Field Report

A Description of Humpback Whale Behaviour Patterns in Nickol Bay Western Australia Using Vessel Based Surveys

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1. Objective

The primary purpose of this study is to identify the normal range of behaviour patterns exhibited by humpback whales in the Nickol Bay region of northern Western Australia. A standardised methodology for collating behaviour types will be used in successive seasons to assess change in behaviour patterns due to anthropogenic disturbance. Part of this assessment will entail analysis of concurrent environmental data so that distinctions between anthropogenic and environmental sources for change in behaviour can be identified if necessary.

2. Introduction

The Centre for Whale Research (CWR) was commissioned by Australian Premium Iron Ltd (API) in July, 2010, to design, conduct and analyse, a series of behavioural surveys that would best complement existing datasets and fill knowledge gaps in humpback whale life history data along the inshore western Pilbara coastline (Figure 1). Knowledge of humpback whale behaviour patterns in this region is limited to surveys near the Dampier Archipelago during the early 1990's and the Kimberley during the mid-1990's (Jenner et al. 2001). The area offshore of the Dampier Archipelago was described as a migration path while the Kimberley was described as a resting and calving ground.

The Centre for Whale Research, in consultation with API, settled on a Before/During/After system of assessing impact to normal whale behaviour patterns in the area. This report represents the "Before" data series.

3. Materials and Methods

4.1 General Concept

Whale pod behaviour distribution plots from systematic vessel surveys during August/September 2011 and 2012, will be used to compare with similar plots from "normally" distributed whales observed in 2010 using quantitative techniques developed to study whale behaviours in Exmouth

Gulf (Jenner *et al.*, 2010). Specifically, whale distribution and behaviour patterns in relation to an area where pile driving activities will be undertaken will be examined using passing mode (vessel does not deviate from trackline) line transects and individual behavioural follows. Before, During and After comparisons such as this require empirical data to be meaningful. Here we describe traditional line transect methods and a new technique for quantifying behaviours patterns, the Pod Activity Index.

4.2 Line Transects

Three observers scanned the horizon from a spotting tower at height of eye of 7 metres during daylight hours while the vessel (the *RV WhaleSong II*) was steaming at 7-8 knots. Two line transects 40 km in length (total 80 km) were conducted from Nickol Bay to north of Legendre Island, overlapping the 2009/2010 aerial survey flight path during the expected peak of season in August/September. The transects were described as either "Inshore" or "Offshore" for comparative purposes (ie. do whales behave differently Inshore vs. Offshore) although it is recognised that the two transects shared a common eastern terminus (Figure 1).

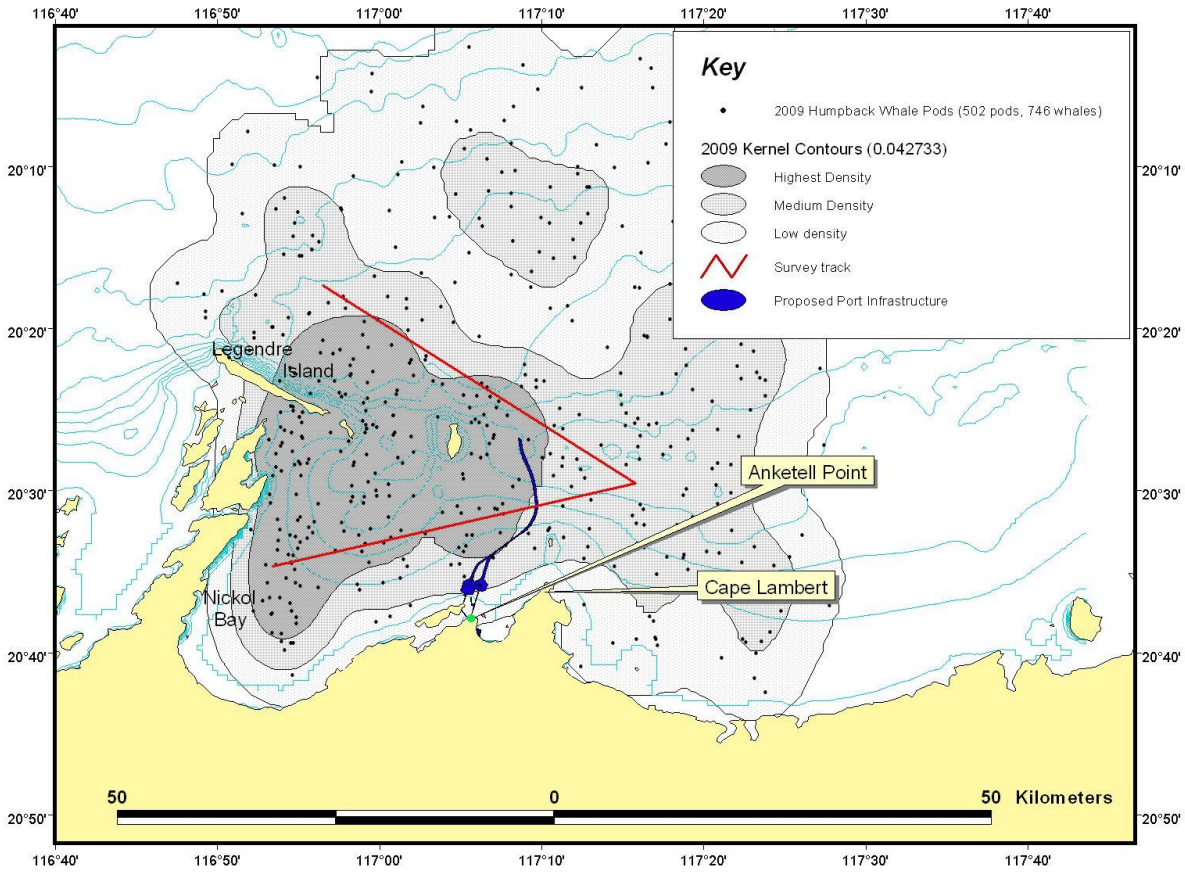

Figure 1. Inshore and Offshore vessel survey transects (red) overlaid on 2009 aerial survey density plot of humpback whales from the August to November period.

Upon sighting a whale or pod of whales, a Global Positioning System (GPS) waypoint was recorded with a sighting cue, and a compass bearing taken to the whale(s) in order to later plot the position of the pod for spatial analysis. Pods composition were described as combinations of either Adults

(whales >11m long), Sub-adults (whales >7m but <10m long) or Calves (whales <7m long and travelling with an adult).

Binoculars (handheld 7 x 50) were used to identify behaviour types that were not readily identifiable by eye. Behaviour types observed were categorised as either Active or Passive depending on whether splashing-type behaviours were observed. Detail of behaviour type sighted (i.e., breaching, pectoral fin slapping, trumpeting, etc.) was listed, and was based on a standardised list of 26 humpback whale behaviours used by CWR since 1990 (see Table 1).

Swim categories were assigned, after agreement from the most experienced spotter, to all pods of whales, and were based on the following general definitions;

- Resting – whales lying submerged or at the surface, not swimming
- Milling - whales swimming in different directions (>20° deviation approx.)within 3 surfacing periods or towards an obstacle that would prevent further migration (i.e. the shoreline)
- Migrating – whales swimming in a straight line (<20° deviation approx.) for more than 3 surfacing periods
- Speed Fast – swim speed >5 knots, whales charging the surface, breathing hard and frequently (intervals <1min)
- Speed Medium – swim speed 3-4 knots, steady downtimes/blow rates, not hard breathing
- Speed Slow – swim speed 1-2 knots, light breathing

4.3 Behavioural Follows

In order to develop a detailed and comparative picture of humpback whale behaviour in relation to the future pile driving and/or dredging activities, focal pod follows were conducted throughout the 2010 study period in range bins radiating outwards at two nautical mile intervals (maximum range 18 nm) from the proposed pile driving site(s) (Figure 2). Each pod focal follow was approximately 30 minutes in duration.

Details of the behaviours observed (Table1) during each surface sequence were recorded and surface/dive sequences marked with a GPS waypoint. The proportion of surface time each pod displayed Active, Passive, and Neutral behaviour was used to calculate a 'Pod Activity Index' (PAI). The index is empirical evidence of behaviour patterns "Before" pile driving, dredging and shipping activities begin, that can be used in a statistical comparative process with similar data collected for the "During" and "After" phases of the project.

Pods of whales are termed either "Active" or "Passive" in this report based on the behaviours they exhibited during observation periods (both Transects and Behavioural Follows).

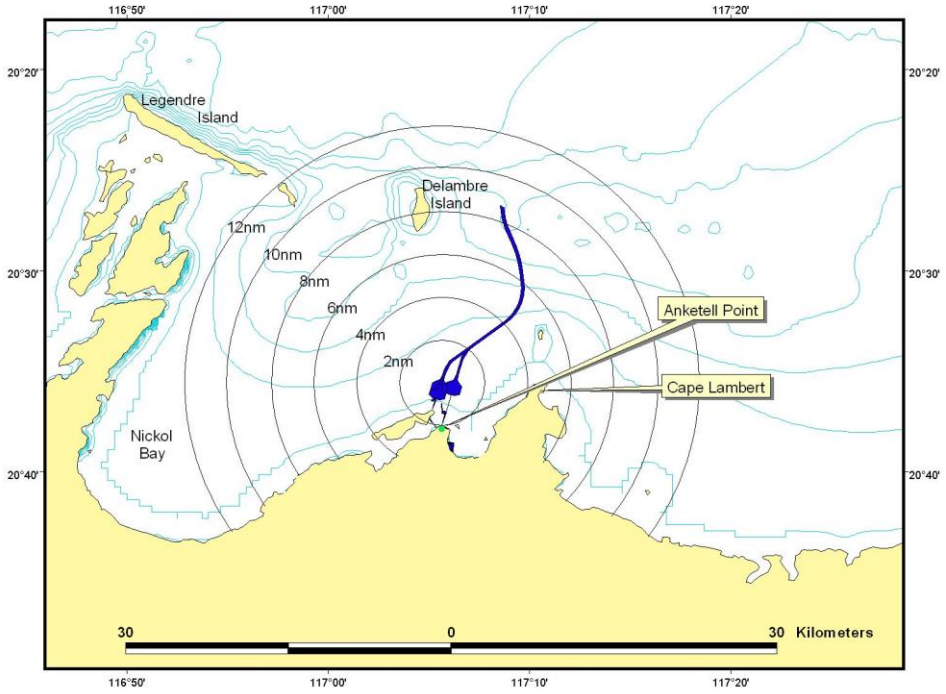

Figure 2. Range rings at 2 nautical mile intervals used for binning behaviours of pods followed for 0.5 hour periods at different ranges to the proposed pile driving activities.

Table 1. Behaviour categories for line transects and behavioural follows.

Active	**Passive**
BREACH	NO BLOW RISE
FLUKE SLAP	SURFACE LYING
HEAD LUNGE	CIRCLING
HEAD SLAP	FLUKE DOWN DIVE
INVERTED FLUKE SLAP	FLUKE EXTENSION
PECTORAL FIN SLAP	FLUKE UP DIVE
PEDUNCLE SLAP	LATERAL FLUKE EXTENSION
PECTORAL FIN WAVE	PEDUNCLE ARCH
TAIL COCK	SURFACE TRAVEL
PEDUNCLE COCK	MUD ROLLING
SPY HOP	
SNAKING	
TRUMPETING	
TAIL SWISH	
UNDERWATER BLOW	
BUBBLE TRAIL	

4.4 Photo-Identification

Where possible, during both the passing mode line transects and the behavioural follows, photographs of the lateral bodies and tail flukes of individual whales were taken with high resolution digital cameras with telephoto lenses. Matching individually identified humpback whales against others photographed within the twenty day study period established maximum residency periods and thereby helped determine the importance of this embayment to the population.

5 Results

5.1 General

A total of 57 behavioural follows and 9 line transects were conducted during 110 hr and 619 nm of survey effort between August 23 and September 13, 2010 (Table 2). A total of 127 humpback whales from 56 pods, 23 which were cow/calf pods, were observed during the behavioural follows and 432 whales in 272 pods, inclusive of 10 calves were sighted during the line transects.

Two species of dolphins were sighted during the line transects, 17 pods of bottlenose dolphins (*Tursiops truncatus*) and 2 pods of Indo Pacific humpback dolphins (*Sousa chinensis*) along with 10 pods of "unidentified dolphins" (those sighted too far away for accurate species identification). No snub fin dolphins nor dugongs were sighted during the 20 day survey period.

Table 2. Daily activity log for the 20 day survey period between August 23 and September 13, 2010.

Day #	Date	# Survey Hours (decimal)	# Nautical Miles (nm)	Activities
1	23-Aug-10	6.87	51.70	1 x Transect Survey.
2	24-Aug-10	1.33	2.70	2 x Behavioural Follows. 1 x practice run & 1 x control.
3	25-Aug-10	2.18	6.90	3 x Behavioural Follows.
4	26-Aug-10	4.17	34.40	1 x Transect survey, shorter trackline.
-	27-Aug-10	-	-	No field work, wind speed >25kts.
5	28-Aug-10	3.12	7.20	3 behavioural follows, photo ID.
6	29-Aug-10	7.22	50.30	1 x Transect survey. 2 x Behavioural Follows.
7	30-Aug-10	9.67	43.54	8 x Behavioural Follows.
8	31-Aug-10	9.53	65.80	1 x Transect survey, 3 x Behavioural Follows.
9	1-Sep-10	9.80	54.90	0.75 Transect survey, 4 x Behavioural Follows.
-	2-Sep-10	-	-	No field work, wind speed >25kts.
10	3-Sep-10	3.52	8.40	4 x Behavioural Follows.
11	4-Sep-10	3.52	29.10	0.75 Transect survey.
12	5-Sep-10	3.03	15.10	3 x Behavioural Follows.
13	6-Sep-10	8.32	31.70	7 x Behavioural Follows.
14	7-Sep-10	2.88	23.80	0.5 x Transect.
15	8-Sep-10	8.23	19.20	10 x Behavioural Follows.
16	9-Sep-10	5.37	44.40	1 x Transect
17	10-Sep-10	7.99	51.30	1 x Transect (T3-T4), 3 x Behavioural Follows
18	11-Sep-10	5.17	20.70	3 x Behavioural Follows.
19	12-Sep-10	6.76	49.80	1 x Transect, 1 x Behavioural Follows
20	13-Sep-10	1.38	8.20	1 x Behavioural Follows
	TOTALS	110.05	619.14	

5.2 Line Transects

A total of 274 pods of humpback whales comprised of 422 individual animals were sighted during 16 line transects (Table 3). Less than four percent (n=10) of pods sighted contained calves. Nearest neighbour analysis for complete spatial randomness (using Arcview ver 3.2) was used to test pod distribution along the survey tracks for evidence of "clumping" during each line transect. Transects

were designated as either “Inshore” or “Offshore” for comparative purposes. All surveys, both inshore and offshore, demonstrated evidence of clumping (Table 4), indicating that some variable may affect pod distribution (ie. distribution is not random).

Table 3. Humpback whale sightings during line transects inshore and offshore near Nickol Bay during the August 23 to September 13, 2010, study period.

Date	Location	#Pods	# Whales	#Calves
23/08/2010	Inshore	34	46	0
26/08/2010	Inshore	19	28	0
29/08/2010	Inshore	24	45	1
31/08/2010	Inshore	17	30	0
01/09/2010	Inshore	27	38	1
04/09/2010	Inshore	17	21	0
07/09/2010	Inshore	15	25	1
09/09/2010	Inshore	19	25	0
12/09/2010	Inshore	8	11	1
23/08/2010	Offshore	35	50	1
26/08/2010	Offshore	19	29	1
29/08/2010	Offshore	7	19	1
31/08/2010	Offshore	19	31	2
01/09/2010	Offshore	2	3	0
09/09/2010	Offshore	8	12	0
12/09/2010	Offshore	4	9	1
Totals		**274**	**422**	**10**

Humpback whale density was estimated by recording pods within visual range by naked eye from 7 m above sea level along a 40 km transect (approx. 2.5 nm either side of the trackline). Densities were similar both inshore and offshore of the Bay and steadily decreased over the course of the study period (Figure 3).

Table 4: Nearest neighbor test results for complete spatial randomness for each line transect.

Date	N	R	Z	Result
23/08/2010	44	7.25E-06	-12.6898	CLUMPED
26/08/2010	33	8.20E-06	-10.9897	CLUMPED
29/08/2010	17	6.94E-06	-7.8877	CLUMPED
31/08/2010	26	8.43E-06	-9.7547	CLUMPED
1/09/2010	22	1.03E-05	-8.973	CLUMPED
4/09/2010	13	1.40E-05	-6.89758	CLUMPED
7/09/2010	12	1.11E-05	-6.627	CLUMPED
9/09/2010	20	9.45E-06	-8.55543	CLUMPED
12/09/2010	10	1.09E-05	-6.04959	CLUMPED

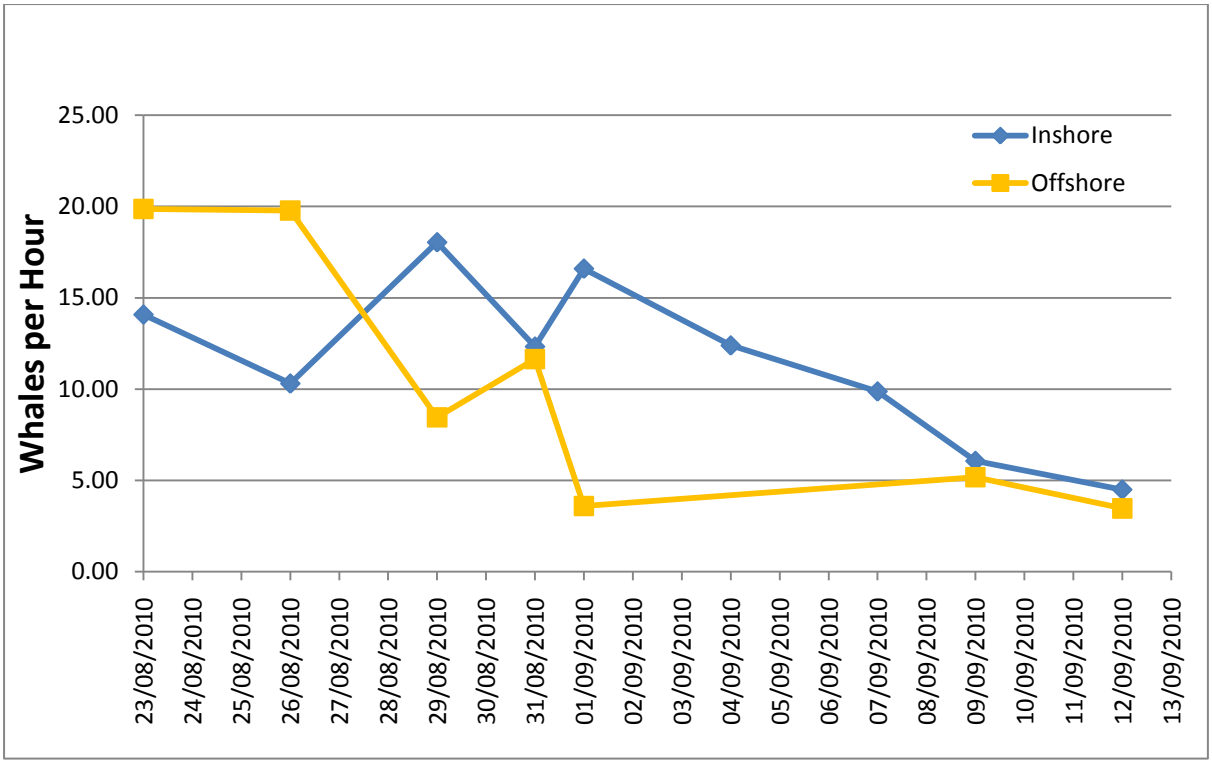

Figure 3. Humpback whale density measured using passing-mode line transects, both inshore and offshore near Nickol Bay, from August 23 to September 13, 2010.

The majority of humpback whale pods sighted, both Inshore (74.7%) and Offshore (57.8%), were classified as Passive although there was a higher proportion (42.1% vs 25.2%) of Active pods sighted on the Offshore transect (Figure 4). The large majority (60% and 47%) of pods sighted Inshore and Offshore were Migrating (swimming) rather than Milling or Resting at Medium (ca. 3-4 knots) speeds (Figures 5 and 6).

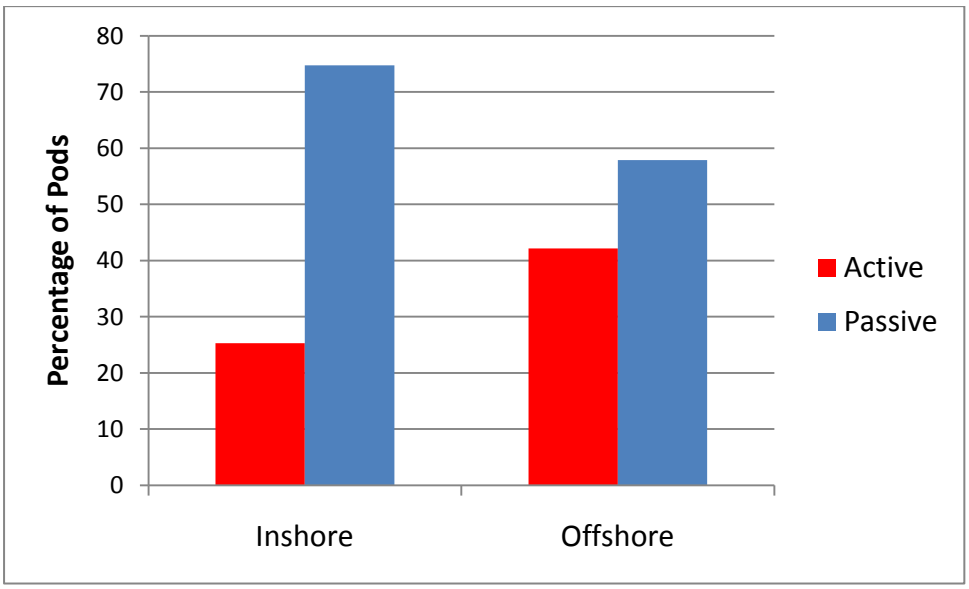

Figure 4. Percentage of humpback whale pods sighted displaying Active or Passive behaviour patterns during Inshore and Offshore line transects during the August 23 to September 13, 2010, study period.

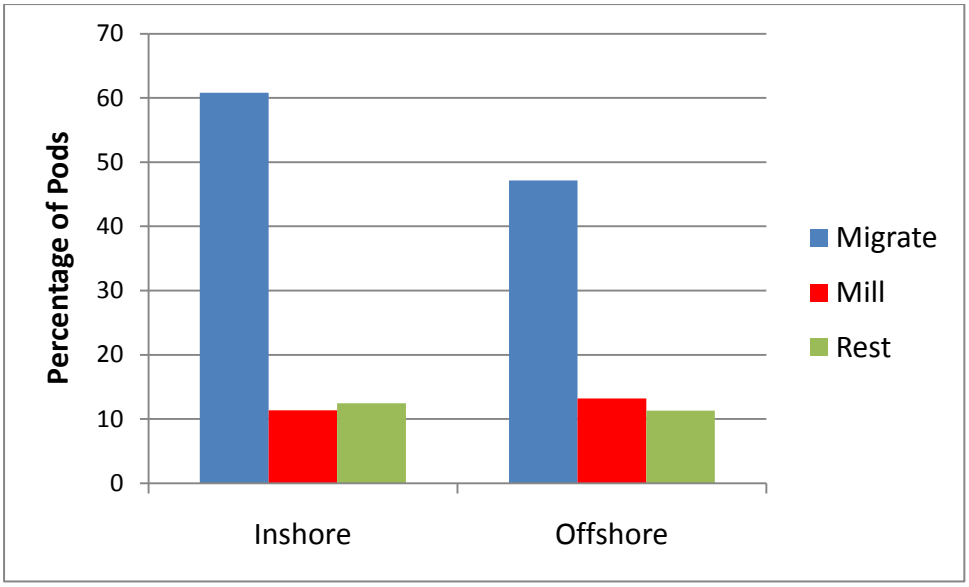

Figure 5. Percentage of humpback whale pods sighted Migrating, Milling or Resting during Inshore and Offshore line transects during the August 23 to September 13, 2010, study period.

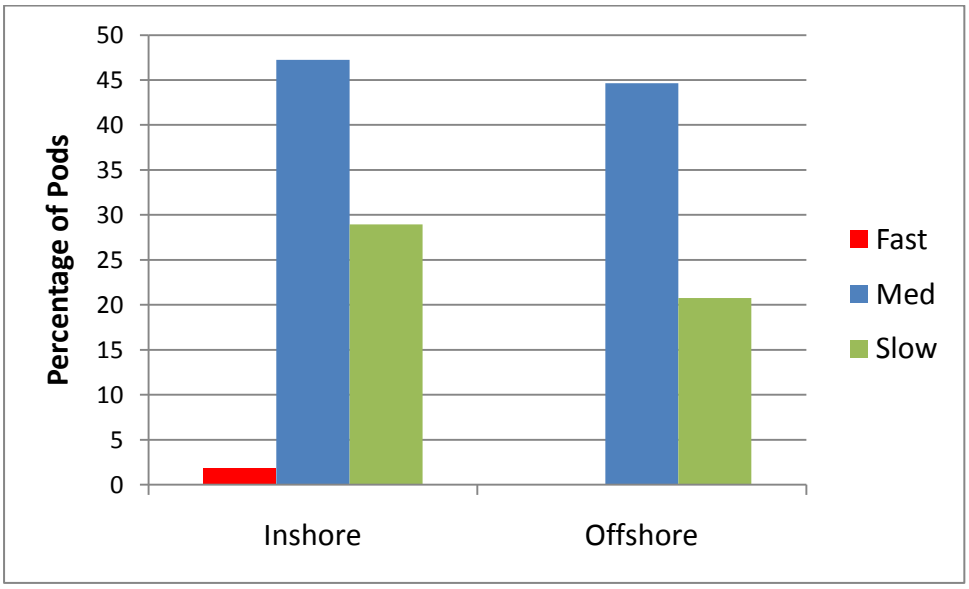

Figure 6. Percentage of humpback whale pods sighted swimming Fast, Medium or Slow speeds during Inshore and Offshore line transects during the August 23 to September 13, 2010, study period.

Density distribution plots of whales sighted during the transects were constructed for all whales sighted inshore and offshore of the bay, and then for pods classified as Active or Passive. Active and Passive plots included resting, milling and migrating pods.

Pods of whales sighted on the inshore were, in general, found in higher densities towards the eastern end of the transect, Offshore Nickol Bay and north of Anketell Point and Cape Lambert (Figure 7). Pods that were described as Active were found in highest density directly north of Cape Lambert (Figure 8). Highest densities of pods described as Passive were found north of Anketell Point/Cape Lambert and also in a small area in central Nickol Bay (Figure 9).

Pods of whales sighted on the offshore transect east and North of Nickol Bay were, in general, more evenly distributed than inshore (Figure 10). However, examining the distribution of pods described as Active showed that these whales were in highest densities north of Delambre Island (Figure 11). Pods of whales described as Passive offshore the bay were more evenly distributed (Figure 12).

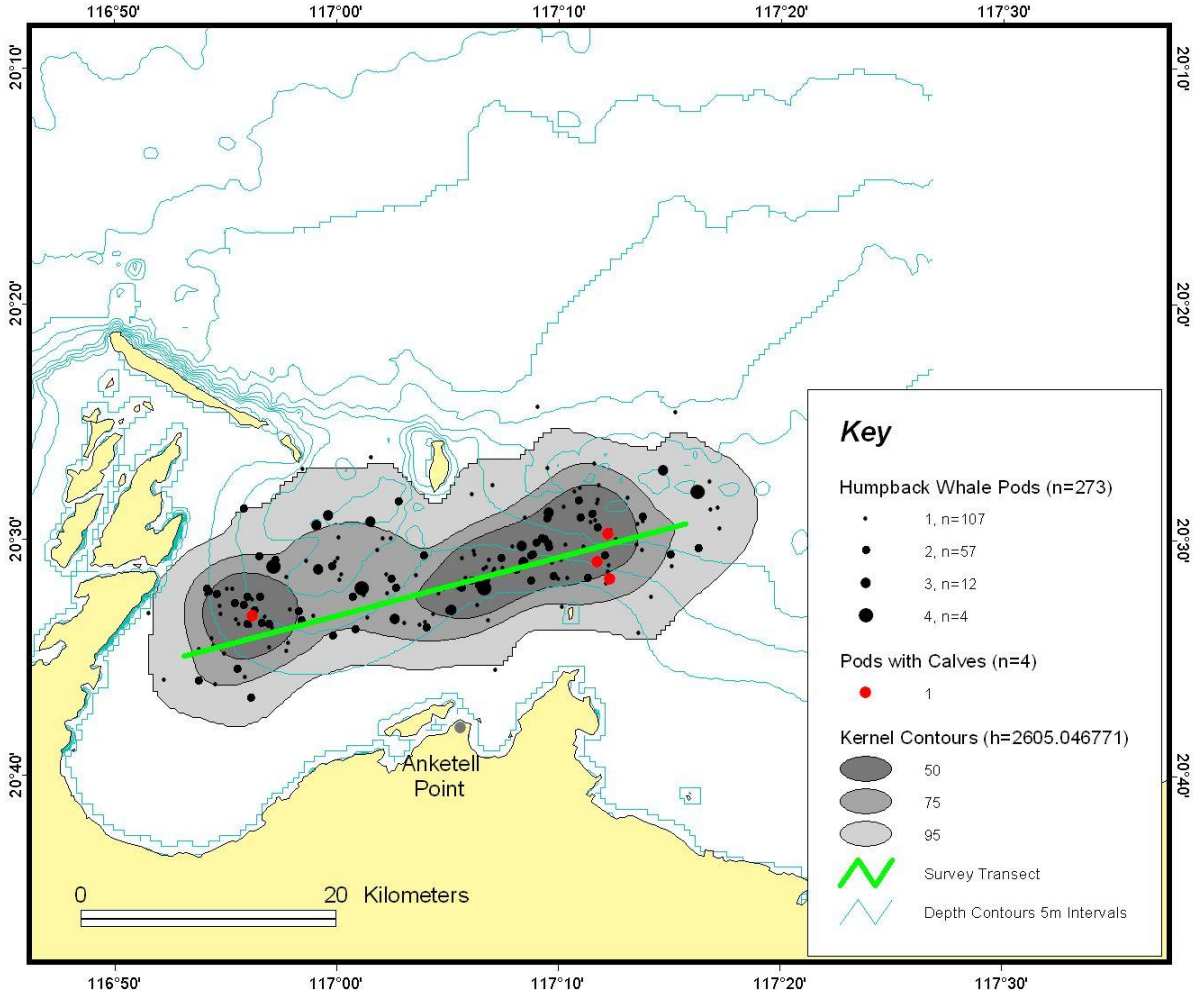

Figure 7. All humpback whale pods sighted Inshore near Nickol Bay during the August 23 to September 13, 2010, study period.

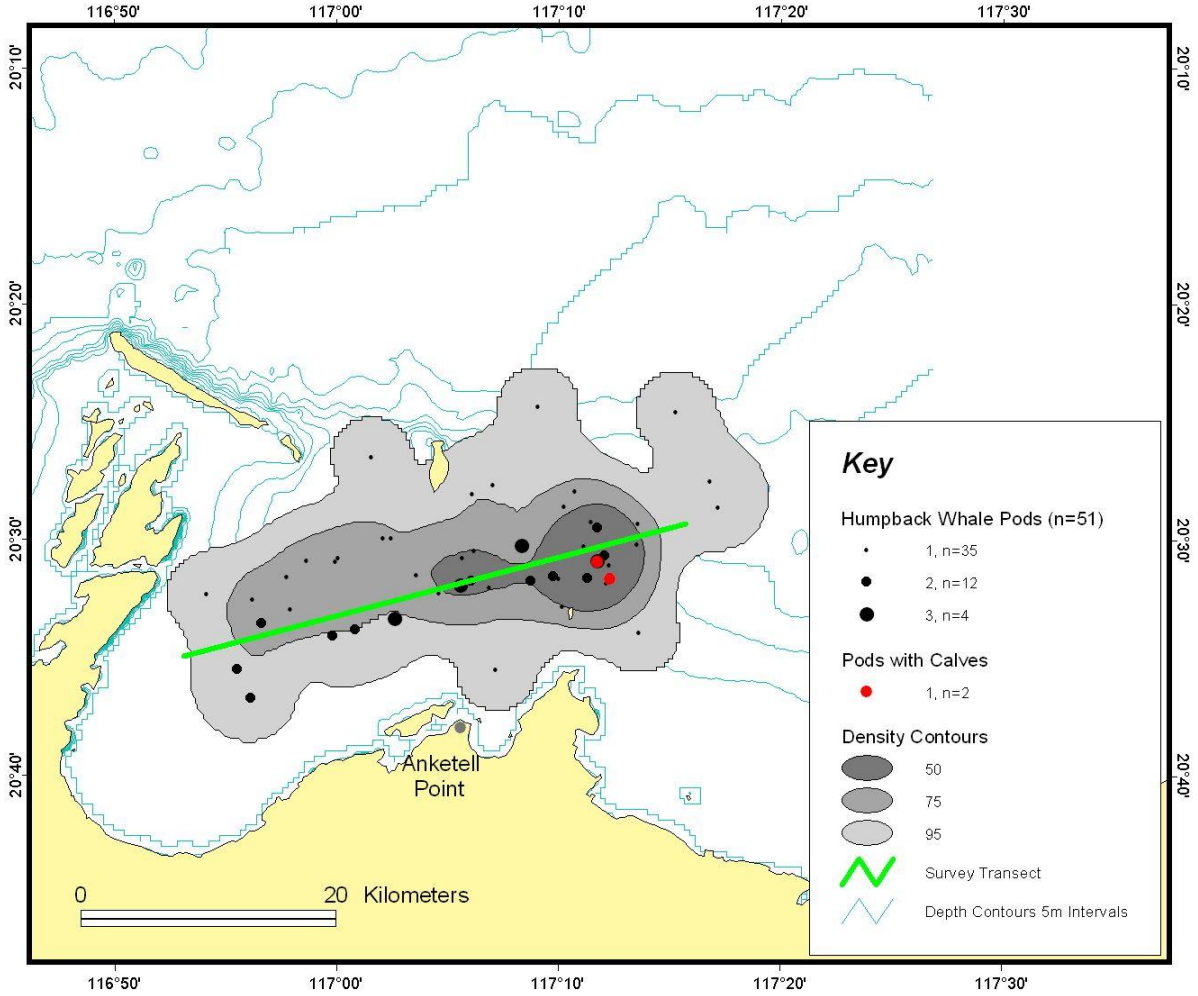

Figure 8. All humpback whale pods sighted Inshore near Nickol Bay and demonstrating Active behaviours during the August 23 to September 13, 2010, study period.

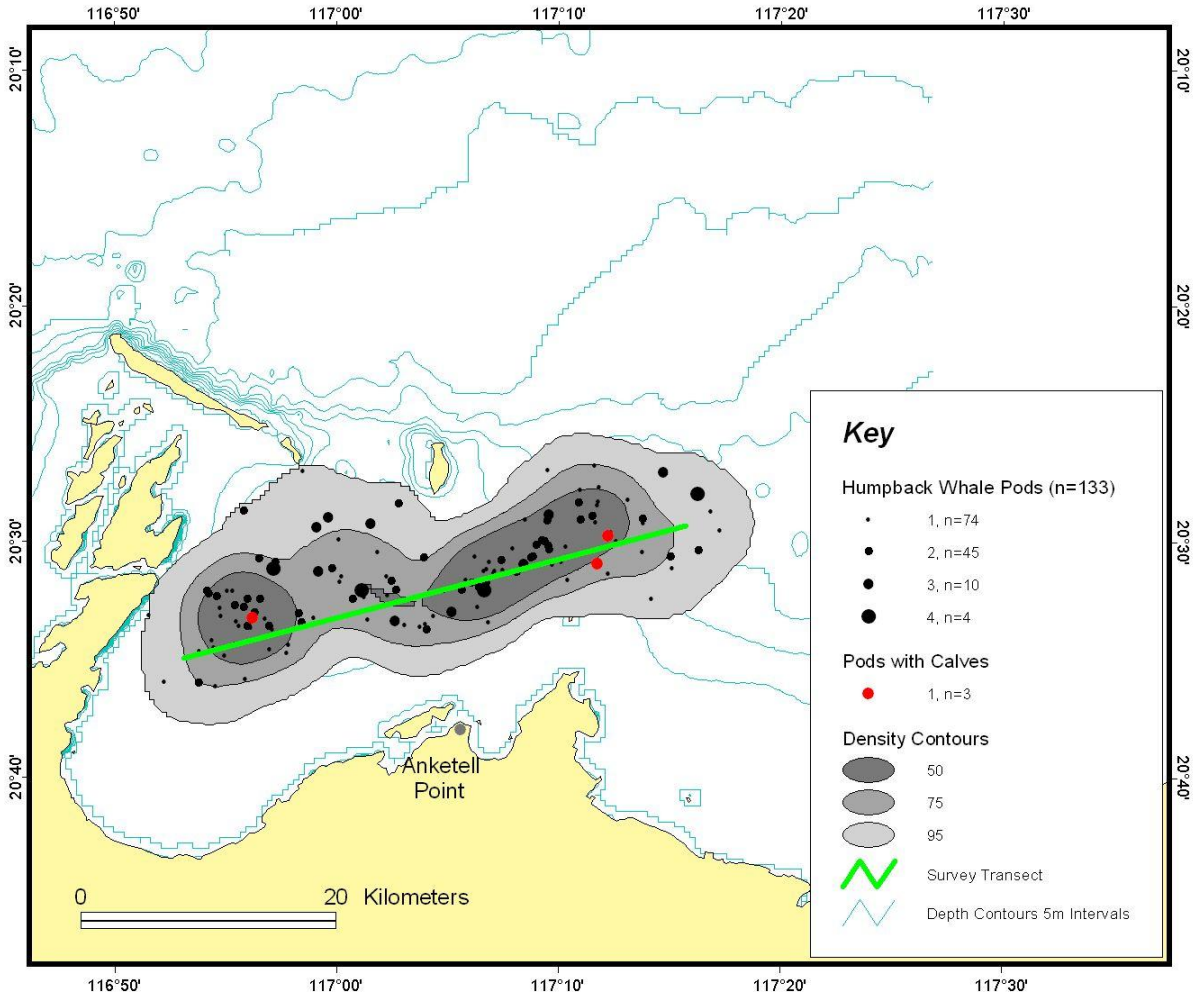

Figure 9. All humpback whale pods sighted Inshore near Nickol Bay and demonstrating Passive behaviours during the August 23 to September 13, 2010, study period.

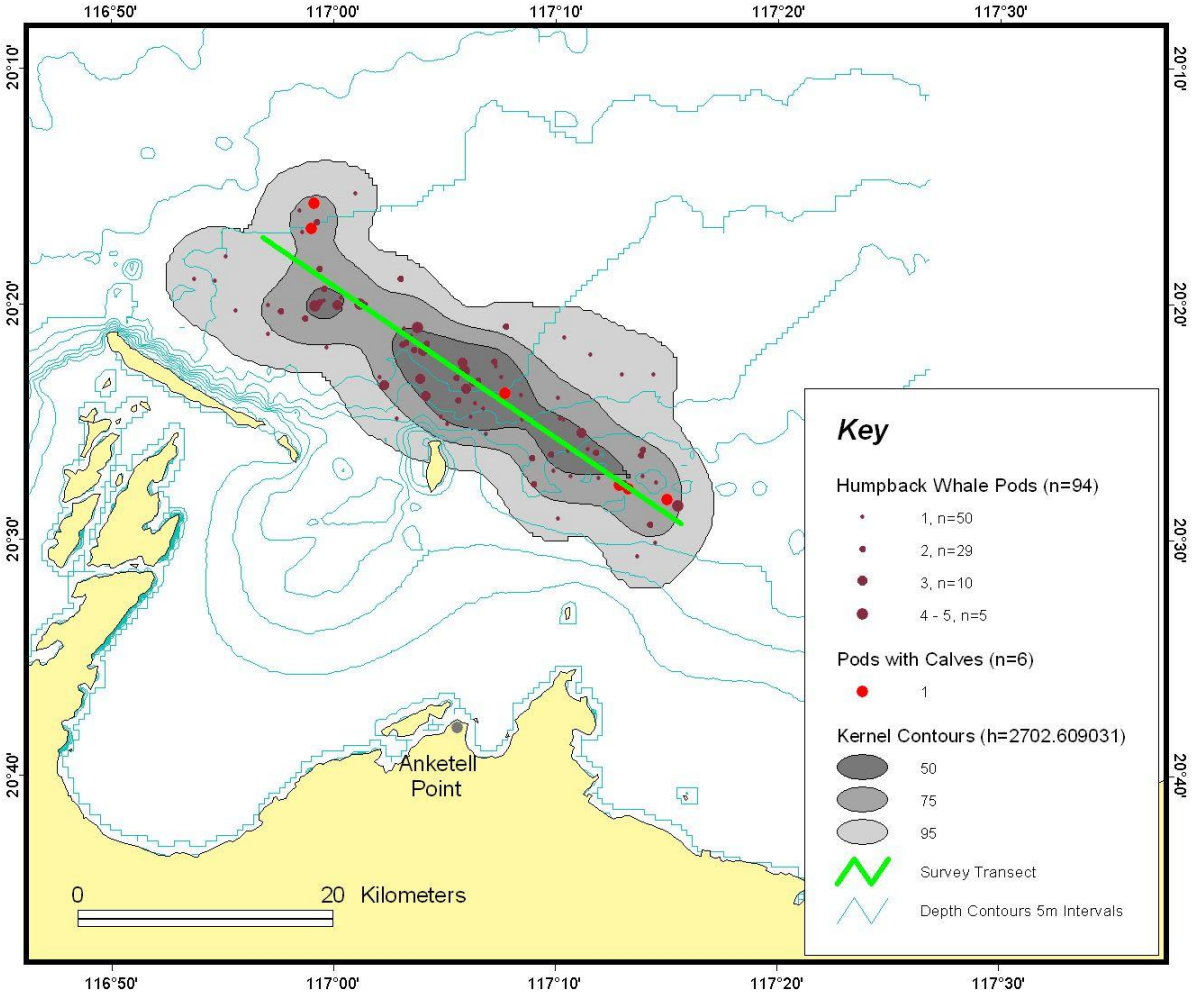

Figure 10. All humpback whale pods sighted Offshore near Nickol Bay during the August 23 to September 13, 2010, study period.

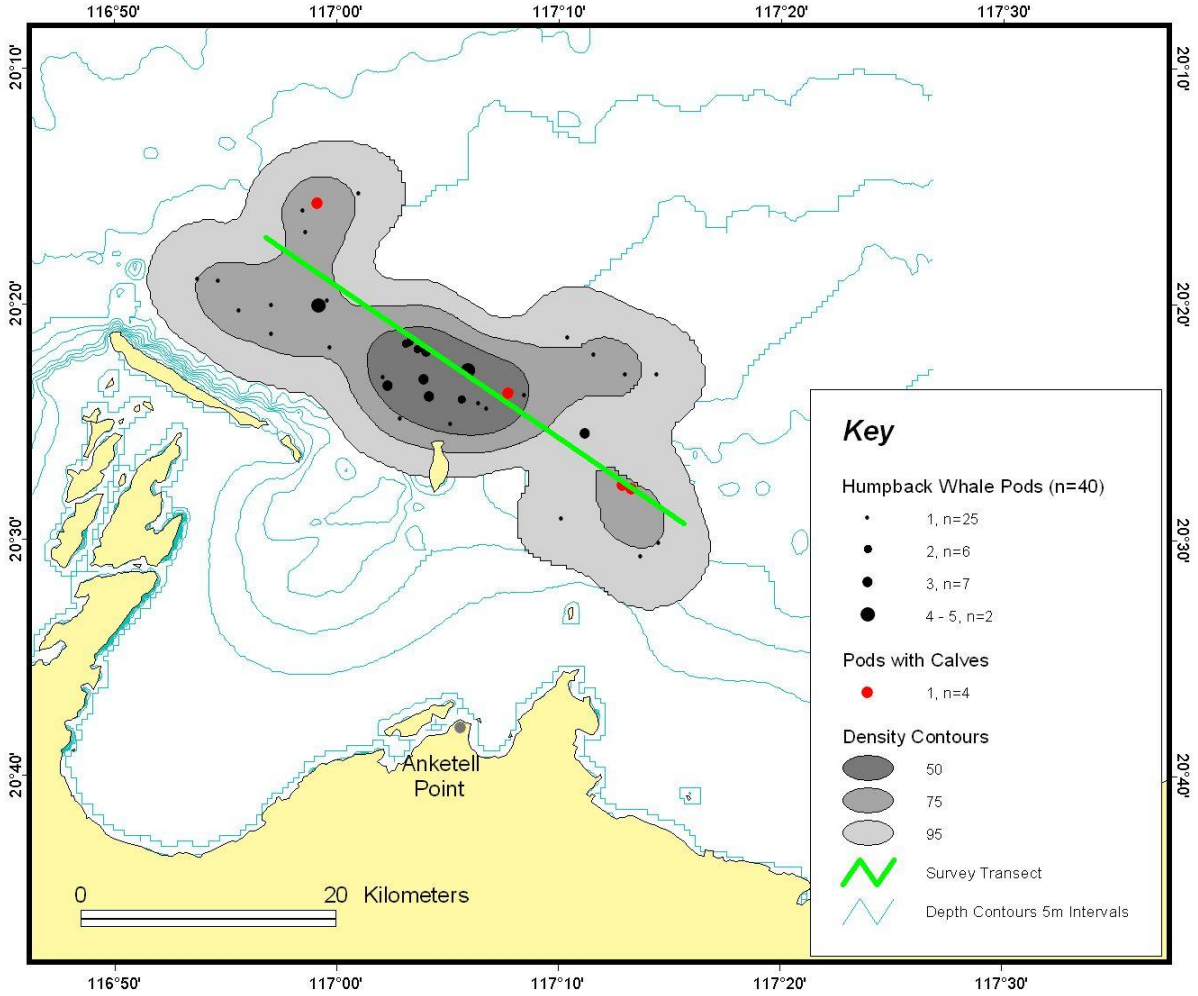

Figure 11. All humpback whale pods sighted Offshore near Nickol Bay and demonstrating Active behaviours during the August 23 to September 13, 2010, study period.

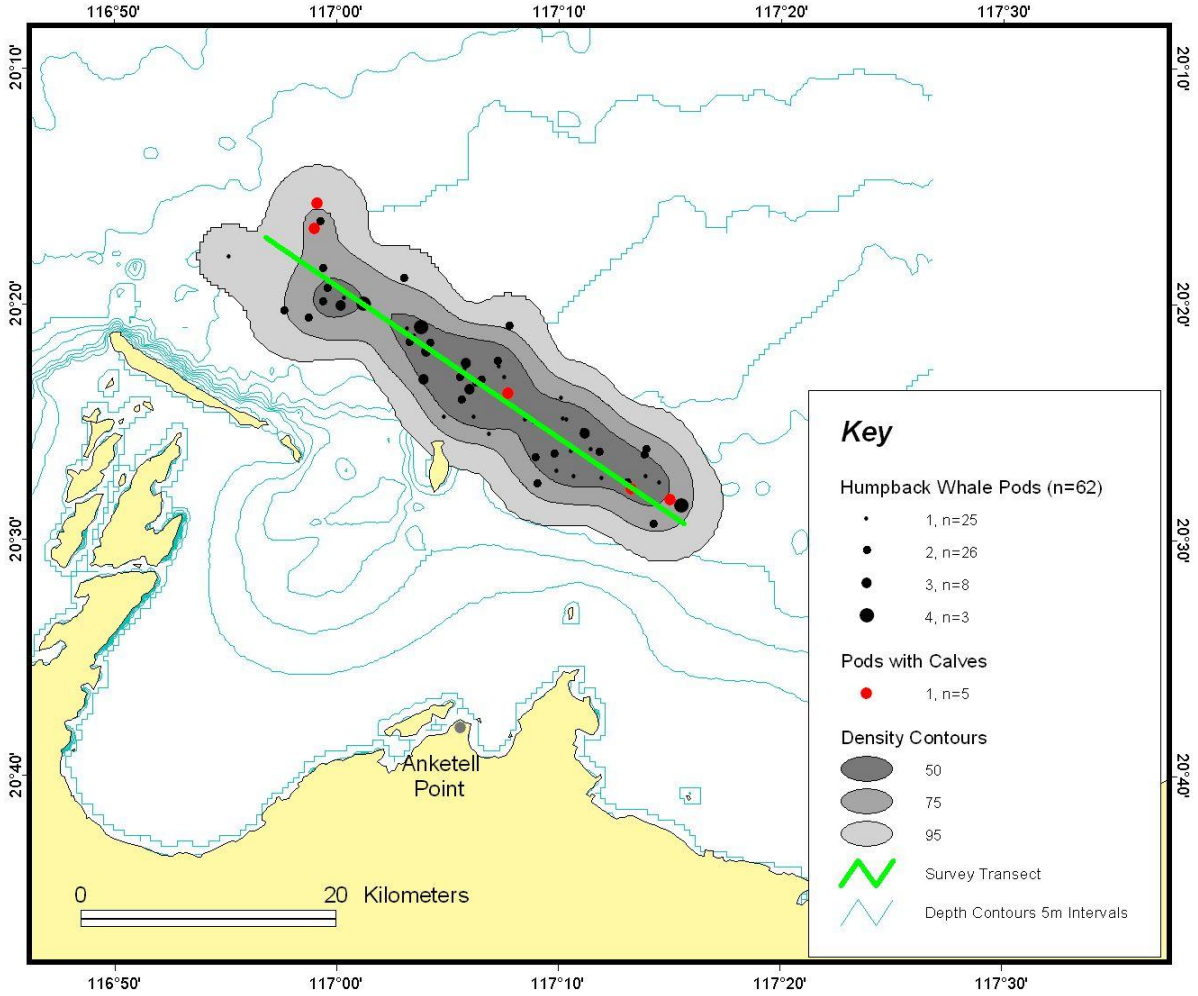

Figure 12. All humpback whale pods sighted Offshore near Nickol Bay and demonstrating Passive behaviours during the August 23 to September 13, 2010, study period.

5.3 Direct Behavioural Follows

A total of 56 behavioural follows were conducted during the survey period. No pods were sighted within two nautical miles of the proposed port facility and low numbers (< 3) were sighted out to four nautical miles (Table 5, Figure 13).

Table 5. Numbers of pod follows in each 2nm range bin radiating out from the proposed port facility.

Range Bin	Number of Follows
0 to 2	0
2 to 4	2
4 to 6	6
6 to 8	7
8 to 10	8
10 to 12	9
12 to 14	12
14 to 16	10
16 to 18	2
Total	**56**

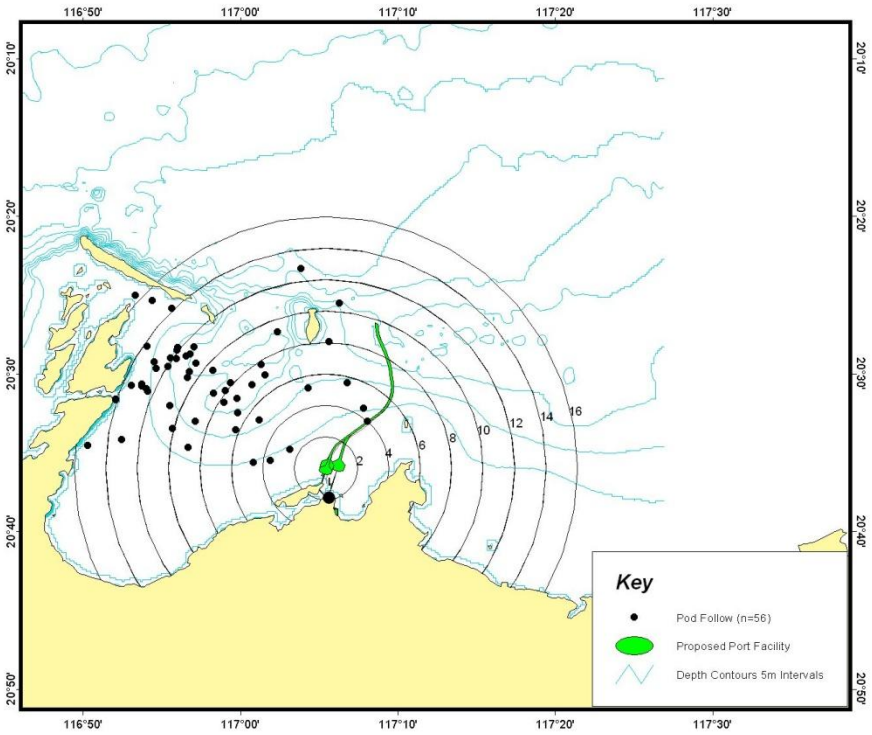

Figure 13. Start positions of 56 behavioural follows during the August 23 to September 13, 2010, study period.

Pod Activity Index levels were calculated for each pod for to establish behaviour patterns within each two nautical mile range bin at increasing distance from the proposed port facility. The maximum PAI (indicating active behaviour) was 0.76 in the 8-10 nm range bin while the lowest PAI was -0.70 in the 10-12 nm bin (Figure 11)

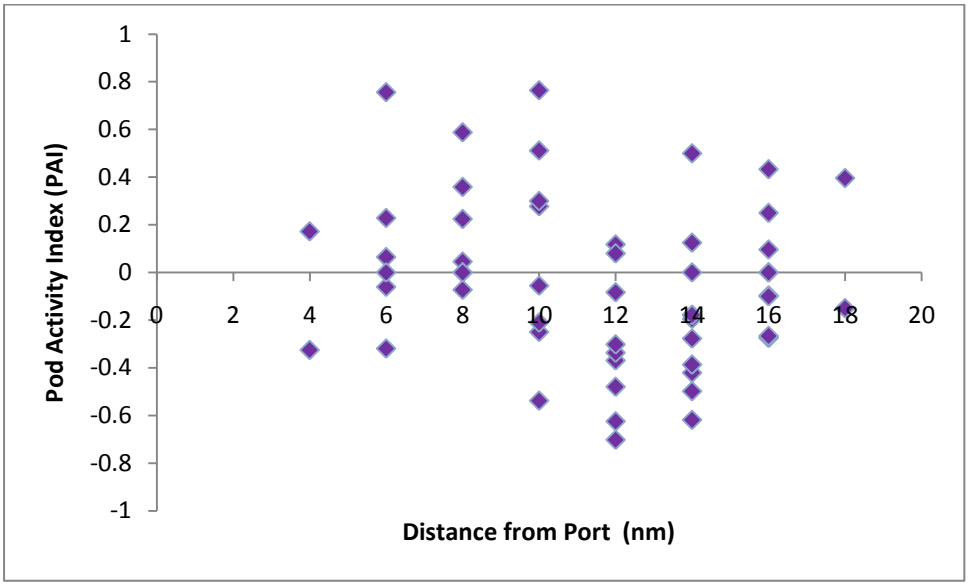

Figure 14. Pod Activity Index values for all 56 pod follows at increasing range from the proposed port facility.

Averaging the PAI values for each bin showed a trend towards Neutral behaviour patterns (Figure 14). Three range bins (4-6, 6-8 and 16-18 nm) showed more positive values, indicating Active behaviour patterns while four range bins (2-4, 8-10, 10-12 and 12-14) had more Passive behaviour patterns. One range bin (14-16nm) was scored Neutral and had equal numbers of Active and Passive behaviour types recorded (Figure 15). No area had completely Active or Passive behaviour types.

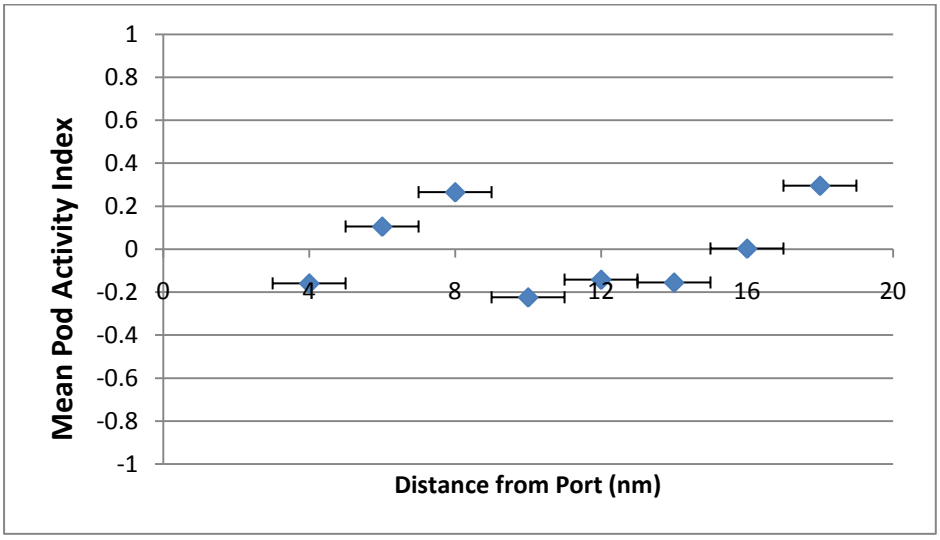

Figure 15. Mean pod activity index levels reported for each two nautical mile range bin during the August 23 to September 13, 2010, study period.

5.4 Photo-Identification

A total of 118 individual humpback whales, including 23 cow/calf pods, were photo-identified during the twenty day study period. No resights were found of any whales within this study period.

6 Discussion

This report summarises a study programme carried out over 20 days between August 23 and September 13, 2010, in the Nickol Bay region. Vessel based survey techniques were used to establish a baseline understanding of humpback whale behaviour patterns prior to the construction of a new port facility. Surveys were conducted over the expected peak of season, confirmed both by previous aerial surveys (Jenner and Jenner, 2009) and the steadily decreasing number of sightings during the current survey period which is consistent with a peak in mid-late August.

A series of systematic passing mode line transects were used to show patterns in humpback whale behaviour and distribution Inshore and Offshore of Nickol Bay. Whales Inshore and Offshore were found in equal proportions Resting and Milling while whales Offshore were more often found exhibiting Active behaviours. Two flux points where whales were more Active and appeared to "decide" whether to enter Nickol Bay or to continue migrating were observed. North of Cape Lambert, where whales could enter the Bay from the east, high higher activity levels were observed, and also to the north of Delambre Isalnd where whales could also enter (or exit) the Bay. In all other areas, surveyed whales were largely reported as demonstrating Passive behaviours.

More detailed examinations of behaviour patterns through behavioural follows of individual pods resulted in a wide range of values for the Pod Activity Indexes. No definite pattern of behaviour could be observed with increasing/decreasing range from the proposed port facility within Nickol Bay. It is important to note that whales were seldom sighted within 4 nm of the proposed port area and no whales were sighted within 2 nm of the area. This may be due to the natural barrier formed by shallow water between a small islet and the northern tip of Cape Lambert which prevents whales from approaching Anketell Point directly from the east.

Smoothing the behavioural follows dataset by averaging the index values for each two nautical mile range bin away from the proposed port facility resulted in values close to Neutral for each bin. In conclusion, it is the opinion of the authors that a reasonable understanding of the role that Nickol Bay plays for this population of humpback whales has been obtained using the two techniques described above. There were no consistently Active, nor consistently Passive, regions within the Bay which is a useful record for the baseline dataset.

Also useful are the results of the photo-identification study, that show that whales in this population are not resting for extended periods in Nickol Bay. Put into a regional perspective, residency periods in Exmouth Gulf for cow/calf pods can approach 2 weeks and that for adult males 3 weeks (CWR unpublished satellite tag and photo-id data). It is interesting to note, however, that behaviour patterns observed for both cow/calf pods and non-cow/calf pods in both Exmouth Gulf and Nickol Bay are quite similar (Figure 16). It may be that humpback whales exhibit similar behavioural patterns throughout their range in Western Australia and what is significant is the amount of time they spend in each area, particularly cow/calf pods.

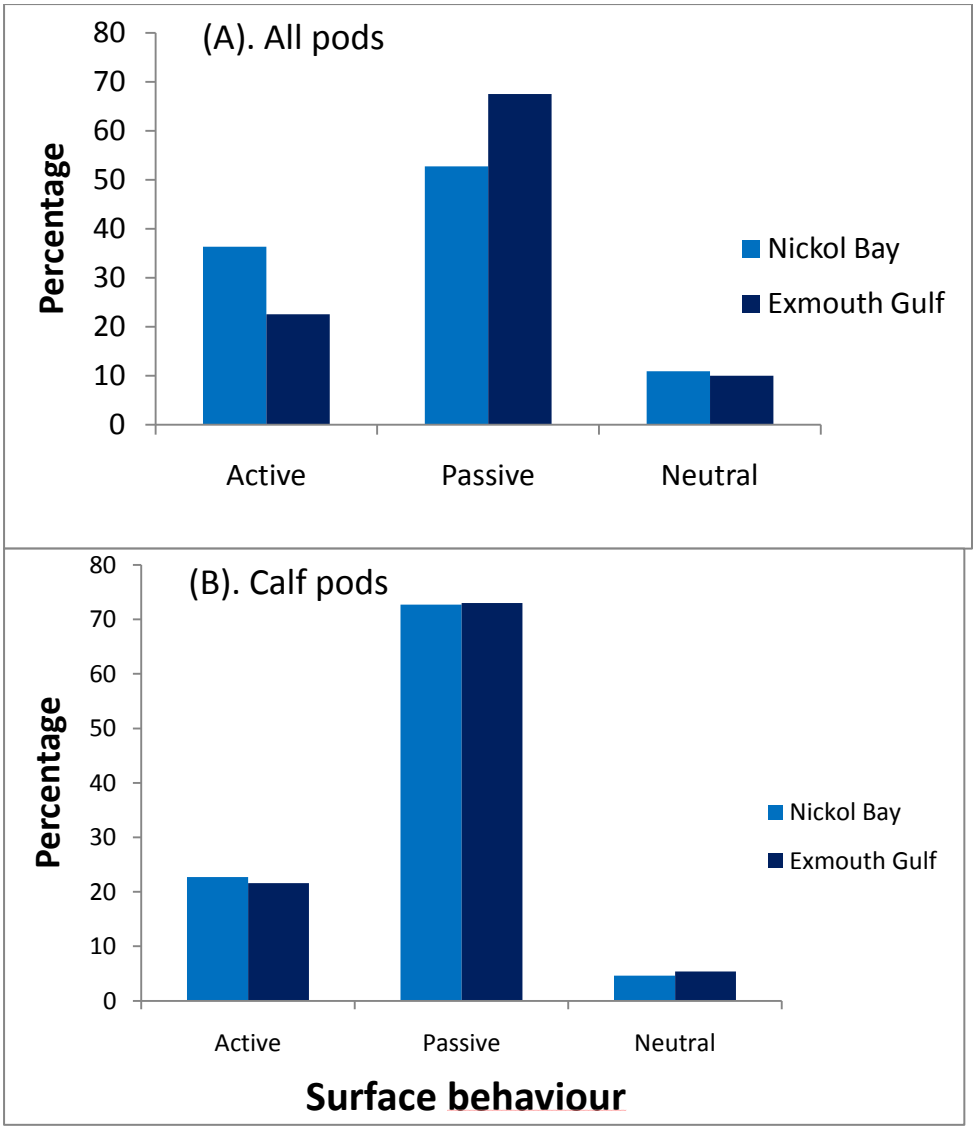

Figure 16. A comparison of behaviour patterns of humpback whales in Nickol Bay and Exmouth Gulf using identical survey techniques. (prepared by Gabrielle Cummins from CWR unpublished data).

What appears to be different about humpback whale usage of Nickol Bay, compared to Exmouth Gulf, is the overall density of whales that use the area. Densities of whales at peak season in Exmouth Gulf approach 73 whales/hour during vessel line transects while those conducted during the course of this survey in Nickol Bay at peak season densities are much lower at less than 20 whales/hour (Figure 17).

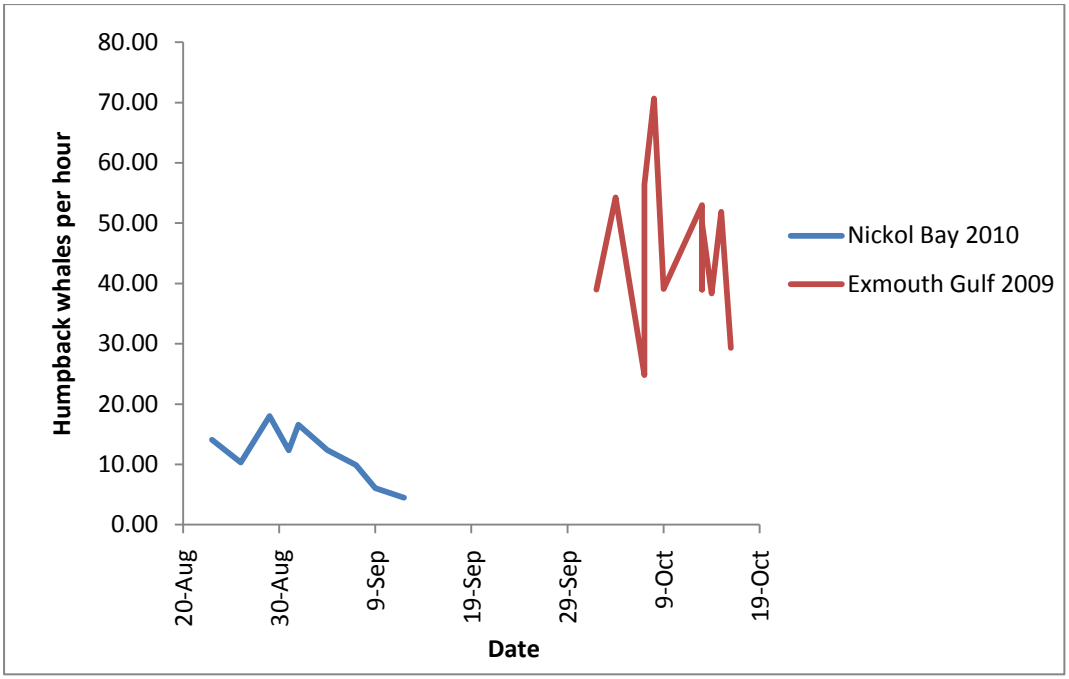

Figure 17. Comparison of humpback whale density during peak of season using vessel line transects at Nickol Bay and Exmouth Gulf (from Jenner *et al.*, 2010).

7. Summary

Vessel based surveys were conducted across a twenty day period during August and September, 2010, near Nickol Bay, Western Australia, a time period identified from aerial surveys in 2009 as the peak of season for humpback whales in the region. Behaviours of whale pods using two techniques, direct follows and passing mode line transects, were recorded in order to build a baseline understanding of "normal" humpback whale behaviour patterns in this area prior to development of the Anketell Point Iron Ore Port facility.

Passing mode surveys near Nickol Bay identified the majority of humpback whale pods sighted, both Inshore and Offshore, as Passive although there was a higher proportion of Active pods sighted on Offshore transects. The large majority of pods sighted were Migrating (swimming) rather than Milling or Resting at Medium (ca. 3-4 knots) speeds.

The portion of pods identified during the passing mode surveys as containing calves of the year was 3.6% Inshore and 9% Offshore. A low majority of cow/calf pods sighted during the line transects were resting (57%).

Behaviour patterns were consistent for 56 pods of whales followed for 0.5 hour periods Inshore near Nickol Bay at various ranges from the proposed port facility. Behaviour patterns for 52.7% of pods were classified as Passive while 36.3% were categorised as Active, and 10.9% were Neutral.

Pods containing calves were less often (22.7%) reported displaying Active behaviours.

Whales in Nickol Bay displayed almost identical behaviour patterns to those in Exmouth Gulf, a known resting area for humpback whales, however, unlike Exmouth Gulf no evidence of residency periods of over 24 hours was found, and maximum whale density values were significantly lower.

Given the relatively low residency periods (less than 24 hours) and low whale density values in the area, it appears that Nickol Bay is not used by humpback whales as major resting or staging area for this population despite relatively large numbers of sightings there each season. An adequate baseline from which to judge behavioural change in the proportion of the population that uses the Bay has been created.

7 Conclusions

This study documents humpback whale behaviour patterns in a quantified manner so that future comparisons can be made during, and after, anthropogenic disturbances to the region. More specifically,

- Humpback whales use Nickol Bay in peak numbers during mid-late August
- The large majority of whales, including cow/calf pods, sighted Inshore near Nickol Bay were Passive, with Active pods sighted more commonly during Offshore transects
- The large majority of pods sighted both Inshore and Offshore near Nickol Bay were Migrating (swimming) rather than Milling or Resting at Medium speeds.
- The majority of Active whales are located at the eastern and northern entrances to the Bay
- Low numbers of cow/calf pods use Nickol Bay during the peak of season
- Overall densities of whales in Nickol Bay are substantially lower than Exmouth Gulf
- Residency periods for whales in Nickol Bay are unlikely to be longer than 24 hours.

8 References

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