# TOTAL EP MYANMAR YWB 2D SEISMIC SURVEY

## Marine Mammal Observation (MMO) Reports

09 May 2016

Total EP Myanmar

EPI Group

# 2D Seismic Survey

## Cetacean Report

| | |
|---|---|
| Client | Total Exploration |
| Area | YWB Block, Myanmar |
| Dates | 22nd April 2016 – 8th May 2016 |
| Contractor | Polarcus |
| Vessel | M/V Polarcus Asima |
| Chase Vessels | Opal and Crest Adventurer |
| Marine Mammal Observers | Layne Olson and Crystal Shaw |
| PAM Operators | Layne Olson and Crystal Shaw |

EPI REPORT No. 1782-MMO

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# 1.0 Introduction

## 1.1. Objectives

A 2D seismic acquisition survey was conducted in the YWB block - offshore Myeik, Myanmar by the M/V Polarcus Asima on behalf of Total Exploration from the 22nd of April to the 8th of May 2016. In accordance with Total's Initial Environmental Examination (IEE), two dedicated marine mammal observers (MMOs) / passive acoustic monitoring operators (PAM) were required onboard to conduct visual and acoustic monitoring throughout the survey to detect marine mammals and sea turtles. The centre of the survey area is located approximately 210nm from Yangon and 164nm from Myeik. Depths of the prospect area ranged between 500m to over 2000m. Throughout the project the MMOs conducted visual observations between 00:00 – 12:00 UTC (06:30 – 18:30 local time) whilst acoustic monitoring was conducted between 12:01 – 23:59 UTC (18:31 – 6:29 local time). Procedures, outcomes, observations and seismic activity with regards to all MMO and PAM efforts are documented below.

During seismic operations Total Exploration required the JNCC guidelines for minimising the risk of injury and disturbance to marine mammals for seismic surveys (September 2013) to be used as a baseline, along with additional recommendations as outlined in the IEE with regards to species specific exclusions zones.

Water depths for this project were over 200m, so within accordance to the JNCC a 60-minute pre-shooting survey for marine mammals and sea turtles was conducted prior to all air gun operations by either the MMO or PAM operator on watch. Further continuous monitoring was conducted during shooting activities. The primary aim of visual monitoring was to assess the presence of marine fauna within two defined exclusion zones around the gun arrays, as recommended within the IEE:

1) A 2800-meter exclusion zone for all Mysticete species (baleen whales)
2) A 800-meter exclusion zone for sea turtles and Odontocete species (toothed whales, dolphins, and porpoises)

If a protected animal was observed within the designated exclusion zone before air gun operations began, air gun activity would be delayed 20 minutes after the protected species left the exclusion zone.

- MMO observation time during daylight hours amounted to 166 hours and 34 minutes.
- 52 marine mammals were observed during four sightings.
- Of the sightings, one was a joint sighting of short finned pilot whales (*Globicephala macrorhynchus*) with a pod of unidentified dolphin species, one was a pod of spinner dolphins (*Stenella longirostris roseiventris),* one was a pod of an unidentified species of dolphin, and one was a whale sighting from the family Balaenopteridae.
- Passive acoustic monitoring during hours of darkness amounted to 132 hours and 08 minutes.
- No acoustic detections occurred.

## 1.2. Location Map

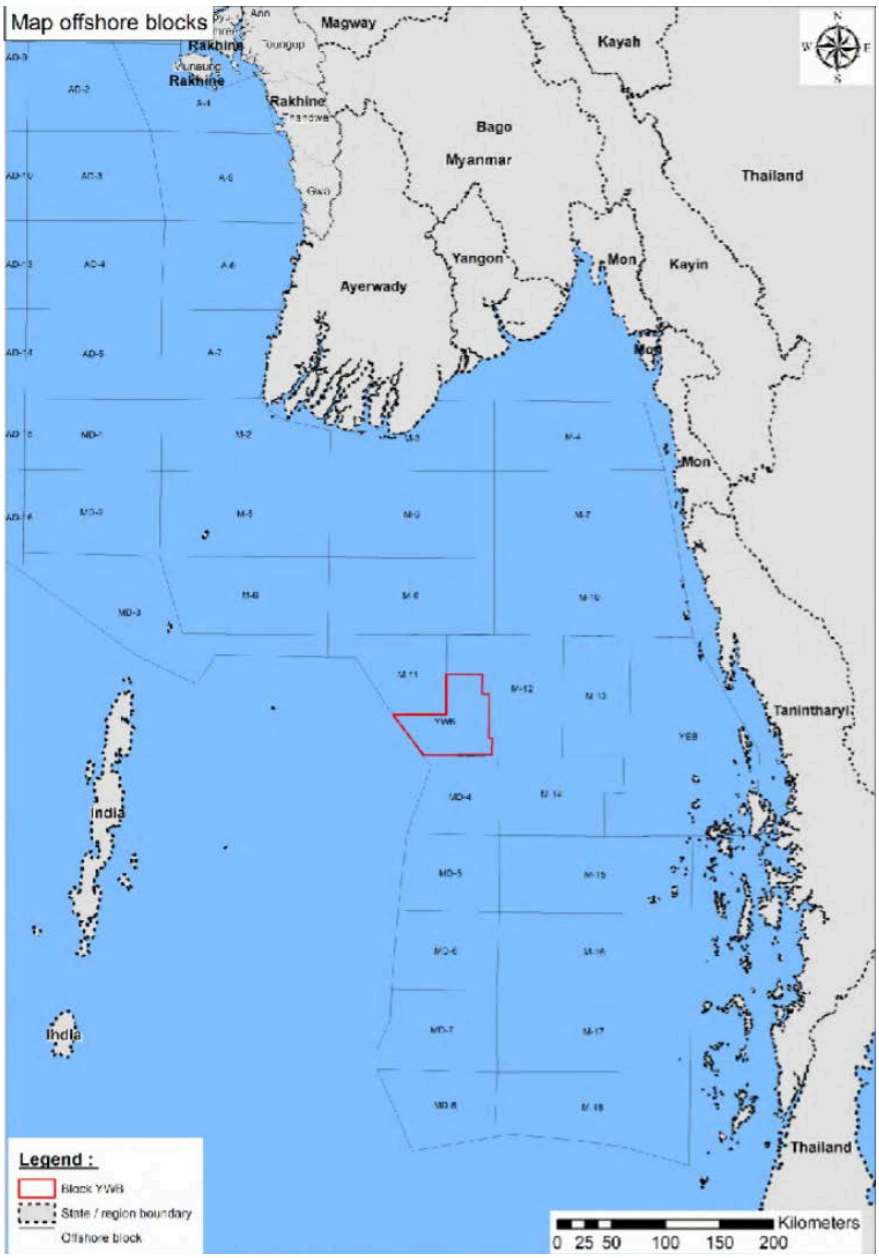



**Figure 1**: Sight of the 2D seismic survey area within relation to offshore blocks

**Table A:** Survey area specs

| Survey Area | |
|---|---|
| Area | 2001.35 km (sail line length) |
| Average line length (km) | 58.86 km |
| Number of sail lines | 36 |
| Heading (deg) | 134° & 314° and 38° & 218° |

### 1.3. Programme Map

Figure 2 shows the survey area and sail lines including line turns. The Asima deployed a 4300 cubic inch array and one streamer x 10,050m long for the 2D acquisition. Using the marine seismic optimization tool, SurvOPT, Polarcus has modelled the proposed acquisition scenario in order to determine the most efficient sequence of sail lines, minimizing line change duration and maximizing productive time.

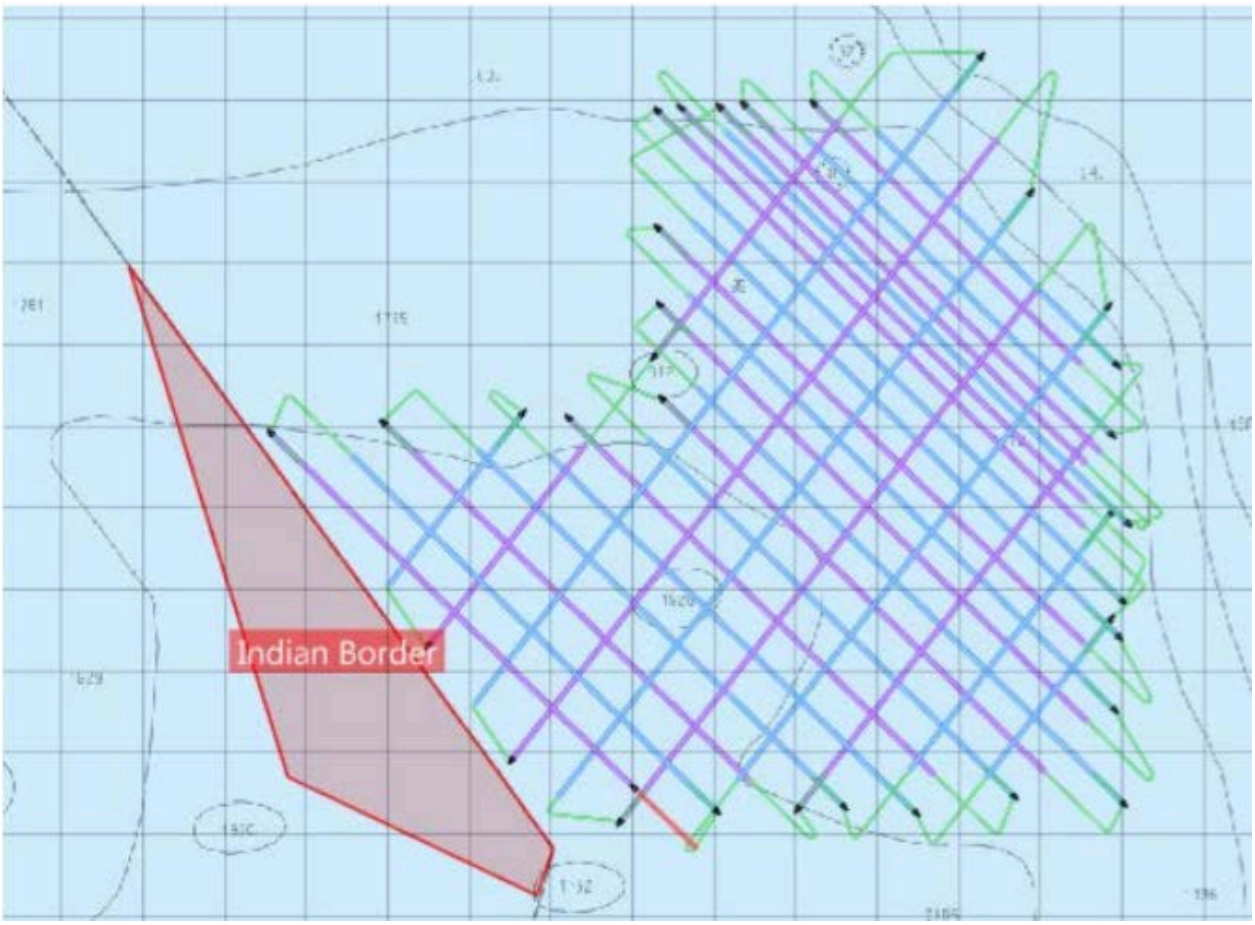



**Figure 2**: Pre-plots for survey area including line changes

### 1.4. Marine mammal species occurrence

Twenty-nine species of marine mammals are known to range within southeast Asia (Shirihai & Jarrett, 2006). However, minimal research has been undertaken in Myanmar waters, therefore species presence is not well known in this area. Table B indicates species that are believed to be located in the area and therefore were considered as being potentially encountered in and around the prospect area. This includes seven species of baleen whale, four toothed whale species, two species from the genus Kogia, fourteen species of dolphin, one porpoise species, and a single sirenian species.

**Table B**: Marine mammal species that may be encountered

| Suborder | Family | Scientific Name | Common Name |
|---|---|---|---|
| Mysticeti | Balaenopteridae | *Balaenoptera musculus* | Blue Whale |
| Mysticeti | Balaenopteridae | *Balaenoptera physalus* | Fin Whale |
| Mysticeti | Balaenopteridae | *Balaenoptera borealis* | Sei Whale |
| Mysticeti | Balaenopteridae | *Balaenoptera edeni* | Bryde's Whale |
| Mysticeti | Balaenopteridae | *Balaenoptera omurai* | Omura's Whale |
| Mysticeti | Balaenopteridae | *Balaenoptera acutorostrata* | Northern Minke Whale |
| Mysticeti | Balaenopteridae | *Megaptera novaeangliae* | Humpback Whale |
| Odontoceti | Physerteridae | *Physeter macrocephalus* | Sperm Whale |
| Odontoceti | Kogiidae | *Kogia breviceps* | Pygmy Sperm Whale |
| Odontoceti | Kogiidae | *Kogia sima* | Dwarf Sperm Whale |
| Odontoceti | Ziphiidae | *Ziphius cavirostris* | Cuvier's Beaked Whale |
| Odontoceti | Ziphiidae | *Mesoplodon densirostris* | Blainville's Beaked Whale |
| Odontoceti | Ziphiidae | *Indopacetus pacificus* | Longman's Beaked Whale |
| Odontoceti | Delphinidae | *Orcinus orca* | Orca |
| Odontoceti | Delphinidae | *Globicephala macrorhynchus* | Short-finned Pilot Whale |
| Odontoceti | Delphinidae | *Pseudorca crassidens* | False Killer Whale |
| Odontoceti | Delphinidae | *Feresa attenuata* | Pygmy Killer Whale |
| Odontoceti | Delphinidae | *Peponocephala electra* | Melon-headed Whale |
| Odontoceti | Delphinidae | *Tursiops truncatus* | Common Bottlenose Dolphin |
| Odontoceti | Delphinidae | *Tursiops aduncus* | Indo-Pacific Bottlenose Dolphin |
| Odontoceti | Delphinidae | *Sousa chinensis* | Indo-Pacific Humpback Dolphin |
| Odontoceti | Delphinidae | *Stenella attenuata* | Pantropical Spotted Dolphin |
| Odontoceti | Delphinidae | *Stenella longirostris* | Spinner Dolphin |
| Odontoceti | Delphinidae | *Stenella coeruleoalba* | Striped Dolphin |
| Odontoceti | Delphinidae | *Lagenodelphis hosei* | Fraser's Dolphin |
| Odontoceti | Delphinidae | *Steno bredanensis* | Rough-toothed Dolphin |
| Odontoceti | Delphinidae | *Orcaella brevirostris* | Irrawaddy Dolphin |
| Odontoceti | Phocoenidae | *Neophocaena phocaenoides* | Finless Porpoise |
| Sirenia | Sirenidae | *Dugong dugon* | Dugong |

In the vicinity of the prospect area it is also possible to encounter five species of turtle (Table C). There were no sea turtle sightings for the duration of this project.

There are a total of seven species of sea turtles found worldwide; five of which can be found offshore Myanamar. Four of these five belong to the family Cheloniidae classified as such because of their hard shells: the olive ridley (*Lepidochelys olivacea*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricate*), and green sea turtle (*Chelonia mydas*). The leatherback (*Dermochelys coriacea*) has a carapace that is covered by leathery skin making it the only species found within the Dermochelyidae family (Wynne & Schwartz 1999). Threats to all sea turtle populations are mostly anthropogenic and include vessel strikes, marine debris, pollution, harvestings of eggs and meat, entanglement in fishing gear, and habitat destruction (Mortimer & Donnelly 2008, NOAA 2010, CITES.org).

The International Union for Conservation of Nature (IUCN) classifies the olive ridley, leatherback, and loggerhead as “vulnerable”; the green sea turtle as “endangered”; and the hawksbill sea turtle as “critically endangered”. Critically endangered is the last category before becoming extinct.

**Table C:** Turtle species that may be encountered

| Suborder | Family | Scientific name | Common name |
|---|---|---|---|
| Cryptodira | Dermochelyidea | *Dermochelys coriacea* | Leatherback turtle |
| Cryptodira | Cheloniidae | *Lepidochelys olivacea* | Olive Ridley turtle |
| Cryptodira | Cheloniidae | *Caretta caretta* | Loggerhead turtle |
| Cryptodira | Cheloniidae | *Chelonia mydas* | Green turtle |
| Cryptodira | Cheloniidae | *Eremochelys imbricata* | Hawksbill turtle |

### 1.4.1. Potential Impacts on Marine Mammals

Possible impacts of seismic air guns on marine mammals include physical, perceptual, behavioural and indirect effects. Physical effects may appear in four different ways: Threshold Shift (TS), Temporary Threshold Shift (TTS), Permanent Threshold Shift (PST) and Bubbles.

**Threshold Shift -** any auditory damage done and is the metabolic exhaustion of sensory cells and cellular damage.

**Temporary Threshold Shift -** damage done as a result of brief exposure to noise and recovery will occur after several minutes or hours depending on the level and duration of exposure.

**Permanent Threshold Shift -** damage done as a result of chronic or intense exposure to acoustic noise and the animal will not recover.

**Bubbles -** bubbles in the bodies of whales may occur if the normal dive sequence of whales and dolphins is disturbed, similar to decompression sickness in humans (Hooker et.al 2009, Hooker et.al 2012).

Perceptual effects include auditory masking that occurs when there is an increased background noise level of a frequency that renders the signal of interest undetectable. This may leave the marine mammal with a reduced ability to communicate, echolocate, and navigate, leading to an overall reduction of individual and population viability.

Behavioral effects refer to any instance when a marine mammal actively avoids an area due to seismic activity which present potential complications if the area in question is used for feeding, breeding, migrating, or as a calving ground. Other potential behavioral effects include reduced/altered vocalization rates, startle/fright reactions, alterations to dive profiles, which have the potential to lead to physical effects, such as nitrogen gas bubbles within tissues, (Hooker et.al 2009, Hooker et.al 2012) and altered surfacing behavior, i.e. shorter periods spent at the surface and fewer blows.

The last type of effect, indirect effects, may cause an alteration in the levels of prey in the area which could potentially lead to decreased feeding, thus either fewer marine mammals in the area, or a reduction in the health of the animals that are in the area due to lack of food, negatively affecting breeding and life expectancy (Gordon *et al.*, 1996, 2003).
The seismic source, however, is not the sole agent that may potentially alter the behaviour and presence of marine mammals in an area. General shipping noise and noise from surrounding installations may also prove to be a factor. If an area has permanent installations, then it is possible that some marine mammals may become habituated to the noise surrounding them whilst other may have already permanently left the area (Wartzok *et al*, 2004). Alternatively in areas where the noise exposure is not constant and may only have a limited period of shipping or seismic activity contributing to the noise levels, it may be seen that populations of marine mammals under these conditions (occasional exposure) may display varied reactions when encountering this increased subaquatic noise, dependant on previous levels of exposure.

### 1.4.2. Soft Start Procedure

The JNCC (Joint Nature Conservancy Council) *Guidelines for minimising acoustic disturbances to marine mammals from Seismic Surveys* (JNCC, 2010) were adopted for the duration of the survey along with

added mitigation actions required through the Initial Environmental Examination (IEE) created by Total. These guidelines stipulate the following mitigation requirements:

- **Pre-Shoot Search** – All seismic gun activity will be preceded by a pre-shoot search. There will be a 60-minute pre-search before any shooting of airguns as described in the JNCC due to water depths being greater than 200 metres throughout the prospect area. In an occurrence where odontocetes (toothed cetaceans) or sea turtles are detected within 800 metres of the air gun source while conducting the pre-shoot watch, then the soft start will be delayed 20 minutes after the marine mammals have left the 800-meter exclusion zone. An enlarged exclusion zone of 1800 metres will be implemented for mysticetes (baleen whales).

- **Soft Start** – Air guns must always be soft started over a period of a minimum of 20 minutes and a maximum of 40 minutes. Soft start and run in time until the start of a new line should not exceed 40 minutes. If this event happens, then a reason must be stated in the Soft Start Logs supplied by the seismic observers on board. Any break in seismic activity lasting longer than ten minutes will require a 20-40 minute soft start.

- **Shut Down** – As per the JNCC, there are no shut downs required once airgun activity has commenced.

- **Turtle Pauses** – No pauses in airgun activity were allowed for any sea turtle species observed heading towards the airgun array.

All seismic air gun operations were recorded on the JNCC 'Record of Operations' form which includes the duration of the soft start, the time the airguns stop firing, the length of the pre-firing watch, whether animals were detected during this watch, and if so, what action was taken. The seismic crew provided data on the duration of the soft start and the time spent shooting. This was then verified against the MMOs logged gun use times recorded during daily mammal observation sessions

# 2.0 Vessel & Equipment

## 2.1. Vessels on the survey

The fleet for the Total Myanmar Block YWB project was comprised of the Polarcus Asima as acquisition vessel; one Support Vessel, the Opal; and one Chase Vessel, the Crest Adventurer.
Vessel Specs from the following vessels:

- Opal – provided supplies, fuel, crew changes, chase vessel, emergency tow
- Crest Adventurer – chase, fishing liaison / communications and utility vessel

| | |
|---|---|
| Survey Vessel - **Polarcus Asima** | Call Sign: VSAT1: VSAT2:<br>asima.master@polarcus.com<br>C6XK6 +47 236<br>Bridge Master<br>asima.bridge@polarcus.com asima.partymanager@polarcus.com |
| Support Vessel - **Opal** | Call Sign: Phone : E-mail :<br>9HA2265 +870 773 166 772<br>opal@skyfile.com |
| Chase Vessel – **Crest Adventurer** | Call Sign: Phone: Email:<br>9V7449 +870 773 173 132<br>crestadventurer@pacificradiance.com.sg |

### 2.1.1. Source Vessel

| M.V. Asima | Specification | |
|---|---|---|
|  | Length Overall | 92.0m |
| | Beam | 21.0m |
| | Max Draft | 7.5m |
| | Gross Tonnage | 7894 |
| | Propulsion | Diesel Electric |
| | Maximum Speed | 15.0 knots |
| | Bollard Pull | 135 tons |

**Figure 3**: Source vessel

### 2.1.2. Support Vessel

# POLSKIE RATOWNICTWO OKRĘTOWE

Est. 1951


## OPAL
## OFFSHORE SERVICE VESSEL TOWING FIRE FIGHTER 1

| MAIN DESCRIPTION | |
|---|---|
| Port of Registry: | Valletta |
| Call sign | 9HA2265 |
| Flag: | Malta |
| IMO number | 9489479 |
| Delivered | 2009 |
| Classification | DNV |
| Class | +1A1 Tug Supply Vessel Fire Fighter 1 |
| Operating Area | Unrestricted trade |
| Bollard pull | 67 tons |
| Cruising speed | 10 knots |
| Maximum Speed | 13 knots |

| MAIN DIMENSIONS | |
|---|---|
| LOA | 59,25 m |
| Beam | 14,95 m |
| Max Draught | 4.95 m |
| GRT | 1678 tons |
| NRT | 503 tons |
| Clear deck | 350 m² |
| Deck strength | 7.5 mt / m² |
| Deck cargo | 500 mt |

| TANKS CAPACITIES & PUMPS | |
|---|---|
| Fuel Oil capacity | 540 m³ |
| Fresh Water capacity | 370 m³ |
| Drill Water capacity | 400 m³ |
| Liquid Mud capacity | 420 m³ |
| Cement tank capacity | 187 m³ |
| Discharge rate fuel | 150 m³ / hr |
| Discharge rate fresh water | 125 m³ / hr |
| Discharge rate drill water | 100 m³ / hr |
| Discharge rate Liquid Mud | 2 x 70 m³ / hr |
| Bulk cement | 2 x 13 m³ / min |

| MACHINERY | |
|---|---|
| Main Engines | 2 x 1920 kW 1600 rpm Caterpillar |
| BHP | total 5150 |
| Propellers | two CPP in Kort Nozzle |
| Bow thruster | 371 kW tunnel CPP 59 kN |
| Joystick | Bridge Mate type |

| DECK & TOWING EQUIPMENT | |
|---|---|
| Towing/AH winch | double drum 1 x electro-hydraulic HAW, mentrade 2 |
| Drums Capacity | 2 x 1000 m / 56 mm |
| Line pull | 150 mt |
| Break holding | 200 mt |
| Spare reel | 1000 m / 56 mm |
| Capstan | 2 x 5 mt |
| Tugger Winch | 2 x10 mt |
| Stern roller | 4.50 m x 1.60 m 180 mt SWL |
| Shark Jaws | Kamfork SWL 300 mt |
| Tow pins | 2 with turntable top flaps |
| Deck crane | 10 600 kg at 5,45 m, 3 260 kg at 15,95 m |
| Hose Reel : | hydraulic operated fuel hose 150 mtrs |
| Work Boat Davit | Vestdavit PLR-12002 SWL 12 000 kg |

| FIFI AND ANTI POLLUTION | |
|---|---|
| FIFI | class 1 |
| Capacity | 2 x 1550 m³ / hr |
| Monitors | 2 x 1200 m³ / hr one with 300 m³ / hr foam |
| Oil dispersant | 1 set 2 spray booms 6 m |

**Figure 4:** Support Vessel "Opal"

### 2.1.3. Chase Vessel

TECHNICAL SPECIFICATIONS

Pacific Radiance

15 Pandan Road
Singapore 609263
Tel : +65 6238-8881
Fax : +65 6278-2759
email : commercial@pacificradiance.com

*Group of Companies*
Pacific Crest Pte Ltd
Alstonia Offshore Pte Ltd
Strato Maritime Services Pte Ltd
Prime Offshore International Pte Ltd
Titan Offshore Equipment Pte Ltd
Crest Subsea International Pte Ltd

**M.V. "Crest Adventurer"**

**36M /2000BHP UTILITY / SUPPORT VESSEL**


**OUTLINE SPECIFICATION**

| GENERAL | |
|---|---|
| Keel laid | 2008 |
| Year Built/Delivered | 2009 |
| GRT / NRT | 387/116 |
| Class Notation | 1 + HULL + MACH TUG, Unrestricted Navigation |
| Class | B.V. |
| Flag | Singapore |
| Call Sign | 9V7449 |
| Official Number | 394209 |
| IMO Number | 9512965 |
| **DIMENSION** | |
| Length Overall | 36.00 m |
| Length BP | 33.28 m |
| Breadth Moulded | 9.8 m |
| Depth Moulded | 4.3 m |
| Draught Designed | 3.5 m |
| **PERFORMANCE** | |
| Maximum Speed | 12.0 knots (Approx) |
| Type of Fuel | Marine Gas Oil |
| Bollard Pull (Static) | 26T |
| **CAPACITIES** | |
| Fuel Oil | 260.06 m³ (Approx) |
| Fresh Water | 93.16 m³ (Approx) |
| Ballast Water | 49.02 m³ (Approx) |
| Dirty Oil | 3.855 m³ (Approx) |
| **DISCHARGE RATES** | |
| Fuel Oil Pump | 1 x 30 m³/hr @ 40m Head |
| Fresh Water Pump | 1 x 35 m³/hr @ 40m Head |
| **MACHINERY** | |
| Main Engines | Caterpillar 3508B |
| Rating | 2 x 1000 BHP @ 1600 rpm |
| Gear Box | Reintjes WAF562L ratio 5.947 to 1 |
| Diesel Gen. Set | Caterpillar 3406 |
| Revolution | 2 x 215kw @ 1500 rpm |
| Bow Thruster | HRP 2001 TT (2.8T Thrust) |
| Bow Thruster Engine | N/A - (Electrotor ATB) |
| Rating | 150kw |
| Propellers | FPP x 2 (with Kort Nozzle) |
| Rudders | 2 x Conventional |
| **ACCOMMODATION** | |
| Crew | 2 x 1 man cabin = 2 men<br>5 x 2 men cabin = 10 men<br>2 x 4 men cabin = 8 men |
| Total | 20 men bunk<br>All cabins fully air-conditioned |
| **DECK AREA** | |
| Deck Cargo Bay | 27m x 10m (Approx) |
| Deck Strength | 5 tonnes/m² |
| Clear Deck Area | 120m² |

| RADIO & NAVIGATION EQUIPMENT | |
|---|---|
| Radar no.1 | 1 x JRC (NWZ 164) |
| Radar no.2 | 1 x Furuno (RFD-118) |
| Projection Magnetic Compass | 1 x Sauna Keike MR-150A |
| GPS | 2 x Furuno (GP-90) & 1 JRC |
| Anemometer | 1 x Demg / Portable |
| Echo Sounder | 1 x JRC (NJA-98) |
| Speed Log | 1 x JRC (NMW-65) |
| Gyro Compass | 1 x Cplath 736 - 032 |
| AIS | 1 x JRC (MCM779) |
| Autopilot | 1 x Camnav (200 IF) |
| GMDSS Radio | 2 x JRC (NCM-1770 |
| 2 Way Radio Telephone | 3 x JRC (JHS-7) |
| EPIRB | 1 x JRC (JQE-103) |
| SART | 2 x ACR (PF-3) |
| Navtext Receiver | 1 x JRC (NCR-333) |
| Weather Fax | 1 x JRC (JA x 98) |
| Aft Shaft Rev Meter | 2 x ZF (785 CE) |
| Electromagnetism Sensor | 2 x Yantai Anlte (DC24V) |
| **DECK & AUX. EQUIPMENT** | |
| Electric Hydraulic Windlass | 2 Tonnes @ 12m/min |
| Stockless Bower Anchor | 2 x 660kg |
| Anchor Chain/Cable | 2 x 412.5m total length @ 22mm Dia. Grade 2 Stud link chains |
| Towing Winch | Electric Hydraulic Driven, 20 Tonnes @ 5m/min Break Holding 50 Tonnes |
| Capacity of Drum | 650m length of 36mm Dia. Wire |
| **FIRE FIGHTING EQUIPMENT** | |
| | 1/4 C/W FIFI 2 x Fire-monitor 800m3/hr |
| Fire Main | 1 x 33m³/hr @ 30m Head |
| Fire Main Hydrants | 6 x 20m x 40mm Dia. c/w brass coupling/nozzle |
| Fireman's Outfit | As per SOLAS and Class requirement |
| Portable Fire Extinguisher | As per SOLAS and Class requirement |
| Emergency Fire Pump | 25m³/hr @ 40m Head, Engine Driven |
| Fire Detection and Alarm | As per SOLAS and Class requirement |
| Fixed CO2 System | Protected Zone: Engine Room |
| **LIFE SAVING EQUIPMENT** | |
| Inflatable Liferaft | 2 units |
| Life Jacket | 28 units |
| Life Buoy | As per SOLAS and Class requirement |
| First Aid Box | As per SOLAS and Class requirement |
| Line Throwing Apparatus | As per SOLAS and Class requirement |
| Parachute Distress Rocket | As per SOLAS and Class requirement |
| Orange Smoke Signals | As per SOLAS and Class requirement |
| Embarkation Rope Ladder | As per SOLAS and Class requirement |
| **OTHERS** | |
| Sewage Treatment Plant | 1 unit (cap: 1 Tonnes) |
| Oily Bilge Water Separator | 1 unit (cap: 0.5m³/hr) @ 15 ppm |

Particulars are believed to be correct but not guaranteed. Owners reserve the right to amend the specifications without notification

*Updated-Oct13-Rev13*

**Figure 5:** Chase Vessel "Crest Adventurer"

### 2.1.4. MOGEs

Throughout the survey, the occurrence of fishing vessels and fishing gear was present and lead to survey lines being aborted. Onboard Myanmar Oil and Gas Enterprise (MOGE) representatives assisted with requirements and acted as Fisheries Liaison Officers (FLOs) during the project. There were two MOGE representatives onboard the Polarcus Asima for the duration of the project as well as two MOGE representatives onboard the Crest Adventure.

**Picture 1:** Crest Adventurer approaches fishing vessel near prospect area

## 2.2. Seismic Equipment and Sound Emissions

### 2.2.1. Specifications

For this project, ASIMA was used in a 1 x 10050m configuration. Smaller vanes were utilized to maintain sub-array separations. All of the Polarcus vessels use Sercel Sentinel II Solid Streamers and the SEAL Recording System.

One 4300 $in^3$ (No In-line Stagger between Subarrays) source array was deployed for this survey. This 2D array designed by Polarcus consisted of 4 sub-arrays x 12 Bolt air-guns and had wide dimensions 40m (width) x 14m (length).

| Parameter | Specification | Reference Contract Clause |
|---|---|---|
| Manufacturer and Type | Sercel Sentinel solid streamers | PLCS Standard |
| Number of Streamers | 1 | Exhibit B1 |
| Streamer Separation (Front-end) | N/A | |
| Receiver Group Interval | 12.5 m (one overlapping hydrophone)<br>8 Hydrophones per group | PLCS Standard |
| Active Streamer Length | 10050m | Post-Award MEETING 03/02/2016 |
| Active Streamer Section Length | 150m | PLCS Standard |
| Number of Receiver Groups per Streamer | 804 | Post-Award MEETING 03/02/2016 |
| Nominal Streamer Depth | 12m ±10% (avg) | LN - Email 18/02/2016 |
| Number of Streamer Depth Controllers | Every 300m (max distance between depth indicators shall not exceed 600m) | PLCS Standard |
| Streamer Depth Control Fin Angle | N/A | |
| Compass Interval | 300m | PLCS Standard |
| Lateral Steering Devices Interval (DigiFin) | Every 300m<br>N.B. Max Number of units is 63 per streamer. See Streamer layout diagram Appendix B & C. | EL - Email 16/04/2016 |
| Fan Mode To Be Used | N/A | |
| Fan Mode Tail Separation (Adjacent Streamers) | N/A | |
| Streamer feathering (maximum angle) | 10°<br>The streamer feathering of overlapped segments shall not differ by more than 5°, unless otherwise agreed by COMPANY SUPERVISOR. | Discuss with OBC any instances exceeding 10° feather |

**Table D:** Streamer parameters

| Parameter | Specification | Reference Contract Clause |
|---|---|---|
| Manufacturer and Type | BOLT 1900 LLXT<br>BOLT 1500 LL | PLCS Standard |
| Number of Sources | 1 | Exhibit B1 |
| Centre of Source Arrays Separation | N/A | |
| Shot Point Interval | 25m single source | Exhibit B1 |
| Nominal Inline Seismic Offset (COS-NRG) | ~100m | MOB |
| Nominal Source Array Volume | 4300 $in^3$ ( No Stagger) | LN - Email 18/02/2016 |
| Nominal Operating Pressure | 2000 psi (±5% from Nominal on average) | Exhibit D |
| Pressure Drop Test | Start of job and each line change | PLCS Standard |
| Nominal Source Depth | 8m ±0.5m (avg for array) | LN - Email 18/02/2016 |
| Peak to Peak Output (SEAL: 2 – 200 Hz) | 158.7 barm | Nucleus Model 25oC |
| Primary/Bubble Ratio (SEAL: 2 – 200 Hz) | 21.2 | Nucleus Model 25oC |
| Synchronization | ± 1.0 - 1.5 ms (flag)<br>> ± 1.5 ms (misfire) | PLCS Standard |
| Sub-array Separation (2-3) | 20m ±1m(avg)<br>+/- 20% from nominal for more than 90% of the seismic line or segment of seismic line | Exhibit D |
| Sub-array Separation (1-2; 3-4) | 10m ±1m(avg)<br>+/- 20% from nominal for more than 90% of the seismic line or segment of seismic line | Exhibit D |
| Number of NF Sensors per Sub-array | 6 | PLCS Standard |
| Number of Pressure Gauges per Sub-array | 2 | PLCS Standard |
| Number of Depth Indicators per Sub-array | 6 (min 2/sub-array) | PLCS Standard |
| Number of RGPS Units per Sub-array | 2 | PLCS Standard |
| Number of Acoustic Devices per Sub-array | 1 | PLCS Standard |
| Firing sensor type | Solenoid | PLCS Standard |
| Timing resolution | 0.1 ms | PLCS Standard |
| Air Compressors | 3 x LMF 1800 CFM | PLCS Standard |
| Source Controller | Seamap GunLink 4000 | PLCS Standard |
| NFH SEGD Format | 8058 IEEE Floating Point | GL4000 Long Phone |
| NFH polarity | SEG (inverted in GL4k) | +ve first break for QC display purposes |
| NFH Record Length | 9.0 secs<br>(9*1024ms = 9216ms) | GL4000 Long Phone (must be shorter than record length) |
| NFH Sample Rate | 1ms | GL4000 Long Phone |

**Table E**: Source parameters

### 2.2.2. Towing Configuration

The source consisted of one array configured in four sub arrays (Figure 6). Forty-eight airguns within the 4-sub arrays were towed approximately 300m aft of the vessel and were submerged to a depth of eight metres. The operating volume of the array was 4300cu in and was shot with a 25m shot point interval.

By gradually adding specific volumes of guns, soft start was initiated via gunlink by cluster. All soft starts for this 2D project ranged in length from 20 to 21 minutes.

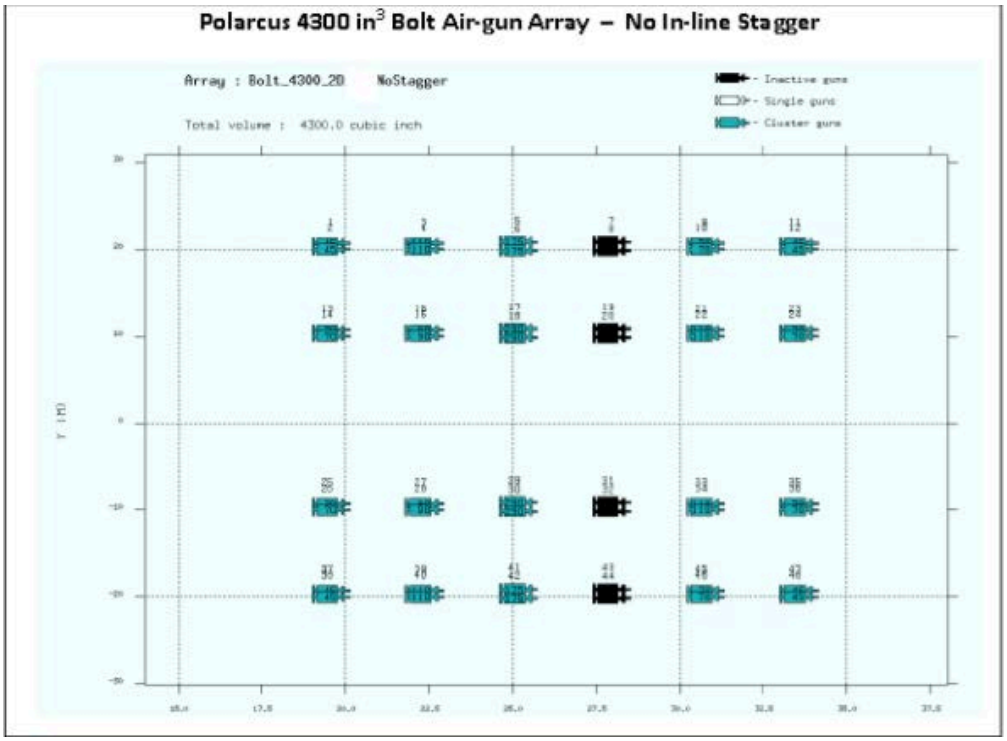



**Figure 6:** Source Layout

## 2.3. Passive Acoustic Monitoring (PAM) and communications

During the hours of darkness acoustic monitoring was required. The purpose of the PAM system was to detect marine mammals that may stray into the 800 or 2800m exclusion zones, as well as around the guns, during times of seismic airgun activity and inactivity.

Both PAM operators carried out acoustic watches for marine mammal presence over approximately 6-hour periods each day. The ability to operate the PAM system does not depend on daylight, nor is it affected by weather conditions, although very rough conditions can limit PAM use. As a result acoustic monitoring was used during hours of darkness as the sole monitoring method whilst visual observations could not be made.

Passive acoustic monitoring was used as a mitigation tool, in line with JNCC Guidelines, to increase the likelihood of detecting marine mammals in the vicinity of the airgun array and to complement visual observations carried out by the marine mammal observer. However, PAM does have the following limitations:

- Animals do not vocalize all of the time and may pass by undetected.
- Current PAM systems do not give accurate estimates of range. The accuracy can be estimated at +/-300 meters, which means animals detected and calculated to be within 500 meters from the source could, in reality, be 500 + 300 = 800 meters, but their detection would still lead to a delay in the soft-start. Although, at present it is not possible to express the range accuracy of most PAM systems in numerical terms.
- PAM systems do not have a reliable range determination facility or can only calculate the range for some species. For example, baleen whales vocalize at frequencies which are very difficult to detect using current PAM systems, whereas harbor porpoise utilize high frequencies (130 kHz) and thus has a very short acoustic detection range; In such cases, the detection of a confirmed cetacean vocalization should still be used to initiate postponement of the soft-start if the PAM operator is able to make a judgment about the range of the animals from the airgun source, because of their experience gained in differentiating between distant and close vocalizations. In the absence of PAM systems capable of range determination, this expert judgment will constitute the basis for deciding whether an area is free from cetaceans prior to the soft-start.

PAM monitoring effort was not continuous as there was no requirement for seismic source shut down if marine mammals entered the respected exclusion zones whilst the guns were firing. Where soft starts occurred during the night, the PAM operator was solely responsible for 60-minute acoustic pre-shoot watches. The seismic observers gave notice to the PAM operator 60 minutes prior to any airgun operations.

In addition to listening to real time audio acoustic feeds directly through hydrophones, visual cues of cetacean presence were monitored via spectrograms and click detectors, contained within PAMGuard. The PAM operators completed standardised recording forms throughout the survey. The forms consisted of:

- Effort and Operations recording form – details of PAM watches and seismic operations and any mitigation action.
- Acoustic detection recording form – details of each marine mammal detected.

### 2.3.1. Equipment

The PAM system was provided by MSeis and consisted of a single linear towed array, 250m in length, terminated with a 9m length sensor streamer section. This sensor section contained four MSeis type two hydrophones with a sensitivity -201 dB, gain 30 dB, filter cap 150 pF, (2000 Hz to 150 kHz).

Both sets of hydrophones employed PA1 preamplifiers. Also to be found within this sensor tube was a depth sensor based on a Keller PA-9SE-20 bar 4-20mA sensor.

The tow cable was connected at the inboard end to an 80m deck cable which ran to the PAM station located in the instrument room.

The MSeis Nighhawk 3 PAM Base equipment is a permanent installation onboard Polarcus ships. It consists of:

- The acquisition unit, an essential module of the PAM system, it interfaces on-board components with the in water components. The key features are hydrophone output, array power supply, depth monitoring, voltage monitoring,
- Fast Track Ultra 8R sound card mixer for digitally sampling the Low Frequency (LF) sound. Max. Sampling rate of 96Khz. Two headphone outputs with gain were available from this unit.
- A signal conditioner consisting of a National Instruments 9201 High Frequency (HF) acquisiton device, used in detecting narrow band HF clicks; depth acquisition device MC 201; and filtering electronics.

The outputs from the above acquisition units were fed into a Fujitsu i3 3.30 Ghz computer running PAMGuard v1.12.04 BETA software.

In addition to real time acoustic monitoring via headphones, PamGuard also allows an operator to visually monitor high and low frequency sound using spectrogram and click detector displays. Match filters and energy sum functions are applied to the raw data enabling the localization and tracking of marine mammals. Additional whistle and click detection modules are used to trigger automatically and record into a log file, these recorded files are checked to identify whale sounds such as clicks and groans along with dolphin pulse trains during periods PAM was unmanned. Range estimates performed by the software are accurate to within 500m ±50m and present a left/right ambiguity. All PamGuard data produced was archived allowing the operator to perform further spectral analysis after survey completion.

### 2.3.2. Deployment

The PAM cable was deployed via the vessel's starboard side tag line winch, located on the streamer deck. The cable was then fed through a sliding shuttle which enabled a tow point at a range of 190m from the airgun array, at a bearing of 45°. Hydrophones were deployed to a depth of 5m.


**Picture 2:** PAM cable set up

**Picture 3:** Sliding Shuttle with PAM cable

# 3.0 Observations

### 3.1. Marine Mammal Survey Methods

A dedicated watch for marine mammals and sea turtles commenced on the 22nd of April and concluded on the 8th of May, resulting in a total of 298 hours 42 minutes spent on watch. This watch was maintained during daylight hours from 00:00 to 12:00 UTC, when weather and overhead conditions permitted.

Observations for marine mammals and sea turtles were conducted from the following vantage points: inside the vessel's bridge, outside on the bridge wings (14 meters above sea level), the crane deck aft (12.7 meters) and the helideck (10 meters) allowing 360˚ vision.

The observation technique used to spot marine mammals and sea turtles was to scan the visible area of sea using the naked eye and scanning areas of interest with 7x50 binoculars (e.g. waves going against the prevailing direction, white water during calm periods, and bird feeding activity). This technique gave both a wide field of view and the ability to have a sufficient range of 5-6km in ideal conditions.

Data was recorded on the standard JNCC recording forms. When animals were observed, the JNCC 'Record of Sightings' forms were used. A sighting is defined as an encounter with an animal or group of animals i.e. encountering a group of ten dolphins at one time is still counted as one sighting.

A daily record was also kept of the location, effort, weather and sea conditions on the JNCC 'Location and Effort' forms. The vessel's position was recorded at least once every hour to determine which licensing blocks have been traversed during the watch. Wind direction and force was determined from the Helicopter Management System (HMS) computer on the bridge, and this information, combined with observations of the weather and sea state was described using the JNCC methodology as 'glassy', 'slight', 'choppy' or 'rough'. Swell height was recorded as low (<2m), medium (2-4m) or large (>4m). Visibility was classed as poor (<1km), moderate (1-5km) or good (>5km).

### 3.2. Marine Mammal Sightings

A total of four visual sightings occurred on the source vessel during this survey. Sightings consisted of short finned pilot whales (*Globicephala macrorhynchus)* mixed with unidentified delphinidae species, dwarf spinner dolphins (*Stenella longirostris roseiventris),* an unidentifiable species of the family delphinidae, and one whale sighting from the *Balaenopteridae* family. All sightings with the exception of one, took place while the guns were firing at full volume. No mitigation actions were required as none of the sightings occurred during prewatch. Visual sightings and location details from the source vessel, Polarcus Asima is depicted in the chart below.

**Table F –** Source vessel sightings

| Sightings from Source Vessel 2D | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Vessel** | **Date** | **Time (UTC)** | **Sighting** | **Latitude N** | **Longitude W** | **Species** | **No.** | **Behaviour** | **Comments** |
| Polarcus Asima | 21 Apr 16 | 22:50 | 1 | 13°25.64 | 96°09.07 | Short finned pilot whales and Unident. Dolphins | 25 | milling | Airguns inactive |
| Polarcus Asima | 26 Apr 16 | 0:35 | 2 | 13°29.68 | 96°59.48 | Unidentified Dolphins | 10 | leaping | Airguns firing at full power |
| Polarcus Asima | 3 May 16 | 1:10 | 3 | 13°27.87 | 96°0.32 | Spinner Dolphins | 15 | Porpoising / travel | Airguns firing at full power |
| Polarcus Asima | 7 May 16 | 2:23 | 4 | 13°39.05 | 96°52.43 | Family: *Balaenopteridae* | 2 | Blow/milling | Airguns firing at full power |

The first sighting occurred on April 21st 2016 at 22:50 UTC when a group of approximately 20 short finned pilot whales were observed milling 1500meters from the port beam of the vessel. At 23:03UTC three individuals from an unidentifiable species of dolphin where observed leaping near the pod of short finned pilot whales. The group of mixed species was last observed at 23:10 UTC, appearing to be slowly moving in a north-eastern direction. Guns were not deployed during this sighting. No mitigation required.


**Picture 4:** Short finned pilot whales with unidentified dolphin species (Sighting 001)

The second sighting occurred on April 26th at 00:35 UTC when a pod of approximately ten unidentified dolphins were observed leaping approximately 2km from the vessel's port bow. At 00:36 UTC leaping ceased and visual was lost.

The third sighting occurred on May 3rd at 1:10 UTC when a pod of spinner dolphins (*Stenella longirostris*; subspecies *roseiventris*) were seen porpoising across the vessel's bow approximately 1km away. The pod travelled in a northern direction and was last seen approximately 1.5km from the starboard bow at 1:16 UTC.


**Picture 5:** Spinner dolphins (Sighting 003)

The fourth and last sighting occurred on May 7th at 02:23 UTC when one vertical, bushy blow was briefly seen approximately 3km from the bow of the vessel. At 02:32 UTC another single vertical, bushy blow was observed approximately 2.5km from the starboard bow. At 2:42 UTC two individuals were seen approximately 1km from the starboard side of the vessel. They were moving very fast and changing directions of travel often. Individuals were not diving deep but occasionally would lower bodies a few meters underwater and return to the surface. The vessel continued to travel at a heading of 312° and individuals came approximately 600m from airgun array at 02:56 UTC. At 03:01 UTC individuals when approximately 800m astern when visual was lost in glare as the vessel continued on. The vessel was in full production (airguns at full volume) for the duration of the entire sighting. No mitigation was required.

Individuals were of the Balaenopteridae family and were quite possibly northern minke whales *(Balaenoptera acutorostrata).* However, species identification could not be made with 100% certainty due to markings of color being poorly defined, initially due to distance, and later due to glare. Minke whales are known for having white bands on the outer margins of their pectoral fins; typically have thin, light gray forward direction chevron between the pectoral fins; and are white ventrally. Their small size (approx. 8-9m in length) is typically used for identification; however, the Omura's whale (*Balaenoptera omurai)* is close in size to the minke, growing between 10m to 11m in length. Dorsal fins of Omura's whale are tall and falcate as are minke whales. For these reasons, the possibility of sighting 004 being Omura's whales cannot be ruled out. Little is known about Omura's whales, as they are rare and have only recently been classified as a species of their own in 2003 (Roach, J. 2003).

**Picture 6:** Family: Balaenopteridae (Sighting 004)

**3.3.**

**Other Wildlife**

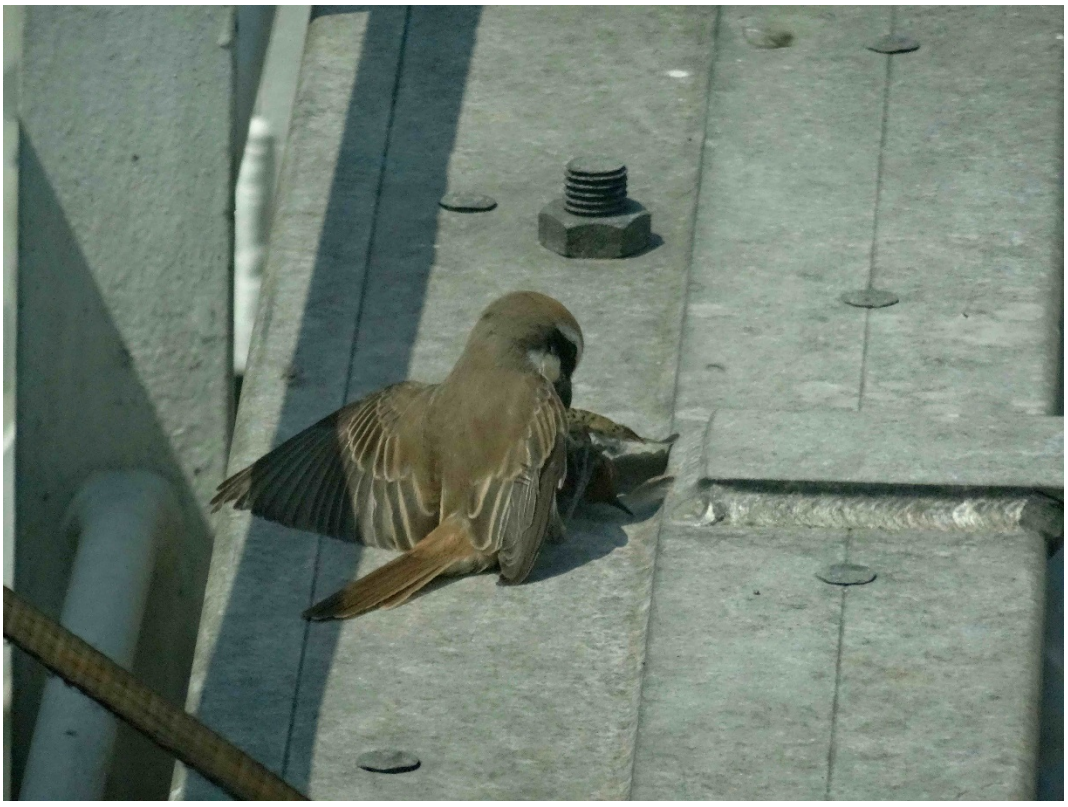
Different bird species were observed during the project and are listed below with photos of the sightings.

Identified Bird Species

| Common Name | Scientific Name |
|---|---|
| Barn Swallow | *Hirundo rustica* |
| Brown Shrike | *Lanius cristatus* |
| Cattle Egret | *Bubulcus ibis* |
| Crow-Billed Drongo | *Dicrurus annectans* |
| Chinese Sparrowhawk | *Accipiter soloensis* |
| Japanese Sparrowhawk | *Accipiter gulari* |

**Barn Swallows** Hirundo rustica

**Brown Shrike** Lanius cristatus



**Brown Shrike** Lanius cristatus

**Brown Shrike** Lanius cristatus

**Cattle Egret** *Bubulcus ibis*

**Crow-billed Drongo** *Dicrurus annectans*

**Chinese Sparrowhawk** *Accipiter soloensis*

Japanese Sparrowhawk - female *Accipiter gulari*

Japanese Sparrowhawk *Accipiter gulari*

Japanese Sparrowhawk *Accipiter gularis*

### 3.4. Total Airgun Operation Hours

Airguns were active for a total of 295 hours and 26 minutes. Of this, 275 hours and 33 minutes accounted for time spent at full volume; 13 hours and 17 minutes accounted for soft start procedures; 6 hours and 36 minutes of gun testing (Figure 7). In accordance with the JNCC guidelines, to prepare for this gun activity, 38 pre-shoot searches were completed; 19 during hours of daylight and 19 during hours of darkness.

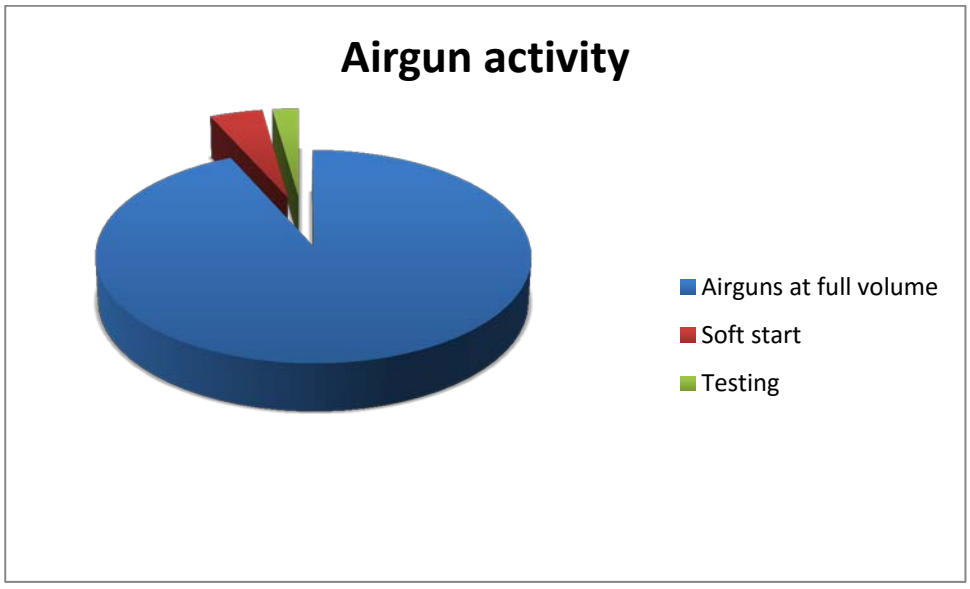



**Figure 7** – Total airgun operations

### 3.5. Time Spent On Watch

The two dedicated MMOs/PAM operators spent a total of 163 hours and 26 minutes monitoring the sea surface during daylight hours and a total of 133 hours and 54 minutes during hours of darkness. A combined total of 43 hours was spent both acoustically and visually during pre-firing watches prior any air gun testing or starting of a new line.

Throughout the project, airguns fired at full volume for 275 hours and 33 minutes, were used for soft start for 13 hours and 17 minutes, were used for testing for 6:36, and were silent for 97 hours and 20 minutes. The amount of time spent on watch, visual and acoustic, during these times are represented in the chart below (Figure 8).

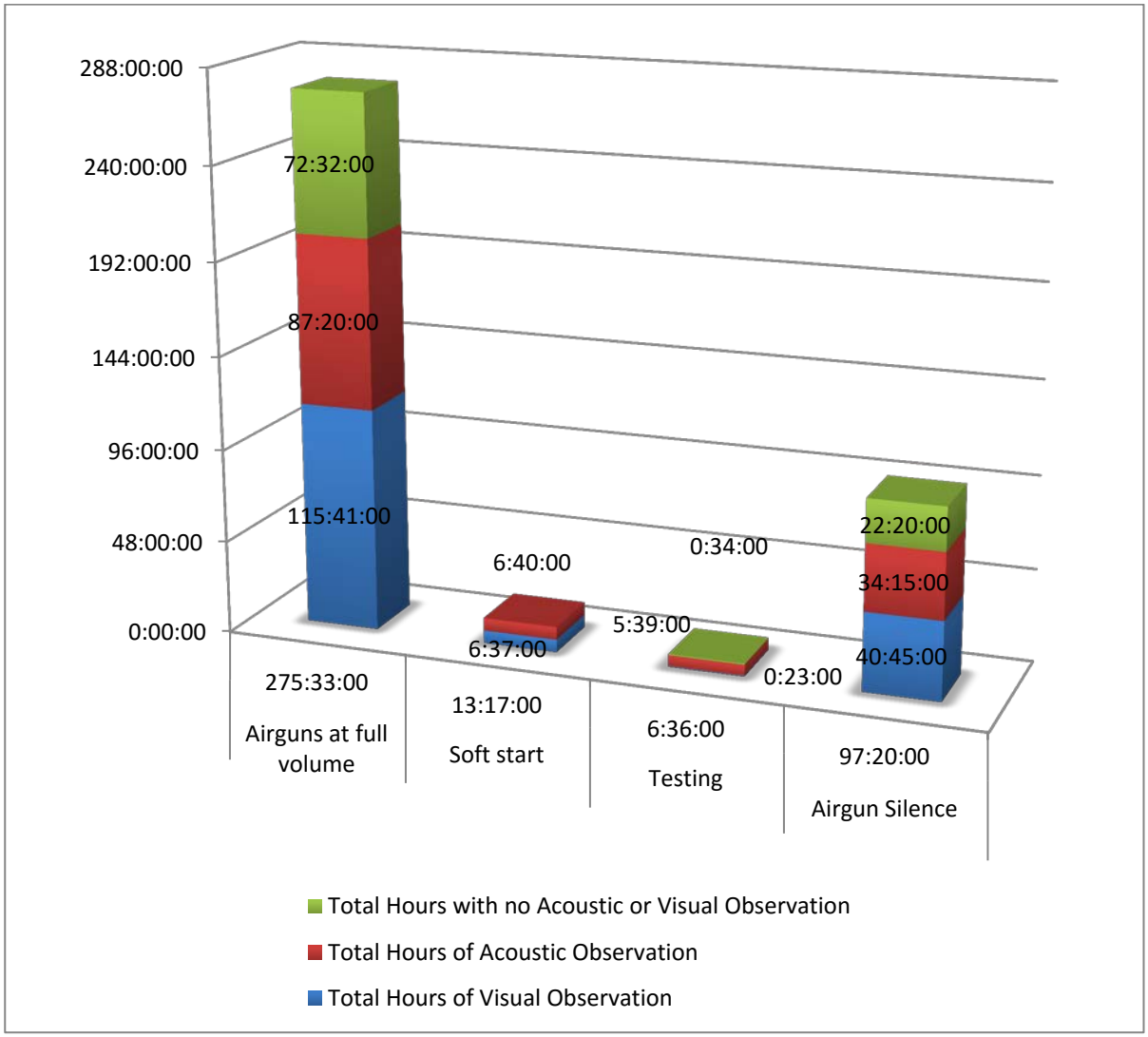



**Figure 8:** Hours of acoustic and visual effort for duration of project

### 3.6. Weather Conditions

Throughout the project wind and sea conditions were relatively calm, as reflected in the range of B1 – B4 on the Beaufort Wind Force Scale observed during visual watch. The Beaufort Wind Force Scale is an empirical measure, widely utilised in the marine sector, correlating wind speed to observed sea surface conditions.

The ocean swell remained below 2m for the duration of the survey.

Conditions were free of rain, for the most part. The lone instance of precipitation during visual observation was a period of moderate rain on 7 June, recorded during a span of 22 minutes. The near-absence of rain and lack of fog, coupled with the aforementioned calm sea state, lent to a grade of “good visibility” for the entirety of the survey, indicating clear visibility of at least 5km.

### 3.7. Compliance With Guidelines

There were not any non-compliance issues for the duration of this project.

### 3.8. Conclusions

Due to the short nature of the project and infrequent sightings, there is insufficient data to meaningfully analyse sighting rate and range relative to air gun activity. The prospect area seems to have had very few surveys carried out on it, with little information on actual sightings made here, from what we have monitored there seems to have been very little activity here.

### 3.9. Recommendations

The MMO / PAM operators would recommend Total to consider “turtle pauses” for future projects. Although there were no sea turtle sightings during this project, five species of sea turtles are found in Myanmar waters, all of which have decreasing population statuses.

### 3.10. Acknowledgements

The marine mammal observers / passive acoustic monitoring operators would like to thank Total Exploration for taking the best practice approach by using the JNCC guidelines throughout the 2D seismic acquisition survey. They would also like to extend their thanks to all the crew onboard the Polarcus Asima for all of their help and cooperation received whilst onboard.

### 3.11. References

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# Appendices

The following list of appendices are the standard forms associated with the JNCC. They are appended to the PDF as attachments.

**Appendix A MMO Forms**

**Appendix B PAM Forms**