

BIODIVERSITY SURVEY OF THE MONTARA FIELD OIL LEAK

Report produced for WWF-Australia



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EXECUTIVE SUMMARY

- 0.1 WWF-Australia commissioned AES Applied Ecology Solutions Pty Ltd to run an independent scientific survey of the area affected by the Montara H1 oil well leak, which including transit time, took place from 24 – 30 September 2009. This report presents the findings from the three-day period 26 – 28 September spent in the vicinity of the main oil leak zone.
- 0.2 The purpose was to do a rapid biodiversity assessment with the following objectives:
- Collect line transect data for seabirds, marine mammals, sea snakes and marine turtles and where possible, compare these quantitatively and qualitatively to initial risk predictions, based on calculations in AES (2009);
 - Ground-truth information from MODIS satellite images of slick extent; and
 - Gather information directly on the intensity of surface slicks.
- 0.3 The area affected by the leak is about 300 nautical miles (550 km) from Darwin. The environment is characterised by relatively high geomorphic diversity compared to other shelf-regions of Australia, as well as unique sedimentology (Australian Government, 2008, Figure 1). The Indonesian Throughflow Current is the dominant oceanographic feature of the bioregion, which interacts with the carbonate Sahul Banks to form vertical mixing zones, important for surface wildlife in nutrient-poor tropical waters (Australian Government, 2008). There is little published information on this area of Australia and mostly anecdotal or grey literature regarding species of seabird, marine reptile and marine mammal.
- 0.4 Oil was encountered from early on the first day of the trip (26th). The morning of the 26th is also when most sea snakes were recorded. This was leading into the drop-off at the edge of the Sahul Banks in about 70m depth. Seventeen sea snakes were seen in just seven minutes and 42 overall throughout the first day. Nearing the Jabiru well, schools of tuna, along with feeding Sooty and Bridled Terns stretched to the horizon in all directions. We began to see some of the rarer seabirds, including Matsudaira's Storm Petrels, visitors from remote islands south of Japan, along with Streaked Shearwaters and numerous pods of Spinner Dolphins and Bottlenose Dolphins. Oil sheen was encountered patchily throughout the day and we occasionally crossed concentrated lines of waxy particles, presumed to be residue from the oil spill further south (Table 5, Figure 22). The evening was spent at anchor in Jabiru shoals in just 17 metres of water, 400 miles offshore. A Leaches' Storm Petrel, Hawksbill Turtle and flocks of Sooty Terns feeding with tuna were foraging in oil sheen as the sun set.
- 0.5 The following day we headed into deeper water behind Jabiru shoals and encountered an impressive 21 pods of dolphins that day, including a large dispersed group of about 80 Spinner Dolphins over the Jabiru Shoals at dawn. After heading for a few hours toward the source of the Montara oil leak the wind rose slightly and we were forced east by an increasingly pungent smell of oil, which was giving observers dry throats and a bad taste in the back of their mouths. Our new course passed directly between the Jabiru and Challis wells and late afternoon we encountered a thick layer of oil like a soft yellow crust, accompanied by moderately heavy oil sheen and a strong oil smell. This was about flush with the edge of the Sahul Banks. Two groups of

- Spinner Dolphins, sea snakes and Sooty Terns were observed in the slick which continued until night fall. We headed south to anchor just east of the Montara H1 oil leak exclusion zone.
- 0.6 On the final day we headed northwest along the edge of the exclusion zone but surprisingly encountered relatively little oil except for long broad slicks of sheen, with the densest areas located where we were the previous night. This area was also along the edge of the Sahul Banks and apparent mixing along its edge was concentrating algae, flying fish, jellyfish, flotsam and jetsam along its length. A relatively high abundance of small pelagic seabirds such as Matsudaira's Storm Petrels and Wilson's Storm Petrels were joined by Red-necked Phalaropes and Common Noddies. By early afternoon we turned to head in the direction of Darwin and by dusk encountered the same high density of oil as seen the night before.
 - 0.7 204 nautical miles of survey line were run in the three days at an average speed of about 7 knots (Figure 3). We recorded 17 species of seabird, three species of cetacean and four marine reptiles including one species of marine turtle (Table 1). Flatback turtle was also seen on the 29th in oil sheen on the return leg towards the Bonaparte Gulf. At least twelve of the species were listed migratory and one, Hawksbill Turtle, is listed threatened and considered 'vulnerable' to extinction under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (Table 2).
 - 0.8 Survey lines were chosen to coincide with a range of habitats. Data was entered in real time in the survey database, along with date, time and location of every sighting. Numerically, Spinner Dolphin was the most abundant species encountered (202), followed by Sooty Tern (176). Both species were recorded regularly interacting with oil sheen (Table 3 & Figure 9).
 - 0.9 Of the ten most common species recorded, Sooty Tern was one of only three that also nest on Ashmore Reef. The others were Common Noddy and Brown Booby. All other most abundant species: Streaked Shearwater, Pan-tropical Spotted Dolphin, Bottlenose Dolphin, Bulwer's Petrel and Matsudaira's Storm Petrel and 'sea snakes' (this group was lumped together pending identification and made up 10% of all sightings) would not be expected to make land fall in Australia during the period of the leak.
 - 0.10 Densities and encounter rates with dolphins and sea snakes were very high. Seabird diversity was low compared to areas around Ashmore Reef, for example, but high compared to other tropical waters. The community of species encountered is quite typical of this area of the northwest shelf but rarely encountered anywhere else in Australian waters.
 - 0.11 The survey was planned to coincide with locations where oil was expected to occur. This was based on satellite images online at Skytruth (Figure 21) and information provided by AMSA (Figure 18). By the 28th it appeared as though oil was mainly concentrated over the Sahul Banks to the northeast of our survey and we encountered the densest sheen twice on the evening of the 27th and 28th, about 50 Nm from the source of the leak (Figure 24). On the return journey back to Darwin we passed through oil sheen up to about 140Nm from the Montara H1 oil well. This was also an area where we encountered a number of Flatback Turtles.

- 0.12 Surface oil could be readily detected by extensive patches or continuous glassy water, particles of white waxy residue and, in areas of moderate to high sheen thickness, strong smell and the presence of a soft yellow crust of unweathered wax with volatiles. Oil sheen was present for the majority of the three days of the survey so most animals were likely to have interacted with it to some degree.
- 0.13 Satellite images only appear to show the portion of the slick that is exposed to 'sunglint'. Official estimates of the size of the slick from AMSA indicate that it is about 6,000km² (25 x 70 Nm) but we found oil sheen at distances beyond 70Nm from the well head. The latest satellite images from Skytruth (Figure 21) indicate that the leak has covered at least 10-25,000 km².
- 0.14 The data presented in this report should be interpreted against the statutory definitions of what is "likely" to be a "significant impact" (section III.2) and not just concentrate on harm to wildlife. Commonwealth policy and legal case history defines "significant impact" as an impact that is "important, notable or of consequence having regard to its context and intensity". The report finds that the area meets some of the criteria for conservation importance established by the *ANZECC Guidelines for Establishing the National Representative System of Marine Protected Areas* and that there are a range of potential impacts on wildlife and the Commonwealth Marine Environment, the significance of which would depend on the magnitude, duration, intensity and frequency of the leak.

PART I. BACKGROUND

I.1 INTRODUCTION

WWF-Australia commissioned AES Applied Ecology Solutions Pty Ltd to run an independent scientific survey of the area affected by the Montara H1 oil well leak, which including transit time, took place from 24 – 30 September 2009. (Figure 5).

The report *Montara Field Oil Leak Biodiversity Values* (AES, 2009) had found that:

The extent of any impact and therefore the final list of habitats, communities and species likely to be affected will depend on the magnitude, scale and duration of the leak. At this time, the visible extent of the surface slick seems to have exceeded conservative modelling and its direction is being determined by wind. Even in its current location, it has the potential to expose a very significant proportion of marine fauna populations to toxicity. The level impact however, is impossible to determine at this stage.

Given that any assessment of the potential effects of the oil leak could not be reasonably determined without field observation, the aim of the survey was to do a rapid biodiversity assessment including direct observations of wildlife and oil effects.

I.1.1 RAPID BIODIVERSITY ASSESSMENT

Rapid biodiversity assessments are not designed to be exhaustive full-scale scientific inventories. They provide a snapshot of site ecology and biodiversity value, combining prior knowledge with field surveys for ground-truthing.

Field surveys are a rudimentary and essential part of biodiversity assessment (EIANZ, 2009; Hill et al., 2005). Surveyors with ecological knowledge and experience can gain direct ground-based understanding about biodiversity, especially the interaction between ecosystem processes, habitat and species. The survey team was therefore chosen to comprise individuals with significant field knowledge and experience on marine ecosystems, species identification and searching.

Combined with prior knowledge (e.g. other studies and anecdotal information), the extent, duration and intensity of any environmental effects,

and published information on species ecology and behaviour, rapid biodiversity assessments are highly informative for scoping the value of an area. They would normally be used to identify the need for more detailed work.

I.1.2 SURVEY OBJECTIVES

The survey provided opportunity to test hypotheses reported in AES, (2009) about the value of the area in terms of species richness, the presence of important marine species, including threatened and / migratory species, and their role in the *functioning and integrity* of the marine ecosystem. Ecosystem function and integrity are both matters for consideration under policy guidelines of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), relating to protection of the Commonwealth Marine Environment (DEWHA, 2005). This was the only controlling provision for the Montara 3, 4, 5 and 6 wells approved by the Commonwealth as AC/RL3 on 3 September 2003¹. This includes production licences for AC/L7 and AC/L8.

Many of the species recorded on the survey are also either listed marine or migratory so as well as functioning components of the Commonwealth Marine Environment, are also protected in their own right under Part 3 of the EPBC Act.

The main objectives of the survey therefore, were to:

- Collect line transect data for seabirds, marine mammals, sea snakes and marine turtles and where possible, compare these quantitatively and qualitatively to initial risk predictions, based on calculations in AES (2009);
- Ground-truth information from MODIS satellite images of slick extent; and
- Gather information directly on the intensity of surface slicks.

I.1.3 SITE DESCRIPTION

The area affected by the Montara Oil leak is about 300 Nautical Miles (550 km) offshore. To get there from Darwin requires crossing the Bonaparte Gulf, a depression about 50 Nm wide and then another 50 Nm wide plateau about 70m deep. It has some different oceanographic influences compared to other parts of the northwest shelf. For example, tides in the Ord River valley are in the region of 3-4m, whilst tides in the area affected by the Montara Oil Field Leak are only 0.5-1m.

According to the Interim Marine and Coastal Regionalisation for Australia (IMCRA) (Australian Government, 2006) the survey area falls within the

¹ Commonwealth of Australia, EPBC Act 1999. Decision to Approve the Taking of an Action, issued 3 September 2003.

Northwest IMCRA Transition, Provincial Bioregion No. 26 (IMCRA 4.0). This is an area that covers about 305,550 km². It is the only IMCRA shelf bioregion to contain seven geomorphic unit classes (Figure 1). The bioregion includes the 3rd-highest abundance of pinnacles, banks and sand banks (Class 1) for all the IMCRA shelf bioregions and the largest area of Clas 11 units, dominated by extensive banks that make up the Sahul Banks

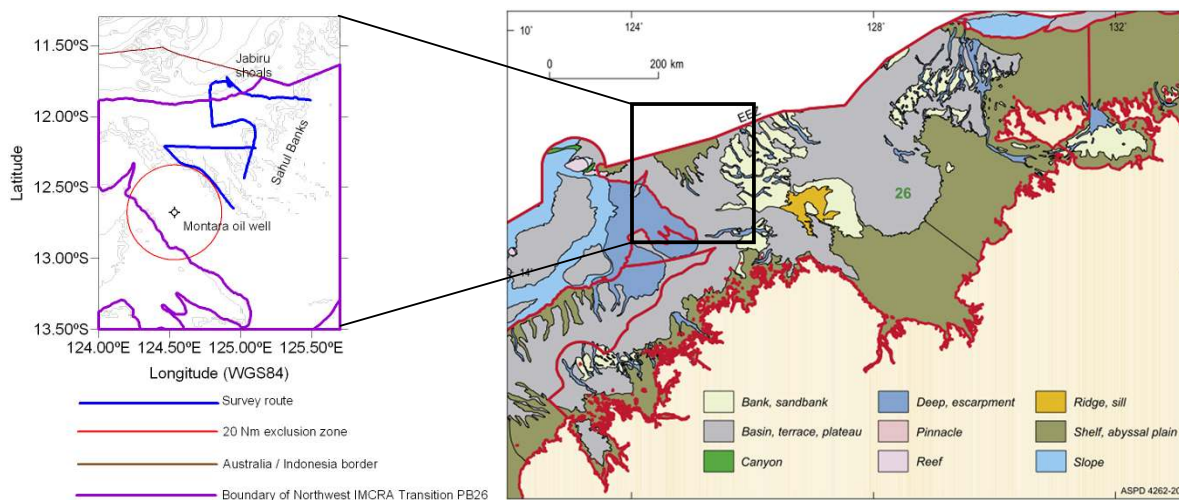


Figure 1: Survey area and boundary of Northwest IMCRA transition PB 26. Geomorphic unit classes are mapped (right) from Benthic Fact Sheets (Department of the Environment and Heritage (National Oceans Office) 2005². Note, boundaries of the EEZ and bio-regions may have changed.

The Northwest IMCRA Transition is otherwise referred to as the Northwest Shelf Transition in the *North-west Marine Bioregional Plan: Bioregional Profile* (Australian Government, 2008).

The bioregional profile recognises both its diversity, in terms of geomorphic classes, and its unique nature noting that “the different sedimentology on the shelf in the bioregion is likely to be indicative of seabed environments not found elsewhere in the North-west Marine Region”.

The Sahul Banks are a carbonate rim-shelf about 70m deep. More than 70% of the carbonate banks in Australia occur in this bioregion and are thought to be “sites of enhanced biological productivity” (Australian Government, 2008).

The coincidence of the Indonesian Throughflow Current and Sahul bank establishes mixing zones and nutrient fronts along its edge. It is noted in the bioregional profile that “the shelf break is generally a dynamic zone where vertical mixing results in a mixed water mass that intrudes offshore from the shelf break across the slope at approximately the 100m depth contour (Brewer *et al.* 2007), as well as inshore across the continental shelf into the adjacent Northwest Shelf Province” (Australian Government, 2008).

² <http://www.environment.gov.au/coasts/mbp/publications/general/benthic-factsheets.html>

Nearby, just inside the Indonesian border, are Jabiru Shoals that rise to less than 20m in places, providing habitat for threatened species such as Hawksbill Turtle. Their western edges are sheer-sided drop-offs leading into a deep ocean trench that crosses the Australia / Indonesia border and bisects the Sahul Banks in a north-south direction. Currents from the Indonesian Throughflow Current would sweep directly into the area via this trench before colliding with the edge of the Sahul Banks to the east and south.

The Indonesian Throughflow Current is a 200-300m deep layer of warm low-density surface water from the Timor Sea that flows southwest. It is strongest during the southeast monsoon from September to October but starts to weaken during the doldrums period of October to November when wind speeds usually average less than 10 knots daily. It is the dominant oceanographic feature of the area (Australian Government, 2008).

Throughout the southeast monsoon period, ecological production at the sea surface is particularly high, fuelling the pelagic food chain (Hobday, 2001; Mustoe et al., 2008). Plankton production provides habitat for flying fish (Piontowski et al., 1995) and provides rich energy food for breeding seabirds, especially where this is concentrated into nutrient fronts (Dunlop et al., 1988; Jaquemet et al., 2005). Nutrient fronts are associated with steep bathymetric features and / or the coincidence of different ocean currents at sea. They are particularly important for biodiversity in generally nutrient-poor tropical waters (Hobday, 2001).

I.1.4 EXISTING KNOWLEDGE AND INFORMATION

There is very little published on seabirds, marine mammals and marine reptiles for this area and limited historic anecdotal evidence or grey (unpublished) literature.

The Sahul Banks was surveyed by the Australian Geological Survey Organisation (AGSO) in 1993³. In terms of seabirds, there have been few expeditions to the area. The Handbook of Australian New Zealand and Antarctic Birds (Marchant et al., 1990) refers to collected specimens and sightings of species such as Matsudaira's Storm Petrels periodically between 1968 and 1974. In 1987 a survey on the R.V. Franklin visited a nearby area east of Ashmore Reef with the objective to "examine the currents and water properties" (Cresswell, 1987). The ship's master Captain Neil Cheshire is an avid ornithologist and along with N. Dunlop and R. Wooler made the first observations of birds "not known from the Indian Ocean until this year" including Tahiti Petrel *Pterodroma rostrata*. At that time they noted the "growing list of migratory species from the central and north Pacific"

³ Australian Institute of Marine Sciences. Big Bank Shoals of the Timor Sea: An environmental resource Atlas <http://www.aims.gov.au/pages/reflib/bigbank/pages/bb-09k.html>

including Bulwer's Petrel *Bulweria bulweria*, Streaked Shearwater *Calonectris leucomelas* and Matsudaira's Storm Petrel *Oceanodroma matsudairae*.

Since then, annual survey trips from Broome to Ashmore Reef (Simon Mustoe, personal observations) have provided insight into likely species composition. However, given the nature of the Sahul Banks region north of the Montara H1 well, this area was expected to have its own unique character.

Despite significant investment into research and descriptions of fauna and ecosystems around Scott Reef and Ashmore Reef, there does not seem to be an equivalent level of investment or primary survey data available for the Sahul Shelf and Sahul Banks areas near Montara H1. Further, we are not aware of surveys of seabirds, marine mammals or marine reptiles having been done prior to the approval of Montara, Challis or Jabiru oil wells. The preliminary documentation for approval of the Montara Field development (URS Australia, 2003) under the EPBC Act did not reference any such surveys.

If extensive baseline surveys were done to inform exploration and production approvals or monitoring this information would be a valuable contribution to assessing likely impacts and risk from the Montara field oil leak.

I.1.5 TRIP NARRATIVE

Please note, the laptop computer used to enter data was set to eastern standard time. Times in this report appear as Darwin Time + 0.5 hours.

I.1.5.1 24th –September 2009

Departed Darwin at about 08:45 and headed around Charles Point before plotting a course due west. This route would take us approximately 290 nautical miles to a point just within the slick, as determined by Skytruth satellite data from the 17th September. The journey was likely to take about 36 hours, arriving at dawn on the 26th.

On leaving Darwin harbour, we recorded Lesser Crested, Crested, Whiskered, Little and Gull-billed Terns, plus Brown Booby. One turtle on the way out was possibly an Olive-Ridley, seen briefly. The waters around Darwin Harbour are extremely turbid. The coastal ecology is very rich and with significant tidal mixing, turbid waters extend well out to sea. A light film of reddish algae was present in some mixing zones, along with scattered cuttlefish shells.

We spent the rest of the morning setting up databases and discussing sampling and survey methods. Surveying began shortly after lunch at 15:30. Sunset was about 6:45 pm and though it was still light enough to see for some time after that (nautical twilight about 7:30pm), we finished dedicated surveying shortly after sunset. Depending on direction of travel and degree of cloud cover, it did remain light enough for casual observation beyond this time on some evenings.

Throughout the afternoon, a steady stream of frigatebirds were recorded, including four Great Frigatebirds close to the coast and 18 Lesser Frigatebirds, all flying in an ENE direction. At 4pm, we encountered two, possibly associated pods of 12 Indo-Pacific Humpback Dolphins approximately 35 nautical miles from shore. Fifteen minutes later, a mother and calf Humpback Whale appeared – notably quite far north, particularly this late in the season. Before nightfall, two groups of Bottlenose Dolphins and two groups of Spinner Dolphins were added to the list. As well as four species of cetacean, four species of sea snake were also recorded, including Golden, Hardwicks, Stoke's and an unidentified and thread-like *Disteira* sp.

I.1.5.2 25th September 2009

By morning, we were beyond any coastal turbidity and in relatively blue water. Depths were about 70m throughout the day, as we crossed the broad but shallow trench that marks the ancient course of the Ord River. Very few seabirds were seen all day, although there was evidence of surface production, with the constant presence of flying fish and some algae. We noted some white specks in the water and speculated that they may have been broken up pieces of cuttlefish shell. In hindsight however, these could have been wax particles. It was not until the following day that we were aware these existed.

For most of the day we saw only five Bridled Terns, twelve Brown Boobies and two Common Terns. Late afternoon, just before passing into shallower water again, we recorded two Bulwer's Petrels, a migrant from northwest Pacific waters. There were only three encounters with cetaceans: one pod of seven Spinner Dolphins and two pods totally eight Bottlenose Dolphins.

I.1.5.3 26th September 2009

We arrived just after dawn at a location over a relatively shallow part of the Sahul Bank and lingered for a short while before breakfast, continuing our cruise west at about 08:00. We were within the area predicted as having the oil slick but it was not immediately apparent at dawn. Almost immediately, we encountered sea snakes with 17 in the space of just seven minutes. This turned out to be a morning dominated by sea snakes. Most individuals appeared to be of the same species, subsequently identified as Spotted Sea Snake *Hydrophis (ornatus) ocellatus* though at the time, it was unclear what they were. There were yet more sea snakes then at about 08:30, the first Streaked Shearwater was seen, shortly followed by another and then much to the excitement of the birders on the trip, a storm petrel – there are several rarely seen species that occur in this area and a Bulwer's Petrel. At this stage, we were still over the edge of the Sahul Banks, in depths of about 70m.

At 09:10 we crossed a thick patch of white snowflake-like material, which on closer inspection appeared to be a flocculating waxy compound, presumed to be a residue from the oil leak. Nearby a couple of dolphins surfaced briefly but weren't identified and a sea snake surfaced in the midst of the wax layer.

There was an obvious surface sheen layer associated with the wax particles and we started to record surface sheen and wax particle density and size systematically throughout the day. In the morning, we were mostly passing through areas of patchy light sheen with small wax particles at varying density but wildlife encounters were almost continual. Every minute or two, we were recording sea snakes, dolphins (including a pod of 14 Bottlenose Dolphins with a calf) and various seabirds. Our first Matsudaira's Storm Petrel was at 12:01, just after we crossed a dense waxy slick (11:47) and then a heavy algal bloom with some wax particles within (11:53). We speculated that the presence of algae was to do with vertical mixing of nutrients along the Sahul Bank edge.

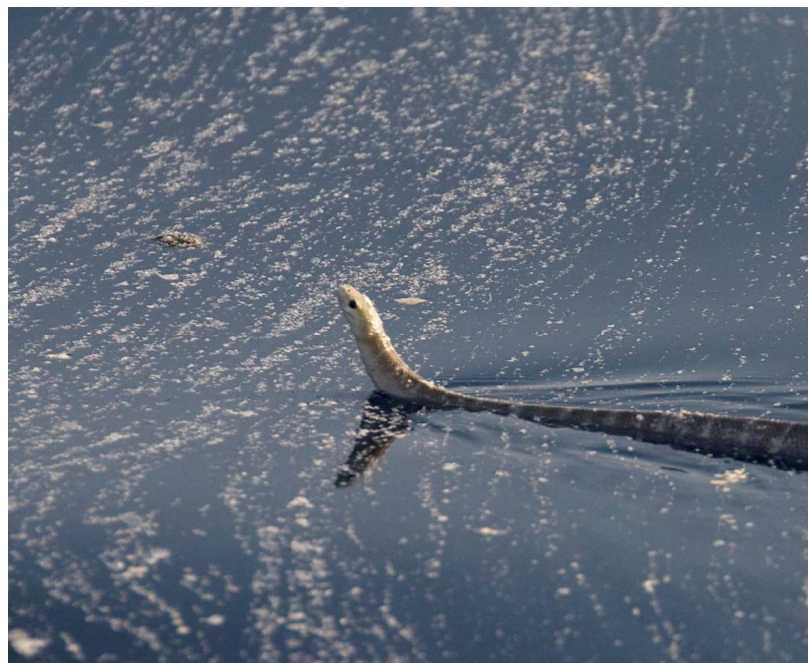


Figure 2: Spotted Sea Snake *Hydrophis (ornatus) ocellatus* surfacing in surface sheen with wax particles.

Our route continued into deeper water in the afternoon and we modified our course slightly to head just north of the Jabiru drilling platform. The weather had improved significantly, making it difficult to assess the nature of oil on water without close inspection of the surface. The sea was like glass but there still appeared to be scattered light sheen with occasional areas of wax particles.

For several hours, we passed through really high densities of feeding tuna. The Captain identified these as 'long-fin' tuna. From time to time, a scan to the horizon with binoculars would see fish leaping almost as far as the horizon in all directions. There were lots of Sooty and Bridled Terns plus we began to record large 'rafting' flocks of Streaked Shearwaters soon after lunch, in flocks of almost 50 birds with Wedge-tailed Shearwaters and occasional Matsudaira's Storm Petrels and Bulwer's Petrels. Dolphins were encountered regularly in

small groups with six unidentified to species at 13:15; a pair of Spinner Dolphins came to the bow at 13:19; and another two unidentified at 13:42. We hit a big patch of algae at 13:46 and coincidentally, about 100 terns (Sooty / Bridled), plus flying fish and Streaked Shearwaters.

At 14:30 we passed through an area of slick more extensive and thicker than we had seen before though surrounding waters were still largely dominated by extensive light sheen and because of the very calm conditions, quite a few birds were resting on the water, including Streaked Shearwaters and Brown Boobies. At four thirty in the afternoon we had our first encounter with Pan-tropical Spotted Dolphins. A pod of 30 lingered around the boat for a short while and were perfectly visible underwater off the bow in the glassy conditions. Half an hour later, another 20 Spinner Dolphins associated with some light sheen and wax particles. Late in the afternoon we reached a series of shoals that rose to about 17m depth and you could see the coral sea floor through the water. Just beyond these was a trench, with drop-offs on the western edge to about 300m. Heading out into this late afternoon we saw relatively little fauna and did not detect oil sheen. This seemed to stop at the shoal-edge, possibly held back by currents to the north. We anchored back in the shoals in amongst distinct oil sheen and wax particles, where we observed several storm petrels including a probably Swinhoe's and Leaches' Storm Petrel, Bulwer's Petrel and feeding terns and tuna. At this point we were only a few miles from the border with Indonesia and it seemed odd to be at anchor 400 miles offshore with no land in site and seabirds, usually confined to abyssal offshore water, drifting by a few tens of metres away, whilst a Hawksbill Turtle fed in the shallows.

I.1.5.4 27th-September 2009

We started a bit after dawn this morning, providing the crew some relaxation time as they had been working nights for some time. We weighed anchor at about 08:00 and headed west off the back of the Jabiru Shoals. The depth sounder showed almost vertical walls to these features and within a mile or so, we were in more than 300m of water. The sea was covered in current lines where mixing and upwelling was occurring and flying fish were abundant. Our first encounter with dolphins was almost immediate: six animals at 08:14, followed shortly after by a widespread pod of about 80 Spinner Dolphins at 08:32, Bottlenose Dolphins at 08:55, more Spinner Dolphins at 09:03 and seven Pan-tropical Spotted Dolphins at 09:07. This pattern remained for most of the day as we followed the edge of the deep water south towards Montara. An Indonesian Iceboat and three tenders were in the distance and appeared to be in Australian waters. Customs advised that they were fishing within legal limits. The oil sheen present at anchor soon gave way to blue water and although we recorded the occasional patch of sheen, it was less extensive overall compared to the previous day. It was speculated that, with the Indonesian Throughflow Current flowing southwest, surface water was likely to be pushed back over the Sahul Banks.

The occasional lone Frigatebird was one of the few we saw during the survey, most being within a day steam from Darwin on the way out. It was noted that Frigatebirds are a particularly useful indicator of the presence of marine mammals – they’d often be seen circling over pods of dolphins. Our path south took us through an area of high abundance for cetaceans but relatively few seabirds, except for regular Matsudaira’s Storm Petrels, Bulwer’s Petrel and the occasional Wilson’s Storm Petrel. Presumably, these birds compete well in this environment where surface nutrients are so low density, they survive by picking small widely scattered scraps.

At 10:38 we encountered a pod of about 20 small dolphins or whales. The cetacean observers lament is that occasionally cetaceans are very inhospitable and surface only occasionally. It was initially thought the animals may have been Rough-toothed Dolphins. Inspection of photos at the time led us to think they were Melon-headed Whales but subsequent scrutiny suggests they could have been Risso’s Dolphins. These are all relatively small cetaceans and can be very inconspicuous. We never saw more than a fraction of the back and dorsal fin, enough to confirm they were not Bottlenose, Spinner or Pan-tropical Spotted Dolphins but not enough to finally confirm a species.

About 11:00 we encountered an area of dense waxy particles. Matsudaira’s Storm Petrels were resting on the water and Pan-tropical Spotted Dolphins surfacing through oil sheen. The abundance of dolphins continued with sightings every half hour to an hour, 21 in all during the day. A single Pomarine Jaeger at midday was a pleasant surprise. Along with the Common Terns we’d been seeing, this is a non-breeding visitor from Siberia.

Shortly after midday, we decided to turn east on account of observers getting a foul taste in their mouths and an acrid turpentine-like smell on the wind, which was not blowing from a southerly direction. Our new survey direction took us between the 5Nm exclusion zones around the Jabiru and Challis floating drill rigs. Two pods totalling about 20 Spinner Dolphins were seen about the same time.

The rest of the afternoon was in similar conditions though we started to encounter more extensive oil sheen and started to see more Sooty Terns and Brown Boobies. At 15:06 we encountered a slick of oil described as “long thin stream, cream with rainbow sheen”. Dolphin pods were seen an hour each side of this (e.g. within about 7 Nm). As we approached the Sahul Banks edge again about 16:00 sea snakes occasionally appeared, with one at 16:30 and another at 17:09. A Frigatebird and Streaked Shearwater were recorded close to a dense patch of waxy particles at 16:49. Wind conditions were starting to increase to a Beaufort force 3 and weather reports for the next day were poor, predicting 25 knots. Sea snake numbers started to escalate significantly around 17:00 as we further approached the Sahul Bank and at 18:06 we reached a thick soft yellow crust of oil and extensive surface sheen. There was a strong smell of oil in the air and, despite the contamination, two groups of 2 and 11 Spinner

Dolphins, numerous Sooty Terns and Sea Snakes were interacting with the oiled surface.

We continued to pass through this area of oil until nightfall. Surface sheen was visible to the horizon. We headed south that night to make anchor in about 50m of water about 5Nm east of the Montara H1 oil leak exclusion zone.

I.1.5.5 28th-September 2009

We began the survey just before 08:00 and made a course on a tangent with the edge of the Montara H1 oil leak exclusion zone. Surface sheen was notably patchy to scattered with little or no evidence of waxy particles until about 10:00. Bird density was quite low, with occasional Streaked Shearwaters and a Lesser Frigatebird but regular small numbers of Sooty Terns. At about 11:00 we started to see long broad slicks in the water, considered to be natural current lines but they too contained oil and occasionally some waxy particles. Despite being in close proximity to the Montara H1 oil leak we found on light sheen throughout this area. We speculated that both a period of northerly winds overnight and the effect of surface currents in the still calm conditions for many days, may have pushed the oil away from our location. Contrary to weather forecasts from the day before, the weather actually calmed towards midday so conditions were again perfect for surveying.

At about 12:00 we started to see quite high densities of small seabirds that characteristically follow current lines to feed, particularly Red-necked Phalaropes, Matsudaira's Storm Petrels and Wilson's Storm Petrels. Common Noddies were particularly abundant in this area as we had not recorded many during the rest of the survey. Flying fish were also abundant and there was a lot of large jetsam and flotsam such as nautilus shells, as well as Blubber Jellies (*Catostylus* sp.) and many surface-dwelling fish. This area appeared to mark a distinct oceanographic boundary as we passed along the outer edge of the Sahul Banks. Once sea snake was seen. Surface sheen throughout the period was extensive to patchy but a light covering.

Our survey track turned to the east as we were forced to begin the journey back towards Darwin. Across the deeper sediments outside the Sahul Banks, the abundance and diversity of seabirds fell and mostly terns occurred in patches, associated with current lines, where we also recorded a prevalence of flying fish. Oil remained patchy to extensive but light sheen for most of the afternoon though with wind conditions increasing, it became more difficult to spot. At 13:35 we stopped for a sample of a slick and by 14:10 were crossing heavier sheen with floating particles at high density.

At 17:35 we arrived close to the edge of the Sahul Banks again, and encountered some moderately thick oil sheen. Diversity and abundance of wildlife increased with the appearance of Matsudaira's Storm Petrel, Common Noddy, Spinner Dolphins (surfacing through slick), Brown Booby, Bulwer's Petrel and three Arctic Jaegers – visitors from Siberia, practising kleptoparasitism, stealing food from terns. At 19:12 we began to see sea snakes

again just before we entered the patch of heavy oil sheen and yellow waxy particles with a strong oil smell at sunset. We were within a couple of miles of the location the day before. At twilight, a Spinner Dolphin was seen leaping through the slick and a pair of Bridled Terns were perched on flotsam.

I.1.5.6 29th September 2009

This was the final day return journey crossing the Bonaparte Gulf. We began about 110 miles east of the Montara H1 oil leak and on sun rise, patches of oil were evident. Several Wilson's Storm Petrels were seen to feed in these. The last area of oil sheen we spotted with any certainty was about 140Nm from the Montara H1 oil leak.

The area seemed quite ecologically productive as we passed some patches of algae, though small waxy particles were present in these. It was speculated that the same processes that concentrate algae into slick lines would also concentrate wax particles and possibly oil. Weather conditions were reasonable for surveying but species abundance was generally low, as was expected from the trip out across the Bonaparte Gulf on the 25th. However, we were sampling slightly west of the drop-off and as we approached it, started to see sea snakes and turtles. The turtles were identified from photos as Flatback Turtles, though other species could also have been present. Also near the edge of the Bonaparte Gulf were two pods of 15 and 17 Spinner Dolphins. Near the end of the day we passed a very thick soupy line of marine algae, brownish in colour and a few dead Caper White migratory butterflies in the surface. This was to add to the increasing list of migratory birds seen on the trip, including numerous birds such as Rainbow Bee-eaters, Fork-tailed Swifts, Oriental Plovers, Sanderling and bizarrely, a female Red-backed Buttonquail.

Figure 3: Survey route map and locations with contours. Note, the drop-offs around the Jabiru Shoals, Sahul Banks and Bonaparte Gulf mark approximate the 100m contour. Three days were spent surveying near the main area of oil effect. Two days were spent either side in transit across the Bonaparte Gulf.

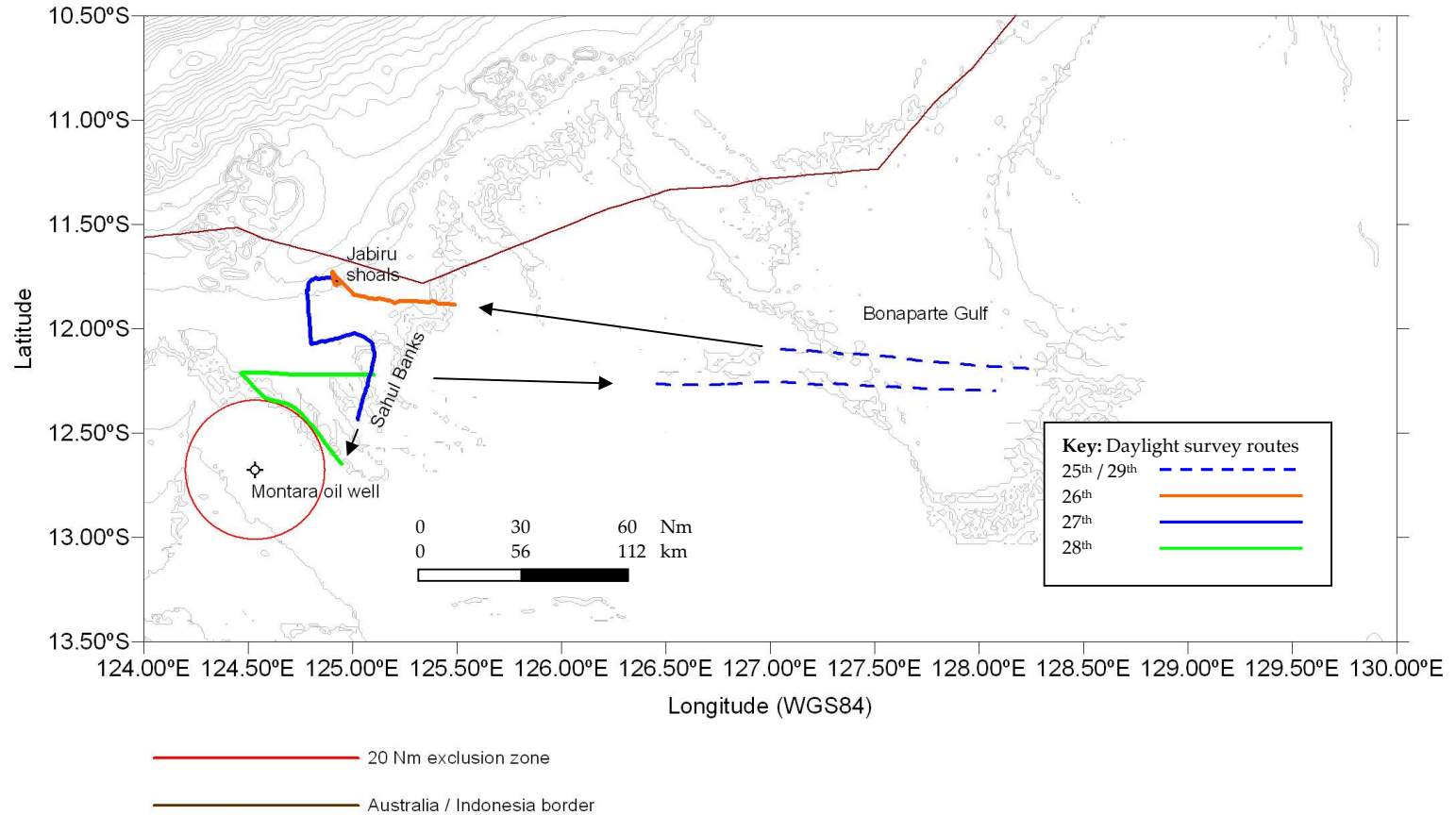


Figure 4: Survey route map and locations, surface relief map

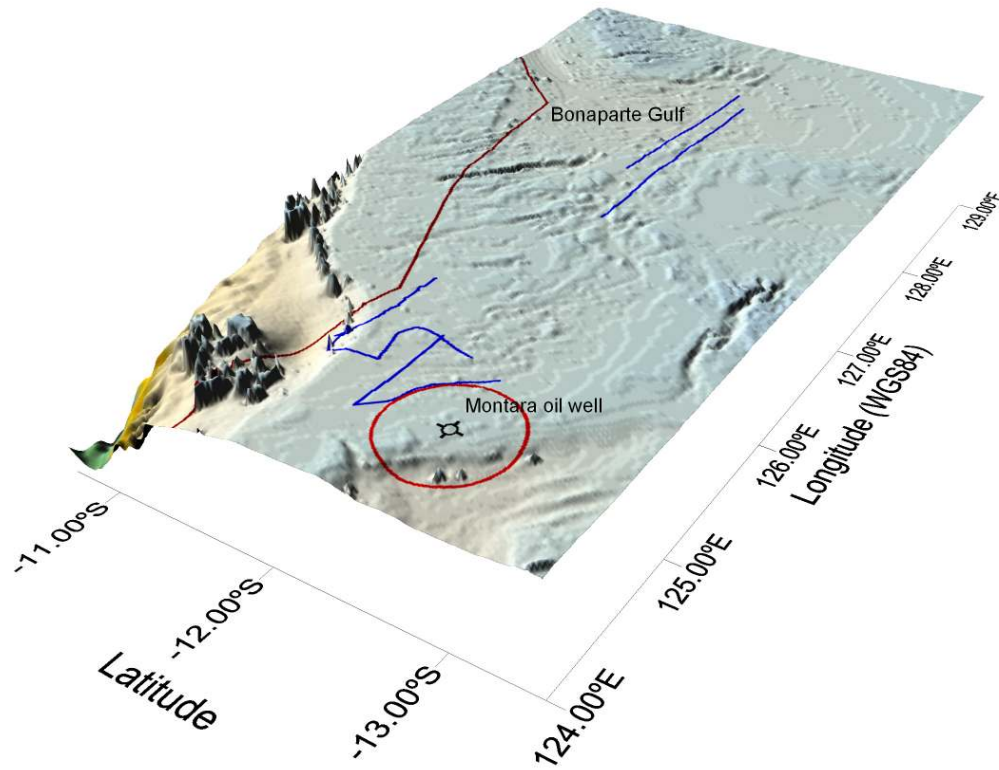
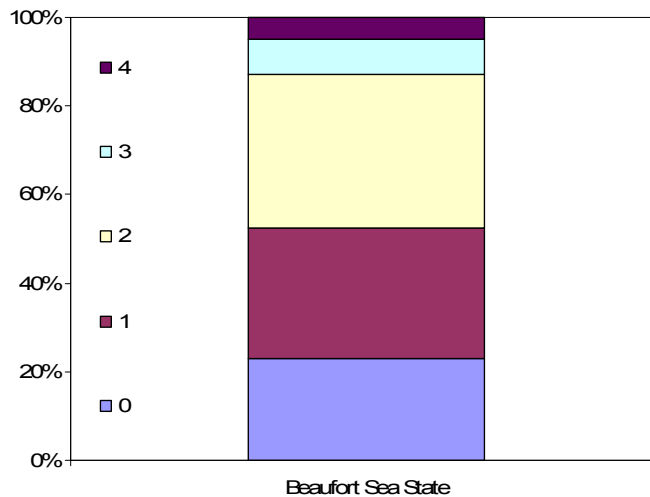
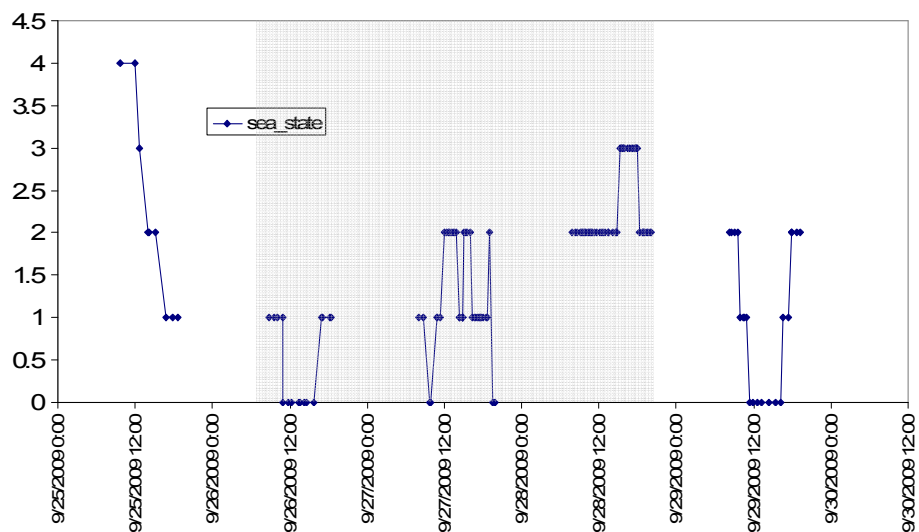


Figure 5: Sea states recorded during the survey measured as the sea state component of the Beaufort Scale. For most of the time spent in the vicinity of the oil slick conditions were ideal for surveying marine fauna (less than Beaufort Sea State 3 for 87% of the time). Shaded area is 3-day period in immediate vicinity of oil leak.



PART II. SURVEY REPORT

II.1 INTRODUCTION

The expedition was from 24 – 30 September but a day each end of the cruise was spent in near-coastal waters. Just over fifty nine hours of observation was completed from the 25 - 29 September covering a distance of about 360 Nm (665 km) including transit to and from the site via the Bonaparte Gulf. This amounts to an average speed of 6.1 knots including stopping time. Speed over ground whilst steaming varied between about 6.5 and 7.5 knots depending on tides and currents. Weather conditions were ideal for surveying (Figure 5).

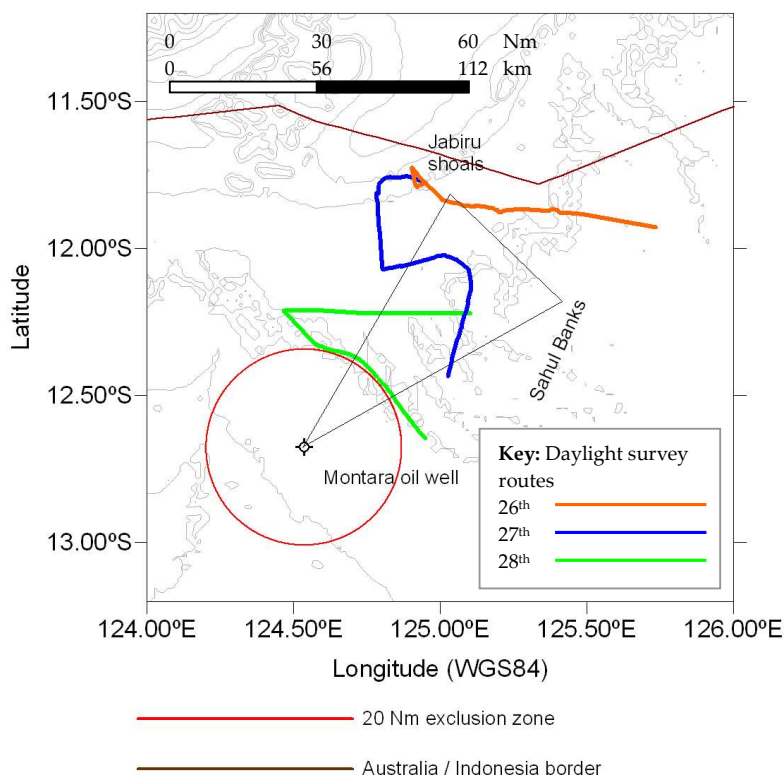


Figure 6: Transects of three-day survey within the vicinity of the oil leak from the Montara Oil leak. The area marked as a triangle is from an Australian Marine Safety Authority (AMSA) Press Release on 3 September titled “Montara Well Head – Observation of Oil Behaviour”.⁴

⁴ AMSA Clean up Continues in the Timor Sea.

http://www.amsa.gov.au/Marine_Environment_Protection/Montara_Well_Head_Platform/2009September_TimorSeaCleanup1.asp 3 September 2009.

Three days were spent surveying in the predicted vicinity of the oil spill from the 26-28 September covering a distance of 204 Nm of transect (Figure 6). The main body of ocean affected by surface oil was about 300 nautical miles (48 hours steaming) from Darwin.

During the period 26-28 September we recorded 17 species of seabird, three species of dolphin, plus another unidentified cetacean (Melon-headed Whale / Risso's Dolphin) and four marine reptiles including one species of sea turtle (Table 1). Eleven of the species are listed migratory on the EPBC Act, or twelve if Spotted Bottlenose Dolphin is included, and one is listed threatened (Table 2). An additional threatened and migratory species, Flatback Turtle, has been included as this was seen on the 29th in a distant area of oil sheen.

Table 1: Marine species observed from 26-28 September.

Species	26-Sep-08	27-Sep-08	28-Sep-08	Total
Arctic jaeger			3 (1)	3 (1)
Booby sp.		3 (1)		3 (1)
Bottlenose Dolphin	14 (1)	16 (2)		30 (3)
Bridled Tern	5 (3)	2 (2)	2 (1)	9 (6)
Brown Booby	3 (3)	11 (8)	5 (5)	19 (16)
Bulwer's Petrel	8 (8)	13 (11)	5 (4)	26 (23)
Common Noddy	3 (2)	1 (1)	43 (16)	47 (19)
Common Tern	3 (3)	1 (1)	5 (2)	9 (6)
Dolphin sp.	39 (7)	57 (10)	4 (1)	100 (18)
Flying Fish	86 (34)	276 (64)	274 (88)	636 (186)
Frigatebird sp.		4 (2)	1 (1)	5 (3)
Leaches' Storm Petrel		1 (1)		1 (1)
Lesser frigatebird			1 (1)	1 (1)
Mahi mahi		1 (1)		1 (1)
Matsudaira's Storm Petrel	5 (5)	10 (8)	11 (10)	26 (23)
Melon-headed Whale / Risso's Dolphin		20 (1)		20 (1)
Pan-tropical Spotted Dolphin	30 (1)	47 (2)		77 (3)
Pomarine jaeger		1 (1)		1 (1)
Red-necked Phalarope			6 (3)	6 (3)
Sea snake sp.	42 (34)	19 (19)	8 (7)	69 (60)
Shark sp.	1 (1)			1 (1)
Sooty tern	55 (28)	64 (32)	57 (27)	176 (87)
Spinner Dolphin	25 (2)	161 (9)	16 (2)	202 (13)
Zebra Shark <i>Stegostoma fasciatum</i>		1 (1)		1 (1)
Storm Petrel sp.	6 (2)	5 (4)		11 (6)
Streaked Shearwater	97 (14)	3 (2)	1 (1)	101 (17)
Swinhoe's Storm Petrel		1 (1)		1 (1)
Tern sp.	223 (14)	13 (7)	4 (4)	240 (25)
Turtle sp.	2 (2)			2 (2)
Wedge-tailed shearwater	8 (5)			8 (5)
Wilson's Storm Petrel	2 (2)	9 (7)	4 (3)	15 (12)
Totals	657 (171)	741 (199)	450 (177)	
Number of species	20	26	18	

Table 2: Listed threatened and / or migratory species recorded during the survey. Note, a Commonwealth Protected Matter search online did not identify species marked with an asterisk. This is further evidence for incomplete baseline biodiversity information for these areas.

Species	Commonwealth Threat Status	Migratory	Notes
Spotted Bottlenose Dolphin <i>Tursiops aduncus</i> (Arafura/Timor Sea populations)		Y	Genetics incomplete. Uncertain whether this was observed in the area.
Hawksbill Turtle <i>Eretmochelys imbricata</i>	Vulnerable	Y	Over the Jabiru shoal. Seen surfacing in oil sheen.
Flatback Turtle <i>Natator depressus</i>	Vulnerable	Y	Mostly well east of the affected area but still within some oil sheen.
Streaked Shearwater <i>Calonectris leucomelas</i>		Y	Locally abundant. Commonly seen on water - seen resting in oil sheen.
*Common Tern <i>Sterna hirundo</i>		Y	Low density - migrating through area.
*Lesser Frigatebird <i>Fregata ariel</i>		Y	Low density - seen feeding in oil sheen.
*Wilson's Storm Petrel <i>Oceanites oceanicus</i>		Y	Relatively widespread, low density - seen feeding in oil sheen.
*Leaches' Storm Petrel <i>Oceanodroma leucorhoa</i>		Y	Uncommon, widespread.
*Red-necked Phalarope <i>Phalaropus lobatus</i>		Y	Uncommon, low density - seen feeding in oil sheen.
*Wedge-tailed Shearwater <i>Puffinus pacificus</i>		Y	Widespread and uncommon.
*Pomarine Jaeger <i>Stercorarius pomarinus</i>		Y	Widespread and uncommon.
*Arctic Jaeger <i>Stercorarius parasiticus</i>		Y	Widespread and uncommon.
*Brown Booby <i>Sula leucogaster</i>		Y	Widespread and common - seen feeding and resting in oil sheen.

II.2 BIOLOGICAL SURVEY

II.2.1 METHODOLOGY

With three days to survey the main body of oil, referenced to satellite images and data from the Australian Marine Safety Authority (section II.3), we aimed for a triangular survey design, as within the time available, this would minimise bias associated with environmental gradients including bathymetry and distance from the oil leak source (Linden et al., 1996). The sampling design had to be modified on 27 September as we were forced to head east to escape fumes originating from the leak to the south (Figure 6). The final survey sampled a wide variety of habitats typical of the region, as evidenced by the range of water depths and bathymetry (see Figure 1 & Figure 3). The closest we approached the Montara H1 oil well was at a distance just beyond the 20Nm (37km) exclusion zone.

Data was entered in real time on a laptop computer running IFAW “Logger” software. Forms for recording sightings, environment and oil effects were customised and all entries stamped with a time, date, latitude and longitude (WGS84). Track data was stored continuously by GPS both in Logger and using Oziexplorer with customised route maps and bathymetry developed in

Surfer 8.0 software based on the Australian Bathymetry and Topography Grid (Commonwealth of Australia, 2005).

High quality optical equipment is particularly important as tropical seabirds in particular, tend to maintain a distance from the vessel. The smaller petrels and storm-petrels are difficult to identify, requiring good views and prior experience. Many of the marine mammals species we expected to see do not routinely bow-ride and both turtles and sea snakes often dive out of sight when vessels approach. Observers used Leica 10x50 BN and 8x50 BA binoculars. A pair of Fujinon 20x150 MT 'Big-Eye' binoculars were erected on deck and used for scanning ahead and whenever distant identification was needed.

II.2.2 SPECIES ACCOUNTS

Species accounts are provided in the following sections for the nine most numerous species, plus sea snakes, identified during the survey of the main oil affected area from 26-29th September. Sea snake data are combined because they were not identified to species at the time. Photographic material was required for confirmation after returning to shore. Three species comprised almost 10% of wildlife observations.

II.2.2.1 [Long-snouted] Spinner Dolphin

Spinner Dolphins are the most widespread and abundant cetacean species occurring on the northwest shelf but appear to be particularly abundant in the Sahul Shelf area.



Spinner Dolphins surfacing in extensive light oil sheen with a high density of small wax particles.

We encountered 202 Spinner Dolphins in 13 pods but 34% percent of cetacean encounters were Spinner Dolphins, so about one third of the unidentified dolphins (114 individuals, 21 encounters) were also likely to be this species.

Eighty percent of all Spinner Dolphin individuals were encountered on the 27 September, including one large pod of about 80 animals in the vicinity of Jabiru Shoals.

Spinner Dolphins are not considered a threatened species and despite being listed as migratory on the Convention on the Conservation of Migratory Species of Wild Animals (CMS), are not listed migratory on the EPBC Act. Along with all other cetaceans, they are afforded general protection under section 238 of the EPBC Act, from interference, killing or injury.

Spinner Dolphins were commonly encountered, particularly over and adjacent to the shoals and the edge of the Sahul Banks. Densities were much higher than in the vicinity of the Bonaparte Gulf and, based on experience of observers in other areas, more abundant than around Ashmore and Scott Reef. There were numerous records of Spinner Dolphins interacting with surface oil (Table 3).

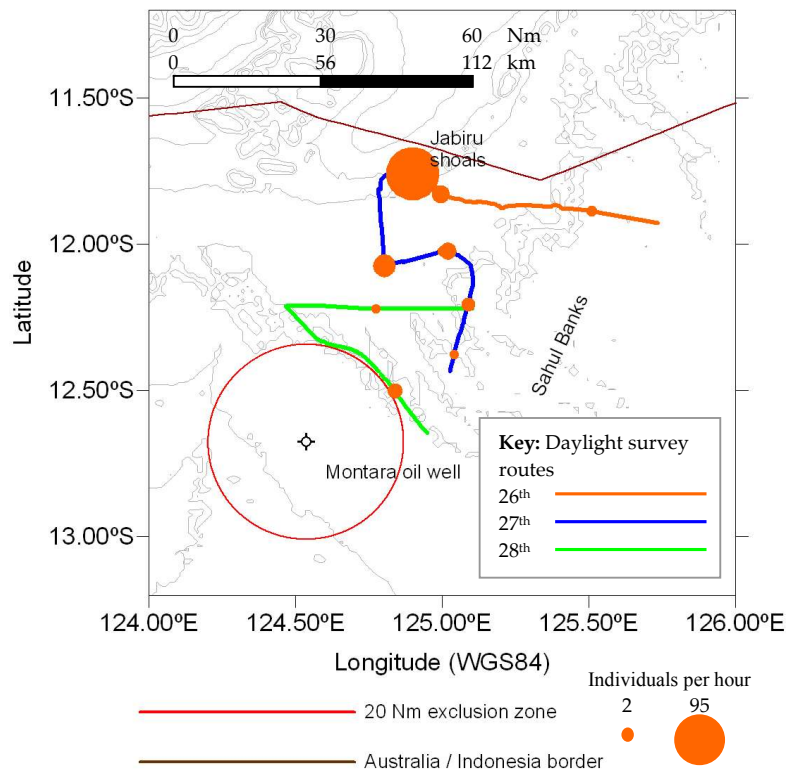


Figure 7: Hourly counts and distribution of Spinner Dolphins. Hourly count range

Table 3: Summary of recorded interactions between Spinner Dolphins and oil slick

Date and Time	Latitude	Longitude	Comment	Number	Oil Behaviour (see key)
9/25/2009 18:20	-12.10747	127.1753		7	Null
9/26/2009 10:44	-11.88351	125.4794		5	Ext, lig, 1
9/26/2009 17:05	-11.80044	124.9598	Dolphins were in slick	20	Ext, lig, 3
9/27/2009 8:32	-11.76101	124.8951		80	Null
9/27/2009 9:03	-11.76061	124.8569		15	Ext, lig, 3
9/27/2009 12:54	-12.06507	124.8024		10	Ext, lig,
9/27/2009 13:16	-12.06967	124.8145	Just before heading change due to strong oil smell	10	Ext, lig, 1
9/27/2009 13:25	-12.06724	124.8259		10	Ext, lig,
9/27/2009 14:48	-12.03757	124.9532	In sheen with particles	5	Ext, lig, 2
9/27/2009 15:56	-12.04024	125.0589	8 mins after thick oil slick	18	Ext, lig,
9/27/2009 18:17	-12.26027	125.075		11	Ext, mod, 2
9/27/2009 19:48	-12.41314	125.03	In fairly heavy oil	2	Ext, mod, 2
9/28/2009 10:28	-12.41809	124.7678	Seen spinning in oil sheen	14	Ext, lig, 3
9/28/2009 17:59	-12.22158	124.8273		2	Ext, lig, 2
9/28/2009 20:16	-12.22114	125.0998	Breaches out of heavy slick as light fades	1+	Ext, mod, 4
9/29/2009 14:19	-12.26286	127.2975		17	Null
9/29/2009 16:13	-12.27713	127.5293		15	Null

Key: KEY: Oil effect: The extent of oil (ext = extensive, pat = patchy, spa = sparse); The weight of surface oil (lig = light, mod = moderate, hea = heavy); The size of wax particles: 1 = small particles:low density ; 2 = small particles:high density ; 3 = large particles:low density ; 4 = large particles:high density

II.2.2.2 Sooty Tern

Sooty Terns are only common in the remote tropical offshore environment. They breed on islands including Ashmore Reef usually starting in about October / November but this varies(Higgins, 1996; Mustoe & Edmunds, 2008). Juvenile birds were seen twice on the survey, suggesting that some locally breeding birds had begun a few weeks earlier.



Sooty Tern. Chris Sanderson, for WWF-Australia. Photograph taken whilst in an area of extensive to patchy light sheen with small low density wax particles.

Sooty terns were the most abundant seabird recorded with 176 individuals and 87 encounters, though a large proportion of the 240 unidentified terns were also likely to be this species. They are very similar at a distance from Bridled Terns, a migrant which was passing through the area during the survey.

Sooty terns associate strongly with tuna on which they depend to drive prey to the surface (Au et al., 1986; Brooke et al., 2006). During the survey, Sooty Terns were seen most often with schools of tuna, particularly on the 26th September to the east of the Jabiru oil well.

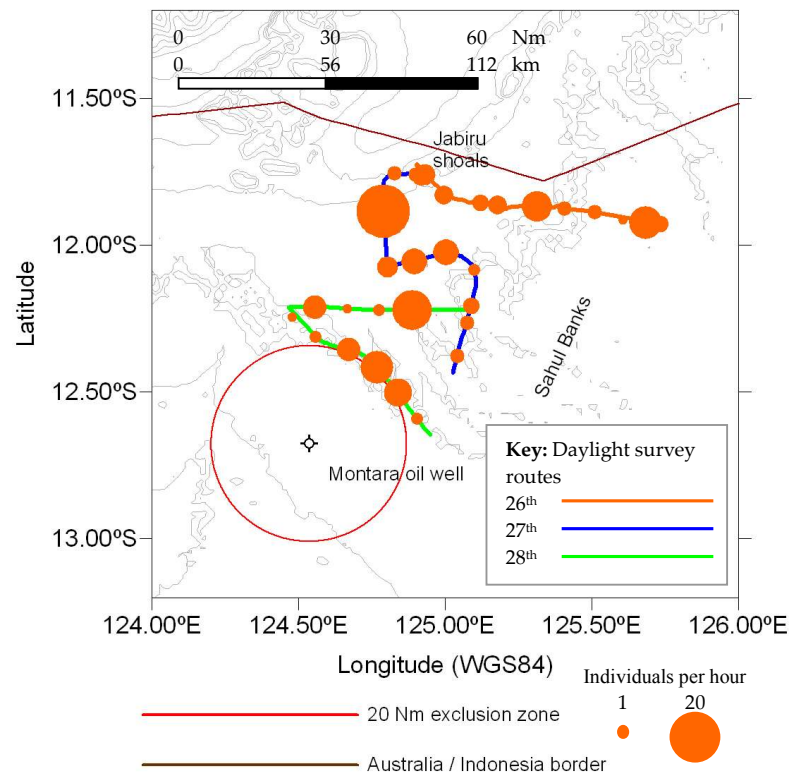


Figure 8: Hourly counts and distribution of Sooty Terns.

Sooty Terns forage by dipping and diving into the water for fish, so they regularly come into contact with the surface. They were often seen foraging in areas with oil sheen. Figure 9 represents the number of Sooty Terns recorded against observations of the amount of surface sheen (section II.3.6). This shows that 84% of encounters were in areas with some surface sheen. The graph also compared the time spent in different categories of oil behaviour compared to the number of Sooty Terns seen. Compared to the distribution of oil, fewer than expected Sooty Terns were seen in areas with no oil sheen and moderate oil sheen than in areas with light oil sheen.

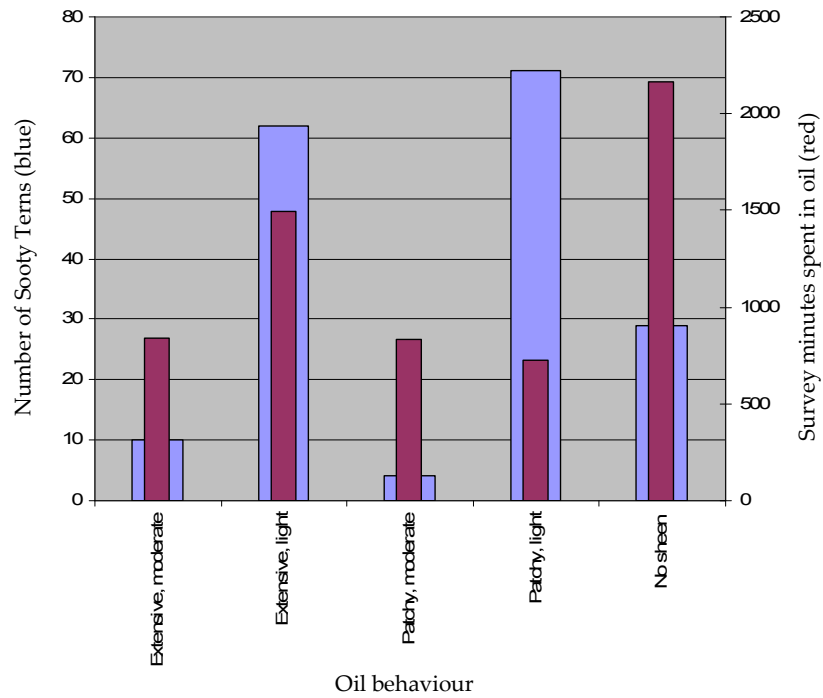


Figure 9: Number of Sooty Terns recorded in surface oil of different extent and surface weight (for methods, see section II.3.6).

II.2.2.3 Streaked Shearwater

Locally abundant but widespread along the Sahul Shelf edge. Streaked Shearwater breeds in Japan, Russia and eastern China. Wintering birds off Australia arrive in about September and return to breeding grounds in about May.



Streaked Shearwaters taking off, with a Wedge-tailed Shearwater in the foreground. Kara Burns Photography, for WWF-Australia. This was in a period of scattered light oil sheen with small low density wax particles.

With 101 individuals recorded, this was the second most abundant sea bird but we had only 17 encounters. Streaked Shearwaters were seen to gather in large flocks east of Jabiru platform on the 26th, in the same area we observed masses of feeding tuna and Sooty Terns. One flock of 28 and another of 36 were seen rafting on the water.

Streaked Shearwater is listed migratory on the EPBC Act.

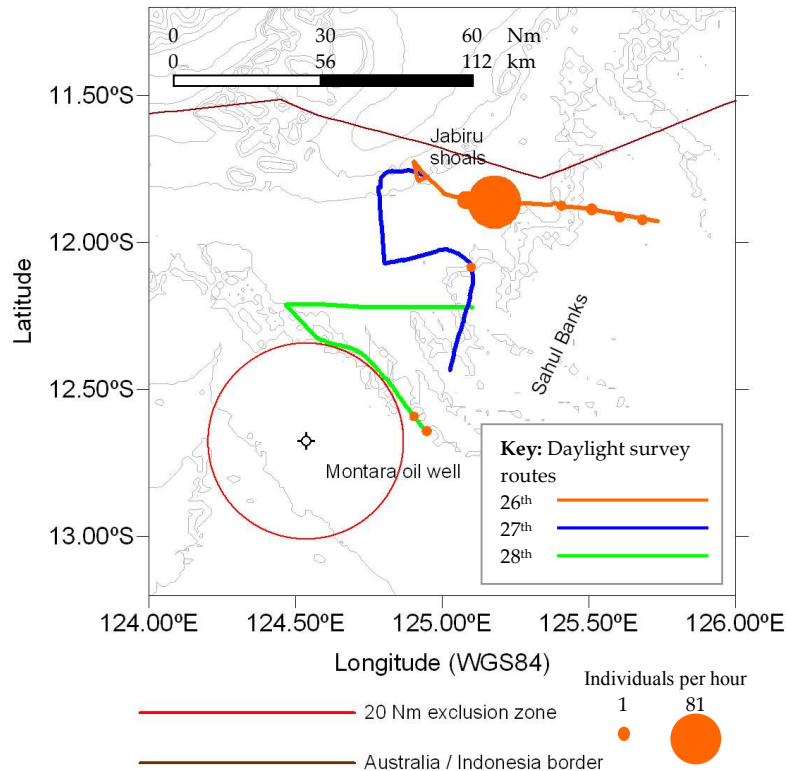


Figure 10: Hourly counts and distribution of Streaked Shearwaters.

II.2.2.4 Pan-tropical Spotted Dolphin

A widespread but infrequently seen tropical water species, most often associated with deep water off the northwest shelf.



Pan-tropical Spotted Dolphins. Deb Glasgow, for WWF-Australia.

A total of 77 animals in three separate encounters were seen. These were mostly in the vicinity of Jabiru Shoals. They are not listed migratory on the EPBC Act. Along with all other cetaceans, they are afforded general protection under section 238 of the EPBC Act, from interference, killing or injury.

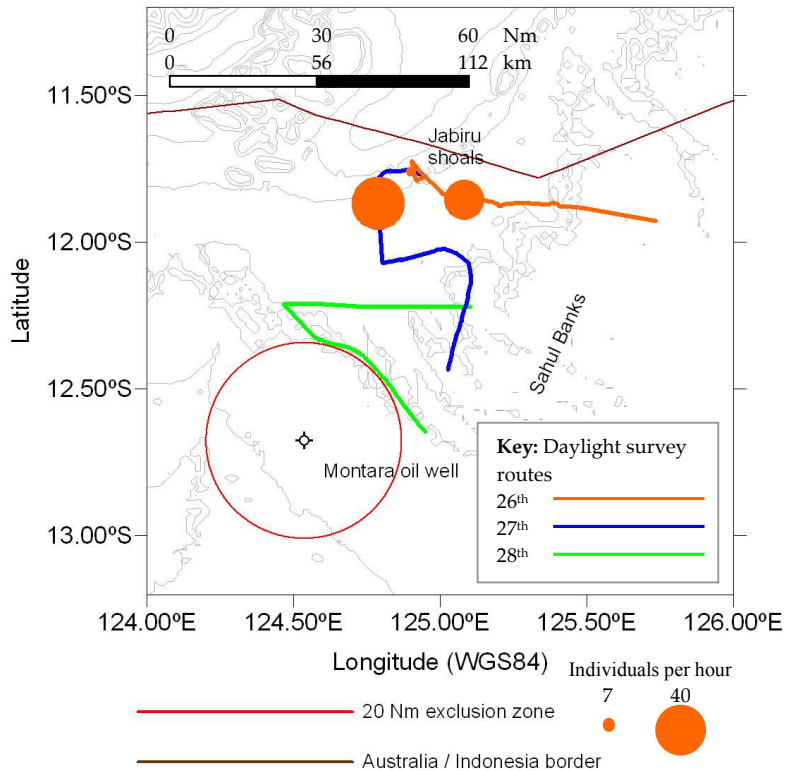


Figure 11: Hourly counts and distribution of Pan-tropical Spotted Dolphins.

II.2.2.5 Common Noddy

Common Noddies were notably more mostly found near the edge of the 20 Nm exclusion zone than anywhere else during the survey. They breed on nearby Ashmore Reef but their dispersal at sea is poorly known.



Common Noddy. Kara Burns Photography, for WWF-Australia. This was photographed in a period of extensive to patchy light oil sheen with occasional areas of small low density wax particles.

Forty-seven individuals were seen over 19 encounters. Most birds were flying past, though one group of 11 was noted feeding on the 28th in the vicinity of patchy light oil sheen with some areas of unweathered oil. As with other terns, they regularly make contact with the sea, dipping and diving to take prey and are vulnerable to oiling.

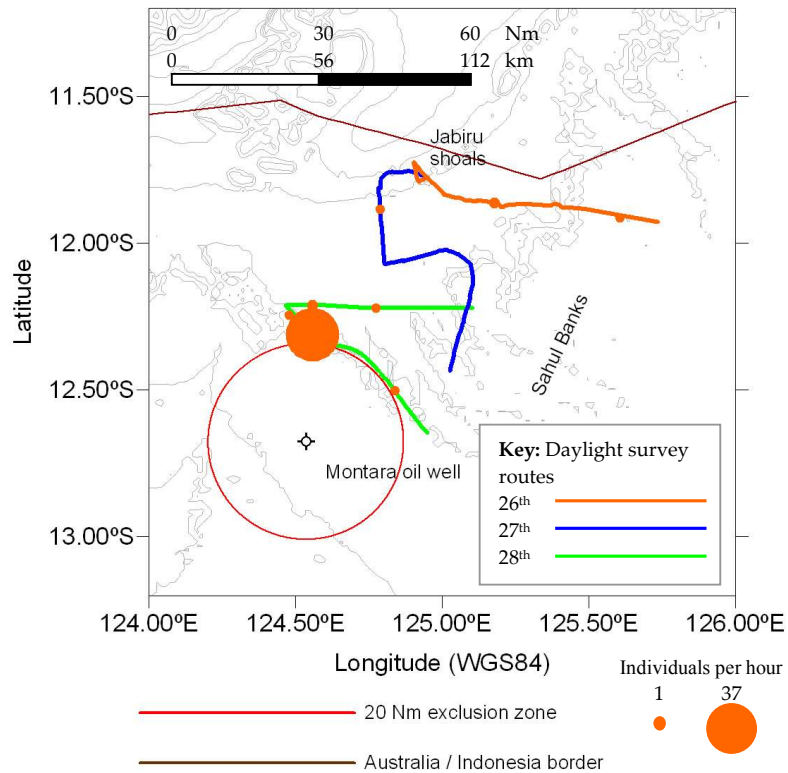


Figure 12: Hourly counts and distribution of Common Noddy.

II.2.2.6 Bottlenose Dolphin

Three pods of Bottlenose Dolphin were seen, totalling 30 individuals. These were mostly at the edge of the Sahul Banks and near Jabiru Shoals.



Bottlenose Dolphin. Chris Sanderson, for WWF-Australia. Note, at least two bottlenose and a spinner dolphin showed signs of emaciation, though other animals appeared healthy. This pod was in an area of extensive light sheen with large, low density wax particles.

Due to taxonomic uncertainties, it is virtually impossible to know if Bottlenose Dolphins in any given area represent a given species. Increasingly, genetic work is finding distinct populations and in some cases, potentially new species e.g. in South Australia, Shark Bay and Melbourne’s Port Phillip Bay (Ross, 2006).

The Commonwealth refers to Spotted Bottlenose Dolphin *Tursiops aduncus* of the Arafura/Timor Sea and this may include this species. The Commonwealth offer no advice on the precise range or identification of such individuals. During the survey we saw what we regarded as being two ‘types’ of bottlenose dolphin. Animals over the Sahul Bank were only moderately sized, compared to larger and more heavily marked ‘offshore’ types in the trench to the north.

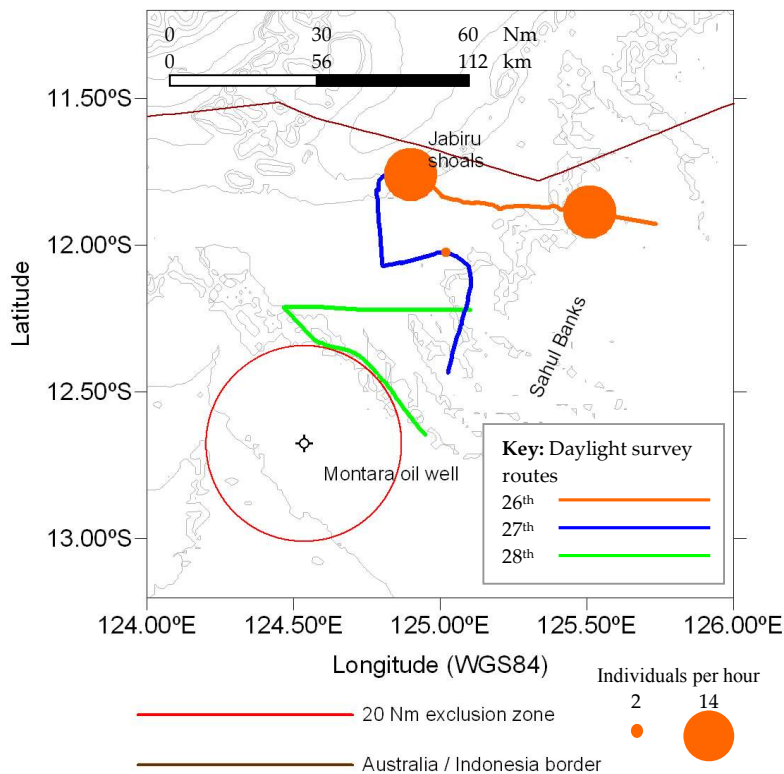


Figure 13: Hourly counts and distribution of Bottlenose Dolphins.

II.2.2.7 Brown Booby

A common and widespread species and one of the more common breeding birds at Ashmore Reef. The largest colonies in the world are in the Kimberley on the Lacapedes (~17,000 nests).



Brown Booby. Seen taking off in the vicinity of light oil sheen.

Like other boobies, Brown Booby is likely to be limited to foraging within relatively close range of breeding colony. At any time of year however, there are expected to be non-breeders at sea and post-breeders. For example, at least one juvenile was seen during the survey, suggesting that nesting is drawing to a close in some cases.

Nineteen Brown Boobies were seen in 16 encounters but the largest groups were in the Bonaparte Gulf. Brown Boobies feed by diving directly into the water and also commonly rest on the surface. Two individuals were seen taking off from within oil sheen. This species is likely to be vulnerable to oil contamination.

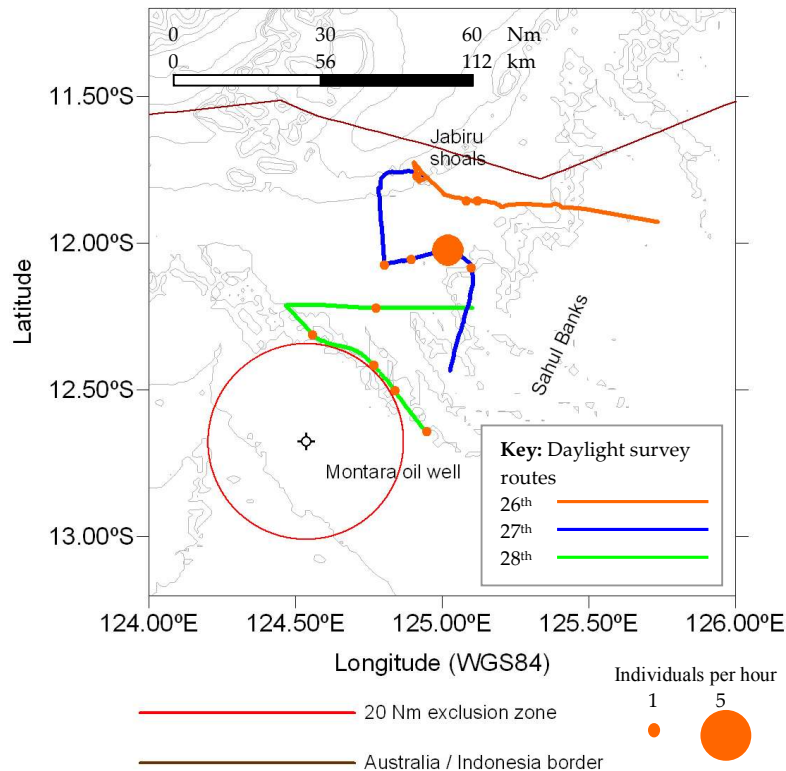


Figure 14: Hourly counts and distribution of Brown Booby.

II.2.2.8 Bulwer’s Petrel

The fifth most common seabird with 26 individuals in 23 encounters was Bulwer’s Petrel, a migrant to Australian waters from Japan and eastern China until about May.



Bulwer’s Petrel. Chris Sanderson, for WWF-Australia. Seen in an area of extensive light oil sheen.

Bulwer’s Petrels are a highly pelagic tropical seabird, most often seen at low density in relatively nutrient-poor areas. Despite being a long-distant migrant

it is not listed on the EPBC Act. It is a regular migrant to Australian waters (Marchant & Higgins, 1990).

Like other tropical 'petrels' and 'storm-petrels', Bulwer's are likely to forage by picking small particles from the surface, which may make this species prone to contamination from oil particles. It also commonly rests on the water during still periods. This was observed on several occasions.

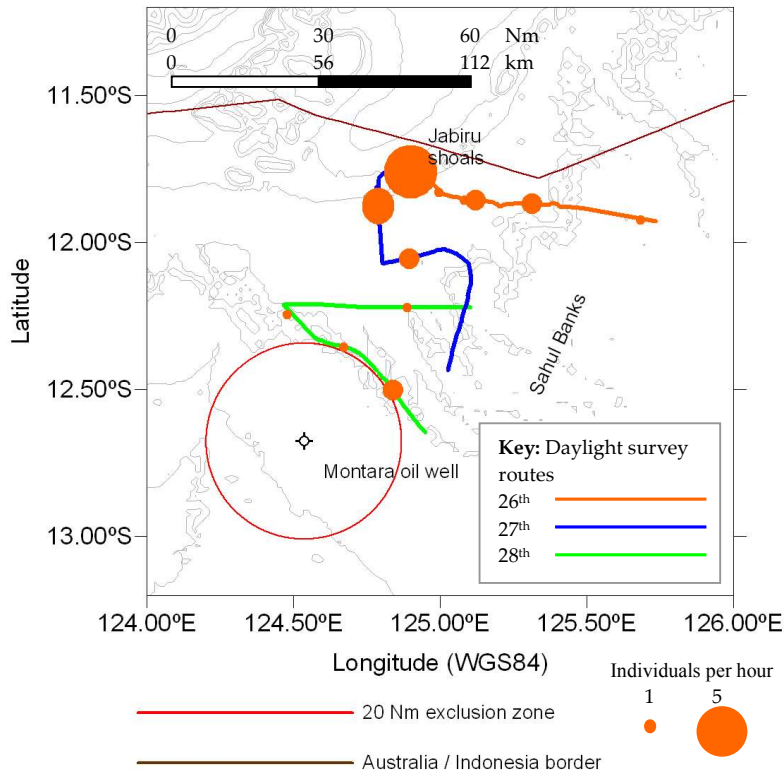


Figure 15: Hourly counts and distribution of Bulwer's Petrels.

II.2.2.9 Matsudaira's Storm Petrel

Matsudaira's Storm Petrel is a migrant from remote islands off southern Japan and returns to breed in December / January. It is extremely rare in Australia beyond the outer regions of the north west shelf and has an estimated world population of just 20,000 individuals (BirdLife International, 2004).



Matsudaira's Storm Petrel. Kara Burns Photography, for WWF-Australia. Seen in an area of extensive, light oil sheen.

Twenty-six individuals were seen in 23 encounters over three days. The species was not seen at all in the Bonaparte Gulf. Core distribution was split between the deep water southwest of Jabiru Shoals and the Sahul Bank edge north of the Montara oil field exclusion zone on the 28th. Most of the birds seen on this day were foraging along a slick line comprising light sheen as well as algae and a number of other pelagic birds including Red-necked Phalaropes. The encounter rate of 26 birds in 59 hours (0.44 birds/hr) is slightly higher than 20 birds seen in 61 hours (0.33 birds/hr) south of Ashmore Reef in 2004⁵ and less than the 50 birds seen in 64 hours (0.78 birds/hr) in 2008⁶.

Like Bulwer's Petrel and the other Storm-Petrels seen during the survey (Wilson's Storm Petrel, Leaches' Storm Petrel and possible Swinhoe's Storm Petrel), they forage by dipping onto the surface, picking up small particles. Several times, birds were seen resting on the water in calm weather. These behaviours are likely to make the species prone to oil contamination.

⁵ http://www.ecology-solutions.com.au/ashmore_reef/ashmore_reef.htm

⁶ http://www.ecology-solutions.com.au/2008%20ASHMORE%20REEF/species_list.html

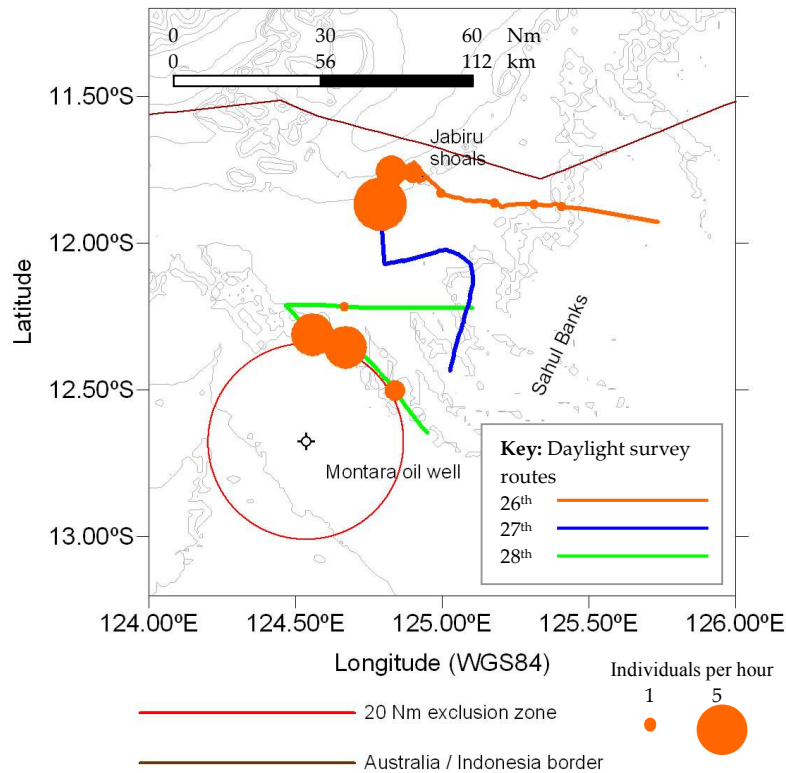


Figure 16: Hourly counts and distribution of Matsudaira’s Storm Petrels.

II.2.2.10 Sea Snakes

A higher diversity of sea snakes occurs in northern Australia than anywhere else in the world (Heatwole, 1999). The northwest shelf has about 16 species (Heatwole et al., 1994) with thirteen having been recorded from Ashmore Reef alone, including three local endemics (Australia, 2002). All Australian sea snakes are permanently marine so they never visit land even to breed.



Sea snakes, from left to right, Spectacled Sea Snake *Disteira kingii*, Spotted Sea Snake *Hydrophis (ornatus) ocellatus*, Olive-headed Sea Snake *Disteira major*. Chris Sanderson, for WWF-Australia.

We recorded 69 sea snakes of three species: Spotted Sea Snake *Hydrophis (ornatus) ocellatus*, Olive-headed Sea Snake *Disteira major* and Spectacled Sea

Snake *Disteira kingii*. Photographic reference material brought back to shore was necessary for expert identification of Spotted Sea Snake.

Each species occurred in 'patches', most likely corresponding to particular benthic habitat types (Heatwole & Cogger, 1994). Our observations were also consistent with the fact that sea snakes appear to be limited to feeding at depths of less than about 100m (Heatwole, 1975). This explains the pattern of distribution at the edge and over the Sahul Banks. The greatest density was observed at the beginning of the 26th, when 42 sea snakes were seen in 34 encounters.

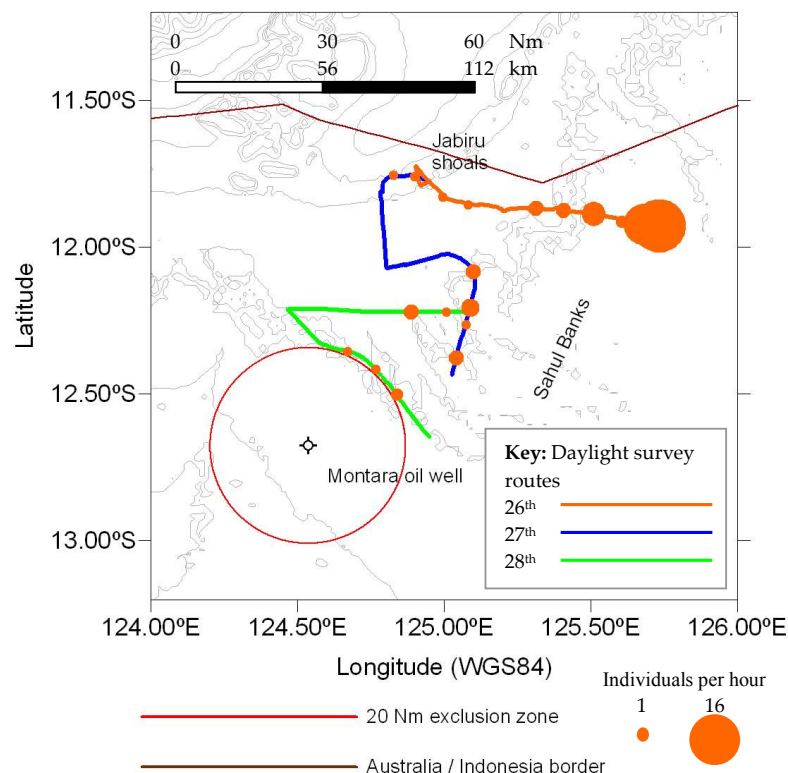


Figure 17: Hourly counts and distribution of sea snakes.

II.2.3 SUMMARY AND DISCUSSION

This was only a three day survey at one particular time of year. Density of animals and species list will vary seasonally and more species would be found if a longer-period survey was done.

Marine mammals occurred at high density in some areas. A total of nearly 430 individuals were encountered in 38 separate sightings of which 21 were on the 27th in the area between Jabiru Shoals and north east of the exclusion zone (

Figure 4). Forty-seven percent of individuals were Spinner Dolphins *Stenella longirostris*, 18% Pan-tropical Spotted Dolphins *Stenella attenuata*, 7% Bottlenose Dolphins *Tursiops sp.*⁷ and the rest unidentified. In addition to these species, at least ten other species are likely to be present.

Five species of marine reptile were seen in 83 encounters. Sea snakes are a particularly important and conspicuous component of the northwest shelf's biodiversity. This area of the north west shelf has more species than anywhere else on earth. With some expert advice and reference material e.g. Cogger, 2000; Wilson, 2005; Wilson et al., 2005 we were able to identify three species: *Disteira major*, *D. kingii* and *Hydrophis (ornatus) ocellatus*.

Only two species of sea turtle were positively identified. At least one Hawksbill Turtle *Eretmochelys imbricate* was surfacing near the vessel at anchor on Jabiru Shoals on the evening of the 26th and several Flatback Turtles *Natator depressus* were seen feeding well east of the Sahul Banks on the 29th.

Fourteen species of seabird were recorded during the survey. The most numerous of these in descending order of abundance were Sooty Tern *Onychoprion fuscatus*, Streaked Shearwater, Common Noddy *Anous stolidus*, Brown Booby *Sula leucogaster*, Bulwer's Petrel and Matsudaira's Storm Petrel. Only three of the 17 species recorded breed at Ashmore Reef and Cartier Island National Nature Reserves. Other species that breed on those islands such as Red-footed Booby are likely to be restricted to within about 100km of the nest during the breeding season which may explain why they were not recorded during this survey (Jaquemet et al., 2005; Marchant & Higgins, 1990). A number of other species including Brown Boobies and Sooty Terns are also breeding at this time of year and may also be expected at relatively low densities far from breeding colonies.

The majority of birds are migratory and most of them (10 species) are listed migratory. The two most common migratory species: Bulwer's Petrel and Matsudaira's Storm Petrel are visitors from breeding islands near Japan and off the coast of eastern China. These birds, though known to occur in this area for many years (Cresswell, 1987; Marchant & Higgins, 1990), are yet to be listed as migratory on the EPBC Act. There is missing knowledge and incomplete listing for much of Australia's marine wildlife. Notably, these species, along with most of the birds that occur commonly in the affected area are will not come ashore at Ashmore or other islands in the Kimberley.

II.2.3.1 Distance Sampling Results

One of the objectives of the survey was to establish whether the density of sea snakes or turtles was within densities predicted in AES, (2009). A rough calculation suggested that sea snakes could occur at densities between 2.0 – 5.0 per km² and sea turtles at 1.1 – 2.8 per km². This was based on some simple

⁷The genetics of bottlenose dolphins is incomplete, see section II.2.2.6.

'rules of thumb' regarding detection at sea and data on encounter rate in other parts of the northwest shelf.

During the survey we gathered Distance Sampling data (Buckland et al., 1993; Bibby et al., 2000; Mustoe et al., 2005; Fasham et al., 2005), measuring angle and bearing to sea snakes and sea turtles. Data for marine mammals was also collected and analysed for interest. Sea turtles were recorded too few times for analysis, so only sea snake data is shown here. From these data, we have derived a detection probability curve and adjusted our sightings for sea snakes overlooked with distance from our cruise track line. The analytical method is shown in Appendix 2. These data were collected from 25-29th September so are likely to under not over-estimate densities, as the results include areas of relatively low sea snake and marine mammal encounter rate in the Bonaparte Gulf.

The density estimates shown here are only indicative of our survey route. To extrapolate densities to a wider area would require a more rigorous sampling design. Therefore, these results should only be interpreted in accordance with the objective, which is to test these results against predictions.

On our track lines, the density estimate of sea snakes was 29.3 ± 12.5 sea snakes per square kilometre. This is much higher than the range of 2.0 – 5.0 per km² published in AES (2009). This is not surprising as the frequency of sea snakes encountered was much higher than in trips south of Ashmore Reef.

Analysis of data for dolphins determined a density of approximately 2.6 cetaceans per square kilometre of our track line surveyed.

Conversely, sea turtles appear to occur at very low density within the affected area and very likely much lower than the estimates predicted in AES (2009).

II.3 DESCRIPTION OF OIL EFFECTS

II.3.1 BACKGROUND INFORMATION

The Australian Marine Safety Authority (AMSA) website⁸ contains information regarding the potential behaviour of oil. In summary:

- Oil, depending upon its form and chemistry, causes a range of physiological and toxic effects;
- Low molecular weight aliphatics of oil can have anaesthetic properties and aromatic components such as benzene are known carcinogens and very toxic to humans and wildlife. Volatile components of oil can burn eyes, burn skin, irritate or damage sensitive membranes in the nose, eyes and mouth. Hydrocarbons can trigger pneumonia if it enters lungs. Benzene, toluene and other light hydrocarbons of oil and fuels if inhaled, are transferred rapidly to the bloodstream from the lungs and can damage red blood cells, suppress immune systems, strain the liver, spleen and kidneys and even interfere with the reproductive system of animals and humans;
- Some oils will become more "sticky" as they weather and have a greater tendency to adhere to surfaces such as animal skins, fur, hair or feathers; and
- Some liquid oils will form solid waxes very quickly after only a few hours of weathering at sea, others will leave little residue and other oils may contain high levels of persistent hydrocarbons.

Some information regarding the likely behaviour of the crude oil is also contained in the preliminary documentation advice provided to the Commonwealth for approval of the development (URS Australia, 2003).

In previous studies in the Timor Sea the light Australian crude oils commonly found in the region usually weather to less than 20 per cent of the initial discharge within 7 to 10 days. In this case however the analysis of Montara crude supplied by Newfield shows a wax content of approximately 11 percent which is likely to result in some "moussing" of the oil and hence a reduction in the evaporation.

In a press release on 3 September AMSA identified three areas of oil concentration emanating from the leak (Figure 18). Area A, marked by a blue circle is the main areas of containment or recovery and has dispersant spraying operations and about 100% coverage of oil sheen, heaviest to about 5 Nm from the well head. Area B has about 50% coverage of sheen and area C about 10% coverage.

Most of the surface oil we encountered during our survey overlaps with Area C and Area B. We did not survey Area A as it was within the exclusion zone.

⁸ The Effects of Maritime Oil Spills on Wildlife including Non-Avian Marine Life
http://www.amsa.gov.au/Marine_Environment_Protection/National_Plan/General_Information/Oiled_Wildlife/Oil_Spill_Effects_on_Wildlife_and_Non-Avian_Marine_Life.asp

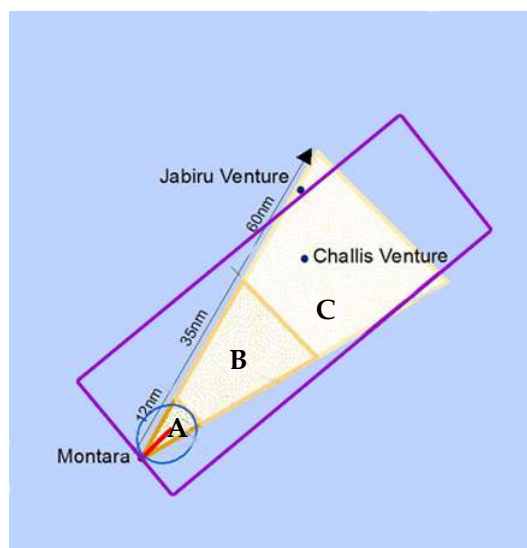


Figure 18: Oil behaviour map published by AMSA in a Press Release on 3 September titled “Montara Well Head – Observation of Oil Behaviour” (see Figure 6 for this overlaid with our survey route).

AMSA has been spraying dispersant since the leak began, mostly at a distance of 2-5Nm from the source of the leak. According to their published figures (Figure 19) as of 19 October 2009, over 150,000 litres of dispersant has been applied. Up until the 22 October 2009, the leak had been running for 62 days with estimates of 300-400 barrels per day leaking into the surrounding water, equivalent to about 403,000 litres. Data on the magnitude, intensity and duration of the leak are summarised in Table 4.

Table 4: Magnitude and duration of the leak.

Magnitude	<ul style="list-style-type: none"> ▪ It has been reported that 300 – 400 barrels of oil per day are leaking from the well head⁹. ▪ Seasonally high temperatures are creating conditions for evaporation. ▪ About 50 tonnes of dispersant was deployed initially. Total dispersant deployed by 19 October was about 150,500 litres. ▪ Dispersant is mostly being applied within 2-5Nm of the well head in a northeast direction. ▪ The cumulative amount of oil at 400 barrels per day since the leak began on the 21st August (by 9th October) would be 62 days x 400 barrels = 25,200 barrels (1 tonne = 7.33 barrels¹⁰), 3,437 tonnes or 403,160 litres.
Spatial Extent	<ul style="list-style-type: none"> ▪ AMSA reported a rectangular area approx. 28 km to the north and 112 km to the east of the rig increasing to dimensions of 25 x 70Nm (6,000 km²)

⁹ Questions to the Senate from Senator Siewert to Minister Wong concerning the figure of 300-400 barrels of oil per day (7th September 2009). No confirmation was able to be given about whether this figure was accurate or not. The figure of 400 barrels was confirmed by PTTE P Australasia in a press release to Channel 7 news on 12 September (<http://au.news.yahoo.com/a/-/australian-news/6025670/four-weeks-till-oil-leak-under-control/>) though it has also been reported that the ‘spilling oil appear[s] to be diminishing’ (<http://www.news.com.au/story/0,27574,26064788-29277,00.html>)

¹⁰ <http://www.bp.com/conversionfactors.jsp>

	<ul style="list-style-type: none"> On Saturday September 12th, news reports indicated that the company, PTTEP Australasia, anticipated that it would take up to four weeks to have the oil under control and that the current size of the slick was about 46 km wide and 130 km long (6,000km²). MODIS satellite data imagery from SkyTruth indicates that the slick has ranged from at least 10-25,000km² in size. The area affected by oil is changing over time. This is important, as over time, the spatial area affected in terms of the distribution of animals may be larger than any given 'snapshot'. Patches of oil were detected during our surveys at about 140Nm from the leaking well. These could be emanating from the Montara H1 well leak. If so, this indicates that the geographic range of oil surface sheen coverage over the full period of the leak may be larger than the higher estimates from satellite imagery. Waxy residues are likely to take continued time to weather.
Duration	<ul style="list-style-type: none"> 62 days from 21 August to 22 October 2009. Ongoing.

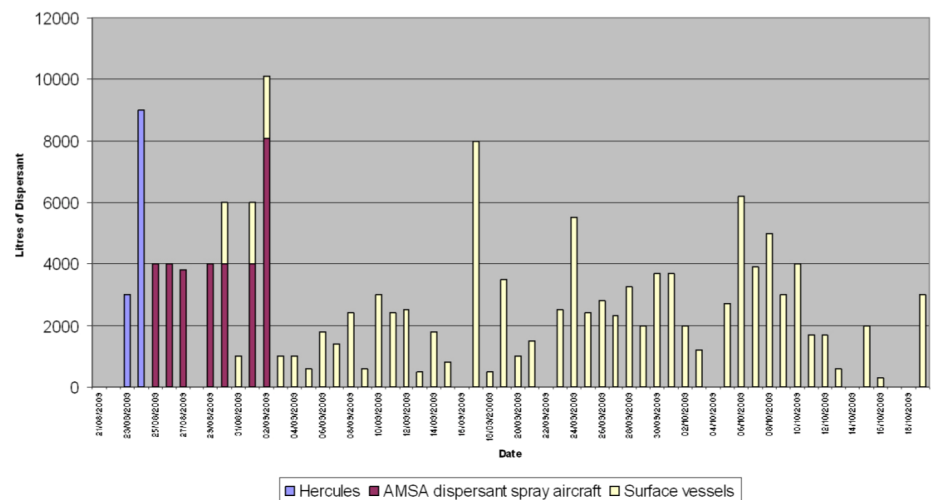


Figure 19: Dispersant use summary from AMSA up to 11 October 2009¹¹

II.3.2 SATELLITE IMAGES

Satellite images showing the extent of the slick were available online from SkyTruth for the 17th and 24th September. An approximate outline of the area of oil slick is shown for these days in Figure 20. These helped us position our survey transects and give an impression of the possible wider geographic coverage of surface sheen. From these images, it has been suggested that surface sheen could have extended to about 15,000km².

¹¹ http://www.amsa.gov.au/Marine_Environment_Protection/Montara_Well_Head_Platform/Media/Dispersant-table.pdf

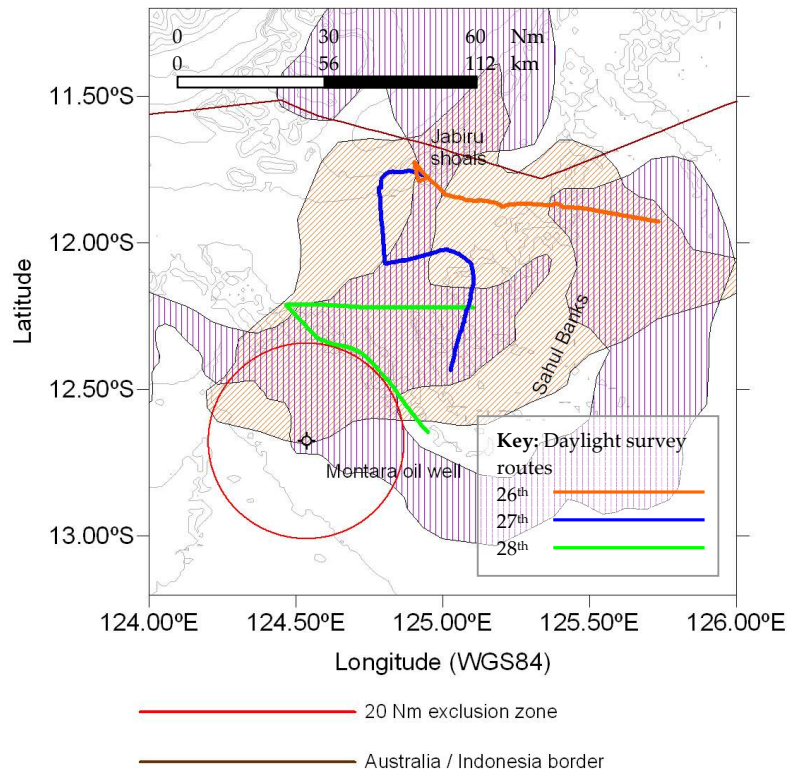


Figure 20: Survey transects and apparent extent of oil sheen visible from MODIS satellite images on SkyTruth¹² (orange diagonal hatching = 3 September; purple vertical hatching = 17 September). Note, without ground-truthing, these images are only used as a guide.

Three other images are available, two from the 24th of September, just before we embarked on the trip, and another from the 28th September. The images from the 24th are from Skytruth. The first MODIS Terra image indicates a footprint size of about 25,000 km², though it is noted that the full extent can only be seen if there is 'sunglint'. Satellite images therefore have to be interpreted with care.

¹² SkyTruth's photostream: <http://www.flickr.com/photos/skytruth/>

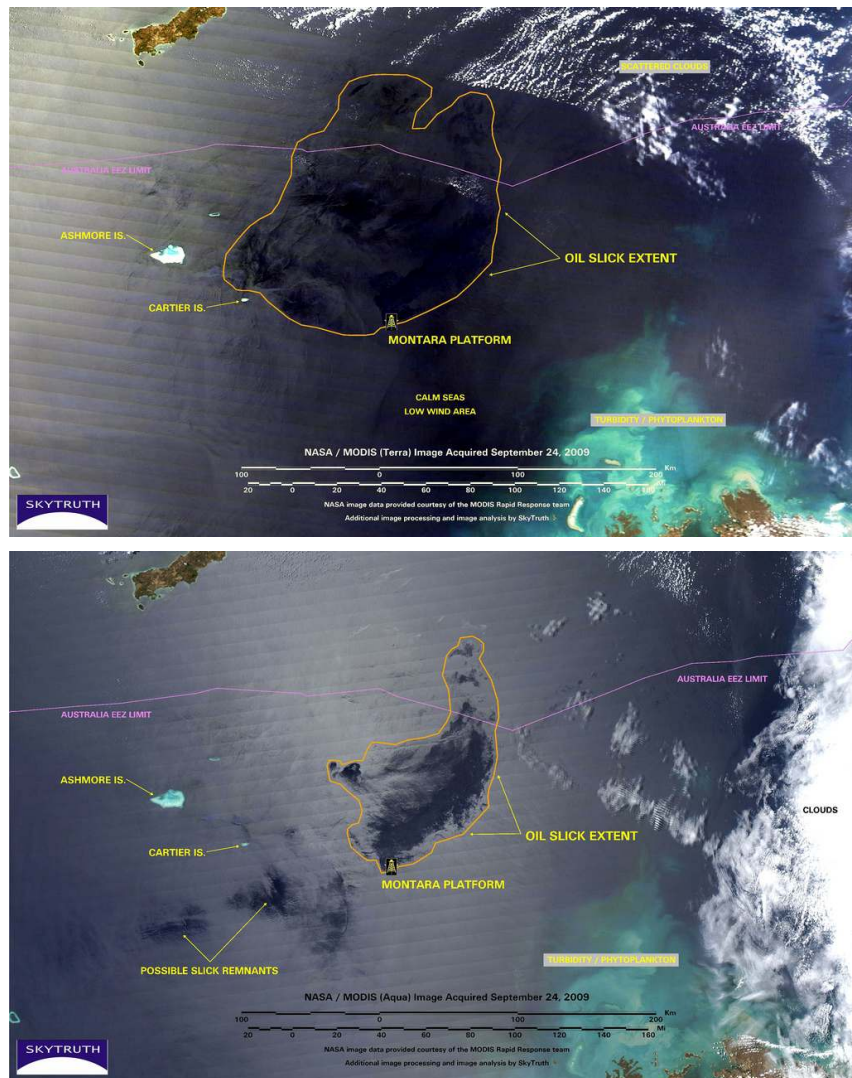


Figure 21: Detail from NASA / MODIS image taken from the Terra satellite (top) and the Aqua satellite (bottom) on September 24, 2009. These images were taken five hours apart. They show slicks and sheen from the Montara offshore oil well. The orange line delineates an 33,850 km² region (top) and 13,514 km² region of ocean partially covered by patchy oil slicks and sheen. According to Skytruth, the differences in the area of sheen covered is a result of strong sun glint in the second image, which may have obscured a large proportion of the slick seen earlier.

II.3.3 SURVEY OVERVIEW

Throughout the survey surface sheen was often evident. We were initially cautious to confirm the presence of surface oil and expected low-density sheen to be particularly difficult to identify in the exceptionally calm conditions between 26 – 27th September. It soon became obvious that surface oil could be readily identified. However, the nature of the oil varied and it also coincided with accumulations of algae and plankton that in some cases could obscure detection.

Surface oil could be identified by:

1. Extensive patches or continuous glassy water;
2. Particles of white waxy residue of varying size and density, floating on the surface. The larger of these could be seen to leave an oil trail on the surface (Figure 22 P) but oil sheen always seemed to be in association with these particles;
3. Smell. In the patches of moderate to heavy surface sheen, there was a strong smell like turpentine. This would cause a drying of the back of the mouth and slight bad taste; and
4. In moderately heavy patches, a clearly visible oil layer on waves or in the wake of the vessel.

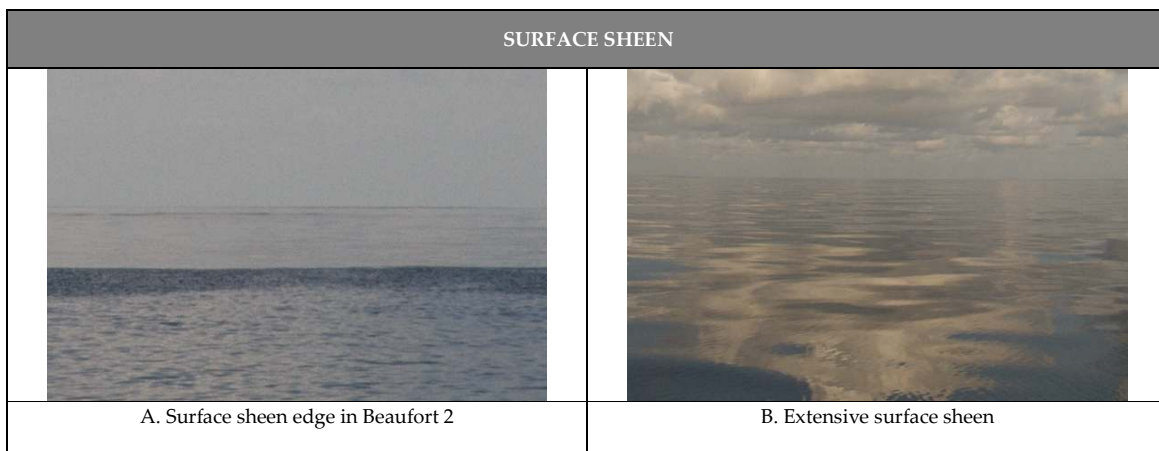
After the survey was complete, the Captain reported that oil had stuck to the side of the vessel and was washed off after returning to shore. This was despite the fact that the last day and a half of the cruise had been through 'clean' seawater and heading into some heavy wave conditions caused by sea breezes off Darwin.



II.3.4 OIL ON SURFACE BEHAVIOUR







Figure 22 illustrates the behaviour of oil on the sea surface, as we observed it during the survey. Surface oil mostly ranged from a light sheen with small particles of waxy residue to larger particles, some of which were concentrated into slick-lines. To the northeast of the exclusion zone we encountered a soft yellow crust that appeared to be residual waxes with oily patches around and remaining volatiles.



Figure 22: Oil on surface behaviour.





Photo credits, Kara Burns Photography A, B, G – O, R; Chris Sanderson, E, F, J.

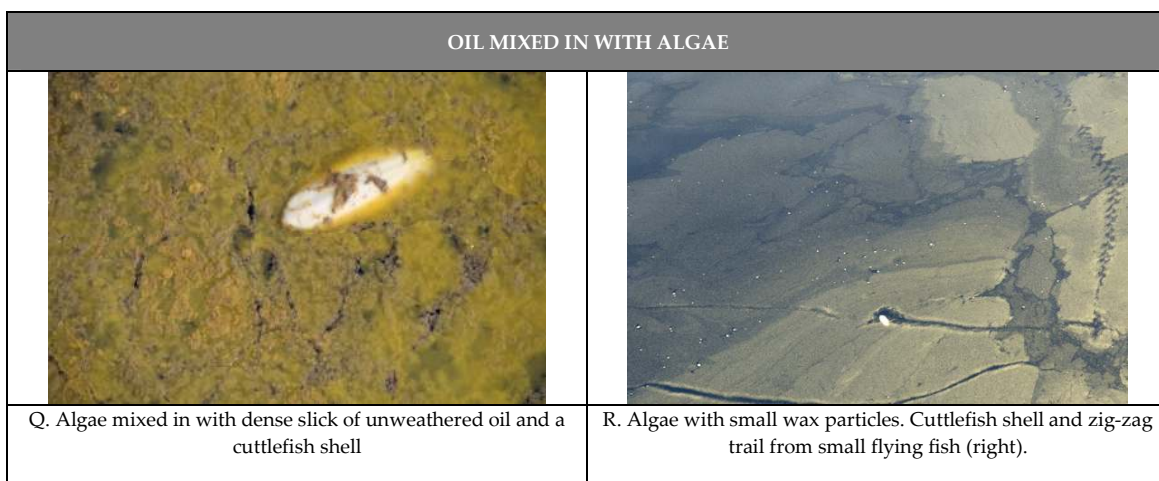


	
<p>C. Moderately thick oil surface sheen</p>	<p>D. Thick oil sheen on waves. This gave off a strong odour like turpentine.</p>

WAX PARTICLES	
	
<p>E. Small low density wax particles with surface algae</p>	<p>F. Close up of flocculated wax particles</p>
	
<p>G. Large wax particles at high density</p>	<p>H. Wax particles concentrated into slicks</p>
	
<p>I. Densely concentrated slick of wax particles</p>	<p>J. Thick surface sheen with some wax particles</p>

	
<p>K. Large wax particles at high density</p>	<p>L. Low density slick of small wax particles in surface sheen with cuttlefish shells</p>

LIGHTLY WEATHERED 'YELLOW' SLICKS	
	
<p>M. Lightly weathered 'yellow' oil and waxes forming dense slick</p>	<p>N. Yellowish-brown weathered surface oil in slick</p>
	
<p>O. Surface sheen with lightly weathered wax particles</p>	<p>P. Oil patch with rainbow colour around lightly weathered wax particle</p>



II.3.5 SURFACE OIL OBSERVATIONS AND SAMPLING

Samples of surface oil, water and algae were taken periodically throughout the course of the survey and are summarised in Table 5. Images relating to samples have been archived and some are shown, where indicated, in Figure 22. Sample locations are shown on the map (Figure 23).

Table 5: Oil samples taken with notes on species present and related images.

Sample #	Date and time	Latitude	Longitude	Image cross reference to Figure 22	Species present*			Notes
					Dolphins	Sea Snakes	Seabirds	
See Figure 23 for map								
1	26/09/09 – 09:15	-11.91645	125.6233	F, H	✓	✓		Patch of wax.
2	26/09/09 – 11:53	-11.87019	125.3736	R				Algae + white flecks
3	26/09/09 – 12:18	-11.87043	125.3353					Blue water
4a	26/09/09 – 13:02	-11.86879	125.2452					Lots of white particles
4b	26/09/09 – 13:15	-11.8694	125.2209		✓			More algae some white particles
4c	26/09/09 – 13:47	-11.86211	125.1729				✓	Big patch of algae
5	26/09/09 – 14:44	-11.85803	125.1185	K				Heavy wax particles
6	26/09/09 – 16:05	-11.83783	125.0164					Heavy waxy slick over deeper water
7	26/09/09 – 17:22	-11.77064	124.9386	I	✓			Slick sample taken
8	NULL							
9	27/09/09 11:00	-11.8453	124.7861	G	✓			Thick white waxy pieces
10	27/09/09 12:25	-12.00257	124.7981					Water sample
11	27/09/09 13:00	-12.07231	124.803					Heavy yellow sample in thick slick
12	27/09/09 14:10	-12.05667	124.8835	L				Yellow patches, streaks of oil
13	27/09/09 16:29	-12.08196	125.0985	O				Slick
14	27/09/09 17:12	-12.1582	125.0993	M, N, P, Q	✓			Thick slick yellow
15	27/09/09 18:12	-12.25216	125.0744	A, B				
16	28/09/09 13:13	-12.26616	124.5002				✓	White particles
17	29/09/09 – 16:30	-12.27863	127.5642					Algae slick
18	29/09/09 – 17:05	-12.28019	127.6364					Algae and white particles

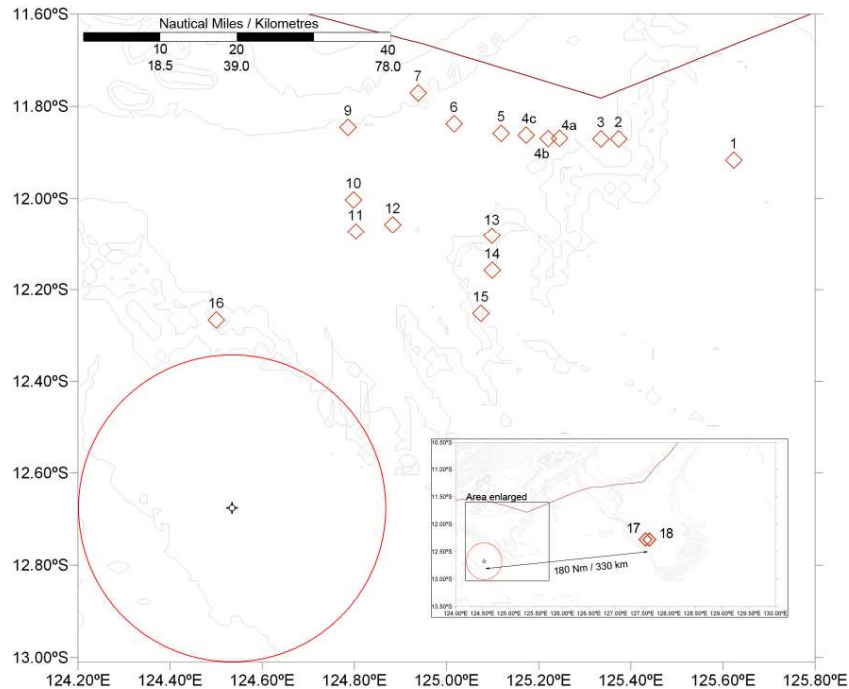


Figure 23: Locations where surface samples were taken.

II.3.6 DAILY ACCOUNTS

A qualitative record of surface oil was kept from the 26th September onwards. We recorded:

- The extent of oil (extensive, patchy, sparse);
- The weight of surface oil (light, moderate, heavy);
- The size of wax particles (small, large); and
- The density of wax particles (low density, high density).

These results are summarised in Figure 24. Twice during the survey we encountered relatively high levels of surface oil over the Sahul Banks edge northeast of the Montara oil well. Otherwise, there were patches of heavier material but light sheen and wax particles were extensively recorded, though often patchily.

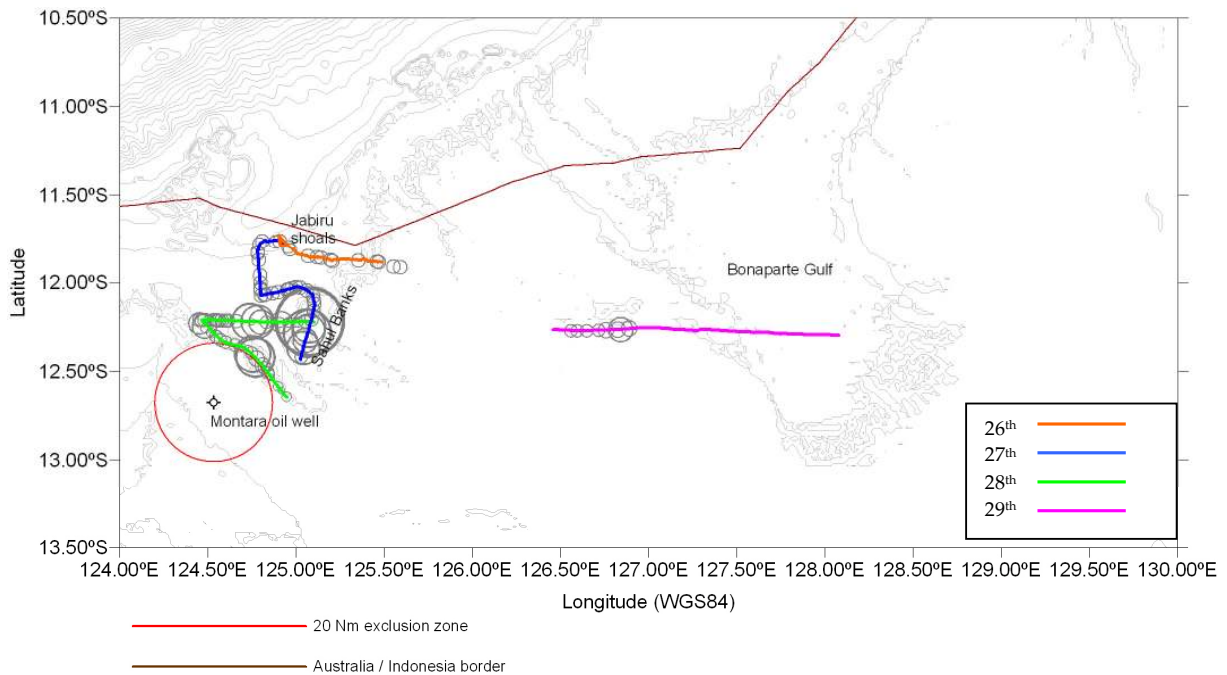


Figure 24: Results of assessment of oil on surface. These results combine qualitative estimates of sheen weight, extent and presence of waxy particles.

As well as oil, we also recorded the presence of non oil-slick surface anomalies including nutrient fronts and algal slicks, though on numerous occasions these coincided with surface sheen.

II.3.6.1 Northern Transect 26th September

Our initial confirmed encounter with oil was at the far north of our survey area, approximately 70 Nm from Montara. As we passed over the edge of the Sahul Bank at dawn on the 26th, we found high density particles of a white waxy compound at the surface. Closer inspection revealed this to be an oily substance at times concentrated in lines. The density of the surface material increased to the point that surface sheen could be seen.

As we headed west past the northern tip of the exclusion zone for the Jabiru rig we did not record the presence of oil. With hind sight however, it is likely there was also oil sheen in this area. It took us until the end of this first day to fully identify the range of effects associated with surface oil.

We anchored that night on the edge of the Sahul Bank in about 17m of water in amongst obvious oil sheen, which we could smell as well as see. Seabirds and a single Hawksbill Turtle were foraging through the surface slick.

II.3.6.2 Centre Transect 27th September

We began the day from anchorage at the edge of the Sahul Bank and headed northeast in the direction of the Indonesian border before resuming a southerly course in the direction of Montara, following the contours of the deep ocean trench that bisects the Australian border. Little or no surface oil was evident in this area.

As we headed south, oil sheen became apparent again and we began to smell the oil strongly at approximately 40 Nm from Montara. The survey team began to develop dry mouths and complained of a developing foul taste and mildly stinging eyes, so we were forced to head east as a precaution and the problem soon abated. Our course then took us around the exclusion zone for the Chalice rig and we turned southward in the afternoon. Surface sheen was evident in these areas but it was not until late afternoon that we encountered a very heavy patch of surface oil. This location was just over 40 Nm from Montara. The surface was covered in a moderate to thick layer yellowish-brown in colour. Rainbow patterns were evident on the water and a distinct trail of oil behind particles of yellowish wax. Ripples on the water would reveal a blackish streaked tinge to the waves and there was a very strong turpentine smell. We were still within this dense patch of surface oil by nightfall.

II.3.6.3 Southern Transect 28th September

We began the survey due east of Montara, just beyond the exclusion zone at a distance of approximately 25 Nm. The wind began as a light to moderate north easterly so there was no risk of significant fumes from the leak. Our route took us northwest, skirting the exclusion zone. Again, light oil sheen was evident but we did not find any particularly heavy patches of weathering oil. Instead, we discovered long and broad slicks of surface sheen.

For several miles, we followed a line of oil sheen which contained waxy particles as well as algae and relatively large numbers of seabirds including Common Noddy, Matsudaira's Storm Petrels and Red-necked Phalaropes.

After lunch, we headed east again through patchy surface sheen, though wind conditions had increased slightly. There was varying size and density of waxy particles on the surface. On dusk we again encountered the very thick area of oil slick seen the day before.

II.3.6.4 Eastern Transect 29th September

After leaving the main oil-affected area, we steamed overnight east towards Darwin. At dawn, approximately 120 Nm from Montara, we encountered an area of light sheen and there was a moderate density of light waxy particles on the surface. This continued until at least 140 Nm from Montara. Overnight, the vessel's desalination filter became soiled by a brown residue. The desalination plant had been turned off since oil was first encountered on the 26th. It had

been turned on at about midnight on the 29th, approximately 60 Nm from Montara and was drawing sea water from about 1m below the surface.

PART III. IMPLICATIONS OF FINDINGS

III.1 INTRODUCTION

Another objective was to consider the evidence, direct or indirect, of the likely risk to marine biodiversity including potential species and ecosystem impacts and its ecological implications, particularly in terms of the Commonwealth Marine Environment and listed threatened and / or migratory species.

Such interpretation requires careful consideration of “what is an impact?” Impacts are rarely if ever quantifiable in absolute terms:

The complexity of ecosystems, sampling limitations and lack of opportunities for follow-up monitoring mean that predictions for EcIA [Ecological Impact Assessment] must often be made with considerable uncertainty (Treweek, 1999).

Finding direct evidence e.g. dead or oiled wildlife, is not necessarily practical or realistic. Unless animals are maimed or die on the spot, they may move away. For example, the foraging range of seabirds may be larger than the extent of the spill itself. Species such as sea snakes and cetaceans may sink to the sea floor.

Standard best practice for environmental monitoring and assessment is instead to identify the extent, duration, frequency and intensity of any change compared to baseline (EIANZ, 2009; Treweek, 1999). This includes describing observed interactions between species and the slick and hence their vulnerability.

The design of the survey and presentation of results follows a framework guided by the Commonwealth’s principal significant impact guidelines (DEWHA, 2005) (Table 6, Appendix 1).

III.2 INTERPRETATION FRAMEWORK

There are a wide variety of potential direct and indirect effects of oil recognised from research after oil spills in the past. In ecological assessment

terms however, an ‘impact’ is not measured by an effect occurring but its significance in terms of biological change (Hill et al., 1997; Treweek, 1999). Unfortunately, quantitative scientific data on the population of any given species or even levels of toxicity in recovered samples, is rarely enough to understand the degree of impact. A full research understanding of ecosystem processes and long-term effects on breeding biology could require many years of work and natural variation could still mask much of the statistical power.

Impact assessment depends instead on understanding both the nature of the receiving environment and the nature of the threat. Hence, there is a “long-held body of case law from environmental litigation in Australia that the term “significant” means an impact that has an ‘important or notable effect on the environment’: *Tasmanian Conservation Trust Inc. v Minister for Resources* (1995) 55 FCR 516” (Christie, 2008). In the EPBC Act and after *Booth v Bosworth* (2001) 114 FCR 39, Branson J concluded that the question of a “significant impact” under the EPBC Act required simultaneous consideration whether the impact was “important, notable or of consequence having regard to its context and intensity”.

It is not within the scope of this report to determine what may or may not be significant. It is fitting however, to use the terms “context” and “intensity” to present results, so any subsequent interpretation is policy-relevant. Even to consider impacts on listed species requires a holistic understanding of likely consequence on habitat and ecosystem processes. The Commonwealth recognises this in relation to listed threatened species and listed migratory species. Examples are shown in Table 6 (from DEWHA, 2005, see also Appendix 1).

Table 6: Examples of significance thresholds defined by the Commonwealth in terms of protected matters and habitat.

An action is likely to have a significant impact if it is likely to:	
The Commonwealth Marine Environment	<ul style="list-style-type: none"> ▪ have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution; ▪ result in a substantial change in air quality or water quality which may adversely impact on biodiversity, ecological integrity; social amenity or human health; and ▪ result in persistent and potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected.
Listed threatened species and ecological communities	<ul style="list-style-type: none"> ▪ adversely affect habitat critical¹³ to the survival of a species; or ▪ disrupt the breeding cycle of a population.
Listed migratory species	<ul style="list-style-type: none"> ▪ substantially modify (including by altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.

¹³ Habitat critical to the survival of a species or ecological community = areas that are necessary: for activities such as foraging, breeding, roosting, or dispersal; for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community); or to maintain genetic diversity and long term evolutionary development. Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the Minister under the EPBC Act.

III.3 IMPACT CONTEXT

Context includes the sensitivity and vulnerability of biodiversity assets to change. This includes biodiversity value of species and ecosystems e.g. threatened and / migratory species; any other species (listed or otherwise) that perform a function in the integrity of the Commonwealth Marine Environment, and other processes and services related to the Commonwealth Marine Environment. These factors are discussed in the following sections.

III.3.1 IS THE AREA NOTABLE OR IMPORTANT IN TERMS OF BIODIVERSITY?

Because of the apparent lack of other general surveys of pelagic wildlife in the Timor Plateau, we can only make an anecdotal comparison with other areas. From experience, very high densities of sea snakes and cetaceans were observed, along with relatively large numbers of some migratory species such as Streaked Shearwater, though an unusually large flock of 324 birds were seen south of Ashmore Reef on 30th October 2004¹⁴. Experience suggests that the pelagic wildlife community in this part of the Timor Plateau has fewer species but a similar density of pelagic seabirds compared to areas around Scott Reef and Ashmore Reef (Simon Mustoe, personal observations).

The overall importance of an area can only be judged according to criteria that describe its value. The ANZECC Guidelines for Establishing the National Representative System of Marine Protected Areas are used here as a context for the survey findings, and therefore the importance of the area affected by the oil leak. There are a number of principles that we cannot address with these data so these are marked in the table below. Only factors for which this survey can realistically contribute knowledge are discussed.

Table 7: Survey results in the context of criteria for conservation importance

<p>Ecological importance</p> <ul style="list-style-type: none"> - contributes to maintenance of essential ecological processes or life support systems; - contains habitat for rare or endangered species; - high species diversity; 	<p><i>No relevant data from survey</i></p> <p>The status of most marine species in this region is uncertain. Only two listed threatened species were recorded: Hawksbill Turtle and Flatback Turtle. Both were in association with submerged reefs.</p> <p>Species diversity is not particularly high compared to other parts of the northwest shelf but is high compared to most tropical offshore environments.</p>
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¹⁴ Ashmore Reef Cruise Trip Report 24-31 October 2004. http://www.ecology-solutions.com.au/ashmore_reef/ashmore_reef.htm

contains components/habitat on which other species or systems are dependent – e.g. nursery areas, juvenile areas, feeding, breeding or rest areas, primary production areas; and	It is not certain how this compares with other parts of the Timor Plateau Biogeographic Region. High densities of sea snakes and cetaceans, plus frequent encounters with migratory seabirds indicates that this area supports breeding, feeding and resting (non-breeding) for a range of species. High levels of biomass, particularly for tropical waters, is indicative of notable surface and benthic productivity.
contained or isolated self-sustaining ecological unit;	<i>No relevant data from survey</i>
State, national or international importance – areas qualifying for listing under policies and agreements for biodiversity conservation;	<i>No relevant data from survey</i>
Uniqueness – unique species, populations, communities or ecosystems as well as unique or unusual geographic features;	The coincidence of oceanographic and bathymetric features, including the Indonesian Throughflow Current, shoals, pinnacles and the Sahul Banks creates a wide variety of habitat niches and contributes to the areas’ species richness, high fauna density (e.g. sea snakes and cetaceans) and community of species.
Productivity – populations or communities with high natural biological productivity;	<i>No relevant data from survey</i>
Vulnerability – the susceptibility or low resilience to natural processes;	<i>No relevant data from survey</i>
Biogeographic importance;	<i>No relevant data from survey</i>
Naturalness – the degree the area has been protected from human induced change.	The area has until recent years been isolated from industrial activity. Modifications have occurred due to fishing, for example, shark populations have been reduced. In more recent years, the area has been protected from illegal fishing. Compared to other shallow reef systems in Australia, it is likely to be relatively intact.

III.3.2 VULNERABILITY TO OIL CONTAMINATION?

The list of protected matters is shown in Table 2. For any species, vulnerability- like risk and impacts - is a function of context and intensity. There are three main considerations:

1. The sensitivity of individuals of a species to direct or indirect contamination effects;
2. The species’ population status (e.g. rare or endangered); and

3. The degree of existing significant environmental pressure on populations. These factors are discussed in the following sections.

III.3.3 POPULATION STATUS OF PROTECTED SPECIES

One would normally refer to threatened species listing for such advice. However, there has been little historic effort to assess the conservation status of many marine species. There is much missing knowledge and incomplete threat listing, so available information cannot always be adequately and usefully interpreted.

For example, Australian Sea Snakes do not yet appear on the IUCN Red List (IUCN, 1994) although common birds such as Silver Gull appear, even as 'Least Concern'. Further, sea snake taxonomy is not complete (Heatwole & Cogger, 1994). Similarly, the reason seabirds such as Matsudaira's Storm Petrel and Bulwer's Petrel are not listed on international agreements between Australia, Japan and China, is due to limited knowledge as opposed to listing advice. Matsudaira's Storm Petrel is considered by BirdLife International as 'data deficient' and has a very limited breeding range (BirdLife International, 2004). Even less is known about the species' status in Australian waters. The same can be said for all other species recorded during the survey, for which there are very few at-sea observations, limited taxonomic information and no dedicated long-term monitoring.

We recorded a maximum of three EPBC listed threatened species during the survey:

- Hawksbill Turtle *Eretmochelys imbricata*
- Flatback Turtle *Natator depressus*
- Spotted Bottlenose Dolphin *Tursiops aduncus* (Arafura / Timor Sea Populations).

Whether the Bottlenose Dolphins we saw were 'Spotted Bottlenose Dolphins' is questionable. There appears to be incomplete information about the distribution and genetic status of the species (Ross, 2006).

Of the listed migratory species (Table 2), only Hawksbill Turtle and Flatback Turtle are recognised as threatened. Despite its abundance, there is evidence of declines in Sooty Terns elsewhere in Australia. The species has declined by 50% on Michaelmas Cay (Turner, 2002) and by 84% on Raine Island between 1993 and 2003 (Batianoff et al., 2005) in the Great Barrier Reef but similar data does not seem to be available for Ashmore Reef where 10,000 – 50,000 pairs were recorded nesting in 1983 and 1988 (Milton, 1999). Similarly, Common Noddy and Brown Booby declined on Raine Island between 1993 and 2003 by 95% and 40% respectively (Batianoff & Cornelius, 2005). All other key species recorded during the survey do not nest in Australia so their population status here is completely unknown.

III.3.4 EXISTING ENVIRONMENTAL PRESSURES

Taking into consideration existing pressures addresses cumulative impacts and is one of the basic tenets of ecological assessment (Raff, 1997). Although the area affected by the oil spill is far offshore, there have been other human influences in nearby ocean. These should be taken into account. Any additional pressures or threats should be considered additional to the existing conditions.

Legal and illegal fishing has contributed to declines of sharks throughout the Timor Plateau area, including Ashmore Reef. The Australian Institute of Marine Sciences (AIMS) reports 4 -17 times less abundance of sharks at fished reefs¹⁵. Foreign gill-net fisheries for sharks in the Arafura and Timor Seas in the early to mid 1980s also resulted in bycatch of cetaceans and sea snakes.

Dolphins were killed as bycatch in Taiwanese gill-net fisheries in the Arafura and Timor Seas of northern Australia. It has been estimated that this include 8,400 Bottlenose Dolphins between 1974-1986, 4,900 Spinner Dolphins between 1981 and 1985 and 560 Pan-tropical Spotted Dolphins (Ross, 2006). For comparison, the total of 13,860 dolphins is equivalent to all the dolphins over about 5,330 km² at densities observed during our survey.

Taiwanese trawlers in the northwest shelf from 1980-1990 were also estimated to have caught about 49,000 sea snakes (Ward, 1996). *Hydrophis ornatus*, the commonest species¹⁶ observed during our survey, constituted the largest proportion (31%) of specimens. Based on the average density estimates of 29.3 sea snakes per square kilometre from our survey, this would amount to sea snakes from an area of 1,672 km².

There is no evidence of more recent trawl activity and despite the fact sea snakes are considered to have low fecundity and high levels (80-90%) of juvenile mortality (Heatwole et al., 1993), populations are likely to have recovered and significant control measures are placed on fishing fleets in the north west shelf to limit and manage bycatch. It is possible that damage by trawling to the reef itself could be an ongoing constraint to recovery (Ward, 1996) but it is not certain to what extent this would have affected the Sahul Banks area in the vicinity of Montara H1.

III.3.5 POTENTIAL EFFECTS ON ECOSYSTEM PROCESSES

Sea snakes, seabirds and cetaceans are abundant marine top predators. Predatory animals are an essential component of the food chain (Rooney, 2006). In recent years, research has started to suggest that top predators may even be important for building ecosystem resilience in the face of climate

¹⁵ Australian Institute of Marine Science. *Shark Fin...A Devastating Legacy*. September 2006.

¹⁶ We recorded *Hydrophis (ornatus) ocellatus*, the 'Spotted Sea Snake', though this is by some authorities, considered a subspecies of *Hydrophis ornatus*.

change (Sala, 2006). This is to say that, although species are considered important in their own right, they are also a conspicuous and integral part of ecosystem function.

For instance, seabirds transfer energy between offshore nutrient fronts and breeding islands (Allaway et al., 1984; Anderson et al., 1999), so their persistence in the environment is critical to long-term ecological succession of tropical island vegetation. They also depend on relationships with other species. Sooty and other terns are considered dependent on tuna for foraging (Au & Pitman, 1986; Brooke et al., 2006). Altering the pelagic environment, for example, by displacing fish from areas of dissolved hydrocarbon (DeGraeve, 1982; Drury et al., 1969) could therefore have impacts on seabirds as well as fish and marine mammals.

Oil could also affect natural processes at sea. Surface material is naturally deposited along oceanographic fronts, where nutrients are rapidly taken up by algae “secondary production” and in turn grazed by zooplankton. These areas are particularly important for marine fauna in otherwise nutrient-poor tropical waters (Dunlop & Cheshire, 1988; Jaquemet et al., 2005). Any floating surface material will collect at these locations. For example, cuttlefish shells were commonly seen on nutrient fronts during the survey. These were also places where surface samples were collected (see Figure 22 M & Q). A coincidence of oil sheen and natural processes, particularly when concentrated into oceanographic fronts, can increase the intensity of effect as it is along these fronts that many species forage and feed. For example, just north of the exclusion zone, there was algae and a visibly high load of plankton including tiny Cephalopods (squid and cuttlefish), jellyfish and larger plankton-feeders such as abundant flying fish. These lines were being navigated by predatory fish such as Mahi Mahi (dolphin fish) and surface-feeding seabirds including Matsudaira’s and Wilson’s Storm Petrels, Red-necked Phalaropes, Common Noddies, Bridled Terns and Bulwer’s Petrels.

There is also the possibility that surface oil directly influences natural processes. For example, natural surface bacteria can respond rapidly to pollution incidents. One study found an out of season increase by three orders of magnitude for oil-degrading bacteria exposed to diesel fuel and crude oil (Delille et al., 1997). Although this can be beneficial, it may also attract wildlife as bacterial processes fuel the food chain. In another study, low concentrations of crude oil caused the death of coral heads by promoting the growth of predatory bacteria (Mitchell et al., 2005).

It is not within the scope of this report to review ecosystem effects in more detail or to suggest that any of these effects necessarily occurred. It does indicate however, the links between species, biochemical and oceanographic processes in the environment. Substantial changes in surface chemistry or significant displacement / mortality of pelagic fauna could alter these conditions.

III.3.6 VULNERABILITY TO OIL CONTAMINATION

Seabirds

Vulnerability to surface pollutants in seabirds has been commonly assessed in offshore oil and gas areas (Carter et al., 1993; Skov et al., 2002) using semi-quantitative methods (Williams et al., 1995). For any given species, its Offshore Vulnerability Index (OVI) = $2a + 2b + c + d$ where a is percentage of time spent on the water; b is population size, c is recoverability and d is reliance on the marine environment.

Table 8 calculates this for species observed offshore during the survey. All species score relatively highly, as all are mostly marine species (d) and seabird populations on which these species are compared (see notes below table), are considered relatively slow to recover breeding productivity. Population and time spent on the water are major determinants of risk and both Brown Booby and Matsudaira's Storm Petrel score highly. For British Storm Petrels, time spent on water is relatively small but this probably underestimates the risk for Matsudaira's Storm Petrel in the very calm conditions of the northwest shelf in October. Birds are commonly seen resting on the surface. Brown Booby scores highly both because it spends a significant amount of time resting on the surface and a significant proportion of the world population occurs in the northwest shelf.

Table 8: Calculation of Offshore Vulnerability Index (OVI) for key species of seabird. Note these figures are only relative and do not imply any absolute level of risk for a given species.

	Population Size Global / Australia / Ashmore Reef				OVI	
	(a)	(b)	(c)	(d)		
Sooty Tern	21-22 million ¹ / Unk / 10-50,000 prs ²	1.5	2	5	5	16
Streaked Shearwater	3 million ¹ / Unk / NA	3.5	1	5	5	19
Common Noddy	180,000 – 1.1 million ¹ / Unk / 13-35,000 prs ²	1.5	3	5	5	18
Brown Booby*	200,000 ¹ / Unk / 200 ³	3	4	5	5	24
Bulwer's Petrel	500,000 – 1 million / Unk / NA	1	1	5	5	14
Matsudaira's Storm Petrel	20,000 / Unk / NA	1	4	5	5	20

1. BirdLife International, 2004, 2. Milton, 1999, 3. Marchant & Higgins, 1990

*Only a few Brown Boobies breed at Ashmore. The largest colony in the world (c 17,000 pairs) occurs on the Lacapedes (Marchant & Higgins, 1990). Unk = population unknown; NA = not applicable (i.e. does not nest on Ashmore Reef).

(a), (c), (d) in the absence of Australian data, comparative data have been used for European species with a similar biology as published in Williams et al., (1995). Sooty Tern & Common Noddy = Common Tern; Streaked Shearwater = Manx Shearwater; Brown Booby = Eurasian Gannet; Bulwer's Petrel & Matsudaira's Storm Petrel = British Storm Petrel.

(b) scores are weighted for local abundance, as this relates to the ecology of the relevant area of the Commonwealth Marine Environment. Where no local abundance estimates are included, these have been ignored. However, as Matsudaira's Storm Petrel is particularly abundant in the

Timor Plateau, it is likely that a significant proportion of the 20,000 birds occur, so this was elevated to a high score.

AMSA reports the effects on seabirds from oil may include:

- Contact with crude oil or refined fuel oils. This causes feathers to collapse and matt and change the insulation properties of feathers and down.
- Matting of feathers. This can severely hamper the ability of birds to fly.
- A breakdown in the water proofing and thermal insulation provided by the feathers. This often causes hypothermia.
- Oiled feathers. This can cause the seabirds to lose buoyancy, sink and drown because of increased weight or lack of air trapped in the feathers.
- Body weight decreases quickly as the metabolism attempts to counteract low body temperature.
- Severe irritation of the skin.
- They ingest the oil in an attempt to preen themselves.
- Irritation or ulceration of the eyes, skin, mouth, or nasal cavities
- The food searching instincts such as diving and swimming are inhibited.
- Ingestion of oil via their prey if their food chain becomes contaminated.
- Poisoning or intoxication.

Ingestion of oil can be sub-lethal or acute and will depend to a large extent on the type of oil, its weathering stage and inherent toxicity. These internal effects can include:

- the destruction of red blood cells, important for the immune response,
- alterations of liver metabolism,
- adrenal tissue damage,
- pneumonia,
- intestinal damage,
- reduced reproduction ability,
- reduction in the number of eggs laid,
- decreased fertility of eggs,
- decreased shell thickness and
- disruption of the normal breeding and incubating behaviours (6).

It has been estimated that as little as four microlitres of petroleum contaminating a fertile egg can cause the embryo to die (4).

It is also possible that birds such as Matsudaira's Storm Petrel and Bulwer's Petrel could directly ingest substantial quantities of wax particles. These species forage by picking small particles off the surface and wax ingestion may be just as likely as ingestion of small plastic particles, which has been demonstrated in similar species in the North Pacific (Blight et al., 1998).

Marine Mammals, Turtles and Sea Snakes

Marine mammals and marine reptiles are susceptible to oil contamination differently to seabirds but due to the fact they are air-breathing they must regularly surface. Impacts, particularly on marine mammals, are poorly known. Carcasses usually sink at sea, at least initially, animals may cover a significant range and capture and study of live animals is almost impossible.

AMSA reports the effects on marine mammals and marine reptiles from oil may include:

- hypothermia due to conductance changes in skin, resulting in metabolic shock,
- toxic effects and secondary organ dysfunction due to ingestion of oil,
- congested lungs,
- damaged airways,
- interstitial emphysema due to inhalation of oil droplets and vapour,
- gastrointestinal ulceration and haemorrhaging due to ingestion of oil during grooming and feeding,
- eye and skin lesions from continuous exposure to oil,
- decreased body mass due to restricted diet and
- stress due to oil exposure and behavioural changes.

They also report that:

- Dolphins are smooth-skinned, hairless mammals, so oil tends not to stick to their skin, but they can inhale oil and oil vapour. This is most likely to occur when they surface to breathe. This leads to damaging of the airways, lung ailments, mucous membrane damage or even death. A stressed or panicking dolphin would move faster, breathe more rapidly and therefore surface more frequently into oil and so increase exposure.
- Dolphins eyesight may also be affected by oil. They might also consume oil-affected food or may even starve due to the lack of available food or an inability to find food.
- Chronic ingestion of subtoxic quantities of oil may have subtle effects which would only become apparent through long-term monitoring. The transfer of petroleum hydrocarbons through the mothers milk to sucking young is another way oil affects dolphins.
- It is also possible that oil pollution impairs dolphins immune system and causes secondary bacterial and fungal infections.

For marine turtles, they report:

Little information is available on the effects of oil on sea turtles but the following effects are likely.

- If turtles surface in an oil slick to breathe oil will affect their eyes and damage airways or lungs.
- Sea turtles will also be affected by oil through contamination of the food supply or by absorption through the skin.

III.4 IMPACT INTENSITY

Intensity relates to the degree of environmental effect. Standard best practice would be to compare outcomes to baseline conditions, including magnitude, spatial extent, frequency, duration and reversibility (EIANZ, 2009; Treweek, 1999). This is also consistent with policy for the EPBC Act, which says:

Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (DEWHA, 2005).

III.5 CONCLUSIONS

III.5.1 SURVEY LINE TRANSECT RESULTS

We recorded 17 species of seabird, three species of cetacean and four marine reptiles including one species of marine turtle (Table 1). Another 10 species of cetacean occur within the region and may occur in the affected area. It is also likely we overlooked some species of sea snake and there are other seabirds that would also likely occur at different times of the year. The species list is a function of seasonality and the short amount of time spent on site. Nevertheless, the results provide a reasonable basis on which to scope biodiversity value.

At least twelve species recorded were listed migratory on the EPBC Act - this number would be thirteen if Spotted Bottlenose Dolphin was included but due to genetic uncertainties and lack of information on this species, we cannot be sure it qualifies. Two species of sea turtle were listed threatened and vulnerable to extinction (Table 2). Only three of the 17 recorded species breed on Ashmore Reef. All other species would remain at sea for the duration of the oil leak.

When interpreting threat status for any species, it is necessary to be aware of missing or incomplete evidence for most marine species, including taxonomic information in some cases. Further, there appears to be very little documented survey data for the Timor Plateau on which to base assumptions about threats or declines. Species such as Matsudaira's Storm Petrel are data deficient (BirdLife International, 2004) but world population estimates are low. The abundance of this bird in the region indicates that the Timor Plateau may support a significant proportion of the world's known population. It is a migrant from Japan, is not listed migratory on the EPBC Act but may be considered an important component of the Commonwealth Marine Environment.

The area would be considered of "conservation importance" according to certain criteria of the ANZECC *Guidelines for Establishing the National Representative System of Marine Protected Areas*:

- It contains habitat for rare or endangered species;
- species diversity, though not particularly high compared to other parts of the northwest shelf, is high compared to most tropical offshore environments;
- it contains nursery areas, juvenile areas, feeding, breeding or resting areas and primary production areas;
- It appears to support a relatively unique and rich community of species and habitats, in part owing to a complex bathymetry (including shoals, pinnacles and the Sahul Banks) and influence of the Indonesian Throughflow Current; and
- Despite some modifications to the surrounding environment through illegal and legal fishing in the past, it has until recently been protected from human induced change.

There was evidence of notable surface and benthic productivity. Not only was this visible as oceanographic fronts, particularly along the Sahul Shelf edge, it

was also indicated by unusually high densities of species. For example, dolphins were encountered at densities of approximately 2.6 per square kilometre, compared to aerial survey densities in Ningaloo Reef and the Exmouth Gulf between 0.06 – 0.49 per square kilometre (Preen et al., 1997).

Sea snake encounter rate and therefore also density was much higher than predicted from surveys south of Ashmore Reef. Estimates of nearly 30 per square kilometre are likely to be conservative for reef areas where most sea snakes were seen, as the survey data included areas of water more than 100m deep and other lower-density areas well to the east.

Seabird encounter rates did not appear to be significantly higher than other areas of the Timor Plateau but the species community is unusual and rarely encountered outside this region. The Timor Plateau represents the main non-breeding range within Australian waters for species such as Streaked Shearwater and Matsudaira's Storm Petrel. It is also within the range of a large proportion of the world's breeding Brown Boobies and will be used by both breeding and non-breeding seabirds from Ashmore Reef, possibly throughout the year, though there is little field observation data to support this.

III.5.2 EXTENT OF SLICK

We only sampled three transects but found extensive to patchy surface sheen throughout most of the survey, even in waters situated over 100 Nm from the source of the leak. The furthest that surface sheen was found with any certainty was about 140 Nm from the Montara H1 well. It was assumed that it originated from this source. From satellite images, the core area affected by the slick at any one time would appear to be between 10-25,000 km².

There were areas where particles of white waxy residue of varying size and density were floating on the surface. In places, these were concentrated into slick lines.

In the patches of moderate to heavy surface sheen, there was a strong smell like turpentine. This would cause a drying of the back of the mouth and slight bad taste. During a brief period of southerly wind on the 27th, the vessel was turned away due to strong airborne odour.

In one particular area of the survey surface sheen was particularly thick, accompanied by slicks of yellowish, presumably unweathered, wax particles.

III.5.3 INTENSITY OF THE OIL SLICK

Information regarding the magnitude, duration and intensity of the slick can be found in section II.3. Note, a snapshot of the oil slick may not fully represent its effect over time. Winds and currents move the slick around and patches of surface sheen and wax particles do occur some distant from source. Over time therefore, the cumulative area affected could be larger.

Based on estimates of 400 barrels per day, the total amount of oil released over 62 days since the leak began would be over 400,000 litres. In addition, about

150,000 litres of dispersant have been applied (Figure 19) According to information published by AMSA, evaporation can occur, with the potential for 'stickier' fractions to remain behind. These, along with emulsions and wax particles may take much longer periods to weather. With no significant winds forecast for the area until November, wave conditions are still likely to be too benign for rapid break down of surface oil.

III.5.4 ASSESSING IMPACTS TO WILDLIFE AND THE ECOSYSTEM

This report does not draw a conclusion about the significance of the oil leak's impacts. However, interpretation of data on biodiversity value and the effects of the oil leak should be interpreted using the proper legal definition of "significant impact". Commonwealth policy and legal case history defines "significant impact" as an impact that is "important, notable or of consequence having regard to its context and intensity".

On numerous occasions, seabirds, sea snakes and marine mammals were seen interacting with surface sheen but no dead wildlife was found. Despite the large area covered by the slick, a seabird feeding in the area could cross a slick 100 Nm wide in a few hours. With light oil sheen seen over most of the area, the risk would be from the gradual build up of oil on feathers. It is also likely that birds such as Matsudaira's Storm Petrel would directly ingest wax particles. However, it is unlikely that this would cause immediate mortality or injury. Potential toxicity effects on marine mammals, seabirds and sea snakes, though poorly known, may be subtle and not necessarily visibly apparent in the short or long-term and some carcasses may sink.

In terms of the effects on the ecosystem, there are numerous ocean processes that could be altered by significant amounts of oil being added to the surface or water column. It is outside the scope of this report to review these effects in detail. However, there are substantial links between species, biochemical and oceanographic processes. Changes in surface chemistry, nutrients, or displacement / mortality of pelagic fauna could alter conditions and the extent to which this may be significant would be a factor of the magnitude, extent and duration of the effect.

There are a wide variety of direct and indirect effects on wildlife, wildlife habitat and the ecosystem that could potentially occur. Some direct consequences are summarised on the AMSA website (see section III.3.6). In regards to the statutory definition of "significant impact", harm to wildlife is only one consideration in the assessment of *impacts* on listed migratory species, the Commonwealth Marine Environment (CME) and all other species in the CME that form part of its function and integrity (Table 6). The data presented in this report will provide some evidence towards considering whether the impact from the Montara H1 oil leak is likely to have been "significant".

III.6 RECOMMENDATIONS

1. Further, ongoing biodiversity monitoring would help to understand more about the density and distribution of listed migratory and threatened species but also marine species and communities that contribute to the function and integrity of the Commonwealth Marine Environment.
2. Ongoing monitoring of the oil spill itself is unlikely to yield any single measure of change that could be used to determine the level of consequence. Any monitoring should be carefully designed so that:
 - a. It is independently done by a suitably qualified ecological practitioner, preferably a certified environmental practitioner (CEnvP).
 - b. The objectives are realistic and recognise that where statistically significant proof cannot be obtained, there are appropriate best practice alternatives to assessing impacts;
 - c. The data is presented in a manner that is policy-relevant (e.g. the context and intensity criteria for significance assessment); and
 - d. Any limitations of interpretation are properly recognised.
 - e. Monitoring results should be interpreted not just based on single species data but a more holistic and policy-relevant understanding of ecosystem processes, habitat function and integrity, as per the EPBC Act and related policy;
3. Consideration should be given to revisiting migratory species lists for species such as Matsudaira's Storm Petrel that may warrant more protection in Australian waters;
4. Listing advice for other species, such as Brown Booby, Sooty Tern and Common Noddy should reflect any new information regarding their local and national population status. If such data does not exist, effort should be made to collect it;
5. Consideration should be given to how to use vessels of opportunity (e.g. seismic vessels) and other dedicated and non-dedicated surveys to address the gap in biodiversity data for protected matters in the marine environment. Design of such surveys should be policy-relevant and utilise properly qualified ecologists with both field skills and a strong understanding of marine ecological processes and policy.
6. Information from this report should be used to redress any potential omissions in oil spill contingency plans, Environment Plans under the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999* (Cth) and other approvals under the EPBC Act.
7. A strategic monitoring plan for the whole of the northwest shelf should be developed, to ensure that all relevant data is available for decision-makers

and proponents and to make sure that decisions are made based on robust, up-to-date information of immediate relevance to a location, or that such data is gathered using appropriate standard methods.

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Appendix 1: Matters of National Environmental Significance.

Matter of National Environmental Significance	Definition.	Significance threshold. <i>An action is likely to have a significant impact on the environment in a Commonwealth marine area if there is a real chance or possibility that the action will:</i>
The Commonwealth Marine Environment	Defined in s24 of the EPBC Act as any waters, seabed, airspace of the sea inside the seaward boundary of the Exclusive Economic Zone and continental shelf. http://www.environment.gov.au/coasts/information/marinearea.html	<ul style="list-style-type: none"> ▪ modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results; ▪ have a substantial adverse effect on a population of a marine species¹⁷ or cetacean including its life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) and spatial distribution; ▪ result in a substantial change in air quality or water quality which may adversely impact on biodiversity, ecological integrity; social amenity or human health; and ▪ result in persistent and potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected.
Ramsar sites	Ashmore Reef is a Ramsar Site. It is the ecological character of such a site that is protected, which may include any component of its ecosystem.	<ul style="list-style-type: none"> ▪ areas of the wetland being destroyed or substantially modified; ▪ the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected; or ▪ a substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health.
Listed threatened species and ecological communities	Species and communities for which Australia has pledged protection under international conventions, including the Convention on Biological Diversity. Their conservation status varies as critically endangered; endangered; or vulnerable.	<ul style="list-style-type: none"> ▪ lead to a long-term decrease in the size of a population¹⁸; ▪ reduce the area of occupancy of the species; ▪ fragment an existing population into two or more populations; ▪ adversely affect habitat critical¹⁹ to the survival of a species; ▪ disrupt the breeding cycle of a population; ▪ modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; ▪ introduce disease that may cause the species to decline; or ▪ interfere with the recovery of the species.;
Listed migratory species	Species listed on one or more international agreements that Australia	<ul style="list-style-type: none"> ▪ substantially modify (including by altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of

¹⁷ The EPBC Act also list “marine species” and “cetaceans”. These are material to any consideration of impacts on the Commonwealth Marine Environment but there are also strict liability offences associated with recklessly killing or injuring marine species.

¹⁸ Population = a geographically distinct regional population, or collection of local populations; or a population, or collection of local populations, that occurs within a particular bioregion. Note, for species listed as ‘vulnerable’ the population has to be deemed ‘important’. In relation to migratory species, means the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries including Australia.

¹⁹ Habitat critical to the survival of a species or ecological community = areas that are necessary: for activities such as foraging, breeding, roosting, or dispersal; for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community); or to maintain genetic diversity and long term evolutionary development. Such habitat may be, but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the Minister under the EPBC Act.

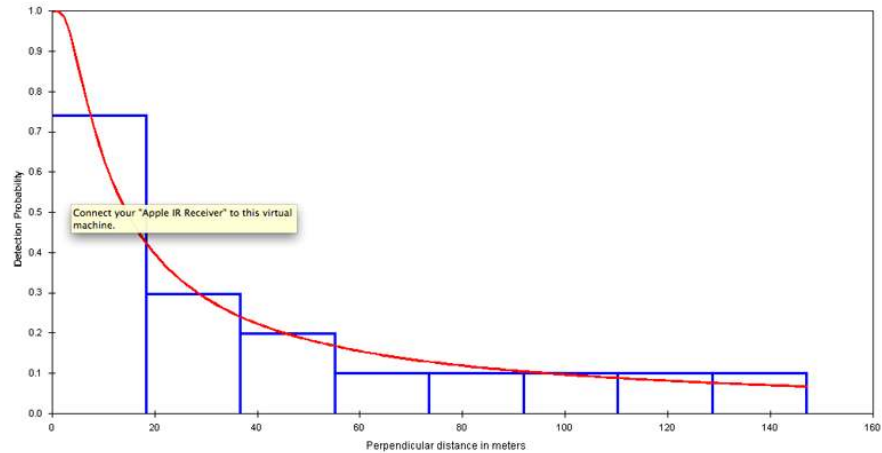
Matter of National Environmental Significance	Definition.	Significance threshold. <i>An action is likely to have a significant impact on the environment in a Commonwealth marine area if there is a real chance or possibility that the action will:</i>
	has with other countries.	important habitat for a migratory species; <ul style="list-style-type: none"> ▪ seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion²⁰ of the population of a migratory species.

²⁰ Ecologically significant proportion - Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an 'ecologically significant proportion' of the population varies with the species (each circumstance will need to be evaluated). Some factors that should be considered include the species' population status, genetic distinctiveness and species specific behavioural patterns (for example, site fidelity and dispersal rates).

Appendix 2: Density Calculations

Sea Snakes

We analysed 36 observations pooling data for all species and discarded the outlying records, consistent with analytical recommendations (Buckland et al., 1993). Analysis was done using Distance 5.0 (Thomas et al., 2009), using a Hazard Rate model with cosine series expansion and size-bias regression method for cluster analysis. This resulted in the following detection function.



Probability of detection = 0.22

Effective Strip Width = 31.7 m

Density was calculated by Distance 5.0 based on our trip distance of 359 Nm. This is likely to under-estimate sea snake density within the area we sampled north of Montara H1 as a significant proportion of the survey was through the less productive parts of the Bonaparte Gulf.

The final density estimate would be 0.94 ± 0.40 sea snakes per square kilometre. However, this estimate is only for sea snakes that were at the surface. To adjust for sea snakes underwater requires data on dives and time spent at the surface.

There is little published data on surfacing times. One study on Yellow-bellied Sea Snake (Rubinoff et al., 1985) found they spent 87% of their time beneath the surface. The study reports data from 15 sea snakes and 202 separate dives with an average of 38 minutes below the surface and 5.8 minutes at the surface. This is within the variation of dive times published by other authors (e.g. Heatwole, 1975).

If sea snakes are only detectable for 13% of the time at the surface, then $g(0) = 0.13$. However, a single sea snake at the surface for 5.8 minutes would only be detectable for a shorter period. For example, the vessel was travelling at an average speed of 7.0 knots (216 m per min) and we detected sea snakes out to distances of about 300m, so sea snakes were detectable on the surface for $t = 1.4$ minutes. So however long sea snakes spent at the surface, we are likely to

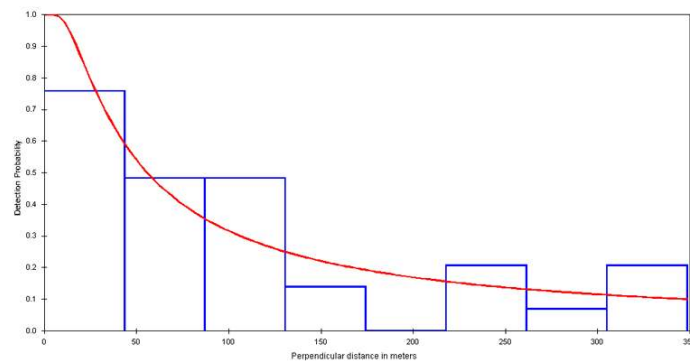
have overlooked a significant proportion ahead of the vessel on the track line. The proportion of sea snakes missed underwater is likely to be $1.4 / 38.0 + 5.8 \times = 0.032$.

Adjusting the density estimate for this figure yields a result of 29.3 ± 12.5 sea snakes per square kilometre. This is much higher than the range of 2.0 – 5.0 per km² published in AES (2009). This is not surprising as the frequency of sea snakes encountered was much higher than in trips south of Ashmore Reef.

Conversely, sea turtles appear to occur at very low density within the affected area and very likely much lower than the estimates predicted in AES (2009).

Dolphins

Using methods described for sea snakes (above) we recorded distance sampling data for dolphins. This resulted in the following detection curve.



Probability of detection = 0.29

Effective Strip Width = 102 m

Density was calculated using Distance 5.0 software (Thomas et al., 2009) and our survey distance of 359 Nm. The final density estimate is 2.08 ± 0.85 individual dolphins per square kilometre, with an average group size of 8.06 ± 6.06 . However, this estimate is only for dolphins at the surface.

As with the sea snake calculations, estimates need to be adjusted for dive and surfacing times. Given the varying and often shallow water environment surveyed, there may also be considerable variation in dive times. Summaries published in the *Encyclopaedia of Marine Mammals* (Stewart, 2002) for Pan-tropical Spotted Dolphins and Bottlenose Dolphins suggest dive times of two to three minutes but with no information on surfacing times. Because we regularly saw pods feeding near the surface, most of our surveys were over relatively shallow water and our detection distances were regularly out to 500m or further, it is assumed that this factor would have relatively little influence on the density estimate. For example, if dolphins were at the surface on average for 80% of the time and we could detect them up to 500m from the vessel, the time available for detection at the surface would be 2.3 minutes. With dive times of only two or three minutes, we can assume they would be

detectable 100% of the time whilst at the surface. Therefore, we would multiply the density estimate by $1/0.8 = 1.25$.

In conclusion therefore, we would assume a density of approximately 2.6 cetaceans per square kilometre surveyed. As a comparison, aerial surveys of dolphins in Ningaloo Reef and the Exmouth Gulf reported densities of dolphins between 0.06 – 0.49 per square kilometre (Preen et al., 1997).

Appendix 3: Survey database content