WATER QUALITY, AMBIENT TOXICITY AND BIOLOGICAL INVESTIGATIONS IN THE HOUSTON SHIP CHANNEL AND TIDAL SAN JACINTO RIVER

OCTOBER 1991

TECHNICAL SECTION
WATER QUALITY MANAGEMENT BRANCH
WATER MANAGEMENT DIVISION
U.S. EPA-REGION 6
1445 ROSS AVENUE
DALLAS, TX 75202-2733

WATER QUALITY, AMBIENT TOXICITY AND BIOLOGICAL INVESTIGATIONS IN THE HOUSTON SHIP CHANNEL AND TIDAL SAN JACINTO RIVER

Philip A. Crocker[1], George J. Guillen[2], Richard D. Seiler[2]
Elise Petrocelli[3], Michele Redmond[4], Willie Lane[5],
Terry A. Hollister[6], David W. Neleigh[7]
and George Morrison[8]

October 1991

[1]Technical Section, Water Quality Management Branch, U.S. EPA, Region 6, 1445 Ross Avenue, Dallas, TX 75202-2733

[2]Biology Program, Texas Water Commission, District 7, 5144 E. Sam Houston Parkway N., Houston, TX 77015

[3]SAIC c/o U.S. EPA, Environmental Research Laboratory, South Ferry Road, Narragansett, RI 02882

[4]SAIC c/o U.S. EPA, Hatfield Marine Science Center, 2111 S.E. Marine Science Drive, Newport, OR 97365-5260

[5]Environmental Analysis Section, Surveillance Branch, U.S. EPA, Region 6, 1445 Ross Avenue, Dallas, TX 75202-2733; Present address: Compliance Monitoring Section, Houston Branch, U.S. EPA, 10625 Fallstone Road, Houston, TX 77099

[6]Inorganics Section, Houston Branch, U.S. EPA, 10625 Fallstone Road, Houston, TX 77099

[7]Technical Section, Water Quality Management Branch, U.S. EPA, Region 6, 1445 Ross Avenue, Dallas, TX 75202-2733; Present address: Texas Section, RCRA Permits Branch, U.S. EPA, Region 6, 1445 Ross Avenue, Dallas, Texas 75202-2733

[8]EPA, Environmental Research Laboratory, 27 Tarswell Drive, Narragansett, RI 02882

TABLE OF CONTENTS

FIGURES

TABLES

Executive Summary

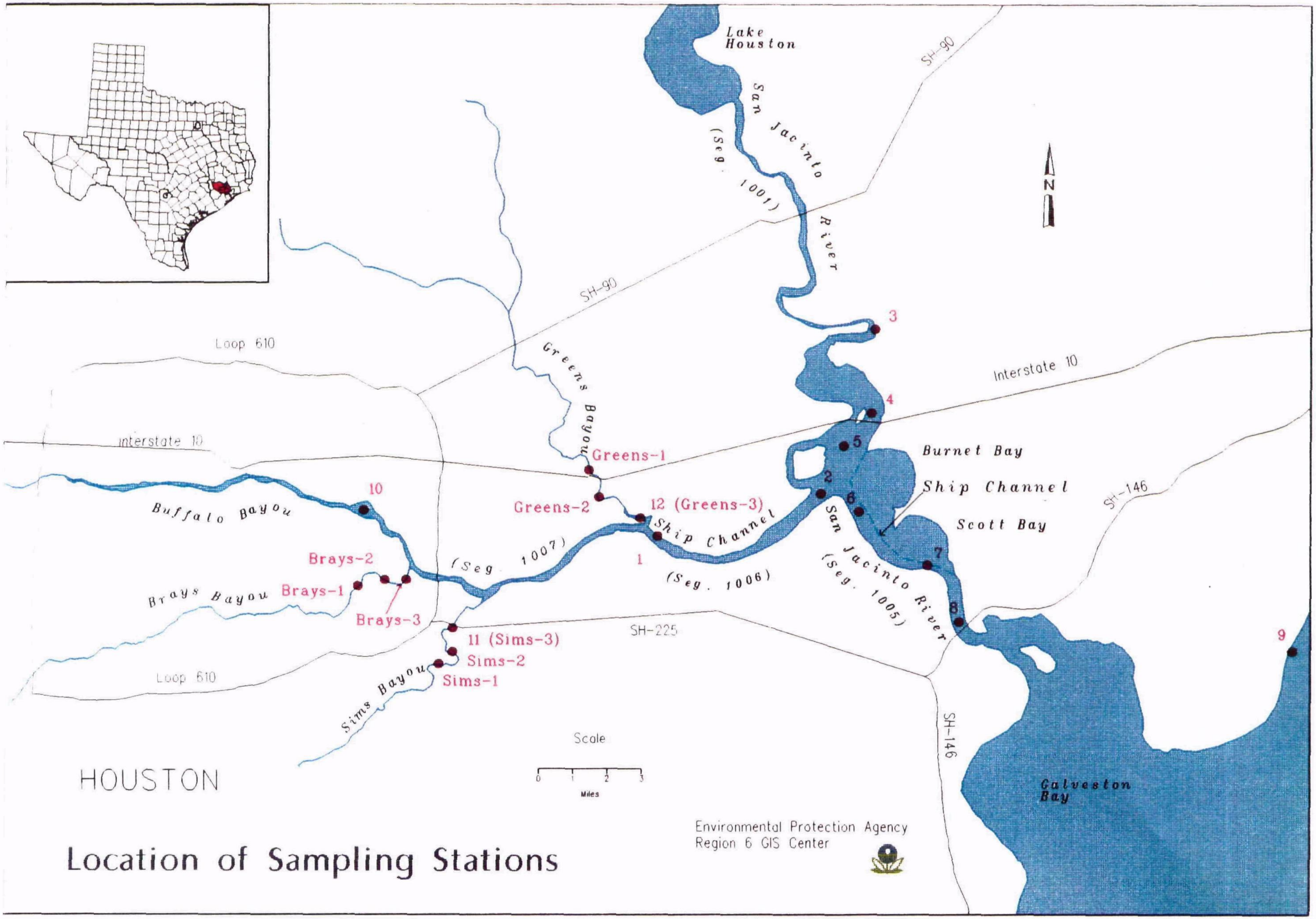
From 1988 to 1990 EPA-Region 6, in conjunction with the Texas Water Commission, conducted a water quality and ambient toxicity investigation of the Houston Ship Channel/San Jacinto River. The primary purpose was to determine if there were toxic conditions in the Ship Channel (segments 1006, 1007), tidal portions of the San Jacinto River (segments 1001, 1005) as well as three tidal tributaries (Brays, Greens and Sims Bayous). This information was gathered to better define water quality management needs for these waters, particularly with regard to toxics control of point source discharges.

The primary objective was to collect and analyze ambient water for priority pollutants, and to test ambient water for toxicity using short-term chronic marine testing protocols. These protocols incorporated the following test organisms: mysid shrimp (Mysidopsis bahia), inland silverside (Menidia beryllina), sheepshead minnow (Cyprinodon variegatus), sea urchin (Arbacia punctulata) and red alga (Champia parvula). Also, chemical analyses of bottom sediments and fish tissue, and toxicity testing of sediments were conducted on a limited scale.

Five surveys of the Ship Channel and tidal San Jacinto River were completed during August 1988, January 1989, February 1990, May 1990 and July/August 1990. Sampling of the three tributaries took place in September 1989. Follow-up sampling for heavy metals was also conducted at selected stations in January 1991. The map presented on the following page shows the relevant water quality segments and sampling station locations. The study was initiated using a core sampling network of nine stations, including two stations in segments 1001 (#3, 4) and 1006 (#1, 2), four stations in segment 1005 (#5-8) and a reference station in Trinity Bay at Umbrella Point (#9, segment 2422). This network was expanded in February 1990 to include stations in the Ship Channel Turning Basin (#10) and Sims Bayou (#11), both in segment 1007, and Greens Bayou (#12, segment 1006). Two additional stations (1A and 3A) were also established for nekton community monitoring.

The ambient toxicity results show no significant chronic toxicity effects to the sea urchin and sheepshead minnow. Significant growth effects were found for the inland silverside for stations 1-8 in January 1989 when compared to the reference site (#9). However, these differences may have been due to exceptional growth observed for fish exposed to reference site water. In contrast, in July/August 1990, growth of inland silversides exposed to reference site water was significantly lower than growth in the laboratory control.

Toxicity was most pronounced in the algal and mysid tests, with significant effects found at each station at least once out of four or five sampling events, with the exception of the algal test at station 5. The most impacted stations, where toxicity was found on three sampling events, include stations 11 and 12 for the mysid


Lake Houston
San Jacinto River
(Seg. 1001)
SH-90
SH-90
Loop 610
Interstate 10
Interstate 10
Greens Bayou
Greens-1
Greens-2
12 (Greens-3)
Ship Channel
(Seg. 1006)
(Seg. 1007)
Buffalo Bayou
10
Brays-2
Brays-1
Brays-3
Brays Bayou
11 (Sims-3)
Sims-2
Sims-1
Sims Bayou
SH-225
Loop 610
1
2
3
4
5
6
7
8
9
Burnet Bay
Ship Channel
Scott Bay
San Jacinto River
(Seg. 1005)
SH-146
SH-146
Galveston Bay
N
Scale
0 1 2 3
Miles
HOUSTON
Environmental Protection Agency
Region 6 GIS Center
Location of Sampling Stations

test. Significant toxicity to the alga was found three times at stations 1 and 2, and for each of the four sampling events at station 6 (downstream of Lynchburg Ferry). The data indicate that ambient toxicity in the Ship Channel varies temporally and spatially. Accordingly, the potential exists for impairment of the aquatic life use designated for segments 1001 and 1005. Ambient toxicity was most frequent in industrialized portions of the Ship Channel and its tidal tributaries. Continued routine or periodic ambient toxicity monitoring at fixed stations would be useful to assess the long-term impact and the effectiveness of point and/or nonpoint source toxics controls.

Dissolved oxygen data (DO) indicate that DO may be more limiting to aquatic life than toxic chemicals. Water quality standards (WQS) were not achieved in segment 1005 during warm weather conditions. DO water quality standards for this segment are 4 mg/l average and 3 mg/l minimum. Ship Channel segments 1006 and 1007, and their smaller tributaries, had pronounced hypoxia during warm weather conditions. However, the DO water quality standards (averages) of 2 mg/l average and 1.5 mg/l minimum for segment 1006 and 1 mg/l (minimum) for segment 1007 were not intended to support aquatic life uses. In several instances DO concentrations fell below the required minima, resulting in anoxic conditions.

Exceedances of chronic aquatic life and/or human health WQS or criteria were found for arsenic, copper, cyanide, lead, manganese, nickel, selenium, and total residual chlorine. However, during the course of this project segments 1006 and 1007 were required to meet only acute criteria. Nickel water quality standards exceedances in Segment 1005 during the August 1988 survey were of particular concern, and resulted in listing this segment under the Section 304(l)(B) of the Clean Water Act ("short list"). Several organic priority pollutant compounds were detected at low concentrations including phthalate compounds, alpha BHC, gamma BHC, and several volatile organic compounds. Chloroform was frequently detected in the 1-15 ug/l range, particularly at stations 1, 2, 10, 11 and 12.

Ship Channel bottom sediments were relatively nontoxic to the amphipod (Ampelisca abdita) and sheepshead minnow (elutriate procedure), with the exception of stations 1, 6 and 11. EPA organic priority pollutants were not detected in sediments collected from Ship Channel stations. However, several polynuclear aromatic hydrocarbons, a phthalate, and pesticides were detected in tributary sediments (stations 11 and 12). The metals in highest concentration when compared with the reference site included aluminum, iron, manganese and zinc. Other metals found at lower concentrations include arsenic, barium, chromium, cobalt, copper, lead, mercury, nickel and vanadium.

A variety of metals and organic priority pollutants were detected in edible fish and crab tissue. In most cases, where detected, concentrations were well below levels of concern. Unfortunately, detection limits for some organics were too high to assess the carcinogenic risk to humans. In some samples antimony (Segments 1001 and 1005), arsenic (all segments tested) and lead (Segments 1001 and 1005) appeared slightly elevated. There presently are no legally binding numeric criteria for these contaminants in fish tissue, and arsenic is presently under review by EPA. It is difficult to evaluate the risk to human health resulting from consumption of fish tissue containing arsenic since some evidence suggests that arsenic in seafood is organically bound and is readily metabolized by humans. In a separate investigation (Crocker and Young 1990), fish and crab tissue collected from the Ship Channel contained elevated levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin.

A nekton survey was conducted to compare the fish community in segments 1001, 1005, 1006 and 2422. The cumulative number of taxa found through seine collections was highest in segment 1001. The values for segments 1005 and 1006 were comparable. Highest and lowest gill net catch rates were observed in segments 2422 and 1006, respectively. Based on similar biological and hydrological characteristics and the presence of a commercial blue crab fishery observed in segment 1006, the previously established habitat use designation for this segment should be reevaluated. In spite of the low DO concentrations the Houston Ship Channel appears to be sustaining a fishery use.

Overall, the results of the nekton survey, as well as statistical trends analysis for heavy metals (Elliott 1990), provide evidence that water quality in the Houston Ship Channel has improved over the last 20 years. However, water quality continues to be impacted by a combination of point and nonpoint sources. The greatest concerns based on the study results are the low DO values for the three Ship Channel segments and tidal tributaries (Brays, Greens and Sims Bayous), periodic exceedances of state and EPA criteria for toxic substances, and periodic occurrence of ambient toxicity in all segments tested.

Future water quality management efforts should focus on cumulative reductions in biological oxygen demanding (BOD) and chemical oxygen demanding (COD) substances; nutrient loading; metals loading; and whole effluent toxicity. The state of Texas is presently evaluating point source loadings of metals to determine which facilities require waste load allocations. The newly adopted Texas WQS will require application of chronic aquatic life and human health standards, and chronic whole effluent toxicity testing of discharges in segments 1006 and 1007.

Recommendations

Based on the results of this study the following recommendations are offered:

1. Due to the nickel WQS excursions, the state's efforts to develop a total maximum daily load (TMDL) on nickel for the Houston Ship Channel are justified.

2. TMDL's may be necessary for other metals as well, particularly copper. Ambient and effluent data for copper and possibly other heavy metals should be evaluated to better define this need. The state has already taken steps to investigate these metals concerns.

3. The state and/or EPA should conduct periodic (e.g., quarterly) ambient toxicity testing at selected stations as a means to assess cumulative toxic effects of point and nonpoint discharges on aquatic life.

4. Based on the findings of the nekton survey conducted as part of this study, the state should assign aquatic life uses for segments 1006 and 1007. The state has recently adopted WQS revisions requiring application of chronic aquatic life criteria, human health criteria, and chronic whole effluent toxicity testing for these segments which would protect this use.

5. Periodic monitoring of antimony, arsenic, lead, dioxins and furans in edible tissue of fish and other seafood organisms in the Ship Channel and associated waters is recommended.

6. Future water quality investigations should attempt to better characterize tidal tributaries to the Ship Channel, including Brays, Greens and Sims Bayous, particularly with regard to ambient concentrations, sediment contamination and sources of toxic substances.

7. Presently, tributary and Ship Channel segments are combined in the state water quality standards. Based on the different hydrologic and habitat characteristics, the state should consider separating tributary and mainstem segments.

8. Long-term efforts should focus on decreasing BOD, COD and nutrient loading to Ship Channel segments and tributaries to prevent the occurrence of hypoxic conditions during low flow, warm weather conditions.

Acknowledgements

Many individuals played a significant role in these investigations. We are especially grateful to the Texas Water Commission (TWC) staff which provided assistance in the field as well as input on study design. These individuals include Randy Palachek, Cathy Albrecht, David Trimm (presently with Entrix Corp.), Mark Luedke, Linda Broach, Jim Rice and Rusty Evelo. These individuals were constantly faced with--and overcame--adversity which took the form of mechanical failures of the sampling vessels, running aground, extreme climatic conditions, long hours, and tight time frames.

Brian Cain (U.S. Fish and Wildlife Service-Clear Lake) provided valuable input concerning toxics monitoring activities in the Houston Ship Channel, and assisted in the reconnaissance survey.

Toxicity testing support was provided for the first two surveys by Robert Burgess, Pamela Comelo, Wendy Greene, Kathleen McKenna, Deborah Robson, Mark Tagliabue and Glen Thursby, all with SAIC-Narragansett, RI. Testing support on the final three surveys was provided by Wayne McCulloch, Jeffrey Black and Virginia Soln, all with EA Engineering, Science and Technology-Sparks, MD.

Chemical analyses of water and bottom sediments were conducted by the U.S. EPA Regional Laboratory, Houston. These analyses were coordinated by Barbara Feldman, Dave Stockton and Michael Daggett. Fish tissue analyses were performed under contract with Versar, Inc., McLean VA. Harry Kreigh (ESAT-Houston) and Mel Ritter (EPA-Houston) reviewed the QA/QC for the Versar fish tissue data.

Bruce McDonell (EPA-Dallas, presently with LCU Water Research Inst.) provided some valuable ideas and field survey assistance. Barbara Schrodt (EPA-Dallas) produced the report cover and the dissolved oxygen graphics. Kelly Moseman (CSC-Dallas) produced the map of the study area. Kim Owen (EPA-Dallas) typed appendix 3. Mimi Dannel (EPA-Dallas) developed a program to facilitate calculation of the marine ammonia water quality criteria.

This study was funded partly by using inhouse (EPA Region 6 and TWC) resources, and partly through considerable funding provided by U.S. EPA Headquarters. Funding was provided by Permits Division (Contract 68-01-7310, fish tissue analyses, August 1989) and the Assessment and Watershed Protection Division (AWPD) These grants included: 68-02-4254, for fish tissue analyses conducted in January 1989; and 68-03-3529 and 68-C9-0012 for toxicity testing. Two 104(b)(3) grants (X-006417-01-0 and X-006425-01-2) were provided by U.S. EPA Region 6 to the Texas Water Commission for the nekton survey and for field sampling assistance using funds obtained from U.S. EPA Headquarters AWPD.

We appreciate the technical review of the draft report by Sharon Parrish, Diane Evans and Mike Morton (EPA-Dallas), Dave Stockton (EPA-Houston), and Randy Palachek and Jeff Kirkpatrick (TWC-Austin).

INTRODUCTION

The Houston Ship Channel is located in Harris County, within the San Jacinto River Basin on the southeast Texas coast. It consists of a dredged channel created along portions of Buffalo Bayou and the San Jacinto River extending for about 25 miles between the Turning Basin in Houston to its mouth at Morgans Point on Galveston Bay (TWC 1987). This inland portion of the Ship Channel is comprised of three segments (1005, 1006 and 1007) which are classified in the Texas Water Quality Standards (TWC 1988a; 1991).

Designated beneficial uses for Ship Channel segments 1007 and 1006 include industrial water supply and navigation. The water quality standards for dissolved oxygen (DO) are 1.0 mg/l minimum for segment 1007, and 2.0 mg/l average and 1.5 mg/l minimum for segment 1006. The Texas Water Commission (TWC) has recently proposed chronic whole effluent toxicity requirements for all discharges and chronic numeric criteria for these segments (TWC 1991). By contrast, beneficial uses for segments 1001 include primary contact recreation, non-contact recreation and high aquatic life use. Designated uses for Ship Channel segment 1005 are the same, except primary contact recreation is non included. In order to protect the high aquatic life use in these segments the DO water quality standard was established as 4.0 mg/l average; 3.0 mg/l minimum.

The Houston Ship Channel is heavily impacted by point source discharges. The wasteload allocation lists approximately 400 industrial and municipal facilities which discharge directly or indirectly to this system (TDWR 1984). This point source influence has resulted in an effluent-dominated, tidally influenced flow regime. The system is also impacted by nonpoint sources, particularly urban runoff, and intrusion of contaminated groundwater. Except for the routine fixed station monitoring conducted by the TWC, recent studies to evaluate water quality including analysis of toxic substances in this system have been lacking.

Stanley (1989) has reviewed the growth and development of the Houston ship Channel, as well as water quality trends. Both Stanley (1989) and Eckhardt (1971) mentioned that in the late 1960's some considered the Houston Ship Channel to be the most polluted waterbody in the country, and possibly the world. Stanley's (1989) review indicates that reduced metals loading over the past 20 years has lead to more substantial declines of concentrations in water than in sediments. Arsenic, chromium and lead in water have shown the strongest declines. Arsenic, cadmium and lead concentrations in sediments appear to be trending downward. For many metals the high degree of variability complicates determinations on trends (Stanley 1989). Elliott (1990) evaluated statistical trends for heavy metals in Ship Channel waters during 1979-1989. Ambient data had been collected under the state monitoring network and entered into STORET. The analysis provided evidence that arsenic, cadmium, chromium and possibly mercury are decreasing; silver and selenium are increasing; and copper has been relatively stable.

This investigation included sampling of five water quality segments: (1) Segment 1007, Houston Ship Channel/Buffalo Bayou, which extends from a point immediately upstream of Greens Bayou confluence to a point 100 m upstream of US 59 including tidal portions of tributaries; (2) Segment 1006, Houston Ship Channel, which extends from immediately upstream of the San Jacinto River confluence to a point immediately upstream of Greens Bayou, including tidal portions of tributaries; (3) Segment 1005, Houston Ship Channel/San Jacinto River, which extends from the confluence with Galveston Bay at Morgans Point to a point 100 m downstream of IH 10; (4) Segment 1001, Tidal San Jacinto River, which extends from a point from 100 m downstream of IH 10 to the Lake Houston Dam; and (5) Segment 2422, Trinity Bay, served as a reference site.

The present study was undertaken based on two concerns. First, we were concerned that there was a high potential for toxic impact in segments 1001 and 1005 due to poor water quality from upstream segments 1006 and 1007. Toxic impact to 1001 was believed possible due to upstream saltwater intrusion, which under critical conditions, extends as far upstream as the Lake Houston Dam. The second reason for this study related to the NPDES program. Due to the effluent dominated nature of the Ship Channel, we believed the potential existed for an ambient toxicity problem in the Ship Channel. The EPA "Third Round Permit Strategy" was designed primarily to control whole effluent toxicity of individual discharges rather than the cumulative effects of multiple discharges. Thus, this investigation served also to evaluate the need for a separate strategy to address multiple discharges.

The overall purpose of the study was to characterize water quality of the Houston Ship Channel and tidal san Jacinto River, particularly with relation to toxic substances and ambient toxicity. The primary objective was to collect and chemically analyze ambient water for EPA priority pollutants and conduct ambient toxicity using short-term chronic marine testing protocols. Chemical analyses of bottom sediments and fish tissue, toxicity testing of sediments and a fish community assessment were also performed, but on a more limited scale.

METHODS AND MATERIALS

Study Design

An attempt was made to evaluate ambient conditions of segments 1001, 1005, 1006 and 1007. A fifth segment, 2422, Trinity Bay, was also sampled throughout the study. This station, located at Umbrella Point, served as a reference site since it was located out of direct influence of the Houston Ship Channel. Station locations were not positioned immediately downstream of facility discharges since we were more interested in overall water quality within the segment than effects due to specific points of influence. Station locations are described in Tables 1 and 2. A total of six surveys were conducted to address study objectives. Specific components evaluated during these surveys are presented in Table 3. Multiple sampling surveys were conducted to assess water quality during different seasons and hydrological conditions. The first two surveys in August 1988 and January 1989 consisted of nine stations, one of which was a reference site located, for the most part, out of the influence of the Houston Ship Channel, in Trinity Bay. A third survey conducted in September 1989 addressed tidal portions of three tributaries to the Ship Channel: Brays, Greens and Sims Bayous. The remaining three surveys, completed in February, May and July-August of 1990, consisted of monitoring the original nine stations, plus three additional ones: the Ship Channel Turning Basin, and Greens and Sims Bayous.

Sample Collection and Handling

Water samples were collected in mid-channel using a Johnson-Keck groundwater pump-type sampler or a Van Dorn sampler. During the first two surveys samples consisted of vertical composites made up of combined grab samples collected every five meters (m), i.e., 1 m, 5 m, 10 m, 15 m, etc. During subsequent surveys only surface water (1 m depth) was collected for testing and chemical analysis. It was initially thought that vertical composite sampling would yield more representative samples by taking into account the salinity gradient typical of this sub-estuary. However, after examining the data it was apparent that there was little difference between surface water, vertical composites, and bottom water from a toxicity and toxic constituent standpoint. Therefore, for subsequent sampling only surface water was sampled at depth of 1 m. Samples were placed in pre-cleaned containers which were first rinsed with ambient site water. Sample container type and preservation procedures were consistent with standard methods (U.S. EPA 1984). Samples destined for dissolved metals analysis were filtered using a 0.45 micron membrane filter generally within a few hours of collection. This period was necessary based on time constraints during sampling and as a precaution to reduce the possibility for sample contamination in the field. All samples were chilled to 4°C immediately after collection. While the majority of water samples were collected during surveys from August 1988-August 1990, follow-up sampling was also conducted at several stations in January 1991. These samples were analyzed for arsenic, copper, mercury and nickel.

Multiple samples per station were collected for toxicity testing. During the first two surveys samples were collected on Monday to initiate toxicity tests, with subsequent samples collected on Wednesday and Friday for test water renewal. During the remaining surveys, this procedure was abbreviated by collecting samples on Monday and Wednesday only, and eliminating the Friday collection.

The majority of sediment samples were collected during the first two surveys (August 1988; January 1989) at stations 1-9. Stations 11 and 12 were sampled during the final survey (July/August 1990). Sediment samples were collected using a weighted Peterson Grab for channel stations and an Eckman sampler for shallower bayou stations. Samples consisted of composites of three grabs collected from the same site. Upon collection samples were combined and gently but uniformly mixed. Samples were placed in pre-cleaned glass jars with teflon-lined lids using a teflon scoop. Effort was taken to minimize headspace in samples. Sample preservation consisted only of chilling samples to 4°C using wet ice immediately after collection.

Fish and some crab samples were collected using gill nets. Other crab samples were collected from baited crab pots. These procedures are consistent with EPA recommended sampling guidance (U.S. EPA 1982). The initial plan was to collect five to six adult specimens of an economically important benthic fish species as well as a crab species at each station in summer (August 1988) and winter (January 1989). However, it was soon realized that this would not always be possible based on time constraints, species availability and adverse weather conditions. In most cases we were able to collect at least a few individuals of each species which were used to make up composite samples. Upon returning to the laboratory, fish were identified, measured in terms of total length, and wrapped in heavy duty aluminum foil which had been pre-rinsed with hexane. Crabs were processed similarly although carapace width was recorded rather than total length. The wrapped samples were placed in Ziplock plastic bags and refrigerated until shipment.

Standard EPA chain-of-custody and sample handling procedures were followed for water, sediment and tissue (U.S. EPA 1983a). Tagged samples were place in ice chests, chilled with wet ice or blue ice, and shipped overnight by Federal Express to the appropriate laboratory.

Toxicity Testing of Ambient Water

A brief description of the standard marine chronic tests utilized is provided below (U.S. EPA 1988a):

Sheepshead minnow (Cyprinodon variegatus) larval survival and growth test; sheepshead minnow embryo-larval survival and teratogenicity test; inland silverside (Menidia beryllina) larval survival and growth test; mysid shrimp (Mysidopsis bahia) survival, growth and fecundity test; sea urchin (Arbacia punctulata) fertilization test; and the algal (Champia parvula) reproduction test. Sheepshead minnow, inland silverside and mysid shrimp were considered key ambient toxicity indicators since all of these species are indigenous to the Galveston Bay system. A brief description of the protocols used is given below.

The sheepshead minnow embryo-larval survival and teratogenicity test was performed by the EPA Houston Lab. For this test 10 fertilized eggs ≤ 18 h old were placed randomly in 400 ml nalgene culture dishes containing 250 ml of test or control water. Two replicates were used to test each water sample. Test water was renewed daily. Due to the early life stage feeding was not necessary. For this study incidence of teratogenicity and mortality were combined as a reflection of worst case conditions, although incidence of terata are generally rarely observed. Salinities of ambient test water did not require adjustment.

The sheepshead minnow survival and growth test was performed only during the February 1990 survey under contract with EA Engineering, Science and Technology, Inc., Sparks, MD (EA). For this test 10 larvae ≤48 h post-hatch were placed randomly in 1 liter beakers containing 500 ml of test or control water. Four replicates were used to test each water sample. Fish were fed and test water was renewed daily. Survival and growth (measured in dry weight per individual) were monitored over a 7 day period. Salinities of test water did not require adjustment.

The inland silverside survival and growth test is very similar to the sheepshead minnow test described above. Testing was performed by ERL-Narragansett for the first two surveys and EA for the final three surveys. Ten larvae ≤8 days post-hatch were placed randomly in 1 liter beakers containing 500 ml of test or control water. Three replicates were used to test each water sample. Fish were fed and test water was renewed daily. Survival and growth were monitored over 7 days. Salinities of test water were adjusted to 20 parts per thousand (o/oo) using hypersaline brine made from natural (Narragansett Bay) seawater or artificial sea salts.

The mysid test was performed by ERL-Narragansett for the first two surveys, the EPA Houston Lab for the third (bayous), and by EA for the final three surveys. Four or five juveniles 7-8 days old were placed in 10 cm culture bowls containing 100 ml of test or control water. Eight replicates were used to test each water sample. Shrimp were fed and test water was replaced daily. Survival and growth were monitored over 7 days. In addition, reproductive potential was established as the percentage of females containing eggs in the oviducts or brood pouch. Salinities of test water were adjusted to 20 o/oo using hypersaline brine or artificial sea salts.

The sea urchin fertilization test was performed by ERL-Narragansett during the first and second surveys. This test involves exposure of a dilute sperm suspensions to water samples for one hour. Eggs were then added and fertilization takes place over the next 20 minutes. At this point the tests were terminated and samples were preserved. Percent fertilization is determined through microscopic examination of aliquots. Salinities of test water were adjusted to 20 o/oo using hypersaline brine.

The algal reproduction test was performed by ERL-Narragansett during the first, second and fourth surveys. This test consisted of exposing the male and female plants together to test water for two days, at which time fertilization takes place. This was followed by placing female plants in a control medium for a 5-7 day recovery period, during which the cystocarps (evidence of reproduction) developed. The number of cystocarps were counted and toxicity was expressed as the reduction in number of cystocarps compared to the control. Salinities of test water were adjusted to 30 o/oo using hypersaline brine.

Toxicity Testing of Bottom Sediments

Toxicity of bottom sediments were tested using two protocols, the amphipod (*Ampelisca abdita*) acute survival test and the sheepshead minnow embryo-larval survival and teratogenicity liquid phase elutriate test.

The amphipod test was performed by ERL-Narragansett for stations 1-9 during the first and second surveys using standard American Society for Testing and Materials methodology (ASTM 1990). Application of this methodology in another Gulf coast estuarine situation has been documented by Redmond *et al.* (1991). Sediments were press sieved (2 mm) to remove large debris and potential predator species. The test consisted of 10 day exposure of juvenile amphipods to sediment samples under flow-through conditions. Filtered and aerated Narragansett Bay water taken from a relatively unimpacted location served as the water source. Thirty amphipods were placed in each 900 ml canning jar containing 200 ml of sediment and 600 ml of overlying water. Three replicates were used for each sediment sample. After 10 days the test was terminated and the contents of each test vessel were sieved through a 0.5 mm screen. Recovered animals were counted and any missing individuals were counted as mortalities.

The sheepshead minnow liquid phase elutriate test was conducted by the EPA Houston laboratory. Sediment test solutions were prepared according to Green *et al.* (1988). A volume of dilution water equal to four times the dry weight of the sediment was added to a nalgene mixing bottle containing the appropriate amount of sediment. This material was mixed end-over-end for 24 h, after which time the suspension was centrifuged at 10,000 RPM's for 10 minutes. The resulting eluate was used for testing and renewals. Sediment eluates were tested at 100% only. The sheepshead minnow embryo-larval survival and teratogenicity test described above was used to test toxicity of elutriates.

Nekton Survey

A complete description of the nekton sampling procedures is presented in Appendix 1. Nekton communities in segments 1001, 1005, 1006 and 2422 were sampled in August 1988 and January 1989. Three stations per segment were sampled using three 50 ft. replicate hauls made with a 15 ft. common sense seine. Two stations per segment were sampled using 200 ft. experimental (multiple mesh size) gill nets. Number of species, number of taxa, and total number of organisms were tabulated. Shannon-Weiner diversity (H') and Evenness indices (J) were computed for each gill-net and seine sample.

In addition, field measurements of water temperature, dissolved oxygen (DO), salinity, pH and secchi disk readings taken during nekton surveys. Both this and the nekton catch data were pooled and subjected to a two-way analysis of variance (ANOVA) to examine segment and seasonal differences. Catch data and the relationship between the physicochemical and population parameters were determined by linear correlation.

Physicochemical Measurements

Field Hydrolab measurements including pH, temperature, salinity, conductivity, dissolved oxygen (DO), as well as total residual chlorine (TRC) and secchi disk measurements were recorded at each station sampled. TRC was measured using a field titrimetric procedure. Physicochemical measurements were taken for surface water (1 ft.) and one or more vertical profiles were taken for all stations during each survey. These profile measurements were taken every 5-10 ft., i.e., 1, 10, 20, 30 ft., etc. to just above the bottom.

Chemical Analysis

Water and sediment samples were analyzed by the EPA Houston Lab. A listing of all conventional and toxic pollutants and their corresponding limits of detection are presented in Appendix 2. Water samples were analyzed using standard procedures for conventional and priority pollutants (U.S. EPA 1983a; 1984). Sediments were analyzed following EPA interim guidelines (U.S. EPA 1981).

Arsenic, selenium and thallium were analyzed with a Perkin & Elmer 5000 Atomic Absorption Spectrophotometer. Mercury was analyzed with a Spectro Products Inc. HG-3 Mercury Analyzer. Other metals were analyzed with a Jarrel Ash ICP-1150 Spectrophotometer. Volatile organics were analyzed with a Finnigan Model 4530 GC/MS, and pesticides and PCB's were analyzed with a Tracer 560 GC/ECD and HP 5890 GC/EDC. Chemical concentrations for sediment were reported on a dry weight basis.

Fish tissue analyses were conducted under contract by Versar Inc. Edible tissue samples of fish and crab were prepared at the laboratory. Fish tissue consisted of skinned fillets while crab tissue consisted of only the whitish flesh picked off of the body after removing the carapace, gill apparatus and internal organs. A listing of parameters analyzed are presented in Appendix 2. Arsenic, selenium and thallium were analyzed by atomic absorption spectroscopy with Zeeman background correction using EPA procedures (U.S. EPA 1983). Analysis for antimony, beryllium, cadmium, chromium, copper, lead, nickel, silver and zinc was done by inductively coupled plasma (ICP) using EPA SW846 method 6010. Mercury was analyzed by cold vapor atomic absorption using the method in the U.S. FWS manual "Patuxent Analytical Manual for Metals." Pesticides were analyzed using national Contract Laboratory Program (CLP) procedures which follow EPA method 8080.

Volatile and semivolatile organics were analyzed following EPA OSW Method 8240 and Method 8270, respectively. These procedures were developed by U.S. EPA-Region 4 (1988).

Data Evaluation

A combination of professional judgement, statistical procedures and available criteria were used to evaluate data. Toxicity data was evaluated in terms of statistical differences at $P<0.05$. Such determinations of significance are useful for differentiating the degree of impact between sites.

Chemical water quality is evaluated primarily through comparisons with U.S. EPA water quality criteria (U.S. EPA 1976; 1986) and state water quality standards (WQS) (TWC 1988a; 1991). Unionized ammonia was calculated from total ammonia using procedures presented by Hampson (1977) and compared with EPA criteria (U.S. EPA 1989a). Individual dissolved oxygen measurements were compared with DO minima and state WQS, while water column averages were compared to the average WQS. The state defines the average concentration in tidal waters to be the depth integrated mean of the mixed surface layer. If there is stratification, the mixed surface layer, that portion of the water column from the surface to the depth where conductivity is 6,000 umhos/cm greater than the surface value. In some highly stratified situations this may exclude bottom readings.

Sediments were evaluated using published national or state-specific percentile levels (Greenspun and Taylor 1979; Staples et al. 1985; TWC 1988b). These percentiles have been statistically derived using the STORET database. In addition, interim sediment quality criteria (U.S. EPA 1988b) were used where appropriate.

Fish tissue data was assessed using EPA's risk-based approach for carcinogens; reference doses (RfD's) were used for noncarcinogens (U.S. EPA-Region 4, 1991; U.S. EPA 1989b). Fish tissue "levels of concern" (LOC) were based on the following equations:

$$LOC = \frac{RL \times BW}{q1^* \times CR} \text{ for carcinogens or } = \frac{RfD \times BW}{CR} \text{ for noncarcinogens,}$$

where:
q1*=Cancer Potency Factor $(mg/kg/day)^{-1}$
RfD=Reference Dose (mg/kg/day)
RL=Risk Level (e.g., 0.0001 for cancer risk of 1 x 10-4)
CR=Consumption Rate (kg/day)
BW=Adult Body Weight (70 kg)

The consumption rate used was 0.015 kg/day as proposed by the TWC (1991). As followed by Crocker and Young (1990), an LOC for carcinogens of 1 in 10,000 (1×10^{-4}) served as a benchmark to establish potential problem sites/segments. To develop information on the risks over given waterbodies, fish and crab tissue concentrations were averaged by segment before comparing with the

LOC. Average tissue concentrations specific substances were calculated using the actual values when detected, and one-half the detection limit when not detected.

Quality Assurance

Prior to initiating this study a quality assurance (QA) project plan was prepared (U.S. EPA-Region 6 1988), which served as a framework for which analyses would be performed, survey schedules, responsibilities, etc. In general, data generated for this study was of good quality. All of the laboratories performing analyses have QA plans and standard operating procedures (SOP's) which are consistently followed. SOP's for biomonitoring laboratories include reference toxicant testing.

During the August 1988 and February 1990 surveys, mysid lab control survivals were 78.0% and 79.5%, respectively, which failed the criterion for acceptability of ≥80% outlined in U.S. EPA (1988a). While there is some question concerning data quality for these test results, we believe that these values are close enough to the criterion to warrant inclusion.

Another item concerns the lack of a laboratory control for mysids and inland silversides during the January 1989 survey. A laboratory control was omitted due to a shortage of test organisms. Although this is a shortcoming, due to the high survival exhibited for the reference site (station 9), we believe these data to be of sufficient quality to warrant inclusion.

Finally, the U.S. EPA (1988a) recommends that water samples not exceed a holding time of 36 h before being used in toxicity tests. Due to practical considerations, since sampling could only be conducted on two instead of three days during the last three surveys, this holding time was exceeded during the second half of the 7 day tests. However, sufficient volume was provided to allow daily test water renewal. We believe this approach did not significantly compromise data quality.

The EPA Houston Laboratory maintains records of all QA/QC data collected for the water and sediment analyses performed for this project. The EPA Houston Laboratory also conducted a QA/QC review of the Versar Inc. fish tissue data.

RESULTS

Toxicity Testing of Ambient Water

Table 4 qualitatively summarizes all of the ambient toxicity findings. Tables 5-10 present the ambient toxicity testing data for the various protocols used. There was no significant toxicity observed for the sea urchin test conducted one time in August 1988 and three times in January 1989. Because of these findings, continued use of this test was considered a low priority. In addition, no significant toxicity was found for the sheepshead minnow embryo-larval tests conducted at four stations in August 1988 and January 1989. The sheepshead minnow growth and survival tests conducted at each of the 12 stations in February 1990 also showed no significant effects.

The inland silverside test which was performed at all stations during five surveys showed toxicity during the January 1989 survey. Stations 1-8 demonstrated significantly reduced growth when statistically compared with the reference site. ERL-Narragansett did not include a laboratory control based on a shortage of test organisms, thus the only means of comparison was with the reference site. The finding of significant toxicity in test samples, while statistically correct, may only reflect the exceptional growth rate observed in the control. The reference site fish had a final mean individual dry weight of 0.863 mg. Weights for test waters ranged from 0.605 mg to 0.702 mg, which are greater than the 0.50 mg criterion for acceptable control growth. Based on these factors, the occurrence of significant toxicity to the silverside should be considered inconclusive. Ironically, the only other occasion where significant toxicity (growth) effects were found was at the station 9 reference site during the July 1990 survey.

Ambient toxicity was most pronounced for the mysid shrimp and algal tests, with significant effects found at least once (except for the alga at station 5) out of four or five sampling events. Algal toxicity was most extreme at station 6 (San Jacinto River below Lynchburg Ferry) where significant effects were found for each of the four sampling events. Toxicity was found on three sampling events at stations 1 and 2 (Ship Channel below Greens Bayou and at San Jacinto Monument) for the algal test, and stations 11 and 12 (Sims and Greens Bayous) for the mysid. Relative toxicity of samples from these stations treated with sodium thiosulfate was slightly greater than for untreated samples, although these differences do not appear appreciable. This indicates total residual chlorine was not contributing to the observed ambient toxicity. Mysid mortality was greatest (zero percent survival) at stations 1, 2 and 4 (San Jacinto River at IH10) during the July 1990 survey.

Toxicity Testing of Bottom Sediments

Sediment toxicity testing results are presented in Table 11. Based on the difficulty of sampling sediments and funding constraints, sediment toxicity testing was somewhat limited in terms of time and location. Both the sheepshead minnow elutriate and amphipod tests worked well with the Ship Channel sediments. In general sediments were not very toxic. Station 11 was the only station tested that was toxic to the sheepshead minnow while stations 1 and 6 were the only ones significantly toxic to the amphipod.

Nekton Survey

The following discussion is a brief summary of the nekton survey results. A complete discussion of the fishery and physicochemical data, including statistical analyses are presented in Appendix 1.

Overall, a total of 4993 organisms comprising 41 taxa were collected during both study periods with gill nets and seines. Both seines and gill nets targeted mainly shoreline fish populations. Seines served to selectively sample smaller species (<5 inches total length) and juvenile life stages while the gill nets primarily targeted larger organisms at deeper depths (>6 ft.).

A total of 789 organisms representing 33 taxa were collected from gill nets during the August 1988 and January 1989 surveys. For all segments, catches were generally higher during the August sampling. Highest and lowest catch rates were generally observed for segments 2422 and 1006, respectively. Catch rates in segment 1001 were also generally higher than in segments 1005 and 1006.

Higher numbers of taxa were collected in August 1988 than in January 1989. The highest number of taxa per segment was collected in segment 1001 in August 1988. The fewest taxa were collected in segment 1005 during January 1989. The relatively low number of taxa may however be partly due to the poor catch of one gill net which was accidentally tangled due to ship traffic. The number of taxa in segments 1005 and 1006 were similar during January 1989. Diversity and evenness indices fluctuated considerably between stations with no apparent pattern.

Several patterns in species composition between segments and sampling events was observed. Sea catfish (Arius felis) was one of the numerically dominant taxa in all segments during August 1988. In addition, blue crab (Callinectes sapidus) were most abundant in segments 1001 and 1006 during August 1988. Species such as Gulf Menhaden (Brevoortia patronus) and gizzard shad (Dorosoma cepedianum) dominated January 1989 gillnet catches. Blue crab continued to be abundant in segment 1006 during January 1989.

Seine catches yielded a total of 4204 organisms representing 25 taxa. Significant spacial and temporal patterns in abundance were observed. Lower total number of organisms were generally observed in January 1989 collections. Highest total number of organisms were collected in segments 1001 and 2422. Although yielding significantly lower number of taxa than segments 1001 and 2422, segment 1006 was not significantly different than segment 1005.

Diversity varied significantly between segments. Diversity values in segment 1001 were greater than those obtained from catches in segment 1006. Evenness did not vary significantly between stations and sampling periods.

Except for segment 2422, August 1989 collections were dominated by bay anchovy (Anchoa michilli). Grass shrimp was the dominant species collected in segment 2422 during this period. Segment 1006 also contained a high percentage of Gulf menhaden and spot during August 1988.

Gulf menhaden was numerically dominant in seine collections within segments 1005, 1006 and 2422 during January 1989. However, grass shrimp (Palaemonetes pugio) was dominant in segment 1001 during January 1989.

While conducting this survey we also observed a commercial fishery for blue crabs in segments 1001, 1005 and 1006 and the lower portions of segment 1007. Over 30 crab pots were present in segment 1006 alone during the survey in August 1988. It appeared that the majority of the crabbing in segments 1006 and 1007 was by one or two fishermen. Crab pots randomly sampled during the survey in segments 1001, 1005 and 1006 were found to contain similar high numbers of blue crabs. This is the first documented commercial fishing activity in the Houston Ship Channel in recent times. It appears that, since 1990, crabbing has diminished or stopped.

Physicochemical Field Measurements

All field monitoring data, including water temperature, pH, conductivity, salinity, dissolved oxygen (DO), secchi disk, and total residual chlorine (TRC) are presented in Appendix 3.

Salinity, conductivity, temperature and pH were generally within acceptable ranges for support of aquatic life and were in compliance with WQS. During several surveys, particularly during May 1990, salinity was unusually low due to flooding resulting from high winter and spring rainfall. Surface water temperatures at stations located in segments 1006 and 1007 were generally several degrees higher than the reference site, probably due to the influence of numerous thermally altered effluent discharging to Ship Channel segments.

A pH range of 6.5-9.0 must be maintained for all waters in the state. The WQS for pH were not achieved on two occasions, stations 5 and 7 in May 1991, with values of 6.46 and 6.45, respectively. The pH excursions are considered to be relatively insignificant.

There were a considerable number of DO WQS excursions observed during the course of this study (Table 12). Most of the violations took place during the August 1988 survey when temperatures were high. All excursions of the average mixed surface layer DO WQS took place at that time. Many violations of the DO minima WQS also occurred during August 1988 survey. However, DO minima violations also took place in numerous instances subsequent to that survey, particularly at tributary stations and at the Turning Basin (Station 10).

These comparisons of measured concentrations with state water quality standards indicate that hypoxic conditions are most prevalent during warm weather months. During these periods depths of $\geq$10 feet are most impacted (Figures 2-4). Upper segments of the Ship Channel (1006 and 1007) and tidal tributaries were most prone to hypoxic conditions. However, in general, WQS violations at stations were more pronounced in 1988 than in 1990, possibly indicating temporal improvement of water quality. Overall, the DO data are reflective of an organically enriched system with limited flushing and reaeration capacity. It should be realized that while a number of stations showed no WQS violations as such, the water quality standards for segments 1006 and 1007 (including tidal tributaries) were established to protect against nuisance/anoxic conditions rather than to protect aquatic communities. Accordingly, the relatively low frequency of standards violations gives an overly optimistic picture of the actual severity of low DO conditions in these waters.

There were some problems with the field titrimetric method used to analyze total residual chlorine (TRC). First, manganese interference often hampered the precision of the test to accurately quantify TRC. Data were not included if the separate manganese (Mn) interference test was not performed concurrently with the TRC test. Secondly, the level of detection of this field method was supposed to have been approximately 0.1 mg/l. In many instances we felt that the measurements lacked this level of precision. While we do not disqualify the data, we believe they should be interpreted with some degree of caution. A summary of stations/times where TRC was detected (therefore, where EPA acute and chronic water quality criteria of 13 ug/l and 7.5 ug/l were exceeded) is presented in Table 13. When detected, TRC was present at fairly low levels. TRC was not detected at stations 1, 2, 5 and 9. For the most part, TRC was not detected in the laboratory analysis, suggesting that the substance volatilized during sample handling and storage. While the data suggest a potential problem with TRC both in tributary and several channel stations, measurement methods were not precise enough for definitive conclusions.

Chemical Analysis of Ambient Water

Data for conventional water quality parameters is presented in Tables 14 and 15. Chloride, sulfate, alkalinity, total suspended solids (TSS), total organic carbon (TOC), total dissolved solids, and sulfide concentrations were within ranges commonly observed in the Galveston Bay system.

Total cyanide was detected only once, at station 6 (surface water) in January 1989, at a concentration of 30 ug/l. This value exceeded the WQS of 5.6 ug/l. However, total cyanide values are not directly comparable with WQS which are in terms of cyanide amenable to chlorination. Total cyanide did not exceed the 20 ug/l detection limit in bottom or vertical composite samples collected at station 6.

TRC (laboratory analysis of collected samples) was detected at station 3 on two dates (August 1988; January 1989). It was not possible to compare these values to field measurements since on the first date a Mn correction test was not conducted to address possible Mn interference, and on the second date TRC was not measured in the field.

Oil and grease was undetected at most stations and times. However, it was detected at relatively high concentrations at stations 1, 2 and 7 during January 1989. This may have been due to an oil spill, industrial discharges or nonpoint source runoff.

Ammonia was most elevated at the bayou stations. The EPA marine chronic aquatic life criterion of 0.035 mg/l unionized ammonia (NH_3) (U.S. EPA 1989) was exceeded in Sims Bayou (station 11) in May 1990 and July 1990. NH_3 concentrations for these dates were 0.038 mg/l and 0.053 mg/l, respectively. The primary cause for these elevated concentrations is believed to be municipal effluent loading.

Tables 15-17 present data for metals in ambient water. The following dissolved metals were undetected: aluminum, antimony, beryllium, cadmium, chromium, cobalt, mercury, thallium and vanadium. The dissolved metals which were detected, as well as stations and concentration ranges are listed below:

Metals Detected	Stations Where Detected	Range of Detected Values (ug/l)
Arsenic	1-3, 5, 6, 12	4.6-11.3
Barium	1-12	69-184
Copper	1,2,4,6,8	3.5-9.2
Iron	1, 2, 5, 11	27-68
Lead	2	123
Manganese	1-12	10-164
Nickel	1-12	6.6-36
Selenium	1	60
Zinc	1-12	19-78

Table 18 summarizes which water quality criteria and WQS were exceeded. The parameters of greatest concern are arsenic and nickel. Arsenic exceeded EPA human health criteria at stations 3 and 5 which are located in segments designated for aquatic life use. Exceedances of the criterion is not necessarily applicable for stations 1, 2, 10 and 12 which are not designated as such. However, detectable values at these stations indicate point source contributions. Nickel exceedances were most evident during the first survey in August 1988, although a number of detected values were found after this date.

An additional series of samples were collected from the Ship Channel in January 1991. These samples were analyzed for arsenic, copper, mercury and nickel (Table 17). Special effort was made to reduce the copper level of detection as much as possible. Through ICP-Atomic Emission an instrument detection level of 1 ug/l copper was achieved. Arsenic, mercury and nickel were not detected at any of the sites sampled. Copper exceeded chronic WQS at stations 1, 4 and 8. While these data are supported through QA/QC data, the values should be considered preliminary based on the limited application of ICP-Atomic Emission in ambient marine waters. These data indicate the need for more stringent point source controls to protect against chronic toxicity due to copper.

Table 19 presents organic priority pollutant data for ambient water. Most priority pollutant organic compounds were not detected in ambient waters. Detected compounds, including tentatively identified compounds are listed below:

Organics Detected	Stations Where Detected	Range of Detected Values (ug/l)
2-Methoxy-2-Methyl-Propane	1, 2, 5, 6	7.6-76.2
Bis (2-Ethylhexyl) Phthalate	1, 3, 5, 7, 10-12	4-46
Chloroform	1, 2, 5, 6, 10-12	2.1-15.6
Bromodichloromethane	10, 11	2.4-11
1,2-Dichloroethane	12	3.8
Chlorodibromomethane	10	3.1-4.8
Di-n-Butyl Phthalate	1, 9, 11	2-6
2,6-Dinitrotoluene	1	8
1,1,2-Tridecane	1	17

From this summary, it is evident that chloroform and bis (2-ethylhexyl) phthalate have the most widespread occurrence. While these compounds are also common laboratory contaminants, with one exception, they were not detected in field blanks which were collected, stored and analyzed in the same manner as ambient water samples. The one exception was that phthalates were present in the August 1988 field blank although this was a result of storing water in a plastic container. Concentrations of these and other organic priority pollutants were low, and no EPA water quality criteria nor state WQS were exceeded.

Chemical Analysis of Bottom Sediments

Sediment chemistry data are presented in Tables 20 and 21. Antimony, beryllium, cadmium, selenium, silver and thallium were undetected in all sediment samples.

The metals detected, stations and the range of detected values were as follows:

Metal Detected	Stations Where Detected	Range of Detected Values (mg/kg)
Aluminum	1-12	933-24,188
Arsenic	11, 12	4.8-5.1
Barium	1-12	6-356
Chromium	1-12	2-59
Cobalt	1-8, 11, 12	3-10
Copper	1-12	2-48
Iron	1-12	1,634-21,731
Lead	1-9	3-39
Mercury	2, 11	0.3-0.4
Nickel	1-8	2-22
Vanadium	1, 2, 4-8, 11, 12	5-43
Zinc	1-12	9-695

The EPA has not yet developed sediment quality criteria for metals. Therefore, assessment of the degree of contamination is somewhat problematic. However, the data were compared to the 85th percentiles for chemical concentrations in sediment reported by Greenspun and Taylor (1979) and TWC (1988b). Comparisons of measured concentrations with percentile values are listed in Table 22.

The highest degree of metals contamination was found at stations 2 (Houston Ship Channel near monument) and 11 (Sims Bayou). TWC and/or EPA 85th percentile value exceedances for zinc were found at stations 1, 2, 5, 6 and 11. Although there are no percentile values to compare with the data, there appears to be high sediment concentrations of aluminum, iron and to a lesser degree, barium. As a general rule, these metals were highest in the industrialized areas and lower in downstream portions of Segment 1005, and lowest at stations 9 (Trinity Bay reference site) and 3 (San Jacinto River). Concentrations of these metals at stations 1 and 2 were comparable to those at stations 11 and 12.

Priority pollutant organic compounds were not detected in sediment samples collected from stations 1-9 in August 1988 and January 1989 surveys. However in July 1990 sediment samples collected from stations 11 (Sims Bayou) and 12 (Greens Bayou) contained a number of acid/base neutral compounds and pesticides (Table 21). EPA has not completed development on marine sediment quality criteria, although interim criteria are available for two compounds detected, DDT and Phenanthrene. The criteria were calculated using an assumed total organic carbon concentration of 1.5%, which is the overall average for sediments collected from stations 1-8. This assumption was necessary since TOC data were not collected at stations 11 and 12. The DDT concentration of 230 ug/kg at station 12 exceeded the DDT criterion of 12.4 ug/kg. The phenanthrene criterion of 2085 ug/kg was not exceeded at station 11 (concentration=506 ug/kg).

As with metals in sediment, 50th percentile (median concentration) and 85th percentile values have been published for organics using EPA's STORET database. These percentile values and stations in exceedance of these values are presented in Table 22.

This comparison indicates that station 11 has elevated concentrations of phenanthrene, fluoranthene, pyrene, bis(2-ethylhexyl)phthalate and chlordane. The type of contamination at station 12 is somewhat different, with the presence of DDE and DDT being most significant. In addition to the organic priority pollutants found at these two sites, a great number of unidentifiable (non-priority pollutant) acid/base neutral compounds were found at relatively high concentrations.

<u>Chemical Analysis of Fish Tissue</u>

The fish tissue data is presented in Table 23. Criteria, considered to be levels of concern, used in evaluating fish tissue concentrations are listed in Table 24. Table 25 presents an average of all samples for fish and crab tissue by segment number. Finally, Appendix 4 presents the QA review of the fish tissue data.

Average fish and crab tissue concentrations for the four segments sampled were compared with the levels of concern in order to discern the degree of risk from fish consumption. Most priority pollutant metals were detected in edible fish and crab tissue. Mercury was detected in fish but not crab samples collected from segments 1001, 1005 and 1006. Concentrations were an order of magnitude less than the FDA Action Level of 1.0 mg/kg. Copper and zinc, which rarely reach dangerous levels in fish or crab tissue, did not appear elevated in the three study segments compared to the Trinity Bay reference site.

The three parameters of greatest concern include antimony, arsenic and lead. The antimony level of concern was slightly exceeded for fish in segments 1001 and 1005 and crabs in segment 1005.

The average concentrations of arsenic in tissue for segment 1005 (fish and crab) and Segment 2422 (fish) exceeded a risk level of 1×10^{-4}, assuming a consumption rate of 15 g/d. Average tissue concentrations of lead for both crab and fish from segments 1001 and 1005 exceeded the level of concern, 0.833 mg/kg. This value, which serves as the basis for the state's human health WQS for lead, was developed recently by the Texas Water Commission and the Texas Department of Health. It is based on existing knowledge on the relationship between consumption rate and blood level.

For numerous oranic priority pollutants, detection limits were too high to adequately assess risk to human health (Appendix 2). Ten organic priority pollutants were detected in fish and/or crab tissue, although the concentrations found were well below the levels of concern. It is interesting to note the low levels of volatile organic compounds (VOC's), DDD and DDE and phthalates for these samples. The greatest number of organic priority pollutants were found in crabs collected from Segment 1006 and fish from

DISCUSSION

A similar ambient toxicity investigation was conducted in the Calcasieu Estuary June-July, 1988 (Cunningham et al. 1990). As with the present study the mysid shrimp chronic test was more sensitive than the inland silverside and sheepshead minnow tests. In the present investigation the red algal test was comparable to the mysid test in terms of sensitivity, although sites toxic to one species were not necessarily toxic to the other. In both studies, a number of possible toxicants were detected in the water column, therefore, determination of which particular substances caused the toxicity is problematic. While both sites are heavily influenced by industrial discharges, the Calcasieu Estuary had a higher percentage of stations with toxic and contaminated sediments. The results of this study confirm our belief that ambient toxicity should be evaluated over time. Only with repeated, continual monitoring of ambient toxicity at fixed stations can one develop an estimate of the temporal variation of toxicity for a given waterbody. Ambient toxicity would not have been found to any great degree had we sampled only once or twice. We believe the need for repeated fixed station ambient toxicity is greater in complex systems such as the Houston Ship Channel and associated waters where it is important to address seasonal influences, changes in treatment efficiency of wastewater discharges, varying flow conditions, etc. Likewise, it is advantageous to have multiple datasets for chemical parameters with which to evaluate water quality conditions.

The ambient toxicity observed with mysid shrimp, alga, and inland silverside indicate possible toxic impacts to the indigenous aquatic community. Presently EPA and the state of Texas require use of sheepshead minnow and mysid shrimp under the Third Round NPDES Permit Strategy. Continued periodic ambient toxicity monitoring using mysids would be useful to assess the effectiveness of the Third Round Strategy. Implementation of the Third Round Strategy is roughly two-thirds complete, and it is not yet possible to fully gauge its effectiveness. However, undoubtedly it is resulting in some water quality improvement.

An encouraging finding was the general lack of sediment toxicity in Ship Channel bottom sediments. Exceptions to this were station 1 (below Greens Bayou), 6 (San Jacinto River near Lynchburg Ferry) and 11 (Sims Bayou). The occurrence of sediment toxicity was much lower than that found in the Calcasieu Estuary (Cunningham et al. 1990), where about two-thirds of the stations tested were significantly toxic to the amphipod. There are two possible reasons which may have accounted for the relatively low incidence of sediment toxicity. First, sediments were collected in mid-channel rather than as a transect. Ship Channel samples consisted of three-part composites generally collected from mid-channel. For the Calcasieu study, samples were collected along a transect consisting of side-channel-side subsamples. It is appropriate to include side areas since they serve as habitat for benthic organisms, and there is a greater likelihood for deposition of toxic substances. Secondly, segments 1005, 1006 and 1007 are routinely dredged. Maintenance dredging would complicate using sediments as an indicator of long-term contamination. In addition to sediment removal and circulation by dredging, another possible factor which could influence the sedimentation process is ship traffic. In several instances large ships were seen churning up bottom sediments with their propellers. Considering the high volume of ship traffic into and out of the Ship Channel, this could be a significant factor. Bulk sediment metal concentrations were highest in industrialized areas, with lower levels found as one proceeds downstream. Aluminum and iron, while present naturally, seemed to best portray this distribution. The tidal bayou stations were the only locations where contamination by organic chemicals was evident. Contaminants included bis (2-ethylhexyl) phthalate (Greens and Sims Bayous); pesticides including chlordane, DDE and DDT (Greens Bayou); and polynuclear aromatic hydrocarbons including phenanthrene, fluoranthene and pyrene (Sims Bayou).

Under Section 304(l)(B) of the Clean Water Act, EPA included segment 1005 on the "short list" based on excursions of the state water quality standard for nickel found in this study. This water quality standard is designed to protect marine life from chronic toxicity due to nickel exposure. Determination of other water quality standards violations were less defensible due to limitations of the field measurement as in the case of total residual chlorine, or were less widespread in occurrence. In this study, it was not possible to fully evaluate standards compliance for all parameters. While in general the detection limits for most organic priority pollutants was adequate, detection limits for some of the metals were higher than the WQS. These include mercury, silver, and in some cases in earlier surveys nickel, copper, lead and cyanide. As the survey progressed, efforts were made to improve detection levels. However, unfortunately, it was not feasible to address all parameters. Any follow-up studies need to carefully consider detection limits as an important data quality objective.

Other studies provide insight on point sources which may be contributing to ambient concentrations of nickel. Goodman (1989) calculated point source loadings of toxic substances to the Ship Channel using discharge monitoring reports submitted by facilities to the State. The analysis showed that the majority of nickel contributions were made in segment 1007, with approximately 9.35 lbs./day being discharged. The total point source discharges to the Galveston Bay system was 17.66 lbs./day. The Gulf Coast Waste Disposal Authority-Washburn Tunnel (GCWA) facility accounted for 50% of the point source discharges of nickel to the Bay. In 1990 EPA required major facilities discharging to the Houston Ship Channel to collect data on nickel concentrations in their effluents (Dannel 1991). A total of nine facilities were found to discharge greater than one pound per day of nickel. Results of this analysis were in agreement with those in Goodman (1989) in that the most significant nickel discharger was GCWDA. However, nickel loading (13.5 lbs./day) using the recent data was greater. Other significant dischargers included Occidental (~10 lbs./day), Rhom and Haas (5.83 lbs./day) and the City of Houston (4.105 lbs./day). The state is presently developing a total maximum daily load (TMDL) to better regulate nickel inputs to the Ship Channel.

Follow-up sampling conducted in January 1991 showed copper levels in the Ship Channel exceeding the state chronic WQS for copper. These analyses was performed using ICP-Atomic Emission whereby a lower detection limit was possible. Although the data are preliminary, the results show copper WQS violations in the Ship Channel, indicating the need to further investigate ambient levels and sources of copper.

Volatile organic compounds (VOC), including chloroform, and phthalates were the organic compounds most frequently detected. These compounds were found at a number of stations within the three Ship Channel segments. Chloroform is commonly found in wastewaters discharged by organic chemical manufacturers and pulp and paper mills. There are several such facilities discharging to segments 1006 and 1007. Overall, there were no EPA water quality criteria for carcinogenic organic chemicals exceeded at the 1×10^{-5} risk level. However, analyses indicate that a great number of both VOC and Acid/Base Neutral compounds were detected but could not be identified using the EPA Mass Spectral Library. Thus, it would appear that non-priority pollutants are more prevalent than priority pollutant organics.

The nekton survey provided useful data to indicate that segment 1006 supports an aquatic community, as well as a commercial blue crab fishery. State WQS presently do not designate an aquatic life use for this segment. Hydrologically and biologically, segment 1005 was very similar to 1006, particularly in January 1989 when gill net data showed that segments 1005 and 1006 had a similar number of taxa. Similar species compositions, catch rates, number of taxa, and water quality parameters (DO and salinity) were observed along the shoreline of these two segments. The greatest number of taxa collected by gillnet were found in segment 1001 (August 1988) and 2422 (January 1989).

Additional observations by one of the authors and unpublished data collected by the National Oceanic and Atmospheric Administration (NOAA) during the study period substantiate the extensive use of deeper waters of the Ship Channel by the nekton community. Seiler et al. (1991) compared nekton communities in segments 1006 and 1007 during 1988-89. They found 84 species overall, 76 species in segment 1006 and 59 species in segment 1007. Early life stages were found, indicating that the waterbody is used as a nursery area. They believe that although DO was seasonally depressed during warm weather periods, this does not have a completely detrimental effect to shoreline nekton communities. This may be due in part to better reaeration potential in these shallower waters. Another factor may be the ability of local populations to tolerate and/or avoid hypoxic areas. This avoidance may take the form of diurnal or seasonal movements.

In the upper Ship Channel segments (1006, 1007), and particularly the tributaries to the Ship Channel, low DO is viewed as a major limiting factor in support of healthy, balanced aquatic communities in these waters. In fact, we believe that hypoxia may be more important than the effects of toxic chemicals in limiting this use. The WQS for DO in these segments are designed to protect against nuisance conditions rather than to protect aquatic communities. Nevertheless, DO conditions are not so low as to preclude use of this waterbody by aquatic life.

The problem of low DO was most extreme during warm weather periods (May-September) when stratification develops and biological activity increases. Often DO would be within acceptable levels in the upper 5-10 feet of the water column and decrease to levels of <1 mg/l at greater depths. This is believed to be due to organic and nutrient loading primarily from municipal and industrial dischargers. Hypoxic conditions in the Ship Channel may be exacerbated by salinity stratification. The tributaries are quite impacted from algal blooms. This is evidenced visually through the water color, as well as through DO and pH depth profiles.

Although a variety of metals and organics were present in edible fish tissue, most concentrations were relatively low. However, three metals, antimony, arsenic and lead, exceeded levels of concern. Two factors which could possibly have influenced concentrations of these metals in edible fish tissue were: (1) in several cases sea catfish was collected for tissue analysis. This species is an opportunistic benthic-feeding species which is not commonly consumed by humans. (2) When averaging fish and crab tissue concentrations by segment, one half of the detection limit was used when one or more values were not detected. Particularly in the case of antimony, which had a detection limit of 3 mg/kg, this procedure may have introduced bias.

The arsenic tissue value is based on the EPA cancer potency factor at a risk level of 1×10^{-4}. Arsenic was ubiquitous in fish and crab tissue in the four segments sampled. Surprisingly the reference site had the highest level in fish tissue. Therefore, the bioaccumulation of arsenic may not necessarily be entirely due to point source discharges. Since arsenic was found in fish and crab tissue taken from the reference site, it is possible that arsenic bioaccumulation is ubiquitous.

EPA is presently reviewing the status of arsenic with regard to its potency and its significance in seafood. Some information suggests that arsenic in seafood is present as an organoarsenical and is readily excreted once consumed by man and animals (April 1990). This uncertainty complicates interpretation in the assessment of human health risk. A study by Texas A&M University in 1990 (TAMU 1991) detected arsenic in all edible fish tissues analyzed from the Galveston Bay system. Concentrations for sea catfish (Arius felis) collected from the mouth of the Ship Channel at Morgans Point contained an average of 1.98 mg/kg wet weight (range of 0.02-16.49 mg/kg). In comparison, average values for fish and crabs in the present study ranged from 0.25 mg/kg to 2.16 mg/kg wet weight. Antimony fish tissue data from other studies was not available.

The lead level of concern (0.833 mg/kg) was established by the state of Texas Water Commission and Health Department and serves as the basis for the human health WQS. This level of concern was exceeded for crabs and fish in segments 1001 and 1005. In another study, lead concentrations in sea catfish collected from Morgans Point were much lower, averaging 0.01 mg/kg wet weight in edible tissue (range: 0.0-0.08 mg/kg) (TAMU 1991). Values for other fish species collected at this site were similar, the overall average for Galveston Bay being 0.016 mg/kg.

In a previous study by Crocker and Young (1990), toxic equivalence concentrations (TEC) of 2,3,7,8-tetrachlorodibenzo-p-dioxin and 2,3,7,8-tetrachlorodibenzo furan in catfish, blue crab and oysters exceeded EPA's fish tissue level of concern. Subsequent to these analyses, the Texas Department of Health (TDH) analyzed additional seafood samples from the Ship Channel at Morgans Point, and upper Galveston Bay (TDH 1990). Concentrations of these samples were lower, but high enough to warrant concern with regard to health risk from consumption of seafood. Based on these findings the TDH issued a fish consumption advisory for the Houston Ship Channel and contiguous waters. Both as a result of these analyses, and based on presence of bleached kraft pulp and papermill discharges which are known to contain dioxins and furans, EPA included the Ship Channel (Segment 1005) on the 304(l)(B) list. This designation will require that water quality based controls for dioxin be established for dioxin dischargers.

LITERATURE CITED

April, Robert W. Memorandum to Cindy Sonich-Mullin, January 24, 1990. U.S. Environmental Protection Agency, Washington, D.C.

ASTM (American Society for Testing and Materials). 1990. Guide for conducting solid phase 10-day static sediment toxicity tests with marine and estuarine amphipods, E 1167.

Crocker, Philip A. and Carl Young. 1990. Tetrachlorodibenzo-p-dioxin and -dibenzofurans in edible fish tissue at selected sites in Arkansas, Louisiana and Texas. U.S. Environmental Protection Agency, Region 6, Water Quality Management Branch, Dallas, TX. March 1990.

Cunningham, Patricia, Randall Williams, Robert Chessin, Keith Little, Philip A. Crocker, Michael Schurtz, Charles Demas, Elise Petrocelli, Michele Redmond, George Morrison and R. Kirk Manuel. 1990. Toxics Study of the lower Calcasieu River. Research Triangle Institute, Research Triangle Park, NC. NTIS# PB90 226150/AS.

Dannel, Mary B. 1991. Unpublished data: nickel concentrations in Houston Ship Channel facility discharges. U.S. Environmental Protection Agency, Region 6, Water Quality Management Branch, Dallas, TX.

Eckhardt, B. 1971. How we got the dirtiest stream in America. Texas International Law Journal 7(1):5-28.

Elliott, Robert B. Memorandum to Jack V. Ferguson, March 16, 1990. Trends for heavy metals in the Houston Ship Channel and tidal San Jacinto River. U.S. Environmental Protection Agency, Region 6, Dallas, TX.

Goodman, Timothy M. 1989. Estimate of toxic material loading to the Galveston Bay system. Masters Thesis, University of Texas at Austin, Austin, TX. May 1989.

Greene, Joseph C., Cathy L. Bartels, William J. Warren-Hicks, Benjamin Parkhurst, Gregory L. Linder, Spencer A. Peterson and William E. Miller. 1988. Protocols for short term toxicity screening of hazardous waste sites. U.S. Environmental Protection Agency, Environmental research Laboratory, Corvallis, OR.

Greenspun, R.L. and P.L. Taylor. 1979. Nonparametric and comparison to criteria approaches to analyzing ambient water, fish and sediment residue data for metals, pesticides and several of the non-pesticide organic priority pollutants. U.S. Environmental Protection Agency, Monitoring and Data Support Division.

Hampson, B.L. 1977. Relationship between total ammonia and free ammonia in terrestrial and ocean waters. J. Cons. int. Explor. Mer. 37(2):117-122.

Redmond, Michele S., Kathleen M. McKenna, Elise A. Petrocelli, K. John Scott, Philip A. Crocker and Charles R. Demas. 1991. Use of toxicity test with the amphipod Ampelisca abdita to determine sediment toxicity in the lower Calcasieu River Estuary, Louisiana. Draft Manuscript.

Seiler, Richard and George Guillen. 1991. Utilization of the upper Houston Ship Channel by fish and macroinvertebrates with respect to water quality trends. In: Proceedings of the Galveston Bay Characterization Workshop, February 21-23, 1991, Houston, TX. Galveston Bay National Estuary Program. February 1991. GBNEP P-6. Pp. 39-45.

Stanley, Donald, W. 1989. Historical trends in water quality and fisheries resources in Galveston Bay, Texas (Draft Report). Report prepared for the National Ocean Pollution Program Office, National Oceanic and Atmospheric Administration, Rockville, MD by the Institute for Coastal and Marine Resources, East Carolina University, Greenville, NC.

Staples, Charles A., A. Frances Werner and Thomas J. Hoogheem. 1985. Assessment of priority pollutant concentrations in the United States using STORET database. Environmental Toxicology and Chemistry 4:131-142.

TAMU (Texas A & M University). 1991. Toxic contaminant characterization of aquatic organisms in Galveston Bay (Draft Report). Geochemical and Environmental Research Group, Texas A & M University, College station, TX. April 1991.

TDH. 1990. Unpublished data for dioxins and furans (analysis by Triangle Laboratories, Research Triangle Park, NC for the Texas Department of Health, Austin, TX). August 1990.

TDWR. 1984. Waste load evaluation for the Houston Ship Channel System in the San Jacinto River Basin. Texas Department of Water Resources, Austin, TX. WLE-1. July 1984.

TDWR. 1984. Waste load evaluation for the Houston Ship Channel System in the San Jacinto River Basin. Texas Department of Water Resources, Austin Texas. WLE-1. July, 1984.

TWC. 1987. Intensive survey of the Houston Ship Channel System. Texas Water Commission, Austin, TX. IS 87-09. July 1987.

TWC. 1988a. Texas Water Quality Standards. Texas Water Commission, Austin, TX. April 29, 1988.

TWC. 1988b. Texas Water Commission percentiles, ranges and averages for some parameters in the Texas water quality database. Texas Water Commission, Austin, TX.

TWC. 1991. Texas Water Quality Standards. Texas Water Commission, Austin, TX. July 1991.

U.S. EPA. 1976. Quality criteria for water. U.S. Environmental Protection Agency, Washington, D.C. NTIS# PB-263943.

U.S. EPA. 1981. Interim methods for the sampling and analysis of priority pollutants in sediments and fish tissue. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH. EPA 600/4-81-055.

U.S. EPA. 1982. Sampling protocols for collecting surface water, bed sediment, bivalves, and fish for priority pollutant analysis. U.S. Environmental Protection Agency, Office of Water Regulations and Standards. Final Draft.

U.S. EPA. 1983a. Methods for chemical analysis of water and wastes. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH. EPA-600/4-79-020, revised March 1983.

U.S. EPA. 1983b. NEIC policies and procedures. National Enforcement Investigation Center, U.S. Environmental Protection Agency, Denver, CO. EPA/330/9-78-001-R.

U.S. EPA. 1984. Guidelines establishing test procedures for the analysis of pollutants under the Clan Water Act; Final rule and interim final rule and proposed rule. Federal Register 49(209):1-210.

U.S. EPA. 1986. Quality criteria for water. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440/5-86-001. May 1, 1986.

U.S. EPA. 1988a. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH. EPA/600/4-87/028. May 1988.

U.S. EPA. 1988b. Interim sediment criteria values for nonpolar hydrophobic organic contaminants. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. May 1988. SCD# 17.

U.S. EPA. 1989a. Ambient Water Quality Criteria for Ammonia (Saltwater)-1989. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440/5-88-004. April 1989.

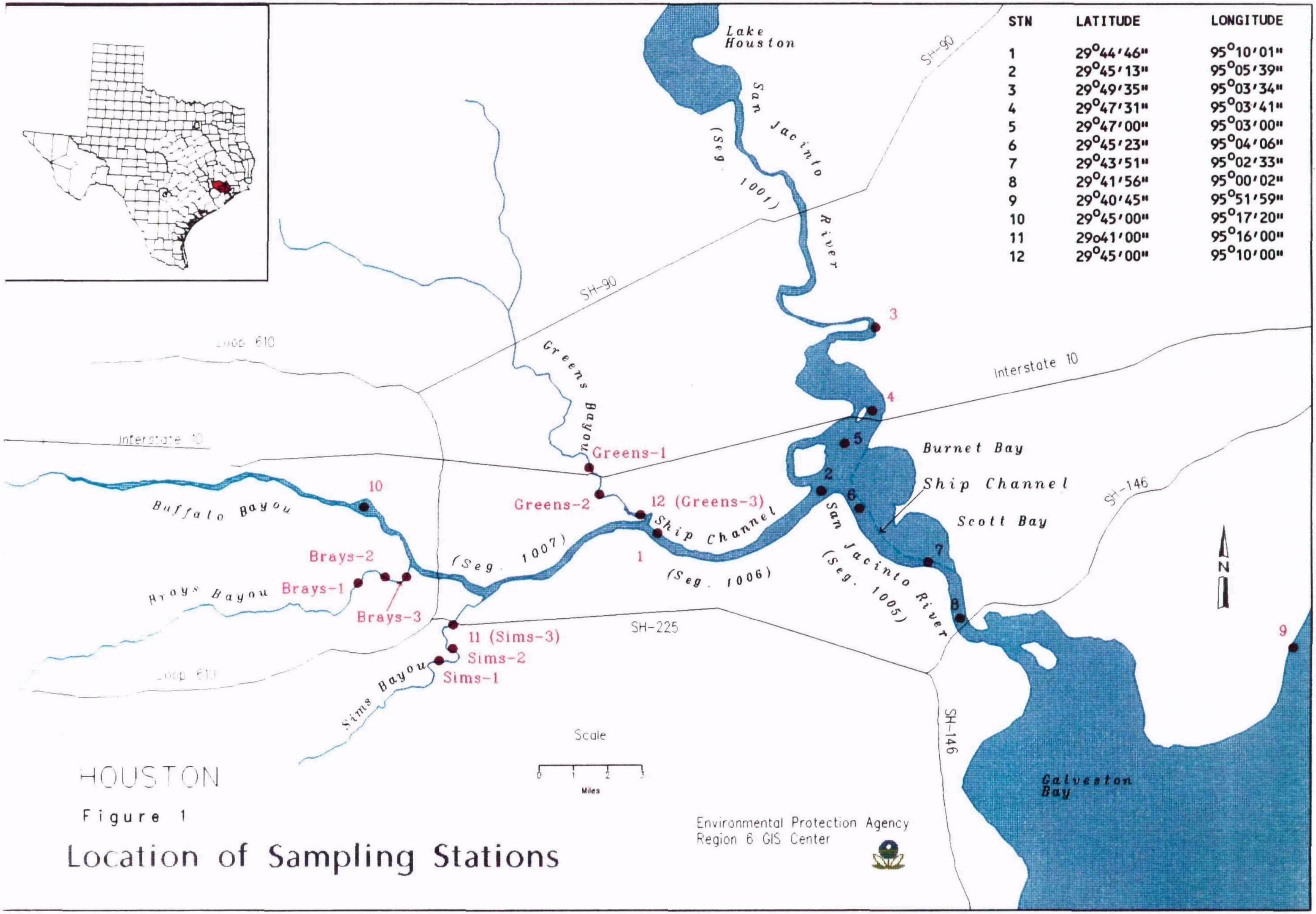
U.S. EPA. 1989b. Assessing human health risks from chemically contaminated fish and shellfish: a guidance manual. U.S. Environmental Protection Agency, Office of water regulations and standards. EPA-503/8-89-002. September 1989.

U.S. EPA-Region 4. Letter from Karen Gourdine, February 25, 1991, containing Toxic Substances Spreadsheet. U.S. Environmental Protection Agency, Region 4, Atlanta, GA.

U.S. EPA-Region 4. 1988. Extraction and analysis of organics in biological tissue. Method OB 3/88. U.S. Environmental Protection Agency, Region 4, Atlanta, GA. July 5, 1988.

U.S. EPA-Region 6. 1988. Tidal San Jacinto River project plan. U.S. Environmental Protection Agency, Region 6, Water Quality Management Branch, Dallas, TX. July 1988.

FIGURES



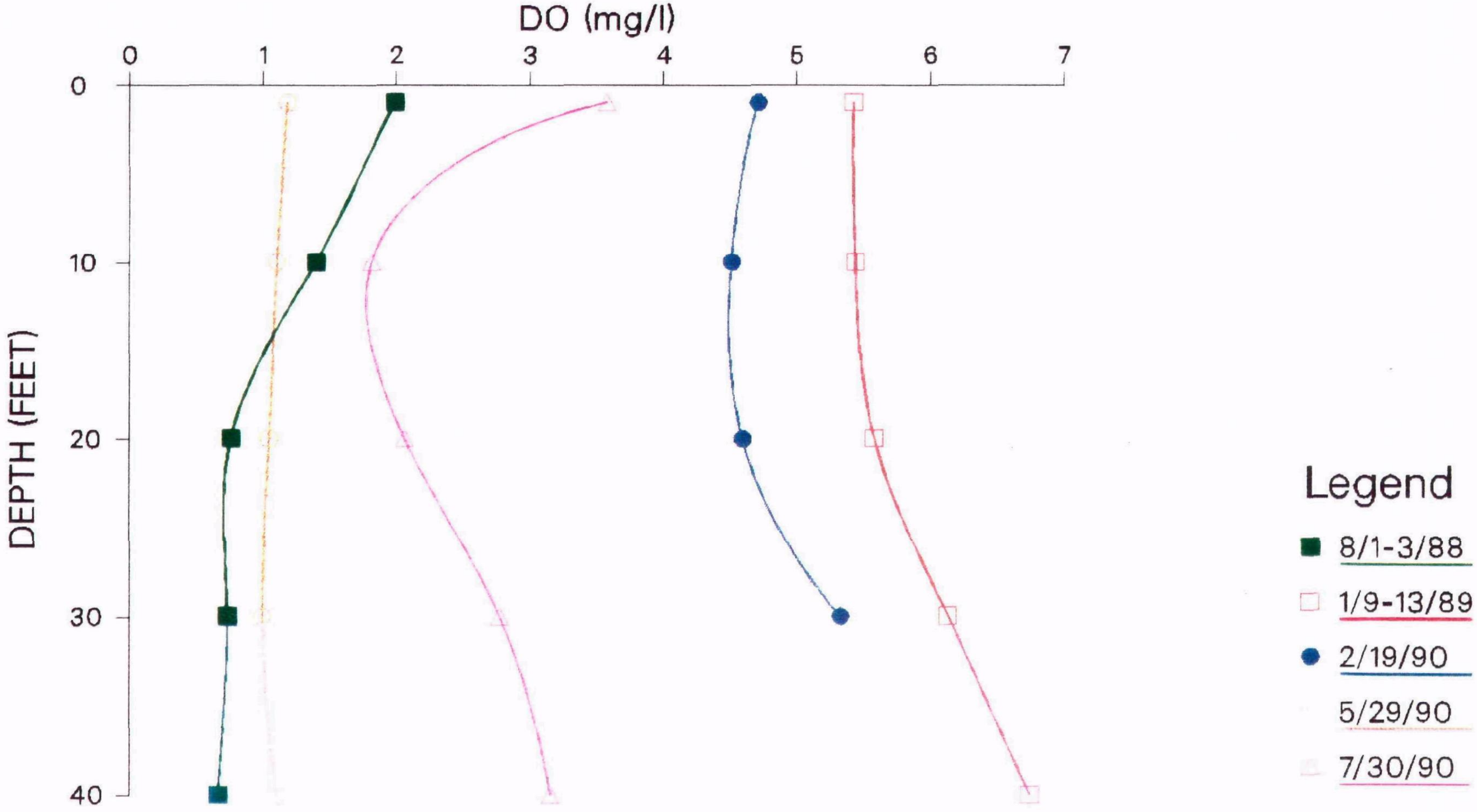
STN	LATITUDE	LONGITUDE
1	29°44'46"	95°10'01"
2	29°45'13"	95°05'39"
3	29°49'35"	95°03'34"
4	29°47'31"	95°03'41"
5	29°47'00"	95°03'00"
6	29°45'23"	95°04'06"
7	29°43'51"	95°02'33"
8	29°41'56"	95°00'02"
9	29°40'45"	95°51'59"
10	29°45'00"	95°17'20"
11	29o41'00"	95°16'00"
12	29°45'00"	95°10'00"

Figure 1

Location of Sampling Stations

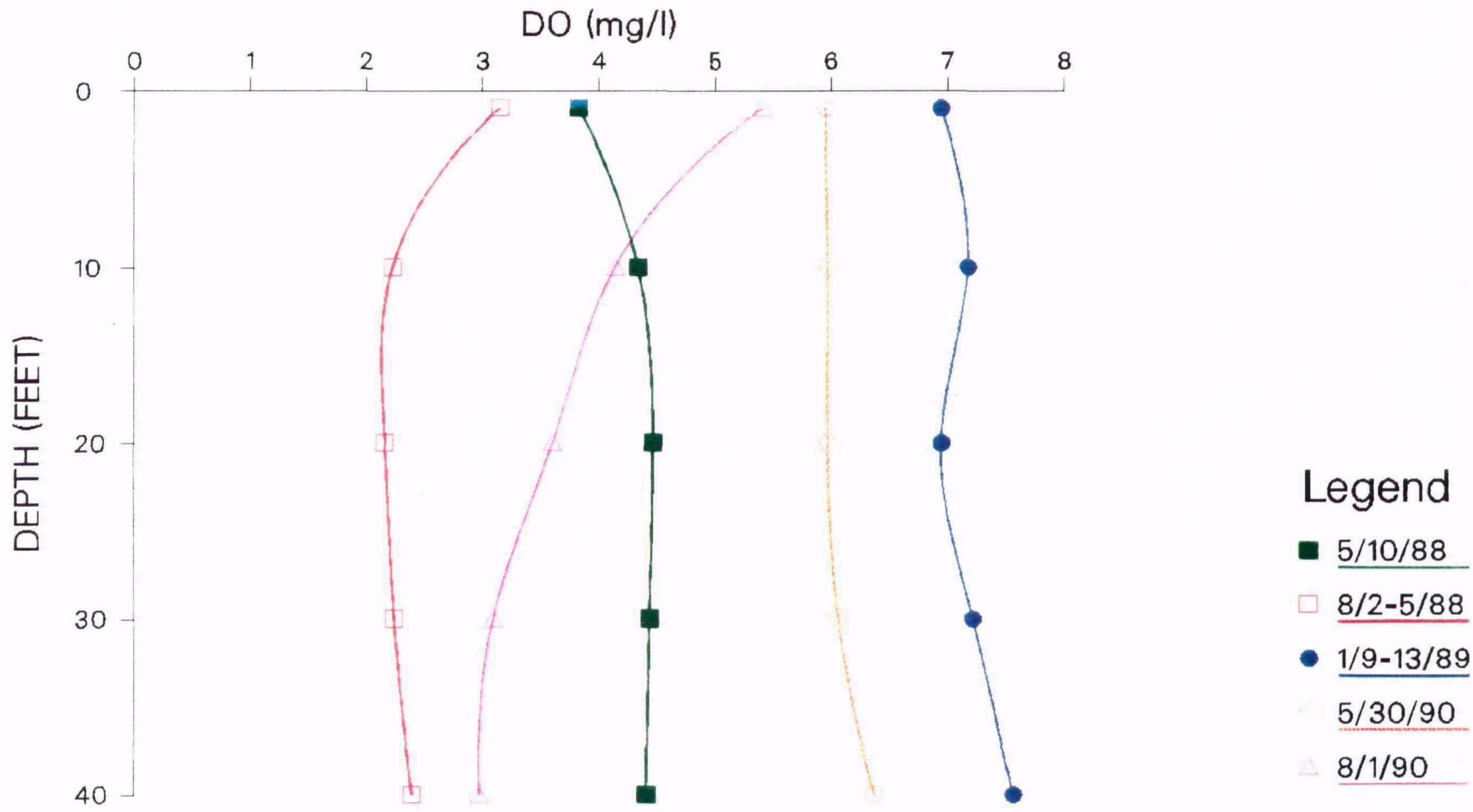
DISSOLVED OXYGEN PROFILE
HOUSTON SHIP CHANNEL, STATION 1

FIGURE 2



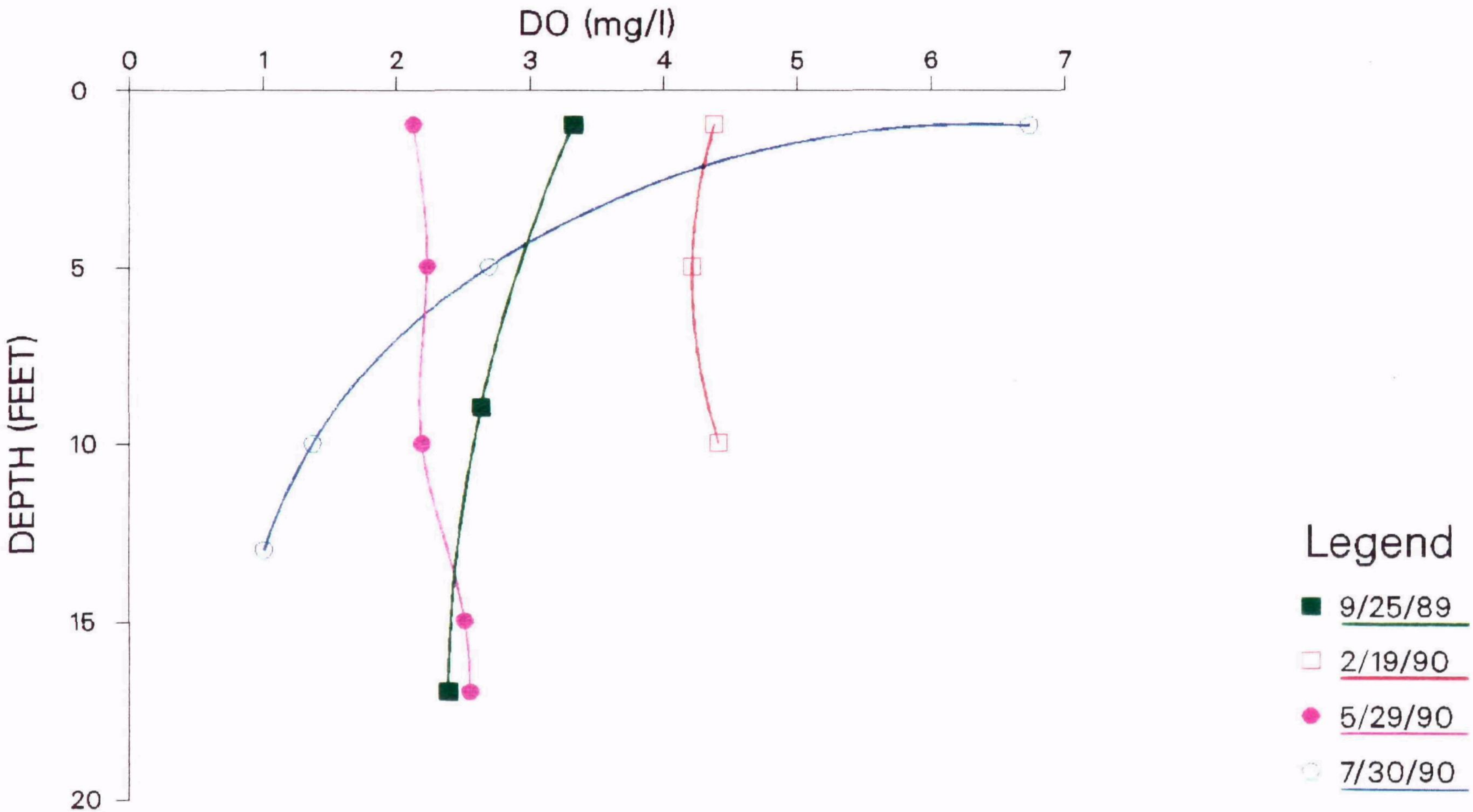
DISSOLVED OXYGEN PROFILE
TIDAL SAN JACINTO RIVER, STATION 6

FIGURE 3



DISSOLVED OXYGEN PROFILE
GREENS BAYOU, STATION 12

FIGURE 4



TABLES

TABLE 1. PRIMARY SAMPLING STATIONS.

STATION	SEGMENT*	LOCATION**	STATE STATION	RIVER MILE FROM GALVESTON BAY***	TOTAL DEPTH (FT.)
1	1006	HOUSTON SHIP CHANNEL 0.3 MILE DOWNSTREAM OF GREENS BAYOU CONFLUENCE, MIDWAY BETWEEN CHANNEL MARKERS 150 AND 152	0.5 KM DOWNSTREAM OF 1006.0200	15.2	45
2	1006	HOUSTON SHIP CHANNEL AT SAN JACINTO MONUMENT, UNDER POWERLINES	1006.0100	10.5	50
3	1001	SAN JACINTO RIVER TIDAL AT RIVER BEND ADJACENT TO CAFE AT CANAL STREET, HIGHLANDS, TX	-	9.4 (8.6)	18
4	1001	SAN JACINTO RIVER 100 M UPSTREAM OF I-10 BRIDGE	1001.0100	9.4 (2.4)	24
5	1005	SAN JACINTO RIVER AT BARGE LOADING AREA AT BUOY 6, APPROXIMATELY ONE MILE DOWNSTREAM OF THE I-10 BRIDGE	STATION QG (TWC 1987) 1005.0600	9.4 (1.2)	17
6	1005	SAN JACINTO RIVER/HOUSTON SHIP CHANNEL BETWEEN CHANNEL MARKERS 125 AND 126	NEAR STN Q (TWC 1987) (1005.0500)	9.3	50
7	1005	SAN JACINTO RIVER/HOUSTON SHIP CHANNEL ADJACENT TO SCOTT BAY AT CHANNEL MARKER 114	STATION U (TWC 1987) (1005.0170)	6.0	46
8	1005	SAN JACINTO RIVER/HOUSTON SHIP CHANNEL ONE KM DOWNSTREAM OF BAYTOWN TUNNEL AT CHANNEL MARKER 99	STATION X (TWC 1987) (1005.0120)	2.1	51
9	2422	TRINITY BAY AT UMBRELLA POINT, 100 M OFFSHORE, NEAR CRAWLEY'S BAIT CAMP AND POWER-GENERATING WINDMILL (REFERENCE SITE)	-	-	5
10	1007	HOUSTON SHIP CHANNEL/BUFFALO BAYOU, TURNING BASIN (MID-BASIN)	STATION F (TWC 1987) (1007.0800)	24.8	39
11	1007	SIMS BAYOU 100 M UPSTREAM OF SH-225 BRIDGE	-	20.8 (1.5)	15
12	1006	GREENS BAYOU 100 M DOWNSTREAM OF HARRIS COUNTY DRAINAGE CANAL	-	15.6 (0.4)	18

*SEGMENTS ARE LISTED IN THE STATE WATER QUALITY STANDARDS (WQS); THE WQS DO NOT DIFFERENTIATE BETWEEN MAINSTEM AND TRIBUTARY SEGMENTS.

**ALL RIVERINE STATIONS WERE SAMPLED AT MID CHANNEL.

***FOR TRIBUTARY SEGMENTS THE RIVER MILE DISTANCE SHOWN IS FROM THE MOUTH OF THE TRIBUTARY TO GALVESTON BAY; THE VALUE IN PARENTHESES IS THE DISTANCE FROM THE MOUTH OF THE TRIBUTARY TO THE STATION LOCATION.

TABLE 2. TRIBUTARY SAMPLING STATIONS, SEPTEMBER 1989.

STATION	SEGMENT*	LOCATION**	STATE STATION	RIVER MILE FROM GALVESTON BAY***	TOTAL DEPTH (FT.)
BRAYS-1	1007	BRAYS BAYOU, 100 M UPSTREAM OF I-45 BRIDGE	-	23.0 (3.3)	17
BRAYS-2	1007	BRAYS BAYOU, 100 M UPSTREAM OF LAWNDALE AVENUE BRIDGE	-	23.0 (2.3)	16
BRAYS-3	1007	BRAYS BAYOU, 100 M UPSTREAM OF 75TH STREET BRIDGE	STATION GC (1007.9405) (TWC 1987)	23.0 (1.6)	21
GREENS-1	1006	GREENS BAYOU, 50 M UPSTREAM OF I-10 BRIDGE	STATION KC (1006.9204) (TWC 1987)	15.6 (3.8)	28
GREENS-2	1006	GREENS BAYOU AT RIVER BEND	-	15.6 (2.5)	21
GREENS-3	1006	GREENS BAYOU, 100 M DOWNSTREAM OF HARRIS DRAINAGE CANAL; SAME SITE AS STATION #12	-	15.6 (0.4)	18
SIMS-1	1007	SIMS BAYOU, 100 M UPSTREAM OF GALVESTON ROAD BRIDGE	STATION HB (1007.9350) (TWC 1987)	20.8 (3.5)	11
SIMS-2	1007	SIMS BAYOU, 100 M UPSTREAM OF PARK PLACE BOULEVARD BRIDGE	-	20.8 (2.5)	14
SIMS-3	1007	SIMS BAYOU, 100 M UPSTREAM OF SH-225 BRIDGE; SAME SITE AS STATION #11	-	20.8 (1.5)	15

*SEGMENTS ARE LISTED IN THE STATE WATER QUALITY STANDARDS (WQS); THE WQS DO NOT DIFFERENTIATE BETWEEN MAINSTEM AND TRIBUTARY SEGMENTS.

**ALL RIVERINE STATIONS SAMPLED AT MID-CHANNEL

***FOR TRIBUTARY SEGMENTS THE RIVER MILE DISTANCE SHOWN IS FROM THE MOUTH OF THE TRIBUTARY TO GALVESTON BAY; THE VALUE IN PARENTHESES IS THE DISTANCE FROM THE MOUTH OF THE TRIBUTARY TO THE STATION LOCATION. AN ATTEMPT WAS MADE TO POSITION STATIONS APPROXIMATELY ONE, TWO AND AND THREE MILES UPSTREAM OF THE SHIP CHANNEL.

TABLE 3. SURVEY ACTIVITIES AND DATES*.

ACTIVITY/DATE	ACTIVITY DATE (MONTH/DAY) BY STATION												
	1	2	3	4	5	6	7	8	9	10	11	12	FIELD BLANK
AMBIENT WATER CHEMICAL ANALYIS													
AUG-88	8/1	8/1	8/1	8/1	8/1	8/2	8/1	8/1	8/1				8/1
JAN-89	1/12	1/12	1/11	1/11	1/11	1/12	1/12	1/12	1/11				1/12
FEB-90	2/20	2/20	2/19	2/20	2/20	2/20	2/20	2/20	2/19	2/19	2/19	2/20	2/20
MAY-90	5/29	5/30	5/29	5/30	5/30	5/30	5/30	5/30	5/29	5/29	5/29	5/29	5/29
JUL-90	7/30	7/31	7/30	7/31	7/31	7/31	7/31	7/30	7/30	7/30	7/30	7/30	7/30
JAN-91 (METALS ONLY)	1/14	1/14		1/14		1/14		1/14					1/8
SEDIMENT CHEMICAL ANALYSIS AND TOXICITY TESTING**													
AUG-88	8/10	8/10	8/3	8/3	8/3	8/2	8/3	8/10	8/3				
JAN-89	1/10	1/10	1/10	1/10	1/10	1/10	1/10	1/10	1/10				
JUL-90											8/1	8/1	
AMBIENT TOXICITY TESTING													
AUG-88	8/1	8/1	8/1	8/1	8/1	8/1	8/1	8/1	8/1				
	8/3	8/3	8/3	8/3	8/3	8/3	8/3	8/3	8/3				
	8/5	8/5	8/5	8/5	8/5	8/5	8/5	8/5	8/5				
JAN-89	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9	1/9				
	1/11	1/11	1/11	1/11	1/11	1/11	1/11	1/11	1/11				
	1/13	1/13	1/13	1/13	1/13	1/13	1/13	1/13	1/13				
FEB-90	2/19	2/19	2/19	2/19	2/19	2/19	2/19	2/19	2/19	2/19	2/19	2/19	
	2/21	2/21	2/21	2/21	2/21	2/21	2/21	2/21	2/21	2/21	2/21	2/21	
MYSIDS***	3/15	3/15	3/15	3/15	3/15	3/15	3/15	3/15	3/15	3/15	3/15	3/15	
MAY-90	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	5/29	
	5/31	5/31	5/31	5/31	5/31	5/31	5/31	5/31	5/31	5/31	5/31	5/31	
JUL-90	7/30	7/30	7/30	7/30	7/30	7/30	7/30	7/30	7/30	7/30	7/30	7/30	
	8/1	8/1	8/1	8/1	8/1	8/1	8/1	8/1	8/1	8/1	8/1	8/1	
FISH AND CRAB TISSUE CHEMICAL ANALYSIS AND NEKTON SURVEY													
AUG-88	8/5	8/5	8/3	8/3		8/5		8/2	8/2				
JAN-89		1/18	1/18	1/18		1/20		1/20	1/24				

*SEP-89: AMBIENT WATER CHEMICAL ANALYSES AND TOXICITY TESTING IN BRAYS-1 TO -3: 9/20; GREENS-1 TO -3: 9/25; SIMS-1 TSIMS-1 TO -3: 9/12.

**TOXICITY TESTING USING THE AMPHIPOD WAS NOT CONDUCTED IN JUL-90; TESTING USING THE SHEEPSHEAD MINNOW TEST WAS CONUCTED ON THE FOLLOWING DATES AND STATIONS: AUG-88 (4,5,9); JAN-88 (1,4,6,9); AND JUL-90 (9,11,12).

***DUE TO POOR CONTROL SURVIVAL IN THE MYSID TEST, ADDITIONAL SAMPLES WERE COLLECTED IN MARCH FOR RETESTING.

TABLE 4. SUMMARY OF AMBIENT TOXICITY RESULTS.

	STATION											
TEST/DATE	1	2	3	4	5	6	7	8	9	10	11	12
<u>AMBIENT WATER</u>												
SHEEPSHEAD MINNOW												
8/88	-			-		-			-			
1/89	-			-		-			-			
9/89											-	-
2/90	-	-	-	-	-	-	-	-	-	-	-	-
INLAND SILVERSIDE												
8/88	-	-	-	-	-	-	-	-	-			
1/89	+	+	+	+	+	+	+	+	-			
2/90	-	-	-	-	-	-	-	-	-	-	-	-
5/90	-	-	-	-	-	-	-	-	-	-	-	-
7/90	-	-	-	-	-	-	-	-	+	-	-	-
MYSID SHRIMP												
8/88	-	-	-	-	-	-	-	-	-			
1/89	+	-	-	-	-	-	-	-	-			
9/89											+	-
3/90	-	-	-	-	-	-	-	-	+	+	+	+
5/90	-	-	-	-	+	-	+	+	+	-	-	+
7/90	+	+	+	+	-	-	-	+	-	+	+	+
RED ALGA												
8/88	+	+	+	-	-	+	+	-	-			
1/11/89	+	+	-	+	-	+	-	-	-			
1/13/89	+	+	-	+	-	+	+	+	+			
2/90	-	-	-	-	-	+	-	-	-	+	+	+
SEA URCHIN												
8/88	-	-	-	-	-	-	-	-	-			
1/89	-	-	-	-	-	-	-	-	-			
<u>BOTTOM SEDIMENTS</u>												
SHEEPSHEAD MINNOW												
8/88				-	-				-			
1/89	-			-		-			-			
7/90											+	-
AMPHIPOD												
8/88	-	-	-	-	-	-	-	-	-			
1/89	+	-	-	-	-	+	-	-	-			

- = NO SIGNIFICANT TOXICITY
+ = SIGNIFICANT TOXICITY COMPARED TO CONTROL

TABLE 5. AMBIENT TOXICITY TO THE SHEEPSHEAD MINNOW.

STATION	EFFECTS AFTER SEVEN DAYS EXPOSURE (MEAN VALUES)					
	AUG-88		JAN-89		FEB-90	
	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)*	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)*	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)
LABORATORY CONTROL	97.0		95.0		94.0	0.19
1 SURFACE					97.0	0.13
1 COMPOSITE	97.0		100.0			
1 BOTTOM						
2 SURFACE					92.5	0.16
2 COMPOSITE						
3 SURFACE					97.5	0.18
3 COMPOSITE						
4 SURFACE					97.5	0.16
4 COMPOSITE	97.0		95.0			
5 SURFACE					100.0	0.18
5 COMPOSITE						
6 SURFACE					92.5	0.17
6 COMPOSITE	90.0		90.0			
6 BOTTOM						
7 SURFACE					92.5	0.21
7 COMPOSITE						
8 SURFACE					92.5	0.21
8 COMPOSITE						
9 SURFACE	100.0		95.0		92.5	0.19
10 SURFACE					95.0	0.12
11 (SIMS-3) SURFACE					95.0	0.14
11 " " D**					92.5	0.15
12 (GREENS-3) SURFACE					92.5	0.17
12 " " D**					100.0	0.17

*ON THESE DATES ONLY SURVIVAL WAS EVALUATED.
**DUPLICATE SAMPLES WERE COLLECTED AND TESTED FOLLOWING ADDITION OF SODIUM THIOSULFATE.
NOTE: NO SIGNIFICANT (P=0.05) EFFECTS WERE FOUND.

TABLE 6. AMBIENT TOXICITY TO THE INLAND SILVERSIDE.

STATION	AUG-88 SURVIVAL (%)	AUG-88 FINAL MEAN DRY WT. (MG)	JAN-89 SURVIVAL (%)	JAN-89 FINAL MEAN DRY WT. (MG)	FEB-90 SURVIVAL (%)	FEB-90 FINAL MEAN DRY WT. (MG)	MAY-90 SURVIVAL (%)	MAY-90 FINAL MEAN DRY WT. (MG)	JUL-90 SURVIVAL (%)	JUL-90 FINAL MEAN DRY WT. (MG)
	EFFECTS AFTER SEVEN DAYS EXPOSURE (MEAN VALUES)									
LABORATORY CONTROL	93.3	0.579	--*		100.0	0.86	95	0.77	95.0	0.65
1 SURFACE	91.1	0.536	96.7	0.641 b	96.0	0.82	100.0	0.80	90.0	0.61
1 COMPOSITE	84.4	0.600	96.7	0.610 b						
1 BOTTOM	97.8	0.564	100.0	0.702 b						
2 SURFACE					100.0	0.94	97.0	0.85	97.0	0.61
2 COMPOSITE	93.3	0.570	93.3	0.629 b						
3 SURFACE					100.0	0.88	97.0	0.85	97.0	0.52
3 COMPOSITE	95.6	0.548	90.0	0.646 b						
4 SURFACE					96.0	0.91	100.0	0.84	97.0	0.52
4 COMPOSITE	91.1	0.596	100.0	0.605 b						
5 SURFACE					100.0	0.88	93.0	0.82	97.0	0.60
5 COMPOSITE	91.1	0.596	100.0	0.646 b						
6 SURFACE	95.6	0.551	93.3	0.678 b	91.0	0.97	93.0	0.88	100.0	0.53
6 COMPOSITE	95.6	0.560	100.0	0.679 b						
6 BOTTOM	97.8	0.609	96.7	0.634 b						
7 SURFACE					100.0	0.86	90.0	0.83	100.0	0.57
7 COMPOSITE	95.4	0.633	93.3	0.618 b						
8 SURFACE					100.0	0.86	93.0	0.78	96.0	0.52
8 COMPOSITE	87.2	0.576	93.3	0.634 b						
9 SURFACE	91.1	0.584	96.7	0.863	100.0	0.97	93.0	0.78	93.0	0.50 a
10 SURFACE					100.0	1.02	97.0	0.73	93.0	0.56
11 (SIMS-3) SURFACE					100.0	0.96	100.0	0.71	93.0	0.57
11 " " D**					100.0	0.74	100.0	0.61	86.0	0.57
12 (GREENS-3) SURFACE					100.0	0.83	97.0	0.65	97.0	0.57
12 " " D**					100.0	0.87	97.0	0.73	100.0	0.52

*ON THIS DATE THE REFERENCE STATION WAS USED AS THE PERFORMANCE CONTROL.
**DUPLICATE SAMPLES WERE COLLECTED AND TESTED FOLLOWING ADDITION OF SODIUM THIOSULFATE.
a-SIGNIFICANTLY DIFFERENT (P=0.05) FROM LABORATORY CONTROL.
b-SIGNIFICANTLY DIFFERENT (P=0.05) FROM REFERENCE STATION (#9).

TABLE 7. AMBIENT TOXICITY TO MYSID SHRIMP.

STATION	EFFECTS AFTER SEVEN DAYS EXPOSURE (MEAN VALUES)														
	AUG-88			JAN-89			MAR-90			MAY-90			JUL-90		
	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)	FEMALES WITH EGGS (%)	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)	FEMALES WITH EGGS (%)	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)	FEMALES WITH EGGS (%)	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)	FEMALES WITH EGGS (%)	SURVIVAL (%)	FINAL MEAN DRY WT. (MG)	FEMALES WITH EGGS (%)
LABORATORY CONTROL	78.0	0.259	39.0	--*			79.5	0.33	88.0	99.0	0.42	84.0	94.0	0.38	70.0
1 SURFACE	87.5	0.225	35.0	96.9	0.225 b	68.7	77.0	0.32	52.0	92.0	0.39	80.0	0.0 a	--	0.0
1 COMPOSITE	87.5	0.245	28.0	93.8	0.260	83.3									
1 BOTTOM	92.5	0.228	61.0	87.5	0.265	81.3									
2 SURFACE							66.0	0.34	61.0	88.0	0.37	80.0	0.0 a	--	0.0
2 COMPOSITE	85.0	0.327	56.0												
3 SURFACE							77.5	0.35	79.0	93.0	0.43	72.0	34.0 a	0.41	0.0
3 COMPOSITE	72.5	0.249	44.0												
4 SURFACE							72.0	0.34	74.0	87.0	0.40	90.0	0.0 a	--	0.0
4 COMPOSITE	90.0	0.251	52.0	90.6	0.264	66.7									
5 SURFACE							67.5	0.34	55.5	82.0 a	0.39	57.0	77.0	0.41	63.0
5 COMPOSITE	87.5	0.247	56.0												
6 SURFACE	90.0	0.258	68.0	90.6	0.278	95.2	74.0	0.32	70.0	95.0	0.42	82.0	69.0 b	0.35	25.0
6 COMPOSITE	77.5	0.286	39.0	93.8	0.267	69.0									
6 BOTTOM	85.0	0.202	57.0	81.3	0.268	63.9									
7 SURFACE							67.5	0.32	70.0	74.0 a	0.43	81.0	97.0	0.43	39.0
7 COMPOSITE	95.0	0.272	63.0												
8 SURFACE							67.5	0.33	89.0	60.0 a	0.38	86.0	69 a	0.35	33.0
8 COMPOSITE	82.5	0.288	77.0	84.4	0.288	93.8									
9 SURFACE	90.0	0.250	59.0	84.4	0.306	87.5	45.0 a	0.27	75.0	57.0 a	0.37	67.0	100.0	0.40	54.0
10 SURFACE							61.5	0.27 a	37.0 a	86.0	0.39	90.0	46.0 a	0.39	17.0
11 (SIMS-3) SURFACE							67.5	0.26 a	21.0 a,b	92.0	0.36	77.0	69.0 a	0.43	0.0
11 " " D**							70.0	0.23 a	57.0	88.0	0.34 a	52.0 a	41.0 a	0.43	0.0
12 (GREENS-3) SURFACE							80.5	0.25 a	5.5 a,b	78.0	0.32 a	68.0	83.0	0.42	45.0
12 " " D**							75.0	0.23	50.0 a	68.0 a	0.37	81.0	54.0 a	0.38	0.0

*ON THIS DATE THE REFERENCE STATION WAS USED AS THE PERFORMANCE CONTROL.
**DUPLICATE SAMPLES WERE COLLECTED AND TESTED FOLLOWING ADDITION OF SODIUM THIOSULFATE.
a-SIGNIFICANTLY DIFFERENT (P=0.05) FROM LABORATORY CONTROL.
b-SIGNIFICANTLY DIFFERENT (P=0.05) FROM REFERENCE STATION (#9).

TABLE 8. AMBIENT TOXICITY TO THE SEA URCHIN.

	PERCENT FERTILIZATION			
	AUG-1-88	JAN-9-89	JAN-11-89	JAN-13-89
LABORATORY CONTROL*	82.3	98.3	99.7	97.3
PERFORMANCE CONTROL**	93.7	64.7	100.0	96.3
1 SURFACE	87.8	100.0	100.0	98.6
1 COMPOSITE	92.2	99.0	99.7	97.9
1 BOTTOM	91.7	99.7	100.0	98.0
2 SURFACE				
2 COMPOSITE	92.4	99.7	100.0	99.0
3 SURFACE				
3 COMPOSITE	94.1	99.7	100.0	97.6
4 SURFACE				
4 COMPOSITE	97.9	99.7	99.0	97.0
5 SURFACE				
5 COMPOSITE	97.7	100.0	100.0	96.0
6 SURFACE	97.9	99.3	100.0	97.3
6 COMPOSITE	97.3	100.0	100.0	96.3
6 BOTTOM	94.7	99.0	99.0	96.6
7 SURFACE				
7 COMPOSITE	97.8	100.0	100.0	96.3
8 SURFACE				
8 COMPOSITE	98.4	97.3	99.7	96.6
9 SURFACE	97.7	98.0	100.0	97.3
10 SURFACE				
11 (SIMS-3) SURFACE				
12 (GREENS-3) SURFACE				

*LABORATORY CONTROL CONSISTED OF BRINE + DEIONIZED WATER.

**PERFORMANCE CONTROL CONSISTED OF AMBIENT WATER FROM NARRAGANSETT BAY, RI.

NOTE: NO SIGNIFICANT (P=0.05) EFFECTS WERE FOUND.

TABLE 9. AMBIENT TOXICITY TO THE RED ALGA.

	REPRODUCTIVE EFFECTS							
	AUG-1-88		JAN-11-89		JAN-13-89		FEB-19-90	
	CYSTOCARPS PRODUCED		CYSTOCARPS PRODUCED		CYSTOCARPS PRODUCED		CYSTOCARPS PRODUCED	
STATION	MEAN	(SD)	MEAN	(SD)	MEAN	(SD)	MEAN	(SD)
LABORATORY CONTROL	12.5	(2.1)	45.8	(10.0)	27.8	(7.2)	16.8	(3.7)
PERFORMANCE CONTROL	10.0	(2.8)	48.2	(15.4)	24.5	(11.4)	21.9*	(1.7)
1 SURFACE	0.3	(0.2) a,b,c	3.1	(1.3) a,b,c	5.4	(4.9) a,b	10.5	(1.0)
1 COMPOSITE	0.1	(0.1) a,b,c	23.9	(2.2) a,b	4.6	(3.5) a,b		
1 BOTTOM	4.0	(2.8) b	35.2	(7.3)	14.3	(7.5)		
2 SURFACE							15.9	(4.2)
2 COMPOSITE	0.8	(0.7) a,b	19.0	(3.3) a,b	1.9	(0.5) a,b		
3 SURFACE							19.1	(3.2)
3 COMPOSITE	7.0	(2.4) b	37.2	(1.2)	29.3	(9.5)		
4 SURFACE							14.7	(5.7)
4 COMPOSITE	7.8	(5.7)	25.3	(9.7) a,b	12.1	(3.7) a,b		
5 SURFACE							16.6	(3.4)
5 COMPOSITE	4.4	(4.7)	58.3	(32.3)	12.8	(7.2)		
6 SURFACE	4.0	(2.1) a,b	34.3	(8.8)	7.2	(3.2) a,b	9.0	(3.3) d
6 COMPOSITE	4.7	(3.0) b	25.4	(3.6) a,b	13.6	(3.9)		
6 BOTTOM	5.7	(2.6) b	45.7	(4.0)	10.3	(5.3) a,b		
7 SURFACE							12.1	(5.1)
7 COMPOSITE	4.9	(2.4) b	43.0	(13.4)	13.4	(4.5)		
8 SURFACE							18.8	(4.7)
8 COMPOSITE	10.5	(5.2)	22.0	(0.8) a,b	20.7	(8.4)		
9 SURFACE	7.0	(4.1)	28.5	(6.9) a,b	14.3	(3.5)	15.5	(5.4)
10 SURFACE							8.1	(7.1) d
11 (SIMS-3) SURFACE							1.5	(0.7) c,d
12 (GREENS-3) SURFACE							9.9	(7.4) d

*ON THIS DATE A LOW SALINITY CONTROL WAS USED AS THE PERFORMANCE CONTROL BASED OR RELATIVELY LOW SALINITY OF AMBIENT WATER SAMPLES.
a-SIGNIFICANTLY DIFFERENT (P=0.05) FROM THE PERFORMANCE CONTROL (WATER FROM NARRAGANSETT BAY, RI).
b-SIGNIFICANTLY DIFFERENT (P=0.05) FROM THE LABORATORY CONTROL (BRINE + DEIONIZED WATER).
c-SIGNIFICANTLY DIFFERENT (P=0.05) FROM THE REFERENCE SITE (STATION #9).
d-SIGNIFICANTLY DIFFERENT (P=0.05) FROM THE POOLED LOW SALINITY AND REGULAR LAB CONTROLS.

TABLE 10. AMBIENT TOXICITY FOR BRAYS, SIMS AND GREENS BAYOUS, SEPTEMBER 1989.

STATION	MYSID SHRIMP SURVIVAL (%)	MYSID SHRIMP FINAL MEAN DRY WT. (MG)	SHEEPSHEAD MINNOW SURVIVAL (%)	FATHEAD MINNOW SURVIVAL (%)	DAPHNIA PULEX-48H SURVIVAL (%)
	EFFECTS AFTER SEVEN DAYS EXPOSURE				
BRAYS BAYOU					
CONTROL	94.3	0.20	93.0	93.0	97.0
SALINITY CONTROL				97.0	0.0
BRAYS-1	91.4	0.21	97.0	97.0	0.0*
BRAYS-2	89.6	0.18	93.0		
BRAYS-3	91.4	0.20	93.0		
GREENS BAYOU					
CONTROL	97.5	0.22	93.0		
GREENS-1	97.5	0.20	90.0		
GREENS-2	92.5	0.21	100.0		
GREENS-3	95.0	0.20	97.0		
SIMS BAYOU					
CONTROL	97.5	0.23	93.0	93.0	97.0
SIMS-1	92.5	0.18 a	100.0	100.0	100.0
SIMS-2	92.5	0.15 a	90.0		
SIMS-3	45.0 a	NM b	90.0		

*THERE WAS 0% MORTALITY IN THE SALINITY CONTROL, INDICATING THAT EFFECTS OBSERVED FOR BRAYS-1 ARE DUE TO OSMOTIC INTOLERANCE RATHER THAN TOXICITY.
a-SIGNIFICANTLY DIFFERENT (P=0.05) FROM LABORATORY CONTROL.
b-NOT MEASURED.

TABLE 11. SEDIMENT TOXICY TO THE AMPHIPOD AND SHEEPSHEAD MINNOW (ELUTRIATE).

	PERCENT SURVIVAL				
	AMPHIPOD		SHEEPSHEAD MINNOW ELUTRIATE		
	AUG-88	JAN-89	AUG-88	JAN-89	JUL-90
CONTROL*	98.9	96.7	95.0	95.0	97.0
LOW SALINITY CONTROL**	91.1				
1	85.6	77.8 a		90.0	
2	92.2	97.8			
3	98.9	100.0			
4	95.6	92.2	80.0	100.0	
5	95.6	88.9	75.0		
6	96.7	76.7 a,b		90.0	
7	95.6	94.4			
8	100.0	94.4			
9	97.8	94.4	100.0	90.0	100.0
10					
11					83.0 a
12					97.0

*AMPHIPOD CONTROL WAS A PERFORMANCE CONTROL CONISTING OF CLEAN SEDIMENT FROM LONG ISLAND SOUND, NY.

**THIS CONTROL WAS INCLUDED DUE TO THE RELATIVELY LOW INTERSTITIAL SALINITY ON THIS DATE.

a-SIGNIFICANTLY DIFFERENT (P=0.05) FROM THE CONTROL.

b-SIGNIFICANTLY DIFFERENT FROM THE REFERENCE SITE (STATION #9).

TABLE 12. EXCEEDANCES OF MINIMA AND AVERAGE WATER QUALITY STANDARDS FOR DISSOLVED OXYGEN.*

EXCEEDANCES OF DO WQS-MINIMA				EXCEEDANCES OF DO WQS-AVERAGE**			
STATION	DATE	WQS	RANGE OF DEPTHS EXCEEDING WQS (FEET)	DATE	WQS	AVG. CONC.	RANGE OF DEPTHS EXCEEDING WQS (FEET)
1	8/1/88	1.5	10-40	8/1/88	2.0	1.26	1-25
	8/3/88	1.5	10-40	8/3/88	2.0	1.18	1-30
2	8/3/88	1.5	15, 20	8/1/88	2.0	1.79	1-30
3	8/1/88	3.0	10-20	8/1/88	4.0	3.27	1-20
	8/3/88	3.0	5-20	8/3/88	4.0	3.11	1-20
	8/5/88	3.0	20				
4				8/1/88	4.0	3.45	1-22
				8/3/88	4.0	3.44	1-24
5	8/1/88	3.0	10, 15	8/1/88	4.0	3.02	1-15
				8/3/88	4.0	3.45	1-15
6	8/2/88	3.0	1-45	8/2/88	4.0	2.24	1-40
	8/3/88	3.0	1-45	8/3/88	4.0	2.26	1-40
	8/5/88	3.0	1-40	8/5/88	4.0	2.16	1-25
7	8/1/88	3.0	25-45	8/1/88	4.0	3.61	1-35
	8/3/88	3.0	25-40	8/3/88	4.0	3.41	1-40
8				8/3/88	4.0	3.84	1-35
10	2/19/90	1.0	36				
	5/29/90	1.0	35				
	7/30/90	1.0	10-30				
12	7/30/90	1.5	10, 13				
BRAYS-1	8/31/90	1.0	15				
	9/20/89	1.0	8, 16				
BRAYS-3	9/20/89	1.0	10, 20				
GREENS-1	8/31/89	1.5	25				
	9/25/89	1.5	14, 27				
SIMS-1	9/12/89	1.0	10				
SIMS-2	9/12/89	1.0	13				

*WATER QUALITY STANDARDS FROM TWC (1991); ALL WQS AND CONCENTRATIONS IN MG/L.

TABLE 13. WATER QUALITY CRITERIA EXCEEDANCES FOR TOTAL RESIDUAL CHLORINE.*

STATION	DATE	TRC CONC. (MG/L)
3	2/19/90	0.1
	7/30/90	0.1
	8/1/90	0.1
4	5/30/90	0.1
	7/31/90	0.1
6	8/2/88	0.15
7	7/30/90	TRACE (<0.1)
	8/1/90	TRACE (<0.1)
8	1/13/89	0.5
	7/31/90	0.1
	8/1/90	0.1
10	2/19/90	TRACE (<0.1)
	7/30/90	0.1
	8/1/90	0.1
11	2/21/90	0.25
	7/30/90	0.1
	8/1/90	TRACE (<0.1)
12	2/20/90	TRACE (<0.1)
(GREENS-3)	9/25/89	TRACE (<0.1)

*EPA ACUTE AND CHRONIC CRITERIA ARE 0.013 MG/L AND 0.0075 MG/L, RESPECTIVELY.

TABLE 14. CHEMICAL ANALYSIS OF AMBIENT WATERS: CONVENTIONAL PARAMETERS.

PARAMETER/ DATE/ SAMPLE TYPE*		CONCENTRATION BY STATION (MG/L) 1	2	3	4	5	6	6 dup	7	8	9	10	11	12	FIELD BLANK
ALKALINITY															
Aug-88	S	122					121				83				
	C	126	122	106	117	120	115	122	121	118					6
	B	120					124								
Jan-89	S	122					125				114				
	C	118	122	114	116	124	122		122	114					<5
	B	122					116								
Feb-90	S	134	124	55	70	82	101	117	106	98	102	170	188	140	5
May-90	S	106	102	42	78	86	88	88	88	98	104	114	184	148	5
Jul-90	S	132	131	105	113	130	130	132	130	128	107	160	174	120	<5
AMMONIA (TOTAL)															
Aug-88	S	0.80					0.14				0.03				
	C	0.51	0.36	0.10	0.06	0.13	0.13	0.12	0.07	0.11					<0.10
	B	0.27					0.10								
Jan-89	S	0.71					0.47				0.36				
	C	0.64	0.53	0.13	0.39	0.41	0.44		0.39	0.38					0.07
	B	0.43					0.39								
Feb-90	S	0.84	0.69	0.13	0.23	0.38	0.47	0.38	0.40	0.27	0.19	0.54	1.17	0.80	0.02
May-90	S	0.15	0.07	0.05	0.09	0.06	0.07	0.08	0.08	0.02	0.04	0.50	1.58	0.22	0.07
Jul-90	S	0.18	0.31	0.18	0.07	0.08	0.14	0.21	0.17	0.12	0.02	0.22	1.12	0.07	0.04
CHLORIDE															
Aug-88	S	12700					7810				7820				
	C	13000	7760	5400	6930	7290	8960	8540	8860	7030					<5
	B	9580					9720								
Jan-89	S	8910					12200				13000				
	C	15700	13300	11700	13400	13500	12800		14200	14700					2
	B	12900					15300								
Feb-90	S	3600	5110	179	1670	2910	5270	4530	5660	6450	1940	689	641	2400	<1
May-90	S	198	566	114	578	693	737	745	929	88	131	59	284	132	<1
TOTAL RESIDUAL CHLORINE															
Aug-88	S	<0.1					<0.1				<0.1				
	C	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1					
	B	<0.1					<0.1								<0.1
Jan-89	S	<0.1					<0.1				<0.1				
	C	<0.1	<0.1	0.15	<0.1	<0.1	<0.1		<0.1	<0.1					<0.1
	B	<0.1					<0.1								
Feb-90	S	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
May-90	S	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Jul-90	S	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CYANIDE															
Aug-88	S	<0.02					<0.02				<0.02				
	C	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02					<0.02
	B	<0.02					<0.02								
Jan-89	S	<0.02					0.03				<0.02				
	C	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02					<0.02
	B	<0.02					<0.02								
Feb-90	S	<0.02					<0.02								
May-90	S	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Jul-90	S	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

TABLE 14. CHEMICAL ANALYSIS OF AMBIENT WATERS: CONVENTIONAL PARAMETERS.
(CONTINUED)

PARAMETER/ DATE/	SAMPLE TYPE*	CONCENTRATION BY STATION (MG/L) 1	2	3	4	5	6	6 dup	7	8	9	10	11	12	FIELD BLANK
OIL & GREASE															
Aug-88	S	<5					<5				<5				
	C	<5	<5	<5	<5	<5	<5	<5	<5	<5					<5
	B	<5					<5								
Jan-89	S	79					<5				6				
	C	7	33	<5	<5	<5	<5		37	8					<5
	B	63					7								
Feb-90	S	<5	16	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
May-90	S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Jul-90	S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
SULFATE															
Aug-88	S	575					1960				1470				
	C		1210	830	1100	1330	1240	1510	1800	1520					6
	B	1590					1970								
Jan-89	S	1110					1360				1350				
	C	1300	1700	1280	1320	1380	1420		1570	1640					<1
	B	1770					1740								
Feb-90	S	612	675	17	220	370	640	660	750	725	250	82	195	340	<1
May-90	S	93	146	62	121	141	171	142	171	34	30	45	126	71	<1
SULFIDE															
Aug-88	S	0.07					0.03				0.06				
	C	0.05	0.05	0.07	0.08	0.06	0.06	0.03	0.04	0.02					0.04
	B	0.11					0.02								
Jan-89	S	0.02					<0.01				0.01				
	C	<0.01	0.01	<0.1	0.02	0.01	0.01		0.01	<0.01					
	B	0.02					0.01								
Feb-90	S	0.02	0.02	0.07	0.04	0.01	0.03	0.04	<0.01	0.03	0.05	0.03	0.03	0.03	<0.01
Jul-90	S	0.02	<0.1	0.02	0.01	0.03	<0.01	0.01	<0.01	<0.01	<0.01	0.01	0.01	0.02	<0.01
TOTAL DISSOLVED SOLIDS															
Aug-88	S	12000					15900				16000				
	C	14000	15300	11200	13900	15200	17800	17600	20000	21000					536
	B	18000					20600								
Jan-89	S	15600					20100				20200				
	C	18500	20600	17700	19900	19700	21700		14200	23200					<10
	B	21200					23000								
Feb-90	S	6000	7550	495	3440	4250	7150	7450	9050	9900	3980	1370	1320	9880	1
May-90	S	679	1480	425	1420	1720	1820	1760	2160	560	472	364	978	620	1
Jul-90	S	5480	6770	5490	7780	7750	7530	10600	8040	9500	4950	2490	1550	4410	<1
TOTAL SUSPENDED SOLIDS															
Aug-88	S	6					16				19				
	C	8	14	8	11	12	21	21	28	34					<2
	B	8					47								
Jan-89	S	15					17				19				
	C	21	25	20	18	18	22		24	18					2
	B	22					16								
Feb-90	S	24	44	15	33	36	30	27	31	64	20	9	78	20	<1
May-90	S	27	32	26	17	30	51	57	63	112	306	30	14	26	1
Jul-90	S	9	8	12	12	9	10	8	11	12	13	8	9	16	<1

TABLE 14. CHEMICAL ANALYSIS OF AMBIENT WATERS: CONVENTIONAL PARAMETERS.
(CONTINUED)

PARAMETER/ DATE/ SAMPLE TYPE*		CONCENTRATION BY STATION (MG/L) 1	2	3	4	5	6	6 dup	7	8	9	10	11	12	FIELD BLANK
TOTAL ORGANIC CARBON															
Aug-88	S	8					4				4				
	C	8	7	10	7	6	4	5	<1	4					4
	B	5					4								
Jan-89	S	5					<1				<1				
	C	<1	<1	<1	<1	<1	<1		<1	<1					<1
	B	<1					6								
Feb-90	S	7	7	9	6	10	6	5	5	4	5	6	10	6	<1
May-90	S	12	10	12	8	8	7	7	6	6	7	8	11	8	<1
Jul-90	S	4	4	6	3	2	2	2	3	2	<1	4	6	4	<1

*C - VERTICAL COMPOSITE SAMPLE
S - SURFACE WATER GRAB SAMPLE
B - BOTTOM GRAB SAMPLE

TABLE 15. CHEMICAL ANALYSIS FOR BRAYS, GREENS AND SIMS BAYOUS, SEPTEMBER 1989: DISSOLVED METALS AND CONVENTIONAL PRAMETERS.

	CONCENTRATION BY STATION									
	BRAYS BAYOU			GREENS BAYOU			SIMS BAYOU			FIELD
PARAMETER	1	2	3	1	2	3*	1	2	3*	BLANK
DISSOLVED METALS (UG/L)										
ANTIMONY	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
ARSENIC	<18.4	<18.4	<18.4	<18.4	<18.4	<18.4	<4.6	<4.6	<4.6	<4.6
BERYLLIUM	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
CADMIUM	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
CHROMIUM	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
COPPER	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
LEAD	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
MERCURY	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
NICKEL	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
SELENIUM	<19.2	<19.2	<19.2	<19.2	<19.2	<19.2	<4.8	<4.8	<4.8	<4.8
SILVER	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
THALLIUM	<15.2	<15.2	<15.2	<15.2	<15.2	<15.2	<15.2	<15.2	<15.2	<15.2
ZINC	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
CONVENTIONAL PARAMETERS (MG/L)										
ALKALINITY	168	160	158	124	120	118	184	176	156	
AMMONIA (TOTAL)	1.26	1.20	1.09	0.08	0.08	0.03	1.12	1.13	1.04	
TOTAL RESIDUAL CHLORINE	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
HARDNESS	821	1030	1080	1390	1480	1690	192	387	548	
TOTAL DISSOLVED SOLIDS	4140	5740	5930	8380	8760	10200	1100	2550	3690	
TOTAL SUSPENDED SOLIDS	17	21	26	22	32	40	13	13	13	

*SIMS-3 AND GREENS-3 LOCATIONS WERE THE SAME AS STATION 1 STATIONS 11 AND 12, RESPECTIVELY;
NOTE: ORGANIC PRIORITY POLLUTANTS WERE NOT ANALYZED IN SEPTEMBER 1989.

PARAMETER/ DATE/ SAMPLE TYPE*	STATION NUMBER 1	2	3	4	5	6	6 dup	7	8	9	10	11	12	FIELD BLANK
ALUMINUM														
Aug-88 C	<100	<100	<100	<100	<100	<100	<100	<100	<100	-	-	-	-	<100
S	<100	-	-	-	-	<100	-	-	-	<100	-	-	-	
B	<100	-	-	-	-	<100	-	-	-	-	-	-	-	
ANTIMONY														
Aug-88 C	<60	<60	<60	<60	<60	<60	<60	<60	<60	-	-	-	-	<60
S										<100				
Jan-89 C	<60	<60	<60	<60	<60	<60	<60	<60	<60	-	-	-	-	<60
S	<60	-	-	-	-	<60	-	-	-	-	-	-	-	
B	<60	-	-	-	-	<60	-	-	-	-	-	-	-	
Feb-90 S	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
May-90 S	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S/T	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
Jul-90 S	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S/T	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
ARSENIC														
Aug-88 C	<18.4	<18.4	<18.4	<18.4	<18.4	<46	<46	<18.4	<18.4	-	-	-	-	<18.4
S	<18.4	-	-	-	-	<46	-	-	-	<18.4	-	-	-	
B	<18.4	-	-	-	-	<46	-	-	-	-	-	-	-	
Jan-89 C	<46	<46	<46	<46	<46	<46	-	<46	<46	-	-	-	-	<46
S	<46	-	-	-	-	<46	-	-	-	<46	-	-	-	
B	<46	-	-	-	-	<46	-	-	-	-	-	-	-	
Feb-90 S	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18
May-90 S	8.9	6.5	<4.6	<4.6	4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	9.1	<4.6
S/T	7.4	<4.6	<4.6	<4.6	5.2	4.9	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	11.3	<4.6
Jul-90 S	5.3	5.2	5.3	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	5.4	<4.6	5.6	<4.6
S/T	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18	<18
BARIUM														
Aug-88 C	86	80	156	103	82	74	75	70	69	118	-	-	-	<10
S	86	-	-	-	-	78	-	-	-	-	-	-	-	
B	73	-	-	-	-	69	-	-	-	-	-	-	-	
Jan-89 C	123	118	183	173	130	126	-	167	116	184	-	-	-	<10
S	121	-	-	-	-	119	-	-	-	-	-	-	-	
B	114	-	-	-	-	119	-	-	-	-	-	-	-	
Feb-90 S	100	93	81	81	84	87	87	87	80	87	117	94	143	<10
BERYLLIUM														
Aug-88 C	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	<5
S	<5	-	-	-	-	<5	<5	-	-	<5	-	-	-	
B	<5	-	-	-	-	<5	<5	-	-	-	-	-	-	
Jan-89 C	<5	<5	<5	<5	<5	<5	-	<5	<5	-	-	-	-	<5
S	<5	-	-	-	-	<5	-	-	-	<5	-	-	-	
B	<5	-	-	-	-	<5	-	-	-	-	-	-	-	
Feb-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
May-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
S/T	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Jul-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
S/T	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

TABLE 16. CHEMICAL ANALYSIS OF AMBIENT WATERS: METALS.
(CONTINUED)

PARAMETER/ DATE/ SAMPLE TYPE*	STATION NUMBER 1	2	3	4	5	6	6 dup	7	8	9	10	11	12	FIELD BLANK
CADMIUM														
Aug-88 C	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	<5
S	<5	-	-	-	-	<5	<5	-	-	<5	-	-	-	
B	<5	-	-	-	-	<5	<5	-	-	-	-	-	-	
Jan-89 C	<5	<5	<5	<5	<5	<5	-	<5	<5	-	-	-	-	<5
S	<5	-	-	-	-	<5	-	-	-	<5	-	-	-	
B	<5	-	-	-	-	<5	-	-	-	-	-	-	-	
Feb-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
May-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
S/T	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Jul-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
S/T	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
CHROMIUM														
Aug-88 C	10	<10	<10	<5	<10	<10	<10	<10	<10	-	-	-	-	<10
S	11	-	-	-	-	10	-	-	-	<10	-	-	-	
B	<10	-	-	-	-	<10	-	-	-	-	-	-	-	
Jan-89 C	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-	-	<10
S	<10	-	-	-	-	<10	-	-	-	<10	-	-	-	
B	<10	-	-	-	-	<10	-	-	-	-	-	-	-	
Feb-90 S	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
May-90 S	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
S/T	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Jul-90 S	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
S/T	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
COBALT														
Aug-88 C	<20	<20	<20	<20	<20	<20	<20	<20	<20	-	-	-	-	<20
S	<20	-	-	-	-	<20	-	-	-	<20	-	-	-	
B	<20	-	-	-	-	<20	-	-	-	-	-	-	-	
COPPER														
Aug-88 C	<20	<20	<20	<20	<20	<20	<20	<20	<20	-	-	-	-	<20
S	<20	-	-	-	-	<20	-	-	-	<20	-	-	-	
B	<20	-	-	-	-	<20	-	-	-	-	-	-	-	
Jan-89 C	<20	<20	<20	<20	<20	<20	-	<20	<20	-	-	-	-	<20
S	<20	-	-	-	-	<20	-	-	-	<20	-	-	-	
B	<20	-	-	-	-	<20	-	-	-	-	-	-	-	
Feb-90 S	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
May-90 S	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
S/T	<10	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Jul-90 S	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
S/T	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
IRON														
Aug-88 C	44	33	<25	<25	28	29	<25	<25	<25	-	-	-	-	<25
S	68	-	-	-	-	<25	-	-	-	<25	-	-	-	
B	32	-	-	-	-	<25	-	-	-	-	-	-	-	
Jan-89 C	<25	<25	<25	<25	<25	<25	-	<25	<25	-	-	-	-	<25
S	<25	-	-	-	-	<25	-	-	-	<25	-	-	-	
B	<25	-	-	-	-	<25	-	-	-	-	-	-	-	
Feb-90 S	<25	<25	284	<25	<25	<25	<25	<25	<25	<25	<25	27	<25	<25

TABLE 16. CHEMICAL ANALYSIS OF AMBIENT WATERS: METALS.
(CONTINUED)

PARAMETER/ DATE/ SAMPLE TYPE*	STATION NUMBER 1	2	3	4	5	6	6 dup	7	8	9	10	11	12	FIELD BLANK
LEAD														
Aug-88 C	<30	<30	<30	<30	<30	<30	<30	<30	<30	-	-	-	-	<30
S	<30	-	-	-	-	<30	-	-	-	<30	-	-	-	
B	<30	-	-	-	-	<30	-	-	-	-	-	-	-	
Jan-89 C	<30	123	<30	<30	<30	<30	<30	<30	<30	-	<30	<30	<30	<30
S	<30	-	-	-	-	<30	-	-	-	<30	-	-	-	
B	<30	-	-	-	-	<30	-	-	-	-	-	-	-	
Feb-90 S	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
May-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
S/T	9.2	6.4	5.2	6.2	5.7	5.4	5.2	5.8	5.4	11	10	6.3	8	<5
Jul-90 S	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
S/T	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
MANGANESE														
Aug-88 C	83	77	136	75	67	36	34	15	<5	-	-	-	-	<5
S	96	-	-	-	-	65	-	-	-	10	-	-	-	
B	53	-	-	-	-	11	-	-	-	-	-	-	-	
Jan-89 C	51	31	12	28	26	25	-	16	15	-	-	-	-	<5
S	68	-	-	-	-	43	-	-	-	<5	-	-	-	
B	23	-	-	-	-	<5	-	-	-	-	-	-	-	
Feb-90 S	79	70	12	34	35	43	41	33	19	<5	62	89	164	<5
MERCURY														
Aug-88 C	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	<0.2
S	<0.2	-	-	-	-	<0.2	-	-	-	<0.2	-	-	-	-
B	<0.2	-	-	-	-	<0.2	-	-	-	-	-	-	-	nv
Feb-90 S	<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
May-90 S	<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
S/T	<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
Jul-90 S	<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														
Aug-88 C	29	33	36	<20	27	30	<20	26	20	-	-	-	-	<20
S	29	-	-	-	-	27	-	-	-	34	-	-	-	
B	<20	-	-	-	-	<20	-	-	-	-	-	-	-	
Jan-89 C	<20	<20	<20	<20	<20	<20	-	<20	<20	-	-	-	-	<20
S	<20	-	-	-	-	<20	-	-	-	<20	-	-	-	
B	<20	-	-	-	-	<20	-	-	-	-	-	-	-	
Feb-90 S	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
May-90 S	7.6	<6	<6	<6	<6	<6	<6	<6	<6	<6	6.6	12.9	<6	<6
S/T	<6	6.9	<6	6.5	8.3	<6	<6	<6	6.8	9.3	<6	9.4	9.1	<6
Jul-90 S	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
S/T	7.1	6.1	<6	<6	<6	6.1	<6	<6	<6	<6	6.3	7.9	<6	<6

TABLE 16. CHEMICAL ANALYSIS OF AMBIENT WATERS: METALS.
(CONTINUED)

PARAMETER/ DATE/ SAMPLE TYPE*	STATION NUMBER 1	2	3	4	5	6	6 dup	7	8	9	10	11	12	FIELD BLANK
SELENIUM														
Aug-88 C	60	<48	<48	<48	<48	<48	<48	<48	<48	-	-	-	-	<48
S	<48	-	-	-	-	<48	-	-	-	<48	-	-	-	
B	<48	-	-	-	-	<48	-	-	-	-	-	-	-	
Jan-89 C	<48	<48	<48	<48	<48	<48	-	<48	<48	-	-	-	-	<48
S	<48	-	-	-	-	<48	-	-	-	<48	-	-	-	
B	<48	-	-	-	-	<48	-	-	-	-	-	-	-	
Feb-90 S	<19	<19	<19	<19	<19	<19	<19	<19	<19	<19	<19	<19	<19	<19
May-90 S	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
S/T	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Jul-90 S	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8
S/T	<48	<48	<48	<48	<48	<48	<48	<48	<48	<48	<48	<48	<48	<48
SILVER														
Aug-88 C	<10	<10	<10	<5	<10	<10	<10	<10	<10	-	-	-	-	<10
S	<10	-	-	-	-	<10	-	-	-	<10	-	-	-	
B	<10	-	-	-	-	<10	-	-	-	-	-	-	-	
Jan-89 C	<10	<10	<10	<10	<10	<10	<10	<10	<10	-	-	-	-	<10
S	<10	-	-	-	-	<10	-	-	-	<10	-	-	-	
B	<10	-	-	-	-	<10	-	-	-	-	-	-	-	
Feb-90 S	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
May-90 S	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
S/T	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Jul-90 S	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
S/T	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
THALLIUM														
Aug-88 C	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<15.2	-	-	-	-	<3.8
S	<3.8	-	-	-	-	<3.8	-	-	-	<3.8	-	-	-	
B	<3.8	-	-	-	-	<15.2	-	-	-	-	-	-	-	
Jan-89 C	<76	<76	<76	<76	<76	<76	<76	<76	<76	-	-	-	-	<76
S	<76	-	-	-	-	-	-	-	-	<76	-	-	-	
B	<76	-	-	-	-	-	-	-	-	-	-	-	-	
Feb-90 S	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15
May-90 S	<3.8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
S/T	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8
Jul-90 S	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8
S/T	<38	<38	<38	<38	<38	<38	<38	<38	<38	<38	<38	<38	<38	<38
ZINC														
Feb-90 S	32	30	51	19	<14	19	32	<20	28	26	53	78	46	<14
May-90 S	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
S/T	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
Jul-90 S	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40
S/T	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40
VANADIUM														
Aug-88 C	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	-	-	-	<30
S	<30					<30								
B	<30					<30								

* C - VERTICAL COMPOSITE SAMPLE; DISSOLVED METALS ANALYSIS
S - SURFACE GRAB SAMPLE; DISSOLVED METALS ANALYSIS
B - BOTTOM GRAB SAMPLE; DISSOLVED METALS ANALYSIS
S/T - SURFACE GRAB SAMPLE; TOTAL METALS ANALYSIS

TABLE 17. DISSOLVED METAL CONCENTRATIONS FOR AMBIENT WATER COLLECTED IN JANUARY 1991.

STATION OR SITE	SAMPLE DATE	CONCENTRATION IN UG/L ARSENIC	COPPER	MERCURY	NICKEL
1	1/14	<20	4.9	<0.2	<22
2	1/14	<20	4.2	<0.2	<22
4	1/14	<20	9.2	<0.2	<22
6	1/14	<20	3.5	<0.2	<22
8	1/14	<20	7.2	<0.2	<22
FIELD BLANK	1/8	<20	2.3	<0.2	<22

TABLE 18. SUMMARY OF WATER QUALITY CRITERIA AND STANDARDS EXCEEDED.

PARAMETER	CRITERIA TYPE*	CRITERIA VALUE (UG/L)	SAMPLE DATE	SAMPLE TYPE**	CONCENTRATION BY STATION (UG/L) 1	2	3	4	5	6	7	8	9	10	11	12
AMMONIA	EPA-AQUATIC LIFE	35	MAY-90	S/T											38	
(UNIONIZED)			JUL-90												53	
ARSENIC	EPA-HUMAN HEALTH	1.4	MAY-90	S/D	8.9	6.5										9.1
	(1 x 10-5)		"	S/T	7.4				4.6							11.3
			JUL-90	S/D	5.3	5.2	5.3		5.2					5.4		5.6
COPPER	STATE WQS	4.37	JAN-91	S/D	4.9			9.2				7.2				
CYANIDE	STATE WQS	5.6	JAN-89	C/T						30						
LEAD	STATE WQS	5.6	JAN-89	C/D		123										
MANGANESE	EPA-AQUATIC LIFE	100	AUG-88	C/D			136									
	(U.S. EPA 1976)		FEB-90	S/D												164
NICKEL	STATE WQS	13.2	AUG-88	C/D	29	33	36		27	30	26	20	34			
SELENIUM	STATE WQS	54	AUG-88	C/D	60											

*AQUATIC LIFE CRITERIA ARE CHRONIC VALUES FOR MARINE WATERS; CHRONIC CRITERIA NOT ENTIRELY APPLICABLE IN SEGMENTS 1006 (STATIONS 1, 2, 12) AND 1007 (STATIONS 10, 12) DUE THE LACK OF A DESIGNATED AQUATIC LIFE USE.

**C=VERTICAL COMPOSITE; S=SURFACE GRAB; D=DISSOLVED; T=TOTAL, WHOLE WATER.

TABLE 19. CHEMICAL ANALYSIS OF AMBIENT WATERS: ORGANIC PRIORITY POLLUTANTS.

DATE/ STATION*	COMPOUND**	CONCENTRATION (UG/L)
Aug-88		
1	1 Unknown Compound (ABN)	4
	2-Methoxy-2-Methyl-Propane (VOC)***	38.1
1 Surface	Bis (2-Ethylhexyl) Phthalate	18
	1 Unknown Compound (ABN)	4
	2-Methoxy-2-Methyl-Propane (VOC)***	42.3
1 Bottom	2-Methoxy-2-Methyl-Propane (VOC)***	9.8
2	2-Methoxy-2-Methyl-Propane (VOC)***	7.6
3	Bis (2-Ethylhexyl) Phthalate	15
	1 Unknown Compound (ABN)	7
4	ND	
5	Bis (2-Ethylhexyl) Phthalate	8
	5 Unknown Compounds (ABN)	4-94
	2-Methoxy-2-Methyl-Propane (VOC)***	76.2
6	2-Methoxy-2-Methyl-Propane (VOC)***	21.8
6 Duplicate	1 Unknown Compound (ABN)	5
	2-Methoxy-2-Methyl-Propane (VOC)***	30.1
6 Surface	2-Methoxy-2-Methyl-Propane (VOC)***	30.5
6 Bottom	ND	
7	Bis (2-Ethylhexyl) Phthalate	46
8	ND	
9	ND	
Field Blank	Bis (2-Ethylhexyl) Phthalate	709****
	18 Unknown Compounds (ABN) (17 of Which are Phthalates)	63-530
Jan-89		
1	2 Unknown Compounds (ABN)	8,32
	1,1,2-Tridecane (ABN)***	17

TABLE 19 (CONTINUED)

STATION	COMPOUND	CONC.
1	Chloroform	3
1 Surface	2 Unknown Compounds (ABN)	13,41
	Chloroform	4.6
1 Bottom	ND	
2	4 Unknown Compounds (ABN)	4-43
3	ND	
4	ND	
5	ND	
6	ND	
6 Surface	ND	
6 Bottom	2 Unknowns (ABN)	4,35
7	ND	
8	ND	
9	ND	
Field Blank	ND	
Feb-90		
1	1 Unknown Compound (ABN)	13
	C_6H_{12} Isomer (VOC)***	6.5
	1 Unknown Hydrocarbon (VOC)	5.9
	Chloroform	3.7
2	1 Unknown Compound (ABN)	9
	Chloroform	4.6
3	ND	
4	Unknown Hydrocarbon (VOC)	7.1
5	2-Methoxy-2-Methylpropane (VOC)**	7.8
6	ND	
6 Duplicate	1 Unknown Comound (ABN)	4
7	1 Unknown Compound (ABN)	4

TABLE 19 (CONTINUED)

STATION	COMPOUND	CONC.
8	ND	
9	ND	
10	1 Unknown Compound (ABN)	5
	Chloroform	9.3
	Bromodichloromethane	6.7
	Chlorodibromomethane	2.7
11	2 Unknown Compounds (ABN)	5,28
	Chloroform	6.3
	Bromodichloromethane	2.4
	2 Unknown Hydrocarbons (VOC)	5.1,7.6
12	1 Unknown Compound (ABN)	7
	1,2-Dichloroethane	3.8
	Chloroform	3.6
Field Blank	ND	
May-90		
1	Di-n-Butyl Phthalate	6
	Bis (2-Ethylhexyl) Phthalate	25
	6 Unknown Compounds (ABN)	5-9
	2,6-Dinitrotoluene	8
2	6 Unknown or Tent. Ident. Comp. (ABN) (Includes 2 Dimethyl Benzene Isomers and 1 Trimethyl Isomer)	4-6
3	Bis (2-Ethylhexyl) Phthalate	12
4	1 Unknown Compound (ABN)	32
5	1 Unknown Compound (ABN)	23
6	2 Unknown Compounds (ABN)	4,30
7	1 Unknown Compound (ABN)	28
8	1 Unknown Compound (ABN)	26
9	Di-n-Butyl Phthalate	2
	1 Unknown Compound (ABN)	6
10	Bis (2-Ethylhexyl) Phthalate	19
	Chloroform	12
10	Bromodichloromethane	7.8
	Chlorodibromomethane	3.1

TABLE 19 (CONTINUED)

STATION	COMPOUND	CONC.
11	Di-n-Butyl Phthalate	4
	Bis (2-Ethylhexyl) Phthalate	28
	11 Unknown Compounds (ABN)	4-140
12	Bis (2-Ethylhexyl) Phthalate	11
	Alpha-BHC	0.125
12	Gamma-BHC (Lindane)	0.041
Field Blank	ND	
Jul-90		
1	10 Unknown Compounds (ABN)	4-43
	Chloroform	3.6
2	6 Unknown Compounds (ABN)	6-41
	Chloroform	2.7
3	2 Unknown Compounds (ABN)	4,9
4	1 Unknown Compounds (ABN)	7
5	7 Unknown Compounds (ABN)	4-26
	Chloroform	2.3
6	7 Unknown Compounds (ABN)	4-23
	Chloroform	2.3
7	10 Unknown Compounds (ABN)	4-51
8	13 Unknown Compounds (ABN)	4-35
9	ND	
10	1 Unknown Compound (ABN)	5
	Chloroform	15.6
	Bromodichloromethane	11
	Chlorodibromomethane	4.8
11	4 Unknown Compounds (ABN)	5-43
	Chloroform	4.7
12	2 Unknown Compounds (ABN)	5,6
	Chloroform	2.1
Field Blank	1,1,2-Trichloro-1,2,2-Trifluoromethane (VOC)***	6

TABLE 19 (CONTINUED)

*Aug-88 and Jan-89 data are for vertical composite samples, except where specified otherwise; data for later dates are for surface water.

**Only parameters which were detected were listed; ABN=acid/base neutral compound; VOC=volatile organic compound.

***Tentatively identified compound.

****Field blank water was exceptionally high in phthalates resulting from storage of water in plastic cubitainers.

TABLE 20. CHEMICAL ANALYSIS OF SEDIMENTS: METALS AND CONVENTIONAL PARAMETERS.

PARAMETER/ DATE	CONCENTRATION BY STATION (MG/KG DRY WEIGHT) 1	2	3	4	5	6	7	8	9	11	12
ALUMINUM											
Aug-88	21603	24188	2153	3080	6473	9093	24293	11650	963		
Jul-90										23800	15600
ANTIMONY											
Aug-88	<16.8	<19.2	<8	<6.2	<7.5	<7.9	<18.4	<10.9	<7.8		
Jan-89	<7.9	<15.8	<5.8	15.8	<7.9	<14.1	<15.7	<9.3	<5.3		
Jul-90										<81	<59
ARSENIC											
Aug-88	<4.5	<5.7	<2.2	<2.3	<2.6	<2.6	<6.1	<3.2	<2.0		
Jan-89	<3.6	<4.8	<2.7	<3.3	<2.4	<4.3	<4.2	<3.9	<2.5		
Jul-90										5.1	4.8
BARIUM											
Aug-88	300	206	16	23	51	65	206	122	6		
Jul-90										206	356
BERYLLIUM											
Aug-88	<1.4	<1.6	<0.7	<0.5	<0.6	<0.7	<1.5	<0.9	<0.6		
Jan-89	<0.7	<1.3	<0.5	<1.3	<0.7	<1.2	<1.3	<0.8	<0.4		
Jul-90										<7	<5
CADMIUM											
Aug-88	<1.4	<1.6	<0.7	<0.5	<0.6	<0.7	<1.5	<0.9	<0.6		
Jan-89	<0.7	<1.3	<0.5	<1.3	<0.7	<1.2	<1.3	<0.8	<0.9		
Jul-90										<7	<5
CHROMIUM											
Aug-88	59	56	5	6	12	14	41	18	2		
Jan-89	26	37	3	22	6	21	18	15	2		
Jul-90										57	21
COBALT											
Aug-88	8	10	<2.7	<2.1	3	4	9	5	<2.6		
Jul-90										9	9
COPPER											
Aug-88	31	23	<2.7	3	5	6	15	8	<2.6		
Jan-89	20	20	3	16	7	17	15	12	2		
Jul-90										48	21
IRON											
Aug-88	18769	21451	2489	2943	6106	7541	21731	11053	1634		
Jul-90										19200	14700
LEAD											
Aug-88	39	31	5	7	8	8	23	9	5		
Jan-89	34	31	5	25	19	30	25	19	3		
Jul-90										<40	<29
MANGANESE											
Aug-88	313	780	84	58	205	329	1528	496	54		
Jul-90										382	361

TABLE 20. CHEMICAL ANALYSIS OF SEDIMENTS: METALS AND CONVENTIONAL PARAMETERS. (CONTINUED)

PARAMETER/ DATE	CONCENTRATION BY STATION (MG/KG DRY WEIGHT)										
	1	2	3	4	5	6	7	8	9	11	12
MERCURY											
Aug-88	<0.3	0.3	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1		
Jan-89	<0.2	<0.3	<0.1	<0.3	<0.1	0.5	<0.2	<0.2	<0.1		
Jul-90										0.4	<0.2
NICKEL											
Aug-88	16	19	<2.7	2	6	6	18	9	<2.6		
Jan-89	13	14	<1.9	8	<2.6	9	7	7	<1.8		
Jul-90										22	15
SELENIUM											
Aug-88	<1.2	<1.5	<0.6	<0.6	<0.7	<0.7	<1.6	<0.8	<0.5		
Jan-89	<1	<1.3	<0.7	0.9	<0.6	<1.1	<1.1	<1	<0.7		
Jul-90										<23	<16
SILVER											
Aug-88	<2.8	<3.2	<1.3	<1	<1.3	1.3	<1.3	<1.8	<1.3		
Jan-89	<1.3	<2.6	<1	<2.6	<1.3	<2.4	<2.6	<1.6	<0.9		
Jul-90										<13	<10
THALLIUM											
Aug-88	<1	1.2	<0.5	<0.5	<0.6	<0.5	<1.3	<0.7	<0.4		
Jan-89	<7.6	<10.1	<5.7	<7	<5.1	<9	<8.8	<8.2	<5.2		
Jul-90										<9.4	6.6
VANADIUM											
Aug-88	28	33	<4	5	9	13	35	18	<3.9		
Jul-90										43	31
ZINC											
Aug-88	152	144	17	33	38	32	91	44	9		
Jan-89	134	140	26	135	695	245	109	84	32		
Jul-90										229	155
CONVENTIONAL PARAMETERS											
CYANIDE											
Aug-88	<1	<1	<1	<1	<1	<1	<1	<1	<1		
SULFUR*											
Aug-88	30.1	27	16.5	8.86	13.7	23.8	12	16.5	ND		
Jan-89	137	126	6.16	56.2	4.9	36.1	67.6	90.1	3.65		
Jul-90										23	18
TOC											
Aug-88	3590	3310	323	515	734	1220	1500	1550	251		
Jan-89	3410	1750	728	1650	923	1540	1690	1780	542		

*TENTATIVELY IDENTIFIED USING EPA METHOD 625.

TABLE 21. CHEMICAL ANALYSIS OF SEDIMENTS: ORGANIC CHEMICALS*.

STATION	COMPOUND	CONCENTRATION (UG/KG DRY WT)
11	PHENANTHRENE	506
	FLUORANTHENE	737
	PYRENE	782
	BIS (2-ETHYLHEXYL) PHTHALATE	15,200
	CHLORDANE	381
	16 UNKNOWN COMPOUNDS (ABN)	2,200-23,000
	1 UNKNOWN HYDROCARBON	300
12	BIS (2-ETHYLHEXYL) PHTHALATE	972
	4,4'-DDE	20
	4,4'-DDT	230
	11 UNKNOWN COMPOUNDS (ABN)	800-18,000

*DATA FOR JULY 1990; NO ORGANICS DETECTED AT OTHER SAMPLING STATIONS/TIMES.

TABLE 22. SEDIMENT QUALITY PERCENTILES EXCEEDED.

PARAMETER	REFERENCE; PERCENTILE LEVEL	VALUE (MG/KG)	SAMPLE DATE	CONCENTRATION BY STATION (MG/KG)					
				1	2	5	6	11	12
CHROMIUM	TWC (1988b); 85TH%	36	1/89		37				
COPPER	TWC (1988b); 85TH%	34	7/90					48	
MERCURY	TWC (1988b); 85TH%	0.30	8/88		0.3				
			7/90					0.4	
NICKEL	TWC (1988b); 85TH%	19	8/88		19				
			7/90					22	
ZINC	TWC (1988b); 85TH%	140	8/88	152	144				
	U.S. EPA (1979); 85TH%	170	1/89		140	695	245		
			7/90					229	155
PHENANTHRENE	STAPLES et al. (1985); 50TH%	0.5	7/90					0.506	
FLUORANTHENE	STAPLES et al. (1985); 50TH%	0.5	7/90					0.737	
PYRENE	STAPLES et al. (1985); 50TH%	0.5	7/90					0.782	
BIS(ETHYLHEXYL)PHTHALATE	STAPLES et al. (1985); 50TH%	1	7/90					15.2	
	GREENSPUN AND TAYLOR (1979); 85TH%	8.9							
CHLORDANE	STAPLES et al. (1985); 50TH%	0.002	7/90					0.381	
	TWC (1988b); 85th%	0.001145							
DDE	STAPLES et al. (1985); 50TH%	0.0001	7/90						0.020
	TWC (1988b); 85th%	0.0065							
	GREENSPUN AND TAYLOR (1979); 85TH%	0.018							
DDT	STAPLES et al. (1985); 50TH%	0.0001	7/90						0.230
	TWC (1988b); 85th%	0.008							
	GREENSPUN AND TAYLOR (1979); 85TH%	0.019							

TABLE 23. CHEMICAL ANALYSIS OF EDIBLE FISH AND CRAB TISSUE: HEAVY METALS AND ORGANIC PRIORITY POLLUTANTS.

DATE/ STATION/ SAMPLE DESCRIPTION*	CONTAMINANTS	CONCENTRATION (MG/KG)***
<u>Aug-88</u>		
STATION 1		
Blue Crab	Arsenic	0.3
(<u>Callinectes</u> <u>sapidus</u>)	Chromium	0.75
N=7; CW-Not Recorded	Copper	9.8[a]
Lipid Content=0.595%	Cyanide	<0.51
	Selenium	14[b]
	Zinc	27
STATION 2		
Sea Catfish	Arsenic	0.25[b]
(<u>Arius</u> <u>felis</u>)	Chromium	0.65
N=5; TL=27.9 cm	Copper	0.48[a,c]
Lipid=1.995%	Cyanide	<0.51
	Mercury	0.11
	Zinc	24
	Bis (2-Ethylhexyl) Phthalate	1.2[d]
Blue Crab	Arsenic	0.39
(<u>Callinectes</u> <u>sapidus</u>)	Chromium	1.9
N=7; CW=14.5 cm	Copper	5.9[a]
Lipid Content=0.418%	Zinc	32
	Tetrachloroethene	0.021[e]
STATION 3		
Blue Crab	Chromium	0.68
(<u>Callinectes</u> <u>sapidus</u>)	Copper	7.6[a]
N=7; CW=12.8 cm	Cyanide	<0.51
Lipid Content=0.395%	Silver	0.48[b,c]
	Zinc	41
	Dichloromethane	0.091
STATION 4		
Sea Catfish	Antimony	4[b]
(<u>Arius</u> <u>felis</u>)	Arsenic	0.36[b]
N=5; TL=28.0 cm	Chromium	1.1
Lipid Content=2.385%	Copper	1.5[a]
	Cyanide	1.48
	Lead	5.5

TABLE 23 (CONTINUED)

STATION/DESCRIPTION	CONTAMINANTS	CONC.
STATION 4, Cont'd...	Silver	1[b]
	Zinc	36
	Bis (2-ethylhexyl) Phthalate	0.450[d,e]
	DDE	0.031
Blue Crab (Callinectes sapidus) N=7; CW=14.7 cm Lipid Content=0.795%	Chromium	1.7
	Copper	7.2[a]
	Lead	4.9[c]
	Silver	1.5[b]
	Zinc	37
	Bis (2-Ethylhexyl) Phthalate	0.27[d,e]
STATION 6		
Sea Catfish (Arius felis) N=5; TL-Not Recorded Lipid Content=1.995	Antimony	3.8[b]
	Arsenic	1.0[b]
	Chromium	1.4
	Copper	1.2[a]
	lead	7.8
	Silver	0.86[b]
	Zinc	21
	Bis (2-Ethylhexyl) Phthalate	0.32[d,e]
	DDE	0.1
DUPLICATE-FISH Sea Catfish (Arius felis) N=5; TL-Not Recorded Lipid Content=1.995%	Arsenic	0.6[b]
	Chromium	0.48[c]
	Copper	0.54[a]
	Mercury	0.11
	Zinc	23
	Bis (2-Ethylhexyl) Phthalate	0.33[d,e]
	DDE	0.084
Blue crab (Callinectes sapidus) N=7; CW-Not Recorded Lipid Content=0.596%	Antimony	4.2[b]
	Chromium	1.3
	Copper	5.9[a]
	Lead	6.7
	Silver	1.2[b]
	Zinc	33
	Bis (2-Ethylhexyl) Phthalate	0.37[d,e]
	Di-n-Butyl Phthalate	0.32[d,e]
	Tetrachloroethene	0.035
DUPLICATE-CRAB Blue Crab (Callinectes sapidus) N=7; CW-Not Recorded Lipid Content=0.394%	Arsenic	0.52
	Chromium	0.68
	Copper	7[a]
	Cyanide	<0.51
	Silver	0.52[b]
	Zinc	35
	Dichloromethane	0.12[d]
	Tetrachloroethene	0.03

TABLE 23 (CONTINUED)

STATION/DESCRIPTION	CONTAMINANTS	CONC.
STATION 8		
Sea Catfish	Antimony	3.3[b]
(*Arius felis*)	Arsenic	2.4[b]
N=5; TL=29.2 cm	Chromium	1
Lipid Content=1.986%	Copper	1.1[a]
	Lead	5.2
	Silver	0.63[b]
	Zinc	29
	Bis (2-Ethylhexyl) Phthalate	0.67[d,e]
	DDE	0.023
	Dichloromethane	0.05
	Toluene	0.013[e]
Blue Crab	Arsenic	0.68
(*Callinectes sapidus*)	Chromium	0.84
N=6; CW=14.4 cm	Copper	5.8[a]
Lipid Content=1.583%	Lead	5.8
	Selenium	0.61[b]
	Silver	0.66[b]
	Zinc	36
	Bis (2-Ethylhexyl) Phthalate	0.73[d,e]
	Dichloromethane	0.018[e]
	Diethyl Phthalate	1.7[d]
STATION 9 (Reference Site)		
Sea Catfish	Arsenic	4.2[b]
(*Arius felis*)	Chromium	0.64
N=5; TL=27.1 cm	Copper	0.81[a]
Lipid Content=1.194%	Cyanide	0.56
	Zinc	23
	Bis (2-Ethylhexyl) Phthalate	0.33[d,e]
	Dichloromethane	0.05
Blue Crab	Arsenic	0.25
(*Callinectes sapidus*)	Chromium	0.65
N=7; CW=16.2 cm	Copper	6.2[a]
Lipid Content=0.396%	Zinc	36
	Diethyl Phthalate	1.0[d,e]
Jan-89		
STATION 1		
Blue Crab	Arsenic	0.95[b]
(*Callinectes sapidus*)	Chromium	12[a]
N=5; CW-Not Recorded	Copper	9.8
Lipid Content=0.79%	Cyanide	<0.5
	Selenium	1.1[a]

TABLE 23 (CONTINUED)

STATION/DESCRIPTION	CONTAMINANTS	CONC.
STATION 1, Cont'd...	Silver	1.2[b]
	Zinc	51
	Chloroform	0.037
	4,4'-DDD	0.077
	4,4'-DDE	0.064
	Tetrachloroethene	0.028
	Toluene	0.023[e]
STATION 2		
Spot**	Arsenic	0.38[b]
(<u>Leiostomus</u> <u>xanthurus</u>)	Chromium	1.1[a]
N=3; TL=23.5 cm	Copper	2.4[c]
Lipid Content=0.4%	Cyanide	1.02
	Silver	0.56[c]
	Zinc	15
	Toluene	0.066
	1,1,1-Trichloroethane	0.34
Blue Crab	Arsenic	0.54[b]
(<u>Callinectes</u> <u>sapidus</u>)	Chromium	1.4[a]
N=5; CW=15.3 cm	Copper	6.6
Lipid Content=0.58%	Cyanide	<0.5
	Selenium	1.1[a]
	Silver	0.9[b,c]
	Zinc	38
	Chloroform	0.045
	Di-n-Butyl Phthalate	0.5
	Tetrachloroethene	0.034
	1,1,1-Trichloroethane	0.015[e]
	Toluene	0.042[e]
STATION 3		
White Bass**	Arsenic	0.5[b]
(<u>Morone</u> <u>crysops</u>)	Chromium	1.0[a]
N=5; TL=30.4 cm	Copper	2.1[c]
Lipid Content=1.19%	Cyanide	0.6
	Mercury	0.1
	Selenium	0.86
	Zinc	7.6
	Di-n-Butyl Phthalate	0.29[d,e]
	1,1,1-Trichloroethane	0.033
Blue Crab	Arsenic	0.43[b]
(<u>Callinectes</u> <u>sapidus</u>)	Chromium	1.2a
N=5; CW=14.9 cm	Copper	6.9
Lipid Content=0.39%	Cyandide	<0.5
	Selenium	0.56[a]
	Zinc	32
	Bis (2-Ethylhexyl) Phthalate	0.23[c]
	Toluene	0.026[e]

TABLE 23 (CONTINUED)

STATION/DESCRIPTION	CONTAMINANTS	CONC.
STATION 4		
White Bass**	Arsenic	0.37[b]
(*Morone crysops*)	Chromium	1.1[a]
N=5; TL=29.3 cm	Copper	1.4[c]
Lipid Content=1.57%	Cyanide	0.69
STATION 4, Cont'd...	Mercury	0.22
	Selenium	0.96
	Zinc	7.5
Blue Crab	Arsenic	0.46
(*Callinectes sapidus*)	Chromium	0.85[a,c]
N=5; CW=16.4 cm	Copper	10
Lipid Content=1.38%	Cyanide	<0.5
	Selenium	1.1[a]
	Silver	0.83[b,c]
	Zinc	35
	Bis (2-Ethylhexyl) Phthalate	0.23[c]
	Di-n-Butyl Phthalate	0.33[c]
	Toluene	0.034[e]
STATION 6		
Striped Mullet	Chromium	1.1[a]
(*Mugil cephalus*)	Copper	0.94[c]
N=1; TL=44.2 cm	Cyanide	0.73
Lipid Content=2.58%	Zinc	6.8
	Dichloromethane	0.026
	Tetrachloroethene	0.023
	DDE	0.071
STATION 8		
Red Drum**	Chromium	0.5[a,c]
(*Sciaenops ocellatus*)	Copper	0.88[c]
N=4; TL=40.8 cm	Cyanide	0.53
Lipid Content=0.4%	Selenium	0.87
	Zinc	4.8
STATION 9		
Spotted Seatrout	Chromium	0.92[a,c]
(*Sciaenops ocellatus*)	Copper	0.94[c]
N=8; TL=25.2 cm	Cyanide	1.83
Lipid Content=1.34%	Selenium	0.93
	Zinc	7.0

TABLE 23 (CONTINUED)

*TL=Average total length; CW=Average carapace width.

**Due to limited fish numbers, these samples contained other species as described below:

Station 2 included one striped mullet;
Station 3 included one yellow bass; and
Station 4 included one spot and one striped mullet.
Station 8 included one striped mullet.

***The following footnotes relate to the analytical results:

[a]Indicates duplicate analysis is not within control limits;
[b]Indicates sample recovery not within control limits;
[c]Indicates detected value between contract required detection limit and the instrument detection limit;
[d]Indicates possible contamination due to presence of contaminant in blank; and
[e]Estimated value, used when the mass spectral data indicates the presence of a compound that meets the identification criteria but the result is less than the specified detection limit.

TABLE 24. TISSUE CRITERIA FOR CONTAMINANTS DETECTED IN EDIBLE FISH AND CRAB TISSUE*.

PARAMETER	CARCINOGEN	q1* OR RfD	DATE	TISSUE CRITERIA (MG/KG) NON-CARCIN-OGEN	CARCINOGEN 10-5	CARCINOGEN 10-4	FDA ACTION LEVEL
ANTIMONY	NO	RfD=0.0004	(1/87)	1.87			
ARSENIC	YES	q1*=1.75	(6/21/88)		0.027	0.27	
CHROMIUM (III)	NO	RfD=1	(3/88)	4667			
COPPER	NO	-		-			
MERCURY	NO	RfD=0.0003	(2/89)				1.0
LEAD	YES***	-	(10/89)	0.833**			
SELENIUM	NO			5.4			
SILVER	NO	RfD=0.003	(6/88)	14			
ZINC	NO	-		-			
CYANIDE	NO	RfD=0.02	(3/88)	93.3			
BIS(2-ETHYLHEXYL)PHTHALATE	YES	q1*=0.014	(2/89)		3.33	33.3	
CHLOROFORM	YES	q1*=0.0061	(6/88)		7.65	76.5	
DDD	YES	q1*=0.34	(8/88)		0.137	1.37	
DDE	YES	q1*=0.24	(9/88)		0.194	1.94	
DICHLOROMETHANE	YES	q1*=0.0075	(1/89)		6.22	62.2	
DI-N-BUTYL PHTHALATE	NO	RfD=0.1	(1/87)	467			
DIETHYL PHTHALATE	NO	RfD=0.8	(9/87)	3733			
TETRACHLOROETHENE	YES		(10/80)		1.17	11.7	
TOLUENE	NO	RfD=0.2	(8/90)	933			
1,1,1-TRICHLOROETHANE	NO	RfD=0.09	(6/88)	420			

SOURCE OF TISSUE CRITERIA (EXCEPT LEAD): EPA-REGION 4 (1991); CALCULATED USING LATEST q1 OR RfD AND FISH CONSUMPTION RATE OF 15 G/DAY.
**LEVEL OF CONCERN FOR LEAD DEVELOPED BY TEXAS DEPARTMENT OF HEALTH AND TEXAS WATER COMMISSION.

TABLE 25. SUMMARY OF CHEMICAL DATA FOR EDIBLE FISH AND CRAB TISSUE*.

	TISSUE CONCENTRATION (MG/KG WET WEIGHT)								
	SAN JACINTO RIVER TIDAL SEGMENT 1001		HSC/SAN JACINTO RIVER SEGMENT 1005		HOUSTON SHIP CHANNEL SEGMENT 1006		TRINITY BAY SEGMENT 2544		FISH TISSUE CRITERIA (MG/KG)
PARAMETER	CRAB	FISH	CRAB	FISH	CRAB	FISH	CRAB	FISH	
ANTIMONY		2.33	3.0	2.2					1.87
ARSENIC	0.28	0.41	1.01	0.85	0.55	0.32	0.25	2.16	0.27
CHROMIUM	1.11	1.07	1.03	0.90	4.01	0.88	0.65	0.78	4667
COPPER	7.93	1.67	6.03	0.93	8.03	1.44	6.2	0.88	-
CYANIDE	~0.44	0.92	~0.34	0.4	~0.44	~0.77		1.2	93.3
LEAD	3.1	3.5	4.8	4.1					0.833
MERCURY		0.12		0.06		0.08			1.0
SELENIUM	0.54	0.69		0.37	4.11			0.59	5.4
SILVER	0.77	0.5	0.78	0.45	0.65	0.41			14
ZINC	36.3	17.0	32.3	16.9	37.0	19.5	36.0	15.0	-
BIS(2-ETHYLHEXYL)PHTHALATE	0.32	0.27	0.53	0.337		0.69		0.253	33.3
CHLOROFORM					0.027				76.5
DDD				0.022	0.056				1.37
DDE		0.017	0.014	0.045	0.052				1.94
DICHLOROMETHANE	0.032		0.97	0.025				0.33	62.2
DIETHYL PHTHALATE							1.0		3733
DI-N-BUTYL PHTHALATE	0.4	0.34	0.3		0.463				467
TOLUENE	0.021		0.084		0.022	0.039			933
1,1,1-TRICHLOROETHANE		0.019		0.015	0.013	0.176			420
TETRACHLOROETHENE				0.019	0.024				11.7

*AVERAGE VALUES FOR FISH AND CRAB SAMPLES COLLECTED AT STATIONS IN THE RESPECTIVE SEGMENTS; VALUES ARE LISTED IF THE PARAMETER WAS DETECTED IN ONE OR MORE SAMPLES FROM A GIVEN SEGMENT; WHERE A PARAMETER WAS NOT DETECTED, ONE-HALF THE DETECTION LIMIT WAS USED IN CALCULATING THE AVERAGE; SEE PREVIOUS TABLES LISTING ALL DETECTED VALUES AND DESCRIBING TISSUE CRITERIA.

APPENDICES

Appendix 1

Biological Survey of Shoreline Nekton Communities of the Lower Houston Ship Channel and Adjacent Waters (TWC segments 1001, 1005, 1006 and 2422), August 1988 and January 1989.

Biological Survey of Shoreline Nekton Communities of the Lower Houston Ship Channel and Adjacent Waters (TWC segments 1006, 1001, 1005 and 2422) August 1988 and January 1989

Performed in partial fulfillment
of EPA Section 104(b)(3)
Grant No. X-006425-01-2

George J. Guillen
and
Richard D. Seiler

Texas Water Commission
Field Operations Division
District 7
Houston, Texas

April 8, 1991

ABSTRACT

The most recent comprehensive characterization of the nekton communities of the lower portion (TWC segments 1006 and 1005) of Houston Ship Channel (HSC) was last conducted by Chambers and Sparks (1959). During that study they found very few organisms in the HSC above the confluence of the San Jacinto River. Data collected by the Texas Water Commission monitoring program at two water intake structures during the 1970's indicated that segment 1006 generally had a higher number of species annually than segment 1007 (TDWR 1980). Little or no data has been collected on the nekton communities of the lower or upper (TWC segment 1007) HSC since the late 1950's.

The purpose of this survey was to determine if there were any identifiable trends in nekton abundance that might be related to monitored water quality in segments 1006 ,1005 and 1001. Shoreline nekton communities were sampled during August 1988 and January 1989 with gillnets and seines. Numbers of individuals per taxa, numbers of taxa and total number of organisms were tabulated. Shannon-Weiner diversity (H') and evenness indices (J) were calculated for each gillnet and seine sample. Water temperature (C), pH, conductivity (uMHOS), salinity (ppt), dissolved oxygen (ppm), and secchi disc turbidity (in.) were also measured during sampling events.

Segment 1006 generally exhibited lower salinities whereas segment 1001 and 2422 exhibited higher salinities. Higher dissolved oxygen (DO) levels were observed during January 1989 sampling at all segments than in August 1988. DO was not significantly different between segments 1005 and 1006 during both August 1988 and January 1989. DO levels were significantly higher in segments 1001 and 2422 when compared to segments 1005 and 1006.

Highest and lowest gillnet catch rates were observed in segments 2422 and 1006 respectively. Higher number of taxa were collected in segment 1001 during August 1988. The sea catfish, Arius felis, was numerically dominant in all segments during August 1988. The blue crab was also numerically abundant in segments 1001 and 1006 during August 1988. Blue crab and/or Gulf menhaden, Brevoortia patronus dominated January 1989 catches.

Overall, lower total number of organisms were observed in January 1989 seine collections. The highest total number of organisms were collected in segments 1001 and 2422. The highest cumulative number of species collected occurred in segment 1001. Segments 1005 and 1006 had similar number of taxa. Gulf menhaden was prevalent in January 1989 seine catches. August 1989 seine collections were generally dominated by bay anchovy (Anchoa mitchilli). Significant positive correlations between number of taxa, H', J and dissolved oxygen were observed. These correlations were strongly related to similar spacial trends between stations.

Based on similar biological and hydrological characteristics and

presence of a commercial blue crab fishery observed in segment 1006, the previously established aquatic habitat use designation for segment 1006 may need to be reevaluated.

INTRODUCTION

The most recent comprehensive characterization of the nekton communities of the lower portion of Houston Ship Channel (HSC) was last conducted by Chambers and Sparks (1959). During that study they found very few organisms in the HSC above the confluence of the San Jacinto River. Little or no data has been collected on the nekton communities of the lower (TWC segments 1006 and 1005) or upper (segment 1007) HSC since the late 1950's. Data collected by the Texas Water Commission monitoring program at two water intake structures during the 1970's indicated that segment 1006 generally had a higher number of species annually than segment 1007 (TDWR 1980). Since then gradual improvements in overall water quality have been documented through reductions in conventional pollutant loading and increased levels of dissolved oxygen (EPA 1980 and Kirkpatrick 1987).

In conjunction with the hydrological, chemical and toxicological data collected during the current overall survey updated information on the shoreline nekton communities inhabiting the HSC and San Jacinto River was needed. Ecological surveys provide information on long-term cumulative impacts of physical and chemical alterations of water quality and associated habitat on aquatic life. This information complements short-term surveys of existing water and sediment quality. Shoreline nekton communities were selected for several reasons over other components of the ecosystem. Fish and macroinvertebrates are normally higher in the food chain and therefore temporally integrate effects on lower trophic levels (e.g. benthic organisms and herbivores). In addition, due to dredging activities and ship traffic benthic communities would be heavily influenced and potentially confound any water quality related trends. Finally the taxonomy and identification of fish and common macroinvertebrates is fairly simple and facilitates quick determination of species abundance.

METHODS

Shoreline nekton communities were sampled during August 1988 and January 1989 with gillnets and seines. Nekton communities were sampled at designated stations located in segments 1001, 1005, 1006 and 2422 during these two months. Additional sampling stations were also established in segments 1001 and 1006 to provide more spatial coverage (Table 1).

A total of 3 sampling stations per segment were sampled with a 15 ft. minnow seine in segments 1001, 1005, and 1006 (n=9) (Table 1). Only 1 station (station 9) was sampled in segment 2422. At each

Table 1. Nekton sampling stations monitored during August 1988 and January 1989.

STATION	GILL/SEINE	SEGMENT	ADDITIONAL DESCRIPTION
1	G/S	1006	Greens Bayou confluence
1A	S	1006	State monitoring station 1006.0125, Lat./Long. 29 44' 16 N / 95 06' 36 W
2	G/S	1006	HSC at the San Jacinto Monument
3	G/S	1001	San Jacinto River at the Cafe
3A	S	1001	San Jacinto River at the Railroad Bridge (0.75 miles due north of I-10)
4	G/S	1001	San Jacinto River at I-10
6	G/S	1005	San Jacinto River (HSC) at CM 125
7	S	1005	San Jacinto River (HSC) at CM 114
8	G/S	1005	San Jacinto River (HSC) at CM 99
9	G/S	2422	Trinity Bay at Umbrella Point
10	G	2422	Replicate shoreline station located approximately 0.75 miles west of station 9

station three 50 ft. replicate hauls were made with a 15 ft. common sense seine. The dimensions of the common sense seine were 15 ft. long by 4 ft. deep constructed of 35 lb test 1/8 inch nylon delta weave square mesh net material with heavy lead lines. The seine was pulled parallel to shore for a distance of 50 feet prior to landing on the shoreline. All fish and macroinvertebrates were removed, identified to lowest taxa, and enumerated. Numbers of individuals per taxa, numbers of taxa and total number of organisms were tabulated. In addition, water temperature (C), pH, conductivity (uMHOS), salinity (ppt) and dissolved oxygen (ppm) were measured with a Hydrolab Surveyor II multiparameter meter at 1 ft. depth. Secchi disc turbidity readings were taken sporadically to the nearest 0.5 inch. All measurements and calibration procedures followed standardized methods used by the TWC (Buzan et al. 1987).

A total of two stations per segment were sampled with gillnets in segments 1001, 1005, 1006 and 2422 (Table 1). At each station one gillnet was fished suspended from the bottom (1 to 5-10 feet) for an average of 18 hours. Experimental gillnets which measured 200 ft by 8 ft long were used. Each gillnet was constructed of 8 individual 25 ft. panels. Each of the panels was constructed of one of the following square inch mesh sizes: ½, 1, 1½, 2, 2½, 3, 3½, 4. The smaller size mesh was fished nearest to the shoreline. Upon retrieval all fish and macroinvertebrates were removed, identified to lowest taxa, and enumerated. Numbers of individuals per taxa, numbers of taxa and total number of organisms were tabulated. Water temperature (C), pH, conductivity (uMHOS), salinity (ppt) and dissolved oxygen (ppm) were measured with a Hydrolab Surveyor II multiparameter meter, generally at 1 ft. and bottom depth during initial deployment and/or retrieval. Secchi disc turbidity readings (0.5 in. increments) were taken during some sampling events.

Shannon-Weiner diversity (H') and Evenness indices (J) were computed for each gillnet and seine sample (Ludwig and Reynolds 1988). Collections with zero catch were deleted from the analysis. In collections having only one species a J value of zero was assigned to the sample.

Data from 1 ft. measurements of water temperature, dissolved oxygen, salinity, pH and secchi disc readings obtained during gillnet and seine sampling were pooled and subjected to further statistical analysis. Two-way analysis of variance (ANOVA) was used to examine segment and seasonal differences in selected shallow water (<1 ft.) parameters (water temperature, D.O., salinity, and pH). When significant (alpha < 0.05), differences were observed Tukey's multiple range test was used to examine trends in these parameters between segments and sampling periods. When significant interactions between segment and sampling periods occurred the data was reclassified according to a cell means model, where each cell corresponded to a segment-sampling period grouping (e.g. August-1006). The reclassified data was then subjected to a one-way ANOVA and Tukey's multiple range test if necessary. The relationship of hydrological variables was further ascertained through linear correlation analysis. All analyses were conducted using the SAS statistical analysis software package (SAS Institute Inc. 1988).

Catch data and computed parameters from seine collections were also subjected statistical analysis using a nested two-way ANOVA to examine segment and seasonal differences. All catch parameters were subjected to the Shapiro-Wilk test for normality (SAS Institute Inc. 1988). Only total catch exhibited consistent deviation from the normal distribution and was therefore log transformed (ln (catch + 1)) prior to further analyses. The distribution of log transformed total catch data was not significantly different from a normal distribution. When significant differences (alpha <0.05) were detected using the ANOVA test, Tukey's multiple range test was used to examine trends in population parameters between segments and sampling periods. When significant interactions between segment and sampling periods occurred the data was reclassified according to a cell means model, where each cell corresponded to a segment-sampling period grouping. The reclassified data was then subjected to a one-way ANOVA and Tukey's multiple range test if necessary. The relationship between water temperature, salinity, dissolved oxygen and turbidity (secchi disc) and population parameters were determined by linear correlation analysis. Due to the small sample size, statistical analyses of gillnet catches were not conducted.

STUDY AREA

The Houston Ship Channel (segments 1005, 1006 and 1007) system is part of the San Jacinto River Basin and is located south of Houston, Texas at the northwestern corner of the Galveston Bay system. The Houston Ship Channel is a deep channel that has been dredged at mid-channel to a depth of approximately 40 ft. (12 m) to allow for passage of ocean-going ships and vessels. Channel widths range from 404 to 2,592 ft. from the Turning Basin to Morgans Point at the bottom of segment 1005. The middle and lower portions (segments 1006 and 1005) of the Houston Ship Channel were studied during this study. Advective velocities range from 0.020 to 0.030 ft/s under low flow conditions (TDWR 1984).

The San Jacinto River (segment 1001) is tidal from the Lake Houston to the Houston Ship Channel. Average depths range from 6.2 to 18.4 ft. (Kirkpatrick 1987). During low flow conditions of the San Jacinto River, widths can range between 230 to 3,350 ft. (Kirkpatrick 1987). Advective velocities range from 0.0007 to 0.004 ft/s during low flow conditions (TDWR 1984).

Trinity Bay (segment 2422) covers an area of 337 km^2. The area is an open bay system varying in depth from 2 to 8 ft. Discharges from the Trinity River heavily influence the salinity regime and water quality of this bay segment. The purpose of establishing this station was to primarily provide baseline water quality data on a system not influenced by the loading of the HSC. Biological data was predominately collected at this station to provide supplemental information for that effort.

All of the stations sampled with gillnets and seines were open sandy and/or muddy substrate shorelines. Very little submerged aquatic vegetation (SAV) or attached algae was observed at any station. Stations sampled in segments 1006 usually contained various type of debris (e.g. tires, concrete, barrels) along the shoreline. Stations in segment 1001 usually contained some submerged brush. Although not sampled an extensive coastal marsh system was located in the adjacent lower portions of segment 1001. Stations in segments 1005 possessed very little shoreline debris and/or cover.

Segment 2422 was an open bay area characterized by having varying amounts of concrete riprap and submerged pilings. Constant wind induced wave action was usually present. The other three segments were well protected but still subjected to extensive wind and ship induced wave action.

In general the amount of physical variability between stations was minimal. The majority of variation in nekton populations would most probably be induced by water quality fluctuations. This hypothesis is further reinforced based on known permitted discharge data. Segments 1006, 1005, 1001 and 2422 have the highest to lowest amounts of permitted discharge rates (361.57, 37.22, 15.88, 0.9 MGD, respectively) (TWC 1990).

RESULTS

HYDROLOGICAL DATA

A detailed listing of hydrological data is provided in Appendices 1, 2, 3, and 4. Hydrological monitoring conducted during gillnet and seine collections revealed significant trends in water temperature between sampling events and segments (Tables 2, 3, 4). There were significant interactions between segments and collection period (Table 2). Analysis of water temperature data indicated that little variation was observed in surface water temperatures between segments during August 1988 (Tables 3 and 4) During January 1989 water temperatures in segment 1005 and 1006 were significantly higher than 1001 and 2422 (Table 4).

Significant trends in salinity (conductivity) between sampling events and segments were observed (Table 5). In general, salinity gradients appeared more distinct during the initial gillnet sampling in August (Fig. 1). Segment 1006 generally exhibited lower salinities whereas segment 1001 and 2422 exhibited higher salinities (Fig. 1). Due to interaction between seasonal and geographical trends this pattern was not consistent temporally (Tables 6 and 7).

Significant shoreline dissolved oxygen trends were observed during

Table 2. Analysis of variance of dependent variable temperature (TEMP).(1 ft. readings).

Source	DF	F Value	Pr > F
Model	7	547.47	0.0001
Error	34		
Corrected Total	41		
SEGMENT	3	10.68	0.0001
TIME	1	3465.15	0.0001
SEGMENT*TIME	3	4.85	0.0065

DF = degrees of freedom, F Value = computed F test statistic.
Pr > F = probability of observing a greater F if H_o is true.

Table 3. Analysis of variance of variance and mean and standard deviations of dependent variable temperature (TEMP) using interaction corrected cell means model. (1 ft. readings).

Source	DF	F Value	Pr > F
Model	7	547.47	0.0001
Error	34		
Corrected Total	41		

CELL			TEMP	
SEGMENT	MO.	N	Mean	SD
1001	1	6	12.9666667	0.65319726
1001	8	5	28.9000000	0.74161985
1005	1	6	15.3000000	0.52535702
1005	8	7	29.1857143	1.29412592
1006	1	6	15.1500000	0.60249481
1006	8	6	29.0000000	0.54772256
2422	1	3	13.0000000	0.10000000
2422	8	3	28.1666667	0.76376262

Table 4. Tukey's Studentized multiple range (HSD) test for variable: TEMP (Alpha= 0.05 Confidence= 0.95 df= 34 MSE= 0.595987 Critical Value of Studentized Range= 4.563). Comparisons significant at the 0.05 level are indicated by '***'.

CELL Comparison SEGMENT/MO					Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
1005	8	-	1006	8	-1.200	0.186	1.572	
1005	8	-	1001	8	-1.173	0.286	1.744	
1005	8	-	2422	8	-0.700	1.019	2.738	
1005	8	-	1005	1	12.500	13.886	15.272	***
1005	8	-	1006	1	12.650	14.036	15.422	***
1005	8	-	2422	1	14.467	16.186	17.905	***
1005	8	-	1001	1	14.833	16.219	17.605	***
1006	8	-	1001	8	-1.408	0.100	1.608	
1006	8	-	2422	8	-0.928	0.833	2.595	
1006	8	-	1005	1	12.262	13.700	15.138	***
1006	8	-	1006	1	12.412	13.850	15.288	***
1006	8	-	2422	1	14.239	16.000	17.761	***
1006	8	-	1001	1	14.595	16.033	17.472	***
1001	8	-	2422	8	-1.086	0.733	2.552	
1001	8	-	1005	1	12.092	13.600	15.108	***
1001	8	-	1006	1	12.242	13.750	15.258	***
1001	8	-	2422	1	14.081	15.900	17.719	***
1001	8	-	1001	1	14.425	15.933	17.442	***
2422	8	-	1006	1	11.255	13.017	14.778	***
2422	8	-	2422	1	13.133	15.167	17.201	***
2422	8	-	1001	1	13.439	15.200	16.961	***
1005	1	-	1006	1	-1.288	0.150	1.588	
1005	1	-	2422	1	0.539	2.300	4.061	***
1005	1	-	1001	1	0.895	2.333	3.772	***
1006	1	-	2422	1	0.389	2.150	3.911	***
1006	1	-	1001	1	0.745	2.183	3.622	***
2422	1	-	1001	1	-1.728	0.033	1.795	

Table 5. Analysis of variance and mean and standard deviations of dependent variable salinity (SAL). (1 ft. readings).

Source	DF	F Value	Pr > F
Model	7	4.74	0.0008
Error	36		
Corrected Total	43		
SEGMENT	3	3.23	0.0335
TIME	1	0.01	0.9103
SEGMENT*TIME	3	7.93	0.0003

Level of SEGMENT	N	SAL Mean	SAL SD
1001	12	15.5750000	1.90268948
1005	13	15.4923077	3.45626521
1006	13	14.2846154	2.52680502
2422	6	17.4166667	1.20069424

Level of TIME	N	SAL Mean	SAL SD
JAN	22	15.2636364	2.53725488
AUG	22	15.5772727	2.85989208

Level of SEGMENT	Level of TIME	N	SAL Mean	SAL SD
1001	JAN	6	16.4833333	1.14789663
1001	AUG	6	14.6666667	2.16024690
1005	JAN	6	12.7833333	2.71765831
1005	AUG	7	17.8142857	2.02684366
1006	JAN	7	15.2428571	2.07593926
1006	AUG	6	13.1666667	2.71416040
2422	JAN	3	17.8333333	0.28867513
2422	AUG	3	17.0000000	1.73205081

Table 6. Analysis of variance of dependent variable salinity (SAL) using interaction corrected cell means model. (1 ft. readings).

Dependent Variable: SAL

Source	DF	F Value	Pr > F
Model (CELL)	7	4.74	0.0008
Error	36		
Corrected Total	43		

Table 7. Tukey's Studentized multiple range (HSD) test for variable: SAL (Alpha= 0.05 Confidence= 0.95 df= 36 MSE= 4.454325 Critical Value of Studentized Range= 4.547). Comparisons significant at the 0.05 level are indicated by '***'.

CELL Comparison SEGMENT/MO. SEGMENT/MO.	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
2422 JAN - 1005 AUG	-4.664	0.019	4.702	
2422 JAN - 2422 AUG	-4.708	0.833	6.374	
2422 JAN - 1001 JAN	-3.449	1.350	6.149	
2422 JAN - 1006 JAN	-2.093	2.590	7.274	
2422 JAN - 1001 AUG	-1.632	3.167	7.965	
2422 JAN - 1006 AUG	-0.132	4.667	9.465	
2422 JAN - 1005 JAN	0.251	5.050	9.849	***
1005 AUG - 2422 AUG	-4.702	-0.019	4.664	
1005 AUG - 1001 JAN	-2.445	1.331	5.107	
1005 AUG - 1006 JAN	-1.056	2.571	6.199	
1005 AUG - 1001 AUG	-0.628	3.148	6.923	
1005 AUG - 1006 AUG	0.872	4.648	8.423	***
1005 AUG - 1005 JAN	1.255	5.031	8.807	***
2422 AUG - 1001 JAN	-4.282	0.517	5.315	
2422 AUG - 1006 JAN	-2.926	1.757	6.440	
2422 AUG - 1001 AUG	-2.465	2.333	7.132	
2422 AUG - 1006 AUG	-0.965	3.833	8.632	
2422 AUG - 1005 JAN	-0.582	4.217	9.015	
1001 JAN - 1005 JAN	-0.218	3.700	7.618	
1001 JAN - 1006 JAN	-2.535	1.240	5.016	
1001 JAN - 1001 AUG	-2.101	1.817	5.735	
1001 JAN - 1006 AUG	-0.601	3.317	7.235	
1006 JAN - 1006 AUG	-1.699	2.076	5.852	
1006 JAN - 1005 JAN	-1.316	2.460	6.235	
1001 AUG - 1006 AUG	-2.418	1.500	5.418	
1001 AUG - 1005 JAN	-2.035	1.883	5.801	
1006 AUG - 1005 JAN	-3.535	0.383	4.301	

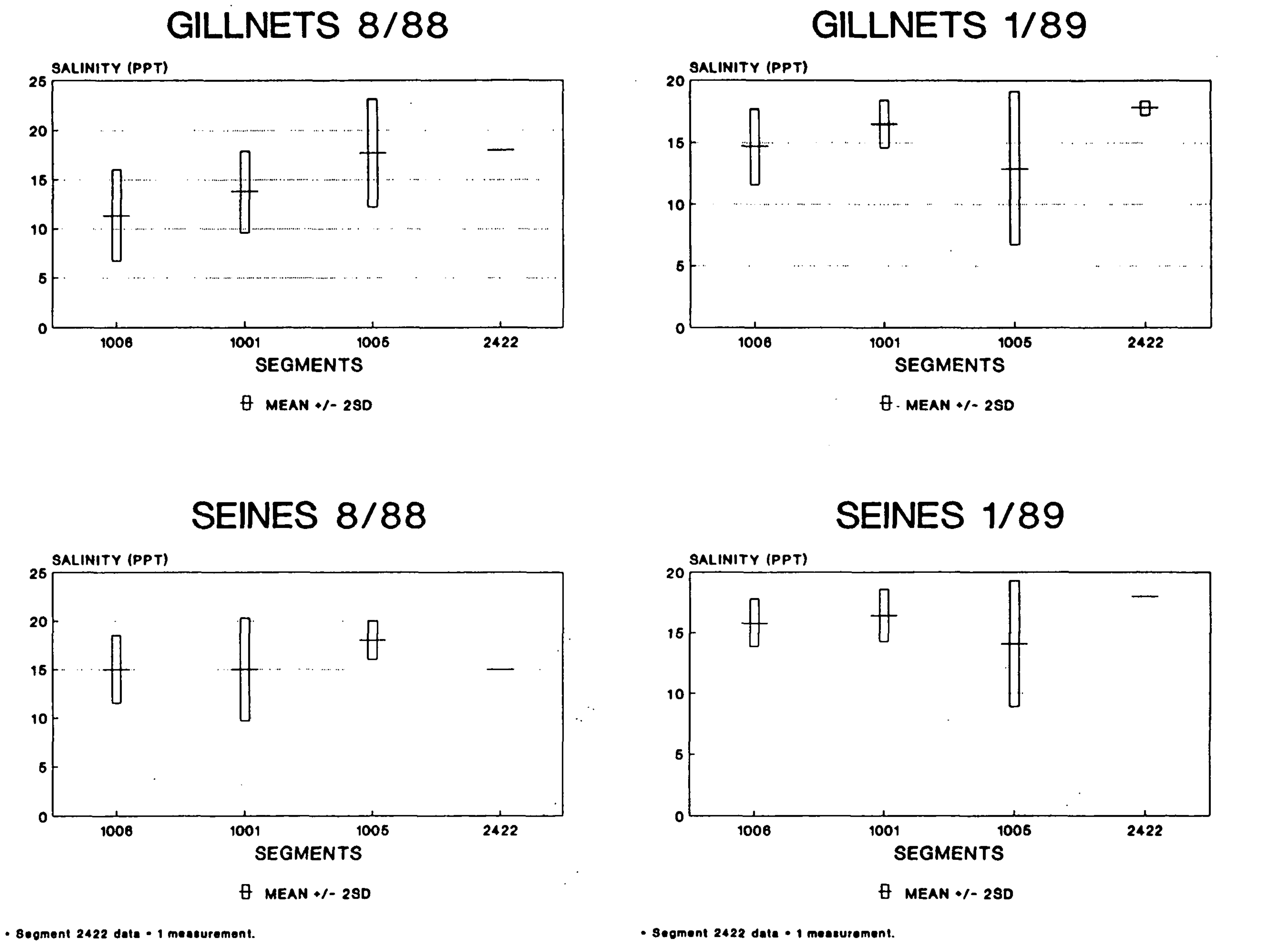


Figure 1. Salinity trends measured during gillnet and seine collections. Note: 2 SD re[redacted]s t[redacted]wo[redacted]and[redacted] de[redacted]ti[redacted]

Table 8. Analysis of variance and mean and standard deviations of dependent variable dissolved oxygen (D.O). (1 ft. readings).

Source	DF	F Value	Pr > F
Model	7	23.54	0.0001
Error	34		
Corrected Total	41		
SEGMENT	3	34.57	0.0001
TIME	1	52.88	0.0001
SEGMENT*TIME	3	0.19	0.9020

Level of SEGMENT	N	DO Mean	DO SD
1001	11	9.24545455	2.10872646
1005	12	5.54166667	1.48658139
1006	13	5.07692308	1.83537183
2422	6	8.23333333	1.43898112

Level of TIME	N	DO Mean	DO SD
JAN.	22	8.04545455	2.07427033
AUG.	20	5.33000000	2.14674785

Level of SEGMENT	TIME	N	DO Mean	DO SD
1001	JAN	6	10.5000000	1.67332005
1001	AUG	5	7.7400000	1.55659886
1005	JAN	6	6.7000000	0.79246451
1005	AUG	6	4.3833333	1.00681014
1006	JAN	7	6.4571429	0.55933634
1006	AUG	6	3.4666667	1.38948432
2422	JAN	3	9.5333333	0.11547005
2422	AUG	3	6.9333333	0.30550505

Table 9. Tukey's Studentized multiple range (HSD) test for variable: DO (Alpha= 0.05 Confidence= 0.95 df= 34 MSE= 1.283651 Critical Value of Studentized Range= 3.820). Comparisons significant at the 0.05 level are indicated by '***'.

SEGMENT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
1001 - 2422	-0.541	1.012	2.565	
1001 - 1005	2.426	3.704	4.981	***
1001 - 1006	2.915	4.169	5.422	***
2422 - 1005	1.162	2.692	4.222	***
2422 - 1006	1.646	3.156	4.667	***
1005 - 1006	-0.760	0.465	1.690	

Table 10. Analysis of variance and mean and standard deviation values of dependent variable pH (1 ft. readings).

Source	DF	F Value	Pr > F
Model	7	7.98	0.0001
Error	32		
Corrected Total	39		
SEGMENT	3	16.19	0.0001
TIME	1	1.95	0.1717
SEGMENT*TIME	3	1.13	0.3500

Level of SEGMENT	N	PH Mean	PH SD
1001	11	8.06363636	0.28730725
1005	11	7.55454545	0.26594600
1006	12	7.39166667	0.23532698
2422	6	7.85000000	0.12247449

Level of TIME	N	PH Mean	PH SD
1	20	7.76000000	0.35451969
8	20	7.62000000	0.36935221

Level of SEGMENT	Level of TIME	N	PH Mean	PH SD
1001	1	6	8.18333333	0.27141604
1001	8	5	7.92000000	0.25884358
1005	1	5	7.50000000	0.12247449
1005	8	6	7.60000000	0.35213634
1006	1	6	7.48333333	0.07527727
1006	8	6	7.30000000	0.30983867
2422	1	3	7.90000000	0.00000000
2422	8	3	7.80000000	0.17320508

Table 11. Tukey's Studentized multiple range (HSD) test for variable: PH (Alpha= 0.05 Confidence= 0.95 df= 32 MSE= 0.058896 Critical Value of Studentized Range= 3.832) Comparisons significant at the 0.05 level are indicated by '***'.

SEGMENT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
1001 - 2422	-0.1201	0.2136	0.5473	
1001 - 1005	0.2287	0.5091	0.7895	***
1001 - 1006	0.3975	0.6720	0.9464	***
2422 - 1005	-0.0382	0.2955	0.6292	
2422 - 1006	0.1296	0.4583	0.7871	***
1005 - 1006	-0.1116	0.1629	0.4373	

Table 12. Analysis of variance and mean and standard deviation values of secchi disc measurements.

Source	DF	F Value	Pr > F
Model	7	4.11	0.0046
Error	23		
Corrected Total	30		
SEGMENT	3	2.67	0.0711
TIME	1	17.70	0.0003
SEGMENT*TIME	3	1.92	0.1539

Level of SEGMENT	N	SECCHI Mean	SECCHI SD
1001	8	26.8750000	9.3264218
1005	11	17.2727273	6.3732395
1006	9	24.3333333	8.9721792
2422	3	22.6666667	14.4337567

Level of TIME	N	SECCHI Mean	SECCHI SD
1	18	26.3888889	7.72420861
8	13	16.6923077	8.34050973

Level of SEGMENT	Level of TIME	N	SECCHI Mean	SECCHI SD
1001	1	5	32.2000000	6.30079360
1001	8	3	18.0000000	6.00000000
1005	1	6	19.8333333	1.47196014
1005	8	5	14.2000000	8.78635305
1006	1	5	26.6000000	9.68504001
1006	8	4	21.5000000	8.38649708
2422	1	2	31.0000000	0.00000000
2422	8	1	6.0000000	.

Table 13. Correlation between hydrological variables. (Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / Number of Observations).

	SECCHI	TEMP	PH	SAL	DO
SECCHI	1.00000	-0.83235	0.28381	-0.19819	0.44982
	0.0	0.0001	0.0800	0.1919	0.0028
	45	45	39	45	42
TEMP	-0.83235	1.00000	-0.27209	-0.01799	-0.61412
	0.0001	0.0	0.0534	0.8943	0.0001
	45	57	51	57	54
PH	0.28381	-0.27209	1.00000	0.24346	0.87762
	0.0800	0.0534	0.0	0.0852	0.0001
	39	51	51	51	51
SAL	-0.19819	-0.01799	0.24346	1.00000	0.30763
	0.1919	0.8943	0.0852	0.0	0.0236
	45	57	51	60	54
DO	0.44982	-0.61412	0.87762	0.30763	1.00000
	0.0028	0.0001	0.0001	0.0236	0.0
	42	54	51	54	54

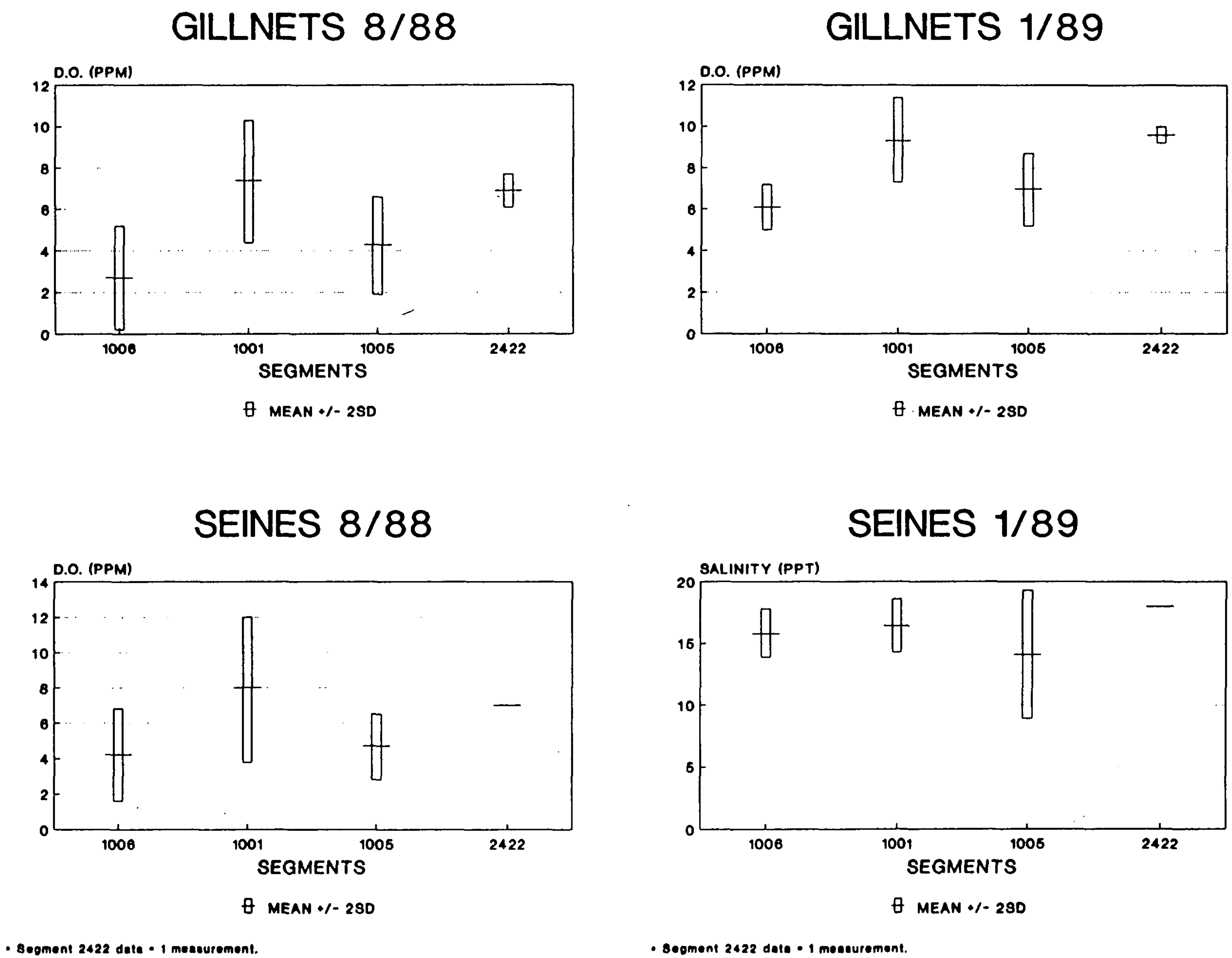


Figure 2. Dissolved oxygen trends measured during gillnet and seine collections.

the survey (Table 8). Higher dissolved oxygen levels were observed in all segments during January 1989 sampling, than in August 1988 (Tables 8 and 9 and Fig. 2). Highest dissolved oxygen levels were generally recorded at most stations located in segment 1001, while lowest levels were recorded at station 1 in segment 1006 (Appendices 1, 2, 3, and 4, and Figs. 2). During August 1988 dissolved oxygen levels in segment 1006 sometimes fell below 2.0 ppm (Figs. 2). Results of statistical analyses indicate that during both sampling periods dissolved oxygen levels were significantly higher in segments 1001 and 2422 when compared to segments 1005 and 1006 (Table 9). Dissolved oxygen levels were not significantly different between segments 1005 and 1006 (Table 9 and Fig. 2).

Statistically significant trends in pH were observed between segments (Tables 10). Although significant the maximum difference between average measurements was less than 0.7 pH units (Table 10). Segment 1001 pH levels were significantly higher than in segments 1005 and 1006 (Table 11). Lowest pH levels were generally observed in 1006 (Table 11).

Secchi disc readings varied between 10 and 41 inches (Appendices 1, 2, 3, and 4, and Table 12). Individual stations measurements varied considerably between sampling events and were heavily influenced by wave action generated by passing ships. Although not statistically significant the lowest mean secchi disc readings were observed in segment 1005 (Table 12). Secchi disc measurements made during the August 1988 were significantly higher than in January 1989 (Tables 12).

Significant linear correlations between various hydrological variables were observed (Table 13). Secchi disc readings were highly negatively correlated with water temperature. This relationship is primarily due to the previously documented seasonal trend in water temperature and turbidity (Tables 3 and 12). Similar negative correlations between dissolved oxygen and temperature can be attributed to documented seasonal and spatial trends between segments (Tables 3 and 8).

Less stronger positive correlations between dissolved oxygen and salinity were also observed (Table 13). This association is partly attributable to observed spatial patterns in these parameters (Tables 6 and 8). Weaker correlations between pH and water temperature are difficult to interpret.

BIOLOGICAL DATA

Overall a total of 4993 organisms comprising 41 taxa were collected during both study periods with gillnets and seines (Appendices 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14). Although no statistics are presented here on organism lengths the seine selectively sampled organisms < 5 inches total length (TL), while the gillnets were more selective toward larger organisms. The majority of fish and invertebrates collected were juveniles of estuarine species. Both seines and gillnets primarily targeted shoreline fish populations. The gillnets did however sample at deeper depths (>6 feet) on occasions. This contrasts to the studies conducted by Chambers and Sparks (1959) which utilized trawling gear to sample side bays and deeper channel locations in segments 1005 and 1006.

Gillnets

A total of 789 organisms representing 33 taxa were collected in gillnets during January 1989 and August 1988 (Appendices 5 and 6). For all segments total catches were generally higher during August 1988 than in January 1989 (Fig. 3). Highest and lowest catch rates were generally observed in segments 2422 and 1006 respectively (Fig. 3). Catch rates in segment 1001 were also generally higher than in segments 1005 and 1006.

Higher number of taxa were collected in August 1988 than in January 1989 (Fig. 4). The highest number of taxa per segment was collected in segment 1001 during August 1988. The lowest number of taxa was collected in segment 1005 during January 1989. This low number of taxa may however be partly due to the poor catch of one gillnet which was accidently tangled by ship traffic. Number of taxa in segments 1005 and 1006 were similar during January 1989 (Fig. 4). Diversity (H') and evenness (J) indices fluctuated erratically between stations with no apparent pattern (Appendices 5 and 6).

Several patterns in species composition between segments and sampling events were observed. Hardhead catfish, Arius felis, was one of the numerically dominant taxa in all segments during August 1988 (Fig. 5). In addition, blue crab, Callinectes sapidus were numerically abundant in segments 1001 and 1006 during August 1988. Species such as Gulf menhaden, Brevoortia patronus, and gizzard shad, Dorosoma cepedianum, dominated January 1989 gillnet catches (Fig. 5). Blue crab continued to be abundant in catches in segment 1006 during January 1989.

Seines

Seine catches yielded a total of 4204 organisms representing 25 taxa (Appendices 7, 8, 9, 10, 11, 12, 13, and 14). Significant spatial and temporal patterns in abundance were observed (Tables 14 and 15). Lower total number of organisms were generally observed in January 1989 collections (Figs. 6 and 7). Highest total number of organisms were collected in segments 1001 and 2422 (Table 14 and 15). Catch rates in segments 1005 and 1006 were not significantly different (Table 15).

Significant differences in number of taxa collected were observed between segments (Tables 16 and 17). The highest number of taxa in sample collections were generally observed in segment 1001 samples (Table 17 and Figs. 8 and 9). Although yielding significantly lower number of taxa than segments 1001 and 2422, segment 1006 was not significantly different than 1005 (Table 17). Due to the

Table 14. Analysis of variance of seine catches (ln(total catch + 1)).

Source	DF	F Value	Pr > F
Model	13	5.25	0.0001
Error	44		
SEGMENT	3	14.79	0.0001
DATE	1	6.67	0.0132
SEGMENT*DATE	3	2.14	0.1086
STATION(SEGMENT)	6	1.06	0.3983

Table 15. Tukey's Studentized multiple range (HSD) test for variable: seine catch (Alpha= 0.05 Confidence= 0.95 df= 44 MSE= 1.276232). Critical Value of Studentized Range= 3.776). Comparisons significant at the 0.05 level are indicated by '***'.

SEGMENT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
1001 - 2422	-0.788	0.644	2.076	
1001 - 1005	0.770	1.790	2.810	***
1001 - 1006	1.497	2.532	3.566	***
2422 - 1005	-0.276	1.146	2.568	
2422 - 1006	0.455	1.888	3.320	***
1005 - 1006	-0.278	0.742	1.762	

Table 16. Analysis of variance of number of taxa in seine collections.

Source	DF	F Value	Pr > F
Model	13	6.01	0.0001
Error	44		
Corrected Total	57		
SEGMENT	3	20.76	0.0001
DATE	1	2.80	0.1015
SEGMENT*DATE	3	0.79	0.5069
STATION(SEGMENT)	6	1.26	0.2949

Table 17. Tukey's Studentized multiple range (HSD) test for variable: seine taxa (Alpha= 0.05 Confidence= 0.95 df= 44 MSE= 1.951659 Critical Value of Studentized Range= 3.776). Comparisons significant at the 0.05 level are indicated by '***'.

SEGMENT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
1001 - 2422	-0.703	1.069	2.840	
1001 - 1005	1.140	2.402	3.663	***
1001 - 1006	2.368	3.647	4.926	***
2422 - 1005	-0.425	1.333	3.092	
2422 - 1006	0.807	2.578	4.350	***
1005 - 1006	-0.016	1.245	2.507	

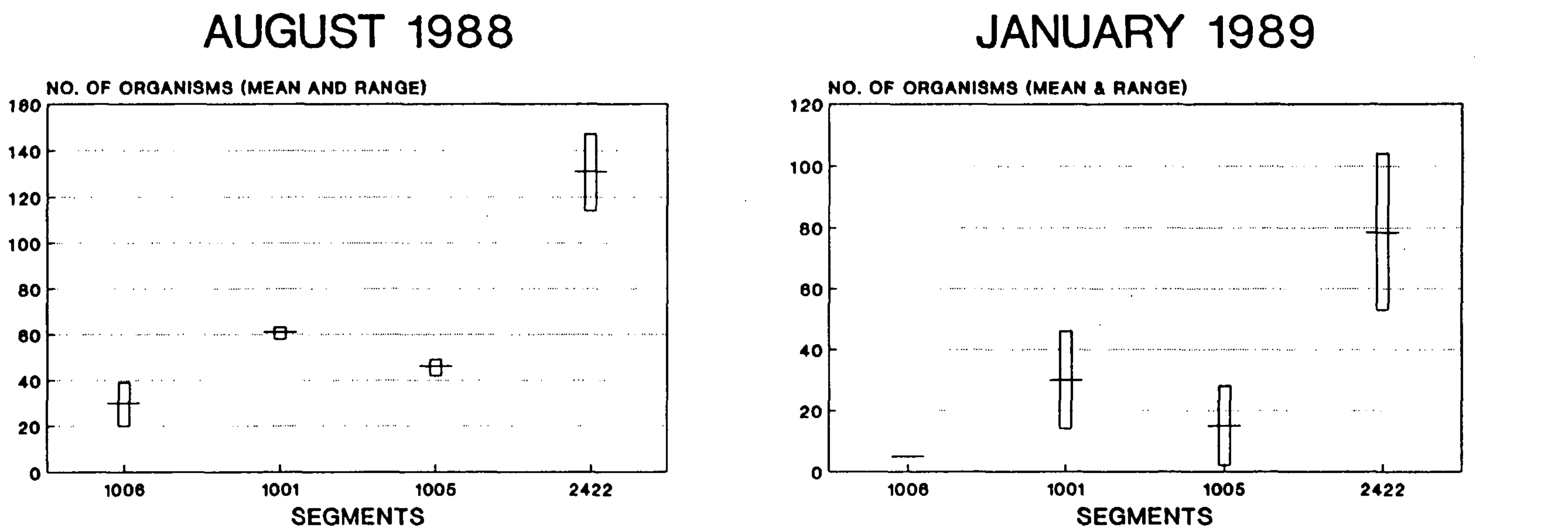


Figure 3. Gillnet catches during the survey.

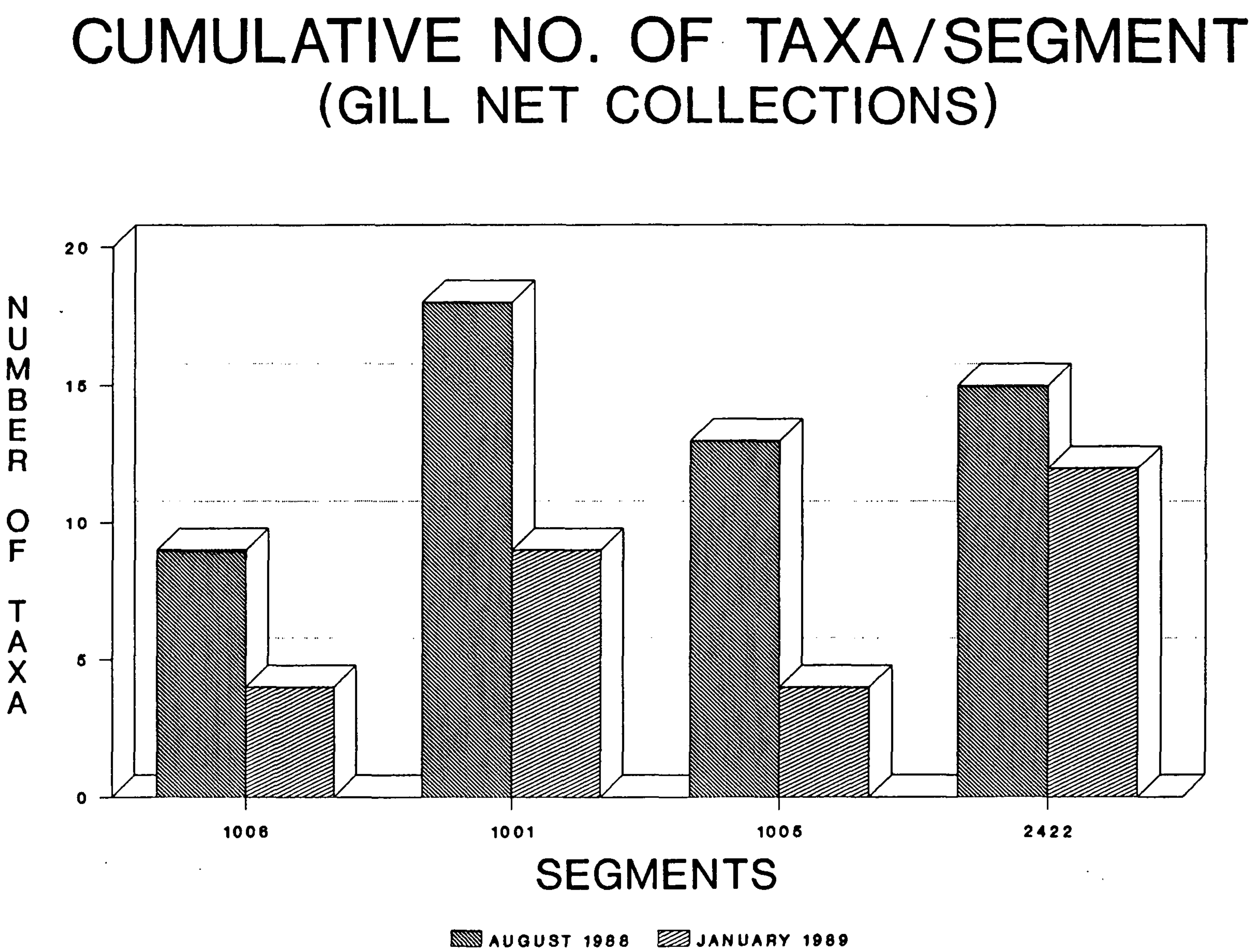


Figure 4. Cumulative number of taxa collected with gillnets.

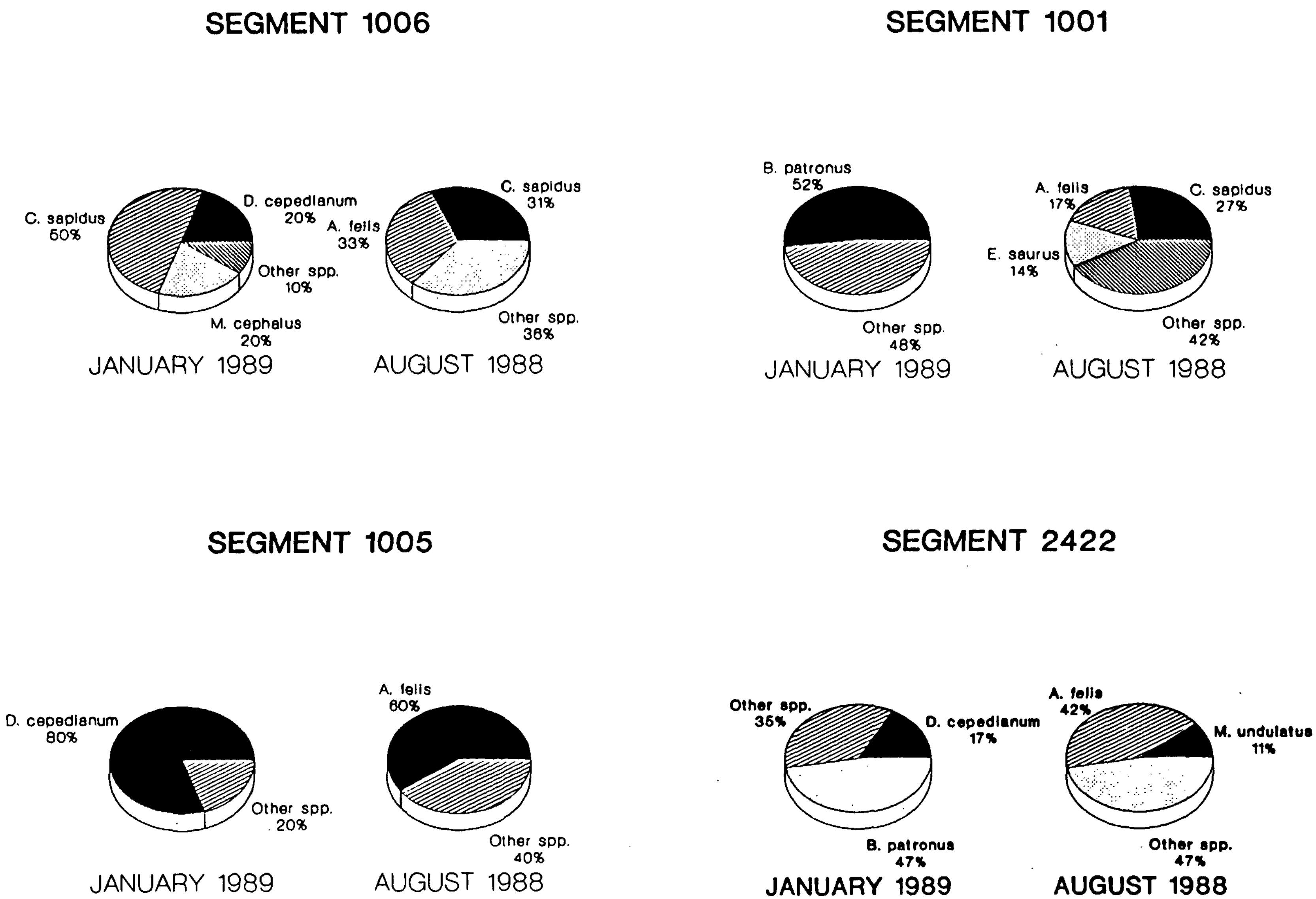


Figure 5. Species composition of gillnet collections.

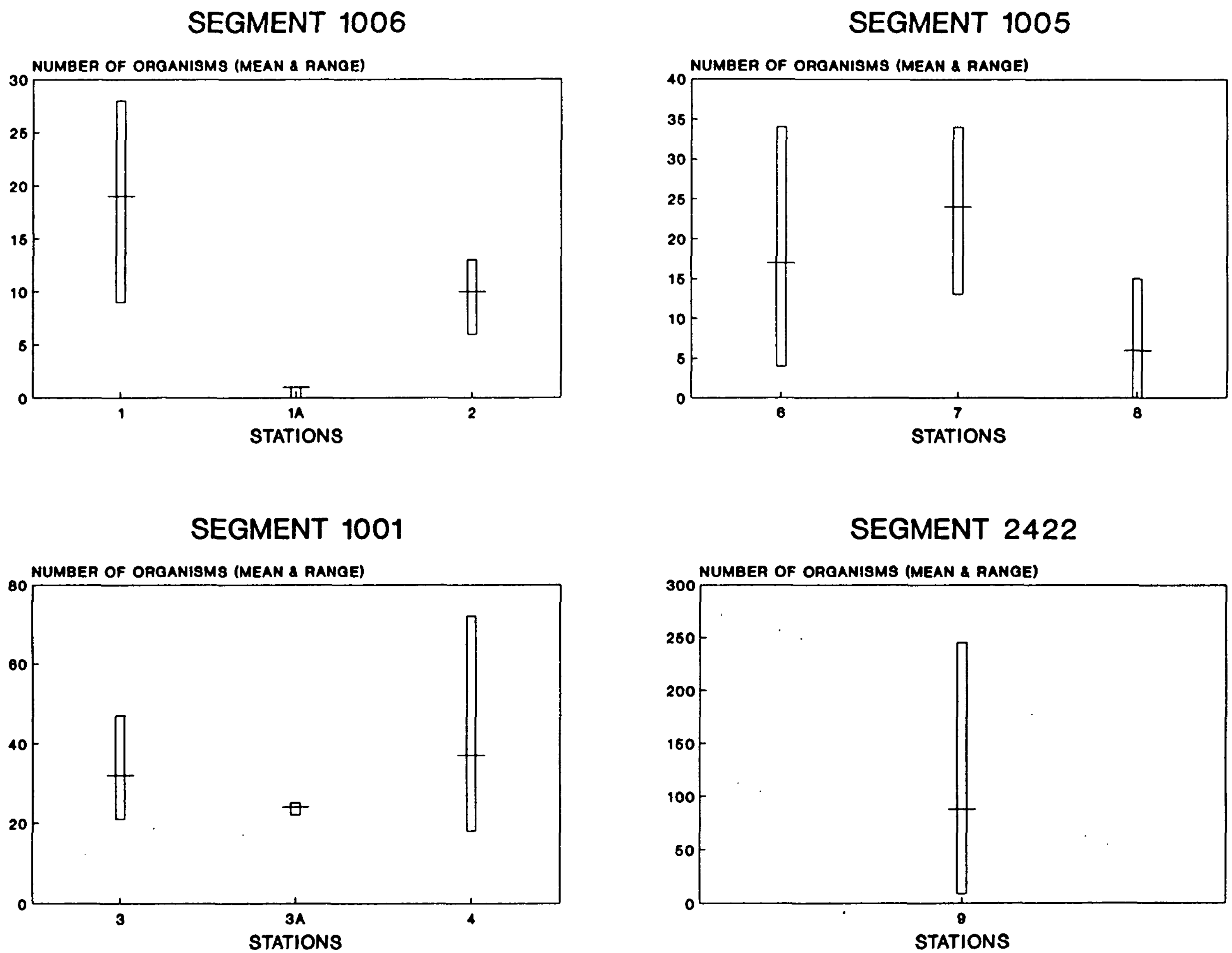


Figure 6. Number of organisms collected with seines during August 1988.

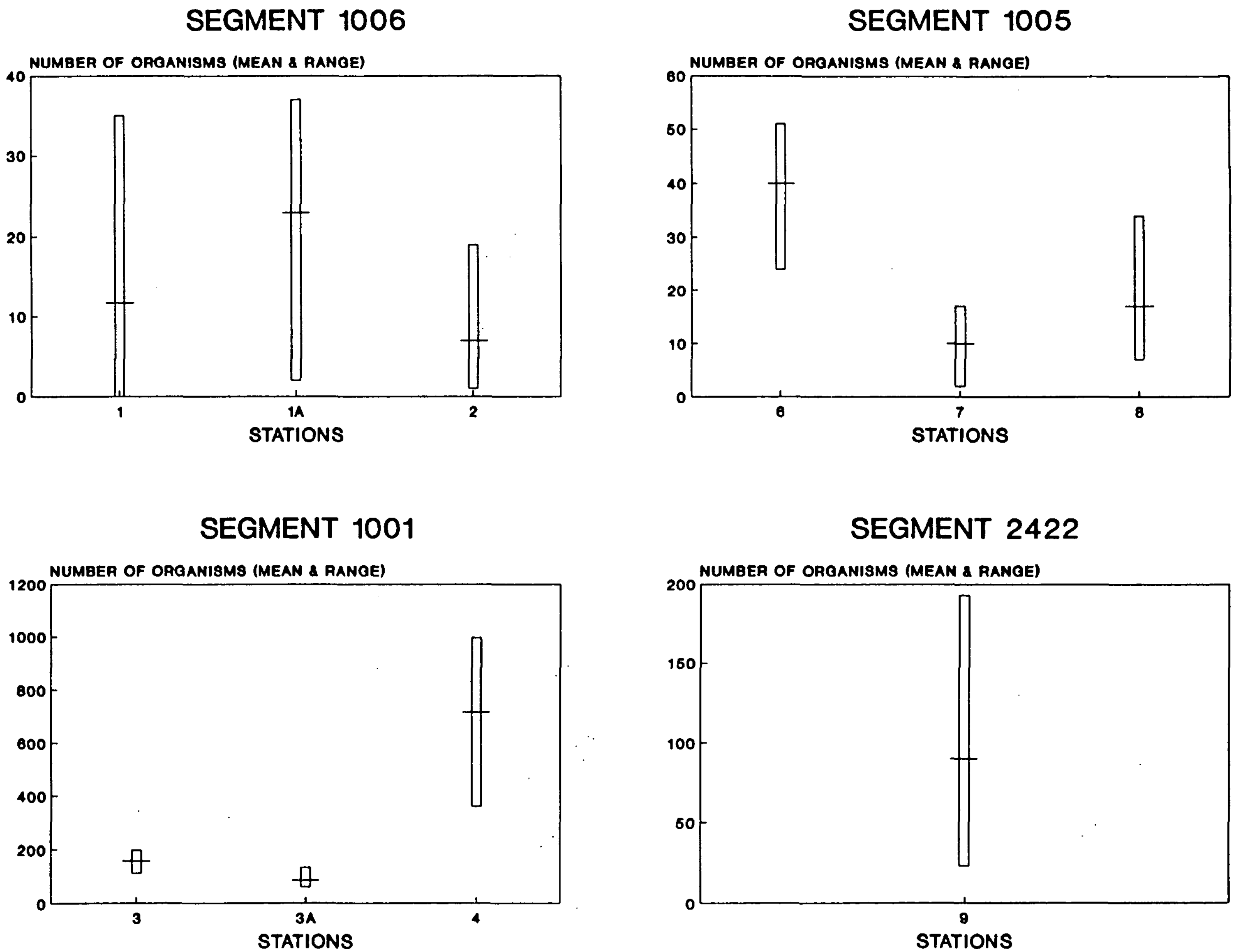


Figure 7. Number of organisms collected with seines during January 1989.

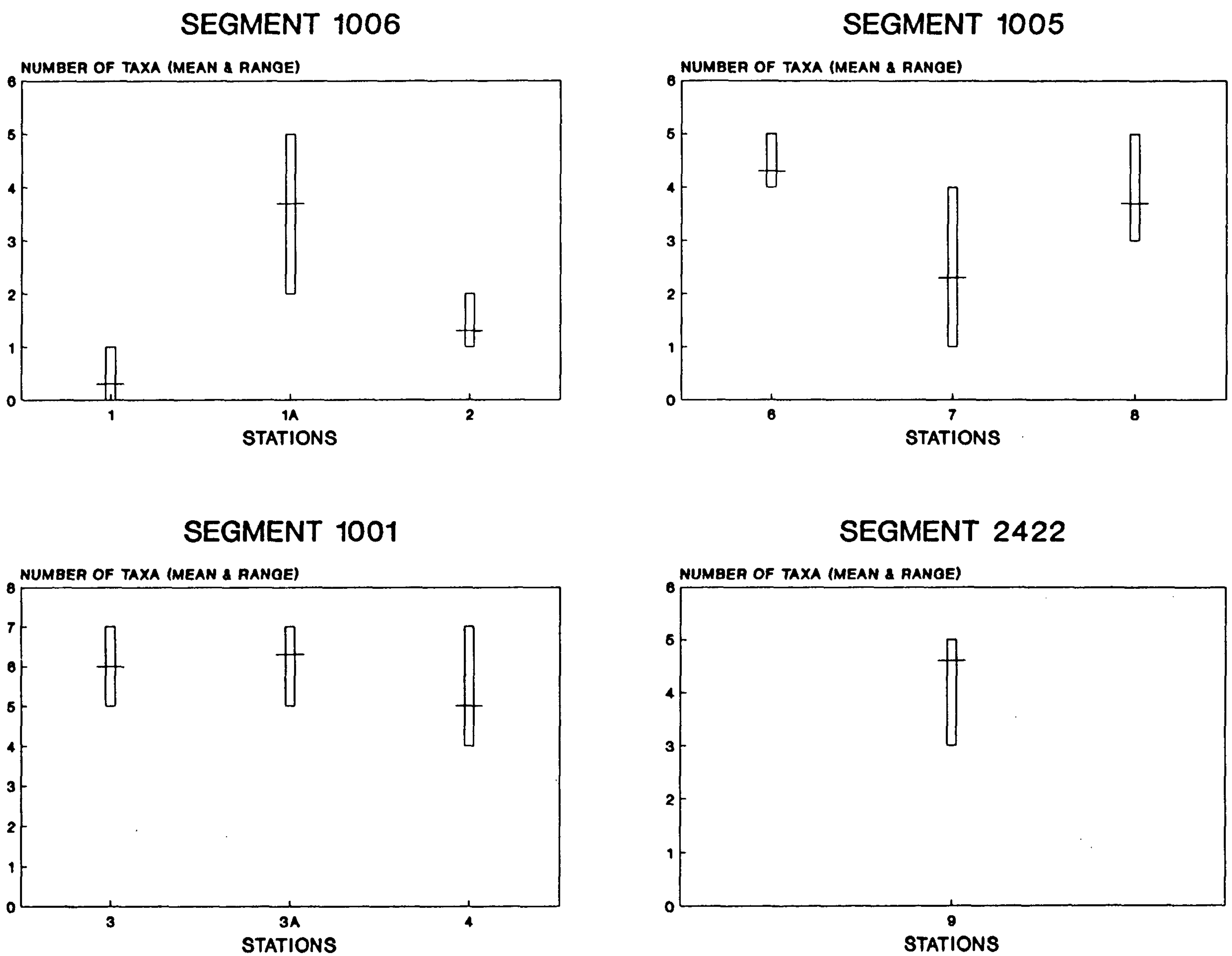


Figure 8. Number of taxa collected with seines during August 1988.

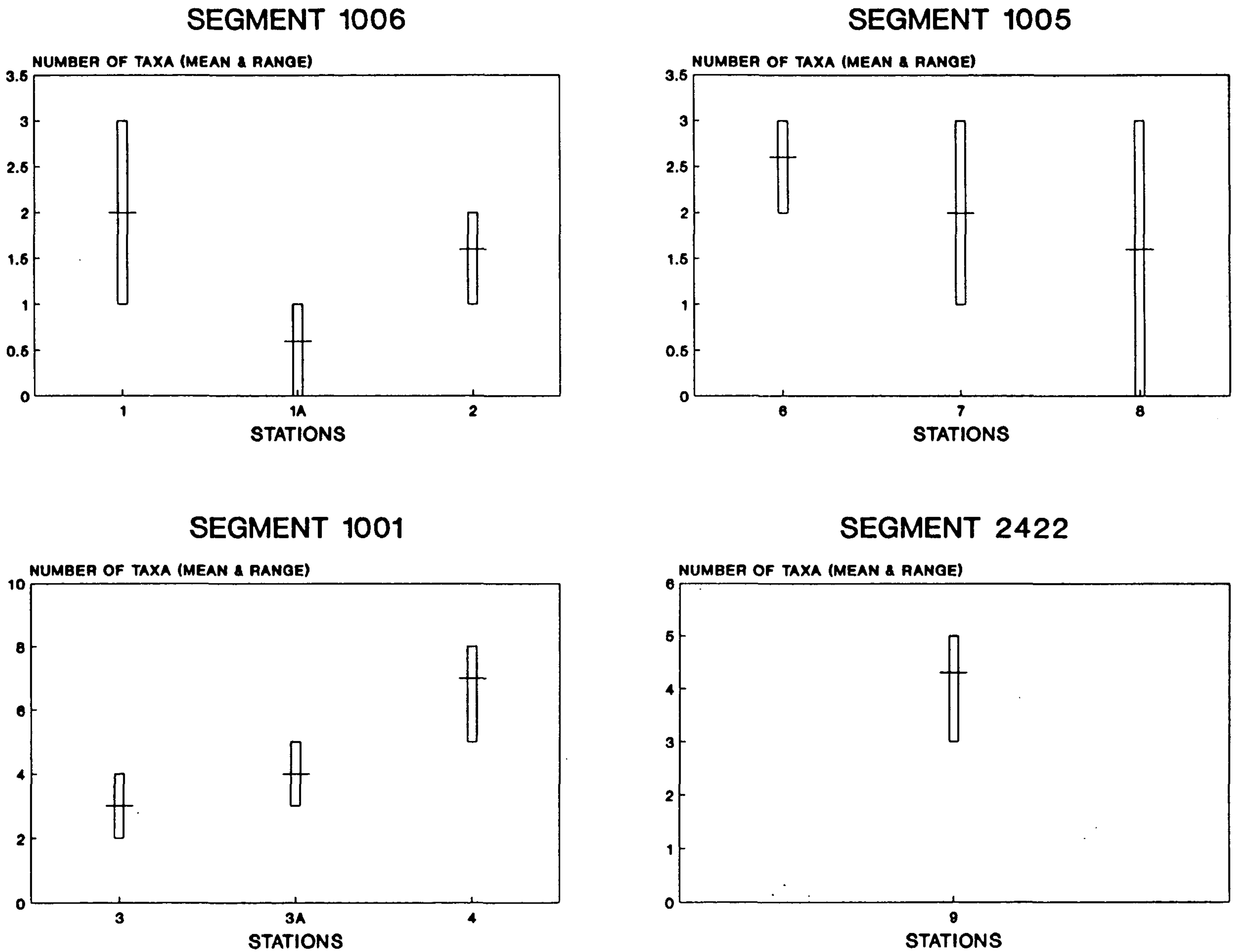


Figure 9. Number of taxa collected with seines during January 1989.

strong relationship between effort and number of species collected, and the higher number of replicate collections made in segments 1001, 1005, 1006, it was necessary to delete segment 2422 from examination of the cumulative number of species per segment. Based on the cumulative number of species observed segment 1001 had the overall highest number of taxa collected (Fig. 10). Cumulative number of taxa was similar in January 1989 collections made within segments 1005 and 1006.

Diversity (H') varied significantly between segments (Tables 18 and 19). Diversity values in segment 1001 were greater than those obtained from catches in segment 1006 (Table 19 and Figs. 11 and 12). Evenness (J) did not vary significantly between stations or collection periods (Table 20). Evenness (J) was extremely variable during the study period ranging from 0 to 0.994 (Figs. 13 and 14).

Significant correlations between dissolved oxygen, pH and number of species (SPP), diversity (H'), and evenness (J) (Table 21). Positive correlations between number of species, H' and J and pH was partly attributable to similar spatial patterns between stations and/or segments (Tables 11, 17, and 19 and Figs. 13 and 14). Positive correlations between number of species, H', J and dissolved oxygen was primarily due to spatial patterns in these parameters (Tables 9, 17 and 19 and Figs. 13 and 14). Highest values of these parameters were generally observed in segments 1001 and 2422, which also had the highest dissolved oxygen levels.

Gulf menhaden was prevalent in seine collections within all segments during January 1989 (Fig. 15). Grass shrimp (Palaemonetes pugio) was however numerically dominant in segment 1001 collections during January 1989. In contrast, sheepshead minnow was a co-dominant taxa in segment 1006 (Fig. 15).

Except for segment 2422 August 1989 collections were dominated by bay anchovy (Figs. 15). Grass shrimp was the dominant species collected in segment 2422 during this period. Segment 1006 also contained a high percentage of Gulf menhaden and spot during August 1988.

While conducting this survey we also observed an extensive fishery for blue crabs in segments 1006, 1005 and 1001 and the lower portions of 1007. Over 30 pots were present in segment 1006 alone during the survey in August 1988. The majority of the crabbing occurring in 1006 and 1007 was primarily conducted by 1-2 fisherman. Crab pots randomly sampled during the survey in segments 1001, 1005 and 1006 were found to contain similar high numbers of blue crabs. This is the first documented commercial fishing activity in the Houston Ship Channel in recent times.

Table 18. Analysis of variance of diversity H' of seine catches.

Source	DF	F Value	Pr > F
Model	13	1.66	0.1099
Error	40		
Corrected Total	53		
SEGMENT	3	4.73	0.0064
DATE	1	0.01	0.9233
SEGMENT*DATE	3	0.96	0.4187
STATION(SEGMENT)	6	0.60	0.7258

Table 19. Tukey's Studentized multiple range (HSD) test for variable: seine H' (Alpha= 0.05 Confidence= 0.95 df= 40 MSE= 0.144898) Critical Value of Studentized Range= 3.791. Comparisons significant at the 0.05 level are indicated by '***'.

SEGMENT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
1001 - 2422	-0.312	0.172	0.657	
1001 - 1005	-0.018	0.332	0.682	
1001 - 1006	0.136	0.504	0.873	***
2422 - 1005	-0.325	0.160	0.644	
2422 - 1006	-0.166	0.332	0.830	
1005 - 1006	-0.196	0.172	0.541	

Table 20. Analysis of variance of eveness (J) of seine collections.

Source	DF	F Value	Pr > F
Model	13	1.39	0.2060
Error	40		
Corrected Total	53		
SEGMENT	3	2.37	0.0848
DATE	1	1.02	0.3180
SEGMENT*DATE	3	0.82	0.4892
STATION(SEGMENT)	6	1.20	0.3240

Table 21. Correlation between hydrological variables and catch. (Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / Number of Observations).

	CATCH	SPP	H	E
SECCHI	-0.08578	-0.22260	0.00289	0.05905
	0.5844	0.1514	0.9861	0.7210
	43	43	39	39
TEMP	0.18613	0.13235	-0.03346	-0.11446
	0.1736	0.3354	0.8176	0.4287
	55	55	50	50
PH	0.24638	0.59271	0.53743	0.34468
	0.0879	0.0001	0.0002	0.0220
	49	49	44	44
SAL	0.06982	0.15557	0.08650	0.14394
	0.6025	0.2436	0.5380	0.3038
	58	58	53	53
DO	0.17398	0.50021	0.49826	0.41243
	0.2174	0.0002	0.0004	0.0040
	52	52	47	47

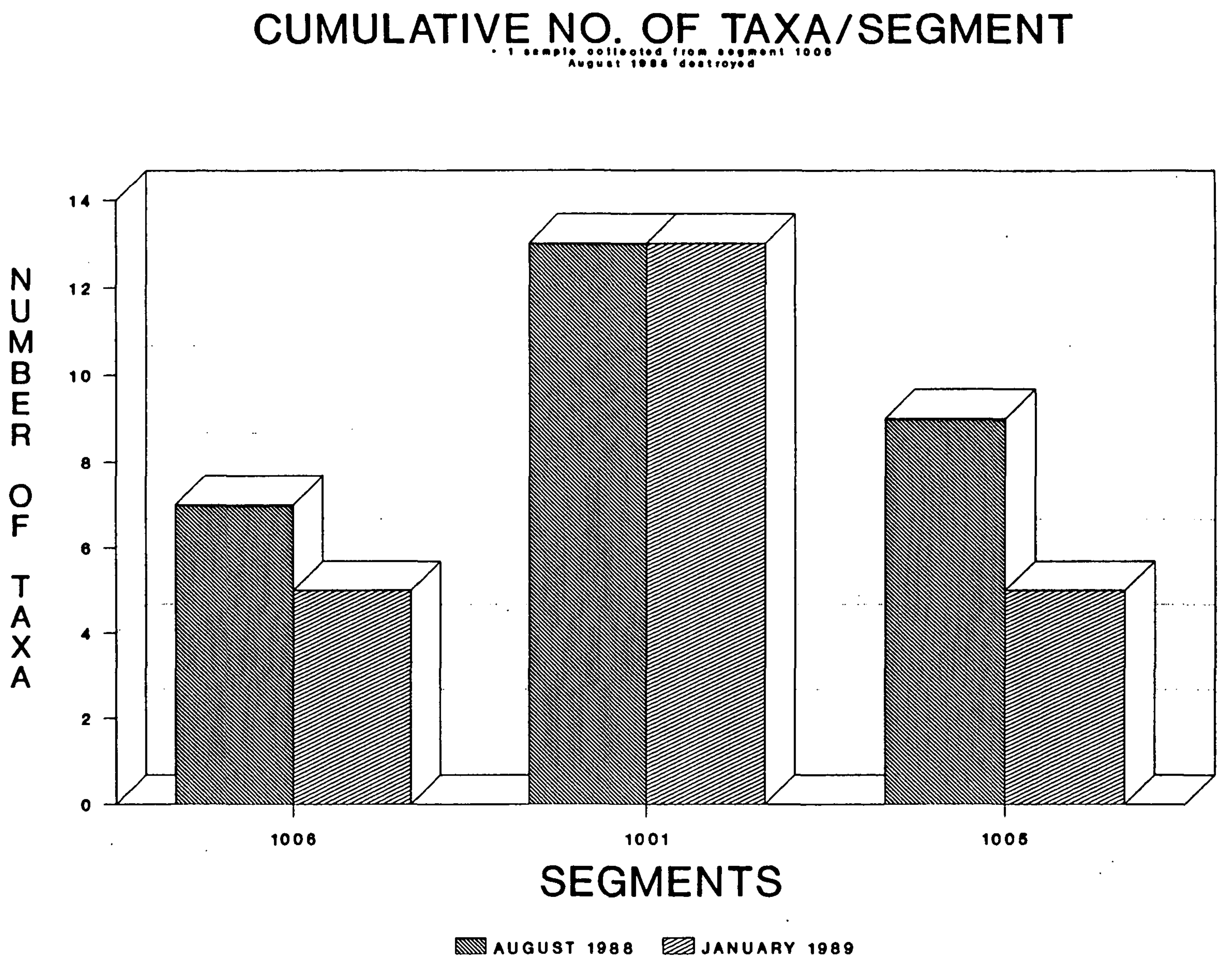


Figure 10. Cumulative number of taxa collected with seines.

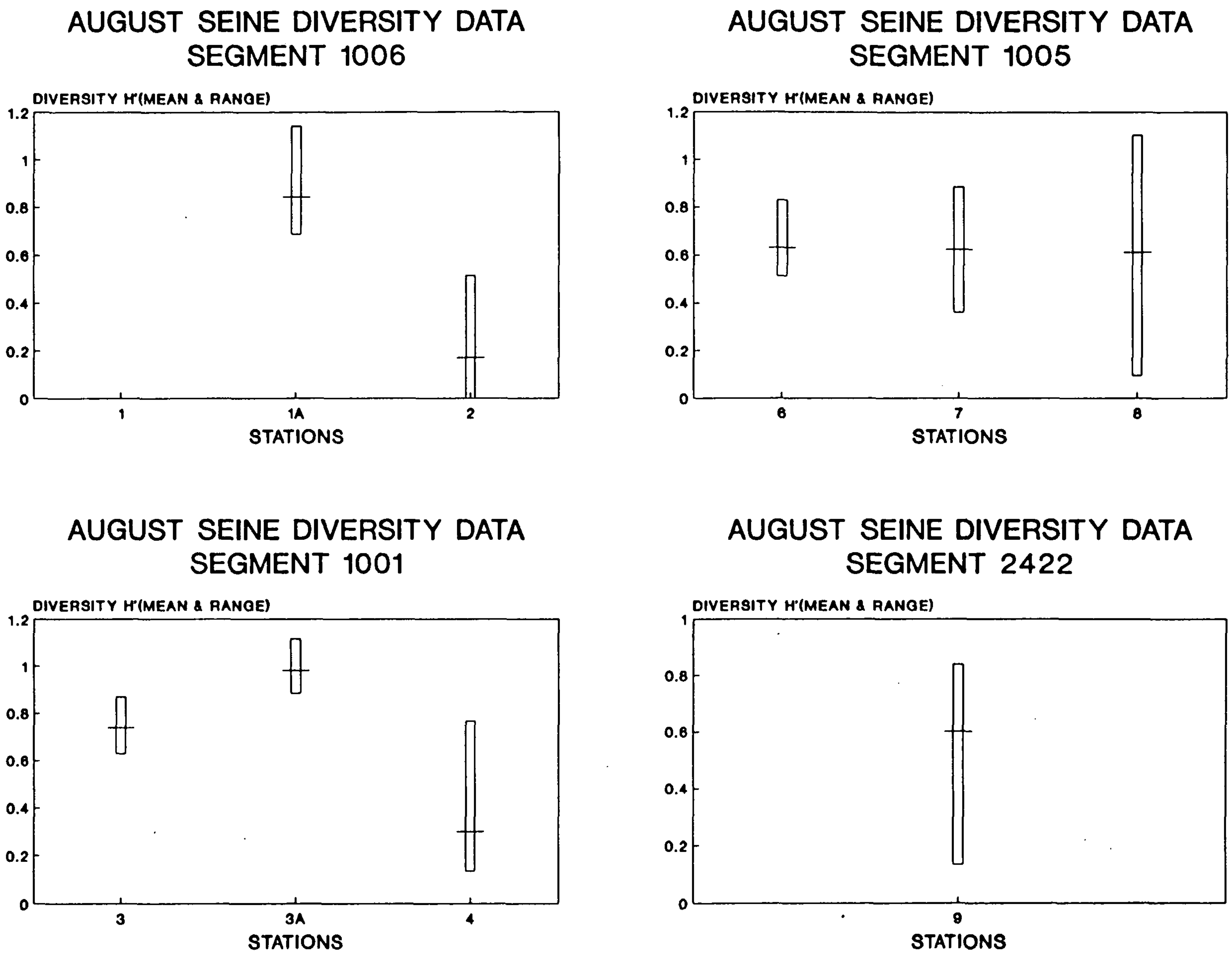


Figure 11. Diversity (H') of seine collections during August 1988.

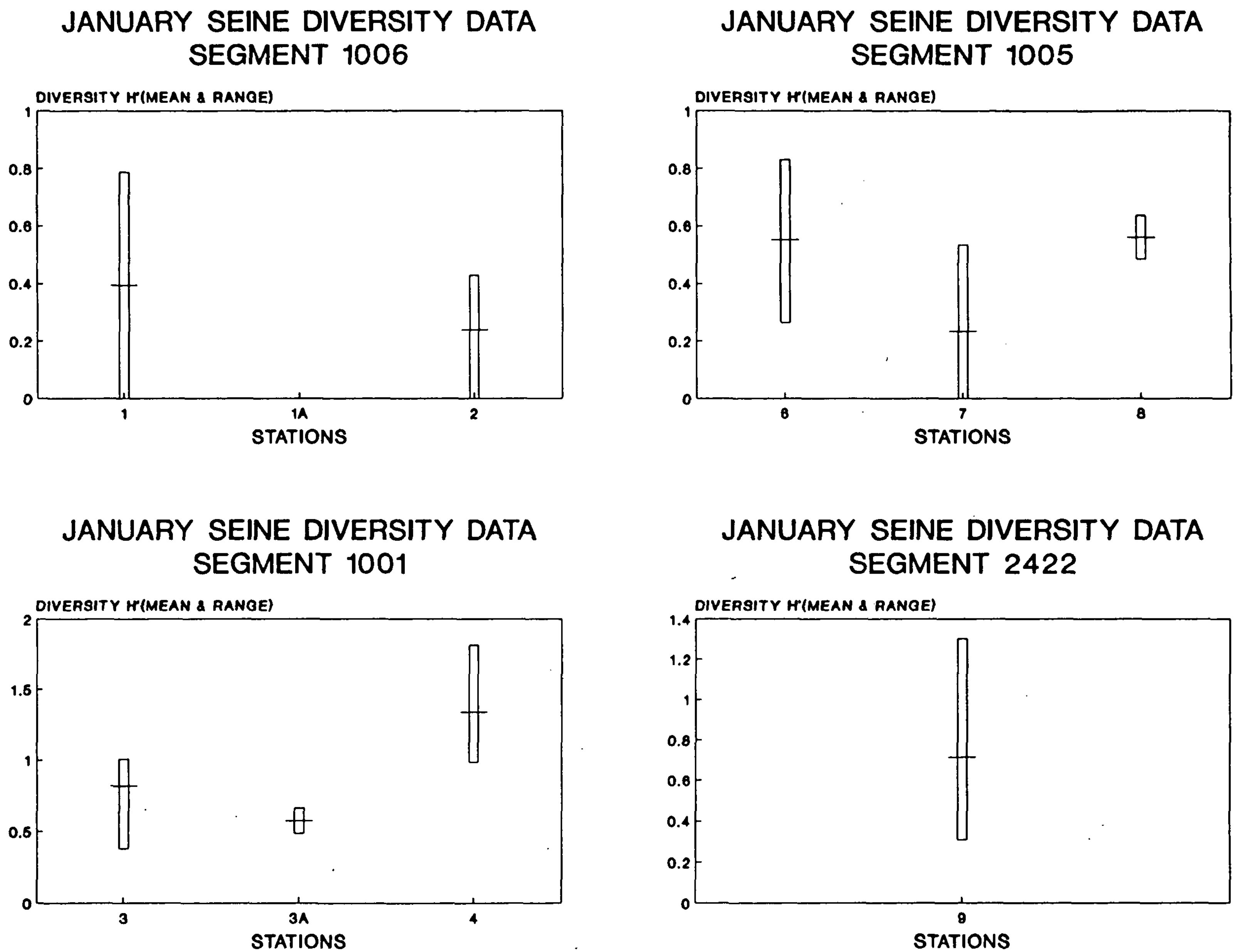


Figure 12. Diversity (H') of seine collections during January 1989.

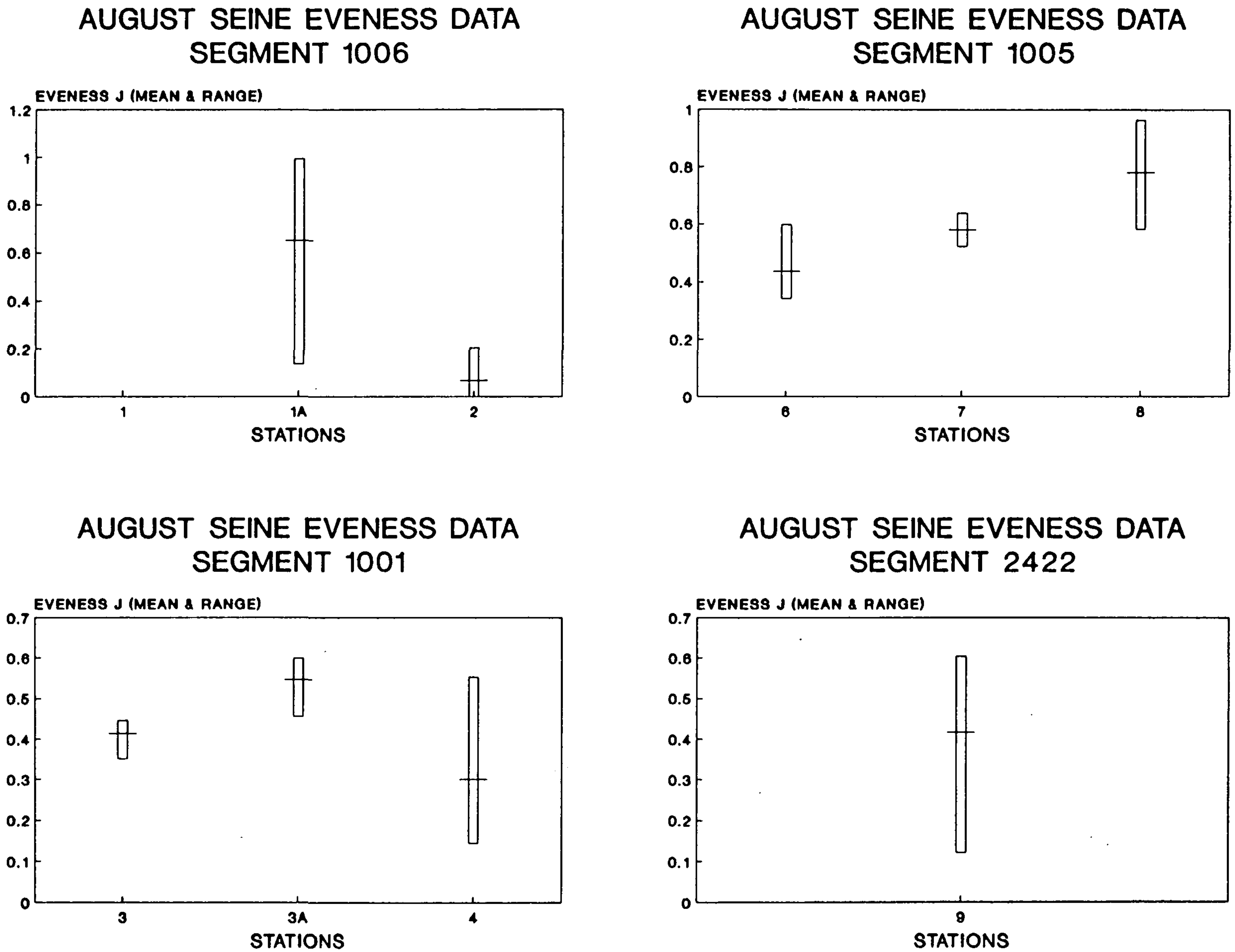


Figure 13. Eveness (J) of seine collections during August 1988.

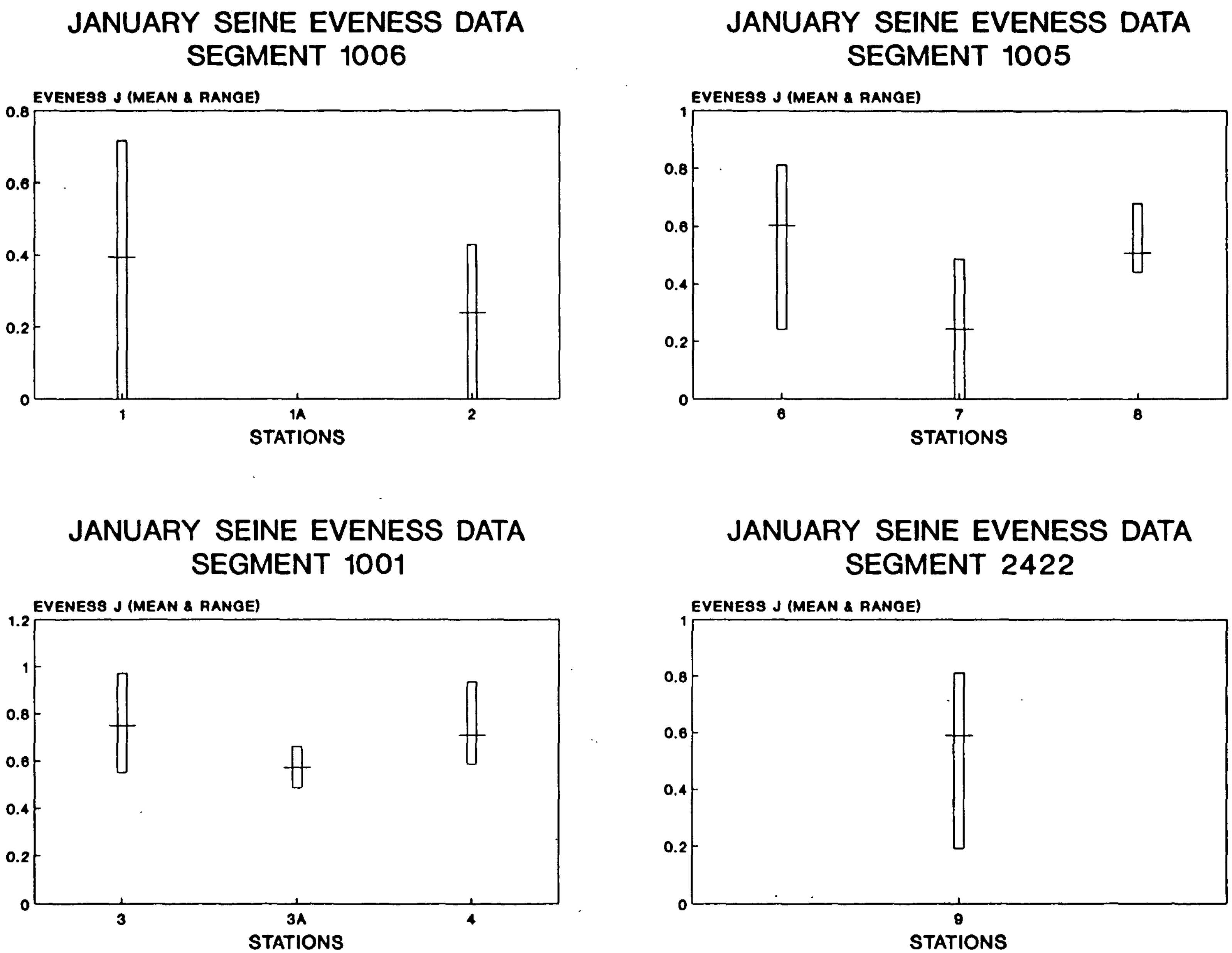


Figure 14. Eveness (J) of seine collections during January 1989.

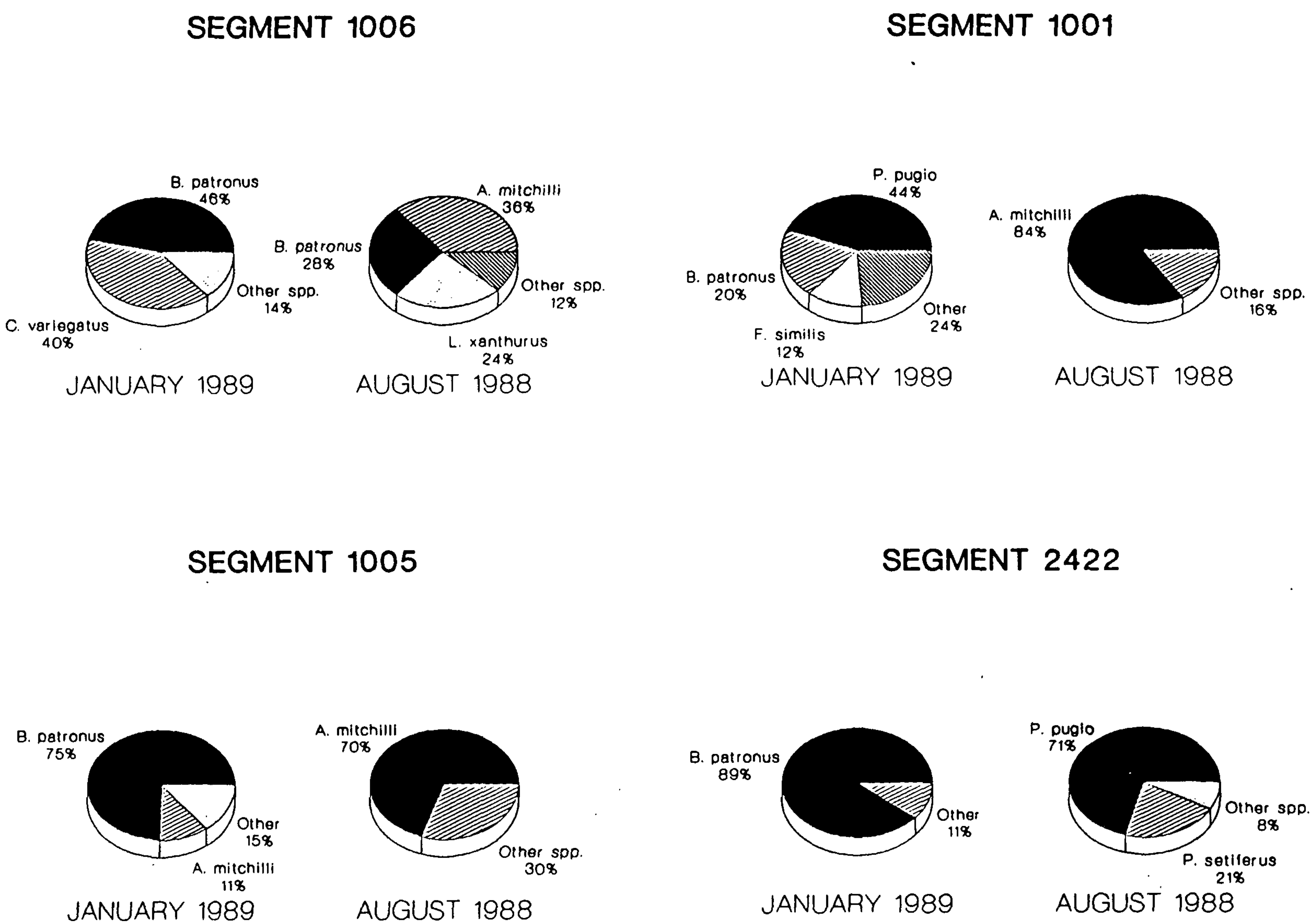


Figure 15. Species composition of seine collections.

DISCUSSION

Estuarine fish populations are characterized by the overwhelming seasonality in utilization of shallow water habitats which is partly attributable to spawning periods and resulting recruitment by immature stages. Due to the dynamic nature of estuaries these species are often subjected to wide variations in water quality (e.g. salinity fluctuations during floods). As a consequence the majority of species utilizing these estuarine habitats are adapted to a highly variable salinity regime. Zein-Eldin and Renaud (1986) documented the wide salinity tolerance range of white and brown shrimp. Many other species exhibit similar tolerances (Copeland and Bechtel 1974). Less data is available to substantiate claims that some species can tolerate low dissolved oxygen levels (Heath 1987). However, some species such as bay anchovy and sea catfish have been known to tolerate low dissolved oxygen levels (1.5 ppm) for various periods of time (Muncy and Wingo 1983; Robinette 1983).

The purpose of this survey was to determine if there are any identifiable trends in nekton abundance that might be attributable to monitored water quality in segments 1006 and/or 1005. Based on this survey it was difficult to discern whether any large scale relationship exists. Segment 1001 presents what is perhaps the best 'control' area we have to compare nekton communities in segment 1006. Segment 1005, which also has a high quality aquatic habitat use designation, also serves as a downstream comparison (TWC 1990). The water chemistry and nekton communities in segment 1001 were significantly different from 1006 in many ways. Higher dissolved oxygen levels, numbers of organisms, number of taxa, and diversity (H') were observed in segment 1001. It appears that segment 1006 nekton communities have been impacted by adverse water quality. Based on the smaller differences observed in the population parameters between segment 1001 and 1006 during January 1989, effects of these impacts may be less severe in winter months. Extremely low dissolved oxygen levels (<2.0 ppm) were observed at Station 1 in segment 1006 during August 1988. Remaining stations in segment 1006 yielded collections with similar catches to those in segments 1001 and 1005.

Hydrologically and biologically segment 1005 was very similar to 1006. This was especially true during the January 1989 sampling period. Similar species compositions, catch rates, number of taxa and water quality parameters (dissolved oxygen and salinity) was observed along the shoreline zone of the these two segments. As previously mentioned the shoreline zones were also very similar in physical characteristics.

Based on the water quality variables monitored dissolved oxygen was the only variable which appeared to vary in a consistent manner which might influence the nekton community. However, as previously mentioned segments 1005 and 1006 appeared to have similar dissolved oxygen regimes in the shoreline zone (excluding the upper reaches of 1006 at station 1, near Greens Bayou).

The study documents the extensive use of the HSC and San Jacinto river as habitat for adult and immature species of crustaceans and fish. Preliminary observations made on concurrent projects conducted during the study period by one of the authors and other agency (NOAA) personnel substantiates the extensive use of the deeper waters of the channel by nekton. That data has not presently been analyzed. Future analysis and publication of that data will clarify the comparative utilization of deep and shallow water habitats within the HSC.

During the late 1950's little if any aquatic life was collected and/or observed in segment 1006 (Chambers and Sparks 1959). Since then as a result of increased state and federal environmental regulation and resulting improvements in wastewater treatment technology and resulting water quality, the overall utilization of these areas by shoreline nekton communities in the Houston Ship Channel has improved. Based on similar biological and hydrological characteristics and presence of a commercial blue crab fishery observed in 1006, the previously established aquatic habitat use designation for segment 1006 may need to be reevaluated.

LITERATURE CITED

Buzan, D., P. Roques and B. Griffin. 1987. Texas Water Commission Water Quality Monitoring Procedures Manual. Austin, Texas.

Chambers, G.V. and A.K. Sparks. 1959. An ecological survey of the Houston Ship Channel and adjacent bays. Publications of the Institute of Marine Science 6:213-250.

Copeland, B.J. and T.J. Bechtel. 1974. Some environmental limits of six Gulf coast estuarine organisms. Contributions in Marine Science 18: 169-204.

EPA (U. S. Environmental Protection Agency). 1980. A water quality success story: Lower Houston Ship Channel and Galveston Bay. Office of Water Planning and Standards. U.S. Environmental Protection Agency. Washington, D.C.

Heath, A.G. 1987. Water pollution and fish physiology. CRC Press. Boca Raton, Florida.

Kirkpatrick, J. 1987. Intensive survey of the Houston Ship system: segments 1001, 1005, 1006, 1007, 1013, 1014, 2421, 2426, 2427, 2428, 2429, 2430, 2436. February 26-28, 1985. Texas Water Commission. IS 87-09. Austin, TX.

Muncy, R.J. and W.M. Wingo. 1983. Species profiles: life histories requirements of coastal fishes and invertebrates (Gulf of Mexico) -- sea catfish and gafftopsail catfish. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.5. U.S. Army Corps of Engineers, TR EL-82-4.

Robinette, H.R. 1983. Species profiles: life histories requirements of coastal fishes and invertebrates (Gulf of Mexico) -- bay anchovy and striped anchovy. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.14. U.S. Army Corps of Engineers, TR EL-82-4.

SAS Institute Inc. 1988. SAS/STAT Users Guide. Release 6.03 ed. SAS Institute Inc. Cary, N.C. 1028. pp.

TDWR. 1980. Houston Ship Channel Monitoring Program 1973-1978. Texas Department of Water Resources Report LP-122. April 1980, Austin, Texas.

TDWR. 1984. Waste Load Evaluation for the Houston Ship Channel System in the San Jacinto River Basin. Texas Department of Water Resources Report No. WLE-1, July 1984, Austin, Texas.

TWC (Texas Water Commission). 1990. The state of Texas Water quality inventory. 10th edition. LP 90-06. Texas Water Commission. Austin, TX.

Zein-Eldin, Z.P. and M.L. Renaud. 1986. Inshore environmental effects on brown shrimp, *Penaeus aztecus*, and white shrimp, *P. setiferus*, populations in coastal waters, particularly of Texas. Marine Fisheries Review 48: 9-19.

Appendix 1. Physical and hydrological data collected in the field during August 1988 gillnet collection.

STATION	SEGMENT	DEPLOY.	DATE	TIME	SECCHI (IN.)	TOTAL DEPTH(FT)	TEMP. (C)	pH	COND. (uMHOS)	SALINITY (PPT)	D. O. (PPM)
1	1006	SET	8-4-88	1709	*******	5	30.0	7.0	19000	10.0	3.9
1	1006	PICKUP	8-5-88	953	13	*******	28.5	7.0	15500	10.0	1.4
2	1006	SET	8-4-88	1912	33	6	28.5	7.1	22000	14.0	2.9
2	1006	PICKUP	8-5-88	1320	*****	******	******	***	*******	*******	*********
3	1001	SET	8-2-88	1941	*******	*******	29.0	7.8	19000	12.0	6.4
3	1001	PICKUP	8-3-88	1303	18	6	30.0	8.2	23000	12.0	7.7
4	1001	SET	8-2-88	1840	*******	********	28.0	7.7	24000	15.0	9.3
4	1001	PICKUP	8-3-88	1013	24.5	16	28.5	7.7	25000	16.0	6.0
6	1005	SET	8-4-88	1830	26	5.5	28.0	7.2	25000	16.0	3.3
6	1005	PICKUP	8-5-88	1230	*******	*******	31.3	7.4	27500	14.7	3.2
8	1005	SET	8-1-88	2020	*******	4	28.0	8.2	31500	20.0	5.3
8	1005	PICKUP	8-2-88	1630	20	*******	28.0	7.7	31000	20.0	5.2
9	2422	SET	8-1-88	1845	*******	5	29.0	7.9	29000	18.0	7.2
9	2422	PICKUP	8-2-88	938	******	********	27.5	7.9	29000	18.0	6.6

Note: (1) Hydrological measurements made at one foot depth. (2) * denote measurement not made. (3) Total depth refers to sampled area.

Appendix 2. Physical and hydrological data collected in the field during January 1989 gillnet collections.

STATION	SEGMENT	DATE	DEPLOY.	TIME	SECCHI (IN.)	TOTAL DEPTH FT.	DEPTH FT.	TEMP (C)	pH	COND. (uMHOS)	SAL. PPT	D.O. (PPM)
1	1006	1-16-89	SET	1549	34	14	1	15.6	7.5	23800	14.0	5.9
							5	15.6	7.5	24000	14.4	5.9
							10	15.5	7.5	25900	14.8	5.8
							13	15.4	7.5	25900	15.7	6.3
1	1006	1-17-89	PICK	1135	33	12	1	15.2	7.5	24900	15.0	5.6
							5	15.2	7.5	24900	14.9	5.6
							10	15.3	7.4	25100	15.1	5.8
2	1006	1-17-89	SET	1657	28	3	1	14.7	7.6	27900	17.0	6.5
2	1006	1-18-89	PICK	1225	10	3	1	16.1	7.4	19400	11.3	7.3
3	1001	1-17-89	SET	1517	30	17	1	13.6	8.5	25300	15.2	12.0
							5	13.2	8.2	26900	16.3	9.1
							10	13.2	8.2	27000	16.4	9.1
							15	13.1	8.2	27100	16.5	9.2
3	1001	1-18-89	PICK	930	35	16	1	13.9	8.3	24800	14.9	9.8
							5	13.8	8.3	25400	15.3	9.7
							10	13.7	8.2	26000	15.7	9.4
							15	13.1	8.1	27100	16.3	9.9
4	1001	1-17-89	SET	1728	24	13	1	13.1	7.8	29000	17.7	7.9
							5	13.2	7.8	29000	17.7	7.8
							10	13.1	7.8	29000	17.7	8.2

Note: (1) *** denote measurement not made. (2) Total depth refers to sampled area.

Appendix 2. Physical and hydrological data collected in the field during January 1989 gillnet collections.

STATION	SEGMENT	DATE	DEPLOY.	TIME	SECCHI (IN.)	TOTAL DEPTH FT.	DEPTH FT.	TEMP (C)	pH	COND. (uMHOS)	SAL. PPT	D.O. (PPM)
4	1001	1-18-89	PICK	1110	41	11	1	12.7	7.9	28000	17.0	9.6
							5	12.7	7.9	28200	17.2	9.6
							10	12.9	7.7	28300	17.3	9.4
6	1005	1-19-89	SET	1153	21.5	5	1	15.8	7.4	19800	11.5	6.1
							4	15.8	7.4	19900	11.7	6.3
6	1005	1-20-89	PICK	838	17	5	1	15.7	7.5	15600	8.9	6.1
							4	15.7	7.5	16550	9.0	6.2
8	1005	1-19-89	SET	1430	20	5	1	14.5	7.6	27400	16.7	7.9
							4	14.5	7.6	27600	16.8	8.0
8	1005	1-20-89	PICK	935	20	5	1	14.9	7.7	23500	14.1	7.6
							4	14.9	7.7	23700	14.2	7.7
9	2422	1-23-89	SET	1540	31	4	1	13.0	7.9	29300	18.0	9.6
							3	13.0	7.9	29300	18.0	9.9
9	2422	1-24-89	PICK	900	*******	3	1	13.1	7.9	28700	17.5	9.4
							3	13.1	7.9	28600	17.5	9.6

Note: (1) *** denote measurement not made. (2) Total depth refers to sampled area.

Appendix 3. Physical and hydrological data collected in the field during August 1988 seine collections.

SEGMENT	STATION	DATE	TIME	SECCHI (IN.)	DEPTH (FT.)	TEMP. (C)	pH	COND. (uMHOS)	SAL. (PPT)	D. O. (PPM)
1006	1	8-1-88	1545	19	1	29	7.42	20000	13	2.8
1006	1A	1-8-88	1443	21	1	29	7.72	25500	16	5.3
1006	2	8-1-88	1404	>7	1	29	7.68	25500	16	4.5
1001	3	8-2-88	1951	*******	1	29	7.8	19000	12	6.4
1001	3A	8-3-88	1543	12	1	29	8.2	25500	16	9.3
1001	4	8-3-88	1626	*******	1	********	********	********	17	********
1005	6	8-1-88	1312	13	1	30	7.77	30500	17	5.3
1005	7	8-1-88	1228	6	1	29	7.46	29000	18	4
1005	8	8-1-88	1131	6.5	1	30	*********	29000	19	*********
2422	9	8-1-88	0947	6	1	28	7.68	23000	15	7

Note: (1) Hydrological measurements made at one foot depth. (2) * denote measurement not made. (3) Total depth refers to sampled area.

Appendix 4. Physical and hydrological data collected in the field during January 1989 seine collections.

SEGMENT	STATION	DATE	TIME	SECCHI (IN.)	TEMP. (C)	pH	COND. (uMHOS)	SAL. (PPT)	D. O. (PPM)
1006	1	1-17-89	1135	33	15.21	7.46	24900	15	5.6
1006	1A	1-16-89	1110	********	14.72	7.52	26000	15.6	6.53
1006	2	1-16-89	1023	28	14.66	7.54	27700	16.9	6.72
1001	3	1-17-89	1517	30	13.57	8.54	25300	15.2	12.04
1001	3A	1-17-89	1403	31	12.33	8.36	27900	16.9	11.73
1001	4	1-17-89	1315	>13	12.3	8.3	28100	17.2	12.06
1005	6	11-19-89	1130	21.5	15.77	7.41	19800	11.5	6.11
1005	7	1-19-89	1312	20.5	15.21	NA	23400	14	6.53
1005	8	1-19-89	1430	20	14.5	7.51	27400	16.7	7.85
2422	9	1-23-89	1540	31	12.98	7.91	29300	18	9.61

Note: (1) Hydrological measurements made at one foot. (2) *** denote measurement not made.

Appendix 5. August 1988 gillnet catch statistics.

STATION	1 Green Bayou	2 S.J. Mon.	3 Cafe	4 SJ@I-10	6 CM 125	8 CM 99	9 U.Pt.#1	10 U.Pt. #2
SEGMENT	1006	1006	1001	1001	1005	1005	2422	2422
SPECIES COLLECTED								
INVERTEBRATES								
Callinectes sapidus	7	11	30	3	2	1	1	2
Menippe mercenaria	0	0	0	0	0	1	0	0
Penaeus aztecus	0	0	0	1	0	0	0	0
Penaeus setiferus	1	0	0	0	0	0	0	0
FISH								
Elops saurus	0	0	4	13	3	0	0	2
Brevoortia patronus	6	3	0	5	1	7	4	26
Dorosoma cepedianum	3	1	8	5	1	0	7	1
Dorosoma petenense	1	0	0	0	0	0	0	0
Ictalurus furcatus	0	0	3	0	0	0	0	0
Arius felis	0	20	0	21	37	18	84	67
Bagre marinus	0	0	0	1	0	0	0	0
Fundulus grandis	0	0	0	2	0	0	0	0
Morone chrysops	0	0	3	0	0	0	0	0
Micropterus salmoides	0	0	1	0	0	0	0	0
Lobotes surinamensis	0	0	0	0	0	0	1	0
Orthopristis chrysoptera	0	0	0	1	0	0	0	0
Archosargus probatocephalus	0	0	0	0	0	0	3	2
Lagodon rhomboides	0	0	0	0	0	1	0	0
Bairdiella chrysoura	0	0	0	0	0	0	3	1
Cynoscion arenarius	0	0	0	0	0	0	0	1

Appendix 5. August 1988 gillnet catch statistics.

STATION	1	2	3	4	6	8	9	10
	Green Bayou	S.J. Mon.	Cafe	SJ@I-10	CM 125	CM 99	U.Pt.#1	U.Pt. #2
SEGMENT	1006	1006	1001	1001	1005	1005	2422	2422
SPECIES COLLECTED								
Cynoscion nebulosus	0	0	0	0	0	0	0	2
Leiostomus xanthurus	2	0	2	2	0	1	0	0
Micropogonias undulatus	0	0	0	2	0	0	36	3
Pogonias cromis	0	0	2	2	0	0	1	0
Sciaenops ocellatus	0	1	2	2	1	1	0	0
Mugil cephalus	0	2	2	1	4	0	0	1
Polydactylus octonemus	0	0	0	0	0	5	4	2
Scomberomorus maculatus	0	0	0	0	0	6	0	0
Citharichthys spilopterus	0	0	0	1	0	0	0	0
Paralichthys lethostigma	0	0	0	1	0	1	3	4
Unidentifiable fish	0	1	1	0	0	0	0	0
COMMUNITY STATISTICS								
Total # of Organisms	20	39	58	63	49	42	147	114
Mean # of Organisms/Segment	-	30	-	61	-	46	-	131
Total # of Species	6	6	10	16	7	10	11	13
Cumulative # of species per segment	-	9	-	18	-	13	-	15
Mean # of Species/Segment	-	6.0	-	13.0	-	8.5	-	12.0
Diversity (H')	1.543	1.243	1.650	2.181	0.956	1.727	1.345	1.384
Eveness (J')	0.779	0.694	0.717	0.786	0.491	0.750	0.561	0.539

Appendix 6. January 1989 gillnet catch statistics.

	1 G.Bayou	2 S.J. Mon.	3 Cafe	4 SJ@I-10	6 CM 125	8 CM 99	9 U.Pt.#1	10 U.Pt. #2
SEGMENT	1006	1006	1001	1001	1005	1005	2422	2422
SPECIES COLLECTED					* tangled			
INVERTEBRATES								
Callinectes sapidus	3	2	0	0	0	0	0	0
FISH								
Alosa chrysochloris	0	0	0	3	0	0	2	7
Brevoortia patronus	0	0	5	2	0	1	20	62
Dorosoma cepedianum	1	1	29	2	1	23	16	14
Dorosoma petenense	0	0	0	0	0	0	1	0
Morone chrysops	0	0	4	2	0	0	0	0
Morone mississippiensis	0	0	2	0	0	0	0	0
Morone saxatilis x chrysops	0	0	1	0	0	0	0	0
Bairdiella chrysoura	0	0	0	0	0	0	0	2
Cynoscion arenarius	0	0	0	0	0	0	0	1
Cynoscion nebulosus	0	0	1	0	0	0	1	5
Leiostomus xanthurus	0	1	4	2	0	0	3	1
Micropogonias undulatus	0	0	0	0	0	0	1	0
Pogonias cromis	0	0	0	0	0	0	0	2
Sciaenops ocellatus	0	0	0	0	0	3	0	0
Mugil cephalus	1	1	0	3	1	1	8	10
Paralichthys lethostigma	0	0	0	0	0	0	1	0
Total # of Organisms	5	5	46	14	2	28	53	104
Mean # of Organisms/Segment	-	5	-	30	-	15	-	78.5

Appendix 6. January 1989 gillnet catch statistics.

	1 G.Bayou	2 S.J. Mon.	3 Cafe	4 SJ@I-10	6 CM 125	8 CM 99	9 U.Pt.#1	10 U.Pt. #2
SEGMENT	1006	1006	1001	1001	1005	1005	2422	2422
SPECIES COLLECTED					* tangled			
Total # of Species	3	4	7	6	2	4	9	9
Cumulative # of species per segment	-	4	-	9	-	4	-	12
Mean # of Species/segment	-	3.5	-	6.5	-	3.0	-	9.0
Diversity (H')	0.950	1.332	1.259	1.772	0.693	0.639	1.601	1.372
Eveness (J')	0.865	0.961	0.647	0.989	1.000	0.461	0.728	0.625

Appendix 7. Seine catch statistics for segment 1006, August 1988.

STATION	GREENS BAYOU				#1A OXYCHEM				#2 SAN JACINTO MON.				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006
SPECIES COLLECTED													
INVERTEBRATES													
Callinectes sapidus	0	0	0	0.0	4	3	0	2.3	2	0	4	2.0	1.4
Palaemonetes pugio	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Penaeus aztecus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Penaeus setiferus	0	0	0	0.0	1	0	0	0.3	0	0	0	0.0	0.1
FISH													
Elops saurus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Brevoortia patronus	0	35	0	11.7	0	0	0	0.0	0	0	0	0.0	3.9
Anchoa mitchilli	0	0	0	0.0	30	10	5	15.0	0	0	0	0.0	5.0
Arius felis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Fundulus grandis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Fundulus similis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Menidia beryllina	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Oligoplites saurus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Cynoscion nebulosus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Leiostomus xanthurus	0	0	0	0.0	1	7	6	4.7	0	1	15	5.3	3.3
Pogonias cromis	0	0	0	0.0	1	0	0	0.3	0	0	0	0.0	0.1
Mugil cephalus	0	0	0	0.0	0	1	0	0.3	0	0	0	0.0	0.1
Mugil curema	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Paralichthys lethostigma	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Symphurus plagiusa	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Sphoeroides parvus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0

Appendix 7. Seine catch statistics for segment 1006, August 1988.

STATION	GREENS BAYOU				#1A OXYCHEM				#2 SAN JACINTO MON.				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006
SPECIES COLLECTED													
Total # of Organisms	0	35	0	11.7	37	21	11	23.0	2	1	19	7.3	14.0
Total # of Species	0	1	0	0.3	5	4	2	3.7	1	1	2	1.3	1.8
Cumulative # of species per segment	-	-	-	1	-	-	-	6	-	-	-	2	7
Diversity (H')	-	0.000	-	0.000	0.703	1.142	0.689	0.845	0.000	0.000	0.515	0.172	0.339
Eveness (J)	-	0.000	-	0.000	0.137	0.824	0.994	0.652	0.000	0.000	0.205	0.068	0.240

Appendix 8. Seine catch statistics for segment 1006, January 1989.

STATION	GREENS BAYOU				#1A OXYCHEM				#2 SAN JACINTO MON.				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006
SPECIES COLLECTED													
INVERTEBRATES													
Mysidae spp.	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Callinectes sapidus</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Palaemonetes pugio</u>	0	*	3	2	0	1	0	0	0	0	0	0	1
<u>Penaeus setiferus</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
FISH													
<u>Brevoortia patronus</u>	9	*	20	15	1	0	0	0	0	0	2	1	5
<u>Anchoa mitchilli</u>	0	*	5	3	0	0	0	0	0	0	0	0	1
<u>Cyprinodon variegatus</u>	0	*	0	0	0	0	0	0	11	6	11	9	3
<u>Fundulus grandis</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Fundulus similis</u>	0	*	0	0	0	0	0	0	1	0	0	0	0
<u>Menidia beryllina</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Micropogonias undulatus</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Sciaenops ocellatus</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Gobiosoma bosci</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Citharichthys spilopterus</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
<u>Symphurus plagiusa</u>	0	*	0	0	0	0	0	0	0	0	0	0	0
Total # of Organisms	9	*	28	19	1	1	0	1	12	6	13	10	10
Total # of Species	1	*	3	2.0	1	1	0	0.7	2	1	2	1.7	1.4
Cumulative # of species per segment	-	*	-	3	-	-	-	2	-	-	-	3	5
Diversity (H')	0.000	*	0.787	0.394	0.000	0.000	-	0.000	0.287	0.000	0.429	0.239	0.211
Eveness (J')	0.000	*	0.717	0.359	0.000	0.000	-	0.000	0.414	0.000	0.619	0.344	0.234

Appendix 9. Seine catch statistics for segment 1001, August 1988.

STATION	#3 S.J. RIVER AT CAFE				#3A S.J. RIVER AT R.R.				#4 S.J. RIVER AT I-10				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
SPECIES COLLECTED													
INVERTEBRATES													
Callinectes sapidus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Palaemonetes pugio	11	11	2	8.0	1	0	2	1.0	166	0	15	60.3	23.1
Penaeus aztecus	0	1	3	1.3	0	0	0	0.0	0	0	0	0.0	0.4
Penaeus setiferus	3	5	6	4.7	5	7	8	6.7	48	8	8	21.3	10.9
FISH													
Elops saurus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Brevoortia patronus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Anchoa mitchilli	130	167	86	127.7	19	10	99	42.7	751	763	330	614.7	261.7
Arius felis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Fundulus grandis	0	0	0	0.0	0	0	0	0.0	0	0	1	0.3	0.1
Fundulus similis	0	0	0	0.0	2	0	1	1.0	0	1	2	1.0	0.7
Menidia beryllina	16	11	11	12.7	38	41	18	32.3	31	21	3	18.3	21.1
Oligoplites saurus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Cynoscion nebulosus	2	0	0	0.7	0	0	0	0.0	0	0	0	0.0	0.2
Leiostomus xanthurus	0	2	2	1.3	1	1	2	1.3	0	0	1	0.3	1.0
Pogonias cromis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Mugil cephalus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Mugil curema	0	0	0	0.0	0	0	2	0.7	0	0	0	0.0	0.2
Paralichthys lethostigma	0	0	0	0.0	0	1	0	0.3	0	0	0	0.0	0.1
Symphurus plagiusa	0	0	1	0.3	0	0	0	0.0	0	0	0	0.0	0.1
Sphoeroides parvus	0	0	0	0.0	1	0	0	0.3	0	0	0	0.0	0.1

Appendix 9. Seine catch statistics for segment 1001, August 1988.

STATION	#3 S.J. RIVER AT CAFE				#3A S.J. RIVER AT R.R.				#4 S.J. RIVER AT I-10				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
SPECIES COLLECTED													
Total # of Organisms	162	197	111	156.7	67	60	132	86.3	996	793	360	716.3	319.8
Total # of Species	5	6	7	6.0	7	5	7	6.3	4	4	7	5.0	5.8
Cumulative # of species per segment	-	-	-	8	-	-	-	9	-	-	-	7	13
Diversity (H')	0.716	0.629	0.869	0.738	1.117	0.946	0.885	0.982	0.766	0.188	0.398	0.451	0.724
Eveness (J)	0.445	0.351	0.446	0.414	0.599	0.588	0.455	0.547	0.552	0.144	0.205	0.300	0.420

Appendix 10. Seine catch statistics for segment 1001, January 1989.

STATION	#3 S.J. RIVER AT CAFE				#3A S.J. RIVER AT R.R.				#4 S.J. RIVER AT I-10				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
SPECIES COLLECTED													
INVERTEBRATES													
Mysidae spp.	0	0	0	0	0	0	*	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0	2	0	*	1	1	0	3	1	1
Palaemonetes pugio	13	9	41	21	19	21	*	20	1	3	5	3	15
Penaeus setiferus	0	1	0	0	0	1	*	1	1	1	0	1	1
FISH													
Brevoortia patronus	0	1	0	0	0	0	*	0	34	14	2	17	6
Anchoa mitchilli	0	0	0	0	0	0	*	0	1	0	0	0	0
Cyprinodon variegatus	0	0	0	0	0	0	*	0	0	0	0	0	0
Fundulus grandis	7	10	0	6	0	0	*	0	0	0	0	0	2
Fundulus similis	0	0	0	0	0	0	*	0	28	0	3	10	3
Menidia beryllina	9	0	0	3	0	0	*	0	0	0	0	0	1
Micropogonias undulatus	0	0	6	2	0	1	*	1	4	0	3	2	2
Sciaenops ocellatus	0	0	0	0	1	0	*	1	0	0	0	0	0
Gobiosoma bosci	0	0	0	0	0	0	*	0	0	1	1	1	0
Citharichthys spilopterus	0	0	0	0	0	1	*	1	0	0	0	0	0
Symphurus plagiusa	0	0	0	0	0	1	*	1	2	1	1	1	1
Total # of Organisms	29	21	47	32	22	25	*	24	72	20	18	37	31
Total # of Species	3	4	2	3.0	3	5	*	4.0	8	5	7	6.7	6.2
Cumulative # of species per segment	-	-	-	6	-	-	-	8	-	-	-	9	13
Diversity (H')	1.066	1.006	0.382	0.818	0.485	0.661	*	0.573	1.219	0.984	1.816	1.340	0.910
Eveness (J')	0.970	0.726	0.551	0.749	0.442	0.411	*	0.427	0.586	0.611	0.934	0.710	0.629

Appendix 11. Seine catch statistics for segment 1005, August 1988.

STATION	#6 S.J.RIVER @ CM 125				#7 S.J. RIVER @ CM 114				#8 S.J. RIVER @ CM 99				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005
SPECIES COLLECTED													
INVERTEBRATES													
Callinectes sapidus	2	1	1	1.3	2	2	1	1.7	1	0	0	0.3	1.1
Palaemonetes pugio	14	1	1	5.3	0	0	0	0.0	0	2	1	1.0	2.1
Penaeus aztecus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Penaeus setiferus	0	3	1	1.3	0	0	1	0.3	1	3	1	1.7	1.1
FISH													
Elops saurus	0	1	0	0.3	0	0	0	0.0	0	0	0	0.0	0.1
Brevoortia patronus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Anchoa mitchilli	34	40	21	31.7	0	15	8	7.7	2	13	8	7.7	15.7
Arius felis	0	0	0	0.0	0	0	0	0.0	2	16	0	6.0	2.0
Fundulus grandis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Fundulus similis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Menidia beryllina	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Oligoplites saurus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Cynoscion nebulosus	0	0	0	0.0	0	0	0	0.0	1	0	0	0.3	0.1
Leiostomus xanthurus	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Pogonias cromis	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Mugil cephalus	1	0	0	0.3	0	0	0	0.0	0	0	0	0.0	0.1
Mugil curema	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Paralichthys lethostigma	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Symphurus plagiusa	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0.0
Sphoeroides parvus	0	0	0	0.0	0	0	1	0.3	0	0	0	0.0	0.1

Appendix 11. Seine catch statistics for segment 1005, August 1988.

STATION	#6 S.J.RIVER @ CM 125				#7 S.J. RIVER @ CM 114				#8 S.J. RIVER @ CM 99				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005
SPECIES COLLECTED													
Total # of Organisms	51	46	24	40.3	2	17	11	10.0	7	34	10	17.0	22.4
Total # of Species	4	5	4	4.3	1	2	4	2.3	5	4	3	4.0	3.6
Cumulative # of species per segment	-	-	-	6	-	-	-	4	-	-	-	6	9
Diversity (H')	0.829	0.549	0.514	0.631	0.000	0.362	0.886	0.416	0.095	1.103	0.639	0.612	0.553
Eveness (J)	0.598	0.341	0.371	0.437	0.000	0.523	0.639	0.387	0.963	0.796	0.582	0.780	0.535

Appendix 12. Seine catch statistics for segment 1005, January 1989.

STATION	#6 S.J.RIVER @ CM 125				#7 S.J. RIVER @ CM 114				#8 S.J. RIVER @ CM 99				
REPLICATE	1	2	3	MEAN	1	2	3	MEAN	1	2	3	MEAN	GRAND MEAN
SEGMENT	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005
SPECIES COLLECTED													
INVERTEBRATES													
Mysidae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	0	0	0	0	0	0	0	0	0	0	0	0	0
Palaemonetes pugio	0	0	0	0	1	0	0	0	0	0	1	0	0
Penaeus setiferus	0	0	0	0	0	0	0	0	0	0	0	0	0
FISH													
Brevoortia patronus	32	1	9	14	24	1	34	20	2	0	13	5	13
Anchoa mitchilli	1	0	4	2	0	11	0	4	0	0	1	0	2
Cyprinodon variegatus	0	0	0	0	0	0	0	0	1	0	0	0	0
Fundulus grandis	0	0	0	0	0	0	0	0	0	0	0	0	0
Fundulus similis	0	0	0	0	0	0	0	0	0	0	0	0	0
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropogonias undulatus	1	3	1	2	0	1	0	0	0	0	0	0	1
Sciaenops ocellatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiosoma bosci	0	0	0	0	0	0	0	0	0	0	0	0	0
Citharichthys spilopterus	0	0	0	0	0	0	0	0	0	0	0	0	0
Symphurus plagiusa	0	0	0	0	0	0	0	0	0	0	0	0	0
Total # of Organisms	34	4	14	17	25	13	34	24	3	0	15	6	16
Total # of Species	3	2	3	2.7	2	3	1	2.0	2	0	3	1.7	2.1
Cumulative # of species per segment	–	–	–	3	–	–	–	4	–	–	–	4	5
Diversity (H')	0.264	0.562	0.830	0.552	0.168	0.535	0.000	0.234	0.637	–	0.485	0.561	0.449
Eveness (J')	0.241	0.811	0.756	0.603	0.242	0.488	0.000	0.243	0.918	–	0.442	0.680	0.509

Appendix 13. Seine catch statistics for segment 2422, August 1988.

STATION	#9 UMBRELLA PT.			
REPLICATE	1	2	3	MEAN
SEGMENT	2422	2422	2422	2422
SPECIES COLLECTED				
INVERTEBRATES				
Callinectes sapidus	2	2	4	2.7
Palaemonetes pugio	1	1	188	63.3
Penaeus aztecus	0	0	0	0.0
Penaeus setiferus	17	40	0	19.0
FISH				
Elops saurus	0	0	0	0.0
Brevoortia patronus	0	0	0	0.0
Anchoa mitchilli	3	7	0	3.3
Arius felis	0	0	0	0.0
Fundulus grandis	0	0	0	0.0
Fundulus similis	0	0	0	0.0
Menidia beryllina	0	0	0	0.0
Oligoplites saurus	0	0	1	0.3
Cynoscion nebulosus	0	3	0	1.0
Leiostomus xanthurus	0	0	0	0.0
Pogonias cromis	0	0	0	0.0
Mugil cephalus	0	0	0	0.0
Mugil curema	0	0	0	0.0
Paralichthys lethostigma	0	0	0	0.0
Symphurus plagiusa	0	0	0	0.0
Sphoeroides parvus	0	0	0	0.0
Total # of Organisms	23	53	193	89.7
Total # of Species	4	5	3	4.0
Cumulative # of species per segment	–	–	–	6
Diversity (H')	0.828	0.841	0.133	0.601
Eveness (J)	0.604	0.523	0.121	0.416

Appendix 14. Seine catch statistics for segment 2422, January 1989.

STATION	#9 UMBRELLA PT.			
REPLICATE	1	2	3	MEAN
SEGMENT	2422	2422	2422	2422
SPECIES COLLECTED				
INVERTEBRATES				
Mysidae spp.	1	0	0	0
Callinectes sapidus	0	1	0	0
Palaemonetes pugio	1	5	2	3
Penaeus setiferus	0	0	0	0
FISH				
Brevoortia patronus	227	1	7	78
Anchoa mitchilli	15	1	0	5
Cyprinodon variegatus	0	0	0	0
Fundulus grandis	0	0	0	0
Fundulus similis	0	0	0	0
Menidia beryllina	0	0	0	0
Micropogonias undulatus	1	1	0	1
Sciaenops ocellatus	0	0	0	0
Gobiosoma bosci	0	0	0	0
Citharichthys spilopterus	0	0	0	0
Symphurus plagiusa	0	0	0	0
Total # of Organisms	245	9	9	88
Total # of Species	5	5	3	4.3
Cumulative # of species per segment	-	-	-	6
Diversity (H')	0.309	1.303	0.530	0.714
Eveness (J')	0.192	0.810	0.764	0.589

Appendix 2

Detection Limits for Chemical Analysis of Water, Sediment and Fish Tissue.

Appendix 2. Detection Limits for Chemical Analysis of Water, Sediment and Fish Tissue.

Parameters Analyzed	Detection Limits*		
	Water	Sediment	Fish Tissue
Heavy Metals	(ug/l)	(mg/kg)	(ug/kg)
Aluminum	100	9.6-135	
Antimony	60	18.4	3.0
Arsenic	18	6.1	0.25
Beryllium	5	1.5	0.2
Cadmium	5	1.5	0.5
Chromium	10	3.1	0.5
Cobalt	20	2.1-5.0	
Copper	20	6.1	0.5
Cyanide	5-30	1.0	0.5
Lead	5-30	9.2	5.0
Mercury	0.2	0.2	0.1
Nickel	6-20	6.1	2.0
Selemium	20	1.6	0.5
Silver	10	3.1	0.5
Thallium	3.8	1.3	0.5
Vanadium	30	5.0-40	
Zinc	30-40	1.5	0.2
Conventional Parameters	(mg/l)	(mg/kg)	(mg/kg)
Alkalinity	5		
Ammonia	0.01		
Chlorine	0.01		
Cyanide	0.02		0.5
Oil & Grease	5		
Sulfide	0.01		
TDS	1		
TSS	1		
TOC	4	5	
Acid/Base Neutral Compounds	(ug/l)	(ug/kg)	(ug/kg)
Phenol	4	2000	1100
bis(2-Chloroethyl)Ether	2	1000	1100
2-Chlorophenol4	4	2000	1100
1,3-Dichlorobenzene	2	1000	1100
1,4-Dichlorobenzene	2	1000	1100
Benzyl Alcohol	4	2000	1100
1,2-Dichlorobenzene	2	1000	1100
2-Methylphenol	6	3000	1100
bis(2-chloroisopropyl)Ether	2	1000	1100
4-Methylphenol	6	3000	1100

PARAMETER	WATER	SEDIMENT	FISH
Acid/Base Neutral Compounds, Continued			
N-Nitroso-Di-n-Propylamine	6	3000	1100
Hexachloroethane	2	1000	1100
Nitrobenzene	2	1000	1100
Isophorone	4	2000	1100
2-Nitrophenol	10	5000	1100
2,4-Dimethylphenol	6	3000	1100
Benzoic Acid	10	5000	5400
bis(2-Chloroethoxy)Methane	2	1000	1100
2,4-Dichlorophenol	6	3000	1100
1,2,4-trichlorobenzene	2	1000	1100
Naphthalene	2	1000	1100
4-Chloroaniline	4	2000	1100
Hexachlorobutadiene	2	1000	1100
4-Chloro-3-Methylphenol	8	4000	1100
2-Methylnaphthalene	2	1000	1100
Hexachlorocyclopentadiene	10	5000	1100
2,4,6-Trichlorophenol	6	3000	1100
2,4,5-Trichlorophenol	6	3000	5400
2-Chloronaphthalene	2	1000	1100
2-Nitroaniline	8	4000	5400
DimethylPhthalate	2	1000	1100
Acenaphthylene	2	1000	1100
3-Nitroaniline	8	4000	1100
Acenaphthene	2	1000	1100
2,4-Dinitrophenol	30	15000	5600
4-Nitrophenol	8	4000	5600
Dibenzofuran	2	1000	1100
2,4-Dinitrotoluene	6	3000	1100
2,6-Dinitrotoluene	6	3000	1100
Diethylphthalate	2	1000	1100
4-Chlorophenylphenyl Ether	8	4000	1100
Fluorene	2	1000	1100
4-Nitroaniline	8	4000	5400
4,6-Dinitro-2-Methylphenol	20	10000	5600
N-Nitrosodiphenylamine	4	2000	1100
4-Bromophenylphenyl Ether	8	4000	1100
Hexachlorobenzene	2	1000	1100
Pentachlorophenol	15	7500	1100
Phenanthrene	2	1000	1100
Anthracene	2	1000	1100
Di-n-Butylphthalate	2	1000	1100
Fluoranthene	2	1000	1100
Benzidine	20	10000	1100
Pyrene	2	1000	1100
Butylbenzylphthalate	4	2000	1100
3,3-Dichlorobenzidine	10	5000	2200
Benzo(a)Anthracene	8	4000	1100
bis(2-Ethylhexyl)Phthalate	4	2000	1100
Chrysene	8	4000	1100
Di-n-Octyl Phthalate	4	2000	1100

APPENDIX 2 (CONTINUED)

PARAMETER	WATER	SEDIMENT	FISH
Acid/Base Neutral Compounds, continued	(ug/l)	(mg/kg)	(ug/kg)
Benzo(b)Fluoranthene	8	4000	1100
Benzo(k)Fluoranthene	8	2000	1100
Benzo(a)Pyrene	8	4000	1100
Indeno(1,2,3-cd)Pyrene	8	4000	1100
Dibenzo(a,h)Anthracene	8	4000	1100
Benzo(g,h,i)Perylene	8	4000	1100
Volatile Compounds	(ug/l)	(mg/kg)	(ug/kg)
Acetone	5	250	
Acrolein	100	5000	
Acrylonitrile	100	5000	
Benzene	2	100	25
2-Butanone	5	250	
Carbon Disulfide	5	250	25
Carbon Tetrachloride	2	100	25
Chlorobenzene	2	100	25
1,2-Dichloroethane	2	100	25
1,1,1-Trichloroethane	2	100	25
1,1-Dichrloroethane	2	100	25
1,1,2-Trichloroethane	2	100	25
1,1,2,2-Tetrachloroethane	2	100	25
Chloroethane	2	250	50
Chloroform	2	100	25
1,1-Dichloroethene	2	100	25
Trans-1,2-Dichloroethene	2	100	25
Cis-1,2-Dichloroethene	2	100	
1,2-Dichloropropane	2	100	25
Trans-1,3-Dichloropropene	2	100	25
Cis-1,3-Dichloropropene	2	100	
Ethylbenzene	5	250	25
2-Hexanone	5	250	50
4-Methyl-2-Pentanone	5	250	50
Methyl-2-Pentanone	5	250	50
Chloromethane	5	250	50
Bromomethane	5	100	50
Bromoform	2	100	25
Bromodichloromethane	2	100	25
Chlorodibromomethane	2	100	25
Styrene	5	250	25
Tetrachloroethene	2	100	25
Toluene	5	250	25
Trichloroethene	2	100	25
Vinyl Acetate	5	250	25
Vinyl Chloride	5	250	50
O-Xylene	5	250	25
M-Xylene and/or P-Xylene	5	250	25

APPENDIX2 (CONTINUED)

PARAMETER	WATER	SEDIMENT	FISH
Pesticides and PCBs	(ug/l)	(mg/kg)	(ug/kg)
alpha-BHC	0.040	40	20
beta-BHC	0.060	40	20
delta-BHC	0.050	40	20
gamma-BHC (Lindane)	0.030	40	20
Heptachlor	0.040	40	20
Aldrin	0.040	40	20
Heptachlor epoxide	0.040	50	20
Endosulfan I	0.040	40	20
Dieldrin	0.040	40	20
4,4-DDE	0.040	40	20
Endrin	0.050	50	20
Endosulfan II	0.040	40	20
4,4-DDD	0.050	40	20
Endrin aldehyde	0.050	50	20
Endosulfan sulfate	0.060	50	20
4,4-DDT	0.040	50	20
Methoxychlor	0.060	150	100
alpha-Chlordane	0.200	200	100
gamma-Chlordane	0.200	200	100
Toxaphene	2.000	500	200
PCB Aroclor-1016	0.500	2000	100
PCB Aroclor-1221	3.000	3000	100
PCB Aroclor-1232	0.500	2000	100
PCB Aroclor-1242	0.500	1000	100
PCB Aroclor-1248	0.500	2000	100
PCB Aroclor-125	0.500	1000	200
PCB Aroclor-1260	0.500	1000	200

* Values are generalized; DL's varied to some extent based on sample dilution.

Appendix 3

Field Data.

FIELD DATA

DO=Dissolved Oxygen
SD=Secchi Disk Depth
TRC=Total Residual Chlorine

STATION	DATE/ TIME (H)	DEPTH (FT.)	TEMP. (C)	pH (SU)	COND. (uMHO/CM)	SALINITY (O/OO)	DO (MG/L)	SD (IN.)	TRC (MG/L)
1	8/1/88* 1720	1	30.16	7.27	19700	11.5	1.68	38	<0.1
		5	30.17	7.39	19900	11.6	1.62		
		10	30.14	7.35	20200	11.8	1.48		
		15	30.13	7.30	21000	12.4	1.24		
		20	29.95	7.30	23500	13.9	0.80		
		25	29.88	7.33	25600	15.3	0.75		
		30	29.83	7.39	27800	16.9	0.95		
		35	29.80	7.44	29600	18.0	1.05		
		40	29.80	7.52	31000	19.3	1.06		
1	8/3/88 1445	1	30.04	7.30	19600	11.5	2.29	37.5	-**
		5	30.74	7.28	20100	11.8	1.88		
		10	30.17	7.21	20500	12.1	1.32		
		15	29.95	7.22	22200	13.4	0.88		
		20	29.93	7.23	23600	14.1	0.71		
		25	29.91	7.23	24400	14.7	0.60		
		30	29.89	7.22	25400	15.3	0.55		
		35	29.88	7.23	26500	16.0	0.43		
		40	29.87	7.30	27600	16.8	0.26		
1	1/9/89 1535	1	16.41	7.56	26700	16.1	5.56		<0.1
		10	16.83	7.55	27700	16.8	5.44		
		20	16.90	7.56	27800	17.0	5.50		
		30	16.88	7.56	28200	17.4	5.56		
		40	16.93	7.61	28800	17.6	5.59		
1	1/11/89 1521	1	17.26	7.51	25200	15.0	5.11		<0.1
		10	16.88	7.51	25400	15.2	5.10		
		20	16.77	7.55	26600	16.2	5.32		
		30	16.61	7.62	29100	17.9	5.71		
		40	15.87	7.83	33100	20.6	6.68		
1	1/12/89* 1436	1	18.43	7.33	24100	14.4	5.01	25.0	<0.1
		10	17.80	6.89	24400	14.7	5.10		
		20	17.07	7.43	26900	16.2	5.44		
		30	16.40	7.53	30400	18.6	6.26		
		40	15.99	7.59	32100	20.0	7.34		
1	1/13/89 1224	1	15.66	7.46	25300	15.2	6.02		<0.1
		10	16.27	7.42	26500	16.0	6.04		
		20	16.29	7.46	27300	16.6	6.05		
		30	16.61	7.62	29100	17.9	5.71		
		40	15.87	7.83	33100	20.6	6.68		
1	2/19/90 1730	1	17.83	7.23	10930	5.9	4.71		<0.1
		10	17.61	7.23	11330	6.1	4.59		
		20	17.51	7.28	12330	6.8	4.59		
		30	17.23	7.45	15500	8.5	5.32		
		34	17.12	7.58	17200	10.0	5.86		
1	2/20/90* 1300	1	17.65	7.42	11650	6.3	5.09		<0.1

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
1	2/21/90 1255	1	17.36	7.36	12500	6.9	6.71	-	<0.1
1	5/29/90* 1220	1	28.3	7.15	1163	0.1	1.16	7.0	<0.1
		10	28.2	7.15	1163	0.1	1.11		
		20	28.2	7.16	1162	0.1	1.05		
		30	28.2	7.20	1159	0.1	1.00		
		40	28.2	7.27	1153	0.1	1.10		
		42	28.1	7.45	1149	0.1	1.23		
1	5/31/90 1145	1	29.14	7.19	1246	0.1	2.03	9.0	<0.1
1	7/30/90* 1334	1	30.81	7.30	9220	4.8	3.58	23.6	<0.1
		10	30.28	7.24	1161	6.3	1.82		
		20	30.20	7.35	17700	10.3	2.06		
		30	29.98	7.68	26800	16.3	2.77		
		40	29.98	7.79	30600	18.9	3.15		
1	8/1/90 1234	1	31.05	7.49	11430	6.1	4.20	36.0	<0.1
2	8/1/88 1830	1	30.18	7.47	24100	14.5	2.03	28.0	-
		5	30.18	7.34	24000	14.3	1.98		
		10	30.16	7.35	24100	14.6	1.82		
		15	30.13	7.37	24500	14.7	1.77		
		20	30.08	7.35	24700	15.2	1.68		
		25	30.04	7.36	25900	15.6	1.54		
		30	29.85	7.45	27300	16.9	1.77		
		35	29.79	7.60	31000	19.2	1.95		
		40	29.73	7.68	33000	20.3	2.14		
2	8/3/88 1527	1	31.49	7.32	23400	14.1	2.50	31.5	-**
		5	31.05	7.30	23700	14.2	2.32		
		10	30.33	7.25	24200	14.5	1.55		
		15	30.00	7.24	24900	15.1	1.21		
		20	30.00	7.27	25100	15.1	1.21		
		25	29.98	7.27	25600	15.7	1.60		
		30	29.89	7.38	27700	16.9	1.79		
		35	29.87	7.42	28700	17.6	1.89		
		40	29.87	7.44	29200	17.9	1.94		
2	1/9/89 1625	1	16.68	7.68	29600	18.2	6.43	-	<0.1
		10	16.70	7.69	29600	18.3	6.40		
		20	16.70	7.78	29900	18.4	6.44		
		30	16.73	7.88	30400	18.6	6.50		
		40	16.70	7.92	31200	19.9	6.49		
2	1/11/89 1433	1	17.12	7.60	28000	17.1	6.04	-	<0.1
		10	16.64	7.62	29000	17.8	6.05		
		20	16.20	7.68	30300	18.7	6.41		
		30	15.96	7.74	31800	19.6	6.62		
		40	15.33	7.85	34100	21.5	6.75		
2	1/12/89* 1257	1	17.24	7.57	28800	17.7	6.42	-	<0.1
		10	17.06	7.57	29200	18.0	6.26		
		20	16.75	7.64	29600	18.3	6.40		
		30	16.24	7.72	31700	19.2	7.36		
		40	16.37	7.68	31500	20.3	6.48		
2	1/13/89 1053	1	16.21	7.53	28700	17.6	6.71	-	<0.1
		10	16.25	7.52	29000	17.7	6.65		
		20	16.28	7.51	29200	17.9	6.63		
		30	16.28	7.53	29900	18.3	6.58		
		40	16.06	7.54	32300	19.9	7.54		

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
2	2/19/90	1	17.15	7.39	13010	7.2	6.21	-	<0.1
	1530	10	17.21	7.35	13590	7.6	5.74		
		20	16.91	7.47	15900	9.1	5.67		
		30	16.35	7.76	18700	11.0	6.15		
		33	16.24	7.83	20700	12.2	6.21		
2	2/20/90*	1	17.41	7.57	14450	8.1	6.12	-	<0.1
	1327								
2	2/21/90	1	16.61	7.57	14270	8.1	7.26	-	<0.1
	1224								
2	5/29/90	1	28.08	7.26	2470	0.8	3.87	6.5	<0.1
	1324	10	27.99	7.26	2480	0.8	3.89		
		20	27.94	7.27	2490	0.8	4.06		
		30	27.93	7.32	2550	0.9	4.28		
		40	27.87	7.38	2620	0.9	4.81		
		45	27.87	7.38	2610	0.9	5.04		
2	5/30/90*	1	27.93	7.19	2460	0.8	3.66	8.0	<0.1
	1051	10	27.90	7.18	2450	0.8	3.67		
		20	27.90	7.18	2470	0.8	3.74		
		30	27.87	7.18	2480	0.8	3.84		
		40	27.86	7.18	2500	0.8	4.02		
		47	27.87	7.15	2500	0.9	4.12		
2	5/31/90	1	28.40	7.21	2440	0.8	3.57	11.0	<0.1
	1123								
2	7/30/90	1	31.85	7.31	10920	5.9	3.58	28.4	<0.1
	1400	10	30.68	7.28	11660	6.3	2.69		
		20	30.30	7.61	20400	11.9	3.24		
		30	30.04	7.80	28700	17.5	3.22		
		40	29.96	7.87	33200	20.7	3.41		
		44	29.97	7.82	33300	20.7	3.45		
2	7/31/90*	1	30.41	7.41	11280	6.1	4.43	34.5	<0.1
	1145								
2	8/1/90	1	30.64	7.46	15200	8.6	3.76	35.5	<0.1
	1218								
3	8/1/88	1	30.46	7.64	17400	10.0	4.42	25.5	-**
	0950	5	30.37	7.56	17500	10.1	3.57		
		10	30.37	7.56	18400	10.8	2.85		
		15	30.25	7.50	19400	11.3	2.81		
		20	30.20	7.65	19500	11.4	2.68		
3	8/3/88	1	30.67	7.55	18200	10.5	5.24	25.0	
	1121	5	30.27	7.46	18700	10.8	2.63		
		10	30.29	7.49	19400	11.3	2.45		
		15	30.26	7.61	20100	11.8	2.63		
		20	30.26	7.61	20300	11.9	2.58		
3	8/5/88	1	33.19	8.54	16300	9.3	13.20	15.0	
	1514	10	30.78	7.58	19600	11.4	3.17		
		20	30.59	7.37	20500	12.1	1.33		
3	1/9/89	1	15.96	8.44	25300	15.2	10.07	-	-**
	1329	10	16.02	8.39	25800	15.6	9.06		
		20	16.19	8.33	27000	16.2	8.53		
3	1/11/89*	1	15.25	8.33	26300	15.8	9.03	23.0	
	1046	10	14.86	8.06	28000	17.1	7.82		
		20	14.79	8.02	28300	17.2	7.83		

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
3	1/13/89	1	14.94	8.26	26200	15.8	8.37	24.0	<0.1
	1053	5	14.97	8.25	26200	15.9	8.35		
		10	15.11	8.22	26400	16.0	8.11		
		15	15.63	8.11	27200	16.6	7.84		
		20	15.66	8.09	27800	16.9	7.91		
3	2/19/90*	1	15.4	7.8	795	0.0	-	-	0.1
	1057	5	15.4	7.9	813	0.0	-		
		10	15.5	8.0	957	0.0	-		
		15	15.9	7.7	3720	1.4	-		
		19	16.2	7.7	6450	3.2	-		
3	2/21/90	1	15.51	7.70	1157	0.1	9.45	-	<0.1
	1143								
3	5/29/90*	1	25.0	6.56	-	0.0	6.2	-	<0.1
3	5/31/90	1	28.55	7.19	653	0.0	4.93	11.0	<0.1
	1040	5	28.32	7.16	654	0.0	4.74		
		10	28.32	7.13	653	0.0	4.47		
		15	28.25	7.14	650	0.0	4.40		
		20	28.24	7.14	660	0.0	4.43		
		25	28.22	7.15	661	0.0	4.31		
3	7/30/91	1	31.31	8.21	8720	4.5	9.03	21.3	0.1
	1106	5	30.82	8.14	8760	4.5	8.43		
		10	30.81	7.88	10380	5.5	5.70		
		15	30.68	7.68	11140	6.0	4.47		
		20	30.62	7.63	11390	6.2	4.16		
3	8/1/90	1	31.86	8.40	9950	5.3	9.17	-	0.1
	1150								
4	8/1/88*	1	30.14	7.62	22900	13.7	3.95	24.0	-**
	1050	5	29.96	7.55	22900	13.7	3.61		
		10	29.82	7.54	22900	13.7	3.42		
		15	29.81	7.53	23000	13.7	3.31		
		20	29.79	7.50	22900	13.7	3.23		
		22	29.77	7.50	23000	13.7	3.19		
4	8/3/88	1	30.21	7.48	23100	13.7	3.76	22.0	-**
	1243	5	30.02	7.48	23100	13.8	3.75		
		10	29.95	7.46	23300	13.9	3.38		
		15	29.91	7.46	23300	13.9	3.35		
		20	29.83	7.43	23300	13.9	3.20		
		24	29.82	7.41	23300	13.9	3.18		
4	8/5/88	1	34.28	8.53	21500	12.8	15.06	14.0	-
	1542	13	31.30	7.96	22000	13.0	7.50		
		25	30.30	7.41	23000	13.8	3.01		
4	1/9/89	1	14.75	7.91	28800	17.6	7.33		
	1401	10	14.88	7.91	28900	17.7	7.32		
		19	15.48	7.88	29200	18.0	7.53		
4	1/11/89	1	15.54	7.80	29900	18.4	7.33	32.0	-**
	1318	10	15.24	7.72	30400	18.7	6.96		
		20	15.42	7.66	30200	18.9	7.81		
4	1/13/89	1	15.26	7.75	29900	18.5	7.50	24.0	<0.1
	1159	5	15.28	7.74	30000	18.3	7.50		
		10	15.35	7.74	30100	18.6	7.55		
		15	15.29	7.74	30200	18.4	7.55		
		19	15.25	7.74	30200	18.6	7.60		

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
4	2/19/90	1	14.74	7.83	2998	1.1	-	-	<0.1
	1140	5	14.72	7.83	2990	1.1	-		
		10	15.02	7.77	6160	2.9	-		
		15	15.88	7.73	10220	5.5	-		
		20	16.10	7.60	11670	6.4	-		
		22	16.11	7.80	12440	6.8	-		
4	2/20/90*	1	15.76	7.73	4400	1.9	8.40	-	<0.1
	1205								
4	2/21/90	1	16.17	7.60	10500	5.6	10.28	-	<0.1
	1106								
4	5/29/90	1	24.0	7.08	-	1.0	6.40	-	<0.1
	1250								
4	5/30/90*	1	27.55	7.54	2320	0.7	6.08	11.5	0.1
	1119	5	27.51	7.54	2320	0.7	6.07		
		10	27.49	7.54	2320	0.7	6.04		
		15	27.48	7.54	2310	0.7	6.06		
		20	27.46	7.55	2330	0.7	6.20		
		22	27.46	7.55	2320	0.7	6.15		
4	5/31/90	1	28.06	7.68	1830	0.5	6.85	16.0	<0.1
	1022								
4	7/30/90	1	32.18	8.38	12420	6.8	9.63	18.9	<0.1
	1150	5	30.98	8.10	12720	7.0	7.26		
		10	30.86	8.11	12860	7.1	7.75		
		15	30.74	7.84	13160	7.3	5.96		
		20	30.73	7.75	13230	7.3	5.31		
		25	30.73	7.63	13600	7.5	4.50		
4	7/31/90*	1	31.13	8.33	12210	6.7	8.0	20.5	0.1
	1200								
4	8/1/90	1	31.83	8.36	12400	6.8	8.69	20.5	<0.1
	1138								
5	8/1/88*	1	30.64	7.52	24300	14.5	3.49	21.0	-**
	1205	5	30.34	7.48	24400	14.6	3.27		
		10	29.95	7.44	25100	15.1	2.69		
		15	29.92	7.45	25300	15.2	2.66		
5	8/3/88	1	30.87	7.54	24300	14.5	3.89	-	-**
	1350	5	30.41	7.51	24400	14.6	3.27		
		10	30.08	7.50	24400	14.6	3.38		
		15	30.06	7.46	24500	14.6	3.27		
5	8/5/88	1	32.60	7.85	33600	14.1	6.51	-	
	1557	5	30.70	7.88	23900	14.0	4.42		
		10	30.66	7.53	23800	14.1	3.98		
5	1/9/89	1	15.65	7.86	29600	18.2	6.97	-	<0.1
	1426	10	15.65	7.87	29700	18.3	6.98		
5	1/11/89*	1	15.50	7.74	30800	19.0	6.81	23.0	<0.1
	1342	10	15.49	7.75	31000	19.1	6.88		
5	1/13/89	1	15.47	7.72	30500	19.1	7.18	16.0	<0.1
	1300	5	15.47	7.71	31000	19.2	7.09		
		10	15.54	7.72	31000	19.2	7.12		
		15	15.45	7.74	30800	19.2	7.20		

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
5	2/19/90	1	15.16	7.68	7550	3.8	-	-	<0.1
	1205	5	15.15	7.73	7780	4.0	-		
		10	15.15	7.74	8330	4.3	-		
		11	15.18	7.79	8330	4.3	-		
5	2/20/90* 1148	1	15.50	7.81	8380	4.3	8.01	-	<0.1
	2/21/90 1049	1	16.18	6.86	12370	6.8	8.21	-	<0.1
5	5/29/90 1330	1	24.5	6.46	-	1.0	6.4	-	<0.1
5	5/30/90*	1	27.55	7.51	2760	1.0	5.79	7.0	<0.1
	1144	5	27.53	7.51	2760	1.0	5.77		
		10	27.53	7.50	2760	1.0	5.81		
		15	27.53	7.49	2760	1.0	5.84		
5	5/31/90 1013	1	28.03	7.63	2470	0.8	6.27	15.0	<0.1
5	7/30/90	1	30.84	7.63	13420	7.5	4.96	23.6	<0.1
	1210	5	30.73	7.54	13630	7.6	4.75		
		10	30.67	7.53	13660	7.6	4.74		
		15	30.56	7.51	14000	8.0	4.43		
5	7/31/90* 1217	1	30.83	7.63	13040	7.2	4.40	27.5	<0.1
5	8/1/90 1125	1	30.73	7.88	15600	8.9	5.85	20.0	<0.1
6	5/10/88	1	24.29	7.22	19000	11.1	3.82	-	-
		10	24.18	7.27	19400	11.4	4.33		
		20	24.16	7.28	20100	11.2	4.46		
		30	24.09	7.28	21300	12.6	4.43		
		40	24.05	7.28	23300	14.0	4.40		
		45	24.03	7.28	23800	14.1	4.36		
6	8/2/88*	1	30.04	7.37	24900	15.0	2.80	23.0	0.15
	0945	5	29.93	7.33	25000	15.0	2.62		
		10	29.86	7.34	25100	15.1	2.32		
		15	29.74	7.32	25600	15.3	2.09		
		20	29.76	7.34	26000	15.9	1.97		
		25	29.80	7.36	26500	16.1	2.03		
		30	29.84	7.42	28300	17.5	2.08		
		35	29.85	7.42	29800	18.3	2.12		
		40	29.85	7.45	30500	18.9	2.20		
		45	29.85	7.49	31700	19.9	2.11		
6	8/3/88	1	30.55	7.33	25000	15.0	2.52	23.0	
	1730	5	30.52	7.32	25100	15.1	2.41		
		10	30.42	7.32	25300	15.3	2.43		
		15	30.32	7.32	25500	15.5	2.25		
		20	30.17	7.34	26400	16.0	2.17		
		25	30.01	7.35	26700	16.3	1.93		
		30	29.94	7.40	27900	17.1	2.08		
		35	29.88	7.50	29700	18.2	2.34		
		40	29.84	7.54	30700	18.9	2.24		
		45	29.83	7.60	31700	19.7	2.21		

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
6	8/5/88	1	30.83	7.33	25300	15.2	2.17	29.0	
	0930	5	30.40	7.34	26200	15.8	2.04		
		10	30.35	7.34	26400	16.0	1.93		
		15	30.30	7.37	27200	16.5	2.05		
		20	30.32	7.42	28100	17.2	2.34		
		25	30.32	7.53	30300	18.8	2.48		
		30	30.32	7.60	31600	19.5	2.55		
		35	30.33	7.66	33000	20.6	2.71		
		40	30.33	7.68	33600	20.8	2.73		
6	1/9/89	1	16.25	7.81	31100	19.2	7.17	-	<0.1
	1140	10	16.54	7.83	31500	19.4	7.06		
		20	16.47	7.84	32500	20.2	7.06		
		30	16.55	7.86	33000	20.5	7.13		
		40	16.71	7.90	34900	21.7	7.19		
6	1/11/89	1	16.07	7.68	30600	18.9	6.40	25.0	<0.1
	0944	10	15.48	7.80	32300	20.1	6.84		
		20	15.20	7.86	33500	20.9	7.02		
		30	14.83	7.92	35500	22.5	7.33		
		40	14.83	7.93	36000	22.7	7.26		
6	1/12/89*	1	17.05	7.70	30400	18.8	6.89	25.0	<0.1
	1243	10	16.90	7.61	30700	18.9	7.37		
		20	16.65	7.64	31000	19.1	6.66		
		30	16.00	7.72	33300	20.3	6.81		
		40	15.30	7.84	35300	21.9	7.51		
6	1/13/90	1	15.71	7.68	30300	18.7	7.30	-	-**
	1038	10	15.76	7.67	30600	18.8	7.42		
		20	15.94	7.76	30900	19.1	7.03		
		30	15.95	7.72	31300	19.4	7.57		
		40	15.99	7.77	32200	19.8	8.29		
6	2/19/90	1	15.80	7.72	11020	6.0	-	-	<0.1
	1225	10	16.35	7.81	14830	8.4	-		
		20	16.39	7.85	17000	9.8	-		
		30	16.21	8.07	19200	11.2	-		
		40	16.05	8.18	23300	13.9	-		
		44	16.02	8.17	24400	14.6	-		
6	2/20/90* 1128	1	16.09	7.62	13140	7.3	7.04	-	<0.1
6	2/21/90 1036	1	16.44	7.41	16300	9.1	7.61	-	<0.1
6	5/29/90 1358	1	24.5	6.56	-	1.0	6.60	-	<0.1
6	5/30/90	1	27.48	7.59	2870	1.0	5.95	11.0	<0.1
	1030	10	27.48	7.59	2890	1.1	5.92		
		20	27.47	7.60	2910	1.1	5.97		
		30	27.46	7.60	2950	1.1	6.06		
		40	27.45	7.63	2980	1.1	6.27		
		47	27.44	7.62	2990	1.1	6.37		
6	5/31/90 1005	1	27.95	7.62	2720	1.0	5.89	12.0	<0.1
6	7/30/90 1240	1	31.06	7.26	13060	7.2	3.12	24.4	<0.1
6	7/31/90 1130	1	30.39	7.41	13030	7.2	3.91	31.0	<0.1

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
6	8/1/90	1	30.83	7.72	15200	8.6	5.41	30.5	<0.1
	1111	10	30.44	7.64	17500	10.1	4.14		
		20	30.41	7.68	22300	13.2	3.60		
		30	30.16	7.78	31400	19.8	3.09		
		40	30.00	7.81	35700	22.4	2.97		
		48	29.98	7.81	35000	22.5	2.92		
7	8/1/88*	1	30.11	7.64	26600	16.1	3.76	26.0	
	1910	5	30.18	7.55	26400	16.0	3.84		
		10	30.29	7.67	26900	16.3	4.44		
		15	30.21	7.68	27200	16.4	4.71		
		20	30.16	7.66	27300	16.7	3.80		
		25	29.98	7.53	28700	17.0	2.81		
		30	29.83	7.65	31000	19.1	2.71		
		35	29.79	7.71	32500	20.7	2.80		
		40	29.77	7.81	35400	22.1	2.89		
		45	29.76	7.86	36200	22.8	2.76		
7	8/3/88	1	30.69	7.58	26400	15.9	4.37	25.0	-**
	1700	5	30.67	7.57	26300	15.9	4.65		
		10	30.50	7.58	26700	16.2	4.00		
		15	30.19	7.53	27800	16.9	3.34		
		20	30.05	7.54	28500	17.5	3.01		
		25	29.91	7.56	29500	18.1	2.78		
		30	29.91	7.54	29100	17.9	2.87		
		35	29.89	7.65	31400	19.4	2.88		
		40	29.85	7.69	32200	20.0	2.77		
		45	29.80	7.71	33600	20.9	2.81		
7	8/5/88	1	30.06	7.42	26100	15.8	3.44	25.0	<0.1
	0910	5	30.01	7.46	26700	16.3	3.25		
		10	30.08	7.45	27200	16.5	3.25		
		15	30.14	7.41	28300	17.3	3.33		
		20	30.18	7.59	29500	18.1	3.48		
		25	30.21	7.68	31800	19.7	3.76		
		30	30.24	7.78	34200	21.4	3.87		
		35	30.23	7.83	36900	23.3	3.64		
		40	30.21	7.87	38900	24.8	3.51		
		45	30.21	7.88	40200	25.7	3.49		
7	1/9/89	1	15.90	7.77	32500	20.1	7.34		
	1046	10	15.78	7.73	32400	20.1	7.39		
		20	16.15	7.68	33200	20.8	7.30		
		30	16.43	7.75	34800	21.8	7.26		
		40	16.58	7.84	35600	22.6	7.35		
7	1/11/89	1	14.81	7.87	32700	20.4	7.34	35.0	<0.1
	0902	10	14.92	7.86	33700	21.0	7.16		
		20	14.80	7.89	35200	22.0	7.25		
		30	14.74	7.95	36600	23.2	7.24		
		40	14.76	7.95	36600	23.0	7.24		
		50	14.69	7.97	37000	23.4	7.12		
7	1/12/89*	1	16.40	7.72	32000	19.8	7.04	27.5	<0.1
	0930	10	16.31	7.77	32000	19.9	7.02		
		20	15.61	7.78	34000	21.0	7.20		
		30	15.38	7.89	34300	21.7	7.00		
		40	14.93	7.88	36700	23.2	7.50		
7	1/13/91	1	15.36	7.64	30700	18.8	7.78		
	0924	10	15.57	7.67	30800	19.1	7.82		
		20	15.81	7.68	31200	19.4	7.69		
		30	15.89	7.71	32300	20.0	7.60		
		40	15.89	7.76	32900	20.6	8.05		

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
7	2/19/90	1	16.17	7.83	14700	8.3	-	-	<0.1
	1315	10	16.11	7.88	15000	8.5	-		
		20	16.15	7.94	16800	9.5	-		
		30	15.96	8.16	23100	13.5	-		
		40	15.84	8.25	27900	16.8	-		
		45	15.88	8.25	28900	17.7	-		
7	2/20/90* 1106	1	16.06	7.64	16200	9.2	7.10	-	<0.1
7	2/21/90 1015	1	16.28	7.69	17000	9.8	9.16	-	<0.1
7	5/29/90 1420	1	24.5	6.45	-	1.0	7.20	-	<0.1
7	5/30/90*	1	27.60	7.72	3430	1.4	6.38	11.0	<0.1
	1000	10	27.57	7.72	3420	1.4	6.43		
		20	27.41	7.77	3490	1.4	6.61		
		30	27.32	7.78	3540	1.4	6.59		
		40	27.18	7.85	3560	1.5	6.86		
		43	27.05	7.85	3600	1.5	7.11		
7	5/31/90 0950	1	28.11	7.74	3200	1.2	6.51	11.0	<0.1
7	7/30/90 1253	1	31.16	7.73	14620	8.2	6.16	17.7	<0.1
7	7/31/90* 1112	1	29.94	7.68	14690	8.2	5.37	25.5	<0.1 (trace)
7	8/1/90	1	30.71	7.75	14470	8.1	5.71	25.5	<0.1
	1055	10	30.37	7.76	18400	10.7	4.81		(trace)
		20	30.46	7.79	21200	12.5	4.26		
		30	30.11	7.80	33800	21.1	3.18		
		40	30.02	7.80	35500	22.3	3.06		
		44	30.02	7.80	35800	22.5	3.13		
8	8/1/90*	1	30.39	8.18	29400	18.0	8.06	22.0	
	2000	5	30.35	8.10	29400	18.1	7.01		
		10	30.25	7.96	29600	18.2	5.70		
		15	30.12	7.90	31200	19.2	4.70		
		20	30.06	7.92	31900	19.7	4.56		
		25	30.06	7.93	31900	19.9	4.65		
		30	29.91	7.88	34300	20.6	4.16		
		35	29.82	7.90	35300	22.0	3.54		
		40	29.80	7.93	37400	23.5	3.30		
		45	29.79	7.94	36800	23.3	3.25		
8	8/3/90	1	30.58	7.67	28400	17.3	4.90	29.0	-**
	1625	5	30.21	7.66	28800	17.6	4.39		
		10	30.26	7.62	29100	17.8	3.86		
		15	29.95	7.62	29900	18.4	3.55		
		20	29.93	7.63	30100	18.5	3.44		
		25	29.81	7.71	31800	19.8	3.40		
		30	29.78	7.82	33500	20.9	3.63		
		35	29.80	7.83	33700	21.1	3.55		
		40	27.79	7.89	35500	22.3	3.56		
		45	29.79	7.90	36500	22.9	3.37		
		48	29.80	7.89	36700	23.2	3.31		

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
8	8/5/88	1	29.96	7.71	29100	17.9	4.59	25.0	<0.1
	0747	5	30.01	7.76	30100	18.5	4.66		
		10	30.01	7.77	30800	19.0	4.72		
		15	30.07	7.82	32200	20.0	4.85		
		20	30.09	7.85	33800	21.0	4.63		
		25	30.18	7.88	36700	23.2	4.39		
		30	30.25	7.93	38500	24.3	4.36		
		35	30.29	7.96	40400	25.8	4.45		
		40	30.30	7.97	41800	26.7	4.31		
		45	30.29	7.96	42100	27.0	4.32		
8	1/9/89	1	15.69	7.90	34100	21.2	7.37		<0.1
	0939	10	16.03	7.92	34800	21.8	7.31		
		20	16.38	7.96	36600	23.1	7.29		
		30	16.39	8.02	37600	23.6	7.41		
		40	16.48	8.00	38400	24.3	7.20		
8	1/11/89	1	14.58	7.92	34700	21.8	7.01	26.0	<0.1
	0839	10	14.70	7.91	36400	22.8	7.31		
		20	14.72	7.92	37300	23.5	7.37		
		30	14.70	7.94	37900	24.0	7.42		
		40	14.68	7.95	38200	24.2	7.41		
8	1/12/89*	1	15.68	7.76	33700	20.9	7.10	32.0	<0.1
	0820	10	15.46	7.82	34100	21.4	7.06		
		20	15.42	7.80	35200	22.1	7.14		
		30	15.08	7.83	37000	23.3	7.27		
		40	14.91	7.93	38000	24.0	7.26		
8	1/13/89	1	15.29	7.72	32100	19.9	7.89	<0.1	0.5
	0850	10	15.46	7.71	32300	20.1	7.76		
		20	15.63	7.72	33100	20.4	7.78		
		30	15.56	7.75	34700	21.6	7.48		
		40	15.45	7.70	36200	22.6	8.52		
8	2/19/90	1	15.57	8.02	16900	9.6	-	-	<0.1
	1337	10	15.65	8.07	19800	11.5	-		(Trac
		20	15.66	8.15	22800	13.6	-		
		30	15.35	8.24	26700	16.2	-		
		40	15.33	8.19	29500	18.2	-		
		48	15.36	8.20	29700	18.3	-		
8	2/20/90*	1	15.73	7.70	17000	9.7	8.80	-	<0.1
	1048								(Trac
8	2/21/90	1	15.96	7.67	19200	11.2	9.08	-	<0.1
	0958								
8	5/29/90	1	24.5	7.64	-	1.0	7.4	-	-
	1450								
8	5/30/89	1	27.12	7.95	2390	0.8	6.76	10.0	<0.1
	0938	10	27.11	7.95	2440	0.8	6.76		
		20	27.18	7.93	2620	0.9	6.69		
		30	27.27	7.87	3010	1.1	6.50		
		40	27.34	7.83	3400	1.4	6.58		
		48	27.61	7.68	5930	1.8	5.87		
8	5/31/90	1	27.62	8.08	562	0.0	7.17	6.0	<0.1
	0930								
8	7/30/90*	1	31.34	7.65	15900	8.8	6.76	23.6	<0.1
	1312								

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
8	7/31/90 1049	1	29.82	7.74	16200	9.2	5.56	21.5	0.1
8	8/1/90 1036	1	30.69	8.07	18500	10.6	7.04	25.5	0.1
		10	30.36	8.07	19200	11.3	5.64		
		20	30.33	7.82	25800	15.5	4.45		
		30	30.25	7.83	34100	21.3	3.89		
		40	30.14	7.82	35700	22.4	3.77		
9	8/1/88* 0815	1	29.58	7.73	25900	15.6	5.26	21.0	<0.1
		3	29.57	7.71	26100	15.7	5.28		
9	8/3/88 0930	1	29.25	7.86	30200	18.6	5.82	22.0	-**
		3	29.23	7.86	30200	18.6	5.76		
9	8/5/88 1510	1	31.00	-	-	15.0	10.4	27.5	-
9	1/13/89*** 0830	1	10.67	7.83	29700	18.2	9.12	-	<0.1
9	2/19/90* 1130	1	13.00	7.71	-	2.0	10.8	-	<0.1
9	2/21/90 0952	1	13.00	6.93	-	0.0	10.6	-	<0.1
9	5/29/90* 1115	1	25.00	8.2	756	0.0	7.9	-	<0.1
9	5/31/90 1145	1	30.00	6.9	-	0.0	8.3	-	<0.1
9	7/30/90* 1250	1	32.5	7.4	11000	5.0	7.6	-	<0.1
9	8/1/90 1410	1	30.0	8.0	9000	6.0	4.2	-	<0.1
10	2/19/90 1100	1	16.92	7.22	1900	0.5	5.02	-	<0.1 (Trace)
		10	18.13	6.96	9650	5.1	2.23		
		20	18.13	6.90	10430	5.6	1.77		
		30	18.00	6.90	10800	5.8	1.16		
		36	17.90	6.83	11200	6.1	0.51		
10	2/21/90 1358	1	18.08	7.17	4770	2.3	9.79	-	<0.1
10	5/29/90 1145	1	28.5	7.05	548	0.0	1.15	8.0	<0.1
		10	28.4	7.03	582	0.0	1.09		
		20	28.4	7.03	563	0.0	1.12		
		30	28.5	7.03	563	0.0	1.17		
		35	28.2	6.98	573	0.0	0.48		
10	5/31/90 1235	1	28.93	7.13	602	0.0	2.15	9.0	<0.1
10	7/30/90 1154	1	31.03	7.26	4760	2.2	4.34	37.0	0.1
		10	29.51	7.01	11540	6.3	0.10		
		20	29.91	7.10	14700	8.3	0.57		
		30	29.94	7.14	15900	9.0	0.91		
		35	29.92	7.26	17200	9.8	1.16		
10	8/1/90 1322	1	30.75	7.54	12190	0.1	2.82	12.0	0.1

STATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
11	2/19/90*	1	17.85	7.53	2340	0.7	4.66	-	<0.1
	1216	5	17.73	7.53	2360	0.8	4.62		
		10	17.83	7.50	2840	1.0	4.08		
		12	18.21	7.20	8570	4.3	2.32		
11	2/21/90	1	18.2	7.54	2270	0.1	6.12	-	0.25
	1334								
11	5/29/90*	1	28.00	7.54	1570	0.3	4.59	24.0	<0.1
	1100	5	27.90	7.52	1570	0.3	4.58		
		10	27.93	7.51	1560	0.3	4.40		
		15	28.00	7.47	3630	1.5	4.04		
		16	27.92	7.46	4000	1.6	4.00		
11	5/31/90	1	29.18	7.73	1390	0.2	6.49	24.0	<0.1
	1215								
	7/30/90*	1	31.30	7.74	2870	1.1	5.84	21.3	0.1
	1233	5	30.18	7.74	3130	1.2	5.36		
		10	30.18	7.57	4830	2.2	4.53		
		12	30.10	7.36	6650	3.3	3.02		
11	8/1/90	1	31.48	7.67	2190	0.7	4.03	29.0	<0.1
	1342								(Trac
12	2/19/90	1	17.66	7.35	5960	2.9	4.38	-	<0.1
	1400	5	17.18	7.30	7300	3.6	4.21		
		10	17.41	7.22	11290	6.1	4.41		
12	2/20/90	1	17.62	7.49	6830	3.4	4.51	-	<0.1
	1242								(Trac
12	2/21/90	1	17.48	7.35	9000	4.7	9.48	-	<0.1
	1307								
12	5/29/90*	1	28.41	7.36	965	0.0	2.13	10.0	<0.1
	1240	5	28.37	7.39	952	0.0	2.23		
		10	28.30	7.41	943	0.0	2.19		
		15	28.20	7.46	924	0.0	2.51		
		18	28.10	7.47	921	0.0	2.55		
12	5/31/90	1	28.78	7.53	998	0.0	3.80	9.0	-
	1157								
12	7/30/90*	1	31.75	7.70	7360	3.7	6.73	16.5	<0.1
	1310	5	30.64	7.32	8920	4.6	2.69		(Trace)
		10	30.39	7.21	10240	5.5	1.37		
		13	30.35	7.23	11050	6.0	1.01		
12	8/1/90	1	31.24	7.92	5470	2.6	5.80	23.5	-
	1244								
Brays-1	8/31/90	1	30.23	8.17	810	0.0	7.00	-	-
		15	29.19	7.15	4730	2.1	0.48		
Brays-1	9/20/89*	1	28.08	8.37	942	0	9.80	25.6	<0.1
	1200	8	28.40	7.05	9000	4.6	0.12		
		16	29.92	6.87	11430	6.2	0.13		
Brays-2	9/20/89*	1	27.14	8.00	1309	0.2	6.32	31.1	<0.1
	1300	8	29.28	6.97	10820	5.9	1.06		
		15	29.58	6.93	12880	7.1	2.43		

[redacted]ATION	DATE/TIME	DEPTH	TEMP.	pH	COND.	SALINITY	DO	SD	TRC
Brays-	9/20/89*	1	28.50	8.02	2240	0.7	6.22	33.5	<0.1
[redacted]	1420	10	29.63	6.97	12700	7.0	0.13		
		·20	29.78	6.92	14140	7.9	0.17		
Greens	8/31/89	1	30.89	8.03	2290	0.7	8.61	-	-
1	1300	25	29.19	6.99	7740	3.9	0.20		
[redacted]eens	9/25/89*	1	24.48	7.67	6170	3.0	5.10	31.50	<0.1
1	1140	14	26.96	7.09	13890	7.7	0.44		
		27	27.27	7.03	15300	8.7	0.31		
[redacted]eens	1/11/89	1	17.64	7.58	13280	7.4	5.32	-	-
2	1622								
[redacted]eens	9/25/89*	1	25.73	7.58	9910	5.3	5.13	20.0	<0.1
	1258	10	26.20	7.24	13800	7.7	2.08		
		20	26.55	7.21	15200	8.7	1.61		
[redacted]eens	9/25/89*	1	26.22	7.40	14240	7.9	3.32	19.7	<0.1
	1400	9	26.13	7.34	15300	8.6	2.63		(Trace)
		17	26.40	7.34	16500	9.4	2.38		
[redacted]ms-	9/12/89*	1	29.62	7.75	3890	0.3	4.04	18.5	<0.1
	1400	5	29.35	7.63	1890	0.5	3.85		
		10	29.90	7.15	1600	1.7	0.16		
[redacted]ms-	9/12/89*	1	30.62	7.69	1970	0.5	4.43	-	<0.1
	1313	7	30.70	7.52	4710	2.1	3.14		
		13	30.37	7.09	7150	3.6	0.18		
Sims-	9/12/89*	1	30.09	7.50	4000	1.7	4.34	31.1	<0.1
[redacted]	1043	7	29.99	7.37	4900	2.2	3.37		
		14	30.30	7.09	9860	5.2	1.45		

[redacted]*Chemical analyses conducted on these samples.
[redacted]*Manganese interference was not measured.
***Sample destined for chemical analysis collected on 1/12/89; field data not collected on that date.

Appendix 4

Quality Assurance Review of Fish Tissue Chemical Analysis.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VI
HOUSTON BRANCH
6608 HORNWOOD DRIVE
HOUSTON, TEXAS 77074

Memorandum

Date: March 20, 1989

Subject: Data Review Forms for San Jacinto River Study

From: Michael L. Daggett, Chief, Organic Section, 6E-HO

To: Philip A. Crocker, Technical Section, 6W-QT

Enclosed you will find the data review forms for the San Jacinto River Study which you requested.

Should you have any questions or need any further assistance, please feel free to call on me.

ORGANIC QA CHECKLIST TASK 1; ASSIGN 7a

Site SAN JACINTO RIVER Contract No. 68-01-7360

Case No. ______ Laboratory VERSAR

Reviewed By M.C. RITTER Matrix FISH + CRAB TISSUE

Date 3/2/84 + 2/24/84 Acct. # 99960761 & A53

Sample No. CRAB 1, 2, 3, 4, 6, 6A, 8 AND 9
FISH 2, 4, 6, 6A, 8 AND 9.

OVERALL COMMENTS (To be completed by EPA PERSONNEL)

	VOA	BNA	PEST	OTHER
1. Holding Times	NA	NA	NA	
2. Tuning/Performance	A	A	U	
3. Calibrations	A	A	A	
4. Blanks	A	A	A	
5. Surrogate Recovery	A	A	A	
6. Matrix Spike/Duplicate	A	A	U	
7. Compound Identity	P	P	U	
8. Case Assessment	P	P	U	

COMMENTS OR CLARIFICATIONS (See Attached)

A - Acceptable - All items delivered; all criteria met.

P - Provisional - Data usable; some non-essential review items missing or criteria were not met.

U - Unacceptable - Data unusable; essential review missing or criteria not met.

COMMENTS/CLARIFICATIONS

REGION VI CLP QA REVIEW

CASE SAN JACINTO RIVER SITE FISH & CRABS TISSUE LAB VERSAR

The following is a summary of sample qualifiers used by Region VI in reporting this CLP Case data:

No.	Acceptable	Provisional	Unacceptable
VOA		6 FISH 8 CRABS	
BNA		6 FISH 8 CRABS	
PEST		4-CRABS	4 CRABS
OTHER			6 FISH

COMMENTS:

SEE ATTACHED SHEETS (3)

M. C. Ritter
3/2/89

Data package is considered as provisional for BNA and VOA analysis of six (6) fish and eight (8) crab tissue samples. Because of problems with the pesticide analysis portion of these samples, the data for pesticides is considered as not usable. Nothing of significance was found for the target compound list (TCL) compounds in the BNA and VOA fractions save for the usual lab/processing contaminants such as phthalates (BNA) and solvents such as acetone and dichloromethane (VOA). Several fish samples were reported bythe lab to contain low ppb, from 20 to 100 ppb, of DDE pesticide, but it is opinion of 6E-HO that the identification here is false positives combine with poor chromatography and that no measurable DDE was found in these fish. Although most QC criteria of the methods was met, the resultant identities and amounts reported for some compounds in each of the various fractions leaves the overall Case assessment less than acceptable. Probably the best thing about this data is that no VOA compounds such as halogenated hydrocarbons were found and that no TCLs were found in the BNAs save for pphthalates; also the pesticide data show that except for four or five compounds, the remainder of the pesticide target list was not present in these samples.

For the pesticdes, the present of DDE was indicated by a very small peak on the backside of very large hump; the integration areas seem to be wrong and the confirmation analysis for all samples showed a large negative deflection in the backside of the peak; areas reported by the confirmation analysis quantitation report were inconsistent with the GC chromatograms for the capillary runs on DB-5 for fish samples reported positive on the mixed-phase GC column. A prime example of this is in sample Fish 8: here DDE was found at 23 ppb; the fish 8 QC sample, not spiked with DDE, was reported as 55 ppb; fish 8 matrix spike duplicate was reported with DDE well below the 20 ppb detection limit, i.e., not found. The last run seems to be the only one of the three for fish 8 that has the correct area counts for the primary GC analysis using the mixed phase column.

For the fish and crab samples, the matrix spikeduplicate data for the pesticides was incredibly poor. Recoveries of 170-1200% for fish and 180-2400% (the lab reported 2405%) for crab spikes for lindane, heptaclor, and aldrin. These recoveries were due to the combination of interferences, poor chromatography and/or poor judgement. The CLP/SW846 methods used here may be good for water and soils, but perhaps not so good for tissue.

Presuming that the QC data from the matrix spikes is suppose to be indicative of the recoveries from these matrices, then all detection limits and recoveries are in doubt. Some of the pesticide data is good; crab samples #1,#3, #4. and #6 showed acceptable data with little or no problems. Most of the sample data for the primary analytical GC column, the mixed phase, showed huge "humps" which effectively blotted out all pesticides from about lindane to dieldrin (includes heptaclor, hept. epoxide and aldrin) making the detection limits and identities very difficult-see Crab#2, Fish#2, #4, #6,#6A,#8,#9 and Crab#6A,#8. In addition, the data for Crab #9 was mixed up, the chromatograms obviously not those of a sample and the same was true for Crab 6A MSD; the data included for these two crab samples was either mixed up and is mislabelled or some other data was used.

For the VOAs, almost all samples, but especially the crab tissues, were reported with extremely high amounts of solvents such as acetone and 2-butanone. Crab 3 (5ppm),crab 4 (13ppm),#6 (54), 6A (1), #8 (35) and #9 (6ppm). Lower amounts of acetone were reported for the fish. The lab offered no explanation, save to say that such data was reported. Clearly such amounts make no sense and must be due to some other source but the tissue such as vial or tissue grinder contamination. In fish #2, VOA QC sample, the MS has dichloromethane as not detected (ND) and 2-butanone as 110 ppb; the MSD here has 1000ppb and ND, respectively. Such solvent related data for acetone, etc., is to be dismissed or rejected for these samples and must not be used to indicate the presence or absence of these compounds in these tissue samples. The VOA data do show the absence of any target compounds such as volatile chlorinated hydrocarbons or aromatics.

For the BNAs nothing of significance was found if the phthalates are discounted. Many non-TCLs were found as tentative identified compounds, TICs, should be considered as not due to the sample. TICs seen in the BNA fish/crab were often seen in the blanks or are qualified by the lab as "B". Some TICs were not qualified by the lab but should have been given a flag. For example, Fish 2 has TICs at scans 253,728,877,1939 and 2260 which match those for blank SBLK96 (which is a crab blank) at scans 247,737,1690 and2254,respect. Another example is Fish 9, scan 247 is "B" flagged by the lab in the TIC list, but scan 253 in Fish 2_see above- was not given a "B" flag although they are the same material.

The VOA and BNA had good QC data to support their analyses. The data packages were complete. Fish #2 was used for VOA QC and Fish #8 was the BNA QC sample. Here all QC parameters were within CLP windows although no limits exist for tissue samples for such surrogate and spike recvoeries. Although some of chromatography here for the BNAs is poor, due to interferences form the fish oils, etc., the sample data for the target compounds is good.

In other instances of BNA TICs which were questionable, some other examples are where the BNA data for the crab shows a TIC at about scan 2250 and resultant data for samples is "B" qualified ,but for the fish data, the same scan 2250 or so BNA TIC shows up repeatedly and is not qualified in the fish samples.In crab #3, the TIC 1,1,2-Tricchloroethane is given at an estimated value of 210 ppb; this compound is a VOA target compound which was not found in the VOA to a detection limit of 50 ppb. How can this be a legitimate material due to the tissue sample as found in the BNA? Again, for Crab #3, scan 322 looks like 1,1,2,2-tetrachloroethane at an est 500ppb; this target VOA was not found at the 50 ppb level. Scan 1047 in Crab 4 is listed as est. 980 "JB"; scan 1045 in Crab 3 is the same thing with no "B".

In summary most BNA non-target compounds or TICs appear to be due to solvent and/or processing artifacts. Many such TICs are qualified by the lab as "B" related, but many TICs are not qualified and probably should be given such flags. The confusion thus exist over what is/or isn't present in the samples as non-target compounds.

Report Conclusions and recommendations- Do not use pesticide data, especially for the three compounds reported at such extremely high recoveries, as evidence for presence or absence of such pesticides in the samples. Because of problems in the pesticides, this data should not be used at all. BNA and VOA data should be used with caution. The VOA and BNA data showed the absence of target compounds except for some solvents such as acetone in the VOA and phthalates in the BNA. Non-targets or TICs should be dismissed for the BNAs; many of the VOA TICs could be legitmate, such as the sulfur compounds or the amines.

M L Ritter
US EPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VI
HOUSTON BRANCH
6608 HORNWOOD DRIVE
HOUSTON, TEXAS 77074

INORGANIC QC CHECKLIST

Site SAN JACINTO RIVER
Case No. 5030-15-2-1
Reviewed by MAHMOUD ELFEKY
Date 2-22-89

Contract No. 68-01-7310
Contractor VERSAR
Matrix FISH & CRAB
Acct # 9960 Z61 SF # A23B2F

Sample No.

STATION 1 (CRAB)	STATION 4 CRAB	STATION 6D CRAB	STATION 9 CRAB
STATION 2 (CRAB)	STATION 4 FISH	STATION 6D FISH	STATION 9 FISH
STATION 2 FISH	STATION 6 CRAB	STATION 8 CRAB	
STATION 3 CRAB	STATION 6 FISH	STATION 8 FISH	

COMMENTS (To be completed by EPA Personnel)

1.	Data Completeness	✓	Acceptable		Provisional		Unacceptable
2.	Instrument Calibration Tune	✓	Acceptable		Provisional		Unacceptable
3.	Interference Check Sample	✓	Acceptable		Provisional		Unacceptable
4.	Blank Analysis	✓	Acceptable		Provisional		Unacceptable
5.	Matrix Spikes	✓	Acceptable		Provisional		Unacceptable
6.	Duplicates	✓	Acceptable		Provisional		Unacceptable
7.	Field Blanks	NA	Acceptable		Provisional		Unacceptable
8.	Other	NA	Acceptable		Provisional		Unacceptable

ADDITIONAL COMMENTS

1- DATA PACKAGE CONSISTED OF EIGHT CRAB AND SIX FISH SAMPLES, ANALYZED FOR ARSENIC, SELENIUM, THALLIUM, ANTIMONY, BERYLLIUM, CADMIUM, CHROMIUM, COPPER, SILVER, LEAD, MERCURY, NICKEL,

Acceptable - All items delivered; all criteria met

Provisional - Data usable; some non-essential review items missing or criteria were not met

Unacceptable - Data unusable; essential review items missing or criteria not met

INORGANIC QA CHECKLIST
CONTINUATION PAGE

CASE NO. EC30-15-2-1 **SITE** SAN JACINTO RIVER

COMMENTS:

ZINC AND CYANIDE.

2- HOLDING TIMES:

ANALYSES WERE COMPLETED IN 72 DAYS FOR MERCURY, 71 DAYS FOR CYANIDE AND 96 DAYS FOR THE REST OF THE ELEMENTS. ALL SAMPLE WERE PRESERVED AT 4°C, DURING PREPARATION AND ANALYSIS.

3- CALIBRATION:

BOTH INITIAL AND CONTINUING CALIBRATION MET ACCEPTANCE CRITERIA.

4- BLANKS

NO CONTAMINATIONS WERE REPORTED IN THE BLANK. ALL CONCENTRATIONS IN THE INITIAL, CONTINUING AND PREPARATION BLANKS, WERE BELOW THE DETECTION LIMITS.

5- ICP INTERFERENCE CHECK:

DATA WERE ACCEPTABLE. ALL RECOVERY RESULTS FELL BETWEEN 75-125%.

6- LAB CONTROL SAMPLE:

RECOVERY OF CHROMIUM, LEAD, ARSENIC AND SELENIUM DID NOT MEET ACCEPTANCE CRITERIA. DATA ASSOCIATED WITH THESE ANALYTES IN THE SAMPLES SHOULD BE QUALIFIED AS ESTIMATED.

7- MATRIX SPIKE SAMPLE ANALYSIS:

SPIKE RECOVERY OF ANTIMONY, ARSENIC, SELENIUM, AND SILVER DID NOT MEET ACCEPTANCE CRITERIA, MAY BE DUE TO MATRIX INTERFERENCE.

8- DUPLICATE SAMPLE ANALYSIS:

RPD OF COPPER AND SELENIUM DID NOT

INORGANIC QA CHECKLIST
CONTINUATION PAGE

CASE NO. 5c30-15-2-1 SITE SAN JACINTO RIVER

COMMENTS:

MEET ACCEPTANCE CRITERIA, MAY BE DUE TO MATRIX EFFECTS.

9- DATA COMPLETENESS AND OVERALL ASSESSMENT:

DATA WERE COMPLETE. ALL REQUIRED DELIVERABLES WERE PRESENT.

DUE TO THE FACT THAT THE QA CRITERIA WERE FOR ADVISORY ONLY. THE PROBLEMS IN THE SPIKE RECOVERY, DUPLICATE ANALYSIS RESULTS AND LABORATORY CONTROL SAMPLE RECOVERY RESULTS, SHOULD NOT CRITICALLY AFFECT THE QUALITY OF THE DATA.

TRACES OF CONTAMINANTS WERE REPORTED IN THE SAMPLES. LEAD WAS REPORTED, IN BOTH THE CRAB AND FISH. IN STATIONS #4, 6 & 9. CHROMIUM, COPPER AND ZINC WERE PRESENT IN SMALL AMOUNTS IN ALL THE STATIONS, IN THE CRAB AND FISH.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6 - HOUSTON BRANCH
6608 HORNWOOD DRIVE
HOUSTON, TX 77074

ORGANIC QA CHECKLIST

Site San Jacinto River

Contract No. 68-02-4254

Task 219

Contractor Versar

Versar Project Number: 5037.219.2

Reviewed by Harry A. Kreigh - ESAT

Matrix Fish/Crab

Date December 18, 1989

Sample No.					
	2F	8F	3C		
	3F	9F	4C		
	4F	1C			
	6F	2C			

OVERALL COMMENTS (To Be Completed by EPA Personnel)

	VOA	BNA	PEST	OTHER
1. Holding Times	P	P	P	N/A
2. Tuning/Performance	A	A	P	N/A
3. Calibrations	P	A	P	N/A
4. Blanks	A	A	A	N/A
5. Surrogates	P	A	A	N/A
6. Matrix Spike/Duplicate	A	A	P	N/A
7. Compound Identity	P	P	P	N/A
8. Case Assessment	P	P	P	N/A

COMMENTS OR CLARIFICATIONS **(See Attached)**

A - Acceptable - All items delivered; all criteria met.

P - Provisional - Data usable; some non-essential review items missing or criteria were not met.

U - Unacceptable - Data unusable; essential review items missing or criteria not met.

NA - Not Applicable

COMMENTS/CLARIFICATIONS
REGION 6 QA REVIEW

Task 219 Site San Jacinto River Lab Versar

The following is a summary of sample qualifiers used by Region 6 in reporting this CLP data:

No.	Acceptable	Provisional	Unacceptable
VOA		10	
BNA		10	
PEST		10	
Other	N/A		

COMMENTS: The case consisted of 6 composite fish samples and 4 composite crab samples for organic priority pollutants by SW-846 Methods 8240, 8270, and 8080. Sample holding times could not be verified due to missing chain-of-custody records and conflicting sample receipt dates. VOA sample 2F exceeded the linear calibration range for acetone and 2-butanone and had an outlying surrogate recovery, but was not reanalyzed due to an insufficient amount of sample. Pesticides were indicated > CRQL in samples 2F and 4C, but were not reported due to performance problems on the confirmation column, and the samples were not reanalyzed. The BNA and Pesticide extracts were split following GPC clean-up, but conflicting dilution factors were reported for the two fractions.

Acetone, 2-butanone, phthalates, G-BHC, DDD, and DDE were reported in the samples. Results for 6 fish samples and 4 crab samples are provisional due to problems with holding times, instrument performance, calibrations, surrogate and MS/MSD recoveries, and compound identification and quantitation.

1. **Holding Times** - Provisional. The laboratory reported conflicting sample receipt dates of 1/25/89 or 5/25/89. VOA analyses were performed from 6/2/89 to 6/14/89. Split BNA/Pesticide extractions were performed on 6/2/89 and the BNA analyses were completed on 6/15/89. Pesticide/PCB analyses of the fish extracts were completed on 7/24/89. The crab samples were re-extracted on 7/25/89 due to unspecified sample preparation problems and the Pesticide/PCB analyses were completed on 8/18/89. The laboratory was requested to resubmit chain-of-custody records to document sample collection and receipt dates. Sample results are provisional pending submission of the requested documentation.

ORGANIC CLP/QA REVIEW
CONTINUATION PAGE

TASK 219 **SITE** San Jacinto River

COMMENTS:

2. **Tuning/Performance** - Provisional. BFB and DFTPP met GC/MS tuning criteria. Although summaries of internal standard areas were not provided, VOA and BNA internal standard areas were within QC control limits.

Results for DDD and endosulfan sulfate are estimated in sample 4C due to a severe baseline disturbance on the confirmation column. The sample was not reanalyzed even though both compounds were indicated > CRQL on the primary column. The DDD identification in sample 6F is tentative and the result is estimated due to inconsistent quantitation on the primary and confirmation columns. DDD peak integration was questionable on the confirmation column due to a severe baseline disturbance just prior to peak elution. Result for G-BHC in sample 2F is estimated because the compound was indicated > CRQL on the primary column, but was not reported due to a major interference on the confirmation column.

3. **Calibrations** - Provisional. Acetone results are estimated in sample 8F and all crab samples because the compound failed %D calibration criteria. Results for 2-butanone are unusable in samples 1C, 2C, 3C, and 4C because the compound failed minimum RRF criteria. Acetone and 2-butanone results for sample 2F are estimated because the sample concentrations exceeded the linear calibration range and the sample was not reanalyzed. Those results should be used with caution. Results for DDD and DDE are estimated in sample 1C because those compounds failed %D calibration criteria.

4. **Blanks** - Acceptable. The method blanks contained acetone, methylene chloride, 2-butanone, and bis(2-ethylhexyl)phthalate. Sample results < 10x the maximum blank levels should be considered estimates. The VOA compound 1,1,2,2-tetrachloroethane was reported as a TIC in the BNA blank. The Pesticide/PCB blank was not contaminated by target compounds.

5. **Surrogates** - Provisional. Results associated with VOA surrogate S3 are estimated in sample 2F because the surrogate recovery exceeded QC control limits and the sample was not reanalyzed. BNA surrogate recoveries met QC guidelines. The DBC recovery for PBLK87 exceeded the advisory QC limit due to coeluting interferences, but sample surrogate recoveries were within the control limits.

6. **Matrix Spike/Matrix Spike Duplicate** - Provisional. Most VOA and BNA MS/MSD recoveries met QC requirements, but nearly all Pesticide MS/MSD recoveries exceeded the control limits for %RPD. The DDD result for sample 2F is estimated as a consequence.

ORGANIC CLP/QA REVIEW
CONTINUATION PAGE

TASK 219 **SITE** San Jacinto River

COMMENTS:

7a. **Compound Identity** - Provisional. High concentrations of acetone and 2-butanone were reported for most VOA samples. Chlorinated hydrocarbons and toluene were also present in some samples. The 2-butanone result for sample 4F is estimated because the reported value is inconsistent with the raw data. The toluene results for sample 2C, 3C, and 4C were flagged "X" due to mass spectral interferences. Those identifications should be considered tentative as a consequence.

Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were reported for BNA. Those results should be considered estimates due to possible laboratory contamination. Sample spectra met identification criteria. Numerous TICs were characterized as organic acids, sulfur compounds, or alcohols. The BNA results may have been miscalculated due to an incorrect dilution factor. The laboratory bench sheets for the split BNA/Pesticide extracts list conflicting extract volumes (2 or 3 mls) for GPC clean-up. The reported BNA quantitation limits may also be too low based on the raw data and should be used with caution. BNA results are provisional pending laboratory clarification.

DDD, DDE, and G-BHC were reported for Pesticide/PCBs. Results for G-BHC in sample 4F and DDD and DDE in sample 1C are estimated because the confirmation data yielded lower concentrations than the reported values. Pesticide/PCB results should be considered provisional pending verification of the dilution factor for GPC clean-up.

7b. **Data Completeness** - Provisional. Chain-of-custody records were omitted from the data package. BNA: The surrogate recoveries reported for sample 3C on Form II (p. 300006) were inconsistent with the raw data. Pesticide/PCB: A chromatogram (p. 100140) was missing for PBLK96. Inconsistent sample peak areas were reported in the following data:

Sample 1C - p. 100011 and 100013
Sample 2C - p. 100018 and 100020
Sample 2CMS - p. 100144 and 100146.

Page 10037 was missing from the raw data for sample 4C. The laboratory was notified of omissions and needed corrections.

8. **Case Assessment** - Data for 6 fish samples (2F, 3F, 4F, 6F, 8F, and 9F) and 4 crab samples (1C, 2C, 3C, and 4C) are provisional due to problems with holding times, instrument performance, calibrations, surrogate and MS/MSD recoveries, and compound identification and quantitation.

In Reference to: Project: 5037.219.2
EPA Contract: 68-02-4254; Task 219

REGIONAL/LABORATORY COMMUNICATION SYSTEM
FAX Record Log

Date of FAX:	December 20, 1989
Laboratory Name:	Versar
Lab Contact:	Dr. Reza Karimi
Region:	6
Regional Contact:	Harry Kreigh - ESAT
FAX initiated by:	______Laboratory ___X___Region

In reference to data for the following samples:

Priority pollutants in fish/crab tissue

Summary of Questions/Issues:

A. General

1. Please submit chain-of-custody records. Various documentation list receipt dates as 1/25/89 or 5/25/89.

2. Split BNA and Pesticide/PCB extractions were performed on 6/2/89. The BNA bench sheets indicate 3 mls of the initial 4 ml extract were processed by GPC, while the Pesticide/PCB bench sheets for the fish samples indicate 2 mls of the 4 ml extract were processed by GPC. Which is correct? Please correct the erroneous dilution factor and resubmit Form Is for the affected fraction.

B. VOA

1. Samples 2CRE, 3CRE, and 4CRE: 2-butanone should be reported. Include spectra.

2. Sample 4F: The reported 2-butanone concentration is inconsistent with the raw data. Please recheck the calculation.

C. BNA

1. Sample 3C: The surrogate recoveries are incorrect on Form II (p. 30006).

2. I cannot reproduce the reported quantitation limits. Based on the reported dilutions, a 20 g sample and the lowest calibration standard (20 ng/ul), I calculated a quantitation limit of 740 ug/kg. Please explain.

To: Dr. Reza Karimi Versar
In Reference to: Project: 5037.219.2; Task 219
EPA Contract: 68-02-4254

Summary of Questions/Issues:

D. Pesticide/PCB

1. PBLK96: p. 100140 is missing.

2. Sample 2F: G-BHC was indicated > CRQL on the primary column, but was obscured by interference on the confirmation column. Why wasn't the sample reanalyzed on the third column?

3. Sample 6F: The area reported for DDD on the confirmation column may be high due to an unstable baseline. Please perform a manual integration.

4. The following raw data report inconsistent sample areas:
   Sample 1C: pages 100011 and 100013
   Sample 2C: pages 100018 and 100020
   Sample 2CMS: pages 100144 and 100146

5. Sample 4C: p. 100037 is missing. A severe baseline disruption precluded detection of DDD and endosulfan sulfate on the confirmation column. Why wasn't the sample reanalyzed?

Summary of Resolution:

Please fax your response to items A1, A2, and C2 to:
(713) 981-7330.

Other resubmissions can be sent to the following address:
US EPA Region 6 Laboratory
6608 Hornwood Drive
Houston, TX 77074

If you have any questions, please contact me at (713) 953-3430.

Signature: [signature] Date: December 20, 1989

Distribution: (1) Lab Copy, (2) Region Copy, (3) SMO Copy

Versar INC.

April 20, 1989

Phil Crocker
U.S. Environmental Protection Agency
Region VI
Water Quality Management Branch (6W-QT)
1445 Ross Avenue
Dallas, TX 75202-2733

Subject: Response to QC Review and Delivery of Work Plan for San Jacinto River Fish and Crab Sample Analysis II (EPA Contract No. 68-02-4254, Task 219)

Dear Phil:

Attached is our laboratory's response to the QC review you forwarded to us last month. Several issues have been clarified and data corrections made where necessary. Also enclosed is the work plan and cost estimate for the subject task. We will not initiate sample analysis until you have (1) reviewed and responded to the attached QC discussion and (2) approved the enclosed work plan. If you feel all is in order and approve our initiation of laboratory efforts, please call Liz Bryan of EPA-OTS at (202) 382-3873. If you have any questions concerning the attached please call me or Judy English. We look forward to working for you again.

Sincerely,

Douglas A. Dixon
Director
Exposure Assessment Division

Attachment
cc: J. Bernarding
G. Contos
File 5037.219.1/8571H
File 5030.015.1

Versar INC.

SAN JACINTO RIVER FISH AND CRABS
GC ORGANIC ANALYSIS
VERSAR PROJECT 5030.15.2

The EPA data review noted a number of problems with the pesticide analyses of the fish and crabs. These are discussed below.

The EPA review stated that there were problems with the identification and quantification of DDE in the samples, specifically in fish #8. We agree that the identification of DDE was difficult in these samples due to the interferences present. The reasons for the inconsistency in the DDE results can be seen in a more detailed analysis of the chromatograms. There was a large interference (the "hump" mentioned in the EPA review) in the middle of the pesticide chromatograms. Data interpretation, due to the complexity of the chromatograms, was primarily based on retention times and raw areas alone, rather than qualitative peak analysis. While the sample chromatography was poor for the sample, its MS, and its MSD, the analyst had little or no recourse short of reextraction and reanalysis. Since all of the sample was used in the original extraction, we could not reextract. Packed column data for sample #57653, it's MS and MSD were integrated by three different methods. The integration method, chosen by the software, resulted in different baselines and different areas for the three analyses. Only one of the results from the capillary analyses was anomalous. This may indicate the influence of the negative peak (detector quenching) in the region of the DDE peak, but the results were consistent for two of the three capillary injections. The DDE results could probably be determined at or just below the reported limit, but the results may be slightly inflated due to the various integration methods. We believe that the capillary column data is more accurate than the packed column data. However, in accordance with a CLP style quantitation, sample results are reported from packed column analyses, as capillary data are not acceptable under current protocol. Within the restrictions of the requested method, no capillary columns are included in the list of acceptable columns.

Reanalysis of the raw data was not possible, as the data was not stored electronically. This being the case, the raw data included on the chromatogram reports was the only data available. With electronic storage the analysts could have reconstructed the chromatograms, set the baselines appropriately, and modified the peak integration parameters. While this would not have solved all of the problems associated with these analyses, it would have greatly reduced the discrepancies represented in the packed column analytical results. Since these analyses were done we have implemented a system where all data files are stored electronically. This should help in future analyses of this type.

The major problem with the pesticide analyses was the interference in the center of the chromatogram. The interfering compounds caused a

Versar INC.

large hump in the packed column chromatograms and a large dip in the capillary chromatograms. As the EPA reviewer stated, this affects about 5 compounds in the center region of the chromatograms. Further laboratory investigation is being conducted to determine the nature and source of the contamination observed, as well as to define the most appropriate clean-up procedure for the interference. No remaining sample extract is available, so we have no options for a more detailed investigation into the samples previously extracted. For future work we might conduct a study on some unrelated samples to determine the most appropriate and effective procedural modifications.

The EPA review noted the high spike recoveries for three of the pesticides. These three compounds elute in the center of the chromatogram where the interfering compounds were present. The interferences resulted in the high recoveries. The recoveries for the remaining three spiked compounds were all reasonable, indicating that extraction efficiency was acceptable and that compounds were not lost during processing. The major problem is the interfering compounds discussed above. We are confident that the recoveries would improve dramatically if the interferences were not present.

Sample 57654 was mislabelled as 57653MSD in both the quantitative analysis and the confirmation analysis. While this appears to be a clerical error, logbook and sample data concur as labeled. This indicates to us that the error was one of mechanical, rather than clerical nature. The analytical sequence was programmed appropriately, as indicated in the instrument injection log, however sample 57654 was mistakenly placed in the autosampler location for sample 57653MSD, and vice versa. This problem was noted in the data interpretation, as the recovery data was correct as reported, however no corrections were made for the chromatogram labeling, nor was any other documentation of the problem included. It is, as yet, unclear why no documentation of the error was included, and it is clearly an ommission on our part.

In summary, the pesticide data had one major weakness; the interfering compounds in the center of the chromatogram. This affects the results for about five of the pesticides. The analysis for the remaining pesticides did not have major problems. Our corrective action in response to this problem is to identify the source of the interferences, and either eliminate the source or add cleanup steps that will eliminate the interferences.

Reza A. Karimi

Reza A. Karimi, Section Chief
Gas Chromatography Section
Laboratory Operations

Versar INC.

SAN JACINTO RIVER FISH AND CRABS
GC/MS ORGANIC ANALYSIS
VERSAR PROJECT 5030.15.2

The following comments have been prepared in response to data validation performed by Melvin Ritter of US EPA Region VII. GC/MS organic analyses of fish and crab tissue samples were performed in November 1988.

Volatile Organic Analysis

The data reviewer has indicated a concern for the amount of acetone and 2-butanone confirmed present in both the fish and especially the crab analyses. The statement that "these results make no sense and must be due to some other source but the tissue..." is not necessarily accurate.

Acetone and 2-butanone confirmed present in the majority of the fish and crab samples does not appear to be due to laboratory contamination. Although the presence of these two compounds may often result from background levels present in the laboratory, concentrations are typically less than 10 ppb (ug/kg). The sources of the acetone and 2-butanone in the tissue samples quantified at part per million levels must be further investigated. Laboratory prepared reagent blanks were extracted and analyzed. No contamination was observed which may have resulted from the sample containers used to store the fish fillets and the crab tissue. Also, the blanks did not indicate contamination from the tissue grinder apparatus.

Acetone can be generated from biogenic sources including metabolism and biological fermentation or degradation. The storage of the tissue prior to homogenization (e.g. temperature, aerobic vs. anaerobic conditions) may have contributed to the levels of volatile compounds present. The samples were received by Versar in a frozen state and they remained frozen for an extended period of time (~6 weeks) prior to authorization for sample preparation, extraction, and analysis. After the whole fish and crabs were prepared into analyzable samples, the tissues were stored in an area that was free from volatile organics.

The review indicates that inconsistencies were present in target analyte identifications in the VOA QC sample: the matrix spike contains 2-butanone, but methylene chloride is not detected whereas the matrix spike duplicate sample has methylene chloride present at a concentration of 1000 ppb with no 2-butanone.

Target analytes in the volatile MS and MSD QC analyses did exhibit some sample variations, however the identifications and quantifications are correct. The matrix spike aliquot was analyzed on October 21, 1988 (GC/MS File No.U4628).

Versar INC.

The initial analysis of the matrix spike duplicate aliquot was noncompliant and was not submitted with the data package. Reanalysis was not performed until November 9, 1988 (GC/MS File No. U4859). The fish fillet sample used for the MSD analysis was acquired from a different subsample bottle. This bottle was not maintained in the refrigerator used to isolate samples from external volatile organics.

Semivolatile Organic Analysis (BNA)

Specific problems were questioned pertaining to the use of "B" flags for tentatively identified compounds reported in semivolatile analyses. Mr. Ritter has noted that "Fish 2 has TIC's at scans 253, 728, 877, 1939 and 2260 which match those for blank SBLK96 (which is a crab blank) at scans 247, 737, 1690 and 2254, respect."

Nontarget compounds detected in the reagent blanks extracted in conjunction with fish samples cannot be applied to analyses of crab samples. The blanks extracted for each matrix were prepared independently. SBLK49 applies only to the fish samples. Other semivolatile reagent blanks apply to crab samples only.

Additional examples cited by the reviewer were evaluated.

Reevaluation of B flags applied to semivolatile analyses of all fish samples resulted in corrections to Scan 253 in Fish 2 (Station 2) and Scan 1939 for Fish 6 (Station 6).

Volatile target analytes were noted by the reviewer on two library searched peaks present in the semivolatile analysis of Crab sample #3.

Nontarget analytes represent tentative identifications only. The identity of compounds eluting at scans 173 and 322 were listed on the TIC summary page as "unknown" and "unknown chlorinated hydrocarbon". These are the identifications chosen by the GC/MS chemist based upon the purity, fit, and reverse fit search parameters. For a hit to be a positive identification all three values are typically greater than 900. Purity and reverse fit values are usually greater than 800 for consideration of compound specific identifications. These values were 759,952,784 and 651,977,651 for compounds present at scans 173 and 322, respectively. The EPA/NBS mass spectral library contains over 42,000 entries; due to the search routine, improper identifications can be made by the software. Also, the library selects TIC compounds without regard to relative retention times.

Versar INC.

These chlorinated solvents although not confirmed present in these field samples nor in the laboratory reagent blanks are sometimes an artifact of the methylene chloride (dichloromethane) used for the semivolatile extractions.

Another specific use of flags was questioned for scan 1045 in Crab #3.

TIC present at scan 1045 in Crab 3 correlates to scan 1054 in SBLK96. TIC Form revised with B flag added.

It is important to note that the nontarget semivolatile compound present at scan ~1936 is oleyl alcohol. This compound is sometimes detected in laboratory reagent blanks. It is an artifact of the glass wool used during filtration and concentration of the organic sample extracts. However the Merck Index states that this compound is also a constituent of fish oil; therefore, Melvin Ritter's comments that "Non-targets or TICs should be dismissed for the BNAs" is not accurate. Nontarget compounds not flagged with a "B" should be considered as being present in the tissue samples. Oleyl alcohol (Scan ~1936) may also be a constituent of the field samples although flagged with a "B".

Revised data summary forms attached.

April 12th, 1989

Lawrence P. Pollack
GC/MS Data Quality Manager
Laboratory Operations

Versar Inc., Laboratory Operations
6850 Versar Center, Springfield VA 22151 (703) 750-3000

SAMPLE ID
STATION 2

Organics Analysis Data Sheet
(Page 4)

Tentatively Identified Compounds

	CAS Number	Compound Name	Fraction	RT or Scan	Estimated Concentration (ug/Kg or ug/l)
1		UNKNOWN ORGANIC ACID	BNA	239	4,100 J
2		UNKNOWN	BNA	253	1,500 J B
3		UNKNOWN	BNA	728	1,000 J
4		UNKNOWN	BNA	877	8,300 J
5		UNKNOWN	BNA	1554	3,900 J
6		UNKNOWN ORGANIC ACID	BNA	1571	550 J
7		UNKNOWN	BNA	1692	5,000 J
8		UNKNOWN	BNA	1791	2,500 J
9		UNKNOWN	BNA	1939	1,300 J,B
10		UNKNOWN	BNA	1968	4,400 J
11		UNKNOWN	BNA	2260	36,000 J
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

4-12-99

Fish

Versar Inc., Laboratory Operations
850 Versar Center, Springfield VA 22151 (703) 750-3000

SAMPLE ID
STATION 6

Organics Analysis Data Sheet
(Page 4)

Tentatively Identified Compounds

	CAS Number	Compound Name	Fraction	RT or Scan	Estimated Concentration (ug/Kg or ug/l)
1		UNKNOWN	BNA	252	1,400 J,B
2		UNKNOWN	BNA	750	2,800 J
3	98-92-0	3-PYRIDINECARBOXAMIDE	BNA	896	4,500 J
4		UNKNOWN	BNA	1065	420 J
5		UNKNOWN	BNA	1192	480 J
6		UNKNOWN ALDEHYDE	BNA	1444	1,200 J
7		UNKNOWN	BNA	1478	4,000 J
8		UNKNOWN	BNA	1675	2,300 J
9		UNKNOWN	BNA	1690	3,300 J
10		UNKNOWN	BNA	1939	2,200 J B
11		UNKNOWN	BNA	1967	9,200 J
12		UNKNOWN	BNA	2266	37,000 J
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

4-12-89

Versar Inc., Laboratory Operations
6850 Versar Center, Springfield VA 22151 (703) 750-3000

SAMPLE ID
CRAB 3

Organics Analysis Data Sheet
(Page 4)

Tentatively Identified Compounds

	CAS Number	Compound Name	Fraction	RT or Scan	Estimated Concentration (ug/Kg or ug/l)
1		UNKNOWN	BNA	173	210 J
2		UNKNOWN	BNA	180	4,200 J
3		UNKNOWN	BNA	189	4,400 J
4		UNKNOWN	BNA	241	1,700 J
5		UNKNOWN	BNA	258	720 J
6		UNKNOWN ORGANIC ACID	BNA	292	1,600 J
7		UNKNOWN CHLORINATED HYDROCARBON	BNA	322	510 J
8	100-52-7	BENZALDEHYDE (ACN)(DOT)	BNA	382	750 J
9		UNKNOWN	BNA	568	2,900 J
10		UNKNOWN	BNA	731	340 J,B
11	10433-34-8	BENZENEETHANAMINE, N-(1-METHYLETHYLIDENE)-	BNA	775	580 J
12		UNKNOWN	BNA	888	300 J
13		UNKNOWN	BNA	961	630 J,B
14		UNKNOWN	BNA	1006	280 J
15		UNKNOWN HYDROCARBON	BNA	1045	850 J B
16		UNKNOWN	BNA	1079	200 J
17		UNKNOWN	BNA	1312	2,600 J
18		UNKNOWN	BNA	1583	330 J
19		UNKNOWN AMIDE	BNA	1681	2,700 J,B
20		UNKNOWN ORGANIC ACID	BNA	1702	340 J,B
21		UNKNOWN	BNA	1928	3,100 J,B
22		UNKNOWN	BNA	2223	2,000 J,B
23					
24					
25					
26					
27					
28					
29					
30					

4-12-89