Plan

CDN/ID S4100AH717908

Operational and Scientific Monitoring Plan

Offshore Victoria

Review record (record the last 3 revisions here or the revisions required to achieve current approval version)

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THE THREE WHATS

What can go wrong?

What could cause it to go wrong?

What can I do to prevent it?

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1 Introduction

1.1 Purpose

This Offshore Victoria Operational and Scientific Monitoring Plan (OSMP) provides the framework for environmental monitoring response to Level 2 and Level 3 offshore oil spills from petroleum activities undertaken by Beach Energy Ltd (Beach) in the Otway and Bass Basins.

The OSMP is a component of the environmental management framework, which also includes activity specific Environment Plans (EP), the Offshore Victoria – Otway Basin Oil Pollution Emergency Plan (OPEP) (CDN/ID S4100AH717907) and the BassGas Offshore OPEP (CDN/ID 3972816).

The OSMP has been developed to satisfy the requirements of Regulation 14(8AA) and 14(8D) of the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (OPGGS(E)R), Regulation 16 of the Victorian *Offshore Petroleum and Greenhouse Gas Storage Regulations 2011* (OPGGSR) and Regulation 19 of the Tasmanian *Petroleum (Submerged Lands) (Management of Environment) Regulations 2012* (P(SL)(ME)R).

The OSMP is to be read in conjunction with the relevant EP, OPEP and OSMP Addendum when considering the existing environment, values and sensitivities, credible oil spill risks and potential impacts, response activities and the decision processes that will apply in the event that a spill occurs. The relevant EP also describes any related performance standards, notification requirements and/or reporting compliance.

1.2 Scope

1.2.1 Activities

This OSMP is relevant to all Beach petroleum activities within the Otway and Bass Basins regulated under the Commonwealth OPGGS(E)R, Victorian OPGGSR and Tasmanian P(SL)(ME)R. This includes, but is not limited to the following activity types:

- Operation of a facility or pipeline
- Vessel activities
- Drilling.

1.2.2 Oil type

Spill risks from the above activities that could result in a Level 2 or Level 3 spill event include two oil types:

- Gas condensate
- Marine diesel.

This OSMP is relevant to all oil types and states (i.e. fresh and weathered); and all distributions throughout the environment (e.g. surface, entrained, dissolved and shoreline).

1.2.3 Geographic extent

This OSMP is relevant and applicable to all Commonwealth and State marine and coastal areas that are potentially at risk of exposure to oils in the event of a Level 2 or Level 3 spill resulting from Beach's petroleum activities within the Otway and Bass Basins.

The spatial extent of any particular operational or scientific monitoring study will depend on the actual and/or potential area exposed by an individual spill event. Therefore, monitoring extent would only be finalised once a spill event has occurred and be at a sufficient scale to meet monitoring objectives.

1.3 Definitions/Acronyms

Definitions of terms used in this plan:

Terms/acronym	Definition/expansion
AMSA	Australian Maritime Safety Authority
ANOVA	Analysis of variance
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Governments
API	American Petroleum Institute
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BACI	Before After Control Impact
Beach	Beach Energy Ltd
Control Agency	The Control Agency for an oil spill response is the government agency or company assigned by legislation, administrative arrangement or within the relevant contingency plan to control response activities to an oil spill
DJPR	(Victoria) Department of Jobs, Precincts and Regions
DPIPWE	(Tasmania) Department of Primary Industries, Parks, Water and Environment
EP	Environment Plan
EPBC Act	(Commonwealth) Environment Protection and Biodiversity Conservation Act 1999
EMBA	Environment that may be Affected
EMLO	Emergency Management Liaison Officer
EMT	Emergency Management Team
EUL	Environment Unit Lead
HSE	Heath, Safety and Environment
Incident Controller	The individual responsible for the management of all incident control activities across an incident (Note: for spill events where Beach is the Control Agency, this is the equivalent of the EMT Leader)
IMT	Incident Management Team
IvC	Impact versus Control
LCL	Lower control limit
LEL	Lower explosive limit

Terms/acronym	Definition/expansion
Level 2	Level 2 incidents are more complex in size, duration, resource management and risk and may require deployment of jurisdiction resources beyond the initial response (as per NatPlan)
Level 3	Level 3 incidents are generally characterised by a degree of complexity that requires the Incident Controller to delegate all incident management functions to focus on strategic leadership and response coordination and may be supported by national and international resources (as per NatPlan)
MBACI	Multiple Before After Control Impact
MNES	Matters of national environmental significance
Monitoring Provider	Service provider for environmental monitoring studies; may be one or multiple companies (as required)
NATA	National Association of Testing Authorities
NatPlan	National Plan for Maritime Environmental Emergencies
NOAA	(United States) National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OPGGS(E)R	(Commonwealth) Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OPGGSR	(Victoria) Offshore Petroleum and Greenhouse Gas Storage Regulations 2011
OSMP	Operational and Scientific Monitoring Plan
OSRL	Oil Spill Response Limited
OPEP	Oil Pollution Emergency Plan
PAH	Polycyclic aromatic hydrocarbons
PERMANOVA	Permutational multivariate analysis of variance
PSD	Particle size distribution
P(SL)(ME)R	(Tasmania) Petroleum (Submerged Lands) (Management of Environment) Regulations 2012
Ramsar	Convention on wetlands of international importance
SAP	Sampling and Analysis Plan
SD	Standard deviation
SMART	Special Monitoring of Applied Response Technologies
SME	Subject Matter Expert
SOP	Standard operating procedures
SQGV	Sediment quality guideline value
Statutory Authority	The Statutory Authority has the statutory responsibility for marine pollution incidents in their area of jurisdiction
TOC	Total organic carbon
TPH	Total petroleum hydrocarbon
UCL	Upper control limit
USEPA	United States Environment Protection Authority
VOC	Volatile organic compound

2 OSMP Framework

2.1 Overview

This OSMP provides the framework for Beach's environmental monitoring response to Level 2 and Level 3 offshore oil spills from their petroleum activities undertaken in the Otway and Bass Basins.

This OSMP lists a series of possible studies (with types of sampling techniques and parameters) that may be undertaken in the event of a spill. This OSMP is not intended to be prescriptive, but to provide a flexible framework such that the finalised monitoring studies are fit for purpose and tailored to the specific location, oil type, environmental sensitivities, and the nature and scale of the individual spill.

This OSMP incorporates regulatory guidance from the following documents:

- Guidance note – Oil pollution risk management (NOPSEMA 2018)
- Information paper – Operational and scientific monitoring programs (NOPSEMA 2016).

2.2 Objectives

The objectives of this OSMP are:

- Identify and describe the operational and scientific monitoring that may be implemented in the event of a Level 2 or Level 3 oil spill to the marine or coastal environment
- Demonstrate an appropriate degree of readiness to implement this monitoring in the event of an oil spill to the marine or coastal environment.

2.3 Types of monitoring

Oil spill monitoring has been divided into two types, operational and scientific, which are undertaken for two distinct, but closely related, purposes (NOPSEMA 2016).

Operational monitoring (also known as Type I or response phase monitoring) which collects information about the spill and associated response activities to aid planning and decision making during the response or clean-up operations. Operational monitoring may include both initial response phase monitoring (i.e. rapid qualitative and observational data gathering for situational awareness) and advanced response phase monitoring (i.e. quantitative measurement) (Hook et al. 2016). Operational monitoring typically finishes when the spill response is terminated.

Six operational monitoring studies have been identified (see Section 4):

- O1: Oil characterisation and behaviour
- O2: Water quality
- O3: Sediment quality
- O4: Marine fauna surveillance
- O5: Dispersant efficacy

- O6: Fish tainting.

Operational monitoring studies complement the Monitoring and Evaluate response strategy described in the relevant OPEP. This response strategy may include spatial surveillance techniques and spill trajectory predictions. Operational monitoring (e.g. Study O5) can also be directly related to a particular response strategy (i.e. Chemical Dispersants) (see Section 2.4).

Scientific monitoring (also known as Type II or recovery phase monitoring) which is focussed on non-response objectives and evaluating environmental impact and recovery from both the spill event itself as well as from any response activities. Results from scientific monitoring studies may also be used to identify and recommend remediation requirements where required. Scientific monitoring may continue for extended periods after a spill response is terminated.

Seven scientific monitoring studies have been identified (see Section 5):

- S1: Water quality impact assessment
- S2: Sediment quality impact assessment
- S3: Subtidal habitats impact assessment
- S4: Intertidal and coastal habitats impact assessment
- S5: Marine fauna impact assessment
- S6: Fisheries impact assessment
- S7: Heritage and socioeconomic impact assessment.

Operational and scientific monitoring studies may occur simultaneously (i.e. scientific monitoring can start before a response operation is completed). There may also be an information flow between studies, for example data from operational monitoring may be used to trigger the initiation of scientific studies.

Different oil types, spill locations, and volumes require different studies to form a fit–for–purpose operational and scientific monitoring program that is able to determine the extent, severity and persistence of environmental impacts from the oil spill.

2.4 Study design and standard operating procedures

Where appropriate, sampling design and procedures will be aligned with existing standards or guidance notes. These include, but are not limited to:

- Oil Spill Monitoring Handbook (Hook et al. 2016)
- Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018)
- Parks Victoria Standard Operating Procedure for Biological Monitoring of Subtidal Reefs (Edmunds and Hart 2005)
- Parks Victoria Standard Operating Procedure for Biological Monitoring of Intertidal Reefs (Hart and Edmunds 2005)
- Industry Recommended Subsea Dispersant Monitoring Plan (American Petroleum Institute 2013)

- Dispersant Application Monitoring Field Guide Tier I Visual Observation (OSRL 2011)
- Special Monitoring of Applied Response Technologies (NOAA 2006).

References to relevant standard operating procedures are provided within study tables in Section 4 and 5.

Consideration has also been given to the scopes and procedures within the Industry OSMP that is currently under preparation by APPEA (APPEA 2019).

2.5 Baseline environmental state

Baseline monitoring provides information on the condition of ecological receptors prior to or spatially independent (e.g. if used in control chart analyses) of a spill event. This is of importance for scientific monitoring where the ability to detect changes between pre-impact and post-impact conditions is necessary.

Given the large aerial extents of predicted oil exposure (or EMBA) from worst-case spill scenarios, and the inherent spatial and temporal variability in the environment, an ongoing or pre-impact baseline monitoring program is not planned.

However, Appendix B provides a database of known literature and studies relevant to environmental receptors within the Otway and Bass Basins that may provide suitable baseline data and/or contextual information in the event of a spill.

In addition, there are also operational and scientific monitoring studies that are suited to pre-impact baseline monitoring (Table 2-1). Therefore, in the event of a Level 2 or Level 3 oil spill, reactive pre-impact monitoring should, where practicable, be implemented to gather additional data on the current state of the environment.

Table 2-1: Study scopes appropriate for post-spill pre-impact sampling (reactive baseline)

Study	Pre-impact sampling	Post-impact sampling
Operational monitoring		
O1: Oil characterisation and behaviour		✓
O2: Water quality	✓	✓
O3: Sediment quality	✓	✓
O4: Marine fauna surveillance		✓
O5: Dispersant efficacy		✓
O6: Fish tainting		✓
Scientific monitoring		
S1: Water quality impact assessment	✓	✓
S2: Sediment quality impact assessment	✓	✓
S3: Subtidal habitats impact assessment	✓	✓
S4: Intertidal and coastal habitats impact assessment	✓	✓
S5: Marine fauna impact assessment	✓	✓
S6: Fisheries impact assessment		✓
S7: Heritage and socioeconomic impact assessment	✓	✓

2.6 Links to response options

The objectives of individual operational monitoring studies are typically associated with one or more specific response strategies (Table 2-2).

Table 2-2: Operational monitoring and response strategies

Response strategy	Study O1 Oil characterisation and behaviour	Study O2 Water quality	Study O3 Sediment quality	Study O4 Marine fauna surveillance	Study O5 Dispersant efficacy	Study O6 Fish tainting
Source control	✓	✓	✓			
Monitor and evaluate	✓	✓	✓	✓		✓
Assisted natural dispersion	✓	✓		✓		✓
Chemical dispersants	✓	✓	✓		✓	✓
Containment and recovery	✓			✓		
Protection and deflection	✓	✓	✓	✓		
Shoreline clean-up	✓		✓	✓		
Oiled wildlife response	✓			✓		

2.7 Links to environmental values and sensitivities

The types of environmental values and sensitivities (including matters of national environmental significance) known to occur in the Otway and Bass Basins and the related operational and scientific monitoring studies area shown in Table 2-3.

For the identification and descriptions of values and sensitivities present within an environment that may be affected (EMBA) for a particular activity, refer to the description in the relevant EP.

For an identification of key areas at risk, the associated environmental values and sensitivities and the links to relevant operational and scientific monitoring studies, refer to the relevant OSMP Addendum.

Table 2-3: Environmental values and sensitivities and related operational and scientific monitoring studies

Environmental value and sensitivities	Matters of national environmental significance	Value or sensitivity present in region		Operational Monitoring						Scientific Monitoring						
		Otway Basin	Bass Basin	Study O1	Study O2	Study O3	Study O4	Study O5	Study O6	Study S1	Study S2	Study S3	Study S4	Study S5	Study S6	Study S7
				Oil characterisation and behaviour	Water quality	Sediment quality	Marine fauna surveillance	Dispersant efficacy	Fish tainting	Water quality impact assessment	Sediment quality impact assessment	Subtidal habitats impact assessment	Intertidal and coastal habitats impact assessment	Marine fauna impact assessment	Fisheries impact assessment	Heritage and socioeconomic impact assessment
Protected areas																
Australian Marine Parks	✓[1]	✓	✓		✓	✓	✓			✓		✓		✓		✓
State marine protected areas		✓	✓		✓	✓	✓			✓	✓	✓	✓	✓		✓
State terrestrial protected areas		✓	✓			✓	✓				✓			✓		✓
Wetlands of international importance (Ramsar wetlands)	✓	✓	✓		✓	✓	✓				✓		✓	✓		✓
Ecological features																
Key ecological features	[2]	✓	×		✓					✓		✓				
Threatened ecological communities	✓	✓	✓		✓							✓	✓			

Environmental value and sensitivities	Matters of national environmental significance	Value or sensitivity present in region		Operational Monitoring						Scientific Monitoring							
		Otway Basin	Bass Basin	Study O1	Study O2	Study O3	Study O4	Study O5	Study O6	Study S1	Study S2	Study S3	Study S4	Study S5	Study S6	Study S7
				Oil characterisation and behaviour	Water quality	Sediment quality	Marine fauna surveillance	Dispersant efficacy	Fish tainting	Water quality impact assessment	Sediment quality impact assessment	Subtidal habitats impact assessment	Intertidal and coastal habitats impact assessment	Marine fauna impact assessment	Fisheries impact assessment	Heritage and socioeconomic impact assessment
Threatened and migratory species	✓	✓	✓				✓							✓		
Invertebrates		✓	✓											✓	✓	
Fish		✓	✓											✓	✓	
Sharks		✓	✓				✓							✓		
Cetaceans		✓	✓				✓							✓		
Pinnipeds		✓	✓				✓							✓		
Turtles		✓	✓				✓							✓		
Birds		✓	✓				✓							✓		
Subtidal benthic habitats		✓	✓									✓				
Intertidal benthic habitats		✓	✓										✓			
Wetlands of national importance		✓	✓		✓	✓	✓						✓	✓		

Environmental value and sensitivities	Matters of national environmental significance	Value or sensitivity present in region		Operational Monitoring						Scientific Monitoring						
		Otway Basin	Bass Basin	Study O1	Study O2	Study O3	Study O4	Study O5	Study O6	Study S1	Study S2	Study S3	Study S4	Study S5	Study S6	Study S7
				Oil characterisation and behaviour	Water quality	Sediment quality	Marine fauna surveillance	Dispersant efficacy	Fish tainting	Water quality impact assessment	Sediment quality impact assessment	Subtidal habitats impact assessment	Intertidal and coastal habitats impact assessment	Marine fauna impact assessment	Fisheries impact assessment	Heritage and socioeconomic impact assessment
Cultural and heritage features																
World Heritage properties	✓	×	×													✓
Commonwealth Heritage places		×	✓		✓	✓	✓				✓		✓			✓
National Heritage places	✓	✓	✓		✓	✓	✓				✓		✓			✓
Indigenous Protected Areas		✓	✓			✓					✓		✓			✓
Areas of Aboriginal cultural heritage sensitivity		✓	✓			✓					✓		✓			✓
Shipwrecks		✓	✓		✓					✓		✓				✓
Socioeconomic features																
Commercial fisheries		✓	✓						✓						✓	

Environmental value and sensitivities	Matters of national environmental significance	Value or sensitivity present in region		Operational Monitoring						Scientific Monitoring							
		Otway Basin	Bass Basin	Study O1	Study O2	Study O3	Study O4	Study O5	Study O6	Study S1	Study S2	Study S3	Study S4	Study S5	Study S6	Study S7
				Oil characterisation and behaviour	Water quality	Sediment quality	Marine fauna surveillance	Dispersant efficacy	Fish tainting	Water quality impact assessment	Sediment quality impact assessment	Subtidal habitats impact assessment	Intertidal and coastal habitats impact assessment	Marine fauna impact assessment	Fisheries impact assessment	Heritage and socioeconomic impact assessment
Tourism and recreation		✓	✓		✓	✓	✓		✓		✓	✓	✓	✓		✓
Coastal settlements		✓	✓		✓	✓					✓		✓	✓		✓
Shipping		✓	✓		✓					✓						✓
Petroleum industry		✓	✓		✓					✓						✓

Notes:

1. Commonwealth marine areas are listed as a MNES under the EPBC Act. Marine protected areas are marine areas which are recognised to have high conservation value.
2. Key ecological features are not MNES and have no legal status in their own right; however, they may be considered as components of the Commonwealth marine area.

3 Implementation

3.1 Overview

This section outlines the following:

- roles and responsibilities for personnel involved in implementing operational and scientific monitoring
- communications and notification to key external stakeholders
- review and revision schedule for this OSMP
- environmental performance outcomes, standards and measurement criteria related to this OSMP.

3.2 Roles and responsibilities

Beach is responsible for the implementation and adherence to the requirements of this OSMP for events where they are the Control Agency. Key roles and responsibilities are identified in Table 3-1. Depending on the scale of the event, individual people may perform multiple roles; similarly, multiple people may share the same role. The Emergency Response Team (EMT) Leader (or delegate) is the key position responsible for overseeing the implementation of this OSMP (Table 3-1).

For oil spill events where the Control Agency is not Beach (e.g. vessel spills in Commonwealth waters), the relevant Control Agency would be responsible for the initiation and implementation of response phase (i.e. operational) monitoring requirements (AMSA 2019). It is noted that implementation may be delegated to another agency or company (including Beach) to provide services. Beach maintains the responsibility to initiate and implement the recovery phase (i.e. scientific) monitoring, in conjunction with support agencies, local government and statutory authorities where relevant.

Table 3-1: Roles and responsibilities for OSMP implementation

Role	Timing	Responsibilities
Emergency Management Team (EMT) Leader	Emergency response	• Overall responsibility for providing and coordinating operational emergency management activities • Equivalent to role of Incident Controller • Overall responsibility for implementation of this OSMP during an oil spill response • Overall responsibility for ensuring safe operations during OSMP implementation
EMT Environment Leader	Emergency response Ongoing	• Implementation of the OSMP • Initiation of operational and scientific monitoring studies • Termination of operational and scientific monitoring studies • Interface with EMT, Planning and Logistics Leaders and Monitoring Provider • Activation of Monitoring Provider/s • Day-to-day coordination of operational and scientific monitoring • Review and approval of operational and scientific monitoring plans and data reports • Interface with external agencies including NOPSEMA, DJPR and DPIPWE

Role	Timing	Responsibilities
EMT Planning Leader (or delegate)	Emergency response	• Interface with EMT Environment Leader for OSMP implementation (as required) • Provides operational monitoring data to EMT to support response planning
EMT Logistics Leader (or delegate)	Emergency response	• Interface with EMT Environment Leader for OSMP implementation (as required) • Support (as required) for implementing operational monitoring (e.g. site access etc.) • Support (as required) for mobilising plant and equipment (e.g. vessels, air support, vehicles etc.)
Emergency Management Liaison Officer (EMLO)	Emergency response	• Interface between Beach EMT and State Control Agency Incident Management Team (IMT)
Monitoring Provider – Study Lead	Emergency response Ongoing	• Interface with EMT Environment Leader • Implementation of individual monitoring studies (as required) • Prepare monitoring plans and sampling procedures • Review and approve data reports • Ensure compliance with requirements of this OSMP
Monitoring Provider – Field Personnel	Emergency response Ongoing	• Undertake field sampling and observations • Ensure compliance with requirements of this OSMP
Monitoring Provider – Office Personnel	Emergency response Ongoing	• Prepare data reports • Ensure compliance with requirements of this OSMP

3.3 Capability, training and competency

Personnel involved in implementing this OSMP may be sourced from both internal (i.e. Beach) and external (e.g. Monitoring Provider) resources. The number of personnel needed to fulfil roles for any given event depends on the event's circumstances. Depending on the scale of the event, individual people may perform multiple roles; similarly, multiple people may share the same role.

3.3.1 Capability

A capability needs assessment for the implementation of the OSMP studies is included in the OSMP Addendum specific to each EP's activities and relevant spill scenarios. The capability needs assessment identifies the minimum number of personnel to manage and implement the OSMP studies and the type of platforms (vessel, aircraft or vehicles) required to perform the studies. The studies have been group where appropriate to ensure effective use of resources.

3.3.2 Training and Competency

Training and competency for Beach EMT roles are described within the Offshore Victoria – Otway Basin Oil Pollution Emergency Plan (OPEP) (CDN/ID S4100AH717907) and the BassGas Offshore OPEP (CDN/ID 3972816). This training matrix includes OSMP Awareness training for all relevant personnel.

Minimum competency requirements for individuals to fulfil OSMP-specific roles are identified within the operational and scientific monitoring study tables (Section 4 and 5). Minimum competencies can vary from degree qualified and

experienced personnel (e.g. typical requirement for Study Leads) to an awareness level (e.g. typical for immediate response phase field sampling).

3.3.2.1 Internal resources

Internal capability within Beach includes offices and personnel based in Perth (Western Australia), Adelaide (South Australia), Melbourne (Victoria) and New Plymouth (New Zealand). Internal resources with appropriate environmental and/or oil spill response competencies will fulfil the OSMP-related roles of:

- EMT Leader
- EMT Environment Leader.

Internal Beach personnel may also perform Monitoring Provider (Study Lead, Field Personnel and Office Personnel) roles and responsibilities, particularly during first-response operational monitoring.

3.3.2.2 External resources

External personnel will primarily perform Monitoring Provider (Study Lead, Field Personnel and Office Personnel) roles and responsibilities, particularly during scientific monitoring.

External resources and capability are reviewed prior to an activity commencing to ensure appropriate agreements / activations are in place (see Section 3.7).

3.4 Monitoring

This OSMP lists a series of possible operational and scientific monitoring studies (with types of sampling techniques and parameters) that may be undertaken in the event of a spill; these studies are outlined in Sections 4 and 5. This OSMP is not intended to be prescriptive, but to provide a flexible framework such that the finalised monitoring studies are fit for purpose and tailored to the specific location, oil type, environmental sensitivities, and the nature and scale of the individual spill.

In the event of a Level 2 and Level 3 oil spill, a series of steps beginning with the preparation of an appropriate Sampling and Analysis Plan (SAP) is implemented (Figure 3-1). While the decision to initiate and terminate a particular study is the responsibility of Beach (EMT Environment Leader), the SAP, field survey and reporting is primarily undertaken by the Monitoring Provider (Beach personnel may undertake or assist with operational monitoring, particularly during initial response phase).

Figure 3-1 also shows the flow of information (grey dashed lines) between the operational and scientific monitoring streams and associated OPEP processes.

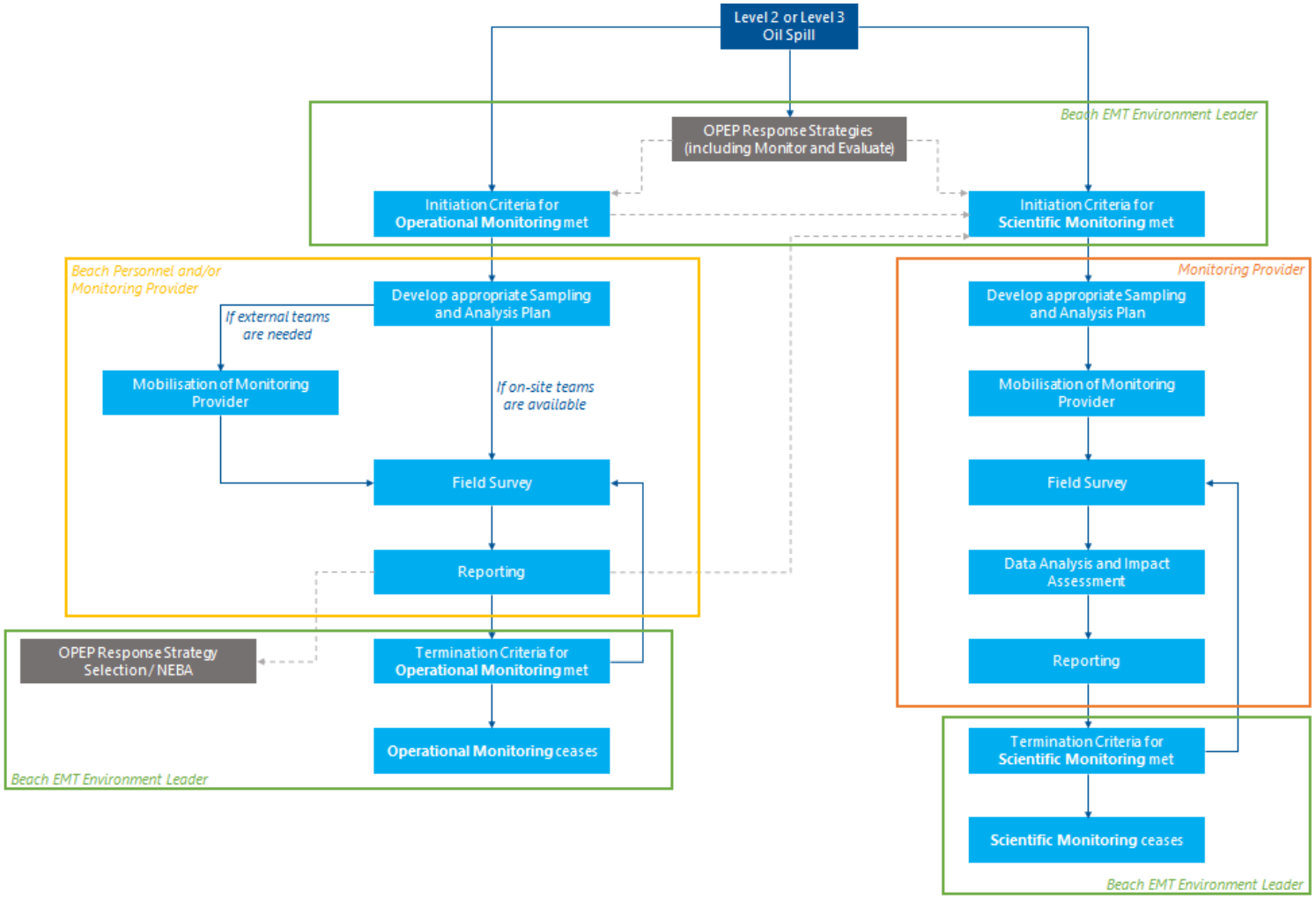

Figure 3-1: Implementation process for operational and scientific monitoring

3.5 Communication and notification

Stakeholder (including regulators) consultation and external notification requirements are described in the activity-specific EPs. This includes the requirement to consult with:

- Department of Jobs, Precincts and Regions (Victoria) and/or Department of Primary Industries, Parks, Water and Environment (Tasmania), in the event that an oil spill is likely to impact State waters
- Department of the Environment and Energy (DoEE), in the event that an oil spill is likely to impact matters of national environmental significance
- Director of National Parks, in the event that an oil spill and/or response activity are likely to impact an Australian Marine Park.

Consultation may also be undertaken with the above agencies or additional agencies (e.g. Heritage Victoria) in the event of a Level 2 or Level 3 oil spill with respect to input and/or review of a spill-specific Sampling and Analysis Plan (SAP) for scientific monitoring studies.

3.6 Review and revisions

This Offshore Victoria OSMP is subject to review, and revised if necessary, on an annual basis to incorporate the following:

- Significant change in the oil spills risks associated with Beach activities and/or facilities within offshore Victorian waters
- Significant environmentally relevant changes (e.g. changes to relevant legislation, stakeholder information, MNES, State/Commonwealth management plans, or availability of new literature)
- Findings from internal or external audits or exercises
- Lessons learned following any actual spill event.

Review records will be detailed in Beach Document Information and History tables (Section 7). Subsequent revisions to the OSMP (or supporting guides and procedures) will be actioned and closed-out as soon as practicable following the review.

As part an EP, Regulation 19 of the OPGGS(E)R also provides for the revision of the OSMP at least 14 days before the end of the period of five years from the most recent approval of an associated EP.

3.7 Environmental Performance Outcomes

Environmental performance outcomes, standards and measurement criteria related to this OSMP have been defined in Table 3-2.

Table 3-2: Environmental Performance Outcomes, Standards and Measurement Criteria

Environmental Performance Outcome	Control Measure	Environmental Performance Standard	Responsible Person	Measurement Criteria
Undertake oil spill response in a manner that will not result in additional impacts to marine environment, coastal habitat and oiled wildlife.	NOPSEMA accepted Operational and Scientific Monitoring Plan	Operational and scientific monitoring capability shall be maintained in accordance with the OSMP: • a month prior to the commencement of drilling a review of the contracted OSMP provider/s capability will be undertaken by Beach to ensure that the OSMP requirements can be met by the contracted OSMP provider/s. • during drilling the contracted OSMP provider/s will provide a monthly report to show that capability as detailed in the OSMP is maintained. • the contracted OSMP provider/s capability to meet the requirements detailed in the OSMP will be tested prior to commencing drilling.	Senior Crisis, Emergency & Security Advisor	Outcomes of internal audits and tests demonstrate preparedness

4 Operational Monitoring

4.1 Overview

The following sections outline the individual operational monitoring studies that may be implemented in the event of a Level 2 or Level 3 oil spill to the marine or coastal environment. The tables describe the objective, initiation and termination criteria, timing, monitoring (types of sampling techniques and parameters), reporting, resources and competencies.

The studies are presented separately below; however, in practice they may be undertaken simultaneously.

Six operational monitoring studies have been identified:

- O1: Oil characterisation and behaviour
- O2: Water quality
- O3: Sediment quality
- O4: Marine fauna surveillance
- O5: Dispersant efficacy
- O6: Fish tainting.

The operational monitoring studies described in this OSMP complement the Monitor and Evaluate response strategy described in the OPEP in providing information to support decision-making around response activity.

Note: due to the rapid weathering characteristics of gas condensate and marine diesel, operational monitoring studies O1, O2, O3 and O4 are not considered relevant for a pipeline rupture or vessel collision event where there is only a short period of oil release. The time that would elapse between a spill occurring and monitoring personnel being on site would render the data collected unnecessary in informing response strategies. Studies O1, O2, O3 and O4 are, therefore, only actioned (once initiation criteria are met) as a result of a loss of well control incident.

4.1.1 General design considerations

An event-specific sampling and analysis plan (SAP), appropriate to the nature and scale of the event, should be developed and in place before conducting field sampling. The following items should be considered when developing the SAP:

- Nature and scale of the spill (e.g. surface or subsea release, instantaneous or ongoing release, etc.)
- The environment which may be affected (e.g. subtidal or intertidal, depth, presence of other sensitive receptors, etc.)
- Program design aims, which may include but, not limited to the determination of the extent of oil, and the spatial and temporal distribution of the oil
- The sampling plan should have flexibility to be adjusted based on conditions in the field and as new information about the even becomes available

- The number of sites and samples to be collected should be spill-specific and take into account level of effort, potential logistical limitations, weather conditions, sample holding times, freight/transport options etc. that if not properly managed can compromise sample integrity
- Where time permits, appropriate QA/QC samples should be collected to allow assessment of local variability and ascertain potential for introduction of sample contamination throughout the collection and analysis process
- Appropriate QA/QC protocols for sample handling, storage and transport should be included to limit the potential for contamination and ensure sample integrity meets laboratory requirements.
- Monitoring frequency should consider weathering of the spilled oil, with frequency decreasing as the rate of change in the spilled oil decreases (i.e. monitoring effort is concentrated towards the beginning of a spill)
- Subsea sampling in the vicinity of project infrastructure should be designed to avoid damage to or entanglement with this infrastructure
- Health and safety factors associated with working in a range of environments with consideration of prevailing weather.

4.2 Study O1: Oil characterisation and behaviour

An overview of the key components of Study O1 are provided below:

Component	Description
Objective	To provide an assessment of the oil properties and visual observations of the behaviour and weathering of the spilled oil
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• Any related scientific monitoring studies have been initiated by the EMT Environment Leader (or delegate) **and** • The EMT Environment Leader (or delegate) considers that continuation of monitoring under Study O1 will not result in a change to the scale or location of active response options **or** • The EMT Environment Leader (or delegate) has advised that agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the response **or** • The EMT Environment Leader (or delegate) has advised that continuation of monitoring under Study O1 may increase overall environmental impact
Timing	• Where required, the Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 4 hours of initiation criteria being met • Where required, an initial SAP to be available within 12 hours of initiation criteria being met • Field surveys to commence within 24 hours of initiation criteria being met Note: the initial SAP may be revised as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study O1: • Vessel or shore-based

Component	Description

	• Collection of an oil sample
	  ◦ Surface skimming (sampling pole with container)
	  ◦ Oleophilic absorbent pads
	• Behaviour and weathering
	  ◦ Visual observations

Standard Operating Procedures	The following references are provided as guides for standard operating procedures (SOP) that may be implemented under Study O1: • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the Sampling and Analysis Plan (SAP).
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study O1: • Physical properties (e.g. viscosity, pour point, density, wax content) • Chemical properties (e.g. hydrocarbon characterisation, volatile content) • Oil component concentrations (e.g. TRH, BTEX, PAH, MAH) • Visual records of extent and state (e.g. colour/optical effect on surface, form (slick, emulsion, mousse etc), presence waxy residue)
Guidelines	N/A
Reporting	• Results from laboratory sampling reported as available to EMT Environment Leader • Final report prepared within one-week of termination criteria being met and report provided to EMT Environment Leader
Key Resources	• Monitoring Provider or Responder Personnel • Vessels • Analytical laboratory services

Key Competencies	• Monitoring Provider – Study Lead
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 10 years experience in environmental practice
	  ◦ Familiarisation with relevant requirements of the OSMP and OPEP
	• Monitoring Provider – Field Personnel
	  ◦ Familiarisation with oil sampling and recording techniques
	• Vessel provider
	  ◦ Certificate of survey with appropriate service category
	• Analytical laboratory
	  ◦ NATA accredited

4.3 Study O2: Water quality

An overview of the key components of Study O2 are provided below:

Component	Description
Objective	To provide a rapid assessment of the presence, type and concentrations of oil (and dispersant chemicals where relevant) in offshore and intertidal waters

Component	Description
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• Any related scientific monitoring studies have been initiated by the EMT Environment Leader (or delegate) **and** • The EMT Environment Leader (or delegate) considers that continuation of monitoring under Study O2 will not result in a change to the scale or location of active response options **or** • The EMT Environment Leader (or delegate) has advised that agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the response **or** • The EMT Environment Leader (or delegate) has advised that continuation of monitoring under Study O2 may increase overall environmental impact
Timing	• Where required, the Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 4 hours of initiation criteria being met • Where required, an initial SAP to be available within 12 hours of initiation criteria being met • Field surveys to commence within 24 hours of initiation criteria being met Note: the initial SAP may be revised as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study O2: • Surface water sample collection ◦ Sampling pole with container ◦ Hose with peristaltic pump • Sub-surface water sample collection ◦ Niskin bottle (or similar) ◦ Hose with peristaltic pump • In-situ profiles ◦ Physio-chemical profiles ◦ Fluorometer
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study O2: • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP.
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study O2: • Oil concentrations (e.g. TRH, BTEX, PAH, MAH) • Physical parameters (e.g. temperature, salinity, DO, pH) • Fluorescence • Dispersant chemicals (if applied)
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study O2: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018) • Oil spill modelling (NOPSEMA 2019)

Component	Description
Reporting	• Results from in-situ sampling reported daily to the EMT Environment Leader • Results from laboratory sampling reported as available to EMT Environment Leader • Final report prepared within one-week of termination criteria being met and report provided to EMT Environment Leader
Key Resources	• Monitoring Provider • Vessels • Analytical laboratory services
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Field Personnel ◦ Familiarisation with oil and water sampling and recording techniques • Vessel provider ◦ Certificate of survey with appropriate service category • Analytical laboratory ◦ NATA accredited

4.4 Study O3: Sediment quality

An overview of the key components of Study O3 are provided below:

Component	Description
Objective	To provide a rapid assessment of the presence, type and concentrations of oil (and dispersant chemicals where relevant) in offshore, intertidal and shoreline sediments
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from the OPEP Monitor and Evaluate response strategy indicates potential and/or actual sediment contact **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• Any related scientific monitoring studies have been initiated by the EMT Environment Leader (or delegate) **and** • The EMT Environment Leader (or delegate) considers that continuation of monitoring under Study O3 will not result in a change to the scale or location of active response options **or** • The EMT Environment Leader (or delegate) has advised that agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the response **or** • The EMT Environment Leader (or delegate) has advised that continuation of monitoring under Study O3 may increase overall environmental impact
Timing	• Where required, the Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 4 hours of initiation criteria being met • Where required, an initial SAP to be available within 12 hours of initiation criteria being met • Field surveys to commence within 24 hours of initiation criteria being met Note: the initial SAP may be revised as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date

Component	Description
	Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites

Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study O3:
	• Subtidal sample collection
	  ◦ Grab or core sampler
	• Intertidal/shoreline sample collection
	  ◦ Cores or auger
	  ◦ Sediment box

Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study O3: • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP.
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study O3: • Oil concentrations (e.g. TRH, BTEX, PAH, MAH) • Dispersant chemicals (if applied) • Total organic carbon • Physical parameters (e.g. PSD)
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study O3: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018) • Oil spill modelling (NOPSEMA 2019)
Reporting	• Results from in-situ observations reported daily to the EMT Environment Leader • Results from laboratory sampling reported as available to EMT Environment Leader • Final report prepared within one-week of termination criteria being met and report provided to EMT Environment Leader
Key Resources	• Monitoring Provider • Vessels (island access) • Vehicles (mainland access) • Analytical laboratory services

Key Competencies	• Monitoring Provider – Study Lead
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 10 years experience in environmental practice
	  ◦ Familiarisation with relevant requirements of the OSMP and OPEP
	• Monitoring Provider – Field Personnel
	  ◦ Familiarisation with sediment sampling and recording techniques
	• Vessel provider
	  ◦ Certificate of survey with appropriate service category
	• Analytical laboratory
	  ◦ NATA accredited

4.5 Study O4: Marine fauna surveillance

An overview of the key components of Study O4 are provided below:

Component	Description
Objective	To provide a rapid assessment of the presence, type and location of oiled marine fauna
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• Any related scientific monitoring studies have been initiated by the EMT Environment Leader (or delegate) **and** • The EMT Environment Leader (or delegate) considers that continuation of monitoring under Study O4 will not result in a change to the scale or location of active response options **or** • The EMT Environment Leader (or delegate) has advised that agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the response **or** • The EMT Environment Leader (or delegate) has advised that continuation of monitoring under Study O4 may increase overall environmental impact
Timing	• Where required, the Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 4 hours of initiation criteria being met • Where required, an initial SAP to be available within 12 hours of initiation criteria being met • Field surveys to commence within 24 hours of initiation criteria being met Note: the initial SAP may be revised as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites

Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study O4:
	• Systematic surveillance
	  ◦ Aerial observations from fixed-wing or helicopter
	  ◦ Vessel-based observations
	  ◦ On-ground shoreline observations
	• Unmanned surveillance
	  ◦ UAV and/or satellite
	• Opportunistic / incidental observations
	• Carcass collection and tissue sampling

Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study O4: • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be recorded under Study O4 where possible: • Presence and identification (species group / species) of oiled fauna • State of oiled fauna • Presence and state of any carcass
Guidelines	N/A
Reporting	• Results from in-situ observations reported daily to the EMT Environment Leader

Component	Description
	• Final report prepared within one-week of termination criteria being met and report provided to EMT Environment Leader
Key Resources	• Monitoring Provider • Vessels • Aircraft • Vehicles

Key Competencies	• Monitoring Provider – Study Lead
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 10 years experience in environmental practice
	  ◦ Familiarisation with relevant requirements of the OSMP and OPEP
	• Monitoring Provider – Field Personnel
	  ◦ Familiarisation with the fauna observation and recording techniques
	  ◦ Oiled, injured, and diseased fauna handling to be undertaken by trained personnel
	• Vessel provider
	  ◦ Certificate of survey with appropriate service category
	• Aircraft
	  ◦ Current registration with CASA
	• Analytical laboratory
	  ◦ NATA accredited

4.6 Study O5: Dispersant efficacy

An overview of the key components of Study O5 are provided below:

Component	Description
Objective	Determine the effectiveness of dispersant application and reduce surface VOCs (where relevant)
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** the Chemical Dispersant response strategy from the OPEP has been selected for use
Termination trigger	• Any related scientific monitoring studies have been initiated by the EMT Environment Leader (or delegate) **and** • The EMT Environment Leader (or delegate) considers that continuation of monitoring under Study O5 will not result in a change to the scale or location of active response options **or** • The EMT Environment Leader (or delegate) has advised that agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the response **or** • The EMT Environment Leader (or delegate) has advised that continuation of monitoring under Study O5 may increase overall environmental impact
Timing	Study O5 is to be undertaken at the same time as the Chemical Dispersant response strategy
Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling and surveillance may be implemented under Study O5: • Visual observations ◦ Aerial or vessel based • Oil and water sampling

Component	Description
	◦ Water sampling techniques as per Study O1 (e.g. niskin bottle, hose with peristaltic pump, etc.) ◦ Fluorometer ◦ Underwater video surveillance • Air quality monitoring ◦ In-situ detectors
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study O5: • Oil Spill Monitoring Handbook (Hook et al 2016) • Industry Recommended Subsea Dispersant Monitoring Plan (American Petroleum Institute 2013) • Dispersant Application Monitoring Field Guide Tier I Visual Observation (OSRL 2011) • Special Monitoring of Applied Response Technologies (NOAA 2006) SOP will be confirmed by the Monitoring Provider during preparation of the SAP
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study O5: • Oil concentrations (e.g. TRH, BTEX, PAH, MAH) • Fluorescence • VOCs and %LELs
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study O5: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018) • Oil spill modelling (NOPSEMA 2019) • Workplace Exposure Standards for Airborne Contaminants (Safe Work Australia 2018)
Reporting	• Results from in-situ observations reported daily to the EMT Environment Leader • Final report prepared within one-week of termination criteria being met and report provided to EMT Environment Leader
Key Resources	• Monitoring Provider • Vessels • Aircraft
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Field Personnel ◦ Familiarisation with vessel-based and/or aerial-based oil spill monitoring ◦ Familiarisation with relevant sampling techniques (e.g. sub-surface video surveillance, use of fluorometer, water sample collection, air quality monitoring) • Vessel provider ◦ Certificate of survey with appropriate service category • Aircraft ◦ Current registration with CASA • Analytical laboratory ◦ NATA accredited

4.7 Study O6: Fish tainting

An overview of the key components of Study O6 are provided below:

Component	Description
Objective	To provide an assessment of the potential of fish tainting in areas of recreational and/or commercial fisheries
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from Study O2 has confirmed exposure to offshore waters above the ANZG (2018) 99% species protection levels **and** this exposure occurred in waters that intersect with active fisheries **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• Any related scientific monitoring studies have been initiated by the EMT Environment Leader (or delegate) **and** • The EMT Environment Leader (or delegate) considers that continuation of monitoring under Study O6 will not result in a change to the scale or location of active response options **or** • The EMT Environment Leader (or delegate) has advised that agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the response **or** • The EMT Environment Leader (or delegate) has advised that continuation of monitoring under Study O6 may increase overall environmental impact
Timing	• Where required, the Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 4 hours of initiation criteria being met • Where required, an initial SAP to be available within 12 hours of initiation criteria being met • Field surveys to commence within 24 hours of initiation criteria being met Note: the initial SAP may be revised as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study O6: • Systematic fish sample collection ◦ Olfactory evaluation ◦ Tissue collection • Opportunistic carcass collection and tissue sampling
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study O6: • Oil Spill Monitoring Handbook (Hook et al 2016) • Managing Seafood Safety after an Oil Spill (Yender, Michel and Lord 2002) SOP will be confirmed by the Monitoring Provider during preparation of the SAP
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study O6: • Odour and appearance • Chemical analysis of tissue samples (e.g. TRH, BTEX, PAH, MAH)
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study O6:

Component	Description
	• Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018) • Australia New Zealand Food Standards Code
Reporting	• Results from laboratory sampling and sensory analysis reported as available to EMT Environment Leader • Final report prepared within one-week of termination criteria being met and report provided to EMT Environment Leader
Key Resources	• Monitoring Provider • Vessels • Analytical laboratory services
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Field Personnel ◦ Familiarisation with oil and water sampling and recording techniques • Monitoring Provider – Olfactory Assessment ◦ Trained and/or experienced olfactory analysts • Vessel provider ◦ Certificate of survey with appropriate service category • Analytical laboratory ◦ NATA accredited

5 Scientific Monitoring

5.1 Overview

The following sections outline the individual scientific monitoring studies that may be implemented in the event of a Level 2 or Level 3 oil spill to the marine or coastal environment. The tables describe the objective, initiation and termination criteria, timing, monitoring (types of sampling techniques and parameters), reporting, resources and competencies.

The studies are presented separately below; however, in practice they may be undertaken simultaneously.

Seven scientific monitoring studies have been identified:

- S1: Water quality impact assessment
- S2: Sediment quality impact assessment
- S3: Subtidal habitats impact assessment
- S4: Intertidal and coastal habitats impact assessment
- S5: Marine fauna impact assessment
- S6: Fisheries impact assessment
- S7: Heritage and socioeconomic impact assessment.

Scientific monitoring generally has objectives relating to attributing cause-effect interactions of the spill or the spill-response activities with changes to the surrounding environment. Where impacts are identified, the studies also have the objective of identifying and recommending remediation activities, and monitoring for recovery. Consequently, such studies are required to account for natural or sampling variation, and study designs must be robust and produce defensible data. Scientific monitoring is typically conducted over a wider study area, extending beyond the spill footprint, and a longer time period, extending beyond the spill response.

5.1.1 General design considerations

Guidance on various experimental monitoring approaches for scientific monitoring (e.g. use of baseline data in 'before versus after' analyses, and alternative approaches such as 'control versus impact' and 'gradient approach') is provided in Appendix A. .

Termination criteria for some of the scientific monitoring modules require the use of guidelines and/or benchmark values. Where available, Australian guidelines (e.g. ANZG 2018) or regionally relevant data is used. Where these are unavailable for a selected parameter, toxicity screening benchmarks developed by the USEPA in response to the Deepwater Horizon incident (e.g. USEPA 2015), or other international guidelines (e.g. USEPA 2017) may be adopted.

5.2 Study S1: Water quality impact assessment

An overview of the key components of Study S1 are provided below:

Component	Description
Objective	Determine the impact to, and recovery of, offshore and intertidal water quality from oil exposure and/or any impacts associated with response activities
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from the Study O2 has confirmed exposure to offshore or intertidal waters **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• The EMT Environment Leader (or delegate) considers that: ◦ Hydrocarbon concentrations in offshore waters have returned to within the expected natural dynamics of baseline state and/or control sites **or** ◦ Hydrocarbon concentrations in offshore waters are below relevant ANZG (2018) 99% species protection levels or other applicable benchmark values **and** • The EMT Environment Leader (or delegate) considers that: ◦ Relevant water quality parameter (e.g. chemicals from dispersant) concentrations in offshore waters have returned to within the expected natural dynamics of baseline state and/or control sites **or** ◦ Relevant water quality parameter (e.g. chemicals from dispersant) concentrations in offshore waters are below relevant ANZG (2018) 99% species protection levels or other applicable benchmark values **and** • The EMT Environment Leader (or delegate) in conjunction with relevant government agency, considers that water quality values within protected areas (i.e. Australian Marine Parks, Ramsar wetlands or State marine protected areas) have not been impacted or have returned to within the expected natural dynamics of baseline state **and** • Agreement has been reached with the Statutory Authority relevant to the spill to terminate the monitoring
Timing	• Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 24 hours of initiation criteria being met An initial SAP, prepared by the Monitoring Provider, to be available within 48 hours of initiation criteria being met • Consultation with relevant agencies to commence as soon as practicable after initiation criteria are met • Field surveys to commence within 72 hours (3 days) of initiation criteria being met Note: the initial SAP may be revised following consultation with relevant agencies and/or as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
Monitoring Design	The following are monitoring designs recommended for different spill extents/behaviour; final design will be confirmed during preparation of the SAP by the Monitoring Provider.
	Spill Extent / Behaviour: • Spill plume concentrated around source, dissipating with distance Monitoring Design: • Gradient approach
	Spill Extent / Behaviour: • Spill plume has dissipated away from source Monitoring Design: • Gradient approach • Lines of Evidence
	Spill Extent / Behaviour: • Nearshore spill or spill reaches shoreline Monitoring Design: • BACI (if appropriate baseline data available)

Component	Description	
		• IvC • Gradient approach
	• Spill interacts with area of biological importance (e.g. bay/shoal/island)	• BACI (if appropriate baseline data available) • IvC
Scope	All areas (intertidal, offshore) and water depths are included within the scope for Study S1. Note: where Management Plans for protected area (e.g. Australian Marine Parks, State marine protected areas, Ramsar wetlands) exist, the SAP will include consideration of any specific sampling and/or values that require monitoring	
Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study S1: • Surface water sample collection ◦ Sampling pole with container ◦ Hose with peristaltic pump • Sub-surface water sample collection ◦ Niskin bottle (or similar) ◦ Hose with peristaltic pump • In-situ profiles ◦ Physio-chemical profiles ◦ Fluorometer • Visual records of any damage or change due to response activities	
Sampling Frequency	• Initial sampling frequency will be determined by during preparation of the SAP by the Monitoring Provider • Ongoing sampling frequency will be determined by the Monitoring Provider in consultation with the EMT Environment Leader following each monitoring and reporting event until termination criteria are met.	
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study S1: • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP	
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study S1: • Oil concentrations (e.g. TRH, BTEX, PAH, MAH) • Physical parameters (e.g. temperature, salinity, DO, pH) • Fluorescence • Dispersant chemicals (if applied) and/or other water quality parameters as necessary to identify any impacts from response activities	
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study S1: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018) • Oil spill modelling (NOPSEMA 2019) • Acute and Chronic Screening Benchmarks for Water and Sediment Quality (USEPA 2015) • National Recommended Water Quality Criteria - Aquatic Life (USEPA 2017)	
Reporting	• Data report to be provided to EMT Environment Leaderfollowing the completion of each field survey	

Component	Description
	◦ The data report will also contain on-going trend analysis allowing for the tracking of impacts and recovery, identification/recommendations on any remediation works or active management (including changes to existing sampling or additional sampling required) that should be considered • Final impact assessment report (addressing impacts from spill event and any relevant response activities) to be provided to EMT Environment Leader following the termination criteria being met
Key Resources	• Monitoring Provider • Vessels • Analytical laboratory services
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Field Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experienced in the relevant sampling and/or recording techniques • Monitoring Provider – Office Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experienced in water quality data analysis • Vessel provider ◦ Certificate of survey with appropriate service category • Analytical laboratory ◦ NATA accredited

5.3 Study S2: Sediment quality impact assessment

An overview of the key components of Study S2 are provided below:

Component	Description
Objective	Determine the impact to, and recovery of, offshore, intertidal and shoreline sediment quality from oil exposure and/or any impacts associated with response activities
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from the Study O3 has confirmed exposure to shoreline sediments **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• The EMT Environment Leader (or delegate) considers that: ◦ Hydrocarbon concentrations in sediments have returned to within the expected natural dynamics of baseline state and/or control sites **or**

<table>
<tr><th>Component</th><th>Description</th></tr>
<tr><td></td><td>

Hydrocarbon concentrations in sediments are below relevant ANZECC/ARMCANZ SQGV (Simpson et al. 2013) other applicable benchmark values and

The EMT Environment Leader (or delegate) considers that:

Relevant sediment quality parameter (e.g. chemicals from dispersant) concentrations have returned to within the expected natural dynamics of baseline state and/or control sites or
Relevant sediment quality parameter (e.g. chemicals from dispersant) concentrations in are below relevant ANZECC/ARMCANZ SQGV (Simpson et al. 2013) other applicable benchmark values and

The EMT Environment Leader (or delegate) in conjunction with relevant government agency, considers that sediment quality values within protected areas (i.e. Australian Marine Parks, Ramsar wetlands or State marine protected areas) have not been impacted or have returned to within the expected natural dynamics of baseline state and
Agreement has been reached with the Statutory Authority relevant to the spill to terminate the monitoring

</td></tr>
<tr><td>Timing</td><td>

Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 24 hours of initiation criteria being met
An initial SAP, prepared by the Monitoring Provider, to be available within 48 hours of initiation criteria being met
Consultation with relevant agencies to commence as soon as practicable after initiation criteria are met
Field surveys to commence within 72 hours (3 days) of initiation criteria being met

Note: the initial SAP may be revised following consultation with relevant agencies and/or as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date

Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
</td></tr>
<tr><td>Monitoring Design</td><td>
The following are monitoring designs recommended for different spill extents/behaviour; final design will be confirmed during preparation of the SAP by the Monitoring Provider.
<table>
<tr><th>Spill Extent / Behaviour</th><th>Monitoring Design</th></tr>
<tr><td>Spill plume concentrated around source, dissipating with distance</td><td>Gradient approach</td></tr>
<tr><td>Spill plume has dissipated away from source</td><td>Gradient approach
Lines of Evidence</td></tr>
<tr><td>Nearshore spill or spill reaches shoreline</td><td>BACI (if appropriate baseline data available)
IvC
Gradient approach</td></tr>
<tr><td>Spill interacts with area of biological importance (e.g. bay/shoal/island)</td><td>BACI (if appropriate baseline data available)
IvC</td></tr>
</table>
</td></tr>
<tr><td>Scope</td><td>
All areas (shoreline, intertidal, offshore) are included within the scope for Study S2.

Note: where Management Plans for protected area (e.g. Australian Marine Parks, State marine protected areas, Ramsar wetlands) exist, the SAP will include consideration of any specific sampling and/or values that require monitoring
</td></tr>
<tr><td>Sampling Techniques</td><td>
Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study S2:

Subtidal sample collection

Grab or core sampler

Intertidal/shoreline sample collection

</td></tr>
</table>

Component	Description
	◦ Cores or auger ◦ Sediment box • Visual records of any damage or change due to response activities
Sampling Frequency	• Initial sampling frequency will be determined by during preparation of the SAP by the Monitoring Provider • Ongoing sampling frequency will be determined by the Monitoring Provider in consultation with the EMT Environment Leader following each monitoring and reporting event until termination criteria are met.
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study S2: • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study S2: • Oil concentrations (e.g. TRH, BTEX, PAH, MAH) • Dispersant chemicals (if applied) • Total organic carbon • Physical parameters (e.g. PSD)
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study S2: • ANZECC/ARMCANZ SQGV (Simpson et al. 2013) • Oil spill modelling (NOPSEMA 2019) • Acute and Chronic Screening Benchmarks for Water and Sediment Quality (USEPA 2015)
Reporting	• Data report to be provided to EMT Environment Leader following the completion of each field survey ◦ The data report will also contain on-going trend analysis allowing for the tracking of impacts and recovery, identification/recommendations on any remediation works or active management (including changes to existing sampling or additional sampling required) that should be considered • Final impact assessment report (addressing impacts from spill event and any relevant response activities) to be provided to EMT Environment Leader following the termination criteria being met
Key Resources	• Monitoring Provider • Vessels (island access) • Vehicles (mainland access) • Analytical laboratory services
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Field Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experienced in the relevant sampling and/or recording techniques

Component	Description

	• Monitoring Provider – Office Personnel
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 5 years experience in environmental practice
	  ◦ Experience in sediment quality data analysis
	• Vessel provider
	  ◦ Certificate of survey with appropriate service category
	• Analytical laboratory
	  ◦ NATA accredited

5.4 Study S3: Subtidal habitats impact assessment

An overview of the key components of Study S3 are provided below:

Component	Description
Objective	Determine the impact to, and recovery of, subtidal habitats from oil exposure and/or any impacts associated with response activities
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from the OPEP Monitor and Evaluate response strategy or Study O2 or O3 indicates potential and/or actual exposure to near-bottom waters or sediments **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• The EMT Environment Leader (or delegate) considers that disturbance parameters (e.g. species composition, percent cover) and health parameters (e.g. leaf condition) have returned to within the expected natural dynamics of baseline state and/or control sites **and** • The EMT Environment Leader (or delegate) in conjunction with relevant government agency, considers that subtidal habitat quality values within protected areas (i.e. Australian Marine Parks, Ramsar wetlands or State marine protected areas) have not been impacted or have returned to within the expected natural dynamics of baseline state **and** • Agreement has been reached with the Statutory Authority relevant to the spill to terminate the monitoring
Timing	• Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 24 hours of initiation criteria being met • An initial SAP, prepared by the Monitoring Provider, to be available within 72 hours of the initiation criteria being met • Consultation with relevant agencies to commence as soon as practicable after initiation criteria are met • Field surveys to commence within 120 hours (5 days) of initiation criteria being met Note: the initial SAP may be revised following consultation with relevant agencies and/or as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
Monitoring Design	The following are monitoring designs recommended for different spill extents/behaviour; final design will be confirmed during preparation of the SAP by the Monitoring Provider.
	Spill Extent / Behaviour — Monitoring Design

Component	Description	
	• Spill plume concentrated around source, dissipating with distance	• Gradient approach
	• Spill plume has dissipated away from source	• Gradient approach • Lines of Evidence
	• Nearshore spill or spill reaches shoreline	• BACI (if appropriate baseline data available) • IvC • Gradient approach • Lines of Evidence
	• Spill interacts with area of biological importance (e.g. bay/shoal/island)	• BACI (if appropriate baseline data available) • IvC • Lines of Evidence
Scope	Soft and hard substrate subtidal benthic habitats and their associated organisms covered by Study S3 include: • Hard (scleractinian) corals, turf and coralline algae • Sponges and other filter feeders • Macroalgae (including turf and encrusting coralline algae) and seagrasses; • Kelp • Large and conspicuous (i.e. epifaunal) motile invertebrates (e.g. crustaceans and molluscs) Note: where Management Plans for protected area (e.g. Australian Marine Parks, State marine protected areas, Ramsar wetlands) exist, the SAP will include consideration of any specific sampling and/or values that require monitoring	

Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study S3:
	• Dive / towed video / drop camera / ROV surveys
	  ◦ Transects
	  ◦ Quadrats
	  ◦ Sediment grab (for soft-bottom habitat)
	• Remote sensing
	• Biological sample collection
	• Records of any damage or change due to response activities	

Sampling Frequency	• Survey timing should coincide with that appropriate for the habitat and/or community of interest • Initial sampling frequency will be determined by during preparation of the SAP by the Monitoring Provider • Ongoing sampling frequency will be determined by the Monitoring Provider in consultation with the EMT Environment Leader following each monitoring and reporting event until termination criteria are met	
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study S3: • Parks Victoria Standard Operating Procedure for Biological Monitoring of Subtidal Reefs (Edmunds and Hart 2005) • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP	
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study S3: • Habitat/substrate type	

Component	Description
	• Abundance and percent cover • Diversity • Distribution • State (e.g. evidence of stress, necrosis, leaf condition etc.) • Chemical analysis of tissue samples (e.g. TRH, BTEX, PAH, MAH)
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study S3: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018)
Reporting	• Data report to be provided to EMT Environment Leader following the completion of each field survey ◦ The data report will also contain on-going trend analysis allowing for the tracking of impacts and recovery, identification/recommendations on any remediation works or active management (including changes to existing sampling or additional sampling required) that should be considered • Final impact assessment report (addressing impacts from spill event and any relevant response activities) to be provided to EMT Environment Leader following the termination criteria being met
Key Resources	• Monitoring Provider • Vessels • ROV

Key Competencies	• Monitoring Provider – Study Lead
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 10 years experience in environmental practice
	  ◦ Familiarisation with relevant requirements of the OSMP and OPEP
	• Monitoring Provider – Field Personnel
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 5 years experience in environmental practice
	  ◦ Commercial dive qualifications
	  ◦ Experienced in the relevant sampling and/or recording techniques
	  ◦ Experienced in commercial ROV operations
	• Monitoring Provider – Office Personnel
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 5 years experience in environmental practice
	  ◦ Experience in identification, analysis and interpretation of benthic habitat data
	• Vessel provider
	  ◦ Certificate of survey with appropriate service category
	  ◦ Suitable for commercial diving operations

5.5 Study S4: Intertidal and coastal habitats impact assessment

An overview of the key components of Study S4 are provided below:

Component	Description	
Objective	Determine the impact to, and recovery of, intertidal and coastal habitats from oil exposure and/or any impacts associated with response activities	
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from the OPEP Monitor and Evaluate response strategy or Study O2 or O3 indicates potential and/or actual exposure to near-bottom waters or sediments **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence	
Termination trigger	• The EMT Environment Leader (or delegate) considers that disturbance parameters (e.g. species composition, percent cover) and health parameters (e.g. leaf condition) have returned to within the expected natural dynamics of baseline state and/or control sites **and** • The EMT Environment Leader (or delegate) in conjunction with relevant government agency, considers that intertidal habitat quality values within protected areas (i.e. Ramsar wetlands or State marine protected areas) have not been impacted or have returned to within the expected natural dynamics of baseline state **and** • Agreement has been reached with the Statutory Authority relevant to the spill to terminate the monitoring	
Timing	• Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 24 hours of initiation criteria being met • An initial SAP, prepared by the Monitoring Provider, to be available within 72 hours of the initiation criteria being met • Consultation with relevant agencies to commence as soon as practicable after initiation criteria are met • Field surveys to commence within 120 hours (5 days) of initiation criteria being met Note: the initial SAP may be revised following consultation with relevant agencies and/or as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites	
Monitoring Design	The following are monitoring designs recommended for different spill extents/behaviour; final design will be confirmed during preparation of the SAP by the Monitoring Provider.	
	Spill Extent / Behaviour	Monitoring Design
	• Spill plume concentrated around source, dissipating with distance	• Gradient approach
	• Spill plume has dissipated away from source	• Gradient approach • Lines of Evidence
	• Nearshore spill or spill reaches shoreline	• BACI (if appropriate baseline data available) • IvC • Gradient approach • Lines of Evidence
	• Spill interacts with area of biological importance (e.g. bay/shoal/island)	• BACI (if appropriate baseline data available) • IvC • Lines of Evidence

Component	Description
Scope	Intertidal and coastal habitats covered by Study S4 include: • Mangroves • Saltmarsh • Macroalgae and seagrass (only those occurring in the intertidal zone) • Invertebrates (molluscs, crustaceans) and other rocky, muddy and sandy shore biota occurring in the intertidal zone • Shoreline/coastal areas Note: where Management Plans for protected area (e.g. Ramsar wetlands) exist, the SAP will include consideration of any specific sampling and/or values that require monitoring
Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study S4: • Ground / dive / snorkel / drop camera ◦ Transects ◦ Quadrats ◦ Sediment grab (for soft-bottom habitat) • Remote sensing • Biological sample collection • Records of any damage or change due to response activities
Sampling Frequency	• Survey timing should coincide with that appropriate for the habitat and/or community of interest • Initial sampling frequency will be determined by during preparation of the SAP by the Monitoring Provider • Ongoing sampling frequency will be determined by the Monitoring Provider in consultation with the EMT Environment Leader following each monitoring and reporting event until termination criteria are met
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study S4: • Parks Victoria Standard Operating Procedure for Biological Monitoring of Intertidal Reefs (Hart and Edmunds 2005) • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study S4: • Habitat/substrate type • Abundance and percent cover • Diversity • Distribution • State (e.g. evidence of stress, necrosis, leaf condition etc.) • Chemical analysis of tissue samples (e.g. TRH, BTEX, PAH, MAH) • Condition and quality of coastal environment (e.g. evidence of disturbance to sediment profile or environmental values from response [shoreline clean-up, oiled wildlife] activities)
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study S4: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018)
Reporting	• Data report to be provided to EMT Environment Leader following the completion of each field survey

Component	Description
	◦ The data report will also contain on-going trend analysis allowing for the tracking of impacts and recovery, identification/recommendations on any remediation works or active management (including changes to existing sampling or additional sampling required) that should be considered • Final impact assessment report (addressing impacts from spill event and any relevant response activities) to be provided to EMT Environment Leader following the termination criteria being met
Key Resources	• Monitoring Provider • Vessels (island access) • Vehicles (mainland access)
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Field Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experienced in the relevant sampling and/or recording techniques • Monitoring Provider – Office Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experience in identification, analysis and interpretation of benthic habitat data • Vessel provider ◦ Certificate of survey with appropriate service category

5.6 Study S5: Marine fauna impact assessment

An overview of the key components of Study S5 are provided below:

Component	Description
Objective	Determine the impact to, and recovery of, marine fauna from oil exposure and/or any impacts associated with response activities
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from the Study O4 has confirmed exposure to marine fauna **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• The EMT Environment Leader (or delegate) considers that disturbance parameters (e.g. population size, breeding success) have returned to within the expected natural dynamics of baseline state and/or control sites **and** • The EMT Environment Leader (or delegate) in conjunction with relevant government agency, considers that protected marine fauna (i.e. threatened or migratory species) have not been impacted or have returned to within the expected natural dynamics of baseline state (including any assessment against management requirements in Conservation Advices and/or Recovery Plans) **and**

<table>
<tr><th>Component</th><th>Description</th></tr>
<tr><td></td><td>• Agreement has been reached with the Statutory Authority relevant to the spill to terminate the monitoring</td></tr>
<tr><td>Timing</td><td>• Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 24 hours of initiation criteria being met
• An initial SAP, prepared by the Monitoring Provider, to be available within 72 hours of initiation criteria being met
• Consultation with relevant agencies to commence as soon as practicable after initiation criteria are met
• Field surveys to commence within 96 hours (4 days) of initiation criteria being met
Note: the initial SAP may be revised following consultation with relevant agencies and/or as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date
Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites</td></tr>
<tr><td>Monitoring Design</td><td>The following are monitoring designs recommended for different spill extents/behaviour; final design will be confirmed during preparation of the SAP by the Monitoring Provider.
<table>
<tr><th>Spill Extent / Behaviour</th><th>Monitoring Design</th></tr>
<tr><td>• Spill reaches shoreline with known roosting/breeding/nesting/haul-out habitat</td><td>• BACI (if appropriate baseline data available)
• Control chart (if appropriate baseline data available)
• IvC
• Gradient approach
• Lines of Evidence</td></tr>
<tr><td>• Spill intersects with area of biological importance (e.g. foraging areas)</td><td>• BACI (if appropriate baseline data available)
• Control chart (if appropriate baseline data available)
• IvC
• Gradient approach
• Lines of Evidence</td></tr>
</table></td></tr>
<tr><td>Scope</td><td>Marine fauna covered by Study S5 include:
• Seabirds and shorebirds
• Marine megafauna (pinnipeds, reptiles, sharks, cetaceans)
Note: where Conservation Advice and/or Recovery Plans exist for protected marine fauna, the SAP will include consideration of any specific sampling and/or values that require monitoring</td></tr>
<tr><td>Sampling Technique</td><td>Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study S5:
• Systematic surveillance (e.g. transects)
◦ Aerial observations from fixed-wing or helicopter
◦ Vessel-based observations
◦ On-ground shoreline observations
• Unmanned surveillance
◦ UAV and/or satellite
• Tissue sample collection and analysis
• Opportunistic / incidental observations
• Carcass collection and tissue sampling
• Records of any damage or change due to response activities</td></tr>
</table>

Component	Description
Sampling Frequency	• Survey timing should coincide with that appropriate for the marine fauna of interest • Initial sampling frequency will be determined by during preparation of the SAP by the Monitoring Provider • Ongoing sampling frequency will be determined by the Monitoring Provider in consultation with the EMT Environment Leader following each monitoring and reporting event until termination criteria are met
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study S5: • Oil Spill Monitoring Handbook (Hook et al 2016) SOP will be confirmed by the Monitoring Provider during preparation of the SAP
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study S5: • Nest/burrow presence • Abundance (adults, juveniles, fledging/hatchling etc) • Density • Distribution • State (e.g. evidence of stress, oil cover, injured etc.) • Chemical analysis of tissue samples (e.g. TRH, BTEX, PAH, MAH) • Presence and state of any carcass
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study S4: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018)
Reporting	• Data report to be provided to EMT Environment Leader following the completion of each field survey ◦ The data report will also contain on-going trend analysis allowing for the tracking of impacts and recovery, identification/recommendations on any remediation works or active management (including changes to existing sampling or additional sampling required) that should be considered • Final impact assessment report (addressing impacts from spill event and any relevant response activities) to be provided to EMT Environment Leader following the termination criteria being met
Key Resources	• Monitoring Provider • Vessels • Aircraft • Vehicles • Analytical laboratory services
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Field Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experienced in the relevant sampling and/or recording techniques

Component	Description
	◦ Oiled, injured, and diseased fauna handling to be undertaken by trained personnel • Monitoring Provider – Office Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experience in identification, analysis and interpretation of biota data • Vessel provider ◦ Certificate of survey with appropriate service category • Analytical laboratory ◦ NATA accredited

5.7 Study S6: Fisheries impact assessment

An overview of the key components of Study S6 are provided below:

Component	Description
Objective	Determine the presence of, and recovery from, oil taint in commercially or recreationally important fish species and/or any impacts associated with response activities
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from Study O6 has confirmed the presence of fishing tainting **or** • Allegations of damage are received from commercial fisheries or government agencies **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• The EMT Environment Leader (or delegate) considers that: ◦ Fish or shellfish show no presence of tissue taint **or** ◦ PAH levels in fish and shellfish tissue have returned to within the expected natural dynamics of baseline state and/or control sites **or** ◦ PAH levels in fish and shellfish tissue are at or below regulatory levels of concern **and** • Agreement has been reached with the Statutory Authority relevant to the spill to terminate the monitoring
Timing	• Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 24 hours of initiation criteria being met • An initial SAP, prepared by the Monitoring Provider, to be available within 72 hours of initiation criteria being met • Consultation with relevant agencies to commence as soon as practicable after initiation criteria are met • Field surveys to commence within 120 hours (5 days) of initiation criteria being met Note: the initial SAP may be revised following consultation with relevant agencies and/or as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
Monitoring Design	The following are monitoring designs recommended for different spill extents/behaviour; final design will be confirmed during preparation of the SAP by the Monitoring Provider.
	Spill Extent / Behaviour — Monitoring Design

Component	Description	
	• Offshore spill	• Gradient approach • Lines of Evidence
	• Nearshore spill or spill reaches nearshore areas	• BACI (if appropriate baseline data available) • IvC • Gradient approach • Lines of Evidence

Sampling Techniques	Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study S6:
	• Systematic fish sample collection
	  ◦ Olfactory evaluation
	  ◦ Tissue collection
	• Opportunistic carcass collection and tissue sampling
	• Records of any damage or change due to response activities	

Sampling Frequency	• Survey timing should coincide with that appropriate for the fish species of interest • Initial sampling frequency will be determined by during preparation of the SAP by the Monitoring Provider • Ongoing sampling frequency will be determined by the Monitoring Provider in consultation with the EMT Environment Leader following each monitoring and reporting event until termination criteria are met	
Standard Operating Procedures	The following references are provided as guides for standard operating procedures that may be implemented under Study S5: • Oil Spill Monitoring Handbook (Hook et al 2016) • Managing Seafood Safety after an Oil Spill (Yender, Michel and Lord 2002) SOP will be confirmed by the Monitoring Provider during preparation of the SAP	
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study S6: • Odour and appearance • Chemical analysis of tissue samples (e.g. TRH, BTEX, PAH, MAH) • Fish health indicators and biomarkers (e.g. liver enzymes, PAH metabolites)	
Guidelines	The following references are provided as guidelines or thresholds that may be appropriate for comparison of results during Study O1: • Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters Quality (ANZG 2018) • Australia New Zealand Food Standards Code	
Reporting	• Data report to be provided to EMT Environment Leader following the completion of each field survey ◦ The data report will also contain on-going trend analysis allowing for the tracking of impacts and recovery, identification/recommendations on any remediation works or active management (including changes to existing sampling or additional sampling required) that should be considered • Final impact assessment report (addressing impacts from spill event and any relevant response activities) to be provided to EMT Environment Leader following the termination criteria being met	
Key Resources	• Monitoring Provider • Olfactory Analysis Panel • Vessels • Analytical laboratory services	

Component	Description

Key Competencies	• Monitoring Provider – Study Lead
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 10 years experience in environmental practice
	  ◦ Familiarisation with relevant requirements of the OSMP and OPEP
	• Monitoring Provider – Field Personnel
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 5 years experience in environmental practice
	  ◦ Experienced in the relevant sampling and/or recording techniques
	• Monitoring Provider – Office Personnel
	  ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area
	  ◦ Minimum 5 years experience in environmental practice
	  ◦ Experience in analysis and interpretation of biota data
	• Monitoring Provider – Olfactory Assessment Panel
	  ◦ Trained and/or experienced olfactory analysts
	• Vessel provider
	  ◦ Certificate of survey with appropriate service category
	• Analytical laboratory
	  ◦ NATA accredited

5.8 Study S7: Heritage and socioeconomic impact assessment

An overview of the key components of Study S7 are provided below:

Component	Description
Objective	Determine the impact to, and recovery of, heritage and socioeconomic features from oil exposure and/or any impacts associated with response activities
Initiation trigger	• The EMT Environment Leader (or delegate) has confirmed that a Level 2 or Level 3 offshore oil spill has occurred **and** data from the OPEP Monitor and Evaluate response strategy or Study O2 or O3 indicates potential and/or actual exposure to known areas of heritage or socioeconomic features **or** • Allegations of damage are received from other users (e.g. tourism operators, heritage groups) s or government agencies **or** • The EMT Environment Leader (or delegate) advises that either full or partial implementation of the study is to commence
Termination trigger	• The EMT Environment Leader (or delegate) considers that considers that disturbance parameters (e.g. hydrocarbon visibility and concentration, condition/quality, area usage levels) have returned to within the expected natural dynamics of baseline state and/or control sites **and** • The EMT Environment Leader (or delegate) in conjunction with relevant government agency, considers that heritage and/or socioeconomic features have not been impacted or have returned to within the expected natural dynamics of baseline state **and** • Agreement has been reached with the Statutory Authority relevant to the spill to terminate the monitoring

<table>
<tr><th>Component</th><th>Description</th></tr>
<tr><td>Timing</td><td>
• Monitoring Provider/s will be activated (refer to the relevant OSMP Addendum for the petroleum activities) within 24 hours of initiation criteria being met
• An initial SAP, prepared by the Monitoring Provider, to be available within 72 hours of initiation criteria being met
• Consultation with relevant agencies to commence as soon as practicable after initiation criteria are met
• Desktop and/or field surveys to commence within 96 hours (4 days) of initiation criteria being met
Note: the initial SAP may be revised following consultation with relevant agencies and/or as required due to the nature of an ongoing spill event, changing operational requirements and/or results from data collected to date
Note: timing of mobilisation and field surveys is dependent on safe operating conditions (e.g. weather, sea state, etc.) and operational access to sites
</td></tr>
<tr><td>Monitoring Design</td><td>
The following are monitoring designs recommended for different spill extents/behaviour; final design will be confirmed during preparation of the SAP by the Monitoring Provider.
<table>
<tr><th>Spill Extent / Behaviour</th><th>Monitoring Design</th></tr>
<tr><td>• Offshore spill</td><td>• Gradient approach
• Lines of Evidence</td></tr>
<tr><td>• Nearshore spill or spill reaches nearshore areas</td><td>• IvC
• Gradient approach
• Lines of Evidence</td></tr>
</table>
</td></tr>
<tr><td>Scope</td><td>
Heritage and socioeconomic features covered by Study S7 include:
• Cultural and heritage features (e.g. World, Commonwealth or National heritage listed places)
• Indigenous heritage features (e.g. Indigenous Protected Areas, areas with artefacts or other cultural sensitivity)
• Underwater cultural heritage features (e.g. shipwrecks, sunken artefacts)
• Socioeconomic features (e.g. tourism and recreational activities, commercial shipping, other marine users)
Note: commercial fisheries are included within Study S6.
</td></tr>
<tr><td>Sampling Techniques</td><td>
Sampling techniques will vary depending on the individual event and final monitoring design. The following types of sampling may be implemented under Study S7:
• Desktop assessment
  ◦ Identification of heritage and/or socioeconomic features at risk based on direct or indirect change to ambient environmental conditions (e.g. water and sediment quality) or values
  ◦ Notifications to any relevant government agencies (e.g. Heritage Victoria, Department of the Environment and Energy etc.) as required
  ◦ Assessment of each affected feature and development of appropriate monitoring and management recommendations and develop appropriate
• Field data collection
  ◦ Visual inspection and records of any changes to condition, exposure to oil, changes in behaviour or use etc.
  ◦ Systematic surveillance (e.g. transects) using aerial, vessel or on-ground observations as appropriate
  ◦ Records of any damage or change due to response activities
</td></tr>
<tr><td>Sampling Frequency</td><td>• Initial sampling frequency will be determined by during preparation of the SAP by the Monitoring Provider</td></tr>
</table>

Component	Description
	• Ongoing sampling frequency will be determined by the Monitoring Provider in consultation with the EMT Environment Leader following each monitoring and reporting event until termination criteria are met
Standard Operating Procedures	SOP for heritage and socioeconomic studies will be developed in consultation with the appropriate government agency with responsibility for protection of features
Parameters	Sampling parameters will vary depending on the individual event and final monitoring design. The following types of parameters may be analysed under Study S6: • Visual appearance • Condition (e.g. evidence of oil cover, damage etc.) • Use of parameters from other studies as required (e.g. water and sediment quality monitoring)
Guidelines	N/A
Reporting	• Data report to be provided to EMT Environment Leader following the completion of each desktop or field survey ◦ The data report will also contain on-going trend analysis allowing for the tracking of impacts and recovery, identification/recommendations on any remediation works or active management (including changes to existing sampling or additional sampling required) that should be considered • Final impact assessment report (addressing impacts from spill event and any relevant response activities) to be provided to EMT Environment Leader following the termination criteria being met
Key Resources	• Monitoring Provider • Vessels
Key Competencies	• Monitoring Provider – Study Lead ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental practice ◦ Familiarisation with relevant requirements of the OSMP and OPEP • Monitoring Provider – Socioeconomic and Heritage Specialist ◦ Bachelor degree in environmental or social science from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 10 years experience in environmental/social practice ◦ Experienced in interpretation and management of heritage, social and economic data • Monitoring Provider – Field Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experienced in the relevant sampling and/or recording techniques • Monitoring Provider – Office Personnel ◦ Bachelor degree in environmental science/engineering from a recognised institution or equivalent tertiary study in technical area ◦ Minimum 5 years experience in environmental practice ◦ Experience in analysis and interpretation of heritage, social and economic data • Vessel provider ◦ Certificate of survey with appropriate service category

6 References/Associated documents

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7 Document information and history

Revision History

Rev	Date	Changes made in document	Reviewer/s	Consolidator	Approver
0	19/06/2019	N/A	PW	GLE	TF
1	04/11/2019	Changes in response NOPSEMA RFFWI 5 September 2019	PW	Xodus	PW
2	19/12/2019	Changes in response NOPSEMA OMR 4 December 2019	PW	Xodus	PW
3	28/01/2020	Changes in response to NOPSEMA RFFWI 14 January 2020	PW	Xodus	PW
1	XX/XX/XXX	e.g. annual review, no changes made			

Appendix A Approaches for Scientific Monitoring Design

This appendix provides guidance (as provided in APPEA 2019) on survey design approaches that may be utilised for scientific monitoring:

- Impact versus Control (IvC)
- Gradient of Impacts
- Before-After-Control-Impact (BACI)
- Control Chart
- Lines of Evidence.

The design of monitoring studies should ensure, as far as possible, that the planned monitoring activities are practicable and that the objectives of the study will be met. The design must result in the collection of meaningful data and, where practicable, data that are sufficiently powerful to detect ecologically relevant changes.

The final survey design(s) can depend on a variety of factors, included but not limited to:

- Scale and pattern of potential effects of the spill
- Availability of baseline data and/or ability to rapidly obtain baseline data
- Time frame available to gather pre- and post-spill data
- Availability of operational monitoring data
- Availability of appropriate control sites
- Statistical approach proposed for data analysis
- Range of possible chronic and acute effects on the parameters of concern, based on the characteristics of the spill
- Monitoring frequency required to ensure short-and long-term impacts are detected
- Legislative requirements
- Available resources and equipment to conduct the work in terms of personnel, logistics, and access.

Note: data collection can depend on several constraints (as outlined above) and on access given logistical and safety constraints applicable to a spill event. Therefore, the survey designs recommended within the implementation guides for each scientific monitoring module, may not be able to be implemented exactly as intended. For example, there may be inadequate number of control sites because of the size of the spill and therefore data collected from an expected BACI design may need to be analysed as a gradient approach etc.

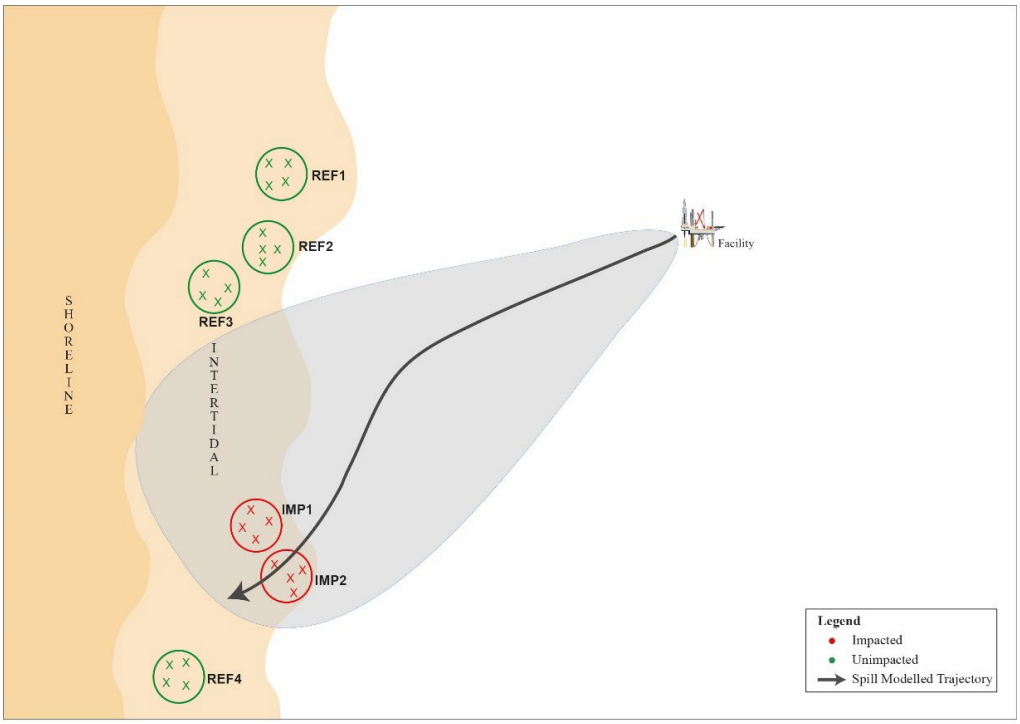
A. 1. Before-After-Control-Impact (BACI) approach

Where appropriate baseline data are available, consideration should be given to developing a beyond BACI monitoring program design (Underwood 1991; 1994) or similar extended BACI design (MBACI), which monitors a range of control and impact sites, and can do so over time (Figure A-1). Where robust, appropriate baseline data for exposure sites are not

available, pre-exposure sampling of locations that lie within the hydrocarbon spill trajectory should be prioritised to obtain baseline data prior to hydrocarbon exposure.

Exposure sites should be selected first, encompassing a representative selection of locations within the area affected by hydrocarbons. Where practicable, the monitoring program design may consider stratified sampling along environmental gradients (e.g. level of hydrocarbon exposure etc.). Comparable control sites beyond the area affected by hydrocarbons should then be selected, with monitoring conducted at all sites. Clearly obtaining control sites pre-exposure can be challenging and is heavily reliant on predicting the extent of hydrocarbon movement.

The suggested statistical analysis of data collected using the BACI approach includes a univariate or multi-factorial analysis of variance (ANOVA) and equivalent non-parametric tests, all of which will compare between treatment (impact versus reference) and time (before versus after). Components of variation may help partition a sum of squares into different sources and describe the importance of factors within tests.



(Source: APPEA 2019)

Notes:

1. A modification to the beyond BACI design, is known as an MBACI design. MBACI designs incorporate multiple impact locations, whereas beyond BACI designs include only one impact location.
2. The above design consists of four reference/control locations and two impact locations, with four nested sites in each. The number of replicates (e.g. quadrats or transects) per site should be set based on resourcing, and /or the results of the power analysis (if applicable).
3. The area affected by the spill is indicated by the grey shaded area, or the area of influence.
4. Design assumes the area of influence has been affected equally.

Figure A-1: Example of an MBACI design for shoreline and/or intertidal communities

A. 2. Impact versus Control (IvC) approach

For some locations and receptors, baseline data may not exist, may not be recent and applicable, or was collected using methods that are unrepeatable in the current study. If there is a lack of baseline information that can feed into a BACI design, an IvC approach can be used to assess impacts. However, due to the unknown status of the parameter before impact, there is a higher likelihood of encountering Type I error (falsely concluding that an impact has occurred) with this approach. For example, if the status of the parameter to be measured was already naturally lower at impact sites than control sites before the impact occurred, but this was not measured, a conclusion may be reached using the IvC approach that an impact has occurred when it may be natural variation. For this reason, sampling designs should always try to collect or use baseline data (i.e. aim for a BACI design), and if an IvC design is used, it is important to ensure that the control sites are comparable to the impact sites in every way possible except for the presence or absence of the studied effect (hydrocarbon). This may include, but not be limited to, site physical aspect, substrate, current regimes, and community composition.

Because of the higher likelihood of Type I error, it is also useful to collect additional data on relevant physical environmental parameters that are likely to be different at impact and control sites and may affect the conclusion of the assessment. Biological information may also be relevant, such as degree of sub-lethal and lethal impacts to populations. These parameters can be examined later for any potential co-variance with the observed changes in the parameter of interest, to understand whether hydrocarbons or natural variation affected the outcome. The physical and biological information can therefore augment and act as additional evidence to help interpret conclusions from any IvC analyses. As with the BACI approach, when using the IvC approach it is important to understand the scale of natural variation that may affect the outcome of the assessment by replicating sites within sampling locations and replicating samples within each site.

The suggested statistical approach for analysing the data collected using the IvC approach is a multi-factorial ANOVA (to account for nested data), including PERMANOVA and non-parametric tests, to test whether the level of variation among treatments (IvC) is greater than the level of variation within treatments. Components of variation may help partition variance into different sources and help infer whether the effect of hydrocarbons or spatial variation was responsible for any detected change in the receptors.

A. 3. Gradient approach

The gradient approach can be used in some instances where a lack of suitable control sites prohibits using a BACI or IvC approach. Sampling should be established along a gradient of predicted effect (based on input of data from operational monitoring, surveillance or modelling), with sites established at various distances from the source of impact or along a gradient of magnitudes of concentrations of hydrocarbons. The gradient approach can also be used in combination with a BACI or IvC approach to help infer the cause of a detected impact and describe thresholds of impacts at which a response appears to have occurred. The gradient approach also provides a 'line of evidence' that the source of potential impact (hydrocarbons) was responsible for the observed effect, rather than natural variation. However, care should be taken to ensure awareness of any natural gradients in the parameter measured and take these into account when interpreting the data.

When designing a study using a gradient approach, relevant operational and scientific monitoring data (e.g. water and sediment quality), and modelling should be considered. Prior knowledge or prediction of the likely gradient of effect will greatly improve the efficiency of the sampling design by minimising the collection of data points that provide no additional information in the analysis (e.g. data points showing similar or no effects that do not help to characterise the gradient of effect), though noting these may aid in statistical power of gradient description so shouldn't necessarily be discouraged.

Typically, the level of observed impact will decline at distance from the source of a hydrocarbon release, with this decline likely to be exponential (i.e. large changes close to a release that quickly decrease in severity); therefore, sampling effort can be distributed along the gradient of effect in a way that best characterises the changes in the parameter measured.

If possible, multiple (> two) sites could be sampled at each distance along the gradient (if logistics and time permit) to provide an understanding of small-scale variation. Sites should also be sampled at distances where no environmental effect is predicted or observed, if possible, to characterise the full extent of the effect's gradient.

The suggested statistical analysis for the gradient approach includes correlation analysis between impact (measurements of hydrocarbon/stress; x-axis) and measurement parameter (biological response; y-axis), and associated regression analyses, may include least-squares regression line and hypotheses testing to determine if the trend is significantly different from zero.

A. 4. Control chart approach

The control chart approach is applicable in the following circumstances:

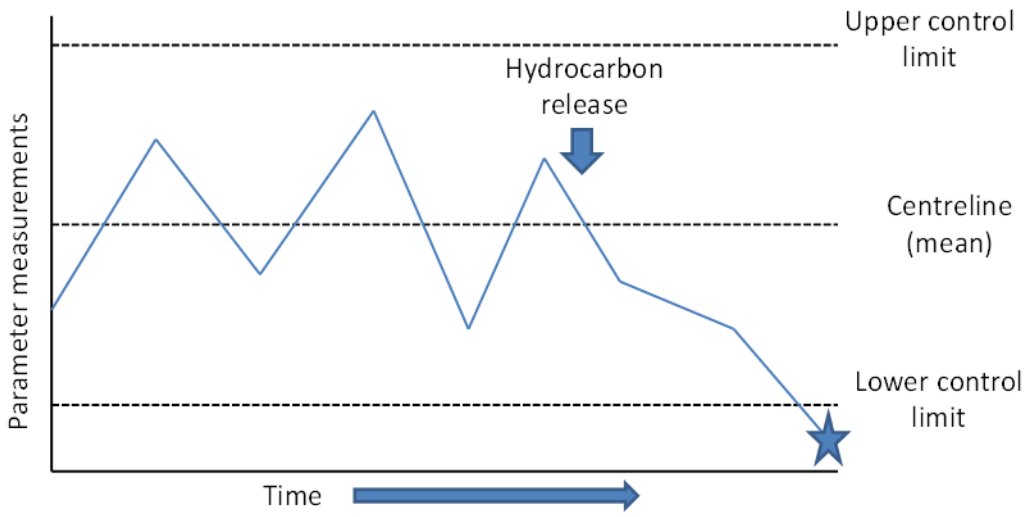
- When long-term (multi-year) datasets exist for the measured parameter;
- When a large amount of natural variation exists in the measured parameter;
- When predicting the expected range of outcomes from an impact.

One of the causal criteria described in the lines of evidence approach is 'strength of association' (Hill 1965), exemplified by a 'larger decline in individuals in areas affected by hydrocarbon than in control areas'. The control chart approach takes this causal criterion a step further and uses rules to establish whether a detected change in a parameter at impact sites is outside what would be expected to occur naturally. This technique requires tracking a parameter over time and determining whether an observed change is within the bounds of what has been observed to occur naturally at that impact site or at control sites.

A control chart has a central line for the mean, an upper control limit (UCL; e.g. typically 3 standard deviations [SD] above the mean), and a lower control limit (LCL; e.g. typically 3SD below the mean), which are typically all determined from historical data (Gotelli and Ellison 2004). The mean line can be constructed using data from i) historical data of an impact site prior to it being affected by hydrocarbons (i.e. what the mean used to be), or ii) control locations, whereby either historical or recent data is used for comparison to other sites (i.e. a control site historical data compared to impact site). The approach is then based on calculating the mean (ongoing) for an impact site to compare against the control chart. Any observations outside the UCL and LCL suggest that increased variation has been observed that are inconsistent with other data and may post a simple way to detect change in a system (Figure A-2).

In addition, if ongoing data collection is possible following a potential impact, the control chart approach can be used to examine the direction of change and whether this is consistent or inconsistent with other data. These data and interpretation may provide a weight of evidence of a directional change in a given parameter.

The control chart approach is only useful if there is an adequate knowledge of natural variability in a given parameter whether from historical sources or similar sites/locations. Control chart approaches can be a powerful tool for detecting impacts for systems that are naturally highly variable.



(Source: APPEA 2019)

Note: The star represents a measurement beyond the likely anticipated variation, which needs to be investigated.

Figure A-2: Example Control Chart showing Centreline (mean), Upper Control Limit (3 SD above mean), Lower Control Limit (3 SD below mean), and Measurements

A. 5. Lines of evidence approach

The lines of evidence approach is applicable in the following circumstances:

- Can be combined with any of the above monitoring designs to provide inferential evidence of an effect;
- Are useful to support evidence of effect if there are limited (or only one) impact locations;
- Are useful to support evidence of effect if the effect radiates outward from source;
- Are useful to infer cause of change if limited or no baseline data exist;
- Are useful to infer cause of change if limited or no control sites exist.

When a sampling design is suboptimal, or if conclusions from more formal tests are inconclusive, a lines of evidence approach can be used to help infer the cause of an observed change (i.e. attribute change to the hydrocarbon release or to other causes, such as natural variation). Within the lines of evidence approach, inference is developed based on carefully structured arguments. A weakness of this method is that the evidence may be largely circumstantial because it is based on correlations (Downes et al. 2002), which does not necessarily imply causation. Each causal argument may be weak when considered independently but combined they may provide strong circumstantial evidence and support for a conclusion (Downes et al. 2002).

This approach was originally developed in medicine (Hill 1965) but has been used more recently in ecological studies (e.g. Downes et al. 2002; McArdle 1996; Suter 1996; Beyers 1998; Fabricius 2004). Causal criteria have been developed for categorizing arguments from studies on disease on humans (Hill 1965), and these can be applied to ecological arguments (Hill 1965). With lines of evidence, there is a need to seek evidence not only to support the impact prediction, but evidence to rule out plausible alternative predictions, such as that the observed difference was due to natural processes (Downes et al. 2002; Beyers 1998).

In the lines of evidence approach, a set of descriptions should be developed for all or some of the causal criteria listed in Table A-1 before the survey is undertaken (see Downes et al. 2002 for further criteria and examples). Data would then be collected that allows each line of evidence to be tested or objectively questioned. The final assessment of whether an impact is likely to have occurred should be based on the 'weight of evidence' from examining multiple lines of evidence.

Example generalised lines of evidence descriptions are provided in Table A-2. These should be modified and tailored to individual scientific monitoring module, as required and each parameter investigated.

Table A-1: Causal criteria and description in the context of ecological impact Assessment

(Source: Hills 1965, in APPEA 2019)

Causal criterion	Description
Strength of association	A large proportion of individuals are affected in the impact area relative to control areas
Consistency of association	The association was observed by other investigators at other times and places
Specificity of association	The effect is diagnostic of exposure
Temporality	Exposure must precede the effect in time
Biological gradient	The risk of effect is a function of magnitude of exposure
Biological plausibility	A plausible mechanism of action links cause and effect
Experimental evidence	A valid experiment provides strong evidence of causation
Coherence	Similar stressors cause similar effects
Analogy	The causal hypothesis does not conflict with existing knowledge of natural history and biology

Table A-2: Causal criteria and example lines of evidence descriptions that could be used to assess whether a change in a measured parameter was due to the effects of a hydrocarbon release

(Source: APPEA 2019)

Causal criterion	Evidence supportive of a hydrocarbon release impact	Evidence unsupportive of a hydrocarbon release impact
Strength of association	Larger decline in individuals in areas affected by hydrocarbon than in control areas	Similar declines in individuals in areas affected by hydrocarbon and control areas
Consistency of association	Consistent finding of declines in a range of biota in areas affected by hydrocarbon	Inconsistent declines in biota in areas affected by hydrocarbon (e.g. declines in one species but not in other similar species)
Specificity of association	Number of individuals affected correlates with hydrocarbon concentrations	No correlation between number of individuals affected and hydrocarbon concentration
Temporality	Decline in individuals immediately preceded by contact with hydrocarbon	Decline in individuals occurred before or long after hydrocarbon contact

Causal criterion	Evidence supportive of a hydrocarbon release impact	Evidence unsupportive of a hydrocarbon release impact
Biological gradient	Changes in individuals aligned with exposure to hydrocarbon spills or concentrations	Decline in individuals occurs with increasing distance from a hydrocarbon spill or hydrocarbon concentrations
Biological plausibility	Evidence from literature of sensitivity to detected hydrocarbon concentration for species where declines are observed	Evidence from literature suggests lack of sensitivity to detected hydrocarbon concentration for species where declines are observed
Experimental evidence	A valid experiment provides strong evidence of causation	Not applicable (N/A)
Coherence	Evidence of a decline in species abundance, habitat, and food source with increasing hydrocarbon exposure	Evidence of a decline in species abundance, but no other evidence of expected declines associated with exposure
Analogy	Apparent declines in hatchling numbers despite no apparent decline in numbers of adults	Apparent declines in hatchling numbers associated with decreased numbers of adults

Appendix B Baseline Information

A database of known literature and studies relevant to environmental receptors within the Otway and Bass Basins that may provide suitable baseline data and/or contextual information in the event of a spill.

Source	Description	Relevant Scientific Monitoring Study
Group / Agency		
Birdlife Australia	Shorebirds 2020	S5: Marine fauna impact assessment
Parks Victoria	Signs of Healthy Parks program, including:	
	• Subtidal Reef Monitoring Program ◦ Popes Eye Component of the Port Phillip Heads MNP ◦ Reef Biota at Beware Reef Marine Sanctuary ◦ Reef Biota at Bunurong Marine National Park and Surrounding Coast ◦ Reef Biota at Eagle Rock Marine Sanctuary ◦ Reef Biota at Jawbone Marine Sanctuary ◦ Reef Biota at Marengo Reefs Marine Sanctuary ◦ Reef Biota at Marine Protected Areas in the Twofold Shelf region ◦ Reef Biota at Merri Marine Sanctuary ◦ Reef Biota at Phillip Island ◦ Reef Biota at Point Addis Marine National Park ◦ Reef Biota at Port Phillip Bay Marine Sanctuaries ◦ Reef Biota at Port Phillip Heads Marine National Park ◦ Reef Biota at Ricketts Point Marine Sanctuary ◦ Reef Biota at Wilsons Promontory Marine National Park ◦ Reef Biota on the Western Victorian Coast ◦ Reef Biota within the Twofold Shelf Bioregion ◦ Reef Surveys at Twelve Apostles Marine National Park and The Arches Marine Sanctuary ◦ The Reef Biota at Point Cooke Marine Sanctuary ◦ Western Victorian Coast	S3: Subtidal habitats impact assessment
	• Intertidal Reef Monitoring Program ◦ Intertidal Reef Biota of Central Victoria's Marine Protected Areas ◦ Intertidal Reef Biota of Northern Port Phillip Bay Marine Sanctuaries ◦ Reef biota in Central Victoria and Port Phillip Bay Marine Sanctuaries	S4: Intertidal and coastal habitats impact assessment
	• Shallow Water Habitat Mapping at Victorian Marine National Parks and Marine Sanctuaries ◦ Eastern Victoria ◦ Western Victoria	S3: Subtidal habitats impact assessment S4: Intertidal and coastal habitats impact assessment

Source	Description	Relevant Scientific Monitoring Study

	• Mapping the Benthos in Victoria's Marine National Parks
	  ◦ Cape Howe Marine National Park
	  ◦ Discovery Bay Marine National Park
	  ◦ Point Addis Marine National Park
	  ◦ Point Hicks Marine National Park
	  ◦ Twelve Apostles Marine National Park
		S3: Subtidal habitats impact assessment
		S4: Intertidal and coastal habitats impact assessment

	• Reef Life Survey	S3: Subtidal habitats impact assessment

	• Community-based monitoring programs, including:
	  ◦ Intertidal Rocky Shore Monitoring
	  ◦ Seagrass Monitoring
	  ◦ Subtidal Reef Monitoring
		S3: Subtidal habitats impact assessment
		S4: Intertidal and coastal habitats impact assessment

	• Marine Natural Values Study, including:
	  ◦ Marine Protected Areas of the Otway Bioregion
	  ◦ Marine Protected Areas of the Central Victoria Bioregion
	  ◦ Marine Protected Areas of the Victorian Embayments Bioregion
	  ◦ Marine Protected Areas of the Victorian Embayments Bioregion
	  ◦ Marine Protected Areas of the Flinders and Twofold Shelf Bioregions
		S1: Water quality
		S2: Sediment quality
		S3: Subtidal habitats impact assessment
		S4: Intertidal and coastal habitats impact assessment
		S5: Marine fauna impact assessment

	Other publications, including:	
	• Marine Habitat Mapping Project	S3: Subtidal habitats impact assessment
	• Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast	S4: Intertidal and coastal habitats impact assessment
	• Managing Hooded Plover in Victoria	S5: Marine fauna impact assessment
	• Birds as Environmental Indicators	S5: Marine fauna impact assessment
	• Rocky Shores of Marine National Parks and Sanctuaries on the Surf Coast Shire – Values, uses and impacts	S4: Intertidal and coastal habitats impact assessment
	• Identification of threats to natural values in Victoria's Marine National Parks and Marine Sanctuaries	S3: Subtidal habitats impact assessment S4: Intertidal and coastal habitats impact assessment S5: Marine fauna impact assessment
	• Monitoring the macroinvertebrates and soft sediments in the Marine National Parks in Western Port	S4: Intertidal and coastal habitats impact assessment
	• Mud Islands Seagrass and Coastline Mapping 2011-12	S4: Intertidal and coastal habitats impact assessment
	• Yaringa and French Island MNP Habitat Mapping	S3: Subtidal habitats impact assessment S4: Intertidal and coastal habitats impact assessment

Source	Description	Relevant Scientific Monitoring Study
Victorian National Parks Association	Reefwatch	S3: Subtidal habitats impact assessment
Journals		
Deep-Sea Research Part II: Topical Studies in Oceanography	McCauley, R. D., A. N. Gavrilov, C. D. Jolliffe, R. Ward, and P. C. Gill. (2018). Pygmy blue and Antarctic blue whale presence, distribution and population parameters in southern Australia based on passive acoustics. Deep-Sea Research Part II: Topical Studies in Oceanography 157-158: 154-168	S5: Marine fauna impact assessment
Marine Ecology Progress Series	Bruce, B. D., D. Harasti, K. Lee, C. Gallen & R. Bradford. (2019). Broad-scale movements of juvenile white sharks Carcharodon carcharias in eastern Australia from acoustic and satellite telemetry. *Marine Ecology Progress Series*, 619: 1-15	S5: Marine fauna impact assessment
	Gill, P.C., M.G. Morrice, B. Page, R. Pirzl, A.H. Levings and M. Coyne (2011). Blue whale habitat selection and within-season distribution in a regional upwelling system off southern Australia. Marine Ecology Progress Series, 421: 243–263.	S5: Marine fauna impact assessment
Marine Mammal Science	Kirkwood, R., Warneke, R.M., Arnould. J.P. (2009). Recolonization of Bass Strait, Australia, by the New Zealand fur seal, Arctocephalus forsteri. Marine Mammal Science 25(2): 441 –449	S5: Marine fauna impact assessment
The Journal of Wildlife Management	Gill, P.C., R. Pirzl, M.G. Morrice & K. Lawton (2015). Cetacean diversity of the continental shelf and slope off southern Australia. The Journal of Wildlife Management.	S5: Marine fauna impact assessment
Universities		
Curtin University Centre for Marine Science	Gavrilov, A. (2012). Seismic signal transmission, pygmy blue whale abundance and passage and ambient noise measurements during and after the Bellerive seismic survey in Bass Strait, 2011, Curtin University centre for Marine Science	S5: Marine fauna impact assessment