Data Report – Report No. 2008-03

Historical datasets of dugong (*Dugong dugon*) observations in the Kimberley region of Western Australia.

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INTRODUCTION

Background

The dugong (*Dugong dugon*), a large marine vertebrate herbivore, occurs throughout Western Australian waters from Shark Bay through the Kimberley and into the Northern Territory. This species is regarded both as an important Keystone species from an ecological perspective (Marsh et al. 1999) and an important cultural species for many Indigenous communities. Given the extensive coastline of WA and the historically limited threatening activity that dugongs have traditionally been exposed to, WA represents an important location for the species' conservation, on both national and international levels. The recent development of a Management Plan for dugongs at a state level (DEC 2007) is the latest of templates (e.g. Marsh et al. 1999, 2002) for the synthesis of existing research and datasets as well as a pro-forma for the identification of future research needs. These documents highlight the importance of WA as a whole for dugong conservation, but also illustrate the need to understand the distribution and abundance of populations throughout the State as well as their level of interconnectedness.

Population abundance estimates of dugongs which have been determined to date in WA have been calculated from aerial surveys in Shark Bay, Exmouth Gulf and Ningaloo Reef (Marsh et al., 1994; Preen et al., 1997; Gales et al., 2004; Holley et al., 2006; Hodgson 2007). The only additional survey to have been conducted outside of these locations was undertaken in 2000 and covered the Pilbara region from Exmouth Gulf to the southern limit of the Kimberley region (Prince et al. 2001) (Fig 1.).

Given the importance of the Shark Bay and Exmouth populations, monitoring of these regions has occurred every five years, since 1989. Five years is considered the minimum time needed to identify large scale fluctuations (Marsh et al. 1994). Shark Bay, a World Heritage Listed Area incorporating a Marine Park, is particularly important for dugong conservation with a recently estimated population of ~ 10,000 dugongs at a density of between 0.65 and 0.95 / Km^2 (Hodgson 2007). Shark Bay has minimum threatening activity and relatively clear water allowing good sighting of dugongs and, as a result, much of the dugong research and associated funding within WA has been focussed on this location.

By contrast for the Kimberley region of WA, which is known from Indigenous knowledge and anecdotal reports as an important location for dugongs within WA (Prince, 1986; Marsh et al. 2002; DEC 2007), there are no dugong abundance estimates or distribution data. The remoteness of the region, large tidal variation and water turbidity make aerial surveys, the standard method for determining population abundance estimates and distribution patterns, difficult. The strong cultural attachment of the many Indigenous peoples of the region to the dugong has resulted in deep cultural knowledge of where dugongs occur at different times of the year. However, anecdotal information suggests that even traditional knowledge has gaps on dugong distribution at times when they are not visible and there is an inconsistent picture of animal density due to fluctuations in numbers of animals seen and hunted from year to year.

Research Need and Objective

Many sections of the northern WA coastline have become heavily industrialised in the last three decades particularly throughout the Pilbara region where offshore and onshore oil and gas exploration and processing facilities are abundant. There have been recent moves to develop similar industry along the Kimberley coast to access the Browse Basin, a 140,000 Km^2 offshore gas field approximately 300km off the Kimberley Coast. This has resulted in extensive debate and the need to define the natural values of this region, which is considered to be one of the world's most ecologically diverse (WWF 2008).

Given the remoteness of the Kimberley and the costs involved in undertaking research programs in this region, desktop studies of unpublished data are a valuable first step in defining natural values. While unpublished dugong distribution and abundance datasets may not be standardised or provide the capacity for detailed analysis they can provide useful historical snapshots with which to focus future research needs.

This data report reproduces hard copy format maps and summary data collected in two programmes:

1. Estimates of dugong abundance and distribution in the West Kimberley region collected during preliminary assessment surveys conducted by Dr RIT Prince in 1984 and a series of strip transect aerial surveys throughout 1985; and
2. A longitudinal dataset of incidental observations from 1996-2007, covering both the west and east Kimberley collected by the Australian Customs Service.

The strip transect surveys and incidental observation datasets have been entered into a GIS framework with associated metadata. A full description of the methodologies used in the collection of these datasets as well as the processes involved in incorporating them into a GIS framework are listed below.

METHODOLOGY

This data report is comprised of two components as defined by each dataset listed below;

1) 1984 assessment survey and 1985 Strip Transect Series
2) 1996-2007 Incidental Observation Records

These surveys represent the only attempts to quantify the Kimberley dugong population to date and although there are inherent problems in the acquiescence of data, described below, they represent an important dataset of baseline dugong distribution throughout the Kimberley.

Region Description – For the purposes of this report the Kimberley region will be divided into two section corresponding to Management Units 4 and 5 (Fig.1), as defined in the Dugong Management Program for WA 2007-2016 (DEC 2007).

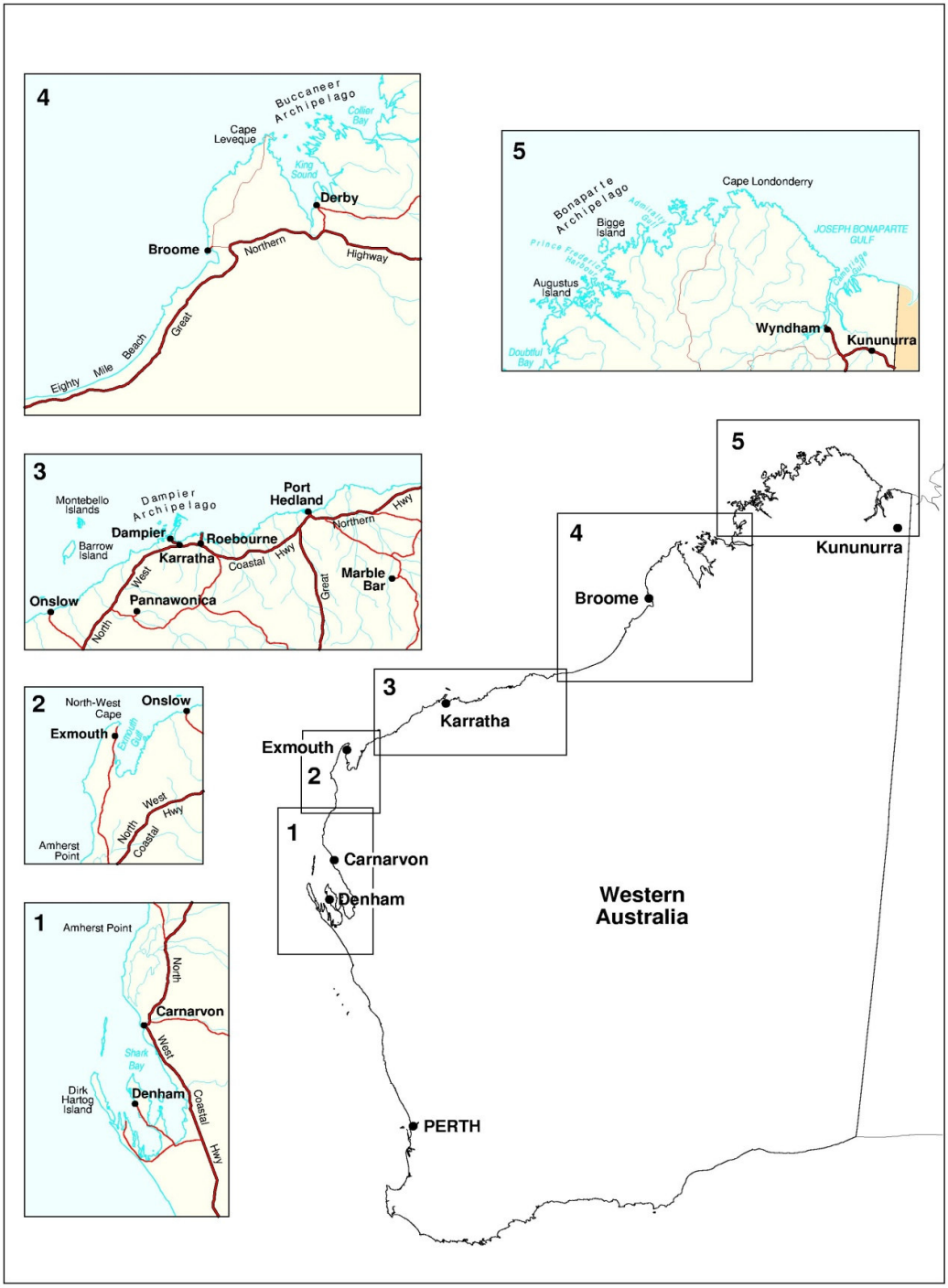

Figure 1: Dugong management units for Western Australia incorporating the study areas (units 4 and 5) for which historical dugong data have been collated.

1984 Assessment Surveys and 1985 Strip Transect Series

This series of surveys represents the first attempt to quantitatively assess dugong distribution and abundance throughout the west Kimberley region. The 1985 survey was divided into two sections:

- The southern section, which extended from LaGrange Bay to Broome (Fig. 2); and
- The northern section, which commenced just north of Broome and extended to Cape Leveque including the Lacepede Islands and into King Sound (Figs. 3-6).

The 1984 surveys were longshore surveys ranging from Exmouth Gulf through to the WA/NT border and were a pilot program for the development of the 1985 survey program. Full methodology and results for these surveys are accounted for in Prince (1986), however a summary of results relevant to this report for the West Kimberley region are presented in Table 1. No raw data was available for digitisation for these preliminary surveys.

1985 Strip Transect Series

For all sections two flights were conducted during each of April, July and October resulting in a total of 12 flights. Each flight within each survey area was replicated, with transects flown perpendicular to the coast at a height of 275m and speed of 90 knots. Distances between transects varied as did the lengths of transects as flights were generally made to a point where visibility restricted the sighting potential. Observations were conducted by a single observer with markers delineating a strip on the water surface equivalent to 400m wide. Flights were conducted during neap tides to maximise sighting potential. Aside from dugong observation other megafauna, such as dolphins and turtles, were also recorded, but for the purposes of this report only dugong sightings are described.

Survey limitations

Given that the year of the survey preceded the establishment of standardised methodology (Marsh and Sinclair, 1989) and that flight lines, extent of transects, and that exact positioning of sightings were estimated during flights, overall accuracy of data is limited. In addition, for the majority of flights only one observer was present recording all above listed information as well as observing therefore negating any mark recapture component. Buckland et al. (2001) advise against this form of sampling for determining population abundance with any abundance estimate likely to be extremely negatively biased. Therefore, no effort is made here to provide estimate of population abundance from the west Kimberley region, the observations recorded represent direct counts of total number of dugongs seen.

GIS Representation

During conduct of the survey transect lines, times of sightings along each individual transect and details of observations were recorded on copies of the relevant nautical charts of the survey area as well as in field notes by the observer. When digitising these observations the positions as marked on the maps were correlated with the relevant field notes and the positions were plotted in the GIS package ArcGIS 9 onto a .tiff file of the relevant chart in the datum WGS 1984. Along with sighting locations, total numbers of dugongs seen as well as the ratio of adults to calves, transect id, date of survey and the block location were recorded in the attribute file.

For clarity, survey flights which were conducted north of Broome were separated into blocks. These blocks as labelled are; Southern Dampier (SD) - from Broome north to Red Bluff, Northern Dampier (ND) - Red Bluff to Cape Leveque, Lacepede Islands (LP)– covering all these islands and adjacent reef platforms, and King Sound (KS) – Easton Point to Carlisle Head incorporating Sunday Island. As no dugongs were observed in the King Sound block no further analysis was conducted. All transects south of Broome were included in a single block called 80 Mile Block (80M). Block areas and transect lengths were defined within a Mercator projection. In order to determine dugong density within the survey boundaries, transect areas were calculated based on the perceived height of the aircraft, transect length and survey strip width.

1996 -2007 Incidental Observation Records

This dataset comprises records of dugongs observed during regular Australian Customs Coastwatch flights throughout northern Australia. Security restrictions prevent the provisioning of flight details, however Customs has provided the dates latitude and longitude and number and description of dugongs as seen during these flights. The dataset was collected between 1996 and 2007 and extends from Shark Bay WA through to Cairns QLD and into the Torres Strait. For the purposes of this report only observations between 80 Mile Beach and the Northern Territory border were examined.

Survey Limitations

Given the paucity of information on flight paths, heights, duration and numbers of observers due to security restrictions, this dataset could only be viewed as direct observations and no inference being drawn on numbers of dugongs observed by year or by month given that the survey effort will have differed with each flight undertaken.

GIS Representation

This dataset was provided by Customs in a spreadsheet format, which was subsequently imported into ArcGis 9 and converted into a shapefile format. Observational data was then represented by year and by month (Figs. 6a -6l and 7a-7l).

RESULTS

1984 Assessment Surveys

Table 1 lists a summary of observations from these surveys in the regions that were surveyed in greater detail in 1985.

Table 1:Summary table adapted from Prince (1986) of dugong observations from a pilot study throughout the West Kimberley in 1984.

REGION	DATE	TOTAL DUGONGS SEEN	FLIGHT TIME (minutes)
Cape Bossut-Broome	July	11 Adults	65
Broome – Cape Leveque	July & August	46 Adults 7 Calves	216
Roebuck Bay	August	29 Adults 2 Calves	97

1985 Strip Transect Series

Listed below is a summary of the flight details and number of dugongs observed over the entire survey period. Table 2 summarises each flight by block and by month with calculated densities of each location. Figures 2,3,4 and 5 graphically illustrate the distribution of dugongs by month and total observed within each block.

Survey Dates - *Admiral Bay – Broome*;
Survey 1 - 13&20 April
Survey 2 - 11&13 July
Survey 3 - 07&09 October

Broome – Swan Island;
Survey 1 - 15&16 April
Survey 2 – 12&14 July
Survey 3 – 08&10 October

Total transects flown - 66

Total approximate length of transects – 1117.5Km

Total approximate area surveyed – 448.26 Km^2

Total number of dugongs observed – 221

Total number of adult dugongs – 187

Total number of calves - 34

Table 2: Summary table of numbers and densities of observed dugongs within each west Kimberley survey block by survey month.

Block	Survey Area Km^2	Month	Flight	Observed Numbers	Total	Density	Overall Density
80M	157.12	April	(a)	11	18	0.07	0.11
			(b)	7		0.04	
		July	(a)	48	56	0.31	0.36
			(b)	8		0.05	
		Oct	(a)	9	45	0.06	0.29
			(b)	36		0.23	
SD	72.01	April	(a)	13	15	0.18	0.21
			(b)	2		0.03	
		July	(a)	2	9	0.03	0.12
			(b)	7		0.1	
		Oct	(a)	1	3	0.01	0.04
			(b)	2		0.03	
ND	111.80	April	(a)	5	10	0.04	0.09
			(b)	5		0.04	
		July	(a)	13	31	0.12	0.28
			(b)	18		0.16	
		Oct	(a)	5	5	0.04	0.04
			(b)	0		0	
LP	55.64	April	(a)	14	25	0.25	0.45
			(b)	11		0.2	
		July	(a)	1	4	0.02	0.07
			(b)	3		0.05	
		Oct	(a)	0	0	0	0
			(b)	0		0	

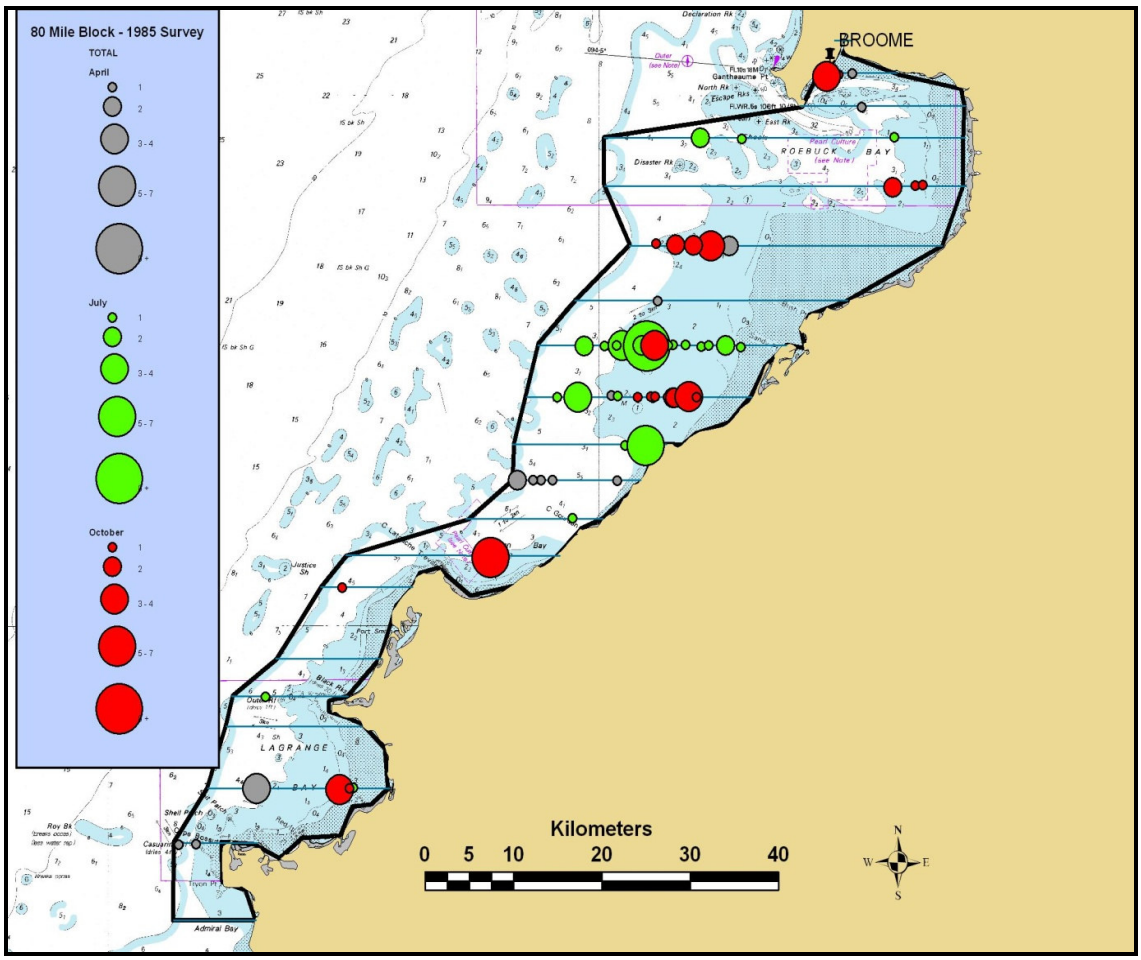

Figure 2: Total observed dugongs by survey month within 80 Mile Block south of Broome.

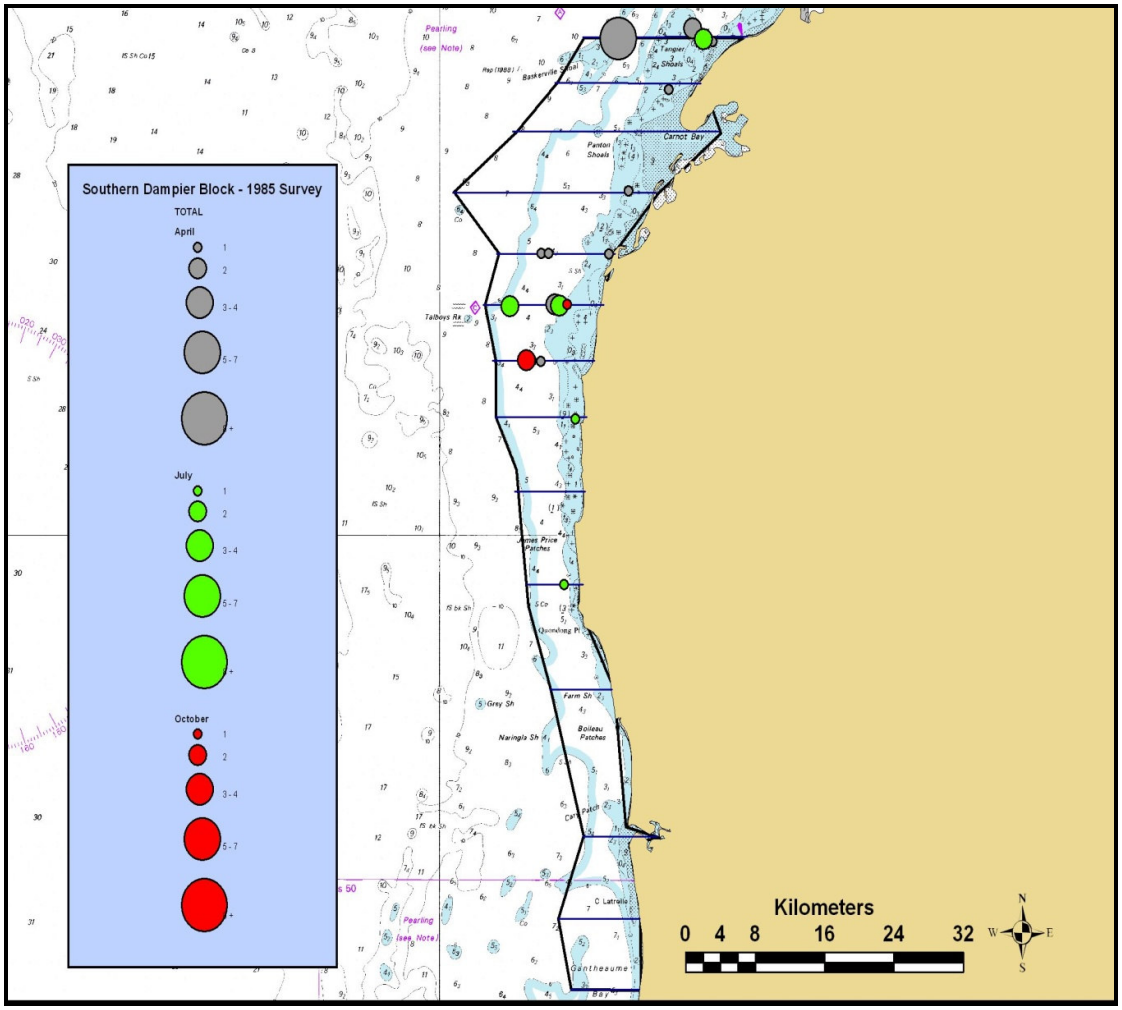

Figure 3: Total observed dugongs by survey month within Southern Dampier Block north of Broome.

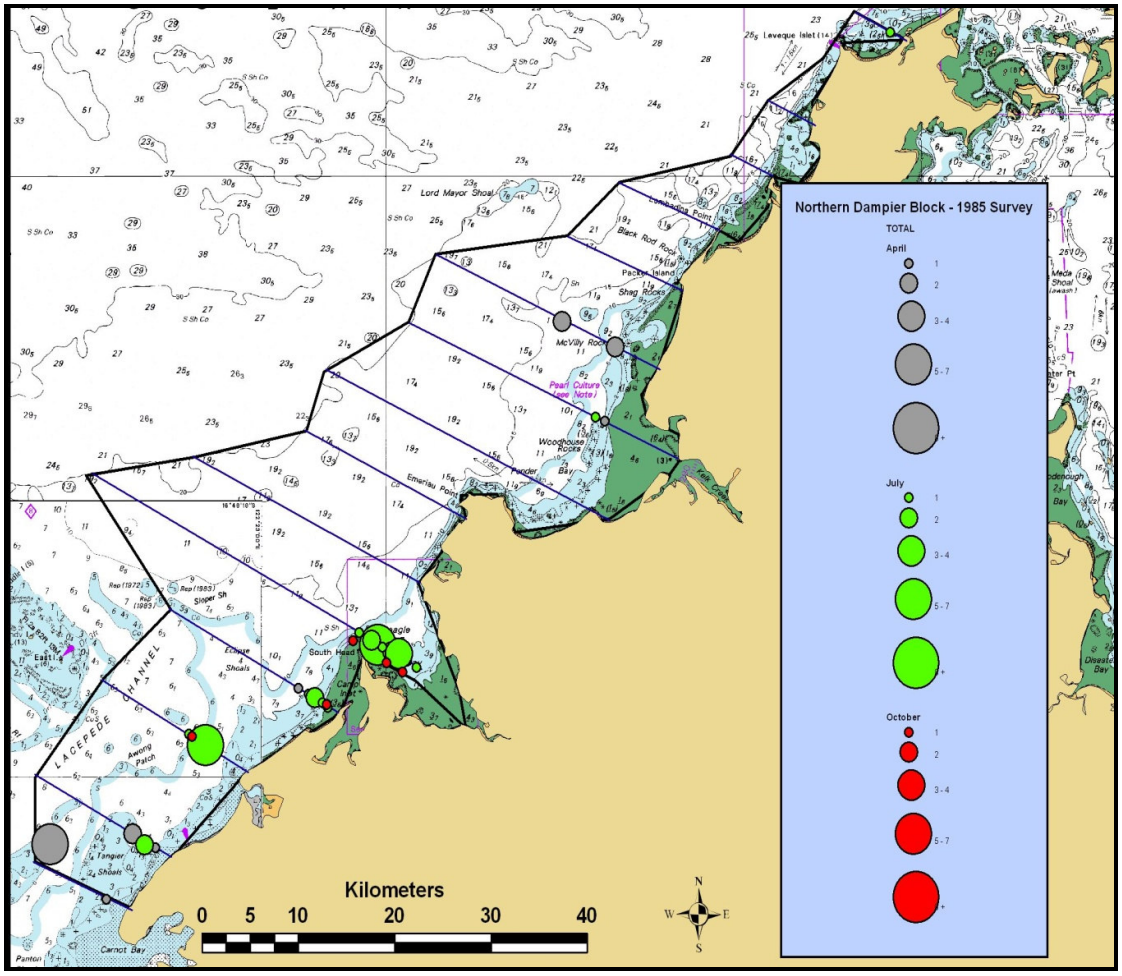

Figure 4: Total observed dugongs by survey month within Northern Dampier Block north of Broome.

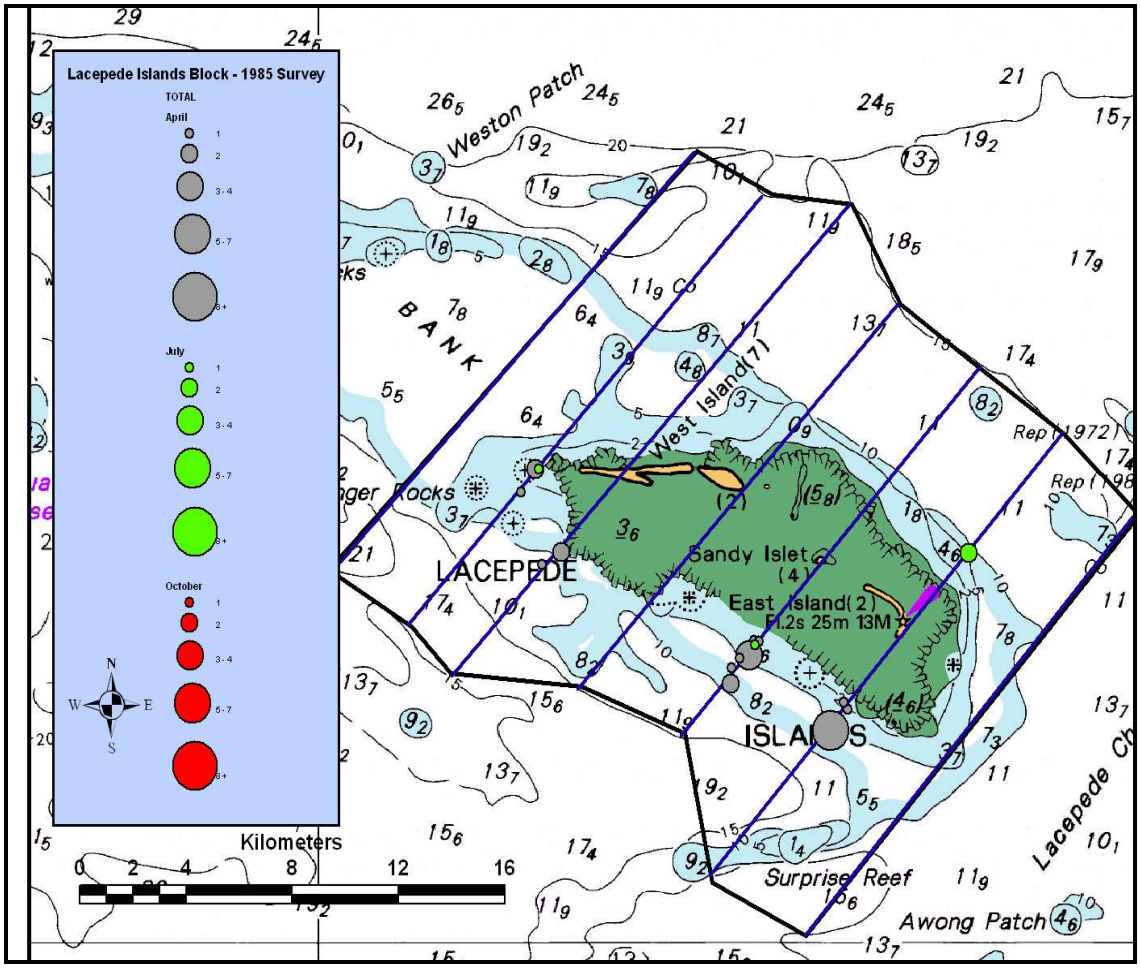

Figure 5: Total observed dugongs by survey month within Lacepede Islands Block north of Broome.

1996 -2007 Incidental Observation Records

The distribution of dugongs as recorded from Customs Coastwatch Flights is represented in the following series of maps; Figures 6a through 6l show distribution from years 1996-1997, while figures 7a through 7l represent monthly pooled observations over the 1996-2007 period.

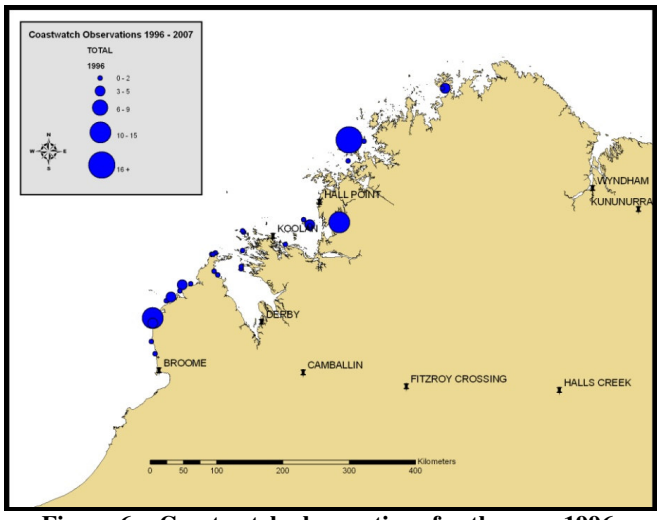

Figure 6a: Coastwatch observations for the year 1996.

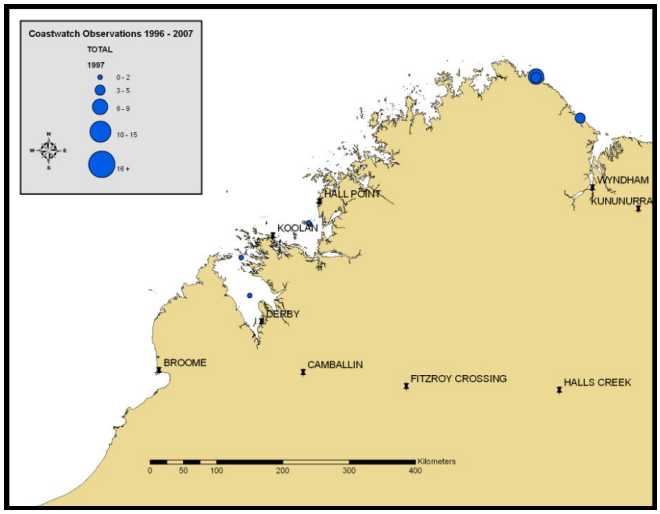

Figure 6b: Coastwatch observations for the year 1997.

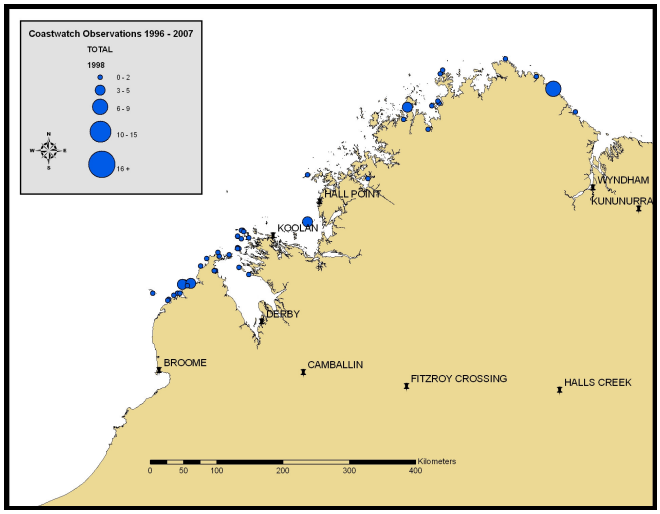

Figure 6c: Coastwatch observations for the year 1998.

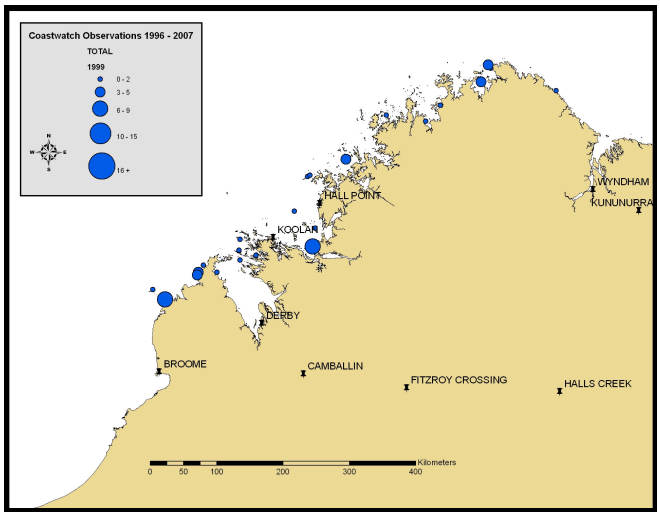

Figure 6d: Coastwatch observations for the year 1999.

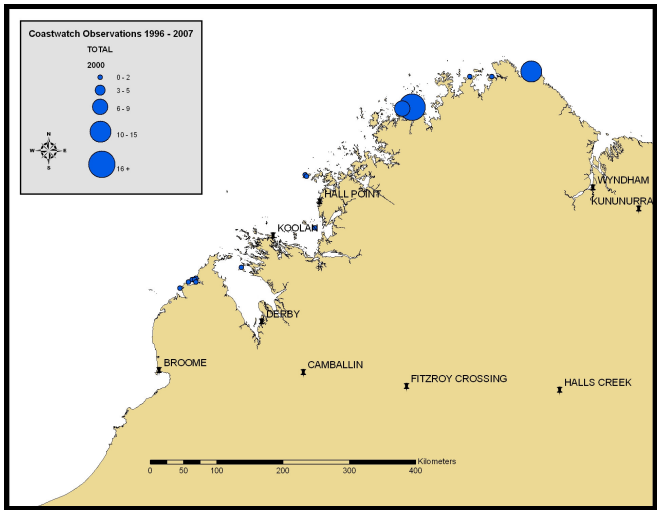

Figure 6e: Coastwatch observations for the year 2000.

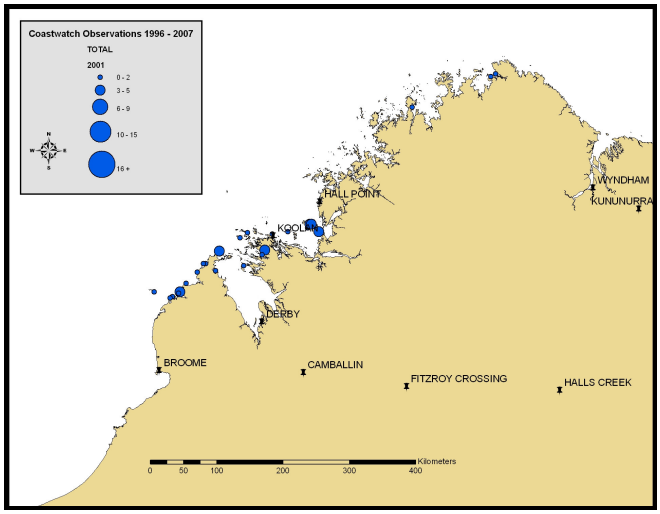

Figure 6f: Coastwatch observations for the year 2001.

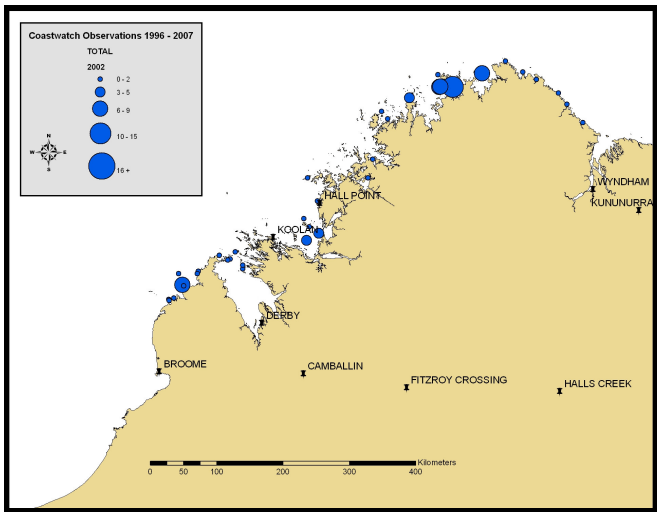

Figure 6g: Coastwatch observations for the year 2002.

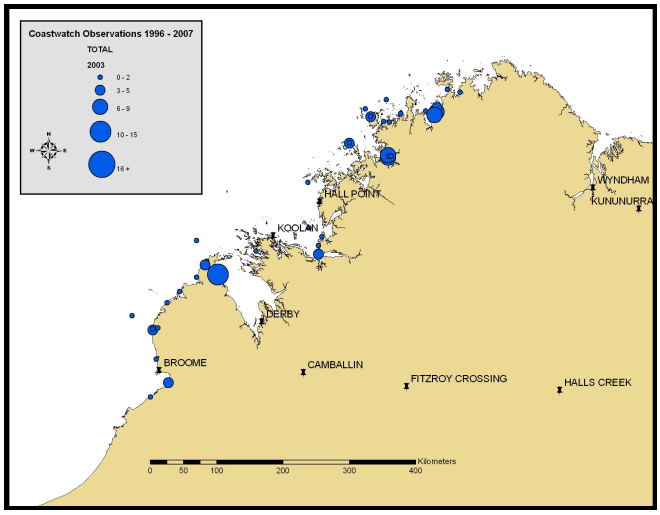

Figure 6h: Coastwatch observations for the year 2003.

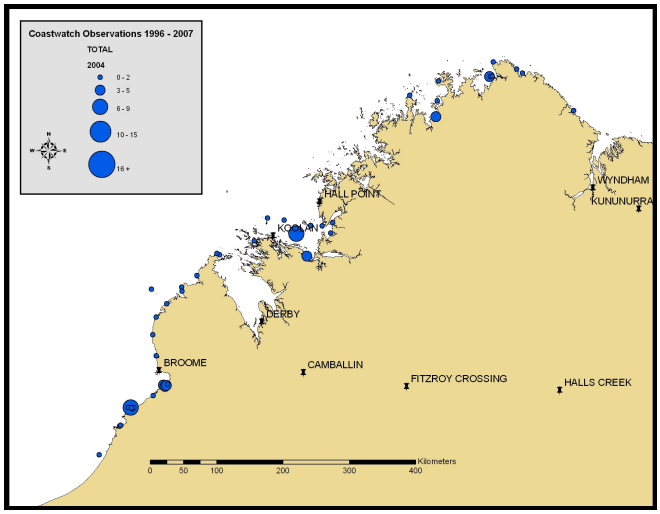

Figure 6i: Coastwatch observations for the year 2004.

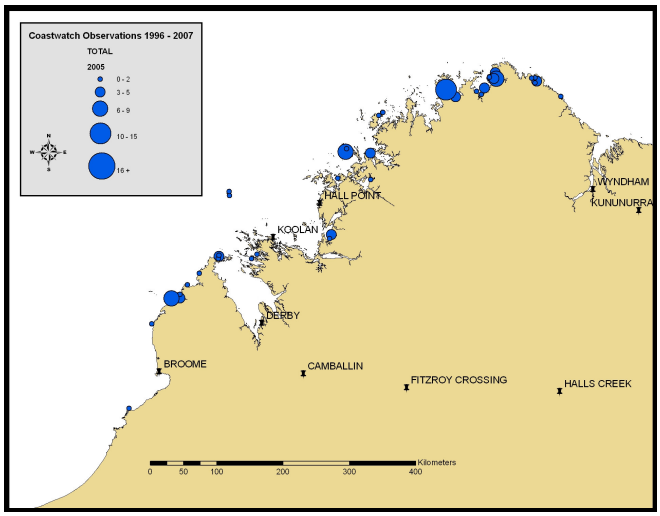

Figure 6j: Coastwatch observations for the year 2005.

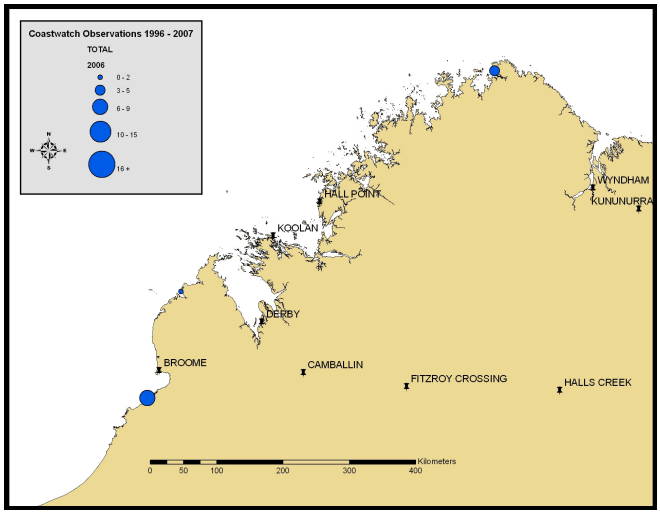

Figure 6k: Coastwatch observations for the year 2006

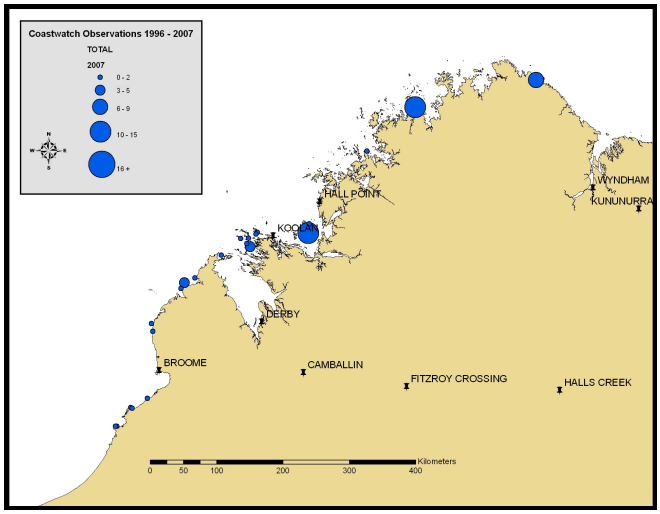

Figure 6l: Coastwatch observations for the year 2007.

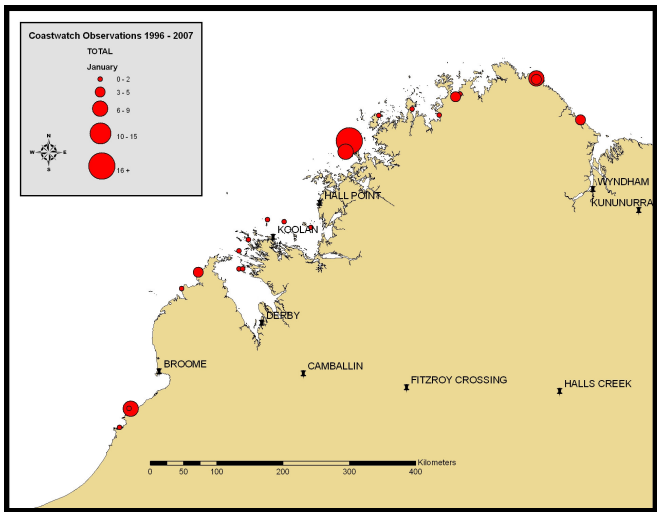

Figure 7a: Pooled 1997-2007Coastwatch observations for the month of January.

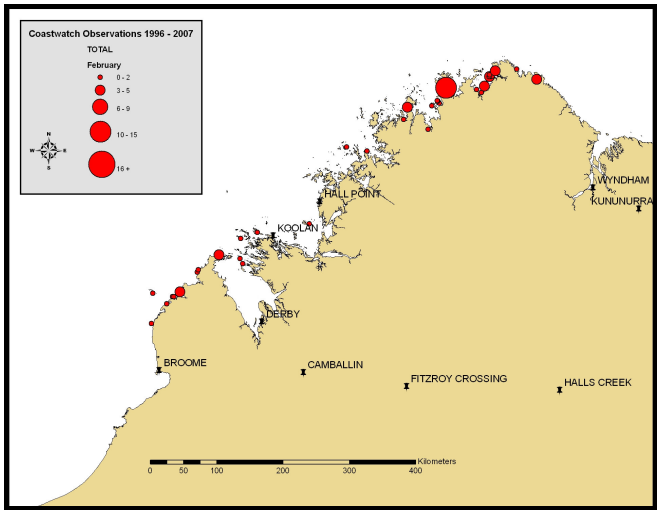

Figure 7b: Pooled 1997-2007Coastwatch observations for the month of February.

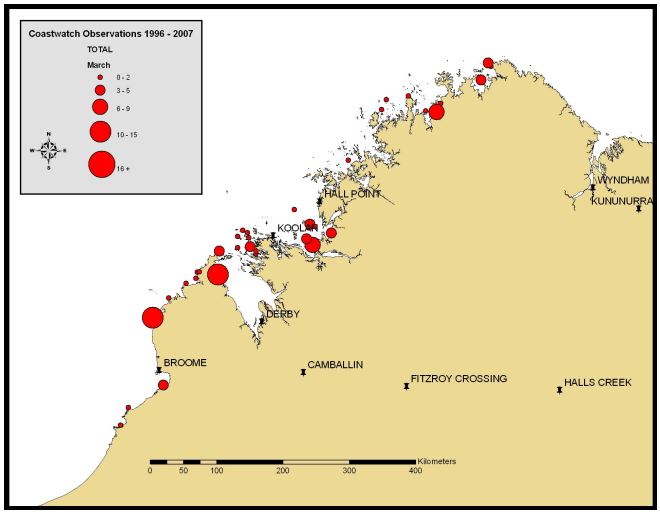

Figure 7c: Pooled 1997-2007Coastwatch observations for the month of March.

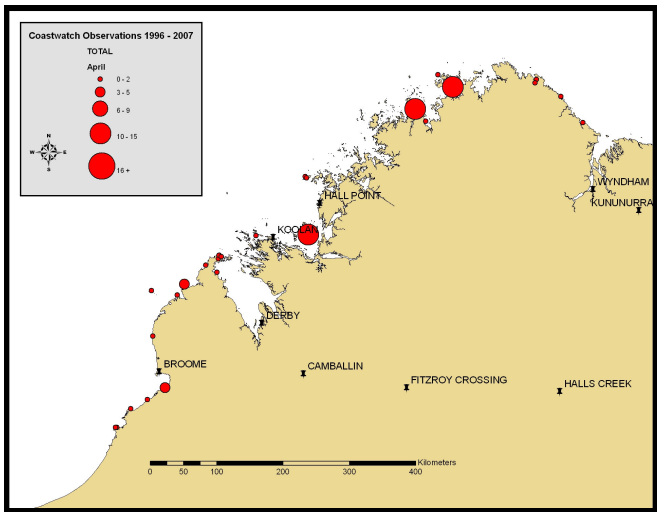

Figure 7d: Pooled 1997-2007Coastwatch observations for the month of April.

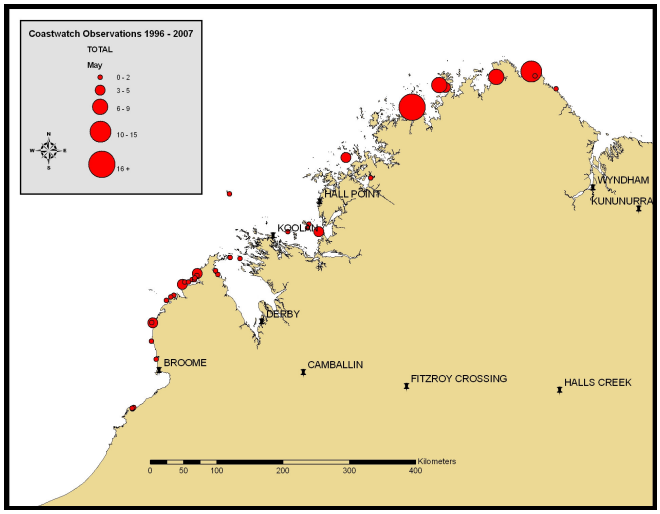

Figure 7e: Pooled 1997-2007Coastwatch observations for the month of May.

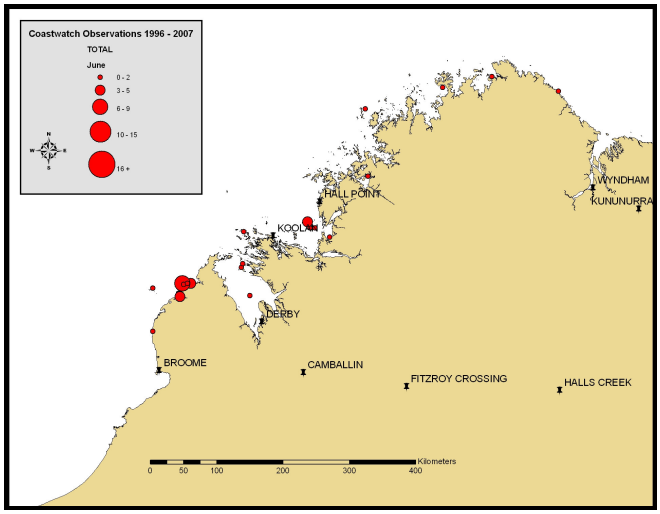

Figure 7f: Pooled 1997-2007Coastwatch observations for the month of June.

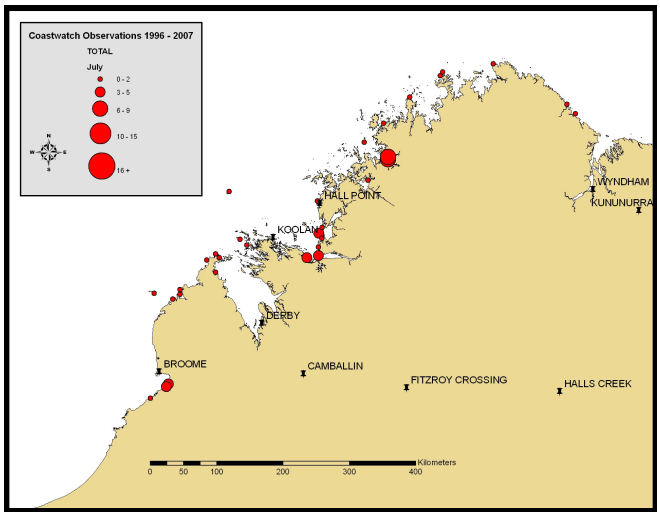

Figure 7g: Pooled 1997-2007Coastwatch observations for the month of July.

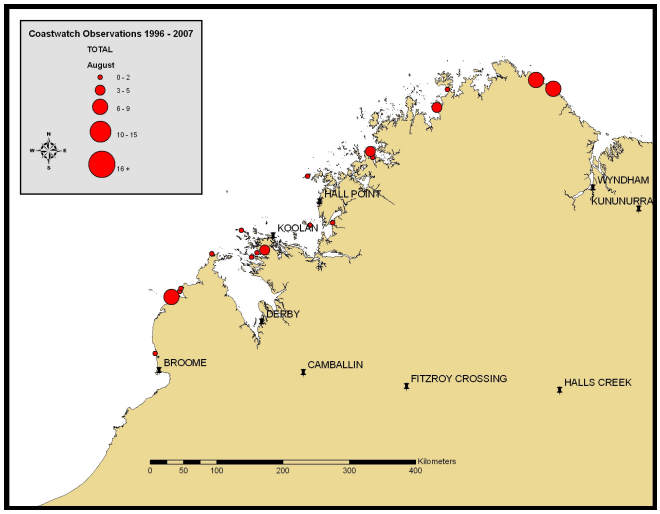

Figure 7h: Pooled 1997-2007Coastwatch observations for the month of August.

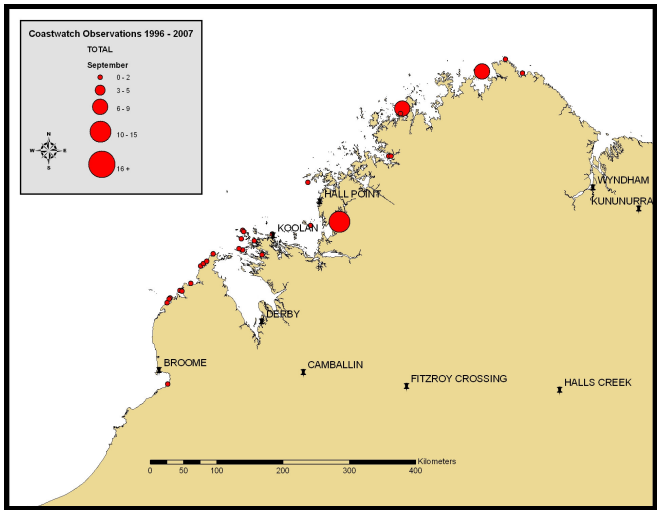

Figure 7i: Pooled 1997-2007Coastwatch observations for the month of September.

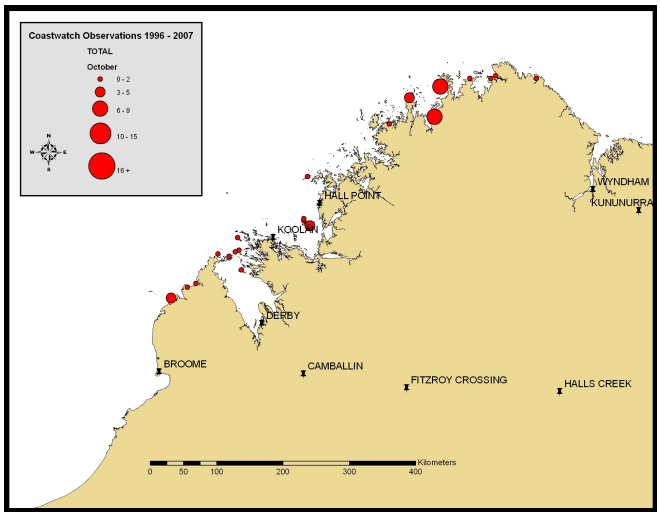

Figure 7j: Pooled 1997-2007Coastwatch observations for the month of October.

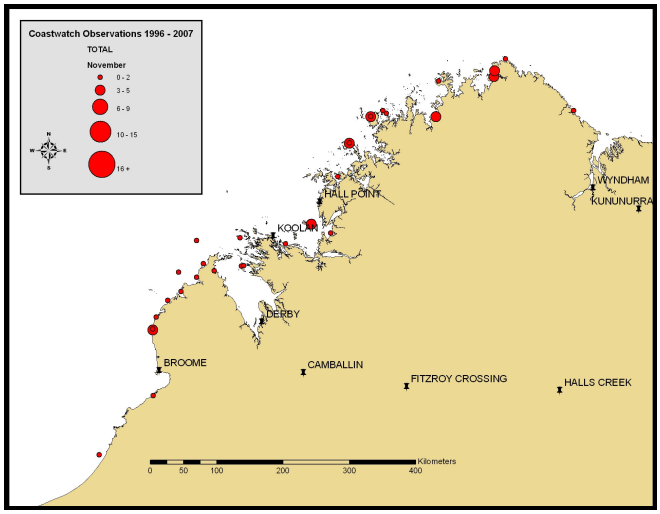

Figure 7k: Pooled 1997-2007Coastwatch observations for the month of November.

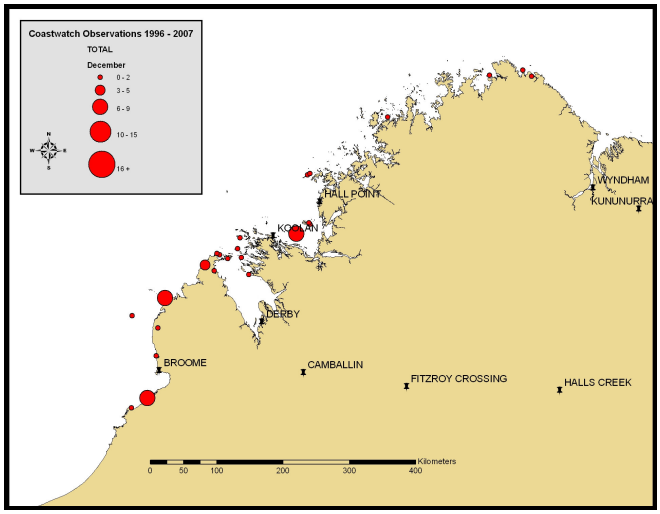

Figure 7l: Pooled 1997-2007Coastwatch observations for the month of December.

CONCLUSION AND RECOMMENDATIONS

Although limited in providing abundance estimates these datasets provide a valuable framework for the development of additional aerial surveys and tracking studies to best determine the spatial and temporal distribution of dugongs throughout the Kimberley. This region represents the only remaining area within Australia that has a large population of dugongs with no quantitative estimates available.

The undertaking of aerial surveys for dugongs of the region using methodology developed by Marsh and Sinclair (1989) and Pollock et al. (2006) as used throughout Australia including Shark Bay and the Pilbara regions should be seen as a necessary first step. Conducting these surveys with proven methodologies would, by providing an abundance estimate and distribution pattern for the region, fulfil a number of requirements at both a State and National level through the provision of data for;

- assessment of development applications and proposals,
- providing a baseline value for determining sustainable hunting levels,
- the development and undertaking of tracking studies to define movements habitat structure and usage,
- completing the picture in terms of a national abundance estimate and distribution guide and;
- provide an estimate of other large marine vertebrate populations.

The conduct of these surveys would be a large undertaking and would possibly require the concurrent use of at least 2 survey teams to cover not only that area as surveyed during 1985, but the entire region east to the Northern Territory border (Fig 1). These surveys would need to be timed to occur during the northern Australian dry season on neap tides, and seek to include members of the local Indigenous communities as observers.

REFERENCES

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., & Thomas, L. (2005) Introduction to distance sampling: Estimating abundance of biological populations. Oxford University Press, Oxford, UK.

Department of Environment and Conservation (2007) Dugong (*Dugong dugon*) Management Program for Western Australia 2007 – 2016.

Gales, N. J., McCauley, R. D., Lanyon, J. M. & Holley, D. K. (2004). Change in abundance of dugongs in Shark Bay, Ningaloo and Exmouth Gulf, Western Australia: evidence for large scale migration. *Wildlife Research*, 31, 283-290.

Hodgson, A.J. (2007) The distribution, abundance and conservation of dugongs and other marine megafauna in Shark Bay Marine Park, Ningaloo Marine Park and Exmouth Gulf. Report to Department of Environment and Conservation.

Holley, D. K., Lawler, I. R. & Gales, N. J. (2006). Summer survey of dugong distribution and abundance in Shark Bay reveals additional key habitat area. *Wildlife Research*, 33, 243-250.

Marsh, H. & Sinclair, D.F. (1989). Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. *Journal of Wildlife Management*. **53**(4): 1017-1024.

Marsh, H., Prince, R. I. T., Saalfeld, W. K. & Shepherd, R. (1994). The distribution and abundance of the dugong in Shark Bay, Western Australia. *Wildlife Research*, 21, 149-161.

Marsh, H., Eros, C., Corkeron, P., and Breen, B. (1999). A conservation strategy for dugongs: implications of Australian research. *Marine Freshwater Research* **50**: 979-90.

Marsh, H., Penrose, H., Eros, C., and Hughes, J. (2002). Dugong: Status Report and Action Plans for Countries and Territories. UNEP: 164pp

Mustoe, S., and Edmunds, M. (2008) Coastal and marine natural values of the Kimberley. WWF, Sydney, Australia.

Pollock K, Marsh H, Lawler I, and Alldredge M. (2006). Modelling availability and perception processes for strip and line transects: an application to dugong aerial surveys. *Journal of Wildlife Management* **70**:255-262.

Preen, A. R., Marsh, H., Lawler, I. R., Prince, R. I. T. & Shepherd, R. (1997). Distribution and abundance of dugongs, turtles, dolphins and other megafauna in Shark Bay, Ningaloo Reef and Exmouth Gulf, Western Australia. *Wildlife Research*, 24, 185-208.

Prince, R.I.T. (1986) Dugong in Northern Waters of Western Australia – 1984. Department of Conservation and Land Management Western Australia Technical Report No.7. vi +38pp. (Dept. Cons. Land Management : Perth)

Prince, R.I.T., I.R. Lawler and H.D. Marsh. (2001). The distribution and abundance of dugongs and other megavertebrates in Western Australian coastal waters extending seaward to the 20m isobath between North West Cape and the DeGrey river mouth, Western Australia, April 2000. Report for Environment Australia.