

# Final Adaptive Management Program

## Maxima 3D Marine Seismic Survey, Scott Reef

Woodside Energy Ltd.

Rev 0
September 2007

**Maxima 3D Marine Seismic Survey, Scott Reef**
Final Adaptive Management Program

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# 1 Introduction

## 1.1 Project Description

Woodside Energy Ltd. (WEL) is undertaking a three-dimensional (3D) marine seismic survey (Maxima 3D Marine Seismic Survey or Maxima 3D MSS) over an area of approximately 362 square kilometres covering both State and Commonwealth waters of Scott Reef. South and North Scott Reefs (collectively known as Scott Reef) are situated in the Browse Basin approximately 430 kilometres north of Broome in Western Australia (**Figure 1**).

The Maxima 3D MSS is a key component in Woodside's Browse LNG Development and is designed to provide important sub-surface information for the southern portion of the Torosa gas field. This information will be a key consideration for further appraisal drilling and a subsequent decision on the development. The total duration of the survey will be approximately 60-70 days with the principal data acquisition phase of the survey continuing from 22nd September for a period of 50-60 days. The precise duration of the seismic acquisition is heavily dependent on weather and sea state conditions encountered during the survey.

As a condition to entering into the data acquisition phase (Phase Two), Woodside was required to complete a preliminary field survey at Scott Reef, or Phase One, to verify predictions of impact on marine fauna, principally fish and corals, as well as verify minimum airgun capacities for operation. This Final Adaptive Management Program (AMP) presents a summary of results from Phase One to demonstrate that the Phase Two survey can be in compliance with various environmental approval conditions.

Phase One of the Maxima 3D MSS commenced on 15th September 2007 and concluded on 19th September 2007. Phase Two commences on Saturday 22nd September 2007. Woodside has made significant commitments to minimise impacts on the environment through the impact assessment and the formal approvals process under the Environmental Protection Act (WA) and the Environmental Protection and Biodiversity Conservation Act (Commonwealth). Since first referring the survey, Woodside has reduced the survey area, adopted smaller airgun arrays and conducted significant environmental monitoring programs to ensure that evidence is presented to demonstrate the survey can be conducted without significant environmental impact. Phase One preliminary field survey was an extensive exercise to verify the predictions and commitments made in the Environmental Protection Statement (Woodside 2007b) and to ensure that compliance with the various conditions of approval can be met throughout the survey. The environmental monitoring and investigations associated with Maxima 3D MSS have been conducted by over 20 scientific specialists from around the world with the assistance of numerous support personnel.

## 1.2 Environmental Management and Monitoring Programs

As part of the environmental management and monitoring for Maxima 3D MSS, WEL have received approval to conduct the marine seismic survey in accordance with an Environment Plan (EP) (Woodside, 2007a) accepted by the Western Australian Department of Industry and Resources (DoIR). The EP is the overarching management document and describes the proposed activity, the existing environment, potential environmental risks and impacts and strategies to minimise those risks. The strategies are presented within the EP as either specific 'stand-alone' operational procedures or detailed in activity-specific Management and Monitoring Plans. The activity-specific Plans and Programs underpin the EP and have been developed by Woodside, in accordance with the Government of Western Australia's 'Ministerial Conditions', to limit the potential impacts this survey may have on the environment (Government of Western Australia, 2007).

The five management plans that have been developed under the EP are:

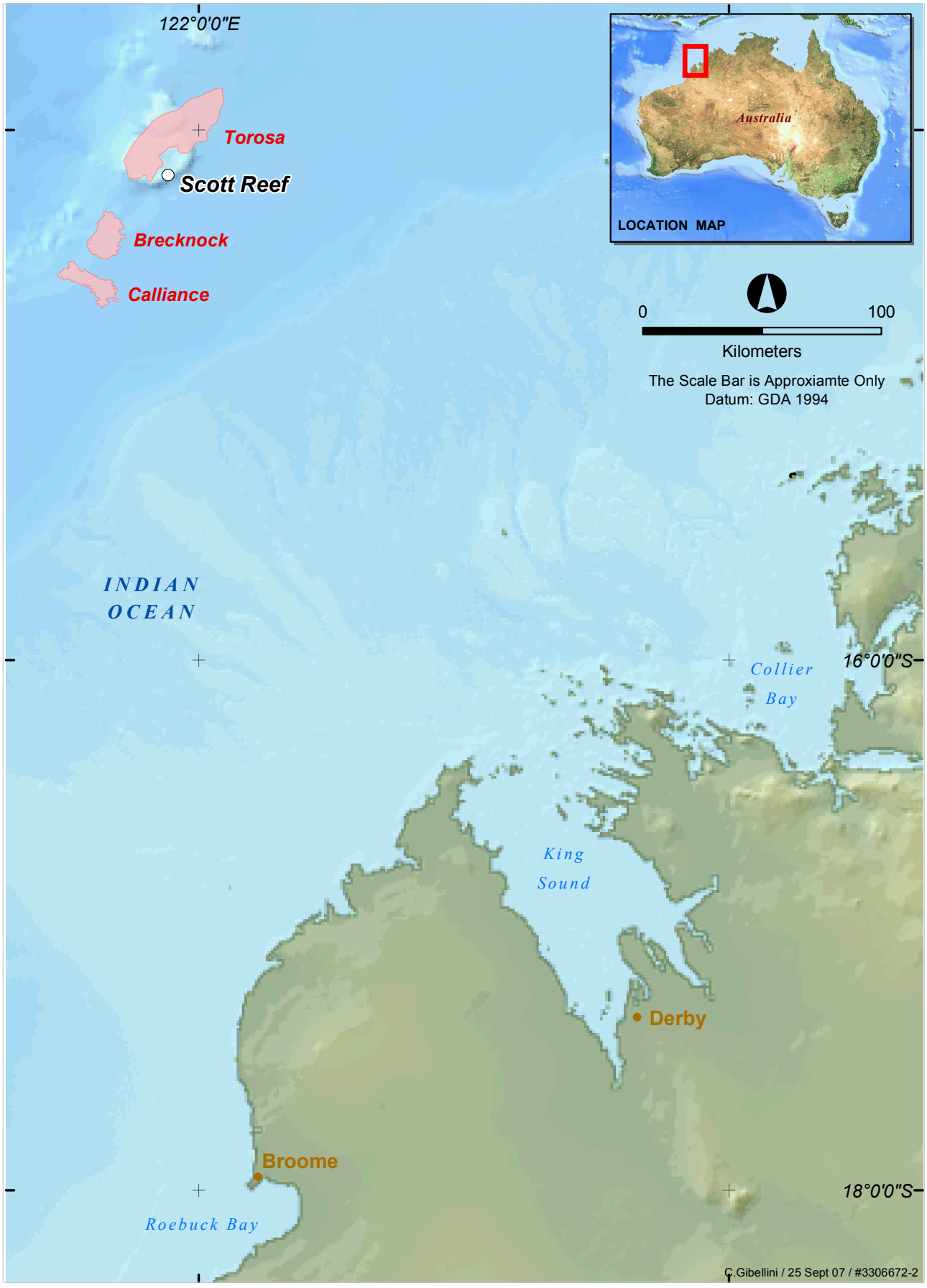
- Draft Adaptive Management Program;
- Final Adaptive Management Program;
- Cetacean Monitoring Program;
- Non-Indigenous Marine Species Management Plan;
- Fish Monitoring Program; and,
- Oil Spill Contingency Plan.

This document presents the Final Adaptive Management Program, which is a critical management document for the Phase Two component of the survey and should be read in conjunction with the EP.

## 1.3 Purpose of the Final Adaptive Management Program

As part of the commitments to manage and limit the potential environmental impacts the survey may have on the marine resources at Scott Reef, Woodside committed to the development and implementation of an Adaptive Management Program (AMP) for Seismic Operations. This has been deemed a requirement as set out in Condition 7 of the Ministerial Conditions (Government of Western Australia, 2007). These conditions required Woodside to submit a Final Adaptive Management Program prior to commencing Phase Two.

Figure 1 Location Map, Scott Reef



The specific conditions are as follows:

7-1 The proponent shall undertake seismic operations in accordance with the operational framework in Schedule 3.

7-2 Prior to the commencement of phase I of the Maxima 3D Marine Seismic Survey, the proponent shall obtain approval from the CEO (on advice of the Department of Fisheries and the Department of Industry and Resources) for a Draft Adaptive Managment Program.

The objective of this program is to ensure the implementation of the proposal complies with conditions 6-5, 6-6 and 6-7.

7-3 Following approval of the Draft Program, the proponent shall undertake a preliminary field survey, or phase I of the Maxima 3D Marine Seismic Survey:

1. at Scott Reef, but not in State Waters other than within the areas defined in Schedule 2 and Figure 1; and
2. using the same air gun array and other seismic acquisition equipment to be used during phase II of the Maxima 3D Marine Seismic Survey.

7-4 This object of the preliminary survey, or phase I, is to develop the Final Adaptive Management Program for Phase II of the survey, and is to include:

1. Defined and measurable trigger values for modifying and ceasing operations plus a framework of associated operational responses to ensure compliance with conditions 6-5, 6-6 and 6-7 and with the provisions of this statement within State Waters.
2. Operational procedures for ensuring trigger values referred to in point 1 above are met, including:
   (1) time-frames for responses;
   (2) responsible personnel; and
   (3) communication pathways which will ensure that the responsible personnel can assess measured impacts against the required trigger values and implement necessary operational procedures within the required time-frames.

7-5 The preliminary field survey, or phase I of the Maxima 3D Marine Seismic Survey is to be:

1. of sufficient duration to complete field experimentation necessary to ensure that phase II of the Maxima 3D Marine Seismic Survey will be compliant with conditions 6-5, 6-6 and 6-7 and to address the requirements of condition 5-2; and
2. in sufficient time prior to the commencement of phase II of the Maxima 3D Marine Seismic Survey to allow the results of field experimentation to be interpreted and used where necessary to refine the design and operational procedures for the delivery of phase II of the Maxima 3D Marine Seismic Survey in a manner compliant with this statement.

7-6 Following completion of Phase I of the survey, the proponent is to submit to the CEO a Final Adaptive Management Program at least two business days prior to the commencement of Phase II. The report shall include:

1. confirmation that implementation of Phase II of the survey will comply with this Statement; and
2. details of any proposed modifications to the design or operation to Phase II as a result of the findings of Phase I.

7-7 The proponent shall implement the Final Adaptive Management Program required by condition 7-6.

7-8 The proponent shall make the Final Adaptive Management Program required by condition 7-6 publicly available in a manner approved by the CEO.

Related to the above are the following conditions:

6-5 The proponent shall not cause category 1, category 2 or category 3 impacts as defined in Table 2 and in accordance with condition 5-7, in areas of the mapped habitats in State waters depicted in Figure 2, that exceed the predicted percentage areas in Table 3 by more than five percent of the total area of each habitat in State Waters.

6-6 Subject to any authority under another written law, nothing in this statement authorises the proponent to kill any animal except:

1. pelagic fish eggs and larvae within 10 metres of the airgun array as a result of airgun emissions; and
2. fish collected and used for research purposes under condition 7 or 9.

6-7 The proponent shall not cause damage to coral or other habitats as a result of air gun emissions.

## 1.4 Objectives of the Adaptive Management Program for Seismic Operations

The objective of the AMP for Seismic Operations is to demonstrate that the implementation of Phase Two of the Maxima 3D MSS can be carried out in compliance with conditions 6-5, 6-6 and 6-7 of the Ministerial Conditions (Government of Western Australia, 2007) as presented above (**Section 1.3**).

In order to meet the requirements of the various conditions, the Maxima 3D MSS was divided into two parts:

- Phase One Maxima 3D MSS (Phase One survey); and
- Phase Two Maxima 3D MSS (Phase Two survey).

The Phase One survey consisted of a preliminary survey at Scott Reef to trial the proposed seismic survey vessel and airgun array to be used for the Phase Two survey. As part of this preliminary survey a series of scientific investigations were designed to ensure the proposed seismic survey vessel and airgun array to be used for the Phase Two survey does not result in any non-compliances of conditions 6-5, 6-6 and 6-7 of the Ministerial Conditions.

Draft AMP trigger values were tested during the Phase One survey and a series of operational responses have been developed to ensure ongoing compliance during the Phase Two of the seismic survey.

The results of this Phase One survey have been used to develop this Final AMP which presents defined and measurable trigger values for modifying and ceasing Phase Two operations as well as a framework of operational responses to ensure compliance with conditions 6-5, 6-6 and 6-7 of the Ministerial Conditions.

An additional aspect of the survey was the verification of the minimum airgun configuration for the Phase Two survey. The results of this exercise have been integrated into the operational responses and commitments of the Phase Two survey.

## 1.5 Structure of this Final AMP Document

This document presents the results of the Phase One survey which, as described above, have been evaluated for conformance with Ministerial Conditions. Based on the results of this Phase One survey, Final AMP Trigger Values have been established for the Phase Two survey.

The remainder of this Final AMP document is therefore set out as follows:

- **Section 2** presents details on the Phase One survey, including a summary of the results and an evaluation of the Phase One survey against conformance with the Ministerial Conditions;
- **Section 3** details the verification of minimum airgun array configuration for the Phase One survey;
- **Section 4** details the Final AMP trigger values and a framework of associated operational responses for the Phase Two survey; and
- **Section 5** details the Phase Two Marine Faunal Observations.

# 2 Phase One Survey

## 2.1 Introduction

This section presents details on the Phase One survey along with an explanation of the treatment of data and a summary of Phase One survey.

Phase One survey was conducted according to the requirements of the Draft AMP, which was approved by the WA Department of Environment and Conservation (DEC), on advice of WA Department of Fisheries (DoF) and the WA Department of Industry and Resources (DoIR). The initial stages of scoping the adaptive management concept for Maxima 3D MSS involved Government as well as non-Government organisations, such as World Wildlife Foundation (WWF), Pennsylvania State University and Curtin University.

Comment and feedback during the drafting of methodologies and other components of the Draft AMP was provided by a range of Government organisations, including:

- WA DEC (specifically the EPA Service Unit, the Environmental Management Branch in the Conservation Division and the Marine Ecosystems Branch);
- WA DoF;
- WA DoIR;
- WA Museum;
- Commonwealth Department of Environment and Water Resources (DEW); and
- Australian Institute of Marine Science (AIMS).

### 2.1.1 Survey Details

The Phase One survey was undertaken between the 15th to the 19th September 2007. A 2055 cubic inch airgun array was employed during the Phase One survey, which is the array that will be utilised during Phase Two of the survey (See **Section 3**). The shot point interval was 18.75m. Details on the minimum airgun array configuration to be used for the Phase Two survey are presented in **Section 3**.

Overall, the results from the Phase One survey indicate that the impacts that may occur during Phase Two are less than those predicted in the Environmental Protection Statement (EPS) and that the environmental conditions for the survey can be met.

Health and safety constraints for safe navigation of the seismic survey vessel resulted in a restriction to the proximity exposure cages containing fish could be placed in relation to the seismic airgun. This was triggered by the need to place exposure cages in depths shallower than planned due to barotraumas seen in fish during testing of the deployment of cages prior to the control and baseline experiments. As a result, the closest cage was placed approximately 45 metres from the centre line of the seismic airgun pass, in approximately five metres of water. At this point, cumulative sound exposure levels (SEL) were measured at 189 dB re 1µPa2.s. Cages placed further from the airgun line pass received lower cumulative SELs. No impacts associated with any of the impact categories defined in **Table 3** were observed in any fish in any of the cages.

### 2.1.2 Study Team

A significant amount of resources were required to execute the work summarised in this document. Highly respected scientific institutions and researchers in the field of underwater acoustics and fish biology were engaged to conduct the environmental investigations documented in this report.

Woodside utilised the services of its principle environmental consultant, SKM – ERM, to coordinate the scientific components of the environmental program. Specialists were sub-contracted to ensure robust methodologies and analysis techniques were employed to meet the objectives of the adaptive management conditions associated with the approval of the Maxima 3D MSS. Key members of the scientific, operations and survey management are presented in this section.

Particular mention should be made of the vessel masters and crew from the following vessels who assisted with various aspects of the environmental monitoring and completed the program successfully and without any health or safety incidents:

- Kimberley Quest I (operated by Pearl Sea Coastal Cruises);
- Veritas Voyager (operated by CGG-Veritas);
- M/V Empress (operated by Empress Marine);
- Mary V (operated by Oceanic Offshore);
- M/V First Class (operated by Bhagwan Marine);
- M/V Sea Sprint (operated by TUCF);
- M/V Pacific Crest (operated by OMS Australia); and
- OMS Voyager (operated by OMS Australia).

| Name | Role |
|---|---|
| **Woodside** | |
| Craig Williams | Operations Geophysicist, Field Coordinator Phase One |
| Rob Hearn | Fish collection, adaptive management program environmental support |
| Cameron Grebe | Approvals coordination, adaptive management program design (Perth) |
| James Eu | Diving supervisor |
| Mark Taylor | Senior Geophysicist (Perth) |
| Ralph Weiss | Project Manager (Geophysics Operations, Maxima) (Perth) |
| Jeremy Fitzpatrick | Senior Geophysicist (Perth) |
| Cher Gibellini | External communications (Perth) |
| Rebecca Sermon | Logistics support & administration (Perth) |
| Ben Godwin, Paul Round | Onboard Client Representative (on Veritas Voyager) |
| **Woodside – Blue Planet Marine** | |
| Stephen Robey, David Donnelly and Simon Childerhouse | Marine fauna observations |
| **Woodside – Pearl Sea Coastal Cruises** | |
| Lynne Ralston | Broome logistics & personnel support , Kimberley Quest (Broome) |
| **Australian National University** | |
| James Fox | Indonesian translation, consultation and Indonesian fishing activities data gathering |
| **SKM-ERM** | |
| Craig Reid | AMP/FMP Coordinator, Environment Studies Coordinator |
| Paul de Lestang | Fish collection, invasive species |
| Denise McCorry | Coral monitoring & field coordination |
| Steve Marns & Derek Dufall | Fish collection and husbandry support |
| Tim Harriden, Dave Kozak, Terry Carr | Diving and fish collection |
| Russell Hurley | Dive Medical Technician |
| Mark Lorkin | Project Director SKM-ERM (Perth) |
| David Evans | Project Manager ERM (Perth) |
| Martin Heller | Project Manager SKM (Perth) |
| **SKM-ERM – Australian Institute of Marine Science** | |
| Chris Battershil | Senior Supervising Scientist |
| Marcus Stowar | Baited remote underwater video (BRUVS) |
| Jamie Colquhuon, Damien Jorgensen | Coral damage monitoring and remote underwater video |
| Tim Cooper, Tim Hyndes, Ian Miller, Alistair Cheal & Chris Robertson | Fish behaviour monitoring (baseline) – diving and BRUVS |
| **SKM-ERM – Curtin Marine Science and Technology** | |
| Rob McCauley, Chandra Salgado-Kent & Malcolm Perry | Noise logging, sound exposure modelling & calculation, auditory brain stem response (ABR) chamber assistance |
| **SKM-ERM – Pennsylvania State University** | |
| Mardi Hastings & Jennifer Miksis-Olds | Fish hearing sensitivity, auditory brainstem response & auditory threshold identification |
| **SKM-ERM – NT Department of Fisheries** | |
| John Humphries | Fish pathologist |

## 2.2 Specific Objectives

As described in **Section 1.4**, the Phase One survey consisted of a preliminary survey at Scott Reef to trial the proposed seismic survey vessel and airgun array to be used for the Phase Two survey. In order to verify whether the proposed equipment would allow Phase Two operations to be completed in compliance with the Ministerial Conditions, a Draft AMP was developed. The purpose of the Draft AMP was to test the proposed equipment against a series of trigger levels based on specific monitoring objectives. These were as follows:

1) To monitor and report on the SELs as a result of airgun emissions from the Phase One survey to ensure compliance with condition 6-5;
2) To monitor and report on any faunal mortality from the Phase One survey to ensure compliance with condition 6-6;
3) To monitor and report on any coral damage as a result of airgun emissions from the Phase One survey to ensure compliance with condition 6-7; and,
4) To monitor and report on specific acoustic impacts to fish as a result of airgun emissions from the Phase One survey to ensure compliance with condition 6-5
5) To undertake a verification exercise to determine the minimum airgun capacities required for data acquisition and use in Phase Two to ensure compliance with condition 5-2; and
6) To allow the development of defined and measurable trigger values and a framework of associated operational responses for the Final AMP for Phase Two of the survey to ensure compliance with condition 7-4.

The results of each of monitoring objectives 1 to 4 are presented in the following sections, along with the key overarching objective. Objective 5 is reported in **Section 3** and Objective 6 is discussed further in **Section 4**.

Details on the design and methodology of each monitoring objective are provided in the Draft AMP (Woodside, 2007c).

## 2.3 Overarching Objective

### 2.3.1 Objective

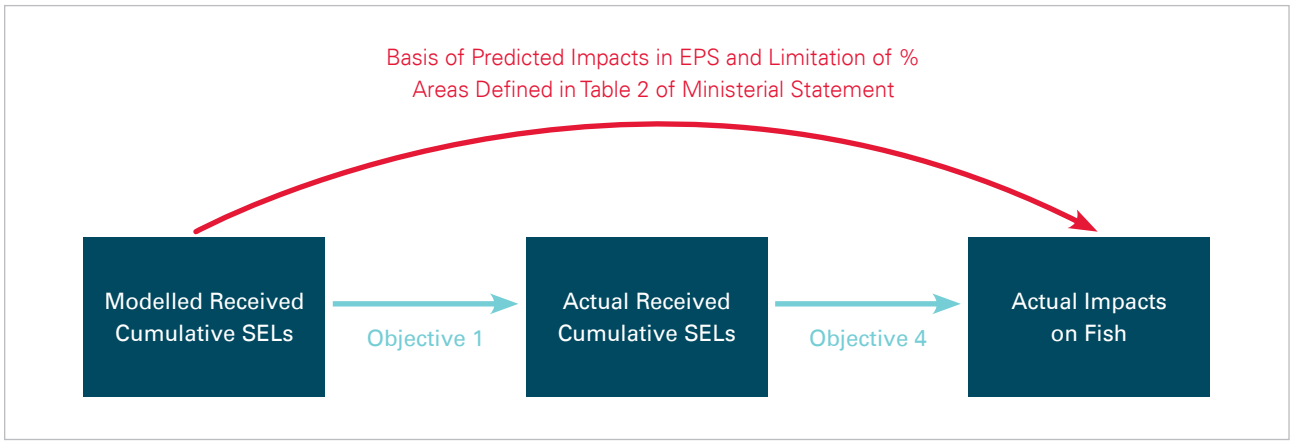
The key overarching objective of the Draft AMP was to determine whether areas exposed to various predicted impacts fall within allowable limits as required by Ministerial Condition 6-5. The EPS (Woodside, 2007) assessment of potential for impacts on site attached fishes was based on a predicted relationship between (modelled) sound exposure levels (SEL, in dB re 1µPa2.s) and actual impacts on fish. Due to the limited amount of published data on impacts from actual SELs, the AMP was designed to include an investigation of the relationship between:

- Modelled SELs and actual SELs; and
- Actual SELs and fish impacts from both single and repeat lines.

The overarching hypothesis tested was therefore:

$IH_1$ *In accordance with Ministerial Condition 6-5, the percentage areas of each habitat type exposed to SELs from acoustic emissions from airguns discharged along a single and repeat seismic survey sail lines that cause category 1, category 2 and category 3 impacts, will not exceed the percent areas presented in Table 2 of the Ministerial Statement by more than five per cent.*

This hypothesis was tested via two specific monitoring objectives, as illustrated below:



Where:

- Objective 1 is for the purpose of investigating if the received cumulative SELs, verified through Objective 4, are comparable to those predicted to occur as a result of seismic operations; and
- Objective 4 is for the purpose of investigating the relationship between actual received SELs and the impacts on fish exposed to airgun emissions from both single and repeat seismic survey sail lines.

### 2.3.2 Results

Based on the results discussed in **Sections 2.4** and **2.7**, the predicted total percentage areas of each mapped habitat within each impact category are within five per cent of predicted levels.

### 2.3.3 Compliance Testing

Based on the results of the Objective 1 and Objective 4, the null hypothesis is accepted. No changes to the airgun array or shot point interval used during the Phase One survey are thus considered to be required for the Phase Two survey in order to achieve compliance with Condition 6-5 of the Ministerial Conditions.

## 2.4 Objective 1 - Sound Exposure Level (SEL) Mapping

### 2.4.1 Objective

The objective of the SEL Mapping was to determine if the relationship between modelled and actual received cumulative SELs would result in any exceedances greater than five per cent of the total percentage areas of each mapped habitat predicted to receive cumulative sound exposure levels equivalent to the three noise categories. This is critical in linking the impacts associated with each category to mapped habitat exposures for each of the impacts. To meet this objective, cumulative SELs were monitored during the Phase One survey within separate habitats predicted to be exposed to one of each of the three impact categories for verification of the transmission loss model. The model was calibrated against these measured values and the cumulative SELs for each impact category utilised to calculate the areas of habitat that contain fish experiencing impacts for each category.

The results have been used to develop Final AMP trigger values to ensure that the Phase Two survey will be compliant with condition 6-5 of the Ministerial Conditions (Government of Western Australia, 2007) (see **Section 4**).

Table 1 Total areas and predicted percentages of benthic habitats in State Waters exposed to the three levels of impacts as defined in Table 2.

| Benthic Habitat Type | Total Habitat Area ($km^2$) | Predicted Percentages of total habitat areas exposed to the three levels of impacts as defined in Table 2 – State Waters Only | | |
|---|---|---|---|---|
| | | Percentage area exposed to impacts above the threshold for category 1 | Percentage area subject to impacts above the threshold for category 2 | Percentage area subject to category 3 impacts |
| | | % | % | % |
| Deeper-Water High Diversity | 16.38 | 50 | 44 | 9 |
| Deep-Water Coral Assemblage | 64.21 | 46 | 39 | 8 |
| Deep-Water Foliaceous Coral | 49.77 | 27 | 23 | 3 |
| Reef Slope | 35.87 | 14 | 1 | 0 |
| Deep-Water Outcrops | 3.21 | 8 | 6 | 1 |
| Reef Flat | 85.70 | 1 | 0 | 0 |
| All other benthic habitat type not included above | 74.10 | 0 | 0 | 0 |
| Total | 329.24 | | | |

### 2.4.2 Hypotheses

The impact hypothesis for the monitoring was as follows:

$IH_1$ *The relationship between modelled and actual received sound exposure levels associated with airgun emissions do not result in any exceedances greater than five per cent of the total percentage areas of each mapped habitat predicted to receive cumulative sound exposure levels equivalent to the three noise categories.*

Based on the above, the following null hypothesis was tested:

$H_0$ *The relationship between modelled and actual received SELs ensures that the areas exposed to cumulative sound exposure levels within one metre of the sea floor equivalent to category 1, category 2 and category 3 are not more than five percent greater than the predicted total percentage areas for each habitat in State Waters as defined in Table 1.*

### 2.4.3 Results

SELs were measured before, during and after exposure to airgun emissions during the Phase One survey. All monitoring was conducted in accordance with the methodology presented in the Draft AMP.

The results of the SEL Mapping have been summarised in proformas completed during the Phase One survey (Appendix A). As specified in the Draft AMP, ranges of cumulative SELs have been verified through both monitoring of sound exposure levels observed during the Phase One survey and impacts in fish as per Objective 4.

The results of Objective 4 are discussed in **Section 2.8**. It is important to note from these results that no impacts were recorded in any of the fish cage experiment trials, as per those predicted to have the potential to occur in **Table 2** of the Ministerial Conditions. Nevertheless, in order to provide a conservative approach in the prediction of percentage areas of each mapped habitat area exposed to airgun emissions during the Phase Two survey, it is considered appropriate to apply the cumulative SEL ranges presented in the table below for the SEL Mapping.

These values have been derived by specific advice from Dr. Mardi Hastings, confirmed by Dr. Rob McCauley, who are both involved with the field components of Phase One:

> "Rob McCauley and I have discussed the use of a difference of 3 dB to discriminate between different impact categories. We agree that 3 dB is equivalent to a doubling of the sound exposure (or intensity) on a linear scale, and that a minimum difference of 3 dB would be needed to differentiate an effect caused by exposure to sound. The 3DB demarcation can be applied to effects on behaviour, auditory sensitivity, auditory tissue, and non-auditory tissues."
>
> (Email from Hastings, M, 19th September 2007)

Table 2 Sound Exposure Levels for SEL Mapping

| Impact category | Range of Cumulative Sound Energy Levels *(over single seismic line sequence)* predicted to cause each level of impact (dB re 1 µPa².s) | | Impacts associated with each category as a result of exposure to air gun emissions from a single seismic line or from adjacent planned and infill seismic lines |
|---|---|---|---|
| | Predicted Sound Exposure Levels | Sound Exposure Level for SEL Mapping | |
| 1 | 180 to <187 | 192 to <195 | No impacts observed in any fish exposed to a cumulative SEL of 189 dB re 1 µPa².s. In order to see a change in auditory sensitivity a minimum increase of 3 dB re 1 µPa².s, which indicates a doubling of sound exposure on a linear scale, would be required. As such, 192 dB re 1 µPa².s is considered appropriate for the lower bound end of the range for Category 1 SEL Mapping. |
| 2 | 187 to <200 | 195 to <200 | In the absence of any evidence to prove otherwise, the Sound Exposure Level should be applied as close as possible to the predicted range. However, as the predicted SEL range has been proven to be incorrect for Category 2, an increase of 3 dB re 1 µPa².s above the lower bound end of the range for Category 1 SEL Mapping has been applied for Category 2 SEL Mapping. |
| 3 | ≥ 200 | >200 | In the absence of any evidence to prove otherwise, the Sound Exposure Level should be applied as close as possible to the predicted range. As the Category 3 range has not been proven to incorrect, the original predicted range is considered appropriate to apply. |

Using the values in **Table 2**, the total percentage areas of each mapped habitat predicted to receive cumulative sound exposure levels, i.e. sum of energy received from all seismic survey signals, equivalent to the three impact categories was tested in two ways: a spatial modelling approach for impact category 1 and a comparison with the typical swath width for impact categories 2 and 3. The modelling followed a similar approach to that presented in the EPS (Woodside, 2007), however, incorporated a correction factor based on the findings of the actual SELs received at the underwater acoustic loggers deployed during the Phase One survey. This correction factor was derived through a comparison of the predicted airgun signal levels for the appropriate airgun array orientation and receiver depth and that of measured values. The correction factor was calculated for different ranges/levels and applied when predicting received levels on a spatial grid.

The results of this validated modelling indicated that the distances presented in **Table 3** would be the maximum range at which the cumulative SEL would be reached within one metre of the seabed for a receiver (fish) depth typical of that in the south reef lagoon. In water depths greater than that of the lagoon, the distances given in **Table 3** would be expected to be lower, i.e. these levels would occur at distances closer to the shot point.

The results of the SEL Mapping calculations for impact category 1 are presented in Appendix C, which shows the comparison of 189 dB re 1 µPa2.s instead of 192 dB re 1 µPa2.s to illustrate that compliance with the five per cent exposure would be achieved with an even lower threshold than that inferred in **Table 2** above.

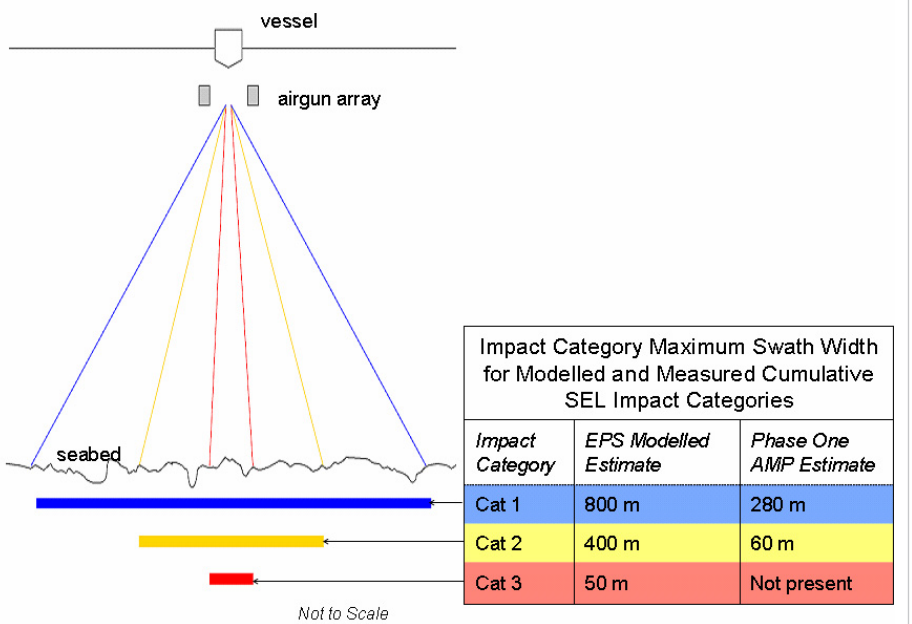
In addition, **Figure 2** clearly illustrates that the areas that would be exposed to each of the impact categories derived during the Phase One of the survey are significantly below those predicted in the EPS. Significantly, Category 3 impact category is absent as there are no areas that would receive cumulative sound energy levels above 200 dB re 1 $\mu Pa^2$.s during the Phase Two survey. In fact, the calibrated modelling identified a maximum SEL of only 196 dB re 1 $\mu Pa^2$.s.

Based on these results, the predicted total percentage areas of each mapped habitat within each impact category are well within five per cent of predicted levels.

Table 3 Maximum Distance of Sound Exposure Levels (SELs) Within One Metre Above the Seafloor Based on Phase One Survey Validated Transmission Loss Modelling

| Cumulative Sound Exposure Level (SEL) (dB re 1 $\mu Pa^2$.s) | Maximum Distance from Shot Point (m) at one metre above the seafloor |
|---|---|
| 187 | 880 |
| 189 | 500 |
| 192 | 140 |
| 195 | 30 |
| 200 | Not reached |

Figure 2 Cross Section View of Typical Swath Width for Each Impact Category




Impact Category Maximum Swath Width for Modelled and Measured Cumulative SEL Impact Categories

| *Impact Category* | *EPS Modelled Estimate* | *Phase One AMP Estimate* |
|---|---|---|
| Cat 1 | 800 m | 280 m |
| Cat 2 | 400 m | 60 m |
| Cat 3 | 50 m | Not present |

### 2.4.4 Compliance Testing

Based on the results of the SEL Mapping, the null hypothesis is accepted. No changes to the airgun array or shot point interval used during the Phase One survey are thus considered to be required for the Phase Two survey in order to achieve compliance with Condition 6-5 of the Ministerial Conditions.

## 2.5 Objective 2 - Monitor Faunal Mortality

### 2.5.1 Objective

The objective of the faunal mortality monitoring was to confirm that faunal mortality, other than pelagic fish eggs and larvae within ten metres or the airgun array or those required for the research purposes, did not occur during the Phase One survey at South Scott Reef.

The results have been used to develop Final AMP trigger values to ensure that the Phase Two survey will be compliant with condition 6-6 of the Ministerial Conditions (Government of Western Australia, 2007) (see **Section 4**).

### 2.5.2 Hypotheses

The impact hypothesis for the faunal mortality monitoring was as follows:

$IH_1$ *Airgun emissions do not result in faunal mortality, other than pelagic fish eggs and larvae within ten metres of the airgun array.*

Based on the above, the following null hypothesis has been tested:

$H_0$ *There is no difference in faunal mortality, other than those that could be expected with pelagic fish eggs and larvae within ten metres of the airgun array, before and after airgun emissions.*

### 2.5.3 Results

Baseline and Impact faunal mortality monitoring was conducted during the Phase One survey. All monitoring was conducted in accordance with the methodology presented in the Draft AMP. In addition to the observational monitoring, any mortality from the fish cage experiments for Objective 4 was also recorded.

The results of the faunal mortality monitoring are presented in the proformas completed during the Phase One survey (**Appendix A**). Based on these results, no faunal mortality observed through the monitoring could be reasonably attributed to airgun emissions.

### 2.5.4 Compliance Testing

Based on the results of the faunal mortality monitoring, the null hypothesis is accepted. No changes to the airgun array or shot point interval used during the Phase One survey are thus considered to be required for the Phase Two survey in order to achieve compliance with Condition 6-6 of the Ministerial Conditions. Further monitoring for fauna mortality will continue during Phase Two of the survey as described in **Section 5**.

## 2.6 Objective 3 – Coral Damage Monitoring

### 2.6.1 Objective

The objective was to confirm that damage to coral habitats as a result of airgun emissions during the Phase One survey at South Scott Reef was avoided.

The results have been used to develop Final AMP trigger values to ensure that the Phase Two survey will be compliant with condition 6-7 of the Ministerial Conditions (Government of Western Australia, 2007).

### 2.6.2 Hypotheses

The impact hypothesis for the monitoring was as follows:

$IH_1$ *Airgun emissions do not damage corals within State Waters at South Scott Reef.*

Based on the above, the following null hypothesis has been tested:

$H_0$ *There is no more than five per cent difference in countable broken coral colonies per frame between those collected before and that after exposure to airgun emissions.*

### 2.6.3 Results

The results of the coral damage monitoring are presented in the proformas completed during the Phase One survey (Appendix A). Coral damage measured as recently exposed skeleton (white scars/breakage) for the two predominant coral growth forms (plating and branching) of the deep lagoonal coral community investigated was negligible, both, before and after the airgun emissions and for both the seismic and control areas. Based on these results, no coral damage observed through the monitoring was attributed to airgun emissions.

### 2.6.4 Compliance Testing

Based on the results of the coral damage monitoring, the null hypothesis is accepted. No changes to the airgun array or shot point interval used during the Phase One survey are thus considered to be required for the Phase Two survey in order to achieve compliance with Condition 6-7 of the Ministerial Conditions.

## 2.7 Objective 4 – Verification of Specific Acoustic Impacts to Fish

### 2.7.1 Objective

The main objective of this task was to verify the sound exposure levels where impact categories occur (**Table 4**).

A secondary objective of this task was to confirm the Temporary Threshold Shift (TTS) recovery time for category 1 impacts, in accordance with condition 5-7 as follows:

"For the duration of phase Two of the Maxima 3D MSS, the proponent shall ensure that the maximum temporary threshold shift recovery time defining category 1 impacts (refer to **Table 2**) is no greater than the minimum time interval between sail lines of seismic shots within horizontal distances of 800 metres and 400 metres as outlined in conditions 5-5 and 5-6 and shall ensure that the maximum temporary threshold shift recovery time defining category 1 impacts, and the minimum time interval between sail lines of seismic shots are both greater than or equal to six hours."

The results have been used to develop Final AMP trigger values to ensure that the Phase Two survey will be compliant with condition 6-5 of the Ministerial Conditions (Government of Western Australia, 2007).

### 2.7.2 Hypotheses

The impact hypothesis for this task was as follows:

$IH_1$ *The relationship between actual received SELs and impacts on fish associated with airgun emissions from single or repeat seismic survey sail lines does not result in any exceedances greater than five per cent of the total percentage areas of each mapped habitat predicted to receive cumulative sound exposure levels equivalent to the three impact categories.*

Based on the above, the following null hypothesis has been tested:

$H_0$ *The relationship between sound exposure levels and observed impacts to fish within each impact category ensures that the areas exposed to cumulative sound exposure levels within one metre of the sea floor equivalent to category 1, category 2 and category 3 are not more than five per cent greater than the predicted total percentage areas for each habitat in State Waters as defined in Table 1.*

Table 2 Impact Categories - Fish

| Impact category | Range of Cumulative Sound Energy Levels *(over single seismic line sequence)* predicted to cause each level of impact (dB re 1 $\mu Pa^2.s$) | Impacts associated with each category as a result of exposure to air gun emissions from a single seismic line or from adjacent planned and infill seismic lines |
|---|---|---|
| 1 | 180 to <187 | • Temporary threshold shift from which at least 98 per cent of fish recover within six hours or the time interval greater than six hours, determined in accordance with conditions 5-7.<br>• No non-auditory tissue damage.<br>• No direct mortality. |
| 2 | 187 to <200 | • Temporary threshold shift from which fish may not recover within six hours or the time interval greater than six hours, determined in accordance with conditions 5-7.<br>• Permanent threshold shift.<br>• Non-auditory tissue damage unlikely, (less than five per cent of any fish population exhibiting non-auditory tissue damage.<br>• No direct mortality. |
| 3 | Equal to or greater than 200 | • Temporary threshold shift.<br>• Permanent threshold shift.<br>• Possible injury to non-auditory tissues.<br>• No direct mortality. |

### 2.7.3 Results

Verification of specific acoustic impacts to fish was monitored as part of the Phase One survey. All monitoring and test procedures were conducted in accordance with the Draft AMP.

All fish used in the tests were caught at Scott Reef with the following species used in the experiments:

- Species 1
  Blue green damselfish (a Pomacentrid) (*Chromis viridis*)
  (Non-fleeing, non-hearing specialist)
- Species 2
  Bluestripe Seaperch *(Lutjanus kasmira*)
  (Fleeing, non-hearing specialist)
- Species 3
  Sabre Squirrelfish (a Holocentrid) (*Sargocentron spiniferum*)
  (Non-fleeing, non-hearing specialist)
- Species 4
  Pinecone Soldierfish (a Holocentrid) (*Myripristis murdjan*)
  (Non-fleeing, hearing specialist)

In addition to the above, a selection of alternative Holocentrid species were collected and tested, however due to limited overall numbers the four species above were selected for assessment purposes.

The results of the verification of impacts to fish are presented in the proformas completed during the Phase One survey (Appendix A). Based on the results, no impacts to fish were observed within the fish located in each of the three exposure cages (**Table 5**).

As verified in the results of Objective 1, none of the above ranges of sound exposure levels result in the percentages of total habitat area exposed to each impact category to be greater than five percent of that predicted (see **Section 2.2**).

### 2.7.4 Compliance Testing

Based on the results of the monitoring for Objective 4, the null hypothesis is accepted. No changes to the airgun array or shot point interval used during the Phase One survey are thus considered to be required for the Phase Two survey in order to achieve compliance with Condition 6-5 of the Ministerial Conditions.

In addition to the above, based on the results of the monitoring for Objective 4, there is no indication to increase the minimum time interval of six hours between sail lines of seismic shots within horizontal distances of 800 metres and 400 metres.

## 2.8 Conformance of Ministerial Conditions

The results of the Phase One survey were analysed upon completion of the monitoring tasks. The focus of the analyses was to evaluate whether the null hypotheses for each task had been accepted thereby confirming that the airgun array and seismic acquisition equipment employed during the Phase One survey would meet the Ministerial Conditions (Government of Western Australia, 2007).

In order to satisfy the above, evaluation of the monitoring was undertaken through the completion of the monitoring proformas. The completion of the proformas has allowed compliance checking against trigger values for each objective under the Draft AMP, and thereby determines whether operational modifications are necessary for the Phase Two survey at Scott Reef.

A summary of the findings of the Phase One survey is presented in **Table 6**.

Table 5 Impacts Observed at Fish Cages during Phase One

| Exposure Cage | Cumulative SELs recorded at fish cages (dB re 1 μPa$^2$.s) | Observed impacts associated with each category as a result of exposure to airgun emissions from a single seismic line or from adjacent planned and infill seismic lines |
|---|---|---|
| 1 | 183 | • No Temporary Threshold Shift<br>• No non-auditory tissue damage<br>• No direct mortality |
| 2 | 187 | • No Temporary Threshold Shift[a]<br>• No non-auditory tissue damage<br>• No direct mortality |
| 3 | 189 | • No Temporary Threshold Shift[a]<br>• No non-auditory tissue damage<br>• No direct mortality |

Note: [a] As no TTS data were collected on Species 1- Damselfish (*Chromis viridis*) and Species 2 -Sea Perch (*Lutjanus kasmira*) within the 0-6 hour period, it is considered reasonable to assume that the findings of the hearing specialist, i.e. Species 4 Holocentrid (*Myripristis murdjan*), could be applied to these non-hearing specialist fish.

Table 3 Trigger Values for Draft AMP

| Monitoring Objective | Null Hypothesis | Trigger Value | Null Hypothesis Accepted / Rejected | Conformance with Ministerial Conditions |
|---|---|---|---|---|
| Objective 1 - SEL Mapping | The relationship between modelled and actual received SELs ensures that the areas exposed to cumulative sound exposure levels within 1 metre of the sea floor equivalent to category 1, category 2 and category 3 are not more than five per cent greater than the predicted total percentage areas for each habitat in State Waters as defined in Table 1. | Rejection of Null Hypothesis | Accepted | Conformance with Condition 6-5 |
| Objective 2 – Faunal Mortality Monitoring | There is no difference in total mortality of reptiles or marine mammals before and following seismic operations.<br>There is no difference in total mortality of fish, other than those that could be expected with pelagic fish eggs and larvae. | Rejection of Null Hypothesis<br>Rejection of Null Hypothesis | Accepted<br>Accepted | Conformance with Condition 6-6<br>Conformance with Condition 6-6 |
| Objective 3 – Coral Damage Monitoring | There is no more than five per cent difference in countable broken coral colonies per frame between those collected before and that after exposure to airgun emissions. | Rejection of Null Hypothesis | Accepted | Conformance with Condition 6-7 |
| Objective 4 - Verification of Specific Acoustic Impacts to Fish | The relationship between sound exposure levels and observed impacts to fish within each impact category ensures that the areas exposed to cumulative sound exposure levels within one metre of the sea floor equivalent to category 1, category 2 and category 3 are not more than five per cent greater than the predicted total percentage areas for each habitat in State Waters as defined in Table 1. | Rejection of Null Hypothesis | Accepted | Conformance with Condition 6-5 |

In summary, the results of the Phase One survey has allowed the proposed airgun configuration proposed to be used in the Phase Two survey to be tested for compliance with the Ministerial Conditions 6-5, 6-6 and 6-7. The findings have indicated that no trigger levels of any of the Phase One survey monitoring objectives would be exceeded and as such, conformance with the relevant Ministerial Conditions can be met for Phase Two.

# 3 Verification of Minimum Airgun Array Configuration for Phase Two Survey

As a commitment to minimise environmental impact WEL committed in the EPS (Woodside 2007b) to using the smallest airgun array configuration that delivers acceptable seismic data acquisition. The assessment in the EPS was based on a 3255 cubic inch airgun array and WEL made commitments during the final submission of the EPS to utilise an airgun array below 3000 cubic inches. In accordance with condition 5-2 of the Ministerial Conditions, a preliminary survey was also required to determine the minimum airgun capacities required for seismic acquisition:

> 5-2 Prior to the commencement of phase II (see note 2) of the Maxima 3D Marine Seismic Survey, the proponent shall conduct preliminary surveys to determine minimum air gun capacities required for seismic data acquisition and shall use these minimum levels for all seismic data acquisition during phase II of the Maxima 3D Marine Seismic Survey. At no time shall air gun arrays with a combined capacity greater than 3000 cubic inches be discharged.

In order to satisfy this requirement, a preliminary survey was completed as follows:

1) The survey vessel Veritas Voyager acquired a single transect within the approved acquisition area for the Calliance 3D Marine Seismic Survey (Calliance 3D MSS); within exploration permit WA-275P and retention lease WA-28R. The transect selected is located in open water approximately 80 kilometres south of Scott Reef and data was acquired using the full array of seismic acquisition equipment (i.e. four streamers and two source arrays).

   The prime-line acquisition during the single transect utilised the full 3255 cubic inch airgun array configuration, which is the approved source array size for the Calliance 3D MSS. While this array size exceeds the maximum size allowable for the Maxima 3D MSS, it is the standard array for this survey vessel and is also the basis for the SEL modelling included in the Maxima EPS. As such, it is a representative base case for evaluation of alternative source arrays. The testing program and the specific location of the test line segment were selected because:

   - approval to acquire data in the Calliance 3D MSS area had been granted by DoIR;
   - the activity could be performed away from the spatial and temporal confines of other Phase One activities in the south Scott Reef lagoon;
   - the activity allowed confirmation of the minimum source array size prior to the exposure testing discussed in **Section 2** above;
   - the water depth and depth to the subsurface objective are similar to the bulk of the deeper-water portion of Maxima; and
   - as outlined above, the full 3255 cubic inch array could be used as a base case.

   An additional benefit was a reduction in potential impacts at Scott Reef during Phase One.

2) An 11 kilometre long segment of the test line (600 shots) was subsequently re-shot using two smaller source array configurations (2580 cubic inch and 2055 cubic inch arrays). The smaller of these (2055 cubic inch capacity) is the smallest tuned source array configuration available for use by the Veritas Voyager.

3) Seismic data from the test segment for all three source array configurations was processed aboard the survey vessel and transmitted to Perth for analysis. All three array sizes resulted in acceptable seismic data quality although, as expected, there was a slight decrease in energy penetration with decreasing array size. The preliminary field survey then commenced at south Scott Reef as described in **Section 2** of this document, utilising the 2055 cubic inch array.

4) Following completion of the preliminary field survey fish exposure tests within the south Scott Reef lagoon, the Veritas Voyager deployed its full array of seismic acquisition equipment and recorded a single transect using the 2055 cubic inch source array configuration (i.e. using the same specifications planned for the Phase Two survey). This transect was located within the Maxima 3D MSS survey area in both State and Commonwealth Waters and was selected to verify that the array configuration produced acceptable seismic data quality across a range of water depths and seafloor conditions representative of the survey area. Seismic data from the verification line was processed aboard the survey vessel and transmitted to Perth for analysis. Seismic data quality was considered to be acceptable and confirmed the results of minimum airgun array tests conducted in the Calliance area.

The detail supporting the conclusions of the preliminary survey is presented in **Appendix B**. Based on these results discussed above, the minimum airgun configuration required for the Phase Two survey is as follows:

- Airgun Array: 2055 cubic inches
- Shot Point Interval: 18.75 metres

The above airgun configuration will thus be employed for the Phase Two survey.

# 4 Final Adaptive Management Program Trigger Values, Operational Responses and Responsible Personnel

## 4.1 Introduction

The following section presents the trigger values and operational responses of the Final AMP for the Phase Two survey. Personnel responsible for the implementation of these operational responses are also presented.

## 4.2 Final AMP Trigger Values

The Phase One survey has verified that the airgun configuration, i.e. airgun array and source point interval, to be used during the Phase Two survey does not exceed the Draft AMP trigger values (see **Section 2** and **3**). As a consequence, the Final AMP trigger values are based on compliance checking that the airgun array and source point interval does not exceed that to which has been proven to be acceptable.

Such an approach is considered to be appropriate due to:

- The fixed nature of the source of impact: Seismic surveys require airgun discharges with precise sound pressure characteristics. This requires the operation of finely tuned sophisticated equipment that has a limited potential for output variability;
- The consistency of the impact pathway: The SELs that marine fauna are exposed to will not change as a result of factors external to the configuration of the seismic airgun array. Potential changes in environmental conditions, such as may be encountered during a monitoring program for other marine operations, are not able to affect the impact pathway associated with acoustic effects on marine animals. For example, the actual effects of dredging programs can differ from predicted effects if environmental factors, such as currents, change. In contrast, the SEL associated with seismic airgun discharges will not vary with environmental conditions. Therefore the SELs verified through the Phase One survey can be seen as valid for the whole survey. No further monitoring of received SELs, fish behavioural or damage to auditory systems, etc is therefore considered necessary during the Phase Two survey. As such, variations in sound exposure levels experienced in the marine environment, and hence biological responses, over and above those predicted to occur can safely be predicted to not occur as long as the seismic equipment operates within the approved specifications.

On this basis, the following trigger values will be employed for the Final AMP for the Phase Two survey.

### Trigger Value A – Airgun Array

- The average deviation (AvDev) in the ten to 70 Hz band-width from the spectrum of the full array shall not exceed ±3.0 dB; and,
- At any frequency in the range ten to 70 Hz the spectral value in dB shall deviate by no more than "3.0+AvDev" dB from the amplitude of the full array at the same frequency.

Compliance with Trigger Value A will ensure the power level of the source array over the frequency range specified does not vary by more than the accepted amount from shot to shot. As such, sound exposure levels would not be expected to increase above that proven to be acceptable in the Phase One survey. No adverse biological impacts are therefore expected to occur should the Phase Two survey be compliant with Trigger Value A.

### Trigger Value B – Source Positioning

- The spatial separation between adjacent shots shall not deviate from the proposed shotpoint separation by any distance greater than 6 metres.

Compliance with Trigger Value B will ensure that the source separation between adjacent shots along a line will be kept within a distance known not to increase the potential sound exposure level above that proven to be acceptable in the Phase One survey. No adverse biological impacts are therefore expected to occur should the Phase Two survey be compliant with Trigger Value B.

## 4.3 Operational Responses

Any non-compliance with Trigger Values A and B will result in an implementation of the actions described in **Table 4**. If operations are shut down, they will only recommence following verification that the survey can continue in a manner compliant with conditions 6-5, 6-6 and 6-7 of the Ministerial Conditions.

Communication pathways for the exceedance of a trigger value during the Phase Two survey are also presented in **Table 4**. Responsibilities of Woodside, the Seismic Survey Contractor and specific positions within these organisations are defined in **Section 4.4**.

Table 4 Actions and Communication Pathways for Exceedance of Trigger Value during Phase Two Survey

| Trigger | Action | |
|---|---|---|
| | Onboard Client Representative (Woodside) | Project Manager (Woodside) |
| A Single Trigger Value Exceeded | 1. Inform Project Manager (Woodside);<br>2. Check seismic survey equipment and report on cause of exceedance;<br>3. Rectify unacceptable practice if identified. | 1. Seek clarification from Onboard Client Representative to determine the cause of the exceedance;<br>2. Request the Onboard Client Representative to work with the Party Manager (CGG Veritas) and Vessel Master to critically review methods;<br>3. Make agreement on the measures to be implemented to minimise re-occurrence of exceedance. |
| More than One Trigger Value Exceedance Within a 24 Hour Period | 1. Instruct Party Manager (CGG Veritas) to immediately power down the airgun array and commence investigation;<br>2. Inform Project Manager (Woodside);<br>3. Check seismic survey equipment and report on cause of exceedance;<br>4. Rectify unacceptable practice if identified;<br>5. Restart works only once equipment has been modified to meet agreed Phase Two specifications. | 1. Notify DEC, DoIR, DoF and DEW;<br>2. Seek clarification from Onboard Client Representative to determine the cause of the exceedance;<br>3. Request the Onboard Client Representative to work with the Party Manager (CGG Veritas) and Vessel Master to critically review methods;<br>4. Make agreement on the measures to be implemented to minimise re-occurrence of exceedance. |

## 4.4 Responsible Personnel

The roles and responsibilities of the various parties involved in the Phase Two survey are discussed in detail in the EP for the Maxima 3D MSS (Woodside 2007a). Additional responsibilities pertinent to the adaptive management required under this Program are presented in the following sections.

### 4.4.1 Woodside (WEL)

As part of the Phase Two survey, WEL will:

- Nominate an onboard representative, Onboard Client Representative (Woodside), to supervise the Seismic Survey Contractor (SSC), CGG Veritas, and MFOs' activities and ensure that the requirements in the Final AMP are fully complied with;
- Retain Marine Faunal Observers (MFOs) to undertake marine faunal observations during the Phase Two survey;
- Develop appropriate contract clauses to ensure that the SSC and MFO will have qualified professionals to fulfil the Final AMP requirements;
- Notify the DEC, DoIR and DoF when exceedance of Final AMP trigger levels have been recorded by SSC; and
- Ensure Phase Two survey is completed in compliance with Ministerial Conditions.

Specific positions of responsibility identified in **Table 4** above are as follows:

- **Project Manager (Woodside):** is responsible for:
  - ensuring the implementation of all elements of the EP;
  - reviewing the EP as necessary;
  - submission of all regulatory authority reports (including incident reports);
  - completion of environmental audit of survey operations;
  - ensuring that all survey vessel crew members complete an HSE induction; and
  - liaising with regulatory authorities as required.
- **Onboard Client Representative (Woodside):** is responsible for ensuring the Vessel Master Veritas Voyager, Party Manager (CGG Veritas) and all crew are adhering to the requirements of the EP and reporting all incidents in accordance with Woodside's incident reporting system. The Onboard Client Representative, or in his/her absence, the Vessel Master is responsible for notifying the Acquisition Duty Manager of any incidents. The Acquisition Duty Manager is then responsible for reporting to the Designated Authority (DA) and to other external bodies, and activating the Woodside Communications Centre if required.

### 4.4.2 Seismic Survey Contractor

As part of the Phase Two survey the Seismic Survey Contractor will:

- work within the scope of the contract with Woodside and other tender conditions;
- provide assistance to the MFOs in carrying out marine faunal observations;
- implement operational procedures to identify any occurrences when trigger levels are exceed;
- implement corrective actions in discussion with the Onboard Client Representative; and
- if instructed by the Onboard Client Representative, cease works until further notice as long as it is safe to do so.

Specific positions of responsibility identified in **Table 4** above are as follows:

- **Party Manager (CGG Veritas):** is responsible for the safe and environmentally acceptable execution of the offshore seismic programme in a manner consistent with the performance objectives and environmental management procedures detailed in the EP and this Final AMP. This includes ensuring compliance with Environmental Protection and Biodiversity Conservation (EPBC) Act 'Particular Manner' conditions and Government of Western Australia (2007) Ministerial Conditions. The Party Chief reports to the Vessel Master in this regard. The Party Chief is responsible for immediately notifying the Onboard Client Representative (Woodside) of any incidents that are likely to negatively impact on the performance objectives outlined in the EP or this Final AMP.
- **Vessel Master Veritas Voyager:** has overall and ultimate responsibility for, and authority with regard to, safety of their vessel and all onboard, and is responsible for implementing safety policies and procedures and ensuring all emergency drills are conducted. The Vessel Master is responsible for notifying AMSA and other authorities as per maritime requirements, and for ensuring that vessel procedures are followed in the event of an emergency or spill. The Vessel Master is also responsible for implementing instructions from the Party Manager (CGG Veritas) associated with the implementation of this Final AMP.

### 4.4.3 Marine Faunal Observers

As part of the Phase Two survey the MFOs will:

- undertake marine faunal observation monitoring during the Phase Two survey (See **Section 5**); and
- validate and confirm the monitoring results through completion of monitoring logs and provision to WEL.

# 5 Marine Faunal Observations during the Phase Two Survey

In addition to the trigger values for the Final AMP to ensure the Phase Two survey will be compliant with the Ministerial Conditions (see **Section 4**), there is a requirement to *"immediately shut down the array if observations of marine fauna during post-seismic line observations, or during any other surveillance activity, provide a reasonable basis to suspect that the survey is in non-compliance with conditions 6-5, 6-6 and 6-7."* (Schedule 3, F – Operational Procedures, Condition 7).

A step-wise approach to the implementation of responses to be employed should mortality in marine fauna be observed during the Phase Two survey is presented in **Figure 2**. Reporting periods to the DEC are also indicated in **Figure 2**.

On the basis of the above, any dead fauna, other than fish eggs and larvae within ten metres of the airgun array, observed as part of the MFOs for the Phase Two survey for which there is a reasonable basis to attribute mortality to airgun emissions would result in immediate shutdown of the seismic source array. It is noted, however, until there is a reasonable basis to attribute faunal mortality to seismic airgun emissions, acquisition will continue as normal.

If causes are expected to be other than airgun emissions, consideration shall also be given by Woodside as to reporting requirements and adjustments or cessation of the survey in order to comply with various provisions of the Environmental Protection Act, Wildlife Conservation Act and Conservation and Land Management Act.

Where appropriate, comparisons will be made with the data collected during the Phase One survey on observed mortality in order to reduce the likelihood of incorrectly attributing impacts, thereby providing a more robust Phase Two survey.

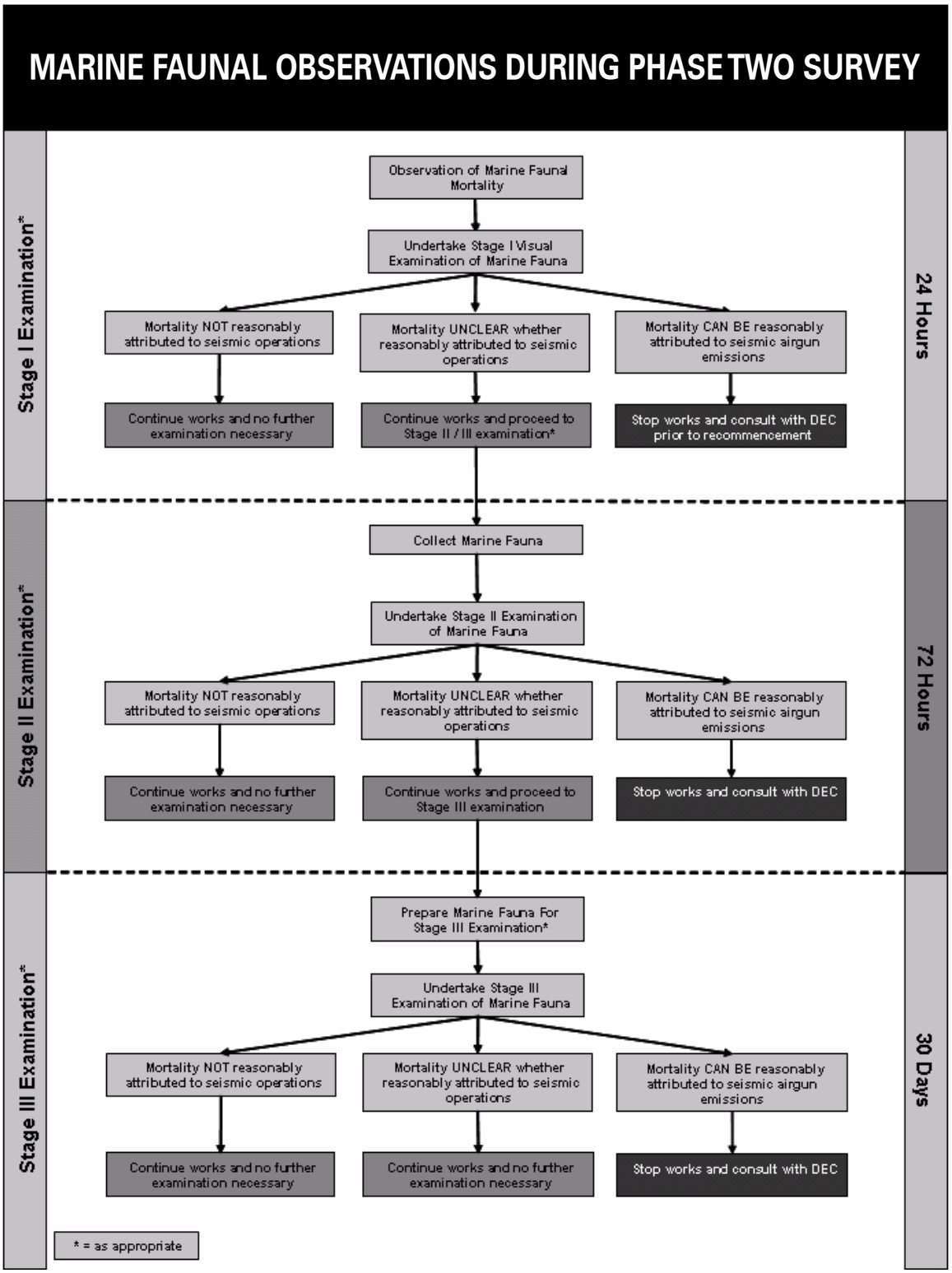
The methodology has been based on a series of examinations, designed to determine whether any observed fauna mortality can be reasonably attributed to seismic emissions. These have been termed Stage I, II and III levels of examination. A description of each level of examination is presented below and is reflected in **Figure 2**.

1. **Stage I Examination** - The initial examination would consist of a visual examination of marine fauna. Observational indicators of a potential impact may include clinical abnormalities e.g. disturbances of swimming or balance, neuromuscular abnormalities, abnormal responses, abnormal station in the water column, and changes in colouration, which may indicate moribund state. The Stage I examination could be conducted from the vessel and negate the need for collection and handling of any fauna. Comparisons should be made to any data on baseline mortality collected during the Phase One survey to assist in impact attribution, if applicable. The results of the Stage I examination should be compiled and reported to the DEC within 24 hours of initial observation.

2. **Stage II Examination** – Should no conclusive decision be made during the Stage Two examination, moribund, or dead marine fauna should be collected for gross / sub-gross examination, if possible. Examination should be undertaken onboard the vessel. Observational indicators of a potential impact may include the presence of gross pathological changes e.g. tissue trauma, swim bladder rupture and haemorrhage. Comparisons should be made to any data on baseline mortality collected during the Phase One survey to assist in impact attribution, if applicable. The results of the Stage II examination should be compiled and reported to the DEC within 72 hours of initial observation.

3. **Stage III Examination** - Should no conclusive decision be made during the Stage Two examination, the specimen or appropriate tissues should be examined for the presence of histopathological changes at the cellular level not visible at the gross or sub-gross level. Indicators of potential impact may include loss of cilia, brain haemorrhage and tissue trauma, in comparison with normal animal physiology. Such an examination will require the involvement of specialised pathologists appropriately selected for the tasks. Examinations should be undertaken in accordance in controlled conditions, i.e. laboratory conditions, where appropriate. On this basis, the results of the Stage III examination should be compiled and reported to the DEC within 30 days of initial observation.

Figure 2 Schematic of Operational Responses for Marine Faunal Mortality Observations During Phase Two Survey



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# Appendix A Monitoring Results Summary Proformas

**Project:** Phase I Maxima 3-D Marine Seismic Survey

**Program:** Draft Adaptive Management Program

**Task:** Faunal Mortality Monitoring

**Date:** 19-Sep-07

**Baseline Faunal Mortality Monitoring**

| No. | Date Collected | Common Name | Species (if possible) | Number | Cause of Mortality | Mortality Related to Air Gun Emissions | Trigger Value Exceeded |
|---|---|---|---|---|---|---|---|
| 1 | 13-Sep-07 | Boxfish | | 1 | Unknown | No | No |

**Impact Faunal Mortality Monitoring**

| No. | Date Collected | Common Name | Species (if possible) | Number | Cause of Mortality | Mortality Related to Air Gun Emissions | Trigger Value Exceeded |
|---|---|---|---|---|---|---|---|
| 1 | - | - | - | - | - | - | No |

**Fish Cage Experiments**

| No. | Date Collected | Common Name | Species (if possible) | Number | Cause of Mortality | Mortality Related to Air Gun Emissions | Trigger Value Exceeded |
|---|---|---|---|---|---|---|---|
| 1 | 14-Sep-07 | Holocentrid | *Sargocentron spiniferum* | 2 | Aerator in onboard fish tank not working properly | No | No |
| 2 | 16-Sep-07 | Damsel Fish | *Chromis viridis* | 8 | Erosive and necrotising dermitis | No | No |
| 3 | 18-Sep-07 | Damsel Fish | *Chromis viridis* | 6 | Erosive and necrotising dermitis | No | No |

**Notes**

Following the identification of the erosive and necrotising dermitis in the Damselfish within the fish cage experiments, the baseline fish were examined to verify whether this was present. The results of this indicated that at the time of examination 23% of captured fish demonstrated signs of infection. It was thus assumed that this was a pre-existing condition and not as a result of the air gun emissions.

**Approvals**

***Approved by Environmental Project Coordinator*** ***Name:***_____ ***Date:***_____

***Signature:***_____

***Approved by Woodside Representative*** ***Name:***_____ ***Date:***_____

***Signature:***_____

| | |
|---|---|
| **Project:** | **Phase I Maxima 3-D Marine Seismic Survey** |
| **Program:** | **Draft Adaptive Management Program** |
| **Task:** | **Coral Damage Monitoring (Fine scale)** |
| **Date:** | **18-Sep-07** |

| Transect (Site | Control Line | | | | Impact Line | | | |
|---|---|---|---|---|---|---|---|---|
| | Baseline Coral Mean damage (mean ±95%CI, n=45) | Impact Coral Damage (mean ± 95%CI, n=45)) | T-test statistic | Trigger Level Exceeded | Baseline Coral Damage (mean ± 95%CI, n=45) | Impact Coral Density (mean ± 95%CI, n=45) | T-test statistic | Trigger Level Exceeded |
| 1 | 0.02 ± 0.01 | 0.02 ± 0.02 | N.S. | No | 0.035 ± 0.047 | 0.02 ± .02 | N.S. | No |
| 2 | 0.02 ± 0.03 | 0.003 ± 0.005 | N.S. | No | 0.065 ± 0.095 | 0.008 ± 0.01 | N.S. | No |
| 3 | 0.008 ± 0.01 | 0.003 ± 0.005 | N.S. | No | 0.002 ± 0.005 | 0.02 ± 0.02 | N.S. | No |
| 4 | 0.01 ± 0.01 | 0.02 ± 0.02 | N.S. | No | 0.006 ± 0.118 | 0.04 ± 0.05 | N.S. | No |

**Notes** **OVER ALL COMPLIANCE: Y**

Some natural coral fragmentation evident, possibly from feeding activities of larger fish.
In some areas of reef evidence of pathogenic attach on foliaceous corals and subsequent recovery
Very little fragmentation of branching corals
No discernable damage to corals after seismic runs
ANOVA Time/Seismic/Interaction terms NS (NB Arcsin transformed, but data remain intractably heterogeneous due to large zero count)
Paired T-Tests all Non significant (N.S.):
Seismic and Control Transects Before T=1.147, P =0.12, NS, Accept Ho
Seismic Before and After 3 Passes T=0.98, P= 0.163, NS, Accept Ho
Control Before and After 3 Passes T=1.119, P= 0.133, NS, Accept Ho
Seismic and Control After 3 Passes on Seismic T=1.47, P=0.07, NS, Accept Ho

**Approvals**

***Approved by Environmental Project Coordinator*** ***Name:***_____ ***Date:***_____

***Signature:***_____

***Approved by Woodside Represent*** ***Name:***_____ ***Date:***_____

***Signature:***_____

| | |
|---|---|
| **Project:** | **Phase I Maxima 3-D Marine Seismic Survey** |
| **Program:** | **Draft Adaptive Management Program** |
| **Task:** | **Verification of Impacts (*Non-Auditory Tissue Damage*)** |
| **Date:** | **19-Sep-07** |

| Examination: Organs / Tissues | Percent of Samples with Non-Auditory Tissue Damage | | | | | | Percent of Samples with Non-Auditory Tissue Damage related to Air Gun Emissions | | | | | | AMP Trigger Value Exceeded | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | | | Control | | | Impact Pass-1 | | | Impact Pass-2 | | | | | |
| | Species | | | Species | | | Species | | | Species | | | Species | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| | n=6 | n=11 | n=4 | n=12 | n=2 | n=2 | n=17 | n=28 | n=11 | n=7 | n=4 | n=9 | | | |
| Eyes | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Integument (Skin, fins) | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Lateral line | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Buccal Cavity | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Gills | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Peritoneum & Mesentery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Gonad | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Intestine | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Liver / Pancreas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Spleen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Stomach | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Oesophagus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Heart & Pericardium | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Vasculature | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Swim Bladder | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Kidney | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Musculature | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |
| Skeleton | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No | No | No |

**Notes**

Based on gross and sub-gross pathological examination of the baseline fish, the control fish and the fish exposed to the air-gun blasts, there was no tissue trauma or degenerative or necrotising processes or lesions observed which were referable to blast

**Approvals**

***Approved by Environmental Project Coordinator***

***Name:***_____

***Signature:***_____

***Approved by Woodside Representative***

***Name:***_____

***Signature:***_____

**Project:** Phase I Maxima 3-D Marine Seismic Survey

**Program:** Draft Adaptive Management Program

**Task:** Verification of Impacts (*Temporary Threshold Shift Recovery*)

**Date:** 19-Sep-07

| Species | Baseline | Control | Impact Pass | Impact Monitoring | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Category 1 | | | Category 2 | | | Category 3 | | |
| | Baseline ABR Threshold Determined | Control ABR Threshold Determined | Impact ABR Threshold Determined | Evidence of TTS within 0-6 hours following exposure | Evidence of TTS post-6 hours following exposure | AMP Trigger Level Exceeded | Evidence of TTS within 0-6 hours following exposure | Evidence of TTS post-6 hours following exposure | AMP Trigger Level Exceeded | Evidence of TTS within 0-6 hours following exposure | Evidence of TTS post-6 hours following exposure | AMP Trigger Level Exceeded |
| 1 | Yes | Yes | Yes | No | No | No | - | - | No* | - | No | No* |
| 2 | Yes | Yes | Yes | No | No | No | - | - | No* | - | No | No* |
| 3 | Yes | Yes | Yes | No | No | No | No | - | No | No | No | No |
| 4 | Yes | Yes | Yes | No | No | No | No | No | No | No | - | No |

**Notes**

Species 1 Damselfish *(Chromis viridis)*
Species 2 Sea Perch *(Lutjanis kasmira)*
Species 3 Holocentrid *(Sargocentron spiniferum)*
Species 4 Holocentrid *(Myripristis murdjan)*

* = Note that although no TTS data were collected on Species 1- Damselfish (Chromis viridis) and Species 2 -Sea Perch (Lutjanis kasmira) within the 0-6 hour period, it is considered reasonable to assume that the findings of the hearing specialist, ie Species 4 Holocentrid (Myripristis murdjan), could be applied to these non-hearing specialist fish.

**Approvals**

***Approved by Environmental Project Coordinator*** ***Name:***_____ ***Date:***_____

***Signature:***_____

***Approved by Woodside Representative*** ***Name:***_____ ***Date:***_____

***Signature:***_____

# Appendix B Verification of Minimum Airgun Array Configuration

Acquisition of marine seismic data uses an impulsive acoustic source: in general, compressed air is released from an array of 'airguns' of various capacities. For successful data acquisition the array must be 'tuned', meaning that the combination and spatial arrangement of airguns of different sizes is carefully selected to minimise unwanted 'bubble effects' caused by oscillations of the discharged air bubbles within the water before they dissipate. These effects can be further reduced by incorporating very small time delays between discharges of the individual airguns. The net effect is illustrated in **Figure B-1**.

The airguns carried aboard the survey vessel Veritas Voyager can be configured as three different tuned arrays. The full array has a capacity of 3255 cubic inches. An intermediate (and rarely used) array has a capacity of 2580 cubic inches. The smallest tuned array available has a capacity of 2055 cubic inches. All three arrays were used to acquire data over a single line segment within the Calliance 3D MSS area, located approximately 80 kilometres south of Scott Reef. Examples of the seismic data from the three test transects are illustrated in **Figures B-2**, **B-3** and **B-4**.

All three array sizes resulted in acceptable seismic data quality although, as expected, there is a slight decrease in energy penetration with decreasing array size. Power spectra for the portions of data bounded by the coloured polygons in **Figures B-2** to **B-4** are plotted in **Figure B-5**. All three spectra lie within a range of 0-3dB from 0-95Hz, with the smaller 2055 cubic inch array generally having the lowest power of the three at any frequency.

Following confirmation that the 2055 cubic inch source array configuration provided adequate seismic data quality in the Calliance 3D MSS, the Veritas Voyager deployed its full array of seismic acquisition equipment and recorded a single verification transect using the 2055 cubic inch array configuration (i.e. using the same specifications planned for the Phase Two survey) within the Maxima 3D MSS survey area. This transect is located in both State and Commonwealth areas and was selected to verify that the chosen source array configuration produced acceptable seismic data quality across a range of water depths and seafloor conditions representative of the survey area. Seismic data from the verification line was processed aboard the survey vessel and transmitted to Perth for analysis. **Figure B-6** shows an example of seismic data from the verification transect. Seismic data quality was considered to be acceptable and confirmed the results of minimum airgun array tests conducted in the Calliance area.

Figure B-1: The Principle of a Tuned Airgun Array. Note the reduction in the bubble pulse effect for the combined array (red trace).

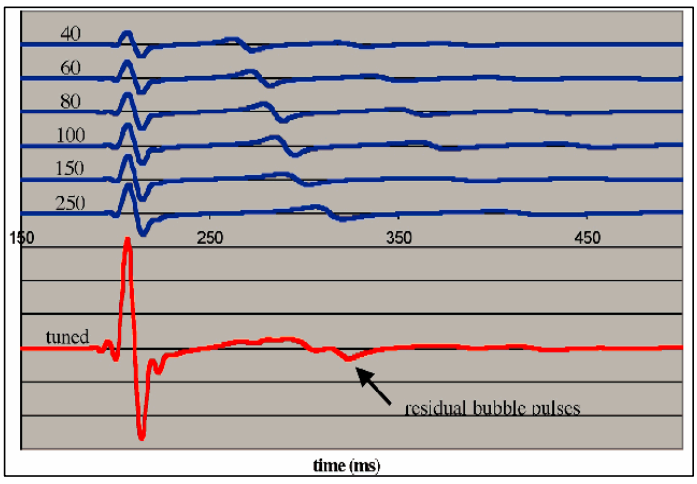


Figure B-2: Sample of Seismic Data From the Calliance 3D MSS Area (3255 cubic inch array)

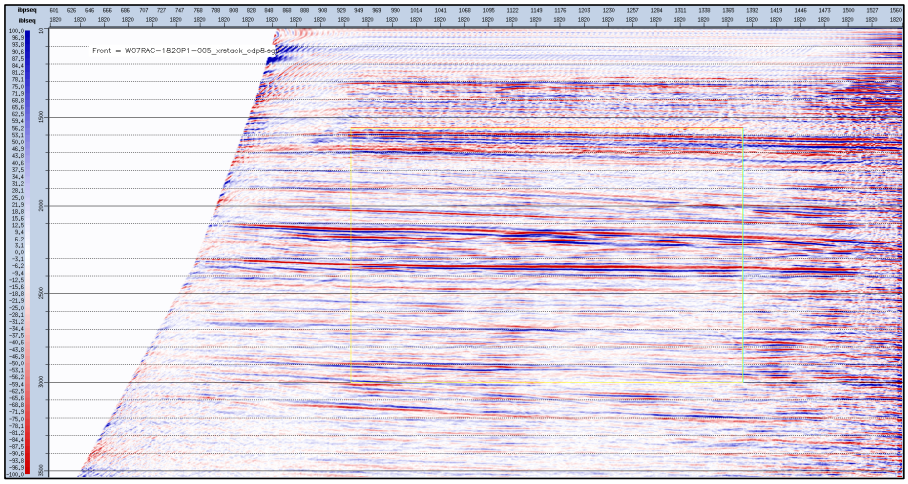


Figure B-3: Sample of Seismic Data From the Calliance 3D MSS Area (2850 cubic inch array)

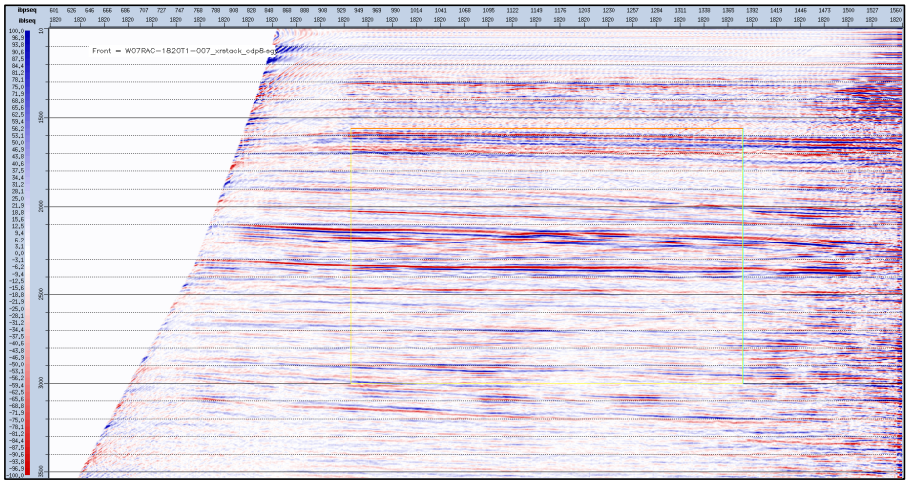


Figure B-4: Sample of Seismic Data From the Calliance 3D MSS Area (2055 cubic inch array)

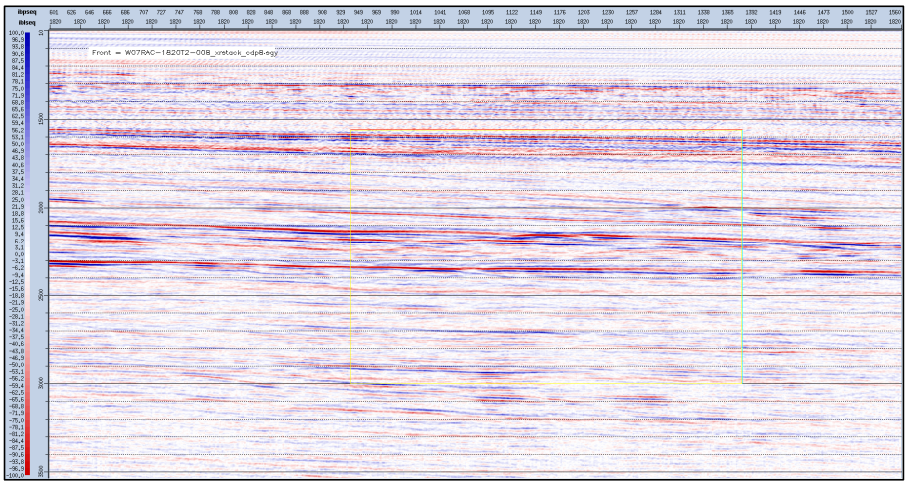


Figure B-5: Power Spectra of Seismic Data From the Calliance 3D MSS Area for Three Different Source Arrays

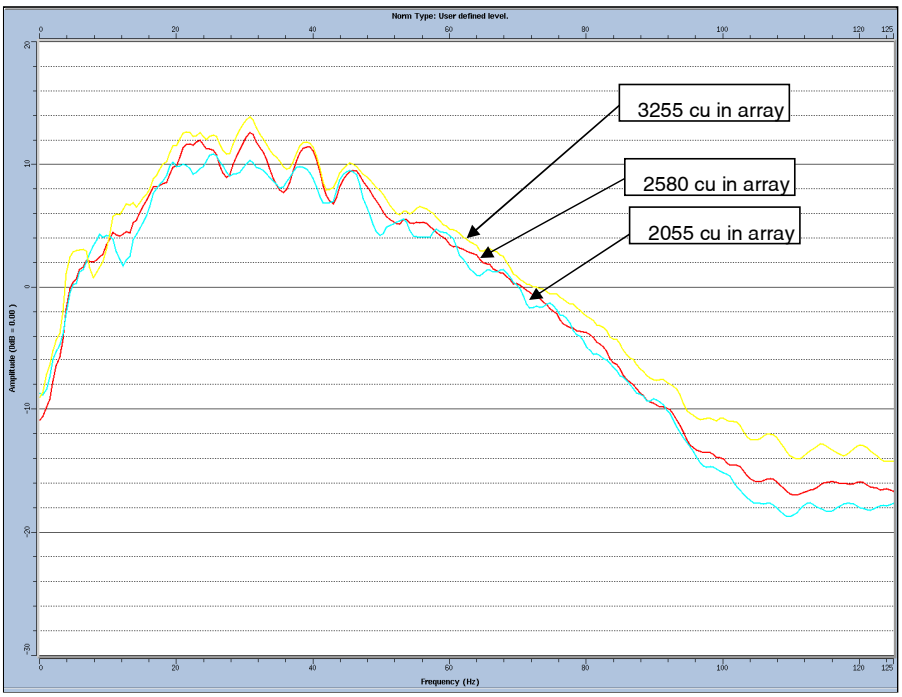
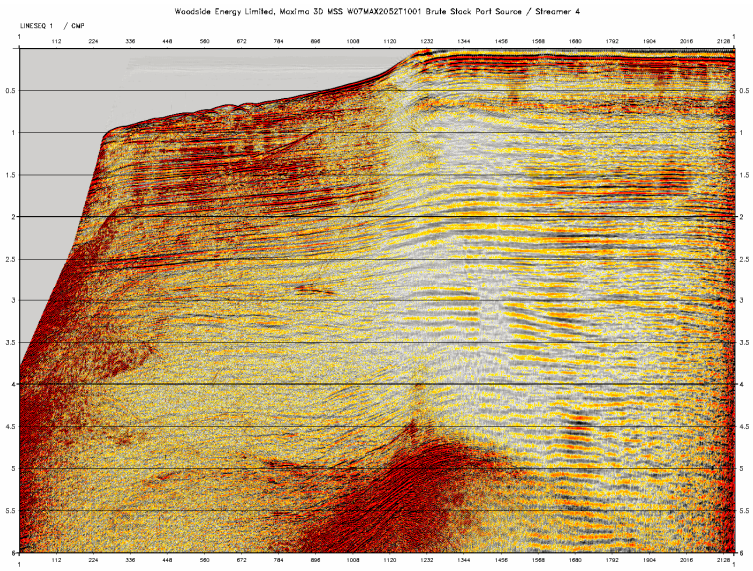



Figure B-6: Sample of Seismic Data From the Maxima 3D MSS Area (2055 cubic inch array)



# Appendix C Mapping of Habitat Impact Exposure to Selected Sound Exposure Levels