Analysis of spotlighting data from Barrow Island Nature Reserve, Western Australia

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SUMMARY

Spotlighting data for two *ca* 30 km line transects on Barrow Island, one in the disturbed oilfield and one in a relatively undisturbed area, searched opportunistically from 1972 to 1997, are presented. From 1998 to 2003 and again in 2007 the same two transects were counted six times per trip and the perpendicular distance of animals sighted from the centre line of the transect was recorded allowing analysis by DISTANCE software to correct for visibility differences. Density calculations of *Isoodon auratus*, *Trichosurus vulpecula*, *Bettongia lesueur* and *Lagorchestes conspicillatus* either showed no significant difference between transects within a trip or were significantly higher in the northern, undisturbed transect. Effective Strip Widths (ESW) were significantly wider in the southern, disturbed transect for three of the species, presumably because of increased visibility due to vegetation clearance resulting from oilfield development and operation. Combining data from all trips for all four mammal species also revealed a higher animal density and a narrower ESW in the northern area.

INTRODUCTION

Barrow Island Nature Reserve, as well as being of enormous nature conservation significance for other reasons, is one of Australia's most important mammal conservation areas. It supports 14 terrestrial mammal species, more than any other Western Australian island (Abbott and Burbidge 1995), of which five are listed as threatened pursuant to the *Wildlife Conservation Act 1950* (WA) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). No exotic mammals are currently known to occur there: the introduced House Mouse *Mus domesticus* and Black Rat *Rattus rattus* have been present on Barrow Island, but have been eradicated (Morris 2002). A producing oil field has been located on Barrow Island since 1964. Until 1999 the operator was West Australian Petroleum Pty Ltd (WAPET); the operator now is Chevron Australia Pty Ltd. A major liquefied natural gas plant is planned to be constructed on the island to process natural gas from the offshore Gorgon and Jansz fields.

Five of Barrow Island's mammal species (including four of the threatened species) are readily detected by spotlighting along the many hundreds of kilometres of gravel roads on the island. In 1972, two spotlight transects were established, one within the oilfield in the southern part of the island and one in the relatively undisturbed northern part of the island. The aim was to test whether mammal numbers had been affected by the development of the oil field and at the same time detect any introduced predators such as feral cats (*Felis catus*) or red foxes (*Vulpes vulpes*). Mammal numbers along these transects have been counted many times; until 1998 counts were opportunistic and usually associated with inspections of the island by nature conservation statutory authorities (successively the Western Australian Wildlife Authority, National Parks and Nature Conservation Authority, and Conservation Commission of Western Australia) and, successively, Department of Fisheries and Fauna, Department of Fisheries and Wildlife, Department of Conservation and Land Management and Department of Environment and Conservation staff. Usually only two nights' counting was possible every two years.

In 1998, a mammal monitoring project based primarily on trapping commenced on Barrow Island, conducted jointly by the Department of Environment and Conservation and Chevron Australia. Between 1998 and 2003, and again in 2007, counting was conducted over six nights with the perpendicular distance of each animal sighted from the centre of the road also being recorded.

METHODS

Barrow Island is composed largely of tertiary limestone with skeletal soils on uplands and shallow alluvial soils in valleys. The vegetation is a *Triodia* hummock grassland (*T. wiseana* on skeletal soils, *T. angusta* on alluvials and *T. pungens* on sand) with emergent low clumps of *Ficus* and scattered *Pittosporum*.

The transects are shown in Figure. 1. Each was just less than 30 km long. Each transect was searched simultaneously by two teams. Each team used a four-wheel drive tray-top vehicle, with a spotlighter standing on the tray behind the cab searching for animals with a single 100 W spotlight. A data recorder was located in the cab of the vehicle, along with the driver. Vehicles were driven at 13-15 km/h. On the first night one team counted the north transect and the other the south one; on the second night the same teams counted the other transect, in the reverse direction. The same spotlighter, or combination of spotlighters, worked on consecutive nights. Work commenced at or soon after 1900 hrs. All animals seen on the road or on either side of the road were recorded whether sighted in the spotlight or in vehicle headlights by the spotlighter, driver or recorder.

Counts from 1972 to 1997 were made at different times of the year, but mostly in summer (November to March). Since 1998, six counts were conducted over seven to ten days, and for each animal sighted the odometer distance from the start of the transect was recorded plus the estimated perpendicular distance of each animal when first sighted from the centre of the transect (ie, the centre of the road). The time the observation was made was also recorded, as a check against the correct recording of the odometer reading. At the end of each transect the total odometer distance and the total time taken to complete the transect were noted. Wind speed and moon condition were recorded, but have not been used in the analyses.

Data from 1998 onwards were analysed using DISTANCE 3.5 (© 1998-1999 Research Unit for Wildlife Population Assessment, University of St. Andrews). Data from the six nights of spotlighting were combined and the Half-normal + Cosine model was used with no truncation of data. The model was chosen after testing several models on a selection of data, as being the best model overall based on the Akaike information criterion (Buckland *et al*. 2001). Data for 1999 were not anlaysed as two transects were not completed.

RESULTS

Species sighted were Golden Bandicoot (*Isoodon auratus*), Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*), Burrowing Bettong or Boodie (*Bettongia lesueur*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus conspicillatus*) and Barrow Island Euro (*Macropus robustus isabellinus*). Rodents (Western Chestnut Mouse *Pseudomys nanus* and Common Rock-rat *Zyzomys argurus*) were recorded as ‘rodent’. A few ‘rodent’ records were of *Pseudantechinus* sp. Rock-wallabies (*Petrogale lateralis lateralis*) were recorded infrequently and only on the northern transect; data for this species have been excluded from the analyses. Records of *M. robustus* were too few for analysis.

The length of the transects, recorded on a GPS receiver, were: North 29.8 km and South 29.6 km. Odometers on the vehicles used varied somewhat with distances recorded from 1998 to 2007 being: North mean 29.6 (range 28.4 – 30.2, SE = 0.06), South mean 29.1 (27.5 – 30.0, SE = 0.08). No corrections have been made for odometer error in the analyses.

Data from 1972 to 1997 for are presented in Fig. 2. Inspection of Figure 1 shows no consistent difference in mammal numbers sighted between North and South; however, *L. conspicillatus* and *T. vulpecula* numbers were often higher in the South. No introduced mammals were detected.

Counts in 1999 to 2007 were conducted in September, October or November. Data from 1998 to 2003 and 2007 (excluding 1999) are presented in Table 2. Table 3 provides outputs from DISTANCE 3.5 analyses. The DISTANCE analyses showed no significant difference in species density between North and South for all species for some years. However, there were significant differences ($p<0.05$) for species density between North and South for some species in some years, with North having a higher density of *L. conspicillatus* in 1998, 2001 and 2003, *I. auratus* in 2000, *T. vulpecula* in 2000, 2002 and 2007, and *B. lesueur* in 1998, 2001 and 2003.

DISCUSSION

While we attempted to control as many variables as possible (North and South transects being counted on consecutive nights by the same teams, the same spotlighter operating for the same amount of time each night, repeated counts of the transects during the same trip), other variables could not be controlled. In particular, while the transects were chosen to represent areas outside and within the oilfield, the vegetation types and terrain, while broadly similar, could not be considered the same and the transects could not be randomly selected. It is not possible to select random transects for vehicle-based spotlighting on Barrow Island as we had no choice but to use existing roads. However, our data do provide comparisons in calculated density for several mammal species along roads, which are a common feature of Barrow Island.

Between 1972 and 1997 only two nights' counting was possible on most occasions. Night to night variability when counting was spread over six nights between 1998 and 2007 suggests that these data should be viewed with caution. It would not be appropriate to compare data between years, as personnel and equipment have varied, as has visibility, which was better in the south in 1972 and subsequent years, soon after the end of oilfield development, compared with later years when revegetation of many disturbed areas was more extensive.

Visibility variability between North and South has been corrected since 1998 by the DISTANCE software, which revealed significantly larger Effective Strip Widths (ESW, also known as Effective Detection Radius) in the South than the North for three of the four species (Table 5), presumably because of greater disturbance and hence greater visibility within the oilfield. *I. auratus*, the smallest of the four species, is difficult to see far from the road because it is readily obscured by *Triodia* hummocks and the ESW were not significantly different for this species between transects. Visibility is better in the oilfield, where there are numerous side roads, cleared oil well 'leases', pipelines and regenerating 'borrow' pits as well as other infrastructure, meaning that animals can be more readily detected in a spotlight beam further from the centre line of the transect. *T. vulpecula*, in particular, which has very strong eye reflectance, can be seen at considerable distance if there are no impeding obstacles. The significantly lower density of some mammal species on the South transect in some years since 1998 may be due to habitat clearance in the South; although differences in terrain and habitat can not be ruled out. None of the species showed significant differences in density between transects in all years.

We noted considerable variability between nights in the number of mammals seen. Table 4 shows the number of *L. conspicillatus*, a comparatively easily-detected species, on six nights in November 2001. Ideally, we would have tested how many nights of spotlighting per trip are necessary to reduce variability to acceptable levels but, because the length of each field trip was dictated by the trapping program, this was not possible.

Overall, with all data from five mammal species combined for 1998, 2000-2003 and 2007 (Table 5), the density of the larger species (ie, those in Table 1 excluding ‘rodents’) in the North is significantly higher than in the South ($p<0.05$) and the Effective Strip Width is higher in the South.

The spotlight transects were established to permit a quick and easy method of detecting gross differences between animal density within and outside the oilfield, as well as detecting any significant changes in animal numbers. It was hoped that introduced mammals, if present, would also be detected. Data from 1972 to 1997, suggest that, while total numbers varied from year to year (probably due primarily to rainfall variation, but also to observer ability, changing visibility and detectability differences from night to night), there were no gross differences between the two transects, nor were any feral mammals detected. Inspection of Table 1 suggests differences between North and South for some species in some years, with more animals often being sighted in the South; however, no reliability should be placed on these results as the data are uncorrected for visibility.

The results reported here suggest that the oilfield development may have reduced the area of habitat available to some mammal species near roads. However, the data and analyses are not robust and spotlighting transects may not provide a high-quality method of monitoring threatened mammals on Barrow Island. Trapping (Morris and Burbidge in prep.) may be a better monitoring method, but the traps used only occasionally catch *L. conspicillatus* and never catch *M. robustus* and other monitoring methods are required for these species. If road-based spotlighting transects are to be used in future, a new North transect will need to be selected as the Gorgon development will straddle the current North transect and roads will be closed or realigned. Alternatively, different methods could be considered using people on foot, with a backpack battery and hand-held spotlight (eg, Short and Turner 1992), but this may lead to significant safety issues within the oilfield.

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REFERENCES

Abbott I and Burbidge AA (1995). The occurrence of mammal species on the islands of Australia: A summary of existing knowledge. *CALMScience* **1,** 259-324.

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL and Thomas L. 2001. Introduction to distance sampling. Estimating abundance of biological populations. Oxford University Press, Oxford.

Morris KD, 2002. The eradication of the black rat (*Rattus rattus*) on Barrow and adjacent islands off the north-west coast of Western Australia. In Turning the tide: the eradication of invasive species (ed by CRVeitch and MN Clout), pp. 219-225. IUCN SSC Invasive Species Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK.

Short, J. and Turner, B. (1992). The distribution and abundance of the banded and rufous hare-wallabies, *Lagostrophus fasciatus* and *Lagorchestes hirsutus*. *Biological Conservation* **60**, 157-166.

Year	Transect	*Isoodon auratus*	*Trichosurus vulpecula*	*Bettongia lesueur*	*Lagorchestes conspicillatus*	*Macropus robustus isabellinus*	*Rodents,.*	*Total*
1998	North	16.7±3.9	7.7±0.8	6.2±1.9	27.0±3.6	5.3±0.8	2.0±0.8	64.8±4.3
	South	19.3±4.3	7.2±1.2	5.8±1.5	28.0±2.5	1.2±0.3	3.7±0.9	65.2±6.7
2000	North	22.5±3.2	11.3±2.0	9.2±1.9	17.0±2.4	4.0±1.0	4.2±2.3	68.2±8.9
	South	19.8±2.8	8.7±1.5	2.8±0.3	24.0±2.0	2.3±0.9	4.2±2.0	61.8±5.6
2001	North	11.0±1.5	8.7±0.6	5.5±1.3	20.3±4.4	1.6±0.6	1.7±0.4	48.8±5.0
	South	14.3±1.4	8.7±1.7	6.2±1.0	26.3±3.1	2.0±0.7	2.5±1.2	60.0±4.4
2002	North	14.5±2.2	7.8±1.4	0.5±2.3	25.0±3.0	1.5±0.8	1.3±0.2	59.7±4.7
	South	15.2±2.6	5.0±0.7	3.8±1.4	22.0±2.1	3.8±0.9	1.5±0.6	51.3±2.9
2003	North	8.8±1.7	5.2±1.0	9.0±0.9	13.8±2.8	3.5±1.4	0.8±0.3	41.2±4.3
	South	13.2±1.8	4.5±1.8	4.5±1.1	16.3±1.7	2.3±0.6	0.8±0.3	41.7±3.6
2007	North	8.8±1.7	7.3±2.1	4.8±1.1	19.8±3.1	0.8±0.2	4.7±1.1	46.3±7.8
	South	14.0±1.9	7.5±0.8	4.2±0.7	22.7±3.6	2.7±0.5	4.7±1.3	55.7±3.7

Table 1. Barrow Island Nature Reserve, mean ± standard error of individual animals sighted during six spotlighting traverses 1998, 2000-2003 and 2007, along each of two transects.

Isoodon auratus

		ESW	D	D LCL	D UCL	D CV	Difference?
1998	North	6.686	0.917	0.756	1.112	0.098	} ns
	South	7.382	0.963	0.709	1.052	0.100	
2000	North	4.848	1.339	1.179	1.521	0.065	} * N>S
	South	6.711	0.896	0.712	1.127	0.117	
2001	North	10.106	0.573	0.482	0.681	0.087	} ns
	South	13.576	0.434	0.292	0.646	0.202	
2002	North	15.457	0.396	0.333	0.472	0.089	} ns
	South	12.624	0.462	0.345	0.618	0.148	
2003	North	8.206	0.718	0.566	0.909	0.120	} ns
	South	11.101	0.574	0.472	0.698	0.099	
2007	North	10.427	0.498	0.331	0.751	0.207	} ns
	South	9.094	0.660	0.476	0.915	0.166	

Trichosurus vulpecula

		ESW	D	D LCL	D UCL	D CV	Difference?
1998	North	12.516	0.429	0.302	0.611	0.177	} ns
	South	21.324	0.266	0.185	0.383	0.183	
2000	North	7.759	0.718	0.598	0.863	0.093	} * N>S
	South	11.664	0.437	0.359	0.532	0.099	
2001	North	17.381	0.332	0.251	0.440	0.141	} ns
	South	14.224	0.366	0.235	0.568	0.223	
2002	North	16.519	0.348	0.259	0.468	0.149	} * N>S
	South	41.434	0.117	0.090	0.152	0.130	
2003	North	12.152	0.491	0.372	0.647	0.139	} ns
	South	23.687	0.259	0.156	0.431	0.255	
2007	North	10.108	0.531	0.431	0.654	0.105	} * N>S
	South	17.884	0.315	0.234	0.423	0.149	

Bettongia lesueur

		ESW	D	D LCL	D UCL	D CV	Difference?
1998	North	7.879	0.734	0.571	0.943	0.126	} ns
	South	8.060	0.740	0.391	1.402	0.323	
2000	North	6.341	0.964	0.743	1.250	0.131	} * N>S
	South	17.339	0.288	0.227	0.366	0.117	
2001	North	8.549	0.643	0.454	0.911	0.174	} ns
	South	11.033	0.493	0.355	0.686	0.166	
2002	North	9.566	0.662	0.552	0.794	0.092	} * N>S
	South	25.317	0.216	0.147	0.318	0.192	
2003	North	8.851	0.649	0.501	0.841	0.131	} * N>S
	South	17.598	0.320	0.242	0.422	0.139	
2007	North	12.710	0.423	0.318	0.562	0.142	} ns
	South	12.483	0.417	0.326	0.534	0.122	

Lagorchestes conspicillatus

		ESW	D	D LCL	D UCL	D CV	Difference?
1998	North	11.501	0.656	0.540	0.797	0.099	} * N>S
	South	30.865	0.193	0.170	0.219	0.063	
2000	North	9.951	0.682	0.563	0.825	0.097	} ns
	South	12.621	0.519	0.439	0.612	0.084	
2001	North	14.673	0.457	0.383	0.545	0.090	} * N>S
	South	28.518	0.234	0.201	0.272	0.077	
2002	North	30.472	0.220	0.167	0.289	0.139	} ns
	South	35.009	0.203	0.165	0.249	0.105	
2003	North	16.349	0.379	0.294	0.488	0.128	} * N>S
	South	33.246	0.202	0.170	0.239	0.086	
2007	North	17.437	0.362	0.311	0.422	0.077	} ns
	South	19.706	0.356	0.299	0.423	0.088	

Key:
- ESW — Effective Strip Width or Effective Detection Radius (metres)
- D — Density of individuals (animals/ha – note data are total of 6 transects)
- D LCL — Density of individuals (lower analytical confidence limit) per ha
- D UCL — Density of individuals (upper analytical confidence limit) per ha
- D CV — Density of individuals analytical coefficient of variance

ns not significant
* significant difference between North and South transects, p>0.05

Table 2. Vehicle traverse spotlighting data: DISTANCE 3.5 analyses

Species	**North**	**South**	**Difference?**
Isoodon obesulus	9.29 ± 1.50	10.08 ±1.15	ns
Trichosurus vulpecula	12.74 ± 1.51	21.70 ± 4.34	*
Bettongia lesueur	8.98 ± 0.87	15.31 ± 2.51	*
Lagorchestes conspicillatus	16.73 ± 2.98	26.66 ± 3.56	*

ns not significant
* significant difference between North and South transects

Table 3. Mean 'Effective Strip Widths' (metres) for the four commonly-sighted species: 1998, 1999-2003 and 2007.

Date	16th	17th	19th	20th	22nd	23rd
North	22	27	9	6	34	24
South	32	22	17	22	27	38

Table 4. Number of hare-wallabies observed over six nights in October 2001

	ESW	**D**	**D LCL**	**D UCL**	**D CV**	**Difference?**
North	12.250	2.743	2.572	2.924	0.033	} * N>S
South	15.896	2.108	1.968	2.257	0.035	

Table 5. DISTANCE 3.5 analysis of all species combined except 'rodents' from 1998, 2000-2003 and 2007 trips. Abbreviations as in Table 2.

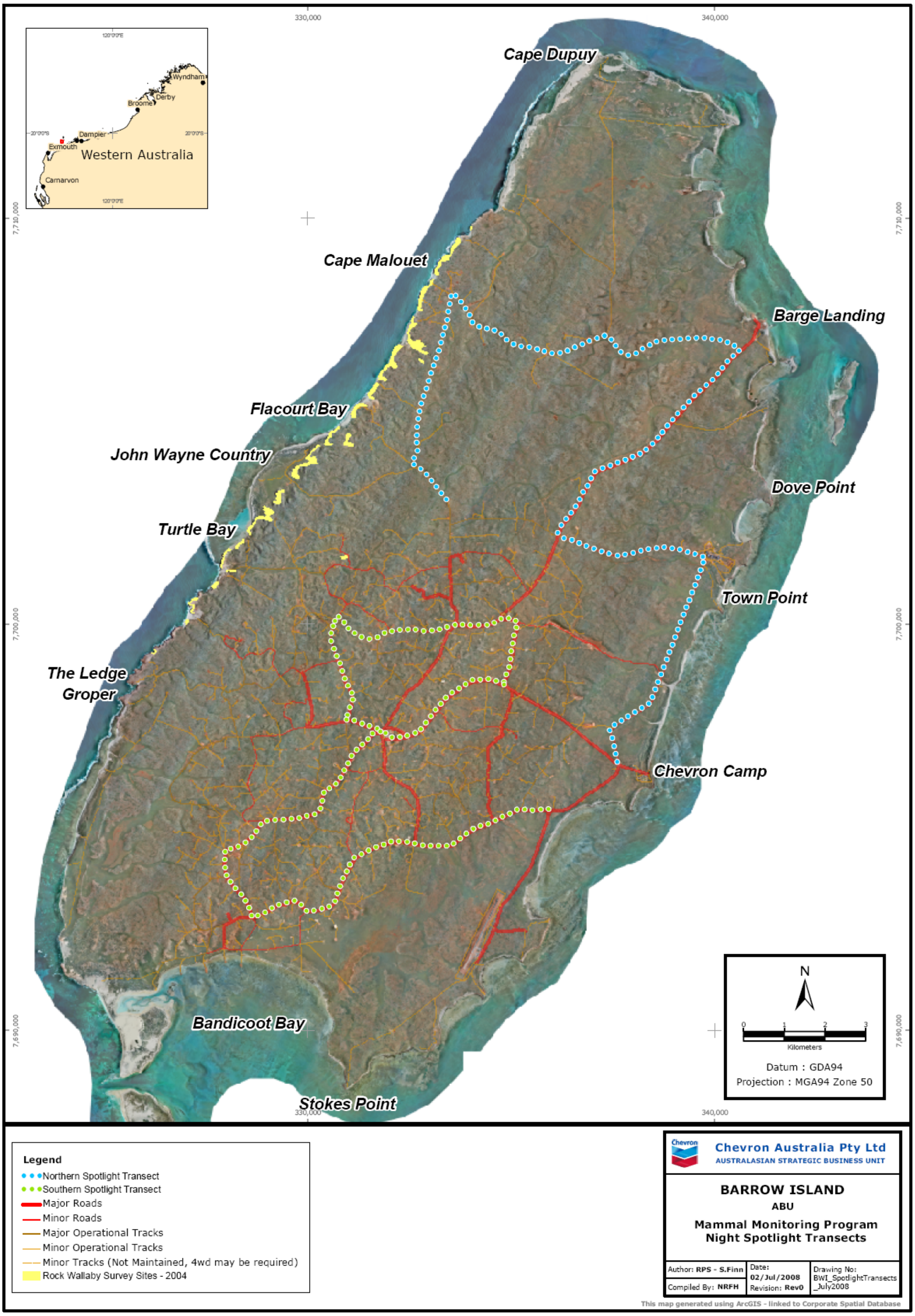
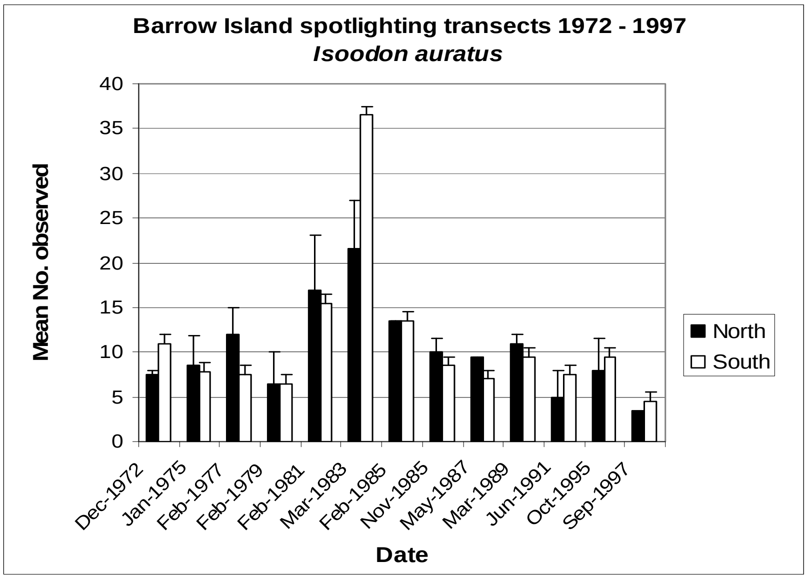


Figure 1. Barrow Island showing spotlighting routes.



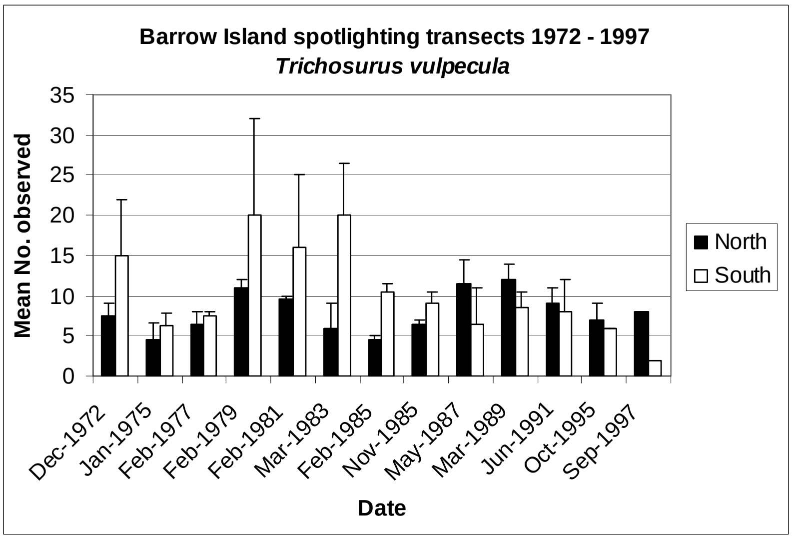
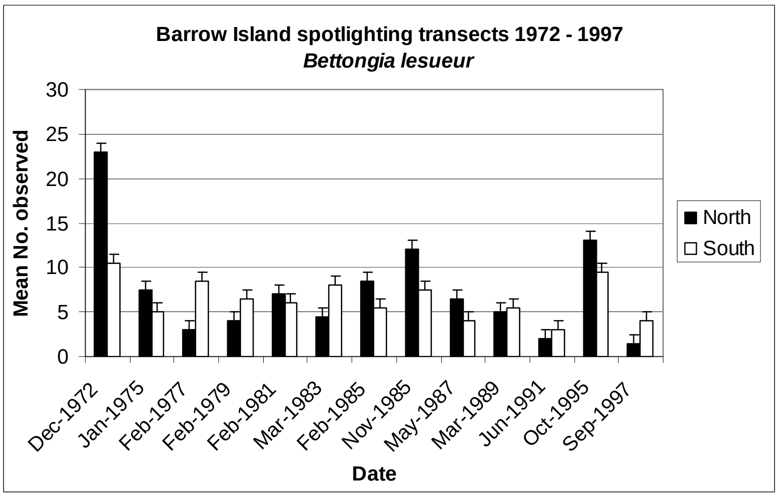
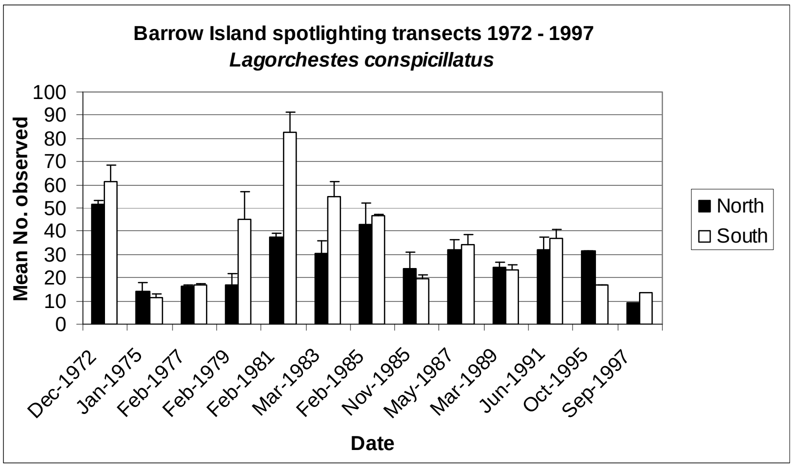


Figure 2. Barrow Island Nature Reserve spotlighting data 1972 – 1997. Means of between two and four counts on each transect are shown with Standard Error bars.




Barrow Island spotlighting transects 1972 - 1997
Lagorchestes conspicillatus
Mean No. observed
100
90
80
70
60
50
40
30
20
10
0
Dec-1972
Jan-1975
Feb-1977
Feb-1979
Feb-1981
Mar-1983
Feb-1985
Nov-1985
May-1987
Mar-1989
Jun-1991
Oct-1995
Sep-1997
Date
North
South