Technical Appendix S10

Ichthys Gas Field Development Project: nearshore development area—assessment of marine heritage survey methods

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ICHTHYS GAS FIELD

DEVELOPMENT PROJECT:

NEARSHORE DEVELOPMENT AREA

Assessment of Marine Heritage Survey Methods

Darwin Harbour
Northern Territory

February 2011

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NEARSHORE DEVELOPMENT AREA

Assessment of Marine Heritage Survey Methods

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Cover image: Portion of 1925 chart of Darwin Harbour East Arm.

(Royal Australian Navy. 1925. *Australia North coast, Port Darwin*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.map-rm3396, Accessed 6th December 2010).

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Abbreviations used

CRISP	Continuous profiling system
EIS	Environmental impact statement
EO	Expended ordnance
UXO	Unexpended ordnance
LAT	Lowest Astronomical Tide
MG	Magnetic gradiometer, which comprises of a pair of magnetometers separated by a fixed distance.
NRETAS	Natural Resources, Environment Arts and Sport
ppt	Parts per thousand
WWII	World War Two

Executive Summary

This report reviews remote sensing data collected for INPEX as part of the planning and preparation works for the construction of nearshore facilities in Darwin Harbour, which forms part of the Ichthys field development project. The Environmental and Heritage Branch of the Northern Territory Department of Natural Resources, Environment, Arts and Sport (NRETAS) had requested that an appropriately qualified maritime archaeologist assess the suitability and limitations of the survey methods and data analysis employed by INPEX for the detection of submerged wrecks.

The review found that over 70 vessels are known to have been lost in Darwin Harbour, with the precise locations of 10 shipwreck sites being known to NRETAS. One major event was the 1897 cyclone, in which 18 pearling luggers and other craft were wrecked having been blown southwards from Frances Bay with some ending up in the mangroves in the southern part of Darwin Harbour. Most of these sailing vessels would have been timber hulled and of small (< 100) tonnage.

Up to 25 planes are thought to have been lost in Darwin Harbour during WWII, with only 5 having been located. A further 10 planes were lost in the sea north and west of Darwin. It is possible that a plane wreck may be located along the route of the proposed pipeline.

Cables, nets and munitions associated with WWII are located within proposed development areas, as are moorings. The likelihood of ballast mounds being present is low and no maritime infrastructure such as jetties or wharves, are known to have been constructed within the study area.

The wrecks of smaller timber hulled vessels, if located on sandy seabed, may have become partially buried with frames and in-organic components protruding from the seabed – giving the appearance of a concentration of low relief debris. The majority of wrecked vessels would have some ferrous content of varying magnitudes.

The cultural heritage significance of these sites will vary according to their level of preservation. Shipwrecks older than 75 years located in Darwin Harbour are considered to be protected under the Commonwealth *Historic Shipwrecks Act 1976* and so would require a permit to disturb.

The optimum remote sensing technologies for locating the identified submerged cultural heritage within Darwin Harbour is side scan sonar and magnetometer while for the proposed dredge disposal ground off Darwin, side scan sonar is sufficient. A magnetometer survey has been conducted for the western portion of the proposed primary dredge envelope in Area A. A combination of irregular seabed with maghaemite-rich laterites throughout portions of Darwin Harbour severely compromises the ability of side scan sonar and magnetometer to identify signs of potential low relief remains of timber hulled sites.

Remote sensing surveys to date have located the remains of a number of wrecks, which are relatively large, metallic and have high profiles. The data collected does not appear to have been assessed in the survey reports for the presence of low profile timber hulled shipwreck sites. Remains of the WWII submarine net at the entrance to Darwin Harbour has been correctly identified.

The data provided in association with the remote sensing survey reports were assessed as best as possible, with some additional anomalies being identified for further investigation. Side scan sonar data for the eastern portion of the proposed dredge envelope was unavailable for review.

It is concluded that the remote sensing data obtained for the development of the nearshore facilities in Darwin Harbour was of a high quality for the detection of the

identified submerged cultural heritage. The surveys undertaken for the proposed pipeline route and dredging disposal ground were the optimum given the seabed topography and composition. A magnetometer survey within the remainder of the proposed dredge envelope would be an important measure for the detection of shipwrecks.

In most cases the data collected to date was not interrogated adequately for the presence of timber hulled sailing vessels, which would present as low relief debris clusters on the seabed. Reviewing most of the data collected to date has mitigated this. This has resulted in some additional anomalies of potential cultural significance being identified. Side scan sonar data however from the eastern portion of the proposed primary and the secondary dredge envelopes within Area A was not available for review. It is possible that one or more wrecks associated with the 1897 cyclone may be present within these locations.

The following recommendations relate to the augmentation of existing data and collection of new data for the purposes of delivering best practice during the EIS phase in the detection and assessment of the submerged cultural heritage that may be impacted by the proposed seabed development.

Recommendation 1 *Review side scan sonar data from the eastern portion of the proposed primary dredge area and the secondary dredge area on the eastern side of Blaydin Point, within Area A*

A maritime archaeologist should carry out this review.

Recommendation 2 *Undertake magnetometer survey in eastern portion of the proposed primary dredge area and the secondary dredge area on the eastern side of Blaydin Point, within Area A.*

A maritime archaeologist should be consulted about the parameters of the survey and review the results.

Recommendation 3 *Diving inspection of anomalies identified in this review.*

The dive inspection should be carried out under instructions provided by a maritime archaeologist, with the archaeologist reviewing and assessing the significance of the finds. For selected anomalies an appropriately qualified maritime archaeologist should participate in the diving and/or being on site to direct divers. The diving inspection would examine the:

- Twenty three sonar contacts– both ferrous and non-ferrous – identified in the 2010 remote sensing survey of the western portion of Area A;
- Five seabed anomalies of potential cultural significance in the western portion of the primary dredge location within Area A identified through the review of side scan sonar data collected in 2010 (Table 6);
- Sonar contacts identified in the 2008 remote sensing survey of Area A (Table 8);
- Large rectangular iron/steel box in Area A identified by divers in 2008 (site 12);
- Side scan sonar anomalies in Area B not inspected by divers (Table 9), and;
- Rubble mound at 691870E 8626463N in Area B identified by divers in 2010.

1.0 Introduction

1.1 Background

INPEX, an oil and gas exploration and production company is proposing to bring liquefied natural and petroleum gases to Darwin from the Browse Basin, around 450 km north north east of Broome, via a sub-sea pipeline. The liquids and gas will come ashore at a purpose-built industrial facility at Blaydin Point on the southern side of Darwin Harbour. The processed gas will be exported from the facility over both land and water.

For this project, INPEX has undertaken a number of surveys within the proposed development footprint to obtain the necessary geotechnical and geophysical data for design purposes as well as to identify the presence of submerged wrecks and other significant objects. These surveys utilised the following technologies and activities:

- Multi-beam swathe bathymetry
- Side scan sonar
- Sub-bottom profiling
- Refraction survey
- Diver inspections of identified wrecks or anomalies
- Magnetic Gradiometer survey of the Darwin Harbour pipeline route

The Environmental and Heritage Branch of the Northern Territory Department of Natural Resources, Environment Arts and Sport (NRETAS) has requested that an appropriately qualified maritime archaeologist assess the suitability and limitations of the survey methods and data analysis employed by INPEX for the detection of submerged wrecks. In response, INPEX sought the services of a maritime archaeologist to:

1/ Assess the suitability and limitations of the survey methods employed by INPEX within the nearshore infrastructure development footprint and offshore spoil disposal ground to detect maritime objects of heritage significance;

2/ Review data collected to determine whether there are any potential maritime 'contacts' identified through the surveys, which have not been adequately assessed to determine whether they have heritage significance, and;

3/ Review historic shipwrecks databases to assess the likelihood of any unknown wrecks being present within the harbour and based on available data such as vessel dimensions, age, materials etc., indicate where possible the likelihood of detection based on the survey methods employed.

The resulting report was also to clearly indicate what types of objects and features could be picked up by the survey methods and what type of objects or features may be missed. The review was to focus on larger structures such as plane and vessel wrecks rather than individual and small heritage items. Cosmos Archaeology was commissioned on the 18th November 2010 to undertake the assessment.

1.2 Development proposal as it relates to this study

The near-shore infrastructure relevant to this study that will need to be constructed are:

- An approximately 27 km length of pipeline from the mouth of Darwin Harbour parallel to the existing Bayu-Undan Gas Pipeline to the western side of the Middle Arm Peninsula;
- A pipeline shore crossing on the western side of Middle Arm Peninsula;
- A product loading jetty on the north western end of Blaydin Point with two berths;
- A dredged shipping channel, approach area, turning basin and berthing area for the product tankers, and;
- A dredge spoil disposal ground outside Darwin Harbour, 12 km north-west of Lee Point.

The above works will involve a combination of dredging, piling, dumping and possibly trenching using water jets with respect to the pipeline, all of which will impact the seabed and hence potentially impact significant submerged cultural heritage.

1.3 Information supplied

Documentation provided by INPEX relevant to this study is presented in the table below:

File name	Study Area	Type	Description
B280-AV-REP 0002.001_0	B	SSS, MG	Report on the conduct and findings of the survey conducted in Oct/Dec 2009.
B280-AV-REP-0001_0	B	SSS, MG	Field report which is superseded by B280-AV-REP 0002.001_0
B280-DV-ALI-0081.001_0 to 86.001_0	B	SSS, MG	Series of charts showing SSS and GM
B280-DV-GEN-0001.001_0	B		General map of survey area.
C036AH0038_1	B, C	SSS, ES	Report on the conduct and findings of the survey conducted in February 2009. Survey extended over small portion of Area B.
C036-AH-DTA-0007_CTR 2 21	B, C	SSS, ES	Charts showing digitised seabed features obtained from SSS
C090-SH-DTA-0513	B, C	SSS, ES	GIS layers and CAD files that were used to produce C036-AH-DTA-0007_CTR 2 21
DEV-CEX-DW-0051_0 to 52_0	A	ES	Bathymetric charts with located wrecks marked.
DEV-CEX-DW-0053_0 to 54_0	A	MBS	Multi beam sonar charts with located wrecks marked.
DEV-CEX-DW-0055_0 to 56_0	A	SSS	Digitised from SSS showing located wrecks and debris.
DEV-CEX-DW-0057_0 to 60_0	A	SBP	Isopachs and depth to rockhead.

DEV-CEX-DW-0061_0	A	SBP	Geological profiles.
DEV-CEX-DW-0063 to 0074	B	SSS, ES, MBS, SBP	A series of charts covering the pipeline route and landfall. Depict digitised seabed features obtained from SSS
DEV-CEX-RP-0045_3_ADDENDUM 1 Rev 3	A, B		Historical background and extent of UXO assessment
DEV-CEX-RP-0045_3	A		Historical background and extent of UXO assessment
DEV-CEX-RP-0066-01_1	A, B	SSS, ES, MBS, SBP	Report on the findings of the survey undertaken February/March 2008
DEV-CEX-RP-0066-02_0	A, B	SSS, ES, MBS, SBP	Report on the conduct of the survey undertaken February/March 2008
DEV-CEX-RP-0083_B	A	Diver	Diver based assessment of 16 targets undertaken in May 2008
L440AU0001.01_0	A	SBP	Detail on SBP carried out.
L440DU0001_0 to 23_0	A	SBP	Track plots and refraction profiles
P0804 Wrecks Interim Report	A	MBS	MBS images of wrecks
P0804_MBES-XYZ	A, B	MBS	CAD related files that were used in DEV-CEX-RP-0066-01_1
P0804-WREKCS data files	A		GIS layers that were used to produce DEV-CEX-RP-0066-01_1
UXO SSS Mosaic odds.tif	A	SSS	SSS mosaic.
L380-AU-REP-0001_0	A	MG, SSS	Report on the conduct and findings of the survey conducted in October 2010
A075-AH-REP-0002_A	B	Diver	Diver based assessment of targets undertaken in April-November 2010
L380-DU-DTL-0001.001_0	A	MG, SSS	Chart showing ferrous and non-ferrous sonar contacts.
L380-DU-DTL-0002.001_0 to 004_0	A	MG	Charts showing track plots and ferrous anomalies
L380-DU-DTL-0003.001_0 to 0004.004_0	A	SBS	Multi beam sonar charts
L380-DU-DTL-0005.001_0 to 0006.004_0	A	SSS	Charts showing sonar and magnetic contacts on side scan sonar imagery
L380-DU-DTL-0007.001_0	A	MG, SSS	Overall chart showing magnetic gradients and sonar contacts
L380-DU-DTL-0008.001_0 to 004_0	A	MG, SSS	Charts showing magnetic gradients and sonar contacts
L380-DU-DTL-0009.001_0 to 0010.004_0	A	MG	Charts showing quasi analytical signals

Table 1 List of documents supplied for this study.

SSS = Side Scan Sonar, MG = Magnetic Gradiometer, ES = Echo Sounder, MBS = Multi-beam Sonar, SBP = Sub-bottom Profiler

The charts provided in most cases date back to 2008 when the dredge envelope was slightly larger and incorporated some known wrecks. For this study the proposed extent of dredging is presented in the draft EIS for the project (Figure 1).

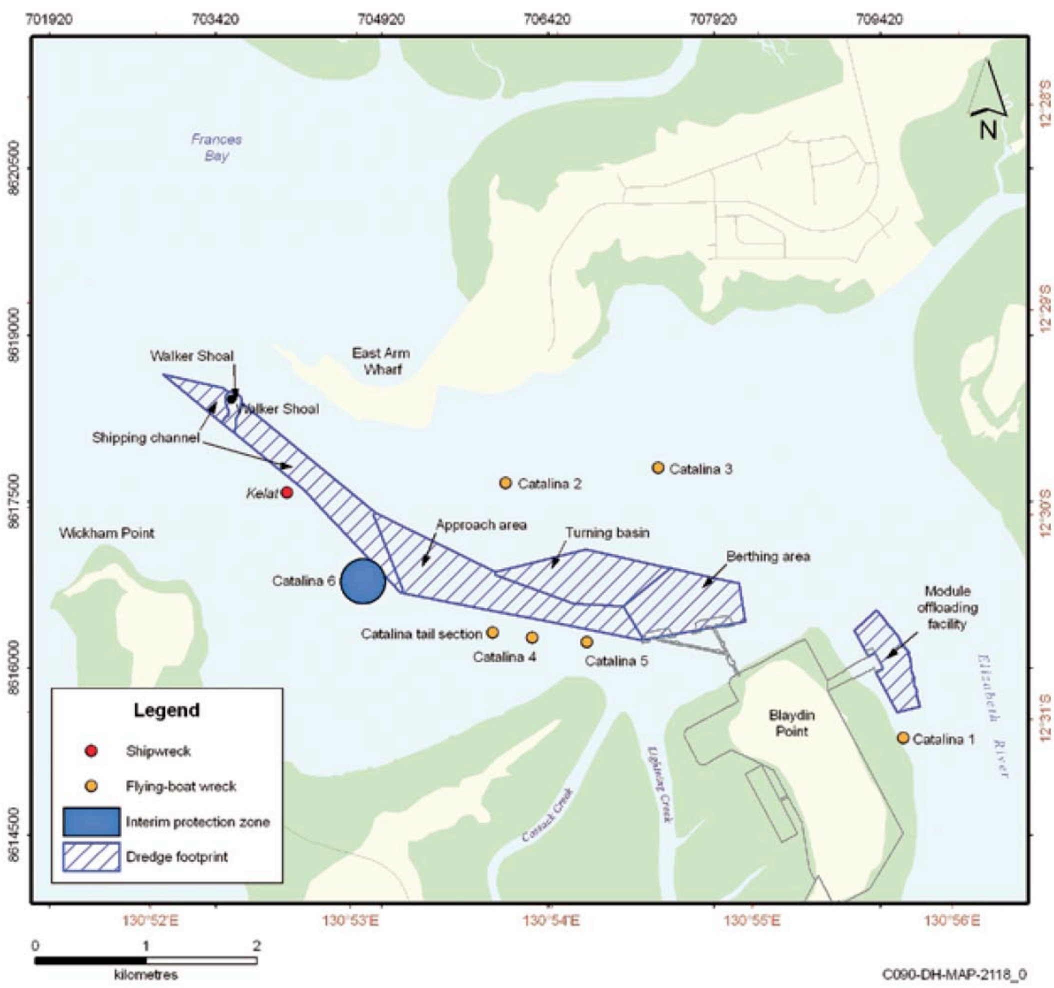

Figure 1 Current extent of proposed dredging envelope. Also shows positions of located wrecks. (In INPEX.2010. *Ichthys Gas Field Development Project: Draft environmental impact statement*: Figure 5-22).

1.4 The study area

The study area for this assessment comprises three distinct areas:

- Area A : Proposed shipping channel, turning basin, berthing area, jetty and immediate vicinity between East Arm and Blaydin Point.
- Area B : Pipeline corridor, as defined by marine geophysical survey.
- Area C : Dredge disposal ground (Figure 2).

Figure 2
Study area showing the three areas assessed for this report.
(Source ; Google Maps)

1.5 Objective of the study

The objective of this study is to:

- Assess the effectiveness of remote sensing techniques deployed to date in determining the presence and/or absence of culturally significant submerged maritime heritage within the proposed seabed development envelope.

1.6 Approach to the study

To achieve the study objective the following tasks were undertaken:

Task 1/ Predictive modelling

To determine whether the remote sensing techniques used to date have been effective it was necessary to obtain an indication of the variety, extent, frequency, condition (which informs the 'detectability' of objects) and significance of the submerged maritime heritage that may be present. This was done by gaining an understanding of the activities that have taken place on and within the vicinity of the seabed development envelope since European settlement. Resources used included wreck databases available online and through NRETAS, secondary historical documents (held by NRETAS, the consultant and on-line library services), relevant archaeological studies, and limited archival research mainly in the form of photographic images. Given the time frame for this study, extensive archival research was not undertaken and it was believed that for a study at this level, it was not necessary. The findings of this aspect of the study are presented in **Sections 2 and 3** of this report.

Task 2/ Review of remote sensing techniques deployed

The aim of this review was to determine the adequacy of the combined surveys for the detection of submerged maritime heritage. The emphasis of the review was on coverage, the equipment parameters set for each survey, and the manner in which the data was processed. Any gaps identified were to be highlighted with its relevance, level of risk for the impact on potential maritime heritage and mitigation measures. The findings of this review are presented in **Section 4**.

Task 3/ Review of assessment of potential cultural anomalies

The possible presence of unexploded ordnance required a higher level of attention to seabed debris than would otherwise have been the case for projects of this kind. Divers had also examined potential cultural anomalies detected in the surveys. While it was thought unlikely that potential cultural anomalies within the seabed development envelope had been 'missed', it is possible that cultural material identified by divers may not have been adequately assessed for their heritage significance. The findings of this review are presented in **Section 5** of the report.

Task 4/ Conclusion and Recommendations

The report on the findings was to conclude with an assessment of the adequacy of the remote sensing carried out to date with reference to its effectiveness in detecting predicted submerged maritime heritage. It was to identify gaps, if any, in the surveys and was to assess the risks to the predicted submerged maritime heritage should such gaps not be closed. The conclusion may have possibly included recommendations for possible re-surveys and re-inspections.

1.7 Previous work

There have been no heritage studies undertaken specific to the study area; however, there are a number of articles and reports which have been used to create a historical background for the study area. Of particular use were those by S. Jung (1996 and 2000) which focused on the Catalina wrecks from World War Two (WWII).

2.0 Potential status of the submerged maritime heritage

2.1 Environment and morphology

The primary geographical area of the INPEX Ichthys Gas Field Development Project relevant to this report includes the entrance to Darwin Harbour, approximately between Mandorah and Fannie Bay, through to the coastal waters around Blaydin Point and Middle Arm Peninsula below the low water mark (Areas A and B).[1] A secondary area, Area C, is located in more open waters, approximately 12 km north west of Lee Point (see Figure 2). The following discussion will examine Areas A and B separately to Area C as the former are inside Darwin Harbour and have different characteristics to the more exposed Area C.

Areas A and B

Darwin Harbour is subject to large diurnal tidal variations (macrotidal). The difference between low and high tide during springs can be up to 7.5 m.[2] This can result in current velocities between 2 to 2.5 m/s (4 to 5 kts). The tidal flows are the strongest in the narrowest sections of the harbour; the areas most relevant to this study being the East Arm channel, and the stretch of water between Tale Head and Emery Pt (Larrakeyah).

The waters of Darwin Harbour are relatively well protected. The greatest fetch is to the north west, from Beagle Gulf, thereby making the coastline around the western side of Wickham Point the most exposed within the study area. Having noted this, the ambient wave height in the harbour in the summer months can reach around 1 m.[3] Waves generated by localised cyclonic activity can be much higher. It has been modelled that waves reached heights of 4.5 m in the harbour during Cyclone Tracy but were substantially lower – 0.7 m – within the inner parts of the harbour.[4] During such events, tidal heights can potentially increase up to 9.1 m LAT, which is around 2 m higher than the highest annual spring high tide.[5]

Water temperatures in the near shore development area of Darwin Harbour are typically high, ranging from 23.5°C to 32.7°C.[6] Salinity varies within the harbour during the year. The large influx of fresh water from adjacent streams during the wet season is responsible for this variation. During the months of February and March, salinity levels can be as low as 19 parts per thousand (ppt), while during the dry season levels rise to around 37 ppt.[7] The global average for salinity is 35 ppt. During the wet season, water stratification can occur where freshwater intrusions from the adjoining streams can form a layer over the denser saline waters of the harbour.

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[1] **INPEX**, **2010**, Ichthys Gas Field Development Project: Draft environmental impact statement, 33
[2] *Ibid*., 56.
[3] *Ibid.,* 56.
[4] *Ibid.,* 56
[5] *Ibid.,* 56
[6] *Ibid.,* 62
[7] *Ibid.,* 62

The large tidal variations within the harbour result in the waters remaining well oxygenated, ranging from 74 to 96%.[8] There are some differences in dissolved oxygen levels from the mouth of the harbour where they are the highest, to waters closer to the streams at low tide where they are the lowest. Higher dissolved oxygen levels are also found closer to the water surface than at the base of the water column.

Darwin Harbour is well known for its poor visibility for diving due to suspended sediments in the water. Turbidity is at its highest during wet season spring tides due to the capacity of the spring water flows to mobilise sediments that have been flushed into the harbour from the land.[9] During these times, light levels at the bottom of the harbour can be 1% of that at surface levels.

The strong tidal flows coupled with the large volumes of water flowing out from the streams entering the harbour, have had a scouring effect on the seabed, creating and/or enlarging relatively deep channels, which are drowned Pleistocene river courses.

The main channel through Darwin Harbour mostly ranges between 15-25 m deep, with a maximum depth of 36 m. At Wickham Point the channel forks, with the western and shallower channel/tributary trending southwards into the Middle Arm. A smaller channel separates Channel Island from Wickham Point.[10] The eastern and deeper channel shapes a course to the south east between East Arm to the north and Wickham and Blaydin Points to the south. The deepest part of the channel is 21.5 m LAT.[11] The channel continues in a south easterly direction, eventually connecting with the Elizabeth River riverbed. Two steep sided flat bottomed channels, Cossak and Lightening Creeks, enter East Arm between Blaydin and Wickham Points.[12]

The sides of the main drainage channels are mostly rocky and the sediments within Areas A and B are coarse sands with some gravels, silt and clay.[13] Towards the north west portion of Area A and the central portion of Area B, the seabed is more gravelly and provides a thin covering over sandstone and phyllite formations of which large weathered sand veneered expanses are also exposed in the form of relatively flat/level pavements.[14] At the entrance to Darwin Harbour there are numerous cemented ridges.[15]

The thickness of the sediments over the sandstone and phyllite substrate varies. To the north of Blaydin Point there are several metres of unconsolidated sediments over weathered rock.[16] Similar thicknesses are found to the east of Blaydin Point where there are several metres of mud and lag deposits (gravel) over the bedrock. In the north west corner of Area A where there are extensive areas of exposed sand veneered bedrock, there are pockets of sediments up to 6 m thick.[17]

To the north of Wickham Point there is a 200 m wide and up to 11 m high ridge of rock, which trends towards the north west. The highest point of this underwater ridge

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8 *Ibid.*, 62
9 *Ibid.,* 63
10 *Ibid.,* Figure 3-11
11 **Fugro Survey Pty Ltd, August 2008** *Report on the Ichthys Field Development, Darwin Harbour Geophysical Site Surveys 2008*. Volume 1a, 2-15
12 *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008** Volume 1a, 2-15
13 *Opp.Cit.*, **INPEX**, **2010**: 64, 69 and Figure 3-16.
14 *Ibid.,* 71.
15 **Fugro Survey Pty Ltd March 2010** *Report on the Offshore Pipeline Route Unexploded Ordnance (UXO) Survey.* Volume 1 – Survey Results, 5
16 *Opp. Cit*. **INPEX**, **2010**: 69.
17 *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008** Volume 1a, 2-25

forms Walker Shoal, which comes to within 4 m of the surface.[18] Dredging for the East Arm Wharf has cut through the bedrock platform north of Walker Shoal. Dredging has taken place elsewhere on the edges of the channel for the development of the East Arm Wharf.[19] This has resulted in changes to the bathymetry in water depths over 10 m LAT, within approximately 400 m from the western extremity of the wharf.[20]

Shell Island forms the south western tip of a similar reef formation to Walker Shoal, and is now mostly reclaimed as part of the East Arm Port development, which is outside the study area. Shell Island sits at the north western tip of a large sandbank with a sandy upper stratum with high gravel content toward its base, which extends to the south east before curving to the east ending at a point 1 km to the north west of Blaydin Point.[21] A second bank, with an east-west orientation is situated to the north of the eastern tip of the first bank, and a third bank lies to the west of Blaydin Point, orientated north to south. These banks range in length from between 1.3 to 3.3 km, 350 to 400 m wide and up to 10 m high with a water clearance of less than 1 m. A sandbank is also located in Area B between Channel Island and the Conoco Phillips LNG Plant on Wickham Point.[22] The bank is over 1.5 km long, 12 m high and has a minimum of 0.6 m of water over it.

Sand waves and mega ripples are present on the sandbanks in Area A and on the sandy seafloor around them. Sand waves are also present throughout the northern half of Area B.[23] Throughout Area A there are also large zones of seabed mounds, which are sometimes referred to as 'hummocky ground'. As high as 0.5 m, the mounds could have been created by animals such as holothurians.[24] Silty to sandy seabed is present in Area B close to the landfall of the proposed pipeline with coarser sediments covering shallower waters towards the south.[25]

Silty seabed surfaces are found in the more shallow waters adjacent to the mangrove flats around Blaydin and Wickham Points; their occurrence signifying sheltered waters not greatly affected by strong tidal currents.[26] More carbonate (shell) based sediments mixed with sand and gravels are situated in the spits and shoals close to the entrance to the harbour.[27] Mangroves fringe the greater part of the shoreline at Blaydin Point, becoming less abundant towards the northern extremity. The very north eastern tip of Blaydin Point is devoid of mangroves, and horizontal rock platforms extend from the shore in northerly and easterly directions. Mangrove mud flats dissected by shallow, 0.3 m deep runnels, characterise the greater part of the rest of the mid to nearshore area. An area of subtidal hard pavement is located approximately 2 km to the north-west of Blaydin Point.[28] Mudflats are also present within Area A, adjacent to the western shore of Wickham Point. [29]

Area C

Area C is located 15 to 20 km north of the mouth of Darwin Harbour, and shares characteristics with the offshore marine environment. The seabed in the vicinity of

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[18] *Ibid.,* 2-15
[19] *Opp.Cit*., **INPEX**, **2010:** 56.
[20] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008** Volume 1a, 2-17
[21] *Ibid.,* 2-16 and 19
[22] *Ibid.,* 2-32
[23] *Ibid.,* 2-54
[24] *Ibid.,* 2-17
[25] *Ibid.,* 2-36
[26] *Ibid.,* 2-19
[27] *Ibid.,* 2-55
[28] *Ibid*., 2-77.
[29] *Opp.Cit*., **INPEX**, **2010:** Figure 3-16

Area C is composed of clay/silts and is featureless, though sand waves in places can reach 4.9 m in height.[30] Geophysical surveys conducted confirm this characterisation of the area as a flat, featureless seabed at depths ranging 15 – 20 m. There is a higher content of carbonate sand in this area, possibly due to its relative proximity to shore.[31]

Area C is exposed to greater swells and localised wind-generated waves than in Darwin Harbour. Relatively protected to the east and to some extent from the north by the Tiwi Island, the greatest fetch is from the western quadrants. Highest ambient wave activity takes place in the summer months when westerly winds are constant.[32] Wave heights during this season vary between 1 to 2 m. Cyclones can increase wave heights by 50% to 100% with accompanying increases in current velocities.

Water temperature in Area C is a constant 23.5°C with salinity close to the global average of 35 ppt.[33]

2.2 Known history

The following history focuses on known cultural activity that has taken place on the waters of East Arm and the western side of Darwin Harbour. The history has been compiled using secondary sources supplemented with some archival research in the form of online newspaper and photographic sources.

Darwin Area Prior to European Settlement (50 000 B.P. to 1868 A.D.)

Aboriginals have been living on the north coast of Australia since at least 50,000 B.P.[34] These early coastal communities engaged in some maritime activities, including inshore spearing and netting of marine animals in bark canoes.[35] In the mid 18th century, the Aboriginal communities came into contact with Indonesian fishermen, who sailed their perahus from Macassar in southern Sulawesi, to northern Australia in search of trepang (also referred to *bêche-de-mer,* or sea slugs), for the Chinese market.[36] Through this contact with the Macassan fleets, Aborigines adopted some new items into their material culture, including small dugout sailing canoes or 'lepa-lepa'.[37] These dugout canoes were superior to the Aboriginal bark canoes as they allowed for more intensive exploitation of the local marine resources.[38] The Larrakia maintain that they had contact with Macassans visiting the Darwin area; however, the intensity of this contact is not clear at present.[39]

European exploration of the northern coast of Australia began with Dutch visitation during the 17th century. Between 1824 and 1838, three military outposts were established on the north coast: Fort Dundas (1824-29) on Bathurst Island, and Fort Wellington (1828-29) and Victoria (1838-49) on the Cobourg Peninsula; for the purpose of instigating trade with the Macassans and thus bypassing the Dutch

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[30] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008** Volume 1a, 2-40
[31] *Ibid*., 2-78.
[32] *Ibid*., 2-36
[33] *Ibid*., 2-42.
[34] **Flood**, **J**, **2004**, Archaeology of the Dreamtime: The story of prehistoric Australia and its people, 86.
[35] **Coroneos**, **C**, **1996**, The Shipwreck Universe of the Northern Territory, 13.
[36] *Opp.Cit*., **Flood**, **J**, **2004**, 258.
[37] **Macknight**, **C**, **1976**, The Voyage to Marege, 90.
[38] *Opp.Cit*., **Coroneos**, **C**, **1996,** 13.
[39] **Wikipedia – History of Darwin** http://en.wikipedia.org/wiki/History_of_Darwin

controlled Indonesian archipelago.[40] It was not however until 1839 that Darwin Harbour was 'discovered' by John Lort Stokes of HMS *Beagle*, who named the place after one of his former shipmates, evolutionist Charles Darwin.[41]

The Darwin Settlement (1868 to 1941)

Following the abandonment of the military outposts, the north coast was left without a permanent British settlement until 1863 when it was annexed by the South Australian Government and renamed the Northern Territory (Figure 3).[42] A new settlement was soon planned and in 1868 the town of Palmerston (now Darwin) was established.[43] The underlying rationale for the creation of Darwin was that the site was chosen as the landfall for the undersea telegraph from Banjoewangie (Banyuwangi) on the east coast of Java. From Darwin the telegraph was to continue overland to Adelaide.

Figure 3
Portion of 1870 chart of Darwin Harbour showing a poorly charted East Arm.

(National Library of Australia. 1870. Australia – NW Coast, Port Darwin & Adjacent inlets. Held by the National Library Australia. [Online] Available http://nla.gov.au/nla.map-rm3392-e-cd, Accessed 6th December 2010).

Following the discovery of gold at Pine Creek in 1871, Darwin saw a growth in population and capital, providing the impetus for its development as a port.[44]

40 *Opp*. *Cit*., **Coroneos**, **C**, 1996, 15.
41 **Darwin City Council**, **2010**, History of Darwin, http://www.darwin.nt.gov.au.
42 **Powell**, **A**, **1982**, Far Country: A short history of the Northern Territory, 74.
43 *Opp*. *Cit*., **Coroneos**, **C**, 1996, 16.
44 *Ibid*., 16.

Despite this, Darwin had a non-Aboriginal population of only 4,768 in 1881; compared to that of South Australia with 275,344.[45]

Due to its small size, there were few maritime activities in Darwin, and vessels present in the harbour were largely limited to Chinese sampans, dugout canoes and a few steam-powered craft.[46] Given the size of the settlement and the relative size of the harbour, most vessels would have congregated in the north eastern corner of the harbour, an expanse of water known as Frances Bay. Large passenger and cargo steamships occasionally passed Darwin to destinations in south-east Asia, often carrying Chinese immigrants to Australian ports (Figure 4).[47] These included the S.S. *Brisbane* and the S.S. *Australian*; which were wrecked in 1874 and 1906, respectively.[48]

Figure 4
Portion of 1886 chart of Darwin Harbour showing East Arm as well as North and South Shell Islands.

(National Library of Australia. 1886. *Australia – North Coast, Port Darwin*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.map-rm3393-e-cd -, Accessed 6th December 2010).

Towards the end of the 19th century, pearling developed into a lucrative industry. Europeans also expanded into trepanging when the number of Macassan visitations

[45] **Steinberg**, **D**, **2008**, Shipwreck Salvage in the Northern Territory: The wreck of the Brisbane as a case study in site salvage and material cultural reuse, 19.
[46] **Masson**, **E**, **1915**, An Untamed Territory: The Northern Territory of Australia, 29.
[47] *Opp.Cit.*, **Coroneos**, **C**, 1996, 18.
[48] *Opp.Cit.*, **Steinberg**, **D**, 2008, 14.

began to decline, due largely to the taxes and licences imposed on them (Figures 5 to 8).[49]

Figure 5
Photo showing pearling lugger in water with two masts

(Bleezer, F. National Library of Australia. ca1897. *Pearling lugger in water, Palmerston, former name of Darwin, ca. 1897*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.pic-vn3797826, Accessed 6th December 2010).

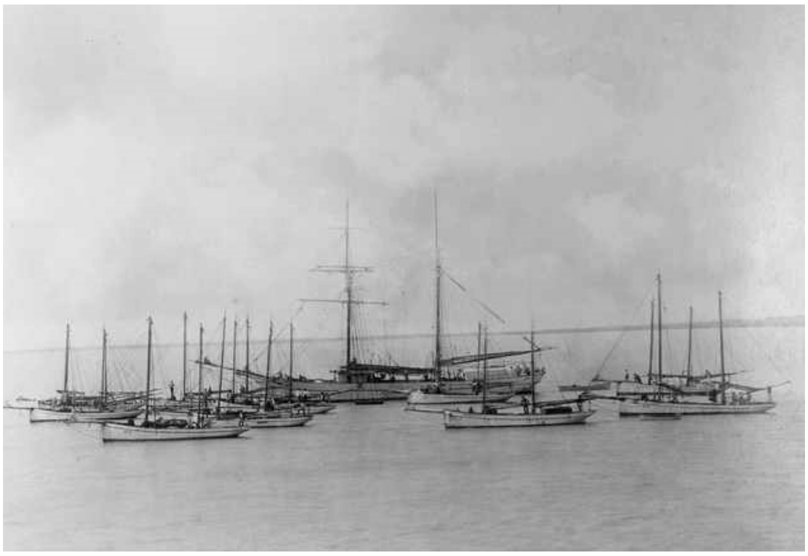

Figure 6
Photo showing luggers and mothership or supply schooner in the centre.

(State Library of South Australia. ca 1895. *Pearl shelling fleet at Palmerston*. Held by the State Library of South Australia. [Online] Available http://images.slsa.sa.gov.au/mpcimg/24250/B24187_25.htm, Accessed 6th December 2010).

[49] *Opp.Cit.*, **Macknight**, **C**, 1976, 117.

Figure 7
Photo showing pearling luggers Frances Bay. This photo seems to have been taken from around Stuart Park looking south over Frances Bay.

(Brown, P. Date unknown. *Pearling boats on Darwin Harbour, looking Fannie Bay probably taken from Dinah Beach area*. Held by the National Library of Australia. [Online] Available http://hdl.handle.net/10070/19355, Accessed 6th December 2010).

Figure 8
Photo showing boats in Frances Bay with Fort Hill in background.

(National Library of Australia. Date unknown. *Boats in Darwin Harbour*. Held by the National Library of Australia. [Online] Available http://hdl.handle.net/10070/9078, Accessed 6th December 2010).

On 6 January 1897, Darwin was hit by one of the most destructive cyclones ever recorded at the time; causing £8 000 damage to the pearling industry.[50] Forty seven vessels were reported as being in the harbour at the time. During the cyclone, craft of all kinds were either sunk at their moorings or blown ashore and a number of boats were never recovered. An article in the Northern Territory Times and Gazette reports that:

> "*Out of 29 pearling luggers in the bay, 18 – score were wrecked. Some have since been located and raised, but at time of writing there*

[50] **Northern Territory Times & Gazette**, **1897**, Monday 25th January 1897: Terrible Hurricane at Port Darwin, 2.

> *are eighteen declared lost. A number of the boats were swept over to the southern side of the bay and cast up among the mangroves*".[51]

The boats that were reported 'missing' were the cutter *Ark*, luggers *Black Jack*, *Brisbane*, *Cleopatra*, *Florence*, *Gertrude*, *Jack*, *Midge*, *Mumelhaba*, *Nebraska*, *Olive*, *Roebuck*, *Revenge*, *Scout*, *Sapphire*, the Government's steam launch *Warrill*, the steam launch *Maggie* and three sampans.[52] The steam launch *Zulieke* (*Zulieke*?) was reported to have become a total wreck on a reef off Quarantine Island.[53] As can be seen in Figure 9, until at least 1925, the area around Blaydin Point was not properly charted and as a result, it is possible that if vessels sank in this area they may not have been salvaged.

Figure 9
Portion of 1925 chart of Darwin Harbour showing lack of seabed knowledge around Blaydin Point.

(Royal Australian Navy. 1925. *Australia North coast, Port Darwin*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.map-rm3396, Accessed 6th December 2010).

World War Two to the present (1941 to 2010)

During World War II, Darwin Harbour was transformed into a strategic defensive base by allied forces defending Australia's northern coastline. Over the course of the war, Darwin and its surrounding areas endured a total of 64 airborne attacks by the Japanese.[54] The first and largest of these was carried out by 188 aircraft on 19th February 1942 and targeted the harbour's shipping and infrastructure.[55]

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[51] *Ibid*., 3
[52] **Western Mail**, **1897**, Friday 15th January 1897: A Terrible Hurricane, 15.
[53] *Opp*. *Cit*., **Northern Territory Times & Gazette**, **1897**, 3.
[54] *Opp*. *Cit*., **Powell**, **A**, **1982**, 202.
[55] **McCarthy**, **S**, **1992**, World War II Shipwrecks and the First Japanese Air Raid on Darwin 19 February 1942, 3.

In response to the airborne attacks, anti-aircraft gun troops were established at a number of locations in Darwin Harbour, including a battery at East Arm. [56] Also built in the East Arm sector was the Royal Australian Air Force (RAAF) Flying Boat Base to service the Catalina squadrons and the Lugger Maintenance Section (LMS) or Special Operations Unit, both located on Quarantine Island (Figures 10 to 12).[57] Quarantine Island at the time was essentially a hill isolated from the mainland by peak-flood tides and tidal deposits. It is now connected to the mainland by an artificially constructed causeway, which forms part of the new port.

Figure 10 Portion of 1942 map showing Quarantine Island.

(Great Britain War Office, General Staff, Australian Section. 1942. *Sketch map Darwin*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.map-rm3609, Accessed 6th December 2010).

[56] *Opp.Cit.*, **G-tek Australia 2008**, 16.
[57] **Jung**, **S**, **2000**, Quarantine Island, East Arm and its significance for solving the Darwin Harbour Catalina Puzzle, 106.

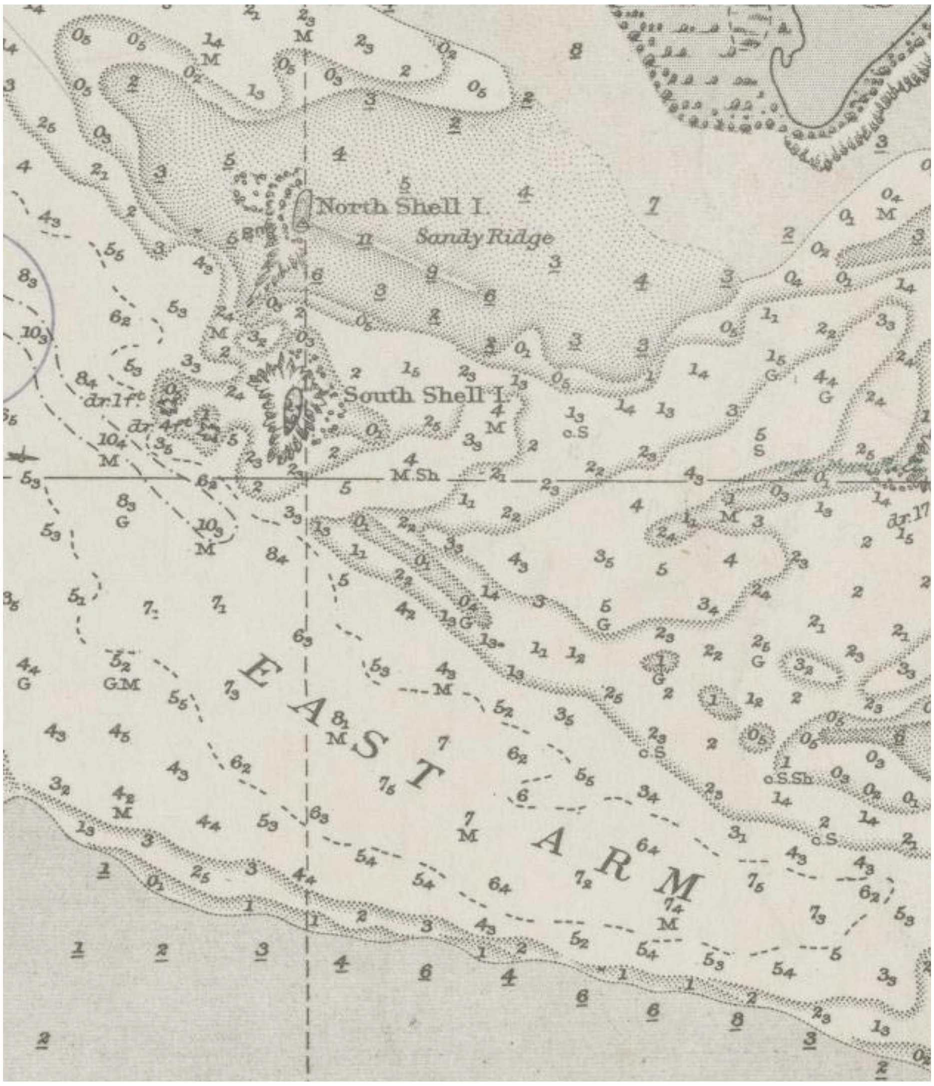

Figure 11 Portion 1944 shows the location in East Arm of where the Catalinas were berthed.

(Great Britain Hydrographic Department. 1944. *Australia – North Coast, Darwin*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.map-rm3397, Accessed 6th December 2010).

Figure 12 Catalina flying boats moored in East Arm.

(Martin, W. 1943. *Catalina Flying Boats Moored in the Harbour*. Held by the Australian War Memorial. [Online] Available http://cas.awm.gov.au/item/061585, Accessed 6th December 2010).

Japanese forces also used submarines to conduct scouting, torpedo attacks and mine laying activities on the northern Australian coastline.[58] In response to this threat, anti-submarine infrastructure was constructed, such as a 6 km long anti-submarine boom net, between Dudley Point and West Point (Figure 13).[59] Indicator loops and sonar systems were also put in place at the entrance to Darwin Harbour to detect any ships moving near the boom gates (Figure 14).[60]

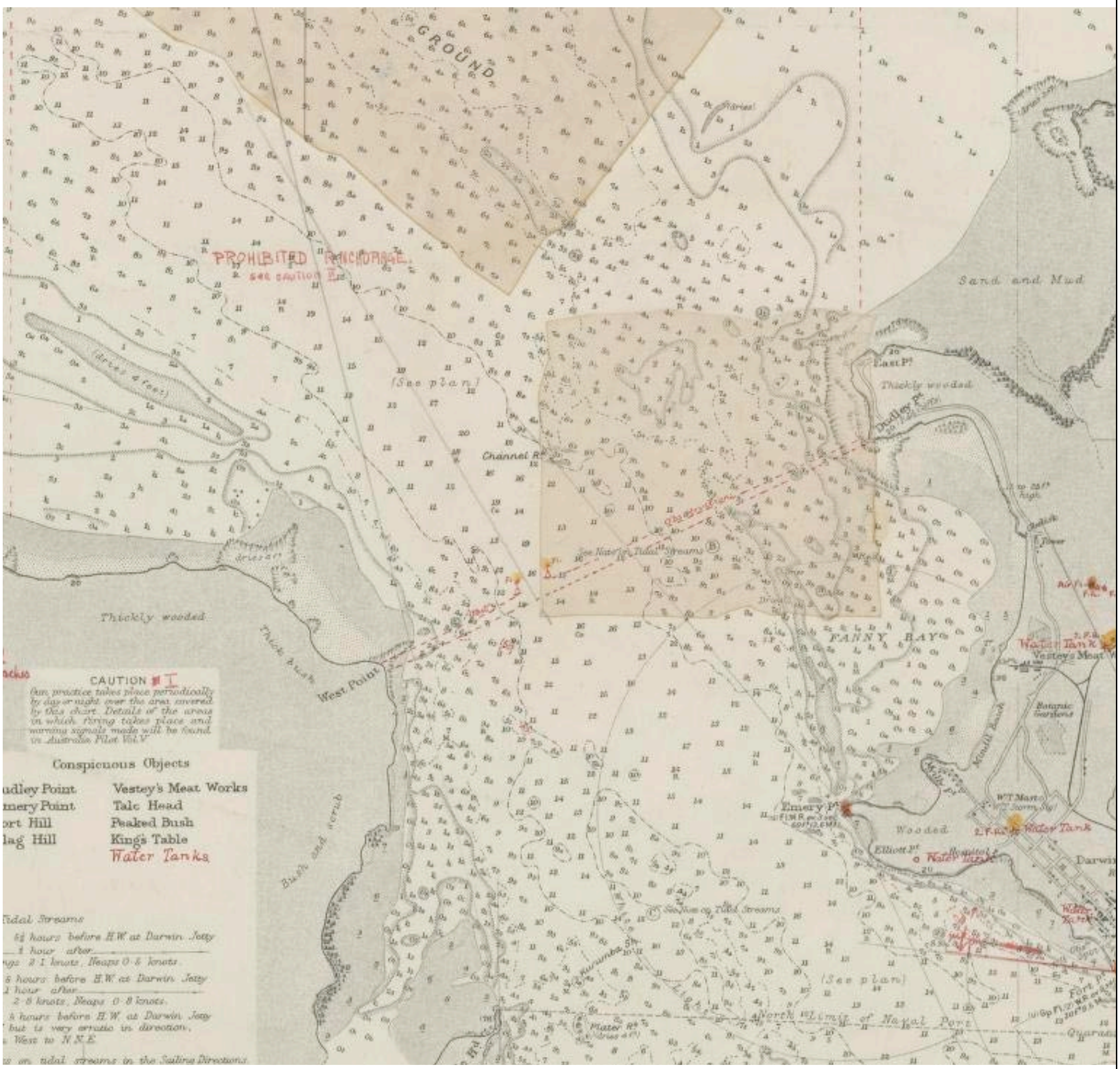

Figure 13 Portion of 1938 chart showing submarine net alignment.
(Great Britain Hydrographic Department. 1938. *Australia - North coast, Port Darwin*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.map-rm3395, Accessed 6th December 2010).

58 **G-tek Australia**. **2008**, Post Activity Report: Unexplained ordnance assessment Darwin and Northern Australia exercise area, 6.
59 **Forster**, **P**, **2010**, Fixed Naval Defences in Darwin Harbour 1939-1945, http://www.navy.gov.au.
60 *Ibid*., http://www.navy.gov.au.

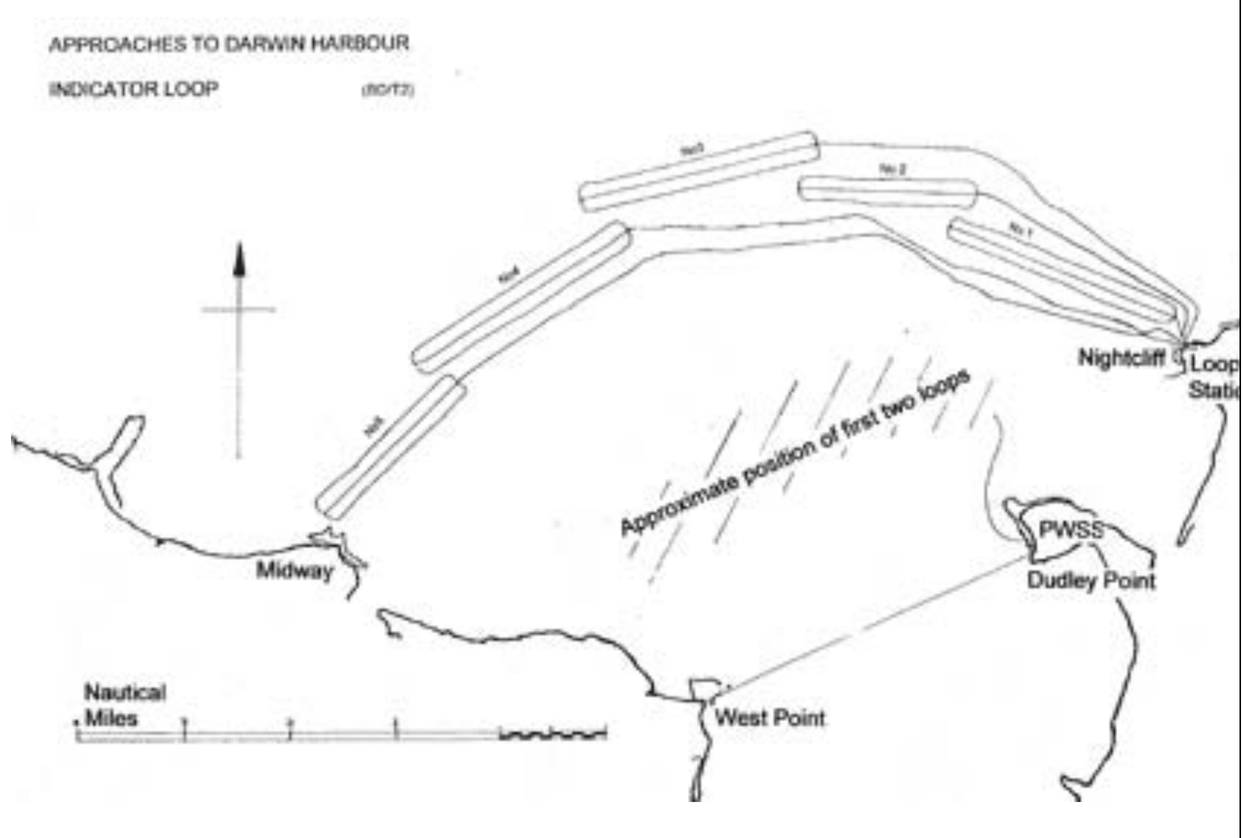

Figure 14 Location of indicator loops in relation to submarine net.
(Forster, P. 2010. *Fixed Naval Defences in Darwin Harbour 1939-1945*. [Online] Available http://www.navy.gov.au/Fixed_Naval_Defences_in_Darwin_Harbour_1939_-_1945, Accessed 1st December 2010).

During the first airborne attack on the 19 February 1942, eight ships anchored in the harbour were sunk; some of which were partly salvaged for scrap metal by both government and commercial operators; including a Japanese salvage company in 1959.[61] Allied military aircraft were also destroyed in this first raid, including three Catalinas. There is a debate over the number of Japanese aircraft shot down.[62] From this first raid until the last on 12 November 1943, the allied and Japanese forces lost a total of about 77 and 131 aircraft respectively.[63] Forty seven of these total losses are reported to have been lost in the general region of Darwin Harbour. This should not be taken as a definitive amount as there are many incidents where a specific crash location was not recorded and some Japanese losses may have been double counted.

Cyclone Tracy is the latest natural disaster to have struck Darwin. On Christmas Day in 1974, nine vessels were stranded or wrecked; the remains of the steel hulled *Booya* only being found in 2003.

[61] **Steinberg**, **D**, **2009**, Raising the War: Japanese salvage divers and allied shipwrecks in post-war Darwin, 12.
[62] **Dunn**, **P**, **2002**, Australia at War, http://home.st.net.au/~dunn/ozcrashes/nt146.htm.
[63] **Department of the Environment**, **Water**, **Heritage and the Arts**, **2010**, The Japanese Bombing of Darwin and Northern Australia, http://www.cultureandrecreation.gov.au.

2.3 Known wrecks within the study area

Seventy five shipwrecks, including 3 sampans, are known to be situated within the Darwin Harbour area (Annex 1). The information has been obtained from the Australian National Historic Shipwreck Database, supplemented with contemporary newspaper accounts of the 1897 cyclone and recent discoveries in the Harbour.[64] [65] [66]

When looking at the assemblage of known wrecks from the perspective of when they were lost, three distinct clusters are immediately apparent – 20 wrecks in January 1897, 8 in February 1942 and 13 in December 1974. These groupings reflect the catastrophic events that have befallen Darwin and have created a high number of wrecks, which would seem disproportionate for what was for a long time a minor and relatively young port by Australian standards.

Of interest to this study are the size (tonnage) and hull construction of each ship and whether the vessels were propelled by engines, sail or both. Knowing these characteristics assists in the identification of a wreck and provides a guide as to the condition of the wreck in a given environment. As can be seen in Annex 1, detailed information on most of the wrecks is lacking. Further archival research would eventually, through time consuming effort, fill in most of these blanks. Such work however is beyond the present scope of this study.

All of the wrecks date from the time when steam engines were common and the majority date from the 20th century when even sailing vessels had auxiliary engines onboard. It is doubtful however, that any of the pearling luggers lost in the 1897 cyclone were propelled by steam, although some may have had a steam powered air pump for the divers.

Details on hull construction are also scant. It can be expected that most of the sail propelled vessels lost in the 19th century, as well as some of the Vietnamese vessels were timber hulled. The *Booya* however, is an example of an old sailing vessel with a steel hull.

As can be seen the exact locations of only a fraction (11) of the known shipwrecks is known to the NRETAS. This distinction is important as the locations of some wrecks may be known to individuals but for unknown reasons have not notified the authorities of their finds. Of those unlocated wrecks, 11 were lost around the original port at Stokes Hill and Frances Bay. Such shipwrecks will not be found within the study area. Other wrecks including the *Olga* (1926), was stranded and so may have been refloated while the *Coral* (1932) was broken up indicating that very little of it may be present.

Of the 75 vessels known to have been sunk/lost in Darwin Harbour, 39, not counting those which were recorded as being 'stranded' which may indicate that some may have been refloated, have been lost somewhere in Darwin Harbour and their locations are not presently known.

No shipwrecks have been located in the vicinity of Area C. Only one vessel is reported to have been lost in the area, the *Astraea*, which was lost 'off Darwin' in 1886.[67] No other information is known about the vessel or the circumstances of its loss at present.

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[64] **Commonwealth of Australia 2010** National Historic Shipwreck Database. https://apps5a.ris.environment.gov.au/shipwreck/public/wreck/search.do
[65] *Opp. Cit.*, **Northern Territory Times & Gazette**, **1897**, 3
[66] **McKinnon, J. Raupp, J. *et a*l August 2010** *Wreck Inspection report of the Frances Bay Wreck in Darwin Harbour, NT; 5-9 July 2010*.
[67] *Opp. Cit.*, **Commonwealth of Australia 2010** National Historic Shipwreck Database.

Darwin Harbour has a very high concentration of plane wrecks in comparison with other coastal areas in Australia. All of these wrecks date to the fighting over the skies between 1942 and 1945. Tables 2 and 3 were compiled using information available on the well researched website *Australia at War*, supplemented with the findings of surveys carried out by INPEX for this project and NRETAS records.[68]

As can be seen in Table 2, twenty five planes, all Allied craft, were lost in Darwin Harbour, with 14 of these being in East Arm. The Catalina which crashed during take off in August 1945 was apparently salvaged, while the other 5 Catalinas have been located. There have been apparently no reports of Kittyhawk remains. The 5 wrecked Catalinas were not salvaged partly due to the levels of damage they sustained. This may also be the case for other planes lost during the war that incurred damage and were subsequently abandoned *in situ*. Valuable and undamaged components such as radios and ammunition however may have been partially salvaged.[69]

Service	Qty	Aircraft	Date Lost	How lost	Location
USAAF	8	P-40 Kittyhawk	19/02/42	Shot down by Japanese aircraft	East Arm
US Navy[70]	**3**	**PBY Catalina**	**19/02/42**	**Destroyed by Japanese aircraft**	**East Arm**
USAAF	2	P-40 Kittyhawk	27/04/42	Shot down by Japanese aircraft	Darwin Harbour
USAAF	2	Kittyhawk	16/06/42	Shot down	Darwin Harbour
RAAF	1	F. VC Spitfire	2/05/43	Lost during air raid	Darwin Harbour
RAAF	1	Dornier Flying Boat	11/03/44	-	Darwin Harbour
RAAF	1	LF. VIII Spitfire	About Oct 1944	-	Darwin Harbour
RAAF	1	Spitfire	5/10/44	Crashed during test flight	Darwin Harbour
RAAF	1	LF. VII Spitfire	About Nov 1944	-	Darwin Harbour
RAAF	**1**	**Catalina**	**20/06/45**	**Depth charge explosion**	**East Arm**
RAAF	**1**	**Catalina**	**30/08/45**	**Crashed during take off**	**East Arm**
RAAF	**1**	**Catalina**	**14/12/45**	**Caught fire while moored**	**East Arm**

Table 2 - Planes lost on or over Darwin Harbour.

Further afield, 10 planes, including 7 Japanese planes were lost in the sea off Darwin (Table 3). It is possible that one of these planes could be located in the vicinity of Area C.

[68] **Dunn, P. 2002**. *Australia at War*. [Online] Available http://home.st.net.au/~dunn/ozcrashes/nt146.htm, Accessed 1st Dec 2010.
[69] *Opp.Cit.*, **Jung**, **2000**, 105.
[70] Wrecks in **bold** indicates location is known.

Service	Qty	Aircraft	Date Lost	How lost	Location
USAAF	1	P-40E Kittyhawk	15/02/42	Shot down by "Mavis" flying boat	In sea between Timor and Darwin
Japanese 21st Air Flotilla	1	H6K "Mavis" Flying Boat	15/02/42	Shot down by P-40E Kittyhawk	In sea between Timor and Darwin
Japanese	1	Val	19/2/42	Shot down by AA fire	North of East Point
Japanese	2	Zero	16/06/42	Shot down	Into sea near Darwin
Japanese	3	Zero	2/03/43	Shot down	In sea off NT
RAAF	1	F. VC Spitfire	15/03/43	Shot down by Japanese aircraft	Into sea Darwin area
RAAF	1	BS162	-	-	In sea in Darwin area

Table 3 - Planes lost in the sea off Darwin.

The wreck of a C-47 Dakota which crashed during a test flight in September 1946 was found approximately 3.5 km west of Fannie Bay in 2007 and has been placed under an Interim Conservation Order.[71] It will not be impacted by the proposed development. No additional research has been carried out as to whether there are any other plane wrecks in Darwin Harbour that were lost before or after WWII. In this case it is believed that, other than the recently discovered C47 Dakota, there would only be a few such wrecks, if any.

2.4 Summary of cultural activities within the study area

From the above review of the known history of the study area and known wreck sites, the following cultural activities are identified:

- Resource Exploitation – fishing, trepanging, pearling;
- Exploration;
- Transportation – import and export (people, raw materials, and manufactured goods);
- Cable and net laying, and;
- Air to sea warfare.

2.5 Predicted types of submerged maritime heritage

From the historical summary presented, the following site types can be expected to be found within the study area:

Shipwrecks

Shipwrecks are often found within in the vicinity of ports and coastal communities. As these places serve to attract vessels, there are greater chances of vessels sinking through poor navigation or other mishaps, as well as being deliberately discarded.

[71] **Northern Territory Government, 9/1/07** : Media Release 'Urgent Heritage order Over Plane Crash Site' http://newsroom.nt.gov.au/index.cfm?fuseaction=printRelease&ID=1248

The concentration of vessels in one area also multiplies the number of wreck events of catastrophic events such as cyclones and wartime air raids.

Three shipwrecks are known to be located within Areas A and B – the *Kelat*, *Ellengowan* and the Steel Barge – though these do not fall within the direct impact areas for dredging and piling. It is possible that more wrecks could be present within these areas.

Plane wrecks

It is a peculiar feature of Darwin within an Australian context that an air war was fought overhead for around 2 years. Such events inevitably cause plane wrecks. The remains of 4 plane wrecks (all Catalinas) have been located within Area A though not within the direct impact areas for dredging and piling. It is possible that more plane wrecks could be present within these areas.

Moorings

Throughout the 19th century and into the 20th century, ports with limited infrastructure usually designated anchorages for vessels awaiting their turn to berth or being serviced by lighters. In some cases permanent moorings were established by either the authorities or shipping owners. Moorings in the 19th century were usually large antiquated anchors, with one of the arms cut away while into the 20th century moorings tended to be large concrete blocks, although discarded antiquated engines were also occasionally used. Thick chain can possibly be associated with such moorings, stretched out on the seabed up to 50 m distant.

The East Arm during WWII was associated with the Flying Boat Base on Quarantine Island. The Catalinas would have had permanent moorings across this area, most likely constructed of large concrete blocks. It is unknown whether these moorings were removed when the base was closed down. Thick chain may also be present in the area.

Cable and nets

The rationale for the settlement of Darwin was to provide the labour, expertise, infrastructure and security for the landfall of the undersea telegraph cable. Substantial lengths of this cable may still be *in situ*. The cable was laid across the seabed from Java and was landed at Lameroo Beach, which is below the Northern Territory Parliament House.[72] It is thought that the cable ran northwards to the east of the proposed pipeline route.

There are functioning undersea cables in Darwin Harbour, the most relevant to this study being the power cable from Darwin to Mandorah. These cables have been identified in the marine geophysical survey of Area B.[73]

During WWII Darwin was under threat of Japanese submarine attack. The wreck of *I-124* to the north of Darwin is testament to how close these vessels operated. An anti-submarine boom net was laid across the entrance to Darwin Harbour and associated underwater monitors such as indicator loops were also set up on the seabed (see Figures 13 and 14).[74]

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[72] **Heritage Conservation Services, June 2004** *Goyders Camp and Hughes Avenue; Heritage Assessment Report*: 27
[73] *Opp. Cit.,* **Fugro Survey Pty Ltd March 2010 and** *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008** Volume 1a, 2-55
[74] *Ibid*., 2-29.

The submarine boom net was anchored to the seabed with 5 and 8 ton concrete clumps. 265 clumps were used for the boom, arranged in groups of eight. At the end of the war the net and the loops were removed, however the clumps were left on the seabed in the event that they were required in a future conflict (Figure 15).[75]

Based on the information presented above there is potential for concrete anchors, thick chain, lost net and indicator cable and other associated materials to be found on the seabed within this section of the proposed pipeline.[76] Anti-torpedo nets may also have been set up around the moored Catalinas in East Arm.[77]

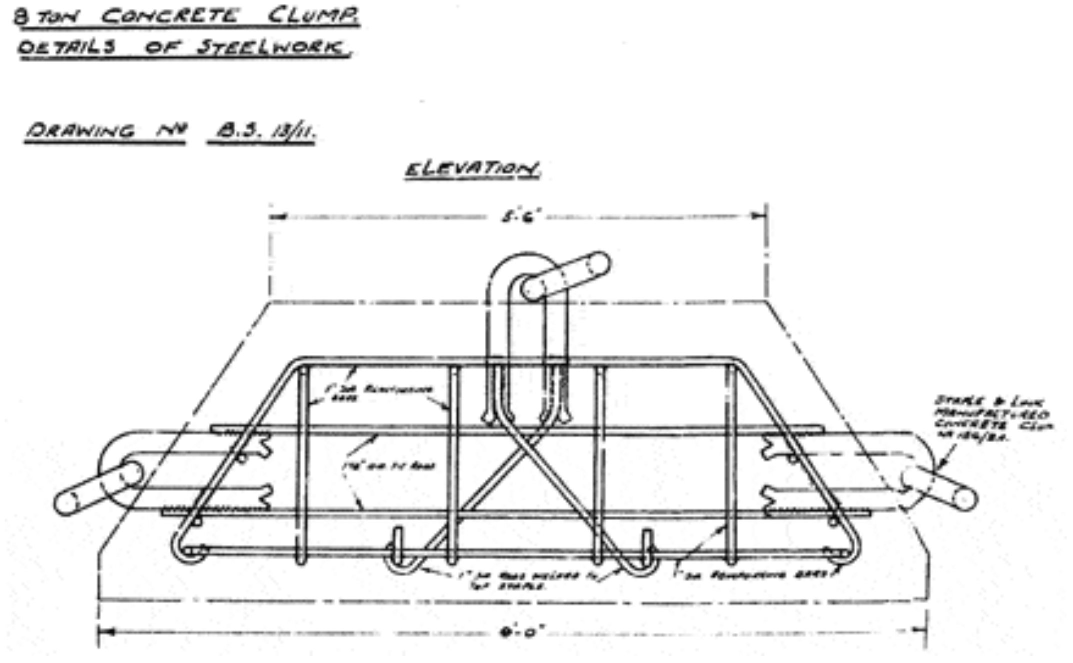

Figure 15 Eight ton concrete clump showing details of steelwork.
(Forster, P. 2010. *Fixed Naval Defences in Darwin Harbour 1939-1945*. [Online] Available http://www.navy.gov.au/Fixed_Naval_Defences_in_Darwin_Harbour_1939_-_1945, Accessed 1st Dec 2010).

Ordnance from WWII, UXO

During the 64 air raids in the Northern Territory between 19 February 1942 and 12 November 1943, over 500 tonnes of bombs were dropped.[78] Expended and unexpended ordnance would be present within the study area. It is understood that 30% of all Japanese air delivered munitions may have failed to function and became UXO.[79]

In addition to Japanese ordnance, there is also potential for Allied EO and UXO to be found within the study area; sources of which might include material from within

[75] *Opp. Cit.*, **Forster, P. 2010**.
[76] *Ibid.*, 31.
[77] **G-tek Australia**. **2008**, Post Activity Report: Unexplained ordnance assessment Darwin and Northern Australia exercise area, 22.
[78] **G-tek Australia**, **2010**, Post Activity Report: Unexplained ordnance assessment Darwin and Northern Australia exercise area Appendum, 2.
[79] *Ibid.*, 4.

damaged shipping, material from active anti submarine and anti aircraft countermeasures, material lost while unloading/loading shipping and items from other general wartime activities.[80] Some munitions may have been dumped upon the cessation of hostilities.

Ballast mounds

It was not uncommon prior to containerisation in the 1950s for vessels to offload ballast in deeper water, or a designated shallow area, in the vicinity of a port prior to taking on a cargo. Such ballast heaps are often lozenge shaped mounds composed of stone.

The above discussion is summarised in the following table:

Type	Area A	Area B	Area C
Shipwrecks	Yes	Yes	Yes
Plane wrecks	Yes	Yes	Yes
Moorings	Yes	Yes	No
Cables/nets	Yes	Yes	No
Ordnance	Yes	Yes	No
Ballast mounds	Yes	Yes	No

Table 4 - Predicted types of submerged cultural heritage present.

2.6 Predicted likelihood of the presence of submerged material heritage

Shipwrecks

As has been discussed in **Section 2.3**, there are 75 known shipwrecks in Darwin Harbour. It is doubtful that further research will dramatically change this number, though this figure will gradually be added to. For example, a wreck recently inspected in Frances Bay has been tentatively identified as the *Huddersfield*; the loss of this vessel in Darwin was not listed on the NHSDB.[81] Other undocumented wrecks that may be present are lighters, small fishing boats, barges and/or tenders, whose loss or abandonment does not get reported either to the authorities or by the newspapers. Such wrecks may appear in the background of photos of the harbour.

It is possible that the discarded remains of dugout canoes may be present throughout Darwin Harbour, more likely on the fringes of the mangroves than on the seabed. With respect to potential Macassan wrecks, it has been reported that the Macassans were in contact with the Larrakia who occupy the land on which Darwin is located. It is possible that one or more of these vessels were lost in Darwin Harbour, but the likelihood of this event taking place can be considered to be extremely remote.

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[80] *Ibid.*, 13.
[81] *Opp. Cit.,* **McKinnon, J. Raupp, J. *et al* August 2010**

As discussed in **Section 2.3** at least 39 vessels known to have been lost in 'Darwin Harbour' are yet to have been located. A number of these vessels would have been lost within proximity to the Stokes Hill wharf, in an area known as Frances Bay. The *Huddersfield* for example was recorded as being lost in 'Darwin Harbour' but has been recently located more precisely in Frances Bay which is to the north of Area A.

This stretch of water bounded by Darwin Harbour to the north and the newly reclaimed East Arm to the south was a usually safe anchorage, protected from the prevailing north westerly winds in the wet season and the weak easterly winds in the dry season. Prior to WWII, vessels moored in this area such as the *Huddersfield*, suffered some mishap and sunk within the Bay, or were broken up along its 'shores'. Vessels attempting to make the shelter of Frances Bay may have come to grief in the wider expanses of Darwin Harbour either by foundering or by striking reefs and low islets such as Walker Shoal or North and South Shell Islands.

The basic predictive model for occurrence of wrecks within Darwin Harbour would be for the frequency of such sites decreasing with distance from Frances Bay, with a higher likelihood for wrecks to be located around reefs and shoals. The cyclone of 1897 however skews the frequency of shipwrecks beyond Frances Bay towards the south. As stated in a contemporary newspaper account where "….*A number of the boats were swept over to the southern side of the bay and cast up among the mangroves*", up to 18 vessels became wrecks between Frances Bay and the mangroves between Wickham and Blaydin Point.[82] The loss of the steam launch *Zulieke* (*Zulieke*?) on a reef off Quarantine Island suggests that the cyclone may have blown the vessels in a more south easterly direction. Some of these vessels were lost in the mangroves, no doubt pushed further inland due to higher than normal water levels. Some vessels may have foundered in the waters between Frances Bay and the southern shore of Darwin Harbour, a few sinking after striking reefs and low-lying islets.

The bombing of Darwin during 1942 also created an anomalous layer of wreck site distribution across Darwin Harbour. Those vessels sunk by the Japanese however have been located and none are presently located within the proposed dredge envelope, jetty alignment and pipeline route.

Based on the above discussion it is possible that a shipwreck may be present within the proposed dredge envelope of Area A; it is unlikely that a shipwreck will be present within the proposed pipeline corridor (Area B) running up the western side of Darwin Harbour, and it is almost certain that the remains of more than one wreck are located amongst the mangroves around Blaydin Point with this likelihood diminishing westwards towards Wickham Point.

There is a remote likelihood of a shipwreck being located in Area C. This is based on the absence of known navigation hazards in a stretch of water, which would have been traversed only by vessels attempting to pass through Clarence Strait into Van Diemen's Gulf and beyond – a relatively low intensity shipping route.

Plane wrecks

The only plane wrecks found within Darwin Harbour are the 6 Catalinas known to have been lost in East Arm. This leaves a reported 19 planes lost during WWII whose locations are not presently known. This figure may not be accurate for the reason that some individual plane losses may have been reported more than once, and that some planes may have been recovered.

[82] *Opp. Cit.,* **Northern Territory Times & Gazette**, **1897**, Monday 25th January 1897

It is postulated that those planes that did crash into the Harbour and were not recovered, are located away from Darwin and the Flying Boat Base on Quarantine Island (now part of East Arm Port). The reason for this being that if they came down in and around the moored Catalinas in East Arm and Stokes Hill wharf their positions would have been more accurately described. It is therefore likely that those planes that came down in East Arm crashed further to the south east and those described as having crashed in Darwin Harbour would most likely be located in the western portion of the Harbour.

It is considered very unlikely that a plane wreck would be located within the proposed dredge envelope in Area A, however it is possible that one or more plane wrecks may be located within the proposed pipeline corridor (Area B). It is considered a remote likelihood that a plane wreck is located within the vicinity of Area C.

Moorings

It is not known at present as to how many Catalinas were, or could have been moored in East Arm. It would be safe to assert that there would have been more than the 6 that were sunk. It is almost certain that moorings associated with the Flying Boat Base are present within Area A, and it is likely that one or more of these moorings would be located within the proposed dredging envelope.

During WWII, designated anchoring spots were established between Wickham Point and Stokes Hill Wharf (Figure 16). It is unclear whether mooring blocks were set at each of these positions but it would appear that these mooring locations were to the west of the proposed dredging envelope. It would be very unlikely that there are moorings within the proposed pipeline corridor of Area B and an extremely remote possibility for Area C.

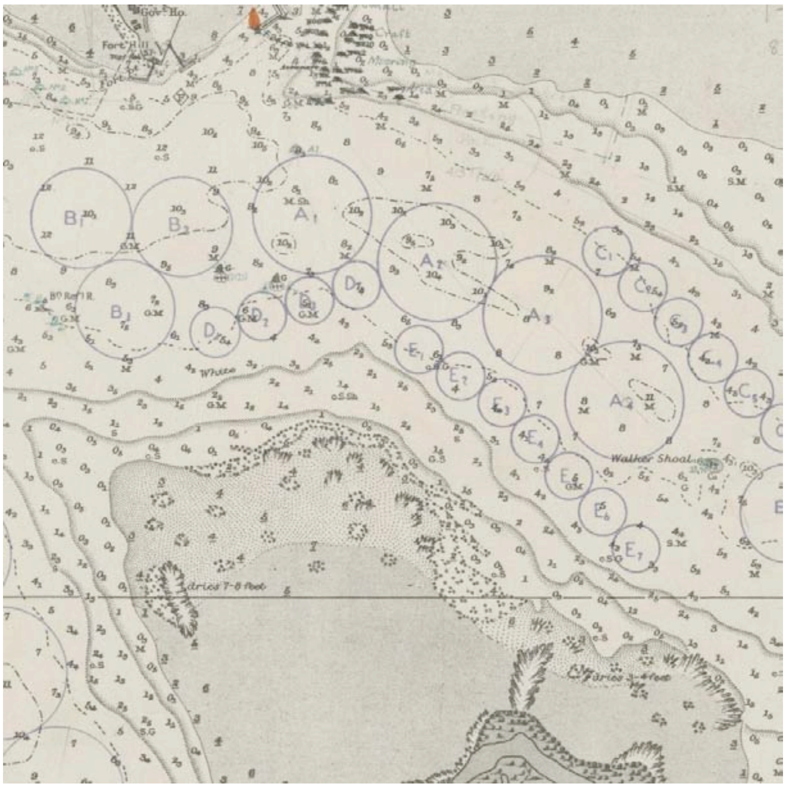

Figure 16 Portion of 1944 navigation chart showing location of allocated moorings.

Great Britain Hydrographic Department. 1944. *Australia – North Coast, Darwin*. Held by the National Library of Australia. [Online] Available http://nla.gov.au/nla.map-rm3397, Accessed 6th December 2010.

Cable and nets

The 5 and 8 ton concrete blocks associated with the submarine boom net should be present in Darwin Harbour in a line between Dudley and West Points. A number of these will very likely be located within the proposed pipeline corridor (Area B). As it is not known whether anti-torpedo nets were established around the moored Catalinas it is uncertain whether any associated materials would be present within Area A.

Ordnance from WWII

The extent and frequency of expended and unexpended ordnance from WWII has been well documented by G-tek Australia.[83] It is almost certain that 3.7" projectiles from the anti-aircraft guns located on East Arm will be found scattered randomly across the Darwin Harbour area, and hence within Area A and the proposed dredging envelope and alignment of the jetty.[84] Ordnance originating from attacking aircraft and/or accidentally dropped during the arming of the Catalinas could also be expected around the existing plane wrecks in East Arm as well as around the former moorings, some of which could be located within the proposed dredging area. It is also possible for remnant Japanese air-delivered munitions to be found on the seabed within the vicinity of the submarine net gate positions (Area B).[85] Ordnance may also be found in association with the downed planes not yet located within Darwin Harbour, especially in the western half (Area B).

Ballast mounds

It is unlikely that ballast mounds would be found in Areas A and B, and it is extremely remote for such features to be present in Area C.

The above discussion is summarized in the following table:

Type	Area A	Area B	Area C
Shipwrecks (Aboriginal)	Possible (in mangroves)	Possible (in mangroves)	No
Shipwrecks (Macassan)	Extremely remote	Extremely remote	Extremely remote
Shipwrecks (European period)	Possible (in dredge area) Almost certain (in mangroves)	Unlikely	Remote
Plane wrecks	Very unlikely	Possible	Remote
Moorings	Almost certain	Unlikely	No
Cables/nets	Uncertain	Very likely	No
Ordnance	Certain	Certain	Remote
Ballast mounds	Unlikely	Unlikely	No

Table 5 - Predicted likelihood of submerged cultural heritage being present

[83] *Opp. Cit,* **G-tek Australia. 2008** and **2010**.
[84] *Ibid*., 17.
[85] *Ibid*., 31.

2.7 Predicted condition of the submerged cultural heritage

Submerged cultural heritage sites deteriorate as a result of direct and indirect impacts by a variety of processes. Damage is categorised as *Mechanical*, *Chemical* or *Biological*:

- *Mechanical* damage occurs when the physical integrity of the site is affected by the impacts of waves, surge, current, floating seaweed, sand abrasion as well as cultural behaviour such as dredging, divers interfering with a site, dragging anchors, fishing nets, or vessels running aground. Increases in mechanical damage to a wreck site can result from increases in tidal flows and average wave heights as well as the increased exposure of sites due to sediment erosion.
- *Chemical* damage relates primarily to the corrosion of the metal components of a site. Changes in pH levels, salinity, light levels (heat) and water movement can dramatically increase electrochemical (corrosion) activity for metal components immersed in seawater.[86]
- *Biological* damage occurs where organic materials, such as wreck timbers, are exposed to biological organisms such as marine borers and bacteria, and in some cases vegetation. In relation to submerged cultural heritage sites, increased biological damage will occur if hitherto buried sites, or partially exposed sites, are further exposed due to sediment erosion. In some cases biological coverage over iron objects has a beneficial effect for that objects long term survival.

If a submerged cultural heritage site suffers from one or more of the above categories of damage it will become further '*scrambled*'. The term '*scrambled'* refers to alterations made to a site that make it more difficult to interpret/understand – that is, it results in the loss of information; which can refer to either a loss/deterioration of physical fabric or loss of context (the relationship between artefacts). The term *'transformation'* is used to describe alteration of material (such as breaking/pulverising, corrosion or marine borer damage) and the term '*translation'* is used to describe the displacement (removal and/or dispersal) of material.[87] The *scrambling* of a submerged cultural heritage site reduces its overall significance. The degree of the reduction of cultural significance for a particular site is related to its scale and extent relative to its assessed values (see **Section 2.8**). The rate at which a submerged cultural heritage site deteriorates naturally depends on three primary factors:

- Location (whether in a high energy or low wave zone)
- Seabed type (soft sediments or rock)
- Site composition or components (iron or timber, engine or no engine)

When a marine heritage site is formed, it undergoes a rapid rate of deterioration in relation to its environment and composition; the three primary factors outlined above. Eventually, the rate of deterioration decreases to an almost imperceptible level. The shipwreck has achieved a near state of equilibrium with its environment. This may

[86] **Brown, R., H. Bump, & D.A. Muncher 1988** "An *in situ* method for determining decomposition rates of Shipwrecks": 143 and **Dean, M., B. Ferrari, I. Oxley, M. Redknap, & K. Watson 1998** *Archaeology Underwater: The NAS Guide to Principles and Practice.*: 224
[87] **Ward, I., P. Larcombe & P. Veth. 1999** "A New Process-based Model for Site Formation." : 561

take decades or just a few years depending on the factors outlined above. Generally speaking, a completely buried site or a site in deeper water is better preserved than that which is in shallow water and resting on a rocky seafloor. This is because such sites are not subjected to wave action, which can physically break down sites and the surrounding waters are not as oxygen rich and colder (which affect rate of biological and chemical attack).

Any change to the environment surrounding a site may result in a change in the rate of deterioration. For example an increase of water turbidity may result in reduction of heat and oxygen levels thereby reducing rate of biological and chemical attack. Increases of water flows over a site increases exposure to oxygen and increases the rate of mechanical damage. If the protective covering of concretion is removed from iron/steel, the rate of corrosion will increase dramatically.

Cultural activity also affects the rate of scrambling of a site. Anchor drags and propeller jet turbulence for example result in mechanical damage and also expose more surface area of the site to biological and chemical attacks.

Assessing the condition, or more precisely, the structural integrity of submerged cultural heritage sites, in particular ship and plane wrecks in this study, is of relevance because this can provide an indication of its 'detectability' using remote sensing techniques. The following discussion on this topic examines the identified site types separately:

Shipwrecks

There is a great variability in the way shipwrecks present on the seafloor. The greatest determining factor is the type of seabed upon which it rests, followed by its hull construction. Size, age of submersion, cargo, propulsion, depth, water temperature and turbidity are also key factors.

For shipwrecks resting on a seafloor composed of sand/silt/mud deposits of at least a few metres thick – such as the southern half of Areas A and B as well as Area C, the following site formation process can be hypothesised:

- Vessel may come to rest on its keel slightly heeled to one side.
- The wreck will settle into the seabed up to a certain depth, dependant on the resistance of the sediments and the weight of the vessel. It is a general rule, especially with iron hulled vessels, that wrecks sink into mud up to their waterline. This provides support for the hull thereby retaining its integrity longer.
- Parts of the vessel, which protrude above the water may be salvaged for re-use. Non-perishable, accessible and high value parts of the vessel situated underwater may also be removed.
- Biological processes will commence immediately, attacking the exposed timbers and other organic elements of the wreck. This will lead to the weakening of the hull integrity and eventual disappearance of the organic elements above the seabed. The waters in and around Darwin Harbour accelerate this process, more so than if the wreck was in colder waters.
- Strong currents propelling branches and vegetation would break down parts of the wreck either by percussion or by accumulated weight.
- Due to the relatively sheltered nature of Darwin Harbour, wind generated waves would affect sites in shallow and intertidal regions. Such waves would act upon the broader surfaces of a wreck thereby breaking down

the exposed component of the wreck into sections. These sections will orientate themselves to provide the least resistance to the direction from which the waves are more commonly generated.

The above mentioned processes pre-disposes towards shipwrecks, especially those with wooden hulls, becoming buried over time. Therefore the logical conclusion to this would be that the older the wreck, the deeper it could be buried. Of course if bedrock or a hard alluvial substrate were present close to the surface of the seabed, less of a timber hull and contents would be preserved.

The typical wreck site appearance/characteristics of a timber hulled vessel would be the bulk of the remains of the wreck to be situated below the seabed surface; preserved up to the turn of the bilge (if flat bottomed hull) or one side from keel to main deck (if deep hull). Large inorganic materials that would have been located in the upper part of a vessel, such as the anchors, winch/capstan, ship's oven/cauldron and even cargo and ballast may be visible above the seabed. If the vessel was propelled by an engine, then the engine itself, water tanks, boilers (if steam) would also be visible above the seabed. A classic 'wreck shape' would not be expected unless the vessel's cargo was completely composed of inorganic materials. More than likely a composition of small to large objects would be visible in a more or less discrete concentration.

Scouring and periodic large storms may expose from time to time organic elements signifying the continual process of the scrambling of the site. Such organic elements may include the frames of the hull exposed only perhaps less than a metre above the seabed. If situated in a strong current environment, significant scour pits can form around exposed features.

The recently inspected wreck in Frances Bay tentatively identified as the *Huddersfield* is a good example of what has been discussed above. The most prominent features of the site are the engine (diesel so therefore no boiler), two water tanks and some of timber hull structure.[88] The side scan image of the site shows no other remarkable features on the seabed other than scattered highly reflective flecks. It can be seen from this example that a timber hulled wrecked without an engine and of a smaller tonnage may appear as low relief and highly reflective debris scatter on the seabed while the bulk of the wreck remains are buried.

With regard to iron/steel hulled vessels, they will retain hull integrity and could be relatively well intact. For the larger vessels the hull along amidships may have collapsed but the stern and bow sections may still be upright, or heeled to one side. The engine components, if any, would be largely intact and *in situ*.

For wrecks coming to rest on a 'hard' seafloor such as the bedrock pavement (sand veneered or exposed) and in areas where this is a very high gravel content – as in the north western portion of Area A and mid-section of Area B, the following site formation process can be hypothesised:

- Vessel will come to rest on its side or upside down. This will put added strain to the integrity of the hull resulting in its collapse relatively sooner.
- Parts of the vessel, which protrude above the water will be salvaged for re-use. Non-perishable, accessible and high value parts of the vessel situated underwater may be removed.
- Biological processes will commence immediately, attacking the exposed timbers and other organic elements of the wreck. This will lead to the

[88] **McKinnon, J. Raupp, J. *et a*l August 2010**: 4

weakening of the hull integrity and eventual disappearance of the organic elements. The waters in and around Darwin Harbour accelerate this process, more so than if the wreck was in colder waters.

- Strong currents propelling branches and vegetation would break down parts of the wreck either by percussion or by accumulated weight.
- Due to the relatively sheltered nature of Darwin Harbour, wind generated waves would only appreciably affect sites in shallow and intertidal regions. Such waves would act upon the broader surfaces of a wreck thereby breaking down the exposed component of the wreck into sections. These sections will orientate themselves to provide the least resistance to the direction from which the waves are more commonly generated.
- Elements of the vessel and cargo will deteriorate rapidly. Steel elements may survive but will be so corroded and may be difficult to identify. Iron components will last considerably longer and will establish a crust of coral thereby protecting it.
- Hull plates of iron wrecks will tend to collapse flat onto the rock over time, the bow and stern sections being the last to breakdown.
- Where there are pockets of sand within the reef/bedrock, vessel and cargo elements may be present and buried.

The above mentioned processes pre-disposes the integrity of shipwrecks to be severely compromised in a short period of time. Iron hulled vessels take longer to breakdown.

The typical wreck site appearance/characteristics would be the bulk of the remains of the hull to be spread across the rocky seabed. For timber hulled ships that may just be remains of ferrous/copper fastenings and copper sheathing. For an iron hull, plates will tend to be laying flat though considerable structures such as the engines and boilers (if any) as well as the bow and stern will remain prominent for some time. Large inorganic materials associated with a timber hulled vessel, such as the anchor, water tanks, winch/capstan, engines (if any) ship's oven/cauldron and even cargo and ballast may be visible on the rocky seabed, protruding from sandy pockets or in flotsam traps. Scouring and periodic large storms may expose from time to time organic elements signifying the continual process of deterioration of a shipwreck site.

Cultural behaviour within the study area will have had the effect of scrambling wreck sites and masking their presence. Dragging of anchors would result in wreck material being spread over a wider area therefore distorting any symmetrical patterns on the seabed, which may indicate a wreck. On the other hand, such activities may also result in the 'ploughing up' of buried cultural material.

The dumping of material, especially during and immediately after WWII, on the seabed throughout Areas A and B has the effect of potentially masking the presence of the subtle signs of the wreck of a small timber hulled sailing vessel. The WWII era iron hulled wrecks in Darwin Harbour are unique in an Australian context in the way in which they were salvaged – the superstructures were cut away leaving the cargo in the holds exposed.

With regards to the unlocated shipwrecks known to exist within Darwin Harbour, there are a few that are known to be steel/iron hulled. They will likely be largely intact on the seabed whether it be on sand or rock. The majority of these unlocated wrecks are likely to be small timber hulled (< 100 tons) sailing vessels of which a number may have had auxiliary engines. The pearling luggers lost in the 1897 as well as some of the vessels lost prior to that event most likely did not have engines.

Such wreck sites would be low relief sites in both rocky and sandy seabeds, with more debris discernable in the sandier seabed.

For those areas within Area A, which have already been dredged – approximately up to 400 m around East Arm Wharf - it is extremely unlikely that any remains of a shipwreck would be present.

Plane wrecks

The known plane wrecks in Darwin Harbour – the five Catalinas – show a remarkable level of integrity given the nature of their sinking and their relatively weak aluminum frames.[89] The other planes known to have been lost in and around Darwin Harbour are unlikely to be in a similar condition. Shot down, their condition depends much on their velocity, angle and attitude when they struck the water. It can be expected that in many cases the planes disintegrated on impact leaving a scatter of wings, fuselage, propellers, engine and weapon components strewn over a wide area. Such sites whether on rocky or sandy seabed would appear to be composed of dispersed linear high to low relief and highly reflective structures.

Moorings

Moorings are selected for their durability and therefore remain in a solid condition, whether they be anchors or concrete blocks. They have a tendency to become buried over time in sandy/silty seabeds. Associated chain can also become buried, with exposed sections eventually corroding to a point where they become brittle and break easily. The length of time required for chain to reach this state of deterioration depends very much on its thickness, but it can be expected that such material in Darwin Harbour will still retain some tensile strength.

Cable and nets

On a sandy/silty seabed, wire and netting can become partially buried. Similarly to chain, exposed sections eventually corrode to a point where they become brittle and break easily, but the length of time required to reach this state of deterioration depends very much on the object's thickness. Given that these objects are around 70 years old, they can be expected to still retain tensile strength. They would appear as meandering low relief and highly reflective linear anomalies. The associated 'clumps' would appear as round or square low relief and highly reflective objects.

Ordnance from WWII

Generally ordnance resting on rocky sea beds in high energy environments will corrode and disintegrate at a more rapid rate while those in lower energy environments or completely buried will retain their integrity for much longer.[90] Such objects will appear as scattered low relief and highly reflective debris on the seabed.

[89] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 1a; Appendix C
[90] **G-tek Australia. 2010**:6

Ballast mounds

Ballast mounds are usually composed of rock and occasionally of scrap iron. They will present as high relief and highly reflective on the seabed.

2.8 Predicted significance of the submerged cultural heritage

It is not within the scope of this report to prepare significance assessments for the submerged cultural heritage that may be present within the study areas as much depends on their physical condition. Some general statements however can be made which can serve as a guide for how significant some sites could possibly be.

The cultural heritage significance of a site or object refers to how it rates against select criteria, usually archaeological or scientific, social, historical, aesthetic and educational values. The significance of a site is tempered by its comparative rarity and/or representativeness for that particular class or type of site. Sites are also assessed according to their significance at a local, State/Territory, National and International level. Significance considerations for the different site types identified in this study are as follows:

Shipwrecks

Generally speaking the older a site the less likely that there is historical documentation available or surviving which will tell us about that site. Therefore the remains of that site become much more important in informing us about the past. With respect to the unlocated wrecks of Darwin Harbour, those associated with the early pearling industry would be of great interest, as they would provide information not only about how they were built, but also inform us about local diving technologies and innovations as well as the ethnic compositions of the crew through personal remains which may be present on the wrecks. The Chinese boats lost throughout the 19th century are of interest as they present possibly unique sites within an Australian context and can provide information as to their origins – whether they were built in Darwin or bought over from China. If built locally, questions could be asked as to the potential challenges faced by the presumably Chinese shipwrights in using local woods and how were they overcome. Furthermore, these wrecks also have the potential to demonstrate shipbuilding techniques and styles of craft unique to particular coastal province in China. This in turn may give an indication of the provincial origins of one of Darwin's earliest immigrant groups.

In comparison, the WWII related wrecks may have less archaeological significance as they were production line vessels and their construction plans may still exist. Such sites however have tremendous historical and social significance for Australians as well as local (social) significance for the local diver charter industry.

It should be noted that shipwrecks more than 75 years old in Northern Territory waters are automatically protected under the Commonwealth *Historic Shipwrecks Act 1976*.

Plane wrecks

Like the WWII shipwrecks, the downed planes in Darwin Harbour and beyond may have little to contribute to our understanding of the construction of such machines as many copies of one type were produced. In some cases there may have been short term expedient modifications made to these craft, which may be of interest. The site formation processes for plane wrecks like the Catalinas have been studied which may assist in the long term management of such sites.[91]

The association of these planes with WWII gives such sites high historical significance. Some wrecks may possess war dead which would significantly increase their social significance. That some may have war dead present would amplify their social significance considerably.

Moorings

The significance of moorings would lie largely with where they are located and what that can tell us about anchorages and general usage of Darwin Harbour over time. The moorings themselves have little archaeological value being mostly concrete. On rare occasions other objects such as discarded anchors used as moorings have been found to be significant. . For example in Tasmania a mooring currently in use is a millstone, which was associated with a convict period flourmill.

Cable and nets

Cables and nets associated with the submarine nets would have little archaeological significance but the recording of their location, especially if any are found in East Arm, would be of interest to battlefield historians. The first undersea cable to Australia would have high historical and some archaeological significance, however this feature does not appear to cross over the study areas (Area B in particular).

Ordnance from WWII

Battlefield archaeology is becoming a popular field of study. Such research can include plotting the positions of expended munitions so as to plot the course of a battle. The danger that UXO in Darwin Harbour poses overrides any consideration for the proactive search and recovery of such objects solely for research purposes. Information such as location and munitions type, however obtained during the process of UXO recovery would be of great interest to historians and archaeologists.

Ballast mounds

These site types have some archaeological value as they can provide an indication of the scale and nature of the trade taking place in Darwin Harbour - ballast mounds indicating vessels that arrived in Darwin with no cargo. Analysis of the ballast can indicate the last port of call for a vessel, which in turn can provide some insights into how Darwin has fitted into National and International trade networks.

[91] **Jung, S. 2009.** Site formation process (wing inversion) at Catalina flying boat wreck sites lying in Roebuck Bay, Broome, WA.

3.0 Optimum methods for detection and assessment of potential submerged cultural heritage within the study area.

The potential submerged cultural heritage resource within the study areas is dominated by ship and plane wrecks. The shipwrecks that are yet to be located are mostly small timber hulled sailing vessels, which would appear on the seafloor as a concentrated debris scatter, with some high relief points if the vessel had an auxiliary engine. There may be some symmetry to the debris especially if the timber frames are protruding from the seabed. The ferrous content of these sites would vary, with some of the smaller fishing boats having little iron as part of their structure, fittings or cargo. Only with the extremely unlikely presence of a pre-European vessel would a wreck site display no magnetic signature.

The morphology of the plane wrecks within the study area is expected to vary from being relatively well intact, displaying a low number of high relief thick linear features, to having disintegrated leaving an image of scattered debris over a wide area and a multitude of thin and thick linear features of varying height. Though constructed of aluminium, the engine and weapon components of the planes were ferrous.

Moorings are relatively high relief objects, which can be up to 3 m in size and can have a high ferrous content. Cables and nets would be low to high relief thin linear features while munitions would appear as low relief debris with high ferrous content. Ballast mounds would appear as high reflective low relief mounds with a low likelihood of ferrous content. Based on the above observations the optimum methods for the detection and assessment of potential submerged cultural heritage are listed below in descending order of priority:

1/ ***Side Scan Sonar***. This is the best method of identifying textures on the seabed. Apart from being very suitable for detecting high relief sites such as iron hulls, engine propelled vessels, plane wrecks and moorings; it is also the best technology available to pick up low relief, highly reflective fragments of a timber hulled wreck. Silty to sandy seabed is the best medium for the deployment of the side scan sonar. Rocky, uneven and reflective seabed masks the presence of the low relief sites.

2/ ***Magnetometer/magnetic gradiometer***. The overwhelming majority of the unlocated wrecks will have some ferrous content, and some timber wrecks may have had small engines. A magnetometer operated in conjunction with a side scan sonar would be very useful in prioritising anomalies for investigation. Over rocky, irregular and highly reflective seabed the magnetometer would become the primary means for detecting timber hulled wrecks. The narrower the line spacings, the better for detecting ferrous materials associated with small timber hulled sailing vessels.

3/ ***Sub-bottom profiling.*** The best systems to use to look for buried wrecks, especially those that are water saturated and timber hulled, are chirp or pinger systems. The higher frequencies produce higher resolution images close to the seabed surface. Boomer systems sacrifice resolution for depth of penetration. Sub-bottom profiling that has been carried out to locate the depth of the rock head will not provide useful data for detecting buried shipwrecks. A chirp or pinger system is best used after a site has been found and an understanding of the buried extent is required. As the width of sub-bottom profiler scans are very narrow, a large amount of tracks are required to provide adequate coverage of the seabed.

4/ ***Multi-beam sonar***. Multi-beam sonar is a great tool for providing definition and extent of relatively high relief and large sites. For the system to be useful for locating low relief sites the bin size would need to be at around 0.1 m with the surveyors having been briefed carefully as to what they would be looking for. Wreck sites have been mapped with individual timber frames protruding from the seabed clearly shown, while massive anchors have been erased in the belief that they were eccentric/erroneous points. In some unexplained instances large objects do not appear or are diminished in size and have been found through the scour pit within which they are located.

5/ ***Visual Search***. Whether by diver or remote operated vehicles, visual search techniques are only useful in high visibility (> 30 m) water. Divers should be used to examine anomalies identified using the techniques listed above.

4.0 Remote sensing work undertaken

4.1 Side Scan Sonar Survey

Area A

Between February and March 2008 a combined multi-beam, side scan sonar and sub-bottom profiler survey was conducted.[92] One of the aims of the survey was to "…*identify any potential seabed or sub-seabed obstructions, or conditions which could hinder the construction and operation of the proposed facilities including wrecks and items of debris*". [93] The side scan sonar was used for this purpose, to delineate seabed features and highlight hazardous debris.[94]

The GeoSwath Plus Multibeam System was used as the side scan sonar.[95] It was operated at a frequency of 250kHz and a 60m range. The data was also analysed to check for the presence of small features and items of debris. The interpreted data was then compiled into the seabed features drawings.[96] The quality of the data was considered very good though some artefacts present in the data appear to have been the result of equipment interference.

A side scan sonar survey of the western portion of the seabed currently proposed for dredging was undertaken between October and November 2010 (Figure 17).[97] The objective of the survey was to examine the area for UXO, more specifically "…*to identify metallic contacts that lie at the western end of the proposed dredging area*..."[98] Though the primary remote sensing tool used was a gradiometer (see **Section 4.3**), side scan sonar was used to determine, where possible, the nature of the magnetic contacts visible on the seabed. The side scan sonar (EdgeTech 4200-FS) was set on a 60 m range scale to achieve a high resolution image of the seabed

[92] **Fugro Survey Pty Ltd, August 2008** *Report on the Ichthys Field Development, Darwin Harbour Geophysical Site Surveys 2008*.
[93] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 1;1-1
[94] *Ibid.,*Volume 2;1-3
[95] *Ibid.,* Volume 2;4-5
[96] *Ibid.,* Volume 2;6-3
[97] **Neptune Geomatics Pty Ltd, January 2011,** *Nearshore Unexploded Ordnance and Debris Survey – Final report.:* 8
[98] *Ibid.,* 10

and was towed at 50 m line spacing.[99] The resolution of the final mosaic was 8 pixels per square metre, translating to a grid resolution of 0.12m.[100]

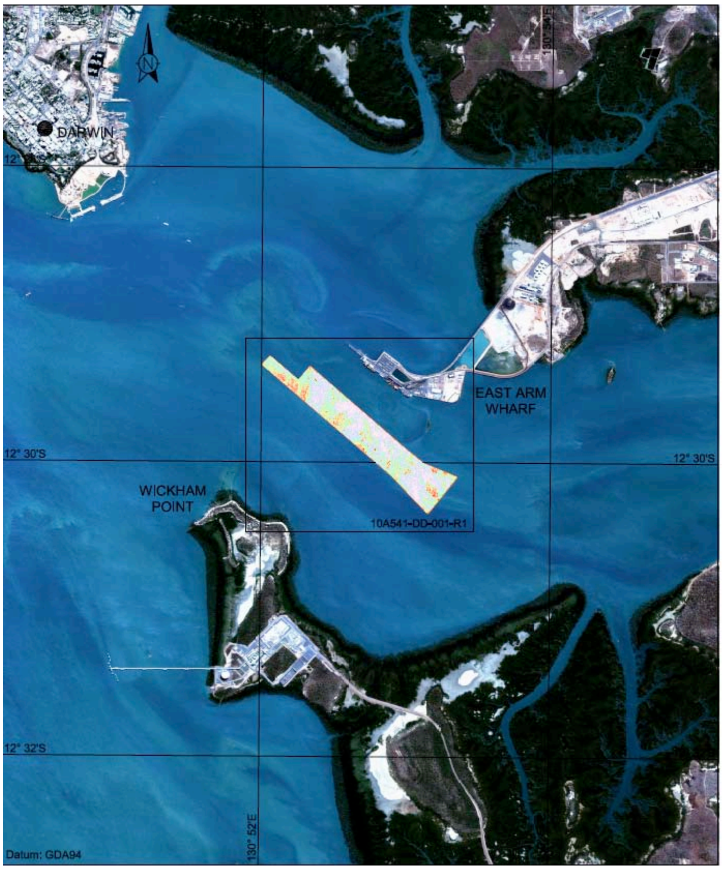

Figure 17 Extent of side scan sonar and gradiometer survey in western portion of Area A undertaken in October/November 2010.

Neptune Geomatics Pty Ltd, January 2011, *Nearshore Unexploded Ordnance and Debris Survey – Final report*: Overall Sidescan Sonar Mosaic Drawing (Neptune no: 10A541-DD-011-R1 and INPEX No: L380-DU-DTL-0001.001_1)

Area B

The February/March 2008 surveys utilised side scan sonar to delineate seabed features and highlight hazardous debris.[101] The system operated within the parameters set for Area A.

A second survey was conducted in February 2009, which encompassed a section of the pipeline route in Darwin Harbour near Weed Reef.[102] The objective of the survey was infill between two areas of existing data at Weed Reef. Approximately 31 km of lines were run. Most of the area covered appears to have been west of Area B.

A combined side scan sonar and magnetic gradiometer (MG) survey of a section of the proposed pipeline route was undertaken between October and December 2009.[103] The purpose of the survey was to identify potential UXO. Approximately 350 km was surveyed, of which 17 km of the survey was within Area B. The width of the survey corridor within Darwin Harbour was 40 m and the survey achieved 100%

[99] *Ibid.,* 12
[100] *Ibid.,* 38
[101] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 2;1-3
[102] **EGS, April 2009 2009** *URS Dredge Material Disposal Area Survey: Side Scan Sonar and Echosounder Survey*
[103] *Opp. Cit.* **Fugro Survey Pty Ltd March 2010**:2

coverage in both high and low frequency. At high frequency, track resolution is considered better than 10 cm.[104]

As UXO appear as single objects or as debris scatter on the seabed, similar to the exposed remains of timber hulled wrecks, the side scan sonar component of this survey is considered suitable for detecting anomalies on the seabed which may be associated with a ship or plane wreck.

Area C

A side scan sonar survey was undertaken in the proposed disposal ground in February 2009.[105] The purpose of the survey was to accurately map the area and identify any objects that may be culturally significant or areas that may be environmentally significant. It was noted though that it was beyond the scope of the survey report to comment on the cultural and heritage significance of all areas mapped. The side scan sonar coverage was 100% and the data collected was of good quality.

4.2 Multi-beam sonar

Area A

The February/March 2008 survey utilised multi-beam sonar for mapping water depths.[106] The GeoSwath system was operated at 250kHz at approximately five pings per second.[107] During the processing stage erroneous points were carefully filtered out and a 1 x 1m digital terrain model (DTM) of the areas was created. On this DTM a 3m x 3m matrix smooth was applied and was interpolated using a 5m x 5m matrix to fill any small gaps that were present.[108] Interestingly for those wrecks which were already known and captured in the survey, the data was further filtered for erroneous points and re-gridded at a higher resolution – 0.1 m bin – so as to provide a more detailed image.[109]

Area B

The February/March 2008 survey utilised multi-beam sonar for mapping water depths.[110] The system operated within the parameters set for Area A.

4.3 Magnetometer/gradiometer

Area A

A survey utilising a magnetic gradiometer was undertaken in the western portion of the proposed dredge area in October and November 2010.[111] The objective of the

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[104] *Ibid*., 8
[105] *Opp. Cit*. **EGS, April 2009.**
[106] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 2;1-3
[107] *Ibid.,* Volume 2;4-2
[108] *Ibid.,* Volume 2;6-3
[109] *Ibid.,* Volume 1a; Appendix C - Wrecks
[110] *Ibid.,* Volume 2;1-3

survey was to locate UXO (see Section 4.1).[112] The magnetic gradiometer (G882-TVG) was calibrated by passing over sections of steel pipe up to 20 kg, which represented the shape of various UXO shells.[113] The line spacing for the survey was approximately 5 m and the towfish was kept at 1-3 m above the seabed.[114]

The survey did encounter areas of high and chaotic magnetic background, which have been interpreted as being natural iron rich lateritic sediments.[115] Some of these areas, such as in the south east and north west corners of the survey area, correlate with rock substrates and/or outcropping.[116] Within these areas it is acknowledged that cultural anomalies present would not be able to be easily distinguished from the background noise.[117]

Area B

A magnetic gradiometer survey was conducted along a section of the proposed pipeline route in conjunction with the deployment of a side scan sonar.[118] Approximately 350 km was surveyed, of which 17 km of the survey was within Area B. As the aim of the survey was to detect the presence of potential UXO, line spacings were 3 m, creating a total 13 survey lines within the 40 m corridor. The height of the sensor was 1.5 to 2 m above the seabed. It was determined that a 5 kg object would be the minimum size of UXO of concern; anything smaller would be very unlikely to pose a hazard to pipeline operations.[119] The line spacing was more than adequate for the detection of an iron/steel hulled wreck, the ferrous components of a European timber wreck (such as hawse pipe, anchors, chain, mast hoops, winches, water tanks, stoves) or those from a plane wreck. The MG would not have been useful for identifying the remains of indigenous and possibly South East Asian watercraft.

It was noted that throughout Area B maghaemite-rich laterites were close to the surface of the seabed.[120] Being large magnetic natural anomalies, any wrecks with ferrous content situated on these features would have been masked by the background noise.

4.4 Seismic Profiling and Refraction

Area A

The February/March 2008 survey utilised a high-resolution sub-bottom profiler for the determination of shallow geology.[121] This conformed with part of the scope of works which was to "...*characterise and map the thickness, distribution and nature of the sedimentary strata*."[122] A surface towed boomer system was used.[123] Data quality

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[111] *Opp Cit.,* **Neptune Geomatics Pty Ltd, January 2011***:* 8
[112] *Ibid.,* 10
[113] *Ibid.,* 12
[114] *Ibid.,* 12, Table 2-3 and 31
[115] *Ibid.,* 56
[116] **Neptune Geomatics Pty Ltd, January 2011)** Nearshore Unexploded Ordnance and Debris Survey; Overall Total Field Drawing – Drawing 1 of 1. Neptune Drawing No. 10A541-DD-016-R0
[117] *Ibid.,* 56
[118] *Opp. Cit.,* **Fugro Survey Pty Ltd March 2010**:2
[119] *Ibid.,*8
[120] *Ibid.,*15
[121] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 2;1-3
[122] *Ibid.,* Volume 1;1-1
[123] *Ibid.,* Volume 2;4-4

was assessed as being generally very good with sufficient penetration to bedrock surface achieved for mapping even in the very shallow water.[124] There was some degradation of the data when passing squalls and occasionally during periods of high tidal current flow. There was also some organic masking in several localised areas.

An additional remote sensing investigation of the shallow geology of the study area was undertaken between December 2008 and January 2009.[125] Referred to as a seismic refraction survey, the objective being to map sub-seabed velocities so as to assist in the interpolation of geotechnical borehole results where dredging and seabed installations are proposed.[126] A secondary objective was to investigate the correlation between seismic velocities and material strengths. The data was acquired using a continuous profiling system (CRISP) in a line spacing of 25 m. A 50 m streamer or hydrophone array was mostly used and this gave a 9 m penetration through the seabed. Greater depth of penetration is achieved with a long streamer, however there a corresponding loss of resolution.[127]

Area B

The February/March 2008 survey utilised a high-resolution sub-bottom profiler for the determination of shallow geology.[128] The system operated within the parameters set for Area A. The December 2008 and January 2009 survey used a continuous profiling system with a 32 m streamer. This gave the effective depth of penetration of 6m.[129] For the October and December 2009 survey of the route, chirp sub-bottom profiler data was used to assist in the interpretation of magnetic anomalies. This chirp data was from a single line of survey along the pipeline route centreline through Darwin Harbour, run with side scan sonar and multi-beam as a continuation of the offshore route survey in Aug to Nov 2008.[130]

5.0 Anomaly identification undertaken

5.1 Desktop assessment

Area A

The 2008 side scan sonar survey identified a suspected 7 wrecks.[131] The identity of most of these wrecks was provided to INPEX as the locations of 3 of the shipwrecks and most of the Catalina's were known.[132] A diving inspection found that a number of wrecks were misidentified, especially the Catalina wrecks, and one anomaly was a rocky ledge (see **Section 5.2**). Divers also inspected a further two anomalies which were thought to be wrecks but turned out to be very large mooring blocks.

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[124] *Ibid.,* Volume 2;7-1
[125] **Fugro Survey Pty Ltd, April 2009** *Report on the Seismic Refraction Survey Ichthys Gas Field Development, Darwin Harbour, Northern Territory- Volume 1*
[126] *Opp. Cit.,* **Fugro Survey Pty Ltd, April 2009:** i
[127] *Ibid.,*4
[128] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 2;1-3
[129] *Opp. Cit.,* **Fugro Survey Pty Ltd, April 2009:** 4
[130] *Opp. Cit.,* **Fugro Survey Pty Ltd March 2010**:15 and **Hamish Mounteney**, Senior Surveyor/INPEX *pers. comm*. email 06/01/2011
[131] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 1a;2-23
[132] *Ibid.,* Volume 1a;Tables 2-2, 2-3 and 2-4

A number of patches of debris were noted around some of the identified wreck sites. Numerous sonar contacts however were identified across the survey area, which were assessed to be such items as cables, chains, wire and other item of debris associated with WWII.[133] Others were assigned to as being of unknown origin.[134] No discrete or concentrated patches of debris which may signify the presence of a timber hulled wreck were highlighted for further investigation.

Raw side scan sonar data from the 2008 survey was not provided for this study for review. Instead a number of charts were provided showing seabed features – colour coded according to type.[135] On these charts sonar contacts have been plotted with their approximate dimensions. It is not known whether these sonar contacts are surrounded by low relief debris, which signifies the presence of a wreck. The coordinates of these sonar contacts are not provided in the report but can be derived from the GIS data provided.

The October/November 2010 magnetic gradiometer and side scan sonar survey of the western portion of the proposed primary dredge envelope identified 217 magnetic anomalies.[136] Of these, 21 had associated side scan sonar contacts.[137] An additional two side scan sonar contacts were identified that had no ferrous content.[138]

Anomalies of up to 843 kg were identified though the majority ranged between 4 to 100 kg. Those anomalies, estimated to be in excess of 200 kg, were not expected to be individual munitions items.[139]

It was assessed that 147 magnetic anomalies were within the range for possible UXO, though it was considered that most of these anomalies were unlikely to be UXO.[140] The ferrous mass for MA200 is a case in point.[141] It has been estimated to be 11 kg, which equates to an 81 mm round. The size of the anomaly however, as derived from the side scan sonar, is around 5.5 x 1.5 x 1.5 m, which is far too large for an 81 mm round.

The anomalies were distributed evenly across the survey area with a higher concentration appearing in the centre trending to the south east. On Walker Shoal, 6 magnetic anomalies were found in the shallower waters of the shoal. The largest of these anomalies, 3.0 x 2.0 x 1.3 m, was considered too large to be munitions.[142] As noted in the report on the survey, Walker Shoal is a known navigation hazard and therefore prospective for the presence of shipwrecks, especially those vessels lost in the 1897 cyclone.

Eleven anomalies were found close to the wreck of the *Kelat*. The survey report connects these objects as being clearly related to the sinking of the vessel.[143] This is a certainty for some of the anomalies but not for all of them.[144]

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[133] *Ibid.,* Volume 1a;2-8
[134] *Ibid.,* Volume 1a;2-23
[135] **Fugro Survey Pty Ltd, July 2008** Ichthys Gas Field Development: Darwin Harbour – Seabed Features Drawing no. DEV-CEX-DW-0055 and 56
[136] *Opp Cit.,* **Neptune Geomatics Pty Ltd, January 2011:**17
[137] *Ibid.,* 56
[138] *Ibid.,* 17
[139] *Ibid.,* Annex B:4
[140] *Ibid.,* 43
[141] *Ibid.,*Table 8.1
[142] *Ibid.,*Table 8.1 and 53
[143] *Ibid.,* 53
[144] Page 11 of the report describes the *Kelat* as a wooden wreck but the dipole signature of the site – Figure 8.1 - clearly shows that it had an iron/steel hull.

The draft report on the October/November 2010 survey was accompanied by a series of charts, which depicted the magnetic anomalies and sonar targets on bathymetric, Quasi Analytical Signal and side scan sonar imagery.

Charts were also provided of the multi-beam sonar survey undertaken in 2008, which give an excellent impression of the roughness/smoothness of the seabed, however the resolution was not high enough for the data to be examined in detail.[145] For example, the sonar contacts presented in the seabed features charts around the wreck of the *Kelat* are not clearly visible on the multi-beam sonar chart. Having said this there are depressions/scours as well as low relief of interest across the southern and eastern portion of the area.

The sub-bottom profiling data provided was not useful in determining the presence of potential buried cultural heritage. In any case the resolution would have been too coarse near the surface of the seabed to identify the subtle remains of a timber wreck. No buried cultural objects were identified. The sediment isopach charts are of interest in that they show significant sand thicknesses in the southern half.[146] Though the northern half of Area A has sediment thicknesses of up to 3 m, these sediments are mostly gravel which will very unlikely contain buried remains of wrecks.

The seismic refraction survey did not identify any buried cultural objects and the data would have been too coarse for the purposes of searching for the buried remains of a timber wreck.

Area B

The wreck of the *Ellengowan* was identified during the February/March 2008 survey, the location of which was already known.[147] The survey noted numerous sonar contacts along the route, which were assessed to be such items as cables, chains, wire and other item of debris associated with WWII.[148] It was also thought because of the high mobility of sediments in some sectors of the proposed pipeline route – where the sand waves occur – that more cultural material could be buried.

High concentrations of cultural material were found over a distance of 4 km along the proposed pipeline route between where the submarine net stretched across Darwin Harbour and where the indicator loops were positioned. Indicator loops were originally positioned within this area (see Figure 14). It was assessed that cables, chain, wire and nets were dumped across a wide area after the boom was dismantled, contrary to historical accounts.[149] Although only a selection of side scan sonar and multi-beam sonar images were made available, this may be the case.[150] The spread of cables and wires could possibly being due to vessels drifting with the tide and wind when this structure was dismantled.

A cluster of linear debris located in the vicinity of 691738.52 m E 8626903.48 m S (KP 5.25) may well be associated with the original indicator loop installation. It could also be the remains of a plane wreck (see below). The sunken 'buoys' noted in the

[145] **Fugro Survey Pty Ltd, July 2008** Ichthys Gas Field Development: Darwin Harbour – Seabed Features Drawing no. DEV-CEX-DW-0055 and 56
[146] **Fugro Survey Pty Ltd, July 2008** Ichthys Gas Field Development: Darwin Harbour – Sediment Isopachs Drawing no. DEV-CEX-DW-0057 and 58
[147] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008** Volume 1a, 2-36
[148] *Ibid.,* 1a;2-56
[149] *Opp. Cit.*, **Forster, P. 2010**.
[150] *Opp. Cit.,* **Fugro Survey Pty Ltd, August 2008**: Volume 1a; Figure 2-19,20,21

area could be possibly the steel reinforced concrete 'clumps' used to anchor the net buoys.[151]

Six discrete areas of low density debris clusters within Darwin Harbour – other than the debris scatter in the vicinity of the former submarine net - were identified along the route.[152] The report on the survey does not provide images of this debris. No discrete or concentrated patches of debris which may signify the presence of a timber hulled wreck were highlighted for further investigation.

In the October/December 2009 survey along the whole 350 km survey length, 184 magnetic anomalies were identified, of which 67 were determined to be the result of cultural origin (ferrous manufacture). Four of these anomalies - FA165, 170, 172, 177 - were located within Area B.

UXO analysis software was used in an attempt to quantify the mass and burial depth of the cultural object.[153] As the scope of the survey was to determine the presence of UXO, all of these anomalies were assessed to be potential UXO. It is also possible that such anomalies could be associated with plane or ship wrecks.[154]

Side scan images of the seabed in the vicinity of the four magnetic anomalies did not show any features suggesting that these anomalies are buried. The report assessed them to be possible UXO ranging in size from a 250lb bomb to an 81mm (mortar?) round.

A large magnetic anomaly was identified at KP 860.4. It correlated with a circular area of low profile linear features, which was thought to be possibly a scatter of metallic debris.[155] This anomaly is in the vicinity of a similarly described anomaly from the February/March 2008 survey (KP5.25 and see above). It is likely that it is associated with the submarine net and indicator loops; however it appears that although the magnetic anomaly was large it did not appear that all of the material visible in the side scan sonar image provided was ferrous. This introduces the possibility that this is a plane wreck that may also have cables and netting in and around it.

The February 2009 survey examined three known wrecks – the USS *Peary*, USS *Meigs* and the USS *Mauna Loa,* whose positions were already known.[156] These sites are located away from the proposed pipeline route.

The survey of the seabed around Weed Reef, of which only a fraction intersects with Area B, found high relief rock outcropping with sediment filled channels and depressions as well as exposed flat rock. Most of the 20 anomalies identified were referred to as 'sinkers'. These were single objects around 1 m across which may have been the weights for small boat moorings or lost fishing anchors.[157] This area has also been used in the past as a place for the detention of Indonesian fishing vessels, which were apprehended in the Australian Fishing Zone.[158] The report on this survey provided only selected side scan sonar images of wrecks or presumed wrecks as well as examples of 'sinkers'.

An anomaly (SC03) located at 695692.0E, 8620238.0N was identified as a wreck. The 21.5 x 3.5 x 2 m sized low relief object appears to be a lozenge shaped and

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151 *Ibid.,* Volume 1a; Figure 2-21
152 *Ibid.,*Volume 1a; Figure 2-7
153 *Opp. Cit.,* **Fugro Survey Pty Ltd March 2010**:4
154 *Opp. Cit.,* **Fugro Survey Pty Ltd March 2010**
155 *Ibid.,*27 and Figure 3.3
156 *Opp. Cit.,* **EGS, April 2009 2009**:19
157 *Ibid.,*25
158 **Hamish Mounteney**, Senior Surveyor/INPEX *pers. comm*. email 06/01/2011

coherent structure. This could be one of three steel hulled vessels – *Ham Luong*, *John Holland Barge*, and *Song Saigon* - sunk deliberately in the early 1980s to create an artificial reef.[159] This site is located approximately 100 m from the centre line of the proposed pipeline route.

Another anomaly, SCO4, identified as a wreck, is located 160 m from the centerline of the proposed pipeline route. It is a high relief intact structure 34 m long and is most likely one of the 3 vessels mentioned above.

The seismic refraction survey did not identify any buried cultural objects and the data may have been too coarse for the purposes of searching for the buried remains of a timber wreck. The data was presented as a digitised interpretation of seabed stratigraphy. No raw data was made available.

Area C

The survey identified two objects on a featureless sandy seabed, both of which were less than 1 m across.[160] Given the size and low frequency of such objects clustered together, they are not part of a shipwreck.

5.2 Diver based assessment

In late 2008 a dive team whose members have excellent knowledge of Darwin Harbour inspected a number of anomalies, which had been identified as being wrecks or obstructions by the February/March 2008 survey.[161] For the most part the dive inspection confirmed the identity of a number of known wrecks. The inspection did identify however a new wreck site, that of one of the USAAF Catalinas that had been sunk during the first airstrike on Darwin.

A number of other anomalies identified as possible wrecks and obstructions were found to be moorings or natural features. One anomaly – site 12 - was a 3.3 x 2.6 x 1.1 m rectangular container with a circular hole at one end.[162] It was assessed to be of steel but the apparent solidity of the object is suggestive of iron. It is possible that this was a ship's water tank. It is likely to have been discarded there deliberately however this may be the only high relief object associated with a timber wreck. It is unclear from the information provided in the report as to whether the divers inspected the surrounding seabed sufficiently to ensure that this was not the site of a shipwreck.

Throughout 2010 the same dive team inspected 22 anomalies identified in the 2009 magnetometer and side scan survey of Area B, as well as 6 cable crossing sites and two transects along the centre line of the proposed pipeline route.[163] The anomalies examined were magnetic in nature and were located at the entrance to Darwin Harbour within 2 km on either side of the alignment of the former WWII submarine net.[164]

The objective of the inspections was to eliminate the possibility that the magnetic anomalies were unexploded ordnance as well as to identify the nature of one very large anomaly close to the pipeline route recommended in the 2009 report on the

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[159] **NT Fish Finder (nd)** Map of Darwin Harbour (portion of publication held by author)
[160] *Opp. Cit.,* **EGS, April 2009**:19
[161] **Tek Ventures, 2008** *Darwin Harbour Site Survey.*
[162] *Opp. Cit.,* **Tek Ventures, 2008:**13
[163] **Tek Ventures, 2010** *INPEX UXO Survey Contact Identification by Divers 2010*:4
[164] *Ibid.,* Figure 2

magnetometer survey for further investigation.[165] The objective of the transect surveys – of which there appears to have been four - were to perform diver-held magnetometer searches for potential UXO.[166] The first two sets of transects, 1000 m and 800 m in length, were located 100 m parallel and to the west of the existing ConocoPhillips gas pipeline towards the southern end of the proposed pipeline route, adjacent to Weed Reef.[167] The second set was laid out in the vicinity of the former alignment of the submarine net and were 2,200 and 1,500 m respectively.[168]

The process of identifying the magnetic anomalies on the seabed followed standard search procedures, used a hand-held magnetometer and was very methodical.[169] Observed objects were raised if they were confidently identified as not being potential UXO. The objective of raising the object was to obtain photographs and to measure its weight.

For the transects, the seabed up to a distance of the 10 m from the centre line was scanned by two divers using a hand-held magnetometer. Regardless of whether anything was found, the diver recorded the type of seabed encountered and other details such as diver and probe depth, if carried out.[170]

The inspections of the anomalies for the most part identified a number of cultural items such as the remains of an electric fan, cables, a motor vehicle engine, a railing and iron drums.[171] The large anomaly to the north of the former alignment of the submarine net is a tangle of cables and sunken (at least 6) mooring buoys. The two transects surveys north (690742E 8627932N to 692238E 8625989N) and south (692607E 8625516N to 693527E 8624332N) of the alignment of the former submarine net identified modern cultural material including small anchors, UXO, cables and mooring blocks associated with the submarine net.[172] Based on the descriptions of the finds there appears that no obvious remains of a plane or shipwreck were found.

The remains of the WWII submarine net and indicator loop are of cultural significance in that they can provide information on these defence systems that may not be available from the surviving historical record. Also of interest is the length of insulated copper and steel cable observed in the vicinity of 692023E 8626266N.[173] As noted in **Section 2.5** the first undersea telegraph cable to Darwin most likely ran northwards to the east of the proposed pipeline route. It is more likely that the cable described is part of the WWII Indicator Loop structure.

The observation by the divers that a rock mound approximately 20 m in length present on the seabed may have been '…*spilled over the side of a large vessel"* is of interest.[174] It would appear that a ballast mound has been described. It is difficult to see why the rock would have been dumped in this area. The location of this feature, 691870E 8626463N, at the entrance to Darwin Harbour is an unusual location for a ballast mound – a ballast mound being defined as a pile of rock and/or metal deliberately discarded by a vessel before taking on cargo. The maximum size of the rocks, 2 m, is also unusual for rock ballast, the rocks often being just large enough to

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[165] *Ibid.,* 7 and *Opp. Cit.,* **Fugro Survey Pty Ltd March 2010**: 27 and Figure 3.3
[166] *Ibid.,* 7 In reviewing the report it is initially unclear as to how many dive transects were carried out. The coordinates for the Stage 1 surveys appear the same as those traversed in Stage 2 of the survey programme (page 7) while Tables 2 and 3 show coordinates for four separate transects.
[167] *Ibid.,* Figure 3
[168] *Ibid.,* Tables 2 and 3
[169] *Ibid.,* 17
[170] *Ibid.,* 18
[171] *Ibid.,* Table 5
[172] *Ibid.,* Tables 6 and 7
[173] *Ibid.,* 26
[174] *Ibid.,* 26 and Table 6

be handled by an individual. It is possible that the larger rocks form part of the natural seabed in this area. An alternative explanation is that the concentration of smaller rocks are the exposed remains of a timber wreck, which was in ballast. It would be expected that other objects in amongst the rock would have provided clearer evidence that this may be a wreck site. However given the objectives of the dive survey it is likely that this feature was not investigated to the level required to determine whether it is a shipwreck.

The two additional transects east of Weed Reef – 697536.71E 8617577.43N to 697965.81E 8616674.25N and 696317.61E 8620208.74N to 696653.91E 8619482.86N – reported a limited number of modern materials on the seabed, such as steel cable, a car battery, a metal fish trap and a pressure cylinder.[175] An amber bottle dated to 1940 was also observed.

[175] *Ibid.,* 88

6.0 Gap analysis

6.1 Identification

Area A

There is a possibility that one or more timber hulled shipwrecks may be located within this area. Such wrecks located within the predominantly sandy seabed in the southern portion could be relatively well preserved.

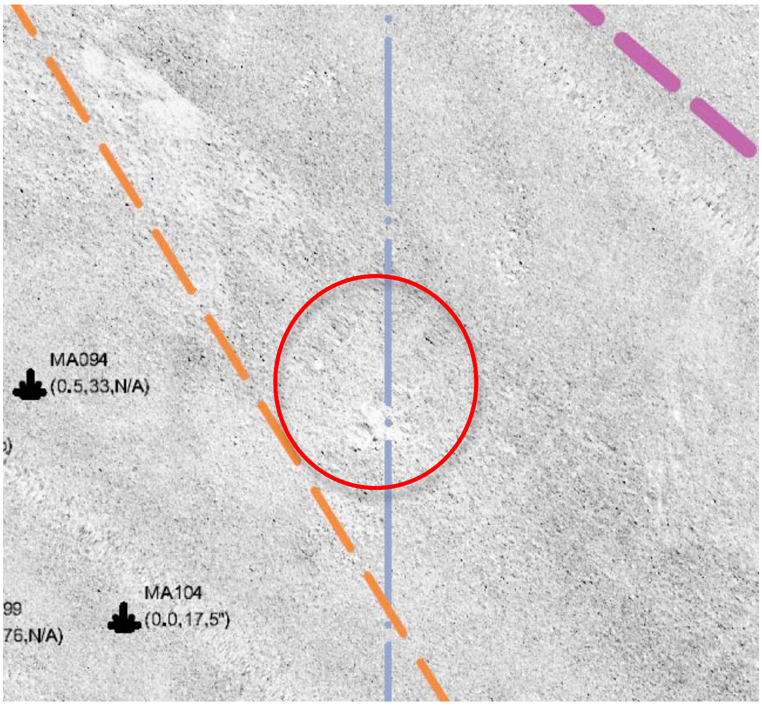
The side scan sonar used in this area was the optimum tool for the detection of small anomalies that may be cultural in origin and associated with a timber hulled shipwreck. The northern portion of Area A has expanses of exposed sandstone pavement with veneers of sand and gravel, which reduces the effectiveness of side scan sonar. In this environment a magnetometer should take primacy. The deployment of a magnetometer in tandem with the side scan sonar in the November/December 2010 survey within this area increased the likelihood that the remains associated with a timber hulled vessel may have been detected. A magnetometer survey has not been conducted for the eastern portion of the proposed primary dredge area, and for the smaller secondary area on the eastern side of Blaydin Point.

Raw side scan data was not made available for this review, though a .tiff mosaic and pdf charts of the November/December 2010 survey were provided. This information was useful for obtaining an overall picture of the seabed in the western portion of the proposed primary dredge area. This area has extensive areas of rock outcropping, particularly around Walker Shoal. The seabed for the most part appears to be composed of coarse sand, or a veneer of finer grained sand over rock rubble and pavement. This morphology can make it difficult to distinguish between what is exposed rock or rubble and the low remains of a small tonnage timber wreck.

Upon review of the pdf charts a number of seabed features – in addition to those sonar contacts identified in the November/December 2010 survey report have been noted as possibly being cultural in origin and possibly associated with a shipwreck. These 5 anomalies are presented in Table 6 below. The exact positions of these potential cultural anomalies are not presented due to the potential for error by scaling from the .pdf charts provided. If these anomalies are further investigated accurate positions should be obtained.

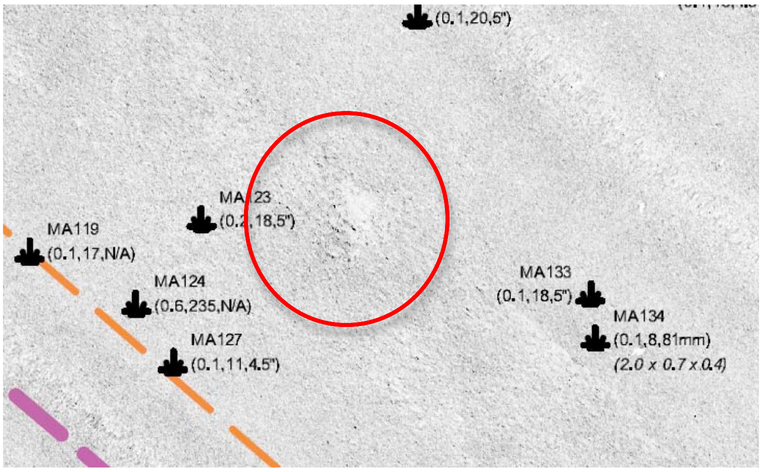
MH 01

Description: Appears to be a possible discrete patch of debris of low relief, approximately 50 m east of MA094.



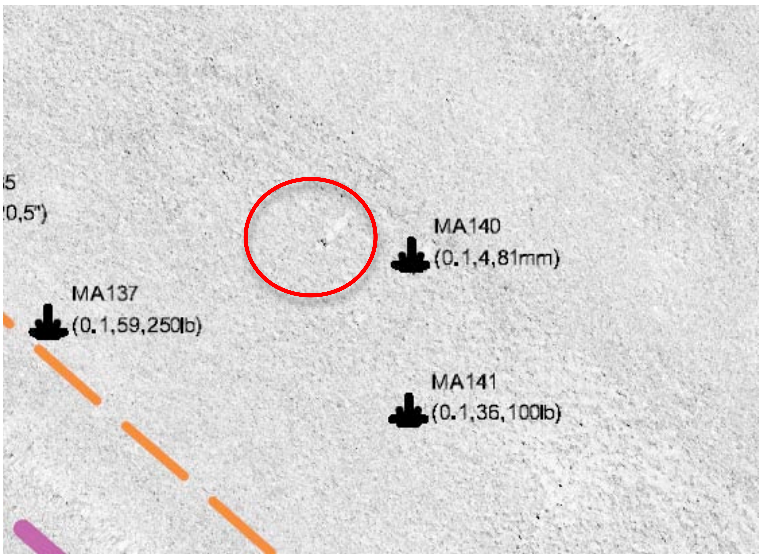
MH 02

Description: Appears to be a possible discrete patch of debris of low relief, approximately 25 m east of MA123.



MH 03

Description: Single small high relief object approximately 15 m west of MA140. Most likely cultural in origin and could be part of what appears to be scattered debris around MA140 or a mooring.



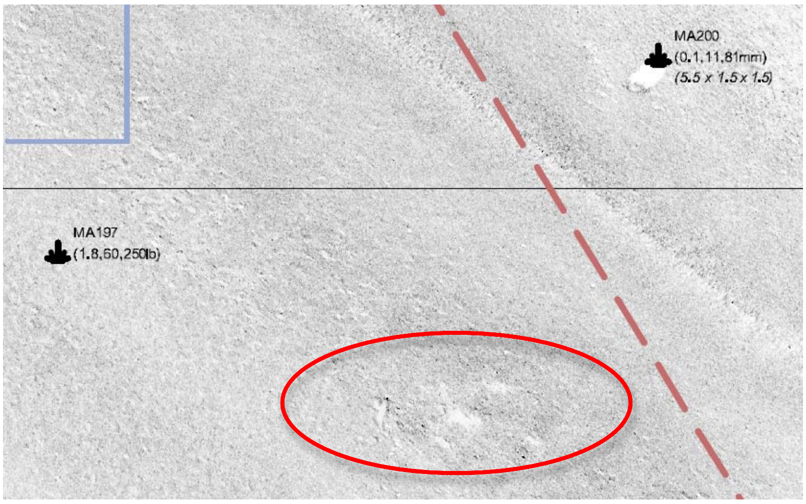
MH 04 **Description:** Appears to be a scatter of low relief debris over 20 m in length to the east of MA191.	
MH 05 **Description:** Appears to be a cluster of low relief debris over 25 m across approximately 50 m to the south - east of MA191.	

Table 6 ***Potential cultural anomalies within western portion of proposed dredging envelope.*** (from **Neptune Geomatics Pty Ltd, January 2011**: L380-DU-DTL-0006.001_1 to .004_1).

In addition, the 2 non-ferrous sonar targets identified in the November/December 2010 survey should also be considered to have potential cultural heritage significance and therefore be inspected:

Target ID	Easting	Northing	SSS contact
SC218	704786.0	8617050.0	3.0 x 1.1 x 1.5 m
SC219	704810.0	8617086.0	2.8 x 1.2 x 1.0 m

Table 7 – Non-ferrous sonar contacts within western portion of proposed dredging envelope.
(from **Neptune Geomatics Pty Ltd, January 2011**: Table 3-1).

A number of sonar targets plotted on charts of the 2008 survey showing seabed features are located in the vicinity of the currently proposed dredge envelope. Those that were not re-identified in the November/December 2010 survey or were from the eastern portion of the proposed primary dredge area are presented in Table 8. In the absence of raw side scan sonar data these targets should be inspected by divers.

Description	Eastings	Northings
SC 1.6 x 1.7 x 0.3 m	704121.917	8618086.615
SC 3.0 x 2.5 x 0.5 m	704120.291	8617704.514
SC 4.0 x 2.2 m	705128.639	8617416.906
SC 6.8 x 3.0 x 0.6 m SC 6.3 x 3.5 x 1.4 m SC 1.3 x 1.1 x 0.8 m (positions to be confirmed)	705270.333	8616547.526

Table 8 - Sonar contacts in vicinity of proposed dredging envelope.
(Derived from **Fugro Survey. July 2008**: Seabed Features Drawing no. DEV-CEX-DW-0055).

The information provided by G-Tek is also of high value for battlefield historians and archaeologists. Some figures provided in the report assessing the extent and frequency of UXO do not appear correctly.[176] It may be the way the figure was processed in the .pdf.

Area B

In this area it is possible that a plane wreck can be present. It is less likely that a shipwreck will be present, although there is a slightly greater chance of such a site being located on the west side of Wickham Point. It is noted that although the objective of the surveys undertaken were to determine the presence of UXO; the techniques used were more than adequate for the detection of possible ship or plane wrecks.

There were areas however within Area B where there is background noise due to the presence of maghaemite rich laterite near the surface, thereby nullifying the efficacy of the magnetometer survey in identifying cultural objects with ferrous content. Sites located in such areas where the seabed is also irregular would be difficult to identify using side scan sonar and/or multi-beam. Sub-bottom profiling would also be ineffective.

The side scan sonar/magnetometer surveys conducted in this area focused mainly on the magnetic anomalies. In the charts provided with the report, the side scan sonar resolution has been reduced but is acceptable. It is noted that these pdf charts contain overlapping side scan sonar images, which are briefly visible when the screen refreshes. Images of the same anomaly taken from different angles are often helpful in determining whether further investigation is required. The following side scan sonar derived anomalies (Table 9) have little ferrous content or are too large to be considered UXO, and were not examined by the 2010 dive survey:

[176] **G-tek Australia. 2010.** *Addendum to G-Tek Australia Pty Ltd Post Activity Report: Unexplained ordnance assessment: Darwin and Northern Australia exercise area*. : Image 9

Description	KP	Reference
High relief linear objects. Could be steep sandwaves or cultural objects.	865.15	B280-DV-ALI-0083.001_0
High relief rectangular shaped object. Has apparent low ferrous content. May be natural exposed ridge of rock or wreck hull. In vicinity of three artificial reefs (shipwrecks).	868.0	B280-DV-ALI-0084.001_0

Table 9 - Side scan sonar anomalies of potential cultural heritage within proposed pipeline corridor.

As with Area A, the figures provided in the G-Tek report assessing the extent and frequency of UXO do not appear correctly.

Area C

The remote sensing techniques employed were sufficient for the predicted cultural heritage and the type of seabed encountered.

6.2 Assessment

Area A

The remote sensing survey undertaken in this area in 2008 was tasked to identify wreck sites. The reporting on the conduct of the survey does not discuss the parameters or criteria for what anomalies qualified as potential wreck sites. No background research as to what type of wrecks, or other forms of submerged cultural sites, may be present and how they may appear on the seabed was provided. It would appear from the findings that larger metallic hulled structures were identified, though some smaller anomalies, which were natural features, were also listed as potential wreck sites. There did not seem to be an awareness that smaller (< 100 tons) timber hulled vessels, with or without high ferrous content, could be present.

With regards to the 2010 remote sensing survey the focus was on identifying cultural objects but only within the context of them being UXO. Special care was taken to equate the magnitude of the magnetic signal with a type of munitions. The 147 magnetic anomalies in the western portion of the proposed primary dredge area assessed to be potential UXO, especially those 21 which registered also as sonar contacts, are potentially the remains of a shipwreck(s). As noted in **Section 5.1** magnetic anomalies detected as being in excess of 200 kg were not expected to be individual munitions and were interpreted in some cases as being natural. Anomalies of such size may however be a substantial section of a marine engine, a winch/capstan, pile of chain, or an anchor of reasonable size, all associated with a timber hulled shipwreck. However it is almost certain that such objects would also register as a sonar contact given that a substantial part of the seabed in the western portion of the proposed primary dredge area is rock pavement with relatively thin sand cover.

The diving inspections carried out were informative and well described, however one site - site 12 - did not appear to be fully assessed as to whether it formed part of a shipwreck.

Area B

As the objective of the remote sensing surveys were to determine the presence of UXO, the assessment of the nature of cultural anomalies detected was viewed as being a possible UXO. So much so that special software was used to determine the size and therefore possible munitions type of the anomaly. Apart from some speculation of the nature of a large anomaly at KP 860.4 – being associated with the WWII submarine net – there was no consideration as to whether these cultural anomalies could be associated with ship or plane wrecks.[177] In addition, seabed anomalies which appeared on the side scan sonar but did not register on the magnetometer were not assessed. The information presented in the reports was sufficient except for an adequate review for anomalies which may be potential cultural heritage. A list of these anomalies is presented previously in Table 8 in **Section 6.1**.

The diving inspections of the magnetic anomalies thought to be potential UXO were carried out to a high standard, as were the transects. Though there is confidence in the divers ability to identify any obvious signs of a shipwreck, the objective of the survey was to locate UXOs and so unusual features were not further investigated. The 20 m rock mound at 691870E 8626463N is a case in point, where it was suspected that it had originated from a vessel. No further investigation took place so to provide a better idea of its nature and whether it was – or wasn't – the exposed remains of a timber wreck site.

Furthermore, detailed information on vessel fittings such as 'old anchors' discovered on the seabed was not provided, presumably because the divers had assessed them to be relatively recent and of little cultural significance. While it is accepted for this report that the anchors are recent, divers who are not trained maritime archaeologists should not be making assessments on the cultural significance of objects found during surveys.

Area C

The anomalies identified in this area appear to have been correctly identified.

[177] *Opp. Cit.,* **Fugro Survey Pty Ltd March 2010**:29

7.0 Conclusion

7.1 Summary of findings

Based on the information and observations presented in this report the findings are summarised as follows:

1. Over 70 vessels are known to have been lost in Darwin Harbour;
2. The precise locations of 10 shipwreck sites are known to NRETAS;
3. During the 1897 cyclone 18 pearling luggers and other craft were wrecked after having been blown southwards from Frances Bay, with some ending up in the mangroves in the southern part of Darwin Harbour;
4. One or more timber hulled sailing vessels of small (< 100) tonnage may be present within Areas A and B;
5. Up to 25 planes were lost in Darwin Harbour during WWII, with 5 having been located;
6. Up to 10 planes were lost in the sea north and west of Darwin.
7. It is very unlikely that an as yet unlocated plane wreck is present within Area A though it is possible that a plane wreck is located within Area B;
8. Cables and nets associated with WWII are located within Area B, moorings in Area A, munitions in A and B, while the likelihood of ballast mounds being present in either area is low;
9. The wrecks of smaller timber hulled vessels if located on sandy seabed may have become partially buried with frames and in-organic components protruding from the seabed – giving the appearance of a concentration of low relief debris. The majority of wrecked vessels would have some ferrous content of varying magnitudes;
10. The cultural heritage significance of these sites will vary according to their level of preservation;
11. Shipwrecks older than 75 years located in Darwin Harbour are considered to be protected under the Commonwealth *Historic Shipwrecks Act 1976* and it is an offence to disturb such sites without a permit;
12. The optimum remote sensing technologies for locating the identified submerged cultural heritage within the study areas are side scan sonar and magnetometer for Areas A and B, with side scan sonar being sufficient for Area C;
13. A magnetometer survey has not been conducted for the eastern portion of the proposed primary dredge envelope and the secondary area on the eastern side of Blaydin Point in Area A;
14. A combination of irregular seabed with maghaemite-rich laterites throughout portions of Areas A and B severely compromises the ability

of side scan sonar and magnetometer to identify signs of potential low relief remains of timber hulled sites;

15. Remote sensing surveys to date in Area A located the remains of a number of wrecks which are relatively large, metallic and have high profiles;
16. The remote sensing survey reports do not appear to have assessed the acquired data for the presence of low profile timber hulled shipwreck sites;
17. Remains of the WWII submarine net at the entrance to Darwin Harbour has been identified by divers working for INPEX;
18. The data provided in association with the remote sensing survey reports were assessed as best as possible, with some additional anomalies being identified for further investigation, and;
19. Side scan sonar data from eastern portion of Area A was unavailable for review.

Based on the above findings it has been assessed that the remote sensing data obtained for the development of the nearshore facilities in Darwin Harbour was of a high quality for the detection of the identified submerged cultural heritage. The surveys undertaken in Areas B and C were the optimum given the seabed topography and composition. A magnetometer survey within the remainder of the proposed dredge locations in Area A would be an important measure for the detection of shipwrecks.

In most cases the data was not interrogated adequately for the presence of timber hulled sailing vessels, which would present as low relief debris clusters on the seabed. Reviewing most of the data collected to date has mitigated this. This has resulted in some additional anomalies of potential cultural significance being identified. However the side scan sonar data from the eastern portion of the proposed primary and the secondary dredge envelopes within Area A was not available for review. It is possible that one or more wrecks associated with the 1897 cyclone may be present within these locations.

7.2 Recommendations

The following recommendations relate to the augmentation of existing data for the purposes of delivering best practice in the detection and assessment of the submerged cultural heritage that may be impacted by the proposed seabed development during the EIS phase.

Recommendation 1 *Review side scan sonar data from the eastern portion of the main proposed dredge area and the smaller segment proposed on the eastern side of Blaydin Point in Area A*

A maritime archaeologist should carry out this review.

Recommendation 2 Undertake magnetometer survey in eastern portion of the proposed primary dredge area and the secondary dredge area on the eastern side of Blaydin Point, within Area A.

A maritime archaeologist should be consulted about the parameters of the survey and review the results.

Recommendation 3 Diving inspection of anomalies identified in this review.

The dive inspection should be carried out under instructions provided by a maritime archaeologist, with the archaeologist reviewing and assessing the significance of the finds. For selected anomalies an appropriately qualified maritime archaeologist should participate in the diving and/or being on site to direct divers. The diving inspection would examine the:

- Twenty three sonar contacts– both ferrous and non-ferrous – identified in the 2010 remote sensing survey of the western portion of Area A;
- Five seabed anomalies of potential cultural significance in the western portion of the primary dredge location within Area A identified through the review of side scan sonar data collected in 2010 (Table 6);
- Sonar contacts identified in the 2008 remote sensing survey of Area A (Table 7);
- Large rectangular iron/steel box in Area A identified by divers in 2008 (site 12);
- Side scan sonar anomalies in Area B not inspected by divers (Table 9), and;
- Rubble mound at 691870E 8626463N in Area B identified by divers in 2010.

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Annex 1 Known shipwrecks in Darwin Harbour

Name	Type	Hull	Tonnage	Date Lost	How Lost	Location
Gulnare	Schooner			1872	Filled with stones to make jetty	Near Fort Hill
Hibernia	Ketch		13	1882		Darwin Harbour
S.F. Hersey				16/12/1886		Darwin Harbour
Bear Sing				1886	Foundered	Darwin Harbour
Margaret				1888		Darwin Harbour
Ellengowan[178]	**Single screw steamer**	**Iron**	**37**	**27/04/1888**	**Sank at moorings**	**Channel Island**
Chinese fishing boat				31/08/1888		Darwin Harbour
Flying Cloud	Cutter	Timber	28	1894	Wrecked in storm	Darwin Harbour - Frances Bay
Florence	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Mumelhaba	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Nebraska	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Gertrude	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Jack	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Sapphire	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Scout	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Olive	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Revenge	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Roebuck	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Zulieka	Steam launch			6/01/1897	Cyclone	Darwin Harbour
Ark	Pearling lugger/cutter			6/01/1897	Cyclone	Darwin Harbour
Black Jack	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Brisbane	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Cleopatra	Pearling lugger			6/01/1897	Cyclone	Darwin Harbour
Warrill	Steam launch			6/01/1897	Cyclone	Darwin Harbour
Maggie	Steam launch			6/01/1897	Cyclone	Darwin Harbour
Sampans x 3				6/01/1897	Cyclone	Darwin Harbour
Flowerdale				20/05/1899	Stranded	Darwin Harbour
Midge				1907	Stranded	Darwin Harbour
Africa				1915		Darwin Harbour
Leichhardt				1915	Stranded - caught fire	Darwin Harbour
Spray				1915	Cyclone	Darwin Harbour
Cameo				8/03/19	Foundered	Darwin Harbour
Rachel Cohen	Barquentine	Timber	150	16/01/24	Caught fire and sank	Darwin Harbour - Frances Bay
Olga		Timber		31/08/26	Stranded	Darwin Harbour
Huddersfield***	**Schooner**	**Timber**	**174**	**6/12/1928**		**Darwin Harbour**
Coral				1932	Broken up	Darwin Harbour
Harbour Tug				1942	Foundered	Darwin Harbour
SS *British Motorist*	**Steamship**	**Steel**	**4088**	**19/02/42**	**Bombed by Japanese air raid**	**Darwin Harbour**
Kelat	**Sailing Ship**	**Iron**	**1822**	**19/02/42**	**Bombed by Japanese air raid**	**East Arm**
SS *Mauna Loa*	**Twin screw steamer**		**3405**	**19/02/42**	**Bombed by Japanese air raid**	**Darwin Harbour**

[178] Wrecks in **bold** are those whose exact locations are known to the NRETAS
* Listed on the NHSDB as 'DH Unidentified Wreck 1'

USAT *Meigs*	**Twin screw steamer**	**Steel**	**6491**	**19/02/42**	**Bombed by Japanese air raid**	**Darwin Harbour**
SS *Neptuna*	**Twin screw steamer**	**Steel**	**3607**	**19/02/42**	**Bombed by Japanese air raid**	**Darwin Harbour**
USS *Peary*	**Twin screw steamer**	**Steel**	**1190**	**19/02/42**	**Bombed by Japanese air raid**	**Darwin Harbour**
SS *Zealandia*	**Twin screw steamer**	**Steel**	**3482**	**19/02/42**	**Bombed by Japanese air raid**	**Darwin Harbour**
Lighter No.2			86	1943	Lost by enemy action	Darwin Harbour
Dawn				12/04/43	Blown ashore in gale	Darwin Harbour
Yampi Lass	Sailing vessel - lugger	Timber		12/04/43	Blown ashore in gale	Darwin Harbour
East Arm Barge 2				1945		East Arm
East Arm Two Part Barge	Barge			1945		East Arm
Charles Todd	Motor vessel	Timber		24/12/74	Cyclone Tracy	Darwin Harbour - Iron Ore Wharf
Chinta	Yacht			24/12/74	Cyclone Tracy	Darwin Harbour - Stokes Hill Wharf
Edwina May		Steel		24/12/74	Cyclone Tracy	Darwin Harbour - Stokes Hill Wharf
Darwin Princess		**Steel**		**24/12/74**	**Cyclone Tracy**	**Darwin Harbour**
Nimrod	Yacht	Timber		24/12/74	Cyclone Tracy	Darwin Harbour - Stokes Hill Wharf
Rasta				24/12/74	Cyclone Tracy	Darwin Harbour
Jenny Wright		Steel		24/12/74	Cyclone Tracy	Darwin Harbour - Iron Ore Wharf
Arnhem T				25/12/74	Cyclone Tracy	Darwin Harbour - Frances Bay
Scallywag				25/12/74	Cyclone Tracy	Darwin Harbour
Betty Joan		Timber		25/12/74	Cyclone Tracy	Darwin Harbour - Frances Bay
Blue Bird		**Steel**	**130**	**25/12/74**	**Cyclone Tracy**	**Darwin Harbour - Iron Ore Wharf**
Carina				25/12/74	Cyclone Tracy	Darwin Harbour - Stokes Hill Wharf
Booya	**Schooner**	**Steel**	**188**	**25/12/74**	**Cyclone Tracy**	**Darwin Harbour**
Vietnamese Refugee Boat 1				1976	Stranded	East Arm
Vietnamese Refugee Boat 2				1976	Stranded	East Arm
Con Dao 3		Timber		19/05/78	Scuttled by Vietnamese crew	East Arm
John Holland Barge	Barge	Steel		1982	Sunk to form artificial reef	Middle of Darwin Harbour
Song Saigon	Motor vessel	Steel		1982	Scuttled to form artificial reef	Middle of Darwin Harbour
Ham Luong		Steel		1983	Scuttled	Middle of Darwin Harbour
DH Unidentified Wreck 2						Darwin Harbour
Landing barge	Barge					Darwin Harbour
Vietnamese Refugee Boat		Timber				East Arm
Yu Han 22		Timber			Scuttled	Weed Reef