The Relationship Between Acute and Population Level Effects of Exposure to Dispersed Oil, and the Influence of Exposure Conditions Using Multiple Life History Stages of an Estuarine Copepod, *Eurytemora affinis*, as a Model Planktonic Organism.

Final Report Submitted to

The Coastal Response Research Center

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Abstract

This project was directed at a critical need for information about long term effects/delayed effects on plankton populations affected by short-term (24 hours or less) exposure to dispersants and dispersed oil. This study examines the relationship between sublethal exposure and population level effects of the estuarine copepod, *Eurytemora affinis*, to short-term dispersant, water-accommodated fractions (WAF) and chemically enhanced water accommodated fractions (CE-WAF) of weathered oil under normal and UV light conditions. In this study, static constant acute toxicity experiments determined 24- and 48-hour LC_{50} concentrations for nauplii, copepodites and adults using dispersant Exxon Corexit® 9500 and weathered Alaskan North Slope crude oil. The 24-hour LC_{50} concentrations for adult, copepodite and nauplii were 19, 15 and 10 ppm for Corexit® 9500; 28, 32 and 81 ppb for total PAHs (TPAH) in WAF; and, 60, 42 and 15 ppb for TPAH in CE-WAF. The most sensitive life stage, nauplii, was exposed to dispersant, WAF and CE-WAF at previously determined LC_{50} concentrations. Under either ambient laboratory or UV light conditions, nauplii that survived toxicant exposure were followed for approximately three generations in order to develop life history tables and population profiles. *E. affinis* is a relatively sensitive species (based on acute toxicity) to dispersant alone, WAF or CE-WAF. However, for organisms surviving an initial exposure approximating the 24-hour LC_{50} value for a 24-hour period, there was no evidence of any change in fecundity or overall population growth in culture over approximately three generations, with or without exposure to UV light after exposure to the toxicant.

Keywords: Dispersed Oil Toxicity, Chemically Enhanced Water Accommodated Fraction, CROSERF, TPH and LC_{50}.

Acknowledgements

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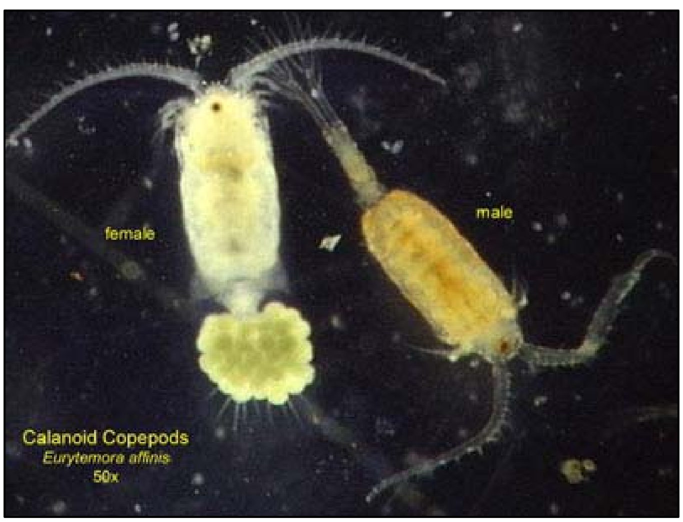
1.0 Introduction

The 2005 National Academy of Sciences report, "Understanding Oil Spill Dispersants: Efficacy and Effects" included a discussion of the difficulty of making the environmental tradeoff decisions associated with the use of dispersants (NRC 2005). A key concern of the Committee was the difficultly in relating traditional toxicity tests to population or community level impacts. As the Committee further acknowledged, this issue is not unique to oil spill decision-making but is a central issue in eco-toxicology. Nevertheless, oil spill response planners must make these decisions on a regular basis. The degree of difficulty that is encountered is a function of the perceived level of risk associated with making an incorrect decision, which, in turn, is a function of the specific spill. This study allows an initial evaluation of the significance of four associated concerns – acute toxicity, photoenhanced toxicity, multi-generational effects and fecundity as they relate to population dynamics.

Proponents of dispersant use generally dismiss potential impacts to plankton communities (and water column habitats as well) if the dilution is rapid enough to limit the magnitude and duration of exposure so that only a small fraction of the population (or habitat) is exposed to concentrations likely to be "of concern," while opponents envision serious impacts. This "of concern" level is usually loosely defined by local decision-makers based on whatever knowledge they have concerning the median lethal concentration (LC_{50}) values for representative species, and field observations from other oil spills with a (highly variable) qualitative safety factor included. Obviously, these judgments are highly subjective, potentially controversial, and for many participants there is a lingering concern that sub-lethal effects for important planktonic or benthic species with sensitive life history stages may be more important than currently recognized.



E. affinis, MSGEP 2009 (J. Adam Frederick)

The difficultly planners have in making dispersant-use decisions varies depending on a number of factors; however, in all cases, it would be beneficial if long-term effects of short-term exposure were more clearly understood. Among the recommendations in the NRC (2005) report was that toxicity tests need to be expanded by evaluating delayed effects, which could include a wide range of physiological changes that might affect population dynamics. Multi-generational tests examine these types of impacts; however, these are time-consuming and logistically challenging for many common species. Planktonic crustacean species offer many advantages for this type of study. Individuals are small, the life cycle is short, many have a history of use in toxicity testing and are easy to culture in the laboratory, and they are frequently important links in the coastal aquatic food web. In this experiment we used an estuarine copepod, *Eurytemora affinis,* which is a common coastal and estuarine species, with a generation time of approximately 2 weeks, and which is representative of many holoplanktonic organisms.

Further, the potential for photoenhanced toxicity has been raised as a concern by Barron and Ka'aihue (2001) and Barron *et al*. (2003). As noted by the NRC (2005), this issue has not been well investigated, and while the significance in the field is probably somewhat limited (to areas of very clear water and the presence of sensitive organisms), it remains an unresolved issue. Injury and risk to aquatic organisms from an oil spill may be underestimated if it based on standard laboratory bioassays and existing toxicity databases that do not account for the phototoxicity of oil (Barron, 2002). Tests for this study were conducted using environmentally relevant UV intensities to determine population level impacts of exposed copepods.

A final concern was fecundity, which describes the number of eggs produced by an individual female (Lagler, 1949). Since the study of fecundity is a major component to having a full understanding of its biology and population dynamics, efforts were made to determine the effects of dispersant, the water-accommodated fraction (WAF) of oil and chemically enhanced (CE)-WAF (i.e. dispersed oil) on egg production.

2.0 Objectives

Dispersant use during oil spills involves environmental trade-offs between impacts to the water column and benthic resources (such as coral reefs) compared to other habitats (e.g., salt marshes or mangroves). Laboratory data for water column organisms consist almost entirely of constant exposure and acute toxicity information. This study examines effects of short-term exposure to dispersant alone, the water accommodated fraction, and dispersed weathered ANS crude oil on the life history of the copepod *E. affinis* in order to define the relationships among acute toxicity, sub-lethal exposures, and population level effects for water column organisms. Additionally, as noted by Barron (2003), the toxicity of chemically dispersed oil cannot be adequately evaluated without an assessment of the potential for photoenhanced toxicity, so an environmentally-relevant UV light regime was applied after 24 hours of toxicant exposure to allow bioaccumulation of phototoxic petroleum hydrocarbons prior to conducting population studies. To investigate the impact of sublethal concentrations (based on the 24-hour LC_{50}) on fecundity, a study was conducted to ascertain an increase or decrease in reproduction when using initially exposed nauplii and transferring survivors to seawater to grow to maturity.

3.0 Methods

3.1 Test Organisms, Solutions and Maintenance

Test Organisms

E. affinis, MSGEP 2009 (J. Adam Frederick)

E. affinis is a calanoid copepod, a ubiquitous estuarine species common in much of the United States, and is an important component of estuarine food webs. *E. affinis* is a standard test organism for the US Environmental Protection Agency's Chesapeake Bay Program, which published standard protocols for culturing and toxicity testing (Ziegenfuss and Hall, 1998). *E. affinis* has a short generation time allowing multiple generations to be observed in a relatively short period of time. The species also exhibits a wide range of salinity tolerance, inhabiting freshwater to hypersaline environments (Wolff, 2000), which means it can be cultured at salinities appropriate for dispersed oil testing.

For this study, brackish seawater (initial salinity range 10-15 ppt) was collected in Lusby, Maryland, near the mouth of the Patuxent River in the Chesapeake Bay. After pumping seawater through a series of filters (5, 1 and 0.5 µm), the salinity was raised to 20 ppt using Instant Ocean© (Aquarium Systems, Inc., Mentor, OH). *E. affinis* were obtained from Chesapeake Biological Laboratory (initial culture seawater range 10-15 ppt, 20°C) and slowly increased to 20 ppt salinity. The copepods were maintained in 20 ppt seawater at 20-25°C and fed an algal mixture of *Isochrysis galbana* and *Thalassiosira weissflogii* three times a week. The *I. galbana* and *T. weissflogii* algal cultures were started from cultures received from Chesapeake Bay Laboratory in Solomons, Maryland and maintained using an f/2 medium for nutrients (Guillard, 1975; Guillard and Ryther, 1962) (Aquatic Ecosystems, Inc., Apopka, FL) and seawater. Seawater reference toxicant test solutions using cadmium (from $CdCl_2$) (Alfa Aesar, Ward Hill, MA) were

Isochrysis galbana and *Thalassiosira weissflogii*, A. Slaughter (EM&A 2007) prepared in concentration ranges appropriate to provide a measure of relative sensitivity for the test organism, *E. affinis* (Ziegenfuss and Hall, 1998).

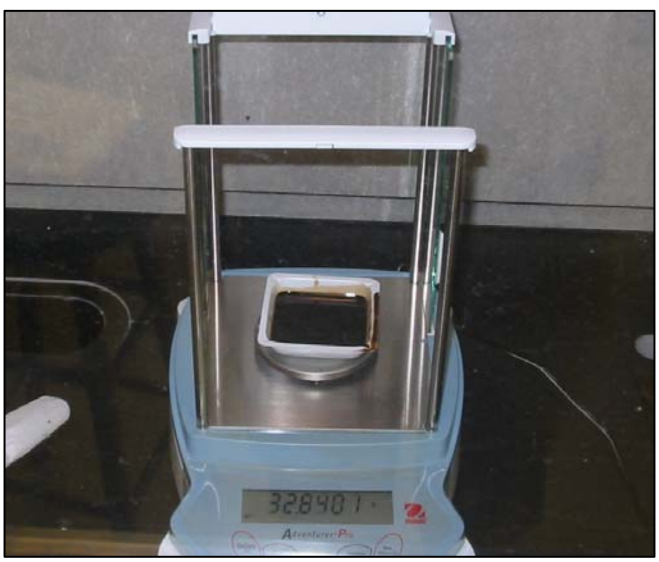
Water Quality and Light Parameters

Seawater salinity, dissolved oxygen, pH and temperature were monitored during each experiment in a subset of the containers as well as throughout copepod and algal culturing (Milwaukee Instruments, Rocky Mount, NC) (Sper Scientific, Scottsdale, AZ). Fluorescent tube artificial lighting was used to provide a photoperiod of 16 hours light and 8 hours dark (16L:8D).

Environmentally relevant UV intensities were chosen based on UVA and UVB underwater readings we obtained on a sunny day in the middle Chesapeake Bay near the mouth of the Patuxent River (38°19'12" N, 76°27'27"W), 10 cm below the surface in March of 2007. These irradiance intensities were between 15-20 $\mu W/cm^2$ for UVB and 1700-2000 $\mu W/cm^2$ for UVA, measured using an IL1400 radiometer with SUL240/SUL033 detectors (International Light, Peabody, MA).

Test Chemicals and Solution Preparation

Toxicity tests were conducted using Corexit® 9500 (C9500) (Nalco/Exxon Energy Chemicals, L.P. Sugarland, Texas) and weathered Alaskan North Slope (ANS) oil. For experimental use, fresh ANS oil was measured gravimetrically and weathered by 20% through evaporation in a fume hood at room temperature for approximately 8 hours. Weathered crude oil is distinguished from fresh or unweathered crude oil by the loss of the low molecular weight constituents such as the normal hydrocarbons less than n-C12, the alkylbenzenes and, to some extent, naphthalene and its alkyl homologues (NOAA 1997). Table D-2 presents the analytical results for the PAH analysis of both whole (neat) and weathered ANS crude oil used in these experiments. For whole oil, this obviously represents only a partial characterization, since it does not include the low molecular weight aliphatic and monoaromatic constituents likely to have evaporated.

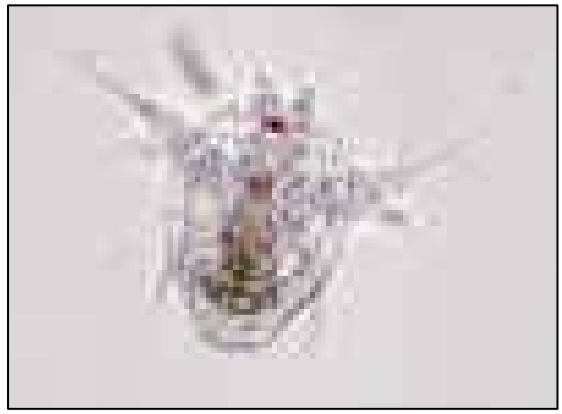


Weathering Oil, A. Slaughter (EM&A 2007)

All exposure solutions were prepared according to Chemical Response to Oil Spills: Ecological Effects Research Forum (CROSERF) protocols (Singer *et al.*, 2000). The oil and dispersant were measured by mass using gas-tight syringes (Hamilton Co., Reno, NV) and dispensed into glass aspirator bottles containing 2 L of 20 ppt seawater with approximately 20% headspace. Dispersant solutions were stirred for five minutes prior to use in experiments. WAF solutions were prepared by low energy (no vortex) mixing of weathered ANS. CE-WAF solutions were prepared by 20-25% vortex mixing of weathered C9500 and ANS (1:20

dispersant:oil). WAF and CE-WAF solutions were covered with aluminum foil and stirred for 18 hours, the CE-WAF rested for six hours prior to experimental use.

3.2 Acute Toxicity Impacts - LC_{50}



E. affinis nauplii (GLERL 2009)

Acute toxicity is commonly measured by the median lethal concentration (LC_{50}), that concentration which causes mortality in 50% of exposed organisms. To establish this value, gravid *E. affinis* were isolated and nauplii were collected and grown for various life stage LC_{50} experiments using dispersant, WAF or CE-WAF solutions. For each life stage (naupliar, copepodite and adult), a constant static 24- or 48-hour exposure experiment consisted of three replicates of a control and four increasing concentrations with each replicate containing 250 mL of toxicant or control seawater in a 1 L glass beaker. *E. affinis* were introduced into the solution, fed and remained for the duration of the experiment until they were counted for survivability at 24 or 48 hours. The LC_{50} for dispersant was generated using data from ultraviolet-visible spectroscopy (UV/Vis). Polycyclic aromatic hydrocarbon (PAH) LC_{50}'s used gas chromatography/mass spectrometry (GC/MS) data and total petroleum hydrocarbons (TPH) LC_{50}'s were calculated using an experimentally derived correlation factor applied to the PAH values, see Appendix D for a thorough explanation and background information for the hydrocarbon analytical protocols.

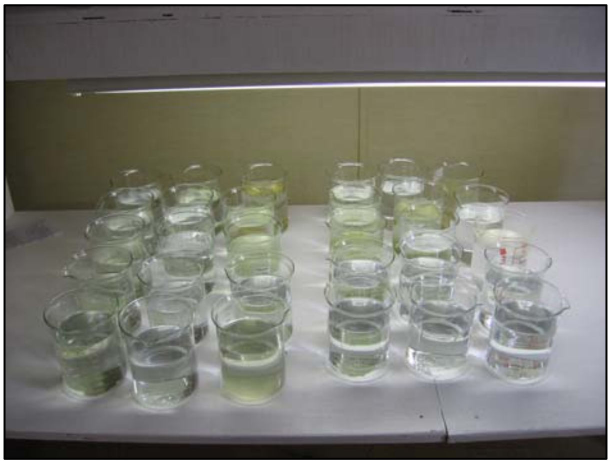
3.3 Population Studies

Population Study, A. Slaughter (EM&A 2007)

To examine the population consequences of short-term exposure, nauplii were exposed to control seawater and previously determined 24-hour toxicant solutions for dispersant alone, WAF and CE-WAF, under two light conditions: 1) ambient laboratory light; and, to study the effects of phototoxicity, 2) full solar radiation.

Initially, 4 day-old nauplii were exposed for 24 hours to control seawater and two solutions with concentrations close to the previously determined LC_{50} for each toxicant. Concurrently, 25 copepods were transferred into a subsample of each solution and 25 copepods were transferred into each beaker as a gauge for the solution's toxicity of the solution. After 24 hours, the subsample beakers were counted, and the copepods in the solution that more closely caused 50% mortality were used for population study.

To begin the population study under ambient light conditions, thirty 1 L beakers (15 controls, 15 toxicants) were prepared with 750 mL fresh seawater and 30 mL of algal mixture, and each beaker received 10 previously exposed nauplii survivors. During the grow out period, beakers were lightly covered, placed under ambient laboratory light with a 16L:8D cycle, and fed 30 mL algal mixture three times a week. At T =12 days, 19 days, and 26 days, five control and five toxicant beakers were counted to quantify life history stages.



Population Study, A. Slaughter (EM&A 2007)

Under the UV light scenario, prior to beginning the population study, previously exposed nauplii were transferred into beakers with fresh seawater and placed outdoors in direct sunlight in a controlled temperature water bath for 4 hours, between 10 am and 2 pm. To simulate desired UVA/UVB intensities at 10 cm below the surface of the water, beakers were covered with nylon mesh for partial screening and monitored with a UVA/UVB detector every 30 minutes to ensure correct exposure. After UV exposed beakers were moved inside, nauplii were counted in sets of 10 and placed in individual beakers to begin population studies, as described above.

3.4 Fecundity Study

To investigate the impact of sublethal concentrations on fecundity, a study was conducted to ascertain an increase or decrease in reproduction when using initially exposed nauplii and growing them to maturity in fresh seawater.

Fecundity Study, A. Slaughter (EM&A 2007)

As in the populations study, 4-day old nauplii were exposed for 24 hours to control seawater and two solutions with concentrations close to the previously determined LC_{50} for each toxicant, including pre-counted subsamples. After determining the appropriate concentration with mortality closest to 50% as a gauge for the solution's toxicity, the nauplii were transferred to fresh seawater to grow to maturity. As adult females became gravid, they were transferred into individual 20 mL vials, and, upon hatching, nauplii from the initial egg sacs were immediately counted for the fecundity estimate. No attempt was made to determine the potential for additional broods from individual females.

3.5 Chemical Analysis

Reference Toxicant - Cadmium

Reference toxicant solutions of $CdCl_2$ were analyzed by Andrew Heyes PhD, Chesapeake Biological Laboratory, in Solomons, MD using an inductively coupled plasma mass spectrometer (HP4500 Agilent, Santa Clara CA).

Dispersant

C9500 concentration measurements were made using a Hewlett Packard 8451A Diode Array Spectrophotometer (Norwalk, CT). Spectral analysis indicated it absorbed well in the UV range, with a functional λ_{max} of 234 nm. The concentration of dispersant was calculated from absorbance readings at λ_{max} using predetermined daily calibration curves during testing periods.

PAH

The WAF and CE-WAF solutions were analyzed for PAHs by GC/MS by Joel Baker, PhD, Chesapeake Biological Laboratory (CBL) in Solomons, MD. Fifty-three individual PAHs, including methylated species and dibenzothiophenes were quantified by selected ion mass spectrometry with isotope dilution. Compounds were identified and quantified using authentic standards based on retention time and ion fragmentation in selective ion monitoring mode. Details on the analytical protocols used by CBL are presented in Appendix D.

TPH

The TPH values were calculated by applying a correlation factor to the PAH values that were measured by GC/MS. To generate the correlation factor, a range of WAF and CE-WAF samples encompassing all experimental loading rates were analyzed for PAH using GC/MS and for TPH using gas chromatography/flame ionization detector (GC/FID). Calibration curves were obtained for both WAF and CE-WAF solutions to determine a correlation between PAH and TPH. See Appendix D for a thorough explanation and background information for this process.

3.6 Statistical Analysis

As per CROSERF protocol (Singer *et al*., 2000), the Probit (probability unit) test was used for estimating 24-, 48- and 96-hour LC_{50} values if the test data were normally distributed. Trimmed Spearman-Karber was used for non-parametric distributions. Variation within and among the test populations was assessed by using three replicate exposure chambers within each test treatment.

Statistical differences in population and fecundity experimental results were determined using the Student's-t Test (2-tailed), as provided in the Microsoft Excel Data Analysis Tool. No statistical comparisons were made of the calculated LC_{50} values because replicates were not available.

4.0 Results

4.1 Overall Test Conditions

Detailed data tables for all experiments and analytical chemistry are included in the Appendices. The primary data sets are Appendix B, Experimental Data, and Appendix D, PAH Measurement and TPH Calculation. Please refer to the Table of Contents for details.

Water Quality Parameters

Table 4-1 summarizes the water quality conditions (temperature, salinity, dissolved oxygen and pH) measured throughout the experiments. All water quality conditions were within acceptable parameters for *E. affinis*. See Table A-1 for complete experimental water quality data.

Table 4-1 Water Quality Parameters

	Dispersant				WAF				CE-WAF			
	Temp (°C)	Salinity (ppt)	DO (mg/L)	pH	Temp (°C)	Salinity (ppt)	DO (mg/L)	pH	Temp (°C)	Salinity (ppt)	DO (mg/L)	pH
LC50	**n=12**				**n=6**				**n=12**			
Mean	21.62	20.02	7.51	7.93	21.18	20.00	7.20	7.85	21.47	20.00	7.63	7.78
SD	1.33	0.02	0.52	0.23	1.92	0.00	0.28	0.20	0.28	0.00	0.79	0.24
Population	**n=10**				**n=10**				**n=10**			
Mean	21.06	19.5	8.1	7.835	20.69	19.275	8.645	8.135	20.83	19.3	7.85	8.1
SD	0.57	0.55	0.38	0.33	0.96	1.15	0.60	0.60	0.61	1.04	0.28	0.35

Reference Toxicant Tests

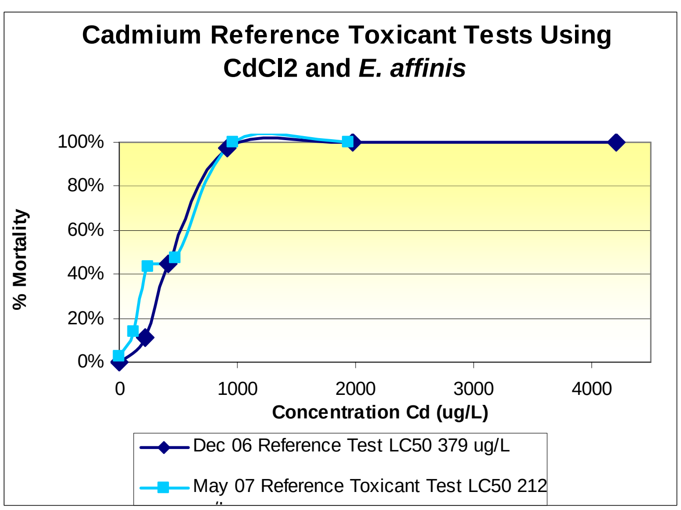


Figure 4-1 Cadmium Reference Toxicant Test using $CdCl_2$ and *E. affinis*

Reference toxicant test results (Figure 4-1) were within acceptable limits for adult *E. affinis* using cadmium chloride as a reference toxicant. The mean LC_{50} for both reference tests was 303 ppb for adult *E. affinis*, which was slightly higher than published data from tests that used more sensitive naupliar life stages (Hall *et al.*, 1995).

4.2 Acute Toxicity Results

The summary results of the acute toxicity studies are shown below, one experiment per life stage, toxicant, and exposure (see Appendix B for details). The calculated 24- and 48-hour LC_{50} values for C9500 are in Table 4-2, oil and dispersed oil based on measured total (T)PAH values in Table 4-3 and oil and dispersed oil calculated TPH values in Table 4-4. The method used to calculate the estimated TPH values is described in Appendix D and the analytical results for the TPAH analysis are given in Appendix B for each experiment, while details for individual PAH analytes can be found in Appendix D, Table D-2. The calculated TPH values are included to provide an approximate link to other studies where values were reported as TPH and not TPAH. Note that values for C9500 are in ppm, while all values for WAF and CE-WAF (measured or calculated) are reported in ppb. It was extremely difficult to create WAF solution concentrations high enough to complete the toxicity tests. Loading rates as high as 3 to 6 gms/liter were sometimes used (which equates to approximately 22 to 45 g/m2, based on the geometry of the mixing chamber). Such concentrations are much higher than values likely to occur in the open ocean, except right at the source of a spill.

As discussed in Appendix C, we were unable to obtain reproducible results using the CROSERF flow-through chambers, and as a result we used static exposures of 24 and 48 hours. This is a considerably higher exposure that would have occurred using the "spiked" exposure protocol developed for CROSERF.

Since there is only one value for each calculated LC_{50}, statistical comparisons are not possible, but when exposed to C9500 alone (Table 4-2) all the LC_{50} values for nauplii were slightly lower than for either juveniles or adults. Also, all three life stages showed a lower LC_{50} value for 48- versus 24-hour exposures to C9500 alone. All were much less sensitive to C9500 alone than to either WAF or CE-WAF (Table 4-3, Table 4-4). Observed 24- and 48-hour LC_{50} values for C9500 ranged from 6 to 10 ppm for nauplii, and from 10 to 19 ppm for juveniles and adults combined.

Measured PAH LC_{50} values for both WAF and CE-WAF appear unchanged for the 48- versus 24-hour exposures, with the exception of nauplii. In addition, for all but one exposure (24-hour WAF), nauplii appear more sensitive than copepodites, which are more sensitive than adults. In no instance, however, was the TPAH LC_{50} value greater than 100 ppb (0.1 ppm).

Table 4-2 Summary of Measured C9500 LC_{50} values for *E. affinis*

		LC_{50} (ppm)	
	Copepods	**Copepodites**	**Nauplii**
C9500			
24-h	19.2	14.6	9.5
48-h	15.3	9.6	6.3

Table 4-3 Summary of Measured PAH LC_{50} values for *E. affinis*

	Measured PAH LC_{50} (ppb)		
	Copepods	**Copepodites**	**Nauplii**
WAF			
24-h	28.1	31.8	81.0
48-h	78.5	46.3	16.2
CE-WAF			
24-h	60.4	43.1	15.3
48-h	50.5	40.4	9.7

Table 4-4 Summary of Calculated TPH LC_{50} values for *E. affinis*

	Calculated TPH LC_{50} (ppb)		
	Copepods	**Copepodites**	**Nauplii**
WAF			
24-h	746	762	2055
48-h	2087	749	707
CE-WAF			
24-h	858	601	231
48-h	799	564	148

4.3 Population Studies

The summary results for the population study (see Appendix E for the actual organism counts over time) are shown in Figure 4-2 through Figure 4-3. Each graph compares the population levels after 12, 19 and 26 days (initial dispersant only experiments were run until day 33), based on starting with 10 immature individuals (either controls or animals exposed for 24 hours to a solution approximating the 24-hour LC_{50} value for that toxicant and surviving, as shown on the graph). In all cases (C9500 only, WAF and CE-WAF exposure) a non-UV and a UV light exposure was conducted (see Section 3.3 for details on the exposure protocol). Error bars indicate the standard deviation for the total population, based on five replicates. The results of the statistical analyses for the six population studies are shown in Table 4-5.

There are only rarely differences between the control and treatment groups, regardless of exposure regime, which are significant, and the direction of the change is not consistent. For example, the WAF non-UV experimental results showed the most significance, but at t = 12 the treatments were significantly lower than the controls, at t = 19 there was no difference, and at t = 26 the results were mixed. In some cases the population level declined at the end of the test period, and in others it did not, but the patterns were similar for both controls and treatments in each experiment. Exposure to UV light for a 4-hour period after treatment appeared to depress the population size for both the controls and the treatments equally, in comparison to the non-UV light experiments. Overall, the variability between replicates appears much more important than any treatment effect.

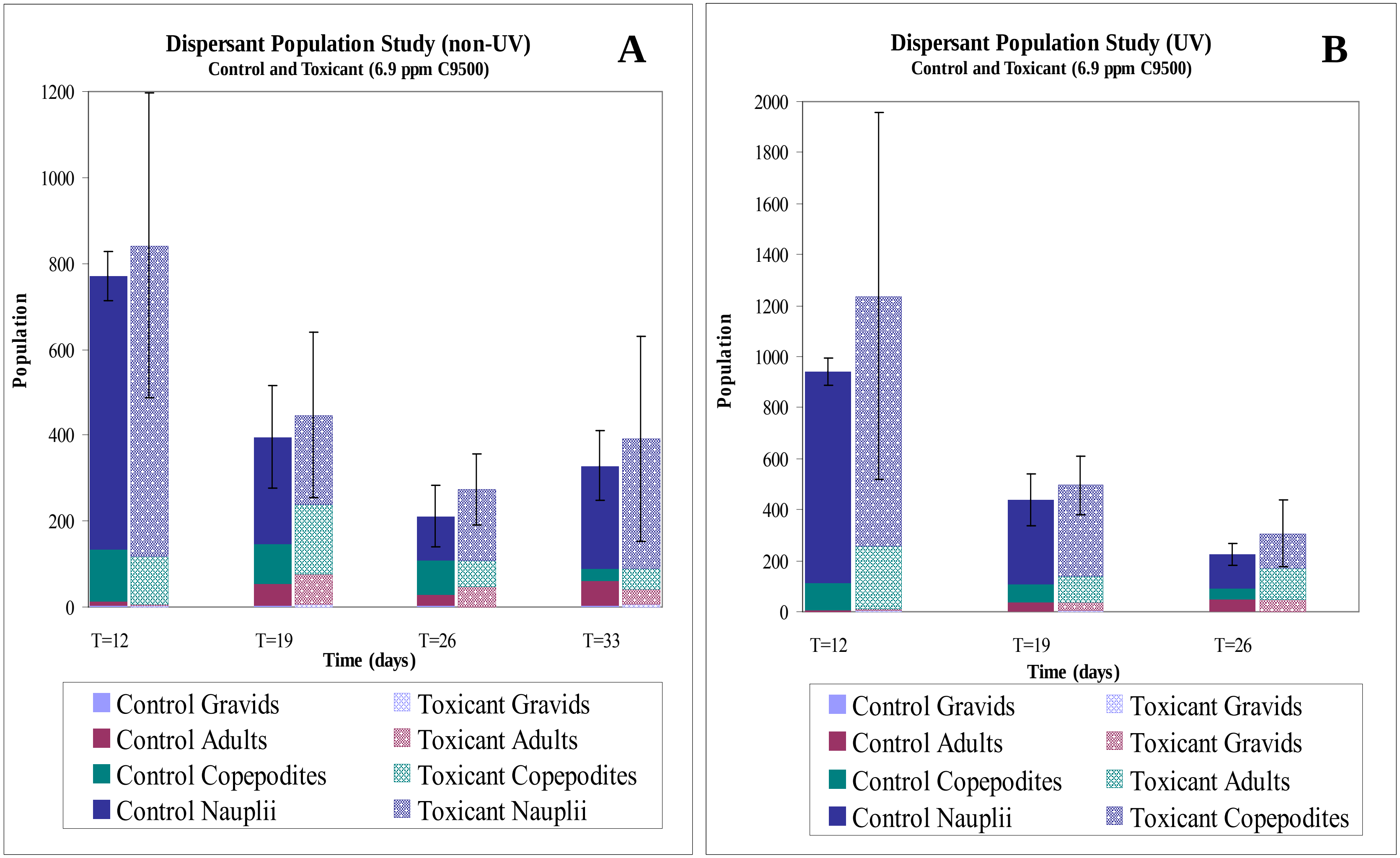


Figure 4-2 Population Study – Dispersant Non-UV (Graph A) and UV (Graph B).
Standard deviation error bars based on total count (all life stages), N=5. See Appendix E for more details.

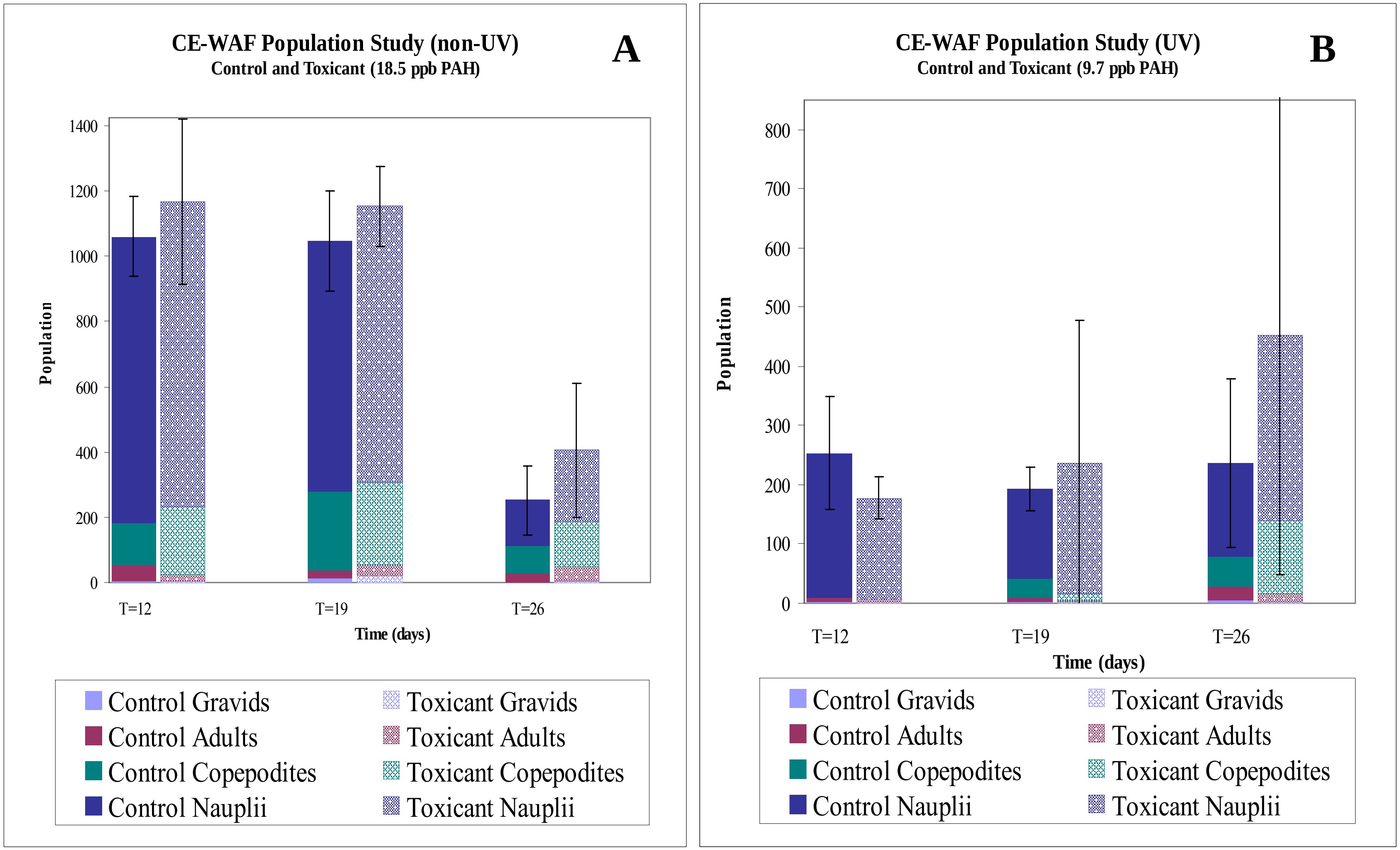


Figure 4-3 Population Study – CE-WAF Non-UV (Graph A) and UV (Graph B).
Standard deviation error bars based on total count (all life stages), N=5. See Appendix E for more details.

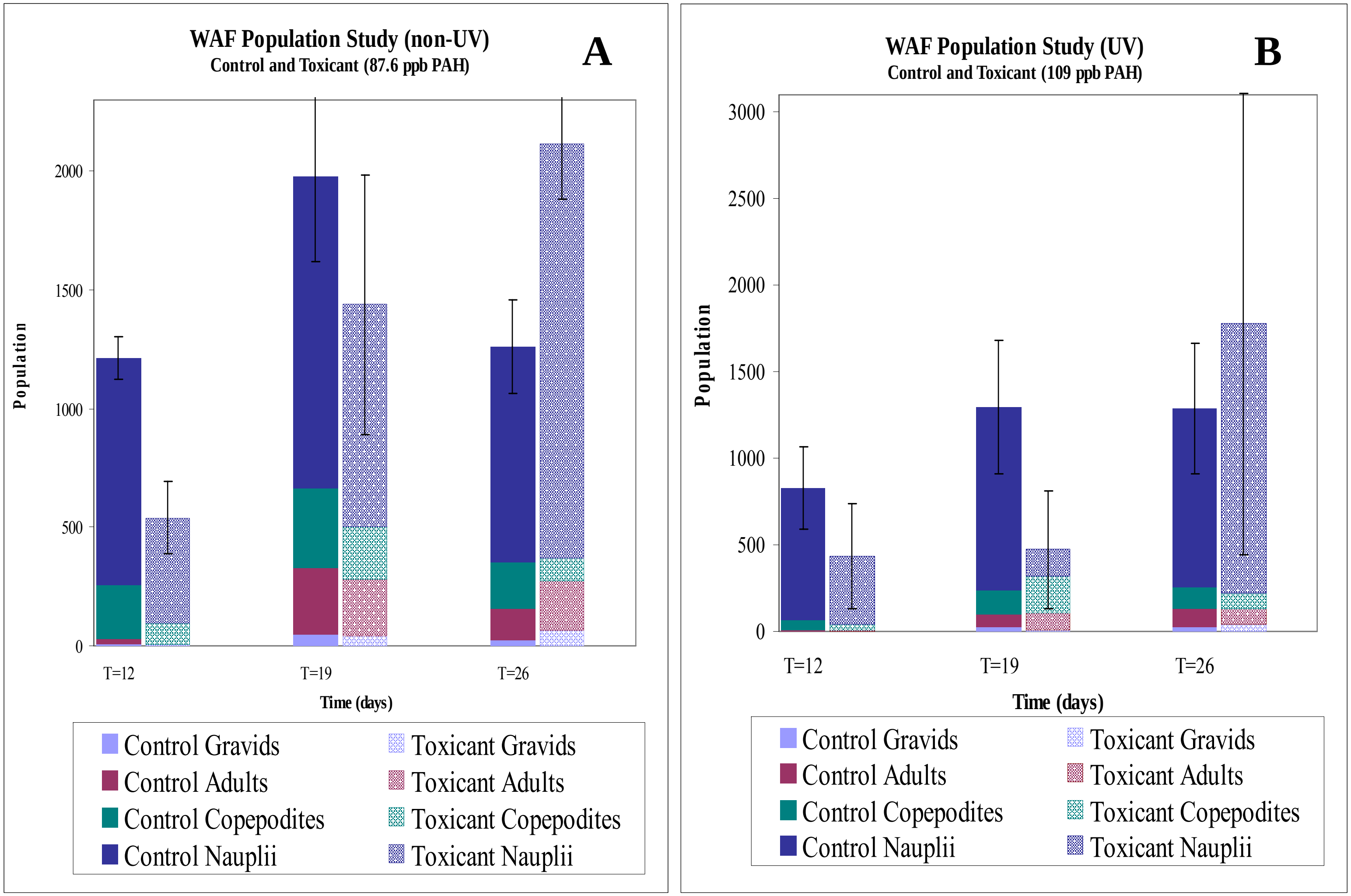


Figure 4-4 Population Study – WAF Non-UV (Graph A) and UV (Graph B).
Standard deviation error bars based on total count (all life stages), N=5. See Appendix E for more details.

The average surface irradiance ranged from 3.3 – 3.6 mW/cm^2 for UVA and 40-49 $\mu W/cm^2$ for UVB. Nylon screening was used to filter the intensity of the light in order to attain the targeted irradiance that approximated the attenuated sunlight in the water column. The average filtered irradiance ranged from 1.7-2.2 mW/cm^2 for UVA and 15-20 $\mu W/cm^2$ for UVB, Table 4-6.

Table 4-5 Summary of Population Study Statistical Analysis

	T=12	T=19	T=26
Dispersant Non-UV	**Figure 4.2 A**		
Total	ns	ns	ns
Nauplii	ns	ns	ns
Copepodite	ns	ns	ns
Copepod	* *(l)*	ns	ns
Dispersant UV	**Figure 4.2 B**		
Total	ns	ns	ns
Nauplii	ns	ns	ns
Copepodite	ns	* (h)	ns
Copepod	ns	ns	ns
CE-WAF Non-UV	**Figure 4.3 A**		
Total	*ns*	*ns*	*ns*
Nauplii	*ns*	*ns*	*ns*
Copepodite	*ns*	*ns*	*ns*
Copepod	*ns*	*ns*	*ns*
CE-WAF UV	**Figure 4.3 B**		
Total	*ns*	*ns*	*ns*
Nauplii	* *(l)*	*ns*	*ns*
Copepodite	*ns*	* *(l)*	*ns*
Copepod	*ns*	*ns*	*ns*
WAF Non-UV	**Figure 4.4 A**		
Total	** *(l)*	*ns*	** *(h)*
Nauplii	** *(l)*	*ns*	** *(h)*
Copepodite	** *(l)*	*ns*	* *(l)*
Copepod	** *(l)*	*ns*	*ns*
WAF UV	**Figure 4.4 B**		
Total	*ns*	** *(l)*	*ns*
Nauplii	*ns*	** *(l)*	*ns*
Copepodite	*ns*	*ns*	*ns*
Copepod	*ns*	*ns*	*ns*

*** p < 0.05 Student T-test**
**** p < 0.01 Student T-Test**
ns - not significant
(h) Toxicant count higher than control
(l) Toxicant count lower than control
N=5

Table 4-6 Mean solar irradiance measured during naupliar exposure of *E. affinis*

Toxicant	UVA mW/cm²				UVB µW/cm²			
	Surface		Screen		Surface		Screen	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6.9 ppm C9500	3.28	0.03	2.17	0.05	40	2.6	16	1.5
9.7 ppb PAH CE-WAF	3.63	0.48	1.93	0.09	44	7.9	16	3.1
109 ppb PAH WAF	3.48	0.45	1.74	0.13	49	4.5	17	3.0

1) Toxicant - Actual concentrations
2) Nylon Mesh Screen

4.4 Fecundity Study

A comparison of the effect on fecundity, as described in Section 3.4, was made using sublethal naupliar exposure at approximate 24-hour LC_{50} levels (measured concentrations):

- 6.9 ppm C9500
- 107 ppb PAH WAF
- 9.3 ppb PAH CE-WAF

After exposure, nauplii were grown through adulthood. As they became gravid, the adults were harvested and isolated in individual vials, and the hatched nauplii counted. The mean number of nauplii in the first brood produced by female copepods after hatching under laboratory conditions ranged from 22.4 to 28.9 nauplii per gravid copepod. Minimum fecundity was found in the control while maximum fecundity was found with C9500. Statistically, the number of nauplii for exposures to C9500 and WAF were significantly higher than the control (P=0.05, Student's t test). There was no significant difference between the control and the CE-WAF. The summary of this study is found in Table 4-7 and more detailed information can be found in Appendix F.

Table 4-7 Summary of Sublethal Naupliar Exposure Effects on Fecundity for *E. affinis* using 24-h LC_{50} concentrations

Toxicant	Mean[1]	SD
Control	22.43	4.22
C9500	28.93	4.07
WAF	27.07	4.35
CE-WAF	25.21	5.59

[1]Mean nauplii per beaker (n=14)

5.0 Discussion and Importance to Oil Spill Response/Restoration

Management decisions about dispersant use are frequently contentious, depending on circumstances. It is certainly true that when dispersants are considered as a response option, the risk to water column organisms, particularly planktonic forms, increases, based on an increased exposure to petroleum hydrocarbons as well as exposure to the dispersant mixture itself. A determination as to whether or not this increased risk is sufficient to restrict the use of dispersants needs to be based on a comparison of the risk to water column organisms versus the potential reduction in risk to whatever resources would be affected if the use of dispersants were not allowed. This comparison is always made, either explicitly or implicitly, when an oil spill response plan is implemented. Either way, the decision is based on the way the participants perceive the potential risks and benefits, which varies significantly from place to place. So, for a risk comparison approach to be successful in choosing the appropriate response options, it must be based on the best available information – integrated into the decision in an appropriate manner.

This project focused on obtaining information relevant to one of the key components in this debate, the potential risks to planktonic organisms and was designed to address the following questions:

- What is the sensitivity of the test organism (*E. affinis*) to oil, dispersed oil, and dispersant, when exposed under standard laboratory test conditions and how does this compare to other, commonly used species?
- How does this sensitivity vary with life history stage?
- Do sublethal effects (defined here as exposure but not death) appear to translate into population level consequences?
- Does exposure to any of the three toxicants appear to increase adverse effects of subsequent exposure to UV light?
- How do the toxicity results obtained in these experiments relate to exposures likely to occur in real-world situations?
- Can the information gained in the laboratory experiments be used to expand our understanding of the risk to water column organisms?

Each of these questions is addressed below.

What is the sensitivity of the test organism (*E. affinis*) to dispersant when exposed under standard laboratory test conditions and how does this compare to other, commonly used species? How does this sensitivity vary with life history stage?

The LC_{50} values for static, non-renewal 24- and 48-hour exposures to dispersant alone were shown in Table 4-2, and ranged from 6.3 ppm C9500 for 48-hour naupliar exposure to 19.2 ppm C9500 for 24-hour adult exposure. The relative sensitivity of the three life history stages of *E. affinis* to C9500 shows decreasing sensitivity with age, with nauplii being the most sensitive and adults the least. Toxicity also increased with increasing exposure time, and the 48-hour values are 25 to 50 percent lower.

As part of the earlier CROSERF testing program, a 96-hour constant exposure LC_{50} of 5 ppm was calculated for adult *E. affinis* (Aurand and Coelho, 2005). This value is lower than, but generally consistent with, the values determined in the present study when the longer exposure time in the CROSERF program is taken into consideration.

Adult *E. affinis*, the larvae of the Pacific oyster (*Crassostrea gigas*), and larvae of the red abalone (*Haliotus rufescens*) were the most sensitive organisms to dispersant alone (either C9500 or C9527) in the CROSERF testing (Aurand and Coelho, 2005). All showed LC_{50} values of around 5 ppm for constant 96-hour exposures and 10-15 ppm for spiked exposures (based on a concentration declining by approximately 50% every 2 hours).

George-Ayers and Clark (2000) summarized all available acute toxicity data for C9500, and of the 24 species reported, only three (the amphipod, *Allorchestes compressa*; Tanner crab (*Chionoecetes bairdi*) larvae; and zygotes of the brown alga, *Phyllospora comosa*) were as sensitive under 48- to 96-hour constant exposures as *E. affinis*. So, conditions protective of *E. affinis* appear conservative for most species when evaluating the risk of exposure to dispersant alone.

What is the sensitivity of the test organism (*E. affinis*) to oil (WAF) and dispersed oil (CE-WAF) when exposed under standard laboratory test conditions and how does this compare to other, commonly used species? How does this sensitivity vary with life history stage?

Based on the measured PAH values (Table 4-3), LC_{50} results for WAF and CE-WAF exposures (for either 24- or 48-hour static, constant exposures) are similar. Also, there is no consistent difference between life history stages for either treatment, except that three out of four results for nauplii indicate they may be more sensitive than later stages. Our measured PAH values are not directly comparable to CROSERF results (which were reported as *measured* TPH), but the *calculated* TPH values from our study presented in Table 4-4 range from 0.1 to 2.1 ppm. These values bracket the only CROSERF-reported values for exposure to WAF or CE-WAF of weathered ANS (0.3 ppm TPH (96-hr LC_{50} for WAF exposure) for larvae of the Tanner crab (*C. bairdi*) and 0.7 ppm TPH (96-hr LC_{50} for CE-WAF exposure) for juveniles of the silversides minnow, *Menidia beryllina*) see Table 5-1.

Table 5-1 Constant 96-hr Exposure LC_{50} Toxicity Values Obtained During the CROSERF Study (Values for TPH expressed as ppm)

Test Species		Fresh Oil		Weathered Oil	
		WAF	CE-WAF	WAF	CE-WAF
Fish	*Menidia beryllina* juveniles	15.6	12.4		0.7
		14.8	4.6		
	Atherinops affinis juveniles		1.1		
Decapod	*Chionoecetes bairdi* larvae	2.5	1.3	0.3	0.4
Mysid	*Mysidopsis bahia* juveniles	2.6	1.4		
	Holmesimysis costata juveniles		1.0		

* Blue highlighting indicates Prudhoe Bay crude oil instead of EPA standard ANS

Source: Aurand and Coelho (2005)

In the CROSEREF program five species were tested with constant exposure to fresh ANS or to Prudhoe Bay crude oil (both are from the same oil field), including *C. bairdi* and *M. beryllina*.

Both of these species were less sensitive to fresh oil than weathered oil, the other three were not tested with weathered oil.

The three additional species, *Mysidopsis bahia* (American mysid), *Holmesimysis costata* (kelp forest mysid) and *Atherinops affinis* (topsmelt minnow) were tested using only fresh ANS WAF and/or CE-WAF. *M. beryllina* appears to be less sensitive than the other species, which all showed WAF or CE-WAF 96-hour constant exposure LC_{50}s in the range of 1 to 2.6 ppm, similar, but slightly higher than the values we obtained for *E. affinis* with weathered oil.

The NRC (2005) compiled available acute toxicity data since 1989 on oil and dispersed oil as part of their evaluation of dispersant use issues (see their Table 5.6, beginning on page 232). The only additional information listed in that compilation was for larvae of the Pacific herring (*Clupea pallasi*), with a total PAH 24-hr LC_{50} of 199 ppb when exposed to weathered ANS (Barron *et al*., 2004), which is slightly higher than the total PAH LC_{50} values in Table 4-3, which ranged from 10 to 81 ppb.

In general, ANS appears to be a moderately toxic oil in comparison to other crude oils (Aurand and Coelho, 2005, Table 7.15, p. 90; NRC, 2005, Table 5.6, p. 232), and so conditions protective for *E. affinis* would likely be protective of many, but not all, planktonic species for similar oils.

Toxicity of oil is primarily a function of exposure to low-molecular- weight aromatic hydrocarbons, and to a much lesser extent to low-molecular weight aliphatic hydrocarbons, which usually evaporate quickly, along with the BTEX compounds. All of the individual compounds of concern have a similar mode of action (narcosis), and so their effects are additive. This is the basis for the modeling approach of French-McCay (2002), who has developed a predictive model based on the critical body residue (CBR) concept. As part of developing that model, she also examined the literature for data sets on PAH exposure for marine organisms which could be used to verify and calibrate the model, which takes into account both the duration of and temperature during exposure. The theoretical results indicate that the response is exponential over time, and that after approximately 24-hours there is little change in predicted LC_{50} values. Prior to the 24-hour mark, however, there is a significant increase in predicted LC_{50} values with decreasing exposure time (regardless of temperature). So, the ppm-hour concept (proposed for oil spill studies by Anderson *et al*., 1981, 1984) may be of value, but only for short exposure times, much shorter than usually used in toxicity studies. The original ppm-hour approach assumed that time and concentration were direct multipliers, an assumption recognized as unrealistic early on, except possibly as an approximation over a narrow range (1 hour to 4 days was cited by NRC, 1989, but even that appears too long). In our (very limited) study, except for *E. affinis* nauplii, the 48-hour values were not consistently lower (more toxic) than those for 24 hours, which is consistent with the above discussion. French-McCay (2002) also concluded that the predicted *incipient* (at equilibrium) LC_{50} value for *E. affinis* was approximately 20 ppb TPAH, which is similar to our values for the three life history stages tested (10 to 78 ppb TPAH). *E. affinis* was among the more sensitive species modeled, as well, supporting it as a conservative indicator species.

In oil spill research, authors generally report toxicity data for only one time duration (usually 24, 48 or, most frequently, 96 hours), and rarely, if ever, for exposures of less than 24 hours. So, even though both time and concentration play a role in toxic response to hydrocarbon exposure, the available data set is not adequate to support or refine the ppm-hour concept. To date, the largest exception to this generalization about exposure time is the spiked exposures done in the CROSERF study (see Aurand and Coelho (Eds.), 2005. In that study a declining exposure concentration was used by all cooperating laboratories, with a half-life of approximately two hours, and this "spiked" exposure gave LC_{50} values that were consistently lower than corresponding constant exposure LC_{50}s. Unfortunately, the CROSERF exposure chamber proved to be incompatible with *E. affinis*, and so no spiked exposures were done in this study. The 24- and 48-hour exposures which were used are very conservative in comparison to the real world.

Since exposure to hydrocarbons during oil spills is highly variable, an approach integrating duration and concentration, such as that of French-McCay (2002) should allow a more accurate estimate of impacts. However, the lack of short exposure tests is a deficiency in model calibration. Models can be expensive and time consuming to run, and thresholds can be developed for a more rapid assessment. If tests covering a wider range of durations were available, they could be extrapolated through the use of the ratio of the two test endpoints. For even larger data sets, then regression analysis can be used to estimate general temporal relationships (Suter, 1993). Care must be observed in either case not to overextend the data set, and to ensure that no other test conditions influence the results.

Do sublethal effects appear to translate into population level consequences? Does exposure to any of the three toxicants appear to increase adverse effects of exposure to UV light?

Based on the results in Table 4-7, females who survived exposure to WAF, CE-WAF, or dispersant did not appear to be at a reproductive disadvantage. Under the experimental temperature regime used (approximately 21°C) all of the results indicate approximately 20 to 30 viable nauplii in first egg clutches per exposed female. There is a suggestion in the data that all of the treatments (WAF, CE-WAF, and C9500 alone) may have increased egg production in the initial clutch. This effect, known as hormesis, or a favorable biological response to a low dose of a toxicant, has been observed for other toxicants and would be consistent with the survival of only the "stronger" exposed females.

Berdugo *et al.* (1977) obtained different results when exposing *E. affinis* to the WAF (measured using a gas chromatography method published by Corner *et al*., 1976) of aromatic heating oil for short times. In their experiments, complete mortality occurred after 6 hours to exposures to WAF concentrations of 1.8 to 2 ppm. This is a higher toxicity than observed in our experiments, and probably reflects the difference in composition of fresh "aromatic heating oil" versus weathered ANS. In other experiments, they exposed females carrying their first egg sac to the same solutions for periods of between 10 and 240 minutes, and then monitored egg production and life span. They found that life span and egg production (mostly a function of life span) decreased over controls, and the decrease was approximately linear with increasing exposure time. The differences were significant versus controls for exposures of 90 minutes or more. In addition, other experiments by Berdugo *et al.* (1977) confirmed reductions in feeding when exposed to low concentrations, but with recovery when removed from the exposure medium. In contrast to many early studies, these experiments used actual, not nominal concentrations, but we have no knowledge of how the two analytical approaches actually compare, but given the changes in analytical protocols the numbers are unlikely to be equivalent.

Differences in the experimental protocols probably account for some of the differences between the two studies. In our study, nauplii were exposed and then surviving females isolated for fecundity studies. In the study by Bedugo *et al.* (1977) ovigerous females were exposed, so eggs were exposed also. In addition, the inherent toxicities of the oils appear different, and the exposure protocols were as well. In our study, the initial exposure concentration was an approximation of the 24-hour LC_{50} value; in their study it was a shorter exposure to a concentration known to be lethal after 6 hours.

This study, and the study by Bedugo *et al*. (1977) demonstrate a range of reported outcomes for differently exposed individuals, as would be expected. But in our population growth studies, organisms at or below the 24-hour LC_{50} value that survived the initial exposure, whether to C9500, WAF or CE-WAF, did not appear to be at any disadvantage.

There was significant variation between the subsequent population growth studies (see Figures 4-2 through 4-4), but there was no indication that any treatment (with or without subsequent 4 hour exposure to UV light) was in any way consistently different than the control. The high variance reflects the natural variability in the growth of a population generated from 10 random individuals. In some cases there was a population decline towards the end of the study, which was probably artificially introduced by not increasing the food density, but the trends in all experiments clearly suggest that the affect was not a function of the treatment.

Enhanced PAH toxicity under ultraviolet light has been demonstrated by a number of authors, and has been raised as an issue with respect to dispersant use by Barron and Ka'aihue, 2001; Duesterloh *et al*., 2002, and Barron *et al*., 2003). Most such studies, including the three referenced here, have examined acute effects; we were more interested in the consequences for subsequent generations. Our experiments examined one aspect of the long-term risk associated with photosensitization by comparing population growth of cultures stocked with animals which had survived a 24-hour exposure to WAF or CE-WAF, followed by a 4-hour exposure to environmentally relevant levels of UV light, in comparison to control populations. We saw no significant difference from controls (Table 4-5). There is no evidence that populations were responding to any synergistic effects under these exposure scenarios.

There were instances where populations crashed at the end of the monitoring period. Since the amount of food added to the cultures was not adjusted based on population size, and the decline was usually noted in experiments with high population levels, it is probably best explained as a food limitation.

How do the toxicity results obtained in these experiments relate to exposures likely to occur in real-world situations? Can the information gained in the laboratory experiments be used to expand our understanding of the risk to water column organisms?

The key element in interpreting the meaning of the toxicity results is to evaluate them in the context of exposures which are likely to be encountered in the natural environment in the event of an actual oil spill. Anticipated exposures for dispersant alone are determined by the application rate and method, the effectiveness in targeting the oil, assuming dispersant which actually comes into contact with the slick will be incorporated into dispersed oil droplets, and the weather and hydrographic conditions at the time of the application. Water column concentrations of dispersed oil are driven by the same parameters, along with the efficacy of the dispersant once it is in contact with the oil. Even though the processes in the field are more complex, the resultant solutions (for dispersant alone) or suspensions (in the case of dispersed oil droplets) are similar in both the laboratory and the field. The same cannot be said of WAF solutions made in the laboratory, using mixing conditions which do not necessarily mimic field conditions.

To our knowledge, there have never been any field studies which have quantified dispersant-only concentrations after an actual application. This is because the low application rates (usually about 5 gallons per acre) mean that dilution to levels which are non-detectable is almost instantaneous. For example, an application of 5 gallons/acre (industry planning standard), assuming mixing to one meter depth, would amount to an initial concentration of approximately 5 ppm, which would rapidly dilute within minutes. Given that this is the same concentration obtained for a dispersant-only 24- or 48-hour LC_{50} value in this study, and that *E. affinis* appears to be a sensitive species, relative to other species that have been tested, there is little risk to the plankton community from exposure to dispersant alone.

Concentrations of dispersed oil in the field could exceed the LC_{50} values obtained for CE-WAF exposures in this study (approximately 0.2 to 2 ppm TPH). The critical question is for how long and over what area, both of which are incident-specific. Field experiments in the North Sea, where dispersant was used to disperse slicks of 15 cubic meters (approximately 95 barrels) of Troll (North Sea) crude oil indicated that concentrations of dispersed oil reached approximately 23 ppm immediately after treatment, declining to 15 ppm within 15 minutes. At a depth of ten meters the initial concentration was 1.5 ppm, declining to 0.062 ppm within 45 minutes (Strom-Kristiansen *et al*., 1997). During the same test, Coelho *et al*. (2002) conducted toxicity tests initiated in the field with water samples from various depths. Statistically significant results were obtained at depths up to 5 meters, but only for initial samples, when concentrations were still elevated. During the response to the Sea Empress oil spill, a spill of approximately 72,000 tonnes, dispersants were used extensively to limit shoreline impacts and Batten *et al*. (1998) reviewed long-term plankton records for the southern Irish Sea before and after the event to try to ascertain effects to the plankton. They concluded that most common taxa showed no significant changes. Barnacle larvae were not recorded post-spill, which may reflect injury to shoreline populations contributing to the plankton.

Based on our interpretation of these data, exposed field populations of sensitive species (such as *E. affinis*) would be depressed, based on the loss of affected individuals in areas of high concentration (defined here as concentrations at least as high as the measured 24-hour LC_{50} values for some period of time) and some level of sublethal effects in other areas, but then will begin a rapid recovery. Our results, while limited, suggest that oil spill modeling studies of holoplanktonic species need to account for mortality, but they do not need to adjust population growth parameters because the inherent population variability is greater than any sublethal effects. This is consistent with field observations which indicate little to no measurable impact to holoplanktonic communities, either with or without the use of dispersants.

6.0 Technology Transfer

The results of this project can be used to address concerns in any geographic region. Toxicity results are always species-specific, so the absolute results cannot be transferred to other species. However, the relationships which are identified between acute and long-term population-level effects, as well as the changes which result from changes in the exposure conditions are applicable to species with similar life history patterns and physiologies.

The project provides previously unavailable information on the relationship of acute and possible delayed physiological effects of dispersed oil under varying environmental conditions on a representative planktonic organism. In summary, we saw no evidence that holoplanktonic organisms which survive exposure to WAF or CE-WAF are at any reproductive disadvantage, and populations of subsequent generations (when compared to controls) are indistinguishable. This information confirms limited field observations which report few or no observable impacts to holoplankton in the vicinity of oil spills.

This information should be integrated into comparative risk assessments and planning discussions held in support of dispersant-use decision making, as well as training exercises and spill drills.

7.0 Achievement and Dissemination

7.1 Publications

At the time this report is being submitted to the Coastal Response Research Center, EM&A has not submitted the report for formal publication. EM&A plans on disseminating this report via the following methods:

- Submit a manuscript to Marine Pollution Bulletin
- Provide a PDF-version of this report on the EM&A website
- Incorporate the results from this study in future Ecological Risk Assessments that EM&A may conduct for the U.S. Coast Guard
- Incorporate the results of this study into the EM&A "Oil Spill Training Program" that is offered to Federal and state agency personnel, other stakeholders, oil spill industry personnel and non-governmental organization staff.

7.2 Presentations

Coelho, G., D. Aurand, A. Slaughter, and J. Baker. 2006. Acute and population level effects of exposure to dispersant, oil and dispersed oil on multiple life history stages of *Eurytemora affinis*. SETAC North American Annual Meeting, 5-6 November. Montreal, CANADA.

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Appendix A Water Quality Data

Table A-1 Water Quality Data

	Corexit C9500				WAF				CE-WAF			
	Temp (°C)	Salinity (ppt)	DO (mg/L)	pH	Temp (°C)	Salinity (ppt)	DO (mg/L)	pH	Temp (°C)	Salinity (ppt)	DO (mg/L)	pH
	n=12				n=6				n=12			
LC50												
Mean	21.7	20.0	57.7	7.9	20.9	20.0	7.6	7.7	21.9	20.0	7.5	7.9
SD	*1.0*	*0.0*	*0.5*	*0.1*	*1.3*	*0.0*	*0.5*	*0.1*	*0.7*	*0.0*	*0.5*	*0.1*
	n=5				n=5				n=5			
Population												
Mean	20.8	19.4	8.1	7.9	21.5	18.8	9.1	8.0	20.5	18.6	7.7	8.3
SD	*0.4*	*0.5*	*0.3*	*0.3*	*1.8*	*1.8*	*1.1*	*0.6*	*0.0*	*2.1*	*0.1*	*0.2*
	n=5				n=5				n=5			
Population - UV												
Mean	21.4	19.6	8.1	7.8	19.9	19.8	8.2	8.3	21.2	20.0	8.0	7.9
SD	*0.8*	*0.5*	*0.4*	*0.4*	*0.1*	*0.5*	*0.1*	*0.6*	*1.2*	*0.0*	*0.4*	*0.5*

	CdCl2 n=6			
	Temp (°C)	Salinity (ppt)	DO (mg/L)	pH
Reference Tox.				
Mean	20.6	19.5	7.5	7.9
SD	*1.7*	*0.5*	*0.0*	*0.1*

Appendix B Experimental Data

Table B-1 Experimental Data

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured Disp.; Calc. TPH	Measured PAH *(ppb)*	EMA Sample #	Notes	*E. affinis* *Surviving/Original* A	B	C	LC50 (Dispersant) or LC50 (TPH)	LC50 (PAH)	[1]Life Stage	Method
Method Development														
6/24/2006	7			*(ppm)*							7.19 ppm		N	SD
	C9500		0	0.39				12/12	12/12	12/12				*Spiked*
			5	6.38				10/12	9/12	8/12	95%			
			10	8.57				3/12	4/12	6/12	Lower Conf. 6.08			
			15	15.74				0/12	1/12	0/12	Upper Conf. 8.52			
			25	26.04				1/12	1/12	1/12				
			40	40.72				0/12	0/12	0/12				
7/21/2006	9			*(ppm)*							29.80 ppm		A	SD
	C9500		0	0.79				12/12	11/12	11/12				*Spiked*
			5	3.9				12/12	12/12	8/12	95%			
			10	14.4				11/12	10/12	7/12	Lower Conf. 24.34			
			20	21.37				7/12	9/12	11/12	Upper Conf. 39.40			
			40	38.57				4/12	7/12	1/12				
			80	81.11				1/12	2/12	1/12				
8/4/2006	10			*(ppm)*									A	FT
	C9500		0	0				12/12	12/12	12/12				*Spiked*
			5	3.75				11/12	***	11/12	N/A - Mortality Rate too Low			
			10	12.5				12/12	10/12	11/12				
			20	21.2				9/12	11/12	11/12				
			40	38.5				8/12	5/12	7/12				
			80	78.9				3/12	9/12	9/12				
8/9/2006	11										N/A Range Finding for Mortality		A	FT
	C9500	102.65	100					2/12	8/12	6/12				*Spiked*
	48 Hour	184.30	200					4/12 !	0/12	0/12				
8/15/2006	12			*(ppm)*							85.0 ppm		A	FT
	C9500		0	1.64				12/12	12/12	12/12				*Spiked*
			12.5	11.7				11/12	12/12	11/12	95%			
			25	23.72				10/12	10/12	11/12	Lower Conf. 71.50			
			50	43.52				10/12	9/12	10/12	Upper Conf. 103.5			
			100	101.4				11/12	5/12	6/12				
			200	195.7				0/12	0/12	1/12				
8/24/2006	14			*(ppm)*									A	SD
	C9500		0	0.92				10/12	11/12	12/12				*Spiked*
			12.5	13.4				3/12	2/12	2/12	N/A - Mortality Rate too High			
			25	23.9				0/12	0/12	0/12				
			50	51.33				0/12	1/12	0/12				
			100	106.19				0/12	0/12	1/12				
			200	184.09				0/12	0/12	0/12				

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured Disp.; Calc. TPH	Measured PAH (ppb)	EMA Sample #	Notes	*E. affinis* *Surviving/Original* A	B	C	LC50 (Dispersant) or LC50 (TPH)	LC50 (PAH)	[1]Life Stage	Method
9/9/2006	16			*(ppm)*							21.4 ppm		A	SD
	C9500		0	1.19				12/12	11/12	11/12				*Spiked*
			12.5	14.3				10/12	8/12	7/12	95%			
			25	20.83				4/12	5/12	4/12	Lower Conf. 15.53			
			50	46.99				5/12	3/12	3/12	Upper Conf. 29.59			
			100	109.7				3/12	1/12	3/12				
			200	191.36				0/12	0/12	0/12				
9/22/2006	17			*(ppm)*							74.4 ppm		A	FT
	C9500		0	0.49				12/12	12/12	11/12				*Spiked*
			12.5	10.57				10/12	10/12	12/12	95%			
			25	26.6				10/12	8/12	12/12	Lower Conf. 60.99			
			50	50.98				9/12	8/12	12/12	Upper Conf. 90.77			
			100	109.28				3/12	3/12	3/12				
			200	192.28				1/12	0/12	0/12				
10/2/2006	18			*(ppm)*									C	SD
	C9500		0	0.13				12/12	12/12	12/12				*Spiked*
			5	3.83				12/12	7/12	9/12	95%			
			10	9.33				7/12	6/12	5/12	Lower Conf. 7.67			
			20	21.11				1/12	7/12	2/12	Upper Conf. 13.30			
			40	43.54				0/12	2/12	0/12				
			80	77.24				0/12	0/12	0/12				
10/3/2006	19	Copepodites & Nauplii						Copepodites & Nauplii						SD
	WAF	0	0					12/12	12/12		25 (Unreliable Conf. limits)		N	
	48 Hour	24.9	25					6/12	6/12					
		101.9	100	Did not submit samples to CBL				2/12	6/12					
		Copepods						Copepods						*Spiked*
		0	0					12/12	12/12		NA - Mortality Rate too Low		A	
		24.9	25					12/12	11/12					
		101.9	100					12/12	12/12					
10/16/2006	22			*(ppm)*									A	SE
	C9500		0					12/12	11/12	12/12				*Constant*
			3.125	Gravimetrically				0/12	0/12	1/12				
			6.25	prepared				0/12	0/12	0/12	NA-Mortality Rate too High			
			12.5	solutions				0/12	0/12	0/12				
			25					0/12	0/12	0/12				
			50					0/12	0/12	0/12				
10/27/2006	23							Altered Food and Dilution Methods					A	SD, SE & Static
	C9500		5											*Spiked*
			10											*&*
			20											*Constant*

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured Disp.; Calc. TPH	Measured PAH *(ppb)*	EMA Sample #	Notes	*E. affinis* *Surviving/Original* A	B	C	LC50 (Dispersant) or LC50 (TPH)	LC50 (PAH)	[1]Life Stage	Method
10/24/2006	24	Oil/Disp											A	SE
	CE-WAF	0	0					12/12						*Constant*
	24 Hour	24.4/2.25	25	Did not submit samples to CBL				2/12						
	1:10	49.5/5.1	50					0/12						
		90.9/9.65	100					0/12						
11/2/2006	25a			*(ppm)* Day 1/Day 2				FT					A	FT
	C9500		0	0			11/12 12/12	12/12	12/12	12/12	NA-Mortality Rate too Low			*Constant*
	48 Hour		5	4.93/5.25			12/12 9/12	9/12	7/12	8/12				
	25b			Day 1				Static					A	Static
	C9500		0	0			12/12 12/12	12/12	12/12	12/12	NA-Mortality Rate too Low			*Constant*
	48 Hour		5	4.93			11/12 10/12	11/12	10/12	12/12				
	25c			Day 1/Day 2				FT					A	FT
	C9500		0	0							NA-Only two chambers continued for 96 hours			*Constant*
	96 Hour		5	4.93/5.25			3/12	1/12						
	25d			Day 1				Static					A	Static
	C9500		0	0			12/12 12/12	11/12	12/12	12/12	NA-Mortality Rate too Low			*Constant*
	96 Hour		5	4.93			9/12 7/12	9/12	8/12	10/12				
LC50 Preliminary Experiments														
11/15/2006	28	Oil/Disp		*(ppb)*							216.2 ppb	31.99 ppb	A	Static
	CE-WAF	0	0	0	0	EMA 0013		10/10	10/10	10/10				*Constant*
	96 Hour	22.4/1.1	12.5	218	15.6	EMA 0014		10/10	10/10	9/10	95%	95%		
		44.8/2.3	25	340	24.38	EMA 0015		9/10	7/10	8/10	Lower Conf. 43.06	Low Conf 14.63		
		100.4/4.5	50	432	30.92	EMA 0016		3/10	6/10	3/10	Upper Conf. 1085	Up conf 69.94		
		200.4/9.2	100	1962	140.57	EMA 0017		7/10	2/10	2/10				
11/27/2006	30	Oil/Disp											A	Static
	CE-WAF	0	0					10/10	10/10	10/10				*Constant*
	24 Hour	110.2/5.1	62.5	Did not submit samples to CBL				0/10	0/10	0/10	N/A - Mortality Rate too High			
		241.3/12.5	125					0/10	0/10	0/10				
		460/24.6	250					0/10	0/10	0/10				
		951/48.8	500					0/10	0/10	0/10				
1/2/2007	41			*(ppm)*			There was a high mortality rate in controls. The experiment was terminated and will be repeated.						N	Static
	Disp.		0	0										*Constant*
	48 Hour		3	2.837										
			6	5.566										
			12	10.937										
			24	26.384626										
1/4/2007	42	Oil/Disp		*(ppb)*							1806 ppb	45.31 ppb	C	Static
	CE-WAF	0	0	1	0.06	EMA 0043		10/10	10/10	10/10				*Constant*
	96 Hour	39.8/2.5	20	180	12.9	EMA 0044		9/10	10/10	10/10	95%	95%		
		75.1/3.8	40	255	18.24	EMA 0045		9/10	6/10	7/10	Lower Conf. 1094	UpConf 37.00		
		148.4/7.6	80	619	44.33	EMA 0046		5/10	7/10	8/10	Upper Conf. 2984	LowConf 55.49		
		319.1/14.8	160	1584	113.5	EMA 0047		0/10	1/10	0/10				

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured **Disp.;** Calc. **TPH**	Measured **PAH** *(ppb)*	**EMA Sample #**	**Notes**	*E. affinis* *Surviving/Original* A	B	C	**LC50** (Dispersant) **or LC50** (TPH)	**LC50** (PAH)	[1]Life Stage	Method
1/17/2007	46	Oil/Disp									N/A	N/A	N	Static
	CE-WAF	0	0					10/10	10/10	10/10				*Constant*
	48 Hour	72.9/4.5	37.5	Did not submit samples to CBL				Due to high mortality in the lowest concentration, the experiment was terminated and will be repeated.						
		135.8/6.9	75											
		275.6/15.5	150											
		600.7/31.2	300											
1/23/2007	49	Oil/Disp									N/A	N/A	N	Static
	CE-WAF	0	0					10/10	10/10	10/10				*Constant*
	48 Hour	17.8/0.8	10	Did not submit samples to CBL			Mortality too high, repeat experiment.	2/10	4/10	1/10				
		36.6/2.2	20					1/10	1/10	0/10				
		74.8/4.1	40					1/10	1/10	1/10				
		141.6/8.7	80					1/10	0/10	0/10				
2/5/2007	51			*(ppm)*									N	Static
	Disp.		0	0				8/10	8/10	8/10				*Constant*
	24 Hour		3	2.86			Mortality too high, repeat experiment.	0/10	0/10	0/10				
			6	5.67				1/10	1/10	2/10				
			12	10.46				0/10	0/10	0/10				
			24	24.71				0/10	0/10	0/10				
2/8/2007	53			*(ppm)*									N	Static
	Disp.		0	0				10/10	10/10	10/10				*Constant*
	24 Hour		3	2.9			Mortality rates too high, repeat experiment	1/10	3/10	4/10				
			6	5.42				2/10	2/10	0/10				
			12	10.47				0/10	0/10	0/10				
			24	25.21				0/10	0/10	0/10				
2/14/2007	54			*(ppm)*									N	Static
	Disp.		0	0				10/10	3/10	6/10				*Constant*
	24 Hour		3	2.18			Mortality rates too high, repeat using older nauplii	3/10	1/10	2/10				
			6	4.61				0/10	0/10	0/10				
			12	11.11				0/10	0/10	0/10				
			24	24.97				0/10	0/10	0/10				
2/28/2007	57	Oil/Disp									31.75 ppm	NC	N	Static
	CE-WAF	0	0	0	0	EMA 0078		10/10	10/10	10/10				*Constant*
	24 Hour	9.2/0.4	5	119	8.52	EMA 0079		7/10	7/10	8/10	95%			
		18.4/0.9	10	362	25.91	EMA 0080		4/10	5/10	7/10	Lower Conf. 12.40			
		42.1/1.5	20	83	5.92	EMA 0081		6/10	7/10	5/10	Upper Conf. 81.27			
		74.6/3.8	40	77	5.49	EMA 0082		5/10	4/10	5/10				
3/20/2007	60			Mortalities										
	Dispersant		0	1/120			Remaining nauplii were put back into fresh seawater. After another 24 hrs, they were counted again. Controls remained the same. All other concentrations showed an increase in mortality rates.				Due to these numbers, 25 nauplii were exposed to 6.9 ppm C9500. After 24 hours, 16/25 nauplii were found. A 6.9 ppm C9500 solution will be used for the next growout.			
	Study		5.18	14/120										
	w/ LC50s		6.18	15/120										
	24 Hour		7.18	95/120										
			8.18	104/120										

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured **Disp.;** Calc. **TPH**	Measured **PAH** *(ppb)*	**EMA Sample #**	**Notes**	*E. affinis* *Surviving/Original* A	B	C	**LC50** (Dispersant) **or LC50** (TPH)	**LC50** (PAH)	[1] Life Stage	Method
LC50 Experiments														
11/15/2006	27			*(ppm)*							19.21 ppm		A	Static
	C9500		0	0				10/10	10/10	10/10				*Constant*
	24 Hour		10	9.52				8/10	9/10	9/10	95%			
			20	17.96				5/10	5/10	7/10	Lower Conf. 15.99			
			40	38.83				0/10	2/10	0/10	Upper Conf. 23.08			
			80	83.91				0/10	0/10	0/10				
11/20/2006	29			*(ppm)*							15.13 ppm		A	Static
	C9500		0	0				10/10	10/10	10/10				*Constant*
	48 Hour		5	4.25				10/10	8/10	10/10	95%			
			10	8.03				8/10	10/10	7/10	Lower Conf. 12.05			
			20	19.4				3/10	2/10	5/10	Upper Conf. 19.00			
			40	39.6				1/10	0/10	3/10				
11/28/2006	31	Oil		*(ppb)*							2087 ppb	79	A	Static
	WAF	0	0	0	0.01	EMA 0018		10/10	10/10	10/10				*Constant*
	48 Hour	454	250	6063	227.95	EMA 0019		7/10	10/10	9/10	No CL			
		925.5	500	3112	117	EMA 0020		8/10	9/10	8/10				
		1817	1000	3988	149.93	EMA 0021		5/10	7/10	6/10				
		3697	2000	3404	127.98	EMA 0022		6/10	5/10	4/10				
11/29/2006	32	Oil/Disp		*(ppb)*							858 ppb	79.29 ppb	A	Static
	CE-WAF	0	0	5	0.37	EMA 0023		10/10	10/10	10/10				*Constant*
	24 Hour	38.2/2.1	20	722	51.73	EMA 0024		7/10	9/10	8/10		95%		
		78.2/4.0	40	929	66.58	EMA 0025		5/10	7/10	6/10		Low Conf 72.54		
		146.3/9.1	80	898	64.33	EMA 0026		1/10	1/10	0/10		Up Conf 86.67		
		318.6/15.5	160	1931	138.32	EMA 0027		0/10	0/10	0/10				
12/4/2006	33	Oil/Disp		*(ppb)*							799 ppb	51	A	Static
	CE-WAF	0	0	1	0.08	EMA 0028		10/10	10/10	10/10				*Constant*
	48 Hour	17.2/1.5	10	376	26.92	EMA 0029		9/10	10/10	9/10				
		40.3/2.0	20	345	24.72	EMA 0030		10/10	8/10	9/10				
		77.6/4.3	40	646	46.29	EMA 0031		10/10	9/10	9/10				
		144.7/6.8	80	1029	73.72	EMA 0032		0/10	0/10	0/10				
12/6/2006	34A			*(ppm)*							14.57 ppm		C	Static
	C9500		0	0				10/10	10/10	10/10				*Constant*
	24 Hour		5	4.76				6/10	9/10	7/10	95%			
			10	10.18				8/10	7/10	8/10	Lower Conf. 12.16			
			20	19.33				5/10	3/10	1/10	Upper Conf. 16.56			
			40	37.89				0/10	0/10	0/10				
12/6/2006	34B			*(ppm)*							13.06 ppm		C	Static
	C9500		0	0				10/10	10/10	8/10				*Constant*
	48 Hour		5	4.76				LIP	9/10	7/10	95%			
			10	10.18				6/10	7/10	8/10	Lower Conf. 10.08			
			20	19.33				5/10	2/10	1/10	Upper Conf. 16.91			
			40	37.89				0/10	0/10	0/10				

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured **Disp.**; Calc. **TPH**	Measured **PAH** *(ppb)*	**EMA Sample #**	**Notes**	***E. affinis* *Surviving/Original*** A	B	C	**LC50** (Dispersant) **or LC50** (TPH)	**LC50** (PAH)	[1]Life Stage	Method
12/11/2006	35			*(ppm)*							9.45 ppm		N	Static
	C9500		0	0				9/10	10/10	10/10				*Constant*
	24 Hour		5	4.24				7/10	7/10	9/10	95%			
			10	8.7				6/10	5/10	7/10	Lower Conf. 7.48			
			20	19.38				0/10	0/10	0/10	Upper Conf. 11.95			
			40	39.82				0/10	0/10	0/10				
12/13/2006	36	Oil/Disp		*(ppb)*							538 ppb	40.43 ppb	C	Static
	CE-WAF	0	0	6	0.43	EMA0033 A		10/10	10/10	10/10				*Constant*
	48 Hour	16.9/0.5	7.5	130	9.32	EMA0034 A		10/10	10/10	10/10	95%	95%		
		26.4/1.4	15	196	14.01	EMA0035 A		10/10	8/10	8/10	Lower Conf. 431	UpConf 25.70		
		55.7/2.2	30	377	27.02	EMA0036 A		6/10	7/10	6/10	Upper Conf. 782	LowConf 63.59		
		120.3/5.6	60	624	44.71	EMA0037 A		5/10	4/10	5/10				
12/12/2006	37			*(ppm)*							9.62 ppm		C	Static
	C9500		0	0				10/10	10/10	10/10				*Constant*
	48 Hour		5	5.24				8/10	7/30	7/10	95%			
			10	9.55				6/10	4/10	5/10	Lower Conf. 7.14			
			20	19.61				2/10	3/10	1/10	Upper Conf. 12.96			
			40	40.22				0/10	0/10	0/10				
12/18/2006	38	Oil		*(ppb)*							2591 ppb	46.38 ppb	C	Static
	WAF	0	0	4	0.16	EMA0033 B		10/10	10/10	10/10				*Constant*
	48 Hour	673.3	375	34	1.28	EMA0034 B		10/10	8/10	10/10	No CL	95%		
		1482.2	750	683	25.68	EMA0035 B		9/10	7/10	9/10		LowConf 34.51		
		2981.1	1500	724	27.23	EMA0036 B		9/10	6/10	8/10	1324	UpConf 62.34		
		6022.5	3000	1410	52.99	EMA0037 B		3/10	5/10	5/10				
12/19/2006	39	Oil/Disp		*(ppb)*			Continued to 48 HR				636 ppb	44.20 ppb	C	Static
	CE-WAF	0	0	3	0.21	EMA 0038	since mortality was too	10/10	10/10	10/10				*Constant*
	48 Hour	22.9/1.9	12.5	242	17.353	EMA 0039	low for 24 HR results.	10/10	10/10	10/10	95%	95%		
		48.2/2.6	25	328	23.46	EMA 0040	Therefore, a repeat	10/10	9/10	10/10	Lower Conf. 566	UpConf 36.26		
		91.9/4.5	50	571	40.87	EMA 0041	number for 48 HR	7/10	5/10	5/10	Upper Conf. 726	Low Conf 53.88		
		190.0/10.7	100	866	62.01	EMA 0042	Copepodites in C9500.	2/10	3/10	2/10				
1/8/2007	43			*(ppm)*							6.33 ppm		N	Static
	Disp.		0	0				10/10	10/10	10/10				*Constant*
	48 Hour		3	2.837				8/10	5/10	5/10	95%			
			6	5.32				5/10	6/10	6/10	Lower Conf. 3.21			
			12	11.42				2/10	1/10	1/10	Upper Conf. 10.13			
			24	25.505				0/10	0/10	0/10				
1/8/2007	44	Oil		*(ppb)*							707 ppb	16	N	Static
	WAF	0	0	4	0.14	EMA 0048		10/10	10/10	10/10				*Constant*
	48 Hour	993.1	500	488	18.33	EMA 0049		4/10	7/10	7/10				
		1880.4	1000	2510	94.37	EMA 0050		6/10	7/10	5/10				
		3964.9	2000	1728	64.95	EMA 0051		2/10	2/10	1/10				
		7814.6	4000	1547	58.14	EMA 0052		1/10	1/10	1/10				

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured Disp.; Calc. TPH	Measured PAH *(ppb)*	EMA Sample #	Notes	*E. affinis* *Surviving/Original* A	B	C	LC50 (Dispersant) or LC50 (TPH)	LC50 (PAH)	[1]Life Stage	Method
1/10/2007	45	Oil/Disp		*(ppb)*							601 ppb	43.06 ppb	C	Static
	CE-WAF	0	0	0	0	EMA 0053		10/10	10/10	10/10				*Constant*
	24 Hour	69.4/3.6	37.5	326	23.33	EMA 0054		10/10	10/10	10/10		95%		
		141.7/8.0	75	723	51.76	EMA 0055		4/10	4/10	3/10		Low Conf 38.85		
		288.4/14.6	150	1372	98.28	EMA 0056		0/10	0/10	0/10		Up Conf 47.72		
		611.2/27.5	300	1048	75.09	EMA 0057		0/10	0/10	0/10				
1/18/2007	47	Oil		*(ppb)*							2055 ppb	80.98 ppb	N	Static
	WAF	0	0	6	0.24	EMA 0063		10/10	10/10	10/10				*Constant*
	24 Hour	975.8	500	2123	79.83	EMA 0064		8/10	9/10	8/10	No CL	95%		
		1859.9	1000	2189	82.3	EMA 0065		6/10	7/10	6/10		Low Conf 79.40		
		3733.2	2000	2003	75.29	EMA 0066		4/10	4/10	4/10		Up Conf 82.58		
		7550.4	4000	2158	81.14	EMA 0067		3/10	3/10	4/10				
1/30/2007	50	Oil/Disp		*(ppb)*							213 ppb	15.19 ppb	N	Static
	CE-WAF	0	0	2	0.13	EMA 0068		10/10	10/10	10/10				*Constant*
	24 Hour	9.3/0.5	5	170	12.18	EMA 0069		7/10	5/10	6/10	95%	95%		
		18.5/1.0	10	307	21.96	EMA 0070		5/10	4/10	5/10	Lower Conf. 151	Low Conf 11.42		
		38.0/1.9	20	306	21.94	EMA 0071		2/10	1/10	3/10	Upper Conf. 253	Up Conf 20.19		
		74.6/3.8	40	450	32.25	EMA 0072		1/10	2/10	0/10				
2/6/2007	52	Oil/Disp		*(ppb)*							199 ppb	14.21 ppb	N	Static
	CE-WAF	0	0	0	0	EMA 0073		9/10	10/10	10/10				*Constant*
	48 Hour	4.7/0.2	2.5	80	5.71	EMA 0074		7/10	7/10	1/10		95%		
		9.3/0.6	5	147	10.51	EMA 0075		6/10	7/10	9/10		Low Conf 11.60		
		17.0/1.4	10	221	15.8	EMA 0076		8/10	3/10	3/10		Up Conf 17.41		
		37.9/2.2	20	245	17.52	EMA 0077		2/10	1/10	2/10				
2/18/2007	56			*(ppm)*							5.18 ppm		N	Static
	Disp.		0	0				10/10	10/10	10/10				*Constant*
	24 Hour		3	3.07				8/10	7/10	8/10	Lower Conf. 4.12			
			6	5.51				4/10	4/10	4/10	Upper Conf. 6.50			
			12	11.49				2/10	0/10	1/10				
			24	24.5				0/10	0/10	0/10				
6/20/2007	69	Oil		*(ppb)*							746 ppb	28	A	Static
	WAF	0	0	0	0.01	EMA 0114		10/10	10/10	10/10				*Constant*
	24 Hour	1418.2	750	1217	45.75	EMA 0115		10/10	8/10	7/10				
		2946.4	1500	836	31.44	EMA 0116		8/10	6/10	6/10				
		5643.8	3000	933	35.06	EMA 0117		4/10	6/10	4/10				
		11976	6000	553	20.8	EMA 0118		3/10	3/10	4/10				
6/26/2007	70	Oil		*(ppb)*							762 ppb	32	C	Static
	WAF	0	0	3	0.1	EMA 0119		10/10	10/10	10/10	Lower Conf. 672			*Constant*
	24 Hour	1334.1	750	314	11.8	EMA 0120		10/10	9/10	10/10	Upper Conf. 877			
		2806.8	1500	760	28.59	EMA 0121		8/10	7/10	1/10				
		5814.4	3000	734	27.6	EMA 0122		6/10	5/10	5/10		29		
		11702.1	6000	901	33.86	EMA 0123		4/10	3/10	3/10				

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured Disp.; Calc. TPH	Measured PAH *(ppb)*	EMA Sample #	Notes	*E. affinis Surviving/Original* A B C	LC50 (Dispersant) or LC50 (TPH)	LC50 (PAH)	[1]Life Stage	Method
Preliminary Grow Out Experiments												
3/2/2007	58	Day #	T=12 Control	T=12 Tox	T=19 Control	T=19 Tox	T=26 Control	T=26 Tox	T=33 Control	T=33 Tox		
	5.18 ppm	Counts	698	597	711	770	435	707	93	81		
	C9500		643	706	985	1090	429	311	108	173		
	Growout		719	661	532	766	476	389	151	180		
			682	684	746	762	746	512	90	233		
			622	612	1063	551	351	245	173	255		
		Mean	*685*	*652*	*813*	*788*	*416*	*433*	*123*	*184*		
		SD	*28*	*46*	*206*	*193*	*48*	*183*	*37*	*67*		
3/21/2007	61	Day #	T=12 Control	T=12 Tox	T=19 Control	T=19 Tox	T=26 Control	T=26 Tox	T=33 Control	T=33 Tox		
	6.9 ppm	Counts	735	424	356	437	279	168	262	372		
	C9500		707	719	319	350	295	235	436	657		
	Growout		754	784	271	358	136	332	352	126		
			805	1394	461	308	160	376	237	611		
			849	887	570	781	183	254	359	195		
		Mean	*770*	*842*	*395*	*447*	*211*	*273*	*329*	*392*		
		SD	*57*	*354*	*120*	*193*	*72*	*82*	*80*	*239*		
4/3/2007	62	Day #	T=12 Control	T=12 Tox	T=19 Control	T=19 Tox	T=26 Control	T=26 Tox				
	6.9 ppm	Counts	916	849	474	597	193	458				
	C9500		969	1522	395	384	220	146				
	UV exposure		981	498	584	350	205	313				
	Growout		854	2343	307	454	299	409				
			976	970	441	592	201	208				
		Mean	*939*	*1236*	*440*	*475*	*224*	*307*				
		SD	*54*	*720*	*102*	*115*	*43*	*131*				
5/7/2007	65	Day #	T=12 Control	T=12 Tox	T=19 Control	T=19 Tox	T=26 Control	T=26 Tox				
	10 ppm	Counts	895	1120	1278	1176	124	199		Measured Results (ppb)		
	CE-WAF		1006	1083	987	1240	178	252		TPH (calc.)	PAH	
	Growout		1190	1602	1107	993	245	402	EMA 0095	0.14	0.01	
			1172	1102	1004	1067	329	721	EMA 0096	258	18.5	
			1039	930	862	1291	383	452				
		Mean	*1060*	*1167*	*1048*	*1153*	*252*	*405*				
		SD	*123*	*254*	*155*	*123*	*106*	*205*				
5/30/2007	66	Day #	T=12 Control	T=12 Tox	T=19 Control	T=19 Tox	T=26 Control	T=26 Tox				
	2000 ppm	Counts	1325	342	2568	1539	1585	2307		Measured Results (ppb)		
	WAF		1206	545	1772	1811	1105	2238		TPH (calc.)	PAH	
	Growout		1163	436	1859	2084	1090	1713	EMA 0099	0.14	0.01	
			1099	695	2033	921	1258	2174	EMA 0100	1222	87.6	
			1281	676	1648	834	1265	2131				
		Mean	*1215*	*539*	*1976*	*1438*	*1261*	*2113*				
		SD	*90*	*152*	*359*	*547*	*199*	*233*				

Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured Disp.; Calc. TPH	Measured PAH *(ppb)*	EMA Sample #	Notes	*E. affinis* Surviving/Original A	B	C	LC50 (Dispersant) or LC50 (TPH)	LC50 (PAH)	[1]Life Stage	Method
5/28/2007	67	Day #	T=12 Control	T=12 Tox	T=19 Control	T=19 Tox	T=26 Control		T=26 Tox					
	10 ppm	Counts	245	195	161	620	312		5			Measured Results (ppb)		
	CE-WAF		283	138	166	95	177		862			TPH (calc.)	PAH	
	UV Exposure		393	227	170	16	448		159		EMA 0102	0	0	
	Growout		139	180	220	132	91		347		EMA 0103	136	9.7	
			206	149	244	321	155		891					
		Mean	*253*	*178*	*192*	*237*	*237*		*453*					
		SD	*19*	*36*	*37*	*242*	*143*		*405*					
6/12/2007	68	Day #	T=12 Control	T=12 Tox	T=19 Control	T=19 Tox	T=26 Control		T=26 Tox					
	2000 ppm	Counts	1145	979	1360	372	769		662			Measured Results (ppb)		
	WAF		928	341	1221	728	1295		3718			TPH (calc.)	PAH	
	UV Exposure		493	297	1913	920	1081		1768		EMA 0111	0	0	
	Growout		822	243	906	101	1618		2300		EMA 0113	1519	108.8	
			750	314	1084	253	1681		433					
		Mean	*828*	*435*	*1297*	*475*	*1289*		*1776*					
		SD	*239*	*306*	*383*	*340*	*379*		*1331*					
						Other								
11/7/2006	26		*(ppb)*	*(ppb)*							384 ppb		A	Static
	CdCl2		0	2.1		EMA0007		12/12	12/12	11/12				*Constant*
			250	220		EMA0008		11/12	11/12	10/12	95%			
			500	410		EMA0009		4/12	6/12	4/12	Lower Conf. 333			
			1000	920		EMA0010		0/12	0/12	1/12	Upper Conf. 448			
			2000	1970		EMA0011		0/12	0/12	0/12				
			4000	4210		EMA0012		0/12	0/12	0/12				
4/27/2007	64		*(ppb)*	*(ppb)*							200 ppb		A	Static
	CdCl2		0	1.2		EMA0089		11/12	12/12	12/12				*Constant*
			125	123		EMA0090		9/12	7/12	9/12	95%			
			250	246		EMA0091		4/12	6/12	3/12	Lower Conf. 146			
			500	473		EMA0092		4/12	4/12	5/12	Upper Conf. 276			
			1000	963		EMA0093		0/12	0/12	0/12				
			2000	1941		EMA0094		0/12	0/12	0/12				
3/15/2007	CBL	4047.1/4L	1000	58	45.5	EMA 0088								
						EMA 0085								
	B&B	ANS Oil	Neat			EMA 0086	Fingerprint							
		ANS Oil	Weathered			EMA 0087	Fingerprint							
8/18/2007	71											Measured Results (ppb)		
												TPH (calc.)	PAH	
	Fecundity Study								Control		EMA 0124	0	0	
									10 ppm CEWAF		EMA 0125	130	9.3	
									2000 ppm WAF		EMA 0128	1498	107.3	
8/18/2007	72			Measured Results (ppb)								Measured Results (ppb)		
				TPH	PAH							TPH	PAH	
		Control		<	0				Control		EMA 0135	<	0	
	PAH TPH Correlation Study	500 ppm WAF		865	56				2.5 ppm CEWAF		EMA 0136	27.6	8.1	
		1000 ppm WAF		1209	48				20 ppm CEWAF		EMA 0137	258	28	
		2000 ppm WAF		1237	35				80 ppm CEWAF		EMA 0138	935	73	
		3000 ppm WAF		1585	44				160 ppm CEWAF		EMA 0139	4302	257	
		6000 ppm WAF		1769	61				300 ppm CEWAF		EMA 0140	5332	412	

[1]*E. affinis* Life Stages: A - Adult Copeod; C - Copepodite; and N - Nauplii

Table B-2 Key for Table B-1 Experimental Data

Experimental Data Key												
1	2	3	4	5	6	7	8	8	10	11	12	13
Date	Expt # Toxicant	Loading Rate (mg/2L)	Target Conc. (ppm)	Measured Disp.; Calc. TPH	Measured PAH *(ppb)*	EMA Sample #	Notes	*E. affinis* *Surviving/Original* A B C	LC50 (Dispersant) or LC50 (TPH)	LC50 (PAH)	[1]Life Stage	Method

Experiments are grouped according the following methods/tests:

Method Development

LC50 Preliminary Experiments

LC50 Experiments

Preliminary Grow Out Experiments

Other (Reference Tox Test, Fecundity, TPH/PAH Studies)

Column Title Explanation

1	Date experiment started.
2	Experiment number and toxicant used.
3	Loading rate mg/2L - toxicant, measured gravimetrically and dispensed into 2L seawater.
4	Target Concentration - Loading rate determined by target concentration.
5	Measured Dispersant - analyzed using UV/Vis Spectrophotometer; Calc. TPH - correction factor applied to original PAH values (See Appendix D).
6	PAH - PAH results measured by GC/MS.
7	EM&A Sample Number for analytical testing.
8	Notes
9	*E. affinis* Surviving/Original - surviving copepods our of original total number, three replicates.
10	LC50 (Dispersant) and (TPH) - calculated using PROBIT
11	LC50(PAH) - LC50 generated using PROBIT
12	Life Stage - *E. affinis* Life Stages: A - Adult Copeod; C - Copepodite; and N - Nauplii
13	Method - Method used for experiment: SD (Stepped Declining); FT (Flow Through); SE (Stepped Exposure); Constant Static Concentrations

Appendix C Experimental Timeline
Method Development and Final Experiments

<u>Method Development</u>

Seawater Procurement, Copepod & Algal Culturing
2/15/06 - 5/12/06

LC_{50}

- **Flow Through Chambers** (9 experiments) 5/01/06 - 11/22/06
  In order to develop a data set that can be directly related to existing information from the CROSERF program, standard CROSERF protocols were used for all experiments (see Singer *et al*., 2000 and Aurand, 2005). The CROSERF flow-through chambers simulate short-term "spiked" exposures with the intent to develop data more closely resembling potential field exposures. Initially, several experiments were performed using adult copepods with great success; however, later experiments using nauplii and copepodites resulted in low control survivability. It was determined that juvenile copepods were too small to function viably in a CROSERF flow through chamber due to its construction including a fritted glass through which the solution passes and possibly traps small organisms. The size of *E. affinis* nauplii is 0.1-0.4 mm (Torke 2001).

- **Stepped Decline** (8 experiments) 6/14/06 - 10/26/06
  Subsequently, a series of experiments were performed to relate toxicant dilution concentration data between flow-through chambers and open beakers due to the above described juvenile copepod problems, as well as for future UV exposure experiments. To simulate the flow through chamber's dilution, measured aliquots of seawater were added to 50 mL of toxicant every hour until a maximum dilution of 6% (50 mL/750 mL * 100) of the original concentration. For dilution purposes, the stepped declining scenario resulted in dilution concentrations very close to flow-through concentrations. However, when using adult copepods, this procedure resulted in a higher mortality rate than similar flow-through experiments.

- **Static Non-Renewal** (12 experiments) 11/2/06 - 11/15/06
  Finally, the stepped declining concentration scenario was discontinued due to high mortalities and method development continued with constant static exposure. A comparison test between constant flow-though and constant static non-renewal exposure was performed. Based on these and other method development results, it was decided to use Static Constant Non-renewal exposure for 24 and 48 hours for LC_{50} determination.

Population (7 experiments)
Gravid Experiments 6/12/06, 8/16/06, 9/12/06
Trials 12/22/06 - 4/5/07
Initial population experiments involved lifecycle studies estimating potential population growth over 30 days using various starting points, i.e. multiple sets consisting of 1 gravid female, 3 gravid females, 10 gravid females or 10 nauplii per beaker. Based on these

preliminary experiments, it was decided to begin population experiments using 10 nauplii per beaker.

UV Exposure (4 experiments)
Initial contact with Mace Barron 8/15/06
Trials 2/15/07 - 4/2/07
Initial UV experiments to fine tune solar radiation exposure. Beakers were maintained in a constant temperature bath with mesh screens used to simulate exposure at 10 cm below the surface of the water. Temperature, screening, and duration was determined for experimental UV exposure scenario.

Other (3 experiments)

- Staining (Rose Bengal) 9/13/06 - 10/5/06
- Life Stage Monitoring 10/9/06-10/17/06
- Food & Dilution Altering (10/23/06)

Final Experiments

Reference Toxicant Tests (2 experiments)
11/7/06
4/27/07

LC_{50} (Static Non-Renewal) (18 experiments)

- Dispersant: 11/15/06 - 2/22/07
- WAF: 11/28/06 - 1/22/07; After population experiments, increased loading rate to 6000 ppm to try to cause enough mortality to generate an LC_{50} for copepods and copepodites 6/20/07 - 6/30/07
- CE-WAF: 11/15/06 - 3/4/07

Population (6 experiments)

- Dispersant UV/non-UV: 3/21/07 - 4/3/07 (final count 4/29/07)
- WAF UV/non-UV: 5/30/07 - 6/12/07 (final count 7/10/07)
- CE-WAF UV/non-UV: 5/7/07 - 5/28/07 (final count 6/25/08)

Fecundity (2 experiments)
8/18/07 - 8/30/07

Appendix D PAH Measurement and TPH Calculation

The WAF and CE-WAF solutions were analyzed for PAHs and TPH by GC/MS by Joel Baker, PhD, Chesapeake Biological Laboratory in Solomons, MD. Extensive chemical characterization (n-alkanes and n-alkenes and 53 PAH (rather than the 40 listed by CROSERF), including 29 parent PAHs, 11 monomethyl-, 9 dimethyl- and 1 trimethyl-substituted PAHs, dibenzothiophene and two methylated dibenzothiophenes) of the WAF and CE-WAF fractions was carried out. PAHs were quantified at various time points by gas chromatography/electro-impact mass spectrometry using isotope dilution.

At the beginning of each exposure experiment, aliquots of each test solution were fortified with method recovery standards (perdeuterated PAHs and alkanes) and extracted via liquid-liquid methods. The extracts were concentrated under nitrogen, fractionated using alumina liquid-solid chromatography, and analyzed for alkanes/alkenes and PAHs by capilliary gas chromatography/electron impact mass spectrometry. Target alkanes and alkenes were those ranging from decane/decane (C_{1O}) to C_{36}, which were quantified by comparing their total mass spectrometric response (scanning from 70 to 510 m/z) to authentic hydrocarbon standards. The 52 PAH target analytes (listed in the order reported by CBL), included in "Total PAH" were:

Naphthalene
Acenapthene
I-Methylphenanthrene
4-Methylchrysene
2- Methylnaphthalene
2,3,5-Trimethylnapthalene
9- Methylanthracene
Benzo[b]fluoranthene
Azulene
Fluorene
9,10-Dimethylanthracene
Benzo[k]fluoranthene
I-Methylnaphthalene
I-Methylfluorene
Fluoranthene
Dimethylbenz[a]anthracene
Biphenyl
Dibenzothiophene
Pyrene
Benzo[e]pyrene
2,7-Dimethylnaphthalene
Phenanthrene
3,6-Dimethylphenanthrene
Benzo[a]pyrene
1,3-Dimethylnaphthalene
Anthracene
Benzo[a]fluorene
Perylene
1,6-Dimethylnaphthalene
2-Methyldibenzothiophene
Retene
3-Methylchloanthrene
1,4-Dimethylnaphthalene
4-Methyldibenzothiophene
Benzo[b]fluorene
Indeno[1,2,3-c,d]pyrene
1,5-Dimethylnaphthalene
2-Methylphenanthrene
Cyclopenta[c,d]pyrene
Dibenz[a,h+ac]anthracene
Acenapthylene
2-Methylanthracene
Benz[a]anthracene
Benzo[g,h,i]perylene
1,2-Dimethylnapthalene
4,5-Methylenephenanthre
Chrysene+Triphenylene
Anthanthrene
1,8-Dimethylnapthalene
1-Methylanthracene
Napthacene
Coronene

One hundred microliters of an injection internal standard containing 1000 ng/ml of acenapthene-*d10*, phenanthrene-*d10*, benzo[a] anthracene-*dl2*, benzo[a]pyrene-*d12* and benzo[ghi]perylene-*d12* were added to each extract just prior to injection. Samples were quantified using an Agilent Technologies 6890/5973 gas chromatograph/mass spectrometer in electron ionization mode equipped with a Programmable Temperature Vaporization (PTV) large volume injector and a 30m x 0.25 mm i.d. with a 0.25 mm film thickness DB-5 GC Column (J&W Scientific, Inc. Folson, CA). Ten microliters of each extract was injected using the pulsed splitless mode with an injector temperature program of 50%C for 1 min, then ramped to 250%C at 600%C/min and held for the duration of the run. The oven temperature program was held at an initial temperature of 40%C for 1 min, then ramped to 280%C at 10%C/min followed by a 5%C/min ramp to a final temperature of 31O%C and held for 10 min. Compounds were identified and quantified using authentic standards based on retention time and ion fragmentation in selective ion monitoring mode.

To maintain comparability with previous studies that reported 'total petroleum hydrocarbons' as the total integrated FID response between C_{1O} and C_{36}, Dr Baker attempted to calculate a TPH-MS as the integrated signal of the total ion chromatogram over the C_{1O} and C_{36} retention time window.

Based on the work of Reddy and Quinn (1999), a mixed analytical standard of normal alkanes, amended with $C_{20}D_{42}$ internal standard, was analyzed, and the responses of the fragments m/z 57 (C_4H_9+) and 66 (C_4D_9+) were used to calculate response factors for each of the n-alkanes from C_{10} to C_{36}. Since the instrument response decreased systematically with increasing carbon number, a non-linear relationship between carbon number and relative response factor was derived. The sample ion chromatograms for m/z 57 were integrated in five time windows between the retention times of C_{10} and C_{36}, each with their own response factor relative to $C_{20}D_{42}$, the resulting mass in each window was summed, resulting in a total mass of detected hydrocarbons eluting between C_{10} and C_{36}.

The advantage of this method was that it used authentic alkane standards and corrected for varying instrument response with carbon number. However, since the m/z 57 (C_4H_9+) fragment was quantified, only those oil components that include alkane constituents that produce this fragment were included in the TPH concentration. It was determined that this method was not comparable to the Chemical Response to Oil Spills: Ecological Effects Research Forum (CROSERF) TPH protocols (Singer *et al*., 2000) using GC-FID because the m/z 57 method only measured aliphatic fractions. As a result, the m/z 57 method considerably underestimated the TPH present in solution. After conferring with the CRRC chemistry expert, the decision was made to reject the TPH values generated by the m/z 57 method since it yielded unacceptable results.

In order to report TPH results quantified in a manner consistent with those previously published in CROSERF, EM&A enlisted the assistance of B&B Laboratories (Texas) to generate a correlation factor using PAH data (generated by University of Maryland) to calculate TPH values. The correlation factor was determined by analyzing a range of WAF and CE-WAF samples encompassing all experimental loading rates. PAH was analyzed using GC/MS and TPH was analyzed using gas chromatography/flame ionization detector (GC/FID). Calibration curves were obtained for both WAF and CE-WAF solutions to determine a correlation between PAH and TPH. This correlation factor derived from the calibration curves was applied to original PAH values for all the samples to generate a “calculated TPH” that more closely relates to the CROSERF protocol.

The error in this correction is approximately 10%. Since biological toxic effects are typically compared by order of magnitude differences, a 10% error for TPH estimations was deemed acceptable.

Tables D-1 through D-3 present the detailed analytical results for all hydrocarbon analyses. Early in the study, samples of whole (neat) and weathered oil were analyzed for the target PAHs. This was done to generally characterize the composition of the original oil and the oil used in the experiments. Since only the target PAHs were analyzed it is only a partial characterization, especially for the neat oil. The results of the analysis are presented in Table D-1. The results for all of the samples taken during the biological experiments are show in Table D-2. Table D-3 shows TPH and PAH recovery data.

Table D-1 Results of PAH Analysis of Whole (Neat) and Weathered Alaskan North Slope Crude Oil (CBL 2007)

Compound	EMA 004 500ul	EMA 003 500ul
	Weathered Oil	Neat Oil
	Concentration (ng/g)	
Napthalene	432,878.62	323,354.50
2-Methylnapthalene	1,061,082.76	786,344.50
Azulene	1,511.03	1,296.00
1-Methylnapthalene	596,747.59	451,588.50
Biphenyl	120,788.28	95,402.50
2,7-Dimethylnapthalene	948,525.52	744,417.50
1,3-Dimethylnapthalene	1,051,196.55	858,644.00
1,6-Dimethylnapthalene	536,555.17	455,767.00
1,4-Dimethylnapthalene	291,494.48	223,753.00
1,5-Dimethylnapthalene	131,901.38	110,239.50
Acenapthylene	ND	ND
1,2-Dimethylnapthalene	160,753.79	127,045.50
1,8-Dimethylnapthalene	ND	ND
Acenapthene	64,256.55	2,005.00
2,3,5-Trimethylnapthalene	2,534,089.66	2,125,059.00
Fluorene	259,895.86	215,739.00
1-Methylfuorene	433,575.86	366,616.50
Dibenzothiophene	635,846.21	540,883.50
Phenanthrene	648,773.10	548,302.50
Anthracene	2,835.86	8,168.50
2-Methyldibenzothiophene	817,008.28	695,423.00
4-Methyldibenzothiophene	621,673.79	521,096.00
2-Methylphenanthrene	352,316.55	299,139.50
2-Methylanthracene	379,582.76	320,905.50
4,5-Methylenephenanthrene	1,656.55	2,845.50
1-Methylanthracene	496,138.62	411,965.00
1-Methylphenanthrene	337,235.86	285,775.00
9-Methylanthracene	5,889.66	5,017.50
9,10-Dimethylanthracene	23,001.38	19,507.00
Fluoranthene	7,771.03	7,700.50
Pyrene	24,184.14	22,548.50
3,6-Dimethylphenanthrene	22,908.97	ND
Benzo[a]fluorene	69,708.97	56,116.50
Retene	156,871.72	156,128.50
Benzo[b]fluorene	35,300.00	30,011.00
Cyclopenta[c,d]pyrene	ND	ND
Benz[a]anthracene	14,622.07	12,897.50
Chrysene+Triphenylene	79,580.69	66,059.00
Napthacene	11,720.69	8,261.00
4-Methylchrysene	67,206.90	58,452.50
Benzo[b]fluoranthene	15,233.10	14,370.00
Benzo[k]fluoranthene	1,893.10	ND
Dimethylbenz[a]anthracene	19,965.52	20,748.50
Benzo[e]pyrene	21,418.62	19,549.50
Benzo[a]pyrene	3,004.83	2,009.50
Perylene	3,686.90	4,748.00
3-Methylchloanthrene	4,595.17	4,266.00
Indeno[1,2,3-c,d]pyrene	992.41	690.50
Dibenz[a,h+ac]anthracene	1,233.79	1,272.50
Benzo[g,h,i]perylene	5,168.28	4,666.50
Anthanthrene	ND	ND
Corenene	692.41	708.50
ng/g	13,514,971.03	11,037,505.00
mg/mg	13.51497103	11.037505

Table D-2 TPH and PAH Data (CBL 2007)

EMA Sample #	13	14	15	16	17	18	19	20	21	22	23	24
Sample Type	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	WAF	WAF	WAF	WAF	WAF	CE-WAF	CE-WAF
ANS Loading g/2L	0.0000	0.0224	0.0448	0.1004	0.2004	0.0000	0.4540	0.9255	1.8169	3.6967	0.0000	0.0382
C9500 g/2L	0.0000	0.0011	0.0023	0.0045	0.0092	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0021
Volume extracted (mL)	950	952	952	980	950	750	420	925	850	855	960	875
TPH Concentrations (ng/mL)												
TPH ng/mL	19.3000	58.6977	128.0053	198.5316	4664.1456	152.9160	116.0289	94.5074	28.9111	91.8882	72.6308	266.5218
Corrected TPH ng/mL	**193.00**	**586.98**	**1280.05**	**1985.32**	**46641.46**	**1529.16**	**1160.29**	**945.07**	**289.11**	**918.88**	**726.31**	**2665.22**
PAH Concentration (ng/mL)												
Napthalene	ND	0.0069	0.0371	0.0099	11.6127	ND	36.4295	22.9642	37.3016	37.3119	0.0038	3.8939
2-Methylnapthalene	ND	ND	ND	ND	26.8785	ND	60.8100	31.2669	40.4883	32.7531	0.0054	10.9122
Azulene	ND	0.0023	0.0063	ND	0.0093	ND	0.0524	0.0276	0.0346	0.0286	ND	0.0200
1-Methylnapthalene	ND	0.6252	1.8732	2.4141	20.3538	ND	39.0850	20.2200	24.4494	20.6946	0.0038	6.5433
Biphenyl	ND	0.5875	1.2732	0.9352	3.5905	ND	6.7521	3.5099	4.1123	3.3744	0.0027	1.3805
2,7-Dimethylnapthalene	ND	1.4261	2.4608	2.5678	8.4633	ND	11.7181	5.5038	6.0637	4.9330	0.0021	4.0857
1,3-Dimethylnapthalene	ND	1.8025	3.0704	4.0137	9.9039	ND	15.1058	7.1290	7.6005	6.5434	0.0027	4.9929
1,6-Dimethylnapthalene	ND	0.9714	1.5342	1.9792	6.1662	ND	9.0324	4.1675	4.8287	3.6160	0.0013	2.9192
1,4-Dimethylnapthalene	ND	0.7375	1.3405	1.2711	2.8215	ND	4.3840	2.0495	2.1965	1.9107	0.0014	1.4467
1,5-Dimethylnapthalene	ND	0.4579	0.8109	0.6106	1.4041	ND	2.1883	1.0163	1.1715	0.8824	0.0006	0.6822
Acenapthylene	0.0011	ND	ND	ND	ND	0.0001	ND	ND	ND	ND	0.0007	ND
1,2-Dimethylnapthalene	ND	0.3292	0.5129	0.6705	1.5929	ND	2.6667	1.2487	1.3676	1.1529	0.0004	0.8056
1,8-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenapthene	0.0007	0.0675	0.1293	0.1405	0.4457	0.0003	0.5504	0.2680	0.2984	0.2465	0.0057	0.1349
2,3,5-Trimethylnapthalene	ND	1.3164	2.2946	2.1264	6.6539	ND	5.0158	2.2667	2.5601	1.8076	0.0021	2.2403
Fluorene	ND	1.0204	1.5870	1.9460	4.9913	ND	7.2399	3.3610	3.8851	2.7711	0.0082	1.6231
1-Methylfuorene	0.0025	1.4155	1.7131	1.8904	4.2370	ND	4.0461	1.8017	2.1012	1.4841	0.0026	1.6927
Dibenzothiophene	ND	0.4016	0.6422	1.3828	5.3936	ND	4.7661	2.1277	2.1078	1.2923	0.0028	0.7702
Phenanthrene	ND	1.2208	1.4442	3.5368	7.8465	ND	9.4645	4.2366	4.9448	3.8062	0.1197	3.2323
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyldibenzothiophene	ND	0.3865	0.5431	0.7589	2.9430	0.0004	1.0813	0.4697	0.4737	0.2584	0.0004	0.3178
4-Methyldibenzothiophene	ND	0.1721	0.2527	0.5398	2.3262	0.0002	0.7525	0.3206	0.3436	0.1729	0.0001	0.2003
2-Methylphenanthrene	ND	0.6101	0.6709	0.8788	2.5731	0.0030	1.4470	0.6437	0.7646	0.5196	0.0052	0.8015
2-Methylanthracene	ND	0.3153	0.2993	0.8392	2.6821	0.0019	1.4859	0.6458	0.7662	0.5351	0.0064	0.8063
4,5-Methylenephenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0024	ND
1-Methylanthracene	ND	0.9595	1.0497	1.2791	3.5500	ND	2.0805	0.9358	1.1115	0.7727	ND	1.0173
1-Methylphenanthrene	ND	0.6167	0.6735	0.8560	2.3879	ND	1.4693	0.6493	0.7650	0.6563	ND	0.9655
9-Methylanthracene	ND	ND	ND	0.0075	0.0306	ND	ND	ND	ND	ND	ND	0.0077
9,10-Dimethylanthracene	ND	0.0042	0.0054	0.0091	ND	ND	0.0275	0.0141	0.0189	0.0120	ND	0.0044
Fluoranthene	ND	0.0142	0.0127	0.0154	0.0422	0.0020	0.0358	0.0207	0.0194	0.1728	0.1048	0.0150
Pyrene	ND	0.0321	0.0326	0.0388	0.1187	0.0017	0.0647	0.0340	0.0345	0.1327	0.0591	0.0415
3,6-Dimethylphenanthrene	ND	0.0043	0.0055	0.0093	ND	ND	0.0281	0.0145	0.0194	0.0122	ND	0.0045
Benzo[a]fluorene	ND	0.0350	0.0385	0.0529	0.2951	ND	0.0610	0.0282	0.0341	0.0294	0.0015	0.0549
Retene	ND	0.0065	0.0093	0.0356	0.5361	0.0003	0.0128	0.0064	0.0085	0.0056	0.0003	0.0213
Benzo[b]fluorene	ND	0.0173	0.0189	0.0269	0.1356	ND	0.0305	0.0137	0.0167	0.0123	0.0006	0.0251
Cyclopenta[c,d]pyrene	ND	0.0001	0.0006	ND	ND	0.0002	ND	ND	ND	ND	ND	ND
Benz[a]anthracene	ND	0.0022	0.0022	0.0052	0.0586	ND	0.0039	0.0028	0.0033	0.0049	0.0021	0.0049
Chrysene+Triphenylene	ND	0.0334	0.0330	0.0510	0.3275	0.0005	0.0517	0.0258	0.0298	0.0396	0.0105	0.0526
Napthacene	ND	ND	ND	0.0057	0.0665	ND	ND	ND	ND	ND	ND	ND
4-Methylchrysene	ND	0.0046	0.0056	0.0133	0.1365	ND	0.0040	0.0036	0.0042	0.0013	ND	0.0128
Benzo[b]fluoranthene	ND	ND	ND	ND	ND	ND	0.0029	0.0018	0.0019	0.0193	0.0103	0.0046
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	0.0005	ND	ND	ND	ND
Dimethylbenz[a]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[e]pyrene	ND	ND	ND	ND	ND	ND	0.0048	0.0023	0.0012	0.0045	0.0026	ND
Benzo[a]pyrene	ND	ND	ND	ND	ND	ND	ND	0.0012	ND	0.0049	0.0014	ND
Perylene	ND	ND	ND	ND	ND	ND	0.0013	0.0002	ND	ND	ND	ND
3-Methylchloanthrene	ND	ND	ND	ND	ND	ND	ND	0.0005	ND	ND	ND	ND
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h+ac]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Corenene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH ng/mL	**0.00**	**15.60**	**24.38**	**30.92**	**140.57**	**0.01**	**227.95**	**117.00**	**149.93**	**127.98**	**0.37**	**51.73**

EMA Sample #	25	26	27	28	29	30	31	32	33A	33B	34A	34B
Sample Type	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	WAF	CE-WAF	WAF
ANS Loading g/2L	0.0782	0.1463	0.3186	0.0000	0.0172	0.0403	0.0776	0.1447	0.0000	0.0000	0.0169	0.6733
C9500 g/2L	0.0040	0.0091	0.0155	0.0000	0.0015	0.0020	0.0043	0.0068	0.0000	0.0000	0.0005	0.0000
Volume extracted (mL)	925	935	900	940	900	995	945	960	918	890	924	875
TPH Concentrations (ng/mL)												
TPH ng/mL	109.9945	404.8937	6545.6791	87.9169	195.7976	146.6271	231.9512	6630.4661	574.5654	98.9809	93.0710	141.0003
Corrected TPH ng/mL	**1099.95**	**4048.94**	**65456.79**	**879.17**	**1957.98**	**1466.27**	**2319.51**	**66304.66**	**5745.65**	**989.81**	**930.71**	**1410.00**
PAH Concentration (ng/mL)												
Napthalene	5.2602	4.0776	16.2633	0.0076	0.0279	0.0198	1.2158	7.6014	0.0021	0.0059	0.1938	ND
2-Methylnapthalene	14.6722	14.5179	30.8935	0.0116	ND	ND	6.2526	15.2143	0.0031	0.0169	1.0485	ND
Azulene	0.0165	0.0278	0.0103	ND	0.0041	0.0107	0.0186	0.0053	ND	ND	0.0017	ND
1-Methylnapthalene	9.1002	9.0064	18.3699	0.0046	3.6691	2.0997	7.1434	9.1717	0.0021	0.0120	0.6906	ND
Biphenyl	1.9739	2.2178	3.3961	0.0063	1.0924	1.0016	1.6741	1.6856	ND	0.0037	0.2292	0.0011
2,7-Dimethylnapthalene	4.9331	4.7221	7.8751	0.0066	2.8295	2.5795	4.2192	3.8849	0.0012	0.0087	0.7275	0.0074
1,3-Dimethylnapthalene	6.2738	6.0804	9.7504	0.0050	4.1646	3.7114	5.4662	4.8995	0.0015	0.0094	0.9245	0.0104
1,6-Dimethylnapthalene	3.5155	3.5319	5.3378	0.0033	1.9650	1.9180	3.0311	2.7184	0.0008	0.0050	0.5590	0.0071
1,4-Dimethylnapthalene	1.8398	1.8102	2.8150	0.0028	1.1753	1.2729	1.6290	1.3133	0.0006	0.0023	0.2774	0.0037
1,5-Dimethylnapthalene	0.8360	0.8543	1.2044	0.0014	0.6089	0.6571	0.7535	0.6850	0.0002	0.0012	0.1343	0.0020
Acenapthylene	ND	ND	ND	0.0003	ND	ND	ND	ND	ND	0.0013	ND	0.0001
1,2-Dimethylnapthalene	1.0801	1.0876	1.5402	0.0012	0.5898	0.5757	0.9547	0.7449	0.0004	0.0012	0.1549	0.0025
1,8-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0029	ND	0.0028
Acenapthene	0.1750	0.2040	0.4843	0.0012	0.0990	0.1180	0.1609	0.1660	0.0003	0.0015	0.0255	0.0005
2,3,5-Trimethylnapthalene	2.5665	2.5328	5.7110	0.0056	1.8676	2.1385	2.2703	3.3964	0.0012	0.0022	0.4258	0.0210
Fluorene	2.4489	2.5757	4.0218	0.0038	1.1966	1.3631	2.1572	2.5090	0.0012	0.0040	0.4042	0.0227
1-Methylfuorene	1.9834	1.9195	3.7447	0.0036	1.3937	1.6422	1.8009	2.3534	0.0023	0.0023	0.5217	0.0900
Dibenzothiophene	1.3983	0.8655	4.0855	0.0009	0.5803	0.0801	0.2541	2.7740	0.0015	0.0013	0.3850	0.1214
Phenanthrene	4.0607	3.9805	6.6348	0.0052	2.1072	2.0703	3.5954	4.1661	0.0118	0.0076	0.9544	0.3220
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyldibenzothiophene	0.4254	0.2449	2.4236	0.0006	0.3830	0.0786	0.0914	1.5411	0.0006	0.0039	0.1742	0.0568
4-Methyldibenzothiophene	0.2980	0.1569	1.9562	0.0002	0.2470	0.0323	0.0328	1.1824	0.0004	0.0028	0.1087	0.0422
2-Methylphenanthrene	0.7786	0.8079	2.2606	0.0025	0.6157	0.7050	0.7675	1.3967	0.0011	0.0087	0.2752	0.0971
2-Methylanthracene	0.7752	0.8527	2.3978	0.0012	0.5963	0.6391	0.7495	1.4919	0.0012	0.0109	0.2797	0.1040
4,5-Methylenephenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	0.0006	ND	ND	ND
1-Methylanthracene	1.0050	1.0610	2.9047	ND	0.8117	0.9477	0.9637	2.0685	ND	0.0146	0.4043	0.1723
1-Methylphenanthrene	0.9365	0.9614	2.4304	ND	0.7355	0.8459	0.8896	1.5419	ND	0.0109	0.3432	0.1344
9-Methylanthracene	0.0162	0.0073	0.0280	ND	ND	ND	ND	0.0178	ND	ND	0.0035	ND
9,10-Dimethylanthracene	0.0096	0.0077	0.0759	ND	0.0034	0.0049	0.0068	0.0451	ND	0.0009	0.0013	0.0063
Fluoranthene	0.0164	0.0166	0.0365	0.0015	0.0122	0.0137	0.0131	0.0211	0.0660	0.0011	0.0060	0.0033
Pyrene	0.0409	0.0440	0.1094	0.0016	0.0297	0.0334	0.0335	0.0670	0.2895	0.0031	0.0143	0.0086
3,6-Dimethylphenanthrene	0.0097	0.0078	0.0770	ND	0.0034	0.0049	0.0069	0.0462	ND	0.0009	0.0014	0.0064
Benzo[a]fluorene	0.0461	ND	0.2829	0.0013	0.0383	0.0477	0.0443	0.1722	0.0003	0.0026	0.0190	0.0092
Retene	0.0114	0.0224	0.2723	0.0008	0.0092	0.0145	0.0133	0.1514	0.0004	0.0017	0.0030	0.0021
Benzo[b]fluorene	0.0222	0.0283	0.1360	0.0002	0.0190	0.0227	0.0217	0.0806	0.0009	0.0011	0.0090	0.0046
Cyclopenta[c,d]pyrene	ND	ND	ND	0.0002	ND	ND	ND	ND	0.0168	0.0002	ND	ND
Benz[a]anthracene	0.0031	0.0060	0.0500	ND	0.0033	0.0045	0.0045	0.0343	0.0015	0.0007	0.0013	0.0008
Chrysene+Triphenylene	0.0406	0.0562	0.3032	0.0022	0.0326	0.0418	0.0396	0.1864	0.0008	0.0038	0.0165	0.0091
Napthacene	ND	ND	0.0538	0.0003	ND	ND	ND	0.0372	0.0007	ND	ND	ND
4-Methylchrysene	0.0067	0.0137	0.1236	0.0003	0.0058	0.0090	0.0055	0.0726	ND	0.0009	0.0015	0.0009
Benzo[b]fluoranthene	0.0016	0.0057	0.0729	ND	0.0025	0.0033	0.0031	0.0692	ND	0.0006	0.0006	0.0004
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethylbenz[a]anthracene	ND	0.0030	0.0469	ND	ND	0.0021	0.0012	0.0613	ND	0.0002	0.0007	0.0002
Benzo[e]pyrene	0.0028	0.0077	0.0695	0.0005	0.0023	0.0047	0.0045	0.0744	0.0032	0.0007	0.0013	0.0008
Benzo[a]pyrene	ND	ND	ND	ND	0.0006	ND	ND	0.0374	ND	0.0005	0.0008	0.0007
Perylene	ND	0.0022	0.0233	ND	0.0003	0.0015	0.0010	0.0146	ND	0.0004	0.0004	0.0002
3-Methylchloanthrene	ND	ND	0.0334	ND	ND	0.0006	0.0004	ND	ND	0.0004	ND	ND
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	0.0018	ND	ND	ND
Dibenz[a,h+ac]anthracene	ND	ND	0.0021	ND	ND	ND	ND	0.0039	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	0.0158	ND	ND	ND	ND	0.0175	0.0079	ND	ND	ND
Anthanthrene	ND	ND	ND	ND	ND	ND	ND	ND	0.0010	ND	ND	ND
Corenene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH ng/mL	**66.58**	**64.33**	**138.32**	**0.08**	**26.92**	**24.72**	**46.29**	**73.72**	**0.43**	**0.16**	**9.32**	**1.28**

EMA Sample #	35A	35B	36A	36B	37A	37B	38	39	40	41	42	43
Sample Type	CE-WAF	WAF	CE-WAF	WAF	CE-WAF	WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF
ANS Loading g/2L	0.0264	1.4822	0.0557	2.9901	0.1203	6.0318	0.0000	0.0229	0.0482	0.0919	0.1900	0.0000
C9500 g/2L	0.0014	0.0000	0.0022	0.0000	0.0056	0.0000	0.0000	0.0019	0.0026	0.0045	0.0107	0.0000
Volume extracted (mL)	938	925	1038	926	909	950	900	900	935	910	890	930
TPH Concentrations (ng/mL)												
TPH ng/mL	153.4465	132.7635	716.8046	67.1719	882.2694	637.8523	164.9421	103.8155	696.6273	1139.2815	7606.9514	180.7826
Corrected TPH ng/mL	**1534.46**	**1327.63**	**7168.05**	**671.72**	**8822.69**	**6378.52**	**1649.42**	**1038.16**	**6966.27**	**11392.82**	**76069.51**	**1807.83**
PAH Concentration (ng/mL)												
Napthalene	0.3156	2.5598	0.8102	2.9744	4.3246	10.3625	0.0105	0.4463	0.3068	2.8247	8.3553	0.0033
2-Methylnapthalene	1.6913	5.5961	4.5966	4.2386	11.1793	12.2967	0.0474	2.3146	2.7456	8.8638	11.7587	0.0032
Azulene	0.0033	0.0063	0.0078	0.0074	0.0160	0.0123	ND	0.0059	0.0067	0.0136	0.0185	ND
1-Methylnapthalene	1.0899	3.9711	3.0648	5.4904	6.6488	8.2658	0.0239	1.8345	2.5255	5.5602	9.0803	0.0026
Biphenyl	0.3562	0.9659	0.7708	1.1810	1.3415	1.5478	0.0089	0.4698	0.6949	1.1832	1.5650	0.0011
2,7-Dimethylnapthalene	1.0616	1.4014	2.0220	1.6953	2.8074	2.1405	0.0200	1.4171	1.9079	2.7284	3.2135	0.0019
1,3-Dimethylnapthalene	1.3470	2.0198	2.5263	2.3411	3.4642	2.9116	0.0165	1.7435	2.4303	3.6005	4.1622	0.0035
1,6-Dimethylnapthalene	0.8392	1.1700	1.5750	1.3624	2.1970	1.7394	0.0120	1.0962	1.4629	1.9587	2.4937	0.0013
1,4-Dimethylnapthalene	0.4086	0.6134	0.7494	0.6826	1.0089	0.8700	0.0050	0.5094	0.7190	0.9785	1.1504	0.0010
1,5-Dimethylnapthalene	0.2040	0.3120	0.3791	0.3625	0.5144	0.4316	0.0022	0.2548	0.3500	0.5225	0.6177	0.0005
Acenapthylene	ND	ND	ND	ND	ND	ND	0.0018	ND	ND	ND	ND	0.0011
1,2-Dimethylnapthalene	0.2466	0.3776	0.4460	0.4038	0.6038	0.5287	0.0024	0.2851	0.4053	0.5951	0.6833	0.0004
1,8-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	0.0028	ND	ND	ND	ND	ND
Acenapthene	0.0404	0.0903	0.0804	0.1070	0.1124	0.1225	0.0018	0.0475	0.0757	0.1178	0.2157	0.0013
2,3,5-Trimethylnapthalene	0.8726	0.8297	1.3693	0.8410	1.4336	1.1895	0.0053	0.9689	1.3099	1.6075	2.5097	0.0018
Fluorene	0.6450	1.3261	1.2038	1.3003	1.5344	1.9225	0.0055	0.6620	1.1118	1.5650	1.9948	0.0020
1-Methylfuorene	0.7414	0.8123	1.0687	0.7608	1.0677	1.1743	0.0030	0.7489	1.0594	1.2541	1.7333	0.0018
Dibenzothiophene	0.5939	0.2626	1.0684	0.7004	1.2205	1.7047	0.0012	0.7679	1.1600	1.3261	2.0072	0.0007
Phenanthrene	1.4036	1.7774	2.1414	1.2859	2.3208	2.8185	0.0076	1.4010	2.0995	2.5821	2.8065	0.0046
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyldibenzothiophene	0.2201	0.0595	0.3690	0.1689	0.3615	0.3785	0.0012	0.3262	0.4079	0.4271	1.1269	0.0018
4-Methyldibenzothiophene	0.1463	0.0387	0.2637	0.1097	0.2584	0.2655	0.0010	0.2248	0.2934	0.3205	0.8326	0.0010
2-Methylphenanthrene	0.3573	0.2851	0.5000	0.2305	0.4612	0.4404	0.0035	0.3644	0.4775	0.5694	1.0076	0.0032
2-Methylanthracene	0.3655	0.2953	0.5038	0.2330	0.4707	0.4435	0.0049	0.3775	0.4916	0.5906	1.0837	0.0036
4,5-Methylenephenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Methylanthracene	0.5193	0.4599	0.7109	0.4046	0.6565	0.7446	0.0050	0.5363	0.6862	0.8513	1.4882	0.0046
1-Methylphenanthrene	0.4437	0.3663	0.5968	0.2724	0.5648	0.5553	0.0046	0.4529	0.5816	0.6157	1.1512	0.0032
9-Methylanthracene	ND	ND	0.0043	ND	0.0042	0.0045	ND	0.0036	0.0041	0.0045	0.0127	ND
9,10-Dimethylanthracene	0.0018	0.0082	0.0038	0.0074	0.0043	0.0106	0.0005	0.0018	0.0034	0.0048	0.0379	ND
Fluoranthene	0.0072	0.0076	0.0086	0.0059	0.0079	0.0121	ND	0.0074	0.0090	0.0097	0.0196	0.0018
Pyrene	0.0184	0.0172	0.0258	0.0152	0.0220	0.0219	0.0014	0.0178	0.0226	0.0268	0.0584	0.0016
3,6-Dimethylphenanthrene	0.0018	0.0084	0.0039	0.0076	0.0044	0.0109	0.0005	0.0018	0.0034	0.0049	0.0388	ND
Benzo[a]fluorene	0.0222	0.0146	0.0379	0.0140	0.0300	0.0222	0.0010	0.0228	0.0316	0.0413	0.1383	0.0008
Retene	0.0049	0.0035	0.0186	0.0030	0.0113	0.0049	0.0012	0.0051	0.0125	0.0223	0.1399	0.0009
Benzo[b]fluorene	0.0112	0.0070	0.0185	0.0064	0.0151	0.0106	0.0004	0.0111	0.0152	0.0200	0.0673	0.0002
Cyclopenta[c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[a]anthracene	0.0015	0.0012	0.0042	0.0013	0.0027	0.0023	ND	0.0015	0.0029	0.0048	0.0313	ND
Chrysene+Triphenylene	0.0193	0.0118	0.0346	0.0108	0.0271	0.0186	0.0020	0.0193	0.0306	0.0389	0.1639	0.0015
Napthacene	ND	ND	0.0033	ND	ND	0.0013	ND	ND	ND	0.0038	0.0312	ND
4-Methylchrysene	0.0022	0.0008	0.0092	0.0009	0.0060	0.0027	0.0005	0.0029	0.0066	0.0105	0.0563	0.0004
Benzo[b]fluoranthene	0.0016	0.0004	0.0055	0.0005	0.0039	0.0015	0.0003	0.0020	0.0034	0.0044	0.0447	0.0006
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0010	ND	ND
Dimethylbenz[a]anthracene	ND	0.0006	0.0041	0.0003	0.0016	0.0007	0.0006	0.0005	0.0025	ND	ND	ND
Benzo[e]pyrene	0.0024	0.0015	0.0074	0.0008	0.0051	0.0034	0.0008	0.0020	0.0054	0.0082	0.0675	0.0005
Benzo[a]pyrene	ND	ND	0.0017	0.0007	ND	ND	ND	ND	ND	0.0041	0.0096	0.0004
Perylene	0.0004	0.0006	0.0017	0.0003	ND	ND	ND	ND	ND	0.0019	0.0145	0.0002
3-Methylchloanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0123	ND
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0009	ND
Dibenz[a,h+ac]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0015	ND
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0008	0.0104	ND
Anthanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Corenene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH ng/mL	**14.01**	**25.68**	**27.02**	**27.23**	**44.71**	**52.99**	**0.21**	**17.35**	**23.46**	**40.87**	**62.01**	**0.06**

EMA Sample #	44	45	46	47	48	49	50	51	52	53	54	55
Sample Type	CE-WAF	CE-WAF	CE-WAF	CE-WAF	WAF	WAF	WAF	WAF	WAF	CE-WAF	CE-WAF	CE-WAF
ANS Loading g/2L	0.0398	0.0751	0.1484	0.3191	0.0000	0.4931	1.8804	3.9649	7.8146	0.0000	0.0694	0.1417
C9500 g/2L	0.0020	0.0038	0.0076	0.0148	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0036	0.0080
Volume extracted (mL)	930	965	935	955	940	950	990	988	975	970	940	925
TPH Concentrations (ng/mL)												
TPH ng/mL	357.4251	268.9558	728.8050	20437.9801	216.3846	155.9378	51.0596	187.1240	52.1737	59.4303	238.7788	7261.5715
Corrected TPH ng/mL	**3574.25**	**2689.56**	**7288.05**	**204379.8**	**2163.85**	**1559.38**	**510.60**	**1871.24**	**521.74**	**594.30**	**2387.79**	**72615.72**
PAH Concentration (ng/mL)												
Napthalene	0.0360	1.8104	5.5469	9.8399	0.0110	0.4167	18.0523	12.4567	11.8999	0.0019	0.6577	2.0269
2-Methylnapthalene	0.7669	3.9418	10.4350	18.0537	0.0213	2.5406	26.6519	15.0706	14.8875	ND	3.5048	8.1507
Azulene	0.0072	0.0081	0.0173	0.0084	ND	0.0028	0.0254	0.0154	0.0178	ND	0.0092	0.0041
1-Methylnapthalene	2.2408	2.8481	7.0980	10.9261	0.0152	2.0362	19.5519	11.1803	11.6047	ND	3.5985	7.7273
Biphenyl	0.3368	0.5447	1.3247	2.0339	0.0042	0.3333	2.0362	2.0836	1.8135	ND	0.7871	1.4119
2,7-Dimethylnapthalene	1.2789	1.2566	2.5313	4.8715	0.0097	1.1663	4.0927	2.7842	2.4385	ND	1.7613	3.4475
1,3-Dimethylnapthalene	1.7326	1.7096	3.3967	5.9762	0.0128	1.6283	5.5815	3.6506	3.1275	ND	2.3897	4.2054
1,6-Dimethylnapthalene	1.0246	0.9670	1.9839	3.3553	0.0065	1.0080	2.9949	2.2145	1.9928	ND	1.3829	2.5976
1,4-Dimethylnapthalene	0.4881	0.4736	0.9535	1.7287	0.0035	0.5279	1.4835	1.0530	0.9005	ND	0.6844	1.1831
1,5-Dimethylnapthalene	0.2636	0.2397	0.4850	0.7284	0.0018	0.2647	0.7934	0.5436	0.4846	ND	0.3433	0.5955
Acenapthylene	ND	ND	ND	ND	0.0009	ND	ND	ND	ND	0.0001	ND	ND
1,2-Dimethylnapthalene	0.2548	0.2663	0.5500	0.9113	0.0018	0.3332	0.8969	0.6301	0.5511	ND	0.3984	0.6507
1,8-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenapthene	0.0527	0.0550	0.1188	0.3911	0.0014	0.0855	0.2092	0.1452	0.1276	ND	0.0714	0.2321
2,3,5-Trimethylnapthalene	0.6571	0.5883	1.3192	7.2390	0.0049	0.7087	1.4887	1.3100	0.9363	ND	1.0070	2.6524
Fluorene	0.4829	0.5054	1.3950	4.3135	0.0047	1.0895	2.3029	2.0213	1.4940	ND	0.9602	1.7878
1-Methylfuorene	0.4748	0.4273	1.0283	4.6746	0.0038	0.7780	1.1561	1.0779	0.7769	ND	0.8217	1.7212
Dibenzothiophene	0.5207	0.5190	1.2182	5.8212	0.0031	1.3693	1.8544	1.6032	1.3882	ND	0.9983	2.0691
Phenanthrene	0.7606	0.7340	1.9525	7.8634	0.0092	1.8222	2.5608	2.2069	1.7236	ND	1.6011	2.8584
Anthracene	ND	ND	ND	ND	ND	ND	ND	2.3639	ND	ND	ND	ND
2-Methyldibenzothiophene	0.2523	0.2198	0.4172	3.9829	0.0020	0.3559	0.4006	0.3706	0.3079	0.0003	0.3451	1.3370
4-Methyldibenzothiophene	0.1884	0.1649	0.3255	3.1012	0.0014	0.2791	0.2961	0.2821	0.2438	0.0002	0.2520	1.0418
2-Methylphenanthrene	0.2130	0.1891	0.4397	3.1915	0.0024	0.3094	0.3692	0.3485	0.2613	ND	0.3483	1.0771
2-Methylanthracene	0.2157	0.1974	0.4675	3.3502	0.0029	0.3233	0.4003	0.3658	0.2754	0.0009	0.3512	1.1635
4,5-Methylenephenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Methylanthracene	0.3125	0.2710	0.6507	4.8815	0.0029	0.4665	0.6165	0.6268	0.4859	ND	0.5082	1.5773
1-Methylphenanthrene	0.2542	0.2262	0.5082	3.3373	0.0029	0.3811	0.4519	0.4270	0.3282	ND	0.4382	1.2095
9-Methylanthracene	ND	ND	0.0044	0.0437	ND	ND	0.0032	0.0035	ND	ND	ND	0.0133
9,10-Dimethylanthracene	0.0015	0.0012	0.0047	0.1086	ND	0.0063	0.0088	0.0102	0.0068	ND	0.0034	0.0397
Fluoranthene	0.0045	0.0036	0.0078	0.0481	0.0022	0.0086	0.0097	0.0087	0.0055	ND	0.0071	0.0178
Pyrene	0.0121	0.0099	0.0217	0.1424	0.0028	0.0171	0.0193	0.0212	0.0127	ND	0.0175	0.0545
3,6-Dimethylphenanthrene	0.0015	0.0012	0.0048	0.1111	0.0004	0.0064	0.0090	0.0104	0.0069	ND	0.0035	0.0406
Benzo[a]fluorene	0.0160	0.0140	0.0320	0.3771	0.0003	0.0185	0.0195	0.0198	0.0136	ND	0.0239	0.1471
Retene	0.0080	0.0062	0.0164	0.4004	0.0006	0.0058	0.0041	0.0057	0.0033	0.0002	0.0066	0.1433
Benzo[b]fluorene	0.0076	0.0067	0.0156	0.1886	0.0001	0.0091	0.0094	0.0098	0.0067	ND	0.0112	0.0693
Cyclopenta[c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[a]anthracene	0.0020	0.0021	0.0042	0.0781	ND	0.0020	0.0015	0.0021	0.0015	ND	0.0019	0.0291
Chrysene+Triphenylene	0.0148	0.0140	0.0310	0.4273	0.0011	0.0164	0.0144	0.0169	0.0104	0.0003	0.0227	0.1590
Napthacene	0.0010	0.0010	0.0025	0.0967	ND	0.0016	ND	0.0011	0.0009	ND	ND	0.0325
4-Methylchrysene	0.0036	0.0034	0.0077	0.1526	0.0001	0.0019	0.0013	0.0024	0.0013	ND	0.0039	0.0590
Benzo[b]fluoranthene	0.0030	0.0022	0.0049	0.1712	0.0007	0.0038	0.0012	0.0009	0.0008	ND	0.0024	0.0476
Benzo[k]fluoranthene	ND	0.0003	0.0005	0.0193	ND	0.0015	0.0002	0.0002	ND	ND	ND	ND
Dimethylbenz[a]anthracene	0.0017	0.0022	0.0031	0.1834	0.0004	0.0011	0.0004	0.0008	ND	ND	0.0011	0.0463
Benzo[e]pyrene	0.0031	0.0035	0.0064	0.2080	0.0008	0.0025	0.0015	0.0015	0.0008	0.0002	0.0035	0.0619
Benzo[a]pyrene	0.0013	0.0013	0.0013	0.0241	0.0007	0.0015	0.0008	0.0011	0.0007	0.0001	ND	0.0134
Perylene	0.0011	0.0005	0.0007	0.0407	0.0004	0.0004	0.0003	0.0006	0.0001	0.0002	0.0005	0.0224
3-Methylchloanthrene	0.0004	0.0007	ND	0.0492	ND	ND	ND	ND	ND	ND	ND	0.0286
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	0.0055	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h+ac]anthracene	ND	ND	ND	0.0074	ND	ND	ND	ND	ND	ND	ND	0.0020
Benzo[g,h,i]perylene	ND	ND	0.0006	0.0287	ND	ND	ND	ND	ND	ND	ND	0.0079
Anthanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Corenene	ND	ND	ND	0.0081	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH ng/mL	**12.90**	**18.24**	**44.33**	**113.50**	**0.14**	**18.33**	**94.37**	**64.95**	**58.14**	**0.00**	**23.33**	**51.76**

EMA Sample #	56	57	63	64	65	66	67	EMA-A	68	69	70	71
Sample Type	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	Seawater	CE-WAF	CE-WAF	CE-WAF	CE-WAF
ANS Loading g/2L	0.2884	0.6112	0.0000	0.0729	0.1358	0.2756	0.6007	0.0000	0.0000	0.0093	0.0185	0.0380
C9500 g/2L	0.0146	0.0275	0.0000	0.0045	0.0069	0.0155	0.0312	0.0000	0.0000	0.0005	0.0010	0.0019
Volume extracted (mL)	975	930	845	835	930	870	980	997	895	925	905	875
TPH Concentrations (ng/mL)												
TPH ng/mL	17201.1748	5657.1267	112.5705	385.8605	100.4380	103.9746	89.3729	0.0348	ND	367.2766	916.1398	72.3888
Corrected TPH ng/mL	**172011.7**	**56571.27**	**1125.70**	**3858.61**	**1004.38**	**1039.75**	**893.73**	**0.35**	**ND**	**3672.77**	**9161.40**	**723.89**
PAH Concentration (ng/mL)												
Napthalene	8.0643	13.3519	0.0269	21.1766	18.9905	21.6670	20.0514	ND	0.0273	0.8400	1.6667	2.0307
2-Methylnapthalene	15.0136	16.3628	0.0663	22.3898	24.5274	20.6189	22.8810	ND	0.0379	2.1890	4.1613	4.5782
Azulene	0.0088	0.0212	0.0001	0.0180	0.0210	0.0184	0.0219	ND	ND	0.0010	0.0018	0.0066
1-Methylnapthalene	10.7469	11.0240	0.0417	13.5364	15.0419	12.6763	14.5400	ND	0.0199	1.3105	2.4243	2.8399
Biphenyl	1.9336	1.7933	0.0069	2.1082	2.2784	1.9711	2.1477	ND	0.0033	0.2657	0.4718	0.5558
2,7-Dimethylnapthalene	4.7232	3.5429	0.0221	2.9360	3.1794	2.6612	2.9807	ND	0.0080	1.0742	1.8504	1.7525
1,3-Dimethylnapthalene	5.7349	4.6729	0.0264	3.9628	4.1211	3.4665	3.7948	ND	0.0084	1.2515	2.1141	2.1757
1,6-Dimethylnapthalene	3.4060	2.4378	0.0143	2.1961	2.4591	2.0847	2.4524	ND	0.0055	0.8399	1.4345	1.3874
1,4-Dimethylnapthalene	1.5377	1.2182	0.0063	1.0553	1.1698	0.9880	1.0758	ND	0.0023	0.3506	0.6009	0.6214
1,5-Dimethylnapthalene	0.8164	0.6220	0.0035	0.5843	0.5687	0.4998	0.5835	ND	0.0012	0.1675	0.3272	0.3336
Acenapthylene	ND	ND	0.0005	ND	ND	ND	ND	0.0001	0.0006	ND	ND	0.0489
1,2-Dimethylnapthalene	0.8784	0.6862	0.0031	0.6537	0.6864	0.5903	0.6562	ND	0.0014	0.2040	0.3574	0.3699
1,8-Dimethylnapthalene	ND	ND	0.0029	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenapthene	0.2898	0.2118	0.0013	0.1460	0.1556	0.1323	0.1516	0.0008	0.0008	0.0391	0.0821	0.0489
2,3,5-Trimethylnapthalene	5.9520	2.5168	0.0048	1.0530	1.1265	0.9027	1.1589	ND	0.0020	0.6381	1.1264	0.8824
Fluorene	3.7471	1.9237	0.0027	1.5022	1.6706	1.3829	1.8049	0.0047	0.0021	0.2754	0.5129	0.5903
1-Methylfuorene	3.8534	1.6956	0.0013	0.8494	0.8593	0.7331	0.9156	0.0008	0.0007	0.3391	0.5840	0.5394
Dibenzothiophene	4.7012	2.1731	0.0010	1.4832	1.5081	1.3323	1.6428	ND	0.0008	0.3590	0.6670	0.5711
Phenanthrene	6.5071	2.9547	ND	1.8771	1.8776	1.6769	2.0342	ND	ND	0.5812	1.0315	1.0595
Anthracene	ND	ND	ND	ND	ND	ND	ND	0.0002	ND	ND	ND	ND
2-Methyldibenzothiophene	3.1774	1.2478	0.0005	0.3770	0.3372	0.3066	0.3644	ND	0.0005	0.2649	0.4730	0.2441
4-Methyldibenzothiophene	2.4724	0.9824	0.0003	0.2982	0.2670	0.2411	0.2849	0.0002	0.0004	0.2065	0.3677	0.1818
2-Methylphenanthrene	2.6138	1.0314	0.0012	0.3194	0.2919	0.2617	0.3059	ND	0.0008	0.2037	0.3448	0.2317
2-Methylanthracene	2.9369	1.1051	0.0010	0.3370	0.3050	0.2726	0.3138	0.0004	0.0012	0.2077	0.3508	0.2435
4,5-Methylenephenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Methylanthracene	3.8315	1.5105	ND	0.4900	0.4490	0.4152	0.5049	ND	ND	0.2488	0.4210	0.3028
1-Methylphenanthrene	2.7803	1.1298	ND	0.3654	0.3366	0.3110	0.3732	ND	ND	0.2361	0.3716	0.2760
9-Methylanthracene	0.0333	0.0127	ND	ND	ND	ND	0.0032	ND	ND	ND	0.0043	0.0046
9,10-Dimethylanthracene	0.0932	0.0340	ND	0.0074	0.0073	0.0056	0.0095	ND	ND	ND	ND	ND
Fluoranthene	0.0388	0.0159	ND	0.0075	0.0057	0.0055	0.0068	0.0029	ND	0.0034	0.0054	0.0051
Pyrene	0.1319	0.0524	ND	0.0148	0.0127	0.0125	0.0152	0.0017	0.0005	0.0118	0.0168	0.0123
3,6-Dimethylphenanthrene	0.0953	0.0348	ND	0.0076	0.0074	0.0057	0.0097	ND	0.0002	0.0039	0.0097	0.0018
Benzo[a]fluorene	0.3209	0.1336	ND	0.0207	0.0141	0.0140	0.0162	ND	0.0003	0.0168	0.0366	0.0144
Retene	0.3416	0.1091	ND	0.0100	0.0036	0.0043	0.0051	ND	0.0002	0.0144	0.0392	0.0036
Benzo[b]fluorene	0.1638	0.0606	ND	0.0104	0.0073	0.0070	0.0084	ND	ND	0.0079	0.0159	0.0069
Cyclopenta[c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[a]anthracene	0.0692	0.0218	ND	0.0024	0.0012	0.0015	0.0019	ND	ND	0.0017	0.0067	0.0011
Chrysene+Triphenylene	0.3714	0.1357	0.0003	0.0173	0.0106	0.0113	0.0129	0.0004	0.0005	0.0177	0.0424	0.0125
Napthacene	0.0774	0.0254	ND	0.0017	ND	0.0015	ND	ND	ND	ND	0.0045	ND
4-Methylchrysene	0.1389	0.0470	ND	0.0042	0.0010	0.0020	0.0019	ND	ND	0.0068	0.0200	0.0017
Benzo[b]fluoranthene	0.1492	0.0540	ND	0.0031	0.0011	0.0011	0.0012	ND	ND	ND	ND	0.0008
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethylbenz[a]anthracene	0.3721	0.0347	ND	0.0021	0.0005	0.0012	0.0004	ND	ND	ND	0.0026	0.0003
Benzo[e]pyrene	0.0675	0.0474	ND	0.0031	0.0014	0.0016	0.0015	ND	0.0002	0.0025	0.0069	0.0007
Benzo[a]pyrene	ND	0.0100	0.0004	ND	0.0006	ND	0.0009	ND	ND	0.0016	ND	ND
Perylene	0.0467	0.0163	ND	0.0011	0.0001	ND	0.0002	ND	ND	ND	0.0019	ND
3-Methylchloanthrene	ND	0.0204	ND	0.0009	ND	0.0003	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h+ac]anthracene	0.0040	0.0012	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	0.0351	0.0064	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Corenene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH ng/mL	**98.28**	**75.09**	**0.24**	**79.83**	**82.30**	**75.29**	**81.14**	**0.01**	**0.13**	**12.18**	**21.96**	**21.94**

EMA Sample #	72	73	74	75	76	77	Seawater B	Seawater C	78	79	80	81
Sample Type	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	Seawater	Seawater	CE-WAF	CE-WAF	CE-WAF	CE-WAF
ANS Loading g/2L	0.0746	0.0000	0.0047	0.0093	0.0170	0.0379			0.0000	0.0092	0.0184	0.0421
C9500 g/2L	0.0038	0.0000	0.0002	0.0006	0.0014	0.0022			0.0000	0.0004	0.0009	0.0015
Volume extracted (mL)	900	880	875	861	893	886	988	787	921	894	936	988
TPH Concentrations (ng/mL)												
TPH ng/mL	1827.2412	4.7742	3.3145	4.1099	39.0474	276.8368	76.5335	11.3789	3.2794	513.7299	596.0566	119.2357
Corrected TPH ng/mL	**18272.41**	**47.74**	**33.15**	**41.10**	**390.47**	**2768.37**	**765.33**	**113.79**	**32.79**	**5137.30**	**5960.57**	**1192.36**
PAH Concentration (ng/mL)												
Napthalene	1.9685	ND	0.3669	0.7621	1.1971	1.0892	ND	0.0027	ND	0.4730	1.5740	0.6022
2-Methylnapthalene	5.9318	ND	0.9628	1.9274	3.2044	3.3585	ND	0.0019	ND	0.4881	2.9079	0.7151
Azulene	0.0017	ND	ND	0.0009	ND	ND	ND	ND	ND	0.0029	0.0041	0.0017
1-Methylnapthalene	3.8151	ND	0.5812	1.1541	1.9072	2.0815	ND	ND	ND	0.6374	2.9392	0.8052
Biphenyl	0.8064	ND	0.1206	0.2343	0.3910	0.4593	ND	ND	ND	0.0916	0.4140	0.0583
2,7-Dimethylnapthalene	2.4896	ND	0.4840	0.9000	1.3750	1.4662	ND	ND	ND	0.2999	1.7541	0.2915
1,3-Dimethylnapthalene	3.2101	ND	0.6081	1.0584	1.7688	1.8235	ND	ND	ND	0.8903	2.9205	0.7188
1,6-Dimethylnapthalene	1.8701	ND	0.3818	0.7442	1.0547	1.2023	ND	ND	ND	0.3353	1.5554	0.3591
1,4-Dimethylnapthalene	0.8624	ND	0.1723	0.3009	0.4984	0.5258	ND	ND	ND	0.2929	0.8363	0.2499
1,5-Dimethylnapthalene	0.4994	ND	0.0905	0.1747	0.2495	0.2969	ND	ND	ND	0.2207	0.4285	0.1947
Acenapthylene	ND	0.0001	ND	ND	ND	ND	ND	ND	ND	0.0055	0.0781	0.0019
1,2-Dimethylnapthalene	0.5324	ND	0.0983	0.1802	0.2844	0.3252	ND	ND	ND	0.0933	0.4295	0.0969
1,8-Dimethylnapthalene	ND	ND	ND	ND	ND	ND	ND	0.0048	ND	0.0033	ND	0.0045
Acenapthene	0.1221	ND	0.0125	0.0212	0.0358	0.0482	ND	ND	ND	0.1009	0.1596	0.0392
2,3,5-Trimethylnapthalene	1.5498	ND	0.3173	0.5249	0.6868	0.7778	0.0002	0.0011	ND	0.6482	1.5115	0.2993
Fluorene	1.0130	ND	0.1260	0.2347	0.3999	0.5163	ND	0.0049	ND	0.3161	0.7212	0.2253
1-Methylfuorene	0.9091	0.0003	0.1707	0.3033	0.3877	0.4826	ND	0.0015	ND	0.4937	0.8959	0.2525
Dibenzothiophene	1.2286	ND	0.1668	0.3007	0.4573	0.5985	ND	0.0009	ND	0.3424	1.0055	0.1538
Phenanthrene	1.7229	ND	0.2806	0.5305	0.7342	0.9076	ND	0.0031	ND	0.3097	1.3313	0.2072
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0078	ND	ND
2-Methyldibenzothiophene	0.7012	ND	0.1409	0.1991	0.2148	0.2857	ND	ND	ND	0.4583	0.7826	0.1141
4-Methyldibenzothiophene	0.5617	ND	0.1026	0.1439	0.1589	0.2162	ND	ND	ND	0.2939	0.5895	0.0770
2-Methylphenanthrene	0.5029	ND	0.1098	0.1687	0.1724	0.2207	ND	0.0011	ND	0.1857	0.5759	0.0576
2-Methylanthracene	0.5006	ND	0.1131	0.1702	0.1719	0.2202	ND	ND	ND	0.3285	0.6193	0.0846
4,5-Methylenephenanthrene	ND	ND	ND	0.0218	ND	ND	ND	ND	ND	ND	ND	ND
1-Methylanthracene	0.5986	ND	0.1388	0.2112	0.2102	0.2835	ND	ND	ND	0.4660	0.8041	0.1196
1-Methylphenanthrene	0.5364	ND	0.1272	0.1965	0.1992	0.2469	ND	ND	ND	0.3382	0.6012	0.0959
9-Methylanthracene	0.0050	ND	ND	ND	ND	0.0046	ND	ND	ND	0.0052	0.0079	ND
9,10-Dimethylanthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	0.0078	0.0004	0.0023	0.0041	0.0034	0.0044	0.0003	0.0030	0.0007	0.0085	0.0100	0.0043
Pyrene	0.0231	ND	0.0060	0.0091	0.0084	0.0144	ND	0.0024	0.0013	0.0306	0.0352	0.0246
3,6-Dimethylphenanthrene	0.0127	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]fluorene	0.0512	ND	0.0087	0.0106	0.0098	0.0163	ND	ND	ND	0.0665	0.0804	0.0184
Retene	0.0589	ND	0.0029	0.0024	0.0033	0.0110	ND	ND	ND	0.0823	0.0710	0.0069
Benzo[b]fluorene	0.0239	ND	0.0040	0.0051	0.0051	0.0076	ND	ND	ND	0.0303	0.0356	0.0054
Cyclopenta[c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[a]anthracene	0.0090	ND	0.0009	0.0008	0.0008	0.0021	ND	ND	ND	0.0114	0.0149	0.0016
Chrysene+Triphenylene	0.0549	0.0001	0.0081	0.0094	0.0088	0.0157	ND	ND	ND	0.0769	0.0958	0.0248
Napthacene	0.0108	ND	ND	ND	ND	ND	ND	ND	ND	0.0088	0.0117	ND
4-Methylchrysene	0.0271	ND	0.0011	0.0021	0.0019	0.0065	ND	ND	ND	0.0256	0.0378	0.0029
Benzo[b]fluoranthene	0.0084	ND	ND	ND	ND	ND	ND	ND	ND	0.0104	0.0153	0.0014
Benzo[k]fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0010	ND	ND
Dimethylbenz[a]anthracene	0.0034	ND	ND	ND	ND	ND	0.0002	0.0001	ND	0.0108	0.0147	0.0007
Benzo[e]pyrene	0.0096	ND	ND	ND	ND	ND	ND	ND	ND	0.0146	0.0219	0.0022
Benzo[a]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0071	ND
Perylene	0.0044	ND	ND	ND	ND	ND	ND	ND	ND	0.0031	0.0050	ND
3-Methylchloanthrene	0.0056	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h+ac]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0062	0.0053	ND
Anthanthrene	ND	ND	ND	ND	ND	ND	0.0001	0.0001	ND	ND	ND	ND
Corenene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH ng/mL	**32.25**	**0.00**	**5.71**	**10.51**	**15.80**	**17.52**	**0.00**	**0.03**	**0.00**	**8.52**	**25.91**	**5.92**

EMA Sample #	82	88	84	83	95	102	103	96	99	100	111	113
Sample Type	CE-WAF	WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	CE-WAF	WAF	WAF	WAF	WAF
ANS Loading g/2L	0.0746	4.0472	0.0186	0.0000	0.0000	0.0000	0.0188	0.0179	0.0000	3.9122	0.0000	4.0040
C9500 g/2L	0.0380	0.0000	0.0010	0.0000	0.0000	0.0000	0.0011	0.0010	0.0000	0.0000	0.0000	0.0000
Volume extracted (mL)	999	1175	950	950	930	960	910	925	885	910	960	880
TPH Concentrations (ng/mL)												
TPH ng/mL	281.2128	57.8722	638.7740	7.0078	3.9894	0.7215	9.6384	295.8044	14.1958	4.7724	2.0433	6.4061
Corrected TPH ng/mL	**2812.13**	**578.72**	**6387.74**	**70.08**	**39.89**	**7.22**	**96.38**	**2958.04**	**141.96**	**47.72**	**20.43**	**64.06**
PAH Concentration (ng/mL)												
Napthalene	0.4541	3.7189	1.3563	ND	ND	ND	0.1829	1.2619	ND	16.1599	ND	25.8691
2-Methylnapthalene	0.4801	8.3836	3.4783	ND	ND	ND	1.0653	3.3112	ND	25.3459	ND	28.8757
Azulene	0.0143	0.0144	0.0015	ND	ND	ND	0.0014	0.0038	ND	0.0220	ND	0.0297
1-Methylnapthalene	1.1415	10.9799	1.9448	ND	ND	ND	0.7298	2.1578	ND	17.5644	ND	20.1240
Biphenyl	0.0483	1.7564	0.3832	ND	ND	0.0013	0.2405	0.4115	0.0018	1.6723	ND	3.8074
2,7-Dimethylnapthalene	0.1898	2.8915	1.5596	ND	ND	ND	0.9413	1.3129	ND	4.0300	ND	4.6562
1,3-Dimethylnapthalene	0.7315	4.3019	2.0044	ND	0.0018	ND	1.0572	1.5574	0.0017	5.3360	ND	5.1843
1,6-Dimethylnapthalene	0.3358	2.4379	1.0730	0.0007	0.0011	ND	0.8455	0.9934	ND	3.3593	ND	5.2124
1,4-Dimethylnapthalene	0.2919	1.2712	0.5089	0.0005	0.0003	ND	0.3411	0.4059	0.0008	1.4490	ND	1.5085
1,5-Dimethylnapthalene	0.2655	0.6077	0.2733	0.0002	0.0011	ND	0.1885	0.2447	0.0008	0.8452	ND	1.4547
Acenapthylene	0.0020	0.0929	ND	0.0002	0.0006	ND	ND	0.0496	0.0006	ND	ND	ND
1,2-Dimethylnapthalene	0.0924	0.7313	0.2829	ND	0.0003	ND	0.2180	0.2758	0.0004	1.0559	0.0002	1.1715
1,8-Dimethylnapthalene	0.0064	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenapthene	0.0664	0.1453	0.0512	ND	ND	ND	0.0346	0.1207	ND	0.2713	ND	0.3387
2,3,5-Trimethylnapthalene	0.2732	1.0386	0.8339	ND	0.0013	0.0013	0.6809	0.8304	0.0014	1.1926	0.0005	1.3847
Fluorene	0.2298	1.4926	0.4192	ND	0.0023	ND	0.3356	0.3898	0.0045	1.9347	ND	2.2510
1-Methylfuorene	0.2289	0.7347	0.4584	ND	0.0011	0.0006	0.3973	0.5534	0.0010	0.9568	ND	1.1313
Dibenzothiophene	0.0774	1.3088	0.5019	ND	ND	ND	0.4242	0.5934	0.0007	1.7242	ND	0.7718
Phenanthrene	0.0996	1.7489	0.7167	ND	ND	ND	0.7023	0.8852	ND	2.3362	ND	2.7496
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyldibenzothiophene	0.0846	0.3123	0.3379	ND	0.0004	0.0002	0.2552	0.4563	0.0003	0.3536	0.0002	0.1223
4-Methyldibenzothiophene	0.0510	0.2486	0.2659	ND	ND	ND	0.1719	0.3375	ND	0.2574	ND	0.0727
2-Methylphenanthrene	0.0299	0.2685	0.2394	ND	0.0007	ND	0.1780	0.4245	ND	0.3374	ND	0.4128
2-Methylanthracene	0.0610	0.2771	0.2460	ND	0.0008	ND	0.1758	0.4083	ND	0.3284	ND	0.4029
4,5-Methylenephenanthrene	ND	ND	ND	ND	ND	ND	ND	0.0039	ND	0.0028	ND	0.0066
1-Methylanthracene	0.0832	0.3751	0.2753	ND	ND	ND	0.2687	0.5787	ND	0.4994	ND	0.6099
1-Methylphenanthrene	0.0647	0.2857	0.2100	ND	ND	ND	0.2208	0.4133	ND	0.3595	ND	0.4613
9-Methylanthracene	ND	ND	0.0039	ND	ND	ND	0.0016	0.0053	ND	0.0024	ND	0.0032
9,10-Dimethylanthracene	ND	ND	0.0036	ND	ND	ND	0.0260	0.1150	ND	0.0635	ND	0.0780
Fluoranthene	0.0035	0.0063	0.0024	ND	ND	ND	0.0042	0.0080	ND	0.0106	ND	0.0131
Pyrene	0.0218	0.0163	0.0106	ND	ND	ND	0.0124	0.0260	ND	0.0218	ND	0.0272
3,6-Dimethylphenanthrene	ND	ND	0.0037	ND	ND	ND	0.0011	ND	ND	0.0113	ND	0.0173
Benzo[a]fluorene	0.0151	0.0164	0.0152	ND	ND	ND	0.0124	0.0665	ND	0.0225	ND	0.0292
Retene	0.0069	0.0077	0.0208	ND	ND	ND	0.0023	0.0486	ND	0.0036	0.0006	0.0059
Benzo[b]fluorene	0.0044	0.0076	0.0065	ND	ND	ND	0.0063	0.0297	ND	0.0123	0.0003	0.0146
Cyclopenta[c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	0.0013	ND	ND	ND	ND
Benz[a]anthracene	ND	0.0021	0.0027	ND	ND	ND	0.0008	0.0118	ND	0.0017	ND	0.0020
Chrysene+Triphenylene	0.0242	0.0141	0.0142	ND	ND	ND	0.0116	0.0796	ND	0.0171	0.0003	0.0220
Napthacene	0.0016	ND	ND	ND	ND	ND	ND	0.0057	ND	ND	0.0002	ND
4-Methylchrysene	0.0045	0.0034	0.0087	ND	ND	ND	0.0010	0.0197	ND	0.0018	ND	0.0021
Benzo[b]fluoranthene	0.0016	0.0014	0.0005	ND	ND	ND	0.0004	0.0102	ND	0.0006	ND	0.0009
Benzo[k]fluoranthene	ND	ND	0.0001	ND	ND	ND	ND	0.0013	ND	ND	ND	ND
Dimethylbenz[a]anthracene	ND	0.0009	0.0046	ND	ND	ND	ND	0.0134	ND	0.0006	ND	0.0009
Benzo[e]pyrene	0.0027	0.0020	0.0013	ND	0.0003	ND	0.0006	0.0185	0.0010	0.0009	ND	0.0010
Benzo[a]pyrene	ND	ND	0.0016	ND	ND	ND	ND	0.0036	ND	ND	ND	ND
Perylene	ND	ND	0.0002	ND	ND	ND	ND	0.0062	ND	0.0003	ND	0.0003
3-Methylchloanthrene	ND	ND	ND	ND	ND	ND	ND	0.0034	ND	ND	ND	ND
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	0.0004	ND	ND	ND	ND
Dibenz[a,h+ac]anthracene	ND	ND	0.0003	ND	ND	ND	ND	0.0016	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	0.0007	ND	ND	ND	ND	0.0067	ND	ND	ND	ND
Anthanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Corenene	ND	ND	ND	ND	ND	ND	ND	0.0021	ND	ND	ND	ND
Total PAH ng/mL	**5.49**	**45.50**	**17.52**	**0.00**	**0.01**	**0.00**	**9.74**	**18.47**	**0.01**	**87.56**	**0.00**	**108.83**

EMA Sample #	114	115	116	117	118	119	121	123	124	125	128	122	120
Sample Type	WAF	WAF	WAF	WAF	WAF	WAF	WAF	WAF	Control	CE-WAF	WAF	WAF	WAF
ANS Loading g/2L	0.0000	1.4182	2.9464	5.6438	11.9760	0.0000	2.8068	11.7021	0.0000	0.0215	3.8644	5.8144	1.3341
C9500 g/2L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.0000	0.0000	0.0000
Volume extracted (mL)	965	915	945	915	1005	960	925	905	960	950	950	900	1015
<u>TPH Concentrations (ng/mL)</u>													
TPH ng/mL	3.8456	12.0330	3.9488	7.9875	17.1787	11.9692	2.3940	16.8365	4.0065	29.0991	12.6792	20.3989	0.7443
Corrected TPH ng/mL	**38.46**	**120.33**	**39.49**	**79.87**	**171.79**	**119.69**	**23.94**	**168.37**	**40.06**	**290.99**	**126.79**	**203.99**	**7.44**
<u>PAH Concentration (ng/mL)</u>													
Napthalene	ND	15.0830	4.8858	4.8752	1.7973	ND	0.0413	1.0200	ND	0.0961	21.0672	0.4271	ND
2-Methylnapthalene	ND	9.9454	5.1087	4.9658	2.4369	ND	ND	5.1973	ND	0.2437	20.0750	2.1636	0.8415
Azulene	ND	0.0104	0.0104	0.0070	0.0046	ND	0.0067	0.0072	ND	0.0164	0.0174	0.0044	0.0024
1-Methylnapthalene	ND	8.1629	7.3860	4.3911	2.3734	ND	5.8042	4.3924	ND	0.0792	14.9329	2.6327	1.3867
Biphenyl	ND	1.1748	1.1924	0.7123	0.3862	ND	1.0662	0.6751	ND	0.3521	2.2723	0.3671	0.0828
2,7-Dimethylnapthalene	ND	1.4717	1.5261	2.9994	1.7167	0.0026	3.6994	3.5572	ND	1.5286	8.9826	2.9139	1.2152
1,3-Dimethylnapthalene	ND	2.4943	2.7756	4.9952	3.3563	0.0029	5.4147	5.9648	ND	0.9067	11.3268	5.6990	2.5513
1,6-Dimethylnapthalene	ND	1.5519	1.5513	2.7370	1.9515	0.0016	3.6939	3.5739	ND	0.9473	8.1852	3.4484	1.4353
1,4-Dimethylnapthalene	0.0002	0.7877	0.7919	1.7182	1.1033	0.0011	1.5967	1.6980	ND	0.7700	3.4316	1.9633	1.1294
1,5-Dimethylnapthalene	ND	0.6310	0.7322	1.0853	0.7669	0.0016	1.1344	1.0187	ND	0.5252	1.9517	1.8345	1.1786
Acenapthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dimethylnapthalene	ND	0.4204	0.4092	0.8874	0.5576	0.0011	0.9815	0.8834	ND	0.2844	2.2419	1.0178	0.3857
1,8-Dimethylnapthalene	ND	ND	ND	0.0190	0.0148	0.0077	ND	0.0184	ND	0.0090	ND	0.0232	0.0285
Acenapthene	ND	0.2219	0.2357	0.1622	0.1229	0.0017	0.1227	0.1630	ND	0.0422	0.2496	0.1143	0.0912
2,3,5-Trimethylnapthalene	ND	0.5382	0.7369	1.8980	1.2284	0.0037	1.6140	1.9333	ND	1.4479	3.3708	2.1613	0.6643
Fluorene	ND	0.8093	1.0748	0.9292	0.6240	0.0018	0.8705	0.7809	ND	0.3182	1.7548	0.6150	0.1771
1-Methylfuorene	0.0009	0.4605	0.6254	0.6339	0.4538	0.0048	0.4886	0.5963	ND	0.3540	1.0129	0.4838	0.1445
Dibenzothiophene	ND	0.3127	0.3031	0.3290	0.2146	0.0026	0.2440	0.1999	ND	0.1679	1.2191	0.1052	0.0244
Phenanthrene	ND	0.7537	0.9272	0.9891	0.5952	0.0124	0.7566	0.6647	ND	0.1817	1.8599	0.5004	0.1352
Anthracene	ND	ND	ND	0.0344	0.0191	ND	ND	0.0393	ND	0.0078	ND	0.0226	0.0045
2-Methyldibenzothiophene	ND	0.0766	0.0692	0.2482	0.1738	0.0053	0.1659	0.2105	ND	0.3252	0.9018	0.1809	0.0467
4-Methyldibenzothiophene	ND	0.0415	0.0366	0.1448	0.0937	0.0036	0.0852	0.1239	ND	0.1127	0.6336	0.0826	0.0174
2-Methylphenanthrene	ND	0.1386	0.1698	0.2040	0.1178	0.0058	0.1406	0.1703	ND	0.1004	0.3401	0.1208	0.0303
2-Methylanthracene	ND	0.1352	0.1785	0.2043	0.1284	0.0063	0.1419	0.1715	ND	0.0319	0.3283	0.1326	0.0377
4,5-Methylenephenanthrene	ND	0.0037	0.0064	0.0074	0.0053	ND	0.0020	0.0113	ND	ND	0.0040	0.0060	0.0015
1-Methylanthracene	ND	0.2312	0.3382	0.4656	0.3021	0.0133	0.2593	0.4670	ND	0.2180	0.5630	0.3155	0.0786
1-Methylphenanthrene	ND	0.1594	0.1911	0.2379	0.1462	0.0100	0.1847	0.2081	ND	0.1452	0.4139	0.1330	0.0379
9-Methylanthracene	ND	0.0014	0.0027	0.0037	0.0021	0.0017	0.0015	0.0031	ND	0.0017	0.0030	0.0018	0.0165
9,10-Dimethylanthracene	ND	0.0443	0.0594	0.0443	0.0183	0.0012	0.0153	0.0214	ND	0.0278	0.0504	0.0222	0.0077
Fluoranthene	0.0040	0.0070	0.0118	0.0078	0.0133	ND	0.0043	0.0061	ND	0.0058	0.0079	0.0062	ND
Pyrene	ND	0.0190	0.0265	0.0184	0.0194	ND	0.0090	0.0148	ND	0.0147	0.0179	0.0167	0.0100
3,6-Dimethylphenanthrene	ND	0.0083	0.0116	0.0104	0.0072	0.0005	0.0046	0.0084	ND	0.0015	0.0106	0.0077	0.0047
Benzo[a]fluorene	0.0002	0.0167	0.0220	0.0200	0.0131	0.0010	0.0099	0.0146	ND	0.0149	0.0209	0.0151	0.0063
Retene	ND	0.0047	0.0067	0.0260	0.0116	0.0013	0.0096	0.0138	ND	0.0075	0.0161	0.0202	0.0119
Benzo[b]fluorene	ND	0.0068	0.0088	0.0082	0.0061	0.0005	0.0049	0.0066	ND	0.0065	0.0106	0.0072	0.0023
Cyclopenta[c,d]pyrene	0.0004	ND	ND	ND	ND	ND	ND	ND	ND	0.0081	ND	ND	ND
Benz[a]anthracene	0.0003	0.0014	0.0026	0.0033	0.0018	ND	0.0008	0.0018	ND	ND	0.0017	0.0018	0.0010
Chrysene+Triphenylene	0.0010	0.0165	0.0212	0.0185	0.0127	0.0011	0.0077	0.0128	ND	0.0138	0.0147	0.0143	0.0088
Napthacene	ND	0.0006	ND	0.0020	ND	ND	ND	0.0007	ND	ND	0.0009	0.0010	0.0004
4-Methylchrysene	ND	0.0015	0.0022	0.0110	0.0052	0.0004	0.0033	0.0046	ND	0.0049	0.0070	0.0094	0.0047
Benzo[b]fluoranthene	ND	ND	0.0012	0.0010	0.0009	ND	ND	ND	ND	ND	ND	0.0022	ND
Benzo[k]fluoranthene	ND	ND	ND	0.0004	0.0004	ND	ND	ND	ND	ND	ND	0.0006	ND
Dimethylbenz[a]anthracene	ND	ND	ND	0.0015	0.0006	ND	ND	ND	ND	ND	ND	0.0018	0.0009
Benzo[e]pyrene	0.0005	0.0010	0.0014	0.0017	0.0009	ND	ND	0.0007	ND	0.0006	ND	0.0013	0.0007
Benzo[a]pyrene	ND	ND	0.0011	ND	ND	ND	ND	ND	ND	ND	ND	0.0025	ND
Perylene	ND	0.0003	0.0003	0.0005	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
3-Methylchloanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-c,d]pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz[a,h+ac]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Corenene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH ng/mL	**0.01**	**45.75**	**31.44**	**36.06**	**20.80**	**0.10**	**28.59**	**33.86**	**0.00**	**9.32**	**107.30**	**27.60**	**11.80**

Table D-3 TPH and PAH Recovery Data (CBL 2007)

EMA Sample #	13	14	15	16	17	18	19	20	21	22	23	24	
Recoveries													
d8-Napthalene	0.1311	0.0732	0.2813	0.0357	0.2055	0.0064	0.0995	0.1102	0.1221	0.2173	0.2857	0.1915	
d10-Fluorene	0.4826	0.6903	0.7569	0.5761	0.9226	0.0152	0.6031	0.6259	0.7071	0.4731	0.5807	0.6889	
d10-Fluoranthene	0.8199	0.7181	0.6520	0.5865	0.6319	0.3786	0.5335	0.6065	0.6703	0.5616	0.6680	0.6474	
d12-Perylene	0.7020	0.6760	0.8017	0.6702	0.4683	0.3962	0.4627	0.5430	0.6226	0.5646	0.6967	0.0000	
	25	26	27	28	29	30	31	32	33A	33B	34A	34B	
d8-Napthalene	0.1349	0.0522	0.1303	0.1572	0.2311	0.1260	0.0802	0.1005	0.1161	0.1195	0.0227	0.0032	
d10-Fluorene	0.6908	0.5242	0.6728	0.5509	0.6869	0.5991	0.5991	0.4882	0.3234	0.2920	0.2639	0.0043	
d10-Fluoranthene	0.6996	0.5279	0.5196	0.5798	0.6309	0.5445	0.5352	0.3427	0.3265	0.3315	0.3374	0.1468	
d12-Perylene	0.7943	0.6514	0.5152	0.5318	0.7399	0.5707	0.5696	0.6067	0.6357	0.4873	0.5451	0.3895	
	35A	35B	36A	36B	37A	37B	38	39	40	41	42	43	
d8-Napthalene	0.0235	0.0469	0.0358	0.0316	0.0652	0.1780	0.0966	0.0541	0.0276	0.0551	0.0976	0.2018	
d10-Fluorene	0.3135	0.2327	0.3796	0.2658	0.3589	0.2988	0.3850	0.3574	0.3738	0.3953	0.4512	0.3042	
d10-Fluoranthene	0.3338	0.3015	0.3431	0.2997	0.2996	0.4125	0.4396	0.3807	0.3629	0.3427	0.3728	0.2735	
d12-Perylene	0.7028	0.5680	0.7510	0.5764	0.6493	0.7922	0.8162	0.8171	0.7233	0.7520	0.6230	0.4946	
	44	45	46	47	48	49	50	51	52	53	54	55	
d8-Napthalene	0.0890	0.0640	0.0886	0.0797	0.2617	0.0072	0.1627	0.1507	0.3394	0.0221	0.0654	0.1022	
d10-Fluorene	0.2305	0.1632	0.3190	0.6448	0.4055	0.1957	0.4221	0.3649	0.2878	0.0974	0.2707	0.3637	
d10-Fluoranthene	0.1861	0.1237	0.2774	0.4247	0.3636	0.2752	0.4090	0.3461	0.2582	0.2216	0.3299	0.2820	
d12-Perylene	0.3483	0.2619	0.6354	0.5527	0.6938	0.4772	0.7045	0.6525	0.4831	0.4611	0.5514	0.4172	
	56	57	63	64	65	66	67	EMA-A	68	69	70	71	
d8-Napthalene	0.0922	0.0915	0.1444	0.1006	0.1305	0.0706	0.2249	0.3756	0.4241	0.3826	0.3517	0.2472	
d10-Fluorene	0.5603	0.3132	0.2201	0.2675	0.3334	0.2313	0.3300	0.7017	0.6895	0.8058	0.8139	0.6333	
d10-Fluoranthene	0.4386	0.2264	0.1979	0.2543	0.2710	0.2436	0.3318	0.8326	0.6830	0.6920	0.6615	0.6533	
d12-Perylene	0.5684	0.3308	0.3422	0.4690	0.4723	0.4813	0.5319	0.6878	0.9634	0.9572	0.8435	0.6367	
	72	73	74	75	76	77	Seawater B	Seawater C	78	79	80	81	
d8-Napthalene	0.1158	0.4686	0.3560	0.3085	0.2448	0.1339							
d10-Fluorene	0.6445	0.6755	0.7455	0.6550	0.6689	0.6184							
d10-Fluoranthene	0.5480	0.7250	0.7409	0.7075	0.6593	0.6366							
d12-Perylene	0.5412	0.7717	0.8387	0.8510	0.8893	0.8872							
	82	88	84	83	95	102	103	96	99	100	111	113	
d8-Napthalene			0.2920	0.2941	0.2364	0.4475	0.0725	0.2714	0.1948	0.2003	0.0023	0.6876	
d10-Fluorene			0.6439	0.8289	0.4757	0.8684	0.5837	0.5524	0.4139	0.5839	0.0799	0.6913	
d10-Fluoranthene			0.5843	0.5232	0.5906	0.9638	0.5990	0.5398	0.5179	0.6895	0.9783	0.9782	
d12-Perylene			0.9051	0.9029	0.6611	0.9141	0.6605	0.4985	0.4784	0.5755	0.8314	0.8038	
	114	115	116	117	118	119	121	123	124	125	128	122	120
d8-Napthalene	0.0031	0.4052	0.5176	0.4845	0.5189	0.4320	0.2738	1.2622	0.4049	0.1887	0.6686	0.7044	0.4809
d10-Fluorene	0.0386	0.6607	0.7088	0.6651	0.5160	0.8215	0.3972	0.6354	0.7507	0.7708	0.8865	0.6350	0.7024
d10-Fluoranthene	0.8788	0.8702	0.9155	0.7279	0.6404	0.7772	0.4354	0.7042	0.7577	0.7897	0.7697	0.8450	0.7875
d12-Perylene	0.7643	0.8032	0.7591	0.6844	0.5929	0.8296	0.3898	0.6886	0.7539	0.7098	0.7440	0.8761	0.7730

Appendix E Population Study

Table E-1 Population Study

	T=12		T=19		T=26		T=33		T=62^	
	Total	*Std. Dev.*	**Total**	*Std. Dev.*	**Total**	*Std. Dev.*	**Total**	*Std. Dev.*	**Total**	*Std. Dev.*
6.9 ppm C9500										
Control	770	*57*	395	*120*	211	*72*	329	*80*	1508	*414*
Toxicant	842	*354*	447	*193*	273	*82*	392	*239*	1854	*873*
6.9 ppm C9500 UV										
Control	939	*54*	440	*102*	224	*43*				
Toxicant	1236	*720*	475	*115*	307	*131*				
10 ppm (L.R.*) CE-WAF										
Control	1060	*123*	1048	*155*	252	*106*				
Toxicant	1167	*254*	1153	*123*	405	*205*				
10 ppm (L.R.*) CE-WAF UV										
Control	253	*95*	192	*37*	237	*143*				
Toxicant	178	*36*	237	*242*	453	*405*				
2000 ppm (L.R.*) WAF										
Control	1215	*90*	1976	*359*	1261	*199*				
Toxicant	539	*152*	1438	*547*	2113	*233*				
2000 ppm (L.R.*) WAF UV										
Control	828	*239*	1297	*383*	1289	*379*				
Toxicant	435	*306*	475	*340*	1776	*1331*				

* L.R. = Loading Rate
^ Continued grow out from T=26 until day 62 using three randomly chosen and previously counted beakers.

Table E-2 Population Study (% Life Stages)

	T=12					T=19					T=26				
	Total	*SD*	% Adult	% Cope-podite	% Nauplii	Total	*SD*	% Adult	% Cope-podite	% Nauplii	Total	*SD*	% Adult	% Cope-podite	% Nauplii
6.9 ppm C9500															
Control	770	*57*	1.5 *(0.4)*	16.1 *(2.5)*	82.4*(2.4)*	395	*120*	13.3*(5.9)*	24.3*(5.0)*	62.4*(5.8)*	211	*72*	18.8*(7.9)*	43.2*(21.8)*	41.1*(29.5)*
Toxicant	842	*354*	0.9*(0.3)*	13.4*(2.5)*	85.7*(2.5)*	447	*193*	18.8*(6.9)*	37.3*(13.6)*	43.9*(15.1)*	273	*82*	17.8*(11.7)*	22.4*(7.7)*	59.8*(10.4)*
6.9 ppm C9500 UV															
Control	939	*54*	0.7*(0.1)*	16.3*(1.8)*	88.2*(1.7)*	440	*102*	9.2*(3.3)*	16.3*(5.6)*	74.5*(7.7)*	224	*43*	22.6*(6.9)*	19.3*(7.4)*	58.10*(7.7)*
Toxicant	1236	*720*	2.1*(0.7)*	20.3*(7.5)*	78.6*(7.8)*	475	*115*	8.2*(2.0)*	22.3*(6.4)*	69.5*(7.5)*	307	*131*	16.9*(8.7)*	40.1*(23.4)*	43.1*(17.8)*
10 ppm (L.R.*) CE-WAF															
Control	1060	*123*	5.4*(4.1)*	11.9*(5.5)*	82.7*(2.6)*	1048	*155*	3.1*(1.6)*	25.0*(8.9)*	71.9*(9.7)*	252	*106*	12.1*(3.8)*	34.1*(10.0)*	53.81*(8.9)*
Toxicant	1167	*254*	2.1*(1.0)*	17.6*(3.1)*	80.3*(2.5)*	1153	*123*	4.6*(0.9)*	22.3*(7.8)*	73.1*(8.0)*	405	*205*	13.5*(4.1)*	36.8*(11.9)*	49.7*(14.4)*
10 ppm (L.R.*) CE-WAF UV															
Control	253	*95*	3.2*(1.8)*	0.0*(0.0)*	96.2*(1.8)*	192	*37*	5.0*(1.8)*	17.3*(3.2)*	77.6*(5.0)*	237	*143*	17.4*(13.5)*	18.9*(11.0)*	63.8*(8.8)*
Toxicant	178	*36*	3.5*(0.4)*	0.14(0.32)	96.3*(0.5)*	237	*242*	7.2*(10.1)*	2.7*(4.6)*	90.2*(9.5)*	453	*405*	22.7*(43.3)*	27.4*(24.0)*	50.0*(33.1)*
2000 ppm (L.R.*) WAF															
Control	1215	*90*	2.2*(0.5)*	18.9*(4.6)*	78.9*(4.1)*	1976	*359*	16.7*(3.1)*	17.0*(3.7)*	66.3*(2.1)*	1261	*199*	11.4*(7.8)*	15.7*(1.7)*	72.9*(6.7)*
Toxicant	539	*152*	1.6*(0.5)*	16.8*(5.6)*	81.5*(6.0)*	1438	*547*	20.2*(6.1)*	15.2*(5.6)*	64.7*(3.7)*	2113	*233*	13.2*(5.4)*	4.7*(2.7)*	82.1*(7.9)*
2000 ppm (L.R.*) WAF UV															
Control	828	*239*	1.1*(0.2)*	7.0 *(0.8)*	91.9*(0.8)*	1297	*383*	8.1*(1.9)*	11.2*(3.6)*	80.7*(5.0)*	1289	*379*	11.0*(3.8)*	10.9*(6.0)*	78.0*(9.5)*
Toxicant	435	*306*	2.5*(0.7)*	6.5*(4.6)*	91.0*(4.5)*	475	*340*	27.4*(15.3)*	46.5*(18.2)*	26.1*(18.1)*	1776	*1331*	9.8*(6.3)*	5.0*(7.5)*	85.2*(8.8)*

* L.R. = Loading Rate

Appendix F Fecundity Data

Table F-1 Fecundity Data

Beaker # Control	Nauplii per Gravid	Beaker # C9500*	Nauplii per Gravid	Beaker # CE-WAF*	Nauplii per Gravid	Beaker # WAF*	Nauplii per Gravid
Control 1	26	C9500 1	31	CE-WAF 1	26	WAF 1	24
Control 2	21	C9500 2	29	CE-WAF 2	25	WAF 2	30
Control 3	18	C9500 3	21	CE-WAF 3	31	WAF 3	29
Control 4	28	C9500 4	28	CE-WAF 4	29	WAF 4	25
Control 5	25	C9500 5	31	CE-WAF 5	21	WAF 5	29
Control 6	28	C9500 6	28	CE-WAF 6	24	WAF 6	35
Control 7	24	C9500 7	26	CE-WAF 7	14	WAF 7	25
Control 8	26	C9500 8	34	CE-WAF 8	28	WAF 8	19
Control 9	19	C9500 9	30	CE-WAF 9	23	WAF 9	23
Control 10	26	C9500 10	26	CE-WAF 10	27	WAF 10	32
Control 11	21	C9500 11	35	CE-WAF 11	24	WAF 11	28
Control 12	19	C9500 12	25	CE-WAF 12	16	WAF 12	32
Control 13	15	C9500 13	26	CE-WAF 13	34	WAF 13	23
Control 14	18	C9500 14	35	CE-WAF 14	31	WAF 14	25
Mean	**22**	**Mean**	**29**	**Mean**	**25**	**Mean**	**27**
SD	4.2	*SD*	4.1	*SD*	5.6	*SD*	4.4

N=14

<u>Subsample Survivability Data After 24 Hour Exposure</u>

*Indicates the solutions which were used in the Fecundity Study

Control	25/25	*6.9 ppm C9500	12/25	*10 ppm CE-WAF (L.R.) 9.3 ppb PAH (Measured)	13/25	1000 ppm WAF (L.R.)	25/25
		8.0 ppm C9500	8/25	15 ppm CE-WAF (L.R.)	18/25	*2000 ppm WAF (L.R.) 107 ppb PAH (Measured)	16/25