REVIEW OF NET ENVIRONMENTAL BENEFIT ANALYSIS FOR THE RESPONSE TO THE MONTARA OIL WELL RELEASE, SEPTEMBER 2009

Net environmental benefits are the gains in environmental services or other ecological properties attained by remediation or ecological restoration, minus the environmental injuries caused by those actions.[1] The Net Environmental Benefit Analysis (NEBA) is a framework that assesses the benefits and negative affects of using oil dispersants as a response to the oil well release in the Montara oil field (the well release). The flow of services for each remedial action is in this case from the incident to use of dispersal, but will ultimately also include natural attenuation and ecological restoration. This NEBA will evaluate whether this flow of services will produce positive environmental benefits and the magnitude of these benefits.

Rebecca Efroymsom and others provide the following rationale for completing a NEBA:

> *"NEBA has the potential to help land managers avoid the possibility that the selected remedial or ecological restoration alternative will provide no net environmental benefit over natural attenuation of contaminants and ecological recovery. An alternative may provide no net environmental benefit because: (1) the remedial or ecological restoration action is ineffective (the action does not substantially change the risk) or (2) the remediation alternative causes environmental injuries greater than the damage associated with the contamination because (a) the need for remediation has been driven by human health risk, not ecological risk; (b) the ecological injury from contamination has been overestimated because of conservative assumptions; or (c) injuries associated with remediation were not properly addressed… NEBA is recommended if any of the remedial or restoration alternatives potentially has significant negative ecological effects or minimal ecological benefits. Finally, NEBA is needed when the multiple alternatives are beneficial, but the one with the greatest net benefits is not apparent without formal analysis."*[2]

The Australian Maritime Safety Authority (AMSA) has previously completed a NEBA of the use of dispersants in the Montara oil spill clean up as part of their *Incident Action Plan*. Following completion of the initial NEBA, the incident response so far has been to commence:

- surface application of dispersant on oil will be conducted by the *Lady Gerda* vessel. This, in conjunction with the Containment and Recovery Strategy will be the primary response methods utilised during this operational period;
- containment and recovery of oil will be conducted using the *Lady Valisia* vessel and the *Pacific Battler* vessel; and
- aerial application of dispersant was conducted daily until 3 September. Further use of aerial dispersant application will not occur until an assessment of the effectiveness of the surface application of dispersant, and the containment and recovery operations is undertaken.

[1] Efroymson RA, Nicolette JP, and Suter GW II. 2003. A Framework for Net Environmental Benefit Analysis for Remediation of Petroleum-Contaminated Sites. ORNL/TM-2003/17. Oak Ridge National Laboratory, Oak Ridge, TN, USA

[2] *Ibid: 1*

AMSA continues to coordinate the emergency spill response, in accordance with Australia's *National Plan to Combat Pollution of the Sea by Oil and Other Noxious and Hazardous Substances*. The NEBA completed by AMSA reflected the context of the spill response: that the immediate priority was to deal with the spill and limit the impact on the environment of both the spill and the clean up operations and ultimately, seal the well. This NEBA represents an update of the previous NEBA completed by AMSA, which includes further information as it has become available and following necessary initial response to the incident.

This NEBA focuses on evaluation of environmental rather than the economic or human cost/benefits. This is a difficult undertaking because large data gaps exist on oil spill response generally, let alone in an environmental context. This NEBA recognises that the protection priorities in response to the well release include, in order of descending priority:

- Urgency of the spill;
- Human health and safety;
- Habitat and cultural;
- Rare and/or endangered species;
- Commercial resources; then
- Amenities.

Physical considerations

Location of the incident and sensitivities

On Friday 21 August 2009, during activity being undertaken by the *West Atlas* jack-up drilling rig, that is operated by Atlas Drilling, through the Montara Wellhead Platform, which is a separate structure to the rig, a hydrocarbon release was observed from the Montara H1 ST1 well at 0530 (WST). The *West Atlas* is located at 124deg 32min 5sec E and 12deg 40min 33sec S. The *West Atlas* Oil Rig was evacuated safely while AMSA deployed assets to combat oil spills and assumed a combat agency role at request of the company who owned the rig (PTTEP).

The rig is approximately 105 and 148 kilometres from Cartier Island Marine Reserve and Ashmore Reef National Nature Reserve respectively. Other sensitive habitats in the region are Hibernia Reef and the Jabiru Shoals which are located outside the Australian Exclusive Economic Zone. The Western Australian coastline is 180 kilometres from the origin of the well release.

Oceanography

The major ocean currents that could influence the movement of the oil are the Indonesian Through-flow and the seasonal Holloway Current. These and other major currents in the Region flow polewards (see figure 1). To date, oil has generally moved to the north and north-east. Stochastic modelling based on a seven day predictive model[3] indicates that there is a low possibility of oil reaching the Western Australian coastline or offshore Islands; however, as of 25 September 2009 situation reporting by AMSA reported that:

[3] modelling has errors of margin beyond a 48 hour forecast.

> *the closest sheen to the mainland remained at **144 km**, with patches of sheen (assessed as 10%) some **475 km** to the east of Ashmore Reef. Sheen was also observed out to **166 km** to the east of the platform into open waters. No sheen was observed in the vicinity of Cartier Islet.*

Operational response activities to date have been conducted in calm open seas with clear skies. These conditions typically cause low levels of natural mixing between oil and water compared with choppy conditions or wet weather. Calm conditions may also reduce the amount of natural weathering.

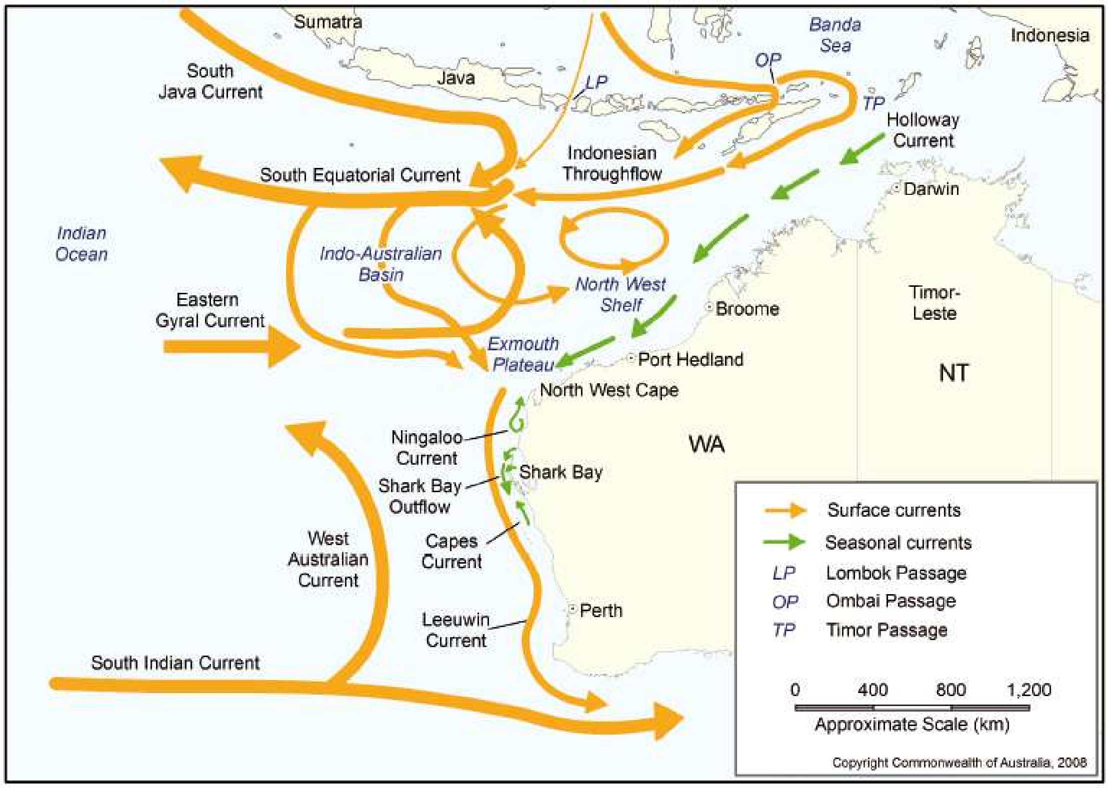

Figure 1: Surface currents in the North-West marine region.[4]

Ecological considerations

From an ecological perspective, the foremost question is: will the clean-up promote ecosystem recovery? If the answer is 'no', there is no ecological justification for clean-up intervention, though of course there may be overriding socio-economic considerations.[5] This section evaluates the ecological character which could potentially be impacted by the well release and remediation or restoration processes.

Coral and seabed habitat

Coral reef communities are generally considered to be highly sensitive to both oil and oil/dispersant mixtures, causing loss of symbiotic zooxanthellae (tiny algae living in

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[4] Department of the Environment, Water, Heritage and the Arts (DEWHA) 2008 '*The North-west Marine Bioregional Plan – Bioregional profile*' Published by DEWHA, Canberra, Australia p. 23

[5] Baker, J.M. (1999) 'Ecological effectiveness of oil spill countermeasures: how clean is clean?' *Pure Applied Chemistry* 71(1): p. 138

coral), reduced metabolism, cellular atrophy, decreased reproductive success, impaired tissue development, behavioural changes and death of the coral.[6] However, coral reefs are by no means certain to be negatively impacted if oil comes in contact with this habitat. Healthy coral communities have been identified among natural oil and gas seeps in the Red Sea and this interaction is entirely plausible in the Timor Sea, where seeps have been releasing low levels of hydrocarbons for many thousands of years.[7] A total of 255 species of scleractinian coral have been recorded across both Ashmore and Cartier Reefs[8]. Although toxicity tests have not yet been undertaken in these reefs, there is no evidence to suggest that they may not be resilient to low level exposure to oil and gas.

Both oil and dispersants (and mixtures of these) have been shown to have a toxic effect on corals, coral larvae, fish larvae (affecting photosynthesis, respiration, reproduction) and can cause mortality if exposed to high concentrations for a prolonged period. [9]

A recent study that evaluated the use of dispersants in response to oil spills in tropical marine environments found that the ecotoxicological impacts of the various dispersants on the corals could be rated on a scale from the least to the most harmful agent, as follows: Slickgone > Petrotech > Inipol > Biorieco > Emulgal > Dispolen.[10] These findings strongly support use of Slickgone as the dispersant of choice to minimise the risk of impacts on coral and other habitats.

Several key ecological features that were identified in the North and North-West Bioregional Profiles should also be considered in this NEBA. These include the: Carbonate Banks in the Joseph Bonaparte Gulf; Limestone pinnacles in the Bonaparte Depression; Ancient coastline at 125m depth contour; Carbonate terrace and bank system of the Van Diemen Rise; and the Shelf break and slope of the Arafura Shelf.[11] Significant impact of any one of these key ecological features during response operations should be avoided.

Sensitive marine reserves and coastal coral communities are likely to be threatened by the oil as it drifts into their immediate proximity. In response to scenarios where sensitive areas may be threatened if no dispersant action is taken and if dispersant use is deemed the most appropriate response, Robert Fiocco and Alun Lewis argue that the "dispersant response should be initiated as soon as possible and as far out to sea as possible to maximize effectiveness and avoid impacts".[12] Nevertheless, use of chemical dispersants should not occur directly on coral habitats and exposed sand or mud habitat. Instead mechanical and natural dispersant methods are more appropriate in these habitats. Additionally, as is discussed in the next section, offshore use of chemical dispersants should only be conducted in a way that reduces the likelihood of impact from drift of chemical dispersants or treated oil.

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[6] *Pers. comm.* Australian Institute of Marine Science
[7] *Ibid*
[8] DEWHA, 2009, Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve Information for Visitors
[9] *Pers. comm.* Australian Institute of Marine Science
[10] Shafir S, Van Rijn J, Rinkevich B (2007) Short and long term toxicity of crude oil and oil dispersants to two representative coral species. Environmental Science & technology 41, 5571-5574
[11] See: DEWHA, 2008 '*The North-west Marine Bioregional Plan – Bioregional profile*' Published by DEWHA, Canberra, Australia; and DEWHA, 2008 '*The North Marine Bioregional Plan – Bioregional profile*' Published by DEWHA, Canberra, Australia.
[12] Fiocco, R.J., and Lewis, A. (1999) 'Oil spill dispersants' *Pure Applied Chemistry*, 71(1): p. 35

Shoreline habitat

There is a risk that oil from the well release will reach and potentially affect shoreline habitat on islands and the Australian coastline, namely in the Kimberley bioregion. Although ocean modelling suggests that oil and sheen is travelling away from these shoreline habitats, there is a possibility that this may shift due to meteorological and oceanographic trends.

These habitats are of a similar category to coral and seabed habitats when evaluating their sensitivity to response mechanisms. The use of chemical dispersants should not occur directly on shoreline habitats, and instead mechanical and natural dispersant methods are more appropriate in these habitats. Additionally, as is discussed below, offshore use of chemical dispersants should only be conducted in a way that reduces the likelihood of impact from drift of chemical dispersants or treated oil. The operational response to the well release should consider the sensitivity of these species to oil and oil-dispersant mix, and take all steps necessary to avoid a situation where species mortality may arise.

Seabirds

The North-West region supports approximately 50000 seabirds of 26 species and up to 2000 waders of 30 species.[13] Reports suggest that nationally important colonies of Sooty, Bridled and Crested Tern and Common Noddy nest on Middle and East Islands at Ashmore Reef between May and December each year. Sooty, Bridled and Crested Terns have also been recorded in significant numbers in April-June in some years and September-December in others. Common Noddies were present more often in significant numbers during the September-December period.[14] Ashmore Reef also supports internationally significant numbers of four wader species (the Eastern Curlew; Grey Tailed Tattler; Ruddy Turnstone; and Lesser Sand Plover) during their northern and southern migration in April-May and September-November respectively.[15]

Since the spill was reported, the Department has been working closely with the Australian Maritime Safety Authority and relevant Commonwealth and state agencies to implement a plan of action to help any wildlife affected by the oil spill in Commonwealth waters. The operational response has also included, aerial and water based surveillance of the region that is undertaken daily. Trained observers, in addition to reporting information on the operational response to the leak, will also report any sightings of wildlife in the area. The operational response to the well release should consider the sensitivity of these species to oil and oil-dispersant mix, and take all steps necessary to avoid a situation where species mortality may arise.

Marine Megafauna

Significant populations of three marine turtle species feed in the region year round. Ashmore Reef provides critical nesting habitat for the Green turtles whose nesting activity occurs throughout the year peaking around January. It is thought that

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[13] Milton D.A. (2005) ‘Birds of Ashmore Reef National Nature Reserve: an assessment of its importance for seabirds and waders,’ *The Beagle, Records of the Museums and Arts Galleries of the Northern Territory*, Supplement 1: pp. 133-141
[14] Milton 2005: 137
[15] *Ibid*: 138-9

Ashmore and Cartier support approximately 11,000 marine turtles and that the Ashmore and Cartier population of Green turtles is genetically distinct from the other two breeding populations in the region.[16] Nests tend to be above the high tide mark. Turtles also nest on the coast and could be impacted if oil reaches the coastline. It is difficult to predict precise environmental outcome, however it can be considered that some environmental damage will occur to coastal systems if oil reaches these areas.

Historically, 17 sea snake species have been recorded in the reefs and channels of the Sahul Shelf.[17] Sea snake monitoring by Charles Darwin University indicates a significant decline in sea snake populations at Ashmore Reef. A three-part research program to investigate this more closely began with a survey in November 2005. Part three of the research reports that “the abundance of both species and numbers within the Ashmore Reef National Nature Reserve has decreased alarmingly since about 2000 to the present state where sea snakes are rare at Ashmore Reef. The reasons for sea snake decline remains unknown.[18]

A range of pelagic species are also known to forage in the region throughout the year, including billfish, sharks, tuna ,cetaceans such as dolphins and pilot whales, and dugong. The area is also known to be a fishery for Goldband snapper.

Toxicological data is currently poor for the affects of oil and/or oil dispersant mix on marine megafauna; however, there is a high probability that the affects upon these species would be severe and easily result in mortality. Consequently, the response to the well release should consider the sensitivity of these species to oil and oil-dispersant mix, and take all steps necessary to avoid a situation where species mortality may arise.

Assessment of oil properties

Overall, the level of impact which actually occurs will depend on a complex interaction between many factors including: concentration, age, chemical and physical properties of the oil (or oil/dispersant mixture) at the time of contact.[19]

Modelling and chemical testing available to AMSA indicates that the liquid oil seeping from the Montara Well head is potentially between 10 and 30% non-evaporative. The oil is a light crude oil with a wax content of 11%. These residues could travel long distances at sea and fetch up on reefs or beach on remote coastlines. Weathering analysis is being conducted by AMSA to confirm behaviour of the oil and this will be factored into further monitoring and response to the well release and any potential impacts.

A cost/benefit of environmental of response options

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[16] DEWHA 2008 ‘*The North-west Marine Bioregional Plan – Bioregional profile*’ Published by DEWHA, Canberra, Australia. p. 41

[17] Guinea, M. L (2007) ‘*Final Report Survey March 16 – April 2 2007: Sea Snakes of Ashmore Reef, Hibernia Reef And Cartier Island with comments on Scott Reef*’ Unpublished report prepared for the Department of the Environment, Water, Heritage, and the Arts, Canberra 2007

[18] Guinea, M. L (2008) ‘*An Assessment of Sea Snake Abundance at Ashmore Reef National Nature Reserve, Ashmore Reef and Cartier Island Territory, Stage Three*’, Unpublished report prepared for the Department of the Environment, Water, Heritage, and the Arts, Canberra 2008.

[19] *Pers. comm.* Australian Institute of Marine Science

Chemical dispersion

Changes in weather conditions may cause oil to reach sensitive areas such as Ashmore Reef, Cartier Island and Western Australian wetlands that are recognised for their international significance. Therefore, until oil has stopped flowing from the *West Atlas*, there is a risk to sensitive areas that requires an immediate response.

The use of chemical dispersants in maritime oil spills has always been a controversial issue and the topic of much debate between responders, scientists, the public, media and environmental action groups. However, a major conclusion from response to the *Sea Empress* oil spill in Milford Haven (UK) in February 1996 was the value of having a well planned aerial dispersant capability in place as a first response measure to oil spills at sea, along with close targeting and monitoring of application operations by boat and aerial surveillance craft.[20] The initial use of chemical dispersant in response to the Montara well release was based on stochastic modelling of the properties and chemistry of the oil available to AMSA modellers, Asia Pacific Applied Science Associates (APASA). The following recommendation was provided:

> "*the National Plan approved dispersants will likely have success on the unweathered fresh oil being released from the platform. The use of aerial dispersants in this spill is a sound approach but only on fresh oil. Residual oil that is more than 1-2 days old would have limited dispersability*".

The APASA modelling results (Tables 1 and 2 at Attachment A) indicate that there is the potential for surface oil spilt from an 8 week leak at *West Atlas* to reach shorelines in the region. In particular, the Ashmore Cartier Reef and Island group to the west were calculated by the model to be the most 'at risk' of contact by surface slicks of partially weathered oil. However, of importance to the evaluation by this NEBA, the potential for surface oil impacts are significantly reduced by the use of chemical dispersants.

This modelling is consistent with a detailed review by the US National Research Council, which concluded that the use of dispersants as a first response option should be considered along with mechanical measures.[21] Fiocco and Lewis support this view, stating that: [f]or many large oil spills, dispersants can be the only practical at-sea response. Over 25 years of studies and experience have shown that dispersant can reduce the environment and/or economic damage that would otherwise be caused by an oil spill".[22] Fiocco and Lewis further state that ""[i]f sensitive resources are likely to be threatened by the oil as it drifts, and if dispersant is deemed to be the most appropriate response, the dispersant response should be initiated as soon as possible and as far out at sea as possible to maximize effectiveness and avoid impacts".[23] Visual and flurometric testing has been used in conjunction with any application of chemical dispersants at the well release site. This testing has provided strong indications that there has been a notable reduction in the size and potential impact of the oil following application of chemical dispersant.

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[20] For further detail on this event and lessons learned see AMSA website at: http://www.amsa.gov.au/Marine_Environment_Protection/National_Plan/General_Information/Dispersants_Information/Use_of_Chemical_Dispersants_in_the_Sea_Empress_spill.asp

[21] National Research Council (1989) *Using Oil Spill Dispersants on the Sea*. National Academy Press, Washington, DC

[22] Fiocco and Lewis 1999: 41

[23] *Ibid*: 35

On this basis of this cost/benefit analysis, a significant reduction of risk to sensitive environmental areas can be expected through the use of dispersants until the cessation of fresh oil discharge from the well release. In accordance with APASA advice, chemical dispersant use should only be relied upon to treat oil that is 1-2 days old. Furthermore, dispersants should only be applied to the thickest patches of oil and *not* on sheen where dispersants are less effective and the excessive costs may outweigh environmental benefits.[24]

Mechanical dispersion

Mechanical recovery is generally considered as the primary option for containing or recovering oil from spills. Spills are often within close proximity to the coast and sensitive sites; however, the Montara spill is in open water in a highly remote location. Under the calm conditions experienced so far, skimmers are of some use; however because spills spread rapidly into relatively thin surface slicks mechanical recovery of the oil is difficult and inefficient in most cases.[25]

Boom equipment can also be used to limit surface water oil movement. Each boom has three chambers (one of air and two of water) so that it floats with the tide and can then sit on the bottom at low tide. To deploy it requires approximately five 100kg anchors per 100 metres to secure it in place. In deploying it we would need to be sure that the anchors would not be impacting anything on the bottom, or at the least that bottom damage is minimised or adequately assessed as necessary if it is deployed to protect immediate threats to sensitive areas. If coastal areas need protection several flat bottom vessels would be required with enough power to tow the boom into place. Although such an operation is possible, deployment of booms in remote marine reserves would be a first in Australian response terms.

Advice from within AMSA suggests that sorbent boom is not appropriate because weathered oil is not expected to absorb into the materials and that the waste and pollution issues from sorbents could become a problem in themselves (i.e. a high quantity of sorbent would be needed which would need to be disposed of and in sensitive areas it would be difficult to avoid some release of sorbent as a pollutant in its own right).

Some shoreline cleanup of oil at sensitive areas should be expected. Manual equipment can compliment booms and skimmers by collecting and removing any oil that reaches coastal areas to strand on the high tide mark. Further emphasis on mechanical dispersion may be appropriate if the heavy oil changes direction and threatens sensitive areas.

Natural dispersion

The obvious benefit of natural dispersion is that there are no foreseen negative impacts as a consequence of relying on it as a response method. However, the immediate priority has been to deal with the spill and limit the impact on the environment of both the spill and the clean up operations. Reliance on natural dispersant methods alone would not meet this objective.

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[24] *Ibid: 38*
[25] *Ibid*: 30

Ultimately, the risk presented by the timescale for natural cleaning combined with its potential deleterious affects are too high without being supplemented by another form of dispersion. When the benefits of chemical and mechanical dispersant methods are outweighed by the costs (particularly with regards to the environment), natural methods become a more appropriate method to rely upon.

Recommended response

- This NEBA evaluates which response will result in ecosystem recovery from the well release and has determined that a mixed approach of initial dispersant on recent oil in conjunction with: mechanical dispersant methods used in the conditions that they are most effective within; and reliance on natural dispersant further to the other two methods available.
- A significant reduction of risk to sensitive environmental areas can be expected through the use of dispersants until the cessation of fresh oil discharge from the well release. In accordance with APASA advice, chemical dispersant use should only be relied upon to treat oil that is 1-2 days old. Furthermore, dispersants should only be applied to the thickest patches of oil and *not* on sheen where dispersants are less effective and the excessive costs may outweigh environmental benefits.
- This NEBA suggests that there are numerous advantages to relying on a mixture of natural, chemical, and mechanical dispersant methods with consideration for their costs and benefits under certain conditions. These cost/benefits should be considered in light of the risk posed by the well release to sensitive areas and/or wildlife.
- Use of chemical dispersants should not occur directly on coral habitats, mangroves or exposed sand or mud habitat. Instead mechanical and natural dispersant methods are more appropriate in these habitats. Additionally, ffshore use of chemical dispersants should only be conducted in a way that reduces the likelihood of impact from drift of chemical dispersants or treated oil.
- Toxicological data is currently poor for the affects of oil and/or oil dispersant mix on marine megafauna; however, there is a high probability that the affects upon these species would be severe and easily result in mortality. Consequently, the response to the well release should consider the sensitivity of these species to oil and oil-dispersant mix, and take all steps necessary to avoid a situation where species mortality may arise.
- On this basis, until there is a cessation of oil discharge from the well release, there remains a net environmental benefit in continuing to apply the mixture of dispersant methods recommended in this NEBA.

Attachment A: Summary of APASA modelling on dispersant effectiveness

Table 1 Summary from the 100 OILMAP single simulations of the West Atlas Spill Event assuming 50% dispersant effectiveness (based on historical met-ocean conditions)

Location	Distance from Spill Site (km & Nm)	Probability of Being Oiled	Age of Oil if Shoreline Stranding Occurs
Cartier Island	106km or 57Nm	39 in 100 spills	> 3 days
Ashmore Reef	162km or 87Nm	30 in 100 spills	> 5 days
Hibernia Reef	146km or 79Nm	10 in 100 spills	> 7 days
Browse Island	188km or 101Nm	10 in 100 spills	> 9 days
Kimberly Coastline	219km or 118Nm	5 in 100 spills	> 15 days
Seringapatam Reef	290km or 157Nm	Unlikely	> 25 days
Scott Reef	330km or 180Nm	Unlikely	> 25 days
Adele Island	340km or 184Nm	Low risk	> 25 days
Joseph Bonaparte Gulf	370km or 200Nm	Low risk	> 28 days
West NT coastline, Darwin and Bathurst Island	610km or 330Nm	Low risk	> 28 days
Timor	various	Unlikely	> 24 days
Indonesia	various	Low risk	> 24 days

Table 2 Summary from the 100 OILMAP single simulations of the West Atlas Spill Event assuming no dispersant application (based on historical met-ocean conditions)

Location	Distance from Spill Site (km & Nm)	Probability of Being Oiled	Age of Oil if Shoreline Stranding Occurs
Cartier Island	106km or 57Nm	50 in 100 spills	> 3 days
Ashmore Reef	162km or 87Nm	47 in 100 spills	> 5 days
Hibernia Reef	146km or 79Nm	22 in 100 spills	> 7 days
Browse Island	188km or 101Nm	25 in 100 spills	> 9 days
Kimberly Coastline	219km or 118Nm	20 in 100 spills	> 15 days
Seringapatam Reef	290km or 157Nm	< 10 in 100 spills	> 25 days
Scott Reef	330km or 180Nm	< 10 in 100 spills	> 25 days
Adele Island	340km or 184Nm	< 10 in 100 spills	> 25 days
Joseph Bonaparte Gulf	370km or 200Nm	12 in 100 spills	> 28 days
West NT coastline, Darwin and Bathurst Island	610km or 330Nm	12 in 100 spills	> 28 days
Timor	various	< 10 in 100 spills	> 24 days
Indonesia	various	< 10 in 100 spills	> 24 days