The Houston Ship Channel

Utilization of the Upper Houston Ship Channel by Fish and Macroinvertebrates with Respect to Water Quality Trends

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At present very little information exists on the fish and macroinvertebrate communities which reside in the upper portions of the Houston Ship Channel (HSC). Early studies on nekton populations indicated little utilization of these areas. Chambers (1960) found the area above the confluence of the San Jacinto River to be virtually devoid of nekton. By the mid 1970s, diversity and utilization of Segment 1006 (San Jacinto River to Greens Bayou) by nekton had greatly improved, yet Segment 1007 (Greens Bayou to the Turning Basin) remained depauperate (TWDB 1980). Since this period there has been considerable improvement in the water quality due to increased state and federal regulations and more restrictive effluent requirements. In addition to routine water quality monitoring, the Texas Water Commission (TWC) has recently been monitoring nekton populations in HSC stream segments 1006 and 1007. The objectives of this monitoring program are to characterize nekton populations in the upper HSC and to assess the impacts of water quality trends on these communities.

Study Site and Methods

From March 1988 through July 1989, nekton were collected from revolving screens of the cooling water intake structures at the Houston Lighting and Power Deepwater Generating Plant (Segment 1007) and the Occidental Chemical Deer Park Plant (Segment 1006). Four thirty-minute replicate samples were collected every two weeks at each location. Revolving screen data from August 1988 to July 1989 are discussed in this report.

Beginning in August of 1988 additional collections were taken by seine and gillnet at one site in each segment. From September 1988 to August 1989 seining was expanded to monthly sampling at six locations, three in Segment 1006 and three in Segment 1007. Three replicate 50-ft seine hauls were made with a 45 ft by four ft straight seine. Seining was discontinued in May 1989 at one station in Segment 1007 due to high water, debris and inaccessibility. Gillnet sampling was continued every two months at one station in each of the segments 1006 and 1007 with a 200 ft by eight ft experimental gillnet of eight 25 panels ranging from four to 1/2 inch bar mesh. Sample site locations are shown on Figure 1.

All organisms collected were identified to lowest possible taxa and enumerated. Numbers of individuals per taxa, numbers of taxa and total numbers of organisms were recorded for each replicate, and mean catch per unit effort, mean number of taxa and cumulative number of taxa were tabulated for each month and segment.

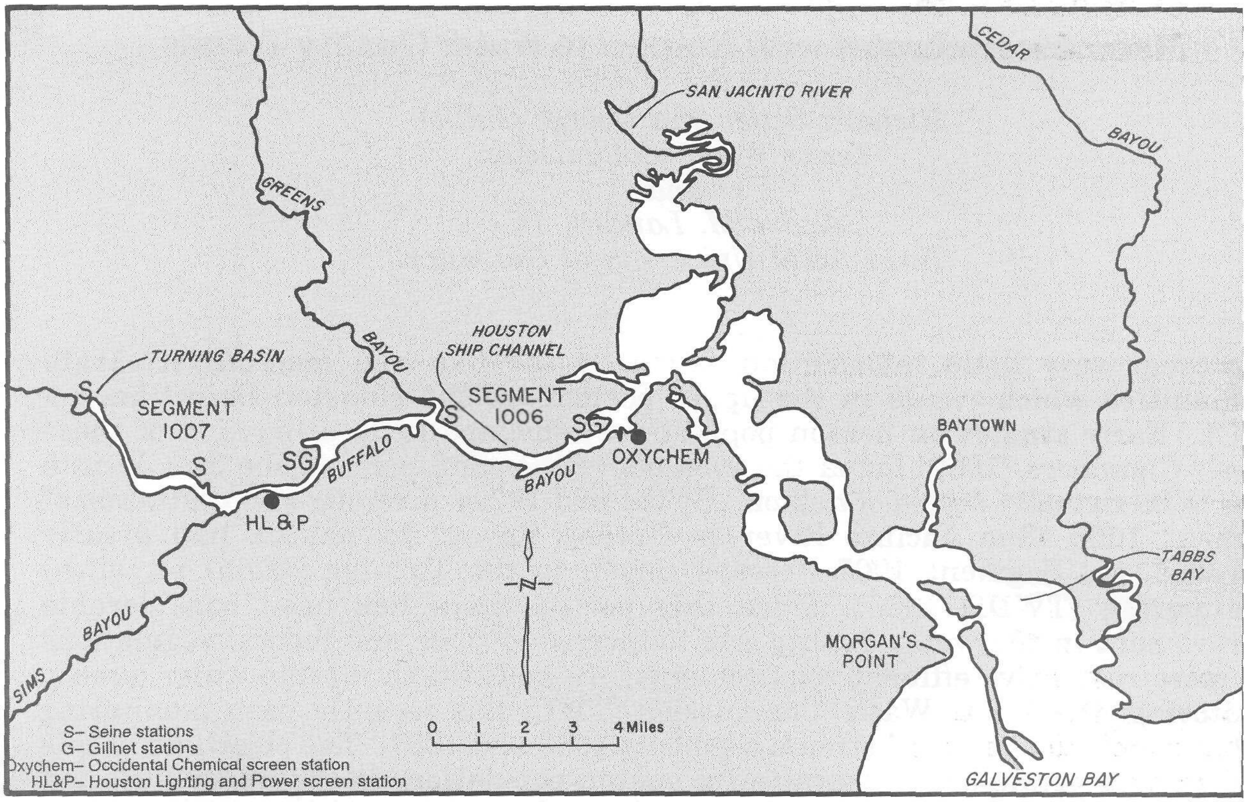

Figure 1. Map of study area, showing Houston Ship Channel Segments 1006 and 1007, with sampling stations indicated.

Temperature, pH, conductivity, salinity and dissolved oxygen were measured at one foot below the surface and one foot off the bottom with a Hydrolab Surveyor II multi-parameter water quality measuring instrument. Mean monthly values for each segment were tabulated from data collected at each sampling event.

Results

Hydrological data closely followed expected seasonal trends (Fig. 2). Mean bottom (20 ft) dissolved oxygen levels in Segment 1007 ranged from a high of 6.9 mg/l in February 1989 to a low of 0.2 mg/l in June 1989. In contrast dissolved oxygen values were consistently 1.0 - 1.5 mg/l higher in Segment 1006. Mean bottom temperatures were similar in both segments and exceeded 30 C in summer months. During most of the survey mean surface dissolved oxygen and temperatures were similar in both segments. Salinities varied widely both spatially and temporally during the study period, reaching peak levels in August 1988 during a drought period, and dropping to fresh water conditions during heavy flooding in June and July 1989. In general mean salinities were lower in Segment 1007 than Segment 1006.

A total of 33,042 organisms representing 84 taxa were collected during August

1988 through July 1989. A total of 19,707 organisms composed of 65 taxa were collected from the revolving screens. Catch rates from seines and gillnets were 13,055 organisms representing 48 taxa and 280 organisms representing 16 taxa, respectively. Total catch rates and number of taxa collected from all sampling gear were generally greater in Segment 1006 (76 taxa) than in 1007 (59 taxa).

Mean catch per unit effort (CPUE), mean number of taxa, and cumulative number of taxa in revolving screen samples were highest in Segment 1007 during the cooler months (November 1988 - March of 1989; Fig 3). The highest values of these parameters were observed in February, when water temperatures in Segment 1007 were at their lowest and bottom dissolved oxygen levels were at their peak. Lowest values were obtained in the summer months of 1989, when dissolved oxygen and salinity levels were at their minimum. In contrast, mean CPUE and mean number of taxa in Segment 1006 were highest in the summer and early fall when mean bottom temperatures and mean dissolved oxygen levels were at their highest and lowest respectively. Cumulative number of taxa were also highest in Segment 1006 during the winter months when estuarine organisms seek out the deeper and warmer waters of the channel.

Seine and gillnet catches in both segments varied greatly throughout the study (Fig. 3). Seasonal surface water temperatures had the greatest hydrological influence on catches in both segments. In Segment 1006, mean CPUE, mean number of taxa and cumulative number of taxa were highest in the summer and fall months and lowest in the winter. In contrast, lowest gillnet CPUE and number of taxa were observed during the summer months in Segment 1007. Seine catches in Segment 1007 exhibited seasonal trends similar to 1006.

Revolving screen and gillnet catches in Segment 1007 were dominated by blue crab, *Callinectes sapidus* (Table 1.). In contrast, adult and juvenile resident species of fish such as sheepshead minnow, *Cyrinodon variegatus*, sailfin molly, *Poecilia latipinna*, and Gulf killifish, *Fundulus grandis*, generally dominated seine catches in Segment 1007 (Table 2). Revolving screen and seine catches in Segment 1006 were composed primarily of bay anchovy, *Anchoa mitchilli*. Gillnet collections in Segment 1006 were comprised mainly of blue crab (Table 3). Overall trends in dominance by various taxa were strongly influenced by seasonal utilization of these areas by juvenile organisms (Tables 1,2, and 3).

Discussion

Segments 1006 and 1007 of the HSC currently possess no "aquatic life use designation," and an increased utilization of these areas by nekton communities may have implications on the future aquatic life use designation of these segments. Results of this survey document the extensive use of the upper portions of the HSC by a variety of organisms, and establish this area as important habitat for juvenile fish and macroinvertebrates. Segment 1006 maintains a healthy and viable population of nekton year-round. During the winter months, richness and abundance of organisms in Segment 1007 equals or exceeds that of Segment 1006. In the summer months during periods of low dissolved oxygen, Segment 1007 maintains a viable shoreline assemblage of organisms.

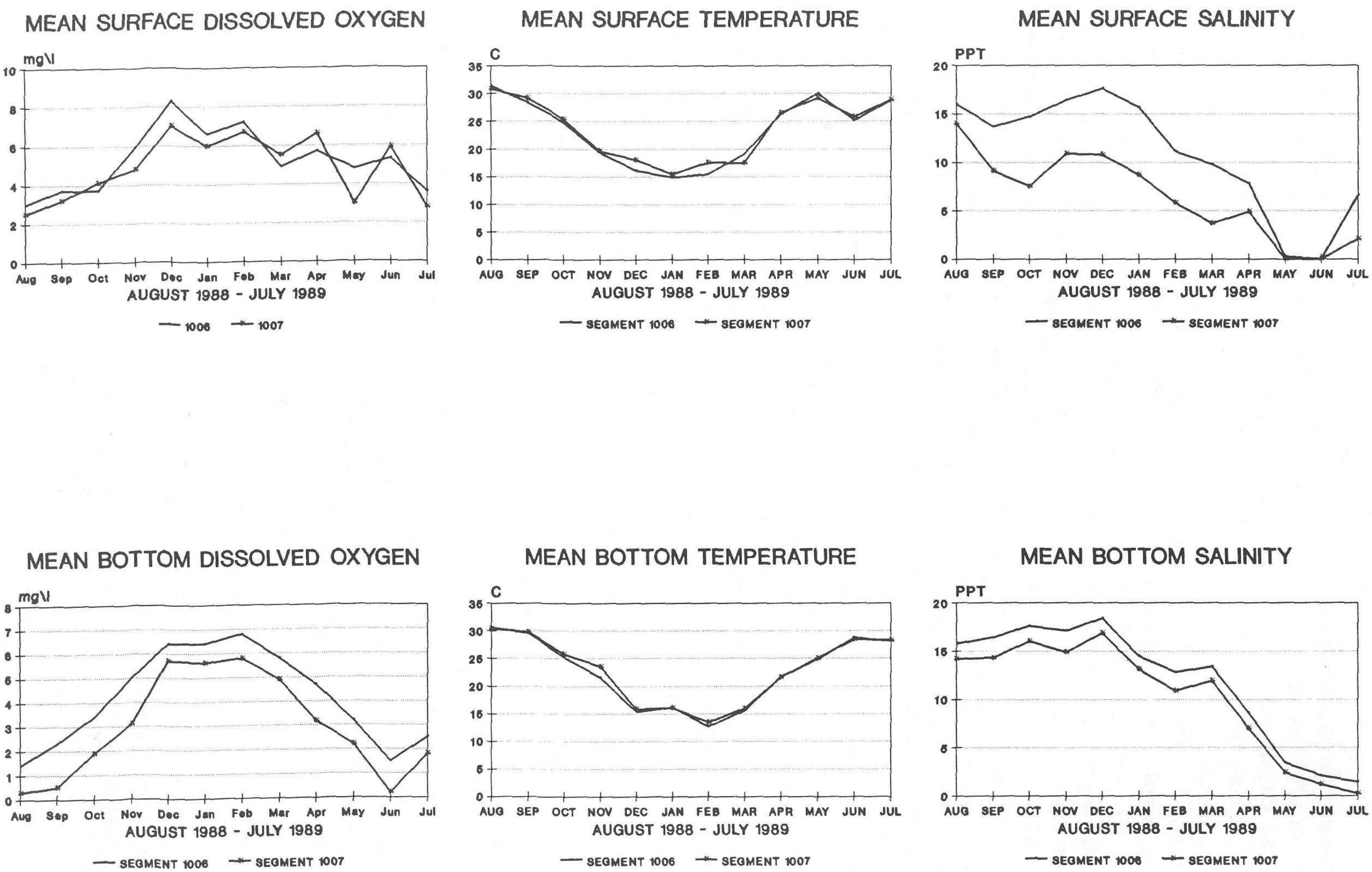

Figure 2. Mean surface and bottom dissolved oxygen, temperature, and salinity in segments 1006 and 1007.

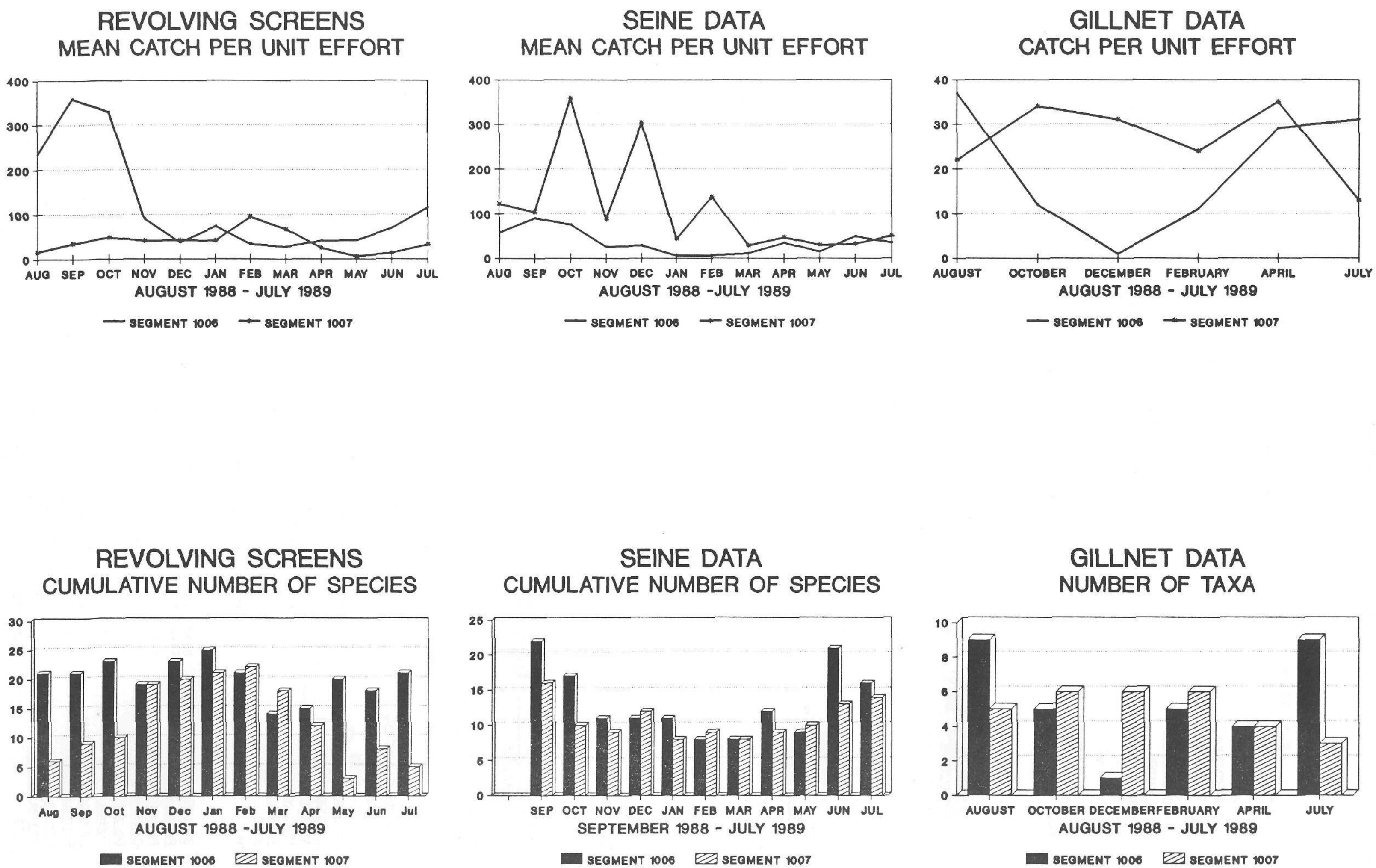

Figure 3. Mean catch per unit effort and cumulative number of taxa collected by revolving screens, seines, and gillnets in segments 1006 and 1007.

Table 1. Monthly percent catch of dominant species collected by revolving screens in segments 1006 and 1007.

SEGMENT 1006		DATE											
COMMON NAME	SPECIES	8–88	9–88	10–88	11–88	12–88	1–89	2–89	3–89	4–89	5–89	6–89	7–89
brown shrimp	Penaeus aztecus	****	****	****	****	****	****	****	****	****	30.7	****	****
white shrimp	Penaeus setiferus	6.4	5.2	****	****	****	18.9	13.5	8.4	6.5	****	****	8.8
Sergestid shrimp	Acetes americanus	****	11.3	48	52.4	28.3	7.9	****	****	****	****	****	****
grass shrimp	Palaemonetes pugio	****	****	****	****	****	****	****	****	****	20.8	****	****
blue crab	Callinectes sapidus	****	****	****	****	9	5.2	10.9	6.5	14.9	16.6	43.5	78.1
gulf menhaden	Brevoortia patronus	****	****	****	****	36.7	23.1	12.4	28.4	****	8.7	****	****
bay anchovy	Anchoa mitchilli	66.2	72.7	39.6	25.7	5.3	23.4	21	9.8	18.6	****	****	****
hardhead catfish	Arius felis	****	****	****	****	****	****	6.4	****	****	****	****	****
gulf killifish	Fundulus Grandis	****	****	****	****	****	****	****	****	****	****	****	****
silver perch	Bairdiella chrysoura	11.9	****	****	****	****	****	****	****	****	****	****	****
sand seatrout	Cynoscion arenarius	****	****	****	****	****	****	****	****	****	****	41.1	****
Atlantic croaker	Micropogonias undulatus	****	****	****	****	****	5.5	23.6	36.7	50	****	****	****
Other species	n=45	15.5	10.8	12.4	21.9	20.7	16	12.2	10.2	10	23.2	15.4	13.1
* No. species < 5% of total		n=18	n=18	n=21	n=17	n=19	n=19	n=15	n=9	n=11	n=16	n=16	n=19

SEGMENT 1007													
COMMON NAME	SPECIES	8–88	9–88	10–88	11–88	12–88	1–89	2–89	3–89	4–89	5–89	6–89	7–89
brown shrimp	Penaeus aztecus	****	****	****	5.8	****	****	****	****	8.9	****	****	****
white shrimp	Penaeus setiferus	24	27	6.5	11.3	12.9	30.3	11.4	8.6	6.8	12.5	****	****
seabob	Xiphopenaeus kroyeri	****	****	****	****	****	5.3	****	****	****	****	****	****
Sergestid shrimp	Acetes americanus	****	****	29.1	15	****	****	****	****	****	****	****	****
blue crab	Callinectes sapidus	67.2	60.4	19.4	19.6	8.7	12	****	6.2	26	83.3	84.9	96.8
gulf menhaden	Brevoortia patronus	****	****	****	****	14.4	7.1	9.4	7.1	****	****	****	****
bay anchovy	Anchoa mitchilli	****	****	****	29.6	37.8	25	25.2	28.9	16.7	****	****	****
sheepshead minnow	Cyprinodon variegatus	5.6	****	****	****	****	****	****	****	****	****	****	****
sand seatrout	Cynoscion arenarius	****	****	19.6	****	****	****	****	****	****	****	****	****
Atlantic croaker	Micropogonias undulatus	****	****	****	****	6.3	12	42.8	41.2	33.3	****	****	****
star drum	Stellifer lanceolatus	****	****	15.7	****	****	****	****	****	****	****	****	****
Other species	n=35	3.2	12.6	9.7	18.7	19.9	8.3	11.2	8	8.3	4.2	15.1	3.2
* No. species < 5% of total		n=3	n=7	n=5	n=14	n=15	n=15	n=18	n=13	n=7	n=1	n=7	n=4

* Species which comprise less than 5 % of total are not listed.

Table 2. Monthly percent catch of dominant species collected by seine in segments 1006 and 1007.

SEGMENT 1006		DATE											
COMMON NAME	SPECIES	8–88	9–88	10–88	11–88	12–88	1–89	2–89	3–89	4–89	5–89	6–89	7–89
brown shrimp	Penaeus aztecus	****	8	12.9	****	****	****	****	****	****	****	****	****
white shrimp	Penaeus setiferus	****	47.6	61.3	****	****	****	****	****	****	****	****	****
grass shrimp	Palaemonetes pugio	****	6.5	****	7.3	27	23.6	****	****	6.1	****	****	****
blue crab	Callinectes sapidus	10.4	5.5	5.8	****	****	5.5	****	****	5.2	****	33.5	11.5
gulf menhaden	Brevoortia patronus	****	****	****	****	12	16.4	57.4	28.6	30	52.6	9.4	****
threadfin shad	Dorosoma petenese	****	****	****	****	****	****	****	****	****	****	6.5	****
bay anchovy	Anchoa mitchilli	****	12.5	****	61.4	19.7	****	****	56.1	21.6	****	****	****
sheepshead minnow	Cyprinodon variegatus	****	****	****	****	5.4	****	****	****	****	15.3	33	****
gulf killifish	Fundulus grandis	****	****	****	****	****	5.5	****	****	****	****	5.1	****
longnose killifish	Fundulus similis	****	7.2	7.1	****	22	7.3	****	****	****	5.1	****	****
inland silverside	Menidia beryllina	****	****	****	****	****	5.5	****	****	****	****	****	****
spot	Leiostomus xanthurus	40.5	****	****	****	****	****	****	****	25.5	****	****	****
Atlantic croaker	Micropogonias undulatus	****	****	****	****	****	5.5	9.3	****	****	****	****	****
striped mullet	Mugil cephalus	30.1	****	****	19.3	7.7	23.6	18.5	6.1	****	16.1	****	****
white mullet	Mugil curema	13.3	****	****	****	****	****	****	****	****	****	****	71.2
Other species	n=30	5.7	12.7	12.9	12	6.2	7.1	14.8	9.2	11.6	10.9	12.5	17.3
* No. species < 5% of total		n=5	n=16	n=13	n=8	n=6	n=3	n=5	n=5	n=7	n=5	n=16	n=14

SEGMENT 1007													
COMMON NAME	SPECIES	8–88	9–88	10–88	11–88	12–88	1–89	2–89	3–89	4–89	5–89	6–89	7–89
white shrimp	Penaeus setiferus	****	15.5	****	****	****	****	****	****	****	****	****	****
grass shrimp	Palaemonetes pugio	****	10	****	****	****	****	****	****	****	****	****	****
blue crab	Callinectes sapidus	13.4	****	****	****	****	****	****	****	****	****	50.5	****
threadfin shad	Dorosoma petenese	****	****	****	****	****	****	****	****	****	5.7	****	****
bay anchovy	Anchoa mitchilli	****	5.1	****	****	****	****	****	****	****	****	****	****
sheepshead minnow	Cyprinodon variegatus	5.5	21.6	39	22.6	30.4	35.8	75.2	73.7	41.5	****	****	15.6
gulf killifish	Fundulus grandis	79.2	23.8	13.9	27.8	40.2	5.5	6.5	****	25.4	24.6	10	52.2
sailfin molly	Poecilia latipinna	****	10.2	33.9	9.8	19.5	28.3	8.6	5.1	20.1	48	15.3	7.5
inland silverside	Menidia beryllina	****	****	10.7	34.9	****	24.4	8.6	10.6	5.2	14.3	15.3	13.6
Other species	n=18	1.9	13.8	2.5	4.9	9.9	6	1.1	10.6	7.8	7.4	8.9	11.1
* No. species < 5% of total		n=2	n=10	n=6	n=5	n=9	n=4	n=5	n=5	n=5	n=6	n=9	n=10

* Species which comprise less than 5 % of total are not listed.

Table 3. Monthly percent catch of dominant species collected by gillnet in segments 1006 and 1007.

SEGMENT 1006		DATE											
COMMON NAME	SPECIES	8–88	9–88	10–88	11–88	12–88	1–89	2–89	3–89	4–89	5–89	6–89	7–89
blue crab	Callinectes sapidus	29.7		16.7		****		****		58.6			9.7
ladyfish	Elops saurus	13.5		****		****		****		****			9.7
skipjack herring	Alosa chrysochloris	****		****		****		27.3		****			6.5
gulf menhaden	Brevoortia patronus	****		****		****		****		****			6.5
gizzard shad	Dorosoma cepedianum	****		16.7		****		27.3		****			****
hardhead catfish	Arius felis	10.8		33.3		****		****		6.9			32.3
blue catfish	Ictalurus furcatus	****		****		****		****		****			9.7
spot	Leiostomus xanthurus	5.4		16.7		****		18.2		****			****
striped mullet	Mugil cephalus	18.9		16.7		100		18.2		31			19.4
white mullet	Mugil curema	13.5		****		****		****		****			****
Southern flounder	Paralichthys lethostigma	****		****		****		9.1		****			****
Other species	n=3	8.2		0		0		0		3.5			6.2
* No. species < 5% of total		n=3								n=1			n=2

SEGMENT 1007													
COMMON NAME	SPECIES	8–88	9–88	10–88	11–88	12–88	1–89	2–89	3–89	4–89	5–89	6–89	7–89
blue crab	Callinectes sapidus	27.3		26.5		12.9		****		80			76.9
ladyfish	Elops saurus	9.1		****		****		****		****			****
skipjack herring	Alosa chrysochloris	****		****		25.8		****		****			****
gulf menhaden	Brevoortia patronus	****		11.8		****		****		****			****
gizzard shad	Dorosoma cepedianum	****		17.7		12.9		45.8		****			****
blue catfish	Ictalurus furcatus	****		****		****		****		****			7.7
gulf killifish	Fundulus grandis	50		5.9		****		****		****			****
spot	Leiostomus xanthurus	****		****		22.6		12.5		****			****
striped mullet	Mugil cephalus	9.1		35.3		22.6		29.2		14.3			15.4
Other species	n=3	4.6		2.9		3.2		12.5		5.7			0
* No. species < 5% of total		n=1		n=1		n=1		n=3		n=2			

* Species which comprise less than 5 % of total are not listed.

Literature Cited

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Water Quality and Ambient Toxicity Investigation of the Houston Ship Channel and Tidal San Jacinto River

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From 1988 to 1990 EPA Region 6, in conjunction with the Texas Water Commission (TWC), conducted a water quality and ambient toxicity investigation of the Houston Ship Channel (HSC) and San Jacinto River. The primary purpose was to determine if there were toxic conditions in the HSC (Texas Water Quality segments 1006 and 1007), tidal portions of the San Jacinto River (segments 1001 and 1005) as well as three tidal tributaries (Bray's, Green's and Sim's Bayous). This information was gathered to better define water quality management needs for these waters, particularly with regard to toxicants 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*). Chemical analyses of bottom sediments and fish tissue, and toxicity testing of sediments were also conducted on a more limited scale.

Five surveys were completed August, 1988, January, 1989, February, 1990, May, 1990, and July/August, 1990. Sampling of the three tributaries took place in September, 1989. The study was initiated using a core sampling network of nine stations (Fig. 1), 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 Sim's Bayou (#11), both in Segment 1007, and Greens Bayou (#12, Segment 1006).

The ambient toxicity results showed 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. These differences may have been due to exceptional growth for fish exposed to reference site water rather than toxic effects of test water. On one other occasion (Station 9, July 1990) growth was significantly lower in test water than the control.

Toxicity was most pronounced in the algal and mysid shrimp tests, with significant effects found at least once (except for the alga at Station 5) out of four or five sampling events. The most impacted stations, where toxicity was found on three sampling events, include stations 1 and 2 for the algal test, and stations 11 and 12 for the mysid test. Significant toxicity to the alga was found for each of the four sampling events at Station 6 (downstream of Lynchburg Ferry). This recurring pattern of ambient toxicity indicates that water quality is variable and

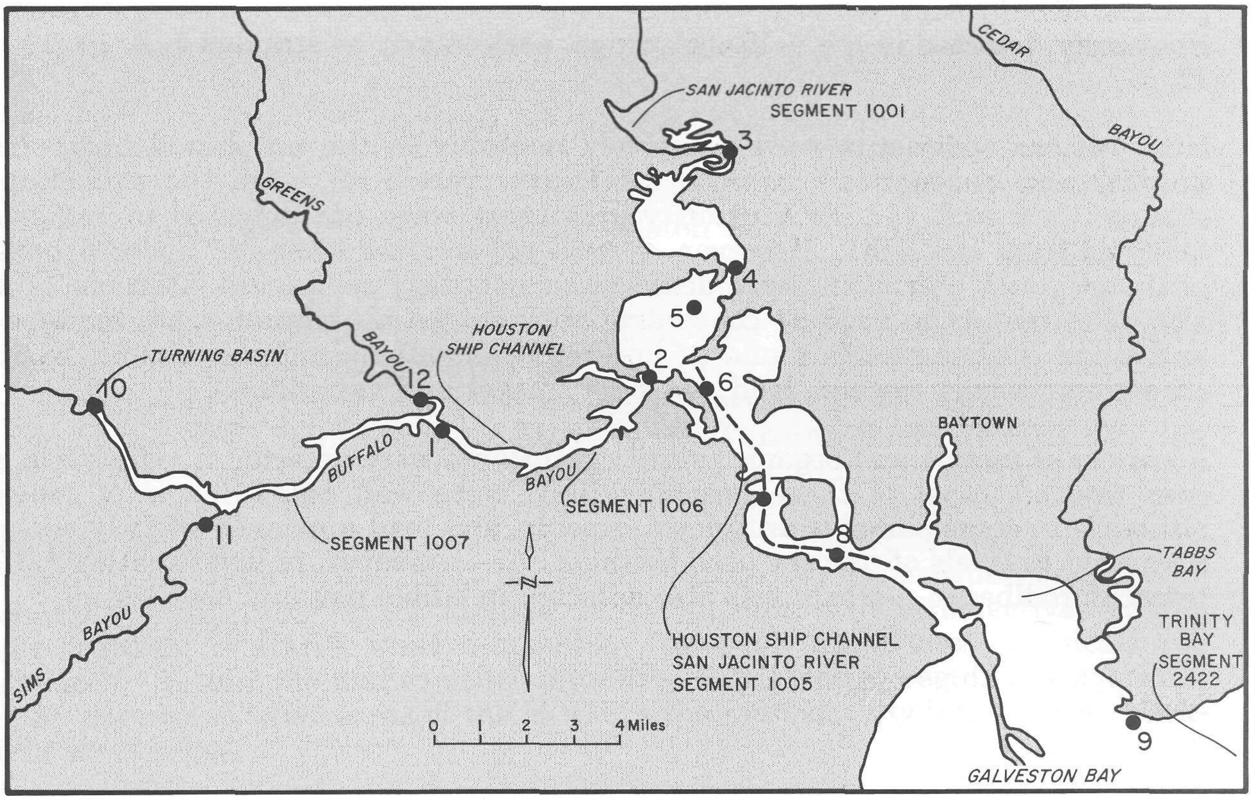

Figure 1. Location of sampling stations.

that the potential exists for impairment of the aquatic life use designated for segments 1001 and 1005. Continued routine or periodic ambient toxicity monitoring at fixed stations would be useful to assess the effectiveness of point and/or nonpoint source toxicants controls.

Dissolved oxygen data indicate that DO may be more limiting to aquatic life than toxic chemicals. Water quality standards were not achieved in Segment 1005 during warm weather conditions. DO water quality standards for this segment are 4.0 mg/l average and 3.0 mg/l minimum. Segments 1006 and 1007, particularly smaller tributaries, had pronounced hypoxia during warm weather conditions. However, the DO water quality standards of 2.0 mg/l average and 1.5 mg/l minimum for Segment 1006 and 1.0 mg/l average and minimum for Segment 1007 were not intended to promote a viable fishery in these segments.

Chemical-specific criteria exceedances were found for ammonia, arsenic, copper, cyanide, lead, manganese, nickel, selenium, and total residual chlorine. However, many of the metals criteria exceedances are not entirely applicable in segments 1006 and 1007 due to the lack of a designated aquatic life use. Nickel water quality standards esceedance in Segment 1005 were of concern, and resulted in listing this segment under the Section 304(l)(B) of the Clean Water Act ("short list of toxic waters"). 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.

HSC 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 priority pollutants were not detected in sediments collected from the HSC. However, several polynuclear aromatic hydrocarbons, a phthalate, and pesticides were detected in tributary sediments (stations 11 and 12). The metals in highest concentration 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. Most of these concentrations were well below levels of concern, although in some samples antimony, arsenic, and lead appeared slightly elevated compared to levels of concern used by the EPA. In a separate investigation 2,3,7,8-tetrachlorodibenzo-p-dioxin was also detected in edible fish and crab tissue.

Industrial Point Source Discharges Into the Houston Ship Channel

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Note: This study was funded by the Galveston Bay Foundation. The results presented is this paper are preliminary pending final approval and publication.

The Houston Ship Channel (HSC) is a 51-mile-long dredged navigation channel extending from Bolivar Roads at the Gulf of Mexico across 25 miles of Galveston Bay, and inland to the Turning Basin near downtown Houston. The inland portion of the HSC, from Morgan's Point to the Turning Basin, follows the San Jacinto River for ten miles and then Buffalo Bayou for 16 miles. Along this inland portion are located numerous industries which utilize the channel for wastewater discharge, cooling water, and transportation of raw materials and/or products. The quality of water in the HSC is greatly affected by numerous point source discharges (TWC 1990) which include toxic compounds. The objectives of this project were to: 1) clarify what is meant by "toxic" or "hazardous" chemicals and substances; 2) compile and compare data available through regulatory agencies; and 3) determine what areas of the HSC are the most heavily impacted by point-source discharges.

The term "toxic" has both biological as well as legal definitions. Biologically, the toxicity of a substance is determined by exposure or dosage, concentration, and the quality of the organism's environment. This is known as the "dose-effect relationship." The difficulty in evaluating the impact of various chemicals introduced into the environment lies in the complexity of the interactions involving the dose-effect relationship and environmental variables such as turbidity, pH, oxygen availability, etc. The many variables, some of which are in a constant state of fluctuation, make it difficult to make a definitive statement of the actual biological risks associated with chemical compounds in the environment.

When environmental laws were written, legal definitions of "toxic" and "hazardous" were established, and lists of legally defined toxic or hazardous substances were created. In the Texas Administrative Code ("TAC"), Sections 307.1 - 307.10 (the Texas Water Quality Standards), toxicity is defined as "the occurrence of lethal or sublethal adverse effects on representative, sensitive organisms due to exposure to toxic materials." The TAC lists 30 toxic substances with acute and chronic criteria for marine and fresh waters. At the federal level, the EPA has listed the toxic pollutants defined in the Clean Water Act. This list is now known as the "priority pollutants" list, consisting of 126 chemicals (Wise, *et. al.*, 1981). The Clean Water Act Section 502 (13) defines a toxic pollutant.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA") and the 1986 Superfund Amendment and Reauthorization Act ("SARA") regulate hazardous substances, which are defined in CERCLA Section 101 (14). SARA was enacted in part for the purpose of informing the public and government officials about releases of designated chemicals into the environment. Title III of this Act is entitled "Emergency Planning and Community Right-to-

Know." Under Section 313 of Title III, certain industries are required to report, on an annual basis, the amounts of chemicals their facilities release into the environment, either routinely or as a result of accidents. The resulting SARA data base is referred to as the Toxic Chemicals Release Inventory, or "TRI."

The Resource Conservation and Recovery Act (RCRA) regulates the transport, storage, and disposal of hazardous waste. A waste is legally defined as hazardous if it meets certain characteristics (ignitability, corrosivity, reactivity, TCLP toxicity), or if it is listed as a waste from certain specific and non-specific sources.

Study Area and Methods

TWC stream Segments 1005, 1006, and 1007 of the HSC were utilized for this study. These three stream segments encompass the inland portion of the HSC from the Turning Basin, located approximately five miles downstream from US 59, to Morgan's Point in Galveston Bay.

Two 1988 data sets on point source discharges in the study area were compiled and compared. These data originated from self-monitoring and self-reporting by industry for compliance with: 1) SARA Title III Section 313 (TRI), and 2) the Texas Administrative Code, reported to TWC.

The TRI data were reported by industries as estimates of pounds per year (lbs/yr) calculated using mass balance equations or acceptable engineering estimations. The inclusion of readily available monitoring data was optional for these reporting industries. For this study, TRI data were supplemented with TWC self-reported data for those EPA designated major dischargers, and two EPA designated minor dischargers, that were not required to report to the TRI system.

The TWC self-reported data were submitted monthly by industries as milligrams per liter (mg/l) or pounds per day (lbs/day), on a daily average or daily maximum basis. Daily average concentrations were calculated by the discharging industry using effluent monitoring data. For this study a formula was used to convert mg/l to lbs/yr, to make data comparisons possible.

Certain industrial dischargers to the ship channel are not required to report to the TRI system. These are facilities that handle either industrial hazardous waste and/or industrial wastewater, or store industrial waste or hazardous products in bulk tank storage areas, but are not manufacturing facilities. Therefore their permitted discharges to the ship channel are regulated by the Clean Water Act and the Texas Administrative Code, but not by Section 313. The discharges of three commercial handlers of industrial wastewater and one Publicly Operated Treatment Works ("POTW") as reported to TWC were included in total loading estimates made for this study.

To determine the consistency of these data systems, TWC and TRI loading estimates for 1988 were compared for parameters reported to each system. To determine total loading from discharges in the study area, reported loadings were summed by stream segment for each parameter. In cases where an industry reported different values of a particular parameter to the two data systems, the higher number was used in tabulating these total loading estimates. All numbers were rounded to the nearest whole number.

Results and Discussion

A total of 97 industrial dischargers in the study area were permitted by the TWC. Twenty-nine of these industries reported to TRI discharges of 68 of 320 toxic substances listed in Section 313. Segment 1005, extending from Morgan's Point to the San Jacinto River (12 miles long), received an estimated 45,507 lbs/year of toxic substances (legally defined). Segment 1006, from the San Jacinto River to Green's Bayou (six miles long), receives 607,968 lbs/year. Segment 1007, from Green's Bayou to the Turning Basin (14 miles long), receives 181,428 lbs/year, for a total loading to these three segments in 1988 of 834,903 lbs/year. The shortest segment, 1006, receives the greatest amount of toxic substances discharged from the reporting industries.

When comparing the TRI data base with the TWC self-reporting data base, in many instances the figures reported to each data base for the discharge of particular substances were not the same, with loading differences sometimes in the hundreds, or even thousands of pounds. However, these comparisons may be influenced in some cases by limitations on the two data systems, below.

SARA TRI data:

1. are only required for certain types and sizes of facilities;
2. are only required for facilities that meet certain thresholds for source and quantity of toxic substances;
3. are based primarily on engineering estimates;
4. include stormwater runoff as well as process wastewater; and
5. are limited in cross-checking by the number of available SARA inspectors in EPA Region 6.

TWC data, on the other hand:

1. are derived from effluent monitoring, with standard procedures, sampling frequency, type, and locations specified by the permit;
2. are strictly self-reported;
3. are required solely on permitted parameters; and
4. are somewhat limited in cross-checking by the number of available TWC inspectors.

For some parameters, for example metals, the figure reported to TRI was for compounds of those metals, whereas the figure reported to TWC was specifically the elemental form. However, in other cases, there is no obvious explanation for the differences in the amounts reported.

Toxicity varies greatly among the discharged compounds reported. In fact, though highly toxic to aquatic life, the ammonia, ammonium sulfates, hydrochloric acid, sulfuric acid and phosphoric acid reportedly discharged are substantially neutralized within a short distance from the point of discharge. Elimination of these five classes of compounds from consideration focuses attention on the more damaging components. The 1988 totals of toxic substances discharged into the ship channel, minus the above substances, for Segments 1005, 1006, and 1007 are 32,607, 84,165, and 152,693 lbs/year, respectively.

Conclusions

It is difficult, if not impossible, to accurately determine the toxic loading from point source discharges to the HSC under the current regulatory framework. There is a lack of consistency in the data available from different agencies. For example, in 1988, one industry reported a zero discharge of benzene to TWC, but reported the discharge of 250 lbs of benzene to TRI. Some inconsistencies may have resulted from differences in the reporting systems, but the data presented in this report can be considered conservative regarding the estimates of total loading.

Of the total number of industrial dischargers into the Houston Ship Channel, less than one-third (1/3) reported the release of toxic substances to TRI under SARA Title III Section 313. The remainder of the industries either are not required to report, or are in violation of the SARA regulations.

The degree of toxicity and the fate of the various toxic substances in the aquatic environment are not addressed in the current regulatory framework.

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Survey of Floatable Debris in the Houston Ship Channel

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The Environmental Protection Agency (EPA), with assistance from the Texas Water Commission (TWC), conducted two surveys of floating debris in the Houston Ship Channel (HSC) in 1990. The surveys were done as part of a national program designed to characterize floating debris in harbors throughout the United States in order to better understand the marine and land-based sources of debris in the marine environment.

While the particular sources of marine debris are hard to define, its effects are more evident. Marine debris is not only an aesthetic problem, but also a threat to wildlife, human health and safety, and our economy. In Texas alone, volunteers picked up over 230 tons of plastic, glass, paper, rubber, and cloth items from Gulf of Mexico beaches in a three-hour period. This amounts to over a ton of trash per mile.

EPA sampled by boat for debris in the HSC from Alexander Island to past Turkey Bend for three days in February and two days in September of 1990. Samples were collected using a 0.5 x 1 x 4 m neuston net with a 0.3 mm mesh size. In the laboratory , debris were separated by type, counted, and their amounts recorded.

During both sampling efforts there was a large amount of debris in the upper reaches of the HSC, especially in Buffalo Bayou. There was little sewage-related waste collected, and most of the debris was indicative of storm water discharges. Although the water level was not particularly high at the time, debris in the trees indicated water height may rise 20 ft. due to storm events.

Debris consisted of plastic resin pellets, plastic pieces and bags, styrofoam cups and fast-food containers, toys, bottles, jugs, and general street litter. The plastic pellets were found to be more abundant in Houston than in any other harbor surveyed in the United States. One sample contained over 200,000 of the tiny pellets.

Over 60 species of birds are known to ingest plastic pellets, which can cause starvation and malnutrition in some cases. Plastic bags have been mistaken for food by sea turtles, causing starvation or blockage of the digestive tract. Other types of debris found in the Ship Channel have been known to cause entanglement of wildlife, divers and boat propellers, and blockage of boat cooling-water intake systems. The economy is also adversely affected by costly cleanup efforts and declines in tourism due to marine debris.

Harmful debris inevitably makes its way into Galveston Bay via the HSC. Public awareness of the effects of marine debris and better control over debris entering the bay through stormwater runoff could mean a positive change for Galveston Bay through increased living resources, safer recreation and a healthier economy.