NOAA Technical Memorandum NOS OR&R 4

Matrix Effects on Fluorometric Monitoring and Quantification of Dispersed Oil in the Open Ocean and Coastal Environment:

Results of the 1999 R/V *Ferrel* Research Project

Seattle, Washington

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NOAA is responsible for protecting and restoring marine and coastal environments impacted by spills and hazardous substance releases. The Office of Response and Restoration (OR&R) is the focal point for NOAA's spill preparedness, emergency response, and restoration programs. OR&R's Hazardous Materials Response Division and its contingent of on-scene Scientific Support Coordinators have earned a wide reputation for delivering scientifically valid solutions to the Federal On-Scene Coordinator (the U.S. Coast Guard in the coastal zone, or EPA in inland areas).

OR&R's Coastal Protection and Restoration Division and Damage Assessment Center are critic al components of NOAA's natural resource trusteeship responsibilities. The CPR Division works closely with the U.S. Environmental Protection Agency to redress the environmental effects of hazardous waste sites across the United States. Coastal Resource Coordinators provide site-specific technical expertise in ecological risk assessment and coastal remediation issues. This expertise ranges from physical science to ecology, marine biology, and oceanography. In their NOAA trusteeship role, CRCs assess the longer-term risks to coastal resources (including threatened and endangered species) from Superfund-site contamination, support decision-making for site remedies and habitat restoration, and negotiate protective remedies with the responsible parties to ensure that cleanup, restoration, and recovery are appropriate and fully monitored.

While the HAZMAT and CPR divisions work to prevent and minimize injury to natural resources during spill response and waste site remediation activities, the Damage Assessment Center focuses on addressing the injury that remains after the cleanup or response. DAC's Rapid Assessment Program goes on-scene at oil or hazardous materials releases to assess damages to NOAA trust resources, including National Marine Sanctuaries and National Estuarine Research Reserves. DAC works with other trustees and NOAA's Office of General Counsel in pursuing compensation from responsible parties to restore injured resources. The compensation DAC receives is designed to benefit the natural resources injured by the release.

The Regional Programs section actively engages local and regional communities in integrating sound coastal resource management, oil spill prevention and response, and safe and efficient marine transportation. Administered collaboratively with the NOS Coastal Services Center, Regional Projects serves as liaison between NOS scientific and technical expertise and the needs of the maritime industry, port authorities, coastal resource managers, and other NOAA clients in the coastal zone. Regional Programs matches specific coastal-zone conditions and needs with tailored services, tools, and products from across NOS, including physical oceanographic real-time systems, electronic chart systems, coastal geographic information systems frameworks, photogrammetry, and digital hydrographic surveys.

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To achieve the study objectives, the investigation took advantage of the operational schedule of the NOAA research vessel *Ferrel*' between April and September 1999. During this period, the *Ferrel* conducted coastal oceanographic studies in the Atlantic Ocean and Gulf of Mexico waters, including support for the Sustainable Seas Project. The study also took advantage of the expertise of the *Ferrel*"s Navigation Officer, LTjg Paulene Roberts. Roberts helped develop the current SMART fluorometric protocols that were modified and used for this investigation and provided field support in collecting and analyzing samples when it did not conflict with shipboard duties. Without the support of RADM Evelyn Fields, Director of the Office of Marine and Aviation Operations, and CDR Paul Moen, Commanding Officer of the NOAA Ship *Ferrel*, this investigation would have been impossible. The fluorometric instrument used for this study was provided by Roland Guidry, the Oil Spill Coordinator of the Office of the Governor, State of Louisiana. The principal author wishes to acknowledge and thank Paulene Roberts, whose volunteer efforts were provided gratis.

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INTRODUCTION

Background

For six months, scientific data were collected at 52 locations in the Atlantic Ocean and Gulf of Mexico aboard the NOAA Ship *Ferrel*, R-492. Sixty-two independent water samples were collected and analyzed to evaluate background fluorescence by a long-wavelength fluorometric system. The focus was to identify the potential for matrix effects related to monitoring of dispersed oil. The fluorometric technique was similar to that used in marine environments during oil-spill responses. A working hypothesis can be stated as follows: Variations in natural seawater composition will negatively affect analytical precision and accuracy when using fluorometry to quantify dispersed oil. in ambient marine waters. Quantifying the extent and environmental conditions that matrix effects present to analytical problems was a primary research objective.

Seawater monitoring and fluorescence detection following aerial application of dispersants to an oil slick can provide timely information on the proof of action of chemically enhanced dispersion. Dispersants can enhance the transfer of oil from the water surface into the water column, thereby mitigating potential injury to rafting birds and shoreline resources. The use of dispersants is clearly a trade-off: increased short-term injury to water-column resources in order to minimize injury to surface-water and shoreline resources. Dispersants are simply surfactants dissolved in a solvent carrier; chemical surfactants reduce the interfacial tension between water and oil, allowing the oil to break into tiny droplets that are dispersed into the water column. If properly conducted, fluorometry can provide information on two critical elements of assessing and managing dispersant use in coastal waters—concentration and transport of the dispersed oil plume.

A fluorometric technique was selected for field monitoring to support U.S. Coast Guard (USCG) oversight and Regional Response Team (RRT) interests when dispersants are used in the marine environment. One such plan developed for use in the Gulf of Mexico was adopted in 1994 as the Special Response Operations Monitoring Plan, or SROMP, but has since been replaced. The older plan was used effectively during two spills in January 1998. SROMP has been updated to the Special Monitoring of Applied Response Technologies, or SMART (SMART 2000). SMART provides near real-time feedback to the Federal On-Scene Commander (FOSC) for decision-making. Like SROMP, SMART monitoring utilizes a follow-through fluorometer deployed on a vessel of opportunity. The task of implementing this program during oil spills is part of the U.S. Coast Guard Strike Team mission. The National Oceanic and Atmospheric Administration (NOAA) provides a vital link in the process by providing scientific and technical support through the Scientific Support Coordinator (SSC). This research initiative is consistent with NOAA's role in providing scientific information to help evaluate new technology and field results.

Although fluorometric monitoring is a highly reliable and sensitive analytical technique, there are inherent weaknesses when applying fluorescence dispersed-oil monitoring to estimations of actual, or true, dispersed-oil concentration (Henry et al. 1999). 1) Dispersed-oil values detected by a fluorometric system vary with oil composition and weathering changes; 2) dispersed oil is not a true solution, but particles in suspension; and 3) natural waters contribute a wide range of matrix effects and background fluorescence. This study was designed to investigate the latter two variables (matrix effects, or changes in the liquid medium that can result in inaccurate measurements, and background fluorescence) .

Very little investigation has been published on the interaction of seawater and dispersed oil relative to changes in detector response. Since seawater is a complex mixture of dissolved chemicals, particulates, and living plants and animals, archiving samples for future analysis is problematic. Natural seawater samples change with time. Many seawater constituents contribute to background fluorescence and matrix effects when dispersed oil is present with seawater in the fluorometer's analytical cell. Since the water samples change with storage, only near real-time analyses are valid to investigate this potential problem. Studying the problem required real-time, or near real-time, analysis of actual seawater samples from a wide range of coastal environments. Using the field study conducted on the *Ferrel*, we greatly enhanced our understanding of the range of background seawater fluorescence and the degree to which seawater matrix effects might alter quantitative dispersed-oil values detected by a fluorometric system.

Relative to a working hypothesis, the data suggest that the adverse fluorometric effects observed for open-ocean environments were within typical quality-objective goals. Therefore, the range of seawater composition changes observed in this investigation had very little effect on our ability to detect dispersed oil and meet the SMART mission objective.

Research Objectives

With the focus of evaluating fluorometry as a valid detection method for dispersed oil in the marine environment, the following research objectives were defined:

1. Instrument and method performance. Assesses instrument stability and method reproducibility while operating under field conditions that are often less than ideal.

2. Background fluorescence range. In simplest terms, what values were detected in ambient seawater using the long-wavelength fluorometric system. Evaluate any association between the physical and chemical parameters monitored and background fluorescence detected.

3. Matrix effects. Evaluate natural seawater and natural fluorescence effects on quantifying dispersed oil. Matrix effects are defined as any physical or chemical interaction between the bulk seawater, chemically dispersed oil, and ultraviolet light (excitation and emission) that would result in a measured value different than the true or control value.

Figure 1. Fluorometric water-sample analysis by LTjg Roberts aboard the NOAA R/V *Ferrel.*

Figure 2. The *Ferrel* in port, Key West, Florida.

Table 1. Summary of samples collected and analyzed.

Samp. ID	Date	Time	General Location	Lat. (North)	Long. (West)	Depth(m)	Salinity	Temp. (°C	pH	Sechi(m)
FER01	24-May	20:13	Near Dry Tortugas FL	24°37'99"	82° 52.78' W	15	37	28.0	7.0	4.50
FER02	25-May	6:55	Near Dry Tortugas FL	24°37'99"	82° 52.78' W	15	37	27.0	7.0	5.50
FER03	27-May	6:02	Near Dry Tortugas FL	24°38'04"	82° 52.86' W	15	37	28.0	7.0	5.75
FER04	27-May	16:05	Near Dry Tortugas FL	24°38'04" N	82° 52.86'W	15	37	28.0	7.0	5.75
FER05	27-May	20:40	Near Dry Tortugas FL	24°38'00" N	82° 52.85'W	16	37	28.0	7.0	-
FER06	2-Jun	7:28	Near Dry Tortugas FL	25°00'69" N	81° 54.90W	16	37	27.0	7.0	2.50
FER07	4-Jun	6:33	Near Dry Tortugas FL	25°03'97" N	81° 56.25W	20	37	28.0	7.0	6.50
FER08	6-Jun	20:30	Near Dry Tortugas FL	25°07'85" N	81° 45.21W	16	40	28.0	7.0	4.50
FER09	6-Jun	17:14	USCG Pier Key West FL	24°33'98" N	81° 48.02W	10	37	30.0	7.0	3.00
FER10	18-Jun	8:50	Near Dry Tortugas FL	25°06'00" N	82° 26.00W	34	40	29.0	8.0	>16
FER11	18-Jun	13:10	Near Dry Tortugas FL	24°51'00" N	82° 15.00W	25	38	29.0	8.0	>12
FER12	18-Jun	16:10	Near Dry Tortugas FL	24°51'00" N	81° 53.00W	18	38	29.0	7.5	5.50
FER13	25-Jun	14:57	off SW FL	24°51'00" N	81° 53.00W	14	36	29.5	7.5	-
FER14	25-Jun	15:14	off SW FL	24°51'00" N	81° 53.00W	14	36	30.0	7.5	-
FER15	25-Jun	15:40	off SW FL	24°51'00" N	81° 53.00W	14	36	30.0	7.5	-
FER16	27-Jun	20:20	off SE FL	25°29'48" N	79° 54.87W	420	36	29.0	7.5	-
FER17	28-Jun	20:30	off FL/GA Coast	30°36'25" N	80° 11.82W	54	37	27.5	7.5	-
FER18	29-Jun	8:08	St. Helena Sound SC	32°24'83" N	78° 23.99W	300	37	27.0	7.5	-
FER19	29-Jun	20:20	Lookout Bight NC	33°59'88" N	76° 37.88W	44	37	26.0	7.5	-
FER20	30-Jun	8:00	Cape Hatteras NC	35°42'58" N	75° 21.98W	31	35	25.0	7.0	-
FER21	1-Jul	20:14	Cheasapeake Bay	35°59'78" N	76° 03.28W	14	26	25.0	7.0	-
FER22	2-Jul	8:02	off Delaware Bay	38°35'94" N	74° 33.56W	35	33	21.0	7.0	-
FER23	2-Jul	20:12	off New York	40°08'04" N	72° 36.49W	58	32	20.8	7.0	-
FER24	3-Jul	8:11	off Rhode Island Sd.	41°35'00" N	70° 45.00W	17	31	23.0	7.0	-
FER25	6-Jul	19:42	Boston Harbor MA	42°22'14" N	71° 03.09W	12	30	20.0	7.0	-
FER26	6-Jul	19:47	Boston Harbor MA	42° 22.14N	71° 03.09W	12	30	20.0	7.0	2.00
FER27	7-Jul	17:48	Nanhant Bay MA	42° 26.70N	70° 52.83W	30	33	15.3	7.0	-
FER28	9-Jul	9:00	Gloucester MA	42° 33.26N	70° 44.15W	33	33	15.7	7.0	-
FER29	9-Jul	20:22	USCG Pier Gloucester	42° 36.60N	70° 39.55W	6	34	18.0	7.0	3.00
FER29D	9-Jul	20:43	USCG Pier Gloucester	42° 36.60N	70° 39.55W	6	34	18.0	7.0	3.00
FER30	12-Jul	16:32	Stellwagen Bank	42° 35.56N	70°13'00W	74	33	18.0	6.5	7.00
FER31	12-Jul	18:04	Stellwagen Bank	42° 35.56N	70°13'00W	83	33	19.0	6.5	9.00
FER31D	12-Jul	18:07	Stellwagen Bank	42° 35.56N	70°13'00W	83	33	19.0	6.5	9.00
FER32	13-Jul	12:31	Stellwagen Bank	42° 29.45N	70°14'24W	87	34	19.0	6.5	-

Table 1. Summary of samples collected and analyzed.

Samp. ID	Date	Time	General Location	Lat. (North)	Long. (West)	Depth(m)	Salinity	Temp. (°C	pH	Sechi(m)
FER33	19-Jul	16:23	off New York Bay	39° 02.00N	73° 21'00W	63	33	25.4	6.5	-
FER34	20-Jul	15:55	Cape Hatteras NC	35° 21.38N	75° 1199W	60	35	27.0	7.0	-
FER35	21-Jul	16:02	off Georgetown	32° 56.98N	78° 50.02W	30	36	30.0	7.0	-
FER36	22-Jul	9:00	Charleston Harbor SC	32° 46.40N	79° 56.69W	7	23	30.0	7.0	0.50
FER37	23-Jul	11:13	Priest's Landing GA	31° 57.76N	81° 00.71W	10	24	32.0	6.5	1.00
FER38	27-Jul	9:45	Gray's Reef	31° 29.93N	80° 52.69W	19	37	30.0	7.0	>12
FER39	28-Jul	8:52	Gray's Reef	31° 24.21N	80° 53.76W	19	37	30.0	7.0	9.00
FER40	3-Aug	21:00	Priest's Landing GA	31° 57.76N	81° 00.72W	8	30	32.0	6.0	1.00
FER41	5-Aug	12:56	Atlantic Ocean	31° 05.88N	79° 56.56W	52	37	29.0	7.0	>12
FER42*	1-Aug	-	Great Dismal Swamp NC	-	-	3	0	-	5.0	0.40
FER43	9-Aug	15:40	off Georgia	31° 15.48N	80° 52.82W	17	36	30.0	7.0	-
FER44	10-Aug	8:20	off Cape Canaveral FL	28° 43.28N	80° 23.69W	23	37	27.0	7.5	-
FER45	10-Aug	12:35	off FL	28° 03.93N	80° 14.19W	25	37	29.0	8.0	-
FER46	10-Aug	11:35	off south FL	26° 25.56N	80° 02.84W	20	37	28.0	8.0	-
FER47	11-Aug	3:45	off Miami FL	25° 44.45N	80° 03.70W	140	38	30.1	8.0	-
FER48	15-Aug	16:09	S Entrance, Key West FL	24° 28.79N	81° 43.74W	10	36	32.0	7.0	5.50
FER49	29-Aug	20:01	W of Key West FL	24° 54.17N	82° 51.70W	46	37	30.0	8.0	-
FER50	30-Aug	3:50	Gulf of Mexico	25° 14.88N	84° 06.54W	150	35	31.2	8.0	-
FER51	30-Aug	18:14	Gulf of Mexico	25° 52.06N	86° 35.01W	3500	36	32.2	8.0	>17
FER52	31-Aug	3:53	Gulf of Mexico	26° 26.88N	88° 28.65W	3500	37	31.0	8.0	-
FER53	31-Aug	15:30	Gulf of Mexico	27° 03.89N	90° 39.66W	1600	37	31.0	8.0	-
FER54	1-Sep	4:05	Gulf of Mexico	27° 43.37N	92° 55.17W	520	37	30.0	8.0	-
FER54A	1-Sep	19:47	E. Flower Gard. Banks	27° 54.51N	93° 35.96W	18	37	31.0	8.0	>18
FER55	2-Sep	18:01	W. Flower Gard. Banks	27° 52.59N	93° 40.92W	31	36	31.0	8.0	14.00
FER56	6-Sep	3:54	Gulf of Mexico	28° 28.05N	94° 04.20W	260	37	30.0	8.0	-
FER57	6-Sep	9:04	Galv. Shipping Channel	29° 12.38N	94° 27.62W	18	36	30.0	8.0	-
FER58	6-Sep	9:58	Galv. Shipping Channel	29° 17.78N	94° 36.49W	15	37	29.0	8.0	-
FER59	6-Sep	10:30	Galv. Shipping Channel	29° 20.61N	94° 42.20W	17	35	30.0	7.0	-
FER60	6-Sep	17:30	USCG Stn. Galveston TX	29° 19.96N	94° 46.36W	5	33	31.4	8.0	0.50

* Samp. FER42 was not collected aboard the FERREL, but collected off the M/V Strumpet and transported to the FERREL for analysis.

EXPERIMENTAL DESIGN

A hypothesis for this investigation can be stated as follows: Changes in natural seawater composition will adversely affect our ability to accurately quantify dispersed oil using fluorometry. The null hypothesis could be stated as essentially the reverse: Seawater samples collected from different locations and varying in biological and chemical composition will have no effect on estimating dispersed-oil concentrations. One way to test this hypothesis is to compare natural seawater samples with a control. For this study, the control was a solution of artificial seawater. Both the control and seawater samples were spiked with dispersed oil and reanalyzed. All analyses were conducted on the *Ferrel* under field conditions.

A bench-top fluorometer was set up in the ship's wet lab (see Figure 1), generally used by divers to store equipment. At stations of opportunity–i.e., when the vessel was on-station during its normal operations and as Roberts' duties allowed–water samples were collected and analyzed to characterize background fluorescence. The same samples were allowed to equilibrate to ambient laboratory temperature, then spiked with a dispersed oil and reanalyzed to test our hypothesis. The instrument was calibrated using the standard procedures established for the SMART program. The only difference was in the cell configuration. The SMART program uses a flow-through cell. For this investigation, a cuvette cell was installed so that discrete samples could be analyzed. Fluorometric readings were made at ambient laboratory temperatures. Seawater samples were analyzed immediately after collection.

Each sample was analyzed as a series of six replicates to assess sample variance. Where possible, a measure of water quality (turbidity) was made using a standard sechi disk system. Each water sample was analyzed for salinity using a light refractometer and for pH using an indicator strip. A detailed log was maintained which included sample location (latitude, longitude), date, time, and other information. During the course of investigation, 62 separate field samples were analyzed.

Instrument Information

The SMART Program uses a Turner Design™ Model 10-AU field fluorometer. The instrument is relatively small, rugged, and field-portable (see Figure 1). The instrument was configured with the long-wavelength UV optics kit and the optional, discrete sample cuvette system. With this kit, the excitation energy is centered at 360 nautical miles (nm). The system is designed to detect emissions between 410 and 600 nm. Note, reference to the Turner Design™ system does not constitute an endorsement. The instrument was used for this investigation since it is appropriate for the task and is the current instrument used in the SMART program.

Vessel Information

The *Ferrel*, a 133-foot research vessel, is equipped specifically for oceanographic studies of coastal and inshore waters (see Figure 2). The *Ferrel* has a 9-day endurance due to water capacity, a range of 1,200 nm, and a cruising speed of 10 knots. Modified from a basic design for an offshore oil-rig supply boat, she has twin screws and a bowthruster to improve maneuverability. Various projects, including diving operations, status and trends sampling, and coastal sediment coring make use of her large, open fantail. An aft crane, a midships' trawl winch, and A-frame are the standard mechanical equipment available for operations. The *Ferrel* is also equipped with a 70-ft^2 wet oceanographic and 225-ft^2 dry oceanographic lab. Based in Charleston, South Carolina, the *Ferrel* works on projects along the East and Gulf coasts throughout the year. NOAA's Office of Marine and Aviation Operations operates the vessel .

Methods Overview

As previously stated, the fluorometric calibration procedures followed the SMART protocols (SMART 2000) where appropriate, although the procedures were modified to accommodate the cuvette sample and discrete samples. Standards, blanks, and duplicates provided information to evaluate the instrument's stability, reproducibility, and reliability. The instrument was operated shipboard for five months under various environmental conditions. Sampling protocols were developed to obtain a grab sample without hindering the ship's rigorous schedule.

Sample Collection

Water grab samples were collected by one of two methods: 1) Using a clean, polycarbonate, 1-L sample bottle affixed to a weighted and spring-operated sampling device and using the ship's seawater pumping system. To collect a sample manually, the device was simply lowered over the vessel's side to a depth of 1 meter and triggered. This system could only be operated while the ship was stationary. In an effort to develop a method to sample while the ship was underway, one of the ship's seawater pumping systems with an intake located about 2 m below the sea surface was compared with the manual method. The systems were comparable: no differences in temperature or background fluorescence were observed by direct comparison of samples. The seawater pump was allowed to purge (run) for 5–10 minutes before collecting a sample. Immediately after collection, all samples were brought into the wet laboratory and placed in a styrofoam holder to help maintain ambient water temperatures during preparation for analysis.

Sample Analysis Procedure

The fluoroscein calibration standard (at 90 parts per billion; ppb) was prepared according to SMART protocols and kept refrigerated and in the dark when not used. Before calibration and

sample analysis, the instrument was allowed to equilibrate for a minimum of 15 minutes and the room temperature was recorded. Standards with readings greater than ±30 raw fluorescent units (±10%) were rejected and fresh standards made. Fresh standards were made every two months, regardless, to ensure proper calibration.

During the fluorometer's 15-min. equilibration period, the latitude, longitude, and depth by fathometer were recorded, the sechi disc was deployed when the vessel was stationary, and the water sample collected. The 1-L bottle (remaining in a styrofoam holder) was assessed for actual temperature and salinity. After the instrument equilibration period, six pre-cleaned vials were screened as empty blanks and the values for each recorded. Following analysis of the standard to validate instrument performance, the 1-L bottle was shaken and the six vials filled and capped for analysis. The remaining sample was returned to the styrofoam holder to be spiked with an oil/dispersant solution. All water samples collected shipboard were analyzed for fluorescence background within one hour of collection (most within 10 minutes).

Oil/Dispersant Spiking Experiment

After making background fluorescence readings, five of the six vials were emptied (drained) with the sixth vial maintained as a QA/QC check. A 200-mL subsample of the remaining sample was placed in a 250-mL glass bottle with a foil liner, then the standard Teflon™-lined lid. (Because oil tends to stick to Teflon, the aluminum prevented this potential problem.) A standard of *Exxon Valdez* reference oil was prepared initially at 3.6 g oil premixed with 0.4 g Corexit 9500 dispersant; 0.85 g of the mixture was added to 200 mL of artificial seawater to create a working stock solution. One mL of the shaken, working-stock mixture was removed and placed into the 250-mL sample bottle containing 200 mL of the field sample (the final concentration of dispersed oil at 100% dispersion was ~19 ppm). The bottle containing the oil/dispersant/seawater was then vigorously shaken for one minute. After shaking, the bottle was placed on the counter for 20 seconds and the top 30–50 mL discarded. Aliquots of the spiked sample were then poured into the five previously emptied cuvettes and reanalyzed. The same procedure was used for spiking the artificial seawater control. The control seawater solution (sometimes referenced simply as "Instant Ocean" in this report) was made with deionized water and Instant Ocean™ at 34 parts per thousand; ppt (‰). The solution was maintained at room temperature and remade often, although a check standard of the initial Instant Ocean™ was kept refrigerated and analyzed as a quality-assurance check. The Instant Ocean and natural seawater matrix spikes were prepared and analyzed side-by-side to reduce experimental variance.

RESULTS

A total of 62 independent water samples were collected and analyzed between Boston and Galveston over a five-month period (Figure 3). Overall, a wide range of offshore and nearshore waters were monitored. Table 2 summarizes the sample data collected and provides background fluorescence values measured, as well as the difference between the control (Instant Ocean) and natural, seawater-spiked samples. Ocean depths where samples were collected ranged from 16 to >10,500 feet. Salinity, measured using a refractometer, was 23–40‰. Ambient water temperatures were 15.3–32.2°C and pH 6.0–8.0. The raw data are attached as an addendum. The following sections are organized according to the study's research objectives.

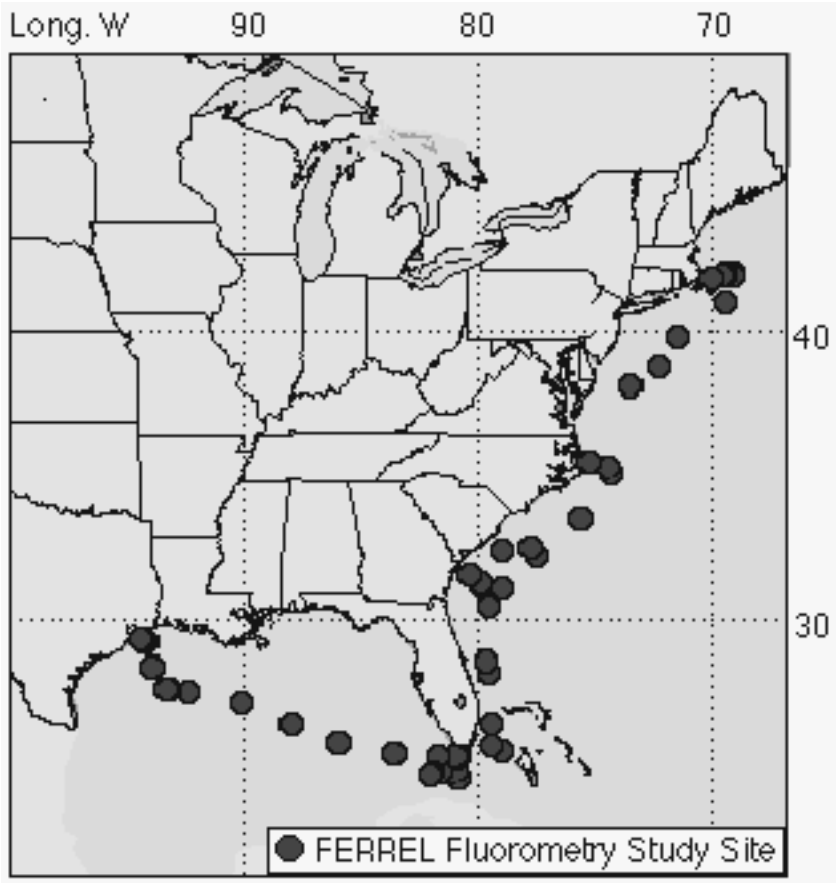


Figure 3. Map showing sampling locations, May to September 1999, between Boston and Galveston by the NOAA Ship *Ferrel*.

Table 2. Summary of fluorometry results

Sample	Date	Local Time	Depth(m)	Salinity	WT (°C)	Lab (°C)	Sechi(m)	Bkg (raw)	Spk (raw)	Spk-Bkg	Est.% Error
FER01	24-May	20:13	15	37	28.0	27.0	4.50	5.13	389.80	384.67	2.6
FER02	25-May	6:55	15	37	27.0	26.0	5.50	3.81	-	-	-
FER03	27-May	6:02	15	37	28.0	28.0	5.75	-1.58	465.20	466.78	24.5
FER04	27-May	16:05	15	37	28.0	29.0	5.75	2.52	440.80	438.28	16.9
FER05	27-May	20:40	16	37	28.0	30.0	-	5.74	470.40	464.66	23.9
FER06	2-Jun	7:28	16	37	27.0	26.0	2.50	3.87	423.40	419.53	11.9
FER07	4-Jun	6:33	20	37	28.0	28.0	6.50	0.94	372.40	371.46	-0.9
FER08	6-Jun	20:30	16	40	28.0	26.0	4.50	4.75	403.80	399.05	6.4
FER09	6-Jun	17:14	10	37	30.0	28.0	3.00	27.47	459.80	432.33	15.3
FER10	18-Jun	8:50	34	40	29.0	25.0	>16	-2.68	443.00	445.68	18.8
FER11	18-Jun	13:10	25	38	29.0	25.0	>12	-1.77	449.00	450.77	20.2
FER12	18-Jun	16:10	18	38	29.0	25.0	5.50	0.43	415.40	414.98	10.7
FER13	25-Jun	14:57	14	36	29.5	24.5	-	11.17	396.40	385.23	2.7
FER14	25-Jun	15:14	14	36	30.0	24.5	-	6.49	403.00	396.52	5.7
FER15	25-Jun	15:40	14	36	30.0	24.5	-	3.50	390.60	387.10	3.2
FER16	27-Jun	20:20	420	36	29.0	24.0	-	-0.65	332.20	332.85	-11.2
FER17	28-Jun	20:30	54	37	27.5	23.0	-	-1.95	301.00	302.95	-19.2
FER18	29-Jun	8:08	300	37	27.0	23.0	-	-1.92	356.60	358.52	-4.4
FER19	29-Jun	20:20	44	37	26.0	23.0	-	-1.95	344.40	346.35	-7.6
FER20	30-Jun	8:00	31	35	25.0	23.0	-	3.16	292.00	288.84	-23.0
FER21	1-Jul	20:14	14	26	25.0	23.0	-	35.93	326.40	290.47	-22.5
FER22	2-Jul	8:02	35	33	21.0	22.0	-	4.89	426.80	421.92	12.5
FER23	2-Jul	20:12	58	32	20.8	21.0	-	2.51	390.20	387.69	3.4
FER24	3-Jul	8:11	17	31	23.0	21.0	-	11.63	353.20	341.57	-8.9
FER25	6-Jul	19:42	12	30	20.0	21.0	-	58.48	485.80	427.32	14.0
FER26	6-Jul	19:47	12	30	20.0	21.0	2.00	49.80	378.20	328.40	-12.4
FER27	7-Jul	17:48	30	33	15.3	21.0	-	7.07	-	-	-
FER28	9-Jul	9:00	33	33	15.7	19.0	-	5.75	363.80	358.05	-4.5
FER29	9-Jul	20:22	6	34	18.0	21.0	3.00	10.72	341.40	330.68	-11.8
FER29D	9-Jul	20:43	6	34	18.0	21.0	3.00	10.75	381.40	370.65	-1.2
FER30	12-Jul	16:32	74	33	18.0	22.0	7.00	2.00	386.00	384.00	2.4
FER31	12-Jul	18:04	83	33	19.0	21.0	9.00	1.67	398.80	397.13	5.9

Table 2. Summary of fluorometry results

Sample	Date	Local Time	Depth(m)	Salinity	WT (°C)	Lab (°C)	Sechi(m)	Bkg (raw)	Spk (raw)	Spk-Bkg	Est.% Error
FER31D	12-Jul	18:07	83	33	19.0	21.0	9.00	1.65	371.40	369.75	-1.4
FER32	13-Jul	12:31	87	34	19.0	18.0	-	1.64	358.40	356.76	-4.9
FER33	19-Jul	16:23	63	33	25.4	23.0	-	-1.70	288.80	290.50	-22.5
FER34	20-Jul	15:55	60	35	27.0	24.0	-	0.16	268.40	268.25	-28.5
FER35	21-Jul	16:02	30	36	30.0	25.0	-	1.83	254.20	252.37	-32.7
FER36	22-Jul	9:00	7	23	30.0	23.0	0.50	174.50	420.20	245.70	-34.5
FER37	23-Jul	11:13	10	24	32.0	25.0	1.00	138.83	401.40	262.57	-30.0
FER38	27-Jul	9:45	19	37	30.0	21.0	>12	3.65	330.20	326.55	-12.9
FER39	28-Jul	8:52	19	37	30.0	22.0	9.00	4.05	309.40	305.35	-18.6
FER40	3-Aug	21:00	8	30	32.0	23.0	1.00	124.67	432.00	307.33	-18.0
FER41	5-Aug	12:56	52	37	29.0	21.0	>12	-3.78	329.00	332.78	-11.3
FER42	1-Aug	-	3	0	-	21.0	0.40	2847.00	-	-	-
FER43	9-Aug	15:40	17	36	30.0	23.0	-	3.69	373.80	370.11	-1.3
FER44	10-Aug	8:20	23	37	27.0	18.0	-	-2.80	380.70	383.50	2.3
FER45	10-Aug	12:35	25	37	29.0	19.0	-	-3.67	404.60	408.27	8.9
FER46	10-Aug	11:35	20	37	28.0	20.0	-	-3.20	362.80	366.00	-2.4
FER47	11-Aug	3:45	140	38	30.1	19.0	-	-1.70	398.80	400.50	6.8
FER48	15-Aug	16:09	10	36	32.0	22.0	5.50	3.33	313.60	310.27	-17.3
FER49	29-Aug	20:01	46	37	30.0	28.0	-	-2.32	319.20	321.52	-14.3
FER50	30-Aug	3:50	150	35	31.2	24.0	-	-3.18	327.00	330.18	-12.0
FER51	30-Aug	18:14	3500	36	32.2	28.0	>17	-4.55	325.60	330.15	-12.0
FER52	31-Aug	3:53	3500	37	31.0	24.0	-	-5.28	321.60	326.88	-12.8
FER53	31-Aug	15:30	1600	37	31.0	28.0	-	-4.42	341.80	346.22	-7.7
FER54	1-Sep	4:05	520	37	30.0	23.0	-	-4.40	333.00	337.40	-10.0
FER54A	1-Sep	19:47	18	37	31.0	25.0	>18	-4.33	334.80	339.13	-9.6
FER55	2-Sep	18:01	31	36	31.0	25.0	14.00	-4.20	429.60	433.80	15.7
FER56	6-Sep	3:54	260	37	30.0	24.0	-	-2.75	345.60	348.35	-7.1
FER57	6-Sep	9:04	18	36	30.0	24.0	-	2.28	403.00	400.72	6.9
FER58	6-Sep	9:58	15	37	29.0	22.0	-	23.28	420.60	397.32	6.0
FER59	6-Sep	10:30	17	35	30.0	22.0	-	14.52	371.20	356.68	-4.9
FER60	6-Sep	17:30	5	33	31.4	25.0	0.50	35.72	380.40	344.68	-8.1
(raw) - All values are mean raw fluorometer units. Fluorometer was calibrated in accordance to SMART.											

Instrument Performance and Methodology

To assess overall precision and accuracy, several factors were investigated relative to the instrument's performance as well as the methodology employed. First, the calibration standard relative to instrument accuracy and reproducibility was examined with respect to time and environmental conditions. Second, the oil-/dispersant-spiked standard was assessed to evaluate procedural reproducibility under field conditions.

To validate instrument calibration, four separate fluoroscein standards (each 90ppb) were analyzed before any unknown samples. No further calibration was required during the at-sea deployment after the fluorometer was initially calibrated on 24 May 1999. The composite results provided a measure of calibration, instrument stability, and reproducibility. A total of 248 standard analyses were performed for this investigation. The statistical results were normally distributed. The average raw fluorescence value of the fluoroscein standard was 316 units with a standard error of the mean (SE) of only 0.54. The analytical variance was only 5%, well within the 20% variability generally allowed for laboratory calibration standards used in environmental studies. Note, the instrument was removed from the vessel in September 1999 and stored until May 2000, at which time the instrument was checked and found to still be within calibration.

Figure 4 compares the calibration standard with temperature (Figure 5 is the same graph with an expanded scale). The standards exhibited a slight trend of increasing values with cooler laboratory temperatures. Fluorometry, in general, is sensitive to the effects of temperature. Any field deployment must take temperature into consideration; the laboratory temperatures aboard the *Ferrel* reflect one of the difficulties of field deployment. The temperature in the ship's space where the fluorometer was operated varied between 18° and 30°C, reflecting a greater variability than the natural seawater temperatures observed. Despite variable laboratory temperatures, the statistical results for the calibration standard were consistent throughout the study and validate instrument performance under these field conditions.

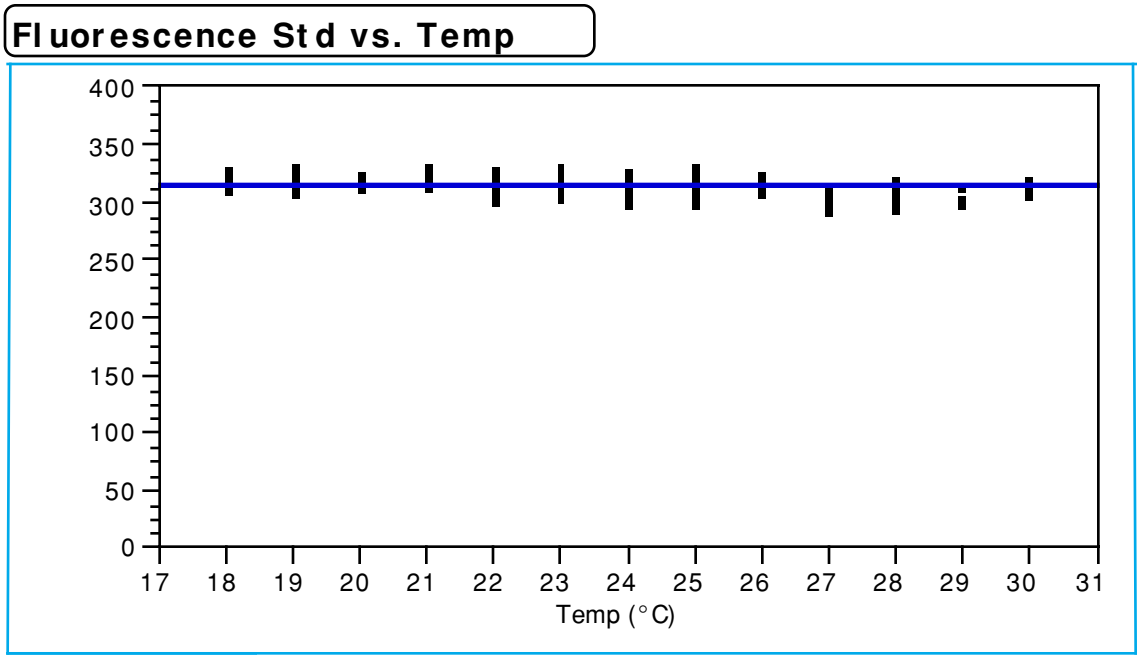


Figure 4. Comparison of the fluoroscein calibration standard (raw fluorescence units) plotted against laboratory temperature. The mean value of 316 is represented by the solid line.

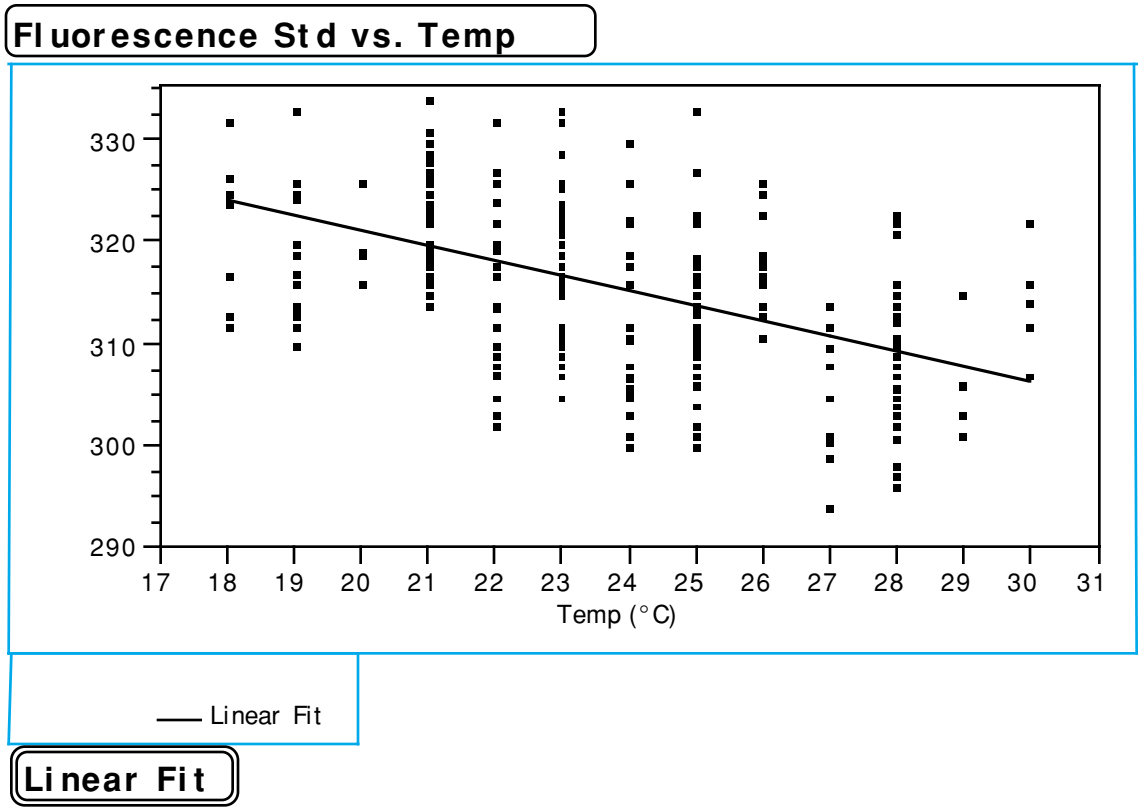


Figure 5. Comparison of the fluoroscein calibration standard (raw fluorescence units) plotted against seawater temperature. The apparent trend shows the effect of laboratory temperature on fluorescence. In general, most solutions exhibit increased fluorescence at cooler temperatures and reduced fluorescence at warmer temperatures. The observations above are consistent with this trend.

In addition to the fluoroscein calibration standard, a second standard was prepared to evaluate matrix effects. An oil/dispersant-spiked control standard (or spiked control) was fairly difficult to prepare under field conditions because it involved accurate volumetric measurements and a serial dilution each time it was used. Further, dispersed oil is not stable while in such solutions since the tiny droplets tend to coalesce with one another and rise to the surface because of their lower density relative to seawater (buoyancy). The statistical evaluation of the spiked control reflects these inherent difficulties.

Despite the complexity noted, the spiked control results were well within the data-quality objectives of ±30%. The mean value observed was 375 raw units with a SE of only 3.6 (n=27). Each spiked control standard was analyzed five separate times. Variance within the five replicates was significantly less, suggesting that manually manipulating the dispersed-oil solution in a field environment was the main contributor to the variance observed .

Background Seawater Samples

Figure 6 plots the background fluorescence values measured using a long-wavelength fluorometer system (360 nm excitation/410–600 nm emission) calibrated as previously reported. The lowest value measured, –5.28 raw units, was in the deep-blue water of the Gulf of Mexico. The sample collected from the *Ferrel* with the highest background fluorescence value, 174.5 raw units, was collected nearshore in a harbor environment. The 62 natural seawater samples varied greatly; the overall mean value for the study data set was 12 raw units with a SD of 33 and SE of 4.3. Although distinct differences were observed at various sampling locations, the causes of the observed differences were not always apparent. Table 3 compares the environmental parameters that characterize the sample locations. To investigate whether any of these environmental factors significantly influenced the observed background values, each was compared with the natural seawater values observed both graphically and statistically.

Table 3. Comparison of the range in physical-environmental parameters monitored during the 1999 cruise of the NOAA Ship *Ferrel* at 52 locations in the Atlantic Ocean and Gulf of Mexico.

	Sea (°C)	pH	Sal. (ppt)	Depth (m)	Sechi (m)	Lab (°C)
Lowest value	15.3	6.0	23	4.8	0.5	18.0
Highest value	32.2	8.0	40	3180	14.0	30.0
Mean	27.0	7.3	35	170	6.4	23.0
SD	4.56	0.52	3.30	590	4.2	2.8
SE	0.58	0.07	0.42	75	0.79	0.35
n	62	62	62	62	28	62

Water depth. All of the samples were collected in coastal waters ranging in depth from 4.8 to 3180 m. Only two samples were collected at ocean depths greater than 260 m. Figure 7 (top) compares ocean depth with near-surface water fluorescence as measured with the long-wavelength fluorometer. Although no clear trend was observed, the results do indicate that no deep-ocean samples exhibit high background values. The high background values observed were only in shallow environments and probably reflect influence from an adjacent estuary. High background values in harbor environments may result from anthropogenic influences as well as estuary input.

Sea temperature. Seawater temperatures were 15–32°C. Of the 62 samples collected, 75% of these samples were at or above 26°C and 39% were at 30°C or greater. Our sample population was biased towards warm, tropical and semi-tropical, seawater conditions. Figure 7 (bottom) compares the observed background values with seawater temperature. There is no apparent

correlation between background fluorescence and seawater temperature in this data set. Failure to show a correlation with temperature does not dismiss the effect of temperature on fluorescence, but rather indicates that the differences observed are not due to changes in temperature alone.

pH. The pH values of the seawater were consistent and within acceptable values; all collected samples were between pH 6 and pH 8 as measured using pH indicator paper. No significant correlation with pH was observed.

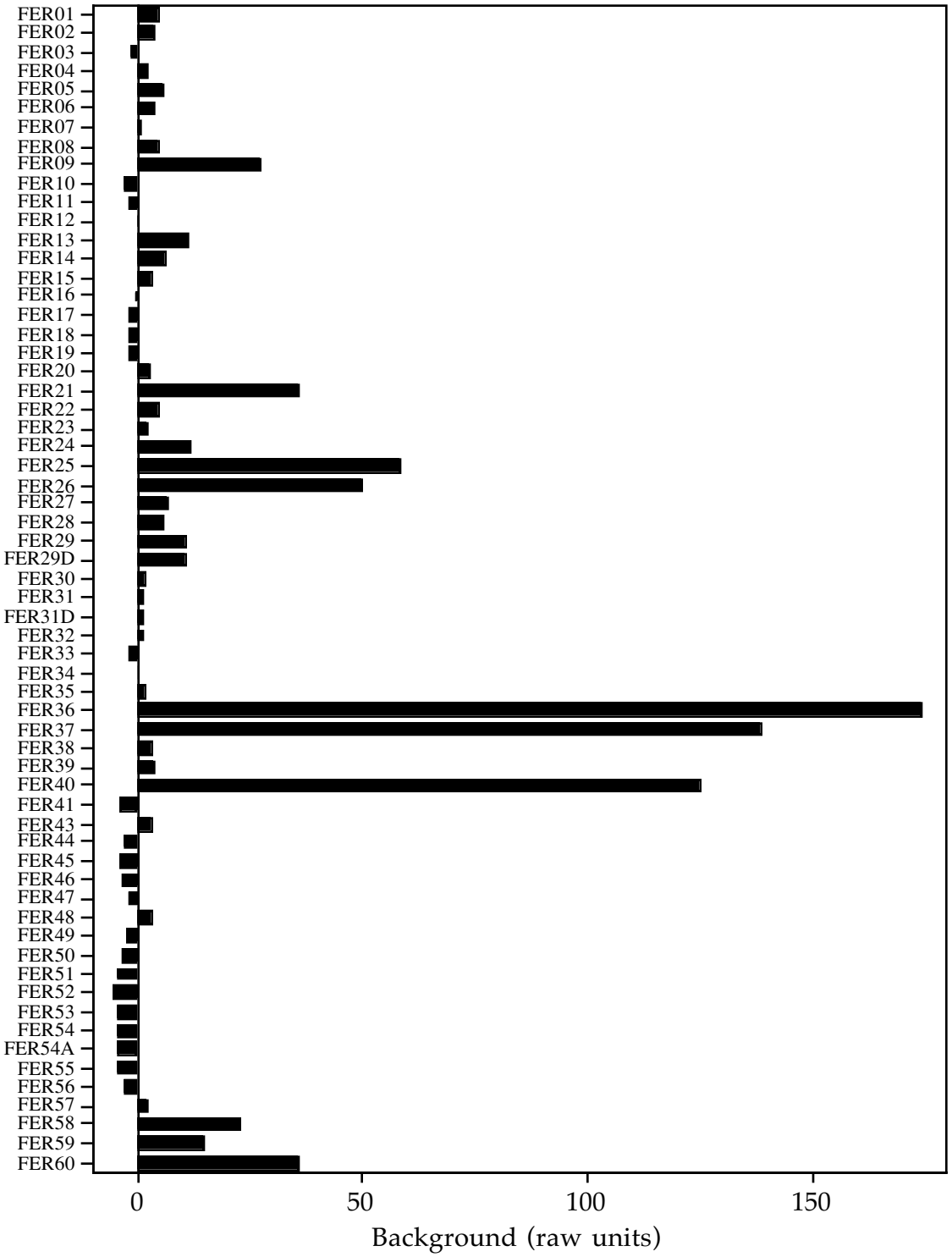


Figure 6. Histogram plot of background fluorescence values sorted by sample ID from samples collected in 1999 aboard the NOAA ship *Ferrel* at 52 locations in the Atlantic Ocean and Gulf of Mexico.

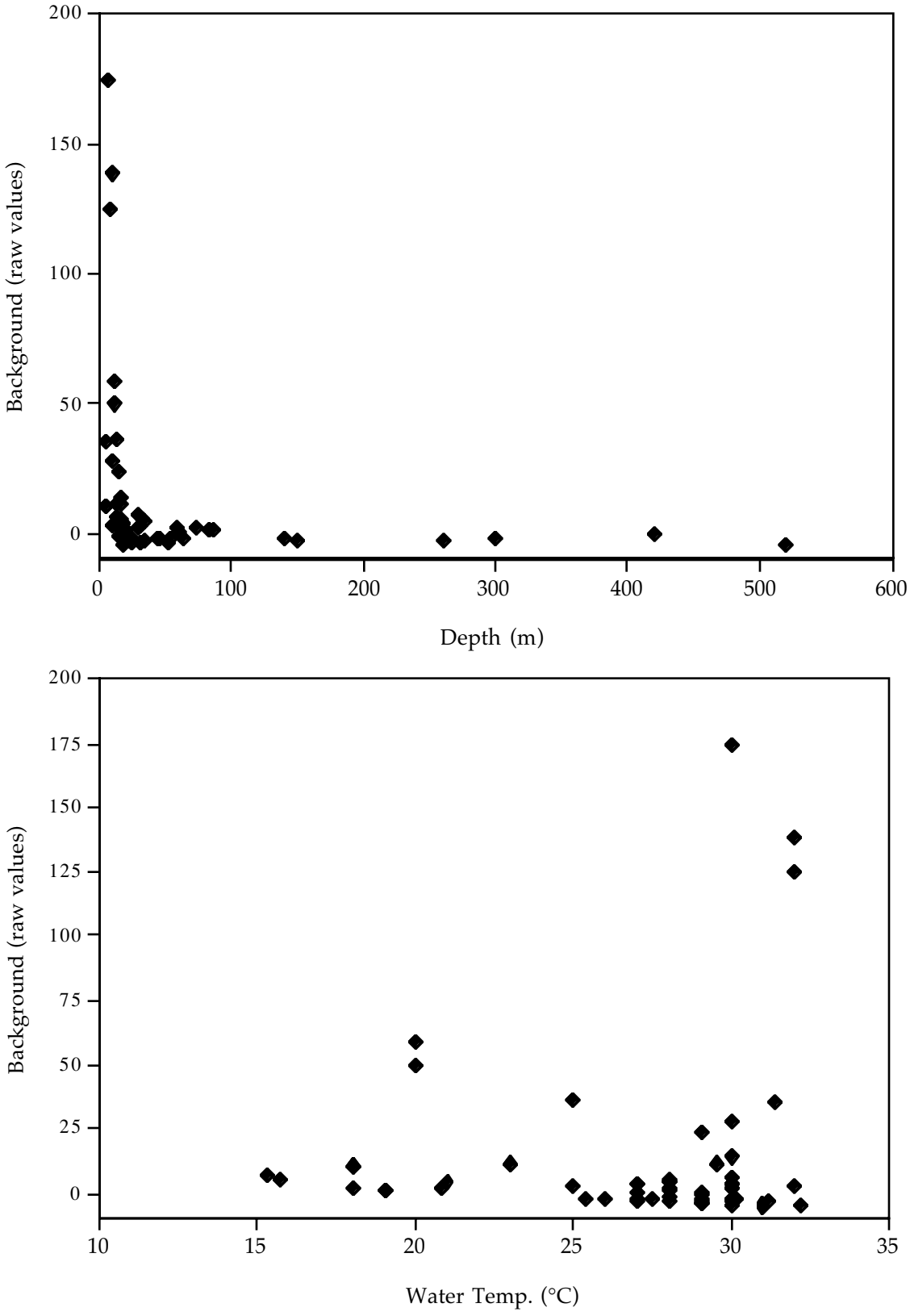


Figure 7. Background fluorescence values vs. water depth (top) and water temperature (bottom) at sampling location.

Salinity. Salinity values were representative of typical coastal waters. Open-ocean saltiness were observed as high as 40 ppt to near-estuarine, 23 ppt. Of the 62 samples, 75% of the samples were at 33 ppt or greater and 25% were at 37 ppt or greater. Figure 8 (top) compares background fluorescence with salinity. While no strong statistical association was observed, it is of note that the highest background values observed were in lower salinity waters, suggesting an estuarine influence.

Sechi disk Sechi disk depth measurements, an indicator of turbidity, represent the depth of sunlight penetration in water. This parameter could be measured only during daylight, when the ship was stationary and the procedure did not interfere with ship operations. This was possible with 28 of the 62 samples collected. The average depth of light penetration was greater than 6.4 m. Figure 8 (bottom) compares background fluorescence and sechi depth. Note, any values reported as >12 m were rounded off to that value for graphic representation.

Figure 9 plots the sechi disc measurements against ocean depth (note the variability). Although a general trend of decreasing sechi disc readings with decreasing ocean depths was shown, the linear correlation is only r=0.26. The sechi disk results suggest a nearshore influence, probably due to the turbidity typical of most estuarine waters.

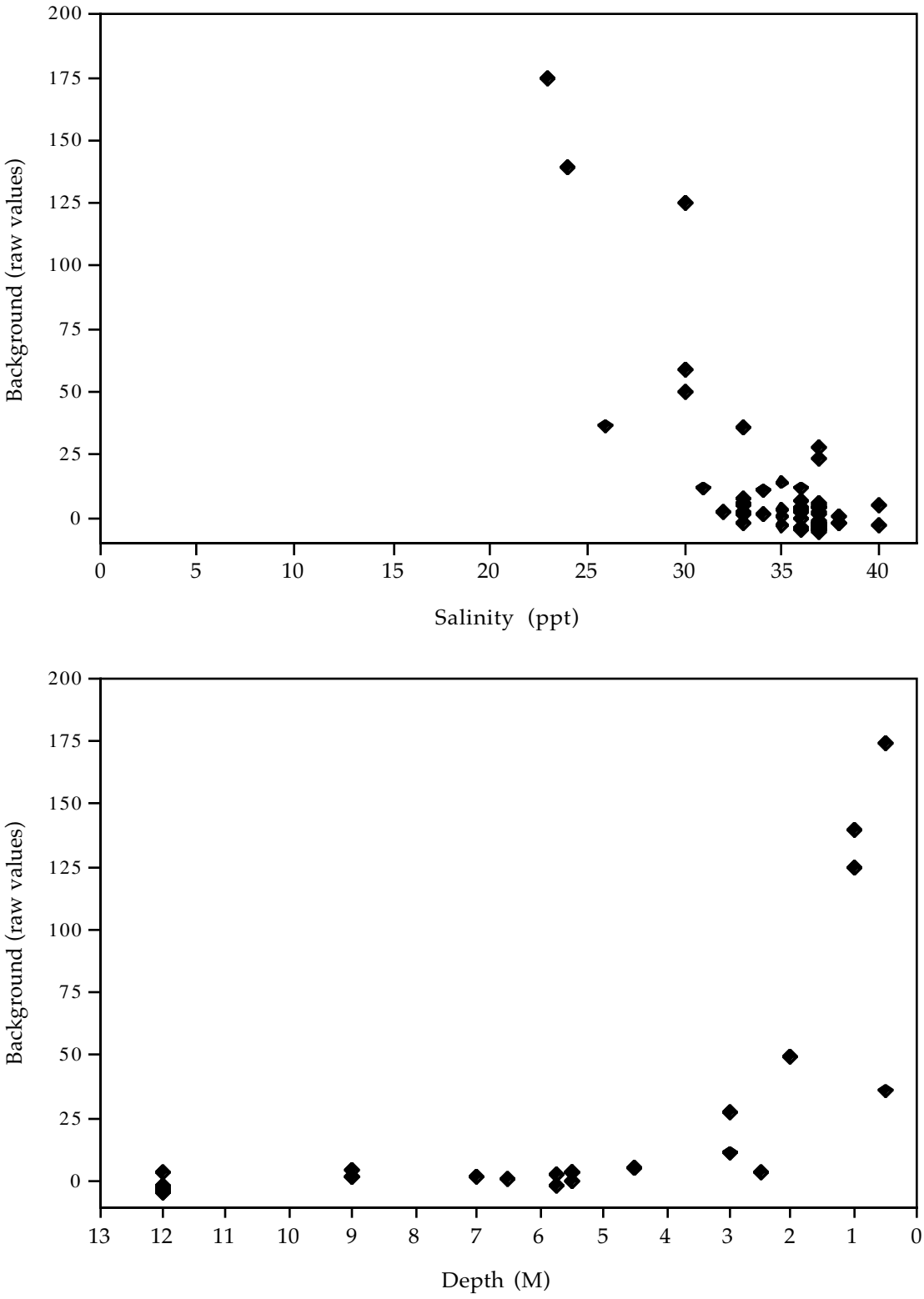


Figure 8. Background fluorescence values relative to salinity (top) and to turbidity as a function of sechi disk depth (bottom).

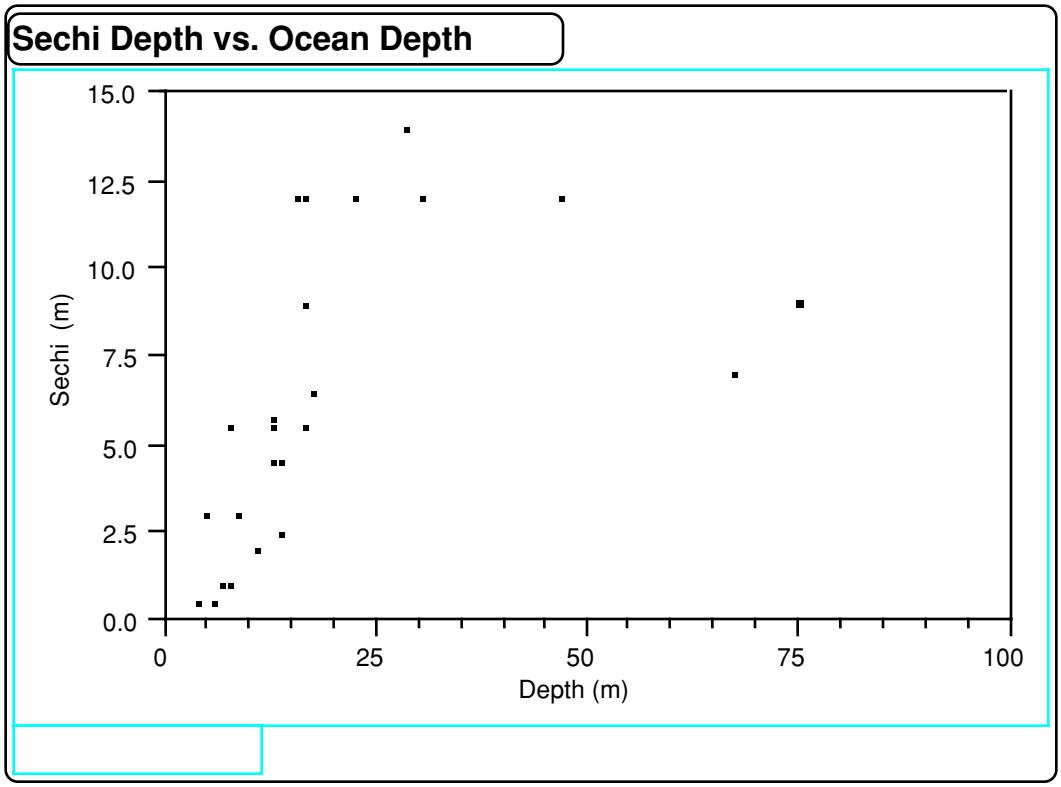


Figure 9. Comparison between sechi disk depth and ocean depth. For graphic purposes, the sample at 3180 m (with a sechi disk depth of >12 m) was deleted.

Table 4 lists the statistical results for a linear regression analysis and analysis of variance (ANOVA) for the background fluorescence values and the environmental parameters documented. The results confirm the correlation observed with salinity, a weak linear correlation with an r^2 of 0.62 yet a highly significant *F* probability of 0.0000, indicating a relationship with salinity. Salinity itself does not increase background values, as apparent by the background values of Instant Ocean™ and values of the higher-salinity, deepwater samples. Instead, the salinity relationship reflects the lack of freshwater influence and common organic matter, a level of particulate contribution associated with low-salinity water sources. Neither depth nor water-temperature parameters correlate statistically with the background values. The sechi depth was not linearly correlated but statistically significant through ANOVA. Examining the sechi depth by a 3° polynomial, the linear correlation is stronger at 0.73 (Figure 10). Yet, it is not clear which additional factors are contributing.

Table 4. Background comparison of physical parameters by linear regression and ANOVA.

	Depth	Water temp.	Salinity	Sechi depth
Linear Regression: r^2	0.0190	0.0078	0.6200	0.3700
ANOVA Prob. $>F_{(0.05)}$ significant	0.2800	0.5000	0.0000	0.0006

In addition to the samples collected during the *Ferrel* cruise, a sample collected from the Great Dismal Swamp in North Carolina was sent to the ship for analysis of background fluorescence (sample FER42). The background value measured in the neat (undiluted) sample was >1000 raw units (off-scale). After a serial dilution of the sample, the background fluorescence using the long-wavelength oil kit was estimated at 2847 raw units. A primary contributor to the extremely high background value was thought to be tannic acid derived from the decay of tree bark within the swamp. The Great Dismal Swamp sample provides evidence of the potential for very high background fluorescence values near some riverine and estuarine environments.

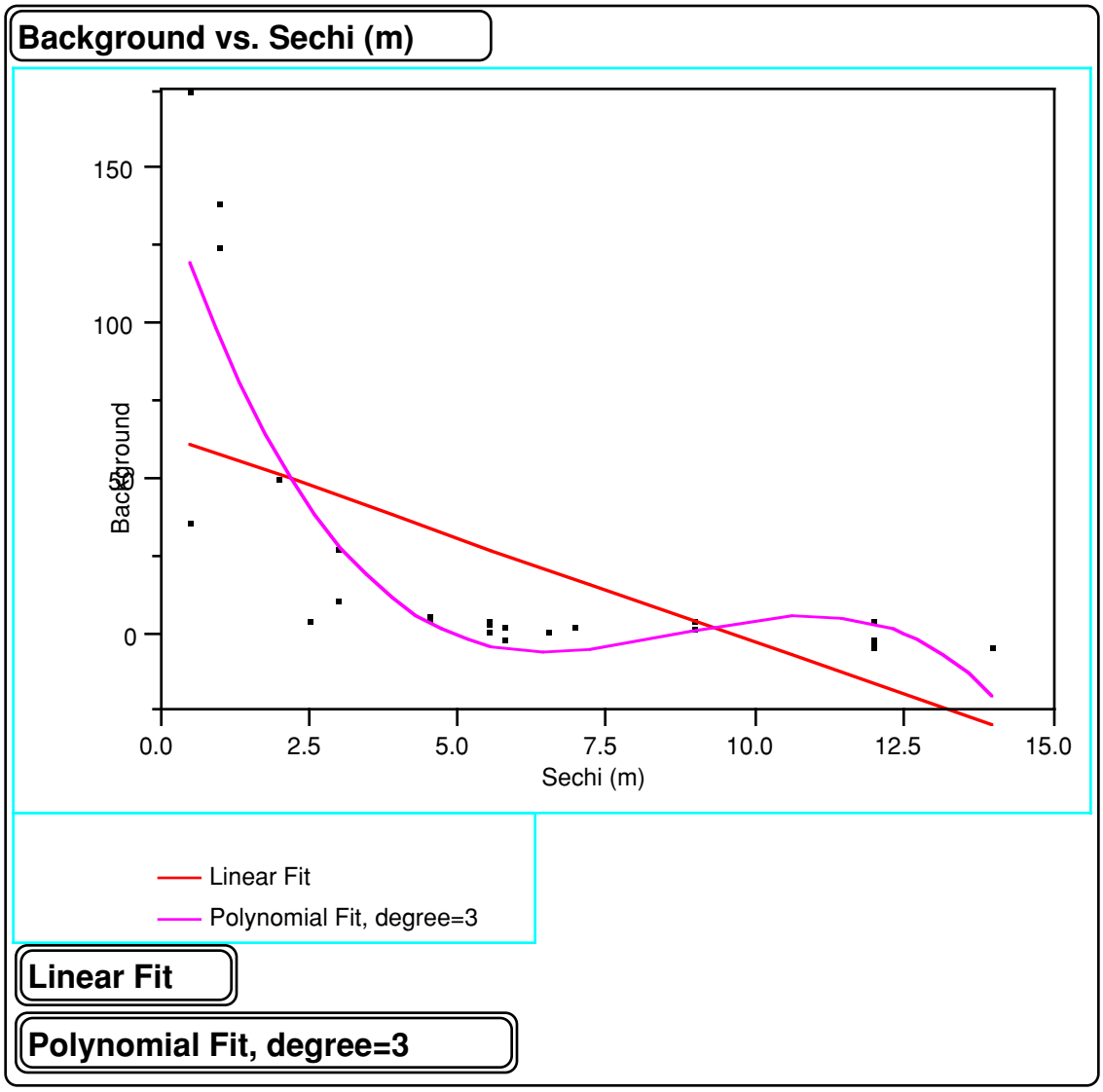


Figure 10. Comparison of sechi disc depths to background fluorescence (raw units). Despite the lack of linear correlation, there is a closer fit for a polynomial to the limited data set. This implies a relationship with additional variable interactions.

Matrix effects

The histogram in Figure 11 compares the percent differences observed between the matrix-spiked seawater samples and the mean control value of 375 units. Clearly, differences in the concentration of dispersed oil-spiked natural seawater were comparable to the mean control spiked with the same dispersant/oil. What is less clear is whether these differences are procedural or methodological variances, changes in physical-oil chemistry, or other matrix effects. A paired *t*-test indicates that the results are not correlated by instrument parameters and truly represent experimental scatter.

Figure 12 compares spiked, natural-seawater values–with the background fluorescence subtracted–with salinity. The regression analysis indicates a weak linear relationship with salinity. To validate the SMART method for efficacy testing of dispersed oil, the actual mechanism is of less value than the overall differences measured. The data-quality objective of ±30% was met by all but two samples; for the two outliers, the maximum difference observed was only 34.5%. Comparisons between spiked, natural-seawater samples and the control showed no statistical differences: the data sets could not be resolved among themselves. The mean and SE for the spiked control were 375 raw units and 3.6, respectively. The mean and SE for the spiked natural seawater, after background subtraction, were 374 raw units and 6.7, respectively.

The spiked, natural-seawater experiment supports the null hypothesis and suggests that matrix effects have a limited impact on monitoring in most offshore marine waters. Significant matrix effects are possible in some nearshore areas given the correlations with salinity and depth. The results from the experiment suggested that riverine and estuarine environments can influence the background values significantly through increased particulate suspension, or turbidity, and dissolved organic matter.

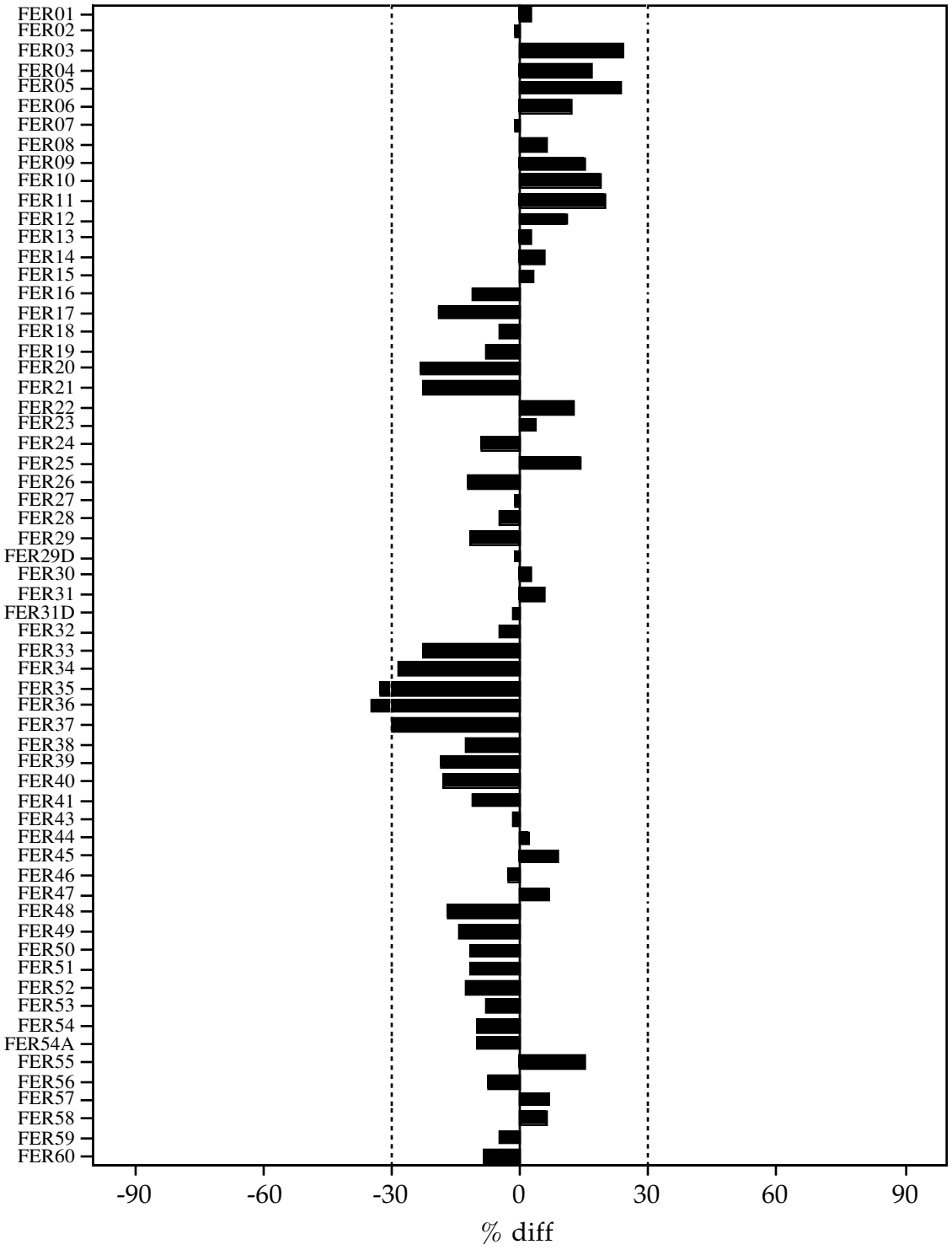


Figure 11. Histogram plot of the relative percent difference between control and matrix spike-sorted by sample ID from samples collected in 1999 aboard the NOAA Ship *Ferrel* at 52 locations in the Atlantic Ocean and Gulf of Mexico.

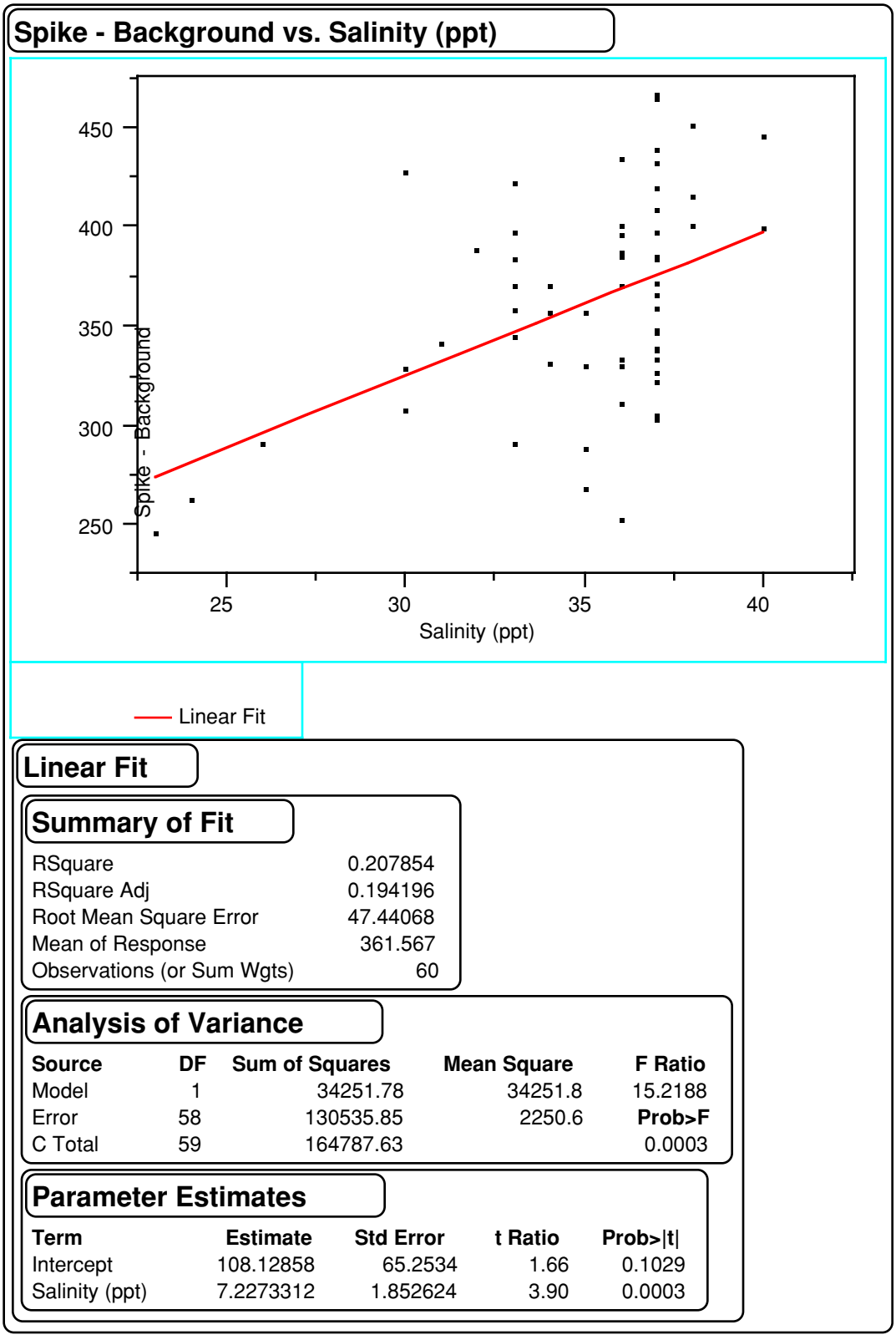


Figure 12. Spiked seawater samples compared with salinity.

DISCUSSION

Fluorometers have an excellent reputation as field monitoring devices for many marine applications such as primary productivity monitoring and quantifying chlorophyll. Fluorometers have been used in the marine environment to assess the fate and transport of dispersed oil as early as the 1980s (Green et al. 1983; Page et al. 1983; Lunel et al. 1997). The current field results derived from the 1999 *Ferrel* field cruise add significantly to the validation of the current SMART protocols. Yet, the results of this study indicate potential problems when the system is used near some estuarine waters. Decision-makers and technical support staff must understandi the fundamentals and weaknesses of fluorometry as applied to monitoring dispersed oil in the water column. The data collected during the *Ferrel* cruise have, in many ways, added confidence to the use of fluorometry to measure dispersed oil plumes in the marine environment and have expanded our understanding of which factors erode the value of fluorometry in coastal marine environments.

A fluorometer's strength involves selectivity of different classes of molecules, specifically aromatic hydrocarbons. When individual aromatic hydrocarbon molecules adsorb energy, electrons are elevated to a higher energy level. The individual molecule is not stable in this excited state and quickly reverts back to a more stable level, emitting the excess energy adsorbed; the result is fluorescence. The light emitted by fluorescence is generally at a longer wavelength than that which was adsorbed (the instrument used for this study had an emission wavelength of 360 nm and a detector selective to a longer wavelength range, 410–600 nm and is selective for large aromatic structures). Fluorometers essentially measure the natural tendency of some compounds to fluoresce after adsorbing ultraviolet (UV) light. Fluorescence differs from bioluminescence in that the latter doesn't require external excitation. Natural seawater "fluorescence" derived from planktonic marine life may contribute to the background values detected.

No two compounds have the exact same adsorption and emission spectra; therefore, fluorometry can be a highly selective analytical tool. Unfortunately, field fluorometers are generally configured with rather broad wavelength emission and detection systems. In its simplest form, a fluorometer is a black box containing a light, transparent cell to contain the sample, a UV lamp (excitation source), a series of optical filters that increase selectivity, a photomultiplier, and a recorder. From an engineering perspective, the physical elements are relatively stable and easily controlled. From an analytical perspective, fluorometers are matrix-sensitive to the solvent type, temperature, and a wide range of chemical interactions between the solute, or target molecules, and solvent. For these investigations, the solvent matrix is natural seawater.

Natural seawater contributes a wide suite of constituents, including dissolved organic matter (DOM) and salts (salinity) as well as extraneous non-target particle matter. Particulates include

suspended sediments, algae, and tiny biological animals that may contribute to background fluorescence or adsorb fluorescence (an effect known as *quenching*). During the 1999 *Ferrel* cruise, background fluorescence values measured using a long-wavelength fluorometer system were highly variable. The lowest value measured, –5.28 raw units, was in the deep-blue water of the Gulf of Mexico. The sample collected from the *Ferrel* with the highest background fluorescence value, 174.5 raw units, was collected nearshore in a harbor environment. When correlated to the physical-chemical parameters recorded at the time of sample collection (ocean depth, water temperature, salinity, etc.), there are no strong statistical correlations, although there are several interesting observations.

There is an apparent relationship between depth and background fluorescence in that all of the deep-water (open-ocean, blue-water) samples demonstrated very low background fluorescence values. All of the samples with elevated background fluorescence values were in shallow, lower-salinity waters characteristic of estuaries. There is a third apparent correlation with turbidity as measured using the sechi disk system. Again, however, this apparent correlation is probably associated with more turbid estuarine waters that are enriched with a greater concentration of plankton and DOM, both of which may contribute to background fluorescence. Anthropogenic source pollution may have also contributed in the harbor sites investigated.

In past investigations, a trend has been identified when water samples were analyzed to compare relative background fluorescence values (Mopper and Schultz 1993; Yentsch 1994; Henry and Roberts unpubl. data). In general, the authors found that open-ocean waters fluoresce less than most riverine waters. Estuarine and coastal-shelf waters (nearshore, green water) generally ranked between open-ocean and riverine. DOM is clearly a contributor to nearshore fluorescence; and in the case of the Great Dismal Swamp sample, a limiting factor to the applicability of fluorometry. The minimum detection limit of dispersed oil is directly related to the ability of the instrument to differentiate oil fluorescence from that of background fluorescence. If the background level detected in the Dismal Swamp sample was quantified as dispersed crude oil, the observed concentration would be 140 ppm (significantly greater than the 19 ppm standard used for this investigation and typical of dispersed oil concentrations).

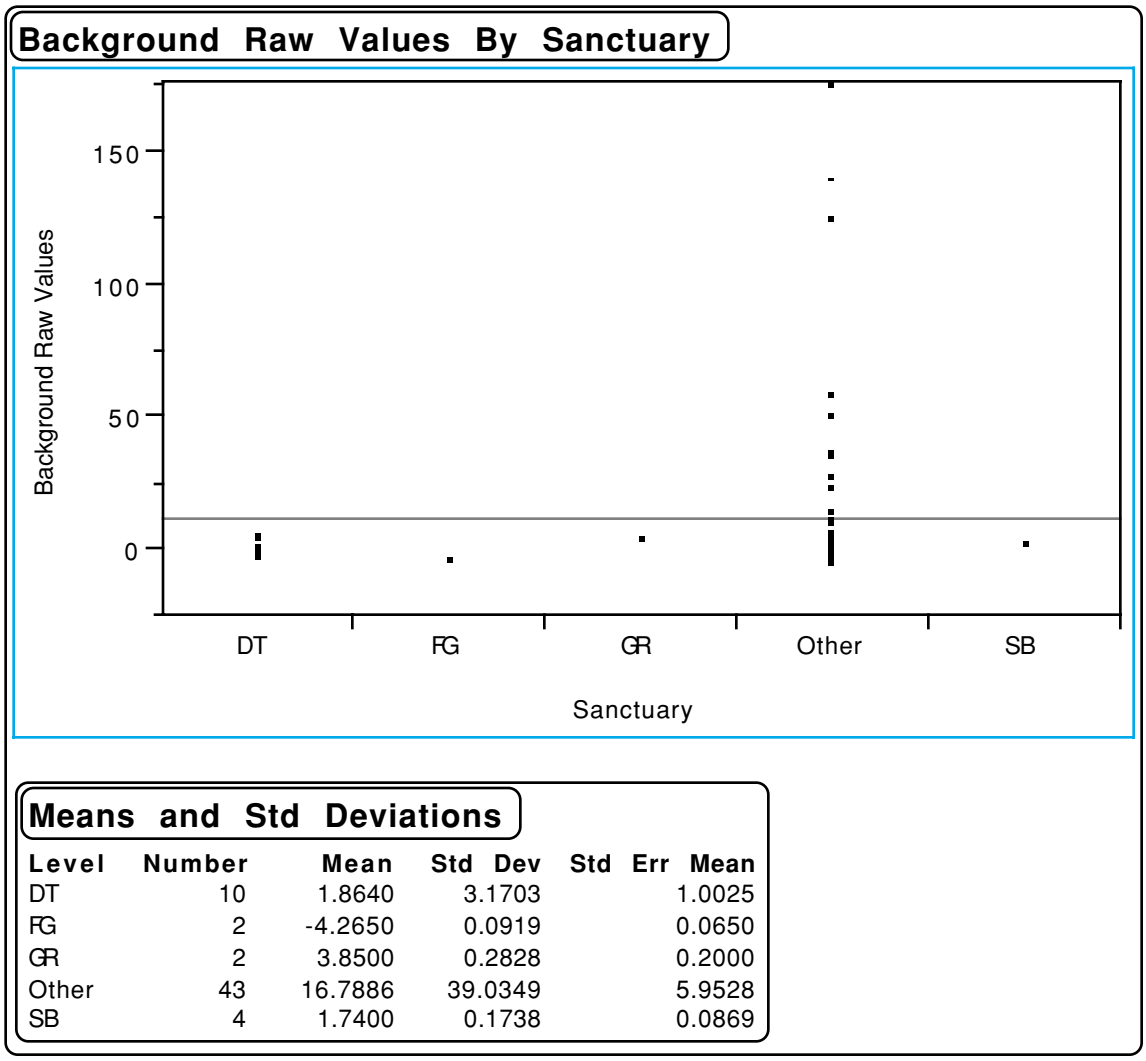
Dispersed oil contributes its own particular problems to fluorometry. Dispersed oil is not in true solution, but rather exists as small particles or droplets suspended in the water column. Fluorometers work best on analytes in solution with the matrix being analyzed. Monitoring the fluorescence of dispersed oil droplets adds several additional variances, including changes in fluorescence response due to changes in droplet size and oil composition. Petroleum is not a single compound, but rather a mixture of hundreds of thousands of different chemicals. Oils from different production locations are unique and, correspondingly, the fluorometry response to each is different (Henry et al. 1999). Alaskan North Slope Crude and South Louisiana Crude, for example,

have different detector response values for the same concentration due to the relative difference in aromatic hydrocarbon composition. For this study, only one oil was used–Alaskan North Slope–thus, any variances observed in the spiked samples and control are not due directly to differences in oil composition. Still, the same droplets of dispersed oil may behave differently in waters of different ionic strength. Therefore, observed differences may be, in part, due to physical-chemical changes such as size of dispersed oil droplets.

Differences in water masses should be acknowledged and/or accounted for in future fluorometry studies. An example of fluorescent responses that are interesting and unresolved is shown in Figure 13. During the *Ferrel* cruise, many of the National Marine Sanctuaries were sampled: Stellwagen Bank, Massachusetts; Gray's Reef, Georgia; the proposed sanctuary at Dry Tortugas, Florida; and Flower Garden Banks, Texas. The date indicates that the surface waters at most of the marine sanctuaries were below the mean background fluorescence value and typical of the majority of the values recorded. Figure 14 shows the sanctuary water responses to oil/dispersant spiked results without subtracting the background. It appears that some form of matrix effects are observed. The true nature of the physical-chemical change is unknown and may be worthy of further investigation.

With respect to the information collected during the 1999 *Ferrel* cruise, changes in natural seawater composition did not have a significant negative effect on the ability to accurately quantify dispersed oil using fluorometry. The null hypothesis is apparently true (at least within the limits of the water bodies investigated by this study). Seawater samples collected from different locations and varying in biological and chemical composition had little effect on estimating dispersed-oil concentrations within our data-quality objectives that were statistically resolvable. By comparing spiked, natural seawater samples with a control spiked sample, and processing it identically, any observed differences would be related to matrix effects. Unfortunately, the degree of variance observed in both the spiked seawater and spiked control reduced the potential for resolving subtle matrix.

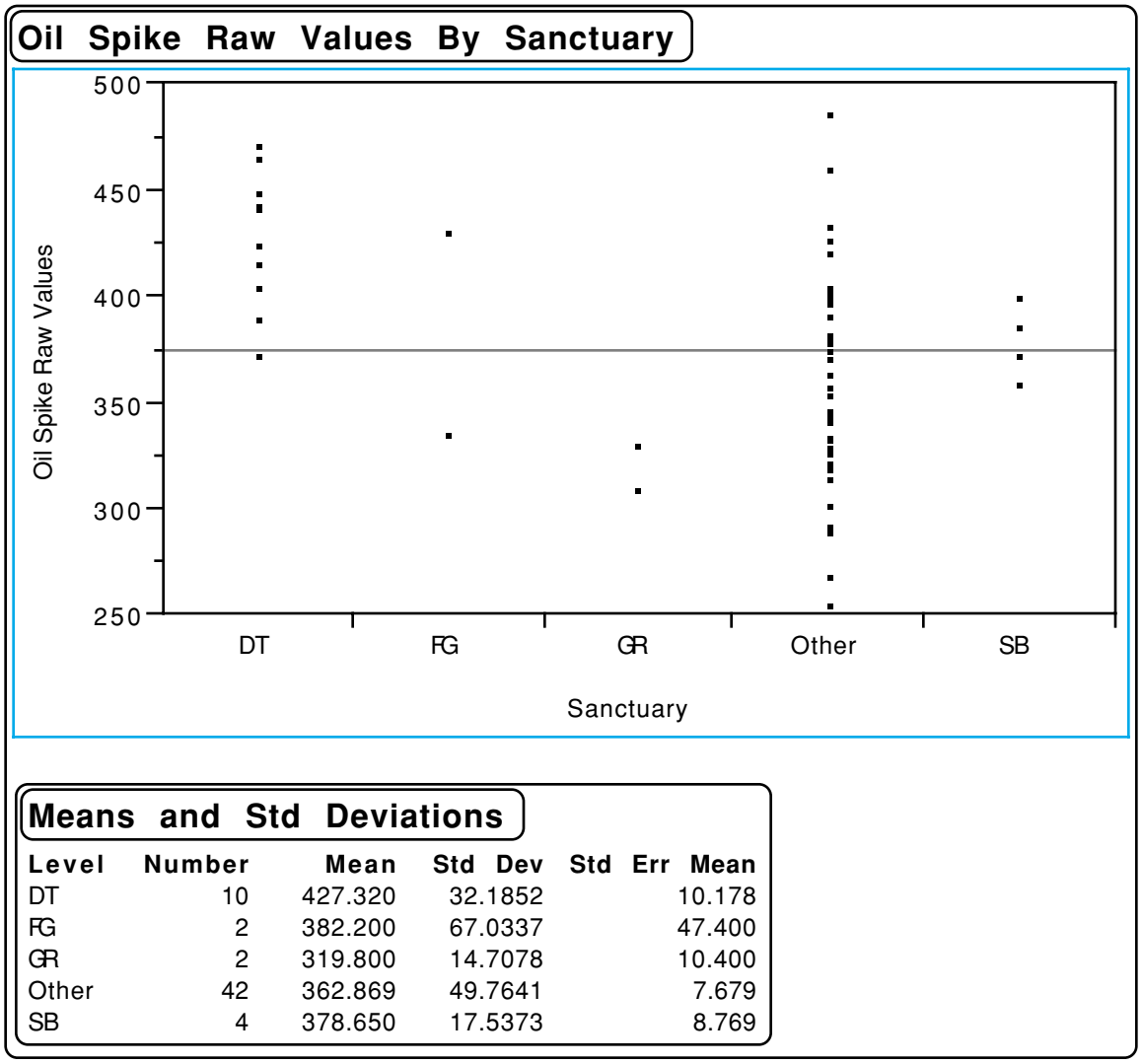
A fluorometric system is a highly effective tool in assessing the efficacy of dispersant use, but converting fluorometric response values into "true" dispersed oil-in-water concentrations can be problematic. This investigation was designed to evaluate potential problems encountered when using fluorometers as monitoring tools offshore during dispersant operations. Based on this study, in the context of potential limitations in nearshore waters, Green et al.'s (1983) conclusions are still true today. If a field fluorometer is used with water sampling and subsequent laboratory analyses, a good assessment of the true range of dispersant concentration is possible.



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
DT	10	1.8640	3.1703	1.0025
FG	2	-4.2650	0.0919	0.0650
GR	2	3.8500	0.2828	0.2000
Other	43	16.7886	39.0349	5.9528
SB	4	1.7400	0.1738	0.0869

Figure 13. Plot of the background fluorometric values according to marine sanctuary location: Dry Tortugas (DT), Flower Garden Banks (FG), Gray's Reef (GR), and Stellwagen Bank (SB). All remaining samples are "other." Statistical values are included for comparison.



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
DT	10	427.320	32.1852	10.178
FG	2	382.200	67.0337	47.400
GR	2	319.800	14.7078	10.400
Other	42	362.869	49.7641	7.679
SB	4	378.650	17.5373	8.769

Figure 14. Plot of the oil-spiked fluorometric values according to marine sanctuary location: Dry Tortugas (DT), Flower Garden Banks (FG), Gray's Reef (GR), and Stellwagen Bank (SB). All remaining samples are "other." Statistical values are included for comparison.

CONCLUSIONS

It would appear that the null hypothesis is, to some degree, true. For most offshore waters, background fluorescence and matrix effects have only a minor effect on monitoring dispersed oil with a long-wavelength, field fluorometer system. The authors believe that this same statement would not hold true for all estuarine and freshwater systems significantly enriched with dissolved and suspended materials. These materials may contribute to the fluorescence detected and attenuate the UV light within the detector cell.

Additional research in the nearshore and inshore coastal zone is required to fully delineate the practical limits for using fluorometers to track dispersed oil. Clearly, information collected during the 1999 *Ferrel* cruise added significantly to our understanding and confidence in using a field fluorometer to detect changes in dispersed oil concentration, as well as meeting the mission objectives of the SMART program.

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ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER00	24-May	F Std.	1	6.27	299.00	299.00	301.00	-
FER00	24-May	F Std.	2	6.45	294.00	291.00	296.00	-
FER00	24-May	F Std.	3	6.22	301.00	302.00	299.00	-
FER00	24-May	F Std.	4	6.81	308.00	307.00	305.00	-
FER00	24-May	F Std.	Mean	6.44	300.50	299.75	300.25	-
FER00	24-May	DIW	5	-	0.11	0.28	0.00	-
FER00	24-May	DIW	6	-	-0.40	-0.10	0.30	-
FER00	24-May	DIW	7	-	-0.70	-0.40	-0.40	-
FER00	24-May	DIW	Mean	-	-0.33	-0.07	-0.03	-
FER01	24-May	Sample	FER-01A	14.60	2.43	3.40	-	390.00
FER01	24-May	Sample	FER-01B	13.70	9.83	7.30	-	388.00
FER01	24-May	Sample	FER-01C	14.60	4.48	5.20	-	384.00
FER01	24-May	Sample	FER-01D	15.30	4.40	5.22	-	398.00
FER01	24-May	Sample	FER-01E	14.60	4.50	5.06	-	389.00
FER01	24-May	Sample	Mean	14.56	5.13	5.24	-	389.80
FER01	24-May	F Std.	1	-	312.00	-	-	-
FER01	24-May	F Std.	2	-	305.00	-	-	-
FER01	24-May	F Std.	3	-	308.00	-	-	-
FER01	24-May	F Std.	4	-	314.00	-	-	-
FER01	24-May	F Std.	Mean	-	309.75	-	-	-
FER01	24-May	DIW	5	-	0.98	-	-	-
FER01	24-May	IO Cont.	O1	9.76	-	-	-	313.00
FER01	24-May	IO Cont.	O2	11.20	-	-	-	322.00
FER01	24-May	IO Cont.	O3	10.20	-	-	-	318.00
FER01	24-May	IO Cont.	O4	10.60	-	-	-	313.00
FER01	24-May	IO Cont.	O5	10.10	-	-	-	312.00
FER01	24-May	IO Cont.	Mean	10.37	-	-	-	315.60
FER02	25-May	Sample	FER-02A	14.50	0.28	1.13	-	-
FER02	25-May	Sample	FER-02B	12.40	-0.10	1.51	-	-
FER02	25-May	Sample	FER-02C	14.40	1.70	3.40	-	-
FER02	25-May	Sample	FER-02D	13.60	0.10	-0.10	-	-
FER02	25-May	Sample	FER-02E	13.80	10.70	12.60	-	-
FER02	25-May	Sample	FER-02F	15.60	10.20	12.80	-	-
FER02	25-May	Sample	Mean	14.05	3.81	5.22	-	-
FER02	25-May	F Std.	1	-	316.00	-	-	-
FER02	25-May	F Std.	2	-	314.00	-	-	-
FER02	25-May	F Std.	3	-	311.00	-	-	-
FER02	25-May	F Std.	4	-	326.00	-	-	-
FER02	25-May	F Std.	Mean	-	316.75	-	-	-
FER02	25-May	DIW	5	-	2.00	-	-	-
FER02	25-May	DIW	6	-	2.22	-	-	-
FER02	25-May	DIW	7	-	3.56	-	-	-
FER02	25-May	DIW	Mean	-	2.59	-	-	-
FER03	27-May	Sample	FER-03A	12.80	-1.50	-1.20	-	-
FER03	27-May	Sample	FER-03B	9.45	-2.30	-2.00	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER03	27-May	Sample	FER-03C	11.00	-1.00	-0.80	-	-
FER03	27-May	Sample	FER-03D	10.10	-1.50	-1.80	-	-
FER03	27-May	Sample	FER-03E	10.90	-1.90	-1.80	-	-
FER03	27-May	Sample	FER-03F	11.40	-1.30	-1.20	-	-
FER03	27-May	Sample	Mean	10.94	-1.58	-1.47	-	-
FER03	27-May	F Std.	1	-	314.00	-	-	-
FER03	27-May	F Std.	2	-	307.00	-	-	-
FER03	27-May	F Std.	3	-	309.00	-	-	-
FER03	27-May	F Std.	4	-	321.00	-	-	-
FER03	27-May	F Std.	Mean	-	312.75	-	-	-
FER03	27-May	DIW	5	-	1.55	-	-	-
FER03	27-May	DIW	6	-	1.34	-	-	-
FER03	27-May	DIW	7	-	3.26	-	-	-
FER03	27-May	DIW	Mean	-	2.05	-	-	-
FER03	27-May	Sample	FER-03A	10.60	-	-	-	467.00
FER03	27-May	Sample	FER-03B	8.83	-	-	-	456.00
FER03	27-May	Sample	FER-03C	10.10	-	-	-	464.00
FER03	27-May	Sample	FER-03D	9.32	-	-	-	476.00
FER03	27-May	Sample	FER-03E	8.75	-	-	-	463.00
FER03	27-May	Sample	FER-03F	-	-	-	-	-
FER03	27-May	Sample	Mean	9.52	-	-	-	465.20
FER04	27-May	Sample	FER-04A	13.10	2.10	2.97	3.61	-
FER04	27-May	Sample	FER-04B	13.70	2.07	2.66	2.78	-
FER04	27-May	Sample	FER-04C	14.50	0.56	0.94	1.47	-
FER04	27-May	Sample	FER-04D	14.80	3.24	4.88	5.40	-
FER04	27-May	Sample	FER-04E	12.50	2.57	3.82	4.82	-
FER04	27-May	Sample	FER-04F	12.80	4.57	5.34	6.07	-
FER04	27-May	Sample	Mean	13.57	2.52	3.44	4.03	-
FER04	27-May	F Std.	1	-	306.00	311.00	-	-
FER04	27-May	F Std.	2	-	301.00	305.00	-	-
FER04	27-May	F Std.	3	-	303.00	310.00	-	-
FER04	27-May	F Std.	4	-	315.00	320.00	-	-
FER04	27-May	F Std.	Mean	-	306.25	311.50	-	-
FER04	27-May	DIW	5	-	1.26	-	-	-
FER04	27-May	DIW	6	-	1.34	-	-	-
FER04	27-May	DIW	7	-	2.82	-	-	-
FER04	27-May	DIW	Mean	-	1.81	-	-	-
FER04	27-May	Sample	FER-04A	9.85	-	-	-	448.00
FER04	27-May	Sample	FER-04B	10.10	-	-	-	444.00
FER04	27-May	Sample	FER-04C	11.20	-	-	-	440.00
FER04	27-May	Sample	FER-04D	12.00	-	-	-	431.00
FER04	27-May	Sample	FER-04E	9.29	-	-	-	441.00
FER04	27-May	Sample	FER-04F	-	-	-	-	-
FER04	27-May	Sample	Mean	10.49	-	-	-	440.80
FER05	27-May	Sample	FER-05A	14.80	3.51	-	-	458.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER05	27-May	Sample	FER-05B	11.70	3.99	-	-	468.00
FER05	27-May	Sample	FER-05C	11.60	2.01	-	-	485.00
FER05	27-May	Sample	FER-05D	14.00	5.03	-	-	467.00
FER05	27-May	Sample	FER-05E	12.90	17.50	-	-	474.00
FER05	27-May	Sample	FER-05F	11.80	2.38	-	-	-
FER05	27-May	Sample	Mean	12.80	5.74	-	-	470.40
FER05	27-May	IO Cont.	O1	9.76	-	-	-	282.00
FER05	27-May	IO Cont.	O2	11.20	-	-	-	281.00
FER05	27-May	IO Cont.	O3	10.20	-	-	-	276.00
FER05	27-May	IO Cont.	O4	10.60	-	-	-	297.00
FER05	27-May	IO Cont.	O5	10.10	-	-	-	289.00
FER05	27-May	IO Cont.	Mean	10.37	-	-	-	285.00
FER05	27-May	F Std.	1	-	316.00	-	-	-
FER05	27-May	F Std.	2	-	307.00	-	-	-
FER05	27-May	F Std.	3	-	312.00	-	-	-
FER05	27-May	F Std.	4	-	322.00	-	-	-
FER05	27-May	F Std.	Mean	-	314.25	-	-	-
FER05	27-May	DIW	5	-	1.92	-	-	-
FER05	27-May	DIW	6	-	1.22	-	-	-
FER05	27-May	DIW	7	-	3.25	-	-	-
FER05	27-May	DIW	Mean	-	2.13	-	-	-
FER06	2-Jun	Sample	FER-06A	13.60	1.82	2.24	2.24	428.00
FER06	2-Jun	Sample	FER-06B	9.45	3.78	4.50	5.07	427.00
FER06	2-Jun	Sample	FER-06C	11.00	1.27	2.75	2.69	430.00
FER06	2-Jun	Sample	FER-06D	10.10	7.19	8.54	10.30	409.00
FER06	2-Jun	Sample	FER-06E	10.90	4.54	6.34	7.36	423.00
FER06	2-Jun	Sample	FER-06F	11.40	4.61	5.46	5.76	7.38
FER06	2-Jun	Sample	Mean	11.08	3.87	4.97	5.57	423.40
FER06	2-Jun	F Std.	1	-	317.00	-	-	-
FER06	2-Jun	F Std.	2	-	316.00	-	-	-
FER06	2-Jun	F Std.	3	-	316.00	-	-	-
FER06	2-Jun	F Std.	4	-	323.00	-	-	-
FER06	2-Jun	F Std.	Mean	-	318.00	-	-	-
FER06	2-Jun	DIW	5	-	2.29	-	-	-
FER06	2-Jun	DIW	6	-	1.68	-	-	-
FER06	2-Jun	DIW	7	-	3.99	-	-	-
FER06	2-Jun	DIW	Mean	-	2.65	-	-	-
FER07	4-Jun	Sample	FER-07A	14.70	1.27	1.91	3.38	370.00
FER07	4-Jun	Sample	FER-07B	12.60	-1.00	-0.80	-0.70	369.00
FER07	4-Jun	Sample	FER-07C	12.70	-1.20	-1.00	-0.60	372.00
FER07	4-Jun	Sample	FER-07D	14.00	1.80	1.40	2.47	377.00
FER07	4-Jun	Sample	FER-07E	14.10	2.68	3.37	4.25	374.00
FER07	4-Jun	Sample	FER-07F	14.80	2.10	2.41	2.96	3.08
FER07	4-Jun	Sample	Mean	13.82	0.94	1.22	1.96	372.40
FER07	4-Jun	F std.	1	-	311.00	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER07	4-Jun	F std.	2	-	309.00	-	-	-
FER07	4-Jun	F std.	3	-	308.00	-	-	-
FER07	4-Jun	F std.	4	-	322.00	-	-	-
FER07	4-Jun	F std.	Mean	-	312.50	-	-	-
FER07	4-Jun	DIW	5	-	2.57	-	-	-
FER07	4-Jun	DIW	6	-	1.68	-	-	-
FER07	4-Jun	DIW	7	-	3.94	-	-	-
FER07	4-Jun	DIW	Mean	-	2.73	-	-	-
FER08	6-Jun	Sample	FER-08A	13.60	3.39	3.67	4.15	394.00
FER08	6-Jun	Sample	FER-08B	10.30	4.39	4.60	4.60	399.00
FER08	6-Jun	Sample	FER-08C	13.50	6.93	7.70	9.07	414.00
FER08	6-Jun	Sample	FER-08D	12.70	3.72	4.35	4.83	415.00
FER08	6-Jun	Sample	FER-08E	12.80	3.33	4.10	4.90	397.00
FER08	6-Jun	Sample	FER-08F	13.10	6.74	7.68	8.30	12.70
FER08	6-Jun	Sample	Mean	12.67	4.75	5.35	5.98	403.80
FER08	6-Jun	IO Cont.	IO0606A	13.90	-	-	-	406.00
FER08	6-Jun	IO Cont.	IO0606B	14.10	-	-	-	401.00
FER08	6-Jun	IO Cont.	IO0606C	13.80	-	-	-	406.00
FER08	6-Jun	IO Cont.	IO0606D	14.10	-	-	-	410.00
FER08	6-Jun	IO Cont.	IO0606E	11.10	-	-	-	402.00
FER08	6-Jun	IO Cont.	IO0606F	14.50	-	-	-	2.87
FER09	6-Jun	IO Cont.	Mean	13.58	-	-	-	405.00
FER08	6-Jun	F Std.	1	-	317.00	-	-	-
FER08	6-Jun	F Std.	2	-	313.00	-	-	-
FER08	6-Jun	F Std.	3	-	319.00	-	-	-
FER08	6-Jun	F Std.	4	-	325.00	-	-	-
FER08	6-Jun	F Std.	Mean	-	318.50	-	-	-
FER08	6-Jun	DIW	5	-	2.89	-	-	-
FER08	6-Jun	DIW	6	-	1.50	-	-	-
FER08	6-Jun	DIW	7	-	3.93	-	-	-
FER08	6-Jun	DIW	Mean	-	2.77	-	-	-
FER09	6-Jun	Sample	FER-09A	15.10	26.40	27.00	27.60	463.00
FER09	6-Jun	Sample	FER-09B	15.70	28.00	28.30	28.70	463.00
FER09	6-Jun	Sample	FER-09C	13.90	27.60	27.90	29.30	458.00
FER09	6-Jun	Sample	FER-09D	12.50	25.50	25.20	25.70	448.00
FER09	6-Jun	Sample	FER-09E	15.90	27.80	27.80	28.50	467.00
FER09	6-Jun	Sample	FER-09F	13.40	29.50	30.00	30.80	31.40
FER09	6-Jun	Sample	Mean	14.42	27.47	27.70	28.43	459.80
FER09	6-Jun	IO Cont.	IO0610A	13.90	-	-	-	384.00
FER09	6-Jun	IO Cont.	IO0610B	15.40	-	-	-	394.00
FER09	6-Jun	IO Cont.	IO0610C	13.20	-	-	-	377.00
FER09	6-Jun	IO Cont.	IO0610D	12.10	-	-	-	385.00
FER09	6-Jun	IO Cont.	IO0610E	12.70	-	-	-	384.00
FER09	6-Jun	IO Cont.	IO0610F	16.20	-	-	-	27.20
FER09	6-Jun	IO Cont.	Mean	13.92	-	-	-	384.80

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER09	6-Jun	F Std.	1	-	316.00	-	-	-
FER09	6-Jun	F Std.	2	-	310.00	-	-	-
FER09	6-Jun	F Std.	3	-	311.00	-	-	-
FER09	6-Jun	F Std.	4	-	323.00	-	-	-
FER09	6-Jun	F Std.	Mean	-	315.00	-	-	-
FER09	6-Jun	DIW	5	-	2.68	-	-	-
FER09	6-Jun	DIW	6	-	1.55	-	-	-
FER09	6-Jun	DIW	7	-	3.86	-	-	-
FER09	6-Jun	DIW	Mean	-	2.70	-	-	-
FER10	18-Jun	Sample	FER-10A	16.10	-2.90	-	-	453.00
FER10	18-Jun	Sample	FER-10B	12.20	-4.00	-	-	439.00
FER10	18-Jun	Sample	FER-10C	12.30	-0.60	-	-	436.00
FER10	18-Jun	Sample	FER-10D	15.70	-4.40	-	-	442.00
FER10	18-Jun	Sample	FER-10E	16.40	-1.40	-	-	445.00
FER10	18-Jun	Sample	FER-10F	16.50	-2.80	-	-	-2.60
FER10	18-Jun	Sample	Mean	14.87	-2.68	-	-	443.00
FER10	18-Jun	IO Cont.	IO0618A	17.20	-	-	-	433.00
FER10	18-Jun	IO Cont.	IO0618B	13.30	-	-	-	422.00
FER10	18-Jun	IO Cont.	IO0618C	15.70	-	-	-	436.00
FER10	18-Jun	IO Cont.	IO0618D	14.30	-	-	-	423.00
FER10	18-Jun	IO Cont.	IO0618E	17.40	-	-	-	434.00
FER10	18-Jun	IO Cont.	IO0618F	15.40	-	-	-	6.06
FER09	6-Jun	IO Cont.	Mean	15.55	-	-	-	429.60
FER10	18-Jun	F Std.	1	-	322.00	-	-	-
FER10	18-Jun	F Std.	2	-	318.00	-	-	-
FER10	18-Jun	F Std.	3	-	317.00	-	-	-
FER10	18-Jun	F Std.	4	-	333.00	-	-	-
FER10	18-Jun	F Std.	Mean	-	322.50	-	-	-
FER10	18-Jun	DIW	5	-	3.71	-	-	-
FER10	18-Jun	DIW	6	-	2.04	-	-	-
FER10	18-Jun	DIW	7	-	4.74	-	-	-
FER10	18-Jun	DIW	Mean	-	3.50	-	-	-
FER11	18-Jun	Sample	FER-11A	9.18	-0.40	-	-	490.00
FER11	18-Jun	Sample	FER-11B	11.50	-1.80	-	-	455.00
FER11	18-Jun	Sample	FER-11C	14.70	-1.70	-	-	435.00
FER11	18-Jun	Sample	FER-11D	10.90	-3.30	-	-	433.00
FER11	18-Jun	Sample	FER-11E	10.90	-0.90	-	-	432.00
FER11	18-Jun	Sample	FER-11F	12.90	-2.50	-	-	-0.70
FER11	18-Jun	Sample	Mean	11.68	-1.77	-	-	449.00
FER11	18-Jun	F Std.	1	-	310.00	-	-	-
FER11	18-Jun	F Std.	2	-	310.00	-	-	-
FER11	18-Jun	F Std.	3	-	310.00	-	-	-
FER11	18-Jun	F Std.	4	-	323.00	-	-	-
FER11	18-Jun	F Std.	Mean	-	313.25	-	-	-
FER11	18-Jun	DWI	5	-	2.92	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER11	18-Jun	DWI	6	-	1.45	-	-	-
FER11	18-Jun	DWI	7	-	3.78	-	-	-
FER11	18-Jun	DWI	Mean	-	2.72	-	-	-
FER12	18-Jun	Sample	FER-12A	13.50	-0.40	-	-	412.00
FER12	18-Jun	Sample	FER-12B	14.20	2.54	-	-	421.00
FER12	18-Jun	Sample	FER-12C	14.90	-0.10	-	-	417.00
FER12	18-Jun	Sample	FER-12D	15.60	0.00	-	-	417.00
FER12	18-Jun	Sample	FER-12E	15.10	1.61	-	-	410.00
FER12	18-Jun	Sample	FER-12F	12.10	-1.10	-	-	-1.00
FER12	18-Jun	Sample	Mean	14.23	0.43	-	-	415.40
FER12	18-Jun	F Std.	1	-	318.00	-	-	-
FER12	18-Jun	F Std.	2	-	312.00	-	-	-
FER12	18-Jun	F Std.	3	-	318.00	-	-	-
FER12	18-Jun	F Std.	4	-	327.00	-	-	-
FER12	18-Jun	F Std.	Mean	-	318.75	-	-	-
FER12	18-Jun	DIW	5	-	2.96	-	-	-
FER12	18-Jun	DIW	6	-	1.64	-	-	-
FER12	18-Jun	DIW	7	-	3.85	-	-	-
FER12	18-Jun	DIW	Mean	-	2.82	-	-	-
FER13	25-Jun	Sample	FER-13A	13.70	8.35			404.00
FER13	25-Jun	Sample	FER-13B	11.10	3.14			394.00
FER13	25-Jun	Sample	FER-13C	14.90	9.85			395.00
FER13	25-Jun	Sample	FER-13D	15.60	16.20			393.00
FER13	25-Jun	Sample	FER-13E	15.90	13.40			396.00
FER13	25-Jun	Sample	FER-13F	15.70	16.10			18.40
FER13	25-Jun	Sample	Mean	14.48	11.17			396.40
FER13	25-Jun	IO Cont.	IO0625A	16.10	-	-	-	412.00
FER13	25-Jun	IO Cont.	IO0625B	13.70	-	-	-	404.00
FER13	25-Jun	IO Cont.	IO0625C	13.30	-	-	-	409.00
FER13	25-Jun	IO Cont.	IO0625D	14.70	-	-	-	402.00
FER13	25-Jun	IO Cont.	IO0625E	15.50	-	-	-	403.00
FER13	25-Jun	IO Cont.	IO0625F	12.00	-	-	-	-
FER13	25-Jun	IO Cont.	Mean	14.22	-	-	-	406.00
FER13	25-Jun	F Std.	1	-	317.00	-	-	-
FER13	25-Jun	F Std.	2	-	315.00	-	-	-
FER13	25-Jun	F Std.	3	-	320.00	-	-	-
FER13	25-Jun	F Std.	4	-	325.00	-	-	-
FER13	25-Jun	F Std.	Mean	-	319.25	-	-	-
FER13	25-Jun	DIW	5	-	3.95	-	-	-
FER13	25-Jun	DIW	6	-	2.03	-	-	-
FER13	25-Jun	DIW	7	-	4.23	-	-	-
FER13	25-Jun	DIW	Mean	-	3.40	-	-	-
FER14	25-Jun	Sample	FER-14A	15.30	5.49	-	-	419.00
FER14	25-Jun	Sample	FER-14B	15.60	3.85	-	-	407.00
FER14	25-Jun	Sample	FER-14C	13.70	4.45	-	-	395.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER14	25-Jun	Sample	FER-14D	12.70	4.97	-	-	395.00
FER14	25-Jun	Sample	FER-14E	14.80	13.40	-	-	399.00
FER14	25-Jun	Sample	FER-14F	15.90	6.75	-	-	7.26
FER14	25-Jun	Sample	Mean	14.67	6.49	-	-	403.00
FER14	25-Jun	IO Cont.	IO0625A	16.10	-	-	-	412.00
FER14	25-Jun	IO Cont.	IO0625B	13.70	-	-	-	404.00
FER14	25-Jun	IO Cont.	IO0625C	13.30	-	-	-	409.00
FER14	25-Jun	IO Cont.	IO0625D	14.70	-	-	-	402.00
FER14	25-Jun	IO Cont.	IO0625E	15.50	-	-	-	403.00
FER14	25-Jun	IO Cont.	IO0625F	12.00	-	-	-	-
FER14	25-Jun	IO Cont.	Mean	14.22	-	-	-	406.00
FER14	25-Jun	F Std.	1	-	317.00	-	-	-
FER14	25-Jun	F Std.	2	-	315.00	-	-	-
FER14	25-Jun	F Std.	3	-	320.00	-	-	-
FER14	25-Jun	F Std.	4	-	325.00	-	-	-
FER14	25-Jun	F Std.	Mean	-	319.25	-	-	-
FER14	25-Jun	DIW	5	-	3.95	-	-	-
FER14	25-Jun	DIW	6	-	2.03	-	-	-
FER14	25-Jun	DIW	7	-	4.23	-	-	-
FER14	25-Jun	DIW	Mean	-	3.40	-	-	-
FER15	25-Jun	Sample	FER-15A	14.50	2.52	-	-	403.00
FER15	25-Jun	Sample	FER-15B	15.37	3.46	-	-	391.00
FER15	25-Jun	Sample	FER-15C	12.60	0.94	-	-	383.00
FER15	25-Jun	Sample	FER-15D	13.00	4.82	-	-	382.00
FER15	25-Jun	Sample	FER-15E	14.60	6.75	-	-	394.00
FER15	25-Jun	Sample	FER-15F	16.00	2.52	-	-	5.70
FER15	25-Jun	Sample	Mean	14.35	3.50	-	-	390.60
FER15	25-Jun	IO Cont.	IO0625A	16.10	-	-	-	412.00
FER15	25-Jun	IO Cont.	IO0625B	13.70	-	-	-	404.00
FER15	25-Jun	IO Cont.	IO0625C	13.30	-	-	-	409.00
FER15	25-Jun	IO Cont.	IO0625D	14.70	-	-	-	402.00
FER15	25-Jun	IO Cont.	IO0625E	15.50	-	-	-	403.00
FER15	25-Jun	IO Cont.	IO0625F	12.00	-	-	-	-
FER15	25-Jun	IO Cont.	Mean	14.22	-	-	-	406.00
FER15	25-Jun	F Std.	1	-	317.00	-	-	-
FER15	25-Jun	F Std.	2	-	315.00	-	-	-
FER15	25-Jun	F Std.	3	-	320.00	-	-	-
FER15	25-Jun	F Std.	4	-	325.00	-	-	-
FER15	25-Jun	F Std.	Mean	-	319.25	-	-	-
FER15	25-Jun	DIW	5	-	3.95	-	-	-
FER15	25-Jun	DIW	6	-	2.03	-	-	-
FER15	25-Jun	DIW	7	-	4.23	-	-	-
FER15	25-Jun	DIW	Mean	-	3.40	-	-	-
FER16	27-Jun	Sample	FER-16A	17.10	-1.00	-	-	348.00
FER16	27-Jun	Sample	FER-16B	17.30	-1.20	-	-	339.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER16	27-Jun	Sample	FER-16C	15.80	-0.90	-	-	319.00
FER16	27-Jun	Sample	FER-16D	16.60	0.94	-	-	324.00
FER16	27-Jun	Sample	FER-16E	16.30	0.24	-	-	331.00
FER16	27-Jun	Sample	FER-16F	16.60	-2.00	-	-	-1.10
FER16	27-Jun	Sample	Mean	16.62	-0.65	-	-	332.20
FER16	27-Jun	IO Cont.	IO0627A	17.30	-	-	-	337.00
FER16	27-Jun	IO Cont.	IO0627B	16.30	-	-	-	340.00
FER16	27-Jun	IO Cont.	IO0627C	17.70	-	-	-	339.00
FER16	27-Jun	IO Cont.	IO0627D	17.40	-	-	-	338.00
FER16	27-Jun	IO Cont.	IO0627E	14.80	-	-	-	333.00
FER16	27-Jun	IO Cont.	IO0627F	16.20	-	-	-	1.60
FER16	27-Jun	IO Cont.	Mean	16.62	-	-	-	337.40
FER16	27-Jun	F Std.	1	-	322.00	-	-	-
FER16	27-Jun	F Std.	2	-	318.00	-	-	-
FER16	27-Jun	F Std.	3	-	319.00	-	-	-
FER16	27-Jun	F Std.	4	-	330.00	-	-	-
FER16	27-Jun	F Std.	Mean	-	322.25	-	-	-
FER16	27-Jun	DIW	5	-	4.04	-	-	-
FER16	27-Jun	DIW	6	-	2.32	-	-	-
FER16	27-Jun	DIW	7	-	4.75	-	-	-
FER16	27-Jun	DIW	Mean	-	3.70	-	-	-
FER17	28-Jun	Sample	FER-17A	13.30	-1.40	-	-	309.00
FER17	28-Jun	Sample	FER-17B	12.80	-1.70	-	-	304.00
FER17	28-Jun	Sample	FER-17C	12.50	-2.50	-	-	294.00
FER17	28-Jun	Sample	FER-17D	16.20	-1.80	-	-	302.00
FER17	28-Jun	Sample	FER-17E	15.20	-2.30	-	-	296.00
FER17	28-Jun	Sample	FER-17F	15.20	-2.00	-	-	-3.20
FER17	28-Jun	Sample	Mean	14.20	-1.95	-	-	301.00
FER17	28-Jun	IO Cont.	IO0701A	17.80	-	-	-	323.00
FER17	28-Jun	IO Cont.	IO0701B	17.30	-	-	-	326.00
FER17	28-Jun	IO Cont.	IO0701C	18.10	-	-	-	334.00
FER17	28-Jun	IO Cont.	IO0701D	17.80	-	-	-	326.00
FER17	28-Jun	IO Cont.	IO0701E	16.80	-	-	-	331.00
FER17	28-Jun	IO Cont.	IO0701F	16.90	-	-	-	1.68
FER17	28-Jun	IO Cont.	Mean	17.45	-	-	-	328.00
FER17	28-Jun	F Std.	1	-	318.00	-	-	-
FER17	28-Jun	F Std.	2	-	317.00	-	-	-
FER17	28-Jun	F Std.	3	-	323.00	-	-	-
FER17	28-Jun	F Std.	4	-	333.00	-	-	-
FER17	28-Jun	F Std.	Mean	-	322.75	-	-	-
FER17	28-Jun	DIW	5	-	3.85	-	-	-
FER17	28-Jun	DIW	6	-	2.10	-	-	-
FER17	28-Jun	DIW	7	-	4.60	-	-	-
FER17	28-Jun	DIW	Mean	-	3.52	-	-	-
FER18	29-Jun	Sample	FER-18A	17.50	-2.50	-	-	357.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER18	29-Jun	Sample	FER-18B	15.90	-2.20	-	-	364.00
FER18	29-Jun	Sample	FER-18C	17.10	-1.60	-	-	359.00
FER18	29-Jun	Sample	FER-18D	14.90	-1.90	-	-	351.00
FER18	29-Jun	Sample	FER-18E	16.80	-1.30	-	-	352.00
FER18	29-Jun	Sample	FER-18F	15.50	-2.00	-	-	-1.70
FER18	29-Jun	IO Cont.	Mean	19.54	-2.30	-	-	356.60
FER18	29-Jun	IO Cont.	IO0701A	17.80	-	-	-	323.00
FER18	29-Jun	IO Cont.	IO0701B	17.30	-	-	-	326.00
FER18	29-Jun	IO Cont.	IO0701C	18.10	-	-	-	334.00
FER18	29-Jun	IO Cont.	IO0701D	17.80	-	-	-	326.00
FER18	29-Jun	IO Cont.	IO0701E	16.80	-	-	-	331.00
FER18	29-Jun	IO Cont.	IO0701F	16.90	-	-	-	1.68
FER18	29-Jun	IO Cont.	Mean	17.45	-	-	-	328.00
FER18	29-Jun	F Std.	1	-	322.00	-	-	-
FER18	29-Jun	F Std.	2	-	321.00	-	-	-
FER18	29-Jun	F Std.	3	-	326.00	-	-	-
FER18	29-Jun	F Std.	4	-	333.00	-	-	-
FER18	29-Jun	F Std.	Mean	-	325.50	-	-	-
FER18	29-Jun	DIW	5	-	3.93	-	-	-
FER18	29-Jun	DIW	6	-	2.46	-	-	-
FER18	29-Jun	DIW	7	-	4.64	-	-	-
FER18	29-Jun	DIW	Mean	-	3.68	-	-	-
FER19	29-Jun	Sample	FER-19A	16.60	-1.80	-	-	346.00
FER19	29-Jun	Sample	FER-19B	18.60	-1.30	-	-	343.00
FER19	29-Jun	Sample	FER-19C	17.70	-1.60	-	-	343.00
FER19	29-Jun	Sample	FER-19D	16.80	-1.60	-	-	344.00
FER19	29-Jun	Sample	FER-19E	17.50	-2.40	-	-	346.00
FER19	29-Jun	Sample	FER-19F	17.00	-3.00	-	-	-3.20
FER19	29-Jun	Sample	Mean	17.37	-1.95	-	-	344.40
FER19	29-Jun	IO Cont.	IO0701A	17.80	-	-	-	323.00
FER19	29-Jun	IO Cont.	IO0701B	17.30	-	-	-	326.00
FER19	29-Jun	IO Cont.	IO0701C	18.10	-	-	-	334.00
FER19	29-Jun	IO Cont.	IO0701D	17.80	-	-	-	326.00
FER19	29-Jun	IO Cont.	IO0701E	16.80	-	-	-	331.00
FER19	29-Jun	IO Cont.	IO0701F	16.90	-	-	-	1.68
FER19	29-Jun	IO Cont.	Mean	17.45	-	-	-	328.00
FER19	29-Jun	F Std.	1	-	323.00	-	-	-
FER19	29-Jun	F Std.	2	-	315.00	-	-	-
FER19	29-Jun	F Std.	3	-	322.00	-	-	-
FER19	29-Jun	F Std.	4	-	333.00	-	-	-
FER19	29-Jun	F Std.	Mean	-	323.25	-	-	-
FER19	29-Jun	DIW	5	-	3.84	-	-	-
FER19	29-Jun	DIW	6	-	2.35	-	-	-
FER19	29-Jun	DIW	7	-	4.31	-	-	-
FER19	29-Jun	DIW	Mean	-	3.50	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER20	30-Jun	Sample	FER-20A	18.10	2.54	-	-	292.00
FER20	30-Jun	Sample	FER-20B	18.30	3.23	-	-	294.00
FER20	30-Jun	Sample	FER-20C	16.90	4.37	-	-	296.00
FER20	30-Jun	Sample	FER-20D	17.50	3.42	-	-	292.00
FER20	30-Jun	Sample	FER-20E	15.50	3.14	-	-	286.00
FER20	30-Jun	Sample	FER-20F	18.70	2.27	-	-	2.40
FER20	30-Jun	Sample	Mean	17.50	3.16	-	-	292.00
FER20	30-Jun	IO Cont.	IO0701A	17.80	-	-	-	323.00
FER20	30-Jun	IO Cont.	IO0701B	17.30	-	-	-	326.00
FER20	30-Jun	IO Cont.	IO0701C	18.10	-	-	-	334.00
FER20	30-Jun	IO Cont.	IO0701D	17.80	-	-	-	326.00
FER20	30-Jun	IO Cont.	IO0701E	16.80	-	-	-	331.00
FER20	30-Jun	IO Cont.	IO0701F	16.90	-	-	-	1.68
FER20	30-Jun	IO Cont.	Mean	17.45	-	-	-	328.00
FER20	30-Jun	F Std.	1	-	322.00	-	-	-
FER20	30-Jun	F Std.	2	-	319.00	-	-	-
FER20	30-Jun	F Std.	3	-	321.00	-	-	-
FER20	30-Jun	F Std.	4	-	333.00	-	-	-
FER20	30-Jun	F Std.	Mean	-	323.75	-	-	-
FER20	30-Jun	DIW	5	-	3.85	-	-	-
FER20	30-Jun	DIW	6	-	2.19	-	-	-
FER20	30-Jun	DIW	7	-	4.74	-	-	-
FER20	30-Jun	DIW	Mean	-	3.59	-	-	-
FER21	1-Jul	Sample	FER-21A	15.00	34.60	-	-	314.00
FER21	1-Jul	Sample	FER-21B	18.90	35.90	-	-	330.00
FER21	1-Jul	Sample	FER-21C	15.50	34.80	-	-	326.00
FER21	1-Jul	Sample	FER-21D	17.40	36.90	-	-	332.00
FER21	1-Jul	Sample	FER-21E	18.10	36.70	-	-	330.00
FER21	1-Jul	Sample	FER-21F	17.80	36.70	-	-	34.80
FER21	1-Jul	Sample	Mean	17.12	35.93	-	-	326.40
FER21	1-Jul	IO Cont.	IO0701A	17.80	-	-	-	323.00
FER21	1-Jul	IO Cont.	IO0701B	17.30	-	-	-	326.00
FER21	1-Jul	IO Cont.	IO0701C	18.10	-	-	-	334.00
FER21	1-Jul	IO Cont.	IO0701D	17.80	-	-	-	326.00
FER21	1-Jul	IO Cont.	IO0701E	16.80	-	-	-	331.00
FER21	1-Jul	IO Cont.	IO0701F	16.90	-	-	-	1.68
FER21	1-Jul	IO Cont.	Mean	17.45	-	-	-	328.00
FER21	1-Jul	F Std.	1	-	324.00	-	-	-
FER21	1-Jul	F Std.	2	-	316.00	-	-	-
FER21	1-Jul	F Std.	3	-	321.00	-	-	-
FER21	1-Jul	F Std.	4	-	329.00	-	-	-
FER21	1-Jul	F Std.	Mean	-	322.50	-	-	-
FER21	1-Jul	DIW	5	-	4.13	-	-	-
FER21	1-Jul	DIW	6	-	3.08	-	-	-
FER21	1-Jul	DIW	7	-	4.77	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER21	1-Jul	DIW	Mean	-	3.99	-	-	-
FER22	2-Jul	Sample	FER-22A	17.80	6.32	7.50	-	434.00
FER22	2-Jul	Sample	FER-22B	18.30	5.52	6.24	-	421.00
FER22	2-Jul	Sample	FER-22C	18.50	4.18	6.65	-	415.00
FER22	2-Jul	Sample	FER-22D	18.80	4.83	9.03	-	438.00
FER22	2-Jul	Sample	FER-22E	17.60	4.53	7.58	-	426.00
FER22	2-Jul	Sample	FER-22F	16.80	3.93	5.86	-	5.35
FER22	2-Jul	Sample	Mean	17.97	4.89	7.14	-	426.80
FER22	2-Jul	IO Cont.	IO0706A	11.80	-	-	-	397.00
FER22	2-Jul	IO Cont.	IO0706B	16.70	-	-	-	401.00
FER22	2-Jul	IO Cont.	IO0706C	15.30	-	-	-	401.00
FER22	2-Jul	IO Cont.	IO0706D	10.60	-	-	-	393.00
FER22	2-Jul	IO Cont.	IO0706E	13.40	-	-	-	406.00
FER22	2-Jul	IO Cont.	IO0706F	14.70	-	-	-	4.73
FER22	2-Jul	IO Cont.	Mean	13.75	-	-	-	399.60
FER22	2-Jul	F Std.	1	-	322.00	-	-	-
FER22	2-Jul	F Std.	2	-	317.00	-	-	-
FER22	2-Jul	F Std.	3	-	326.00	-	-	-
FER22	2-Jul	F Std.	4	-	332.00	-	-	-
FER22	2-Jul	F Std.	Mean	-	324.25	-	-	-
FER22	2-Jul	DIW	5	-	5.51	-	-	-
FER22	2-Jul	DIW	6	-	2.40	-	-	-
FER22	2-Jul	DIW	7	-	4.90	-	-	-
FER22	2-Jul	DIW	Mean	-	4.27	-	-	-
FER23	2-Jul	Sample	FER-23A	18.60	3.38	5.34	-	395.00
FER23	2-Jul	Sample	FER-23B	10.50	1.85	4.22	-	394.00
FER23	2-Jul	Sample	FER-23C	18.90	4.69	6.16	-	384.00
FER23	2-Jul	Sample	FER-23D	12.40	1.58	4.39	-	389.00
FER23	2-Jul	Sample	FER-23E	12.30	1.88	4.78	-	389.00
FER23	2-Jul	Sample	FER-23F	11.80	1.68	4.27	-	4.30
FER23	2-Jul	Sample	Mean	14.08	2.51	4.86	-	390.20
FER23	2-Jul	IO Cont.	IO0706A	11.80	-	-	-	397.00
FER23	2-Jul	IO Cont.	IO0706B	16.70	-	-	-	401.00
FER23	2-Jul	IO Cont.	IO0706C	15.30	-	-	-	401.00
FER23	2-Jul	IO Cont.	IO0706D	10.60	-	-	-	393.00
FER23	2-Jul	IO Cont.	IO0706E	13.40	-	-	-	406.00
FER23	2-Jul	IO Cont.	IO0706F	14.70	-	-	-	4.73
FER23	2-Jul	IO Cont.	Mean	13.75	-	-	-	399.60
FER23	2-Jul	F Std.	1	-	323.00	-	-	-
FER23	2-Jul	F Std.	2	-	317.00	-	-	-
FER23	2-Jul	F Std.	3	-	324.00	-	-	-
FER23	2-Jul	F Std.	4	-	329.00	-	-	-
FER23	2-Jul	F Std.	Mean	-	323.25	-	-	-
FER23	2-Jul	DIW	5	-	5.98	-	-	-
FER23	2-Jul	DIW	6	-	2.36	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER23	2-Jul	DIW	7	-	4.33	-	-	-
FER23	2-Jul	DIW	Mean	-	4.22	-	-	-
FER24	3-Jul	Sample	FER-24A	15.30	11.60	14.70	-	356.00
FER24	3-Jul	Sample	FER-24B	12.80	12.00	14.60	-	348.00
FER24	3-Jul	Sample	FER-24C	14.50	11.70	14.30	-	357.00
FER24	3-Jul	Sample	FER-24D	16.20	11.40	14.20	-	356.00
FER24	3-Jul	Sample	FER-24E	17.00	11.70	15.00	-	349.00
FER24	3-Jul	Sample	FER-24F	13.50	11.40	14.20	-	14.80
FER24	3-Jul	Sample	Mean	14.88	11.63	14.50	-	353.20
FER24	3-Jul	IO Cont.	IO0706A	11.80	-	-	-	397.00
FER24	3-Jul	IO Cont.	IO0706B	16.70	-	-	-	401.00
FER24	3-Jul	IO Cont.	IO0706C	15.30	-	-	-	401.00
FER24	3-Jul	IO Cont.	IO0706D	10.60	-	-	-	393.00
FER24	3-Jul	IO Cont.	IO0706E	13.40	-	-	-	406.00
FER24	3-Jul	IO Cont.	IO0706F	14.70	-	-	-	4.73
FER24	3-Jul	IO Cont.	Mean	13.75	-	-	-	399.60
FER24	3-Jul	F Std.	1	-	320.00	-	-	-
FER24	3-Jul	F Std.	2	-	315.00	-	-	-
FER24	3-Jul	F Std.	3	-	324.00	-	-	-
FER24	3-Jul	F Std.	4	-	329.00	-	-	-
FER24	3-Jul	F Std.	Mean	-	322.00	-	-	-
FER24	3-Jul	DIW	5	-	6.55	-	-	-
FER24	3-Jul	DIW	6	-	3.42	-	-	-
FER24	3-Jul	DIW	7	-	4.80	-	-	-
FER24	3-Jul	DIW	Mean	-	4.92	-	-	-
FER25	6-Jul	Sample	FER-25A	18.10	69.20	-	-	489.00
FER25	6-Jul	Sample	FER-25B	16.40	68.20	-	-	487.00
FER25	6-Jul	Sample	FER-25C	9.42	6.40	-	-	478.00
FER25	6-Jul	Sample	FER-25D	14.20	69.00	-	-	489.00
FER25	6-Jul	Sample	FER-25E	11.60	70.20	-	-	486.00
FER25	6-Jul	Sample	FER-25F	14.10	67.90	-	-	69.30
FER25	6-Jul	Sample	Mean	13.97	58.48	-	-	485.80
FER25	6-Jul	IO Cont.	IO0706A	11.80	-	-	-	397.00
FER25	6-Jul	IO Cont.	IO0706B	16.70	-	-	-	401.00
FER25	6-Jul	IO Cont.	IO0706C	15.30	-	-	-	401.00
FER25	6-Jul	IO Cont.	IO0706D	10.60	-	-	-	393.00
FER25	6-Jul	IO Cont.	IO0706E	13.40	-	-	-	406.00
FER25	6-Jul	IO Cont.	IO0706F	14.70	-	-	-	4.73
FER25	6-Jul	IO Cont.	Mean	13.75	-	-	-	399.60
FER25	6-Jul	F Std.	1	-	323.00	-	-	-
FER25	6-Jul	F Std.	2	-	320.00	-	-	-
FER25	6-Jul	F Std.	3	-	327.00	-	-	-
FER25	6-Jul	F Std.	4	-	334.00	-	-	-
FER25	6-Jul	F Std.	Mean	-	326.00	-	-	-
FER25	6-Jul	DIW	5	-	6.79	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER25	6-Jul	DIW	6	-	2.74	-	-	-
FER25	6-Jul	DIW	7	-	4.60	-	-	-
FER25	6-Jul	DIW	Mean	-	4.71	-	-	-
FER26	6-Jul	Sample	FER-26A	16.40	49.70	-	-	378.00
FER26	6-Jul	Sample	FER-26B	13.30	49.00	-	-	376.00
FER26	6-Jul	Sample	FER-26C	13.00	50.00	-	-	385.00
FER26	6-Jul	Sample	FER-26D	16.80	49.80	-	-	371.00
FER26	6-Jul	Sample	FER-26E	15.40	49.70	-	-	381.00
FER26	6-Jul	Sample	FER-26F	13.40	50.60	-	-	50.50
FER26	6-Jul	Sample	Mean	14.72	49.80	-	-	378.20
FER26	6-Jul	IO Cont.	IO0706A	11.80	-	-	-	397.00
FER26	6-Jul	IO Cont.	IO0706B	16.70	-	-	-	401.00
FER26	6-Jul	IO Cont.	IO0706C	15.30	-	-	-	401.00
FER26	6-Jul	IO Cont.	IO0706D	10.60	-	-	-	393.00
FER26	6-Jul	IO Cont.	IO0706E	13.40	-	-	-	406.00
FER26	6-Jul	IO Cont.	IO0706F	14.70	-	-	-	4.73
FER26	6-Jul	IO Cont.	Mean	13.75	-	-	-	399.60
FER26	6-Jul	F Std.	1	-	323.00	-	-	-
FER26	6-Jul	F Std.	2	-	320.00	-	-	-
FER26	6-Jul	F Std.	3	-	327.00	-	-	-
FER26	6-Jul	F Std.	4	-	334.00	-	-	-
FER26	6-Jul	F Std.	Mean	-	326.00	-	-	-
FER26	6-Jul	DIW	5	-	6.79	-	-	-
FER26	6-Jul	DIW	6	-	2.74	-	-	-
FER26	6-Jul	DIW	7	-	4.60	-	-	-
FER26	6-Jul	DIW	Mean	-	4.71	-	-	-
FER27	7-Jul	Sample	FER-27A	12.00	7.46	-	-	-
FER27	7-Jul	Sample	FER-27B	14.40	6.75	-	-	-
FER27	7-Jul	Sample	FER-27C	15.20	6.77	-	-	-
FER27	7-Jul	Sample	FER-27D	12.60	6.22	-	-	-
FER27	7-Jul	Sample	FER-27E	15.60	7.59	-	-	-
FER27	7-Jul	Sample	FER-27F	18.60	7.62	-	-	-
FER27	7-Jul	Sample	Mean	14.73	7.07	-	-	-
FER27	7-Jul	IO Cont.	IO0709A	11.80	-	-	-	397.00
FER27	7-Jul	IO Cont.	IO0709B	16.70	-	-	-	401.00
FER27	7-Jul	IO Cont.	IO0709C	15.30	-	-	-	401.00
FER27	7-Jul	IO Cont.	IO0709D	10.60	-	-	-	393.00
FER27	7-Jul	IO Cont.	IO0709E	13.40	-	-	-	406.00
FER27	7-Jul	IO Cont.	IO0709F	14.70	-	-	-	4.73
FER27	7-Jul	IO Cont.	Mean	13.75	-	-	-	399.60
FER27	7-Jul	F Std.	1	-	324.00	-	-	-
FER27	7-Jul	F Std.	2	-	317.00	-	-	-
FER27	7-Jul	F Std.	3	-	324.00	-	-	-
FER27	7-Jul	F Std.	4	-	331.00	-	-	-
FER27	7-Jul	F Std.	Mean	-	324.00	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER27	7-Jul	DIW	5	-	6.90	-	-	-
FER27	7-Jul	DIW	6	-	3.24	-	-	-
FER27	7-Jul	DIW	7	-	4.80	-	-	-
FER27	7-Jul	DIW	Mean	-	4.98	-	-	-
FER28	9-Jul	Sample	FER-28A	15.50	5.67	6.72	-	359.00
FER28	9-Jul	Sample	FER-28B	16.60	5.73	5.62	-	361.00
FER28	9-Jul	Sample	FER-28C	16.80	5.51	5.75	-	359.00
FER28	9-Jul	Sample	FER-28D	16.90	6.69	5.94	-	376.00
FER28	9-Jul	Sample	FER-28E	16.00	5.20	5.16	-	364.00
FER28	9-Jul	Sample	FER-28F	17.20	5.70	5.78	-	5.92
FER28	9-Jul	Sample	Mean	16.50	5.75	5.83	-	363.80
FER28	9-Jul	IO Cont.	A	-	-	-	-	-
FER28	9-Jul	IO Cont.	B	-	-	-	-	-
FER28	9-Jul	IO Cont.	C	-	-	-	-	-
FER28	9-Jul	IO Cont.	D	-	-	-	-	-
FER28	9-Jul	IO Cont.	E	-	-	-	-	-
FER28	9-Jul	IO Cont.	F	-	-	-	-	-
FER28	9-Jul	IO Cont.	Mean	-	-	-	-	-
FER28	9-Jul	F Std.	1	-	320.00	-	-	-
FER28	9-Jul	F Std.	2	-	320.00	-	-	-
FER28	9-Jul	F Std.	3	-	325.00	-	-	-
FER28	9-Jul	F Std.	4	-	333.00	-	-	-
FER28	9-Jul	F Std.	Mean	-	324.50	-	-	-
FER28	9-Jul	DIW	5	-	6.06	-	-	-
FER28	9-Jul	DIW	6	-	2.26	-	-	-
FER28	9-Jul	DIW	7	-	4.65	-	-	-
FER28	9-Jul	DIW	Mean	-	4.32	-	-	-
FER29	9-Jul	Sample	FER-29A	15.00	10.70	-	-	339.00
FER29	9-Jul	Sample	FER-29B	14.60	10.50	-	-	342.00
FER29	9-Jul	Sample	FER-29C	15.90	11.40	-	-	350.00
FER29	9-Jul	Sample	FER-29D	14.30	10.00	-	-	335.00
FER29	9-Jul	Sample	FER-29E	17.10	10.80	-	-	341.00
FER29	9-Jul	Sample	FER-29F	16.50	10.90	-	-	11.40
FER29	9-Jul	Sample	Mean	15.57	10.72	-	-	341.40
FER29	9-Jul	IO Cont.	IO0709A	17.50	-	-	-	383.00
FER29	9-Jul	IO Cont.	IO0709B	15.50	-	-	-	386.00
FER29	9-Jul	IO Cont.	IO0709C	16.00	-	-	-	410.00
FER29	9-Jul	IO Cont.	IO0709D	15.40	-	-	-	391.00
FER29	9-Jul	IO Cont.	IO0709E	18.10	-	-	-	390.00
FER29	9-Jul	IO Cont.	IO0709F	13.00	-	-	-	2.32
FER29	9-Jul	IO Cont.	Mean	15.92	-	-	-	392.00
FER29	9-Jul	F Std.	1	-	319.00	-	-	-
FER29	9-Jul	F Std.	2	-	318.00	-	-	-
FER29	9-Jul	F Std.	3	-	323.00	-	-	-
FER29	9-Jul	F Std.	4	-	328.00	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER29	9-Jul	F Std.	Mean	-	322.00	-	-	-
FER29	9-Jul	DIW	5	-	6.16	-	-	-
FER29	9-Jul	DIW	6	-	2.52	-	-	-
FER29	9-Jul	DIW	7	-	5.10	-	-	-
FER29	9-Jul	DIW	Mean	-	4.59	-	-	-
FER29d	9-Jul	Sample	FER-29dA	15.30	10.60	-	-	385.00
FER29d	9-Jul	Sample	FER-29dB	17.20	10.50	-	-	380.00
FER29d	9-Jul	Sample	FER-29dC	18.70	11.30	-	-	381.00
FER29d	9-Jul	Sample	FER-29dD	16.70	10.40	-	-	383.00
FER29d	9-Jul	Sample	FER-29dE	16.80	10.50	-	-	378.00
FER29d	9-Jul	Sample	FER-29dF	16.70	11.20	-	-	11.40
FER29d	9-Jul	Sample	Mean	16.90	10.75	-	-	381.40
FER29d	9-Jul	IO Cont.	IO0709A	17.50	-	-	-	383.00
FER29d	9-Jul	IO Cont.	IO0709B	15.50	-	-	-	386.00
FER29d	9-Jul	IO Cont.	IO0709C	16.00	-	-	-	410.00
FER29d	9-Jul	IO Cont.	IO0709D	15.40	-	-	-	391.00
FER29d	9-Jul	IO Cont.	IO0709E	18.10	-	-	-	390.00
FER29d	9-Jul	IO Cont.	IO0709F	13.00	-	-	-	2.32
FER29d	9-Jul	IO Cont.	Mean	15.92	-	-	-	392.00
FER29d	9-Jul	F Std.	1	-	319.00	-	-	-
FER29d	9-Jul	F Std.	2	-	318.00	-	-	-
FER29d	9-Jul	F Std.	3	-	323.00	-	-	-
FER29d	9-Jul	F Std.	4	-	328.00	-	-	-
FER29d	9-Jul	F Std.	Mean	-	322.00	-	-	-
FER29d	9-Jul	DIW	5	-	6.16	-	-	-
FER29d	9-Jul	DIW	6	-	2.52	-	-	-
FER29d	9-Jul	DIW	7	-	5.10	-	-	-
FER29d	9-Jul	DIW	Mean	-	4.59	-	-	-
FER30	12-Jul	Sample	FER-30A	16.40	2.49	-	-	389.00
FER30	12-Jul	Sample	FER-30B	16.10	1.14	-	-	380.00
FER30	12-Jul	Sample	FER-30C	15.90	2.93	-	-	381.00
FER30	12-Jul	Sample	FER-30D	15.70	1.86	-	-	392.00
FER30	12-Jul	Sample	FER-30E	16.70	2.10	-	-	388.00
FER30	12-Jul	Sample	FER-30F	15.20	1.46	-	-	3.33
FER30	12-Jul	Sample	Mean	16.00	2.00	-	-	386.00
FER30	12-Jul	IO Cont.	IO0714A	16.10	-	-	-	365.00
FER30	12-Jul	IO Cont.	IO0714B	18.00	-	-	-	354.00
FER30	12-Jul	IO Cont.	IO0714C	18.60	-	-	-	360.00
FER30	12-Jul	IO Cont.	IO0714D	17.50	-	-	-	350.00
FER30	12-Jul	IO Cont.	IO0714E	17.40	-	-	-	342.00
FER30	12-Jul	IO Cont.	IO0714F	15.90	-	-	-	1.99
FER30	12-Jul	IO Cont.	Mean	17.25	-	-	-	354.20
FER30	12-Jul	F Std.	1	-	325.00	-	-	-
FER30	12-Jul	F Std.	2	-	323.00	-	-	-
FER30	12-Jul	F Std.	3	-	328.00	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER30	12-Jul	F Std.	4	-	330.00	-	-	-
FER30	12-Jul	F Std.	Mean	-	326.50	-	-	-
FER30	12-Jul	DIW	5	-	6.65	-	-	-
FER30	12-Jul	DIW	6	-	3.62	-	-	-
FER30	12-Jul	DIW	7	-	7.36	-	-	-
FER30	12-Jul	DIW	Mean	-	5.88	-	-	-
FER31	12-Jul	Sample	FER-31A	15.50	1.36	-	-	412.00
FER31	12-Jul	Sample	FER-31B	16.20	2.10	-	-	402.00
FER31	12-Jul	Sample	FER-31C	15.10	1.31	-	-	395.00
FER31	12-Jul	Sample	FER-31D	16.60	1.83	-	-	385.00
FER31	12-Jul	Sample	FER-31E	16.70	2.06	-	-	400.00
FER31	12-Jul	Sample	FER-31F	15.40	1.35	-	-	3.96
FER31	12-Jul	Sample	Mean	15.92	1.67	-	-	398.80
FER31	12-Jul	IO Cont.	A	-	-	-	-	-
FER31	12-Jul	IO Cont.	B	-	-	-	-	-
FER31	12-Jul	IO Cont.	C	-	-	-	-	-
FER31	12-Jul	IO Cont.	D	-	-	-	-	-
FER31	12-Jul	IO Cont.	E	-	-	-	-	-
FER31	12-Jul	IO Cont.	F	-	-	-	-	-
FER31	12-Jul	IO Cont.	Mean	-	-	-	-	-
FER31	12-Jul	F Std.	1	-	-	-	-	-
FER31	12-Jul	F Std.	2	-	-	-	-	-
FER31	12-Jul	F Std.	3	-	-	-	-	-
FER31	12-Jul	F Std.	4	-	-	-	-	-
FER31	12-Jul	F Std.	Mean	-	-	-	-	-
FER31	12-Jul	DIW	5	-	-	-	-	-
FER31	12-Jul	DIW	6	-	-	-	-	-
FER31	12-Jul	DIW	7	-	-	-	-	-
FER31	12-Jul	DIW	Mean	-	-	-	-	-
FER31	12-Jul	Sample	FER-31A	15.40	1.93	-	-	368.00
FER31D	12-Jul	Sample	FER-31B	15.90	1.03	-	-	373.00
FER31D	12-Jul	Sample	FER-31C	15.10	1.41	-	-	370.00
FER31D	12-Jul	Sample	FER-31D	15.20	2.21	-	-	374.00
FER31D	12-Jul	Sample	FER-31E	15.70	1.58	-	-	372.00
FER31D	12-Jul	Sample	FER-31F	16.30	1.75	-	-	3.38
FER31D	12-Jul	Sample	Mean	15.60	1.65	-	-	371.40
FER31D	12-Jul	IO Cont.	A	-	-	-	-	-
FER31D	12-Jul	IO Cont.	B	-	-	-	-	-
FER31D	12-Jul	IO Cont.	C	-	-	-	-	-
FER31D	12-Jul	IO Cont.	D	-	-	-	-	-
FER31D	12-Jul	IO Cont.	E	-	-	-	-	-
FER31D	12-Jul	IO Cont.	F	-	-	-	-	-
FER31D	12-Jul	IO Cont.	Mean	-	-	-	-	-
FER31D	12-Jul	F Std.	nd	-	-	-	-	-
FER31D	12-Jul	F Std.	nd	-	-	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER31D	12-Jul	F Std.	nd	-	-	-	-	-
FER31D	12-Jul	F Std.	nd	-	-	-	-	-
FER31D	12-Jul	F Std.	Mean	-	-	-	-	-
FER31D	12-Jul	DIW	nd	-	-	-	-	-
FER31D	12-Jul	DIW	nd	-	-	-	-	-
FER31D	12-Jul	DIW	nd	-	-	-	-	-
FER31D	12-Jul	DIW	Mean	-	-	-	-	-
FER32	13-Jul	Sample	FER-32A	17.50	1.74	-	-	359.00
FER32	13-Jul	Sample	FER-32B	18.00	1.57	-	-	364.00
FER32	13-Jul	Sample	FER-32C	15.90	1.64	-	-	354.00
FER32	13-Jul	Sample	FER-32D	14.00	1.26	-	-	356.00
FER32	13-Jul	Sample	FER-32E	16.90	1.82	-	-	359.00
FER32	13-Jul	Sample	FER-32F	17.70	1.81	-	-	3.54
FER32	13-Jul	Sample	Mean	16.67	1.64	-	-	358.40
FER32	13-Jul	IO Cont.	A	-	-	-	-	-
FER32	13-Jul	IO Cont.	B	-	-	-	-	-
FER32	13-Jul	IO Cont.	C	-	-	-	-	-
FER32	13-Jul	IO Cont.	D	-	-	-	-	-
FER32	13-Jul	IO Cont.	E	-	-	-	-	-
FER32	13-Jul	IO Cont.	F	-	-	-	-	-
FER32	13-Jul	IO Cont.	Mean	-	-	-	-	-
FER32	13-Jul	F Std.	1	-	325.00	-	-	-
FER32	13-Jul	F Std.	2	-	325.00	-	-	-
FER32	13-Jul	F Std.	3	-	324.00	-	-	-
FER32	13-Jul	F Std.	4	-	332.00	-	-	-
FER32	13-Jul	F Std.	Mean	-	326.50	-	-	-
FER32	13-Jul	DIW	5	-	8.44	-	-	-
FER32	13-Jul	DIW	6	-	5.12	-	-	-
FER32	13-Jul	DIW	7	-	6.24	-	-	-
FER32	13-Jul	DIW	Mean	-	6.60	-	-	-
FER33	19-Jul	Sample	FER-33A	11.10	-2.10	-	-	289.00
FER33	19-Jul	Sample	FER-33B	11.80	-2.10	-	-	289.00
FER33	19-Jul	Sample	FER-33C	12.90	-1.80	-	-	289.00
FER33	19-Jul	Sample	FER-33D	10.90	-0.80	-	-	287.00
FER33	19-Jul	Sample	FER-33E	11.00	-1.70	-	-	290.00
FER33	19-Jul	Sample	FER-33F	12.90	-1.70	-	-	1.91
FER33	19-Jul	Sample	Mean	11.77	-1.70	-	-	288.80
FER33	19-Jul	IO Cont.	A	-	-	-	-	-
FER33	19-Jul	IO Cont.	B	-	-	-	-	-
FER33	19-Jul	IO Cont.	C	-	-	-	-	-
FER33	19-Jul	IO Cont.	D	-	-	-	-	-
FER33	19-Jul	IO Cont.	E	-	-	-	-	-
FER33	19-Jul	IO Cont.	F	-	-	-	-	-
FER33	19-Jul	IO Cont.	Mean	-	-	-	-	-
FER33	19-Jul	F Std.	1	-	312.00	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER33	19-Jul	F Std.	2	-	312.00	-	-	-
FER33	19-Jul	F Std.	3	-	319.00	-	-	-
FER33	19-Jul	F Std.	4	-	324.00	-	-	-
FER33	19-Jul	F Std.	Mean	-	316.75	-	-	-
FER33	19-Jul	DIW	5	-	6.08	-	-	-
FER33	19-Jul	DIW	6	-	2.64	-	-	-
FER33	19-Jul	DIW	7	-	4.69	-	-	-
FER33	19-Jul	DIW	Mean	-	4.47	-	-	-
FER34	20-Jul	Sample	FER-34A	12.80	0.78	-	-	273.00
FER34	20-Jul	Sample	FER-34B	13.00	0.14	-	-	266.00
FER34	20-Jul	Sample	FER-34C	12.20	-0.10	-	-	268.00
FER34	20-Jul	Sample	FER-34D	12.50	-0.10	-	-	267.00
FER34	20-Jul	Sample	FER-34E	11.80	0.21	-	-	268.00
FER34	20-Jul	Sample	FER-34F	12.50	0.00	-	-	4.80
FER34	20-Jul	Sample	Mean	12.47	0.16	-	-	268.40
FER34	20-Jul	IO Cont.	A	-	-	-	-	-
FER34	20-Jul	IO Cont.	B	-	-	-	-	-
FER34	20-Jul	IO Cont.	C	-	-	-	-	-
FER34	20-Jul	IO Cont.	C	-	-	-	-	-
FER34	20-Jul	IO Cont.	E	-	-	-	-	-
FER34	20-Jul	IO Cont.	F	-	-	-	-	-
FER34	20-Jul	IO Cont.	Mean	-	-	-	-	-
FER34	20-Jul	F Std.	1	-	318.00	-	-	-
FER34	20-Jul	F Std.	2	-	316.00	-	-	-
FER34	20-Jul	F Std.	3	-	316.00	-	-	-
FER34	20-Jul	F Std.	4	-	326.00	-	-	-
FER34	20-Jul	F Std.	Mean	-	319.00	-	-	-
FER34	20-Jul	DIW	5	-	7.02	-	-	-
FER34	20-Jul	DIW	6	-	3.64	-	-	-
FER34	20-Jul	DIW	7	-	5.07	-	-	-
FER34	20-Jul	DIW	Mean	-	5.24	-	-	-
FER35	21-Jul	Sample	FER-35A	9.34	2.25	-	-	255.00
FER35	21-Jul	Sample	FER-35B	9.31	1.64	-	-	256.00
FER35	21-Jul	Sample	FER-35C	10.10	1.52	-	-	257.00
FER35	21-Jul	Sample	FER-35D	11.40	1.73	-	-	252.00
FER35	21-Jul	Sample	FER-35E	9.33	1.94	-	-	251.00
FER35	21-Jul	Sample	FER-35F	8.86	1.88	-	-	4.13
FER35	21-Jul	Sample	Mean	9.72	1.83	-	-	254.20
FER35	21-Jul	IO Cont.	A	-	-	-	-	0.00
FER35	21-Jul	IO Cont.	B	-	-	-	-	0.00
FER35	21-Jul	IO Cont.	C	-	-	-	-	0.00
FER35	21-Jul	IO Cont.	D	-	-	-	-	0.00
FER35	21-Jul	IO Cont.	E	-	-	-	-	0.00
FER35	21-Jul	IO Cont.	F	-	-	-	-	0.00
FER35	21-Jul	IO Cont.	Mean	-	-	-	-	0.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER35	21-Jul	F Std.	1	-	306.00	-	-	-
FER35	21-Jul	F Std.	2	-	306.00	-	-	-
FER35	21-Jul	F Std.	3	-	310.00	-	-	-
FER35	21-Jul	F Std.	4	-	315.00	-	-	-
FER35	21-Jul	F Std.	Mean	-	309.25	-	-	-
FER35	21-Jul	DIW	5	-	6.17	-	-	-
FER35	21-Jul	DIW	6	-	2.15	-	-	-
FER35	21-Jul	DIW	7	-	4.36	-	-	-
FER35	21-Jul	DIW	Mean	-	4.23	-	-	-
FER36	22-Jul	Sample	FER-36A	11.00	174.00	-	-	421.00
FER36	22-Jul	Sample	FER-36B	11.30	173.00	-	-	422.00
FER36	22-Jul	Sample	FER-36C	12.00	176.00	-	-	417.00
FER36	22-Jul	Sample	FER-36D	10.70	175.00	-	-	419.00
FER36	22-Jul	Sample	FER-36E	11.20	175.00	-	-	422.00
FER36	22-Jul	Sample	FER-36F	11.30	174.00	-	-	183.00
FER36	22-Jul	Sample	Mean	11.25	174.50	-	-	420.20
FER36	22-Jul	IO Cont.	A	-	-	-	-	-
FER36	22-Jul	IO Cont.	B	-	-	-	-	-
FER36	22-Jul	IO Cont.	C	-	-	-	-	-
FER36	22-Jul	IO Cont.	D	-	-	-	-	-
FER36	22-Jul	IO Cont.	E	-	-	-	-	-
FER36	22-Jul	IO Cont.	F	-	-	-	-	-
FER36	22-Jul	IO Cont.	Mean	-	-	-	-	-
FER36	22-Jul	F Std.	1	-	310.00	-	-	-
FER36	22-Jul	F Std.	2	-	305.00	-	-	-
FER36	22-Jul	F Std.	3	-	309.00	-	-	-
FER36	22-Jul	F Std.	4	-	320.00	-	-	-
FER36	22-Jul	F Std.	Mean	-	311.00	-	-	-
FER36	22-Jul	DIW	5	-	5.19	-	-	-
FER36	22-Jul	DIW	6	-	1.55	-	-	-
FER36	22-Jul	DIW	7	-	3.94	-	-	-
FER36	22-Jul	DIW	Mean	-	3.56	-	-	-
FER37	23-Jul	Sample	FER-37A	9.71	140.00	-	-	404.00
FER37	23-Jul	Sample	FER-37B	10.10	140.00	-	-	403.00
FER37	23-Jul	Sample	FER-37C	10.40	137.00	-	-	401.00
FER37	23-Jul	Sample	FER-37D	10.10	139.00	-	-	395.00
FER37	23-Jul	Sample	FER-37E	9.41	138.00	-	-	404.00
FER37	23-Jul	Sample	FER-37F	9.94	139.00	-	-	145.00
FER37	23-Jul	Sample	Mean	9.94	138.83	-	-	401.40
FER37	23-Jul	IO Cont.	A	-	-	-	-	-
FER37	23-Jul	IO Cont.	B	-	-	-	-	-
FER37	23-Jul	IO Cont.	C	-	-	-	-	-
FER37	23-Jul	IO Cont.	D	-	-	-	-	-
FER37	23-Jul	IO Cont.	E	-	-	-	-	-
FER37	23-Jul	IO Cont.	F	-	-	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER37	23-Jul	IO Cont.	Mean	-	-	-	-	-
FER37	23-Jul	F Std.	1	-	308.00	-	-	-
FER37	23-Jul	F Std.	2	-	304.00	-	-	-
FER37	23-Jul	F Std.	3	-	314.00	-	-	-
FER37	23-Jul	F Std.	4	-	316.00	-	-	-
FER37	23-Jul	F Std.	Mean	-	310.50	-	-	-
FER37	23-Jul	DIW	5	-	5.33	-	-	-
FER37	23-Jul	DIW	6	-	1.10	-	-	-
FER37	23-Jul	DIW	7	-	4.29	-	-	-
FER37	23-Jul	DIW	Mean	-	3.57	-	-	-
FER38	27-Jul	Sample	FER-38A	12.80	3.99	-	-	335.00
FER38	27-Jul	Sample	FER-38B	12.70	3.90	-	-	326.00
FER38	27-Jul	Sample	FER-38C	12.70	3.13	-	-	325.00
FER38	27-Jul	Sample	FER-38D	12.80	3.68	-	-	334.00
FER38	27-Jul	Sample	FER-38E	12.80	3.64	-	-	331.00
FER38	27-Jul	Sample	FER-38F	13.20	3.55	-	-	8.21
FER38	27-Jul	Sample	Mean	12.83	3.65	-	-	330.20
FER38	27-Jul	IO Cont.	A	-	-	-	-	-
FER38	27-Jul	IO Cont.	B	-	-	-	-	-
FER38	27-Jul	IO Cont.	C	-	-	-	-	-
FER38	27-Jul	IO Cont.	D	-	-	-	-	-
FER38	27-Jul	IO Cont.	E	-	-	-	-	-
FER38	27-Jul	IO Cont.	F	-	-	-	-	-
FER38	27-Jul	IO Cont.	Mean	-	-	-	-	-
FER38	27-Jul	F Std.	1	-	317.00	-	-	-
FER38	27-Jul	F Std.	2	-	318.00	-	-	-
FER38	27-Jul	F Std.	3	-	324.00	-	-	-
FER38	27-Jul	F Std.	4	-	330.00	-	-	-
FER38	27-Jul	F Std.	Mean	-	322.25	-	-	-
FER38	27-Jul	DIW	5	-	8.03	-	-	-
FER38	27-Jul	DIW	6	-	4.07	-	-	-
FER38	27-Jul	DIW	7	-	6.46	-	-	-
FER38	27-Jul	DIW	Mean	-	6.19	-	-	-
FER39	28-Jul	Sample	FER-39A	13.10	3.81	-	-	321.00
FER39	28-Jul	Sample	FER-39B	12.40	3.97	-	-	307.00
FER39	28-Jul	Sample	FER-39C	13.10	3.64	-	-	306.00
FER39	28-Jul	Sample	FER-39D	13.00	3.97	-	-	309.00
FER39	28-Jul	Sample	FER-39E	14.20	4.55	-	-	304.00
FER39	28-Jul	Sample	FER-39F	12.40	4.36	-	-	7.97
FER39	28-Jul	Sample	Mean	13.03	4.05	-	-	309.40
FER39	28-Jul	IO Cont.	A	-	-	-	-	-
FER39	28-Jul	IO Cont.	B	-	-	-	-	-
FER39	28-Jul	IO Cont.	C	-	-	-	-	-
FER39	28-Jul	IO Cont.	D	-	-	-	-	-
FER39	28-Jul	IO Cont.	E	-	-	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER39	28-Jul	IO Cont.	F	-	-	-	-	-
FER39	28-Jul	IO Cont.	Mean	-	-	-	-	-
FER39	28-Jul	F Std.	1	-	314.00	-	-	-
FER39	28-Jul	F Std.	2	-	317.00	-	-	-
FER39	28-Jul	F Std.	3	-	320.00	-	-	-
FER39	28-Jul	F Std.	4	-	327.00	-	-	-
FER39	28-Jul	F Std.	Mean	-	319.50	-	-	-
FER39	28-Jul	DIW	5	-	7.05	-	-	-
FER39	28-Jul	DIW	6	-	3.98	-	-	-
FER39	28-Jul	DIW	7	-	5.90	-	-	-
FER39	28-Jul	DIW	Mean	-	5.64	-	-	-
FER40	3-Aug	Sample	FER-40A	13.50	123.00	-	-	432.00
FER40	3-Aug	Sample	FER-40B	13.30	125.00	-	-	438.00
FER40	3-Aug	Sample	FER-40C	14.00	124.00	-	-	430.00
FER40	3-Aug	Sample	FER-40D	13.50	126.00	-	-	432.00
FER40	3-Aug	Sample	FER-40E	13.90	126.00	-	-	428.00
FER40	3-Aug	Sample	FER-40F	13.30	124.00	-	-	132.00
FER40	3-Aug	Sample	Mean	13.58	124.67	-	-	432.00
FER40	3-Aug	IO Cont.	A	-	-	-	-	-
FER40	3-Aug	IO Cont.	B	-	-	-	-	-
FER40	3-Aug	IO Cont.	C	-	-	-	-	-
FER40	3-Aug	IO Cont.	D	-	-	-	-	-
FER40	3-Aug	IO Cont.	E	-	-	-	-	-
FER40	3-Aug	IO Cont.	F	-	-	-	-	-
FER40	3-Aug	IO Cont.	Mean	-	-	-	-	-
FER40	3-Aug	F Std.	1	-	320.00	-	-	-
FER40	3-Aug	F Std.	2	-	316.00	-	-	-
FER40	3-Aug	F Std.	3	-	319.00	-	-	-
FER40	3-Aug	F Std.	4	-	332.00	-	-	-
FER40	3-Aug	F Std.	Mean	-	321.75	-	-	-
FER40	3-Aug	DIW	5	-	8.02	-	-	-
FER40	3-Aug	DIW	6	-	4.36	-	-	-
FER40	3-Aug	DIW	7	-	6.62	-	-	-
FER40	3-Aug	DIW	Mean	-	6.33	-	-	-
FER41	5-Aug	Sample	FER-41A	13.60	-3.90	-	-	322.00
FER41	5-Aug	Sample	FER-41B	13.50	-3.70	-	-	330.00
FER41	5-Aug	Sample	FER-41C	13.00	-3.90	-	-	338.00
FER41	5-Aug	Sample	FER-41D	13.00	-3.90	-	-	331.00
FER41	5-Aug	Sample	FER-41E	13.30	-3.60	-	-	324.00
FER41	5-Aug	Sample	FER-41F	13.40	-3.70	-	-	-3.40
FER41	5-Aug	Sample	Mean	13.30	-3.78	-	-	329.00
FER41	5-Aug	IO Cont.	A	13.70	-	-	-	324.00
FER41	5-Aug	IO Cont.	B	13.90	-	-	-	324.00
FER41	5-Aug	IO Cont.	C	12.70	-	-	-	321.00
FER41	5-Aug	IO Cont.	D	14.10	-	-	-	325.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER41	5-Aug	IO Cont.	E	13.80	-	-	-	320.00
FER41	5-Aug	IO Cont.	F	13.60	-	-	-	3.38
FER41	5-Aug	IO Cont.	Mean	13.63	-	-	-	322.80
FER41	5-Aug	F Std.	1	-	316.00	-	-	-
FER41	5-Aug	F Std.	2	-	316.00	-	-	-
FER41	5-Aug	F Std.	3	-	314.00	-	-	-
FER41	5-Aug	F Std.	4	-	327.00	-	-	-
FER41	5-Aug	F Std.	Mean	-	318.25	-	-	-
FER41	5-Aug	DIW	5	-	7.26	-	-	-
FER41	5-Aug	DIW	6	-	3.23	-	-	-
FER41	5-Aug	DIW	7	-	5.29	-	-	-
FER41	5-Aug	DIW	Mean	-	5.26	-	-	-
FER42	1-Aug	Sample	FER-42A	13.40	2865.00	-	-	-
FER42	1-Aug	Sample	FER-42B	13.50	2800.00	-	-	-
FER42	1-Aug	Sample	FER-42C	13.60	2790.00	-	-	-
FER42	1-Aug	Sample	FER-42D	13.70	2810.00	-	-	-
FER42	1-Aug	Sample	FER-42E	13.50	2860.00	-	-	-
FER42	1-Aug	Sample	FER-42F	14.20	2955.00	-	-	-
FER42	1-Aug	Sample	Mean	13.65	2846.67	-	-	-
FER42	1-Aug	IO Cont.	A	-	-	-	-	-
FER42	1-Aug	IO Cont.	B	-	-	-	-	-
FER42	1-Aug	IO Cont.	C	-	-	-	-	-
FER42	1-Aug	IO Cont.	D	-	-	-	-	-
FER42	1-Aug	IO Cont.	E	-	-	-	-	-
FER42	1-Aug	IO Cont.	F	-	-	-	-	-
FER42	1-Aug	IO Cont.	Mean	-	-	-	-	-
FER42	1-Aug	F Std.	1	-	315.00	-	-	-
FER42	1-Aug	F Std.	2	-	319.00	-	-	-
FER42	1-Aug	F Std.	3	-	318.00	-	-	-
FER42	1-Aug	F Std.	4	-	326.00	-	-	-
FER42	1-Aug	F Std.	Mean	-	319.50	-	-	-
FER42	1-Aug	DIW	5	-	7.83	-	-	-
FER42	1-Aug	DIW	6	-	2.69	-	-	-
FER42	1-Aug	DIW	7	-	5.74	-	-	-
FER42	1-Aug	DIW	Mean	-	5.42	-	-	-
FER43	9-Aug	Sample	FER-43A	12.90	3.60	-	-	379.00
FER43	9-Aug	Sample	FER-43B	13.00	4.13	-	-	372.00
FER43	9-Aug	Sample	FER-43C	13.20	3.51	-	-	373.00
FER43	9-Aug	Sample	FER-43D	12.50	3.11	-	-	376.00
FER43	9-Aug	Sample	FER-43E	12.60	4.14	-	-	369.00
FER43	9-Aug	Sample	FER-43F	12.70	3.64	-	-	3.77
FER43	9-Aug	Sample	Mean	12.82	3.69	-	-	373.80
FER43	9-Aug	IO Cont.	A	10.80	-	-	-	456.00
FER43	9-Aug	IO Cont.	B	11.00	-	-	-	456.00
FER43	9-Aug	IO Cont.	C	11.10	-	-	-	458.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER43	9-Aug	IO Cont.	D	10.90	-	-	-	455.00
FER43	9-Aug	IO Cont.	E	10.50	-	-	-	458.00
FER43	9-Aug	IO Cont.	F	10.40	-	-	-	4.46
FER43	9-Aug	IO Cont.	Mean	10.78	-	-	-	456.60
FER43	9-Aug	F Std.	1	-	311.00	-	-	-
FER43	9-Aug	F Std.	2	-	310.00	-	-	-
FER43	9-Aug	F Std.	3	-	318.00	-	-	-
FER43	9-Aug	F Std.	4	-	322.00	-	-	-
FER43	9-Aug	F Std.	Mean	-	315.25	-	-	-
FER43	9-Aug	DIW	5	-	7.20	-	-	-
FER43	9-Aug	DIW	6	-	3.04	-	-	-
FER43	9-Aug	DIW	7	-	4.36	-	-	-
FER43	9-Aug	DIW	Mean	-	4.87	-	-	-
FER44	10-Aug	Sample	FER-44A	12.20	-2.40	-	-	383.50
FER44	10-Aug	Sample	FER-44B	13.10	-3.10	-	-	380.50
FER44	10-Aug	Sample	FER-44C	13.00	-3.30	-	-	379.50
FER44	10-Aug	Sample	FER-44D	12.20	-3.30	-	-	379.00
FER44	10-Aug	Sample	FER-44E	12.90	-1.80	-	-	381.00
FER44	10-Aug	Sample	FER-44F	12.10	-2.90	-	-	-2.50
FER44	10-Aug	Sample	Mean	12.58	-2.80	-	-	380.70
FER44	10-Aug	IO Cont.	A	-	-	-	-	-
FER44	10-Aug	IO Cont.	B	-	-	-	-	-
FER44	10-Aug	IO Cont.	C	-	-	-	-	-
FER44	10-Aug	IO Cont.	D	-	-	-	-	-
FER44	10-Aug	IO Cont.	E	-	-	-	-	-
FER44	10-Aug	IO Cont.	F	-	-	-	-	-
FER44	10-Aug	IO Cont.	Mean	-	-	-	-	-
FER44	10-Aug	F Std.	1	-	313.00	-	-	-
FER44	10-Aug	F Std.	2	-	312.00	-	-	-
FER44	10-Aug	F Std.	3	-	317.00	-	-	-
FER44	10-Aug	F Std.	4	-	325.00	-	-	-
FER44	10-Aug	F Std.	Mean	-	316.75	-	-	-
FER44	10-Aug	DIW	5	-	6.46	-	-	-
FER44	10-Aug	DIW	6	-	2.23	-	-	-
FER44	10-Aug	DIW	7	-	4.76	-	-	-
FER44	10-Aug	DIW	Mean	-	4.48	-	-	-
FER45	10-Aug	Sample	FER-45A	12.20	-3.90	-	-	405.00
FER45	10-Aug	Sample	FER-45B	13.10	-3.50	-	-	406.00
FER45	10-Aug	Sample	FER-45C	13.00	-3.60	-	-	401.00
FER45	10-Aug	Sample	FER-45D	12.20	-3.40	-	-	408.00
FER45	10-Aug	Sample	FER-45E	12.90	-3.80	-	-	403.00
FER45	10-Aug	Sample	FER-45F	12.10	-3.80	-	-	-2.00
FER45	10-Aug	Sample	Mean	12.58	-3.67	-	-	404.60
FER45	10-Aug	IO Cont.	A	-	-	-	-	-
FER45	10-Aug	IO Cont.	B	-	-	-	-	-

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER45	10-Aug	IO Cont.	C	-	-	-	-	-
FER45	10-Aug	IO Cont.	D	-	-	-	-	-
FER45	10-Aug	IO Cont.	E	-	-	-	-	-
FER45	10-Aug	IO Cont.	F	-	-	-	-	-
FER45	10-Aug	IO Cont.	Mean	-	-	-	-	-
FER45	10-Aug	F Std.	1	-	310.00	-	-	-
FER45	10-Aug	F Std.	2	-	312.00	-	-	-
FER45	10-Aug	F Std.	3	-	314.00	-	-	-
FER45	10-Aug	F Std.	4	-	319.00	-	-	-
FER45	10-Aug	F Std.	Mean	-	313.75	-	-	-
FER45	10-Aug	DIW	5	-	8.40	-	-	-
FER45	10-Aug	DIW	6	-	4.26	-	-	-
FER45	10-Aug	DIW	7	-	6.08	-	-	-
FER45	10-Aug	DIW	Mean	-	6.25	-	-	-
FER46	10-Aug	Sample	FER-46A	12.20	-3.30	-	-	362.00
FER46	10-Aug	Sample	FER-46B	11.60	-3.40	-	-	362.00
FER46	10-Aug	Sample	FER-46C	11.10	-3.30	-	-	363.00
FER46	10-Aug	Sample	FER-46D	11.40	-3.40	-	-	365.00
FER46	10-Aug	Sample	FER-46E	11.00	-3.20	-	-	362.00
FER46	10-Aug	Sample	FER-46F	11.70	-2.60	-	-	-1.70
FER46	10-Aug	Sample	Mean	11.50	-3.20	-	-	362.80
FER46	10-Aug	IO Cont.	A	10.20	-	-	-	400.00
FER46	10-Aug	IO Cont.	B	11.10	-	-	-	397.00
FER46	10-Aug	IO Cont.	C	9.96	-	-	-	400.00
FER46	10-Aug	IO Cont.	D	10.10	-	-	-	395.00
FER46	10-Aug	IO Cont.	E	13.00	-	-	-	395.00
FER46	10-Aug	IO Cont.	F	10.50	-	-	-	0.00
FER46	10-Aug	IO Cont.	Mean	10.81	-	-	-	397.40
FER46	10-Aug	F Std.	1	-	316.00	-	-	-
FER46	10-Aug	F Std.	2	-	316.00	-	-	-
FER46	10-Aug	F Std.	3	-	319.00	-	-	-
FER46	10-Aug	F Std.	4	-	326.00	-	-	-
FER46	10-Aug	F Std.	Mean	-	319.25	-	-	-
FER46	10-Aug	DIW	5	-	8.86	-	-	-
FER46	10-Aug	DIW	6	-	5.20	-	-	-
FER46	10-Aug	DIW	7	-	7.17	-	-	-
FER46	10-Aug	DIW	Mean	-	7.08	-	-	-
FER47	11-Aug	Sample	FER-47A	12.30	-1.70	-	-	400.00
FER47	11-Aug	Sample	FER-47B	12.00	-1.70	-	-	395.00
FER47	11-Aug	Sample	FER-47C	12.00	-1.60	-	-	399.00
FER47	11-Aug	Sample	FER-47D	12.80	-1.70	-	-	398.00
FER47	11-Aug	Sample	FER-47E	12.10	-1.90	-	-	402.00
FER47	11-Aug	Sample	FER-47F	12.70	-1.60	-	-	-1.90
FER47	11-Aug	Sample	Mean	12.32	-1.70	-	-	398.80
FER47	11-Aug	IO Cont.	A	10.20	-	-	-	414.00

ADDENDUM: RAW DATA FROM FERREL 1999 CRUISE

Site	Date	Analyte	Vial #	Vial Blk	Rep1	Rep2	Rep3	Spike
FER47	11-Aug	IO Cont.	B	11.10	-	-	-	418.00
FER47	11-Aug	IO Cont.	C	9.96	-	-	-	416.00
FER47	11-Aug	IO Cont.	D	10.10	-	-	-	409.00
FER47	11-Aug	IO Cont.	E	13.00	-	-	-	413.00
FER47	11-Aug	IO Cont.	F	10.50	-	-	-	0.00
FER47	11-Aug	IO Cont.	Mean	10.81	-	-	-	414.00
FER47	11-Aug	F Std.	1	-	314.00	-	-	-
FER47	11-Aug	F Std.	2	-	313.00	-	-	-
FER47	11-Aug	F Std.	3	-	316.00	-	-	-
FER47	11-Aug	F Std.	4	-	326.00	-	-	-
FER47	11-Aug	F Std.	Mean	-	317.25	-	-	-
FER47	11-Aug	DIW	5	-	8.00	-	-	-
FER47	11-Aug	DIW	6	-	4.12	-	-	-
FER47	11-Aug	DIW	7	-	6.50	-	-	-
FER47	11-Aug	DIW	Mean	-	6.21	-	-	-