IV. COLIFORM BACTERIA DATA ANALYSIS

Over the last quarter century a substantial amount of indicator bacteria data have been collected by a wide range of agencies. These data were compiled in standard format by Ward and Armstrong (1996). Table IV.1 is a listing of agencies active in coliform data collection, the type of analyses (MF or MPN) performed, and the primary reason for sampling.

Data were analyzed in a multi-step process. The first step was to group the data geographic area as defined with quadrilaterals. Figure IV.1 shows these quadrilaterals, and Figure IV.2 shows the location of the stations where coliform bacteria data have been collected. Data which were "less than" a given value (e.g.,<X cfu/dL, where one deciliter or dL=100mL) were tabulated separately and also included in the overall tabulation at the detection limit (e.g., X cfu/dL). A value of "zero" or "none" was replaced with a "1" to represent a small value but one that would not cause a problem when a log transform was applied. Some of the data were originally reported as >X cfu/dL or "TNTC" (Too Numerous To Count). The > had already been removed from the database by Ward, so the value of "X" was employed for analysis. The values for each quadrilateral were then tabulated as to minimum, geometric mean (which is practically equivalent to the median), and maximum for each data source. It must be noted that the TDH analyzes their MPN data on a station by station basis while this study averages all FC data over quadrilaterals.

The coliform data are analyzed from three perspectives. The first is a direct characterization of data in each TNRCC segment, comparing the data with various criteria. The second is a comparison of the FC and earlier TC data, and the third is an examination of the data for temporal trends.

IV.1 DATA CHARACTERIZATION

In analyzing the data, comparisons were made with three criteria. The first was the value employed by TDH in the regulation of shellfish harvesting waters. For FC this value is a median of 14 cfu/dL and for TC it is 70 cfu/dL. The second criterion employed is for primary contact recreation. The FC criterion is a geometric mean of 200 cfu/dL, with no more than 10% >400 cfu/dL. For the older TC data, a 1,000 cfu/dL value was employed. For secondary contact recreation (e.g., boating) a 2,000 cfu/dL value was used for FC and 10,000 cfu/dL used for the TC data. Summary of the comparison criteria:

	Bacteria Concentrations (cfu/dL)	
Median/Geometric Mean	FC	TC
Shellfish Harvesting	>14	>70
Primary Cont. Recreation	>200 10% >400	>1,000 10% >2,000
Secondary Cont. Recreation	>2,000	>10,000

TABLE IV.1

AGENCIES MONITORING COLIFORM LEVELS IN CORPUS CHRISTI BAY

Agency	Sampling Method	Analysis Method	Reason for Sampling
TNRCC[1]	Grab	MF[6]	Ambient Monitoring
TWDB[2]	Grab	MF[6]	Coastal Data System
TDH[3]	Grab	MPN[7]	Shellfish Regulation
CCB Foun[4]	Grab	MF[6]	La Quinta Channel Survey
CCNCHD[5]	Grab	MF[6]	Routine Shoreline WQ Survey

Note:

[1] TNRCC = Texas Natural Resource Conservation Commission.
[2] TWDB = Texas Water Development Board.
[3] TDH = Texas Department of Health.
[4] CCB Foun = Corpus Christi Bay Foundation.
[5] CCNCHD = Corpus Christi - Nueces County Health Dept.
[6] MF = membrane filter procedures.
[7] MPN = multiple-tube most probable number procedures.

FIGURE IV.1
SELECTED QUADRILATERAL BOUNDARIES

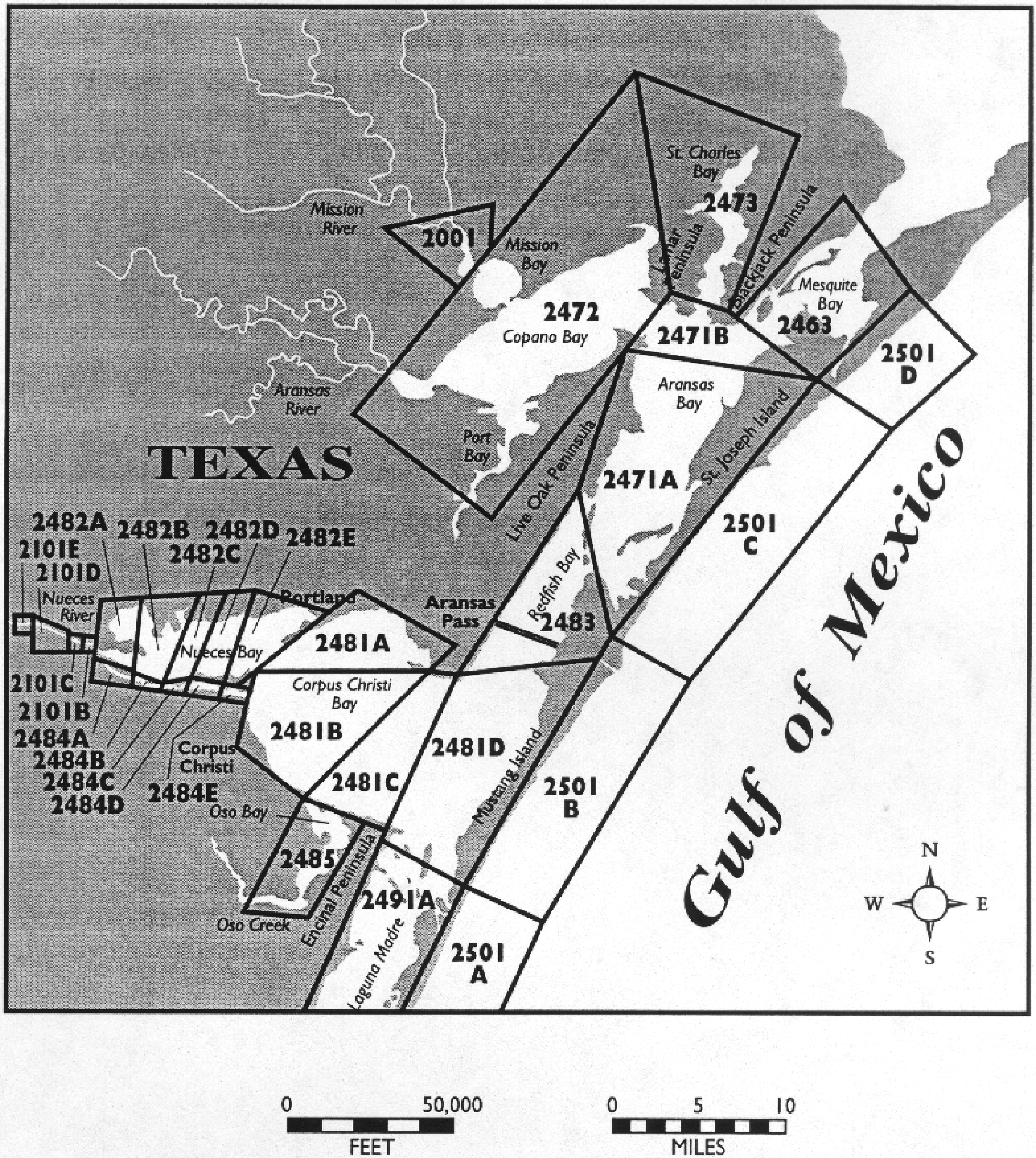


FIGURE IV.2

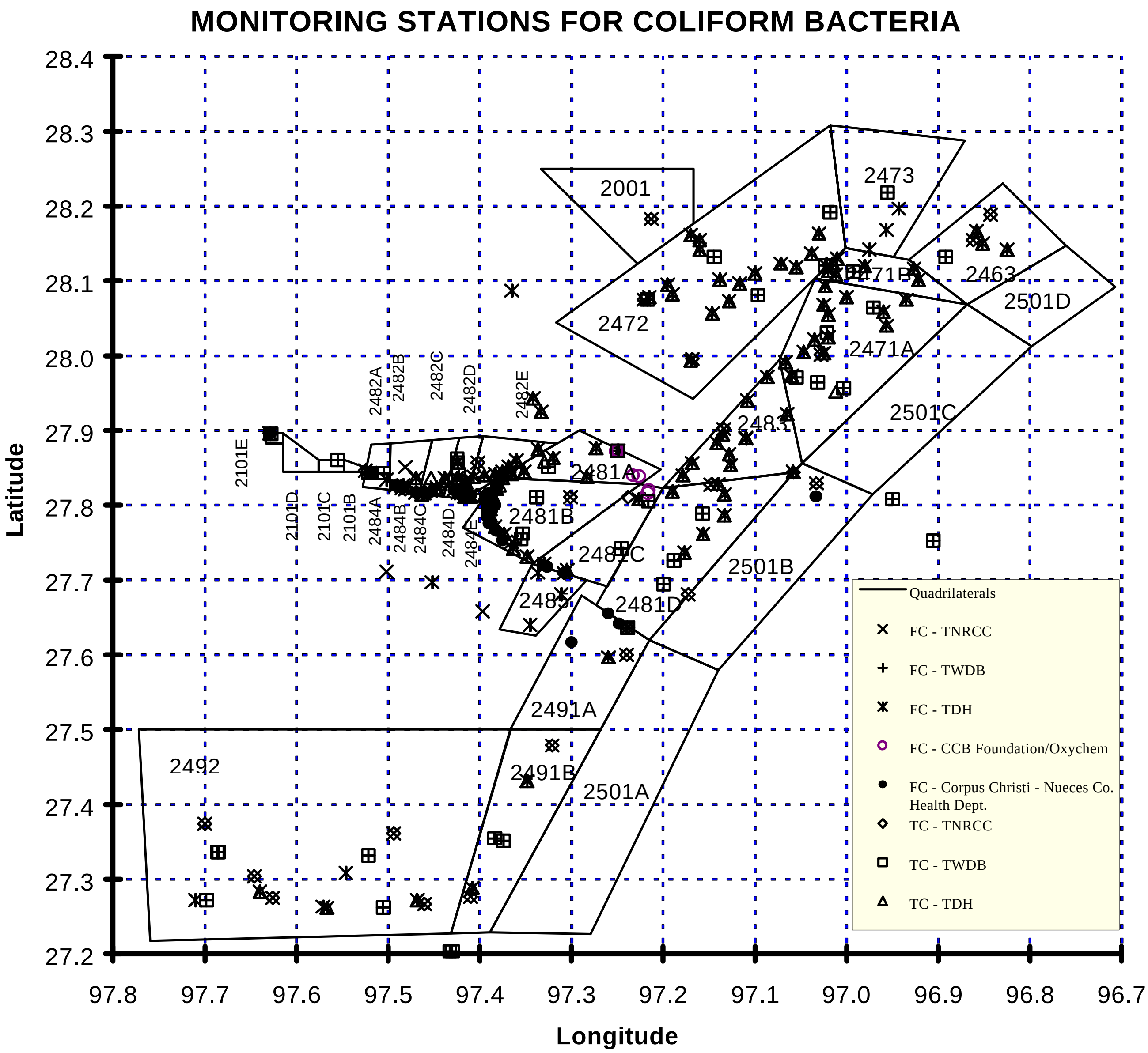

MONITORING STATIONS FOR COLIFORM BACTERIA
Latitude
Longitude
28.4
28.3
28.2
28.1
28.0
27.9
27.8
27.7
27.6
27.5
27.4
27.3
27.2
97.8
97.7
97.6
97.5
97.4
97.3
97.2
97.1
97.0
96.9
96.8
96.7
2001
2473
2472
2471B
2463
2501D
2471A
2501C
2483
2481A
2481B
2481C
2501B
2485
2481D
2491A
2491B
2501A
2492
2101E
2101D
2101C
2101B
2482A
2482B
2482C
2482D
2482E
2484A
2484B
2484C
2484D
2484E
Quadrilaterals
FC - TNRCC
FC - TWDB
FC - TDH
FC - CCB Foundation/Oxychem
FC - Corpus Christi - Nueces Co. Health Dept.
TC - TNRCC
TC - TWDB
TC - TDH

TABLE IV.2
SUMMARY OF FECAL COLIFORM DATA

		Data Period		All Data					No. of Data < DL	FC > 14 cfu/100 mL			FC > 200 cfu/100 mL			FC > 2,000 cfu/100 mL		
Quadri-lateral	Source[1]	Start	End	No. of Data	Min.	Geo Mean	Max.	Segment G. Mean		No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean
2001	TNRCC	04/28/72	04/08/93	40	2	35	24,000	35	6	24	60.0	94	6	15.0	1,786	1	2.5	24,000
2101 B	TNRCC	09/17/73	09/29/92	96	2	46	2,000		25	63	65.6	109	20	20.8	492	0		
2101 C	TWDB	10/16/73	10/16/73	1	66	66	66		0	1	100.0	66	0			0		
2101 E	CCNCHD	10/20/80	09/26/88	50	1	46	22,000		20	36	72.0	94	2	4.0	2,345	1	2.0	22,000
2101 E	TNRCC	09/15/72	06/18/73	4	1	11	100		1	2	50.0	57	0			0		
2101 E	TWDB	09/19/72	05/17/73	2	16	20	24	44	0	2	100.0	20	0			0		
2463	TDH	03/18/76	04/28/94	120	2	3	230		0	13	10.8	45	1	0.8	230	0		
2463	TNRCC	03/28/72	05/06/93	29	1	3	42		19	3	10.3	30	0			0		
2463	TWDB	09/18/72	08/27/75	10	1	1	3	3	3	0			0			0		
2471 A	TDH	06/18/74	03/17/94	604	2	3	1,600		0	31	5.1	47	5	0.8	577	0		
2471 A	TNRCC	12/02/70	04/29/93	24	1	3	20		13	1	4.2	20	0			0		
2471 A	TWDB	09/18/72	08/27/75	22	1	1	7		9	0			0			0		
2471 B	TDH	06/18/74	04/18/94	432	2	3	1,600		0	28	6.5	41	3	0.7	426	0		
2471 B	TWDB	10/17/74	08/27/75	4	1	2	12	3	3	0			0			0		
2472	TDH	06/18/74	03/29/94	575	2	4	1,600		0	87	15.1	74	22	3.8	383	0		
2472	TNRCC	12/02/70	04/28/93	79	1	9	6,000		38	18	22.8	96	5	6.3	1,309	2	2.5	5,692
2472	TWDB	09/18/72	08/27/75	33	1	2	390	4	12	4	12.1	51	1	3.0	390	0		
2473	TDH	10/10/84	04/18/94	71	2	5	920		0	14	19.7	97	5	7.0	339	0		
2473	TNRCC	10/29/73	04/28/93	61	2	17	2,200		31	20	32.8	83	4	6.6	621	1	1.6	2,200
2473	TWDB	09/18/72	08/27/75	10	1	2	72	8	4	1	10.0	72	0			0		
2481 A	CCNCHD	11/04/76	08/17/95	80	1	11	5,750		24	31	38.8	54	4	5.0	857	1	1.3	5,750
2481 A	CCB Found.	01/09/93	03/17/95	21	2	6	90		13	5	23.8	49	0			0		
2481 A	TDH	05/21/74	03/30/94	238	2	3	81		0	12	5.0	36	0			0		
2481 A	TNRCC	10/24/73	05/12/93	20	1	3	60		13	1	5.0	60	0			0		
2481 A	TWDB	09/20/72	08/28/75	10	1	2	10	4	2	0			0			0		

Quadri-lateral	Source[1]	Data Period		All Data					No. of Data < DL	FC > 14 cfu/100 mL			FC > 200 cfu/100 mL			FC > 2,000 cfu/100 mL		
		Start	End	No. of Data	Min.	Geo Mean	Max.	Segment G. Mean		No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean
2481 B	CCNCHD	11/04/76	08/17/95	1,070	1	21	340,000		318	532	49.7	109	139	13.0	829	21	2.0	15,905
2481 B	TDH	06/19/74	03/30/94	267	2	5	1,600		0	47	17.6	61	8	3.0	549	0		
2481 B	TNRCC	11/16/72	05/12/93	66	1	4	93		40	6	9.1	51	0			0		
2481 B	TWDB	09/20/72	08/28/75	9	1	2	26		4	1	11.1	26	0			0		
2481 C	CCNCHD	02/06/78	08/17/95	100	1	15	340,000		38	43	43.0	119	10	10.0	3,121	4	4.0	29,419
2481 C	CCB Found.	01/09/93	03/17/95	11	2	3	3		9	0			0			0		
2481 C	TDH	06/19/74	03/30/94	104	2	4	540		0	17	16.3	76	6	5.8	307	0		
2481 C	TNRCC	10/03/73	04/08/91	24	2	13	1,200		10	7	29.2	101	2	8.3	666	0		
2481 C	TWDB	10/24/74	08/28/75	6	1	1	1		5	0			0			0		
2481 D	TDH	06/18/74	03/30/94	202	2	2	79		0	4	2.0	40	0			0		
2481 D	TNRCC	10/03/73	08/22/78	5	2	8	60		2	1	20.0	60	0			0		
2481 D	TWDB	09/19/72	08/28/75	10	1	1	40	11	4	1	10.0	40	0			0		
2482 A	TWDB	10/24/74	08/28/75	3	8	17	26		0	2	66.7	25	0			0		
2482 B	TDH	05/20/75	05/06/94	47	2	6	350		0	11	23.4	65	3	6.4	350	0		
2482 B	TNRCC	04/13/92	04/13/93	5	2	59	260		1	4	80.0	139	2	40.0	256	0		
2482 C	TDH	05/20/75	05/06/94	51	2	5	540		0	8	15.7	71	3	5.9	357	0		
2482 D	TDH	05/21/74	05/06/94	59	2	8	2,400		0	15	25.4	91	4	6.8	1,021	2	3.4	2,400
2482 D	TNRCC	04/12/76	04/13/93	14	2	3	53		9	2	14.3	33	0			0		
2482 D	TWDB	09/19/72	08/28/75	15	1	2	48		3	1	6.7	48	0			0		
2482 E	TDH	05/21/74	05/06/94	238	2	5	350		0	45	18.9	47	4	1.7	274	0		
2482 E	TNRCC	12/02/70	04/13/93	44	2	6	560	5	21	8	18.2	48	1	2.3	560	0		
2483	TDH	06/18/74	10/12/89	121	2	7	1,600		0	32	26.4	73	7	5.8	732	0		
2483	TNRCC	04/25/72	04/27/93	86	1	9	600	8	48	17	19.8	61	3	3.5	330	0		
2484 A	TDH	10/16/74	05/04/82	5	2	40	1,600		0	3	60.0	208	1	20.0	1,600	0		
2484 A	TNRCC	07/15/71	05/12/93	31	2	7	100		13	7	22.6	33	0			0		
2484 A	TWDB	10/24/74	06/05/75	3	1	2	13	8	0	0			0			0		
2484 B	CCNCHD	07/02/81	07/02/81	2	100	200	400		1	2	100.0	200	1	50.0	400	0		
2484 B	TDH	10/16/74	05/04/82	5	5	36	280		0	3	60.0	120	2	40.0	259	0		

Quadri-lateral	Source[1]	Data Period		All Data					No. of Data < DL	FC > 14 cfu/100 mL			FC > 200 cfu/100 mL			FC > 2,000 cfu/100 mL		
		Start	End	No. of Data	Min.	Geo Mean	Max.	Segment G. Mean		No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean
2484 B	TNRCC	08/10/82	08/10/82	4	20	75	530		0	4	100.0	75	1	25.0	530	0		
2484 C	CCNCHD	07/02/81	07/02/81	2	100	212	450		0	2	100.0	212	1	50.0	450	0		
2484 C	TDH	10/16/74	02/13/84	12	2	23	1,600		0	6	50.0	79	1	8.3	1,600	0		
2484 C	TNRCC	11/16/72	05/12/93	31	2	17	2,200		8	11	35.5	136	5	16.1	640	1	3.2	2,200
2484 D	CCNCHD	07/02/81	07/02/81	3	100	159	400		2	3	100.0	159	1	33.3	400	0		
2484 D	TDH	10/16/74	07/31/85	8	2	36	2,400		0	4	50.0	365	3	37.5	931	1	12.5	2,400
2484 D	TNRCC	10/24/73	05/12/93	28	2	17	10,000		11	8	28.6	524	5	17.9	3,036	4	14.3	5,040
2484 D	TWDB	09/19/72	08/28/75	9	1	6	38		3	3	33.3	30	0			0		
2484 E	CCNCHD	07/02/81	07/02/81	1	100	100	100		1	1	100.0	100	0			0		
2484 E	TDH	06/19/74	07/31/85	17	2	15	2,400		0	7	41.2	136	2	11.8	759	1	5.9	2,400
2484 E	TNRCC	08/10/82	08/10/82	1	10,000	10,000	10,000	22	0	1	100.0	10,000	1	100.0	10,000	1	100.0	10,000
2485	TNRCC	04/25/72	04/27/93	42	2	18	980	18	13	16	38.1	81	4	9.5	479	0		
2491 A	CCNCHD	06/04/86	08/17/95	61	1	19	670		14	31	50.8	64	4	6.6	327	0		
2491 A	TDH	05/07/73	11/08/82	7	2	2	2		0	0			0			0		
2491 A	TNRCC	12/01/70	05/11/93	28	2	5	200		13	3	10.7	58	0			0		
2491 A	TWDB	05/30/74	06/04/75	3	1	3	12		0	0			0			0		
2491 B	TDH	05/07/73	11/08/82	14	2	2	5		0	0			0			0		
2491 B	TNRCC	04/18/72	05/11/93	50	1	3	17		34	1	2.0	17	0			0		
2491 B	TWDB	09/28/72	10/23/74	4	1	1	4	6	1	0			0			0		
2492	TDH	05/07/73	11/10/82	16	2	2	4		0	0			0			0		
2492	TNRCC	09/30/70	05/11/93	57	1	4	50		41	2	3.5	27	0			0		
2492	TWDB	09/27/72	06/04/75	16	1	2	400	3	6	3	18.8	84	1	6.3	400	0		
2501 B	CCNCHD	02/06/78	06/24/80	14	1	20	663		2	7	50.0	121	3	21.4	547	0		
2501 B	TNRCC	04/25/72	04/29/93	15	2	4	30	9	6	3	20.0	23	0			0		

[1]CCNCHD = Corpus Christi - Nueces County Health Department.

TABLE IV.3
SUMMARY OF TOTAL COLIFORM DATA

Quadri-lateral	Source	Data Period		All Data					No. of	TC > 70 cfu/100 mL			TC > 1,000 cfu/100 mL			TC > 10,000 cfu/100 mL		
		Start	End	No. of Data	Min.	Geo Mean	Max.	Segment G. Mean	Data <DL	No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean
2001	TNRCC	04/28/72	06/21/84	13	6	150	24,000	150	2	6	46.2	2,716	5	38.5	4,846	1	7.7	24,000
2101 B	TNRCC	03/19/75	04/03/85	56	1	57	10,000		16	23	41.1	524	6	10.7	2,710	0		
2101 C	TWDB	10/16/73	10/16/73	1	200	200	200		0	1	100.0	200	0			0		
2101 E	TNRCC	06/14/72	06/18/73	5	19	267	33,000		0	3	60.0	1,200	1	20.0	33,000	1	20.0	33,000
2101 E	TWDB	09/19/72	05/17/73	2	17	28	45	64	0	0			0			0		
2463	TDH	11/23/58	04/28/80	91	2	4	170		0	2	2.2	136	0			0		
2463	TNRCC	08/27/70	03/06/85	31	1	6	4,200		19	4	12.9	245	1	3.2	4,200	0		
2463	TWDB	09/18/72	08/27/75	9	1	2	8	4	2	0			0			0		
2471 A	TDH	11/23/58	03/09/81	290	2	3	2,400		0	8	2.8	283	1	0.3	2,400	0		
2471 A	TNRCC	12/02/70	06/28/84	35	1	5	200		18	1	2.9	200	0			0		
2471 A	TWDB	09/18/72	08/27/75	20	1	2	21		2	0			0			0		
2471 B	TDH	11/23/58	03/04/81	207	2	3	1,600		0	5	2.4	340	1	0.5	1,600	0		
2471 B	TWDB	10/17/74	08/27/75	3	1	4	57	3	2	0			0			0		
2472	TDH	11/23/58	03/04/81	317	2	4	2,400		0	20	6.3	190	1	0.3	2,400	0		
2472	TNRCC	12/02/70	04/03/85	82	1	24	24,000		27	21	25.6	551	7	8.5	3,856	1	1.2	24,000
2472	TWDB	09/18/72	08/27/75	25	1	5	470	6	2	4	16.0	150	0			0		
2473	TNRCC	10/29/73	05/07/85	59	1	38	100,000		19	17	28.8	415	4	6.8	4,982	1	1.7	100,000
2473	TWDB	09/18/72	08/27/75	9	1	3	96	28	2	1	11.1	96	0			0		
2481 A	TDH	09/26/60	06/05/78	139	2	3	542		0	5	3.6	126	0			0		
2481 A	TNRCC	10/24/73	06/28/84	28	1	4	19		18	0			0			0		
2481 A	TWDB	09/20/72	08/28/75	9	1	4	40		2	0			0			0		
2481 B	TDH	09/26/60	06/06/78	283	2	6	240,000		0	24	8.5	443	5	1.8	5,132	1	0.4	240,000
2481 B	TNRCC	08/17/72	05/01/85	98	1	9	10,000		48	13	13.3	433	2	2.0	3,873	0		
2481 B	TWDB	09/20/72	08/28/75	8	1	4	220		0	1	12.5	220	0			0		
2481 C	TDH	09/26/60	06/05/78	86	2	3	130		0	2	2.3	120	0			0		
2481 C	TNRCC	10/03/73	04/03/85	29	1	20	100,000		11	7	24.1	1,314	3	10.3	15,874	1	3.4	100,000
2481 C	TWDB	10/24/74	08/28/75	6	1	2	16		4	0			0			0		
2481 D	TDH	09/26/60	03/09/81	88	2	3	2,400		0	1	1.1	2,400	1	1.1	2,400	0		
2481 D	TNRCC	10/03/73	09/26/83	31	1	11	100,000		11	5	16.1	1,107	2	6.5	31,623	1	3.2	100,000
2481 D	TWDB	09/19/72	08/28/75	10	1	3	360	5	3	1	10.0	360	0			0		
2482 A	TWDB	10/24/74	10/24/74	1	60	60	60		0	0			0			0		
2482 B	TDH	07/13/59	05/05/80	14	2	6	170	7	0	1	7.1	170	0			0		

TABLE IV.3 (Concluded)
SUMMARY OF TOTAL COLIFORM DATA

Quadri-lateral	Source	Data Period		All Data					No. of	TC > 70 cfu/100 mL			TC > 1,000 cfu/100 mL			TC > 10,000 cfu/100 mL		
		Start	End	No. of Data	Min.	Geo Mean	Max.	Segment G. Mean	Data < DL	No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean	No. of Data	% Total Data	Geo. Mean
2482 C	TDH	07/13/59	05/05/80	29	1	3	79		1	1	3.4	79	0			0		
2482 D	TDH	07/13/59	05/05/80	47	1	7	2,400		4	7	14.9	627	3	6.4	2,400	0		
2482 D	TNRCC	01/15/74	04/24/85	36	1	6	300		21	2	5.6	212	0			0		
2482 D	TWDB	09/19/72	08/28/75	14	1	3	70		4	0			0			0		
2482 E	TDH	07/13/59	05/05/80	121	1	3	49		1	0			0			0		
2482 E	TNRCC	12/02/70	04/24/85	115	0	11	21,000	6	55	20	17.4	461	6	5.2	3,665	1	0.9	21,000
2483	TDH	03/24/70	03/09/81	87	2	8	280		0	9	10.3	136	0			0		
2483	TNRCC	04/25/72	05/07/85	104	1	13	2,400	10	35	15	14.4	242	2	1.9	1,960	0		
2484 A	TDH	01/18/67	06/06/78	12	2	31	1,600		0	5	41.7	245	1	8.3	1,600	0		
2484 A	TNRCC	07/15/71	01/10/85	39	1	9	310		13	4	10.3	155	0			0		
2484 A	TWDB	04/17/75	06/05/75	2	12	14	17		0	0			0			0		
2484 B	TDH	01/18/67	06/06/78	14	5	141	2,400		0	8	57.1	811	3	21.4	1,832	0		
2484 B	TNRCC	08/10/82	08/10/82	4	20	85	580		0	2	50.0	253	0			0		
2484 C	TDH	01/18/67	06/06/78	21	1	72	2,400		1	11	52.4	510	4	19.0	2,169	0		
2484 C	TNRCC	05/15/72	01/10/85	41	1	32	2,200		8	13	31.7	456	3	7.3	1,627	0		
2484 D	TDH	01/18/67	06/06/78	13	5	95	2,400		0	7	53.8	568	3	23.1	2,400	0		
2484 D	TNRCC	10/24/73	01/10/85	37	1	47	10,000		8	14	37.8	695	4	10.8	5,138	0		
2484 D	TWDB	09/19/72	06/05/75	8	1	8	160		3	2	25.0	126	0			0		
2484 E	TDH	09/26/60	06/06/78	44	2	65	240,000		0	22	50.0	465	7	15.9	4,130	1	2.3	240,000
2484 E	TNRCC	08/10/82	08/10/82	1	10,000	10,000	10,000	38	0	1	100.0	10,000	1	100.0	10,000	0		
2485	TNRCC	04/25/72	04/03/85	28	1	32	10,000	32	10	9	32.1	607	3	10.7	7,606	0		
2491 A	TDH	03/25/64	06/09/81	8	1	2	5		1	0			0			0		
2491 A	TNRCC	12/01/70	05/01/85	45	1	8	10,000		23	2	4.4	1,789	1	2.2	10,000	0		
2491 A	TWDB	05/30/74	10/23/74	2	8	11	14		0	0			0			0		
2491 B	TDH	03/24/64	06/09/81	16	2	3	150		0	1	6.3	150	0			0		
2491 B	TNRCC	04/18/72	05/08/85	76	1	4	92		53	1	1.3	92	0			0		
2491 B	TWDB	09/28/72	10/23/74	4	1	6	39	4	1	0			0			0		
2492	TDH	03/24/64	06/09/81	20	1	3	350		1	1	5.0	350	0			0		
2492	TNRCC	09/30/70	05/08/85	78	1	5	150		52	2	2.6	122	0			0		
2492	TWDB	09/27/72	06/04/75	16	1	3	480	4	5	2	12.5	193	0			0		
2501 B	TNRCC	04/25/72	06/28/84	29	1	4	740	4	10	3	10.3	207	0			0		

Table IV.2 is a summary of FC data and Table IV.3 shows the TC data compared to the criteria discussed above. The following paragraphs address each of the segments shown in Figure IV.1. The discussion begins with the most inland tidal river segments, followed by the estuarine segments moving from north to south and concludes with the gulf. Because the total coliform data are older, generally similar, and more limited in duration, these data will only be addressed as exceptions. Total results that are similar to fecal will not be noted.

Mission River tidal, segment 2001

This segment has a geometric mean FC level for all data of 35 cfu/dL, which is well below the 200 cfu contact recreation criterion. Of the data, 15% of the observations exceed the primary contact recreation level. The geometric mean is higher than the shellfish criterion of 14 cfu/dL and the segment is classified as restricted for shellfish harvesting.

Nueces River Tidal, segment 2101

Stations with FC data were found in three of the four quadrilaterals, but only two data sources (TNRCC and CCNCHD) had a significant number of observations. With each of these the geometric mean level of all data was 46 cfu/dL. The TNRCC data in quadrilateral B had 21% of the observations greater than the contact recreation criterion of 200 cfu/dL. The TC results in Table IV.3 from the 1970s are similar to the FC results, except that only 10% exceeded the contact recreation criterion. The segment is restricted for shellfish harvesting.

Copano Bay, segment 2472

This segment is at the most inland northern end of the area. It is sampled on a routine basis by the TDH and the TNRCC, with very low indicator bacteria concentrations. For example, the geometric mean of the TDH data is 4 cfu/dL. The TWDB sampled to a limited extent during the early 1970s with similar results.

St. Charles Bay, segment 2473

This segment is also at the northern end of the area. Sampling is more limited, but the results are similar to Copano Bay. The geometric mean of the TDH data is 5 cfu/dL and that of the TNRCC data is 17 cfu/dL. About 20% of the TDH data exceed the 14 cfu/dL level and the segment is closed for shellfish harvesting.

Mesquite Bay, segment 2463

This segment is also located on the northern end of the study area. It has a substantial amount of data from the TDH and the TNRCC. The geometric mean of both the larger TDH set and the TNRCC set is 3 cfu/dL

Aransas Bay segment 2471

Stations in this bay have been sampled by the TDH with somewhat higher frequency than the bays mentioned above. Over the twenty year period (1974-94), the TDH amassed approximately one thousand observations in Aransas Bay. This would be a long-term average of monthly observations at four stations, but in practice there are considerably more than four active stations. In addition there were a small number of samples collected by the TNRCC and the TWDB. All data sources indicate low FC levels, with geometric means of 3 cfu/dL or lower.

Redfish Bay, segment 2483

The level of monitoring effort in Redfish Bay is relatively small, with TDH not having any observations since 1989 in the data set. The geometric mean of the FC data for both the TDH and TNRCC monitoring is less than 10 cfu/dL. TDH has recently resumed sampling in Redfish Bay, but no recent data were available.

Nueces Bay, segment 2482

Nueces Bay is geometrically more complex, requiring that it be subdivided into five quadrilaterals. While the area is somewhat more urbanized and receives the flow of a larger river, the FC levels are still quite low. All of the TDH data had a geometric mean of <10 cfu/dL. One TNRCC data set involving only 5 samples had a geometric mean of 59 cfu/dL, still well below the contact recreation criterion of 200 cfu/dL but higher than the shellfish harvesting criterion of 14 cfu/dL.

Corpus Christi Bay, segment 2481

Due to its size and shape, Corpus Christi Bay is broken into four quadrilaterals. The TDH and TNRCC are major players in coliform sampling, as with the other bays. In addition, the CCNCHD is also quite active, particularly in the “B” quad where there are public swimming areas. While the distribution of monitoring effort is somewhat different, the numerical results are very similar to the other study area bays. FC results are quite low in general. Only the CCNCHD data have any geometric means greater than the oyster criterion of 14 cfu/dL. In quadrilateral B, 13% of the observations were > 200 cfu/dL. Presumably less than 10% of these data would exceed 400 cfu/dL, which is part of the contact recreation criterion. A consideration is that many of these stations are in near-shore waters and may thus have higher turbidity and suspended material levels relative to the more open areas typically sampled by the TDH for regulation of oyster harvesting. Overall, FC levels in this segment appear to meet both shellfish harvesting and contact recreation criteria.

Corpus Christi Inner Harbor, segment 2484

This waterbody is divided into five quadrilaterals to accommodate the narrow and sinuous nature. This is a navigation channel with non-contact recreation as a designated use, and there is relatively little routine FC monitoring. However, over the years there has been a substantial number of samples collected. In general, the FC levels in these areas are higher than in most other sections of the CCB study area, although examining the data in Table IV.2 one must be careful to note the number of samples as well as the data range. For example, in quadrilateral E (near the mouth), there is only one TNRCC sample (8-10-82) but it is 10,000 cfu/dL. Viewing the data in aggregate, it would appear that the non-contact recreation use for the segment is appropriate. In reviewing the old TC data in Table IV.3, a substantial percentage of the observations are also higher than the contact recreation criterion for TC.

Oso Bay, segment 2485

The TNRCC appears to be the only agency monitoring in this segment, which is not considered for shellfish harvesting. The TNRCC data with an overall geometric mean of 18 cfu/dL indicate suitability for contact recreation.

Upper Laguna Madre, segment 2491

This includes the JFK Causeway south to Yarborough Pass. There is a substantial amount of data collected over the past quarter century, most of which indicates low FC levels. The CCNCHD data in the northern portion of the segment tend to be somewhat higher than the TNRCC and TDH data, probably reflecting the differences in sampling and stations. Taken as a group, the CCNCHD data indicate the segment is suitable for contact recreation.

Baffin Bay, segment 2492

The only significant monitoring effort in this segment is by the TNRCC. These data indicate low FC levels. The overall geometric mean is 4 cfu/dL and only 4% of these data exceed 14 cfu/dL.

Near Shore Gulf, area 2501

This area is not a TNRCC segment, but is included to encompass existing data that has been collected. FC data exists from two sources, both in quadrilateral B, near the entrance channel and Port Aransas beaches. The CCNCHD data (14 samples collected from 1978-1980) are somewhat higher than the TNRCC data (15 samples collected from 1972-1993), but neither data set suggests a concern with FC levels in the near shore gulf.

IV.2 COMPARISON OF TC AND FC DATA

Up to the mid to late 1970s, the TDH was using only TC MPN data as criteria for classification of shellfish growing waters (Wiles, 1996). Then, both total and fecal MPN test data were used until about 1983. From 1983 on, only FC data have been used.

It is useful to consider both TC and FC data in searching for trends because using both extends the period of record significantly. By way of background, the FC test was originally developed from the TC test as being more specific to enteric wastes. The early studies that developed the FC test assigned a ratio of 5:1 for the TC and FC data. For example, the shellfish TC criterion is 70 while

TABLE IV.4
COMPARISON OF FECAL AND TOTAL COLIFORM DATA

Quadri-lateral	Source[1]	FC Data				TC Data				TC/FC Ratio
		Start	End	No. of Data	Geo Mean	Start	End	No. of Data	Geo Mean	
2001	TNRCC	04/28/72	04/08/93	40	35.1	04/28/72	06/21/84	13	150.3	4.3
2101 B	TNRCC	09/17/73	09/29/92	96	45.7	03/19/75	04/03/85	56	57.1	1.2
2101 C	TWDB	10/16/73	10/16/73	1	66.0	10/16/73	10/16/73	1	200.0	3.0
2101 E	CCNCHD	10/20/80	09/26/88	50	46.2					
2101 E	TNRCC	09/15/72	06/18/73	4	10.7	06/14/72	06/18/73	5	266.6	24.9
2101 E	TWDB	09/19/72	05/17/73	2	19.6	09/19/72	05/17/73	2	27.7	1.4
2463	TDH	03/18/76	04/28/94	120	3.2	11/23/58	04/28/80	91	3.7	1.2
2463	TNRCC	03/28/72	05/06/93	29	3.3	08/27/70	03/06/85	31	5.9	1.8
2463	TWDB	09/18/72	08/27/75	10	1.2	09/18/72	08/27/75	9	1.8	1.5
2471 A	TDH	06/18/74	03/17/94	604	2.6	11/23/58	03/09/81	290	3.1	1.2
2471 A	TNRCC	12/02/70	04/29/93	24	3.1	12/02/70	06/28/84	35	4.6	1.5
2471 A	TWDB	09/18/72	08/27/75	22	1.2	09/18/72	08/27/75	20	2.1	1.8
2471 B	TDH	06/18/74	04/18/94	432	2.9	11/23/58	03/04/81	207	3.5	1.2
2471 B	TWDB	10/17/74	08/27/75	4	1.9	10/17/74	08/27/75	3	3.8	2.1
2472	TDH	06/18/74	03/29/94	575	4.0	11/23/58	03/04/81	317	4.3	1.1
2472	TNRCC	12/02/70	04/28/93	79	9.2	12/02/70	04/03/85	82	23.9	2.6
2472	TWDB	09/18/72	08/27/75	33	2.0	09/18/72	08/27/75	25	5.3	2.6
2473	TDH	10/10/84	04/18/94	71	5.0					
2473	TNRCC	10/29/73	04/28/93	61	17.0	10/29/73	05/07/85	59	38.4	2.3
2473	TWDB	09/18/72	08/27/75	10	1.8	09/18/72	08/27/75	9	3.4	2.0
2481 A	CCNCHD	11/04/76	08/17/95	80	11.1					
2481 A	CCB Found.	01/09/93	03/17/95	21	5.8					
2481 A	TDH	05/21/74	03/30/94	238	2.6	09/26/60	06/05/78	139	3.4	1.3
2481 A	TNRCC	10/24/73	05/12/93	20	3.5	10/24/73	06/28/84	28	3.6	1.1
2481 A	TWDB	09/20/72	08/28/75	10	1.8	09/20/72	08/28/75	9	4.4	2.4
2481 B	CCNCHD	11/04/76	08/17/95	1,070	21.4					
2481 B	TDH	06/19/74	03/30/94	267	4.5	09/26/60	06/06/78	283	5.6	1.2
2481 B	TNRCC	11/16/72	05/12/93	66	4.1	08/17/72	05/01/85	98	9.2	2.2
2481 B	TWDB	09/20/72	08/28/75	9	1.8	09/20/72	08/28/75	8	4.5	2.5
2481 C	CCNCHD	02/06/78	08/17/95	100	14.7					
2481 C	CCB Found.	01/09/93	03/17/95	11	2.8					
2481 C	TDH	06/19/74	03/30/94	104	4.2	09/26/60	06/05/78	86	3.2	0.8
2481 C	TNRCC	10/03/73	04/08/91	24	13.3	10/03/73	04/03/85	29	20.1	1.5
2481 C	TWDB	10/24/74	08/28/75	6	1.0	10/24/74	08/28/75	6	2.4	2.4
2481 D	TDH	06/18/74	03/30/94	202	2.5	09/26/60	03/09/81	88	3.0	1.2
2481 D	TNRCC	10/03/73	08/22/78	5	7.5	10/03/73	09/26/83	31	11.5	1.5
2481 D	TWDB	09/19/72	08/28/75	10	1.4	09/19/72	08/28/75	10	2.5	1.7
2482 A	TWDB	10/24/74	08/28/75	3	17.1	10/24/74	10/24/74	1	60.0	3.5

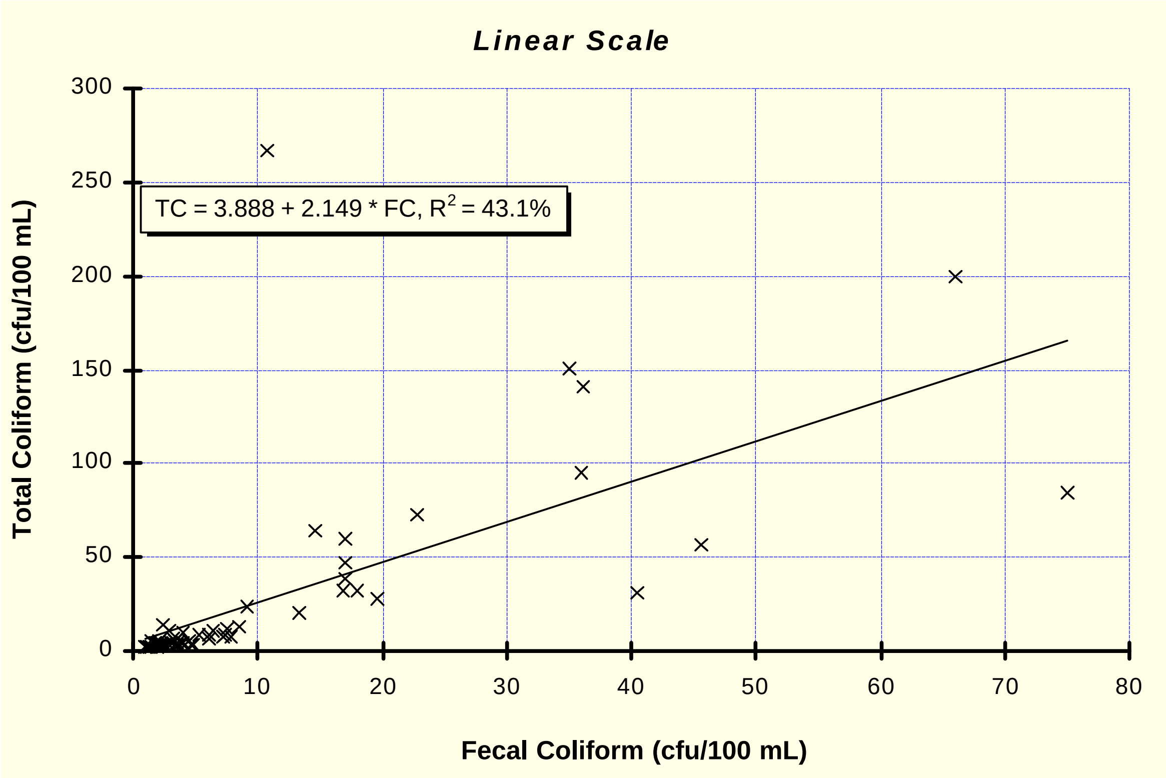
[1]CCNCHD = Corpus Christi - Nueces County Health Department.

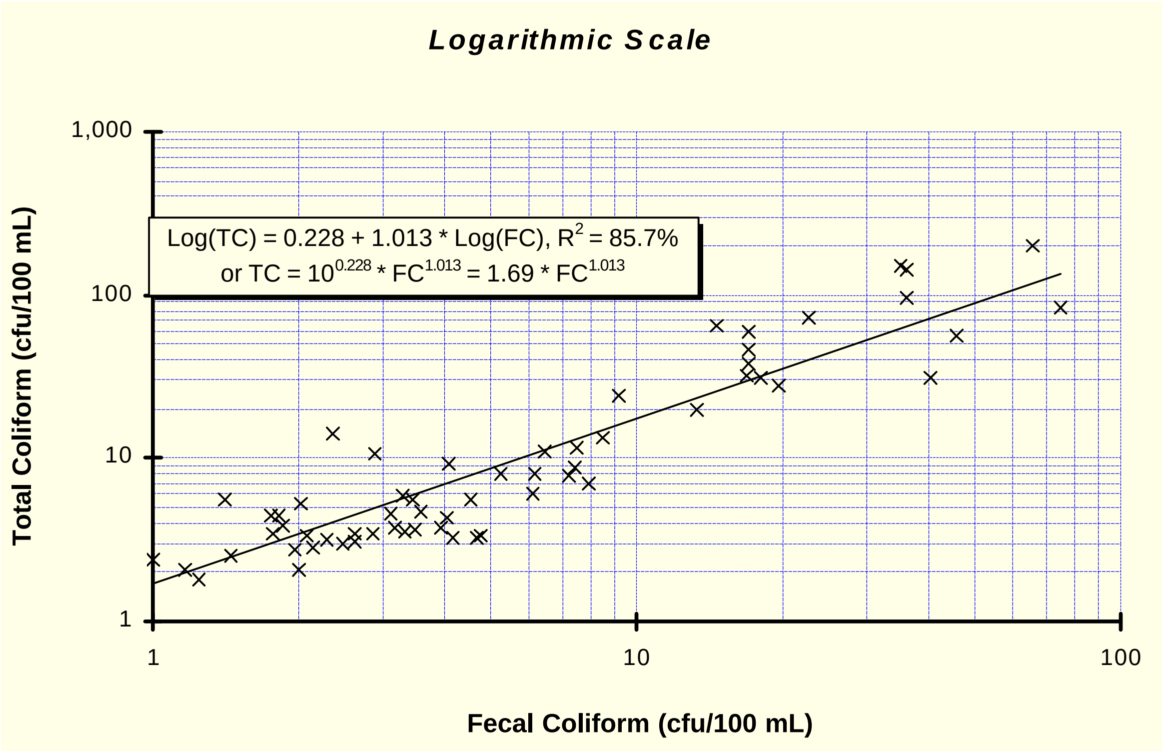
TABLE IV.4 (Concluded)
COMPARISON OF FECAL AND TOTAL COLIFORM DATA

Quadri-lateral	Source[1]	FC Data				TC Data				TC/FC Ratio
		Start	End	No. of Data	Geo Mean	Start	End	No. of Data	Geo Mean	
2482 B	TDH	05/20/75	05/06/94	47	6.1	07/13/59	05/05/80	14	6.0	1.0
2482 B	TNRCC	04/13/92	04/13/93	5	59.4					
2482 C	TDH	05/20/75	05/06/94	51	4.7	07/13/59	05/05/80	29	3.3	0.7
2482 D	TDH	05/21/74	05/06/94	59	7.9	07/13/59	05/05/80	47	7.1	0.9
2482 D	TNRCC	04/12/76	04/13/93	14	3.5	01/15/74	04/24/85	36	5.5	1.6
2482 D	TWDB	09/19/72	08/28/75	15	2.0	09/19/72	08/28/75	14	2.8	1.4
2482 E	TDH	05/21/74	05/06/94	238	4.8	07/13/59	05/05/80	121	3.4	0.7
2482 E	TNRCC	12/02/70	04/13/93	44	6.5	12/02/70	04/24/85	115	11.0	1.7
2483	TDH	06/18/74	10/12/89	121	7.2	03/24/70	03/09/81	87	7.9	1.1
2483	TNRCC	04/25/72	04/27/93	86	8.5	04/25/72	05/07/85	104	13.3	1.6
2484 A	TDH	10/16/74	05/04/82	5	40.4	01/18/67	06/06/78	12	31.2	0.8
2484 A	TNRCC	07/15/71	05/12/93	31	7.4	07/15/71	01/10/85	39	8.8	1.2
2484 A	TWDB	10/24/74	06/05/75	3	2.4	04/17/75	06/05/75	2	14.3	6.1
2484 B	CCNCHD	07/02/81	07/02/81	2	200.0					
2484 B	TDH	10/16/74	05/04/82	5	36.1	01/18/67	06/06/78	14	141.2	3.9
2484 B	TNRCC	08/10/82	08/10/82	4	75.1	08/10/82	08/10/82	4	84.5	1.1
2484 C	CCNCHD	07/02/81	07/02/81	2	212.1					
2484 C	TDH	10/16/74	02/13/84	12	22.8	01/18/67	06/06/78	21	72.5	3.2
2484 C	TNRCC	11/16/72	05/12/93	31	16.9	05/15/72	01/10/85	41	31.8	1.9
2484 D	CCNCHD	07/02/81	07/02/81	3	158.7					
2484 D	TDH	10/16/74	07/31/85	8	36.0	01/18/67	06/06/78	13	95.1	2.6
2484 D	TNRCC	10/24/73	05/12/93	28	17.0	10/24/73	01/10/85	37	46.9	2.8
2484 D	TWDB	09/19/72	08/28/75	9	6.1	09/19/72	06/05/75	8	8.1	1.3
2484 E	CCNCHD	07/02/81	07/02/81	1	100.0					
2484 E	TDH	06/19/74	07/31/85	17	14.7	09/26/60	06/06/78	44	64.5	4.4
2484 E	TNRCC	08/10/82	08/10/82	1	10,000.0	08/10/82	08/10/82	1	10,000.0	1.0
2485	TNRCC	04/25/72	04/27/93	42	18.1	04/25/72	04/03/85	28	31.5	1.7
2491 A	CCNCHD	06/04/86	08/17/95	61	18.6					
2491 A	TDH	05/07/73	11/08/82	7	2.0	03/25/64	06/09/81	8	2.1	1.0
2491 A	TNRCC	12/01/70	05/11/93	28	5.2	12/01/70	05/01/85	45	8.1	1.5
2491 A	TWDB	05/30/74	06/04/75	3	2.9	05/30/74	10/23/74	2	10.6	3.7
2491 B	TDH	05/07/73	11/08/82	14	2.1	03/24/64	06/09/81	16	2.8	1.3
2491 B	TNRCC	04/18/72	05/11/93	50	3.3	04/18/72	05/08/85	76	3.6	1.1
2491 B	TWDB	09/28/72	10/23/74	4	1.4	09/28/72	10/23/74	4	5.6	4.0
2492	TDH	05/07/73	11/10/82	16	2.1	03/24/64	06/09/81	20	3.3	1.6
2492	TNRCC	09/30/70	05/11/93	57	3.6	09/30/70	05/08/85	78	4.7	1.3
2492	TWDB	09/27/72	06/04/75	16	2.3	09/27/72	06/04/75	16	3.2	1.4
2501 B	CCNCHD	02/06/78	06/24/80	14	20.3					
2501 B	TNRCC	04/25/72	04/29/93	15	3.9	04/25/72	06/28/84	29	3.8	1.0
All Data				5,682	2.9			3,196	6.5	2.2

[1]CCNCHD = Corpus Christi - Nueces County Health Department.

FIGURE IV.3
COMPARISON OF FECAL AND TOTAL COLIFORM DATA





the FC value used for the same purpose is 14 cfu/dL. However, this factor of 5 may not apply to all cases.

Ideally a comparison would be made using data where both tests were performed on the same water sample. However, only a small portion of the data involve such splits. To obtain a ratio specific to the study area, all the available data in each quadrilateral were compared as shown in Table IV.4. From this table the data for individual quadrilaterals and segments varies substantially, but most of the TC/FC ratios are in the range of 1 to 3, with very few of the data groupings having TC data that are 5 times higher than the FC data. Overall, the average ratio was 2.2.

Figure IV.3 plots the geometric mean TC and FC data for each quad and uses two forms of regressions, one linear and the other based on the logs of the data. The regressions indicate there is a close relation between the data sets and that while the TC tend to be higher than the FC data, the difference is less than a factor of five for the CCBNEP area.

IV.3 ANALYSIS OF TEMPORAL TRENDS

One of the issues to be addressed in this study is whether there are changes in coliform levels that have occurred over time. In other words, there is interest in the question of whether the bacterial data suggest the quality of the water is improving or declining. To address this issue, data from seven representative quadrilaterals were plotted versus time (Figures IV.4 through IV.10) and regression equations fitted separately to both the TC and FC data. Grouping both the TC and FC data in the same figure allows a period of approximately forty years to be seen, and improves the chance that a temporal trend could be detected. Based on the TC and FC comparison developed above, the difference between the two data sets is small, so no adjustments were made. However, separate regressions were made.

In reviewing the regressions in the figures, the general pattern is for the regression lines slopes to be fairly flat with some of the lines showing upward trends and some downward. It is also interesting to note the variation in sampling effort over time. Table IV.5 summarizes the regression results. In all cases the R^2, which indicates the amount of variance explained by the regression, is quite small. Based on the flat slopes (some positive and some negative, but all small) and very small R^2 values, it is concluded that there is no significant change in coliform bacteria levels occurring with time.

FIGURE IV.4
TRENDS IN COLIFORM DATA FOR SEGMENT 2471 – ARANSAS BAY

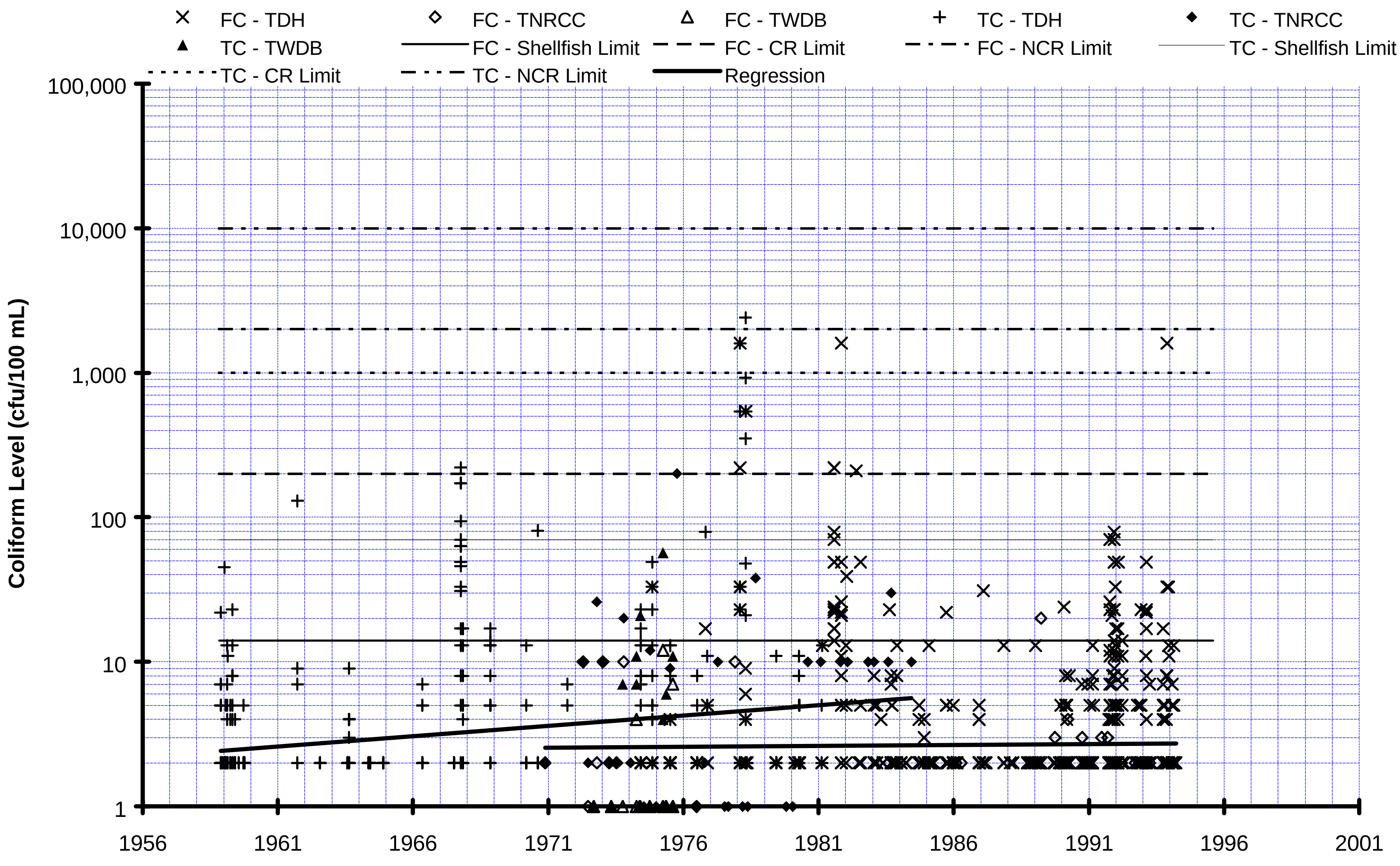


FIGURE IV.5
TRENDS IN COLIFORM DATA FOR SEGMENT 2472 – COPANO BAY

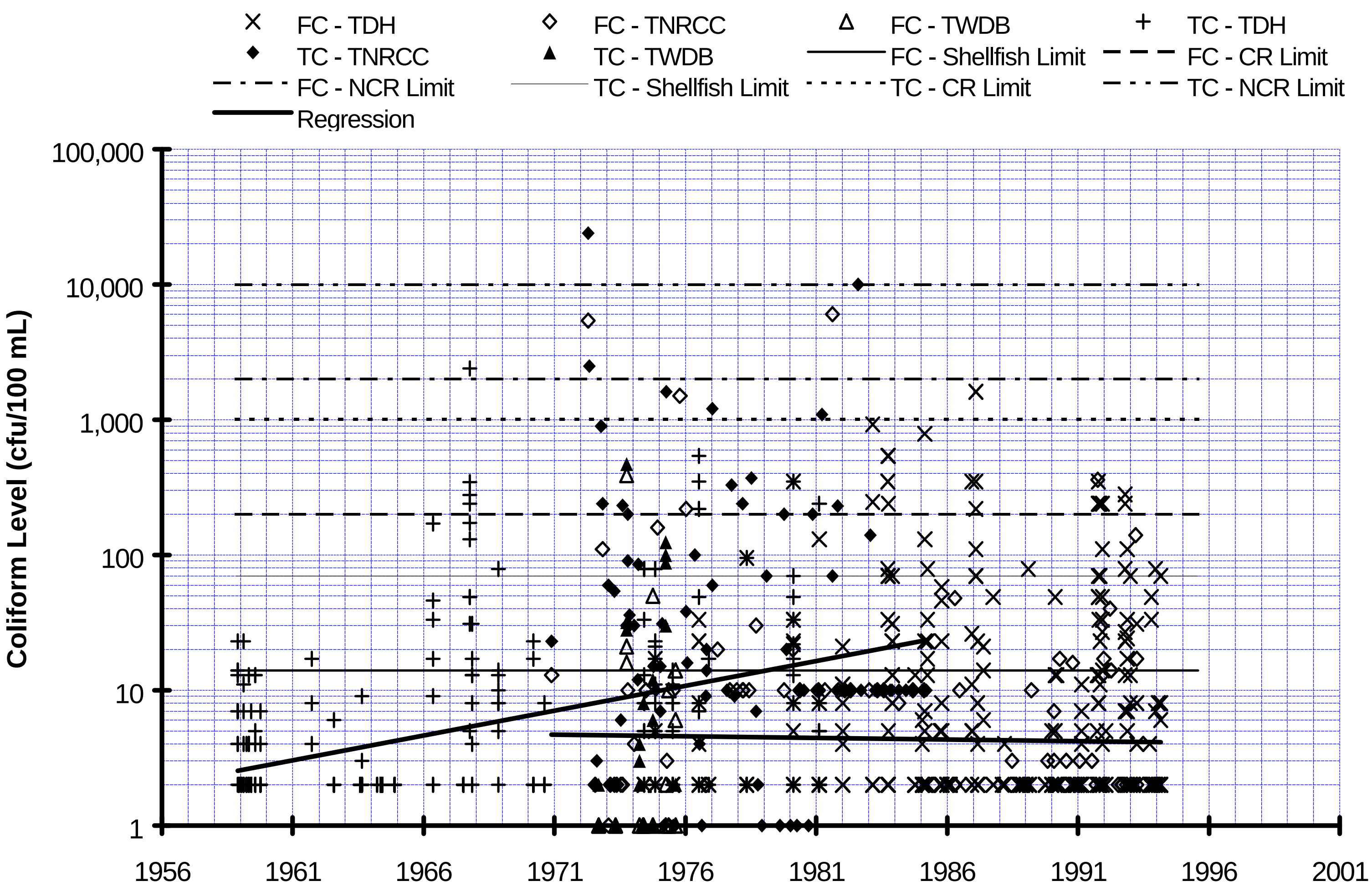


FIGURE IV.6
TRENDS IN COLIFORM DATA FOR SEGMENT 2481A – UPPER CORPUS CHRISTI BAY

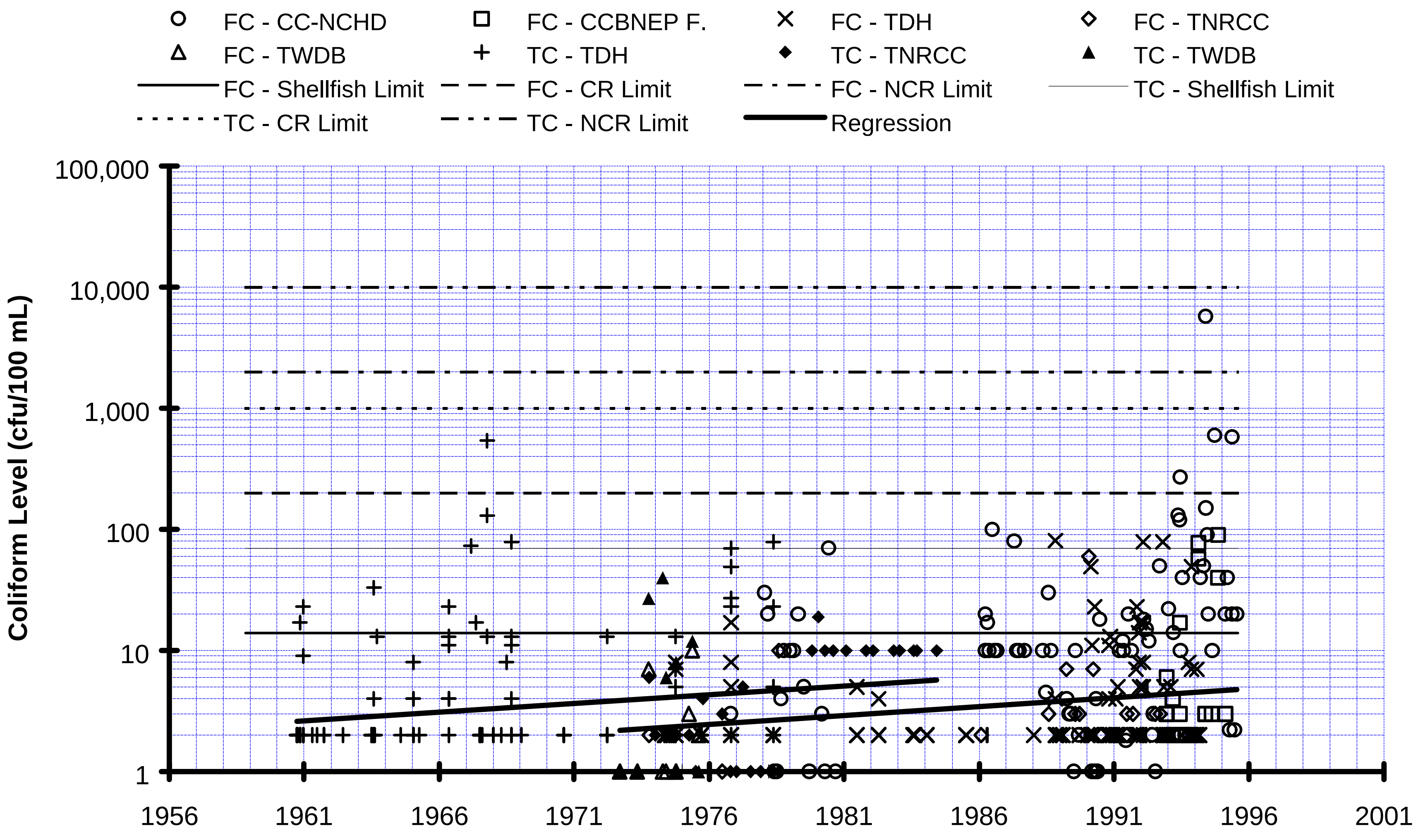


FIGURE IV.7

TRENDS IN COLIFORM DATA FOR SEGMENT 2481B – MIDDLE CORPUS CHRISTI BAY

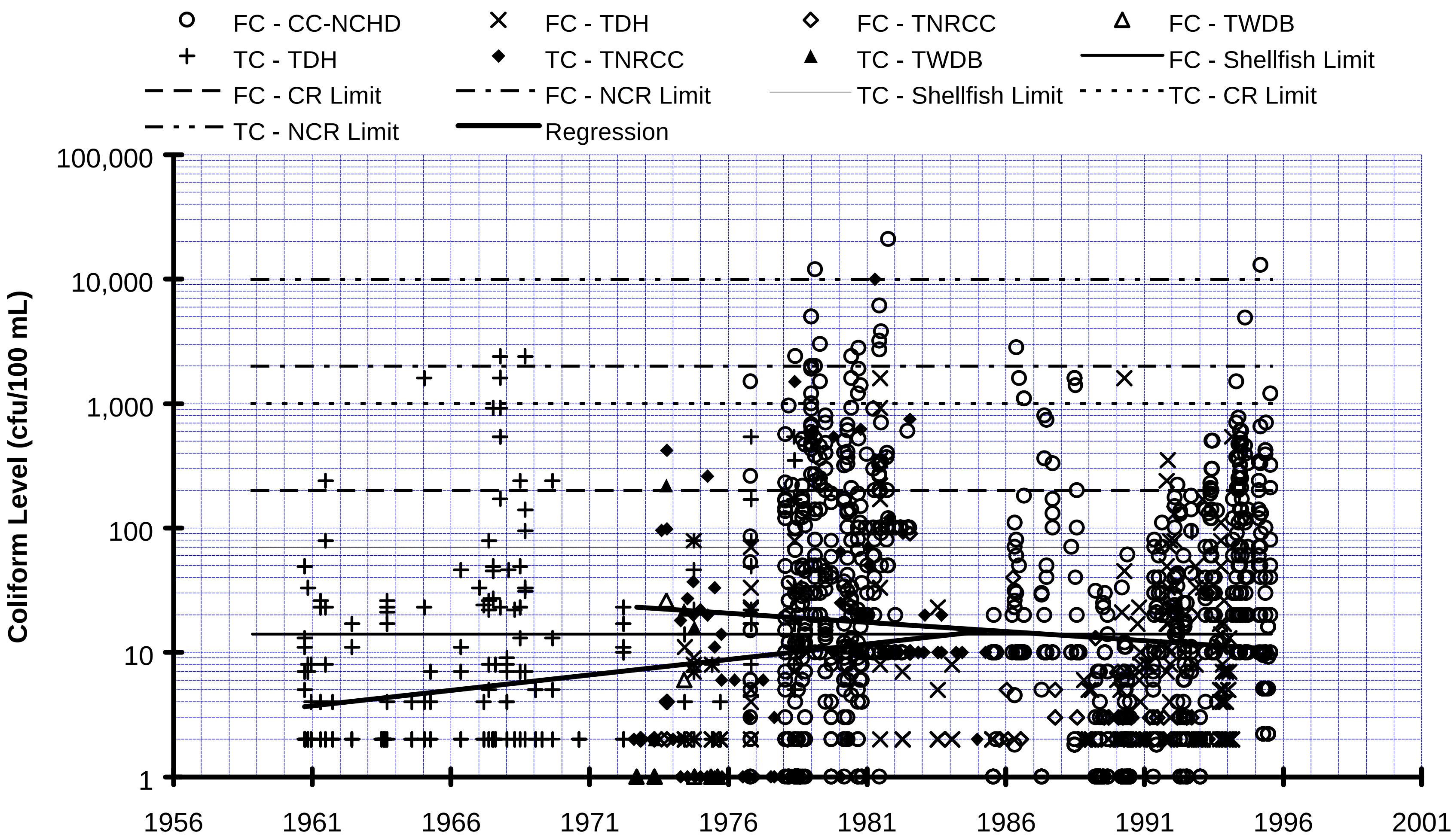


FIGURE IV.8
TRENDS IN COLIFORM DATA FOR SEGMENT 2481C – LOWER CORPUS CHRISTI BAY

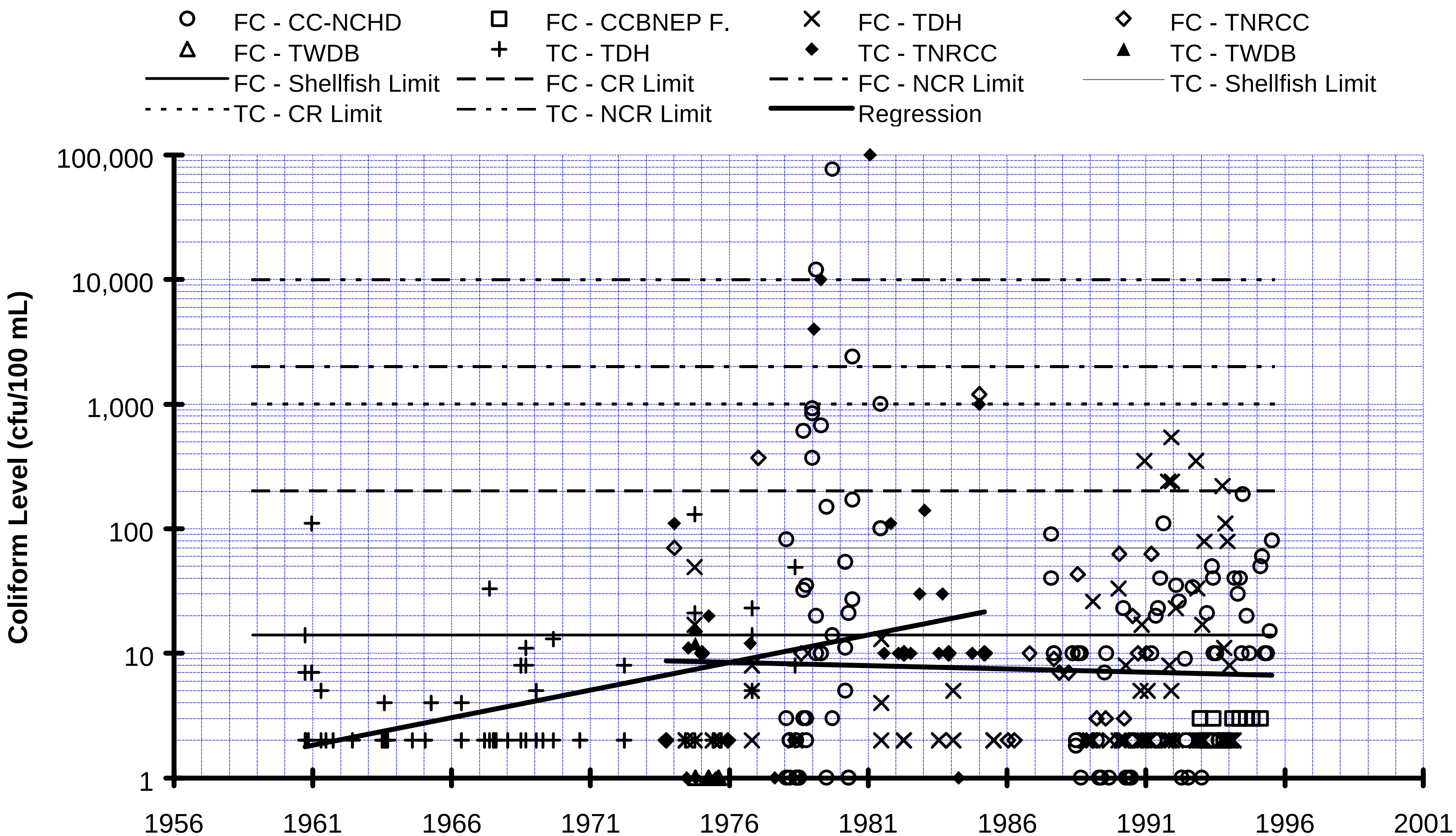


FIGURE IV.9
TRENDS IN COLIFORM DATA FOR SEGMENT 2484 – NUECES BAY

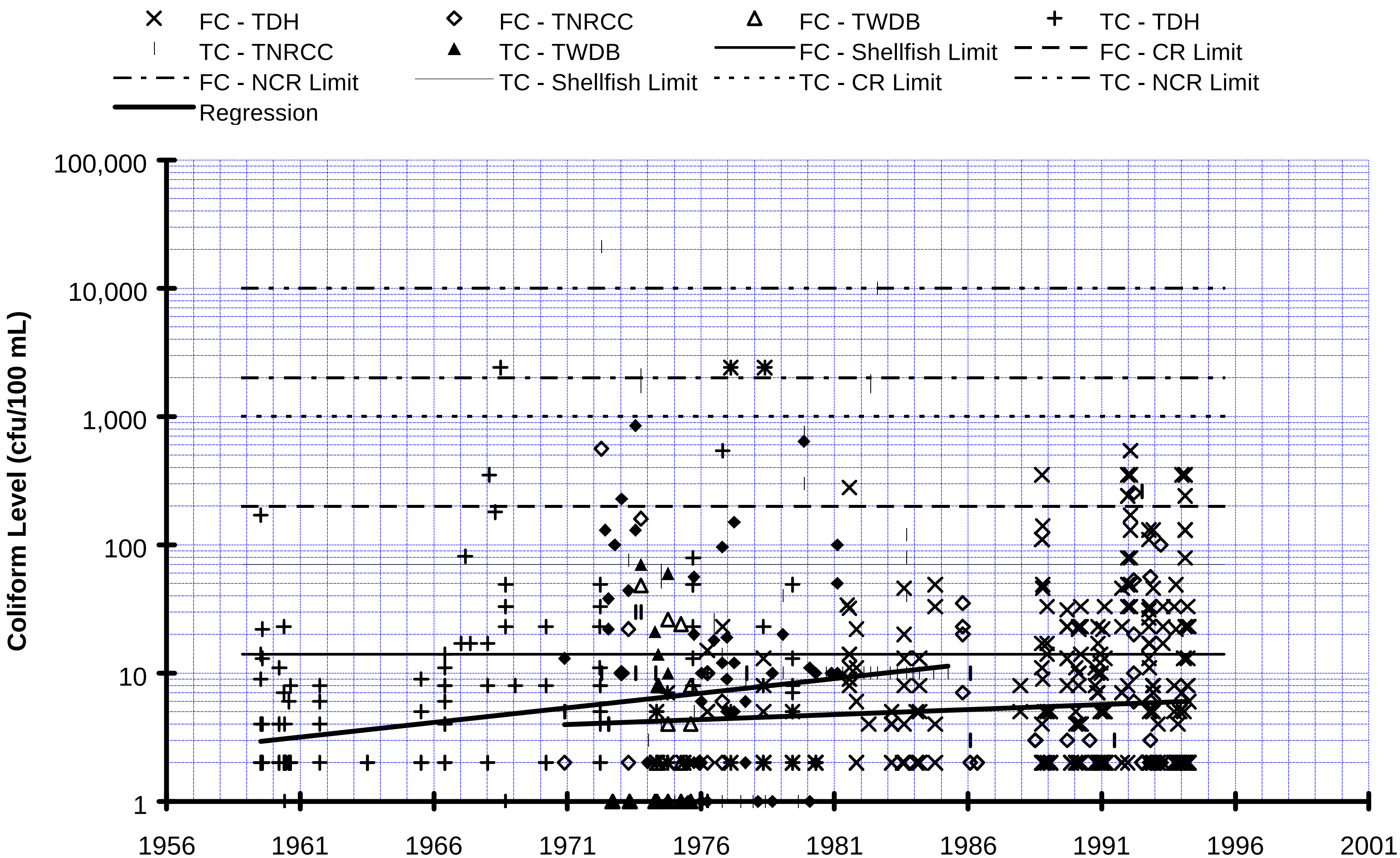


FIGURE IV.10
TRENDS IN COLIFORM DATA FOR SEGMENT 2484 – CORPUS CHRISTI INNER HARBOR

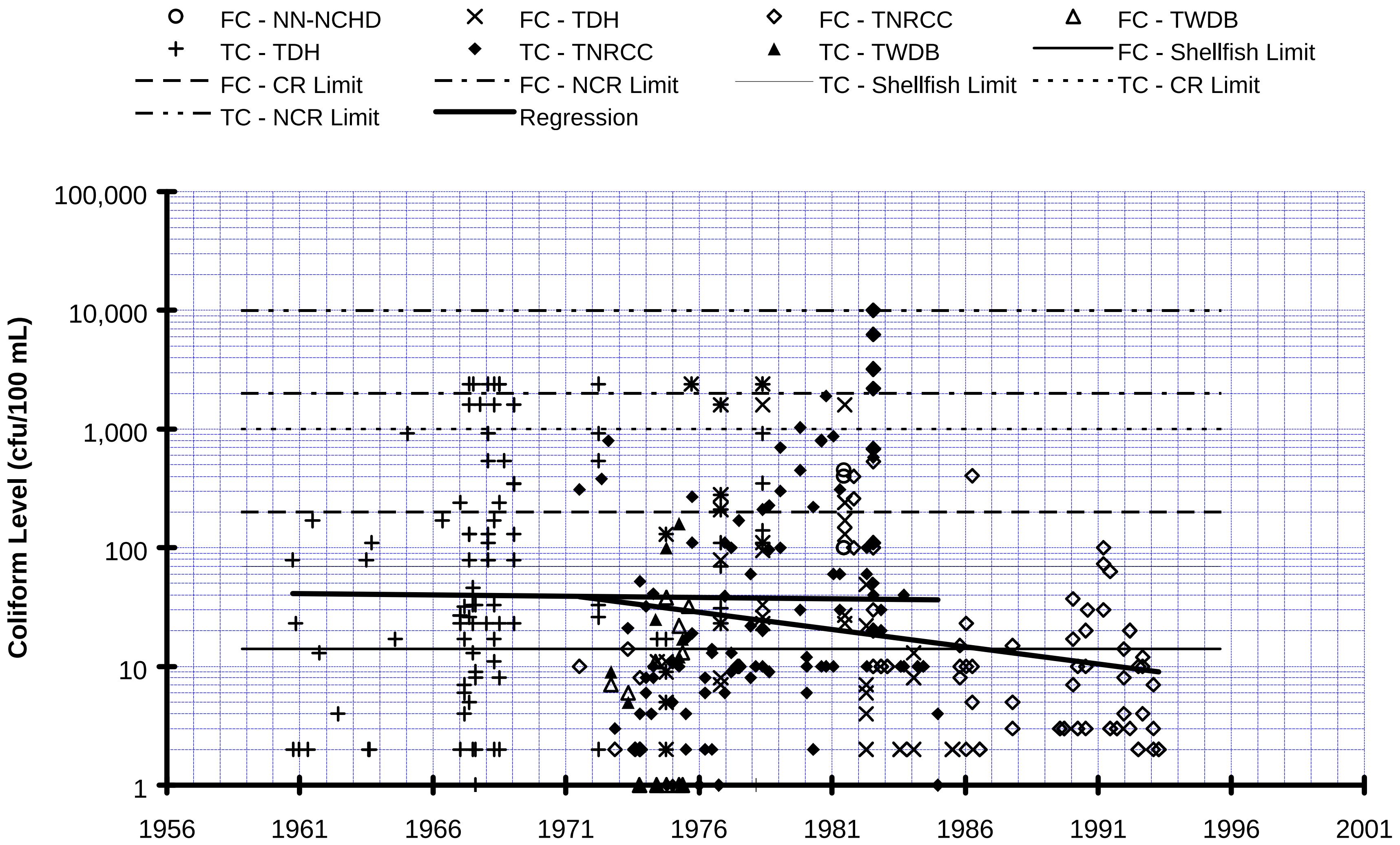


TABLE IV.5
RESULTS OF SELECTED TREND ANALYSIS ON COLIFORM DATA

Quadri-laterals	Regression of Coliform on Time				
	Parameter	Intercept	Slope	R^2	Relations
2471	Log_{10}(FC)	0.316	3.430E-06	0.04%	Log_{10}(FC) = 0.316 + 3.43E-06 * Date
	Log_{10}(TC)	-0.450	3.882E-05	4.78%	Log_{10}(TC) = -0.450 + 3.88E-05 * Date
2472	Log_{10}(FC)	0.833	-6.313E-06	0.05%	Log_{10}(FC) = 0.833 + -6.31E-06 * Date
	Log_{10}(TC)	-1.758	1.005E-04	15.13%	Log_{10}(TC) = -1.758 + 1.00E-04 * Date
2481A	Log_{10}(FC)	-0.733	4.042E-05	3.07%	Log_{10}(FC) = -0.733 + 4.04E-05 * Date
	Log_{10}(TC)	-0.456	3.929E-05	4.06%	Log_{10}(TC) = -0.456 + 3.93E-05 * Date
2481B	Log_{10}(FC)	2.421	-3.983E-05	1.04%	Log_{10}(FC) = 2.421 + -3.98E-05 * Date
	Log_{10}(TC)	-0.948	6.814E-05	4.97%	Log_{10}(TC) = -0.948 + 6.81E-05 * Date
2481C	Log_{10}(FC)	1.325	-1.434E-05	0.16%	Log_{10}(FC) = 1.325 + -1.43E-05 * Date
	Log_{10}(TC)	-2.440	1.212E-04	16.46%	Log_{10}(TC) = -2.440 + 1.21E-04 * Date
2482	Log_{10}(FC)	0.043	2.141E-05	0.75%	Log_{10}(FC) = 0.043 + 2.14E-05 * Date
	Log_{10}(TC)	-0.883	6.213E-05	5.82%	Log_{10}(TC) = -0.883 + 6.21E-05 * Date
2484	Log_{10}(FC)	3.656	-7.922E-05	3.68%	Log_{10}(FC) = 3.656 + -7.92E-05 * Date
	Log_{10}(TC)	1.737	-5.599E-06	0.02%	Log_{10}(TC) = 1.737 + -5.60E-06 * Date

V. SEAFOOD TISSUE ANALYSIS

The combined effects of a technological society which uses a wide range of natural and man-made chemicals, and our increasing ability to detect and quantify these chemicals at extremely low concentrations in food tissue, has raised a relatively new public health issue and placed increasing analytical burdens on public health officials to address the issue. Determining safe levels in food is extremely complex and requires dealing with factors such as:

- variation in the laboratory toxicological dose-response data for individual substances,
- uncertainty over whether or not and to what degree a substance is carcinogenic or exhibits developmental effects, etc.,
- controversy over the methods used to extrapolate laboratory data to field conditions, including the concentration and duration of exposure, and
- uncertainty in the risk level our society might choose to accept.

There is no shortage of tough analytical problems in determining what is safe to eat. In the case of seafood tissue the problem is made more complicated by there being an almost unlimited number of potentially harmful substances that might possibly enter the water and get to seafood tissue (controlled growing conditions such as used for chickens reduces this aspect), a large number of seafood species to address, a wide range of capture locations to consider, and perhaps most important, limited resources to address the issues. Because of this complexity and resource limitations, there is not now an accepted analytical basis available to make a general determination of what concentration of a particular parameter in seafood tissue is safe or unsafe to eat.

The only practical way to address the public health issue is with risk-based fish consumption advisories determined for specific parameters, species, and consuming populations. The EPA, working with a number of state environmental and health departments and a range of other agencies, has developed a four-volume series of guidance documents:

Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories

Volume I: *Fish Sampling and Analysis (1995a)*
Volume II: *Risk Assessment and Fish Consumption Limits (1994)*
Volume III: *Risk Management*
Volume IV: *Risk Communication*

The major goal of these guidance documents is to provide uniform information and procedures for use by state and local agencies responsible for producing seafood consumption advisories. In Texas, the Seafood Sanitation Section of the TDH is responsible for producing seafood consumption advisories.

In the CCBNEP study area TDH officials (Wiles, TDH, Pers. Comm., 1996) have indicated there are currently specific concerns over two situations. One for zinc levels in oysters in Nueces Bay and the other for PCBs in the Inner Harbor. Oyster harvesting in Nueces Bay has been restricted, but at this time there have been no consumption advisories issued for the CCBNEP study area.

V.1 ANALYSIS METHODOLOGY

The objective of this section is to examine existing seafood tissue data in the study area to assess potential human health risks from consumption. Tissue data were compiled from existing sources by Ward and Armstrong (1996). Table V.1 is a listing of the agencies or organizations that contributed seafood tissue data to the overall compilation. The data include a wide range of seafood types and parameter analyses. Table V.1 also lists the organisms sampled by each agency as well as the major types of parameters analyzed.

Figure V.1 shows a plot of the stations where tissue data have been collected along with the various agencies involved. It can be seen that the areal coverage appears to be reasonably good and that there appears to be a higher density of stations in the more developed portions of the study area.

To assess the human health significance of the tissue data, it is necessary to have some means of screening the data. At the same time it must be emphasized that, as noted earlier, there is no single concentration value in tissue that can be used to differentiate between safe and unsafe food.

Three sources were employed for screening values. The first and primary source was EPA (1995a). This document is recent and has included development of a set of screening values (SV) for a range of “target analytes”. Table V.2, reproduced from EPA (1995a), shows these SVs for each analyte.

This list of target analytes was developed by EPA from the standpoint of these substances being relatively toxic, with high bioconcentration factors, and having a long half-life. Other considerations in the selection of the list was whether any states had already issued seafood consumption advisories on the substance and the degree to which monitoring has been conducted. In effect, the list in Table V.2 includes the substances most likely to be a human health concern.

The SVs in Table V.2 were reported to be calculated in a manner that would be protective of human health. However, values higher than the SVs should not be considered as “unsafe” levels. Quoting from EPA (1995a) “exceedance of these SVs should be taken as an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted”. The numerical values used in computing these SVs were:

Seafood Consumption Rate = 6.5 g/day
Average Body Weight = 70 kg, and
Risk Level = 10^{-5} (one additional cancer in 100,000 individuals exposed over a 70 year period)

TABLE V.1

AGENCIES COLLECTING TISSUE DATA IN CORPUS CHRISTI BAY

Agency	Organisms Sampled	Type of Sample	Parameter Range
CCB Foundation	perch southern flounder speckled trout	Whole, Wet Weight	METAL OTHER ORGANICS PAHs PESTICIDES
EMAP	Atlantic croaker brown shrimp gafftopsail catfish hardhead catfish penaeid shrimp (undiff.)	Edible, Wet Weight	METAL PCBs PESTICIDES METAL PCBs
NOS	American oyster	Whole, Dry Weight	METAL PAHs PESTICIDES
TDH	BLACK DRUM	Edible, Wet Weight	METAL PCBs PESTICIDES
	BLACK DRUM COMP	Edible, Wet Weight	
	BLUE CRAB COMP	Edible, Wet Weight	
	BLUE CRABS	Edible, Wet Weight	
	FLOUNDER COMP	Edible, Wet Weight	
	HARDHEAD CATFISH	Edible, Wet Weight	
	MERCENARIA (clam)	Edible, Wet Weight	
	OYSTER COMP	Edible, Wet Weight	
	RED DRUM	Edible, Wet Weight	
	REDFISH COMP	Edible, Wet Weight	
	SHEEPSHEAD	Edible, Wet Weight	
	SHRIMP COMP	Edible, Wet Weight	
	SPECKLED TROUT	Edible, Wet Weight	
	SPECKLED TROUT COMP	Edible, Wet Weight	
	FLOUNDER GAFFTOP CATFISH REDFISH SOUTHERN FLOUNDER	Edible, Wet Weight	METAL
	OYSTERS	Edible, Wet Weight	METAL OTHER ORGANICS

TABLE V.1 (Concluded)
AGENCIES COLLECTING TISSUE DATA IN CORPUS CHRISTI BAY

Agency	Organisms Sampled	Type of Sample	Parameter Range
TDH	OYSTERS	Edible, Wet Weight	PAHs PCBs PESTICIDES
TNRCC	brown shrimp gafftopsail catfish	Whole, Wet Weight	OTHER ORGANICS PAHs PCBs PESTICIDES
	fin perch ladyfish perch pigfish sea catfish Spanish mackerel tarpon	Whole, Wet Weight	OTHER ORGANICS PCBs PESTICIDES
	menhaden spot croaker (spot)	Whole, Wet Weight	OTHER ORGANICS PESTICIDES
	spotted seatrout	Whole, Wet Weight	OTHER ORGANICS PCBs
	whiting	Whole, Wet Weight	PCBs PESTICIDES
	mullet pinfish speckled trout	Whole, Wet Weight	OTHER ORGANICS
USCE	blue crab	Whole, Wet Weight	METAL PAHs PCBs PESTICIDES
USFWS-CCB	American oyster blue crab hardhead catfish shoalgrass	Whole, Wet Weight	METAL

FIGURE V.1

MONITORING STATIONS FOR TISSUE

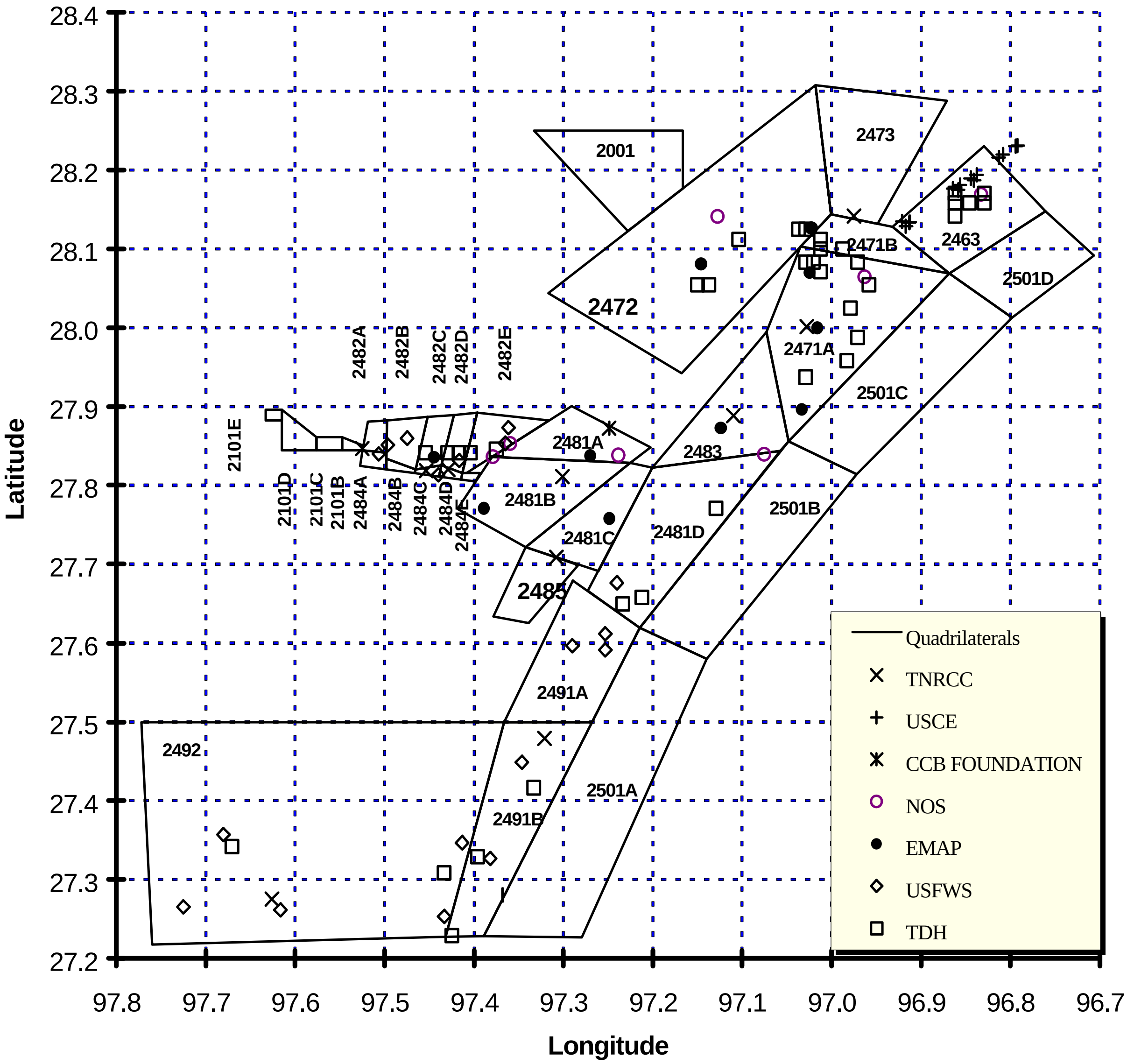


TABLE V.2
DOSE-RESPONSE VARIABLES AND RECOMMENDED SCREENING VALUES (SVs) FOR TARGET ANALYTES

Target analyte	Noncarcinogens: RfD[b] (mg/kg/d)	Carcinogens: SF[b] $(mg/kg/d)^{-1}$	SV[a] (ppm): Noncarcinogens	SV[a] (ppm): Carcinogens ($RL=10^{-5}$)
Metals				
Arsenic (inorganic)[c]	3×10^{-4} [d]	NA[e]	3	—
Cadmium	1×10^{-3}	NA	10	—
Mercury[f]				
Developmental	6×10^{-5} [g]	NA	0.6[g]	—
Chronic systemic	3×10^{-4} [h]	NA	3[h]	—
Selenium[i]	5×10^{-3}	NA	50	—
Tributyltin	3×10^{-5} [d]	NA	0.3	—
Organochlorine Pesticides				
Total chlordane (sum of cis- and trans-chlordane, cis- and trans-nonachlor, and oxychlordane)[j]	6×10^{-5}	1.3	0.6	0.08
Total DDT (sum of 4,4'- and 2,4'-isomers of DDT, DDE, and DDD)[k]	5×10^{-4}	0.34	5	0.3
Dicofol	1×10^{-3} [l]	NA	10	—
Dieldrin	5×10^{-5}	16	0.6	7×10^{-3}
Endosulfan (I and II)	6×10^{-3} [m]	NA	60	—
Endrin	3×10^{-4}	NA	3	—
Heptachlor epoxide	1.3×10^{-5}	9.1	0.1	0.01
Hexachlorobenzene	8×10^{-4}	1.6	9	0.07

TABLE V.2 (Concluded)
DOSE-RESPONSE VARIABLES AND RECOMMENDED SCREENING VALUES (SVs) FOR TARGET ANALYTES

Target analyte	Noncarcinogens RfD[b] (mg/kg/d)	Carcinogens SF[b] $(mg/kg/d)^{-1}$	SV[a] (ppm) Noncarcinogens	SV[a] (ppm) Carcinogens ($RL=10^{-5}$)
Metals				
Lindane (γ-hexachlorocyclohexane; γ-HCH)	3×10^{-4}	1.3[n]	3	0.08
Mirex	2×10^{-4}	NA[o]	2	—
Toxaphene	2.5×10^{-4} [l,p]	1.1	3	0.1
Organophosphate Pesticides				
Chlorpyrifos	3×10^{-3}	NA	30	—
Diazinon	9×10^{-5} [l]	NA	0.9	—
Disulfoton	4×10^{-5}	NA	0.5	—
Ethion	5×10^{-4}	NA	5	—
Terbufos	1.3×10^{-4} [l]	NA	1	—
Chlorophenoxy Herbicides				
Oxyfluorfen	3×10^{-3}	1.3×10^{-1}	30	0.8
PAHs	NA	7.3[d,q]	—	0.01
PCBs				
Total PCBs (sum of Aroclors)	2×10^{-5} [d,r]	7.7[s]	0.2	0.01
Dioxins/furans[t]	NA	1.56×10^{5}	—	7×10^{-7}

While the list in Table V.2 is substantial, there are a number of additional parameters in the database that have been analyzed by one or more of the agencies over the years. In an attempt to provide some measure of comparison for these additional parameters, the EPA Toxic Substance Spreadsheet (EPA, 1995b) was employed. This spreadsheet contains tissue concentration values calculated in a similar manner to EPA (1995a). If there was a value for the parameter of interest in the spreadsheet where there wasn't in EPA (1995a), the spreadsheet value was included after adjustment of carcinogens to a 10^{-5} risk level.

Finally, the US Food and Drug Administration has developed a set of "Action Levels" for food sold in interstate commerce. The fundamental philosophy behind these action levels is somewhat different from the seafood advisories. The advisories are targeted to specific recreational or subsistence fisheries and at-risk populations, while the Action Levels deal with commercial harvesting and distribution.

Table V.3 shows the SVs employed drawn from the three sources, EPA (1995a, b) and the current FDA Action Levels. Where more than one value was found, the lowest value was used for screening.

To assess the data the following procedures were employed. First, the data were grouped by quadrilateral defined to allow separation of the data into the existing TNRCC geographic segments. Next the data were screened for reported non-detects. These were separated for independent tabulation. Data with reported detections were grouped by parameter and quadrilateral, keeping the data source separate.

Since the type of data varies between agencies performing tissue sampling, it was necessary to make adjustments to put the results on a more nearly common basis. First, all of the criteria used to assess relative quality from a human health perspective are in terms of concentration in edible tissue expressed in a wet-weight basis. All of the TDH data are wet weight concentrations in filets. However, much of the TNRCC and other data are whole fish data which will tend to yield higher parameter concentrations. There is simply no way to correct these whole fish data to edible portion data. Comparisons are made in the tables which follow, but the reader is cautioned that an "apple-orange" situation exists. Finally, the oyster tissue data collected by the National Ocean Survey (NOS, Status and Trends) are reported in terms of concentration of oyster meat on a dry weight basis. The laboratory which performed many of the analyses (Texas A&M, Trace Element Research Laboratory) has indicated that the moisture content of oysters is typically close to 85% (Presley, 1996), and this value was used to convert the oyster data to a wet-weight basis.

With the above adjustments, the data for each quadrilateral were tabulated by parameter, with each data source, and minimum, average and maximum values computed. If a concentration screening value existed, it was compared with the raw data and the number exceeding the screening value listed. Finally, the number of observations with non-detects was listed along with the individual detection limits employed.

TABLE V.3

SUMMARY OF SCREENING VALUES FOR TISSUE

Parameter		Screening Value (PPM)				Carcino-gens
		EPA Guidance[1]	EPA Spread sheet[2]	FDA Action Levels[3]	Used for Data Screening	
METAL	ARSENIC	3			3	
METAL	CADMIUM	10			10	
METAL	MERCURY	0.6		1	0.6	
METAL	NICKEL		21.54		21.54	
METAL	SELENIUM	50			50	
PAHs	ACENAPHTHENE		6,462		6,462	Yes
PAHs	ANTHRACENE		32,308		32,308	Yes
PAHs	BENZO(K)FLUORANTHENE		0.0147		0.0147	Yes
PAHs	BENZO-A-PYRENE		0.0147		0.0147	Yes
PAHs	CHRYSENE		0.0147		0.0147	Yes
PAHs	DIBENZ(A,H)ANTHRACENE		0.0147		0.0147	Yes
PAHs	FLUORANTHENE		4,308		4,308	Yes
PAHs	FLUORENE		4,308		4,308	Yes
PAHs	INDENO(1 2 3-CD) PYRENE		0.0147		0.0147	Yes
PAHs	PYRENE		3,230		3,230	Yes
PAHs	TOTAL PAHs	0.01			0.01	Yes
PCBs	AROCLOR1248	0.01			0.01	Yes
PCBs	AROCLOR1254	0.01			0.01	Yes
PCBs	PCBS	0.01		2	0.01	Yes
PESTICIDES	ALDRIN			0.3	0.3	
PESTICIDES	CHLORDANE(TECH MIX & METABS)	0.08		0.3	0.08	Yes
PESTICIDES	DDD TOTAL	0.3			0.3	Yes
PESTICIDES	DDE TOTAL	0.3		5	0.3	Yes
PESTICIDES	DDT SUM ANALOGS	0.3		5	0.3	Yes
PESTICIDES	DIELDRIN	0.007		0.3	0.007	Yes
PESTICIDES	ENDRIN	3			3	
PESTICIDES	HEPTACHLOR			0.3	0.3	
PESTICIDES	HEPTACHLOR EPOXIDE	0.01		0.3	0.01	Yes
PESTICIDES	HEXACHLOROBENZENE	0.07			0.07	Yes
PESTICIDES	LINDANE (BHC-GAMMA ISOMER)	0.08			0.08	Yes
PESTICIDES	MIREX	2		0.1	0.1	
PESTICIDES	TOTAL DDT/DDE/DDD	0.3			0.3	
PESTICIDES	TOXAPHENE	3			3	Yes

Note:

[1] EPA Guidance For Assessing Chemical Contaminant Data For Use In Fish Advisories (1995), EPA 823-R-95-007.

[2] EPA Toxic Substance Spreadsheet obtained from L. Dow (1995), modified to be at a risk level of 10^{-5} for carcinogens.

[3] FDA Action Levels obtained from the Manual of Operations of the National Shellfish Sanitation Program (1995).

V.2 ANALYSIS RESULTS

The full tabulation of these data is a 28 page "summary" table, which is included as Appendix B. From this summary, very few parameters had any tissue samples exceeding the screening values. The parameters which had any exceedances of SVs were: arsenic, total PAHs, total PCBs, two specific PAHs and dieldrin. In addition, the zinc levels of oysters in Nueces Bay were noted by TDH to be high and were thus analyzed. The following paragraphs discuss these parameters, grouped into metals and organics, which had some level of screening value exceedance.

V.2.1 Metals

Table V.4 is a reproduction of the arsenic table from Appendix B, with a breakdown by area and source. There are a total of 21 samples exceeding the SV of 3 ppm. Of these, 18 are from the USFWS-CCB and are whole fish data, with the cautions expressed previously regarding comparison of whole fish and edible tissue data. The bulk of the stations with exceedances are in Baffin Bay (segment 2492) and Laguna Madre (2491 A&B). The remaining three samples are filet data collected by the EMAP program. The locations where the SV exceedances were found are: 2471A (Aransas Bay), 2472 (Copano Bay), and 2481B (the central part of Corpus Christi Bay). There appear to be approximately 18 EMAP stations with Arsenic in the dataset, that are spread over a large number of segments.

Figure V.2 is a time plot of arsenic data from each of the areas where an SV exceedance was observed. The differences in the USFWS-CCB (whole fish) and TDH (filet) data in Baffin Bay are quite apparent. It is expected that the significance of these results were assessed by EPA in the EMAP program, but additional research on these findings may be warranted.

Table V.5 is a reproduction of the zinc table from Appendix B. In the case of zinc there is no screening level. As noted by the TDH (1995 and reproduced as Appendix C) in its analysis of data similar to that shown in Table V.5, zinc is an essential food element. Problems can occur if a diet contains too little or too much zinc. The TDH adopted an oral chronic Minimal Risk Level (MRL) for zinc of 0.3 mg/kg/day, and concluded that eating as little as 0.3 oz per day for ten weeks would produce a dose that would exceed the chronic MRL. Rather than issue a seafood consumption advisory, the TDH elected to simply close the remaining parts of Nueces Bay to oyster harvesting.

V.2.2 Organics

Table V.6 reproduces the section of Appendix B showing total PAHs and total PCBs. Both parameters employ an SV of 0.01 mg/kg from EPA (1995a), and both show a substantial number of SV exceedances. However, the total PAH data are the sum of individual PAH components (e.g., acenaphthylene, anthracene, etc.) from the NOSS&T data. This summation procedure was employed for total PAHs, PCBs and total DDT, by adding components that were actually detected (< values treated separately) that were collected by the same agency on the same day in the same quadrilateral. In checking these data, the original NOS observations were found not to include any "<" although

TABLE V.4
SUMMARY OF AVAILABLE ARSENIC TISSUE DATA IN PPM FOR CCBNEP AREAS

Quadri-lateral		Data Source	Data Type	Above Detection Limits						Below Detection Limits		
				No. of Data	Min.	Avg.	Max.	SV[2]	No. > SV	No. of Data	Min.[3]	Max.[3]
2463		NOS	S (D)	20	0.59	0.9077	1.635	3	0			
2463		USCE7	S	0						14	1	1
2471	A	EMAP	F	3	0.22	1.889	4.74	3	1			
2471	A	NOS	S (D)	20	0.65	1.4394	2.1	3	0			
2471	A	TDH	F	0						6	0.5	0.5
2472		EMAP	F	9	0.03	0.5846	3.58	3	1	2	0.4	0.4
2472		NOS	S (D)	19	0.14	1.1226	1.65	3	0			
2472		TDH	F	0						8	0.5	0.5
2481	A	CCB Found.	S	2	0.22	0.335	0.45	3	0	1	20	20
2481	A	EMAP	F	1	0.32	0.323	0.323	3	0			
2481	A	NOS	S (D)	16	1.08	1.6771	2.16	3	0			
2481	B	EMAP	F	2	0.85	10.124	19.4	3	1			
2481	B	NOS	S (D)	6	0.99	1.2635	1.44	3	0			
2481	C	EMAP	F	1	0.49	0.493	0.493	3	0			
2481	D	NOS	S (D)	3	2.03	2.185	2.355	3	0			
2481	D	TDH	F	2	0.5	0.5	0.5	3	0	15	0.5	0.5
2481	D	USFWS-CCB	S	1	3.31	3.31	3.31	3	1	1	0.2	0.2
2482	B	USFWS-CCB	S	4	0.71	1.0893	1.47	3	0			
2482	C	EMAP	F	1	0.16	0.158	0.158	3	0			
2482	D	USFWS-CCB	S	2	1.53	1.695	1.86	3	0			
2482	E	NOS	S (D)	17	0.92	1.2437	1.905	3	0			
2482	E	USFWS-CCB	S	3	0.14	1.0097	2.17	3	0	1	0.2	0.2
2482	E	TDH	F	0						8	0.5	0.5
2483		EMAP	F	1	0.1	0.095	0.095	3	0			
2484	A	USFWS-CCB	S	1	0.43	0.431	0.431	3	0	1	0.2	0.2
2484	C	USFWS-CCB	S	3	1.24	1.7567	2.57	3	0			
2491	A	USFWS-CCB	S	7	0.22	3.926	6.3	3	5	1	0.2	0.2
2491	B	USFWS-CCB	S	4	0.26	10.935	23.4	3	3			
2492		USFWS-CCB	S	14	0.29	3.9608	6.91	3	10			
2492		TDH	F	0						5	0.5	0.5

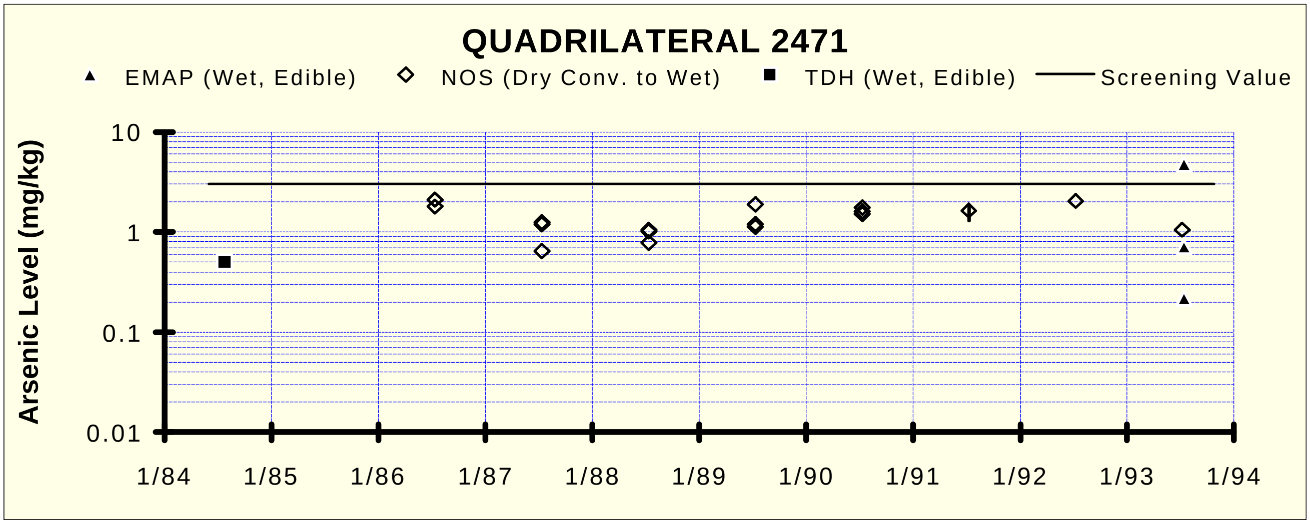
Note:

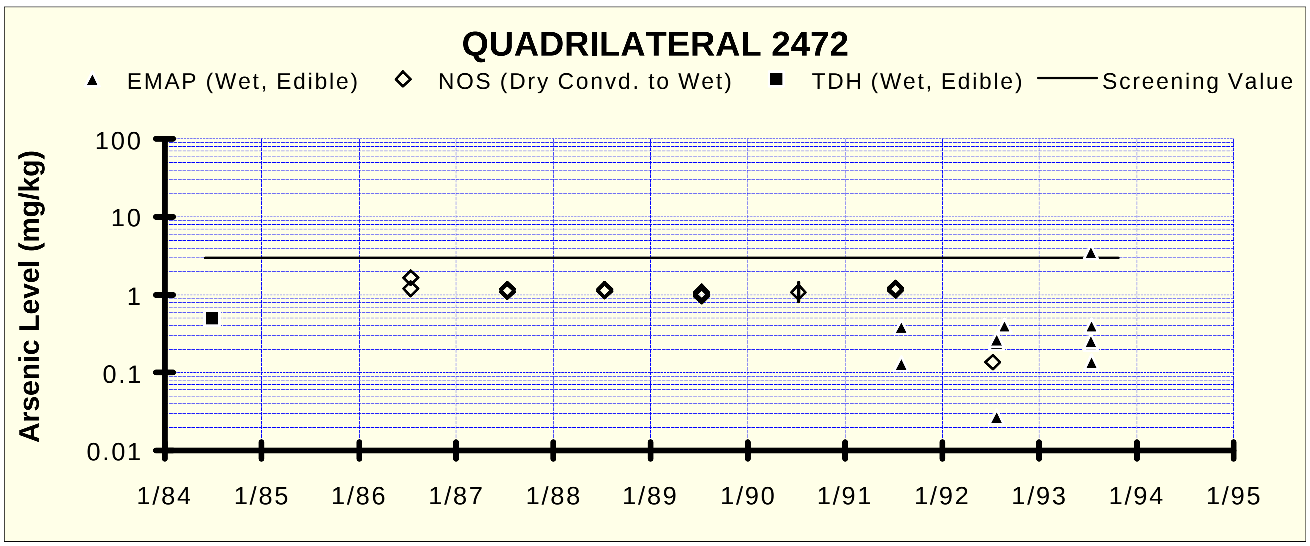
[1]S(D) = wet weight converted from dry weight (NOS oyester data, assume 85% water content), S = wet weight based on whole tissue, F = wet weight based on edible tissue.

[2]SV = Screening Values. Values in the table are from EPA Guidance For Assessing Chemical Contaminant Data For Use In Fish Advisories (1995), EPA 823-R-95-007.

[3]Zero values in the columns indicate that the detection limits are not reported (either a blank or "None" were in the original data files.)

FIGURE V.2
ARSENIC LEVELS IN TISSUE





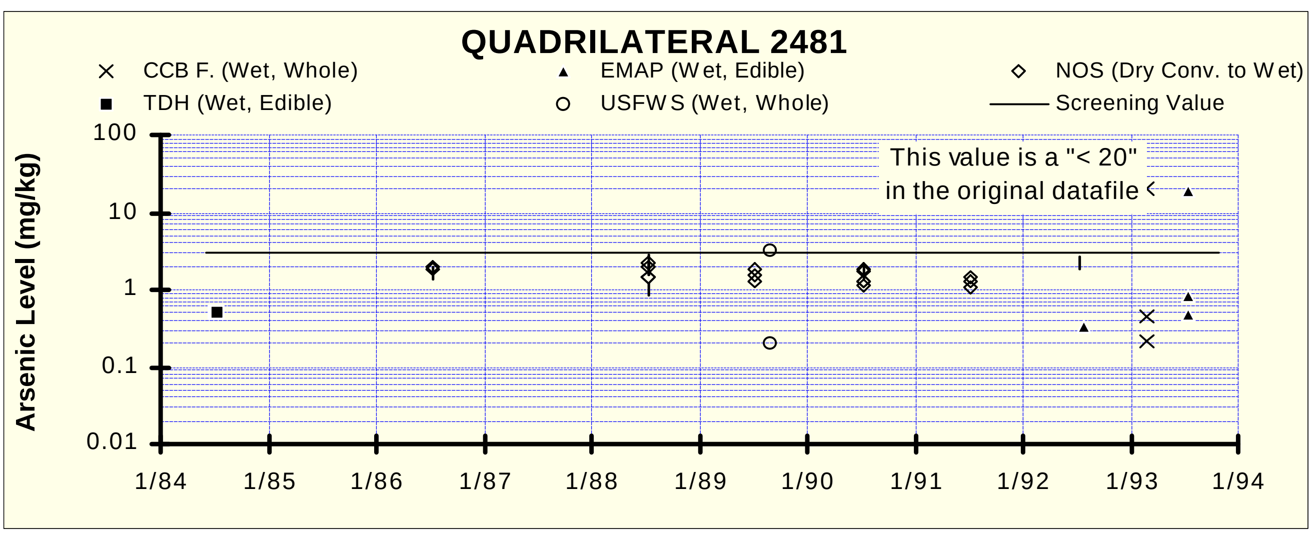
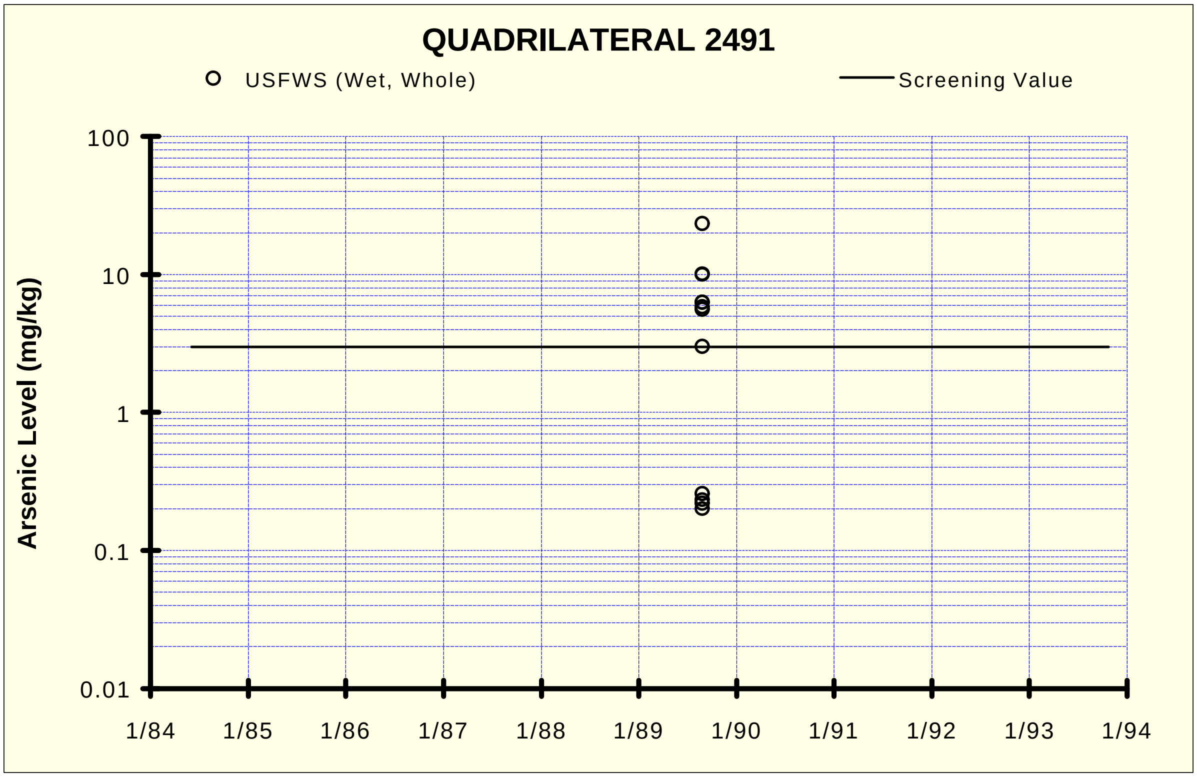


FIGURE V.2 (Concluded)
ARSENIC LEVELS IN TISSUE



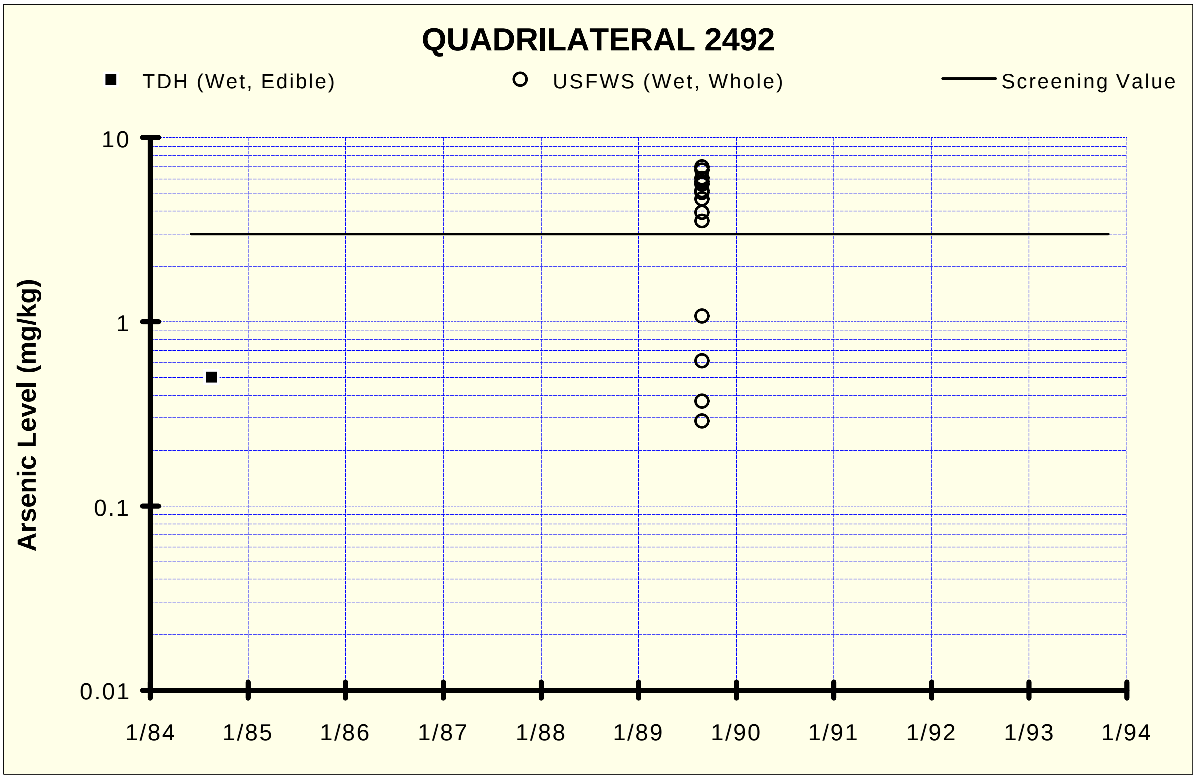


TABLE V.5
SUMMARY OF AVAILABLE ZINC TISSUE DATA IN PPM FOR CCBNEP AREAS

Quadri-lateral	Data Source	Data[1] Type	Above Detection Limits						Below Detection Limits		
			No. of Data	Min.	Avg.	Max.	SV[2]	No. > SV	No. of Data	Min.[3]	Max.[3]
2463	NOS	S (D)	20	27.5	93.023	190.5			0		
2463	TDH	F	23	2.8	54.496	130			0		
2463	USCE7	S	14	23	33.014	58			0		
2471 A	EMAP	F	3	6.98	8.47	9.29			0		
2471 A	NOS	S (D)	20	26.9	209.87	816			0		
2471 A	TDH	F	16	3	47.094	240			0		
2471 B	TDH	F	11	2.8	138.7	260			0		
2472	EMAP	F	11	0.83	7.0156	16.4			0		
2472	NOS	S (D)	19	57.8	201.93	351			0		
2472	TDH	F	15	3.4	67.827	190			0		
2481 A	CCB Found.	S	3	11	14	17			0		
2481 A	EMAP	F	1	5.81	5.81	5.81			0		
2481 A	NOS	S (D)	16	141	520.42	930			0		
2481 B	EMAP	F	2	7.81	7.9	7.99			0		
2481 B	NOS	S (D)	6	914	974.25	1003.5			0		
2481 C	EMAP	F	1	7.62	7.62	7.62			0		
2481 D	NOS	S (D)	3	324	550	666			0		
2481 D	TDH	F	17	3.8	97.182	520			0		
2481 D	USFWS-CCB	S	2	4.19	15.945	27.7			0		
2482 B	USFWS-CCB	S	4	25.6	559.15	1050			0		
2482 C	EMAP	F	1	6.93	6.93	6.93			0		
2482 C	TDH	F	5	13	38.4	53			0		
2482 D	TDH	F	12	3.9	913.22	1800			0		
2482 D	USFWS-CCB	S	2	22.5	127.75	233			0		
2482 E	NOS	S (D)	17	444	669.09	975			0		
2482 E	TDH	F	11	3.9	313.85	1670			0		
2482 E	USFWS-CCB	S	4	1.59	245.57	941			0		
2483	EMAP	F	1	3.82	3.82	3.82			0		
2484 A	USFWS-CCB	S	2	24.3	180.15	336			0		
2484 C	USFWS-CCB	S	3	33.1	797.7	1660			0		
2491 A	USFWS-CCB	S	8	3.89	85.289	241			0		
2491 B	TDH	F	8	1	14.713	48			0		
2491 B	USFWS-CCB	S	4	13.6	20.925	34.8			0		
2492	TDH	F	11	3	6.8818	34			0		
2492	USFWS-CCB	S	14	0.37	65.399	165			0		

Note:

[1]S(D) = wet weight converted from dry weight (NOS oyester data, assume 85% water content), S = wet weight based on whole tissue, F = wet weight based on edible tissue.

[2]SV = Screening Values. Values in the table are from EPA Guidance For Assessing Chemical Contaminant Data For Use In Fish Advisories (1995), EPA 823-R-95-007.

[3]Zero values in the columns indicate that the detection limits are not reported (either a blank or "None" were in the original data files.)

TABLE V.6
SUMMARY OF PAH AND PCB TISSUE DATA IN PPM FOR CCBNEP AREAS

Quadri-lateral	Data Source	Data[1] Type	Above Detection Limits						Below Detection Limits		
			No. of Data	Min.	Avg.	Max.	SV[2]	No. > SV	No. of Data	Min.[3]	Max.[3]
TOTAL PAHs											
2463	NOS	S (D)	6	0.005	0.032	0.060	0.01	4			
2471 A	NOS	S (D)	6	0.007	0.031	0.058	0.01	5			
2472	NOS	S (D)	5	0.009	0.061	0.116	0.01	4			
2481 A	NOS	S (D)	4	0.006	0.040	0.091	0.01	3			
2481 B	NOS	S (D)	2	0.073	0.105	0.136	0.01	2			
2481 D	NOS	S (D)	1	0.025	0.025	0.025	0.01	1			
2482 E	NOS	S (D)	7	0.005	0.056	0.121	0.01	6			
PCBs											
2101 B	TNRCC	S							1	0.04	0.04
2463	TDH	F	0						13	0	0
2463	USCE7	S	0						14	10	10
2471 A	EMAP	F	1	0.006	0.0059	0.0059	0.01	0			
2471 A	TDH	F	0						13	0	0
2471 A	TNRCC	S	0						2	1	1
2471 B	TDH	F	0						8	0	0
2472	EMAP	F	10	6E-04	0.0039	0.0118	0.01	1			
2472	TDH	F	0						13	0	0
2473	TNRCC	S	0						1	0.04	0.04
2481 A	EMAP	F	1	0.004	0.0038	0.0038	0.01	0			
2481 B	TNRCC	S	2	0.08	0.09	0.1	0.01	2	7	0.04	0.04
2481 C	TNRCC	S	1	0.18	0.18	0.18	0.01	1			
2481 D	TDH	F	0						15	0	0
2482 C	EMAP	F	1	0.001	0.0014	0.0014	0.01	0			
2482 C	TDH	F	0						3	0	0
2482 D	TDH	F	5	0.023	0.049	0.078	0.01	5	3	0	0
2482 E	TDH	F	0						2	0	0
2483	TNRCC	S	1	0.081	0.081	0.081	0.01	1			
2484 C	TNRCC	S	11	0.021	0.2037	1	0.01	11	3	0.02	0.02
2484 D	TNRCC	S	1	0.062	0.062	0.062	0.01	1			
2491 B	TDH	F	0						8	2E-05	0.02
2491 B	TNRCC	S	0						5	0.04	0.04
2492	TDH	F	0						6	0	0
2492	TNRCC	S	0						1	0.04	0.04

Note:
[1]S(D) = wet weight converted from dry weight (NOS oyester data, assume 85% water content), S = wet weight based on whole tissue, F = wet weight based on edible tissue.
[2]SV = Screening Values. Values in the table are from EPA Guidance For Assessing Chemical Contaminant Data For Use In Fish Advisories (1995), EPA 823-R-95-007.
[3]Zero values in the columns indicate that the detection limits are not reported (either a blank or "None" were in the original data files.)

many of the values were the same numerical value. This suggests that these were in fact detection levels and that the "<" symbol had been lost in the translation. If this is the case, there is actually no exceedance of the total PAH screening level.

In the case of the total PCBs, it was found that the database contained actual total PCB observations and no summation of cogeners was necessary. From Table V.6, most of the SV exceedances are in segments 2481 (Corpus Christi Bay), 2482 (Nueces Bay) and 2484 (Inner Harbor). Table V.7 is a listing of the raw data for these three segments. Among the noteworthy aspects of this table are: a) much of the data are relatively old, b) the older TDH data did not retain the detection limit with the dataset, and c) the observations are roughly equally divided between whole fish (S) and filet (F), with all observations being on a wet-weight basis. Of the 26 samples in Corpus Christi Bay, only 3 exceed the SV of 0.01 ppm. In contrast, of the 15 samples from the Inner Harbor, 12 exceed the SV. Nueces Bay is intermediate with 6 of 14 samples exceeding the SV.

While there may be actual spatial differences, a few cautionary notes are in order. One is that based on the detection limits reported in the TNRCC data (0.04 or 0.02 ppm) the test was not able to measure to the level of the SV (0.01 ppm). A similar situation probably exists for the TDH data as the TDH laboratory was performing analyses for the TNRCC-TWC-TDWR during most of this time. While some of the data are quite high, most are close to the reported detection limits. Anytime data are reported at levels close to the detection limit, a certain amount of caution is in order. This is particularly true when the EMAP data are considered. While only two samples are available in these segments, these were analyzed with more sensitive equipment, and both values are well below the SV.

Based on this data, there appears to be a need for additional analysis of PCBs in fish tissue from the Inner Harbor and Nueces Bay using modern analytical methods. It is questionable whether the existing data are sufficiently robust to warrant administrative action.

In addition to the PCB situation, there were three additional samples that exceeded SVs. The first is one sample out of 19 of Benzo-A-Pyrene in segment 2472 (Copano Bay) which exceeded the 0.0147 ppm SV by a small (12%) margin. Chrysene had exactly the same numerical result in the same segment, suggesting the possibility of a data problem. Both of these results were with NOS oyster data. The third example was Dieldrin in Corpus Christi Bay whole fish tissue. In this case, two TNRCC samples exceeded the SV, but the remainder of the 43 observations were well below the value.

V.3 DISCUSSION

The available tissue data for the study area have been compiled and compared to current EPA screening values for metals, organics and pesticides. Table V.8 provides a summary of the exceedance percentage for each segment in the study area. Overall, there appears to be very few examples of tissue concentrations that exceed the screening values. This suggests that overall, the risks associated with consumption of seafood caught in the study area are quite small.

TABLE V.7
TISSUE PCB DATA IN SEGMENTS 2481, 2482 AND 2484

Quadrilateral	Source	Date	Organisms	Value (ppm)		Lat	Long	Type[1]
2481A	EMAP	07/29/92	Atlantic croaker		0.00378	27°50'14"	97°16'12"	F
2481B	TNRCC	05/28/86	fin perch	<	0.04	27°48'40"	97°18'04"	S
2481B	TNRCC	08/05/87	pigfish		0.08	27°48'40"	97°18'04"	S
2481B	TNRCC	08/05/87	tarpon	<	0.04	27°48'40"	97°18'04"	S
2481B	TNRCC	06/06/88	spotted seatrout	<	0.04	27°48'40"	97°18'04"	S
2481B	TNRCC	08/15/89	spotted seatrout	<	0.04	27°48'40"	97°18'04"	S
2481B	TNRCC	08/15/89	spotted seatrout	<	0.04	27°48'40"	97°18'04"	S
2481B	TNRCC	08/08/90	spotted seatrout	<	0.04	27°48'40"	97°18'04"	S
2481B	TNRCC	08/09/90	spotted seatrout	<	0.04	27°48'40"	97°18'04"	S
2481B	TNRCC	07/23/91	spotted seatrout		0.1	27°48'40"	97°18'04"	S
2481C	TNRCC	06/18/75	whiting		0.18	27°42'32"	97°18'29"	S
2481D	TDH	07/06/84	BLUE CRAB COMP	<	0	27°38'60"	97°14'00"	F
2481D	TDH	07/06/84	SPECKLED TROUT	<	0	27°38'60"	97°14'00"	F
2481D	TDH	07/06/84	BLUE CRAB COMP	<	0	27°38'60"	97°14'00"	F
2481D	TDH	07/06/84	BLACK DRUM	<	0	27°38'60"	97°14'00"	F
2481D	TDH	07/06/84	RED DRUM	<	0	27°38'60"	97°14'00"	F
2481D	TDH	07/06/84	BLACK DRUM	<	0	27°38'60"	97°14'00"	F
2481D	TDH	07/06/84	OYSTER COMP	<	0	27°39'30"	97°12'45"	F
2481D	TDH	07/06/84	MERCENARIA (clam)	<	0	27°39'30"	97°12'45"	F
2481D	TDH	07/09/84	OYSTER COMP	<	0	27°46'15"	97°07'45"	F
2481D	TDH	07/09/84	RED DRUM	<	0	27°46'15"	97°07'45"	F
2481D	TDH	07/09/84	OYSTER COMP	<	0	27°46'15"	97°07'45"	F
2481D	TDH	07/09/84	RED DRUM	<	0	27°46'15"	97°07'45"	F
2481D	TDH	07/10/84	BLUE CRAB COMP	<	0	27°46'15"	97°07'45"	F
2481D	TDH	07/10/84	BLACK DRUM	<	0	27°46'15"	97°07'45"	F
2481D	TDH	07/10/84	RED DRUM	<	0	27°46'15"	97°07'45"	F
2482C	EMAP	07/23/93	Atlantic croaker		0.00136	27°50'08"	97°26'41"	F
2482C	TDH	09/23/82	SHRIMP COMP	<	0	27°50'30"	97°27'15"	F
2482C	TDH	09/23/82	BLUE CRAB COMP	<	0	27°50'30"	97°27'15"	F
2482C	TDH	09/23/82	BLUE CRAB COMP	<	0	27°50'30"	97°27'15"	F
2482D	TDH	05/05/80	OYSTERS COMP		0.078	27°50'30"	97°25'45"	F
2482D	TDH	09/23/82	SHEEPSHEAD		0.046	27°50'30"	97°25'45"	F
2482D	TDH	09/23/82	OYSTER COMP		0.054	27°50'30"	97°25'45"	F
2482D	TDH	09/23/82	OYSTER COMP	<	0	27°50'30"	97°25'45"	F
2482D	TDH	09/23/82	BLACK DRUM	<	0	27°50'30"	97°25'45"	F
2482D	TDH	09/24/82	BLACK DRUM		0.023	27°50'30"	97°25'45"	F
2482D	TDH	09/24/82	BLACK DRUM	<	0	27°50'30"	97°25'45"	F
2482D	TDH	03/10/83	OYSTERS		0.044	27°50'30"	97°25'00"	F
2482E	TDH	07/12/84	BLUE CRAB COMP	<	0	27°50'30"	97°24'15"	F
2482E	TDH	07/13/94	BLACK DRUM	<	0	27°50'30"	97°24'15"	F
2484C	TNRCC	10/20/77	spotted seatrout		0.033	27°49'08"	97°27'14"	S
2484C	TNRCC	10/20/77	spotted seatrout		0.185	27°49'08"	97°27'14"	S
2484C	TNRCC	10/20/77	Spanish mackerel		0.37	27°49'08"	97°27'14"	S
2484C	TNRCC	10/20/77	perch	<	0.02	27°49'08"	97°27'14"	S
2484C	TNRCC	11/30/78	spotted seatrout		0.021	27°49'08"	97°27'14"	S
2484C	TNRCC	11/30/78	spotted seatrout		0.032	27°49'08"	97°27'14"	S
2484C	TNRCC	11/30/78	spotted seatrout		0.035	27°49'08"	97°27'14"	S
2484C	TNRCC	11/30/78	spotted seatrout		0.11	27°49'08"	97°27'14"	S
2484C	TNRCC	11/30/78	spotted seatrout		1	27°49'08"	97°27'14"	S
2484C	TNRCC	11/30/78	spotted seatrout	<	0.02	27°49'08"	97°27'14"	S
2484C	TNRCC	11/30/78	spotted seatrout	<	0.02	27°49'08"	97°27'14"	S
2484C	TNRCC	08/08/90	spotted seatrout		0.151	27°49'08"	97°27'14"	S
2484C	TNRCC	08/08/90	spotted seatrout		0.184	27°49'08"	97°27'14"	S
2484C	TNRCC	08/06/91	spotted seatrout		0.12	27°49'08"	97°27'14"	S
2484D	TNRCC	12/02/77	spotted seatrout		0.062	27°49'12"	97°25'44"	S

[1]Type: S = whole, wet, F = filet, wet, D = whole, dry.

TABLE V.8
PERCENTAGES OF TISSUE DATA EXCEEDING SCREENING VALUES BY SEGMENT

Segment	Total No. of Data	No. of Data > SV	Percent
METALS[1]			
2101	1	0	0.00%
2463	417	0	0.00%
2471	358	1	0.28%
2472	364	1	0.27%
2481	427	2	0.47%
2482	423	0	0.00%
2483	9	0	0.00%
2484	50	0	0.00%
2491	176	8	4.55%
2492	200	10	5.00%
PAHs[2]			
2101	16	0	0.00%
2463	230	4	1.74%
2471	146	5	3.42%
2472	140	6	4.29%
2473	16	0	0.00%
2481	203	6	2.96%
2482	126	6	4.76%
2483	16	0	0.00%
TOTAL PCBs[3]			
2101	1	0	0.00%
2463	27	0	0.00%
2471	26	2	7.69%
2472	23	1	4.35%
2473	1	0	0.00%

[1]All are arsenic exceedences.

[2]See text regarding data. All are total PAHs exceedences except for segment 2472, which has 4 total PAHs, 1 benzo-a-pyrene and 1 chrysene exceedences.

[3]All are total PCBs exceedences except for segment 2471, which has 2 aroclor exceedences.

TABLE V.8 (Concluded)
PERCENTAGES OF TISSUE DATA EXCEEDING SCREENING VALUES BY SEGMENT

Segment	Total No. of Data	No. of Data > SV	Percent
2481	26	3	11.54%
2482	14	5	35.71%
2483	1	1	100.00%
2484	15	12	80.00%
2491	13	0	0.00%
2492	7	0	0.00%
PESTICIDES[4]			
2101	28	0	0.00%
2463	319	0	0.00%
2471	225	0	0.00%
2472	280	0	0.00%
2473	29	0	0.00%
2481	450	2	0.44%
2482	166	0	0.00%
2483	42	0	0.00%
2484	255	0	0.00%
2491	112	0	0.00%
2492	32	0	0.00%
OTHER ORGANICS			
2101	40	0	0.00%
2471	2	0	0.00%
2472	2	0	0.00%
2473	40	0	0.00%
2481	37	0	0.00%
2483	42	0	0.00%
2484	31	0	0.00%
2491	12	0	0.00%

[4]All are dieldrin exceedences.

From this review there are two situations which appear to warrant more investigation. One is the zinc levels in oysters in Nueces Bay and the other is PCB levels in fish tissue from the Inner Harbor and Nueces Bay. In both cases, additional data collection using sensitive methods is needed to confirm a possible spatial pattern and shed light on possible sources.

VI. DISEASE INCIDENTS

The purpose of this section is to review the available data on water-related diseases, with special emphasis on the *Vibrio* organism. The section also investigates the possible relationship between indicator organism levels and other public health issues, particularly known pathogenic microorganisms in Corpus Christi Bay.

VI.1 REVIEW OF TDH DISEASE DATA

The TDH maintains a statewide system of statistics on a wide range of diseases. When any of a specified list of diseases is encountered by medical professionals, they are required to report the disease to the TDH. These are termed "notifiable diseases". Table VI.1 is a summary of the notifiable diseases which had a significant number of occurrences in the study area.

Table VI.1 is also a compilation of information on the notifiable diseases including the type of organism, its habitat, typical method of transmission, relative likelihood of transmission by water contact or seafood consumption, and clinical symptoms. Most of the diseases monitored by the TDH are severe and life threatening and are not necessarily those commonly associated with water activity. For example, EPA (1986) developed its recommended bacterial criteria for contact recreation largely from observations of gastroenteritis, which is a symptom of several of the bacterial diseases listed in Table VI.1, but can also be produced by a range of other diseases. Of the diseases, only non-cholera *Vibrio* infections do not have a source other than study-area waters.

The literature indicates that many of the bacterial diseases and Hepatitis A can be transmitted by water. However, in almost all cases this refers to contaminated drinking water rather than salt water. Coastal waters are unfavorable environments for most pathogenic organisms (except *Vibrio* bacteria). Accordingly, the proportion of the disease incidents likely to occur from contact with bay water is judged to be low in Table VI.1. Similarly, where a disease is reported to be transmitted in a food, it is estimated that the incidents could possibly be proportional to the amount of seafood in the diet. However, it must be recognized that most of these diseases have little or no history of being transmitted in seafood or being contracted by swimming.

Table VI-2 is a summary of the incidents of each disease in each of the counties, the sum of all the counties, and the state as a whole. Table VI-3 provides disease rates per 100,000 population for the six counties and the state as a whole. Note that cholera is listed separately from the general "*Vibrio* infections" even though cholera is caused by a member of the genus *Vibrio*. This has been the case for many years and the "*Vibrio* infections" listing in the TDH files does not include cholera incidents (B. Ray, TDH, 1996). *V. cholera* appears to be the most significant member of the genus capable of living in freshwater and it has historically been the cause of epidemics spread by contaminated drinking water and food (Dixon, 1982). To a first approximation, the rates involved for the six counties do not appear radically different from the statewide totals. An exception is Hepatitis A in recent years where the study area rate appears markedly higher than the state as a whole and the study area during earlier years. Another possible exception is Shigellosis, where the study area rate appears somewhat higher than the entire state.

TABLE VI.1
SUMMARY OF WATER RELATED DISEASES

Diseases[1]	Organism[1]	Habitat[1]	Transmission[1]	Proportion[2] Likely by		Clinical Symptom[1]
				Water Contact	Sea food	
Bacterial Diseases						
Botulism	Clostridium botulinum	ubiquitous in environment	eating contaminated food, spores enter wound	L	P	gastro-intestinal disorder, wound infection
Campylobacteriosis	Camplyobacter sp.	gastro-intestinal tract of various animals	contaminated foods, water, milk	L	P	systemic disease, febrile illness, gastroenteritis
Cholera	Vibrio Cholerae	warm fresh & estuarine waters, marine organisms	contaminated drinking water & food	L	P	severe diarrheal illness
E. coli 015:H7	Escherichia coli serotype	ubiquitous in environment	consumption of undercooked meat	L	P	severe diarrheal illness
Hemolytic uremia syndrome	Escherichia coli	ubiquitous in environment	consumption of undercooked meat	L	P	renal failure
Listerosis	Listeria monocy-togenes	ubiquitous in environment	contaminated dairy products, and vegetables	L	P	sepsis, meningitis, febrile illness
Salmonellosis	Salmonella sp.	poultry	consumption of contaminated meat and dairy products	L	P	severe gastroenteritis, febrile illness
Shigellosis	Shigella sp.	human reservoir	fecal-oral route	L	P	gastroenteritis, bacterial dysentery
Vibrio Infections	Vibrio sp.	Warm estuarine water and marine organisms	seafood consumption water contact	H	P	gastroenteritis, wound infections, sepsis, death
Viral Diseases						
Encephalitis	enteroviruses, mumps virus, herpes simplex virus	gastro-intestinal, respiratory, and genital tract of humans and animals	mosquito vector previous viral infection	R	R	inflammations of brain parenchyma
Hepatitis A	Hepatitis A virus (HAV)	human reservoir	exchange of bodily fluids, consump. of contami-nated food or water	L	P	liver disorder, febrile illness, mild diarrhea
Hepatitis B	Hepatitis B virus (HBV)	human reservoir	direct exchange of bodily fluids	R	R	liver disorder, febrile illness, diarrhea
Hepatitis C (non A, non B)	Hepatitis C virus (HCV)	human reservoir	direct exchange of bodily fluids	R	R	liver disorder, febrile illness
Hepatitis D	Hepatitis D virus (HBV)	human reservoir	common transfusion associated hepatitis	R	R	liver disorder, severe diarrheal disease
Yellow Fever	Arbovirus	Insects	mosquito vector	R	R	headache, febrile illness, jaundice, vomiting
Dengue	Arbovirus	Insects	mosquito vector	R	R	febrile illness, rash, severe head, back, and muscle pain
Protozoan Diseases						
Malaria	Plasmodium sp.	Insects	mosquito vector	R	R	febrile illness

[1]Source: Baron, E.J., L.R. Perston, and S.M. Fingold. 1994. Bailey and Scott's Diagnostic Microbiology, Ed. Shanadon, James F., Pb. Mosby-Year Book Inc. pp. 321-634.

[2]R = Remote, L = Low, P = Proportional to seafood in diet, H = High.

TABLE VI.2

SUMMARY OF TDH DISEASE DATA IN STUDY AREA

DISEASES	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986
ARANSAS COUNTY										
BOTULISM										
CAMPYLOBACTERIOSI		2								
CHOLERA										
DENGUE										
E. COLI O157:H7			NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS										
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A		1	1		1	1				1
HEPATITIS B			1	3		1	2	1	3	6
HEPATITIS C										
HEPATITIS D										
HEPATITIS NA-NB										
HEP UNSPECIFIED							1			1
LISTERIOSIS								1		
MALARIA										
SALMONELLOSIS		4	3	3	3	4	3	5	1	2
SHIGELLOSIS					1			1		
VIBRIO INFECTIONS					1				1	
YELLOW FEVER										
KENEDY COUNTY										
BOTULISM										
CAMPYLOBACTERIOSI										
CHOLERA										
DENGUE										
E. COLI O157:H7			NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS										
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A										1
HEPATITIS B										
HEPATITIS C										
HEPATITIS D										
HEPATITIS NA-NB										
HEP UNSPECIFIED										
LISTERIOSIS										
MALARIA										
SALMONELLOSIS			1							1
SHIGELLOSIS						1				1
VIBRIO INFECTIONS										
YELLOW FEVER										

TABLE VI.2 (Continued)

SUMMARY OF TDH DISEASE DATA IN STUDY AREA

DISEASES	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986
KLEBERG COUNTY										
BOTULISM										
CAMPYLOBACTERIOSI		5	1	1	2		1	1	3	
CHOLERA										
DENGUE										
E. COLI O157:H7			NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS					1					
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A		1	1	6	9	4	8	10		5
HEPATITIS B		4	1	2	6	2	3	1		
HEPATITIS C			1							
HEPATITIS D										
HEPATITIS NA-NB										1
HEP UNSPECIFIED			1			1	1			1
LISTERIOSIS										
MALARIA										
SALMONELLOSIS		9	5	14	7	11	11	6	16	5
SHIGELLOSIS		6	6	9	12		2	4	10	5
VIBRIO INFECTIONS										
YELLOW FEVER										
NUECES COUNTY										
BOTULISM										
CAMPYLOBACTERIOSI		26	19	18	22	14	6	10	19	19
CHOLERA										
DENGUE										3
E. COLI O157:H7		1	NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS				1		1	1			
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A		278	113	10	31	47	25	14	19	39
HEPATITIS B		32	30	22	33	40	37	34	46	71
HEPATITIS C		8	9	7	1					
HEPATITIS D										
HEPATITIS NA-NB						3			1	6
HEP UNSPECIFIED				4	4	11	5	14	6	19
LISTERIOSIS		3							1	
MALARIA					1	2		1		1
SALMONELLOSIS		80	57	51	46	60	66	90	102	89
SHIGELLOSIS		78	150	73	38	100	50	33	34	37
VIBRIO INFECTIONS		1			1		1		1	
YELLOW FEVER										

TABLE VI.2 (Continued)
SUMMARY OF TDH DISEASE DATA IN STUDY AREA

DISEASES	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986
REFUGIO COUNTY										
BOTULISM										
CAMPYLOBACTERIOSI										
CHOLERA										
DENGUE										
E. COLI O157:H7			NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS										
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A			1							
HEPATITIS B										
HEPATITIS C				1						
HEPATITIS D										
HEPATITIS NA-NB										
HEP UNSPECIFIED										
LISTERIOSIS										
MALARIA										
SALMONELLOSIS		3	4				1	1		
SHIGELLOSIS								3		
VIBRIO INFECTIONS										
YELLOW FEVER										
SAN PATRICIO COUNTY										
BOTULISM										
CAMPYLOBACTERIOSI		4		2	3	2		3		1
CHOLERA										
DENGUE										
E. COLI O157:H7			NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS										
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A		14	10	3	4	13	3	7	9	5
HEPATITIS B		7	6	9	5	4	3	5	7	6
HEPATITIS C			1							
HEPATITIS D						1				
HEPATITIS NA-NB				5			1	3	3	1
HEP UNSPECIFIED										
LISTERIOSIS										
MALARIA										
SALMONELLOSIS		14	19	18	18	16	20	22	15	8
SHIGELLOSIS		15	10	22	13	15	15	35	9	4
VIBRIO INFECTIONS									1	
YELLOW FEVER										

TABLE VI.2 (Concluded)

SUMMARY OF TDH DISEASE DATA IN STUDY AREA

DISEASES	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986
TOTAL OF THE SIX COUNTIES										
BOTULISM										
CAMPYLOBACTERIOSI		37	20	21	27	16	7	14	22	20
CHOLERA										
DENGUE										3
E. COLI O157:H7		1	NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS				1	1	1	1			
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A		294	126	19	45	65	36	31	28	51
HEPATITIS B		43	38	36	44	47	45	41	56	83
HEPATITIS C		8	11	8	1					
HEPATITIS D						1				
HEPATITIS NA-NB				5		3	1	3	4	8
HEP UNSPECIFIED			1	4	4	12	7	14	6	21
LISTERIOSIS		3						1	1	
MALARIA					1	2		1		1
SALMONELLOSIS		110	89	86	74	91	101	124	134	105
SHIGELLOSIS		99	166	104	64	116	67	76	53	47
VIBRIO INFECTIONS		1			2		1		3	
YELLOW FEVER										
STATE OF TEXAS										
BOTULISM		27	2	1	4	7	4	4	4	5
CAMPYLOBACTERIOSI		997	849	996	810	739	625	745	780	803
CHOLERA		4	2	5	3	0	0	1	0	0
DENGUE		1	2	0	2	0	0	0	0	17
E. COLI O157:H7		72	NR	NR	NR	NR	NR	NR	NR	NR
ENCEPHALITIS		54	61	89	121	74	60	74	118	191
HEMOLY UREM SYND		11	NR	NR	NR	NR	NR	NR	NR	NR
HEPATITIS A		2,877	2,798	1,823	2,663	2,722	3,211	2,739	1,886	2,137
HEPATITIS B		1,422	1,354	1,528	1,958	1,789	1,853	1,654	1,487	1,500
HEPATITIS C		305	384	255						
HEPATITIS D		4	1	5						
HEPATITIS NA-NB		9	28	26	144	130	236	149	161	205
HEP UNSPECIFIED		86	157	191	260	287	530	576	599	854
LISTERIOSIS		64	28	26	52	32	40	45	42	28
MALARIA		93	48	45	75	80	79	73	56	84
SALMONELLOSIS		1,983	1,924	1,933	2,317	2,315	2,277	2,334	2,803	2,445
SHIGELLOSIS		2,410	4,581	3,568	2,178	3,550	1,654	2,826	2,087	2,454
VIBRIO INFECTIONS	23	31	17	15	25	25	17	27	20	
YELLOW FEVER										

NR = NOT REPORTABLE.

TABLE VI.3

DISEASE RATES PER 100,000 POPULATION

DISEASES	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	Min	Avg	Max
TOTAL OF THE SIX COUNTIES													
BOTULISM		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAMPYLOBACTERIOSI		8.59	4.73	5.01	6.57	3.94	1.73	3.36	5.23	4.72	1.73	4.87	8.59
CHOLERA		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DENGUE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.08	0.71
E. COLI O157:H7		0.23	NR	NR	NR	NR	NR	NR	NR	NR	0.23	0.23	0.23
ENCEPHALITIS		0.00	0.00	0.24	0.24	0.25	0.25	0.00	0.00	0.00	0.00	0.11	0.25
HEMOLY UREM SYND			NR	NR	NR	NR	NR	NR	NR	NR			
HEPATITIS A		68.26	29.77	4.53	10.94	15.99	8.91	7.45	6.66	12.04	4.53	18.28	68.26
HEPATITIS B		9.98	8.98	8.58	10.70	11.56	11.14	9.85	13.32	19.59	8.58	11.52	19.59
HEPATITIS C		1.86	2.60	1.91	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.73	2.60
HEPATITIS D		0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.03	0.25
HEPATITIS NA-NB		0.00	0.00	1.19	0.00	0.74	0.25	0.72	0.95	1.89	0.00	0.64	1.89
HEP UNSPECIFIED		0.00	0.24	0.95	0.97	2.95	1.73	3.36	1.43	4.96	0.00	1.84	4.96
LISTERIOSIS		0.70	0.00	0.00	0.00	0.00	0.00	0.24	0.24	0.00	0.00	0.13	0.70
MALARIA		0.00	0.00	0.00	0.24	0.49	0.00	0.24	0.00	0.24	0.00	0.13	0.49
SALMONELLOSIS		25.54	21.03	20.51	17.99	22.39	25.00	29.79	31.88	24.79	17.99	24.32	31.88
SHIGELLOSIS		22.98	39.22	24.80	15.56	28.54	16.58	18.26	12.61	11.10	11.10	21.07	39.22
VIBRIO INFECTIONS		0.23	0.00	0.00	0.49	0.00	0.25	0.00	0.71	0.00	0.00	0.19	0.71
YELLOW FEVER		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STATE OF TEXAS													
BOTULISM		0.15	0.01	0.01	0.02	0.04	0.02	0.02	0.02	0.03	0.01	0.04	0.15
CAMPYLOBACTERIOSI		5.42	4.82	5.64	4.67	4.35	3.75	4.42	4.65	4.81	3.75	4.73	5.64
CHOLERA		0.02	0.01	0.03	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.03
DENGUE		0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.10	0.00	0.01	0.10
E. COLI O157:H7		0.39	NR	NR	NR	NR	NR	NR	NR	NR	0.39	0.39	0.39
ENCEPHALITIS		0.29	0.35	0.50	0.70	0.44	0.36	0.44	0.70	1.14	0.29	0.55	1.14
HEMOLY UREM SYND		0.06	NR	NR	NR	NR	NR	NR	NR	NR	0.06	0.06	0.06
HEPATITIS A		15.65	15.89	10.33	15.35	16.02	19.26	16.27	11.24	12.81	10.33	14.76	19.26
HEPATITIS B		7.74	7.69	8.65	11.29	10.53	11.11	9.82	8.86	8.99	7.69	9.41	11.29
HEPATITIS C		1.66	2.18	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	2.18
HEPATITIS D		0.02	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03
HEPATITIS NA-NB		0.05	0.16	0.15	0.83	0.77	1.42	0.88	0.96	1.23	0.05	0.72	1.42
HEP UNSPECIFIED		0.47	0.89	1.08	1.50	1.69	3.18	3.42	3.57	5.12	0.47	2.32	5.12
LISTERIOSIS		0.35	0.16	0.15	0.30	0.19	0.24	0.27	0.25	0.17	0.15	0.23	0.35
MALARIA		0.51	0.27	0.25	0.43	0.47	0.47	0.43	0.33	0.50	0.25	0.41	0.51
SALMONELLOSIS		10.79	10.93	10.95	13.36	13.63	13.66	13.86	16.70	14.65	10.79	13.17	16.70
SHIGELLOSIS		13.11	26.01	20.21	12.55	20.90	9.92	16.78	12.43	14.71	9.92	16.29	26.01
VIBRIO INFECTIONS	0.13	0.17	0.10	0.08	0.14	0.15	0.10	0.16	0.12	0.00	0.00	0.11	0.17
YELLOW FEVER		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Population data used for rates were based on U.S. Census Bureau and TWDB database.

The diseases that are transmitted by insects (primarily mosquitos) are Dengue, Encephalitis, Yellow Fever, and Malaria. The average rate for Dengue in the study area is slightly above the statewide rate (0.08 versus 0.01 per 100,000 population) while the Encephalitis and Malaria rates are lower (0.11 versus 0.55 and 0.13 versus 0.41, for area versus state, respectively) and there was a zero rate for Yellow Fever overall. Based on these results, it would appear that diseases transmitted by insects are not a significant concern for the study-area.

VI.2 THE *VIBRIO* ORGANISM

Among the pathogens listed in Table VI.1, *Vibrios* are of primary concern to the CCBNEP because their primary source is the waters of the study-area, they have medical significance and because of their ability to be transmitted through various contact and noncontact recreational activities and the consumption of seafood. This section summarizes local results and relevant literature on the organism.

The TDH data on *Vibrio* from the study area summarized in Table VI.4 indicates the number of reported incidents in the study area is fairly small. The disease rates per 100,000 population computed in Table VI.3 show more variability than the state as a whole, reflecting the smaller population. The slightly higher average rate per 100,000 population (0.19 for the area versus 0.11 for the entire state) may reflect the greater opportunity for water contact afforded the population in a coastal location.

Vibrio is a bacterial genus containing Gram-negative, rod-shaped, aerobic bacteria which utilize glucose fermentatively and are widespread in many natural aquatic environments. The genus *Vibrio* contains eleven species which are pathogenic for humans. Those of prime medical concern are *V. cholerae, V. parahaemolyticus* and *V. vulnificus*. Other organisms implicated as opportunistic pathogens are *V. alginolyticus*, *V. damsela*, *V. fluvialis*, *V. furnissii*, *V. hollisae*, *V. mimicus*, *V. metschnikovii* and *V. cincinnatiensis* (Morris and Black, 1985; Brayton et al. 1986). A few species are economically important pathogens of fish and shellfish. *V. cholerae* can live in fresh water, but most of the others require saltwater.

Human pathogenic *Vibrios* are naturally-occurring in aquatic environments that are apparently free from endemic disease. The microbial ecology of these pathogens becomes important because this significantly dictates the occurrence and epidemiology of human infections (West, 1989). The environmental conditions which appears to influence the survival of pathogenic *Vibrios* include water temperature, salinity, sediment conditions, nutrient concentrations, and association with higher marine and land organisms.

Water temperature appears to be the single most important factor governing the incidence and density of *pathogenic Vibrios.* Pathogenic *vibrios* are found more frequently in environments whose water temperature exceeds 10°C (50°F) for at least several consecutive weeks (Bockemuhl et al. 1986; Rhode, Smith, and Ogg, 1986; Chan et al. 1989). In some regions this threshold temperature may be higher. Most pathogenic *Vibrios* rapidly disappear from the water column at temperatures below 10°C but can persist in sediments. Under more favorable environmental conditions *Vibrios* can proliferate and reemerge in the water (Williams & La Rock, 1985). At the other extreme,

TABLE VI.4
CASES OF VIBRIO INFECTIONS IN STUDY AREA[1]

Year	Month	Organism	Age	Sex	Specimen[2]	Died	Exposure	Site	Activity
ARANSAS COUNTY									
1995									
1994									
1993									
1992									
1991									
1990									
1989									
1988	7	*parahaemolyticus*	22	M	SP	N	water	Gulf of Mexico	swimming
1987	6	*vulnificus*	76	M	S	N	seawater	Ingleside Bay	fishing scratched hand
NUECES COUNTY									
1995									
1994	6	*alginolyticus*	6	M	W	N	seawater	Padre Island	swimming
1993									
1992									
1991	4	*alginolyticus*	9	M	W	N	seawater	channel	injured with stick while playing
1990									
1989	4	*alginolyticus*	12	F	W	N	seawater	Corpus Christi lake	swimming
1988									
1987	7	*parahaemolyticus*	67	M	W	N	seawater	Corpus Christi bay	unknown
SAN PATRICIO COUNTY									
1995									
1994									
1993									
1992									
1991	5	*vulnificus*	70	F	B	Y	seawater	Copano bay	fishing with shrimp
1990									
1989	10	*vulnificus*	58	M	B	Y	oyster	Louisiana restaurant	eating
1988									
1987									

[1]There were no Vibrio infections reported to the Texas Department of Health by Kenedy, Kleberg, and Refugio Co.
[2]B=blood, S=stool, SP=sputum, W=wound.

pathogenic *Vibrios* are less frequently isolated from natural aquatic environments when water temperatures exceed 30°C (86°F) (Seidler and Evans, 1984; Williams & La Rock, 1985). It would appear that from a temperature limitation standpoint Corpus Christi Bay is ideally suited to *Vibrio* survival in that the water temperature in Corpus Christi Bay is rarely less than 10°C or greater than 30°C.

The role of water temperature was highlighted by Levine and Griffin (1993) in a review of *Vibrio* infections in Gulf Coast states. Figure VI.1, reproduced from this study shows higher *Vibrio* infection rates in warmer months, combined with the strong role played by consuming raw oysters. The study also found that while *V. vulnificus* receives a great deal of interest, in the 1989 data analyzed, *V. parahaemolyticus* and *V. cholerae* accounted for more infections and a similar number of deaths. Of the 121 infections reported, 29 had wound infections and 76% of these were associated with water contact. All patients with primary septicemia had a chronic underlying illness.

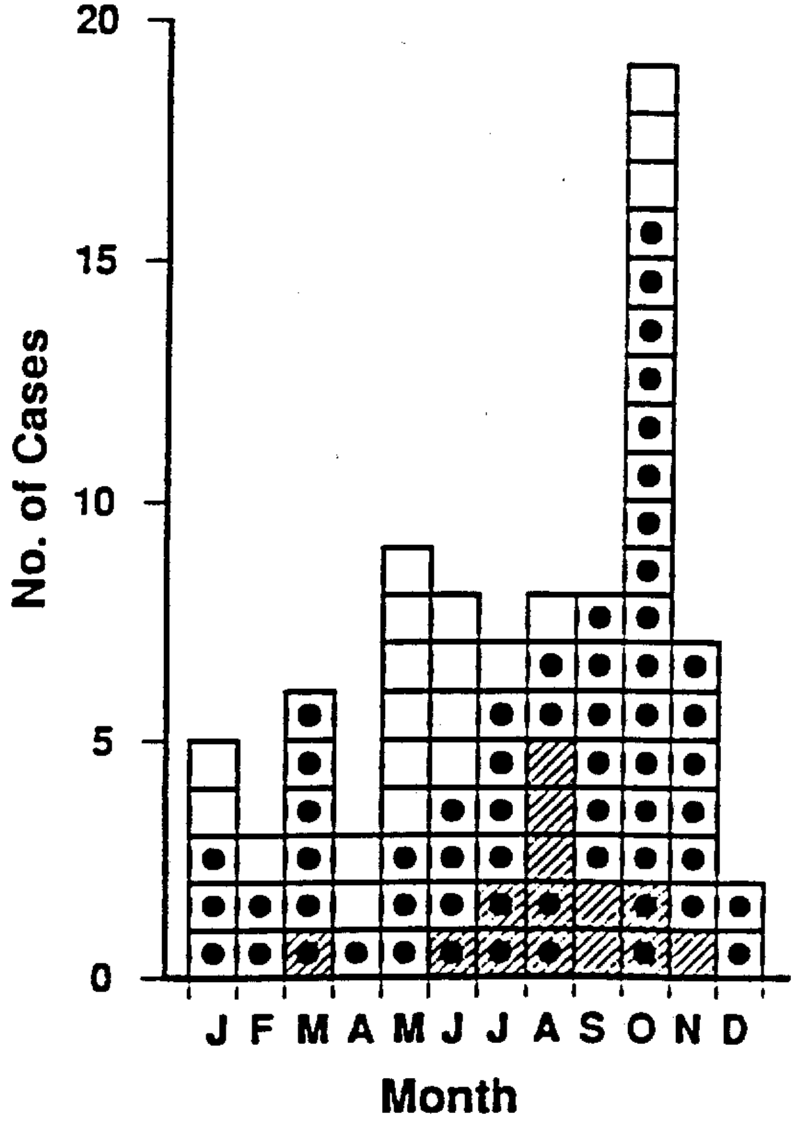
Most pathogenic *Vibrio* species have halophilic characteristics and occur most frequently in water ranging in salinity from 5 to 30 ppt, significantly limiting their presence to estuarine and inshore coastal areas (Lee and West, 1982; Seidler and Evans, 1984; Bockemuhl et al. 1986; Kelly and Dan Stroh, 1988). Pathogenic *Vibrios* may be isolated from some freshwater with less than 5 ppt salinity where it is possible that the interaction of high water temperature and elevated organic nutrient concentration overcomes the deleterious effect of low salinity. *V. cholerae* is non-halophilic and can exist in drinking water supplies that are not disinfected properly as well as estuarine waters. Prolonged survival of pathogenic *Vibrio* species was reported to be possible in high nutrient but low salinity environments (West, 1989).

In the study area, *V. cholerae, V. parahaemolyticus* and *V. vulnificus* were all isolated at a range of swimming beach sites well away from wastewater sources, and also in Oso Bay near an effluent source (Medrano and Mott, 1996). This study found no relation between *Vibrio* levels and salinity, but did find an inverse relation between *V. parahaemolyticus* and Total Coliform bacteria levels.

Most pathogenic *Vibrios* appear to maintain high numbers and prolong their existence by association with a variety of higher organisms in the aquatic environment including plankton, shellfish and fish. In particular the chitin component in plankton appears to enhance significantly this phenomenon of prolonged survival (Huq et al., 1985, 1986). It is likely that, at some stage, all pathogenic *Vibrios* become associated with chitinous parts of planktonic material to both increase numbers of cells in the aquatic environment and to prolong survival in unfavorable conditions (West, 1989).

Oysters and clams may become rapidly contaminated when filter-feeding on planktonic material colonized by pathogenic *Vibrios* and so are often subsequently incriminated as vectors in food-poisoning incidents (Kelly and Dinuzzo, 1985). Association with the flesh of oysters and clams after harvesting prolongs the survival of pathogenic *Vibrios* outside aquatic environments. Storage of contaminated shellfish at inappropriate temperatures can then lead to rapid proliferation of pathogenic *Vibrios* (Karunasagar et al., 1987). Marked seasonal variations of pathogenic *Vibrios*

FIGURE VI.1
VIBRIO INFECTIONS ON THE GULF COAST IN 1989



Cases of *Vibrio* gastroenteritis (□) and primary septicemia (▨) by month of 1989 reported from Alabama, Florida, Louisiana, and Texas. ●, patients who reported eating raw oysters in the week before illness began.

Source: Levine, W.C., P.M. Griffin, and the Gulf Coast *Vibrio* Working Group. 1993. "*Vibrio* Infections on the Gulf Coast: Results of First Year of Regional Surveillance", Journal of Infectious Diseases, Vol. 167, pp. 479-483.

in filter-feeder flesh are often seen since the frequency of contamination is influenced by the numbers of bacteria in the surrounding water column (Kelly and Dan Stroh, 1988; Chan et al. 1989). Crustacean shellfish can also become colonized with pathogenic *Vibrios.* This appears to be dependent on high counts of bacteria in the surrounding water so that it is more commonly observed in warmer climates (Davis and Sizemore, 1982; Huq et al. 1986). Fish from inshore coastal waters and estuaries can be expected to be colonized with low numbers of pathogenic *Vibrios* (West, 1989). The role of land animals in maintaining this pathogenic *Vibrio* in the aquatic environment, and transmitting disease remains unclear (West, 1989). Evidence has been accumulated to suggest that aquatic birds serve as carriers to disseminate *V. cholerae* over wide areas not endemic for cholera (Lee et al. 1982; Ogg, et al., 1989). Interestingly, no other pathogenic *Vibrio* species appear to be harbored by aquatic birds (West, 1989).

Since pathogenic *Vibrio* species occur naturally in marine and estuarine environments, traditional wastewater disinfection has little or no effect on ambient concentrations. An exception is the cholera infection in endemic areas where secondary infections follow contamination of unprotected drinking water supplies or food. Risks of infection with pathogenic *Vibrio* species are most strongly associated with (I) impaired host resistance factors; (ii) occupational or recreational use of natural aquatic environments; and (iii) consumption of contaminated foods, especially seafood (West, 1989).

There is convincing epidemiological evidence that consumption of certain foods, especially raw or lightly cooked seafood and shellfish, is associated with outbreaks of diseases due to pathogenic *Vibrio* species. In particular, infections due to *V. cholerae*, *V. parahaemolyticus* and *V. vulnificus* have been associated with eating raw shellfish (Salmaso et al. 1980; Tacket, Brenner, and Blake, 1984; Levine and Griffin, 1993). Counts of free-living bacteria in water are generally less than required to induce disease in healthy individuals. Increases in number of organisms towards an effective dose can occur as water temperatures rise seasonally followed by growth and concentration of bacteria on higher animals, such as chitinous plankton, or accumulation by shellfish and seafood.

Vibrio infections can be transmitted through various human activities. The most common infection type is gastrointestinal, presumably associated primarily with consumption of seafood. Blood or wound infections are presumably associated with contact and noncontact recreational activities. *V. vulnificus* appears to be most active by this route. Kueh, et al. (1992) investigated the potential for wound infections from marine recreational beaches using artificially-induced wounds in rats. The majority of test organism deaths found in this study were from marine and estuarine bacteria rather than enteric bacteria. Mortality was correlated with FC levels, but deaths were most commonly associated with spread of marine and estuarine organisms (*Vibrio*s prominent) in the blood rather than enteric species.

VI.3 INDICATOR ORGANISMS AND DISEASE RISKS

This section briefly summarizes known information on the relation between the indicator organism (primarily FC) data and disease risk.

Existing FC data compiled in Section IV indicate that waters of the study-area meet applicable criteria for contact recreation. Comparing study-area disease rates with the state as a whole suggests that the study-area is typical of the entire state. This is exactly what would be expected with waters that are suitable for contact recreation.

The data on shellfish harvesting areas reviewed in Section III indicate that the waters of the area are carefully monitored and conservative procedures are followed to restrict harvesting of oysters. The indicator bacteria data indicate areas which are approved for harvesting have concentrations of FC bacteria well below that required by applicable regulations. Similarly, data on toxic substances reviewed in Section V indicates low concentrations of chemicals that might be a concern. Both results tend to suggest that seafood from the area does not pose a significant public health or disease concern. That result appears to be borne out by disease incident data from the area being on a par with statewide figures.

From a different perspective, the *Vibrio* organism does pose a disease risk that is not related to existing indicator organisms (Rodrick, et al. 1984). Medrano and Mott (1996) even noted an inverse relation with TC bacteria. More research on finding a suitable indictor organism to manage this risk more effectively would seem to be in order.

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VII. INJURIES AND ACCIDENTS IN WATER ACTIVITIES

A part of the effort to characterize water-related risks in the study area dealt with physical injuries. As indicated in Section II, a substantial effort was made in contacting police, local health agencies and hospitals to obtain data on water-related injuries and accidents. Table VII.1 is a tabulation of the contacts. Most of these organizations indicated that records which include a persons name are protected by privacy requirements and could not be released without approval from the organization's legal department and incurring fees, presumably for deleting the names from the data. With the resources available to the project it was not practical to overcome these difficulties. One exception was with water-related fatalities where records were provided by the Marine Police of the TPWD.

There was considerable telephone discussion with representatives of the local agencies, and it was possible to characterize the most prevalent injuries at major recreation sites. These were primarily jellyfish stings at major swimming areas such as Magee Beach, North Beach and Padre Island National Seashore, and people falling from rocks at the Corpus Christi Marina.

While most agencies felt they could not provide data for privacy protection reasons, some responses were obtained. The National Park Service responded with the letter reproduced as Table VII.2. The Aransas County Medical Services, Inc. provided a synopsis of recreational accidents during calendar 1995. This is shown in Table VII.3. This is only a very small part of the accident picture and appears to have automobile accidents as well as commercial boating accidents excluded, but it does provide some interesting information. Of the 30 calls received by the Aransas County Emergency Medical Services during 1995 that were associated with recreation, one third were related to water activities such as swimming, fishing, boating or getting on or off of a boat. The next largest category appears to be a tie between bicycling and football, with four incidents each, followed by baseball with three, and the rest relatively rarer events. It would appear that in this coastal county, water-based recreation is popular and entails a substantial number and percentage of all recreational accidents.

Because of problems in obtaining numerical data from the primary sources, it was necessary to resort to newspaper reports. The largest paper, the Corpus Christi Caller Times (CCCT), and the Rockport Pilot newspaper (RP), which has good coastal coverage, were reviewed for the period 1992 to 1995. Table VII.4 provides the initial tabulation from the CCCT and Table VII.5 provides similar information from the RP. In scanning through these tables, two points should be considered. One is that newspaper stories tend to only report larger, more newsworthy incidents. The other is the difficulties in determining which incidents are actually associated with a water activity and which are simply accidents that happened to occur near water. For example, if a knife accident happened while cleaning a fish at a fishing cabin, most would say that is a water-related accident. However, if the same knife wound happened at the same place as a result of a fight, this is not considered water-related accident.

Table VII.6 is a combined tabulation of the water-related incidents in the study area during the last four years that were large enough to be reported in one of the two newspapers. The data are

TABLE VII.1

LIST OF CONTACTS FOR DATA ON INJURIES AND ACCIDENTS

County/City	Agency	Address	Phone No.	Contact	Response
Refugio/Refugio	Dept. of Public Safety	808 Commerce	526-5173	Sylvia	not called out for this type of accident
78377	Sheriff's Office	808 Commerce	526-2351	Joyce Loya	not called on for these
	County Clerk	808 Commerce	526-2233 526-2727	Ida	nothing on record
	Refugio City Police	608 Commerce	526-4533	Josephine	city limits only
	Refugio Rural Health			Donna	records by name only
	Clinic	107 1/2 Swift	526-5328		
Refugio/Bayside 78340	City of Bayside	909 First St.	529-6401		Do not keep that type of record.
Refugio/Woodsboro 78393	City Offices	121 N. Wood	543-4505		Do not keep that type of record.
San Patricio/Sinton	Health Dept.	313 N Rachal Ave.	364-6208		Records of that nature are not kept.
78387	Police Dept.	301 E Market	364-2211		
	Sheriff's Dept.	300 N Rachal Ave.	364-2251	Joanna	Records done daily as they occur, not recorded by type of incident.
San Patricio/	Coastal Bend Hospital	1711 Wheller Ave	758-8585	Mary Ramos	Coordinator position is vacant. Records can not be accessed.
Aransas Pass	Aransas Pass Police	600 W Cleveland	758-5224	Sharon, Arrington	Only involved with death.
San Patricio/Portland	City Hall	900 Moore Ave	643-6501		Do not keep that type of record.
	Police Dept		643-2546		
Nueces/Corpus Christi	Texas Dept of Health, Env. Health	1233 Agnes St.	888-7762		No records of injury.
	Nueces Co. Sheriff		887-2222		
	Nueces Co. Lifeguards	S.P.I.D	949-7023	Cynthia	No access/Privacy Act.
	City-County Health Dept.	1702 Horne Rd.	851-7200		
	C.C. Police Dept.	Adm. calls	886-2600		
		central records	886-2730		
	C.C. Parks & Recreation	1201 Leopard St.	880-3460	Evelyn	Must call city attorney, Norbert Hart.

TABLE VII.1 (Concluded)

LIST OF CONTACTS FOR DATA ON INJURIES AND ACCIDENTS

County/City	Agency	Address	Phone No.	Contact	Response
Nueces/Corpus Christi	City of Corpus Christi		880-3360	Norbert Hart	Due to Privacy Act, records containing names can not be accessed directly. For a fee they might find some information pertaining to us and delete the names.
	C.C. Marina Office	Lawrence T-head	882-7333	Todd Jensen	Has to talk to legal, no access due to Privacy Act.
	Padre Island National Seashore	Malaquite Beach	949-8173	Tom Crowsen	Make a written request. Response: John Miller said he would get us something in a week.
	Memorial Medical Center	7102 Hospital Blvd.	902-4000		By patient, not incident type.
	Bay Area Medical Center	7102 SPID	985-3227		By patient, not incident type.
	Dr's Regional	3315 S. Alameda	857-1400		By patient, not incident type.
	Bayview	6629 Wooldridge	993-9700		By patient, not incident type.
	Spohn Health System	600 Elizabeth	881-3000 985-5000	Spohn Spohn South	By patient, not incident type. By patient, not incident type.
Kenedy/Riviera	Sheriff [Sarita]		294-5205		
	Kleberg Co. Sheriff		296-3203		
	Kenedy Co. Clerk		294-5220		Do not keep that type of record.
Kleberg/Kingsville	Sheriff's Dept.	Admin. calls	595-8500		
78363	City-Co. Health Unit	8604 N Armstrong	592-3324		Not a reportable incident.
	Kingsville Police	203 N Sixth St.	592-4311		
	Spohn Kleberg Memorial	1300 General Cavazos Blvd.	595-1661	Labart Grant	By patient, not incident type.
Aransas/Rockport	Beach Park		749-9302		records by name only
	Health Dept. - Environmental		790-1021		number no longer in service
	Navigation Dist.	Fulton Harbor	729-9122		

TABLE VII.2
LETTER FROM NATIONAL PARK SERVICE

United States Department of the Interior

TAKE PRIDE IN AMERICA

NATIONAL PARK SERVICE
Padre Island National Seashore
9405 South Padre Island Drive
Corpus Christi, Texas 78418

IN REPLY REFER TO:

N16

June 10, 1996

Corpus Christi Bay National Estuary Program
Attn: Dr. Joanna Mott
Texas A&M University- CC
Campus Box 290
6300 Ocean Drive
Corpus Christi, TX 78412

Dear Dr. Mott,

We received your request for release of our records pertaining to human injuries at Bird Island Basin. In reviewing our records, we were able to locate human injuries at the Seashore from 1991-1995. However, our medical assistance records are categorized as to where the injury was treated (usually at our First Aid Station), not were the injury occurred. Consequently, we found very few specific references related to injuries that were treated at Bird Island Basin.

Although we annually have approximately 250,000 visitors at Bird Island Basin, I am not surprised that we have few medical records for injuries treated there, because we generally have very few first aid assistance calls to that particular area. Nevertheless, I have listed all of the injuries that were treated at Bird Island Basin, even though several were not water-related. These include:

<u>1995</u>
1. Fall from motor home - injured legs and feet
2. Cut on foot (minor)

<u>1994</u>
1. Collapsed while windsurfing - exhaustion

<u>1993</u>
1. Cut on foot (minor)

<u>1991</u>
1. Barnacle cut on little toe (minor)
2. Twisted ankle
3. Man-of-War sting on hand

4. Cut on foot (minor)
5. Cut on head (minor)

Thank you for your interest in Padre Island National Seashore. If we can be of further assistance, contact either myself at 937-2621 or John Miller at 949-8173.

Sincerely,

Pat McCrary
Superintendent

TABLE VII.3
SYNOPSIS OF RECREATIONAL ACCIDENTS
YEAR ENDING 1995

01/11/95-	34 year old male fell of bicycle – Non specific injuries – No transport
01/29/95-	Boat hit sandbar in Bay – 35 year old male ejected – fractured femur – Patient transported.
02/01/95-	15 year old male sliding into base on Baseball field – Leg/pelvic injuries – Patient transported.
03/16/95-	12 year old male jumped out of tree – fractured leg – Patient transported.
04/01/95-	41 year old female fell from monkey bars – fractured ankle – Patient transported.
04/09/95-	11 year old male throwing broken – laceration to face – No transport.
05/12/95-	4 year old female fell from bicycle – laceration to forehead – No transport.
05/1/95-	7 year old female kicked “hardhead” catfish – dorsal fin stuck in foot – No transport.
05/19/95-	8 year old male fell of bicycle – dislocated right elbow – Patient transported.
05/20/95-	71 year old male fell of slick bulkhead putting bait bucket in water – critical head injury – Patient transported.
05/20/95-	69 year old female fell while helping above – multiple lacerations – Patient transported.
06/09/95-	6 year old female man-of-war jellyfish sting – No transport.
06/25/95-	24 year old male fell off boat ramp – multiple lacerations – No transport.
07/03/95-	12 year old female slid into base on baseball field – fractured leg – Patient transported.
07/04/95-	87 year old male fell out of boat – facial laceration, fractured nose – No transport.
07/04/95-	54 year old female fell out of boat – forearm laceration arterial bleed – Patient transported.
07/05/95-	16 year old female sustained multiple scrapes and lacerations while trying to climb barnacle covered bulkhead – No transport.
07/06/95-	6 year old male caught foot in pedal of bicycle – fractured digit – No transport.
07/06/95-	12 year old female slid into base on baseball field – dislocated thumb – No transport.
07/07/95-	14 year old female slid into base on baseball field – fractured wrist – Patient transported.
08/23/95-	15 year old female – Cheerleader fell of “pyramid” – spinal injury – Patient transported.
09/02/95-	61 year old female slipped and fell while dancing – Head injury – No transport.
09/09/95-	14 year old male fell off bicycle – fracture forearm – No transport.

TABLE VII.3 (Concluded)
SYNOPSIS OF RECREATIONAL ACCIDENTS
YEAR ENDING 1995

10/05/95-	13 year old male injured while playing football – spinal injury – Patient transported.
10/10/95-	16 year old male injured while playing football – spinal/neck injury – Patient transported.
10/19/95-	14 year old male – injured while playing football – head injury – Patient transported.
10/28/95-	11 year old male – injured while playing football – fractured ankle – Patient transported.
10/29/95-	66 year old female slipped on boat ramp – fractured forearm – Patient transported.
12/16/95-	17 year old male thrown from bull at rodeo – Head/Neck/Chest injuries – Patient transported.
12/22/95-	33 year old male stabbed himself in thigh while cleaning a deer – Arterial bleed – Patient transported.

Source: Aransas County Medical Services, Inc., Aransas County Emergency Medical Services.

TABLE VII.4
INCIDENTS REPORTED IN THE CORPUS CHRISTI CALLER TIMES

Date	Waterbody	Type	Details	Gender	Age	Outcome
01/11/92	Gulf of Mexico, 30 m. east of Port Arnasas	boating accident	two men fell overboard	Male	?	never found
02/10/92	Matagorda Bay	boating accident	two men drowned, two others hospitalized	Males Males	both 19 36&23	death hypothermia
05/05/92	Gulf of Mexico, north of Mustang Island State Park	boat washed ashore	unknown	Male	32	presumed dead
05/10/92	Gulf Intercoastal Waterway, 18 mi. north Port Isabell, intersection with Arroyo, Colorado	tug with barges and two pleasure boats collide	3 passengers of boats, others	Males	23 & 11	death
07/05/92	Gulf of Mexico, 700 ft., north Bob Hall pier	shark attack	shark attacked surfers leash	Male	35	shock
11/22/92	Gulf of Mexico, 5 mi. offshore, 20 mi NE Port Aransas	seagoing jack-up rig capsized	four men rescued by tug, one man missing	Male	?	missing
11/24/92	Aransas Bay, by San Jose Island	body entangled in ships winch	cause of death unknown	Male	39	death
02/20/93	up. Laguna Madre, 1 mi. south of JFK Causeway	accidental drowning	biologist drowns sampling	Male	40	drowned
03/13/93	Corpus Christi Bay, near Demit Island	accidental drowning	shrimp boat capsized in storm	Male	47	drowned
07/02/93	Baffin Bay	fisherman shot at his Baffin Bay cabin	shot 4 times w/20 gauge shotgun	Male	28	death
07/26/93	Corpus Christi Bay	accidental drowning - fell off a tug boat	entangled in lines at rear of boat	Male	mid 40's	drowned
07/27/93	Lydia Ann Channel near Port Aransas	shrimper collided with tug boat	2 treated for fuel ingestion & lacerations one missing	Males Male	46 & ? 58	treated &released death
07/27/93	Corpus Christi Bay	jumped off harbor bridge	not suicide, seeking a thrill	Male	21	missing
11/07/93	Aransas Bay	boat capsized	4 men out for weekend camping, 1 missing	Males Male	23,31&33 ?	hypothermia presumed dead
05/30/94	Gulf of Mexico, Nueces County beaches	jellyfish stings [90% Portuguese man-of-war]	Saturday - 300 reports Sunday - 200 reports reported for 1993: 349 jelly fish stings, 90 cuts, 26 stingray			
12/19/94	Gulf of Mexico, Bob Hall pier	heart attack	on 12/16 man had heart attack after surfing	Male	46	death
03/09/95	GICWW at Matagorda Island	tug boat sunk by loose sulfuric acid barge	Coast Guard rescues crew	Male [3]	?	exposure, treated & released

TABLE VII.4 (Concluded)

INCIDENTS REPORTED IN THE CORPUS CHRISTI CALLER TIMES

Date	Waterbody	Type	Details	Gender	Age	Outcome
03/16/95	Gulf of Mexico, J P Luby County Park	man hit by barbecue pit	chest cut and bruised	Male	?	treated & released
04/21/95	La Quinta Channel and the C. C. Ship Channel	ship-barge collision	hazardous waste spill - cumene	mixed		90 sent to hospital, 2 kept overnight
05/29/95	Gulf of Mexico at Port Aransas	beach rescues	11 people in 5 emergencies, 5-near drownings	?	?	treated & released
06/11/95	Gulf of Mexico, Port Aransas	drowned	man fishing in surf	Male	51	drowned
06/16/95	Mustang Island Beach	beach rescue		Male	13	drowned
06/17/95	Gulf of Mexico off of	boating accident	2 women drown when boat sinks	Female	34	drowned
	Port Aransas			Female	34	drowned
06/19/95	Gulf beach	spinal injury	diving into waves, incident: 4/1/91	Male	19	Quadriplegic
06/26/95	Gulf of Mexico at Bob	drowning	local couple	Male	41	drowned
	Hall pier			Female	35	drowned
06/29/95	Nueces County beaches	stingray	This year so far: 4 cases, Last year : 54 cases		?	
07/02/95	Gulf of Mexico at Mustang Island Park	undertow - 40 ft from shore	revived at beach, died at Bay Area Hospital	Male	47	drowned
			from spring break to last week 30 people pulled out - that's 3X's more than last year	mixed 30	??	treated & released
07/07/95	Corpus Christi Bay	ship-barge collision	exposure to chemical fumes	100	mixed	treated & released
07/08/95	Gulf of Mexico at Mustang Island State Park	skark bite	surfers foot was bit	Male	34	6 inch bite, stiched
07/12/95	Gulf of Mexico	boat capsized	boat lost, people rescued	??	?	exposure
07/17/95	Gulf of Mexico off Port Aransas	shrimp boat sank	6 people rescued and 1 died	Male	43	death
08/28/95	Gulf of Mexico off	near drowning	Coast Guard rescue-taken to	Male	40	shock
	Port Aransas		hospital in Aransas Pass	Female	28	revived at scene
10/10/95	Gulf of Mexico,	overturned		Male	37	unknown
	Matagorda Is.	boat		Female	32	unknown
			boat hit piling, one	Male	64	hypothermia/cuts
02/25/96	Oso Bay	boat capsized	man swam to shore, one held on to piling,	Male	54	missing
			that other unknown	Male	54	death
03/18/96	Gulf of Mexico, Port Aransas jetties	boat capsized	three men fell overboard	Males	50-60	minor cuts

TABLE VII.5
INCIDENTS REPORTED IN THE ROCKPORT PILOT

Date	Waterbody	Type	Details	Gender	Age	Outcome
04/14/90	Near Palm Harbor	infant found buried	face beaten	Male	8.5 mth	death
04/14/90		follow-up to above report	death by murder			
06/12/90	Rockport Harbor	toddler nearly drowned after falling into water	saved by 12 yr old	?	?	survived
08/08/90	Port Aransas Ferry landing	shooting	man fired at police officer with pellet gun officer returned fire	Male	22	death
08/08/90	Gulf of Mexico near Rockport	man overboard	shrimper while working	Male	23	missing
08/11/90	Fulton Beach Road	car overturned	driver lost control of vehicle and nearly drove into water	Males	35,12&10	injured
09/05/90	Cove Harbor	head injury	hit by sailboat boom	Male	35	death
01/09/91	Fulton Harbor	drowning	intoxicated couple fell into water while arguing	Male	55	death
01/19/91		follow-up	woman found, not identified	Female	32	death
01/23/91		follow-up	woman identified			
06/22/91	Port Aransas	boat collision	boat collided with a partially submerged barge, 5 people suffered minor injuries	?	?	minor injuries
07/20/91	Fulton Harbor	drowning	shrimper fell off boat (possible seizure)	Male	?	death
07/27/91		follow-up	boat prop problem			
03/21/92	Port Aransas jetties	capsized boat	heavy waves, rescued by U. S. Coast guard	3 Males	?	survived
04/22/92	Key Allegro canal	some kind of attack	did not drown, fell in water after possible cardiac arrest	Female	81	death
08/12/92	Copano State Fish Pier	car driven into water	driver fell asleep	Male Male	40 29	survived death
09/05/92	Rockport Harbor		eyewitness noticed object shaped like a human torso	Male (?)	?	not found
09/30/92	Fulton Fishing Pier	fall	slipped on pier into water rescued by Sheriffs Dept	Female	30	survived
10/28/92	Little Bay	collision	vehicle hit power line pole and fell in water	Male	37	survived
11/25/92	Near Mud Island	drowning	tangled in boats winch and was dragged into gears	Male	38	death
12/05/92	Mud Island	man found dead on boat	no indication of cause of death	Male	32	death

TABLE VII.5 (Concluded)
INCIDENTS REPORTED IN THE ROCKPORT PILOT

Date	Waterbody	Type	Details	Gender	Age	Outcome
12/12/92		follow-up	Identified apparent suicide			
03/27/93	Laguna Madre	drowning	shrimper drowned approx. March 12.	Male	47	death
04/21/93	Copano Bay	near drowning	man jumped from causeway after surfboards, couldn't catch them (leaped 20 ft into 4 ft of water) rescued by TP&WD	Male	28	survived
11/10/93	Aransas Bay	boat accident	dead engine, boat drifted into choppy bay and sunk, two	Males	31 & 23	rescued
			men found hanging on paltform	Male	31	missing
11/17/93	Tin Can Point	follow-up	missing male found near Tantiki resort			death
05/03/95	Aransas Bay	attempted suicide	man found floating off jetty near Rockport Center for Arts	Male	?	near drowning
05/06/95	Copano Bay	Vibrio infection	Dr. Jones cut leg the previous day working in the yard. Next day worked on boat in the water. That evening complained of leg pain and was dead 48 hours later.	Male	75	death
07/19/95	a back bay ?? Copano	Vibrio infection	shrimp punctured skin while wade fishing	Male	40's	hospitalize d
07/19/95	Fulton Harbor	drowning	car accidently put in drive instead of reverse	Male	72	death
05/01/96	Rockport Harbor	drowning	drove truck into harbor	Male	72	death

categorized into recreational and commercial, and further subdivided into the number of incidents, injuries and deaths for each class.

There are a number of observations that can be made relative to Table VII.6. One is the surprising amount of year-to-year variation. For example, there were 17 incidents in 1995, only two in 1994, and 11 in 1992. One suspects some of this difference may be normal variation in accidents and some may be related to newspaper decisions on whether to cover such stories. Clearly, a newspaper can only cover the larger, more rare events which have a higher level of public interest, and many other events must go unreported. For example, of the 10 water-related accidents listed in Table VII.3 that were responded to by the Aransas County EMS, none were covered in the two papers even though half were serious enough to require ambulance transport.

A second point is the relative importance of recreational and commercial water-related activity in the accident totals. From this sample it would appear that recreational activity accounts for two to three times as many incidents as does commercial activity.

Another major source of information was the Water Fatality reports compiled by the Marine Police of TPWD. Table VII.7 is a tabulation of data for the five counties approximating the study area. (Kenedy County had no fatalities in the database.) Swimming and related activities is the biggest activity associated with the fatalities.

Determining rate information from the available data is numerically straightforward, but the limitations of the data must be recognized. In particular, the number of injuries reported in the newspapers is far smaller than the actual values. Using the data in Table VII.6, the death rate per 100,000 population (residents) would be 1.3 per year. That is 22 accidental deaths (1 death report is from disease) in 4 years or 5.5 deaths per year divided by 4.3 hundred thousand population. The population base could be increased to reflect the visitor component, which would have the effect of lowering the rate. On the other hand, the total incidents reported in the papers is probably not complete. Using TPWD data from Table VII.7 a somewhat higher rate is obtained. The total number of fatalities in the area is 80 in a period of 6.8 years, giving an average rate of 11.8 per year or 2.7 per 100,000 population.

In the case of the accident data, there is no question that the data in Table VII.6 are a substantial undercount. Leaving out the report of 300 jellyfish stings in 1994, there would be an average of 60 injuries per year or 13.9 per 100,000 population, with these dominated by two commercial incidents in 1995. This is a rate in the same general range as some of the disease reports for the area, including Hepatitis, Salmonellosis, and Shigellosis. However, it appears likely that while newspapers stories can give a general indication of the types of incidents, they cannot be expected to provide complete coverage of water-related injuries.

TABLE VII.6
SUMMARY OF WATER-RELATED INCIDENTS IN THE STUDY AREA

Date	News-paper	Recreational			Commercial			Description
		No. of Incidents	No. of Injuries	No. of Deaths	No. of Incidents	No. of Injuries	No. of Deaths	
1995								
9-Mar	CCCT-B1				1	3		Tug sunk by loose barge
21-Apr	CCCT				1	90		Ship-barge collision, gas release
6-May	RP	1		1				Vibrio infection, recent cut exposed to saltwater on boat, died after 48 hours
29-May	CCCT-B1	5	11					Beach rescues reported
11-Jun	CCCT-B1	1		1				Man fishing in surf drowns
16-Jun	CCCT-B1	1		1				13 yr old boy drowns
17-Jun	CCCT-A1	1		2				Two women drown in boat sinking
19-Jun	CCCT-A8	1	1					Man diving into waves injures spine becomes quadrplegic
29-Jun	CCCT-A1	4	4	(stingrays)				54 cases reported in previous year
2-Jul	CCCT-B1	1		1				Beach swimmer dies. From spring break to July 2, 30 swimming rescues
7-Jul	CCCT-B1				1	100		Ship-barge collision, 100 treated for exposure to chemical fumes
8-Jul	CCCT-A1	1	1					Shark bite
12-Jul	CCCT-B1	1	1					Boat capsized, people rescured
17-Jul	CCCT-B1				1	5	1	Shrimp boat sinking
19-Jul	RP	1	1					Vibrio infection from wade fishing
28-Aug	CCCT-B1	1	2					swimmers rescued
10-Oct	CCCT-B1	1	2					Boat overturns, two apparantly rescued
1994								
30-May	CCCT-B1		300					jellyfish/P Man-o-war stings in one day. Same article report results for 1993 of 349 stings, 90 cuts and 26 stingray spines.
19-Dec	CCCT-B1	1		1				heart attack after swimming
1993								
20-Feb	CCCT-B1	1		1				biologist drowns while sampling
13-Mar	CCCT-B1				1		1	shrimp boat capsized, drowning
21-Apr	RP	1	1					Man injured jumping to catch surfboard
26-Jul	CCCT-B3				1		1	tug hand tangled in lines and drowned
27-Jul	CCCT-B4				1	2	1	shrimper-tug collision
7-Nov	CCCT-B7	1	3	1				recreational boat capsized
1992								
11-Jan	CCCT-B3				1		1	crewman overboard
10-Feb	CCCT-B1	1	2	2				boating accident
25-Feb	CCCT-A1	1	1	1				boating accident, hypothermia
18-Mar	CCCT-B2	1	3					boating capsize, people rescued
22-Apr	RP	1		1				81 year old woman falls off of boat with possible heart attack
5-May	CCCT-B2	1		1				boat washed ashore without operator
10-May	CCCT-B1	2	?	2				two recreational boats collide w/ tow
5-Jul	CCCT-B5	1	1					shark attacked surfer
30-Sep	RP	1	1					Woman falls from pier
22-Nov	CCCT-B2				1	4	1	jackup rig collapsed
24-Nov	CCCT-B3				1		1	crew tangled in ships winch and killed
TOTALS		33	335	16	10	204	7	

TABLE VII.7
WATER RELATED FATALITIES FROM TPWD RECORDS

COUNTY	Aransas	Kleberg	Nueces	Refugio	San Patricio	Total
Water Fatality Victim Statistics						
Swimming		1	14		3	18
Wading		1	2			3
Surfing						
Scuba Diving			2			2
Tubing						
Fishing	1		6		2	9
Canoeing						
Windsurfing		2				2
Hunting						
Tried Rescue						
Illegal Entry			1			1
Working	3		5			8
Air Mattress						
Diving	1					1
Jumping						
Jet Ski			1			1
Para-Sailing						
Skiing						
Boating	2		1			3
Other	9		17	2	3	31
Not Stated	1					1
Total Fatalities	17	4	49	2	8	80
No. of Boats Involved	6		11			17

Note:
1. TPWD records from 1/1/90 to 9/24/96 for counties in study area.
2. County data includes the Gulf out to 10 miles.

VIII. ANALYSIS AND DISCUSSION

Previous sections of the report have examined a wide range of public health and safety (PH&S) issues associated with uses of the study-area waters. This section attempts to put this information into an overall context, addressing trends, causative factors, and possible data gaps.

VIII.1 RISKS TO PUBLIC HEALTH AND SAFETY

The major risk mechanisms to PH&S can be divided into the following categories:

- oyster consumption,
- consumption of toxic substances in seafood,
- contracting a disease directly from the water,
- contracting a disease from insects associated with water, and
- encountering an accident while engaged in a water-based activity.

Oysters are treated separately from seafood in general because the primary concern appears to be disease rather than toxic substances and because of the different regulatory structures. This section summarizes information on the current level of risk to PH&S associated with each mechanism.

Oyster Consumption

The practice of eating raw oysters is very old, dating back at least to the coastal indians who inhabited the study area prior to European colonization. One reason might be that oysters were available in coastal areas during the winter when other food might be difficult to obtain. While the practice of eating raw oysters is widespread, there is a very limited oyster fishery in the study area today. Oyster landings in the study area are less than 4% of the state (CCBNEP, Living Resources, 1996), suggesting that most oysters consumed in the area were harvested in other bays.

The existing regulatory program for commercial harvesting and sale of oyster meat was developed at the national level many decades ago in response to strong disease concerns. Some of these disease concerns probably grew out of higher human populations in coastal areas, with little in the way of proper waste treatment and some concerns probably grew out of improper product handling. The regulatory program for dealing with human waste and proper product handling is now well established and it would seem to be quite successful. Oysters are probably the only meat widely sold and consumed in the US without being cooked, and by its very nature of filtering particulate matter (which includes bacterial particulate matter) from the water, has perhaps the greatest potential of any meat to become contaminated. Nevertheless, oysters are widely consumed raw with a level of risk that a significant portion of the public accepts. This rather remarkable fact appears to be due substantially to the success of the existing regulatory program.

In the study-area the data developed in Section VI indicate that the rate of reportable diseases which are associated with oyster consumption is quite small. While many types of diseases could be contracted from oysters, the primary risk from oyster consumption appears to be contracting one of the *Vibrio* diseases. These can produce quite severe symptoms and death can result, particularly if the subject's level of health is not strong. While consuming oysters is one route or mechanism for *Vibrio* infection, it is also possible for infection to result from body contact with bay waters, particularly if an open wound is involved.

Table VIII.1 presents disease incident and death data for *Vibrio* infections as well as a number of other disease incidents from TDH data. The disease incident data are directly from Section VI and the death data are obtained from the statewide ratio of deaths to incidents from *Vibrio* infections.

Consumption of Toxic Substances in Seafood

The data reviewed in Section V indicate that detection of potentially toxic substances at concentrations higher than screening levels is relatively rare. For example, out of approximately 5,500 tissue analyses for toxic substances, less than 100 were detected over screening levels. While several situations were addressed, after analysis only two (zinc in Nueces Bay oysters and PCBs in the Inner Harbor fish) appear to warrant further investigation. Furthermore, neither of these situations pose significant health concerns. Oysters are not common in Nueces Bay and oyster harvesting, if any existed, is now prohibited. The Inner Harbor is not a major fishing area.

Based on the data generated in this study, it would appear that the current PH&S risk from ingestion of toxic chemical substances in seafood tissue is quite small, certainly much smaller than any of the values listed in Table VIII.1. No attempt will be made to produce a numerical estimate of this risk.

Disease from Water Contact

Contracting diseases from swimming in natural waters has long been recognized as a major exposure mechanism. The major disease concern with contact recreation is gastroenteritis (EPA, 1986) which is a symptom of a number of common diseases, some of which are addressed in the TDH data reviewed in Section VI. All of the diseases listed in Table VIII.1 can be transmitted by water contact. However, for the most part the water contact envisioned is contaminated drinking water. Except for *Vibrio* organisms where bay waters are a natural habitat, these disease organisms do not survive well even if introduced to the bay directly (i.e., without wastewater treatment and disinfection).

The Nueces County Health Department has been monitoring FC levels in swimming areas for many years. Overall, these data indicate that the areas monitored are suitable for contact recreation using the State FC criteria, which is the same as the current state criteria.

Insect Disease Transmission

Of the diseases required to be reported to the TDH, several are known to be transmitted by insect vectors. These include Dengue, Encephalitis, Malaria and Yellow Fever. The rate for all of these diseases is relatively small and the data for the study-area are quite similar to that for the entire state. Based on that finding, it would appear that disease transmitted by insects is not a major concern or one that is unique to study-area waters.

TABLE VIII.1
SUMMARY OF PUBLIC HEALTH AND SAFETY INFORMATION

Categories	Incidents Per Year		Deaths Per Year	
	In Area	Rate per 100,000	In Area[7]	Rate per 100,000
VIBRIO INFECTIONS[1] (Oyster consumption and water contact)	0.78	0.19	0.12	0.03
CAMPYLOBACTERIOSIS[2]	20.94	4.87		
HEPATITIS A[2]	78.60	18.28		
SALMONELLA[2]	104.58	24.32		
SHIGELLA[2]	90.60	21.07		
ATER-RELATED ACCIDENTS - PAPERS[3]			5.50	1.28
WATER FATALITIES, TPWD[4]			11.80	2.70
MOTOR VEHICLE ACCIDENTS[5]			67.10	15.60
COMMERCIAL AIR TRAVEL[6]			0.26	0.09

[1] Table VI.3 and TDH data sheets indicating a total of 31 deaths out of 200 *Vibrio* infection reports statewide for period 1987 - 1995.

[2] Table VI.3.

[3] Table VII.6.

[4] Table VII.7.

[5] National Highway Traffic Safety Administration data for 1994, giving a national average fatality rate of 15.6 per 100,000 population.

[6] National Transportation Safety Board, News Digest, data for 1994.

[7] Using a study-area population of 430,000.

Water-Related Accidents

Accident data related to water activates were summarized in Section VII of the report. As noted, data on accidents and minor injuries from official sources such as police or hospitals, were generally not available due to privacy considerations. The only data available from the entire area was from newspaper reporting, which is relatively good for major, highly newsworthy events such as deaths, but is very limited on injuries. For water-related deaths, a rate of 1.3 per 100,000 population was estimated from newspapers. The Marine Police data on water-related deaths in Table VII.7 provided a somewhat higher rate of 2.7 per 100,000.

The water-related injury rate is undoubtedly much higher than the death rate, but obtaining complete quantitative information is quite difficult due to privacy considerations. One of the complicating factors is simply determining what constitutes an injury. For example, it is not clear that a jellyfish sting should be included in injury statistics, although in some cases this can be a painful and serious wound.

Risk Summary

Table VIII.1 includes the water-related death rate data from the study area, and also includes a summary of data from a number of sources. Using 1994 data, available rate information from motor vehicle, commercial air transport, and various water-related activities are summarized. One of the limitations of the table is that in most cases there are not parallel incident and death data. In the case of *Vibrio* infections, the TDH data indicated that 15.5% of the reported infection incidents statewide resulted in death. This mortality rate figure is on the same order as the 7.4% reported by Levine and Griffin (1993) for the entire Gulf.

The major finding is that deaths from water-related accidents pose a substantially higher risk than disease associated with bay use or the other risk mechanisms considered. It is probable that a similar relationship exists for non-fatal illness and injury, although parallel data on this point are not available. While water-use related accidents appear to be the biggest risk factor among water-use risk mechanisms, it is still much safer than motor vehicle accidents.

VIII.2 TRENDS

For the most part there is little information that is collected in a uniform fashion for a period of time from which trend information can be derived. The TDH data analyzed in Section VI. indicate that most diseases have fairly stable rates observed during the last decade. Two exceptions were recent increases in Hepatitis A and Shigellosis in the study area. It is not clear whether these rate increases are significant or if they are related to water contact or seafood consumption.

The harvesting area maps reviewed in Section III indicate that over the years there has been an increase in the area where shellfish commercial harvesting is prohibited. It is not clear how much of this increase can be attributed to changes in regulatory and monitoring procedures and how much can be attributed to changes field data. The review of TC and FC data presented in Section IV indicated no significant temporal trends in the coliform bacteria data, suggesting that the increase in harvesting area closures may be attributable to changes in regulatory and monitoring procedures.

VIII.3 DATA GAPS AND CAUSATIVE FACTORS

Probably the biggest gap in available data is information on diseases and injuries associated with water use. Except for a relatively small number of disease types which must be reported to the TDH and the Marine Police fatality reports, there are little data available. The causative factor is the legitimate need for privacy protection. Hopefully, in the future police and hospital records management systems will evolve to the point where data can be readily made available for research and management purposes with personal identification information removed.

Another gap observed in the project was the relative scarcity of data in the near-shore Gulf portion of the study area. A large part of the recreational and commercial water use occurs in this area, yet there is relatively little monitoring activity. This is understandable to a degree, as one would expect water or tissue concentrations in the bay waters to be more affected by anthropogenic factors than the larger and more remote Gulf. Having data from the near-shore Gulf would still be valuable both as a baseline and because some parameters have sources in the Gulf.

A third gap observed was in the availability of suitable management measures for dealing with naturally occurring pathogens such as *Vibrios*. While EPA (1986) found that coliform bacteria (total and fecal) were relatively poor indicators of swimming-related disease risk, and recommended different tests and criteria, existing regulatory efforts using coliforms have been generally successful in dealing with wastewater-related health risks. However, such efforts are not effective with *Vibrios*. Better procedures to manage this risk in a cost-effective manner are needed.

A fourth data need is for better standardization of procedures for tissue monitoring. In particular, monitoring should standardize on edible tissue rather than whole fish or organ data. There would also be a small advantage in standardizing on reporting results as dry rather than wet weight to avoid variability from varying moisture content. However, this is a much smaller source of variation and is less important.

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