Ohmsett Tests to Determine Optimum Times to Decant Temporary Storage Devices

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Abstract

A series of tests was conducted to study the rate and degree of water separation that can be expected in temporary storage containers commonly used in response operations. The goal of the study was to develop simple rules for various common temporary storage containers that will predict the best time to decant water back into the boomed area and optimize the available volume.

Tests were conducted in the Ohmsett basin using two models of weir skimmer and varying oil type, wave condition and slick thickness.

The volume of water decanted, the water content of the remaining oil and the oil content of the decanted water were measured over time. As well, tests were performed with a storage device in waves to see if wave action appreciably affected separation.

The results indicate that “primary break” (the initial separation of the recovered fluid into a layer containing most of the oil and a layer containing most of the free water) occurs within a few minutes to one hour, depending of the physical characteristics of the oil. Rapidly decanting this free water layer, in appropriate situations, may offer immediate increases of 200 to 300% in available temporary storage space. Initial oil concentrations in the decanted water also depended on the physical properties of the oil; they ranged from 100 to 450 ppm for the most viscous oil to 1400 to 3000 ppm for the least viscous. These declined by a factor of approximately 3 after one hour of settling, and by a factor of approximately 5 after one day.

1.0 Introduction

The preferred approach to cleaning up an oil spill is to contain and thicken the oil slick with booms, and then place skimmers in the oil or emulsion to recover it. The recovered fluids are placed in temporary storage containers for transfer to larger storage vessels or for direct input into the waste recycling and disposal process. The most common type of high-capacity skimmer in use today is the weir skimmer. Water, both in the form of emulsified water and free water, is recovered by weir skimmers operating in waves. In some cases, the transfer pump built into the skimming system can impart enough energy to cause additional emulsification of the recovered fluids. The problem is that the recovered water (both emulsified and free) dramatically reduces the temporary storage space available at the site of skimming operations; this can result in having to stop skimming prematurely when the storage capacity is reached.

In the relatively low-energy environment within a temporary storage device, the recovered fluids will begin to separate into layers of oil, emulsion and water. Periodically discharging the separated water back into the containment boom can considerably extend the available storage space and increase the effective use of available skimming resources to remove oil from the water surface.

There is an optimum time at which the separated water should be discharged, or decanted, from the temporary storage device. This optimum time maximizes the amount of water that can be removed from the temporary storage device, minimizes the oil content of the discharged water, and minimizes the time that the storage is "out of service" while the water is settling out. With the current level of understanding, it is unclear what this optimum time is. It could be that the water should be pumped out continuously during skimming operations, or perhaps time should be allowed for separation before the water is decanted. This decision may also depend on whether or not sensitive resources could be affected by the dispersed oil concentrations in the decanted water.

2.0 Previous Research

It was not the intention of this study to repeat or duplicate the testing of technologically advanced, high-throughput and high-efficiency oil/water separators that has been conducted in Europe (NOFO 1990, Peigne et al. 1993) and the U.S. (Nordvik et al. 1994, Bitting et al. 1993). Such devices are available commercially for oil spill applications in a variety of capacities and efficiencies. Many are intended to reduce the oil content of discharged water to regulatory limits.

The intention of this research project was to provide simple-to-use guidance on the gravity-separation and decanting of temporary storage barges, bladders, containers, etc., that are commonly used to support mechanical oil recovery operations. The decanted water would be returned to the boomed area where the skimmer is operating so that some oil in the discharged water is made available for re-skimming.

A preliminary laboratory-scale study was conducted for Alaska Clean Seas (ACS) in December 1997 (SL Ross 1998) to identify some of the factors that determine the optimum separation time for two crude oils. The study involved three stages:

1) Using the SL Ross oil spill model to predict oil/emulsion properties that could result from several spill scenarios in the Prudhoe Bay area.
2) Searching published reports of skimmer performance to establish the likely recovery rates of oil/emulsion and free water for weir-type skimmers (e.g., Desmi or GT series) operating in a variety of slick and sea conditions.
3) Conducting laboratory-scale (40 mL) tests with mixtures of ANS and Milne Pt. crude oils and emulsions with seawater to ascertain both the rate at which they separate into different phases and the relative volumes of each phase.

It was concluded that offshore and nearshore operations with circular weir skimmers will likely recover considerable volumes of free water. Also, the transfer of the recovered fluids from the skimmer to a temporary storage device could cause additional emulsification of the oil fraction, particularly if the oil is sufficiently weathered to be prone to forming stable emulsions.

The small-scale lab tests indicated that the unemulsified ANS crude oil (density = 890 kg/m^3; viscosity = 100 mm^2/s @ 15 ˚C) would separate out of the recovered fluid in several minutes, while the unemulsified Milne Pt. crude (density = 827 kg/m^3; viscosity = 50 mm^2/s @ 15 ˚C) could take up to twice as long. It was also found that the emulsions of both weathered oils would separate out more quickly than the unemulsified oil. It was postulated that the difference in the rate of separation between the two oils, and between the oils and emulsions, was due in large part to differences in the size of the dispersed oil droplets: larger drop sizes contribute to faster separation. Factors affecting the size of oil drops in water include:

- physical properties of the oil, such as viscosity;
- interfacial tension;
- density (salinity) of the recovered water; and,
- amount of mixing energy supplied,

It was not reasonable to extend these small-scale test results to make predictions for a specific temporary storage system; the study could not accurately represent the level of mixing energy that would be imparted by wave action and a skimmer transfer pump, nor did the small test jars used accurately represent the size or geometry of a storage tank. To adequately address the issue of scale, tests with common weir skimmers and a common temporary storage device geometry were undertaken to determine the best time to remove recovered water.

3.0 Objective

The objective of this study was to conduct large-scale tests of recovered oil/emulsion/water separation rates in order to predict the optimum time for decanting separated water in temporary storage devices.

4.0 Methods

4.1 Test Set-up and Instrumentation

A 15-m (50-ft.) section of 24-in. Conventional containment boom was deployed in a square at the north end of the Ohmsett basin, between the main and auxilliary bridges (Figure 1). Two recovery devices were deployed in the boomed area: a GT-185 skimmer and a Desmi Terminator skimmer (Figure 2). Only one skimmer was operated for a given test.

The skimmer discharge was directed to the oil recovery tank cells located on the auxiliary bridge (Figure 3). The separated water from the oil recovery tanks was either dumped back into the Ohmsett test basin, or directed to a temporary holding tank for water sampling (Figure 4). Oil or emulsion from the oil recovery tank cells was pumped to the oil recovery system.

Waves were generated at the south end of the test basin and recorded using a Datasonics ultrasonic distance meter. Two wave conditions were generated during this test series. Their nominal characteristics are defined in Table 1.

Table 1 Nominal Wave Characteristics

Wave No.	Stroke, cm (in.)	CPM	Type	Nominal Height, cm (in.)	Calculated Wave Length, m (ft.)	Period (sec.)
#1	7.6 (3)	22	Sinusoidal	15 (6)	11.3 (37)	2.8
#2	7.6 (3)	35	Sinusoidal	15 (6)	4.6 (15)	1.7

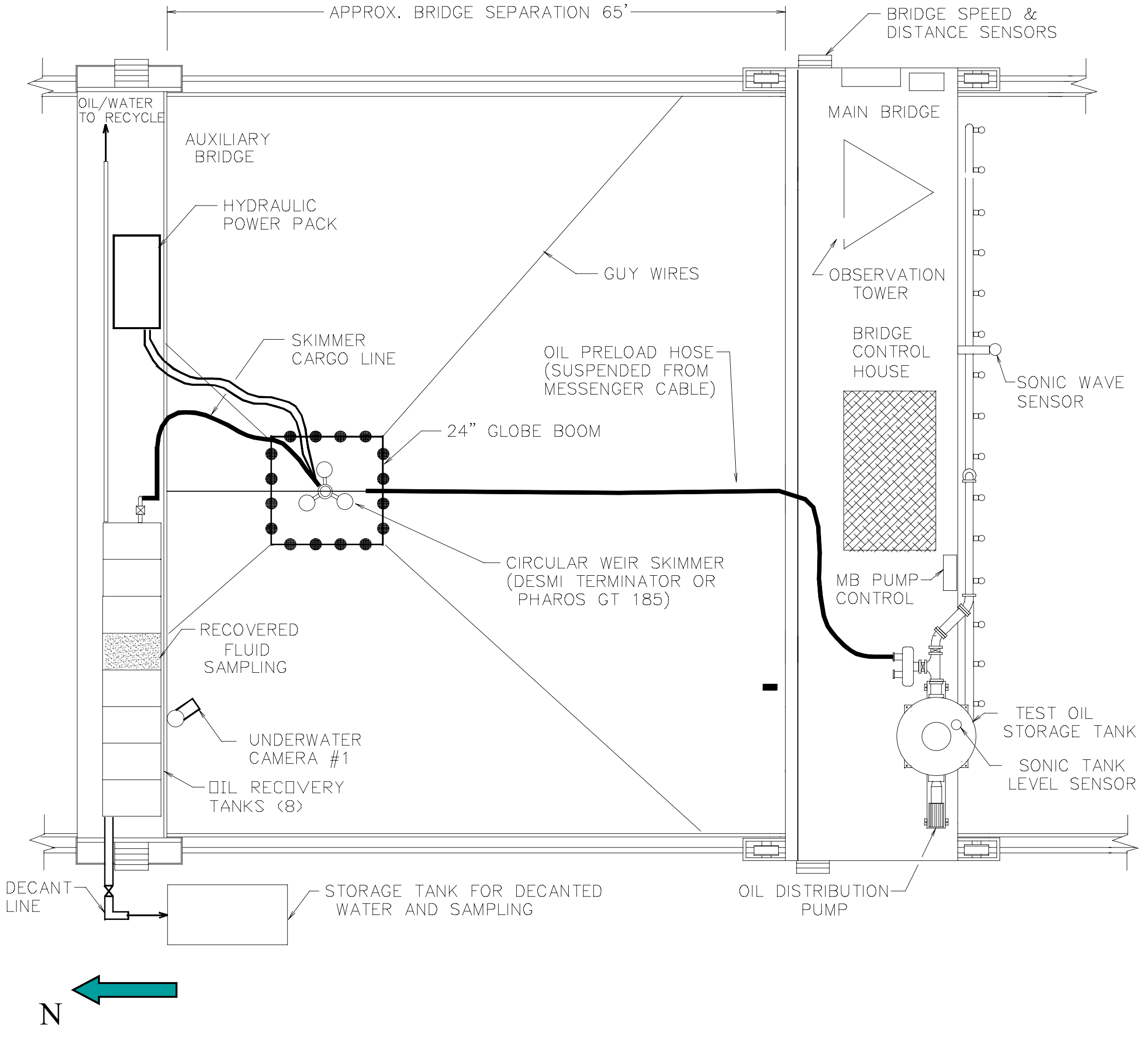


Figure 1 Schematic Layout of Decanting Test Equipment in Ohmsett Basin

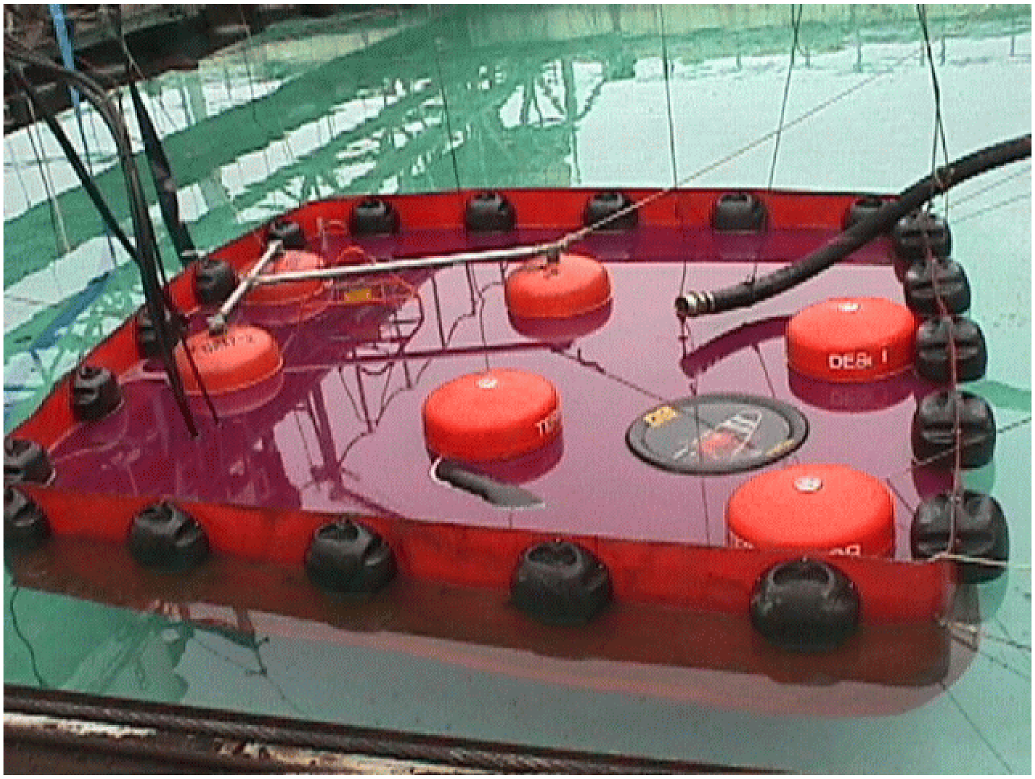


Figure 2 Desmi Terminator (foreground) and GT-185 (background) skimmers in boomed area with Calsol test oil

Figure 3 Oil recovery tank with eight cells on auxiliary bridge

Figure 4 Nalgene tank used to collect decanted water samples for oil content analysis

Before each test the Oil Recovery Rate (ORR) for each skimmer and oil combination was estimated and the volume of oil removed from boomed area during the previous test was estimated. The following procedure was used:

1. The required volume of test oil was added to the boomed area to make up the desired slick thickness (20 or 100 mm, see Test Matrix below).
2. The oil distribution pump was set to supply fresh test oil at the ORR estimated above.
3. The waves were turned on at the desired setting and allowed to come to apparent steady state (this required one minute).
4. The oil distribution pump was started and the skimmer was turned on, with discharge to recovery tank cell #8.
5. When the discharge hose was purged, the skimmer discharge was directed to the oil recovery tank cells sequentially (i.e., fill cell #7, then #6, etc.).
6. Record the time when filling each tank cell was started and finished. Measure and record the depth of fluid in each cell.
7. After the last tank cell was filled, the oil distribution pump, skimmer and waves were stopped.
8. Simultaneously with the filling operation, two minutes after tank cell #7 was filled, the separated water was decanted until the discharge from the bottom was “black”. Generally the water was poured back into the test basin.
9. For selected cells in each test, the decanted water was transferred to a

temporary holding tank on the deck beside the auxiliary bridge. When all water from this tank was decanted, the contents of the temporary holding tank were thoroughly mixed with an electric drill paint mixer and allowed to settle for five minutes to allow large droplets of oil to surface. The surface oil was removed with a sorbent pad, then the temporary holding tank was drained. A small water sample, for oil content analysis, was taken when half the water had been drained. The purpose of this was to estimate the average concentration of "permanently dispersed" oil in the decanted water - i.e., the droplets that would not rise out and recoalesce with the slick if the decanted water was discharged back into a boomed area.

10. The remaining oil recovery tank cells were decanted in sequence at 5, 10, 15, 30, 45, and 60 minutes after the time they each reached full. The purpose of this was to determine the time required for "primary break" of the skimmer discharge product. "Primary break" is the point at which the bulk of the lower density phase has risen to the top and the higher density phase has settled to the bottom; both phases typically contain small droplets of the other phase at this point.
11. The depth of fluid remaining in each cell was measured.
12. Each oil recovery tank cell was mixed and sampled to determine the water content of the fluid remaining.
13. Transfer contents of oil recovery tanks for disposal or reprocessing.
14. Repeat for next test in matrix.

The samples collected were analyzed using standard Ohmsett procedures for water content of oil (ASTM D1796), oil concentration in water (EPA 413.1), density (ASTM D1298), interfacial tension and surface tension (ASTM D971), and kinematic viscosity (ASTM D2983).

The following parameters were varied during the tests:

i) Two circular weir skimmers
  - Desmi Terminator - nominal ORR in waves 20 m^3/hr (90 USgpm)
  - Pharos GT-185 - nominal ORR in waves 10 m^3/hr (45 USgpm)

ii) Two slick thicknesses
  - 20 mm and 100 mm

iii) Three oil types
  - Hydrocal, Calsol and Sundex

iv) Two wave conditions (see Table 1 above)
  - wave #1 and wave #2

In the two-week test period (November 9 to November 20, 1998) the tests shown in Table 2 were completed. During three of these tests (one for each of the three test oils) duplicate samples of the decanted water were placed in vertical columns for 24 hours and then drained. The water from the bottom, middle and top of the columns was sampled and was analyzed for oil content.

The viscosities of the test oils at 9 ˚C, the average temperature of the basin water, are given in Table 3.

Measurements of the slick surface temperatures during the tests showed that the oil in the boom was generally close to the water temperature. The exception to this was the tests with the Sundex oil. In order to pump this product, it was necessary to heat it in the main bridge tank, to approximately 40 ˚C (100 ˚F). The pre-loaded oil would cool to within a few degrees of ambient temperature before each test, however, the makeup oil added during each test would tend to flow directly to the skimmer inlet, thus it is unlikely that this oil was at ambient temperature.

Table 2 Tests Completed

Skimmer	Oil			Wave		Slick Thickness		Comments
	Hydrocal	Calsol	Sundex	#1	#2	20 mm	100 mm	
GT-185	✓		✓	✓	✓	✓	✓	8 tests (2 oils x 2 waves x 2 thickness) + 2 repeats
Desmi	✓	✓	✓	✓	✓	✓	✓	8 tests with Sundex and Calsol (2 x 2 x 2) + 3 with Calsol (20 mm with 2 waves + 100 mm with wave #2) + 3 repeats with double volume of fluid recovered
Desmi	✓			✓	✓	✓		5 tests where recovered fluid directed into open-topped drum on "boat" in waves

Table 3 Estimated viscosity of test oils at tank water temperatures.

Test Oil	Viscosity at 9 ˚C ($mm^2/s = cSt$)
Hydrocal	1100
Calsol	13000
Sundex	300000

For Wave #1 (the longer period of the two settings - see Table 1 above) the average height recorded ranged from 12.4 to 27.4 cm (4.9 to 10.8 in) with an overall mean of 16.6 cm (6.5 in). Most average heights were in the 12.7 to 17.8 cm (5 to 7 in) range. The average periods calculated in the noise-free samples for wave #1 ranged from 2.4 to 2.8 s with an overall mean of 2.5 s.

For the steeper wave #2 the height averages ranged from 12.8 to 20.5 cm (5.0 to 8.1 in) with an overall mean of 16.7 cm (6.6 in). The average periods ranged from 1.7 to 1.9 s with an overall mean of 1.8 s.

5.0 Results and Discussion

The complete test results may be found in the study report (SL Ross 1999). All of the decanting tests assumed that the feed from a skimmer provided a reasonably constant water content over the entire period of the test, which ranged from 3.5 to 4.5 minutes. In order for this to be a reasonable assumption, each test must have been long enough to allow a large number of waves to pass and the fresh oil feed rate had to approximate the ORR of the skimmer. The number of waves that passed through the boomed area in the test period were approximately: 120 and 150 waves in wave No. 2 and, 80 to 110 waves in wave No. 1. The data in the report (SL Ross 1999) shows that, although the fresh oil feed rate was generally lower than the ORR, it was within 50 to 67% of the ORR.

5.1 Water Separation from the Recovered Fluid

Figure 5 shows the water removal results obtained in the 20 mm thick Calsol slicks. The four graphs show the results obtained with the GT-185 skimmer in wave No. 2 (Test 2) and wave No. 1 (Test 3), and with the Desmi skimmer in wave No. 2 (Test 4) and wave No. 1 (Test 5). Each plot shows:

- Percent Decanted - [volume of water decanted/volume of fluid recovered] x 100%;
- Decanted Water Volume; and,
- Water Volume Remaining - [volume of fluid recovered - volume of water decanted] x water content of remaining fluid .

plotted against elapsed time from when the tank cell was filled to when it was decanted.

All the plots clearly show that most of the water can be decanted from the recovered fluid with a delay of only 30 minutes or so. Skimmer type and wave period do not seem to greatly affect the decanting.

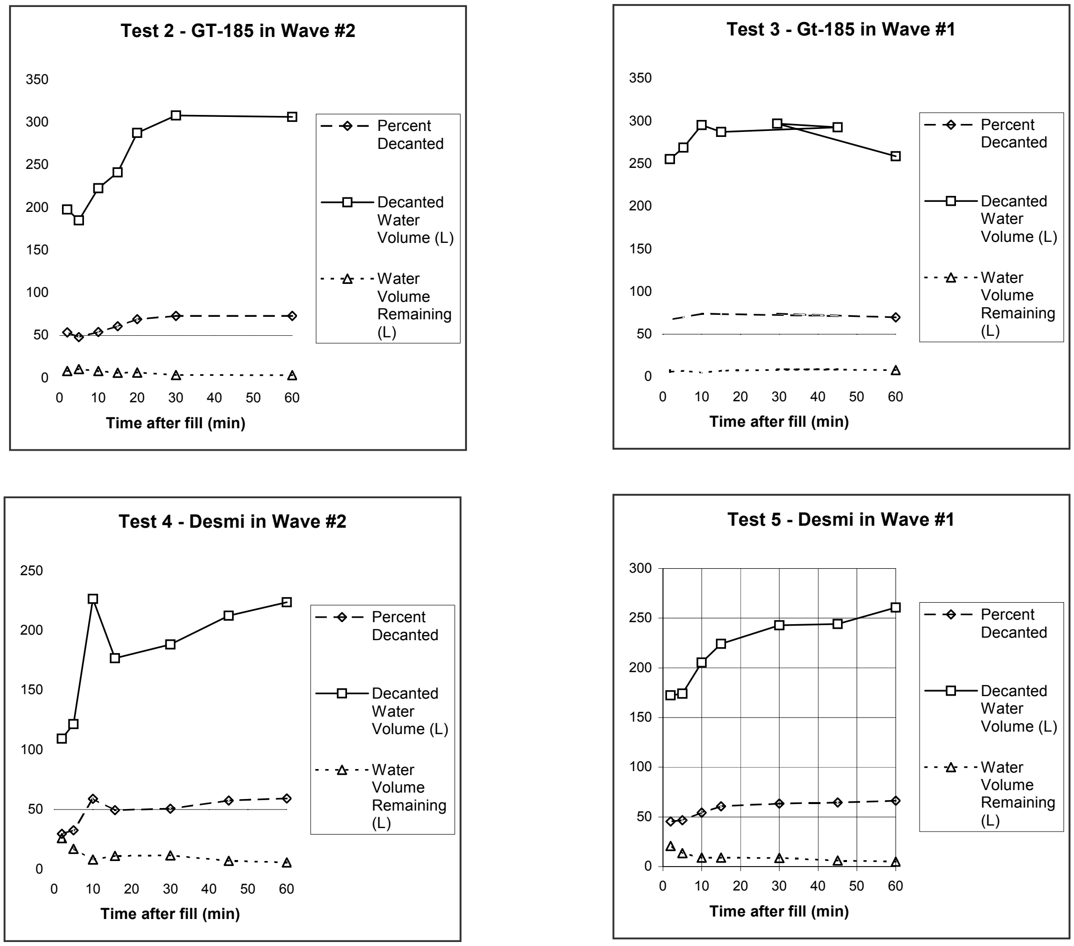


Figure 5 Water Removal from Fluid Recovered from 20 mm Calsol Slicks

Figure 6 shows the results obtained skimming in 100 mm thick Calsol slicks. Much less water was recovered by both skimmers because of the thicker slicks. In fact, no water was collected by the GT-185 operating in wave No. 1. In general a 60-minute delay time was sufficient to allow most of the water to separate out of the recovered fluid. The longer time to achieve primary break for the 100 mm thick slicks may be related to the form of the oil/water mixture entering the tank cells. In the case of the 20 mm slicks, the mixture was likely in the form of oil droplets mixed into a continuous water phase. In the 100 mm case it was probably the opposite (water droplets mixed in a continuous oil phase). The settling of water droplets through a viscous oil phase takes longer than the rise of oil droplets through water.

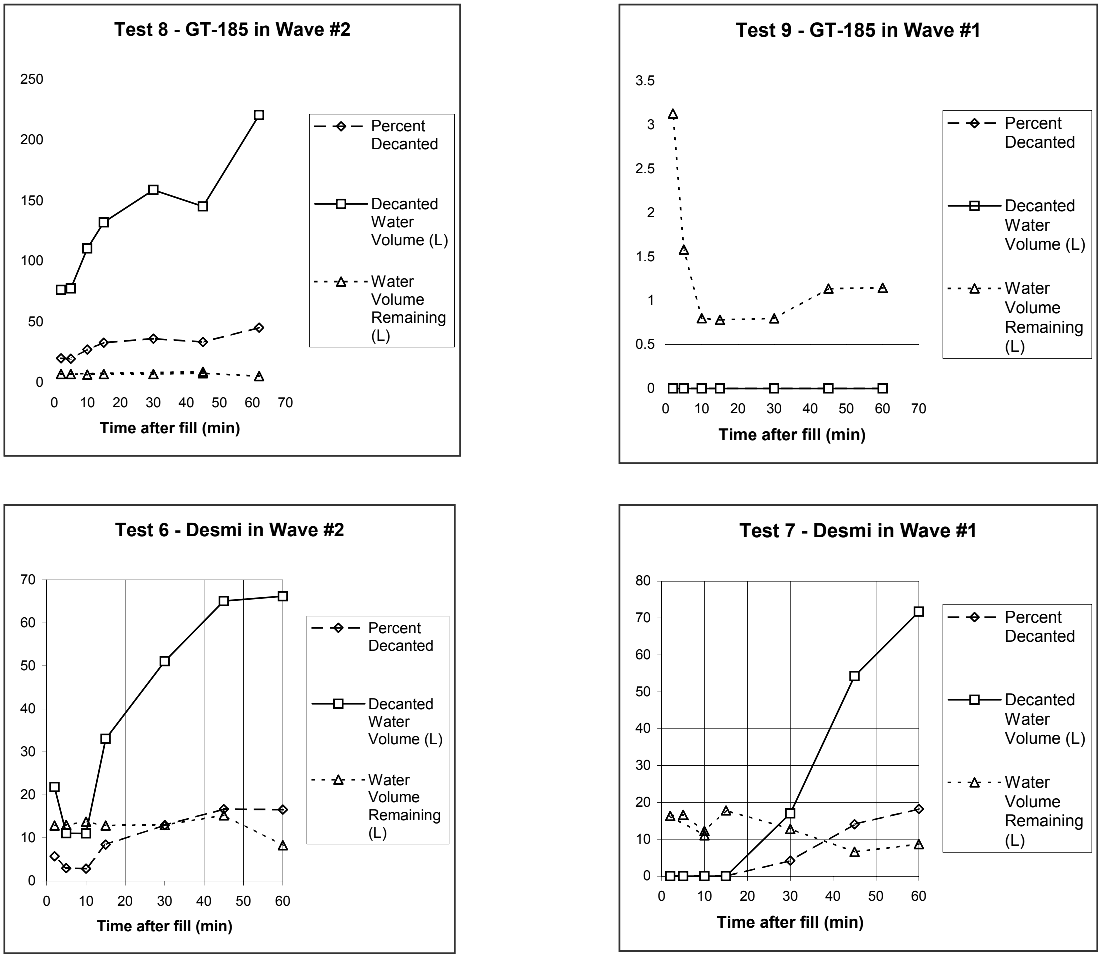
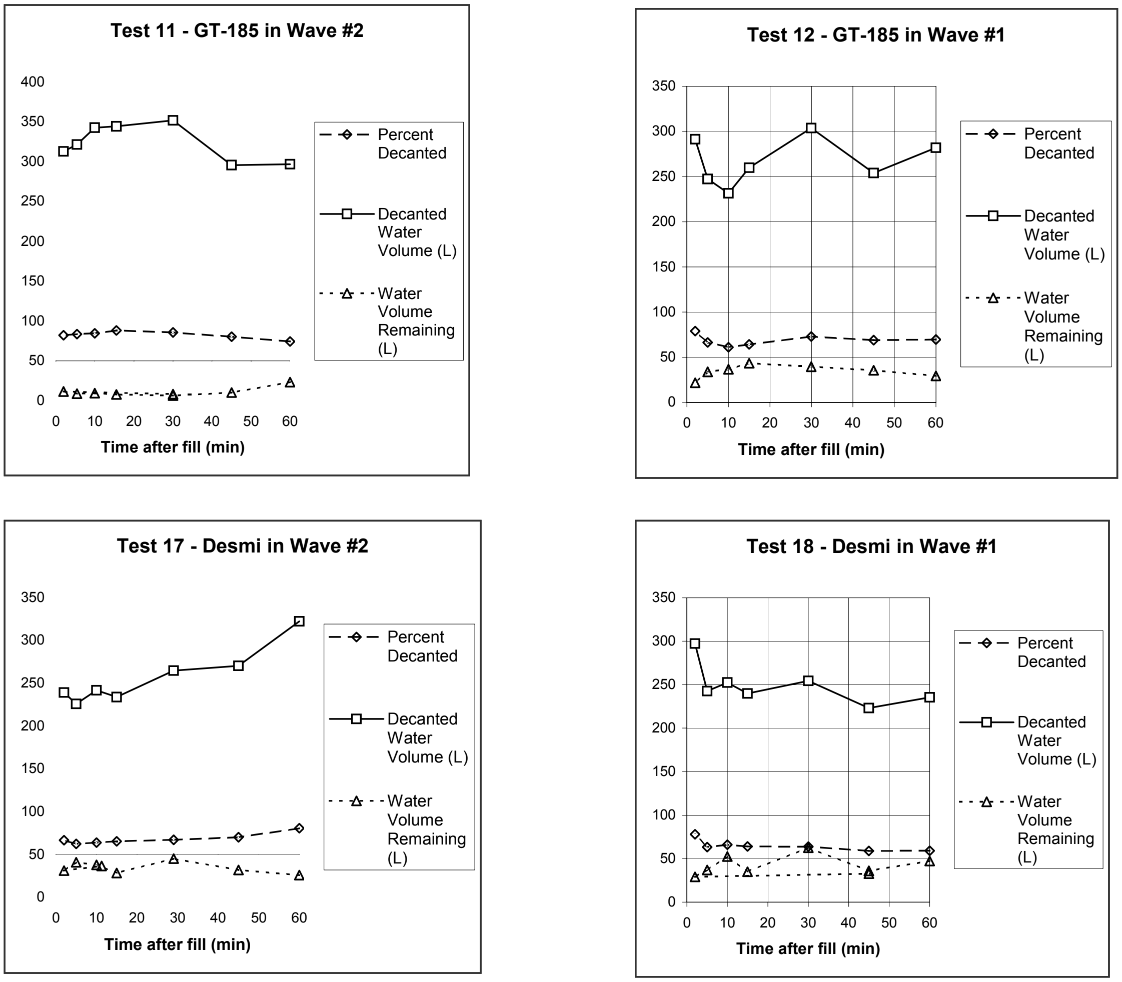


Figure 6 Water Removal from Fluid Recovered from100 mm Calsol Slicks

Figure 7 shows the results obtained with the skimmers operating in 20 mm thick Sundex slicks. The Sundex test oil was the most viscous of the three used. In these tests a considerable amount of water was collected and, because of the high viscosity of the oil the separation process was impeded and 30 to 50 L of water was retained in the fluid remaining in the cells. There is considerable scatter in the data in this Figure and it is difficult to determine the optimum decanting time; however, there appears to be little change in the percent decanted after the first 2 to 5 minutes.



Test 11 - GT-185 in Wave #2

Test 12 - GT-185 in Wave #1

Test 17 - Desmi in Wave #2

Test 18 - Desmi in Wave #1

Figure 7 Water Removal from Fluid Recovered from 20 mm Sundex Slicks

Figure 8 shows the results obtained in the 100 mm thick Sundex slicks. Much more water was recovered during these tests than during the comparable 100 mm thick Calsol slick tests. This is probably due to the higher viscosity of the Sundex oil making it more difficult for the oil to flow to, and over, the lip of the weir. Even after 60 minutes in some cases the percent decanted is still increasing. This is quite likely due to the high viscosity of the Sundex oil. The water droplets settling through the oil in the cells would require much longer to reach the oil/water interface than in the case of a less viscous oil. The differences in time to primary break between the 20 and 100 mm slicks may again relate to the form of the oil/water mixture entering the tank cells. In the case of the 20 mm slicks, the oil droplets are likely dispersed in a continuous water phase, which would allow for a rapid separation (as was the case in the previous small-scale tests - SL Ross 1998). In the case of the 100 mm thick slicks, the oil may have been the continuous phase, with water dispersed in it.

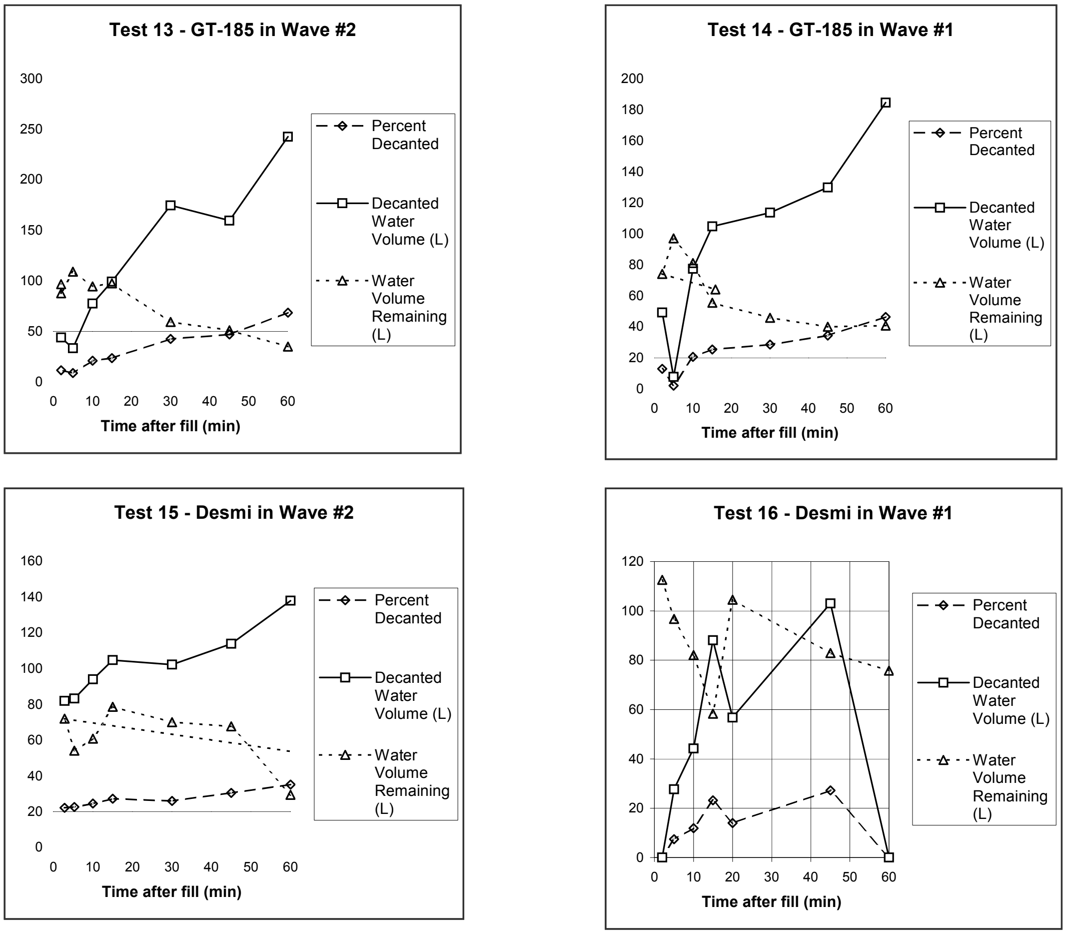


Figure 8 Water Removal from Fluid Recovered from100 mm Sundex Slicks

Figure 9 shows the water removal from fluid recovered from 20 mm thick Hydrocal slicks. The Hydrocal test oil was the least viscous of the three oils. Only results from the Desmi skimmer are available for these slicks; the GT – 185 skimmer was not available for the second week of tests. In both test 21 and test 22 the water removal is essentially complete after 15 minutes settling. The low viscosity of this test oil facilitated the separation and very little water remained in the cells after decanting.

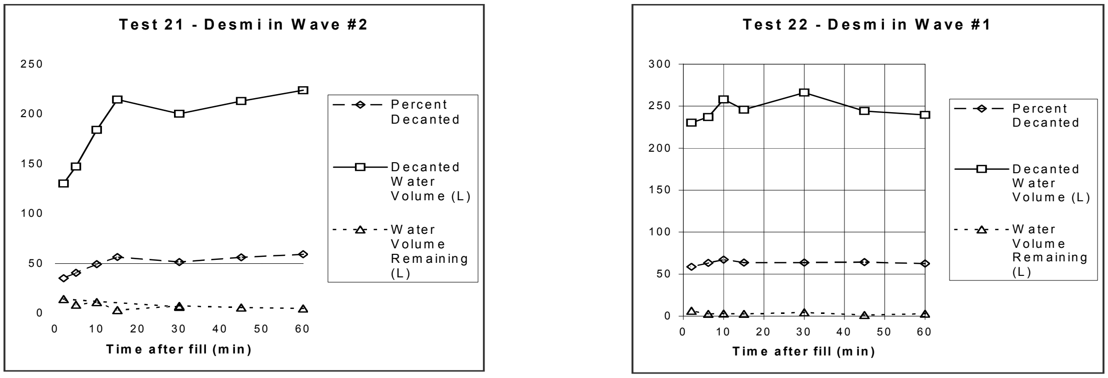


Figure 9 Water Removal from Fluid Recovered from 20 mm Hydrocal Slicks

Figure 10 examines the effect of doubling the recovered volume in wave No. 2 with the Desmi skimmer in 100 mm thick Hydrocal. In test 19, the cells were filled to a depth of approximately 500 mm; in test 20, cells were filled to a depth of approximately one metre. There was very little water decanted in either of these two tests; at the end of test 20 some water had separated and was decanted. It should be noted that in test 19 and test 20, there was some Sundex oil remaining in the boomed area. This may account for the high amount of water remaining in the cells after decanting, which would not normally be expected with this low-viscosity oil. The presence of the Sundex in the Hydrocal would promote stable emulsions. In general, there was little difference between test 19 and test 20; doubling the volume collected appears to have had little effect on decanting.

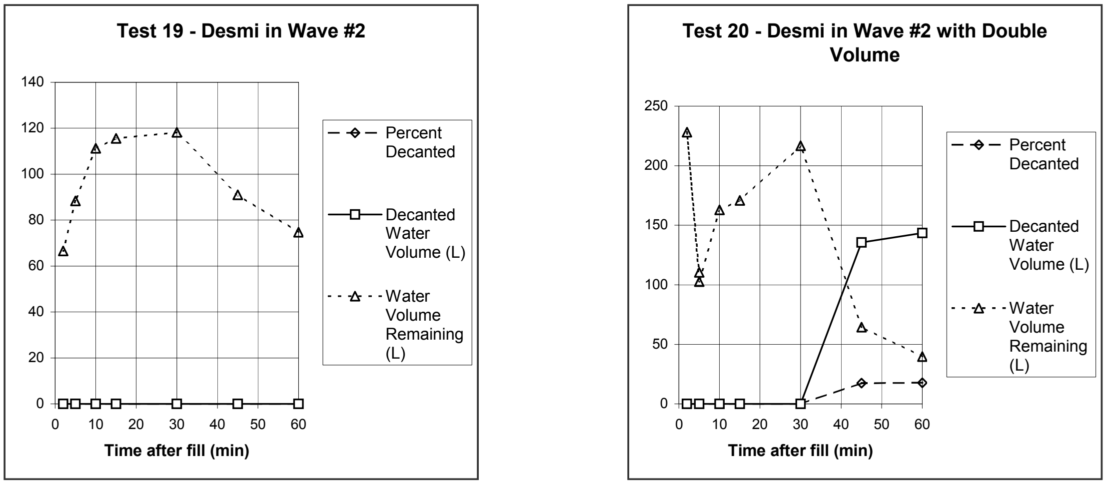


Figure 10 Water Removal from Fluid Recovered from100 mm Hydrocal Slicks

Other tests (not reported in detail here) examined the effect of doubling the volume recovered in 20 mm Hydrocal slicks. Other than the increased volume of water decanted with the larger volume collected there was very little difference in the percentage of water recovered. As with the previous tests shown above, it appears that there was little effect on decanting of doubling the volume of fluid recovered. Tests were also conducted to compare the decanting process in static conditions with decanting from a tank mounted on a small boat to in waves. The data for these may be found in the project report (SL Ross 1999). The data indicates that there was no significant difference in percent decanted in waves compared with static conditions.

5.3 Oil Concentrations in the Decanted Water

This section reviews the results obtained by analysing the oil content of the decanted water from samples taken at different times throughout the separation process.

Figure 11 compares the measured oil content of the decanted water from 20 mm thick Calsol slicks at 2, 30 and 60 minutes after each cell was filled. The lines shown on each graph are a least-squares fit to the data and are intended only to illustrate the trend in oil concentrations over time. For the GT - 185 skimmer tests the initial concentration of oil in the water ranged from 2500 to 3,000 mg/L The concentration of oil in the water declined to approximately 1000 mg/L after 60 minutes. The results from the Desmi skimmer indicated that the initial oil concentrations were in the 1400 to 1800 mg/L range; declining to about 1000 mg/L after one hour's settling. The duplicate data points at 60 minutes in test 5 give an estimate of the reproducibility of the analytical technique.

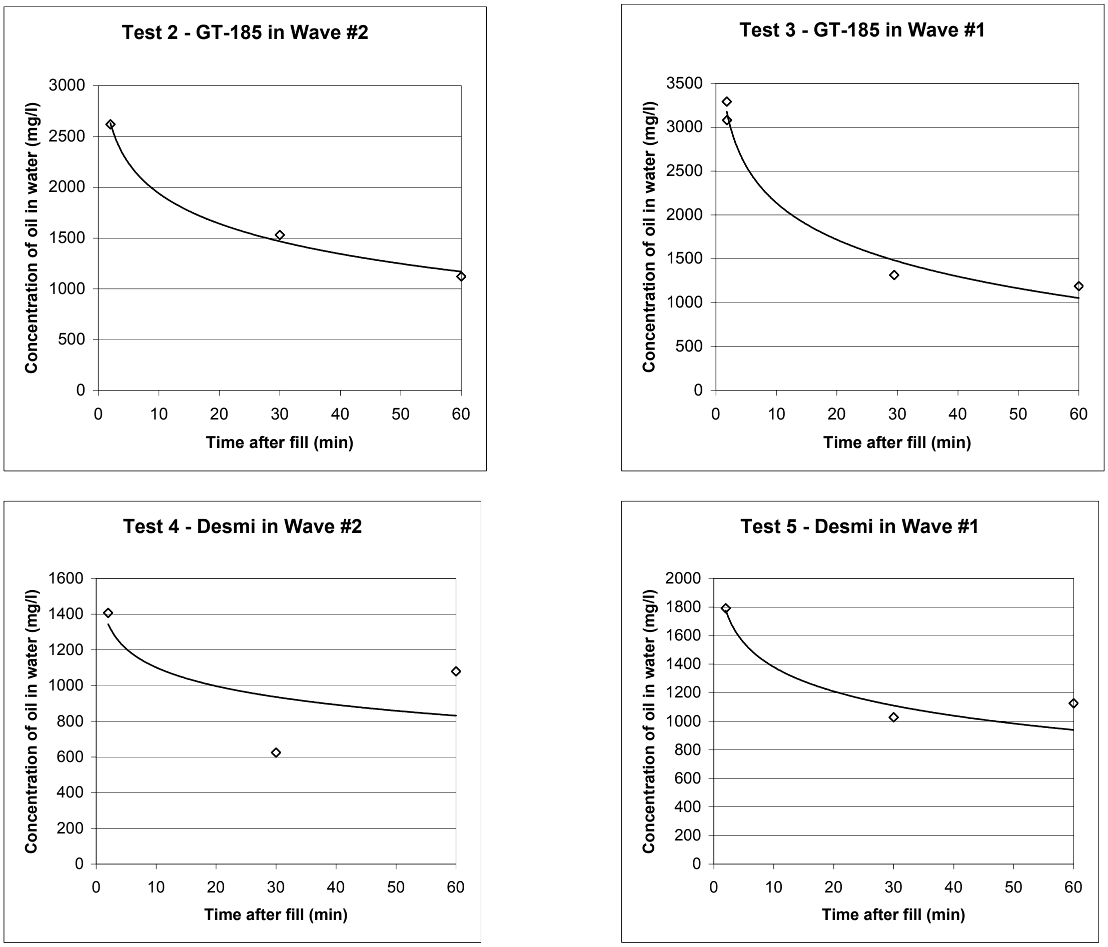


Figure 11 Oil Content of Decanted Water from 20 mm Calsol Slicks

Figure 12 shows the data obtained when skimming in the 100 mm thick slicks of Calsol. Note that only three data sets are plotted because no water samples were collected during test No. 9 with the GT -185 skimmer in wave No. 1. The results for the GT – 185 skimmer in wave No. 2 were very similar to those for the previous set in the 20 mm thick Calsol slicks. The data from the 100 mm Calsol Desmi skimmer tests was too scattered to determine trends; however, the concentrations measured are in the same range as those measured for the 20 mm thick Calsol slicks with the Desmi skimmer.

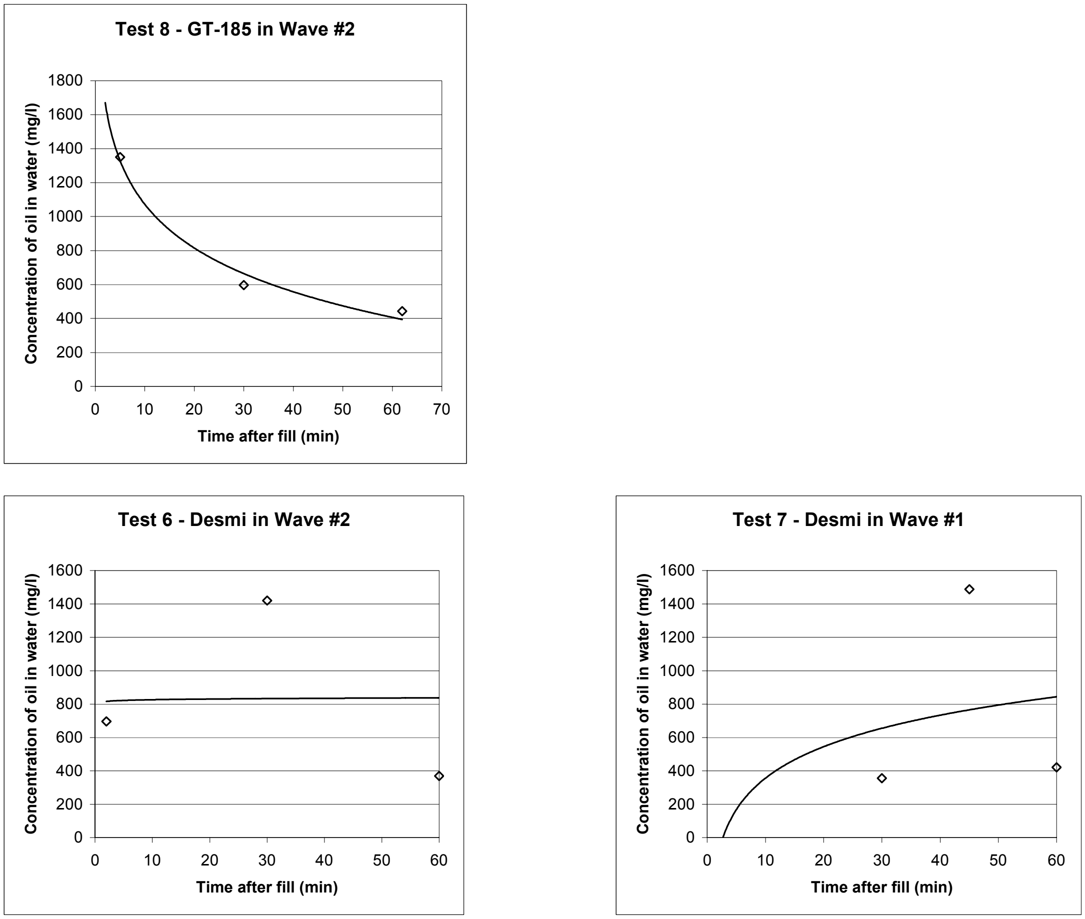


Figure 12 Oil Content of Decanted Water from 100 mm Calsol Slicks

Figure 13 shows the results from the 20 mm thick Sundex slicks. All the oil in water concentrations measured for this oil were much lower than those measured with the Calsol. This is probably due to the higher viscosity of this Sundex oil making it more difficult to produce small oil droplets that could be dispersed into the water for a long period of time. For the GT -185 skimmer operating in wave No. 2 initial oil concentrations were approximately 450 mg/L at 2 minutes declining to 100 mg/L after 60 minutes of settling. In wave No. 1 the concentration of oil in the water remained at 100 to 160 mg/L over the one-hour settling time.

The results for the Desmi skimmer operating in waves No. 2 show a decline in oil in water concentration from an initial value of 100 to approximately 20 mg/L over the 60-minute settling period. In wave condition No. 1 the concentration of oil in the decanted water stayed at approximately 40 to 50 mg/L over the one-hour test.

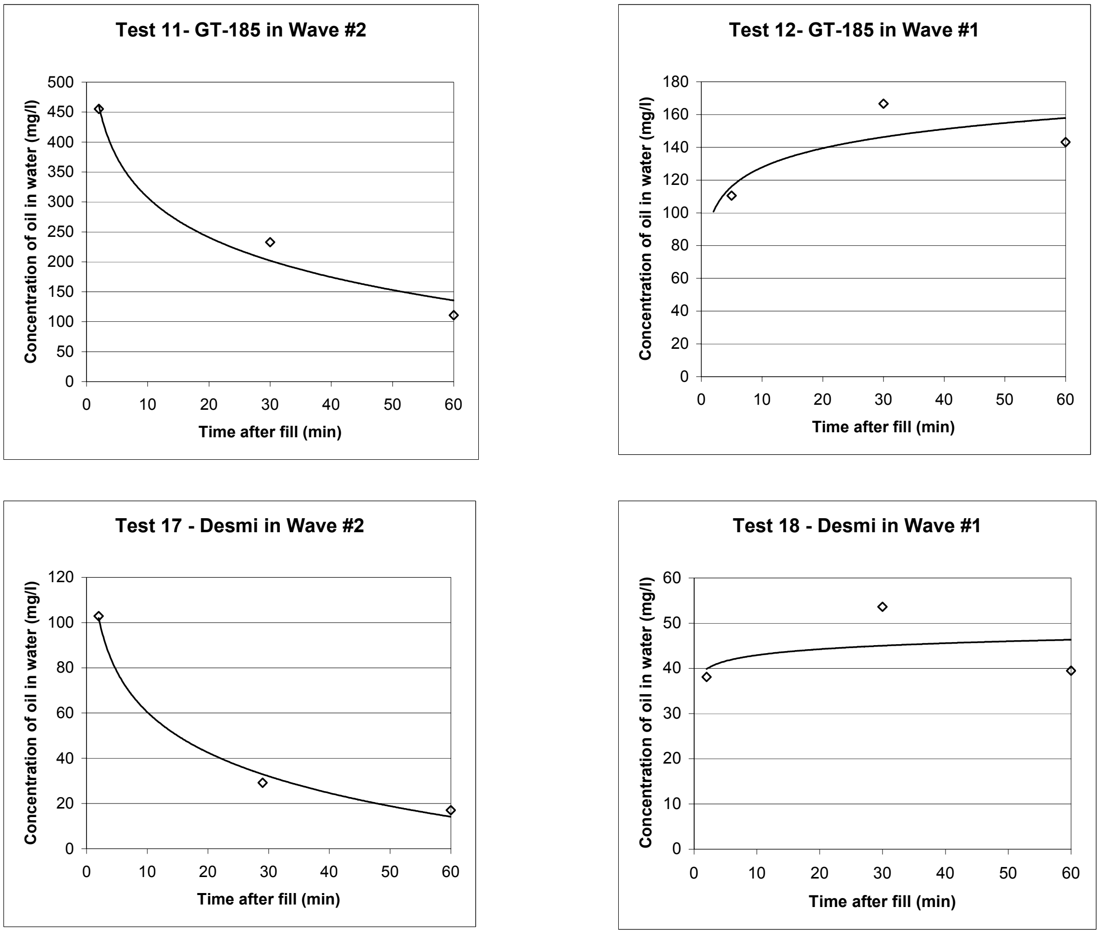


Figure 13 Oil Content of Decanted Water from 20 mm Sundex Slicks

Figure 14 shows the results of the tests in the 100 mm thick Sundex slicks. The results for both the tests with the GT - 185 skimmer gave concentrations in the 100 mg/L range, except for one reading of 250 mg/L, over the entire settling time. The results for the Desmi skimmer indicated a decline from an initial high of 200 mg/L to 100 mg/L over 60 minutes.

Figure 15 shows the results of the tests with the Desmi skimmer in 20 mm thick slicks of Hydrocal. Note that the GT - 185 skimmer was not tested with the Hydrocal oil. The results show a decline from initial oil concentrations of approximately 1000 mg/L to about 200 mg/L over the 60-minute settling time.

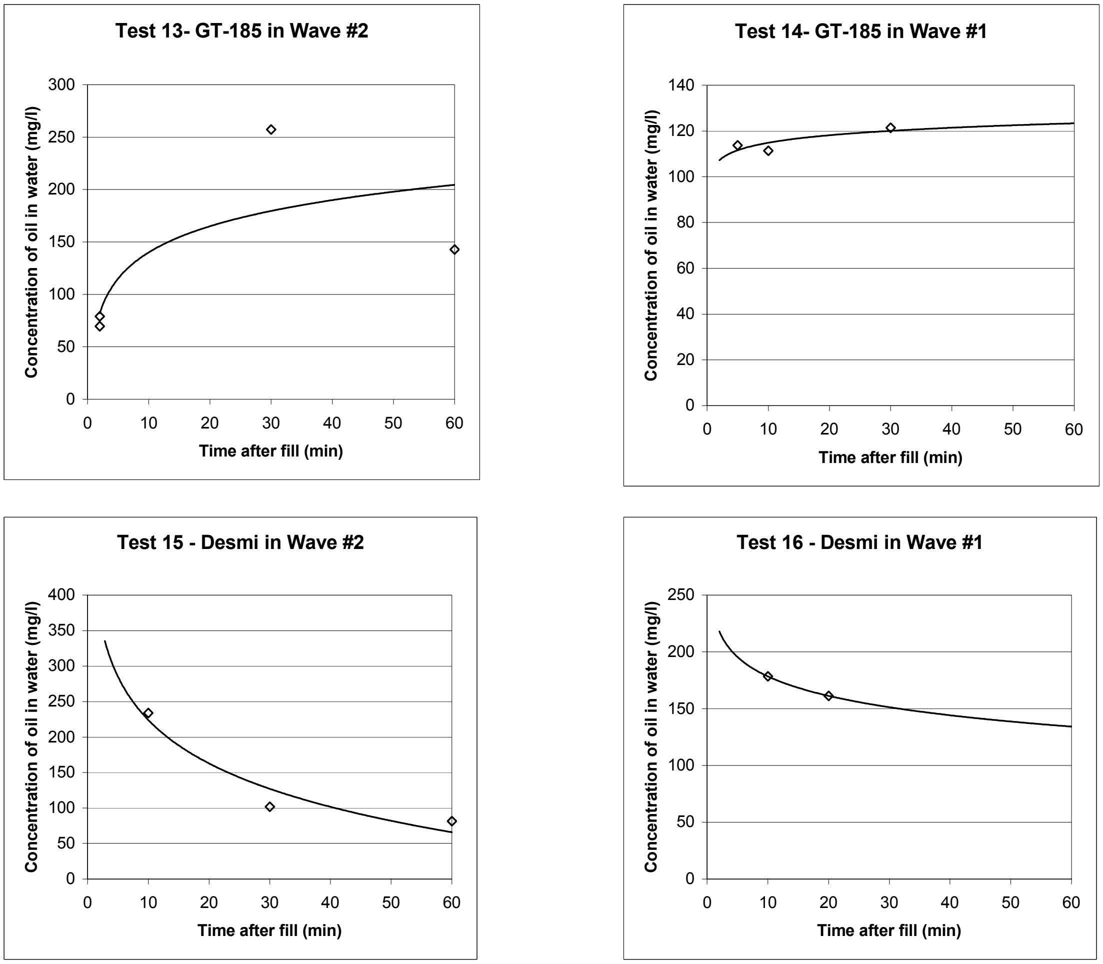


Figure 14 Oil Content of Decanted Water from 100 mm Sundex Slicks

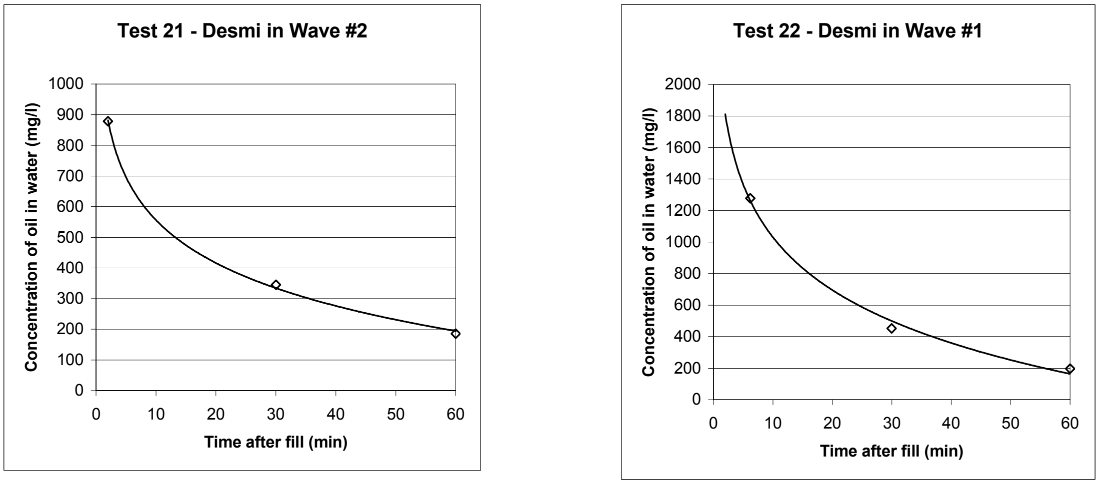


Figure 15 Oil Content of Decanted Water from 20 mm Hydrocal Slicks

Figure 16 shows the results for the Desmi in wave No. 1 with 100 mm thick Hydrocal slicks. No water samples were collected during the tests with the Desmi in wave No. 2 with this slick. As was shown in Figure 15, after 45 to 60 minutes the oil water concentration had declined to approximately 200 mg/L

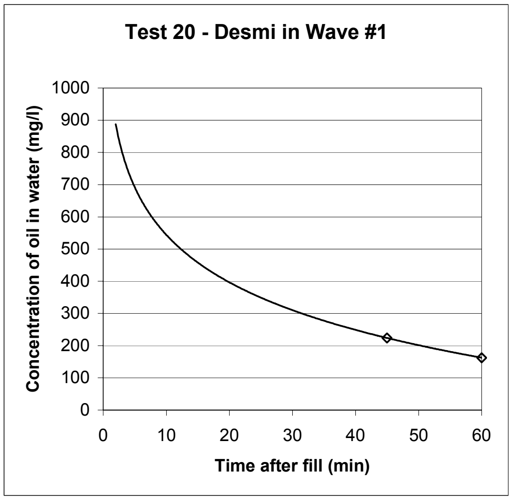


Figure 16 Oil Content of Decanted Water from 100 mm Hydrocal Slick

Tests were conducted with 20 mm slicks of Hydrocal to examine the effect of increased volume [increased height of fluid in a cell] on the concentration of oil in the decanted water. The data from these tests may be found in the project report (SL Ross 1999). There did not appear to be an appreciable difference in oil concentrations. In all four tests the initial oil concentrations were in the 1000 to 2000 mg/L range and declined to 200 mg/L after 60 minutes.

Figure 17 shows the effect of extending the settling time to 24 hours. With the Hydrocal and Calsol test oils, 24 hours of settling reduced the oil in water concentration from approximately 1000 mg/L down to 30 to 70 mg/L For the Sundex oil, a 24-hour settling period reduced the concentration of oil in the decanted water from about 100 mg/L to the 2 to 20 mg/L range.

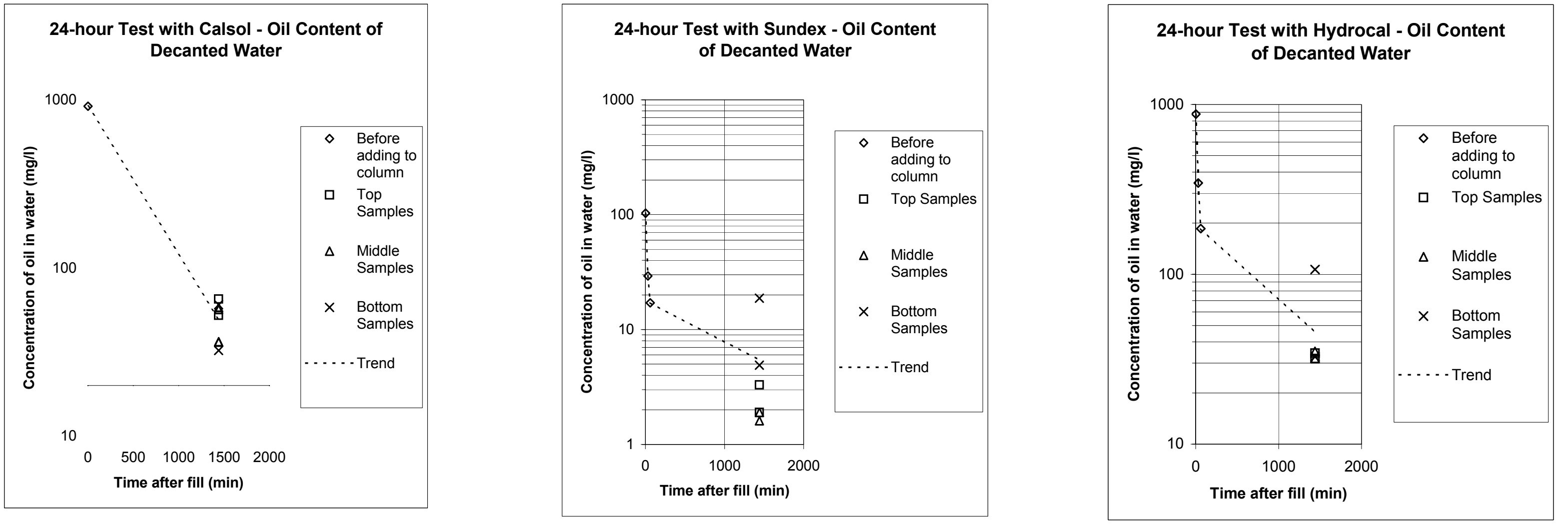


Figure 17 Decrease in Oil Concentration of Decanted Water over 24 Hours

6.0 Conclusions

For the thin slicks of the less-viscous oils the separation of the water from the recovered fluid was essentially complete in 15 to 30 minutes. Up to 60 minutes was required for separation with the thicker, more-viscous slicks.

For the thin slicks, the trend appeared to be faster separation with increasing oil viscosity. This was probably because the recovered product was oil droplets entrained in a continuous water phase. The more viscous the oil the larger the oil droplets in the water; larger oil droplets rise faster than smaller ones.

For the thick slicks, the situation appeared to be different. With these slicks, much less water was recovered by the skimmers, and it is likely that the recovered fluid stream consisted of water droplets suspended in a continuous oil phase. In this case oil viscosity controlled the settling rate: higher oil viscosities meant longer settling times. With the highest viscosity oil, the water was apparently semi-permanently emulsified in the oil and did not settle appreciably over the 60-minute test time.

Doubling the volume of fluid placed in the tank cell [equivalent to doubling the height of the fluid in the tank cell] had no discernible effect on decanting times or the final percent water decanted. Agitating the receiving tank with wave action also had no discernible effect on water separation rate or amount.

The highest concentrations of oil in the decanted water occurred when skimming Calsol slicks. Initial concentrations were in the 1400 to 3000 mg/L range. These declined to 400 to 1000 mg/L after one hour of settling. The lowest concentrations of oil in the decanted water were for the Sundex oil. In these tests, the concentrations were initially in the 100 to 450 mg/L range, declining to about 50 to 150 mg/L after 60 minutes of settling. When skimming Hydrocal the concentrations of oil in the decanted water were initially about 1000 mg/L. These declined to approximately 200 mg/L after one hour. Allowing 24 hours settling further reduced oil concentrations in the decanted water to 30 to 70 mg/L for Calsol, 2 to 20 mg/L for Sundex and 30 to 100 mg/L for the Hydrocal test series.

Doubling the volume of fluid recovered in each cell did not appreciably affect the oil - in - water concentrations.

7.0 Recommendations

- An additional test series with emulsions, and emulsion breakers, should be considered. The concept here is that the available temporary storage space could be further extended by using chemical emulsion breakers to cause the water-in-oil emulsion to break followed by decanting of the water separated from the emulsion.
- A small number of tests should be conducted with a large storage container (with greater water column heights) to confirm the results with the Ohmsett test oils.
- Similar tests should be conducted with fresh and weathered crude oil(s) and diesel fuel to confirm the applicability of the results to these commonly-transported oils.
- Simple, effective and rugged methods to reduce the oil content of rapidly-decanted water should be researched.

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9.0 Disclaimer

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10.0 References

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