SGH | Energy

SGH Energy Longtom Activities

Operational and Scientific Monitoring Program

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1 Introduction

1.1 Scope

This document is the Operational and Scientific Monitoring Program (OSMP) for SGH Energy VICP54 Pty Ltd (SGHE) Longtom activities occurring within production licence VIC/L29 in the Commonwealth waters of the Victorian Gippsland Basin.

This OSMP covers two potential hydrocarbon release scenarios relevant to the SGHE Longtom operations and representative of the worst-case spills from a response perspective, including operational and scientific monitoring:

1. Condensate release – as a result of a blow out of a well
2. Marine Diesel Oil (MDO) release – as a result of vessel fuel tank rupture

These scenarios have been used to inform resourcing requirements for both the Oil Pollution Emergency Plan (OPEP) and this OSMP.

The EMBA defined in the Longtom Environment Plan (EP) (Section 4.1) was determined using stochastic modelling results applying the following thresholds:

- Surface hydrocarbons floating on the sea equal to or above 1 g/m^2, which is considered to be below levels that would cause environmental harm and is more indicative of the areas perceived to be affected due to its visibility on the sea surface
- Shoreline stranded hydrocarbon equal to or above 10 g/m^2, which represents the area visibly contacted by the spill
- Dissolved hydrocarbons within the water column with instantaneous concentrations at or above 6 ppb
- Entrained hydrocarbons with instantaneous concentrations at or above 100 ppb

A larger low exposure zone, based on a level equal to or above 10 ppb instantaneous entrained hydrocarbons, which defines the environment that may be exposed to oil contamination as per the requirements outlined in the NOPSEMA Environment Bulletin (2019) (and corresponds generally with potential for exceedance of water quality criteria) may overlap a number of Australian Marine Parks (including East Gippsland and Beagle) and extend north into NSW waters as far as Wollongong. While this larger zone may not be representative of any adverse effect on the aquatic environment, this OSMP has been designed to be sufficiently flexible to cover all potential impacts across this larger area.

1.2 Objectives

In Australia, oil spill related monitoring has been divided into two types (NOPSEMA 2016):

Type I Monitoring (operational monitoring) – which provides information of direct relevance to spill response operations, i.e. information needed to plan or execute response or clean-up strategies. This type of monitoring provides three key pieces of information:

1. What is the current state of the spill, what is the spill comprised of, where is it and how is it moving?
2. How are response actions affecting the spill (effectiveness and efficiency); and
3. When can response operations cease and move into the next phase of operations (remediation) and monitoring (scientific monitoring).

Type II Monitoring (scientific monitoring) - which is focused on non-response objectives such as estimating environmental damage and post response recovery.

This OSMP provides the operational and scientific monitoring program for SGHE Longtom production operations. Specifically, it:

- Identifies operational and scientific monitoring modules for implementation in the event of an oil spill;
- Describes baseline (pre-spill) monitoring requirements for operational and scientific monitoring;
- Provides standard operating procedures (SOPs) for operational monitoring modules, and detailed descriptions of the methods to be used for scientific monitoring;
- Outlines the communication and decision-making processes associated with operational and scientific monitoring.

1.3 How this plan was prepared

This OSMP is part of an integrated approach to environmental management. The EP and OPEP provide the initial foundation of environmental management for VIC/L29 including oil spills. The EP describes the environmental values of the EMBA and contains an assessment of oil spill risks. The OPEP includes a more detailed evaluation of the possible consequences of an oil spill and details the management and response measures that would be implemented in the event of an oil spill associated with Longtom activities. Monitoring in accordance with this OSMP is identified in the OPEP as one of the preferred response measures to be implemented in such an event.

This OSMP has been developed to satisfy the requirements of the Offshore Petroleum and Greenhouse Gas Storage (OPGGS) (Environment) Regulations 2023. It has also been developed following guidance provided by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) and the Australian Marine Safety Authority (AMSA).

1.4 Structure of the OSMP

This OSMP is integrated with the EP and OPEP and as such does not duplicate information contained in these documents. Where appropriate, sections of the EP and / or OPEP have been summarised and cross-references to the main text in these documents provided. The structure of this OSMP is as follows:

1. Introduction - Describes the scope and location and the objectives of the OSMP and its integration with the EP and OPEP.
2. Context – Summarises the environmental values, sensitivities and impacts; describes the process by which indicators were selected for operational and scientific monitoring; and outlines the approach to developing baseline and pre-spill monitoring.
3. Implementation framework – Describes the responsibilities, communication pathways and how operational monitoring informs decision making in the event of an oil spill.

Attachments 1-3 Operational (Type I) monitoring modules - Include detailed procedures for each of the operational monitoring modules.

Attachment 4 Scientific (Type II) monitoring modules - Includes overview and description of the key features of each of the scientific monitoring modules to enable prompt deployment of the relevant scientific modules in the event of a Level II or III spill. Rather than detailed procedures such as those provided for the Type I monitoring, these Type II modules include links to standard and recognised methods and key organisations or personnel who could implement the specific monitoring program. These modules provide sufficient detail for a qualified and experienced marine scientist with expertise in the relevant field to immediately implement the relevant module when mobilised.

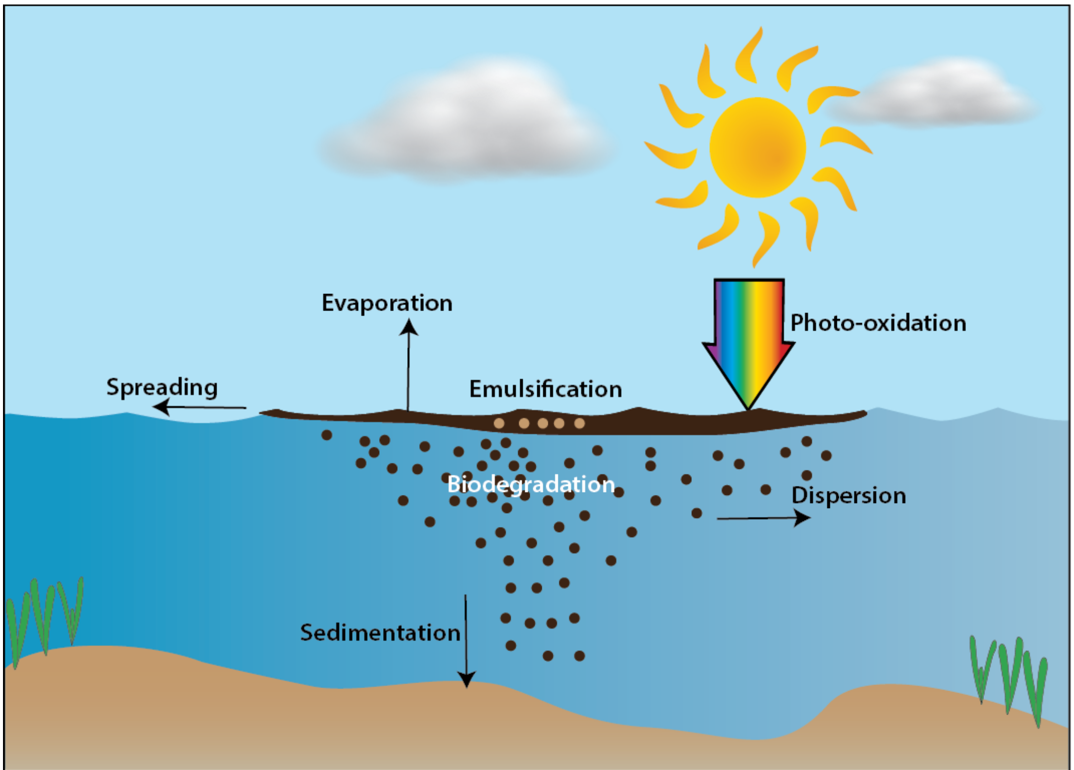
2 Context

2.1 Oil associated stressors

The OPEP details the characteristics of two classes of oil relevant to SGHE Longtom activities (OPEP section 1.6): marine diesel and condensate. Of relevance to monitoring and managing spilled oils is their persistence in the environment and the weathering process. The main processes associated with weathering are illustrated conceptually in Figure 1.

The weathering process is highly dependent on weather and sea conditions, the type of oil, the time it is exposed to weather conditions and the physical / chemical properties of the oil. The two classes of oil relevant to this OSMP have different properties that affect their persistence in the environment. These can be summarised as:

- Diesel - rapid spreading, rapid evaporation and some dispersion/dissolution. May emulsify at low temperatures when fresh.
- Condensate - rapid spreading, rapid evaporation and dispersion/dissolution. Low likelihood of emulsification however may contain inert, relatively non-toxic waxes, which will persist for some time as they degrade.



Evaporation - volatile portions of oil evaporate to the atmosphere
Photo-oxidation - sunlight degrades some components
Emulsification - oil mixes with water to form a mousse like oil-water mixture
Biodegradation - micro-organisms feed on the carbon within the oil
Sedimentation - heavier components of oil settle to the ocean floor
Dispersion - Oil disperses in water reducing concentration

Figure 1: Oil weathering processes (symbols from Integration and Application Network, University of Maryland Center for Environmental Science http://ian.umces.edu/imagelibrary/).

2.2 Environmental values and sensitivities

The EP describes environmental sensitivities, including critical habitats, threatened or endangered species as well as social and economic values within the EMBA. The potential consequences of an oil spill on the values and sensitivities within the EMBA are detailed in the NEBA in Appendix E of the OPEP. The environmental values and sensitivities identified in the OPEP can be summarised as:

- Offshore
  - Sub-tidal rocky reef communities
  - Pelagic fish
  - Plankton
  - Benthic fish and infauna
  - Marine mega-fauna (for example resident Australian and New Zealand fur seals; dolphins and other cetaceans)
  - Seabirds, including resident colonies of little penguins
  - Commercial fisheries for finfish
- Near shore and shoreline
  - Seagrass and macroalgae beds
  - Saltmarsh and coastal vegetation
  - Intertidal rocky reef communities
  - Intertidal flats
  - Sandy shores / beach
  - Shorebirds, including migratory shorebirds listed under international agreements and nesting resident species such as the hooded plover, fairy tern and little tern
  - Breeding and haul-out sites for Australian and New Zealand fur seals
  - Breeding sites for little penguins
  - Ramsar sites (Gippsland Lakes, Corner Inlet)
  - A resident population of the Burrunan dolphin (the Gippsland Lakes)
  - Sites of coastal geomorphic significance
  - Commercial fisheries abalone and scallops

2.3 Indicators

2.3.1 Indicators for operational monitoring

Indicators for operational monitoring have been selected by considering the information needs to inform oil spill response. The OPEP (section 3) describes the response options for an oil spill from Longtom activities. Three operational monitoring modules have been designed to meet the information requirements of these response options (Table 1). The monitoring modules comprise:

- O1: Surveillance and tracking
- O2: Water quality and hydrocarbon monitoring
- O3: Shoreline assessment

Table 1: Cross reference of monitoring modules and response strategies

Response strategies	O1	O2	O3
Offshore			
Monitoring including aerial monitoring, satellite tracking	X		
Natural weathering (evaporation) and dispersion	X	X	
Water sampling and laboratory analysis for TPH		X	
Onshore			
Aerial monitoring and coastline visual monitoring	X	X	X
Natural weathering (evaporation) and dispersion	X	X	X
Water sampling and laboratory analysis for TPH		X	X
Deflection and recovery of weathered condensate / diesel	X	X	
Manual and mechanical clean-up			X

Standard Operating Procedures (SOPs) for each of these modules are provided in Attachments 1 – 3.

2.3.2 Indicators for scientific monitoring

Indicators for scientific monitoring modules were identified using a multi-criteria analysis for indicator selection, which increases both the value and the scientific credibility of monitoring programs (Niemeijer and de Groot 2008). Criteria for indicator selection were adapted from (Niemeijer and de Groot 2008) and comprise:

1. Typical – are representative of the ecological characteristics in the EMBA;
2. Sensitive – are sensitive to the impacts of oil spills in the EMBA; and
3. Measurable – known or standard methods available for measurement.

Typical – representative of ecological characteristics of the EMBA

This criterion has been assessed based on the ecological principle of “regularly supports” (United Nations 1971). That is, for studies on long term impacts to specific species, only those that are known to regularly occur in the region have been included in the monitoring. In this manner, species that are vagrants to the area will be captured for immediate and direct impacts if they were present and impacted at the time of a spill. However, the focus of long-term effects to populations is on species that are known to regularly occur within the EMBA and for which the EMBA provides vital habitat.

Sensitive – are sensitive to the impacts of oil spills

Species and communities can be impacted by both the oil spill and by associated response actions. The mechanisms and cumulative impacts to species and communities have been explored using a stressor model (Figure 2). This does not cover the entire myriad of complexities and pathways associated with oil and response actions in marine estuarine environments, but provides an overview of the main linkages (Gross 2003).

Measurable

The ability to detect a response to an oil spill on a sensitive ecological asset is dependent on a range of factors. In general, it is easier to detect responses in sessile biota and habitats as the direct impact of an oil spill can be easily located and measured. Detection of responses in pelagic and highly mobile species is more difficult. For example, it is unlikely to be feasible to directly measure the effect of an oil spill on populations of highly mobile species that potentially feed in the open waters of the EMBA such as leathery turtles, Australian fur seals and cetaceans. What can be measured are any direct mortality of oiled animals, and a corresponding assessment of the implications on known populations. Ecotoxicology measures of water and elutriated sediment can provide indications of potential impacts to biota. In addition, impacts can be inferred through looking at food web associations through surrogates such as impacts on fish populations.

Scientific monitoring modules

After an application of the three criteria (typical, sensitive and measurable) indicators for Type II scientific monitoring (to be deployed only when indicated by Type I monitoring results) have been identified as:

- S1: Ecotoxicology
- S2: Hydrocarbons in fish and shellfish
- S3: Impact on fish diversity and abundance
- S4: Impact on intertidal habitat
- S5: Impact on sub-tidal habitat
- S6: Impact on coastal vegetation
- S7: Impact on shorebirds and seabirds
- S8: Impact on marine mammals
- S9: Ecological character of Ramsar sites

The relationship between monitoring models and key sensitivities is provided in Table 2. Descriptions of the key features of each of these scientific monitoring programs are provided in Attachment 4.

Table 2: Key sensitivities (as identified in the NEBA) and relevant scientific monitoring modules

Sensitivities	S1	S2	S3	S4	S5	S6	S7	S8	S9
Marine Parks	X	X	X		X	X		X	
Ramsar wetlands	X	X	X	X	X	X	X	X	X
Sites of coastal geomorphic significance				X					
Intertidal habitat	X			X					
Subtidal habitat	X				X				
Plankton	X			X	X				
Seagrass and macroalgae	X			X	X				
Saltmarsh and mangroves	X			X		X			
Invertebrates	X	X	X	X	X				
Fin-fish	X	X	X						
Sharks and rays	X	X	X						
Seals and sea lions	X							X	
Cetaceans	X							X	
Seabirds and shorebirds			X				X		
Human consumption of aquatic foods	X	X	X	X					
Water-based recreation	X	X	X	X	X	X	X	X	X
Traditional Owner cultural values	X	X	X	X	X	X	X	X	X
Cultural and spiritual values	X	X	X	X	X	X	X	X	X

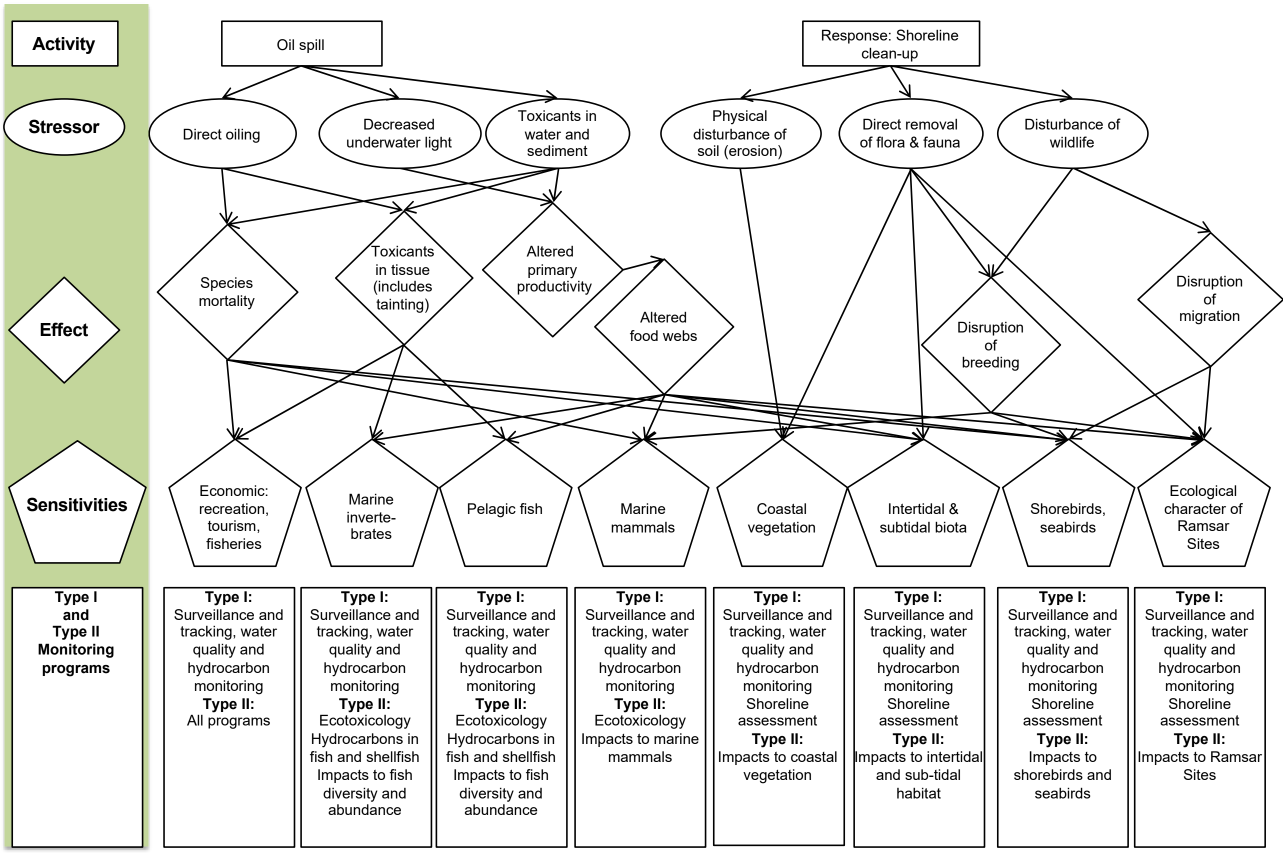


Figure 2: Stressor style conceptual model showing the major linkages between oil spill threats (rectangles), stressors (ovals), ecological effects (diamonds), values (pentagons) and related monitoring programs.

2.4 Approach to baseline monitoring

Baseline information is required to characterise the "natural" variability of the environment prior to a spill (pre-incident) and to provide an indication of existing conditions at the time of a spill in an un-impacted, but comparable area (control or reference site). The most cost and time efficient mechanism to characterise baseline conditions is to use existing data, where available, and to augment this with new data only where necessary.

The EMBA for SGHE Longtom activities covers a very large area with a wide range of environmental sensitivities. However, any given spill is likely to cover only a fraction of this area. It is not feasible to design and implement a baseline monitoring program that characterises the spatial and temporal variability of all species and communities in this large area. Therefore, a "multiple lines and levels of evidence" approach has been adopted. This maximises the use of existing data, with a commitment to conduct regular (five yearly) reviews of existing, relevant information in the EMBA. This will then be augmented with 'reactive' baseline studies at control sites; using post-spill pre-impact data where appropriate if an oil spill occurs.

In terms of determining the effects of an impact (in this case an oil spill) control sites (i.e. as similar as possible in all aspects to the impact or disturbance location, with the exception of the impact) are more relevant than reference sites (undisturbed or natural sites) (Downes et al. 2002). In this manner, it is easier to determine the effect of the impact as separate from other human and natural stressors. Existing baseline information will be essential for informing the selection of relevant control sites outside the impact area of a single spill. However, given the extent of the EMBA, and the need to find sites with similar climatic and other physical and biological characteristics, it is most likely that control sites will be within the EMBA as defined for the OSMP, but outside the area to be impacted by any given single spill.

As all possible permutations or combination of sites cannot be realistically assessed in advance, control sites will be selected post spill, but pre impact. Existing information and baseline monitoring requirements are described for each of the modules provided in this OSMP.

3 Implementation framework

3.1 Communication and information management

Responsibility for the initiation of spill monitoring in the initial response to a spill rests with the OSRT Operations Section Chief. The responsibility for ongoing planning and management of operational and scientific monitoring is the responsibility of the OSRT Planning Section Chief. In the event of a major and ongoing spill the Planning Section Chief will be supported by an Environment Coordinator and a third party Scientific Monitoring Manager.

Data obtained through operational monitoring programs will be reported to the Incident Controller.

The Incident Controller will determine in consultation with the Operations and Planning Section Chiefs the appropriate distribution of the monitoring data i.e. to State Agencies such as DEECA and EPA where there is potential for impact on State waters or shorelines, or DCCEEW where matters of National Environmental Significance may be impacted.

3.2 Decision process

Two key aspects of monitoring associated with oil spills are initiation and termination criteria. That is, at what point is monitoring instigated and at what point should monitoring efforts finish. With respect to initiating monitoring modules, a hierarchical approach has been adopted and is linked to the magnitude of the spill and predicted impacts to environmental values and beneficial uses.

The OPEP (section 2.1) identifies and defines three levels of spill:

- Level 1 – Small localised spill, which can be dealt with at a local site level, i.e. by the offshore vessel monitoring of slick size and location. SGHE CMT is sufficient and call out of a SGHE OSRT is unlikely to be required.
- Level 2 – Moderate spill, likely to impact other marine users, low level oiling of shoreline, requires trajectory analysis and monitoring. SGHE OSRT and State resources may be required.
- Level 3 – Major spill, oil impacts shore and requires a physical response using external resources to respond, samples collected for monitoring purposes. SGHE OSRT, AMOSC and State required and likely to require additional national and potentially international resources

Initiation criteria for operational monitoring are linked to these spill categories and the procedure is as follows (Figure 4):

1. The initiation of Type I monitoring is triggered by:

   a) Confirmed visual observation of a hydrocarbon sheen in the proximity of Longtom activities, and/or

   b) Confirmation from the gas plant of process parameter outside normal operating limits indicating a potential leak.

   In the absence of a confirmed change in process parameters, SGHE will contact other oil and gas operators in the region to determine if responsibility has been claimed. If this is not the case, SGHE will adopt a precautionary approach and initiate Type I monitoring.

2. Visual surveillance (vessel or aircraft) and manual trajectory estimation are implemented and continue until all of the following measures are reached:

   - manual trajectory calculation indicates spill will not reach marine protected areas, state waters, or the shoreline;

- process parameters return to normal and
- hydrocarbons are not visible (taking account of sea state and likelihood of visual observation)

3. In the event of a Level II or Level III spill (see OPEP), 3D modelling by RPS (to be initiated via AMOSC) and water quality and hydrocarbon monitoring are initiated. Samples are collected to measure total petroleum hydrocarbons (TPH) in the water column and to assess physical and chemical properties of the hydrocarbon to determine weathering. Water quality and hydrocarbon monitoring is coordinated with visual surveillance to allow for the collection of samples outside the slick. Operational monitoring continues until all of the following measures are reached:
   - No visible hydrocarbon sheen in the predicted EMBA;
   - Concentration of TPH in the water column in the predicted EMBA is < 7 μg/L (ANZECC water quality (low reliability) trigger value) or the baseline concentration of TPH in the water column in the predicted EMBA, whichever is the greatest and
   - Monitoring data is no longer required to inform spill operations.
4. If the trajectory estimation indicates that the spill is likely to reach the shoreline, then a shoreline assessment (post-spill – pre-impact) will be initiated to identify visible oil on the shoreline, identify environmental sensitivities and establish a benchmark of hydrocarbon presence / concentrations in water and sediment.

Type II scientific monitoring will be implemented only in the event that the results of stage 1 operational monitoring indicate that environmental benefits and values may be at risk. This is expected to only occur only in the event of a Level II or Level III spill.

Termination criteria have been proposed for monitoring modules based on return to baseline conditions and, for operational monitoring, termination of response actions. However, consistent with AMSA (2003) it must be acknowledged that termination criteria will vary under different circumstances. Therefore, the criteria presented should be considered as a guide, with actual termination of monitoring activities occurring with agreement from relevant agencies and community representatives.

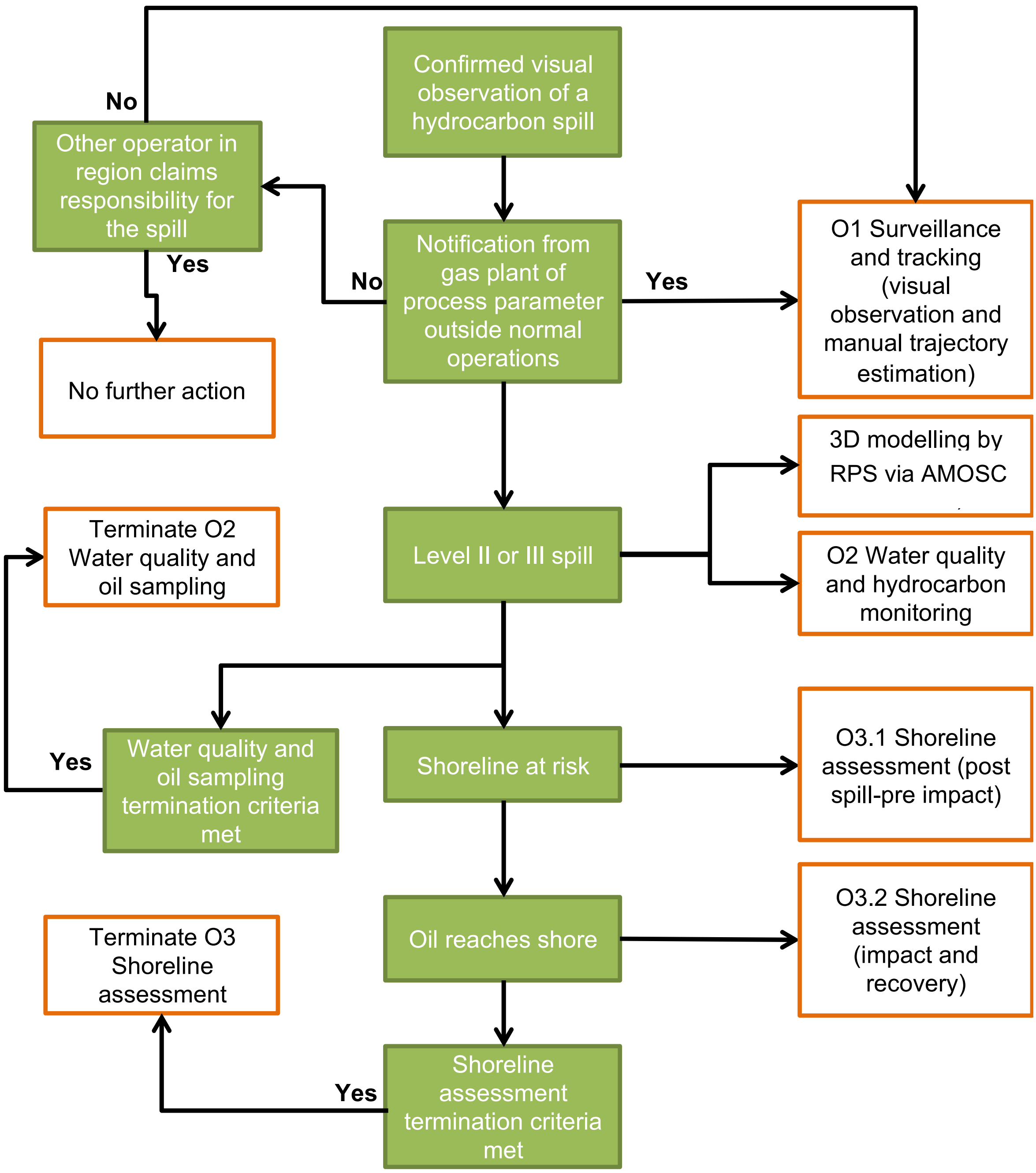


Figure 4: Decision process for operational monitoring.

Operational monitoring also informs the initiation of scientific monitoring modules. Integration of the operational and scientific monitoring modules is provided in Figure 5.

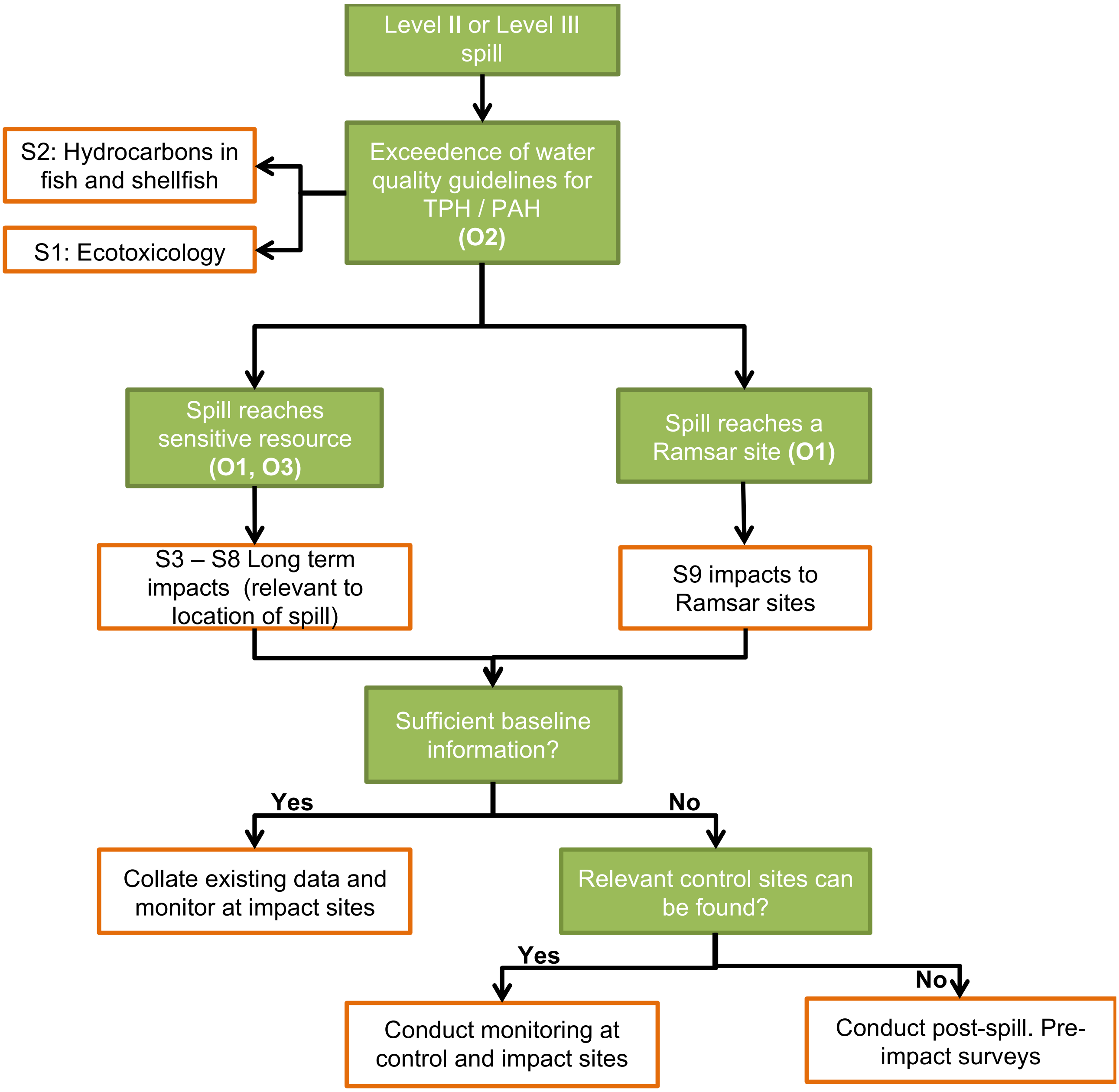


Figure 5: Decision process for scientific monitoring, with indications of operational monitoring modules that inform initiation of scientific monitoring modules.

3.3 Reporting

The reporting requirements for each monitoring module are provided in the standard operating procedures (see attachments). Operational monitoring is specifically targeted at informing response strategies and reporting is designed for rapid communication to the Incident Controller. Scientific monitoring programs have more extensive reporting requirements, with periodic progress reports and a final report produced at the end of the program.

3.4 Resources required

Resourcing requirements have been estimated for each monitoring module based on the Worst Case Discharge Scenario (WCDS – catastrophic well blowout), a partial blowout (indicative of a Level II spill) and a level I MDO spill as shown in Table 3 below.

Table 3: Personnel resources required for each monitoring module

Spill Event	O1:Surveillance & tracking				O2:Water quality & hydrocarbon monitoring			O3:Shoreline assessment		
	O1.1	O1.2	O1.3	O1.4	O2.1	O2.2	O2.3	O3.1	O3.2	O3.3
	Weather and sea state	Trajectory prediction	Visual observation (vessel or aerial)	Remote observation	Hydrocarbon samples	Fluorometer protocol	Water samples	Shoreline character	Oil on shorelines	Shoreline profile
WCDS	**SC**		**2 O**	**SC**	**1 FT**	**1 FT / SC lab**	**1 FT / SC lab**	**3 FT**		
Partial Well failure	**SC**		**2 O**	**SC**	**1 FT**	**1 FT / SC lab**	**1 FT / SC lab**	**3 FT**		
Level I MDO spill	**SC**		**2 O**	**SC**	**N/R**			**N/R**		

Spill Event	S1: Ecotoxicology	S2: Hydrocarbons in fish and shellfish	S3: Fish diversity and abundance	S4: Intertidal habitat
WCDS	**1 FT (in conjunction with O2.1) / SC lab**	**1 FT / SC lab**	**1 FT**	**1 FT**
Partial Well failure	**1 FT (in conjunction with O2.1) / SC lab**	**1 FT / SC lab**	**1 FT**	**1 FT**
Level I MDO spill	**1 FT (in conjunction with O2.1) / SC lab**	**N/R**	**N/R**	**N/R**

Spill Event	S5: Sub-tidal habitat	S6: Coastal vegetation	S7:Shorebirds & seabirds	S8: Marine mammals	S9: Ramsar wetlands
WCDS	**1 FT**	**1 FT**	**1 FT**	**1 FT**	**SC**
Partial Well failure	**N/R**	**N/R**	**1 FT**	**1 FT**	**N/R**
Level I MDO spill	**N/R**	**N/R**	**N/R**	**N/R**	**N/R**

Key: O = Observer, SC = Specialist consultant (office based or lab, in the case of surveillance and tracking this will be provided by AMOSC), FT = Field Team (# field personnel per team as required by OSMP module – generally 2 to 3 personnel)

In the event of the WCDS (an uncontrolled and continuous blowout with shoreline impact) the resource requirements are estimated to require up to 14 field teams, with laboratory support and specialist consultant support.

These resources are not all required immediately as the time of oil to shore is expected to be greater than 6 days.

3.5 Resource Arrangements and Availability

SGHE have been in contact with the main OSMP service providers to other operators including Esso and Beach, and the APPEA OSMP framework. Contractual arrangements with these providers were examined with the aim of having a contract in place to provide SGHE with 24hr 365 days per year access to an Operational and Scientific Monitoring service provider and Manager. These options were found to not be practicable given SGHE's current offshore activities and risk level. An agreement is in place with AMOSC to provide OSMP support for O1. Performance outcomes and standards have been added to the OPEP which incorporate commitments made in relation to the engagement of OSMP services (for O2 - O3 and S1 – S9), where services are yet to be procured.

4 References

Australian Petroleum Production and Exploration Association (APPEA), (undated). A Compilation of Recent Research into the Marine Environment

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand. (2000). Australian and New Zealand guidelines for fresh and marine water quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

BMT WBM. (2011a). Ecological Character Description of the Gippsland Lakes Ramsar Site. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.BMT WBM, 2011b. Ecological Character Description of the Corner Inlet Ramsar Site– Final Report. Prepared for the Australian Government Department of Sustainability, Environment, Water, Population and Communities. Canberra.

Boon, P.I. (2011). Mangroves and Coastal Saltmarsh of Victoria: Distribution, Condition, Threats and Management. Victoria University.

Boon, P.I., Allen, T., Brook, J., Carr, G., and Frood, D. (2011). Mangroves and Coastal Saltmarsh of Victoria: Distribution, Condition, Threats and Management. Department of Sustainability and Environment, Bendigo.

Charlton-Robb, K., Gershwin, L., Thompson, R., Austin, J., Owen, K., and McKechnie, S. (2011). A New Dolphin Species, the Burrunan Dolphin Tursiops australis sp. nov., Endemic to Southern Australian Coastal Waters. PLoS ONE 6(9): e24047.

Charlton-Robb, K., Taylor, A.C., and McKechnie, S.W. (2014). Population genetic structure of the Burrunan dolphin (Tursiops australis) in coastal waters of south-eastern Australia: conservation implications. Conservation Genetics.

Chiaradia, A., Forero, M.G., Hobson, K.A., Swearer, S.E., Hume, F., Renwick, L., and Dann, P. (2012). Diet segregation between two colonies of little penguins Eudyptula minor in southeast Australia. Austral Ecology 37(5): 610–619.

Clemens, R., Oldland, J., Berry, L., and Purnell, C. (2009). Shorebirds 2020 Migratory Shorebird Population Monitoring Project. Birds Australia, Carlton, Victoria.

Danion, M., Le Floch, S., Lamour, F., Guyomarch, J., and Quentel, C. (2011). Bioconcentration and immunotoxicity of an experimental oil spill in European sea bass (Dicentrarchus labrax). Ecotoxicology and environmental safety 74(8): 2167–2174.

Dann, P. and Norman, F.I. (2006). Population regulation in Little Penguins (Eudyptula minor): the role of intraspecific competition for nesting sites and food during breeding. Emu 106(4): 289–296.

Downes, B.J., Barmuta, L.A., Fairweather, P.G., Faith, D.P., Keough, M.J., Lake, P.S., Mapstone, B.D., and Quinn, G.P. (2002). Monitoring Ecological Impacts: Concepts and Practice in Flowing Waters. Cambridge University Press.

Dutson, G., Garnett, S., and Gole, C. (2009). Australia's Important Bird Areas: Key sites for conservation. Birds Australia.

Edmunds, M., Hallein, E., and Flynn, A. (2014). Victorian Subtidal Reef Monitoring Program: The Reef Biota of Beware Reef Marine Sanctuary. Parks Victoria, Melbourne, Australia.

Edmunds, M., Stewart, K., and Pritchard, T. (2011). Victorian subtidal reef monitoring program: the reef biota within the Twofold Shelf Bioregion. Parks Victoria, Melbourne.

EPA Victoria. (2007). Yarra and Maribyrnong Estuaries: Investigation of Contamination in Fish. EPA Victoria, Melbourne, Australia.

EPA Victoria. (2009). Lower Yarra River Fish Study: Investigation of Contaminants in Fish. EPA Victoria, Melbourne, Australia.

Fabris, G., Theodoropoulos, T., Sheehan, A., and Abbott, B. (1999). Mercury and Organochlorines in Black Bream, Acanthopagrus butcheri, from the Gippsland Lakes, Victoria, Australia: Evidence for Temporal Increases in Mercury levels. Marine pollution bulletin 38(11): 970–976.

Food Standards Australia New Zealand. (2005). Final Assessment Report: Proposal P265 Primary Production and Processing Standard for Seafood. Food Standards Australia New Zealand, Canberra.

Frost, K.J., Lowry, L.F., and Hoef, J.M. (1999). Monitoring the trend of harbor seals in Prince William Sound, Alaska, after the Exxon Valdez oil spill. Marine Mammal Science 15(2): 494–506.

Glover, J., Bacher, G., and Pearce, T. (1980). Gippsland Regional Environmental Study: Heavy Metals in Biota and Sediments of the Gippsland Lakes. Arthur Rylah Institute for Environmental Research, Heidelberg, Victoria.

Goldsworthy, S.D., Gales, R.P., Giese, M., and Brothers, N. (2000a). Effects of the Iron Baron oil spill on little penguins (Eudyptula minor). I. Estimates of mortality. Wildlife Research 27(6): 559–571.

Goldsworthy, S.D., Giese, M., Gales, R.P., Brothers, N., and Hamill, J. (2000b). Effects of the Iron Baron oil spill on little penguins (Eudyptula minor). II. Post-release survival of rehabilitated oiled birds. Wildlife Research 27(6): 573–582.

Haag, S.M., Kennish, M.J., and Sakowicz, G.P. (2008). Seagrass habitat characterization in estuarine waters of the Jacques Cousteau National Estuarine Research Reserve using underwater videographic imaging techniques. Journal of Coastal Research: 171–179.

Hale, J. (2011). Baywide Monitoring Program: Ramsar listed Wetlands – Monitoring of Saltmarsh Health and Extent and Intertidal Mudflat Extent (2008 to 2011). Port of Melbourne Corporation, Melbourne, Australia.

Hale, J. (2023). Addendum to the Ecological Character Description for the Gippsland Lakes Ramsar Site. Department of Energy, Environment and Climate Action. East Melbourne

Hart, S.P., Edmunds, M., Ingwersem, C., and Lindsay, M. (2005). Victorian Intertidal Reef Monitoring Program: The Intertidal Reef Biota of Northern Port Phillip Bay Marine Sanctuaries. Parks Victoria, Melbourne, Australia.

Haynes, D., Mosse, P., and Levay, G. (1995). The use of transplanted cultured mussels (Mytilus edulis) to monitor pollutants along the Ninety Mile Beach, Victoria, Australia—I. Extractable organohalogens (EOX). Marine Pollution Bulletin 30(7): 463–469.

Healey, C. (2012). Wetland birds of the Gippsland Lakes: trends over the last 10 years. The Chat 52: 4–7.

Healey, C. (2013). Wetland birds in the Gippsland Lakes important bird area: Diversity and reporting rates over 26 years. The Chat 58: 7–9.

Hook, S., Batley, G., Holloway, M., Irving, P. and Ross, A. (eds). (2016). Oil spill monitoring handbook. Commonwealth Scientific and Industrial Research Organisation (CSIRO) Publishing, Australia

Kenderbone, P. (2000). APMS Operators Manual. Australian Antarctic Division, Kingston, Tasmania.

Kent, J., Jenkins, G., and Acevedo, S. (2013). Temporal and spatial patterns in ichthyoplankton assemblages in bay and open coastal environments. Journal of fish biology 82(2): 408–429.

Keough, M.J., Ross, D.J., and Knott, N.A. (2007). Ecological performance measures for Victorian Marine Protected Areas: Review of the existing biological sampling program. Parks Victoria, Melbourne, Australia.

Kirby, M.F., Brant, J., Moore, J., Lincoln, S., (eds.) (2018). PREMIAM – Pollution Response in Emergencies – Marine Impact Assessment and Monitoring: Post-incident monitoring guidelines. Second Edition. Science Series Technical Report. Cefas, Lowestoft

Kirkwood, R., Pemberton, D., Gales, R., Hoskins, A.J., Mitchell, T., Shaughnessy, P.D., and Arnould, J.P.Y. (2010). Continued population recovery by Australian fur seals. Marine and Freshwater Research 61(6): 695.

Kirkwood, R., Warneke, R.M., and Arnould, J.P.Y. (2009). Recolonization of Bass Strait, Australia, by the New Zealand fur seal, Arctocephalus forsteri. Marine Mammal Science 25(2): 441–449.

Last, P.R., White, W.T., Gledhill, D.C., Hobday, A.J., Brown, R., Edgar, G.J., and Pecl, G. (2011). Long-term shifts in abundance and distribution of a temperate fish fauna: a response to climate change and fishing practices. Global Ecology and Biogeography 20(1): 58–72.

Lin, Q. and Mendelssohn, I.A. (2012). Impacts and recovery of the Deepwater Horizon oil spill on vegetation structure and function of coastal salt marshes in the Northern Gulf of Mexico. Environmental science & technology 46(7): 3737–3743.

Littnan, C.L. and Mitchell, A.T. (2002). Australian and New Zealand fur seals at The Skerries, Victoria: recovery of a breeding colony. Australian Mammalogy 24(1): 57–64.

Lorini, Galley D.J., Li S.-q., Eim C., Kirch U., Lang R.E., Schoner W., Haynes D., and Toohey D. The Use of Transplanted, Cultured Mussels (Mytilus edulis) to Monitor Pollutants along the Ninety Mile Beach, Victoria, Australia III. Heavy Metals. Marine Pollution Bulletin 36(5): 396–399.

Maguire, G.S. (2008). A Practical Guide for Managing Beach-Nesting Birds in Australia. Birds Australia, Melbourne, Australia.

McCutcheon, C., Dann, P., Salton, M., Renwick, L., Hoskins, A.J., Gormley, A.M., and Arnould, J.P.Y. (2011). The foraging range of Little Penguins (Eudyptula minor) during winter. Emu 111(4): 321–329.

Mead, R., Yarwood, M., Cullen, M., and Bacher, G.L. (2012). Report on the 2012 Biennial Hooded Plover Count. Birdlife Australia, Melbourne, Australia.

National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, Minerals Management Service, and US Coast Guard. (2006). Special Monitoring of Applied Response Technologies. NOAA, Seattle, USA.

Niemeijer, D. and de Groot, R.S. (2008). A conceptual framework for selecting environmental indicator sets. Ecological Indicators 8(1): 14–25.

Overeem, R.L., Peucker (nee Mitchelson), A.J., Austin, C.M., Dann, P., and Burridge, C.P. (2007). Contrasting genetic structuring between colonies of the World’s smallest penguin, Eudyptula minor (Aves: Spheniscidae). Conservation Genetics 9(4): 893–905.

Power, B. and Boxshall, A. (2007). Marine National Park and Sanctuary Monitoring Plan 2007-2012. Parks Victoria, Melbourne, Australia.

Punt, A.E., Day, J., Fay, G., Haddon, M., Klaer, N., Little, L.R., Privitera-Johnson, K., Smith, A.D., Smith, D.C., Sporcic, M. and Thomson, R. (2018). Retrospective investigation of assessment uncertainty for fish stocks off southeast Australia. Fisheries Research, 198: 117-128.

Ramsar Convention. (2005). Resolution IX.1 Annex A. A Conceptual Framework for the wise use of wetlands and the maintenance of their ecological character.

Reed, M., French, D.P., Calambokidis, J., and Cubbage, J.C. (1989). Simulation modelling of the effects of oil spills on population dynamics of Northern fur seals. Ecological Modelling 49(1–2): 49–71.

Saintilan, N. (2009). Australian Saltmarsh Ecology. CSIRO Publishing, Collingwood.

Schultz, S.T., Bakran-Petricioli, T., Kruschel, C., and Petricioli, D. (2014). Monitoring of Posidonia meadows under the EC Habitats Directive: vehicular videography can estimate trends in coverage at low cost and high precision. In 5th Mediterranean Symposium on Marine Vegetation.

Tsvetnenko, Y. (1998). Derivation of Australian tropical marine water quality criteria for the protection of aquatic life from adverse effects of petroleum hydrocarbons. Environmental Toxicology and Water Quality 13(4): 273–284.

United Nations. (1971). Convention on Wetlands of International Importance especially as Waterfowl Habitat. In UN Treaty Series No. 14583.

US EPA. (2000). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Volume 1: Fish Sampling and Analysis. US Environmental Protection Agency, Office of Water, Washington, DC.

US EPA, O. (1994). Water Quality Standards Handbook: Second Edition.

Victorian Fisheries Authority (2024). Commercial Fish Production Information Bulletin July 2023 to June 2024. Accessed at https://vfa.vic.gov.au/__data/assets/pdf_file/0018/1101870/VFA-Commercial-Fish-Production-Information-Bulletin-2024.pdf

Warry, F.Y. and Hindell, J.S. (2012). Fish Assemblages and Seagrass Condition of the Gippsland Lakes. Arthur Rylah Institute for Environmental Research, Heidelberg, Victoria.

Weston, M.A. (2003). Managing the Hooded Plover in Victoria: a Review of Existing Information. Parks Victoria, Melbourne.

Weston, M.A., Ehmke, G.C., and Maguire, G.S. (2009). Manage one beach or two? Movements and space-use of the threatened hooded plover (Thinornis rubricollis) in south-eastern Australia. Wildlife Research 36(4): 289.

Williams, J., Gilmour, P., and Edmunds, M. (2007). Victorian Subtidal Reef Monitoring Program: The Reef Biota within the Twofold Bioregion. Parks Victoria, Melbourne, Australia.

Zimmer, I., Ropert-Coudert, Y., Poulin, N., Kato, A., and Chiaradia, A. (2011). Evaluating the relative importance of intrinsic and extrinsic factors on the foraging activity of top predators: a case study on female little penguins. Marine Biology 158(4): 715–722.

Attachment 1. O1: Surveillance and tracking

1. Rationale

The development and implementation of effective responses to oil spills depends critically on the knowledge of likely fate and behaviour of oil once exposed to ambient weather and sea state conditions. The likely trajectories of surface oil can be predicted on the basis of the oil type, and weather conditions (sea currents, wind and temperatures).

2. Implementation trigger

This monitoring protocol directly informs oil spill response strategies and actions. It is triggered immediately that there is a confirmed visual observation of a hydrocarbon sheen and / or notification from the gas plant of process parameters outside normal operating limits indicating a potential leak. In the absence of this, SGHE will contact other oil and gas operators in the region to determine if responsibility has been claimed. If this is not the case, SGHE will adopt a precautionary approach and initiate Type I monitoring).

In the event of a Level II or Level III spill, increased monitoring effort will be required. This will involve the initiation of 3D computer spill trajectory modelling by RPS (which is initiated via AMOSC).

3. Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. Preliminary termination criteria have been developed whereby monitoring continues until all of the following measures are reached:

- manual trajectory calculation and / or Oil Spill Trajectory Modelling (OSTM) indicates spill will not reach marine protected areas, state waters, or the shoreline;
- process parameters return to normal; and
- hydrocarbons are not visible at sea or onshore (taking account of sea state and likelihood of visual observation)

4. Objectives

- To collect and collate relevant weather and sea state conditions to inform Oil Spill Trajectory Modelling;
- To predict the trajectory and fate of the hydrocarbons on the surface and entrained in the water column and predict sensitivities at risk;
    - To conduct surveillance and tracking of the hydrocarbons to:
    - Validate or revise spill trajectory and fate predictions;
    - Inform response planning and operations;
    - Prioritise sensitivities at risk to inform response strategies and Type II monitoring implementation;
    - Provide coordinates of spill location to O2: Water quality and hydrocarbon monitoring team; and
- To determine when termination criteria have been met.

5. Monitoring stages

There are two distinct components of operational monitoring, linked to the stage of the incident (Table 3).

Table 3: Monitoring activities and stages for O1: Surface slick surveillance.

Monitoring stage	Monitoring activity
Post spill – pre impact	Obtain weather, wind and sea current data. Manually calculate trajectory Initiate request for trajectory modelling Conduct visual (aerial and/ or vessel) monitoring and deploy satellite buoys to validate/revise predictions
Post impact - pre response termination	Surveillance and tracking to support water quality and hydrocarbon monitoring and shoreline monitoring teams and necessity of further response actions. Surveillance and tracking until termination criteria are reached.

6. Implementation

The decision process for implementing this operational monitoring program is provided in Figure 6. The size of the spill dictates the level of monitoring initiated. In the event of any spill, preliminary visual observation is required; this may be from a rig, vessel or aircraft. If the spill is visible to the naked eye, determination of weather and sea state (O1.1); Manual trajectory prediction (O1.2); and observations from a vessel (O1.3) are initiated. If the spill is classed as a Level II or Level III event, then more comprehensive monitoring is implemented; with Oil Spill Trajectory Modelling (O1.2) and Aerial surveillance (O1.3) and if it is likely that the spill will persist after sunset (when visual observation is no longer possible) O1.4 Remote observation may be initiated.

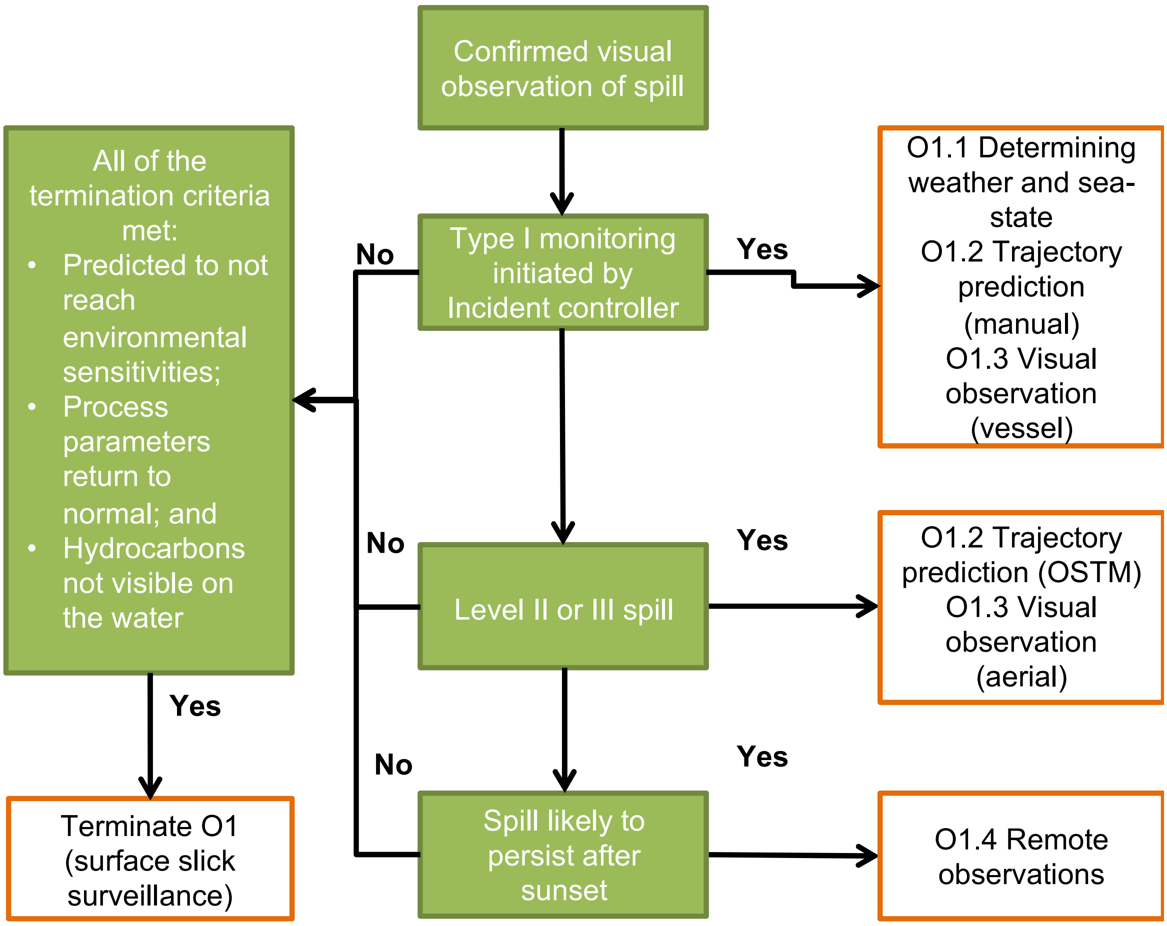


Figure 6: Decision process for operational monitoring module O1: Surface slick surveillance.

O1.1 Determination of weather and sea-state

Weather and sea state data (currents) are required inputs to trajectory estimation (both manual and computer based) and to inform the feasibility of various response actions. Data should be collected from the closest source to the unplanned oil release and be augmented with on site, visual observations. Information is available from the Bureau of Meteorology website (http://www.bom.gov.au/vic/observations/coastal.shtml).

Observations from land, rig or vessel should be made and related to the sea state classifications (Table 4). Data should be updated for each trajectory estimation (manual or computer based) or at the request of the Incident Controller.

Table 4: Sea state classification (AMSA 2003).

Beaufort scale	Wind speed (knots)		Description		Wave height (m)	
	Mean	Range	Wind	Sea	Mean	Maximum
0	0.5	0-1	Calm	Flat	-	-
1	2	1-3	Light air	Ripples	0.1	0.1
2	5	4-6	Light breeze	Small wavelets. No breakers	0.2	0.3
3	9	7-10	Gentle breeze	Large wavelets. Some crests and scattered white caps.	0.6	1.0
4	13	11-16	Moderate breeze	Small waves. Fairly frequent white caps.	1.0	1.5
5	19	17-21	Fresh breeze	Moderate waves. Many white caps. Occasional spray.	2.0	2.5
6	24	22-27	Strong breeze	Large waves. Extensive white foam crests. Some spray.	3.0	4.0
7	30	28-33	Near gale	Sea rises. White foam from breaking waves in streaks.	4.0	5.5
8	37	34-40	Gale	Moderate, long waves. White foam blown in long streaks.	5.5	7.5
9	44	41-47	Strong gale	High waves. Dense streaks of foam. Wave crests begin to topple.	7.0	10.0
10	52	48-55	Storm	Very high waves. Long hanging crests. Foam in large patches. Sea surface largely white.	9.0	12.5
11	60	56-63	Violent storm	Extreme waves (small-medium ships lost to view). Foam covered sea surface. Reduced visibility.	-	-
12		> 64	Hurricane	Air filled with foam and spray. Driving spray. Very reduced visibility.	> 14	-

O1.2 Trajectory prediction

<u>Trajectory Estimation – Manual Method (Vectorial Plotting)</u>

Oil spill trajectory can be roughly calculated by adding the surface current velocity to 3% of the wind velocity (Figure 7).

Calculations:

1. On a map or chart, mark the location of the spill, (origin).
2. Determine the present current direction and speed.

3. Draw a scaled line from the spill origin in the compass direction of the current.

   Length = distance travelled in time interval (in one hour = approximately 1800m x current velocity in knots).

4. Determine the wind direction and speed.
5. Draw a second scaled line, starting from the end of the current vector, in the compass direction of the wind.

   Length = 0.03 x 1800 m x wind velocity in knots.

6. Draw a line from the origin of the spill to the end of wind vector. This is oil movement in one hour.

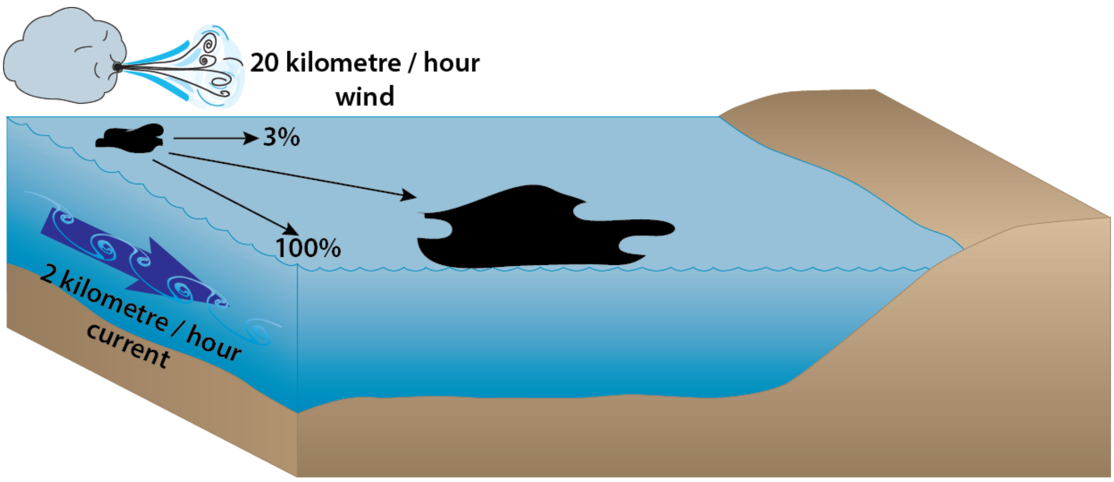


Figure 7: Movement of oil on water (adapted from ITOPF undated). Symbols from Integration and Application Network, University of Maryland Center for Environmental Science http://ian.umces.edu/imagelibrary/.

<u>Trajectory Estimation – Computer based oil spill trajectory modelling (OSTM)</u>

The exact nature of the OSTM that will be implemented will depend on the nature, extent and location of the spill. Condensate spills associated with Longtom activities, will be subsurface and require some form of 3D modelling. Oil Spill Model and Response System (OILMAP) is considered the industry standard for use and complies with the ASTM Standard.

The Incident Controller will initiate an OSTM request through AMOSC 24hr Emergency Number or via the AMSA pollution duty officer on 1800 641792 in conjunction with completing the online proforma request. (http://www.amsa.gov.au/environment/maritime-environmental-emergencies/national-plan/General-Information/OSTM/request-proforma.asp).

Information from the aerial observation (O1.3) and water quality and hydrocarbon monitoring (O2) will be used to update the model outputs on a daily basis.

Outputs of the model are overlaid with the Oil Spill Response Atlas (OSRA) in an operational GIS-based map for spill response. This map, together with the trajectory predictions will be used to assess risks of landfall or interaction with priority areas (inlets, creeks, seal / bird nesting areas, shipwrecks (from OSRA and NEBA sources) and the need for response actions beyond observing natural weathering and degradation.

O1.3 Visual Surveillance

Visual observation of an oil slick can be initiated from a rig, vessel or aircraft. In the event of a Level I spill, and if a rig or vessel is available, then preliminary observations should be initiated. Observers on the rig or vessel should confirm the location and, where possible, extent of the spill and record observations of the behaviour and appearance of the hydrocarbon on the water surface.

The most timely and reliable estimations of the extent and location of the spill are obtained by aerial observation. Aerial observation will be implemented where report of a spill is to be confirmed, in the event of a Level II or Level III spill, or at the direction of the Incident Controller. This procedure should be repeated at morning and in the afternoon, or as directed by the Incident Controller. This procedure is based on AMSA (2003) and is relevant for both aerial and vessel observations.

Equipment and resources

- Fixed-wing aircraft or helicopter with good downward visibility (if aerial surveillance implemented)
- Trained aerial observer
- Radio – for communication to Incident Controller and other monitoring teams
- GPS
- Digital camera (preferably with inbuilt GPS)
- Binoculars
- Base maps / charts of the area
- Clipboard and notebook
- Pens / pencils
- Field sheets (see Attachment O1:A)
- Copy of sample instructions
- PPE (sunglasses, protective clothing)

Preparation for aerial observation

- Determine requirements for aerial / vessel survey e.g. helicopter / fixed wing depending on survey area (generally fixed wing for extensive offshore areas; helicopter for slow speed nearshore surveys).
- Assemble and check required equipment.
- Contact Incident Controller and confirm communication protocols.
- Complete Job Safety Analysis and attend any relevant safety briefings.

Procedure for aerial observation

1. Obtain information on the location of the slick (from O1.2 Trajectory prediction)
2. Develop a flight plan / navigation path to find the slick. This should adopt the "ladder approach" illustrated in Figure 8. For vessel observations, the vessel should follow the leading edge of the hydrocarbon slick.
3. The optimum altitude is 300-500 metres for marine surveillance with aircraft orientated so observer is at a 30 degree angle (approximately).
4. Record preliminary observations of date / time, weather conditions, and observers on field sheet (see Attachment O1:A).

5. Record GPS coordinates (GDA94) of the box coordinates around the maximum area of the slick. If required, communicate these to the O2: Water quality and hydrocarbon sampling monitoring team via radio.
6. Determine the area of the slick (record on field sheet – Attachment O1:A):
   a) Fly the length of the slick and record the time taken and the aircraft speed (1 knot = 0.5m per second)
   b) Fly the width of the slick and record the time taken and aircraft speed.
   c) Calculate the length and the width - distance (metres) = time (seconds) x speed (knots)
   d) Calculate the area (m2) as length x width.

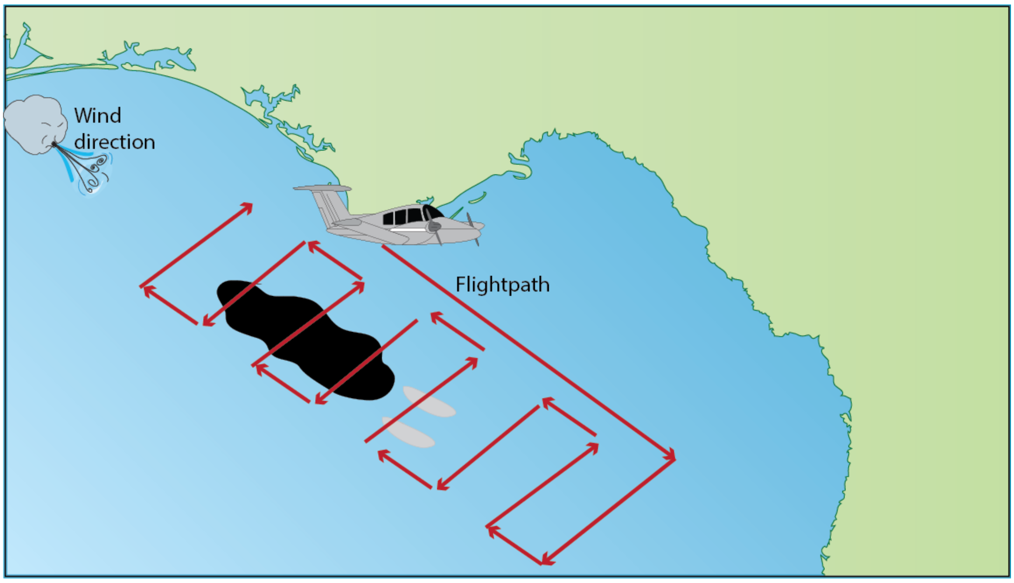


Figure 8: Ladder flight path used to locate slick in the marine environment (symbols from Integration and Application Network, University of Maryland Center for Environmental Science http://ian.umces.edu/imagelibrary/).

7. Determine the thickness and distribution of the oil in the slick (record on field sheet – Attachment 1):
   a) Use the Bonn Agreement Oil Appearance Code (Table 5) and picture guide (Attachment O1:B) of oil colour to estimate the thickness of various parts of the slick
   b) Estimate and record the relative proportions (percentage cover) of clean water and each colour (or thickness) over the slick area (see Figure 9).
8. Estimate the volume of oil on the sea surface (record on field sheet – Attachment O1:A):
   a) Calculate the area of each colour (thickness) of oil, where Area = % cover x total area
   b) Calculate the volume of oil in each colour by multiplying area by estimated thickness of oil in each colour.
   c) Calculate total volume by summing volumes for each colour (thickness).

Table 5: Bonn Agreement Oil Appearance Code (AMSA 2003)

Code	Oil Appearance	Approximate thickness (mm)	Approximate volume (m^3/km^2)
1	Sheen – silver grey	0.0001	0.1
2	Rainbow	0.0003	0.3
3	Dull / Metallic	0.001	1.0
4	Transitional (yellow/brown)	0.01	10
5	Light brown / black	0.1	100
6	Thick dark brown	1.0	1,000
E	Emulsified		

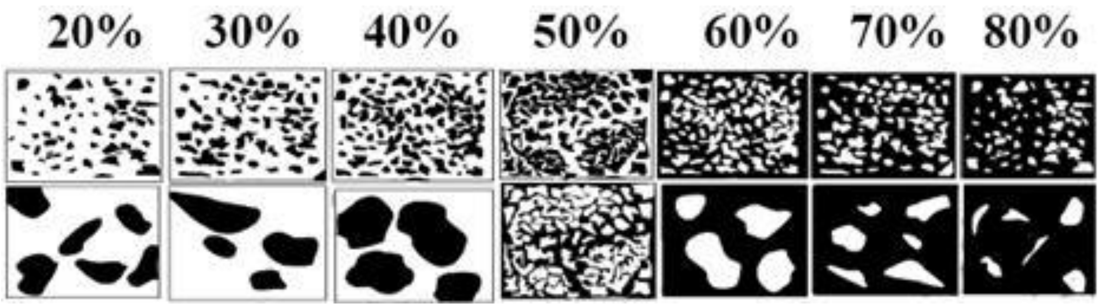


Figure 9: Guide for estimating percentage cover of water quality and oil sampling (AMSA 2003).

9. Take photographs or video of the oil slick (record on field sheet – Attachment O1:A):

a) Take photos or video at a downward angle of 30 to 40 degrees.

b) Avoid photographing into the sun. Use of a polarising filter should be avoided as this will alter the colour of the oil.

c) Turn on camera functions for date and time recording as well PS locations (GDA94).

d) Record details of photos and video taken on Field Sheet (Attachment O1:A)

O1.4 Remote observation

Visual observations via aerial surveillance can be augmented by remote observations using satellite buoys. This is particularly useful for tracking the slick when there is insufficient light to conduct visual observations.

The exact procedures for deployment and calibration will depend on the type of buoys available. The manufactures instructions must be read and followed carefully. The procedure outlined below is for general guidance only.

1. Obtain satellite buoys from AMOSC or other supplier.

2. Arrange 24 hour tracking through RPS.

3. Deploy buoys from a vessel at the leading edge of the spill.

4. Map buoy movements to compare with model predictions and visual data acquired from aerial observations, and inform operational decisions and ongoing visual monitoring requirements.

5. Acquire daily satellite imagery and transmit to operations for interpretation.

6. Acquire and interrogate daily satellite imagery to track movements of oil during night-time and to plan survey areas for the following morning.

7. Health and Safety

A job safety assessment (JSA) must be conducted prior to deployment and incidents reported in accordance with SGHE Incident Management Procedure CORP-HSE-003.

8. Reporting

An experienced and trained analyst must integrate and interpret data provided from all monitoring modules (weather, trajectory estimation, aerial surveillance and remote observations). Typically, data collected from the field is used to update and validate the OSTM.

Consolidated information on the location and predicted trajectory of the slick, together with sensitive receptors in the potential pathway is provided twice daily to the Incident Controller to inform response actions.

A study report detailing all the results of the monitoring is provided to the Incident Controller within one week of termination. This data may be used to inform the outcomes of scientific (type II) monitoring programs.

9. Competencies

Modelling

- AMOSC and AMSA coordinate an oil spill modelling service.
- RPS APASA is a recognised industry leader in predictive modelling of surface and immersed oil during spill incidents.

Monitoring provider (Study Lead – 1 person – note that aerial monitoring will be via AMOSC)

- Bachelor's degree in environmental science or engineering from a recognised academic institution.
- Familiarity with the OSMP and the EMBA.

Monitoring provider (Observers)

- Competency training is required to establish a pool of observers for aerial and vessel-based surveillance; lead observers with recognised oil spill surveillance expertise are available via AMOSC.
- Intimate knowledge of key documents on oil spill guidelines e.g., Oil Spill Monitoring Handbook; Identification of Oil on Water.
- Safety training / induction for aircraft and vessel safety and emergency features.
- Knowledge of the sensitive resources (OPEP Appendix D for OSRA maps)

10. Quality assurance and quality control

Internal audits against procedures documented in this module.

11. Responsibilities

The Incident Controller is responsible for initiating and terminating monitoring activities.

12. Relevant guidelines / standard methods

This monitoring program is based on:

Hook, S., Batley, G., Holloway, M., Irving, P. and Ross, A. (eds). (2016). Oil spill monitoring handbook. Commonwealth Scientific and Industrial Research Organisation (CSIRO) Publishing, Australia

Kirby, M.F., Brant, J., Moore, J., Lincoln, S., (eds.) (2018). PREMIAM – Pollution Response in Emergencies – Marine Impact Assessment and Monitoring: Post-incident monitoring guidelines. Second Edition. Science Series Technical Report. Cefas, Lowestoft.

Parks Victoria Technical Series 79; Marine Natural Values Study Vol 2: Marine Protected Areas of the

Flinders and Twofold Shelf Bioregions

SMART monitoring protocol (U.S. Coast Guard, National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, and Minerals Management Service, 2006, Special Monitoring of Applied Response Technologies, NOAA, Seattle);

Shoreline Assessment manual (third Edition, 2000) Office of Response and Restoration, Hazardous Materials Response Division, National Ocean Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, Washington 98115.

HAZMAT Report No. 2000-1 • August 2000.

Shoreline Clean-up and Assessment Technique (SCAT). Office of Response and Restoration, Hazardous Materials Response Division, National Ocean Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, Washington 98115.

The International Tanker Owners Pollution Federation Limited (ITOPF) Technical Information Paper 1, Aerial Observation of Marine Oil Spills.

The Open Water Oil Identification Job Aid (for aerial observation), version 3 updated August 2016. U.S. Department of Commerce, NOAA (National Oceanic and Atmospheric Administration Office of Response and Restoration), Emergency Response Decision, Seattle Washington.

Attachment O1:A - Visual Observation Field Sheet

1. Survey details

Date	Incident	Aircraft type	Call Sign	Start time	End time	Av altitude / air speed
Wind speed	**Wind direction**	**Visibility**	**Cloud base**	**Sea state**	**Observer 1**	**Observer 2**

2. Oil Slick Details

Slick dimensions GDA94 (Length axis)		Slick dimensions GDA94 (width axis)		Slick dimensions by air speed		Slick grid dimensions
Start latitude		Start latitude		Time length	Av speed	Length
End latitude		End latitude		Time width	Av speed	Width
Start longitude		Start longitude		Time length	Av speed	Length
End longitude		End longitude		Time width	Av speed	Width
					Total grid area	km^2

3 Slick appearance, area and volume

Oil Code	% cover	Grid Area		Area per oil code		Volume Factor	Oil volume	
1 – Silver grey sheen	%		km^2		km^2	0.1 m^3/km^2		m^3
2 – Rainbow	%		km^2		km^2	0.3 m^3/km^2		m^3
3 – Dull / metallic	%		km^2		km^2	1.0 m^3/km^2		m^3
4 – Yellow brown	%		km^2		km^2	10 m^3/km^2		m^3
5 – Black / dark brown	%		km^2		km^2	100 m^3/km^2		m^3
6 – Thick black	%		km^2		km^2	1000 m^3/km^2		m^3
E - Emulsion								
Total								**m^3**

Attachment O1:B – Description of oil appearances (Bonn Agreement 2011)

Code 1 – Sheen (0.04 µm – 0.3 µm)

The very thin films of oil reflect the incoming white light slightly more effectively than the surrounding water (Figure 10) and will therefore be observed as a silvery or grey sheen. The oil film is too thin for any actual colour to be observed. All oils will appear the same if they are present in these extremely thin layers. Oil films below approximately 0.04-µm thickness are invisible. In poor viewing conditions even thicker films may not be observed. Above a certain height or angle of view the observed film may disappear.

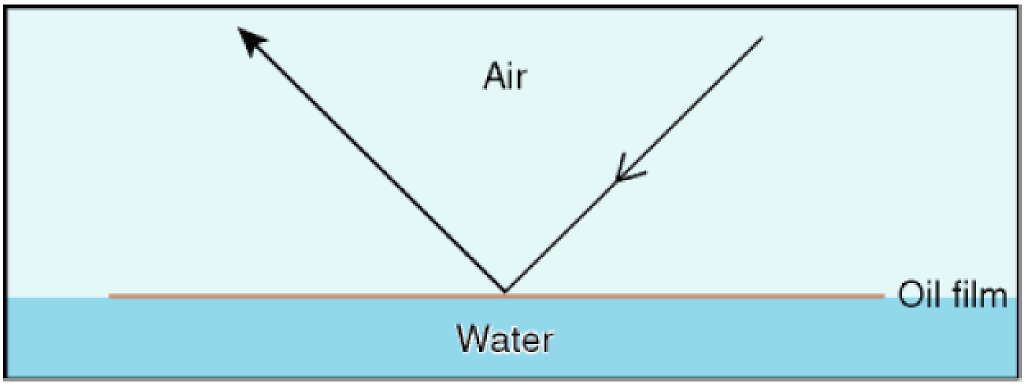


Figure 10: Light Reflecting From Very Thin Oil Films

Code 2 – Rainbow (0.3 µm – 5.0 µm)

Rainbow oil appearance represents a range of colours: yellow, pink, purple, green, blue, red, copper and orange; this is caused by constructive and destructive interference between different wavelengths (colours) that make up white light. When white light illuminates a thin film of oil, it is reflected from both the surfaces of the oil and of the water (Figure 11).

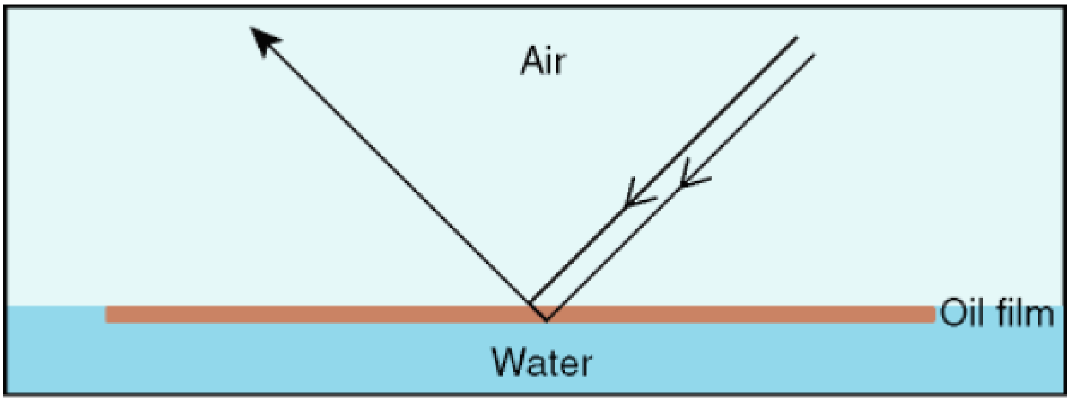


Figure 11: Light Reflecting From Very Thin Oil Films

Constructive interference occurs when the light that is reflected from the lower (oil / water surface combines with the light that is reflected from the upper (oil / air) surface. If the light waves reinforce each other the colours will be present and brighter (Figure 12).

Figure 12: Light Reflecting From Very Thin Oil Films

During destructive interference the light waves cancel each other out and the colour is reduced in the reflected light and appears darker (Figure 13).

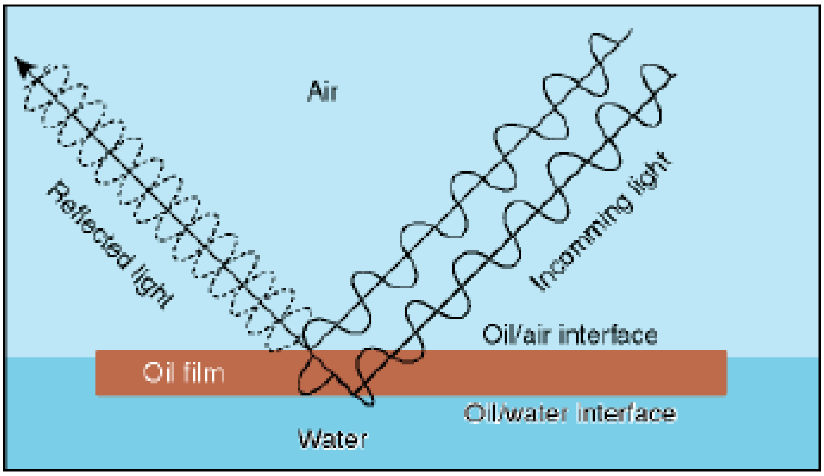


Figure 13: Destructive interference

Oil films with thicknesses near the wavelength of different coloured light, 0.2 µm – 1.5 µm (blue, 400nm or 0.4 µm, through to red, 700nm or 0.7 µm) exhibit the most distinct rainbow effect. This effect will occur up to a layer thickness of 5.0 µm.

All oils in films of this thickness range will show a similar tendency to produce the ‘rainbow’ effect.

A level layer of oil in the rainbow region will show different colours through the slick because of the change in angle of view. Therefore if rainbow is present, a range of colours will be visible.

Code 3 – Metallic (5 µm – 50 µm)

The appearance of the oil in this region cannot be described as a general colour. The true colour of the oil will not be present because the oil does not have sufficient optical density to block out all the light. Some of the light will pass through the oil and be reflected off the water surface. The oil will therefore act as a filter to the light (Figure 14).

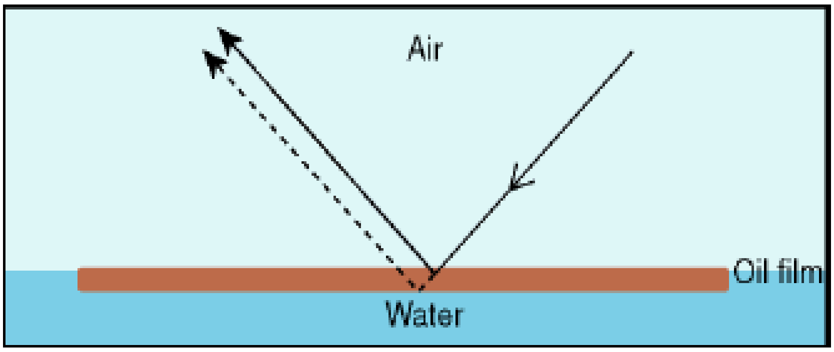


Figure 14: Metallic region

The extent of filtering will depend on the optical density of the oil and the thickness of the oil film. The oil appearance in this region will depend on oil colour as well as optical density and oil film thickness. Where a range of colours can be observed within a rainbow area, metallic will appear as a quite homogeneous colour that can be blue, brown, purple or another colour. The 'metallic' appearance is the common factor and has been identified as a mirror effect, dependent on light and sky conditions. For example blue can be observed in blue-sky.

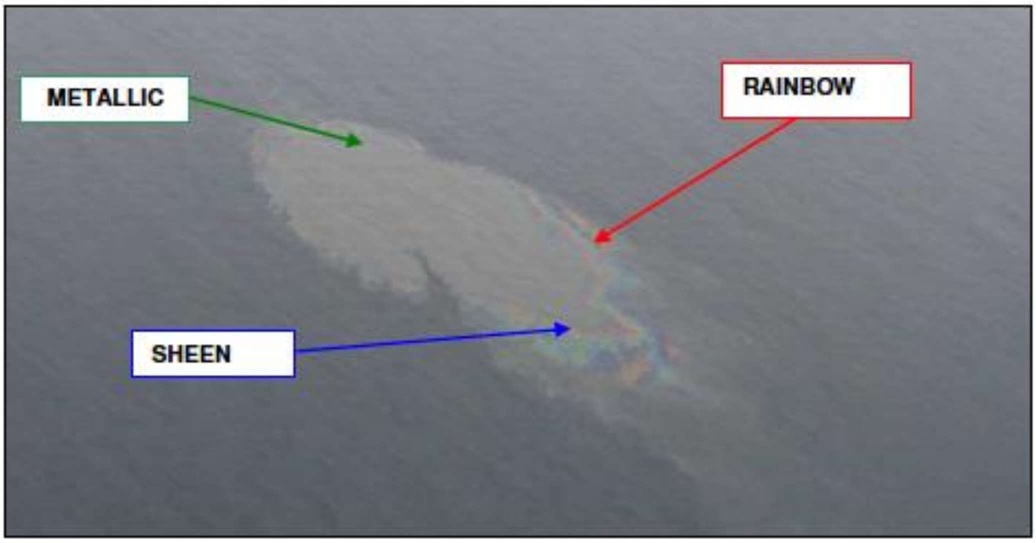


Figure 15: Metallic with sheen and rainbow

Code 4 – Discontinuous true colours (50 µm – 200 µm)

For oil films thicker than 50 µm the light is being reflected from the oil surface rather than the sea surface (Figure 16). The true colour of the oil will gradually dominate the colour that is observed. Brown oils will appear brown, black oils will appear black. In this appearance category the broken nature of the colour, due to thinner areas within the slick, is described as discontinuous. This is caused by the spreading behaviour under the effects of wind and current. 'Discontinuous' should not be mistaken for 'coverage'. Discontinuous implies colour variations and not non-polluted areas.

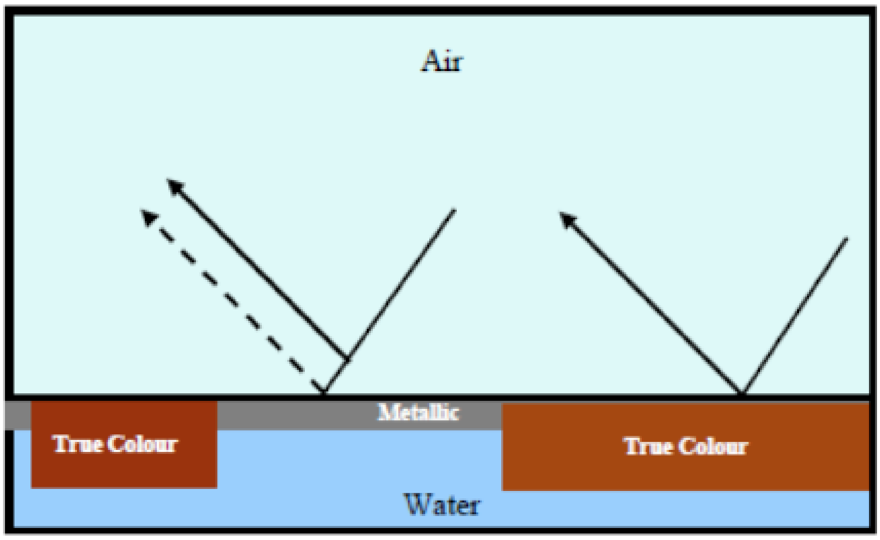


Figure 16: The discontinuous true colour region

Code 5 – True Colours (>200 µm)

The true colour of the specific oil is the dominant effect in this category and the area will be generally homogenous (continuous). It is strongly oil type dependent and colours may be more diffuse in overcast conditions. There is no maximum thickness value for True Colours since it is not possible by visual observation from above to estimate the thickness of oil layers above 200 microns. A spilled oil layer on water that is 0.5 mm thick will look, from the top, exactly the same as an oil layer that is several millimetres thick. The light is reflected from the top surface of the oil; this gives information about the colour and texture of the surface of the oil, but cannot give any direct information about the thickness of the oil layer.

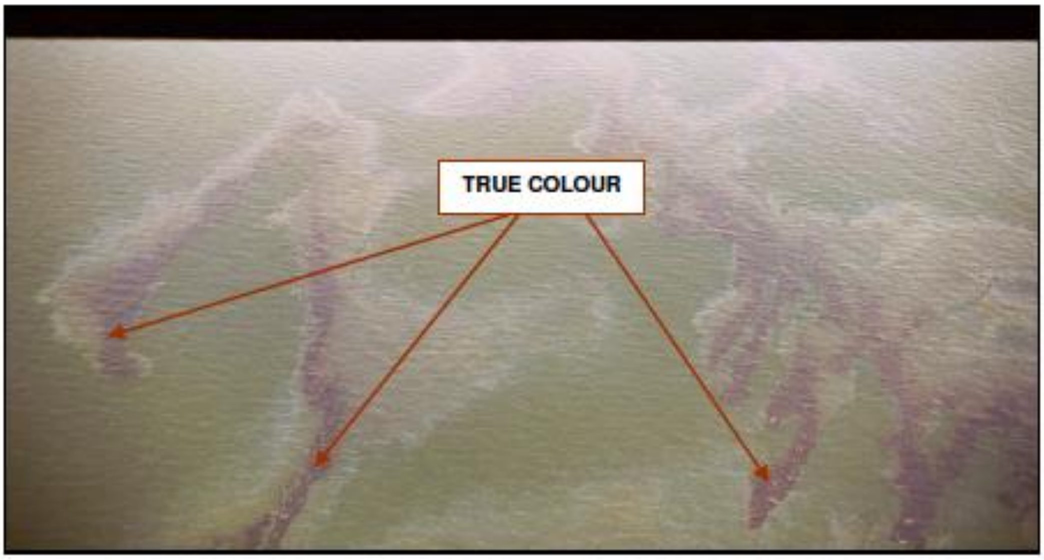


Figure 17: True colour

Code E – Emulsion

Spills of crude oil and some fuel oil are frequently attended by the rapid formation of water-in-oil emulsions (mousse) which are often characterised by a brown / orange colouration and a cohesive appearance. The Appearance Code SHOULD NOT be used to quantify areas of emulsion.

Reliable estimates of water content in an ‘emulsion’ are not possible without laboratory analysis, but accepting that figures of 50% to 80% are typical, approximate calculations of oil quantity can be made, given that most floating emulsions are 1 mm or more thick.

Figure 18: Emulsion

Attachment 2. O2: Water Quality and Hydrocarbon Monitoring

1. Rationale

In the event of a hydrocarbon spill, O1: Surveillance and tracking may not provide sufficient resolution of data to adequately inform oil spill responses and inform decisions regarding:

- The effectiveness of response strategies;
- The point at which active management can stop (i.e. when termination criteria are met); and
- The potential need for scientific (type II) monitoring.

2. Implementation trigger

This monitoring protocol directly informs oil spill response strategies and actions. It is triggered immediately that there is a Level II or Level III spill.

3. Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. Considerations for developing criteria are described briefly below and preliminary criteria provided.

Oil spill response and monitoring is terminated when water quality returns to baseline or (ANZECC and ARMCANZ 2000) trigger values for marine waters. Unfortunately, there are no applicable trigger values for Total Petroleum Hydrocarbons (TPH) for waters in Australia, nor does the US EPA have trigger values for this parameter (US EPA 1994). Guidelines for tropical marine waters were developed using the USEPA method, which is consistent with the national water quality guidelines (ANZECC and ARMCANZ 2000). These suggested a guideline value of 7 µg/L for TPHs in coastal and marine waters (Tsvetnenko 1998). In the absence of baseline data, an interim termination criterion of 7 µg/L TPH has been established.

4. Objectives

- To determine the physical and chemical characteristics of the spilled oil to determine weathering and validate trajectory models;
- To obtain samples of spilled oil for retention and additional analysis if required;
- To establish background concentrations of total petroleum hydrocarbon (TPH) and poly aromatic hydrocarbons (PAH) in sea water;
- To determine concentrations of TPH and PAH within the spill slick to inform response strategies;
- To inform on the need for scientific (type II) monitoring; and
- To determine when termination criteria have been met.
-

5. Parameters

- Physical properties of oil (wax content, pour point, dynamic viscosity, density, volatiles)
- TPH (in situ fluorometry and samples for laboratory analysis)
- Poly-aromatic hydrocarbons (PAHs)
- Trace elements and bio-geomarkers (if fingerprint analysis is required by the Incident Controller)

6. Monitoring stages

There are two distinct components to this monitoring and sampling program linked to the stage of the incident (Table 6).

Table 6: Monitoring activities and stages for O2: Water quality and oil sampling.

Monitoring stage	Monitoring activity
Post spill – pre impact	Background sampling and monitoring in the area, but outside the extent of the oil slick.
Post impact – pre response termination	Sampling in and under the oil slick until termination criteria are consistently reached.

7. Equipment and resources

- Flow-through fluorometer such as the long wavelength Turner AU-10 (or similar) capable of determining TPH concentrations to a detection limit of 1 µg/L. Instrument must be capable of providing a digital readout in real time as well as have the capacity to log results.
- GPS capable of continuous logging time and location
- Sample containers are to be sourced from the appropriate NATA accredited laboratory:
- Glass, Teflon capped vials for TPH and PAH
- Labels for bottles documenting time and location of collection
- Chain of custody sheets (supplied by laboratory)
- Eskys with ice for storing samples
- Water sampler (pump and hoses required for continuous fluorometry and to take water samples for laboratory analysis)
- Equipment decontamination kit (see Attachment O2-B)
- Field sheets (see Attachment O2-A)
- Copy of sample instructions
- PPE (gloves, safety glasses / goggles, overalls)

8. Monitoring locations

The locations for monitoring are relative to the slick and are informed by the monitoring program O1 Surveillance and tracking. This protocol adopts the box coordinate method described in the SMART protocol (NOAA 2006). The observation aircraft provides the on water sampling team with the location of the target oil slick, defined by a four cornered box (Figure 19). Each corner is provided as a GPS northings and easting coordinate (GDA94). The vessel uses this to identify:

- Areas outside the slick for background (no oil) samples; and
- The area of the slick to plot a transect to characterise the slick.

Each monitoring run will require updated coordinates from the aerial surveillance team to ensure that the slick is captured by the on water team.

Note that the trajectory estimation and model should be used to determine the location of post spill, pre-impact samples, with samples collected from areas that the oil has not yet reached, but is in the predicted pathway. Consideration should be given to collecting pre-impact samples from sensitive locations such as Marine Parks or other known sensitivities, as informed by modelling and the Oil Spill Response Atlas

(OSRA) (OPEP Appendix D).

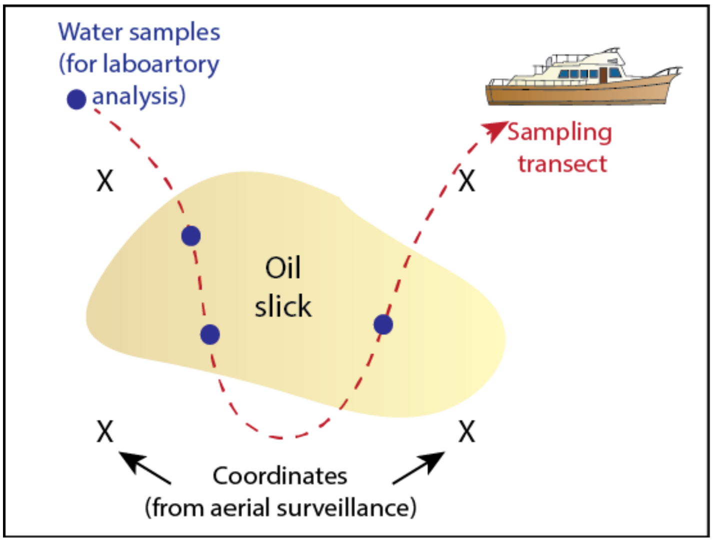


Figure 19: Relative locations of monitoring (adapted from NOAA 2006). Note that water sample collection points are indicative only and will be informed by the size and extent of the slick (symbols from Integration and Application Network, University of Maryland Center for Environmental Science http://ian.umces.edu/imagelibrary/).

9. Implementation

This guideline has been drafted for the use of a flow through fluorometry instrument to measure hydrocarbon concentrations in the water column both in the field as well as to collect water samples for laboratory analysis. The procedure must be modified for alternative instruments (e.g. in situ deployed fluorometer that is lowered over the side of the vessel).

Preparation for monitoring water quality

- Activate monitoring team and vessel provider.
- Contact NATA accredited laboratory to obtain sample containers, eskys, and chain of custody forms. Arrange times for samples to be received by the laboratory and confirm procedure (and timing) for provision of results of analyses.
- Make arrangements for couriers (for laboratory samples) if necessary.
- Contact Incident Controller and confirm communication protocols.
- Complete Job Safety Analysis and attend any relevant safety briefings.
- Assemble equipment required.
- Check equipment
- Set up and check fluorometer, check calibration record, text readouts and logging functions.
- Set up and check pump and hoses water sampler, attach to fluorometer.
- Set up and check GPS, including tracking and logging functions.
- Measure and record the length of the hose between the fluorometer outlet and the bottle end, hose diameter, and flow rate (by filling a bucket). So that samples collected from the outlet and sent to the laboratory can be matched with fluorometer readings.
- Deploy to general monitoring location (as specified by Incident Controller).
- Contact aerial observation team and obtain box coordinates to define area of slick.

O2.1 Hydrocarbon samples

These samples are used to characterise the physical properties of the spilled hydrocarbon to determine extent and progress of weathering. Samples are analysed for physical properties, with samples stored for potential additional analyses such as trace elements if finger print analysis is required (at the direction of the Incident Controller). This protocol is adapted from AMSA (2003).

1. Take sample from the thickest part of the slick, film or dense area of waxy flakes. This is usually the “leading edge” of the slick.
2. If the slick is thick or waxy flakes are present:
3. Attach a clean glass jar to the sampling pole and skim the oil / flakes into the vessel.
4. Carefully transfer the oil into a sample glass container and seal with a Teflon lid. Sample container should be filled to a minimum of 80% full
5. If the slick is thin:
6. Sorbent disk (Teflon wool or glass wool) to a piece of fishing line and lower to the surface slick, dragging across the surface to maximize oil sorbed.
7. Carefully transfer sorbent disk to sample container and seal with Teflon lid. Sample container should be completely full.
8. Label with date, time, location and sampler.
9. Store sample in esky on ice.
10. Record relevant information on field sheet (Attachment O2-A).
11. Decontaminate sampling equipment (see Attachment O2-B).
12. Complete Chain of Custody form provided by the laboratory and forward with samples to the laboratory.

O2.2 Fluorometer protocol

Diesel spill

1. En route to the sampling location, but outside the box coordinates, deploy sampling hose to a depth of 1 metre below the surface (if sea conditions are rough, this may need to be increased to 2 metres to ensure hose does not pass out of the water column as boat rises in swell).
2. Commence logging of fluorometer and GPS.
3. Record relevant information on the Monitoring Field Sheet (see attachment). Manual recording of fluorometer readings and GPS coordinates will be taken at 5 minute intervals at a minimum.
4. When reaching the sampling area, the sampling boat makes the sampling transects at one meter depths across the surface oil slick(s) to determine the level of natural dispersion. Throughout the transect, a constant course a speed should be maintained of 1 – 2 knots.

Condensate spill

Monitoring post a condensate spill follows the same protocol. However, as the condensate moves deeper into the water column additional sampling at depth will be required. This is described as follows:

1. En route to the sampling location, halt the vessel and attempt to maintain constant position.

2. Lower the sampling hose at one metre intervals to a depth of 15 meters (or 1 metre above the bottom, is the water column is less than 15 metres deep).
3. Hold the hose for 2 – 3 minutes at each depth.
4. Record relevant information on the Monitoring Field Sheet (see attachment).
5. Repeat at several locations outside and within the dispersed slick. The exact number of samples required will depend on the size and extent of the slick, but sampling will be conducted at a minimum of three background (outside the slick) locations and five impact (within the slick) locations. This should also correspond with water samples collected for laboratory analysis (see below).

O2.3 Water samples

Water samples are collected from the outlet of the fluorometer and it is important to try to match samples with fluorometer readings. The procedure for collecting samples is as follows (adapted from NOAA 2006):

1. Open valve for water sample collection and allow water to run for ten seconds before opening and filling the bottle.
2. Fill the bottle to the top and allow no headspace in bottles after sealing.
3. Label bottle with exact time of initial filling from the fluorometer clock as well as sampling depth, transect, and the distance of water hose from the outflow port of the fluorometer to the actual collection point of the water sample (to account for residence time of water in the hose)
4. Store filled bottles in esky with ice while on the monitoring vessel. Keep refrigerated (do not freeze) after returning to shore and send to the laboratory as soon as possible.
5. The number of samples will depend on the size and extent of the slick. At a minimum, samples should be collected from three locations outside the slick (background, no oil samples) and five locations from within the slick. For condensate, samples should also be collected at each one metre depth interval.
6. Ensure that field equipment and field duplicate samples are collected as per QA/QC protocols outline below.
7. Complete Chain of Custody form provided by the laboratory and forward with samples to the laboratory.

10. Health and safety

A job safety assessment (JSA) must be conducted prior to deployment and incidents reported in accordance with SGHE Incident Management Procedure CORP-HSE-003.

11. Reporting

An experienced and trained analyst must interpret data from the fluorometer. Results of laboratory tests for TPH can be used to calibrate the readings from the fluorometer and readings transformed into concentrations.

Information from the *in situ* monitoring and laboratory analysis is provided daily to the Incident Controller to inform response actions.

A study report detailing all the results of the monitoring is provided to the Incident Controller within one week of termination. This data may be used to inform the outcomes of scientific (type II) monitoring programs).

12. Quality assurance and quality control

Instrument calibration

The fluorometer must be calibrated according to the manufacturer's instructions prior to deployment.

Field sampling

Sampling will be carried out using unpowdered plastic disposable gloves to minimise the risk of contamination.

Sample bottles must be prepared (with appropriate preservative where required) and provided by the receiving laboratory.

All samples must be placed on ice and transported to the laboratory immediately upon return to the shore.

Chain of Custody forms must be provided by the laboratory and forwarded with each batch of samples to the analysing laboratory,

Field equipment blanks (one per sampling trip) will be collected to test for contamination during sample collection, treatment and storage. These samples are generated by running deionised water or standard seawater (provided by the laboratory) through the sampling apparatus and fluorometer into sample jars (one for each parameter for which samples were collected on the day). These are labelled with the time and date and "field blank".

Field duplicates will be collected to test for contamination during sample collection and laboratory precision. At one randomly selected location per sampling trip, repeat samples are collected for each parameter. These are labelled as "field duplicate".

Data entry

Data from the field sheets that is then entered into a computer system must be quality checked by a second person. Any errors are noted in pen on the field data sheet and corrections made to the electronic file. The person that enters the data and the person who undertakes the quality check must both sign the field sheet.

Laboratory

Samples are analysed by a NATA accredited laboratory according to their standard and approved methods. The Limit of Reporting (LOR) for all samples is to be below that of termination criteria required in the program.

Samples must be analysed within the required holding times for each analytical test:

- PAH – 7 days (when refrigerated < 6 ^{0}C)
- TPH – 14 days (when preserved with sulphuric acid)

Two sets of QA/QC data must be provided by the laboratory:

- Laboratory internal QA/QC reports (e.g. spikes, blanks) including documentation of the methods used; and
- Results for the field QA/QC samples collected in the field.

These will be provided to the monitoring team together with the results of each sampling event. The leader of the monitoring team will critically review the results from both the laboratory and field based QA/QC analyses to ensure the results meet the required quality assurance.

At a minimum the following checks will be made and reported:

- Blanks are below LOR; and
- Duplicates are within 25% relative percent difference.

In the event that either of these QA/QC conditions is breached the Incident Controller must be advised.

13. Competencies

Monitoring provider (Study Lead –1 person either the Environment Coordinator in OSRT or a third party Scientific Monitoring Manager)

- Bachelor's degree in environmental science or engineering from a recognised academic institution.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in using flow through fluorometry and the collection of water and oil samples at sea.

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
Australian Marine Ecology	72 Heller Street Brunswick West VIC 3055 03 9376 2397
CEE	Unit 4 150 Chesterville Road Cheltenham VIC 3192 03 9553 4787 0419 390 459

Laboratory

- NATA accreditation for the analysis of petroleum hydrocarbons in water.

Potential local operators include:

Organisation	Contact	
ALS	Main Melbourne Laboratory 2-4 Westall Road Springvale VIC 3171 03 8549 9600	Traralgon Gippsland Water 4/55 Hazelwood Road Traralgon VIC 3844 03 5176 4170
National Measurement Institute	1/153 Bertie Street, Port Melbourne VIC 3207 1800 020 076	
Leeder Consulting Pty Ltd	33 Steane St, Fairfield VIC 3078 03 9481 4167	

14. Responsibilities

The incident controller is responsible for initiating and terminating monitoring activities.

15. Relevant guidelines / standard methods

This monitoring program is based on:

Hook, S., Batley, G., Holloway, M., Irving, P. and Ross, A. (eds). (2016). Oil spill monitoring handbook. Commonwealth Scientific and Industrial Research Organisation (CSIRO) Publishing, Australia

Kirby, M.F., Brant, J., Moore, J., Lincoln, S., (eds.) (2018). PREMIAM – Pollution Response in Emergencies – Marine Impact Assessment and Monitoring: Post-incident monitoring guidelines. Second Edition. Science Series Technical Report. Cefas, Lowestoft.

ANZECC and ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality.

SMART monitoring protocol (U.S. Coast Guard, National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, and Minerals Management Service, 2006, Special Monitoring of Applied Response Technologies, NOAA, Seattle)

Attachment O2-A: Water quality and oil sampling Field Sheet

Date: _________________ Start and end time:_____________________

Team members:____

On site weather (log all possible entries)

Wind direction (from):__________________ Wind speed:____________________

Sea state:______________ Cloud cover (%):________________

Air temperature:______________ Sea temperature:________________

Comments should include: Presence or lack of surface oil or dispersed oil slick, whether conducting background run, transect in relation to slick, instrument or gear problem, or any other noteworthy event. Positions should always be recorded when a sample is taken. Otherwise, a log entry every five minutes is sufficient.

Time	Water depth (m)	Fluorometer reading	GPS Coordinates (GDP94)	Sample collected			Comments
				Oil	TPH	PAH	

Time	Water depth (m)	Fluorometer reading	GPS Coordinates (GDP94)	Sample collected			Comments
				Oil	TPH	PAH	

Trip blank included (circle one): YES NO

Chain of Custody complete (circle one): YES NO

Time of drop-off to laboratory:__________________________

Completed by: ____________________________ ________________________

Print name Signature

Entry to computer:

Entered by (name& signature)	
Date entered	
Checked by (name& signature)	
Date Checked	

Attachment O2-B Guideline for decontamination of equipment (AMSA 2003)

Rationale

All samples should be kept free of cross contamination. It is sometimes necessary to reuse equipment and so this must be thoroughly cleaned between each use.

Method

1. Metal and some plastic items may be decontaminated after use and reused. Wooden items should be used once and then disposed of.

2. As a general rule, decontamination of equipment in the field is difficult. If field decontamination is necessary instruments should be:

a) Washed or wiped free of obvious contamination (sediment, oil).

b) Rinsed thoroughly with methylene chloride.

c) Rinsed with acetone (or hexane).

d) Rinsed thoroughly with de-ionized water.

e) Store all used solvents in a secure, labelled container.

Note: Plastic gloves should be worn by all persons undertaking decontamination procedures.

3. At base:

a) Wash all equipment with warm water and detergent.

b) Rinse thoroughly with de-ionised water.

c) Rinse with solvent (preferably the same solvent that is used by the laboratory for extracting hydrocarbons from samples).

d) Wrap in solvent washed aluminium foil.

4. The laboratory should be advised of any decontamination procedure used on sampling instruments.

Attachment 3. O3: Shoreline assessment

1. Rationale

If it is predicted that a shoreline may be impacted by a spill, it is useful to obtain information relating to the physical and biological character of the shoreline prior to impact. This information assists in determining the most suitable response and clean-up methods and also in predicting oil behaviour (persistence, burial, distribution). It also provides a baseline for determining the degree of success of response strategies.

Once impacted, the shoreline can be monitored for oil distribution in order to measure the success (or otherwise) of clean-up methods. Although this module is for Type I (operational) monitoring only and does not address impacts of a spill, the information collected may also be useful for informing Type II monitoring of ecological impacts.

2. Implementation trigger

Module O3 is triggered immediately when modelling and/or visual tracking information from Module O1 indicates the potential for oil to impact a shoreline.

3. Termination criteria

Termination criteria for shoreline assessment are dependent on the situation with respect to the physical and biological characteristics of the shoreline(s) in question. Examples of the types of termination criteria that may be applied are provided in Table 7. Termination criteria for any given spill will be agreed with relevant agencies and community representatives.

Table 7: Hierarchy of termination criteria for shoreline assessment (NOAA 2000).

Termination criteria	Applicable situation
No visible oil - Not detectable by sight, smell, feel	This endpoint is often used for sand beaches where oil removal can be effective without delaying resource recovery. Visual inspections are preferred over chemical analyses because it is difficult to sample areas with high variability; time and costs of analysis; and lack of guidelines on what levels are safe. It may be appropriate to conduct limited sampling and analysis to confirm the visual endpoint as safe for human use, such as on recreational beaches.
No more than background	This endpoint is often applied where there is a significant background rate of tarball deposition on the shoreline.
No longer releases sheens that will affect sensitive areas, wildlife, or human health	This endpoint is used where sheening persists after clean-up efforts become ineffective, or on sensitive habitats where further clean-up efforts will cause more harm than natural removal. Residual sheening should persist over a relatively short time period.
No longer rubs off on contact	This endpoint is usually defined as oil removal to a stain or coat, or weathering to the point that it is no longer sticky. It is appropriate for hard substrates (rocky shores, seawalls, riprap, gravel) and vegetation (salt marsh, mangroves). The objective is to prevent oiling of fur, feathers, and feet of wildlife, people, and property during contact with oiled surfaces.
Oil removal to allow recovery/re-colonisation without causing more harm than natural removal of oil residues	This endpoint is used where further oil removal will result in excessive habitat disruption (e.g., trampling of soft sediments and plant roots, mixing oil deeper, extensive sediment removal, vegetation. It is also used for areas with difficult access, which limits the type of clean-up which can be conducted along that shoreline segment.

4. Objectives

To determine the physical, biological and dynamic properties of shorelines in order to:

- Predict the oil behaviour and distribution
- Determine the most appropriate clean-up methods
- To identify sensitive or vulnerable areas or resources.

To determine the characteristics and distribution of the oil on the shoreline in order to predict the potential for oil persistence and / or natural removal.

- To determine the concentration of PAHs in shorelines and near shore sediments.
- To determine the effectiveness of shoreline response strategies.
- To determine when termination criteria have been met.

5. Response stages

There are four distinct components of operational monitoring, linked to the stage of the incident (Table 8).

Table 8: Monitoring activities and stages for O3: Shoreline assessment.

Response stage	Monitoring
Post spill – pre impact	Conduct baseline assessment of the pre-impact physical and biological condition of shoreline
Post impact – pre clean-up	Daily assessment of the oil on shorelines by observation and sediment sample collection.
Clean-up	Visual assessment, sampling, laboratory analyses and reporting of effectiveness of clean-up.
Post clean-up - pre response termination	Visual assessment, sampling, laboratory analyses and determination of compliance with termination criteria Identification of Type II scientific monitoring needs

6. Equipment and resources

- GPS
- Shovels
- Tape measure
- Camera (preferably digital with inbuilt GPS)
- Maps or charts of the area
- Clipboard, pencils, etc.
- Sample containers are to be sourced from the appropriate NATA accredited laboratory:
- Glass, Teflon capped vials for TPH and PAH
- Labels for bottles documenting time and location of collection
- Chain of custody sheets (supplied by laboratory)
- Eskys with ice for storing samples
- Equipment decontamination kit (see Attachment O2-B)
- Field sheets (see attachments)
- Copy of monitoring instructions
- Hydrocarbon field kit (if available)

- Survey equipment (DGPS roving receiver and base station; survey pole fitted with a flat base) and extra batteries (if O3.3. Shoreline profile is implemented)
- PPE (gloves, safety glasses / goggles, overalls)

7. Monitoring locations

The locations for monitoring are relative to the slick and are informed by the monitoring program O1 Surface slick surveillance. If a spill impacts a shoreline, or is predicted to reach a shoreline over a large area, then division of the monitoring location into discrete management areas may be necessary. The two divisions relevant to O3: Shoreline assessment are:

- Sectors - based on logistics considerations. Support facilities such as waste management sites, equipment stores, ablutions, canteens and other support facilities are usually organized within each Sector.
- Segments - lengths of shoreline that can be considered an individual work site. Segment boundaries will generally be defined on the basis of common substrate type, or less usually on common access points, ownership or jurisdiction. Sometimes cleanup or monitoring teams will define “Subsegments” “plots” or “transects” within a Segment. However, planning and response information is usually based at a Segment level, not at smaller units within it.

The procedure for identifying monitoring locations and determining sectors and segments is as follows:

1. Identify the length of shoreline that could be impacted by oil (from O1: Surface slick surveillance).
2. Consult topographic or electronic maps (e.g. Google Earth) and:
   a) Identify access to shoreline;
   b) Estimate travel time between consecutive shorelines
   c) Note available support areas (open spaces, car parks, amenities).
3. Divide shorelines into sectors by considering:
   a) Travel time between any two parts of the shoreline within a sector should be less than two hours; and
   b) Travel time between nominated operations / support centres and all shorelines within a sector should be less than one hour.
4. Name (or number) sectors and mark on maps (hardcopy and / or electronic).
5. Divide each sector into segments by considering:
   a) Segments should be comprised of the same substrates type or combination of substrates (see O3.1 below). Substrate type in the oiled zone (usually the upper intertidal zone) is of primary importance.
   b) Other features affecting the choice of cleanup should be constant within each segment (e.g. drainage, gradient, exposure, biological character, access points).
   c) In some segments, tidal zones are made up of quite different substrates and may need different cleanup methods. These can be subdivided into Sub-segments based on tidal elevation.
6. Name (or number) sectors and mark on maps (hardcopy and / or electronic).

8. Implementation

Shorelines vary considerably in physical and biological characteristics, which results in a variety of shoreline response measures that can be implemented. For this reason, more than for other operational monitoring modules, there must be a degree of flexibility for O3: Shoreline assessment. As such shoreline monitoring needs to be implemented in an adaptive manner that best suits the conditions and response mechanisms put in place for any given spill. The general decision process for implementing this operational monitoring program is provided in Figure 20.

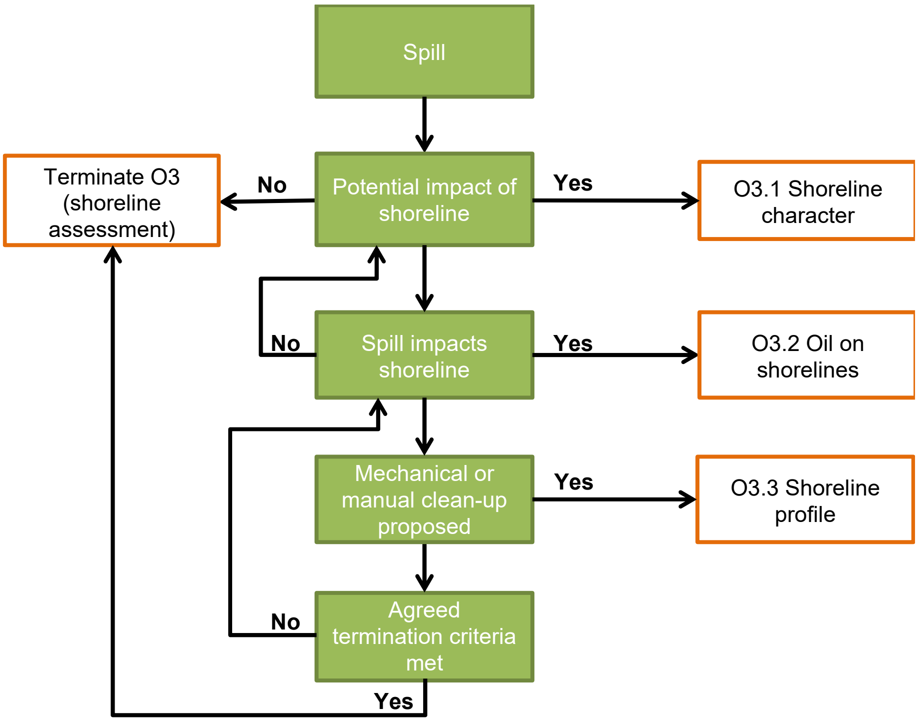


Figure 20: Decision process for O3: Shoreline assessment.

<u>Preparation for shoreline assessment</u>

- Activate monitoring team(s).
- Consult the OSRA (OPEP Appendix D) and NEBA (OPEP Appendix E) and other sources to identify any specific sensitivities at risk within the EMBA. Prepare annotated maps for field observations of the relevant sections of the coastline (subject to the spill scenario), covering:
    - Physical characteristics and substrate types
    - Biological characteristics (e.g. important bird nesting sites, migratory bird sites, penguin colonies, seal colonies)
    - Intertidal wetlands
    - Areas of commercial fisheries activity
    - Culturally sensitive and amenity values
    - Debris that could affect clean-up operations
    - Access issues.
- Contact Incident Controller and confirm communication protocols.
- Complete Job Safety Analysis and attend any relevant safety briefings.
- Assemble equipment required.
- Check equipment (e.g. GPS, batteries, cameras).
- Deploy to monitoring location (as specified by Incident Controller)
- Maintain communication with the Incident Controller to receive updates on:

  - The type and volume of oil
  - Area of likely landfall, and priority areas and sensitivities potentially at risk
  - Timing of likely landfall
  - Likely condition of oil at time of landfall.
- Undertake a calibration exercise on site to ensure that all teams and team members are using the same terminology and estimations. This involves all teams assessing a segment together to agree on descriptions of the physical and biological environment as well as oiling descriptions.

O3.1 Shoreline characteristics (post spill – pre impact)

This is an assessment of the physical and biological characteristics of the shoreline prior to oil impacts. Depending on the size or location of the spill, it may be necessary to conduct an aerial survey in addition to the ground surveys described below. Aerial surveys by fixed-wing plane or helicopter can be used to cover a broader area and quickly assess remote or difficult to access locations. Observations from the air should follow those detailed below, recognising that fine details of physical substrate and species of biota may not be possible to identify from the air.

Physical characteristics

1. Record the following on the field sheet:
   a) Sector and segment name (or number)
   b) Date and time
   c) Survey type (air, foot, vehicle)
   d) Ambient weather conditions
   e) Tide height (confirmed later against tide height charts)
   f) Name(s) of survey team
   g) GPS coordinates (GDA94) for the start and end of the segment.
2. Determine the geomorphic shoreline type, marking one dominant type and as many other types as present: cliff, reef / platform, beach, wetland.
3. Using an existing map (or creating a sketch map if no map is available) mark the location of the different geomorphic types.
4. Assess the gradient of the shoreline (flat, gentle slope, steep slope, vertical).
5. Determine substrate type(s) according to Table 9 and mark locations on the map.
6. Determine the shoreline energy (Figure 21).

Table 9: Characterising shoreline substrate (Hook et al. 2016).

Type	Code	Size	Descriptive notes
Bedrock	R	One continuous piece	Porous / non-porous Crevices / no crevices
Boulder	B	> 256 mm diameter	Porous / non-porous Crevices / no crevices
Cobble	C	64 – 256 mm diameter	Porous / non-porous
Pebble	P	4 – 64 mm diameter	Rounded / flat
Gravel	G	2 – 4 mm diameter	Rounded / flat Compacted / loose
Sand	S	0.06 – 2 mm diameter	Fine / coarse

Mud/silt/ clay	M	< 0.06 mm diameter (field test – mix with water and if it remains in suspension it is silt / mud, if it settles, it is sand).	Organic content Dry / wet
Shellgrit	Sh	Usually with sand	Dry / wet
Concrete	Cc	Artificial	Rubble / riprap
Wood	W	Artificial or debris	Debris / logs / pilings
Metal	Mt	Artificial	Pilings / sheet

Energy	Low → High
Substrate	Mud Sand Grits Pebble Cobble Boulder Bedrock
Form	Swamps Flats Beach Reefs Cliffs
Gradient/ Slope	Flat Gentle slope Steep slope Vertical

Figure 21: Indicators of shoreline energy

<u>Biological characteristics</u>

1. Record the dominant (D) and any other vegetation types and mark their approximate location on the map.
2. Take a representative photograph of each vegetation type.
3. Taking care not to disturb fauna, record the group or species observed, together with any critical life-stage behaviours (feeding, roosting, nesting, presence of juveniles). Mark locations of observations on the map.
4. If possible, take photographs of observed fauna.

<u>O3.2 Oil on shorelines and near shore sediments (all stages)</u>

This is an assessment of oil on the shorelines and near shore sediments. It may be prudent to carry out a pre-impact baseline survey to determine background conditions.

The following monitoring method has been adapted from Hook et al. (2016).

<u>Surface oil</u>

1. Record the following on the field sheet:
   a) Sector and segment name (or number)
   b) Date and time
   c) Survey type (air, foot, vehicle)
   d) Ambient weather conditions
   e) Tide height (confirmed later against tide height charts)
   f) Name(s) of survey team
2. Mark the location of visible oil on a map (or sketch if no map is available).
3. Record the following for the visible oil:
   a) Length (m) that the oil band extends along the shoreline.
   b) Width (m) across the beach (from high to low elevations) that the oil extends.

c) Percentage cover of oil, by visual estimation using Figure 22 as a guide.

d) Oil thickness, according to the categories in Table 10.

e) Oil type, according to categories in Table 10.

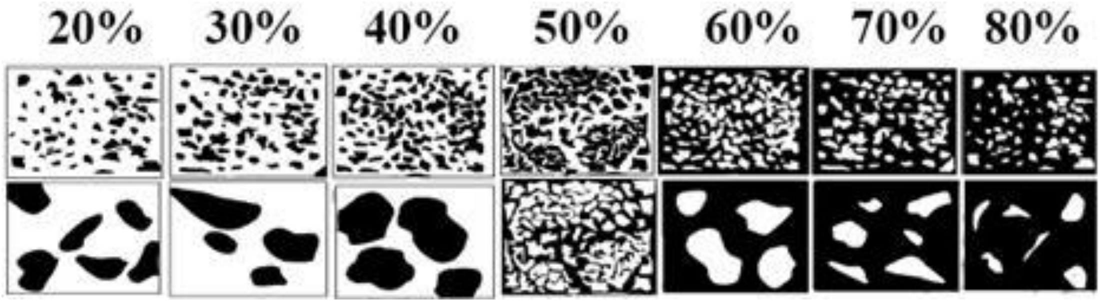


Figure 22: Guide for estimating percentage cover of oil (AMSA 2003).

Table 10: Surface oil thickness and type descriptions (NOAA 2000).

Category	**Description**
Surface oil thickness	
Film	Transparent or iridescent sheen or oily film
Stain	Visible oil, which cannot be scraped off with fingernail
Coat	Visible oil <0.1 cm, which can be scraped off with fingernail
Cover	Oil or mousse from >0.1 cm to <1 cm on any surface
Pooled	Fresh oil or mousse > 1 cm thick
Surface oil type	
Fresh	Unweathered, liquid oil
Mousse	Emulsified oil occurring over broad areas
Tar	Highly weathered oil, of tarry, nearly solid consistency
Tarballs	Discrete accumulations of oil <10 cm in diameter
Patties	Discrete accumulations of oil >10 cm in diameter
Residue	Non-cohesive, oiled surface sediments
Asphalt	Cohesive, heavily oiled surface sediments
No oil	No evidence of any type of oil

Sub-surface oil

1. Dig trenches or pits to detect subsurface oil. Narrow trenches are more suitable for sandy substrates. Pits are more suitable for cobbles or small boulder substrates. The depth required will depend on substrate type and, for sand – pebbles, on sediment mobility (wave energy).
2. Use a GPS to record the location of the pit or sample location for a trench (GDA94).
3. For each pit or location across a transect trench, record the following:
   a) Minimum depth of oil (i.e. the distance in centimetres from the sediment surface to the top of the oil layer)

   b) Maximum depth of oil (i.e. the distance in centimetres from the sediment surface to the bottom of the oil layer)

   c) Substrate type (as per Table 8 above)

   d) The oil type (as per Table 9 above).

Detection of hydrocarbons

A number of naturally occurring substances are similar in appearance, behaviour or odour to petroleum hydrocarbons and may be misreported. There are a number of commercially available field test kits that allow for the detection (and sometimes quantification) of hydrocarbons on surfaces and sediments. Examples include: Hanby TPH Test Kit; and OilScreenSoil. Use of these field kits varies with type and monitoring teams are directed to follow manufacturer's instructions.

The field sheet (see attachment O3-B) provides a space for recording the results of these tests in qualitative or quantitative terms, depending on the type of kit available.

In addition, a sample (or series of samples) of concentrated oil from affected shorelines and near shore sediments is collected for later analysis of PAHs and potential fingerprinting to confirm sources. Samples must be stored in laboratory supplied glass jars with Teflon lids and labelled with: date, location and sampler.

Presence of oiled fauna

Shoreline assessment teams must note the presence of oil-affected fauna and report immediately to the Incident Controller so that relevant agencies and fauna rescue teams can be initiated. Take photos of observed wildlife if it is safe to do so.

O3.3 Shoreline profile (post impact – pre clean-up and post clean-up)

Physical clean-up methods can alter the elevation or profile of sand, pebble or cobble beaches. This may lead to erosion of beach or back beach areas. Shoreline profile may need to be monitored, particularly if heavy machinery is used. This procedure measures the profile of the shoreline prior to mechanical clean-up and then again post clean-up to inform shoreline restoration and allow for response teams to return the shoreline to a profile similar to pre-impact conditions.

- This monitoring requires the use of specialist equipment and a qualified surveyor.
- The bathymetry / topography of the shoreline is measured by the surveyor on foot, by recording the position (GDA94) and elevation at points across the site
- Surveys are conducted in relatively straight lines perpendicular to the shoreline. Sample spacing is uneven, with greater points collected where topography is more variable.
- Coordinates and elevations are stored electronically.
- Upon return to base, coordinates are uploaded into a computer and mapped profile diagrams / graphs produced.

9. Health and safety

A job safety assessment (JSA) must be conducted prior to deployment and incidents reported in accordance with SGHE Incident Management Procedure CORP-HSE-003.

10. Reporting

- Baseline physical and biological shoreline condition report, (pre-impact).
- Twice-daily reports (am / pm during response phase) of visual observations, supported by completed shoreline assessment reports on shoreline distribution of oil
- Shoreline assessment reports of progress and effectiveness of clean-up, as determined by visual extent of coverage and field hydrocarbon testing
- Shoreline profiles provided to the Incident Controller within 24 hours of completion of each survey.

- A study report detailing all the results of the monitoring is provided to the Incident Controller within one week of termination. This data may be used to inform the outcomes of scientific (type II) monitoring programs).

11. Quality assurance and quality control

11.1 Instrument calibration

Surveyor equipment must be calibrated according to manufacturers instructions.

11.2 Field surveys

Field surveyors must complete a calibration exercise where monitoring modules O3.1 and O3.2 are undertaken as a group and standards and terminology agreed upon. This occurs prior to the first survey and every time that new team members are added to the survey team.

11.3 Data entry

Data from the field sheets that is then entered into a computer system must be quality checked by a second person. Any errors are noted in pen on the field data sheet and corrections made to the electronic file. The person that enters the data and the person who undertakes the quality check must both sign the field sheet.

12. Competencies

Monitoring provider (Study Lead - 1 person)

- Bachelor’s degree in environmental science or engineering from a recognised academic institution.

Monitoring provider (Field Team – 2 to 3 people)

- Field surveys of physical and biological characteristics must be conducted by teams with at least one qualified field ecologist, capable of identifying coastal vegetation types and fauna species.
- Shoreline profiles must be conducted by qualified surveyors.

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
Australian Marine Ecology	72 Heller Street Brunswick West VIC 3055 03 9376 2397
CEE Consultants	Unit 4 150 Chesterville Road Cheltenham VIC 3192 03 9553 4787 0419 390 459
Biosis	38 Bertie Street Port Melbourne VIC 3207 03 8646 4800

Hydrocarbon in soil field kits

Hydrocarbon in soil field kits are available from:

United Bio Research(supplier for Hanby Environmental https://hanbytest.com/)

https://www.unitedbioresearch.com.au/suppliers/

Eco Environmental

https://ecoenvironmental.com.au/product/soil-sampling/oilscreensoil-test-kit/

13. Responsibilities

The incident controller is responsible for initiating and terminating monitoring activities.

14. Relevant guidelines / standard methods

This monitoring program is based on:

Hook, S., Batley, G., Holloway, M., Irving, P. and Ross, A. (eds). (2016). Oil spill monitoring handbook. Commonwealth Scientific and Industrial Research Organisation (CSIRO) Publishing, Australia.

Kirby, M.F., Brant, J., Moore, J., Lincoln, S., (eds.) (2018). PREMIAM – Pollution Response in Emergencies – Marine Impact Assessment and Monitoring: Post-incident monitoring guidelines. Second Edition. Science Series Technical Report. Cefas, Lowestoft.

Parks Victoria Technical Series 79; Marine Natural Values Study Vol 2: Marine Protected Areas of the Flinders and Twofold Shelf Bioregions

SMART monitoring protocol (U.S. Coast Guard, National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, and Minerals Management Service, 2006, Special Monitoring of Applied Response Technologies, NOAA, Seattle);

Shoreline Assessment manual (third Edition, 2000) Office of Response and Restoration, Hazardous Materials Response Division, National Ocean Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, Washington 98115.

HAZMAT Report No. 2000-1 • August 2000.

Shoreline Clean-up and Assessment Technique (SCAT). Office of Response and Restoration, Hazardous Materials Response Division, National Ocean Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, Washington 98115.

The International Tanker Owners Pollution Federation Limited (ITOPF) Technical Information Paper 1, Aerial Observation of Marine Oil Spills. Accessed 19 April 2013 from website www.ITOPF.com

The Open Water Oil Identification Job Aid (for aerial observation), version 2 updated July 2012. U.S. Department of Commerce, NOAA (National Oceanic and Atmospheric Administration Office of Response and Restoration, Emergency Response Decision, Seattle Washington.

Attachment O3-A: Shoreline Characteristics Field Sheet

Remember to mark features on map. If no map is available, make a sketch of the site and mark locations on sketch.

General information						
Date (dd/mm/yy)	Time start: Time end:		Team members:			
Survey by (tick one)	Foot		Vehicle		Air	
Tide height (tick one)	High		Medium		Low	
Wind direction (from);	Wind speed		Cloud cover (%)		Air temperature	

Location			
Sector:	Segment:	Start GPS (GDA94):	End GPS (GDA94):

Physical characteristics							
Shoreline geomorphic type (mark one dominant "D" and others present "O")							
Cliff		Reef / platform		Beach		Wetland	
Shoreline gradient (select one)							
Flat		Gentle slope		Steep slope		Cliff	
Shoreline substrate (mark one dominant "D" and others present "O")							
Bedrock		Boulder		Cobble		Pebble	
Gravel		Sand		Mud/silt		Shellgrit	
Concrete		Wood		Metal		Other	

Biological characteristics							
Vegetation (mark one dominant "D" and others present "O")							
Saltmarsh		Seagrass		Macroalgae		Freshwater	
Photographs		Photographs		Photographs		Photographs	

Fauna observations			
Group (e.g. shorebirds, reptiles, etc)	Species	Behaviours (nesting, roosting, feeding, juveniles present)	Photographs

Attachment O3-B: Oil on Shoreline Field Sheet

Remember to mark features on map. If no map is available, make a sketch of the site and mark locations on sketch.

General information							
Date (dd/mm/yy)	Time start: Time end:		Team members:				
Survey by (tick one)	Foot		Vehicle		Air		
Tide height (tick one)	High		Medium		Low		
Wind direction (from);	Wind speed		Cloud cover (%)		Air temperature		
Location							
Sector:	Segment:		Start GPS (GDA94):		End GPS (GDA94):		

Surface oil		
Length of oil band		
Start GPS (GDA94):	Start GPS (GDA94):	Length (m)
Width of oil band		
Start GPS (GDA94):	Start GPS (GDA94):	Width (m)
Thickness and type		
Percentage cover (%)	Thickness	Type

Subsurface oil (each location sampled)					
GPS (GDA94):	Min.depth (cm)	Max. depth (cm)	Substrate type	Oil type	Hydrocarbon field test[1]

Presence of oiled wildlife (note species type, approximate numbers and severity)

[1] Record as presence / absence if qualitative test, or concentration of TPH, if quantitative test available.

Attachment 4: Type II (scientific) monitoring

This Attachment provides an overview and description of the key features of each of the scientific monitoring programs identified in Section 2.2.2 Indicators for Scientific Monitoring:

- S1: Ecotoxicology
- S2: Hydrocarbons in fish and shellfish
- S3: Impact on fish diversity and abundance
- S4: Impact on intertidal habitat
- S5: Impact on sub-tidal habitat
- S6: Impact on coastal vegetation
- S7: Impact on shorebirds and seabirds
- S8: Impact on marine mammals
- S9: Impact on the ecological character of Ramsar sites

Rather than detailed procedures such as those provided for the Type I monitoring (Attachments 1-3), these Type II modules include links to standard and recognised methods and key organisations or personnel who could implement the specific monitoring program in the event of a Level II or Level III spill. These modules provide sufficient detail for a qualified and experienced marine scientist with expertise in the relevant field to immediately initiate and implement the relevant module when mobilised. Detailed design of long-term scientific monitoring programs may be refined in consultation with relevant stakeholders and regulatory agencies following the initial spill response.

The procedure for implementing Type II scientific monitoring is as follows:

1. The trajectory analysis from stage 1 will be used to identify environmental sensitivities likely to be at risk from the spill. Scientific teams will be mobilised to undertake post-spill – pre-impact assessments of these at risk sensitivities identifying key indicators of spill impact. These surveys will establish a benchmark against which impact and recovery can be measured.
2. If ANZECC water quality trigger values (TPH < 7 µg/L) are exceeded in the water associated with any environmental sensitivities, impact monitoring will be implemented. Impact monitoring (and relevant operational monitoring) will continue until impacts to relevant sensitivities have been captured as agreed by relevant stakeholders and regulatory authorities.
3. Recovery monitoring will be undertaken and continue until evaluation of recovery of relevant environmental sensitivities has been adequately evaluated, as agreed by relevant stakeholders and regulatory authorities.

S1 Ecotoxicology

Overview

Ecotoxicology is the study of the effects of chemicals on biota through a series of controlled laboratory trials. In this instance samples of the spilled hydrocarbon are collected either from the source (vessel, rig, gas plant for pipeline contents) or the environment (water column or sediment) and sent to a laboratory to assess the acute and chronic effects on marine organisms. The results will inform the initiation criteria for other monitoring programs and can be used in conjunction with results of other programs to evaluate the effects of the spilled hydrocarbon on environmental sensitivities. In particular, this information would be useful in the identification of potential effects of the spilled hydrocarbon as distinct from other environmental factors.

Objectives

To determine the toxic potential of the spilled hydrocarbon to marine biota. Specifically, to determine the 95% species protection concentration from a species sensitivity distribution.

Initiation criteria

Sampling is initiated in conjunction with O2 Water quality and hydrocarbon monitoring.

Termination criteria

As no chemical treatment is proposed for the diesel or condensate scenarios, this is a one-off test for either diesel or condensate that is conducted at the commencement of a Level II or Level III spill.

Baseline approach

Composition (and toxicology) of hydrocarbons from SGHE' Longtom activities change over time and tests conducted prior to a spill occurring will not necessarily reflect the characteristics of spilled condensate. Samples will be collected post spill for ecotoxicology assessments where practicable.

Sample design

Standard method: Ecotoxicology methods are well documented for water (e.g. US EPA 2002) and sediment (Simpson et al. 2005) and laboratories must have their methods approved as a part of the NATA accreditation process. Samples will be collected from the source where possible, or from the receiving environment (water column or sediment) if necessary.

Parameters: Local species will be selected for tests where appropriate. However, a suite of standard tests like those provided in Table 11 is likely to be appropriate for the EMBA as it covers both chronic and acute toxicity and vulnerable life stages. The exact suite of tests should be decided in conjunction with relevant experts and agencies. A species sensitivity distribution (SSD) needs to be calculated in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. This typically involves eight species from four taxonomic groups.

Table 11: Example toxicity tests

Species	Test
Microalgal (*Nitschia closterium*)	72 hour growth inhibition test
Macroalga (*Ecklonia radiate*)	72 hour germination success
Scallop (*Mimachlamys asperrima*)	48 hour larvae abnormality test
Sea urchin (*Heliocidaris tuberculata*)	1 hour egg fertilization test
	72 hour larvae development test
Crustacean (*Allorchestes compressa*)	96 hour acute survival test
Kingfish (*Seriola lalandi*)	96 hour imbalance test with larval marine fish

Data analysis: Species sensitivity distribution to calculate a 95% species protection concentration. These data are derived according to standard statistical procedures under NATA accredited methods.

Reporting

The appointed contractor is responsible for delivering the toxicology report to the Incident Controller, who is in turn responsible for disseminating the information. The report should include a detailed description of the method, the laboratory results and the Laboratory QA/QC data.

Competencies

Monitoring provider (Study Lead – 1 person)

- Bachelor's degree in environmental science from a recognised academic institution, with experience in ecotoxicology in the marine environment.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the collection of water and oil samples at sea.

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
School of BioSciences	The University of Melbourne Parkville VIC 3010 03 9035 7476
Australasian Marine Associates	242 Hawthorn Road Caulfield North, VIC 3161 0413033500

Laboratory

- NATA accreditation for ecotoxicology assessments for marine and estuarine environments.

Potential local operators include:

Organisation	Contact
Ecotox Services Australia Pty Ltd	Unit 27/2 Chaplin Drive Lane Cove, NSW 2066 02 9420 9481

QA/QC

- NATA accredited laboratories
- Peer review of method and tests. Potential peer reviewers include: Dr Graeme Batley (CSIRO); Dr Angela Capper (James Cook University)
- Internal audits against procedures.

S2 Hydrocarbons in fish and shellfish

Overview

This study is designed to assess the impact of spilled hydrocarbons on fish and fisheries, both from a human health risk (via consumption) and as an indicator of potential impacts to distribution and abundance of native fish (see S3 Fish diversity and abundance). The EMBA contains significant commercial and recreational fisheries and accumulation of hydrocarbons in the flesh of fish and shellfish is a well documented impact pathway of hydrocarbon spills (US EPA 2000, Danion et al. 2011). The results of this monitoring program will inform management of commercial and recreational fisheries during and post spill as well as provide another line of evidence in the assessment of the effects on fish populations (see S3).

Objectives

To measure the concentration of hydrocarbons in the flesh of fish and shellfish post-spill/pre-impact and post impact to determine the effect of a spill from SGHE Longtom activities.

To monitor recovery (return to baseline conditions) if concentrations of hydrocarbon in fish and shellfish are detected above background concentrations.

Initiation criteria

Post-spill pre-impact sample collection initiated when Study Lead has determined that trajectory estimation / modelling (O1) indicate that fish and fisheries may be impacted (open marine environment, coastal and inshore fish habitat and spawning areas).

Post-spill impact sample collection is initiated when Study Lead has determined that TPH concentrations in the water are > 7 µg/L (O2) in key fish habitats (as identified in the OSRA or in consultation with DEPI).

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

"sampling can cease when the concentrations of hydrocarbons in samples collected are statistically similar to those collected pre-spill or post-spill, pre-impact."

Baseline approach

There is little evidence of existing contamination in fish or shellfish from within the EMBA. Historical measures of contaminants in mussels deployed near outfalls along Ninety Mile Beach indicated very low levels of heavy metals and organochlorines (Lorini et al., Haynes et al. 1995, 1995), but hydrocarbons were not tested. Similarly, levels of heavy metals in fish, mussels and seagrass in the Gippsland Lakes were all considered "normal for unpolluted waters" with the exception of mercury, which was higher than expected (Glover et al. 1980). Hydrocarbon contamination of wild caught Australian fish and shellfish is considered a low risk (Food Standards Australia New Zealand 2005) and there is no reason to suggest that the concentrations of hydrocarbons in fish and shellfish in the EMBA would be above environmental or food safety guideline values. As such, it is proposed that post spill pre-impact samples be collected from commercial fisheries within the EMBA, but outside the spill, to establish a baseline.

Sample design

Standard method: The sample design is based on the recognised standard: Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (USEPA 2000), which has been used in a number of instances in Australia, including by the Victorian EPA (EPA Victoria 2007, 2009). It is consistent with the *Standard operating procedure for the collection of seafood samples for the analysis of taint* (Hook et al. 2016).

Sample locations: Sample locations are selected based on the trajectory analysis (O1: Surveillance and tracking) and focus on areas that are known as commercial and recreational fisheries and / or spawning areas as identified in the OSRA or in consultation with DEPI.

Target species: Will vary according to the location and extent of the spill. However, species should be selected based on popularity as a targeted recreational / commercial species and the likelihood of contaminant accumulation. Species should also reflect a range of habitats (e.g. pelagic and bottom dwelling). Where appropriate, preference should be given to sedentary species (e.g. mussels, dusky flathead) that will be resident in the zone over the time of the spill.

Sample size determination: Ideally sample size (number of individuals) would be based on a statistical analysis of the variance in individuals taken. However, as previous studies of contaminants in fish and shellfish from within or nearby the EMBA have resulted in most samples being below the detection limit (e.g. Glover et al. 1980, Fabris et al. 1999), statistical determination of sample sizes is problematic. The USEPA (2000) suggests that a minimum of three composite samples, comprising of 8 – 10 individuals, will provide a 90 percent chance of detecting an effect in most circumstances.

Frequency of sampling: In the absence of an adequate baseline, samples must be collected post-spill pre-impact. Samples should then be collected post impact and weekly for the period that O2: Water quality continues. In the event that statistical analyses indicate that post spill samples are significantly greater than pre-spill samples, sampling should continue on a weekly basis (or as agreed with relevant stakeholders and regulatory agencies).

Parameters: Samples should be taken from skinless fillets and liver tissue for fish, and the flesh of shellfish. Samples should be freeze dried, ground and homogenised.

Testing for TPH and PAH concentrations is to be undertaken by a NATA accredited laboratory using approved methods. Method used must have a limit of reporting (LOR) sufficient to detect concentrations of hydrocarbons considered to be of concern. The laboratory LOR must be above the adopted USEPA screening value for total PAHs of 0.0055 mg/kg as no ANZ Food Standards Maximum Residue Limit (MRL) for hydrocarbons in fish or shellfish exists.

Data analysis: Data is analysed with appropriate statistical tests to compare baseline (post-spill pre-impact) results with samples collected in waters where hydrocarbon concentrations are above background concentrations or ANZECC trigger value of 7 µg/L (whichever is the greater). The hypotheses for data analysis are therefore:

- H0= There is no significant difference in the concentrations of PAH and TPH in the flesh of fish and shellfish from baseline samples and impact samples.
- H1 = The oil spill had a significant effect on the concentrations of PAH and TPH in fish and shellfish.

The exact form of statistical tests will be dependent on the nature and distribution of the data. Justification for test selection must be provided in the method section of reports.

Reporting

The appointed contractor is responsible for delivering the following reports to the Incident Controller, who is in turn responsible for disseminating the information:

- Baseline (post-spill, pre-impact) report
- Survey reports from each sampling event
- Annual reports (if appropriate)
- Final consolidated report.

Each report should include a detailed description of the method, the laboratory results and the Laboratory QA/QC data. A clear statement of the impact of the spill on fish and fisheries must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- Bachelor's degree in biological science from a recognised academic institution, with expertise in marine fish biology. Experience in assessing fish and shellfish taint, statistical analysis and report writing.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the collection of fish and shellfish from marine and estuarine habitats.
- A Fisheries Research Permit is required from DELWP prior to the collection of any fish or shellfish. https://www.wildlife.vic.gov.au/wildlife-research-tourism-and-cinema/flora-and-fauna-research-permits

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
School of BioSciences	The University of Melbourne Parkville VIC 3010 03 9035 7476
Australasian Marine Associates	242 Hawthorn Road Caulfield North, VIC 3161 0413 033 500
Australian Marine Ecology	72 Heller Street Brunswick West VIC 3055 03 9376 2397

Laboratory

- NATA accredited for the analysis of hydrocarbons in fish and shellfish.

Facilities with NATA accreditation for analysis of hydrocarbons in food include:

Organisation	Contact
National Measurement Institute	1/153 Bertie Street, Port Melbourne, VIC 3207 1800 020 076
Advanced Analytical Australia	11 Julius Avenue, North Ryde, 2113 02 9888 9077

QA/QC

- Scientific peer review of detailed methods and reporting. Potential peer reviewers include: Dr Gregory Jenkins (Melbourne University); Dr Kathryn Hassell (Melbourne University); Dr Jackie Myers (Victorian Marine Science Consortium, Queenscliff).
- Internal audits against procedures.

S3: Impact on fish diversity and abundance

Overview

This study is designed to assess the impact of spilled hydrocarbons on the diversity and abundance of native fish. The EMBA contains a diversity and abundance of native marine and estuarine fish species as well as supporting several important fisheries. Data collected from S1 Ecotoxicology and S2 Hydrocarbons in fish and shellfish is used, together with information on the species and abundance of fish to evaluate impacts to native fish populations.

Objectives

To determine the extent and magnitude of impacts of spilled hydrocarbons on the diversity and abundance of native fish communities.

To monitor recovery (return to baseline conditions) of native fish diversity and abundance.

Initiation criteria

Fish surveys are initiated when any of the following criteria are met:

1. Confirmed reports of fish kills associated with the spill;
2. Analysis of hydrocarbons in fish and shellfish (S2) detects concentrations of PAH and / or TPH in fish flesh above pre-spill levels; or
3. Concentrations of hydrocarbons in water or sediment are above the EC50 as determined by ecotoxicology tests of spilled hydrocarbon (S1 Ecotoxicology).

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

“sampling can cease if there is no detectable impact on fish populations; or in the event of an impact, fish populations have returned to baseline conditions.”

Baseline approach

Given that the sampling of fish populations is triggered by the results of other scientific monitoring (S1 and S2) it is not likely that post-spill, pre-impact monitoring will be feasible. In addition, the variability in fish assemblages will require more than a single sampling event to adequately capture baseline conditions. Therefore, there are two options, with respect to baseline data for fish diversity and abundance:

1. Historical data: Victorian Fisheries Authority (VFA) maintains a database of weight, value and locations of commercial fish catch data for all major commercial species, reported annually, with data at a finer scale available upon request. The database reports fish catch for all relevant fish and shellfish species from 1978/9 to current (Victorian Fisheries Authority 20244). This data, which spans many years, would provide a solid baseline against which any changes in commercial species populations could be assessed. Alternatively for further information on Australian Fisheries Management Authority (AFMA) catch data for Commonwealth fisheries see https://www.afma.gov.au/commercial-fishers/resources/commonwealth-fisheries-annual-catch-and-effort-data#

There are a number of previous studies on fish within the EMBA including an assessment of fish populations (Last et al. 2011); larval fish from bays and the open coast (Kent et al. 2013); and a meta-analysis of fish populations (Punt et al. 2018). These may help baseline conditions in the EMBA with respect to non-commercial species.

Parks Victoria undertakes annual monitoring of fish communities in marine protected areas https://www.parks.vic.gov.au/get-into-nature/conservation-and-science/science-and-research/marine-programs . A study of the size and abundance of biota indicated few differences within and outside marine parks along the Victorian Coast, suggesting that data collected by Parks Victoria may provide an adequate baseline for similar habitats outside park areas. Alternatively see https://vnpa.org.au/programs/great-victorian-fish-count/.

2. Control sites: Depending on the location and extent of the spill it may be possible to locate appropriate control sites within the EMBA, but outside the area influenced by the spill. Sites would need to have the same habitat characteristics.

Sample design

Standard method: Sample design and methods will be highly dependent on the location of the spill and the habitat type impacted. Pelagic fish can be sampled by trawl and / or by Baited Remote Underwater Video Station (BRUVS; Power and Boxshall 2007). Fish in seagrass habitats (e.g. in the Gippsland Lakes) can be sampled using beach seine netting (Warry and Hindell 2012). Fish in intertidal or sub-tidal reefs may be surveyed using diver visual surveys using towed or untowed transects (Power and Boxshall 2007). Survey techniques will be matched to the habitat type and sea conditions, but be based on known techniques such as those listed above.

Sample locations: Sample locations are selected based on the trajectory analysis (O1: Surveillance and tracking) and focus on areas that are known as critical habitat, spawning or nursery areas as identified in the OSRA or in consultation with DEPI.

Sample size determination: Sample size will be determined using appropriate statistical tools (e.g. power analysis). Previous statistical analysis to determine appropriate sample sizes in Victorian marine protected areas (Keough et al. 2007, Power and Boxshall 2007) should be used as an initial guide.

Frequency of sampling: Current monitoring of the Victorian marine environment undertaken by Parks Victoria occurs annually. However, this may prove insufficient to detect responses to an oil spill and not adequately capture seasonal variations in fish assemblages. Frequency of sampling will be determined based on the habitat types and the lifecycles of key species, and reviewed after the first 12 months.

Parameters: At a minimum abundance of each species will be recorded during each survey. In the event of the use of netting (trawl or seine), consideration could also be given to measuring the weight and length of target species. Estimations of diversity (indices, species richness, biodisparity) are to be calculated from the field data.

Data analysis: Data is analysed with appropriate statistical tests to compare baseline (post-spill pre-impact or as previously measured by Parks Victoria or other sources) results with samples collected in areas expected to be impacted by the spill. The hypotheses for data analysis are therefore:

- H0= There is no significant difference in the abundance and diversity of native fish from baseline conditions and impact samples.
- H1 = The oil spill had a significant effect on the abundance and / or diversity of native fish populations.

The exact form of statistical tests will be dependent on the nature and distribution of the data.

Justification for test selection must be provided in the method section of reports.

Reporting

The appointed contractor is responsible for delivering the following reports to the Incident Controller, who is in turn responsible for disseminating the information:

- Baseline report describing the methods to be used and justifying the selection of baseline data
- Survey reports from each sampling event
- Annual reports (if appropriate)
- Final consolidated report.

Each report should include a detailed description of the method, the field results and QA/QC data. A clear statement of the impact of the spill on fish populations must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- Bachelor's degree in biological science from a recognised academic institution, with expertise in marine fish biology. Experience in assessing fish and shellfish taint, statistical analysis and report writing.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the collection of fish and shellfish from marine and estuarine habitats.
- A Fisheries Research Permit is required from DEECA prior to the collection of any fish or shellfish. https://www.wildlife.vic.gov.au/wildlife-research-tourism-and-cinema/flora-and-fauna-research-permits

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
School of BioSciences	The University of Melbourne Parkville Victoria 3010 03 9035 7476
Australasian Marine Associates	242 Hawthorn Road Caulfield North, VIC 3161 0413 033 500
Australian Marine Ecology	72 Heller Street Brunswick West VIC 3055 03 9376 2397

QA/QC

- Scientific peer review of detailed methods and reporting. Potential peer reviewers include: Dr Gregory Jenkins (Melbourne University); Dr Kathryn Hassell (Melbourne University); Dr Jackie Myers (Victorian Marine Science Consortium, Queenscliff).
- Internal audits against procedures.

S4: Impact on intertidal habitat

Overview

This study is designed to assess the impact of spilled hydrocarbons on the flora and fauna of intertidal habitats. This includes intertidal rocky reefs, sands and mudflats, seagrass communities, and associated algae, invertebrates and fish. Note that costal vegetation (S6) and shorebirds (S7) that use intertidal habitat are covered by their own specific monitoring modules and so are not considered here.

Objectives

To determine the extent and magnitude of impacts of spilled hydrocarbons on intertidal habitats and associated biotic communities.

To monitor recovery of intertidal habitats and associated biotic communities post spill.

Initiation criteria

Post-spill, pre-impact surveys are initiated when trajectory estimation / modelling (O1) indicate that intertidal habitats may be impacted.

Post-spill impact surveys are initiated when TPH concentrations in the water are > 7 μg/L (O2) in key intertidal habitats (as identified in the OSRA or in consultation with DEECA).

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

"sampling can cease if there is no detectable impact on intertidal habitats; or in the event of an impact, intertidal habitats have returned to baseline conditions."

Baseline approach

There are three options, with respect to baseline data for intertidal habitat monitoring:

1. Historical data: There is a good dataset of intertidal rocky reef habitat in Victorian coasts from Parks Victoria, with five surveys in the last decade (Edmunds et al. 2011). While none of these is located in the EMBA, they could be useful in informing on the natural variability with respect to species cover and condition and to determine sample sizes.

   There are annual survey data of seagrass condition in intertidal habitats of the Gippsland Lakes from 2008 to 2012 (Warry and Hindell 2012). These would form an adequate baseline for assessing change within the Gippsland Lakes and as an indication of natural variability for sites located elsewhere in the EMBA.

2. Control sites: Depending on the location and extent of the spill it may be possible to locate appropriate control sites within the EMBA, but outside the area influenced by the spill. Sites would need to have the same habitat characteristics.

3. Post-spill, pre-impact surveys: Oil spill trajectory analysis will predict the likely extent and distribution of the spill and afford sufficient time for post-spill, pre-impact surveys at sites predicted to be in the pathway of the spill.

It is most likely that a combination of all three approaches will be used to establish a baseline for this monitoring program. Historical data could inform on the likely natural variability, pre-spill post impact could provide a static baseline and control sites used to deduce the effect of the spilled hydrocarbon as distinct from other ambient environmental factors.

Sample design

Standard method: Sample design and methods will be highly dependent on the location of the spill and the habitat type impacted. For intertidal rocky reefs, the standard method developed by Parks Victoria for Victorian marine environments (Hart et al. 2005) is recommended. This method was designed by a team of experts and with considerable rigour with respect to experimental design. Surveys occur at a single reef during a single low tide and target the predominant substratum type. Five fixed transects, each running from high to low shore, are positioned at equal distance across the intertidal area to be surveyed, which is 30-100 m in length. Surveys of biota occur in quadrats at sample locations along each transect and are surveyed for: (1) the density of non-sessile invertebrates; and (2) the percentage cover of macroalgae and aggregated sessile invertebrates.

Seagrass communities in the EMBA (Gippsland Lakes) were surveyed annually using underwater video (Warry and Hindell 2012). This method is been tested elsewhere and proven efficient at detecting changes in condition over time (Haag et al. 2008, Schultz et al. 2014). Consideration should be given to the condition scores developed by Warry and Hindell (2012) for consistency with existing datasets.

Sample locations: Key intertidal habitats in the EMBA, as identified in the OSRA are:

- Intertidal rocky shores: Iron Prince, Bastion Point, Quarry Beach, Shipwreck Creek, Seal Cove, Little Rame Head, Sandpatch Point, Petrel Point, Thurra River, Clinton Rocks, Cloke Rock, Tamboon Inlet, Shelley Beach.
- Intertidal aquatic vegetation communities (e.g. seagrass and kelp communities): Mallacoota and Mallacoota Inlet, Tamboon Inlet, Cann River Estuary (continuously open), Sydenham Inlet, Snowy River Estuary, Yeerung River Estuary (intermittently open), Lake Tyers estuary (intermittently open) and Gippsland Lakes (Lakes Victoria and King.

Sample locations will be selected based on the trajectory analysis (O1: Surveillance and tracking) from the list of locations above or in consultation with DEECA.

Sample size determination: Sample size will be determined using appropriate statistical tools (e.g. power analysis). Previous statistical analysis to determine appropriate sample sizes in Victorian marine protected areas (Keough et al. 2007, Power and Boxshall 2007) should be used as an initial guide, noting that the test areas were outside the EMBA.

Frequency of sampling: Current monitoring of the Victorian marine environment undertaken by Parks Victoria occurs annually as does seagrass monitoring in the Gippsland Lakes. However, this may prove insufficient to detect responses to an oil spill and may not adequately capture seasonal variations in habitat conditions. Frequency of sampling will be determined based on the expected response and recovery times of key habitats and species and be reviewed after 12 months.

Data analysis: Data is analysed with appropriate statistical tests to compare baseline (post-spill pre-impact or as previously measured by Parks Victoria or other sources) results with samples collected in areas expected to be impacted by the spill. The hypotheses for data analysis are therefore:

- H0= There is no significant change in the composition, abundance and condition of intertidal biotic assemblages as a result of the spilled hydrocarbon.
- H1 = The hydrocarbon spill had a significant effect on the abundance, diversity and / or condition of intertidal biotic assemblages

The exact form of statistical tests will be dependent on the nature and distribution of the data. Justification for test selection must be provided in the method section of reports.

Reporting

The appointed contractor is responsible for delivering the following reports to the Incident Controller, who is in turn responsible for disseminating the information:

- Baseline report describing the methods to be used and justifying the selection of baseline data
- Survey reports from each sampling event
- Annual reports (if appropriate)
- Final consolidated report.

Each report should include a detailed description of the method, the field results and QA/QC data. A clear statement of the impact of the spill on intertidal communities must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- Bachelor's degree in biological science from a recognised academic institution, with expertise in marine fish biology. Experience in assessing abundance / diversity of biotic assemblages, statistical analysis and report writing.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the survey and collection of biotic assemblages from intertidal habitats.
- A Fisheries Research Permit is required from DEECA prior to the collection of any fish or shellfish. https://www.wildlife.vic.gov.au/wildlife-research-tourism-and-cinema/flora-and-fauna-research-permits

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
Centre for Aquatic Pollution Identification and Management	School of Biosciences, The University of Melbourne Parkville Victoria 3010 03 9035 7476
Australasian Marine Associates	242 Hawthorn Road Caulfield North, VIC 3161 0413 033 500
Australian Marine Ecology	72 Heller Street Brunswick West VIC 3055 03 9376 2397

QA/QC

- Scientific peer review of detailed methods and reporting. Potential peer reviewers include: Dr Michael Keough (Melbourne University); Dr Fiona Warry (DEECA); Dr Jeremy Hindell (Arthur Rylah Institute).
- Internal audits against procedures.

S5: Impact on sub-tidal habitat

Overview

This study is designed to assess the impact of spilled hydrocarbons on the flora and fauna of sub-tidal habitats. Although much of the sub-tidal area within the EMBA is characterised by sandy substrates, there are significant rocky outcrops that support diverse reef communities. A prominent feature of these shallow reefs is kelps, including string kelp (*Macrocystis pyrifera*) and bull kelp (*Durvillaea potatorum*). These seaweeds provide important habitats for a range of invertebrate and fish biota (Williams et al. 2007). Impact pathways associated with condensate and diesels spills are related to both toxicity, reduction in underwater light and smothering. Effects are highly dependent on communities, species and life history stages. This monitoring program assesses changes in community composition (diversity) and abundance over time and so integrates effects on different species and life history stages.

Objectives

To determine the extent and magnitude of impacts of spilled hydrocarbons on sub-tidal habitats and associated biotic communities.

To monitor recovery of sub-tidal habitats and associated biotic communities post spill.

Initiation criteria

Post-spill, pre-impact surveys are initiated when trajectory estimation / modelling (O1) indicate that sub-tidal habitats may be impacted.

Post-spill impact surveys are initiated when TPH concentrations in the water are > 7 μg/L (O2) in key sub-tidal habitats (as identified in the OSRA or in consultation with DEECA).

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

"sampling can cease if there is no detectable impact on sub-tidal habitats; or in the event of an impact, sub-tidal habitats have returned to baseline conditions."

Baseline approach

There are three options, with respect to baseline data for sub-tidal habitat monitoring:

1. Historical data: There is a good dataset of sub-tidal rocky reef habitat in Victorian coasts from Parks Victoria, with five surveys in the last decade (Edmunds et al. 2011). This includes sites within the EMBA at Point Hicks, Cape Howe and Beware Reef (Williams et al. 2007, Edmunds et al. 2011, 2014). These would form a solid baseline against which change could be assessed at these locations and inform on likely natural variability for other locations within the EMBA.

2. Control sites: Depending on the location and extent of the spill it may be possible to locate appropriate control sites within the EMBA, but outside the area influenced by the spill. Sites would need to have the same habitat and physical characteristics.

3. Post-spill, pre-impact surveys: Oil spill trajectory analysis will predict the likely extent and distribution of the spill and afford sufficient time for post-spill, pre-impact surveys at sites predicted to be in the pathway of the spill.

It is most likely that a combination of all three approaches will be used to establish a baseline for this monitoring program. Historical data could inform on the likely natural variability, post-spill pre-impact surveys could provide a static baseline and control sites used to deduce the effect of the spilled hydrocarbon as distinct from other ambient environmental factors.

Sample design

Standard method: A standard method for sub-tidal reefs has been developed by Parks Victoria for Victorian marine environments (Power and Boxshall 2007, Williams et al. 2007) and is recommended. This method was designed by a team of experts and with considerable rigour with respect to experimental design. For each transect line, four different census methods are used, involving census of the:

- Mobile Fishes and Cephalopods: The densities of mobile large fishes and cephalopods are estimated visually by a diver within each of four contiguous 10 m x 50 m sections located along the transect line. The diver does this by swimming up one side of each 50 m transect section and then back along the other. The diver records the number and estimated size class of fish.
- Invertebrates and Cryptic Fishes: Cryptic fishes and large non-sessile invertebrates (e.g. large molluscs, echinoderms and crustaceans) are counted within each of four contiguous 1 m x 50 m sections located along the transect line. The maximum length of abalone and the carapace length and sex of rock lobsters are also measured whenever possible.
- Macroalgae: The area covered by macroalgal species is quantified by placing a 0.25 m^2 quadrat at 10 m intervals along the transect line and determining the percent cover of the all identifiable plant and macroalgae within the quadrat. These yield twenty 25 m^2 quadrats along each 200 metre transect line at each site.

Sample locations: Key sub-tidal habitats in the EMBA, as identified in the OSRA are: Cape Howe, Conference Point, Cape Howe Marine National Park, Gabo Island, Bastion Point, Quarry Beach, Little Rame Head, Long Reef, Wingan Point, The Skerries, Rame Head, Petrel Point, Thurra River, Point Hicks Marine National Park, Pearl Point, Yeerung River Estuary, Cape Conran, Beware Reef, Point Ricardo and Ricardo Beach.

Sample locations will be selected based on the trajectory analysis (O1: Surveillance and tracking) from the list of locations above or in consultation with DEECA.

Sample size determination: Sample size will be determined using appropriate statistical tools (e.g. power analysis). Previous statistical analysis to determine appropriate sample sizes in Victorian marine protected areas (Keough et al. 2007, Power and Boxshall 2007) should be used as an initial guide, noting that some of the test areas were outside the EMBA.

Frequency of sampling: Current monitoring of the Victorian marine environment undertaken by Parks Victoria occurs annually. However, this may prove insufficient to detect responses to an oil spill and not adequately capture seasonal variations in habitat conditions. Frequency of sampling will be determined based on the expected response and recovery times of key habitats and species and be reviewed after 12 months.

Data analysis: Data is analysed with appropriate statistical tests to compare baseline (post-spill pre-impact or as previously measured by Parks Victoria or other sources) results with samples collected in areas expected to be impacted by the spill. The hypotheses for data analysis are therefore:

- H0= There is no significant change in the composition and abundance of sub-tidal biotic assemblages as a result of the spilled hydrocarbon.
- H1 = The hydrocarbon spill had a significant effect on the abundance and / or diversity of sub-

tidal biotic assemblages

The exact form of statistical tests will be dependent on the nature and distribution of the data. Justification for test selection must be provided in the method section of reports.

Reporting

The appointed contractor is responsible for delivering the following reports to the Incident Controller, who is in turn responsible for disseminating the information:

- Baseline report describing the methods to be used and justifying the selection of baseline data
- Survey reports from each sampling event
- Annual reports (if appropriate)
- Final consolidated report.

Each report should include a detailed description of the method, the field results and QA/QC data. A clear statement of the impact of the spill on sub-tidal habitat and biota must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- Bachelor's degree in biological science from a recognised academic institution, with expertise in marine fish biology. Experience in assessing abundance / diversity of biotic assemblages, statistical analysis and report writing.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the survey and collection of biotic assemblages sub-tidal habitats.
- A Fisheries Research Permit is required from DEECA prior to the collection of any fish or shellfish. https://www.wildlife.vic.gov.au/wildlife-research-tourism-and-cinema/flora-and-fauna-research-permits

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
School of BioSciences	The University of Melbourne Parkville Victoria 3010 03 9035 7476
Australasian Marine Associates	242 Hawthorn Road Caulfield North, VIC 3161 0413 033 500
Australian Marine Ecology	72 Heller Street Brunswick West VIC 3055 03 9376 2397

QA/QC

- Scientific peer review of detailed methods and reporting. Potential peer reviewers include: Dr Michael Keough (Melbourne University); Dr Stephen Swearer (Melbourne University); Dr Jan Carey (Melbourne University); Dr Jan Barton (Deakin University).
- Internal audits against procedures.

S6: Impact on coastal vegetation

Overview

The most common form of coastal vegetation in the EMBA is coastal saltmarsh. Saltmarshes, as defined by Boon et al. (2011) comprise vegetation communities within the intertidal zone that are dominated by halophytic plants. Coastal vegetation could be impacted by oil directly through smothering and toxic effects, or indirectly through shoreline clean-up responses (Lin and Mendelssohn 2012). This study is designed to assess the impact of spilled hydrocarbons on both community composition and condition of coastal vegetation communities in the short – term, and if necessary, extent in the longer-term.

Objectives

To determine the extent and magnitude of impacts of spilled hydrocarbons on the condition, and community composition coastal vegetation communities.

To determine if the hydrocarbon spill resulted in a reduction in coastal vegetation extent.

To monitor recovery of coastal vegetation communities post spill.

Initiation criteria

Post-spill, pre-impact surveys are initiated when trajectory estimation / modelling (O1) indicate that saltmarsh communities may be impacted.

Post-spill impact surveys are initiated when TPH concentrations in the water are > 7 µg/L (O2) in key saltmarsh communities (as identified in the OSRA, in the recent mapping by Boon et al. (2011) or in consultation with DEECA).

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

“sampling can cease if there is no detectable impact on coastal vegetation communities; or in the event of an impact, coastal vegetation communities have returned to baseline conditions.”

Baseline approach

The extent, composition and condition of coastal vegetation has been completed for the entire Victorian coastline, including the EMBA (Boon 2011). Other vegetation is mapped in terms of ecological vegetation classes (DEECA) with more detailed assessments of significant vegetation communities in a number of locations, such as the Gippsland Lakes and Corner Inlet Ramsar sites (BMT WBM 2011a and 2011b, Hale 2023).

This data forms a solid baseline against which change in composition and extent could be measured. It also provides a resource for determining relevant control sites that could be used for reactive baseline studies in the event of a spill.

Sample design

Standard method: Boon et al. (2011) recently developed a condition assessment method specific to Victorian coastal saltmarsh, which may provide a broad framework for the basis of the detailed design. However, finer scale resolution, using absolute measures (rather than scores) will be required to detect changes over time, and a method based on that used by Hale (Hale 2011) for saltmarshes in Port Phillip Bay may provide a more rigorous approach. The method uses quadrats to assess percentage cover of each species and a condition score for dominant species.

In the event that the hydrocarbon spill results in a significant decline in the condition of coastal vegetation communities, a longer-term program, based on remote sensing will be employed to assess changes in vegetation community extent. This should replicate the mapping method employed by Boon et al. (2011) which included ground truthing surveys of GIS based mapping.

Sample locations: Key saltmarsh communities in the EMBA, as identified in the OSRA are located in the following areas: Mallacoota Entrance to Lake Barracoota, Wingan Inlet, Cann River Estuary, Tamboon Inlet, Sydenham Inlet (Bemm River Estuary and Mud Lake), Dock Inlet, Snowy River Estuary and the Gippsland Lakes.

Sample locations will be selected based on the trajectory analysis (O1: Surveillance and tracking) from the list of locations above or in consultation with DEECA.

Sample size determination: Sample size will be determined using appropriate statistical tools (e.g. power analysis). Previous statistical analysis to determine appropriate sample sizes in Victorian saltmarsh communities indicated a high degree of variability and therefore a low probability of detecting small changes (Hale 2011). Consideration will be given in sample design phase to setting realistic expectation of the magnitude of change that can be detected.

Frequency of sampling: Similar monitoring programs for saltmarsh have occurred on an annual basis (Saintilan 2009, Hale 2011). More frequent sampling may be required, particularly at the beginning of the program, commensurate with the extent and severity of the spill and affected area. Sample frequency should be reviewed every 12 months.

Data analysis: Data is analysed with appropriate statistical tests to compare baseline (post-spill pre-impact or control sites) results with samples collected in areas expected to be impacted by the spill. The hypotheses for data analysis are therefore:

- H0= There is no significant change in the composition and condition of coastal vegetation communities as a result of the spilled hydrocarbon.
- H1 = The hydrocarbon spill had a significant effect on the composition and / or condition of coastal vegetation communities.

The exact form of statistical tests will be dependent on the nature and distribution of the data. Justification for test selection must be provided in the method section of reports.

Reporting

The appointed contractor is responsible for delivering the following reports to the Incident Controller, who is in turn responsible for disseminating the information:

- Baseline report describing the methods to be used and justifying the selection of baseline data
- Survey reports from each sampling event
- Annual reports (if appropriate)
- Final consolidated report.

Each report should include a detailed description of the method, the field results and QA/QC data. A clear statement of the impact of the spill on saltmarsh communities must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- Bachelor's degree in biological science from a recognised academic institution, with expertise in coastal vegetation ecology. Experience in assessing coastal vegetation, statistical analysis and report writing.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the survey of coastal vegetation communities.

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
Biosis	38 Bertie Street Port Melbourne VIC 3207 03 8686 4800
Ecology Australia	2/1 Latitude Boulevard Thomastown VIC 3074 03 9489 4191

QA/QC

- Scientific peer review of detailed methods and reporting. Potential peer reviewers include: Dr Paul Boon (Dodo Environmental); Dr Neil Saintilan (Macquarie University)
- Internal audits against procedures.

S7: Impact on shorebirds and seabirds

Overview

This study is designed to assess the impact of spilled hydrocarbons on the roosting, feeding and breeding success of shorebirds and seabirds. The EMBA contains a number of important bird habitats including: migratory shorebird habitats in the Gippsland Lakes (BMT WBM 2011a), Hooded Plover (*Thinornis rubricollis*) nesting on the Ninety Mile Beach and beaches in the east (Weston et al. 2009); Little Tern (*Sternula albifrons*) and Fairy Tern (*Sternula nereis*) nesting at Lake Tyers and Mallacoota Inlet and seabird foraging in the open waters (Dutson et al. 2009). In addition, little penguin (*Eudyptula minor*) utilises habitat along the shoreline of the EMBA, but the greatest concentration is at Gabo Island, which is home to a large resident colony that has been estimated at 35,000 (Dann and Norman 2006). There are smaller breeding colonies located at the Skerries and Tullaberga Island. Impact pathways are via digestion, direct oiling and disturbance of nests and foraging areas during shoreline clean-up. This monitoring program will need to be tailored to the species present, their behaviour and conditions at the time of the spill.

Objectives

To determine the extent and magnitude of impacts of spilled hydrocarbons on shorebirds and seabirds.

To monitor recovery of shorebirds and seabirds impacted by hydrocarbons.

Initiation criteria

Post-spill, pre-impact surveys are initiated when trajectory estimation / modelling (O1) indicate that important seabird and shorebird habitat may be impacted, or as indicated by shoreline assessment monitoring (O3).

Post-spill impact surveys are initiated when any of the following occur:

- Reports of direct oiling of shorebirds or seabirds;
- Hydrocarbons reach the shore in known nesting locations for the beach nesting species;
- Clean-up operations occur on shores.

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

"sampling can cease if there is no detectable impact on seabirds or shorebirds; or in the event of an impact, bird populations and behaviour have returned to baseline conditions."

Baseline approach

There are a number of relevant studies and data sources for establishing a baseline for shorebirds:

- Shorebirds 2020 conducts annual, seasonal monitoring of shorebirds at the Gippsland Lakes, Ninety-mile Beach, Marlo and Mallacoota (BirdLife Australia);
- Birdlife East Gippsland conducts regular surveys of birds, including nesting studies in the Gippsland Lakes region (Healey 2012, 2013);
- Atlas of Living Australia contains records from hundreds of amateur and professional bird watchers in Australia;
- Birdlife Australia has conducted bi-annual counts of Hooded Plover along the Ninety-Mile Beach from 2006 to present. This data is analysed to determine population trends and threats to inform management (Weston 2003, Weston et al. 2009); and
- Fairy Tern and Little Tern nesting and breeding success is conducted annually by DEECA.

The available data covers the most significant and sensitive species and behaviours, and is extensive in both spatial and temporal dimensions. This would provide a good baseline against which change in abundance, diversity and nest success could be assessed and would also inform the selection of monitoring sites.

In addition, if trajectory estimations (O1) indicate that the hydrocarbon spill is likely to reach the shoreline, post-spill, pre-impact surveys of nesting and foraging birds will be undertaken. This will inform both on baseline conditions, and on the sample design of impact and recovery monitoring, with respect to species, locations and behaviours.

Sample design- Standard method: The detailed design of shorebird and seabird monitoring will be highly dependent on the location of the spill and the species potentially affected. Beach nesting species are resident for the breeding season, which for Hooded Plover can be protracted (August to March), with a high site fidelity, that is they return to the same sites to breed each year (Weston 2003, Weston et al. 2009). Monitoring for these species, should follow existing monitoring protocols developed by BirdLife Australia: A Practical Guide to Managing Beach-Nesting Birds in Australia (Maguire 2008).

Monitoring the effects of hydrocarbon on more mobile species such as foraging seabirds and shorebirds is more difficult. These birds may or may not occur in the area at the time of the spill, are highly variable in terms of abundance and community composition in any given year, and are affected by factors outside the EMBA (e.g. in breeding grounds in the northern hemisphere). A purpose built monitoring program, based on existing protocols, will be developed by ornithological experts in the event of a spill. This would involve assessments of direct effects (oiling, disturbance) as well as effects from disruption to the food chain).

Sample locations: Nesting sites for beach-nesting species are well documented and contained in the OSRA. Significant shorebird sites are located at the Gippsland Lakes, Ninety-mile Beach, Marlo and Mallacoota (Clemens et al. 2009). Much of the oceanic waters of the EMBA are considered significant foraging areas for seabirds (Dutson et al. 2009).

Sample locations will be selected based on the trajectory analysis (O1: Surveillance and tracking) from the list of locations above or in consultation with DEECA.

Sample size determination: Birds in affected areas could be measured via a census, rather than a sample, thus negating the need for sample size determination.

Frequency of sampling: Similar monitoring programs for beach-nesting birds have occurred biennially (Mead et al. 2012) and shorebirds are generally monitored through annual counts (Clemens et al. 2009). However, more frequent sampling will be required in the event of a spill reaching significant bird habitat areas. Frequency of sampling will have to balance the need for data with the level of disturbance caused by monitoring techniques. It is likely that survey frequency will be more intensive at the beginning of the program to capture short term impacts, then be reduced to monitor longer term trends and recovery. Sample frequency should be reviewed every 12 months.

Data analysis: Data is analysed with appropriate statistical tests to compare baseline (post-spill pre-impact or control sites) results with samples collected in areas expected to be impacted by the spill. The exact form of statistical tests will be dependent on the nature and distribution of the data. Justification for test selection must be provided in the method section of reports.

<u>Reporting</u>

The appointed contractor is responsible for delivering the following reports to the Incident Controller, who is in turn responsible for disseminating the information:

- Baseline report describing the methods to be used and justifying the selection of baseline data
- Survey reports from each sampling event
- Annual reports (if appropriate)
- Final consolidated report.

Each report should include a detailed description of the method, the field results and QA/QC data. A clear statement of the impact of the spill on shorebirds and seabirds must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- An experienced ornithologist with a minimum of a Bachelor's degree in biological science from a recognised academic institution. Experience in assessing seabirds, shorebirds (including penguins), statistical analysis and report writing.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the survey of sea and shorebirds as well as nesting birds.

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
Biosis	38 Bertie Street Port Melbourne VIC 3207 03 8646 4800
Nature Advisory	Suite 5, 61-63 Camberwell Road Hawthorn East VIC 3124 03 9815 2111

QA/QC

- Scientific peer review of detailed methods and reporting. Potential peer reviewers include: Richard Loyn (formerly Arthur Rylah Institute, now independent); Birdlife Australia (Rob Clemens; Grainne Maguire); Roger Jaensch; Dr Julian Reid (Australian National University)
- Internal audits against procedures.

S8: Impact on marine mammals

Overview

This monitoring program covers cetaceans and seals within the EMBA. There are isolated records of Australian fur seals (*Arctocephalus pusillus doriferus*) along the shoreline of the EMBA, but breeding colonies occur at the Skerries (14,000) and Rag Island (1500), with a haul out site for smaller numbers at Gabo Island (Kirkwood et al. 2010). There are records for a number of whale species within the EMBA including southern right whale (*Eubalaena australis*), pygmy right whale (*Caperea marginata*) and humpback whale (*Megaptera novaeangliae*). Several dolphin species including the first described in 2011 Burrunan dolphin (*Tursiops australis*). Impact pathways for seals from hydrocarbon spills from direct oiling and ingestion, with indirect effects from altered food webs (Reed et al. 1989). This study is designed to assess the impact of spilled hydrocarbons on populations of marine mammals, including abundance, migration and breeding success.

Objectives

To determine the extent and magnitude of impacts of spilled hydrocarbons on marine mammals.

To monitor recovery of marine mammals impacted by hydrocarbons.

Initiation criteria

Post-spill, pre-impact surveys are initiated when trajectory estimation / modelling (O1) indicate that the seal breeding and haul out sites may be impacted, or as indicated by shoreline assessment monitoring (O3).

Post-spill impact surveys are initiated when any of the following occur:

- Reports of direct oiling of marine mammals;
- Hydrocarbons reach the shore in known seal breeding and haul-out sites;
- Concentrations of TPH in the water column are > 7 µg/L within significant proportions of feeding areas.

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

"sampling can cease if there is no detectable impact on marine mammals; or in the event of an impact, populations and behaviour have returned to baseline conditions."

Baseline approach

Population surveys of breeding colonies of seals and haul out sites on the Victorian coast, including colonies in the EMBA were conducted in 2007 and population estimates compared with previous studies (Littnan and Mitchell 2002, Kirkwood et al. 2009, 2010). These surveys (and potential future follow-up surveys) and analysis of data has occurred in the study region and forms a baseline against which change can be assessed. The situation will require review periodically and a post-spill survey using control and impact sites could be considered. Potentially, breeding colonies at Rag Island and The Skerries may be able to be used as comparable sites if one is outside the impact of a spill.

Cetacean data is held for several species by the Marine Mammal Foundation. Populations of Burrunan dolphins (in Port Phillip Bay and the Gippsland Lakes) are closely monitored and adequate data to form a baseline for this species has been collected (Charlton-Robb et al. 2011, 2014).

In addition, a post-spill, pre-impact survey could be used to augment historical data and provide a short-term baseline. If trajectory estimations (O1) indicate that the hydrocarbon spill is likely to reach significant marine mammal habitats, baseline surveys will be undertaken.

Sample design

Standard method: A combination of survey methods will be required for different groups of marine mammals. It is likely that short term impacts to seals will require ground surveys and the methods employed by Kirkwood et al. (2010) should be considered for consistency with historical data. Similarly, the methods of Charlton-Robb et al. (2011, 2014) for Burrunan dolphins should be considered for impacts to dolphin species.

Sample locations: Surveys for seals will be focused on the three significant locations in the EMBA (Gabo Island, the Skerries and Rag Island). Surveys for cetaceans may need to cover a larger area and be mindful of seasonal distributions and migratory routes. The exact locations of sampling sites will be dependent on the timing and location of the spill. Sample locations will be selected based on the trajectory analysis (O1: Surveillance and tracking) from the three locations or in consultation with DEECA.

Sample size determination: Sample size will be determined using appropriate statistical tools (e.g. power analysis). Data collected from the long-term monitoring of marine mammals in Bass Strait may prove useful in preliminary assessments of appropriate sample sizes and survey effort required to detect changes.

Frequency of sampling: Sample frequency, will have to balance the need for data with the level of disturbance caused by monitoring techniques. It is likely that survey frequency will be more intensive at the beginning of the program to capture short term impacts, then be reduced to monitor longer term trends and recovery. Sample frequency should be reviewed every 12 months.

Data analysis: Data is analysed with appropriate statistical tests to compare baseline (post-spill pre-impact) results with samples collected in areas expected to be impacted by the spill. The hypotheses for data analysis are therefore:

- H0= There is no significant effect of spilled hydrocarbon on the abundance, behaviour and breeding success of marine mammals.
- H1 = The hydrocarbon spill had a significant effect on the abundance, behaviour and breeding success of marine mammals.

The exact form of statistical tests will be dependent on the nature and distribution of the data. Justification for test selection must be provided in the method section of reports.

Reporting

The appointed contractor is responsible for delivering the following reports to the Incident Controller, who is in turn responsible for disseminating the information:

- Baseline report describing the methods to be used and justifying the selection of baseline data
- Survey reports from each sampling event
- Annual reports (if appropriate)
- Final consolidated report.

Each report should include a detailed description of the method, the field results and QA/QC data. A clear statement of the impact of the spill on marine mammal populations must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- An experienced marine biologist with a minimum of a Bachelor’s degree in biological science from a recognised academic institution. Experience in assessing marine mammal impacts and populations, statistical analysis and report writing.

Monitoring provider (Field Team – 2 to 3 people)

- Experience in the survey of marine mammals including whales, dolphins and seals.

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
Applied Ecology Solutions	39 The Crescent, Belgrave Heights, 3160 03 9752 6398

<u>QA/QC</u>

- Scientific peer review of detailed methods and reporting. Potential peer reviewers include: Dr Roger Kirkwood (Phillip Island Nature Parks) Dr Simon Goldsworthy (South Australian Research and Development Institute), Dr Kate Charleton-Robb (Monash University), Dr Carol Scarpaci (Victoria University).
- Internal audits against procedures.

S9: Impact on Ramsar Sites

Overview

As a signatory to the Ramsar Convention on Wetlands, Australia has certain obligations, including managing designated sites to maintain their ‘ecological character’ and to have procedures in place to detect if any threatening processes are likely to, or have altered the ‘ecological character’. The Ramsar Convention has defined “ecological character” and “change in ecological character” as (Ramsar Convention 2005):

“Ecological character is the combination of the ecosystem components, processes and benefits/services [CPS] that characterise the wetlands at a given point in time” and

“…change in ecological character is the human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/service.”

The baseline of ecological character is detailed in Ecological Character Descriptions, which have been prepared for each Ramsar site in Australia. These documents provide “Limits of Acceptable Change” (LAC) for critical components, processes and services. Change in ecological character is assessed against these LAC and reported at the national and international level.

The scope of this monitoring program is different from the field based monitoring programs as it is an integration of the results of programs S1 to S8 with respect to the affected Ramsar Site(s) and an assessment against LAC.

Objectives

To determine the extent and magnitude of impacts of spilled hydrocarbons on the ecological character of the Ramsar site(s).

To monitor recovery of components, processes and services of the Ramsar site(s) impacted by hydrocarbons.

Initiation criteria

Post-spill, pre-impact surveys are initiated when trajectory estimation / modelling (O1) indicate that spill may enter a Ramsar site.

Post-spill impact sample collection is initiated when TPH concentrations in the water as a result of spilled hydrocarbons are > 7 µg/L within the Ramsar site boundary.

Termination criteria

Termination criteria for any given spill will be agreed with relevant agencies and community representatives. A preliminary termination criterion is suggested as:

“sampling can cease if there is no detectable impact on ecological character; or in the event of an impact, ecological character has been restored.”

Baseline approach

The ecological character description for a Ramsar site establishes the benchmark and the Limits of Acceptable Change. Results of monitoring programs will be used to assess against the baseline and the LAC to determine effects on ecological character.

Study design

This will be a desk top review of the outputs of relevant scientific monitoring programs (S1 – S8) with an assessment against LAC and benchmark descriptions of ecological character.

Reporting

Annual reports will be produced for the length of S1 – S8 monitoring programs. A clear statement of the impact of the spill on the ecological character of the Ramsar site(s) must be included.

Competencies

Monitoring provider (Study Lead – 1 person)

- An experienced ecologist with a minimum of a Bachelor's degree in biological science from a recognised academic institution. Thorough knowledge and understanding of the Ramsar Convention.

Potential local operators include:

Organisation	Contact
GHD	180 Lonsdale St Melbourne VIC 3000 03 8687 8111 David Petch 0428 963 290, David.petch@ghd.com
Water's Edge Consulting	9 McDermott Avenue Mooroolbark VIC 3138 03 9727 5649

QA/QC

- Scientific peer review of reporting. Potential peer reviewers include: Dr Max Finlayson (Charles Sturt University); Lance Lloyd (Lloyd Environmental Consulting)
- Internal audits against procedures.