The Effectiveness of Corexit 9527 and 9500 in Dispersing Fresh, Weathered, and Emulsion of Alaska North Slope Crude Oil Under Subarctic Conditions

A Preliminary Report

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by

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ABSTRACT

The effect of various states of weathering: no weathering, 20% evaporatively weathered, and emulsification on the effectiveness of oil dispersants Corexit 9527 and Corexit 9500 in dispersing Alaska North Slope crude oil into the water column was tested at a combination of realistic subarctic salinities and temperatures. A modified version of the swirling flask effectiveness test was conducted at temperatures of 3, 10 and 22° C with salinities of 22‰ and 32‰. Petroleum dispersed into the water column following application of dispersant was measured by gas chromatography with FID detection. Results showed dispersants dispersed less than 40% of the fresh oil, none of the weathered oil, and were most effective when used to disperse a stable oil/water emulsion at 10° C. At the combinations of temperature and salinity most common in the estuaries and marine waters of Alaska, the dispersants were largely ineffective (<10% effective, the detection limit of the tests) at dispersing fresh or weathered Alaska North Slope crude oil in laboratory tests.

INTRODUCTION

The effectiveness of dispersants is a fundamental issue in deciding whether to use dispersants to reduce the amount of oil that reaches shore following an oil spill. Factors such as how long the oil has weathered, what the salinity and temperature of the marine water is, and whether data exists to predict the performance of the proposed chemical at dispersing the oil into the water column are all important in determining whether to use dispersants. Environmental factors such as salinity (Blondina et al. 1999) or temperature (Fingas et al. 1991) are known to modify the ability of the dispersant to disperse the oil into the water column.

With the high oil tanker traffic and sensitive vulnerable nearshore habitat, the waters of southcentral Alaska are particularly vulnerable to oil spills. Much of this nearshore habitat serves as natal or rearing habitat for many commercially valuable fish as well as seabirds and marine mammals. The many streams and estuaries serve as essential fish habitat for early life stages of fishes. Eggs and larvae of fish are especially sensitive to the impacts of weathered oil over prolonged periods (Rice et al. 2000). The very qualities of these nearshore habitats that make them ideal habitat for early life stages of fish also makes both the habitat and, by extension, the species, vulnerable to pollution.

It remains difficult to predict how effective dispersants will be under subarctic conditions, especially after the first few days following a spill when the oil has altered composition. In areas such as Prince William Sound in Alaska, environmental conditions can range from 10° C and 22‰ salinity in the summer when freshwater runoff creates brackish water conditions near shore to 3° C and 32‰ salinity during much of the winter. In contrast, much of the work on measuring dispersant effectiveness has been done at temperatures (20-22° C) and salinities (32‰-34‰) most often associated with temperate waters with little freshwater input. Additionally, most of the studies have examined the performance of dispersants on fresh crude oils. Following a spill, a number of chemical and physical processes such as evaporation, dispersion, and oxidation combine to alter the properties of the crude oil (weathering), and potentially altering as well the effectiveness of dispersants. One of the most visible of these weathering processes is the formation of stable oil/water emulsions.

The purpose of the present study is to compare the relative effectiveness of dispersants on different weathering states (fresh, evaporatively weathered, or emulsion) of Alaska North Slope crude oil under subarctic temperatures and salinities. Effectiveness is defined as the percentage of oil that is dispersed into the water column following the application of dispersant. We chose

Corexit 9527, the only dispersant currently stockpiled in Alaska and Corexit 9500, a possible replacement as the two test dispersants. The tests employed the swirling flask method, (Fingas et al. 2000). This test is accepted as the standard method for testing dispersant effectiveness by Environment Canada and the United States Environmental Protection Agency.

MATERIALS and METHODS

Alaska North Slope crude oil was obtained from the Alyeska Service Company in Anchorage, Alaska. Tests were conducted with three types of oils which we designated fresh, weathered, and emulsified. Fresh oil, transferred from sealed containers, was otherwise untreated. This oil simulated oil such as would be initially present in an oil spill. Weathered oil was created by artificially weathered by heating it to 70° C until its initial mass was reduced by 20%. Oil/water emulsion was created by mixing and agitating 600 mL of the fresh oil with 400 mL of 32‰ artificial seawater in a glass Waring blender for 30 minutes. Emulsion formation arises during an oil spill due to wave action and turbulence that mix the surface oil and water. All three liters of oil stock were refrigerated prior to use. The relative normal alkane and polycyclic aromatic compound (PAC) compositions of the three oils, are presented in Figures 1 and 2 respectively. A reference oil, Alberta Sweet crude oil, was obtained from Environment Canada, and tests were run on that oil for both dispersants at a temperature of 22° C and a salinity of 32‰.

The dispersants, Corexit 9527 and 9500 were supplied *gratis* by the manufacturer Exxon Nalco Energy Products. Corexit 9527 contains surfactants in a water base and is the only dispersant currently stockpiled for use in Alaska. Corexit 9500, which contains surfactants in a hydrocarbon base, may soon replace Corexit 9527 as the most common dispersant available.

Test temperature were 3° C, 10° C, and 22° C and test salinities were 22‰ and 32‰. Salinities and the lower two temperatures were chosen to cover the ranges of environmental conditions present over the year in the subarctic waters of Alaska, particularly the waters of Prince William Sound. Tests were done at 22° C to allow comparison with other studies using this standard temperature from EPA protocols (United States Environmental Protection Agency 1996). All tests were done in temperature-controlled rooms where ambient temperature could be regulated ± 1.0° C. All equipment and test solutions were equilibrated to the test temperature for at least 2 days prior to testing. Seawater was prepared by mixing a quantity of Instant Ocean[1] synthetic sea salts (Aquarium System, Mentor, OH) with de-ionized distilled water to create stock solutions of 22‰ and 32‰ salinity. These stock solutions were measured daily with a refractometer to ensure <0.5‰ variation in test salinity.

Swirling flask tests (Fingas et al. 2000) were used to evaluate dispersant effectiveness. The test dispersants (100 μL) were pre-mixed with 2.5 mL of the test oil using positive displacement syringes (dispersant to oil ratio of 1:25). In 5 swirling flasks, 120 mL of synthetic seawater was combined with 100 μL of the pre-mixed dispersant/oil combination. A sixth flask contained 120 mL of seawater together with either 4μL of dispersant only or, on alternate days, 100μL of oil only. A final flask contained only synthetic seawater and served as a blank for quality control. Flasks were agitated for 20 minutes at 150 rpm on an rotary platform shaker (2 cm orbit). Following a 10 minute settling period, a 30 mL aliquot was withdrawn through the spout at the bottom of the flask. Samples were extracted three times with 5mL of 70:30 dichloromethane: pentane. Extracts were combined in a graduated mixing cylinder and topped off to 15mL. 900 μL of extract was transferred to vials and 100μL of internal standard (200 ppm 5α-androstane) was added before the samples were stored at –20° C until analysis.

Total petroleum hydrocarbon concentrations were determined by the internal standard method using GC /FID. Six calibration standards were prepared for evaluating the efficiency of each dispersant/oil mixture. The standards were prepared by extracting 10, 15, 20, 25, 30, and 40μL of oil in three successive 20 mL volumes of 70:30 dichloromethane: pentane to prepare a standard curve for each oil type (details in Fingas et. al. 2000). Standards and samples were analyzed with a HP 5890 GC/FID equipped with a 30 m x 0.25 mm ID DB-5 fused silica column (0.10μm film thickness). GC settings were as follows, injector 290° C, detector 320° C and oven program of 50° C for 1 minute, then 15° C/min to 310 hold 5 minute. Because ANS crude is a medium to heavy oil, dispersant effectiveness was determined by using the area of the unresolved complex mixture (UCM) of the standards and samples relative to the internal standard (Fingas et. al. 1999). The calculated effectiveness values for the five samples were averaged. Results are expressed as percent effectiveness, which is the proportion of oil dispersed. If the standard deviation for the five samples exceeded 10% effectiveness, the results were discarded and the test was repeated. As recommended by Fingas et al. (2000), values below 10% effectiveness were considered below the detection limit (DL) for this method.

Pairwise statistical comparisons of treatment means were performed using a one-way parametric analysis of variance (ANOVA) of transformed effectiveness results. Because results are expressed as percentages, the arcsine square-root transform was used to satisfy the homoscedasticity assumption of ANOVA. Differences in all tests were assumed to be significant at $\alpha<0.05$.

RESULTS

The three oil types used in the tests had similar relative abundances of n-alkanes and

PACs (Figures 1, 2). The distribution patterns of these analytes in fresh oil and in emulsified oil are nearly identical, indicating the emulsification process did not appreciably alter the composition of the oil. Decane and undecane are present at substantially lower relative abundances in the weathered oil compared with the fresh or emulsified oil, but the relative abundances of the PACs are comparable (Figure 2). This indicates the heating process effectively removed hydrocarbons with boiling points below about 175° C, including nearly all of the monocyclic aromatic compounds. By comparison, oil spilled from the T/V *Exxon Valdez* was much more weathered by 11 days after grounding than the weathered oil used in these experiments (compare Figures 2 & 3). The spilled *Exxon Valdez* oil had lost appreciable proportions of the less-substituted naphthalenes by 11 days, indicating more extensive weathering losses of semi-volatile compounds than the oils used here for the dispersant tests.

Without dispersants, dispersion of the oil was almost negligible. Dispersion of the fresh and weathered oils was undetectable at any combination of test temperature and salinity. Dispersion of the emulsified oil was marginally above detection limits (10% dispersion) in 2 out of 8 tests. The detected dispersions of 14.6 % and 13.2% occurred at 3° C and 10° C respectively (22‰ salinity).

The three oil types differed markedly in their susceptibility to dispersion by dispersants with results ranging from non-detectable for all weathered oils upwards to 79% for some emulsions. In addition to oil type, the other three factors examined in this study (*viz.* temperature, salinity and dspersant type) may potentially interact to produce complex patterns of dispersant effectiveness under various combinations of test conditions. These interactions were simplest for the weathered oil, more complex for the fresh oil, and most complex for the emulsified oil. Results are accordingly presented and discussed sequentially for each oil type.

Weathered Oil

Neither dispersant was effective at dispersing weathered oil under any combination of conditions tested. Dispersed weathered oil was consistently below detection limits in all 60 replicate tests.

Fresh Oil

Dispersion of fresh oil was strongly dependent on temperature, and this dependence interacted with salinity. At 22‰ salinity, oil dispersion was only detected at 22° C (Figure 4), with a mean of 15.8% of oil dispersed by Corexit 9500 and 35.2% by Corexit 9527, and the increased dispersion by Corexit 9527 was significant ($P < 0.001$). At 32‰ salinity, oil dispersion was detected at 10° C and at 22° C for both dispersants (Figure 4). The average proportion of fresh oil dispersed by Corexit 9500 was 22.3% and 18.4% at 10° C and 22° C respectively, and this difference was not significant ($P = 0.311$). In contrast, the average proportion of fresh oil dispersed by Corexit 9527 was somewhat lower (15.3%) at 10° C, but somewhat higher (30.5%) at 22° C. Note that the effect of salinity on dispersant effectiveness was negligible at 22° C for either dispersant (35.2% vs. 30.5% for Corexit 9527 [$P=0.074$], and 15.8% vs 18.4% for Corexit 9500 [$P=0.277$]), but was dramatic at 10° C (15.3% vs. undetected for Corexit 9527, and 22.3% vs. undetected for Corexit 9500).

Emulsified Oil

The effect of temperature on the amount of emulsified oil dispersed by the dispersants was closely related to the salinity of the test water. In the higher salinity water, effectiveness of dispersants on emulsion was greatest at 10° C (Figure 5). The mean amount of emulsified oil dispersed by the two dispersants at 3° C or 22° C ranged from 14% to 23%, compared with a range of 29% to 32% at 10° C. The differences in dispersion effectiveness between 3° C and 22° C was not significant, but was significant between those two temperatures and 10° C. The increased dispersion at 10° C might be the result of decreased emulsion stability temperatures between 3° C and 22° C, perhaps as a consequence of the interaction of oil viscosity and oil-seawater surface tension as a function of temperature.

In 32‰ seawater, emulsification enhanced dispersant effectiveness at the lower test temperatures. The proportion of oil dispersed was undetectable at 3° C with fresh oil, but was 19% to 23% with emulsified oil. Higher proportions of emulsified oil were also dispersed at 10° C compared with fresh oil (Figures 4 & 5). However, dispersant effectiveness was significantly lower at 22° C for the emulsified oil compared with the fresh oil.

In contrast, the higher dispersant efficacies resulting from testing oil emulsions in reduced salinity (22‰) water are probably not relevant to field conditions because of osmotic effects. The mean amount of emulsified oil dispersed by Corexit 9500 and 9527 were as high as 42.4% and 72.7% respectively, high enough to be considered effective for field use. However, these emulsions were prepared at 32‰, and were tested at 22‰, which would have subjected aqueous micelles within the emulsion to osmotic shock. This osmotic effect may have enhanced dispersant effectiveness by promoting mixing between the oil and the seawater at a microscopic scale. This osmotic shock effect may also explain the oil dispersion detected for the emulsified oil in the absence of dispersants at 22‰ salinity at lower temperatures as noted previously. It is unlikely that oil would be dispersed into 22‰ seawater following emulsification at 32‰ after an oil spill, so the tests at 22‰ with emulsified oil should be considered highly artificial.

Estimates of the effectiveness of the two dispersants on the reference Alberta Sweet crude oil at 22 ° C/32‰ were consistent. Average dispersion of the reference oil with Corexit 9527 was 59% and 55% in two separate runs (5 replicates each). Dispersion of the reference oil with Corexit 9500 was 47% and 46%. Standard error for each trial was <3%. Values previously reported for Alberta Sweet were 38% for Corexit 9527 and 42% for Corexit 9500 (Fingas et al. 2000).

DISCUSSION

These results clearly indicate that temperature, salinity, and weathering state of the oil tested are important factors to consider when evaluating the effectiveness of these dispersants. Of these three factors, weathering state of the oil had the most profound effect on dispersant performance. These differences are probably due to differences in the behavior of the oil in the flask. Fresh ANS oil was very viscous at low temperatures and spread slowly when added to the flask. Weathered oil formed a cohesive mass on the water's surface even during the shaking process. The emulsion, with the entrained water, spread quickly on the water when applied and went easily into solution.

The repeatability of the tests and the tight confidence intervals suggest our methods were precise, even if not always yielding the same effectiveness values as Fingas et al. (2000). The tests with Alberta Sweet crude oil and Corexit 9527 dispersed 55-59% of the oil as opposed to 38% reported by Fingas et al. (2000). Our values for dispersion of Alberta Sweet crude oil with Corexit 9500 (mean of 46%) are very similar to the value of 42% reported by Fingas et al. (2000) The higher values for the reference oil than those reported by Fingas et al. (2000) for these dispersants suggests that our values, if anything, over-estimate the effectiveness values.

Our results showing a drop in dispersant effectiveness on fresh ANS crude at subarctic temperatures is in contrast to previous tests suggesting that temperature is not a major factor in dispersant effectiveness (Ross 1997). Most recent dispersants are formulated to have low viscosity at low temperatures, offsetting any increases in viscosity of crude oils at subarctic temperatures (Ross 1997). Both Nes and Norland (1983) and Byford et al. (1983) conclude that low temperatures have little effect on dispersant performance. In contrast, Fingas et al. (1991) found a two-fold rise in effectiveness of Corexit 9527 in dispersing Alberta Sweet crude oil with each three-fold rise in temperature. Low temperatures may not affect dispersant but do affect the behavior of the oil and thus the final effectiveness, particularly for an oil like ANS that is relatively heavy and viscous.

There appears to be a significant interaction of temperature and salinity in the behavior of dispersants, an interaction not always obvious when tests are performed at standard temperatures and salinities. Most investigators, working at 22° C, have concluded that estuarine salinities would be unlikely to influence dispersant effectiveness. Ross (1997) has argued that the "slight decline" (32 to 22‰) in salinities in the Gulf of Alaska during the summer months is not of sufficient duration to alter dispersant performance appreciably. In an extensive study, Blondina et al. (1999) determined the effects of salinity on the effectiveness of Corexit 9527 and Corexit 9500 on fresh Alaska North Slope crude oil at 22° C . The results from those tests, which used a modification of the swirling flask method, produced similar results to our tests done at 22° C. Both studies found little difference of dispersant performance at salinities between 22‰ and 32‰ at 22° C. Our results at colder temperatures, however, do suggest that in subarctic areas with significant freshwater runoff, salinity could play an important role in reducing dispersant effectiveness.

The effectiveness of these dispersants when deployed under conditions typical in the Gulf of Alaska are likely to be overestimated by effectiveness tests conducted with fresh oil at 22° C and 32‰ salinity. The proportions of fresh oil dispersed under these conditions was near 25% for both dispersants. The efficacies of these dispersants was either similar or lower at the other test conditions evaluated here (apart from the unrealistic tests at 22‰ with emulsified oil). Measured efficacies were nil on weathered oil and on fresh oil ranged from nil to 25% over temperatures from 3° C to 10° C, and this temperature range is typical for the Gulf of Alaska during most of the year. For each dispersant, dispersant efficacies measured at 22° C and 32‰ salinity only slightly underestimated dispersant performance at 10° C and 32‰ for the emulsified oil, but it is unlikely that this oil state would occur following an oil spill without concurrent weathering.

The dramatic difference in dispersant performance on weathered compared with emulsified oil indicates that predicting dispersant performance under realistic field conditions is not straightforward. The tested dispersants failed to disperse slightly weathered oil, but dispersion of fresh oil that was immediately emulsified was enhanced at temperatures likely in Alaska. Both of these processes, weathering and emulsification, may occur simultaneously in a real oil spill at rates that independently vary with temperature, salinity, and mixing energy. However, the fact that no combination of dispersants, oil states and test conditions led to more than about 35% of the oil dispersed (apart from the artificial situation of osmotically-affected emulsified oil prepared at 32‰ and tested at 22‰), suggests that these dispersants may often fail to disperse appreciable oil when applied under low temperature and low mixing-energy conditions, when weathering processes would predominate over emulsification processes.

There were no striking differences in dispersant performance between the dispersants tested here under test conditions likely to be encountered in Alaska. Corexit 9527 was about twice as effective as Corexit 9500 at dispersing fresh oil at 22° C, but their performance was similar at the lower test temperatures. Both dispersants failed to disperse weathered oil at all test conditions, and their performance with emulsified oil was comparable at 32‰ salinity. Corexit 9527 was nearly twice as effective as Corexit 9500 at 10° C and 22‰ salinity, but as noted above these tests were environmentally unrealistic because of artificial osmotic effects. It therefore appears that the performance of these dispersants is comparable at salinities and temperatures typical of the Gulf of Alaska, and at the low mixing-energy conditions of the swirling flask test.

Weathered oil similar to that used in our tests would be present within a few days of a spill, even in subarctic waters. The conditions used to produce the weathered oil simulate a spill under moderate conditions of wave and wind action. The low molecular weight aromatics, primarily the benzene, toluene, ethylbenzene, and xylene compounds evaporate from the slick surface during the first hours of the slick. For oils of most densities, 50-70% of the evaporative loss occurs in the first 10-12 hours of the spill (MacKay and McAuliffe 1988). Following the Exxon Valdez oil spill in 1989, 20% of the spilled oil had been lost to evaporation within a month (Wolfe et al. 1994). The emulsion used in our test is a stable combination of fresh oil and seawater. It too would likely only be present during the initial phase of the spill.

Caution should be used in extrapolating these laboratory studies to field conditions. Laboratory effectiveness tests are useful in providing an indication of relative performance of dispersants or, as in the case of our research, an understanding of how performance is influenced by type of oil or environmental conditions. The swirling flask test is a conservative test, applying relatively low mixing energy to the oil/water interface. In comparing the relative effectiveness of five laboratory tests using Corexit 9527 to disperse Alaska North Slope crude oil, Ross (1997) measured effectiveness values ranging from 19% for the swirling flask method to 93% for the EXDET method. The EXDET method applies a high mixing energy and probably estimates the maximum capacity of the dispersant to disperse the tested oil. Mixing energy available in a given spill situation may fall anywhere between or below these values.

In conclusion, weathering state, temperature, and salinity are all important but not always predictable factors in the performance of dispersants. The ability of surfactant-based dispersants to increase petroleum accommodation into the water column may vary depending largely on environmental conditions. The nearshore habitats in the subarctic waters of the Gulf of Alaska often serve as natal and rearing habitats for the early life history stages of many commercially important marine fishes, life stages that are very susceptible to long-term damage from oil (Moles 2001). Dispersants may reduce the amount of oil coming on shore, causing less habitat contamination and lowering the potential for long term impacts. In such instances, the use of dispersants must be weighed against any reduced effectiveness due to environmental conditions.

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Fig. 1: Percent composition by weight of alkane hydrocarbons in fresh, weathered, and emulsified Alaska North Slope crude oil. Alkanes are abbreviated by the number of carbon atoms in a chain.

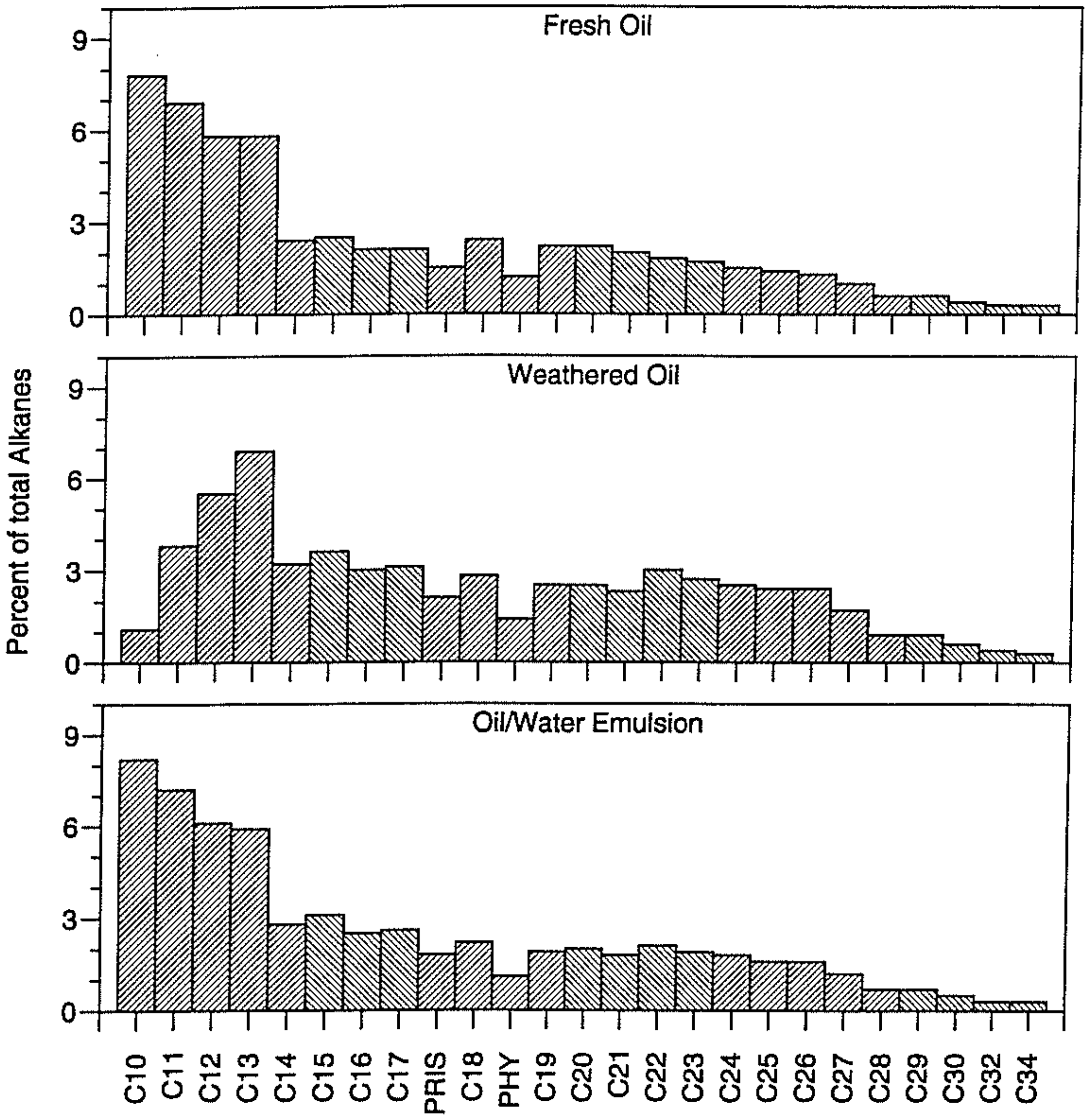


Fig. 2: Percent composition by weight of polycyclic aromatic hydrocarbons (PAH) in fresh, weathered, and emulsified Alaska North Slope crude oil. N=naphthalenes, F=fluorenes, D=dibenzothiophenes, P=phenathrenes, C=crysenes. Numbers following abbreviations are the number of alkyl substituted carbon atoms for each analyte.

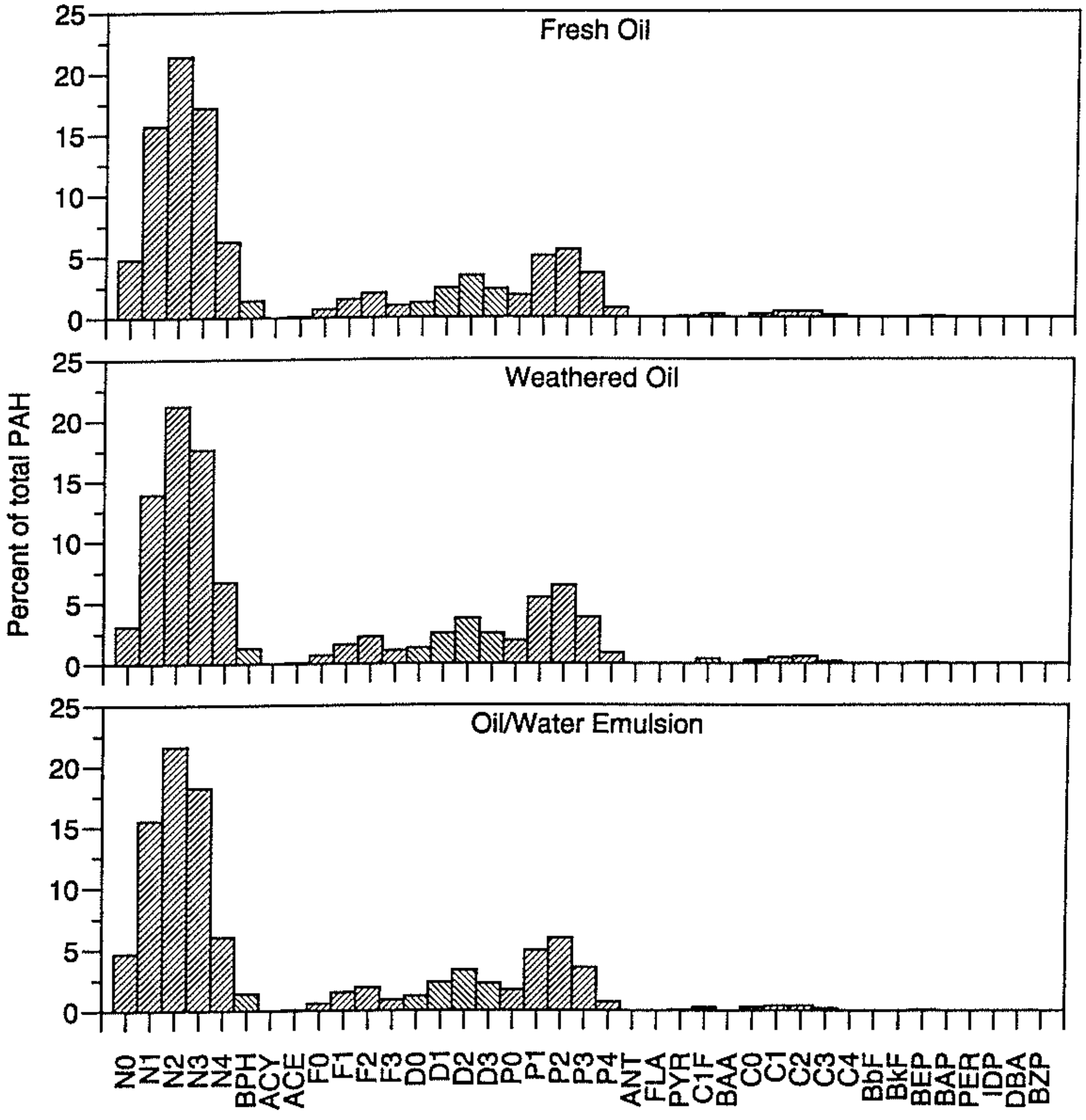


Fig. 3: Percent composition by weight of polycyclic aromatic hydrocarbons in Exxon Valdez oil 11 d post spill. N=naphthalenes, F=fluorenes, D=dibenzothiophenes, P=phenathrenes, C=crysenes. Numbers following abbreviations are the number of alkyl substituted carbon atoms for each analyte.

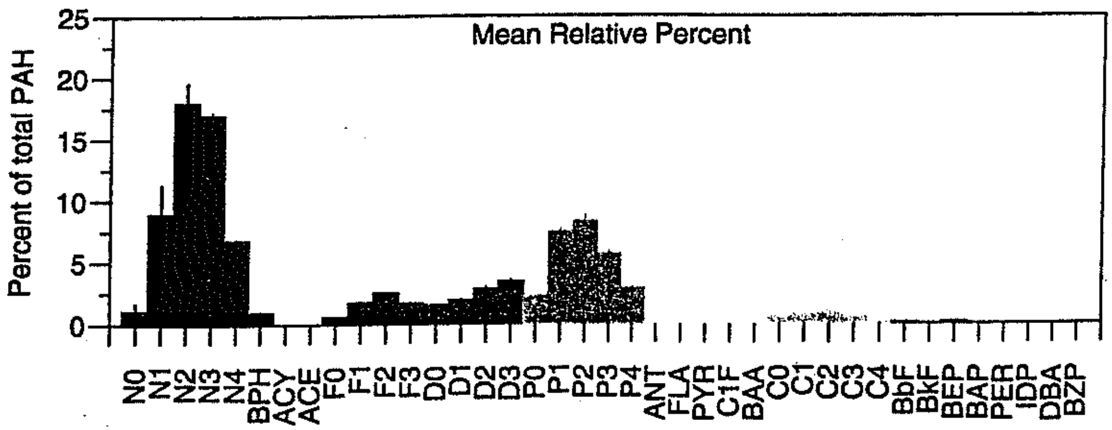


Figure 4. Mean effectiveness (percent total fresh Alaska North Slope crude oil entering the water column) of Corexit 9527 and Corexit 9500 using the swirling flask method. Tested temperatures were 3, 10, and 22°C, tested salinities were 22 and 32‰. Total oil was measured by gas chromatography with FID detection. Error bars are standard error. N=5.

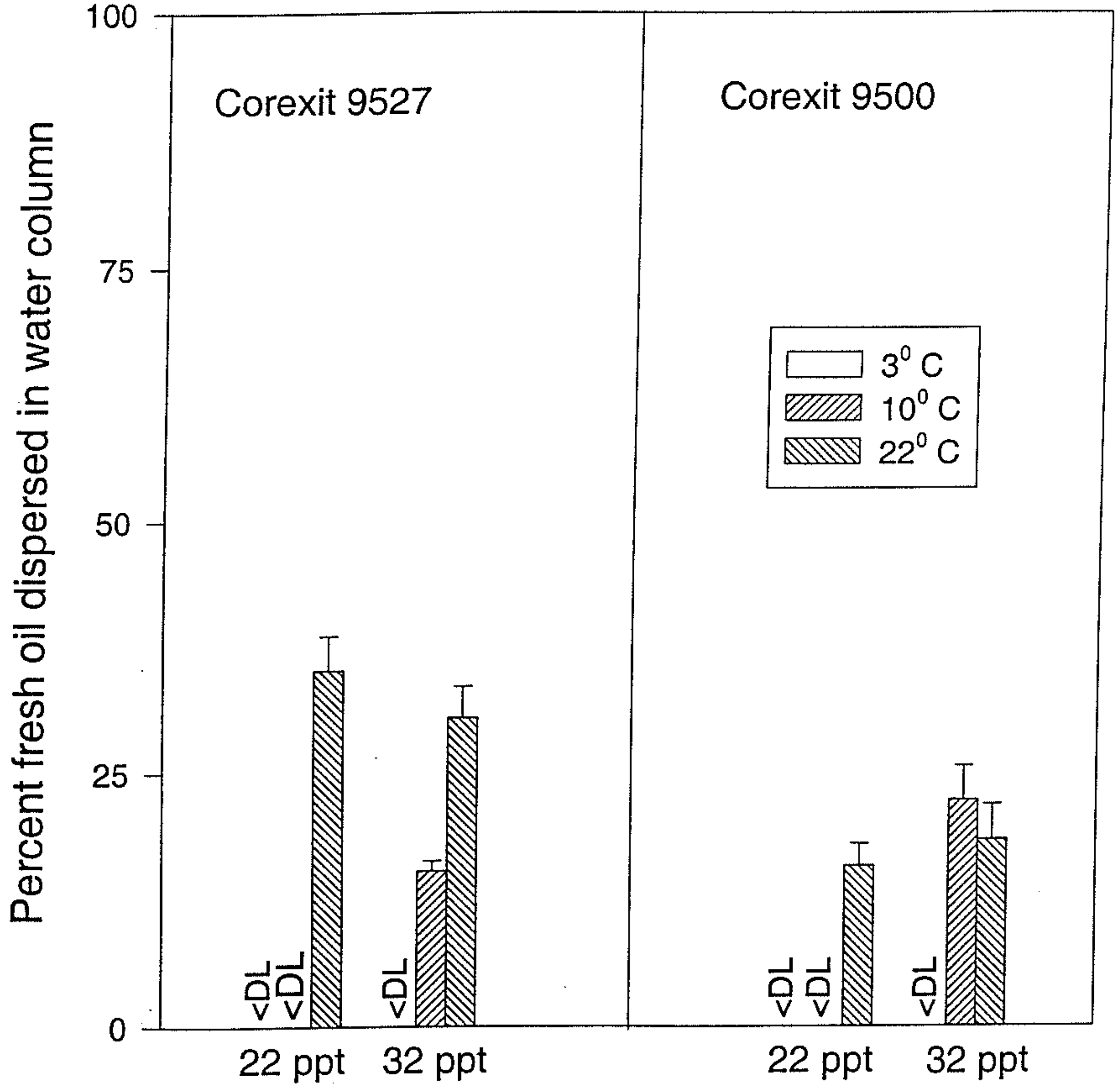
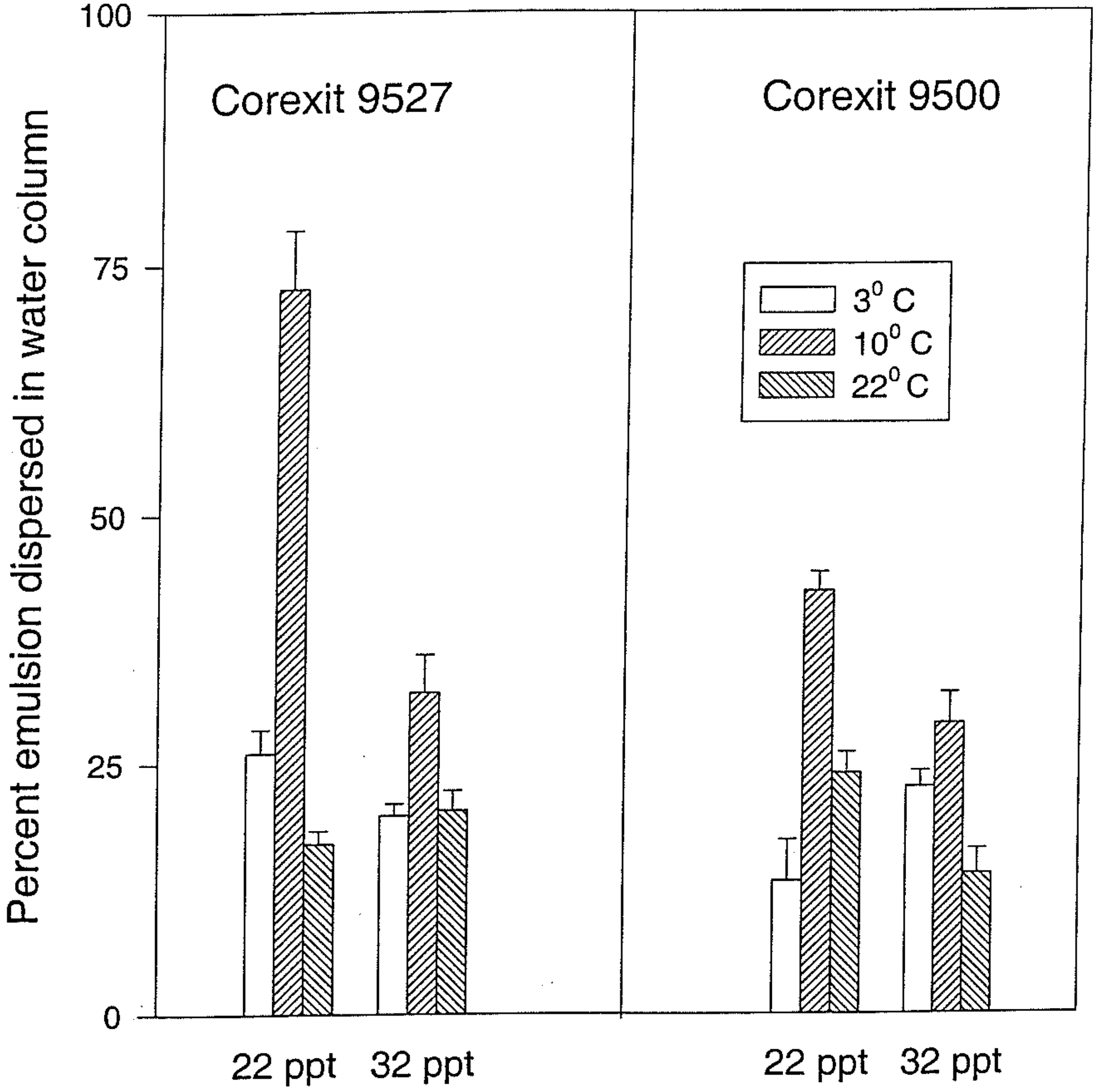


Figure 5. Mean effectiveness (percent total mousse of Alaska North Slope crude oil entering the water column) of Corexit 9527 and Corexit 9500 using the swirling flask method. Tested temperatures were 3, 10, and 22°C, tested salinities were 22 and 32‰. Total oil was measured by gas chromatography with FID detection. Error bars are standard error. N=5.



Efficacy of Corexit 9527 and Corexit 9500 on Fresh Alaska North Slope Crude Oil

	Corexit 9527		Corexit 9500	
Temperature	22‰	32‰	22‰	32‰
3°	9.5	3.1	6.0	8.4
	8.7	0.7	8.7	11.6
	8.2	0.8	12.7	11.8
	7.9	0.6	9.1	7.7
	8.1	0.0	13.0	8.8
10°	8.5	14.8	10.2	27.5
	7.7	16.5	11.1	23.3
	7.7	13.8	10.2	20.0
	7.7	15.3	7.7	17.3
	7.7	16.3	11.7	23.3
22°	30.5	36.0	11.8	12.6
	37.9	29.6	17.9	15.9
	37.8	31.6	17.9	21.0
	38.1	27.5	16.2	21.6
	31.7	27.8	15.2	20.7

Efficacy of Corexit 9527 and Corexit 9500 on Evaporatively Weathered Alaska North Slope Crude Oil

	Corexit 9527		Corexit 9500	
Temperature	22‰	32‰	22‰	32‰
3°	6.3	7.1	6.3	6.3
	6.3	6.3	6.3	6.3
	6.3	6.3	6.3	6.3
	6.3	6.3	6.3	6.3
	6.3	6.3	6.3	6.3
10°	2.5	7.4	3.8	1.7
	1.6	5.7	5.2	3.5
	1.6	3.3	7.4	3.9
	1.4	1.4	3.1	1.4
	1.4	2.9	3.0	2.4
22°	6.3	6.3	6.3	6.3
	6.3	6.3	6.3	6.3
	6.3	6.3	6.3	6.3
	6.3	6.3	6.3	6.3
	6.3	6.3	6.3	6.3

Effectiveness of Corexit 9527 and Corexit 9500 on Emulsion of Alaska North Slope Crude Oil

Temperature	Corexit 9527		Corexit 9500	
	22‰	32‰	22‰	32‰
3°	22.3	20.3	9.6	21.7
	24.3	20.6	8.7	20.7
	27.4	12.0	20.4	22.0
	27.9	24.6	15.8	23.4
	28.5	21.5	11.5	25.4
10°	62.3	39.7	45.1	33.9
	71.5	31.0	42.9	29.0
	76.7	28.4	41.0	30.7
	79.4	30.8	43.2	25.8
	73.8	31.4	39.5	25.7
22°	16.6	20.6	25.3	13.0
	14.2	18.4	21.0	16.2
	17.9	23.5	23.3	16.5
	21.5	21.1	23.2	9.7
	14.9	18.0	27.3	13.9

Efficacy of Corexit 9527 and Corexit 9500 on Alberta Sweet Crude Oil

Temperature	Corexit 9527	Corexit 9500
	32‰	32‰
22°	52.2	44.3
	53.7	45.1
	54.6	44.8
	53.2	47.4
	59.5	46.5