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Oil Spill Modelling - Montara Case Study

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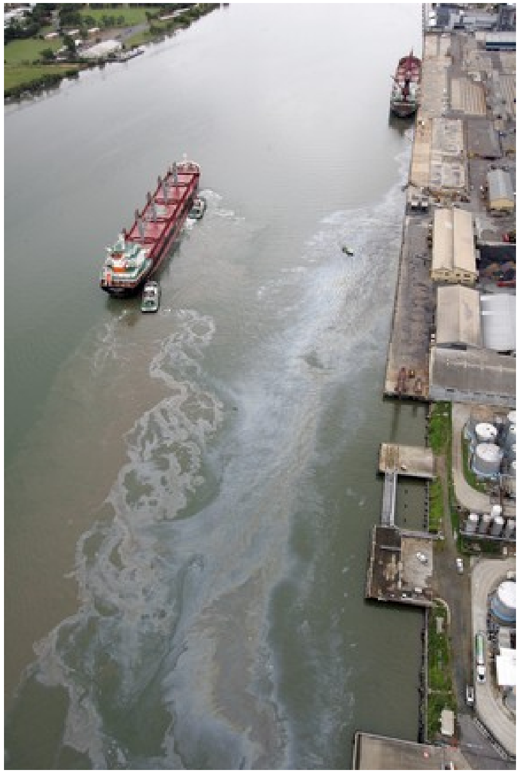
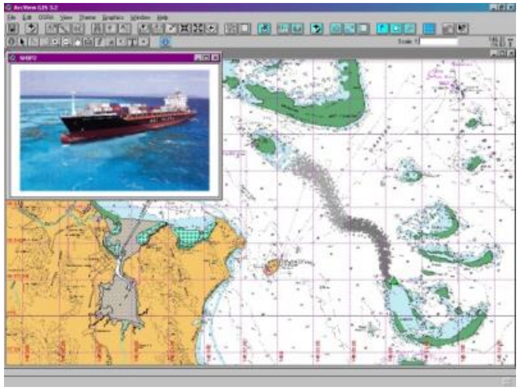
Introduction – Who we are ?

- RPS APASA specialises in the application and development of advanced computer modelling technology for marine environmental, safety and engineering issues.

- RPS APASA is part of the Global RPS Group of Companies and agents for RPS ASA software in the Asia-Pacific region.

- We also operate a 24/7 call-out capability for modelling support for oil and chemical spill response and planning to AMOSC, MNZ, AMSA, and leading petroleum companies.





Montara Case Study

Photo courtesy of PTTEP

- August 21, 2009, reservoir fluids and gases were released from the Montara Platform in the Timor Sea due to the accidental loss of control of the H1 well.
- As a result, crude oil rained down onto the ocean below and flowed for 72 days, releasing up to 28,880 barrels in total, before successful intervention.

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- This presentation demonstrates the operational oceanography undertaken in the forecasting and hindcasting of this spill incident to support both the AMSA response and post spill monitoring studies.
- The Montara Incident had extensive operational oceanographic needs (eg. gas and vapour plume OH&S assessments, stochastic exposure risk assessment, Net Environmental Benefit Analysis of a response using dispersants, ongoing daily forecasts etc).

Photo courtesy of PTTEP

Operational Oceanography Needs for the Montara Response

Satisfying the needs of the Montara response, in a very short time frame, involved the ability to integrate metocean datasets, overflight information, satellite and other observations into oil spill trajectory models (OILMAP and SIMAP) and chemical spill trajectory models (CHEMMAP).

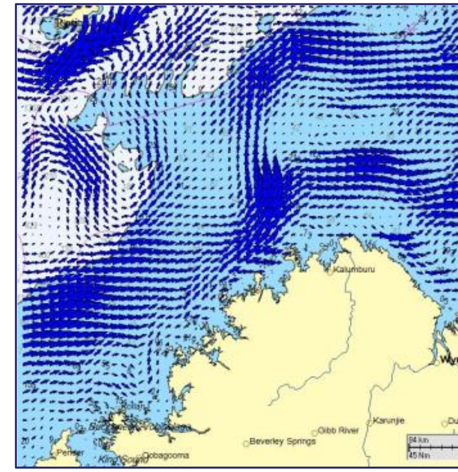
Dispersant, booming and recovery operations (photos courtesy of AMSA)

Coastmap Environmental Data Server - EDS

For fast delivery and integration of metocean data into trajectory models we use the COASTMAP EDS technology.

What is an EDS ?

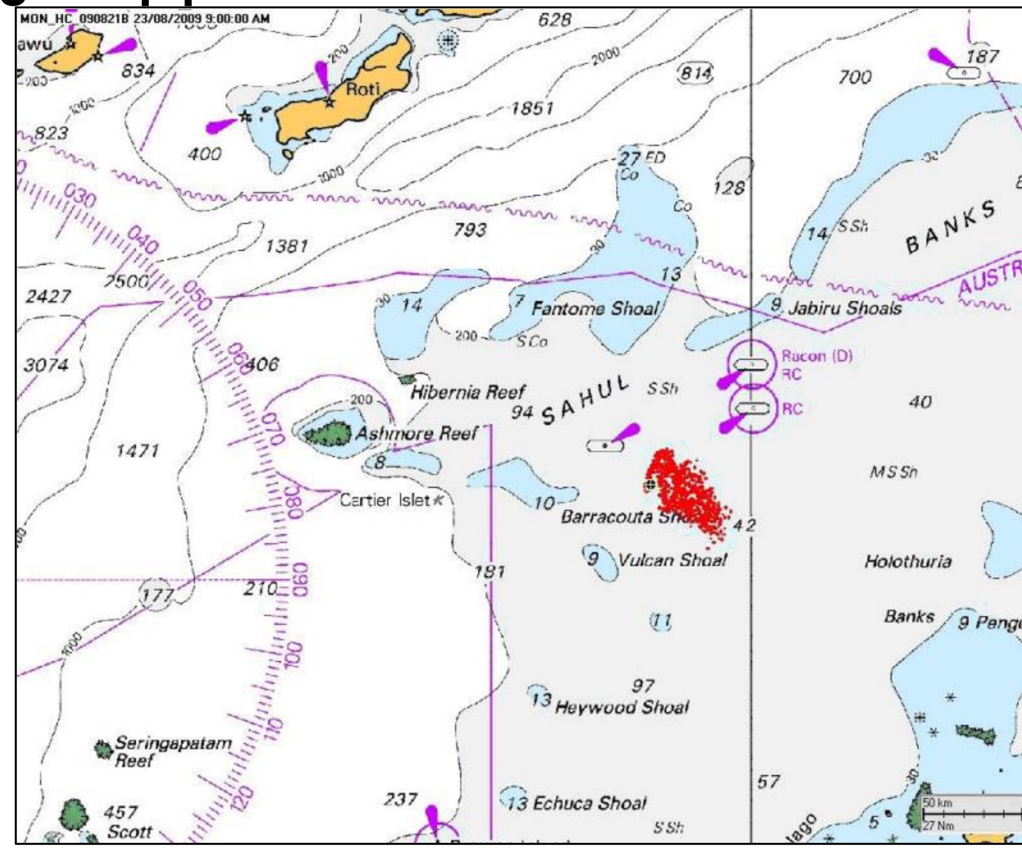
The EDS is a server that aggregates and distributes wind, and current
forecasts and observation data via the internet in a ready to use format for rapid response times. This data ranges from global data to regional forecast products for specific regions.



Example datasets from the EDS: NCOM (top), BLUElink (bottom)

GIS Based Modelling Support

OILMAP, CHEMMAP, SIMAP (and SARMAP) are GIS based models that readily integrates georeferenced data and provides georeferenced outputs. Example right shows OILMAP integration of nautical chart for the Timor Sea and model estimates of oil position 23rd August 2009



Model output highlights the relationship of the spill position in the geographic setting of the Timor Sea

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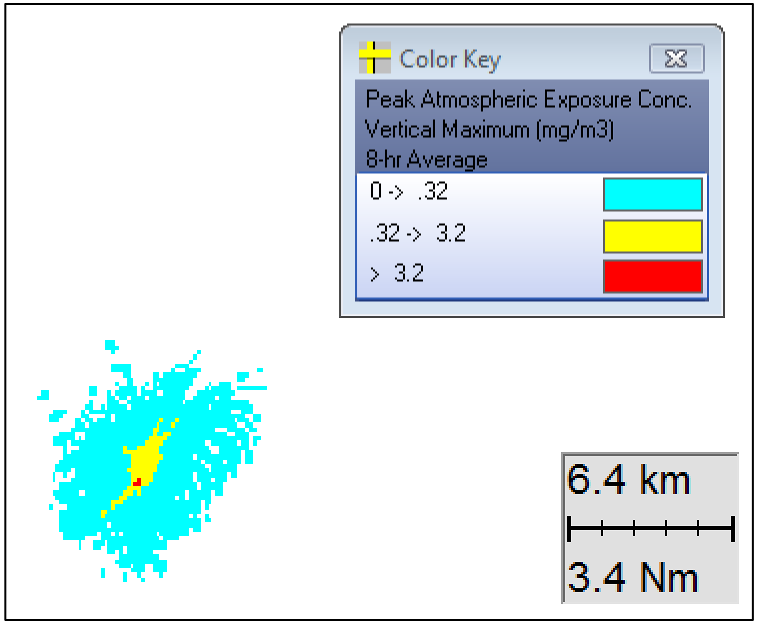
Gas Plume Modelling

CHEMMAP and OILMAP were used to quantify the fate of atmospheric concentrations of the gas plume and vapour fumes from evaporating surface oil to potentially identify any explosion risks and other concentrations of concern for OH&S purpose.



As an example, the model results show the potential for Benzene vapours to exceed OH&S atmospheric triggers immediately near the release site.

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Initial Risk Assessment and NEBA

Using Stochastic trajectory Modelling and long-term metocean datasets it was possible to quantify:

- Ø The most likely and all potential paths for a long duration spill of Montara Crude
- Ø The probabilities of oiling the various open water locations, shoals and shorelines
- Ø The potential timeframes to impact
- Ø Any potential Net Benefit from response strategies as part of Incident Action Plan Development

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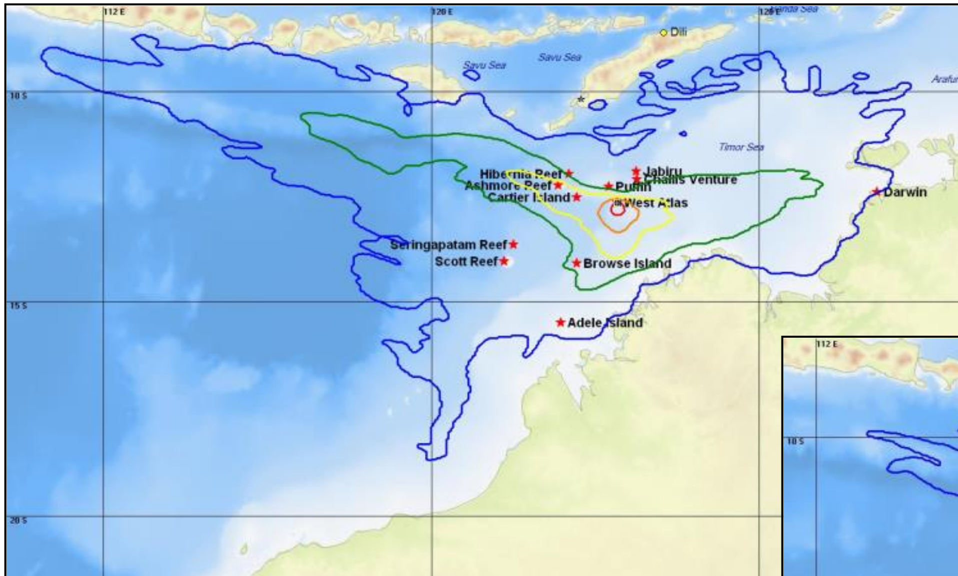
Initial Risk Assessment and NEBA



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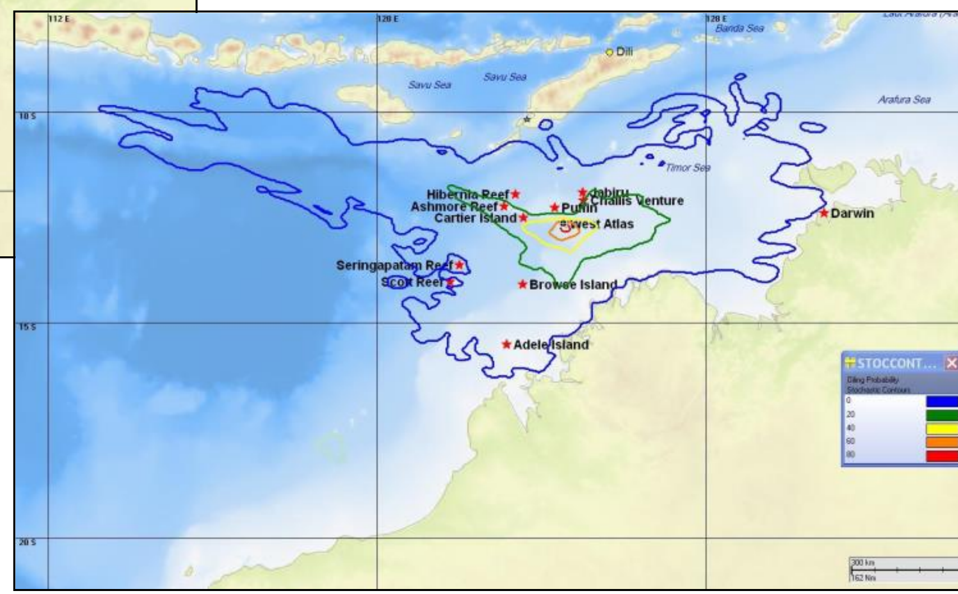
Assume No Response

Stochastic Model outputs (based on long-term historical met-ocean conditions) with and without the application of dispersants

Assume 50% dispersant effectiveness =>



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Initial Risk Assessment and NEBA

Table summarizes the Risk Profile from 100 trajectory simulations using the Stochastic Model (based on long-term historical met-ocean conditions) with and without the application of dispersants

Location	Distance from Spill Site (km & Nm)	Probability of Being Oiled	Time to reach nearby shorelines
Cartier Island	106km or 57Nm	50 in 100 spills (No response) 39 in 100 spills (With Response)	> 3 days
Ashmore Reef	162km or 87Nm	47 in 100 spills (No response) 30 in 100 spills (With Response)	> 5 days
WA Coastal Islands	185km or 100Nm	25 in 100 spills (No response) 10 in 100 spills (With Response)	> 14 days

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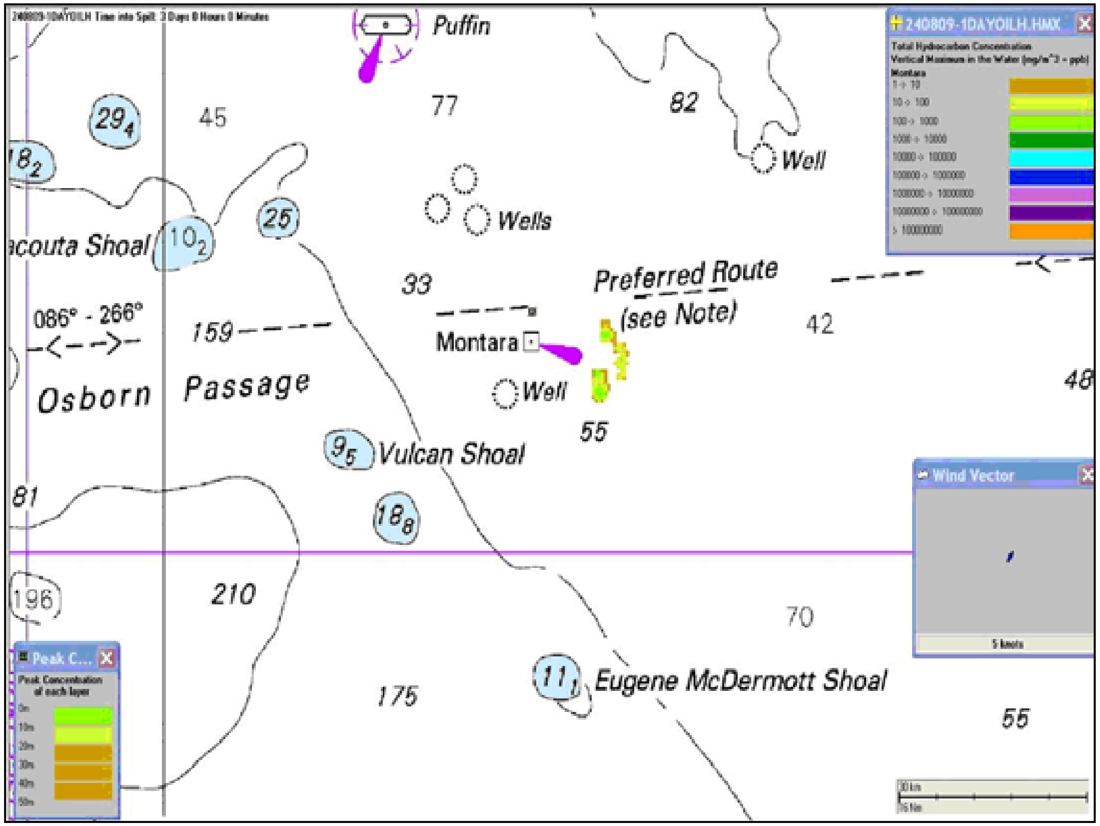
NEBA – Dispersed Oil Concentrations

Simulation of a planned aerial dispersant event using SIMAP to map the potential concentrations and movement of subsurface plumes.

Figure left shows plumes 2 days after dispersant application



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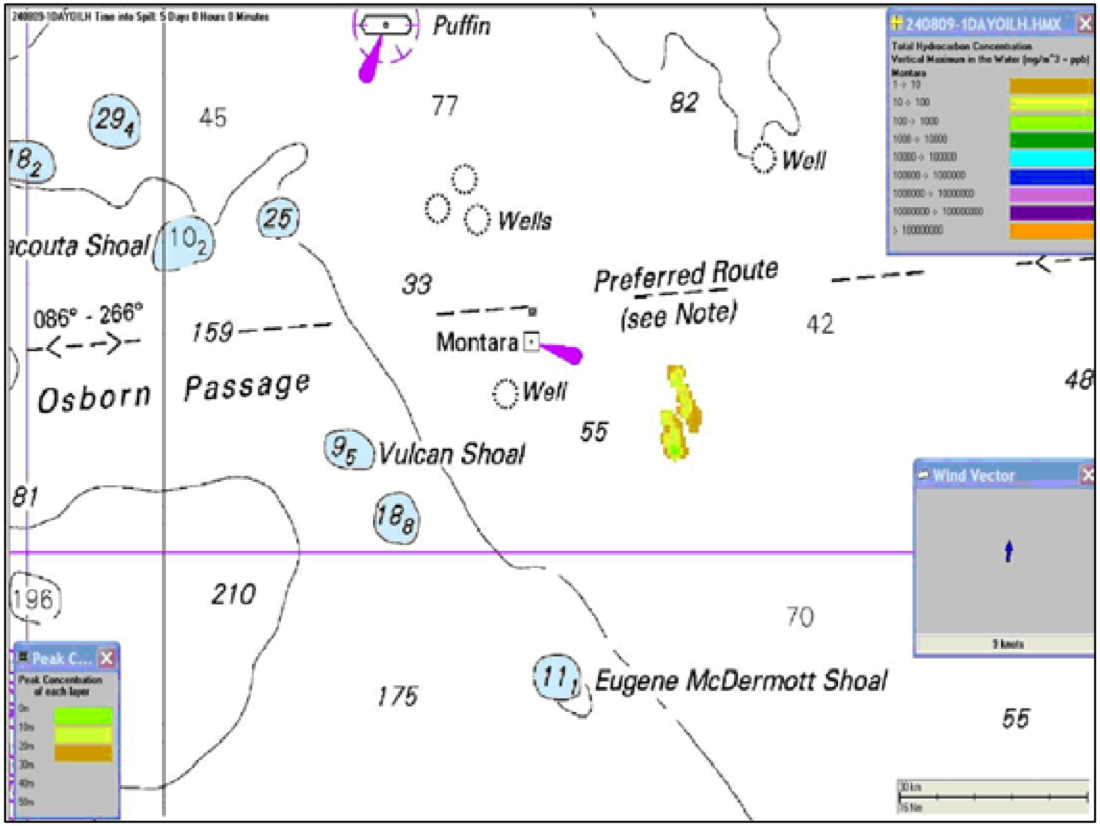
NEBA – Dispersed Oil Concentrations

Simulation of a planned aerial dispersant event using SIMAP to map the potential concentrations and movement of subsurface plumes.

Figure left shows plumes 4 days after dispersant application



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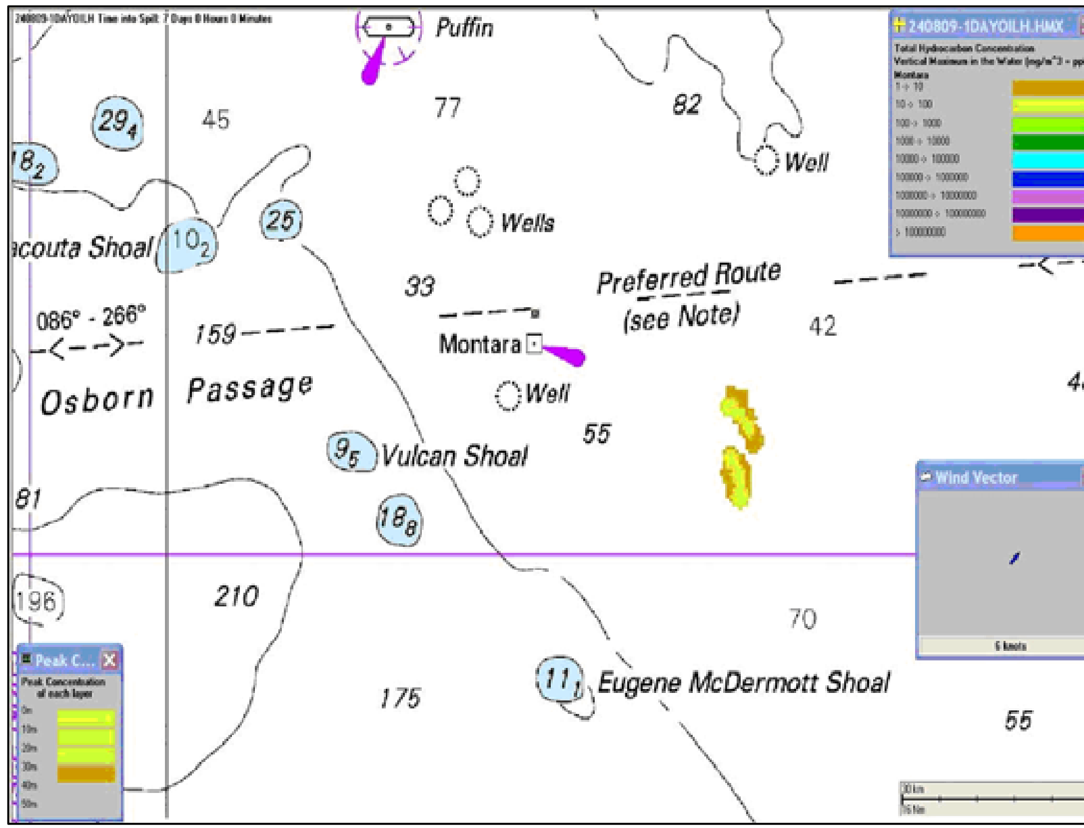
NEBA – Dispersed Oil Concentrations

Simulation of a planned aerial dispersant event using SIMAP to map the potential concentrations and movement of subsurface plumes.

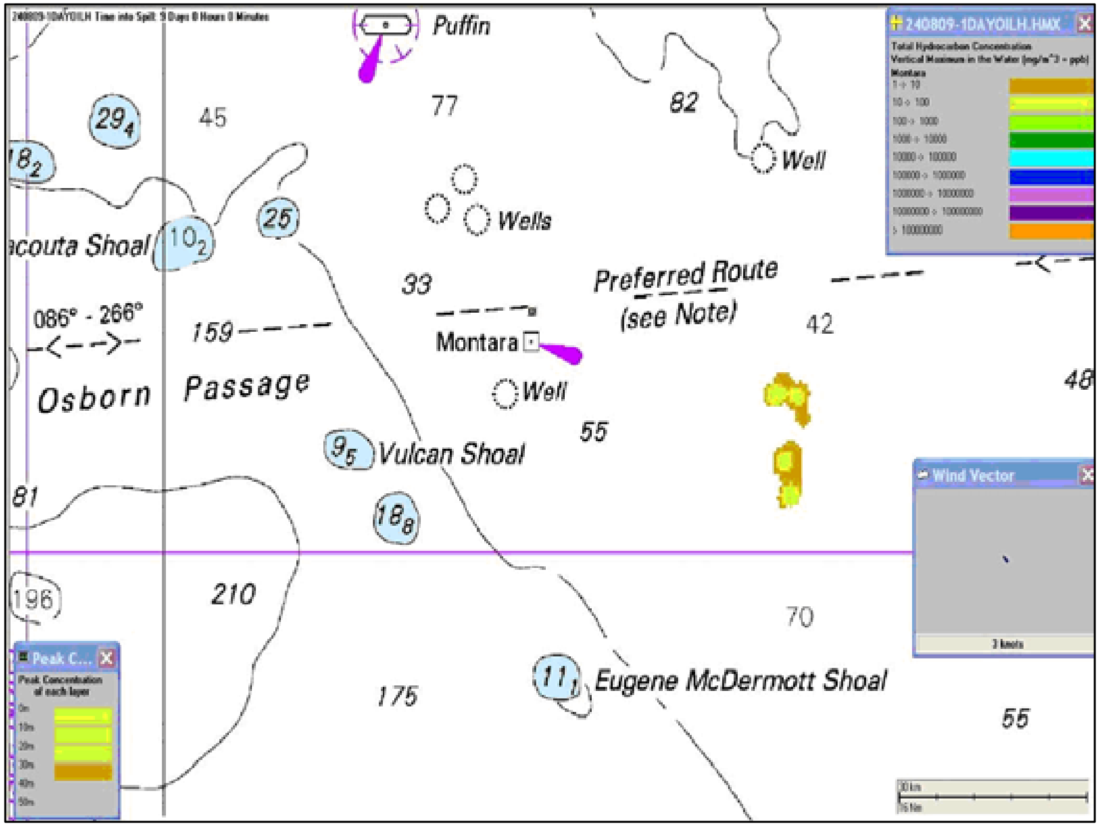
Figure left shows plumes 6 days after dispersant application



NEBA – Dispersed Oil Concentrations

Simulation of a planned aerial dispersant event using SIMAP to map the potential concentrations and movement of subsurface plumes.

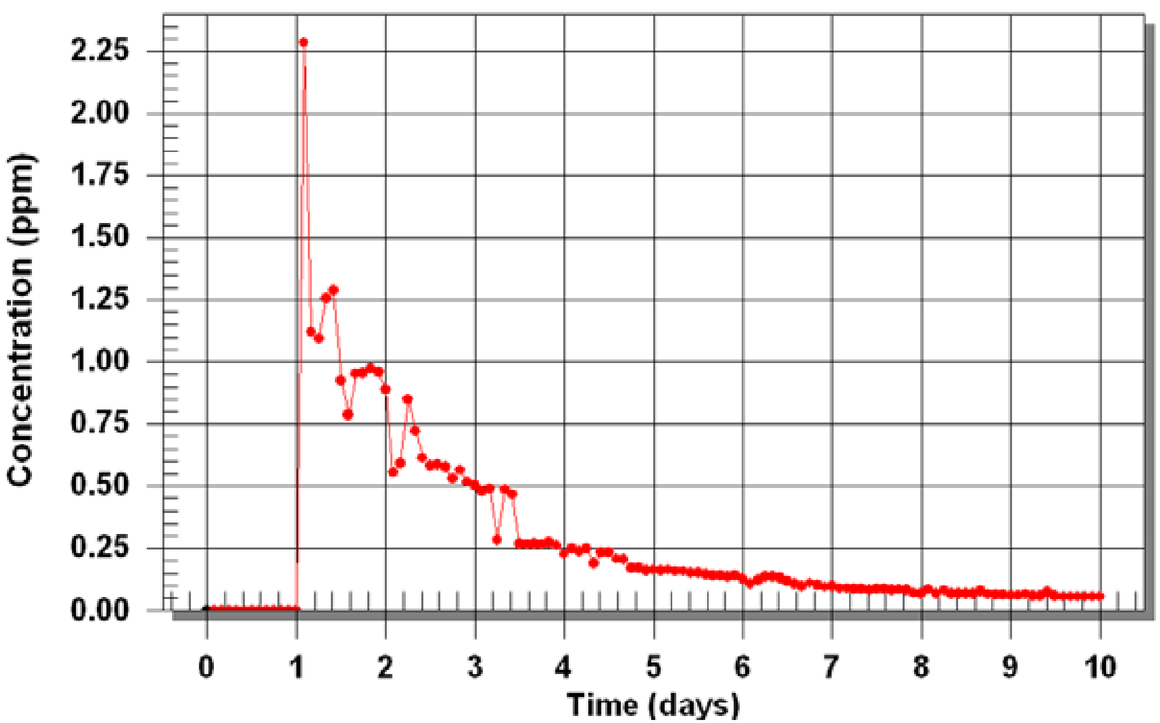
Figure left shows plumes 8 days after dispersant application



NEBA – Dispersed Oil Concentrations

Simulation of a planned aerial dispersant event using SIMAP to map the potential concentrations and movement of subsurface plumes.

Figure shows the calculated maximum hydrocarbon concentration at any location, and at any depth for an assumed 100% dispersant effectiveness scenario



NEBA – Dispersed Oil Concentrations

Parameter	50% dispersant effectiveness	100% dispersant effectiveness
Amount of dispersant used (L)	9000	
Maximum concentration (ppm)	1.66	2.28
Average concentration over 96 hours after dispersant event (ppm)	0.50	0.57
Concentration of hydrocarbons 4 days after dispersant event (ppm)	0.17	0.16
Concentration of hydrocarbons 9 days after dispersant event (ppm)	0.05	0.05

Comparison of dispersant effectiveness to determine the range of possible in water concentrations

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Ongoing Spill Forecasts

- Ongoing Spill Forecast Bulletins were required and issued to The Tactical and Environment Response Teams.
- They were undertaken using OILMAP using various forecast datasets on the COASTMAP EDS to develop a "consensus forecast" of what was expected to occur.
- Spill Forecasts were checked against the daily aerial observations being collected to ensure accuracy was maintained throughout the incident.
- It is important to note that the response trajectory modelling was designed to provide 'search areas for oil' and assumed worst-case parameters and overestimated possible oil positions to minimise the chances of loosing track of oil at any time.

- Daily overflight observations were also useful to interpret satellite images when these became available.
- Overflights were more reliable as satellite images required interpretation.

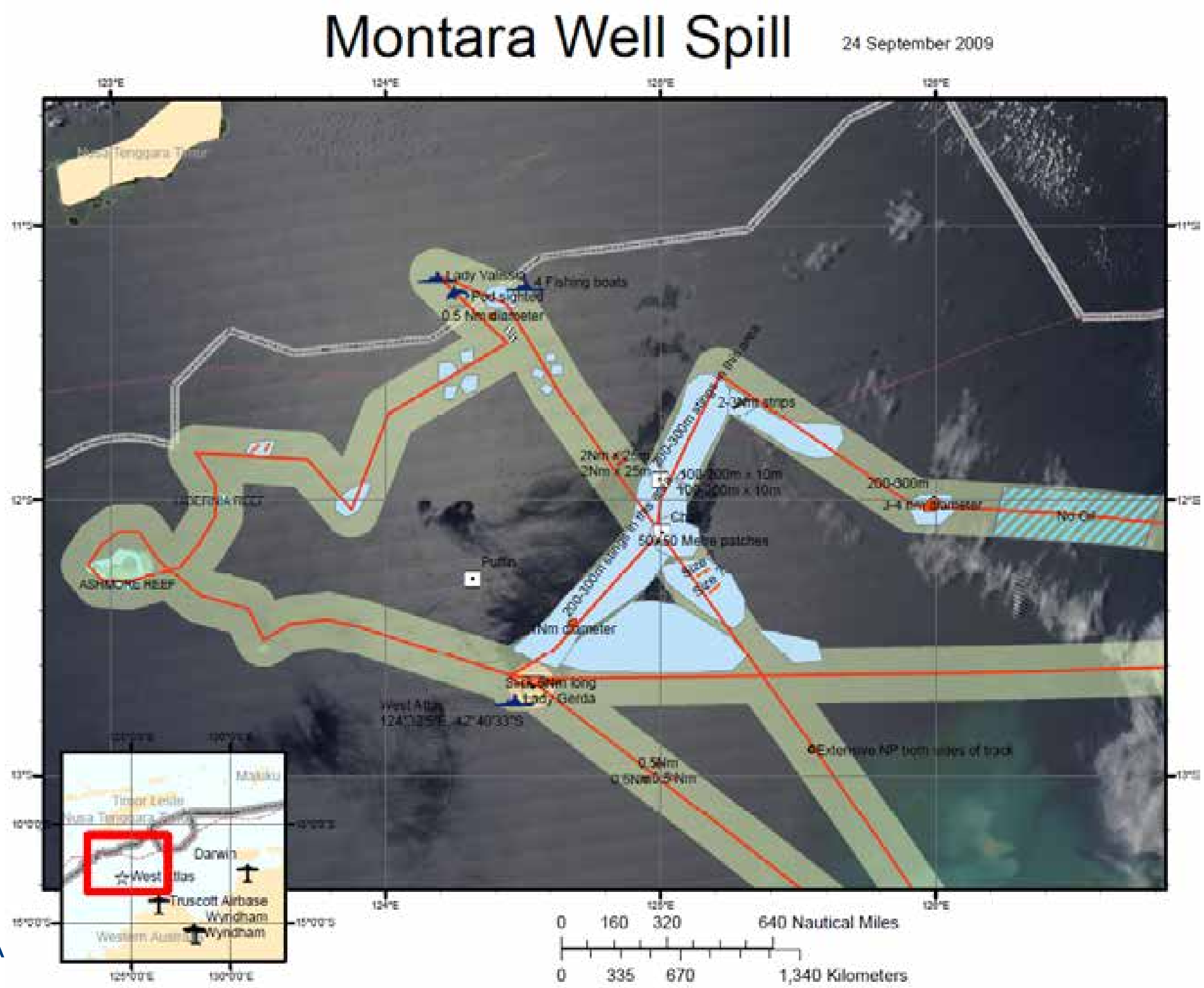


Image courtesy of AMSA

Spill Forecast Bulletin Issued 16th October 2009

Recent overflight and satellite observations have been used to update oil, oil patches and sheen positions within the OILMAP system.

The wind conditions at Montara are expected to be light (<10 kts) and variable in direction over the forecast period.

At the Montara well site, tidal oscillations are expected to strengthen over the week and net drift will be towards southwest near Montara over the forecast period.

Fresh oil flows at Montara are predicted to flow:

17th Oct 2009: SW flow at 9am; NW flow at 3pm (4 to 8 knot SE winds)

18th Oct 2009: SW flow at 9am; NW flow at 3pm (calm ESE winds)

19th Oct 2009: SW flow at 9am; Northward flow at 3pm (8 knot SE to NE winds)

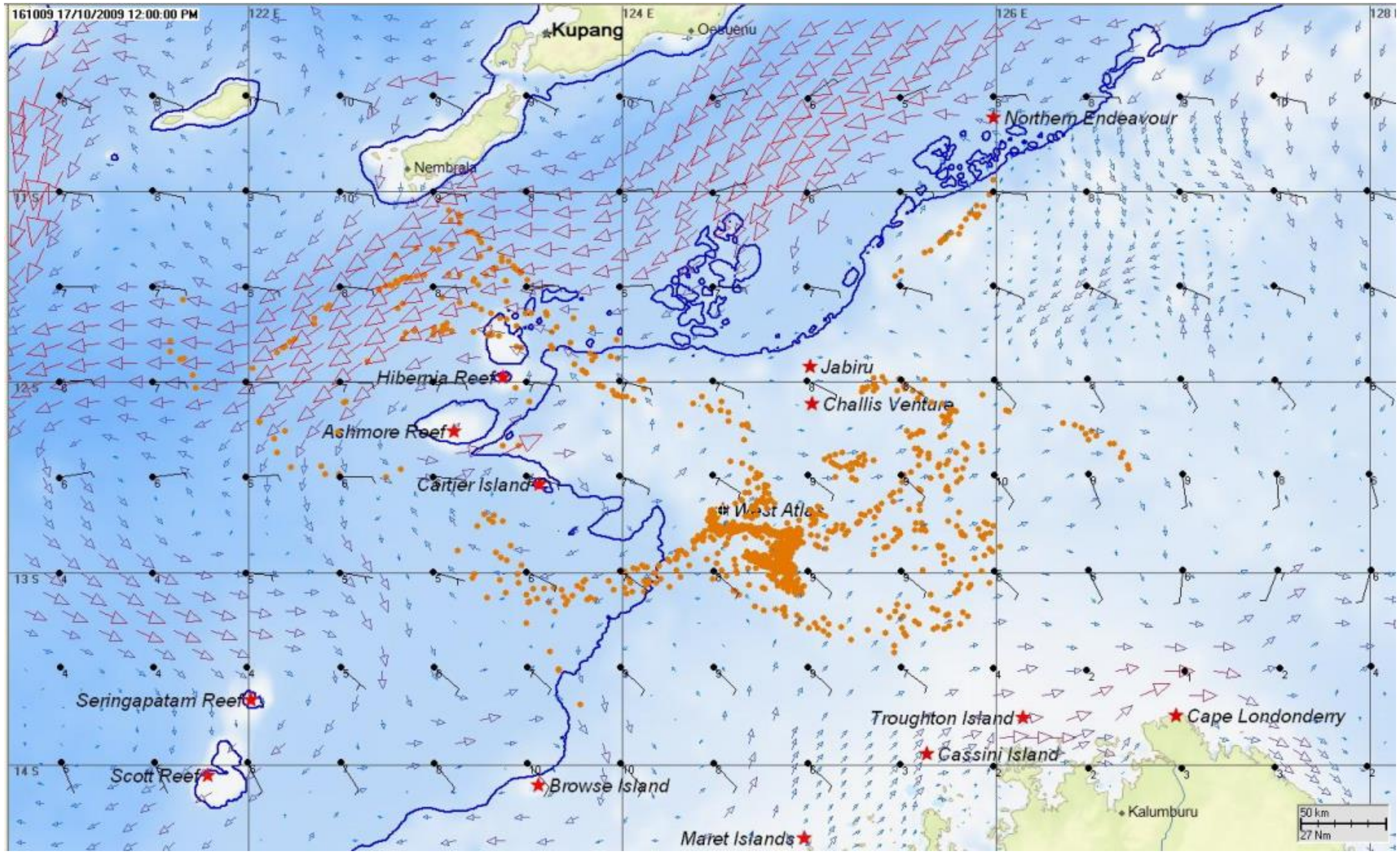
Spill Forecast Bulletin Issued 16th October 2009

To the north, the Indonesian Thru Flow current continues to flow strongly WSW. Shelf-break eddies will continue to entrain patches into the Indonesian Thru Flow where they will be rapidly transported WSW (parallel with the West Timor Coastline) towards the Ashmore, Hibernia and Cartier Reefs as well as dispersing into the Indian Ocean.

The winds are not predicted to be strong over the deeper water to the north hence, it is unlikely that patches will reach the shorelines of West Timor during the forecast period.

Note that the brown dots in the figures indicate “search areas for oil”. The density of the brown dots in the figure below indicates the likelihood of finding weathered oil. Due to the containment and dispersant operations, oil may have been removed, hence this forecast is a ‘worst-case’ depiction of the spill at these times.

Spill Forecast Bulletin Issued 16th October 2009



Forecast for midday 17 Oct 2009

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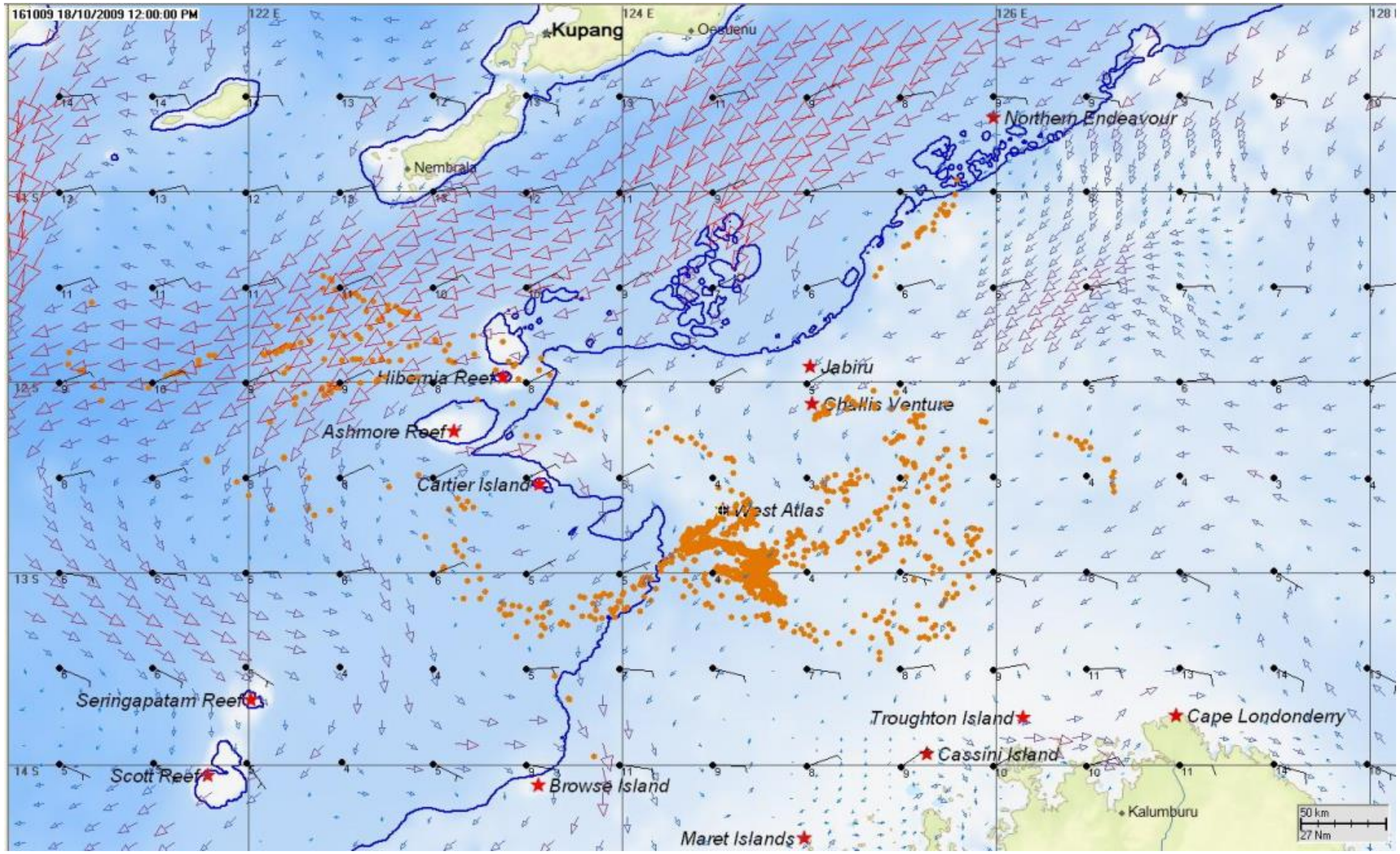
Spill Forecast Bulletin Issued 16th October 2009



Forecast for midday 18 Oct 2009

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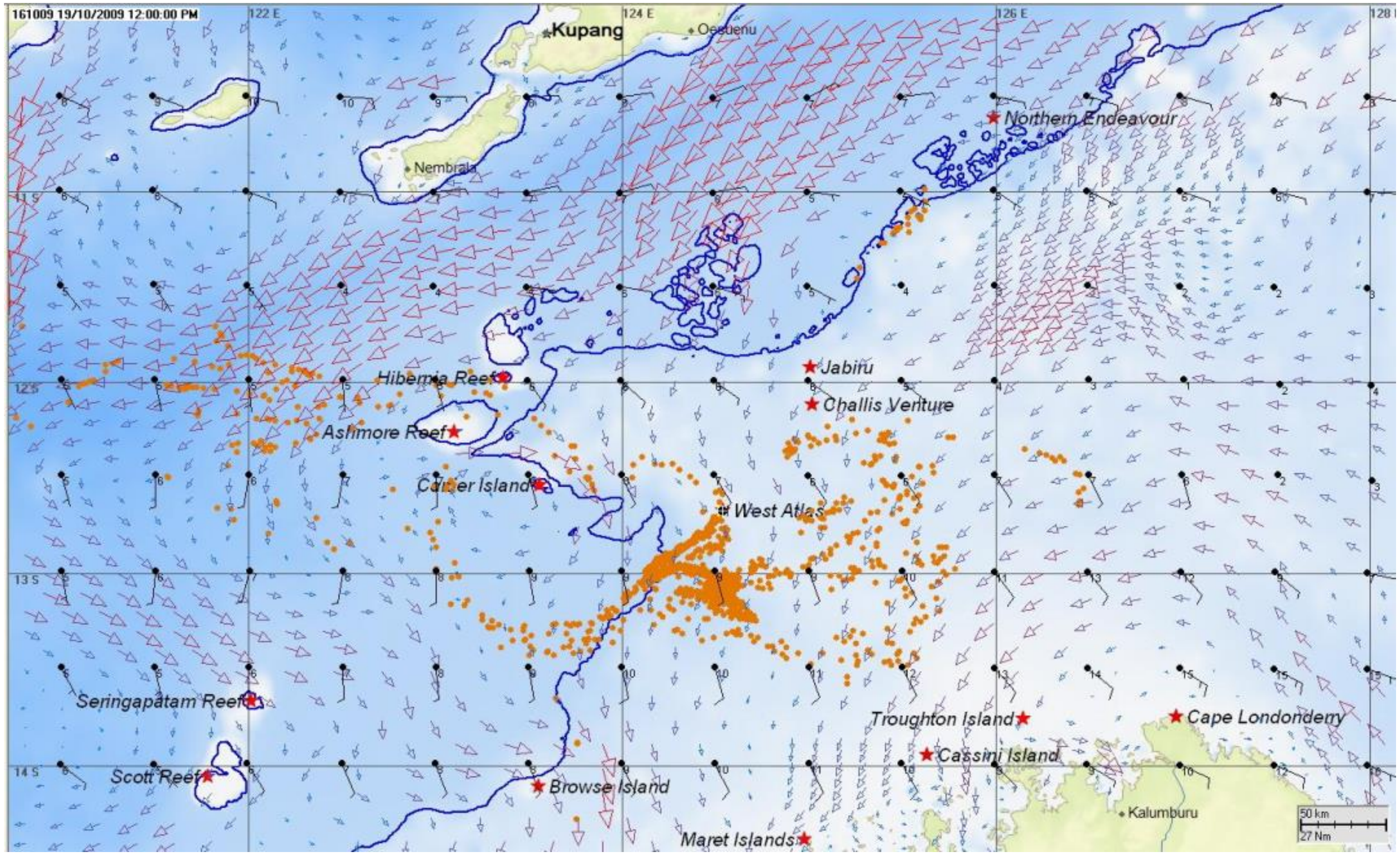
Spill Forecast Bulletin Issued 16th October 2009



Forecast for midday 19 Oct 2009

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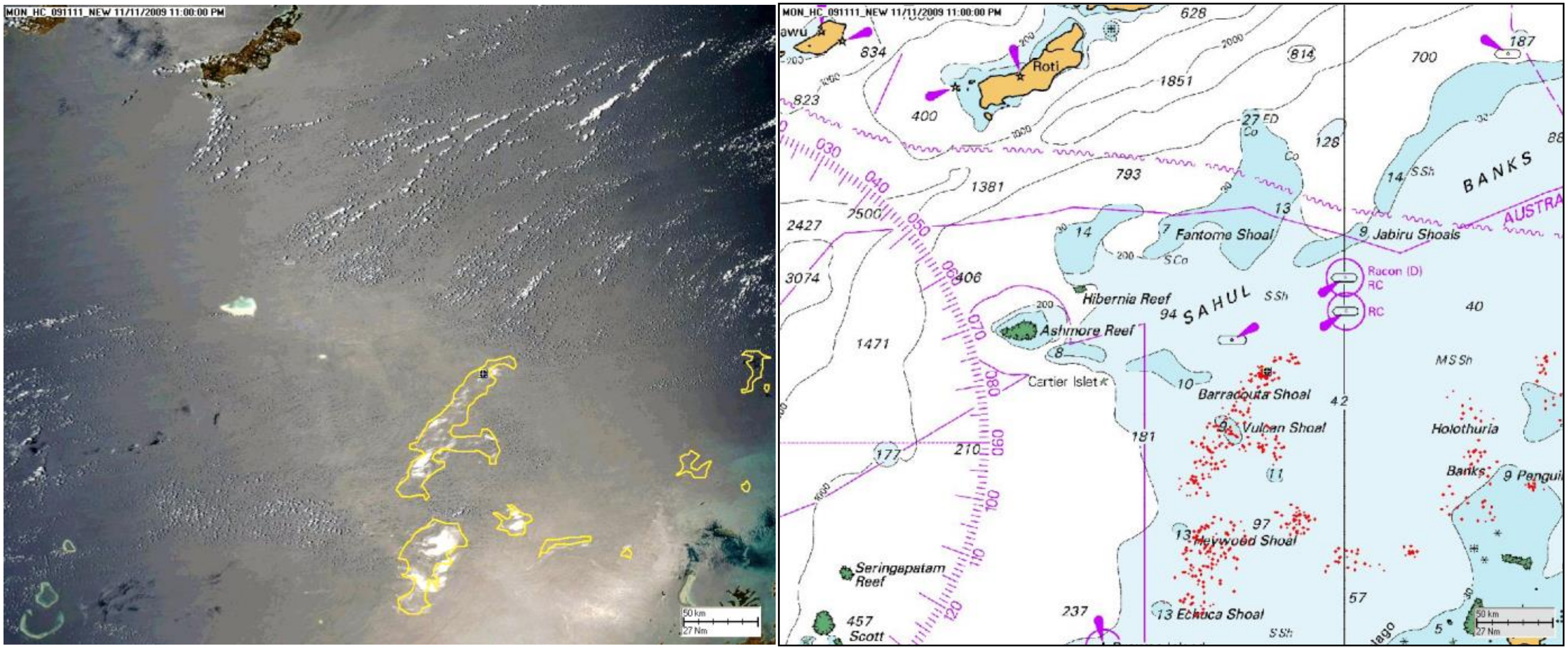
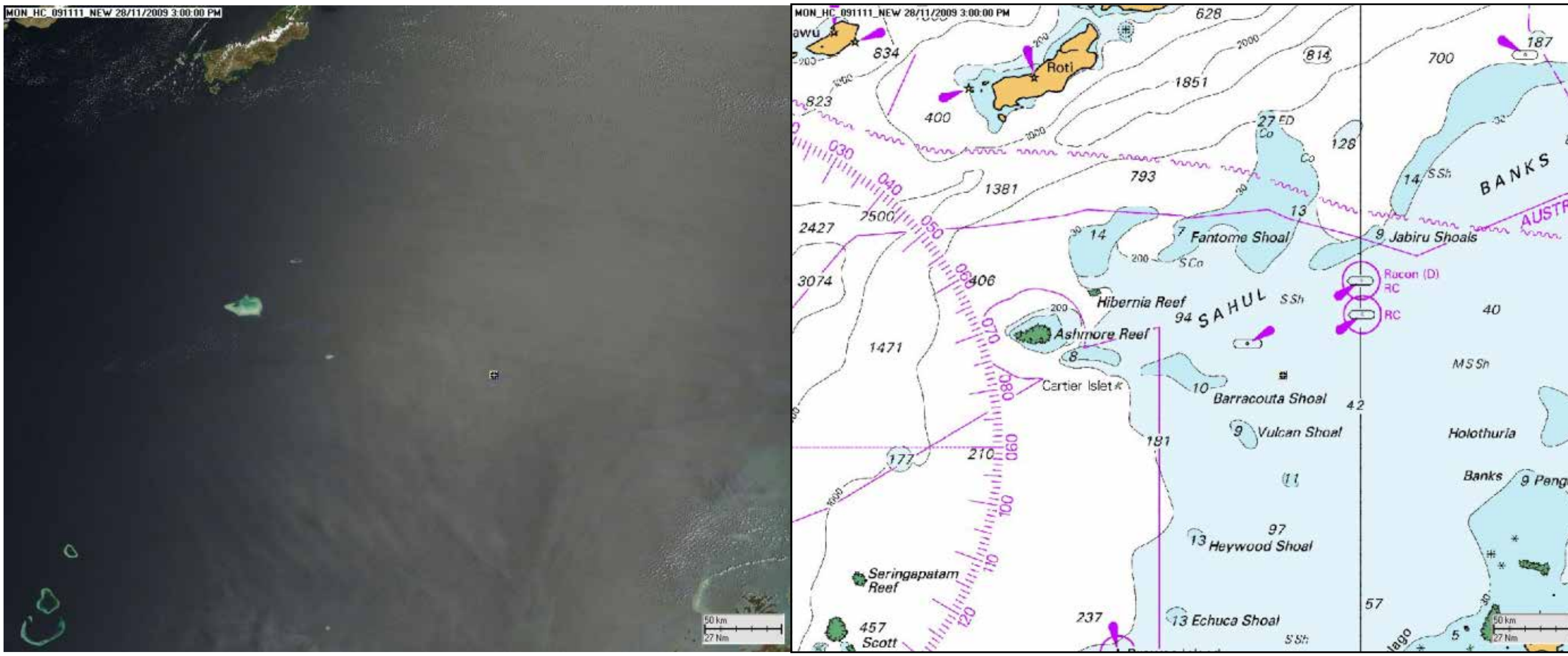
Comparison of Sat image with Spill Forecast



Modis Image and Forecast for 11 November 2009. Note that the uncontrolled flow was successfully stopped by drilling into and plugging the well hole on 4 November 2009

Comparison of Sat image with Spill Forecast



Modis Image and Forecast for 29 November 2009. Note: no visible oil patches in the satellite image or the modelled predictions.

Conclusion

By combining:

- high-resolution tidal currents,
- multiple metocean forecast datasets,
- the assimilation of daily overflight data
- the assimilation of satellite images (when available)

into the oil spill model ultimately provided the most accurate forecast methodology.

This same integrating approach, using reanalysis datasets instead of the forecast datasets, allowed for a final comprehensive (hourly) record of a protracted spill event over time.

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Swept Area Map for Post Spill Monitoring

Relative surface oil exposure map representing up to 99.99% of occurrences of visible surface oil.

The dark blue extents are characterised by one off occurrences of highly weathered oil with durations of less than 2 hours in any one location, often associated with fast moving current regimes.