila ovalis. Typically in standing water at low tide. **Pl. 2.** Habit of Halodule uninervis. This species typically dominates the more exposed micro-habitat areas.

Plate 1

Plate 2

Fig. 6. Pl. 1. Dugong feeding trails in the seagrass beds off Mangrove Point, Roebuck Bay, 1-viii-84. **Pl. 2.** General view of mud banks exposed at low tide alongside the main channel of Dampier Creek to the northward of Buccaneer Rock (position on right hand side middle ground of photo).

Plate 1

Plate 2

Fig. 7. Habitat and habit of Halophila ovata on mud banks to north of Buccaneer Rock (in background, Pl. 1), Roebuck Bay, at low tide on 31-vii-84 (cf. Fig. 6, Pl. 2). **Pl. 1.** General view of habitat, with H. ovata visible in pool in foreground. **Pl. 2.** Growth habit of H. ovata in Buccaneer Rock locality. Typically in pools of standing water.

Plate 1

Plate 2

Fig. 8. Habitat and habit of Halodule uninervis, Barred Creek (Cape Boileau). **Pl. 1.** Growth habit; in pool on raised terrace, rocky to hard shelly substrate - low tide, 28-vii-84. **Pl. 2.** Aerial view from westward of Barred Creek at high tide. Pl. 1 area is off photo to right of mangroves in right foreground. Seagrass was not found in the main channel.

Plate 1

Plate 2

Fig. 9. Habitat and habit of Syringodium isoetifolium at Quondong Point, 29-vii-84. **Pl. 1.** Growth habit; scarce, in sheltered reef pool on sandy substrate - low tide. **Pl. 2.** View from Pl. 1. area back to Quondong Point - track into parking area at right rear.

Plate 1

Plate 2

Fig. 10. Growth habit of Enhalus acoroides; low tide. Pl. 1. Locality = north side of One Arm Point, 4-viii-84. Pl. 2. Locality = Sunday Is channel, southern end, 6-viii-84.

Plate 1

Plate 2

Fig. 11. Habitat and growth habit of Thalassia hemprichii in Sunday Is channel at low tide, 6-viii-84. **Pl. 1.** Mat on raised reef platform. **Pl. 2.** View across channel at southern end facing eastward.

Plate 1

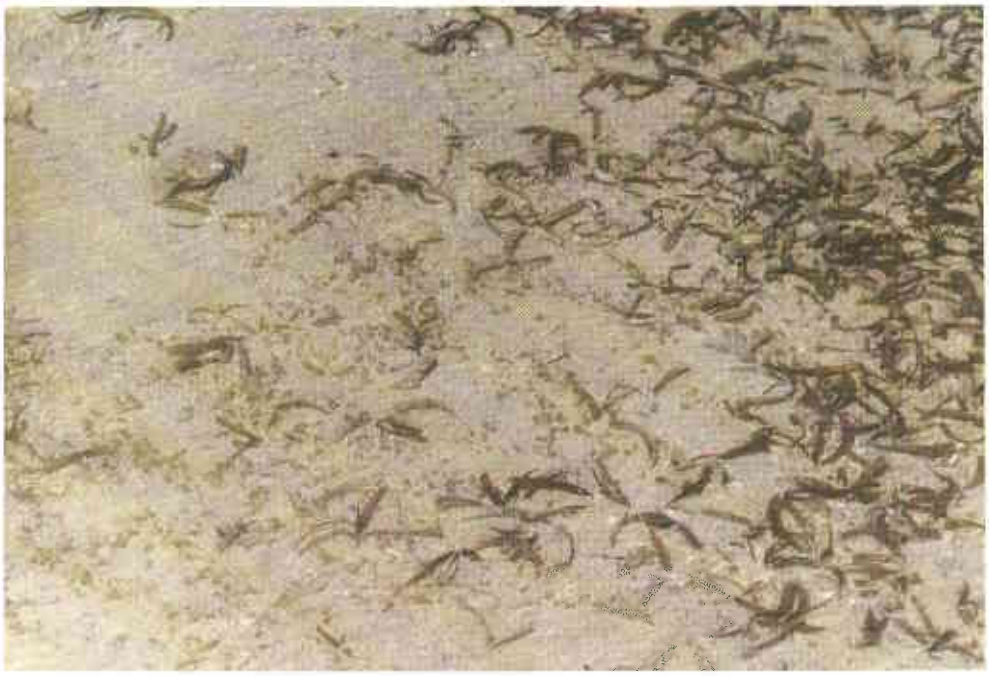

Plate 2

Fig. 12. Habit of mixed stands of Thalassia hemprichii and Halophila spp., low tide. **Pl. 1.** Th. hemprichii and H. ovalis; locality - north side of One Arm Point, 4-viii-84. **Pl. 2.** Th. hemprichii and H. ovata in "blow-out" patch; locality = Sunday Is channel, southern end, 6-viii-84.

Plate 1

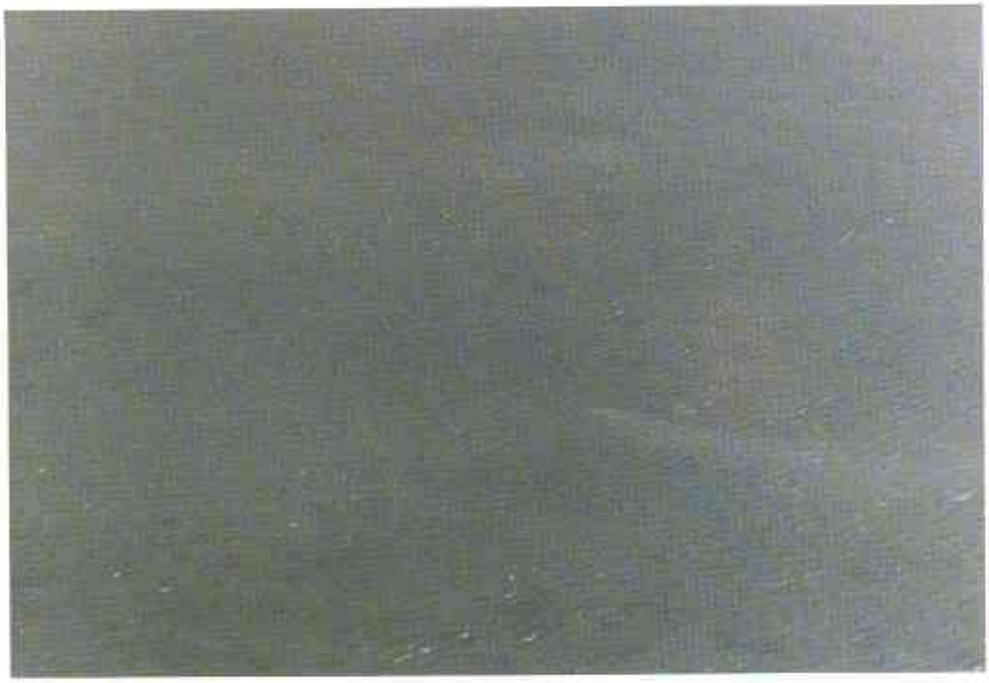

Plate 2

Fig. 13. Pl. 1. Habit of mixed Thalassia hemprichii and Halodule uninervis; locality = north side of One Arm Point, 4-viii-84. **Pl. 2.** Mud plume raised by probable dugong feeding, Vansittart Bay; c. 0924 hrs, 27-vii-84. Animal not seen (cf. Table 4A).

V DISCUSSION

COASTWATCH flights provided the first opportunity to view the northern Western Australian coastline and make an appraisal of the possibilities for doing more intensive dugong studies in this area, and to also assess the possible value of different parts of this coast as important dugong habitat. The once only coverage of this area has indicated the possibilities for further investigation in places such as Napier Broome and Vansittart Bays, and Admiralty Gulf, Montague and York Sounds, but has also highlighted the real difficulties associated with attempts to work effectively in this most isolated part of the state. This experience is invaluable and the exercise would be worth repeating if sufficient funds are not readily obtainable for more detailed work.

The more concentrated effort closer to the COASTWATCH base in Broome has proven the presence of dugong in reasonable abundance on the Dampier Land coast and has incidentally provided observations on distribution and abundance which mesh in with enquiries made and the tentative conclusions drawn from these regarding the recent extent and impact of traditional exploitation of dugong by the Aboriginal communities now present.

The observations made over the Port Hedland to Onslow coastal sector and among the associated offshore islands, supplemented by the CUSTOMS flight data of my Karratha-based colleagues for June 20 (Morris and Marshall, pers. comm.), have confirmed and extended the original survey results and conclusions reported for this area by Prince, Anderson and Blackman (1981), e.g. Exmouth Gulf is an important dugong habitat (c. 200 individuals seen by Morris and Marshall), there are areas of major significance to dugong on the north west coast, and that dugong do occur among and around the offshore island groups in this area. COASTWATCH observers have also reported seeing large numbers of dugong in the vicinity of Cape Preston on different occasions in the past.

The first charter flight in Roebuck Bay on August 7 showed that feeding dugong could be found in the favoured hunting area where several dugong had been seen from a dinghy on August 1 at c. 1400 hours, and also corroborated the additional information of my informant that groups of 6-8 dugong might now be the most seen together in Roebuck Bay. The additional inspection of this same part of the Bay on August 8 confirmed the above observations. From the evidence of the individual mud plumes produced by feeding dugong and the dugong seen surfacing in the vicinity on each occasion there were approximately 20 animals using the northern parts of Roebuck Bay covered by these survey flights. Smaller numbers of dugong were seen elsewhere in the Bay during the first survey which extended down to Cape Villaret. Those seen were scattered in ones and twos at the most.

In total, the survey data suggest that a minimum of 20-30 dugongs were present in the area actually surveyed; but

distribution of these animals appeared to reflect patterning within the bay environment (see Figs. 3 & 3a). Without further knowledge of this apparent link, it is difficult to extrapolate survey data to produce a good estimate of total numbers present. The observations and data obtained suggest that a total of 50 to 100 dugong would be a reasonable first estimate of the numbers present in the Roebuck Bay area around 7-8 August 1984.

It is apparent from the observations on distribution and possible numbers of dugong present that an experienced and persistent hunter could still fairly readily procure a dugong in Roebuck Bay if he wished. However, the apparent level of exploitation presently occurring in the Broome area clearly can not be sustained by this local dugong population if indications of abundance are of the right order. It seems improbable that the true total could be c. five times that suggested above.

The main task of the second charter flight on August 8 was the close inspection of the Montgomery Islands reef area. The few dugong seen here were found adjacent to the south-east sector of the reef, but turtles were most numerous practically all around the reef edge. The reef cover also appeared to be predominantly algae. These observations suggest that the Montgomery Islands area would indeed have been a most desirable site for occupation by the Aboriginal people mid-year, as was the case in previous times. However the comments about dugong in this area may relate more to the probable ease of capture of any that may have ventured far up onto the reef platform at high tide, rather than the absolute abundance of the species. One of my Broome informants had mentioned that dugong distribution in this area was restricted prior to my making this flight. COASTWATCH observers also recalled making very few observations of dugong here (supported by reports on file).

The secondary objective of this second charter flight of doing a detailed coastal - offshore - coastal pattern survey of the Carnot Bay to James Price Point area (where COASTWATCH flights had suggested dugongs were concentrated) had to be abandoned due to time and light restrictions. There are thus no comprehensive quantitative survey data to back up the cumulative impressions of abundance and pattern of distribution of dugong on this section of coast where the tidal pattern and large range appear to impose fairly rigorous limits on the activity patterns that dugongs must maintain to fully exploit their habitat, e.g. feeding patterns appear to be more dependent on the state of the tide than in an area much as Shark Bay, with animals in the Broome area also appearing to have to feed in much deeper water on average. The probability of actually sighting dugong in these northern waters may consequently be lower than in the more southern parts of their range in Western Australia, simply because they are spending a longer period submerged when actively feeding. Those I observed from the dinghy in Roebuck Bay were staying down 2-3 minutes. This was also the time quoted by my informant as that available to get into position to spear a feeding dugong after it was seen to dive. Furthermore, the feeding dugongs observed were spending little time on the surface between dives, and

could not be seen from the air except when close to the surface in most cases.

The comments above should be taken as indicative of what I believe are some of the greater problems to be encountered in attempting dugong surveys around the Kimberley coasts. Nevertheless it is my present opinion that the existing Dampier Land dugong stocks (apart from those in Roebuck Bay) could number several hundred at least. They may be more numerous. This point requires further investigation. The apparent level of exploitation could on this assessment also be having a significant impact and thus requires careful monitoring. Any such monitoring program attempted must involve the Aboriginal communities.

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Raelene Hick and Jill Pryde typed the manuscript and tables.

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