Technical Appendix S12

Ichthys Gas Field Development Project: summary report of dolphin surveys in the Middle Arm and West Arm of Darwin Harbour—January to March 2011

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INPEX

Report for Inshore Dolphin Survey, Darwin Harbour (Middle and West Arm)

Summary Report for Survey Block 1 (28 - 31 January, 2011)

February 2011

C036-AH-REP-0119

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1. Introduction

1.1 Purpose and Scope of this Report

GHD have been contracted by INPEX as part of the Ichthys Project to conduct a pilot study on inshore dolphins and other marine megafauna that utilise Middle and West Arm of Darwin Harbour. The key objectives of the pilot study are to:

1. Determine presence/absence of inshore dolphins
2. Compare distance-sampling and capture-recapture survey techniques to investigate which methodology would provide the most robust estimates of inshore dolphin abundance
3. Conduct photo-ID for comparison with existing catalogues and for use in future surveys
4. Collect appropriate environmental data to determine inshore dolphin habitat preferences

This report provides a summary of the observer training program and presents the initial findings from the first survey event (Survey Block 1). A detailed survey report will be prepared at the completion of the third survey event.

1.2 Overview

The pilot survey design addresses the Scope of Works provided to GHD, with a determination that 'closing mode' would be the best boat-based transect methodology to achieve the above objectives. The pilot study is comprised of one training day for observers and ten days of vessel-based research which will be undertaken as three survey events of four, three and three days respectively); with all survey events to be completed by the end of March 2011. The surveys will be undertaken in accordance with permit requirements granted for this project by the Animal Welfare Authority (Licence No: 016) and the Parks and Wildlife Commission of the Northern Territory (Permit Number: 40123).

2. Methodology

2.1 Overview

To undertake Survey Block 1 and associated training, project personnel from outside of Darwin (Rachel Groom and Isabel Beasley) mobilised to Darwin on January 26, 2011. The training day was conducted on January 27, 2011 for project observers which were followed by four consecutive boat-based survey days from January 28 - 31, 2011. Personnel from outside of Darwin demobilised from Darwin on February 1, 2011.

2.2 Training

Rachel Groom (Project Manager) and Dr. Isabel Beasley (Technical Advisor) led the project training, which consisted of a half day of technical training in the classroom on survey and marine mammal theory, and a half day trialling the boat-based transects in the Middle and West Arms of Darwin Harbour. Project personnel in attendance included: Rachel Groom (GHD), Isabel Beasley (GHD), Greg Oliver (INPEX), Bill Risk (Snr) (LDC), Bill Risk (Jnr)(LDC), Kattie Risk (LDC), Keith Sailor (LDC, Codie Willis (GHD) and Alex Koscielski (GHD). The theory component of the training was delivered in a PowerPoint presentation (provided in Appendix 1) and consisted of:

- Project background
- Inshore dolphin identification
- Boat-based transect survey methodology
- Photo-identification methodology
- Introduction to Cyber-tracker (as per sequence adapted from Beasley *et al.* 2010 for use on the surveys)

2.2.1 Project Safety

Project safety was discussed and detailed with regard to the Job Safety Environmental Analysis (JSEA) which had been developed during the HAZID Workshop (December, 2010). Team members achieved an understanding of project risks, management measures, residual risk and roles and responsibility while engaged on the project.

2.2.2 Boat-based Training

The boat-based training component consisted of:

- Broadsword Marine (Vessel Contractor) safety induction
- Instruction on use of binoculars, Trimble Nomad and water quality-meter
- Trial of the cyber-tracker sequence developed specifically for the INPEX project
- Trial of observer rotation schedules

Undertaking the trial boat surveys provided a positive output which resulted in:

- Discussions between the skipper, Greg Oliver, Rachel Groom and Isabel Beasley on how transect lines in shallow areas were to be established
- Refinement of the Cyber-tracker sequence
- Agreement on the most suitable rotation schedule for the observer team (described further below).

2.3 Boat-based Survey Block 1

Following the training day, the following methodology was used for the boat-based transect surveys.

2.3.1 Transect Lines

The boat-based survey followed the transect lines that were designed for the Scope of Works (INPEX 2010), with slight alterations made when the line was deemed impossible to survey during low tide (upon discussion between the skipper, Greg Oliver, Rachel Groom and Isabel Beasley).

On January 29, 2011 the tide was too low to cover the remaining transect lines, so a search along the Darwin Harbour coastline (approximately 700 m from the coast) was conducted to trial photo-identification. Survey speed was kept constant at 7 knot/hr when possible, which was deemed appropriate for transect surveys. The speed was lower (4-5 knot/hr) on occasions when it was too shallow to navigate at normal survey speed.

2.3.2 Observer Rotation and Observations

An adequate observer rotation is critical to the success of boat-based transect surveys, as it maintains observers are well-rested, alert, and able to concentrate when they are 'on-effort' (i.e. searching along the transect-lines for dolphins). Six observers were available for Survey Block 1, which resulted in a team of three observers covering two transect lines at a time, followed by the other team of three subsequently covering the next two transect lines. One experienced observer was accompanied by two newly trained observers in two teams. This observer rotation worked well, and provided adequate rest for observers prior to going back 'on-effort'.

During the coastline search, the observer rotation was changed from the above schedule, to have three observers on-effort at all times, with observers rotating through each position (left binocular, data recorder, right observer) every 20 minutes. This schedule worked well since the searches were continuous and required increased vigilance during observer changes (i.e. only one person is taking their eyes off the water during rotations rather than the entire team), but the rotation still ensured that observers had adequate rest (1 hour) between their on-effort rotations.

While on-effort for both the transect and coastline searches, the left and right observers looked through binoculars covering the front 50 degrees on their side of the boat. The data recorder was placed between the two binocular observers and searched for dolphins on the track-line, while being responsible to enter data into the Trimble using the Cyber-tracker sequence. During future surveys the data recorder will also have a pair of binoculars with an inbuilt compass to confirm possible sightings without bothering the other two observers (discussed under 'Issue to be addressed prior to Survey Block 2'). It is

recommended that a team of six observers are present for the remaining two Survey Blocks.

2.3.3 Environmental Parameters

Environmental parameters (water depth, temperature, turbidity and salinity) were collected at the start of every transect line, as well as at the location of all cetacean sightings. The 'off-effort' survey team (the three resting observers), are responsible for taking the environmental data, to reduce survey inefficiencies that would otherwise be encountered by observers moving between roles.

2.3.4 Marine Mammal Sightings

Once a dolphin group was sighted, observers determined the angle and distance (either through reading the relevant reticle on binoculars or estimating distance), and the boat the departed the transect line to attempt to get closer to the dolphin group. The boat continued in passing mode for all turtle and crocodile sightings. Once at the estimated location of the dolphin group, the position (via GPS), species, group size, age classes, and predominate behaviour were recorded. If species identity could be made with certainty, the identification was recorded as 'certain'. If the species identification was not 100% certain but some distinguishing features were evident, it was recorded as 'probable'. If a cetacean was sighted but no distinctive characteristics could be determined (i.e., it was only sighted once, or surfaced very quickly and inconspicuously), it was recorded as 'unknown'.

2.3.4.1 Cetacean Behaviour

Cetacean behaviour will be recorded in future events using a hand-held recorder and systematically recorded every five minutes according to the categories developed by Parra (2006) and modified by Palmer (2010):

Foraging: Individuals moving in various directions without an obvious pattern. Dolphins diving frequently and steeply downwards (often preceded by fluke or peduncle arches), with extended submersion times. Rapid accelerations and erratic movement at the surface, indicative of animals chasing fish. Animals seen directly pursuing a fish (e.g. fish jumping at the surface) or with fish in their mouth.

Foraging behind trawler: Repeated diving in varying directions around the side or behind the stern of a trawler boat while the boat is fishing.

Slow travel - moving in slow and persistent directional pattern. Regular surfacing and diving pattern and animals are not underwater for great lengths of time.

Fast travel - moving fast but in a persistent and directional pattern. Regular surfacing and diving patterns and animals are not underwater for great lengths of time.

Socialising: Localised movement. Dive direction is unpredictable. Dolphins in close proximity showing high levels of interaction (animals touching each other, rubbing their bodies). Fins and flukes often break the surface of the water. Frequent aerial behaviour such as leaps and somersaults.

Milling: Movement slow with no apparent direction. Dolphins swim in close proximity, but without interaction. No aerial behaviour, activity levels are low. Dolphins surface in a synchronised manner and most of the time is spent at the waters surface. Dive angles are shallow.

No video or systematic behaviour recordings were taken during Survey Block 1, as a result of observers' first required to become familiar with transect surveys, and being trained in species identification and age-class estimation during a sighting. However, video will be taken during all future surveys when marine mammals are close to the boat, and surfacing frequently.

2.3.5 Photo-identification

Photographs were taken whenever possible for species confirmation and photo-identification studies. A Canon EOS60D digital camera with a 100-400 L-series lens was used for photo-identification. All individuals in the group were photographed, regardless of whether they appeared to be identifiable. All photographs were downloaded immediately after the sighting and analysed upon completion of the Survey Block.

Following completion of Survey Block 1, all photographs were graded according to image quality, as a series of binary variables into the programme EXCEL version 5.1:

Unusable – a photograph which consists of a blank image to separate groups, a splash of water, or an image of a dolphin but no dorsal fin in the image (e.g. only a head, tail, or flipper in the image).

Poor – an image where the dorsal fin could not be clearly seen, the image was blurry, the dorsal fin was not was not perpendicular to the camera, or was severely backlit by the sun. Only very distinct individuals were identifiable.

Good – an image that was clear, the dorsal fin was nearly perpendicular to the camera and there was little backlighting. Most identifying features were seen if present, although slight angles, or dark lighting, made identification questionable.

Excellent – an exceptionally clear, in-focus image, where the dolphin took up more than half the image, the dorsal fin was perpendicular to the photographer and the lighting was excellent. All distinguishing features were seen, if present.

Each image was then catalogued based on the presence, or absence of identifiable features. Each usable image was classified into one of the following two categories:

Unrecognisable – the dolphin had no distinctive features on its dorsal fin or body that could be used to identify it (nothing more was done with these images),

Recognisable – the dolphin could be individually recognised based on distinctive features on its dorsal fin and/or body.

2.4 Data Entry

All data was entered into the Trimble Nomad unit via the Cybertracker program, with a sequence developed specifically for the INPEX surveys. The sequence was adapted slightly each day upon receiving comments and recommendations from team members. The final sequence has now been agreed upon by all personnel and will be used on all subsequent surveys. Hard copy data sheets were also completed to ensure data was not lost while trailing the Trimble Nomad unit. Hard copies will continue to be used for the remainder the pilot study

Distance Estimation

Distance estimation trials were conducted on all observers using a Leica Rangerfinder to 800 meters.

3. Results

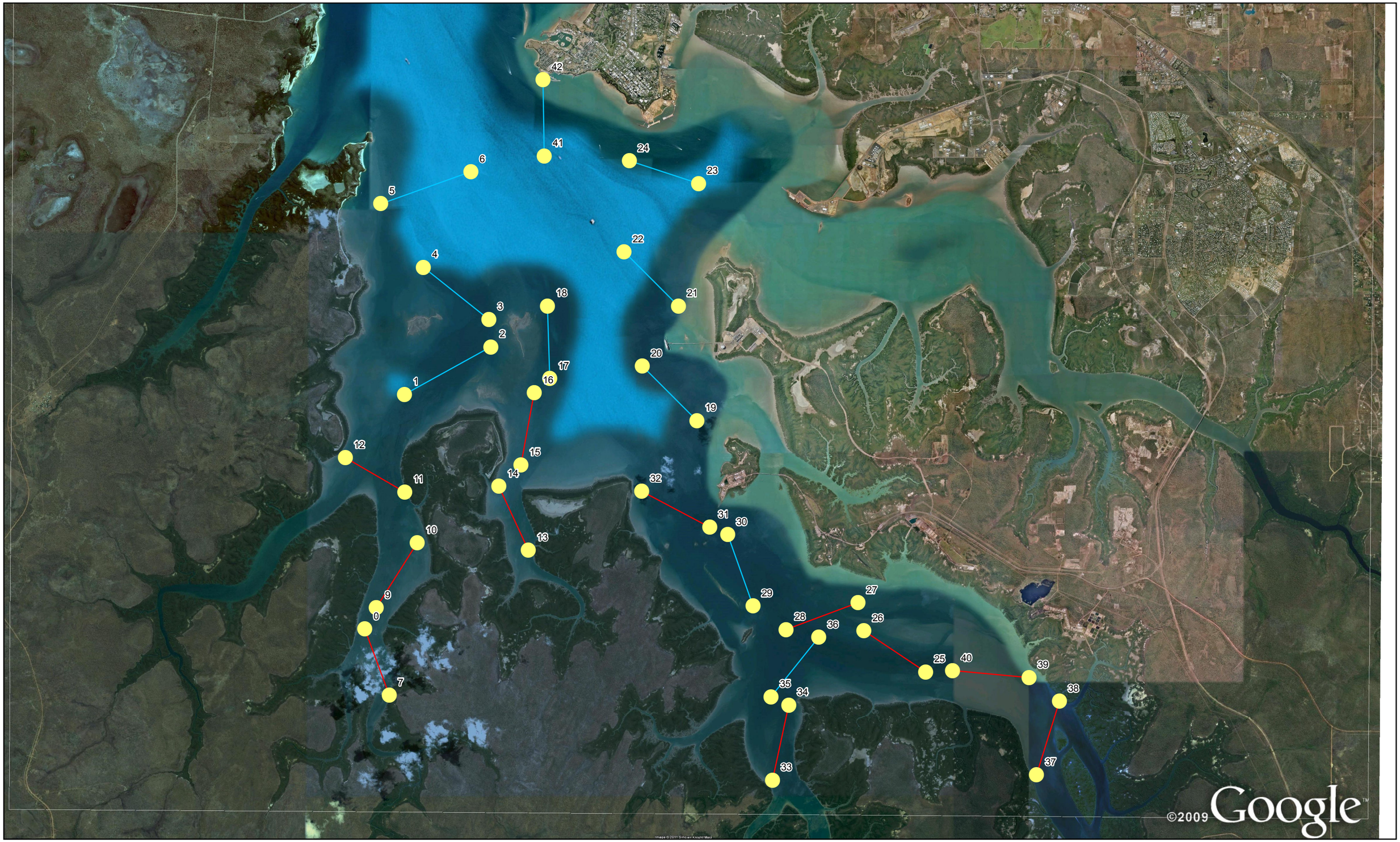
3.1 Transect Lines

The final transect lines that were agreed upon by GHD personnel and the Broadsword Marine skipper are shown in Figure 3-1; the lines in blue are navigable during all tides, while the lines in red are only navigable during mid to high tide. It is only possible to finish all transect lines in one day if no dolphins are sighted and the tides are favourable. It is therefore more realistic to assume that transect lines will be replicated at least twice over each of the three day survey blocks.

A total of 139.4 km of survey were conducted over 40 boat-based hours (Table 3-1). All survey lines were searched three times during Survey Block 1, except for four that were only searched twice. Recorded track lines over the four survey days were downloaded from the GPS are presented in Figure 3-2.

Table 3-1 Summary of total distance travelled during each day, and total distance travelled along transect lines

Date	Total Distance Traveled (km)	On-effort Transects (km)
28 Jan	42.57	28
29 Jan	78.9	48.2
30 Jan	114.23	35.3
31 Jan	106.32	27.9
Total	342.02	139.4



1:90,487 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

- Waypoint
- not tidally restricted
- tidally restricted

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INPEX

INPEX Browse Ltd
Darwin Coastal Dolphin Survey

Job Number	43-21774-017
Revision	B
Date	04 FEB 2010

Survey transect lines for inshore dolphin survey

Figure 3-1

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_017_revB.mxd

Data source: GHD - dolphin survey tracks (2011), Imagery - Google Earth Pro (date extracted 04/02/2011), created by: W W

Level 4, 201 Charlotte St Brisbane QLD 4000 **T** 61 7 3316 3000 **F** 61 7 3316 3333 **E** bnemail@ghd.com **W** www.ghd.com

1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

- 28 Jan (approx. 42.57km)
- 29 Jan (78.93km)
- 30 Jan (114.23km)
- 31 Jan (106.32km)

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INPEX

INPEX Browse Ltd
Darwin Coastal Dolphin Survey

Job Number	43-21774-007
Revision	B
Date	04 FEB 2010

Tracks from Survey Block 1

Figure 3-2

Level 4, 201 Charlotte St Brisbane QLD 4000 **T** 61 7 3316 3000 **F** 61 7 3316 3333 **E** bnemail@ghd.com **W** www.ghd.com

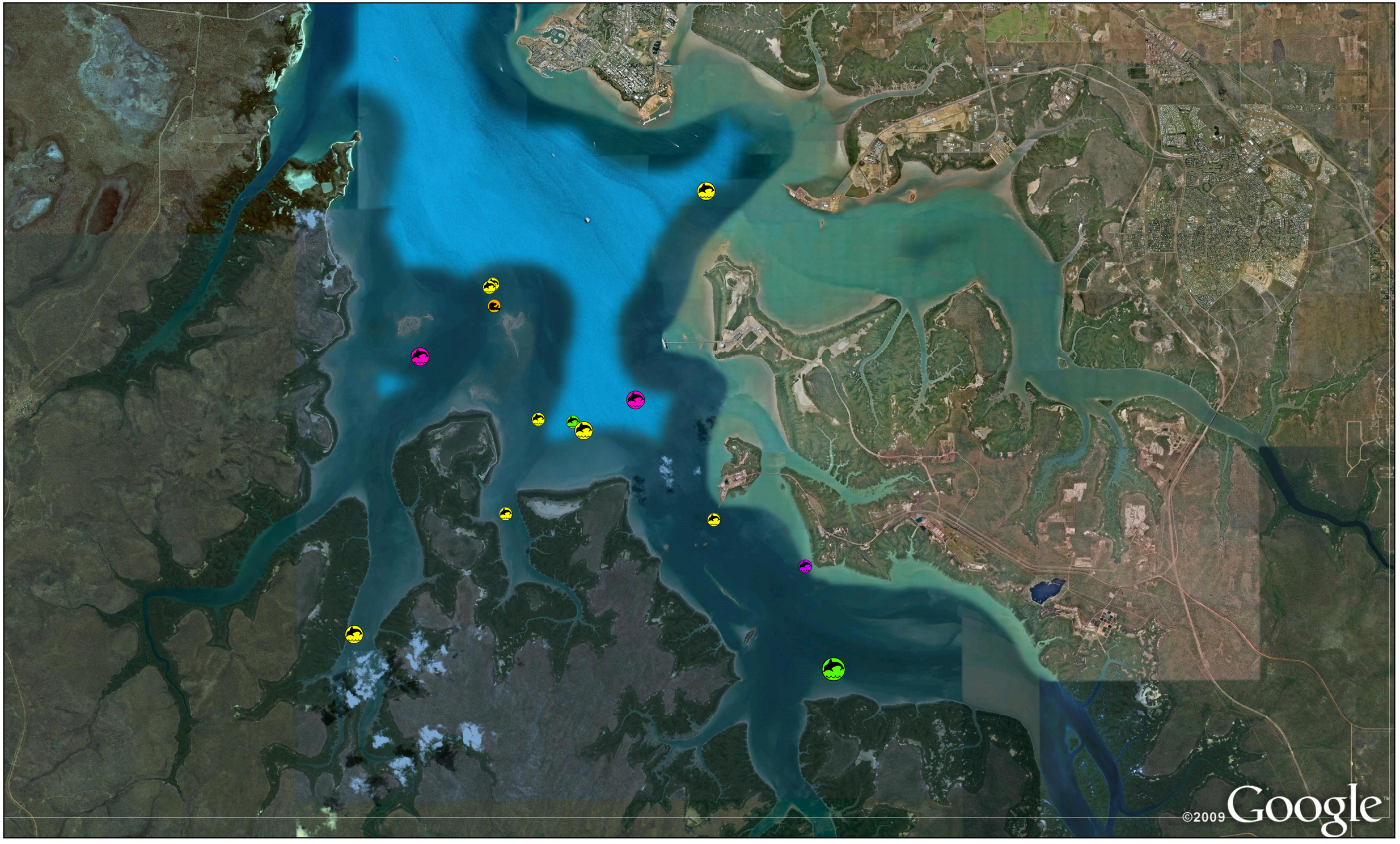
3.2 Marine Mammal Sightings

A total of 15 cetacean groups were observed in 14 separate sightings (Table 3-2; Figure 1); which consisted of humpback, bottlenose and snubfin dolphins, and one dugong (sirenian).

Table 3-2 Summary of marine mammal sightings during boat surveys

Date		Species observed	Identification	Long	Lat	# of individuals
28-Jan-11	1	Humpback/snubfin dolphin	Certain/ Probable	130.776975	-12.591471	4 humpback/ 2 snubfin
28-Jan-11	2	Humpback dolphin	Certain	130.812301	-12.563413	**1**
29-Jan-11	3	Bottlenose dolphin	Certain	130.792345	-12.526834	**6**
29-Jan-11	4	Humpback dolphin	Certain	130.809289	-12.510032	**1**
29-Jan-11	5	Dugong	Certain	130.809599	-12.512249	**1**
29-Jan-11	6	Humpback dolphin	Probable	130.808436	-12.510708	**1**
29-Jan-11	7	Bottlenose dolphin	Certain	130.842497	-12.536928	**5**
29-Jan-11	8	Snubfin dolphin	Certain	130.88862	-12.599539	**13**
29-Jan-11	9	Unknown Dolphin	Certain	130.882022	-12.575595	**1**
30-Jan-11	10	Humpback dolphin	Certain	130.858937	-12.488297	**6**
31-Jan-11	11	Humpback dolphin	Probable	130.860757	-12.564766	**1**
31-Jan-11	12	Humpback dolphin	Probable	130.8199	-12.541411	**2**
31-Jan-11	13	Snubfin dolphin	Probable	130.827933	-12.542026	**1**
31-Jan-11	14	Humpback dolphin	Certain	130.830441	-12.544011	**3**

Three dolphin groups were sighted while on-transect (i.e., on-effort), and the remaining ten groups were sighted while on transit between lines, and during the coastline search (i.e., 'off-effort'). The dugong was sighted while off-effort photographing Sighting #4 (a humpback dolphin group).



1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Marine mammal sightings

- Bottlenose dolphin
- Dugong
- Humpback dolphin
- Snubfin dolphin
- Unknown dolphin

Number of individuals

- 1 - 2
- 3 - 10
- 11 - 13

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INPEX Browse Ltd
Darwin Coastal Dolphin Survey

Job Number 43-21774-012
Revision C
Date 04 FEB 2010

Marine mammals observed during Survey Block 1

Figure 3-3

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_012_revC.mxd

Data source: GHD - dolphin survey tracks (2011), Imagery - Google Earth Pro (date extracted 04/02/2011), created by: W W

Level 4, 201 Charlotte St Brisbane QLD 4000 **T** 61 7 3316 3000 **F** 61 7 3316 3333 **E** bnemail@ghd.com **W** www.ghd.com

1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Species

Crocodile

Turtle

Number of individuals

1

2

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INPEX Browse Ltd
Darwin Coastal Dolphin Survey

Job Number 43-21774-016
Revision B
Date 04 FEB 2010

Other confirmed megafauna sightings from Survey Block 1

Figure 3-4

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_016_revB.mxd

Data source: GHD - dolphin survey tracks (2011), Imagery - Google Earth Pro (date extracted 04/02/2011), created by: W W

Level 4, 201 Charlotte St Brisbane QLD 4000 **T** 61 7 3316 3000 **F** 61 7 3316 3333 **E** bnemail@ghd.com **W** www.ghd.com

3.4 Environmental Parameters

Environmental data were collected at the location of all on-effort data sightings, and off-effort sightings when time allowed. The resulting environmental data for all sightings where the species was confirmed (i.e. 'certain') are shown in

Table 3-3.

Table 3-3 Environmental parameters recorded on survey*

Environmental Parameter	Humpback	Snubfin	Bottlenose	Dugong
28 Jan	n=2			
Depth (m)	8.8 – 20.0			
Temp (^{o}C)	27.4 – 28.4			
Turbidity (NTU)	1.6 – 3.5			
Salinity (ppk)	26.0 – 28.6			
Tide State	Rising / Falling			
29 Jan	n=1	n=1	n=2	N=1
Depth (m)	4.1	7.3	2.8 – 15.0	4.1
Temp (^{o}C)	28.0	29.0	27.8 – 28.2	28.0
Turbidity (NTU)	1.5	2.0	1.5 – 5.2	1.5
Salinity (ppk)	28.0	26.0	26.9 – 28.0	28.0
Tide State	Rising	Rising	Rising	Rising
30 Jan	n=1			
Depth (m)	7.0			
Temp (^{o}C)	28.5			
Turbidity (NTU)	0.7			
Salinity (ppk)	27.8			
Tide State	Rising			
31 Jan	n=1			

Depth (m)	5.4
Temp (^{o}C)	26.9
Turbidity (NTU)	1.3
Salinity (ppk)	28.9
Tide State	Rising

*For all groups where the species identification was 'certain'

3.5 Photo-identification

Photo-identification was trialled on eight of the 15 groups sighted (53%). All groups not photographed were either too evasive to get close to, or sighted behind the survey team while conducting transect surveys (i.e. off effort).

A total of six snubfin dolphin, two bottlenose dolphins, and seven humpback dolphins were photo-identified during Survey Block 1 (Appendix B).

3.6 Cyber-tracker Sequence

The cyber-tracker sequence aimed to capture all relevant information for transect, environmental and photo-identification methodologies in the most straight-forward, easy-to-follow manner. The sequence was discussed with all personnel throughout all survey-days and any outstanding issues were addressed immediately after the survey, to be trailed again the following day. We are confident that the Cybertracker sequence is now finalised and can be used throughout the remainder of the pilot study surveys without further alteration. The final Cybertracker sequence is shown in Appendix C.

3.7 Distance Estimation

In addition to using the compass reticle and bearing, a total of 203 distance estimation trials were conducted during Survey Block 1 to improve observers perception of distance. Graphs of the results are provided in Appendix E, Distances will continue to be tested during Survey Block 2, however, initial results are encouraging in that estimates are mostly close to the true distance, and all observers are both over- and under-estimating distances (which is preferred to either constantly over- or under-estimating distances which biases the resulting abundance estimates. Observers are still rounding estimates to tens and fives (rather than a precise estimate which are preferred); and this matter will be emphasised prior to Survey Block 2.

3.8 Data Entry Quality Assurance

When using the Trimble Nomad unit at-sea, there is potential for data-entry mistakes as a result of the bright-sun on the screen, movement of the boat, probability of observer fatigue and heat-stress, and high excitement during sightings. Data quality and accuracy checks were conducted at the end

of the Survey Block by comparing the Cyber-tracker output files with those of the hardcopy notes. The results were encouraging, with:

- 0/30 (0%) incorrect entries on 28/01/11 (environmental variables were not recorded for comparisons to be enabled on 28/01/11, but were recorded for all subsequent days);
- 0/30 (0%) incorrect entires on 29/01/11;
- 3/54 (5.6%) incorrect entires on 30/01/11 (the busiest survey day in terms of sightings), and
- 2/42 (4.8%) incorrect entries on 31/01/11.

Two of the required changes related to effort data, and three required changes related to environmental data. All sighting data entries were correct.

The required changes to the output data have been included in Appendix D:

4. Discussion

Survey Block 1 resulted in sightings of all three inshore dolphin species known to inhabit the harbour, as well as sightings of dugong, turtle and crocodile. Humpback dolphins were the most frequently sighted, followed by two sightings of both bottlenose and snubfin dolphins. The bottlenose dolphins were confirmed as the 'inshore' type, based on their long rostrum and relatively small body size, as well as relatively small group size.

The transect line design worked very well, and covered the majority of representative habitats in Middle and West Arms of Darwin Harbour. Only minor manipulation of the original design was required when lines were deemed too shallow to transit safely during high tide. An additional transect line (waypoints 41 and 42) was added to the existing design to capture the deep water habitat in the middle of the Harbour ,.Only three of the 14 sightings (21%) were sighted 'on-effort', however, it is likely that this percentage will increase once observers become familiar with the line-transect survey methodology, the transect line positions, and get their 'eye-in' for spotting marine mammals using familiar cues (i.e. splash, birds, fish jumping).

Photo-identification proved successful with seven identifiable images from humpback dolphins, six from snubfin dolphins and two from bottlenose dolphins. It is hoped that the number of photo-identified individuals will increase in subsequent survey blocks with the use of two photographers, rather than one. Using two photographers will enable coverage of both sides of the boat at once, and will also reduce the potential for slips/trips/falls, which are sometimes associated with photographing cetaceans in boats.

4.1 Survey Limitations and Improvements

Some aspects of the survey were noted for improvement prior the commencement of Survey Block 2. Constraints from this survey have been recognised and are outlined below, in some instances these have also been reported in the monthly HSE Report to INPEX.

4.1.1 Air-conditioner exhaust location on bridge

1. The location of the air-conditioner exhaust on the bridge caused discomfort to all observers during surveys as it was mounted immediately forward of the observer team (30 cm spacing from the data-recorder). This outlet is a safety concern as it is likely to contribute to observer fatigue and over-heating during surveys. It is recommended that the air-conditioning outlet is moved to the rear of the bridge, prior to the commencement of Survey Block 2 (this has been agreed upon by Broadsword Marine).

4.1.2 Binoculars

One pair of the project-purchased Fujinon binoculars were damaged when sent from the distributor, as the compass would not turn freely (impeding accurate angle estimates). The compass needs to be repaired before the binoculars are used again during line-transect boat surveys.

As a result of the methodology change to the observer rotation, a third pair of Fujinon binoculars will need to be purchased, so that all observers have access to binoculars when required.

4.1.3 Photo-identification

A second photographer would increase the potential to obtain high quality photo-identification images through covering both sides of the boat at once during sightings. The potential for slips/trips/falls will also be reduced if two photographers are taking photographs at the same time. Personal camera equipment for future surveys (Canon EOS20D digital camera with a fixed 300 mm L-series lens and 2x converter), to contribute to photo-identification efforts may be used.

Appendix A

Training Day PowerPoint Presentation

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INPEX - Coastal Dolphin Survey - Darwin Harbour - Middle and West Arm

Rachel Groom, Senior Marine Ecologist, GHD
Dr. Isabel Beasley, James Cook University, Townsville
Daniel Hazell, Environmental Advisor, INPEX

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Coastal Dolphin Survey - Training

9.00am - 10.30am

- Project Background & Objectives
- Inshore Dolphin Identification
- Methods - Line-transect and Photo-identification

11.00am - 12.30pm

- Cyber-tracker
- Job Safety Sheet

1.30pm - 5.00pm

- On Boat - Trial Transect Lines and Observer Rotations

Project Background

- INPEX Browse Ltd. (INPEX) proposes to develop the natural gas and associated condensate contained in the Ichthys Field (820km west-south-west of Darwin

- INPEX plans to install offshore extraction facilities at the field and a subsea gas pipeline from the field to onshore facilities at Blaydin Point, Darwin Harbour

- There are 3 species of coastal dolphin that commonly use Darwin harbour
  - -- Australian snubfin dolphin (*Orcaella heinsohni*)
  - -- Indo-Pacific humpback dolphin (*Sousa chinensis*)
  - -- Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)




Project Background cont ...

- The populations of these dolphins are believed to be small and may be resident to Darwin Harbour

- Data collected by NRETAS indicates all species utilise East Arm (the site of the majority of near-shore construction activity for the Ichthys Project).

- However, survey effort has not extended into Middle or West Arm of Darwin Harbour

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Project Objectives

Conduct a pilot study of inshore dolphins in Middle and West Arm, Darwin harbour to investigate:

- Presence/absence of inshore dolphins
- Compare distance sampling and capture-recapture survey techniques
- Conduct photo-ID for comparison with existing catalogues and for use in future surveys
- Collect appropriate environmental data to determine inshore dolphin habitat preferences

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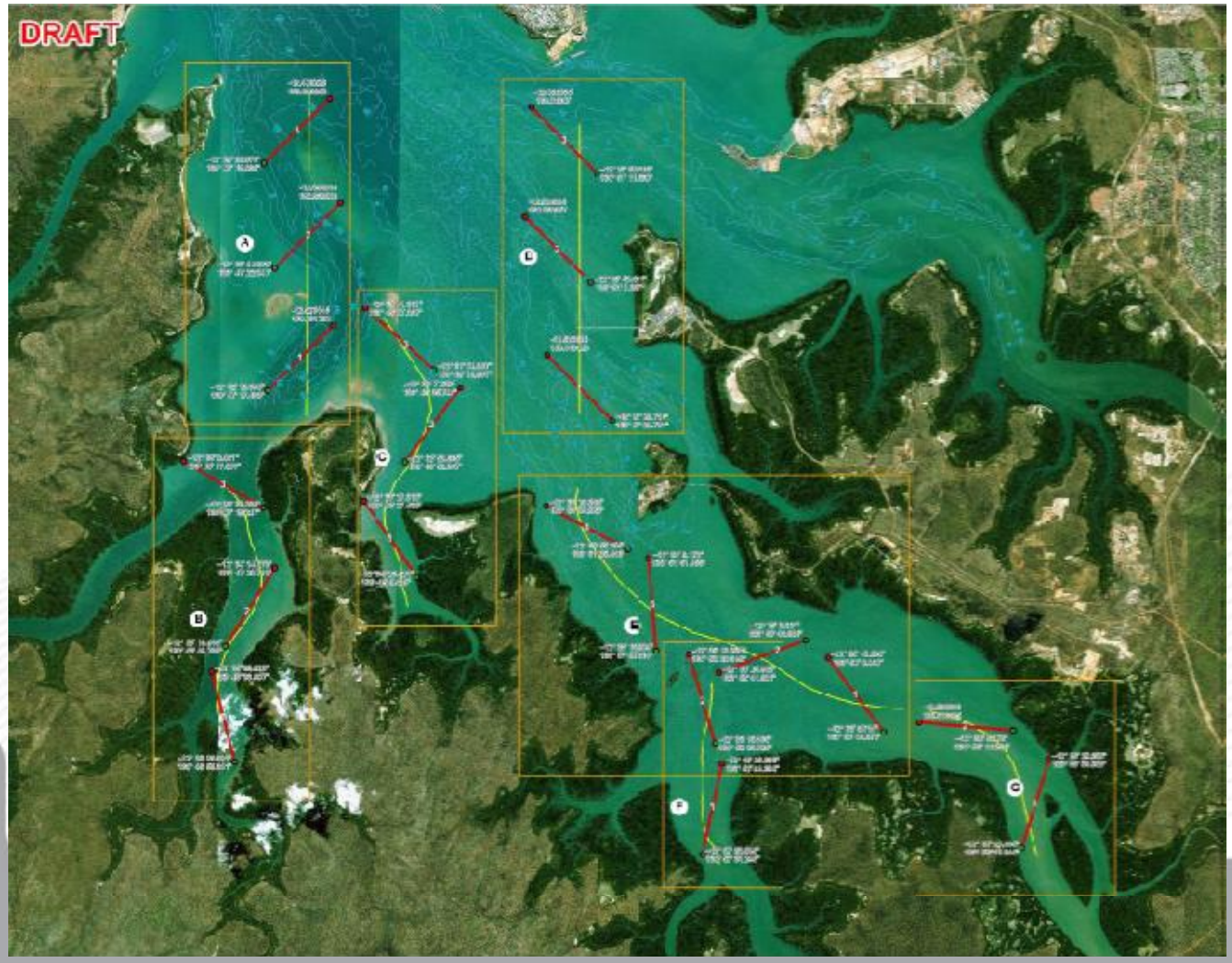
Study Area



Roles and Responsibilities

- INPEX - Client (Rachel to liaise)
- Rachel - Project Manager
- Isabel - Technical Lead
- LDC - Field Officers
- Broadsword Marine - Vessel Contractor

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Survey Schedule (Revised)

3 Survey Blocks – 1 Training Day & 10 Survey Days

- Proposed Dates for January - February Surveys
  - 28-31 January (4 days)
  - xxx-xxxx February (3 days)
  - xxx-xxxx February (3 days)
- Summary Reports Following Each Survey
- Final Report – End of February
- Team Availability? Feedback Needed For Planning


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Inshore Dolphin Identification

Cetacean Species Worldwide - 87 species

Things to take notice of when identifying a cetacean at-sea …

- Size
- Shape and size of the blow
- Colouration
- Shape of dorsal fin/rostrum
- How it moves in the water/group size
- Habitat (eg. range and coastal/oceanic

Importantly …
Always remember that there is the potential for unusual species to appear in unexpected areas - so don't dismiss an ID because it may not have been found in an area before. Eg. Dusky dolphins in Tasmania (Dec 2010)

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Australia - 42 species, plus the dugong

(Northern Australia - 29 species, plus the dugong)

Large toothed whales
Sperm whale

Large baleen whales
Southern right whale
Blue whale
Fin whale
Sei whale
Bryde's whale
Dwarf minke whale
Antarctic minke whale
Humpback whale
Pygmy right whale

Beaked whales
Cuviers beaked whale
Arnoux's beaked whale
Shepherd's beaked whale
Hector's beaked whale
Southern bottlenose whale
True's beaked whale
Gray's beaked whale
Andrew's beaked whale
Ginko-toothed beaked whale
Strap-toothed beaked whale
Blainville's beaked whale

Blackfish
Killer whale
False killer whale
Short-finned pilot whale
Long-finned pilot whale
Pygmy killer whale
Melon-headed whale
Risso's dolphin

Long-beaked dolphins
Pygmy sperm whale
Dwarf sperm whale
Common bottlenose dolphin
Indo-Pacific bottlenose dolphin
Indo-Pacific humpback dolphin
Rough-toothed dolphin
Short-beaked common dolphin
Striped dolphin
Pantropical spotted dolphin
Spinner dolphin

Short-beaked dolphins
Fraser's dolphin
Southern right whale dolphin
Australian snubfin dolphin

Porpoise
Spectacled porpoise

Cetacean At-sea Identification

Baleen whales
(Mysticeti)
-- 2 blowholes
-- 15 species

Toothed whales,
dolphins and
porpoises
(Odontoceti)
-- 1 blowhole
-- 72 species

Baleen whales

9 species in Australia (7 in northern Australia)

Species in northern Australia

- Humpback whale
- Blue whale
- Fin whale
- Sei whale
- Bryde's whale
- Dwarf minke whale
- Antarctic minke whale

Toothed whales (sperm and beaked whales)

12 species in Australia (4 in northern Australia)

Species in northern Australia

- Sperm whale

- Cuviers beaked whale
- Shephard's beaked whale
- Blainville's beaked whale

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Toothed whales (blackfish)

7 species in Australia (6 in northern Australia)

Species in northern Australia

- Killer whale
- False killer whale
- Short-finned pilot whale
- Pygmy killer whale
- Melon-headed whale
- Risso's dolphin

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Toothed dolphins

Long-beaked - 8 in Australia (8 in northern Australia)

Short-beaked - 5 in Australia (4 in northern Australia)

Species in northern Australia

- Common bottlenose dolphin
- Indo-Pacific bottlenose dolphin
- Indo-Pacific humpback dolphin
- Rough-toothed dolphin
- Short-beaked common dolphin
- Striped dolphin
- Pantropical spotted dolphin
- Spinner dolphin

- Pygmy sperm whale
- Dwarf sperm whale
- Australian snubfin dolphin
- Fraser's dolphin

Toothed porpoise

1 species in Australia (0 in northern Australia)

Darwin Harbour 'Possible' Marine Mammals

False killer whale

Short-finned pilot whale

Killer whale

Darwin Harbour Inshore Marine Mammals

3 main inshore dolphin species and dugong

Indo-Pacific humpback dolphin

Australian snubfin dolphin

Dugong

Indo-pacific bottlenose dolphin

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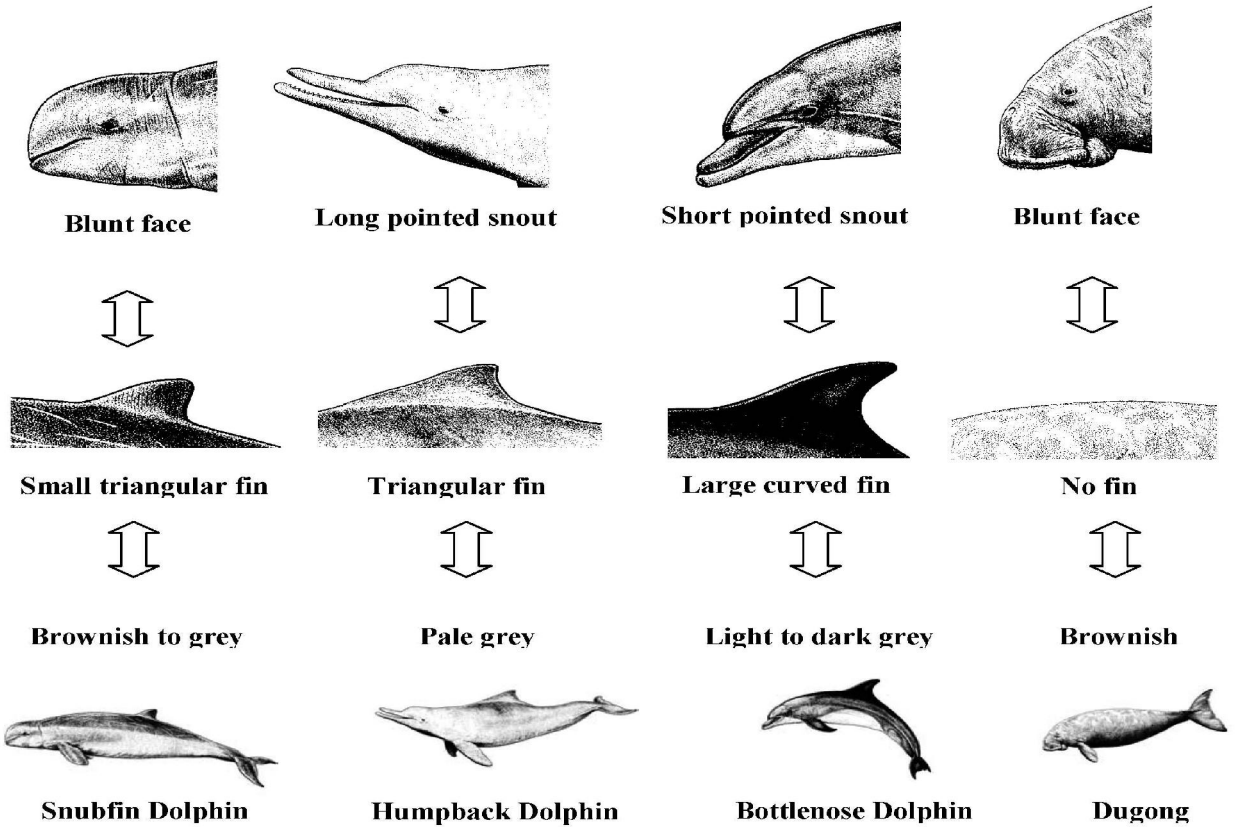
Species Identification



GHD CLIENTS | PEOPLE | PERFORMANCE

But cetaceans are often difficult to identify …


GHD

Survey Methods

Boat Line Transect Surveys

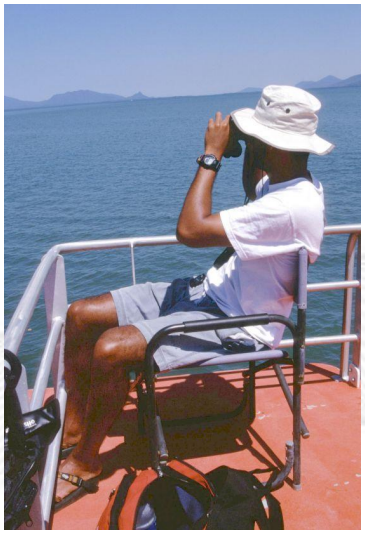
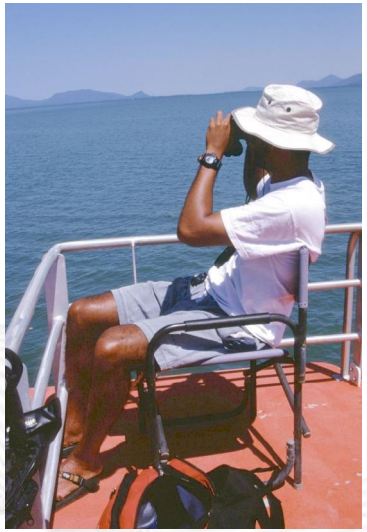


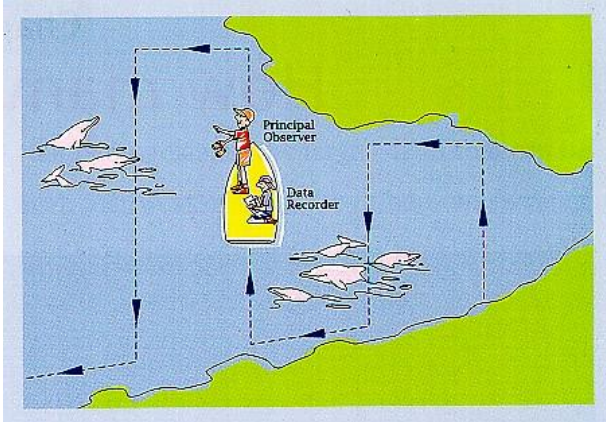
Photo-Identification

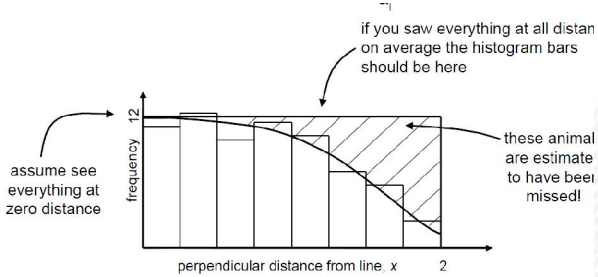
CLIENTS | PEOPLE | PERFORMANCE

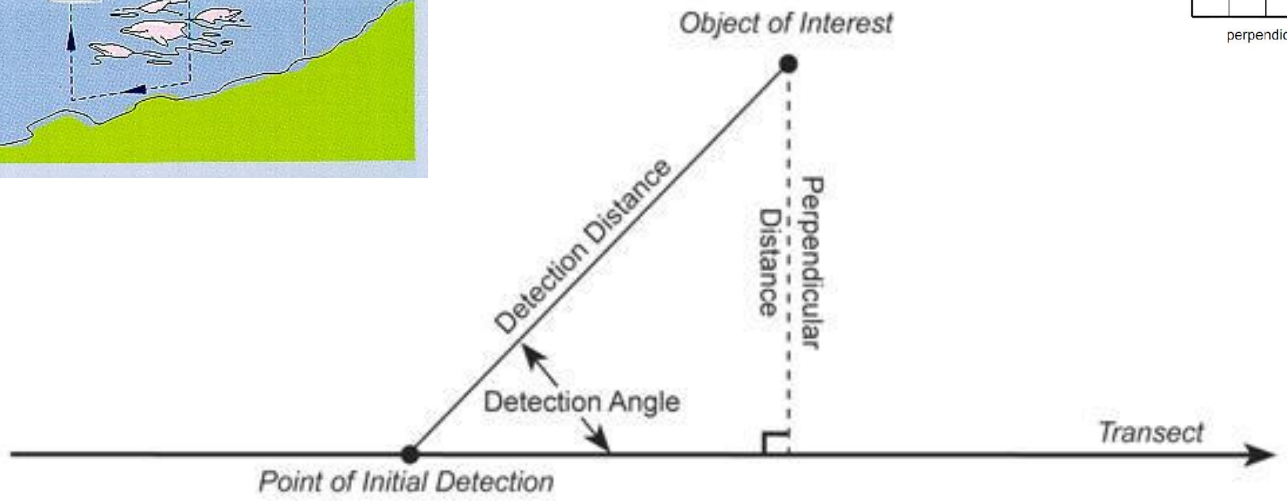
Boat Line Transect Surveys



Transect surveys and distance-sampling

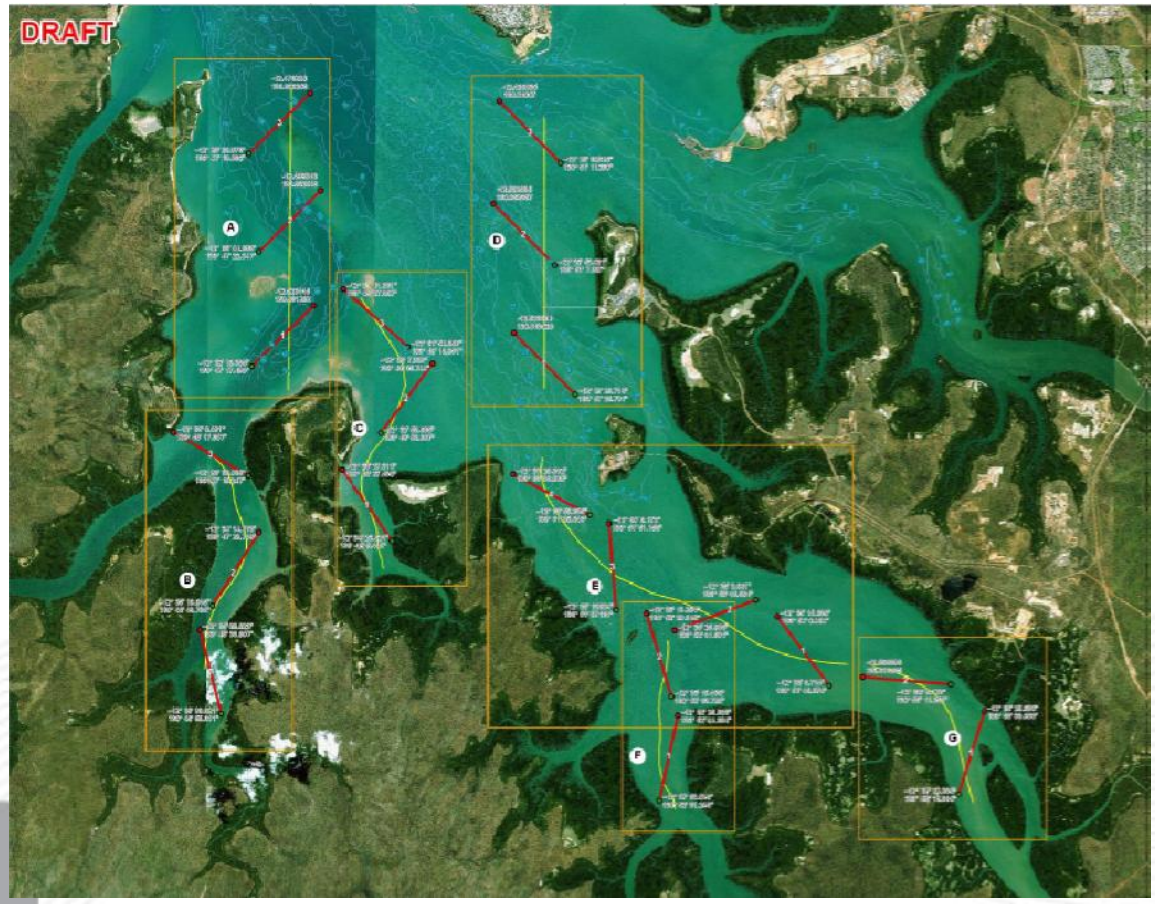






Boat Line Transect Surveys

The lines we plan to do … (20 x 2km)



Boat Line Transect Surveys

Assumptions …

- All dolphins on the transect line are sighted
- Dolphins are sighted prior to reacting to the vessel
- Measurements of the distance to the sighting and the angle of the sighting are taken reliably

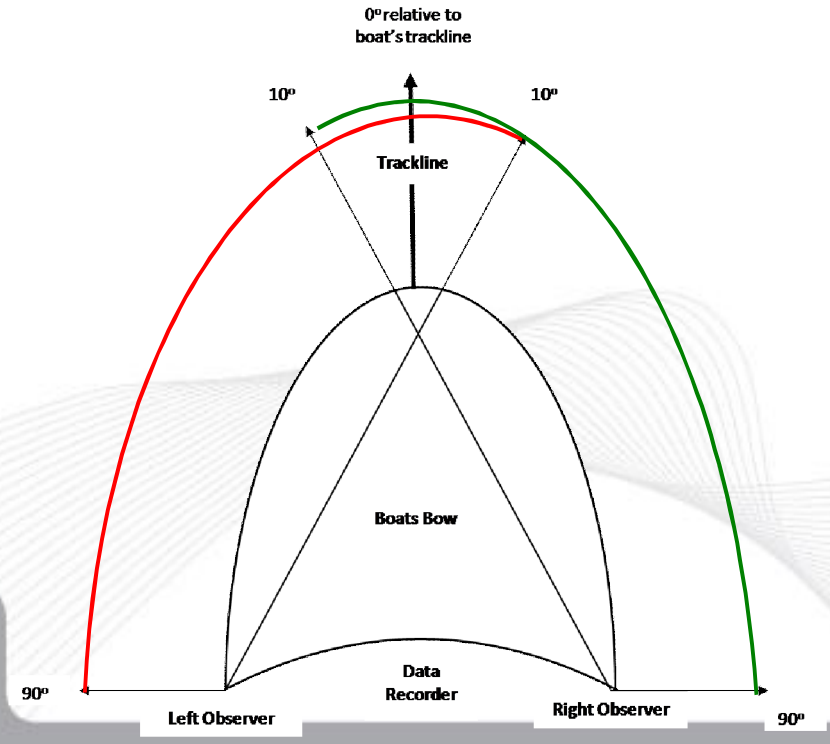
Boat Line Transect Surveys

Due to these assumptions …

- Surveys restricted to good sea conditions (Beaufort 0-3)
- (Travel speed while on effort is relatively slow @7-10 knots (18km/h)
- We use binoculars to attempt to sight dolphins prior to their reacting to the vessel

Boat Line Transect Surveys

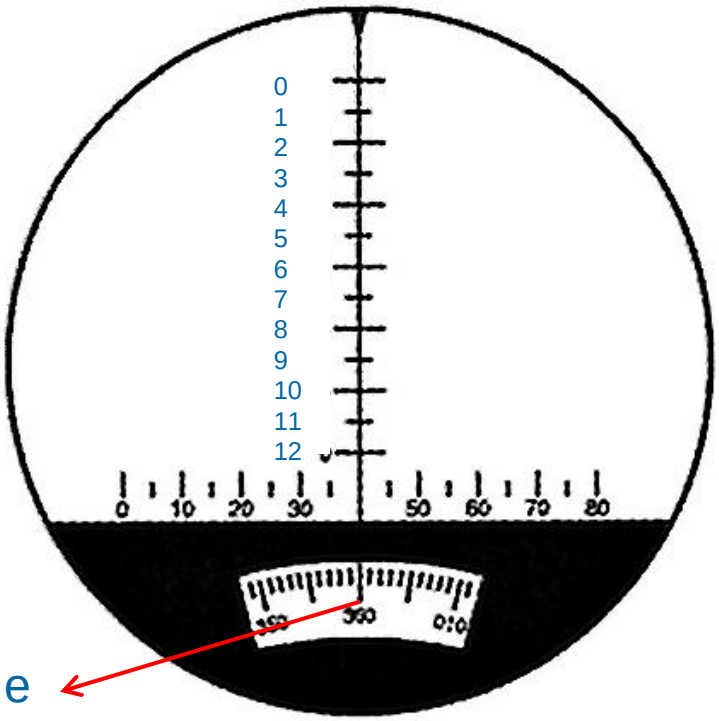
Observers positions and scanning



- A constant number of observers throughout the survey
- Each observer will scan for dolphins using binoculars and naked eye
- Left and Right Observer: from 90 degrees on their side of the boat to 10 degrees on the opposite side of the bow
- The data recorder will scan the entire 180 degrees forward of the boat - and will be responsible for the cybertracker

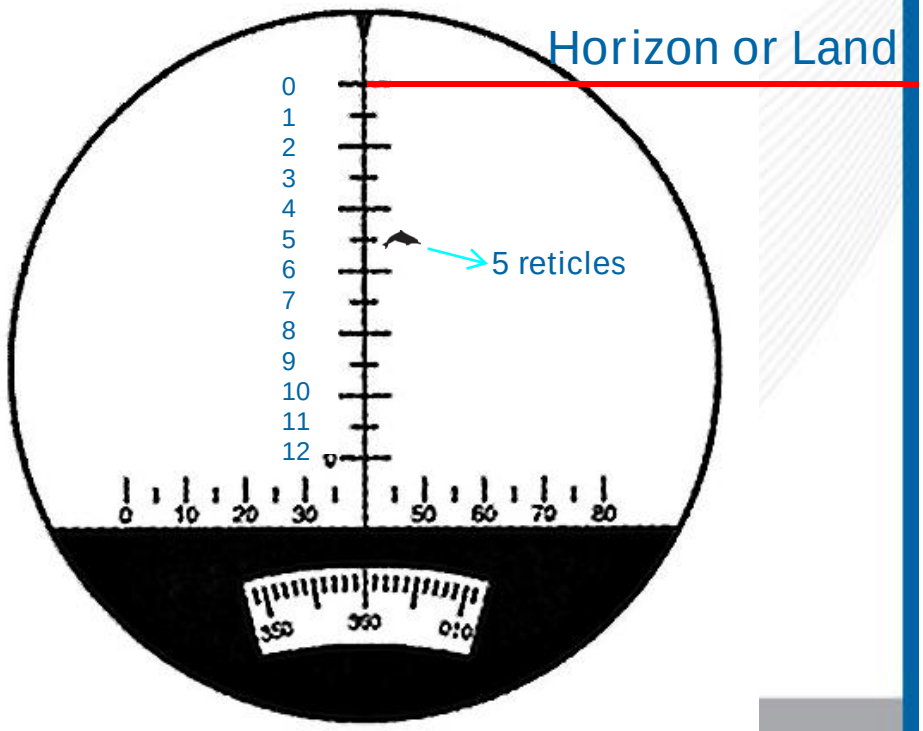
Critical data: Angle to sightings

- Read off the angle on the compass inside the binoculars
- Avoid rounding to fives of degrees, or tens of degrees



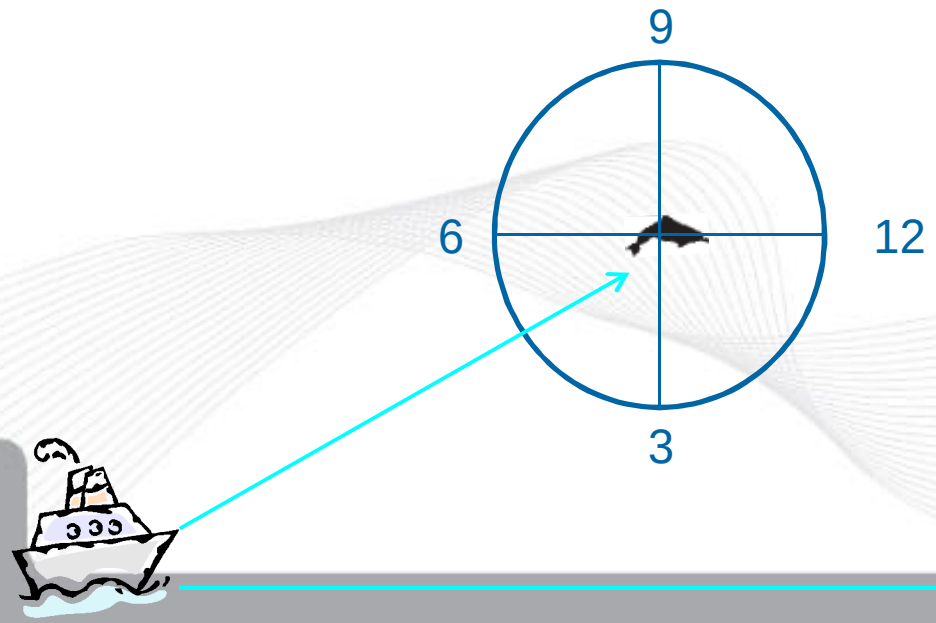
Critical data: Distance to sightings

- Sighting distances are estimated using reticles, which are marks on the binocular lenses
- Each mark is one reticle
- Reading will be from 1 (top) to 12 (bottom)



Critical data: Direction of animals

- Imagine a clock around the animal you first saw
- Note the 'time' the animal is heading



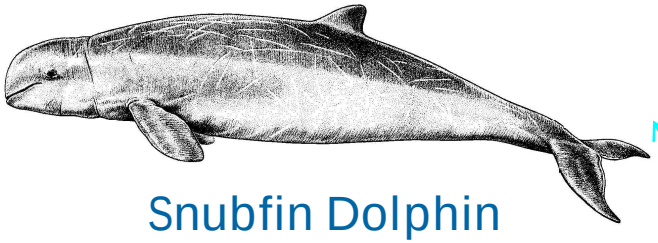
Critical data: School size

- A ‘school’ is defined as dolphins relatively close in spatial cohesion (I.e. each member within 100m of any other member)

- Also record if ‘adults’, ‘juveniles’, or ‘calves’ are in the school

Boat Line Transect Surveys

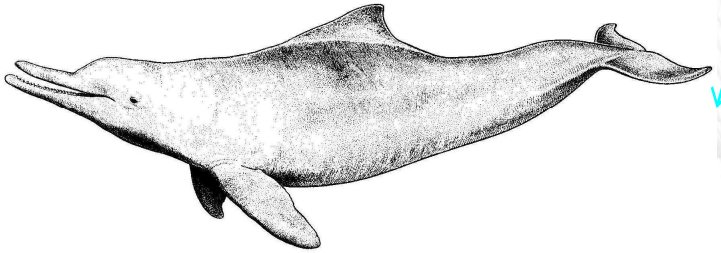
Critical data: Species



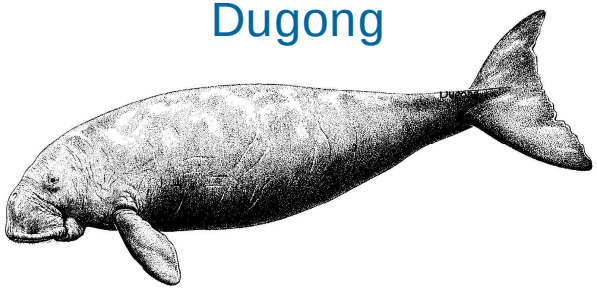
Snubfin Dolphin

Bottlenose Dolphin

Humpback Dolphin



Dugong



Boat Line Transect Surveys

When you see a dolphin or dugong …

1. When you see a dolphin(s), or something that looks like one, say out loud "I have a sighting".

2. Read off the angle (on the compass in the binoculars) to the sighting and tell the data recorder

3. Align the top reticle with horizon or shoreline and count the number of reticles and tell the recorder, if the dolphin is close, estimate the distance based on laser-range finder estimations

   If you see a large school, take angle and reticle readings from centre of the school

4. Note the direction 'on the clock' of the animal you first saw and tell the data recorder

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Photo-Identification

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Photo-identification

- Dorsal fin (nicks/notches/scars)

- Aims to photograph all dolphins in a group - regardless on whether their dorsal fin looks distinctive or not

- Obtain estimates of abundance, mortality, recruitment using the Program MARK to analyse data

Important! - Personal Safety

During boat surveys, PLEASE be responsible to:

- Always wear good polarised sunglasses; a hat; long sleeve shirt and pants; and sunscreen (reapply sunscreen throughout the day)

- Keep hydrated - drink water throughout the day. Keep soft drinks and energy drinks to a minimum

- Rest during breaks to reduce fatigue. Please inform the team leader if you feel unwell at any time during the survey

- Take care where you step on the boat - follow boat guidelines and always hold on to hand-rails


GHD

Appendix B

Photo-identification Images

Snubfin dolphins

OHEI01 (29 Jan 2011 – Sighting 8)

OBRE02 (29 Jan 2011 – Sighting 8)

OBRE03 (left fin) (29 Jan 2011 – Sighting 8)

OBRE04 (right fin) (29 Jan 2011 – Sighting 8)

OBRE05 (29 Jan 2011 – Sighting 8)

OBRE06 (29 Jan 2011 – Sighting 8)

Bottlenose dolphins

TADU01 (29 Jan 2011 – Sighting 3)

TADU02 (29 Jan 2011 – Sighting 3)

Humpback dolphins

SCHI01 (28 Jan 2011 – Sighting 1)

SCHI02 (28 Jan 2011 – Sighting 1)

SCHI03 (30 Jan 2011 – Sighting 10)

SCHI04 (30 Jan 2011 – Sighting 10)

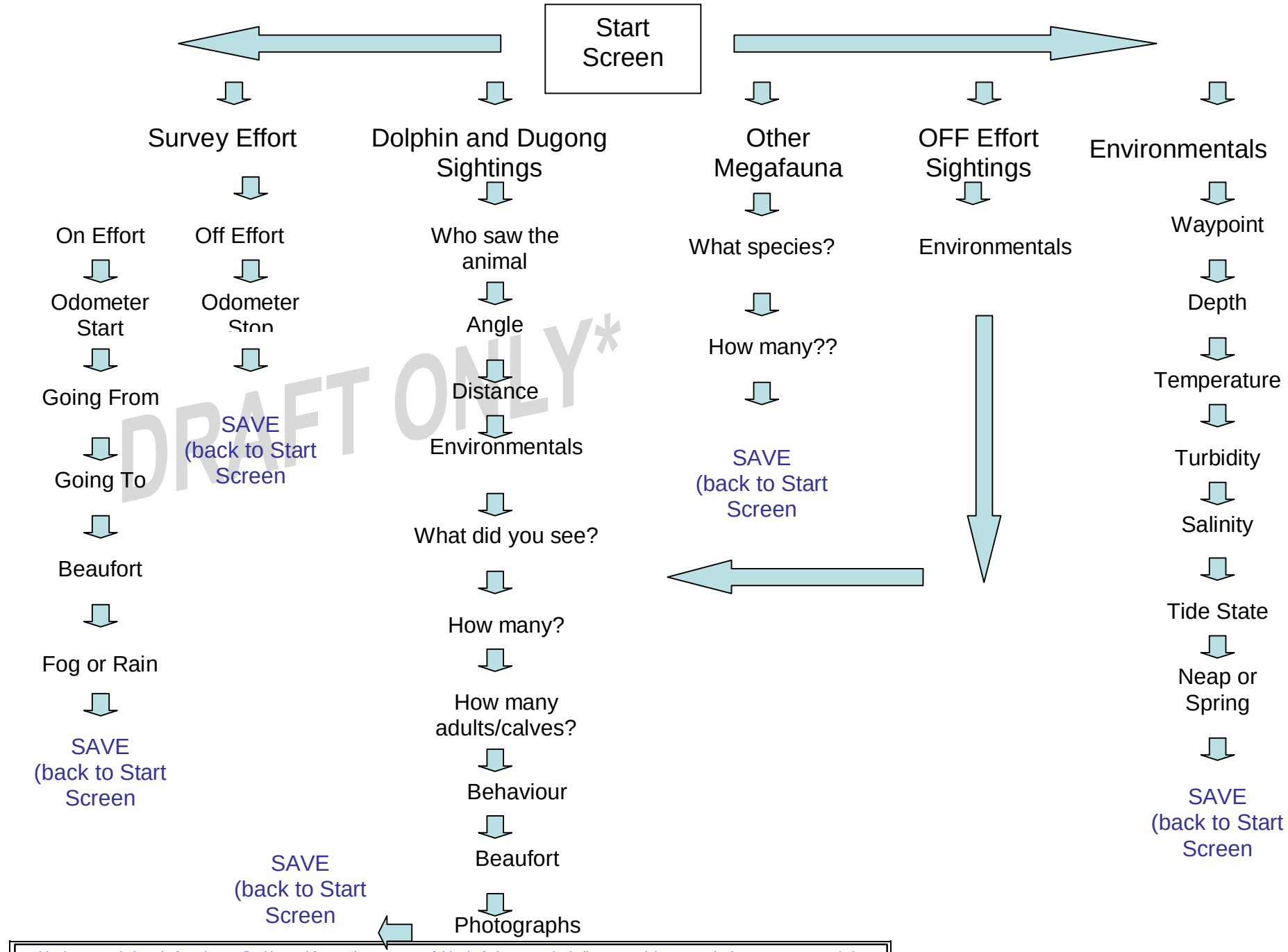
SCHI05 (30 Jan 2011 – Sighting 10)

SCHI06 (30 Jan 2011 – Sighting 10)

SCHI07 (31 Jan 2011 - Sighting 14)

Appendix C

Cybertracker Sequence



Appendix D

Changes to Outputs

Date: 30/01/11 / Time: 11:10:07

Entry category – Environmentals

Cybertracker entry: Depth = 29m

Hardcopy entry: Depth = 17.6m

The depth was changed to 17.6m, based on confirmation of depth from previous and post environmental data.

Date: 30/01/11 / Time: 12:32:41

Entry category – Effort

Cybertracker entry: Odometer stop = 59km

Hardcopy entry: Odometer stop = 58km

The odometer stop distance was changed to 58km, as the hardcopy distance is what is first recorded via the GPS.

Date: 30/01/11 / Time: 13:00:02

Entry category – Environmentals

Cybertracker entry: Depth = 25m

Hardcopy entry: Depth = 9.7m

The depth was changed to 9.7m, based on confirmation of depth from previous and post environmental data.

Date: 31/01/11 / Time: 08:44:00

Entry category – Environmentals

Cybertracker entry: Tide = Falling

Hardcopy entry: Tide = Rising

The tidal state was changed to rising based on other entries where the tide was rising.

Date: 31/01/11 / Time: 11:42:49

Entry category – Effort

Cybertracker entry: Odometer start = 445.2km

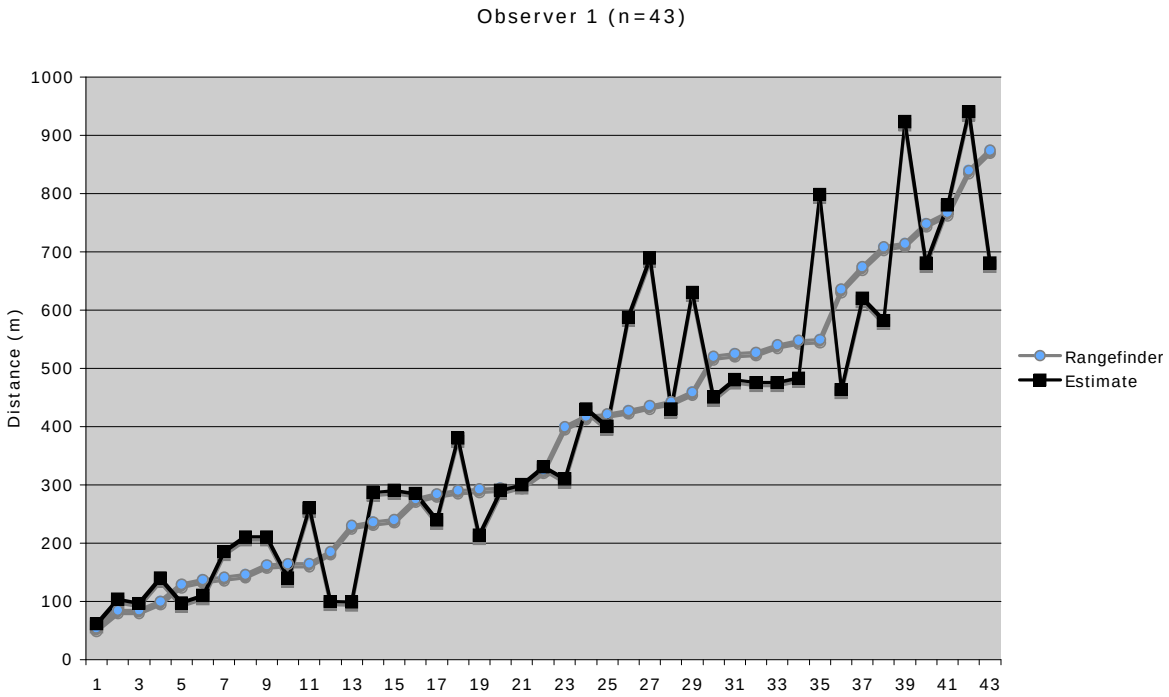
Hardcopy entry: Odometer start = 45.2

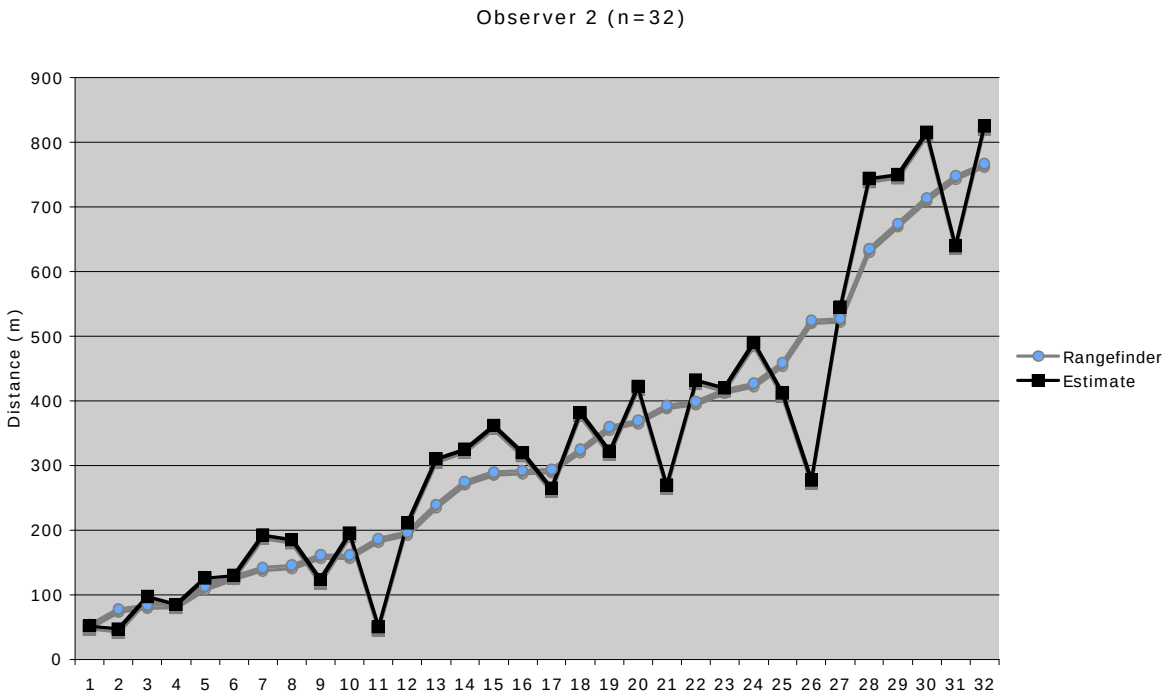
The odometer start distance was changed to 45.2

Appendix E

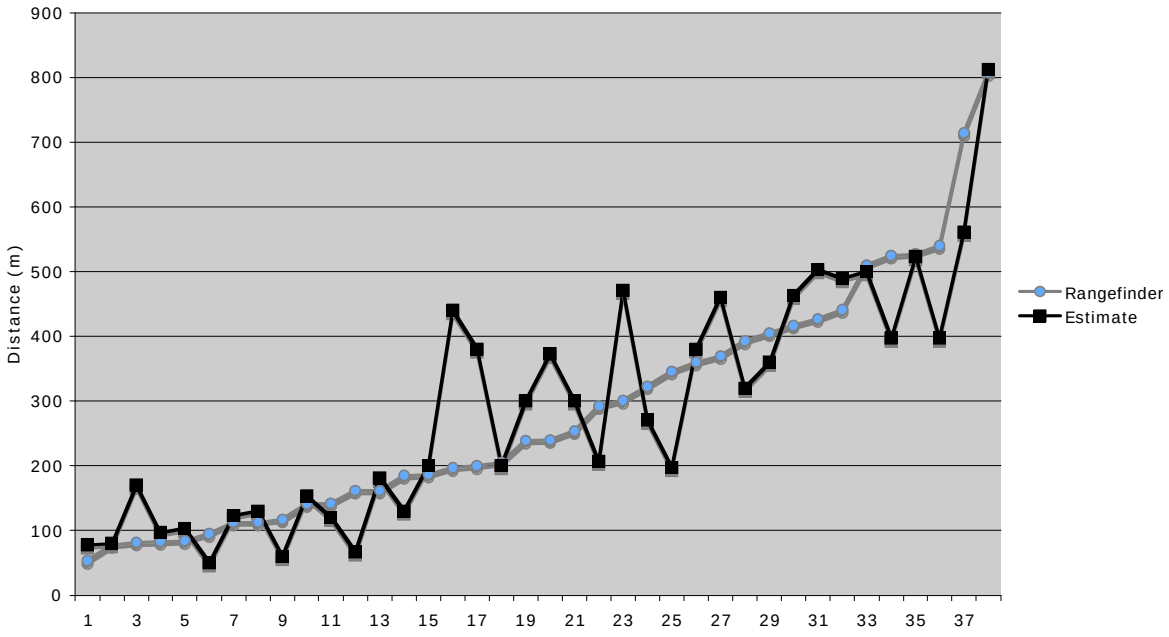
Graphs of Observer Distance Estimation

Line-graphs of distance estimation trials for each of the six observers. The light lines are the actual distance (obtained from the rangefinders), while the black lines are the estimated distances.

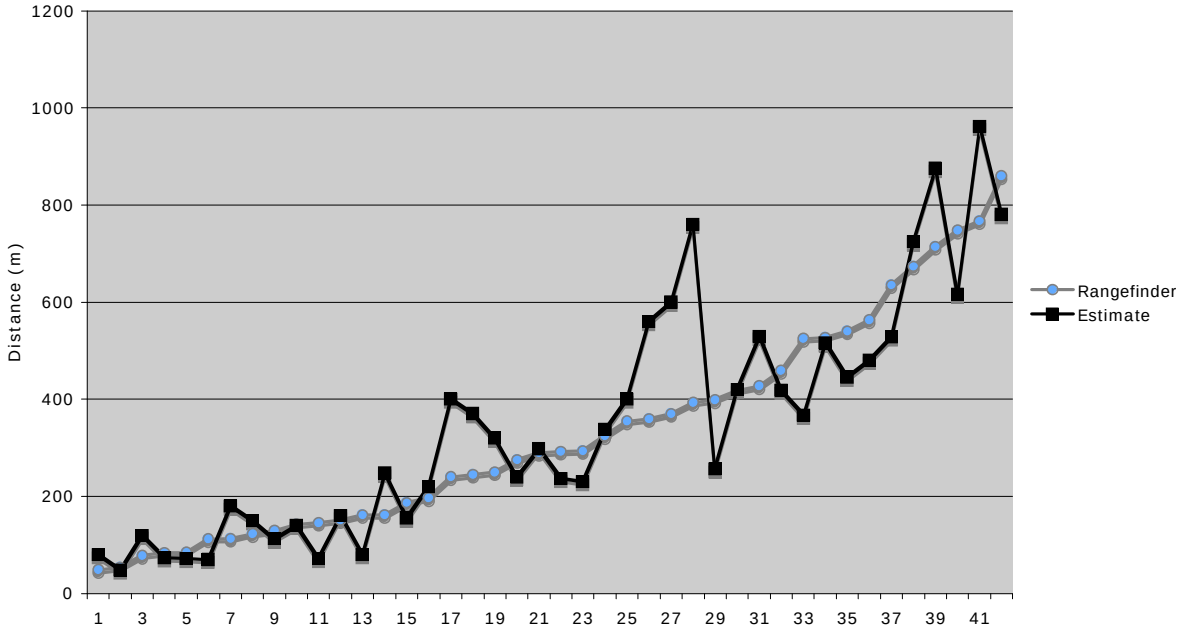


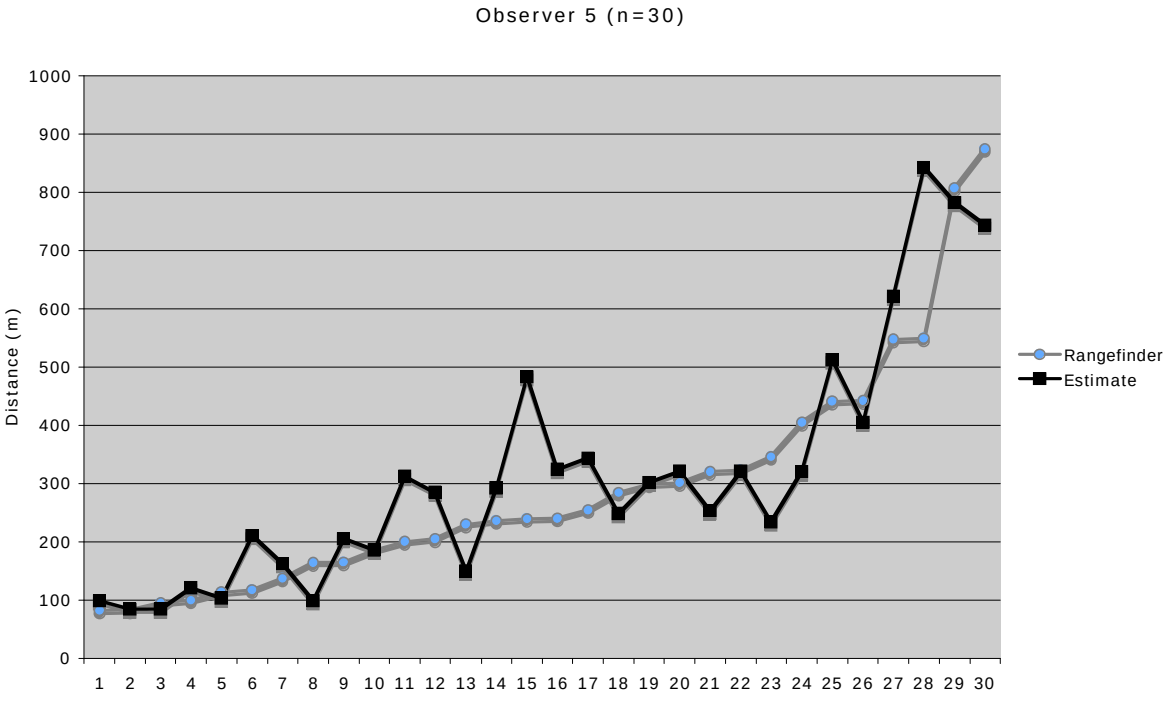


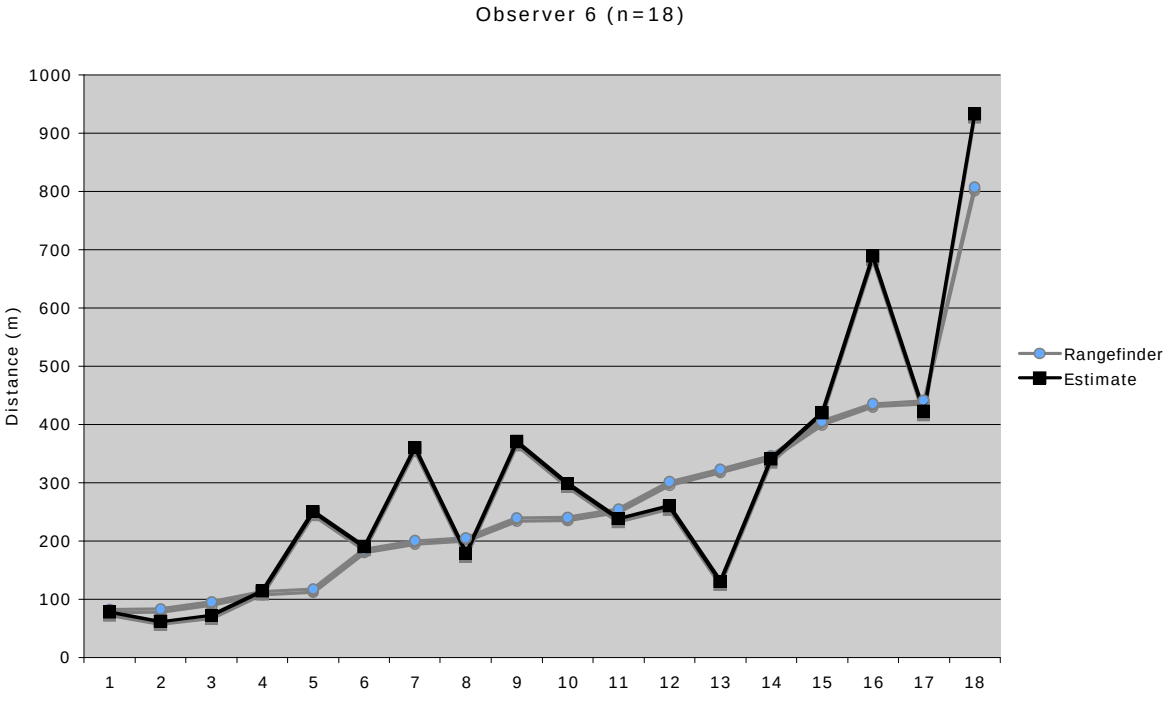
Observer 3 (n=38)



Observer 4 (n=42)







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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
	I Beasley R Groom	D. Dique		R. Groom		04/03/11

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INPEX

Report for Inshore Dolphin Survey, Darwin Harbour (Middle and West Arm)

Summary Report for Survey Block **2** (9 - 11 February)

February 2011

C036-AH-REP-0113

Contents

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Appendices

1. Introduction

1.1 Purpose and Scope of this Report

GHD have been contracted by INPEX as part of the Ichthys Project to conduct a pilot study on inshore dolphins and other marine megafauna that utilise Middle and West Arm of Darwin Harbour. The key objectives of the pilot study are to:

1. Determine presence/absence of inshore dolphins
2. Compare distance-sampling and capture-recapture survey techniques to investigate which methodology would provide the most robust estimates of inshore dolphin abundance
3. Conduct photo-ID for comparison with existing catalogues and for use in future surveys
4. Collect appropriate environmental data to determine inshore dolphin habitat preferences

This summary report presents findings from the second survey effort (Survey Block 2) conducted during February 9 – 11, 2011 inclusive.

1.2 Overview

The pilot survey design addresses the Scope of Works provided to GHD, with a determination that 'closing mode' would be the best boat-based transect methodology to achieve the above objectives. The pilot study is comprised of one training day for observers and ten days of vessel-based research which will be undertaken as three survey blocks of four, three and three days respectively); with all survey days to be completed by the end of March 2011. The surveys will be undertaken in accordance with permit requirements explicitly granted for this project by the Animal Welfare Authority (Licence No: 016) and the Parks and Wildlife Commission of the Northern Territory (Permit Number: 40123).

2. Methodology

2.1 Overview

To undertake Survey Block 2, project personnel from outside of Darwin (Rachel Groom and Isabel Beasley) mobilised to Darwin on February 8, 2011. Other project personnel contracted by Larrakia Development Corporation (LDC) consisted of Bill Risk (Snr), Bill Risk (Jnr), Kattie Risk and Keith Sailor. Three consecutive days of boat-based survey days were conducted from February 9-11, 2011 inclusively on the INPEX approved survey vessel (MV Serious Fun).

2.2 Boat-based Transects – Survey Block 2

The following methodology was used for the boat-based transect surveys during Survey Block 2.

2.2.1 Transect Lines

On the first day of surveys, the original transect lines were covered as illustrated in Figure 3-1 of Summary Report 1 (January, 2011). However, following review of results from Survey Block 1 and survey effort/sightings from February 9 (Survey Block 2), a revised version of the transect lines running east/west across the main harbour were conducted on February 10 and 11 (Figure 2-1). The revised transect design was considered to be a more efficient design. Key reasons for this include:

- Original transect lines presented in Figure 3-1 of Summary Report 1 were relatively short (2 km), taking only 7 - 10 minutes to complete. This short duration 'on-effort' resulted in few dolphins being sighted on the transect line during Survey Block 1 (i.e. 'on-effort', n=3) compared to transiting between lines (i.e. 'off-effort', n=11). Similarly, on February 9, two groups were sighted 'off-effort' and only one group was sighted 'on-effort'. This becomes an important consideration when a minimum of 60 sightings of each species are required to obtain robust estimates of abundance using distance-sampling methodology.
- A trial of the new transect lines resulted in six 'on-effort' sightings and two 'off-effort' sightings, indicating that the revised transect lines enabled more time 'on-effort' to sight dolphin groups.
- The revised transect lines retained the principle of equal coverage probability (Dawson et al. 2008), where a random start point was chosen, with subsequent lines spaced at 2 km intervals. These lines continued down the harbour until the shallow waters of the middle and east arm channels precluded further east/west lines; at which point the original transect lines down the channels were followed.

1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

- Waypoint
- Tidally restricted
- Not tidally restricted

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INPEX

INPEX Browse Ltd
Darwin Coastal Dolphin Survey

Job Number	43-21774-007
Revision	E
Date	21 FEB 2011

Revised Transects for Inshore Dolphin Surveys

Figure 2-1

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_017_rev_e.mxd

Data source: GHD - Transects (2011), Imagery - Google Earth Pro (date extracted 15/02/2011), created by:MS

Level 4, 201 Charlotte St Brisbane QLD 4000 **T** 61 7 3316 3000 **F** 61 7 3316 3333 **E** bnemail@ghd.com **W** www.ghd.com

2.2.2 Observer Rotation and Observations

Observer rotations for Survey Block 2 followed the methodology conducted during Survey Block 1; where a team of three observers conducted observations for two subsequent transects, followed by the other team covering the next two transects. This observer rotation worked well, and provided adequate rest for observers prior to going back 'on-effort'. Each team had an experienced marine fauna observer as part of their team for technical reference.

A coastline search for photo-identification was not conducted during Survey Block 2. While on-effort searching on the transect, the left and right observers looked through binoculars covering the front 50 degrees on their side of the boat. The data recorder was positioned between the two binocular observers and searched for dolphins on the track-line, while being entering data into the Trimble using the Cyber-tracker sequence. All observers had access to a pair of binoculars with inbuilt compass for this survey block, which facilitated the data recorder to confirm possible sightings without impeding the other two observers (no binoculars were available to the data recorder during Survey Block 1).

2.2.3 Environmental Parameters

Environmental parameters (water depth, temperature, turbidity and salinity) were collected at the start of every transect line, as well as at the location of all cetacean sightings. The 'off-effort' survey team (the three resting observers), collected environmental data to reduce survey inefficiencies that would otherwise be encountered by observers moving between roles (i.e. by observers taking excessive time to climb up and down between the back deck of the vessel and bridge).

2.2.4 Marine Mammal Sightings

Once a dolphin group was sighted, observers read off the angle and distance (either through reading the relevant reticle on binoculars or estimating distance), and the boat then departed the transect line in an effort to get closer to the dolphin group. The boat continued in passing mode for all turtle and crocodile sightings. Once at the estimated location of the dolphin group, the position (via GPS), species, group size, age classes, and predominate behaviour were recorded. If the species identification could be made certainty, with the identification was recorded as 'certain'. If the species identification was not 100% certain but some distinguishing features were evident, it was recorded as 'probable'. If a cetacean was sighted but no distinctive characteristics could be determined (i.e. it was only sighted once, or surfaced very quickly and inconspicuously), it was recorded as 'unknown'.

2.2.5 Cetacean Behaviour

Cetacean behaviour was videoed using a hand-held recorder and systematically recorded every five minutes on pre-determined datasheets according to the categories developed by Parra (2006) and modified by Palmer (2010):

Foraging: Individuals moving in various directions without an obvious pattern. Dolphins diving frequently and steeply downwards (often preceded by fluke or peduncle arches), with extended submersion times. Rapid accelerations and erratic movement at the surface, indicative of animals chasing fish. Animals seen directly pursuing a fish (e.g. fish jumping at the surface) or with fish in their mouth.

Foraging behind trawler: Repeated diving in varying directions around the side or behind the stern of a trawler boat while the boat is fishing.

Slow travel - moving in slow and persistent directional pattern. Regular surfacing and diving pattern and animals are not underwater for great lengths of time.

Fast travel - moving fast but in a persistent and directional pattern. Regular surfacing and diving patterns and animals are not underwater for great lengths of time.

Socialising: Localised movement. Dive direction is unpredictable. Dolphins in close proximity showing high levels of interaction (animals touching each other, rubbing their bodies). Fins and flukes often break the surface of the water. Frequent aerial behaviour such as leaps and somersaults.

Milling: Movement slow with no apparent direction. Dolphins swim in close proximity, but without interaction. No aerial behaviour, activity levels are low. Dolphins surface in a synchronised manner and most of the time is spent at the waters surface. Dive angles are shallow.

2.2.6 Data Entry

All data was entered into the Trimble Nomad unit via the Cybertracker program, with a sequence developed specifically for the INPEX surveys. Hard copy data sheets were also completed to ensure data redundancy while using the Trimble Nomad unit. Hard copies will continue to be used for the remainder the pilot study duration.

2.2.7 Distance Estimation

Distance estimation trials were conducted on all observers using a Leica Rangerfinder to 800 meters. There are three main factors to consider when assessing the results of observers undertaking distance estimation trials, these include:

- Rounding distance estimates,
- Consistently over- or under- estimating distances
- Accurately estimating distances

During Survey Block 1 observers were informed of the true distance immediately after their estimate, in order to assist with calibration of estimates throughout the day. During Survey Block 2 observers were informed of the true distance once all estimates had been obtained throughout the day. This methodology simulated actual estimation conditions when the true distance is often unknown and observers are not able to calibrate their estimates.

2.3 Photo-identification

Photographs were taken whenever possible (i.e. depending on the groups' behaviours and time available) for species confirmation and photo-identification studies. Two cameras were available for photo-identification; a Canon EOS60D digital camera with a 100 – 400 mm L-series lens, and a Canon EOS20D digital camera with a 300mm L-series lens coupled with a 2x converter. All individuals in the group were photographed, regardless of whether they appeared to be identifiable. All photographs were downloaded immediately after the sighting and analysed upon completion of the Survey Block.

Following completion of Survey Block 2, all photographs were graded according to image quality, as a series of binary variables into the programme EXCEL version 5.1:

Unusable – a photograph which consists of a blank image to separate groups, a splash of water, or an image of a dolphin but no dorsal fin in the image (e.g. only a head, tail, or flipper in the image).

Poor – an image where the dorsal fin could not be clearly seen, the image was blurry, the dorsal fin was not was not perpendicular to the camera, or was severely backlit by the sun. Only very distinct individuals were identifiable.

Good – an image that was clear, the dorsal fin was nearly perpendicular to the camera and there was little backlighting. Most identifying features were seen if present, although slight angles, or dark lighting, made identification questionable.

Excellent – an exceptionally clear, in-focus image, where the dolphin took up more than half the image, the dorsal fin was perpendicular to the photographer and the lighting was excellent. All distinguishing features were seen, if present.

Each image was then catalogued based on the presence, or absence of identifiable features. Each usable image was classified into one of the following two categories:

Unrecognisable – the dolphin had no distinctive features on its dorsal fin or body that could be used to identify it (nothing more was done with these images),

Recognisable – the dolphin could be individually recognised based on distinctive features on its dorsal fin and/or body.

3. Results

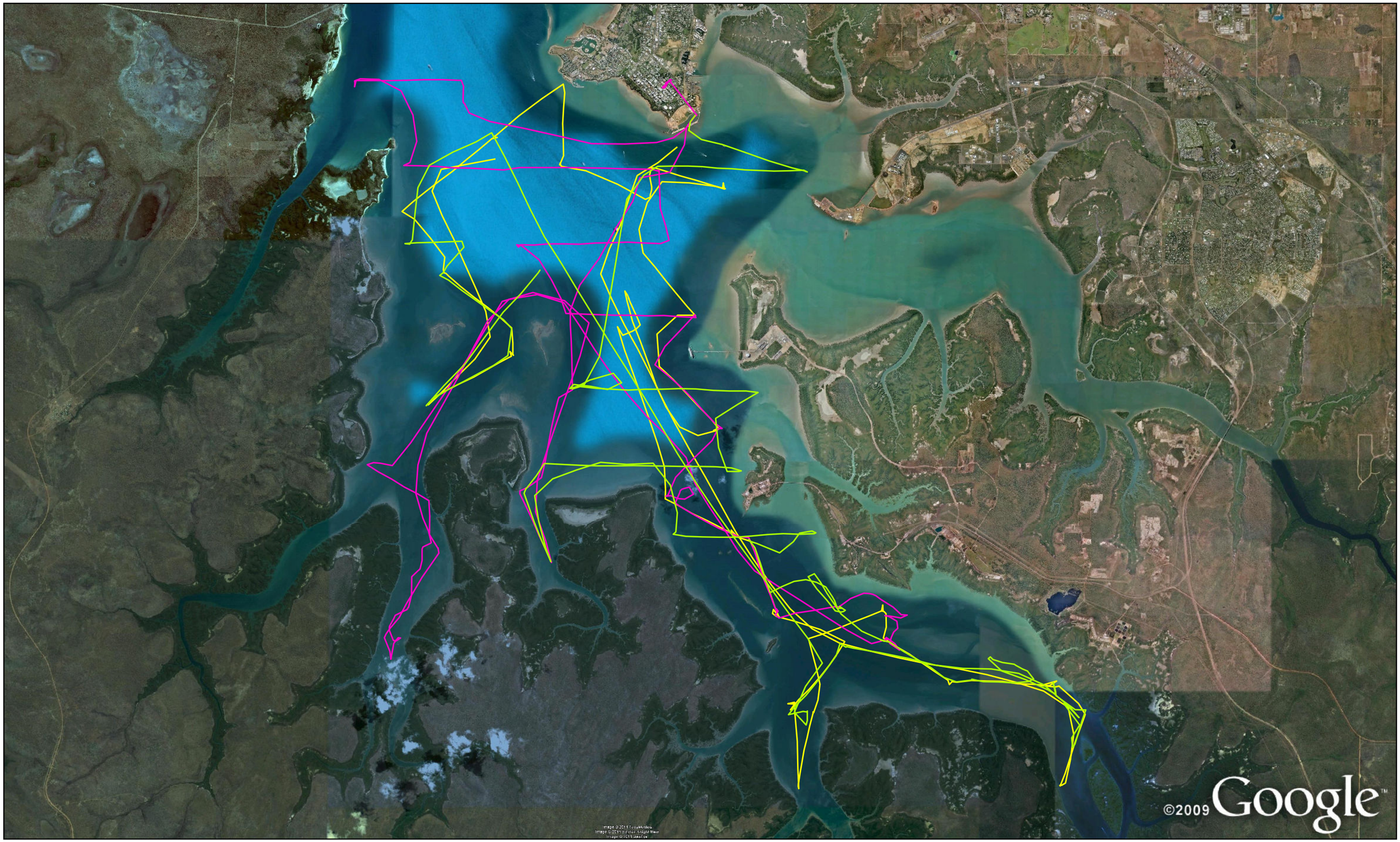
3.1 Transect Lines

The final transect lines that were agreed upon by GHD personnel and the Broadsword Marine skipper are shown in Figure 2-1 and daily track lines are illustrated in Figure 3-1. The lines in blue are navigable during all tides, while the lines in red are only navigable during mid to high tide. It is only possible to finish all transect lines in one day if no dolphins are sighted and the tides are favourable. It is therefore more realistic to assume that transect lines will be replicated at least twice, over each of the three day survey blocks.

A total of 94.2 km of survey were conducted over 7.5 hours on transect (Table 3-1). The transect lines covered are listed in Appendix A.

Table 3-1 Distances Travelled During Survey

Date	Total Distance (travelled km)	Total Time (hh:mm)	On Effort Transect (km)
9 Feb	76.5	2:29	30.2
10 Feb	101.0	2:24	30.3
11 Feb	107.0	2:37	33.7
Total	**284.5**	**7:30**	**94.2**



1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Tracks from Survey

Current Track: 09 FE (Approx 104 km)
Current Track: 10 FE (Approx 113 km)
Current Track: 11 FE (Approx 111 km)

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Tracks from Survey Block 2

Figure 3-1

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_007_rev_d.mxd

Data source: GHD - Survey tracks (2011), Imagery - Google Earth Pro (date extracted 14/02/2011), created by: MS

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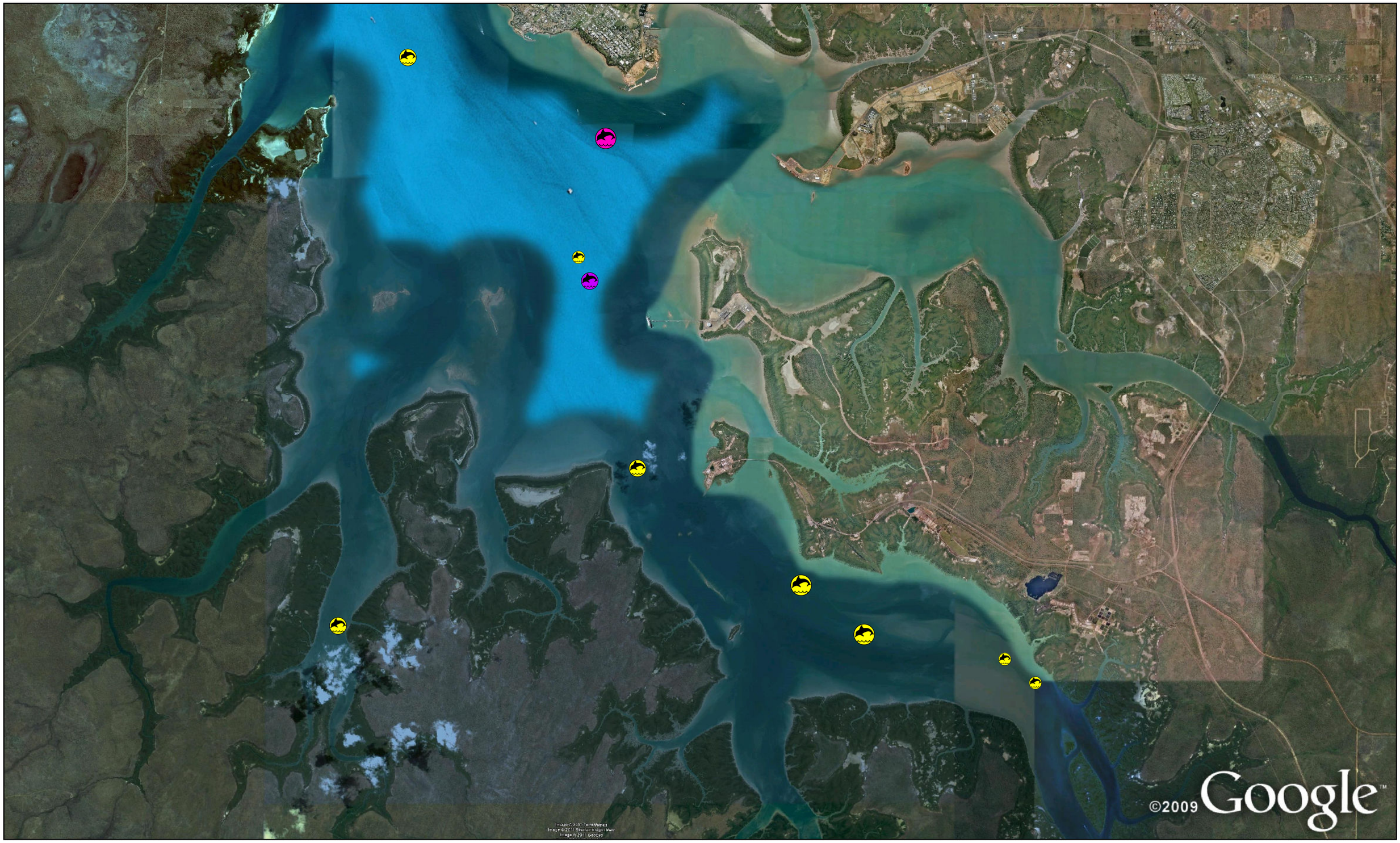
3.2 Marine Mammal Sightings

A total of 10 cetacean groups were observed (Table 2; Figure 3-2); which consisted of eight groups of humpback dolphins, one group of bottlenose dolphins, and one group of unknown delphinids (Survey Block 2 sighting numbers: 15 to 24). No snubfin dolphins or dugong were sighted during Survey Block 2.

Table 3-2 Summary of Marine Mammal Sightings During Boat Surveys

Date	Sighting #	Species	Certainty	Lat	Long	Total # of individuals (# calves)
9-Feb-11	15	Unknown Dolphin	Certain	12.51483	130.83606	4
9-Feb-11	16	Humpback dolphin	Certain	12.50969	130.83351	2
9-Feb-11	17	Bottlenose dolphin	Certain	12.48345	130.83943	7 (2)
10-Feb-11	18	Humpback dolphin	Certain	12.59127	130.78003	4 (1)
10-Feb-11	19	Humpback dolphin	Certain	12.5924	130.89822	7
10-Feb-11	20	Humpback dolphin	Certain	12.55609	130.84709	4 (1)
10-Feb-11	21	Humpback dolphin	Certain	12.46587	130.79489	4
11-Feb-11	22	Humpback dolphin	Certain	12.58164	130.88402	8
11-Feb-11	23	Humpback dolphin	Certain	12.59763	130.92987	1
11-Feb-11	24	Humpback dolphin	Certain	12.60279	130.93681	2

Seven dolphin groups were sighted while on-transect (i.e., on-effort), and the remaining three groups were sighted while on transit between lines, and during the coastline search (i.e., 'off-effort').



1:85,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Marine Mammal Sightings

Bottlenose dolphin

Humpback dolphin

Unknown dolphin

Number of Individuals

1 - 2

3 - 4

5 - 8

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Marine Mammal Sightings from Survey Block

Figure 3-2

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_012_rev_e.mxd

Data source: GHD - Marine Mammal Sightings (2011), Imagery - Google Earth Pro (date extracted 15/02/2011), created by:MS

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3.2.1 Marine Mammal Behaviour

Cetacean behaviour was recorded with a camcorder in addition to a series of photos that captured the behaviours. As defined by Parra (2006) and modified by Palmer (2010) recorded behaviours included:

Socialising: Localised movement. Dive direction is unpredictable. Dolphins in close proximity showing high levels of interaction (animals touching each other, rubbing their bodies). Fins and flukes often break the surface of the water. Frequent aerial behaviour such as leaps and summersaults; and

Fast travel - moving fast but in a persistent and directional pattern. Regular surfacing and diving patterns and animals are not underwater for great lengths of time.

Behaviours that provided more display than feeding or travelling were recorded on camera and include a group of humpback dolphins interacting with a sponge and approaching the survey vessel as illustrated below (Figure 3-3). A group of three dolphins were also recorded in deeper waters of the port where they were observed to leap out of 26 m of water (Figure 3-4).

Figure 3-3 Indo-Pacific humpback dolphins interacting with a sponge

Figure 3-4 Indo-Pacific humpback dolphin leaping out of 26 m of water

As observers become more experienced and where sightings are not only brief encounters, video will be used to capture behaviours as per methodology undertaken by Parra (2006) and Palmer (2010).

3.3 Other Megafauna Sightings

A total of six turtle sightings were confirmed during surveys (Figure 3-5).

3.4 Environmental Parameters

Environmental data were collected at the location of all on-effort data sightings, and off-effort sightings when time allowed. The resulting environmental data for all sightings where the species was confirmed (i.e. 'certain') are shown in Table 3-3.

Table 3-3 Environmental Parameters Recorded on Survey (Certain Sightings Only)

Environmental Parameters	Humpback Average (min-max)	Snubfin Average (min-max)	Bottlenose Average (min-max)	Dugong Average (min-max)
9 Feb	n=1	--	n=1	--
Depth (m)	22.5		14.3	
Temp (^{o}C)	32.1		31.6	
Turbidity (NTU)	6.9		6.0	
Salinity (ppk)	30.9		32.1	
Tide State	Falling		Falling	
10 Feb	n=4	--	--	--
Depth (m)	12.2 (6.4-26.0)			
Temp (^{o}C)	30.0 (28.9-33.5)			
Turbidity (NTU)	4.4 (3.1-5.6)			
Salinity (ppk)	29.6 (28.9-31.2)			
Tide State	Rising/Slack/ Falling			
11 Feb	n=3	--	--	--
Depth (m)	8.4 (4.6-11.0)			
Temp (^{o}C)	33.7 (32.9-34.2)			
Turbidity (NTU)	4.3 (4.0-4.5)			
Salinity (ppk)	27.3 (24.6-29.1)			
Tide State	Slack/Falling			

1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Marine Fauna Sightings

Turtle

Number of Individuals

1

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Other Marine Megafauna Observed on Survey

Figure 3-5

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_016_rev_d.mxd

Data source: GHD: Other marine fauna (2011), Imagery - Google Earth Pro (date extracted 14/02/2011), created by: MS

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3.5 Cyber-tracker Sequence

The cyber-tracker sequence aims to capture all relevant information for transect, environmental and photo-identification methodologies in the most straight-forward, easy-to-follow manner. The sequence developed for Survey Block 1 (shown in Appendix C of the Survey Block 1 summary report), was used successfully during Survey Block 2.

3.6 Distance Estimation

A total of 114 distance estimation trials were conducted during Survey Block 2. Graphs of the results are provided in Appendix C.

3.6.1 Distance Estimation Rounding

A comparison of the estimated distances that were rounded for each survey block, compared to the true distance obtained from the rangefinders are shown in Table 3-4. Nearly half of the estimated distances were rounded during Survey Block 1; however this number was reduced to 32% during Survey Block 2; which was within the upper-range of allowable rounding as calculated by true distances obtained from the laser range-finders (i.e. 13.5 - 34.2%). The amount of rounding during Survey Block 2 was still high, so emphasise will be placed on reducing rounding during Survey Block 3.

Table 3-4 Distance Estimation Rounding

Survey Block 1 (Estimates n=205; Rangefinder n=79)			
Method	**Rounded to 0**	**Rounded to 5**	**Total rounded**
Estimates	41.0%	8.8%	49.8%
Rangefinder	16.5%	17.7%	34.2%
Survey Block 2 (Estimates n=114; Rangefinder n=52)			
Method	**Rounded to 0**	**Rounded to 5**	**Total rounded**
Estimates	16.7%	15.8%	32.5%
Rangefinder	5.8%	7.7%	13.5%

Distances will continue to be tested during Survey Block 3, however, as with Survey Block 2, results are encouraging in that estimates are mostly close to the true distance, and all observers are both over- and under-estimating distances (which is preferred to

either constantly over- or under-estimating distances which biases the resulting abundance estimates).

3.6.2 Over- and Under-Estimating Distance

Most observers are consistently over- and under- estimating distances (Table 3-5), however, Observer 2 is over-estimating more than under-estimating (74% ca. 26% respectively), and Observer 3 is under-estimating more than over-estimating (69% ca. 31%). Prior to Survey Block 3, observers will be shown their respective distance estimation graphs to facilitate improved estimations for Survey Block 3.

Table 3-5 Observer Distance Estimation

Observer	Over-estimations	Under-estimations
1 (n=10)	60%	40%
2 (n=23)	26%	74%
3 (n=16)	69%	31%
4 (n=23)	52%	48%
5 (n=23)	52%	48%
6 (n=19)	42%	58%

3.6.3 Distance Estimation Accuracy

The accuracy of the estimates was assessed for each observer by calculating the percentage difference between the true distance obtained via the rangefinder binoculars, and the observers estimated distances.

The results showed that during Survey Block 1 observers were within 7.1-21.8% of the true distance, whereas during Survey Block 2 observers were less accurate and within 17.8-29.5% of the true distance (Table 3-6).

Table 3-6 Distance Estimation Accuracy

Observer	Survey Block 1 Average % from true distance	Survey Block 1 Range	Survey Block 2 Average % from true distance	Survey Block 2 Range
1 (n=43/n=10)	7.1	0.0 – 24.8	17.8	1.5 – 37.1
2 (n=32/n=23)	16.3	0.0 -73.3	21.7	0.0 – 41.7
3 (n=38/n=16)	21.8	0.6 – 58.6	19.0	0.2 – 45.4
4 (n=42/n=23)	21.4	0.6 – 58.6	29.5	0.4 – 59.0
5 (n=31/n=23)	19.3	0.5 – 50.5	19.6	1.1 – 41.4
6 (n=19/n=19)	20.2	0.9 – 59.8	23.1	1.3 – 51.1

The difference in estimation accuracy between survey blocks occurs because during Survey Block 2 the true estimates were not told to the observers after each estimation, so observers could not 're-calibrate' their estimates.

3.7 Data Entry Quality Assurance

When using the Trimble Nomad unit at-sea, there is potential for data-entry mistakes as a result of the bright-sun on the screen, movement of the boat, probability of observer fatigue and heat-stress, and high excitement during sightings. Data quality and accuracy checks were conducted at the end of the Survey Block by comparing the cyber-tracker output files with those of the hardcopy notes kept by Groom and Beasley. As with Survey Block 1, the results of the data entry quality assurance were extremely encouraging, with only one incorrect entry:

- 0/48 (0%) incorrect sequence entries on 09/02/11
- 0/49 (0%) incorrect sequence entries on 10/02/11; and
- 1/48 (2%) incorrect sequence entries on 11/02/11

The required changes related to environmental data. All sighting data entries were correct.

The required changes to the output data were as follows:

Date: 11/02/11 / Time: 15:29:24

Entry category – Environmentals

Cybertracker entry: Tide = Rising

Hardcopy entry: Tide = Falling

The tide state was changed to 'falling', based on known tide state at the time of data entry, and confirmation of tide state from previous and post environmental data.

3.8 Photo-identification

Photo-identification was conducted on nine of the ten groups sighted (90%). The group not photographed were too evasive to get close to.

A total of three bottlenose dolphins, and eight humpback dolphins were photo-identified during Survey Block 2 (Appendix B). Three of the humpback dolphins were re-sightings from Survey Block 1; SCHI04, SCHI05, and SCHI06.

- From sighting 19 of Survey Block 2, SCHI04 was sighted in a group of six individuals on 30 January 2001 (Sighting 10) near waypoint 23.
- From sighting 22 of Survey Block 2, SCHI05 and SCHI06 were also sighted in the group of six individuals on 30 January 2001 (Sighting 10) near waypoint 23.

4. Discussion

Survey Block 2 resulted in sightings of bottlenose and humpback dolphins, as well as sightings of turtles. No snubfin dolphins, dugong or crocodiles were sighted during Survey Block 2. Humpback dolphins were the most frequently sighted (n=8), followed by bottlenose dolphins (n=1). One group of unidentified cetaceans were sighted; these were likely humpback dolphins.

Of the ten sightings observed during Survey Block 2, seven (70%) were sighted 'on-effort'. This is an improvement to Survey Block 1 where only 21% of sightings were 'on-effort'. The original transect lines were conducted during the first day of Survey Block 1, which resulted in two off-effort sightings and one on-effort sighting. The revised transect lines were conducted on days 2 and 3 of Survey Block 2, which resulted in one off-effort and six on-effort sightings. Revision of the transect design will not affect the final results of line-transect analysis, since the fundamental principles of the design are the same for both transect designs (i.e. the revised transect lines retained the principle of equal coverage probability, and are randomly placed in relation to dolphin distribution within the harbour (Buckland et al. 2001; Dawson et al. 2008) It is likely that the revised transect design in combination with increased experience of observers will assist to achieve high sighting rates while on-effort for Survey Block 3.

Photo-identification once again proved successful with eight identifiable images from humpback dolphins and three from bottlenose dolphins. Three of the humpback dolphin identifications were re-sightings from Survey Block 1, which is encouraging for the use of photo-identification to estimate abundance.

4.1 Survey Limitations and Improvements

Some aspects of the survey were noted for improvement prior the commencement of Survey Block 3. Constraints from this survey have been recognised and are outlined below, in some instances these have also been reported on in the monthly HSE Report to INPEX.

4.1.1 Transect Lines

It has been noted in the above summary report that the transect lines needed revision as they were considered relatively short, resulting in a significant amount of transit time between lines and many dolphins being sighted 'off-effort' rather than 'on-effort'. The transect lines have now been revised based on survey design recommendations in Buckland et al. 2004; Dawson et al 2008) and known bathymetry of Darwin harbour based on experience from Surveys Blocks 1 and 2. The effectiveness and suitability of the revised transect lines for the distance-sampling methodology within the study area will be further assessed during Survey Block 3.

4.2 Survey Limitations and Improvements – Survey Block 1

The following issues were addressed prior to Survey Block 2.

4.2.1 Air-conditioner exhaust location on bridge

1. The location of the air-conditioner exhaust on the bridge caused discomfort to all observers during surveys as it was mounted immediately forward of the observer team (30 cm spacing from the data-recorder). This outlet is a safety concern as it is likely to contribute to observer fatigue and over-heating during surveys. It is recommended that the air-conditioning outlet is moved to the rear of the bridge, prior to the commencement of Survey Block 2 (this has been agreed upon by Broadsword Marine).

Outcome – Broadsword Marine organised for the air-conditioner exhaust to be moved to the back of the flying bridge, which reduced the amount of hot air blowing onto observers, resulting in the transect surveys being much more comfortable to conduct.

4.2.2 Binoculars

One pair of the project-purchased Fujinon binoculars were damaged when sent from the distributor, as the compass would not turn freely (impeding accurate angle estimates). The compass needs to be fixed before the binoculars are used again during line-transect boat surveys.

As a result of the methodology change to the observer rotation, a third pair of Fujinon binoculars will need to be purchased, to ensure that all observers have access to binoculars when required.

Outcome – As a result of the tight turn-around schedule for Survey Block 2, there was no time for the faulty compass within the binoculars to be fixed. However, since Survey Block 3 will be conducted at the start of March, the binoculars will be fixed in time for the next surveys.

An additional pair of Nikon binoculars with inbuilt compass for the data recorder to use during transects was used during the survey. The third pair of binoculars was a great asset for the surveys, and it is recommended that at least three pairs of binoculars with inbuilt compass are available for Survey Block 3.

4.2.3 Photo-identification

A second photographer would increase the potential to obtain high quality photo-identification images through covering both sides of the boat at once during sightings. The potential for slips/trips/falls will also be reduced if two photographers are taking photographs at the same time. Beasley will use her personal camera equipment for future surveys (Canon EOS20D digital camera with a fixed 300 mm L-series lens and 2x convertor), to contribute to photo-identification efforts.

Outcome – Beasley used her personal camera, which significantly assisted with

photo-identification efforts. The downside to using two cameras to conduct photo-identification is that extra time is required to analyse the resulting images. However, the second camera resulted in two identifications that were not 'captured' by the project camera, indicating that the extra analysis is worth the effort. The second camera will also be used during Survey Block 3.

4.3 References

Buckland, S.T., D.R. Anderson., Burnham, K.P., J.L. Laake., D.L. Borchers. and L. Thomas. 2001. Introduction to distance sampling – Estimating abundance of biological populations. Oxford University Press. UK. 432pp.

Dawson, S., P. Wade.,E. Slooten, E. and J. Barlow. 2008. Design and field methods for sighting surveys of cetaceans in coastl and riverine habitats. Mammal Review, 38, 19-49.

Appendix A

Survey Block 2 – Transect Lines Undertaken

Date	Effort	Time	Wpt ID	Lat	Long	Odm	Distance Traveled	Time Traveled	Going From?	Going To?
9/2/11	ON	9:06:01	37	12.624333	130.9381933	1			37	38
9/2/11	OFF	9:16:17	38			2.4	1.4	0:10:16		
9/2/11	ON	9:30:05	39	12.6009367	130.933873	4.7			39	40
9/2/11	OFF	9:39:07	40			6.7	2	0:09:02		
9/2/11	ON	9:49:49	25	12.5995016 7	130.910335	7.8			25	26
9/2/11	OFF	9:59:27	26			9.8	2	0:09:38		
9/2/11	ON	10:12:02	27	12.5842783	130.894315	11.3			27	28
9/2/11	OFF	10:21:48	28			13.3	2	0:09:46		
9/2/11	ON	10:40:06	34	12.6091567	130.878772	15.6			34	33
9/2/11	OFF	10:52:50	33			17.5	1.9	0:12:44		
9/2/11	ON	11:15:03	35	12.605175	130.8751817	21			35	36
9/2/11	OFF	11:24:59	36			23	2	0:09:56		
9/2/11	ON	11:39:14	29	12.5832816 7	130.869783	25.7			29	30
9/2/11	OFF	11:48:14	30			27.7	2	0:09:00		
9/2/11	ON	11:57:14	31	12.5651833	130.8578033	28.9			31	32
9/2/11	OFF	12:05:37	32			30.8	1.9	0:08:23		S15/16 (OFF)
9/2/11	ON	13:14:44	19	12.5401167	130.8550017	43.3			19	20
9/2/11	OFF	13:23:17	20			45.2	1.9	0:08:33		
9/2/11	ON	13:35:12	21	12.5132983	130.848635	47.7			21	22
9/2/11	OFF	13:43:12	22			49.6	1.9	0:08:00		
9/2/11	ON	14:02:09	23	12.485255	130.855715	54.2			23	24

9/2/11	OFF	14:10:08	24			55.9	1.7	0:07:59		S17 (ON)
9/2/11	ON	14:51:18	41	12.4781167	130.81874	60			41	42
9/2/11	OFF	15:00:48	42			61.9	1.9	0:09:30		
9/2/11	ON	15:15:57	6	12.4750816 7	130.8008217	65			6	5
9/2/11	OFF	15:29:18	5			67.9	2.9	0:13:21		
9/2/11	ON	15:46:00	4	12.5070616 7	130.792676	70.6			4	3
9/2/11	OFF	15:55:46	3			72.8	2.2	0:09:46		
9/2/11	ON	16:05:44	2	12.5253	130.806125	74			2	1
9/2/11	OFF	16:18:36	1			76.5	2.5	0:12:52		
						Total KM	30.2	2:28:46		
10/2/11	ON	7:59:11	18	12.5161767	130.8205167	1			18	17
10/2/11	OFF	8:08:09	17			2.2	1.2	0:08:58		
10/2/11	ON	8:14:50	16	12.5361867	130.817611	2.9			16	15
10/2/11	OFF	8:23:48	15			4.8	1.9	0:08:58		
10/2/11	ON	8:32:52	14	12.55839	130.8095467	5.8			14	13
10/2/11	OFF	8:42:05	13			7.6	1.8	0:09:13		
10/2/11	ON	9:24:51	12	12.551423	130.773573	22.8			12	11
10/2/11	OFF	9:33:53	11			24.6	1.8	0:09:02		
10/2/11	ON	9:45:07	10	12.572567	130.788815	26.2			10	9
10/2/11	OFF	9:55:26	9			28.2	2	0:10:19		
10/2/11	ON	10:00:48	8	12.5921767	130.77745	28.9			8	7
10/2/11	OFF	10:01:30	7			29.1	0.2	0:00:42		S18 (ON)
10/2/11	ON	12:13:13	26	12.59103	130.897543	55.2			26	25
10/2/11	OFF	12:13:52	25			55.3	0.1	0:00:39		S19 (ON)
10/2/11	ON	13:27:13	29	12.578545	130.8678367	63			29	30

10/2/11	OFF	13:34:01	30			64.4	1.4	0:06:48		
10/2/11	ON	13:39:26	31	12.56 54567	130.8572 967	65.1			31	32
10/2/11	OFF	13:46:05	32			66.4	1.3	0:06:39		S20 (ON)
10/2/11	ON	14:24:01	19	12.54 02283	130.8550 867	70.9			19	20
10/2/11	OFF	14:33:09	20			73	2.1	0:09:08		
10/2/11	ON	14:46:42	21	12.51 55383	130.8488 717	75.3			21	18
10/2/11	OFF	15:02:37	18			78.7	3.4	0:15:55		
10/2/11	ON	15:18:30	45	12.49 89967	130.809 501	81.4			45	46
10/2/11	OFF	15:36:54	46			85.2	3.8	0:18:24		
10/2/11	ON	15:53:16	24	12.48 1045	130.837 55	87.7			24	44
10/2/11	OFF	16:22:47	44			94.3	6.6	0:29:31		
10/2/11	ON	16:43:03	43	12.46 08267	130.771 043	98.3			43	42
10/2/11	OFF	16:52:58	42			101	2.7	0:09:55		S21 (ON)
						Total KM	30.3	2:24:11		
11/2/11	ON	7:38:13	47	12.48 1085	130.876 025	0			47	24
11/2/11	OFF	7:59:14	24			4.3	4.3	0:21:01		
11/2/11	ON	8:33:50	17	12.53 2005	130.823 085	14.2			17	48
11/2/11	OFF	8:55:23	48			18.8	4.6	0:21:33		
11/2/11	ON	9:11:12	49	12.55 08767	130.860 355	22.2			49	50
11/2/11	OFF	9:34:03	50			27.3	5.1	0:22:51		
11/2/11	ON	9:44:23	14	12.55 77933	130.810 345	28.3			14	13
11/2/11	OFF	9:53:59	13			30.2	1.9	0:09:36		
11/2/11	ON	10:23:04	51	12.56 67167	130.847 038	37.7			51	52
11/2/11	OFF	10:42:07	52			41.3	3.6	0:19:03		
11/2/11	ON	10:57:44	30	12.54 9145	130.864 88	43.9			30	29
11/2/11	OFF	11:02:22	29	12.57 766	130.867 821	44.9	1	0:04:38		S22 (ON)

11/2/11	ON	12:10:22	26	12.59178167	130.89788	52.6			26	25
11/2/11	OFF	12:19:10	25			54.5	1.9	0:08:48		
11/2/11	ON	12:29:20	40	12.600165	130.918605	55.4			40	39
11/2/11	OFF	12:32:54	39	12.600353	130.92499	56.6	1.2	0:03:34		S23 (ON)
11/2/11	ON	13:21:23	38	12.608668	130.9431567	62.1			38	37
11/2/11	OFF	13:27:35	37			63.2	1.1	0:06:12		
11/2/11	ON	14:06:02	36	12.59477167	130.88425	72.6			36	35
11/2/11	OFF	14:15:29	35			74.6	2	0:09:27		
11/2/11	ON	14:25:43	34	12.609476767	130.877743	75.5			34	33
11/2/11	OFF	14:27:27	33			75.9	0.4	0:01:44		
11/2/11	ON	15:33:20	52	12.498575	130.78326	98.4			52	51
11/2/11	OFF	15:41:08	51			100	1.6	0:07:48		
11/2/11	ON	15:52:15	4	12.50788167	130.79235	101			4	3
11/2/11	OFF	16:01:59	3			104	3	0:09:44		
11/2/11	ON	16:06:05	2	12.525215	130.80543	105			2	1
11/2/11	OFF	16:17:37	1			107	2	0:11:32		
						Total KM	33.7	2:37:31		

Appendix B

Photo-identification Images

Bottlenose dolphins

TADU03 – Left side (9 Feb 2011 – Sighting 17)

TADU03 – Right side (9 Feb 2011 – Sighting 17)

TADU04 – Left side (9 Feb 2011 – Sighting 17)

TADU04 – Right side (with possible calf) (9 Feb 2011 – Sighting 17)

TADU05 – Right side (9 Feb 2011 – Sighting 17)

TADU05 – Right side with calf (9 Feb 2011 – Sighting 17)

Humpback dolphins

SCHI08 (9 Feb 2011 – Sighting 16)

SCHI09 – Left side (10 Feb 2011 – Sighting 18)

SCHI09 – Right side (10 Feb 2011 – Sighting 18)

SCHI10 – Left side: associated with calf (10 Feb 2011 – Sighting 18)

SCHI10 – Right side: associated with calf (10 Feb 2011 – Sighting 18)

SCHI04 (Resight) – Left side (10 Feb 2011 – Sighting 19)

SCHI11 – Left side (10 Feb 2011 – Sighting 20)

SCHI11 – Right side (10 Feb 2011 – Sighting 20)

SCHI06 (Resight) – Right side (11 Feb 2011 – Sighting 22)

SCHI12 – Left side (11 Feb 2011 – Sighting 22)

SCHI12 – Right side (11 Feb 2011 – Sighting 22)

SCHI05 (Resight) – Right side (11 Feb 2011 – Sighting 22)

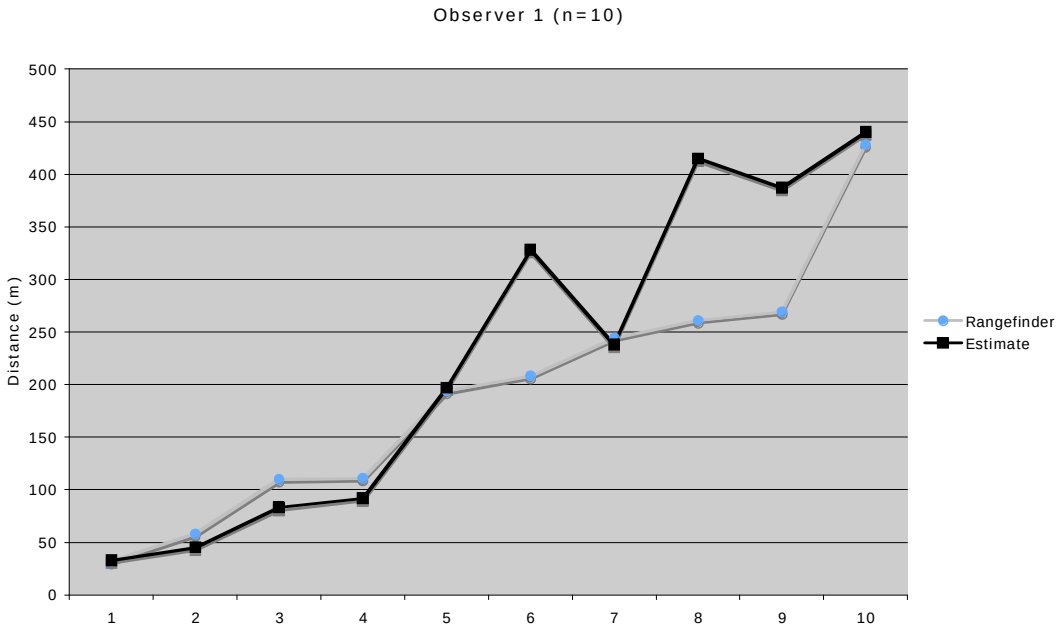
SCHI13 – Left side (11 Feb 2011 – Sighting 22)

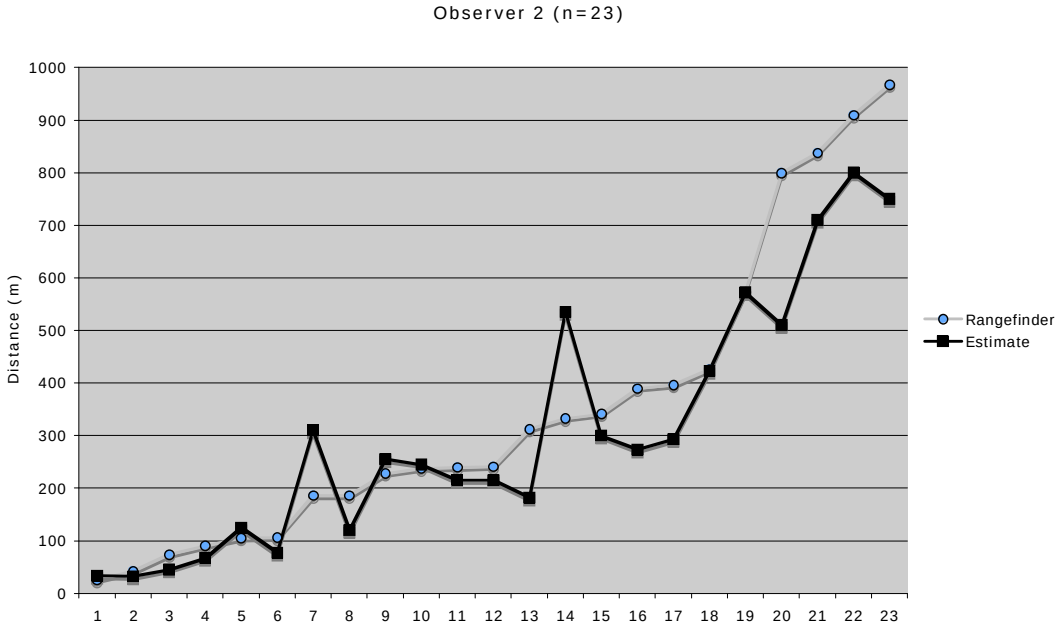
SCHI13 – Right side (11 Feb 2011 – Sighting 22)

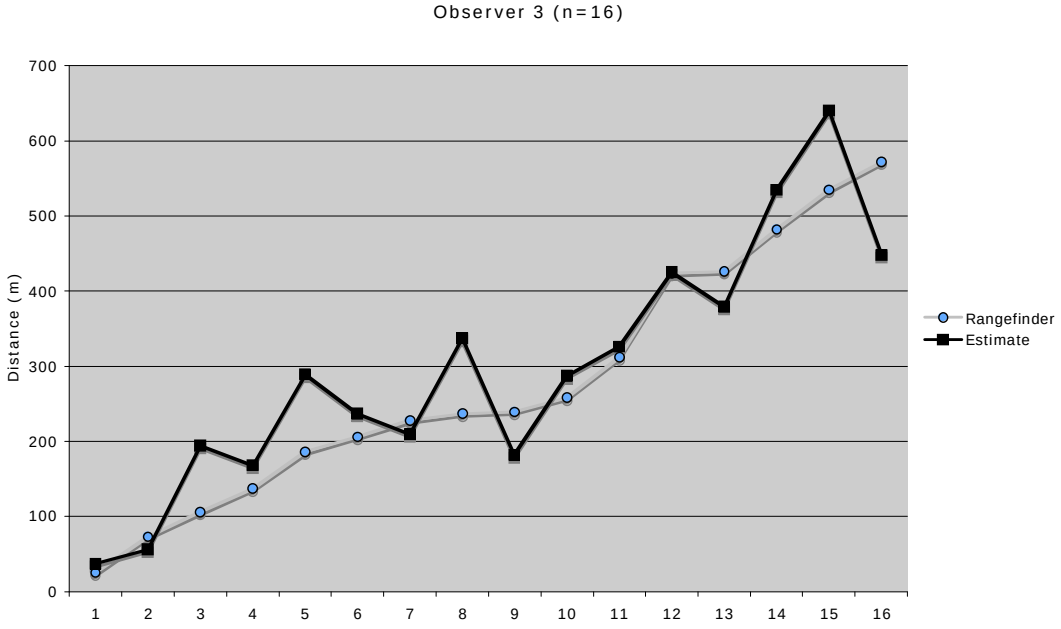
Appendix C

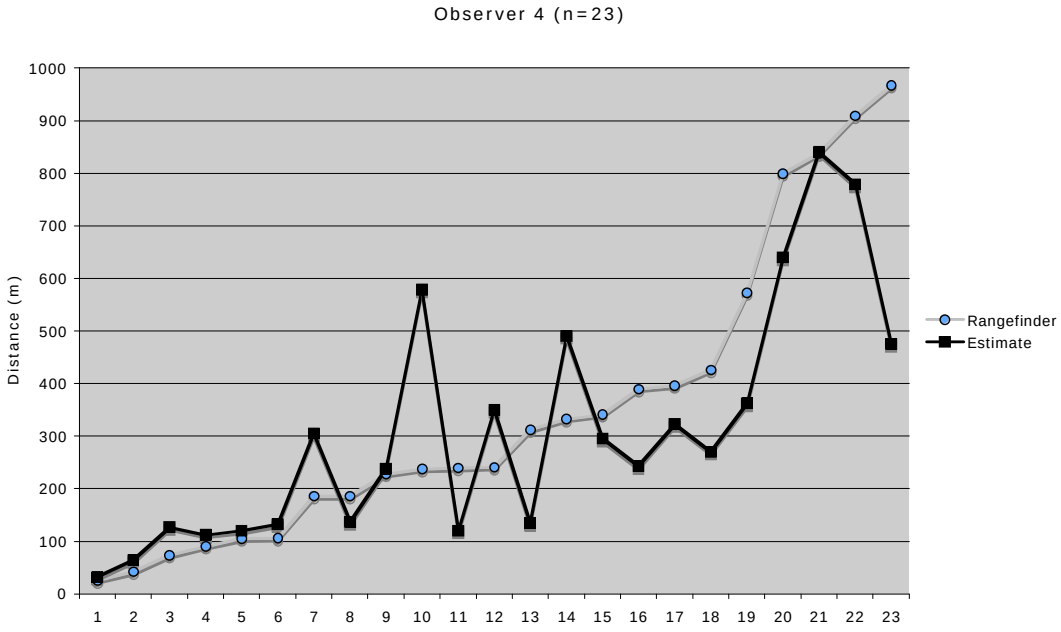
Graphs of Observer Distance Estimation

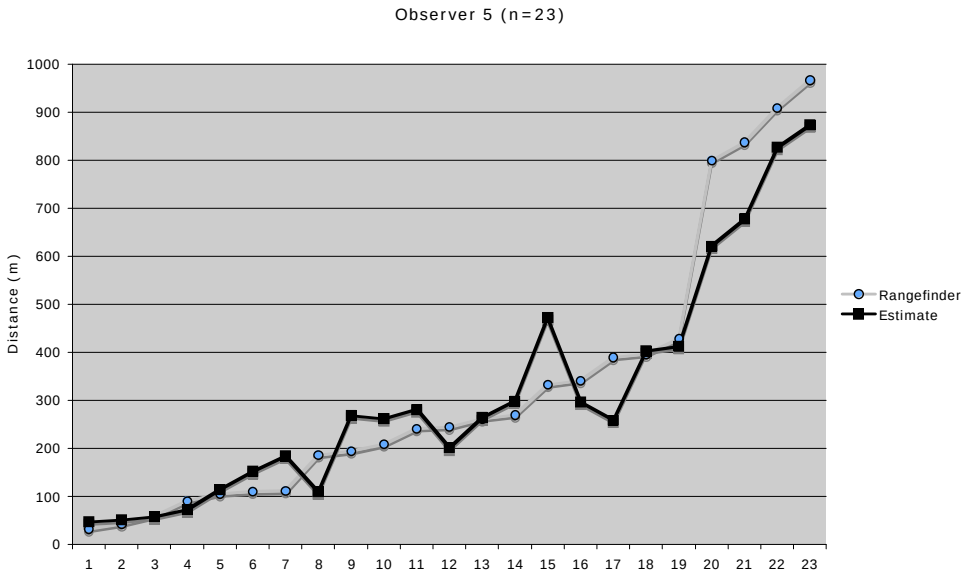
Line-graphs of distance estimation trials for each of the six observers. The light lines are the actual distance (obtained from the rangefinders), while the black lines are the estimated distances.

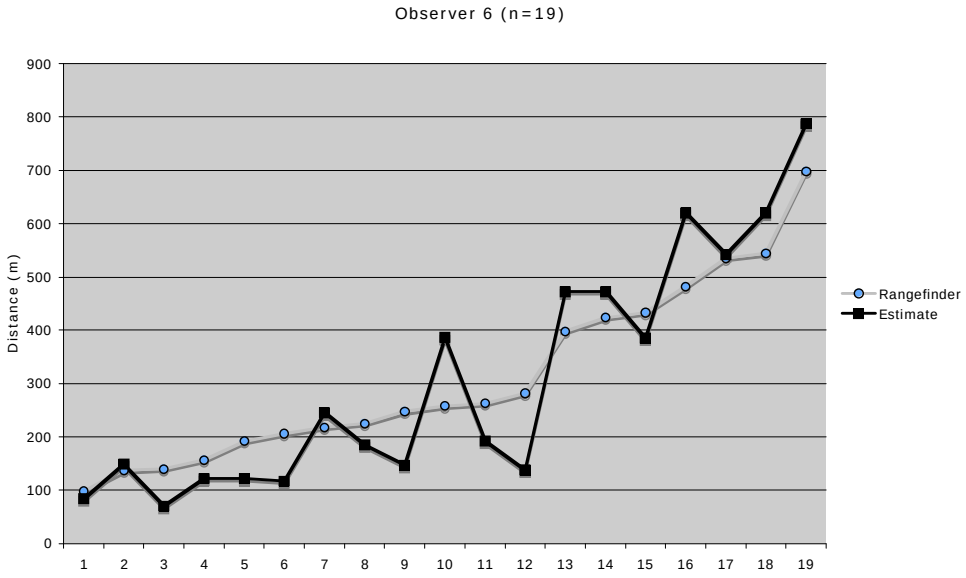


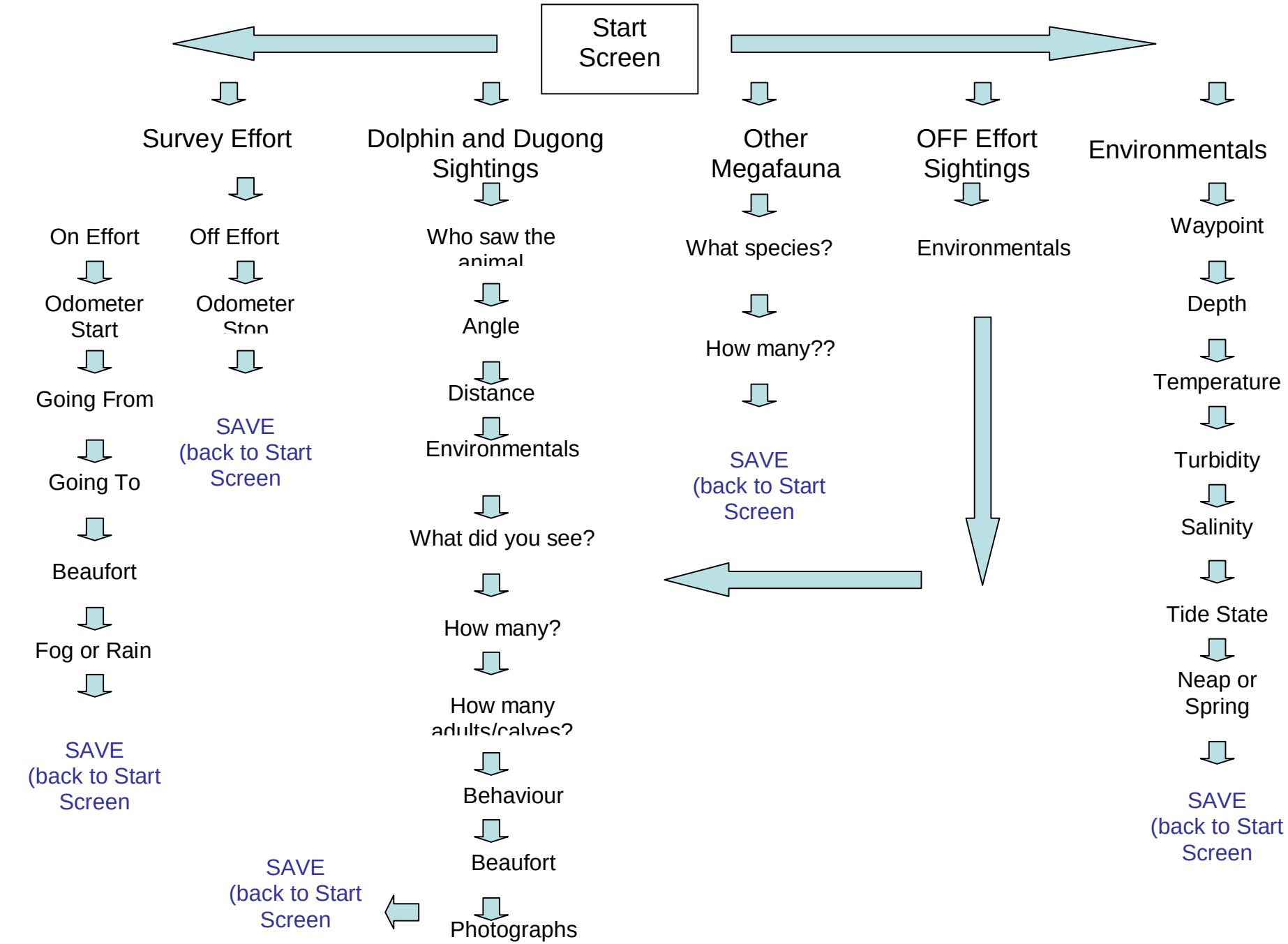












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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	I. Beasley	R. Groom				16/02/11
0	I. Beasley	R. Groom		R. Groom		21/02/11

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INPEX

Report for Inshore Dolphin Survey, Darwin Harbour (Middle and West Arm)

Summary Report for Survey Block 3 (6 - 8 March 2011)

March 2011

C036-AH-REP-0120

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Appendices

Photo 1 Inshore dolphin survey team

Left to Right: Isabel Beasley, Kattie Risk, Rachel Groom, Keith Sailor, Billy Risk (Jnr.), Bill Risk (Snr.).

1. Introduction

1.1 Purpose and Scope of this Report

GHD were contracted by INPEX as part of the Ichthys Project to conduct a pilot study on inshore dolphins and other marine megafauna in Middle and West Arm of Darwin Harbour. The key objectives of the pilot study are to:

1. Determine presence/absence of inshore dolphins
2. Compare distance-sampling and capture-recapture survey techniques to investigate which methodology would provide the more robust estimates of inshore dolphin abundance
3. Conduct photo-ID for comparison with existing catalogues and for use in future surveys
4. Collect appropriate environmental data to determine inshore dolphin habitat preferences.

This summary report provides findings from the third survey block (Survey Block 3), undertaken during March 6 -8, 2011 inclusive.

1.2 Overview

The pilot survey design addresses the Scope of Works provided to GHD, with a determination that 'closing mode' would be the best boat-based transect methodology to achieve the above objectives. The pilot study comprised one training day for observers and ten days of vessel-based research undertaken as three survey blocks of four, three and three days each respectively; with all survey days to be completed by the end of March 2011. The surveys were undertaken in accordance with permit requirements explicitly granted for this project by the Animal Welfare Authority (Licence No: 016) and the Parks and Wildlife Commission of the Northern Territory (Permit Number: 40123).

2. Methodology

2.1 Overview

Project personnel from outside of Darwin (Rachel Groom and Isabel Beasley) mobilised to Darwin on March 5, 2011. Darwin-based project personnel consisted of Bill Risk (Snr), Bill Risk (Jnr), Kattie Risk and Keith Sailor from the Larrakia Development Corporation (LDC). Three consecutive days of boat-based survey days were conducted from March 6 - 8, 2011 on the INPEX approved vessel, MV Serious Fun.

2.2 Boat-based Transects – Survey Block 2

The following method was used for the boat-based transect surveys during Survey Block 3.

2.2.1 Transect Lines

The transect lines used during Survey Block 3 are illustrated in Figure 2-1.

2.2.2 Observer Rotation and Observations

Observer rotations for Survey Block 3 were in accordance with those used during Survey Block 2. A team of three observers monitored two transect lines consecutively, followed by a change of observers. This process was repeated throughout the transect survey. Each observer team comprised of an experienced observer supported by two trained LDC observers. Observer rotation provided adequate rest for observers prior to returning to transect observations ('on-effort').

The left and right observers observed through binoculars covering the forward 50 degrees on their side of the boat while searching on-effort along the transect. The data recorder was positioned in between the two observers with binoculars and searched for dolphins and other marine fauna on the track-line, while entering data into the Trimble using the Cyber-tracker sequence. All observers had access to a pair of binoculars with inbuilt compass. This allowed the data recorder to confirm possible sightings without interrupting the other two observers.

A photo-identification coastline search was conducted during the final day of the third survey block (March 8, 2011). Observer rotation during the coastline search followed the protocol above.

2.2.3 Environmental Parameters

Environmental parameters (water depth, temperature, turbidity, salinity and pH) were collected at the start of each transect line, and at all cetacean sightings. The 'off-effort' survey team (the three resting observers), collected environmental data to reduce survey inefficiencies encountered by observers transitioning between roles (i.e. time to move between the vessel's back deck and bridge).

1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

- Waypoint
- Tidally restricted
- Not tidally restricted

DRAFT

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INPEX Browse Ltd
Darwin Coastal Dolphin Survey

Job Number	43-21774-007
Revision	F
Date	16 MAR 2011

Survey Transects for Inshore Dolphin Surveys

Figure 2-1

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_017_rev_f.mxd

Data source: GHD - Transects (2011), Imagery - Google Earth Pro (date extracted 15/02/2011), created by:MS

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2.2.4 Marine Mammal Sightings

Observers read the angle and distance (by either reading the appropriate reticle on the binoculars or estimating distance) to each observed dolphin group. The boat departed the transect line to allow observers to assess the dolphin group's characteristics. The boat continued in passing mode for all turtle and crocodile sightings with waypoints recorded for these species locations. The position (via GPS), species, group size, age classes, and predominate behaviour were recorded once at the estimated location of the dolphin group. If the species identification was ascertained with certainty, it was recorded as 'certain'. It was recorded as 'probable' if the species identification was not 100% certain but some distinguishing features were evident. It was recorded as 'unknown' if a cetacean was sighted but no distinctive characteristics could be determined (i.e., it was only sighted once, or surfaced very quickly and inconspicuously). Species observation data was recorded on the Trimble and on hardcopy datasheets.

2.2.5 Cetacean Behaviour

Cetacean behaviour was videoed using a hand-held recorder. Video was reviewed after the survey and predominate behaviour systematically recorded every five minutes according to behavioural categories developed by Parra (2006) and modified by Palmer (2010):

- *Foraging* - Individuals moving in various directions without an obvious pattern. Dolphins diving frequently and steeply downwards (often preceded by fluke or peduncle arches), with extended submersion times. Rapid accelerations and erratic movement at the surface, indicative of animals chasing fish. Animals seen directly pursuing a fish (e.g. fish jumping at the surface) or with fish in their mouth.
- *Foraging behind trawler* - repeated diving in varying directions around the side or behind the stern of a trawler boat while the boat was fishing.
- *Slow travel* - moving in slow and persistent directional pattern. There were regular surfacing and diving patterns and animals were not underwater for great lengths of time.
- *Fast travel* - moving fast but in a persistent and directional pattern. There were regular surfacing and diving patterns and animals are not underwater for great lengths of time.
- *Socialising*: Localised movement - dive direction is unpredictable. Dolphins were in close proximity showing high levels of interaction (animals touching each other, rubbing their bodies). Fins and flukes often break the surface of the water. There was frequent aerial behaviour such as leaps and summersaults.
- *Milling* - movement slow with no apparent direction. Dolphins swim in close proximity, but without interaction. No aerial behaviour and activity levels are low. Dolphins surface in a synchronised manner and most of the time is spent at the waters surface. Dive angles are shallow.

2.2.6 Data Entry

All data were entered into the Trimble Nomad unit via the Cybertracker program, with a sequence developed specifically for the INPEX surveys. Hard copy data sheets were completed to ensure redundancy in the event of the Trimble failing.

There is potential for data-entry mistakes when using the Trimble Nomad unit at sea. This results from bright-sun on the screen, movement of the boat, the probability of observer fatigue and heat-stress, and excitement/distraction during sightings. Data quality and accuracy checks were conducted at the end of Survey Block 3 by comparing the cyber-tracker output files with those of the hardcopy notes kept by the survey team.

2.2.7 Distance Estimation

Distance estimation trials were conducted on all observers using a Leica Rangerfinder (up to 800 meters). Three key factors are considered when assessing the results of observers undertaking distance estimation trials. These include:

1. Rounding distance estimates
2. Consistently over- or under- estimating distances
3. Accurately estimating distances

During Survey Block 3 observers were informed of the true distance immediately after their estimate. This assisted with calibration of estimates throughout the day.

2.3 Photo-identification

Photographs of inshore dolphins were taken for species confirmation and photo-identification studies whenever possible (i.e. depending on the groups' behaviours and time available). Two cameras were available for photo-identification; a Canon EOS60D digital camera with a 100-400 L-series lens, and a Canon EOS20D digital camera with a 300m L-series lens coupled with a 2 x converter. All individuals in the group were photographed, regardless of whether they appeared to be distinctly identifiable. All photographs were downloaded immediately after the sighting, and analysed on completion of the Survey Block.

All photographs were graded according to image quality, as a series of binary variables into the programme EXCEL version 5.1:

- *Unusable* – a photograph which consists of a blank image, a splash of water, or an image of a dolphin but no dorsal fin in the image (e.g. only a head, tail, or flipper in the image).
- *Poor* – an image where the dorsal fin could not be clearly seen, the image was blurry, the dorsal fin was not perpendicular to the camera, or was severely backlit by the sun. Only very distinct individuals were identifiable.
- *Good* – an image that was clear, the dorsal fin was nearly perpendicular to the camera and there was little backlighting. Most identifying features were seen if present, although slight angles, or dark lighting, made identification questionable.

- *Excellent* – an exceptionally clear, in-focus image, where the dolphin took up more than half the image, the dorsal fin was perpendicular to the photographer and the lighting was excellent. All distinguishing features were seen, if present.

Each image was catalogued based on the presence, or absence of identifiable features. Each usable image was classified into one of the following two categories:

- *Unrecognisable* – the dolphin had no distinctive features on its dorsal fin or body that could be used to identify it (nothing more was done with these images),
- *Recognisable* – the dolphin could be individually recognised based on distinctive features on its dorsal fin and/or body.

3. Results

3.1 Transect Lines

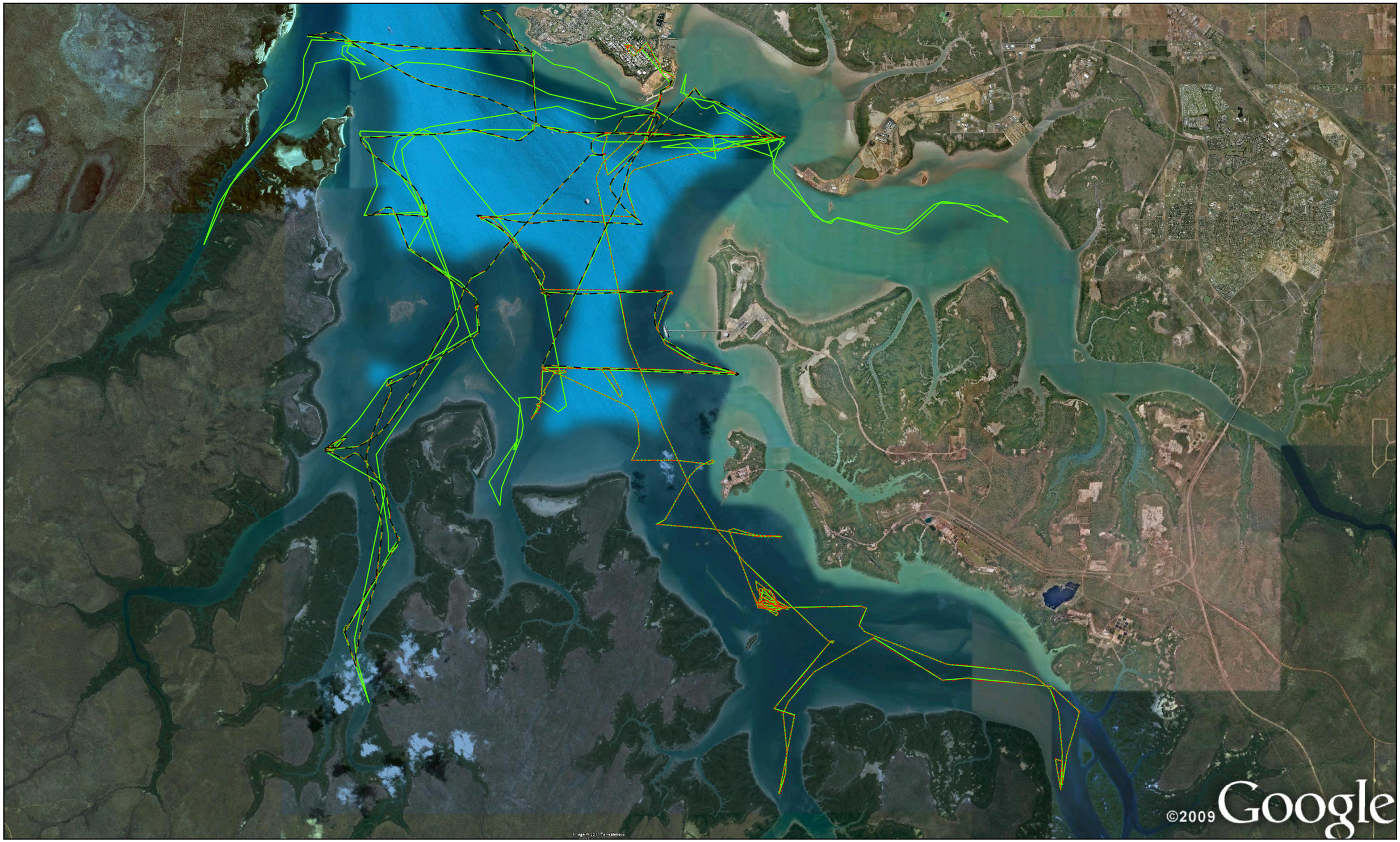
The transect lines used during Survey Block 3 are shown in Appendix A.

- The west arm and east/west transect lines in the middle of the harbour were surveyed (south to lines 49-50; Figure 2-1) on the first day of surveys.
- The middle arm were surveyed on the second day of surveys, along with the east/west transect lines in the middle of the harbour (up to transect lines 47- 41; Figure 2-1).
- The west arm transect lines were repeated in a northerly direction to transect lines 43 - 42 (Figure 2-1) on the third day of the survey block.
- Photo-identification coastal surveys were undertaken along the northern coastline of east arm to the naval base, and six kilometres into Woods Inlet (west coast of the Harbour).

A total of 10 hours was spent on survey of 114.5 km. This survey effort consisted of 7.6 hours on survey of 96.9 km transect, and 2.1 hours conducting 17.6km of coastline surveys (Table 3-1; Figure 3-1).

Table 3-1 Distance travelled during survey

Date	Total Distance Travelled (km)	Total Time (hh:mm)	On-Effort Transect
6 March	94.7	3:03	37.0
7 March	91.9	2:51	32.8
8 March (Transect)	71.2	2:01	27.1
8 March (Photo-id)	17.6	2:05	17.6
Total	275.40	10:00	114.50



1:85,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Track

06-MAR-11
07-MAR-11
08-MAR-11

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Darwin Coastal Dolphin Survey

Tracks from Survey
Block 3

Job Number	43-21774-007
Revision	E
Date	16 MAR 2011

Figure 3-1

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3.2 Marine Mammal Sightings

Eight cetacean groups and one dugong were observed in Survey Block 3 (Table 3-2; Figure 3-2). The dolphin groups were four groups of humpback dolphins, three groups of bottlenose dolphins, and one group of unknown delphinids. No snubfin dolphins were sighted in Survey Block 3.

Table 3-2 Summary of marine mammal sightings during boat surveys

Date	Sighting #	Species	Certainty	Lat	Long	Total #
6-Mar-11	25	Humpback dolphin	Probable	12.46988	130.85555	2
6-Mar-11	26	Dugong	Guess	12.55103	130.77951	1
6-Mar-11	27	Bottlenose dolphin	Certain	12.47302	130.84765	15
7-Mar-11	28	Humpback dolphin	Certain	12.53256	12.53256	5
7-Mar-11	29	Unknown dolphin	Certain	12.53195	130.83354	1
7-Mar-11	30	Bottlenose dolphin	Certain	12.48073	130.84475	12
8-Mar-11	31	Humpback dolphin	Certain	12.53859	130.81634	3
8-Mar-11	32	Bottlenose dolphin	Certain	12.47878	130.85481	12
8-Mar-11	33	Humpback dolphin	Certain	12.47223	130.82672	6

Two dolphin groups and the dugong were sighted while conducting transects (i.e. on-effort), and six dolphin groups were sighted while transiting between transect lines and during the coastline searches (i.e. off-effort).

1:85,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Marine Mammal Sightings

- Bottlenose dolphin
- Humpback dolphin
- Dugong
- Unknown dolphin

Number of Individuals

- 1 - 2
- 3 - 4
- 5 - 6
- 12 - 15

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Darwin Coastal Dolphin Survey

Job Number	43-21774-007
Revision	F
Date	16 MAR 2011

Marine Mammals observed during Survey Block 3

Figure 3-2

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_012_rev_f.mxd

Data source: GHD - Marine Mammal Sightings (2011), Imagery - Google Earth Pro (date extracted 15/02/2011), created by:MS

Level 4, 201 Charlotte St Brisbane QLD 4000 **T** 61 7 3316 3000 **F** 61 7 3316 3333 **E** bnemail@ghd.com **W** www.ghd.com

3.3 Other Megafauna Sightings

One green turtle, one flatback turtle and one eagle-ray were sighted in Survey Block 3 (Figure 3-3). No crocodiles were sighted in Survey Block 3.

3.4 Environmental Parameters

Environmental data were collected at the location of all on-effort data sightings, and off-effort sightings when time allowed. The resulting environmental data for all sightings where the species identification was confirmed (i.e. 'certain') are shown in Table 3-3.

Table 3-3 Environmental parameters recorded on survey ('certain' sightings only)

Environmental Parameters	Average parameter value at species observation locations (min – max)			
	Humpback dolphin	**Snubfin dolphin**	**Bottlenose dolphin**	**Dugong**
6 - 8 March	n=3	not observed on survey	n=1	data not recorded
Depth (m)	5.7 (4.0-8.8)		10.9	
Temp (^{o}C)	28.9 (28.2-30.2)		27.4	
Turbidity (NTU)	27.1 (15.2-34.9)		9.0	
Salinity (ppk)	27.3 (26.4-28.8)		27.1	
pH	6.0 (5.5-6.8)		6.9	
Tide State	Slack/Falling/Rising		Falling	

1:90,000 (at A3)

0 2 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 52

N

LEGEND

Marine Fauna Sightings

Turtle

Eagle Ray

Number of Individuals

1

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Darwin Coastal Dolphin Survey

Other Confirmed Megafauna Sightings from Survey Block 3

Job Number	43-21774-016
Revision	E
Date	16 MAR 2011

Figure 3-3

G:\43\21774\GIS\Maps\Working (Optional)\43_21774_016_rev_e.mxd

Data source: GHD: Other marine fauna (2011), Imagery - Google Earth Pro (date extracted 14/02/2011), created by: MS

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3.5 Cyber-tracker Sequence

The Cyber-tracker sequence was modified to include pH as one of the recorded environmental parameters for Survey Block 3.

3.6 Distance Estimation

A total of 148 distance estimation trials were conducted during Survey Block 3. Graphs of the results are provided in Appendix B.

3.6.1 Distance Estimation Rounding

A comparison of the rounded estimated distances for Survey Block 3 with the true distance obtained from the rangefinders is shown in Table 3-4. Nearly half of the estimated distances were rounded during Survey Block 1. This number was reduced to 32% during Survey Block 2, and further reduced to 20% during Survey Block 3.

Table 3-4 Distance estimation rounding for Survey Block 3

Method	Rounded to 0	Rounded to 5	Total rounded
Estimates	17.4%	2.8%	20.0%
Rangefinder	9.3%	9.3%	19.0%

Estimates n = 144; Rangefinder n = 75

3.6.2 Over and Under-Estimating Distance

A comparison of observer estimations to rangefinder estimations identified that Observers 2 and 5 were consistently over-and under- estimating distances. Observers 1, 3 and 4 were consistently over-estimating distances (Table 3-5).

Table 3-5 Observer distance estimation for Survey Block 3

Observer	Over-estimations	Under-estimations
1 (n=30)	67%	33%
2 (n=22)	50%	50%
3 (n=18)	61%	39%
4 (n=33)	64%	36%
5 (n=21)	57%	43%
6 (n=24)	71%	29%

3.6.3 Distance Estimation Accuracy

The accuracy of the estimates was assessed for each observer by calculating the percentage difference between the true distance obtained via the rangefinder binoculars, and the observers estimated distance.

During Survey Block 3, observers were within 11.9 - 22.5% of the true distance (Table 3-6).

Table 3-6 Distance estimation accuracy for Survey Block 3

Observer	Survey Block 3 Average % from true distance	Survey Block 3 Range
1 (n=30)	12.5	0.7 – 50.4
2 (n=22)	17.1	0.5 - 48.4
3 (n=18)	21.7	2.0 – 45.5
4 (n=33)	13.5	1.3 – 37.2
5 (n=21)	11.9	0.0 – 32.4
6 (n=24)	22.5	1.0 – 55.5

3.7 Dolphin Behaviour

Behaviour was recorded using the hand-held video recorder during two sightings (one humpback dolphin and one bottlenose dolphin sighting). The predominate behaviour of the humpback dolphin group was 'socialising' (Figure 3-4), whereas the predominate behaviour for the bottlenose dolphin group was 'slow travel'.

Figure 3-4 Two humpback dolphins socialising

Surface activity was recorded continuously during sightings, facilitating post-survey analysis of behaviour. This method was preferred to recording behaviour systematically during the sighting because observers were busy taking photo-identification images and environmental parameters. This left only one observer free to record behaviour. The behavioural data takes significant time to analyse, and results will be presented in the final report.

3.8 Photo-identification

Photo-identification was conducted on six of the nine groups sighted (67%). The groups not photographed were:

1. Too evasive to approach, or 2. Sighted once and not resighted.

All photo-identified individuals are shown in Appendix D.

3.9 Data Entry Quality Assurance

There were seven incorrect entries during Survey Block 3. These were amended accordingly (Appendix C).

4. Discussion

4.1 Marine Megafauna Sightings

Survey Block 3 resulted in sightings of three marine mammal species. These included bottlenose dolphins, humpback dolphins and a possible dugong sighting (brief observation only). No snubfin dolphins were sighted during Survey Block 3. Humpback dolphins were the most frequently sighted (n = 4) marine fauna species, followed by inshore bottlenose dolphins (n = 3). One group of unidentified cetaceans was sighted; these were likely to be humpback dolphins based on shape of bodies observed. Only three other megafauna were observed during Survey Block 3; two marine turtles and one eagle-ray.

The frequency of marine megafauna observations was notably lower compared to previous boat surveys (Blocks 1 and 2). The decline in species observations may have been associated with recent cyclonic conditions and heavy rains in the Darwin region.

4.2 Cyber-tracker Sequence

The Trimble unit and associated Cyber-tracker sequence used during surveys worked well. The environmental data sequence included pH in addition to other water quality parameters for Survey Block 3. This provides another environmental reference that can be observed and analysed over time. Importantly, hardcopy notes were included to manage for potential loss of data or recording errors.

Data quality and accuracy of data entry should be emphasised as a high priority during surveys. It is the basis of survey integrity.. The number of data entry errors being relatively minor (n=7) during Survey Block 3;

4.3 Distance Estimation

All observer distance estimations improved during Survey Block 3 compared to the previous two survey blocks. Observer distance estimation to dolphin groups is preferred over obtaining reticle numbers from binoculars because of the high degree of error when reading reticles from a boat (i.e. boat movement makes it difficult to steady the binoculars, and presence of land rather than horizon in the Harbor region). If observers estimate distance is it essential that rangefinders are onboard at all times and distance estimation exercises be conducted throughout the surveys.

4.4 Photo-identification

Photo-identification achieved positive results during Survey Block 3 with five identifiable humpback dolphins (two resighted individuals), and 15 identifiable bottlenose dolphins (six resighted individuals). Photo-identified individuals are shown in Appendix D.

4.5 Survey Limitations and Improvements

No aspects of the survey were noted for improvement. The final report will outline specific recommendations for future surveys.

Appendix A

Survey Block 3 – Transect Lines

Date	Survey Type	Effort	Time	Waypoint ID	Odometer	Distance Traveled	Time Traveled	Going From?	Going To?	Sea State	Weather	Depth
6/3/11	Transect	ON	9:56:31	12	14.8			12	11	1	Clear	3.6
6/3/11	Transect	OFF	10:04:15	11	15.2	0.4	0:07:44					
6/3/11	Transect	ON	10:10:00	12	15.2			1	11	1	Clear	3.6
6/3/11	Transect	OFF	10:15:00	11	16.7	1.5	0:05:00					
6/3/11	Transect	ON	10:21:18	10	18.1			10	9	1	Clear	3.3
6/3/11	Transect	OFF	10:31:46	9	20.2	2.1	0:10:28					
6/3/11	Transect	ON	10:42:09	8	21.1			8	7	1	Clear	6.8
6/3/11	Transect	OFF	10:45:43	7	22	0.9	0:03:34					
6/3/11	Transect	ON	11:12:27	1	29.8			1	2	1	Clear	14.7
6/3/11	Transect	OFF	11:24:07	2	32.3	2.5	0:11:40					
6/3/11	Transect	ON	11:36:29	3	33.4			3	4	1	Clear	10.7
6/3/11	Transect	OFF	11:44:54	4	35.6	2.2	0:08:25					
6/3/11	Transect	ON	12:00:53	52	37.6			52	51	1	Clear	4.6
6/3/11	Transect	OFF	12:07:12	51	38.8	1.2	0:06:19					
6/3/11	Transect	ON	12:19:02	44	41.8			44	41	2	Clear	5.2
6/3/11	Transect	OFF	12:41:16	41	45.9	4.1	0:22:14					
6/3/11	Transect	ON	13:13:12	42	51.5			42	43	3	Clear	16.9
6/3/11	Transect	OFF	13:41:08	43	56.8	5.3	0:27:56					
6/3/11	Transect	ON	14:07:21	41	63.8			41	47	3	Clear	21.3
6/3/11	Transect	OFF	14:30:07	47	69.1	5.3	0:22:46					
6/3/11	Transect	ON	14:59:23	46	76.4			46	45	3	Clear	4.7
6/3/11	Transect	OFF	15:17:20	45	80.2	3.8	0:17:57					
6/3/11	Transect	ON	15:31:14	18	83.4			18	21	3	Clear	9.3
6/3/11	Transect	OFF	15:46:58	21	86.4	3	0:15:44					
6/3/11	Transect	ON	15:59:04	48	90			48	17	3	Clear	7.2
6/3/11	Transect	OFF	16:23:03	17	94.7	4.7	0:23:59					
					TOTAL KM	**37**	**3:03:46**					
7/3/11	Transect	ON	8:13:44	36	0			36	35	0	Clear	15.1
7/3/11	Transect	OFF	8:22:23	35	2	2	0:08:39					
7/3/11	Transect	ON	8:29:38	34	2.9			34	33	0	Clear	8.7
7/3/11	Transect	OFF	8:38:27	33	4.7	1.8	0:08:49					
7/3/11	Transect	ON	8:57:29	26	10			26	25	1	Clear	1.8
7/3/11	Transect	OFF	9:05:51	25	11.8	1.8	0:08:22					

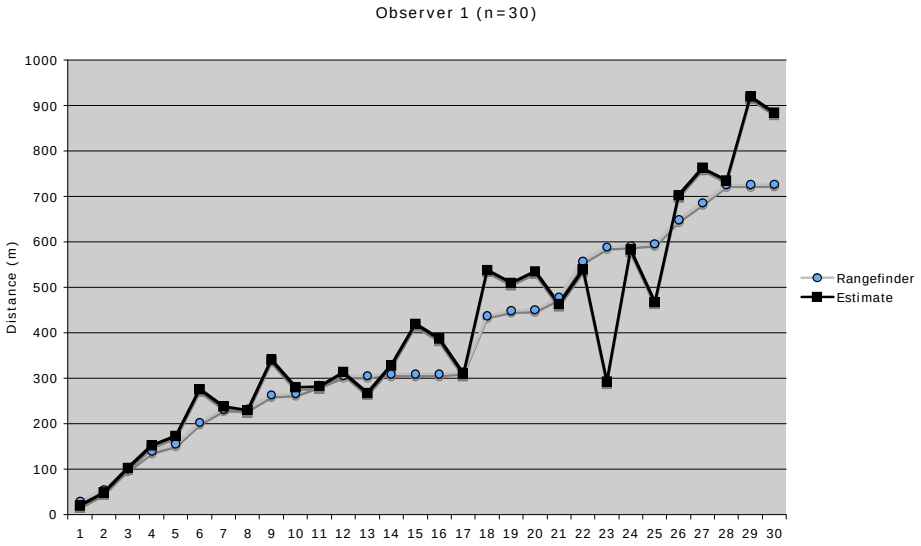
7/3/11	Transect	ON	9:14:01	40	12.7			40	39	1	Clear	9.5
7/3/11	Transect	OFF	9:22:19	39	14.6	1.9	0:08:18					
7/3/11	Transect	ON	9:29:13	38	15.8			38	37	1	Clear	11.6
7/3/11	Transect	OFF	9:31:00	37	16	0.2	0:01:47					
7/3/11	Transect	ON	9:50:05	38 - repeat	18.5			38	37	2	Clear	11.6
7/3/11	Transect	OFF	9:54:12	37	19.3	0.8	0:04:07					
7/3/11	Transect	ON	10:20:29	27	27.8			27	28	4	Rain	8
7/3/11	Transect	OFF	10:26:03	28	29.4	1.6	0:05:34					
7/3/11	Transect	ON	12:13:22	29	43.8			29	30	2	Rain	14
7/3/11	Transect	OFF	12:20:00	30	45.6	1.8	0:06:38					
7/3/11	Transect	ON	12:32:58	54	47.2			54	53	2	Clear	3
7/3/11	Transect	OFF	12:48:32	53	50.2	3	0:15:34					
7/3/11	Transect	ON	13:04:20	49	52.6			49	50	1	Clear	5
7/3/11	Transect	OFF	13:13:24	50	54.5	1.9	0:09:04					
7/3/11	Transect	ON	13:38:31	17	58.7			17	48	1	Clear	4
7/3/11	Transect	OFF	13:40:00	48	59.2	0.5	0:01:29					
7/3/11	Transect	ON	14:21:59	17	62.8			17	48	1	Clear	4
7/3/11	Transect	OFF	14:39:02	48 - S29	64.3	1.5	0:17:03					
7/3/11	Transect	ON	14:43:27	Wpt 11	66.1			Wpt 11	48	2	Clear	
7/3/11	Transect	OFF	14:56:37	48	69.2	3.1	0:13:10					
7/3/11	Transect	ON	15:12:17	21	72.8			21	18	3	Clear	4.4
7/3/11	Transect	OFF	15:26:50	18	75.9	3.1	0:14:33					
7/3/11	Transect	ON	15:40:59	45	78.8			45	46	3	Rain	5.7
7/3/11	Transect	OFF	15:55:32	46	82.4	3.6	0:14:33					
7/3/11	Transect	ON	16:14:14	47	87.7			47	41	2	Clear	4.8
7/3/11	Transect	OFF	16:48:15	41 - S30	91.9	4.2	0:34:01					
					TOTAL KM	**32.8**	**2:51:41**					
8/3/11	Transect	ON	8:13:12	10	0			10	9	0	Clear	6.1
8/3/11	Transect	OFF	8:21:15	9	1.7	1.7	0:08:03					
8/3/11	Transect	ON	8:29:47	8	2.7			8	7	1	Clear	10.7
8/3/11	Transect	OFF	8:39:21	7	4.5	1.8	0:09:34					
8/3/11	Transect	ON	8:59:13	11	10			11	12	0	Clear	8.8
8/3/11	Transect	OFF	9:06:36	12	11.5	1.5	0:07:23					
8/3/11	Transect	ON	9:17:26	1	13.9			1	2	1	Clear	12.5

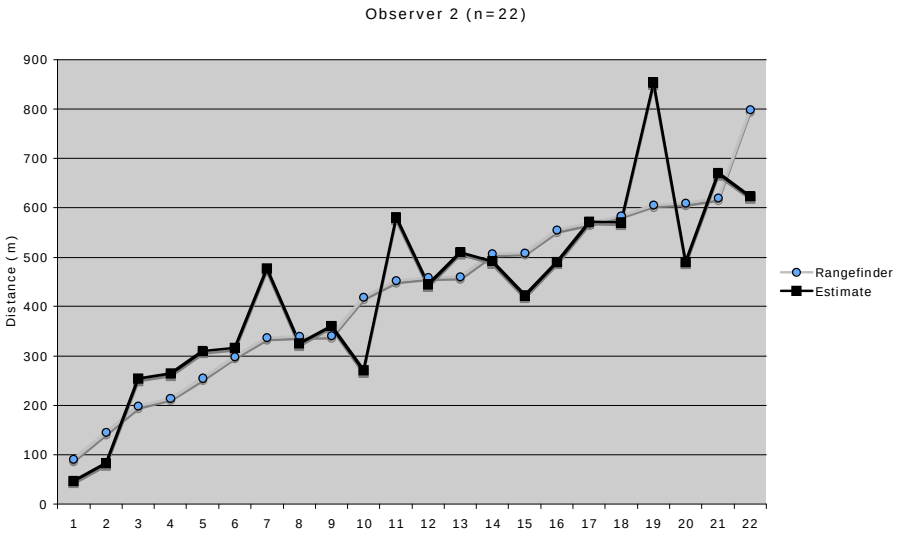
8/3/11	Transect	OFF	9:29:09	2	16.3	2.4	0:11:43					
8/3/11	Transect	ON	9:35:14	3	17.2			3	4	2	Rain	14.5
8/3/11	Transect	OFF	9:43:08	4	19.2	2	0:07:54					
8/3/11	Transect	ON	10:24:13	14	28.7			14	13	2	Rain	3.4
8/3/11	Transect	OFF	10:26:00	13	29.4	0.7	0:01:47					
8/3/11	Transect	ON	11:33:32	51	45			51	52	3	Clear	18.1
8/3/11	Transect	OFF	11:39:14	52	46.5	1.5	0:05:42					
8/3/11	Transect	ON	11:49:28	44	48.9			44	41	1	Clear	6.6
8/3/11	Transect	OFF	12:08:42	41	53	4.1	0:19:14					
8/3/11	Transect	ON	12:11:28	41	53.2			41	47	2	Clear	26.3
8/3/11	Transect	OFF	12:32:00	47 - Void S	57.5	4.3	0:20:32					
8/3/11	Transect	ON	12:58:09	41	64.7			41	47	3	Rain	
8/3/11	Transect	OFF	13:04:01	47	66.3	1.6	0:05:52					
8/3/11	Transect	ON	15:33:32	42	95.4			42	43	2	Clear	16.3
8/3/11	Transect	OFF	15:57:18	43	100.9	5.5	0:23:46					
					TOTAL KM	**27.1**	**2:01:30**					
8/3/11	Photo-id	ON	13:10:58	N coastline	66.7							
8/3/11	Photo-id	OFF	13:45:28	N coastline	73.9	7.2	0:34:30					9.3
8/3/11	Photo-id	ON	14:13:46	47	81.6			47	42	1	Clear	4.3
8/3/11	Photo-id	OFF	15:16:20	S31	85.4	3.8	1:02:34					
8/3/11	Photo-id	ON	15:58:33	Woods Inlet	100.1			Woods Inlet		1	Clear	
8/3/11	Photo-id	OFF	16:26:59	Woods Inlet	106.7	6.6	0:28:26	Woods Inlet				10.6
					TOTAL KM	**17.6**	**2:05:30**					

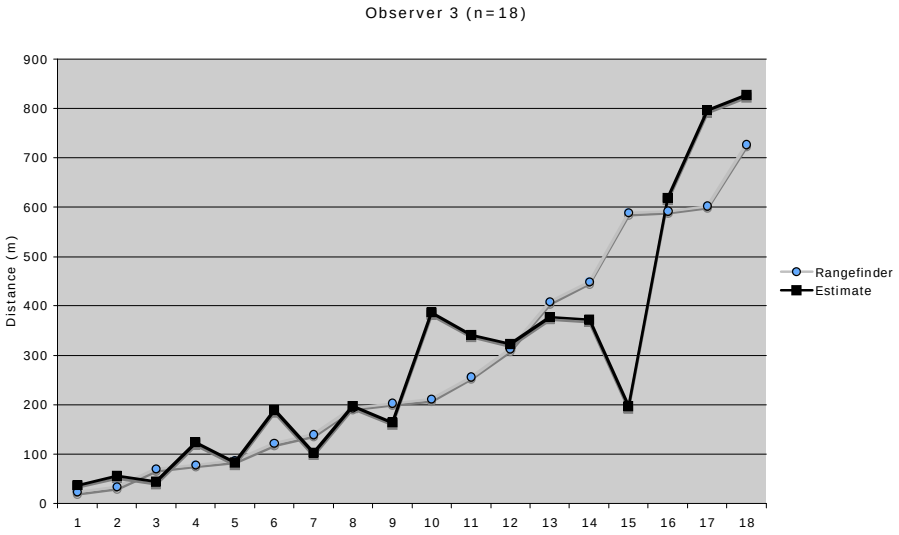
Appendix B

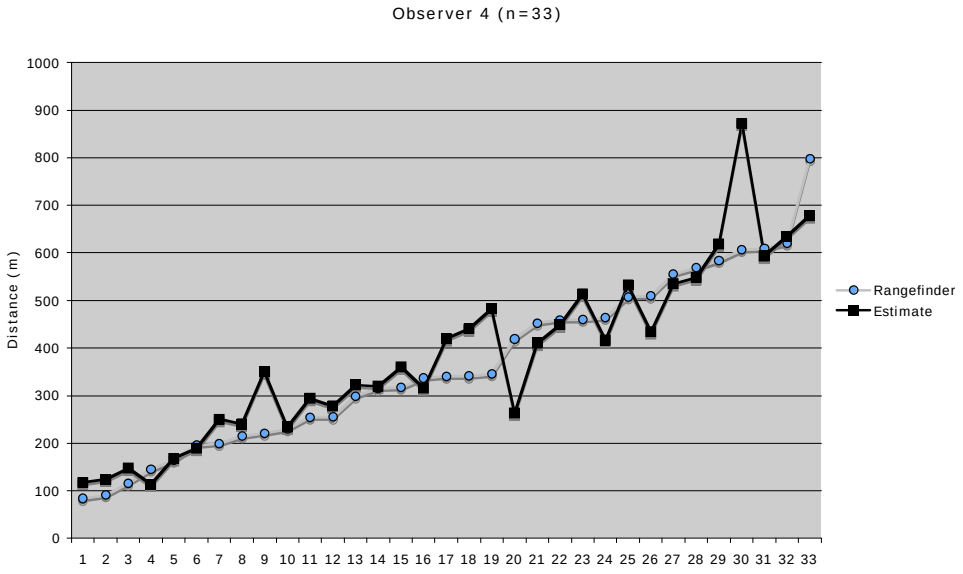
Observer Distance Estimation

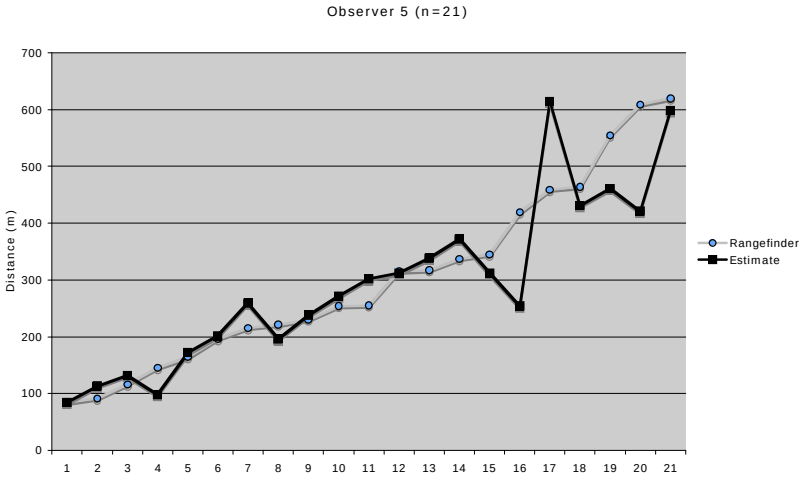
Line-graphs of distance estimation trials for each of the six observers. The light lines are the actual distance (obtained from the rangefinders), while the black lines are the estimated distances.

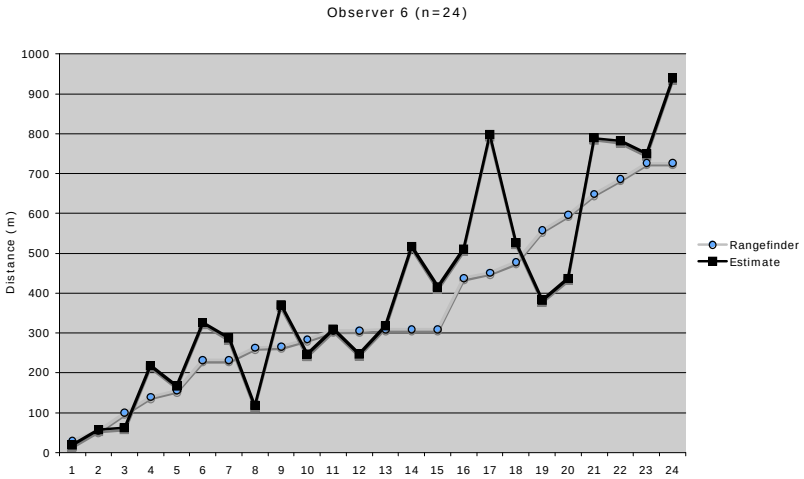












Appendix C

Changes to Outputs

Date: 06/03/11 / Time 10:24:23

Entry category – Environmentals

Cybertracker entry: Tide = Rising

Hardcopy entry: Tide = Falling

The tidal state was changed to falling based on tide state times

Date: 06/03/11 / Time 11:36:11

Entry category – Effort

Cybertracker entry: Odometer stop = 33.4

Hardcopy entry: Odometer stop = 33.5

The odometer stop was changed to 33.5, as the hardcopy distance is what is first recorded via the GPS

Date: 07/03/11 / Time 15:10:13

Entry category – Environmentals

Cybertracker entry: Depth = 4.1

Hardcopy entry: Depth = 4.4

The depth was changed to 4.4 based on the hardcopy notes

Date: 08/03/11 / Time 09:18:33

Entry category – Environmentals

Cybertracker entry: Depth not recorded

Hardcopy entry: Depth = 3.4

The depth was changed to 3.4, based on the hardcopy notes

Date: 08/03/11 / Time 10:41:38

Entry category – Environmentals

Cybertracker entry: Temperature not recorded

Hardcopy entry: Temp = 30.2

The temperature was changed to 30.2, based on the hardcopy notes

Date: 08/03/11 / Time 12:58:09

Entry category – Effort

Cybertracker entry: Odometer stop not recorded

Hardcopy entry: Odometer Stop = 57.5

The odometer stop was changed to 57.5, based on the hardcopy notes

Date: 08/03/11 / Time 15:58:11

Entry category – Effort

Cybertracker entry: Odometer start = 100.1

Hardcopy entry: Odometer start = 101.1

The odometer start was changed to 101.1, as the hardcopy distance is what is first recorded via the GPS

Appendix D

Photo-identification Images

Bottlenose dolphins

TADU01 (Resight) – Left side (8 March 2011 – Sighting 33 / 7 March 2011 – Sighting 30)

TADU01 (Resight) – Right side (8 March 2011 – Sighting 33 / 7 March 2011 – Sighting 30)

TADU02 (Resight) – Left side (8 March 2011 – Sighting 33 / 7 March 2011 – Sighting 30)

TADU02 (Resight) – Right side (8 March 2011 – Sighting 33 / 7 March 2011 – Sighting 30)

TADU03 (Resight) – Left side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27)

TADU03 (Resight) – Right side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27)

TADU04 (Resight) – Left side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU04 (Resight) – Right side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU05 (Resight) – Left side with calf (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU05 (Resight) – Right side with calf (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU06 – Left side (8 March 2011 – Sighting 33)
No Pics

TADU05 – Right side (8 March 2011 – Sighting 33)

TADU07 – Left side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27)
No Pics

TADU07 – Right side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27)

TADU08 – Left side (8 March 2011 – Sighting 33)
No Pics

TADU08 – Right side (8 March 2011 – Sighting 33)

TADU09 – Left side (8 March 2011 – Sighting 33)
No Pics

TADU09 – Right side (8 March 2011 – Sighting 33)

TADU10 – Left side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU10 – Right side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU11 – Left side (6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU11 – Right side (6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU12 (Calf of TADU05) – Left side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)
No Pics

TADU12 (Calf of TADU05) – Right side (8 March 2011 – Sighting 33 / 6 March 2011 – Sighting 27 / 7 March 2011 – Sighting 30)

TADU13 – Left side (7 March 2011 – Sighting 30)
No Pics

TADU13 – Right side (7 March 2011 – Sighting 30)

TADU14 – Left side (7 March 2011 – Sighting 30)

TADU14 – Right side (7 March 2011 – Sighting 30)

TADU15 – Left side (7 March 2011 – Sighting 30)

TADU15 – Left side (7 March 2011 – Sighting 30)
No Pics

Humpback dolphins

SCHI02 (Resight) – Left side (8 March 2011 – Sighting 31)

SCHI02 (Resight) – Right side (8 March 2011 – Sighting 31)

SCHI07 (Resight) – Left side (7 March 2011 – Sighting 30)

SCHI07 (Resight) – Right side (7 March 2011 – Sighting 30)

SCHI14 – Left side (8 March 2011 – Sighting 31)

No Pics

SCHI14 – Right side (8 March 2011 – Sighting 31)

SCHI15 – Left side with associated calf (7 March 2011 – Sighting 30)

SCHI15 – Right side (7 March 2011 – Sighting 30)

No Pics

SCHI16 – Left side (7 March 2011 – Sighting 30)

SCHI16 – Right side (7 March 2011 – Sighting 30)

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Document Status

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0	I Beasley R Groom	W. Freeland		R Groom		16/03/11