# DOUGLAS SHOAL REMEDIATION PROJECT

## Visual Surveys Field Report

June 2019

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Comments and enquiries about this document are welcomed and should be addressed to:

Australian Government
Great Barrier Reef Marine Park Authority

Great Barrier Reef Marine Park Authority
Director of Reef Interventions
280 Flinders Street
(PO Box 1379)
Townsville QLD 4810, Australia

Phone: (07) 4750 0700
Email: info@gbrmpa.gov.au
www.gbrmpa.gov.au

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# Visual Survey Field Report

## Douglas Shoal Remediation Project

Great Barrier Reef Marine Park Authority

**20 June 2019**


Advisian

**Level 31, 12 Creek Street**
**Brisbane Qld 4000**
**Australia**

**advisian**.com

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***Publication note: Appendices not publically released***

# 1 Background

The bulk carrier 'Shen Neng 1' ran aground on Douglas Shoal in April 2010 and remained on the reef for 10-days before being re-floated. The total area directly impacted was approximately 42 ha which makes this incident the largest ship grounding scar known in the Great Barrier Reef Marine Park, and possibly the largest reef-related direct shipping impact in the world. The Great Barrier Reef Marine Park Authority (GBRMPA) established the Douglas Shoal Remediation Project (the Project) in late 2016 with funds from a court settlement associated with the grounding incident.

The Project has as its primary desired outcome that remediation activities support natural recovery at Douglas Shoal.

GBRMPA has identified three key concerns for the ongoing natural recovery in the grounding footprint at Douglas Shoal:

- Antifouling paint (AFP) – previous estimates are that up to 20 tonnes of AFP may have been scraped from the vessel and left on Douglas Shoal as large and small flakes of paint
- Rubble – significant amounts of rubble of various sizes were generated across the impact area by the vessel grounding
- Compaction – the previously complex topography of the site was 'ground down' to a relatively flat topography by the vessel.

Findings from studies undertaken at Douglas Shoal since the grounding were compiled and summarised in the Douglas Shoal Preliminary Site Assessment Report (Costen et al 2017). The report identified that no data are available for 77% of the grounding footprint and surmised that the distribution of physical damage and contamination is focused at four quite distinct areas, described as areas A, C, E and F. The report indicated that these areas represent priorities for further investigation and possible remediation.

In October 2018, Advisian were awarded a contract to provide Planning and Project Management services to GBRMPA for the Douglas Shoal Remediation Project. The planning services include the conduct of targeted fieldwork at Douglas Shoal within the grounding footprint and surrounds, followed by desktop investigations which will include remediation area delineation and options analysis.

The targeted field work includes two main components:

- Seafloor sediment sampling and subsequent laboratory analysis for both physical and chemical characteristics of sediment within the grounding footprint and surrounding areas
- Visual seafloor surveys to examine the extent of the physical damage and to characterise the benthic structure both inside and outside the grounding footprint.

This Field Report is concerned with describing the visual seafloor survey fieldwork. The fieldwork included sonar (Multibeam Echo Sounding (MBES) and Sub Bottom Profiling (SBP)), drop camera and Towed Underwater Video (TUV) survey.

## 1.1 Objectives

The objectives of the visual survey fieldwork were to:

- Address critical knowledge gaps regarding seafloor substrate including substrate type and evidence of physical damage
- Support finalisation of the priority remediation areas and establishment of remediation objectives
- Support establishment of a Monitoring, Evaluation, Reporting and Improvement (MERI) framework for the Project including through development of a georeferenced system to support future fieldwork and remediation management activities
- Facilitate knowledge capture in a systematic manner such that it may be shared and inform other remediation efforts.

## 1.2 Scope

Fieldwork was carried out in accordance with the approved Sampling and Analysis Plan (SAP) (Advisian, 2019). Minor variations to the SAP occurred during the planning and the execution of the field work. These were based on technical considerations, along with logistical and health and safety learnings identified through a scouting trip to Douglas Shoal in January 2019 and during the sediment sampling fieldwork in March 2019.

The visual survey field work was executed over two separate field trips, which were carried out over a two-week period:

1. MBES, SBP and drop camera survey
2. TUV and still image capture

This report describes the visual survey field work, is factual in nature and contains limited analysis of data captured in the field.

## 1.3 Report structure

This report has been structured to address the requirements of the contract between GBRMPA and Advisian for the fieldwork reports and includes:

- Daily logs for weather conditions, work tasks and person-hours worked
- Summary of sampling/surveys conducted and their preliminary findings
- Opportunistic observations that may be relevant for the Project
- Implications of the above findings for remediation planning or operational works
- Observations of unique or protected flora and fauna
- Observations on human visitation (commercial fishing, recreational fishing, low-level flights, etc)
- Observations on unusual conditions, such as visible flood plumes, oil slicks, coral spawn
- Evidence of natural recovery or colonisation of damaged/contaminated locations
- Lessons learned, issues or incidents experienced and opportunities for improvement in future
- Preliminary/selected photographs, videos, Geographic Information System (GIS) files or other data collected during fieldwork (relevant to key implications).

# 2 Field trip details

## 2.1 Daily activity

The visual survey field components were conducted within a 15-day period between Sunday 19 May and Sunday 2 June 2019 (including mobilisation and demobilisation). Summary information regarding daily activities is provided in Table 2-1. More detailed information regarding daily activities is provided in Appendix A.

*Table 2-1 Summary of daily activity*

| Day | Date | Weather conditions | Activity |
|---|---|---|---|
| 1 | Sunday 19 May | N/A | Advisian and subcontractors (Acoustic Imaging) mobilise to Gladstone. |
| 2 | Monday 20 May | N/A | Provisioning of the vessel and setting up of acoustic survey gear (MBES and SBP equipment) on vessel. Undertake vessel induction. |
| 3 | Tuesday 21 May | SE winds 15-20kts,1-1.5m swell, squally rain periods | Field trials and calibration of the acoustic survey gear. |
| 4 | Wednesday 22 May | SE winds 15-20kts,1-1.5m swell, squally rain periods | Depart Gladstone at 1000, steam to North West Island arriving at 1530. |
| 5 | Thursday 23 May | SE winds 10-15kts,1-1.5m swell, squally rain periods | Steam to Douglas Shoal at 0600, undertake MBES survey, return to North West Island at 1930. |
| 6 | Friday 24 May | SE winds 10-15kts,1-1.5m swell, squally rain periods | Steam to Douglas Shoal at 0600, undertake SBP survey, return to North West Island at 1730. |
| 7 | Saturday 25 May | SE winds 15-20kts,1-1.5m swell | Steam to Douglas Shoal at 0600, undertake drop camera survey at selected sites. Depart the Shoal at 1300, steam to Gladstone arriving 1830. |
| 8 | Sunday 26 May | N/A | Pack up equipment. Advisian and Acoustic Imaging staff demobilise to base. |
| 9 | Monday 27 May | N/A | Office. |

| Day | Date | Weather conditions | Activity |
|---|---|---|---|
| 10 | Tuesday 28 May | SE winds 10-15kts, <1m swell | Advisian and subcontractor (Geo Oceans) staff mobilise to Gladstone, provisioning of vessel and setting up equipment. Vessel inductions. Steam to North West Island at 2130, arrive North West Island 0230. |
| 11 | Wednesday 29 May | SE winds 10kts, <1m swell | Steam to Douglas Shoal at 0600, undertake TUV surveys, return to North West Island at 1830. |
| 12 | Thursday 30 May | SE winds 10-15kts, <1m swell | Steam to Douglas Shoal at 0600, undertake TUV surveys, return to North West Island at 1830. |
| 13 | Friday 31 May | SE winds 10-30kts, 1-1.5m swell | Depart North West Island at 1330, arrive Gladstone 1900. |
| 14 | Saturday 1 June | N/A | Advisian staff demobilise to base, Geo Oceans staff pack up vessel. |
| 15 | Sunday 2 June | N/A | Geo Oceans staff demobilise to base. |

## 2.2 Vessels and personnel

A single vessel was utilised during the field trips, the 'Wild Blue'. The 'Wild Blue' is a twin-engine 17m long single hull fibreglass vessel equipped with a 5m inflatable dinghy (Figure 2-1). The vessel can support eight persons and is staffed by two crew members (Skipper and General Hand). A host of specialist personnel were present on the field trips as described in Table 2-2 and Appendix B.


*Figure 2-1 The 'Wild Blue'*

*Table 2-2 Personnel and roles*

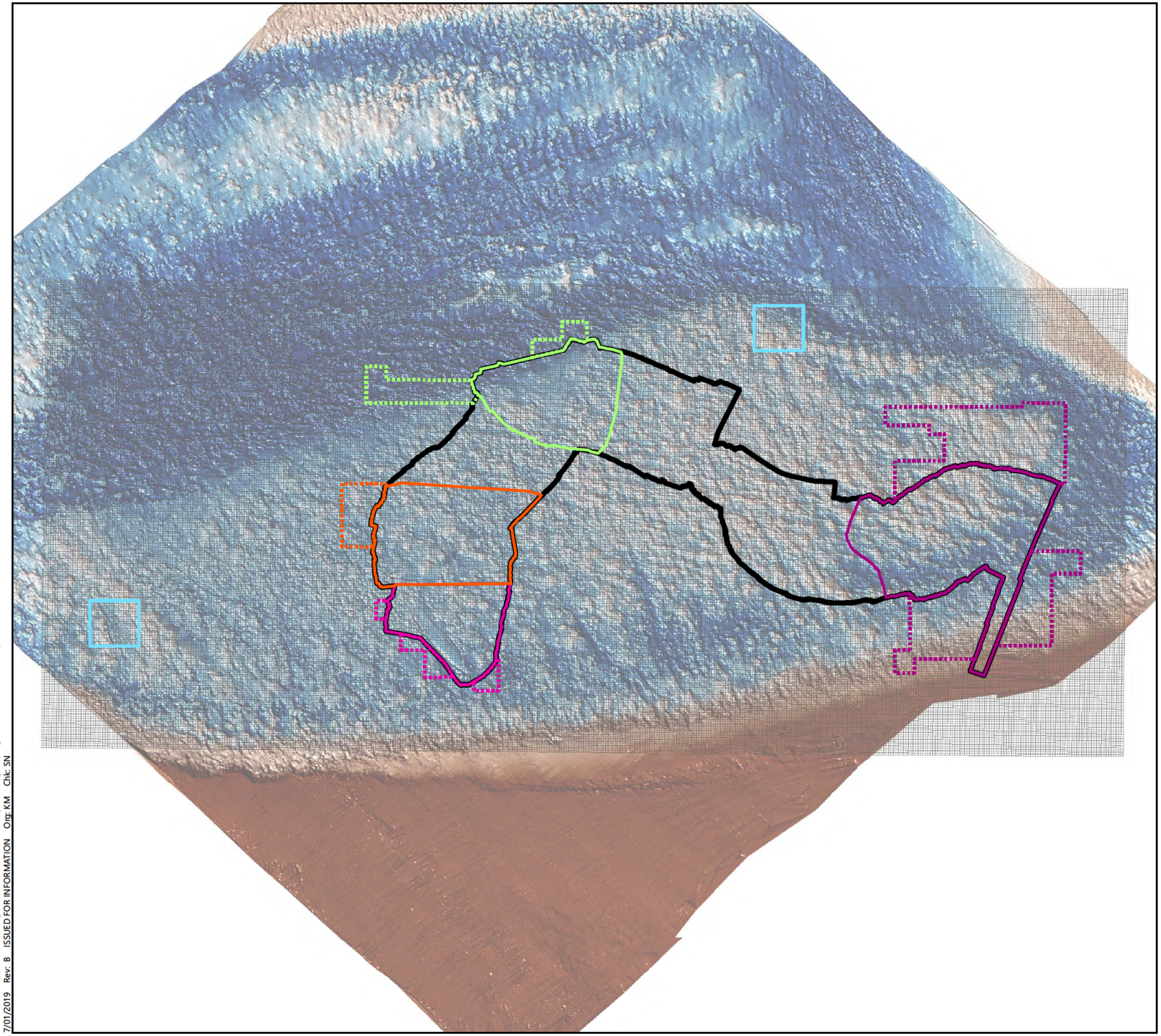
| Role | Company | Participation |
|---|---|---|
| Advisian Field Representative and Field Operations Lead<br><br>Principal Marine Scientist | Advisian | Both trips |
| Skipper | Rob Benn Holdings | Both trips |
| Deck hand | Rob Benn Holdings | Towed Video |
| Skipper | Rob Benn Holdings | Acoustic Surveys |
| Oceanographer | Acoustic Imaging | Acoustic Surveys |
| Geophysicist | Acoustic Imaging | Acoustic Surveys, set up only |
| Towed Video Operator | Geo Oceans | Towed Video |
| Towed Video operator | Geo Oceans | Towed Video |
| General Hand | Gidarjil (Contracted to Geo Oceans) | Towed Video |

## 2.3 Summary of sampling

### 2.3.1 Sonar survey

Typical field operations for the collection of MBES and SBP data are described in the steps set out below and are illustrated in Figure 2-3 to Figure 2-8:

1. During the pre-start meetings the day's activities would be planned and the previous day's 'lessons learnt' communicated.
2. Prior to mobilisation to site all equipment including the satellite positioning system, the MBES and SBP unit, the roll, pitch and yaw correction device (Figure 2-4) were tested and trialled in Gladstone Harbour to ensure all components were functioning correctly.
3. The MBES and SBP units were removed from the mounting pole prior to mobilisation from Gladstone to North West Island so that they would not be damaged in transit.
4. The MBES or SBP unit was attached and secured to the mounting pole and lowered into the water prior to leaving North West Island for Douglas Shoal.
5. The Wild Blue would depart North West Island for Douglas Shoal between 0500 and 0630.
6. Vessels would arrive at Douglas Shoal after 1 to 1.5hrs travel time. During this time the MBES or SBP and the associated GPS positioning system would be checked to ensure all components were operational.
7. The Wild Blue would navigate to the start point as described in the transect plan.
8. A calibration instrument which measures conductivity, temperature, depth and the speed of sound though the water would be lowered into the water and the measurements logged across the water column.
9. The measurements were input to the software package which operates the acoustic imaging process to ensure accurate calibrated data is collected. The speed of sound was measured three times throughout each day at different locations and input to the controlling software.
10. Once the vessel was in position, the sonar surveys would begin:
    a. For the MBES the area encompassing the entire georeferenced virtual seabed area (which includes the grounding footprint and reference areas) (Figure 2-2) was surveyed systematically along predetermined survey lines which allowed for 100% overlap.
    b. For the SBP, the same area covered by the MBES was surveyed but with larger spacing between the transects. In addition, areas identified in previous studies (Negri et al, 2010) and those identified from the preliminary MBES backscatter plot (Figure 2-18) captured on the first day of the surveys were targeted for more closely spaced SBP transects.



# Douglas Shoal Remediation Planning
# Visual Surveys Field Report

## Figure 2-2: Georeferenced virtual seabed 5 x 5m reference grid and sonar survey area

Grounding footprint
5 x 5m reference grid

Bathymetry (Negri et al 2010)
-5m -30m

Priority Area
A
A - outside grounding footprint
C
C - outside grounding footprint
E
E - outside grounding footprint
F
F - outside grounding footprint
Reference areas

Source Information:
Virtual bathymetry, Grounding footprint, Priority areas
Cardno 2017

While every care is taken to ensure the accuracy of this data, WorleyParsons makes no representations or warranties about its accuracy, re iability, completeness or suitability for any particular purpose and disclaims all responsibility and all iability (including without limitation iability in neg igence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



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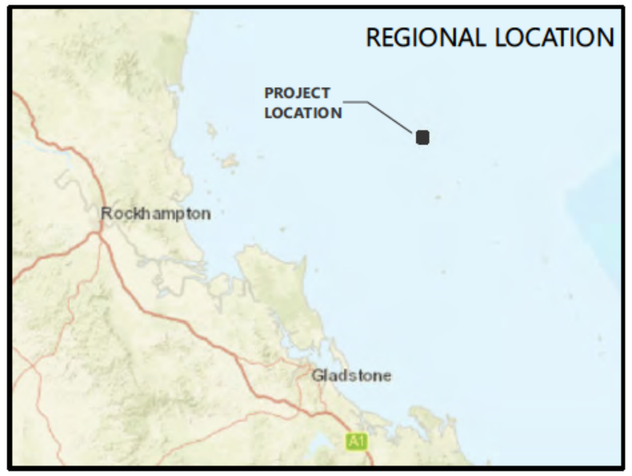


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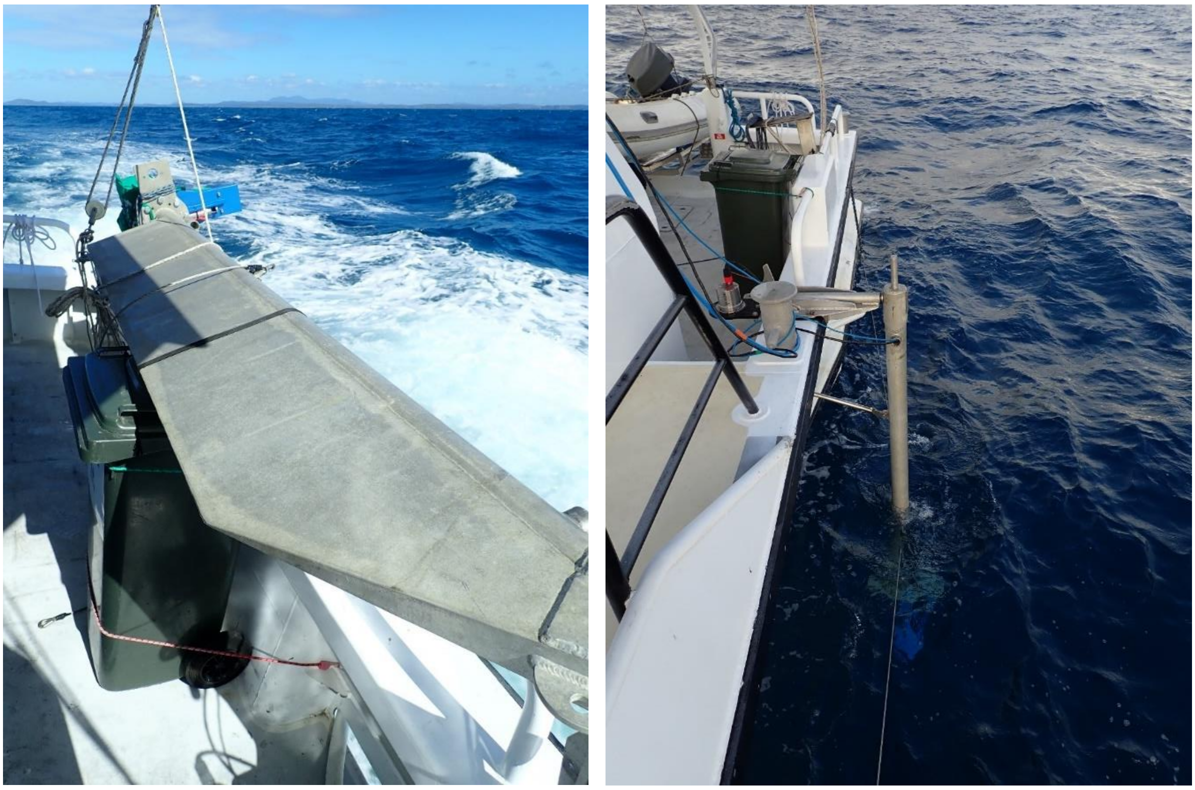

*Figure 2-3 The MBES unit attached to the mounting pole prior to deployment (left) and deployed (right)*


*Figure 2-4 Pitch, roll and yaw measurement device fitted to the mounting pole*

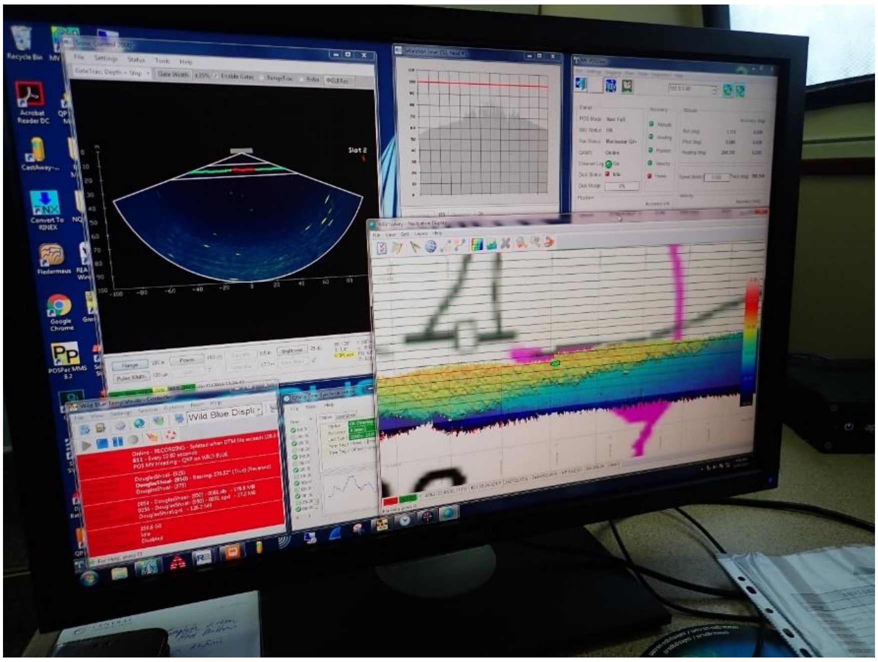

*Figure 2-5 The MBES interface showing extent of the sound beam, quality and initial survey results*

*Figure 2-6 Sub bottom profiler fitted to the end of the mounting pole prior to deployment*

*Figure 2-7 Sub bottom profiler when deployed*

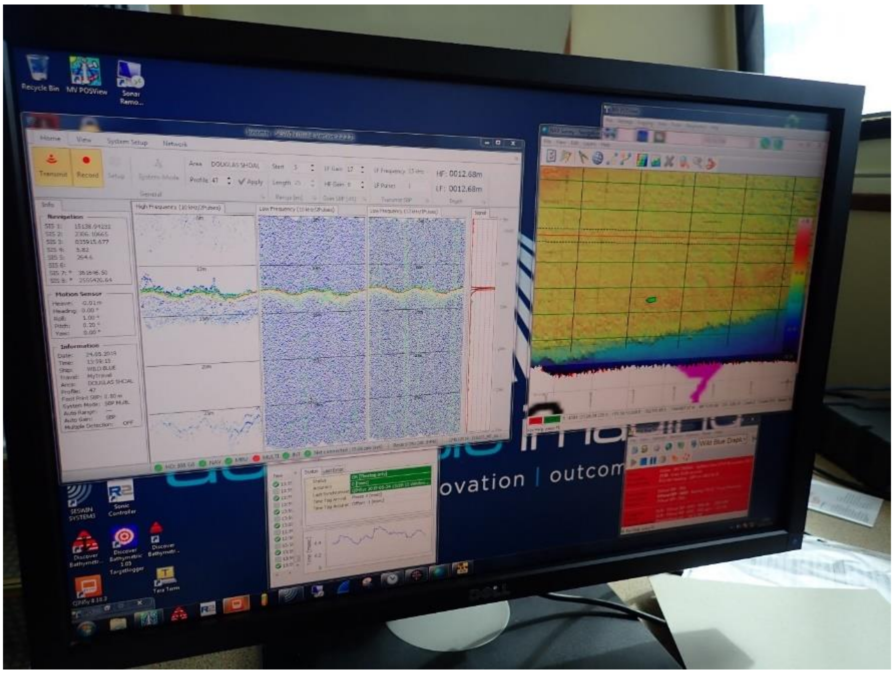

*Figure 2-8 Sub bottom profiler interface showing preliminary results and transect lines overlaid with bathymetry*

### 2.3.2 Drop camera

Ground truthing of flattened areas identified by the MBES survey was undertaken using drop video camera at 20 sites. This enables comparison with the MBES survey results collected during the trip. The drop camera equipment consisted of a GoPro Hero 7 mounted on a solid monopod and attached to a rope capable of supporting 200kg of weight, which was then attached to the vessel (Figure 2-9). Details of the methods used are as follows:

1. The vessel would navigate to the points of interest identified by the MBES.
2. The drop camera would be switched on and an identifier sheet filmed which indicates the date, time and site information.
3. The vessel would come to a stop and the camera would be quickly lowered by hand to within 3m of the seafloor for 30 seconds, then slowly retrieved.
4. The drop camera would be deployed directly beneath and with reference to the vessel's positioning system.
5. Once retrieved, the camera would be downloaded to a laptop and the video checked for quality. The video would be then copied to a backup hard drive.

*Figure 2-9 Drop camera prior to deployment*

### 2.3.3 Towed underwater video

Typical field operations for the collection of TUV data are described in the steps set out below and are illustrated in Figure 2-10 to Figure 2-16

1. During the pre-start meetings the day's activities would be planned and the previous day's 'lessons learnt' communicated.
2. Prior to mobilisation from Gladstone all equipment including the satellite positioning system and the TUV were tested to ensure all components were functioning correctly.
3. The ultra-short-baseline (USBL) transponder unit (Figure 2-10) was removed from the mounting pole prior to mobilisation from Gladstone to North West Island so that it would not be damaged in transit, then re-attached once reaching North West Island.
4. The Wild Blue would depart North West Island for Douglas Shoal between 0500 and 0630.
5. The USBL unit would be lowered into the water upon reaching Douglas Shoal.
6. Vessels would arrive at Douglas Shoal after 1 to 1.5hrs travel time. During this time the TUV and the associated GPS positioning system would be checked to ensure all components were operational.
7. The Wild Blue would navigate to the start point as described in the transect plan.
8. Once the vessel was in position, the TUV surveys would begin.
9. The vessel engines were disengaged and the TUV would be carefully lowered into position (Figure 2-14).
10. The camera would be lowered to within 1 to 2m of the seafloor and the vessel would then travel along the predetermined transect.
11. The height of the camera would be controlled using a hydraulic winch and also by hand as necessary.

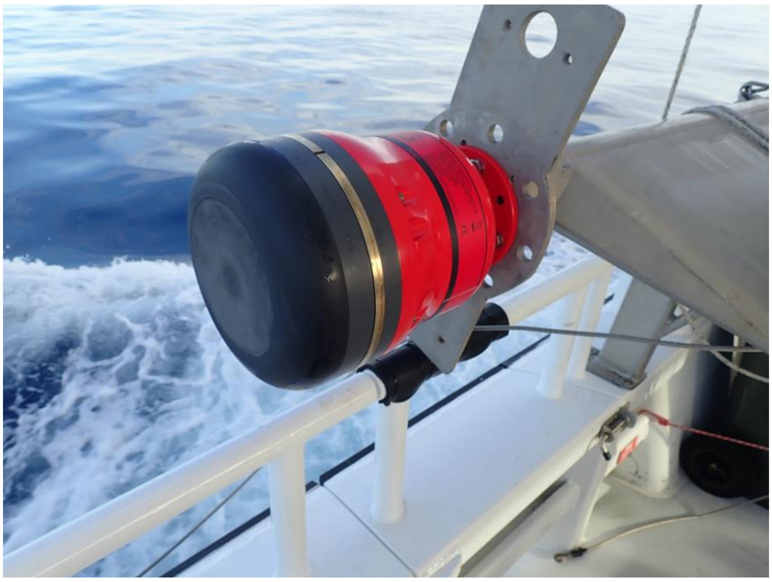

*Figure 2-10 USBL receiver attached to the mounting pole prior to deployment*

*Figure 2-11 Underside of TUV showing downward pointing camera, forward pointing video and forward pointing GoPro to capture high resolution video*

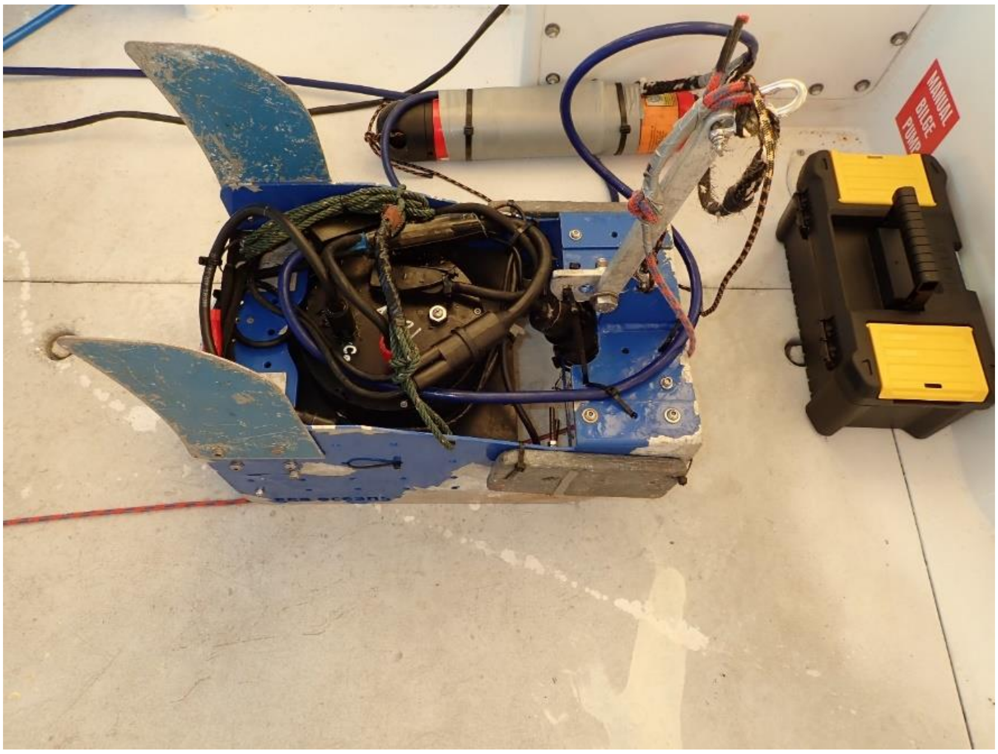


*Figure 2-12 View of the top section of the TUV with the cylindrical USBL transponder in the background*

*Figure 2-13 TUV interface*

*Figure 2-14 Deploying the TUV over the stern of the vessel*


*Figure 2-15 Elevation of the TUV controlled by hand*


*Figure 2-16 Elevation of the TUV controlled by winch cable*

## 2.4 Results and observations

### 2.4.1 Sonar survey

Preliminary results (screen shots) of the bathymetry and backscatter data captured are provided in Figure 2-17 and Figure 2-18. Bathymetry and backscatter images appear to indicate evidence of a flattened area of seafloor in the main grounding. The white patches observed in Figure 2-18 (circled) for priority remediation areas C, E and F may indicate areas where sound pulses sent out by the MBES unit are not reflected to the receiver (typical of flattened solid seafloor). The backscatter data appears to be comparable to that captured by AIMS (Negri *et al*, 2010) just after the grounding incident.

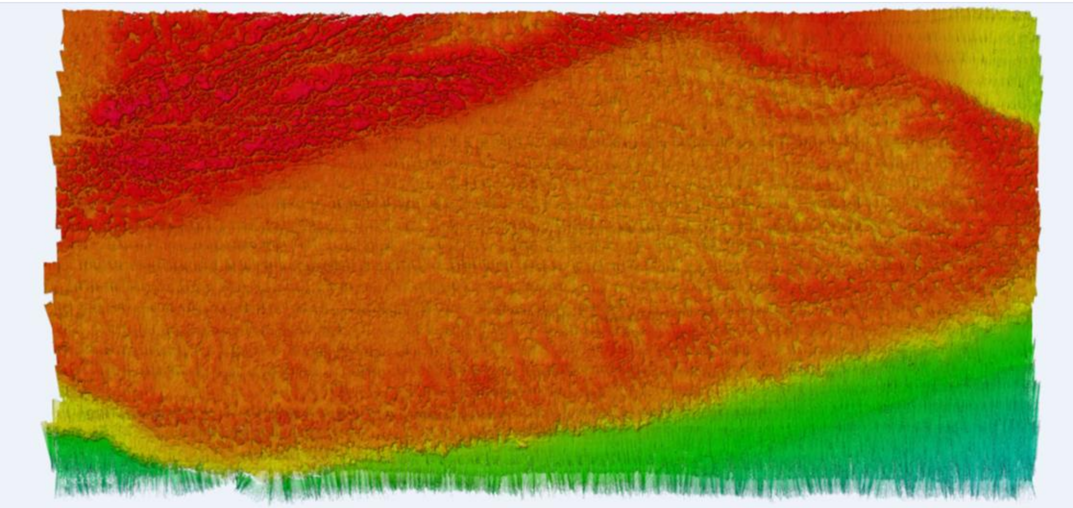

*Figure 2-17 Screen shot of the bathymetry captured*

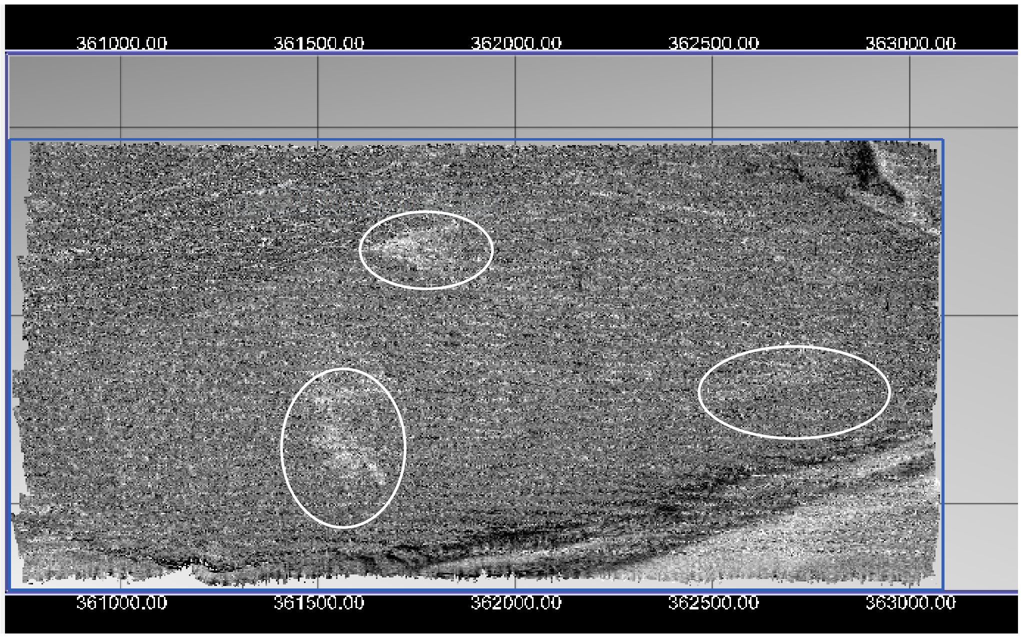


*Figure 2-18 Screen shot of backscatter data across the shoal with flattened areas circled*

### 2.4.2 Drop camera and towed underwater video

A screen shot which represents the coverage of the TUV surveys overlaid onto the bathymetry and the extent of the grounding footprint is provided in Figure 2-19. Drop camera surveys were focused in areas circled in the backscatter image (Figure 2-18)

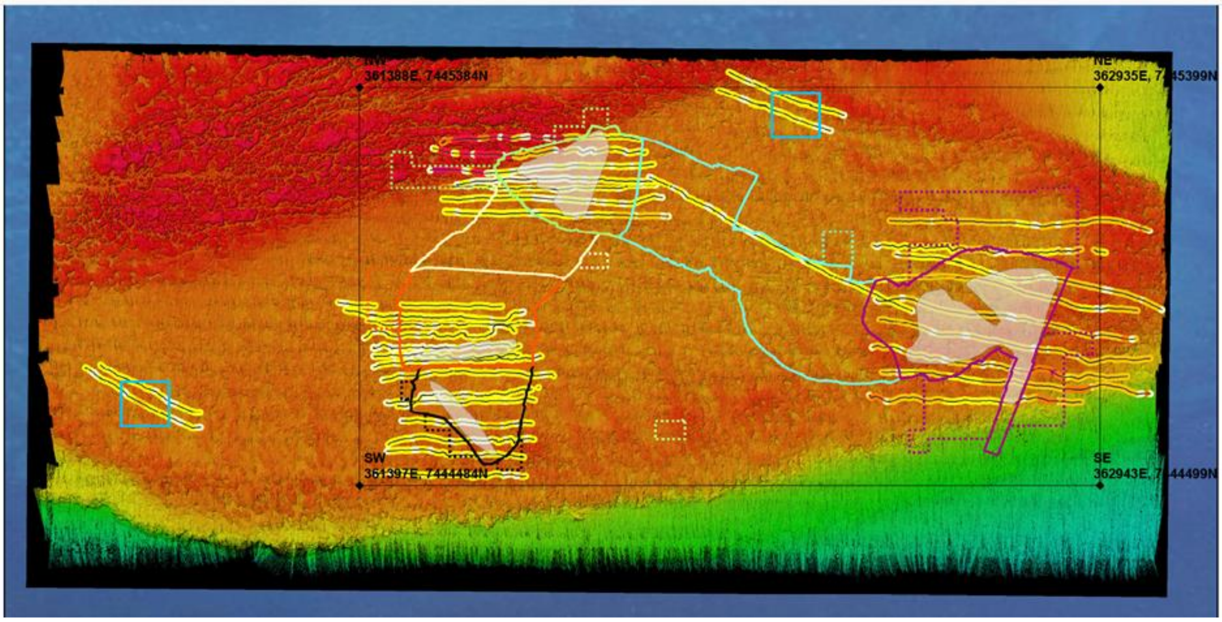


*Figure 2-19 Screen shot showing the TUV transect lines (yellow and red lines)*

Images and videos captured by the drop camera and TUV are currently being collated, reviewed and processed. Some typical low-resolution images captured by the drop camera are provided in Figure 2-20 and Figure 2-21.

*Figure 2-20 Sample of a drop camera image capture of the seafloor in Priority Area C*

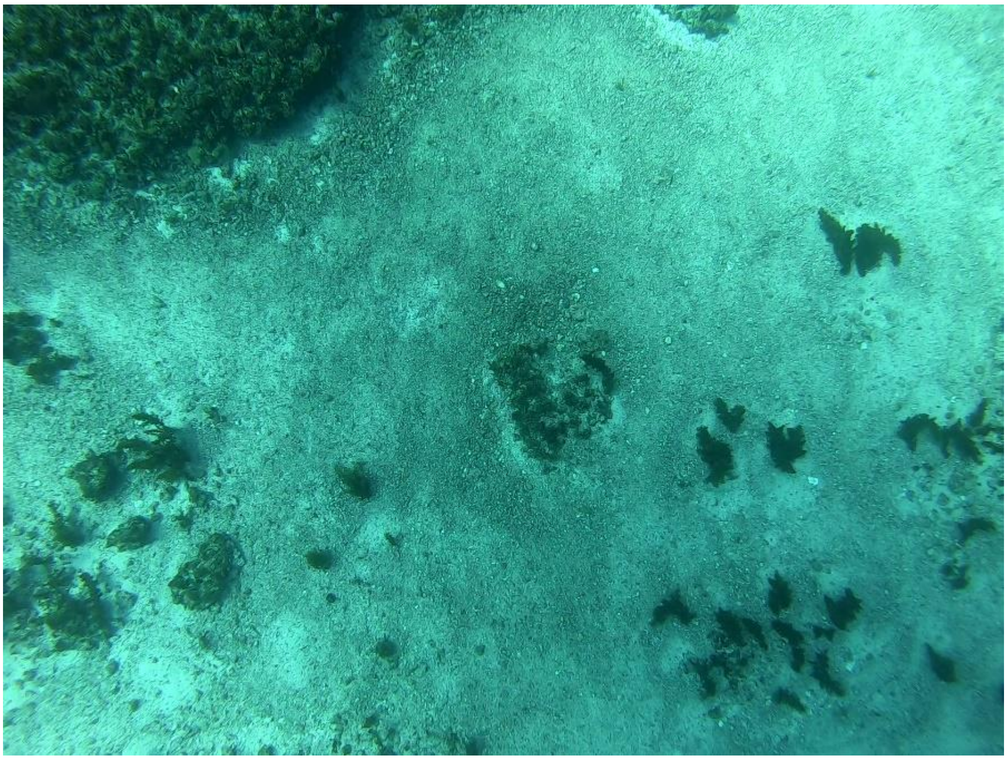

*Figure 2-21 Sample of a drop camera image capture of the seafloor in Priority Area F*

### 2.4.3 Fauna

A profusion of protected fauna was observed during the 12 days spent at Douglas Shoal and in transit between Douglas Shoal and North West Island. Given the high abundance of fauna near the sea surface, vessel speeds when approaching, maneuvering on, and departing the shoal were lowered to reduce the risk of fauna strike.

Fauna observations were incidental, and fauna was not commonly identified to species level. A summary of the fauna observed during the fieldwork is provided in Table 2-3.

*Table 2-3 Fauna observed at Douglas Shoal and surrounds*

| Fauna | EPBC Act* Status | Number Observed | Activity |
|---|---|---|---|
| Green Turtle *(Chelonia mydas)* | Vulnerable | 10 | Basking on the surface or swimming |
| Sea snakes (Banded, Olive Sea Snake etc.) | Listed | 25+ | On seafloor feeding |
| Bottlenose Dolphin, Common Dolphin | Listed | 6 | Bow riding or feeding - spotted while transiting between North West Island and Douglas Shoal |

**Environment Protection and Biodiversity Conservation Act 1999*

### 2.4.4 Human visitation

During the 12 days on site at Douglas Shoal, three vessels were sighted within 2km of the operations. The vessels were less than 10m in length and were either drift fishing or spearfishing. No low-level aircraft were observed flying over the shoal.

### 2.4.5 Tides and currents

The neap tides and swell had very little influence during the sonar surveys as the boat could maintain 4-6kts speed and collected excellent data in the sea conditions encountered. During the TUV surveys the wind, tide and waves were more challenging as the vessel speed required for successful image capture was between 1 and 1.5kts. The TUV transects generally ran with the tidal flow (or with the prevailing wind when the tides were not flowing) which meant the vessel could do a controlled drift with the current and maintain the required speed and orientation by occasionally engaging the engines.

### 2.4.6 Evidence of natural recovery

Evidence of the ship grounding was observed in the video footage as the TUV surveys progressed, including large areas of exposed bare substrate covered in a fine layer of sand and angular rubble

(Figure 2-22). In comparison with images shown in Costen et al, 2017 (refer to *Figure 4-2 Image of physical damage)*, no large rubble banks or fractured and displaced substrate were observed during the TUV surveys, indicating some level of natural recovery. No evidence of ship hull fragments or AFP flakes were observed by the TUV.

*Figure 2-22 Areas of 'angular' rubble in the grounding footprint in Area C*

### 2.4.7 Macroalgae

The macroalgae *Sargassum spp.* was found growing on the shoal (Figure 2-23), covering areas of consolidated sediment and rock in stands up to 1.0 to 1.5m high in places. The algae were less prolific compared to that encountered during the sediment sampling surveys undertaken a month prior. The algae appeared to be dying off, with large strands of macroalgae observed drifting on the sea surface.

*Figure 2-23 Stands of the macroalgae* Sargassum spp. *observed in Priority Area E*

# 3 Lessons learned

As with the sediment sampling field work the visual survey fieldwork provided the opportunity to gain valuable knowledge regarding conditions at Douglas Shoal that are likely to be relevant to future activity for the remediation project. A summary of these is provided in Table 3-1 as 'lessons learned'. No Health, Safety or Environment (HSE) incidents occurred during the field work.

*Table 3-1 Fieldwork lessons learned*

| Challenge | Issue | Solution |
|---|---|---|
| Voice communications | Intermittent and unreliable mobile phone coverage when at North West Island and Douglas Shoal.<br>Vessel to vessel radio contact is intermittent between Douglas Shoal and North West Island. | Mobile phones should utilise the Telstra network which has coverage as far as North West Island but not at Douglas Shoal.<br>Satellite phones used for communications between the team and office. Where work teams are separated, satellite phone should be carried on the separated vessels to enable communication in emergency situations.<br>Future stages of the Project may consider sourcing technology to boost the network signal. |
| Email access | No access available without network stability. | Future stages of the Project may consider sourcing technology to boost the network signal. |
| Diverse team of subcontractors | Communication breakdown between teams. | Ensure clear lines of communications are established prior to mobilisation and re-iterated during pre-start meetings especially during periods of rapid scope changes. |
| Open water nature of Douglas Shoal | Activities at the Shoal are impacted upon by wind, waves and currents during most of the year, causing delays in mobilisations. | Consideration of more infrastructure installed on/near the Shoal during extended work periods (Stream 2) such as moorings. |
| Equipment and personnel transfer between vessels while at Douglas Shoal | Due to the lack of protection from weather and sea conditions at the shoal, transfers carry HSE and equipment loss risk. | Avoid, or if not possible to avoid, minimize the transfer of equipment and personnel at Douglas Shoal.<br>If conditions are appropriate, in water transfer at Douglas Shoal is preferable. |

| Challenge | Issue | Solution |
|---|---|---|
| | | Undertake transfers at sound mooring or anchorage locations (such as at North West Island).<br>For future stages of the remediation project and dependent on remediation activity, consider installation of dedicated moorings at Douglas Shoal to provide for vessel stability when transfers occur. |
| Anchoring on Douglas Shoal | Anchoring was not possible for the fieldwork vessel configurations due to very loose substrate and large areas of smooth rock which did not provide adequate anchoring points. | Fieldwork activities utilise 'live' boating techniques unless in low current (turn of the tide or neap tides) and low wind and swell conditions.<br>For future stages of the remediation project and dependent on remediation activity, consider installation of dedicated moorings at Douglas Shoal to allow for periods of down time and reduce fuel use. |
| Vessel anchoring and mooring arrangements at adjacent areas | Vessels anchoring and mooring arrangements at North West Island carry HSE and equipment loss risk through vessel interactions with each other and/or fringing reef, particularly during periods where weather and sea conditions change rapidly. | Use existing moorings at North West Island where available and appropriate to do so with consideration given to (amongst other things) vessel collision.<br>For future stages of the remediation project and dependent on remediation activity, consider installation of dedicated moorings at multiple locations at North West Island to provide appropriate, available mooring options. |
| Large distance from Douglas Shoal to the mainland | Transfers removes one vessel from work operations, thereby reducing sampling efficiency and requiring use of fuel reserves. | Utilise existing services such as the Heron Island ferry where available to reduce transfer time.<br>Schedule activity such that personnel transfer requirements are minimised. |
| Abundant fauna | Interactions with fauna carry HSE risk. | Limit vessel speeds in sensitive locations. Ensure protocols for interactions with fauna are communicated and adhered too. |
| Undertaking surveys using specialist equipment | Breakdown of one component in the survey equipment chain (such as | Ensure all survey equipment is tested prior to mobilisation to Douglas Shoal. |

| Challenge | Issue | Solution |
|---|---|---|
| | navigations systems, cabling, laptops, camera gear) may result in lost time, including through potential demobilisation from site to repair. | Where appropriate build redundancy into the supply of survey equipment for a program such as extra GPS and camera systems, duplicate cabling and back-up systems. |
| Maintaining video and camera height above the substrate during the TUV surveys which require vessel speeds of 1-1.5kts | Sudden changes in camera/video height causing blurry images and videos<br>TUV unit may be damaged when hitting the seafloor | Where possible, seek to undertake TUV survey during calm periods.<br>Consider tidal current and wind direction during daily field planning.<br>Maintain flexibility in planning TUV transect paths to allow for in-field variation dependent on conditions. |

# 4 Preliminary findings

- The visual surveys completed across the full extent of the priority remediation areas will support a robust assessment of the current state of the shoal with respect to seafloor substrate type and evidence of physical damage, including compaction and the presence of grounding related sediment (angular rubble).
- In conjunction with sediment sampling and analysis work it is likely that priority remediation areas may be further delineated using the visual survey information.
- It appears that evidence of the impact of the grounding still exist at Douglas Shoal with consideration of the correlation between areas traversed by the Sheng Neng 1 and areas that appear (based on the fieldwork) to be affected:
  - Preliminary sonar survey results including preliminary bathymetry and backscatter data appear to show evidence of a flattened area within the grounding footprint, specifically in the areas where the ship sat for many days.
  - A preliminary visual comparison between the AIMS backscatter data (Negri et al, 2010) and the backscatter data collected during this field trip appears to show a similar spatial extent of flattened areas.
  - Evidence of the ship grounding was observed in the video footage as the TUV surveys progressed, including large areas of exposed bare substrate covered in a fine layer of sand and angular rubble.
- In comparison with images shown in Costen et al, 2017, no large rubble banks or fractured and displaced substrate were observed during the TUV surveys, indicating some level of natural recovery.
- Douglas Shoal is a relatively unprotected environment for fieldwork with changeable weather, sea conditions and an abundance of fauna. The shoal is commonly affected by both significant weather systems (such as cyclones) and local rapidly changing conditions. As these elements cannot be avoided, they need be managed through a balance of minimisation of exposure and careful planning for work (including for emergency situations) and particularly with consideration of vessel interactions and HSE risk.

# 5 References

Advisian, 2019. *Sampling and Analysis Plan – Douglas Shoal Remediation Project*. Report prepared by Advisian for the Great Barrier Reef Marine Park Authority, May 2019.

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Negri A, Speare P, Berkelmans R, Stieglitz T, Botting T, Stowar M, Smith S, Steinberg C, Brinkman R, Heron M and Doherty P., 2010. *Douglas Shoal Ship Grounding Survey: RV Cape Ferguson Habitat Damage Monitoring using Multibeam Sonar and Towed Video (TVA) Assessments*. Report prepared by Australian Institute of Marine Science for the Great Barrier Reef Marine Park Authority, October 2010.