

**MARINE MANAGEMENT SUPPORT:
SHARK BAY**

**SUMMER DISTRIBUTION AND ABUNDANCE OF SHARK BAY
DUGONGS**

Data Report: MMS/SBY/SBA – 61/2002

A collaborative project between CALM Marine Conservation Branch, CALM Shark Bay District and
James Cook University

A project funded through
Shark Bay World Heritage Area
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ACKNOWLEDGEMENTS

CALM Collaboration

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- Kevin Crane Marine Operations Officer, Shark Bay District.
- Cheryl Cowell Project Officer World Heritage
- Phil Kindleysides Map presentation - Marine Conservation Branch

External Collaboration

- Dr Ivan Lawler Dugong ecologist - James Cook University.
- Dr Nick Gales Australian Antarctic Division

Funding and Resources.

- Funding for this project was obtained through Commonwealth World Heritage Funding.
- The Department of Conservation and Land Management's Marine Conservation Branch, Wildlife Branch and Shark Bay District have provided additional funding and resources.

SUMMARY

This data report presents the results of the first comprehensive summer aerial survey, conducted during February 2002, to determine dugong abundance and distribution in the Shark Bay World Heritage Property. Along with dugongs the survey also recorded the distribution of other megafauna, such as cetaceans and turtles. The same survey procedures were followed as for previous dugong surveys conducted within the SBWHP during the winters of 1989, 1994 and 1999.

This summer survey was coordinated by the Marine Conservation Branch (MCB) of the Department of Conservation and Land Management (CALM) and conducted in collaboration with James Cook University (JCU) and CALM's Shark Bay District. The Shark Bay World Heritage Management unit of Environment Australia provided funds for the project.

The data collected from this survey will be compared with previous winter surveys in order to gain a clearer understanding of dugong seasonal distribution. Managers of the SBWHP can then apply this information in order to balance the needs of the dugongs against increasing threatening anthropogenic pressures.

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1. INTRODUCTION

1.1 BACKGROUND

A recent status report and action plan for dugongs, produced by the Sirenian Specialist Group (SSG) for the United Nations Environment Program (UNEP), identifies that throughout its historical global range the dugong is represented by relict populations separated by large areas where its numbers have been greatly reduced or where it is already extirpated (Marsh *et al*, 2002). The Shark Bay World Heritage Property, Western Australia, is a location that continues to contain an internationally significant dugong habitat that supports dugongs at higher densities than have been recorded elsewhere.

Using a nationally standardised systematic dugong survey design that provides minimum population estimates and density distribution maps a critical base knowledge of winter distribution patterns and trends in dugong abundance have been developed during the past decade in the Shark Bay World Heritage Property. Further research conducted during this period has indicated that dugongs, due to water temperature fluctuations, are undertaking a seasonal movement pattern within the Bay (Anderson 1986, Marsh *et al* 1994).

An understanding of the summer distribution and abundance of dugongs in Shark Bay is the essential next step in documenting the movements of the animals and determining important habitats. Managers of the Shark Bay World Heritage Property will then be better able to balance the needs of the dugongs against the increasing threatening processes of aquaculture, eco-tourism, hunting, mineral and oil exploration, fishing etc. Aquaculture in particular is a rapidly increasing industry in Shark Bay and lease applications are currently being assessed with limited understanding of the relevance of these areas for dugongs.

1.2 GENERAL

Within the Shark Bay Marine Reserves Management Plan (1996 – 2006) a number of research priorities have been identified for the management of dugongs within the Shark Bay World Heritage property. Of high importance is the need for an aerial survey to ascertain dugong distribution and population estimates within the summer months. Previous surveys have been conducted during the respective winters of 1989, 1994, and 1999 (Marsh, 1994; Preen, 1997, Gales, unpublished data). Whilst dugong distribution is known to be affected by water temperature and forage availability, factors affecting seasonal movements of dugongs within the Shark Bay World Heritage Property are not well understood. This project is the first comprehensive survey of dugong abundance and distribution in Shark Bay during summer and followed established methods for the conduct dugong aerial surveys.

By documenting full summer and winter distribution patterns of dugongs, habitats important to dugongs can be identified and this information will provide a focus for management of the dugongs and their habitat. The project has important and direct links to the concurrent investigation, “Movements and Community based Conservation of Shark Bay Dugongs”, under funding from Natural Heritage Trust, Coast and Clean Seas, Marine Species Protection Program, Project Number: 28624.

The survey was a collaborative project between the Department of Conservation and Land Management (CALM) and James Cook University (JCU) and was coordinated within the research portfolio of the management support section of Marine Conservation Branch (MCB) of CALM. (Section Coordinator Nick D’Adamo). The Field Team Leader for this survey was Dave Holley, Marine Fauna Zoologist MCB. Dr Ivan Lawler of JCU undertook leadership of the observation component of this project. Dr Lawler has substantial experience in the conduct of dugong aerial surveys both in Queensland and Western Australia.

1.3 OBJECTIVES

The objectives of the project as set out in the project application were to:

- Provide a precise minimum population estimate for dugongs within the Shark Bay World Heritage Property during summer.
- Obtain a reliable index of the relative density of dugongs, in various parts of Shark Bay to compare with results of previous surveys.
- To determine dugong group sizes.
- To record sightings and plot the distribution of other large animals (e.g. cetaceans, turtles).

Within this framework this report will:

1. Outline methodology for the conduct of this survey.
2. Report on the data correction techniques.
3. Present combined raw and corrected data on dugong, turtle and cetacean density and abundance within the SBWHP during February 2002.
4. Map the distribution of the various species observed within the survey period.

2. METHODOLOGY

3.1 STUDY AREA

Shark Bay is located on the western most point of the Australian coast between latitudes 24° 35'00" and 27° 00'00" (Figure 1). It is a large (13 000km²), shallow (mainly <15m) basin with restricted oceanic exchange and high rates of evaporation (Walker *et al.* 1988). The bay is located near the northern limit of a transition region between temperate and tropical marine flora and fauna (CALM, 1996). Of the 12 species of seagrass found in the bay, several species are of essentially southern distribution, at the northern limit of their range, as well as species of tropical affinity (Walker *et al.* 1988).

Dugongs within the bay are at the Southern limit of their range on the WA coast and approximate the southward limit of large dugong concentrations on the eastern Australian coast at Moreton Bay (Anderson 1982). With a semi-arid to arid climate conditions, the summer months in Shark Bay are generally less than favourable. Average maximum daily temperatures during summer are 35°C, while southerly winds commonly blow for extended periods at over 25km/hr during this time of the year (CALM 1996).

3.2 AERIAL SURVEY

The survey was conducted during the period of the 4th to 15th February 2002, from a Partenavia 68B aircraft equipped with aviation-approved pseudo wing-struts (false struts, fitted with markers). Flights were conducted during good weather (Beaufort sea state ≤ 3) and at times that minimised glare. Flying times were limited to a maximum of approximately 3 hrs (based on fuel capacity and mass of aircraft load). When weather conditions permitted, three flights were conducted each day. The survey altitude was 137 m (450 ft) flown at 185 km hr⁻¹ (100 knots). The pseudo wing struts were fitted with two horizontal fibreglass rods that were pre-positioned to delineate a 200 m wide transect on the water surface for the observers at the survey altitude.

For comparison with previous surveys within Shark Bay this survey was flown following the same strip transect design. Shark Bay was divided into eight blocks for estimation of regional densities. Within these blocks a series of east west orientated transects set every 2.5' of latitude (4.63 km) apart (Figures 2-5) were flown.

Four observers (counters) were used, two fore and aft of each other on the port side of the aircraft and two similarly seated on the starboard side. The two rear-seat observers (port and starboard) were visually and acoustically screened from the mid-seat observers (but not each other) to ensure independence of observations. A simple coded, verbal recording system was utilised to standardise the observations. Recorded observations included the number of dugongs, turtles and cetaceans seen, where with respect to the aircraft's track the observation was made (high, middle or low), whether the animal was at the surface or not, and if any calves were observed.

The observations of the port and starboard rear-seat observers were mixed and recorded onto one track of a two-track tape recorder, the observations of the mid seat observers were recorded onto the second track of the tape recorder. Observations of the mid-seat observers were also entered by the survey leader (seated in the starboard forward seat next to the pilot) onto a palm-top computer (Hewlett Packard HP 200LX) using a DOS based program. Each evening the computer records were checked and reconciled with taped data.

3.3 DATA CORRECTION

To obtain a precise minimum population estimate, the actual numbers of animals observed are corrected to account for differences between each individual observer and for variations in water clarity. Termed perception-bias correction and availability correction factors respectively, these equations account for animals that may have been missed during the survey. All equations used in the correction of raw data are presented in Marsh and Sinclair (1989).

From the data, perception-bias correction factors could be determined by comparing separate observers on each side of the aircraft. This correction factor is derived by comparing sightings made by both port or starboard observers but which were missed by one observer (Marsh and Sinclair 1989).

Availability correction factors were calculated to determine the proportion of dugongs that were submerged and not visible at the time the aircraft passed overhead (Marsh and Sinclair 1989). The calculation is based upon a comparison of the proportion of dugongs recorded at the surface to below the surface during this survey, with the proportion of dugongs recorded at the surface (via vertical aerial photography) with those below water, for dugong feeding in shallow clear water in

Morton Bay Queensland (when both submerged and surface animals were unambiguously visible).

The availability correction factor was derived using all available data per respective survey, by calculating separately for the port and starboard sides.

3.4 MAPPING

Maps were produced illustrating megafauna distribution in relation to blocks and transect using ArcView 3.2 (ESRI) software.

Detailed descriptions of methods used in mapping are provided in the metadata statement (see Appendices 1-3).

4 RESULTS

The locations for all mega fauna sightings and dugong density plots along each transect are presented in a series of maps (figures 2-5). Table 1 presents corrected data on total estimated number of dugongs within each survey block and calculated population density within each block and throughout entire survey area. Table 2 presents the correction factors, mean group size and observed numbers for all mega fauna. All raw and corrected data of each sighting for all species are stored on CD and held in CALM\MCB\MIS CD library.

Notable results in the data include:

- The total estimated dugong population for the Shark Bay World Heritage Property during February 2002 was 11021 ± 1357 (se).
- Mean dugong group size was 1.22.
- Calves made up 3.6% of the total observed dugong population.
- Dugong density was highest in blocks zero and three at 2.17 and 1.84 dugongs km^{-2} .
- Overall dugong density within the SBWHP was calculated at 0.81 dugongs km^{-2} .
- The total estimated numbers of cetaceans was $10,085 \pm 1098$.
- The majority of identified cetaceans were the bottlenose dolphin (*Tursiops truncatus*). Two small pods of Byrde's whales (*Balaenoptera edeni*) were also identified.
- The total estimated turtle population was $22,296 \pm 1859$. This is a combined estimate for green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles.

Table 1. Block areas and estimated numbers of dugongs in the SBWHP in February 2002.

BLOCK	AREA (km²)	DENSITY (km²)	ESTIMATED NUMBERS
0	1198	2.17	2595.39
1	1160	0.88	1023.18
2	1631	0.31	504.7
3	2388	1.84	4403.85
4	2726	0.59	1626.53
5	812	0.34	278.11
6	2243	0.29	668.52
7	2747	0.35	969.62
Total	14905	0.81	12069.9

Table 2. Estimates of group size and correction factors for all species during February 2002.

	SPECIES		
	DUGONGS	CETACEANS	TURTLES
Total Animals Observed	371	257	604
Mean Group Size	1.22	1.60	1.16
Availability Correction Factor	2.39	3.55	1.81
Starboard Per. Correction Factor	1.03	1.11	1.10
Port Per. Correction Factor	1.07	1.09	1.11

5 METADATA

Metadata statements associated with the recorded distribution of dugongs, cetaceans and turtles within the survey are presented in Appendix I - III.

6 DATA MANAGEMENT

Hard copies of this report will be held at four locations:

1. Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle Western Australia, 6160. Ph (08) 9336 0121
Fax: (08) 9430 5408.
2. Woodvale Library, Science and Information Division, Ocean Reef Rd., Woodvale, Western Australia, 6026. Ph: (08) 9405 5100 Fax (08) 9306 1641.
3. Archives, Woodvale Library, Science and Information Division, Ocean Reef Rd., Woodvale, Western Australia, 6026. Ph: (08) 9405 5100 Fax: (08) 9306 1641.
4. Shark Bay District, Department of Conservation and Land Management, Knight Terrace, Denham. WA 6537. Ph: (08) 9948 1208 Fax: (08) 9948 1024.

The Marine Conservation Branch will hold digital copies of this report at the following:

1. The Marine Conservation Branch Server:
Shareddata on 'Calm-frem-1' [T:\144-Marine Conservation Branch\Shared Data\Current_MCB_reports\MMS\mms_6102]
2. MCB Server full backup DAT tape:
[T:\144-Marine Conservation Branch\Shared Data\Current_MCB_reports\MMS\mms_6102]
3. CD_ROM held at Marine Conservation Branch and Archives (Woodvale Library, Science and Information Division): [MMS_6102]

7 REFERENCES

- Anderson, P.K. (1982) "Studies of dugongs at Shark Bay, Western Australia I. Analysis of Population size, composition and habitat use on the basis of aerial survey." Wildlife Research **9**: 69-84
- Holley, D. (2002) Summer distribution and abundance of Shark Bay dugongs. February 2002. Field Program Report: MMS/SBY/SBA – 54/2002. Marine Conservation Branch, Department of Conservation and Land Management, Perth, Western Australia. (Unpublished report).
- Department of Conservation and land Management (1996). "Shark Bay Marine Reserves - Management Plan 1996-2006".Perth, National Parks and Nature Conservation Authority: 100pp.
- Marsh, H., Prince, R.I.T., Saalfeld, W.K., and Shepherd, R. (1994). "The distribution and abundance of the dugong in Shark Bay, Western Australia." Wildlife Research **21**: 149-161.
- Marsh, H. and D. F. Sinclair (1989). "Correcting for visibility bias in strip transect aerial surveys of aquatic fauna." Journal of Wildlife Management. **53**(4): 1017-1024.
- Preen, A. R., Marsh, H., Lawler, I.R., Prince, R.I.T., and 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.
- Walker, D. I. and A. J. McComb (1988). "Seasonal variation in the production, biomass and nutrient status of *Amphibolis antarctica* and *Posidonia australis* in Shark Bay, Western Australia." Aquatic Botany **31**: 259-275.

FIGURES

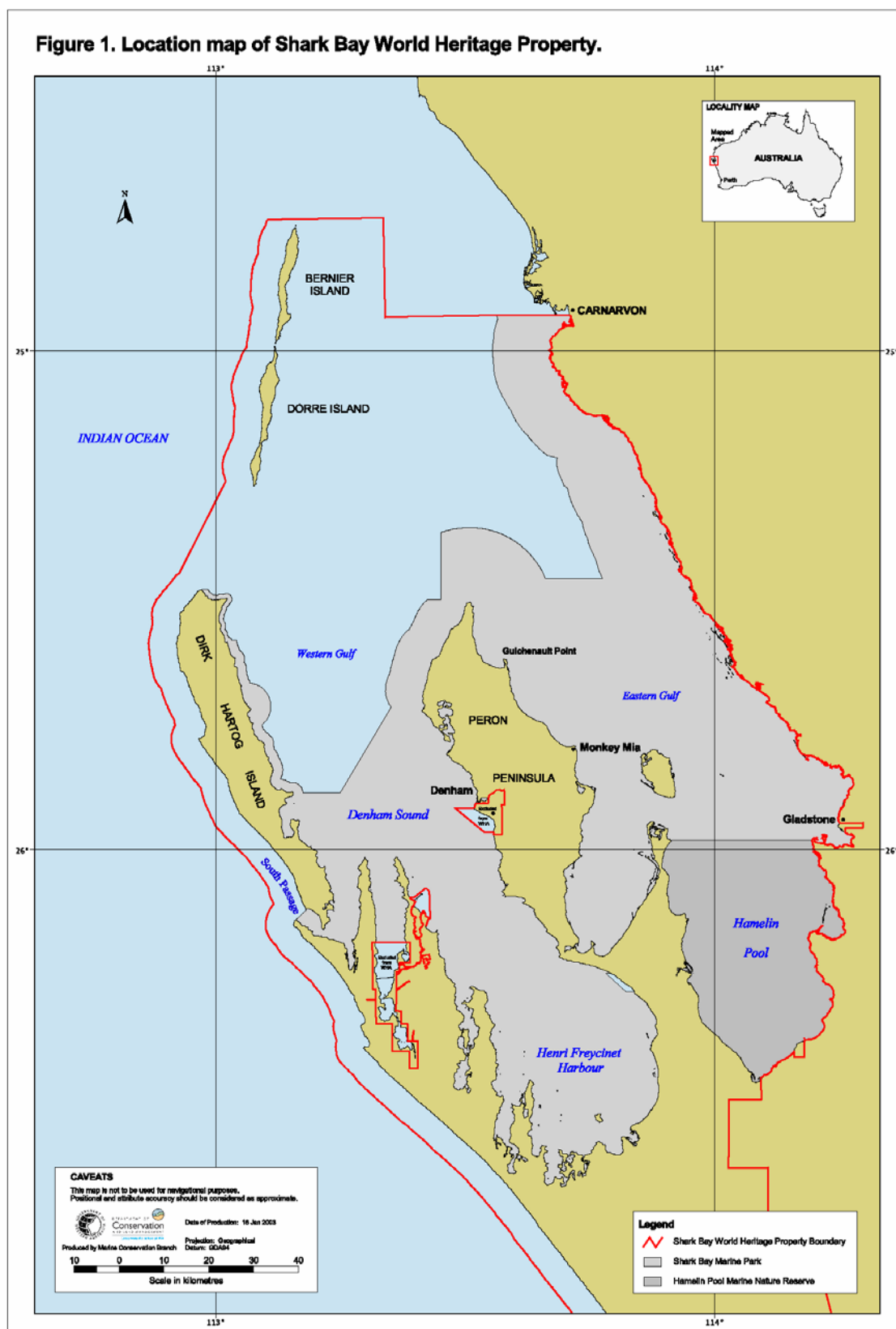


Figure 1. Location map of the Shark Bay World Heritage Property.

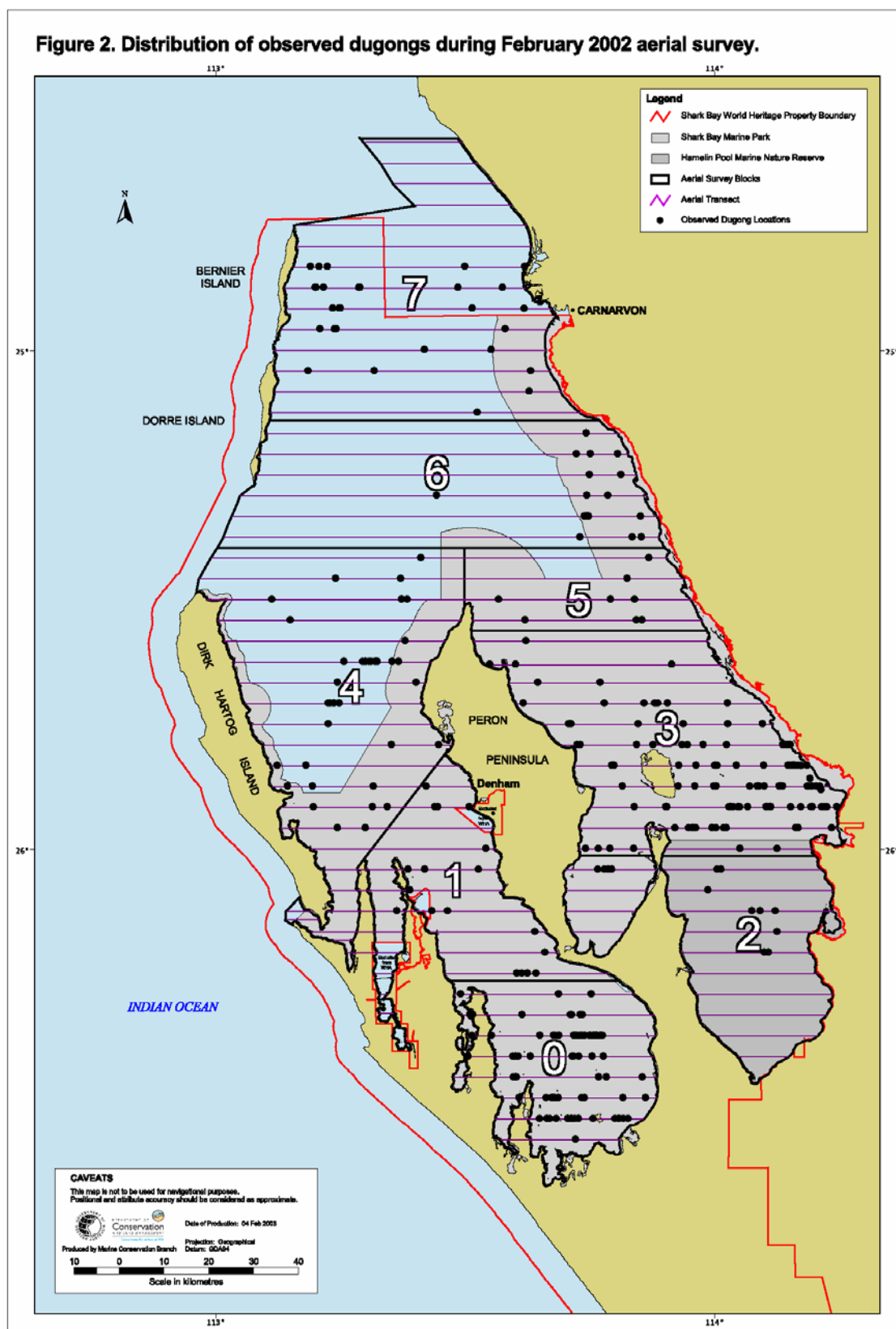


Figure 2. Distribution of observed dugongs during February 2022 aerial survey.

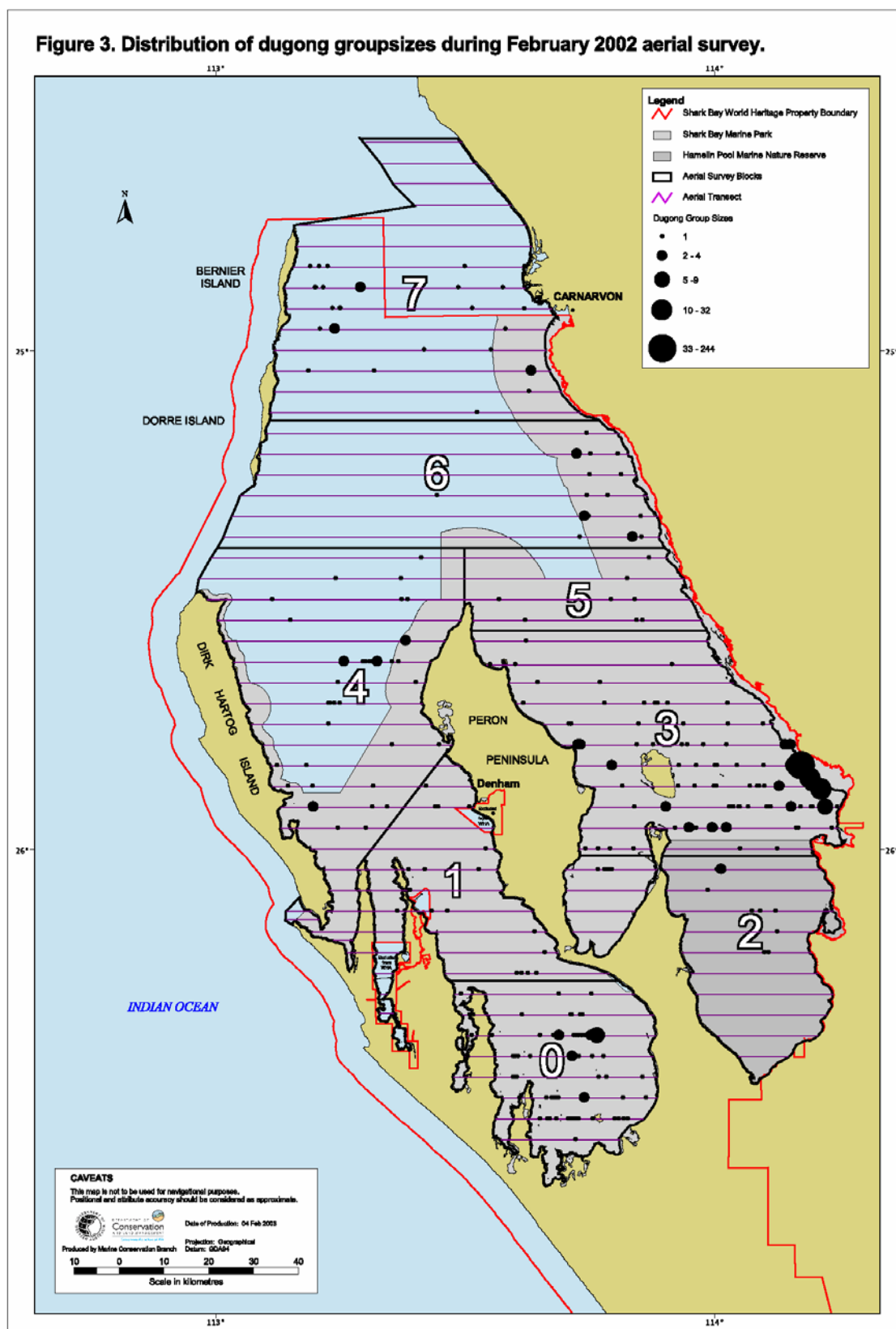


Figure 3. Distribution of dugong group sizes during February 2002 aerial survey.

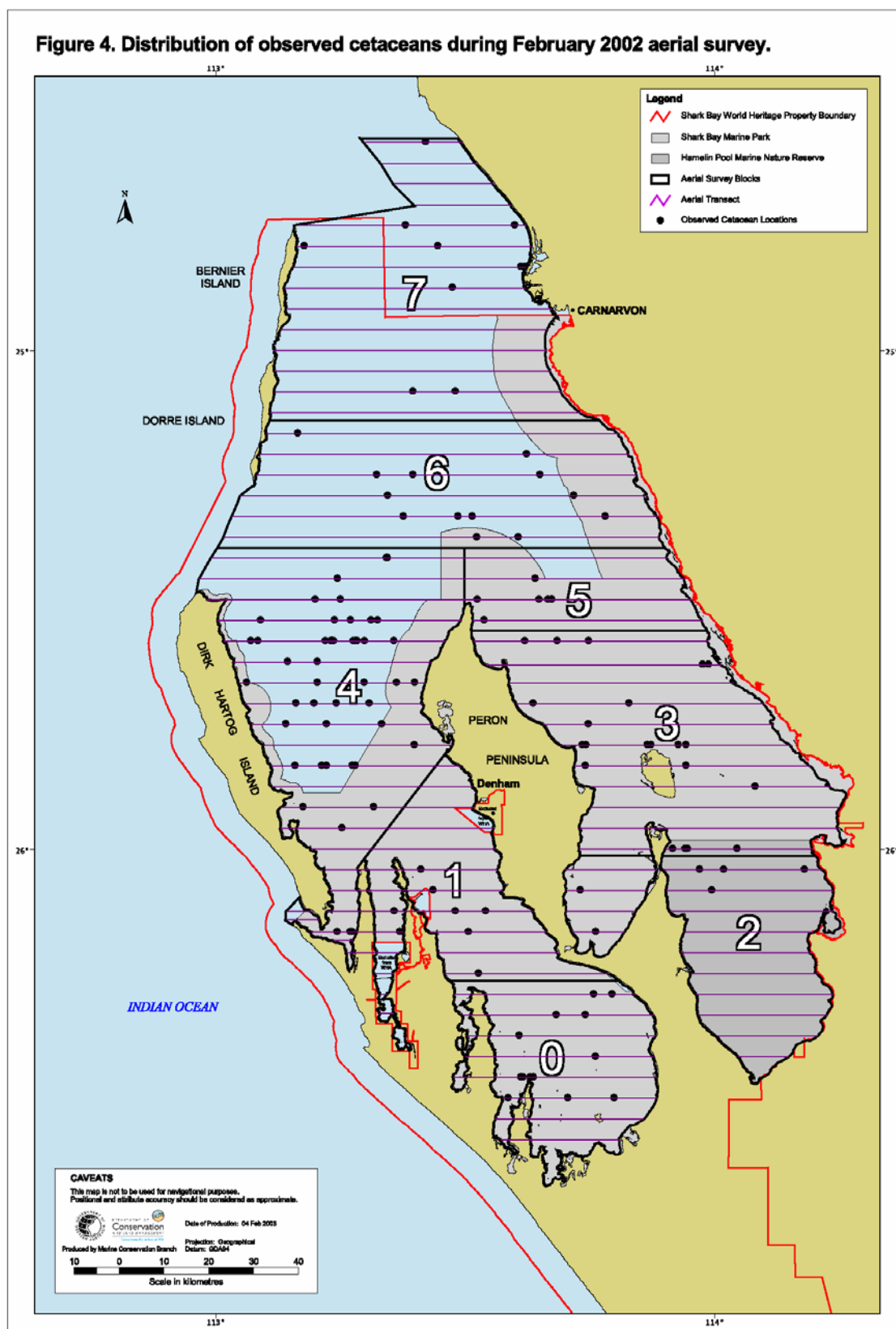


Figure 4. Distribution of observed cetaceans during February 2002 aerial survey.

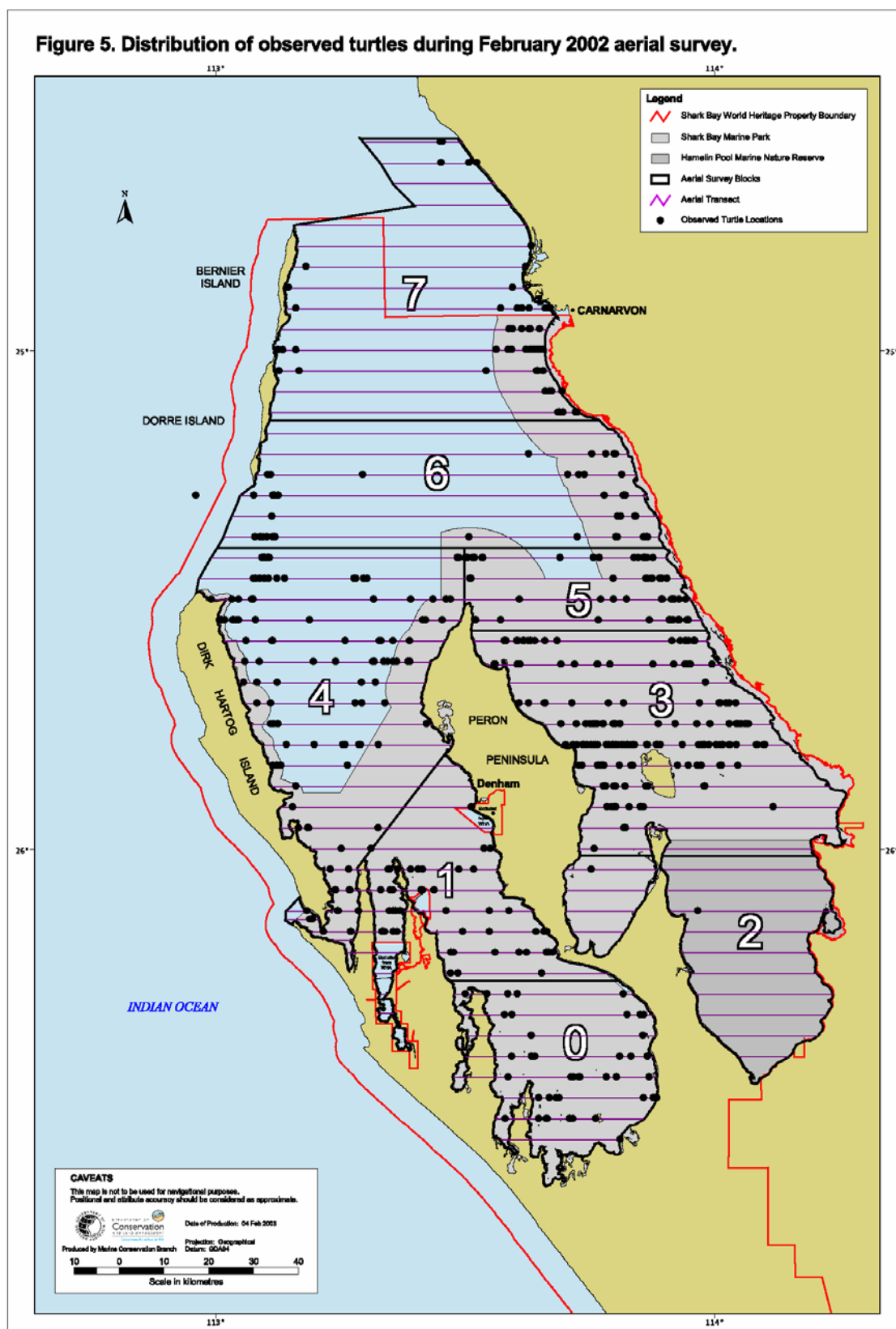


Figure 5. Distribution of observed turtles during February 2002 aerial survey.

APPENDICES

APPENDIX 1 – Metadata for Observed Megafauna during 2002 SBWHP Aerial Survey.

DATASET	
Title	<i>Summer Distribution and Abundance of Megafauna in the Shark Bay Region</i>
Custodian	<i>Department of Conservation and Land Management (CALM)</i>
Jurisdiction	<i>Western Australia</i>
DESCRIPTION	
Abstract	<p><i>This dataset consists of points representing the distribution of megafauna as observed during an aerial survey conducted within the Shark Bay World Heritage Property during February 2002. The data was generated as part of a summer distributional aerial survey conducted to supplement a series of winter surveys conducted in the SBWHP to determine population abundance and distribution of dugongs. A full description of the procedures used for the collection of sightings can be found in:</i></p> <p><i>Marsh, H., and Sinclair, D.F. (1989a). An experimental evaluation of dugong and sea turtle aerial survey techniques. Australian Wildlife Research 16, 639-50.</i></p> <p><i>Marsh, H., and Sinclair, D.F. (1989b). Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. Journal of Wildlife Management 53, 1017-2.</i></p> <p><i>This data was acquired as part of the dugong monitoring program for the management of the Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve. In addition to recording of dugong sightings, sightings of cetaceans and turtles were also recorded.</i></p>
Search Word(s)	<i>Shark Bay World Heritage Property, aerial surveys, dugongs, cetaceans, turtles.</i>
Geographic Extent Name(s)	<i>Shark Bay (SBY) and Zuytdorp (ZUY) IMCRA Regions</i>
DATA CURRENCY	
Begin Date	<i>4/2/2002</i>
End Date	<i>15/2/2002</i>

DATASET STATUS	
Progress	<i>Completed</i>
Maintenance & Update Frequency	<i>As required</i>
ACCESS	
Stored Data Format	<i>DIGITAL ArcView shapefile, Geographic, World Geodetic System 1984 (WGS84). Allfauna_02_wgs84.shp</i> <i>NONDIGITAL Paper base maps showing sighting locations.</i>
Available Format Type	<i>DIGITAL ArcView 3.2 shapefile</i>
Access Constraint	<i>Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.</i>
DATA QUALITY	
Lineage	<ol style="list-style-type: none"> <i>1. Location data for all sightings of megafauna observed during the 2002 summer aerial survey of Shark Bay World Heritage Property recorded as waypoints within aircrafts GPS system in the datum WGS84.</i> <i>2. Combined location data for all megafauna over entire survey period entered into Excel, then imported into ArcView 3.2 and converted to shapefiles representing dugongs, cetaceans and turtles.</i> <i>3. Existing polyline and polygon shapefiles representing transects and survey blocks (See additional metadata) were imported into each active theme and sightings of all megafauna overlaid.</i>
Positional Accuracy	<i>The locations of all sightings as recorded from this survey represent the summer distribution patterns of marine megafauna within the SBWHP. All sightings were recorded from an aircraft flying at a nominal height of 137m and a ground speed of 100 knots along predetermined transects. Observations of animals were recorded if they occurred in relation to transect markers attached to the plane. The equivalent transect width on the water at the flying height is 200m either side of the aircraft. Sighting locations are therefore approximate only and represent an animal's position at during the flight period.</i>
Attribute Accuracy	<i>Methods used in the collection of this dataset are consistent with data collected from previous aerial surveys conducted in the Shark Bay World Heritage Property (See additional metadata). Flight paths were flown as close as possible to marked transects, however turbulence may have resulted in slight variations along each transect.</i>
Logical Consistency	<i>Attribute values have been checked and validated for consistency, and checked for logic in</i>

	<i>relation to attribute names. All attributes that require values have been assigned values. The shapefile has been compiled carefully to avoid overlaps or duplication of points.</i>
Completeness	<i>The dataset is complete as at the date of this metadata statement. The dataset will be upgraded as priorities, time and resources permit.</i>
CONTACT INFORMATION	
Contact Organisation	<i>Department of Conservation and Land Management, Marine Conservation Branch</i>
Contact Position	<i>Marine Zoologist</i>
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Facsimile	<i>08 9430 5408</i>
Electronic Mail Address	<i>davidho@calm.wa.gov.au</i>
METADATA DATE	
Metadata Date	<i>07/03/2002</i>
ADDITIONAL METADATA	
Additional	<i>For further information refer to:</i>

<i>Metadata</i>	<p><i>Marsh, H., and Sinclair, D.F. (1989a). An experimental evaluation of dugong and sea turtle aerial survey techniques. Australian Wildlife Research 16, 639-50.</i></p> <p><i>Marsh, H., and Sinclair, D.F. (1989b). Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. Journal of Wildlife Management 53, 1017-24.</i></p> <p><i>Marsh, H., Prince, R.I.T., Saalfeld, W.K., and Shepherd, R. (1994). "The distribution and abundance of the dugong in Shark Bay, Western Australia." Wildlife Research 21: 149-161</i></p> <p><i>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</i></p>
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APPENDIX 2 – Metadata Statement for 2002 SBWHP Aerial Survey Density Estimation Blocks.

DATASET	
Title	<i>Shark Bay aerial survey blocks.</i>
Custodian	<i>Department of Conservation and Land Management (CALM)</i>
Jurisdiction	<i>Western Australia</i>
DESCRIPTION	
Abstract	<p><i>This dataset consists of a polygon shapefile constructed for use in the estimation of regional densities of dugongs and other megafauna when conducting aerial surveys within the Shark Bay World Heritage Property. The dataset was originally generated by James Cook University when conducting the first standardised aerial survey within the SBWHP in 1989. The dataset has subsequently been used for similar surveys conducted in 1994, 1999 and 2002 to determine population abundance and distribution of dugongs. A full description of the procedures used for the collection of sightings in relation to this dataset can be found in:</i></p> <p><i>Marsh, H., and Sinclair, D.F. (1989a). An experimental evaluation of dugong and sea turtle aerial survey techniques. Australian Wildlife Research 16, 639-50.</i></p> <p><i>Marsh, H., and Sinclair, D.F. (1989b). Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. Journal of Wildlife Management 53, 1017-24.</i></p> <p><i>Marsh, H., R.I.T. Prince, Saalfeld, W.K., and Shepherd, R. (1994). The distribution and abundance of the dugong in Shark Bay, Western Australia. Australian Wildlife Research 21, 149-61.</i></p>
Search Word(s)	<i>Shark Bay World Heritage Property, aerial surveys, density estimation plots.</i>
Geographic Extent Name(s)	<i>Shark Bay (SBY) and Zuytdorp (ZUY) IMCRA Regions</i>
DATA CURRENCY	
Begin Date	<i>June 1989</i>
End Date	<i>15/2/2002</i>
DATASET STATUS	
Progress	<i>Completed</i>
Maintenance	<i>As required</i>

& Update Frequency	
ACCESS	
Stored Data Format	<i>DIGITAL ArcView shapefile, Geographic, World Geodetic System 1984 (WGS84).Block_wgs84.shp</i> <i>NONDIGITAL Paper base maps showing Blocks.</i>
Available Format Type	<i>DIGITAL ArcView 3.2 shapefile</i>
Access Constraint	<i>Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.</i>
DATA QUALITY	
Lineage	<ol style="list-style-type: none"> <i>.The Shark Bay World Heritage Property was divided in eight blocks, estimated from 1:250,000 maps using a digitising tablet.</i> <i>Coordinates for each block were imported into ArcExplorer and converted into a polygon shapefile.</i> <i>Shapefile was then imported into ArcView 3.2 as a polygon shapefile with each block labelled according to block number.</i>
Positional Accuracy	<i>Block boundaries follow existing land boundaries in the datum WGS 84. Due to age of dataset there may be some errors in positioning of blocks.</i>
Attribute Accuracy	<i>Methods used in the collection of this dataset are consistent with data collected from previous aerial surveys conducted in the Shark Bay World Heritage Property (See additional metadata).</i>
Logical Consistency	<i>Attribute values have been checked and validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.</i> <i>The shapefile has been compiled carefully to avoid overlaps or duplication of points.</i>
Completeness	<i>The dataset is complete as at the date of this metadata statement. The dataset will be upgraded as priorities, time and resources permit.</i>
CONTACT INFORMATION	
Contact Organisation	<i>Department of Conservation and Land Management, Marine Conservation Branch</i>
Contact	<i>Marine Zoologist</i>

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State or Locality 2	WA
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Facsimile	08 9430 5408
Electronic Mail Address	davidho@calm.wa.gov.au
METADATA DATE	
Metadata Date	07/03/2002
ADDITIONAL METADATA	
Additional Metadata	<p>For further information refer to:</p> <p>Marsh, H., and Sinclair, D.F. (1989a). An experimental evaluation of dugong and sea turtle aerial survey techniques. <i>Australian Wildlife Research</i> 16, 639-50.</p> <p>Marsh, H., and Sinclair, D.F. (1989b). Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. <i>Journal of Wildlife Management</i> 53, 1017-24.</p> <p>Marsh, H., Prince, R.I.T., Saalfeld, W.K., and Shepherd, R. (1994). "The distribution and abundance of the dugong in Shark Bay, Western Australia." <i>Wildlife Research</i> 21: 149-161</p> <p>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". <i>Wildlife Research</i> 24: 185-208</p>

APPENDIX 3. Metadata Statement for 2002 SBWHP Aerial Survey Flight Transects

DATASET	
Title	<i>Shark Bay aerial survey transects</i>
Custodian	<i>Department of Conservation and Land Management (CALM)</i>
Jurisdiction	<i>Western Australia</i>
DESCRIPTION	
Abstract	<p><i>This dataset consists of a polyline shapefile showing transects which were flown in order to determine population estimates of dugongs and other megafauna within the Shark Bay World Heritage Property. The dataset was originally generated by James Cook University when conducting the first standardised aerial survey within the SBWHP in 1989. The dataset has subsequently been used for similar surveys conducted in 1994, 1999 and 2002 to determine population abundance and distribution of dugongs. A full description of the procedures used for the collection of sightings in relation to this dataset can be found in:</i></p> <p><i>Marsh, H., and Sinclair, D.F. (1989a). An experimental evaluation of dugong and sea turtle aerial survey techniques. Australian Wildlife Research 16, 639-50.</i></p> <p><i>Marsh, H., and Sinclair, D.F. (1989b). Correcting for visibility bias in strip transect aerea surveys of aquatic fauna. Journal of Wildlife Management 53, 1017-24.</i></p> <p><i>Marsh, H., R.I.T. Prince, Saalfeld, W.K., and Shepherd, R. (1994). The distribution and abundance of the dugong in Shark Bay, Western Australia. Australian Wildlife Research 21, 149-61.</i></p>
Search Word(s)	<i>Shark Bay World Heritage Property, aerial surveys, transects</i>
Geographic Extent Name(s)	<i>Shark Bay (SBY) and Zuytdorp (ZUY) IMCRA Regions</i>
DATA CURRENCY	
Begin Date	<i>June 1989</i>
End Date	<i>15/2/2002</i>
DATASET STATUS	
Progress	<i>Completed</i>

Maintenance & Update Frequency	<i>As required</i>
ACCESS	
Stored Data Format	<i>DIGITAL ArcView shapefile, Geographic, World Geodetic System 1984 (WGS84). transects_wgs84.shp NONDIGITAL Paper base maps showing Blocks.</i>
Available Format Type	<i>DIGITAL ArcView 3.2 shapefile</i>
Access Constraint	<i>Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.</i>
DATA QUALITY	
Lineage	<ol style="list-style-type: none"> 1. <i>.The Shark Bay World Heritage Property was divided in eight blocks, estimated from 1:250,000 maps using a digitising tablet.</i> 2. <i>Transects were then placed every 2.5' latitude in an east-west orientation within the Shark Bay World Heritage Boundary.</i> 3. <i>A shapefile was then created in ArcExplorer</i> 4. <i>Shapefile was then imported into ArcView 3.2 as a polyline shapefile</i>
Positional Accuracy	<i>Transects are aligned with every 2.5' of latitude.</i>
Attribute Accuracy	<i>Methods used in the collection of this dataset are consistent with data collected from previous aerial surveys conducted in the Shark Bay World Heritage Property (See additional metadata).</i>
Logical Consistency	<i>Attribute values have been checked and validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.</i> <i>The shapefile has been compiled carefully to avoid overlaps or duplication of points.</i>
Completeness	<i>The dataset is complete as at the date of this metadata statement. The dataset will be upgraded as priorities, time and resources permit.</i>
CONTACT INFORMATION	
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METADATA DATE	
Metadata Date	07/03/2002
ADDITIONAL METADATA	
Additional Metadata	<p>Marsh, H., and Sinclair, D.F. (1989a). An experimental evaluation of dugong and sea turtle aerial survey techniques. <i>Australian Wildlife Research</i> 16, 639-50.</p> <p>Marsh, H., and Sinclair, D.F. (1989b). Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. <i>Journal of Wildlife Management</i> 53, 1017-24.</p> <p>Marsh, H., Prince, R.I.T., Saalfeld, W.K., and Shepherd, R. (1994). "The distribution and abundance of the dugong in Shark Bay, Western Australia." <i>Wildlife Research</i> 21: 149-161</p> <p>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". <i>Wildlife Research</i> 24: 185-208</p>