Appendix F1

Asia-Pacific Applied Science Associates 2014

Browse FLNG Development – Quantitative Spill Risk Assessment, Report produced for Woodside Energy Limited

BROWSE FLNG DEVELOPMENT
Draft Environmental Impact Statement

EPBC 2013/7079
November 2014

Browse FLNG Development

Quantitative Spill Risk Assessment

Rev 3 - 13/05/2014

Prepared for:
Woodside Energy Ltd

Document control form:

Revision	Originated	Edit & review	Authorised	Date
Rev A - Issued for internal review	APASA	M Burling	N/A	30/01/2014
Rev B - Issued for internal review	APASA	M Burling	N/A	06/02/2014
Rev 0 - Issued for internal review	APASA	M Burling	M Burling	07/02/2014
Rev 1 - Issued to Client	APASA	M Burling	M Burling	11/02/2014
Rev 2 - Issued following Client Review	APASA	M Burling	M Burling	10/03/2014
Rev 3 - Issued following Client Review	APASA	D Wright	M Burling	13/05/2014

Document name: J0282 - WEL Browse EIS Spill Modelling - Rev 3.docx

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Contents

Figures

Tables

EXECUTIVE SUMMARY

Asia-Pacific Applied Science Associates (APASA) has undertaken a quantitative hydrocarbon spill risk assessment for Woodside Energy Ltd (WEL), which was required as part of the assessments for the Browse Floating Liquefied Natural Gas (FLNG) project in the Torosa gas field. This study was conducted in a manner consistent with earlier Browse studies, with regard to model grids and metocean forcing data. The Torosa field is located in permit area WA-30-R in the Browse Basin, in the vicinity of a complex of reef structures consisting of Scott Reef North, Scott Reef South and Seringapatam Reef. These are coral atolls that rise steeply from the surrounding shelf.

The objective of the study was to provide an assessment of the probabilities of oil contact (at greater than defined minimum concentrations), the potential concentrations that might be involved, and the minimum state of weathering of the oil in the case of a release of hydrocarbons. The assessment considers a number of specific spill scenarios involving different sources, spill durations and oil types, which were defined by WEL to represent credible scenarios.

WEL identified the following seven hydrocarbon spill risk scenarios for investigation:

1. Blowout at the TRE well centre during drilling operations releasing 3,975 m^3 of Torosa Condensate onto the water surface over 5 days, followed by release of 69,969 m^3 at the seabed (463 m BMSL) over 72 days.

2. Loss of pipeline pressure containment in the TRD flowline discharging 25 m^3 of Torosa Condensate at the seabed (389 m BMSL) over 1 hour.

3.2 Leak due to equipment failure at the FLNG topside, 8 km ENE of the TRD location, releasing 165.3 m^3 of Browse Condensate onto the water surface over 20 min.

4.2 Discharge from an offtake vessel due to major structural failure, releasing 18,000 m^3 of Browse Condensate onto the water surface at approximately 8 km ENE of the TRD location over 24 hours.

4.4 Discharge from an offtake vessel due to major structural failure, releasing 18,000 m^3 of Browse Condensate onto the water surface at the BWA facility over 24 hours.

5. Spill during bunkering operations discharging 13 m^3 of Marine Diesel onto the water surface at approximately 8 km ENE of the TRD location over 5 min.

6. Loss of containment during offtake at the BWB facility, discharging 461.5 m^3 onto the water surface over 5 min.

Oil spill modelling was undertaken using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces. Near-field blowout modelling was undertaken using OILMAP-Deep, which predicts the droplet sizes that are generated by the turbulence of the discharge as well as the centreline velocity, buoyancy, width and trapping depth (if any) of the rising gas and oil plumes.

To define trends and variations in the potential outcomes of a given scenario, a stochastic modelling process was followed for all scenarios, whereby SIMAP was applied to repeatedly simulate the defined spill scenarios using different samples of current and wind data selected randomly from historic time-series data representative of the study area. Results of the repeated simulations were then statistically analysed and mapped to define contours of risk to contact by oil components around the release point at meaningful threshold concentrations and determine the probability of exposure for sensitive receptors.

For this study, thresholds for floating oil and dissolved aromatic hydrocarbon dosage were specified by WEL at ≥0.5 g/m^2, ≥1 g/m^2, ≥10 g/m^2 and ≥25 g/m^2 for floating oil, and at ≥576 ppb.hr, ≥4,800 ppb.hr and ≥38,400 ppb.hr for dissolved aromatic hydrocarbon dosage. Sensitive receptors comprised shorelines, islands and major shoal areas including the Scott Reef complex (South Reef Flats, South Reef Lagoon, Sandy Islet, North Reef Lagoon, North Reef Flats) and Seringapatam Reef.

The main findings of this work are as follows:

Metocean Influences

- Within the Reef complex, tidal currents dominate the short term variability in oil drift, with the local winds exerting an important influence on floating oil.
- Large-scale drift currents will have a significant influence on the trajectory of any oil spilled at the modelled release sites, irrespective of the seasonal conditions. The prevailing drift currents will determine the trajectory of oil that is entrained beneath the water surface.
- Interactions with the prevailing wind will add additional variation in the trajectory of spilled oil and marked variation in the prevailing drift current and wind conditions would be expected over the duration of the long releases. This would be expected to increase the spread of oil during any single event.

Oil Characteristics and Weathering Behaviour

- The Torosa Condensate mixture specified for the surface phase of the blowout contains a low proportion of volatile components and a high proportion of residual components. If exposed to the atmosphere, around 16% of the mass would be expected to evaporate in around 24 hours, another 33% within a few days, and the remaining 51% would be expected to persist on the water surface until entrainment and decay occurs.
- The Torosa Condensate mixture specified for the subsea phase of the blowout is broadly similar to the surface-phase oil, but with a higher proportion of volatile components and a lower proportion of residual components. If exposed to the atmosphere, around 54% of the mass would be expected to evaporate in around 24 hours, another 21% within a few days, and the remaining 25% would be expected to persist on the water surface.
- The Browse Condensate mixture contains a high proportion of volatile components and a significant proportion of residual components. If exposed to the atmosphere,

around 78% of the mass would be expected to evaporate in around 24 hours, another 8% within a few days, and the remaining 14% would be expected to persist on the water surface.

- The marine diesel mixture contains a significant proportion of volatile components and a low proportion of residual components. If exposed to the atmosphere, around 41% of the mass would be expected to evaporate within 24 hours, another 54% within a few days, and the remaining 5% would be likely to persist on the water surface. The influence of entrainment in a real spill event will regulate the degree of mass retention in the system.

Summary of Blowout Scenario

- In the case of the blowout (Scenario 1), floating oil is forecast to potentially drift in all directions, with extended trajectories predicted to the northwest and southwest of the Scott Reef complex – reflecting the influence of the Indonesian Throughflow surface current and the North West Shelf seasonal currents and eddies, respectively.
- The floating oil impacts are predicted to be focused on Scott Reef and Seringapatam Reef, with maximum concentrations of 50 g/m^2 or greater potentially occurring at most points within the reef complexes, and concentrations of 10 g/m^2 or greater potentially occurring in the Kimberley and Argo-Rowley Terrace CMR zones. There are low risks of floating oil concentrations 0.5 g/m^2 or greater being found as far north as the Oceanic Shoals CMR and as far south as the Rowley Shoals.
- Dissolved aromatic hydrocarbons are predicted to largely remain within the Scott Reef flats and lagoons. In terms of dosage, all thresholds are expected to be exceeded throughout the water column within Scott Reef, with the impacts decreasing with increasing depth, and the areal coverage decreasing with increasing threshold level as expected. Most of the reef complex is expected to be subject to dosage levels of 576 ppb.hr or greater, while the occurrence of the 38,400 ppb.hr level is expected to be limited to the South Reef Lagoon and Scott Reef Central/Sandy Islet areas. This is due to both the proximity of the release location and the oscillating currents in the deep channel between Scott Reef North and Scott Reef South that allow the persistence of hydrocarbons over time.

Summary of Subsea Release Scenario

- In the case of the subsea release (Scenario 2), floating oil at the lowest threshold is forecast to be restricted to the immediate vicinity of the release site, with a maximum floating oil concentration in excess of 10 g/m^2. In terms of dissolved aromatic hydrocarbon dosage, the low and moderate thresholds are predicted to be exceeded only in the upper 10 m of the water column around the release site. The nearest sensitive receptor (North Reef Flats) is not expected to be exposed to dosage levels in excess of the low threshold (576 ppb.hr).

Summary of Small Surface Release Scenarios

- In the case of the small surface spills (Scenarios 3.2, 5 and 6), where the spill sites are all located a few kilometres to the east of Scott Reef North, floating oil is predicted to drift to the northeast and south of each release site. Despite the proximity of the Scott Reef and Seringapatam Reef receptors, the maximum floating oil concentration (in excess of 50 g/m^2 in the immediate vicinity of the release site in all three scenarios) has only a small probability of exceeding 10 g/m^2 within Scott Reef in Scenarios 3.2 and 5, and the only predicted contact beyond Scott Reef is at the 0.5 g/m^2 threshold at Kimberley CMR in Scenario 3.2. In Scenario 6, the larger volume of condensate leads to a possibility of concentrations in excess of 25 g/m^2 being found inside Scott Reef, but beyond these receptors there is only a small probability of concentrations of 0.5 g/m^2 or greater being found at Kimberley CMR. In general the expected accumulating volume of oil on relevant shorelines is expected to be low.

- In terms of dissolved aromatic hydrocarbon dosage, the low threshold (576 ppb.hr) may be exceeded in the upper 20 m of the water column in Scenario 3.2, with dosage levels remaining below the low threshold throughout the water column in Scenario 5. In Scenario 6, the low dosage threshold is predicted to be exceeded along the eastern edge of Scott Reef down to a depth of 40 m, with the area of impact decreasing with increasing depth. All receptors within Scott Reef except Scott Reef Central/Sandy Islet show low probabilities of exposure to dosage levels of at least 576 ppb.hr.

Summary of Large Surface Release Scenarios

- In the case of the large surface spills (Scenarios 4.2 and 4.4), where the spill sites are located approximately 10 km east and 40 km southwest of Scott Reef, respectively, the predicted trajectories for floating oil are similar: drift is forecast to occur in any direction after release, with extended trajectories possible to the northwest and northeast of Scott Reef.

- The potential floating oil impacts in both scenarios are predicted to be focused on Scott Reef and Seringapatam Reef, with maximum concentrations of 50 g/m^2 or greater occurring at many points within the reef complexes, and concentrations of 10 g/m^2 or greater potentially occurring in the Ashmore Reef, Cartier Island, Kimberley and Mermaid Reef CMR zones, and also at Rowley Shoals MP (Clerke Reef) as isolated low probability events. There are low risks of floating oil concentrations 0.5 g/m^2 or greater being found as far north as Hibernia Reef and as far south as the Rowley Shoals.

- In both scenarios all thresholds for dissolved aromatic hydrocarbon dosage are expected to be exceeded in the upper 10 m of the water column, with the moderate threshold being exceeded down to 40 m and the low threshold being exceeded down to 60 m. The impacts decrease with increasing depth, and the extent of the exposure area decreases with increasing threshold level. In Scenario 4.2 most of the Scott Reef complex will be exposed to dosage levels of 4,800 ppb.hr or greater to a depth of 40 m, while in Scenario 4.4 dosage levels of this magnitude are also expected on the margins of Scott Reef.

1 INTRODUCTION

1.1 Background

Asia-Pacific Applied Science Associates (APASA) has undertaken a quantitative hydrocarbon spill risk assessment for Woodside Energy Ltd (WEL), which was required as part of the assessments for the Browse Floating Liquefied Natural Gas (FLNG) project in the Torosa gas field. This study was conducted in a manner consistent with earlier Browse studies (APASA, 2012a, 2012b, 2012c, 2013), with regard to model grids and metocean forcing data. The Torosa field is located in permit area WA-30-R in the Browse Basin, in the vicinity of a complex of reef structures consisting of Scott Reef North, Scott Reef South and Seringapatam Reef. These are coral atolls that rise steeply from the surrounding shelf.

The main objective of the study was to provide an assessment of the probabilities of oil contact (at greater than defined minimum concentrations), the potential concentrations that might be involved, and the minimum state of weathering of the oil in the case of a release of hydrocarbons. The assessment included quantifying effects both on the surface and within the water column at a number of depth levels relevant to surrounding benthic habitats.

The assessment considers a number of specific spill scenarios involving different sources, spill durations and oil types, which were defined by WEL to represent credible scenarios. For each of the credible scenarios, an event probability (P1) was provided by WEL. The event probabilities span several orders of magnitude, with the least likely event expected to have a return (or occurrence) period of once in every 5 million years.

WEL identified seven hydrocarbon spill risk scenarios for investigation. The spill locations defined for each scenario are summarised in Table 1-1 and Figure 1-1.

Oil spill modelling was undertaken using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces. Near-field blowout modelling was undertaken using OILMAP-Deep, which predicts the droplet sizes that are generated by the turbulence of the discharge as well as the centreline velocity, buoyancy, width and trapping depth (if any) of the rising gas and oil plumes.

To define trends and variations in the potential outcomes of a given scenario, a stochastic modelling process was followed for all scenarios, whereby SIMAP was applied to repeatedly simulate the defined spill scenarios using different samples of current and wind data selected randomly from historic time-series data representative of the study area. Results of the repeated simulations were then statistically analysed and mapped to define contours of risk around the release point.

The risk derived from the scenario modelling is the conditional probability, or P2, which is related to the outcome after an event has actually occurred. The combined probability (P1xP2) provides an indication of the expected probability of both an event occurring and a particular outcome post event being realised. In this report, contours of the combined (P1xP2) probability are presented in terms of the expected return period, which is the inverse of the probability when expressed in units of 1/yr.

It is important to note that the modelling results in this document that are presented in terms of statistical probability maps are based on many simulations under different conditions. Different locations surrounding the spill site would be affected under each different time-series of environmental forces. Consequently, stochastic probability contours will cover a larger area than that likely to be affected during any one single spill event. The contours should therefore be judged as contours of probability and not representations of the area swept by the slicks arising from a single event.

Table 1-1: Summary of the spill scenarios assessed in this study.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (m BMSL)
1	Blowout at TRE well centre during drilling operations	Torosa Condensate (flashed to surface and seabed)	Surface: 3,975 Seabed: 69,696	1.33×10^{-5}	Surface: 5 days Seabed: 72 days	14° 2' 17.016" S 121° 50' 58.948" E	Surface / 463
2	Loss of pipeline pressure containment in the TRD flowline	Torosa Condensate (flashed to seabed)	25	9.65×10^{-3}	1 hour	14° 0' 31.712" S 121° 57' 17.050" E	389
3.2	FLNG topside leak, 8 km ENE of the TRD location, due to equipment failure	Browse Condensate	165.3	1.73×10^{-3}	20 mins	13° 59' 22.063" S 122° 1' 36.125" E	Surface
4.2	Release from offtake vessel, 8 km ENE of the TRD location, due to major structural failure	Browse Condensate	18,000	1.91×10^{-7}	24 hours	13° 59' 22.063" S 122° 1' 36.125" E	Surface
4.4	Release from offtake vessel at the BWA facility due to major structural failure	Browse Condensate	18,000	1.91×10^{-7}	24 hours	14° 30' 3.422" S 121° 34' 39.595" E	Surface
5	Spill during bunkering operations, 8 km ENE of the TRD location	Marine Diesel	13	1.38×10^{-2}	5 mins	13° 59' 22.063" S 122° 1' 36.125" E	Surface
6	Loss of containment during offtake at BWB facility	Browse Condensate	461.5	4.83×10^{-4}	5 mins	13° 54' 13.662" S 121° 59' 59.536" E	Surface

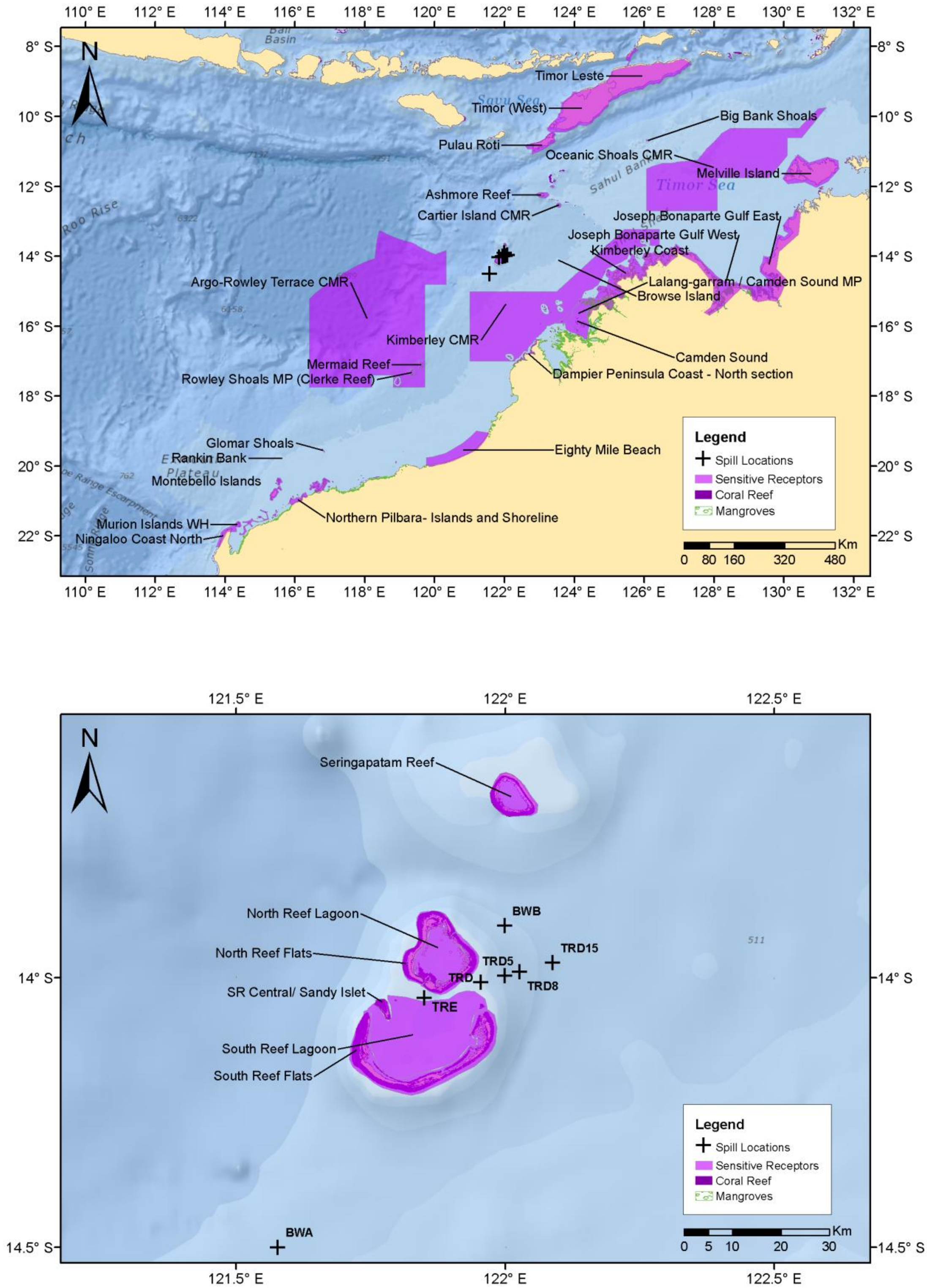


Figure 1-1: Location of the hypothetical spill locations around the Scott Reef area, relative to key sensitive receptors.

1.2 Oceanographic Conditions

The ocean circulation in the Browse Basin region is highly variable, with flow features varying over a range of temporal and spatial scales. These circulation features can be broadly categorised into three main processes:

i. Large-scale and mesoscale motions (length scales of ~100-1,000 km, timescales of days to years);

ii. Shelf-scale, tidally-driven motions such as the barotropic and baroclinic (internal) tides (length scales of ~10-100 km, timescales of hours); and

iii. Small-scale, topographically-generated flows (length scales of ~1-1,000 m, timescales of minutes to hours).

The ability to resolve these features ultimately depends upon the grid resolution of the hydrodynamic model and the availability of appropriate forcing data; the need to include them in long-term oil spill transport simulation, however, is dependent upon their significance for the fate of spilled oil and the level of detail required.

A discussion of the different ocean processes and type of numerical models used to resolve them is presented below.

1.2.1 Large-Scale and Mesoscale Processes

The large-scale and mesoscale ocean circulation (also referred to as drift currents) will be the dominant driver of long-term (> several days) transport of oil floating on the water surface or entrained in the water column, as well as hydrocarbons that dissolve into the water column. Mesoscale ocean processes are generally defined as having horizontal spatial scales of 10-500 km and periods of 10-200 days – processes with scales greater than this are referred to as large-scale. The major persistent large-scale and mesoscale surface currents off the coast of Western Australia are presented in Figure 1-2. They are characterised as follows:

- **Buoyancy driven circulation**. The main buoyancy driven feature in the region is the Indonesian Through Flow (ITF) which conducts warm water from the equator into the Indian Ocean. Buoyancy gradients across the continental shelf due to differential heating and cooling and/or surface runoff may also drive three-dimensional circulation patterns.

- **Wind (Ekman) driven circulation**. The Australian North West Shelf has an annual wind cycle (generally easterly winds during winter, south-westerly winds during summer) which drives seasonal variability in surface circulation patterns.

- **Eddies and jets**. These non-linear features evolve from the large-scale and mesoscale flow field interacting with the bathymetry. These are random features and it is hard to predict their exact timing and location.

Motions at these scales are theoretically simulated by eddy-resolving global circulation models such as the US Navy HYCOM model and the CSIRO/BoM BLUElink Re-analysis model (BRAN; Schiller *et al.*, 2008). APASA has used the output of these models in numerous previous oil spill risk assessment studies. A hydrodynamic model validation

(APASA, 2011) showed that the BRAN hindcast database compared considerably better with measured data than HYCOM, indicating that the BRAN data was preferred for model forcing.

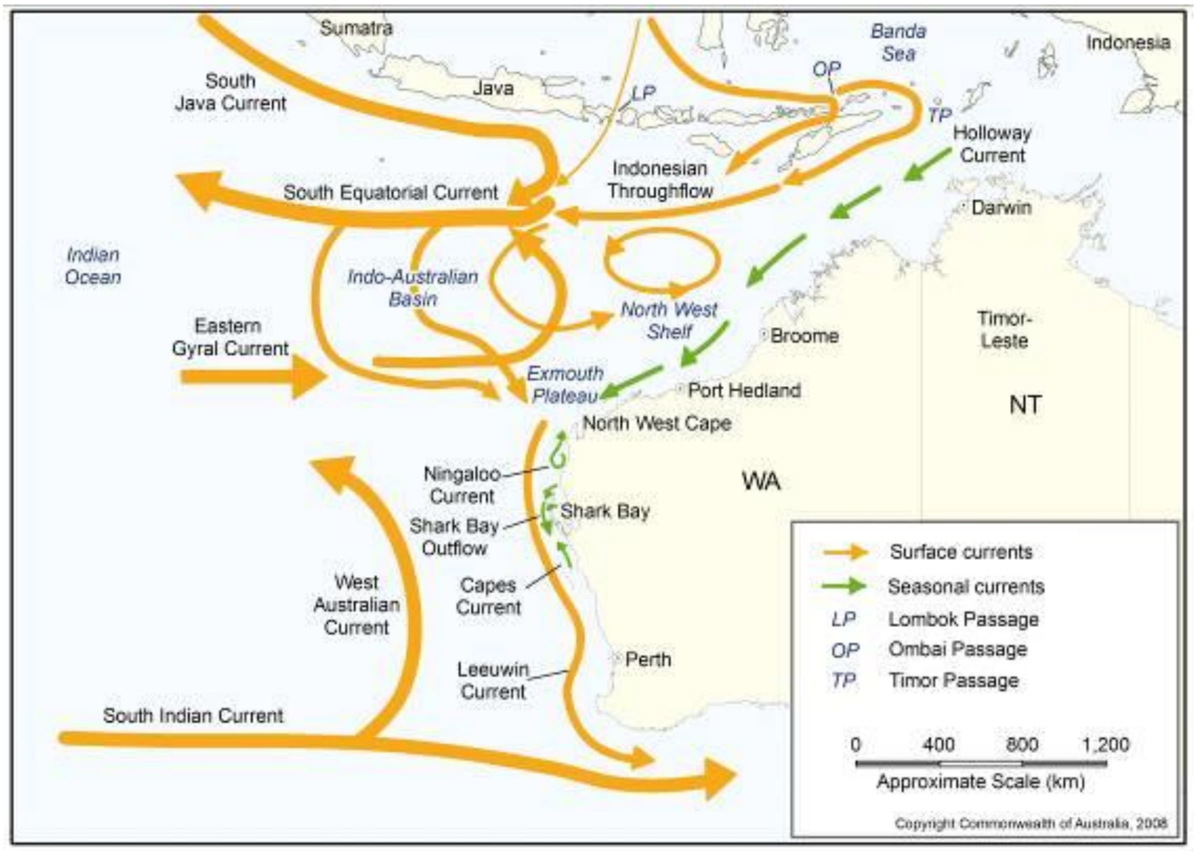


Figure 1-2: A map of the major surface currents off the Western Australian coast (DEWHA, 2008).

1.2.2 Shelf-Scale Tidal Processes

The region is subject to extremely large tides, particularly on the Kimberley Coastline, which can dominate the transport of material over periods of several hours to several days. These tidally-driven motions can be loosely sub-categorised into the two following fields:

- **Barotropic tidal currents**. These currents are forced by the surface tide and are homogenous in the vertical direction, with the exception of a bottom boundary layer, which is affected by drag along the seabed. Spatial variability of these currents is mainly influenced by astronomical forcing and interactions with the bottom topography.
- **Baroclinic tidal currents**. The movement of stratified water over sloping topography results in the generation of internal waves. These waves propagate away from the generation source, both horizontally and vertically, generating variable baroclinic currents along their trajectory. As these internal waves are forced by tidal currents they have the same frequency (semi-diurnal) and are thus also referred to as internal or baroclinic tides.

Although these flows are oscillatory in nature, small non-linearities can produce a net drift that can drive long-term transport within the water column, which will be relevant to oil entrained at these depths from a seabed blowout.

1.2.3 Small-Scale Topographically-Generated Flows

The transport of material in the vicinity of rapidly varying topography with length scales of 100 m to 10 km is mainly influenced by flow features that result from tidal interactions with the topography. Possible circulation patterns that may result include:

- **Eddies, jets and secondary flows**. These features result from flows over rapidly varying topography, such as small islands and headlands. These features can generate residual flows which vary horizontally and vertically.
- **Lee waves and hydraulic jumps**. These are internal disturbances resulting from highly energetic, stratified flow over topography.

Because these processes are generated by flows over steeply changing topography, representation of these fine scale features requires very intensive hydrodynamic modelling at fine spatial scales, ideally using a three-dimensional non-hydrostatic model with specification of density stratification in the water column.

These background details were carefully considered in defining the model approach that was followed in the previous Browse studies carried out by APASA, and a consistent approach was taken in this study (see Section 2).

1.3 Scope of Work

The scope of this assessment included the following components:

1. Preparing a long-run (5-year duration) time-series of spatially varying wind and current data covering the Browse Basin and surrounding regions.
2. Assessing the weathering of the specific oil types involved in each spill scenario (Torosa Condensate, Browse Condensate and marine diesel) under a range of ambient temperatures and metocean conditions for the hypothetical spill locations.
3. Applying a three-dimensional oil spill model, SIMAP, to the hydrocarbon spill scenarios to conduct stochastic modelling of the trajectory and fate of the spilled oil for different spill scenarios that were specified by WEL. This involved repeatedly simulating the defined scenarios using a different time-series of wind and current data, selected at random from the long-term metocean dataset. To ensure seasonal representation, an even number of replicate simulations were completed using metocean data samples with start-times from each calendar-quarter of the year.
4. Calculating risk estimates from the multiple-replicate simulations for each scenario and season combination, including the probability of contact, the minimum time of contact, and the potential concentrations that might be involved. The study assesses and describes forecast risks for each of these scenarios on an annual basis.

Each scenario was modelled for spill starting times within each of four quarterly periods:

- January – March (Quarter 1)
- April – June (Quarter 2)
- July – September (Quarter 3)
- October - December (Quarter 4)

Each simulation was run for the duration of the specified spill plus a further sufficient period after the cessation of discharge to allow for oil concentrations to decrease below the threshold concentrations applied in the analysis. For Scenarios 1 and 6, the simulations continued for 4 weeks after the spill ceased, based on the outcome of sensitivity testing. For Scenarios 2, 3.x and 5, the simulations continued for 3 weeks after spill cessation. For Scenarios 4.x, the run-on period was 6 weeks. It is expected that remnant floating oil in all of cases, which may be present at low thresholds at the end of each simulation, would represent highly weathered and degraded products.

1.4 Terms and Abbreviations

- *Cleaned* – oil that has been removed through clean-up and recovery e.g. Bioremediation, Dispersants, Skimming etc.
- *Degradation (decay)* - the bacterial metabolism or photochemical breakdown of oil components from their long carbon chain form into simpler and biologically inert forms.
- *Dissolution* – the process whereby soluble components of an oil mixture dissolve into the water column to form a hydrocarbon solution. Dissolution involves migration across oil-water interfaces, hence will be faster where there is greater surface area to volume. Hence, faster from entrained droplets than from slicks.
- *Distillation* – the process of separating mixtures base on differences in their boiling points. Distillation is physical separation process.
- *Entrained oil* – droplets or globules of oil that are physically mixed (but not dissolved) into the water column. Physical entrainment can occur either during pressurised release from a sub-surface location, or through the action of breaking waves.
- *Emulsification* – the process of mixing two (or more) liquids that otherwise are immiscible, e.g. oil and water, leading to the dispersion of minute droplets of one into the other. The resulting mixture, where both the dispersing and continuous phases are liquid, is referred as emulsion. An emulsion possesses different physical properties (e.g. density and viscosity) than either of its constituents.
- *Evaporation* – the process whereby components of the oil mixture transferred from the sea surface to the atmosphere.
- *Sedimentation* – the process whereby oil droplets sink and adhere to the seabed. The specific gravity of most oil types is lower than marine water. Sedimentation for these oils requires the loss of light fractions and adhesion to suspended sediment particles from the water.
- *Stranding* - the process whereby oil slicks or films adhere to coastlines. Stranding is a dynamic process that is affected and limited by the viscosity of the oil and the absorbance of the coastline (e.g. sand versus rock). A proportion of the oil may be subsequently re-floated and transported away by currents.
- *Surface bound or floating oil* – oil that remains bound to the surface as a slick or film due to buoyancy and surface tension.
- *Far-field*: - The spatial range that extends beyond the near-field influence where the ambient environment controls the plume trajectory and dilution.
- *Jet phase* - the jet phase is the region of a discharge plume that extends from the port outlet to where the output force and initial momentum of the plume is dissipated and the buoyancy of the plume begins to dominate movement of the plume.
- *Near-field*: - The spatial and temporal range that spans the Jet and Buoyancy phases.
- *Trapping depth*: defines the depth at which a plume reaches neutral buoyancy with ambient water, so that buoyant rise or fall will cease.

2 MODELLING METHODS

2.1 Description of the Models

2.1.1 SIMAP

The spill modelling was carried out using a purpose-developed oil spill trajectory and fates model, SIMAP (Spill Impact Mapping and Assessment Program). This model is designed to simulate the transport and weathering processes that affect the outcomes of hydrocarbon spills to the sea, accounting for the specific oil type, spill situation and prevailing wind and current patterns. The SIMAP model is a three-dimensional spill model and considers the fate of oil while on the surface and in the water column, in either entrained or dissolved form.

SIMAP is an evolution of the US EPA Natural Resource Damage Assessment model (French & Rines, 1997; French, 1998; French *et al.*, 1999) and is designed to simulate the fate and effects of spilled oils and fuels for both the surface slick and the three-dimensional plume that is generated in the water column. SIMAP includes algorithms to account for both physical transport and weathering processes. The latter are important for accounting for the partitioning of the spilled mass over time between the water surface (surface slick), water column (entrained oil and dissolved compounds), atmosphere (evaporated compounds) and land (stranded oil). The model also accounts for the interaction between weathering and transport processes.

The physical transport algorithms calculate transport and spreading by physical forces, including surface tension, gravity and wind and current forces for both surface slicks and oil within the water column. The fates algorithms calculate all of the weathering processes known to be important for oil spilled to marine waters. These include droplet and slick formation, entrainment by wave action, emulsification, dissolution of soluble components, sedimentation, evaporation, bacterial and photo-chemical decay and shoreline interactions. These algorithms account for the specific oil type being considered.

Evaporation rates vary over space and time dependent on the prevailing sea temperatures, wind and current speeds, the surface area of the slick and entrained droplets that are exposed to the atmosphere as well as the state of weathering of the oil. Evaporation rates will decrease over time, depending on the calculated rate of loss of the more volatile compounds. By this process, the model can differentiate between the fates of different oil types.

Entrainment, dissolution and emulsification rates are correlated to wave energy, which is accounted for by estimating wave heights from the sustained wind speed, direction and fetch (i.e. distance downwind from land barriers) at different locations in the domain. Dissolution rates are dependent upon the proportion of soluble, short-chained, hydrocarbon compounds, and the surface area at the oil/water interface of slicks. Dissolution rates are also strongly affected by the level of turbulence. For example, dissolution rates will be relatively high at the site of the release for a deep-sea discharge at high pressure.

In contrast, the release of hydrocarbons onto the water surface will not generate high concentrations of soluble compounds. However, subsequent exposure of the surface slick to breaking waves will enhance entrainment of oil into the upper water column as oil droplets, which will enhance dissolution of the soluble components. Because the compounds that have high solubility also have high volatility, the processes of evaporation and dissolution will be in dynamic competition with the balance dictated by the nature of the release and the weather conditions that affect the oil after release. The SIMAP weathering algorithms include terms to represent these dynamic processes. Technical descriptions of the algorithms used in SIMAP and validations against real spill events are provided in French *et al.* (1999) and French (1998, 2009).

Input specifications for oil types include the density, viscosity, pour-point, distillation curve (volume of oil distilled off versus temperature) and the aromatic/aliphatic component ratios within given boiling point ranges. The model calculates a distribution of the oil by mass into the following components:

- Surface bound or floating oil
- Entrained oil (non-dissolved oil droplets that are physically entrained by wave action)
- Dissolved hydrocarbons (principally the aromatic and short-chained aliphatic compounds)
- Evaporated hydrocarbons
- Sedimented hydrocarbons
- Decayed hydrocarbons

2.1.2 OILMAP-Deep

SIMAP uses specifications of the depth of release to represent spills onto the water surface or into the water column. For subsurface release scenarios, where oil will initially be entrained in the water column as droplets of oil in suspension, it is necessary to define the size-distribution of the droplets and their initial vertical distribution following the initial (within minutes) discharge processes. These processes include the jet induced by the discharge and the dynamic evolution of any associated gas plume. This size distribution will regulate the time for oil droplets to rise to near the sea surface and affect their ability to surface and become floating oil.

High pressure releases (such as a pipeline rupture or gas/oil blowout) tend to generate a distribution with a small to median size (300 µm or less; Johansen, 2003). Due to their larger surface area to volume ratio, droplets of decreasing size will rise under buoyancy at a quadratically slower rate due to viscous resistance exerted by the surrounding water, which can be theoretically derived using Stokes' Law:

$$V = 2 * 9.81 * R^2(\rho_o - \rho_w) / 9\mu$$

Where, V is the rising velocity of oil droplets, ρ_o and ρ_w are the mass density of oil and water, respectively, R is the radius of the oil droplet and μ is the dynamic viscosity of water.

If oil is discharged with little or no gas, the oil droplets must rise to the surface under their own buoyancy (resisted by water viscosity) after the dissipation of a relatively short (~1-2 m) discharge jet. However, if gas is discharged with the oil, it will rapidly expand on exiting the pressurised reservoir and continue to expand as it rises and water pressure reduces. As the discharge moves upward, the density difference between the expanding gas bubbles in the plume and the receiving water results in a buoyant force which drives the plume of gas, oil and water towards the surface.

Oil in the release is rapidly mixed by the turbulence in the rising plume. These droplets (typically a few micrometres to millimetres in diameter) are rapidly transported upward by the rising plume; their individual rise velocities contributing little to their upward motion. As the plume rises, it continues to entrain ambient water, which reduces the buoyancy of the mixture and increases the radius of the plume (Chen & Yapa, 2007; Spaulding *et al.*, 2000).

In shallow water (< 200 m) the rising plume of gas, oil and water will tend to reach the sea surface before deflecting as a radial, surface flow zone which will spread the oil droplets rapidly away from the centre of the plume (Spaulding *et al.*, 2000). The velocity and oil concentrations in this surface flow zone decrease while the depth of the zone increases. Finally in the far field, where the plume buoyancy has been dissipated, ambient currents and the turbulence generated by wind generated waves will determine the subsequent transport and dispersion of the oil droplets.

As water depths increase, the buoyancy of the rising plume is likely to be lost before the plume reaches the surface, because the gas begins to dissolve into the water column due to increased water temperatures and the density of the plume equalises with the surrounding water (Chen & Yapa, 2007; Spaulding *et al.*, 2000). This results in a situation where the oil droplets will have a further distance to rise to the surface under their own buoyancy and be subject to horizontal displacement due to the prevailing water currents. The reduced velocity of these droplets will also increase their susceptibility to trapping by stratification in the water column, and mixing in the near surface layer (typically 5-10 m depth) generated by surface waves.

As water depths increase further (beyond ~ 600m), resulting in higher pressure and colder temperatures at the release depth, a further complication can arise due to part or all of the gas volume converting to a hydrate structure – a solid ice-like lattice structure with specific gravities on the order of 0.92 to 0.96 (Chen & Yapa, 2007; Spaulding *et al.*, 2000). The conversion of the gas into gas-hydrates deprives the plume of its principal source of buoyancy, leaving the oil droplets and gas hydrates to rise a longer distance under their own buoyancy to reach the surface. Hence, oil droplets will have a longer period during which they will be subject to horizontal transport by currents acting at the depth that they occupy.

OILMAP-Deep is an oil spill trajectory and fates model extended for the prediction of oil from sub-surface oil/gas blowouts, including those in deep water (> 600 m) where gas hydrate formation can affect the fate of discharged oil (Spaulding *et al.*, 2000). The blowout model predicts the droplet sizes that are generated by the turbulence of the discharge as well as the centreline velocity, buoyancy, width and trapping depth (if any) of the rising gas plume. Inputs to the model include the depth (hence water pressure); discharge rate; hole size; oil density and viscosity, and the vertical temperature/salinity profile of the receiving water.

2.2 Calculation of Exposure Risks

The stochastic model within SIMAP performs a large number of simulations for a given spill site, randomly varying the spill time for each simulation. The model uses the spill time to select samples of current and wind data from a long time-series of wind and current data for the area. Hence, the transport and weathering of each slick will be subject to a different sample of wind and current conditions.

This stochastic sampling approach provides an objective measure of the possible outcomes of a spill, because environmental conditions will be selected at a rate that is proportional to the frequency that these conditions occur over the study region. More simulations will tend to use the most commonly occurring conditions, while conditions that are more unusual will be represented less frequently.

During each simulation, the SIMAP model records the location (by latitude, longitude and depth) of each of the particles (representing a given mass of oil) on or in the water column, at regular time steps. For any particles that contact a shoreline, the model records the accumulation of oil mass that arrives on each section of shoreline over time, less any mass that is lost to evaporation and/or subsequent removal by current and wind forces.

The collective records from all simulations are then analysed by dividing the study region into a three-dimensional grid. For oil particles that are classified as being at the water surface (floating oil), the sum of the mass in all oil particles (including accounting for spreading and dispersion effects) located within a grid cell, divided by the area of the cell provides estimates of the concentration of oil in that grid cell, at each time step. For dissolved oil particles, concentrations are calculated at each time step by summing the mass of particles within a grid cell and dividing by the volume of the grid cell.

The concentrations of oil calculated for each grid cell, at each time step, are then analysed to determine whether concentration estimates exceed defined threshold concentrations over time.

Risks are then summarised as follows:

- The probability of exposure to a location should a spill occur (P_2) is calculated by dividing the number of spill simulations where any instantaneous contact occurred above a specified threshold at that location divided by the total number of replicate spill simulations. For example, if contact occurred at a location (above a specified threshold) during 21 out of 100 simulations, a probability of exposure of 21% is indicated.
- The minimum potential time to a shoreline location is calculated by the shortest time over which oil at a concentration above a particular threshold was calculated to travel from the source to the location in any of the replicate simulations.
- The maximum potential concentration of oil forecast for each shoreline section is the highest mass per m^2 of shoreline calculated to strand at any location within that section during any of the individual replicate simulations.
- The mean expected maximum concentration of oil forecast to potentially accumulate on each shoreline section is calculated by determining the highest mass per m^2 of shoreline during each of the individual replicate simulations and calculating an average of these estimates across the simulations.

- Similar treatments are applied to dissolved aromatic oil, including calculation of time-varying dosage (see Section 2.3.8). In general, the minimum time for dissolved aromatics to reach an area will be of a similar magnitude to that of floating oil.

Thus, the minimum time to shoreline and the maximum potential concentration estimates indicate the worst potential outcome of the modelled spill scenario for each section of shoreline. However, the mean expected maximum presents an average of the potential outcomes, in terms of oil that could strand. Note also that results quoted for sections of shoreline or shoal are derived for any individual location within that section or shoal, as a conservative estimate. Locations will represent shoreline lengths of the order of ~ 1 km, while sections or regions will represent shorelines spanning tens to hundreds of kilometres and we do not imply that the maximum potential concentrations quoted will occur over the full extent of each section. We therefore warn against multiplying the maximum concentration estimates by the full area of the section because this will greatly overestimate the total volume expected on that section.

The maximum dissolved aromatic hydrocarbon concentration is calculated for water locations surrounding each defined sensitive shoreline or feature. These zones are defined to provide a buffer area around shallow (< 10 m) habitats to allow for spatial errors in model forecasts. The highest calculated value at any time step during any replicate simulation is listed. These values therefore represent worst-case localised estimates (within a grid cell). The averages over all replicate values represent a central tendency of these simulated worst-case estimates.

2.3 Inputs to the Hydrocarbon Risk Assessment

2.3.1 Current Data

The study area is located within the influence of the Indonesian Throughflow, a large-scale current system characterised as a series of migrating gyres and connecting jets that are steered by the continental shelf (Figure 1-2). While the mass flow is generally towards the south-west, year-round, the internal gyres generate local currents in any direction. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. In comparison to drift currents, tidal currents generate only relatively short tidal migrations (distance travelled by a parcel of water over a tidal cycle) that follow an elliptical path with a period of about 12 hours in the study region. Hence, tidal currents add variability to the longer-term drift patterns of portions of an oil spill.

On the continental shelf, in shallower water and closer to the coast, surface winds and tidal dynamics dominate over the large scale current flows (Condie & Andrewartha, 2008). The wind shear on the water surface can generate local-scale currents that can persist for extended periods (multiple hours to days) and result in long trajectories. Hence, the current-induced transport of oil can be variably affected by combinations of tidal, wind-induced and density-induced drift currents. Depending on their local influence, it is critical to consider all these potential advective mechanisms to accurately predict patterns of potential transport from a given spill location.

To appropriately allow for temporal and spatial variation in the current field, spill modelling requires the current speed and direction over a spatial grid covering the potential migration of oil. As measured current data is not available for simultaneous periods over a network of locations covering the wide area of this study, the analysis relied upon hindcasts of the circulation generated by numerical modelling. Estimates of the net currents were derived by combining predictions of the drift currents, available from mesoscale ocean models, with estimates of the tidal currents generated by an APASA model set up for the study area.

2.3.1.1 Tidal Circulation Model

Representations of tidal current speeds and directions (as a function of time) were generated over the study region using a three-dimensional hydrodynamic model, HYDROMAP. The model formulations and output (current speed, direction and sea level) of this model have been validated through field measurements around the world for more than 25 years (Isaji & Spaulding, 1984, 1986; Isaji *et al.*, 2001; Zigic *et al.*, 2003). HYDROMAP current data has also been widely used as input to forecasts and hindcasts of oil spill migrations in Australian waters. This modelling system forms part of the National Marine Oil Spill Contingency Plan (AMSA, 2002). The model is also the hydrodynamic engine used by the Western Australian Police marine search and rescue system.

HYDROMAP simulates the flow of ocean currents within a model region due to forcing by astronomical tides, wind stress and bottom friction. The model employs a sophisticated dynamically nested-gridding strategy, supporting up to six levels of spatial resolution within a single domain. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

To simulate the current patterns over any area of interest, the model must be provided with the following data:

i. Bathymetric data defining the shape of the seafloor;

ii. Amplitude and phase data for tidal constituents, used to calculate sea heights over time at the open boundaries of the model domain, which in turn are used to calculate the propagation of tidal currents through the model region; and

iii. Wind data defining the wind shear stress at the sea surface.

The numerical solution methodology of HYDROMAP follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji & Spaulding (1984).

For this study, a large area stretching from the North West Shelf to the Timor Sea needed to be modelled, with the topographically-complex area around Scott Reef requiring modelling at relatively fine scales (~200 m). Practical considerations, including limitations on computational power, the amount of sub-gridding that was possible over this wide domain, and the desirability of resolving circulation at fine scale around the reef structures indicated that two grid domains should be applied and the outputs spatially merged.

A large-scale grid was established to model tidal currents over the wider North West Shelf and Timor Sea, which had grid refinements in coastal areas (Figure 2-1). This model grid had a resolution of 10 km at the coarsest level and 2.5 km at the finest level (Table 2-1).

A fine-scale grid was established primarily to model the complex tidal circulation in and around Scott Reef (Figure 2-2). This grid had five levels of refinement in the resolution, from 3 km down to 187.5 m (Table 2-1). For simplicity, the reef tops were represented as blockages to tidal flow in this fine-scale model (i.e. permanently dry – represented by the white region in Figure 2-2), because tidal current flows across the reef tops are known to be minimal. Major tidal channels that occur across the reef tops of North Scott Reef were represented in this model.

Table 2-1: Resolution of the HYDROMAP grids used in this study.

	Level 0 (m)	Level 1 (m)	Level 2 (m)	Level 3 (m)	Level 4 (m)
Large grid	10,000	5,000	2,500	-	-
Fine grid	3,000	1,500	750	375	187.5

High-resolution (~50 m) bathymetric data covering Scott and Seringapatam Reefs and the Brecknock, Torosa and Calliance gas fields was supplied by WEL. Bathymetry from the Geoscience Australia 250 m resolution bathymetry database (GA, 2009) was used in regions not covered by the WEL data.

The HYDROMAP models were run for 12 one-month periods, with 4 days of overlapping spin-up for each run, giving a total of one year of tidal currents for the region. Data was output at hourly intervals. This year-long set of tidal current data was used to represent the tidal component of the currents over multiple years (covering the duration of the mesoscale current data) by repeating the data sequence for each year of the stochastic modelling period.

Forecasts from this configuration of the HYDROMAP model were validated against current measurements in the region and found to replicate the tidal currents at all measurement sites very well. The model validation is presented and discussed in detail in APASA (2011). It was recognised that the implementation of HYDROMAP does not fully replicate the internal tide in the region, but it does reproduce the barotropic tide very well. Since the barotropic tidal currents are much stronger than the internal tide in the area, this was deemed acceptable for stochastic modelling purposes.

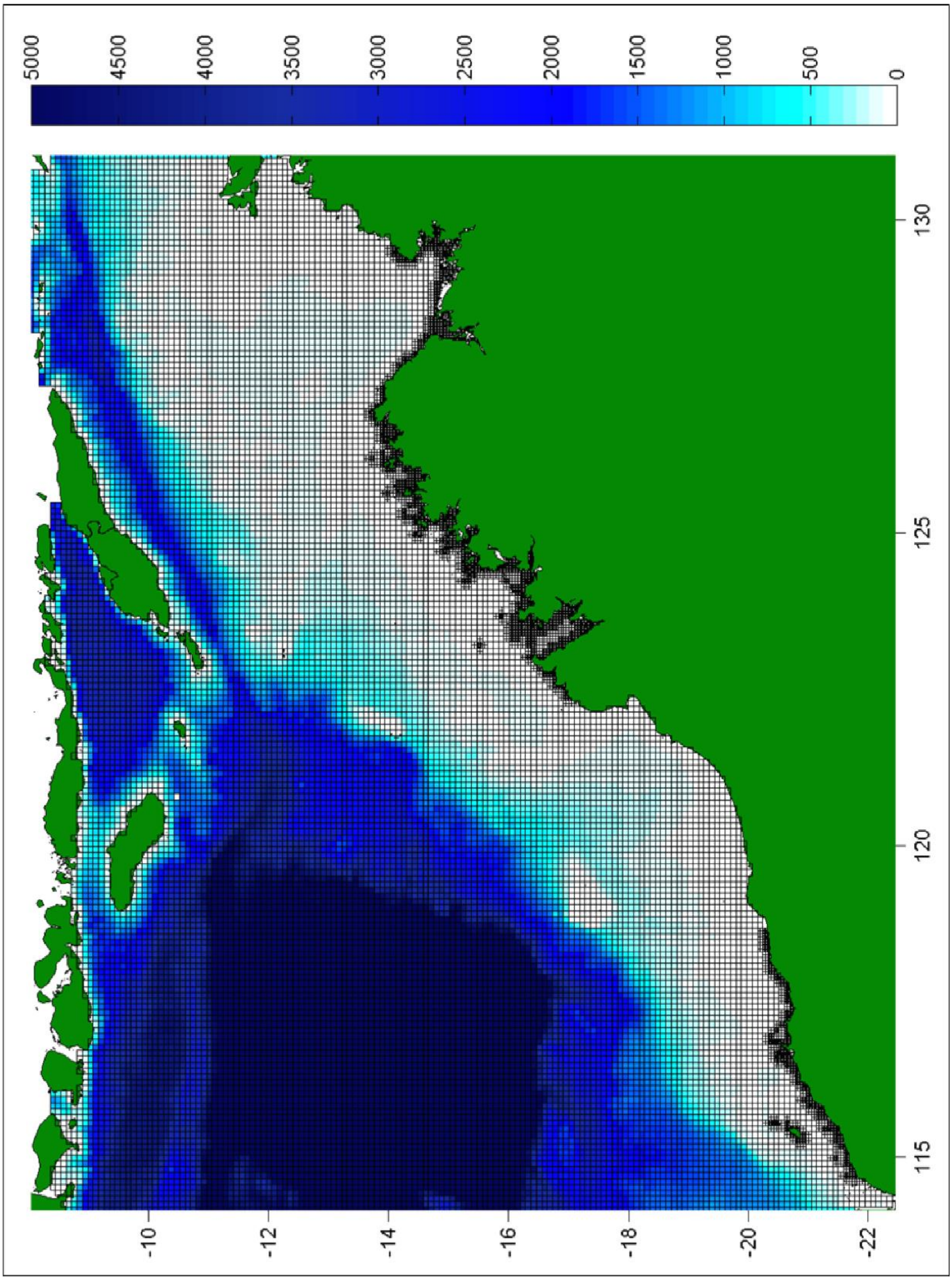


Figure 2-1: Large-scale hydrodynamic model grid (grey wire mesh) used to generate the tidal currents, shown in context with the continental land mass. Higher-resolution areas are indicated by the denser mesh zones. The bathymetry (m) is also displayed.

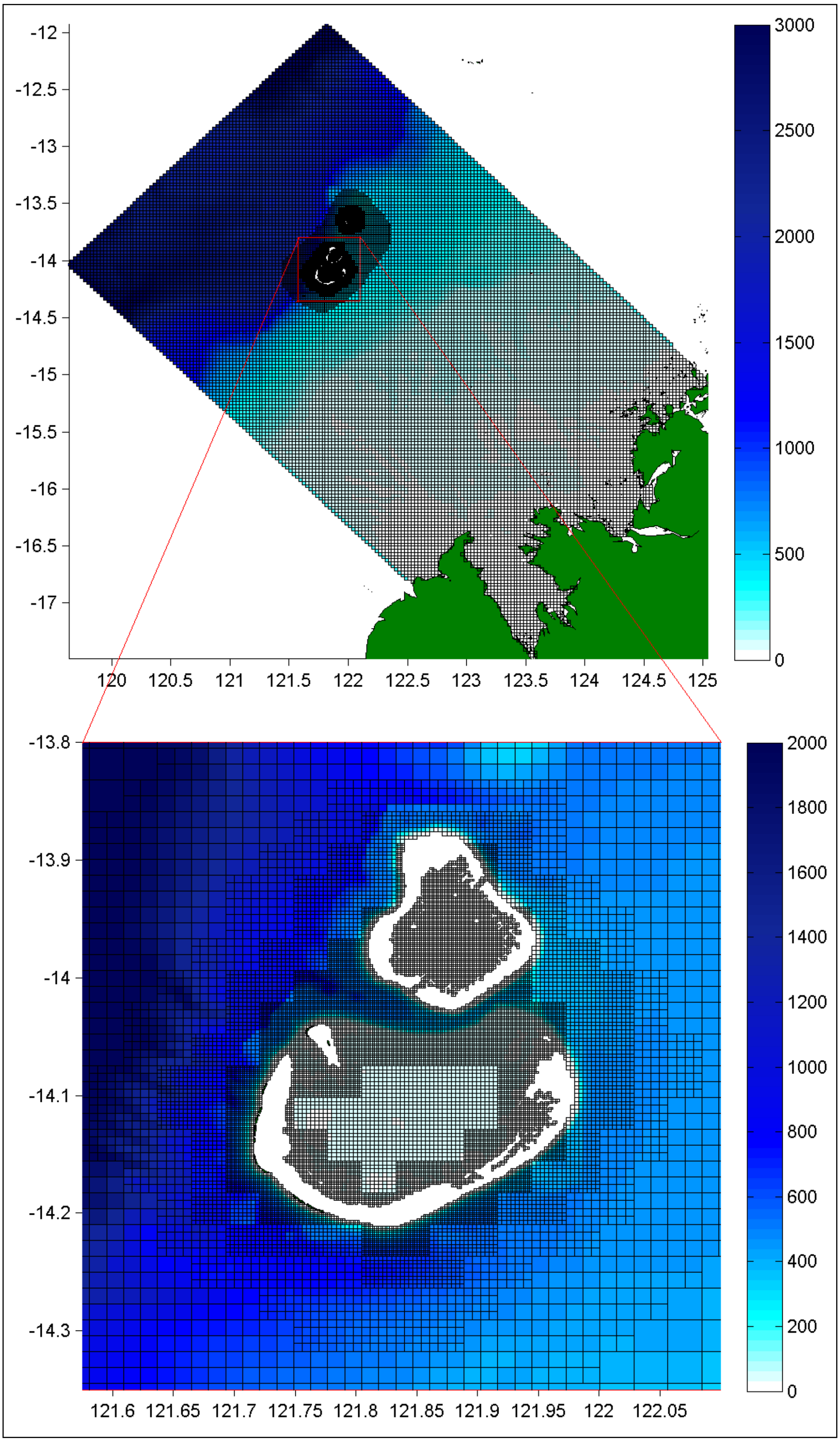


Figure 2-2: Fine-scale hydrodynamic model grid (grey wire mesh) used to generate the tidal currents. The top panel shows the grid in context with the continental land mass, and the bottom panel shows the grid around Scott Reef. Higher-resolution areas are indicated by the denser mesh zones. The bathymetry (m) is also displayed.

2.3.1.2 Mesoscale Circulation Model

Representations of the drift currents that affect the area were available from the BLUElink ocean model, which is sponsored by the Australian Government through the Commonwealth Bureau of Meteorology (BoM), Royal Australian Navy, and Commonwealth Scientific and Industrial Research Organisation (CSIRO). BLUElink is a data-assimilative, three-dimensional ocean model that has been run as a hindcast to evaluate its performance for the ultimate purpose of ocean forecasting (the Bluelink ReANalysis experiment; Oke *et al.*, 2008, 2009; Schiller *et al.*, 2008). The BRAN predictions for drift currents are produced at a horizontal spatial resolution of approximately 1/10th of a degree over the region, at a frequency of once per day, averaged over the 24-hour period. Hence, the BRAN model data provides estimates of mesoscale circulation with horizontal resolution suitable to resolve eddies of a few tens of kilometres' diameter, as well as connecting stream currents of similar spatial scale.

There are several versions of the BRAN database available. The longest running freely-available BRAN hindcast simulation is version 2.1, which spans the 16-year period of 14th October 1993 to 1st January 2007. From this database, currents were obtained for the years 2001 to 2005 (inclusive).

Quarterly current roses of the surface currents derived from the BRAN database at a point near the TRA drill centre (TRD), located on the north-eastern side of Scott Reef, are presented in Figure 2-3. The currents flow predominantly to the northeast in quarters 1 and 4 (summer), to the south and southwest in quarter 2 (autumn and early winter), and to the southwest and east in quarter 3 (late winter and spring).

Current data extracted from the BRAN database was compared against measurements from several current meter moorings in the study area. These comparisons are presented in detail in APASA (2011). In general, the BLUElink model was found to perform consistently better than the alternative source of three-dimensional current fields produced as a hindcast – HYCOM. The BRAN currents display the general seasonal trends in current magnitude and direction as well as similar distributions in deviations from these trends. Hence, this dataset was deemed appropriate for the purposes of the stochastic spill modelling.

As discussed in Section 1.2, the dominant circulation features that would affect hydrocarbon transport in the Browse Basin are large-scale and mesoscale (drift) currents, and barotropic tidal currents. To establish a database of currents that represented these processes, the output from the two HYDROMAP grids were amalgamated with currents from the BRAN database to create a five-year dataset of aggregated current data spanning the period of 1st January 2001 to 31st December 2005.

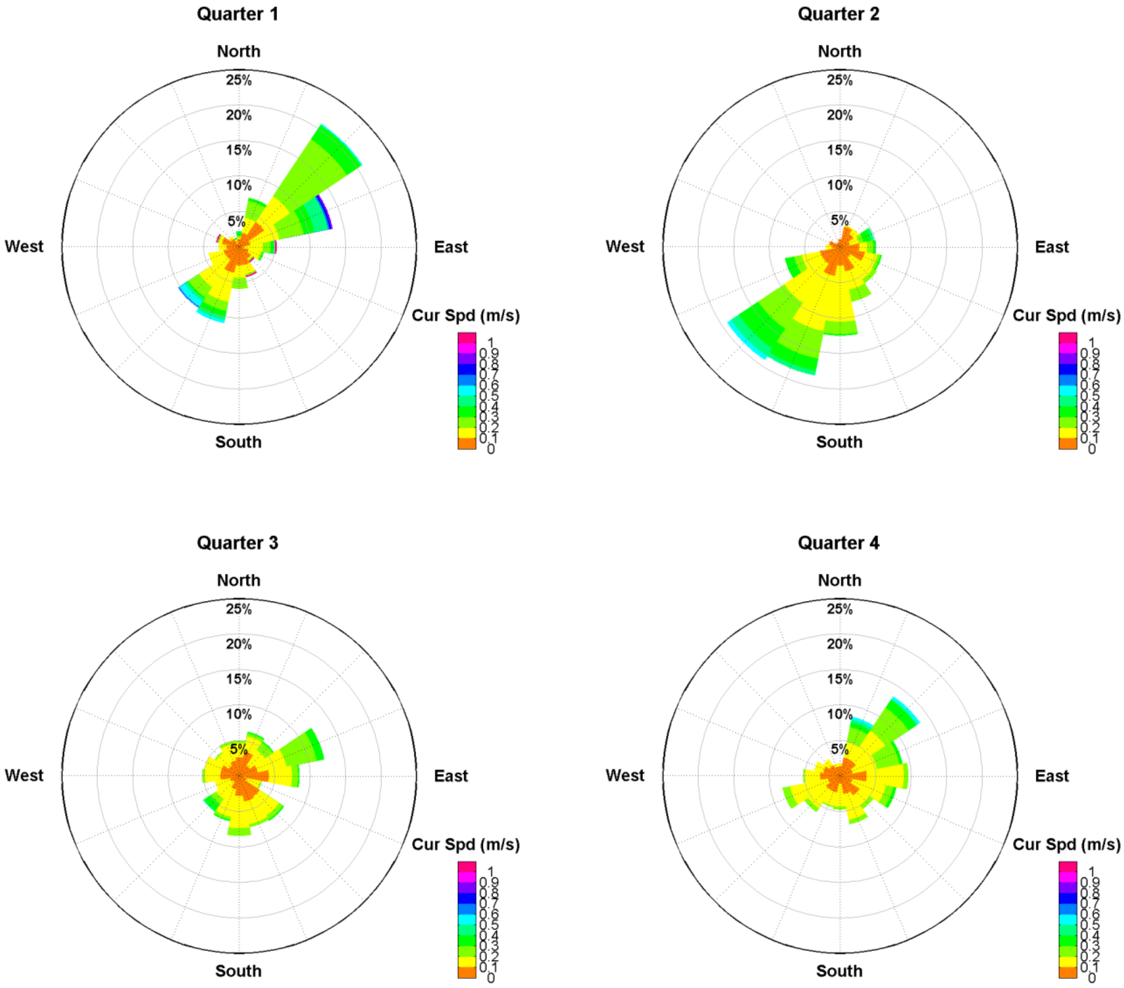


Figure 2-3: Quarterly surface current distribution (2001-2005, inclusive) derived from the BRAN database near the TRA drill centre (TRD). The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

The combined outputs from the fine and large-scale HYDROMAP grids were interpolated onto a third grid. This grid covered the same domain as the large scale grid but included spatial refinements around Scott and Seringapatam Reefs, down to a scale of 310 m. When interpolating the two HYDROMAP current data sets, priority was given to output from the fine-scale grid (Figure 2-2), with areas outside the fine-scale grid filled from the large-scale grid. As the HYDROMAP output datasets spanned a one-year period, the tidal data was simply repeated for four further years to create a five-year dataset at hourly intervals for the same period as the BRAN data.

The BRAN currents were interpolated spatially and temporally to fit the tidal current data, and were amalgamated with the tidal currents, through vector addition, to estimate the net currents. Some adjustment to the derived currents was deemed necessary because the BRAN model grid is too coarse to adequately resolve Scott Reef. Hence, currents in the BRAN model appear to unrealistically flow directly through Scott Reef (Figure 2-4). Field measurements indicate that drift currents flowing past Scott Reef are diverted around this structure and contribute little effect on circulation within the lagoon. To avoid this artefact, BRAN data was not applied within Scott and Seringapatam reefs; only the tidal current data was applied.

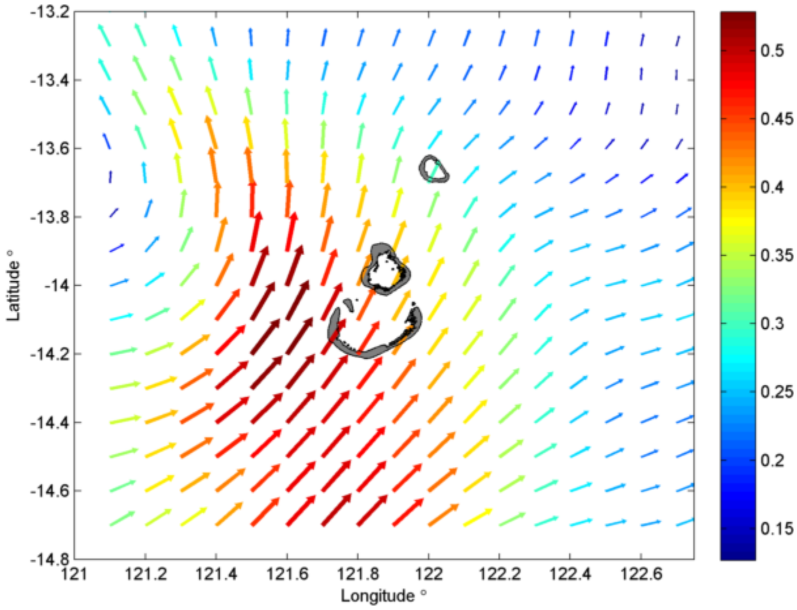


Figure 2-4: Snapshot of the near-surface vector field derived from the BRAN data in the vicinity of Scott Reef.

The current amalgamation produced continuous, representative current fields over the wider North West Shelf and Timor Sea, extending into the Indonesian islands. An example snapshot of the amalgamated current field is presented in Figure 2-5. The influence of the BRAN data can be seen in the eddies and flow representing the Indonesian Throughflow, while the influence of the tidal data is strongest over Scott and Seringapatam Reefs and around the shallower coastal zones.

Vector maps of near-surface currents around Scott Reef are presented for a flood tide (Figure 2-6) and an ebb tide (Figure 2-7). It can be seen in these figures that the influence of BRAN currents is expressed outside of the reef, but has been removed within the reef. Some interesting features of note in these figures are the strong currents in the lagoon between Scott Reef North and Scott Reef South, and the very strong currents in the two tidal channels crossing the reef flat of Scott Reef North, which are the main conduits for exchange between the inner lagoon of this reef and the ocean.

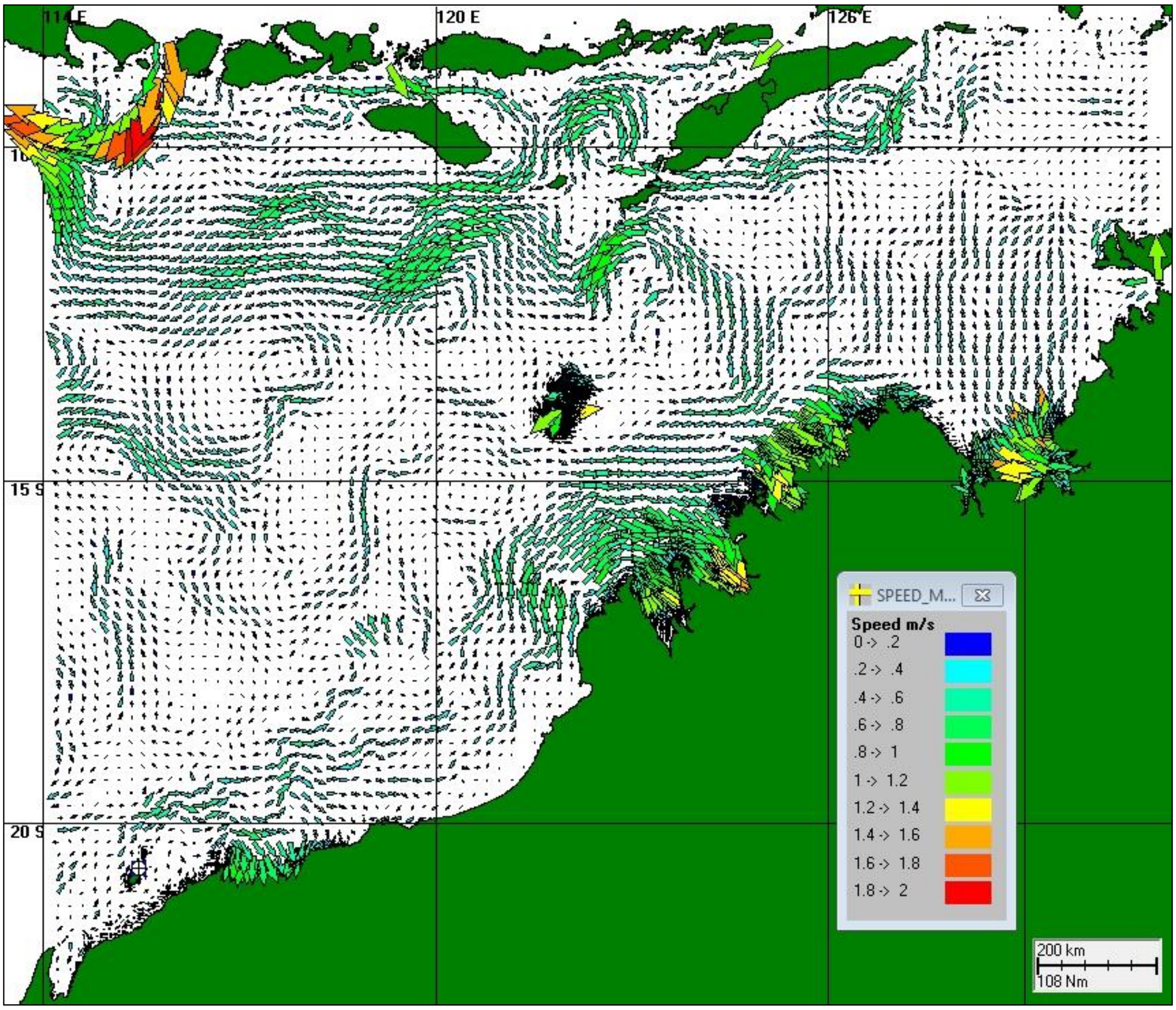


Figure 2-5: Snapshot of the amalgamated current dataset, showing near-surface current vectors at 14:00 on 4th October 2004. For clarity, only every second vector is displayed.

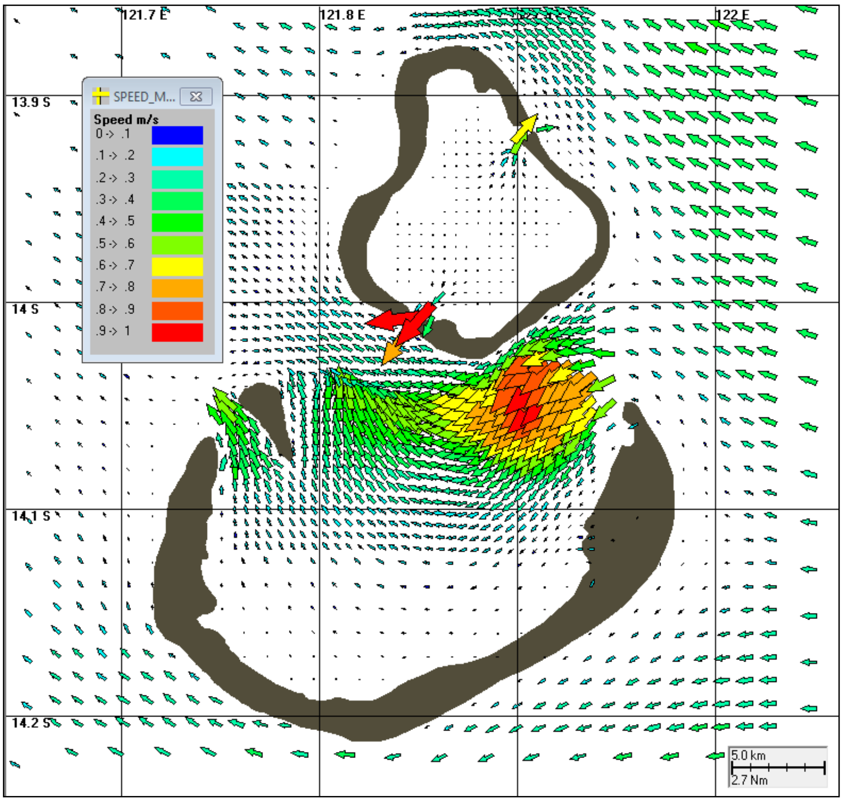


Figure 2-6: Snapshot of the amalgamated currents, showing near-surface vectors around Scott Reef during an ebb tide at 06:00 on 4th October 2004. For clarity, only every second vector is displayed.

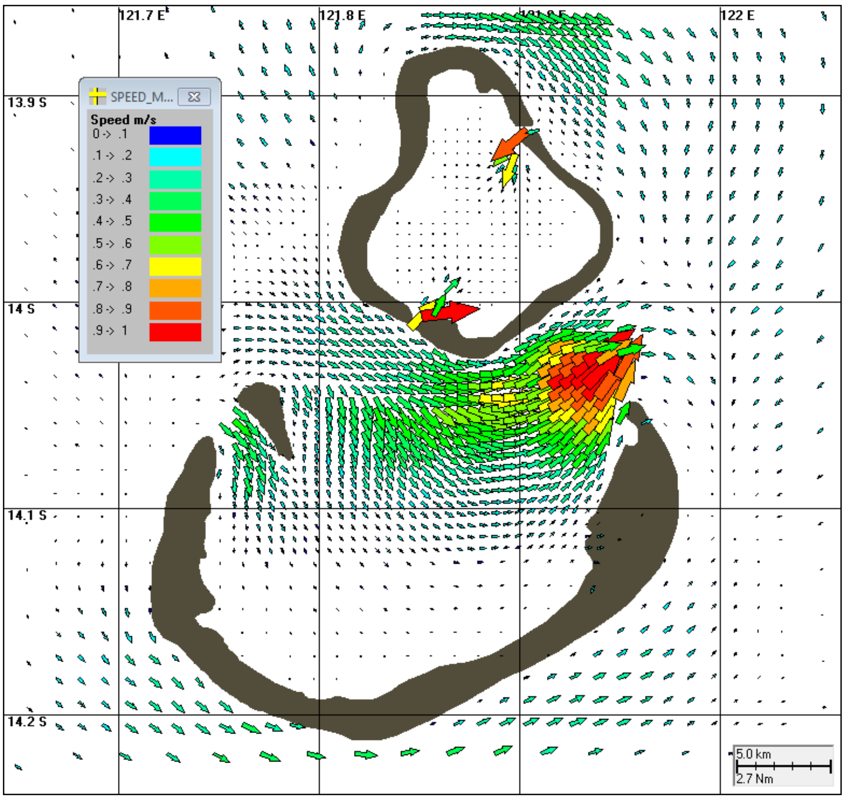


Figure 2-7: Snapshot of the amalgamated currents, showing near-surface vectors around Scott Reef during a flood tide at 12:00 on 4th October 2004. For clarity, only every second vector is displayed.

Estimates for the three-dimensional current field derived by vector addition of tidal and drift current data represented cirulation at depth layers and did not model a vertical component of current. Because vertical currents are known to be significant in the Browse Basin, particularly in the vicinity of Scott Reef due the large amplitude of the baroclinic internal tide (Rayson *et al.,* 2011), it was recognised that significiant vertical velocities (of the order of ~1 cm/s) might act to advect oil suspended in the water column over vertical distances of tens of metres over short timescales (~1 hour). The vertical advection of oil, both upwards and downwards, may affect the potential expoure of reef structures at different depth levels. Hence, the significance of the internal tides were first tested using a forecasted current field that included estimates for the vertical currents.

This modelling compared the differences in outputs if the current field was specified without a vertical component, using conservative estimates of vertical diffusivity to represent the average movement of oil in the vertical over time, and if the current field was specified with vertical currents varying over time. It was found that the two approaches produced similar results when applied to stochastic modelling, because stochastic modelling integrates exposure estimates over time and the vertical currents did not represent net movement.

A simpler approach of parameterising a conservative vertical advection was therefore adopted, which allowed the significant advantage of modelling over the long dataset that could be generated from the BRAN and HYDROMAP data.

2.3.2 Wind Data

Wind information is used in the spill modelling to calculate a contribution to the movement of surface-bound oil due to the wind acting upon the oil surface and the upper skin of the water column (windage).

The spill location for this study, being about 250 km offshore from the mainland, would not be subject to steering of the wind and the diurnal sea breeze effect generated by the mainland land mass. However, oil transported into the inshore coastal zones would be affected by the coastal wind patterns. Significant spatial variation in the wind would also be expected over the potential drift range of any oil that was released at the site.

Archived wind information for offshore waters is available for the development area in a spatially-varying format from the NCEP/NCAR atmospheric hindcast model (Kalnay *et al.*, 1996), which is operated by the National Climatic Data Centre, part of the National Oceanic and Atmospheric Administration (NOAA), an agency of the United States Federal Government. The NCEP wind data are hindcasts for the surface wind, at 6-hourly steps, generated by integration of extensive historic and observed atmospheric data (which will include observations at Mardie Station) using a state-of-the-art atmospheric model with global coverage. An important advantage of applying this data is that it provides estimates of the spatial variation across the study region and, because the data is available as a quality-controlled hindcast for multiple years that match with the current data, it provides important representation of interannual variation.

Spatial wind fields were extracted from the NCEP/NCAR reanalysis database for the period 2001-2005 (inclusive) for a point near the TRA drill centre (TRD). The model was validated against wind data measured at Scott Reef, and this is presented in APASA (2011). The model replicated seasonal wind trends acceptably well, but underestimated extremes. The modelled wind direction was similar to measured values, but was significantly less varied.

Quarterly wind roses from the NCEP/NCAR model at the Browse FLNG location are presented in Figure 2-8. Note that the convention for defining wind direction is the direction the wind blows *from* (as opposed to ocean currents where the convention is the direction the current is flowing *towards*). The winds blow predominantly from the west during quarters 1 and 4 (summer) and from the east and southeast during quarters 2 and 3 (autumn, winter and spring).

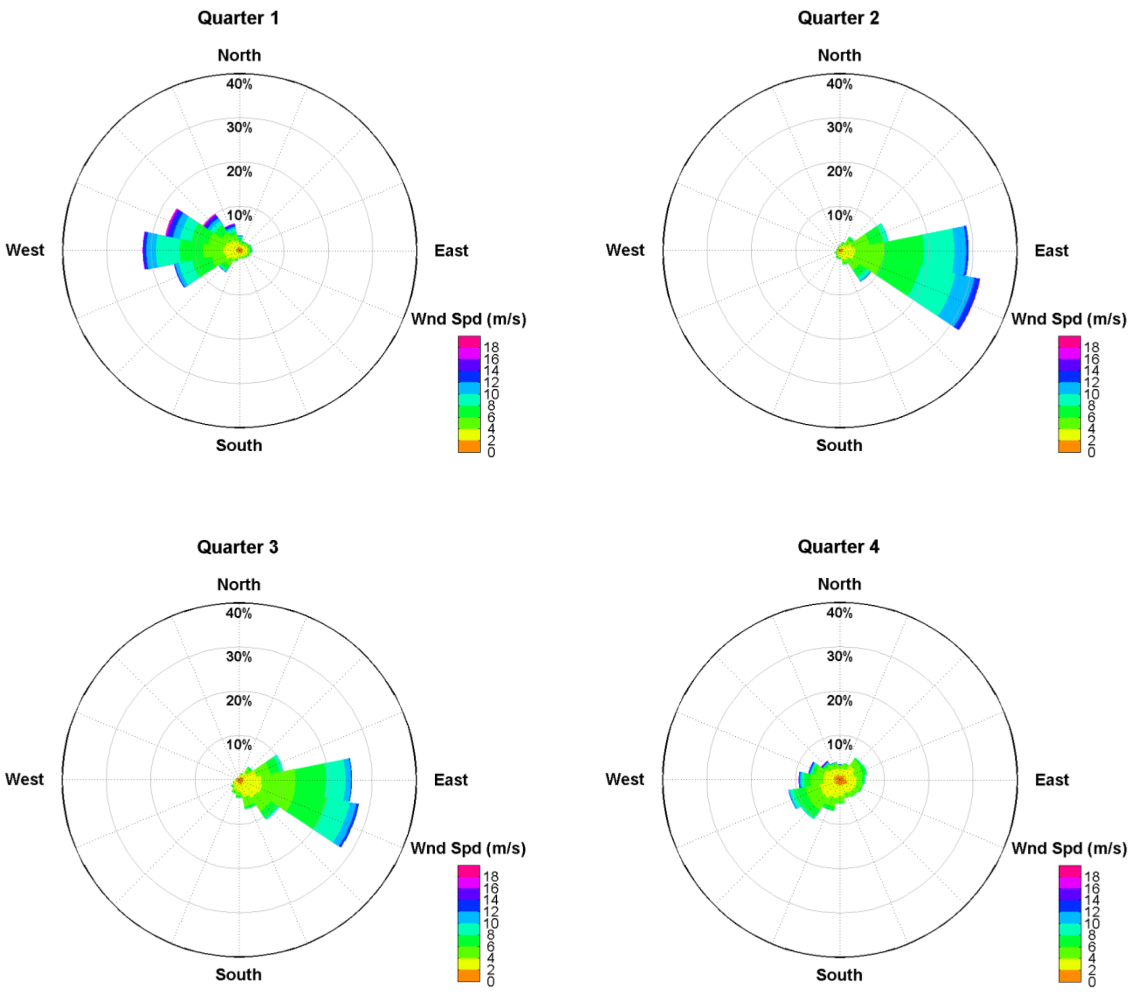


Figure 2-8: Quarterly wind distribution (2001-2005, inclusive) derived from the NCEP/NCAR database near the TRA drill centre (TRD). The colour key shows the wind magnitude, the compass direction provides the direction from which the wind is blowing, and the size of the wedge gives the percentage of the record.

2.3.3 Water Temperature and Salinity Data

Vertical profiles of sea temperature and salinity were retrieved from the BRAN database at a point near the TRA drill centre (TRD), with monthly averages used as input to both SIMAP and OILMAP-Deep. It was assumed that temperature and salinity were spatially homogeneous, and that a monthly average resolution was sufficient for modelling purposes. Near-surface temperatures varied from 26 °C in winter to 30 °C in summer, while deeper water temperatures (~600 m) remained constant at around 8 °C for all seasons (Figure 2-9). The salinity at the ocean surface varied from 34.7 ppt in summer to 34.6 ppt in winter, varying across depth depending on the mixed layer depth.

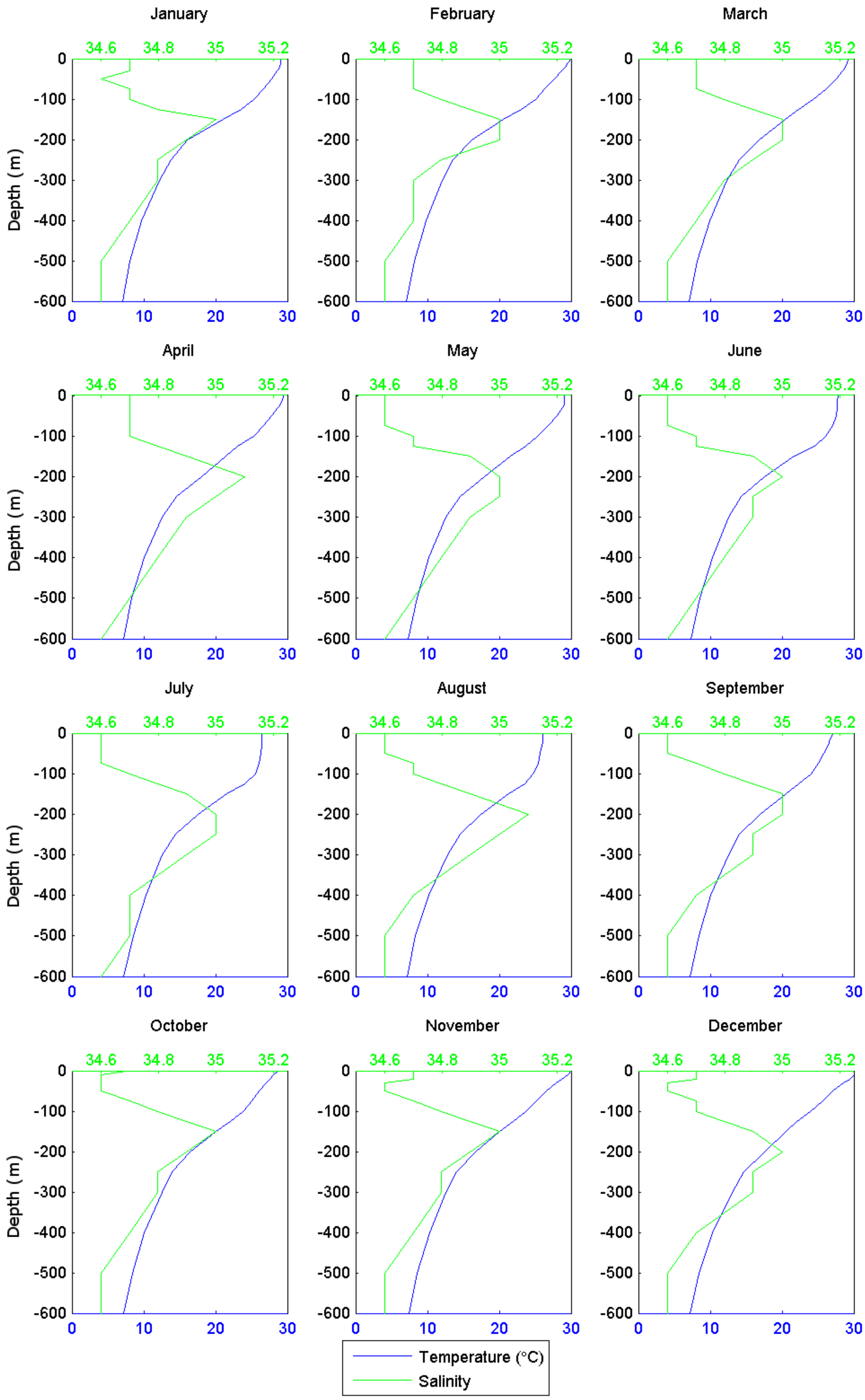


Figure 2-9: Monthly average profiles of temperature (blue) and salinity (green) retrieved from the BRAN database near the TRD location.

2.3.4 Dispersion

A horizontal dispersion coefficient of 10 m^2/s was used to account for dispersive processes acting at the surface that are below the scale of resolution of the input current field, based on typical values for open waters (Okubo, 1971). Dispersion rates within the water column (applicable for entrained and dissolved plumes of hydrocarbons) were specified at 1 m^2/s, based on empirical data for the dispersion of hydrocarbon plumes over the North-West Shelf (King & McAllister, 1998).

2.3.5 Replication

Multiple replicate simulations were completed for each scenario to test for trends and variations in the trajectory and weathering of spilled oil, with an even number of replicates completed using samples of metocean data that commenced within each calendar quarter.

For Scenarios 2, 3.2, 5 and 6, where the simulation durations were 3-4 weeks, a total of 400 replicate simulations were run over the full year (100 per quarter) to capture the temporal variation of currents and winds.

For Scenarios 1, 4.2 and 4.4, where the simulation durations ranged from 6-15 weeks and thus sampled a substantially longer and hence more comprehensive representation of the variations in forcing data than the shorter simulations, a total of 200 replicate simulations were run over the full year (50 per quarter).

2.3.6 Sensitive Receptors

Outcomes of the spill simulations were analysed to separately quantify risks of exposure to each of the shorelines, islands and major shoal areas identified by WEL as potentially sensitive receptors.

All sensitive receptors outlined here were analysed in each scenario; however, only the receptors that were forecast to be contacted by dispersing oil are summarised in the results tables for each scenario.

The sensitive receptors included in this study are summarised in Table 2-2, where these are presented in order according to the approximate distance from the TRE well centre (i.e. hypothetical spill location for Scenario 1) to each receptor, regardless of relative direction.

Table 2-2: Sensitive receptors defined by WEL for assessing risks of exposure in this oil spill modelling study. Receptors are tabulated in order of approximate distance from the TRE well centre (i.e. hypothetical spill location for Scenario 1), with the direction from this location to each receptor also indicated.

Receptor	Distance (km)	Direction	Receptor	Distance (km)	Direction
South Reef Lagoon	<1	S	Rowley Shoals Marine Park (Imperieuse Reef)	250	SW
North Reef Flats	<1	NE	Joseph Bonaparte Gulf West	270	E
North Reef Lagoon	<1	N	Eighty Mile Beach	280	S
South Reef Central / Sandy Islet	<1	SW	Big Bank Shoals	290	NE
South Reef Flats	5	E	Timor Leste	310	NE
Seringapatam Reef	20	N	Joseph Bonaparte Gulf East	380	E
Kimberley CMR	50	S	Glomar Shoals	410	SW
Argo-Rowley Terrace CMR	80	W	Dampier Archipelago	440	SW
Browse Island	90	E	Melville Island	460	E
Adele Island	110	SE	Rankin Bank	460	SW
Ashmore Reef CMR	110	NE	Northern Pilbara- Islands & Shoreline	480	SW
Ashmore Reef	110	NE	Montebello Islands	490	SW
Cartier Island CMR	120	NE	Lowendal Islands	500	SW
Cartier Island	120	NE	Barrow Island	510	SW
Lalang-garram / Camden Sound Marine Park	140	SE	Middle Pilbara- Islands & Shoreline	510	SW
Hibernia Reef	140	NE	Southern Pilbara- Islands	540	SW
Camden Sound	140	SE	Southern Pilbara- Shoreline	540	SW
Dampier Peninsula Coast - North Section	140	SE	Exmouth Gulf South East	580	SW
Kimberley Coast	140	SE	Muiron Islands WH	580	SW
Lacepede Islands	160	S	Ningaloo Coast North WH	590	SW
Pulau Roti	170	N	Ningaloo Coast North	600	SW
Mermaid Reef CMR	200	SW	Ningaloo Coast Middle	640	SW
Mermaid Reef	200	SW	Ningaloo Coast Middle (World Heritage)	640	SW
Timor (West)	210	N	Ningaloo Coast South	670	SW
Rowley Shoals Marine Park (Clerke Reef)	220	SW	Ningaloo Coast South (World Heritage)	670	SW
Clerke Reef	220	SW	Shark Bay Marine Reserve	750	SW
Oceanic Shoals CMR	240	E	Open Ocean Coast Shark Bay	760	SW
Imperieuse Reef	250	SW	Abrolhos Islands	930	S

2.3.7 Contact Thresholds

The SIMAP model will track oil concentrations to very low levels. Hence, it is necessary to define meaningful threshold concentrations for the recording of contact by oil components and determining the probability of exposure at a location (calculated from the number of replicate simulations in which this contact occurred).

The judgement of meaningful levels is complicated and will depend upon the mode of action, sensitivity of the biota contacted, the duration of the contact and the particular toxicity of the compounds that are represented in the oil. The latter factor is further complicated by the change in the composition of an oil type over time due to weathering processes. Without specific testing of the oil types, at different states of weathering against a wide range of the potential local receptors, such considerations are beyond the scope of this investigation.

For this study, thresholds for floating oil and dissolved aromatic hydrocarbon dosage were specified by WEL. These thresholds are summarised in Table 2-3 and are discussed in the following sections.

Table 2-3: Summary of the thresholds applied in this study.

Floating Oil Concentration (g/m^2)	Dissolved Aromatic Hydrocarbon Dosage (ppb.hr)
0.5	576
1	4,800
10	38,400
25	

2.3.7.1 Floating Oil

Floating oil concentrations are relevant to describing the risks of crude oil coating emergent reefs, vegetation in the littoral zone and shoreline habitats, as well as the risk to wildlife found on the water surface, such as marine mammals, reptiles and birds. Floating oil is also visible at relatively low concentrations (> ~ 0.05 g/m^2). Hence, the area affected by visible oil, which might trigger social or economic impacts, will be larger than the area where biological impacts might be expected.

Thresholds for registering contact by surface slicks onto surface waters were assessed at indicative concentrations, based on the relationship between slick thickness and visible appearance (BA, 2003) as indicated in Table 2-4 (see also Figure 2-10 and Figure 2-11).

It is important to note that real spill events generate surface slicks that break up into multiple patches separated by areas of open water. Concentrations calculated and presented in this study represent necessary areal averaging over discrete model cells, and therefore indicate the potential for both higher and lower relative concentrations in the surrounding space.

Table 2-4: The Bonn Agreement Oil Appearance Code.

Code	Appearance (following Bonn visibility descriptors)	Mass per area (g/m^2)	Thickness (µm)	Volume per area (L/km^2)
4	Discontinuous true oil colours	50 to 200	50 to 200	50,000 to 200,000
3	Dull metallic colours	5 to 50	5 to 50	5,000 to 50,000
2	Rainbow sheen	0.30 to 5.0	0.30 to 5.0	300 to 5,000
1	Silver sheen	0.04 to 0.30	0.04 to 0.30	40-300

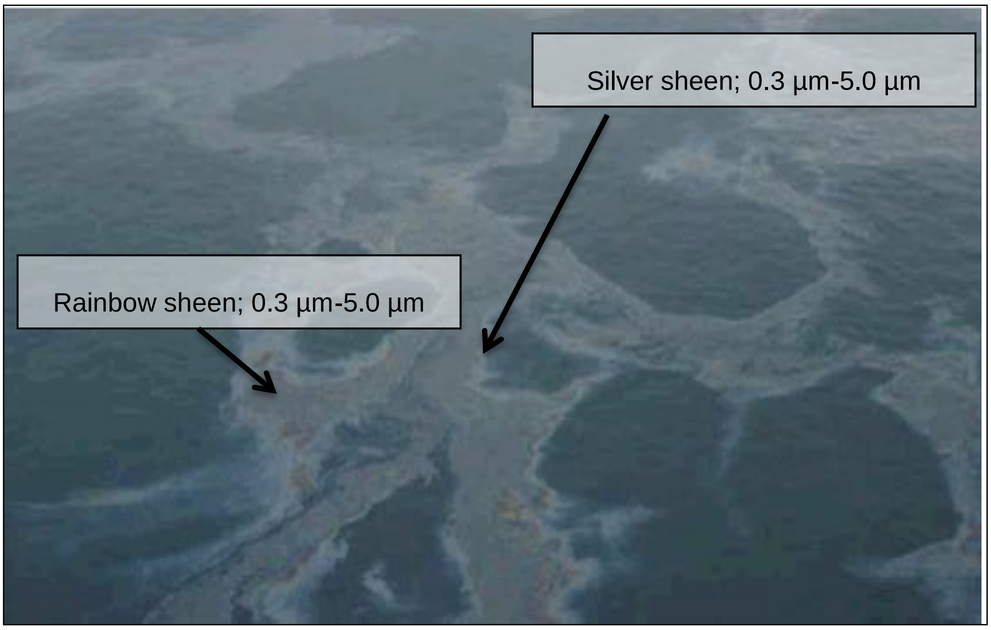


Figure 2-10: A photograph showing a fragmented film of oil displaying silver sheen surrounding rainbow sheen oil. The thickness of the silvery sheen is likely to vary from 0.04-0.3 µm. The thickness of the rainbow sheen is likely to vary from 0.3-5.0 µm (BA, 2003).

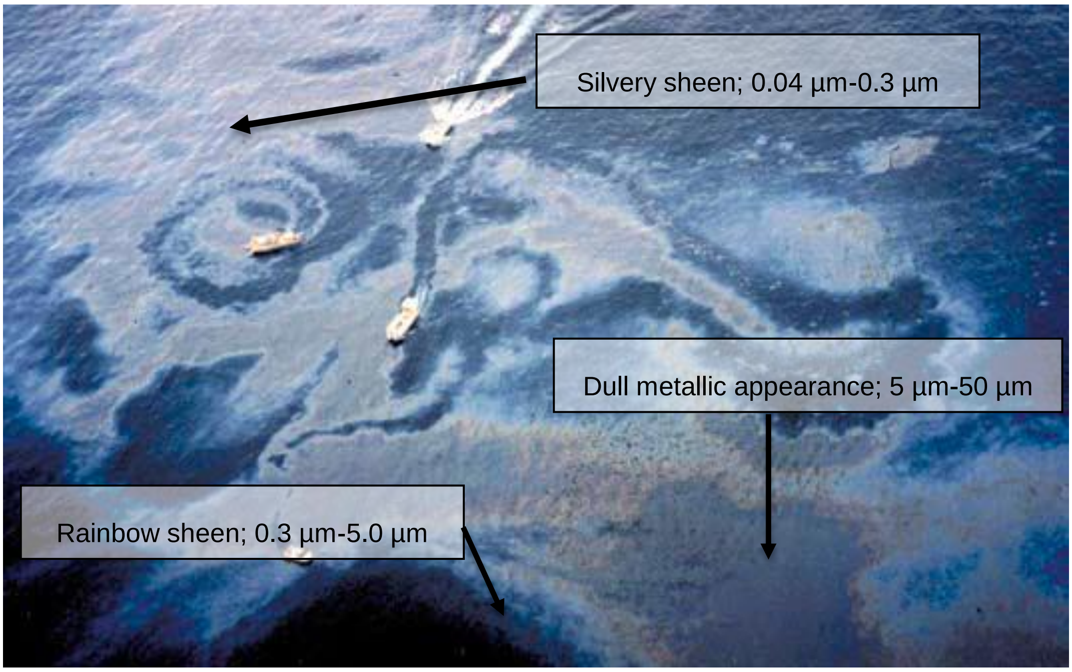


Figure 2-11: A photograph showing dull metallic oil films surrounded by silvery and rainbow sheens. (AMSA, 2009).

The lowest thresholds were set to define zones where there would be visible films of oil on the water surface, which may have economic impacts and may require surveillance. Two thresholds were set to define oil appearing as silver sheen (>0.1 g/m^2) and rainbow sheen (>1 g/m^2).

Estimates for the minimal thickness of floating oil that might result in harm to seabirds through ingestion from preening of contaminated feathers, or the loss of the thermal protection of their feathers, has been estimated by different researchers at approximately 10 g/m^2 (Engelhardt, 1983; Clark, 1984; MMS, 1988; Jenssen, 1994; French, 2000) to 25 g/m^2 (Scholten *et al.*, 1996; Koops *et al.*, 2004). Hence, the 10 g/m^2 threshold was set as a conservative estimate in terms of environmental harm to seabirds, for example, while the 25 g/m^2 threshold was used to screen for open water locations where harmful effects could be more likely.

Table 2-5 provides a summary of the threshold values applied during the modelling study for reporting the sea surface and shoreline exposure.

Table 2-5: Summary of floating oil thresholds applied in this study, and the corresponding potential levels of oiling.

Threshold Concentration (g/m^2)	**Level of Oiling**
0.1	Very light oiling/barely visible
1	Light oiling
10	Moderate oiling
25	Heavy oiling

2.3.7.2 Dissolved Aromatic Hydrocarbons

Concentrations of hydrocarbons dissolved into the water column are the most relevant parameter for indicating risks to organisms that occupy the water column (French, 2000; NRC, 2005; Di Toro *et al.*, 2007). Studies indicate that the dissolved aromatic compounds (typically the mono-aromatic hydrocarbons and the two- and three-ring poly-aromatic hydrocarbons) are commonly the largest contributor to the toxicity of solutions generated by mixing oil into water (French-McCay, 2002; Di Toro *et al.*, 2007). The dosage level (threshold value multiplied by duration) received at a given location in the water column is also used to assess the potential for harmful exposure to sub-surface habitats and species by dissolved aromatic hydrocarbons that dissolve from the spilled oil.

Literature reviews by French (2000) and French-McCay (2002, 2003) showed that the sensitivity of marine organisms to dissolved aromatic hydrocarbons will vary with the exposure time, mixture of hydrocarbons that are present, and the sensitivity of particular species and life stages. The sensitivity of marine organisms to concentrations of aromatic hydrocarbons has been shown to increase exponentially with longer exposure time over periods up to around 4-5 days, when saturation levels are typically reached.

Based on a compilation of results of toxicity testing, French (2000) estimated that a threshold value of 6 ppb should provide a safe screening level that would protect all life stages of most sensitive species, given long exposure periods (96 hr or longer – allowing for saturation levels of exposure). For species of average sensitivity, concentrations of aromatic hydrocarbons that are likely to have a toxic effect, given exposure periods of 96 hr or greater, were estimated by French (2000) to be of the order of 50-1,000 ppb depending upon the mixture of hydrocarbons that were present. The concentrations towards the higher end are expected for turbulent subsea discharges that will maximise the dissolution of soluble hydrocarbons (as opposed to their evaporation to the atmosphere if exposed to the surface) and tend to result in more toxic mixtures.

Thresholds for reporting exposure to dissolved aromatic hydrocarbon dosage in this modelling study (Table 2-6) were defined assuming long exposure periods of 96 hr or longer, following French (2000), and instantaneous concentrations of 6 ppb, 50 ppb and 400 ppb; hence resulting in thresholds of: low dosage at 576 ppb-hr (assuming an average of 6 ppb for at least 96 hr), moderate dosage at 4,800 ppb-hr (assuming an average of 50 ppb for at least 96 hr) and high dosage at 38,400 ppb-hr (assuming an average of 400 ppb for at least 96 hr).

*Table 2-6: Summary of dissolved aromatic hydrocarbon thresholds applied in this study (in **bold**), and the corresponding potential levels of exposure to sensitive species.*

Threshold Concentration (ppb)	Equivalent Dosage for a 96-Hour LC_{50} (ppb-hr)	Level of Exposure
6	***576***	Low dose
50	***4,800***	Moderate dose
400	***38,400***	High dose

2.3.8 Dosage Calculation

The mode of action of soluble hydrocarbons is a narcotic effect resulting from interference with cell function, due to the absorption of hydrocarbons across cell membranes within the tissues of organisms (French-McCay *et al.*, 2004). The narcotic effect varies among specific hydrocarbon compounds, with these variations mostly attributable to the lipid solubility of the compounds. Over periods of hours to a few days, the narcotic effect has been found to be additive, both for the range of soluble hydrocarbons that are present and with increasing exposure concentration or exposure time (French, 2000; NRC, 2005; Di Toro *et al.*, 2007). Because the toxicity of dissolved hydrocarbons to aquatic organisms increases with time of exposure, organisms may be unaffected by brief exposures to a given concentration but affected at long exposures (French-McCay *et al.*, 2004). It is therefore important to calculate the concentrations of hydrocarbons that could build up in the tissues of biological receptors from either long-term exposure or repeated exposure to sub-lethal concentrations. The integrated exposure of a receptor to a contaminant over time, is defined here as the dosage. This parameter quantifies the cumulative impact of a contaminant over time.

There are two important and opposing mechanisms that will affect the cumulative dosage: the rate of uptake, due to the exposure concentration and the duration of exposure, and the rate of removal due to the ability of the organism to expel or metabolise hydrocarbons – a process referred to as depuration. Calculation for these natural removal processes are important so as to avoid falsely forecasting impacts by only allowing for the uptake of hydrocarbons, particularly over long duration blowout simulations.

The uptake of soluble hydrocarbons was calculated over time for each model cell by addition of the concentrations calculated at each subsequent time step, multiplied by the time interval. Depuration was calculated by applying an exponential decay function to the previously accumulated dosage.

A review of the literature describing the observed rates of depuration of hydrocarbons indicates that the reduction of concentration follows an exponential decay. For sub-lethal concentrations, depuration rates will be faster with increased concentration and then decrease as concentrations approach zero. Hence, depuration of the concentrations in a cell over each time step was calculated by applying an exponential decay function to the concentration calculated by uptake.

Observed rates of depuration show significant variation for different soluble hydrocarbons and different organisms, varying from a few days to a few weeks (Solbakken *et al.*, 1984). For this study, the decay coefficient was set so that the dosage would fall to 1% of an initial concentration over 7 days, given no further exposure.

Cumulative dosages at each time step where then compared to threshold dosages and any location where the dosage thresholds were ever exceeded during any simulation were mapped.

To illustrate the effect of allowing for depuration of hydrocarbons over time, an example time-series plot of concentration and dosage at a receptor location is presented in Figure 2-12. The time-series of concentration shows intermittent contacts to hydrocarbons with gaps between contacts, of the order of ~5 days. Such an outcome might be expected, for example, from variation in the position of hydrocarbon plumes resulting from variations in the current field during an ongoing discharge. The lower panel shows the calculated dosage if depuration is not considered (blue line) and the dosage where an exponential depuration rate is allowed for, assuming a time-scale of 7 days for tissue concentrations to reduce to 1% of a starting concentration. The horizontal black lines designate dosage thresholds.

In the case where depuration was ignored (blue line), the calculated dosage simply increases with addition of each hydrocarbon concentration, and remains constant during times where there is no contact to hydrocarbons. In the case where depuration is allowed for (green line), dosage decreases exponentially between exposures. The maximum dosage occurs around day 50, where there was a prolonged (~5 days) exposure to a high concentration. The threshold dosage is not exceeded by the intermittent exposures to low concentrations but is exceeded at around day 48.

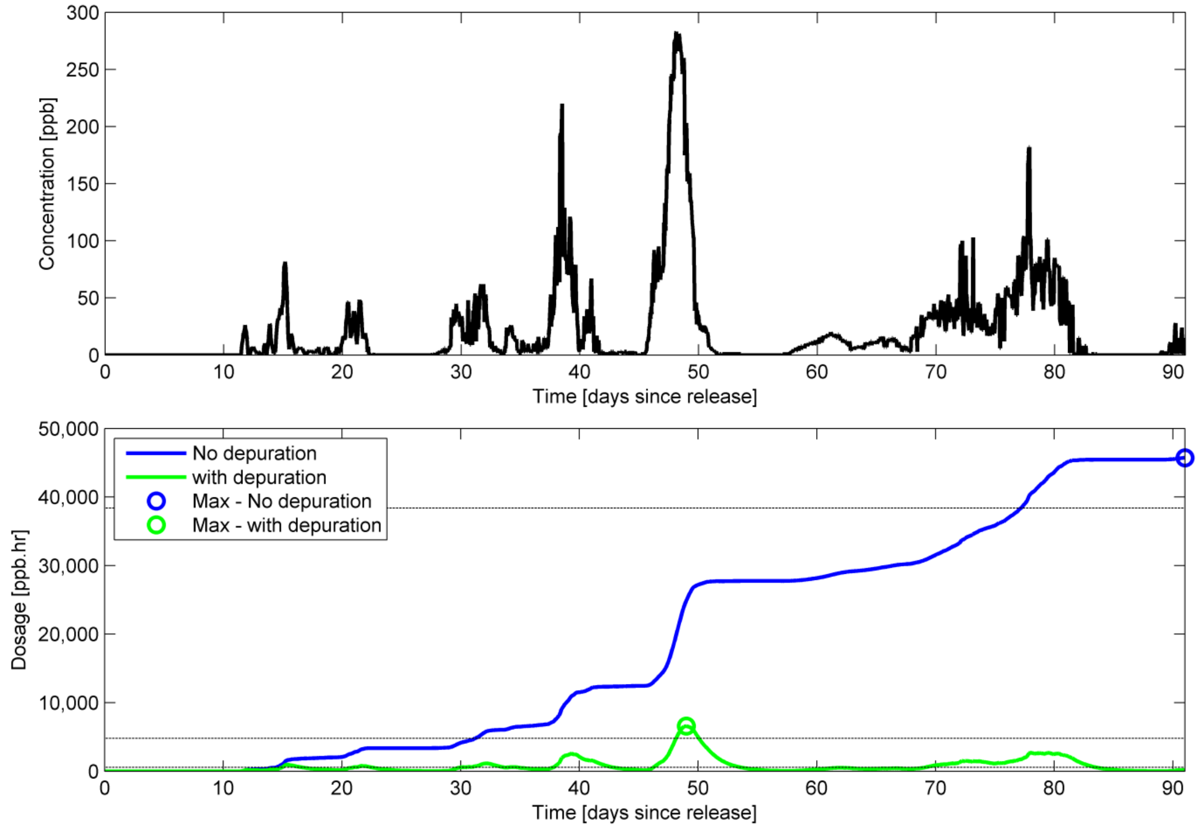


Figure 2-12: Example time series plot of dissolved aromatic hydrocarbon concentration at a receptor point over time (top panel) and calculations for the dosage (sum of concentrations over time) if treated as simply additive over long durations where concentration varied and included periods of nil exposure (bottom panel, blue line), and if calculated allowing for exponential depuration (bottom panel, green line). The black horizontal lines in the bottom panel designate screening thresholds to identify over-dosage. The green and blue circles designate the maximum dosage calculated over the fill duration using each method.

2.3.9 Oil Properties

Characteristics of Torosa Condensate and Browse Condensate were provided by WEL (DRIMS #9262568*). The data for both condensates is an amalgamation of PVT data and assay data from oil expected to be similar in nature (Calliance-1 Condensate). Characteristics of marine diesel were derived from a diesel blended for similar operational temperatures to the study area. The properties of the oils are summarised in Table 2-7.

Table 2-7: Characteristics of the oils used in this study.

Oil Type	Density (kg/m^3)	Viscosity (cP)	Component	Volatile (%)	Semi-Volatile (%)	Low Volatility (%)	Residual (%)	Aromatics (%)
			Boiling Point (°C)	<180 C4 to C10	180-265 C11 to C15	265 – 380 C16 to C20	>380 > C20	Of whole oil < 380 °C BP
Torosa Condensate (surface)	0.8125 (at 25 °C)	2.486 (at 25 °C)	% of total	0.96	15.48	32.79	50.76	26.87
Torosa Condensate (seabed)	0.780 (at 20 °C)	1.092 (at 20 °C)	% of total	14.49	39.93	20.68	24.89	26.13
Browse Condensate	0.780 (at 20 °C)	1.092 (at 20 °C)	% of total	57.0	21.0	8.0	14.0	15.75
Marine Diesel	0.829 (at 25 °C)	4.0 (at 25 °C)	% of total	6.0	34.6	54.4	5.0	3.0

The boiling points are dictated by the length of the carbon chains, with the longer and more complex compounds having a higher boiling point, and therefore lower volatility and evaporation rate.

In the above, the typical evaporation times once the oil reaches the surface and is exposed are around:

- Up to 12 hours for the C4 to C10 compounds (or less than 180 °C BP)
- 24 hours for the C11 to C15 compounds (180-265 °C BP)
- Several days for the C16 to C20 compounds (265-380 °C BP)
- N/A for the residual which will resist evaporation and persist in the marine environment for longer periods, and will be subject to relatively slow degradation

As the major oil properties for the reservoir fluids were based on Calliance-1, detailed discussions of the properties and expected weathering behaviour of this oil are presented initially, followed by a summary of the boiling point distributions of each of the modelled oils.

2.3.9.1 Calliance-1

Fresh unweathered Calliance-1 from the Browse Basin region is a light, mixed paraffinic/naphthenic, highly evaporative, medium pour point, low viscosity and sweet oil. It is very similar to the Gippsland crude oil blend in boiling point range and expected spill behaviour.

From the summary oil assay analysis provided by WEL (2006-FED-013865), Calliance-1 is shown to be a very light oil (API=50.0), with a high level of petroleum gases and gasoline range hydrocarbons with 54% of all the hydrocarbons by weight boiling below 180°C with only 9% by weight of the oil being very heavy hydrocarbons boiling above 380°C. The viscosity of the fresh Calliance-1 is very low (1.4 cSt at 20°C), the pour point is moderate (12°C) and the density low (0.7793) at 15°C (50.0 API).

The very low acid number (<0.05), low sulphur and nitrogen and low metal content indicate that very little to no in-situ biodegradation of the oil has occurred. In-situ oil reservoir biodegradation extent is likely to have a rating of “none” on the internationally accepted biodegradation scale (Peters and Moldowan 1993 and Larter et al 2003). The low asphaltene content (<0.5% by mass) in the Calliance-1 assay indicates that it is highly unlikely that a stable emulsification will occur at sea. (Fingas and Fieldhouse 2004 & 2011) The propensity to emulsify can be indicated by assay data but only determined accurately by laboratory weathering and testing.

Calliance-1 is classified as a mixed paraffinic/naphthenic oil (UOP Characterisation Factor =11.8) and has a high wax content (6.2% mass). By accepted industry definition a high wax content of an oil is classified as where the oil contains greater than 5% by weight of wax. This high wax content and pour point would lead to any marine spill of Calliance-1 oil having about a minimum of 10% by weight of any quantity of persistent solid waxy residues on extended weathering of a spill at sea.

For the purposes of oil spill classification in the United States (EPA & Coast Guard Regulations.) and under International Oil Pollution Compensation (IOPC) Fund categorisation, the proportion of oil by volume with boiling points above 370°C is considered persistent. Where oil has more than 5% by volume in this persistent range, the oil is typically classified as persistent oil. In this case, the provided boiling point distribution shows that approximately 9% by volume of the oil are persistent residues (10% by mass), and therefore Calliance-1 would be considered a persistent oil.

Upon release to the ocean surface, Calliance-1 oil will initially release to the atmosphere the highly volatile hydrocarbons due to the sea surface heating and wind effects. The assay data indicates that a large fraction of the whole oil is expected to evaporate over time scales of hours. Approximately 50% of the mass of the oil is likely to be lost to the atmosphere within the first hour of weathering with about 35% of the oil remaining after 8 hours of summer weathering.

The evaporation of such light hydrocarbons will generate large volumes of volatile organic compounds (VOCs) which may create a hazardous environment to personnel and flammability problem in the vicinity of the spill and downwind of the oil slicks. The oil would also quickly spread on the sea surface and thin out resulting in a larger surface area of oil for increased evaporation for the lighter volatile hydrocarbon components. A high wind speed and high sea and air temperatures (summer conditions) would lead to increased evaporation and reduction in residues; alternatively lower sea and air temperature and wind speeds (winter conditions) would lower the evaporation rate.

On weathering the Calliance-1 oil will undergo a series of rapid changes to appearance, colour and phase state that may affect the ability of spill combat response options such as containment and recovery and chemical dispersant operations.

A fresh spill of Calliance-1 oil has low viscosity and will be highly mobile and will thin quickly on the water surface. The Calliance-1 oil will also rapidly thicken and increase in viscosity as it weathers so it is critical to understand the “window-of-opportunity” for spill response planning. Weathering during a spill the oil may still be fluid for some period of time which may allow a wider window of use of on-water spill containment, skimming, pumping and other oil recovery techniques.

The high wax content of the Calliance-1 oil (6.2% by weight) and high evaporation rate of the lighter hydrocarbon will increase the pour points and viscosity of the oil residues on weathering. On weathering after 24 hours the pour point of the oil residues are likely to exceed the ambient sea surface temperature causing the oil to turn semi-solid and “wax-up”. The fraction boiling above 230°C which consists of about 32% by volume (34.5% by mass) has a density is approximately 0.843 kg/L so would still be floating on the sea surface and the pour point of this fraction is +27°C. As previously stated the more persistent residues (>370C) that will survive extended weathering at sea constitute about 10% by weight of the oil and are expected to be almost pure wax in composition.

The semi-solid waxy weathered residue will remain afloat unless they come in contact or are absorbed by more dense sediment or particulate matter. It is likely it will begin to form thin yellow, orange or white waxy sheets and yellow/white crystalline pancakes once highly weathered. These waxy sheets/pancakes will then begin to break up into small waxy flakes due to the action of the waves and wind over time. These waxy hydrocarbons will also undergo biodegradation by micro-organisms at sea.

Chemical dispersants, in particular those with a high solvent base (e.g. Corexit 9500) are predicted to have excellent effectiveness on fresh Calliance-1 oil spills based upon the assay data. Oil spill dispersant (OSD) effectiveness is likely to drop off considerably after 1-2 days with only very minor effectiveness on the solid residues after this time, unless dispersants used in very high ratios of dispersant to oil, adding more solvents from the dispersant to help in dissolving the residue waxes. This would need to be confirmed with actual dispersant laboratory testing.

Caution should be exercised when using aerial or on-water chemical dispersant operations on highly evaporative oils. Personnel could be exposed to high levels of VOCs and a potential explosive concentration of hydrocarbons can build up in particular during stable atmospheric conditions. Also by dispersing light hydrocarbons into the water column this decreases natural evaporation of VOCs from the water surface and has the potential to increase aquatic toxicity. Chemical dispersant operations should be closely assessed on the basis of net environmental benefit and OH&S outcomes.

2.3.9.2 Torosa Condensate

WEL provided a detailed assessment of the likely composition of this hydrocarbon relevant to the modelled scenario, which included provision for the majority of volatile hydrocarbons to have been flashed off at an appropriate pressure and temperature. While the laboratory assay for Torosa Condensate is very similar to that of Calliance-1, when adjusted in composition and volume, the proportions of volatiles, semi-volatiles and persistent components for the two oils appear different. Note that the mass of all persistent components remains unchanged.

If released to the surface the condensate is expected to be a mixture of volatile and persistent hydrocarbons, with around 51% of the condensate expected to persist in the environment. A very low percentage (<1%) is classified as volatile, with the majority of very high volatiles rapidly flashed off to the atmosphere and not represented in the spill mass balance. Around 48% is classified as semi- to low-volatility, indicating around half of the oil mass of a surface spill would evaporate within a few days.

For subsea releases around 25% expected to persist on the water surface over long periods, around 14% expected to evaporate within a few hours, and around another 61% expected to evaporate within a few days. In each case, the aromatic content of the oil is expected to be 26-27% by mass, with the majority present in the upper boiling point range.

2.3.9.3 Browse Condensate

In comparison to Torosa Condensate, Browse Condensate is more volatile, with around 78% of the mass expected to evaporate within 24 hours and a further 8% within a few days. The remaining 14% of the oil mass is likely to persist in the marine environment over longer periods. The aromatic content of the oil is around 16% by mass, with the majority present in the lower boiling point range.

2.3.9.4 Marine Diesel

Diesel is a mixture of volatile and persistent hydrocarbons (Table 2-7) with a low percentage of volatile and with the greater proportion having moderate to very low volatility. The aromatic content is approximately 3%. Over 40% by mass is predicted to evaporate over the first two days, depending upon the prevailing conditions, with further evaporation slowing over time. The heavier (low volatility) components of diesel have a tendency to entrain into the upper water column due to wind-generated waves, but can subsequently resurface if wind waves abate. Approximately 95% in total is available to evaporate over time, 5% of the oil is shown to be persistent, and overall the aromatic content of the boiling-point range modelled is approximately 3%.

2.3.10 Weathering Characteristics

A series of model weathering tests was conducted to illustrate the potential behaviour of Torosa condensate (flashed to surface and seabed), Browse condensate and marine diesel when exposed to idealised environmental conditions. To illustrate the effect of variable wind speeds on the weathering for each oil type, example model runs were prepared under three constant wind speeds, representing the 10th, 50th and 90th percentile wind speeds derived from measurements at Scott Reef. Using a 12 month dataset of measured winds at Scott Reef, the 10th, 50th and 90th percentile values of wind speed were calculated to be 1.9, 4.9 and 8.5 m/s, respectively. The tests completed were:

- Instantaneous release (1 hour discharge) at a discharge rate of 50 m^3/hr.
- Continuous release at a rate of 50 m^3/hour for 7 days (168 hours).

2.3.10.1 Torosa Condensate (Flashed to Surface)

Weathering tests were conducted on the condensate with properties adjusted relative to flashing the hydrocarbon to surface conditions. This effectively reduces the hydrocarbon to a mixture of the less volatile components, with the lighter and simpler molecules rapidly lost to gas at release. Consequently, the mass component of this volatilisation process is not included in the analysis and is not discussed below.

The mass transfer for an instantaneous release of Torosa Condensate under three different wind speeds (Figure 2-13) shows that higher wind speeds increase the amount of oil that entrains, with almost no entrainment predicted for the lowest wind speed, and approximately 75% entrainment for the highest tested wind speed in the first 12 hours of simulation. A higher rate of entrainment results in more of the aromatic components dissolving into the water column.

The proportion of oil that remains floating on the water surface dictates the total potential evaporation, with entrainment balancing the increase potential for evaporation with higher wind speeds. The most significant difference as the wind speed is increased is the magnitude of the entrained volume. Very little entrainment is predicted low wind speeds, with rates relatively slow at the median value of 4.9 m/s, with a marked increase in entrainment rate expected for higher wind speeds.

In the case of a continuous release (Figure 2-14) the mass transfer shows similar outcomes with little entrainment at median or lower wind speeds and the proportion of aromatics in the water column directly related to the magnitude of the entrainment. There is little overall variation in the proportion of evaporation over time, due primarily to the low volatility of the mixture.

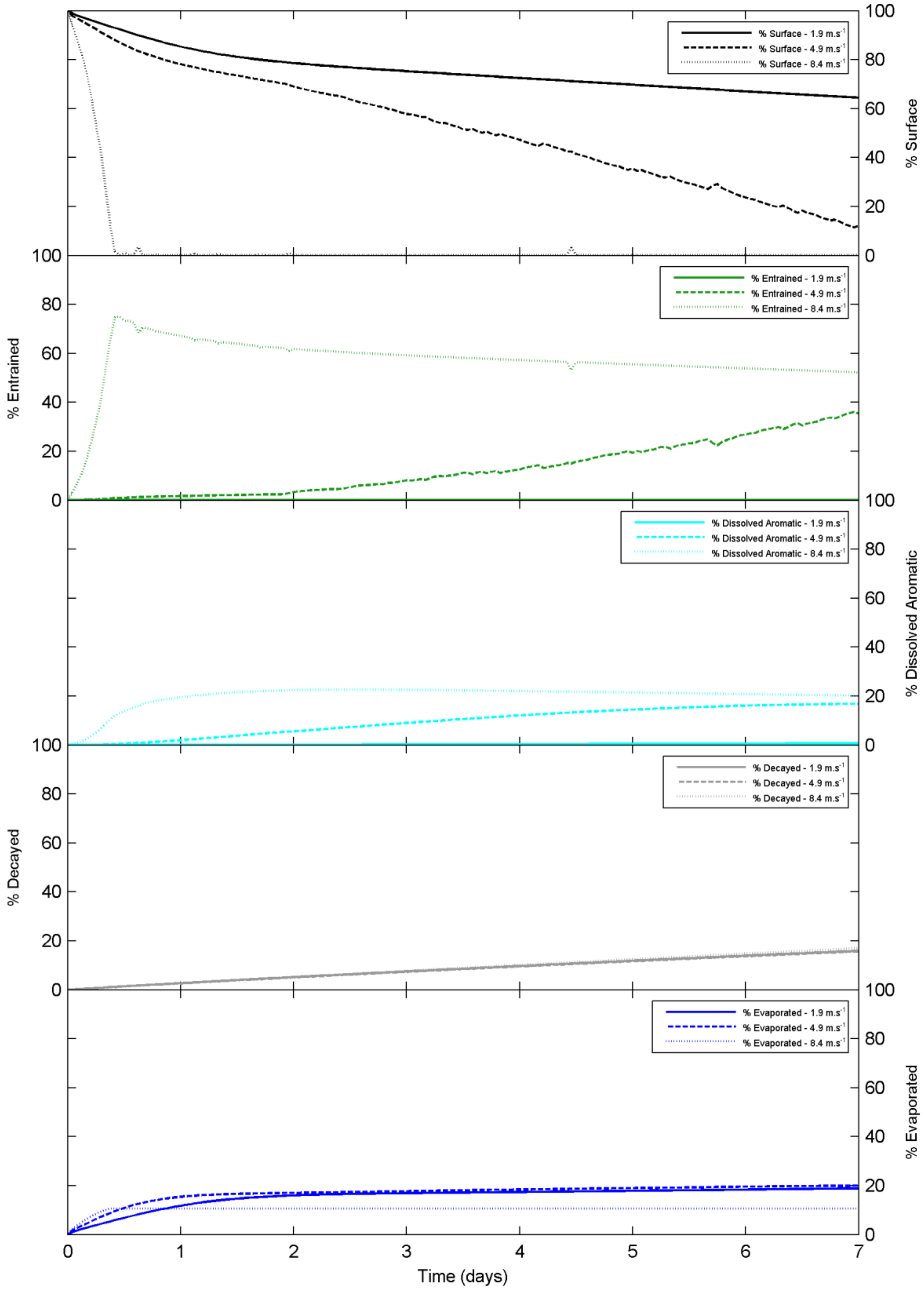


Figure 2-13: Proportional mass balance plot representing the weathering of Torosa condensate (flashed to surface) spilled onto the water surface as a one-off release (50 m^3 over 1 hr) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

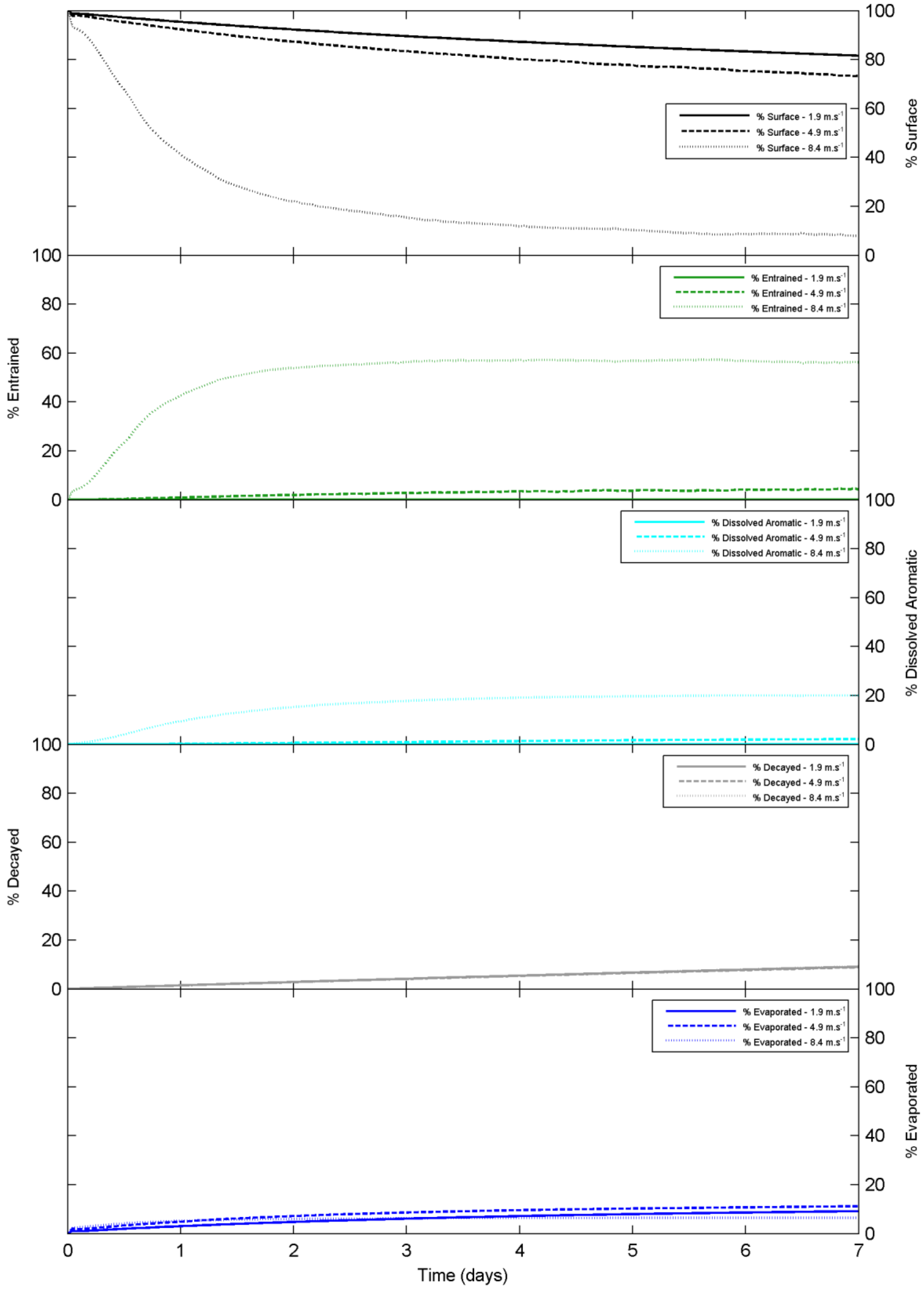


Figure 2-14: Proportional mass balance plot representing the weathering of Torosa condensate (flashed to surface) spilled onto the water surface as a continuous release (50 m^3/hr over 7 days) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

2.3.10.2 Torosa Condensate (Flashed to Seabed)

As with the tests conducted for the “Flashed to Surface” Torosa Condensate fluid, the oil properties and expected composition for the seabed release component were tested in a series of weathering simulations. As discussed previously, the relative proportion by mass of the lighter components is adjusted based on the expected release conditions. Consequently the properties and behaviour in the tests do not represent those of the fluid when assessed under standard laboratory conditions.

The mass transfer for an instantaneous release of Torosa Condensate (flashed to seabed) is shown in Figure 2-15, which represents the expected weathering should the whole released volume would reach the surface. Due to the higher proportion of volatile and semi-volatile components of this oil when compared with the Torosa Condensate (flashed to surface), significantly more evaporation is expected, even at the lower wind speeds. The majority of the evaporation occurs within the first 24 to 48 hours. Entrainment is slow to negligible at median or lower wind speeds, with rapid early entrainment observed for the higher wind speed.

In the case of a continuous release (Figure 2-16) the mass transfer shows similar trends with the degree of evaporation increasing with wind speed, and then regulated by the degree of entrainment for the higher wind speed tested.

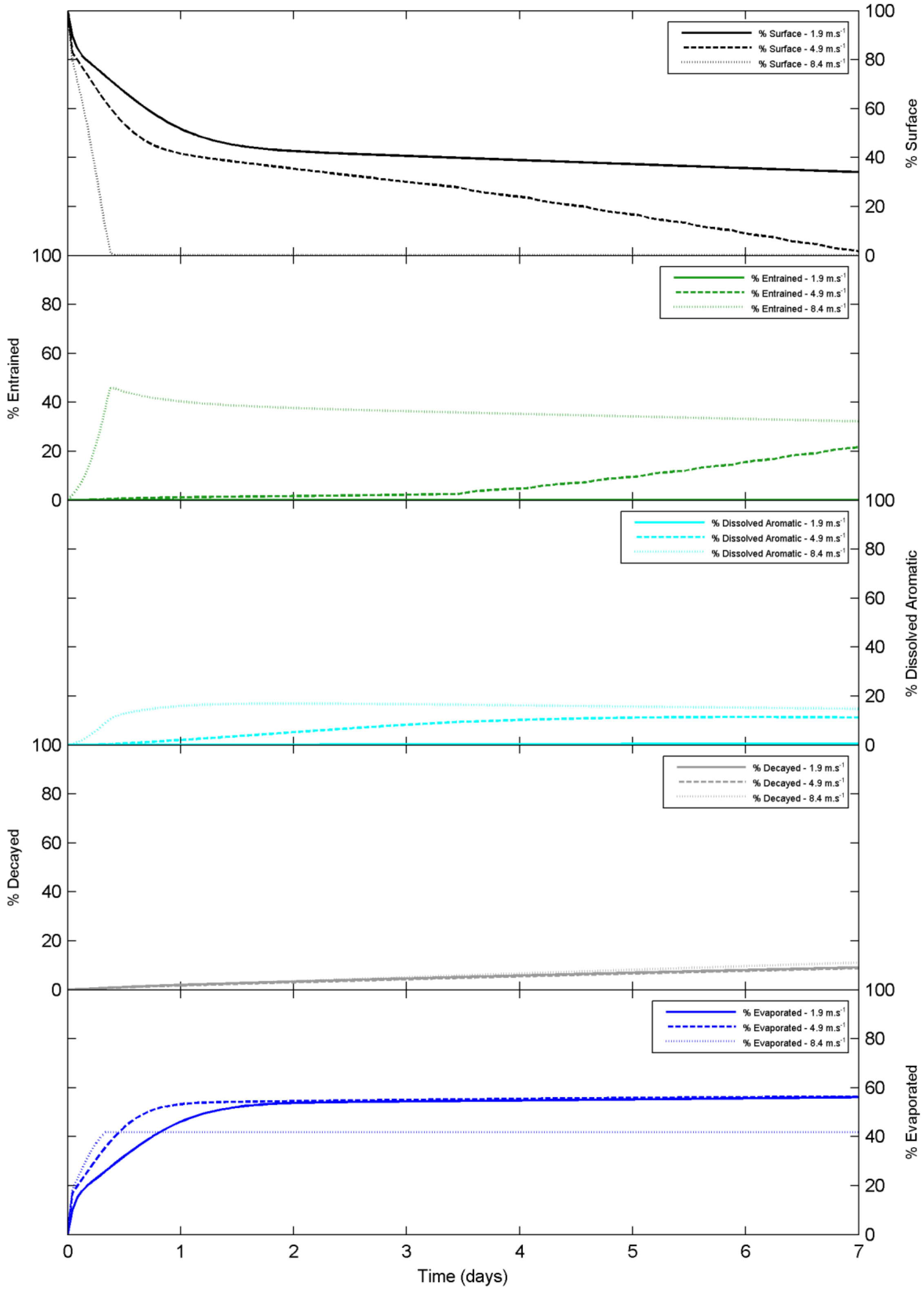


Figure 2-15: Proportional mass balance plot representing the weathering of Torosa condensate (flashed to seabed) spilled onto the water surface as a one-off release (50 m^3 over 1 hr) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

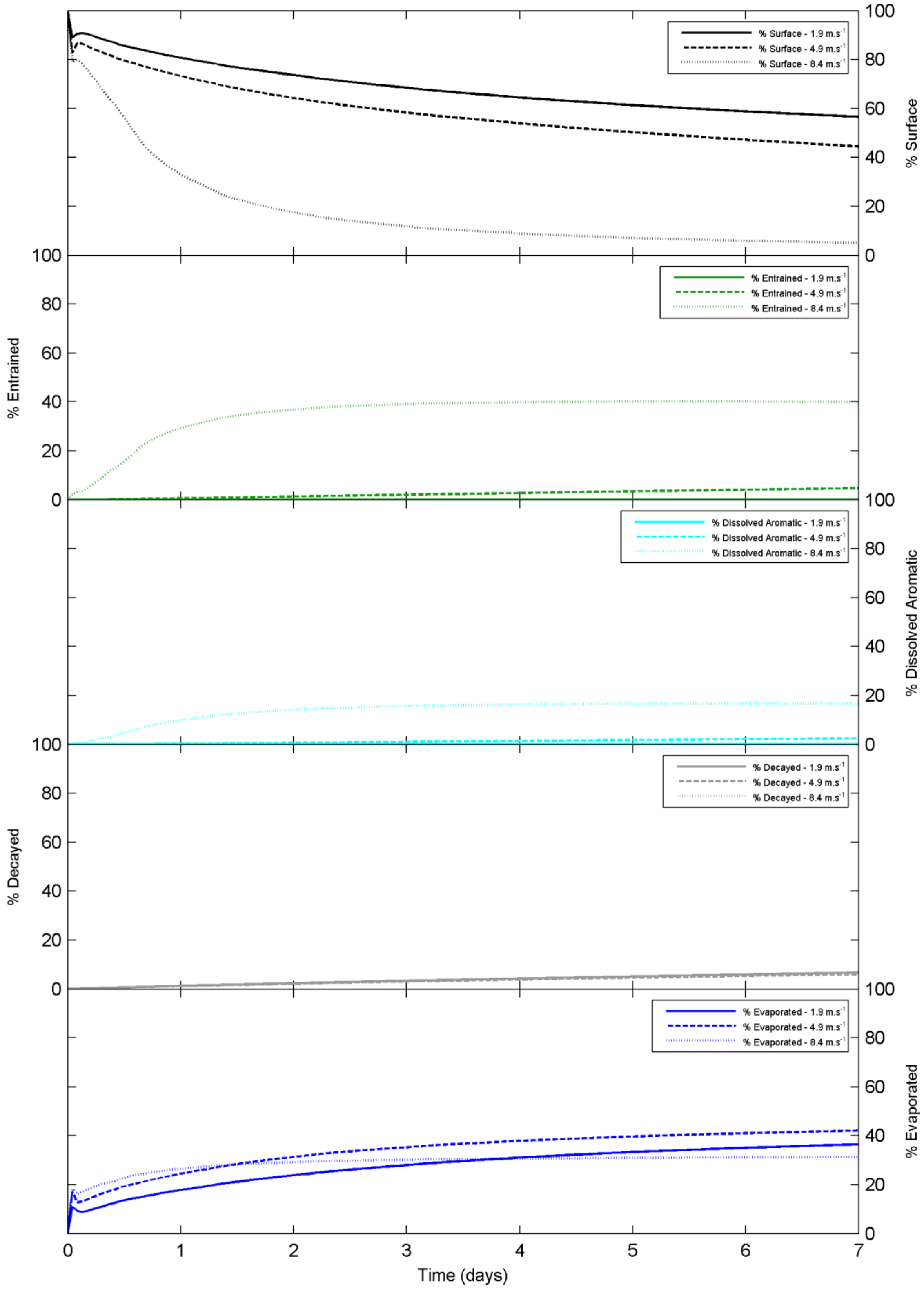


Figure 2-16: Proportional mass balance plot representing the weathering of Torosa condensate (flashed to seabed) spilled onto the water surface as a continuous release (50 m^3/hr over 7 days) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

2.3.10.3 Browse Condensate

The mass transfer for an instantaneous release of Browse Condensate under three different wind speeds (Figure 2-17) shows high initial evaporation rate in the first hours after the spill for all wind speed cases. The high initial evaporation results in 70-80% of the oil being lost to the atmosphere in less than 24 hours. A higher proportion of the oil is likely to remain on the surface for lower wind speeds, as evaporation and entrainment is less. Approximately 20% of the mass is expected to entrain rapidly in the case of the higher wind speed.

In the case of a continuous release (Figure 2-18) the mass transfer shows relatively rapid and consistent evaporation throughout. For the higher wind speed case approximately 25% of the mass is expected to be entrained over time.

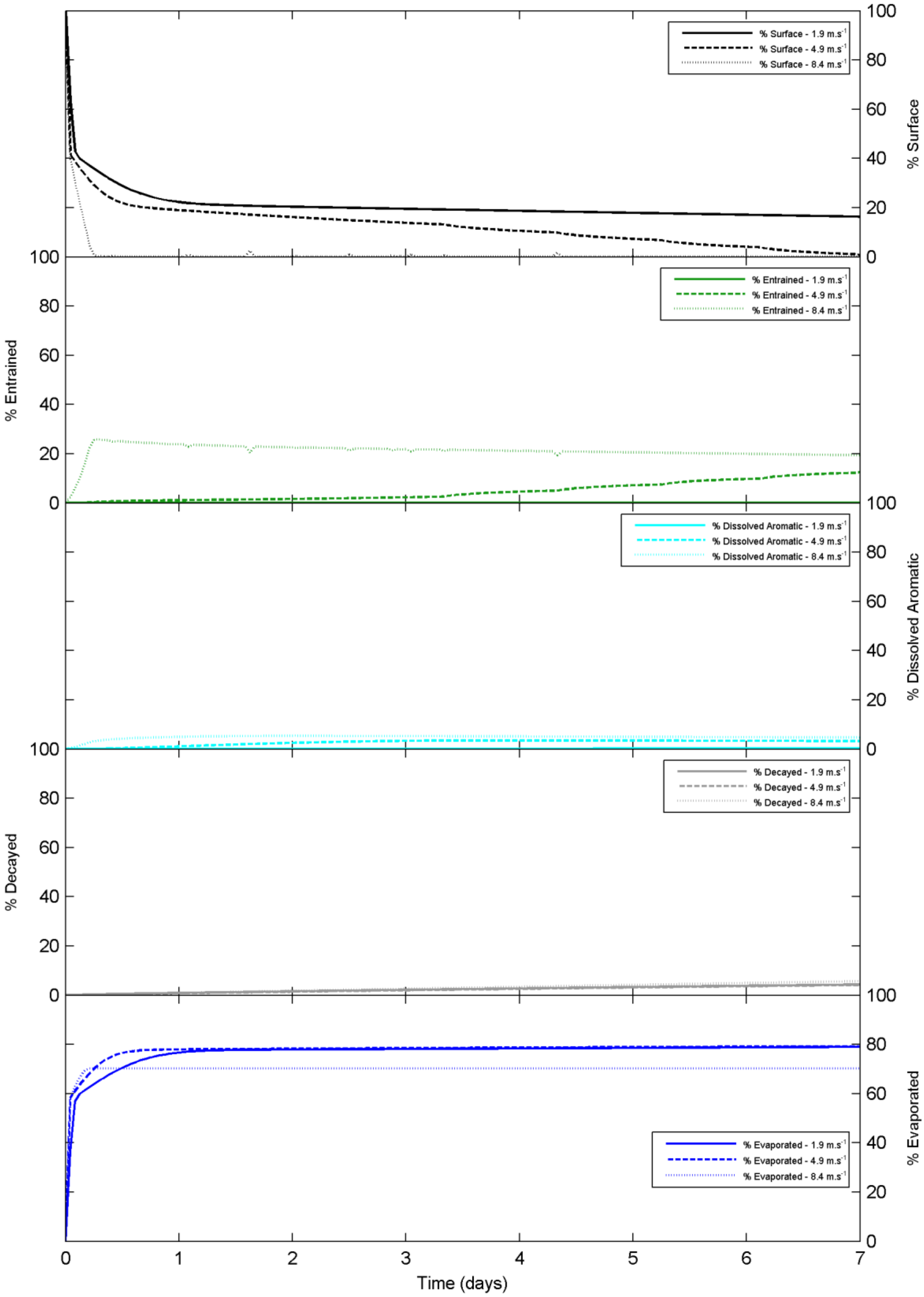


Figure 2-17: Proportional mass balance plot representing the weathering of Browse condensate spilled onto the water surface as a one-off release (50 m^3 over 1 hr) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

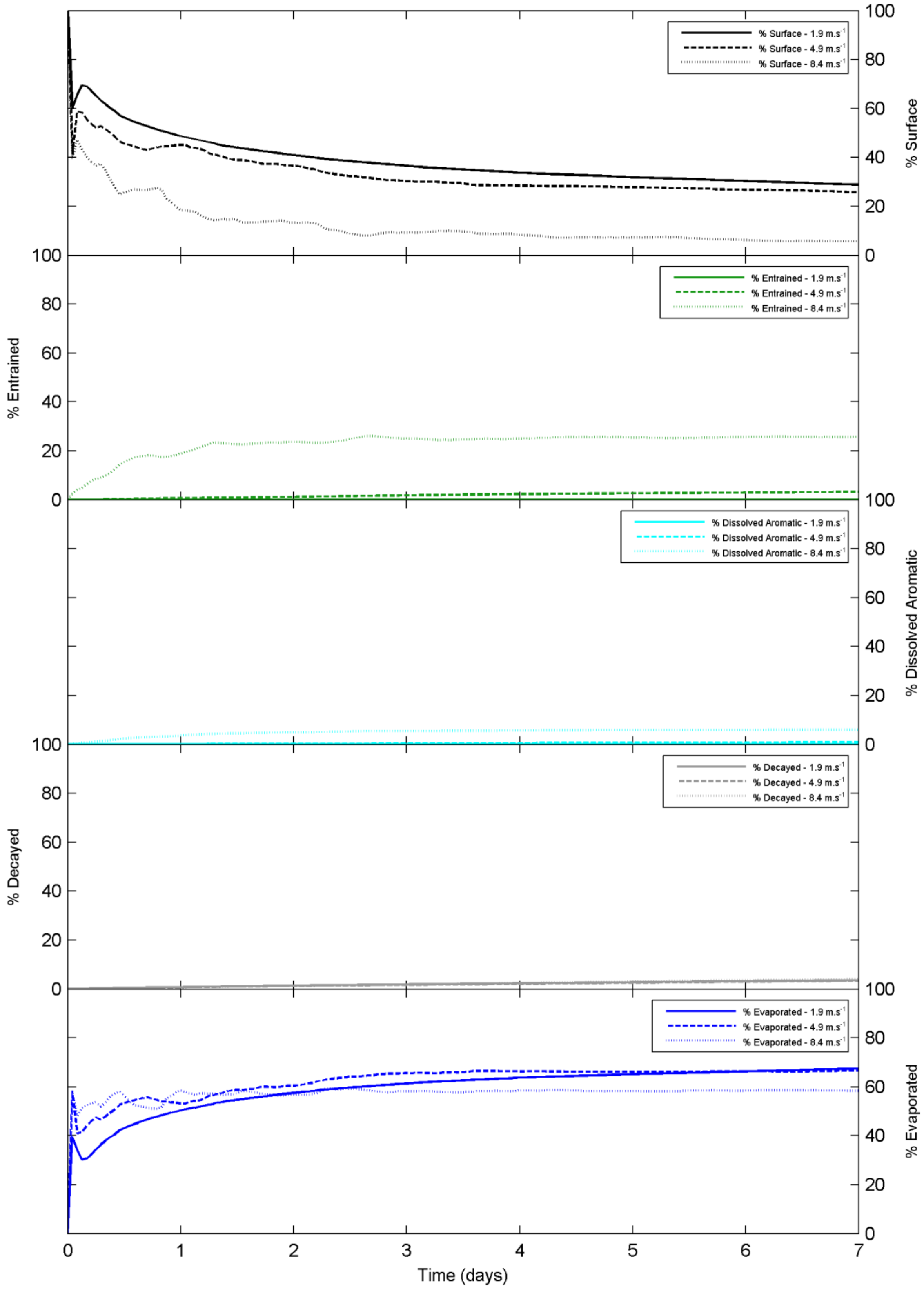


Figure 2-18: Proportional mass balance plot representing the weathering of Browse condensate spilled onto the water surface as a continuous release (50 m^3/hr over 7 days) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

2.3.10.4 Marine Diesel

The mass transfer for an instantaneous release of marine diesel under three different wind speeds is shown in Figure 2-19. For the case with high wind speed 70% of the oil is entrained within 12 hours from the release. The oil entrains gradually for the case with median wind speed, with 40% of the oil entrained at the end of the simulation. There is low or no entrainment for the case with low wind speed. The high entrainment limits the availability for evaporation for the case with the high wind speed (27%). The highest evaporation is observed for the median case, where floating oil entrains gradually during the simulation and the median wind speed facilitates the evaporation.

In the case of a continuous release (Figure 2-20) the mass transfer shows high entrainment at the high wind speed case. A large proportion of the oil remains floating on the water surface at the end of the simulation for the case with medium (60%) and low (72%) wind speeds. Approximately 30% of the oil is expected to evaporate for the median wind speed case, 25% for the case with a low wind speed and 18% for the case with a high wind speed.

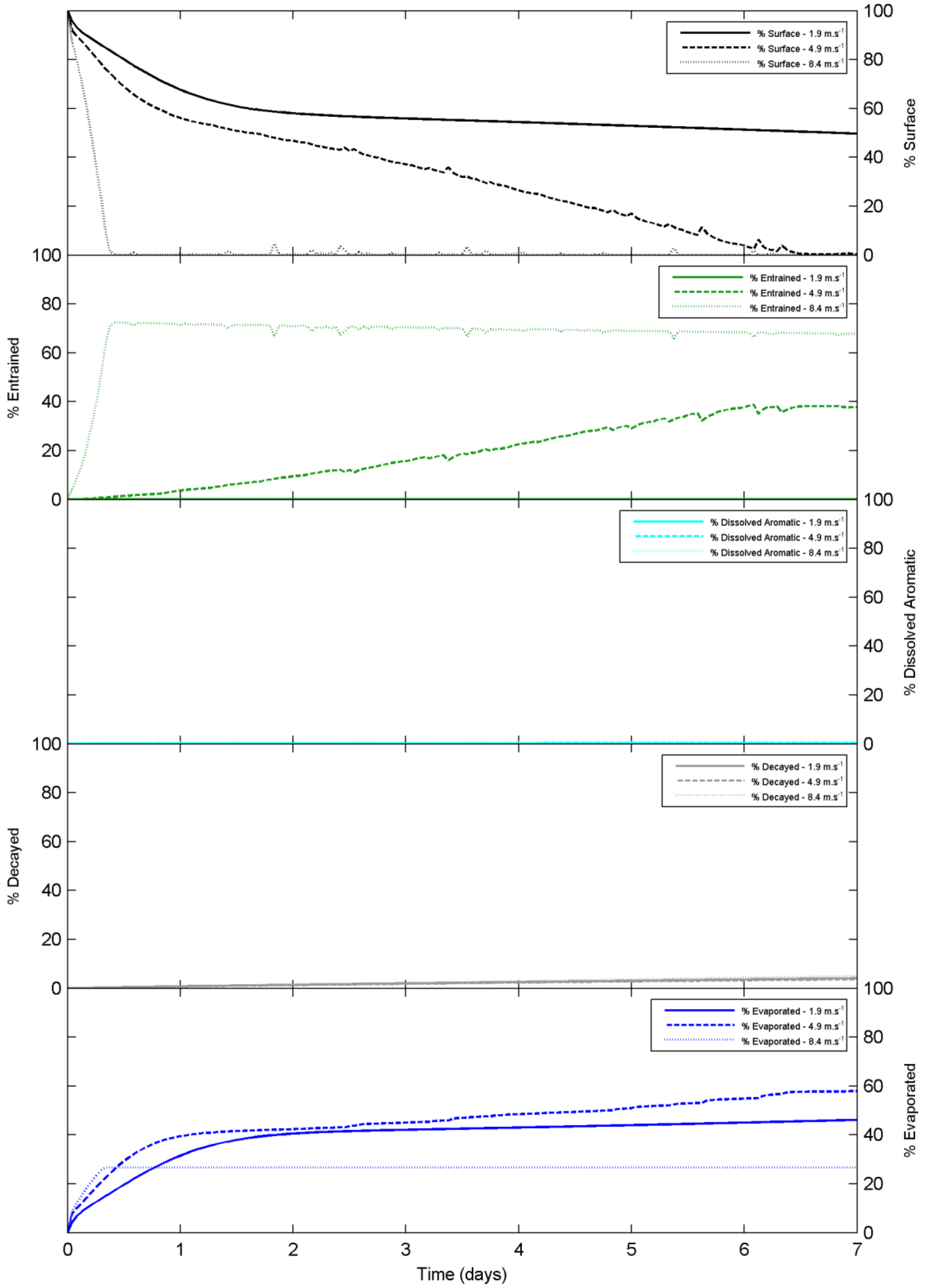


Figure 2-19: Proportional mass balance plot representing the weathering of marine diesel spilled onto the water surface as a one-off release (50 m^3 over 1 hr) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

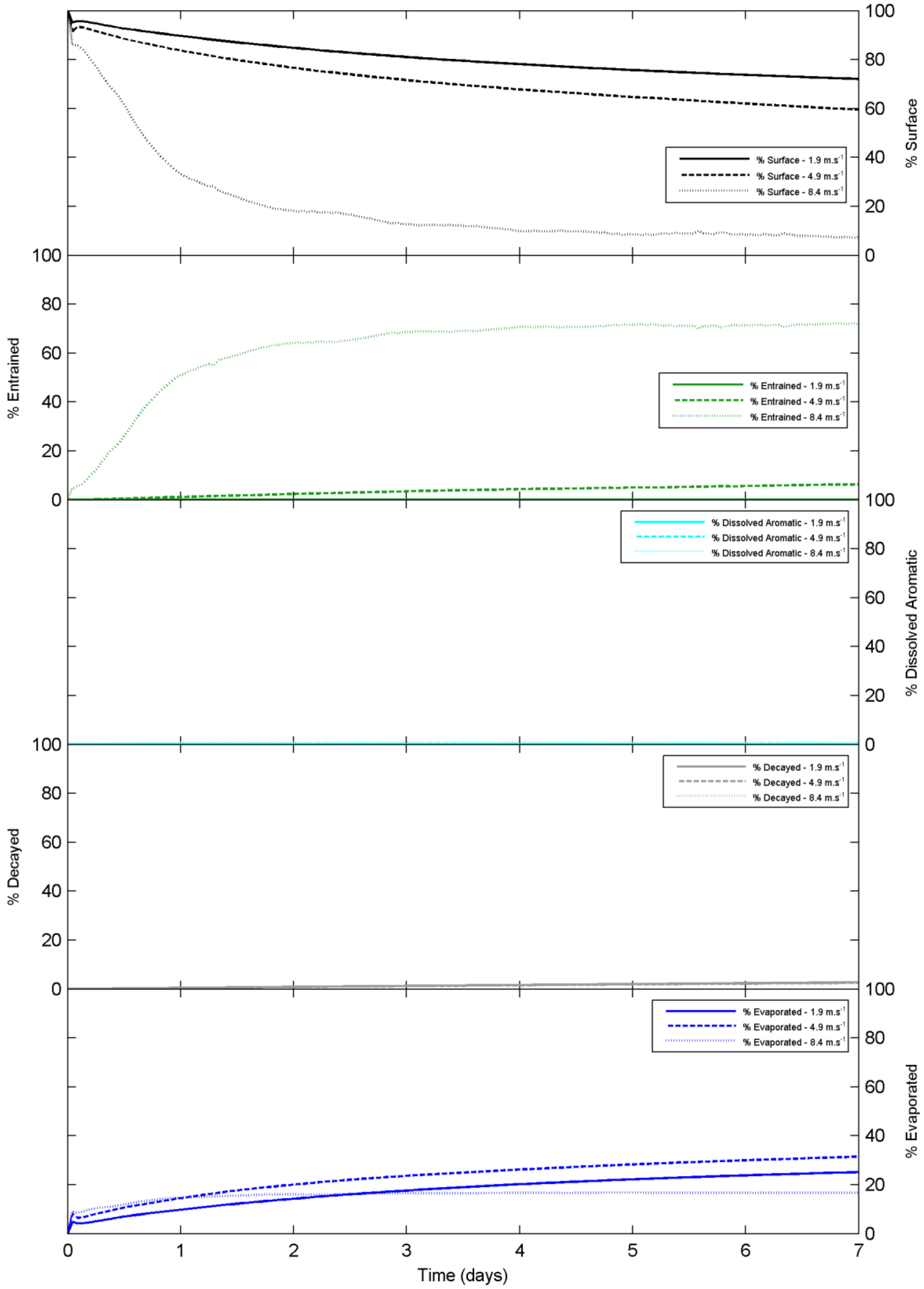


Figure 2-20: Proportional mass balance plot representing the weathering of marine diesel spilled onto the water surface as a continuous release (50 m^3/hr over 7 days) and subject to 3 constant winds of different magnitude (1.9, 4.9 and 8.4 m/s).

2.3.11 Seabed Release Behaviour

High- releases that involve mixed gas and oil will tend to generate relatively small droplet sizes that have slow rise rates, due to viscous resistance imparted by the surrounding seawater, and may become trapped by density layers in the water column (Chen & Yapa, 2002). The buoyancy of the gas cloud may lift entrained oil droplets towards the surface and, in the case of blowouts in relatively shallow water (< 100-200 m), the rising column of gas and entrained water can lift the oil to the surface at a substantially faster rate than would occur from the relative buoyancy of the oil alone, opposed by the viscosity of the water column.

For deeper releases (200-500 m), the gas will expand to entrain oil droplets towards the surface, but the gas and oil will then tend to separate before the oil surfaces because the gas either goes into solution or rises more rapidly than the oil droplets. The height at which the gas lift ceases is referred to as the trapping height. The rate at which oil rises from the trapping height will be determined by a number of factors, including the relative buoyancy of the oil versus local water density, the size of the droplets (increased viscous resistance for smaller sizes), the presence of density barriers in the water column and the action of shear currents that might be present in the water column.

Given the water temperatures and pressures that would be expected at the specified discharge depths, methane and other gases are unlikely to convert to gas hydrates, (semi-solid crystalline structures that would affect the buoyancy of the plume; Figure 2-21). Hence, the potential influences of these processes were not included for this study.

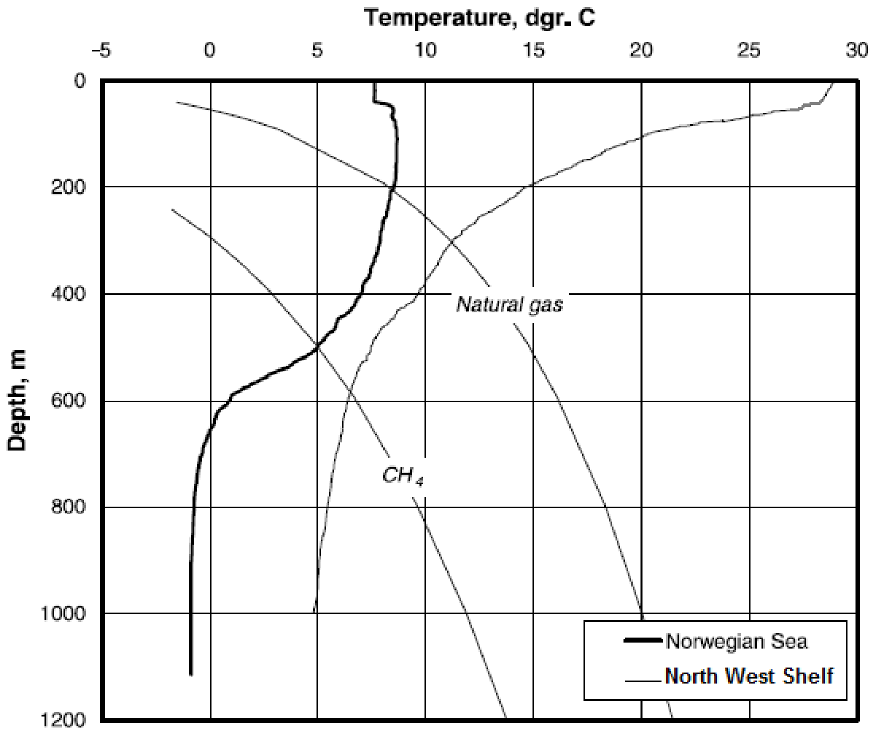


Figure 2-21: Theoretical equilibrium lines for hydrate formation based on the temperature and pressure at the release point. The line for "natural gas" assumes 80% methane, 10% ethane and 10% propane. Typical indicative sea temperature profiles with depth are indicated (Johansen, 2003).

The OILMAP-Deep model was applied to supply the droplet size distribution and the plume dimensions to the SIMAP model for Scenarios 1 and 2. Inputs to the OILMAP-Deep model included specification of the discharge rate, hole size, gas-to-oil ratio, and the temperature of the oil on exiting and before subsequent cooling by the ambient water. The temperature and salinity profiles of the water column were also specified to describe the vertical density profile.

2.3.11.1 Scenario 1

For the uncontrolled blowout of Torosa Condensate at the TRE well centre, the OILMAP-Deep input parameters and the resulting output parameters are presented in Table 2-8.

The results of the OILMAP-Deep simulation predict a cone of rising gas that would entrain the oil droplets and ambient sea water up to a “trapping depth” (where the gas plume becomes neutrally buoyant and its vertical velocity drops to zero) around 361 m above the seabed (and around 102 m below the surface). The mixed plume is initially predicted to rise towards the water surface with a vertical velocity of around 4 m/s, gradually slowing and increasing the plume diameter. The diameter of the central cone at the point of neutral buoyancy is predicted by the model to be approximately 106 m.

The high discharge velocity and turbulence generated by the expanding gas cloud is predicted to generate small oil droplets (~10-60 µm) that will be mixed by turbulence generated by the lateral displacement of the rising water. These droplets will then rise through the water column at variable rates, although their low buoyancy indicates it may take 2-3 days for the first oil to reach the surface. Floating slicks could potentially be created under amenable wind conditions.

Table 2-8: Near-field blowout model parameters for Scenario 1.

OILMAP-Deep	**Parameter**	**Value**
Inputs	Release Depth (m MSL)	463
	Oil Density (g/cm^3) (at 20 °C)	0.780
	Oil Viscosity (cP) (at 20 °C)	1.092
	Oil Temperature (°C)	129
	Gas:Oil Ratio (m^3/m^3)	23,775
	Oil Flow Rate (m^3/d)	968
	Diameter of Pipe (m)	0.31
Outputs	Plume Diameter (m)	106
	Plume Height (m ASB)	361
Predicted Oil Droplet Size Distribution	3.5% droplets of size (µm)	10
	14.9% droplets of size (µm)	20
	24.9% droplets of size (µm)	29
	26.5% droplets of size (µm)	39
	19.7% droplets of size (µm)	49
	10.5% droplets of size (µm)	59

Given the low buoyancy and slow ascent of the released oil, there is a potential for droplets to be advected significant distances from the blowout site before reaching the surface layer of the water column. Given also the likelihood of around 25% of the oil persisting for an indefinite period of time, the likely zone of consequence for floating and dissolved aromatic oil could extend significant distances from the blowout site.

2.3.11.2 Scenario 2

For the leak of Torosa Condensate at the TRD flowline location, the OILMAP-Deep input parameters and the resulting output parameters are presented in Table 2-9.

The results of the OILMAP-Deep simulation predict a cone of rising gas that would entrain the oil droplets and ambient sea water up to a trapping depth approximately 169 m above the seabed (and around 229 m below the surface). The mixed plume is initially predicted to rise towards the water surface with a vertical velocity of around 1.8 m/s, gradually slowing and increasing the plume diameter. The diameter of the central cone at the point of neutral buoyancy is predicted by the model to be approximately 73 m.

The near-instantaneous discharge is expected to be of very low turbulence, with predicted droplet sizes ranging from ~240 µm to ~1,430 µm. The droplets will be mixed by turbulence generated by the lateral displacement of the rising water, and will then rise at variable rates to the surface. The droplet sizes indicate relatively high buoyancy, leading to a strong potential to surface quickly (within an hour of release) and create floating slicks under suitable wind conditions.

Given the likelihood of rapid ascent and buoyancy favouring surfacing, the majority of the oil is expected to be exposed to atmospheric weathering at least initially, which should lead to a significant proportion of the oil mass lost to the atmosphere.

Given the volume of the spill, and the expected behaviour, the likely zone of consequence for floating and dissolved aromatic oil is expected to be very localised.

Table 2-9: Near-field blowout model parameters for Scenario 2.

OILMAP-Deep	**Parameter**	**Value**
Inputs	Release Depth (m BMSL)	389
	Oil Density (g/cm^3) (at 20 °C)	0.780
	Oil Viscosity (cP) (at 20 °C)	1.092
	Oil Temperature (°C)	7
	Gas:Oil Ratio (m^3/m^3)	2,800
	Oil Flow Rate (m^3/h)	25
	Diameter of Pipe (m)	0.30
Outputs	Plume Diameter (m)	73
	Plume Height (m ASB)	169
Predicted Oil Droplet Size Distribution	3.5% droplets of size (µm)	239
	14.9% droplets of size (µm)	477
	24.9% droplets of size (µm)	716
	26.5% droplets of size (µm)	945
	19.7% droplets of size (µm)	1,193
	10.5% droplets of size (µm)	1,432

3 RESULTS

3.1 Overview

Predictions for the probability of contact by oil concentrations equal to or greater than defined thresholds are provided in the following sections to summarise the results of the stochastic modelling.

Contour maps present estimates for the annualised probability of exposure equal to or greater than to the defined minimum thresholds (≥ 1 g/m² and ≥ 10 g/m² for floating oil; ≥ 576 ppb.hr for dissolved aromatic hydrocarbon dosage) for at least one model output time step (1 hour). These contours summarise the outcomes for all replicate simulations commencing in all calendar quarters – a total of 200 replicate simulations for Scenarios 1, 4.2 and 4.4, and a total of 400 replicate simulations for Scenarios 2, 3.2, 5 and 6.

Readers should note that the contour maps presented in this report do not represent the predicted coverage of any one hydrocarbon spill or a depiction of a slick or plume at any particular instant in time. Rather, the contours are a composite of a large number of theoretical slick paths, integrated over the full duration of the simulations relevant to each scenario. The contour maps should be treated as indications of the probability of exposure at defined concentrations, for individual locations, at some point in time after the defined spill commences, given the trends and variations in metocean conditions that occur around the study area.

Locations with higher probability ratings were exposed during a greater number of spill simulations, indicating that the combination of the prevailing wind and current conditions are more likely to result in contact to these locations if the spill scenario was to occur in the future. The areas outside of the finest resolvable contour (or the Zone of Consequence region) indicate that contact will be less likely under the range of prevailing conditions for this region than areas falling within higher probability contours.

It is important to note that the probabilities are derived from the samples of data used in the modelling. Therefore, locations that are not calculated to receive exposure at threshold concentrations or greater in any of the replicate simulations might possibly be contacted if very unusual conditions were to occur. Hence, we do not attribute a probability of nil to areas beyond the lowest probability contour.

Tables are presented to summarise estimates of contact risk for potentially sensitive receptors, summarised for regional locations including those listed in section 2.3.6 that were defined by WEL.

The probability estimates for contact by floating oil that are presented in the tables summarise the probability that oil will arrive at shorelines as floating films at the specified threshold concentration equal to or greater than for at least one time step (1 hour). Note, in addition to the two floating oil thresholds presented in the contour maps two additional thresholds are presented in the tabular results (≥ 0.5 g/m^2 and ≥ 25 g/m^2). The tables show the annualised probability averaged across the calendar quarters. Note that where there is no contact indicated for a sensitive receptor in a given quarter, a probability of zero was applied to that quarter in the calculation of the annual average probability.

The minimum time estimates shown in the tables present the shortest time for any oil to drift from the source to any part of the sensitive receptor from the time of the commencement of the spill. The annualised minimum time is calculated as the lowest minimum time in any calendar quarter, for those quarters where contact was indicated in at least one replicate.

The mean and maximum shoreline concentrations show the concentrations forecast to potentially accumulate over time on any discrete part of a shoreline (calculated for individual portions of shore; grid cells of approximately 650 m length for all Scenarios, except Scenario 5 with grid cells of approximately 400 m). Accumulated concentrations are calculated by summing the mass of oil that arrives at any concentration (including < threshold) over time at a model cell and subtracting any mass lost through evaporation and washing off, where relevant.

Note that it is possible that oil films arriving at concentrations lower than the threshold of instantaneous concentrations for floating oil contact may accumulate over the course of a spill event and result in concentrations of oil onshore higher than the threshold for floating oil. Hence, the mean expected and maximum concentrations of oil accumulated onshore can be higher than the threshold applied to the probability calculations for the arrival of floating oil; as a result of this, in some cases there may be results tabulated for accumulated oil onshore even when the probability of contact by floating oil at threshold concentrations is predicted to nil. It is important to understand that the two parameters (floating concentration and shoreline concentration) are quite distinct, calculated in different ways and representative of alternative outcomes. The floating probability estimates and the shoreline accumulative estimates should be treated as independent estimators of different exposure outcomes, and not compared.

For the dissolved components, the tabulated results summarise interrogations of cells representing the water surrounding the sensitive receptor shorelines, with individual buffer zones as illustrated in Figure 1-1. Buffer zones were defined with consideration of the bathymetry bordering each receptor, natural boundaries or sensible legislative boundaries.

3.2 Scenario 1: Simulation of a 77-Day Surface/Subsea Blowout of 73,671 m^3 of Torosa Condensate at the TRE location

This scenario investigated the probability of exposure to surrounding regions by oil due to an uncontrolled release of Torosa Condensate at the TRE location, with 3,975 m^3 released onto the water surface over 5 days and 69,696 m^3 released from the seabed over the subsequent 72 days. The release is described as a surface/subsea release due to the two phases of the release.

Table 3-1: Summary of the spill scenario.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (m BMSL)
1	Blowout at TRE well centre during drilling operations	Torosa Condensate (flashed to surface and seabed)	Surface: 3,975 Seabed: 69,696	1.33×10^{-5}	Surface: 5 days Seabed: 72 days	14° 2' 17.016" S 121° 50' 58.948" E	Surface / 463

The modelling for this scenario assumed no mitigation efforts are undertaken to collect or otherwise affect the natural transport and weathering of the oil. All sensitive receptors outlined in Section 2.3.6 were analysed; however, only the receptors that were forecast to be contacted by dispersing oil are summarised in this section.

Average Weathering

The average mass balance (Figure 3-1 and Figure 3-2) shows a low level of evaporation during the release, with approximately 10% of the oil evaporated after the 5-day surface release phase, and around 20% of the oil evaporated at the end of the simulation. Approximately 20% of the oil is entrained during the first 5 days, and after commencement of the subsea release phase the proportion of entrained oil peaks at around 55% after 15 days before dropping to around 12% at the end of the simulation. The bulk of the oil mass – around 70% - has decayed in the water column by the end of the simulation. After around 35 days, very little oil is expected to remain floating on the water surface.

The proportion of aromatic hydrocarbons dissolved in the water column peaks after around 11 days at nearly 60% of the released mass of aromatics (Figure 3-3 and Figure 3-4). After 30 days, the aromatic hydrocarbons in floating oil have almost completely evaporated or dissolved (as has the majority of floating oil). At the end of the simulation, practically all of the aromatic hydrocarbon mass has evaporated or decayed.

Trajectory and Weathering of an Example Replicate

An example series of snapshots of a single predicted spill trajectory are presented in Figure 3-5 and Figure 3-6, and associated weathering and fates plots in Figure 3-7. The snapshots display the concentration of oil floating on the water surface based on specified surface oiling thresholds.

The single spill trajectory analysis shows that one day after the blowout initiation (Figure 3-5 b) the oil film is at concentrations greater than 25 g/m^2, and is circling the release site due to the effect of the local tidal flows. After 3 days the floating film is further spread, with the main directions of drift being to the north and northwest, over and around Scott Reef North (Figure 3-5 c), driven by the wind. After 5 days the surface slick has moved westwards and northwards around Scott Reef North, with concentrations near or above 25 g/m^2 along most of the slick's 20 km length (Figure 3-5 d).

Over the next 4 days the slick's northwards travel continues, and with the cessation of the surface release phase the floating oil becomes a discrete moving mass (Figure 3-5 e and Figure 3-5 f). No observable floating slick is shown to result from the subsea phase between days 5 and 9. Later on, between days 12 and 15, the slick moves northeast towards and then around Seringapatam Reef, where it separates into two discrete slicks (Figure 3-5 g and Figure 3-5 h). A small slick of low-concentration oil will remain floating on the surface to the southwest of Seringapatam Reef, with the two larger, patchy slicks continuing to move eastwards with concentrations decreasing progressively as shown by the snapshots between days 15 and day 24 (Figure 3-5 i, Figure 3-5 j and Figure 3-5 k). After approximately 4 weeks from the start of the release, the concentration of floating oil falls below the 0.5 g/m^2 threshold (Figure 3-5 l) and remains at such low levels until the end of the release on day 77. Note that the model keeps track of the oil spillets, even at concentrations smaller than the lowest threshold, for the whole duration of the simulation as shown on the snapshots presented in Figure 3-6.

The weathering curve (Figure 3-7) shows that in this case approximately 10% of the oil is expected to evaporate within 5 days of the release. Recall that this oil type has been modelled as pre-flashed to atmospheric conditions and therefore the very volatile component was not included in the analysis.

More than 80% of the released oil is expected to remain floating on the surface after 5 days. The low wind speeds in this case result in minimal entrainment of the floating oil into the water column, with the rise in the entrained oil proportion (and dissolved aromatic proportion) after 5 days solely due to the commencement of the subsea release phase. Figure 3-4 showed that around 60% of the aromatic components would remain in the floating oil after the initial 5 days.

This example shows how the initial fate of the oil released is strongly influenced by the wind conditions. For example, if the spill happened during a period of stronger winds, a much greater proportion of the spill would be entrained, and hence eventual decay of the entrained components and dissolution of the aromatic components would be enhanced.

Floating Oil

The probability (P_2) contours show that floating oil with concentrations at or above 1 g/m^2 is forecast to potentially occur up to 700 km from the release site (Figure 3-8). The corresponding contours at the 10 g/m^2 threshold are forecast to be restricted to around 200 km from the release site (Figure 3-9). The oil slick is forecast to most likely drift in westerly and easterly directions, within Scott Reef, with drift possible in all directions once outside the reef complex. Extended trajectories are predicted to the northwest and southwest for floating oil at or above 1 g/m^2 threshold. The return-period probabilities (P_1xP_2) at these thresholds are shown in Figure 3-10 and Figure 3-11.

The higher maximum concentrations of floating oil (at or above 50 g/m^2) are expected to generally occur within 50 km of the release site, with some isolated occurrence at larger distances (Figure 3-12). The potential areas of floating oil at or above the defined thresholds are quantified in Table 3-2.

The swept area at each threshold determined for the individually simulated spill events shows a high degree of variability, with the median or expected values significantly exceeded in the worst case. This again highlights the likely influence of the wind on the outcome with the very small footprint outcomes likely to relate to spills commencing in entrainment favourable conditions. In general the distribution of the outcomes becomes less skewed as the threshold increases.

Table 3-2: The potential swept area (km^2) of floating oil with concentrations exceeding defined threshold concentrations in any single spill event. The swept area refers to all areas covered by the slick during the spill simulation with a concentration at the specified threshold.

	0.5 g/m^2	1 g/m^2	10 g/m^2	25 g/m^2
Minimum potential area (km^2)	200	140	76	36
Median potential area (km^2)	4,041	2,365	378	151
Mean potential area (km^2)	5,955	3,512	431	167
Maximum potential area (km^2)	38,394	20,154	1,862	430

Floating oil with concentrations of 25 g/m^2 or greater is expected to contact receptors at Scott and Seringapatam Reefs (Table 3-3). The forecast probabilities of contact for this threshold are 0.5% at Seringapatam Reef, 46% at North Reef Flats, 27% at North Reef Lagoon, 97.5% at South Reef Lagoon, 49% at Scott Reef Central/Sandy Islet and 15% at South Reef Flats. Kimberley CMR and Argo-Rowley Terrace CMR are forecast to be contacted by floating oil concentrations at or above 10 g/m^2.

The minimum time expected for floating oil at the lowest defined threshold (0.5 g/m) to reach any receptor is 1 hour for South Reef Lagoon (in which the release site is located), followed by 3 hours for North Reef Flats and 6 hours for North Reef Lagoon. Beyond the Scott Reef complex, the first receptor expected to be contacted by floating oil at the 0.5 g/m^2 threshold is Kimberley CMR after 135 hours (~5.5 days). Minimum contact times are expected to be slightly higher at higher concentration thresholds.

The worst-case locally accumulated shoreline concentrations are forecast at Scott Reef Central/Sandy Islet (11.4 kg/m^2), while beyond the Scott Reef complex the worst-case accumulated concentration is forecast at Browse Island (2.5 kg/m^2). The maximum accumulated volume along any shoreline is forecast for Scott Reef Central/Sandy Islet (28 m^3), with the maximum volume beyond the Scott Reef complex forecast at Ashmore Reef (6 m^3). These accumulations represent a very small proportion of the total spilled volume.

Dissolved Aromatic Hydrocarbon Dosage

Results of dissolved aromatic hydrocarbon dosage exceeding the defined thresholds at any vertical level are discussed in this section. The results for a variety of levels are also presented in tabular form within the results.

Exceedence of the low dosage threshold (at or above 576 ppb.hr) is expected to potentially occur up to 500 km from the release site in the upper 40 m water column (Figure 3-17, Figure 3-18, Figure 3-19). The areal coverage then reduces below 40 m depth (Figure 3-20). Dosage at the moderate threshold (at or above 4,800 ppb.hr) is expected to be restricted to within 50 km of the release site in the two upper layers of the water column (0-10 m, 10-20 m depths; Figure 3-21, Figure 3-22). Below a depth of 20 m, only the waters within and around Scott Reef are forecast to be exposed to dosages at this threshold (Figure 3-23, Figure 3-24). Areas where the high dosage threshold (at or above 38,400 ppb.hr) is realised are expected only within Scott Reef at all depth layers (Figure 3-25 to Figure 3-28), with very little threshold exceedence expected below 40 m.

Maximum dissolved aromatic hydrocarbon dosage maps at any depth (Figure 3-29 to Figure 3-32) clearly show that the area influenced at the defined thresholds, as well as the maximum threshold exceeded, decreases as the water depth increases.

Figure 3-34 shows the vertical distribution of the maximum dissolved aromatic hydrocarbon dosage along two perpendicular intersections of the release site (transects defined in Figure 3-33). Both transects show the maximum dosage occurring within South Reef Lagoon, in the immediate vicinity of the release site. The transects reflect the greater potential for initial advection and oscillation of the dissolved aromatic hydrocarbons to the east and west, rather than the north and south, locally which is dictated by the local bathymetry constraining the dominant tidal currents in the area.

Probabilities of exceeding the low dosage threshold are forecast at 100% in the surface layer for all assessed receptors of Scott Reef (Table 3-4), with the probability dropping to a low of 67% at greater depths. A similar trend is seen at the moderate threshold, where the surface-layer exceedence probability is predicted to be 100% at all Scott Reef receptors except South Reef Flats (6.5%); at greater depths, the probability at the remaining receptors reduces to a maximum of 74.5%.

At the high dosage threshold, the probability of receptor contact within Scott Reef ranges from no predicted contact (South Reef Flats) to 100% (South Reef Lagoon), with lower probabilities at depth. Beyond Scott Reef, only the low dosage threshold is expected to be exceeded, with maximum probabilities of 1% at Seringapatam Reef and 0.5% at Kimberley CMR and Argo-Rowley CMR. Dosage impacts are therefore expected to be localised.

3.2.1 Average Weathering

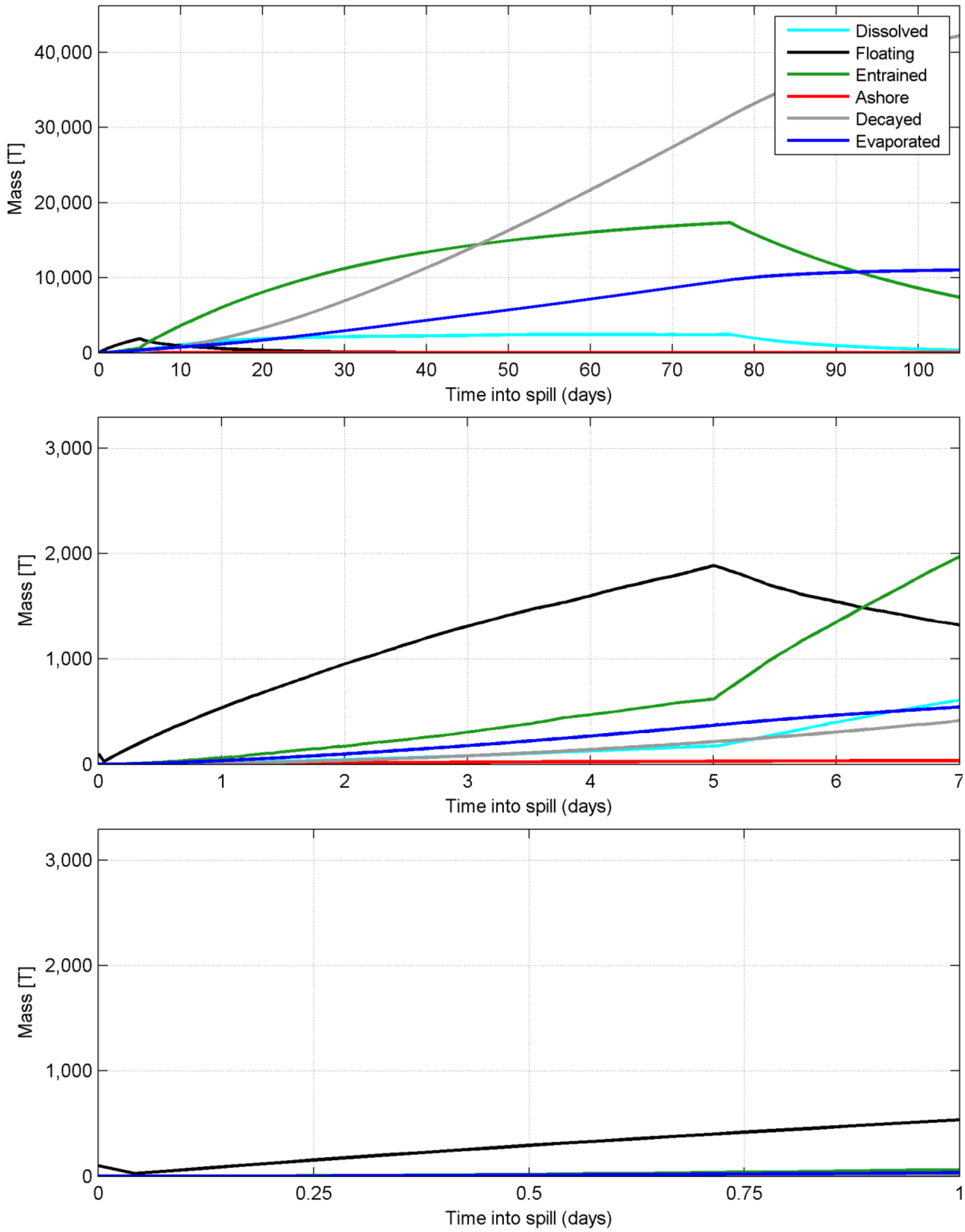


Figure 3-1: Predicted average weathering mass balance (tonnes) resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The distribution over the first 105 days (top), 7 days (middle) and 24 hours (bottom) is given.

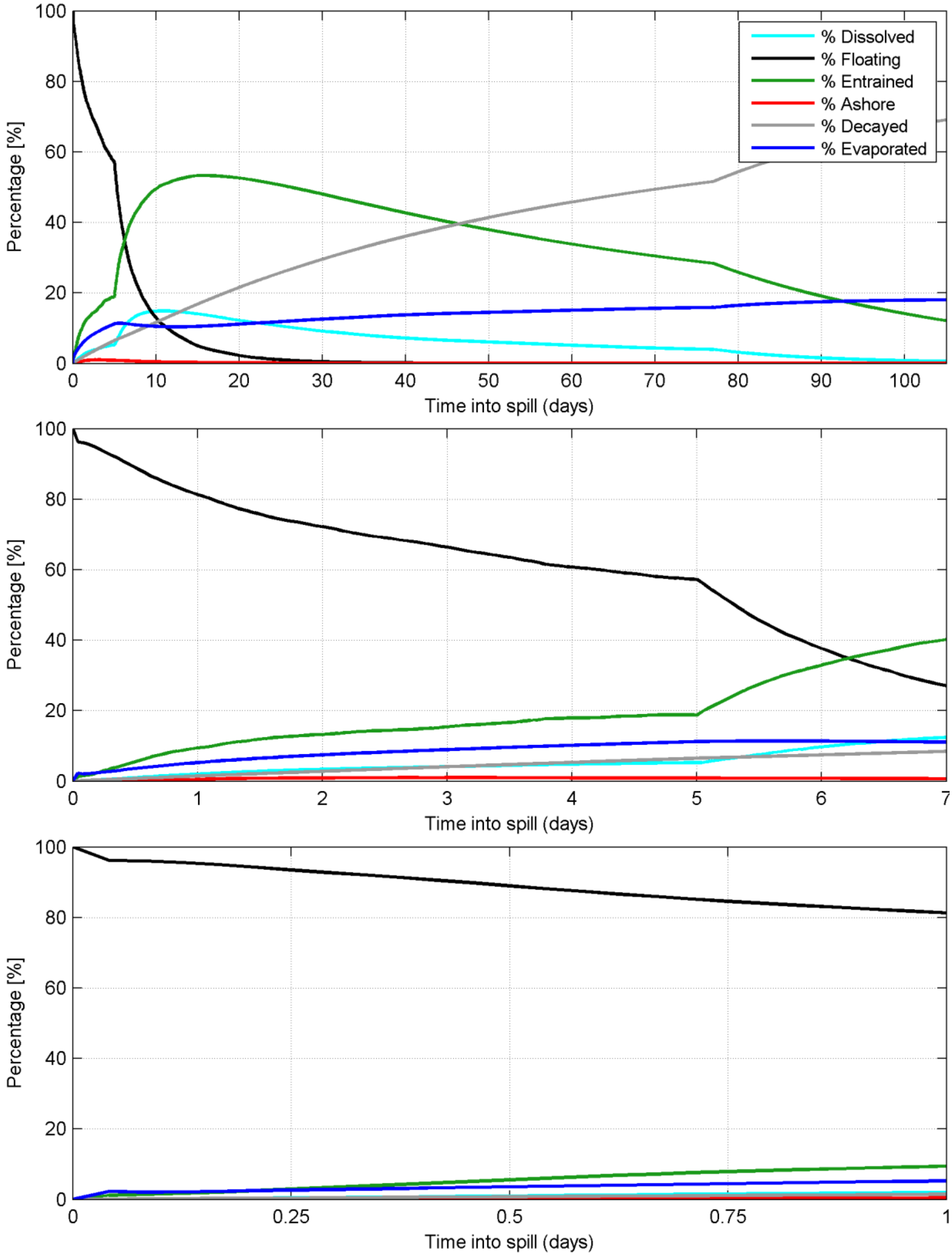


Figure 3-2: Predicted average weathering mass balance (% of total mass) graph resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The distribution over the first 105 days (top), 7 days (middle) and 24 hours (bottom) is given.

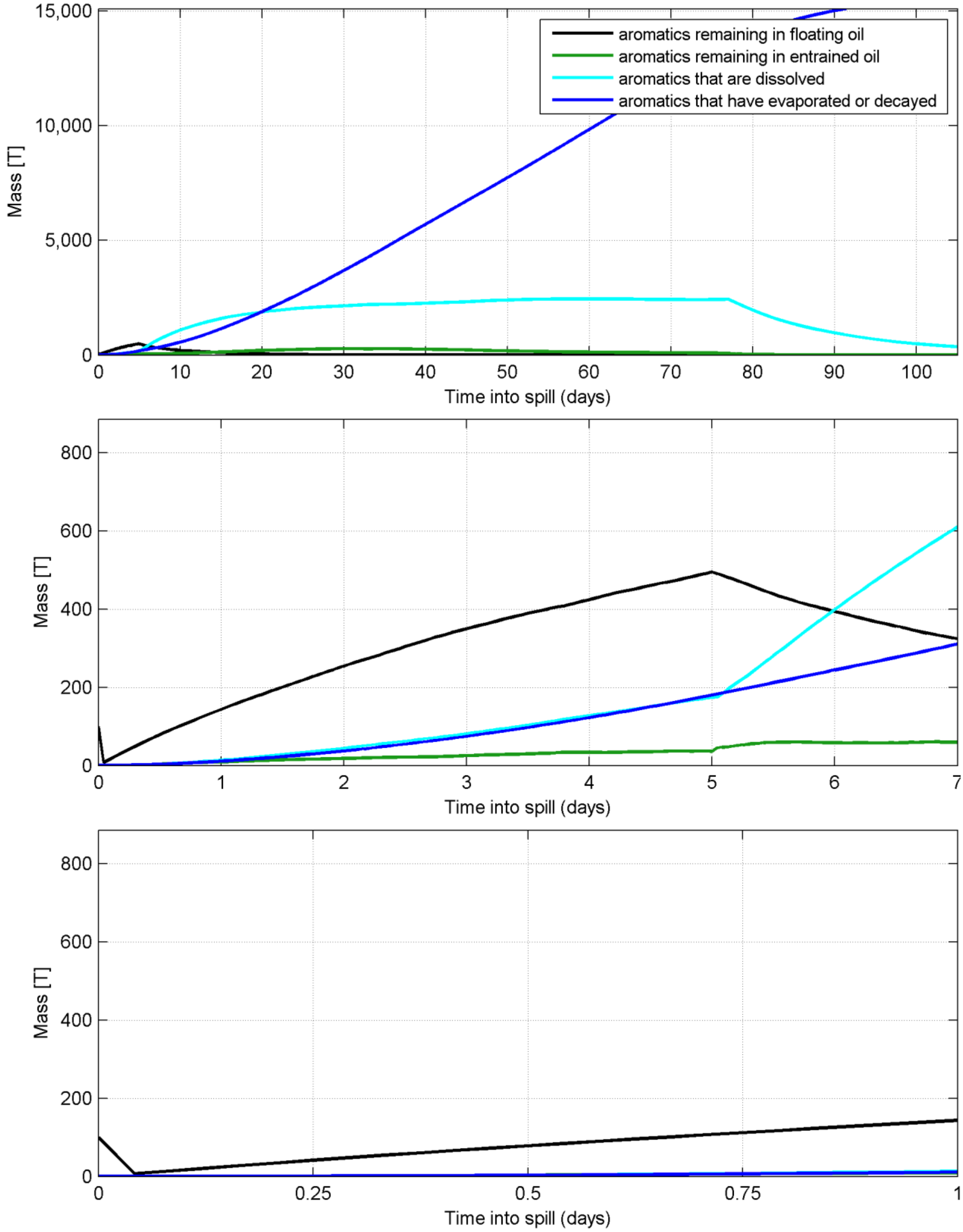


Figure 3-3: Predicted average partitioning of the aromatic hydrocarbons (tonnes) resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The distribution over the first 105 days (top), 7 days (middle) and 24 hours (bottom) is given.

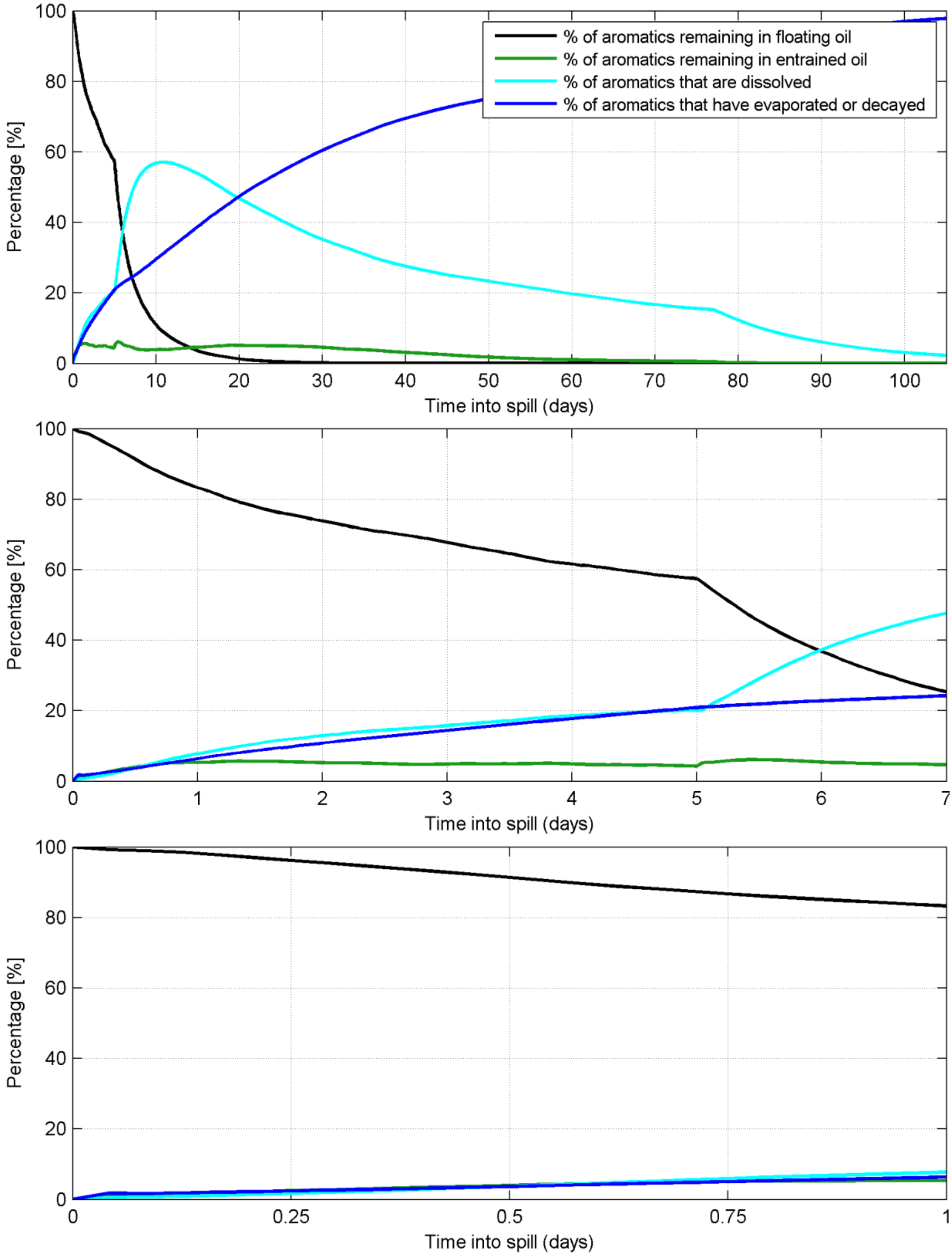


Figure 3-4: Predicted average partitioning of the aromatic hydrocarbons (% of total mass) resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The distribution over the first 105 days (top), 7 days (middle) and 24 hours (bottom) is given.

3.2.2 Trajectory and Weathering of an Example Replicate

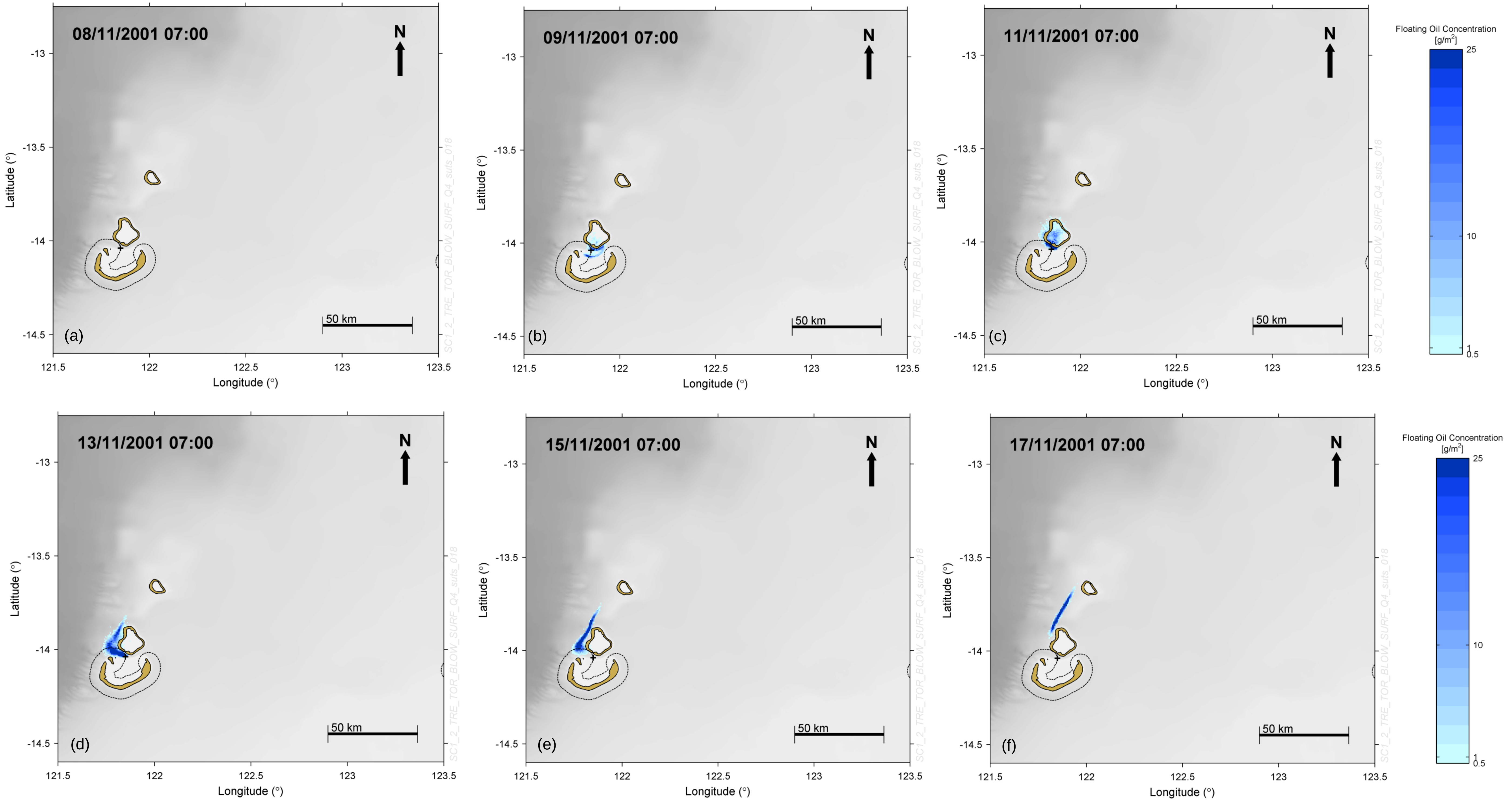


Figure 3-5: Example trajectory and concentration of floating oil for a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location, commencing at 20:00 on 26th of November 2003. The resultant trajectory and concentration at the start of the release (a), and after 1 day (b), 3 days (c), 5 days (d), 7 days (e), 9 days (f), 12 days (g), 15 days (h), 18 days (i), 21 days (j), 24 days (k), and 27 days (l) from the start of the release. Note, after week 4 and until the end of the release in week 11, floating oil concentrations remained below the 0.5 g/m^2 threshold.

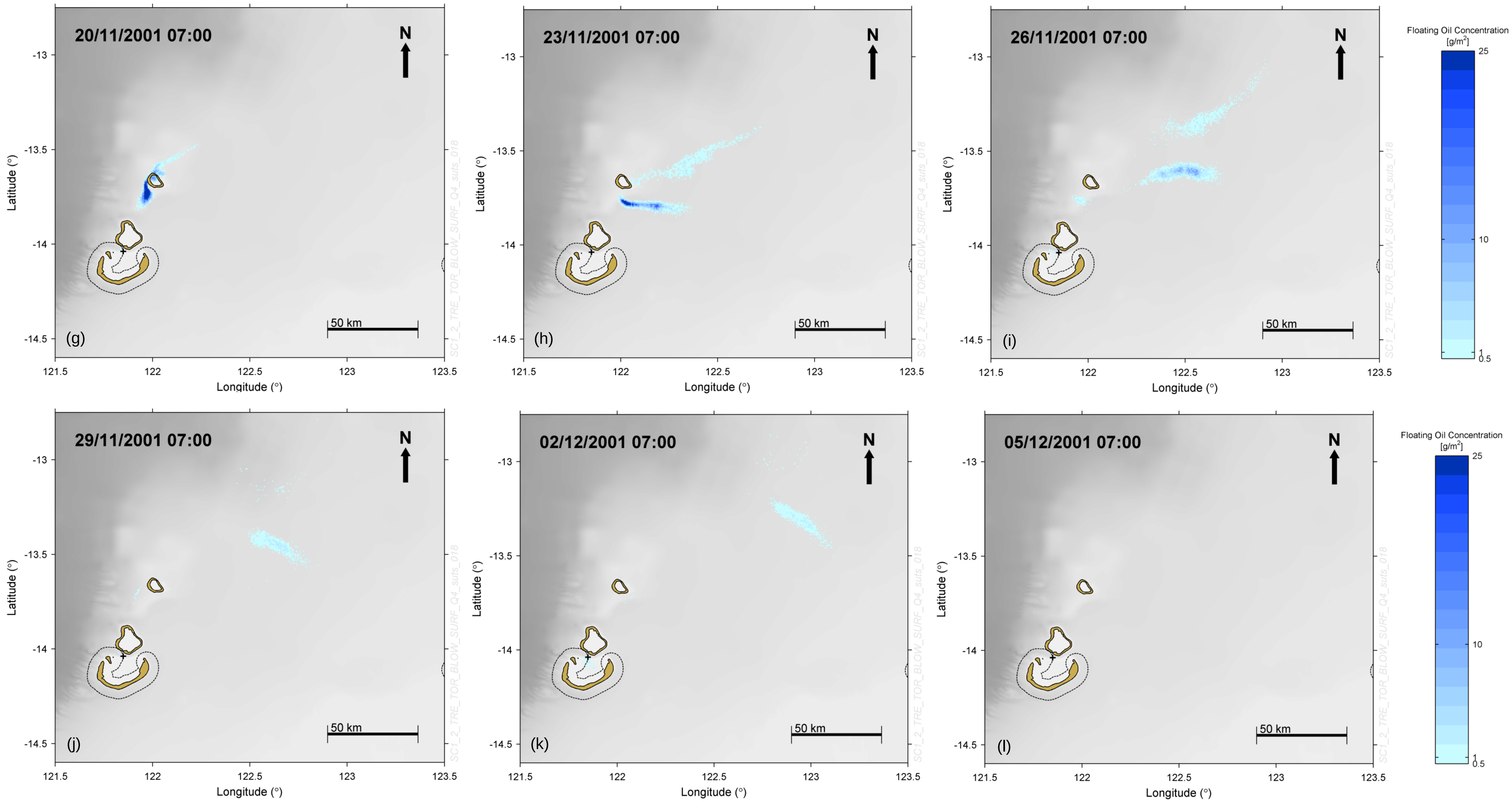


Figure 3-5: Example trajectory and concentration of floating oil for a 77-day 73,671 m3 surface/subsea release of Torosa Condensate at the TRE location, commencing at 20:00 on 26th of November 2003. The resultant trajectory and concentration at the start of the release (a), and after 1 day (b), 3 days (c), 5 days (d), 7 days (e), 9 days (f), 12 days (g), 15 days (h), 18 days (i), 21 days (j), 24 days (k), and 27 days (l) from the start of the release. Note, after week 4 and until the end of the release in week 11, floating oil concentrations remained below the 0.5 g/m2 threshold. (Continued)

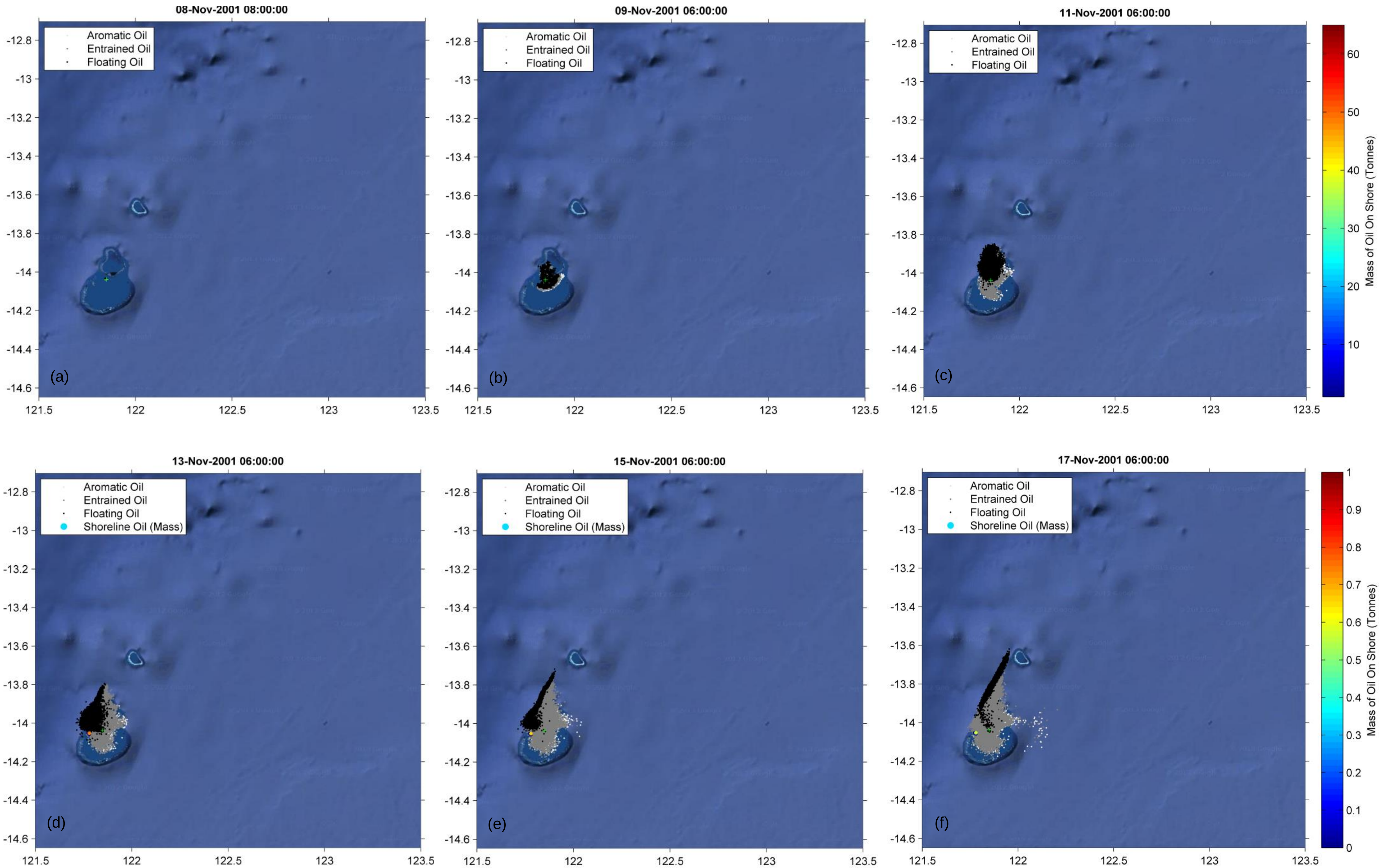


Figure 3-6: Example trajectory of floating oil (black), entrained oil (grey), dissolved aromatic hydrocarbons (white) and shoreline oil (green; mass in Tonnes) for a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location, commencing at 09:00 on 11th of March 2002. The resultant trajectory and concentration at the start of the release (a), and after 1 day (b), 3 days (c), 5 days (d), 7 days (e), 9 days (f), 12 days (g), 15 days (h), 18 days (i), 21 days (j), 24 days (k), 27 days (l),33 days (m), 39 days (n), 45 day (o), 54 days (p), 63 days (q) and 72 days (r) from the start of the release.

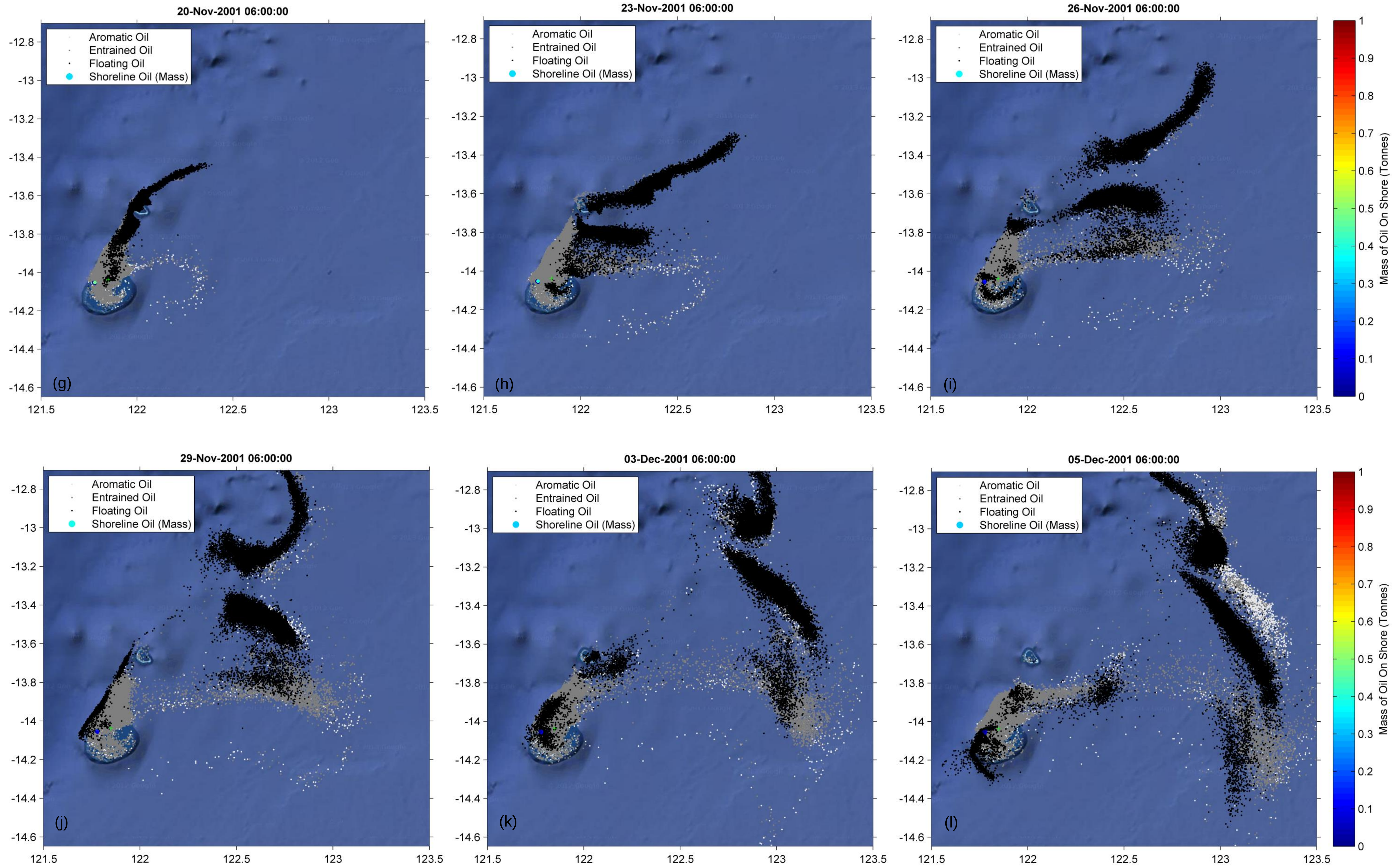


Figure 3-6: Example trajectory of floating oil (black), entrained oil (grey), dissolved aromatic hydrocarbons (white) and shoreline oil (green; mass in Tonnes) for a 77-day 73,671 m3 surface/subsea release of Torosa Condensate at the TRE location, commencing at 09:00 on 11th of March 2002. The resultant trajectory and concentration at the start of the release (a), and after 1 day (b), 3 days (c), 5 days (d), 7 days (e), 9 days (f), 12 days (g), 15 days (h), 18 days (i), 21 days (j), 24 days (k), 27 days (l),33 days (m), 39 days (n), 45 day (o), 54 days (p), 63 days (q) and 72 days (r) from the start of the release. *(Continued)*

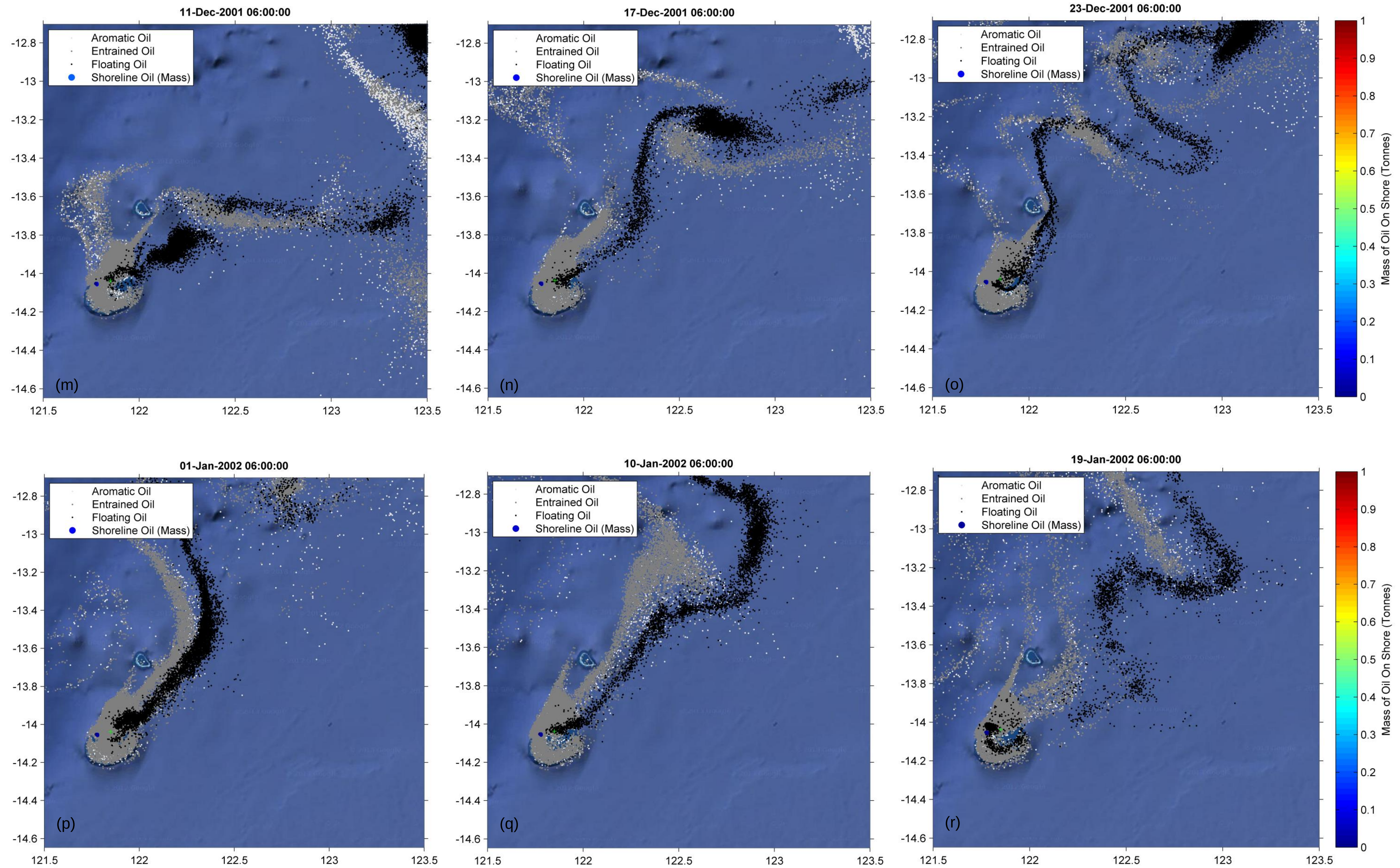


Figure 3-6: Example trajectory of floating oil (black), entrained oil (grey), dissolved aromatic hydrocarbons (white) and shoreline oil (green; mass in Tonnes) for a 77-day 73,671 m3 surface/subsea release of Torosa Condensate at the TRE location, commencing at 09:00 on 11th of March 2002. The resultant trajectory and concentration at the start of the release (a), and after 1 day (b), 3 days (c), 5 days (d), 7 days (e), 9 days (f), 12 days (g), 15 days (h), 18 days (i), 21 days (j), 24 days (k), 27 days (l),33 days (m), 39 days (n), 45 day (o), 54 days (p), 63 days (q) and 72 days (r) from the start of the release. *(Continued)*

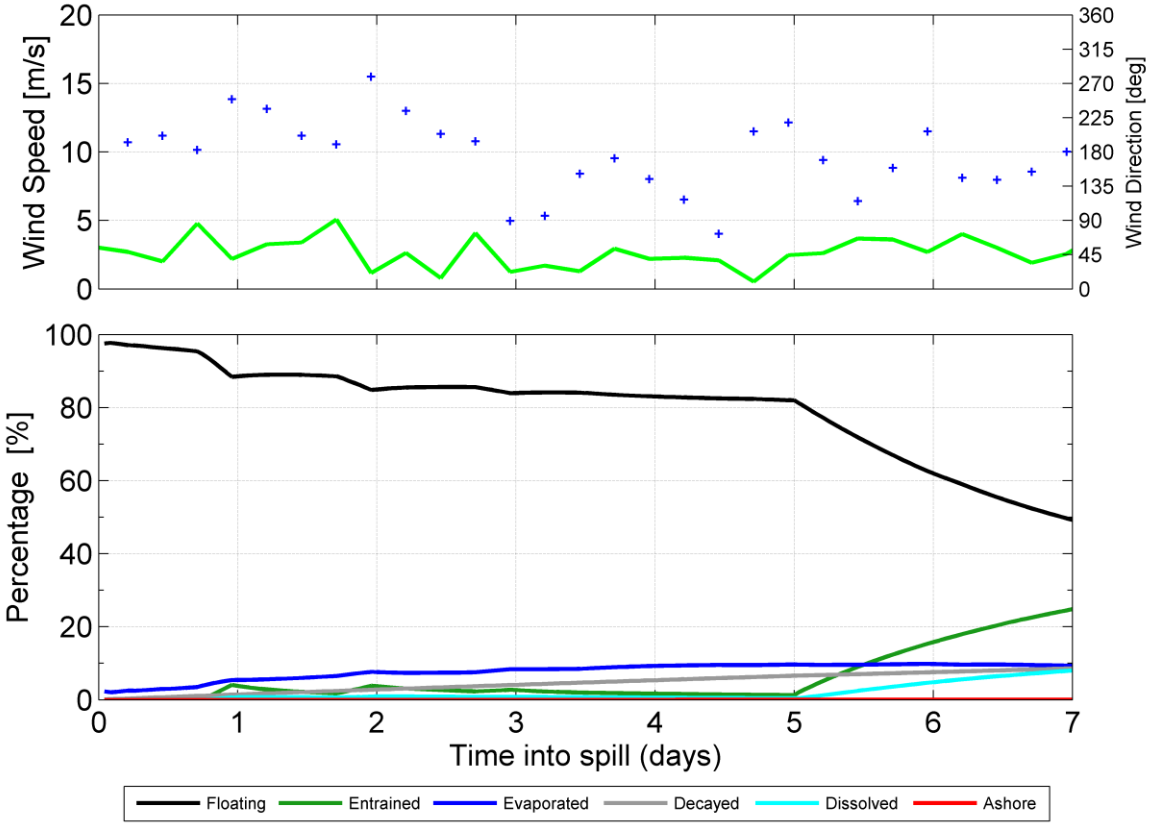
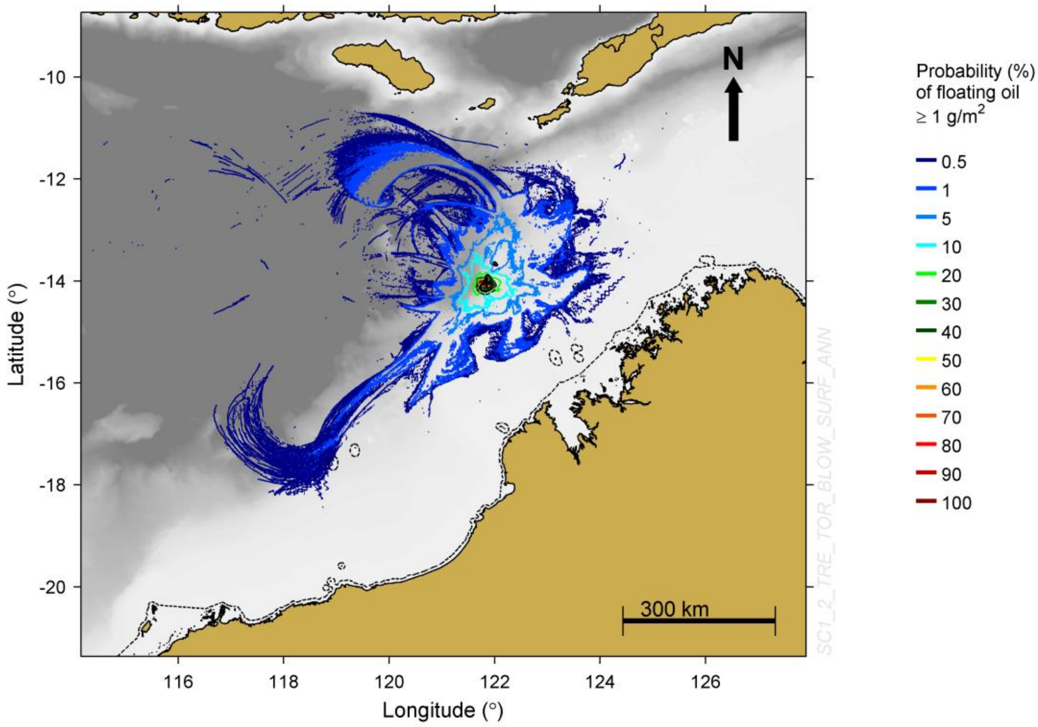


Figure 3-7: Predicted mass balance weathering resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location, commencing at 20:00 on 26th November 2003. The green line in the top figure indicates the wind speed and the blue dots indicate the wind direction (FROM).

3.2.4 Floating Oil



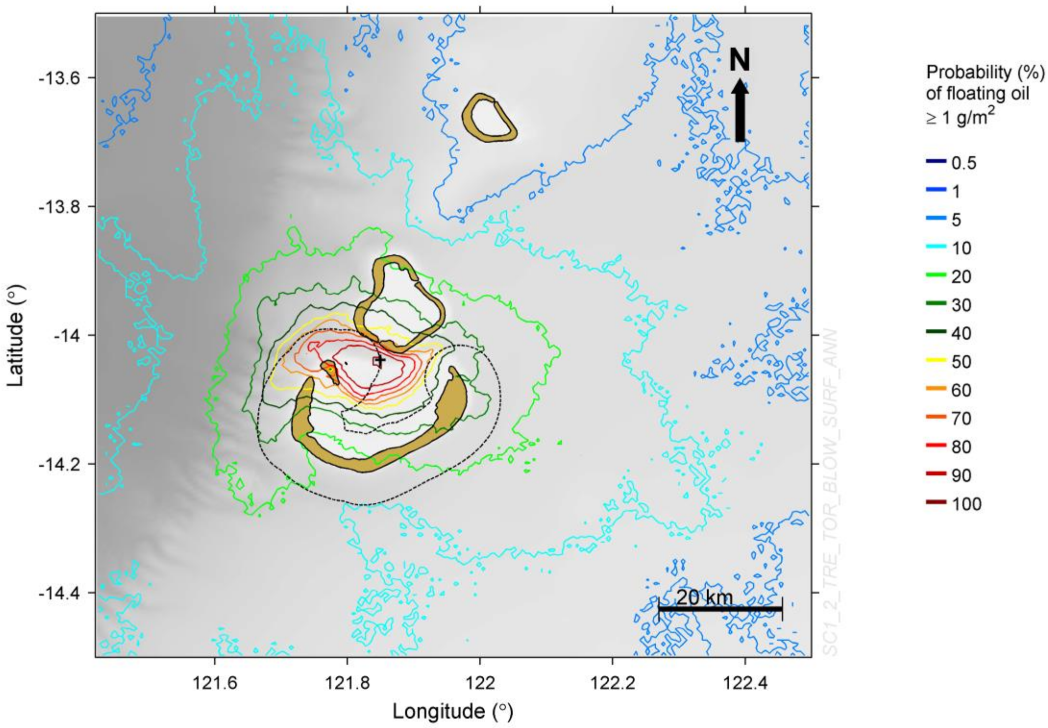


Figure 3-8: Predicted annualised probability (P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

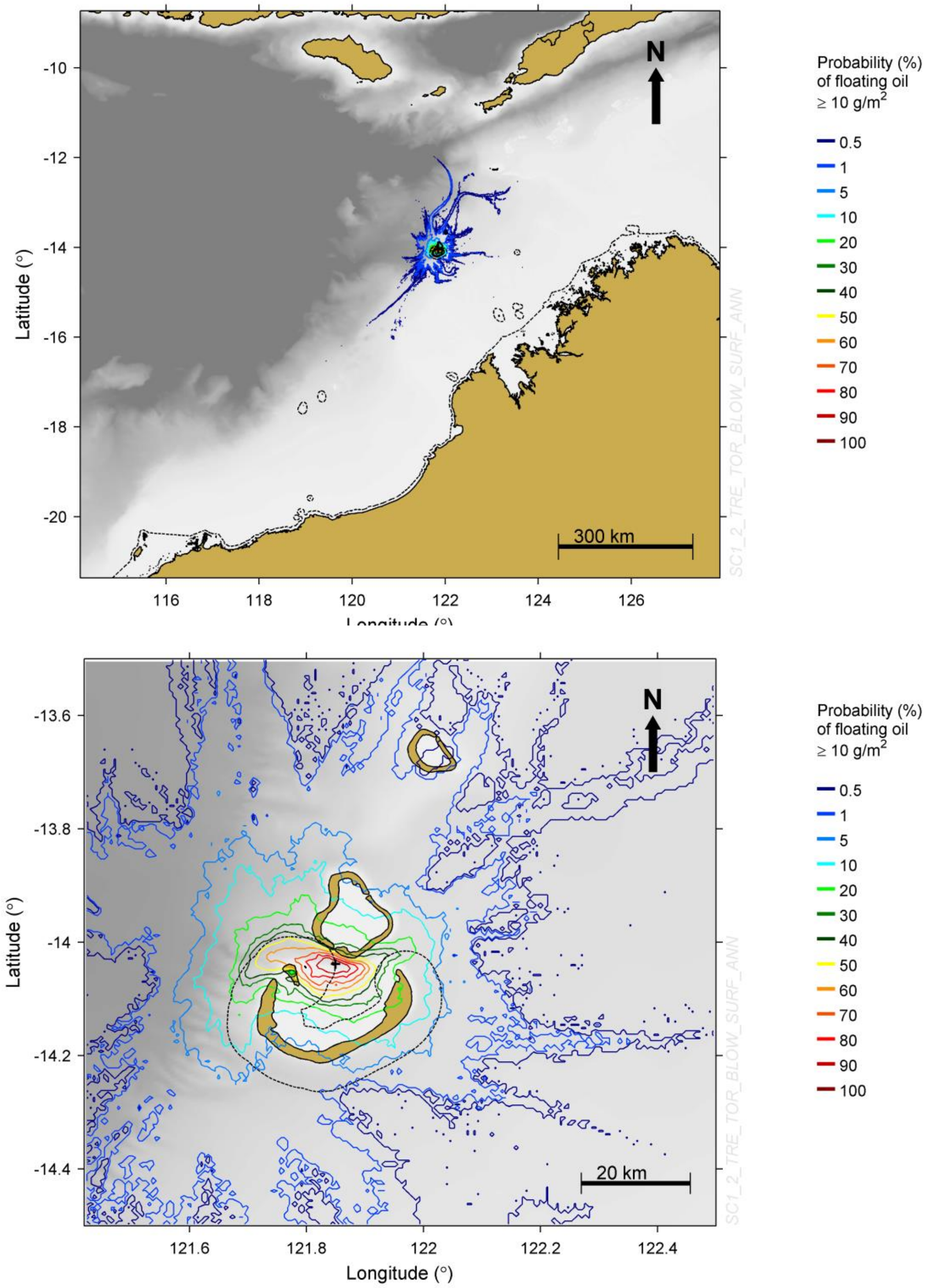


Figure 3-9: Predicted annualised probability (P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

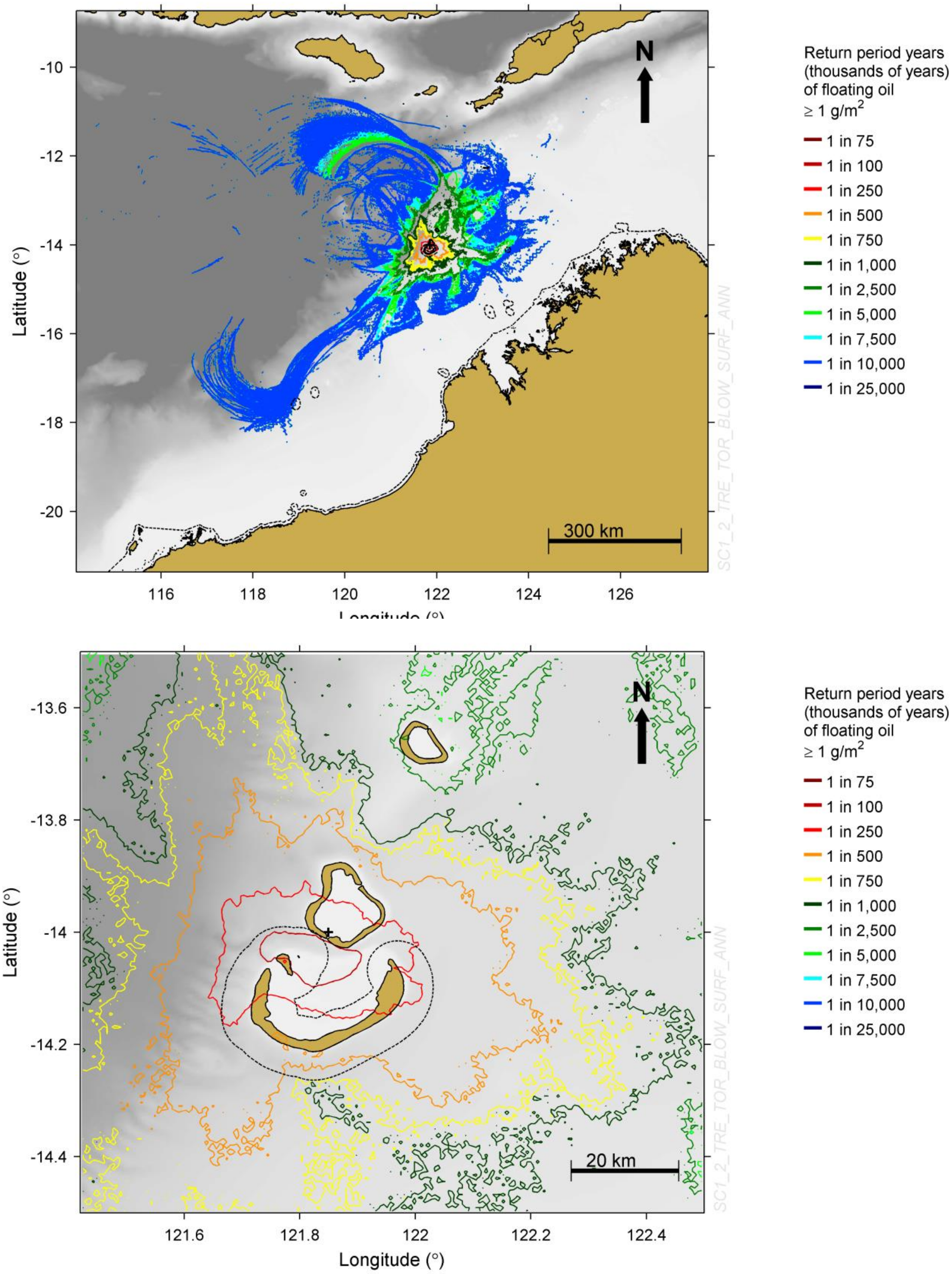
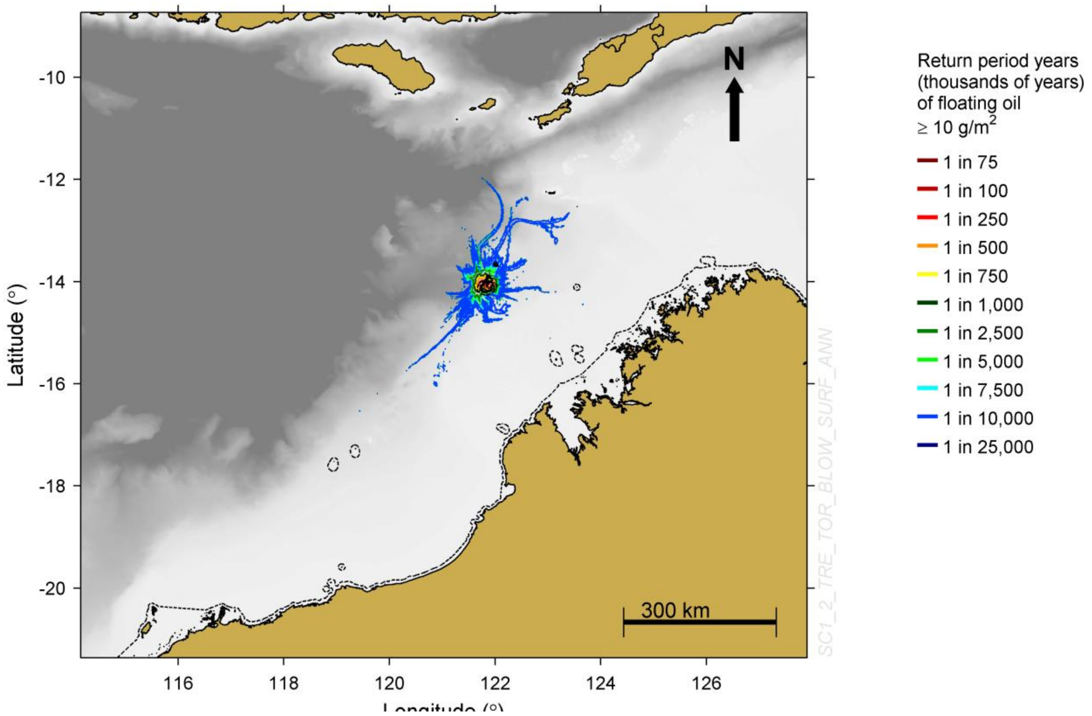


Figure 3-10: Predicted annualised probability ($P_1 x P_2$) of floating oil concentration at or above 1 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



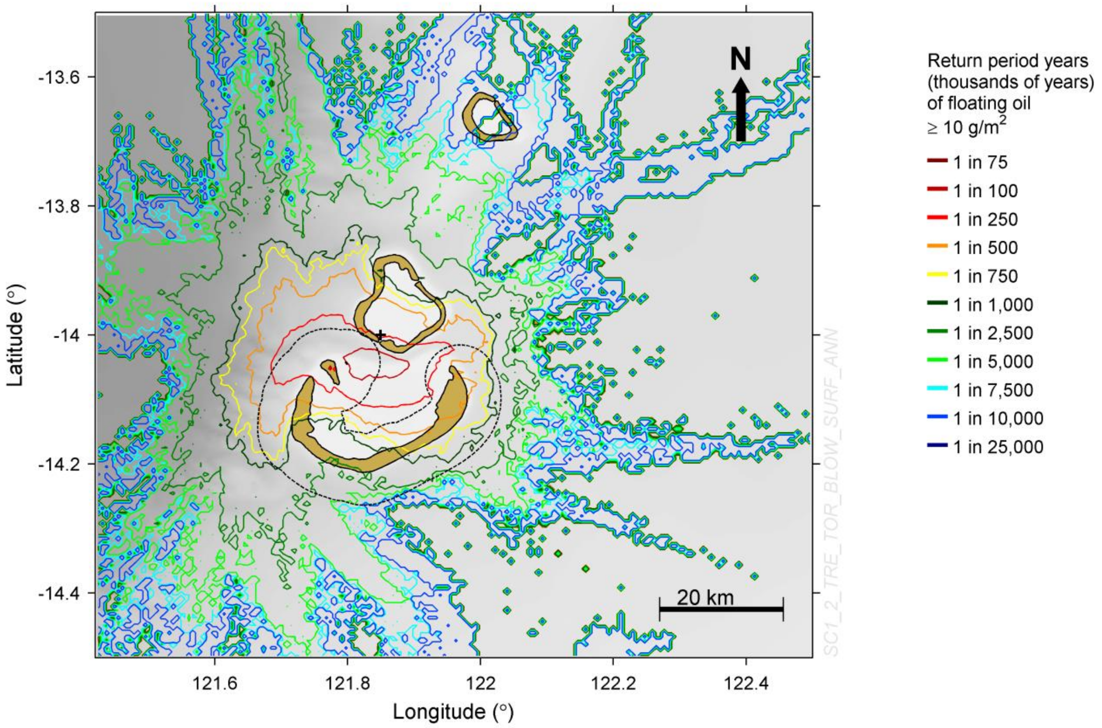


Figure 3-11: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 10 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

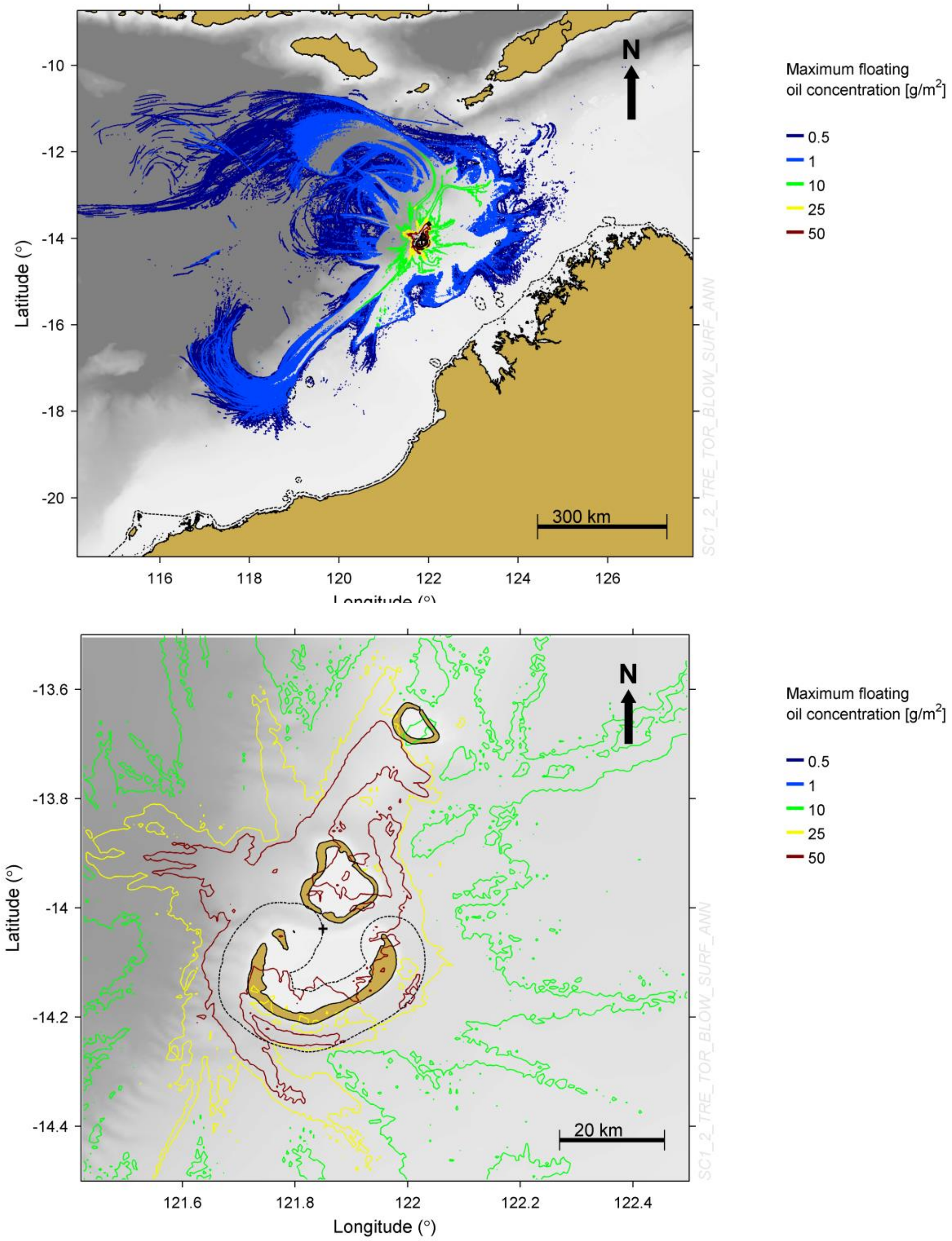


Figure 3-12: Predicted maximum floating oil concentration resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

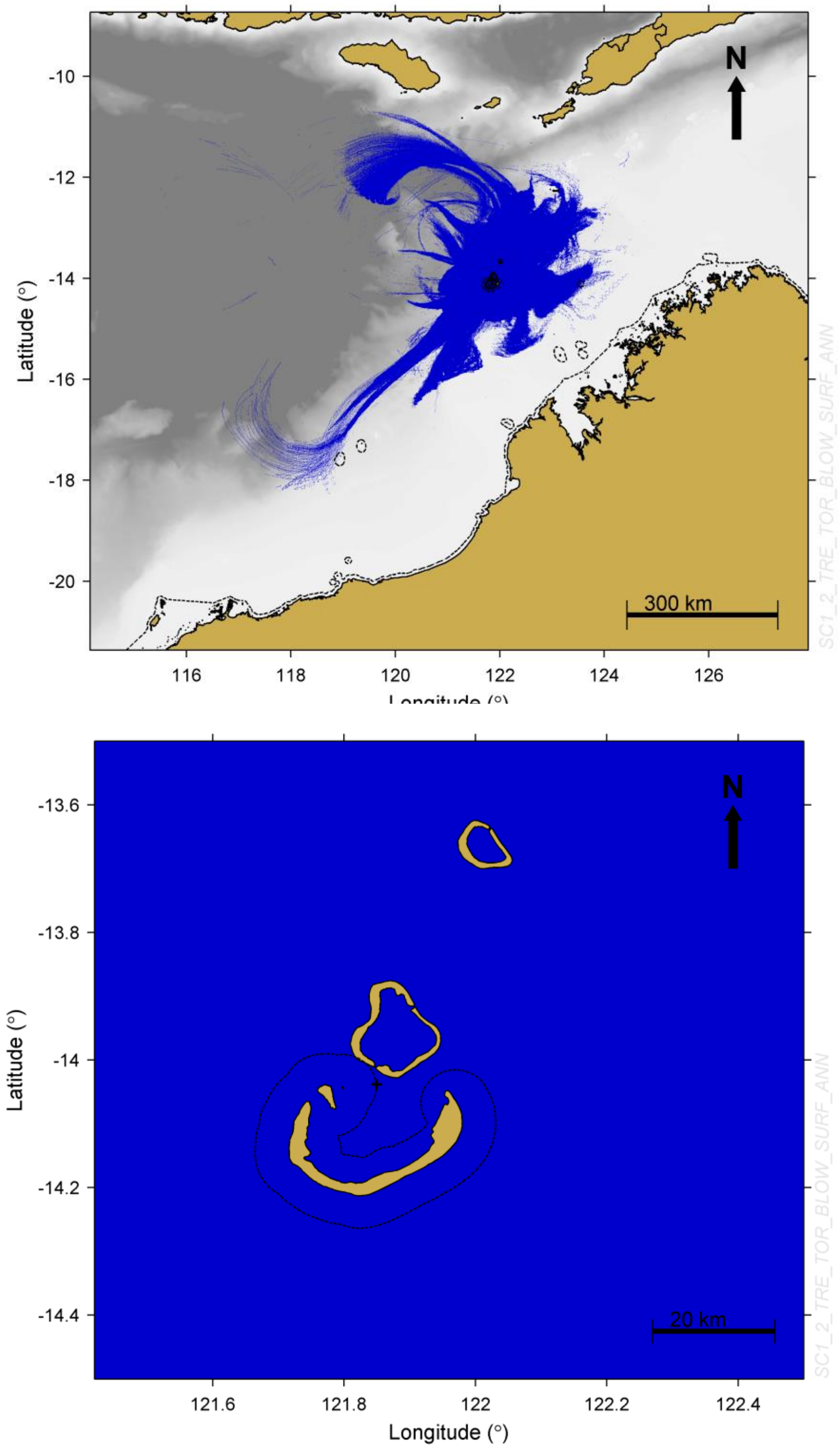


Figure 3-13: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 1 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

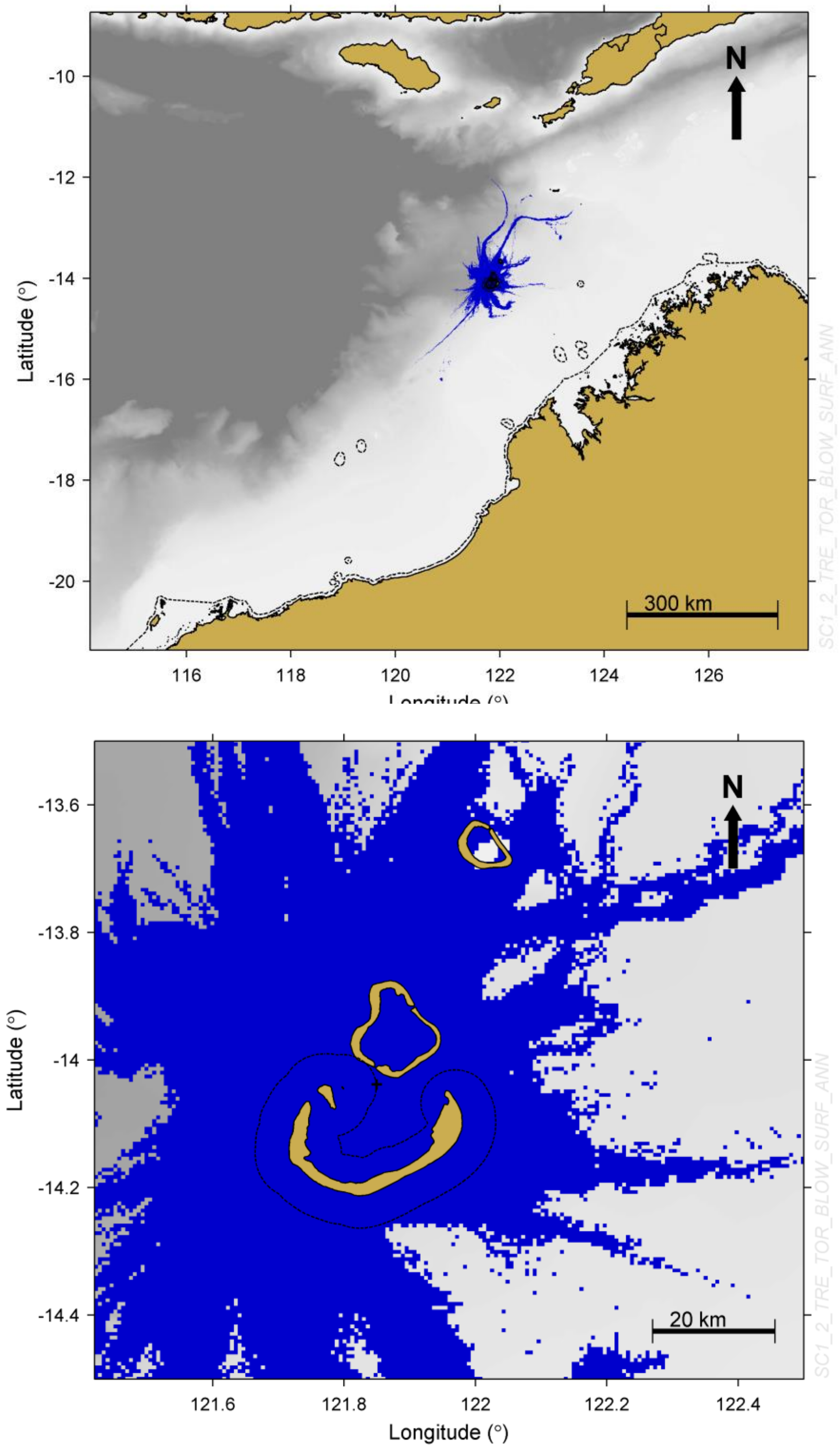
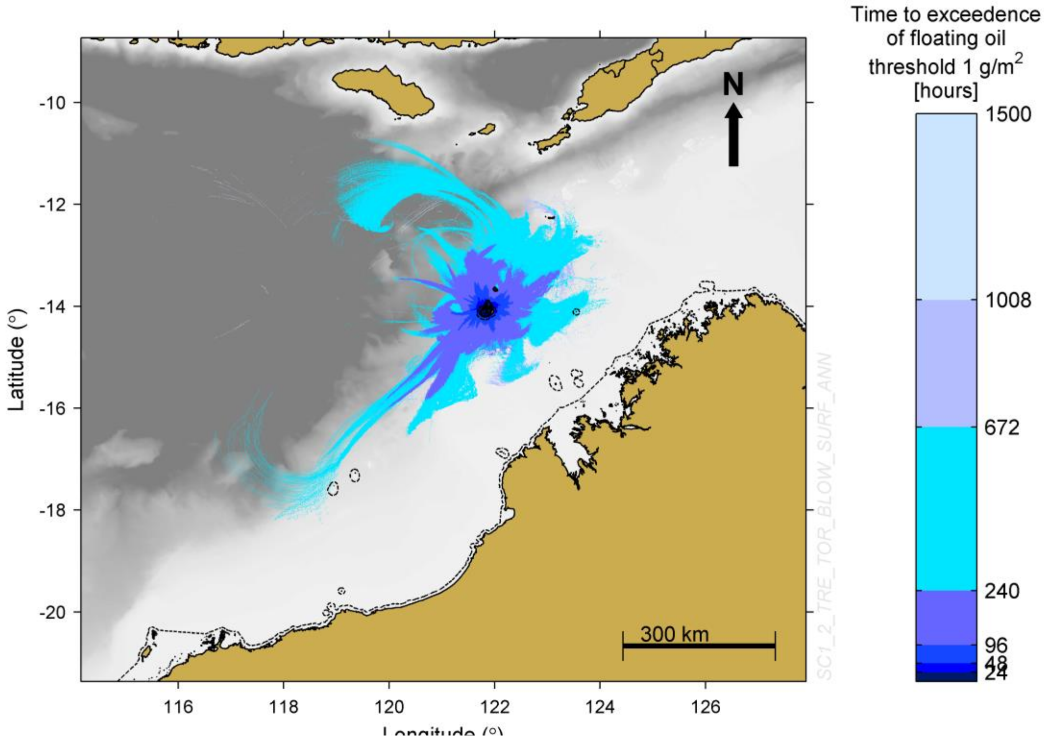


Figure 3-14: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 10 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



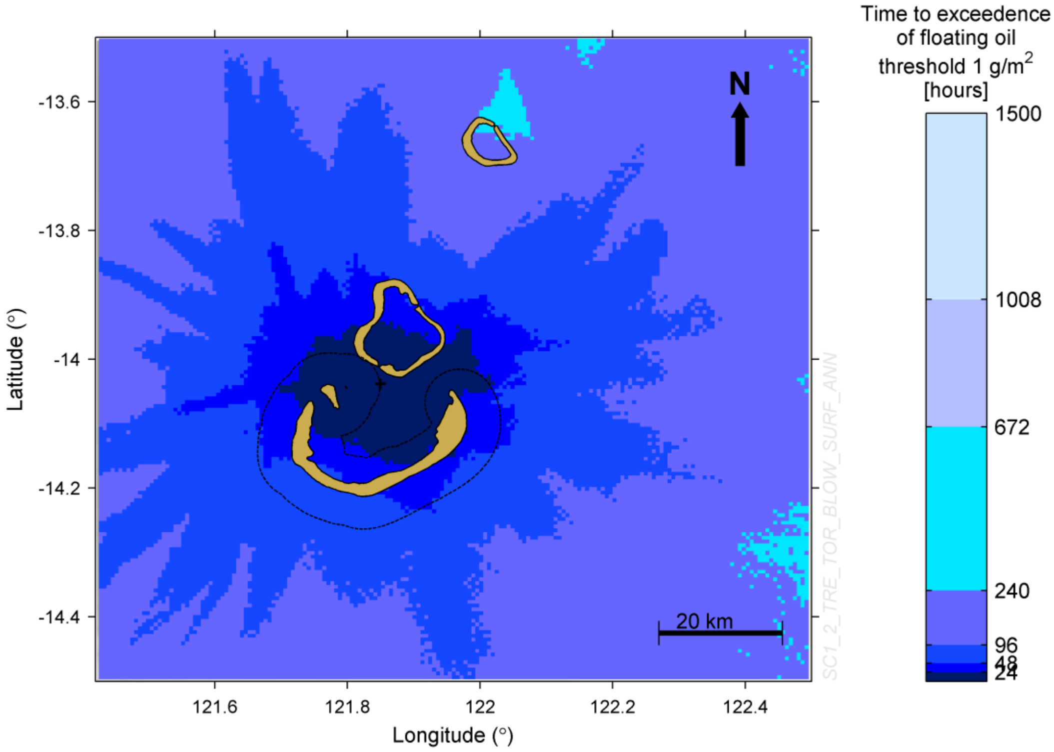


Figure 3-15: Predicted annualised minimum times to threshold for floating oil at or above 1 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

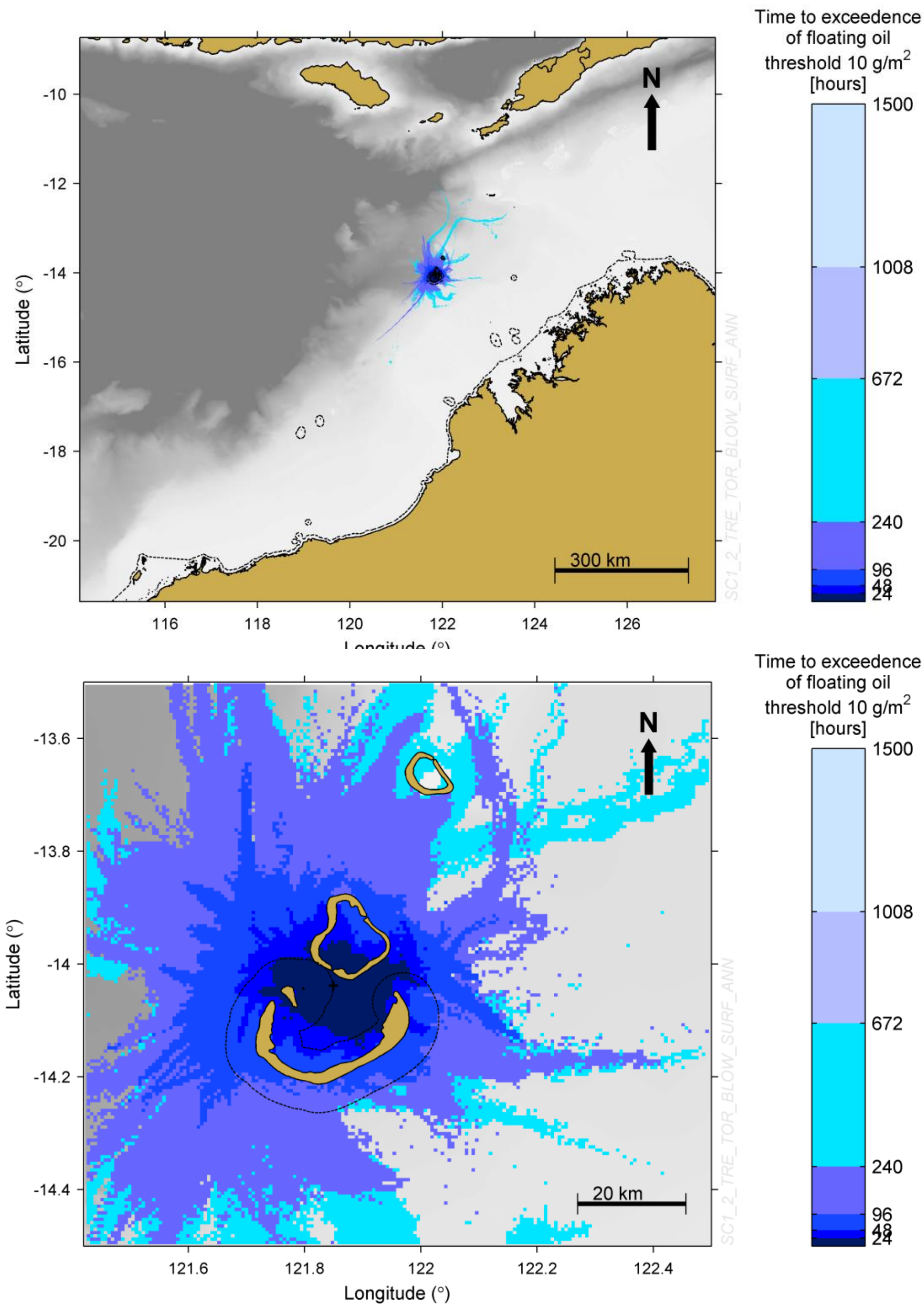


Figure 3-16: Predicted annualised minimum times to threshold for floating oil at or above 10 g/m^2 resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Table 3-3: Expected floating oil outcomes at sensitive receptors across all quarters for a 77-day 73,671 m³ surface/subsea release of Torosa Condensate at the TRE location.

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Timor Leste	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	1	<1	<1
Timor (West)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	0.2	32	<1	<1
Pulau Roti	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	0.2	32	<1	<1
Big Bank Shoals	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Melville Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	0.7	<1	<1
Oceanic Shoals CMR*	0.5	<0.5	<0.5	<0.5	736	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	1.5	0.5	<0.5	<0.5	649	668	NC	NC	NC	NC	NC	NC
Ashmore Reef CMR	3.5	2	<0.5	<0.5	548	548	NC	NC	20	1,907	<1	6
Ashmore Reef	3.5	1.5	<0.5	<0.5	548	548	NC	NC	20	1,907	<1	6
Cartier Island CMR	2	1	<0.5	<0.5	407	535	NC	NC	5.4	220	<1	<1
Cartier Islet	1.5	0.5	<0.5	<0.5	457	556	NC	NC	5.4	220	<1	<1
Joseph Bonaparte Gulf East	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	0.1	5.9	<1	<1
Kimberley CMR*	8.5	5.5	0.5	<0.5	135	139	189	NC	NC	NC	NC	NC
Argo-Rowley Terrace CMR*	2	1.5	0.5	<0.5	219	240	305	NC	NC	NC	NC	NC
Seringapatam Reef	5	4	1	0.5	163	168	241	265	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-3: Expected floating oil outcomes at sensitive receptors across all quarters for a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m^2	Probability (%) of films arriving at receptors at ≥ 1 g/m^2	Probability (%) of films arriving at receptors at ≥ 10 g/m^2	Probability (%) of films arriving at receptors at ≥ 25 g/m^2	Minimum time to receptor (hours) for films at ≥ 0.5 g/m^2	Minimum time to receptor (hours) for films at ≥ 1 g/m^2	Minimum time to receptor (hours) for films at ≥ 10 g/m^2	Minimum time to receptor (hours) for films at ≥ 25 g/m^2	Maximum local accumulated concentration (g/m^2) averaged over all replicate spills	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Joseph Bonaparte Gulf West	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	1.2	<1	<1
North Reef Flats*	86	80	57.5	46	3	3	4	5	NC	NC	NC	NC
North Reef Lagoon*	74	64	38	27	6	6	9	12	NC	NC	NC	NC
Kimberley Coast	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	0.7	34	<1	<1
South Reef Lagoon*	100	100	99.5	97.5	1	1	1	1	NC	NC	NC	NC
SR Central/ Sandy Islet	91.5	84.5	62.5	49	8	8	10	10	2,495	11,395	6	28
South Reef Flats*	71.5	59	30.5	15	9	9	16	27	NC	NC	NC	NC
Browse Island	3.5	2.5	<0.5	<0.5	480	480	NC	NC	43	2,503	<1	4
Lalang-garram / Camden Sound MP	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	0.2	35	<1	<1
Camden Sound	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	1.1	<1	<1
Adele Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	0.4	63	<1	<1
Dampier Peninsula Coast - North section	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	2.9	<1	<1
Lacepede Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	6	<1	<1
Mermaid Reef CMR	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-3: Expected floating oil outcomes at sensitive receptors across all quarters for a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m^2	Probability (%) of films arriving at receptors at ≥ 1 g/m^2	Probability (%) of films arriving at receptors at ≥ 10 g/m^2	Probability (%) of films arriving at receptors at ≥ 25 g/m^2	Minimum time to receptor (hours) for films at ≥ 0.5 g/m^2	Minimum time to receptor (hours) for films at ≥ 1 g/m^2	Minimum time to receptor (hours) for films at ≥ 10 g/m^2	Minimum time to receptor (hours) for films at ≥ 25 g/m^2	Maximum local accumulated concentration (g/m^2) averaged over all replicate spills	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Mermaid Reef	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	0.5	<0.5	<0.5	<0.5	1,263	NC	NC	NC	0.4	60	<1	<1
Clerke Reef	0.5	<0.5	<0.5	<0.5	1,273	NC	NC	NC	0.4	60	<1	<1
Imperieuse Reef	1	1	<0.5	<0.5	352	352	NC	NC	3.8	465	<1	<1
Rowley Shoals MP (Imperieuse)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Eighty Mile Beach	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Glomar Shoals*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Rankin Bank*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Dampier Archipelago	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	1.8	<1	<1
Montebello Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	0.7	<1	<1
Lowendal Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Barrow Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Northern Pilbara-Islands and Shoreline	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	0.2	<1	<1
Southern Pilbara-Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	0.3	<1	<1

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-3: Expected floating oil outcomes at sensitive receptors across all quarters for a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

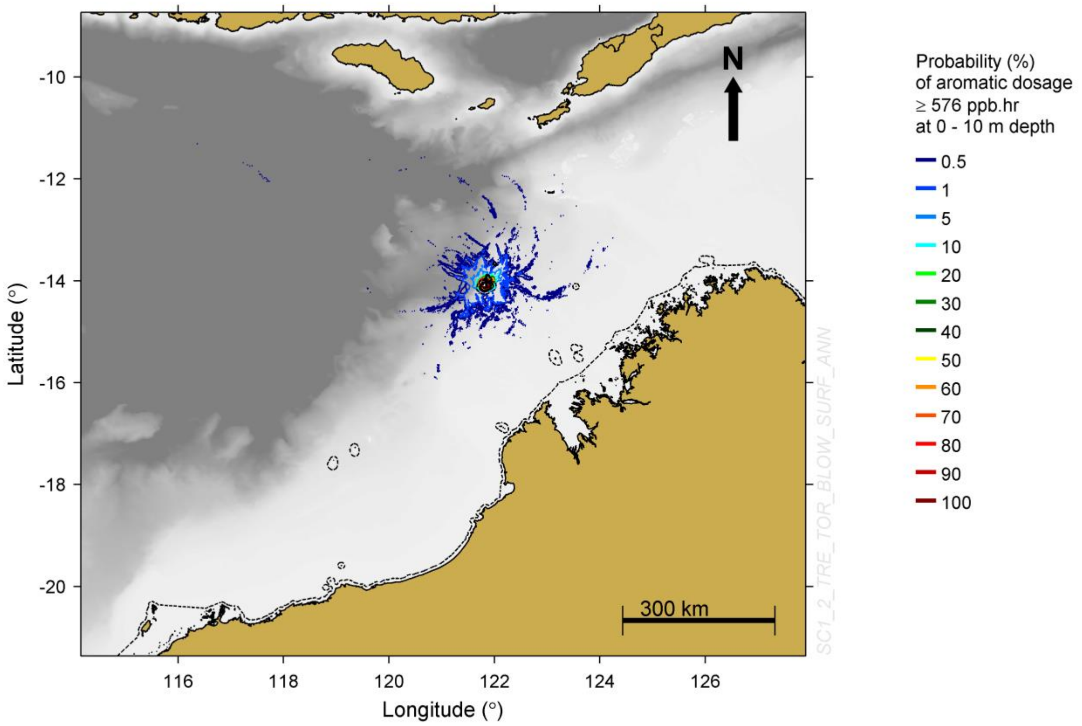
	Probability (%) of films arriving at receptors at ≥ 0.5 g/m^2	Probability (%) of films arriving at receptors at ≥ 1 g/m^2	Probability (%) of films arriving at receptors at ≥ 10 g/m^2	Probability (%) of films arriving at receptors at ≥ 25 g/m^2	Minimum time to receptor (hours) for films at ≥ 0.5 g/m^2	Minimum time to receptor (hours) for films at ≥ 1 g/m^2	Minimum time to receptor (hours) for films at ≥ 10 g/m^2	Minimum time to receptor (hours) for films at ≥ 25 g/m^2	Maximum local accumulated concentration (g/m^2) averaged over all replicate spills	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Muiron Islands (World Heritage)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Ningaloo Coast North (World Heritage)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Ningaloo Coast North	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

3.2.5 Dissolved Aromatic Hydrocarbon Dosage

576 ppb.hr



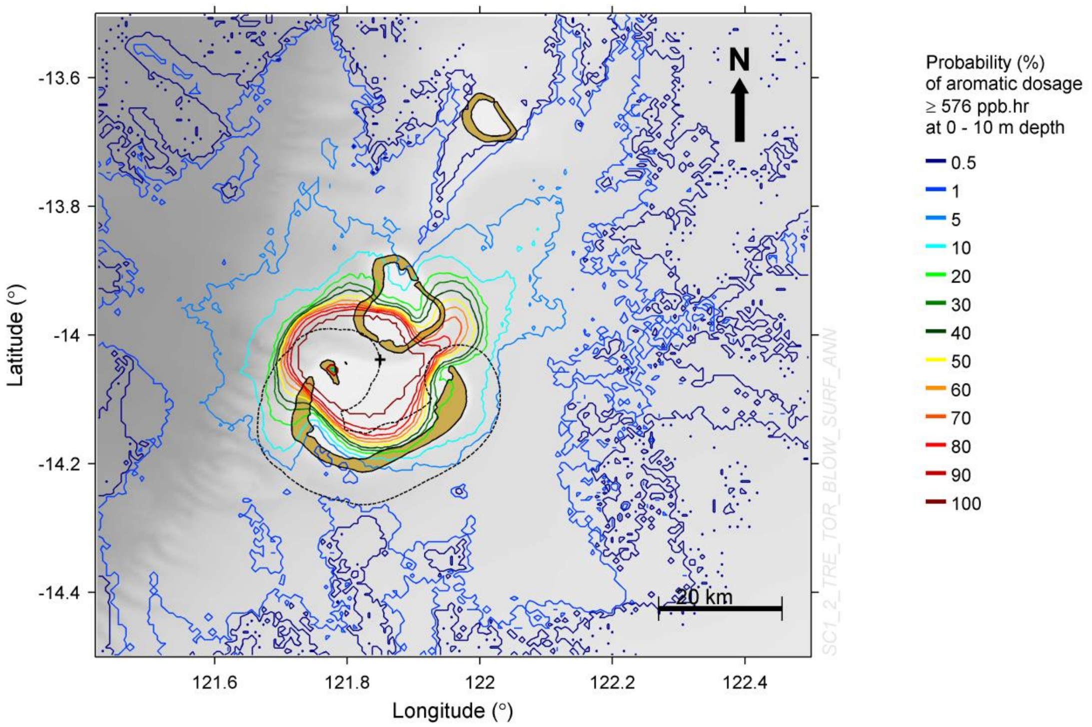


Figure 3-17: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

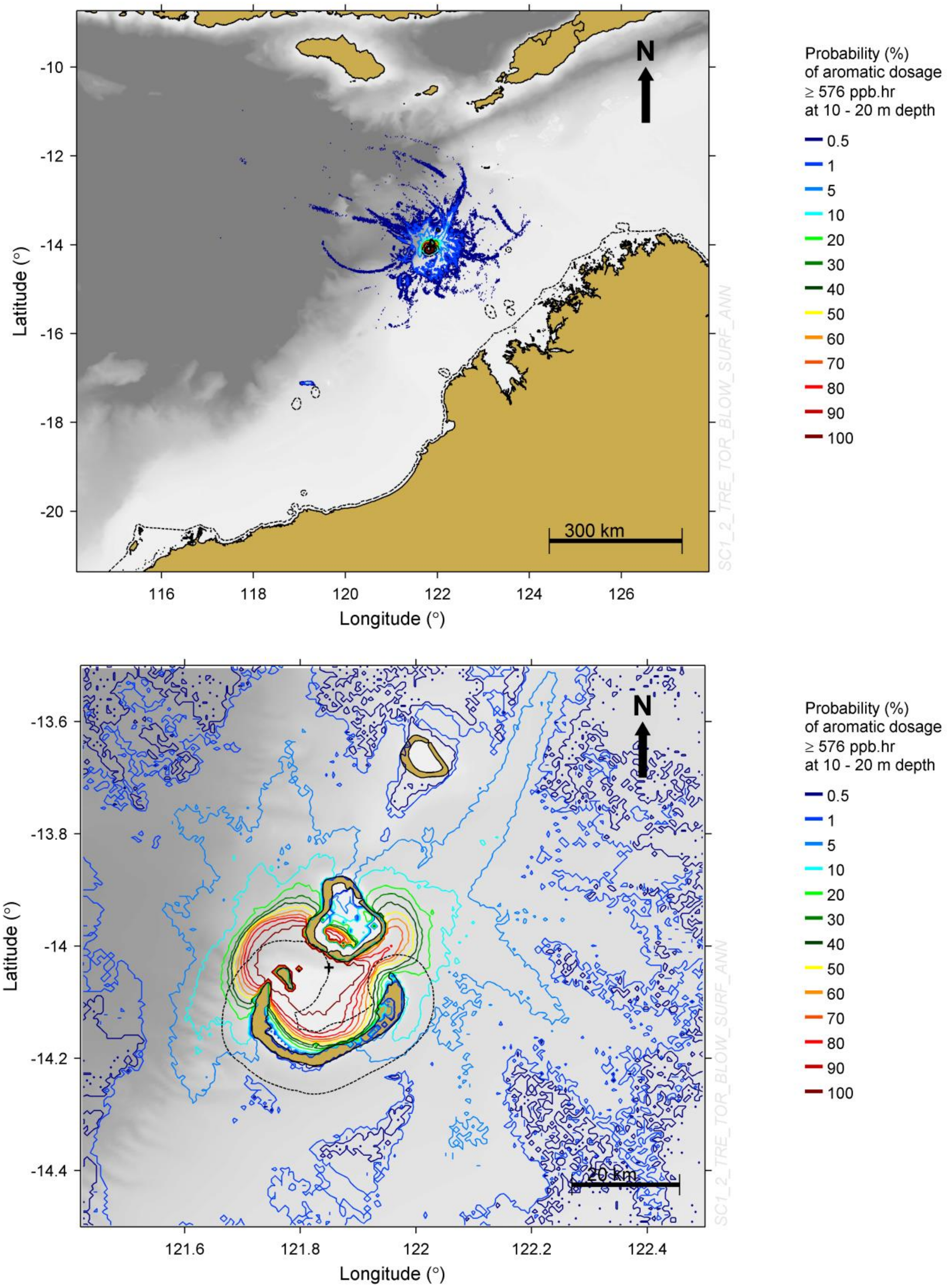


Figure 3-18: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

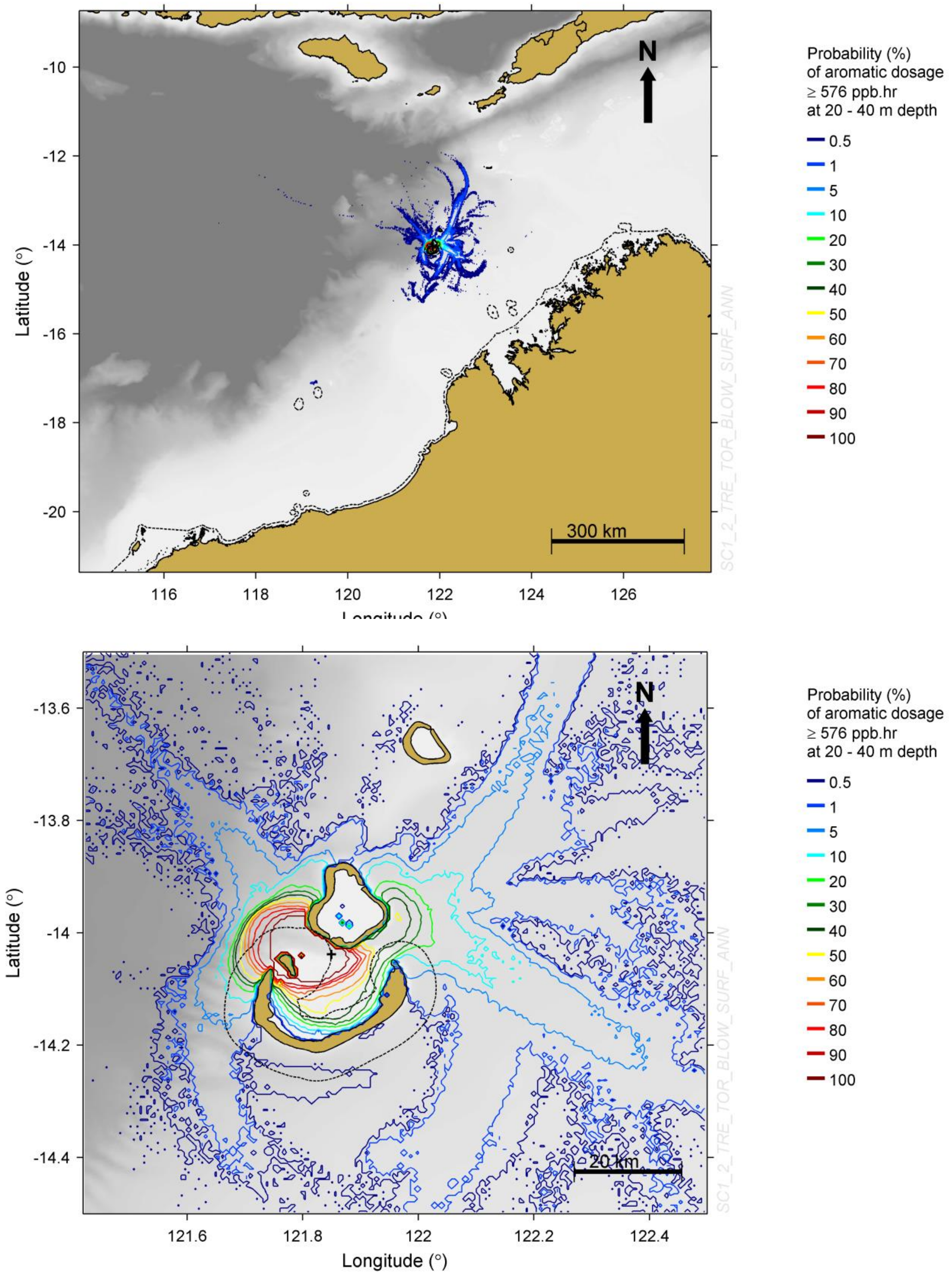


Figure 3-19: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 20 - 40 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

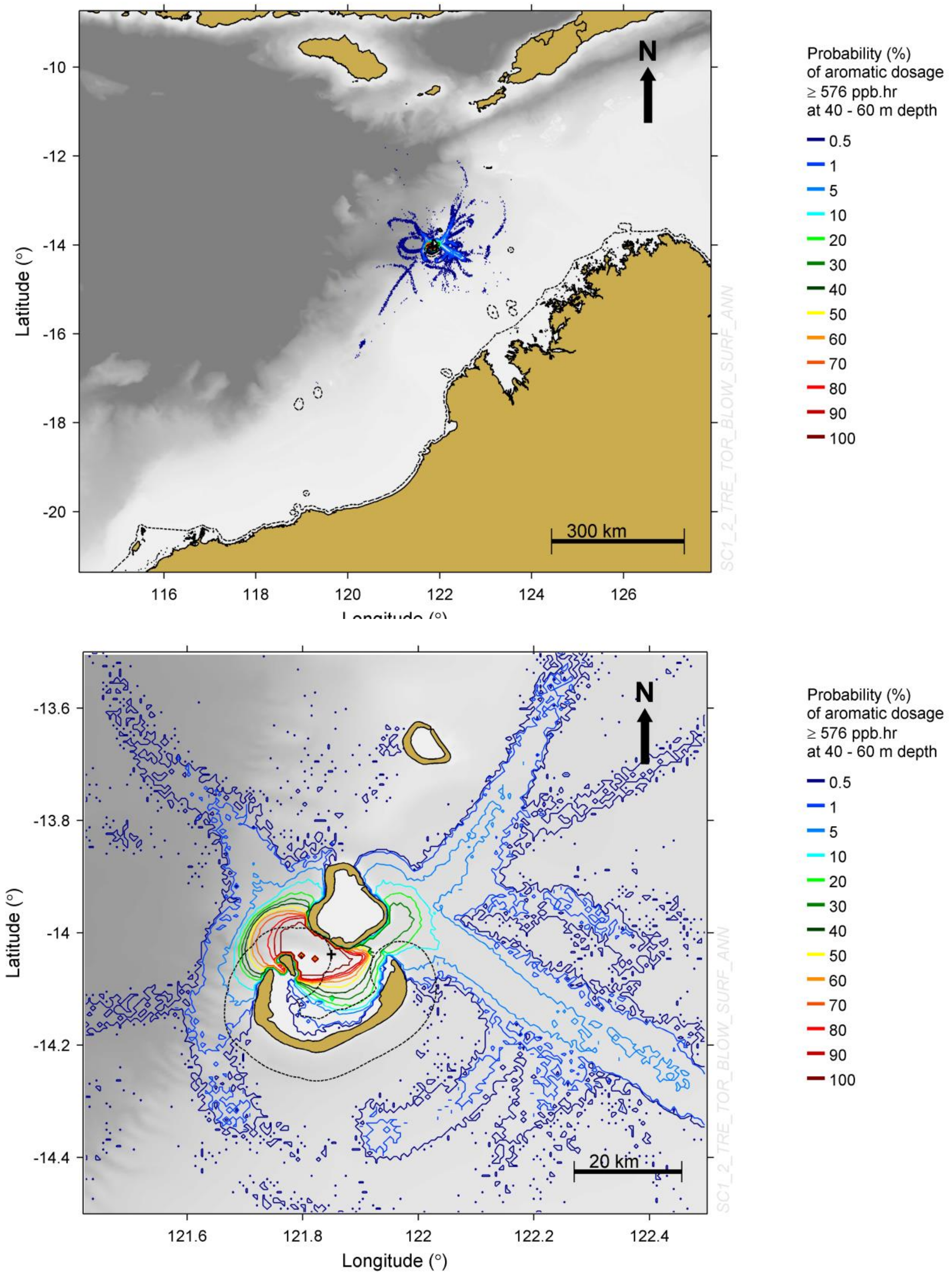


Figure 3-20: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 40 - 60 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

4,800 ppb.hr

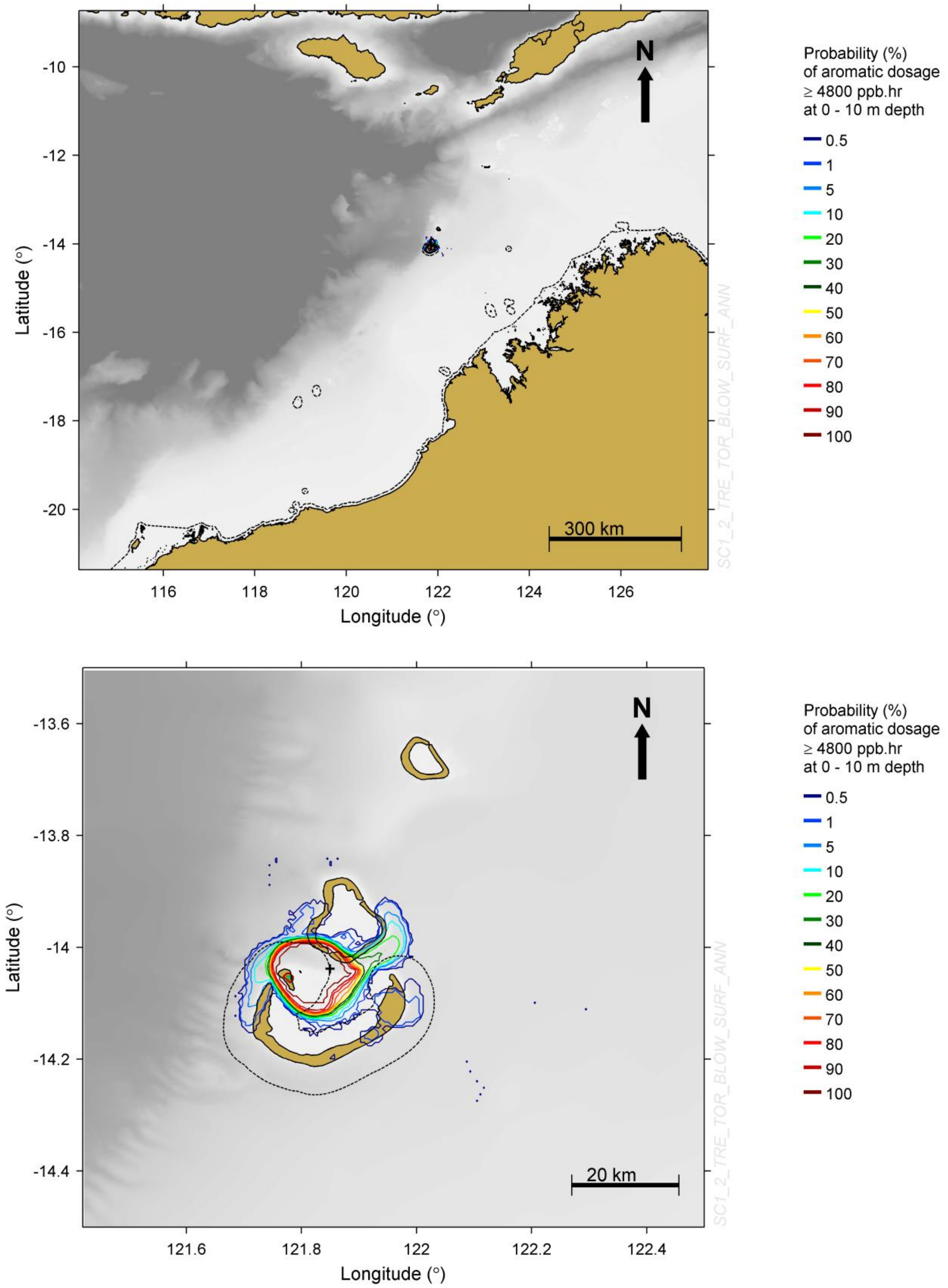
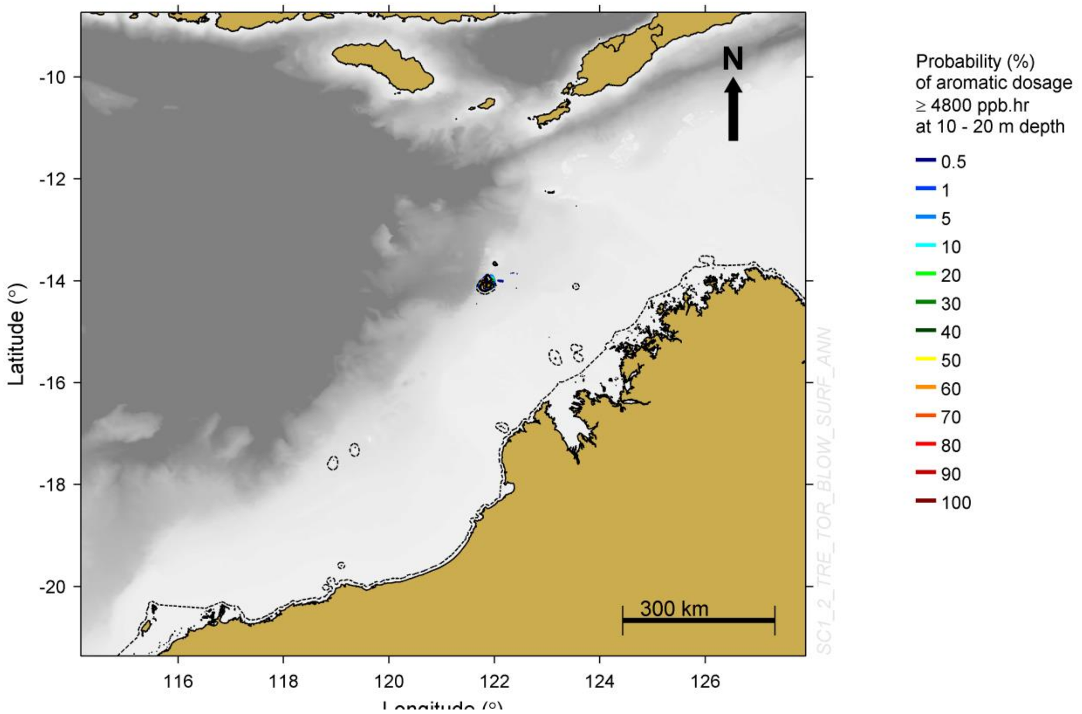


Figure 3-21: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



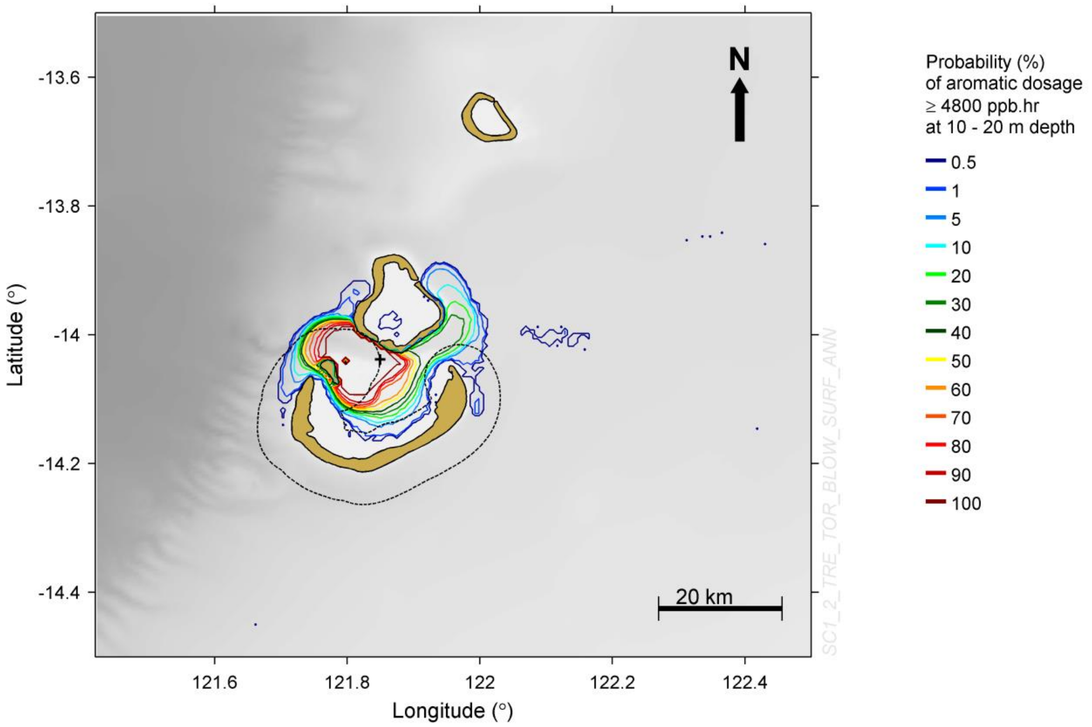


Figure 3-22: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

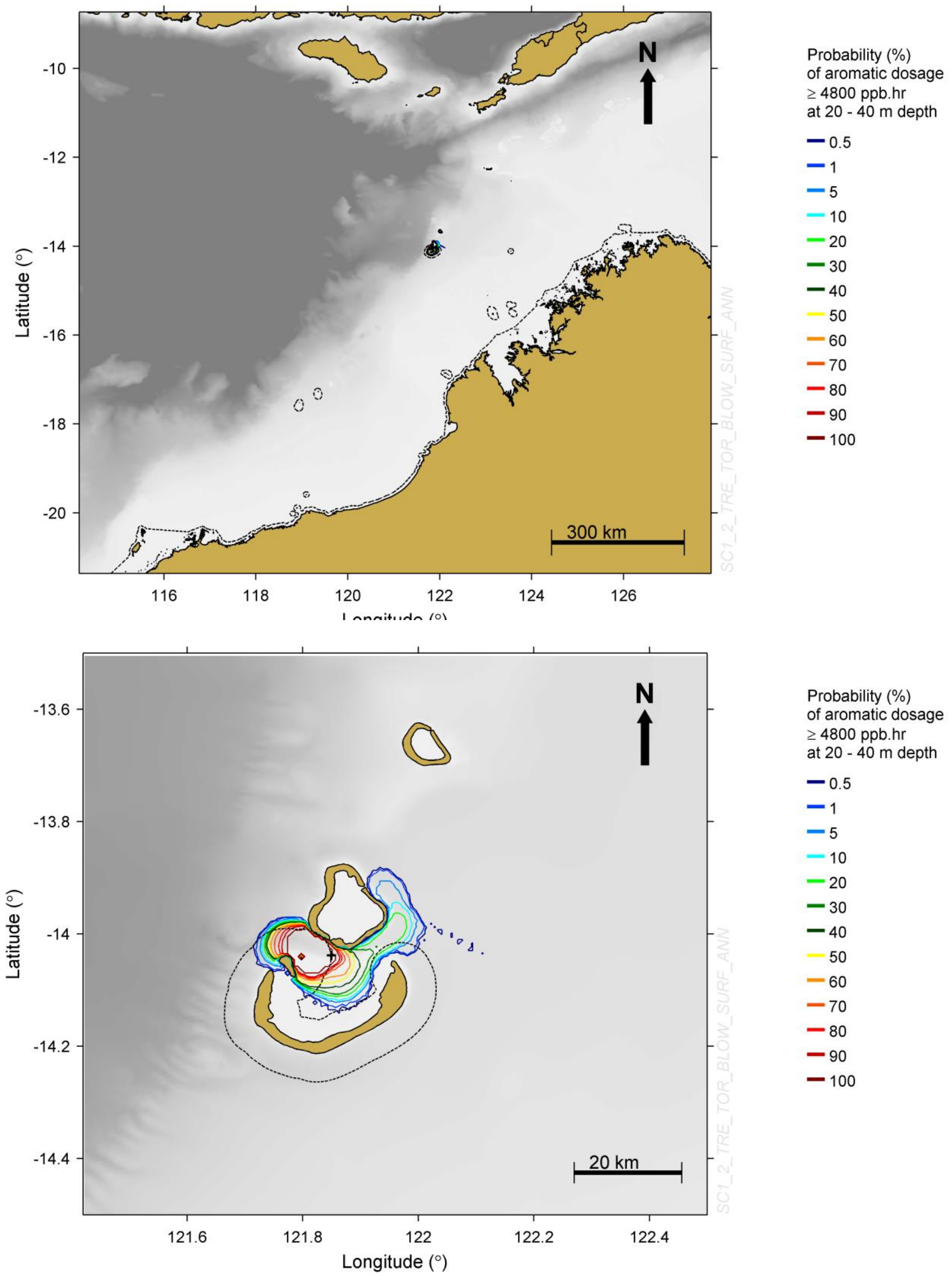


Figure 3-23: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 20 - 40 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

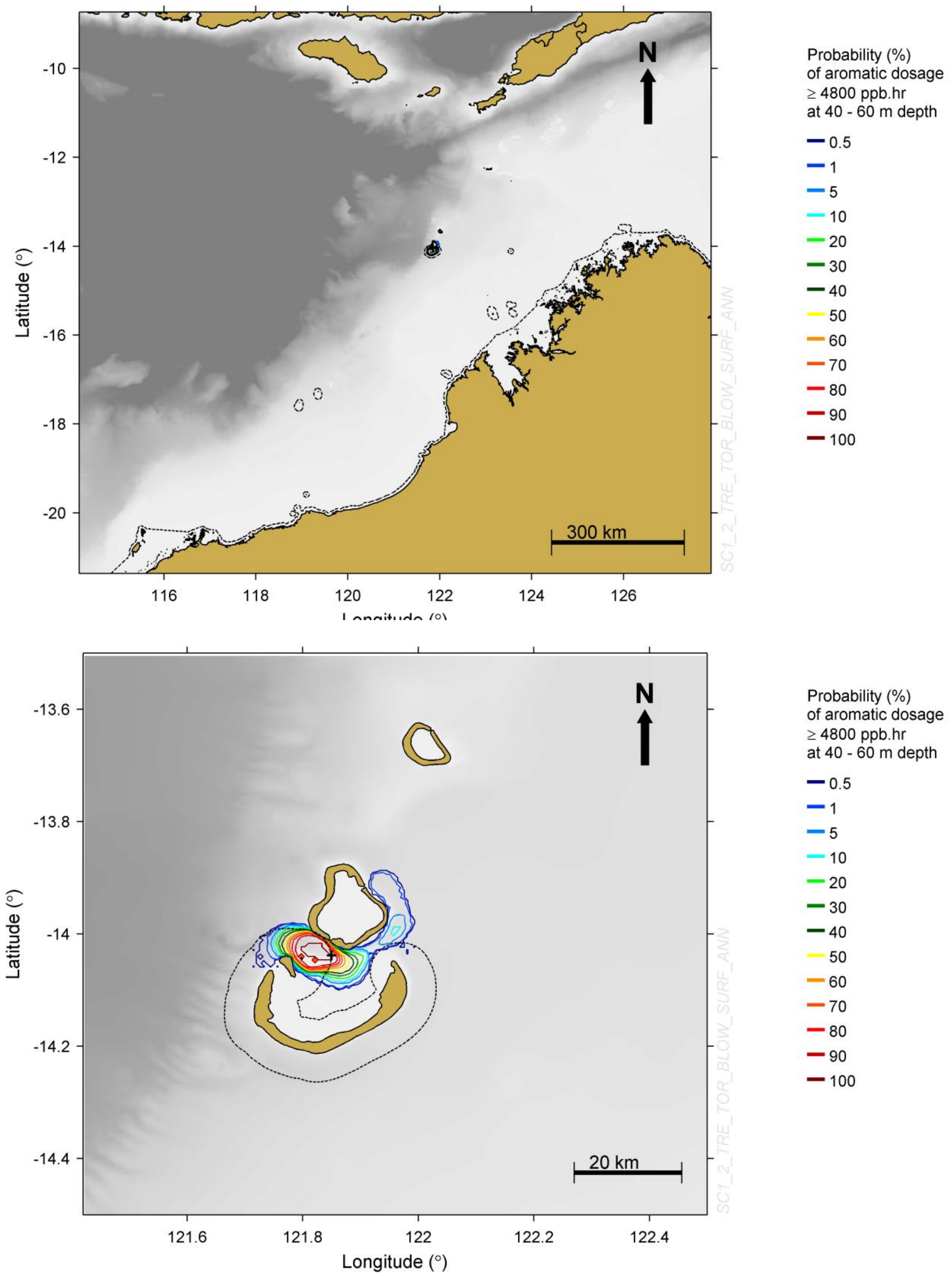
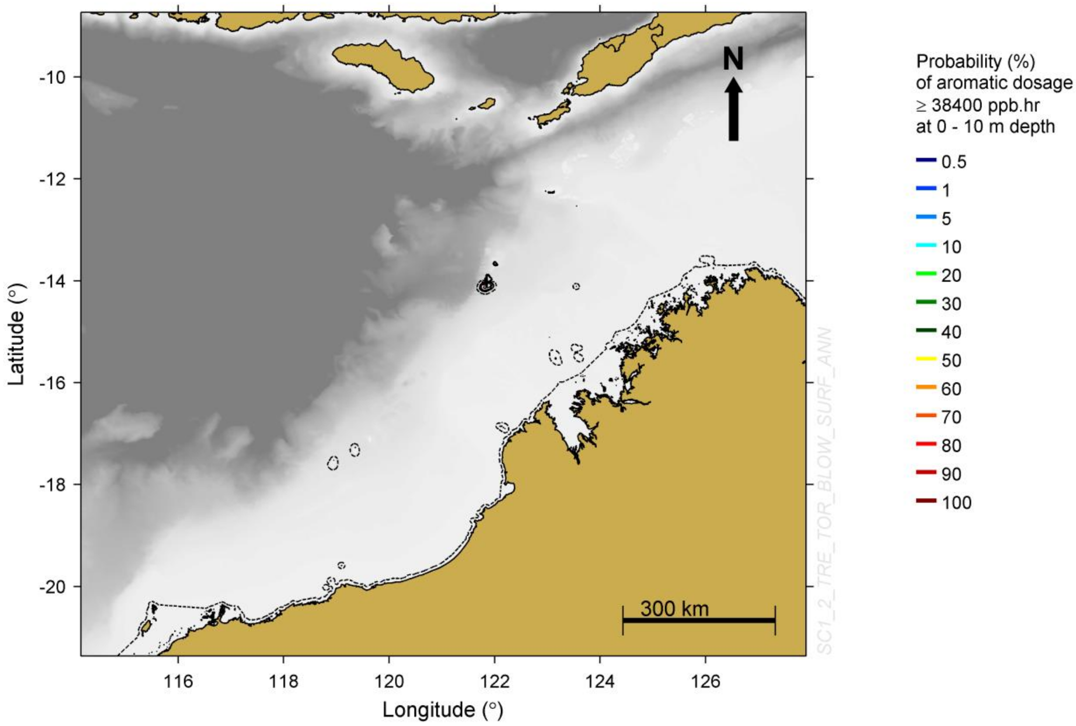


Figure 3-24: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 40 - 60 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

38,400 ppb.hr



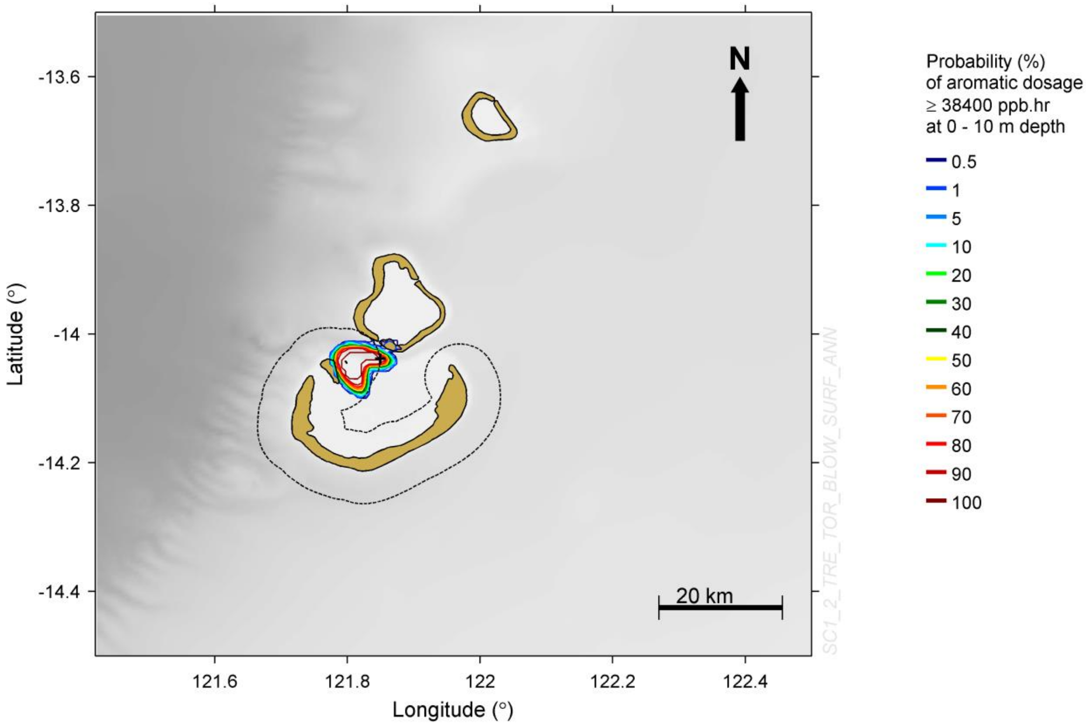


Figure 3-25: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 38,400 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

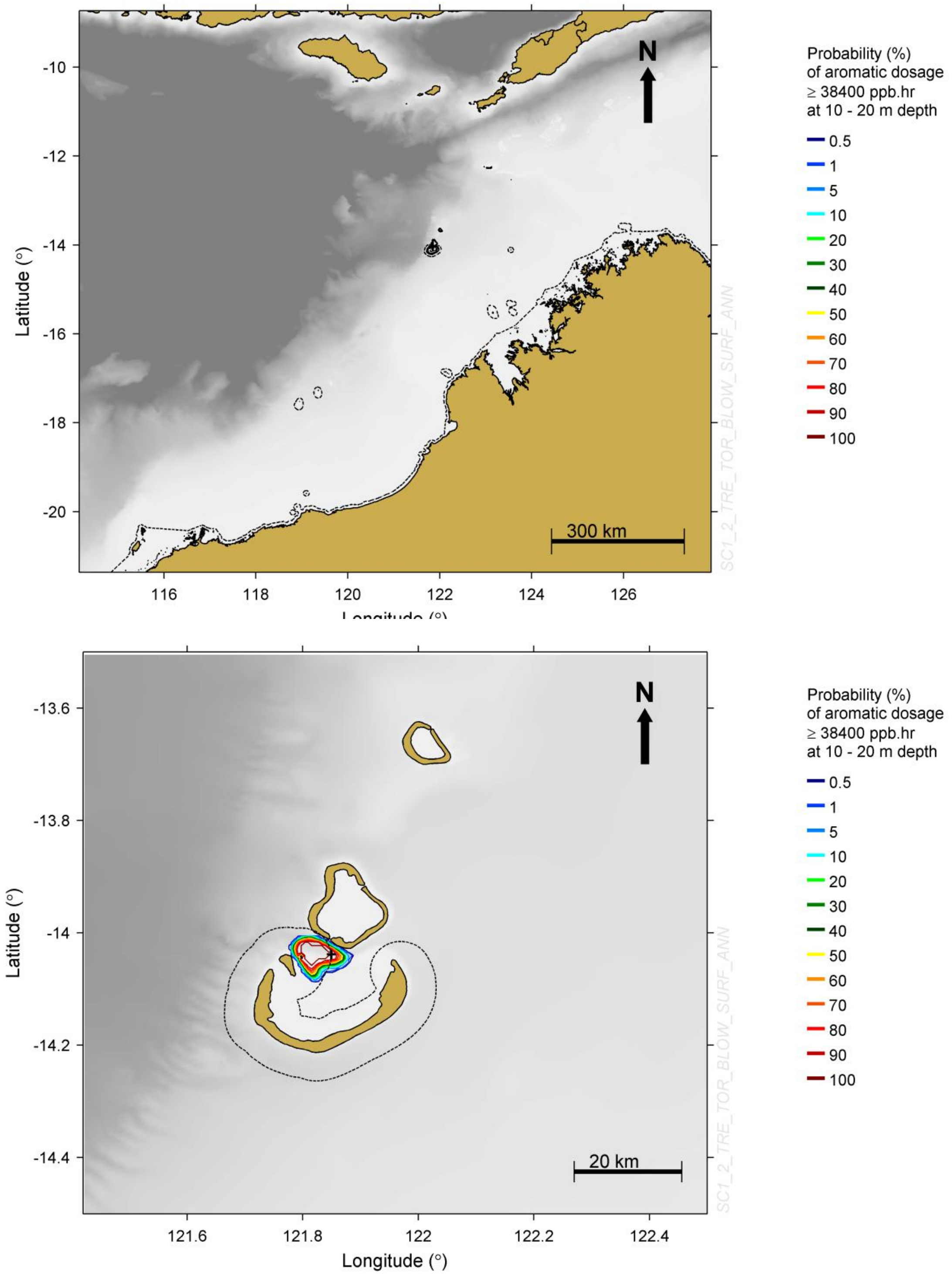


Figure 3-26: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 38,400 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

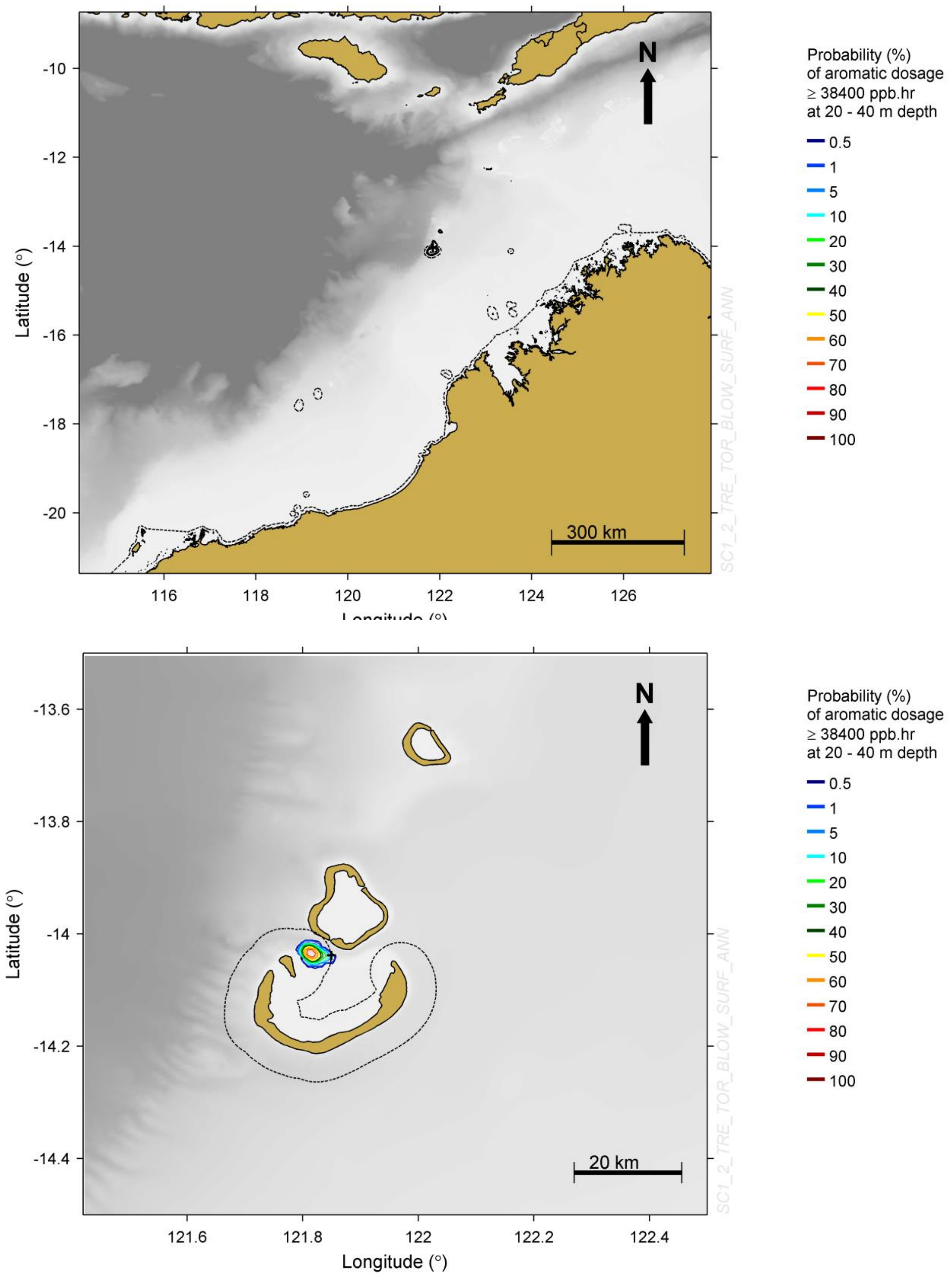


Figure 3-27: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 38,400 ppb.hr at a depth of 20 - 40 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

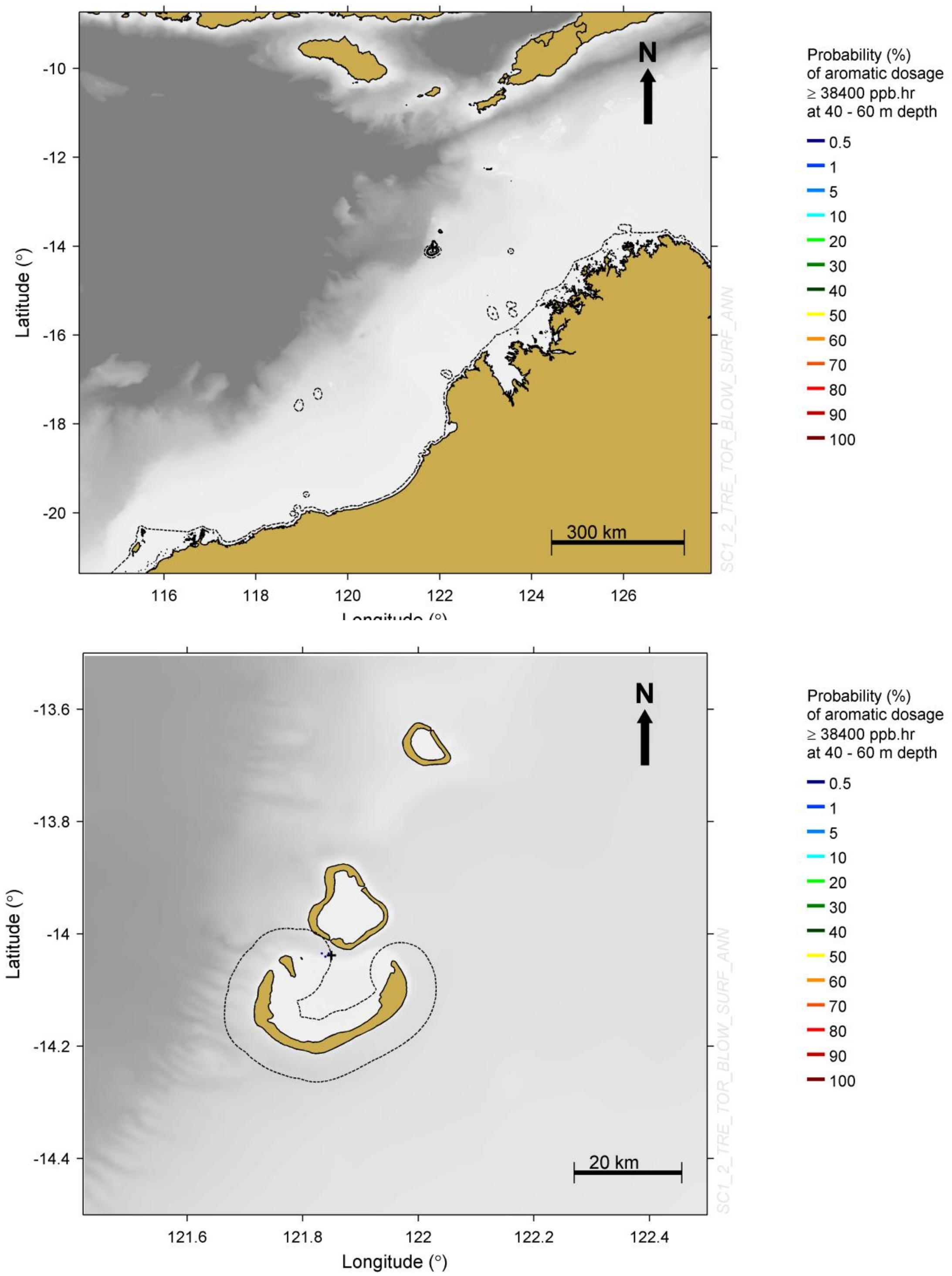
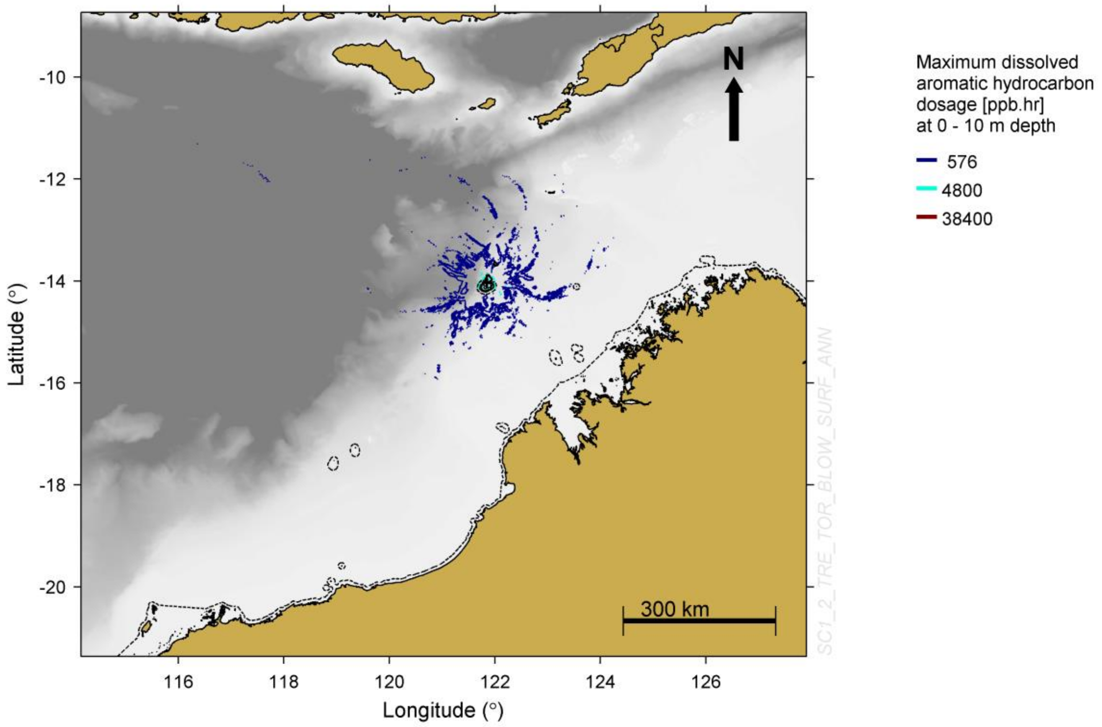


Figure 3-28: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 38,400 ppb.hr at a depth of 40 – 60 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Maximum Aromatic Dosage



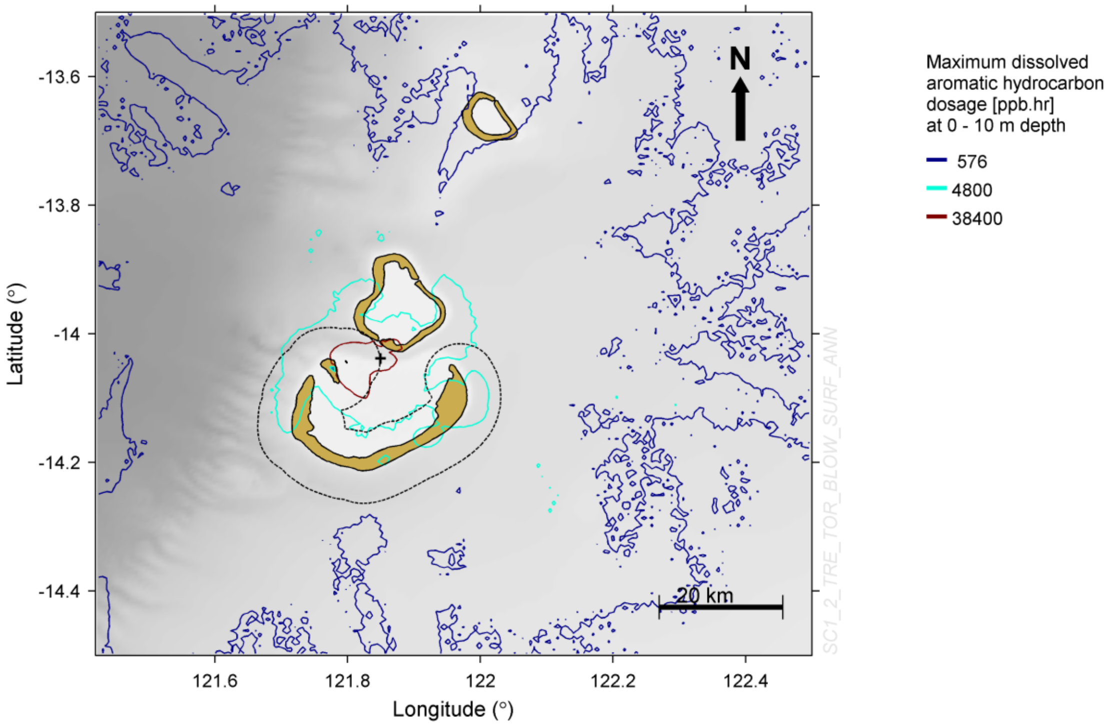
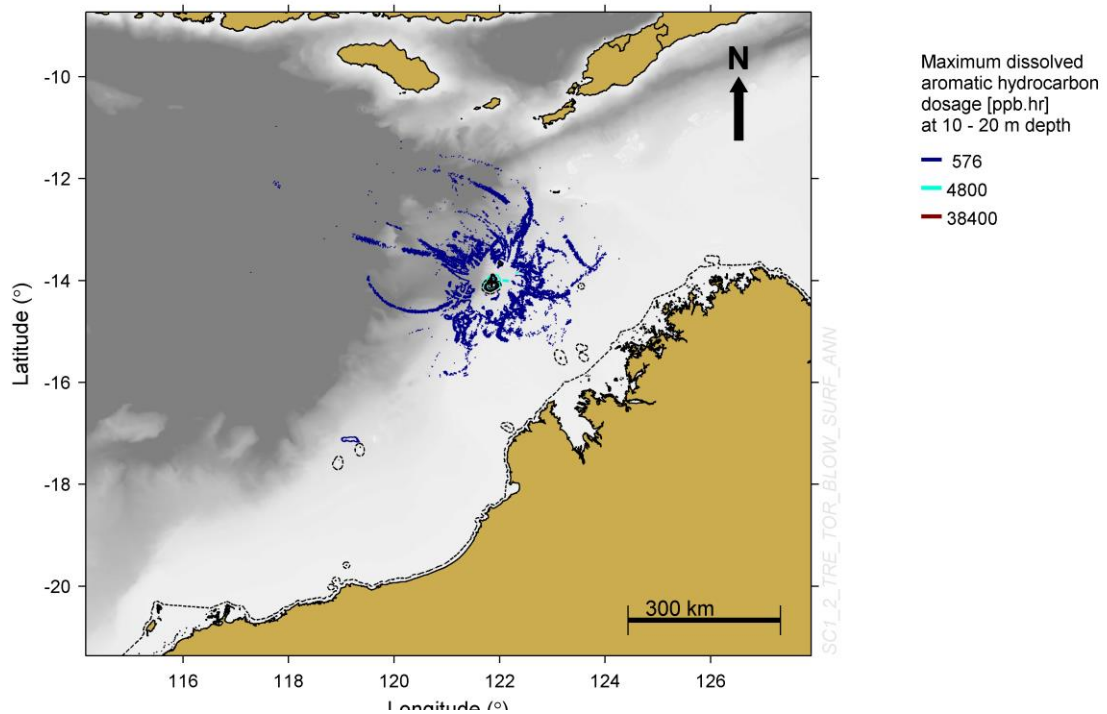


Figure 3-29: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 0 - 10 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



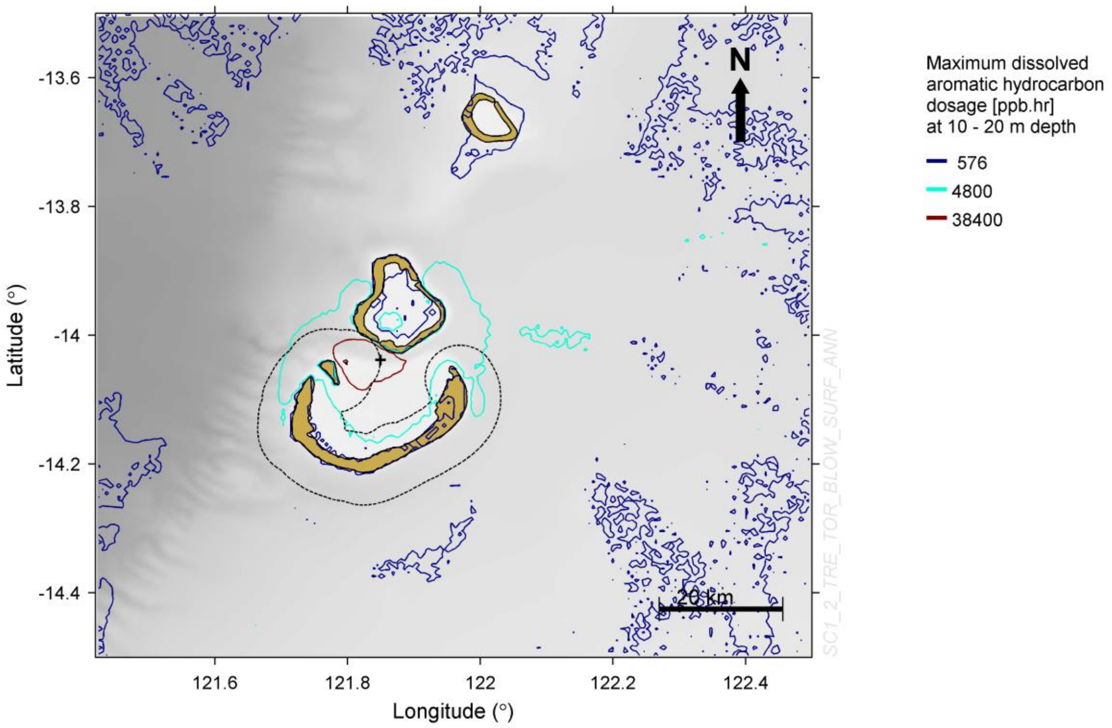
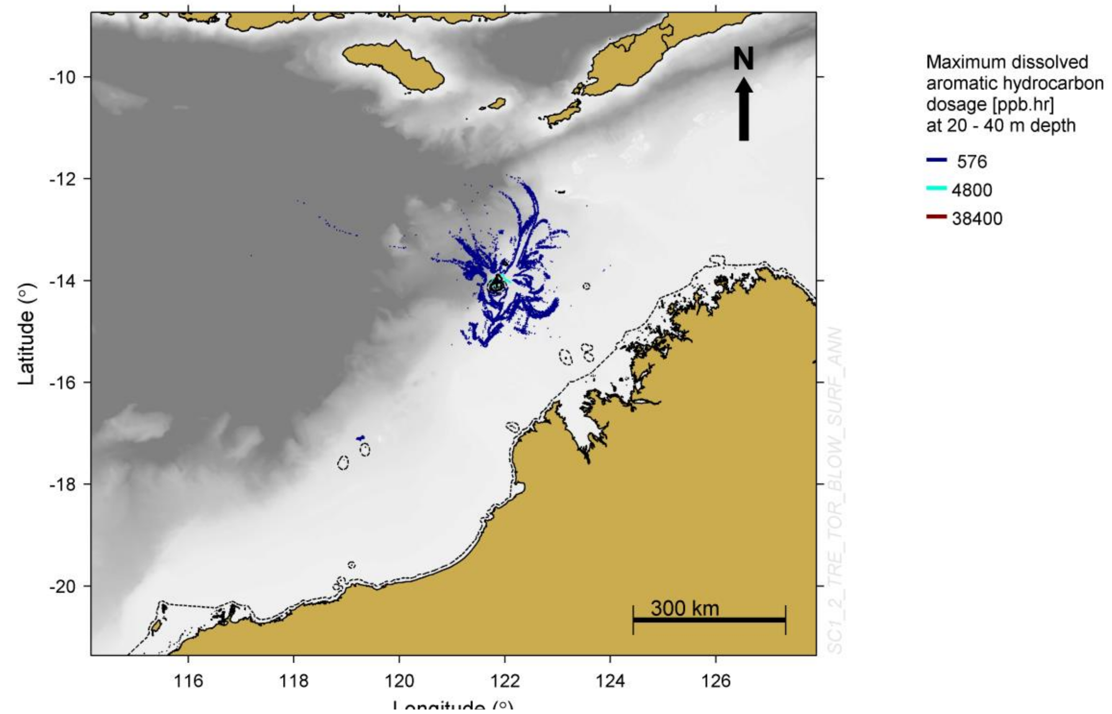


Figure 3-30: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 10 - 20 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



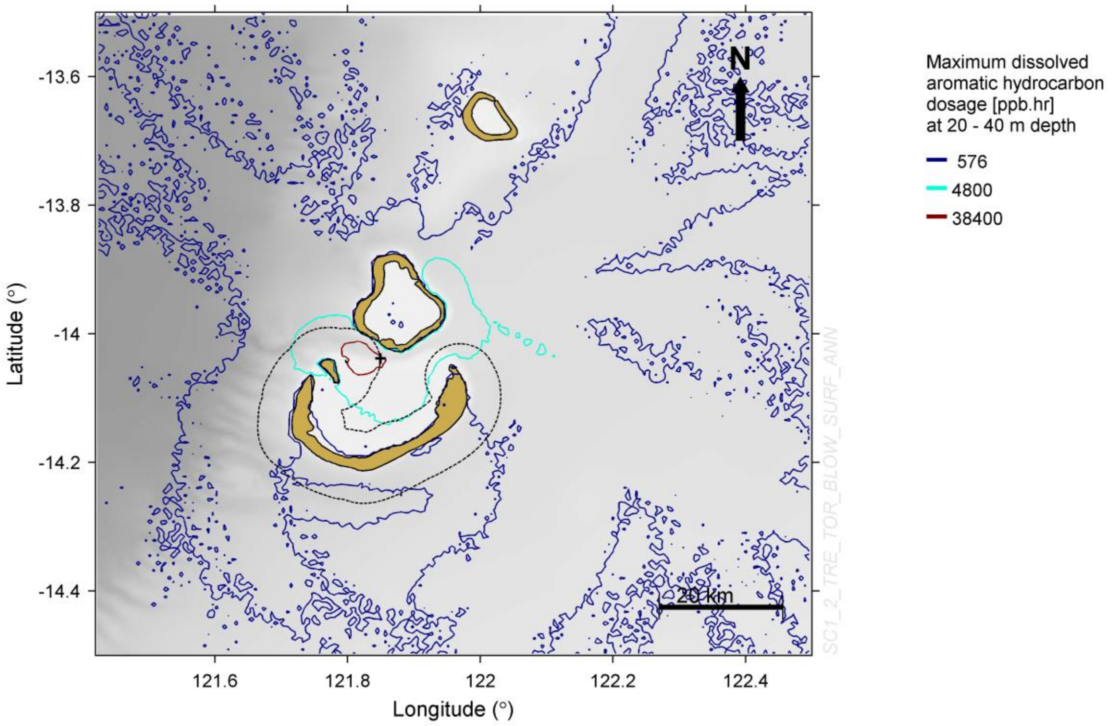


Figure 3-31: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 20 - 40 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

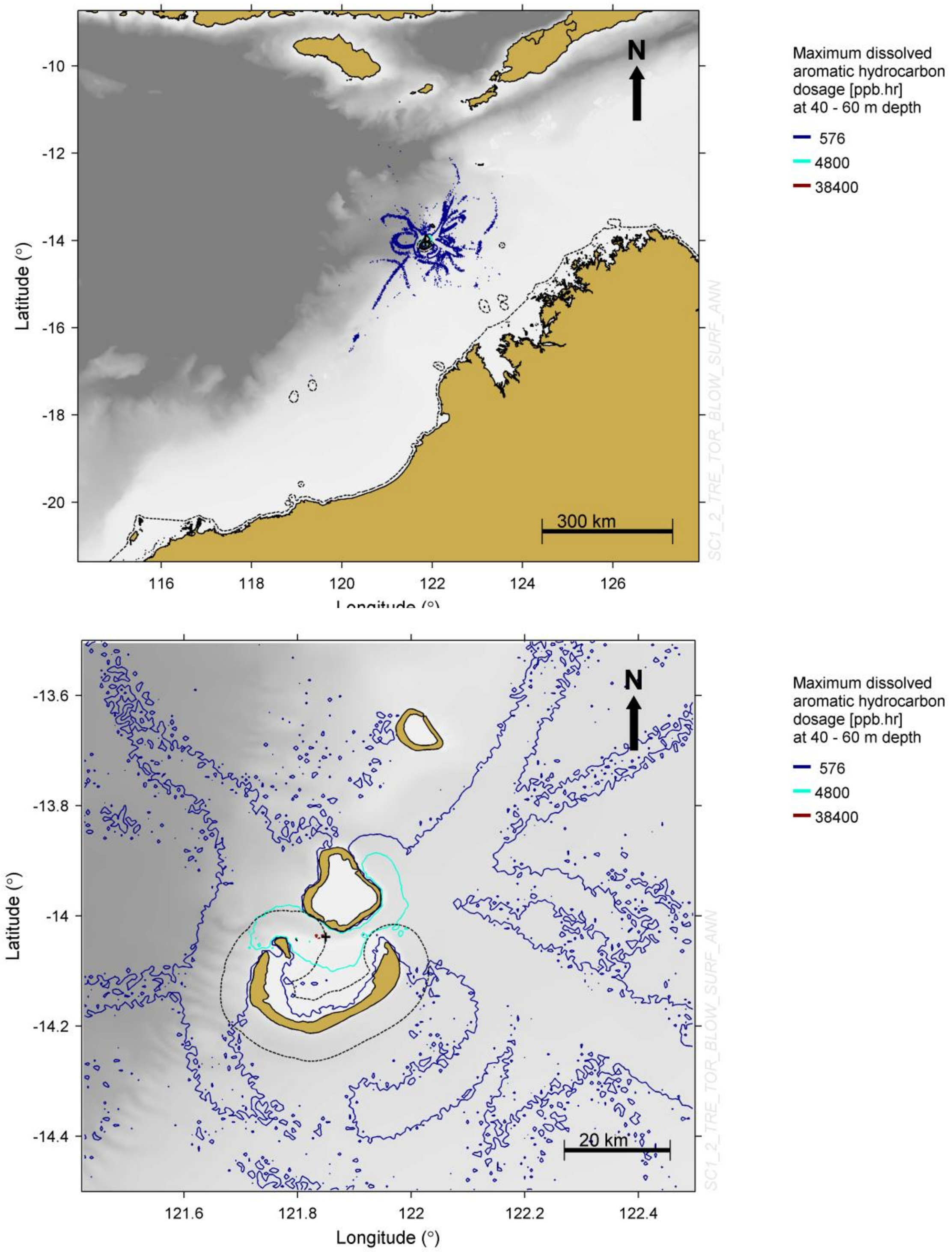


Figure 3-32: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 40 - 60 m (BMSL), resulting from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

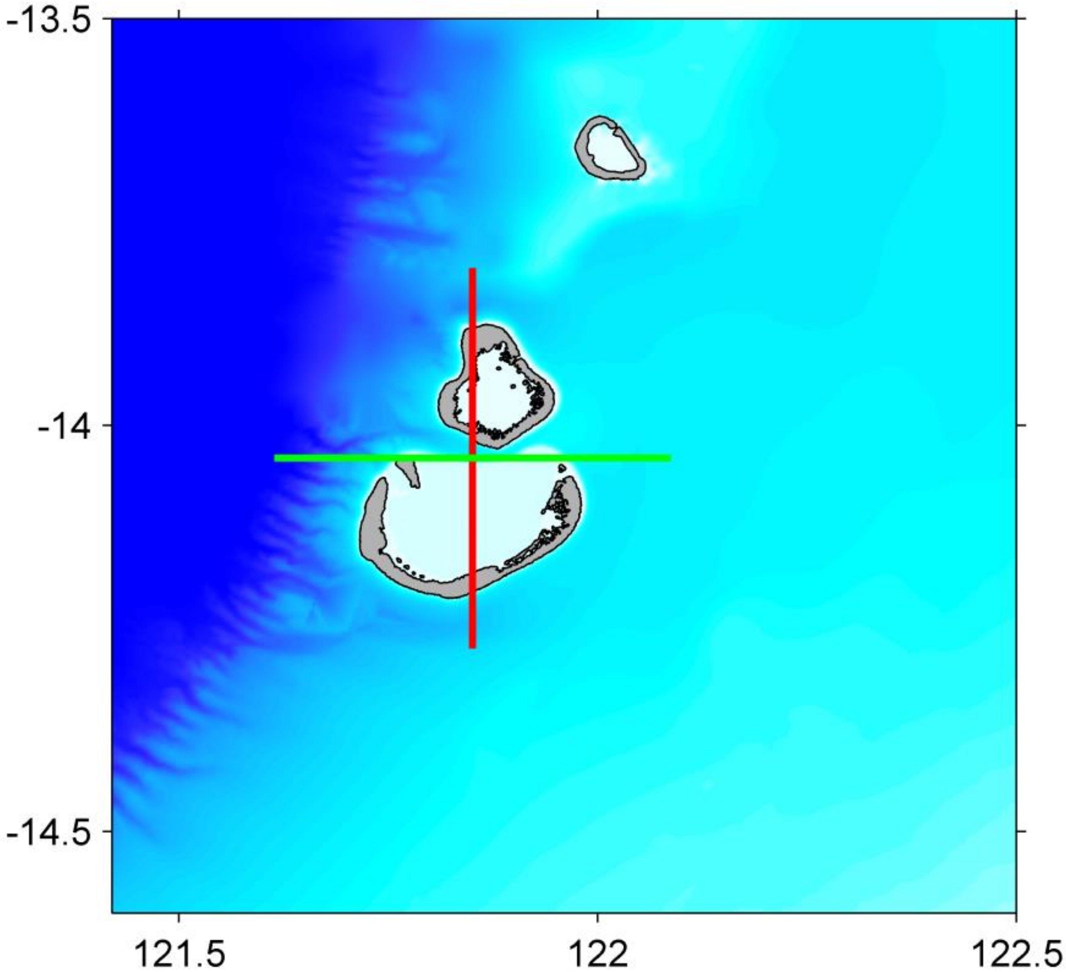


Figure 3-33: Location of the TRE location and the respective vertical transects over a varying latitude (red line) and longitude (green line).

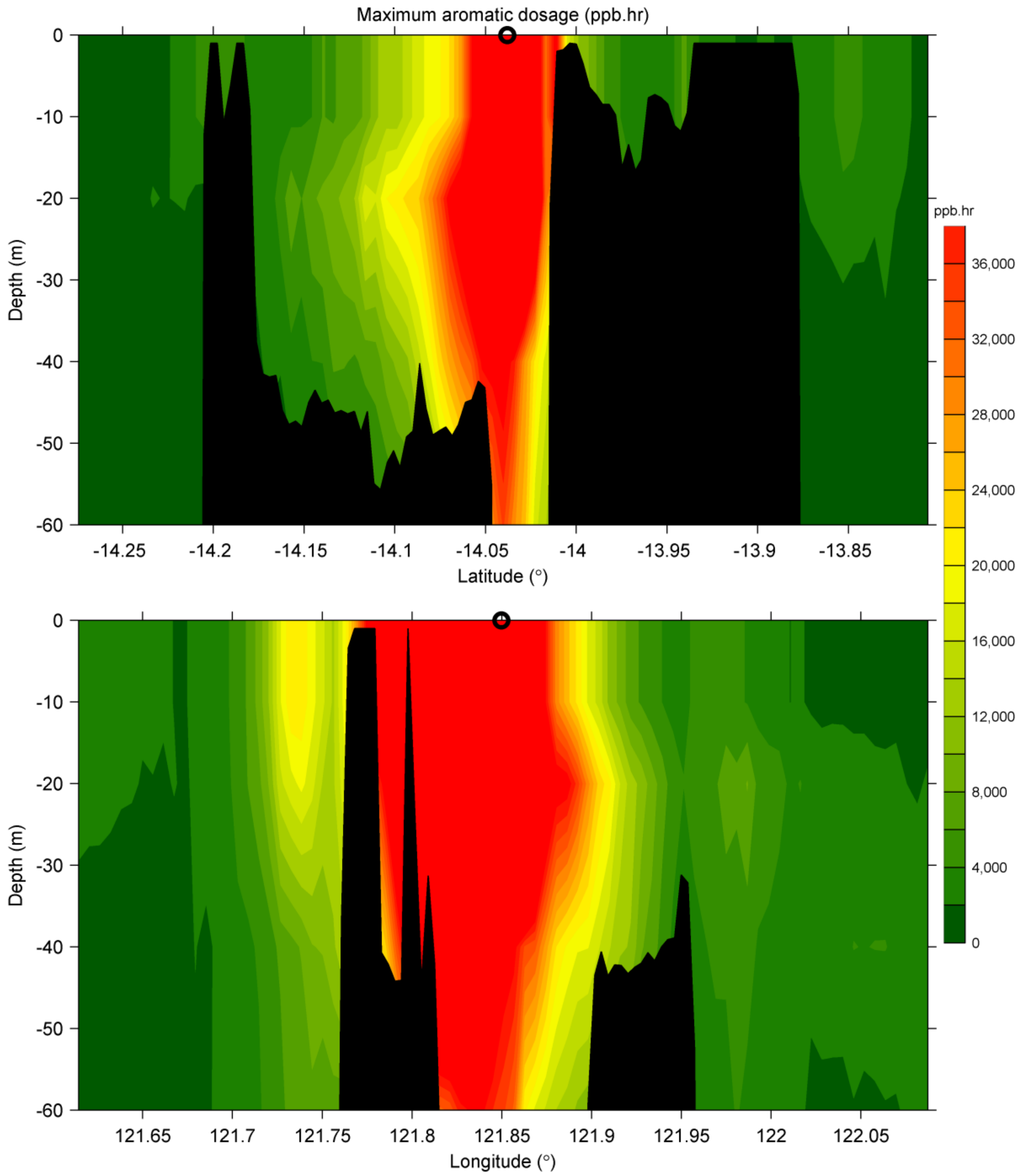


Figure 3-34: Vertical profile showing maximum annualised dissolved aromatic hydrocarbon dosage at a depth of 0 - 60 m (BMSL), across two perpendicular transects intersecting (top, north-south; bottom, east-west) the release reference (black circle over seabed release location) from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. Note – full depth omitted for reasons of clarity.

Table 3-4: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location.

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Timor Leste	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	2	NC	NC
Timor (West)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	16	17	2	3
Pulau Roti	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	60	43	26	32
Big Bank Shoals	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	22	38	42	2
Melville Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Oceanic Shoals CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	9	9	4	2
Hibernia Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	71	169	68	12
Ashmore Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	229	246	231	284
Ashmore Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	87	60	52	57

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-4: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Cartier Island CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	202	336	174	71
Cartier Islet	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	118	72	69	41
Joseph Bonaparte Gulf East	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Kimberley CMR	Probability (%) ≥ 576	0.5	1	1	0.5
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,439	1,851	1,754	1,215
Argo-Rowley Terrace CMR	Probability (%) ≥ 576	0.5	1.5	1	0.5
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	886	1,621	852	667
Seringapatam Reef	Probability (%) ≥ 576	1	2	NC	0.5
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	653	1,203	438	652
Joseph Bonaparte Gulf West	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
North Reef Flats	Probability (%) ≥ 576	100	100	100	100
	Probability (%) ≥ 4,800	100	100	100	85
	Probability (%) ≥ 38,400	3	0.5	NC	NC
	Maximum Dosage	83,027	41,067	25,702	14,148
North Reef Lagoon	Probability (%) ≥ 576	100	100	100	BS
	Probability (%) ≥ 4,800	100	100	74.5	BS
	Probability (%) ≥ 38,400	0.5	NC	NC	BS
	Maximum Dosage	40,130	21,239	14,188	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-4: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Kimberley Coast	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	72	59	36	11
South Reef Lagoon	Probability (%) ≥ 576	100	100	100	100
	Probability (%) ≥ 4,800	100	100	100	100
	Probability (%) ≥ 38,400	100	100	72	NC
	Maximum Dosage	95,623	109,190	62,973	38,292
SR Central/ Sandy Islet	Probability (%) ≥ 576	100	100	BS	BS
	Probability (%) ≥ 4,800	100	100	BS	BS
	Probability (%) ≥ 38,400	25.5	NC	BS	BS
	Maximum Dosage	48,396	26,805	BS	BS
South Reef Flats	Probability (%) ≥ 576	100	100	99	67
	Probability (%) ≥ 4,800	6.5	6.5	NC	0.5
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	13,679	7,996	4,571	5,797
Browse Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	333	260	184	74
Lalang-garram / Camden Sound MP	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	15	13	22	9
Camden Sound	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	12	7	17	3
Adele Island	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	46	18	BS	BS
Dampier Peninsula Coast - North section	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1	1	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-4: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Lacepede Islands	Probability (%) ≥ 576	NC	BS	BS	BS
	Probability (%) ≥ 4,800	NC	BS	BS	BS
	Probability (%) ≥ 38,400	NC	BS	BS	BS
	Maximum Dosage	NC	BS	BS	BS
Mermaid Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	280	262	198	286
Mermaid Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	101	262	198	230
Rowley Shoals MP (Clerke Reef)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	404	517	215	43
Clerke Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	362	266	105	20
Imperieuse Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	22	47	70	64
Rowley Shoals MP (Imperieuse)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	8	25	27	23
Eighty Mile Beach	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	8	30	3	BS
Glomar Shoals	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2	19	16	8

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-4: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Rankin Bank	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	11	13	5
Dampier Archipelago	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Montebello Islands	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Lowendal Islands	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Barrow Island	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Northern Pilbara- Islands and Shoreline	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	NC	NC	BS	BS
Southern Pilbara- Islands	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Muiron Islands (World Heritage)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Ningaloo Coast North (World Heritage)	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-4: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 77-day 73,671 m^3 surface/subsea release of Torosa Condensate at the TRE location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Ningaloo Coast North	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

3.3 Scenario 2: Simulation of a 60-minute Seabed Release of 25 m^3 of Torosa Condensate at the TRD Location

This scenario investigated the probability of exposure to surrounding regions due to a 60-minute seabed release of Torosa Condensate at the TRD location, with a total discharge volume of 25 m^3 over 60-minutes (Table 1-1).

Table 3-5: Summary of the spill scenario.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (m BMSL)
2	Loss of pipeline pressure containment in the TRD flow line	Torosa Condensate (flashed to seabed)	25	9.65x10^{-3}	1 hour	14° 0' 31.71" S 121° 57' 17.05" E	389

The modelling for this scenario assumes no mitigation efforts are undertaken to collect or otherwise affect the natural transport and weathering of the oil. All sensitive receptors outlined in Section 2.3.6 were analysed, however, only the receptors that were forecast to be contacted by dispersing oil are summarised in this section.

Average Weathering

The average mass balance calculated over all the replicate simulations indicates that over the first 24 hours of the release, approximately 40% of the oil mass is lost to evaporation, 15% is floating on the surface, 12% has dissolved and 30% remains entrained following the subsea release (Figure 3-35 and Figure 3-36). The size of the droplets resulting from the release facilitates rapid surfacing allowing much of the volatile fraction to evaporate.

At the end of the simulation approximately 50% of oil has evaporated, 25% remains entrained in low concentrations, 20% has decayed and less than 5% is dissolved or floating on the surface.

The average mass balance curve for aromatic hydrocarbons indicates that over the first 24 hours the initial aromatic mass has dissolved, with a similar mass having evaporated (Figure 3-37 and Figure 3-38). Three days after the release, the aromatic components are either dissolved or have been lost to evaporation and decay.

Trajectory and Weathering of an Example Replicate

An example series of snapshots of a single predicted spill trajectory are presented in Figure 3-53, and associated weathering and fates plots in Figure 3-40. The snap shots display the positions of the Lagrangian 'spillets', colour-coded to represent floating, entrained, aromatic and shoreline oil and do not reflect concentrations. Snapshots indicating the spill trajectory are given at the start of the release and 1 day, 3 days, 5 days, 7 days and 9 days after spill commencement.

One day following the initial release, floating oil, entrained oil and dissolved aromatic hydrocarbons are predicted to have drifted to the northeast of the release site. From day 3 the floating oil travels to the west then north of the release site, while the entrained oil and dissolved aromatic hydrocarbons continue drifting to the northeast and east. The difference in trajectories can be attributed to the stronger influence of wind on the floating oil trajectories compared to the entrained and dissolved components, pushing the floating slick between the north and south reefs and into the open ocean flow.

The mass balance for this replicate indicates that approximately 55% of released oil evaporates after surfacing within hours of being released. Oil remaining on the surface was then re-entrained as wind speeds increased in the latter part of day 1 (Figure 3-40). As the winds abated during the third day following the spill, some of the entrained fraction resurfaced. The initial evaporation resulted in the loss of most of the highly volatile components, so there was little additional evaporation as a result of the resurfacing. Subsequent elevated wind speeds after about 3.5 days resulted in the floating oil re-entraining.

Floating Oil

The probability (P_2) contours show that floating oil with concentrations at or above 1 g/m^2 is forecast to extend up to 10 km from the release site in most directions (Figure 3-41). At the 10 g/m^2 threshold, floating oil is forecast to extend up to 5 km from the release site (Figure 3-42), with a maximum swept area of 1.6 km^2 in a general east-west alignment.

Return-period probabilities (P_1xP_2) at these thresholds are presented in Figure 3-43 and Figure 3-44. The potential areas affected floating oil at or above the defined thresholds over the full simulation by are quantified in Table 1-1. Note the significant range of outcomes, particularly at the lower floating concentration thresholds.

Table 3-6: The potential swept area (km^2) of floating oil with concentrations exceeding defined threshold concentrations in any single spill event. The swept area refers to all areas covered by the slick during the spill simulation with a concentration at the specified threshold.

	0.5 g/m²	1 g/m²	10 g/m²	25 g/m²
Minimum potential area (km²)	1.2	0.8	0.4	0.4
Median potential area (km²)	10.7	6.7	0.8	0.4
Mean potential area (km²)	12.4	7.3	0.9	0.4
Maximum potential area (km²)	42.6	26.8	1.6	0.8

Floating oil slicks with concentrations at or above 1 g/m^2 are forecast to pass through North Reef Flats (7.25%), North Reef Lagoon (2%), South Reef Lagoon (4.75%) and South Reef Flats (0.25%) (Table 3-7). No receptors are forecast to be contacted at 10 g/m^2. The minimum time to contact at the lowest floating oil threshold of 0.5 g/m^2 is predicted to be 4 hours at South Reef Lagoon, and 5 hours at North Reef Flats.

The maximum accumulated shoreline concentration is forecast at South Reef Central/Sandy Islet at 37 g/m^2, with a maximum accumulated volume of less than 1 m^3.

Dissolved Aromatic Hydrocarbon Dosage

Low dosage threshold (at or above 576 ppb.hr) is expected to be limited to within 3 km of the release in the surface layer (0-10 m depth; Figure 3-50), and not expected to occur in deeper waters. No assessed sensitive receptors are expected to be subjected to dosage at the low threshold (Table 3-16).

Moderate or high dosage (at or above 4,800 ppb.hr or 38,400 ppb.hr) is not expected to occur at any depth as a result of this spill scenario.

Figure 3-53 shows the vertical distribution of the maximum dissolved aromatic hydrocarbon dosage along 2 perpendicular intersections of the release site (Figure 3-52). Both the east-west and north-south transects show that the dosage zones are very localised and near to the surface (<20 m depth).

3.3.1 Average Weathering

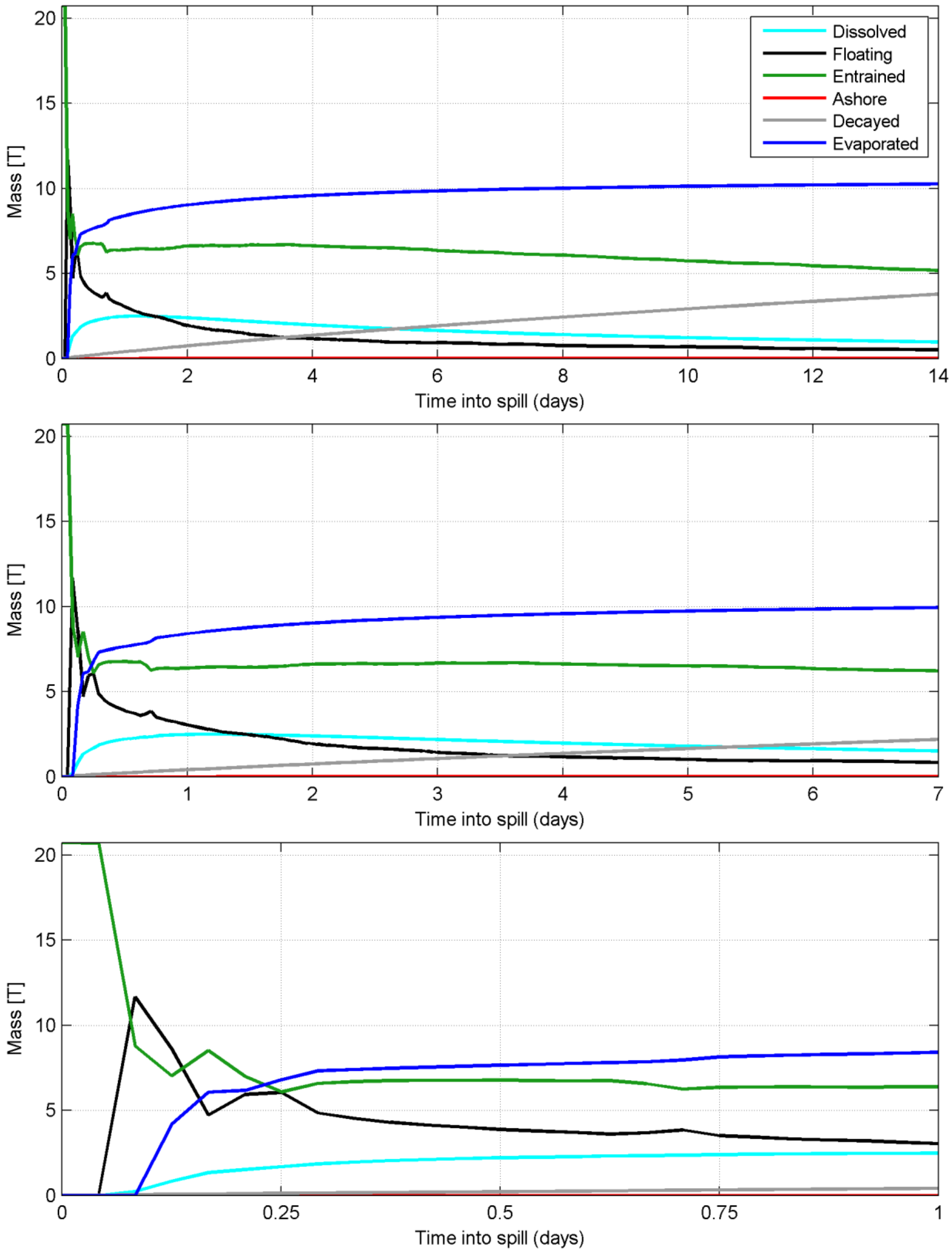


Figure 3-35: Predicted average weathering mass balance (tonnes) resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The distribution over the first 14 days (top), 7 days (middle) and 24 hours (bottom) is given.

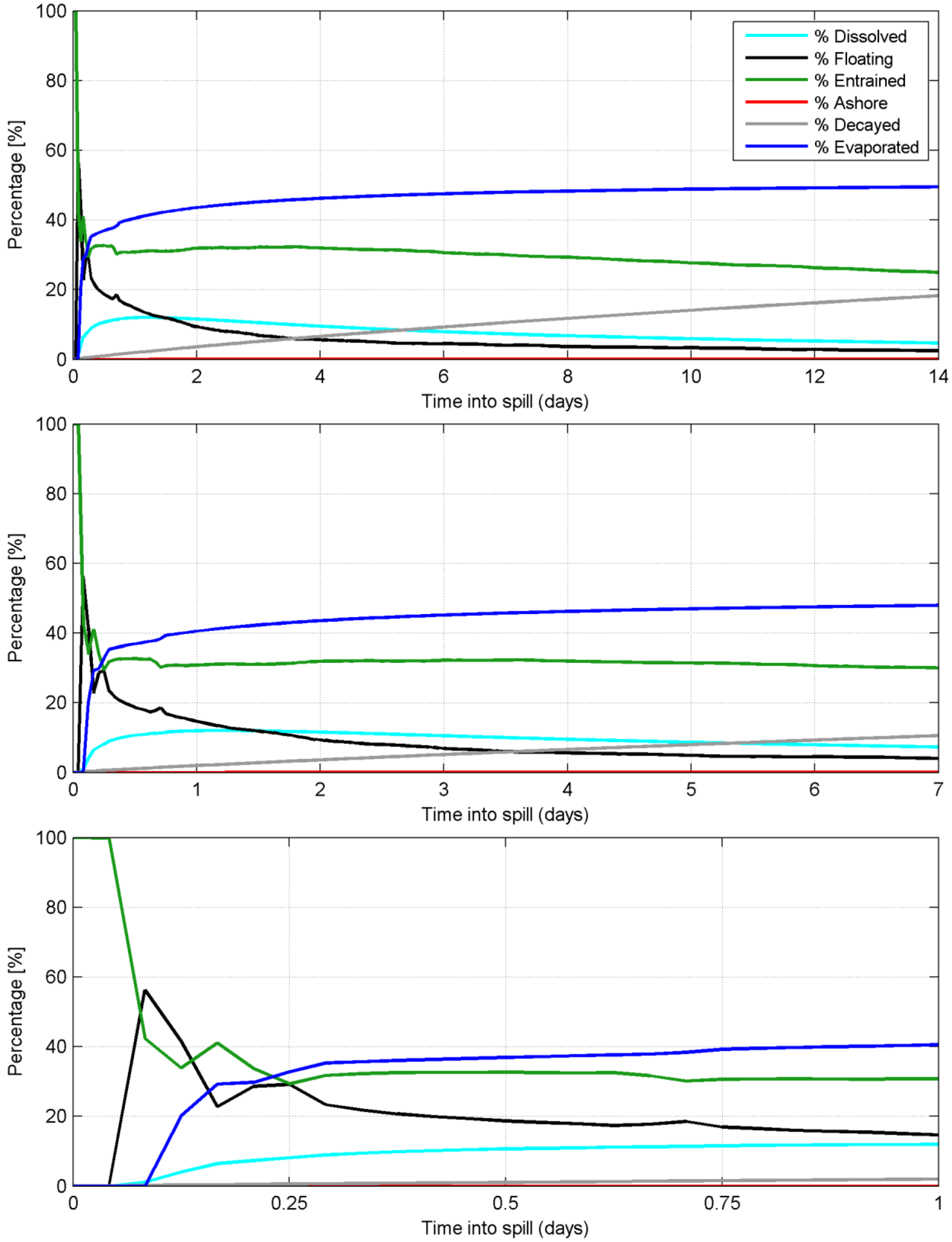


Figure 3-36: Predicted average weathering mass balance (% of total mass) weathering graph resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The distribution over the first 14 days (top), 7 days (middle) and 24 hours (bottom) is given.

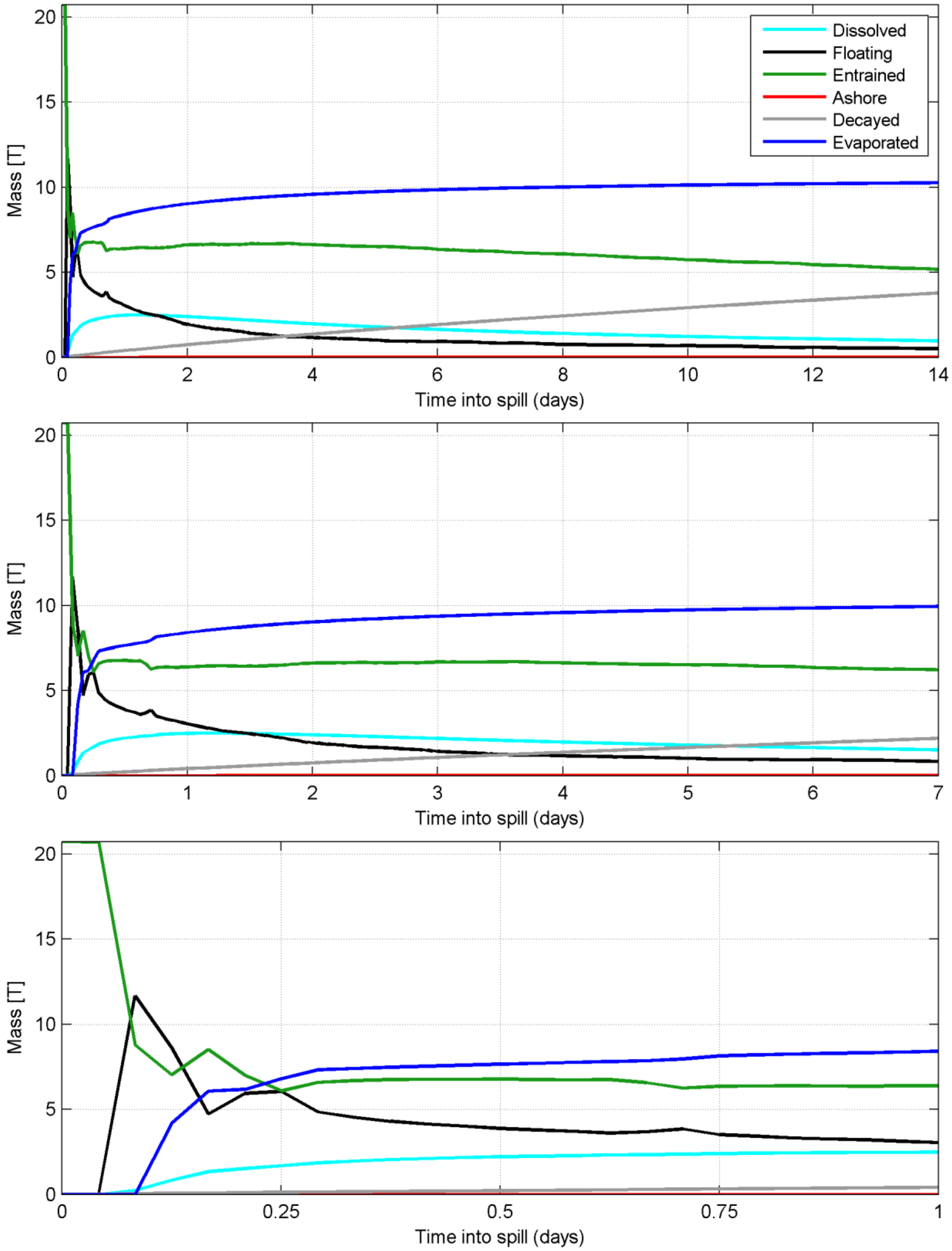


Figure 3-37: Predicted average partitioning of the aromatic hydrocarbons (tonnes) resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The distribution over the first 14 days (top), 7 days (middle) and 24 hours (bottom) is given.

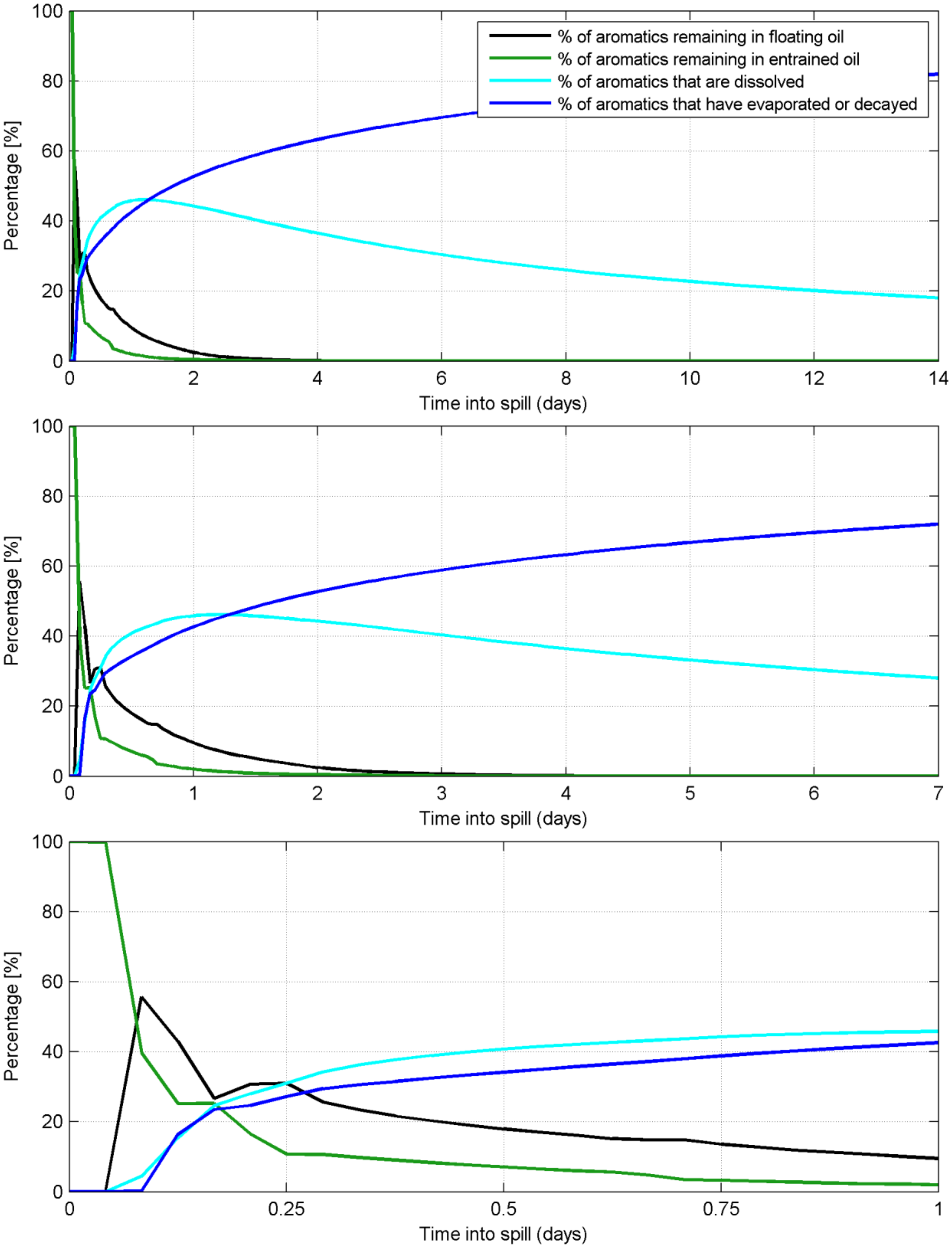


Figure 3-38: Predicted average partitioning of the aromatic hydrocarbons (% of total mass) resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The distribution over the first14 days (top), 7 days (middle) and 24 hours (bottom) is given.

3.3.2 Trajectory and Weathering of an Example Replicate

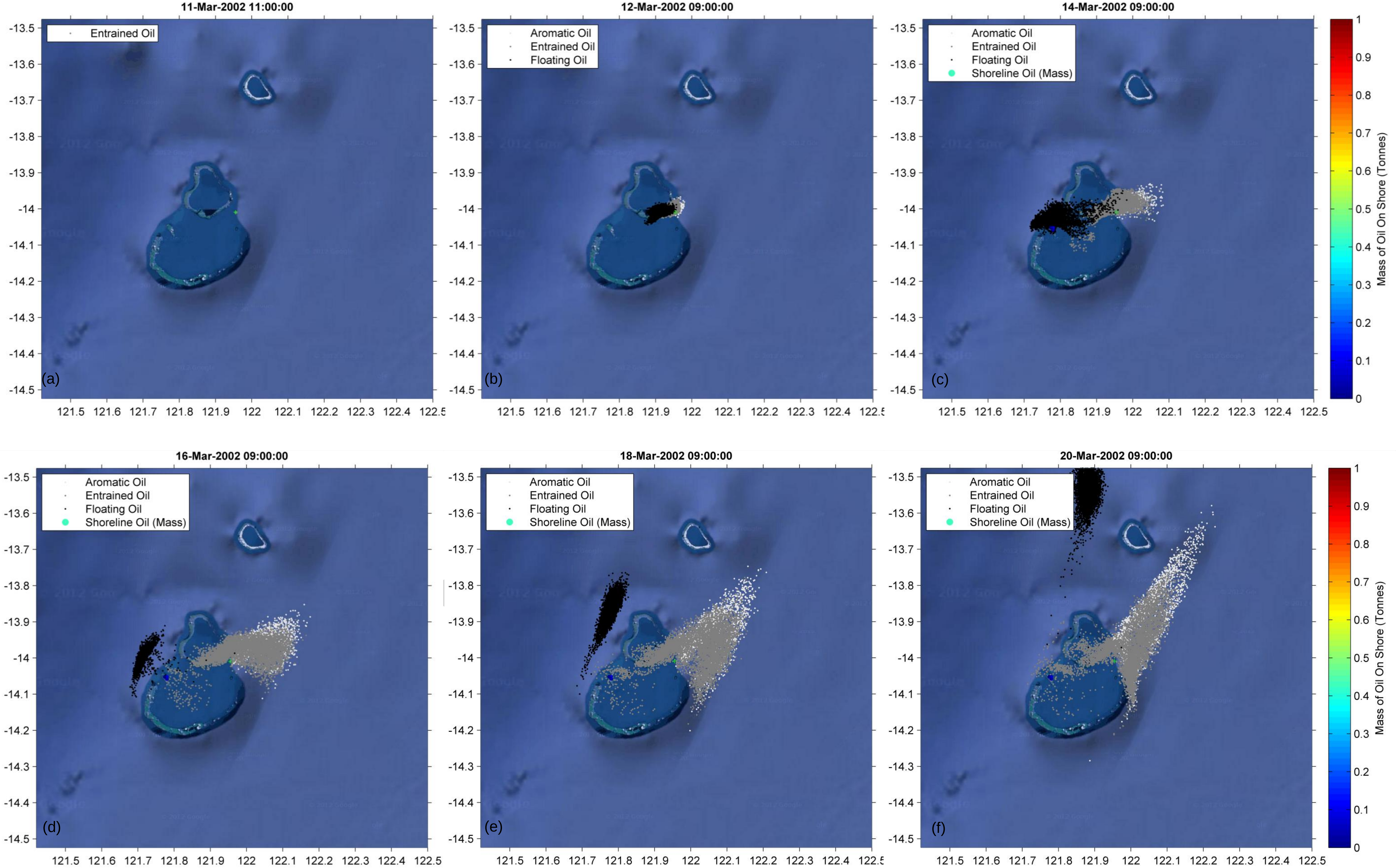


Figure 3-39: Example trajectory of floating oil (black), entrained oil (grey), dissolved aromatic hydrocarbons (white) and shoreline oil (blue; mass in Tonnes) for a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location, commencing at 09:00 on the 11 of March, 2002. The resultant trajectory and concentration at the start of the release (a), 1 day (b), 3 days (c), 5 days (d), 7 days (e) and 9 days (f) after the start of the release are presented.

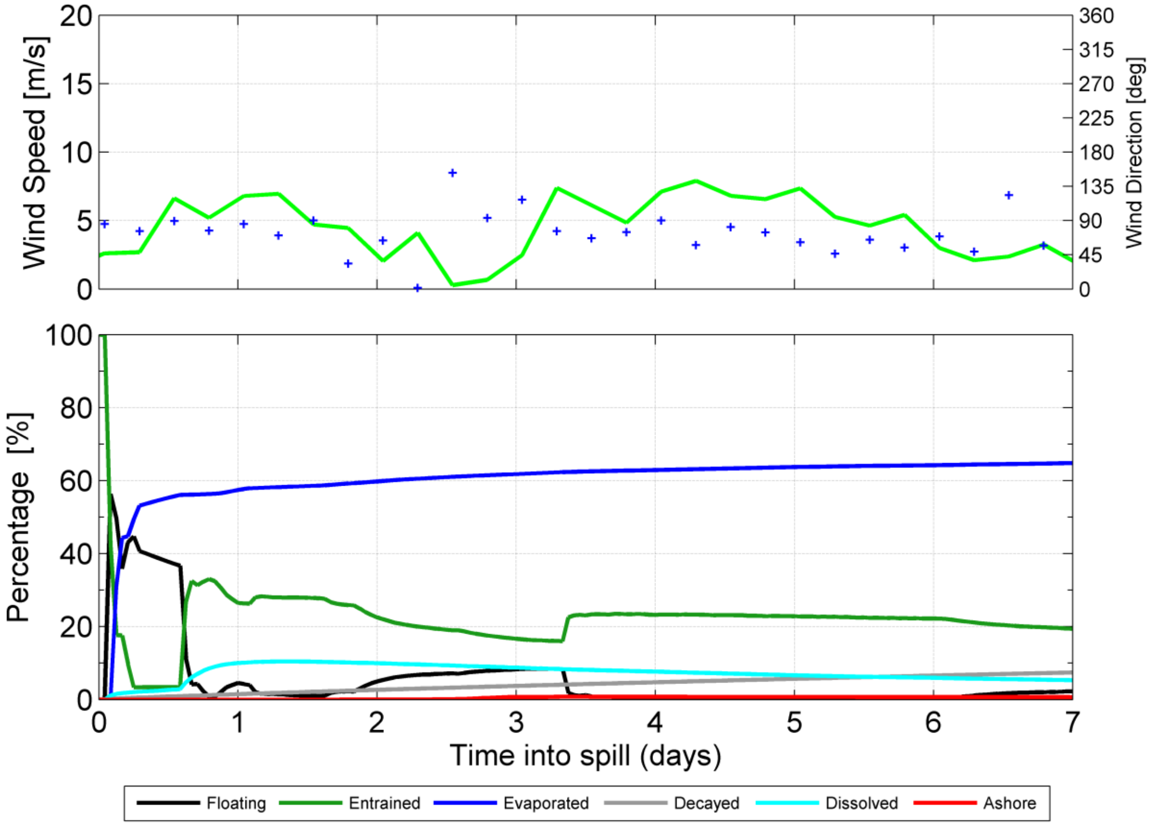


Figure 3-40: Predicted mass balance weathering resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location, commencing at 09:00 on the 11 of March, 2002. The green line in the top figure indicates the wind speed and the blue dots indicate the wind direction (FROM).

3.3.3 Floating Oil

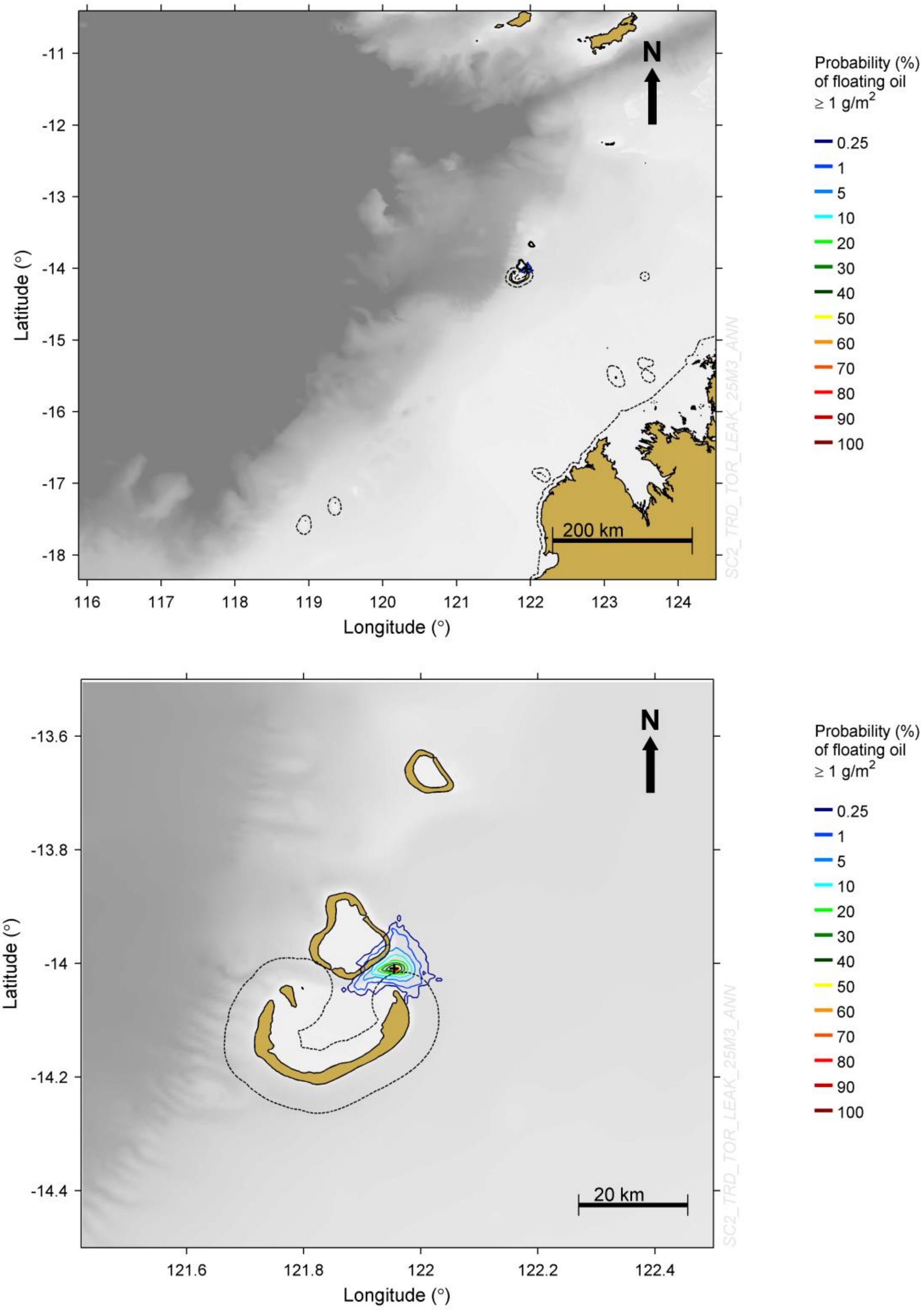


Figure 3-41: Predicted annualised probability (P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

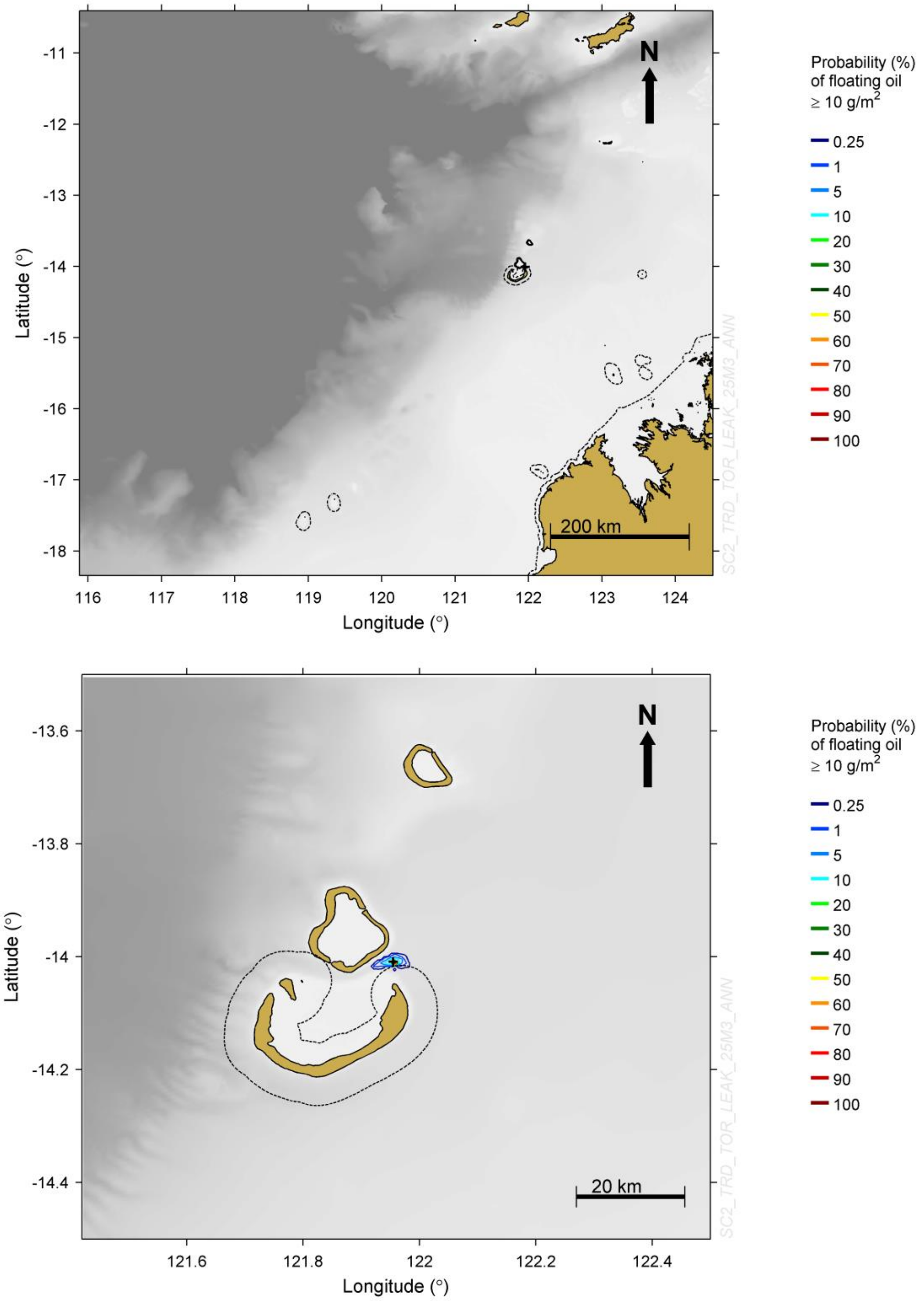


Figure 3-42: Predicted annualised probability (P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

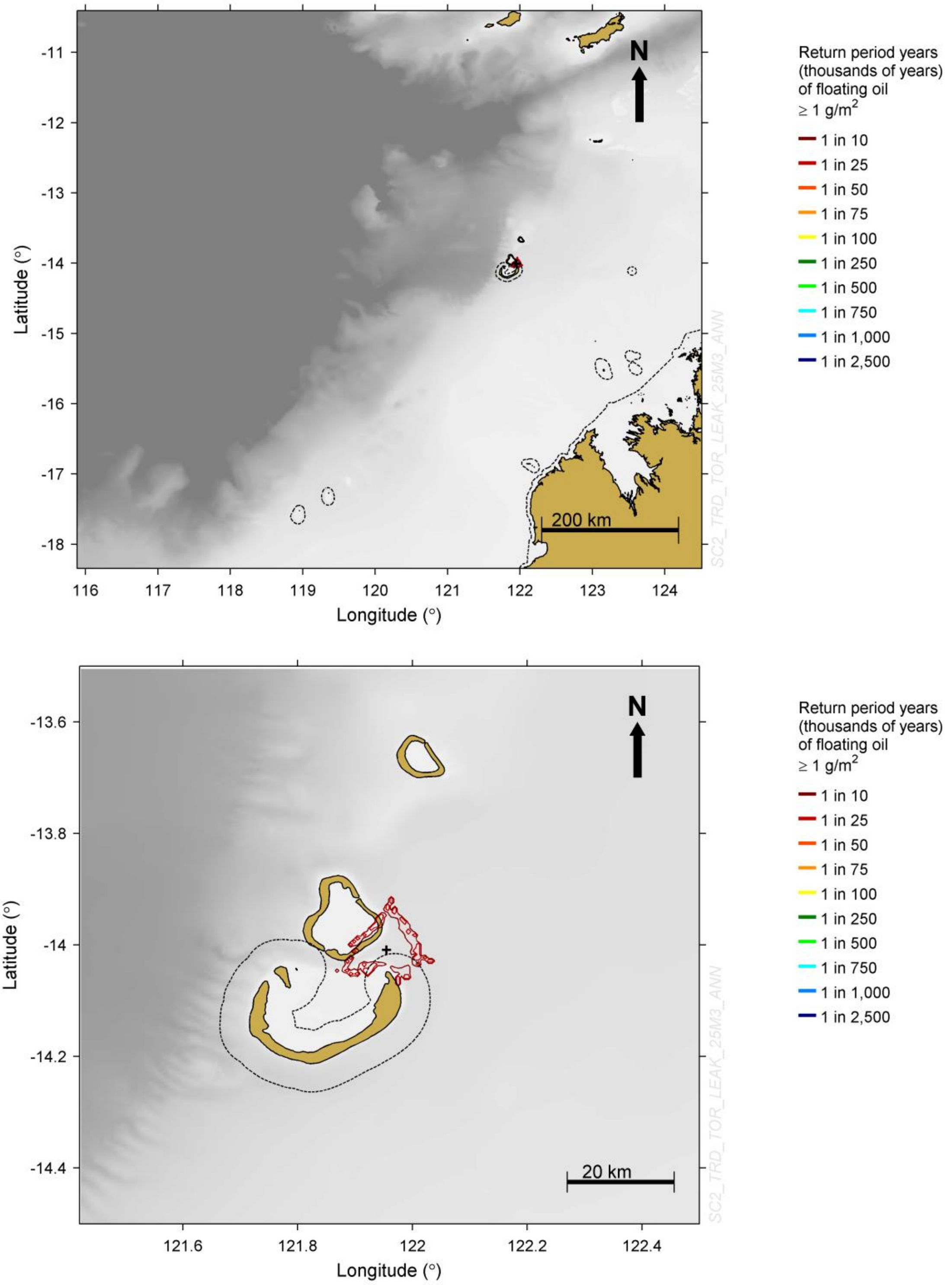
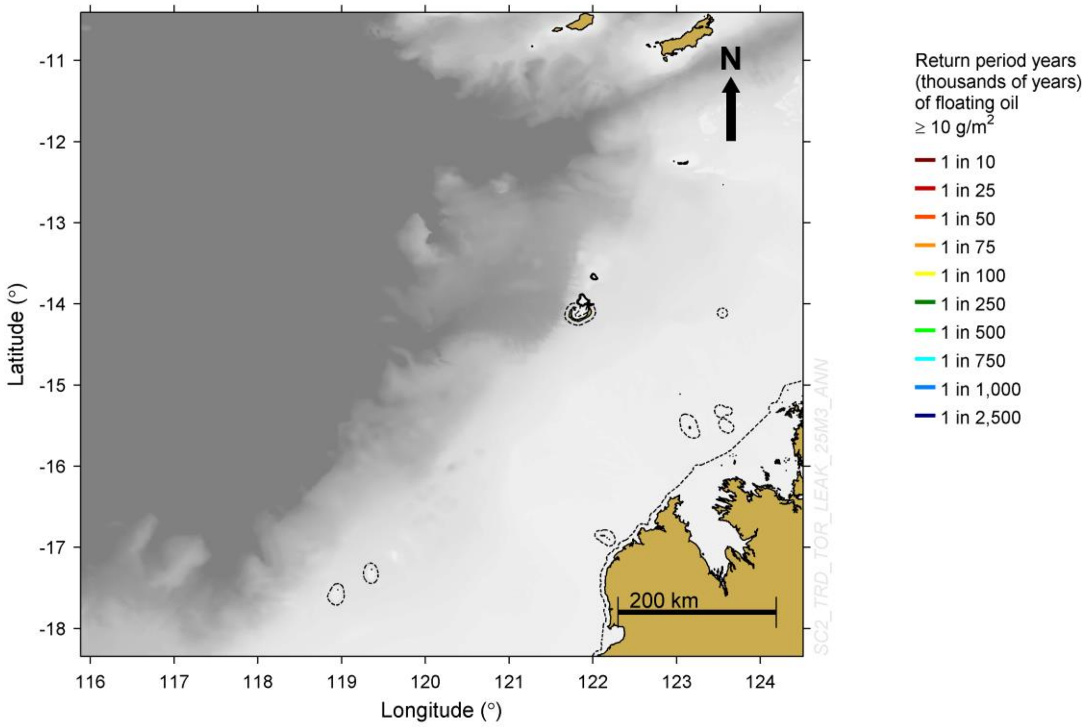


Figure 3-43: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 1 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



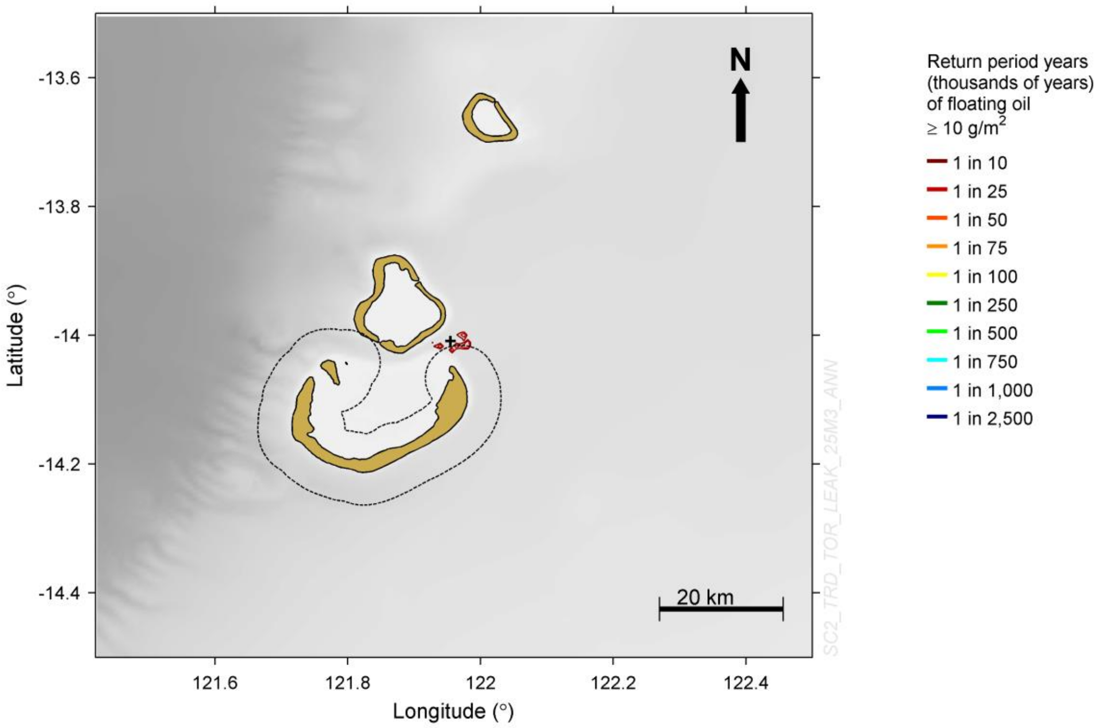


Figure 3-44: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 10 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

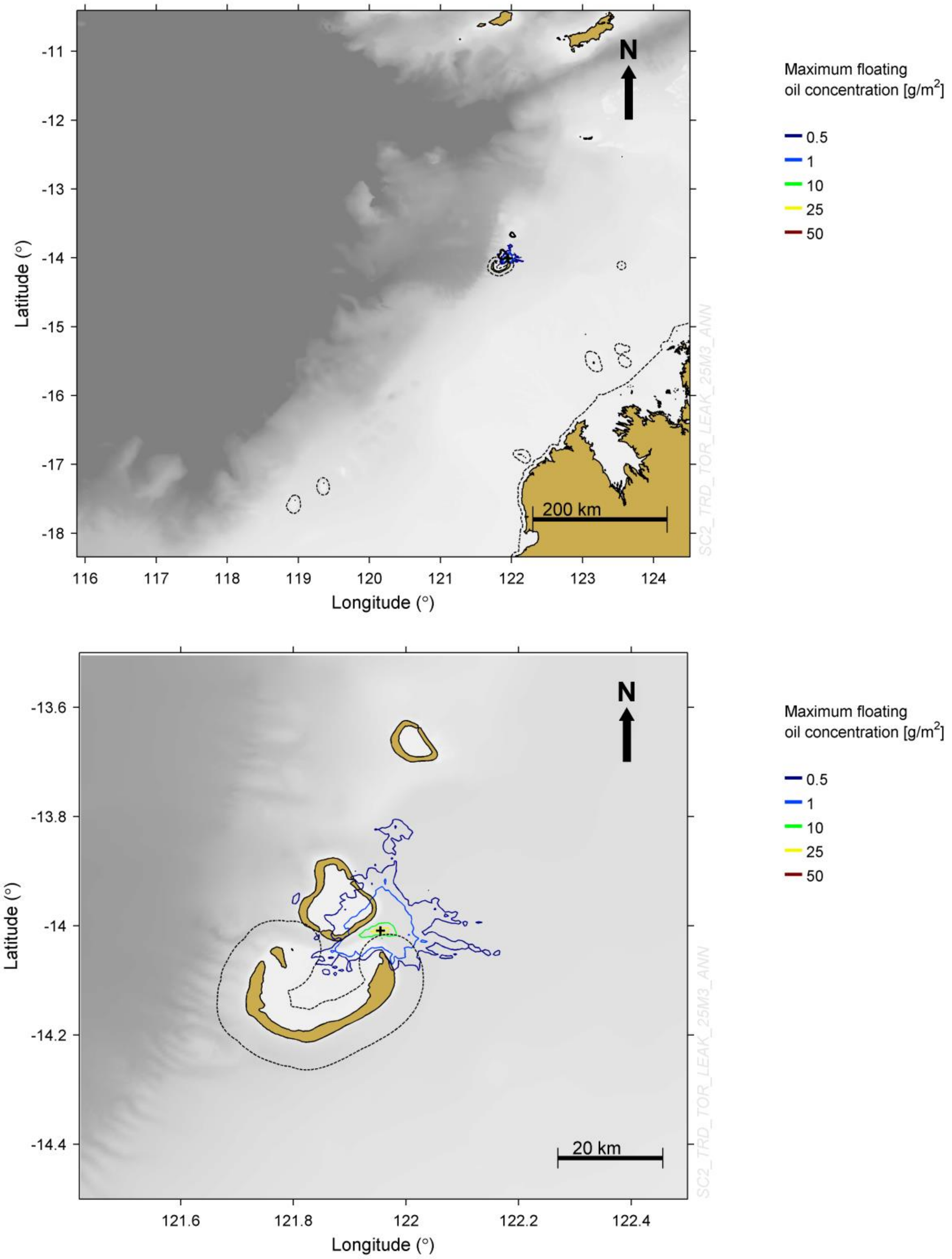


Figure 3-45: Predicted maximum floating oil concentration resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

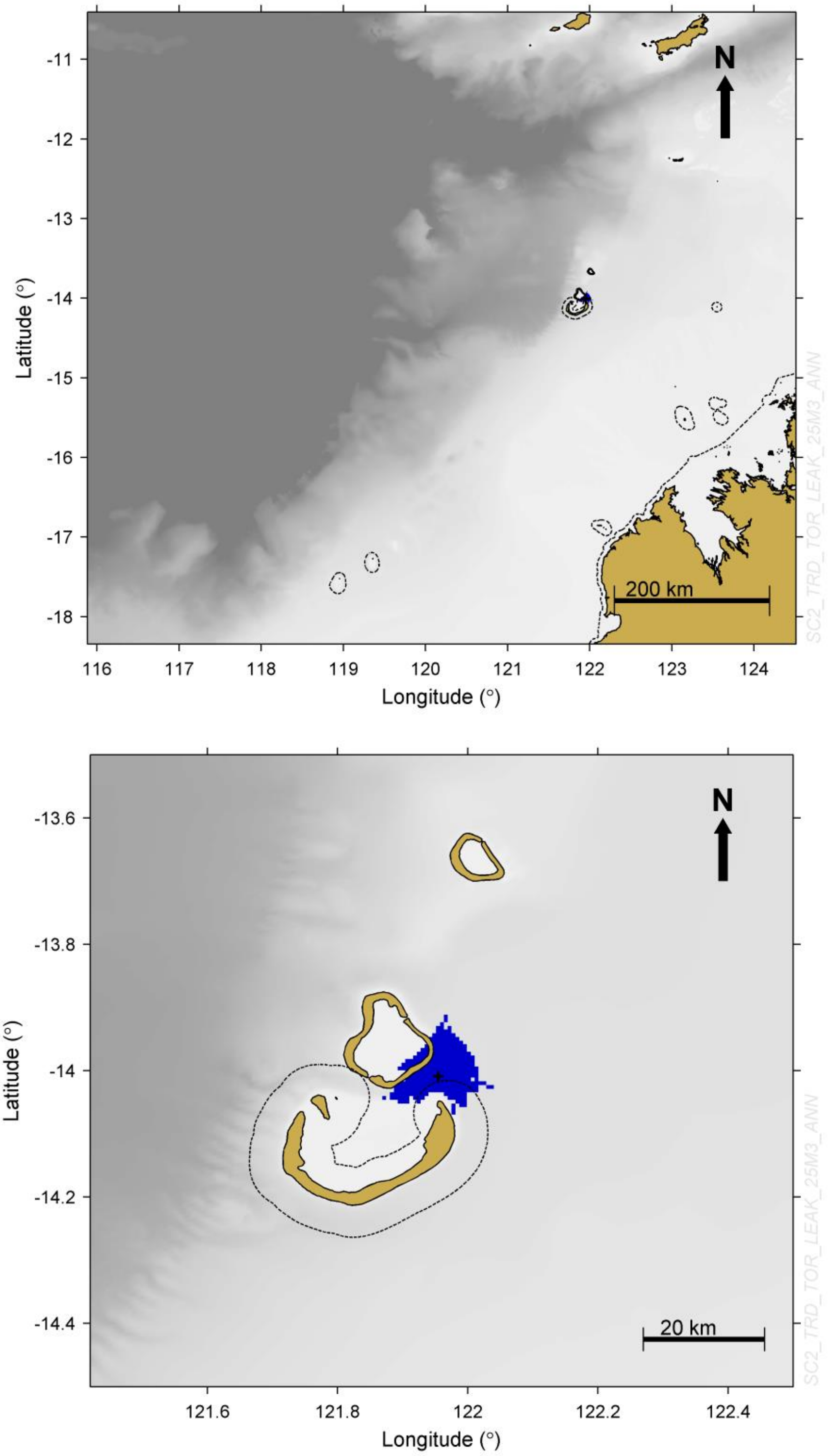


Figure 3-46: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 1 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

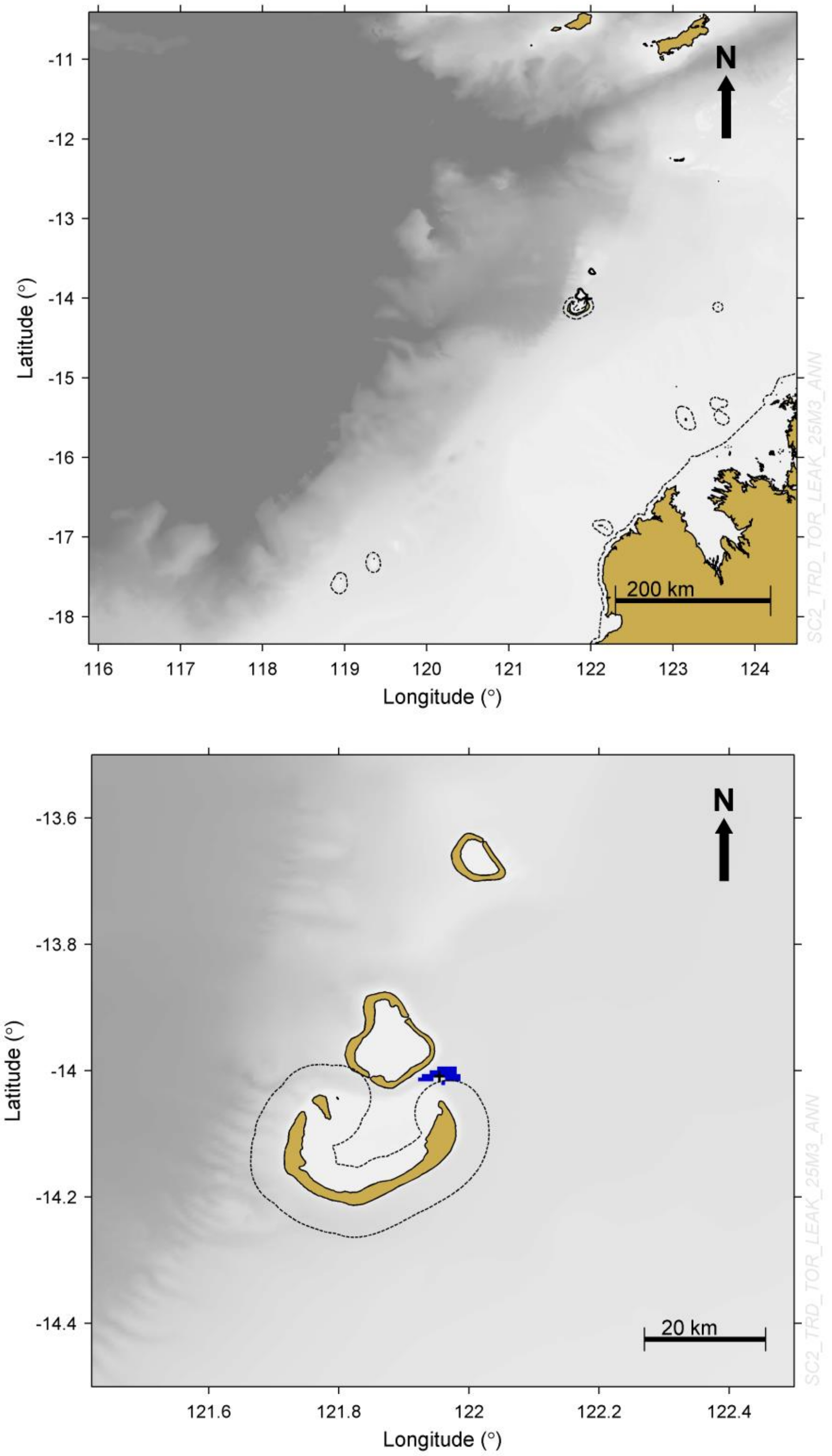
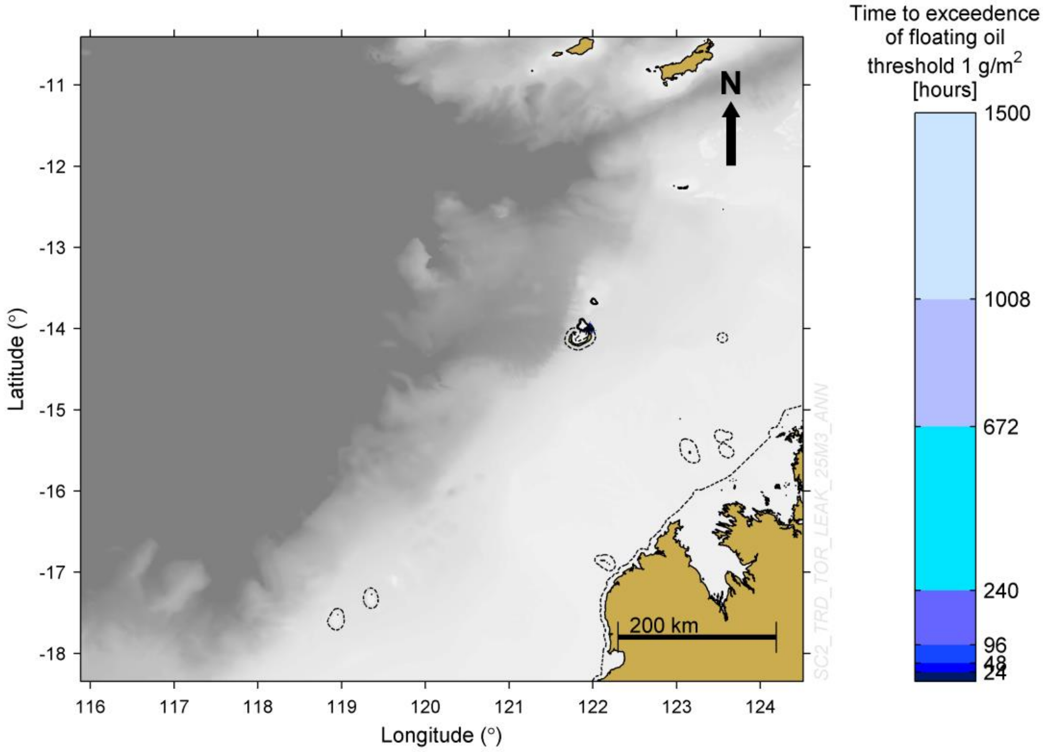


Figure 3-47: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 10 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



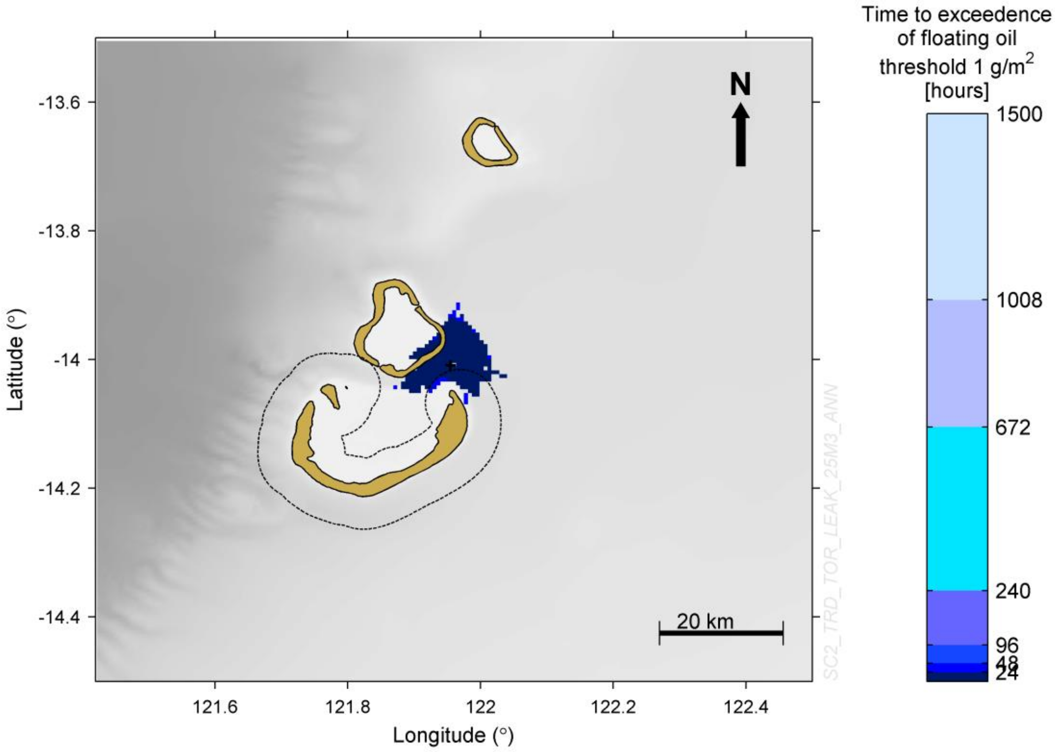


Figure 3-48: Predicted annualised minimum times to threshold for floating oil at or above 1 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

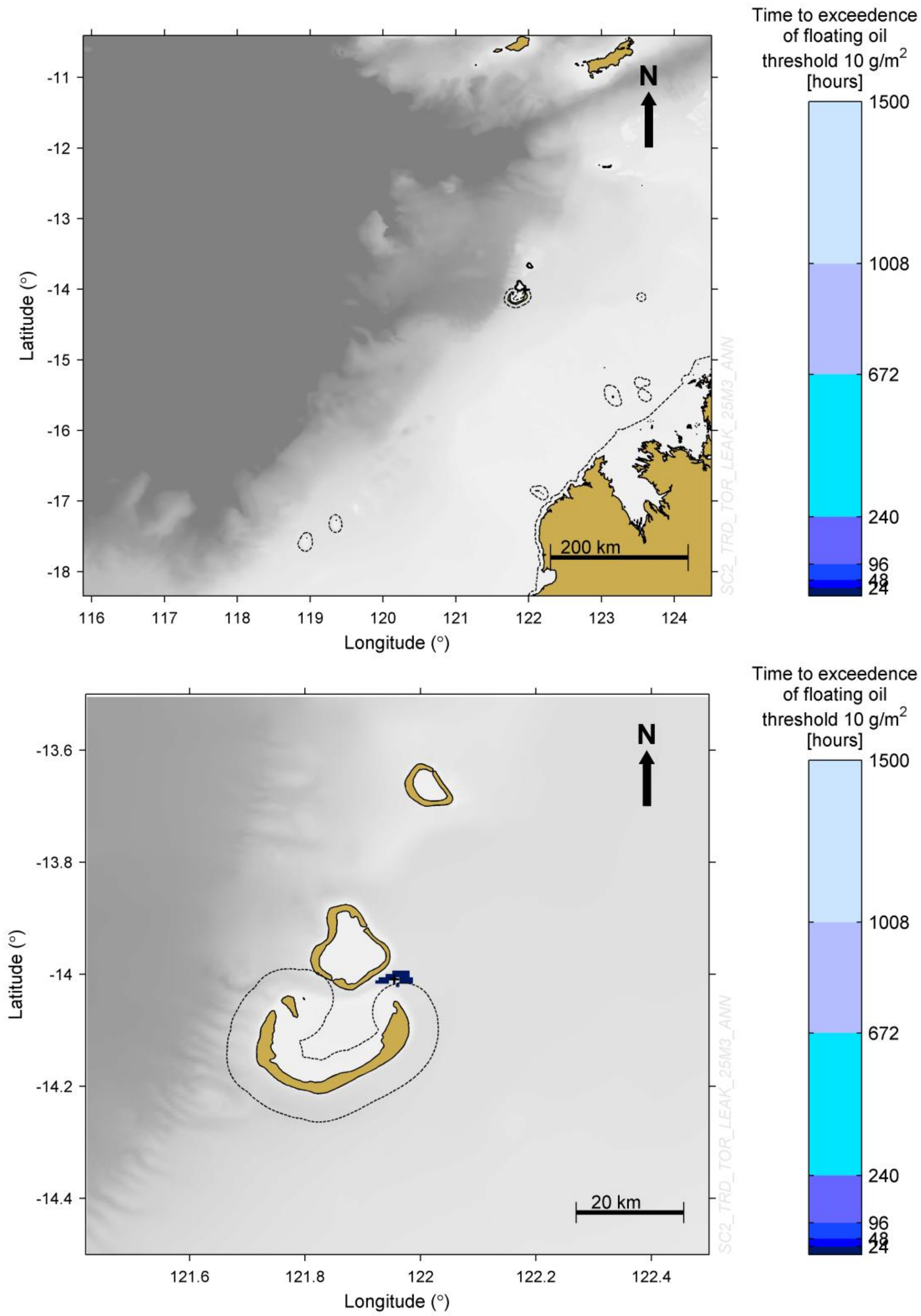


Figure 3-49: Predicted annualised minimum times to threshold for floating oil at or above 10 g/m^2 resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Table 3-7: Expected floating oil outcomes at sensitive receptors across all quarters for a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location.

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Timor (West)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Pulau Roti	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Oceanic Shoals CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Cartier Island CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Cartier Islet	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Kimberley CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Argo-Rowley Terrace CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Seringapatam Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
North Reef Flats*	13	7.25	<0.25	<0.25	5	5	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-7: Expected floating oil outcomes at sensitive receptors across all quarters for a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
North Reef Lagoon*	4.25	2	<0.25	<0.25	12	14	NC	NC	NC	NC	NC	NC
Kimberley Coast	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	0.1	<1	<1
South Reef Lagoon*	6	4.75	<0.25	<0.25	4	5	NC	NC	NC	NC	NC	NC
SR Central/ Sandy Islet	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	1.2	37	<1	<1
South Reef Flats*	0.25	0.25	<0.25	<0.25	29	31	NC	NC	NC	NC	NC	NC
Browse Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Lalang-garram / Camden Sound MP	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Camden Sound	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Adele Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Mermaid Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Mermaid Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-7: Expected floating oil outcomes at sensitive receptors across all quarters for a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Clerke Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Imperieuse Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Imperieuse)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

3.3.4 Dissolved Aromatic Hydrocarbon Dosage

576 ppb.hr

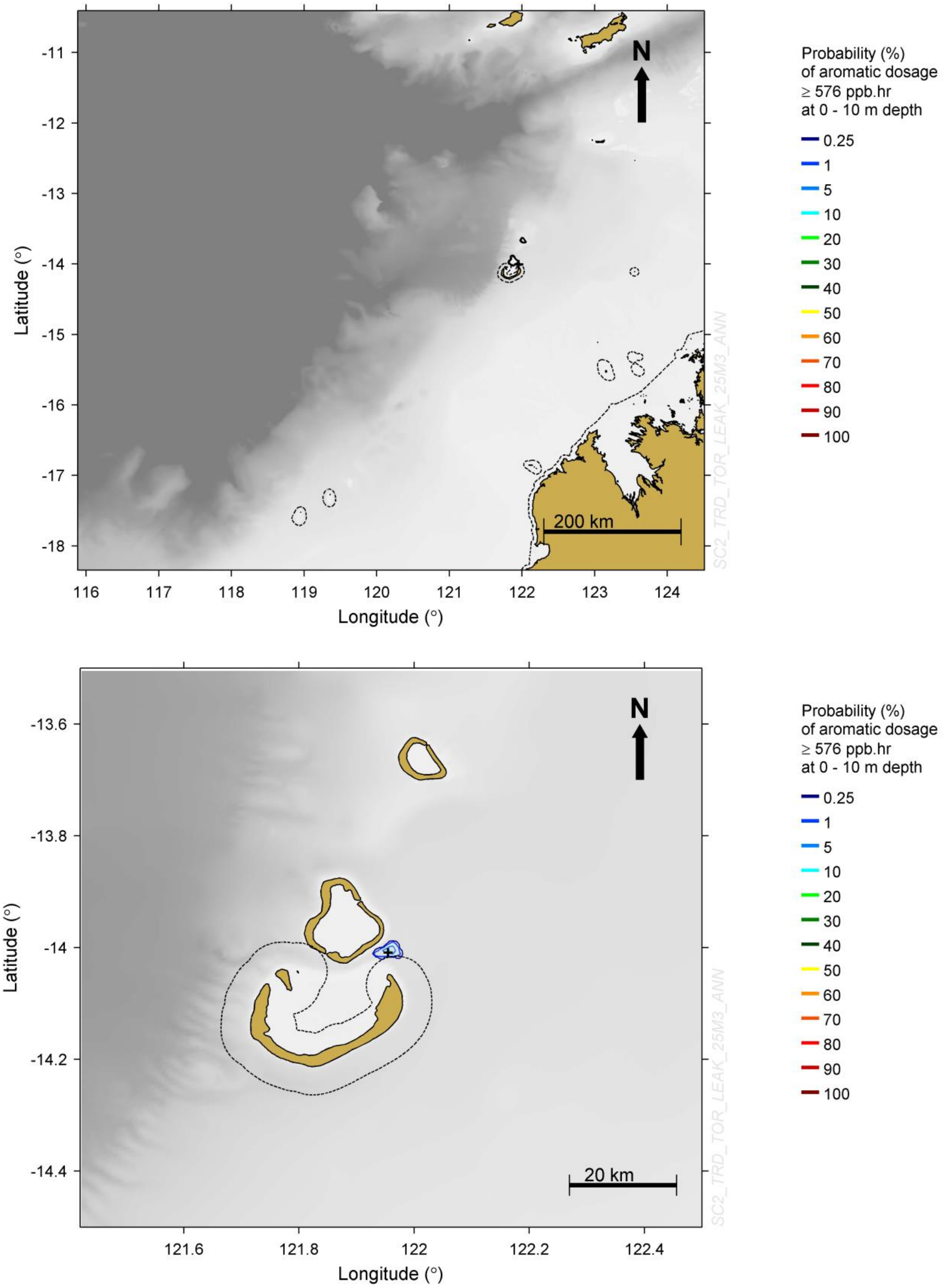
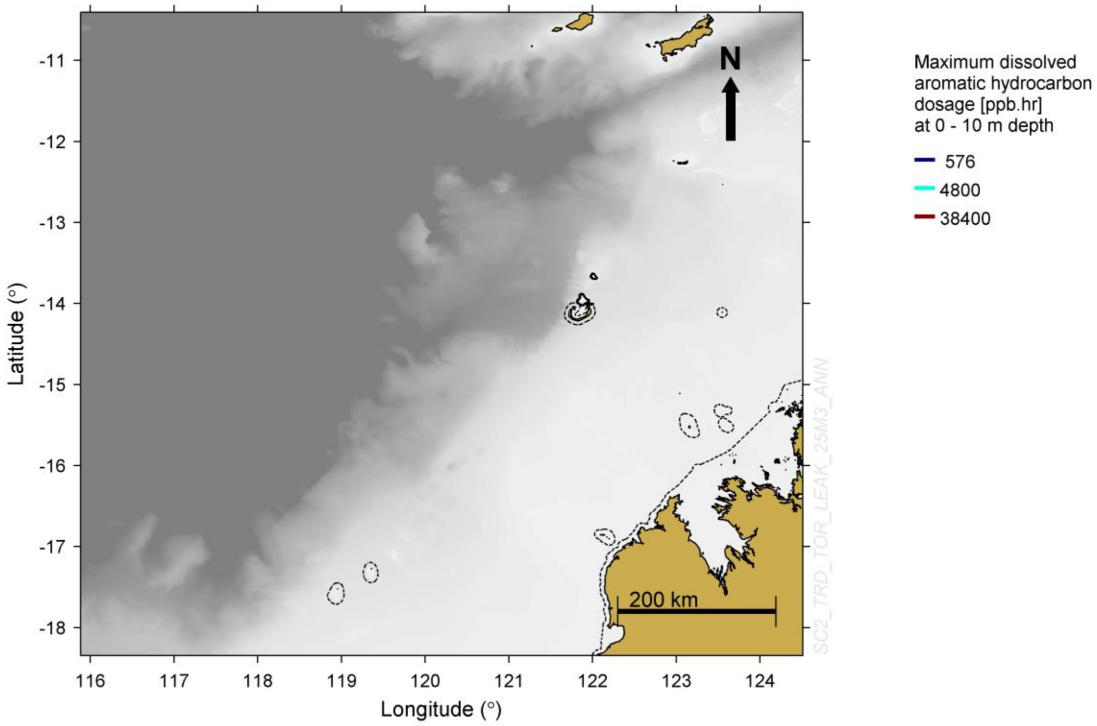


Figure 3-50: Predicted annualised probability(P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Maximum Aromatic Dosage



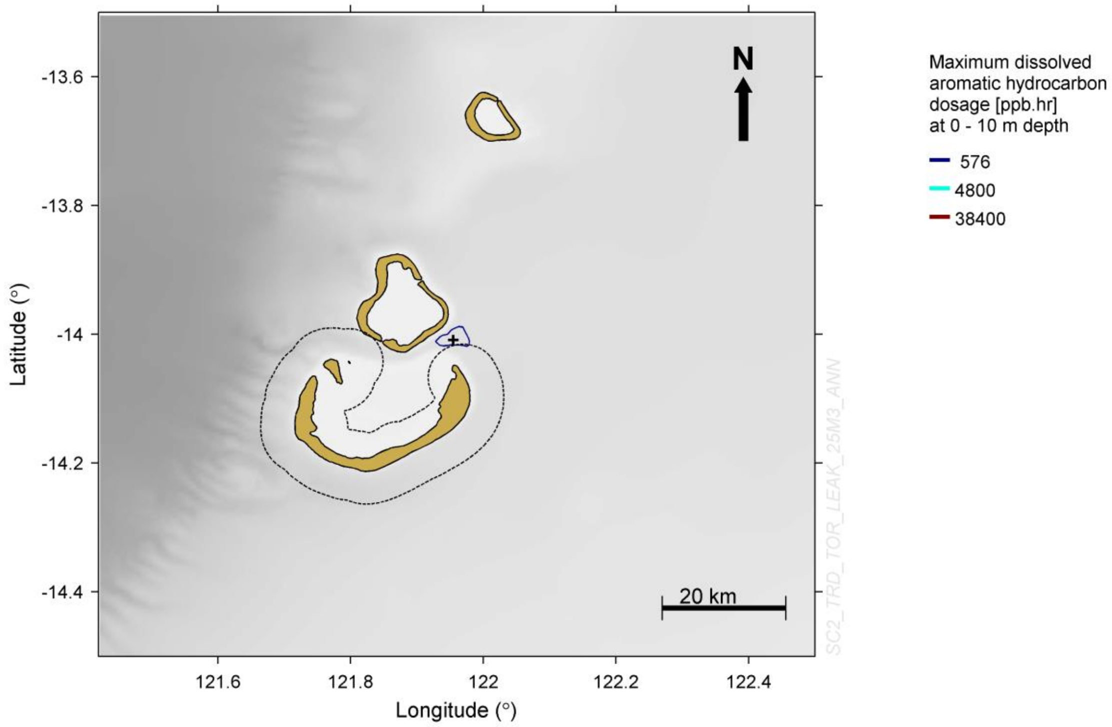


Figure 3-51: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 0 - 10 m (BMSL), resulting from a 60-minute 25 m³ seabed release of Torosa Condensate at the TRD location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

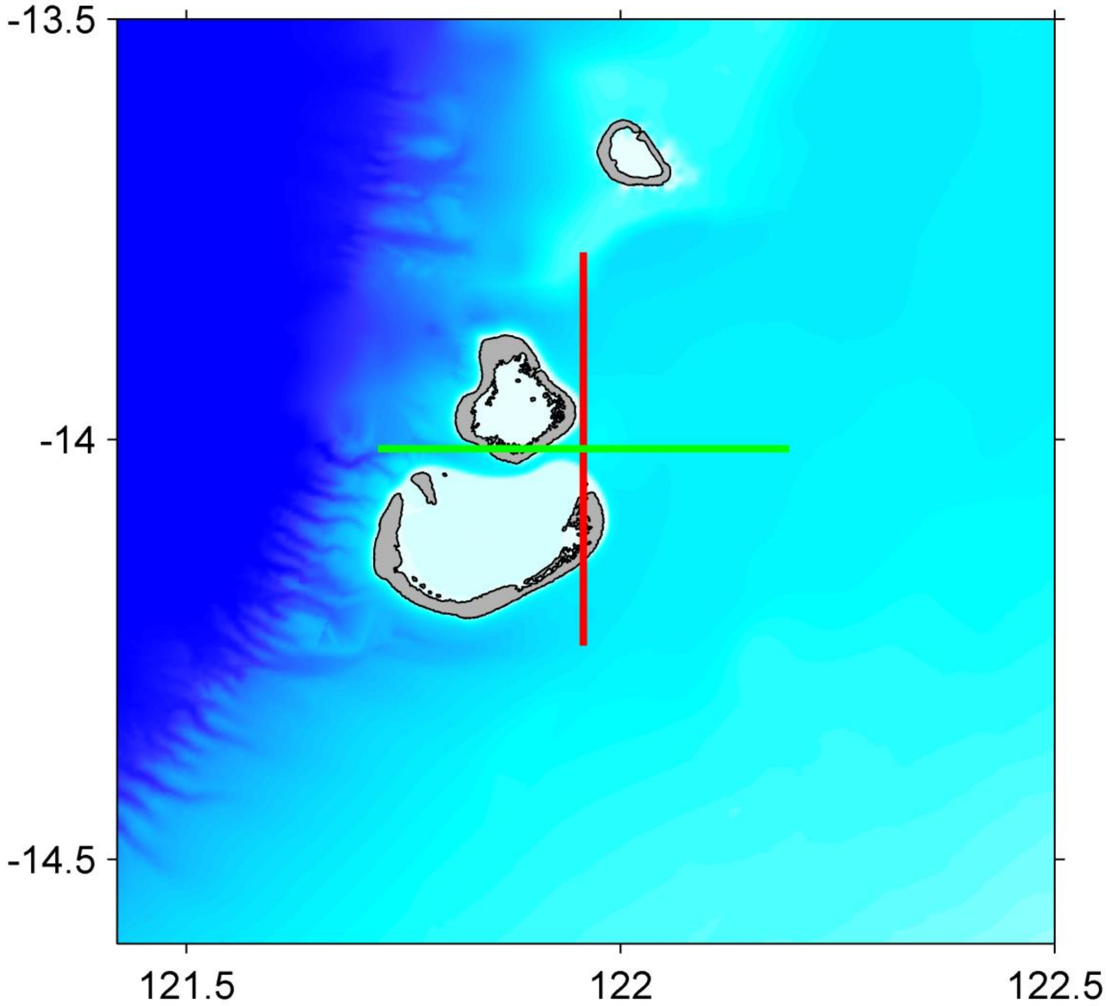


Figure 3-52: Location of the TRD location and the respective vertical transects over a varying latitude (red line) and longitude (green line).

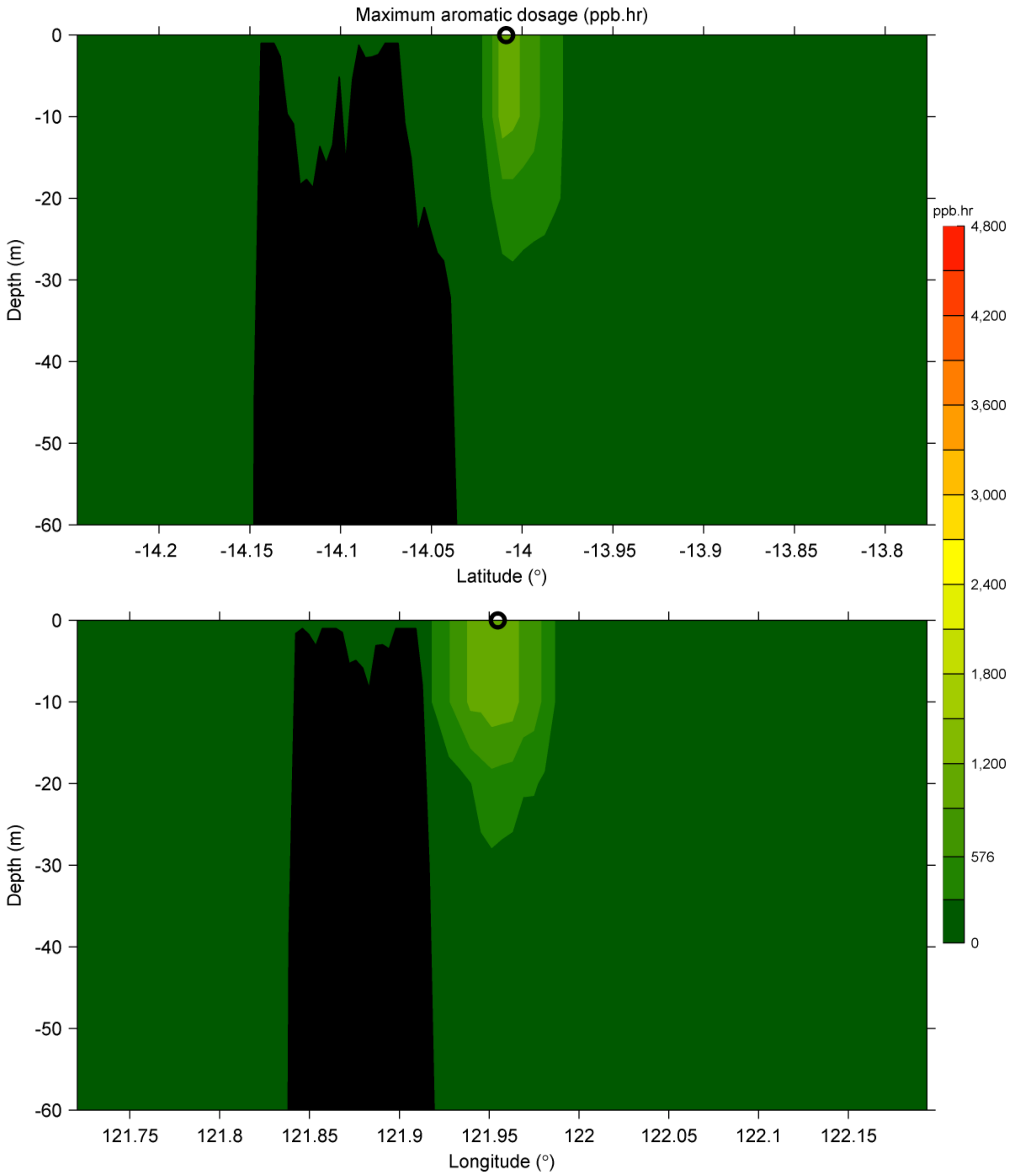


Figure 3-53: Vertical profile showing maximum annualised dissolved aromatic hydrocarbon dosage at a depth of 0 - 60 m (BMSL), across two perpendicular transects intersecting (top, north-south; bottom, east-west) the release reference (black circle over location of subsea release) from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location.

Table 3-8: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 60-minute 25 m³ seabed release of Torosa Condensate at the TRD location.

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Timor (West)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Pulau Roti	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Oceanic Shoals CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Hibernia Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1	2	NC	NC
Ashmore Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Ashmore Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Cartier Island CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	1	NC	NC
Cartier Islet	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Kimberley CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2	2	12	1

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-8: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Argo-Rowley Terrace CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Seringapatam Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	3	7	2	NC
North Reef Flats	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	461	164	31	50
North Reef Lagoon	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	193	22	8	BS
Kimberley Coast	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
South Reef Lagoon	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	120	70	13	1
SR Central/ Sandy Islet	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	3	9	BS	BS
South Reef Flats	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	20	29	6	NC
Browse Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-8: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 60-minute 25 m^3 seabed release of Torosa Condensate at the TRD location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Lalang-garram / Camden Sound MP	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Camden Sound	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Adele Island	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	NC	NC	BS	BS
Mermaid Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Mermaid Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Clerke Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Imperieuse Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Rowley Shoals MP (Imperieuse)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

3.4 Scenario 3.2: Simulation of a 20-minute Surface Release of 165.3 m^3 of Browse Condensate at the TRD8 Location

This scenario investigated the probability of exposure to surrounding regions by oil due to a surface release of Browse Condensate at the TRD8 location, with a total discharge volume of 165.3 m^3 over 20-minutes.

Table 3-9: Summary of the spill scenario.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (mBMSL)
3.2	FLNG topside leak, 8 km ENE of the TRD location, due to equipment failure	Browse Condensate	165.3	1.73×10^{-3}	20 mins	13° 59' 22.06" S 122° 1' 36.12" E	Surface

The modelling for this scenario assumed no mitigation efforts are undertaken to collect or otherwise affect the natural transport and weathering of the oil. All sensitive receptors outlined in Section 2.3.6 were analysed; however, only the receptors that were forecast to be contacted by dispersing oil are summarised in this section.

Average Weathering

The average mass balance shows high evaporation during the release with approximately 70% of the oil evaporated after 24 hours, increasing to nearly 80% over 21 days. Approximately 15% of the oil is entrained on average during the first 6 days and very little oil is expected to remain floating on the surface after approximately 10 days (Figure 3-54 and Figure 3-55).

The amount of aromatic hydrocarbons present in the floating oil decreases relatively rapidly after the cessation of the release due to high rates of evaporation of the more volatile components (Figure 3-56 and Figure 3-57). After 10 days, when there remains little floating oil and therefore remnant aromatics, approximately 10% of the initial aromatic mass is expected to be dissolved into the water column.

Trajectory and Weathering of an Example Replicate

An example series of snapshots of a single predicted spill trajectory are presented in Figure 3-58, with associated weathering and fates plots in Figure 3-59. The snapshots display the concentration of oil floating on the water surface based on specified surface oiling thresholds.

The single spill trajectory analysis shows that one day after the spill (Figure 3-58 b) an oil slick has drifted to the west of the spill site and towards Scott Reef North with a maximum local concentration of approximately 10 g/m^2. After 3 days (Figure 3-58 c) the film has drifted over Scott Reef North and the maximum concentration is approximately 5 g/m^2. After 5 days, the maximum concentration within the oil slick has reduced below 0.5 g/m^2 (Figure 3-58 d).

The weathering curve associated with the single spill trajectory analysis shows that just under 80% of the oil is expected to evaporate within 24 hours of the release under these conditions

(Figure 3-59). The wind speeds were generally low during this simulation, with a small amount of entrainment resulting from two main exceedences above around 6 m/s. The winds were from the east to southeast during the early part of the simulation, assisting in the drift towards Scott Reef North.

Floating Oil

The probability (P_2) contours show that floating oil with concentrations at or above 1 g/m^2 are forecast up to 200 km from the release site (Figure 3-60). At the 10 g/m^2 threshold floating oil is forecast up to 40 km from the release site in isolated patches, with a maximum swept area of 21 km^2 (Figure 3-61). Floating oil is forecast to travel to the northeast, east or south of the release site. The return-period probabilities (P_1xP_2) at these thresholds are shown in Figure 3-62 and Figure 3-63.

Maximum floating oil concentrations at or above 50 g/m^2 is forecast up to approximately 10 km from the release site (Figure 3-64). The potential areas affected by floating oil at or above the defined thresholds during individual spill events are quantified in Table 3-10. Note that there is a significant variation between events in terms of the degree of floating oil impact. In some cases initial evaporation and likely entrainment may result in a very small surface footprint, while in other cases weak winds may lead to the advection of thicker slicks over larger areas.

Table 3-10: The potential swept area (km^2) of floating oil with concentrations exceeding defined threshold concentrations in any single spill event. The swept area refers to all areas covered by the slick during the spill simulation with a concentration at the specified threshold.

	0.5 g/m²	1 g/m²	10 g/m²	25 g/m²
Minimum potential area (km²)	2.8	2.4	1.6	0.8
Median potential area (km²)	94.3	61.8	9.1	3.6
Mean potential area (km²)	137.9	80.8	9.9	3.6
Maximum potential area (km²)	1,058	458.3	28	8.3

Floating oil with concentrations of 10 g/m^2 or greater is expected to pass through North Reef Flats at a forecast probability of 0.25%, equating to contact during 1 of the 400 simulations completed (Table 3-11). At the 1 g/m^2 threshold Seringapatam Reef (0.5%), North Reef Lagoon (4.75%), South Reef Lagoon (7.75%) and South Reef Flats (4.25%) are also forecast to be contacted, with a maximum probability of contact of 8.75% forecast for North Reef Flats.

The minimum time expected for floating oil at the lowest defined threshold (0.5 g/m^2) to reach any receptor is 7 hours at North Reef Flats (8 hours at 10 g/m^2 or greater), followed by 10 hours at South Reef Lagoon. The worst-case locally accumulated shoreline concentration is expected at Scott Reef Central/ Sandy Islet at 124 g/m^2, however the maximum accumulated volume is expected to be below 1 m^3.

Dissolved Aromatic Hydrocarbon Dosage

Dissolved aromatic hydrocarbon dosage at or above the low dosage threshold of 576 ppb.hr is forecast to occur up to 15 km from the release site within the upper 20 m of the water column (Figure 3-71 and Figure 3-72).

Figure 3-74 shows the vertical distribution of the maximum dissolved aromatic hydrocarbon dosage along 2 perpendicular intersections of the release site (Figure 3-73). The east-west transect passes through North Scott Reef and shows the maximum dosage occurring west of the release site near the Reef.

The dissolved aromatic hydrocarbon dosage threshold of 576 ppb.hr is forecast to be exceeded within North Reef Flats in the surface layer during one of the 400 simulations (Table 3-12).

3.4.1 Average Weathering

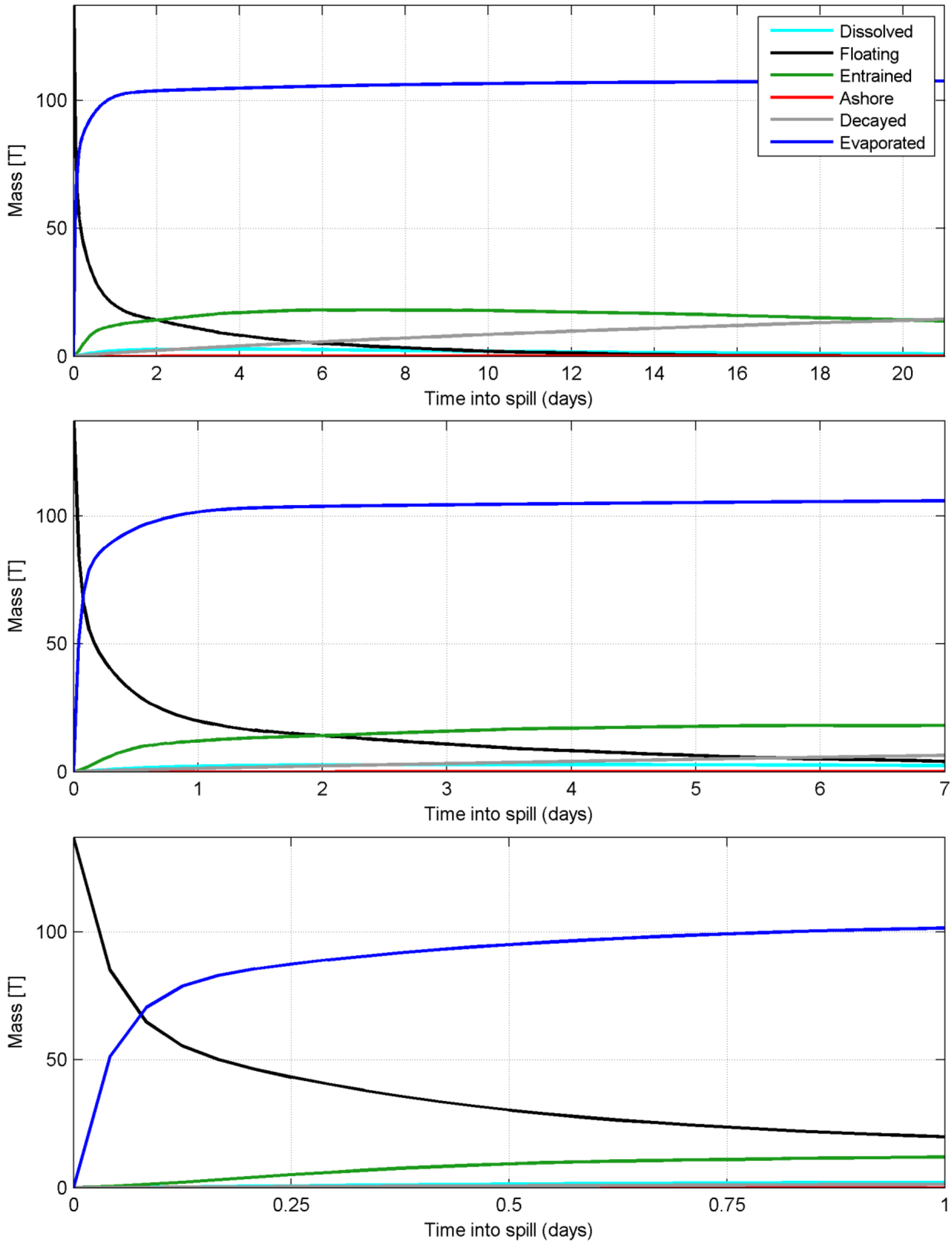


Figure 3-54: Predicted average weathering mass balance (tonnes) resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 21 days (top), 7 days(middle) and 24 hours (bottom) is given.

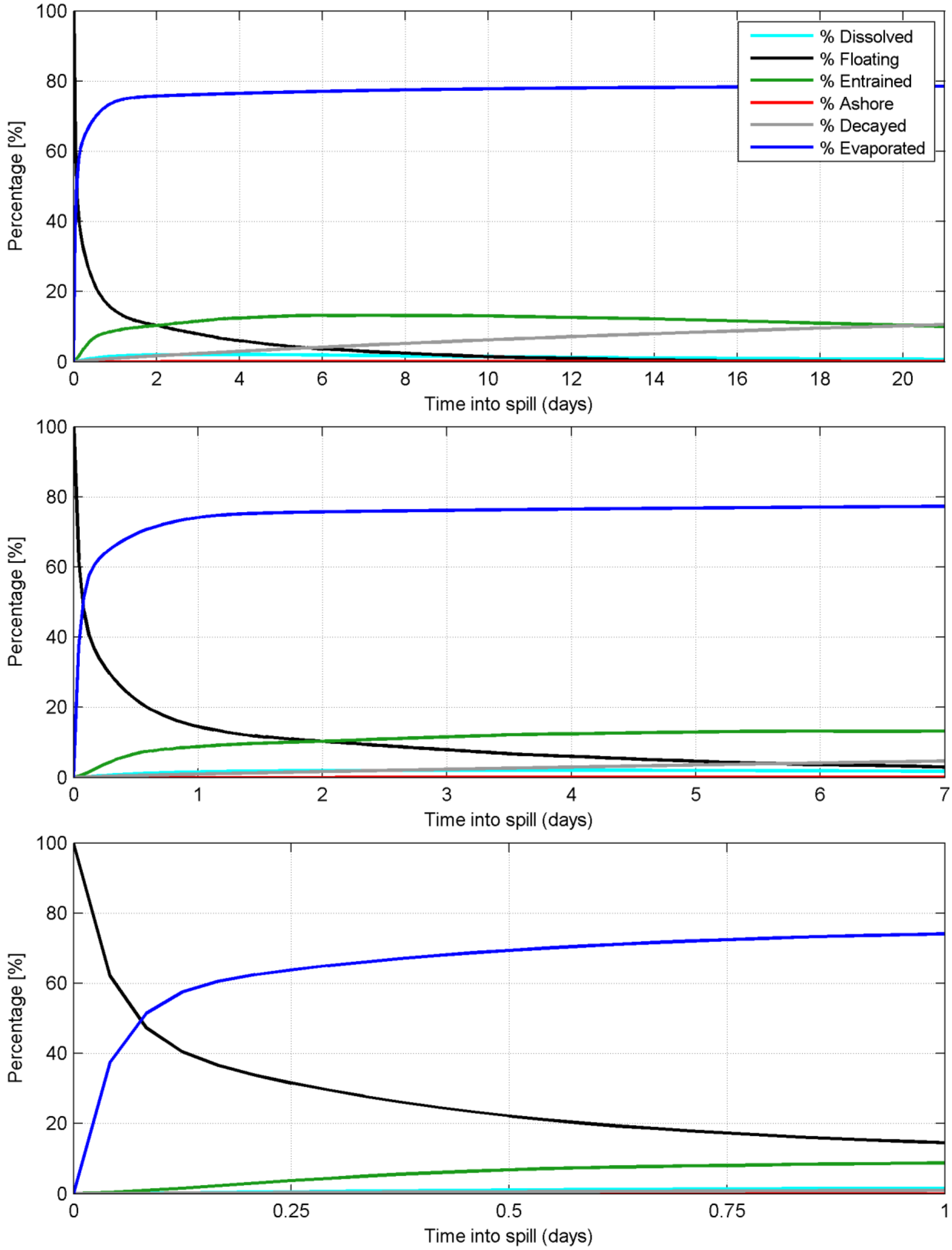


Figure 3-55: Predicted average weathering mass balance (% of total mass) weathering graph resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 21 days (top), 7 days (middle) and 24 hours (bottom) is given.

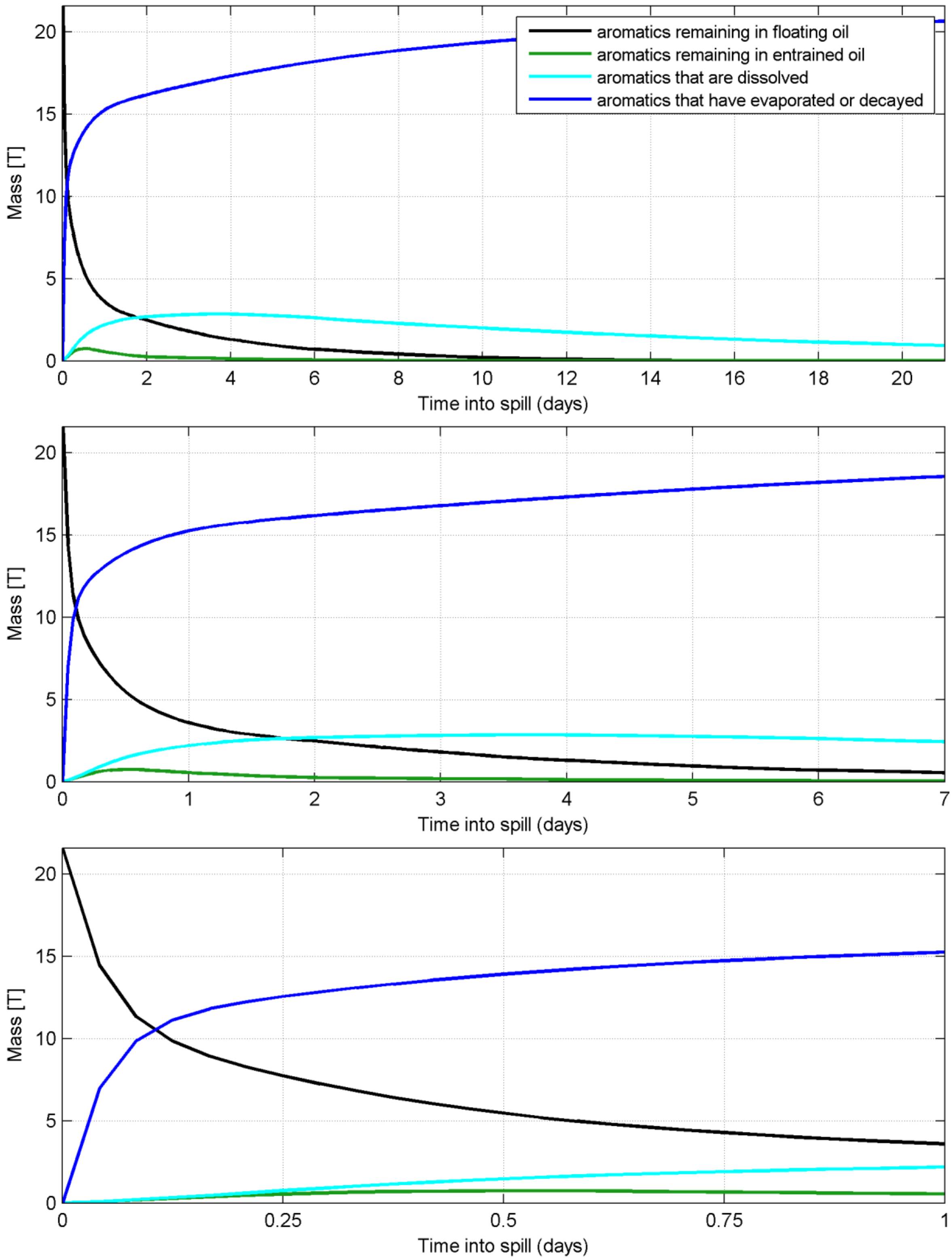


Figure 3-56: Predicted average partitioning of the aromatic hydrocarbons (tonnes) resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 21 days (top), 7 days (middle) and 24 hours (bottom) is given.

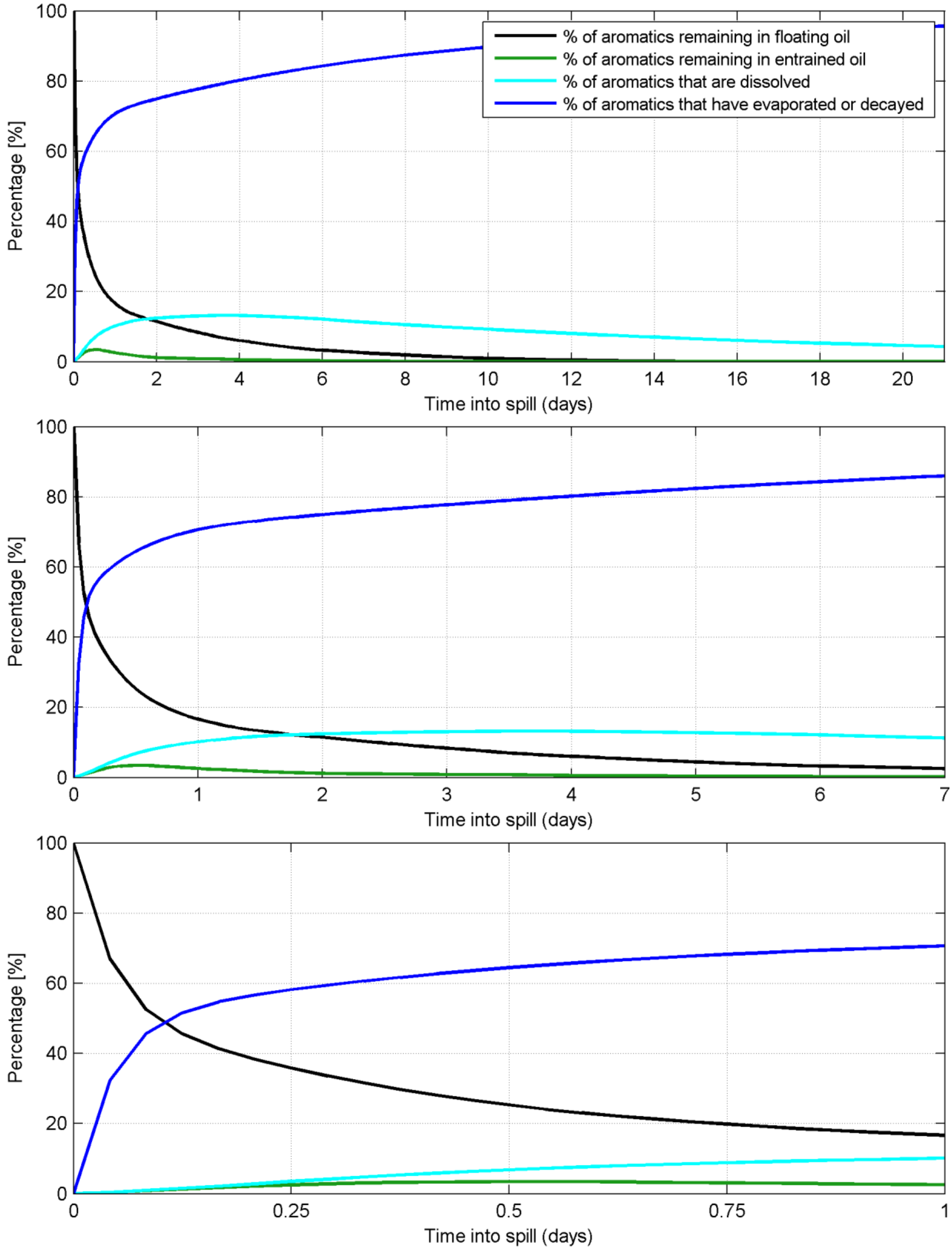


Figure 3-57: Predicted average partitioning of the aromatic hydrocarbons (% of total mass) resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 21 days (top), 7 days (middle) and 24 hours (bottom) is given.

3.4.2 Trajectory and Weathering of an Example Replicate

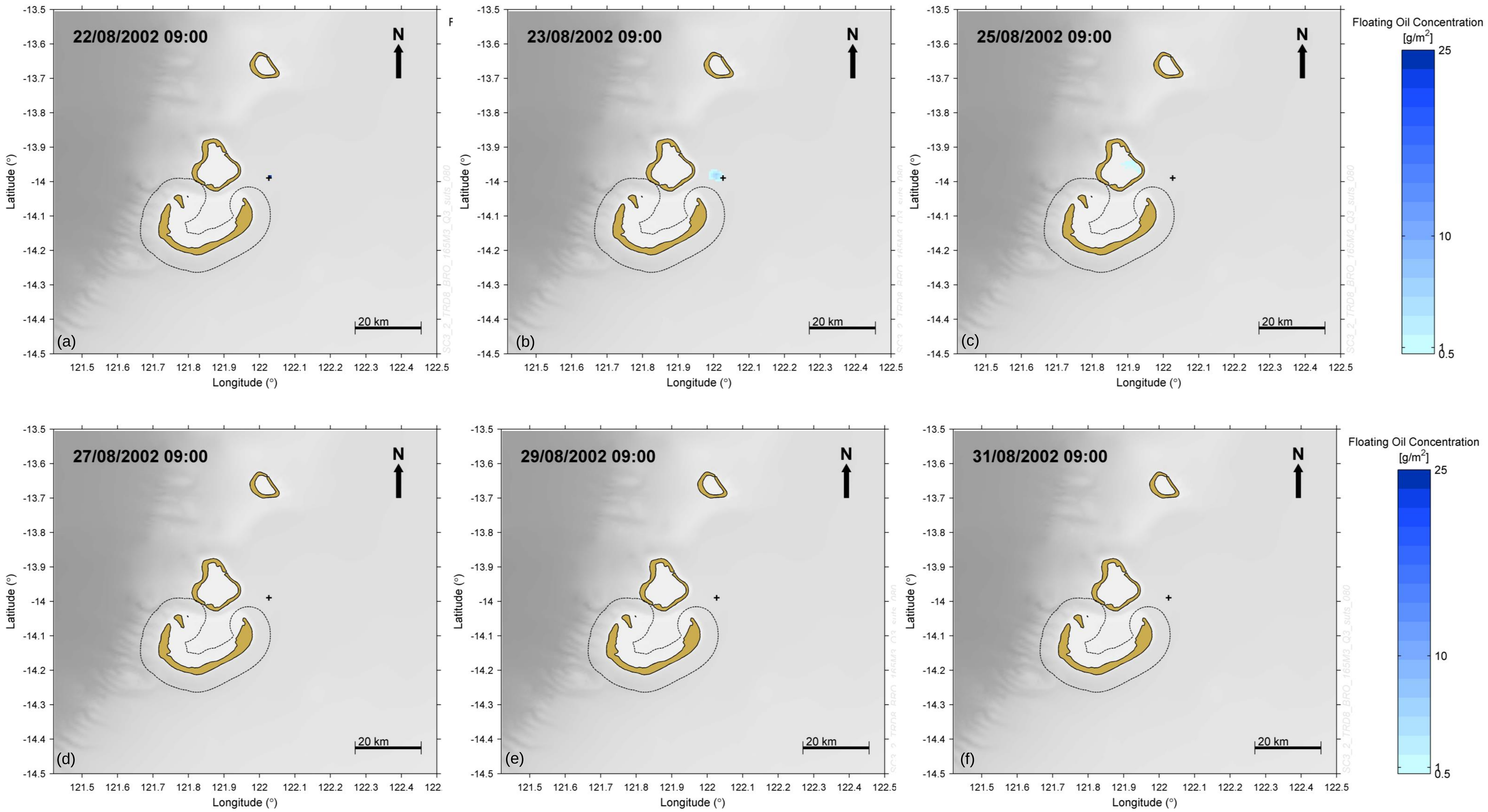


Figure 3-58: Example trajectory and concentration of floating oil for a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location, commencing at 09:00 on the 22 of August, 2002. The resultant trajectory and concentration at the start of the release (a), 1 day (b), 3 days (c), 5 days (d), 7 days (e) and 9 days (f) after the start of the release are presented.

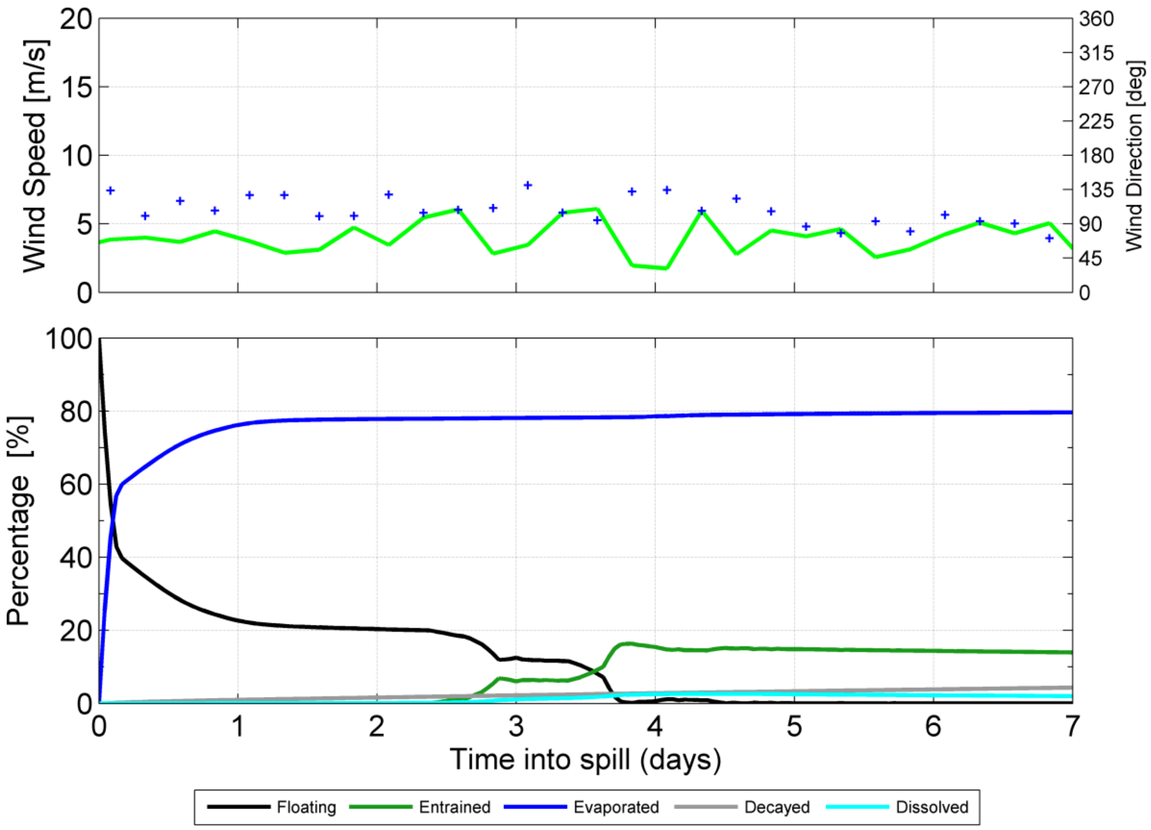


Figure 3-59: Predicted mass balance weathering resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location, commencing at 09:00 on the 22 of August, 2002. The green line in the top figure indicates the wind speed and the blue dots indicate the wind direction (FROM).

3.4.3 Floating Oil

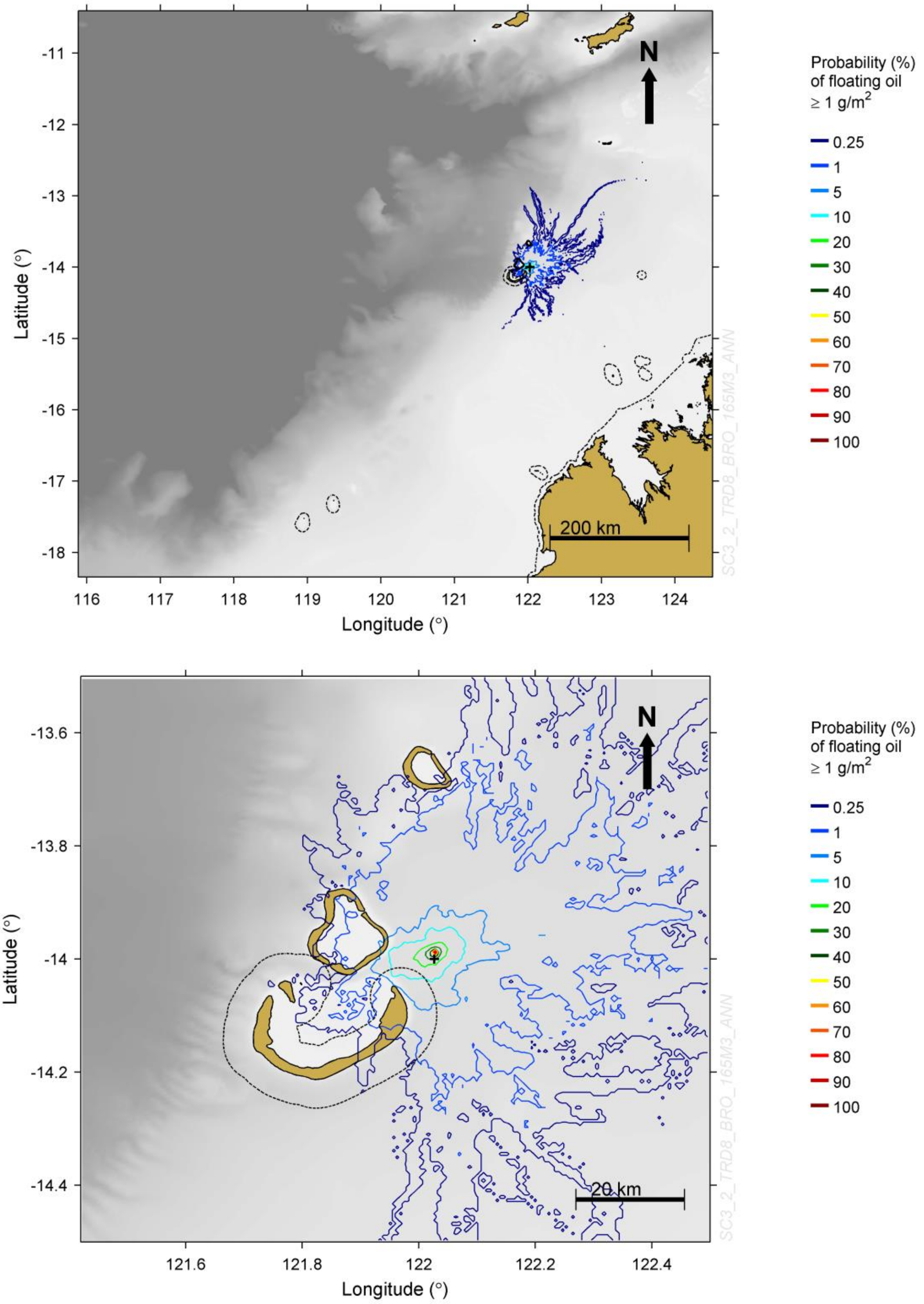
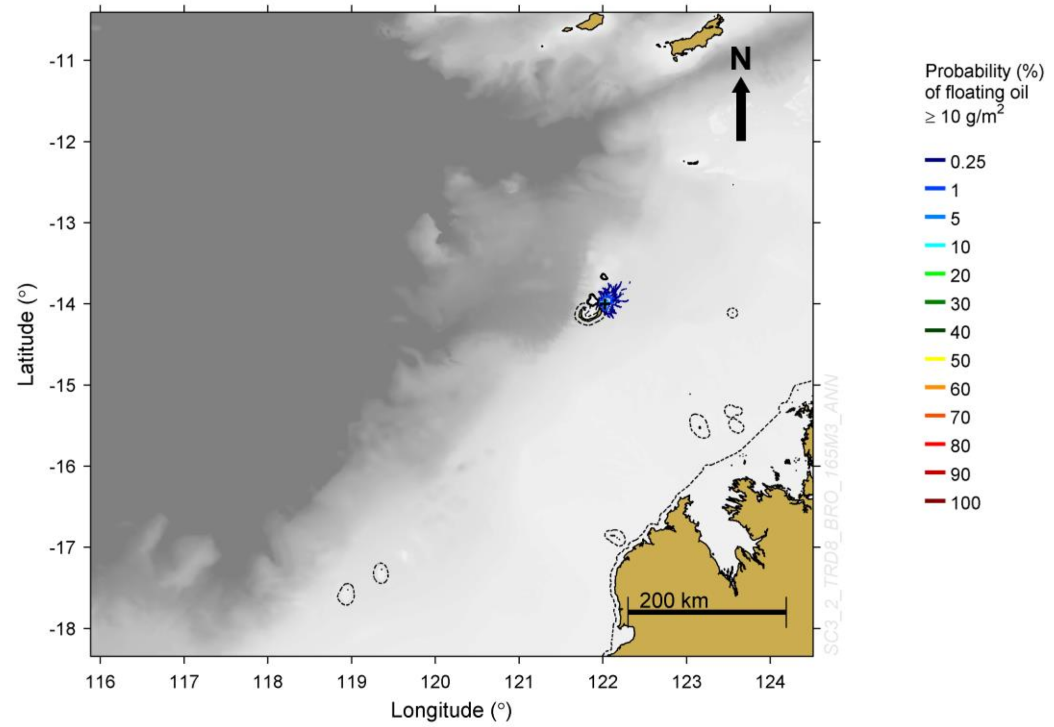


Figure 3-60: Predicted annualised probability (P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



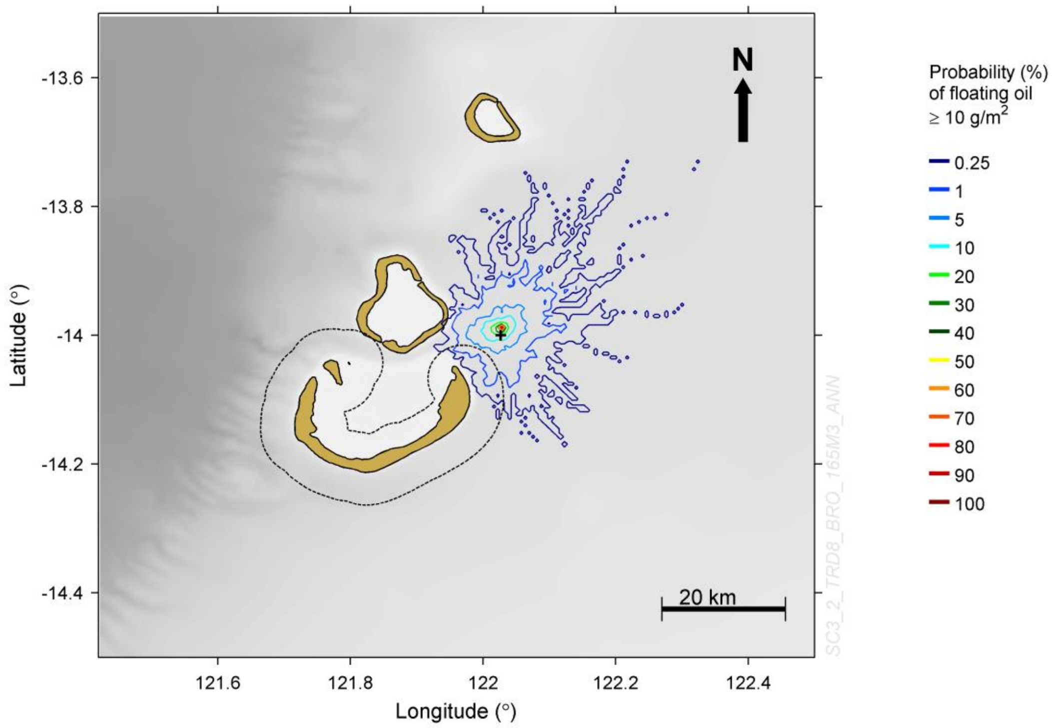


Figure 3-61: Predicted annualised probability (P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

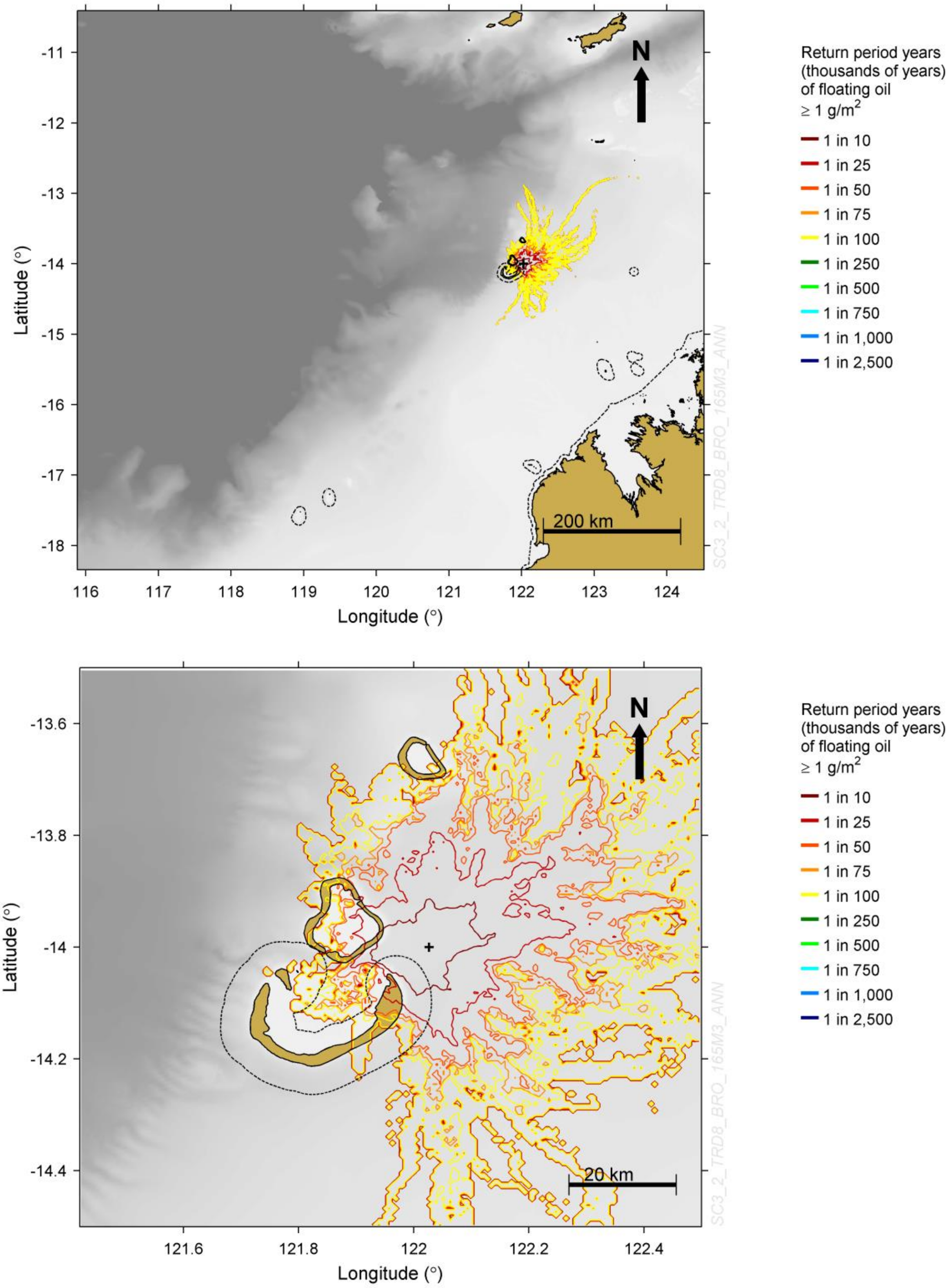
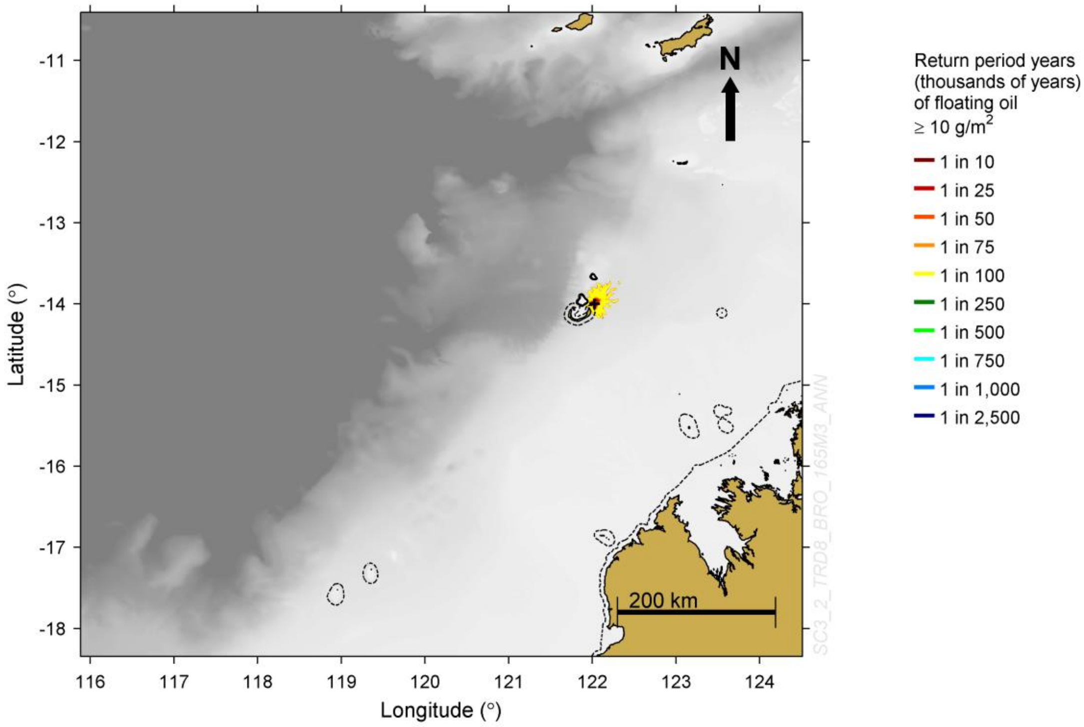


Figure 3-62: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 1 g/m^2 resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



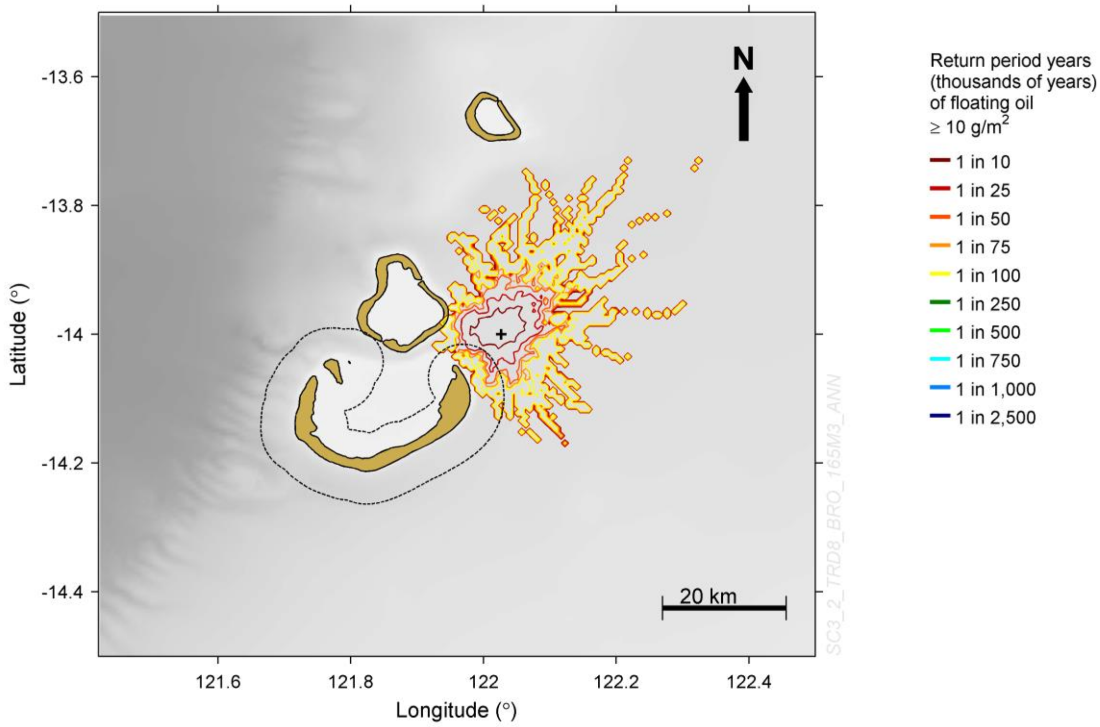


Figure 3-63: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 10 g/m^2 resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

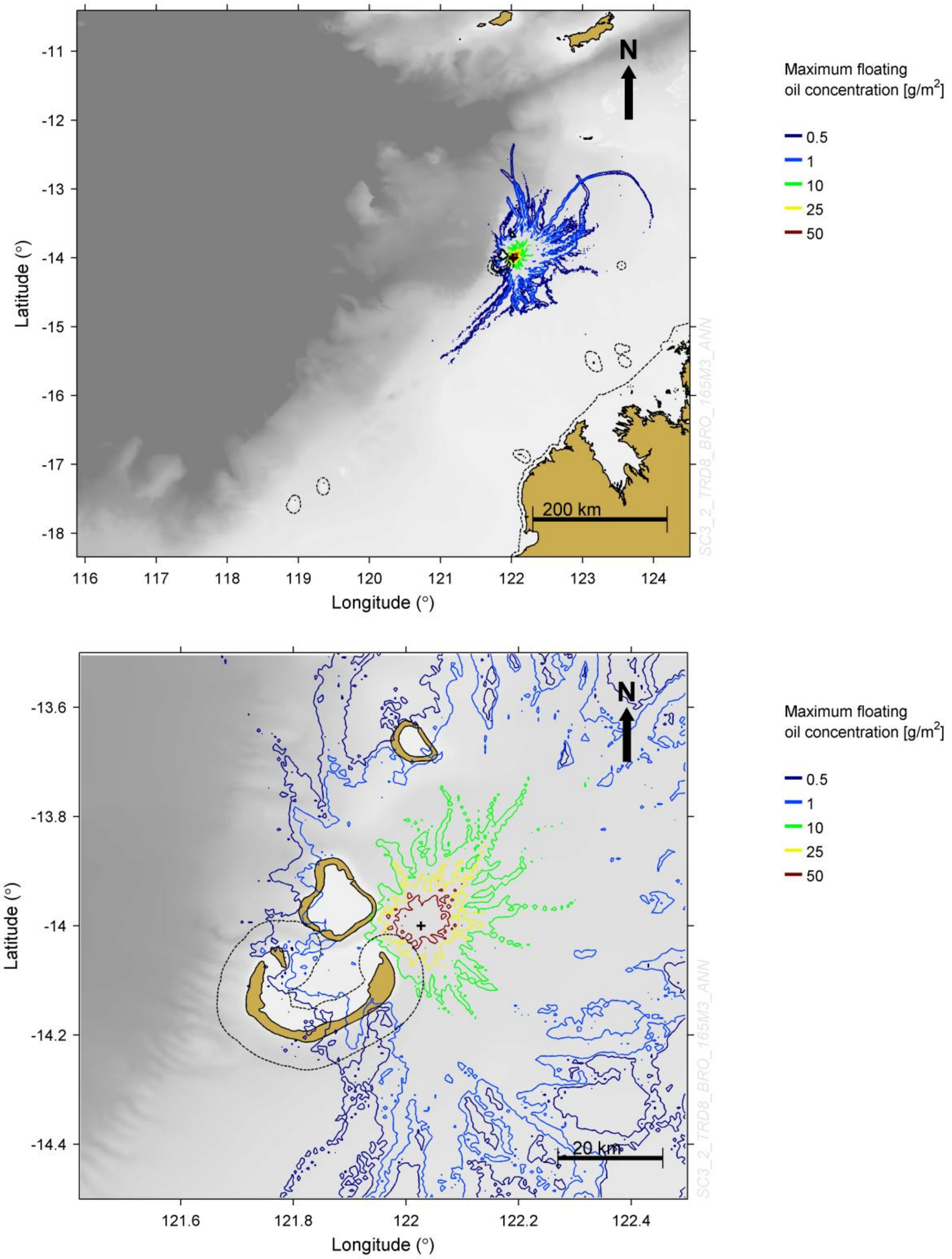


Figure 3-64: Predicted maximum floating oil concentration resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

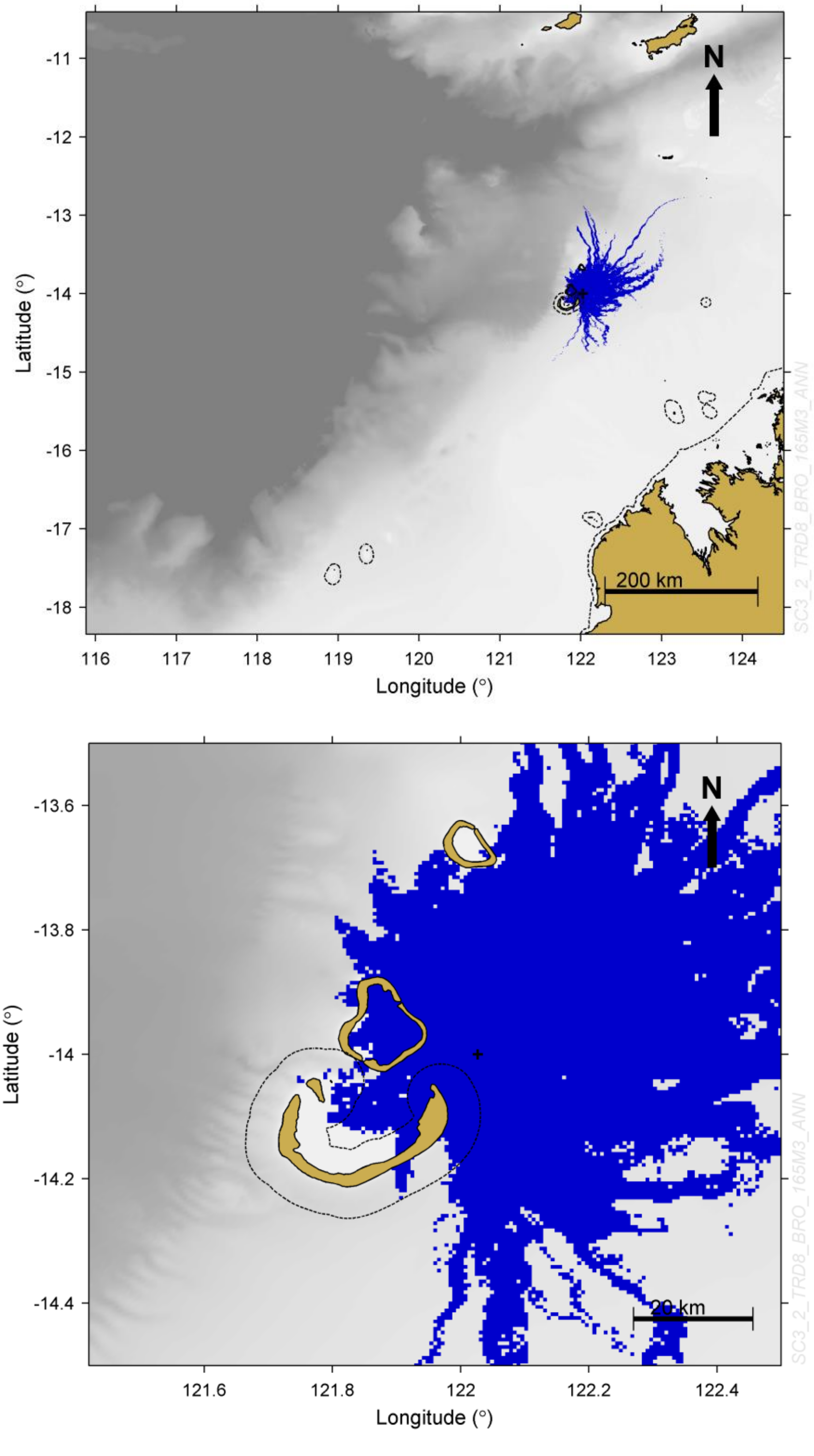
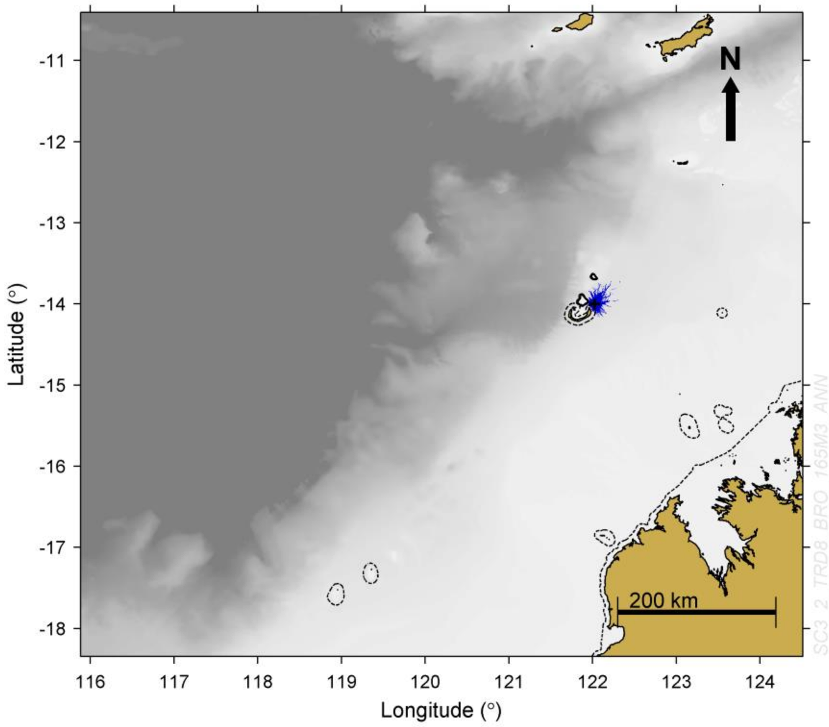


Figure 3-65: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 1 g/m² resulting from a 20-minute 165.3 m³ surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



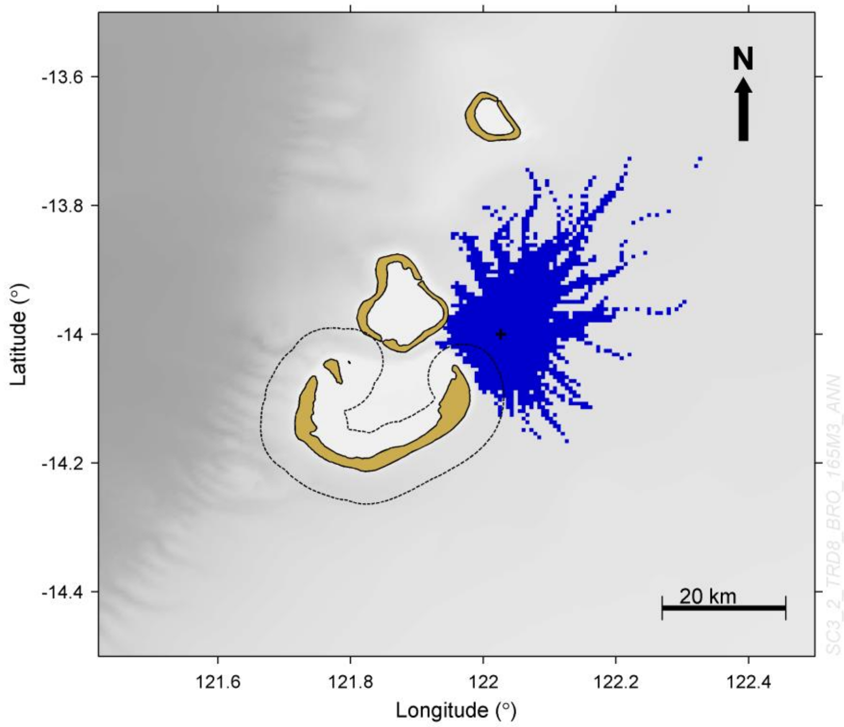


Figure 3-66: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 10 g/m^2 resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

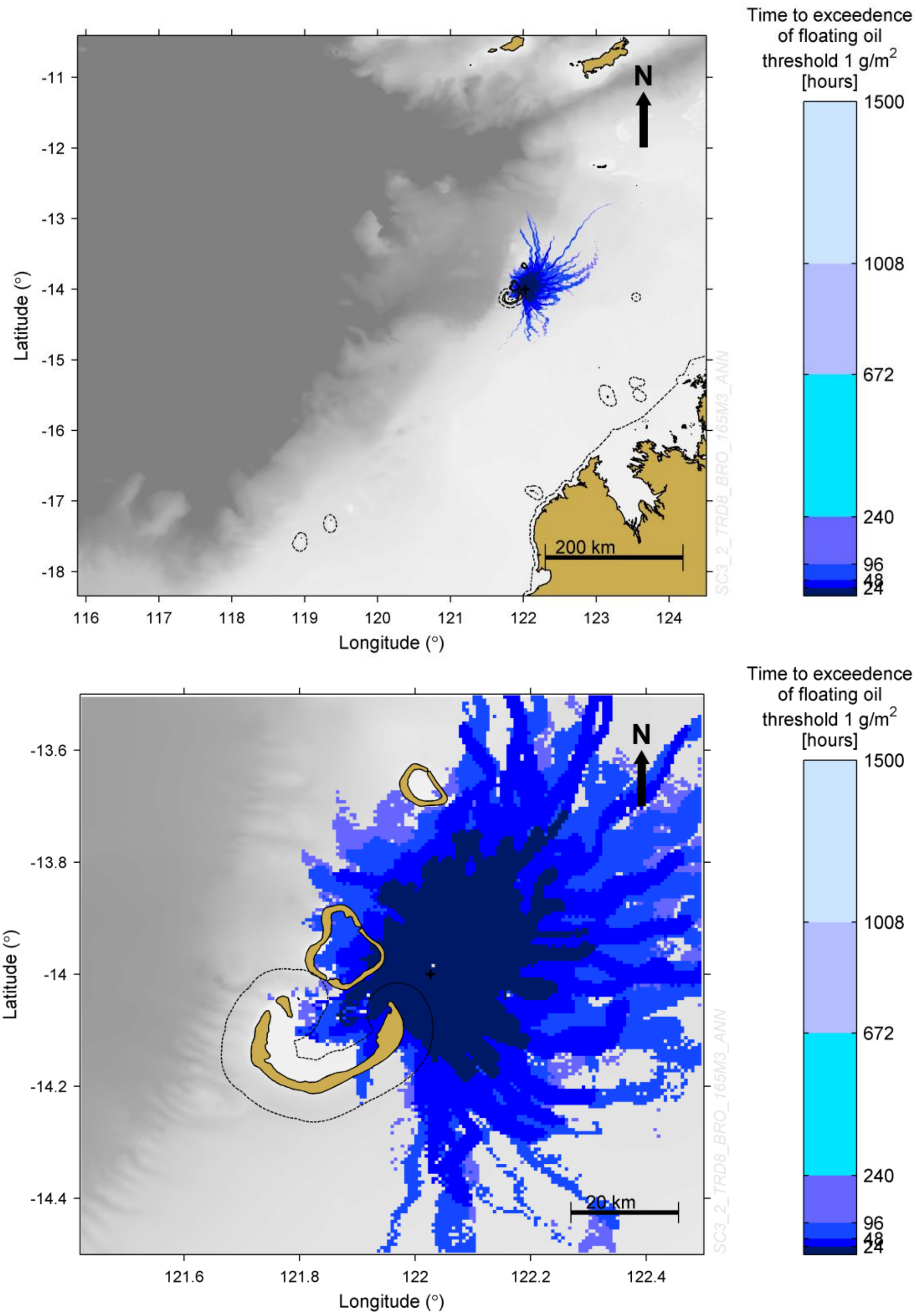


Figure 3-67: Predicted annualised minimum times to threshold for floating oil at or above 1 g/m^2 resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

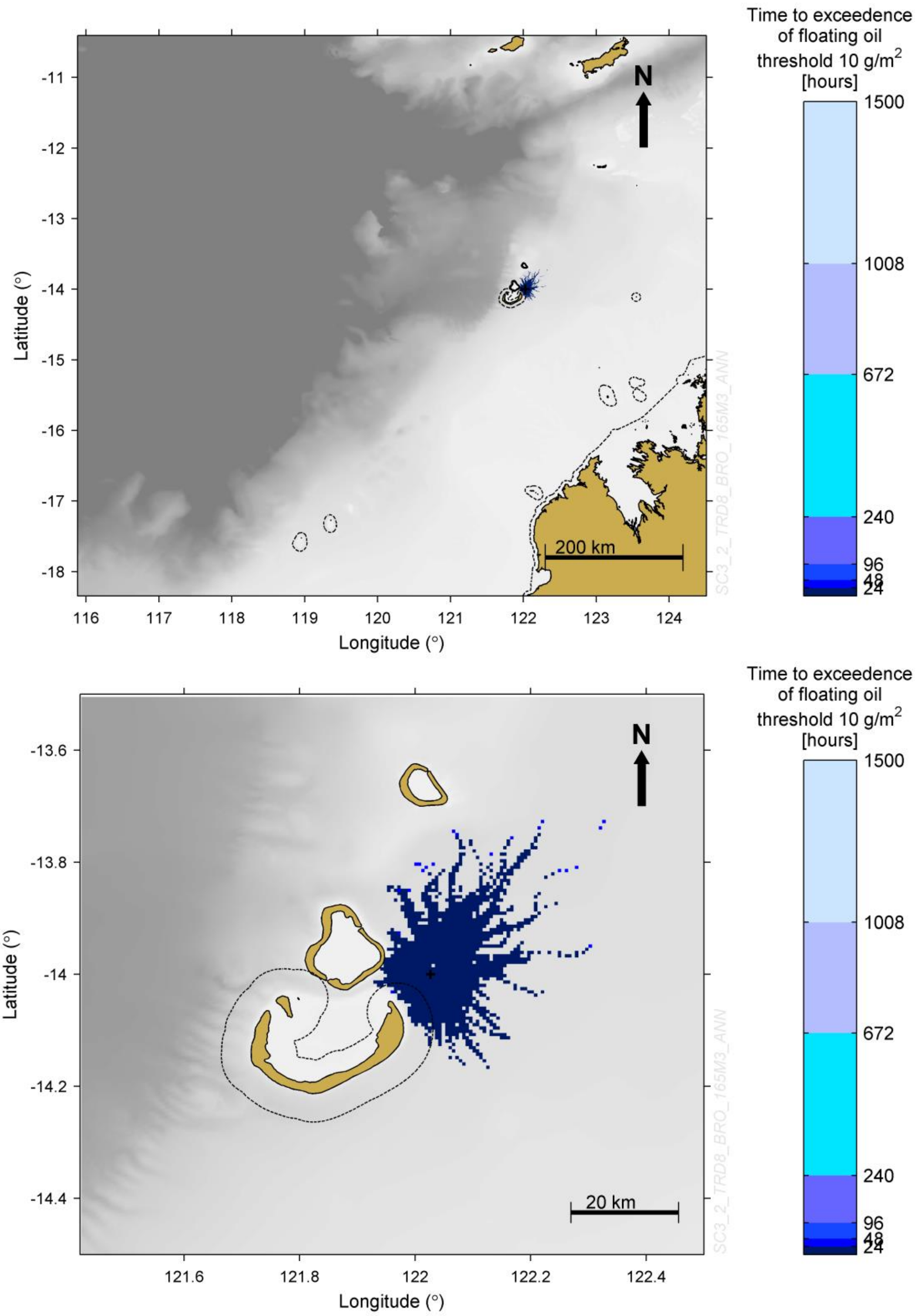


Figure 3-68: Predicted annualised minimum times to threshold for floating oil at or above 10 g/m² resulting from a 20-minute 165.3 m³ surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Table 3-11: Expected floating oil outcomes at sensitive receptors across all quarters for a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location.

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Timor (West)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Pulau Roti	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Oceanic Shoals CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Ashmore Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Cartier Island CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Cartier Islet	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Kimberley CMR*	0.5	<0.25	<0.25	<0.25	155	NC	NC	NC	NC	NC	NC	NC
Argo-Rowley Terrace CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Seringapatam Reef	0.75	0.5	<0.25	<0.25	97	114	NC	NC	NC	NC	NC	NC
North Reef Flats*	11.75	8.75	0.25	<0.25	7	7	8	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-11: Expected floating oil outcomes at sensitive receptors across all quarters for a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
North Reef Lagoon*	6.75	4.75	<0.25	<0.25	11	11	NC	NC	NC	NC	NC	NC
Kimberley Coast	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
South Reef Lagoon*	10.75	7.75	<0.25	<0.25	10	10	NC	NC	NC	NC	NC	NC
SR Central/ Sandy Islet	0.25	<0.25	<0.25	<0.25	132	NC	NC	NC	1.5	124	<1	<1
South Reef Flats*	6.25	4.25	<0.25	<0.25	15	15	NC	NC	NC	NC	NC	NC
Browse Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	18	<1	<1
Lalang-garram / Camden Sound MP	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Camden Sound	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Adele Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Mermaid Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Mermaid Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-11: Expected floating oil outcomes at sensitive receptors across all quarters for a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Clerke Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Imperieuse Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Imperieuse)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

3.4.4 Dissolved Aromatic Hydrocarbon Dosage

576 ppb.hr

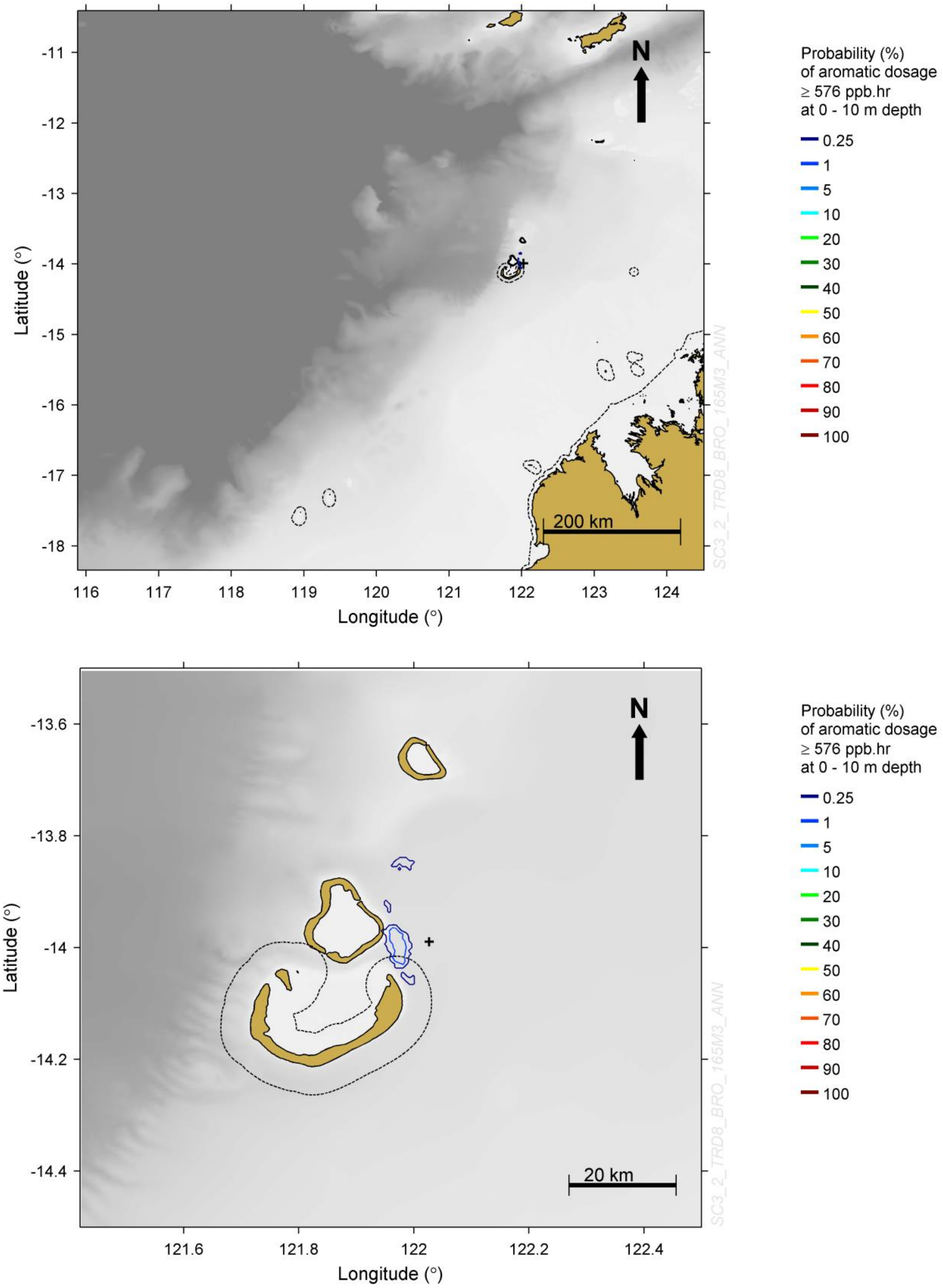
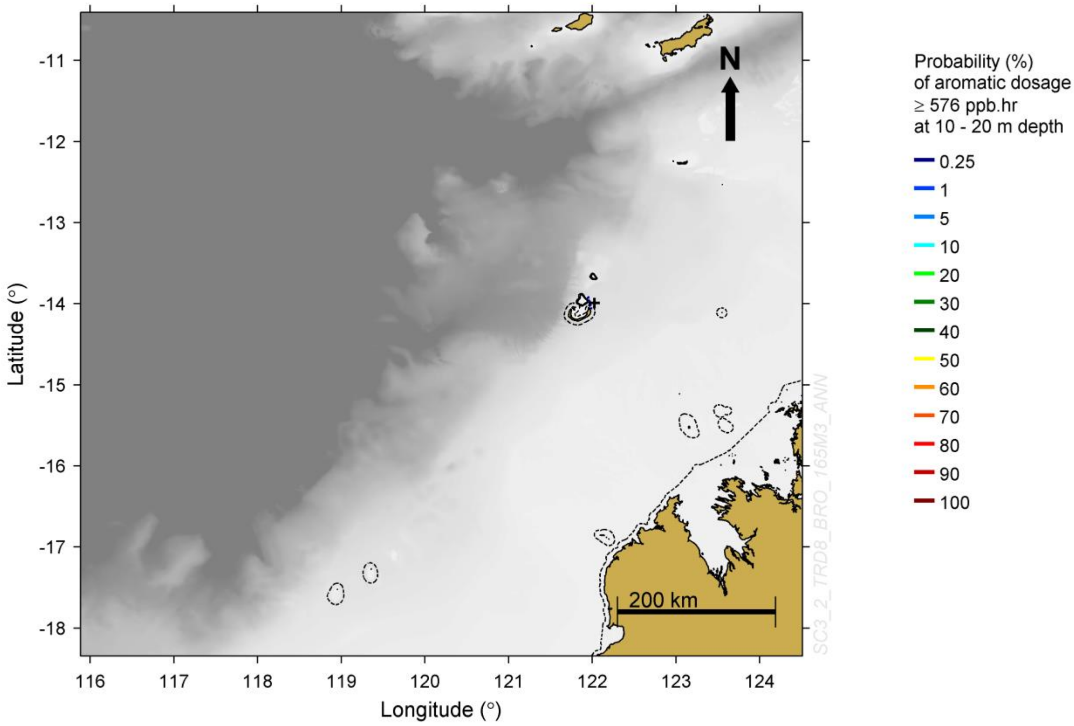


Figure 3-69: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



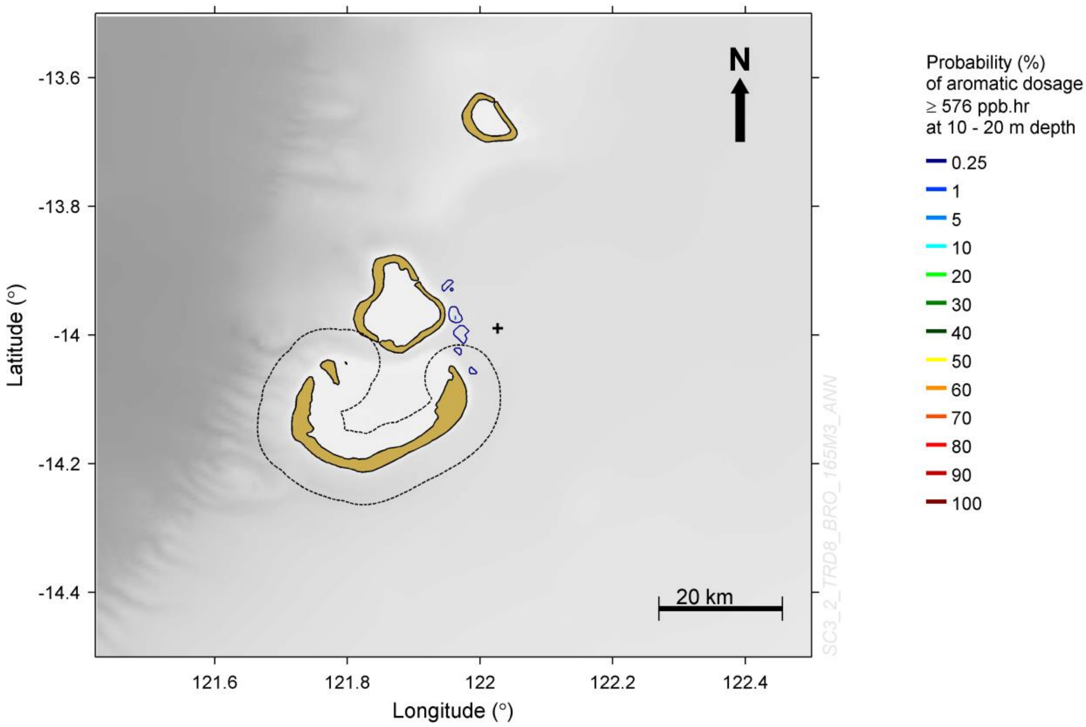
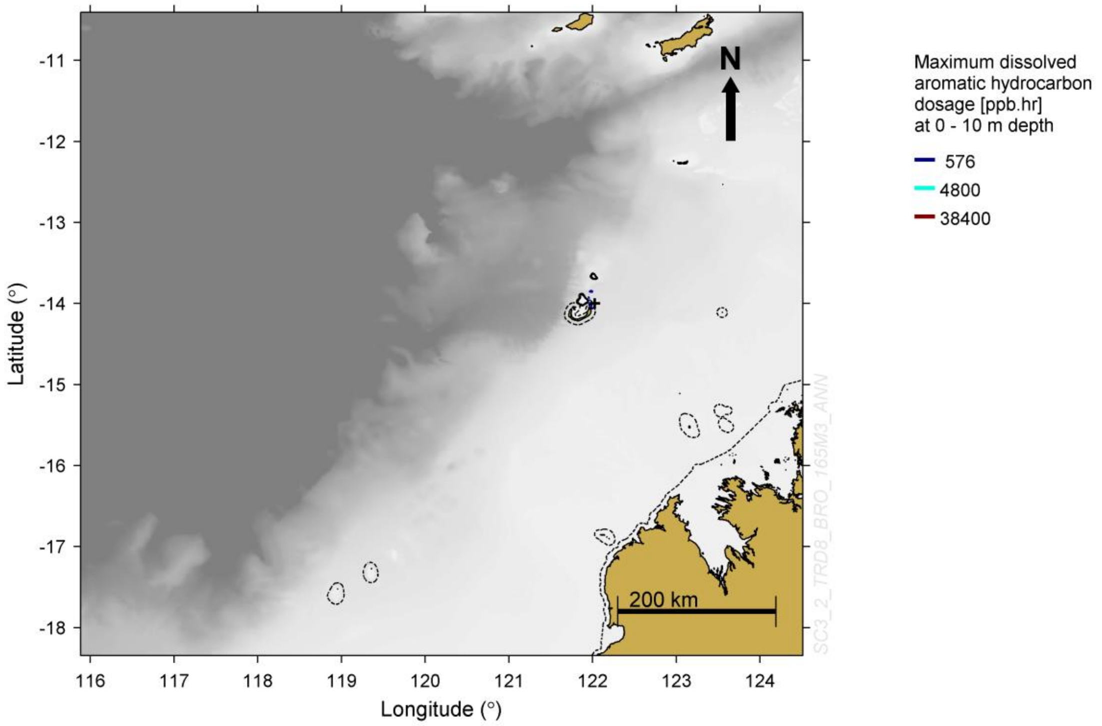


Figure 3-70: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Maximum Aromatic Dosage



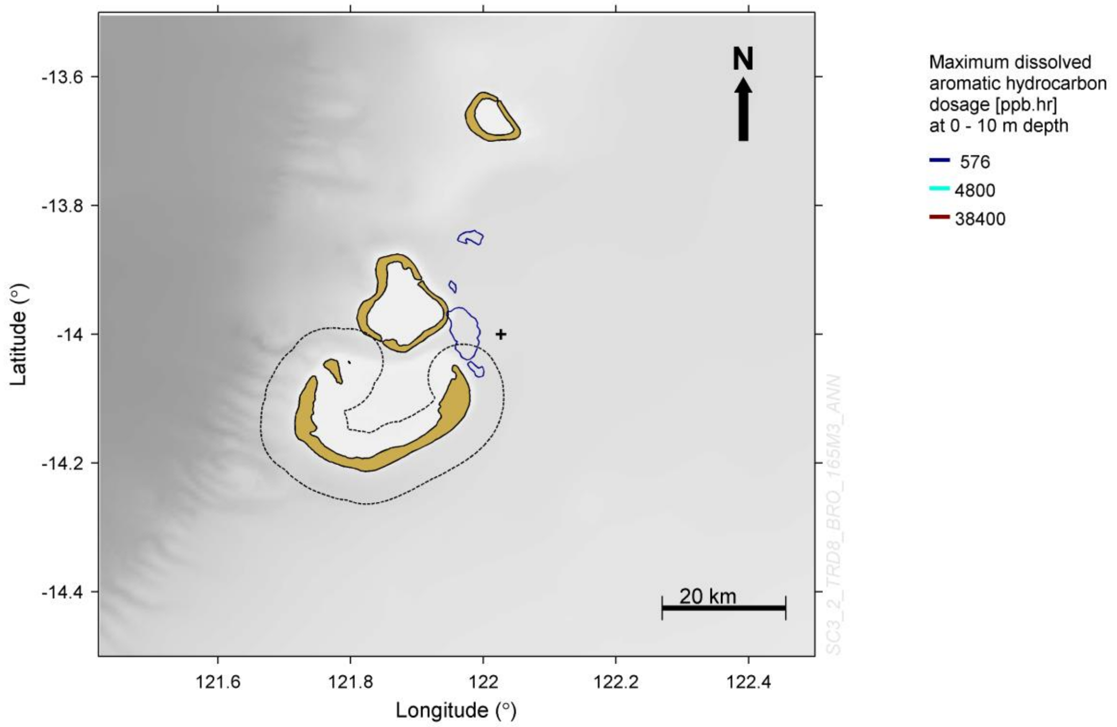
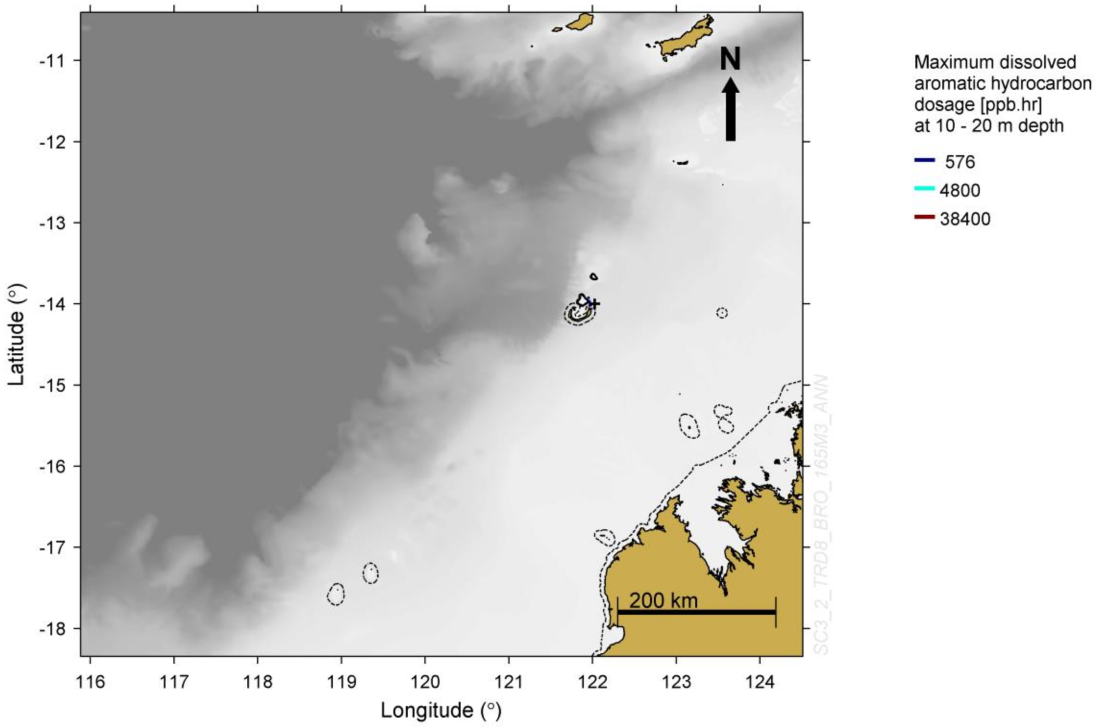


Figure 3-71: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 0 - 10 m (BMSL), resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



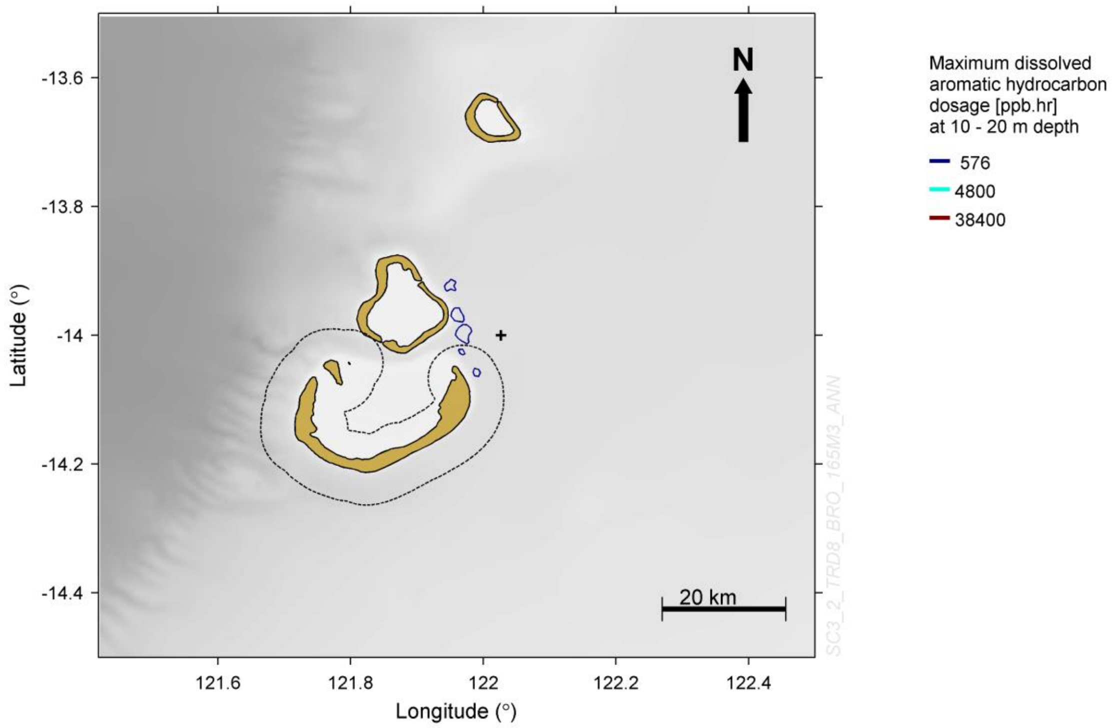


Figure 3-72: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 10 - 20 m (BMSL), resulting from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

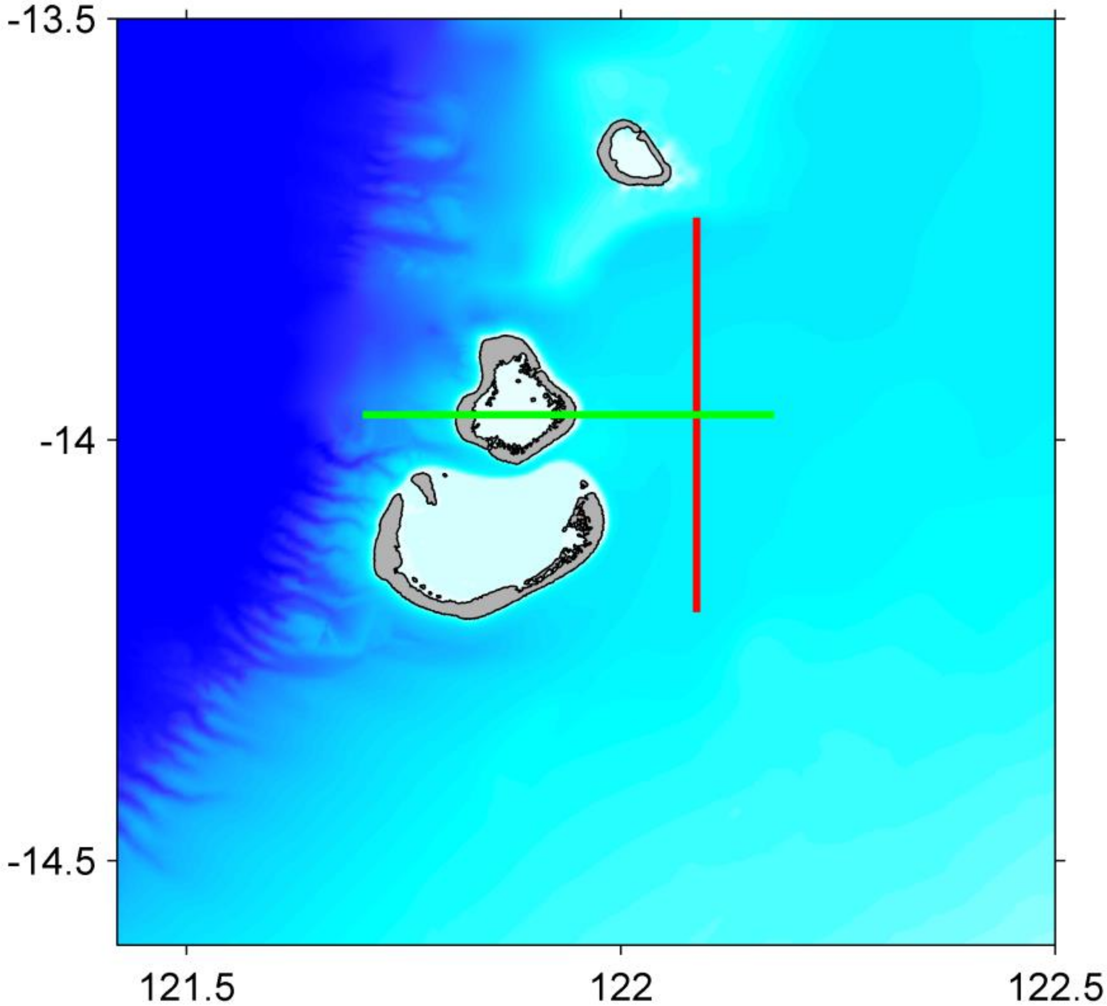


Figure 3-73: Location of the TRD8 location and the respective vertical transects over a varying latitude (red line) and longitude (green line).

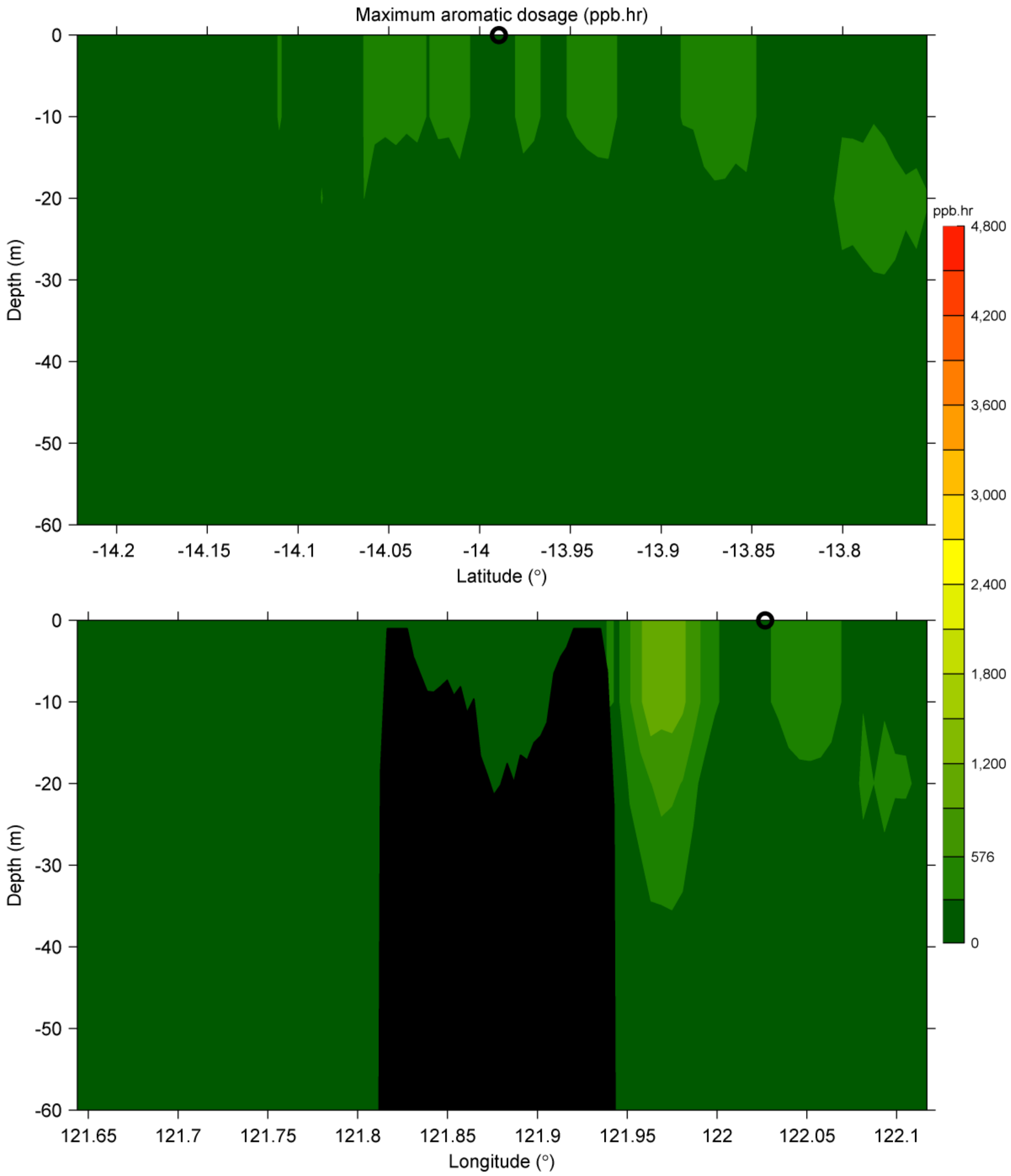


Figure 3-74: Vertical profile showing maximum annualised dissolved aromatic hydrocarbon dosage at a depth of 0 - 60 m (BMSL), across two perpendicular transects intersecting (top, north-south; bottom, east-west) the release point (black circle) from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location.

Table 3-12: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location.

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Timor (West)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Pulau Roti	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Oceanic Shoals CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Hibernia Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	7	9	5	NC
Ashmore Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	4	10	NC	NC
Ashmore Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	9	NC	NC
Cartier Island CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	16	10	10	5
Cartier Islet	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	15	6	6	3
Kimberley CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	41	100	63	25

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-12: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Argo-Rowley Terrace CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	25	45	6	4
Seringapatam Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	73	123	11	2
North Reef Flats	Probability (%) ≥ 576	0.25	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	597	573	120	22
North Reef Lagoon	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	286	139	34	BS
Kimberley Coast	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
South Reef Lagoon	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	492	285	49	9
SR Central/ Sandy Islet	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	97	49	BS	BS
South Reef Flats	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	520	262	51	48
Browse Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	4	7	1	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-12: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 20-minute 165.3 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Lalang-garram / Camden Sound MP	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Camden Sound	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Adele Island	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	NC	NC	BS	BS
Mermaid Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Mermaid Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Clerke Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Imperieuse Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Rowley Shoals MP (Imperieuse)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

3.5 Scenario 4.2: Simulation of a 24-hour Surface Release of 18,000 m^3 of Browse Condensate at the TRD8 Location

This scenario investigated the probability of exposure to surrounding regions by oil due to a surface release of Browse Condensate at the TRD8 location, with a total discharge volume of 18,000 m^3 over 24-hours.

Table 3-13: Summary of the spill scenario.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (m BMSL)
4.2	Release from offtake vessel, 8 km ENE of the TRD location, due to major structural failure	Browse Condensate	18,000	1.91x10^{-7}	24 hours	13° 59’ 22.06” S 122° 1’ 36.12” E	Surface

The modelling for this scenario assumed no mitigation efforts are undertaken to collect or otherwise affect the natural transport and weathering of the oil. All sensitive receptors outlined in Section 2.3.6 were analysed; however, only the receptors that were forecast to be contacted by dispersing oil are summarised in this section.

Average Weathering

The average mass balance shows high evaporation during the modelled release with approximately 45% of the oil evaporating in the first 24 hours, increasing to 75% at the end of the simulation. Approximately 12% of the oil is entrained during the first 5 days with very little expected to remain floating on the surface after approximately 25 days (Figure 3-75 and Figure 3-76).

The amount of aromatic hydrocarbons present in the floating oil decreases relatively rapidly after the cessation of the release due to evaporation (Figure 3-77 and Figure 3-78). After 20 days, the remaining aromatic hydrocarbons have dissolved in the water column and are subject to decay. At the end of the simulation, very little aromatic hydrocarbon mass remains in the system.

Trajectory and Weathering of an Example Replicate

An example series of snapshots of a single predicted spill trajectory are presented in Figure 3-79, and associated weathering and fates plots in Figure 3-80. The snapshots display the concentration of oil floating on the water surface based on specified surface oiling thresholds. The single spill trajectory analysis shows that one day after the spill (Figure 3-79 b) the oil slick is present at concentrations greater than 25 g/m^2, as it drifts towards the north. After 3 days the slick is spread, with the main body drifting towards the northeast while floating oil at lower concentrations (<10 g/m^2) is carried over Scott Reef North (Figure 3-79 c and d). The slick continues drifting towards the northeast, and after 7 days the floating oil concentrations in the vicinity of Scott Reef are approximately 1 g/m^2 or lower (Figure 3-79 e and f).

The weathering curve (Figure 3-80) shows that approximately 40% of the oil is expected to evaporate within 12 hours of the release. The evaporation rate then slows due to the loss of the higher volatility components. After the release ends, 60% of the oil is floating on the water surface. After 7 days of simulation, approximately 80% of the initial mass has evaporated, with a very small degree of entrainment expected when the wind speed reaches around 6 m/s. A very small amount of dissolved aromatic hydrocarbons are present in the water column.

This example shows how the fate of a surface spill is strongly determined by the wind conditions. For example, if the spill happened during a period of stronger winds, a much greater proportion of the spill is expected to entrain, and hence evaporation would be suppressed and dissolution of the aromatic components would be enhanced.

Floating Oil

The probability (P_2) contours show that floating oil with concentrations at or above 1 g/m^2 is forecast to potentially occur up to 400 km from the release site (Figure 3-81). The corresponding contours at the 10 g/m^2 threshold are also forecast to extend up to 400 km from the release site as an isolated case (Figure 3-82). Oil is forecast to most likely drift initially in westerly (towards Scott Reef North) and easterly directions, with extended trajectories in predominantly north-easterly and easterly directions also possible. The return-period probabilities (P_1xP_2) at these thresholds are shown in Figure 3-83 and Figure 3-84.

The higher maximum concentrations of floating oil (at or above 50 g/m^2) are expected to occur within 150 km of the release site (generally within 50 km), with some isolated occurrence at larger distances (Figure 3-85). The potential areas of floating oil at or above the defined thresholds are quantified in Table 3-14.

The variability in individual spill outcomes is expressed in the swept area statistics given in Table 3-14. Depending on the conditions prevailing at and after the spill, the swept area can vary between around a tenth and 18 times the median outcome. For example, the total area of open water contacted by slicks at 10 g/m^2 or greater is predicted to vary between around 50 and 3,300 km^2 with a median of around 475 km^2. In general, the size of the stochastic swept area (integrated over the full set of simulations) is typically an order of magnitude greater.

Table 3-14: The potential swept area (km^2) of floating oil with concentrations exceeding defined threshold concentrations in any single spill event. The swept area refers to all areas covered by the slick during the spill simulation with a concentration at the specified threshold.

	0.5 g/m²	1 g/m²	10 g/m²	25 g/m²
Minimum potential area (km²)	81.7	70.3	48.9	40.7
Median potential area (km²)	1,042	925.4	477.6	307.5
Mean potential area (km²)	2,380	1,872	677.7	367.6
Maximum potential area (km²)	18,273	13,610	3,316	1,413

Floating oil with concentrations of 25 g/m^2 or greater is expected to pass through Kimberley CMR, and Scott and Seringapatam Reefs (Table 3-15). The forecast probabilities of contact for this threshold are 0.5% at Kimberley CMR, 3% at Seringapatam Reef, 29.5% at North Reef Flats, 27% at North Reef Lagoon, 20% at South Reef Lagoon, 6% at Scott Reef Central/ Sandy Islet and 12.5% at South Reef Flats. Ashmore Reef CMR and Cartier Island CMR are forecast to be contacted by floating oil concentrations at or above 10 g/m^2, but less than 25 g/m^2. The minimum time expected for floating oil at the lowest defined threshold (0.5 g/m) to reach any receptor is 7 hours for North Reef Flats, followed by 11 hours for North Reef Lagoon and South Reef Lagoon, with similar times expected at each threshold for the most proximal receptors.

The worst-case locally accumulated shoreline concentrations are forecast at Scott Reef Central/ Sandy Islet and Ashmore Reef CMR (3,117 g/m^2). The maximum accumulated volume along shorelines is forecast for Ashmore Reef CMR (23 m^3) and Kimberley Coast (19 m^3), which equate to around 0.1% of the spilled volume. Note that the potential for accumulation at the most proximal receptors is governed by the amount of permanently emergent shoreline expressed in the model.

Dissolved Aromatic Hydrocarbon Dosage

The low dosage probability contours (at or above 576 ppb.hr) show that occurrence at this threshold may potentially occur up to 650 km from the spill site in the surface layers (0-10 m, 10-20m 20-40 m depths; Figure 3-90, Figure 3-91 and Figure 3-92). Moderate dosage exceedence (at or above 4,800 ppb.hr) is expected to potentially occur up to 120 km in the surface layers (0-10 m, 10-20 m; Figure 3-94 and Figure 3-95). In the 20-40 m depth layer, only isolated contours are observed, suggesting a low likelihood of dosage at this level at North Reef Flats, South Reef Lagoon, Scott Reef Central/ Sandy Islet and South Reef Flats (Figure 3-96).

Isolated occurrences of high dosage (at or above 38,400 ppb.hr) may occur at North Reef Flats, North Reef Lagoon and South Reef Lagoon in the surface layers (0-10 m, 10-20 m; Figure 3-97 and Figure 3-98). No threshold exceedence is expected below 20 m depth.

Maximum dissolved aromatic hydrocarbon dosage maps at any depth (Figure 3-99 to Figure 3-102) shows that the area influenced at the defined thresholds, as well as the maximum threshold exceeded, decreases as the water depth increases.

Figure 3-104 shows the vertical distribution of the maximum dissolved aromatic hydrocarbon dosage along 2 perpendicular intersections of the release site (Figure 3-104). The east-west transect passes through North Scott Reef and shows the maximum dosage occurring at North Reef Lagoon and at North Reef Flats nearer to the release site. The north-south transect shows lower dosage demonstrating that the dissolved aromatic hydrocarbons are expected to drift predominantly towards the west.

Low and moderate dosage is expected to occur at all assessed receptor zones of Scott Reef (Table 3-16). The highest probabilities of exceeding these thresholds are expected at North Reef Flats (38% and 19.5%, respectively) and North Reef Lagoon (36% and 16%, respectively). The high dosage threshold is also exceeded at these receptors, at a probability of 1.5%. Exceedence of the low dosage threshold is expected at Cartier Island CMR, Cartier Islet, Kimberley CMR and Seringapatam Reef (probability 1.5 % or less).

3.5.1 Average Weathering

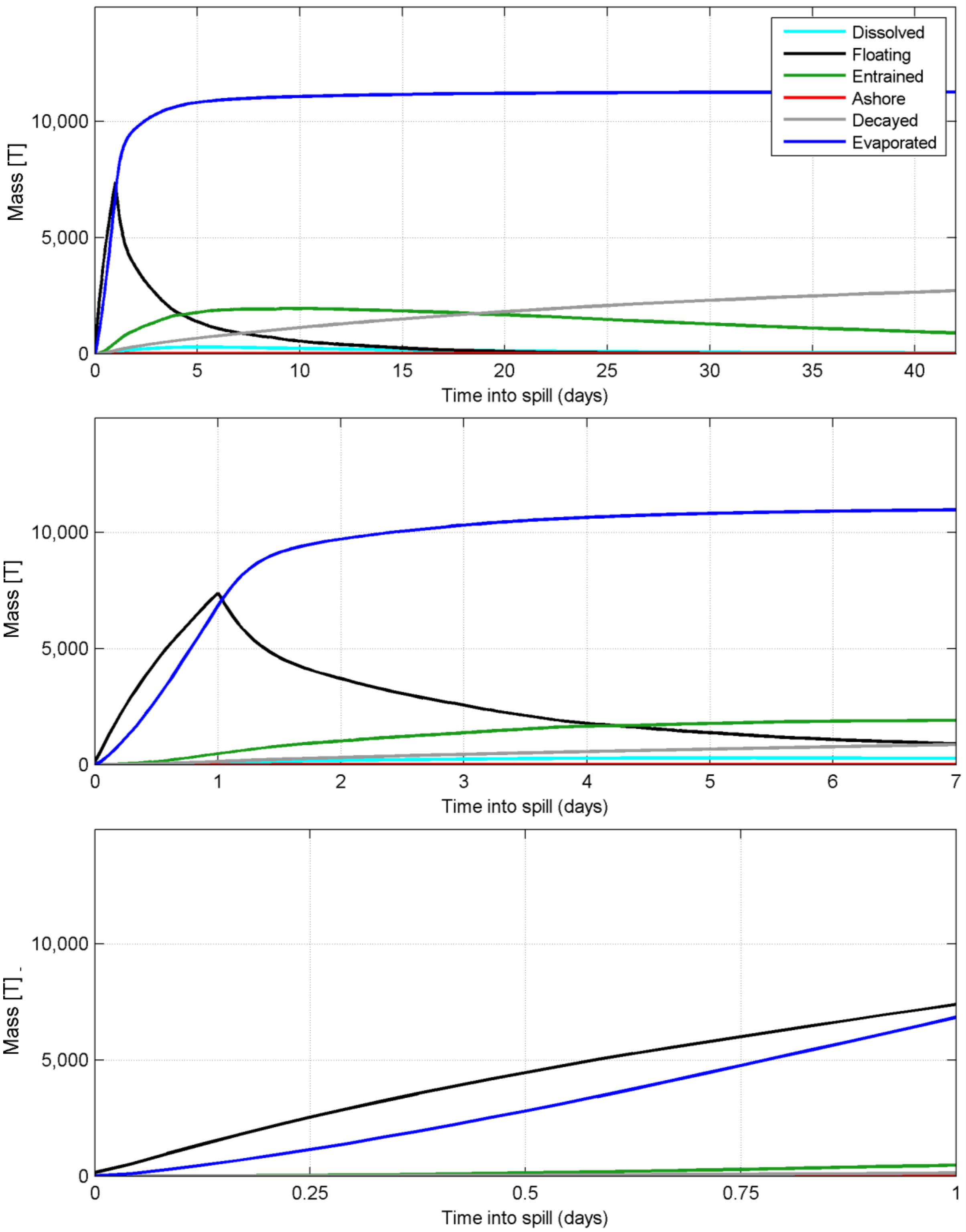


Figure 3-75: Predicted average weathering mass balance (tonnes) resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

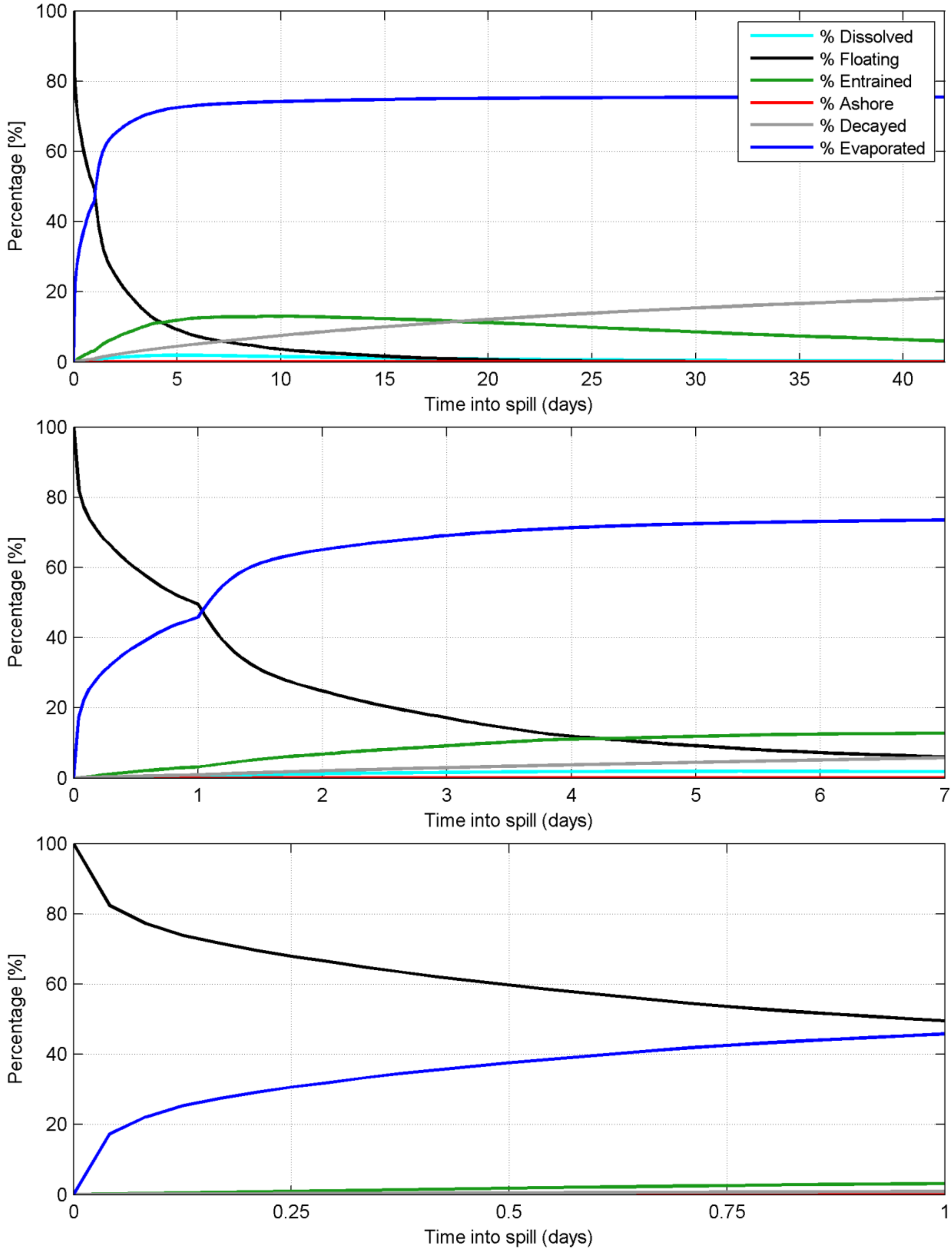


Figure 3-76: Predicted average weathering mass balance (% of total mass) weathering graph resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

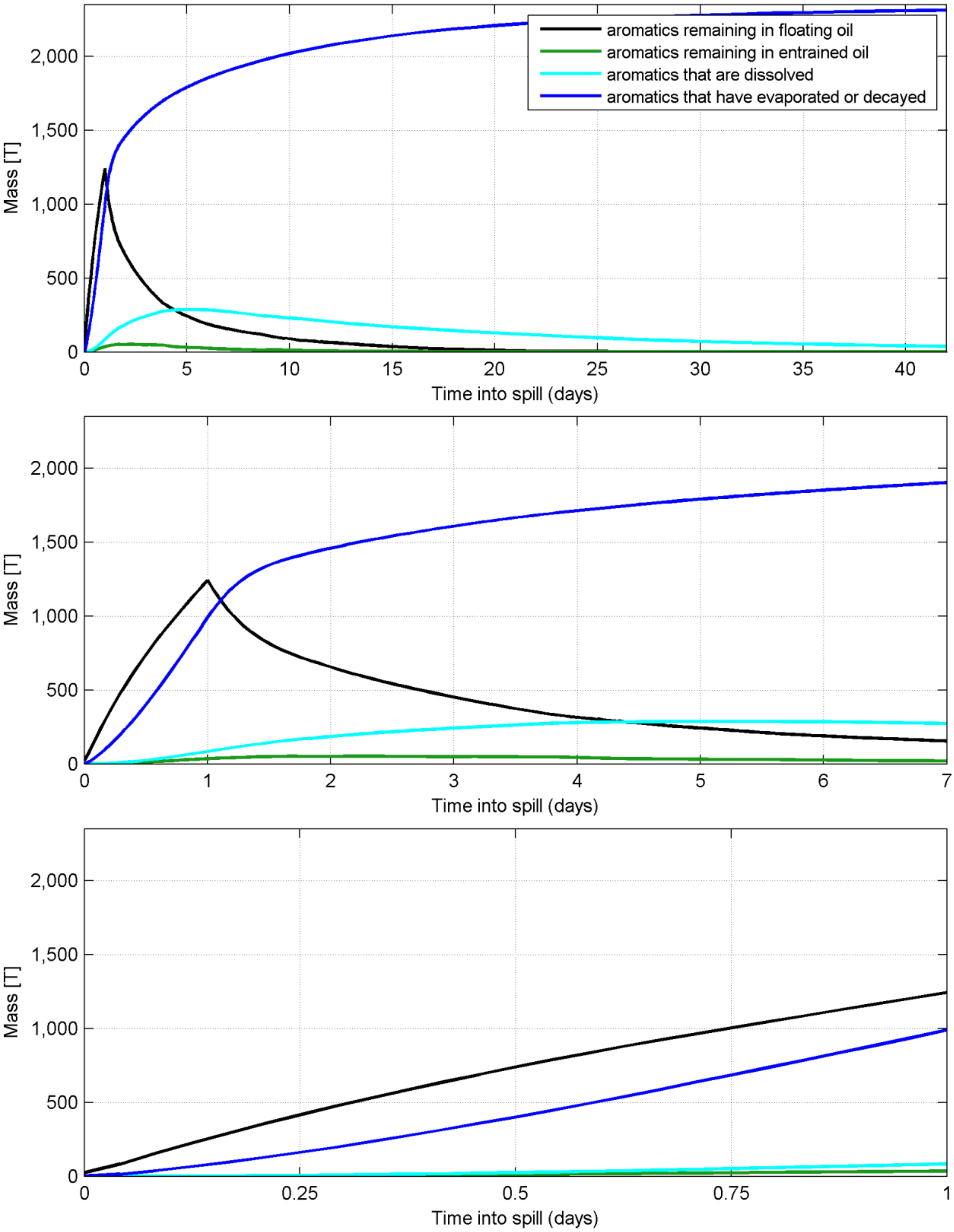


Figure 3-77: Predicted average partitioning of the aromatic hydrocarbons (tonnes) resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

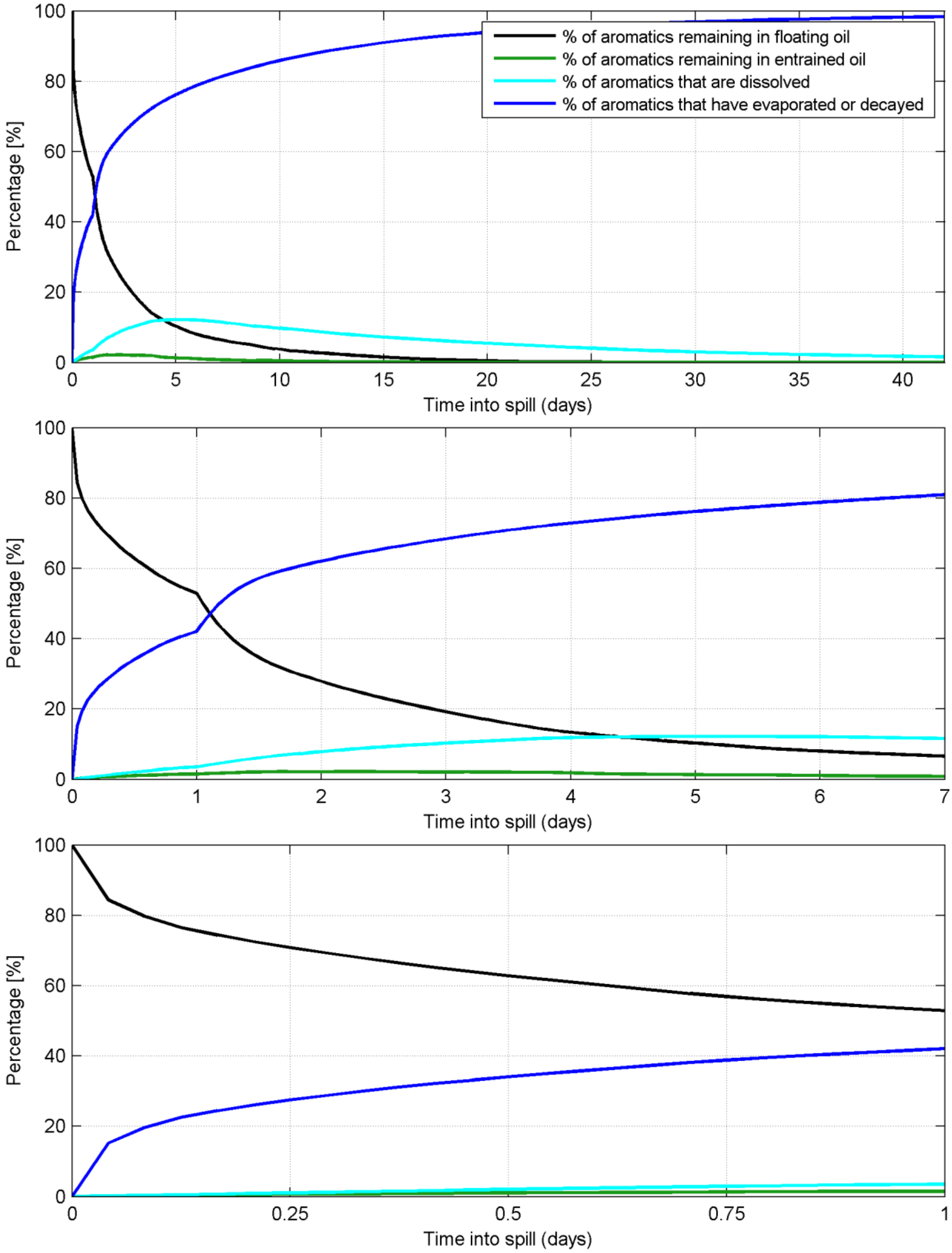


Figure 3-78: Predicted average partitioning of the aromatic hydrocarbons (% of total mass) resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

3.5.2 Trajectory and Weathering of an Example Replicate

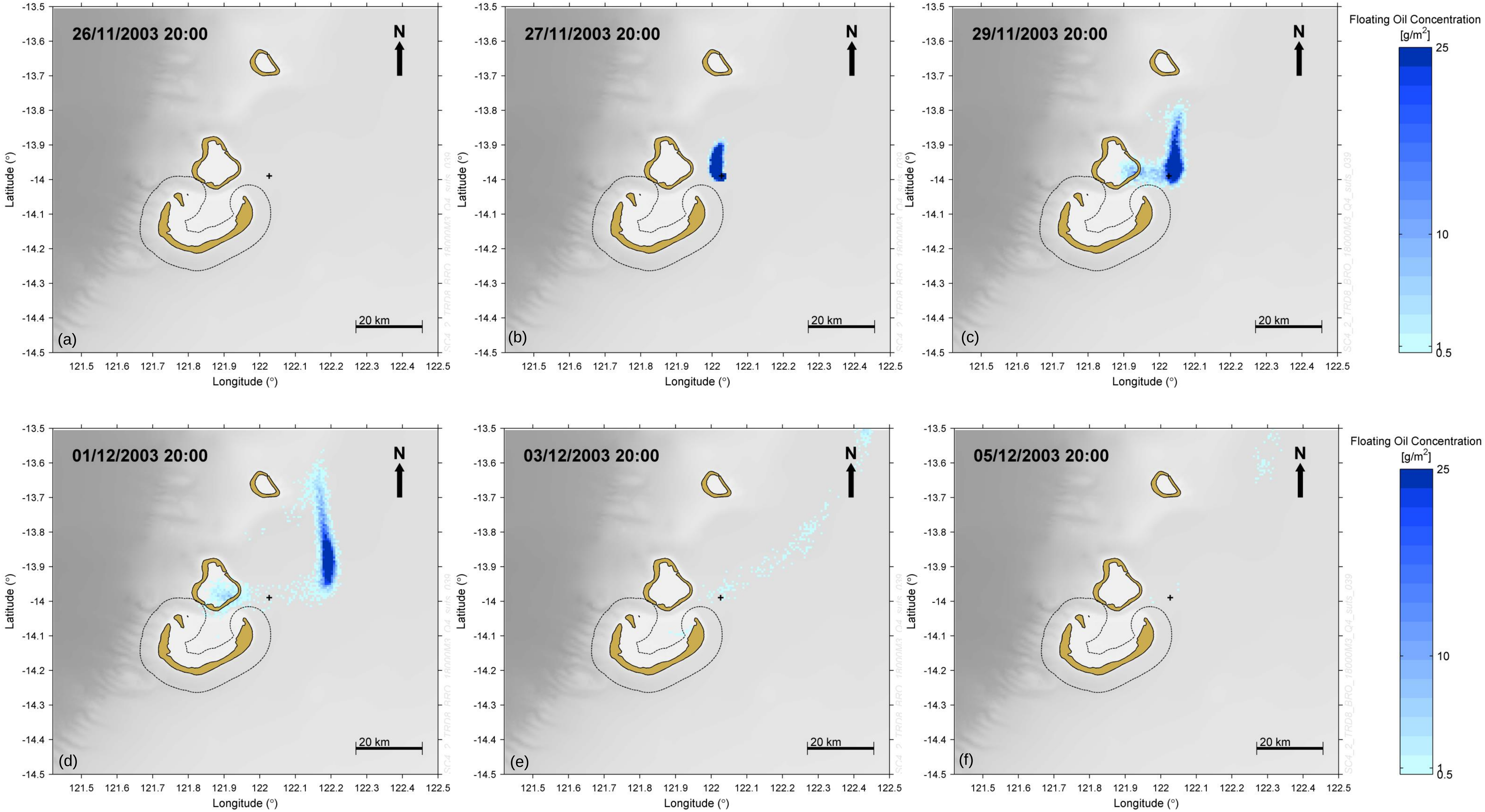


Figure 3-79: Example trajectory and concentration of floating oil for a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location, commencing at 20:00 on 26th of November 2003. The resultant trajectory and concentration at the start of the release (a), and 1 day (b), 3 days (c), 5 days (d), 7 days (e) and 9 days (f) after the start of the release are presented.

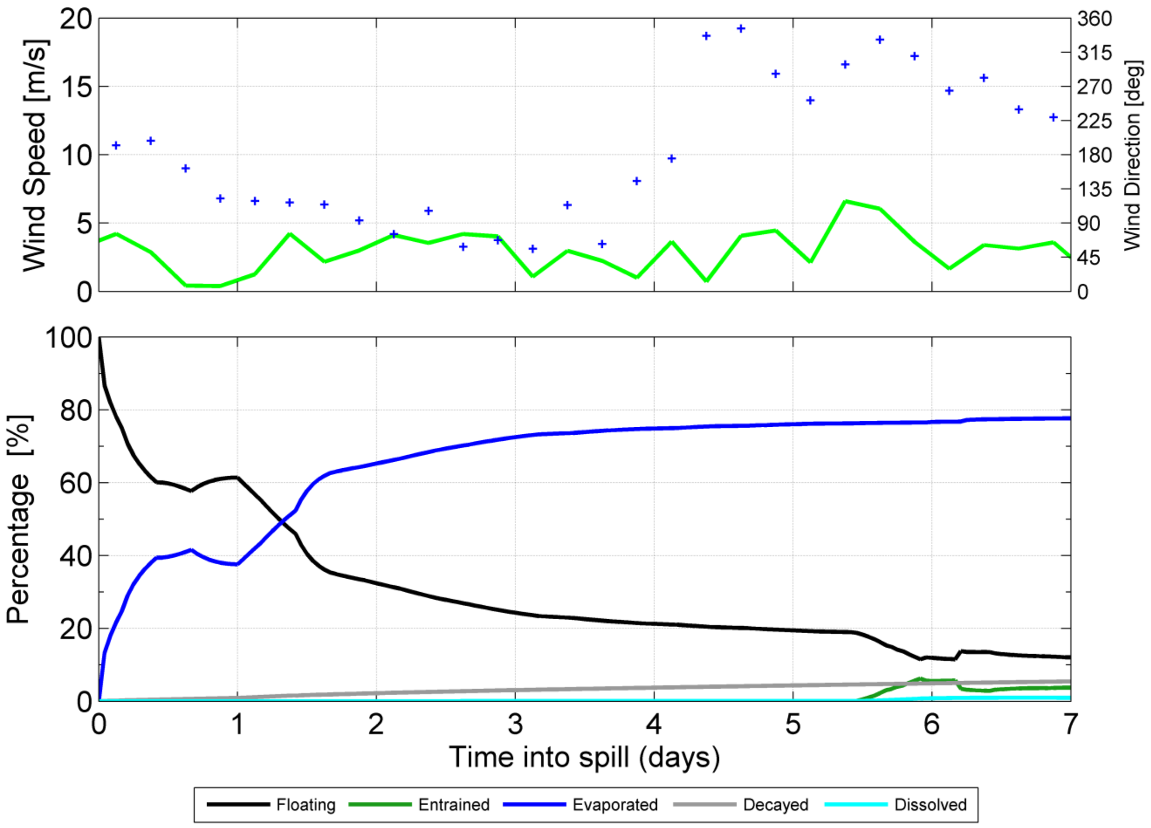


Figure 3-80: Predicted mass balance weathering resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location, commencing at 20:00 on 26th November 2003. The green line in the top figure indicates the wind speed and the blue dots indicate the wind direction (FROM).

3.5.3 Floating Oil

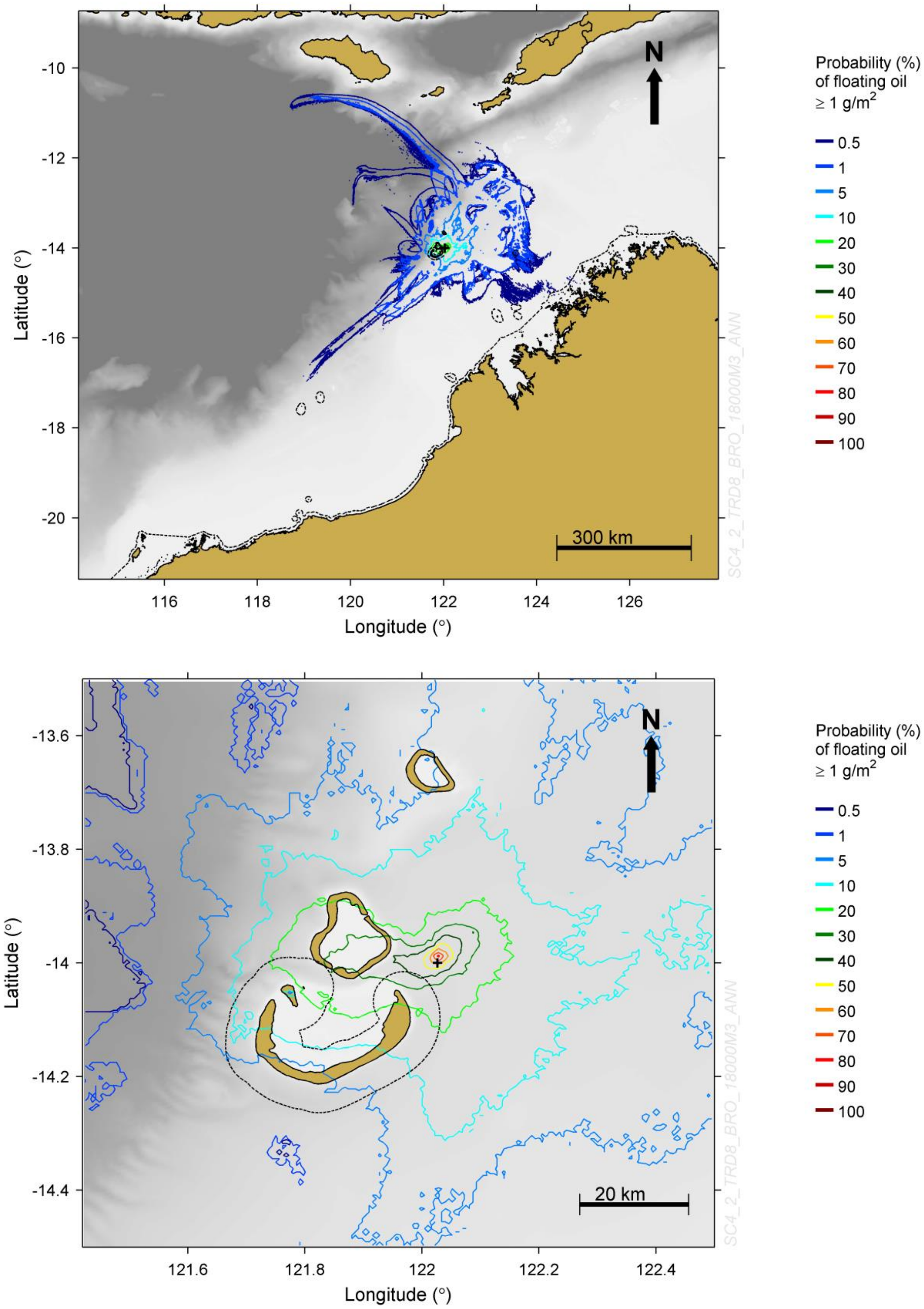


Figure 3-81: Predicted annualised probability (P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

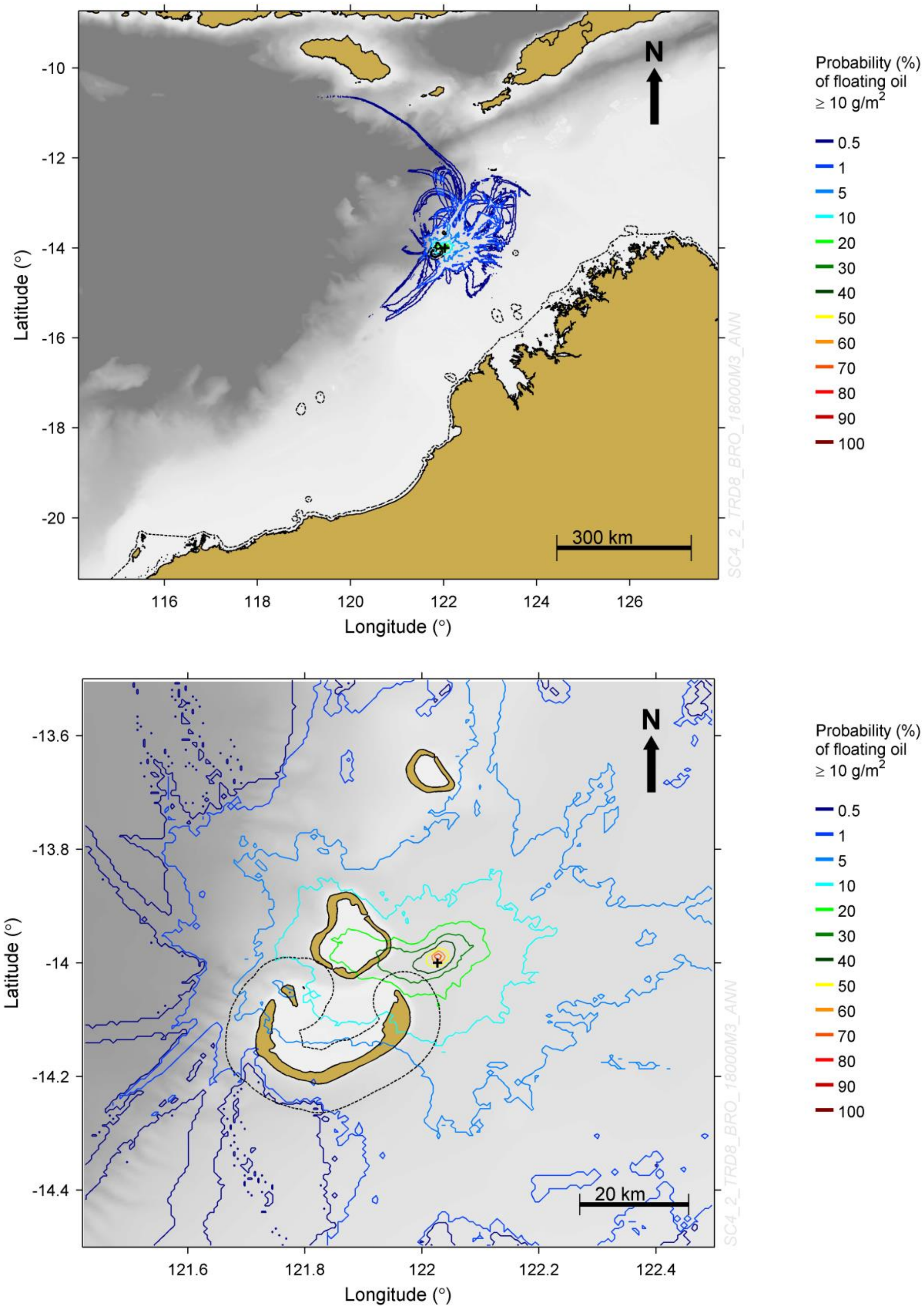
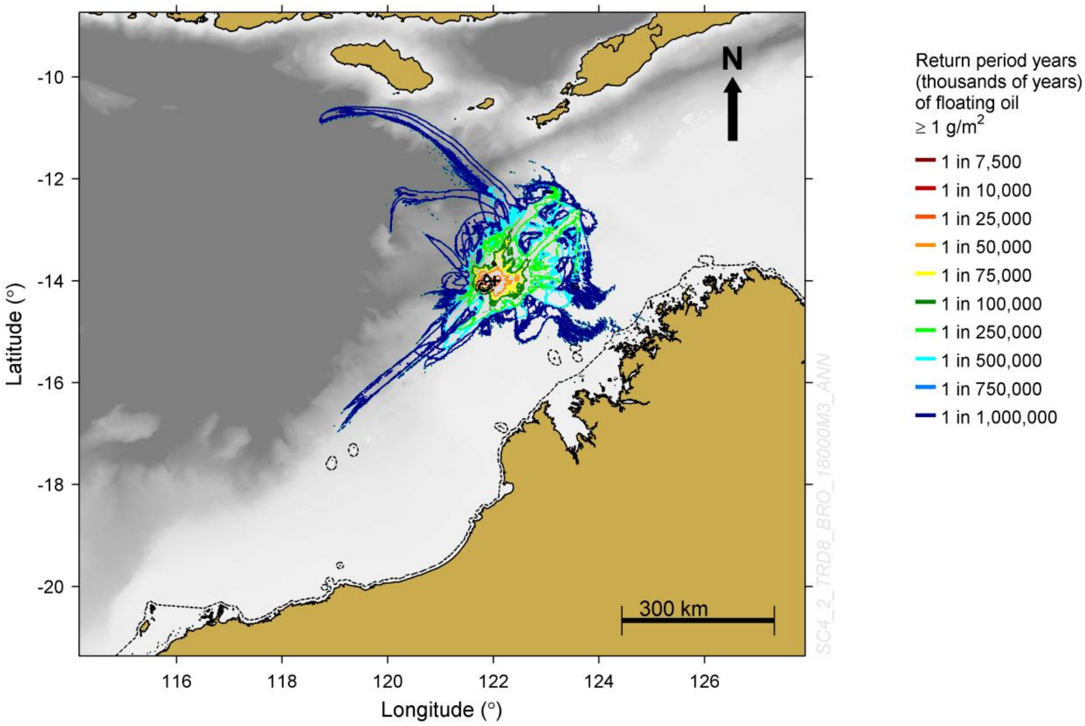


Figure 3-82: Predicted annualised probability (P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



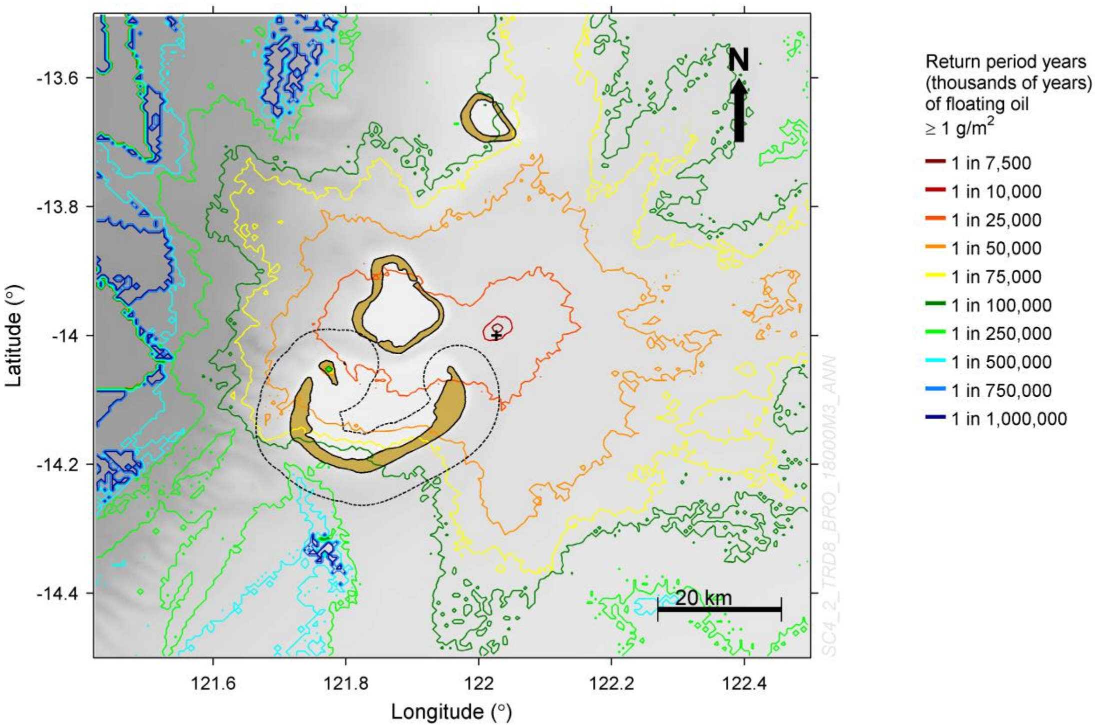


Figure 3-83: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

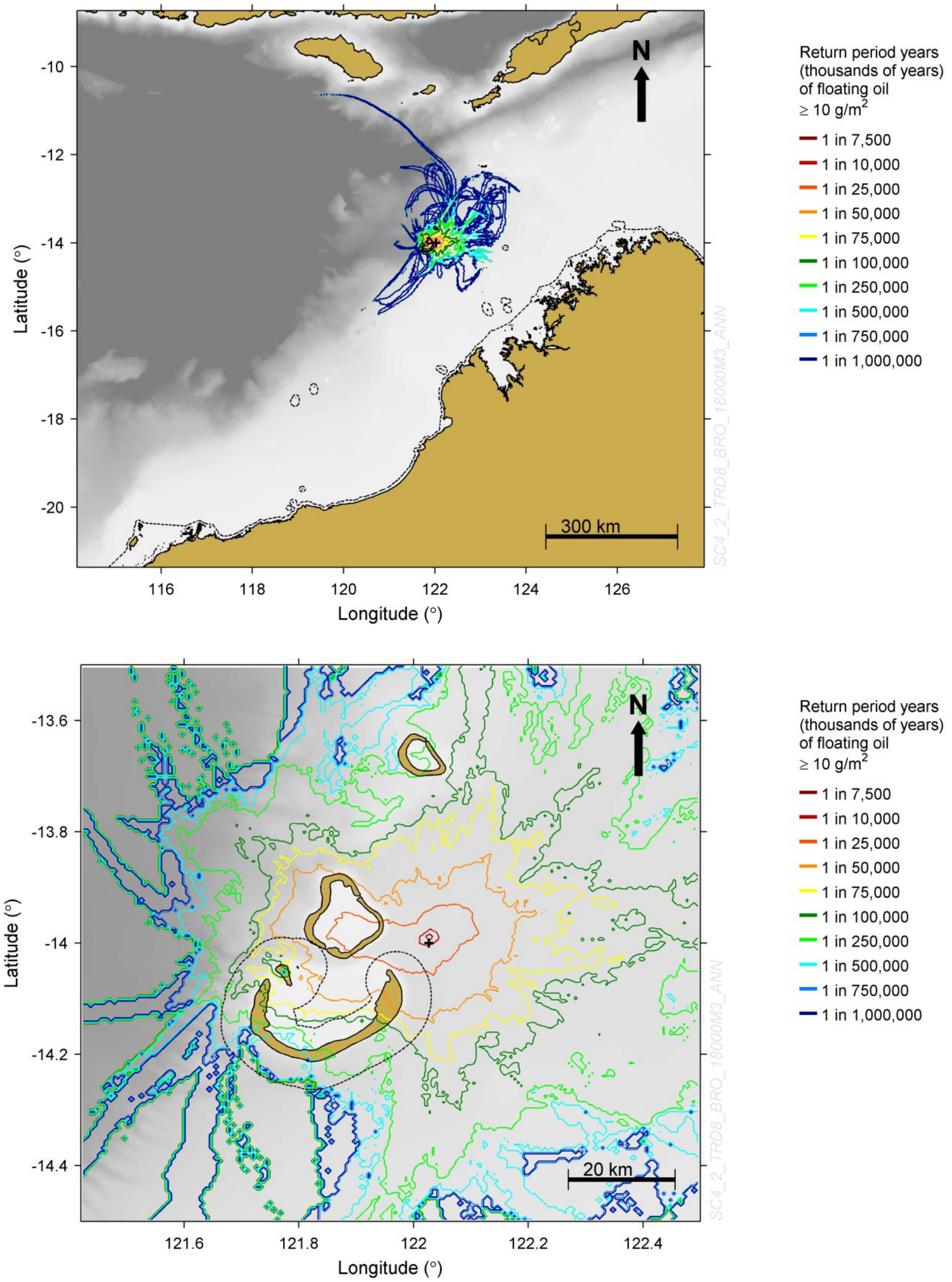
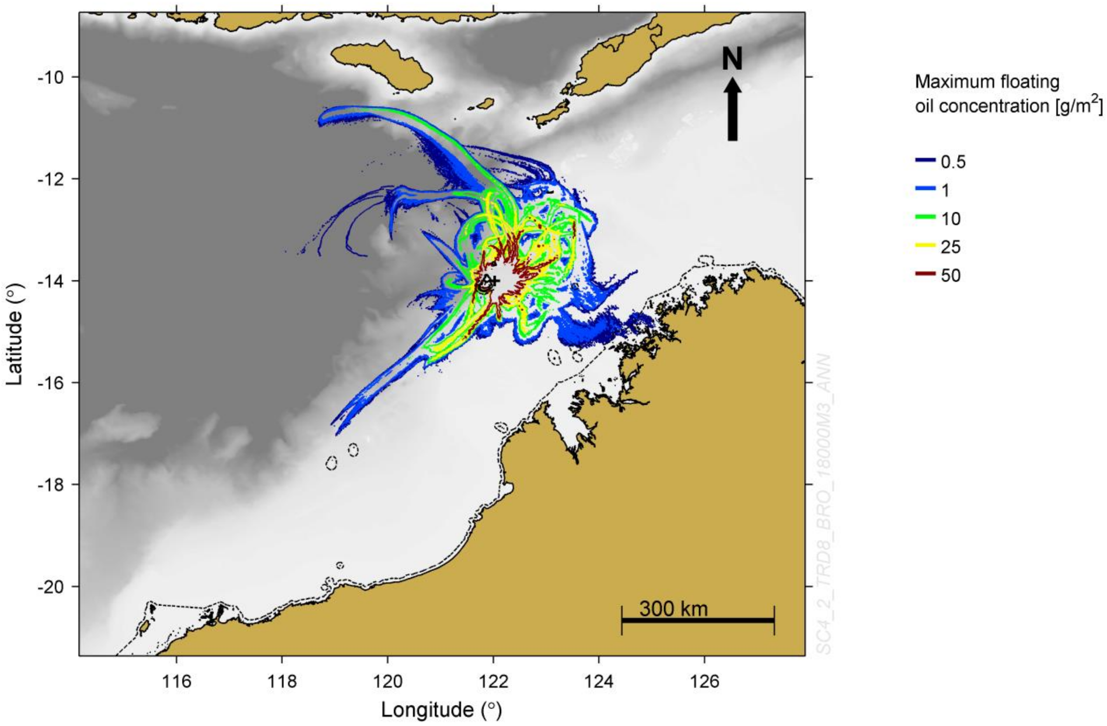


Figure 3-84: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



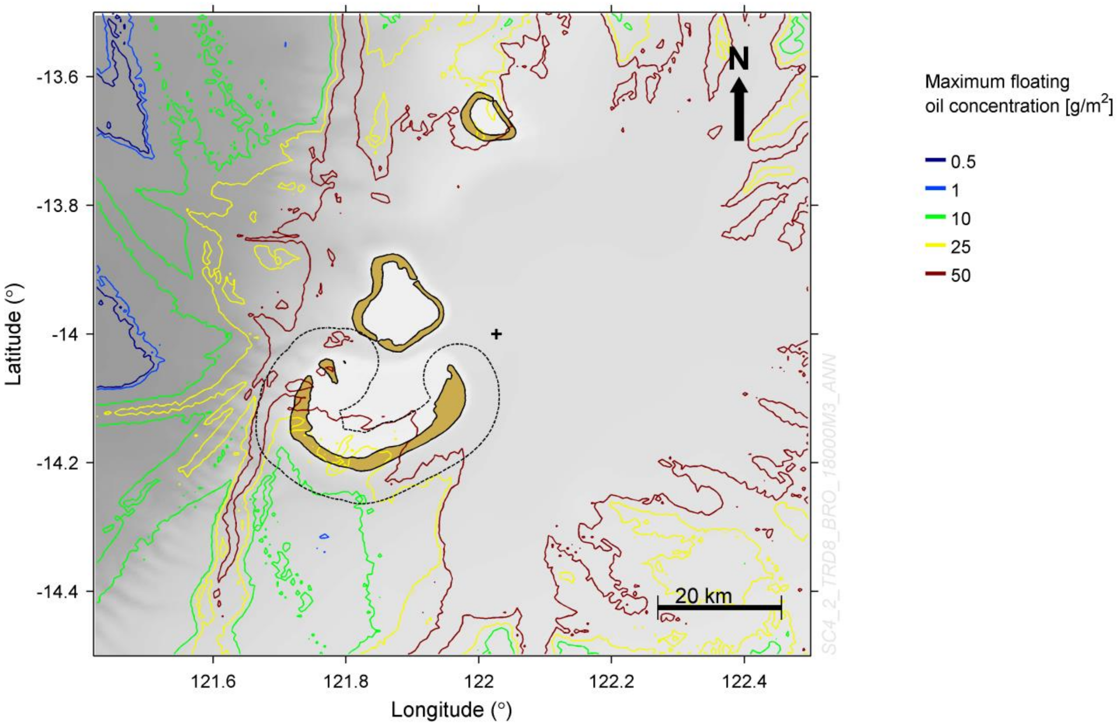
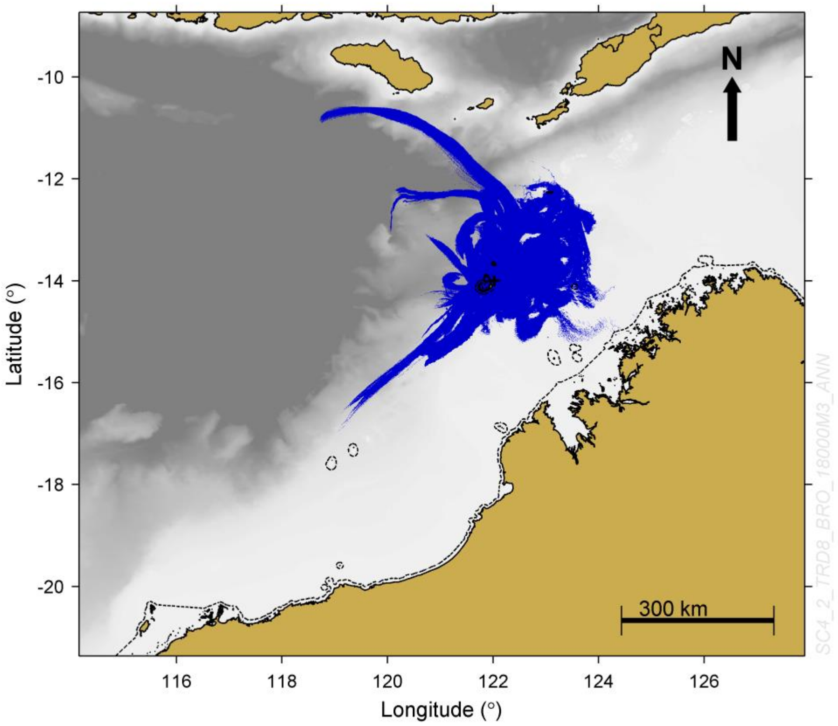


Figure 3-85: Predicted maximum floating oil concentration resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



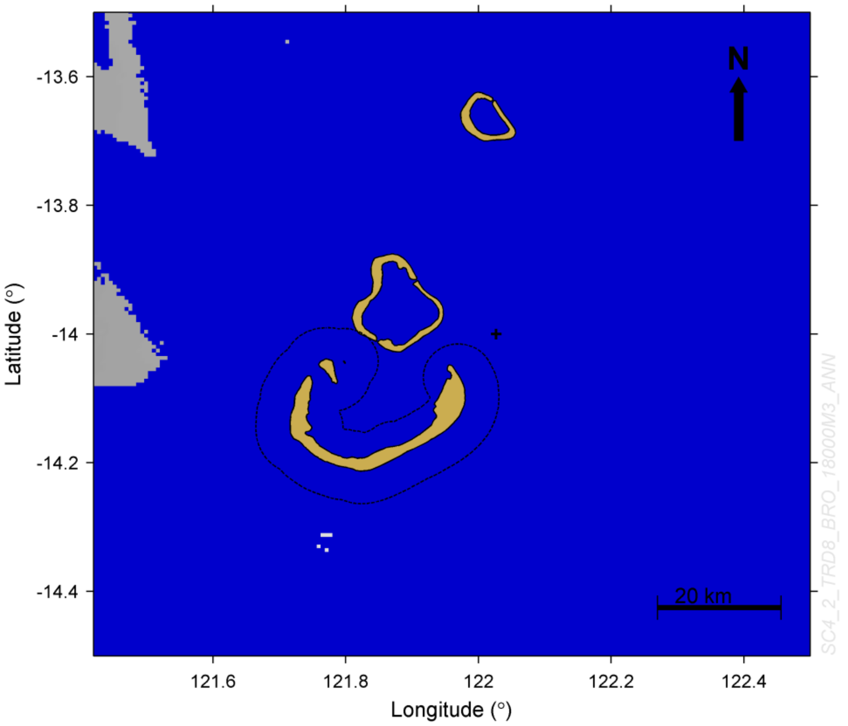


Figure 3-86: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

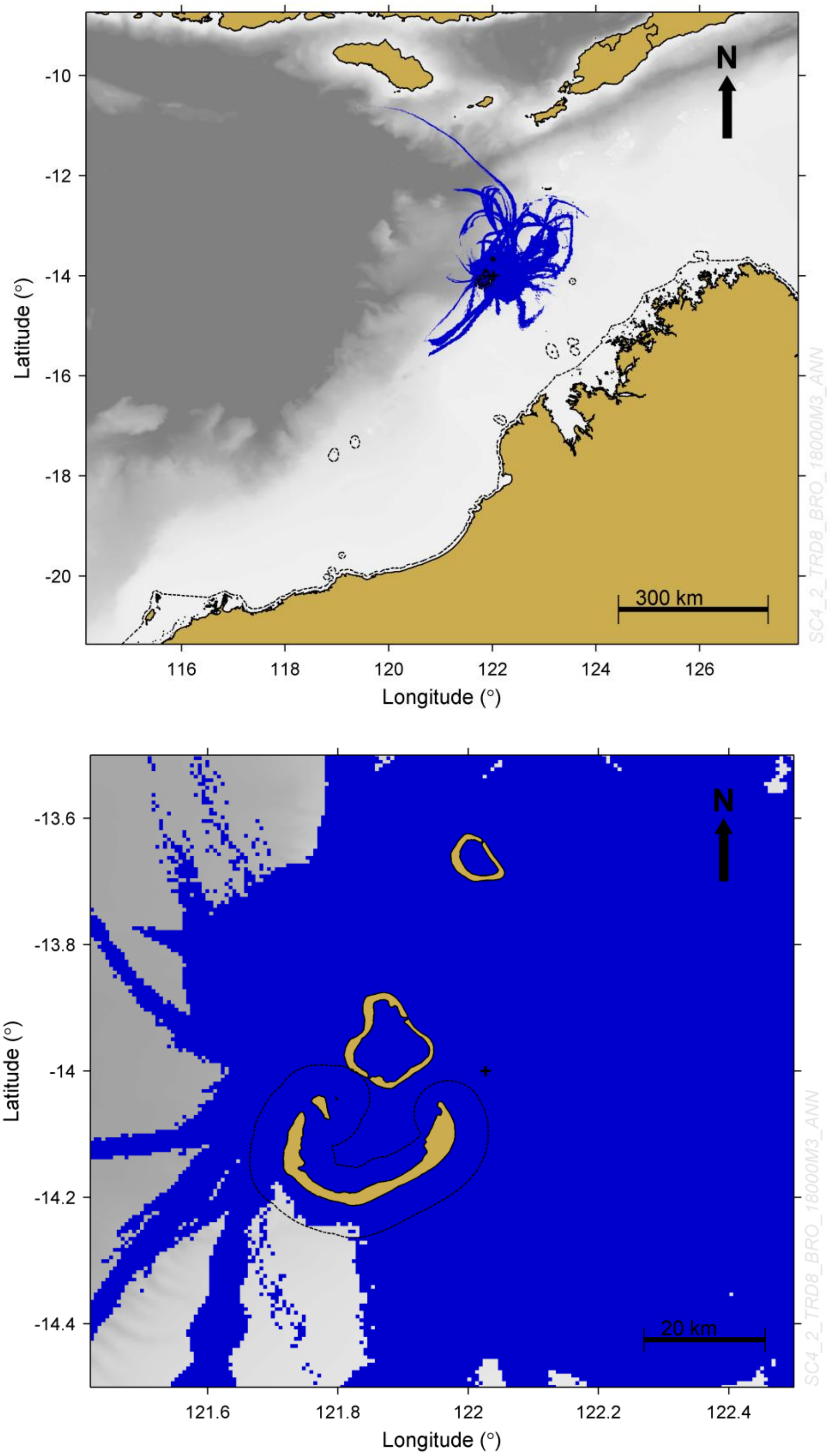
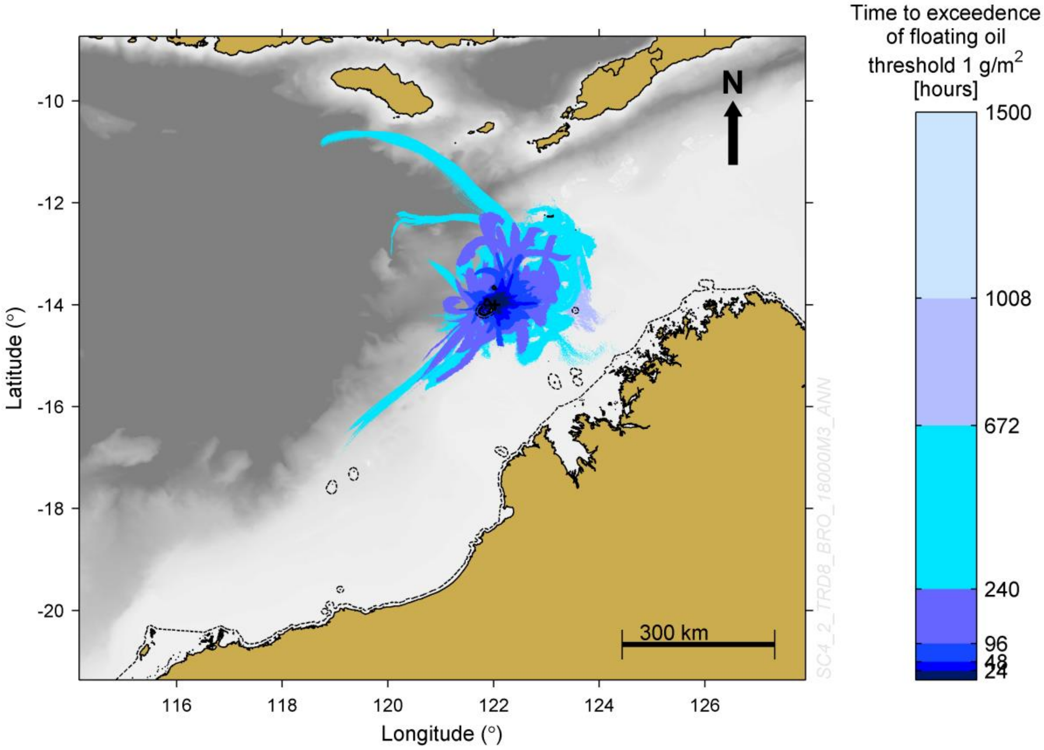


Figure 3-87: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



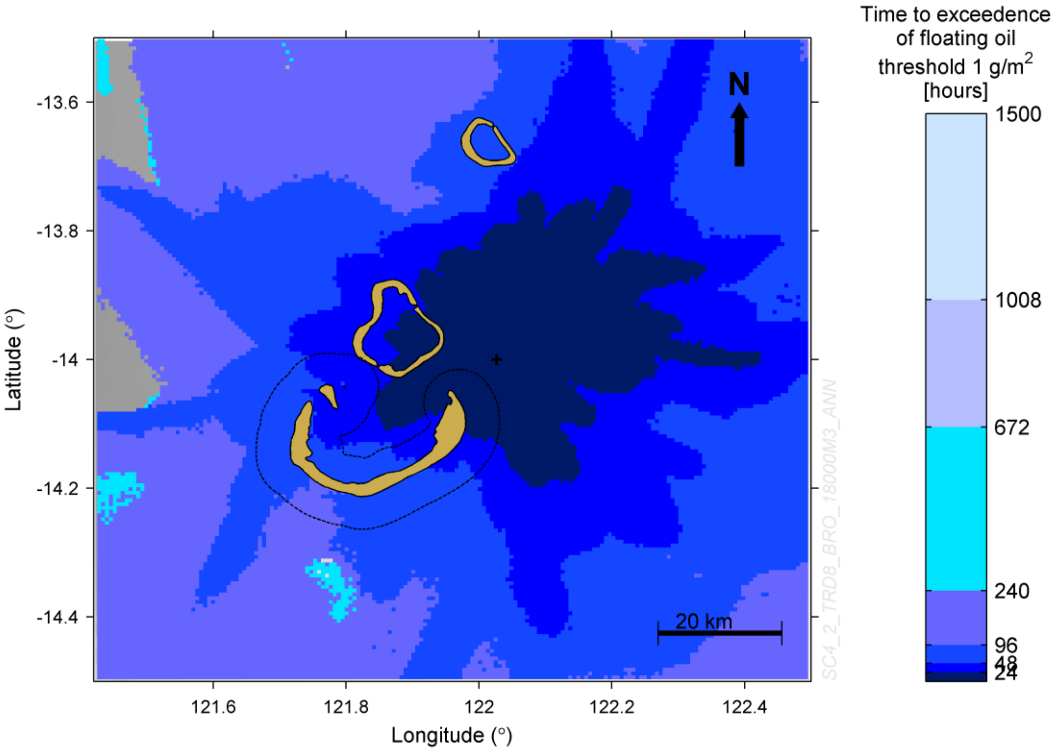


Figure 3-88: Predicted annualised minimum times to threshold for floating oil at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

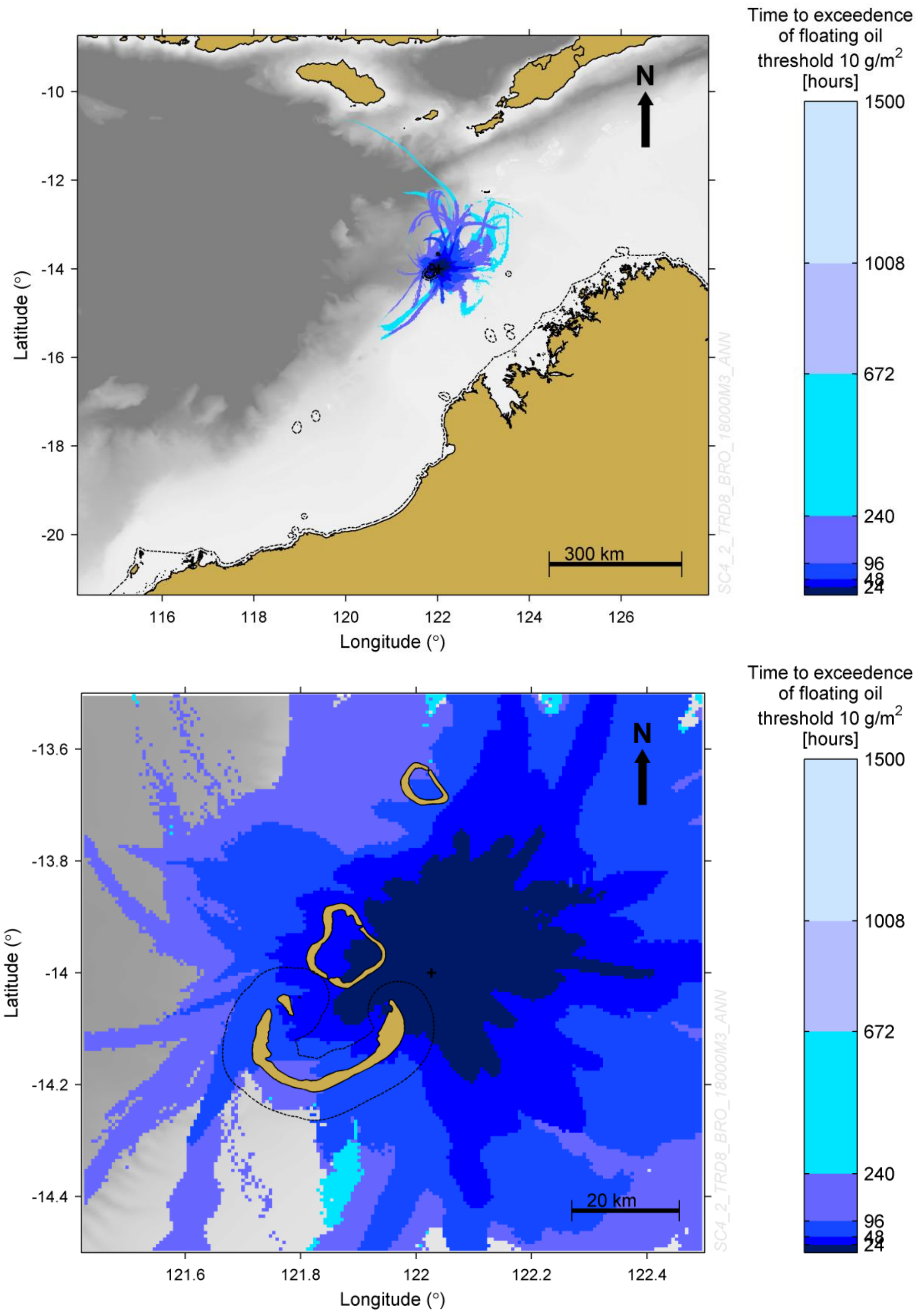


Figure 3-89: Predicted annualised minimum times to threshold for floating oil at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Table 3-15: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location.

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1.0g/m²	Probability (%) of films arriving at receptors at ≥ 10.0g/m²	Probability (%) of films arriving at receptors at ≥ 25.0g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1.0g/m²	Minimum time to receptor (hours) for films at ≥ 10.0g/m²	Minimum time to receptor (hours) for films at ≥ 25.0g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Timor Leste	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Timor (West)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Pulau Roti	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Big Bank Shoals*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Melville Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	NC	NC
Oceanic Shoals CMR*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	0.5	<0.5	<0.5	<0.5	630	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef CMR	4	3	1	<0.5	298	302	466	NC	62	3,117	<1	23
Ashmore Reef	4	3	1	<0.5	320	323	466	NC	62	3,117	<1	23
Cartier Island CMR	3	2.5	0.5	<0.5	357	362	379	NC	11	490	<1	2
Cartier Islet	3	1.5	<0.5	<0.5	393	453	NC	NC	11	490	<1	2
Joseph Bonaparte Gulf East	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-15: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m³ surface release of Browse Condensate at the TRD8 location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1.0g/m²	Probability (%) of films arriving at receptors at ≥ 10.0g/m²	Probability (%) of films arriving at receptors at ≥ 25.0g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1.0g/m²	Minimum time to receptor (hours) for films at ≥ 10.0g/m²	Minimum time to receptor (hours) for films at ≥ 25.0g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Kimberley CMR*	2.5	2	1	0.5	150	150	156	158	NC	NC	NC	NC
Argo-Rowley Terrace CMR*	0.5	0.5	<0.5	<0.5	276	281	NC	NC	NC	NC	NC	NC
Seringapatam Reef	7.5	7.5	4.5	3	40	43	57	59	NC	NC	NC	NC
Joseph Bonaparte Gulf West	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
North Reef Flats*	41.5	40	33	29.5	7	7	7	8	NC	NC	NC	NC
North Reef Lagoon*	40	38.5	30.5	27	11	11	11	12	NC	NC	NC	NC
Kimberley Coast	0.5	<0.5	<0.5	<0.5	812	NC	NC	NC	2.6	512	<1	19
South Reef Lagoon*	33	32.5	24.5	20	11	11	12	12	NC	NC	NC	NC
SR Central/ Sandy Islet	22.5	18	9.5	6	39	39	40	41	320	3,117	<1	8
South Reef Flats*	24.5	23	16	12.5	15	15	16	16	NC	NC	NC	NC
Browse Island	1	0.5	<0.5	<0.5	758	774	NC	NC	11	945	<1	7
Lalang-garram / Camden Sound MP	0.5	<0.5	<0.5	<0.5	690	NC	NC	NC	0.7	139	<1	<1

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-15: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1.0g/m²	Probability (%) of films arriving at receptors at ≥ 10.0g/m²	Probability (%) of films arriving at receptors at ≥ 25.0g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1.0g/m²	Minimum time to receptor (hours) for films at ≥ 10.0g/m²	Minimum time to receptor (hours) for films at ≥ 25.0g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Camden Sound	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Adele Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	NC	NC
Dampier Peninsula Coast - North section	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Lacepede Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Mermaid Reef CMR	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Mermaid Reef	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	2.7	<1	<1
Clerke Reef	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	2.7	<1	<1
Imperieuse Reef	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Rowley Shoals MP (Imperieuse)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Eighty Mile Beach	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Glomar Shoals*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-15: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1.0g/m²	Probability (%) of films arriving at receptors at ≥ 10.0g/m²	Probability (%) of films arriving at receptors at ≥ 25.0g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1.0g/m²	Minimum time to receptor (hours) for films at ≥ 10.0g/m²	Minimum time to receptor (hours) for films at ≥ 25.0g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Rankin Bank*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Dampier Archipelago	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Montebello Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Lowendal Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Barrow Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Northern Pilbara- Islands and Shoreline	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Southern Pilbara- Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Muiron Islands (World Heritage)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Ningaloo Coast North (World Heritage)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Ningaloo Coast North	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

3.5.4 Dissolved Aromatic Hydrocarbon Dosage

576 ppb.hr

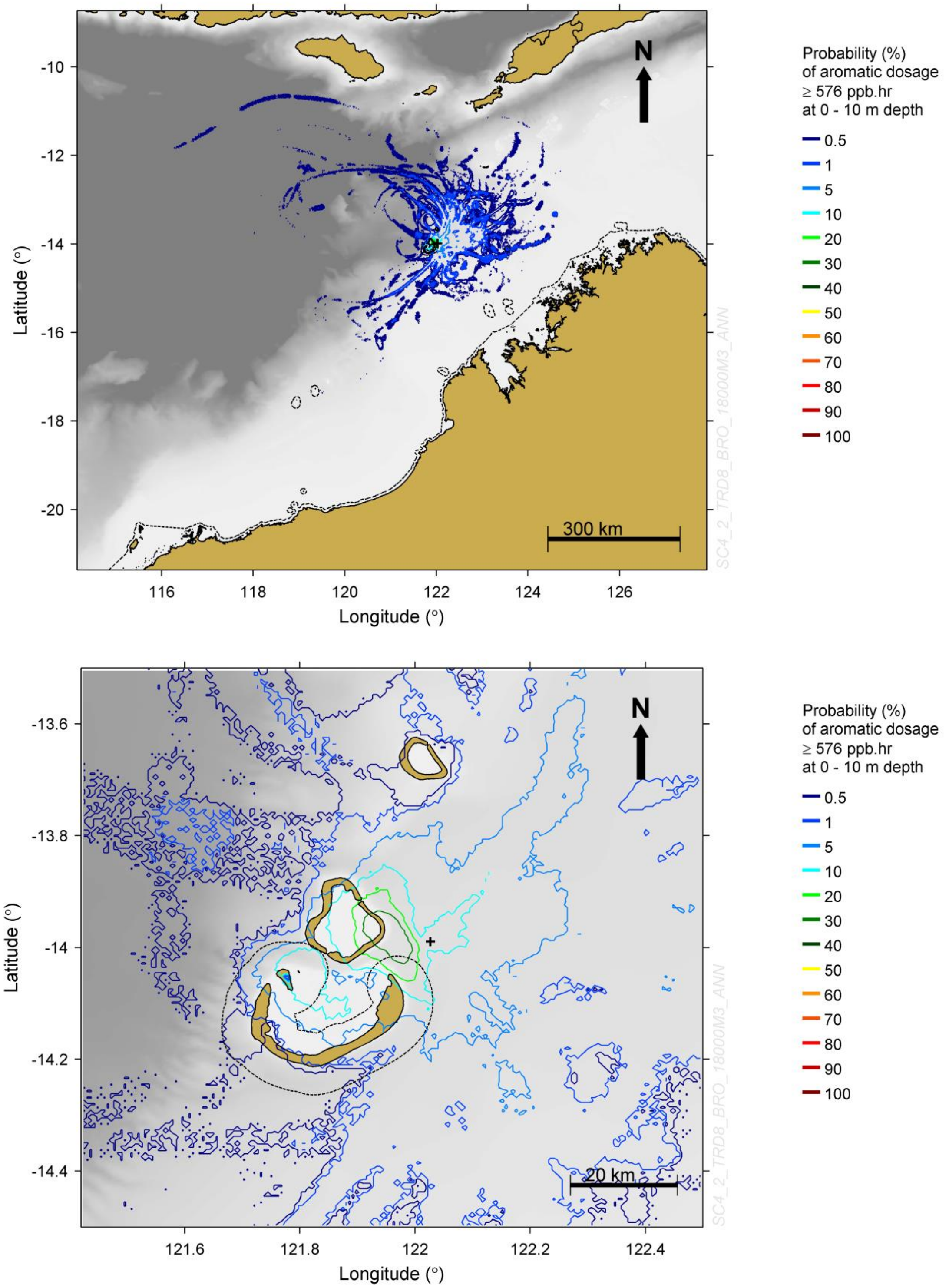


Figure 3-90: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

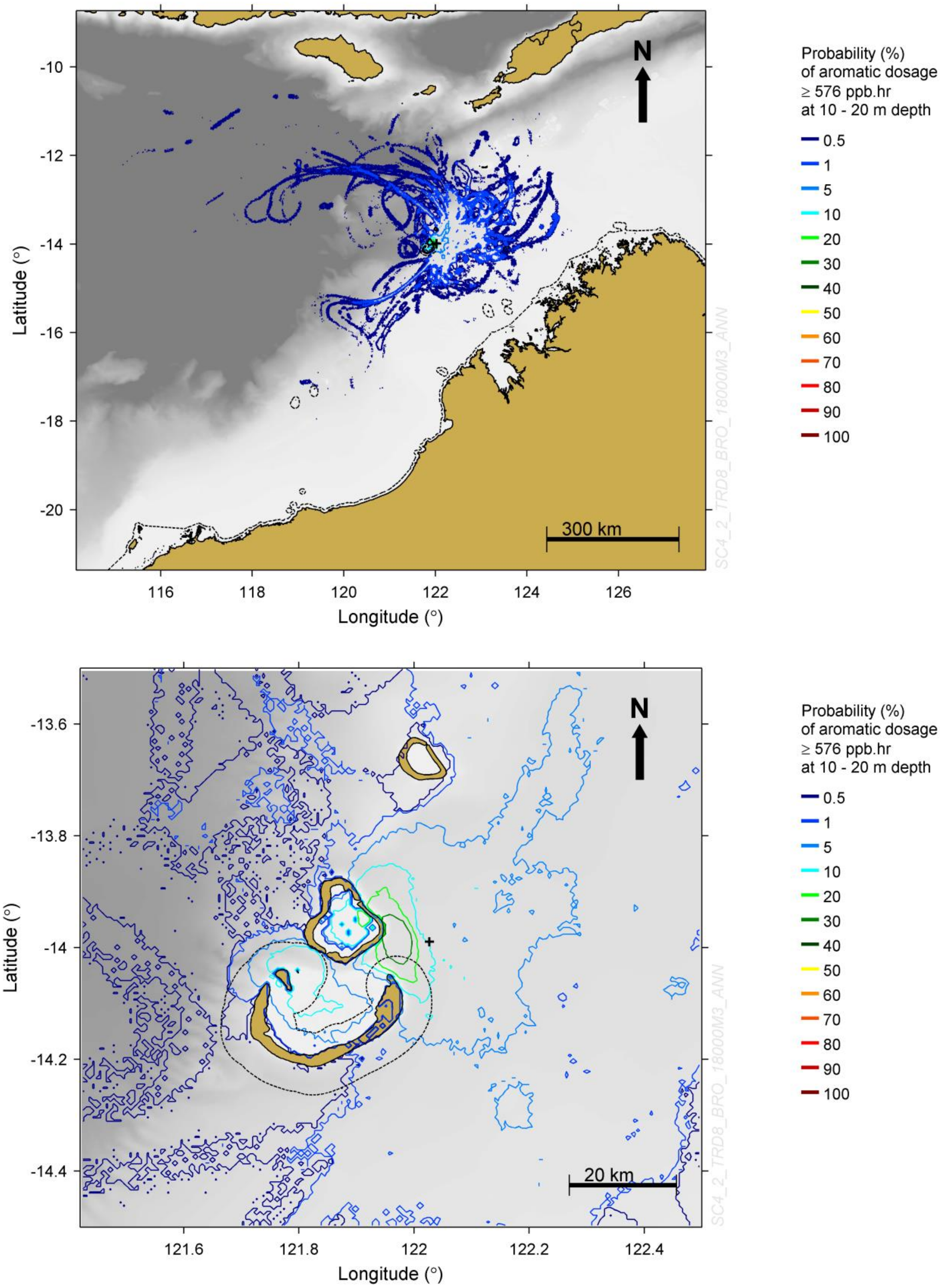


Figure 3-91: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

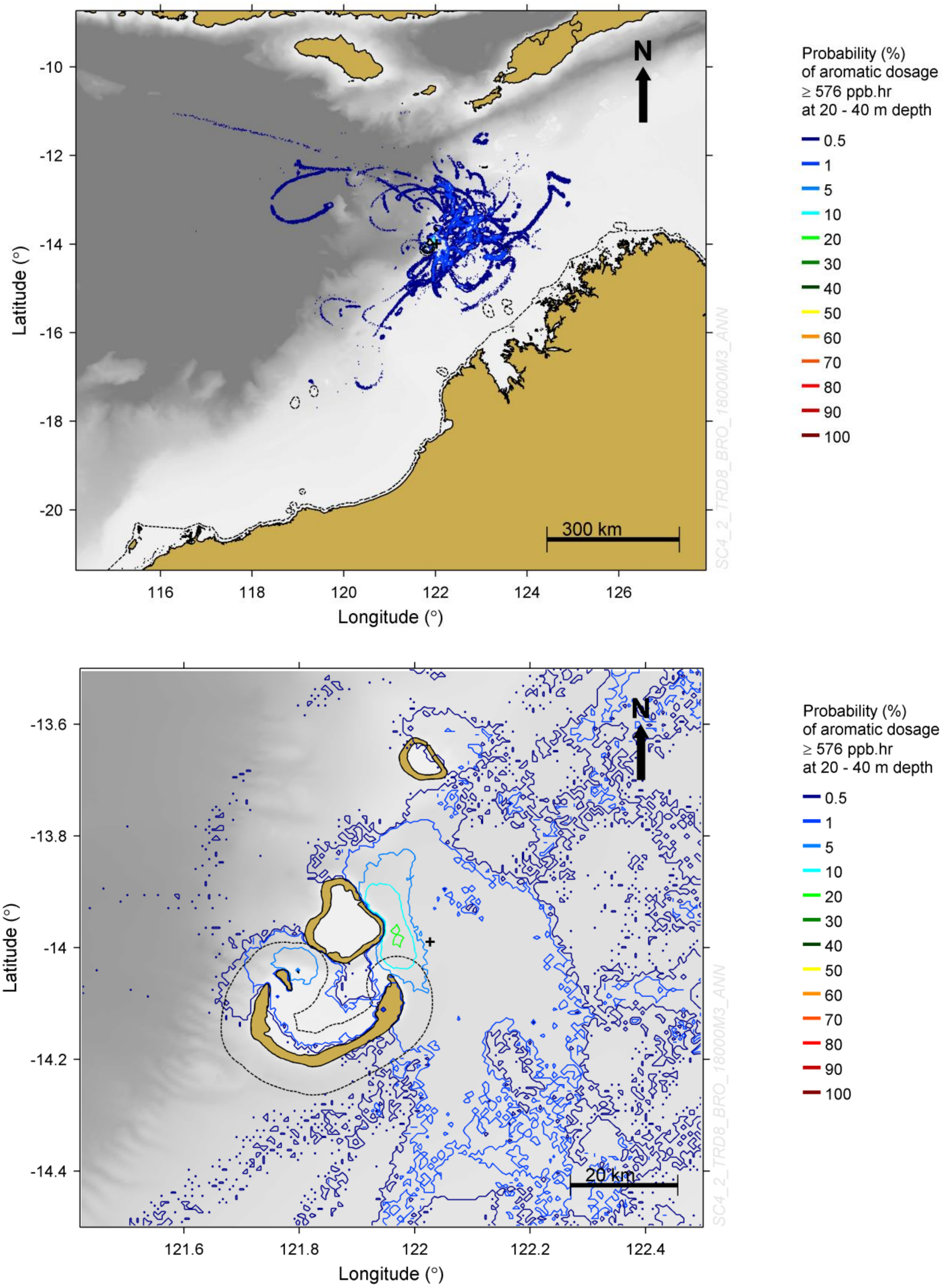
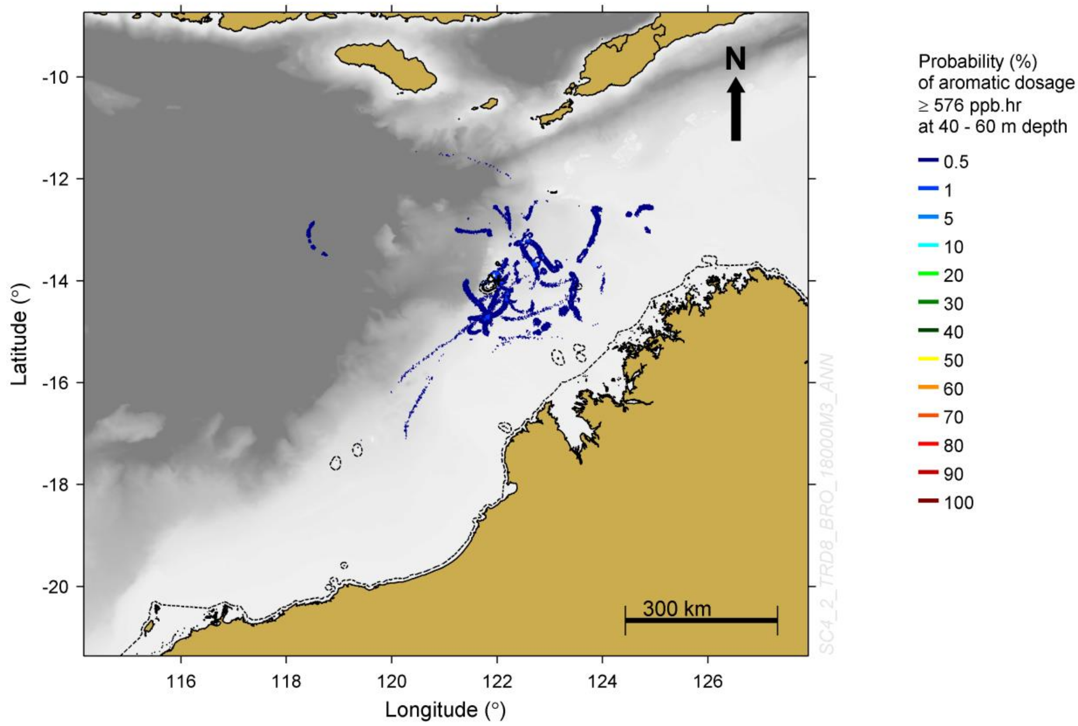


Figure 3-92: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 20 - 40 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



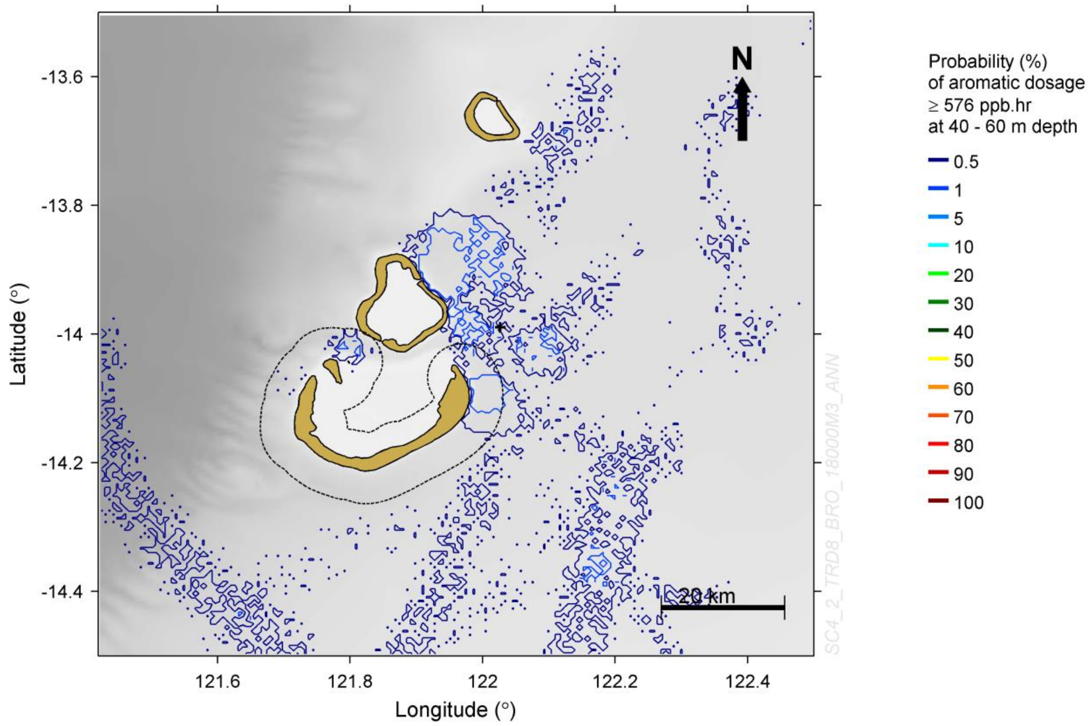
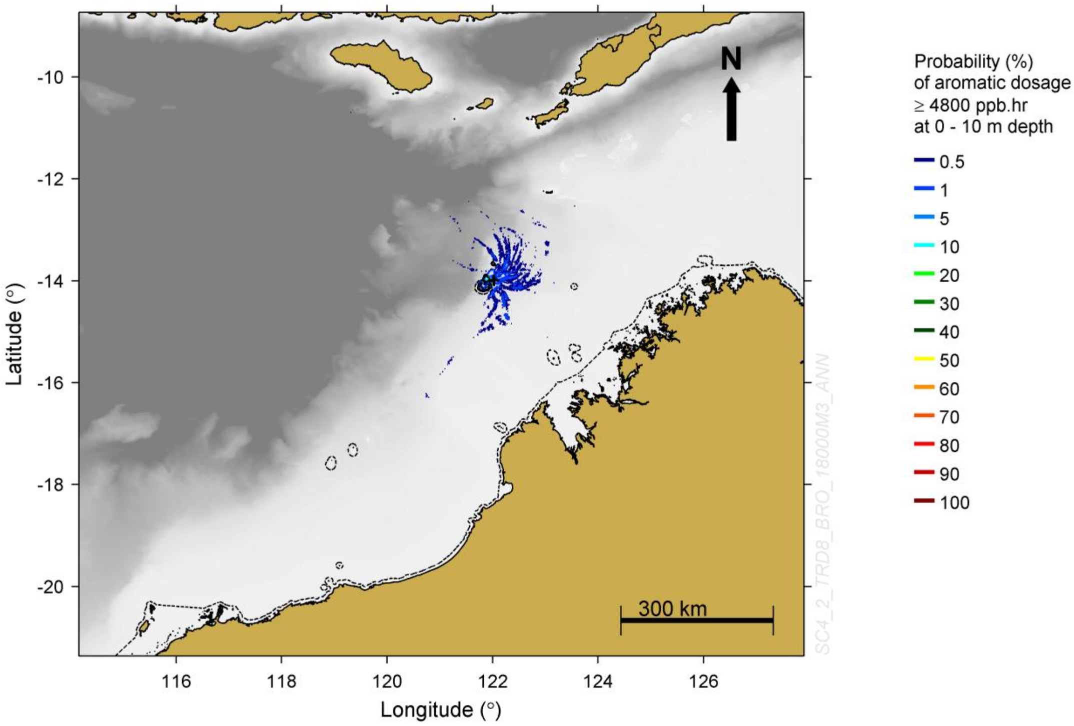


Figure 3-93: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 40 - 60 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

4,800 ppb.hr



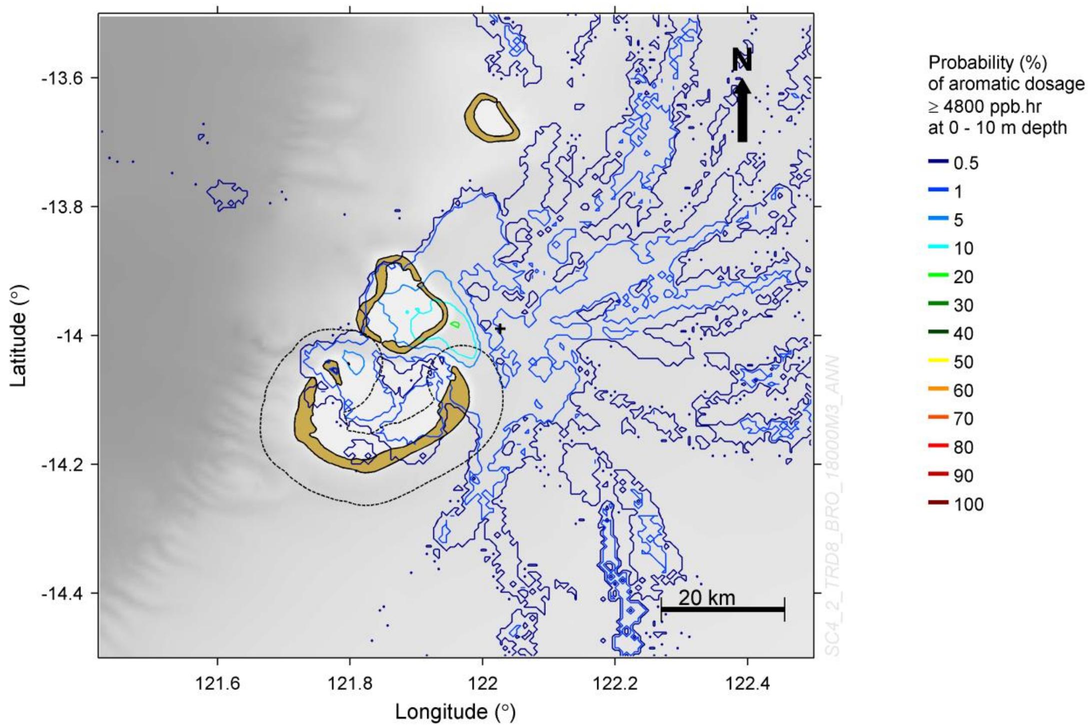


Figure 3-94: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

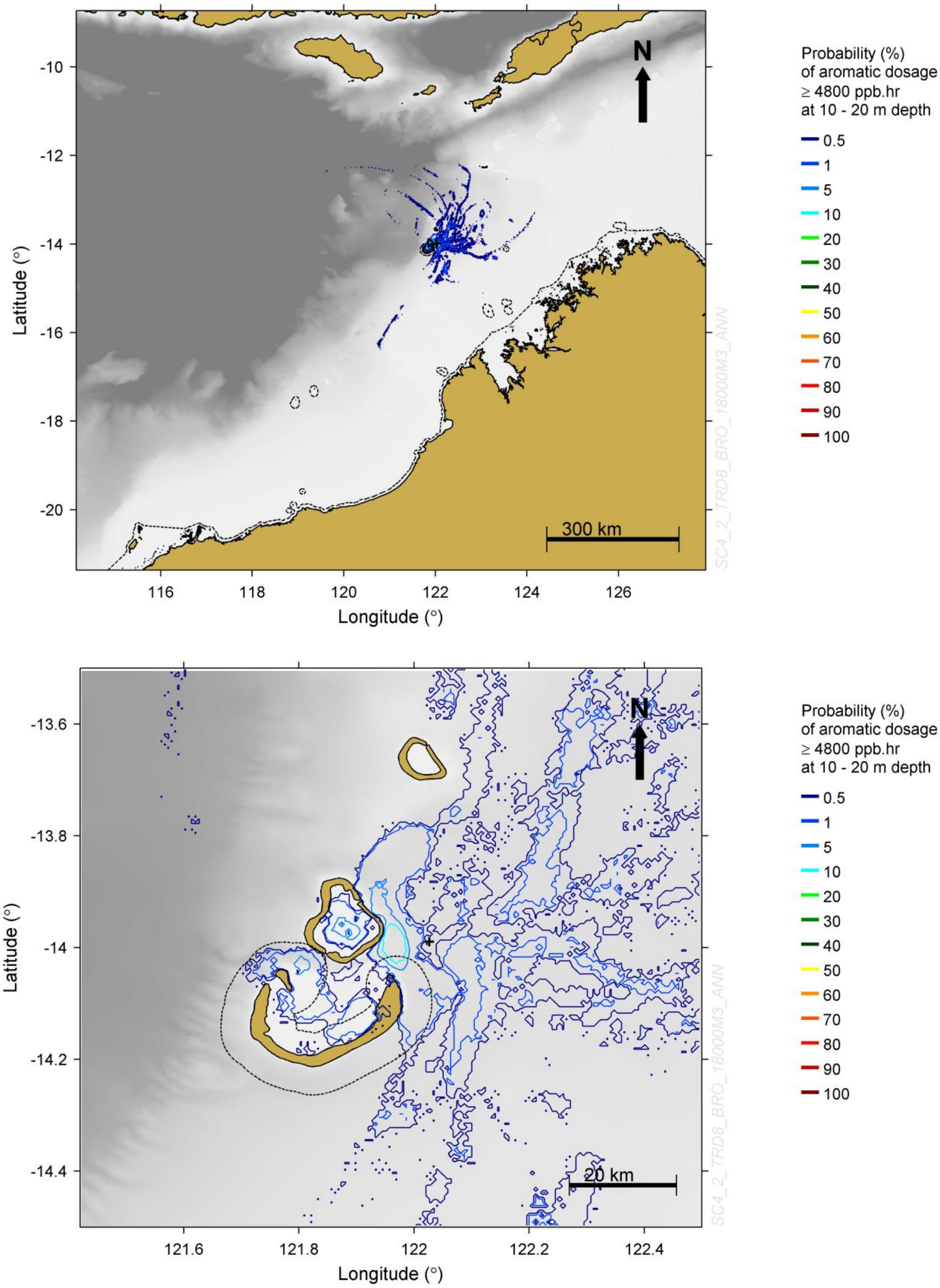
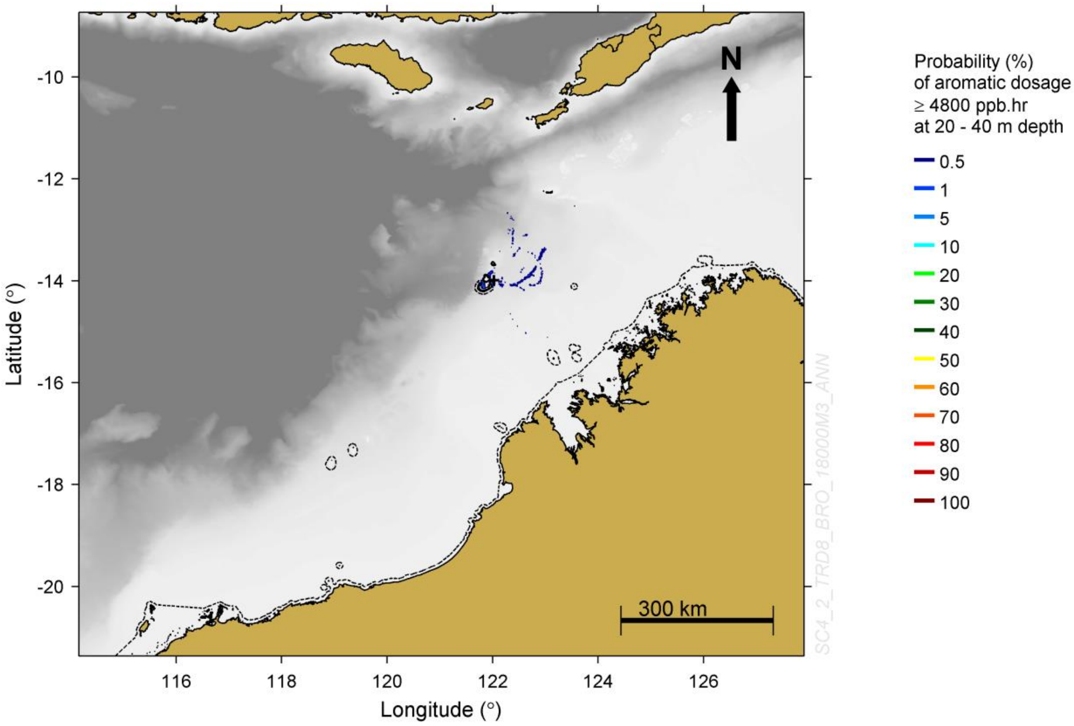


Figure 3-95: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 24-hour 18,000 m³ surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



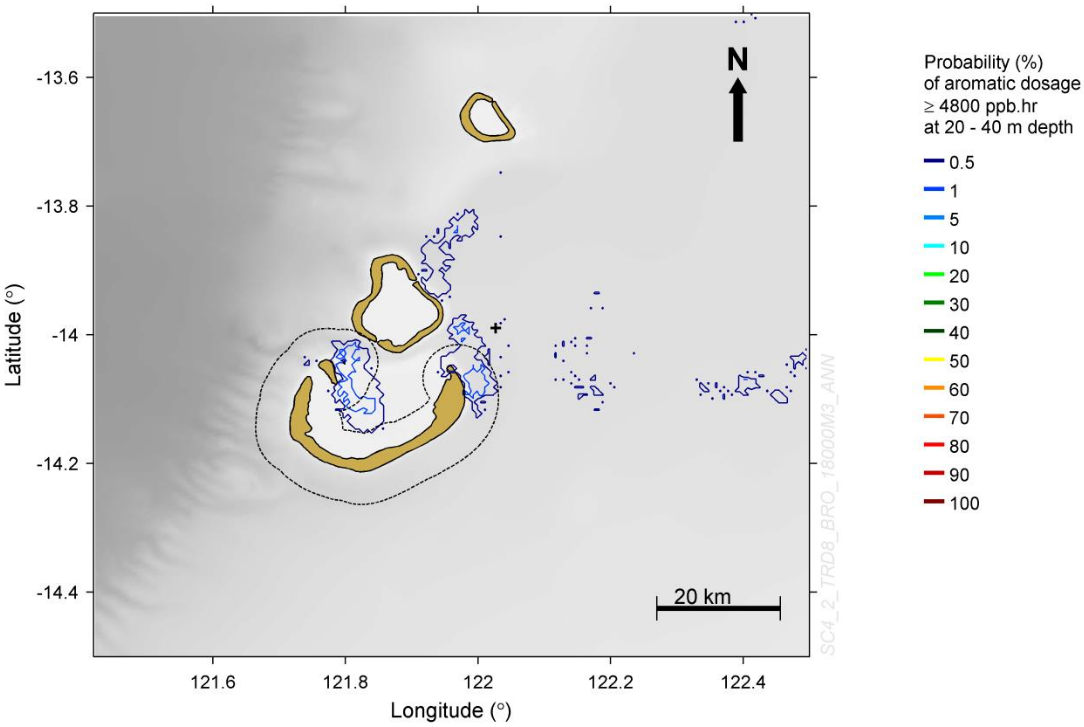
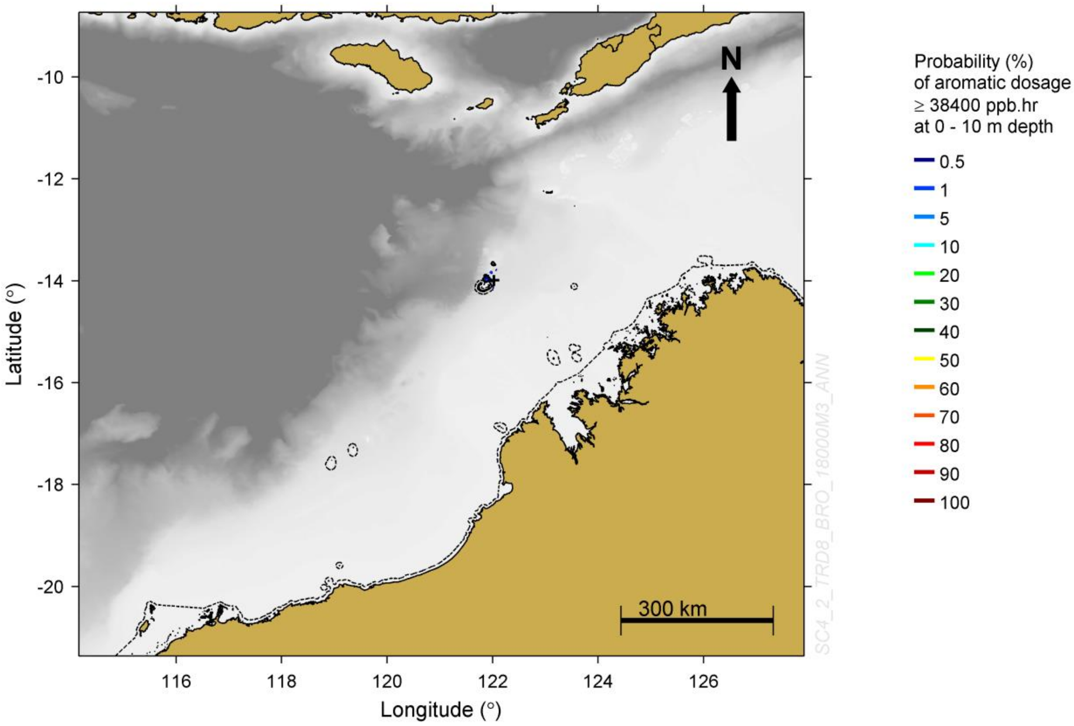


Figure 3-96: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 20 - 40 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

38,400 ppb.hr



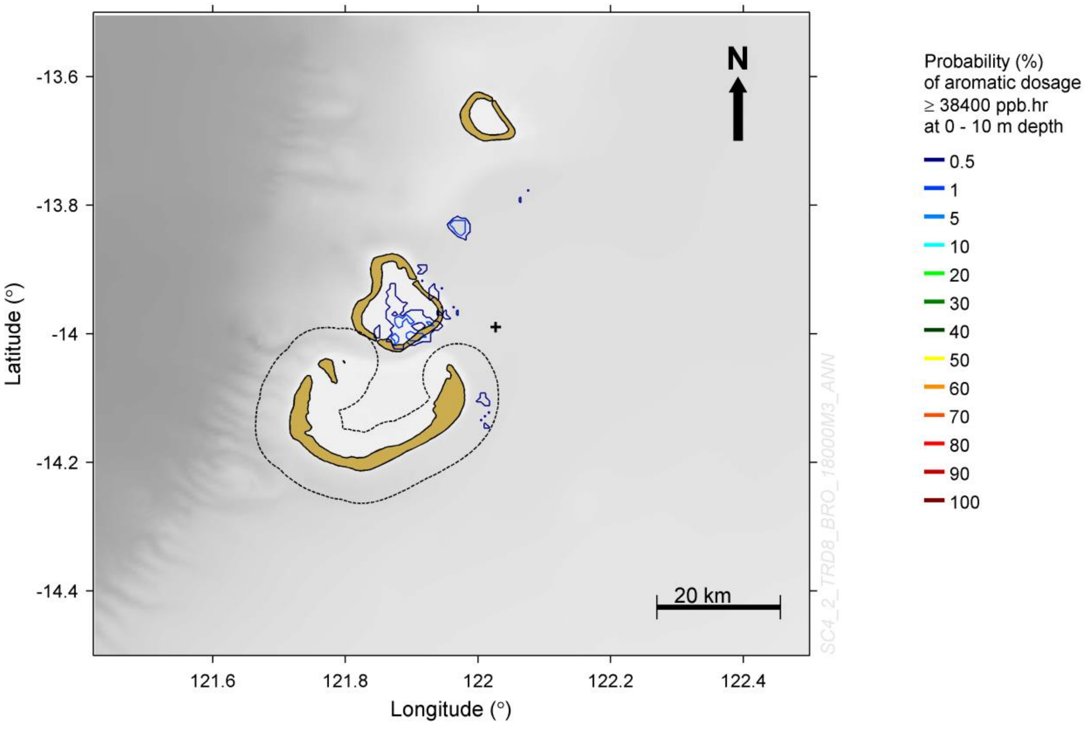
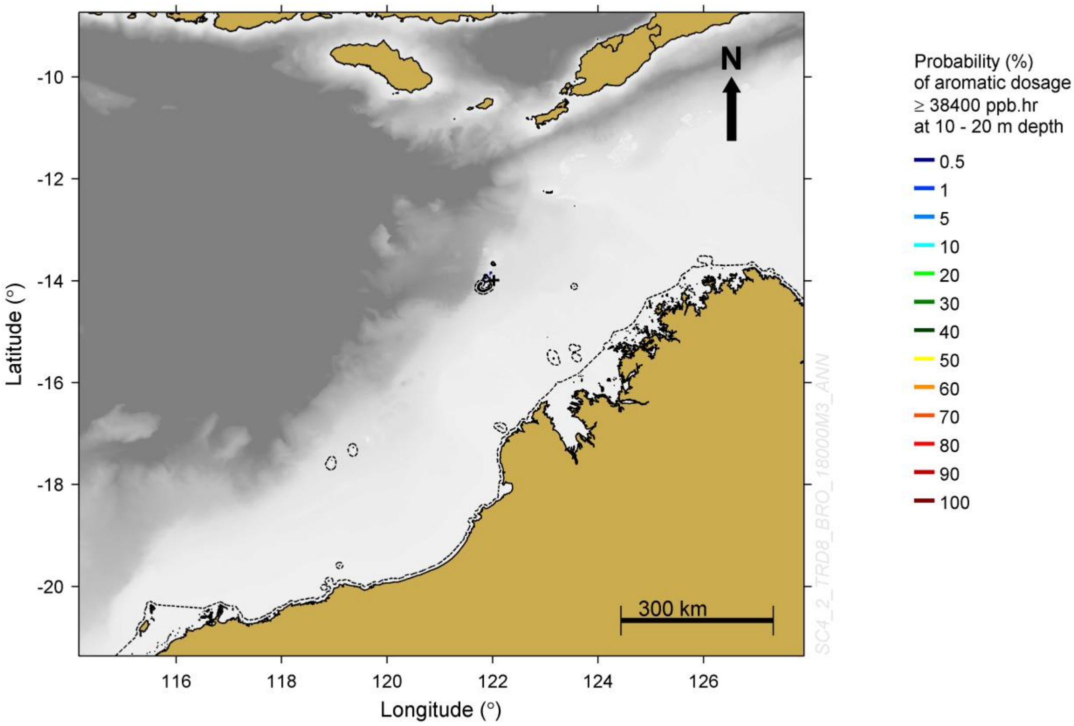


Figure 3-97: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 38,400 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



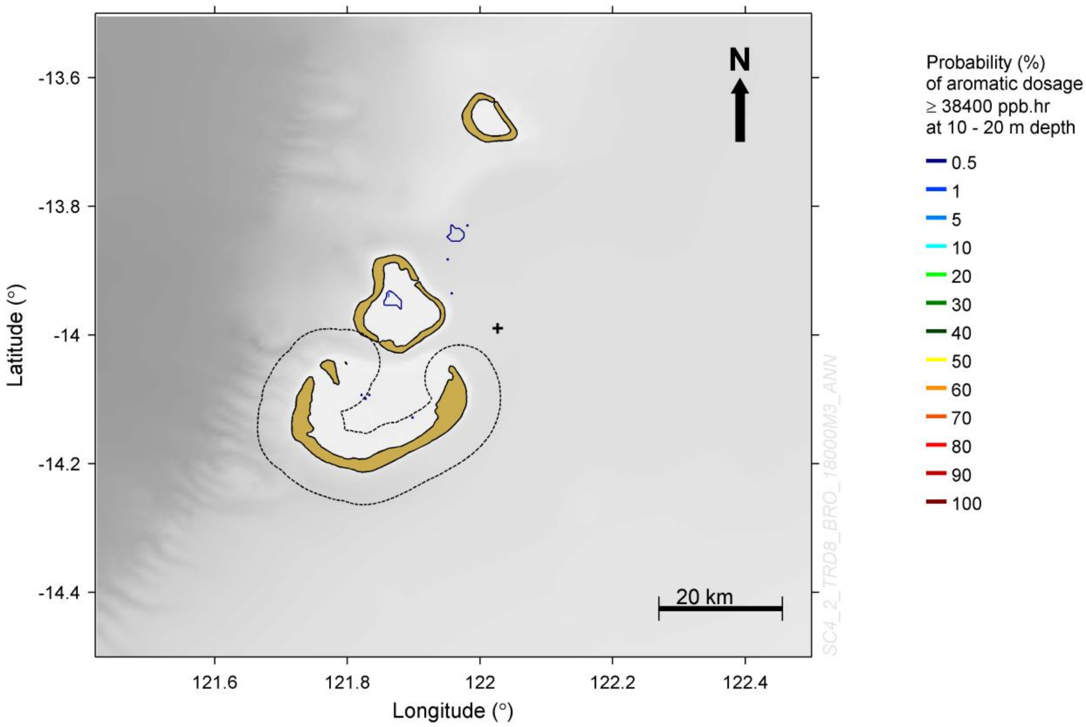
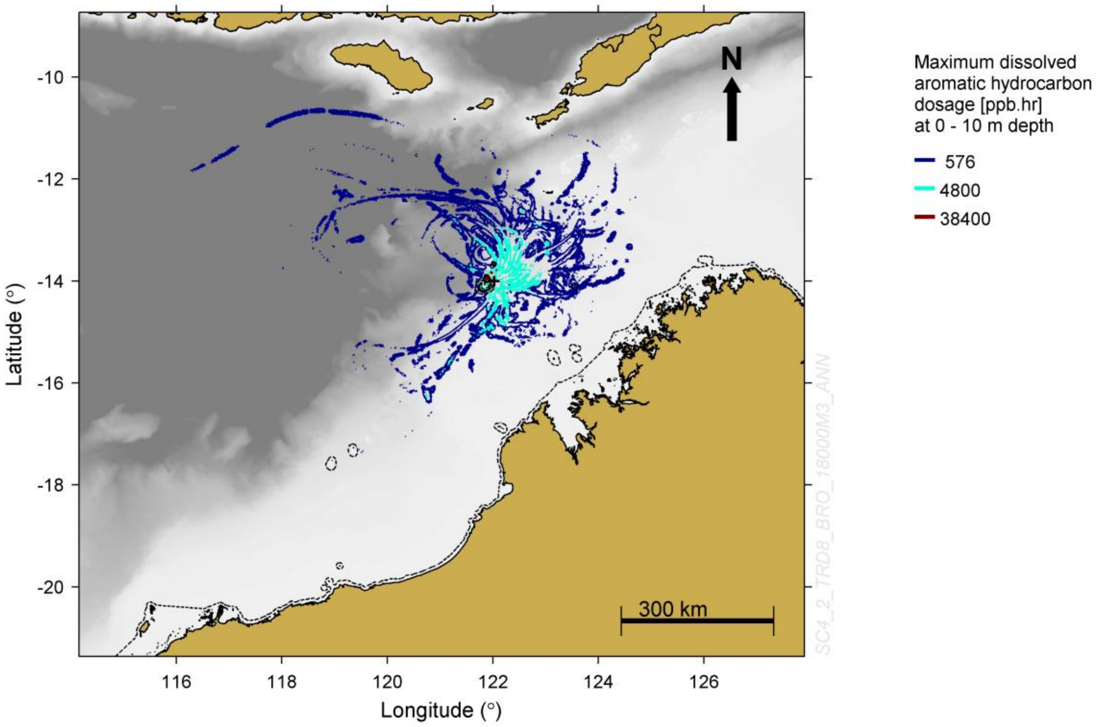


Figure 3-98: Predicted annualised probability of dissolved aromatic hydrocarbon dosage at or above 38,400 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Maximum Aromatic Dosage



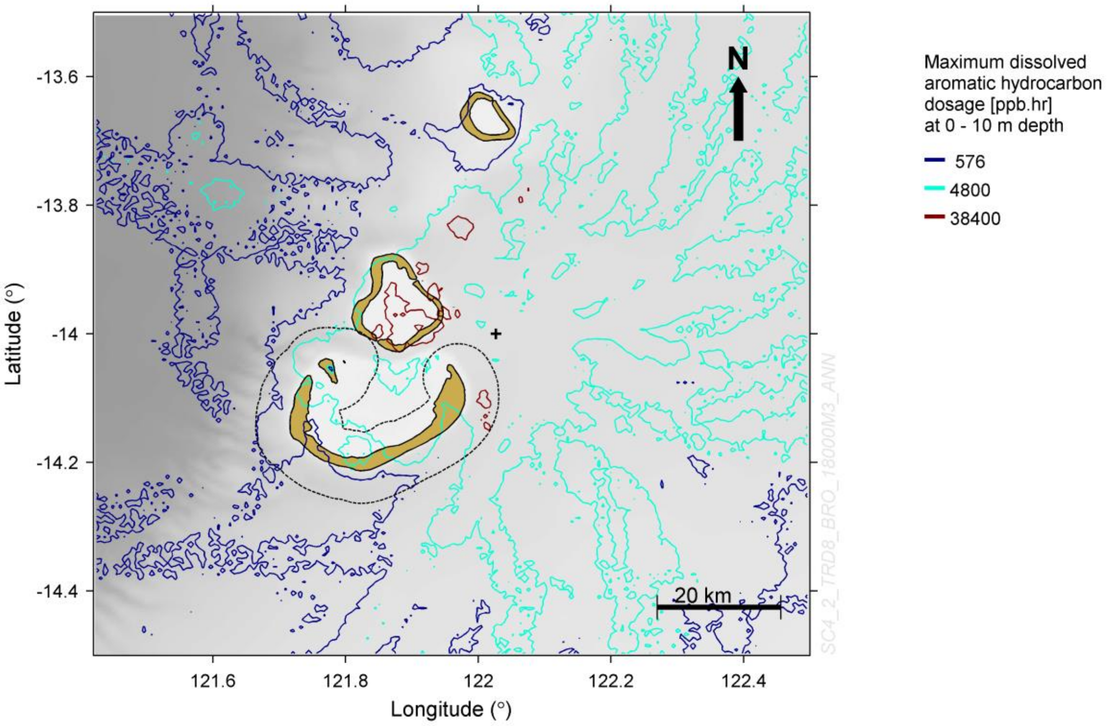
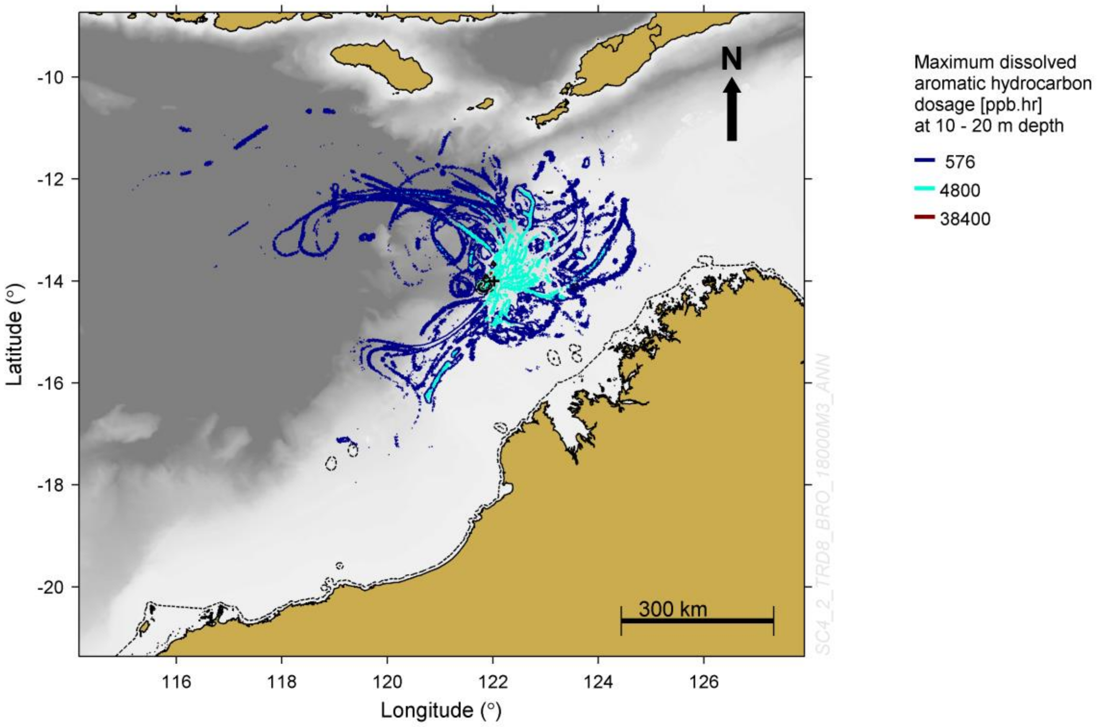


Figure 3-99: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 0 - 10 m (BMSL), resulting from a 24-hour 18,000 m³ surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



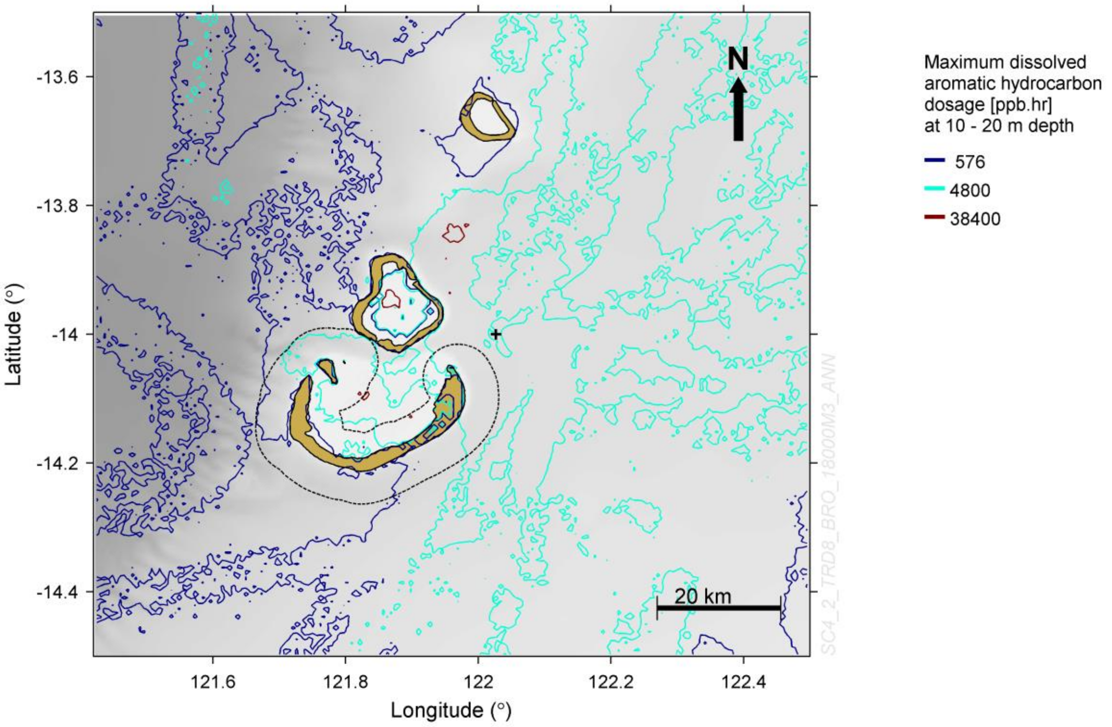
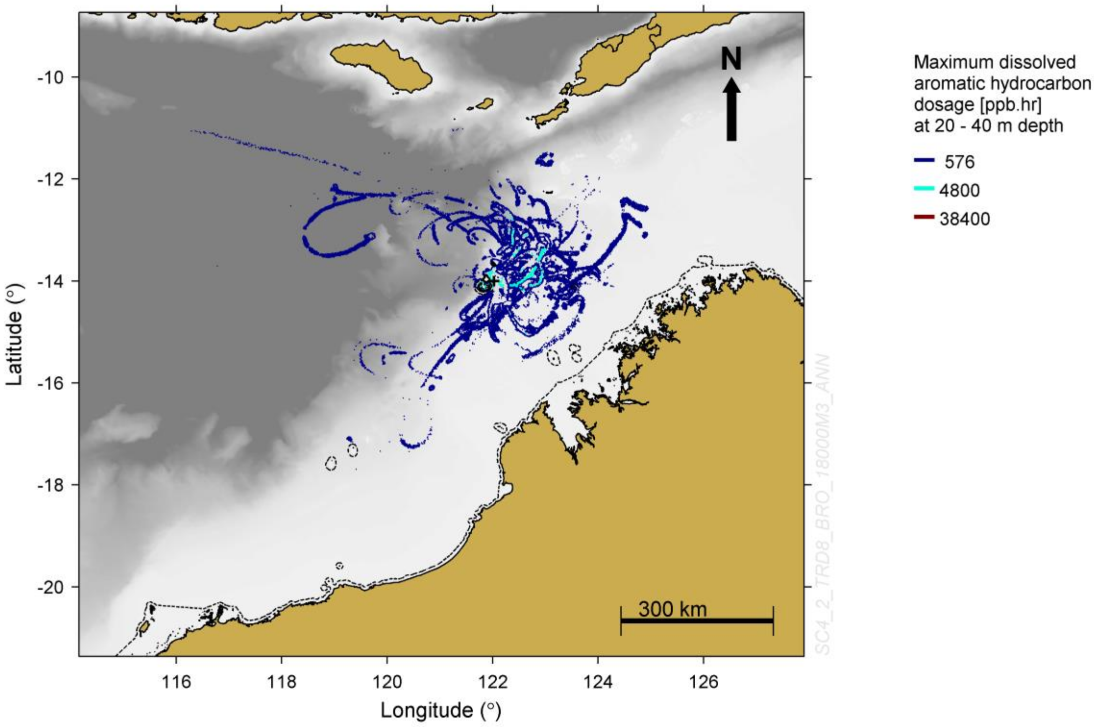


Figure 3-100: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 10 - 20 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



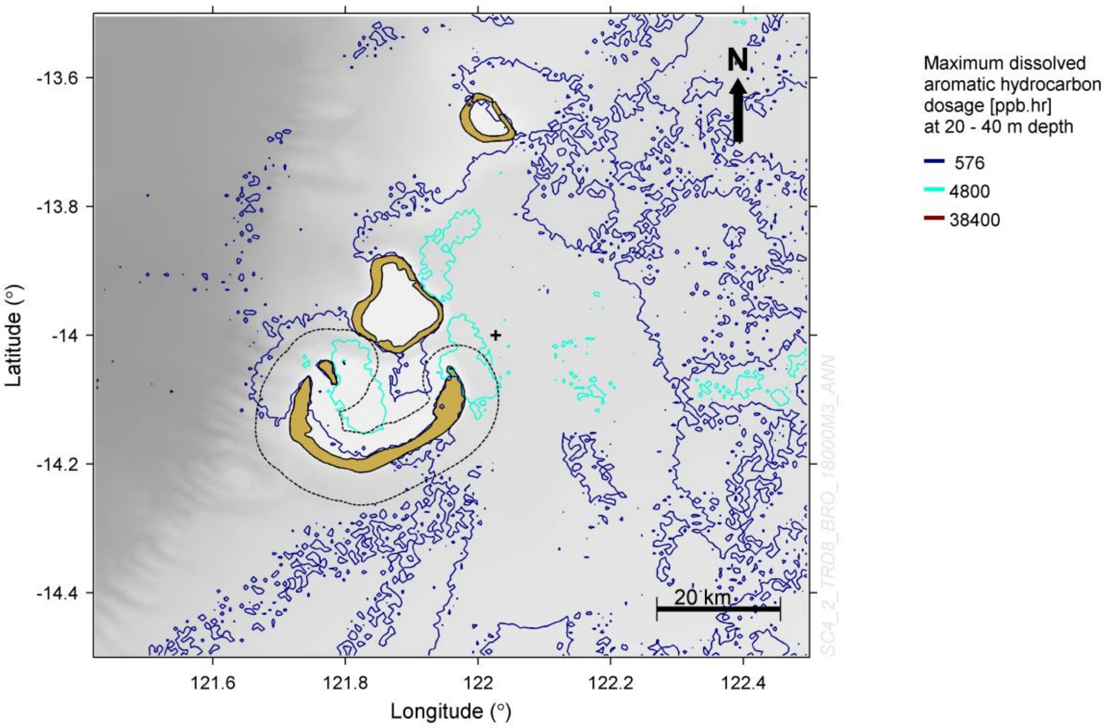
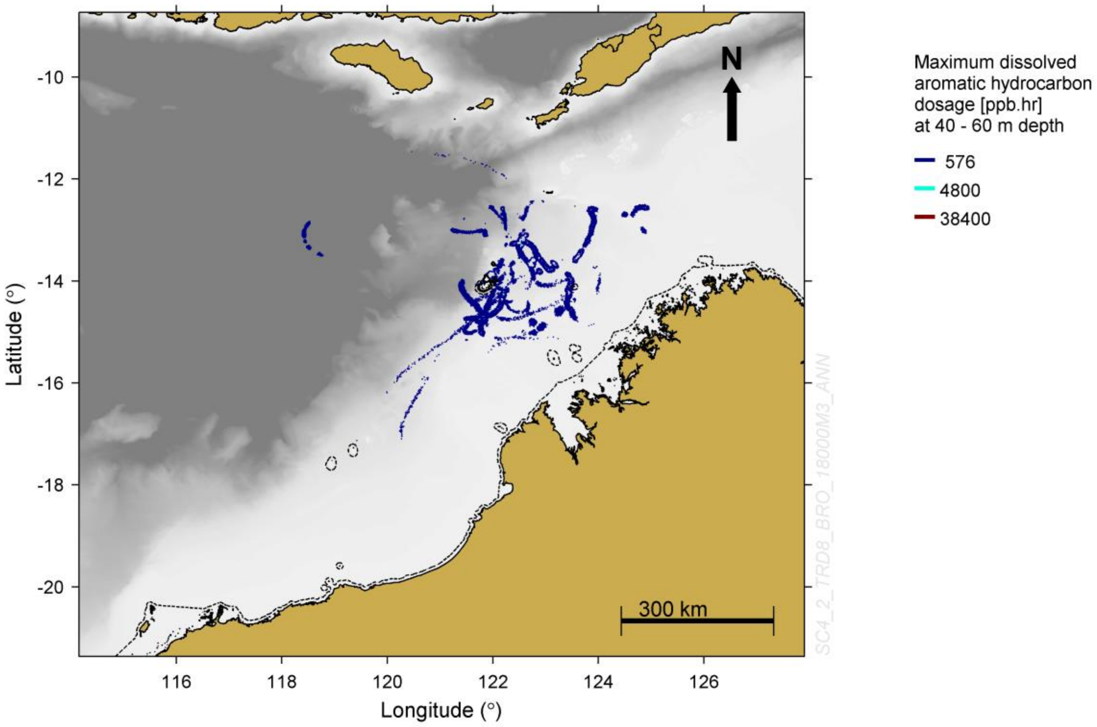


Figure 3-101: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 20 - 40 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



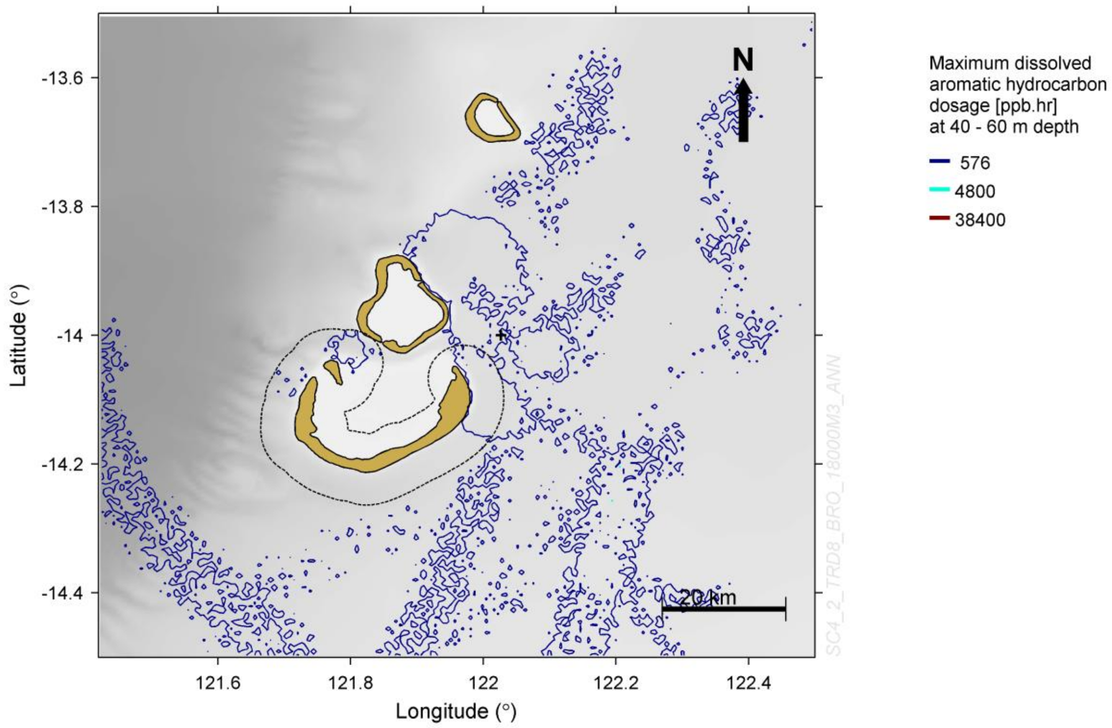


Figure 3-102: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 40 - 60 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

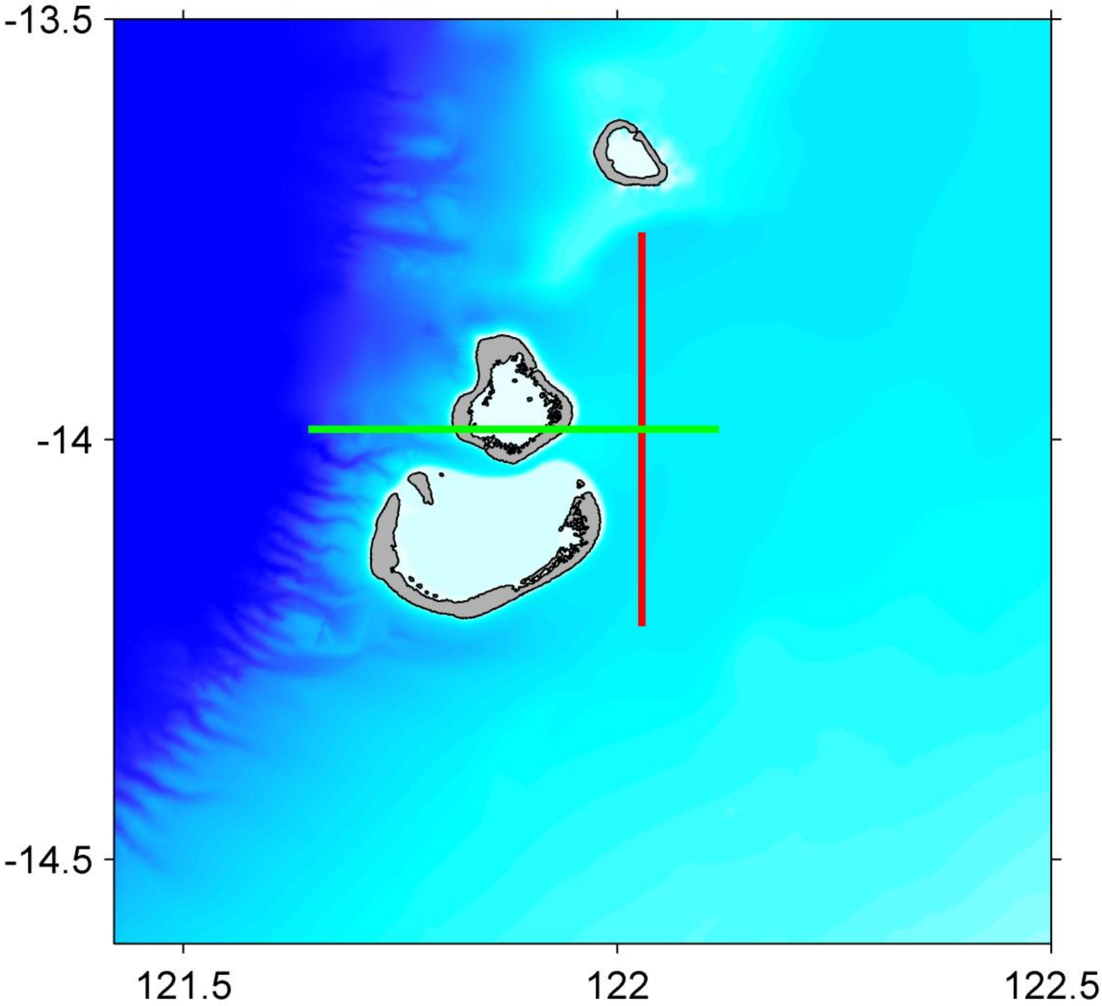


Figure 3-103: Location of the TRD8 location and the respective vertical transects over a varying latitude (red line) and longitude (green line).

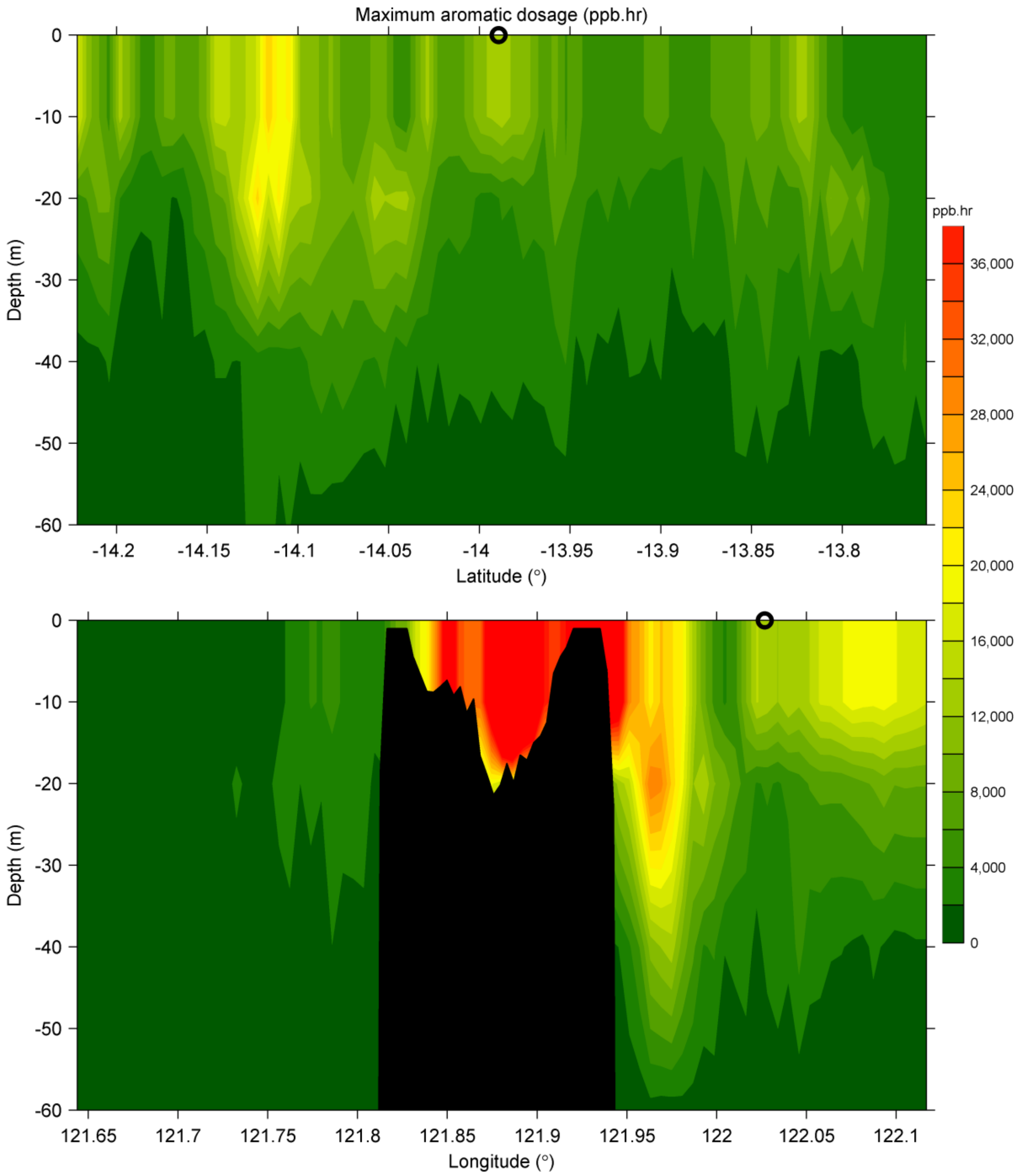


Figure 3-104: Vertical profile showing maximum annualised dissolved aromatic hydrocarbon dosage at a depth of 0 - 60 m (BMSL), across two perpendicular transects intersecting (top, north-south; bottom, east-west) the release point (black circle) from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location.

Table 3-16: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location.

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Timor Leste	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Timor (West)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2	1	1	NC
Pulau Roti	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	8	7	3	NC
Big Bank Shoals	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Melville Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Oceanic Shoals CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Hibernia Reef	Probability (%) ≥ 576	NC	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	513	916	506	17
Ashmore Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	181	114	96	17
Ashmore Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	158	114	45	8

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-16: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Cartier Island CMR	Probability (%) ≥ 576	1.5	1	0.5	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,185	1,848	611	64
Cartier Islet	Probability (%) ≥ 576	1.5	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,087	1,165	265	48
Joseph Bonaparte Gulf East	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Kimberley CMR	Probability (%) ≥ 576	1.5	2	1	1
	Probability (%) ≥ 4,800	0.5	0.5	0.5	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	9,943	9,465	5,714	3,186
Argo-Rowley Terrace CMR	Probability (%) ≥ 576	0.5	0.5	0.5	0.5
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,203	2,213	3,090	2,043
Seringapatam Reef	Probability (%) ≥ 576	0.5	0.5	0.5	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,108	1,403	1,290	344
Joseph Bonaparte Gulf West	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
North Reef Flats	Probability (%) ≥ 576	37.5	38	16.5	1.5
	Probability (%) ≥ 4,800	19.5	10.5	0.5	NC
	Probability (%) ≥ 38,400	1.5	NC	NC	NC
	Maximum Dosage	65,703	21,367	8,054	2,558
North Reef Lagoon	Probability (%) ≥ 576	36	24	10	BS
	Probability (%) ≥ 4,800	16	8	NC	BS
	Probability (%) ≥ 38,400	1.5	1	NC	BS
	Maximum Dosage	93,590	61,074	4,707	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-16: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Kimberley Coast	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
South Reef Lagoon	Probability (%) ≥ 576	22.5	22	9	1
	Probability (%) ≥ 4,800	6.5	6	2	NC
	Probability (%) ≥ 38,400	NC	0.5	NC	NC
	Maximum Dosage	36,564	45,236	28,039	1,260
SR Central/ Sandy Islet	Probability (%) ≥ 576	13	13	BS	BS
	Probability (%) ≥ 4,800	4	2	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	17,529	13,125	BS	BS
South Reef Flats	Probability (%) ≥ 576	13.5	11	4.5	1.5
	Probability (%) ≥ 4,800	3	2.5	1	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	25,725	21,917	20,632	2,683
Browse Island	Probability (%) ≥ 576	2	0.5	1	0.5
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2,581	806	954	593
Lalang-garram / Camden Sound MP	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	11	17	8	NC
Camden Sound	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	7	15	8	NC
Adele Island	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	20	4	BS	BS
Dampier Peninsula Coast - North section	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-16: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Lacepede Islands	Probability (%) ≥ 576	NC	BS	BS	BS
	Probability (%) ≥ 4,800	NC	BS	BS	BS
	Probability (%) ≥ 38,400	NC	BS	BS	BS
	Maximum Dosage	NC	BS	BS	BS
Mermaid Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	403	522	162	493
Mermaid Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	403	522	131	493
Rowley Shoals MP (Clerke Reef)	Probability (%) ≥ 576	NC	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	547	706	265	165
Clerke Reef	Probability (%) ≥ 576	NC	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	403	587	221	57
Imperieuse Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1	1	NC	NC
Rowley Shoals MP (Imperieuse)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Eighty Mile Beach	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Glomar Shoals	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-16: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Rankin Bank	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Dampier Archipelago	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Montebello Islands	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Lowendal Islands	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Barrow Island	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Northern Pilbara- Islands and Shoreline	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	NC	NC	BS	BS
Southern Pilbara- Islands	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Muiron Islands (World Heritage)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Ningaloo Coast North (World Heritage)	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-16: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the TRD8 location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Ningaloo Coast North	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

3.6 Scenario 4.4: Simulation of a 24-hour Surface Release of 18,000 m^3 of Browse Condensate at the BWA Location

This scenario investigated the probability of exposure to surrounding regions due to a 24-hour surface release of Browse Condensate at the BWA location, with a total discharge volume of 18,000 m^3 (Table 1-1).

Table 3-17: Summary of the spill scenario.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (m BMSL)
4.4	Release from offtake vessel at the BWA facility due to major structural failure	Browse Condensate	18,000	1.91x10^{-7}	24 hours	14° 30' 3.422" S 121° 34' 39.595" E	Surface

The modelling for this scenario assumes no mitigation efforts are undertaken to collect or otherwise affect the natural transport and weathering of the oil. All sensitive receptors outlined in Section 2.3.6 were analysed, however, only the receptors that were forecast to be contacted by dispersing oil are summarised in this section.

Average Weathering

The average mass transfer shows high evaporation during the modelled release with approximately 45% of the oil expected to evaporate in the first 24 hours, increasing to 75% at the end of the simulation period of 42 days. Approximately 12% of the oil on average is expected to entrain during the first 5 days. Very little mass is expected to remain floating on the surface after approximately 25 days (Figure 3-105 and Figure 3-106).

The amount of aromatic hydrocarbons in the floating oil decreases relatively rapidly after cessation of the release due to primarily to evaporation of the more highly volatile and soluble components (Figure 3-107 and Figure 3-108). The peak in the dissolved fraction occurs after around 6 days, or 5 days after the cessation of the spill. At the end of the simulation, very little of the initial aromatic hydrocarbon mass remains in the system.

Trajectory and Weathering of an Example Replicate

An example series of snapshots of a single oil spill trajectory where contact at Scott Reef South is expected are presented in Figure 3-109, and associated weathering and fates plots in Figure 3-110. The snapshots display the concentration of oil floating on the water surface based on the specified surface oiling thresholds.

The single spill trajectory analysis shows that one day after the spill (Figure 3-109 b) the oil slick is present at a concentration greater than 25 g/m^2 in parts, as it drifts towards the northeast towards the Reef. After 3 days, the area where the concentration is greater than 25 g/m^2 is reduced as the slick has been swept to the southern edge of South Reef Flats where its subsequent transport becomes influenced by the presence of the Reef (Figure 3-109 c). After 5 days, the oil slick concentration is less than 10 g/m^2 as it begins to drift around the eastern edge of South Reef Flats (Figure 3-109 d), subsequently dispersing into smaller and less coherent patches of approximately 1 g/m^2.(Figure 3-109 e and f).

The weathering curve for this simulated event (Figure 3-110) shows that 45% of the total modelled oil mass is expected to have evaporated by the time the initial 24-hour release phase has ended. Rates of entrainment and evaporation are relatively rapid for the first 48 hours due to the ongoing release of higher volatility components during the 24-hour release phase and the relatively high wind speeds. After 5 days of simulation, approximately 65% of released oil mass has evaporated, 20% has been entrained with very little oil floating on the surface. A small amount of dissolved aromatic hydrocarbons are present in the water column after 7 days.

This example demonstrates that high wind speeds around the time of an oil release can cause high rates of entrainment which counterbalance the losses due to evaporation of surface oil.

Floating Oil

The probability (P_2) contours show that floating oil with concentrations at or above 1 g/m^2 is forecast to occur up to approximately 500 km from the release site (Figure 3-111). The corresponding contours at the 10 g/m^2 threshold generally extend up to 200 km from the release site, with isolated occurrences extending as far as the Rowley Shoals to the south-west (Figure 3-112). Oil is forecast to most likely drift initially towards the northeast (South Reef Flats) or the southwest. The return-period probabilities (P_1xP_2) at these thresholds are shown in Figure 3-113 and Figure 3-114.

The higher maximum concentrations of floating oil (at or above 50 g/m^2) are expected to occur within 100 km of the release site (generally within 70 km), with some isolated occurrences at larger distances (Figure 3-115). The potential areas of floating oil at or above the defined thresholds are quantified in Table 3-18.

The swept area statistics given in Table 3-18 shows significant variability in the potential outcome. Depending on the conditions prevailing at and after the spill, the swept area can vary between around a tenth and 25 times the median outcome. For example, the total area of open water contacted by slicks at 1 g/m^2 or greater is predicted to vary between around 100 and 27,500 km^2 with a median of 1,148 km^2. The size of the stochastic swept area (integrated over the full set of simulations) is always much larger than the area of the individual spill outcomes, and is an order of magnitude larger than the maximum predicted single spill area in this particular instance.

Table 3-18: The potential swept area (km^2) of floating oil with concentrations exceeding defined threshold concentrations in any single spill event. The swept area refers to all areas covered by the slick during the spill simulation with a concentration at the specified threshold.

	0.5 g/m^2	**1 g/m^2**	**10 g/m^2**	**25 g/m^2**
Minimum potential area (km^2)	125	103	65	48
Median potential area (km^2)	1,426	1,148	523	347
Mean potential area (km^2)	2,896	2,290	773	382
Maximum potential area (km^2)	36,030	27,646	3,700	1,215

Floating oil with a concentration of 25 g/m^2 or greater is expected to contact Scott Reef and Seringapatam Reef and to pass through Kimberley CMR and Argo-Rowley Terrace CMR (Table 3-19). The forecast probabilities of contact (or arrival at submerged receptors) for this threshold are 4% at Kimberley CMR, South Reef Lagoon and South Reef Flats, and less than or equal to 1.5% at Argo-Rowley Terrace CMR, Seringapatam Reef, Scott Reef Central/ Sandy Islet and Rowley Shoals MP. Several other receptors are expected to be contacted by floating oil at concentrations between 0.5 and 25 g/m^2, with North Reef Flats and North Reef Lagoon contacted at 1 g/m^2 but not 10 g/m^2.

The minimum time expected for floating oil at the lowest defined threshold (0.5 g/m^2) to reach any shoreline receptor is 46 hours for South Reef Flats. Contact at 10 g/m^2 may be expected within 54 hours at the same receptor.

The worst-case locally accumulated shoreline concentrations are forecast at Scott Reef Central/ Sandy Islet (3,117 g/m^2) and Adele Island (3,116 g/m^2). The maximum accumulated volume along any shoreline section is expected at Scott Reef Central/ Sandy Islet (7 m^3), which is less than 0.1% of the spilled volume. Note that the potential for accumulation at the most proximal receptors is governed by the amount of permanently emergent shoreline expressed in the model.

Dissolved Aromatic Hydrocarbon Dosage

Exceedence of the low dosage threshold (at or above 576 ppb.hr) is expected to occur up to 450 km from the spill site in the upper ocean layers (0-10 m, 10-20m, 20-40 m depths; Figure 3-120, Figure 3-121 and Figure 3-122). The moderate dosage threshold (at or above 4,800 ppb.hr) is expected to be exceeded up to 130 km from the spill site in the nearer surface layers (0-10 m, 10-20 m; Figure 3-124 and Figure 3-125). In the 20-40 m depth layer, only isolated contours are observed, suggesting a low likelihood of dosage exceedence within this depth range at the sensitive habitats of Seringapatam Reef, North Reef Flats and South Reef Flats (Figure 3-126).

Isolated occurrences of high dosage (at or above 38,400 ppb.hr) may occur relatively near to the spill site in the surface layer (0-10 m; Figure 3-127), but no exceedence within an assessed receptor is expected.

Maximum dissolved aromatic hydrocarbon dosage maps (at any depth) are presented in Figure 3-128 to Figure 3-131.

Figure 3-133 shows the vertical distribution of the maximum dissolved aromatic hydrocarbon dosage along two perpendicular transects that intersect at the release site (Figure 3-132). Both transects show that the maximum dosage decreases with depth. Both transects show that higher doses occur in isolated patches away from the release site. This general patchiness of concentration values in the surface layer is likely caused by either the effect of entrained plumes spiralling away from the release site before intersecting the transect some distance from the release site, episodic timing of entrainment driving wind events or the location of local low circulation zones that allow dosage to build over time.

Exceedence of the low dosage threshold is expected to occur at all assessed receptor zones of Scott Reef (Table 3-20). Exceedence of the moderate dosage threshold is expected at North Reef Flats and South Reef Flats in the upper 20 m of the water column. Exceedence of the low and moderate dosage thresholds are also expected at Kimberley CMR (7% and 1.5%), Argo-Rowley Terrace CMR (2% and 0.5%) and Seringapatam Reef (2.5% and 1%). The probability of exceeding the high dosage threshold at any receptor is less than 0.5%.

3.6.1 Average Weathering

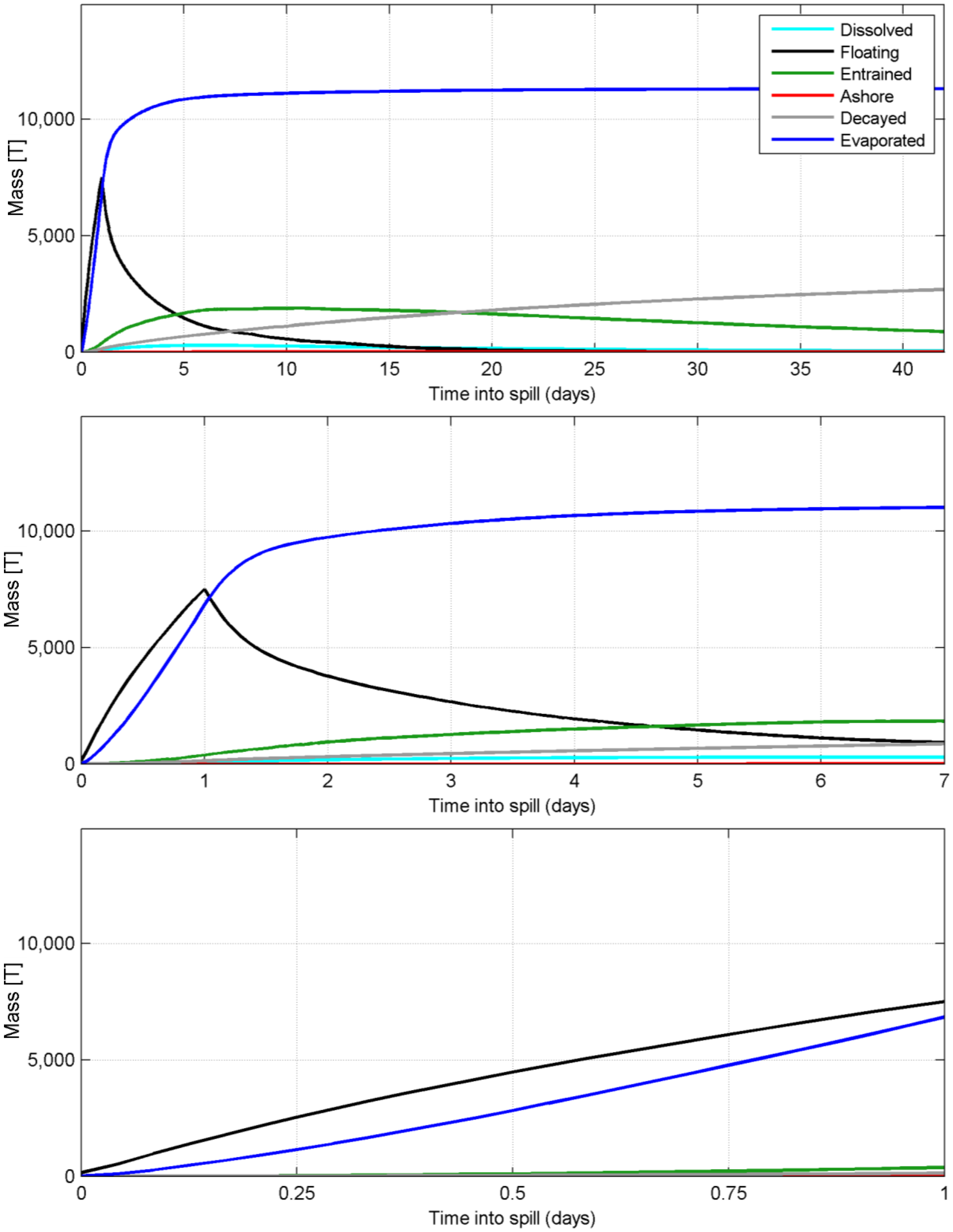


Figure 3-105: Predicted average weathering mass balance (tonnes) resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

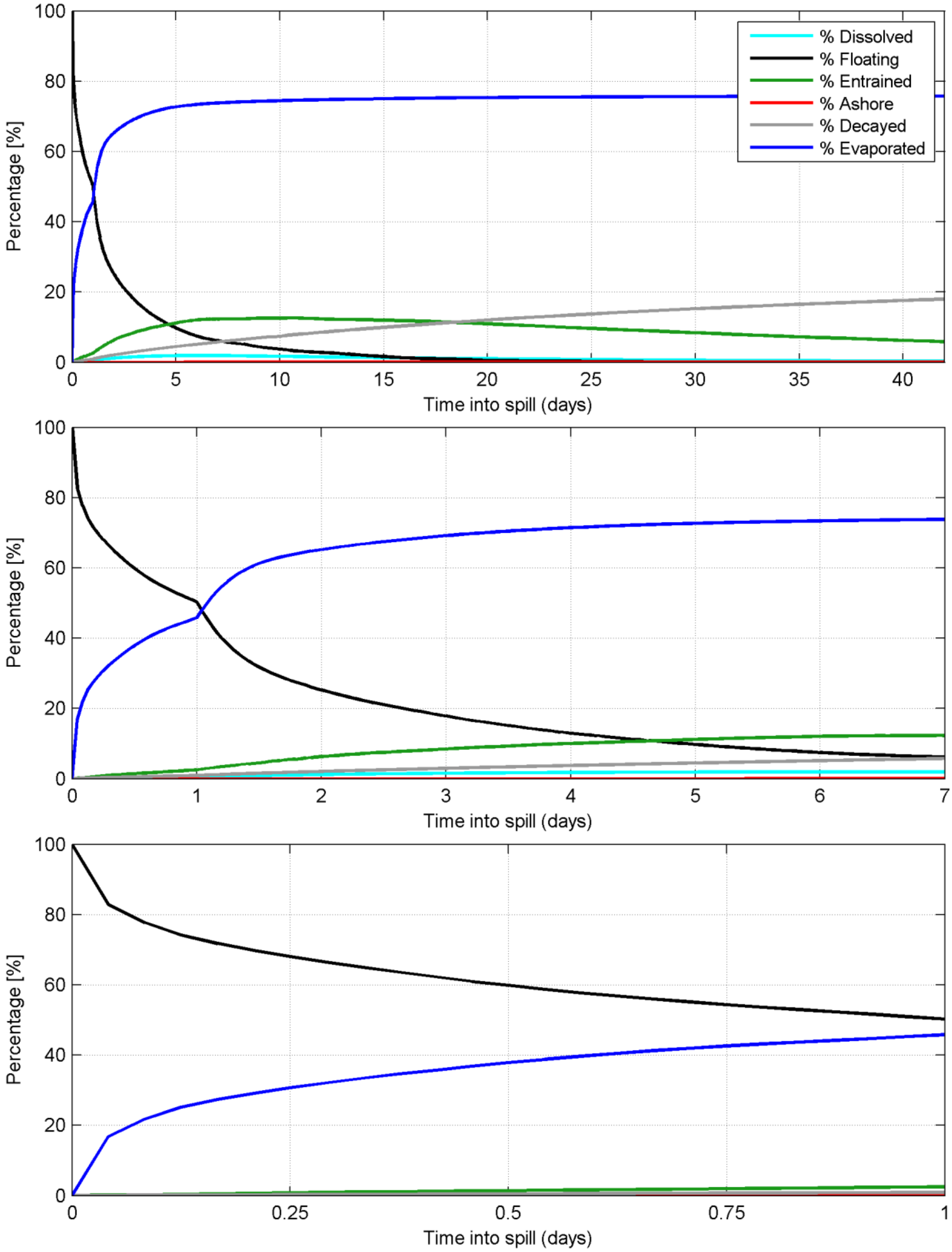


Figure 3-106: Predicted average weathering mass balance (% of total mass) weathering graph resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

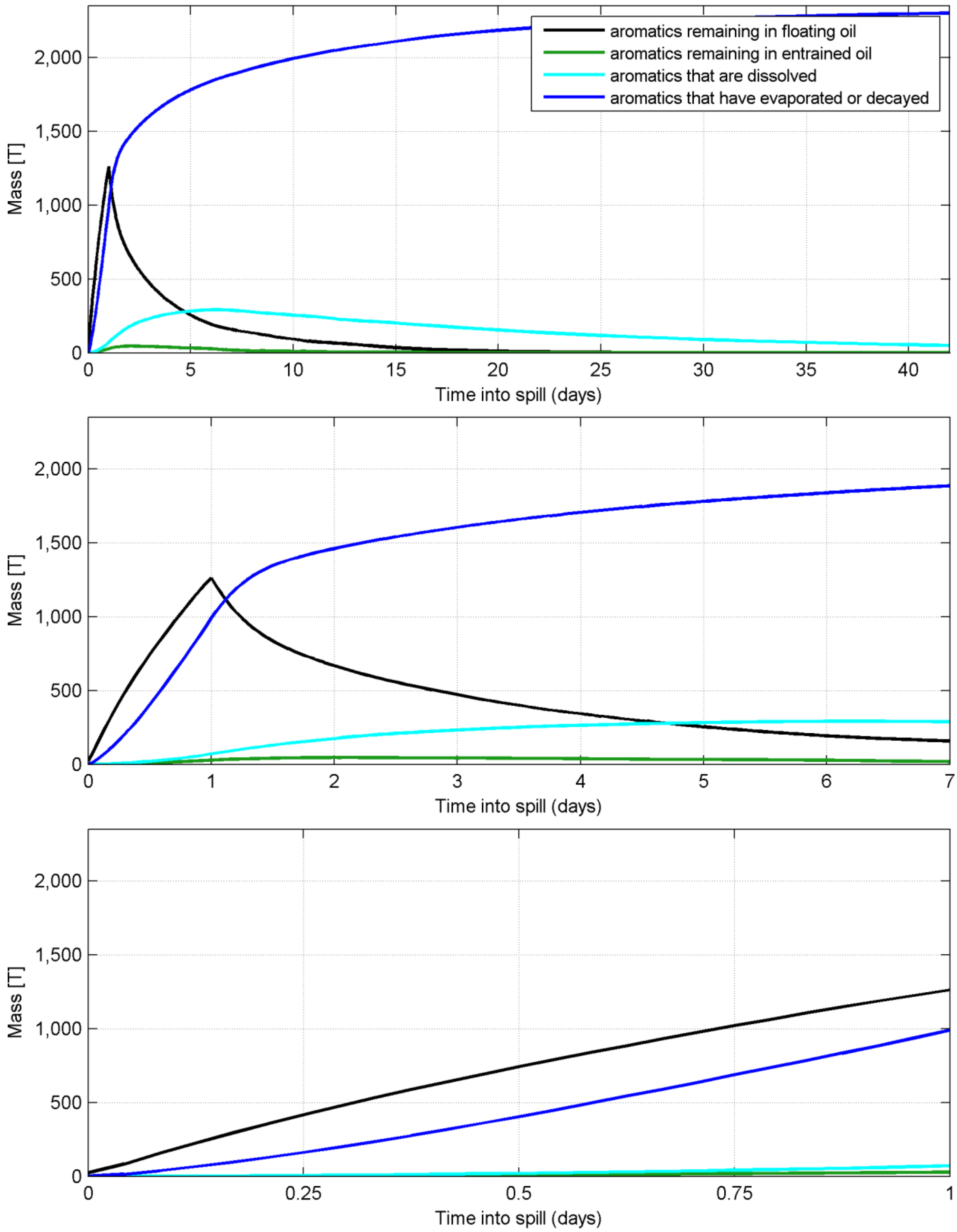


Figure 3-107: Predicted average partitioning of the aromatic hydrocarbons (tonnes) resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

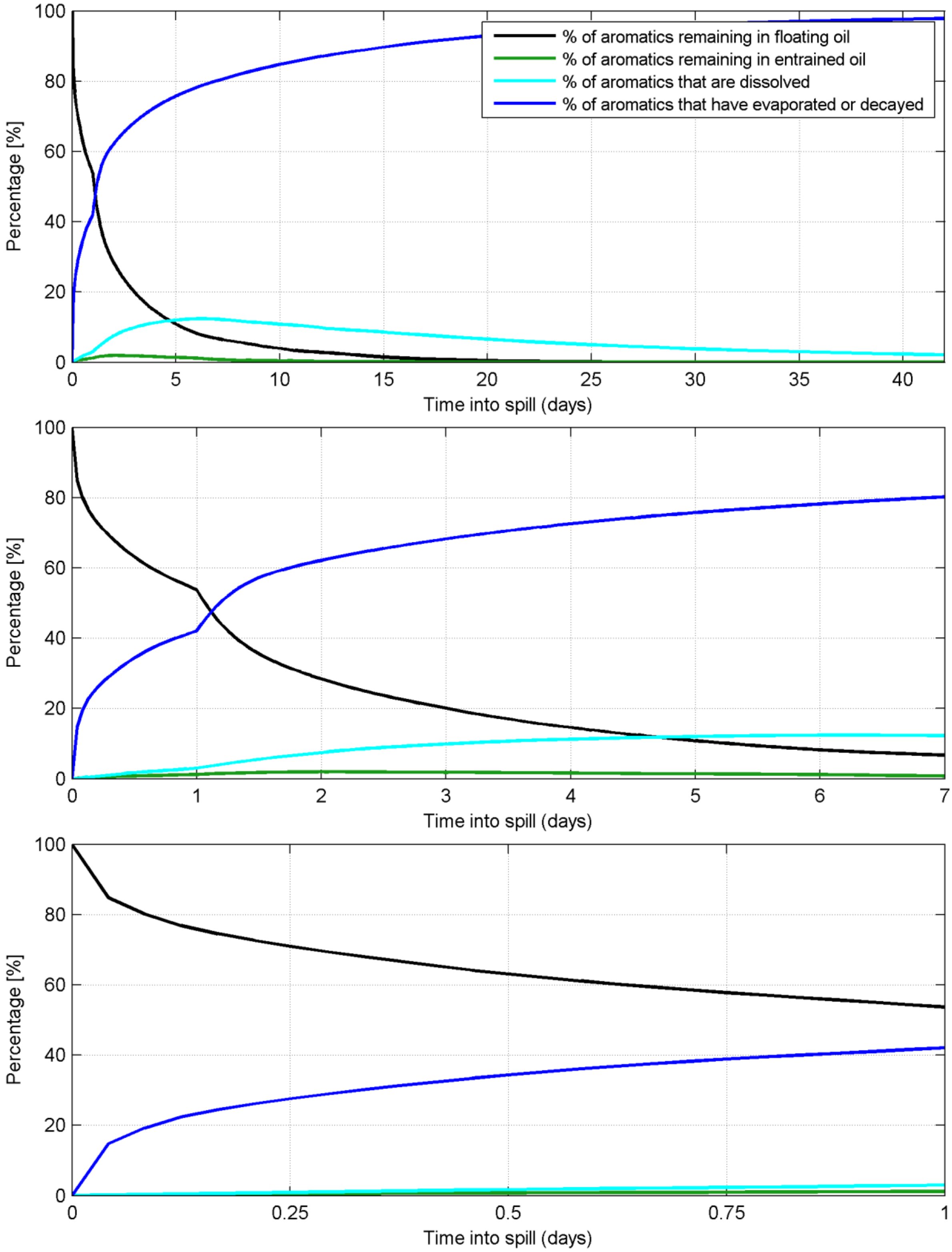


Figure 3-108: Predicted average partitioning of the aromatic hydrocarbons (% of total mass) resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The distribution over the first 42 days (top), 7 days (middle) and 24 hours (bottom) is given.

3.6.2 Trajectory and Weathering of an Example Replicate

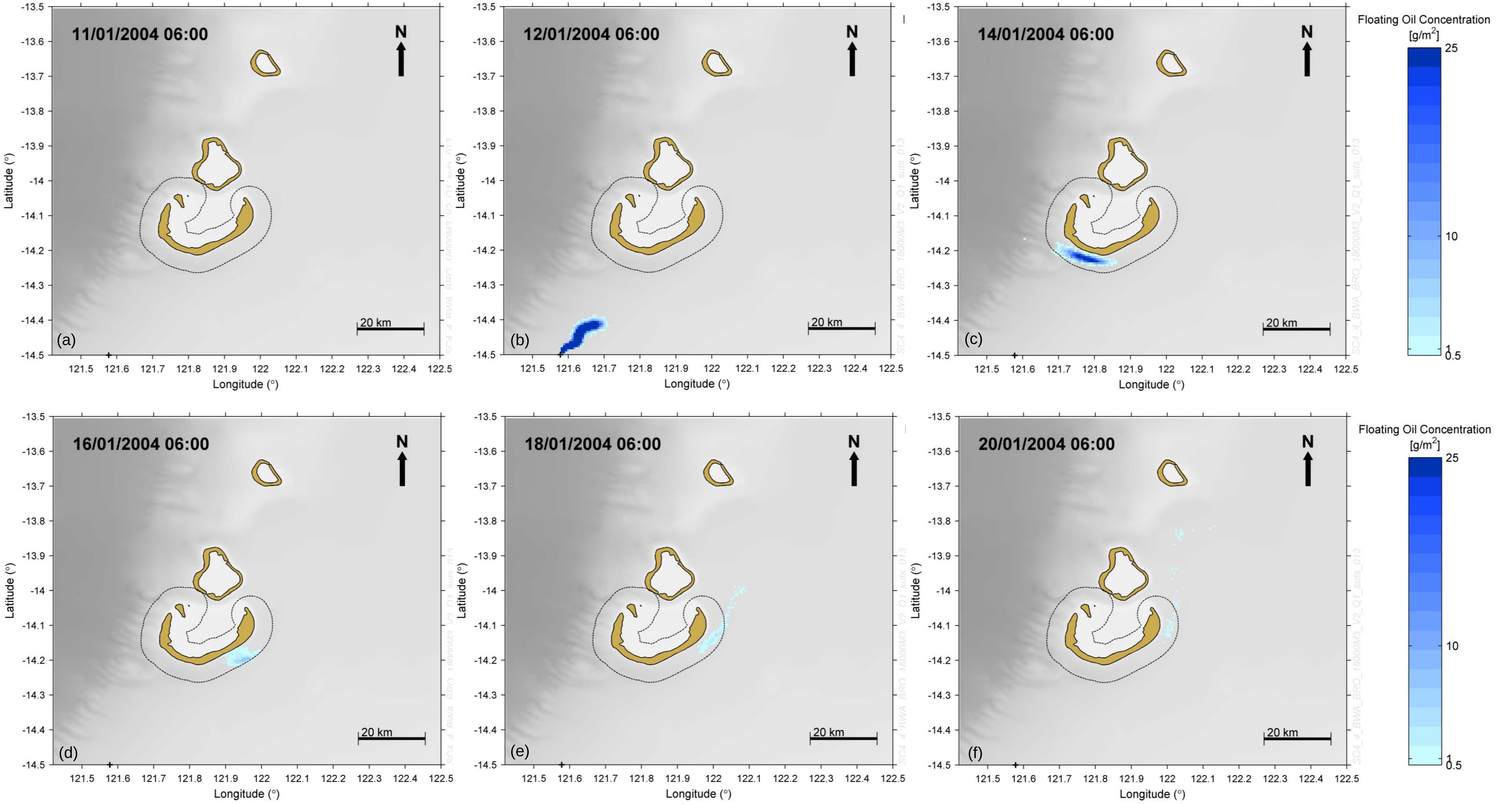


Figure 3-109: Example trajectory and concentration of floating oil for a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location, commencing at 06:00 on 11th January 2004. The resultant trajectory and concentration at the start of the release (a), and 1 day (b), 3 days (c), 5 days (d), 7 days (e) and 9 days (f) after the start of the release are presented.

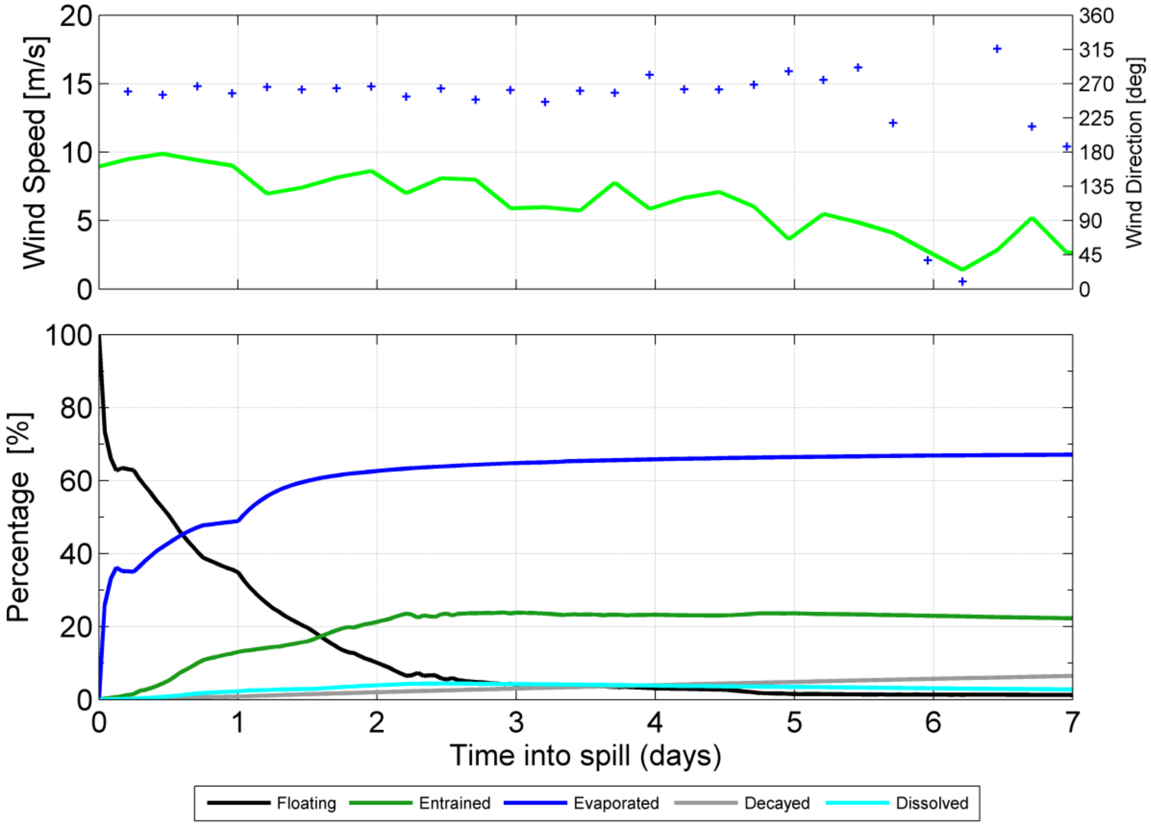
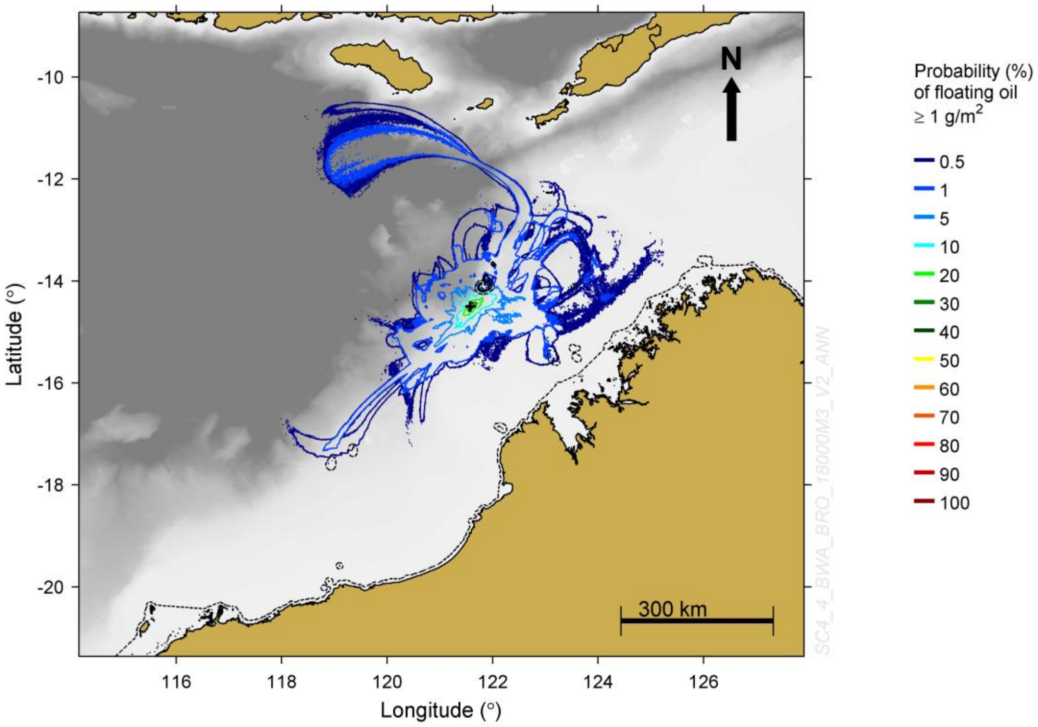


Figure 3-110: Predicted mass balance weathering resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location, commencing at 06:00 on 11th January 2004. The green line in the top figure indicates the wind speed and the blue dots indicate the wind direction (FROM).

3.6.3 Floating Oil



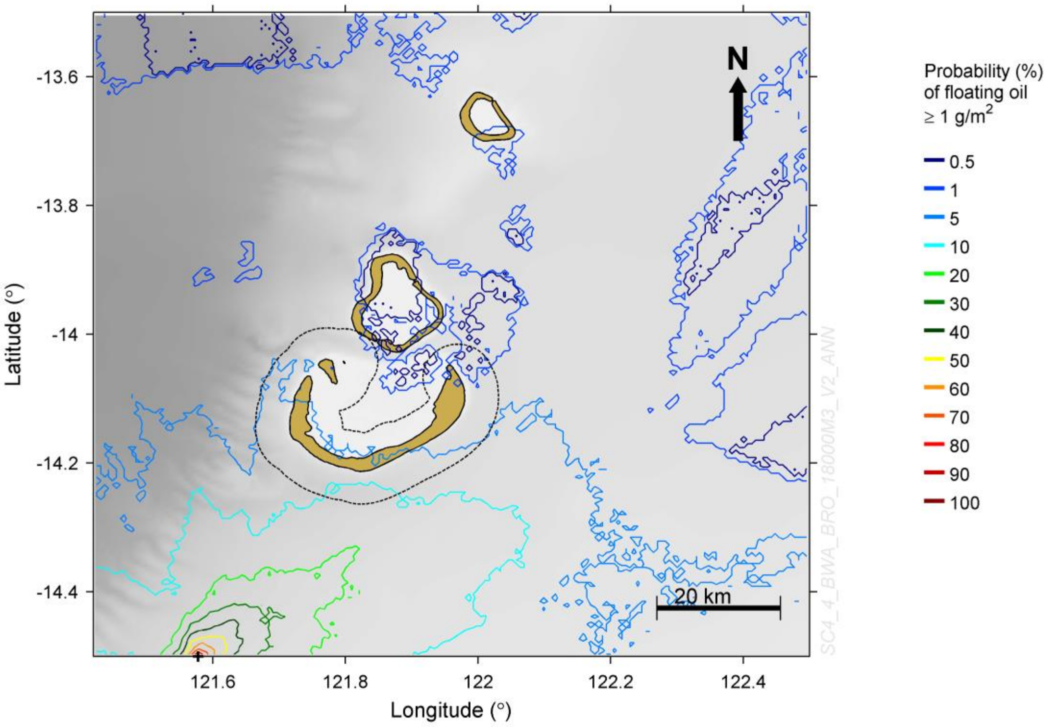


Figure 3-111: Predicted annualised probability (P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

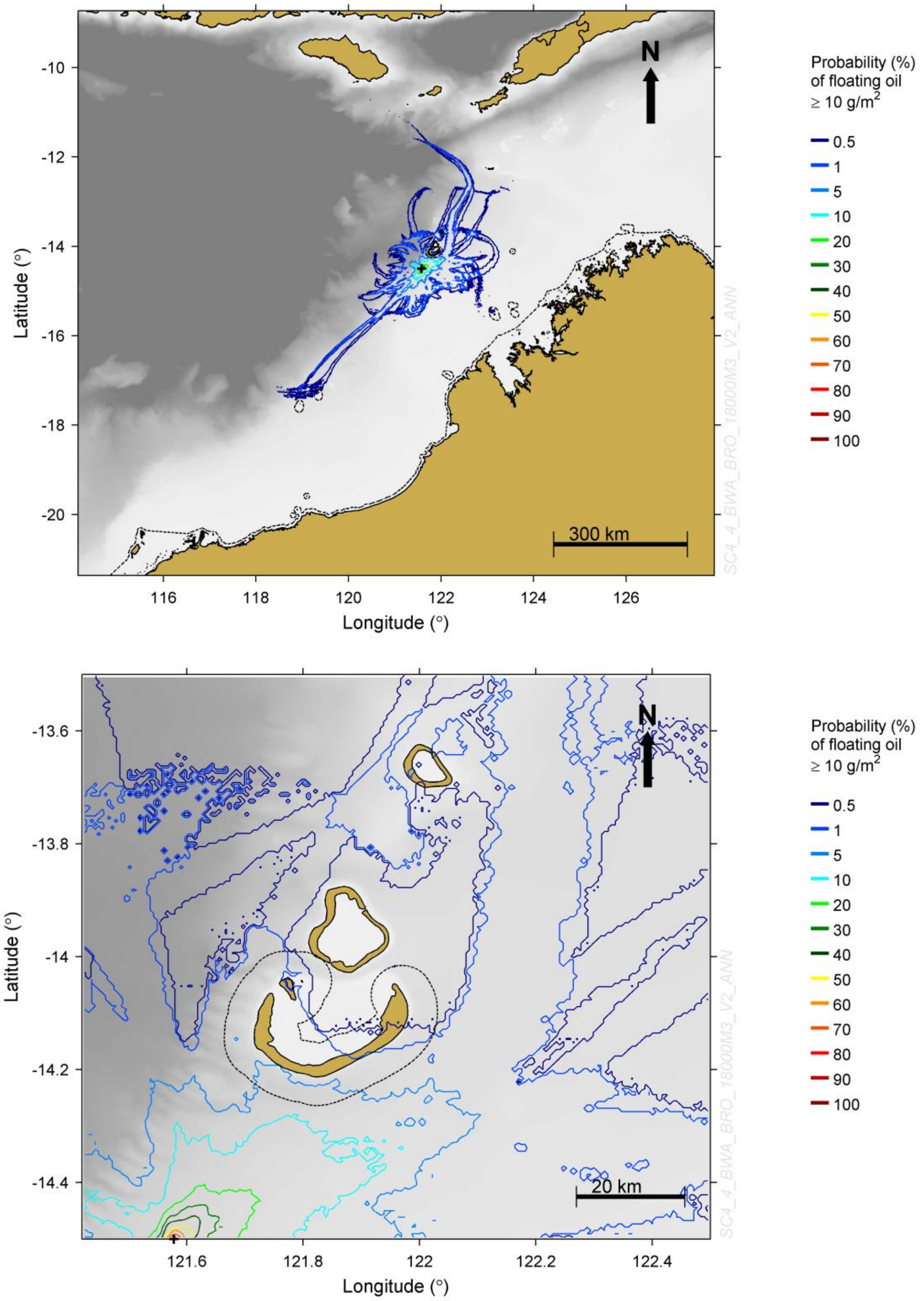


Figure 3-112: Predicted annualised probability (P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

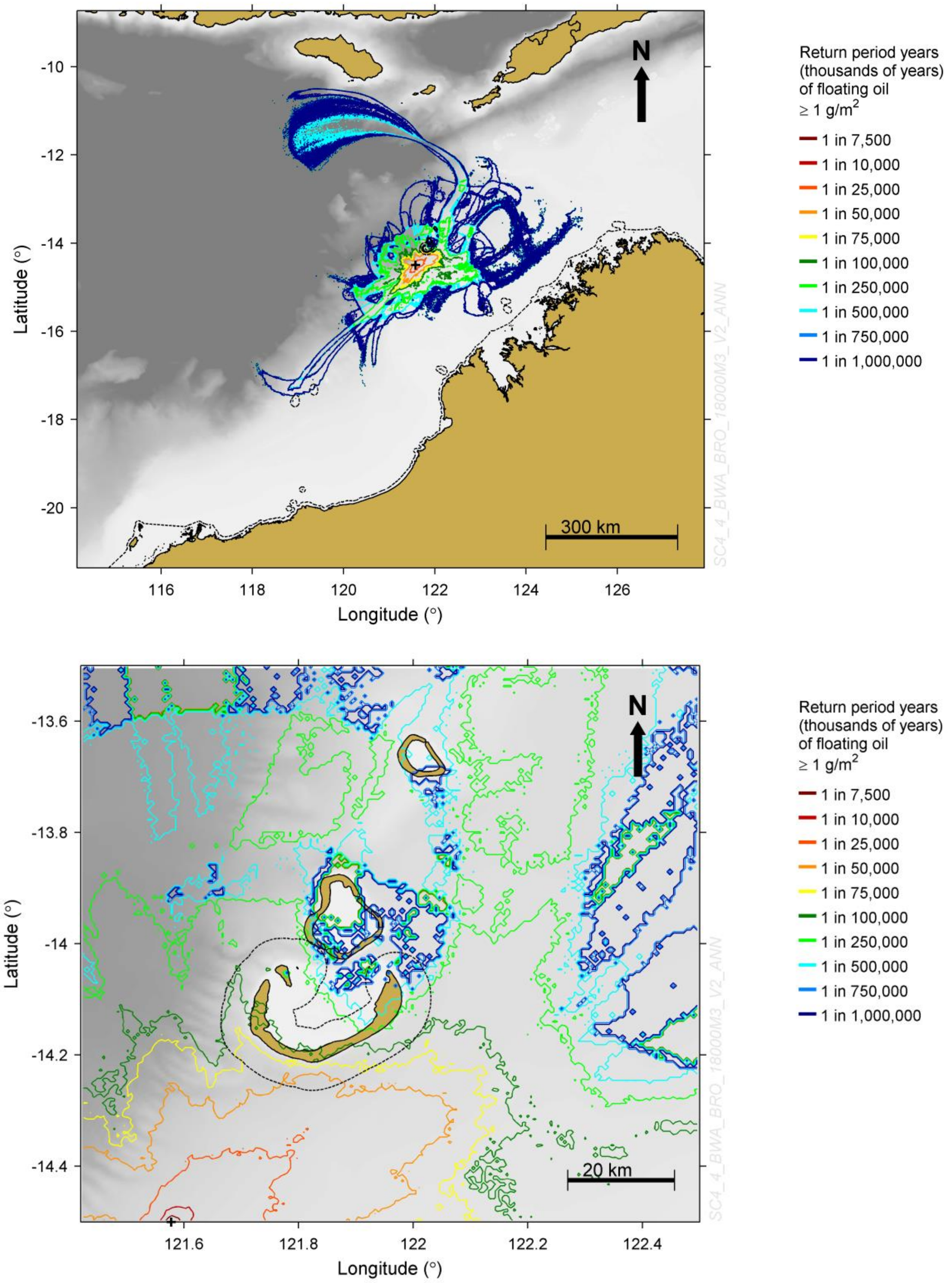


Figure 3-113: Predicted annualised probability (P_1x P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

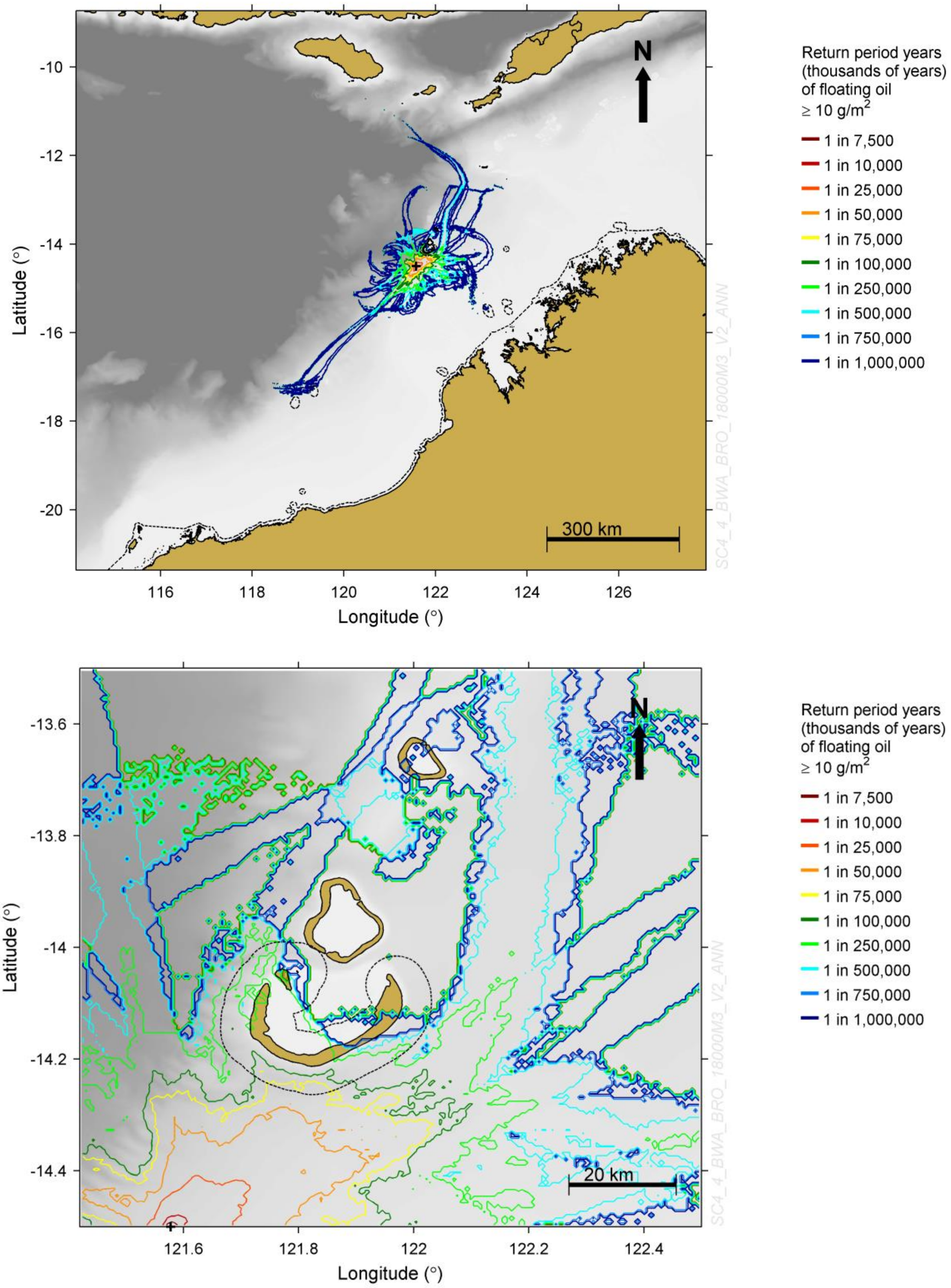
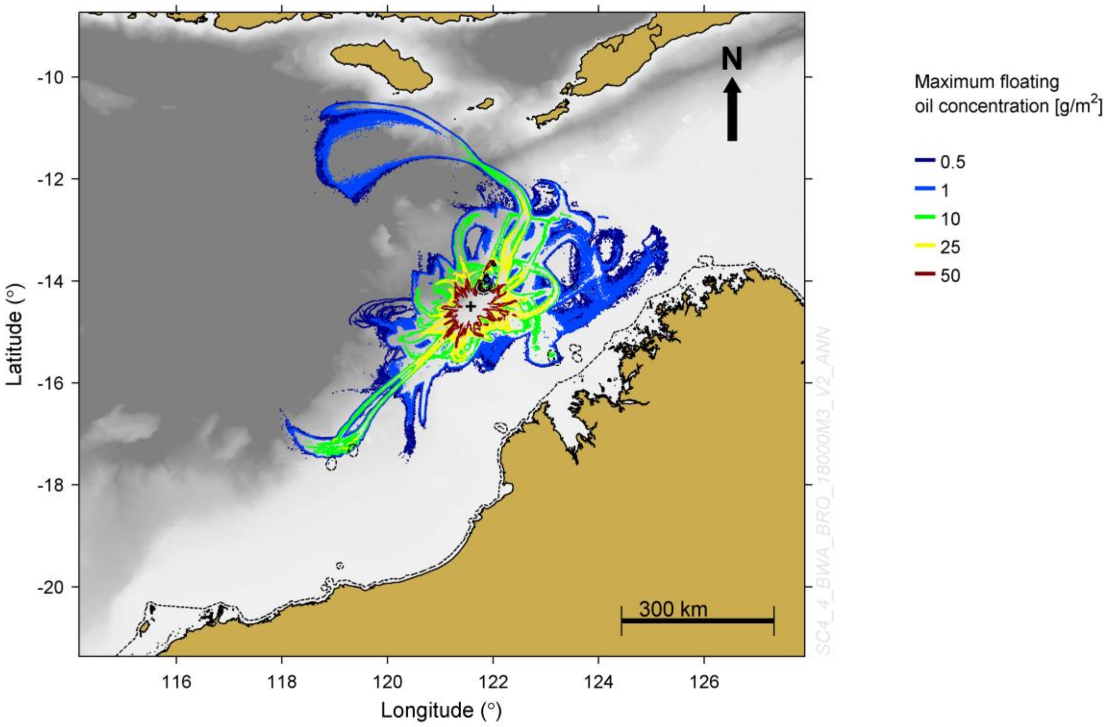


Figure 3-114: Predicted annualised probability (P_1x P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



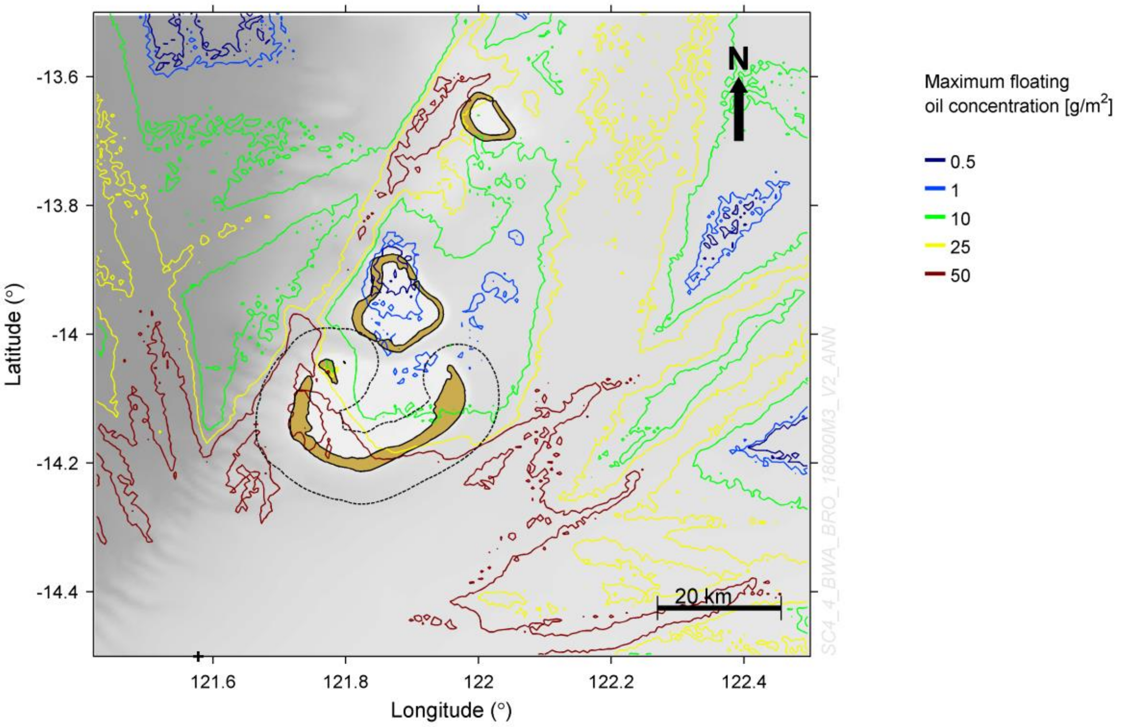


Figure 3-115: Predicted maximum floating oil concentration resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

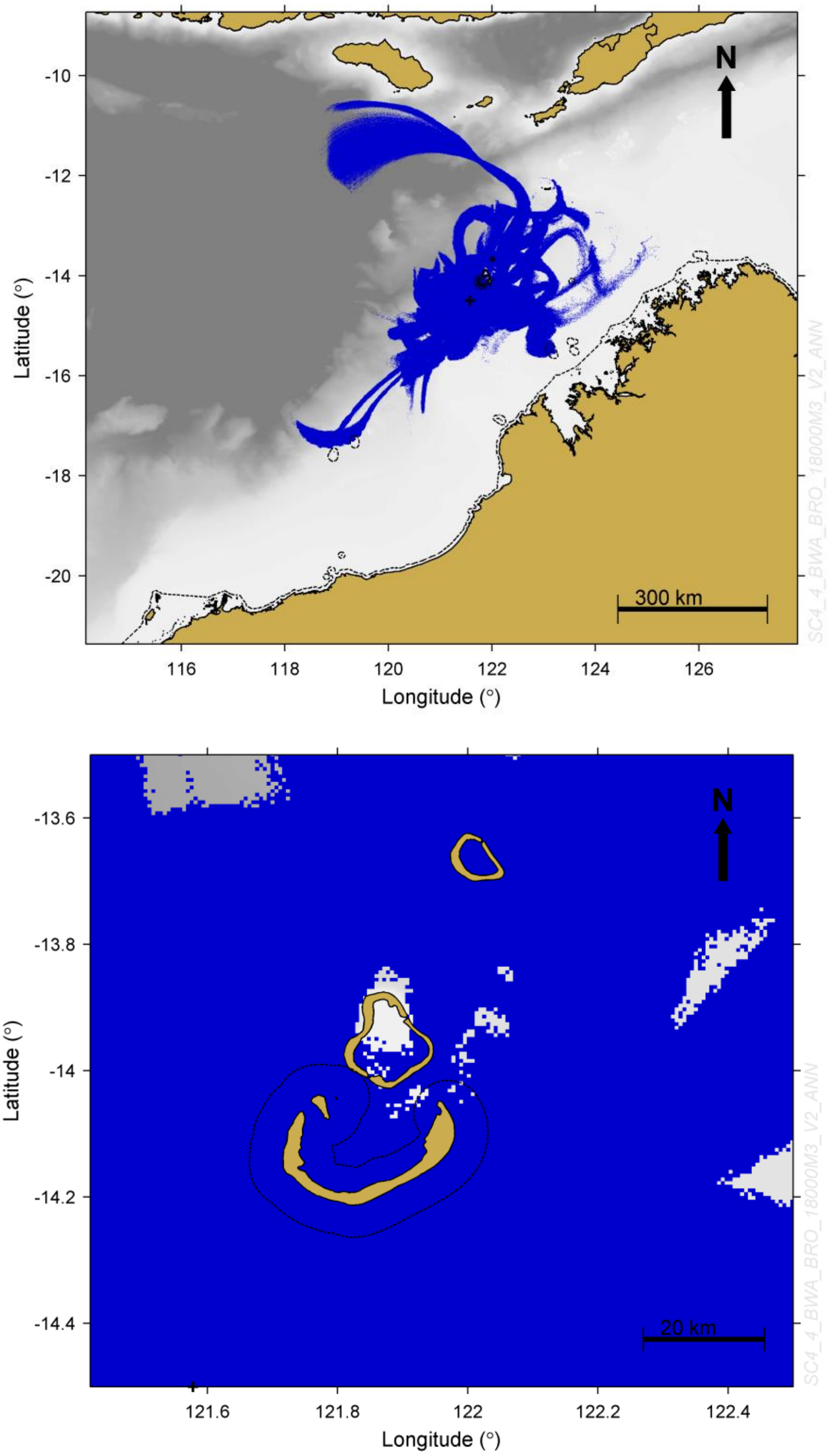


Figure 3-116: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

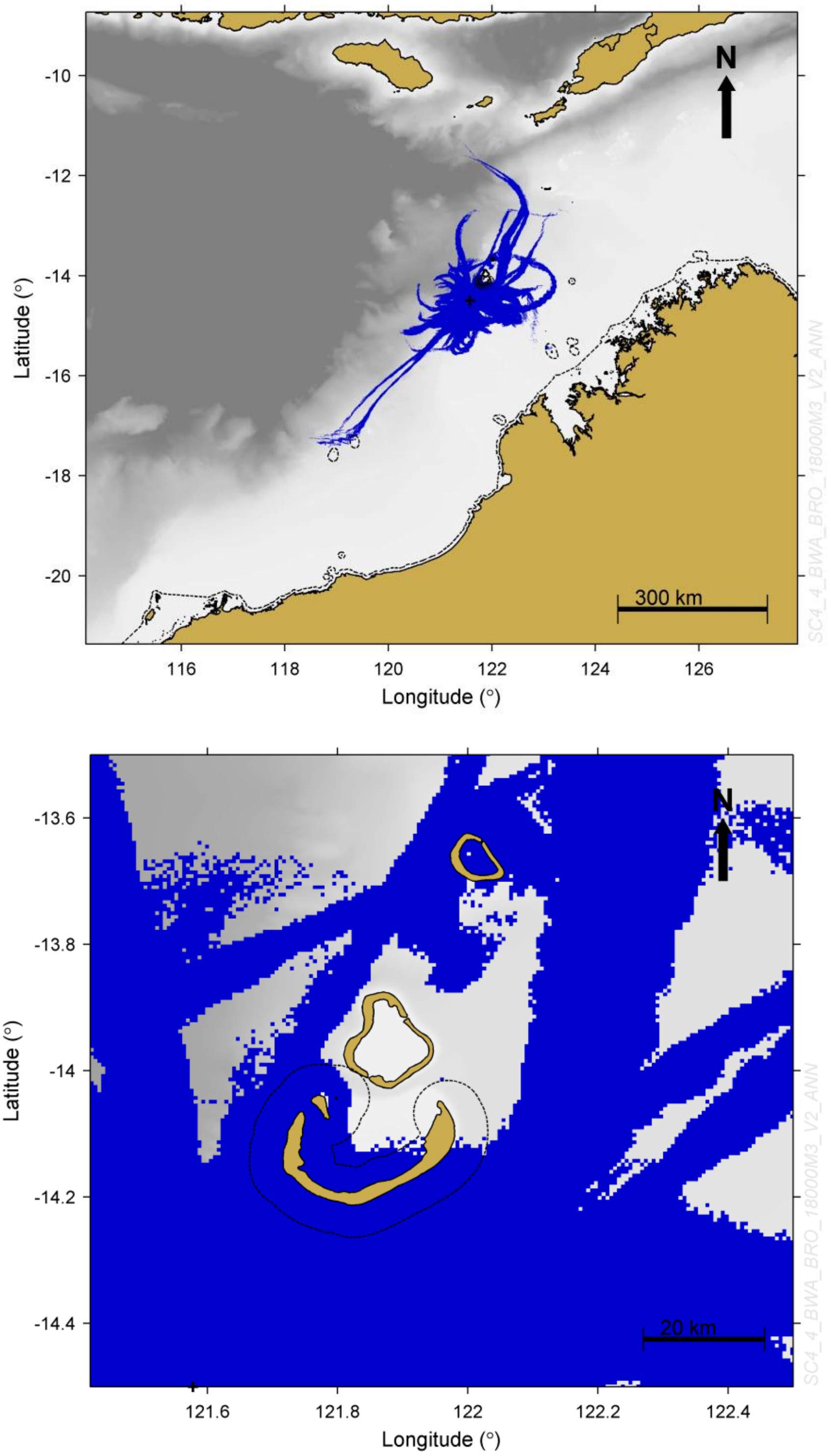
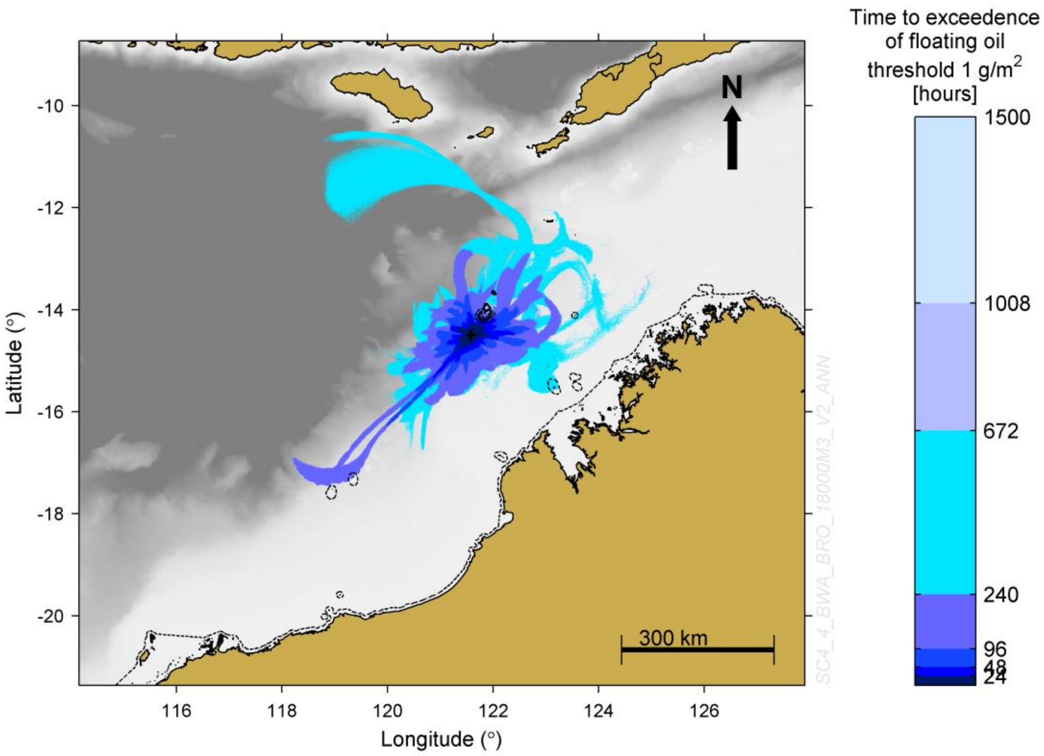


Figure 3-117: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



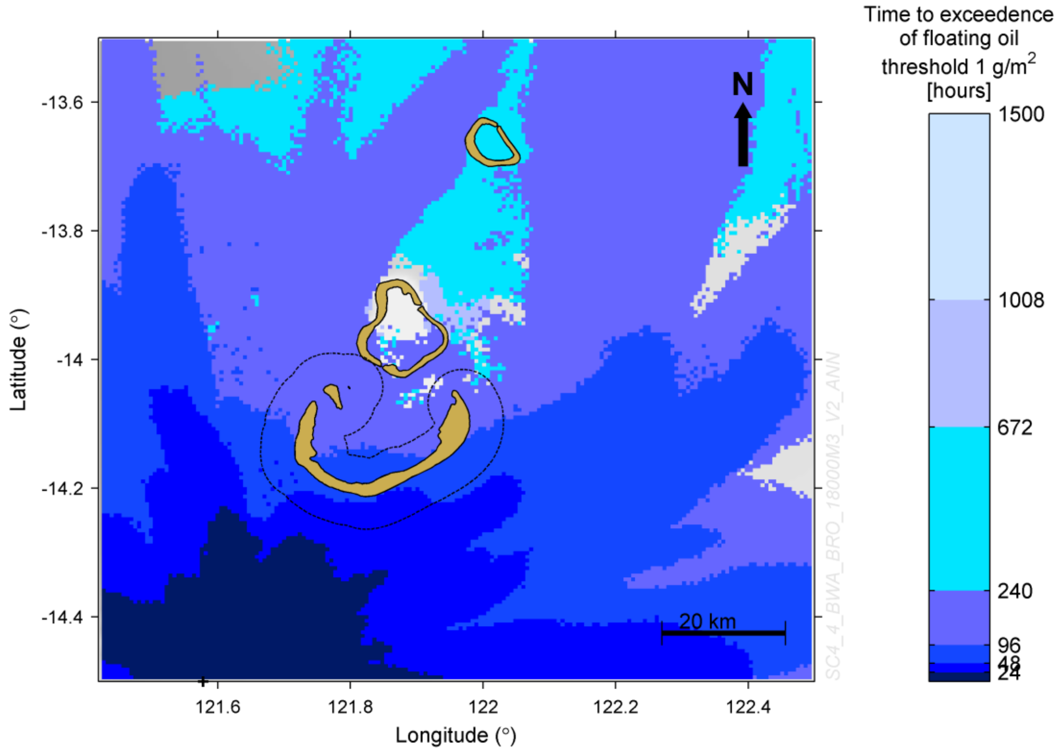


Figure 3-118: Predicted annualised minimum times to threshold for floating oil at or above 1 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

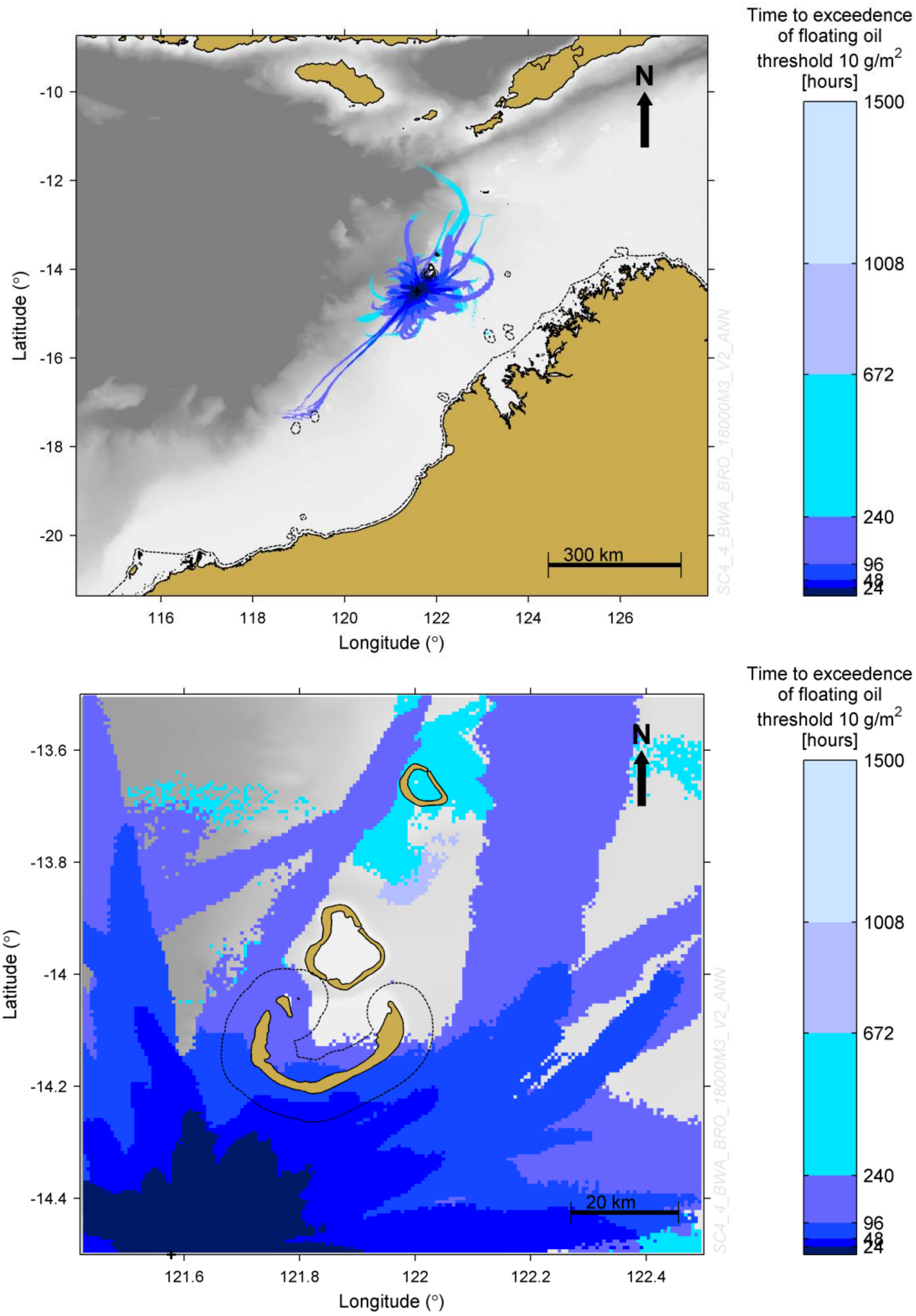


Figure 3-119: Predicted annualised minimum times to threshold for floating oil at or above 10 g/m^2 resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Table 3-19: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location.

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m^2	Probability (%) of films arriving at receptors at ≥ 1 g/m^2	Probability (%) of films arriving at receptors at ≥ 10 g/m^2	Probability (%) of films arriving at receptors at ≥ 25 g/m^2	Minimum time to receptor (hours) for films at ≥ 0.5 g/m^2	Minimum time to receptor (hours) for films at ≥ 1 g/m^2	Minimum time to receptor (hours) for films at ≥ 10 g/m^2	Minimum time to receptor (hours) for films at ≥ 25 g/m^2	Maximum local accumulated concentration (g/m^2) averaged over all replicate spills	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this *shoreline*, in the worst replicate simulation
Timor Leste	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Timor (West)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Pulau Roti	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Big Bank Shoals*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Melville Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Oceanic Shoals CMR*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef CMR	0.5	0.5	<0.5	<0.5	559	568	NC	NC	0.4	55	<1	<1
Ashmore Reef	0.5	<0.5	<0.5	<0.5	652	NC	NC	NC	0.4	55	<1	<1
Cartier Island CMR	0.5	<0.5	<0.5	<0.5	688	NC	NC	NC	0.7	67	<1	<1
Cartier Islet	0.5	<0.5	<0.5	<0.5	711	NC	NC	NC	0.7	67	<1	<1
Joseph Bonaparte Gulf East	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Kimberley CMR*	10	8.5	5.5	4	30	30	31	31	NC	NC	NC	NC
Argo-Rowley Terrace CMR*	1.5	1.5	1.5	1	111	111	113	168	NC	NC	NC	NC
Seringapatam Reef	2.5	2	1	0.5	206	227	244	253	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-19: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m^2	Probability (%) of films arriving at receptors at ≥ 1 g/m^2	Probability (%) of films arriving at receptors at ≥ 10 g/m^2	Probability (%) of films arriving at receptors at ≥ 25 g/m^2	Minimum time to receptor (hours) for films at ≥ 0.5 g/m^2	Minimum time to receptor (hours) for films at ≥ 1 g/m^2	Minimum time to receptor (hours) for films at ≥ 10 g/m^2	Minimum time to receptor (hours) for films at ≥ 25 g/m^2	Maximum local accumulated concentration (g/m^2) averaged over all replicate spills	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Joseph Bonaparte Gulf West	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
North Reef Flats*	3	2.5	<0.5	<0.5	143	180	NC	NC	NC	NC	NC	NC
North Reef Lagoon*	2.5	1	<0.5	<0.5	175	186	NC	NC	NC	NC	NC	NC
Kimberley Coast	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	0.2	32	<1	<1
South Reef Lagoon*	6.5	5.5	4	4	60	61	69	82	NC	NC	NC	NC
SR Central/ Sandy Islet	5	4	2	1.5	122	125	163	173	80	3,117	<1	7
South Reef Flats*	9	7.5	5	4	46	47	54	56	NC	NC	NC	NC
Browse Island	0.5	0.5	<0.5	<0.5	326	326	NC	NC	4.5	386	<1	3
Lalang-garram / Camden Sound MP	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Camden Sound	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Adele Island	1	0.5	0.5	<0.5	558	562	586	NC	18	3,116	<1	5
Dampier Peninsula Coast - North section	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Lacepede Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Mermaid Reef CMR	0.5	0.5	0.5	<0.5	144	145	160	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-19: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m^2	Probability (%) of films arriving at receptors at ≥ 1 g/m^2	Probability (%) of films arriving at receptors at ≥ 10 g/m^2	Probability (%) of films arriving at receptors at ≥ 25 g/m^2	Minimum time to receptor (hours) for films at ≥ 0.5 g/m^2	Minimum time to receptor (hours) for films at ≥ 1 g/m^2	Minimum time to receptor (hours) for films at ≥ 10 g/m^2	Minimum time to receptor (hours) for films at ≥ 25 g/m^2	Maximum local accumulated concentration (g/m^2) averaged over all replicate spills	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Mermaid Reef	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	0.5	0.5	0.5	0.5	172	172	175	177	4.6	913	<1	<1
Clerke Reef	0.5	0.5	0.5	0.5	173	174	186	188	4.6	913	<1	<1
Imperieuse Reef	0.5	0.5	<0.5	<0.5	247	247	NC	NC	<0.1	<0.1	<1	<1
Rowley Shoals MP (Imperieuse)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Eighty Mile Beach	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Glomar Shoals*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Rankin Bank*	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Dampier Archipelago	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Montebello Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Lowendal Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Barrow Island	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Northern Pilbara-Islands and Shoreline	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Southern Pilbara-Islands	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-19: Expected floating oil outcomes at sensitive receptors across all quarters for a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m^2	Probability (%) of films arriving at receptors at ≥ 1 g/m^2	Probability (%) of films arriving at receptors at ≥ 10 g/m^2	Probability (%) of films arriving at receptors at ≥ 25 g/m^2	Minimum time to receptor (hours) for films at ≥ 0.5 g/m^2	Minimum time to receptor (hours) for films at ≥ 1 g/m^2	Minimum time to receptor (hours) for films at ≥ 10 g/m^2	Minimum time to receptor (hours) for films at ≥ 25 g/m^2	Maximum local accumulated concentration (g/m^2) averaged over all replicate spills	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Muiron Islands (World Heritage)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Ningaloo Coast North (World Heritage)	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC
Ningaloo Coast North	<0.5	<0.5	<0.5	<0.5	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

3.6.4 Dissolved Aromatic Hydrocarbon Dosage

576 ppb.hr

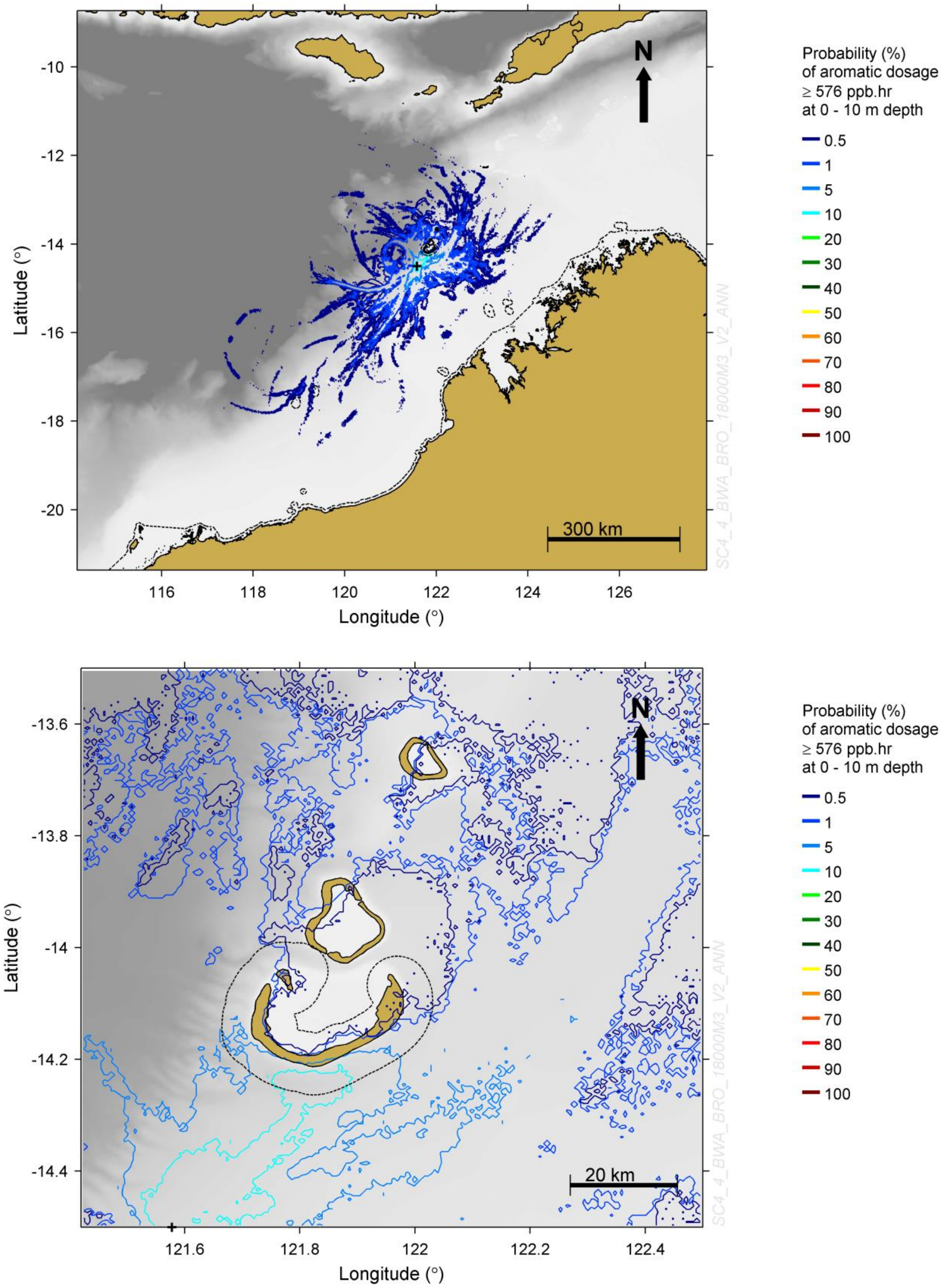


Figure 3-120: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 0 - 10 m (BMSL),, resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

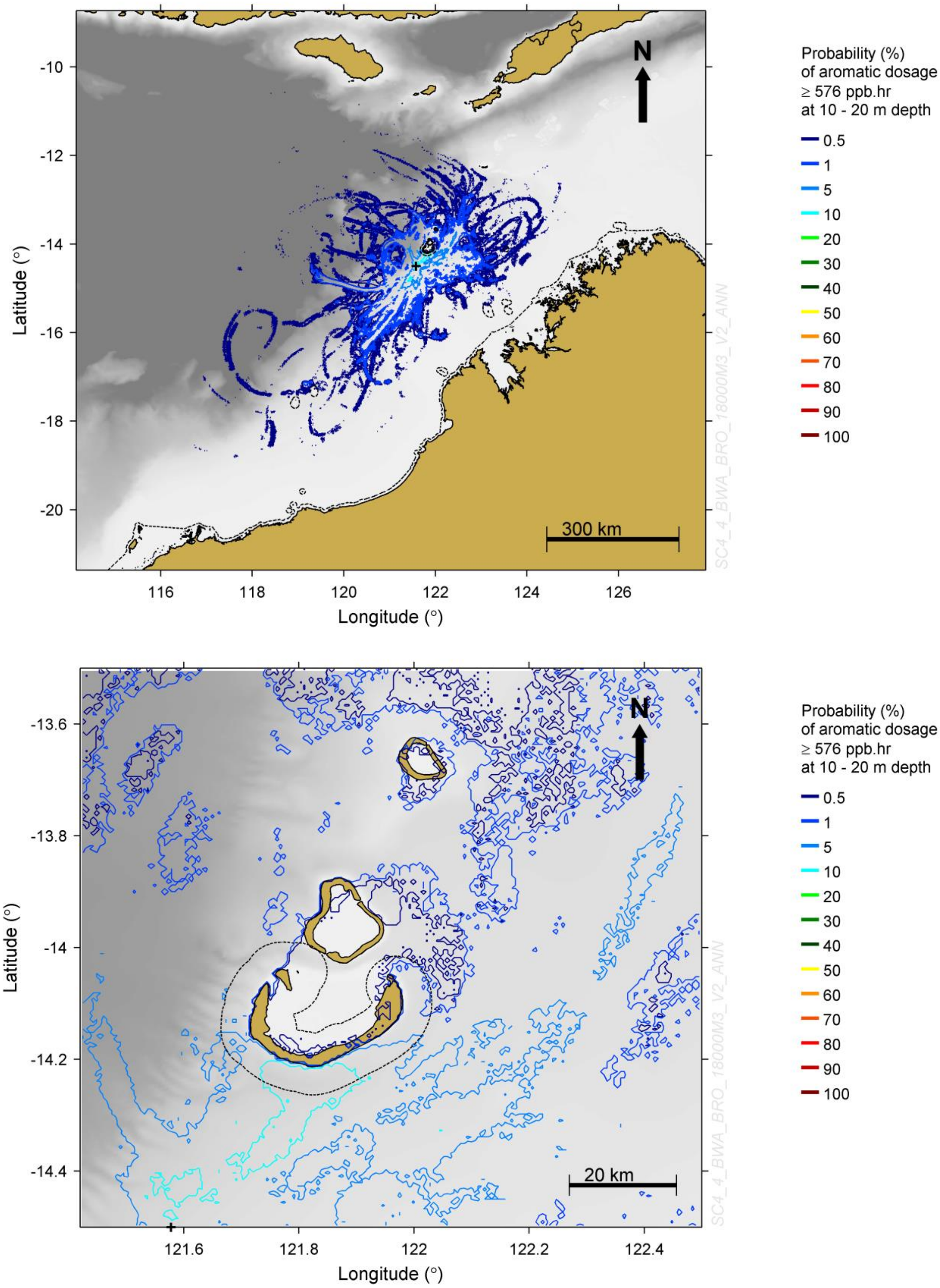


Figure 3-121: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

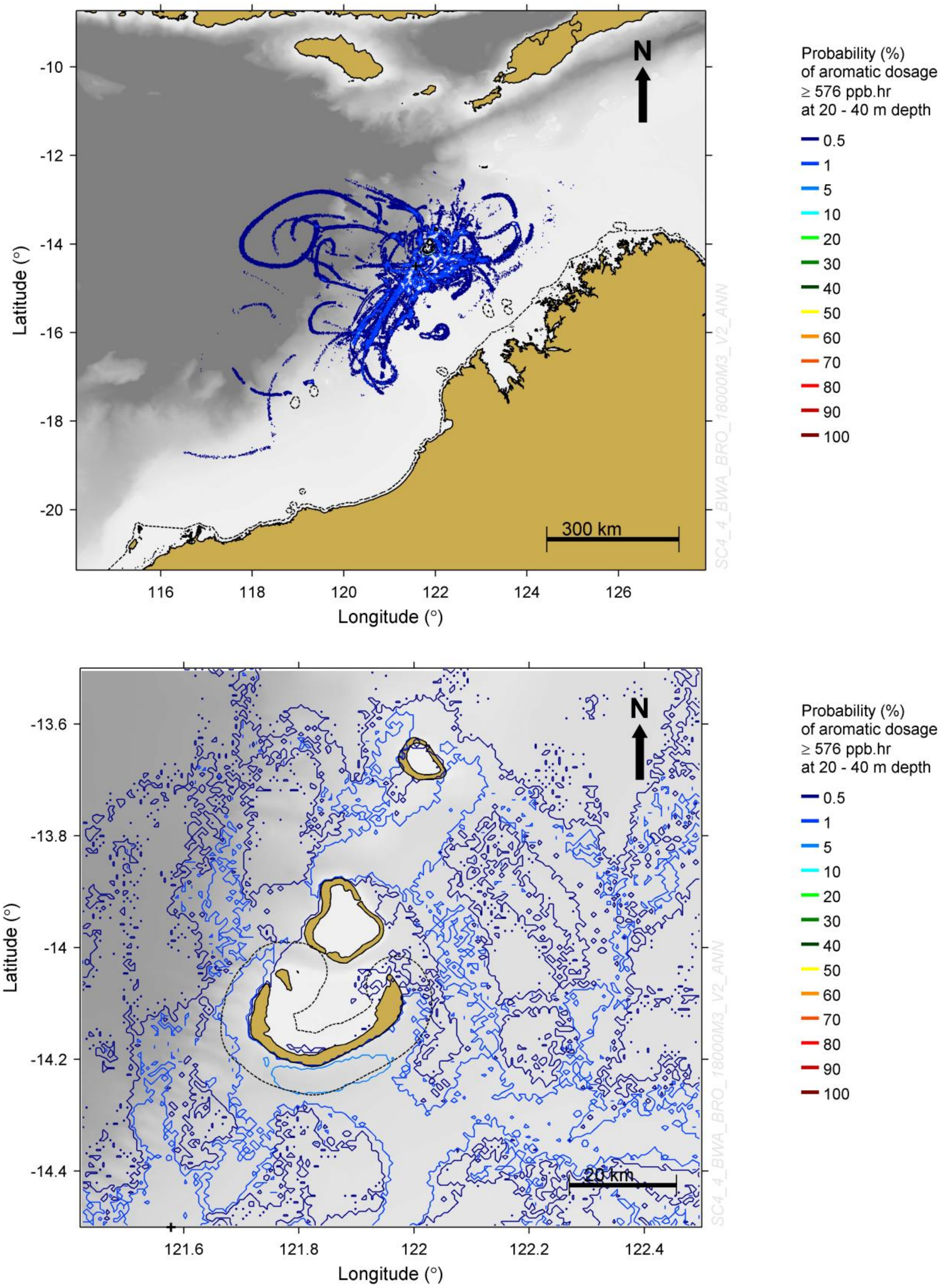
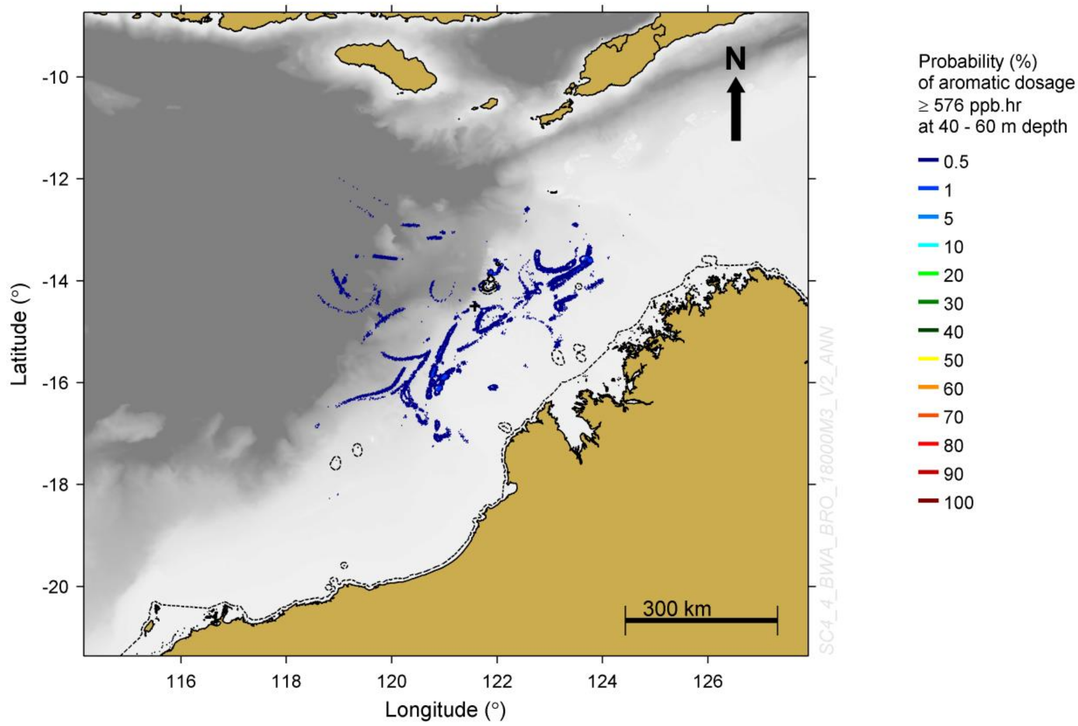


Figure 3-122: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 20 - 40 m (BMSL),, resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



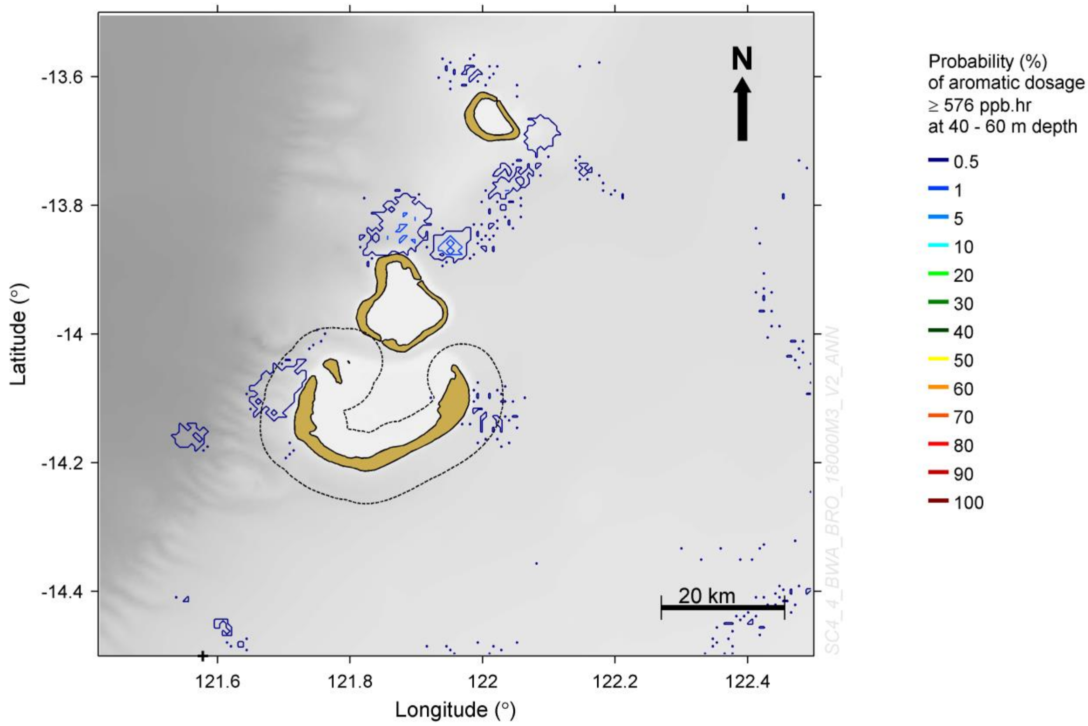
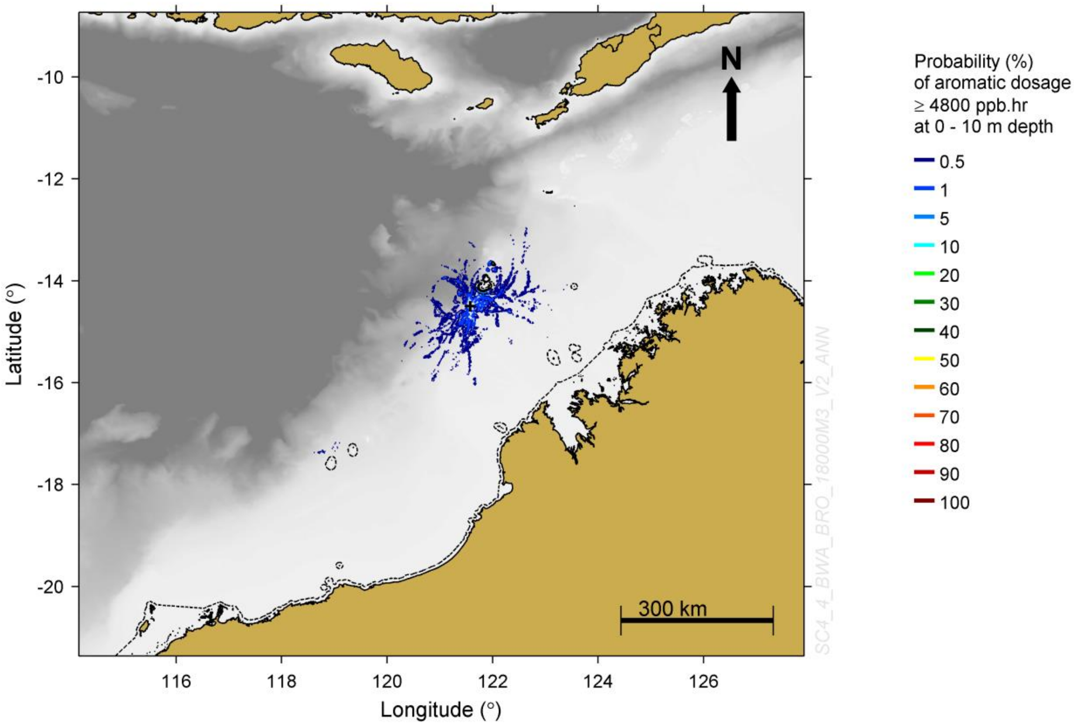


Figure 3-123: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 40 - 60 m (BMSL),, resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

4,800 ppb.hr



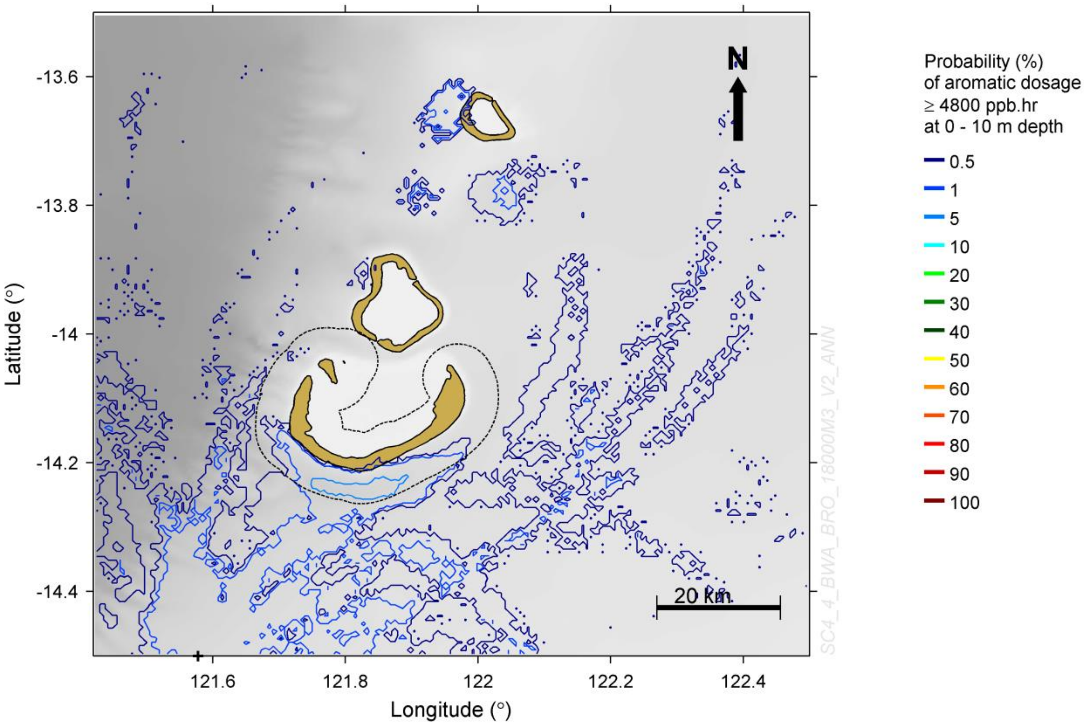
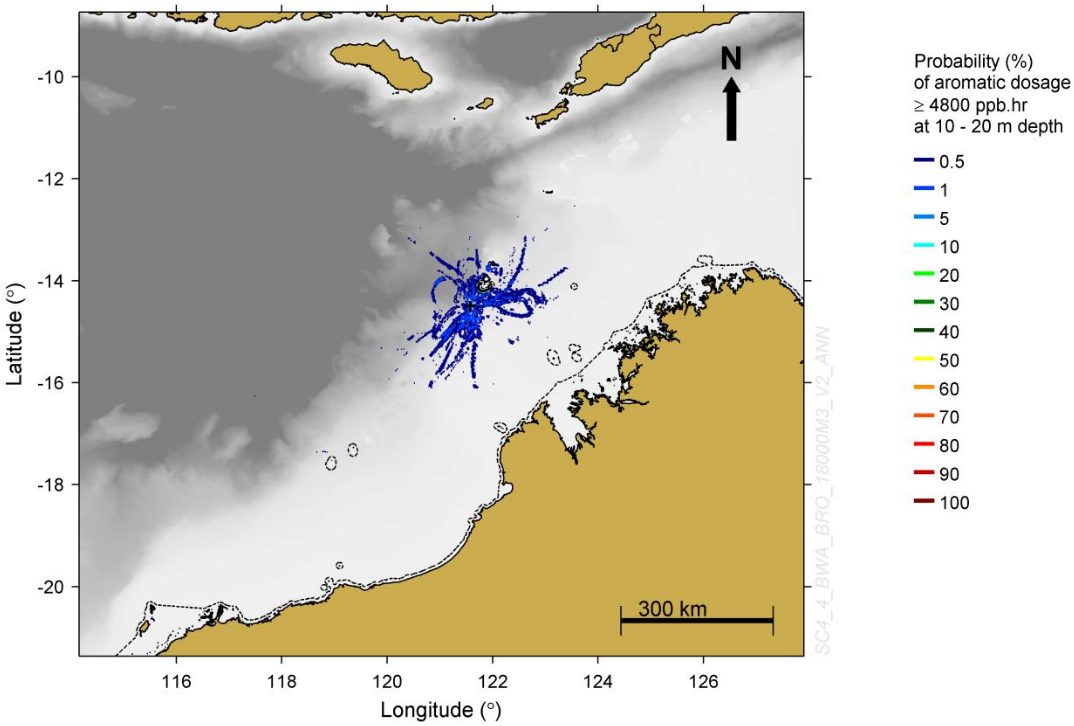


Figure 3-124: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 0 - 10 m (BMSL),, resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



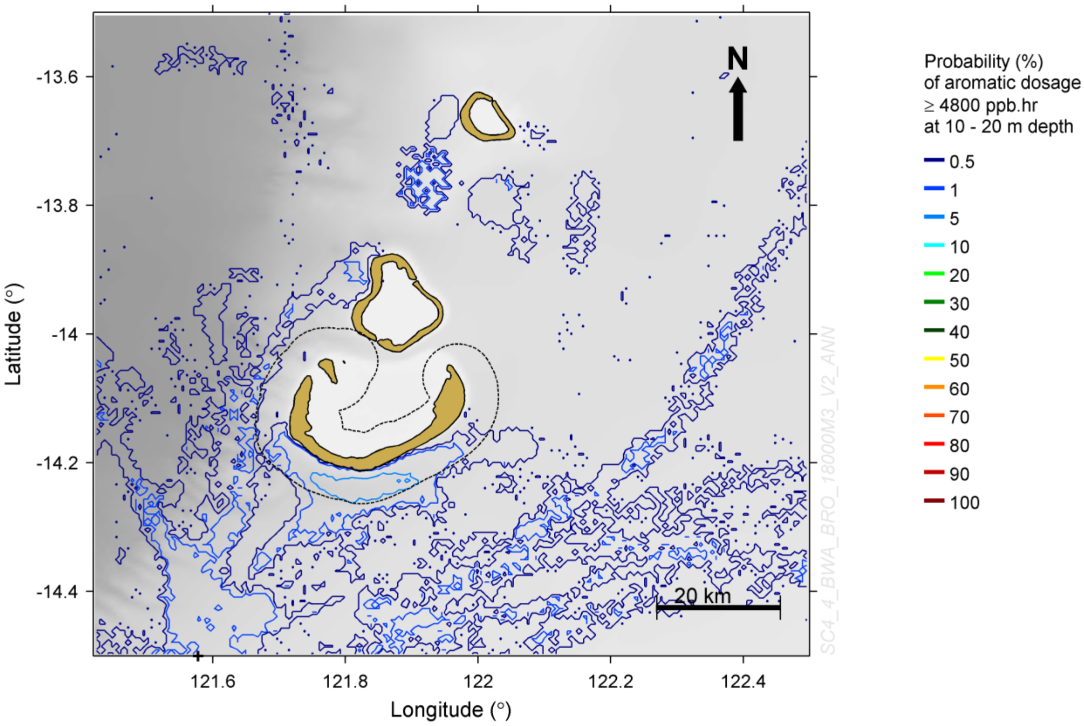


Figure 3-125: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

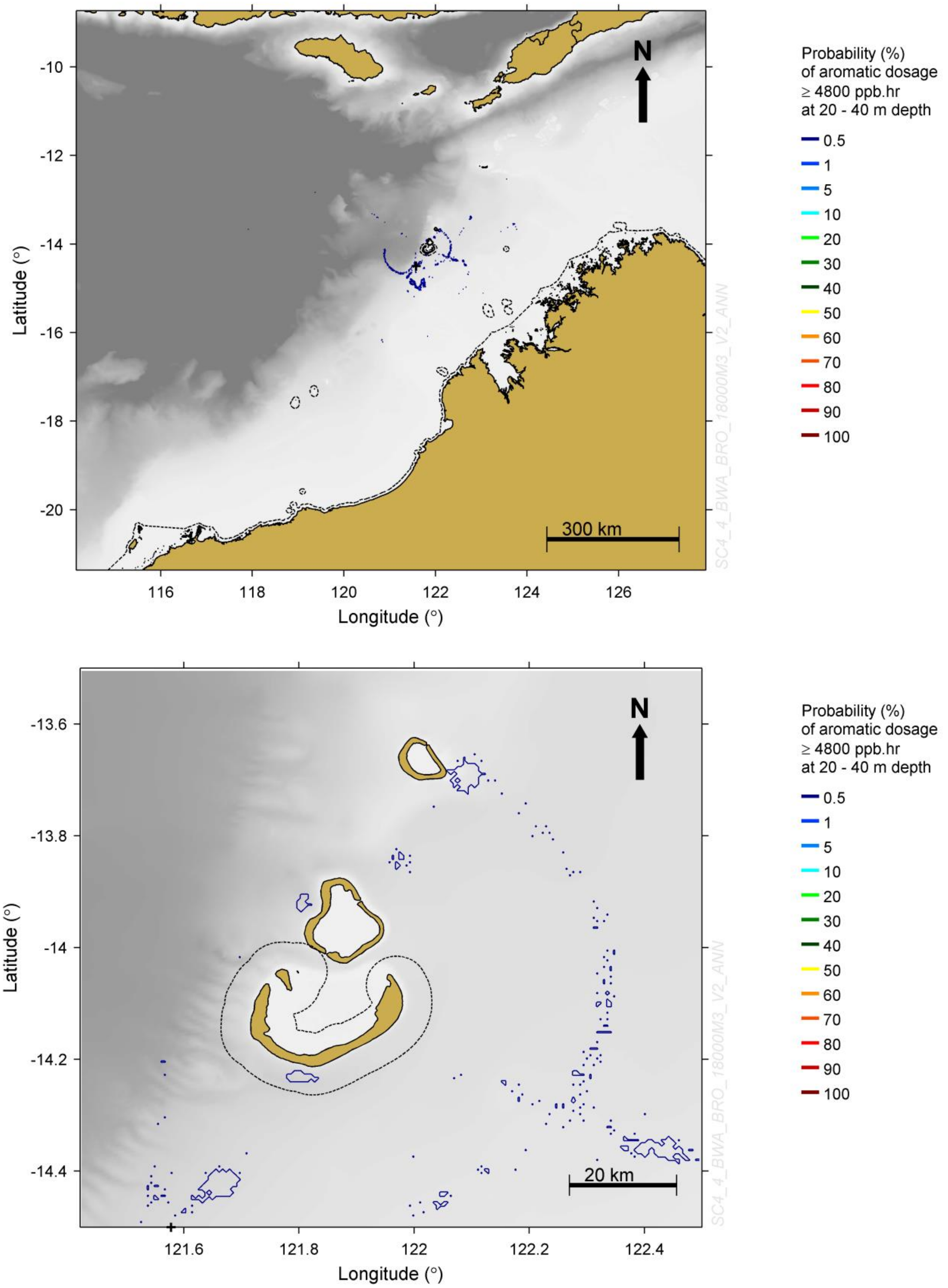
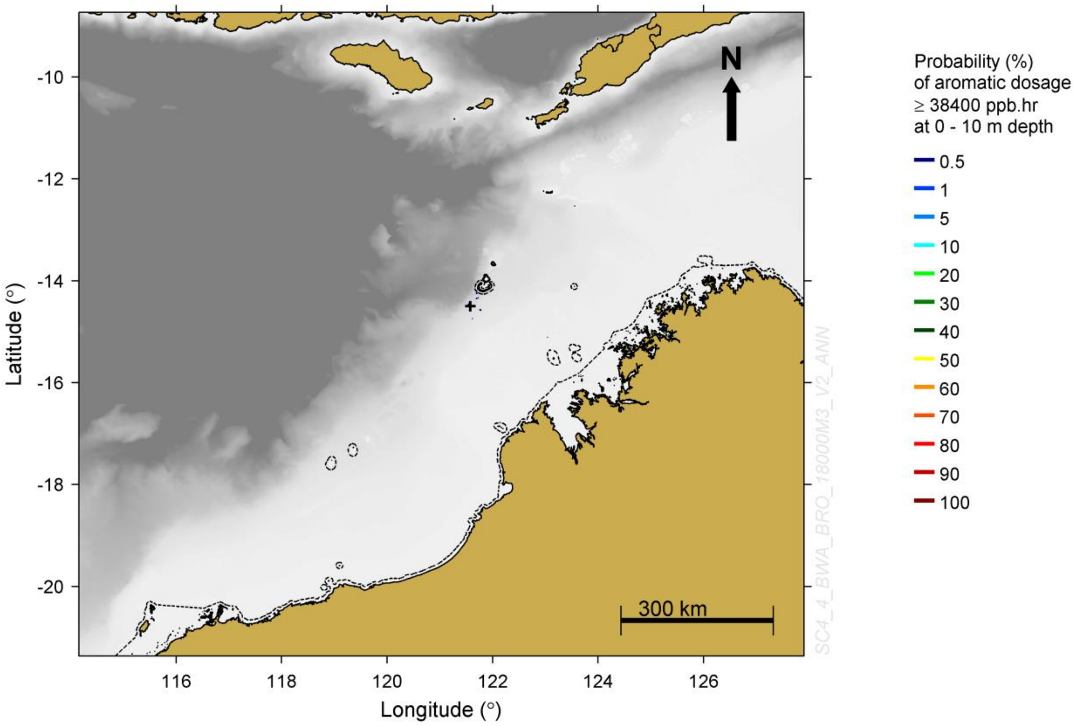


Figure 3-126: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 4,800 ppb.hr at a depth of 20 - 40 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

38,400 ppb.hr



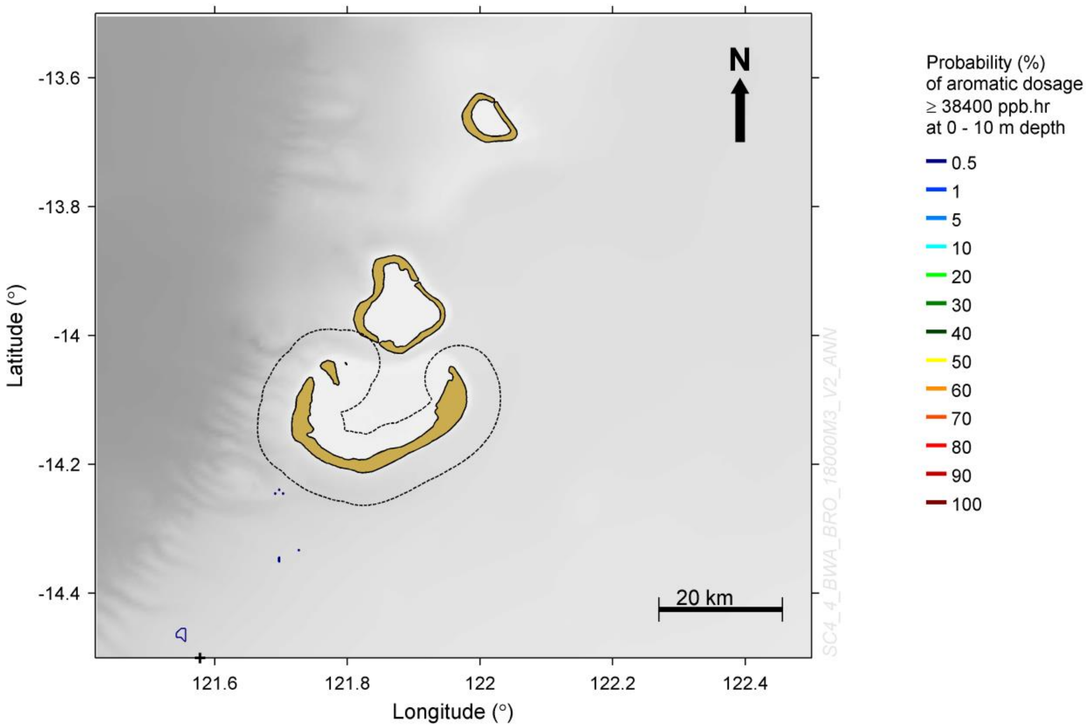


Figure 3-127: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 38,400 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Maximum Aromatic Dosage

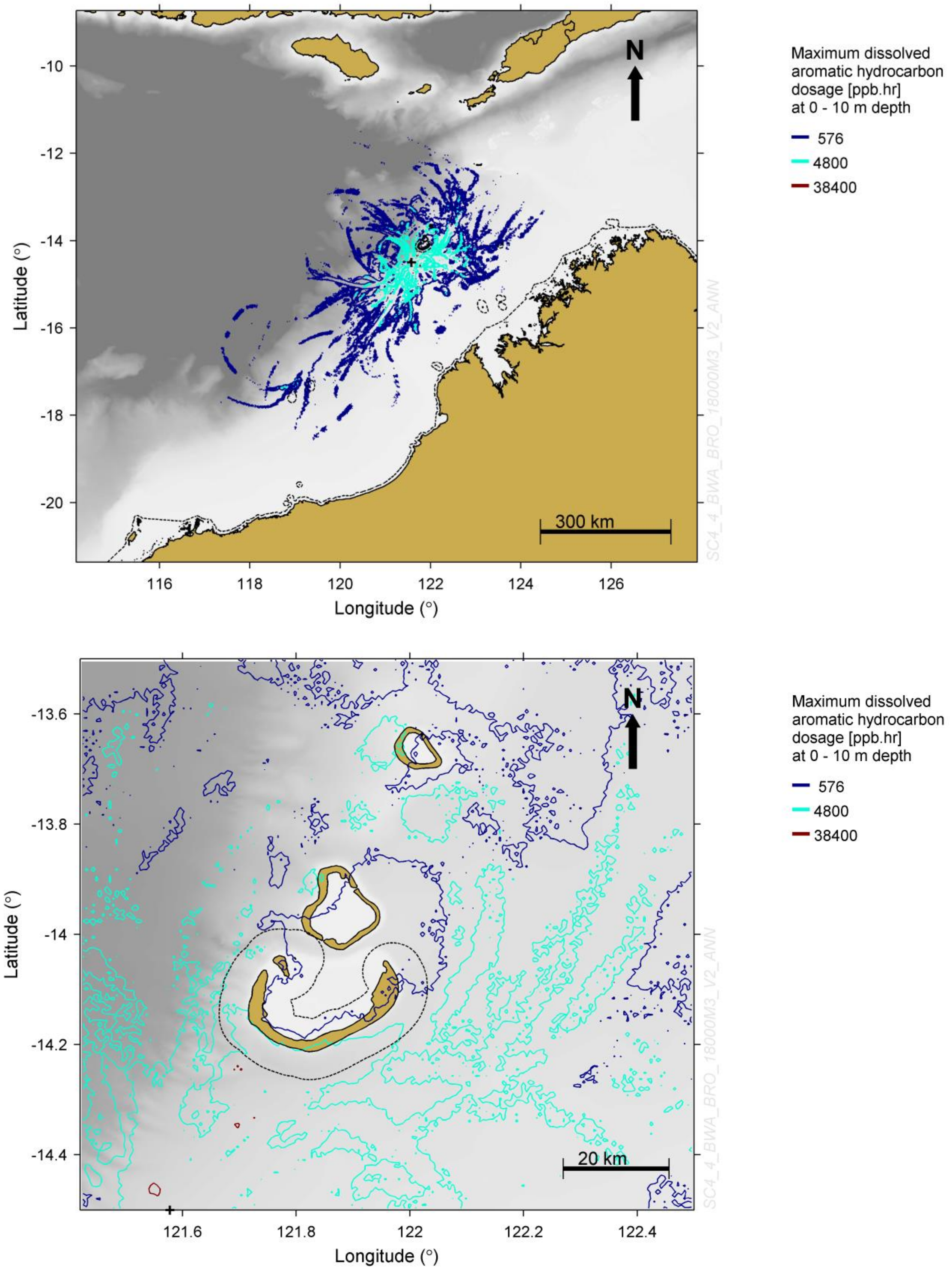


Figure 3-128: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 0 - 10 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

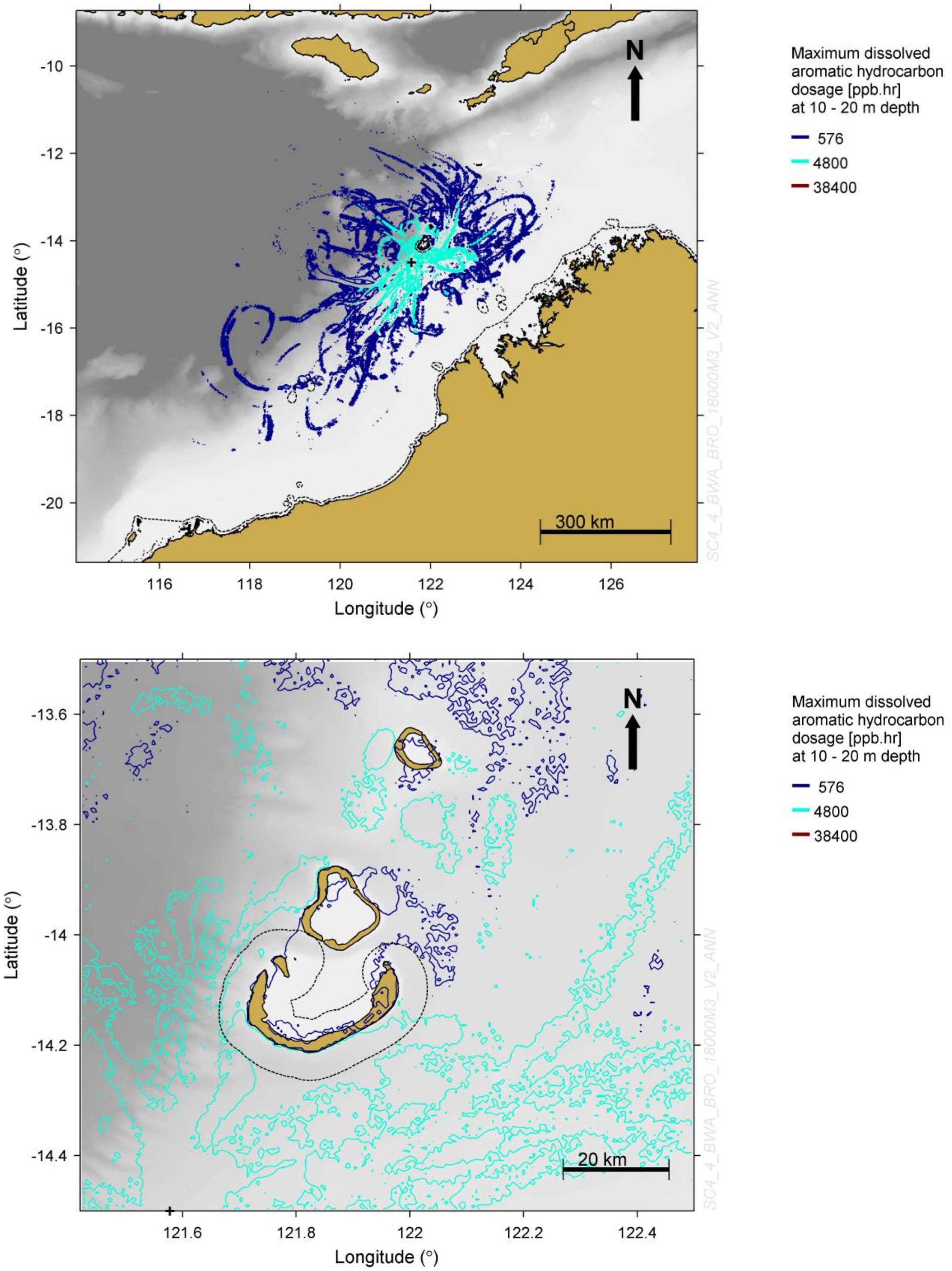
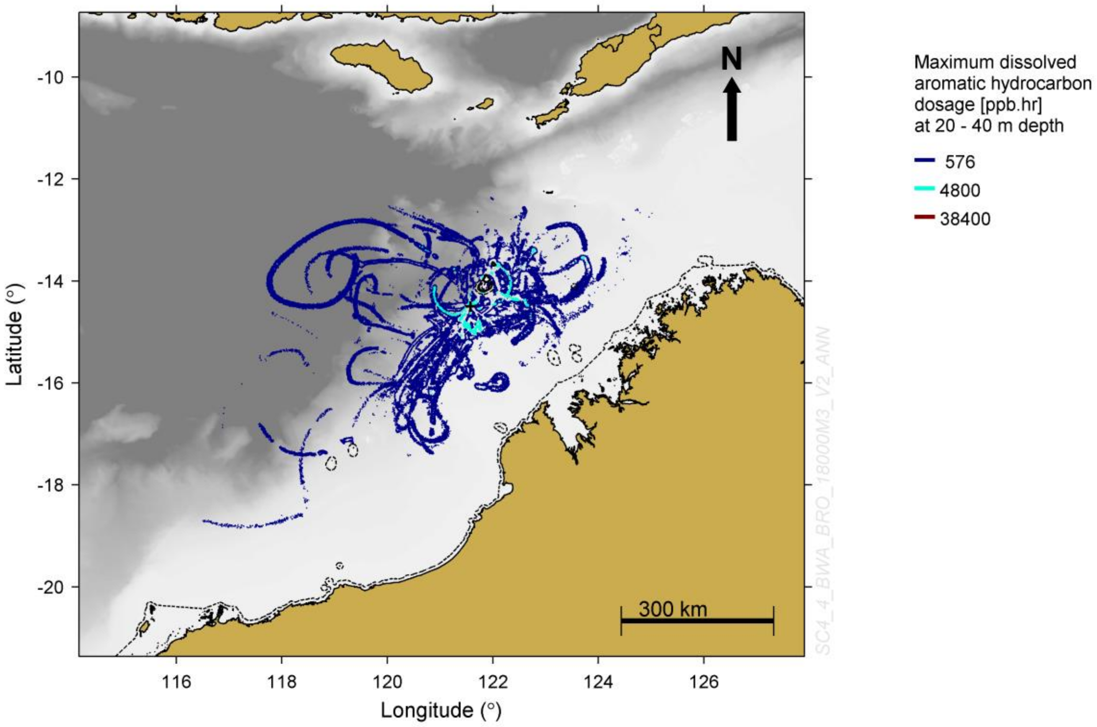


Figure 3-129: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 10 - 20 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



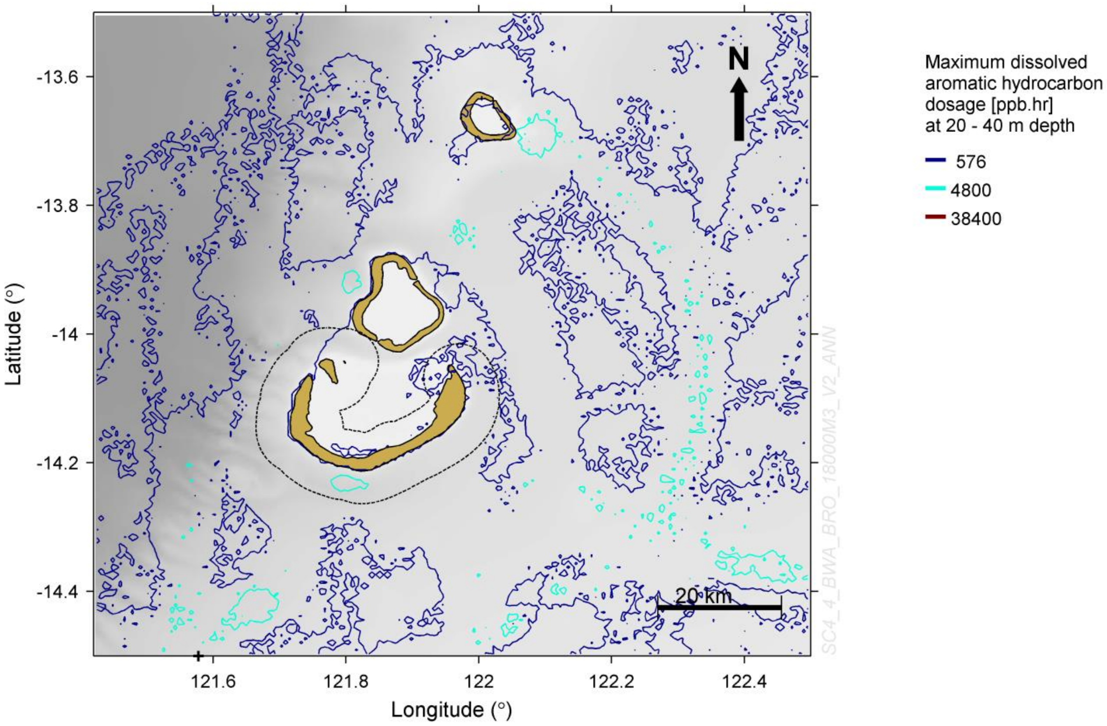
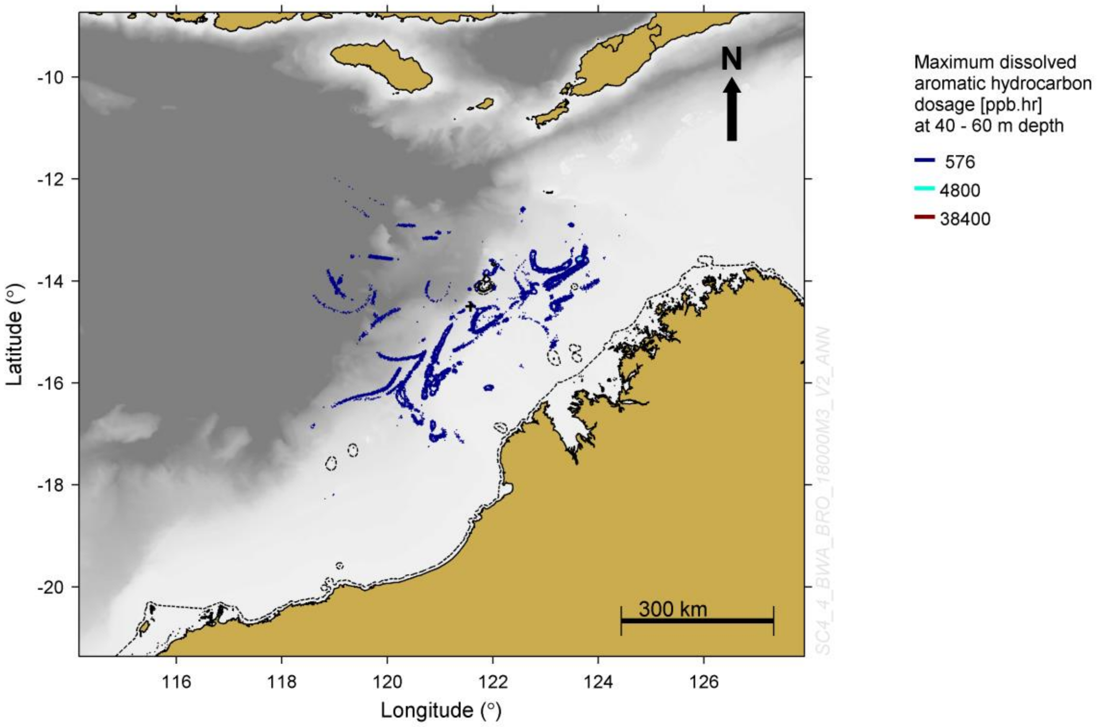


Figure 3-130: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 20 - 40 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



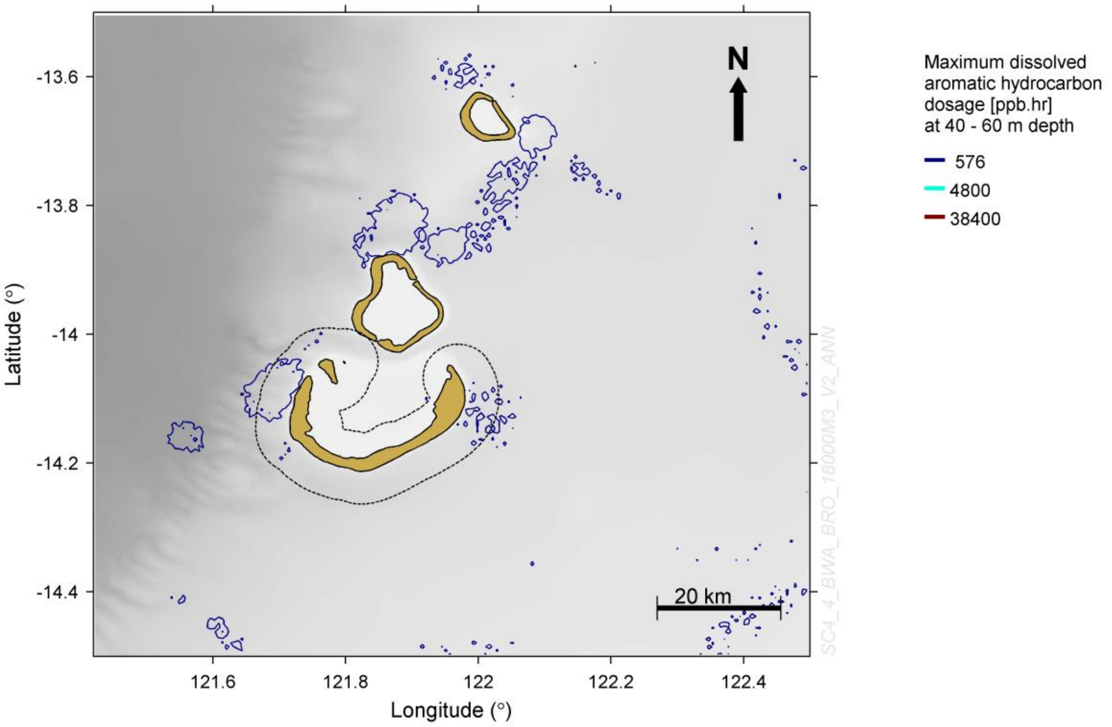


Figure 3-131: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 40 - 60 m (BMSL), resulting from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

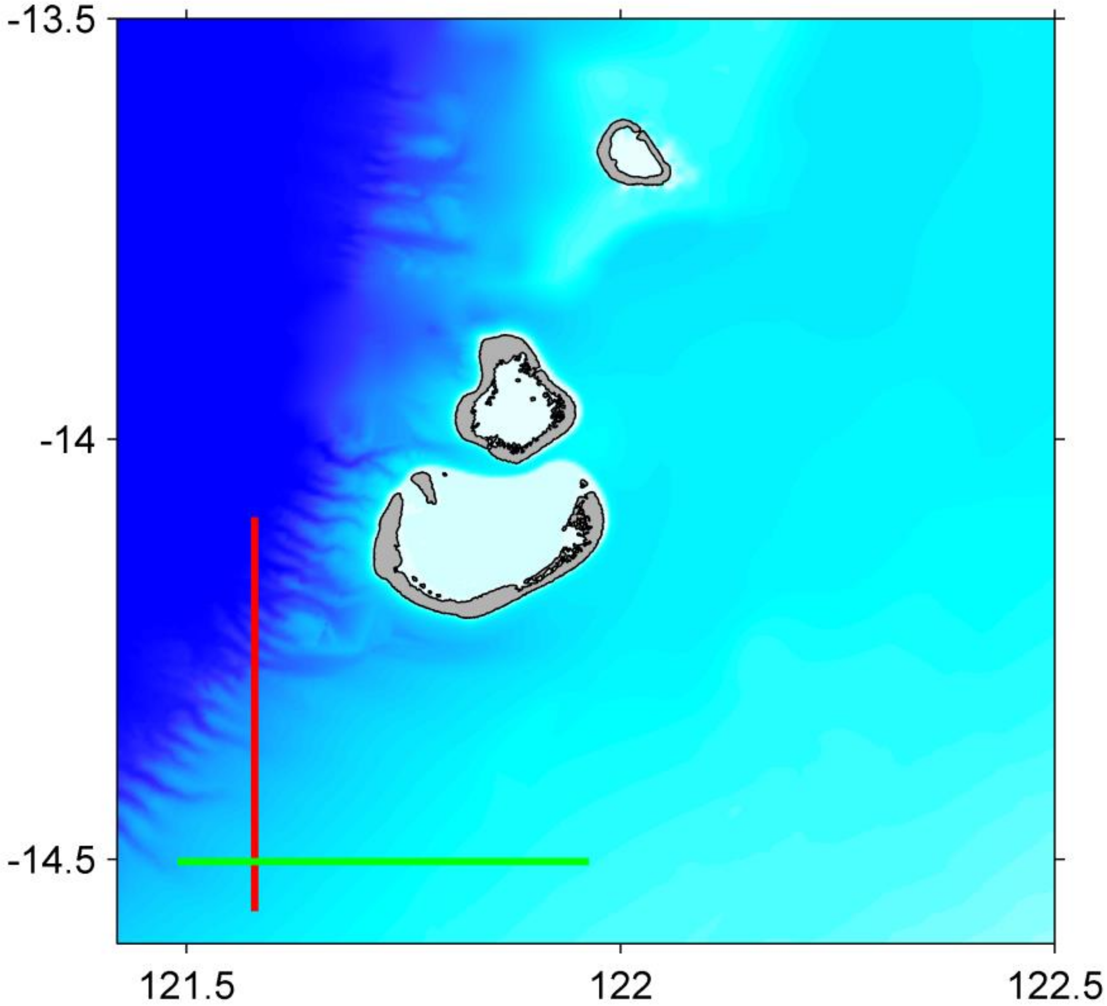


Figure 3-132: Location of the BWA location and the respective vertical transects over a varying latitude (red line) and longitude (green line).

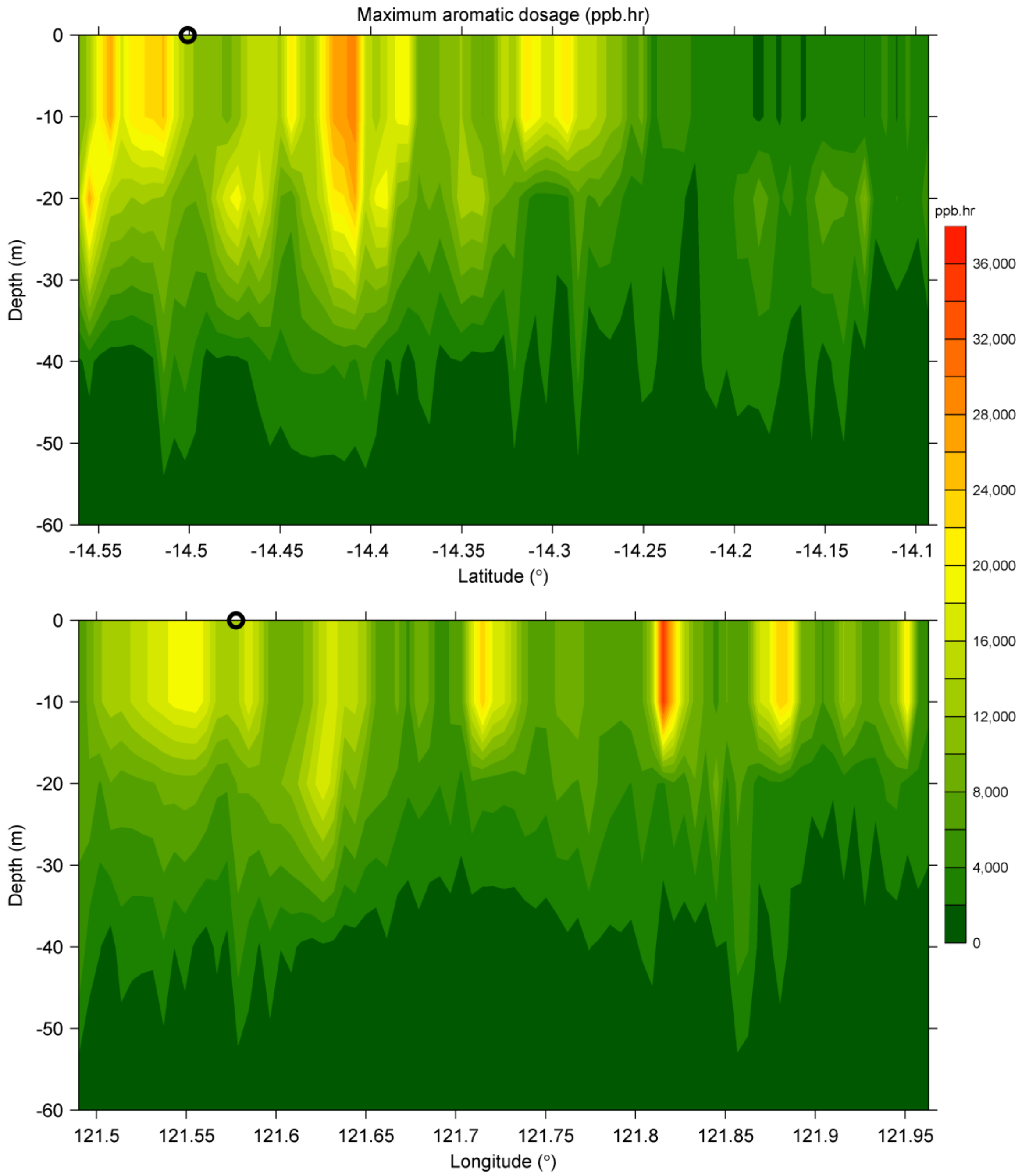


Figure 3-133: Vertical profile showing maximum annualised dissolved aromatic hydrocarbon dosage at a depth of 0 - 60 m (BMSL), across two perpendicular transects intersecting (top, north-south; bottom, east-west) the release point (black circle) from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location.

Table 3-20: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location.

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Timor Leste	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Timor (West)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Pulau Roti	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2	1	NC	NC
Big Bank Shoals	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Melville Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Oceanic Shoals CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Hibernia Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	143	171	73	13
Ashmore Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	269	442	77	31
Ashmore Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	209	362	6	13

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-20: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Cartier Island CMR	Probability (%) ≥ 576	NC	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	575	997	422	332
Cartier Islet	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	520	455	173	192
Joseph Bonaparte Gulf East	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Kimberley CMR	Probability (%) ≥ 576	7	5.5	3	1
	Probability (%) ≥ 4,800	1.5	1.5	1	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	32,090	26,545	9,265	4,403
Argo-Rowley Terrace CMR	Probability (%) ≥ 576	2	2.5	1.5	1
	Probability (%) ≥ 4,800	0.5	0.5	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	9,854	6,752	3,792	2,203
Seringapatam Reef	Probability (%) ≥ 576	2.5	2	1.5	0.5
	Probability (%) ≥ 4,800	1	NC	0.5	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,8043	4,428	5,079	609
Joseph Bonaparte Gulf West	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
North Reef Flats	Probability (%) ≥ 576	2	3.5	2	0.5
	Probability (%) ≥ 4,800	0.5	0.5	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	6,623	13,015	2,490	960
North Reef Lagoon	Probability (%) ≥ 576	1	1	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	3,234	2,087	481	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-20: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Kimberley Coast	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
South Reef Lagoon	Probability (%) ≥ 576	1.5	2	1	0.5
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,964	2,888	1,401	654
SR Central/ Sandy Islet	Probability (%) ≥ 576	1	2	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	2,090	3,589	BS	BS
South Reef Flats	Probability (%) ≥ 576	9.5	10.5	5.5	0.5
	Probability (%) ≥ 4,800	2	3	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	15,557	11,872	3,611	889
Browse Island	Probability (%) ≥ 576	NC	0.5	0.5	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	518	1,361	643	49
Lalang-garram / Camden Sound MP	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Camden Sound	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Adele Island	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	55	121	BS	BS
Dampier Peninsula Coast - North section	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-20: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Lacepede Islands	Probability (%) ≥ 576	NC	BS	BS	BS
	Probability (%) ≥ 4,800	NC	BS	BS	BS
	Probability (%) ≥ 38,400	NC	BS	BS	BS
	Maximum Dosage	NC	BS	BS	BS
Mermaid Reef CMR	Probability (%) ≥ 576	0.5	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,098	1,195	566	283
Mermaid Reef	Probability (%) ≥ 576	0.5	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	651	813	565	225
Rowley Shoals MP (Clerke Reef)	Probability (%) ≥ 576	1	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,806	898	522	17
Clerke Reef	Probability (%) ≥ 576	0.5	0.5	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,806	831	522	2
Imperieuse Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	462	146	1	NC
Rowley Shoals MP (Imperieuse)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	73	21	NC	NC
Eighty Mile Beach	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Glomar Shoals	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-20: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Rankin Bank	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Dampier Archipelago	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Montebello Islands	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Lowendal Islands	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Barrow Island	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Northern Pilbara- Islands and Shoreline	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	NC	NC	BS	BS
Southern Pilbara- Islands	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Muiron Islands (World Heritage)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Ningaloo Coast North (World Heritage)	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-20: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 24-hour 18,000 m^3 surface release of Browse Condensate at the BWA location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Ningaloo Coast North	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

3.7 Scenario 5: Simulation of a 5-minute Surface Release of 13 m^3 of diesel at the Bunker Location

This scenario investigated the probability of exposure to surrounding regions by oil due to a surface release of marine diesel at the Bunker location, with a total discharge volume of 13 m^3 over 5-minutes (Table 1-1).

Table 3-21: Summary of the spill scenario.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (m BMSL)
5	Spill during bunkering operations, 8 km ENE of the TRD location	Marine Diesel	13	1.38×10^{-2}	5 mins	13° 59' 22.06" S 122° 1' 36.12" E	Surface

The modelling for this scenario assumed no mitigation efforts are undertaken to collect or otherwise affect the natural transport and weathering of the oil. All sensitive receptors outlined in Section 2.3.6 were analysed; however, only the receptors that were forecast to be contacted by dispersing oil are summarised in this section.

Average Weathering

The average mass balance indicates that the proportion of marine diesel expected to remain on the water surface after 7 days is around 10%, with approximately 35% being entrained and 50% having evaporated (Figure 3-134 and Figure 3-135). After 21 days it is predicted that very little of the marine diesel will be floating on the surface, while around 30% remains entrained at low concentrations.

Marine diesel has a small proportion of aromatics (approximately 3%), resulting in a forecast maximum mass of dissolved aromatics of around 20 kg (Figure 3-136). Approximately 90% of the available aromatics are expected to evaporate within the first 24 hours.

Trajectory and Weathering of an Example Replicate

An example series of snapshots of a single predicted spill trajectory are presented in Figure 3-138. The snapshots display the location and concentration of floating oil at the start of the release and 1 day, 3 days, 5 days, 7 days and 9 days after spill commencement.

The snapshots show that 1 day after the commencement of this spill event floating oil at low concentrations drifted towards the west, and therefore towards Scott Reef North (Figure 3-138 b). From day 2 no floating oil above 0.5 g/m^2 is forecast in this case. The mass balance for this replicate shows that the mass of floating oil is expected to reduce to less than 1% of the initial spill mass after approximately 5 days. A strong wind event between days 4 and 5 is shown to lead to significant entrainment of the floating oil slick.

Floating Oil

Floating oil with concentrations at or above 1 g/m^2 is forecast to occur up to 60 km from the release site with a maximum potential swept area of 76 km^2 in the worst case (Figure 3-140 and Table 3-22). At the 10 g/m^2 threshold floating oil is expected to occur up to 10 km from the release site (Figure 3-141), with a maximum potential swept area of 2.2 km^2 at this threshold. Floating oil is expected to drift to the northeast or southeast of the release site, with the longest trajectories expected to the northeast.

Table 3-22: The potential swept area (km^2) of floating oil with concentrations exceeding defined threshold concentrations in any single spill event. The swept area refers to all areas covered by the slick during the spill simulation with a concentration at the specified threshold.

	0.5 g/m^2	**1 g/m^2**	**10 g/m^2**	**25 g/m^2**
Minimum potential area (km^2)	0.8	0.8	0.2	0.2
Median potential area (km^2)	28.2	13.6	0.8	0.2
Mean potential area (km^2)	33.5	15.9	0.8	0.2
Maximum potential area (km^2)	181.4	75.6	2.2	0.5

The return-period probabilities ($P_1 x P_2$) at these thresholds are shown in Figure 3-142 and Figure 3-143.

Maximum floating oil concentrations are not expected to exceed 50 g/m^2, but may exceed 25 g/m^2 within 5 km of the release site (Figure 3-144).

Floating oil with concentrations of 1 g/m^2 or greater is expected to contact the North Reef Flats (0.5%), North Reef Lagoon (0.25%) and South Reef Lagoon (1.75%) receptors (Table 3-23). No receptors are forecast to be contacted by floating oil with concentrations exceeding 10 g/m^2. The minimum time expected for floating oil at the lowest defined threshold (0.5 g/m^2) to reach any receptor is 9 hours at North Reef Flats, followed by 11 hours at South Reef Lagoon. Similar times are expected for all contacting thresholds.

The worst-case locally accumulated shoreline concentration is expected at Scott Reef Central/Sandy Islet (65 g/m^2). The maximum accumulated volume in any contacted receptor shoreline is expected to be less than 1 m^3.

Dissolved Aromatic Hydrocarbon Dosage

Dissolved aromatic hydrocarbon dosage is not forecast to reach the lowest assessed threshold of 576 ppb.hr within the model domain (Table 3-24).

3.7.1 Average Weathering

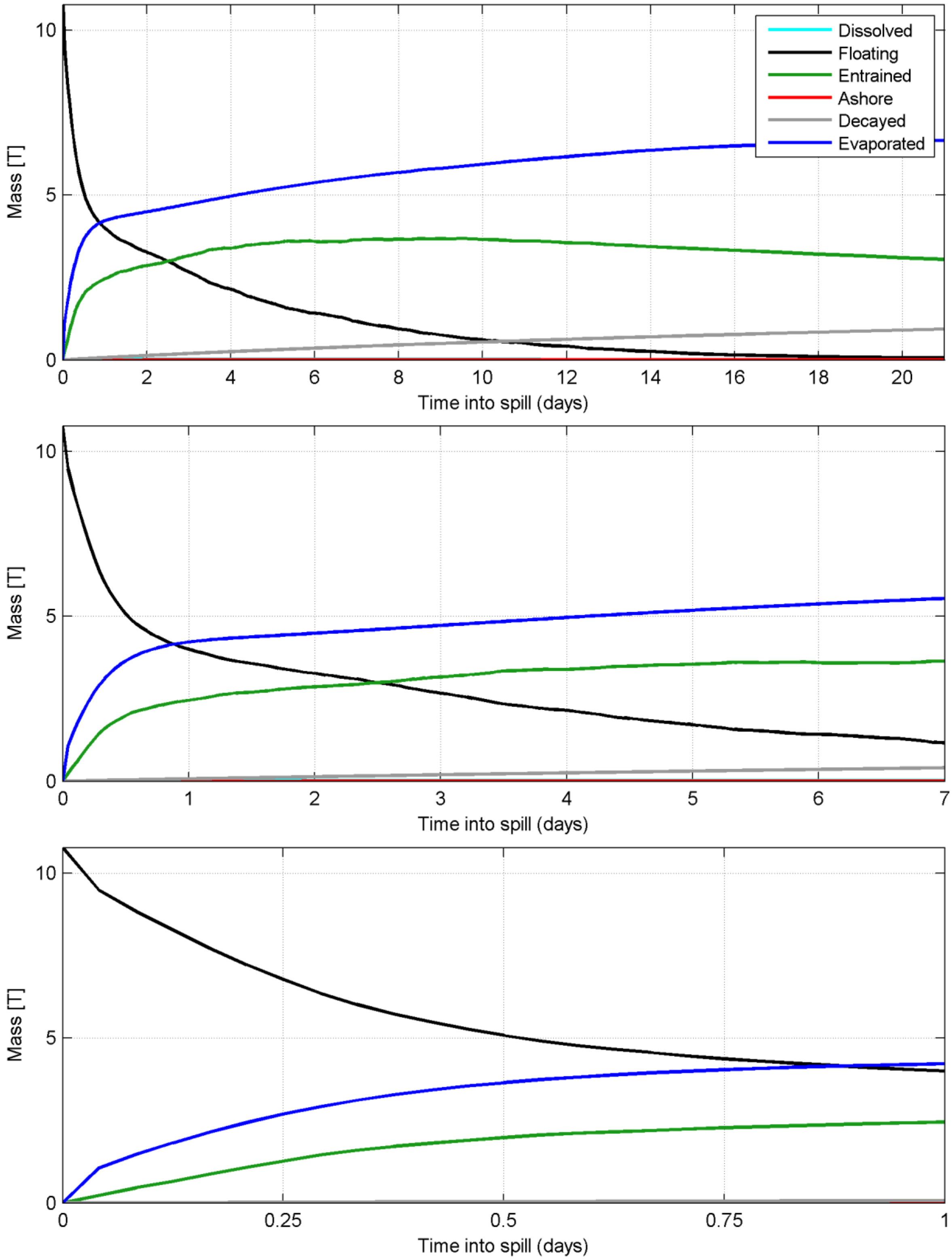


Figure 3-134: Predicted average weathering mass balance (tonnes) resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The distribution over the first 21 days (top), 7 days (middle) and24 hours (bottom) is given.

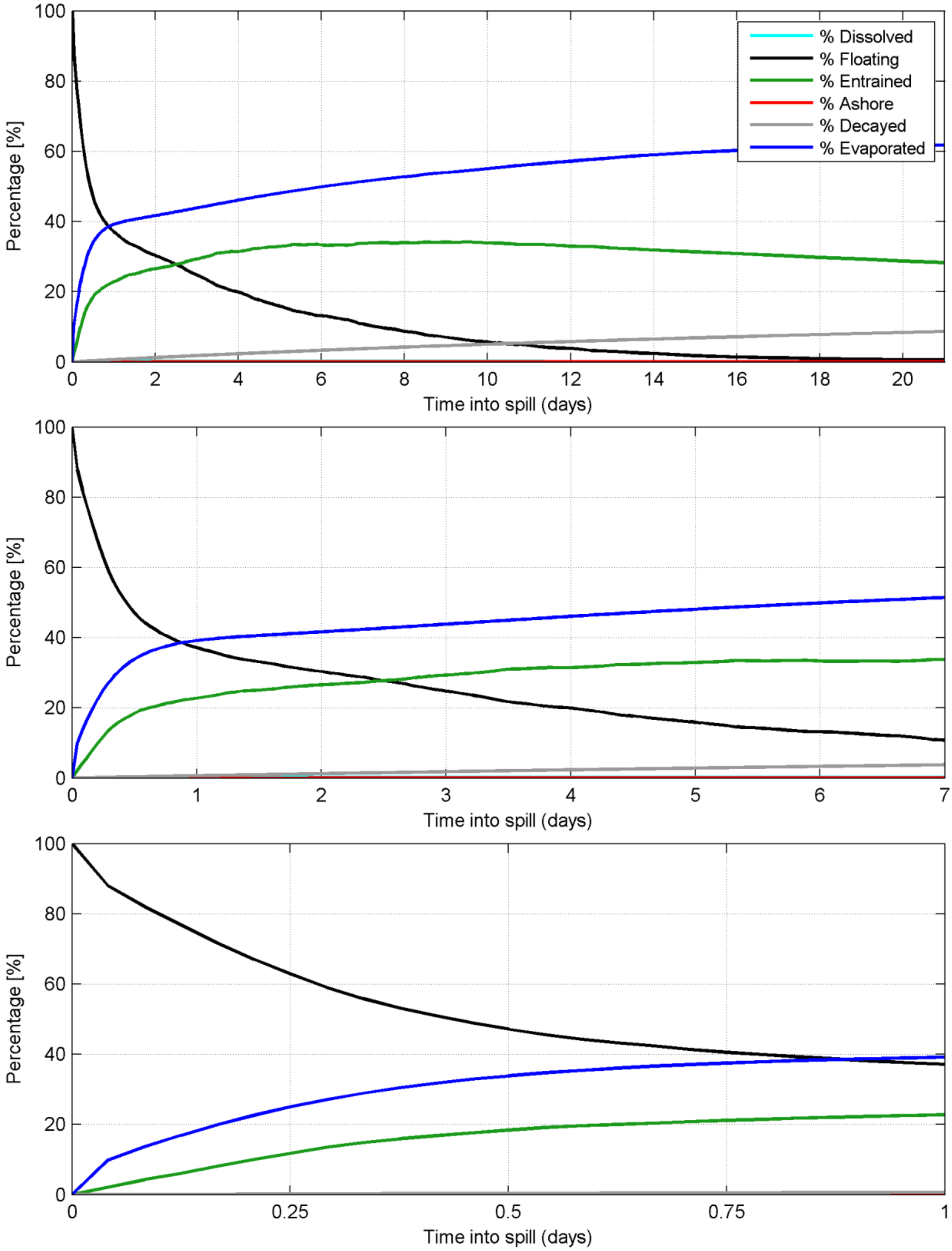


Figure 3-135: Predicted average weathering mass balance (% of total mass) weathering graph resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The distribution over the first 21 days (top), 7 days (middle) and 24 hours (bottom) is given.

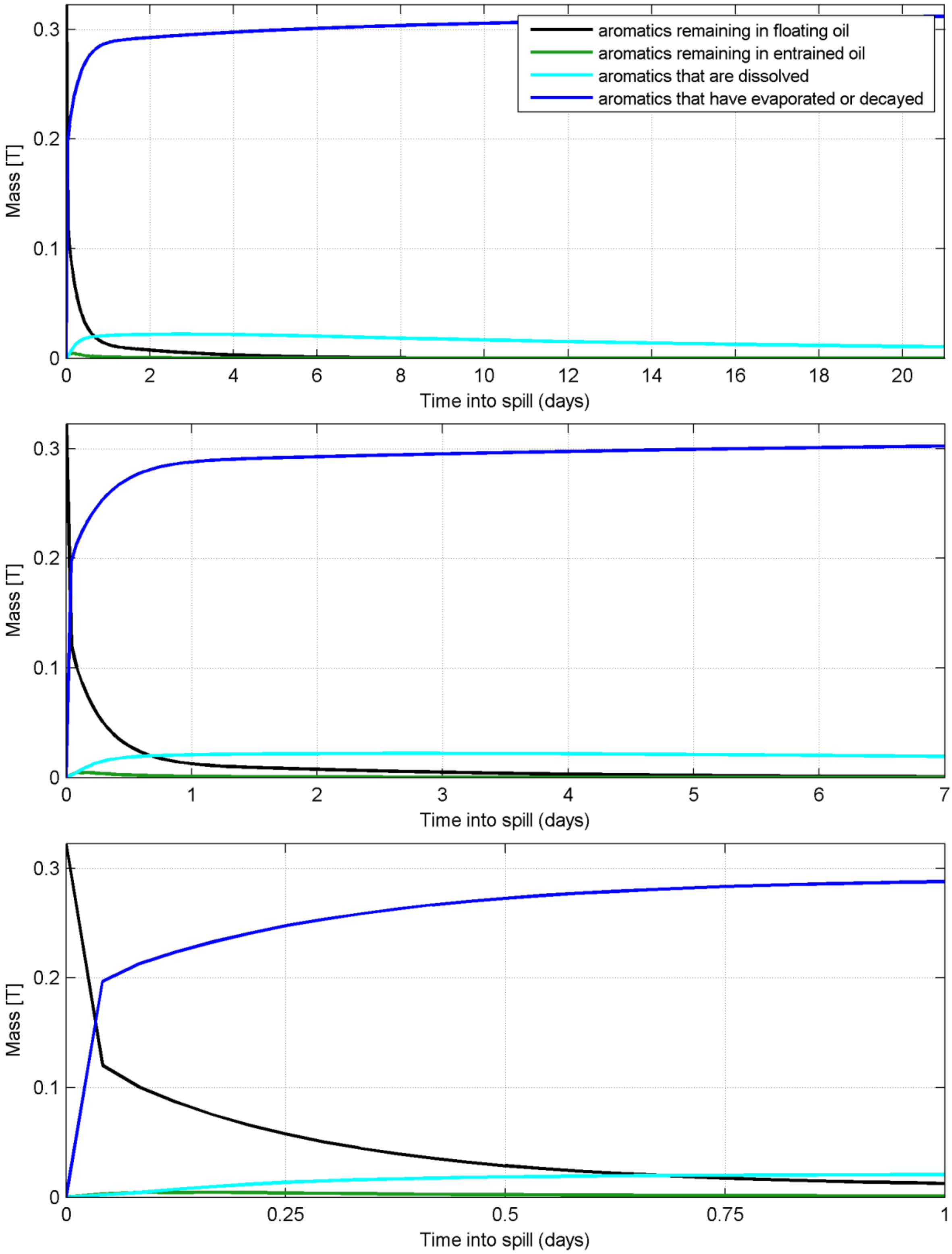


Figure 3-136: Predicted average partitioning of the aromatic hydrocarbons (tonnes) resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The distribution over the first 21 days (top), 7days (middle) and 24 hours (bottom) is given.

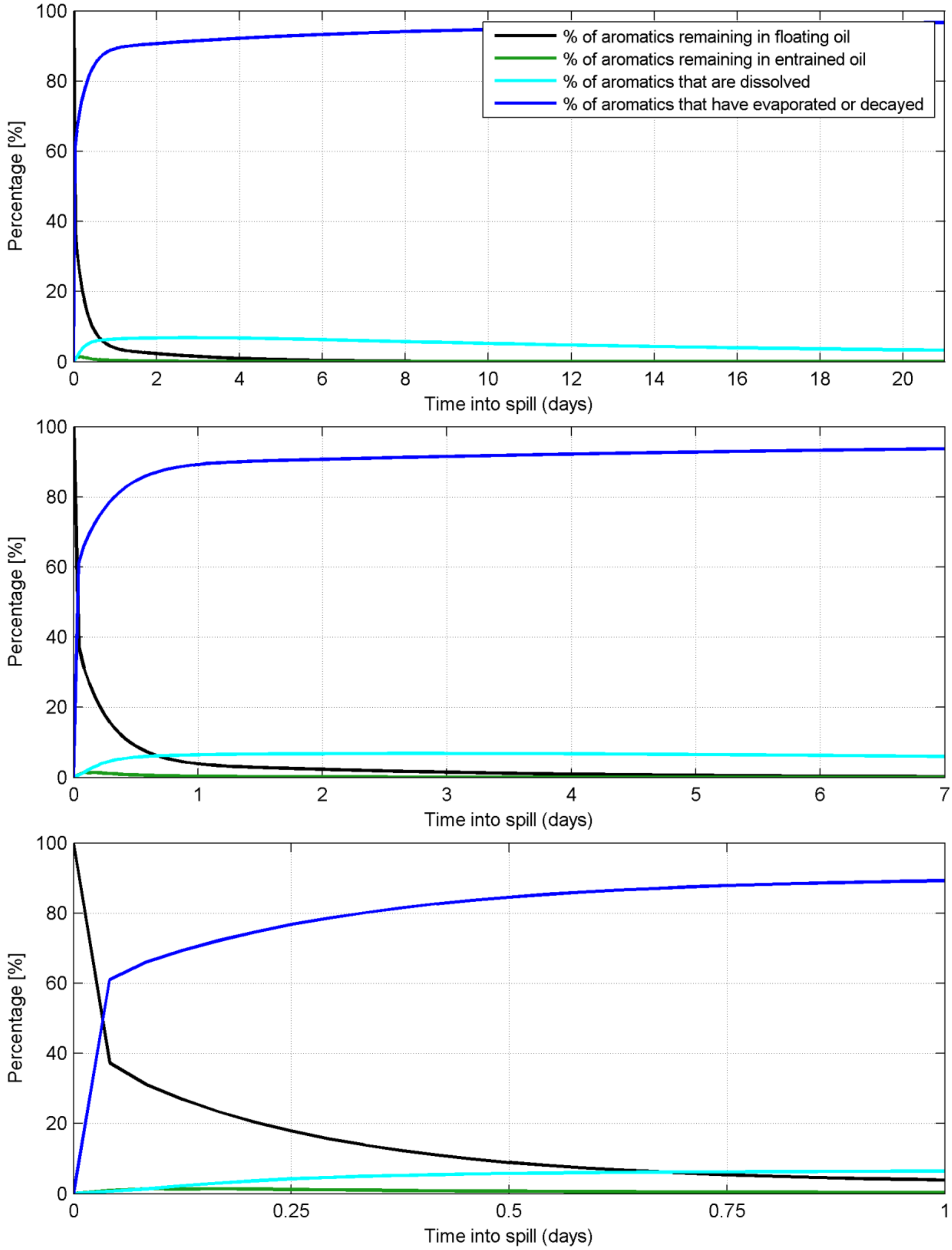


Figure 3-137: Predicted average partitioning of the aromatic hydrocarbons (% of total mass) resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The distribution over the first 21 days(top), 7 days (middle) and 24 hours (bottom) is given.

3.7.2 Trajectory and Weathering of an Example Replicate

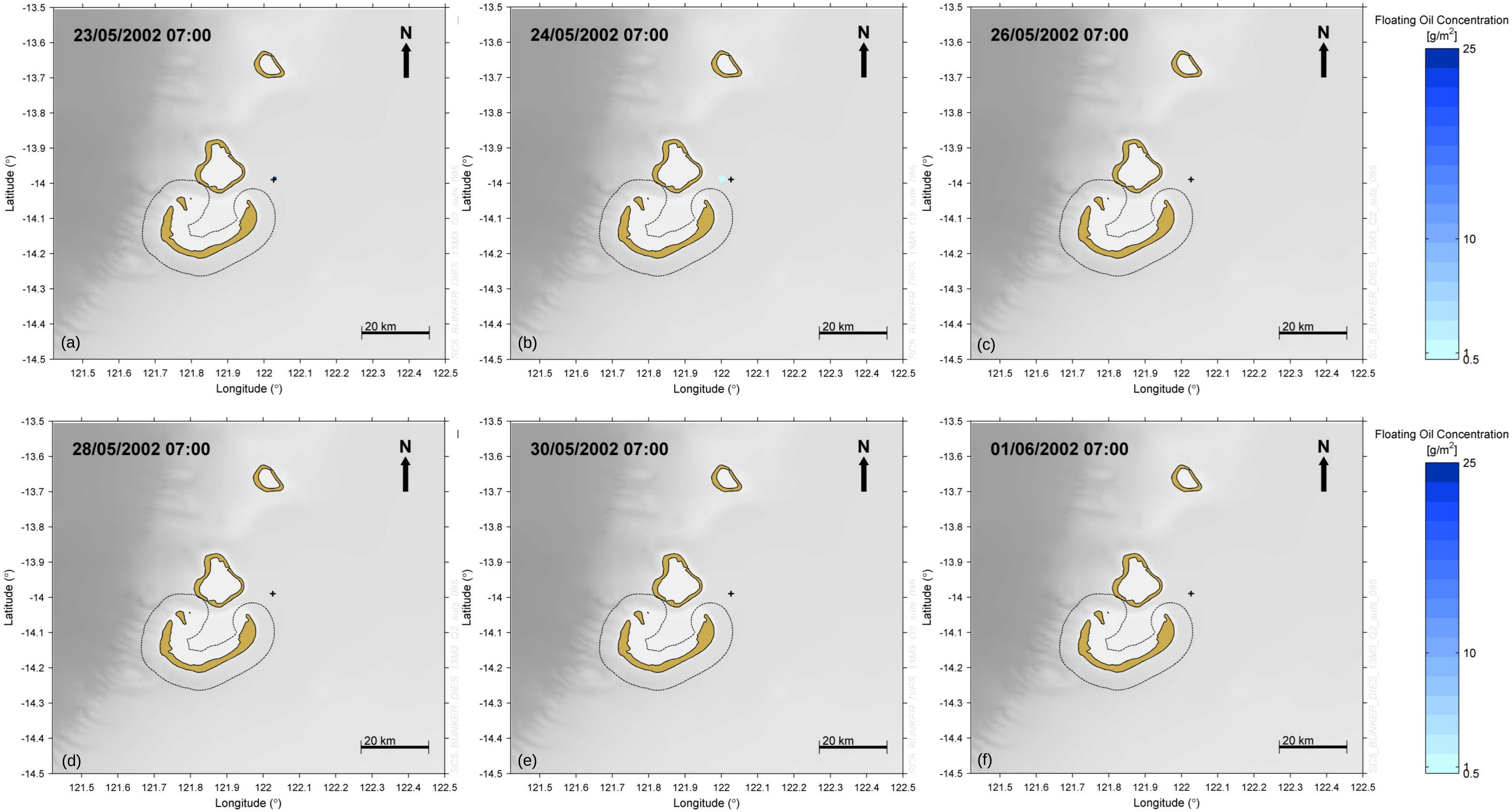


Figure 3-138: Example trajectory and concentration of floating oil for a 5-minute 13 m^3 surface release of diesel at the Bunker location, commencing at 07:00 on the 23 of May, 2002. The resultant trajectory and concentration at the start of the release (a), 1 day (b), 3 days (c), 5 days (d), 7 days (e) and 9 days (f) after the start of the release are presented.

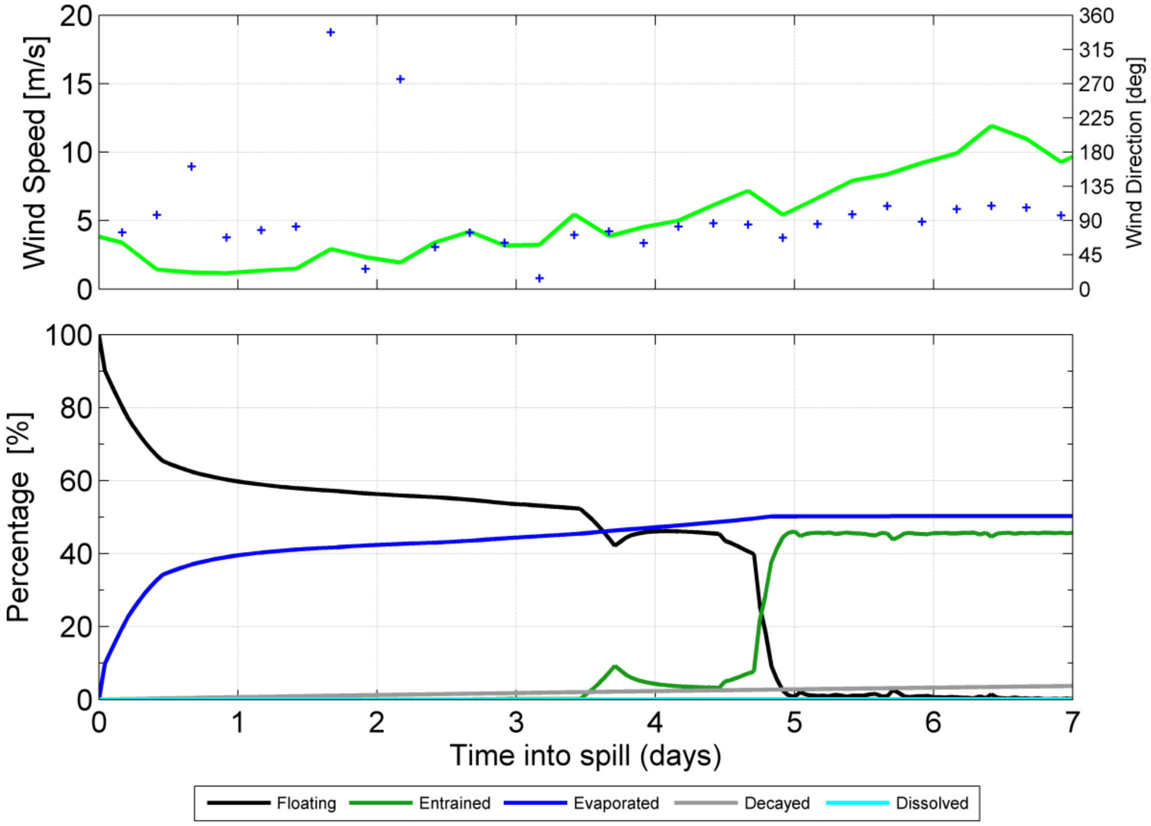
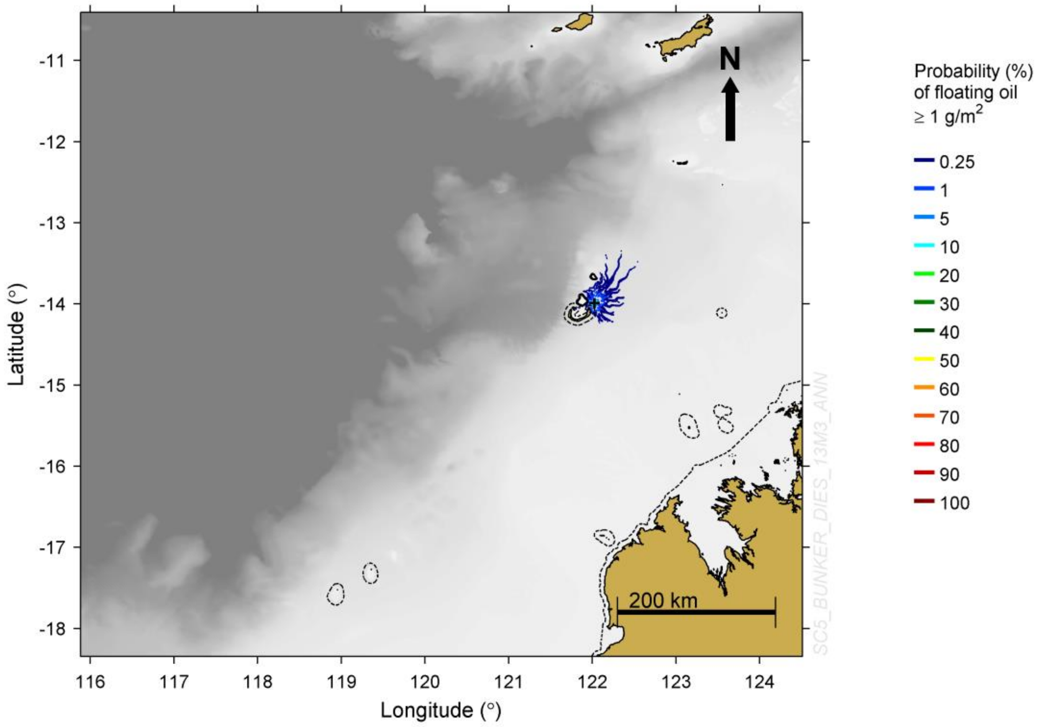


Figure 3-139: Predicted mass balance weathering resulting from a 5-minute 13 m³ surface release of diesel at the Bunker location, commencing at 07:00 on the 23 of May, 2002. The green line in the top figure indicates the wind speed and the blue dots indicate the wind direction (FROM).

3.7.3 Floating Oil



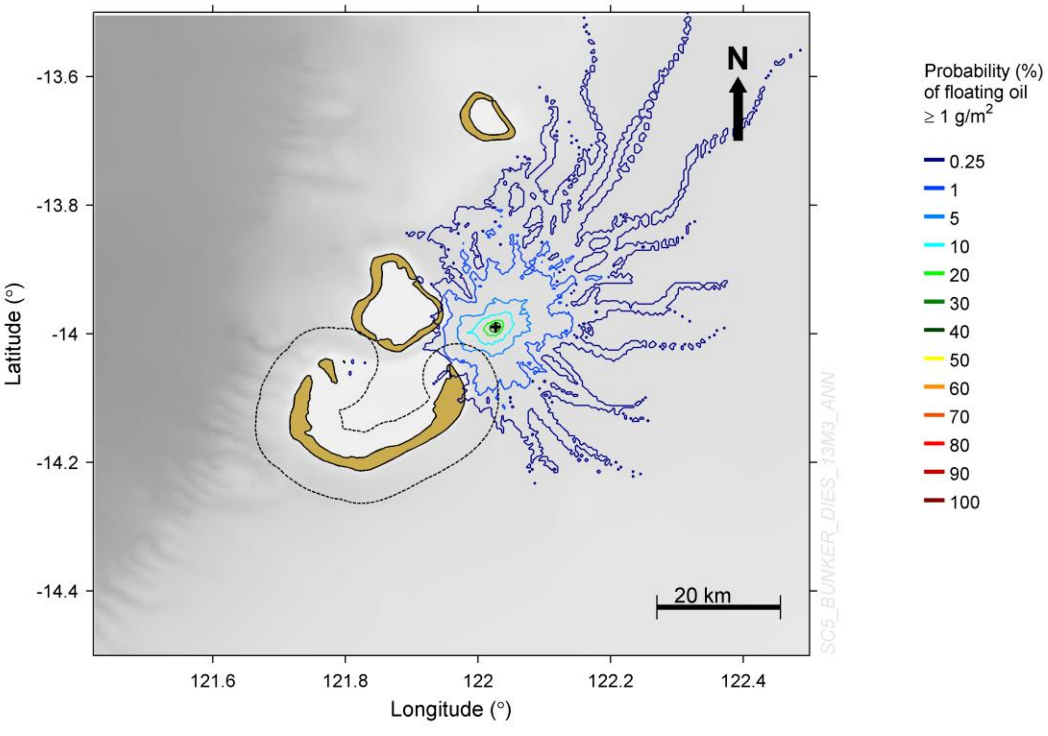
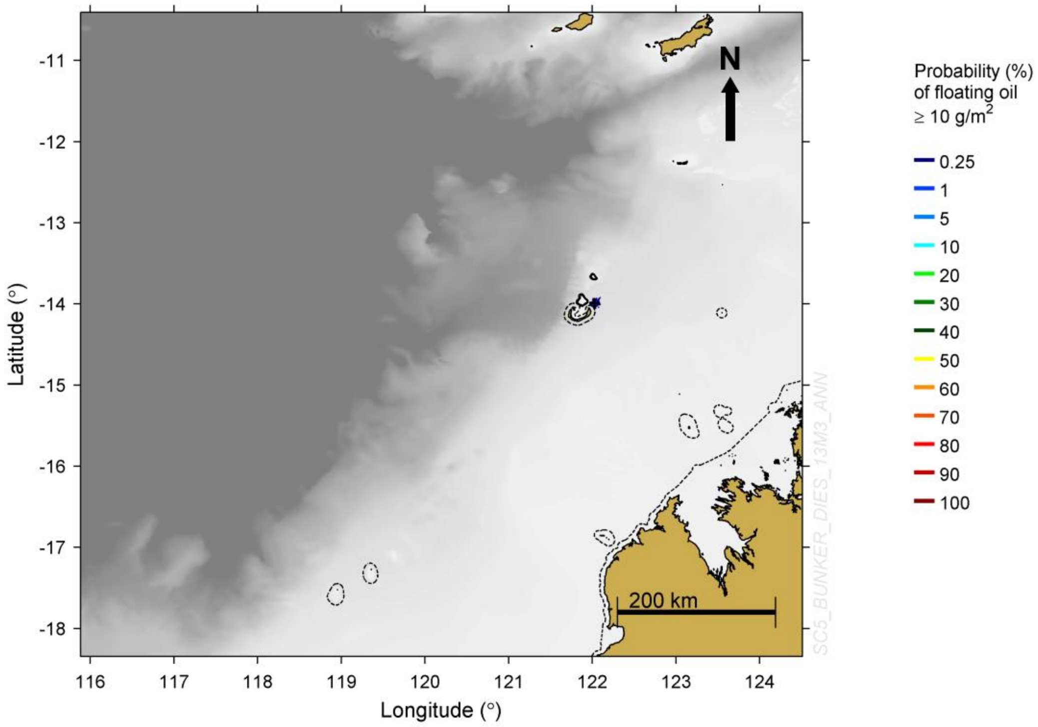


Figure 3-140: Predicted annualised probability (P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



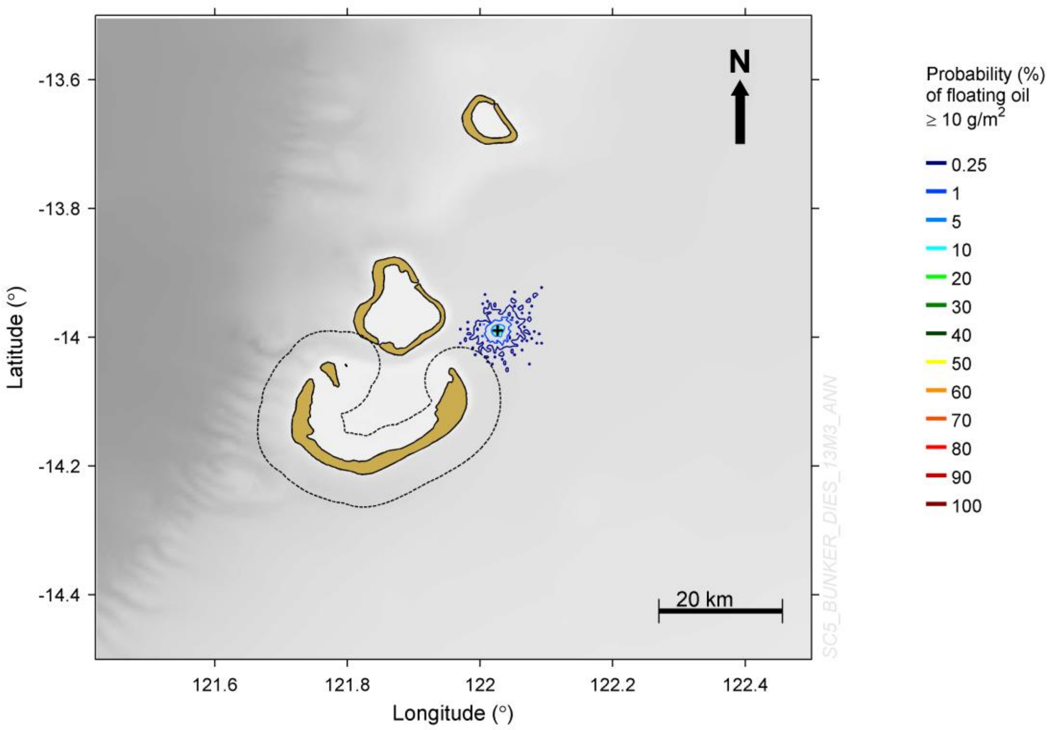
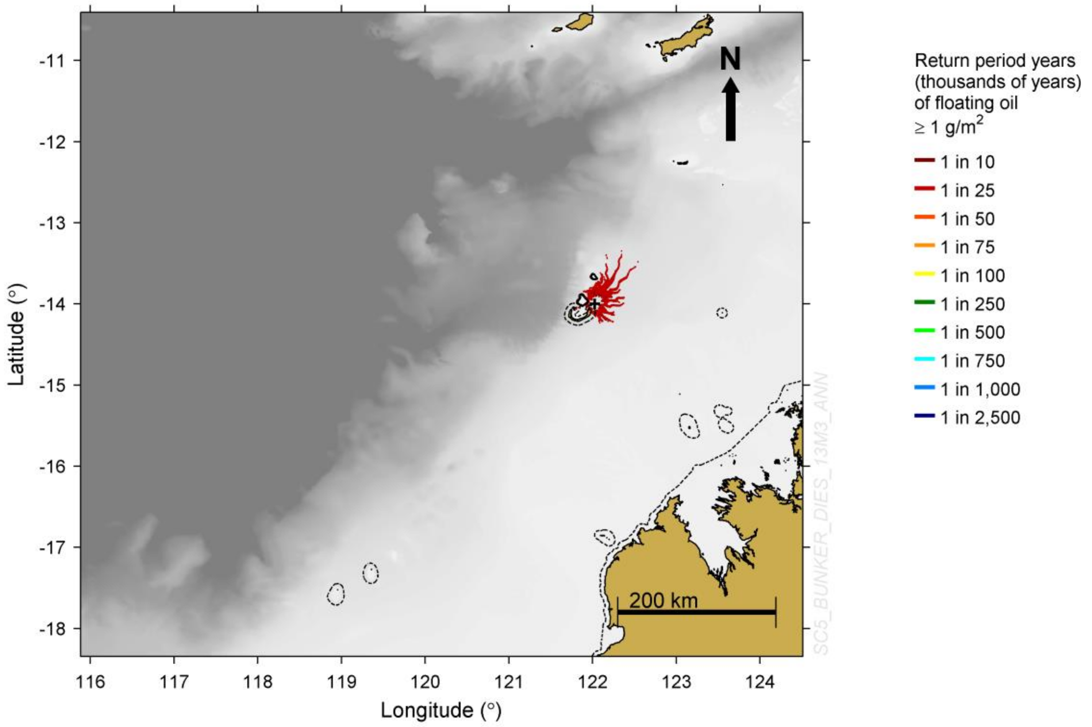


Figure 3-141: Predicted annualised probability (P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



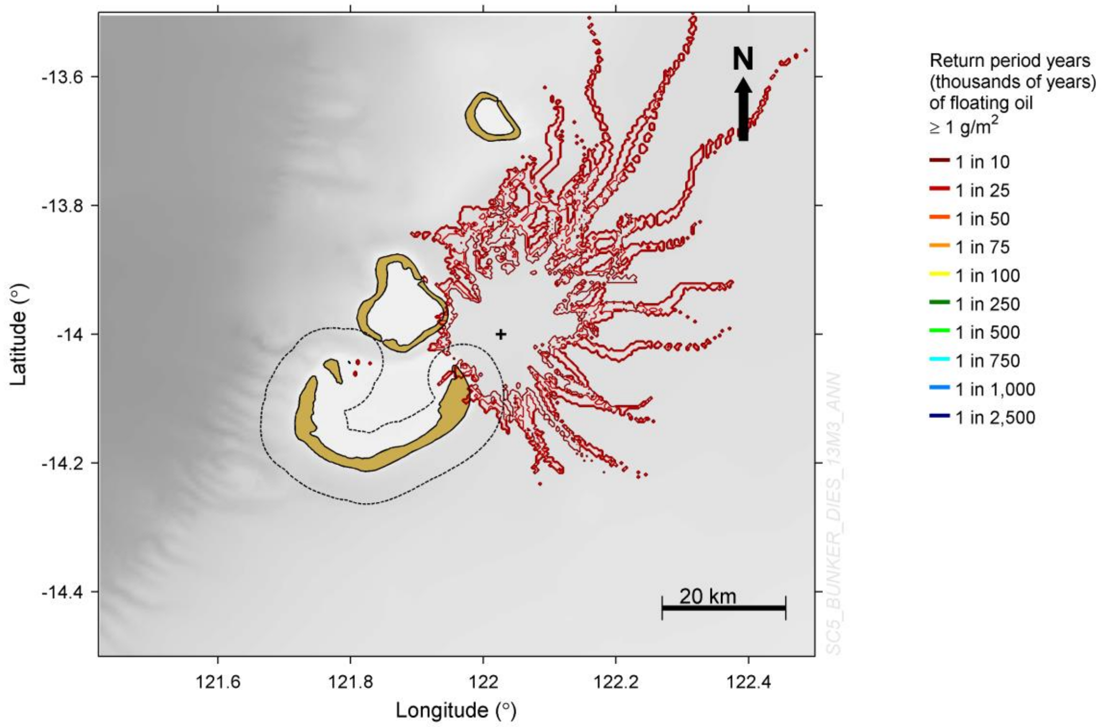
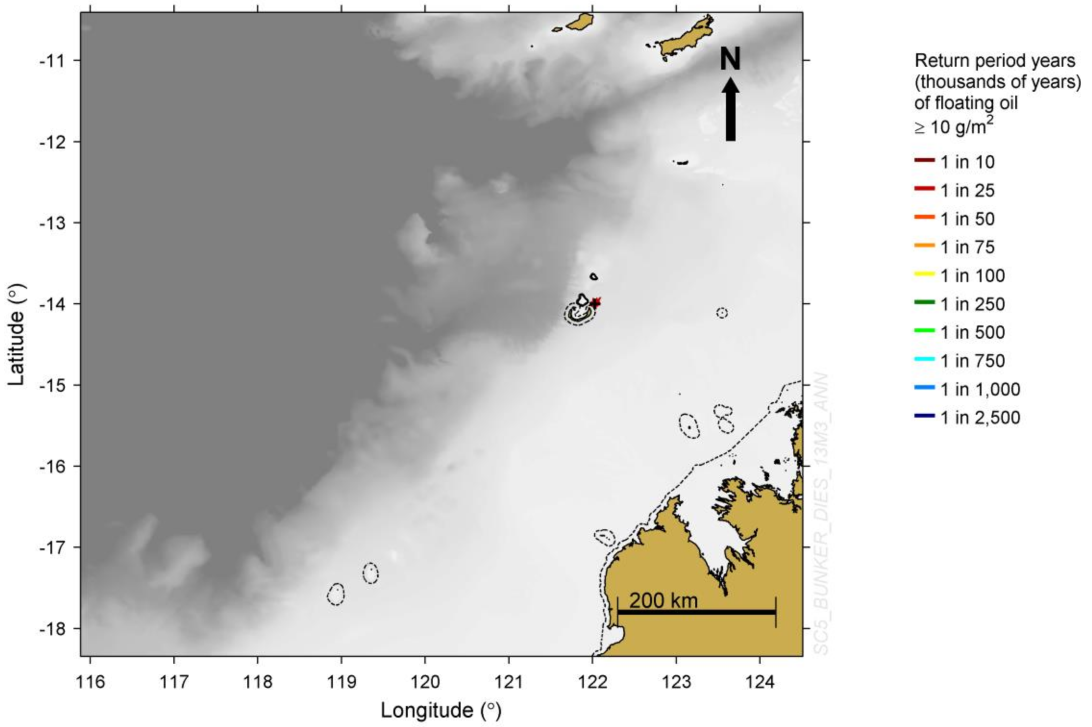


Figure 3-142: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 1 g/m^2 resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



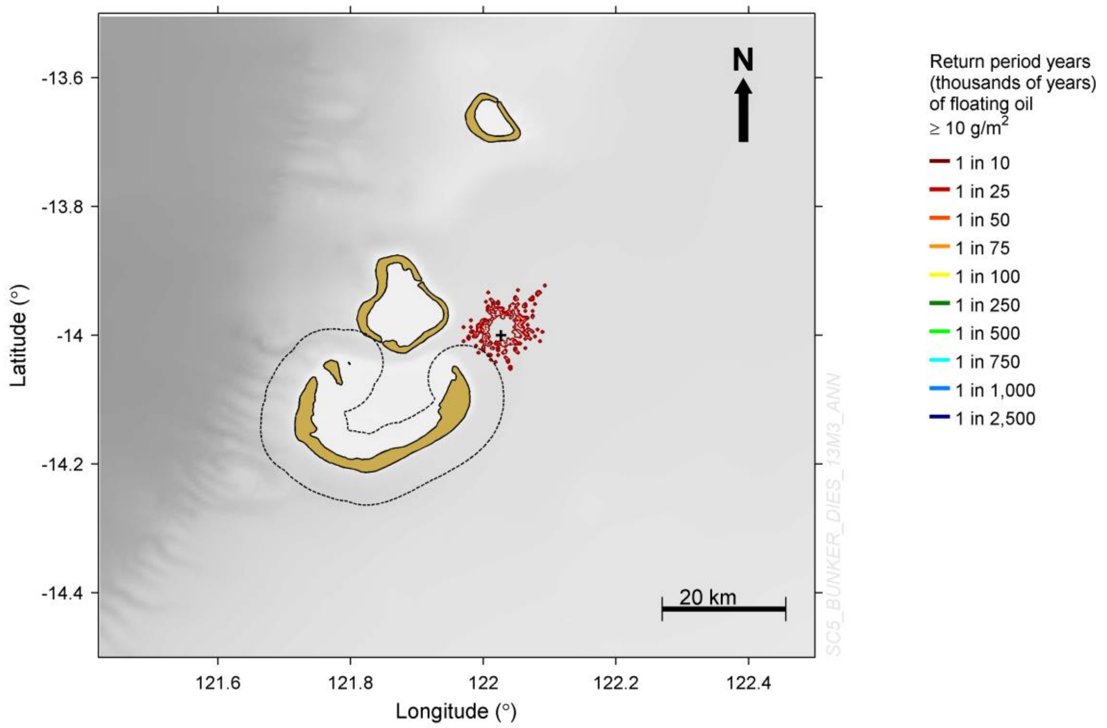


Figure 3-143: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 10 g/m^2 resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

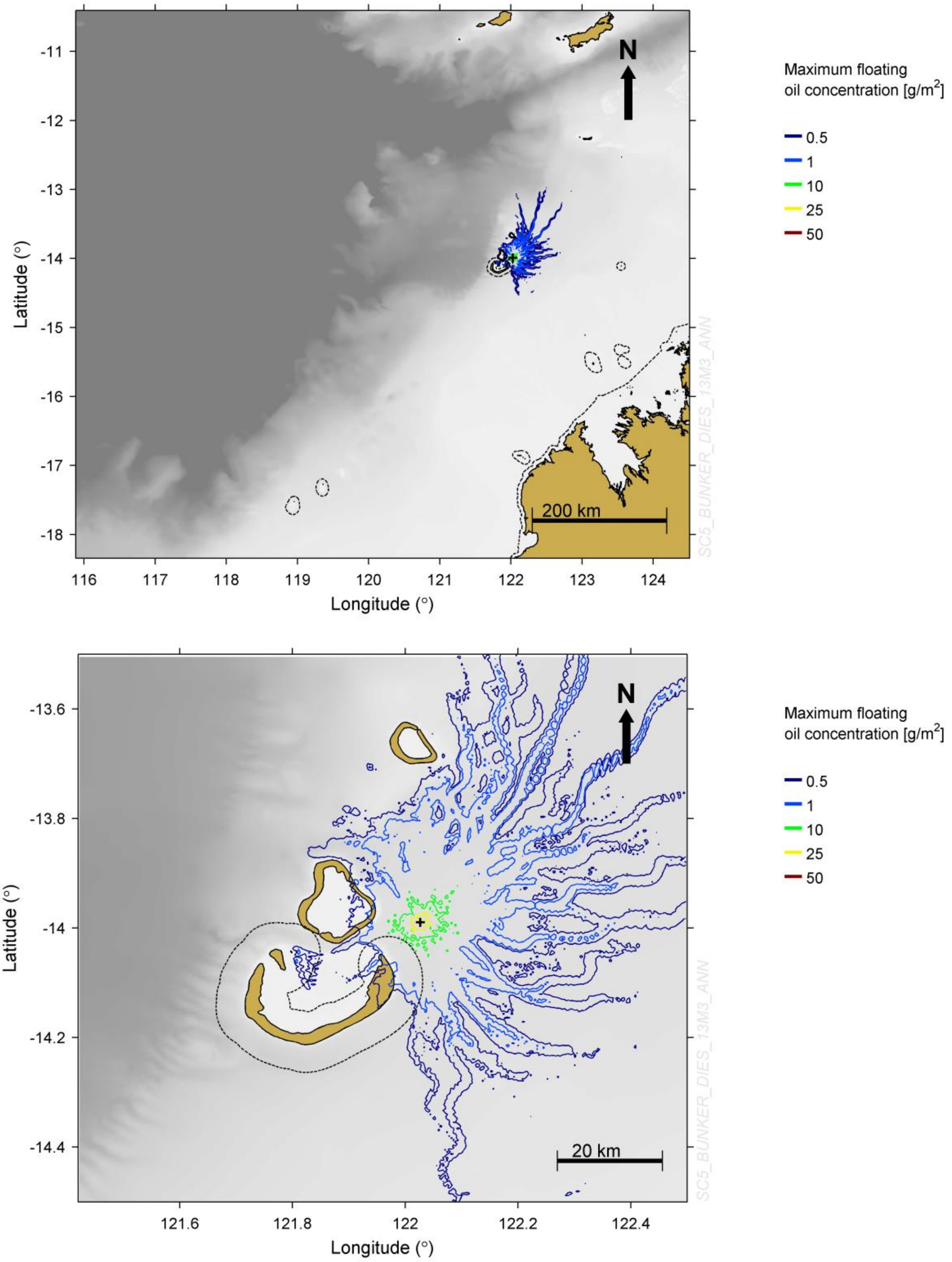


Figure 3-144: Predicted maximum floating oil concentration resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

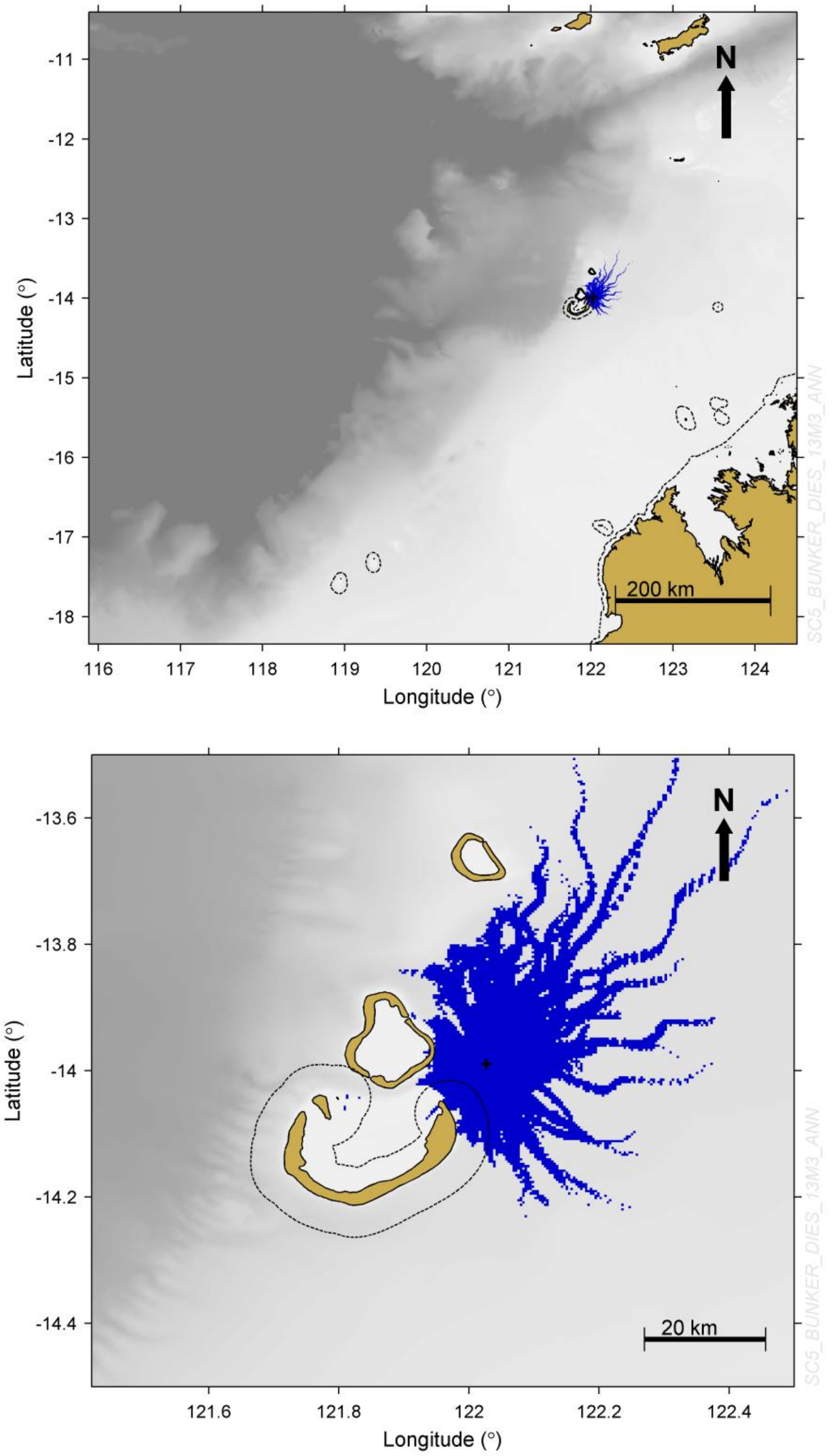


Figure 3-145: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 1 g/m² resulting from a 5-minute 13 m³ surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

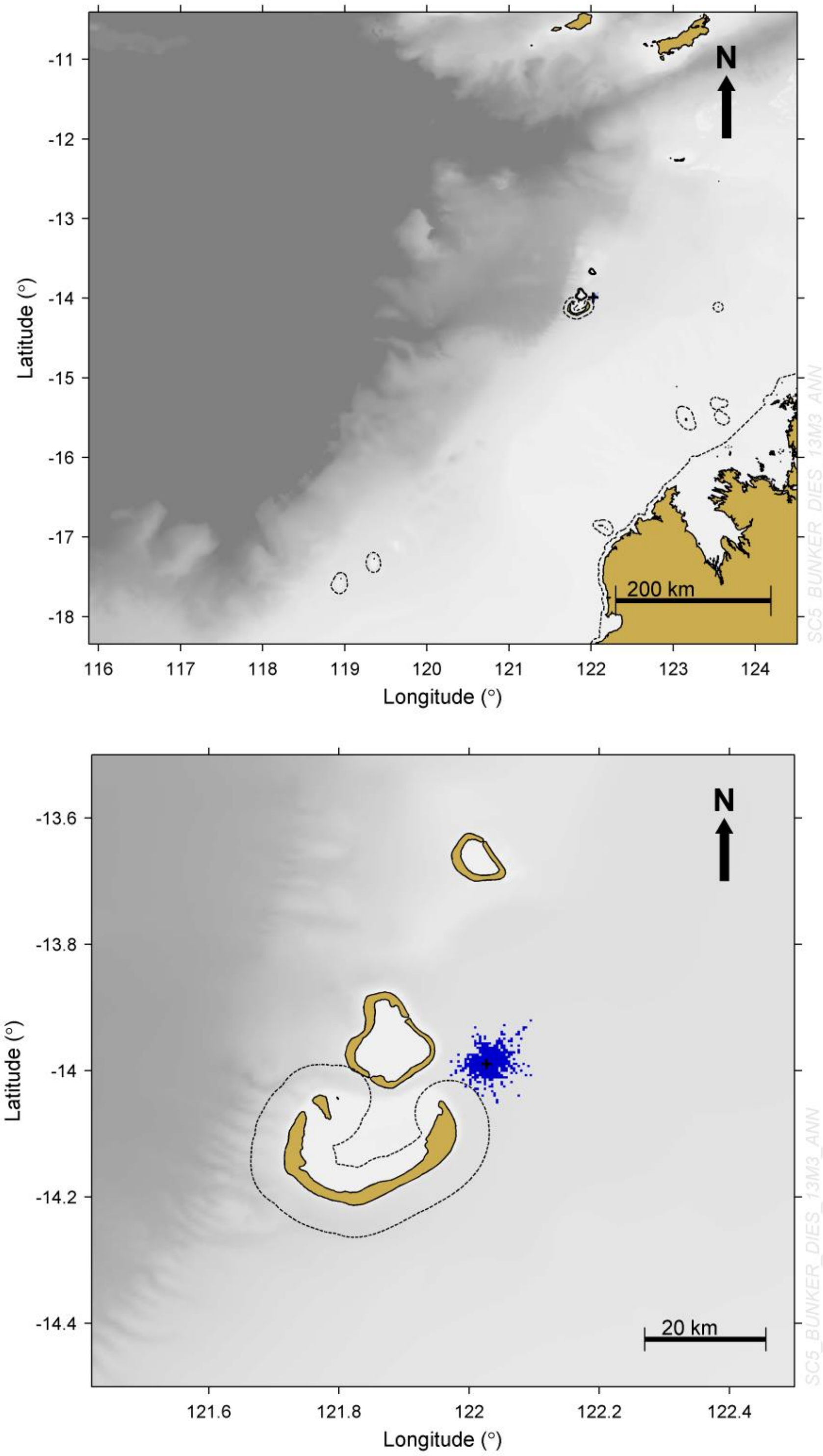


Figure 3-146: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 10 g/m^2 resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

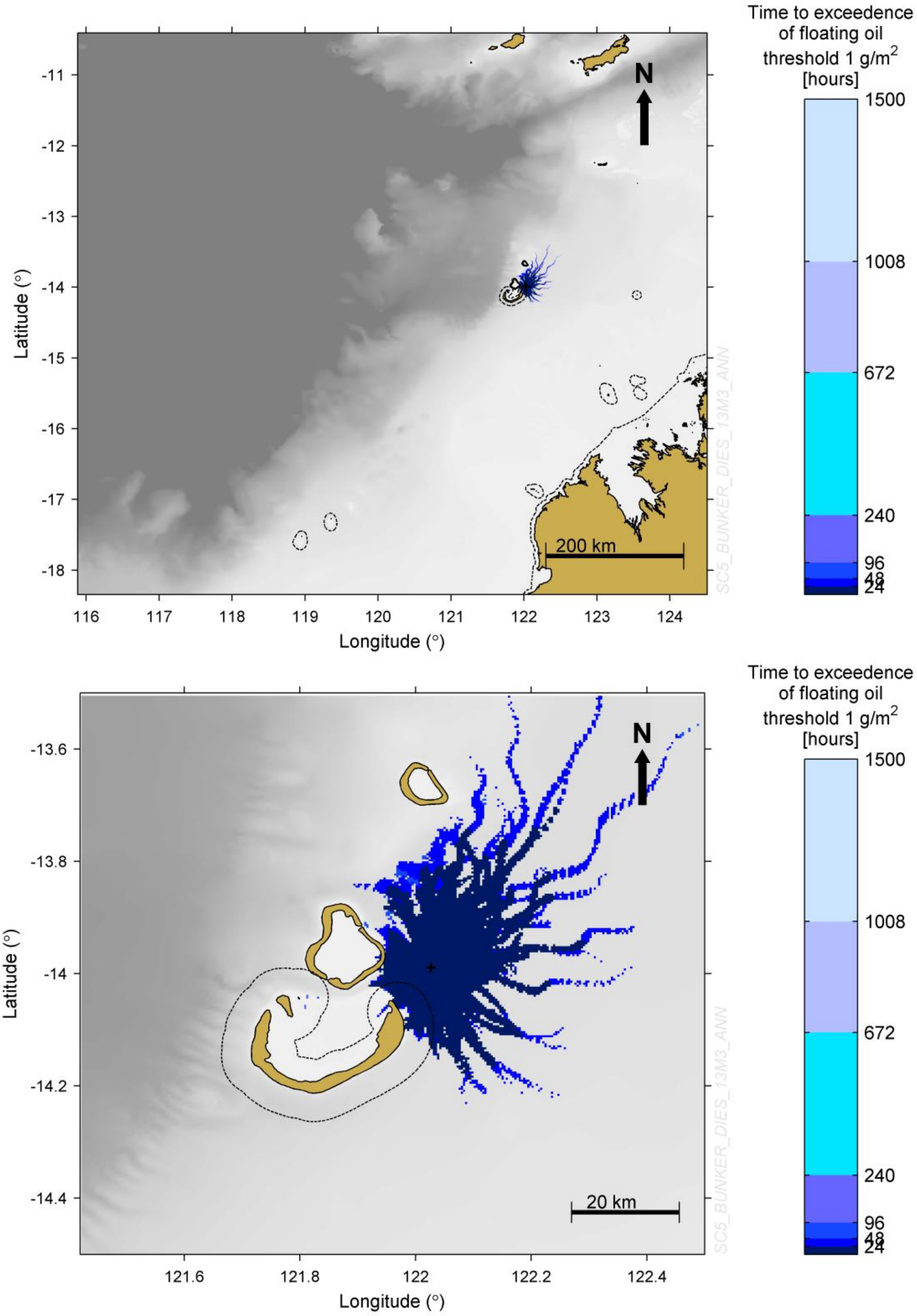
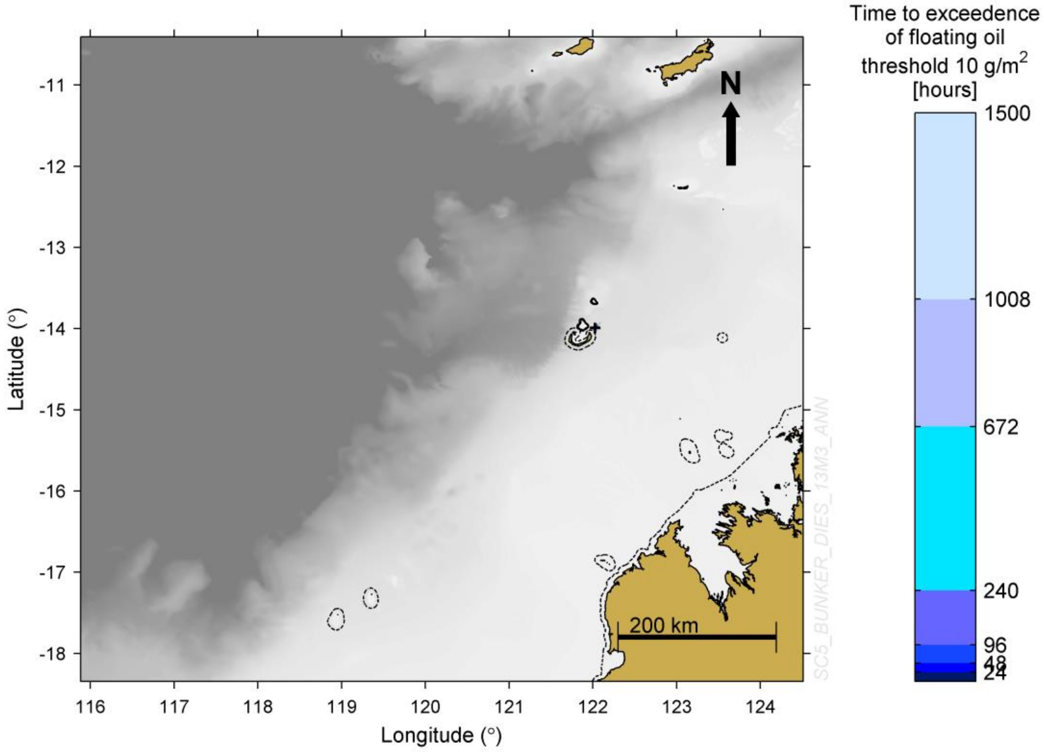


Figure 3-147: Predicted annualised minimum times to threshold for floating oil at or above 1 g/m^2 resulting from a 5-minute 13 m^3 surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



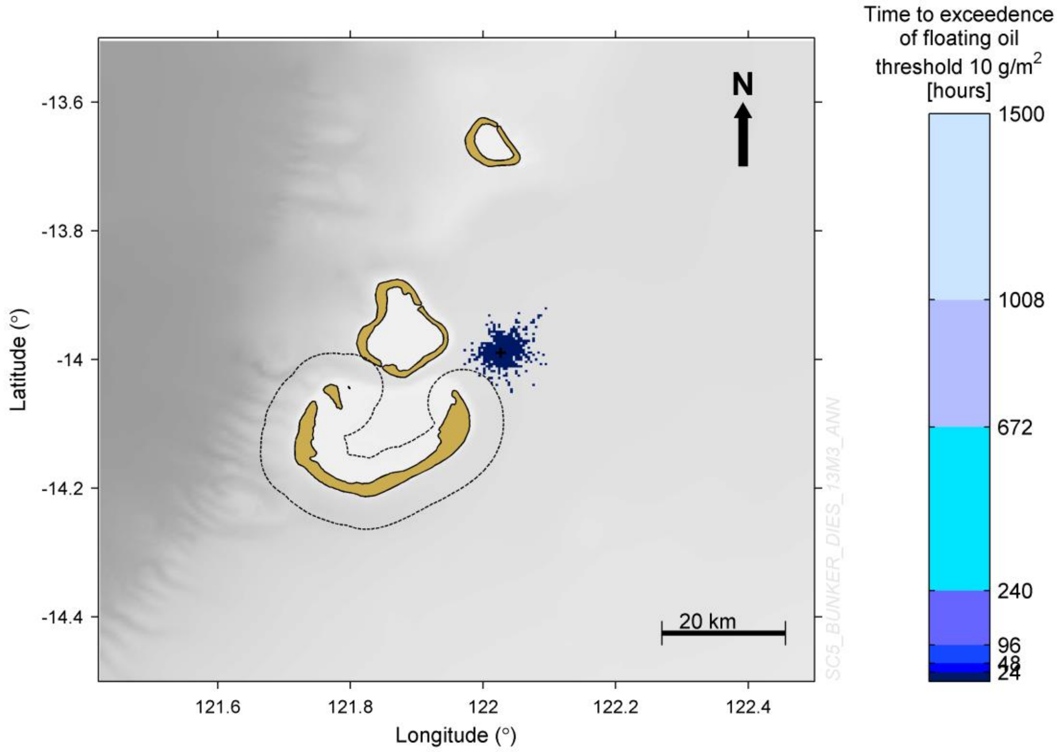


Figure 3-148: Predicted annualised minimum times to threshold for floating oil at or above 10 g/m² resulting from a 5-minute 13 m³ surface release of diesel at the Bunker location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Table 3-23: Expected floating oil outcomes at sensitive receptors across all quarters for a 5-minute 13 m[3] surface release of diesel at the Bunker location.

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Timor (West)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Pulau Roti	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Oceanic Shoals CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	1.6	<1	<1
Ashmore Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	1.6	<1	<1
Cartier Island CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	0.4	<1	<1
Cartier Islet	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	0.4	<1	<1
Kimberley CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Argo-Rowley Terrace CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Seringapatam Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
North Reef Flats*	2.75	0.5	<0.25	<0.25	9	10	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-23: Expected floating oil outcomes at sensitive receptors across all quarters for a 5-minute 13 m^3 surface release of diesel at the Bunker location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
North Reef Lagoon*	1.25	0.25	<0.25	<0.25	23	24	NC	NC	NC	NC	NC	NC
Kimberley Coast	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	1.9	<1	<1
South Reef Lagoon*	4	1.75	<0.25	<0.25	11	12	NC	NC	NC	NC	NC	NC
SR Central/ Sandy Islet	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	0.4	65	<1	<1
South Reef Flats*	1.5	0.25	<0.25	<0.25	17	19	NC	NC	NC	NC	NC	NC
Browse Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	1	<1	<1
Lalang-garram / Camden Sound MP	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Camden Sound	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Adele Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Mermaid Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Mermaid Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-23: Expected floating oil outcomes at sensitive receptors across all quarters for a 5-minute 13 m^3 surface release of diesel at the Bunker location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Clerke Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Imperieuse Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Imperieuse)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

3.7.4 Dissolved Aromatic Hydrocarbon Dosage

Table 3-24: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 5-minute 13 m^3 surface release of diesel at the Bunker location.

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Timor (West)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Pulau Roti	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Oceanic Shoals CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Hibernia Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Ashmore Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Ashmore Reef	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Cartier Island CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Cartier Islet	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Kimberley CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-24: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 5-minute 13 m^3 surface release of diesel at the Bunker location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Argo-Rowley Terrace CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Seringapatam Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
North Reef Flats	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	4	2	1	1
North Reef Lagoon	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	2	NC	NC	BS
Kimberley Coast	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
South Reef Lagoon	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2	5	2	1
SR Central/ Sandy Islet	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
South Reef Flats	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	3	3	1	1
Browse Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-24: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 5-minute 13 m^3 surface release of diesel at the Bunker location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Lalang-garram / Camden Sound MP	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Camden Sound	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Adele Island	Probability (%) ≥ 576	NC	NC	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	NC	NC	NC	BS
Mermaid Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Mermaid Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Clerke Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Imperieuse Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Rowley Shoals MP (Imperieuse)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

3.8 Scenario 6: Simulation of a 5-minute Surface Release of 461.5 m^3 of Browse Condensate at the BWB Location

This scenario investigated the probability of exposure to surrounding regions by oil due to a surface release of Browse Condensate at the BWB location, with a total discharge volume of 461.5 m^3 over 5-minutes.

Table 3-25: Summary of the spill scenario.

Scenario	Description	Fluid	Volume (m^3)	Probability (1/yr)	Duration	Location	Depth (m BMSL)
6	Loss of containment during offtake at BWB facility	Browse Condensate	461.5	4.83x10^{-4}	5 mins	13° 54' 13.662" S 121° 59' 59.536" E	Surface

The modelling for this scenario assumed no mitigation efforts are undertaken to collect or otherwise affect the natural transport and weathering of the oil. All sensitive receptors outlined in Section 2.3.6 were analysed; however, only the receptors that were forecast to be contacted by dispersing oil are summarised in this section.

Average Weathering

The average mass balance indicates that over 75% of the released condensate is expected to rapidly evaporate, and that generally approximately 10% will entrain within the first 24 hours (Figure 3-149 and Figure 3-150). At the end of the 28 day simulation very little oil remains floating and approximately 10% of oil is expected to be entrained at low concentrations, subject to ongoing degradation.

Approximately 70% of the aromatic hydrocarbons are likely to evaporate initially, with about 10% dissolving into the water column in the first 24 hours (Figure 3-151 and Figure 3-152). At the end of the simulations approximately 95% of the initial mass of aromatic hydrocarbons is expected to have either evaporated or decayed, with the remaining 5% dissolved in the water column at low concentrations.

Trajectory and Weathering of an Example Replicate

An example series of snapshots of a single predicted spill trajectory are presented in Figure 3-153, and associated weathering and fates plots in Figure 3-154. The snapshots display the location and concentration of floating oil at the start of the release and 1 day, 3 days, 5 days, 7 days and 9 days after spill commencement.

It is predicted that 1 day after the commencement of this spill event floating oil ranging from 0.5 – 25 g/m^2 may exist west of the release site over Scott Reef North (Figure 3-153 b), penetrating in to the lagoon via the main north channel. From day 3 no floating oil above 0.5 g/m^2 is forecast (Figure 3-153 c to f). The mass balance curve indicates that approximately 75% of the oil evaporates in the first 24 hours (Figure 3-154). Very little floating oil is expected after 7 days, with the majority of remaining oil being entrained.

Floating Oil

Floating oil with concentrations at or above 1 g/m^2 are forecast up to 200 km from the release site, with a maximum potential swept area of 1,100 km^2 in the worst case (Figure 3-155 and Table 3-26). At the 10 g/m^2 threshold, floating oil is forecast up to 100 km from the release site, with a maximum swept area of 143 km^2 (Figure 3-156). Floating oil is forecast to travel to the northeast, east or south of the release site and is most likely to initially drift to the west (towards Scott Reef North).

The potential swept area outcomes (Table 3-26) show that the conditions occurring at and following the spill can greatly influence the extent of floating oil impacts. For example, there is a 200-fold difference between the minimum and maximum outcomes at 1 g/m^2 and a significantly tighter distribution at the higher thresholds. This indicates that exceedence of the higher thresholds will be very localised, most likely due to initial evaporation of the higher volatility cuts.

Table 3-26: The potential swept area (km^2) of floating oil with concentrations exceeding defined threshold concentrations in any single spill event. The swept area refers to all areas covered by the slick during the spill simulation with a concentration at the specified threshold.

	0.5 g/m^2	**1 g/m^2**	**10 g/m^2**	**25 g/m^2**
Minimum potential area (km^2)	5.5	5.1	3.2	2.4
Median potential area (km^2)	145.5	115.1	27	13
Mean potential area (km^2)	256.4	168.9	30.4	13.7
Maximum potential area (km^2)	1,605	1,101	143.3	42.2

The return-period probabilities (P_1xP_2) at these thresholds are shown in Figure 3-157 and Figure 3-158.

Maximum floating oil concentrations at or above 50 g/m^2 are forecast up to 40 km from the release site (Figure 3-159).

Floating oil with concentrations of 25 g/m^2 or greater is expected to pass through North Reef Flats and North Reef Lagoon at forecast probabilities of 1.5% and 0.25%, respectively (Table 3-27). At the 10 g/m^2 threshold South Reef Lagoon (0.75%) and South Reef Flats (0.25%) are also forecast to be contacted, with a maximum probability of contact of 4.75% forecast for North Reef Flats. At the 1 g/m^2 threshold Kimberley CMR, Seringapatam Reef and Scott Reef Central/ Sandy Islet are also forecast to be contacted and no additional receptors are forecast to be contacted at the 0.5 g/m^2 threshold.

The minimum time expected for floating oil at the lowest defined threshold (0.5 g/m^2) to reach any receptor is 7 hours at North Reef Flats, followed by 10 hours at North Reef Lagoon. Similar minimum times apply to the higher thresholds.

The worst-case locally accumulated shoreline concentrations are forecast at Scott Reef Central/Sandy Islet at 705 g/m^2, with a maximum accumulated volume of 2 m^3 (0.4% of the total spill volume).

Dissolved Aromatic Hydrocarbon Dosage

Exceedence of the low dosage level (at or above 576 ppb.hr) is forecast to occur up to 30 km from the release site within the upper 20 m of the water column (Figure 3-164 and Figure 3-165). The extent generally reduces with depth, with only isolated areas in the 20 – 40 m depth layer expected to be affected (Figure 3-166). No exceedence of the moderate dosage threshold (at or above 4,800 ppb.hr) is expected.

Figure 3-171 shows the vertical distribution of the maximum dissolved aromatic hydrocarbon dosage along 2 perpendicular intersections of the release site. The transects demonstrate the relatively localised are of maximum influence, generally to the immediate west of the spill site.

Exceedence of the low dosage threshold is forecast within the receptors North Reef Flats, North Reef Lagoon, South Reef Flats and South Reef Lagoon in the 0 – 10 m depth layer with probabilities of 6%, 1.75%, 0.5% and 0.25% (Table 3-28). Lower probabilities are expected in deeper waters.

3.8.1 Average Weathering

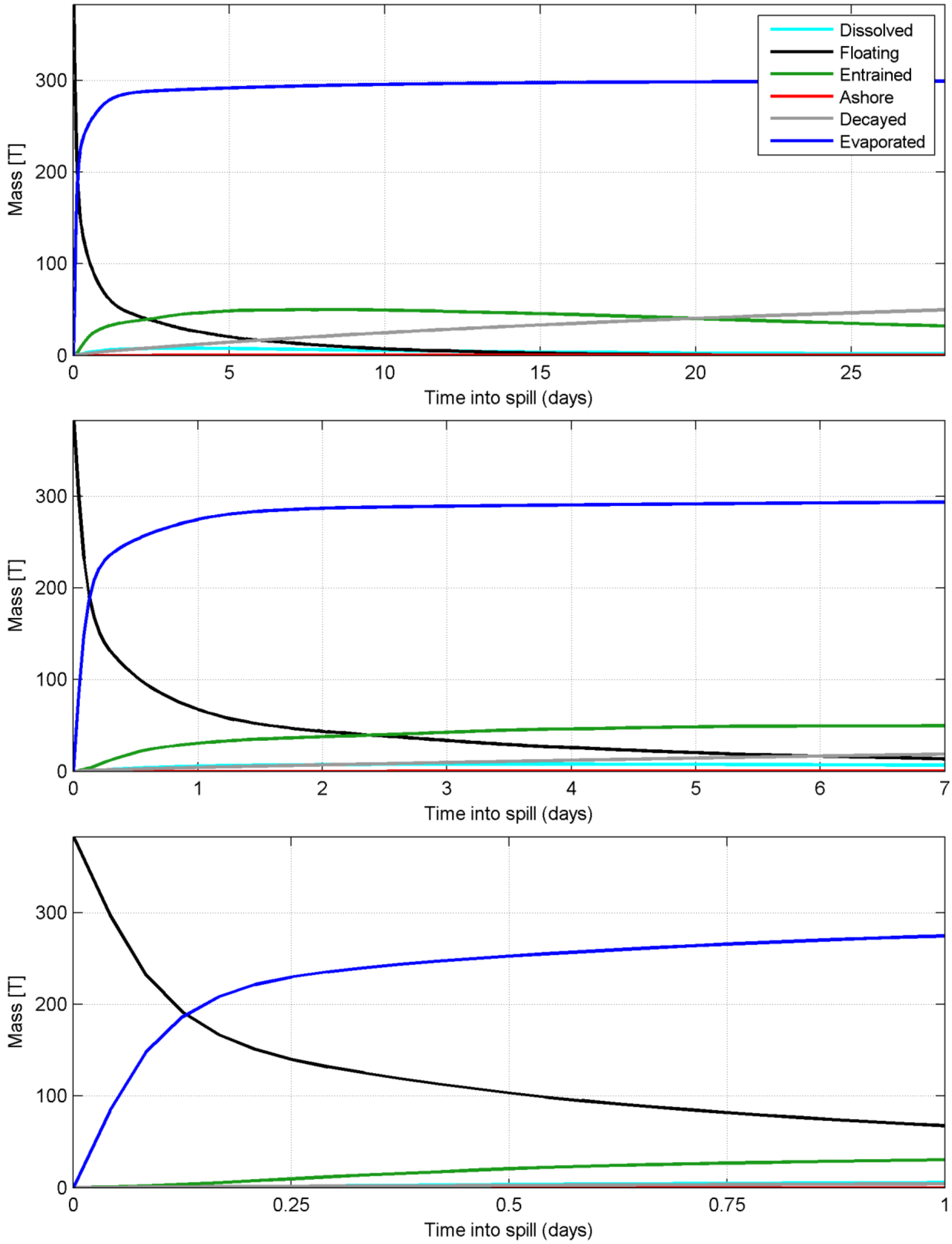


Figure 3-149: Predicted average weathering mass balance (tonnes) resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The distribution over the first 28 days (top), 7 days (middle) and 24 hours (bottom) is given.

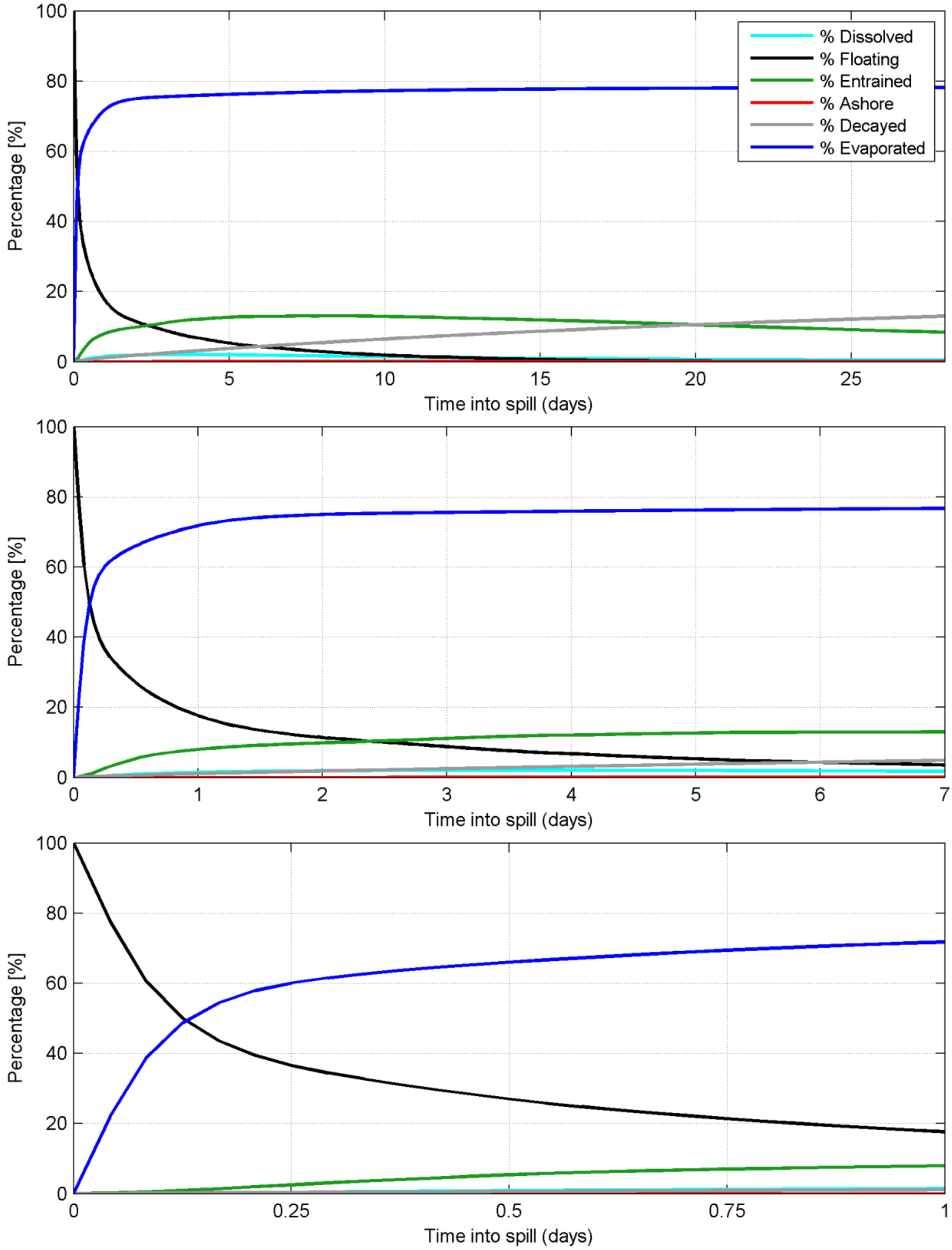


Figure 3-150: Predicted average weathering mass balance (% of total mass) weathering graph resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The distribution over the first 28 days (top), 7 days (middle) and 24 hours (bottom) is given.

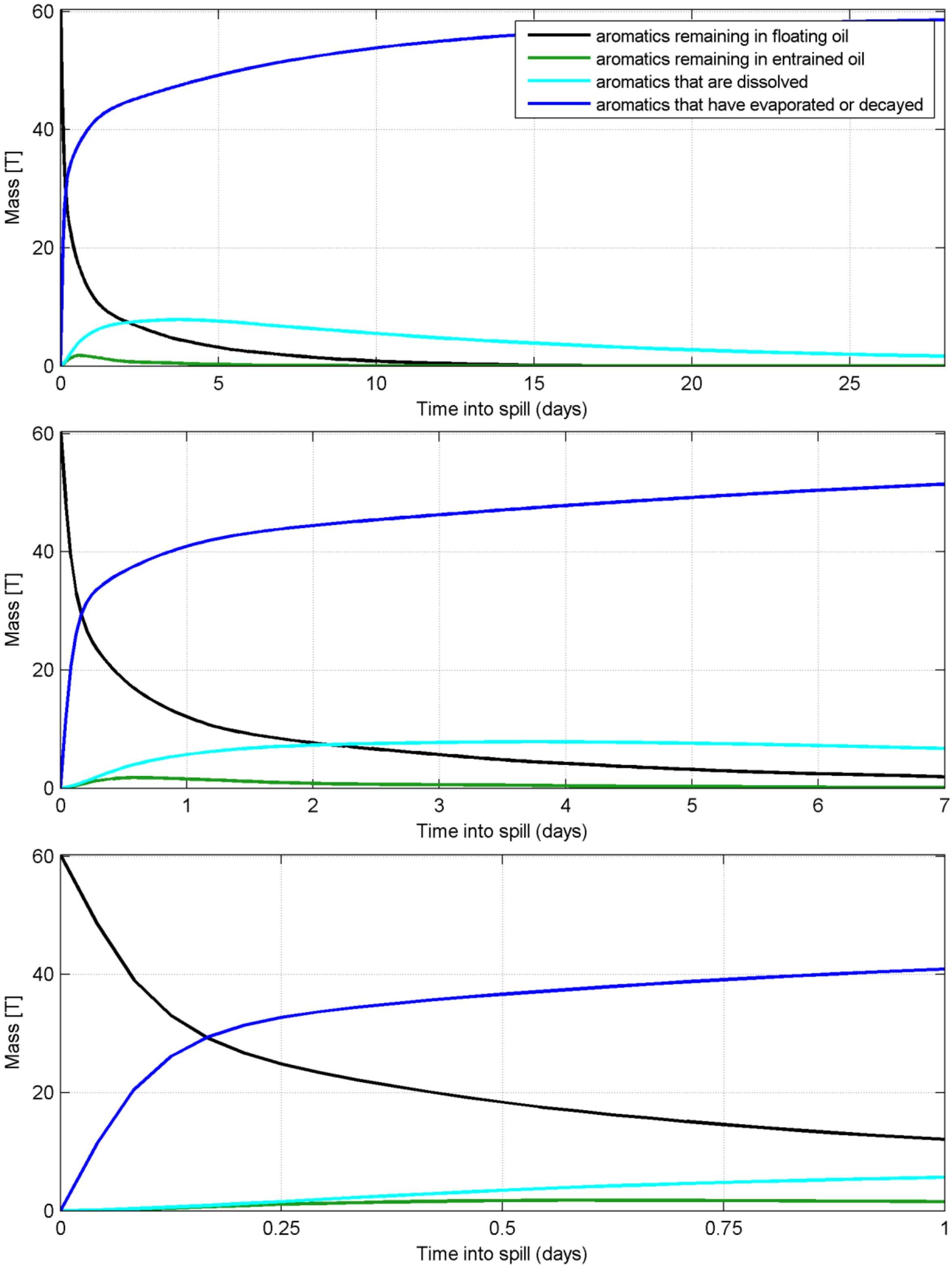


Figure 3-151: Predicted average partitioning of the aromatic hydrocarbons (tonnes) resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The distribution over the first 28 days (top), 7 days (middle) and 24 hours (bottom) is given.

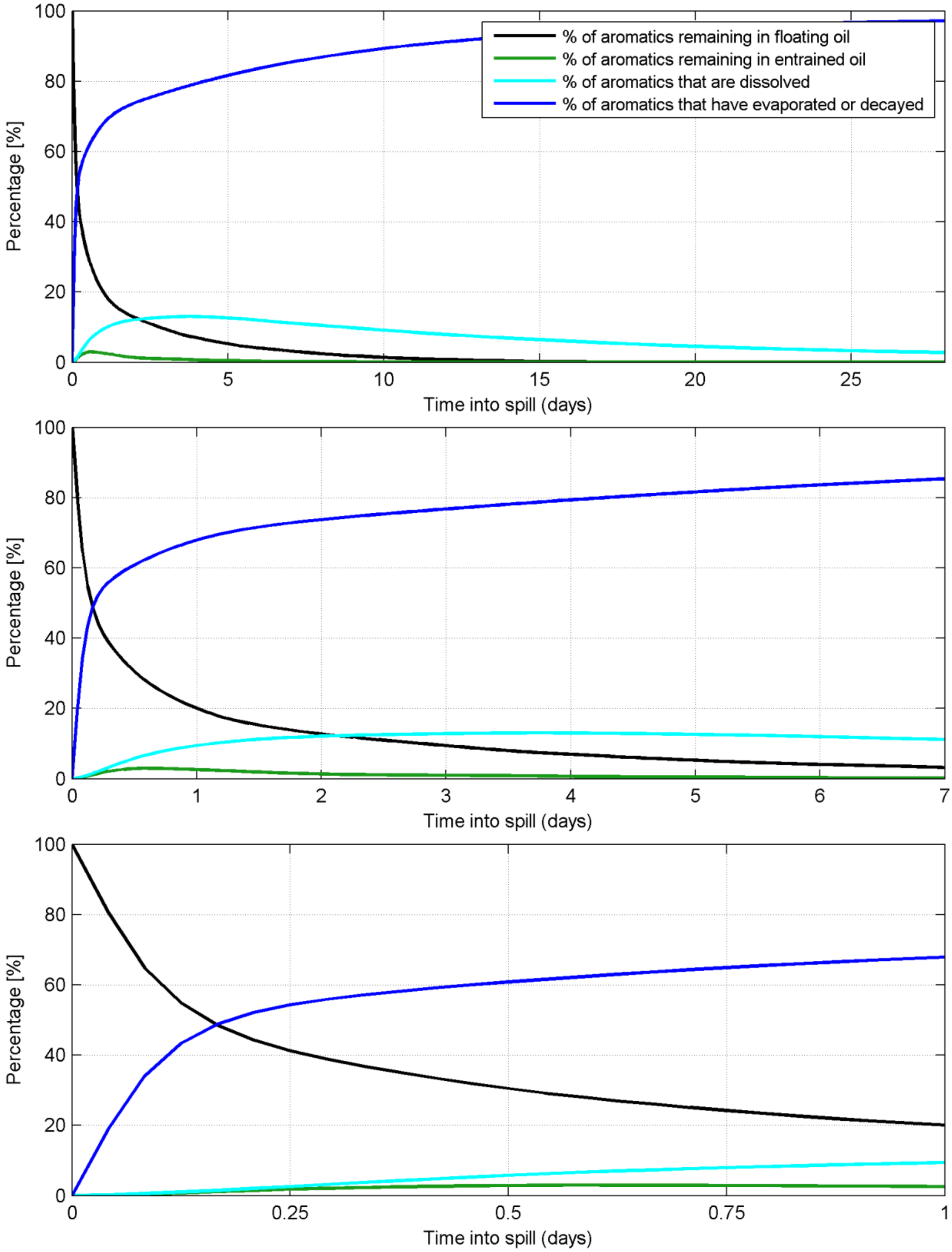


Figure 3-152: Predicted average partitioning of the aromatic hydrocarbons (% of total mass) resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The distribution over the first 28 days (top), 7 days (middle) and 24 hours (bottom) is given.

3.8.2 Trajectory and Weathering of an Example Replicate

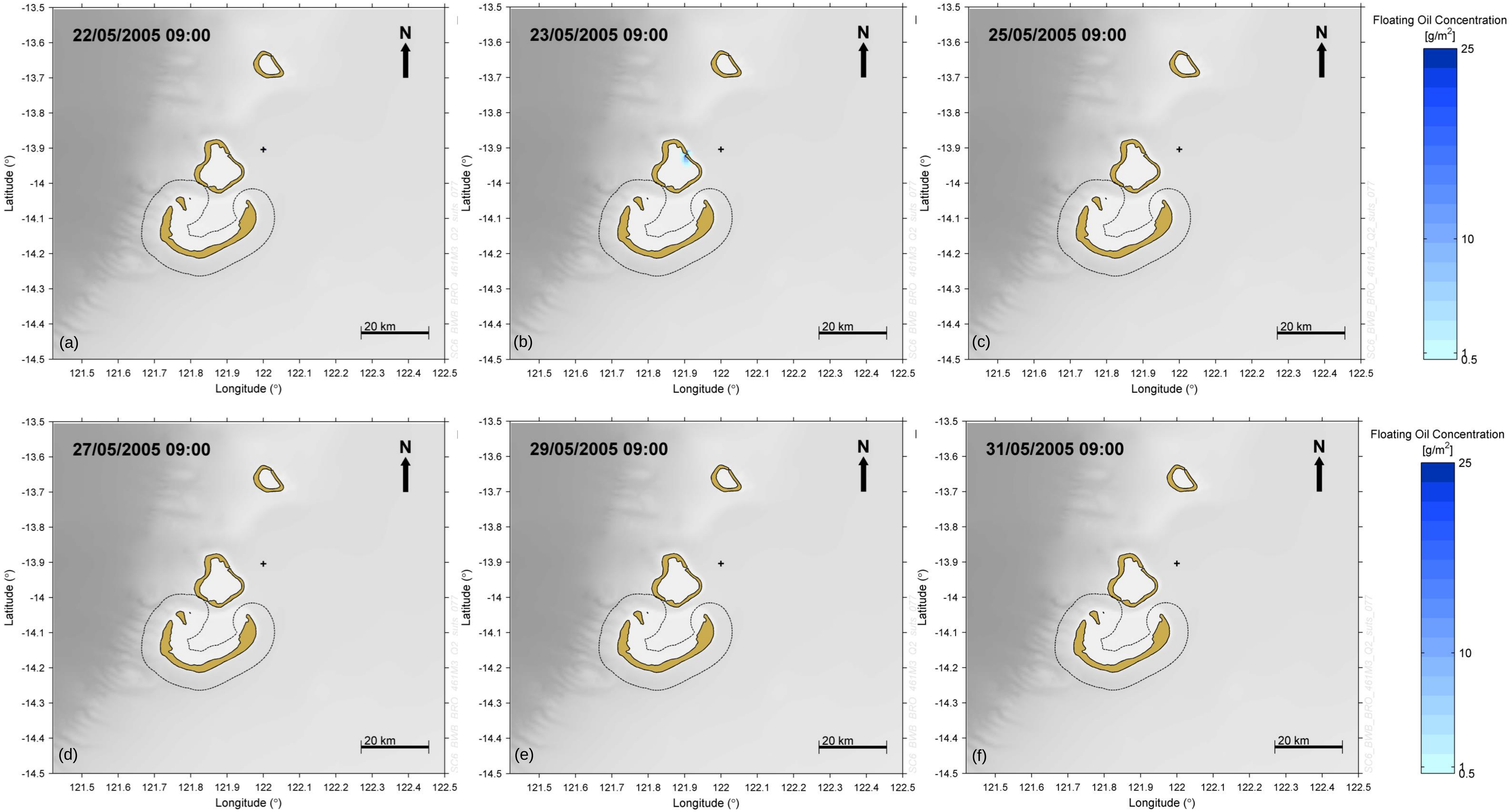


Figure 3-153: Example trajectory and concentration of floating oil for a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location, commencing at 09:00 on the 22 of May, 2005. The resultant trajectory and concentration at the start of the release (a), and 1 day (b), 3 days (c), 5 days (d), 7 days (e) and 9 days (f) after the start of the release are presented.

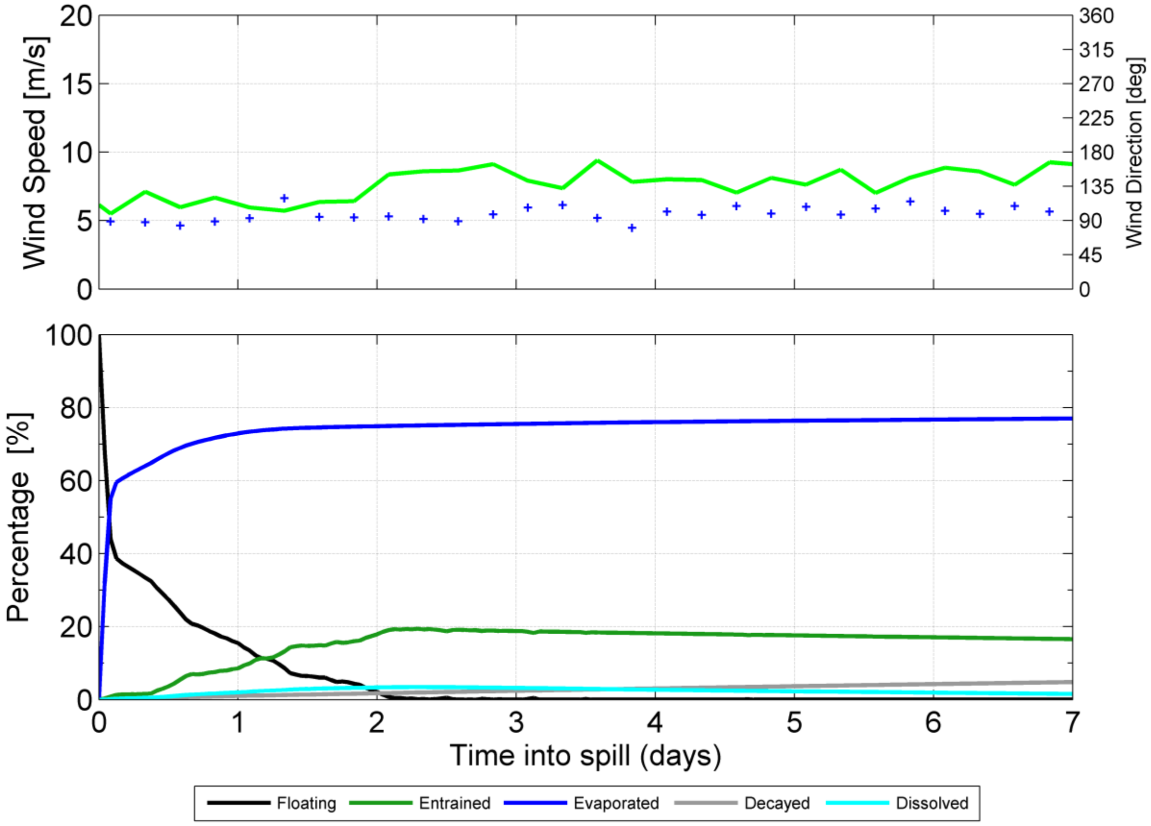


Figure 3-154: Predicted mass balance weathering resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location, commencing at 09:00 on the 22 of May, 2005. The green line in the top figure indicates the wind speed and the blue dots indicate the wind direction (FROM).

3.8.3 Floating Oil

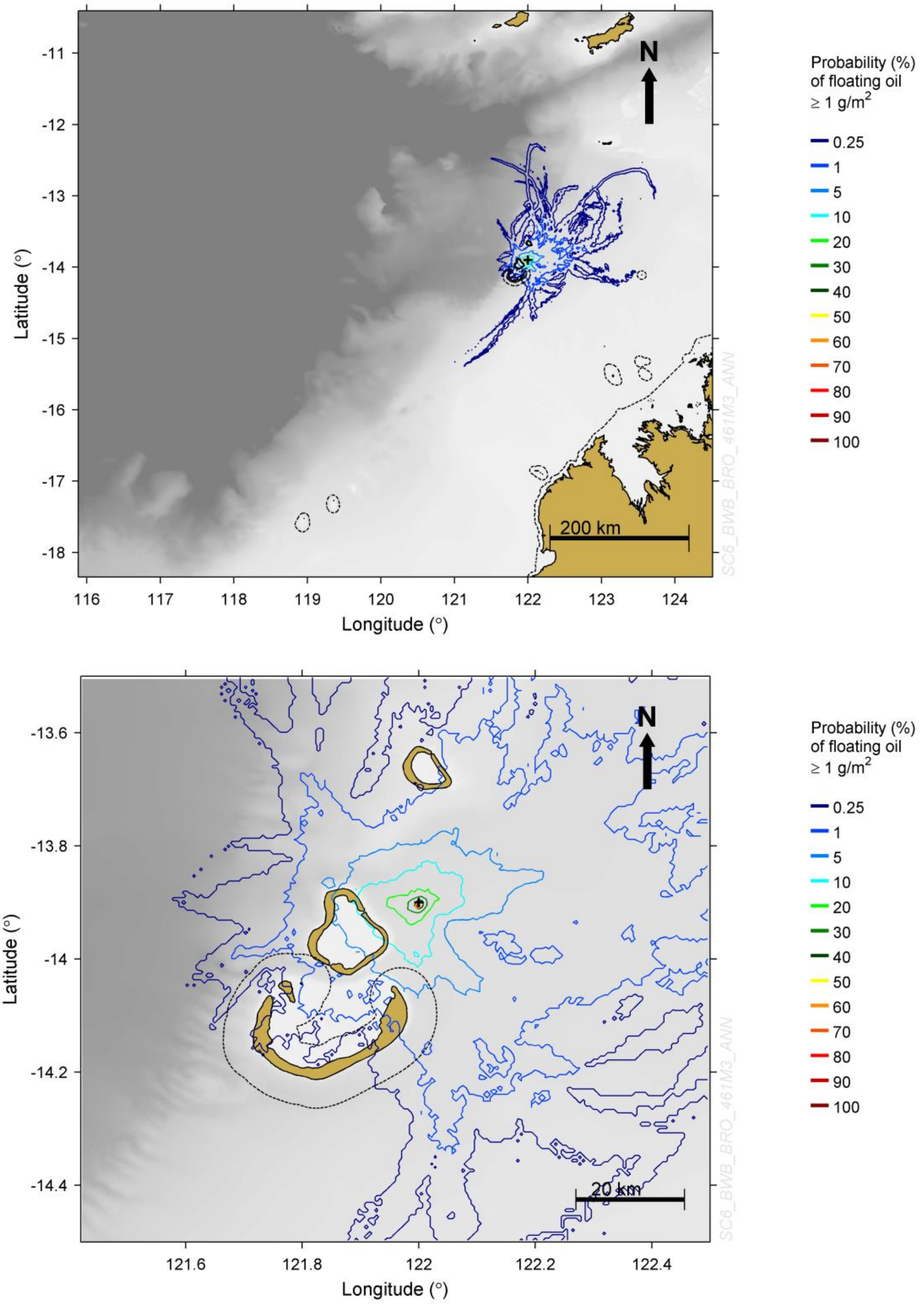
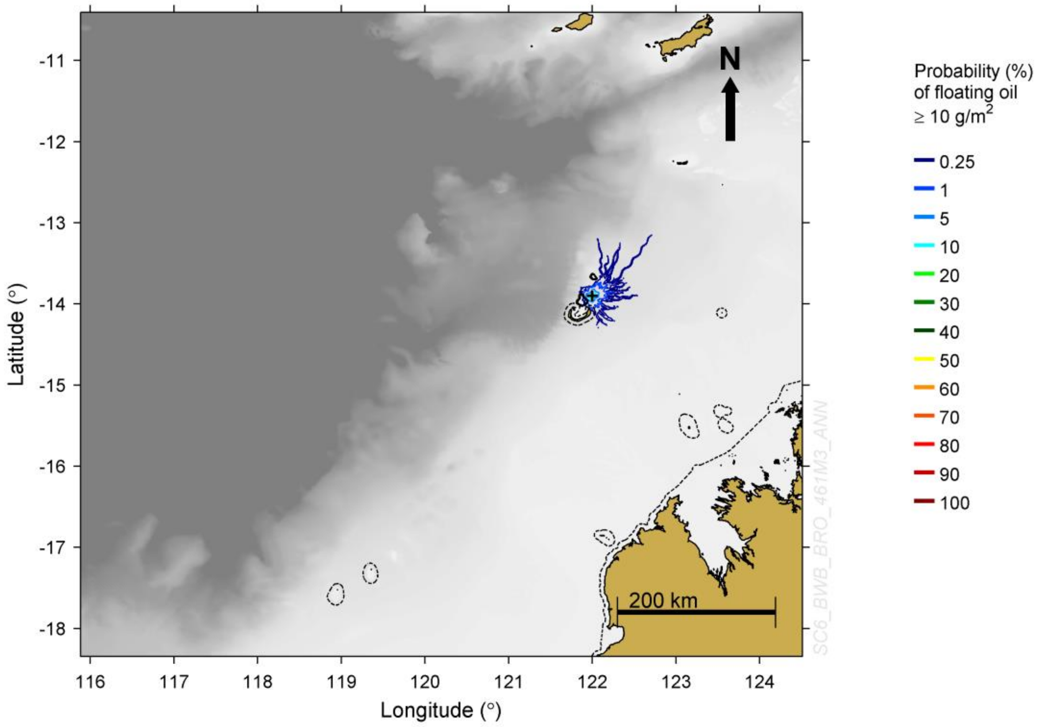


Figure 3-155: Predicted annualised probability (P_2) of floating oil concentration at or above 1 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



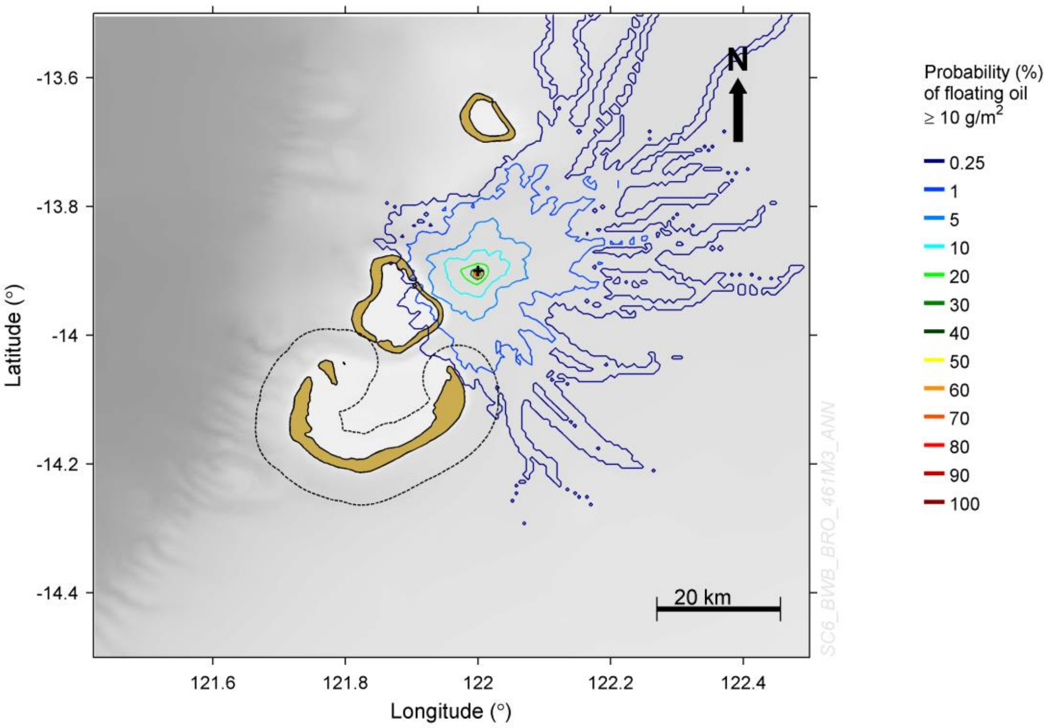


Figure 3-156: Predicted annualised probability (P_2) of floating oil concentration at or above 10 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

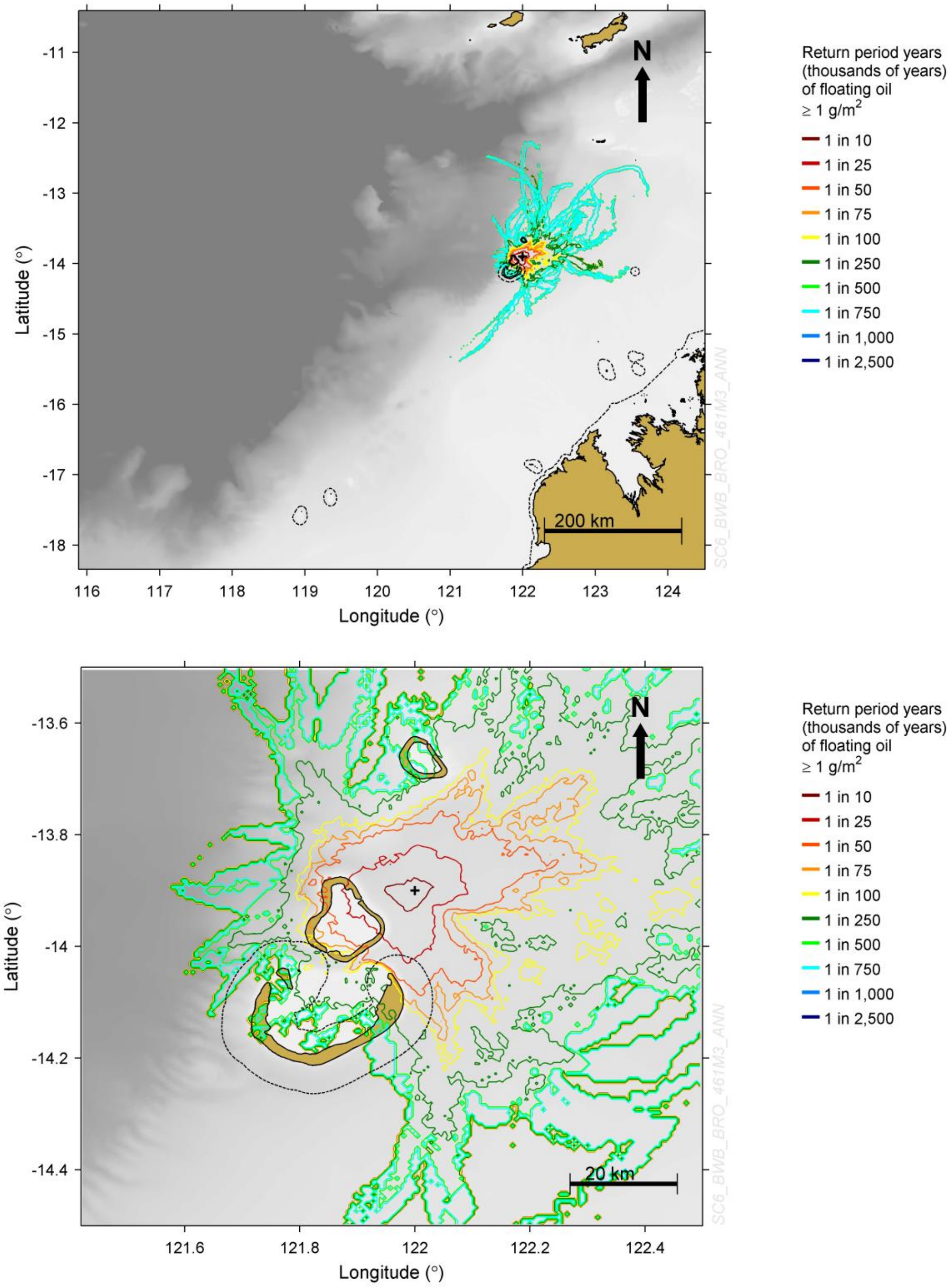
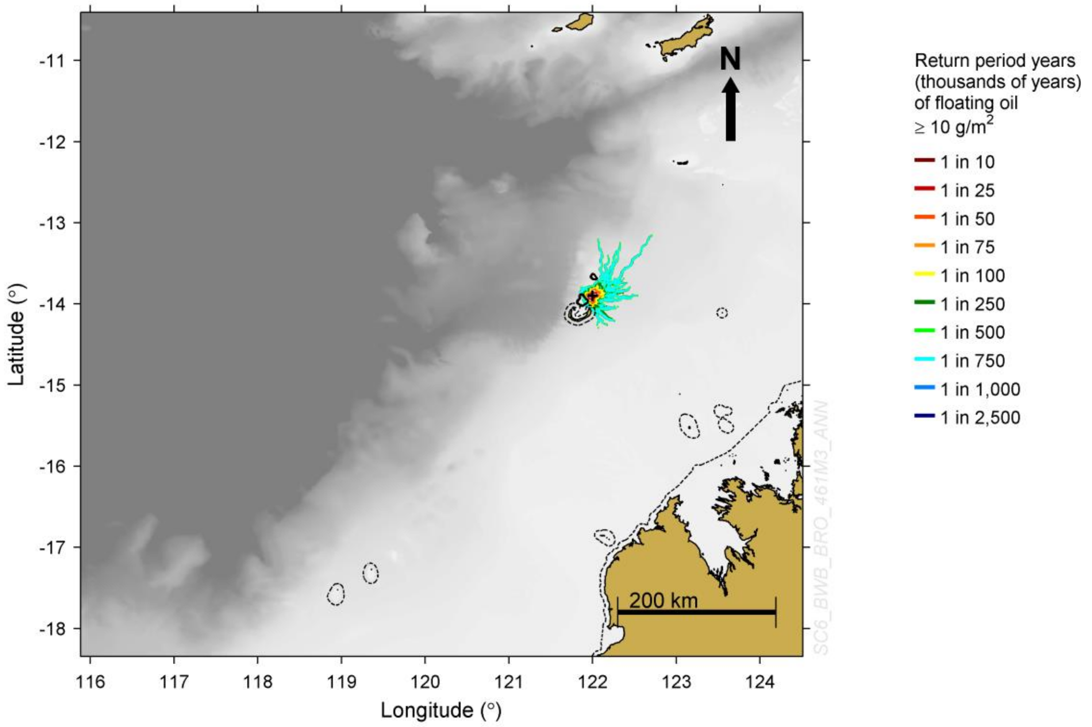


Figure 3-157: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 1 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



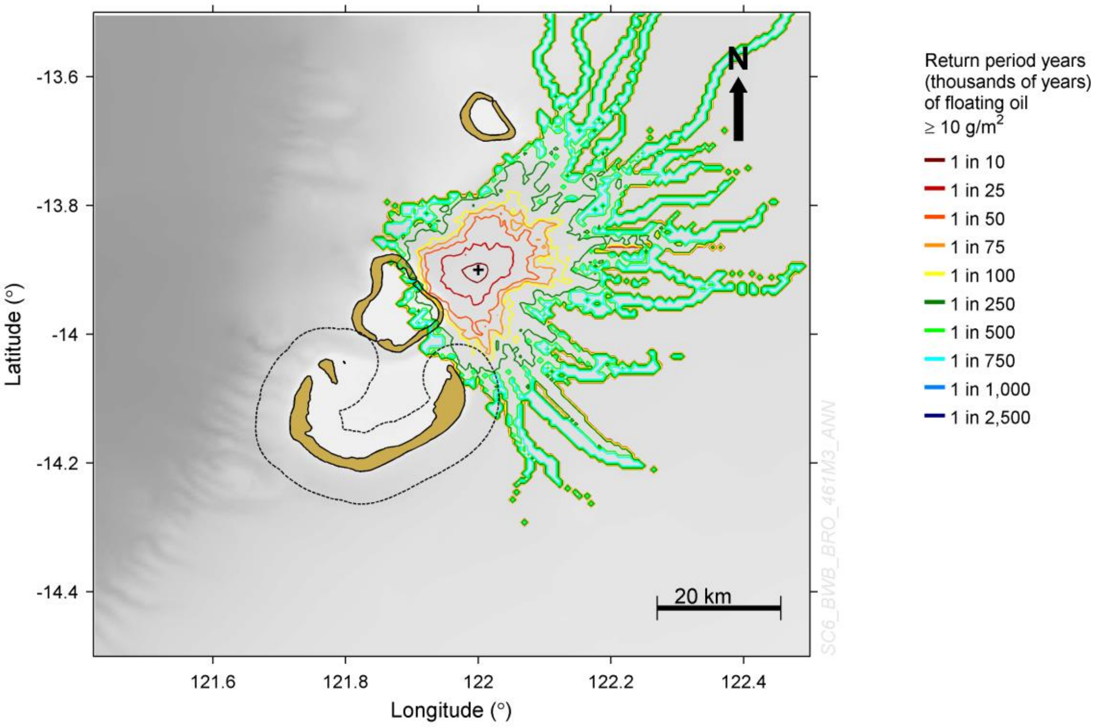


Figure 3-158: Predicted annualised probability (P_1xP_2) of floating oil concentration at or above 10 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

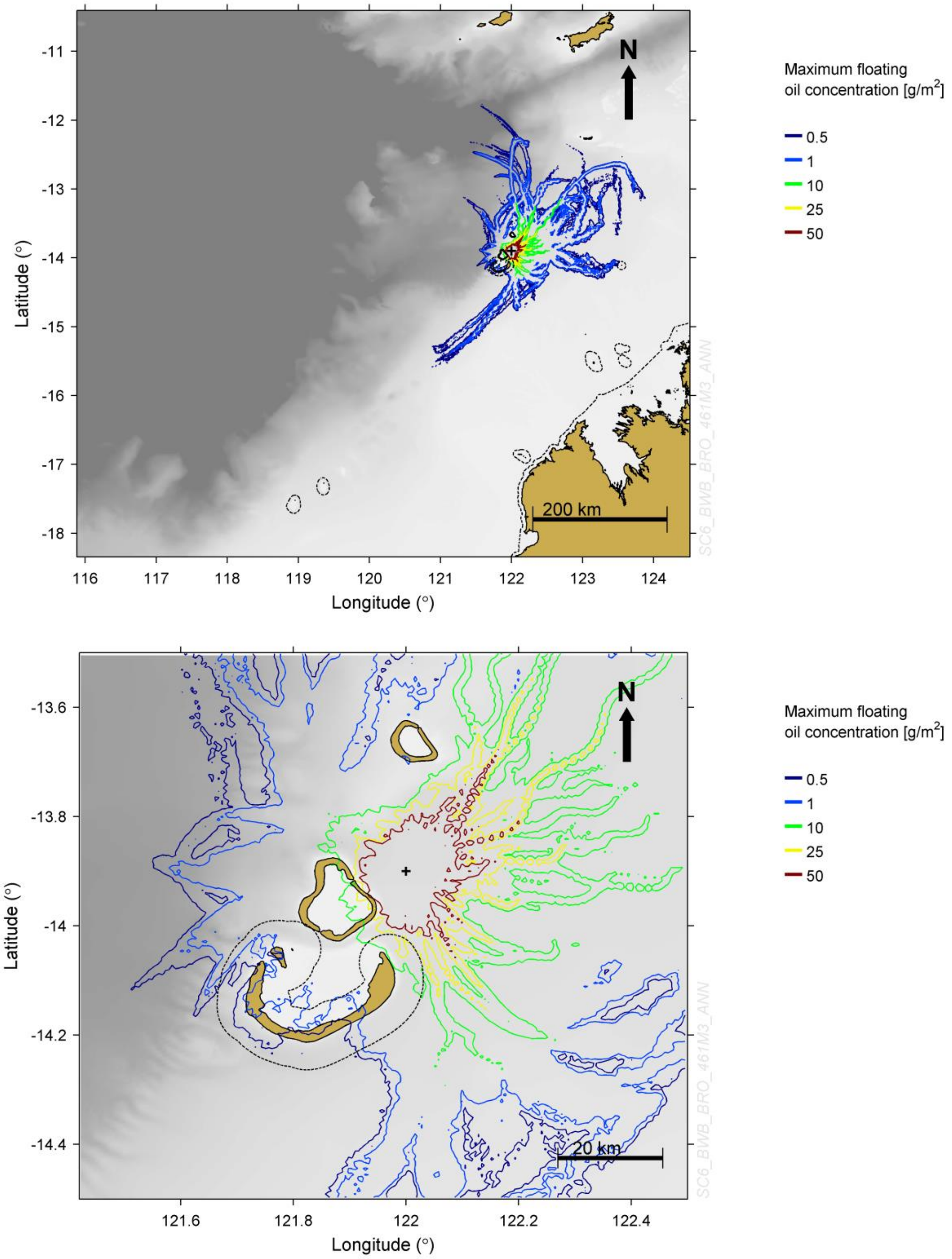


Figure 3-159: Predicted maximum floating oil concentration resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

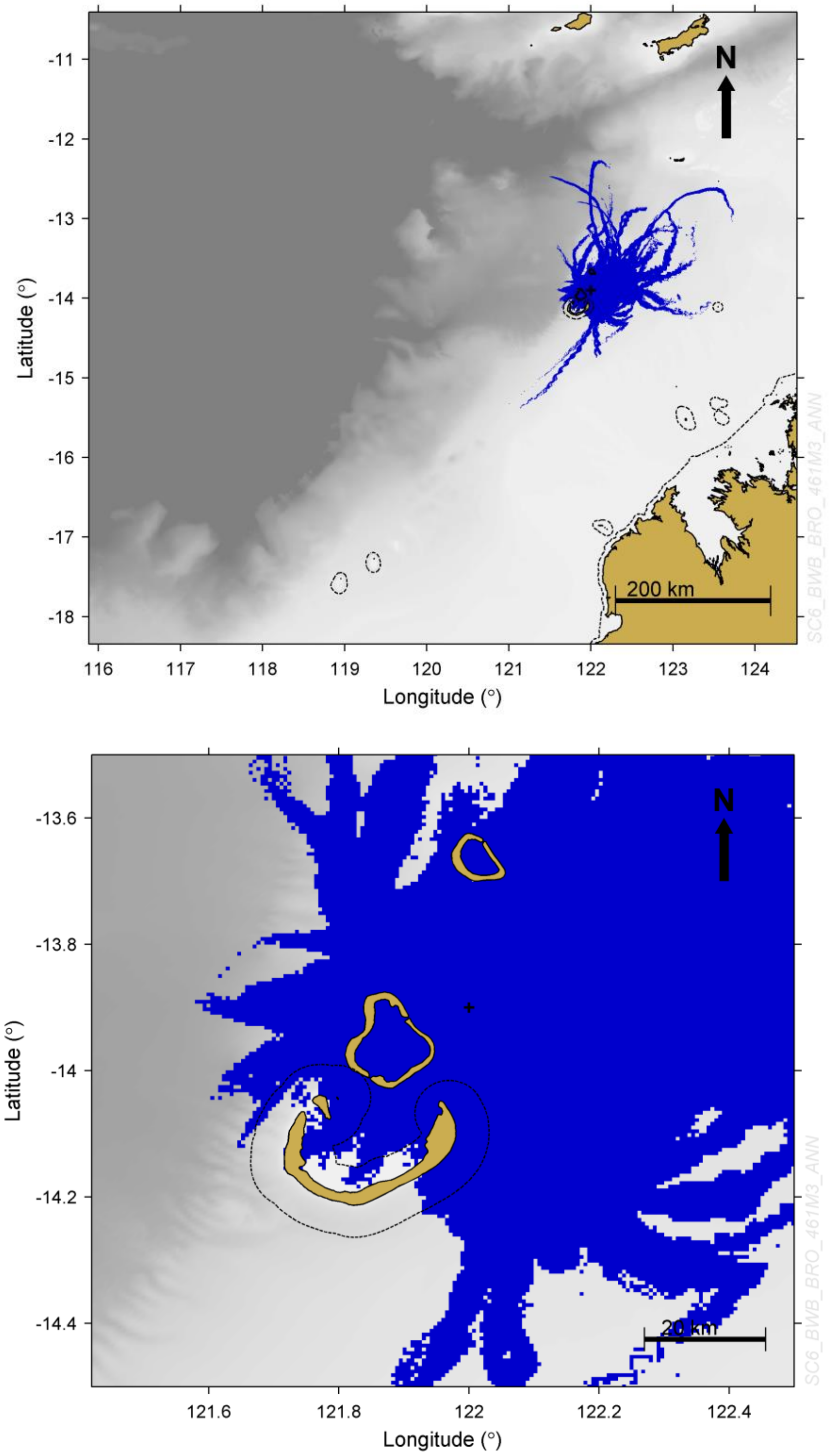


Figure 3-160: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 1 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

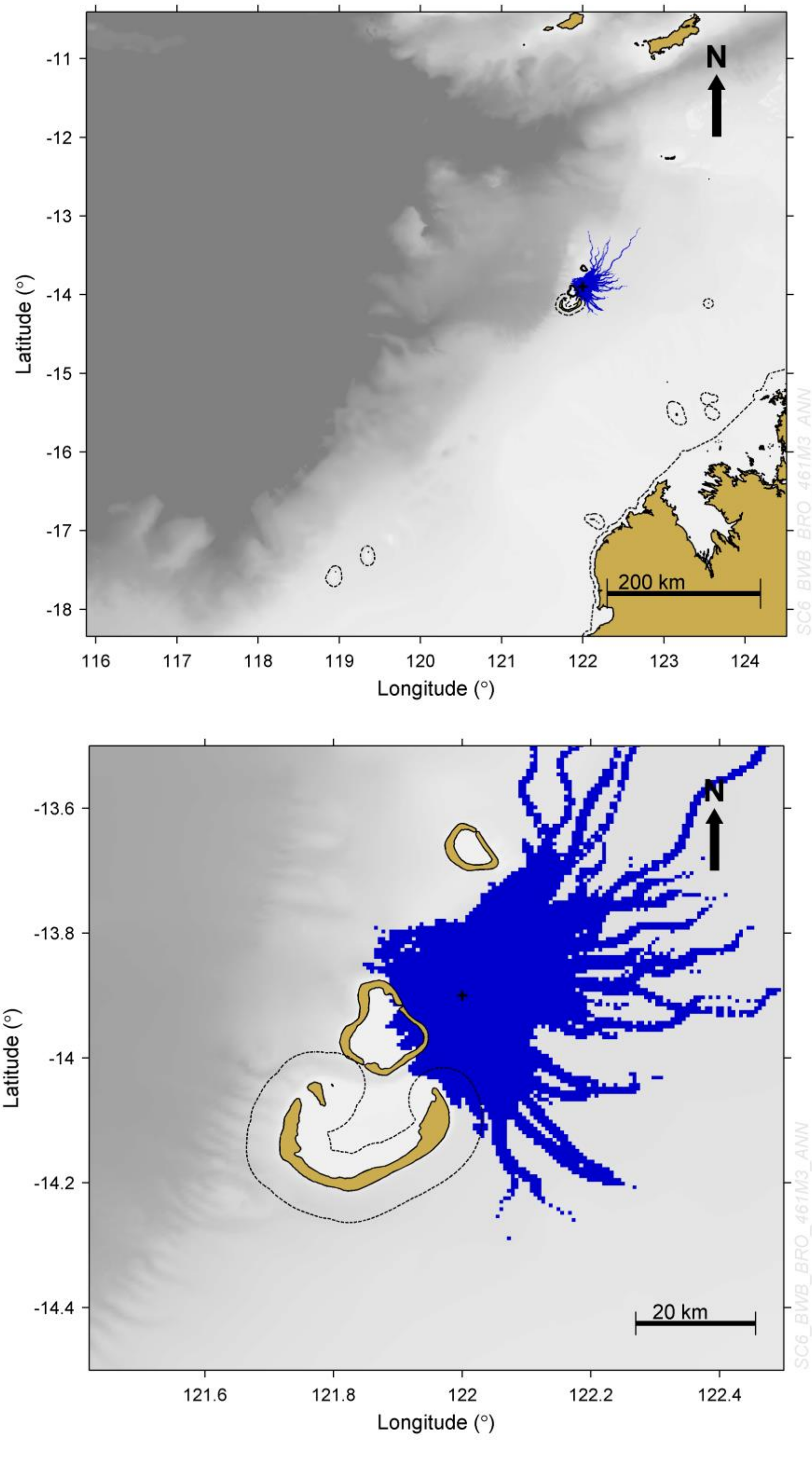


Figure 3-161: Predicted annualised Zone of Consequence (blue shaded area) for floating oil concentration at or above 10 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

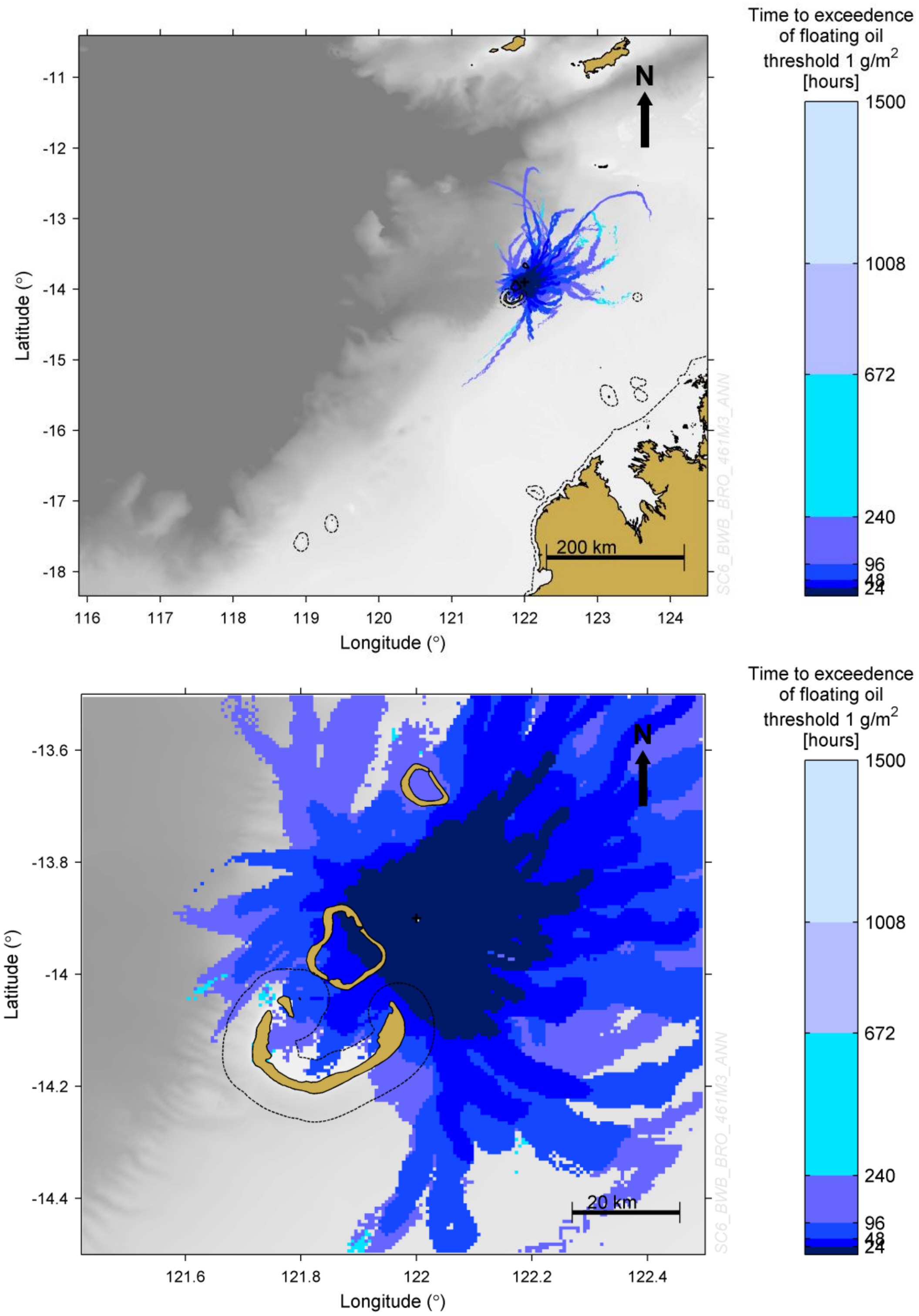
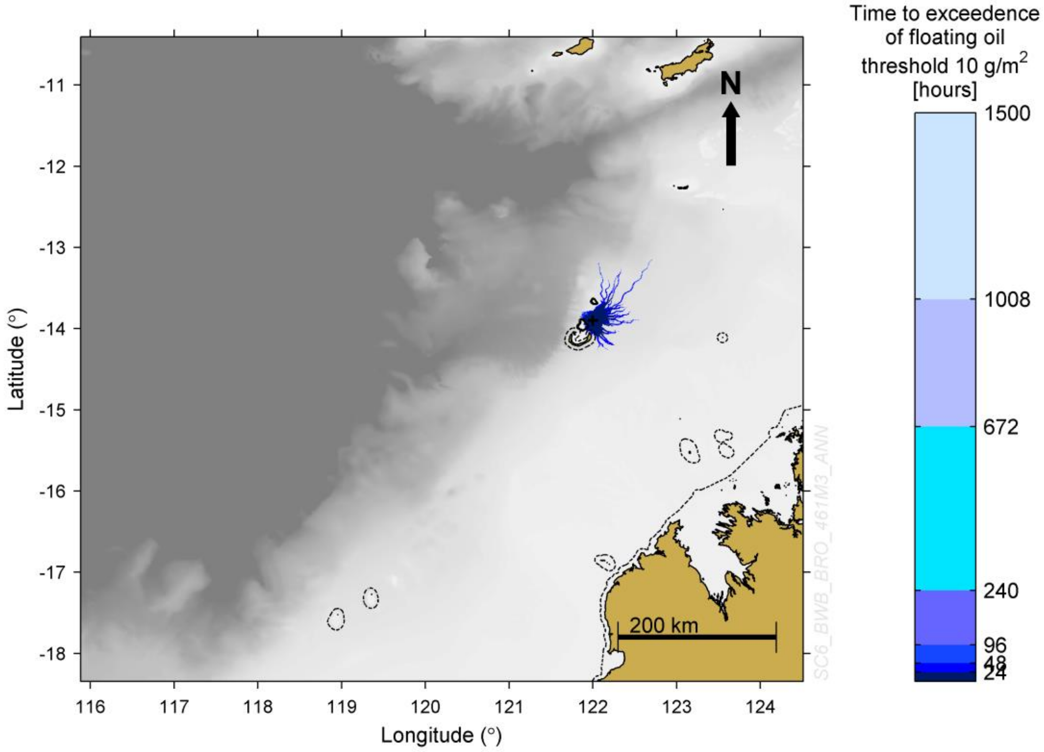


Figure 3-162: Predicted annualised minimum times to threshold for floating oil at or above 1 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



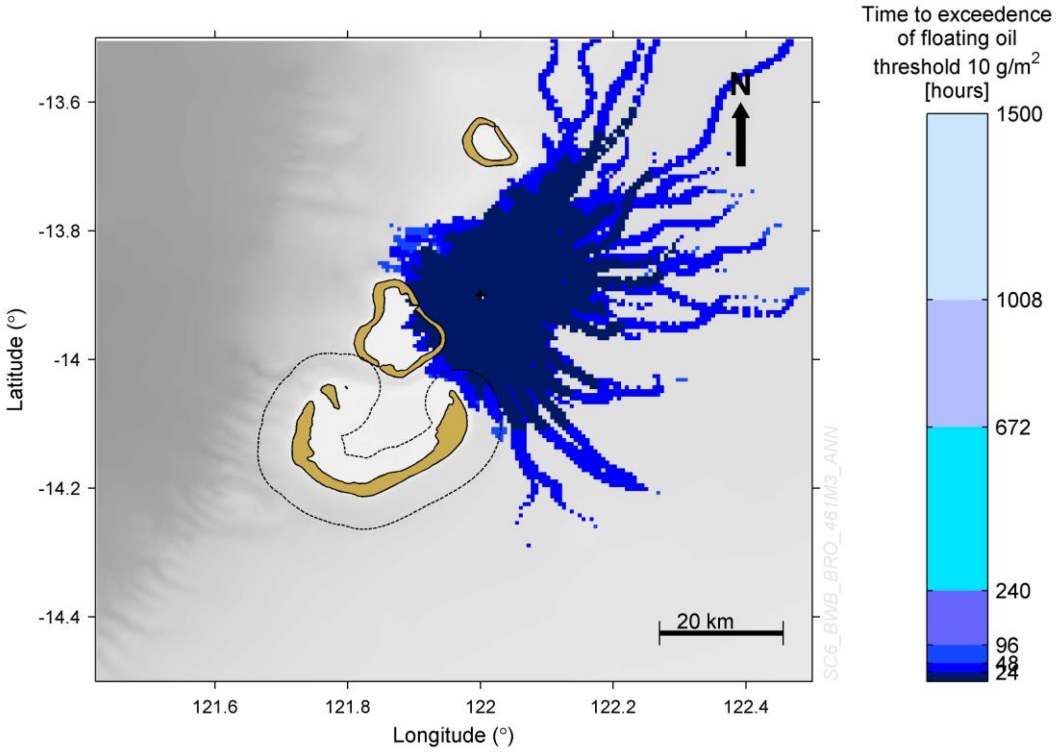


Figure 3-163: Predicted annualised minimum times to threshold for floating oil at or above 10 g/m^2 resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Table 3-27: Expected floating oil outcomes at sensitive receptors across all quarters for a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location.

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Timor (West)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Pulau Roti	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Oceanic Shoals CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	1.1	<1	<1
Ashmore Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	1.1	<1	<1
Cartier Island CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	0.5	<1	<1
Cartier Islet	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	0.5	<1	<1
Kimberley CMR*	0.5	0.25	<0.25	<0.25	167	168	NC	NC	NC	NC	NC	NC
Argo-Rowley Terrace CMR*	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Seringapatam Reef	2	1.25	<0.25	<0.25	47	52	NC	NC	NC	NC	NC	NC
North Reef Flats*	16.25	14.75	4.75	1.5	7	7	7	8	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-27: Expected floating oil outcomes at sensitive receptors across all quarters for a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. (Continued)

	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
North Reef Lagoon*	14.25	12	1.75	0.25	10	11	12	14	NC	NC	NC	NC
Kimberley Coast	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
South Reef Lagoon*	7.25	6	0.75	<0.25	25	26	36	NC	NC	NC	NC	NC
SR Central/ Sandy Islet	2	0.75	<0.25	<0.25	81	87	NC	NC	6.3	705	<1	2
South Reef Flats*	5	3.75	0.25	<0.25	29	31	39	NC	NC	NC	NC	NC
Browse Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	2	<1	<1
Lalang-garram / Camden Sound MP	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Camden Sound	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Adele Island	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Mermaid Reef CMR	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Mermaid Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals MP (Clerke Reef)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

Table 3-27: Expected floating oil outcomes at sensitive receptors across all quarters for a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. (Continued)

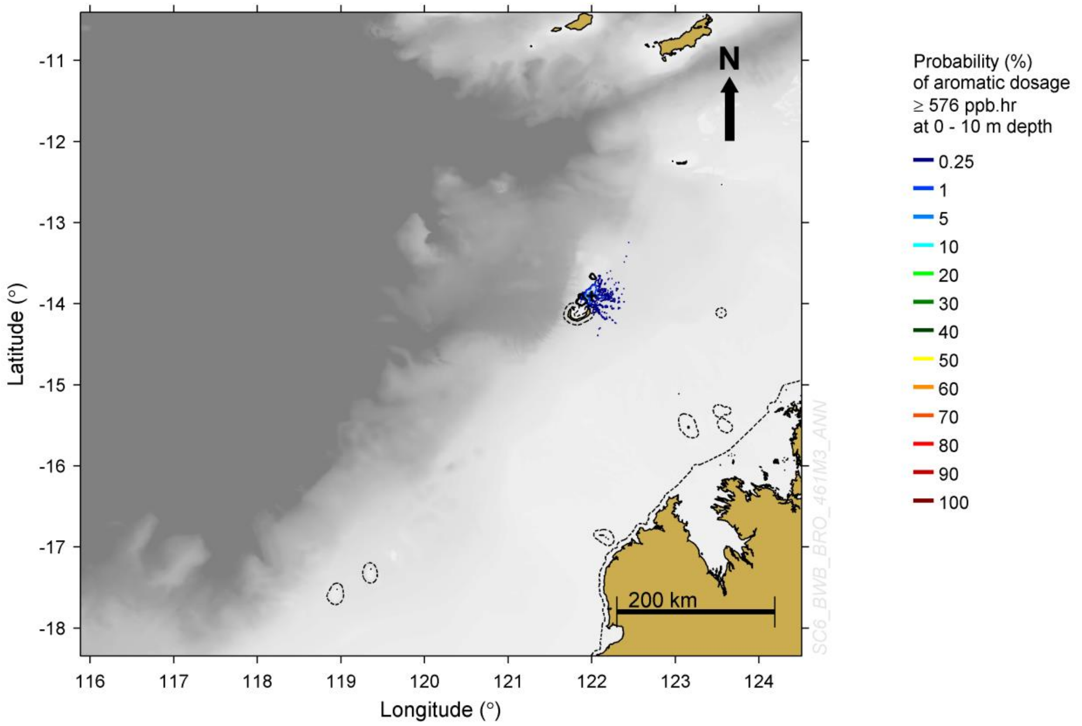
	Probability (%) of films arriving at receptors at ≥ 0.5 g/m²	Probability (%) of films arriving at receptors at ≥ 1 g/m²	Probability (%) of films arriving at receptors at ≥ 10 g/m²	Probability (%) of films arriving at receptors at ≥ 25 g/m²	Minimum time to receptor (hours) for films at ≥ 0.5 g/m²	Minimum time to receptor (hours) for films at ≥ 1 g/m²	Minimum time to receptor (hours) for films at ≥ 10 g/m²	Minimum time to receptor (hours) for films at ≥ 25 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill	Maximum accumulated volume (m³) along this shoreline, averaged over all replicate simulations	Maximum accumulated volume (m³) along this shoreline, in the worst replicate simulation
Clerke Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Imperieuse Reef	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	<0.1	<0.1	<1	<1
Rowley Shoals MP (Imperieuse)	<0.25	<0.25	<0.25	<0.25	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*

3.8.4 Dissolved Aromatic Hydrocarbon Dosage

576 ppb.hr



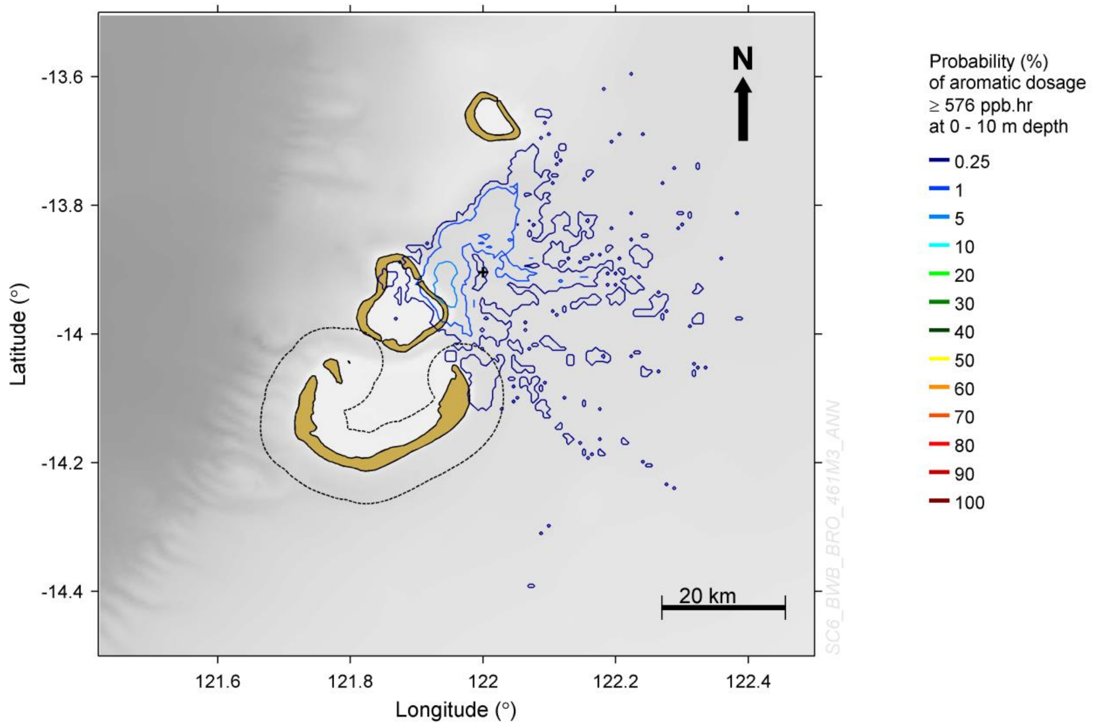
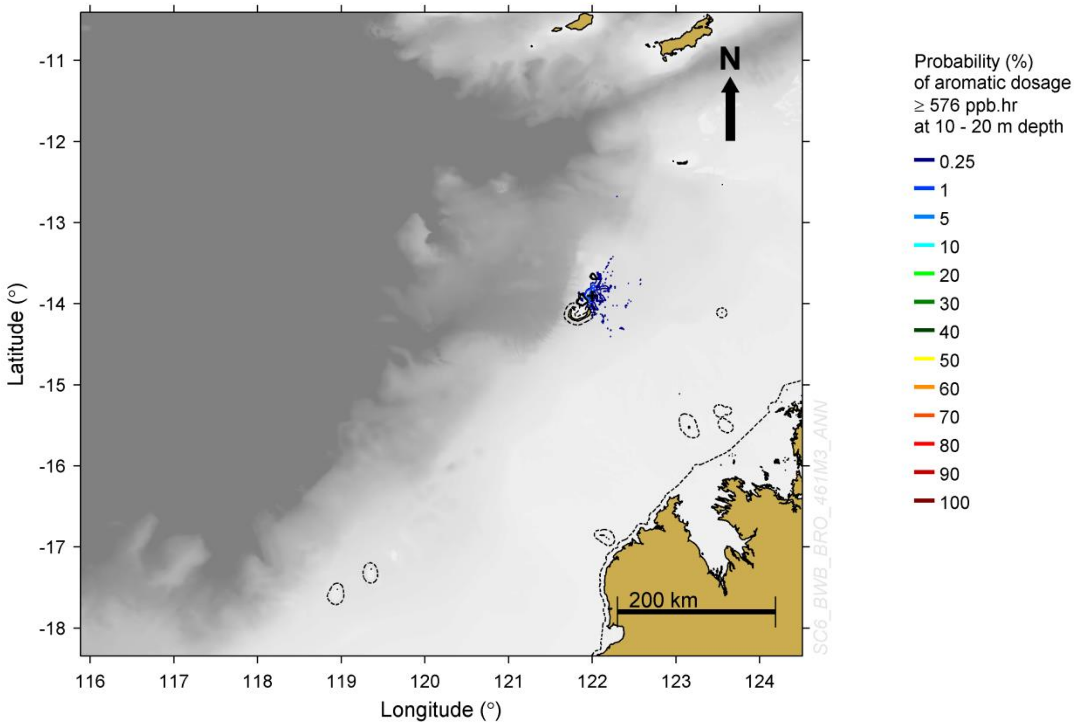


Figure 3-164: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 0 - 10 m (BMSL), resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



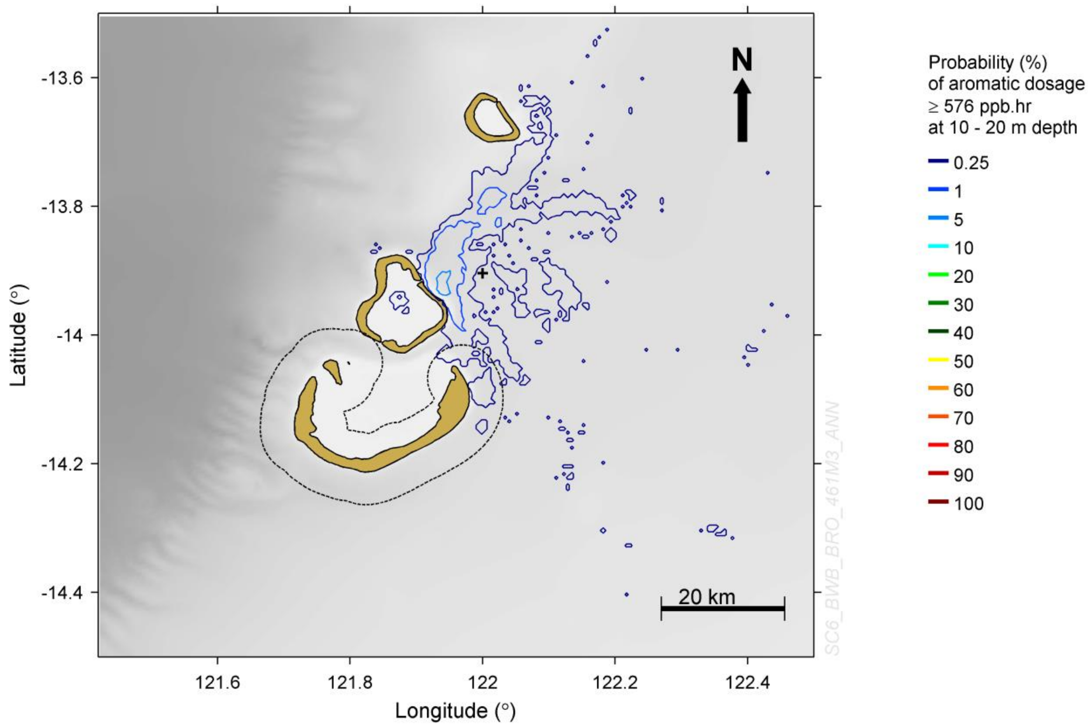
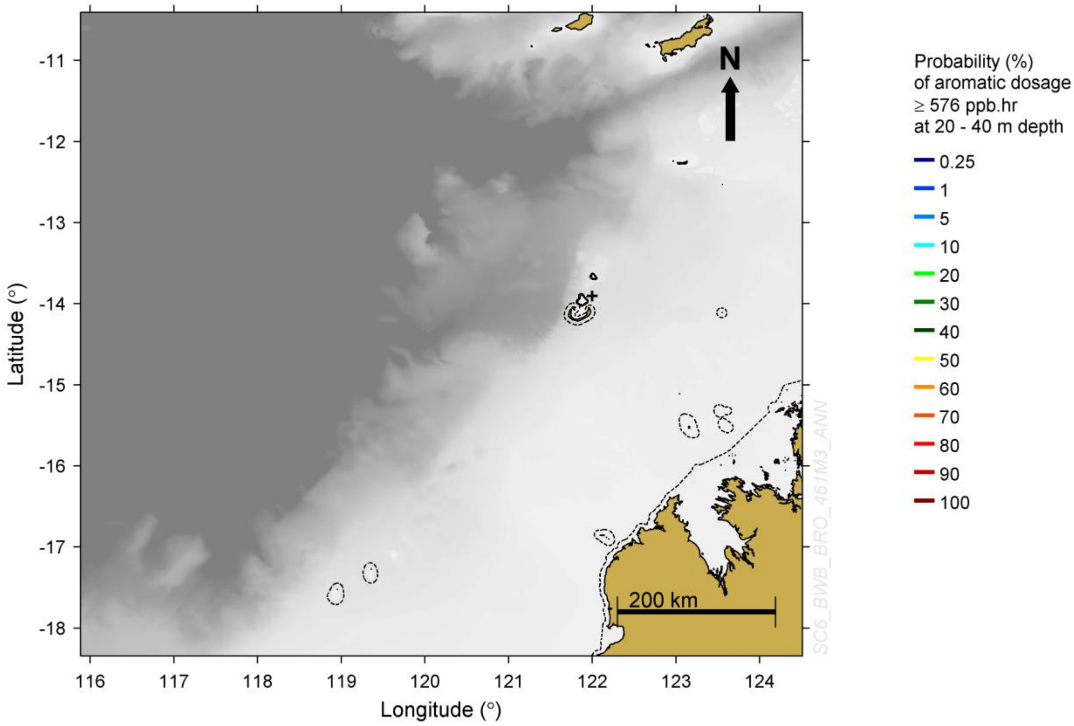


Figure 3-165: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 10 - 20 m (BMSL), resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



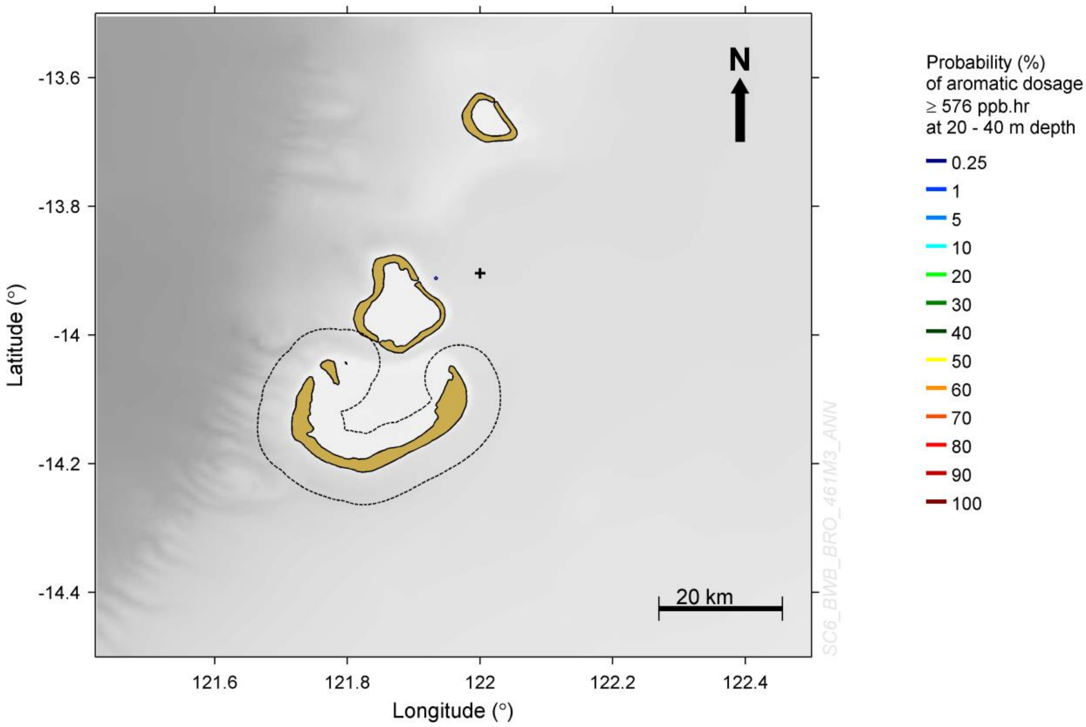


Figure 3-166: Predicted annualised probability (P_2) of dissolved aromatic hydrocarbon dosage at or above 576 ppb.hr at a depth of 20 - 40 m (BMSL), resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

Maximum Aromatic Dosage

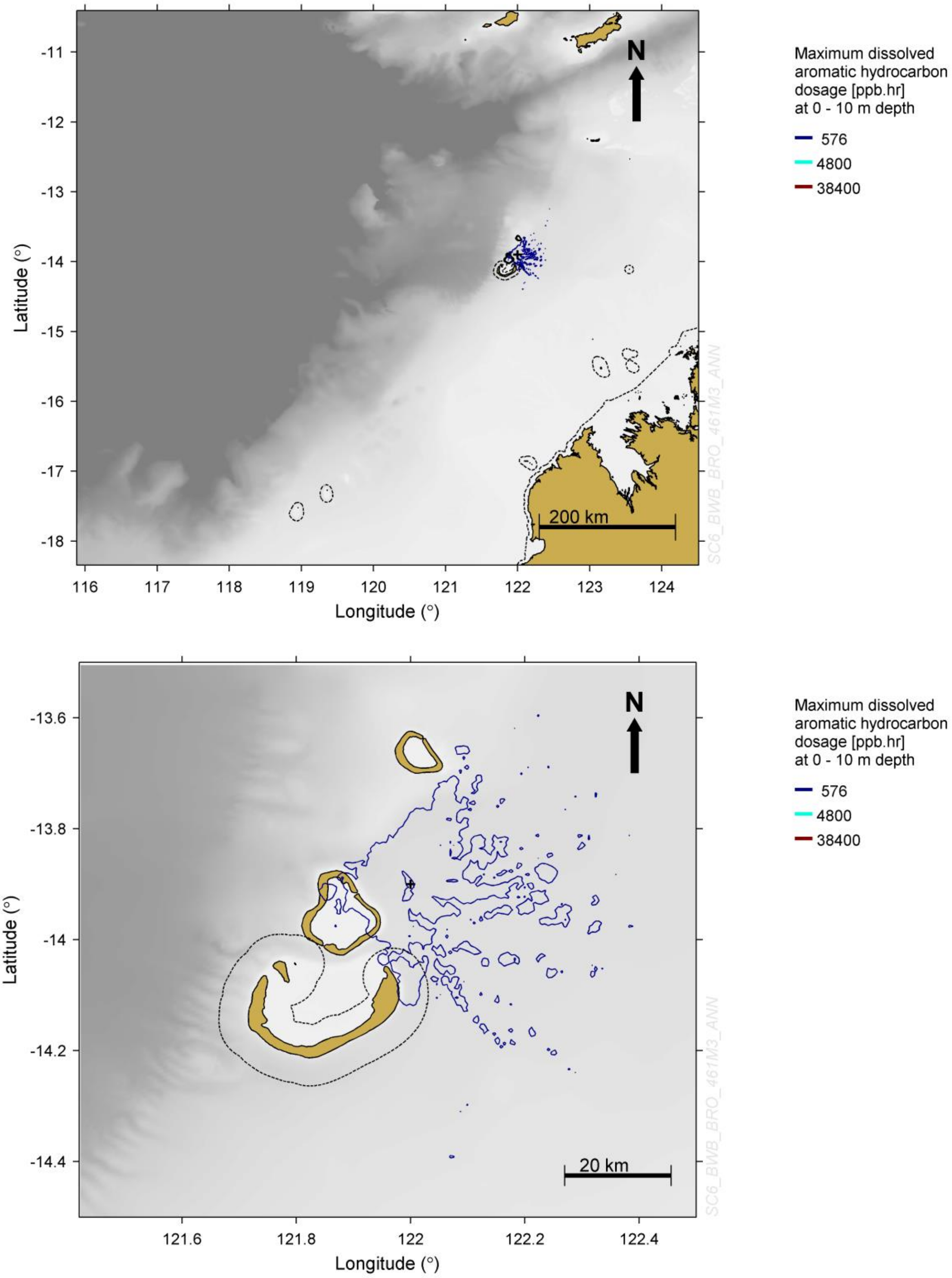
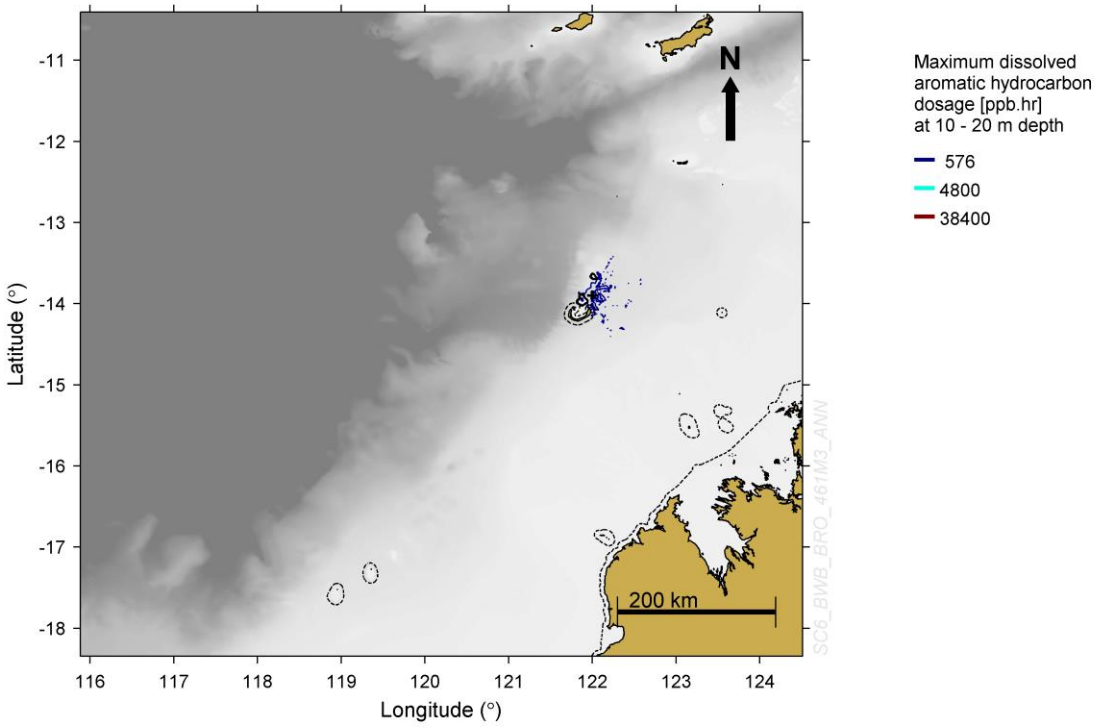


Figure 3-167: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 0 - 10 m (BMSL), resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



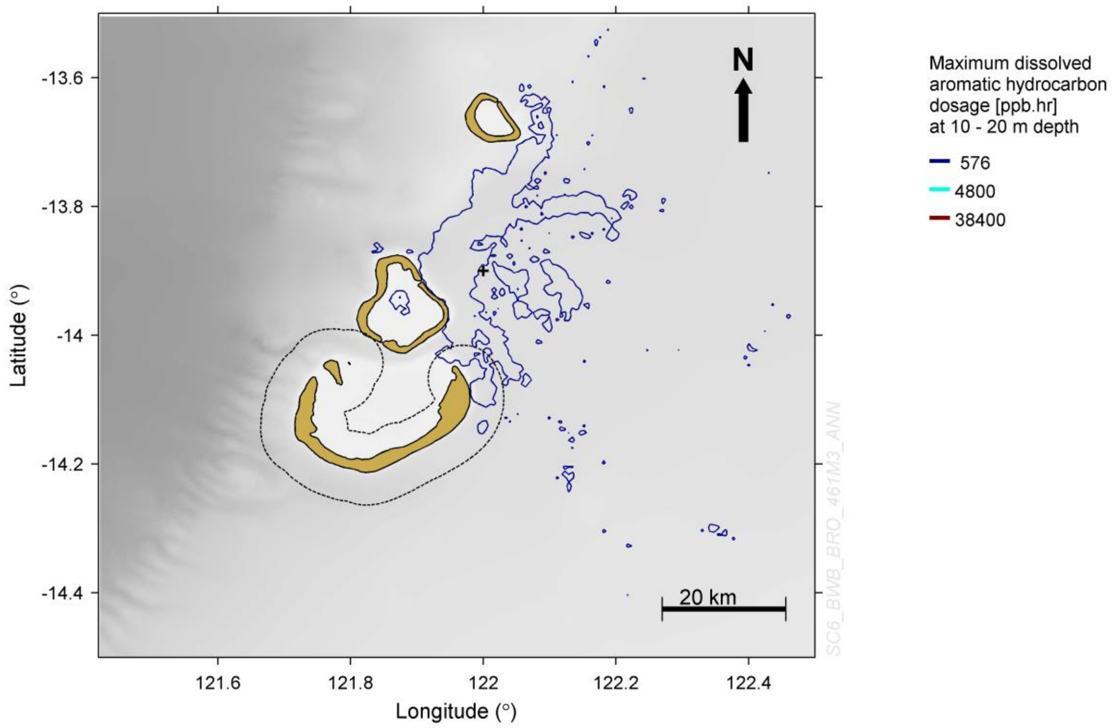
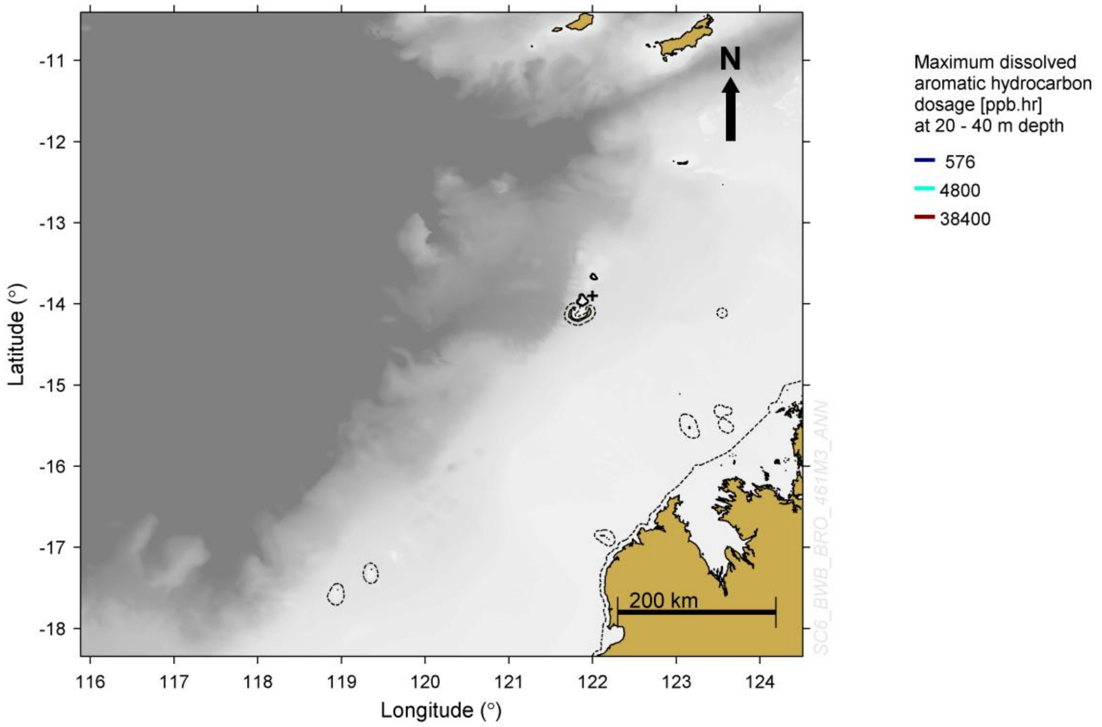


Figure 3-168: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 10 - 20 m (BMSL), resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.



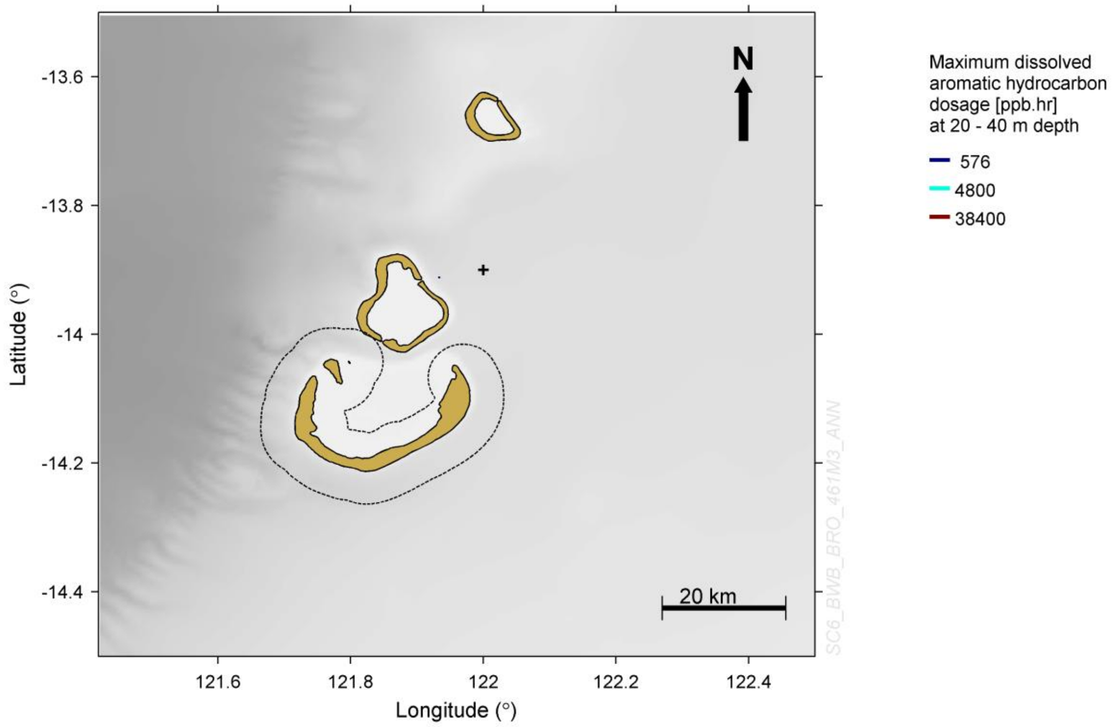


Figure 3-169: Predicted annualised maximum dissolved aromatic hydrocarbon dosage at a depth of 20 - 40 m (BMSL), resulting from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. The dashed black line denotes the State/Commonwealth boundary. Regional (top) and local (bottom) views are presented.

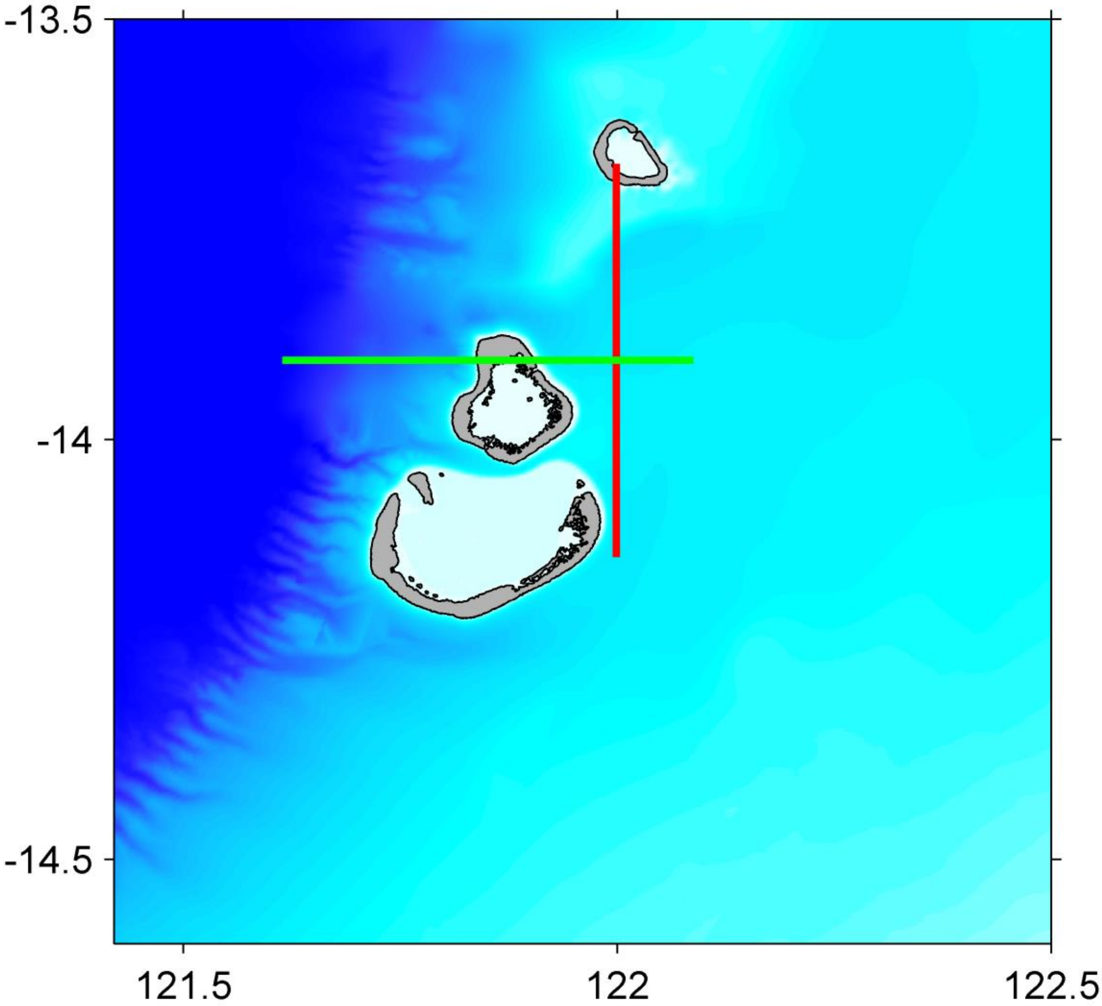


Figure 3-170: Location of the BWB location and the respective vertical transects over a varying latitude (red line) and longitude (green line).

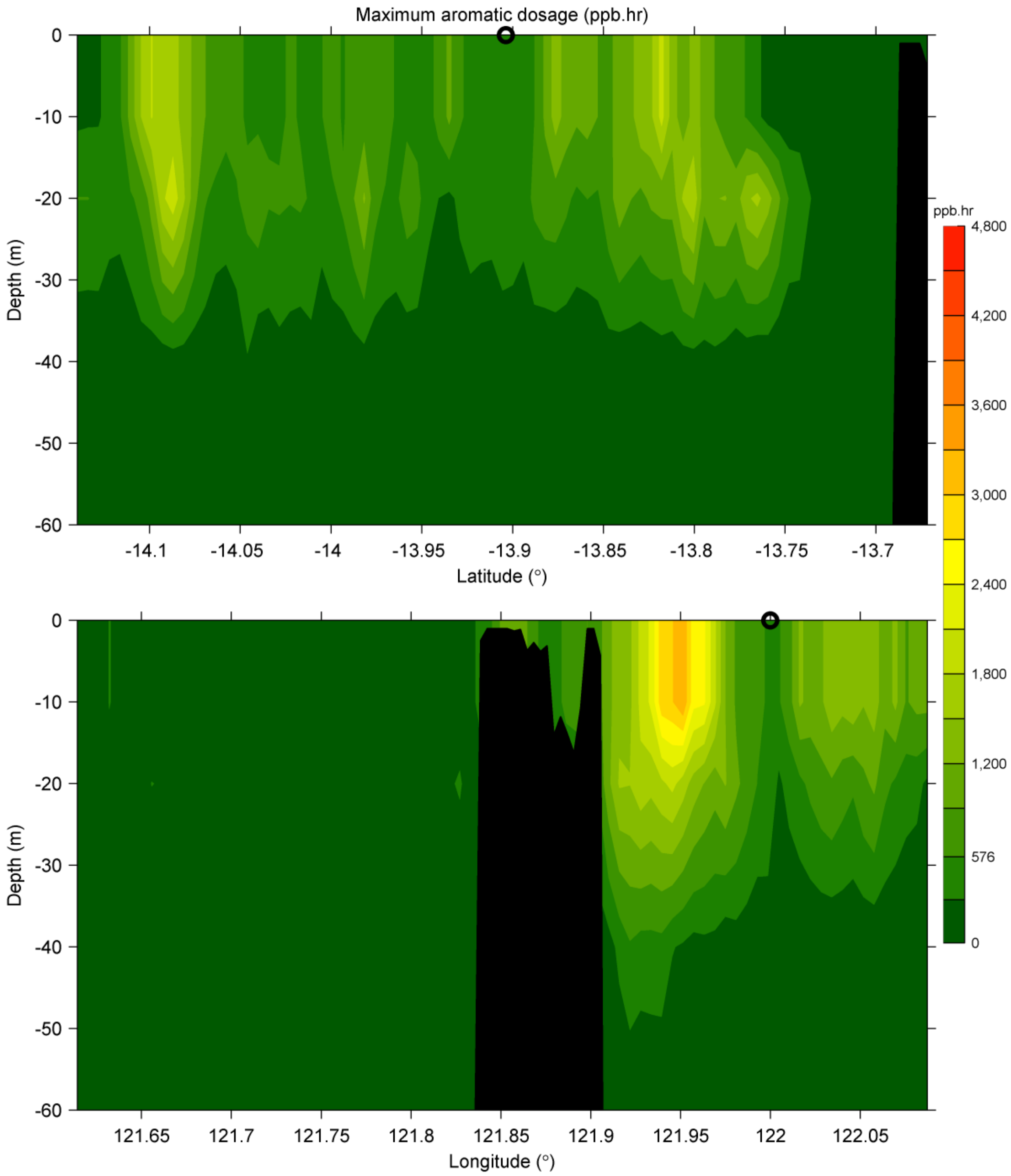


Figure 3-171: Vertical profile showing maximum annualised dissolved aromatic hydrocarbon dosage at a depth of 0 - 60 m (BMSL), across two perpendicular transects intersecting (top, north-south; bottom, east-west) the release point (black circle) from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location.

Table 3-28: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location.

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Timor (West)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Pulau Roti	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Oceanic Shoals CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Hibernia Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	24	102	16	NC
Ashmore Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	19	67	7	4
Ashmore Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2	4	1	NC
Cartier Island CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	157	82	81	4
Cartier Islet	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	118	47	57	2
Kimberley CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	112	158	61	36

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-28: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Argo-Rowley Terrace CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	57	63	45	36
Seringapatam Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	97	360	142	19
North Reef Flats	Probability (%) ≥ 576	6	2.75	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	3,347	1,714	468	110
North Reef Lagoon	Probability (%) ≥ 576	1.75	0.25	NC	BS
	Probability (%) ≥ 4,800	NC	NC	NC	BS
	Probability (%) ≥ 38,400	NC	NC	NC	BS
	Maximum Dosage	1,594	1,270	258	BS
Kimberley Coast	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
South Reef Lagoon	Probability (%) ≥ 576	0.25	0.25	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	774	997	234	18
SR Central/ Sandy Islet	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	77	100	BS	BS
South Reef Flats	Probability (%) ≥ 576	0.5	0.25	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1,082	610	196	27
Browse Island	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	38	9	14	1

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

Table 3-28: Summary of dissolved aromatic hydrocarbon risks in terms of dosage to shallow waters adjacent to shorelines from a 5-minute 461.5 m^3 surface release of Browse Condensate at the BWB location. (Continued)

	Threshold (ppb.hr)	0-10m BMSL	10-20m BMSL	20-40m BMSL	40-60m BMSL
Lalang-garram / Camden Sound MP	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Camden Sound	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Adele Island	Probability (%) ≥ 576	NC	NC	BS	BS
	Probability (%) ≥ 4,800	NC	NC	BS	BS
	Probability (%) ≥ 38,400	NC	NC	BS	BS
	Maximum Dosage	NC	NC	BS	BS
Mermaid Reef CMR	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1	2	5	NC
Mermaid Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1	2	NC	NC
Rowley Shoals MP (Clerke Reef)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	2	6	3	1
Clerke Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	1	4	NC	NC
Imperieuse Reef	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC
Rowley Shoals MP (Imperieuse)	Probability (%) ≥ 576	NC	NC	NC	NC
	Probability (%) ≥ 4,800	NC	NC	NC	NC
	Probability (%) ≥ 38,400	NC	NC	NC	NC
	Maximum Dosage	NC	NC	NC	NC

BS: Specified depth is below subsea.

NC: No contact to receptor predicted for specified threshold.

4 CONCLUSIONS

The main findings of this work are as follows:

Metocean Influences

- Within the Reef complex, tidal currents dominate the short term variability in oil drift, with the local winds exerting an important influence on floating oil.
- Large-scale drift currents will have a significant influence on the trajectory of any oil spilled at the modelled release sites, irrespective of the seasonal conditions. The prevailing drift currents will determine the trajectory of oil that is entrained beneath the water surface.
- Interactions with the prevailing wind will add additional variation in the trajectory of spilled oil and marked variation in the prevailing drift current and wind conditions would be expected over the duration of the long releases. This would be expected to increase the spread of oil during any single event.

Oil Characteristics and Weathering Behaviour

- The Torosa Condensate mixture specified for the surface phase of the blowout contains a low proportion of volatile components and a high proportion of residual components. If exposed to the atmosphere, around 16% of the mass would be expected to evaporate in around 24 hours, another 33% within a few days, and the remaining 51% would be expected to persist on the water surface until entrainment and decay occurs.
- The Torosa Condensate mixture specified for the subsea phase of the blowout is broadly similar to the surface-phase oil, but with a higher proportion of volatile components and a lower proportion of residual components. If exposed to the atmosphere, around 54% of the mass would be expected to evaporate in around 24 hours, another 21% within a few days, and the remaining 25% would be expected to persist on the water surface.
- The Browse Condensate mixture contains a high proportion of volatile components and a significant proportion of residual components. If exposed to the atmosphere, around 78% of the mass would be expected to evaporate in around 24 hours, another 8% within a few days, and the remaining 14% would be expected to persist on the water surface.
- The marine diesel mixture contains a significant proportion of volatile components and a low proportion of residual components. If exposed to the atmosphere, around 41% of the mass would be expected to evaporate within 24 hours, another 54% within a few days, and the remaining 5% would be likely to persist on the water surface. The influence of entrainment in a real spill event will regulate the degree of mass retention in the system.

Summary of Blowout Scenario

- In the case of the blowout (Scenario 1), floating oil is forecast to potentially drift in all directions, with extended trajectories predicted to the northwest and southwest of the Scott Reef complex – reflecting the influence of the Indonesian Throughflow surface current and the North West Shelf seasonal currents and eddies, respectively.
- The floating oil impacts are predicted to be focused on Scott Reef and Seringapatam Reef, with maximum concentrations of 50 g/m^2 or greater potentially occurring at most points within the reef complexes, and concentrations of 10 g/m^2 or greater potentially occurring in the Kimberley and Argo-Rowley Terrace CMR zones. There are low risks of floating oil concentrations 0.5 g/m^2 or greater being found as far north as the Oceanic Shoals CMR and as far south as the Rowley Shoals.
- Dissolved aromatic hydrocarbons are predicted to largely remain within the Scott Reef flats and lagoons. In terms of dosage, all thresholds are expected to be exceeded throughout the water column within Scott Reef, with the impacts decreasing with increasing depth, and the areal coverage decreasing with increasing threshold level as expected. Most of the reef complex is expected to be subject to dosage levels of 576 ppb.hr or greater, while the occurrence of the 38,400 ppb.hr level is expected to be limited to the South Reef Lagoon and Scott Reef Central/Sandy Islet areas. This is due to both the proximity of the release location and the oscillating currents in the deep channel between Scott Reef North and Scott Reef South that allow the persistence of hydrocarbons over time.

Summary of Subsea Release Scenario

- In the case of the subsea release (Scenario 2), floating oil at the lowest threshold is forecast to be restricted to the immediate vicinity of the release site, with a maximum floating oil concentration in excess of 10 g/m^2. In terms of dissolved aromatic hydrocarbon dosage, the low and moderate thresholds are predicted to be exceeded only in the upper 10 m of the water column around the release site. The nearest sensitive receptor (North Reef Flats) is not expected to be exposed to dosage levels in excess of the low threshold (576 ppb.hr).

Summary of Small Surface Release Scenarios

- In the case of the small surface spills (Scenarios 3.2, 5 and 6), where the spill sites are all located a few kilometres to the east of Scott Reef North, floating oil is predicted to drift to the northeast and south of each release site. Despite the proximity of the Scott Reef and Seringapatam Reef receptors, the maximum floating oil concentration (in excess of 50 g/m^2 in the immediate vicinity of the release site in all three scenarios) has only a small probability of exceeding 10 g/m^2 within Scott Reef in Scenarios 3.2 and 5, and the only predicted contact beyond Scott Reef is at the 0.5 g/m^2 threshold at Kimberley CMR in Scenario 3.2. In Scenario 6, the larger volume of condensate leads to a possibility of concentrations in excess of 25 g/m^2 being found inside Scott Reef, but beyond these receptors there is only a small probability of concentrations of 0.5 g/m^2 or greater being found at Kimberley CMR. In general the expected accumulating volume of oil on relevant shorelines is expected to be low.

- Dissolved aromatic hydrocarbon dosage may be exceeded at the low threshold (576 ppb.hr) in the upper 20 m of the water column in Scenario 3.2, with dosage levels remaining below the low threshold throughout the water column in Scenario 5. In Scenario 6, the low dosage threshold is predicted to be exceeded along the eastern edge of Scott Reef down to a depth of 40 m, with the area of impact decreasing with increasing depth. All receptors within Scott Reef except Scott Reef Central/Sandy Islet show low probabilities of exposure to dosage levels of at least 576 ppb.hr.

Summary of Large Surface Release Scenarios

- In the case of the large surface spills (Scenarios 4.2 and 4.4), where the spill sites are located to the east and southwest of Scott Reef, respectively, the predicted trajectories for floating oil are similar: drift is forecast to occur in any direction after release, with extended trajectories possible to the northwest and northeast of Scott Reef.

- The potential floating oil impacts in both scenarios are predicted to be focused on Scott Reef and Seringapatam Reef, with maximum concentrations of 50 g/m^2 or greater occurring at many points within the reef complexes, and concentrations of 10 g/m^2 or greater potentially occurring in the Ashmore Reef, Cartier Island, Kimberley and Mermaid Reef CMR zones, and also at Rowley Shoals MP (Clerke Reef) as isolated low probability events. There are low risks of floating oil concentrations 0.5 g/m^2 or greater being found as far north as Hibernia Reef and as far south as the Rowley Shoals.

- In both scenarios all thresholds of dissolved aromatic hydrocarbon dosage are expected to be exceeded in the upper 10 m of the water column, with the moderate threshold being exceeded down to 40 m and the low threshold being exceeded down to 60 m. The impacts decrease with increasing depth, and the areal coverage decreases with increasing threshold level. In Scenario 4.2 most of the Scott Reef complex will be exposed to dosage levels of 4,800 ppb.hr or greater to a depth of 40 m, while in Scenario 4.4 dosage levels of this magnitude are also expected on the margins of Scott Reef.

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