APPENDIX A – Figures and Photo Documentation

Figure 1 Parallel Turner 10 AU fluorometers (with intakes at 1 and 2-m) used for OHMSETT heavy fuel oil studies.

Figure 2 WET Labs in situ fluorometer

Figure 3 Close up of WET Labs fluorometer

Figure 4 LISST – 100 Particle Size Analyzer with WET Labs Fluorometer attached.

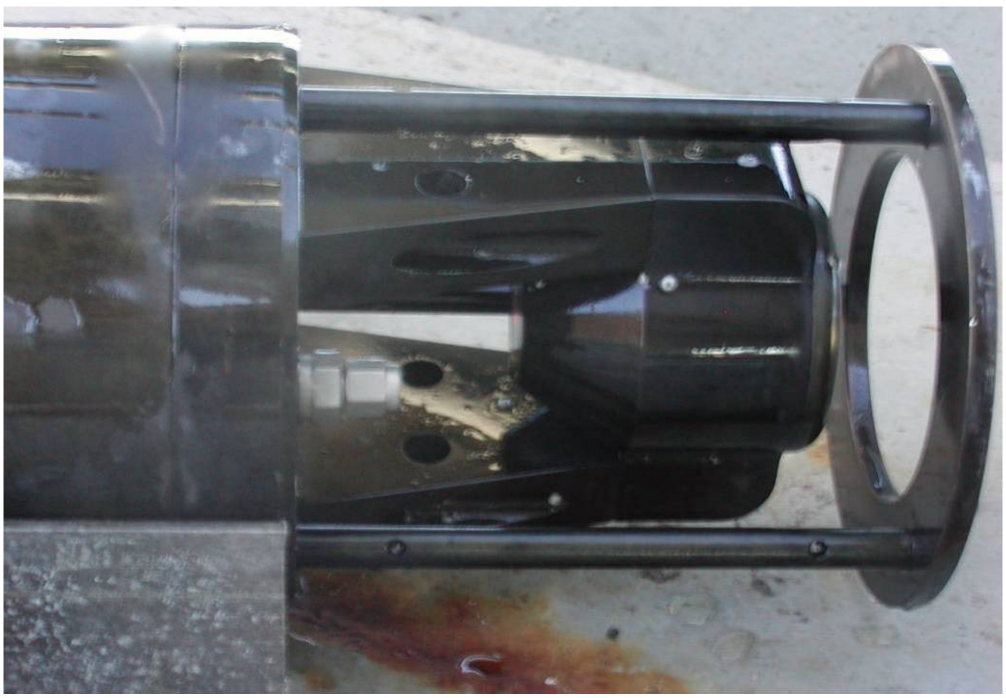

Figure 5 Close up of LISST – 100 Particle Size Analyzer

NAME
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DATE
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TIME
……………………………………………………

Rank	Standard Phrase	Description	10 mins	20 mins	30 mins
1	**No obvious dispersion**	Dispersant being washed off the black oil as white, watery solution leaving oil on surface. Quantity of oil on sea surface not altered by dispersant			
2	**Slow or partial dispersion**	Some surface activity (oil appearance altered). Spreading out of oil. Larger droplets of oil (1 mm in diameter or greater) seen rapidly rising back to sea surface, but overall quantity appears to be similar to that before dispersant spraying			
3	**Moderately rapid dispersion**	Quantity of oil visibly less than before spraying. Oil in some areas being dispersed to leave only sheen on sea surface, but in other areas still some oil present.			
4	**Very rapid and total dispersion**	Oil rapidly disappearing from surface. Light brown plume of dispersed oil visible in water under the oil and drifting away from it			

OTHER COMMENTS

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Figure 6 Blank score sheet used by independent observers to document visual observations of the surface oil and any subsurface oil plume generated during each experiment (from Alun Lewis Consultancy).

Figure 7 Calibration of LISST particle size analyzer and WET Labs fluorometer.

Figure 8 OHMSETT Wave Tank cleanup before testing on October 13, 2003.

Figure 9 Removal/herding remaining surface oil (outside of the test area) before testing – October 13, 2003.

Figure 10 Removal of remaining surface oil from inside secondary containment boom before test initiation on October 13, 2003.

Figure 11 Cleaned tank before initiation of dispersant trials, October 13, 2003.

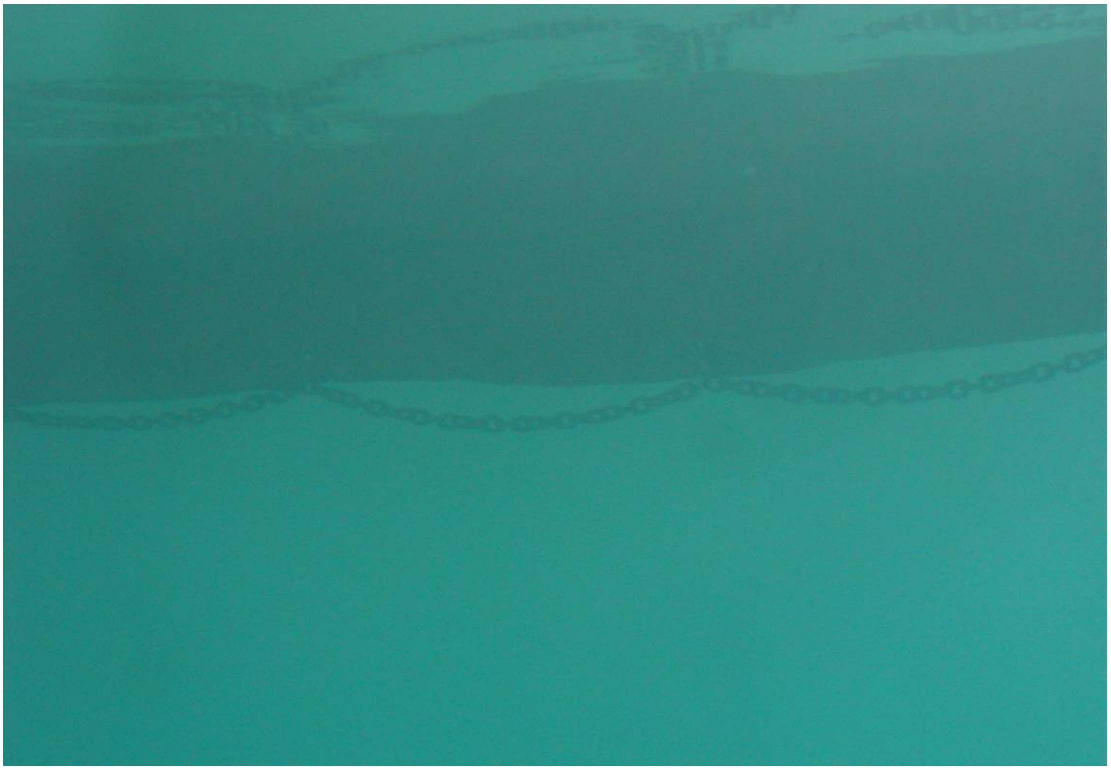

Figure 12 View of anchor-chain-weighted containment boom from under-water window 6-8 feet from boom showing water clarity before initiation of dispersant testing October 13, 2003.

Figure 13 Test tank before initiation of control test with IFO 180 fuel oil and no dispersant, October 13, 2006. The wave generator had not yet been turned on. Photographed looking north.

Figure 14 Wave train before initiation of control test (No. 10) IFO 180 fuel oil, no dispersant, and wave generator set at 33 cycles per minute (cpm). Note trace of oil that was washed off/dripped from oil application manifold before test was started. Photographed looking south toward wave generator.

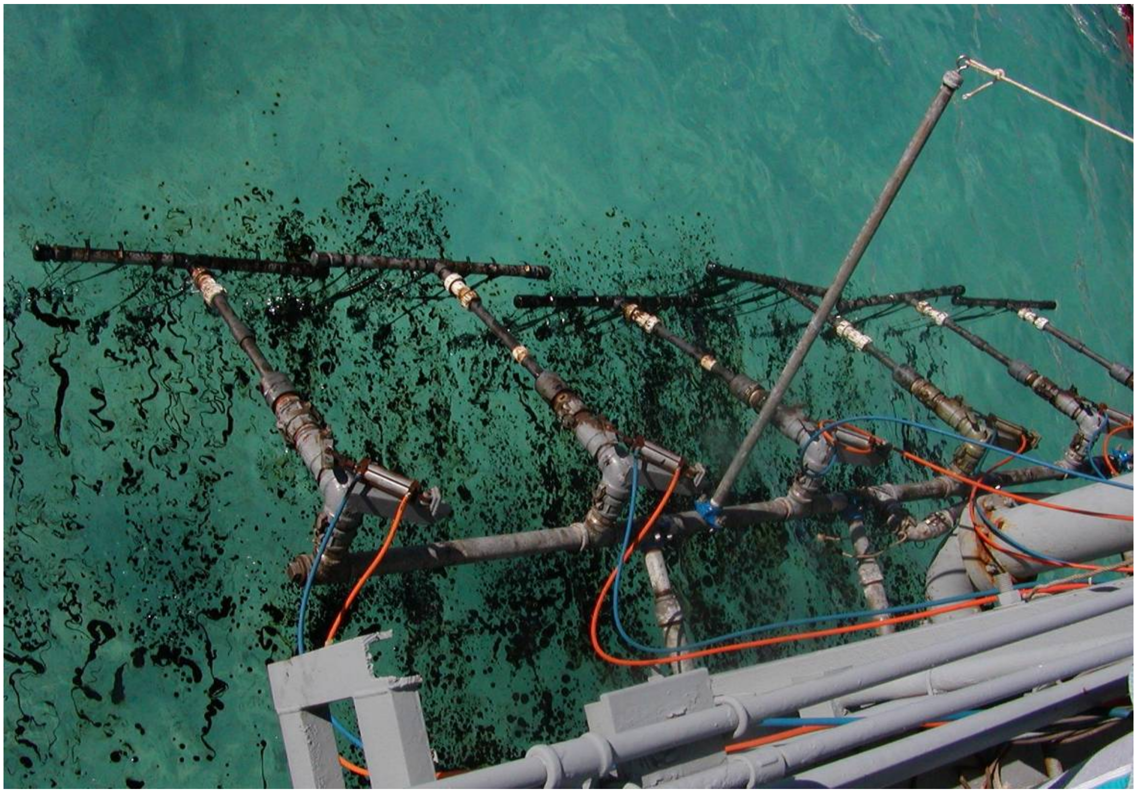

Figure 15 Introduction of IFO 180 fuel oil from oil manifolds beneath movable bridge at initiation of Test No. 10.

Figure 16 Untreated IFO 180 control slick (~15-20 seconds after application to the water surface.

Figure 17 IFO 180 control slick ~50-60 seconds after introduction to tank (looking north)

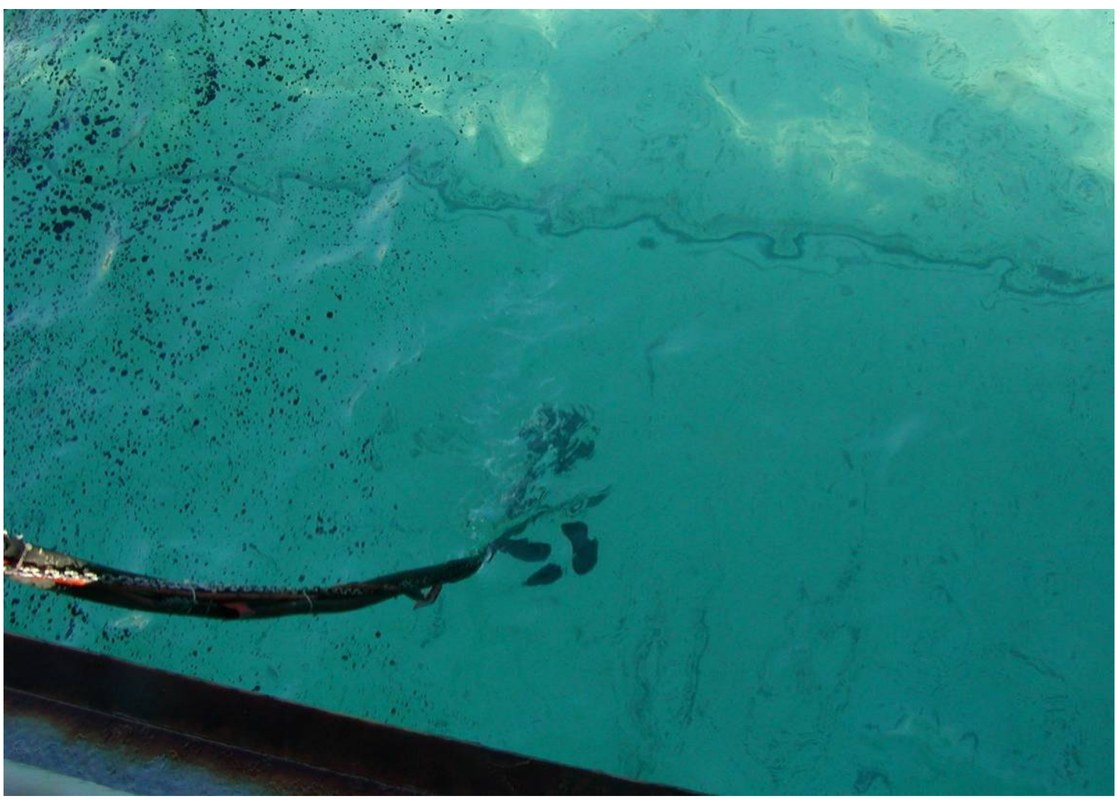

Figure 18 LISST particle size analyzer and WET Labs fluorometer suspended from movable bridge (2 m depth) during control Test No. 10. Note surface oil but no oil cloud below surface.

Figure 19 IFO 180 control slick approximately 15 minutes after initiation of Test No. 10 (looking north). The darker water on the right is due to the shadow from the edge of the tank.

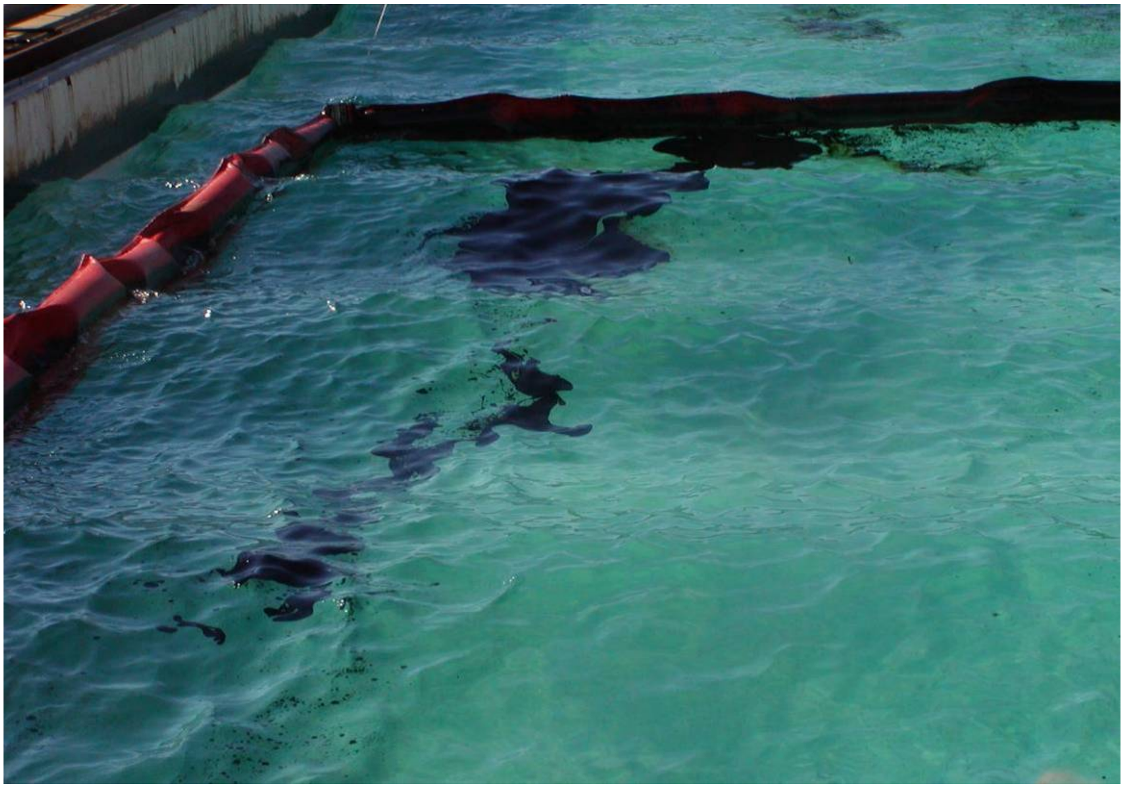

Figure 20 IFO control slick approximately 20 minutes after initiation of Test No. 10 (looking south toward wave generator). The darker water on the left is due to the shadow from the edge of the tank.

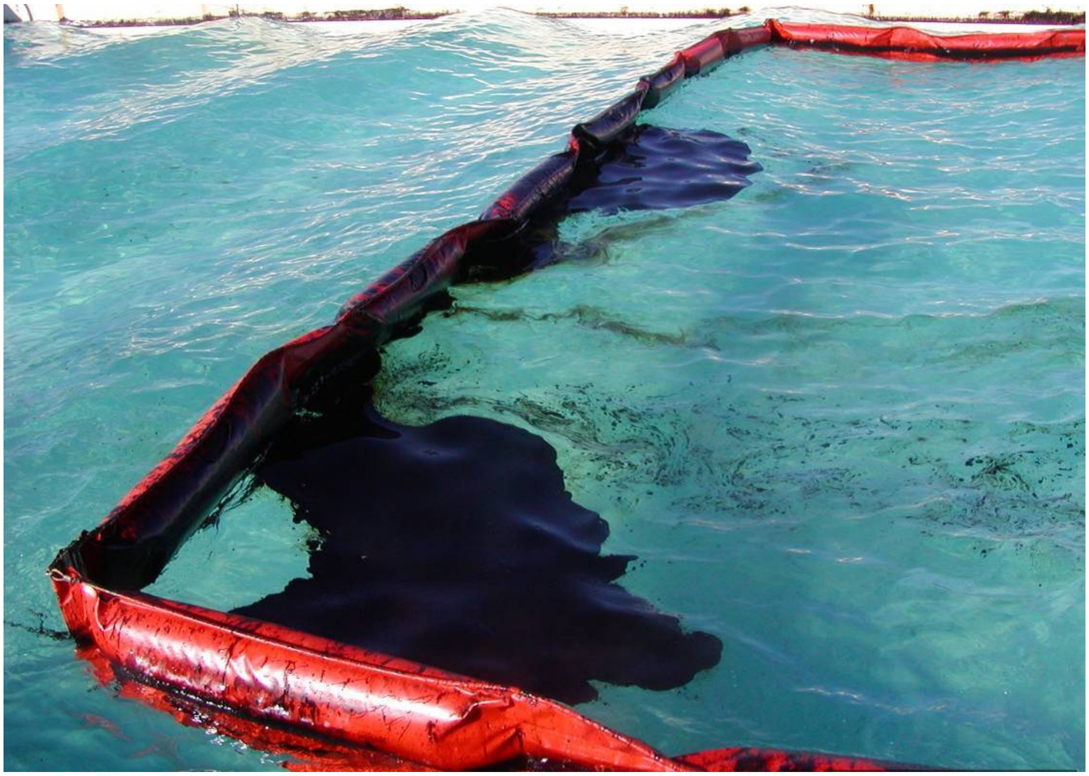

Figure 21 Captured oil at south end of test enclosure boom at termination of IFO 180 control Test No. 10.

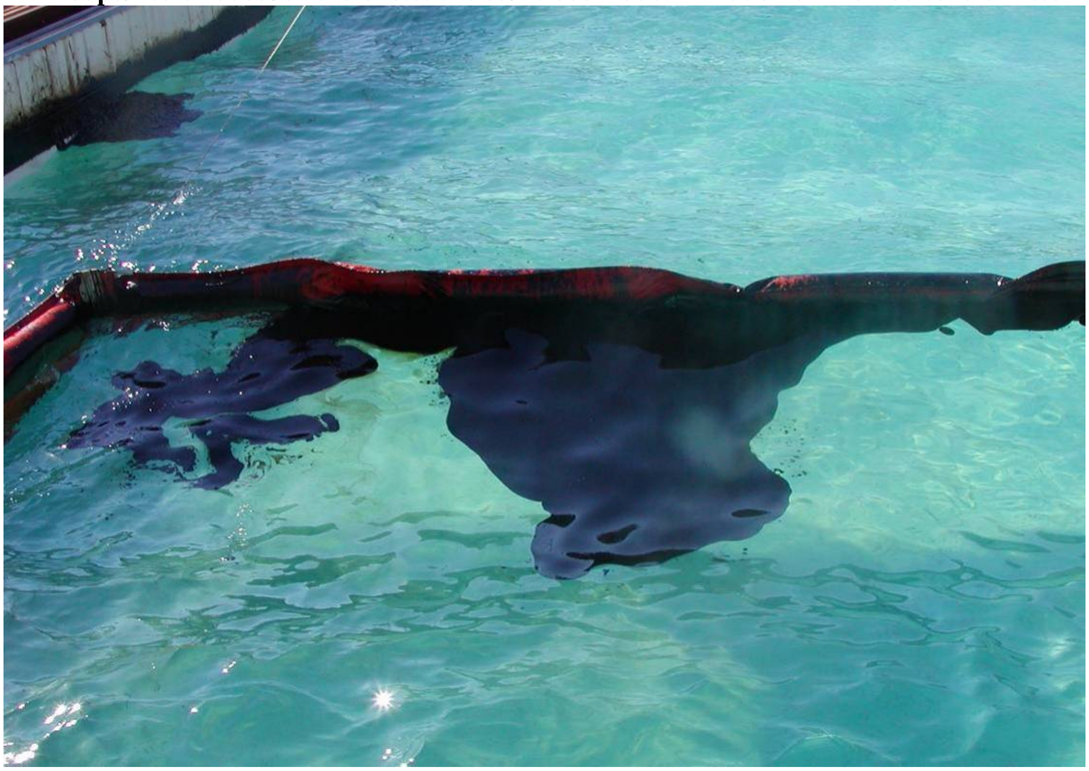

Figure 22 Captured oil at south end of test enclosure boom after waves turned off at termination of control Test No. 10. Note the minor amount of oil outside the test boom adjacent to tank wall. It is not known if this oil escaped the containment boom during the test or it was released from the wave generator where it might have been trapped after an earlier run.

Figure 23 Set-up for Test 11: IFO 180 fuel oil, AGMA DR dispersant (nominal DOR 1:50), wave generator at 30 cpm.

Figure 24 IFO 180 fuel oil addition to tank for Test No. 11 at 11:28:22 hrs, October 13, 2003.

Figure 25 Test No. 11: Dispersant spray boom and in situ fluorometer cable 14 seconds into test.

Figure 26 Test No. 11: Minor (and anomalous) dispersion/entrainment of IFO 180 fuel oil due to turbulence introduced by dragging fluorometer cable through dispersant-treated surface oil.

Figure 27 **Test 11: Dispersant-treated IFO 180 ~ 40 seconds into experiment. Note lack of any significant oil entrainment into the water column.**

Figure 28 **Test 11: Dispersant-treated IFO 180 ~50 seconds into experiment. Still no significant oil entrainment with this dispersant under these test conditions.**

Figure 29 Test No. 11: Still no dispersion/entrainment ~ 2.5 minutes after dispersant treatment.

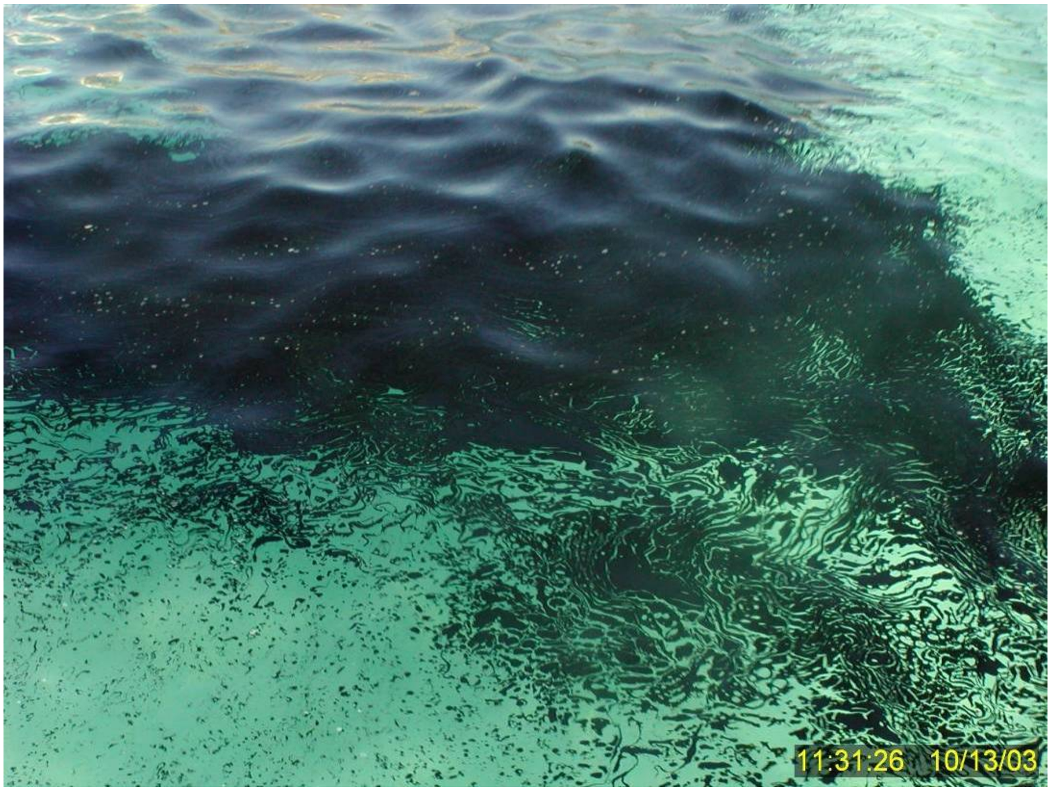

Figure 30 Test No. 11: Close-up of non-dispersing IFO 180 ~ 3 minutes after dispersant treatment.

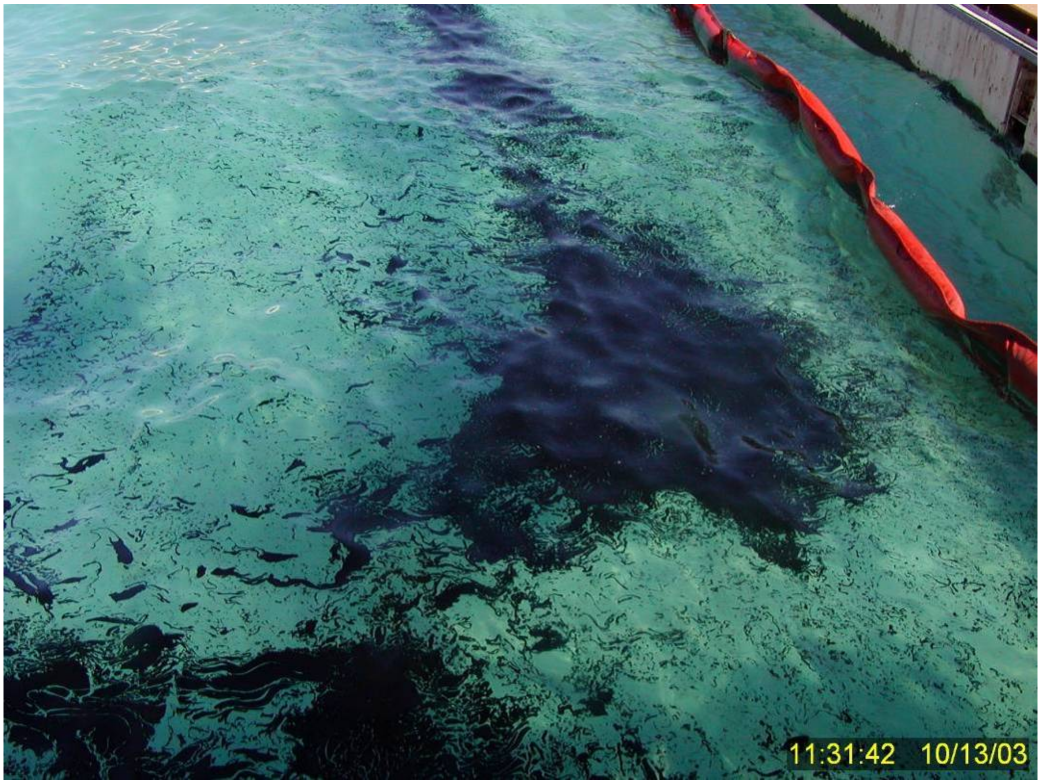

Figure 31 Test No. 11: Drift of non-dispersing IFO 180 ~ 3.25 minutes after treatment.

Figure 32 Test No. 11: Close-up photo of surface slick from Figure 31. Note the lack of any oil entrainment into the water column with this poorer performing dispersant under these test conditions.

Figure 33 Test No. 11: Non-dispersed IFO 180 fuel oil driven by wind to south-east corner of experimental containment boom. Note the water clarity and the lack of any oil outside the test area.

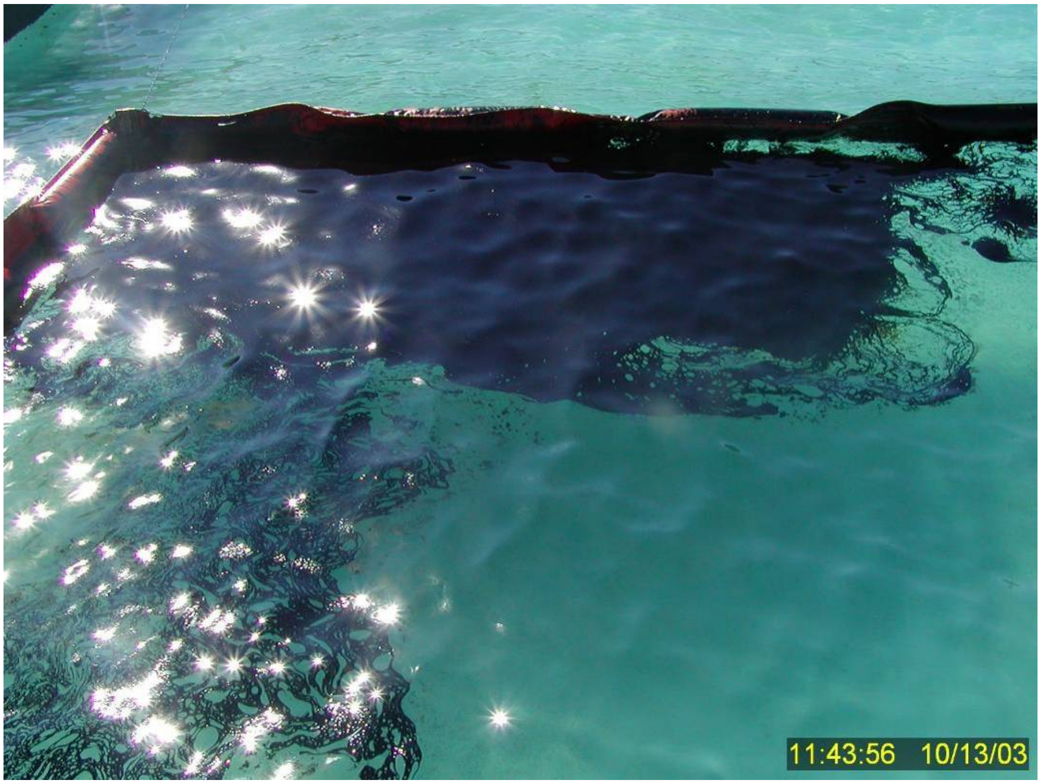

Figure 34 Test No. 11: Close up of non-dispersed surface oil in south-east corner of test boom ~ 22 minutes after initiation of the test. Note the lack of any oil outside the boom.

Figure 35 Test 11: Non-dispersed IFO 180 fuel oil within containment boom ~30 minutes after the conclusion of the test. By this time some residual IFO 380 oil from earlier tests had drifted against the outside of the containment boom used for the test.

Figure 36 Test 11: Close-up of southeast corner of containment boom showing the different appearance of the residual IFO 380 from earlier tests with the non-dispersed IFO 180 from Test 11 before recovery.

Figure 37 Test No. 11: Use of fire monitor spray to herd surface oil into corner of boom to facilitate recovery by vacuum. Note the spray is directed to water surface 10-15 feet from oil to avoid accidental entrainment.

Figure 38 Test No. 11: Use of squeegee to obtain thicker oil slick to facilitate vacuum recovery.

Figure 39 Test No. 11: Squeegee and vacuum hose recovery of surface oil at termination of test.

Figure 40 Test No. 11: Vacuum recovery of non-dispersed surface oil at conclusion of test. A separate oil drum (on left) is used to contain the oil from each test to allow later quantification of recovered oil after allowing for oil/water separation. Collected oil is analyzed for water content by the lab at OHMSETT.

Figure 41 **Initiation of Test No. 12: IFO 180 fuel oil treated with Agma at measured DOR of 1:148 and higher-energy waves at 33.3 cpm.**

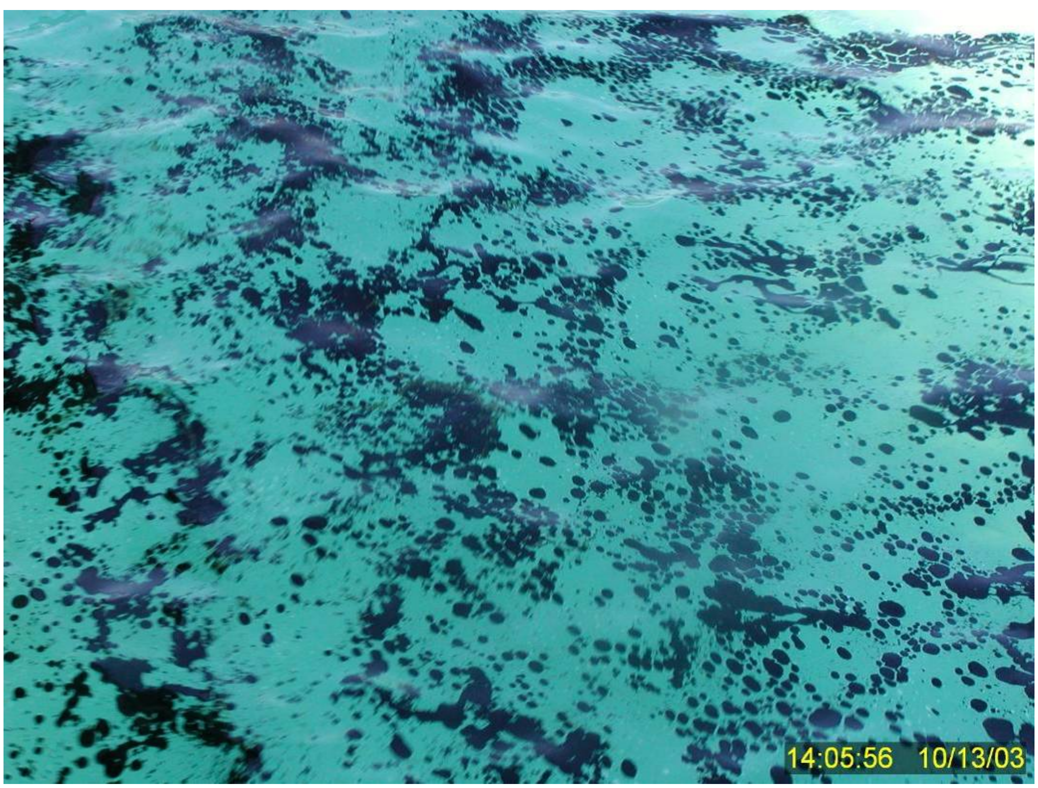

Figure 42 **IFO 180 from Test No. 12 one minute after treatment with Agma dispersant. Note lack of oil spreading resulting in significant dispersant hitting the water rather than the oil (lower DOR).**

Figure 43 Test No. 12: IFO 180 four minutes after treatment with Agma dispersant. Note water clarity and lack of significant dispersion/entrainment into the water column.

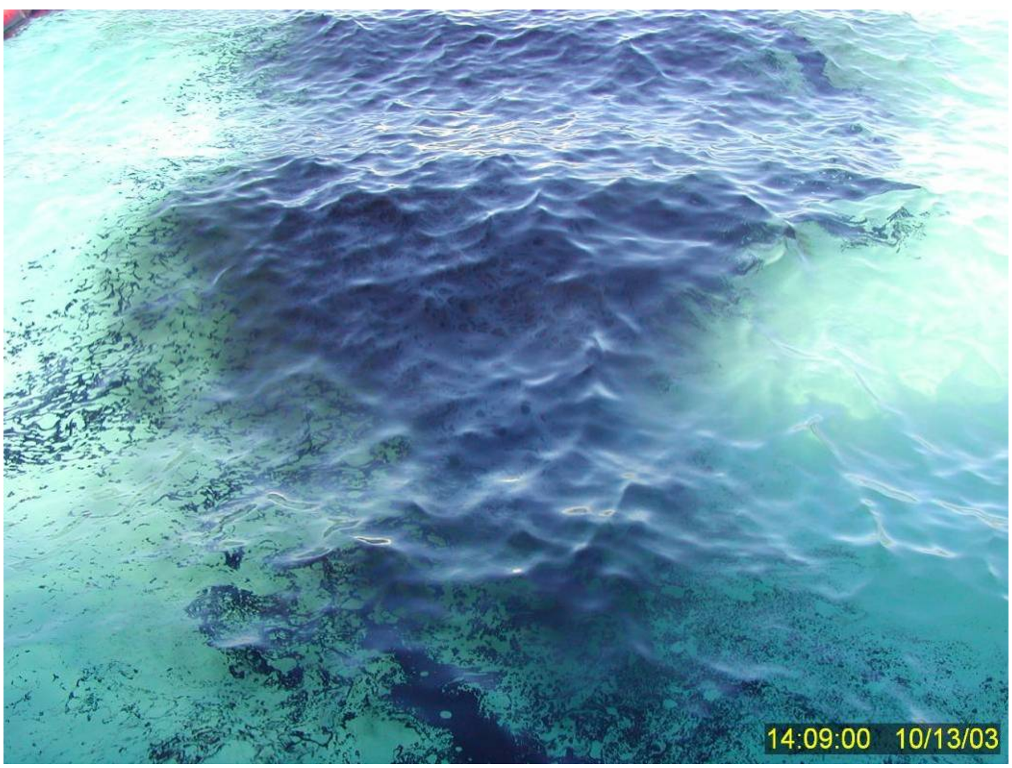

Figure 44 Close up of water surface just after breaking wave passed through oil approximately five minutes after Test No. 12 initiation. Most of the oil in the center of the photo is just subsurface (the water surface is not smooth), while the oil in the foreground is on the water surface.

Figure 45 **Surface (non-dispersed) oil contained within experimental zone (note the clean water within the secondary containment boom) nine minutes after initiation of Test No. 12.**

Figure 46 **Mixture of surface and some subsurface (dispersed) oil ten minutes into Test No. 12. This dispersant was only marginally successful under these conditions, but with time there was more evidence of oil entrainment into the water column.**

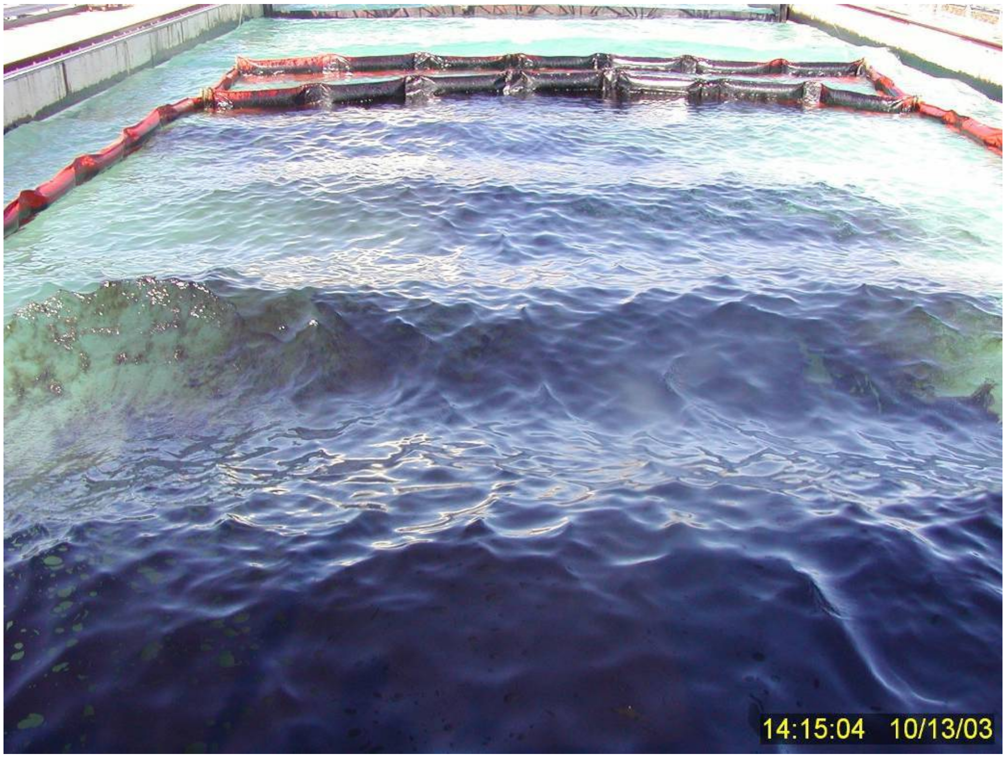

Figure 47 **Gradual breakup of surface oil slick and slow entrainment (dispersion) into water column eleven minutes after dispersant treatment. Note rougher 1-2 inch wave chop on water surface and lateral spread of subsurface dispersed oil plume.**

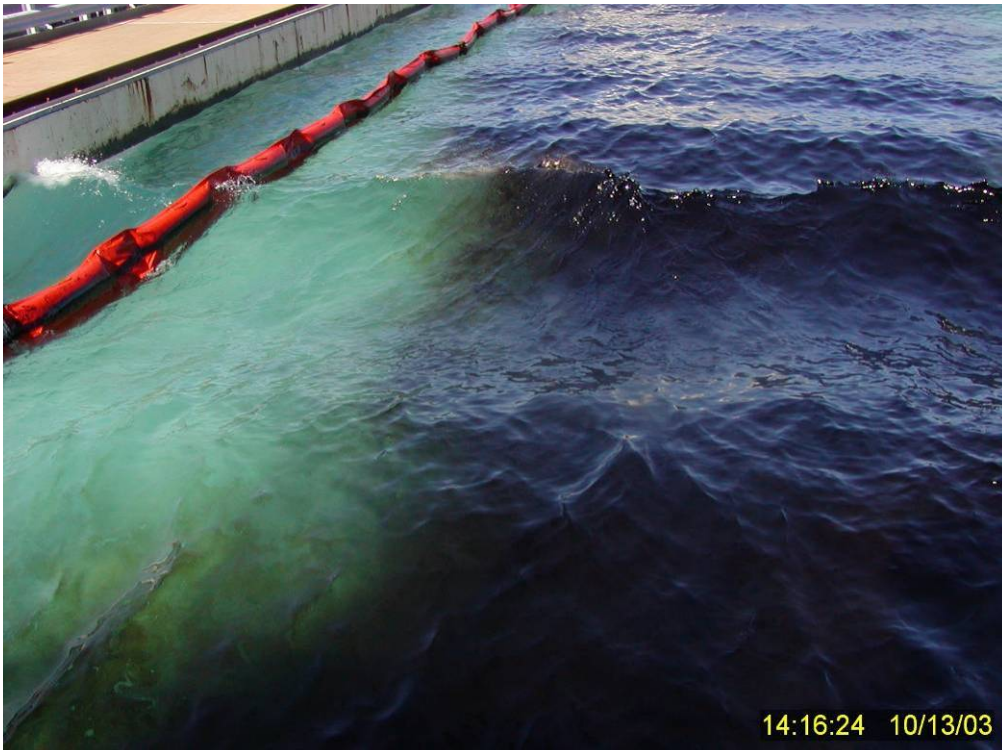

Figure 48 **Lateral spread of subsurface (dispersed) oil twelve minutes after dispersant treatment. Note 2-4 inch breaking wave in upper third of photograph and rough texture of water surface showing lack of coherent oil slick.**

Figure 49 **Poorly dispersed subsurface oil and surface oil residues viewed from the side of the wave tank 16 minutes after initiation of Test Number 12.**

Figure 50 **View from northern-most under water window showing minor discoloration and opacity from the subsurface dispersed oil plume diffusing below the containment boom 17 minutes into Test No. 12. Compare to Figure 12 where the anchor chain can still be observed.**

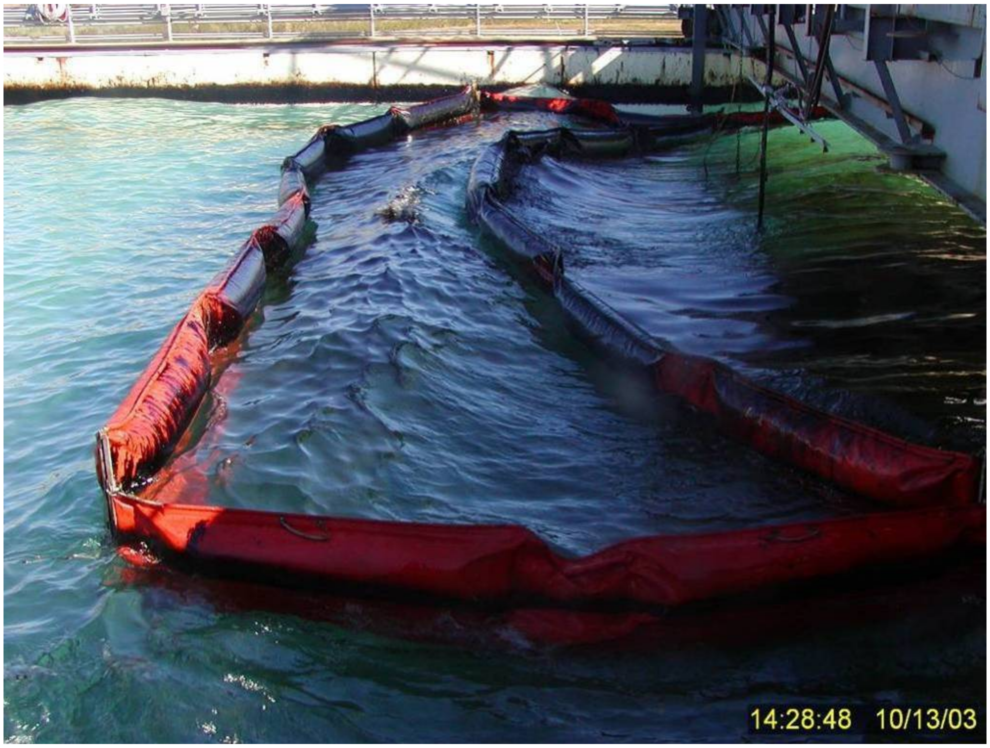

Figure 51 **Wave induced strain on primary containment boom and minor surface oil in secondary containment boom 24 minutes into Test No. 12. Note the discoloration of the water from subsurface dispersed oil droplets both within and outside the secondary containment boom.**

Figure 52 **Overhead photograph of smooth nondispersed surface oil within primary containment boom (on right) and subsurface dispersed oil visible within secondary containment boom. Note there is also some non-dispersed surface oil along the upper edge of the secondary boom but not outside of it.**

Figure 53 **Discoloration of subsurface water by lateral diffusion of dispersed oil outside the containment boom 26 minutes into Test No. 12 (just before the wave turbulence was discontinued at 1434 hrs).**

Figure 54 **Herding of non-dispersed surface oil at the termination of Test 12. Note the fire-monitor spray is directed to the water surface not the oil to avoid unwanted entrainment during collection.**

Figure 55 **Non-dispersed surface oil being herded into the north-east corner of the primary containment boom for collection. Note the surface oil between the containment boom and tank wall that apparently escaped during the test or resurfaced very soon after it was terminated.**

Figure 56 **Residual surface oil outside both the primary and secondary containment booms 20 minutes after the cession of turbulence at the conclusion of Test No. 12 (see also Figure 55). Presumably this was from partially-dispersed oil that was entrained by increased turbulence around the containment boom during the test, although it may also have been lost due to splash-over.**

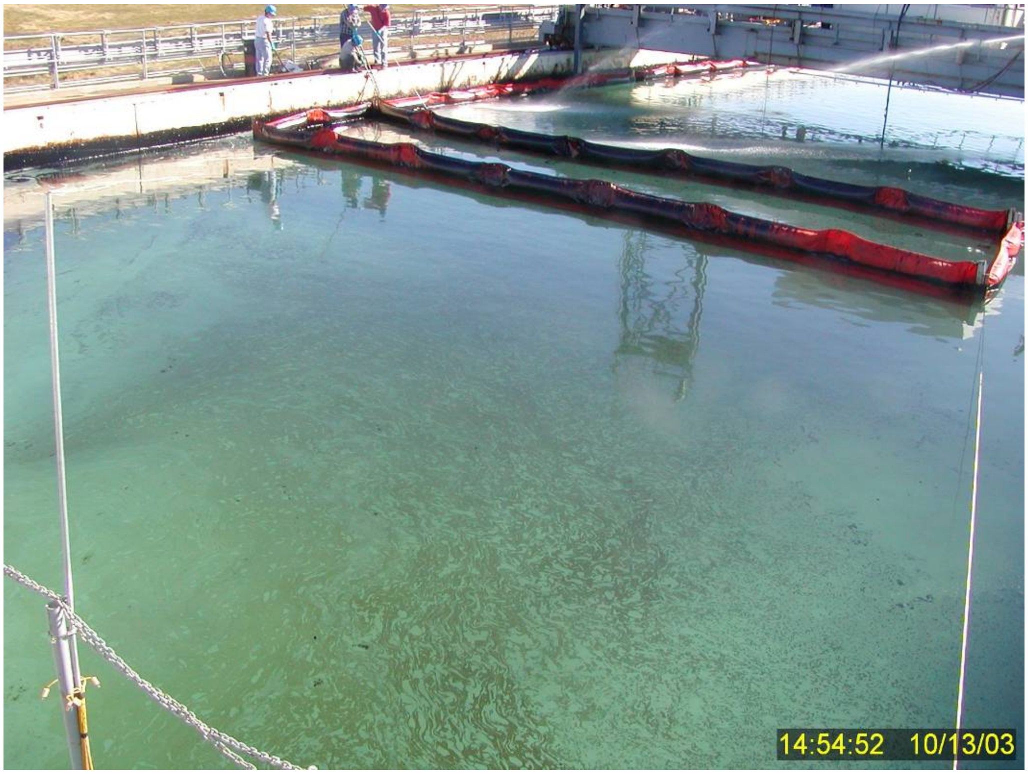

Figure 57 Splashed-over oil and/or resurfacing dispersed oil outside the containment boom ~ 20 minutes after the termination of wave turbulence at the end of Test No. 12.

Figure 58 Resurfacing dispersed oil between the western tank wall and containment boom approximately 35 minutes after termination of wave turbulence at the end of Test No. 12.

Figure 59 Close-up photograph of agglomerating oil droplets resurfacing between the western tank wall and containment boom ~ 36 minutes after turbulence was terminated at the end of Test 12.

Figure 60 Resurfacing dispersed oil droplets outside the secondary containment boom ~36 minutes after turbulence was terminated at the end of Test 12.

Figure 61 Final 13 October 2003 cleaning/polishing the wave tank by using the fire monitors to drive any remaining surface oil beneath the permanent curtain at the extreme north end of the tank.

Figure 62 Preparations for Test 13 on "visitors day" 14 October 2003: IFO 180 fuel oil, Superdispersant 25 (DOR 1:130), and low-energy wave turbulence at 30 cpm.

Figure 63 Addition of IFO 180 fuel oil to water surface for Test No. 13 at ~0916 hrs.

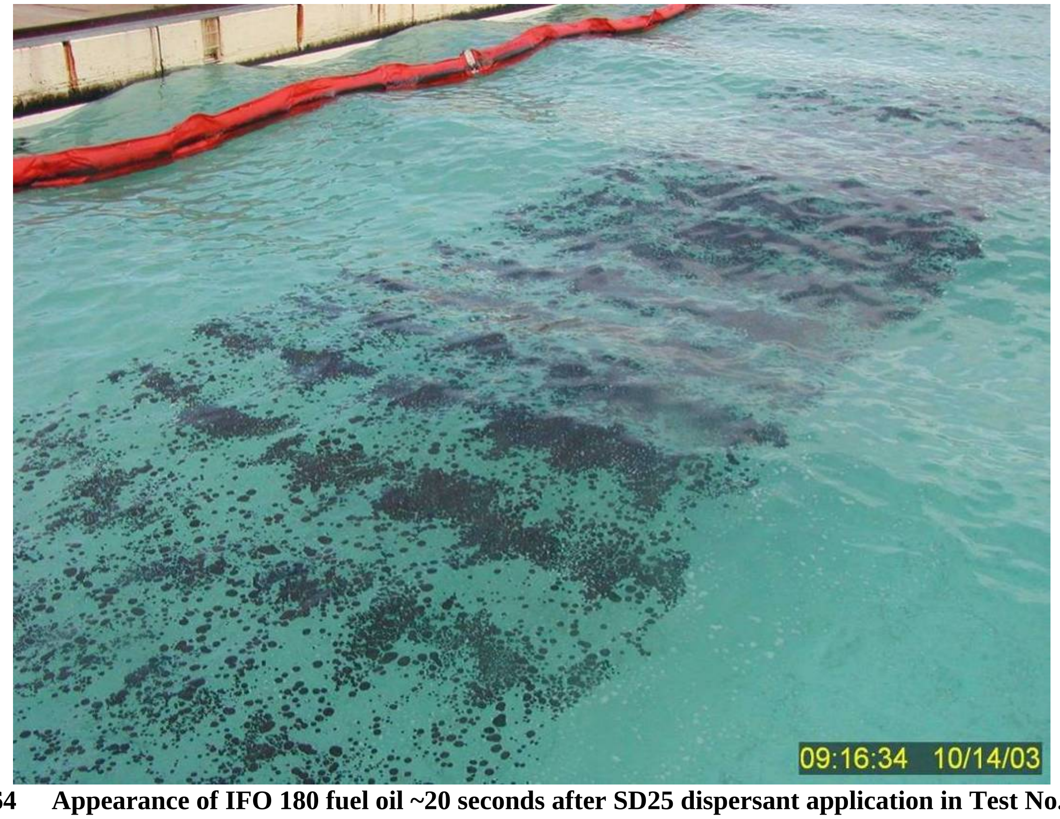

Figure 64 Appearance of IFO 180 fuel oil ~20 seconds after SD25 dispersant application in Test No. 13. Note the uneven (patchy) distribution (lower left-hand corner) before the oil had a chance to spread. This caused much of the dispersant to actually land on the water resulting in under dosing the slick.

Figure 65 Slightly better spreading 60 seconds after the oil was applied to the water surface in Test No. 13, but still no evidence of dispersion/entrainment under these low-energy wave conditions.

Figure 66 Movable bridge positioned over the slick 12 minutes after dispersant application. Note the fluorometer cables passing directly through the slick to provide data from 1- and 2-m directly beneath the oil.

Figure 67 Surface slick showing no dispersion/entrainment 17 minutes into Test 13.

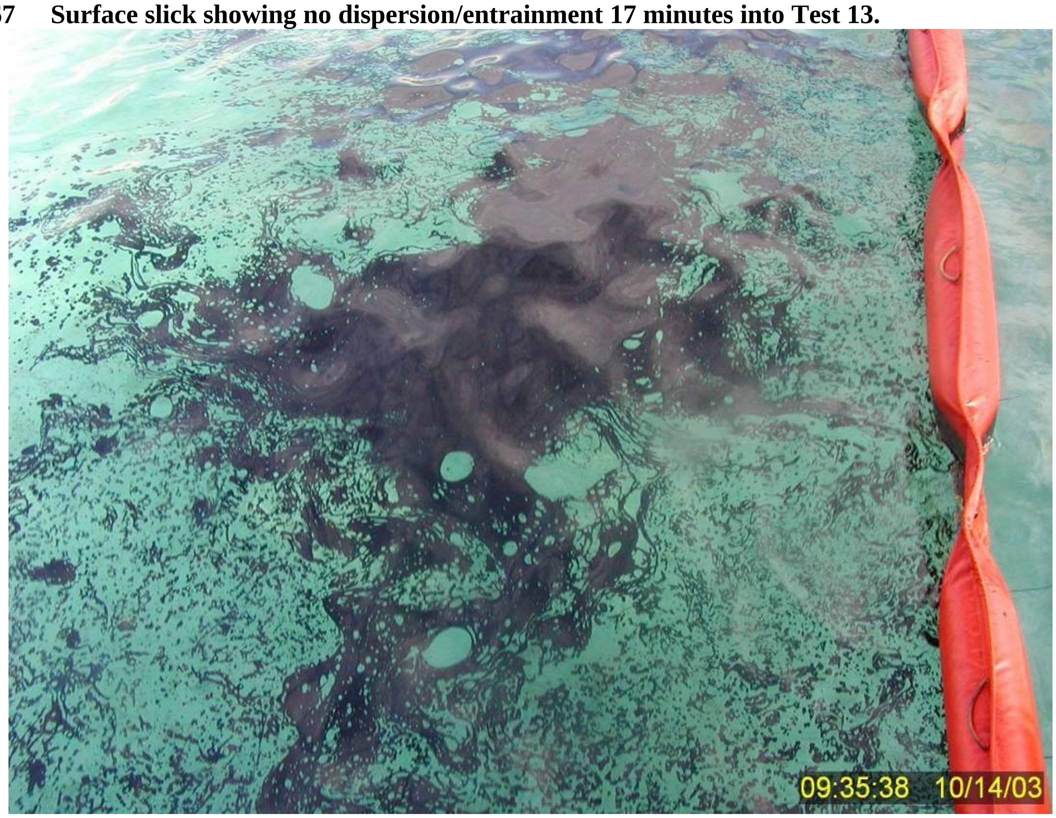

Figure 68 Close up of surface slick from the bridge positioned directly over a larger patch of nondispersed surface oil 19 minutes into Test 13. There was no evidence of any chemically enhanced or natural dispersion noted.

Figure 69 With very light winds from the north, most of the oil drifted to the southeast corner of the containment boom (against the prevailing wave train). This photo shows the movable bridge positioned directly over the slick with the fluorometer cables passing through it.

Figure 70 Underwater view of containment boom and anchor chain showing the water clarity at the end of Test 13.

Figure 71 **Secondary containment zone at the north end of the test tank showing no oil splash-over during Test 13.**

Figure 72 **Set up for Test 14: IFO 180 fuel oil, Corexit 9500 at a nominal DOR of 1:50, and low-energy waves at 30 cpm.**

Figure 73 Submersible pump for USCG SMART fluorometer system deployed from the movable bridge.

Figure 74 USCG SMART system fluorometer set up on movable bridge for Visitors Day tests and training.

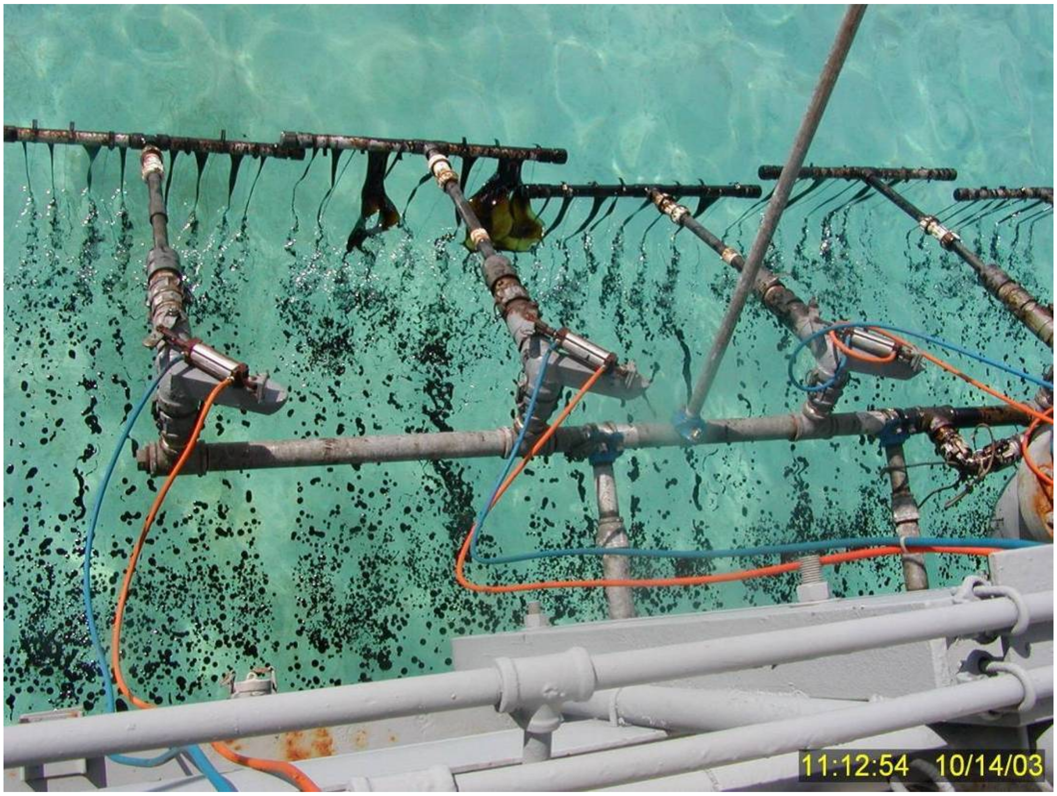

Figure 75 Application of IFO 180 to water surface for Test No. 14 initiation at ~1113 hrs 14 October 2003.

Figure 76 Quarter-sized oil patches and initial IFO 180 fuel oil spreading during the first 20 seconds of Test 14 (~ 12 seconds after dispersant application). Note: patchy oil distribution causes much of the dispersant to land directly on the water surface resulting in under dosing of the oil.

Figure 77 **Appearance of the surface IFO 180 oil slick two minutes after dispersant 9500 application in Test No. 14. Note the lack of any significant dispersion/entrainment into the water column.**

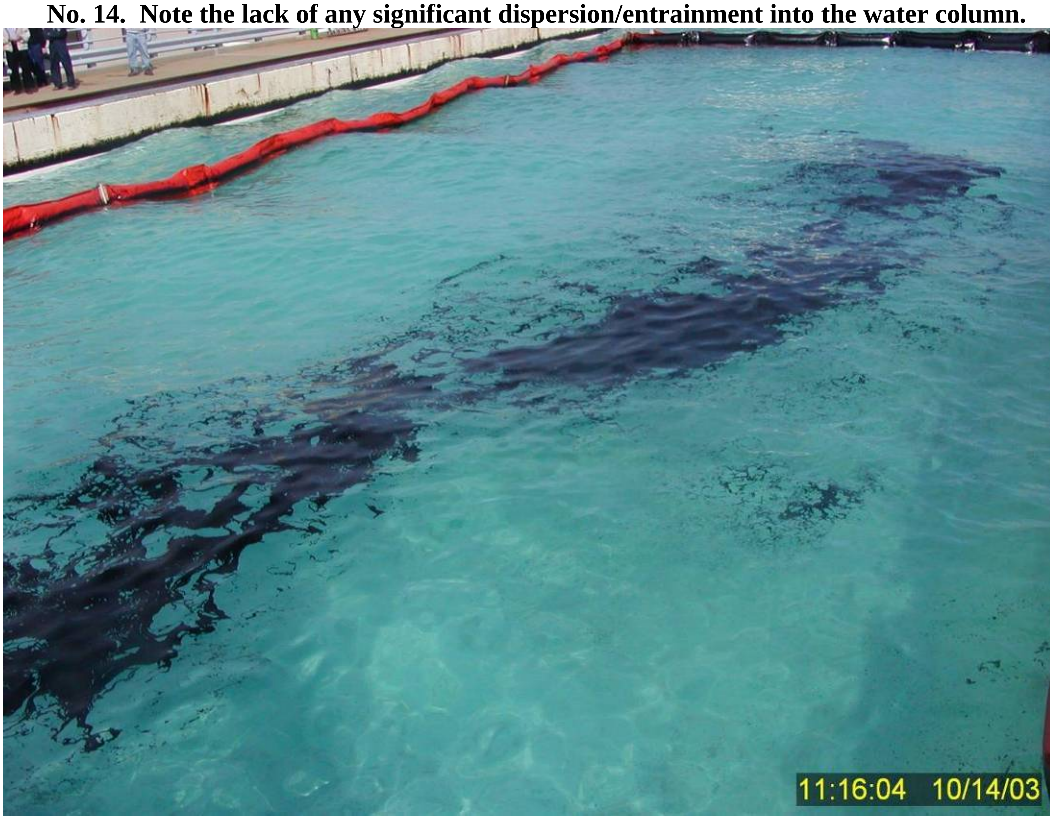

Figure 78 **Overhead view of IFO 180 fuel oil three minutes after Test No. 14 treatment with Corexit 9500 under light energy (low wave turbulence) regime.**

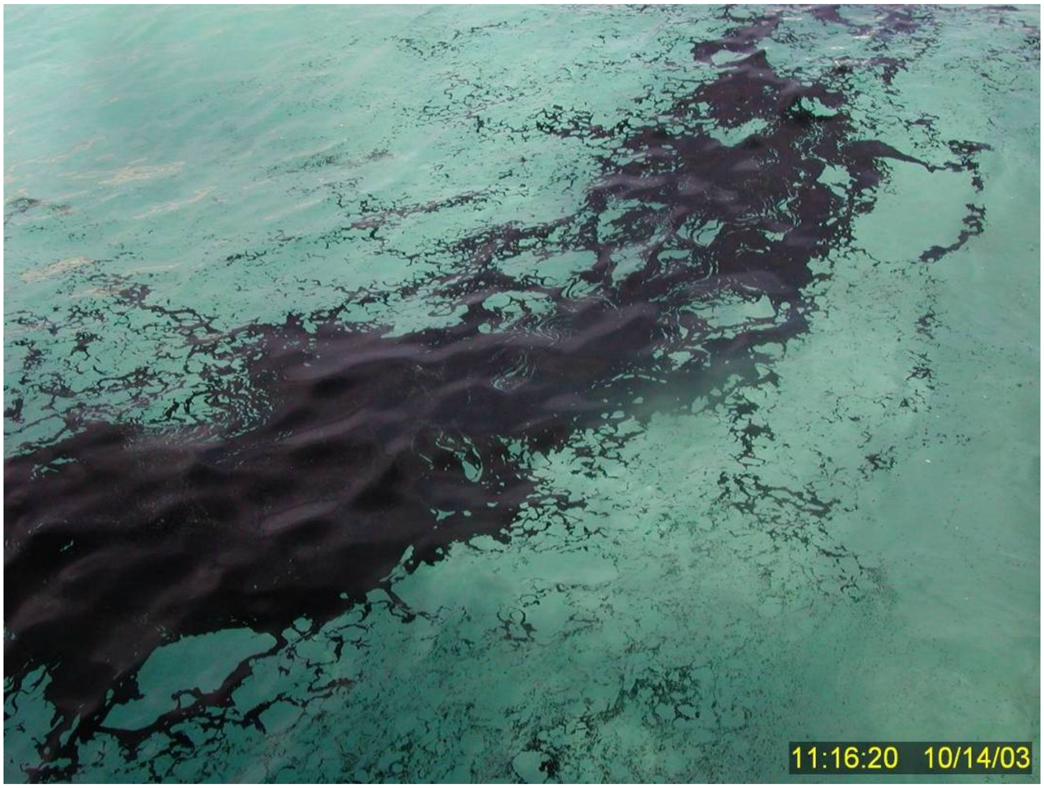

Figure 79 Close up of surface slick three minutes after Test No. 14 dispersant application showing no dispersion/entrainment.

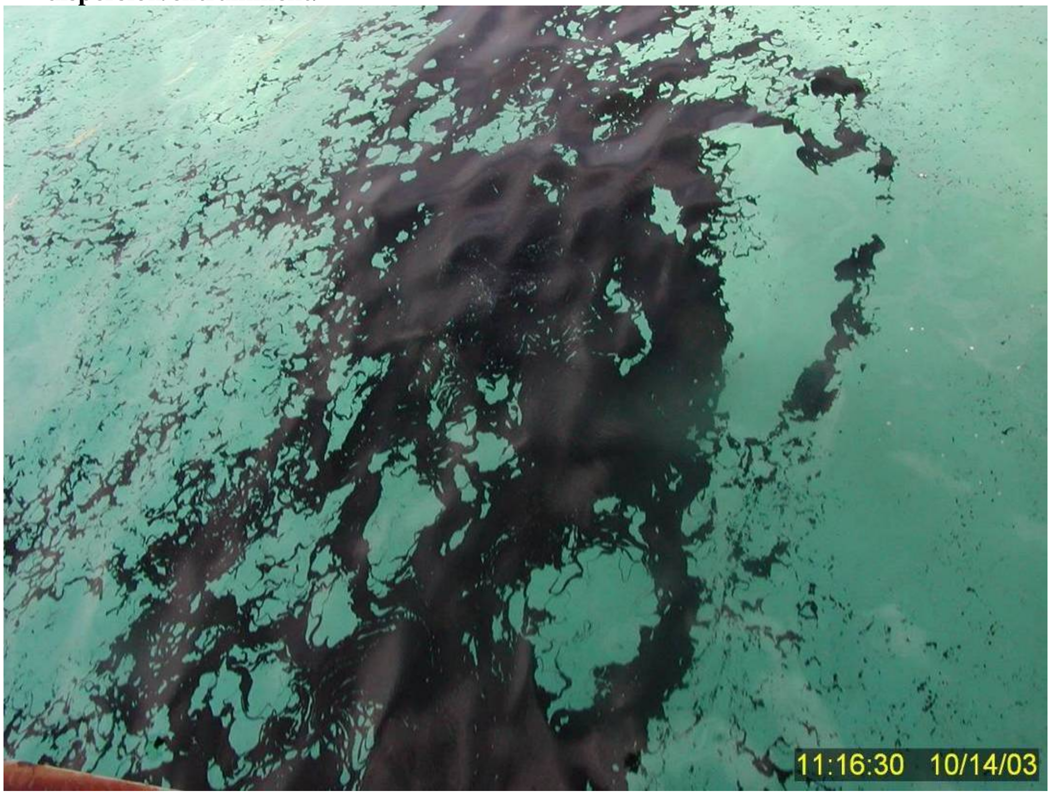

Figure 80 Surface oil slick showing no significant dispersion/entrainment three minutes after treatment.

Figure 81 Fluorometer and submersible pump cables dangling from movable bridge into surface oil slick seven minutes after Test No. 14 Corexit 9500 treatment under low-energy wave regime.

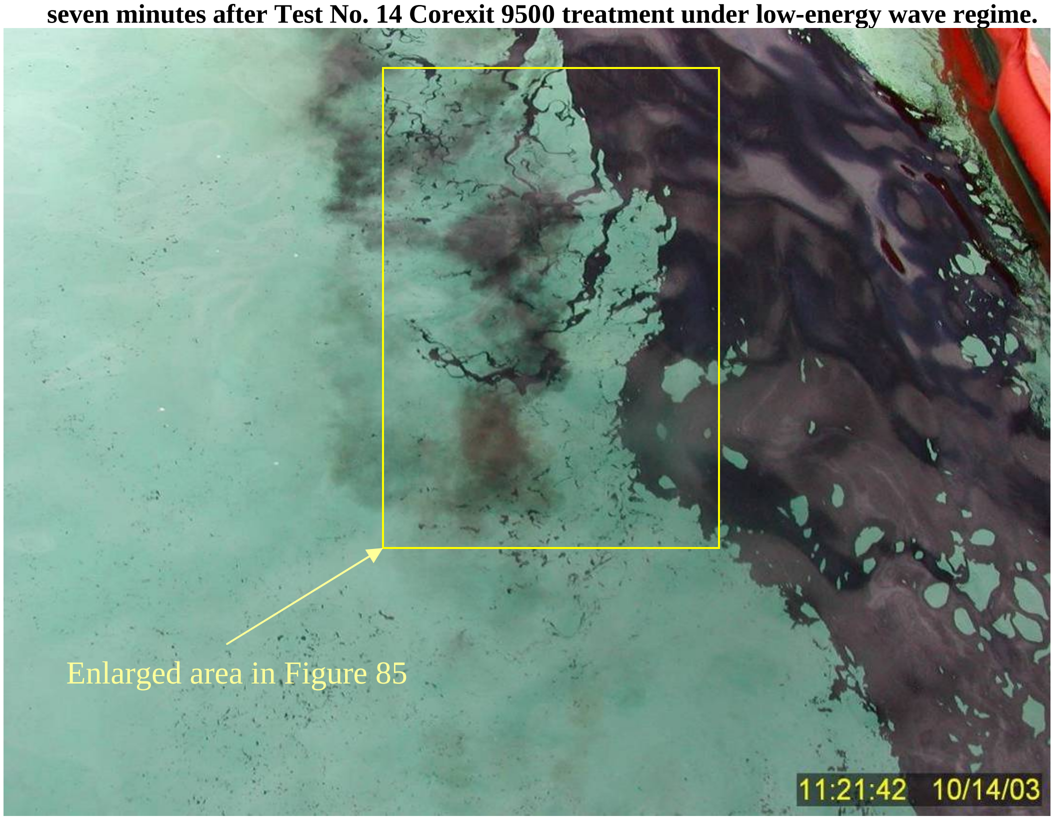

Figure 82 Minor and very localized dispersion/breakup/entrainment of surface oil enhanced by minor turbulence introduced by dragging the fluorometer and submersible pump lines through slick at ~ ½ knot. The yellow rectangle outlines the section of the photograph enlarged in Figure 85.

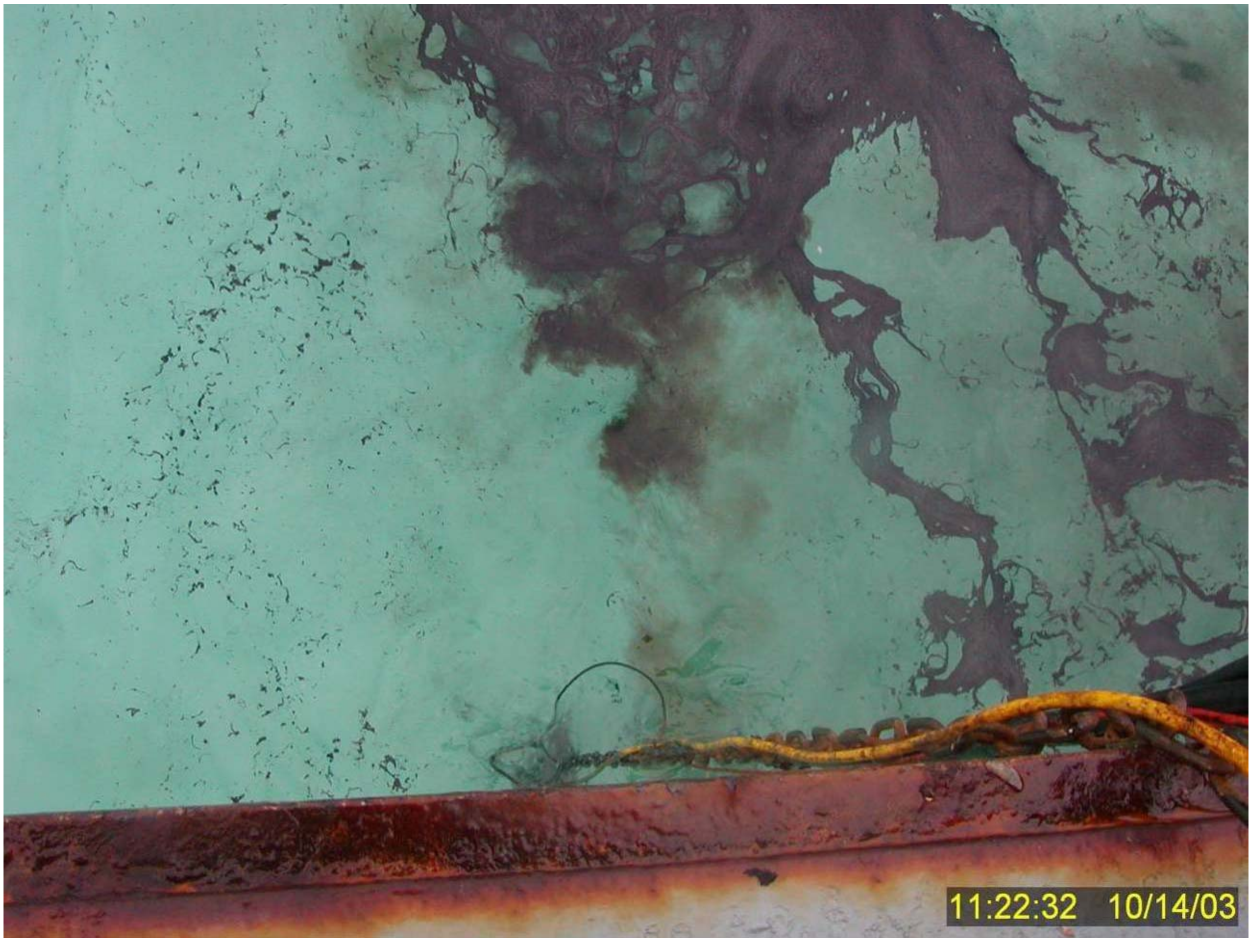

Figure 83 **Anomalous and non-representative dispersion of surface oil caused by minor turbulence from dragging the fluorometer cable through the surface slick. As a result of these observations, the experimental protocol was changed such that submersible pumps and fluorometer cables were pulled out of the water for the first observational/photo documentation pass of the movable bridge over the treated slick. For subsequent observational transects, the cables were carefully positioned to enter the water at the edge of the surface slick to minimize this artificial disturbance and enhanced dispersion.**

Figure 84 Localized dispersion caused by dragging fluorometer cables and submersible pump lines through the surface slick.

Figure 85 Extreme close up of the center section of Figure 82 showing the difference in appearance for nondispersed surface oil (dark black with sharp edges) and the diffuse dispersed/entrained-oil plumes 10-12 inches below the water surface (dark brown to grey-black clouds). The dispersion in this particular test was caused by slightly enhanced turbulence from dragging the fluorometer cables through the water and surface slick, so its generation was an anomaly and not representative of the rest of the tank under these low-energy wave conditions. It is useful, however, because the water clarity and highly localized dispersion facilitate documentation of the stark contrast between surface and subsurface dispersed oil. In slightly higher-energy tests with very effective dispersion, the water-column instantly turns black, and it is almost impossible to visually differentiate between the surface slick and the subsurface dispersed oil plume.

Figure 86 Unusual standing wave pattern (both along and across the tank) that developed approximately 12 minutes into Test No. 14. Note, this was still not a high enough energy regime to facilitate chemical dispersion, and at this time most of the oil had migrated to the east side and north-east corner of the experimental zone.

Figure 87 Containment boom and anchor chain viewed from the underwater window 15 minutes into Test No. 14. The lack of effective oil dispersion under these low-energy conditions lead to remarkable water clarity (compare to the photo in Figure 70 taken before the test).

Figure 88 **Secondary containment boom showing no splash over or dispersed oil plume at the termination of Test No. 14.**

Figure 89 **Non-dispersed surface oil that had been driven by the wind and waves into the northeast corner of the experimental zone during Test No. 14. Note the lack of any significant oil in the secondary containment boom at the top of the figure.**

Figure 90 Pulling the boom to the edge of the tank to facilitate collection of the remaining surface oil that had been herded by the fire monitors into the northeast corner of the experimental boom at the termination of Test No. 14.

Figure 91 Squeegee and vacuum recovery of the last remnants of non-dispersed surface oil from Test No. 14. The white foam is believed to be dispersant that was emulsified by the fire monitor spray during surface oil recovery.

Figure 92 **Initial set up for Test No. 15: IFO 180 treated with Superdispersant 25 (nominal DOR 1:50) and higher wave turbulence at 33.3 cpm.**

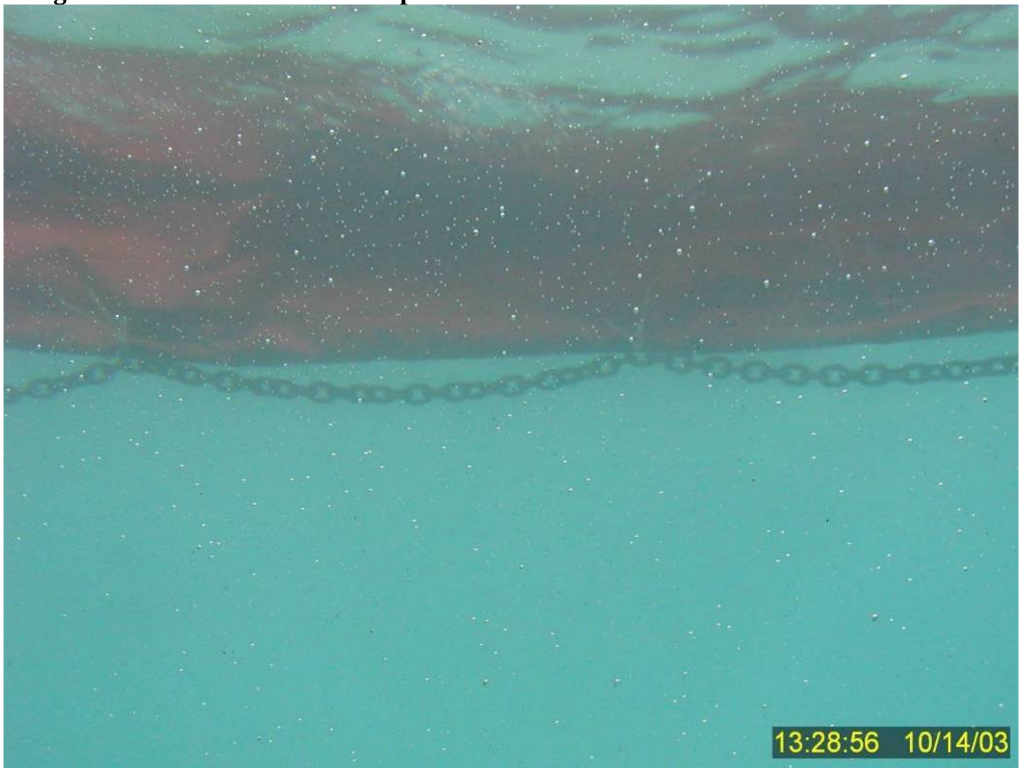

Figure 93 **Containment boom from northern-most underwater window showing water clarity before Test No. 15.**

Figure 94 Wave train viewed from the control room on movable bridge before Test No. 15 initiation (looking south towards wave generator).

Figure 95 Example of cresting wave turbulence at 33.3 cpm before Test No. 15. Usually there are no more than one to three such "breaking" waves within the experimental zone at this frequency setting.

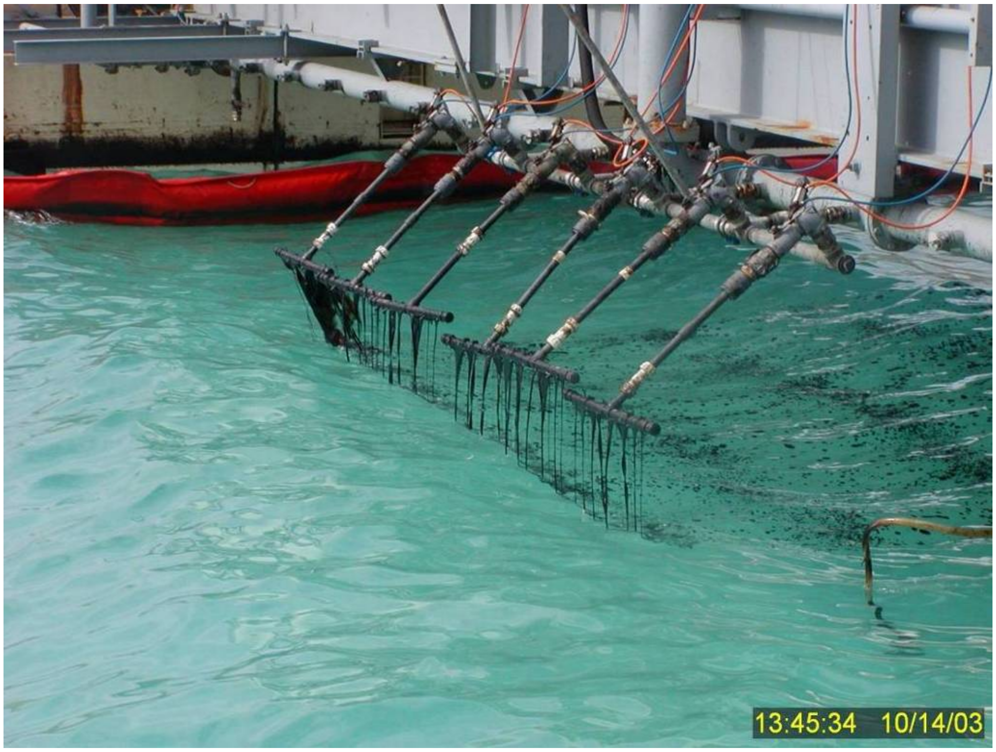

Figure 96 **Addition of IFO 180 fuel oil to the water surface at initiation of Test No. 15. For this operation, the bridge is moved at ½ knot to the south (from the right to the left) so that the oil on the water surface can be treated from a dispersant spray bar mounted on the other side of the bridge (see Figure 97).**

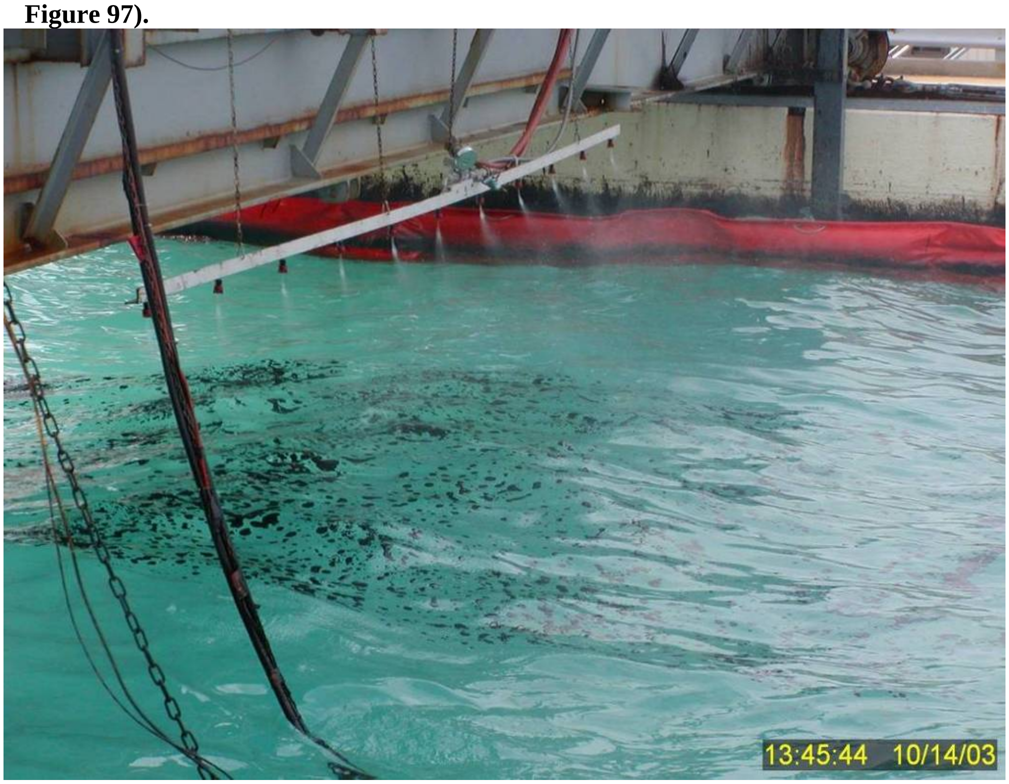

Figure 97 **Application of Superdispersant 25 to surface oil as the bridge is advanced at ½ knot to the south (left). The oil is on the water surface for only 8-10 seconds before dispersant application. Note the fluorometer cables and submersible pump are off to the side of the treated oil.**