Australian Government
Australian Maritime Safety Authority

MONTARA WELL RELEASE
TIMOR SEA

OPERATIONAL MONITORING STUDY O2

MONITORING OF OIL CHARACTER FATE AND EFFECTS

REPORT 01
OIL CHARACTER

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1.0 INTRODUCTION

The information set out in this report is based on an assessment of fresh oil analysis, field observations of response personnel and an analysis of weathered oil samples and photographs supplied by responders to date.

Modelling of oil behaviour undertaken by Asia-Pacific ASA has not been included in this report.

The nature and speed of physical and chemical weathering of the Montara crude oil will contribute to effectiveness of response methods and the potential effects of the spill on the regional ecology

2.0 ASSESSMENT OF MONTARA CRUDE OIL

2.1 Fresh Oil

Montara oil is a waxy oil with a pour point close to that of ambient sea temperatures. Based on an analysis of preproduction oil samples, the crude oil spilled is a medium (Group III) high pour point waxy crude (Table 1).

The most significant property of the oil in regards its anticipated behaviour at sea is its high pour point, which in turn is due to the wax content.

The fact that the pour point is close to the likely air and sea surface temperatures means that the oil's fluidity (viscosity) at sea will fluctuate according to the air and surface water temperature. It is likely that the oil will be or highly viscous (or solid) in the cool nights and become fluid (less viscous) as it warms up during the day.

The extent of this and the speed of any change will depend on ambient air temperatures. In crudes where a high pour point is due to wax, viscosity changes can occur rapidly in response to small changes in temperature.

Non-spreading of the slick is clearly evident in photographs taken of fresh oil close to the Atlas (Figure 1). Other photographs indicate that the oil warms up sufficiently to become fluid (Figure 2).

Table 1 Character of Whole Crude

Property		Value
Density (SG)		0.851
API Gravity		34.8
Pour Point		27 °C
Flash Point		Not reported
Spreading Coefficient*		Not reported
Viscosity (Kinematic)	@40°C	3.726
	@ ambient	Solid < 27 °C Unknown >27 °C
Wax Content (% weight)		11.3%

Source: Intertek Testing Services.
** For liquid phase, i.e. >pour point.*

Figure 1 Fresh Slick Near Atlas (25/08/09)

Source: PTTEP

Figure 3 Spreading Slick Near Atlas (22/08/09)

Source: AAP

It should be noted that when the oil is below its pour point evaporative losses are expected to be negligible.

Computer modelling the non-trajectory behaviour of high pour point, waxy oils is difficult. Nevertheless, estimates of evaporative and other losses when the oil is above its pour point are provided in Table 2.

The data in Table 2 are indicative only but do show the importance of physical dispersion in reducing the persistence of oil slicks. The speed and degree of physical dispersion (breakup) is dependent on sea states (winds) and also the properties of the oil as it weathers (e.g. changes in spreading coefficient).

The data in Table 2 must be considered with due caution as it is based on an instantaneous rather than continuous release and it indicates the anticipated behaviour of the oil rather than the slick. Similarly residual oil that has weathered under the calm conditions that have prevailed for much of the response may not be as prone to physical breakup as the fresh oil.

Table 2 ADIOS 2* Residual Montara Crude Oil (% after Evaporation and Physical Dispersion) at Sea Temperatures above Pour Pont (27^{o}C).
Based on 100 cubic tonne instantaneous release

Sea Temp	Wind Speed	Source	Time After Release (Hours)								
			0	6	12	24	36	48	72	96	120
28^{o}C	5 knot	Evap' Loss	0	8	9	11	13	14	15	16	16
		Physical	0	0	0	0	0	0	0	0	0
		Residual	100	92	91	89	87	86	85	84	84
	10 knot	Evap' Loss	0	8	9	10					
		Physical	0	14	37	68					
		Residual	100	78	54	22	<10				
30^{o}C	5 knot	Evap' Loss	0	8	10	12	14	15	15	16	16
		Physical	0	0	0	0	0	0	0	0	0
		Residual	100	92	90	88	86	85	85	84	84
	10 knot	Evap' Loss	0	8	9	11					
		Physical	0	14	38	68					
		Residual	100	78	53	21	<10				

** ADIOS 2: Automated Data Inquiry for Oil Spills developed by the Hazardous Materials Response Division of the (US) National Oceanographic and Atmospheric Administration (NOAA).*

Modelling also predicts that emulsification will occur after 48 hours weathering of liquid phase (>27^{o}C) if wind speeds of 10 knots are applied. This also results in an increase in viscosity. Interpretation of this output should undertaken with caution as the model also predicts the breakup of the slick under these conditions. Spreading coefficient and other factors will determine whether spreading and breakup or emulsification will occur first.

2.2 Weathered Oil: Observations of the Oil at Sea

Descriptions of the appearance and behaviour of Mintara crude oil have been received regularly from spill responders on site and these have been well supported by photographic evidence.

Observations have been varied.

Close to the source the oil appears to be slowly spreading and confined to well defined slicks as shown in Figure 1. As the oil warms and exceeds its pour point it becomes fluid and spreads more easily, forming less defined and thinned slicks (Figure 2).

Oil contained in booms has ranged from “fresh” liquid oil with a low viscosity and brown colour (Figure 3) to lighter coloured oils, possibly emulsions (Figures 4 to 6). The fresh oil is recovered well by the deployed skimmers and reportedly contains little water (Tom Budd, AMOSC, pers.com).

The emulsions observed range in appearance, possibly reflecting the degree of emulsification, but possibly also reflecting a variable wax content.

Figure 3 Fresh Liquid Oil in Boom

Figure 4 Weathered Oil in Boom Apex

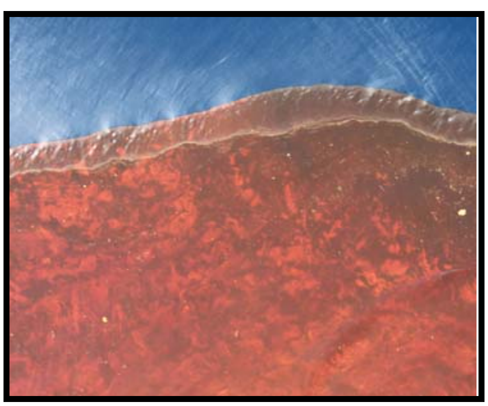


Figure 5 Dark Probably Emulsified Oil. Note Wax Film on Edge of Slick

Figure 6 Oil: Probably Emulsion

The separation of waxes from the oil is increasingly evident (Figures 7 to 9). This could be due to a number of processes which will be investigated in future analyses. It should be noted though that additional modelling of the oil behaviour must take into account the different physical and chemical properties of these waxy residues.

Figure 7(a) and (b) Wax Slick

Figure 8 Waxy Residue

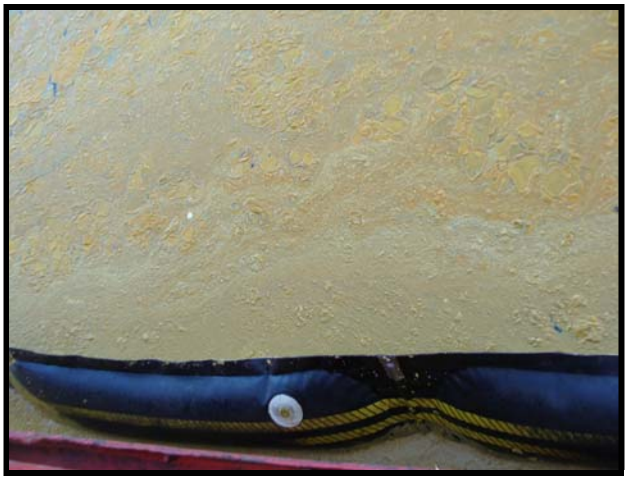
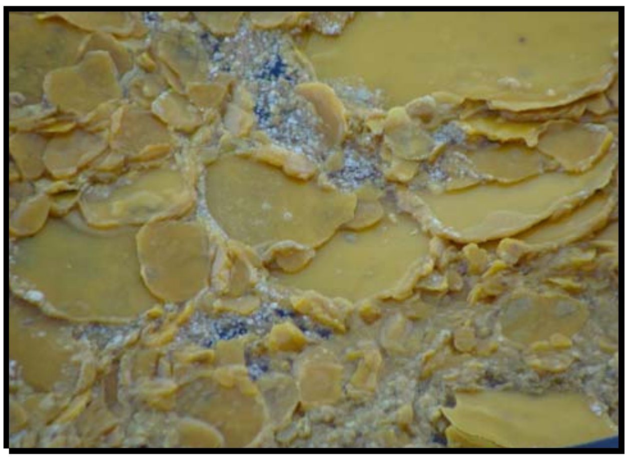


Figure 9 Mixed Slick Oil and Wax (see Fig 9)

Figure 10 Wax "Cake" Residues



The behaviour and potential persistence of the waxy residues at sea will be investigated as will the chemical composition of residues.

Should oil of any form impact shorelines then the behaviour of this will need to be observed. Waxy residues that are solid at sea (see Figure 10) may become fluid if stranded on shorelines.

2.3 Weathered Oil: Analysis of Samples

2.3.1 Sample Quality and Integrity

On the 9th of September, 2009 Leeder Consulting's laboratories received ten samples of oil or oily water. These were taken from:

- OMS Endurance (Rig Tender); 8 samples.
- Challis Venture (Production Platform); 1 sample.
- Sea Pearl (Fishing Vessel); 1 sample.

The samples from the Endurance and Challis Venture were transported to Darwin and thence to the laboratories. The Sea Pearl sample was landed at Broome and transported to WA Transports offices in Perth and then on to the laboratory.

The samples were taken by untrained personnel and before instructions for sampling and sample implements were distributed into the field. Consequently the sampling and subsequent sample handling procedures were poor. All samples experienced prolonged periods without refrigeration.

The samples were sorted on their arrival and each sample was given a unique laboratory number as per Leeder Consulting's quality procedure.

All samples were stratified upon arrival in the laboratory. This is common with high wax oils as the wax forms a matrix in the cold storage. This is clearly shown in Figures 11 and 12. The latter shows a very clear separation of wax, oil, lighter oil (possibly emulsion) and water.

This separation will also be occurring at sea to some extent but in the absence of detailed sample descriptions from the point of collection it is not possible to determine whether the separation was present in the sample at the time it was taken.

Similarly, the emulsions could have been present at the time of sampling or formed during transport. The water present in each jar could be as sampled or formed through the breaking of emulsions during heat exposure in the containers.

Figure 11 Sample No 2 – 2009017823

Figure 12 Sample No 0 – 2009017821

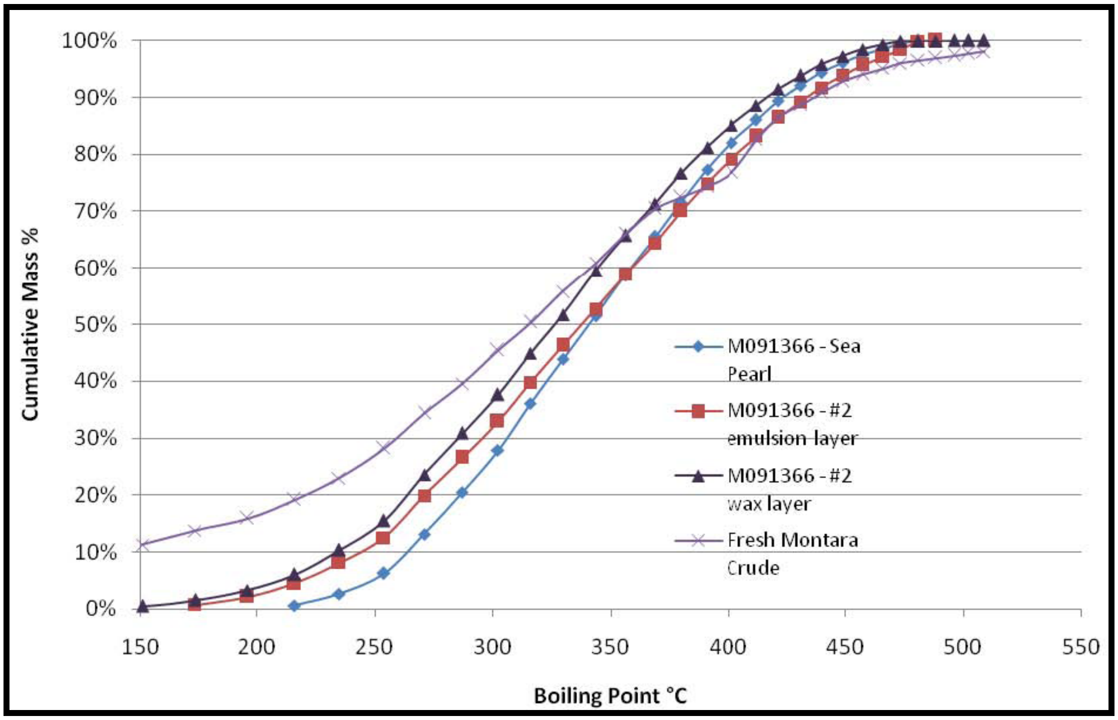
2.3.2 Analysis

To date, simulated distillations have been undertaken on the sample from the "Sea Pearl" (fishing vessel) and one sample from the "Endurance". The results of this analysis (Figure 13 and Table 4) show that all samples are weathered and that a significant loss of light (volatile) hydrocarbons has occurred.

No sample contained hydrocarbons with boiling point of less than 175°C (i.e. less than approximately 10 carbon atoms; <C10). The "Sea Pearl" sample had no hydrocarbons below 210°C (approximately <C12).

Total reduction of oil volume due to evaporation is calculated at an average 34% (between 4% and 66%) for the samples from the "Endurance" and 43% loss for the sample from the "Sea Pearl" compared to fresh Montara crude oil. However, some of these volatiles could have been lost during sample handling and transport.

Figure 13 Simulated Distillation Curves for Oil Samples



Additional analysis of these samples is underway but more detailed information will become available from analysis of samples taken and handled according to sampling protocols.

Table 3 Sample Simulated Distillation Profile of Fresh Montara Crude Oil
(Source Intertek sample ID: 880-0489/02)

Boiling Point	%	Boiling Point	%	Boiling Point	%	Boiling Point	%
18°C	0.9%	150°C	11.2%	250°C	26.5%	350°C	63.6%
65°C	2.3%	160°C	12.2%	260°C	30.7%	360°C	67.2%
70°C	2.6%	170°C	13.4%	270°C	34%	370°C	70.8%
80°C	3.3%	180°C	14.3%	280°C	37.2%	400°C	75.8%
90°C	4.5%	190°C	15.1%	290°C	40.5%	410°C	81.7%
100°C	6.1%	200°C	16.3%	300°C	44.7%	425°C	87.3%
110°C	7.2%	210°C	17.2%	310°C	48%	450°C	93.1%
120°C	8.1%	220°C	20.4%	320°C	51.8%	475°C	96.2%
130°C	9.1%	230°C	22.1%	330°C	55.8%	525°C	98.9%
140°C	10.4%	240°C	23.9%	340°C	59.1%	>525°C	100%

Table 3 Sample Simulated Distillation Profiles and Volume Losses Due to Evaporation

Sample ID		2009017821	2009017822	2009017823	2009017823	2009017823	2009017826	2009017827	2009017829	2009017830
Field ID		#0 (homogenized)	#1 (homogenized)	#2 (homogenized)	#2 Wax layer	#2 Emulsion	#6 (homogenized)	#7 (homogenized)	Sea Pearl	#9 (homogenized)
Date		22-Aug	23-Aug	23-Aug	23-Aug	23-Aug	26-Aug	27-Aug	28-Aug	29-Aug
B.P. °C	126°C	-	-	-	-	0.3%	-	-	-	-
	151°C	-	-	-	-	0.5%	-	-	-	-
	174°C	-	0.4%	0.8%	0.7%	1.5%	0.1%	-	-	-
	196°C	0.8%	1.6%	2.5%	2.1%	3.2%	0.7%	-	-	-
	216°C	3.2%	4.5%	5.8%	4.5%	6.0%	2.5%	-	0.6%	-
	235°C	7.5%	9.3%	10.7%	8.1%	10.3%	6.3%	-	2.6%	-
	254°C	13.9%	16.0%	16.5%	12.5%	15.5%	11.8%	-	6.2%	0.1%
	271°C	22.9%	25.6%	26.0%	19.8%	23.5%	20.8%	-	13.1%	0.8%
	287°C	32.1%	35.7%	34.7%	26.5%	30.8%	29.8%	0.7%	20.5%	2.9%
	302°C	40.3%	43.6%	42.1%	32.9%	37.6%	38.4%	3.4%	27.8%	8.7%
	316°C	49.5%	52.9%	50.5%	39.8%	44.9%	47.6%	8.9%	36.1%	17.0%
	330°C	57.3%	61.0%	57.9%	46.3%	51.6%	55.5%	16.3%	43.8%	25.2%
	343°C	65.3%	68.8%	65.1%	52.7%	59.5%	63.2%	26.1%	51.5%	35.4%
	357°C	72.3%	75.6%	71.8%	58.7%	65.7%	70.4%	35.9%	58.7%	44.9%
	369°C	78.5%	81.4%	77.6%	64.4%	71.4%	76.3%	45.9%	65.5%	54.7%
	380°C	83.6%	86.2%	82.9%	70.0%	76.7%	82.0%	55.1%	71.6%	63.8%
	391°C	88.1%	90.1%	87.2%	74.9%	81.2%	86.5%	65.5%	77.3%	71.6%
	402°C	91.4%	92.9%	90.7%	79.2%	85.1%	90.3%	73.4%	82.0%	78.6%
	412°C	93.9%	95.2%	93.5%	83.1%	88.6%	93.0%	80.0%	86.0%	84.5%
	422°C	95.9%	96.7%	95.7%	86.5%	91.5%	95.2%	85.3%	89.5%	89.0%
	431°C	97.1%	97.8%	97.3%	89.2%	93.8%	96.8%	90.1%	92.1%	92.5%
	440°C	98.1%	98.7%	98.4%	91.7%	95.7%	98.0%	94.2%	94.4%	95.4%
	449°C	98.8%	99.2%	99.1%	93.9%	97.2%	98.8%	96.3%	96.1%	97.3%
	458°C	99.3%	99.7%	99.6%	95.7%	98.4%	99.3%	97.9%	97.5%	98.5%
	466°C	99.7%	99.9%	99.8%	97.1%	99.2%	99.7%	98.9%	98.5%	99.3%
	474°C	100.0%	100.0%	100.0%	98.4%	99.8%	100.0%	99.5%	99.4%	99.7%
	481°C	100.0%	100.0%	100.0%	99.8%	99.9%	100.0%	99.8%	99.9%	99.9%
	>481°C	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% Volume Loss		19%	4%	23%	NA	NA	29%	66%	43%	61%

3.0 SUMMARY

Despite the high wax content and subsequent high pour point the Montara crude oil is losing a significant portion of volume through evaporation. Analysis indicates that this could be as high as 66% over 7 days. However, these figures are approximate only as the period that the oil was at sea before sampling is not known and some losses of volatile components may have occurred during sample handling. Nevertheless thee evaporative losses are broadly consistent with modelled results dorm ADIOS 2.

Higher temperatures and sea states in subsequent weeks are expected to have increased evaporative loses and physical breakup of the slick.

Emulsification of the oil does seems to be occurring although the extent of this is undetermined to date and evidently variable.

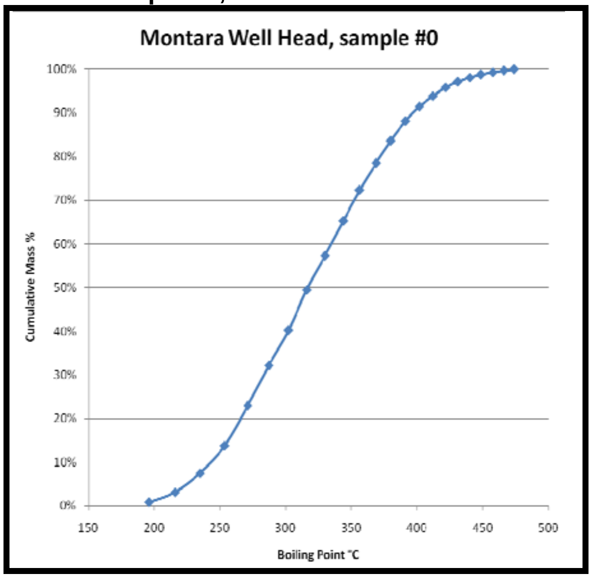
Separation of waxy components of the crude is also apparent and this will be further investigation for fates and effects studies.

4.0 REFERENCES

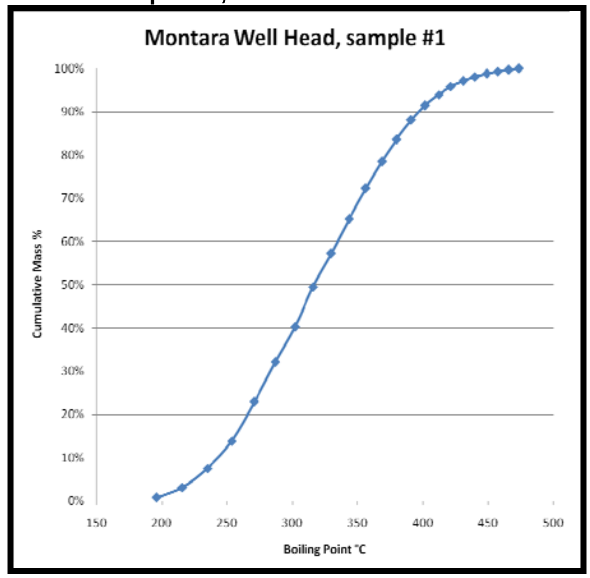
Leeder Consulting. 2009. Montara Crude Oil Characterisation. Report No. M091366. Prepared for Australian Maritime Safety Authority, 23rd September 2009 by Leif Cooper.

ATTACHMENT A
EXTRACT FROM LEEDER CONSULTING REPORT

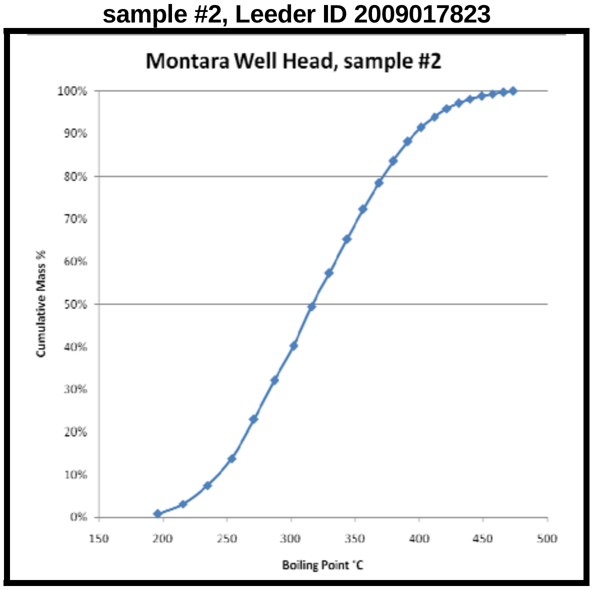
Simulated distillation, Montara Well Head sample #0, Leeder ID 2009017821



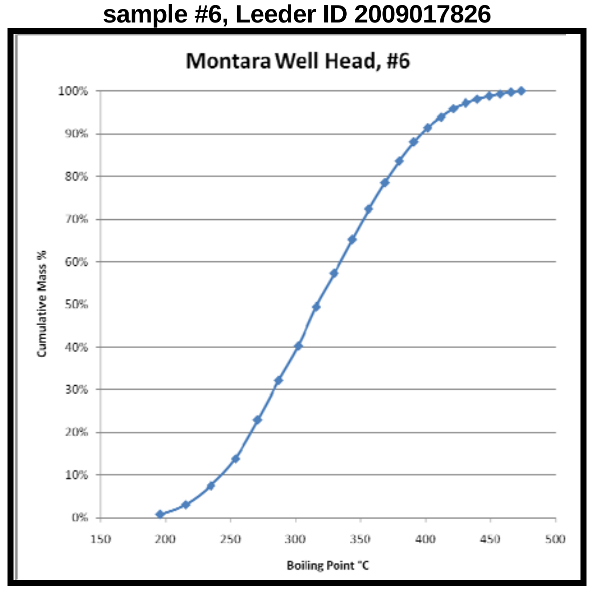
Simulated distillation, Montara Well Head sample #1, Leeder ID 2009017822



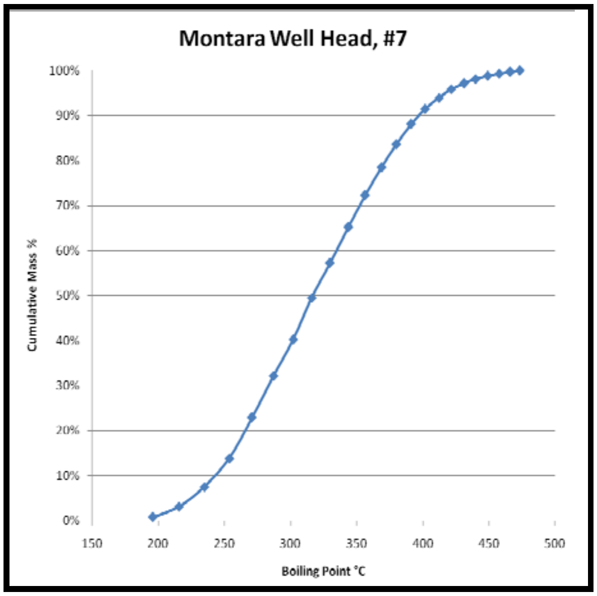
Simulated distillation, Montara Well Head sample #2, Leeder ID 2009017823



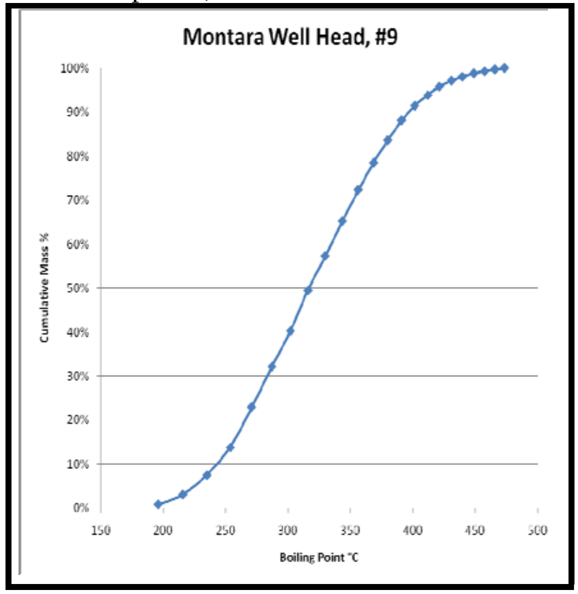
Simulated distillation, Montara Well Head sample #6, Leeder ID 2009017826



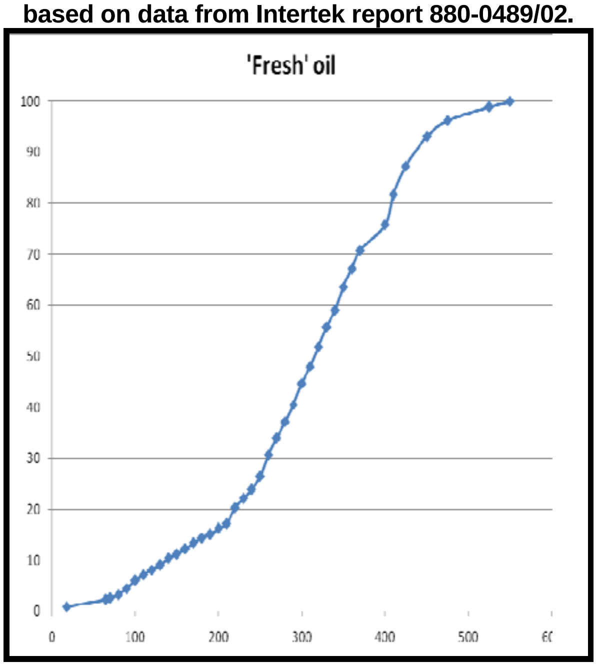
Simulated distillation, Montara Well Head sample #7, Leeder ID 2009017827



Simulated distillation, Montara Well Head sample #9, Leeder ID 2009017830

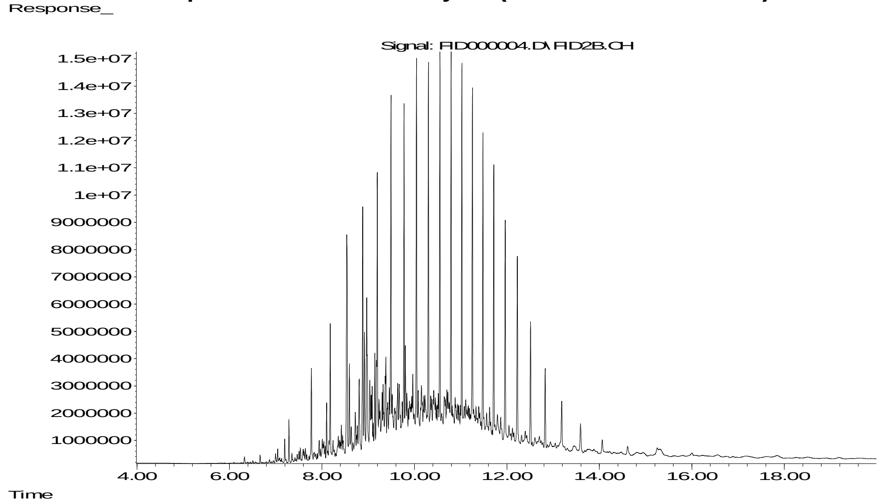


Simulated distillation, fresh Montara crude, based on data from Intertek report 880-0489/02.

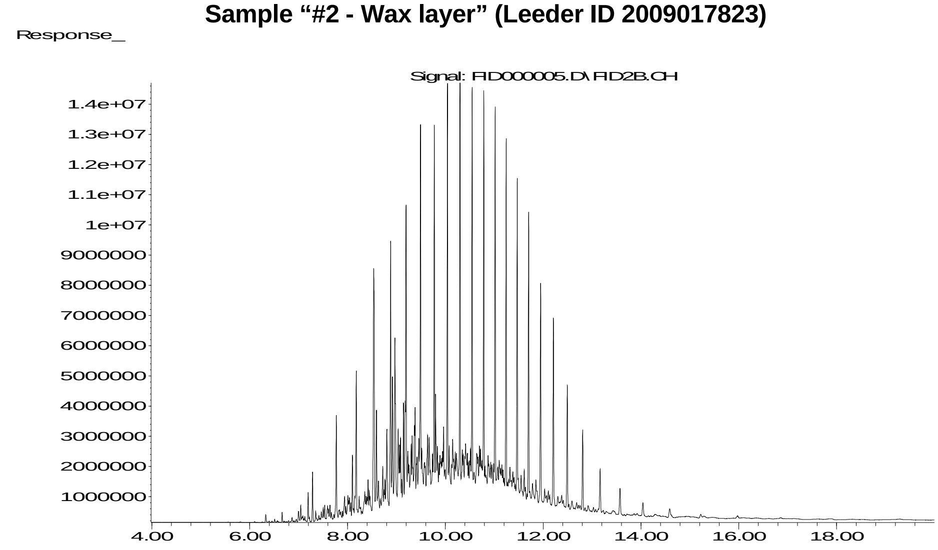


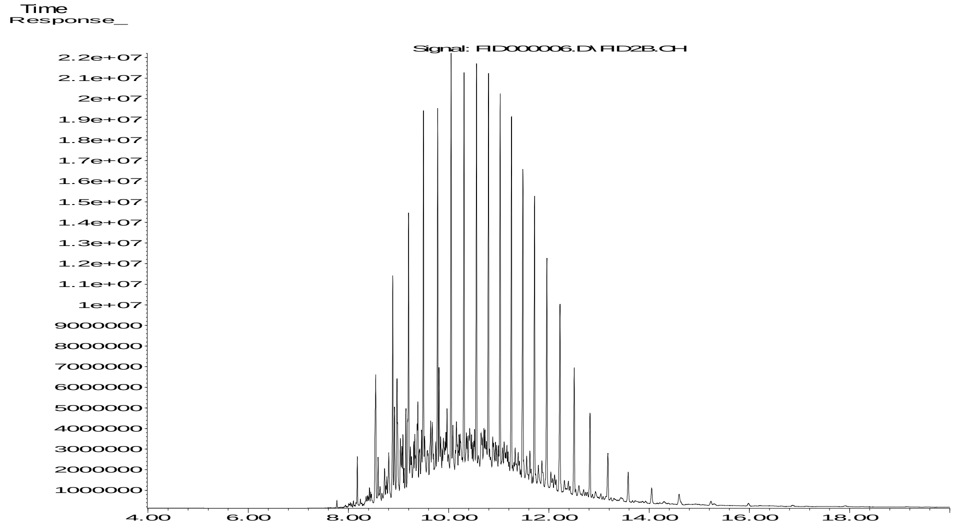
Gas Chromatography Chromatograms

Sample “#2 - Emulsified layer” (Leeder ID 2009017823)



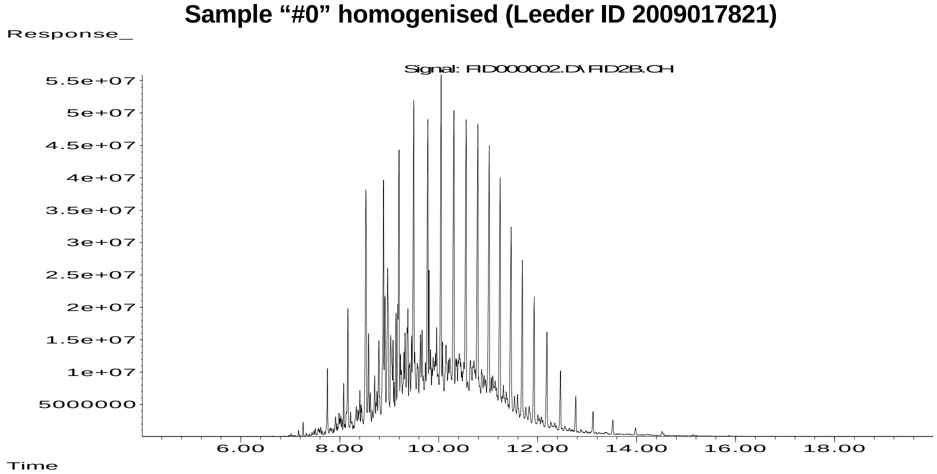
Sample “#2 - Wax layer” (Leeder ID 2009017823)

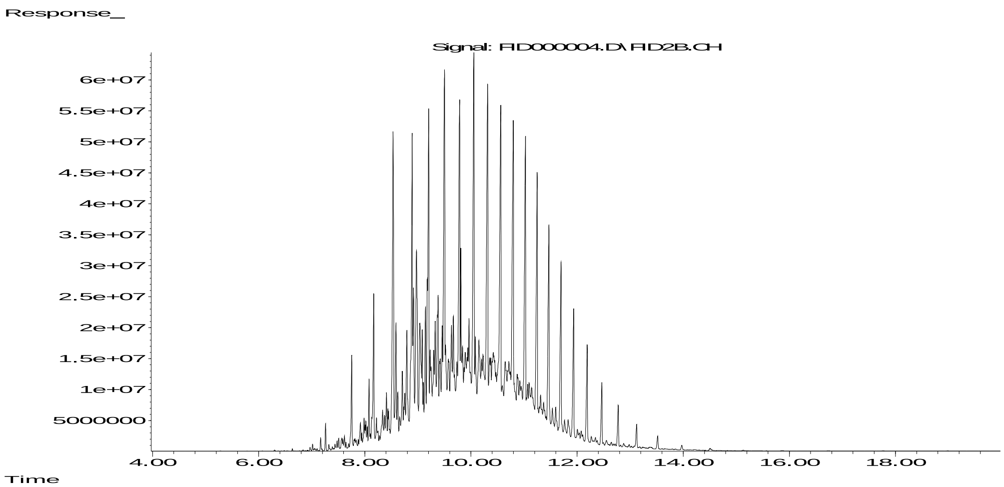




Sample “Sea Pearl” (Leeder ID 2009017829)

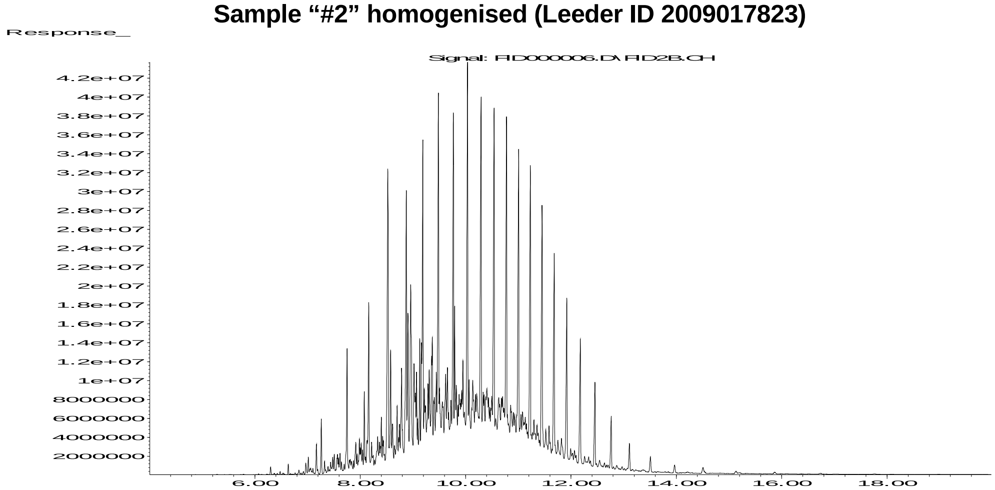
Sample “#0” homogenised (Leeder ID 2009017821)

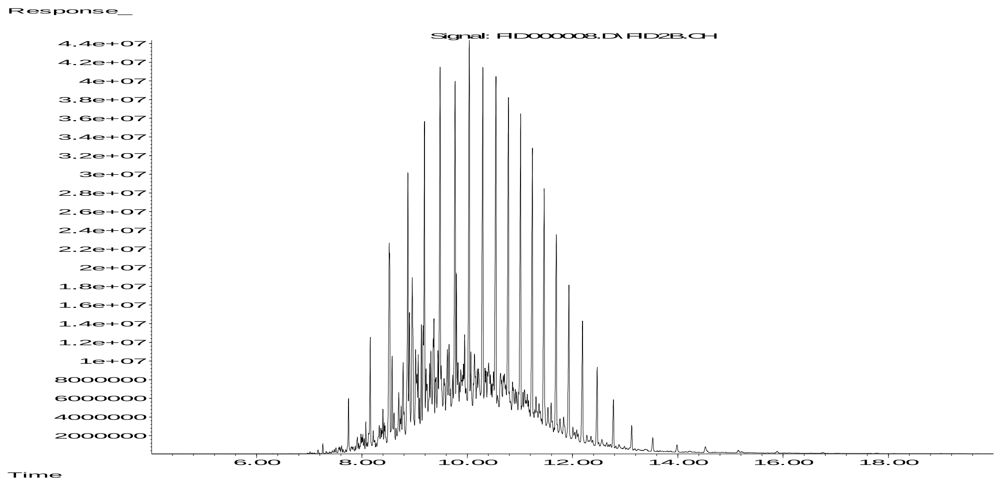




Sample “#1” homogenised (Leeder ID 2009017822)

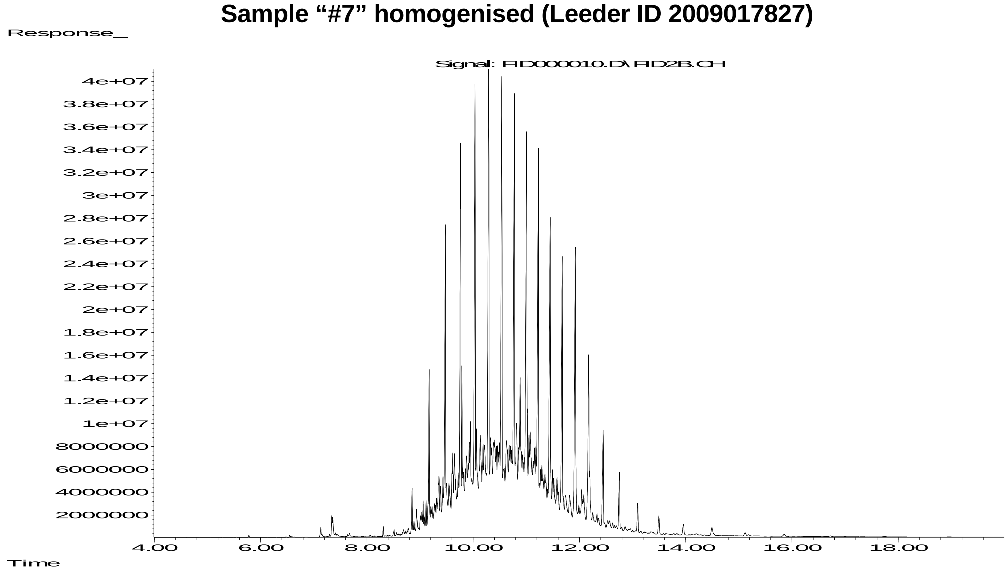
Sample “#2” homogenised (Leeder ID 2009017823)

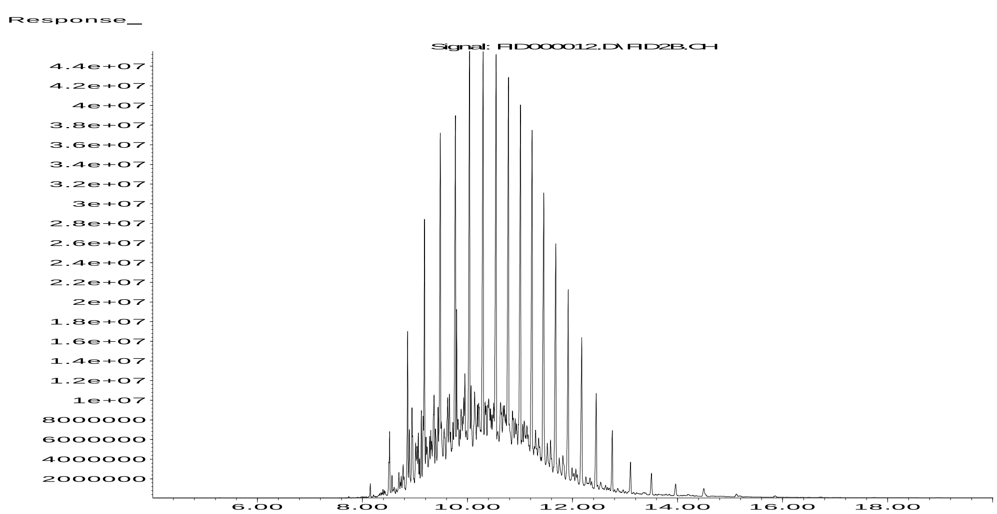




Sample “#6” homogenised (Leeder ID 2009017826)

Sample “#7” homogenised (Leeder ID 2009017827)





Sample “#9” homogenised (Leeder ID 2009017830)

ATTACHMENT B
LIST OF SAMPLES RECEIVED AT LEEDER LABORATORIES AND STATUS

Samples Received and Current Status

Sample No *	Field Sample No	Collection Point	Date	Time	Position		Sample Status**	Analysis Undertaken	Comments
					Lat	Lon			
2009017821	# 0	Endurance	22-Aug	6:00	12° 36.4 S	124° 38.3 E	1	Simulated Distillation, Volatiles and % Loss	
2009017822	# 1	Endurance	23-Aug	5:58	12° 34.8 S	124° 33.4 E	1		
2009017823	# 2	Endurance	23-Aug	10:15	12° 35.3 S	124° 36.44 E	1		
2009017824	# 4	Endurance	24-Aug	315	12° 33.6 S	124° 39.00 E	1		
2009017825	# 5	Endurance	24-Aug	3:30	12° 33.7 S	124° 39.8 E	1		
2009017826	# 6	Endurance	26-Aug	8:45	12° 59.8 S	124° 44.1 E	1		
2009017827	# 7	Endurance	26-Aug	9:45	12° 42.8 S	124° 35.6 E	1		
2009017828	# 8	Endurance	27-Aug	7:15	12° 37.6 S	126° 33.5 E	1		
2009017830	# 9	Challis Venture	29-Aug	16:24 *	12° 07.17S	125° 00.65 E	1		
2009017829	1,20	Sea Pearl	28-Aug	15:00	12° 33 S	124° 56 E	1		

** Leeder Consulting laboratory No.*

*** 0 = No integrity, not suitable for analysis. 1= Little sample integrity, limited analysis possible. 2=Limited sample integrity. Analysis only if needed (no other samples and data gap of significance). 3 = Acceptable but to be analysed only if duplicate samples are unavailable. 4= sample is suitable for full analysis. 5 = sample has full integrity (chain of custody, temp control etc). Suitable for legal use.*