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ENVIRONMENT AUSTRALIA

MARINE SPECIES PROTECTION PROGRAM

FUNDING AGREEMENT
WITH

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT, WA
FOR

AERIAL SURVEY OF THE DISTRIBUTION AND ABUNDANCE OF DUGONGS AND ASSOCIATED MACROVERTEBRATE FAUNA - PILBARA COASTAL AND OFFSHORE REGION, WA

PROGRESS REPORT NO. 3

DR R I T PRINCE

PROJECT MANAGER
CALM

~~NOVEMBER~~ 2000
MAY 2001

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DRAFT

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ON

AERIAL SURVEY OF THE DISTRIBUTION AND ABUNDANCE OF DUGONGS AND ASSOCIATED MACROVERTEBRATE FAUNA - PILBARA COASTAL AND OFFSHORE REGION, WA

Report on the Results of the Survey.

The Distribution and Abundance of Dugongs and Other Megavertebrates in Western Australian Coastal Waters Extending Seaward to the 20 Metre Isobath Between North West Cape and the De Grey River Mouth, Western Australia, April 2000.

R I T PRINCE,
PROJECT MANAGER, WADCALM.
30 November, 2000.

PROGRESS REPORT NO. 3

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The Distribution and Abundance of Dugongs and Other Megavertebrates in Western Australian Coastal Waters Extending Seaward to the 20 Metre Isobath Between North West Cape and the De Grey River Mouth, Western Australia, April 2000.

Introduction

The extensive Western Australian coastline borders relatively shallow tropical and sub-tropical marine waters along approximately half its length, from Shark Bay northwards. It has been shown that the waters of the Shark Bay World Heritage Area, the Ningaloo Reef and Marine Park, and Exmouth Gulf include internationally significant populations of dugongs and sea turtles, and that populations of some of the other larger marine vertebrates, including small and large cetaceans, and whale sharks and manta rays, are also a feature of the regional megafauna (Preen*et al*, 1997).

Preliminary surveys over the coastal waters northward and eastward from North West Cape previously suggested that this area too embraced regionally significant dugong and marine turtle habitats with their associated resident populations plus other members of the megafauna (Prince 1986; Prince, Anderson and Blackman 1981). Considerable progress has since been made in further defining the importance for their dependent sea turtle populations of the regional coastal nesting resource areas, and in linking these with feeding habitats, including those in more remote locations (Prince 1994, 1999, etc).

Similar improvement of knowledge of the regional importance of these north-western Western Australian waters to dugongs and the rest of the megavertebrate fauna as an aid to improving marine conservation prospects and providing further focus on the need for developing better environmental understanding and approaches to management practices by industry based in the area has generally been harder to achieve (Preen 1998). Funds provided to the Western Australian Department of Conservation and Land Management from the Marine Species Protection Program administered by Environment Australia have now enabled work on redressing this deficiency. This report presents the results of the first quantitative aerial survey of dugongs and associated marine megafauna completed in April 2000.

Methods

Study Area

The Western Australian Pilbara offshore waters as mentioned for the purposes of this work extend from North West Cape (*c.* 114°10'E, 21°45'S) northward and eastward up to Poissonier Point on the east side of Breaker Inlet at the mouth of the De Grey River (*c.* 119°15E, 20°S; Figure 1). The coastal geomorphology and habitats to the limits of State waters are generally described in Part I, Section 3.6.5, and dealt with in more detail in Part III, Sections 3.4 through 3.11, of the Report of the Western Australian Marine Parks and Reserves Selection Working Group (CALM 1994). Climatically, the coast is arid, with median precipitation in the range 200-300mm per annum, and open pan evaporation potential in excess of 3000mm per annum. Rainfall is highly variable from year to year, expected over*c.* 20-25 rainy days only. Seasonal incidence grades from uniform around the North West Cape area to summer dominance around the De Grey River. Tropical cyclones crossing the coast over the summer-autumn period usually bring the heaviest rainfalls (Atlas of Australian Resources XX). Some large river systems and numerous smaller watercourses intersect the Pilbara coast. Peak freshwater and sediment discharges into the marine nearshore zone result from extensive run-off from the inland catchments following the heavy rains generated by passage of the tropical cyclones. At most other times, outflow is negligible, with most watercourses drying to chains of pools over the mid-year dry period.

The seaward limit of the coastal waters zone grades into the Rowley Shelf section of theNorth West Shelf Oceanic Province (CALM 1994; Part I, 3.6.6). Off the western Pilbara coast, this transition occurs along and around the chain of limestone islands generally located within the 20m isobath. These islands extend in an arc from North West Cape out to the Barrow Island – Monte Bello Islands area at 115°30'E, 20°20'S, whence the 20m isobath loops back towards the coast, passing eastward of the Lowendal Islands group, and then reflecting to a shore parallel lineament running NE, first passing seaward of the outer Dampier Archipelago islands (Rosemary, Legendre, and Delambre) and thence extending to the eastward end of the study area. Separation from coast to the 20m isobath over this section is generally from x to y km. In total, the study area described covers approximately 23 700 km^2 (Table). The seaward cutoff boundary location along the 20m isobath for the survey area was chosen on several counts – firstly, while dugong feeding trails have been seen elsewhere at depths up to 23m (Lee Long *et al.* 1993), most feeding activity is likely to occur at lesser depths; secondly, the generally subdued inshore bottom slope tends to increase sharply past the 20 m isobath on this coast, suggesting some possible functional ecotone (above, *ibid.*); and, thirdly, the State waters boundary practically coincides with this limit.

Benthic habitats within this study area include: mudflats, intertidal and subtidal sands, rocky shores and wave-cut platforms, limestone pavements, coral and rocky reef, and soft bottom communities (BBG/BHP NW Shelf Resource Atlas 1995).

Exmouth Gulf supports an important long-established prawn trawl fishery, plus further commercial and recreational fisheries. Other prawn trawl, and commercial and recreational fisheries, exploit the waters to the northeast along the main Pilbara coast. There is now an expanding focus on commercial aquaculture within these waters. The whole offshore waters region is also the focus of substantial petroleum exploration and production, with associated offshore and onshore installations, including shipping and processing facilities. There are additional very large port developments associated principally with the iron ore and solar salt industries on the mainland coast (Figure x). Developments to provide a broader industrial base are being planned.

Aerial Surveys

Strip-transect aerial surveys were conducted over the period 7 through 15 April 2000, commencing from Exmouth Gulf, and thence working progressively to termination over the eastern limit of the study area (Figure x+1). Timing of the survey attempt was planned to coincide with the expected occurrence of most favourable light winds on this normally windy coast. Water surface condition is critical to efficient observation.

The primary survey plan was structured to optimize day to day logistics for the operation, due to the limitations on access to suitable operating bases and aircraft duration relative to distances required to be covered when on task. The survey time window chosen also allowed for the best chance of minimizing differences in tidal water movements affecting the particular areas being surveyed while doing the work – the Pilbara coast is subject to semi-diurnal tides, with an April spring tide range of *c.* 2m at Exmouth Gulf increasing to *c.* 6m at Port Hedland, but which latter has a neap tide range of *c.* 2.5m only (National Tidal Facility 2000).

Survey methods followed Marsh and Sinclair (1989a, 1989b), with survey protocols as detailed in Marsh *et al.* (1994) for the first survey of Shark Bay, WA. All transect lines were spaced at 2.5' latitude (4.65km or 2.5nm), and transect lines within survey blocks were generally aligned to intersect the ecological axis of the particular area. Thus, survey lines within the Exmouth Gulf sector were aligned East-West, as before, and for the other previous Western Australian work where the major coastline trend was predominantly North-South (Preen *et al*, 1997). The trend of the coast for the remainder of this Pilbara offshore study area required transect alignments approximately NW – SE to intersect the ecological axes. The consequences for changing sun angles relative to flight paths could not be avoided in this case.

Survey tasks were planned to avoid flying early morning and late afternoon, and during the middle of the day, when glare and below surface light penetration factors would be least favourable for observations, and attempted when expected sea surface conditions would be ≤ Beaufort state 3, and cloud cover <4 oktas. Observations were made at the survey standard operating combination of: altitude 137m, ground speed of 185km h^{-1}, and by pairs of observers independently scanning 200m wide survey strips on each side of the aircraft.

Using a mark-recapture analysis of the survey sightings data for the two members of each observer team, perception-bias correction factors were calculated to compensate for the animals otherwise visible, but not recorded as being seen by the observers (Marsh and Saalfeld 1989). Separate perception-bias correction factors were calculated as necessary for both the port and starboard observer pairs for each of the primary survey target fauna groups, viz., dugongs, marine turtles (turtles), and small cetaceans (dolphins).

Some of the survey target animals present may also be invisible to observers, due to water turbidity or depth of submergence, for instance. Further compensation for this is required in deriving abundance estimates from records of sightings. In contrast with the perception-bias factors, availability correction factors cannot be calculated directly from survey specific data. Required availability correction factors for dugongs on this survey were derived by ....?? Availability correction factors for turtles were ....??, and, for dolphins ....??

Results

Survey Programme

Aerial marine fauna surveys of this type can be completed successfully only where the field programme attempt coincides with timely persistence of the necessarily restrictive required operating conditions. Fortuitously, the Pilbara 2000 survey attempt was completed between the dates 6 and 16 April 2000 - the minimum time practicable for the work using one aircraft, including pilot and survey crew.

Planned timing of the field work fitted our survey within the window found between the diminishing regional flooding after effects attributable to the early March 2000 passage of Tropical Cyclone (TC) Steve along the Western Australian coast, and the subsequent closing out of opportunity mid April 2000, due to the approach of TC Rosita from the north. Premature termination of the survey was narrowly averted when TC Paul, building in the Timor Sea area from 11 April 2000, tracked westward, moving far out into the Indian Ocean.

Exmouth Gulf and Offshore Islands Area

Dugongs

Two dugongs only were seen on transects for this survey, comprising two separate sightings of single adult size dugong (Figure n). The scarcity of dugongs within Exmouth Gulf and offshore within the Exmouth survey block at this time precluded ....../used Pilbara obs for calc? The estimated population was 95 (±62 se) dugong (Table n).

Turtles

Four hundred and fifty-four (454?) turtles were seen on the Exmouth block transects for this survey. The majority of turtles being seen were dispersed sufficiently to be recorded as single individuals, or in small groups of generally less than five individuals, but where turtles were particularly abundant,sequential sightings data were also aggregated by observers before reporting to expedite efficient recording. Thus, the numbers of turtles per group as recorded on task do not necessarily imply any functional behavioural relationship integrating the activities of the turtles being counted. Some further aggregation of recorded sightings has also occasionally been required to facilitate display of these data (Figure nn). Only Chelonid turtles were seen on survey, but observers were not equally proficient at in-flight species identifications. Nevertheless, most of the turtles being seen can confidently be assumed to have been green turtles, but some much fewer loggerhead, hawksbill and flatback turtles would also have been present. Noting this, the estimated mixed Chelonid sea turtle population for the Exmouth block on this survey was 8481 (±1 126 se) individuals, - ??at an average density of 2.26 turtles km^{-2}.

Small Cetaceans - Dolphins

Fifty dolphins in 18 groups of 1 to 8 animals were seen on transects within the Exmouth block for this survey. The sightings data (Figure nnn) do generally indicate the numbers of animals estimated to form functional groups. The majority of the dolphins being seen, and those positively identified by the experienced observers participating on survey, were believed to be *Tursiops* sp. *Sousa* sp. are known from the Exmouth Gulf area (Preen *et al.* 1997). The estimated population of dolphins for the Exmouth block on this survey was 793 (±195 se) individuals (Table n) , - ??at an average density of 0.21 dolphins km^{-2}.

Other Taxa

No whales were seen within the Exmouth block on this survey.
Manta rays; Sharks
Where do we deal with Seasnakes
Significance of the big red jellyfish swarm? Tentative identity presently is for a species not hitherto known inWAust coastal waters - ?explanation of.

Pilbara Coast and Offshore

Dugongs

Fifty-four dugongs were seen on the Pilbara block transects for this survey, comprising 43 separate sightings of single adult size dugong, 4 groups of 2 dugong, and 1 group of 3 dugong (Figure n). Mean group size was 1.12 (± 0.34 se). The estimated population was 2 046 (±376 se) dugong, at an average density of 0.10 dugong km^{-2} (Table n).

Turtles

Two thousand, six hundred and thirty-one (2631?) turtles were seen on the Pilbara block transects for this survey. The majority of turtles being seen were dispersed sufficiently to be recorded as single individuals, or in small groups of generally less than five individuals, but where turtles were particularly abundant,sequential sightings data were aggregated by observers before reporting to expedite efficient recording. Thus, the numbers of turtles per group as recorded on task do not necessarily imply any functional behavioural relationship integrating the activities of the turtles being counted. Some further aggregation of recorded sightings has also occasionally been required to facilitate display of these data (Figure nn). Only Chelonid turtles were seen on survey, but observers were not equally proficient at in-flight species identifications. Nevertheless, most of the turtles being seen can confidently be assumed to have been green turtles, but some much fewer loggerhead, hawksbill and flatback turtles would also have been present. Noting this, the estimated mixed Chelonid sea turtle population for the Pilbara block on this survey was 49039 (±4 069 se) individuals, - ??at an average density of 2.46 turtles km^{-2}.

Small Cetaceans - Dolphins

Two hundred and twenty-seven dolphins in 18 groups of 1 to 15 animals were seen on transects within the Pilbara block for this survey. The sightings data (Figure nnn) do generally indicate the numbers of animals estimated to form functional groups. The majority of the dolphins being seen, and those positively identified by the experienced observers participating on survey, were believed to be *Tursiops* sp. *Sousa* sp. are known from the Exmouth Gulf area (Preen *et al.* 1997). The estimated population of dolphins for the Pilbara block on this survey was 1509 (±411 se) individuals (Table n), - ??at an average density of 0.08 dolphins km^{-2}.

Other Taxa

No whales seen on transects. One minke only seaward of 20m off end/between ends of transect nn
Manta rays; Sharks
Where do we deal with Seasnakes
The big 'white' jellyfish swarms? Possible species identity presently unknown.

Discussion

There is no obvious biologically significant boundary separating the coastal waters within Exmouth Gulf, and out to the offshore islands, from those of the remainder of the Pilbara coast, although the general orientation of the ecological axes does differ. Division of the survey cover and resultant data into two main blocks in analysis is thus largely a matter of convenience. Prior data from similar quantitative aerial surveys covering Exmouth Gulf only (Preen *et al.* 1997; area equivalent to Transects 1 through 18 of the current survey. Transects 19 – 22 were being covered for the first time only in our April 2000 survey) are also available for comparison.

Dugong and Dugong Habitats

It is clear from the sightings data that dugongs were scarce within Exmouth Gulf mid-April 2000, and much fewer in comparison with the 1989 and 1994 survey results. Dugong population estimates derived from these latter surveys suggested *c.* 1 000 dugongs might be found within Exmouth Gulf, whereas the mid-April 2000 survey estimate suggests a population of <100. Two questions are thus raised: What is the possible reason for this change? –and, Where might these nearly 1 000 dugong have gone?

The substantial answer to the first question above is believed to be change in the availability of seagrass forage within Exmouth Gulf as a consequence of habitat damage wrought by severe TC Vance, which passed down through the middle of Exmouth Gulf on 22 March 1999 (Figure). The main answer to the second question seems likely to be a consequent mass movement of dugongs elsewhere, as we have no data suggesting any increase in the numbers of dugong carcases being discovered on the Western Australian coast in the 12 months between our survey and prior passage of TC Vance

(Prince, unpubl. data). Losses of some dugong by strandings due to the *c.* 5m storm surge as TC Vance approached and then entered Exmouth Gulf (BoM: Perth TC Warning Centre 2000) may have occurred (*cf* Marsh 1989), but none have been documented. Formal investigation for this purpose could not be financed. Even so, losses of as few as *c.* 5 - 10% of the population are most unlikely to have gone unnoticed.

The total of 54 dugong sighted, and the population estimate of 2046 (± 376 se) at an average density of 0.10 dugong km^{-2} for the Pilbara waters also suggest that dugong were not particularly abundant in that area mid-April 2000. However, the dugong seen on this latest survey within the Pilbara waters were found in locations where previous observations from longshore surveys (Prince 1986; Prince, Anderson and Blackman 1981, Figure 1), incidental reports (eg, Prince *et al.* 1995; various environmental impact assessment reports, and other unpubl. data), and strandings records (Prince, unpubl. data) suggested they generally ought to be present.

Noting the difference between the longshore and reconnaissance survey approach previously used (*ibid.*), and the strip transect method employed for the April 2000 survey, the actual sightings data across all surveys, spanning the period from February 1977 through April 2000, do suggest a quite consistent pattern of distribution and general abundance, but only the current survey allows an estimation of actual abundance. Taken together, these data support the view that the Pilbara coastal and offshore waters area does include some very important focal dugong habitats. These waters are thus an integral part of the resource areas sustaining dugong presence on the Western Australian coast. The relatively low current abundance of dugongs in this Pilbara area (*cf.* Marsh *et al.* 1994, Table 4 data; and discussion and Table 3 in Preen *et al.* 1997), and the apparent emigration of dugongs from within Exmouth Gulf post-TC Vance (Gales *et al.* 1999 survey report, In Prep; and current data), must be further considered in light of the likely processes affecting temporal and spatial variability of capacity of key habitat areas to support dugong on the appropriate regional scale.

Tropical cyclones are the most obvious major regional temporal and spatial disturbance factor affecting the quality of dugong habitats along the Pilbara coast. The likely extent and severity of soft-bottom seagrass habitat disruption being caused by passage of particular cyclones will certainly depend on the characteristics of the cyclone, including intensity and duration of the event, and the track followed. The Exmouth Gulf and Pilbara coastal habitats had been impacted by a number of severe (Category 5) tropical cyclones in the *c.* 5 years immediately preceding our survey, including TC John, TC Vance, TC Olivia, TC Bobby (Figure x), and some other less intense systems which might still have wrought some ecologically important but qualitatively different changes in the nearshore waters, eg, TC Steve's longshore passage and regional flooding event immediately prior to our survey job.

There is little doubt that the intense wave action and water movements generated by the Category 5 tropical cyclones mentioned above can disrupt soft-bottom habitats across the entire coastal waters within the 20m isobath area targeted for our survey (Scott Condie, *pers. comm.*). Of the events noted, it seems most probable that TC Vance, which had attained severe intensity and developed a wide 'footprint' while moving south-westerly offshore from the west Kimberley coast on March 20, 1999, and sustained this intensity size for the duration of its passage coast parallel and thence down into Exmouth Gulf on March 22, 1999, could have had the greatest single impact on the coastal waters and coastline habitats. Dunefields backing the 80 Mile Beach were severely eroded by high water levels and wave action early on (C. & J. Lewis, *pers. comm.*, including photographs), and similar coastal erosion from the *c.* 5m storm surge as Vance approached Exmouth Gulf was evident around the Onslow – Tubridgi Point area, and at Exmouth itself (BoM: Perth TC Warning Centre 2000).

The other most recent severe TC's noted above generally approached the Pilbara coast on steady courses from seaward to the north or north-westward, so tending to confine their major disturbance impacts to a lesser, but still substantial part of the coast and coastal waters area. However, local event and cumulative impact histories are also relevant to consideration of likely habitat quality status across the area being surveyed.

The early-mid March 2000 passage of TC Steve and resultant flooding and sustained freshwater and silt discharges into the whole of the nearshore waters zone within our survey area following heavy rainfalls of *c.* 100 – 300 mm over catchments of all the regional drainage systems has been mentioned above. Substantial drainage was still occurring as we conducted our survey, with generally extensive turbid outflow plumes extending seaward from each drainage system. Apart from the evident turbidity within those outflow plumes affecting water mass characteristics, and the sightability of survey target fauna therein, we have not yet been able to access tools to further examine the siltation events associated with those plumes. Other possible short-term effects on animal behaviour and distribution are presently unknown.

Severe TC John crossed the Pilbara coast near Depuch Island mid-December 1999, and did cause some considerable redistribution of bottom sediments in that area (N. Miller, *pers. comm.*), and other damage to coastal property extending *c.* 30km towards Port Hedland. The relatively recent disturbance of the benthos due to TC John could still have been exerting direct pressure on dugong distribution within the area affected at the time of our survey, and have been interacting with the previous coastal disturbance in this same area due to TC Vance in March 1999 (above).

TC Vance also impacted the waters of the western part of our survey area between the Dampier Archipelago to offshore islands (Monte Bellos, Barrow, Lowendals), and thence down into Exmouth Gulf. A major part of this same area was previously impacted by the passage of TC Olivia mid-April 1996, and TC Bobby late-February 1995.Unfortunately, we lack any particular detailed knowledge of the extent and condition of the soft-bottom seagrass communities expected to be utilized by the resident dugong in this region, but there is no doubt that the serial substantial disturbance of such benthic communities will adversely impact and influence the availability of sea grass forage for dugongs.

The best documented example of this effect is the Hervey Bay, Queensland, event triggered by cyclone associated disturbance and flooding in February 1992 which led to the loss of*c.* 1 000 km^{-2} of seagrass which was supporting a considerable local dugong population (Preen *et al.* 1995), the consequent loss of most dugong from that area (Preen and Marsh 1995), and the subsequent slow recovery of the seagrass community and dependent dugong population (eg, Lawler and Marsh *?in prep*). Heinsohn and Spain (1974) had previously reported the disruptive impact of a Queensland tropical cyclone on dugongs and the nearshore biota. {Poiner and Co also observed the major disruption of seagrass beds and long-lasting resultant habitat changes ensuing within the Gulf of Carpentaria caused by TC Sandy – NPF reports at least.}

The paucity of specific knowledge of the Pilbara seagrass communities and their particular status re dugong forage resource availability certainly needs to be rectified if we are to

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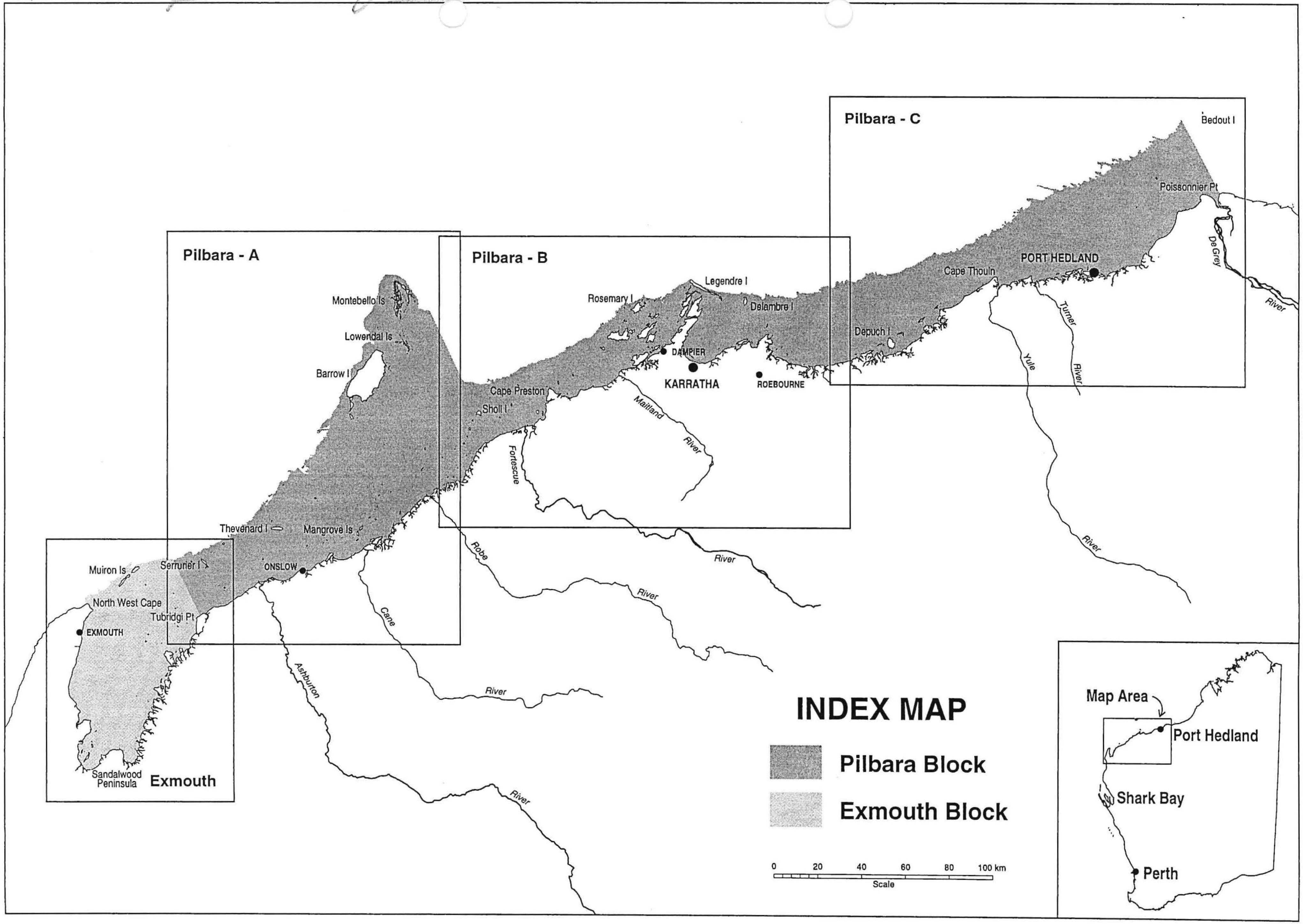
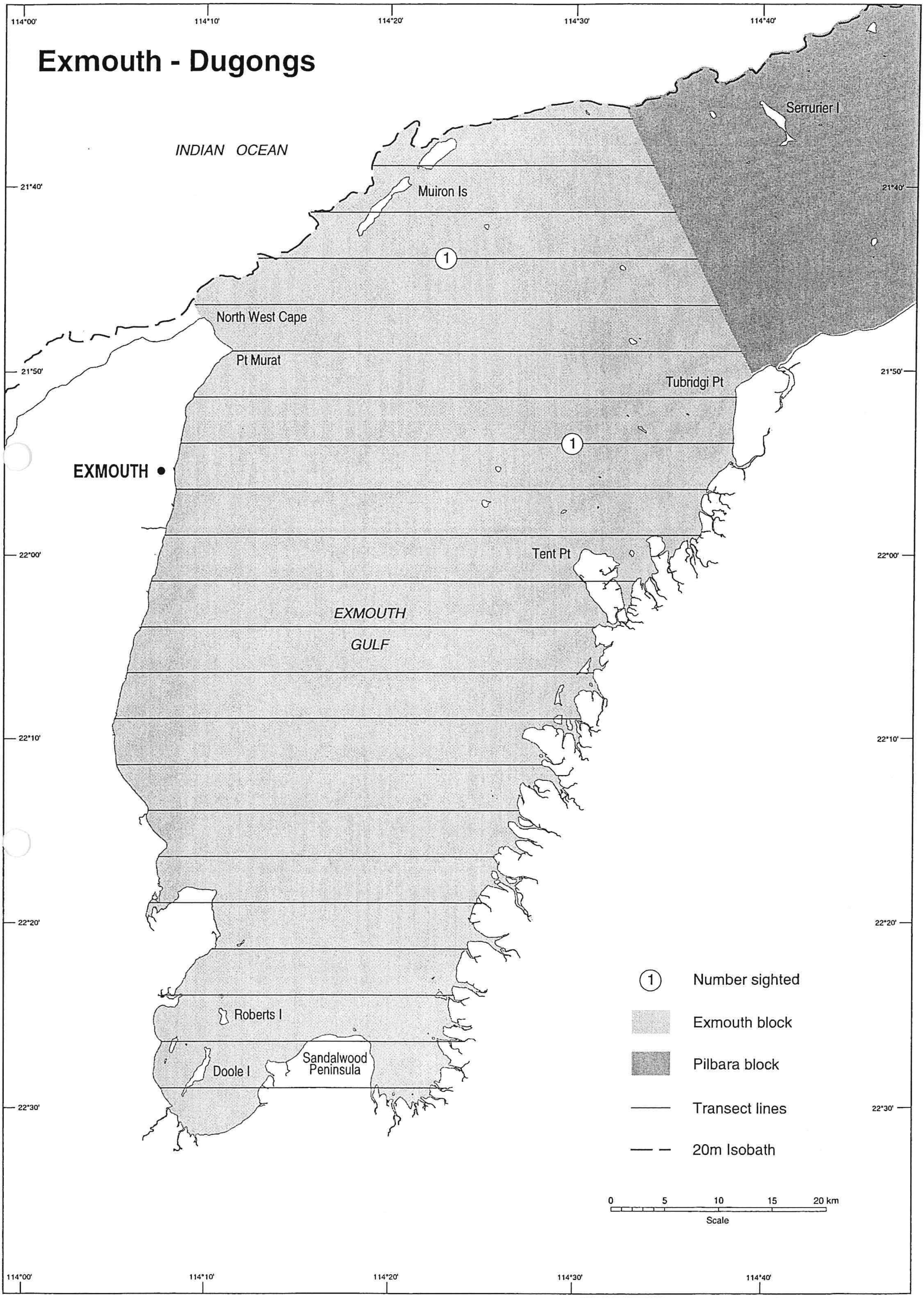
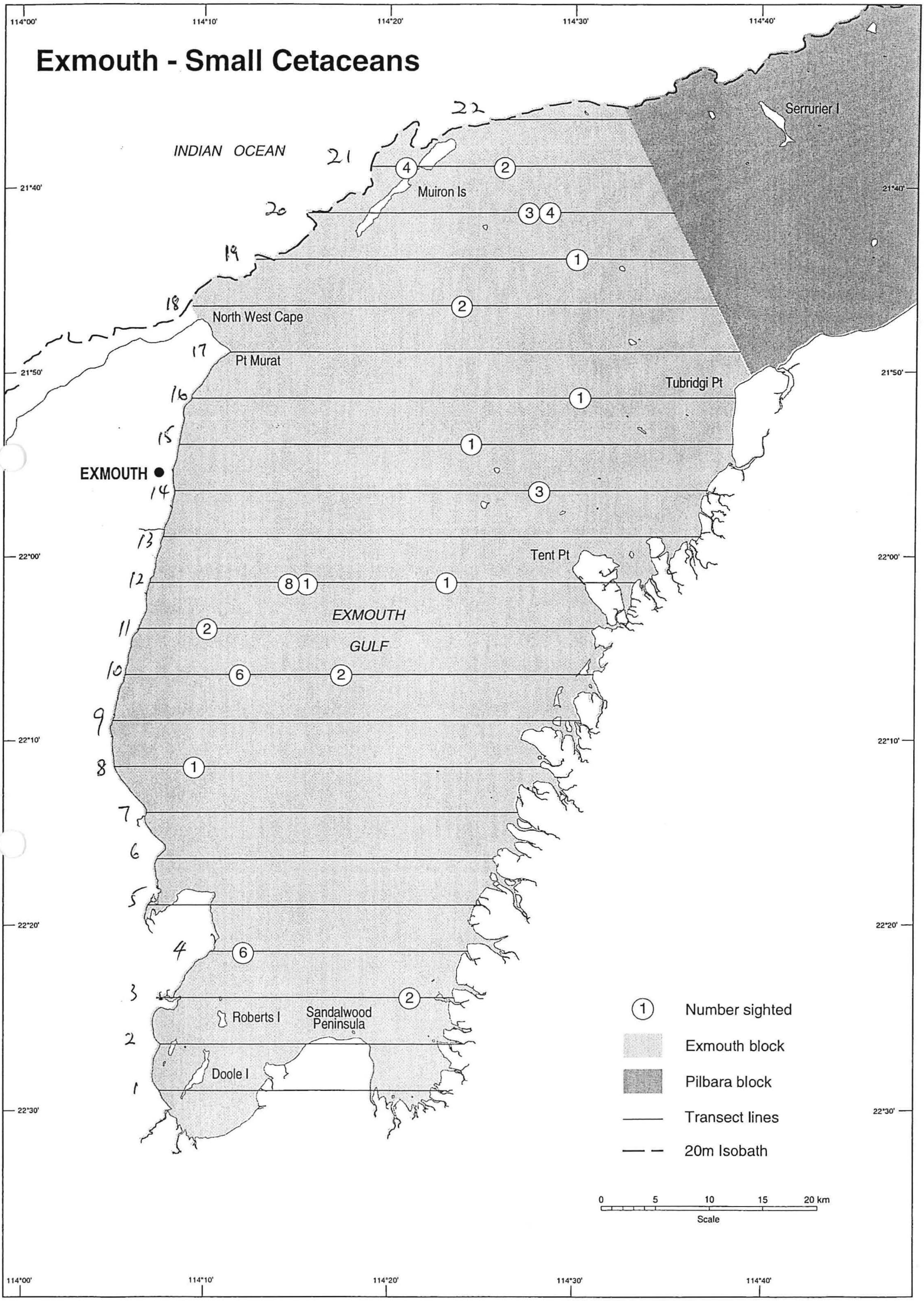
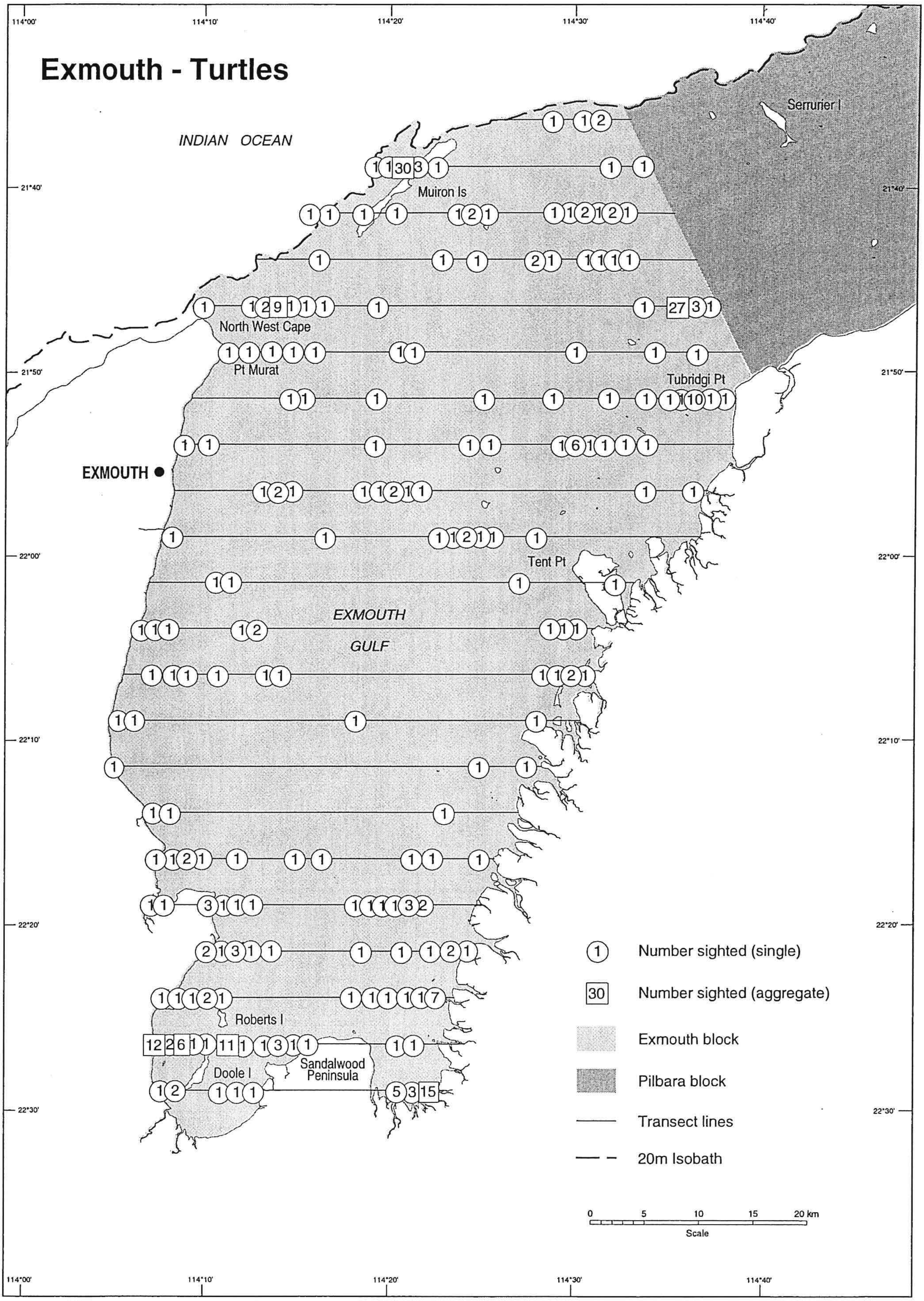


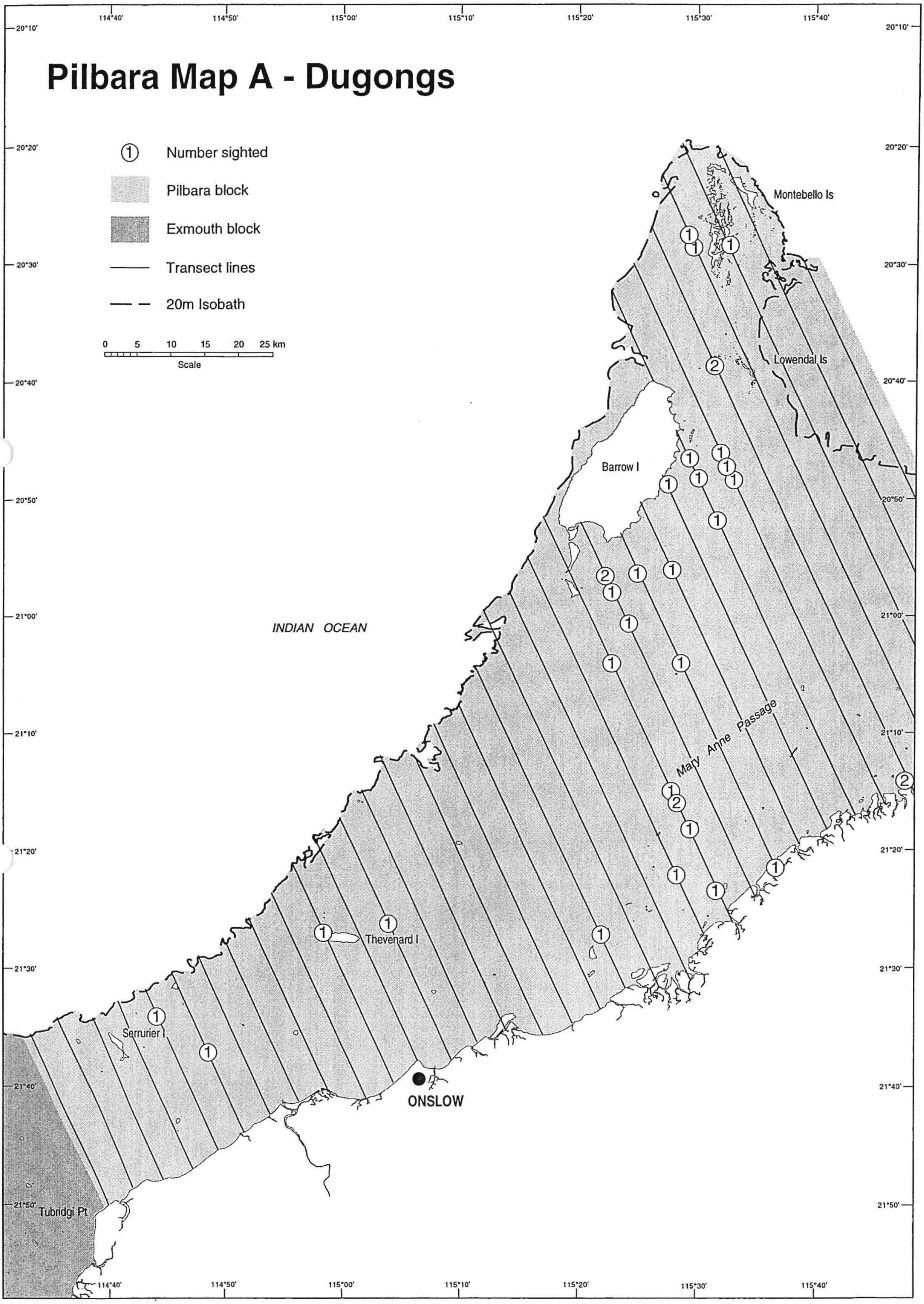

Exmouth - Dugongs
114°00'
114°10'
114°20'
114°30'
114°40'
21°40'
21°50'
22°00'
22°10'
22°20'
22°30'
INDIAN OCEAN
Serrurier I
Muiron Is
North West Cape
Pt Murat
Tubridgi Pt
EXMOUTH
Tent Pt
EXMOUTH
GULF
Roberts I
Doole I
Sandalwood
Peninsula
1
1
Number sighted
Exmouth block
Pilbara block
Transect lines
20m Isobath
0
5
10
15
20 km
Scale


Exmouth - Small Cetaceans
114°00'
114°10'
114°20'
114°30'
114°40'
21°40'
21°50'
22°00'
22°10'
22°20'
22°30'
INDIAN OCEAN
Serrurier I
Muiron Is
North West Cape
Pt Murat
Tubridgi Pt
EXMOUTH
Tent Pt
EXMOUTH
GULF
Roberts I
Sandalwood
Peninsula
Doole I
Number sighted
Exmouth block
Pilbara block
Transect lines
20m Isobath
0
5
10
15
20 km
Scale

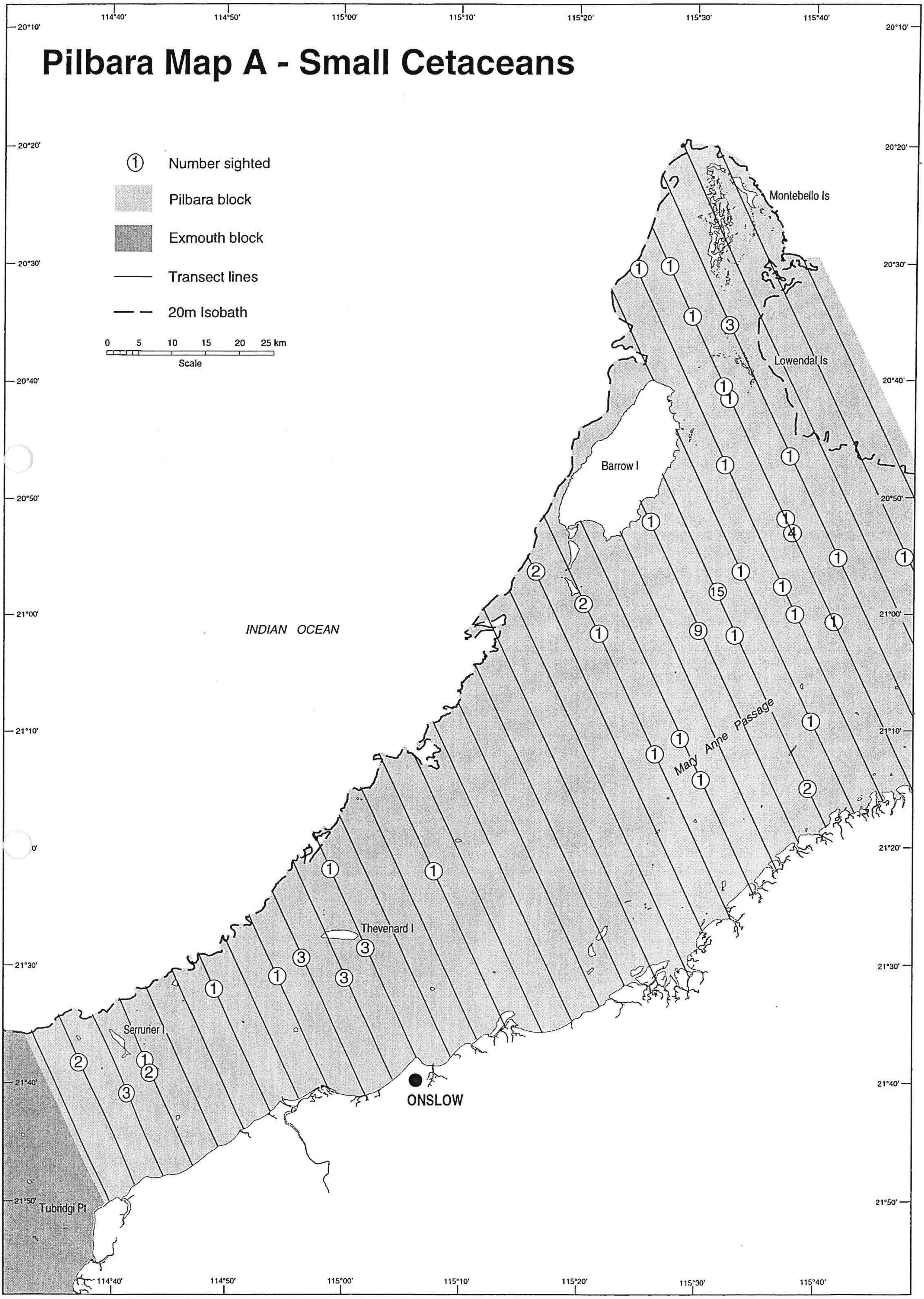


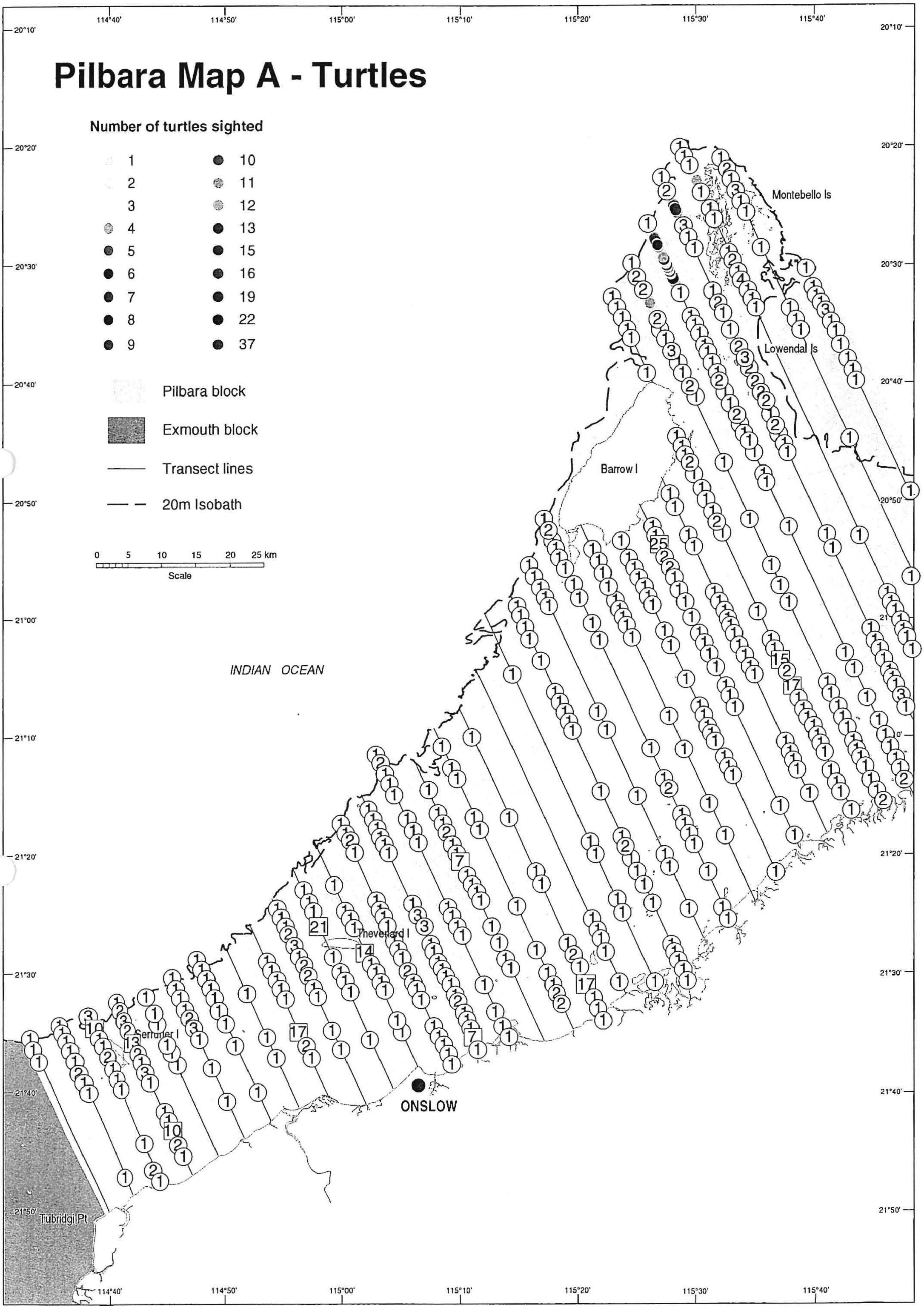
Exmouth - Turtles
INDIAN OCEAN
Serrurier I
Muiron Is
North West Cape
Pt Murat
Tubridgi Pt
EXMOUTH
Tent Pt
EXMOUTH
GULF
Roberts I
Doole I
Sandalwood
Peninsula
Number sighted (single)
Number sighted (aggregate)
Exmouth block
Pilbara block
Transect lines
20m Isobath
0 5 10 15 20 km
Scale

Pilbara Map A - Dugongs



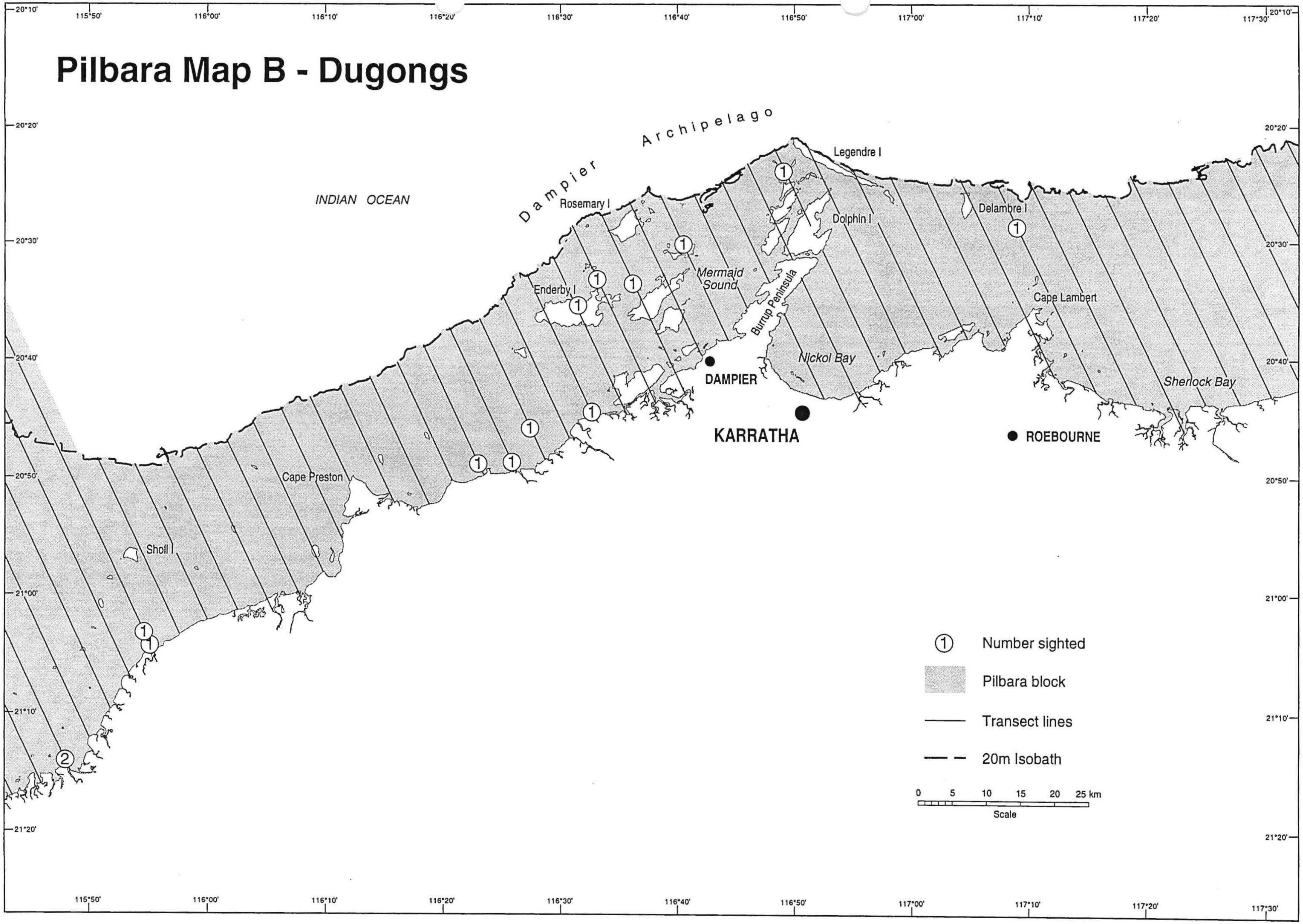
Pilbara Map A - Small Cetaceans



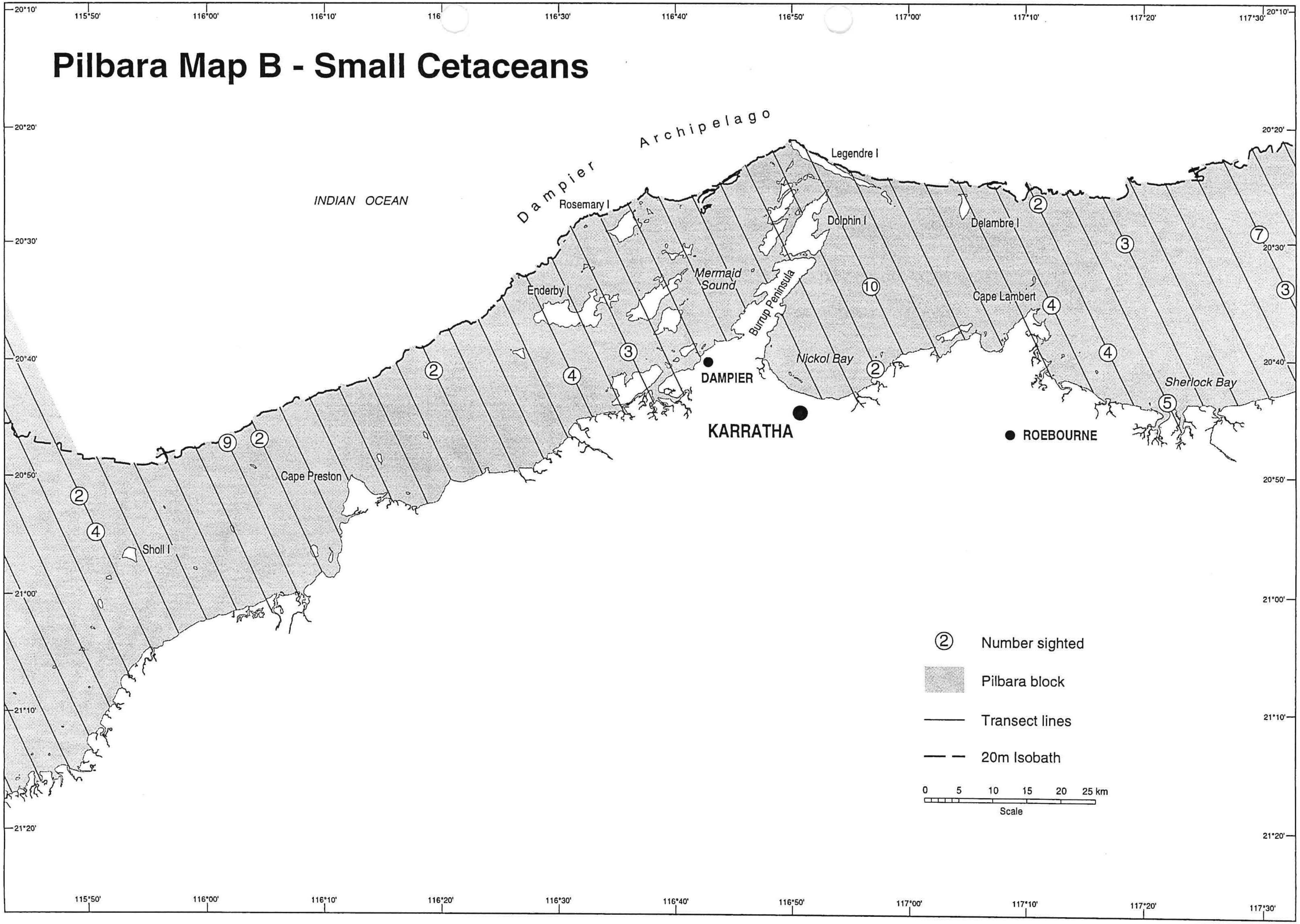


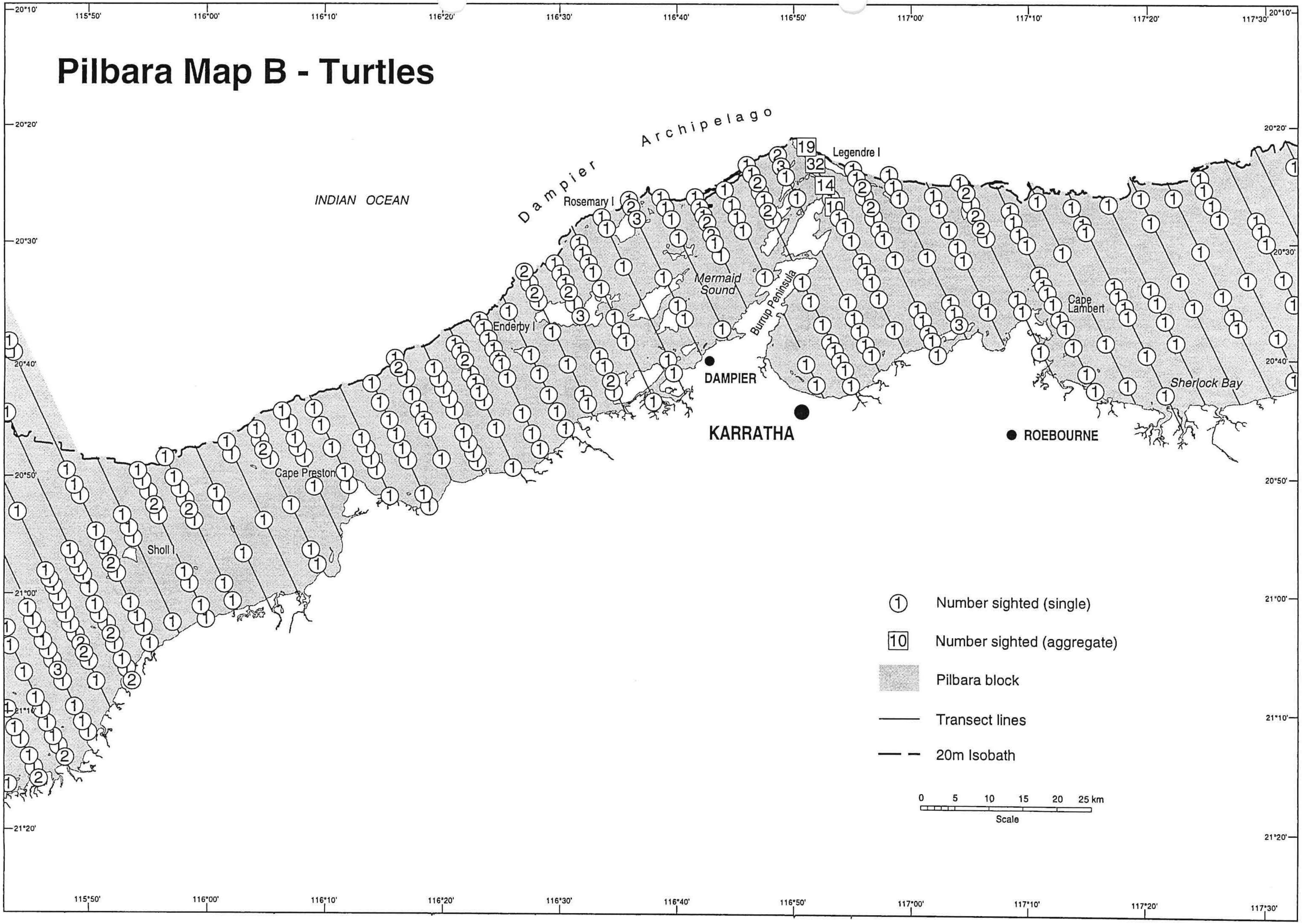
Pilbara Map A - Turtles
Number of turtles sighted
1
2
3
4
5
6
7
8
9
10
11
12
13
15
16
19
22
37
Pilbara block
Exmouth block
Transect lines
20m Isobath
0 5 10 15 20 25 km
Scale
INDIAN OCEAN
Montebello Is
Lowendal Is
Barrow I
Thevenard I
Serrurier I
ONSLOW
Tubridgi Pt
114°40'
114°50'
115°00'
115°10'
115°20'
115°30'
115°40'
20°10'
20°20'
20°30'
20°40'
20°50'
21°00'
21°10'
21°20'
21°30'
21°40'
21°50'

Pilbara Map B - Dugongs



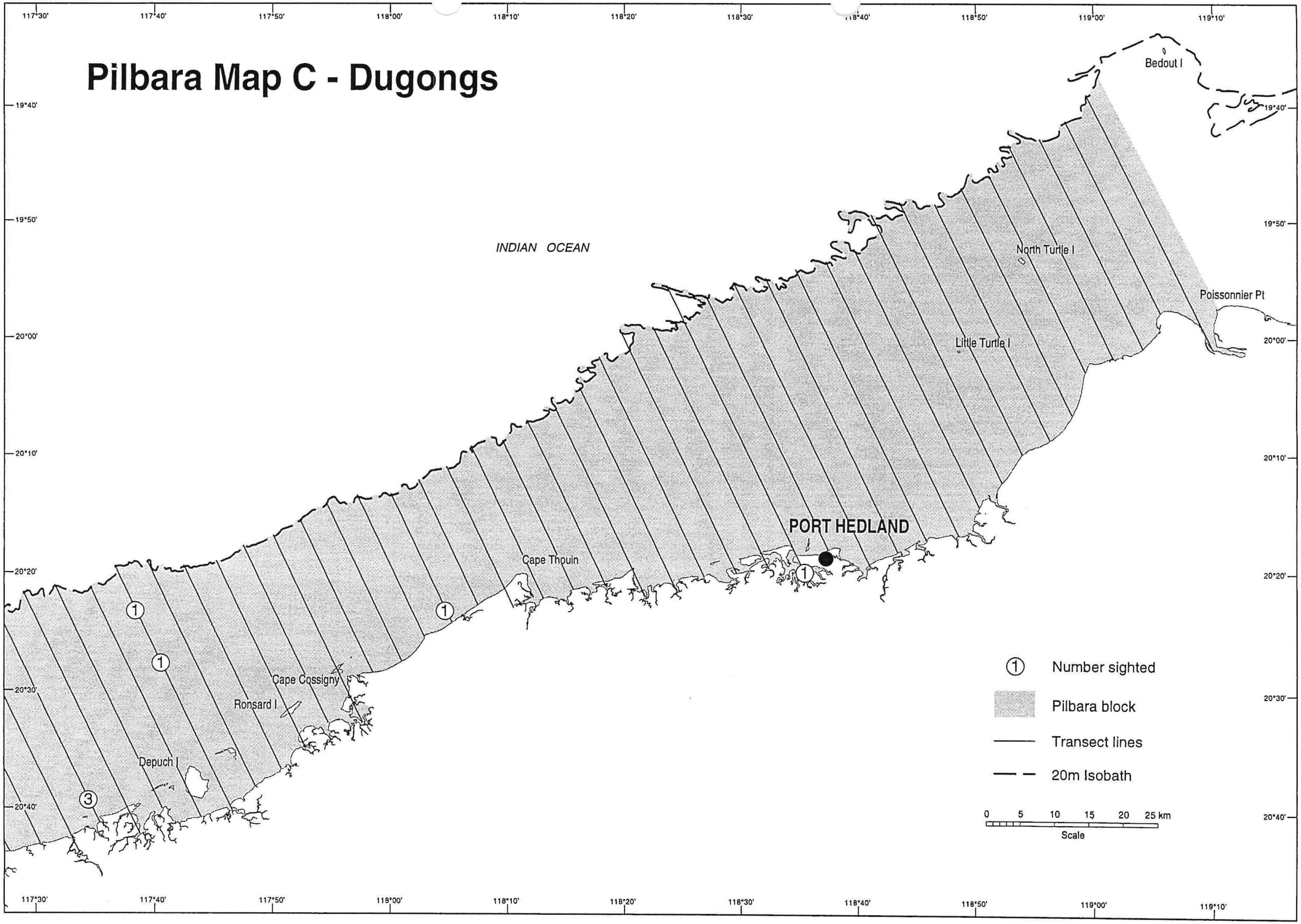
Pilbara Map B - Small Cetaceans



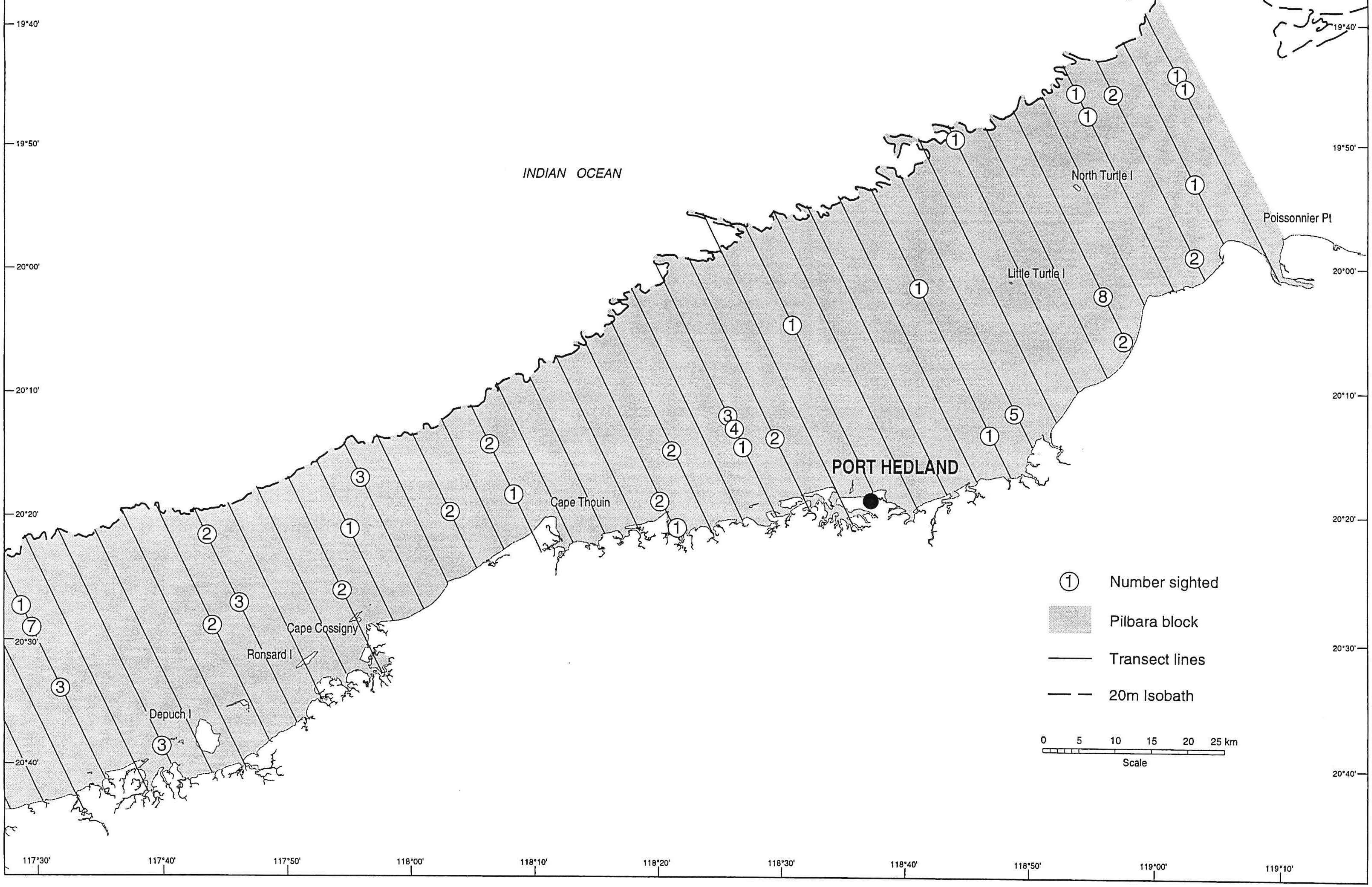


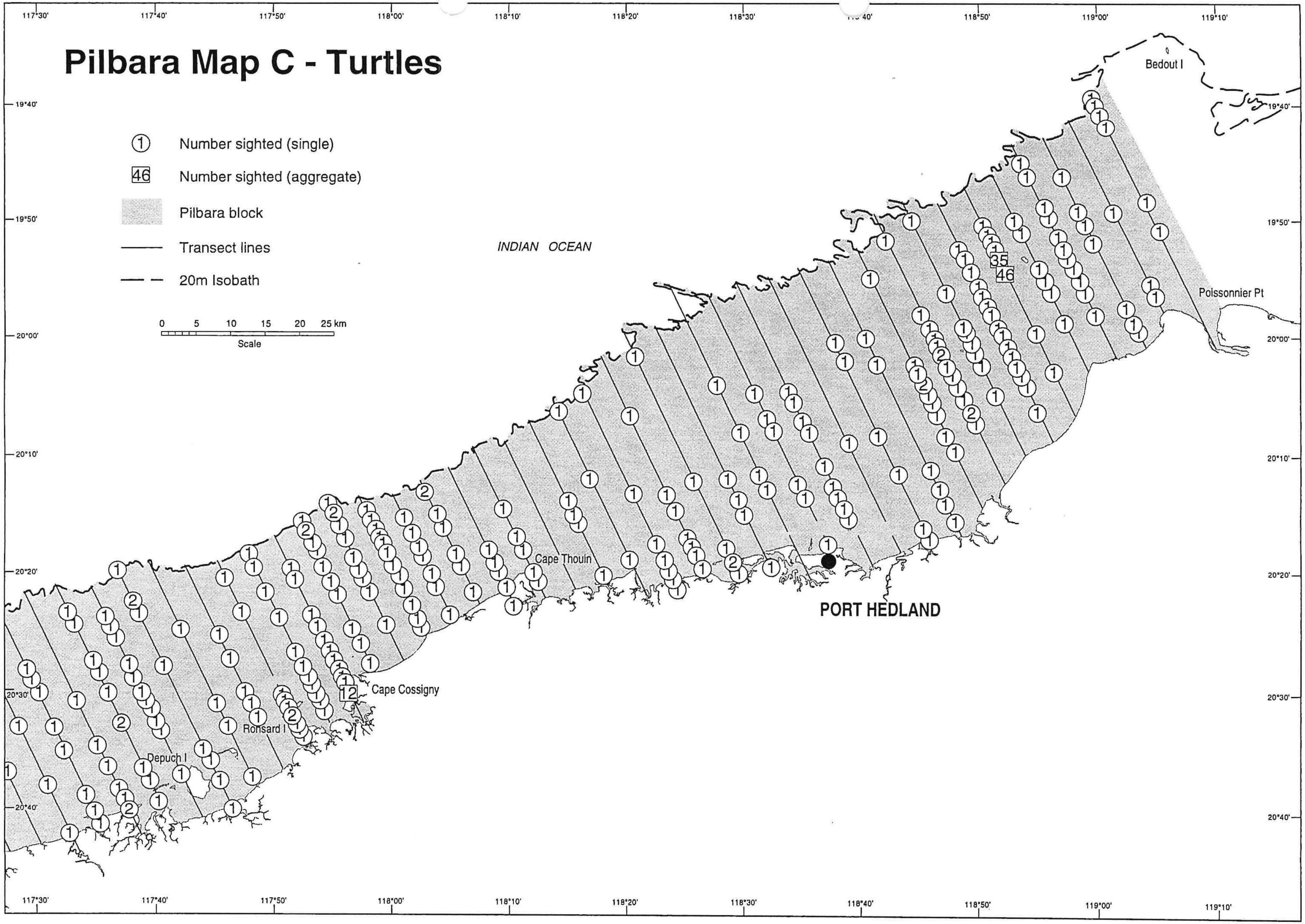
Pilbara Map B - Turtles
INDIAN OCEAN
Dampier Archipelago
Rosemary I
Legendre I
Mermaid Sound
Burrup Peninsula
Enderby I
DAMPIER
KARRATHA
ROEBOURNE
Cape Lambert
Sherlock Bay
Cape Preston
Sholl I
Number sighted (single)
Number sighted (aggregate)
Pilbara block
Transect lines
20m Isobath
0 5 10 15 20 25 km
Scale

Pilbara Map C - Dugongs



Pilbara Map C - Small Cetaceans





Pilbara Map C - Turtles
Number sighted (single)
Number sighted (aggregate)
Pilbara block
Transect lines
20m Isobath
0 5 10 15 20 25 km
Scale
INDIAN OCEAN
Bedout I
Poissonnier Pt
PORT HEDLAND
Cape Thouin
Cape Cossigny
Ronsard I
Depuch I
117°30'
117°40'
117°50'
118°00'
118°10'
118°20'
118°30'
118°40'
118°50'
119°00'
119°10'
19°40'
19°50'
20°00'
20°10'
20°20'
20°30'
20°40'