PRELIMINARY ASSESSMENT OF NONPOINT SOURCE RELATED AMBIENT TOXICITY IN AND AROUND LOWER GALVESTON BAY

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EXECUTIVE SUMMARY

In 1991 aquaculture researchers at the old SeaArama facility in Galveston believed that mortality they were observing in their larval shrimp cultures was a result of toxicity of ambient water in the Gulf of Mexico. The researchers utilized near-shore Gulf of Mexico water for rearing larval shrimp. They hypothesized that 2-butoxyethanol was the toxic agent, originating from Galveston Bay waters flowing into the Gulf following heavy rainfall. However, data were not available to support this hypothesis. The U.S. Environmental Protection Agency (EPA) and the Texas Natural Resource Conservation Commission (TNRCC) in a combined effort decided to conduct a water quality study to investigate these concerns. The purposes of the study were to assess the potential for ambient toxicity in lower Galveston Bay and the Gulf of Mexico following rainfall events, and to determine the need for additional studies for a more complete assessment.

A total of five stations were sampled during three sampling events: (I) November 1992, (II) June 1993 and (III) February 1994. Sampling stations included Galveston Bay near Redfish Reef, Galveston Channel, and near-shore Gulf of Mexico off Galveston Island. Two additional industrialized areas were also sampled, Texas City Ship Channel and Chocolate Bay. An attempt was made to sample following significant rainfall in the Galveston Bay watershed to assess the potential impact of nonpoint source pollution on bay water quality. Ambient surface water samples were collected for chemical analysis of conventional parameters, EPA priority pollutants (heavy metals, VOCs, semi-volatiles, pesticides and PCBs), and chronic toxicity testing with mysids and inland silversides.

Overall, chemical water quality was good for all sites. The chemical analysis yielded no violations of state water quality standards. Bis(2-ethylhexyl) phthalate at the Gulf of Mexico station exceeded the EPA criterion for protection of human health in February 1994, although the significance is doubtful as this is a common lab contaminant. In November 1992 dissolved nickel approached the state's chronic water quality standard at Chocolate Bay. Chronic toxicity data for mysids and inland silversides, although limited, did not indicate significant chronic effects to either species.

Because this was a screening study data should be considered preliminary. Chemical and toxicity data indicate that aquatic life uses in the "open bay" areas sampled are not impacted by toxic substances originating from non-point sources. The need for future open bay type nonpoint source surface water studies is considered low. Studies to assess localized and/or episodic effects of urban stormwater discharges and industrial and agricultural runoff (e.g., western near-shore areas of Galveston Bay; Chocolate Bayou upstream of the area sampled in this study) would be of greater value.

INTRODUCTION

In the spring and summer of 1991, aquaculture researchers reported mortality of the larval shrimp being reared at the old SeaArama facility located on Galveston Island. The researchers hypothesized that the mortality of larval shrimp was due to poor water quality in the Gulf of Mexico. The facility intake pipe which supplied water for rearing shrimp was located in the Gulf, just offshore of Galveston Island. The researchers further postulated that, following rainfall events, Gulf water in the vicinity of the intake was highly dependent on water quality in Galveston Bay. They solicited the assistance of a local university to assess the possible chemical basis for the recurring larval shrimp mortality. The university evidence suggested that the mortality was due to an organic chemical, 2-butoxyethanol (CAS# 111762), which was apparently detected in water samples collected at the facility following heavy rainfall events. Based on the hypothesis put forth by the researchers, and preliminary analyses, the news media capitalized on the threat of poor water quality, and specifically the detected organic chemical, on the bay shrimp fishery. The news media coverage of these events seemed to exacerbate the severity of the issue. The general public and local fishermen were concerned about these reports of toxicity, as was the Gulf of Mexico Fishery Management Council (Nix 1991). Data for supporting or discarding the hypothesis were lacking.

Implication that 2-butoxyethanol acted as a toxic substance either at the aquaculture facility, or in the bay is insupportable for the following reasons: (1) No documentation, such as reports or data on the incidence of mortality or water chemistry results, were produced by the researchers for inspection; (2) It is unknown whether some aspects of the facility itself, such as pipes, tanks, water conditioners, etc., caused a toxic effect; (3) Incidence of disease or physiological condition of the organisms was apparently not assessed; (4) Toxicity testing using standard methods (U.S. EPA 1988) and systematic toxicity identifications (TIE) (U.S. EPA 1994) were not conducted to confirm that mortality was toxicity-related, and, if so, to establish which toxicants may be responsible; (5) Chemical analyses of ambient water and piped water at the facility conducted by the TNRCC did not detect 2-butoxyethanol, although low concentrations of a phthalate and two tentatively identified compounds (TIC) were detected (TNRCC, unpublished data); and (6) concentrations of 2-butoxyethanol found by the university were more than four orders of magnitude lower than acutely toxic concentrations based on data contained in EPA's aquatic toxicity database (AQUIRE 1995).

Based on the last point in particular, EPA does not believe the shrimp mortality at the mariculture facility was affected by ambient concentrations of 2-butoxyethanol. However, EPA felt the need to investigate the possibility of ambient toxicity in Galveston Bay and the Gulf of Mexico following rainfall events. Accordingly, the primary purpose of this study was to collect preliminary data to assess the potential for ambient toxicity in lower Galveston Bay and the Gulf following rainfall events, and to determine if additional, more intensive studies were needed for a more complete assessment of water quality. A secondary purpose was to evaluate the potential for ambient toxicity in waterbodies downstream of two heavily industrialized areas, Texas City Ship Channel and Chocolate Bay. The project objectives were to conduct short-term chronic toxicity testing and priority pollutant chemical analyses at a total of five ambient stations in lower Galveston Bay and the Gulf of Mexico. This study was a joint effort between the EPA Region 6 Office in Dallas, and TNRCC Region 12 in Houston.

MATERIALS AND METHODS

Sampling station locations are presented in Table 1 and Figure 1. Two sampling locations were selected based on the water quality concerns related to ambient toxicity in Lower Galveston Bay following rainfall events: Galveston Channel and the Gulf of Mexico at Galveston Island. The Redfish Island station was selected as an indicator of overall bay water quality. Chocolate Bay and Texas City Ship Channel stations were selected because these areas are considered to be of higher

than average concern due primarily to heavy industrial influence.

Sampling took place on three dates: (I) November 12-13, 1992; (II) June 2-3, 1993; and (III) February 2-3, 1994. An attempt was made to sample after significant rainfall, at least one inch in the Galveston Bay area, to assess the potential collective impact of nonpoint sources on the lower bay system. Multiple sampling events served to provide a temporal perspective, and to improve chances of finding impacts. Because of the areal magnitude of Galveston Bay and adjoining bay systems, and the limited number of sampling stations, this study should be considered very preliminary. However, the study served its purpose, i.e., to estimate potential impacts in several areas in the bay following rainfall events, and to assess the need for more involved study.

Station 5, at the Gulf Coast Fishing Pier was accessed on foot, while all other stations were sampled by boat. Field parameters, including water temperature, pH, dissolved oxygen (DO), conductivity and salinity were recorded at one foot depth, and in some cases one foot off the bottom. Except for metals, grab samples of ambient water were collected using a clean plastic bucket, or by dipping the sample containers directly into the water. Five gallons of water were placed in two 2.5-gallon collapsible plastic containers for the ambient toxicity tests. All samples were tagged and preserved according to standard EPA protocols. Water samples were hand delivered within 24 hours or shipped overnight to the appropriate laboratory.

"Clean" procedures were followed for collection of dissolved heavy metals samples (TNRCC 1994). This involved use of a hand pump to draw water through pre-cleaned silicone tubing. The sample flowed through a disposable filter cartridge at the end of the tube, and then directly into pre-cleaned, pre-acidified high density polyethylene containers. These procedures minimized chances for contamination and ensured that filtration and preservation were instantaneous. Samples for total mercury were collected as above, but not filtered. Samples for dissolved Chromium +6 were filtered, but were preserved in the laboratory subsequent to fixation.

Chemical analysis included conventional parameters (ammonia, total suspended solids, total organic carbon and in some cases chlorine and total dissolved solids), dissolved heavy metal priority pollutants (including chromium +6), total mercury, and the full suite of organic priority pollutants, except 2378-dioxin. All chemical analyses were conducted using standard operating procedures (SOP) by the EPA Regional Laboratory at Houston, Texas. Chronic toxicity testing with mysid shrimp (Mysidopsis bahia) and inland silverside (Menidia beryllina) was conducted using standard methods (U.S. EPA 1988). This testing was performed by the EPA Environmental Research Lab at Gulf Breeze, Florida. Mysids used for testing were cultured on-site while the silversides were procured from a supplier. It should be noted that ambient test waters exceeded the recommended holding time of 36 hrs. This could not be avoided as it was not feasible to sample each site more than once per sampling event. In November 1992 five separate controls were tested for mysids and inland silverside. For other dates a single control was run.

This study was preceded by the development of an approved quality assurance project plan (QAPP) (U.S. EPA 1992). Quality assurance is discussed in the results section of this report as appropriate. Chemical and toxicity data are presented in tabular form. Chemical data were compared with the state water quality standards (TNRCC 1991; 1994) and EPA water quality criteria (U.S. EPA 1993), while ambient toxicity data were assessed by statistically comparing ambient water results with laboratory controls.

Prior to statistical analyses the survival and fecundity data were transformed by taking the arcsine of the square root. Weight data were only tranformed ($\log_{10}$ weight+1)) if needed to bring the variances of the means into statistical equality (Harley's Test, P=0.05). If the data were not normally distributed by the Shapiro-Wilks Test (P=0.01), the control and test water values were compared using the nonparametric Wilcoxon Rank Sum Test (P=0.05). Otherwise, the means

were compared using parametric statistics: t-Tests (P=0.05) (in the November 1992 testing in which there was a separate control for each ambient water treatment); or ANOVA (P=0.05) followed by Dunnett's Test (P=0.05). Reference toxicant testing using copper II sulfate pentahydrate was conducted for each of the three test series as a means of checking test organism health and sensitivity. LC50's values for the reference toxicant tests were calculated using the Trimmed Spearman-Karber Method (Hamilton et al. 1977).

RESULTS

Field Conditions and Conventional Parameters

Antecedent rainfall data are summarized in Table 2 and field parameter data are presented in Table 3. In general salinities were lowest during the second sampling event in June 1993. This may be due to a greater lag time between rainfall and the initiation of sampling compared to the other dates. As a whole the field parameters were within normal ranges, although in some cases dissolved oxygen (DO) was super-saturated. This may be due to rapid increases in surface water temperatures and/or algal blooms. Concentrations of ammonia were low at all stations, chlorine (lab analysis for one date) was undetected, TOC was below detection, and TSS and TDS (analyzed on one date) were within normal ranges.

Priority Pollutants

None of the priority pollutant metals exceeded state water quality standards. Dissolved nickel at station 4 (Chocolate Bay) in November 1992 approached the state chronic standard of 13.2 ug/l (Table 4). On that same date and location copper was detected but did not exceed the state chronic standard of 4.37 ug/l. These metals were not detected in subsequent sampling events, although this may be explained by the higher detection levels for June 1993 and February 1994 analyses (see Appendix A).

None of the organic priority pollutants exceeded state water quality standards. For the most part volatile organic compounds (VOC), semi-volatile compounds, PCBs and pesticides were not detected. In only one case was an EPA water quality criterion exceeded. Bis(2-ethylhexyl)phthalate was found at station 5 (Gulf of Mexico) at a concentration of 65 ug/l in February 1994, exceeding the criterion for protection of human health (1×10^{-5}) of 59 ug/l. In June 1993, di-n-butylphthalate was tentatively identified at a concentration of 33 ug/l at station 2 (Texas City Ship Channel). This concentration was well below the EPA human health water quality criterion; aquatic life criteria are not available. Water quality standards are not available for the above phthalates. The representativeness of the phthalate data is somewhat questionable since phthalates are common lab contaminants.

Tentatively identified and unknown compounds were also detected during the organic chemical analyses, although such data are considered to be of limited usefulness. In November 1992, semi-volatile unknowns were detected at concentrations of 8 ug/l, 10 ug/l, 6 ug/l and 17 ug/l for stations 1, 2, 3 and 5, respectively. In June 1993, a semi-volatile unknown was detected at station 2 at a concentration of 4 ug/l. Thiobismethane (CAS# 75183), a tentatively identified VOC was detected at concentrations of 6 ug/l and 59 ug/l at stations 2 and 3, respectively. No data are available on the toxicity of this chemical to aquatic life (AQUIRE 1995). In February 1994, semi-volatile unknowns were detected at concentrations of 4 ug/l, and 7 ug/l at stations 2 and 5, respectively. One VOC unknown was also found at a concentration of 33 ug/l on this date at station 2.

Ambient Toxicity Testing

Reference toxicant testing is a means of assessing test organism health and sensitivity. This testing was done in conjunction with ambient water testing for the three sampling events (I-III). Sensitivity of mysids and inland silverside was approximately the same after seven days exposure to the reference toxicant,

copper II sulfate pentahydrate. Four day LC50 values for the three test dates were 445, 599 and 513 ug/l copper II sulfate pentahydrate for the inland silverside, and 618, 684 and 691 for the mysid. These values, if expressed as copper concentration, are 0.81, 1.1 and 0.93 times the published LC50 for Menidia peninsulae (Mayer 1987; data for M. beryllina were not available). LC50s for Mysidopsis bahia were 0.87, 0.96 and 0.97 times the published LC50 value for Mysidopsis bahia (Lussier et al. 1985). These data indicate that the health and sensitivity of organisms used in the toxicity tests were normal.

In November 1992 mean survival, weight and fecundity of mysids in test waters was not statistically different than control values, except at station 5 where mean survival of 98% was greater than the control survival of 83% (Table 5). Control fecundity was inadequate since mysids were too immature at the end of the test to distinguish sexes with certainty. Mean survival and weight for inland silversides in the treatments were not significantly different than the respective controls (Table 6).

In June 1993, mysid control weight was only 0.08 mg, which did not achieve test acceptability criterion of 0.20. The mean control weight for the control was significantly lower than four of the five treatments (stations 1, 3, 4 and 5). The reason for the low control weight was not determined. Also the control fecundity acceptability criterion of 50% of female mysids with eggs was not achieved because the mysids were too immature for sexes to be differentiated. Fecundity is not a mandatory test criterion. However because of inadequate control weight the June mysid data should be considered conditional. Survival was good in both the control and test water treatments. All test water weights and fecundities were higher than control values, suggesting (not proving) the absence of toxicity.

In the June 1993 testing of inland silversides, no significant differences between control and test water survival and weight were found, indicating the absence of ambient toxicity to this species. However, these data need to be qualified in that two to seven fish jumped out of the weight pans in four of the six treatments. Statistical comparisons were based on the number of fish remaining in the pans.

In the February 1994 testing of inland silversides, no significant differences were observed between the control and the ambient water endpoints measured, however, the inland silverside data need to be qualified. This was a truncated retest, necessitated by excessive mortality in the first test's control. The mortality may have been due to fish remaining too long in the counting beakers. The small sample size limited the effectiveness of the statistical analysis. For the mysids, mean control weight was significantly less than for one treatment (station 3), although control weight was good and, visually, differences were slight. No significant differences were observed for mysid survival and fecundity.

DISCUSSION

The EPA human health criterion for bis(2-ethylhexyl)phthalate was exceeded at the Gulf of Mexico station on one date. The state does not have water quality standards for this chemical. Its significance is unknown, since there are no obvious sources, and because it is a common lab contaminant. However, its presence deserves note, and any future monitoring should include this parameter. Nickel and copper were were detected but did not exceed standards. Neither metal exceeded state water quality standards. Possible sources of these metals include point source industrial discharges located on Chocolate Bayou. The Chocolate Bayou/Bay system has not been well studied and future assessment of water quality during dry and wet weather would be worthwhile if resources are available.

Aside from the criteria exceedance, the chemical data did not show elevated or otherwise unusual concentrations of conventional and priority pollutants. By the same token, the chronic toxicity tests did not demonstrate the occurrence of ambient water toxicity. This is encouraging in that it appears that designated

uses in open bay and ocean waters are not impaired by toxic substances originating from nonpoint sources, although intensive biological sampling would be required to fully assess aquatic life uses. Although data were limited, sampling was conducted on three separate dates, and two test organisms were utilized as indicators of toxicity to the aquatic community.

The intent of this study was to evaluate potential for episodic toxicity in ambient waters due to nonpoint sources. Nonpoint sources of pollution originate from a number of different land uses including residential, commercial, industrial, agricultural and undeveloped uses. While data are considered preliminary, there does not appear to be a major threat which would impair designated fishery uses at least for the portions of the waterbodies sampled. We suspect the threat of nonpoint sources of toxic substances is much greater along western near-shore areas of Galveston Bay which receive considerable urban and industrial stormwater loading. Fecal coliform levels are elevated in this portion of the bay suggesting the negative influence of stormwater inputs. Contaminants may be patterned similarly. Tributaries within the bay system have historically been more impacted than open bays. Impacts of agricultural pesticides to water quality are likely to be of a localized, episodic nature in areas which are heavily farmed for rice and other crops.

With the exception of the Redfish Island station, sampling locations were situated relatively close to the shore. However, these areas were sparsely populated (with the possible exception of the Gulf of Mexico site), were not situated near tributary inputs, were far downstream of point source discharges, and were not heavily farmed. Thus, it should be evident that the suite of stations sampled do not represent a "worst case scenario" for nonpoint source toxics assessment. The results of this study indicate that additional open bay ambient toxicity studies are of relatively low priority. Should funds be available for nonpoint source toxics assessment in Galveston Bay, a smaller scale approach (e.g., subwatershed scale) should be taken to evaluate water quality in higher risk areas. Such waters include tributaries receiving agricultural runoff, near-shore areas near stormwater inputs, and streams and bayous in residential, urban and industrial land use areas.

CONCLUSIONS

A study to assess toxic nonpoint source impacts in lower Galveston Bay was completed. Data should be considered as preliminary screening results and were used to determine the need for more involved study. Both priority pollutant chemical analyses and chronic toxicity testing were performed for surface water samples collected from five stations on three sampling dates. None of the state water quality standards were exceeded. With the exception of EPA criteria exceedance for bis(2-ethylhexyl)phthalate at the Gulf of Mexico station, priority pollutants were either undetected, or present at low concnetrations. Toxicity test data for mysids and inland silversides did not indicate significant toxicity to either species. Although data are limited, ambient toxicity was not significant. These data indicate that aquatic life uses in the areas sampled are not impacted by nonpoint sources toxics. The need for future "open bay" type nonpoint source surface water studies is considered low. Should funding become available, studies to assess localized and/or episodic effects of stormwater inputs and agricultural runoff would be of greatest value.

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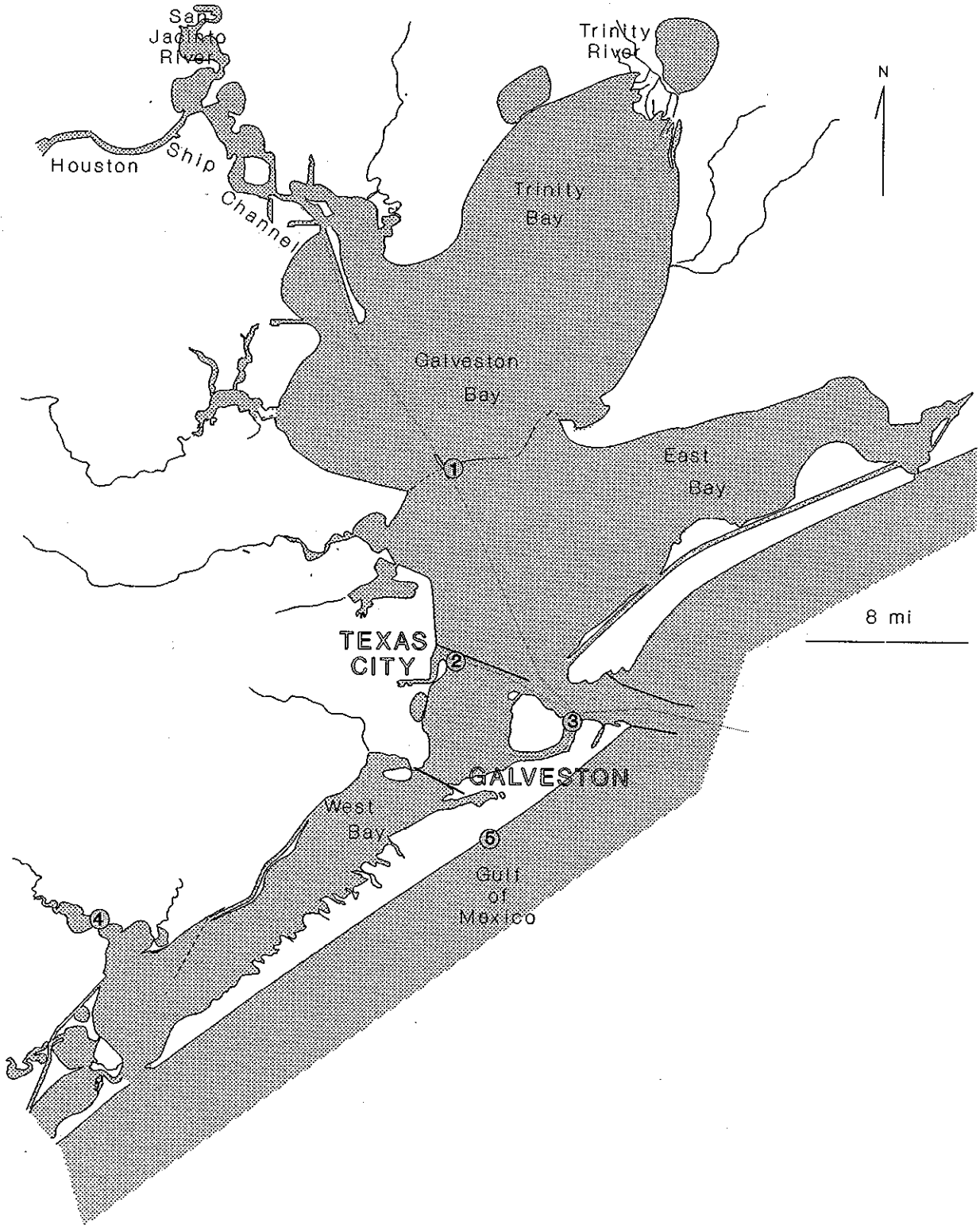

Figure 1. Sampling Station Locations.

Table 1. Sampling Station Locations.

STUDY STATION #	STATE STATION #	LOCATION	LATITUDE	LONGITUDE
1	24390025	Lower Galveston Bay Southeast of Redfish Island at Channel Marker 2	29°30'30"	94°52'37"
2	-	Texas City Ship Channel at Channel Marker 15	29°22'37"	94°51'52"
3	24390450	Galveston Channel between Seawolf Park and USCG Station	29°20'02"	94°46'32"
4	-	Chocolate Bay at Channel Marker 16	29°11'47"	95°09'23"
5	-	Gulf of Mexico at end of Gulf Coast Fishing Pier in Galveston	29°14'53"	94°50'09"

Table 2. Rainfall 10 Days Prior to Sampling.

SAMPLING EVENT	INITIAL SAMPLING DATE	WEATHER STATION LOCATION	DAILY RAINFALL IN INCHES										
			11/2	11/3	11/4	11/5	11/6	11/7	11/8	11/9	11/10	11/11	Total
I	11/12/92	Houston Avg*	.37	T	.01	T			T		.09	.57	1.04**
		Galveston		T	.01						.80	.19	1.0**
			5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30	5/31	6/1	Total
II	6/2/93	Houston Avg	.22	1.13	.11	.24	.03	.23	.09	.11	.56		2.72
		Galveston	.93	.09			.04			T	.37		1.45
			1/23	1/24	1/25	1/26	1/27	1/28	1/29	1/30	1/31	2/1	Total
III	2/2/94	Houston Avg	.02	.02	.18	.09	.27	.94	.16	.12		T	1.8
		Galveston				.06	.01	.07	.15			.04	.33

*Average of 11-12 stations in the Houston area;
**Total rainfall was 2.54" and 4.48" for Houston and Galveston, respectively, if rainfall for 11/1 was taken into account.

Table 3. Sample Collection Information and Field Data.

STATION	DATE	TIME (H)	DEPTH (FT.)	TEMPERATURE (°C)	pH	DO (mg/l)	CONDUCTIVITY (uMho/cm)	SALINITY (o/oo)
1	11-13-92	1010	1	17.09	7.82	-	39,900	-
	6-2-93	1045	1	26.23	8.28	8.34	16,500	8.5
	6-2-93	1045	19	25.25	8.13	7.33	20,100	13.6
	2-2-94	1528	1	10.18	7.67	9.14	33,400	20.8
2	11-13-92	1311	1	18.28	7.89	7.64	44,000	28.5
	6-2-93	1155	1	25.93	8.31	7.77	23,400	13.5
	6-2-93	1155	9	25.86	8.30	7.84	22,600	14.4
	2-2-94	1630	1	11.34	7.64	10.03	39,300	25.0
3	11-13-92	1215	1	17.31	7.82	7.43	41,000	26.2
	6-2-93	1301	1	26.67	8.45	9.34	27,300	18.3
	6-2-93	1301	25	25.84	8.33	7.24	31,300	18.8
	2-2-94	1700	1	10.30	7.72	10.17	37,000	23.4
4	11-12-92	1504	1	20.29	7.81	7.60	34,800	21.9
	11-12-92	1504	9	20.27	7.79	7.47	35,700	22.5
	6-3-93	1000	1	25.91	7.78	6.45	23,200	13.6
	6-3-93	1000	5	25.91	7.75	6.41	23,000	14.1
	2-3-94	0950	1	8.50	7.73	12.72	26,600	16.1
5	11-12-92	1716	1	18.96	8.01	7.61	46,000	30.0
	11-12-92	1716	12	19.01	7.99	7.84	46,000	30.0
	6-2-93	1440	1	26.65	8.46	7.99	29,300	18.2
	6-2-93	1440	12	26.68	8.45	8.03	28,900	18.1
	2-2-94	0928	1	9.11	7.42	10.22	41,000	26.2

Table 4. Concentrations of Heavy Metals and Conventional Parameters.

	STATION 1			STATION 2			STATION 3			STATION 4			STATION 5			BLANK		
	11/92	6/93	2/94	11/92	6/93	2/94	11/92	6/93	2/94	11/92	6/93	2/94	11/92	6/93	2/94	11/92	6/93	2/94
DISSOLVED HEAVY METALS (ug/l)*																		
ARSENIC	<3	<5.8	<3	<3	<5.8	<3	<3	<5.8	<3	<3	<5.8	<3	<3	<5.8	<3	<3	<5.8	<3
CADMIUM	<0.25	<1	<1	<0.25	<1	<1	<0.25	<1	<1	0.26	<1	<1	<0.25	<1	<1	<0.25	<1	<1
CHROMIUM +6	<25	<10	<10	<25	<10	<10	<25	<10	<10	<25	<10	<10	<25	<10	<10	<25	<10	<10
COPPER	1.7	<5	<5	1.8	<5	<5	<1	<5	<5	2.3	<5	<5	1.2	<5	<5	<1	<5	<5
LEAD	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
MERCURY	<0.2	<0.2	-**	<0.2	<0.2	-	<0.2	<0.2	-	<0.2	<0.2	-	<0.2	<0.2	-	<0.2	<0.2	-
TOT. MERCURY*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	<0.2
NICKEL	1.5	<10	<10	<1	<10	<10	1.4	<10	<10	11	<10	<10	3.7	<10	<10	<1	<10	<10
SELENIUM	<50	<5.8	<12	<50	<5.8	<12	<50	<5.8	<12	<50	<5.8	<12	<50	<5.8	<12	<50	<5.8	<12
SILVER	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
ZINC	2.3	<10	<10	4.6	<10	<10	1.2	<10	<10	5.5	<10	<10	5.3	<10	<10	4.3	<10	<10
CONVENTIONAL PARAMETERS (mg/l)																		
CHLORINE	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	<0.1	-	-	-	-
AMMONIA-N	0.05	0.05	0.04	0.04	0.04	0.22	0.05	<0.1	0.09	0.09	0.04	0.07	0.02	0.09	0.10	-	-	-
TOC	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-
TSS	64	24.8	12	12	11	15	32	16	10	62	11	20	27	52	50	-	-	-
TDS	-	-	21,000	-	-	23,100	-	-	23,100	-	-	15,900	-	-	23,100	-	-	-

*All values are for the dissolved fraction, except for total mercury.
**Not analyzed.

Table 5. Mysid Toxicity Results.

STATION	NOVEMBER 1992			JUNE 1993			FEBRUARY 1994		
	PERCENT SURVIVAL	WEIGHT (MG)	PERCENT W/ EGGS	PERCENT SURVIVAL	WEIGHT (MG)	PERCENT W/ EGGS	PERCENT SURVIVAL	WEIGHT (MG)	PERCENT W/ EGGS
CONTROL	87*	0.28*	51.3*	90	0.08	0	95	0.26	62.5
1	95	0.29	71.9	85	0.22	16.7	90	0.26	45.8
2	95	0.28	53.1	95	0.12	47.9	95	0.31	75.0
3	98	0.25	28.1	95	0.21	19.8	98	0.33	71.9
4	90	0.24	36.5	95	0.20	4.2	93	0.28	62.5
5	98	0.31	57.3	95	0.22	19.8	95	0.32	47.9

*Values are the means for five separate controls (survival, weight, fecundity): (1) 85%, 0.30 mg, 47.9%; (2) 95%, 0.29 mg, 62.5%; (3) 90%, 0.23 mg, 31.3%; (4) 83%, 0.26 mg, 49.0%; (5) 83%, 0.30, 65.6%.

Table 6. Inland Silverside Toxicity Results.

STATION	NOVEMBER 1992		JUNE 1993		FEBRUARY 1994	
	PERCENT SURVIVAL	WEIGHT (MG)	PERCENT SURVIVAL	WEIGHT (MG)	PERCENT SURVIVAL	WEIGHT (MG)
CONTROL	85*	1.25*	80	1.27	100	1.35
1	97	1.43	97	1.14	100	1.31
2	80	1.23	97	1.13	93	1.28
3	97	1.52	93	1.07	100	1.33
4	90	1.37	100	1.06	100	1.25
5	87	1.34	93	1.31	100	1.27

*Values are the means for five separate controls (survival; weight): (1) 80%, 1.24 mg; (2) 93%, 1.21 mg; (3) 87%, 1.36 mg; (4) 87%, 1.17 mg, (5) 77%, 1.26 mg.

Appendix A. Detection Levels for Chemical Parameters.

COMPOUND (UNITS)	DETECTION LEVEL BY SAMPLING DATE		
	NOVEMBER 1992	JUNE 1993	FEBRUARY 1994
SEMI-VOLATILE COMPOUNDS (UG/L)			
Acenaphthene	2	2	2
Acenapththylene	2	2	2
Anthracene	2	2	2
Benzidine	20	20	20
Benzoic Acid	10	10	10
Benzo(a)Anthracene	8	8	8
Benzo(a) Pyrene	8	8	8
Benzo(b)Fluoranthene	8	8	8
Benzo(g,h,i)Perylene	8	8	8
Benzo(k)Fluoranthene	8	8	8
Benzyl Alcohol	4	4	4
Bis(2-chloroethoxy)Methane	2	2	2
Bis(2-Chloroethyl)Ether	2	2	2
Bis(2-chloroisopropyl)Ether	2	2	2
Bis(2-Ethylhexyl)Phthalate	4	4	4
4-Bromophenylphenyl Ether	8	8	8
Butylbenzylphthalate	4	4	4
Carbazole	10	10	10
4-Chloraniline	4	4	4
2-Chloronapthalene	2	2	2
2-Chlorophenol	4	4	4
4-Chlorophenylphenyl Ether	8	8	8
4-Chloro-3-Methylphenol	8	8	8
Chrysene	8	8	8
Dibenzofuran	2	2	2
Dibenzo(a,h)Anthracene	8	8	8
1,2-Dichlorobenzene	3	3	3
1,3-Dichlorobenzene	3	3	3
1,4-Dichlorobenzene	3	3	3
3,3'-Dichlorobenzidine	10	10	10
2,4-Dichlorophenol	6	6	6
Diethylphthalate	2	2	2
2,4-Dimethylphenol	6	6	6
Dimethylphthalate	2	2	2
2,4-Dinitrophenol	30	30	30
2,4-Dinitrotoluene	6	6	6
2,6-Dinitrotoluene	6	6	6
4,6-Dinitro-2-Methylphenol	20	20	20
Di-n-Butylphthalate	2	2	2
Di-n-Octyl Phthalate	4	4	4
Fluoranthene	2	2	2
Fluorene	2	2	2
Hexachlorobenzene	2	2	2
Hexachlorbutadiene	5	5	5
Hexachloropentadiene	10	10	10
Hexachloroethane	3	3	3
Ideno(1,2,3-cd)	8	8	8
Isophorone	4	4	4
2-Methylnapthalene	2	2	2
2-Methylphenol	6	6	6
4-Methylphenol	6	6	6
Napthalene	2	2	2
2-Nitroaniline	8	8	8
3-Nitroaniline	8	8	8
4-Nitroaniline	8	8	8
Nitrobenzene	2	2	2
2-Nitrophenol	10	10	10
4-Nitrophenol	13	13	13
N-Nitrosodiphenylamine	4	4	4
N-Nitroso-Di-n-Propylamine	6	6	6
Pentachlorophenol	15	15	15

Appendix A, Continued

COMPOUND (UNITS)	DETECTION LEVEL BY SAMPLING DATE		
	NOVEMBER 1992	JUNE 1993	FEBRUARY 1994
Phenanthrene	2	2	2
Phenol	4	4	4
Pyrene	2	2	2
Pyridine	20	20	20
1,2,4-Trichlorobenzene	3	3	3
2,4,5-Trichlorophenol	6	6	6
2,4,6-Trichlorophenol	6	6	6
VOLATILE COMPOUNDS (UG/L)			
Acetone	2.5	5	5
Acrolein	50	100	100
Acrlonitrile	50	100	100
Benzene	1	2	2
Bromodichloromethane	1	2	2
Bromoform	1	2	2
Bromomethane	2.5	5	5
2-Butanone	2.5	5	5
Carbon Disulfide	2.5	5	5
Carbon Tetrachloride	1	2	2
Chlorobenzene	1	2	2
Chloroethane	2.5	5	5
Chloroform	1	2	2
Chloromethane	2.5	5	5
Dichloromethane	1	2	2
1,1-Dichloroethane	1	2	2
1,2-Dichloroethane	1	2	2
1.1-Dichloroethene	1	2	2
Cis-1,2-Dichloroethene	1	2	2
Trans-1,2-Dichloroethene	1	2	2
1,2-Dichloropropane	1	2	2
Cis-1,3-Dichloropropene	1	2	2
Trans-1,3-Dichloropropene	1	2	2
Ethylbenzene	2.5	5	2.5
2-Hexanone	2.5	5	5
Methylene Chloride	2.5	5	5
4-Methyl-2-Pentanone	2.5	5	5
1,1,2,2-Tetrachloroethane	1	2	2
Tetrachloroethene	1	2	2
Toluene	2.5	5	5
1,1,1-Trichloroethane	1	2	2
1,1,2-Trichloroethane	1	2	2
Trichloroethene	1	2	2
Vinyl Chloride	2.5	5	5
m- and p-Xylene	2.5	5	5
o-Xylene	2.5	5	5
PESTICIDES AND PCBS (UG/L)			
Alpha-BHC	0.05	0.05	0.05
Beta-BHC	0.05	0.05	0.05
Delta-BHC	0.05	0.05	0.05
Gamma-BHC	0.05	0.05	0.05
Heptachlor	0.05	0.05	0.05
Aldrin	0.05	0.05	0.05
Heptachlor Epoxide	0.05	0.05	0.05
Endosulfan I	0.05	0.05	0.05
Dieldrin	0.05	0.10	0.10
4,4'-DDE	0.05	0.10	0.10
Endrin	0.05	0.10	0.10
Endosulfan II	0.05	0.10	0.10
4,4'-DDD	0.05	0.10	0.10
Endrin Aldehyde	0.10	0.10	0.10
Endrin Ketone	0.10	0.10	0.10
Endosulfan Sulfate	0.10	0.10	0.10

Appendix A, Continued

COMPOUND (UNITS)	DETECTION LEVEL BY SAMPLING DATE		
	NOVEMBER 1992	JUNE 1993	FEBRUARY 1994
4,4'-DDT	0.10	0.10	0.10
Methoxychlor	0.20	0.50	0.50
Alpha-Chlordane	0.05	0.05	0.05
Gamma-Chlordane	0.05	0.05	0.05
Toxaphene	2.0	5.0	5.0
Aroclor-1016	1.0	1.0	1.0
Aroclor-1221	2.0	2.0	2.0
Aroclor-1232	1.0	1.0	1.0
Aroclor-1242	1.0	1.0	1.0
Aroclor-1254	1.0	1.0	1.0
Aroclor-1260	1.0	1.0	1.0
DISSOLVED METALS (UG/L)			
Arsenic	3.0	5.5	3.0
Cadmium	0.25	1.0	1.0
Chromium +6	25	10	10
Copper	1.0	5.0	5.0
Lead	5.0	5.0	5.0
Mercury (Dissolved and Total)	0.2	0.2	0.2
Nickel	1.0	10	10
Selenium	50	5.8	12
Silver	0.5	0.5	0.5
Zinc	1.0	10	10
CONVENTIONAL PARAMETERS (MG/L)			
Chlorine	NA	0.1	NA
Ammonia-Nitrogen	0.01	0.01	0.01
Total Organic Carbon	1	1	1
Total Dissolved Solids	NA	NA	1
Total Suspended Solids	1	1	1

NA = Not analyzed