7. SEDIMENT QUALITY OF CORPUS CHRISTI BAY

Sediment data for Corpus Christi Bay were analyzed in exactly the same way as water quality data, therefore the introductory comments of Chapter 6 apply here as well. Again, the data record for each parameter was sorted into two different segmentations of the bay: the Texas Natural Resource Conservation Commission (TNRCC) water quality segments, and the hydrographic-area segments developed for this project. Reference is made to Chapter 3 where both segmentation systems are described and to the defining quadrilaterals given in the Appendix, Tables A-4 and A-5. Similarly, the remarks in Chapter 6 about Corpus Christi Bay being undersampled apply even more strongly to sediment, because there is roughly an order of magnitude less sediment data from Corpus Christi Bay than water quality data. On the other hand, sediment transport processes and kinetics are thought to vary on time scales longer than that of the overlying water, so relative to the time and space scales of natural variability less data would be needed for sediment chemistry than water chemistry (though probably not an order of magnitude). The fundamental problem with sediment data is its spatial sparsity. When distributed into the hydrographic segments, those segments having data generally do not have the temporal density necessary for valid statistics or trend extraction. For most areas of the system, as will be seen, the available data is below the threshold from which meaningful analyses may be performed.

Again, as a preliminary, Table 7-1 (from Ward and Armstrong, 1992a) shows nominal uncertainty levels for each of the primary sediment quality parameters of this study. The discussion in Chapter 6 and the information in Section 4.2.3 apply here as well. Because sediment concentrations are generally much higher than those in the water column, there is less problem with measurements reported as below detection limits than was the case with the water analytes.

TABLE 7-1

NOMINAL UNCERTAINTY IN MEASUREMENT OF SEDIMENT PARAMETERS
(See Table 2-1 for definition of abbreviations)

abbreviation	*units*	*nominal standard deviation (as percentage of value)*
	Conventional Parameters	
SEDAMMN	mg/kg	20
SEDORGN	mg/kg	20
SEDKJLN	mg/kg	20
SEDTOTP	mg/kg	10
SEDVOLS	mg/kg	25
SEDO&G	mg/kg	25
SEDTOC	g/kg	10
	Metals	
SEDMETAS	mg/kg	20
SEDMETBA	mg/kg	5
SEDMETB	mg/kg	20
SEDMETCD	mg/kg	35
SEDMETCR	mg/kg	20
SEDMETCU	mg/kg	25
SEDMETFE	mg/kg	10
SEDMETPB	mg/kg	60
SEDMETMN	mg/kg	5
SEDMETHG	mg/kg	20
SEDMETNI	mg/kg	50
SEDMETSE	mg/kg	35
SEDMETAG	mg/kg	50
SEDMETZN	mg/kg	10
	Organics	
SED-ABHC	μg/kg	25
SED-LIND	μg/kg	25
SED-XDDT	μg/kg	25
SED-ALDR	μg/kg	20

(continued)

TABLE 7-1

(continued)

abbreviation	*units*	*nominal standard deviation (as percentage of value)*
SED-CHLR	µg/kg	25
SED-DIEL	µg/kg	25
SED-ENDO	µg/kg	10
SED-ENDR	µg/kg	20
SED-TOXA	µg/kg	25
SED-HEPT	µg/kg	25
SED-HEPX	µg/kg	20
SED-MTHX	µg/kg	10
SED-PCB	µg/kg	25
SED-MALA	µg/kg	35
SED-PARA	µg/kg	10
SED-DIAZ	µg/kg	20
SED-MTHP	µg/kg	10
SED-24D	µg/kg	15
SED-245T	µg/kg	15
SED-PAH	µg/kg	25
SED-ACEN	µg/kg	15
SED-NAPT	µg/kg	25
SED-FLRA	µg/kg	5
SED-BNZA	µg/kg	10

7.1 Space and Time Variation in Sediment Quality

Table 5-3 presents the baywide summary of sediment data. The historical statistics for each of the study parameters are given in detail in Appendix C, for each of the TNRCC segments and for each of the hydrographic segments (for which data exist); these tables together are regarded as the principal product of this study. As with water quality in Chapter 6, for each sediment parameter there is a pair of tables, the first presenting basic data on magnitude and variance of the measurements, and the second data on the time trend analysis. Tables 7-2 through 7-5 are examples. All hydrographic segments are shown in these tables. In Appendix C, to conserve paper, the only entries in the tables are for those hydrographic areas for which data exist. Reference is made to Sections 6.1 and 6.2 for a discussion of the meaning and computation of the entries in these tables.

In the Chapter 5 survey of the data base, Figures 5-61 through 5-78 depict sampling intensity throughout the bay for several of the key sediment parameters. The sampling activities of the Corps of Engineers in association with channel maintenance dominates the data base in many areas of the bay, and the highest intensity is seen to track the presence of channels (more to the point, the presence of channels with frequent maintenance). Thus, for most of the sediment parameters, large areas of the bay have never been sampled. Moreover, for the measurements which do exist, there is a bias for those regions of the bay most heavily impacted by the activities of man. A few of the parameters, such as TOC and several of the metals, are dominated by the BEG Submerged Lands Project data base (Project Code 12), and are therefore more uniformly distributed.

Average concentrations (with BDL values taken to be 0) of representative parameters are depicted in Figs. 7-1 through 7-48. For Figs. 7-1 through 7-39, the conventional parameters and metals, "no data" designated "ND" means there are fewer than two measurements extant for the given segment. Therefore, we avoid ascribing reality to a single measurement of sediment chemistry, but require the average of a minimum of two measurements in order to plot the result. (For water, it will be recalled, an average of a minimum of three measurements was required.) For volatile organics, Figs. 7-40 through 7-48, the data is so sparse that we plot as well those segments with a single measurement of the parameter, but flag these "means" of a single number by italics. Figures 7-49 *et seq*. display the spatial distribution of time trends, following the same convention as described in Chapter 6. The segments with a "probable" trends have both 95% confidence limits of the same sign, and those with a "possible" trend have both 80% confidence bounds of the same sign. At least three independent measurements (above detection limits) in the period of analysis are required before a trend is presented, so we avoid the artifact of a trend line connecting two measurements.

Following the practice of Chapter 6, principal "component bays" of the study area are identified, and defined by hydrographic segments chosen to be representative of the open regions of that component bay, excluding any segments influenced by local external factors. For the sediment data, Oso Bay, consisting of the broad, seaward section of this bay, was included as a component bay. These principal component bays are defined as follows:

principal component bay	*hydrographic segments*
Aransas	A1-A4, A8-A12, I4-I7
Copano	CP02-CP10
St. Charles	SC2-SC3
Mesquite*	MB1, MB2, AYB, CB
Redfish Bay	RB2-RB9
Corpus Christi	C01-C08, C10, C11, C13, C14, C16-C23
CCSC (open bay)	CCC3-CCC7
Inner Harbor	IH1-IH7
Nueces Bay	NB2-NB5, NB8
Oso Bay	O5-O7
Causeway N	C24, C25, I9
Causeway S	UL01, UL02, UL04, I10
Laguna (King Ranch)	UL03, UL05-UL11, I11-I15
Laguna (Baffin)	UL12-UL14, I16-I18
Baffin	BF1-BF3, AL2, GR2
Aransas Pass area	INL, LAC, CCC1, HI1
GOM inlet	GMI5-GMI7, GMO5-GMO7

*including Carlos and Ayres Bays

Summaries of sediment chemistry for selected conventional parameters, metals, pesticides and PAH's are given in Tables 7-6 through 7-9, respectively. Again, any component bay average consisting of a single measurement was expunged from the table: only averages based upon two or more measurements are retained. The trend analyses by component bay are summarized in Tables 7-10 through 7-25. In these tables, in contrast to the corresponding tables for water analytes (e.g., Tables 6-42 *et seq.*), two separate columns are added tabulating the number of segments in the component bay and those actually having extant data for which a trend analysis can be carried out. For example, in Table 7-10, for Kjeldahl nitrogen (SEDKJLN), in Copano Bay consisting of 9 hydrographic segments (defined above) only *one* segment has adequate data for a trend analysis, and that trend is increasing and probable. (The specific segment and its actual number of data points used in the trend determination, along with time period of analysis and measures of scatter about the trend line, may be found by consulting the corresponding table in Appendix C.)

TABLE 7-2
Period of record statistics for CCBNEP Hydrographic Segments
SEDTOC

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
A1	8	7.38	5.5	8	100	2	760407	2	760407	18	760407	7.38	7.38
A2	6	4.83	1.8	6	100	3	760326	3	760326	8	760625	4.83	4.83
A3	5	7.16	5.2	5	100	2	760625	2	760625	16	760625	7.16	7.16
A4	7	15.00	2.4	7	100	11	760625	11	760625	18	760531	15.00	15.00
A5	2	1.50	0.5	2	100	1	760531	1	760531	2	760531	1.50	1.50
A6	5	5.60	2.7	5	100	2	760531	2	760531	9	760531	5.60	5.60
A8	2	2.50	0.5	2	100	2	760625	2	760625	3	760625	2.50	2.50
A9	3	3.67	0.94	3	100	3	760625	3	760625	5	760625	3.67	3.67
A10	8	7.88	7.6	8	100	1	760531	1	760531	18	760531	7.88	7.88
A11	11	12.00	6.4	11	100	2	760531	2	760531	21	760531	12.00	12.00
A12	7	6.71	6.7	7	100	1	760531	1	760531	19	760531	6.71	6.71
A13	7	4.58	3.2	7	100	1	760531	1	760531	11	760531	4.58	4.58
AL1	8	7.00	3.9	8	100	1	760922	1	760922	12	760922	7.00	7.00
AL2	17	8.06	5	17	100	2	760922	2	760922	17	760922	8.06	8.06
AR1	5	9.60	5.8	5	100	3	760919	3	760919	19	760919	9.60	9.60
AYB	3	6.33	2.6	3	100	4	760812	4	760812	10	760812	6.33	6.33
BF1	13	10.60	6.3	13	100	3	760921	3	760921	21	760921	10.60	10.60
BF2	28	13.40	8.1	28	100	2	760921	2	760921	27	760921	13.40	13.40
BF3	22	11.70	7.2	22	100	4	760921	4	760921	27	760921	11.70	11.70
C01	4	3.19	2.9	4	100	0.74	930723	0.74	930723	8	770625	3.19	3.19
C02	4	8.25	7.2	4	100	2	770625	2	770625	20	770625	8.25	8.25
C03	5	9.80	7.4	5	100	1	770625	1	770625	18	770625	9.80	9.80
C04	7	12.30	1.8	7	100	9	770625	9	770625	15	770625	12.30	12.30
C05	4	14.30	1.9	4	100	11	770625	11	770625	16	770625	14.30	14.30
C06	7	14.10	3.8	7	100	7	770625	7	770625	19	770625	14.10	14.10
C07	6	15.30	1.6	6	100	12	770625	12	770625	17	770625	15.30	15.30

(continued)

TABLE 7-2
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
C08	10	13.00	3.3	10	100	7	770625	7	770625	20	770625	13.00	13.00
C09	5	8.40	7	5	100	1	770625	1	770625	17	770625	8.40	8.40
C10	10	16.00	2.5	10	100	12	930720	12	930720	20	770625	16.00	16.00
C11	16	9.23	4.9	16	100	1	770625	1	770625	17	770625	9.23	9.23
C12	15	6.20	3.2	15	100	1	770625	1	770625	11	770625	6.20	6.20
C13	6	11.80	7.6	6	100	1	770625	1	770625	19	770625	11.80	11.80
C14	17	5.87	6.2	15	88	0.092	931221	0.092	931221	17	770625	5.18	5.19
C15	14	5.15	3.6	14	100	1	770625	1	770625	13	770625	5.15	5.15
C16	3	12.00	2.2	3	100	10	770625	10	770625	15	770625	12.00	12.00
C17	6	7.67	6.3	6	100	1	770625	1	770625	17	770625	7.67	7.67
C18	8	11.00	2.8	8	100	6.8	840930	6.8	840930	15	770625	11.00	11.00
C19	4	4.75	3.3	4	100	1	770625	1	770625	9	770625	4.75	4.75
C20	2	12.00	2	2	100	10	770625	10	770625	14	770625	12.00	12.00
C21	2	10.50	0.5	2	100	10	770625	10	770625	11	770625	10.50	10.50
C22	11	6.73	4.2	11	100	1.1	920729	1.1	920729	14	770625	6.73	6.73
C23	2	5.00	3	2	100	2	770625	2	770625	8	770625	5.00	5.00
C24	3	14.00	3.3	3	100	10	760924	10	760924	18	760924	14.00	14.00
C25	2	11.50	5.5	2	100	6	760924	6	760924	17	760924	11.50	11.50
CB	7	6.61	3.5	7	100	2	760814	2	760814	12	760814	6.61	6.61
CBH	1	0.00	0	0	0								
CBY1	2	14.00	2	2	100	12	760814	12	760814	16	760814	14.00	14.00
CBY2	1	3.00	0	1	100	3	760814	3	760814	3	760814	3.00	3.00
CCC1	4	4.75	1.8	4	100	2	880715	2	880715	7	880715	4.75	4.75
CCC2	5	3.00	1	2	40	2	760713	2	760713	4	760713	1.20	1.26
CCC3	2	2.50	0.5	2	100	2	770625	2	770625	3	770625	2.50	2.50
CCC4	5	4.89	6.4	3	60	0.22	950112	0.22	950112	14	770625	2.93	2.97
CCC5	8	4.00	4.9	8	100	0.12	950112	0.12	950112	11	770625	4.00	4.00

(continued)

TABLE 7-2
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
CCC6	7	3.56	5.3	7	100	0.12	950112	0.12	950112	12	770625	3.56	3.56
CCC7	5	4.71	4	5	100	0.24	950112	0.24	950112	10	770625	4.71	4.71
CCC8	4	0.80	0.85	3	75	0.19	950112	0.19	950112	2	770625	0.60	0.63
CP01	0												
CP02	13	5.00	3	13	100	1	760328	1	760328	11	760328	5.00	5.00
CP03	14	7.64	5.2	14	100	1	760331	1	760331	15	760331	7.64	7.64
CP04	10	9.66	5.5	10	100	2	760331	2	760331	19	910805	9.66	9.66
CP05	8	11.50	5.3	8	100	1	760331	1	760331	15	760331	11.50	11.50
CP06	14	11.40	3.7	14	100	3	760331	3	760331	16	760331	11.40	11.40
CP07	7	7.43	5.6	7	100	1	760331	1	760331	17	760331	7.43	7.43
CP08	12	8.92	7.9	12	100	1	760331	1	760331	21	760331	8.92	8.92
CP09	9	7.56	4.7	9	100	1	760328	1	760328	16	760328	7.56	7.56
CP10	14	10.20	6.3	14	100	1	760328	1	760328	19	920729	10.20	10.20
EF	1	3.00	0	1	100	3	770625	3	770625	3	770625	3.00	3.00
GR1	2	4.50	0.5	2	100	4	760921	4	760921	5	760921	4.50	4.50
GR2	14	8.64	5.1	14	100	2	760921	2	760921	17	760921	8.64	8.64
HI1	3	0.00	0	0	0							0.00	0.10
HI2	0												
I1	4	1.50	0.5	2	50	1	760802	1	760802	2	760813	0.75	0.80
I2	7	4.00	1.1	5	71	3	760813	3	760813	6	760813	2.86	2.89
I3	5	3.05	2.6	5	100	0.086	950111	0.086	950111	6	760813	3.05	3.05
I4	21	3.88	4.7	14	67	0.0031	950111	0.0031	950111	16	760625	2.59	2.62
I5	19	5.68	5.8	16	84	0.023	940105	0.023	940105	16	870715	4.78	4.80
I6	14	9.75	6.3	10	71	0.045	940105	0.045	940105	18	760531	6.96	6.99
I7	10	6.60	5.3	10	100	1	760531	1	760531	21	760531	6.60	6.60
I8	6	2.00	0.82	6	100	1	760531	1	760531	3	760531	2.00	2.00
I9	3	14.00	3	2	67	11	760924	11	760924	17	760924	9.33	9.37

(continued)

TABLE 7-2
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
I10	5	21.00	11	3	60	6	760924	6	760924	32	760924	12.60	12.60
I11	7	17.20	10	5	71	8	760924	8	760924	37	760924	12.30	12.30
I12	6	14.50	14	6	100	5	760924	5	760924	44	760618	14.50	14.50
I13	11	26.50	21	8	73	2	760924	2	760924	57	770210	19.30	19.30
I14	4	21.50	12	4	100	8	770210	8	770210	35	770109	21.50	21.50
I15	3	7.00	0	1	33	7	770210	7	770210	7	770210	2.33	2.40
I16	9	5.77	3.9	4	44	0.068	931221	0.068	931221	11	760921	2.56	2.62
I17	5	7.35	5.7	3	60	0.035	931221	0.035	931221	14	770210	4.41	4.45
I18	13	4.25	3.8	9	69	0.049	931221	0.049	931221	12	771216	2.94	2.97
IH1	1	0.25	0	1	100	0.25	940316	0.25	940316	0.25	940316	0.25	0.25
IH2	1	0.42	0	1	100	0.42	940316	0.42	940316	0.42	940316	0.42	0.42
IH3	2	0.23	0.047	2	100	0.19	940316	0.19	940316	0.28	940316	0.23	0.23
IH4	1	0.59	0	1	100	0.59	940316	0.59	940316	0.59	940316	0.59	0.59
IH5	1	0.68	0	1	100	0.68	940316	0.68	940316	0.68	940316	0.68	0.68
IH6	3	0.66	0.16	2	67	0.5	940316	0.5	940316	0.82	940316	0.44	0.47
IH7	4	0.22	0.024	2	50	0.2	940316	0.2	940316	0.24	940316	0.11	0.16
INL	3	4.50	1.5	2	67	3	760511	3	760511	6	760511	3.00	3.03
LAC	0												
LB	0												
LQ1	5	2.50	0.5	2	40	2	770625	2	770625	3	770625	1.00	1.06
LQ2	4	2.00	0	2	50	2	770625	2	770625	2	770625	1.00	1.05
LS1	1	9.00	0	1	100	9	760921	9	760921	9	760921	9.00	9.00
LS2	7	12.60	6	7	100	4	760921	4	760921	20	760921	12.60	12.60
M1	4	12.30	7	4	100	3	760917	3	760917	19	760917	12.30	12.30
M2	18	9.28	3.3	18	100	4	760917	4	760917	14	760917	9.28	9.28
MB1	4	4.25	2.2	4	100	3	760813	3	760813	8	760813	4.25	4.25
MB2	11	5.18	2.1	11	100	2	760813	2	760813	8	760813	5.18	5.18

(continued)

TABLE 7-2
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
NB1	5	7.80	3.3	5	100	3	760910	3	760910	12	760910	7.80	7.80
NB2	3	4.50	2.5	2	67	2	760910	2	760910	7	760910	3.00	3.03
NB3	3	7.56	3.7	3	100	2.8	910805	2.8	910805	12	930723	7.56	7.56
NB4	4	9.00	4.3	4	100	2	760910	2	760910	13	760910	9.00	9.00
NB5	7	5.14	3	7	100	1	760910	1	760910	10	760910	5.14	5.14
NB6	2	6.50	4.5	2	100	2	760910	2	760910	11	760910	6.50	6.50
NB7	3	3.67	1.7	3	100	2	760910	2	760910	6	760910	3.67	3.67
NB8	4	6.33	2.5	3	75	3	760910	3	760910	9	760910	4.75	4.78
NB9	5	6.40	2.4	5	100	3	760910	3	760910	9	760910	6.40	6.40
ND1	0												
ND2	1	4.00	0	1	100	4	760910	4	760910	4	760910	4.00	4.00
ND3	0												
ND4	0												
NR1	0												
NR2	0												
NR3	1	12.00	0	1	100	12	760910	12	760910	12	760910	12.00	12.00
NR4	2	10.00	7	2	100	3	760910	3	760910	17	760910	10.00	10.00
NR5	2	6.50	3.5	2	100	3	760910	3	760910	10	760910	6.50	6.50
OS1	0												
OS2	0												
OS3	0												
OS4	0												
OS5	2	13.50	0.5	2	100	13	760916	13	760916	14	760916	13.50	13.50
OS6	4	9.75	6.3	4	100	3	760916	3	760916	16	760916	9.75	9.75
OS7	4	5.50	2.9	4	100	3	760916	3	760916	10	760916	5.50	5.50
PB1	1	9.00	0	1	100	9	760916	9	760916	9	760916	9.00	9.00
PB2	14	5.36	3.2	14	100	1	760916	1	760916	12	760916	5.36	5.36

(continued)

TABLE 7-2
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
RB1	2	24.00	14	2	100	10	760713	10	760713	38	760713	24.00	24.00
RB2	6	15.70	6.7	6	100	4	760713	4	760713	23	760713	15.70	15.70
RB3	5	23.70	4.8	3	60	17	760713	17	760713	28	760713	14.20	14.20
RB4	0												
RB5	5	9.20	1.2	5	100	8	760713	8	760713	11	760713	9.20	9.20
RB6	5	9.22	7.1	5	100	4.1	920729	4.1	920729	23	760713	9.22	9.22
RB7	3	3.67	0.94	3	100	3	760713	3	760713	5	760713	3.67	3.67
RB8	3	5.50	1.5	2	67	4	760713	4	760713	7	760713	3.67	3.70
RB9	3	3.33	0.94	3	100	2	760713	2	760713	4	760713	3.33	3.33
SC1	4	7.00	3.9	4	100	2	760925	2	760925	13	760925	7.00	7.00
SC2	8	4.75	1.6	8	100	2	760925	2	760925	8	760925	4.75	4.75
SC3	4	7.50	3.2	4	100	3	760925	3	760925	11	760925	7.50	7.50
UL01	5	16.00	6.9	5	100	6	760924	6	760924	23	760924	16.00	16.00
UL02	3	27.70	9	3	100	19	760924	19	760924	40	760924	27.70	27.70
UL03	11	15.70	17	11	100	4	760924	4	760924	64	760924	15.70	15.70
UL04	0												
UL05	5	9.00	4.3	5	100	3	760924	3	760924	16	760924	9.00	9.00
UL06	10	4.00	1.9	10	100	1	760924	1	760924	8	760924	4.00	4.00
UL07	5	6.80	2.6	5	100	2	760924	2	760924	9	760924	6.80	6.80
UL08	4	3.75	1.9	4	100	2	770109	2	770109	7	770109	3.75	3.75
UL09	5	5.20	3.5	5	100	1	770109	1	770109	9	760924	5.20	5.20
UL10	7	5.43	2.8	7	100	1	770210	1	770210	9	770210	5.43	5.43
UL11	3	8.33	5.4	3	100	1	770210	1	770210	14	770210	8.33	8.33
UL12	2	7.00	0	2	100	7	770210	7	770210	7	770210	7.00	7.00
UL13	2	11.50	9.5	2	100	2	770210	2	770210	21	770210	11.50	11.50
UL14	3	7.00	2.8	3	100	3	771216	3	771216	9	770109	7.00	7.00

(continued)

TABLE 7-2
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
GMI1	7	1.86	0.4	7	100	1	760315	1	760315	2	760302	1.86	1.86
GMI2	9	1.22	0.4	9	100	1	760303	1	760303	2	760519	1.22	1.22
GMI3	12	2.08	0.6	12	100	1	760511	1	760511	3	760511	2.08	2.08
GMI4	6	2.17	0.4	6	100	2	760511	2	760511	3	760511	2.17	2.17
GMI5	14	2.21	0.8	14	100	1	760511	1	760511	3	760511	2.21	2.21
GMI6	10	3.11	2.2	9	90	1	760511	1	760511	8	760511	2.80	2.81
GMI7	18	1.72	0.6	18	100	1	760508	1	760508	3	760511	1.72	1.72
GMI8	8	1.63	0.7	8	100	1	760508	1	760508	3	760814	1.63	1.63
GMI9	5	2.60	2.7	5	100	1	760508	1	760508	8	760508	2.60	2.60
GMO1	32	4.19	2.0	32	100	1	760302	1	760302	11	760302	4.19	4.19
GMO2	47	3.74	2.2	47	100	1	760303	1	760303	8	760519	3.74	3.74
GMO3	61	4.67	2.0	61	100	1	760511	1	760511	9	760511	4.67	4.67
GMO4	26	4.04	1.8	26	100	1	760511	1	760511	8	760511	4.04	4.04
GMO5	49	5.69	2.3	49	100	2	760511	2	760511	10	760511	5.69	5.69
GMO6	24	4.61	2.3	23	96	2	760511	2	760511	9	760511	4.42	4.42
GMO7	68	4.18	2.4	68	100	1	760508	1	760508	14	760508	4.18	4.18
GMO8	33	4.03	2.2	33	100	1	760508	1	760508	8	760508	4.03	4.03
GMO9	33	4.52	2.3	33	100	1	760508	1	760508	9	760508	4.52	4.52

TABLE 7-3
Period of record statistics for CCBNEP Hydrographic Segments
SEDMETZN

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
A1	1	0.0	0.0	0	0							0.0	10.0
A2	2	18.0	0.0	1	50	18.0	760407	18.0	760407	18	760407	9.0	14.0
A3	2	96.3	0.0	1	50	96.0	930720	96.0	930720	96	930720	48.2	53.2
A4	2	42.0	2.0	2	100	40.0	760625	40.0	760625	44	760531	42.0	42.0
A5	1	24.0	0.0	1	100	24.0	760531	24.0	760531	24	760531	24.0	24.0
A6	1	10.0	0.0	1	100	10.0	760531	10.0	760531	10	760531	10.0	10.0
A8	1	0.0	0.0	0	0							0.0	10.0
A9	1	10.0	0.0	1	100	10.0	760625	10.0	760625	10	760625	10.0	10.0
A10	1	70.0	0.0	1	100	70.0	760531	70.0	760531	70	760531	70.0	70.0
A11	2	18.5	8.5	2	100	10.0	760531	10.0	760531	27	760531	18.5	18.5
A12	3	47.0	17.0	2	67	30.0	751103	30.0	751103	64	760531	31.3	34.7
A13	3	28.4	5.7	3	100	21.0	930720	21.0	930720	35	740723	28.4	28.4
AL1	7	35.2	25.0	6	86	14.0	880615	14.0	880615	86	880615	30.2	31.6
AL2	11	45.9	18.0	10	91	9.4	880615	9.4	880615	72	880615	41.7	42.6
AR1	11	31.0	23.0	11	100	3.4	800819	3.4	800819	85	760919	31.0	31.0
AYB	1	6.8	0.0	1	100	6.8	840823	6.8	840823	6.8	840823	6.8	6.8
BF1	22	47.2	22.0	21	95	4.6	880615	4.6	880615	97	860527	45.1	45.5
BF2	21	40.4	26.0	20	95	3.1	880615	3.1	880615	79	880615	38.5	39.0
BF3	23	43.6	36.0	22	96	3.4	880615	3.4	880615	160	860527	41.7	42.1
C01	5	85.9	70.0	5	100	15.0	930723	15.0	930723	210	880615	85.9	85.9
C02	4	54.9	21.0	4	100	31.0	770625	31.0	770625	84	880615	54.9	54.9
C03	5	45.0	31.0	5	100	7.1	880615	7.1	880615	90	880615	45.0	45.0
C04	6	81.9	29.0	6	100	24.0	880615	24.0	880615	120	880615	81.9	81.9
C05	7	93.5	18.0	7	100	60.0	741024	60.0	741024	120	770625	93.5	93.5
C06	7	100.0	17.0	7	100	60.0	880615	60.0	880615	110	880615	100.0	100.0
C07	9	97.1	31.0	9	100	38.0	870331	38.0	870331	130	770625	97.1	97.1

(continued)

TABLE 7-3
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
C08	8	93.7	21.0	8	100	48.0	870331	48.0	870331	120	920729	93.7	93.7
C09	5	55.2	27.0	5	100	19.0	770625	19.0	770625	94	880615	55.2	55.2
C10	13	96.0	28.0	13	100	18.0	880615	18.0	880615	160	930720	96.0	96.0
C11	18	75.6	33.0	16	89	21.0	880615	21.0	880615	160	940724	67.2	68.3
C12	14	44.2	29.0	13	93	5.5	880615	5.5	880615	100	751031	41.1	41.8
C13	7	74.3	29.0	6	86	40.0	880615	40.0	880615	120	880615	63.7	65.1
C14	16	45.6	31.0	13	81	2.6	880615	2.6	880615	90	880615	37.1	38.9
C15	17	75.7	42.0	17	100	9.7	880615	9.7	880615	170	860529	75.7	75.7
C16	4	104.0	18.0	4	100	81.0	880615	81.0	880615	130	770625	104.0	104.0
C17	5	63.4	14.0	5	100	46.0	880615	46.0	880615	84	880615	63.4	63.4
C18	10	96.2	26.0	10	100	43.0	870331	43.0	870331	140	890902	96.2	96.2
C19	3	65.2	2.8	2	67	62.0	880615	62.0	880615	68	770625	43.5	46.8
C20	2	59.2	31.0	2	100	28.0	880615	28.0	880615	90	880615	59.2	59.2
C21	2	52.0	27.0	2	100	25.0	751030	25.0	751030	79	880615	52.0	52.0
C22	11	67.5	53.0	10	91	8.8	920729	8.8	920729	160	890902	61.3	62.2
C23	2	22.3	19.0	2	100	3.6	880615	3.6	880615	41	770625	22.3	22.3
C24	3	25.6	14.0	3	100	5.7	880615	5.7	880615	39	760924	25.6	25.6
C25	3	9.7	2.0	3	100	7.2	880615	7.2	880615	12	760924	9.7	9.7
CB	2	20.0	0.0	1	50	20.0	751103	20.0	751103	20	751103	10.0	12.5
CBH	1	0.0	0.0	0	0							0.0	0.1
CBY1	1	20.6	0.0	1	100	21.0	760814	21.0	760814	21	760814	20.6	20.6
CBY2	1	153.0	0.0	1	100	150.0	760814	150.0	760814	150	760814	153.0	153.0
CCC1	3	47.0	6.0	3	100	41.0	880715	41.0	880715	55	880715	47.0	47.0
CCC2	10	17.7	9.3	10	100	6.2	910919	6.2	910919	38	810507	17.7	17.7
CCC3	10	56.3	23.0	10	100	12.0	930109	12.0	930109	89	720716	56.3	56.3
CCC4	13	42.7	26.0	13	100	19.0	891219	19.0	891219	100	740723	42.7	42.7
CCC5	17	61.5	49.0	17	100	23.0	891219	23.0	891219	190	720716	61.5	61.5

(continued)

TABLE 7-3
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
CCC6	38	64.4	37.0	38	100	4.3	690717	4.3	690717	170	740723	64.4	64.4
CCC7	15	71.7	39.0	15	100	9.7	891219	9.7	891219	140	751209	71.7	71.7
CCC8	26	125.0	68.0	26	100	16.0	910822	16.0	910822	280	790201	125.0	125.0
CP01	0												
CP02	6	19.8	5.3	5	83	11.0	760328	11.0	760328	27	760328	16.5	18.2
CP03	9	43.4	14.0	5	56	28.0	720918	28.0	720918	67	760331	24.1	28.6
CP04	2	81.5	23.0	2	100	59.0	760331	59.0	760331	100	910805	81.5	81.5
CP05	2	36.0	19.0	2	100	17.0	760331	17.0	760331	55	760331	36.0	36.0
CP06	7	69.9	15.0	7	100	42.0	760331	42.0	760331	90	860715	69.9	69.9
CP07	2	56.0	36.0	2	100	20.0	751103	20.0	751103	92	760331	56.0	56.0
CP08	2	0.0	0.0	0	0							0.0	10.0
CP09	3	23.5	9.5	2	67	14.0	760328	14.0	760328	33	760328	15.7	19.0
CP10	16	60.0	26.0	16	100	13.0	760831	13.0	760831	110	940724	60.0	60.0
EF	1	6.6	0.0	1	100	6.6	880615	6.6	880615	6.6	880615	6.6	6.6
GR1	1	44.0	0.0	1	100	44.0	760921	44.0	760921	44	760921	44.0	44.0
GR2	10	35.4	13.0	10	100	7.8	880615	7.8	880615	50	880615	35.4	35.4
HI1	4	4.6	0.8	4	100	3.5	940804	3.5	940804	5.6	880615	4.6	4.6
HI2	1	13.0	0.0	1	100	13.0	880615	13.0	880615	13	880615	13.0	13.0
I1	3	136.0	0.0	1	33	140.0	760813	140.0	760813	140	760813	45.3	45.4
I2	7	52.5	58.0	3	43	5.7	840823	5.7	840823	130	760813	22.5	24.0
I3	12	14.1	5.3	9	75	5.6	840823	5.6	840823	25	950111	10.6	12.2
I4	40	18.6	11.0	39	98	5.4	880127	5.4	880127	50	950111	18.2	18.3
I5	24	30.8	16.0	24	100	8.3	900110	8.3	900110	71	950111	30.8	30.8
I6	25	37.8	29.0	25	100	3.0	900110	3.0	900110	99	930720	37.8	37.8
I7	2	31.5	21.0	2	100	11.0	760531	11.0	760531	52	760531	31.5	31.5
I8	2	13.5	1.5	2	100	12.0	760531	12.0	760531	15	760531	13.5	13.5
I9	4	29.7	34.0	4	100	5.1	880615	5.1	880615	89	760618	29.7	29.7

(continued)

TABLE 7-3
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
I10	6	31.1	33.0	6	100	9.3	880615	9.3	880615	100	760618	31.1	31.1
I11	8	53.5	41.0	6	75	13.0	901116	13.0	901116	120	760618	40.1	42.6
I12	17	57.9	33.0	16	94	8.0	870507	8.0	870507	110	760618	54.5	55.1
I13	12	19.3	13.0	12	100	3.3	880909	3.3	880909	47	770109	19.3	19.3
I14	9	22.9	15.0	9	100	5.5	880909	5.5	880909	47	880615	22.9	22.9
I15	7	34.6	44.0	7	100	8.4	880615	8.4	880615	140	771217	34.6	34.6
I16	15	23.7	22.0	14	93	4.1	880615	4.1	880615	91	771217	22.1	22.8
I17	7	24.1	9.4	7	100	7.7	880615	7.7	880615	39	931221	24.1	24.1
I18	18	38.9	45.0	18	100	3.4	901116	3.4	901116	210	771217	38.9	38.9
IH1	21	478.0	600.0	21	100	9.1	790515	9.1	790515	2600	731024	478.0	478.0
IH2	6	1450.0	950.0	6	100	210.0	940316	210.0	940316	2900	751209	1450.0	1450.0
IH3	16	2480.0	2000.0	16	100	130.0	940316	130.0	940316	6000	751209	2480.0	2480.0
IH4	10	3020.0	3000.0	10	100	93.0	880615	93.0	880615	9700	720716	3020.0	3020.0
IH5	27	1940.0	1800.0	27	100	23.0	910710	23.0	910710	6200	720716	1940.0	1940.0
IH6	31	636.0	570.0	31	100	56.0	910822	56.0	910822	2400	720716	636.0	636.0
IH7	20	388.0	500.0	20	100	31.0	910822	31.0	910822	2000	751209	388.0	388.0
INL	4	7.1	3.7	3	75	2.4	900404	2.4	900404	11	940804	5.3	6.6
LAC	1	5.9	0.0	1	100	5.9	740723	5.9	740723	5.9	740723	5.9	5.9
LB	0												
LQ1	22	35.6	19.0	21	95	5.0	940617	5.0	940617	72	880615	34.0	34.2
LQ2	25	55.8	25.0	24	96	10.0	940617	10.0	940617	99	880524	53.6	53.8
LS1	1	40.0	0.0	1	100	40.0	760921	40.0	760921	40	760921	40.0	40.0
LS2	6	39.6	16.0	6	100	19.0	880615	19.0	880615	64	880615	39.6	39.6
M1	2	44.9	28.0	2	100	17.0	760917	17.0	760917	73	760917	44.9	44.9
M2	8	57.6	12.0	8	100	38.0	760917	38.0	760917	73	760917	57.6	57.6
MB1	18	35.2	22.0	16	89	0.6	760902	0.6	760902	87	860318	31.3	31.8
MB2	4	44.0	7.0	2	50	37.0	760813	37.0	760813	51	760813	22.0	27.0

(continued)

TABLE 7-3
(continued)

Segmt	No.of obs	Avg >DL	Std dev >DL	No. > DLs	% > DLs	Min	date	Min >0	date	Max	date	Avg w/ BDL=0	Avg w/ BDL=DL
NB1	5	106.0	70.0	5	100	44.0	880615	44.0	880615	240	880615	106.0	106.0
NB2	1	430.0	0.0	1	100	430.0	760910	430.0	760910	430	760910	430.0	430.0
NB3	3	145.0	75.0	3	100	41.0	910805	41.0	910805	210	880615	145.0	145.0
NB4	3	93.1	77.0	3	100	23.0	880615	23.0	880615	200	760910	93.1	93.1
NB5	9	89.0	58.0	8	89	18.0	880615	18.0	880615	170	720919	79.1	80.2
NB6	4	98.8	57.0	4	100	29.0	880615	29.0	880615	160	760910	98.8	98.8
NB7	15	138.0	71.0	15	100	33.0	770105	33.0	770105	250	840625	138.0	138.0
NB8	3	75.2	25.0	3	100	47.0	880615	47.0	880615	110	880615	75.2	75.2
NB9	2	31.8	10.0	2	100	22.0	880615	22.0	880615	42	760910	31.8	31.8
ND1	0												
ND2	1	39.3	0.0	1	100	39.0	880615	39.0	880615	39	880615	39.3	39.3
ND3	0												
ND4	1	25.9	0.0	1	100	26.0	880615	26.0	880615	26	880615	25.9	25.9
NR1	0												
NR2	0												
NR3	0												
NR4	9	106.0	82.0	9	100	10.0	810826	10.0	810826	220	850403	106.0	106.0
NR5	2	75.9	4.2	2	100	72.0	880615	72.0	880615	80	751030	75.9	75.9
OS1	3	144.0	100.0	3	100	58.0	841227	58.0	841227	290	801126	144.0	144.0
OS2	0												
OS3	2	50.5	1.5	2	100	49.0	731025	49.0	731025	52	750121	50.5	50.5
OS4	0												
OS5	2	90.1	2.7	2	100	87.0	760916	87.0	760916	93	760916	90.1	90.1
OS6	3	49.6	37.0	3	100	9.0	760916	9.0	760916	98	760916	49.6	49.6
OS7	3	28.9	9.5	3	100	16.0	880615	16.0	880615	39	760916	28.9	28.9
PB1	1	15.0	0.0	1	100	15.0	760916	15.0	760916	15	760916	15.0	15.0
PB2	3	16.0	0.0	1	33	16.0	760916	16.0	760916	16	760916	5.3	12.0

(continued)

TABLE 7-3
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
RB1	1	76.0	0.0	1	100	76.0	760713	76.0	760713	76	760713	76.0	76.0
RB2	2	39.8	34.0	2	100	5.7	760713	5.7	760713	74	760713	39.8	39.8
RB3	3	72.2	18.0	3	100	52.0	940804	52.0	940804	96	940804	72.2	72.2
RB4	1	14.0	0.0	1	100	14.0	880615	14.0	880615	14	880615	14.0	14.0
RB5	4	39.5	15.0	4	100	15.0	880615	15.0	880615	55	760713	39.5	39.5
RB6	4	30.5	29.0	4	100	7.6	880615	7.6	880615	79	760713	30.5	30.5
RB7	2	26.8	0.0	1	50	27.0	880615	27.0	880615	27	880615	13.4	18.4
RB8	18	36.4	16.0	18	100	6.9	790925	6.9	790925	75	731003	36.4	36.4
RB9	1	11.0	0.0	1	100	11.0	740723	11.0	740723	11	740723	11.0	11.0
SC1	1	17.0	0.0	1	100	17.0	760925	17.0	760925	17	760925	17.0	17.0
SC2	6	32.4	16.0	5	83	18.0	760925	18.0	760925	63	720918	27.0	28.7
SC3	9	18.6	16.0	9	100	3.3	810828	3.3	810828	41	860716	18.6	18.6
UL01	7	25.8	11.0	6	86	9.2	880615	9.2	880615	41	880615	22.1	23.5
UL02	3	29.3	23.0	3	100	11.0	880615	11.0	880615	62	880615	29.3	29.3
UL03	8	55.2	80.0	7	88	11.0	880615	11.0	880615	250	880615	48.3	49.6
UL04	1	101.0	0.0	1	100	100.0	880615	100.0	880615	100	880615	101.0	101.0
UL05	3	17.5	1.3	2	67	16.0	880615	16.0	880615	19	880615	11.7	15.0
UL06	8	23.7	17.0	6	75	6.7	880615	6.7	880615	55	880615	17.8	20.3
UL07	5	36.1	26.0	4	80	9.1	880615	9.1	880615	66	880615	28.9	30.9
UL08	4	9.1	3.8	3	75	3.8	880615	3.8	880615	12	760924	6.9	9.4
UL09	2	39.1	24.0	2	100	15.0	880615	15.0	880615	63	880615	39.1	39.1
UL10	5	14.2	12.0	4	80	3.8	880615	3.8	880615	34	770210	11.3	13.3
UL11	3	11.9	3.0	3	100	8.8	880615	8.8	880615	16	770210	11.9	11.9
UL12	3	32.7	8.2	3	100	23.0	770210	23.0	770210	43	770210	32.7	32.7
UL13	3	23.0	1.6	3	100	21.0	770210	21.0	770210	25	770210	23.0	23.0
UL14	5	18.8	4.8	4	80	12.0	880615	12.0	880615	25	771216	15.0	17.0

(continued)

TABLE 7-3
(continued)

Segmt	*No.of obs*	*Avg >DL*	*Std dev >DL*	*No. > DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*Avg w/ BDL=0*	*Avg w/ BDL=DL*
GMI1	4	18.00	0.0	1	25	18	760315	18	760315	18	760315	4.50	15.80
GMI2	4	21.00	0.0	1	25	21	760519	21	760519	21	760519	5.25	16.50
GMI3	5	18.00	1.0	2	40	17	760511	17	760511	19	760511	7.20	16.20
GMI4	3	41.00	0.0	1	33	41	760511	41	760511	41	760511	13.70	23.70
GMI5	5	39.50	14.0	2	40	26	760511	26	760511	53	760511	15.80	24.80
GMI6	20	28.40	27.0	15	75	2.3	900404	2.3	900404	93	860814	21.30	23.50
GMI7	6	22.00	7.0	2	33	15	760511	15	760511	29	760511	7.33	17.30
GMI8	4	153.00	0.0	1	25	150	760814	150	760814	150	760814	38.30	49.50
GMI9	3	0.00	0.0	0								0.00	15.00
GMO1	9	38.30	16.0	6	67	18	760303	18	760303	70	760303	25.60	30.60
GMO2	9	31.80	15.0	8	89	15	760303	15	760303	62	760519	28.20	29.90
GMO3	12	34.30	13.0	10	83	19	760511	19	760511	59	760511	28.60	31.10
GMO4	5	23.30	3.1	4	80	20	760511	20	760511	28	760511	18.60	21.60
GMO5	14	26.20	12.0	13	93	16	760511	16	760511	55	760511	24.30	25.40
GMO6	18	20.70	12.0	13	72	2.4	900404	2.4	900404	44	760511	15.00	16.90
GMO7	18	37.40	17.0	15	83	17	760511	17	760511	81	760508	31.20	33.70
GMO8	7	42.40	16.0	7	100	16	760508	16	760508	60	760508	42.40	42.40
GMO9	7	35.00	13.0	5	71	19	760508	19	760508	59	760508	25.00	29.30

Table 7-4

Time Trend Analysis for CCBNEP Hydrographic Segments: SEDTOC

Seg-ment	*Period of record*		*Analysis period*		*Avg*	*Regression on time*				*95% confidence limits on slope*		
	dates		*Start date*	*End date*	*obs /yr*	*slope (per yr)*	*intercept (@ start)*	*SEE*	*residual variance*	*lower*	*upper*	
A1	760407	760625	760407	760625	37	-2.99E+01	9.80	4.55	0.68	-7.30E+01	1.40E+01	poss
A2	760326	760625	760326	760625	24	8.30E+00	4.00	1.54	0.75	-1.20E+01	2.80E+01	poss
A3	760531	930720	760531	930720	0.29	1.96E-01	6.50	5.00	0.93	-1.10E+00	1.50E+00	poss
A4	760531	760625	760531	760625	100	-3.13E+01	16.00	2.26	0.85	-1.20E+02	5.40E+01	
A5	760531	760531	760531	760531	2							
A6	760531	760531	760531	760531	5							
A8	760625	760625	760625	760625	2							
A9	760625	760625	760625	760625	3							
A10	760531	760625	760531	760625	120	-5.59E+01	9.80	7.37	0.94	-2.80E+02	1.60E+02	
A11	760531	760531	760531	760531	11							
A12	760531	760531	760531	760531	7							
A13	760531	930720	760531	930720	0.41	-3.72E-02	4.70	3.15	1.00	-6.40E-01	5.70E-01	
AL1	760922	760922	760922	760922	8							
AL2	760921	760922	760921	760922	6200	1.96E+03	3.00	4.87	0.94	-2.20E+03	6.10E+03	poss
AR1	760331	760919	760331	760919	11	1.49E+01	4.00	5.06	0.77	-3.50E+01	6.50E+01	poss
AYB	760812	760812	760812	760812	3							
BF1	760921	760921	760921	760921	13							
BF2	760921	760922	760921	760922	10000	-3.18E+03	14.00	7.89	0.96	-9.40E+03	3.10E+03	
BF3	760921	760921	760921	760921	22							
C01	770625	930723	770625	930723	0.25	-2.03E-01	4.00	2.55	0.77	-1.30E+00	9.10E-01	
C02	770625	770625	770625	770625	4							
C03	770625	770625	770625	770625	5							
C04	770625	770625	770625	770625	7							
C05	770625	770625	770625	770625	4							
C06	770625	770625	770625	770625	7							
C07	770625	770625	770625	770625	6							

(continued)

Table 7-4
(continued)

Seg-ment	Period of record dates		Analysis period Start date	Analysis period End date	Avg obs /yr	Regression on time slope (per yr)	Regression on time intercept (@ start)	Regression on time SEE	Regression on time residual variance	95% confidence limits on slope lower	95% confidence limits on slope upper	
C08	770625	920729	770625	920729	0.66	-2.14E-01	13.00	3.16	0.91	-7.80E-01	3.60E-01	
C09	770625	770625	770625	770625	5							
C10	770625	930720	770625	930720	0.62	-3.15E-01	17.00	1.96	0.62	-6.50E-01	1.70E-02	poss
C11	770625	940724	770625	940724	0.94	9.17E-02	9.10	4.92	0.99	-5.90E-01	7.70E-01	poss
C12	770625	770625	770625	770625	15							
C13	760924	770625	760924	770625	8	1.57E+01	2.00	6.18	0.66	-1.50E+01	4.60E+01	poss
C14	760924	931221	760924	931221	0.87	-3.30E-01	6.40	6.07	0.95	-1.20E+00	5.40E-01	
C15	760910	880715	760910	880715	1.2	6.95E-02	4.70	3.61	0.99	-3.90E-01	5.30E-01	poss
C16	770625	770625	770625	770625	3							
C17	770625	770625	770625	770625	6							
C18	770625	890902	770625	890902	0.66	-4.35E-01	13.00	1.84	0.44	-8.20E-01	-4.80E-02	prob
C19	770625	770625	770625	770625	4							
C20	770625	770625	770625	770625	2							
C21	770625	770625	770625	770625	2							
C22	770625	920729	770625	920729	0.73	-3.25E-01	8.90	3.79	0.82	-8.50E-01	2.00E-01	poss
C23	770625	770625	770625	770625	2							
C24	760924	760924	760924	760924	3							
C25	760924	760924	760924	760924	2							
CB	760813	761001	760813	761001	52	-2.79E+01	7.70	3.03	0.77	-8.60E+01	3.00E+01	
CBH	940804	940804										
CBY1	760814	760814	760814	760814	2							
CBY2	760814	760814	760814	760814	1							
CCC1	760713	880715	760713	880715	0.33	-2.78E-02	5.00	1.78	0.99	-1.10E+00	1.00E+00	
CCC2	760713	910919	760713	760713	2							
CCC3	770625	770625	770625	770625	2							
CCC4	770625	950112	770625	950112	0.17	-7.79E-01	14.00	0.09	0.00	-9.20E-01	-6.40E-01	prob

(continued)

Table 7-4
(continued)

Seg-ment	*Period of record dates*		*Analysis period* Start date	End date	*Avg obs /yr*	*Regression on time* slope (per yr)	intercept (@ start)	*SEE*	residual variance	*95% confidence limits on slope* lower	upper	
CCC5	770625	950112	770625	950112	0.46	-5.78E-01	10.00	0.58	0.01	-6.50E-01	-5.10E-01	prob
CCC6	770625	950112	770625	950112	0.4	-6.73E-01	12.00	0.05	0.00	-6.80E-01	-6.70E-01	prob
CCC7	770625	950112	770625	950112	0.28	-4.21E-01	7.70	1.59	0.16	-7.60E-01	-8.10E-02	prob
CCC8	770625	950112	770625	950112	0.17	-1.05E-01	2.00	0.03	0.00	-1.50E-01	-6.30E-02	prob
CP01												
CP02	760328	760328	760328	760328	13							
CP03	760331	760331	760331	760331	14							
CP04	760331	910805	760331	910805	0.65	6.39E-01	8.60	4.68	0.72	-2.00E-01	1.50E+00	poss
CP05	760331	760331	760331	760331	8							
CP06	760328	870715	760328	870715	1.2	-3.27E-01	13.00	3.25	0.78	-7.10E-01	5.50E-02	poss
CP07	760331	760331	760331	760331	7							
CP08	760328	760331	760328	760331	1500	9.18E+02	2.00	7.58	0.93	-1.40E+03	3.30E+03	poss
CP09	760328	760328	760328	760328	9							
CP10	760328	940818	760328	940818	0.76	4.85E-01	6.50	4.68	0.56	1.40E-01	8.30E-01	prob
EF	770625	770625	770625	770625	1							
GR1	760921	760921	760921	760921	2							
GR2	760921	760921	760921	760921	14							
HI1	940804	940804										
HI2												
I1	760802	930216	760802	760813	66							
I2	760813	930216	760813	760813	5							
I3	760813	950111	760813	950111	0.27	-2.66E-01	5.00	1.09	0.17	-4.90E-01	-4.40E-02	prob
I4	760326	950111	760326	950111	0.75	-4.18E-01	7.80	2.76	0.34	-6.10E-01	-2.30E-01	prob
I5	760531	950111	760531	950111	0.86	-5.37E-01	11.00	4.48	0.60	-9.10E-01	-1.60E-01	prob
I6	760531	940105	760531	940105	0.57	-4.36E-01	12.00	5.24	0.69	-9.70E-01	9.90E-02	poss
I7	760531	760531	760531	760531	10							

(continued)

Table 7-4
(continued)

Seg-ment	Period of record dates		Analysis period Start date	Analysis period End date	Avg obs /yr	Regression on time slope (per yr)	intercept (@ start)	SEE	residual variance	95% confidence limits on slope lower	upper	
I8	760531	760531	760531	760531	6							
I9	760924	931221	760924	760924	2							
I10	760924	901116	760924	760924	3							
I11	760924	901116	760924	760924	5							
I12	760618	760924	760618	760924	22	-5.90E+01	25.00	11.90	0.72	-1.90E+02	7.30E+01	
I13	760618	931221	760618	770210	12	3.37E+01	11.00	19.40	0.89	-6.20E+01	1.30E+02	poss
I14	770109	770210	770109	770210	46	-2.09E+02	26.00	9.25	0.59	-9.60E+02	5.40E+02	
I15	770210	931221	770210	770210	1							
I16	760921	931221	760921	931221	0.23	-4.45E-01	7.70	2.15	0.30	-1.30E+00	4.40E-01	poss
I17	770210	931221	770210	931221	0.18	-6.50E-01	11.00	2.45	0.18	-4.60E+00	3.30E+00	
I18	770210	931221	770210	931221	0.53	-3.82E-01	6.50	2.35	0.39	-6.60E-01	-1.10E-01	prob
IH1	940316	940316	940316	940316	1							
IH2	940316	940316	940316	940316	1							
IH3	940316	940316	940316	940316	2							
IH4	940316	940316	940316	940316	1							
IH5	940316	940316	940316	940316	1							
IH6	910822	940316	940316	940316	2							
IH7	910822	940316	940316	940316	2							
INL	760511	940804	760511	760511	2							
LAC												
LB												
LQ1	770625	901220	770625	770625	2							
LQ2	770625	901220	770625	770625	2							
LS1	760921	760921	760921	760921	1							
LS2	760921	760921	760921	760921	7							
M1	760917	760917	760917	760917	4							

(continued)

Table 7-4
(continued)

Seg- ment	Period of record dates		Analysis period Start date	Analysis period End date	Avg obs /yr	Regression on time slope (per yr)	Regression on time intercept (@ start)	Regression on time SEE	Regression on time residual variance	95% confidence limits on slope lower	95% confidence limits on slope upper	
M2	760917	760917	760917	760917	18							
MB1	760813	760813	760813	760813	4							
MB2	760813	760813	760813	760813	11							
NB1	760910	760910	760910	760910	5							
NB2	760910	760910	760910	760910	2							
NB3	760910	930723	760910	930723	0.18	1.16E-02	7.40	3.74	1.00	-6.30E+00	6.30E+00	poss
NB4	760910	760910	760910	760910	4							
NB5	760910	760910	760910	760910	7							
NB6	760910	760910	760910	760910	2							
NB7	760910	760910	760910	760910	3							
NB8	760910	760910	760910	760910	3							
NB9	760910	760910	760910	760910	5							
ND1												
ND2	760910	760910	760910	760910	1							
ND3												
ND4												
NR1												
NR2												
NR3	760910	760910	760910	760910	1							
NR4	760910	760910	760910	760910	2							
NR5	760910	760910	760910	760910	2							
OS1												
OS2												
OS3												
OS4												
OS5	760916	760916	760916	760916	2							

(continued)

Table 7-4
(continued)

Seg-ment	Period of record dates		Analysis period Start date	Analysis period End date	Avg obs /yr	Regression on time slope (per yr)	Regression on time intercept (@ start)	Regression on time SEE	Regression on time residual variance	95% confidence limits on slope lower	95% confidence limits on slope upper	
OS6	760916	760916	760916	760916	4							
OS7	760916	760916	760916	760916	4							
PB1	760916	760916	760916	760916	1							
PB2	760331	760916	760331	760916	30	-2.44E+00	6.00	3.17	0.97	-1.10E+01	6.30E+00	
RB1	760713	760713	760713	760713	2							
RB2	760713	760713	760713	760713	6							
RB3	760713	940804	760713	760713	3							
RB4												
RB5	760713	760713	760713	760713	5							
RB6	760713	920729	760713	920729	0.31	-3.99E-01	10.00	6.62	0.87	-2.30E+00	1.50E+00	
RB7	760713	760713	760713	760713	3							
RB8	760713	940804	760713	760713	2							
RB9	760713	760713	760713	760713	3							
SC1	760925	760925	760925	760925	4							
SC2	760925	760925	760925	760925	8							
SC3	760925	760925	760925	760925	4							
UL01	760924	760924	760924	760924	5							
UL02	760924	760924	760924	760924	3							
UL03	760924	760924	760924	760924	11							
UL04												
UL05	760924	760924	760924	760924	5							
UL06	760924	760924	760924	760924	10							
UL07	760924	760924	760924	760924	5							
UL08	760924	770109	760924	770109	14	3.44E+00	3.00	1.87	0.95	-4.20E+01	4.90E+01	poss
UL09	760924	770109	760924	770109	17	-1.64E+01	9.00	2.92	0.70	-6.30E+01	3.00E+01	
UL10	770210	770210	770210	770210	7							
UL11	770210	770210	770210	770210	3							

(continued)

Table 7-4
(continued)

Seg-ment	*Period of record dates*		*Analysis period Start date*	*End date*	*Avg obs /yr*	*Regression on time slope (per yr)*	*intercept (@ start)*	*SEE*	*residual variance*	*95% confidence limits on slope lower*	*upper*	
UL12	770210	770210	770210	770210	2							
UL13	770210	770210	770210	770210	2							
UL14	770109	771216	770109	771216	3.2	-3.20E+00	9.00	2.45	0.75	-7.40E+01	6.70E+01	
GMI1	760302	760315	760302	760315	200	-7.19E+00	2.00	0.33	0.88	-2.90E+01	1.50E+01	
GMI2	760303	760519	760303	760519	43	4.74E+00	1.00	0.00	0.00	4.70E+00	4.70E+00	prob
GMI3	760511	760519	760511	760519	550	-4.56E+00	2.10	0.64	1.00	-6.00E+01	5.10E+01	
GMI4	760511	760511	760511	760511	6							
GMI5	760511	760511	760511	760511	14							
GMI6	760511	760511	760511	760511	9							
GMI7	760508	760511	760508	760511	2200	8.11E+00	1.70	0.56	1.00	-8.80E+01	1.00E+02	poss
GMI8	760508	760814	760508	760814	30	5.88E+00	1.40	0.46	0.44	6.40E-01	1.10E+01	prob
GMI9	760508	760508	760508	760508	5							
GMO1	760302	760315	760302	760315	900	-1.58E+01	4.50	1.97	0.98	-5.80E+01	2.70E+01	
GMO2	760303	760519	760303	760519	220	4.81E+00	3.50	2.12	0.96	-2.00E+00	1.20E+01	poss
GMO3	760511	760519	760511	760519	2800	-5.04E+00	4.70	2.01	1.00	-6.50E+01	5.50E+01	
GMO4	760511	760511	760511	760511	26							
GMO5	760511	760511	760511	760511	49							
GMO6	760511	760511	760511	760511	23							
GMO7	760508	760511	760508	760511	8300	-2.17E+01	4.30	2.45	1.00	-1.70E+02	1.30E+02	
GMO8	760508	760508	760508	760508	33							
GMO9	760508	760508	760508	760508	33							

Table 7-5
Time Trend Analysis for CCBNEP Hydrographic Segments: SEDMETZN

Segment	*Period of record dates*		*Analysis period* Start date	End date	*Avg obs /yr*	*Regression on time* slope (per yr)	intercept (@ start)	SEE	residual variance	*95% confidence limits on slope* lower	upper	
A1	760407	760407										
A2	760326	760407	760407	760407	1							
A3	760531	930720	930720	930720	1							
A4	760531	760625	760531	760625	30							
A5	760531	760531	760531	760531	1							
A6	760531	760531	760531	760531	1							
A8	760625	760625										
A9	760625	760625	760625	760625	1							
A10	760531	760531	760531	760531	1							
A11	760531	760531	760531	760531	2							
A12	751103	760531	751103	760531	3.5							
A13	740723	930720	740723	930720	0.16	-6.24E-01	33.0	2.0	0.12	-3.60E+00	2.30E+00	
AL1	760922	880615	760922	880615	0.51	2.17E+00	14.0	23.6	0.86	-5.30E+00	9.70E+00	poss
AL2	760922	880615	760922	880615	0.85	1.37E+00	33.0	17.3	0.88	-1.60E+00	4.40E+00	poss
AR1	731029	890516	731029	890516	0.71	-2.30E+00	49.0	19.8	0.75	-5.30E+00	6.90E-01	poss
AYB	840823	840823	840823	840823	1							
BF1	731023	880615	731023	880615	1.4	1.67E-02	47.0	21.6	1.00	-2.00E+00	2.10E+00	poss
BF2	760921	880615	760921	880615	1.7	1.41E+00	28.0	25.3	0.93	-1.10E+00	3.90E+00	poss
BF3	760921	880615	760921	880615	1.9	-7.42E-01	50.0	35.8	0.99	-4.20E+00	2.70E+00	
C01	770625	930723	770625	930723	0.31	-5.27E+00	140.0	63.7	0.84	-2.70E+01	1.70E+01	
C02	770625	880615	770625	880615	0.36	2.90E+00	31.0	15.7	0.56	-7.10E+00	1.30E+01	poss
C03	770625	880615	770625	880615	0.46	-3.08E+00	72.0	28.4	0.82	-1.50E+01	8.80E+00	
C04	770625	880615	770625	880615	0.55	-7.72E-01	88.0	29.0	0.98	-8.60E+00	7.00E+00	
C05	741024	880615	741024	880615	0.51	7.57E-01	86.0	17.5	0.94	-2.80E+00	4.30E+00	poss
C06	770625	880615	770625	880615	0.64	3.65E-02	100.0	16.8	1.00	-5.00E+00	5.10E+00	poss
C07	740723	880615	740723	880615	0.65	-1.98E-01	99.0	30.7	1.00	-4.80E+00	4.40E+00	

(continued)

Table 7-5
(continued)

Seg-ment	*Period of record dates*		*Analysis period* Start date	End date	*Avg obs /yr*	*Regression on time* slope (per yr)	intercept (@ start)	SEE	residual variance	*95% confidence limits on slope* lower	upper	
C08	770625	920729	770625	920729	0.53	1.21E+00	82.0	20.9	0.95	-4.00E+00	6.40E+00	poss
C09	770625	880615	770625	880615	0.46	9.39E-01	49.0	26.8	0.97	-8.20E+00	1.00E+01	poss
C10	741024	930720	741024	930720	0.69	8.57E-01	86.0	27.8	0.97	-2.60E+00	4.30E+00	poss
C11	770625	940724	770625	940724	0.94	1.19E-01	75.0	32.8	1.00	-3.90E+00	4.10E+00	poss
C12	751031	880615	751031	880615	1	-2.01E+00	61.0	26.7	0.85	-5.20E+00	1.20E+00	poss
C13	770625	880615	770625	880615	0.55	1.45E+00	61.0	28.8	0.96	-8.30E+00	1.10E+01	poss
C14	760924	931221	880615	931221	2.4	-6.76E+00	53.0	28.1	0.81	-1.60E+01	2.50E+00	poss
C15	760412	880715	760412	880715	1.4	-6.47E-01	81.0	41.8	1.00	-5.60E+00	4.30E+00	
C16	770625	880615	770625	880615	0.36	-3.19E+00	130.0	9.8	0.30	-9.50E+00	3.10E+00	poss
C17	741024	880615	741024	880615	0.37	2.51E-01	61.0	13.5	0.99	-3.80E+00	4.30E+00	poss
C18	770625	890902	770625	890902	0.82	-2.27E+00	120.0	24.8	0.91	-8.30E+00	3.70E+00	
C19	770625	880615	770625	880615	0.18							
C20	880615	880615	880615	880615	2							
C21	751030	880615	751030	880615	0.16							
C22	770625	920729	840930	920729	1.3	1.76E+00	62.0	52.4	0.99	-1.70E+01	2.00E+01	poss
C23	770625	880615	770625	880615	0.18							
C24	760924	880615	760924	880615	0.26	-1.72E+00	39.0	10.7	0.56	-2.60E+01	2.30E+01	
C25	760924	880615	760924	880615	0.26	-2.89E-01	12.0	1.1	0.33	-2.90E+00	2.30E+00	
CB	751103	840823	751103	751103	1							
CBH	940804	940804										
CBY1	760814	760814	760814	760814	1							
CBY2	760814	760814	760814	760814	1							
CCC1	880715	880715	880715	880715	3							
CCC2	720716	910919	720716	910919	0.52	-5.54E-01	24.0	8.5	0.83	-1.50E+00	4.40E-01	
CCC3	720716	940617	720716	940617	0.46	-1.62E+00	73.0	17.5	0.56	-3.10E+00	-1.10E-01	prob
CCC4	740723	950112	740723	950112	0.64	-1.93E+00	66.0	23.1	0.78	-4.40E+00	5.10E-01	poss

(continued)

Table 7-5
(continued)

Segment	Period of record dates		Analysis period Start date	Analysis period End date	Avg obs /yr	Regression on time slope (per yr)	Regression on time intercept (@ start)	Regression on time SEE	Regression on time residual variance	95% confidence limits on slope lower	95% confidence limits on slope upper	
CCC5	720716	950112	720716	950112	0.76	-4.04E+00	130.0	42.8	0.76	-8.00E+00	-7.50E-02	prob
CCC6	690717	950112	690717	950112	1.5	-9.72E-01	81.0	36.0	0.97	-2.80E+00	8.80E-01	
CCC7	751209	950112	751209	950112	0.79	-2.55E+00	100.0	37.0	0.90	-7.00E+00	1.90E+00	
CCC8	740723	950112	740723	950112	1.3	-5.86E+00	180.0	57.6	0.72	-9.80E+00	-1.90E+00	prob
CP01												
CP02	720918	760328	720918	760328	1.4	-6.64E-01	21.0	5.3	0.97	-7.30E+00	6.00E+00	
CP03	720918	760331	720918	760331	1.4	6.03E+00	30.0	11.3	0.63	-8.30E+00	2.00E+01	poss
CP04	760331	910805	760331	910805	0.13							
CP05	760331	760331	760331	760331	2							
CP06	760331	870715	760331	870715	0.62	2.76E+00	44.0	10.2	0.48	-3.10E-01	5.80E+00	poss
CP07	751103	760331	751103	760331	4.9							
CP08	760331	760331										
CP09	760328	760328	760328	760328	2							
CP10	731228	940818	731228	940818	0.78	2.61E+00	30.0	18.1	0.48	1.20E+00	4.00E+00	prob
EF	880615	880615	880615	880615	1							
GR1	760921	760921	760921	760921	1							
GR2	760921	880615	760921	880615	0.85	4.18E-01	32.0	12.8	0.97	-1.50E+00	2.40E+00	poss
HI1	880615	940804	880615	940804	0.65	-2.22E-01	5.6	0.5	0.42	-8.00E-01	3.50E-01	
HI2	880615	880615	880615	880615	1							
I1	760813	930216	760813	760813	1							
I2	760813	930216	760813	840823	0.37	-8.75E+00	76.0	47.4	0.67	-1.70E+02	1.50E+02	
I3	761001	950111	840508	950111	0.84	9.69E-01	10.0	3.8	0.51	8.70E-02	1.90E+00	prob
I4	760625	950111	760625	950111	2.1	2.16E-01	16.0	11.4	0.99	-6.60E-01	1.10E+00	poss
I5	840823	950111	840823	950111	2.3	1.51E+00	22.0	15.8	0.92	-7.40E-01	3.80E+00	poss
I6	690716	940105	690716	940105	1	3.53E-02	37.0	28.8	1.00	-1.60E+00	1.70E+00	poss
I7	760531	760531	760531	760531	2							

(continued)

Table 7-5
(continued)

Seg-ment	*Period of record dates*		*Analysis period* *Start date*	*End date*	*Avg obs /yr*	*Regression on time* *slope (per yr)*	*intercept (@ start)*	*SEE*	*residual variance*	*95% confidence limits on slope* *lower*	*upper*	
I8	760531	760531	760531	760531	2							
I9	760618	931221	760618	931221	0.23	-3.04E+00	52.0	25.6	0.55	-1.30E+01	7.20E+00	
I10	760618	901116	760618	901116	0.42	-4.06E+00	67.0	21.0	0.41	-8.70E+00	6.20E-01	poss
I11	760618	901116	760618	901116	0.42	-6.88E+00	130.0	22.6	0.31	-1.30E+01	-5.30E-01	prob
I12	731023	890808	731023	890808	1	-6.78E-01	64.0	32.7	0.99	-4.40E+00	3.00E+00	
I13	770109	931221	770109	931221	0.71	-2.71E-01	22.0	12.8	0.99	-1.90E+00	1.40E+00	
I14	770109	880909	770109	880909	0.77	-1.56E+00	37.0	12.8	0.75	-3.90E+00	8.20E-01	poss
I15	770210	931221	770210	931221	0.42	-4.19E+00	76.0	34.7	0.63	-1.00E+01	2.10E+00	poss
I16	760921	931221	771217	931221	0.87	-3.97E+00	69.0	16.5	0.54	-6.70E+00	-1.30E+00	prob
I17	770210	931221	770210	931221	0.42	5.31E-01	18.0	8.9	0.90	-1.30E+00	2.40E+00	poss
I18	770210	931221	770210	931221	1.1	-1.93E+00	56.0	43.4	0.92	-5.40E+00	1.50E+00	
IH1	731024	940316	731024	940316	1	-6.22E+01	970.0	497.0	0.69	-1.10E+02	-1.80E+01	prob
IH2	720716	940316	720716	940316	0.28	-8.14E+01	2000.0	753.0	0.63	-2.30E+02	6.60E+01	poss
IH3	720716	940316	720716	940316	0.74	-2.48E+02	4400.0	1250.0	0.41	-3.70E+02	-1.30E+02	prob
IH4	720716	940316	720716	940316	0.46	-3.54E+02	6300.0	1850.0	0.39	-5.90E+02	-1.20E+02	prob
IH5	720716	940316	720716	940316	1.2	-2.07E+02	4100.0	1230.0	0.48	-2.90E+02	-1.30E+02	prob
IH6	720716	940316	720716	940316	1.4	-5.87E+01	1200.0	442.0	0.61	-8.60E+01	-3.10E+01	prob
IH7	720716	940316	720716	940316	0.92	-3.52E+01	750.0	438.0	0.76	-6.60E+01	-4.20E+00	prob
INL	740723	940804	740723	940804	0.15	6.10E-02	6.3	3.6	0.98	-5.30E+00	5.40E+00	poss
LAC	740723	740723	740723	740723	1							
LB												
LQ1	720716	940617	720716	940617	0.96	-6.53E-01	43.0	18.5	0.92	-1.70E+00	4.20E-01	
LQ2	720716	940617	720716	940617	1.1	-1.23E+00	68.0	23.6	0.87	-2.60E+00	1.50E-01	poss
LS1	760921	760921	760921	760921	1							
LS2	760921	880615	760921	880615	0.51	1.30E+00	30.0	14.5	0.80	-2.40E+00	4.90E+00	poss
M1	760917	760917	760917	760917	2							

(continued)

Table 7-5
(continued)

Seg-ment	*Period of record dates*		*Analysis period Start date*	*Analysis period End date*	*Avg obs /yr*	*Regression on time: slope (per yr)*	*Regression on time: intercept (@ start)*	*Regression on time: SEE*	*Regression on time: residual variance*	*95% confidence limits on slope: lower*	*95% confidence limits on slope: upper*	
M2	760917	760917	760917	760917	8							
MB1	731221	880719	731221	880719	1.1	2.40E+00	13.0	19.6	0.76	-6.90E-02	4.90E+00	poss
MB2	760813	760813	760813	760813	2							
NB1	760910	880615	760910	880615	0.43	1.48E+00	96.0	69.8	0.99	-2.10E+01	2.40E+01	poss
NB2	760910	760910	760910	760910	1							
NB3	880615	930723	880615	930723	0.59	-1.04E+01	170.0	71.3	0.91	-4.40E+02	4.20E+02	
NB4	760910	880615	760910	880615	0.26	-1.36E+01	200.0	13.5	0.03	-4.50E+01	1.70E+01	poss
NB5	720919	880615	720919	880615	0.51	-1.61E+00	100.0	57.0	0.96	-9.80E+00	6.60E+00	
NB6	720919	880615	720919	880615	0.25	-7.75E+00	170.0	17.7	0.10	-1.50E+01	-6.30E-02	prob
NB7	731015	880527	731015	880527	1	2.93E+00	120.0	69.9	0.96	-5.70E+00	1.20E+01	poss
NB8	760910	880615	760910	880615	0.26	5.36E-01	71.0	25.1	0.99	-5.70E+01	5.80E+01	poss
NB9	760910	880615	760910	880615	0.17							
ND1												
ND2	880615	880615	880615	880615	1							
ND3												
ND4	880615	880615	880615	880615	1							
NR1												
NR2												
NR3												
NR4	800910	880615	800910	880615	1.2	2.44E+01	-1.0	51.8	0.40	6.80E+00	4.20E+01	prob
NR5	751030	880615	751030	880615	0.16							
OS1	801126	841227	801126	841227	0.73	-5.65E+01	260.0	43.3	0.17	-3.90E+02	2.70E+02	
OS2												
OS3	731025	750121	731025	750121	1.6							
OS4												
OS5	760916	760916	760916	760916	2							

(continued)

Table 7-5
(continued)

Segment	Period of record dates		Analysis period Start date	Analysis period End date	Avg obs /yr	Regression on time slope (per yr)	Regression on time intercept (@ start)	Regression on time SEE	Regression on time residual variance	95% confidence limits on slope lower	95% confidence limits on slope upper	
OS6	760916	880615	760916	880615	0.26	-9.30E-01	53.0	36.1	0.98	-8.40E+01	8.20E+01	
OS7	760916	880615	760916	880615	0.26	-1.65E+00	35.0	2.7	0.08	-7.90E+00	4.60E+00	poss
PB1	760916	760916	760916	760916	1							
PB2	760331	760916	760916	760916	1							
RB1	760713	760713	760713	760713	1							
RB2	760713	760713	760713	760713	2							
RB3	760713	940804	760713	940804	0.17	2.66E-01	69.0	18.2	0.99	-2.70E+01	2.70E+01	poss
RB4	880615	880615	880615	880615	1							
RB5	760713	880615	760713	880615	0.34	-2.10E+00	52.0	8.8	0.33	-6.60E+00	2.40E+00	poss
RB6	760713	920729	760713	920729	0.25	-4.17E+00	72.0	14.4	0.25	-1.10E+01	3.10E+00	poss
RB7	760713	880615	880615	880615	1							
RB8	731003	940804	731003	940804	0.86	-1.15E+00	46.0	15.1	0.86	-2.70E+00	3.40E-01	poss
RB9	740723	740723	740723	740723	1							
SC1	760925	760925	760925	760925	1							
SC2	720918	760925	720918	760925	1.2	-8.34E+00	53.0	8.8	0.29	-1.80E+01	1.60E+00	poss
SC3	760925	880727	760925	880727	0.76	2.74E-02	18.0	15.7	1.00	-4.20E+00	4.20E+00	poss
UL01	760924	880615	760924	880615	0.51	3.89E-01	22.0	10.4	0.97	-2.90E+00	3.70E+00	poss
UL02	880615	880615	880615	880615	3							
UL03	760924	880615	760924	880615	0.6	2.71E+00	28.0	79.3	0.98	-1.90E+01	2.50E+01	poss
UL04	880615	880615	880615	880615	1							
UL05	760924	880615	880615	880615	2							
UL06	760924	880615	880615	880615	6							
UL07	760924	880615	760924	880615	0.34	2.74E+00	12.0	21.7	0.71	-1.00E+01	1.60E+01	poss
UL08	760924	880615	760924	880615	0.26	-3.67E-01	12.0	3.2	0.71	-7.70E+00	7.00E+00	
UL09	880615	880615	880615	880615	2							
UL10	770210	880615	770210	880615	0.35	-2.33E+00	34.0	2.3	0.04	-3.80E+00	-8.80E-01	prob

(continued)

Table 7-5
(continued)

Seg-ment	Period of record dates		Analysis period Start date	Analysis period End date	Avg obs /yr	Regression on time slope (per yr)	intercept (@ start)	SEE	residual variance	95% confidence limits on slope lower	upper	
UL11	770210	880615	770210	880615	0.26	-5.38E-01	16.0	0.9	0.09	-2.70E+00	1.60E+00	poss
UL12	770210	770210	770210	770210	3							
UL13	770210	770210	770210	770210	3							
UL14	770109	880615	770109	880615	0.35	-7.52E-01	23.0	2.5	0.26	-2.10E+00	6.10E-01	poss
GMI1	760302	760315	760315	760315	1							
GMI2	760303	760519	760519	760519	1							
GMI3	760511	760519	760511	760511	2							
GMI4	760511	760511	760511	760511	1							
GMI5	760511	760511	760511	760511	2							
GMI6	720716	900404	720716	900404	0.85	-7.27E-01	35.0	26.9	0.98	-3.60E+00	2.10E+00	
GMI7	760508	760511	760511	760511	2							
GMI8	760508	760814	760814	760814	1							
GMI9	760508	760508										
GMO1	760302	760315	760302	760315	170	-1.77E+02	41.0	15.6	0.97	-1.50E+03	1.20E+03	
GMO2	760303	760519	760303	760519	38	9.32E+01	27.0	12.3	0.68	-4.20E+01	2.30E+02	poss
GMO3	760511	760519	760511	760519	460	-2.45E+02	35.0	12.8	0.97	-1.40E+03	9.50E+02	
GMO4	760511	760511	760511	760511	4							
GMO5	760511	760511	760511	760511	13							
GMO6	760511	900404	760511	900404	0.94	-1.64E+00	31.0	7.6	0.40	-2.50E+00	-7.50E-01	prob
GMO7	760508	760511	760508	760511	1800	-4.74E+02	40.0	17.4	0.99	-3.20E+03	2.20E+03	
GMO8	760508	760508	760508	760508	7							
GMO9	760508	760508	760508	760508	5							

Table 7-6
Period of record average (with BDL=0) for principal component bays
Conventional sediment quality parameters

Parameter: / *Component bay*	SEDAMMN *No.of obs*	SEDAMMN *Avg*	SEDKJLN *No.of obs*	SEDKJLN *Avg*	SEDTOTP *No.of obs*	SEDTOTP *Avg*
Aransas Bay	0		0		0	
Copano Bay	0		5	1610	9	388
St Charles	0		8	444	8	211
Mesquite	4	0	9	460	9	413
Redfish	0		15	750	17	363
Corpus Christi	0		1		1	
CCSC (bay)	4	117	22	1365	20	634
Inner Harbor	10	165	59	1302	62	488
Nueces Bay	0		1		1	
Aransas Pass	1		3	50	2	190
Oso Bay	0		0		0	
Causeway N	0		0		0	
Causeway S	0		0		0	
Laguna (King Ranch)	0		10	4190	15	636
Laguna (Baffin)	0		0		0	
Baffin Bay	0		12	1725	19	508
GOM inlet	11	42	18	277	12	639

Parameter: / *Component bay*	SEDTOC *No.of obs*	SEDTOC *Avg*	SEDO&G *No.of obs*	SEDO&G *Avg*	SEDVOLS *No.of obs*	SEDVOLS *Avg*
Aransas Bay	78	8.4	1		0	
Copano Bay	101	8.8	9	1230	8	77200
St Charles	12	6.1	8	1570	8	24500
Mesquite	25	5.6	13	2560	8	160000
Redfish	30	10.0	17	452	14	17900
Corpus Christi	134	10.1	6	368	1	
CCSC (bay)	27	3.9	43	387	25	92821
Inner Harbor	13	0.4	97	1151	81	68800
Nueces Bay	21	6.5	10	547	1	
Aransas Pass	10	3.1	3	140	2	1
Oso Bay	10	9.6	0		0	
Causeway N	8	13.2	1		0	
Causeway S	13	21.6	1		0	
Laguna (King Ranch)	81	11.1	18	1008	12	75300
Laguna (Baffin)	34	7.1	0		0	
Baffin Bay	94	10.5	23	913	16	105700
GOM inlet	183	3.6	24	454	12	27100

Table 7-7
Period of record average (with BDL=0) for principal component bays
Sediment metals

Parameter:	SEDMETAS		SEDMETCD		SEDMETCR	
Component bay	*No.of obs*	*Avg*	*No.of obs*	*Avg*	*No.of obs*	*Avg*
Aransas Bay	33	3.98	33	1.89	52	11.4
Copano Bay	30	4.98	30	3.79	42	22.2
St Charles	11	2.53	11	5.00	12	12.5
Mesquite	20	3.70	22	2.92	21	6.8
Redfish	26	3.53	28	0.68	36	9.2
Corpus Christi	115	4.50	112	0.89	142	18.6
CCSC (bay)	90	3.50	86	0.95	90	14.2
Inner Harbor	114	6.33	125	16.41	117	36.1
Nueces Bay	14	3.62	15	1.68	16	12.8
Aransas Pass	12	1.96	12	0.52	12	14.7
Oso Bay	2	2.45	2	0.35	8	14.5
Causeway N	6	1.56	6	0.00	10	9.4
Causeway S	13	4.05	13	0.33	17	13.4
Laguna (King Ranch)	69	3.38	69	0.40	93	9.6
Laguna (Baffin)	32	3.20	32	0.31	51	7.5
Baffin Bay	67	4.09	68	1.22	88	19.6
GOM inlet	31	2.04	29	1.17	82	27.4

Parameter:	SEDMETCU		SEDMETHG		SEDMETNI	
Component bay	*No.of obs*	*Avg*	*No.of obs*	*Avg*	*No.of obs*	*Avg*
Aransas Bay	53	6.53	32	0.038	52	6.67
Copano Bay	50	8.51	22	0.036	42	10.25
St Charles	15	4.55	8	0.030	12	5.51
Mesquite	25	5.28	19	0.158	24	3.75
Redfish	35	6.47	28	0.029	35	6.09
Corpus Christi	143	9.81	113	0.083	139	10.58
CCSC (bay)	88	7.64	92	0.145	88	8.59
Inner Harbor	110	37.39	120	1.097	108	9.72
Nueces Bay	19	9.87	12	0.120	15	6.30
Aransas Pass	12	3.30	12	0.014	12	4.28
Oso Bay	8	10.13	2	0.060	8	3.67
Causeway N	10	7.43	6	0.027	10	3.98
Causeway S	17	14.81	13	0.054	17	7.79
Laguna (King Ranch)	93	8.23	70	0.100	93	6.21
Laguna (Baffin)	51	4.59	32	0.036	51	3.75
Baffin Bay	89	12.82	69	0.088	89	9.68
GOM inlet	81	7.64	31	0.083	81	8.03

(continued)

Table 7-7
Sediment metals (continued)

Parameter: Component bay	SEDMETPB		SEDMETSE		SEDMETZN	
	No.of obs	*Avg*	*No.of obs*	*Avg*	*No.of obs*	*Avg*
Aransas Bay	39	9.14	32	0.31	53	31.3
Copano Bay	50	13.14	15	0.60	49	43.3
St Charles	11	6.17	4	0.70	15	25.5
Mesquite	20	6.87	8	0.60	25	26.5
Redfish	27	7.31	16	0.13	35	33.8
Corpus Christi	112	17.98	109	0.21	144	73.7
CCSC (bay)	91	16.02	68	0.53	93	59.3
Inner Harbor	130	91.66	41	0.78	131	1484.6
Nueces Bay	15	13.15	11	0.12	19	166.5
Aransas Pass	12	6.31	9	0.12	12	16.1
Oso Bay	2	14.00	2	0.00	8	56.2
Causeway N	6	7.33	6	0.05	10	21.7
Causeway S	13	18.33	13	0.56	17	46.8
Laguna (King Ranch)	70	10.86	62	0.40	91	30.4
Laguna (Baffin)	32	11.98	32	0.23	51	26.9
Baffin Bay	69	30.84	59	0.35	87	42.5
GOM inlet	82	14.15	10	0.40	81	29.0

Table 7-8
Period of record average (with BDL=0) for principal component bays
Sediment pesticides and PCB's

Parameter:	SED-ALDR		SED-CHLR		SED-DIAZ	
Component bay	*No.of obs*	*Avg*	*No.of obs*	*Avg*	*No.of obs*	*Avg*
Aransas Bay	5	0.13	26	0.72	1	
Copano Bay	24	0.25	17	1.53	7	1.25
St Charles	12	0.10	12	0.50	8	0.00
Mesquite	16	0.08	11	0.33	4	0.00
Redfish	12	0.01	15	0.01	10	0.00
Corpus Christi	25	0.00	23	0.11	1	
CCSC (bay)	16	0.00	63	0.00	9	0.00
Inner Harbor	38	0.00	54	0.71	32	0.00
Nueces Bay	17	0.08	15	0.27	1	
Aransas Pass	5	0.08	7	0.00	0	
Oso Bay	1		1		1	
Causeway N	1		2	0.00	0	
Causeway S	1		3	0.00	0	
Laguna (King Ranch)	17	0.00	33	0.00	15	0.00
Laguna (Baffin)	0		23	0.00	0	
Baffin Bay	7	0.25	7	5.00	7	1.67
GOM inlet	12	0.00	19	0.00	1	

Parameter:	SED-DIEL		SED-LIND		SED-TOXA	
Component bay	*No.of obs*	*Avg*	*No.of obs*	*Avg*	*No.of obs*	*Avg*
Aransas Bay	5	0.13	2	0.02	25	0.00
Copano Bay	24	0.19	16	0.14	10	12.50
St Charles	12	0.10	8	0.00	10	0.00
Mesquite	16	0.12	12	0.00	9	0.00
Redfish	12	0.00	12	0.02	15	0.00
Corpus Christi	31	0.10	29	0.08	21	0.00
CCSC (bay)	16	0.00	14	0.00	63	0.00
Inner Harbor	38	0.72	37	0.00	54	0.00
Nueces Bay	17	0.08	12	0.03	14	2.50
Aransas Pass	5	0.02	5	0.00	7	0.00
Oso Bay	1		1		1	
Causeway N	1		1		2	0.00
Causeway S	1		1		3	0.00
Laguna (King Ranch)	17	0.00	17	0.00	33	0.00
Laguna (Baffin)	0		0		23	0.00
Baffin Bay	7	0.75	7	0.25	7	12.50
GOM inlet	12	0.00	12	0.00	19	0.00

(continued)

Table 7-8
Sediment pesticides and PCB's (continued)

Parameter: / *Component bay*	SED-XDDT *No.of obs*	SED-XDDT *Avg*	SED-DDT *No.of obs*	SED-DDT *Avg*	SED-PCB *No.of obs*	SED-PCB *Avg*
Aransas Bay	28	0.09	5	0.15	28	0.77
Copano Bay	30	0.24	17	0.41	13	1.83
St Charles	20	0.10	12	0.10	11	1.00
Mesquite	18	0.36	7	0.10	11	0.67
Redfish	24	0.00	11	0.01	18	82.07
Corpus Christi	43	0.74	8	0.15	23	0.48
CCSC (bay)	67	0.97	10	0.00	60	17.00
Inner Harbor	62	0.00	34	0.00	54	48.96
Nueces Bay	18	0.06	7	0.09	18	3.77
Aransas Pass	10	0.00	0		7	0.00
Oso Bay	1		1		1	
Causeway N	2	0.00	0		2	0.00
Causeway S	3	0.00	0		3	0.00
Laguna (King Ranch)	39	0.00	17	0.00	35	13.47
Laguna (Baffin)	23	0.00	0		23	0.00
Baffin Bay	20	1.18	16	1.18	15	15.00
GOM inlet	19	0.00	1		19	6.00

Table 7-9
Period of record average (with BDL=0) for principal component bays
Sediment PAH's and TBT

Parameter: Component bay	SED-ACEN *No.of obs*	SED-ACEN *Avg*	SED-BNZA *No.of obs*	SED-BNZA *Avg*	SED-FLRA *No.of obs*	SED-FLRA *Avg*
Aransas Bay	22	0.06	23	1.00	23	2.1
Copano Bay	11	0.25	11	2.98	11	9.2
St Charles	0		0		0	
Mesquite	9	2.00	9	3.00	5	10.4
Redfish	4	0.20	5	5.37	5	6.1
Corpus Christi	26	0.37	34	7.29	34	12.7
CCSC (bay)	47	0.00	52	0.86	52	2.2
Inner Harbor	16	0.00	20	220.43	20	110.3
Nueces Bay	2	6.35	11	13.08	11	32.5
Aransas Pass	8	0.61	9	2.50	9	5.5
Oso Bay	0		0		0	
Causeway N	1		2	0.00	2	0.0
Causeway S	2	0.00	3	10.00	3	15.0
Laguna (King Ranch)	16	0.00	19	0.00	19	0.0
Laguna (Baffin)	23	0.00	23	0.00	23	0.0
Baffin Bay	0		4	0.00	4	0.0
GOM inlet	7	0.00	7	0.00	7	0.0

Parameter: Component bay	SED-NAPT *No.of obs*	SED-NAPT *Avg*	SED-PAH *No.of obs*	SED-PAH *Avg*	SED-TBT *No.of obs*	SED-TBT *Avg*
Aransas Bay	23	0.36	22	13.8	1	
Copano Bay	9	1.83	5	87.3	7	3.37
St Charles	0		0		0	
Mesquite	8	0.00	0		0	
Redfish	5	0.29	4	38.3	1	
Corpus Christi	34	5.54	11	69.2	5	2.46
CCSC (bay)	52	0.00	47	0.3	0	
Inner Harbor	20	1.43	16	505.7	0	
Nueces Bay	11	3.29	2	512.0	2	11.20
Aransas Pass	9	0.90	5	0.0	0	
Oso Bay	0		0		0	
Causeway N	2	0.00	1		0	
Causeway S	3	0.00	2	0.0	0	
Laguna (King Ranch)	19	0.00	16	0.0	0	
Laguna (Baffin)	23	0.00	23	0.0	0	
Baffin Bay	4	0.00	0		0	
GOM inlet	7	0.00	7	0.0	0	

Table 7-10
Summary of trend analysis by component bay for SEDKJLN
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	0							
Copano Bay	9	1	0.0	0.0	0.0	0.0	100.0		7.52E+00
St Charles	2	1	0.0	0.0	100.0	0.0	0.0		
Mesquite	4	1	0.0	0.0	100.0	0.0	0.0		
Redfish	8	1	0.0	0.0	100.0	0.0	0.0		
Corpus Christi	20	0							
CCSC (bay)	5	3	33.3	0.0	33.3	33.3	0.0	-3.52E+01	
Inner Harbor	7	7	14.3	14.3	71.4	0.0	0.0	-5.61E+00	
Nueces Bay	5	0							
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	1	0.0	0.0	0.0	100.0	0.0		
Laguna (Baffin)	6	0							
Baffin Bay	5	2	0.0	0.0	50.0	50.0	0.0		
GOM inlet	6	6	0.0	0.0	100.0	0.0	0.0		

Table 7-11
Summary of trend analysis by component bay for SEDTOTP
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	0							
Copano Bay	9	1	0	100	0	0	0		
St Charles	2	1	0	0	100	0	0		
Mesquite	4	1	0	100	0	0	0		
Redfish	8	1	100	0	0	0	0	-7.71E+00	
Corpus Christi	20	0							
CCSC (bay)	5	1	0	100	0	0	0		
Inner Harbor	7	3	0	0	100	0	0		
Nueces Bay	5	0							
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	1	0	0	100	0	0		
Laguna (Baffin)	6	0							
Baffin Bay	5	2	0	0	50	50	0		
GOM inlet	6	1	0	0	100	0	0		

Table 7-12
Summary of trend analysis by component bay for SEDTOC
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	number segments	number w/data	prob <0	poss <0	none	poss >0	prob >0	mean prob<0	mean prob>0
Aransas Bay	13	8	0	25	50	25	0		
Copano Bay	9	4	0	25	0	50	25		5.39E-02
St Charles	2	0							
Mesquite	4	1	0	0	100	0	0		
Redfish	8	1	0	0	100	0	0		
Corpus Christi	20	8	12.5	25	37.5	25	0	-2.18E-02	
CCSC (bay)	5	4	100	0	0	0	0	-4.90E-01	
Inner Harbor	7	0							
Nueces Bay	5	1	0	0	0	100	0		
Oso Bay	3	0							
Aransas Pass	4	1	0	0	100	0	0		
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	5	0	0	60	40	0		
Laguna (Baffin)	6	4	25	25	50	0	0	-6.37E-02	
Baffin Bay	5	2	0	0	50	50	0		
GOM inlet	6	2	0	0	50	50	0		

Table 7-13
Summary of trend analysis by component bay for SEDO&G
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	number segments	number w/data	prob <0	poss <0	none	poss >0	prob >0	mean prob<0	mean prob>0
Aransas Bay	13	0							
Copano Bay	9	1	0	0	0	100	0		
St Charles	2	1	0	0	0	100	0		
Mesquite	4	1	0	0	0	100	0		
Redfish	8	1	0	0	100	0	0		
Corpus Christi	20	0							
CCSC (bay)	5	5	40	0	60	0	0	-3.09E+01	
Inner Harbor	7	7	0	0	57.1	42.9	0		
Nueces Bay	5	1	0	0	0	100	0		
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	1	0	0	0	100	0		
Laguna (Baffin)	6	0							
Baffin Bay	5	2	0	0	50	50	0		
GOM inlet	6	1	0	0	100	0	0		

Table 7-14
Summary of trend analysis by component bay for SEDVOLS
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	number segments	w/data	prob <0	poss <0	none	poss >0	prob >0	mean prob<0	mean prob>0
Aransas Bay	13	0							
Copano Bay	9	1	0	0	0	100	0		
St Charles	2	1	0	0	0	100	0		
Mesquite	4	1	0	0	100	0	0		
Redfish	8	1	0	0	100	0	0		
Corpus Christi	20	0							
CCSC (bay)	5	1	0	0	0	100	0		
Inner Harbor	7	7	0	0	85.7	14.3	0		
Nueces Bay	5	0							
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	1	0	0	0	100	0		
Laguna (Baffin)	6	0							
Baffin Bay	5	2	0	0	0	100	0		
GOM inlet	6	1	0	0	0	100	0		

Table 7-15
Summary of trend analysis by component bay for SEDMETCD
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	number segments	w/data	prob <0	poss <0	none	poss >0	prob >0	mean prob<0	mean prob>0
Aransas Bay	13	1	0	0	100	0	0		
Copano Bay	9	2	100	0	0	0	0	-4.01E-02	
St Charles	2	0							
Mesquite	4	1	0	100	0	0	0		
Redfish	8	1	0	0	100	0	0		
Corpus Christi	20	5	0	20	20	40	20		7.85E-04
CCSC (bay)	5	4	0	25	25	25	25		6.28E-03
Inner Harbor	7	7	42.9	57.1	0	0	0	-8.53E-01	
Nueces Bay	5	2	0	0	100	0	0		
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	2	0	0	50	50	0		
Laguna (Baffin)	6	0							
Baffin Bay	5	1	0	0	100	0	0		
GOM inlet	6	1	0	0	0	100	0		

Table 7-16
Summary of trend analysis by component bay for SEDMETCR
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	4	75	0	0	0	25	-4.44E-01	2.18E-01
Copano Bay	9	2	0	0	0	0	100		5.60E-01
St Charles	2	1	0	0	100	0	0		
Mesquite	4	1	0	0	0	100	0		
Redfish	8	4	25	0	50	25	0	-1.04E-01	
Corpus Christi	20	17	17.6	17.6	41.2	23.5	0	-3.14E-01	
CCSC (bay)	5	5	40	0	40	20	0	-5.76E-01	
Inner Harbor	7	7	71.4	0	28.6	0	0	-2.68E+00	
Nueces Bay	5	4	0	25	25	50	0		
Oso Bay	3	1	0	0	100	0	0		
Aransas Pass	4	1	0	100	0	0	0		
Causeway N	3	3	0	100	0	0	0		
Causeway S	4	2	50	50	0	0	0	-3.48E-01	
Laguna (King)	13	9	33.3	11.1	33.3	22.2	0	-3.96E-01	
Laguna (Baffin)	6	3	33.3	0	0	33.3	33.3	-2.58E-01	4.73E-01
Baffin Bay	5	5	0	20	0	80	0		
GOM inlet	6	4	0	25	50	25	0		

Table 7-17
Summary of trend analysis by component bay for SEDMETCU
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	4	25	50	0	25	0	-1.06E-01	
Copano Bay	9	4	0	25	0	50	25		5.26E-02
St Charles	2	2	0	0	50	50	0		
Mesquite	4	1	0	0	0	100	0		
Redfish	8	4	0	50	25	25	0		
Corpus Christi	20	17	11.8	11.8	52.9	23.5	0	-1.03E-01	
CCSC (bay)	5	5	20	40	20	20	0	-2.32E-01	
Inner Harbor	7	7	14.3	42.9	28.6	14.3	0	-5.31E-01	
Nueces Bay	5	4	0	25	25	50	0		
Oso Bay	3	1	0	100	0	0	0		
Aransas Pass	4	1	0	0	0	100	0		
Causeway N	3	3	0	0	66.7	33.3	0		
Causeway S	4	2	0	50	50	0	0		
Laguna (King)	13	10	10	10	10	70	0	-1.06E-01	
Laguna (Baffin)	6	3	0	33.3	33.3	33.3	0		
Baffin Bay	5	5	0	0	20	80	0		
GOM inlet	6	4	0	25	50	25	0		

Table 7-18
Summary of trend analysis by component bay for SEDMETHG
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	0							
Copano Bay	9	2	0	0	50	50	0		
St Charles	2	1	0	0	0	100	0		
Mesquite	4	1	0	100	0	0	0		
Redfish	8	2	0	50	50	0	0		
Corpus Christi	20	9	33.3	22.2	11.1	33.3	0	-3.29E-03	
CCSC (bay)	5	5	100	0	0	0	0	-1.19E-02	
Inner Harbor	7	7	42.9	14.3	42.9	0	0	-7.19E-02	
Nueces Bay	5	2	0	0	50	50	0		
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	1	0	100	0	0	0		
Laguna (Baffin)	6	0							
Baffin Bay	5	2	0	0	100	0	0		
GOM inlet	6	1	0	0	0	100	0		

Table 7-19
Summary of trend analysis by component bay for SEDMETNI
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	4	50	25	0	0	25	-1.59E-01	4.41E-02
Copano Bay	9	2	0	0	0	50	50		7.50E-02
St Charles	2	1	0	0	100	0	0		
Mesquite	4	1	0	0	0	100	0		
Redfish	8	4	0	25	50	25	0		
Corpus Christi	20	17	23.5	17.6	41.2	17.6	0	-1.85E-01	
CCSC (bay)	5	5	0	40	40	20	0		
Inner Harbor	7	7	28.6	28.6	28.6	14.3	0	-2.05E-01	
Nueces Bay	5	4	0	25	25	50	0		
Oso Bay	3	0							
Aransas Pass	4	1	100	0	0	0	0	-4.78E-02	
Causeway N	3	0							
Causeway S	4	2	0	50	50	0	0		
Laguna (King)	13	6	33.3	0	33.3	33.3	0	-1.59E-01	
Laguna (Baffin)	6	3	0	33.3	33.3	0	33.3		9.55E-02
Baffin Bay	5	5	0	0	20	80	0		
GOM inlet	6	4	25	0	25	50	0	-1.25E-01	

Table 7-20
Summary of trend analysis by component bay for SEDMETPB
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	number segments	w/data	prob <0	poss <0	none	poss >0	prob >0	mean prob<0	mean prob>0
Aransas Bay	13	3	33.3	33.3	0	33.3	0	-1.82E-01	
Copano Bay	9	4	0	0	25	75	0		
St Charles	2	2	0	0	0	100	0		
Mesquite	4	1	0	0	0	100	0		
Redfish	8	1	0	100	0	0	0		
Corpus Christi	20	8	12.5	0	12.5	75	0	-1.06E-01	
CCSC (bay)	5	5	40	20	40	0	0	-5.54E-01	
Inner Harbor	7	7	71.4	28.6	0	0	0	-7.34E+00	
Nueces Bay	5	2	0	0	50	50	0		
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	4	0	25	0	75	0		
Laguna (Baffin)	6	2	50	0	50	0	0	-3.93E-01	
Baffin Bay	5	2	0	0	0	100	0		
GOM inlet	6	3	0	0	100	0	0		

Table 7-21
Summary of trend analysis by component bay for SEDMETZN
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr)

component bay	number segments	w/data	prob <0	poss <0	none	poss >0	prob >0	mean prob<0	mean prob>0
Aransas Bay	13	4	25.0	50.0	0.0	25.0	0.0	-3.05E-01	
Copano Bay	9	4	0.0	0.0	25.0	50.0	25.0		2.90E-01
St Charles	2	2	0.0	50.0	0.0	50.0	0.0		
Mesquite	4	1	0.0	0.0	0.0	100.0	0.0		
Redfish	8	4	0.0	75.0	0.0	25.0	0.0		
Corpus Christi	20	16	0.0	12.5	31.3	56.3	0.0		
CCSC (bay)	5	5	40.0	20.0	40.0	0.0	0.0	-1.13E+00	
Inner Harbor	7	7	85.7	14.3	0.0	0.0	0.0	-1.38E+02	
Nueces Bay	5	4	0.0	25.0	50.0	25.0	0.0		
Oso Bay	3	2	0.0	50.0	50.0	0.0	0.0		
Aransas Pass	4	2	0.0	0.0	50.0	50.0	0.0		
Causeway N	3	3	0.0	0.0	100.0	0.0	0.0		
Causeway S	4	2	0.0	50.0	0.0	50.0	0.0		
Laguna (King)	13	10	20.0	30.0	30.0	20.0	0.0	-7.08E-01	
Laguna (Baffin)	6	4	25.0	25.0	25.0	25.0	0.0	-6.62E-01	
Baffin Bay	5	5	0.0	0.0	20.0	80.0	0.0		
GOM inlet	6	3	33.3	0.0	66.7	0.0	0.0	-2.73E-01	

Table 7-22
Summary of trend analysis by component bay for SED-XDDT
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppb/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	0							
Copano Bay	9	1	100	0	0	0	0	-2.92E-02	
St Charles	2	0							
Mesquite	4	1	0	0	0	0	100		5.85E-01
Redfish	8	0							
Corpus Christi	20	1	0	0	100	0	0		
CCSC (bay)	5	0							
Inner Harbor	7	0							
Nueces Bay	5	0							
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	0							
Laguna (Baffin)	6	0							
Baffin Bay	5	0							
GOM inlet	6	0							

Table 7-23
Summary of trend analysis by component bay for SED-PCB
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppb/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	0							
Copano Bay	9	1	100	0	0	0	0	-9.68E-02	
St Charles	2	0							
Mesquite	4	0							
Redfish	8	0							
Corpus Christi	20	0							
CCSC (bay)	5	0							
Inner Harbor	7	3	0	0	100	0	0		
Nueces Bay	5	1	100	0	0	0	0	-3.22E-02	
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	1	0	0	100	0	0		
Laguna (Baffin)	6	0							
Baffin Bay	5	0							
GOM inlet	6	0							

Table 7-24
Summary of trend analysis by component bay for SED-BNZA
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppb/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	0							
Copano Bay	9	1	0	100	0	0	0		
St Charles	2	0							
Mesquite	4	0							
Redfish	8	0							
Corpus Christi	20	1	0	100	0	0	0		
CCSC (bay)	5	0							
Inner Harbor	7	3	0	0	0	33.3	66.7		2.30E+01
Nueces Bay	5	1	0	0	0	100	0		
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	0							
Laguna (Baffin)	6	0							
Baffin Bay	5	0							
GOM inlet	6	0							

Table 7-25
Summary of trend analysis by component bay for SED-PAH
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppb/yr)

component bay	*number segments*	*w/data*	*prob <0*	*poss <0*	*none*	*poss >0*	*prob >0*	*mean prob<0*	*mean prob>0*
Aransas Bay	13	0							
Copano Bay	9	1	0	0	100	0	0		
St Charles	2	0							
Mesquite	4	0							
Redfish	8	0							
Corpus Christi	20	0							
CCSC (bay)	5	0							
Inner Harbor	7	0							
Nueces Bay	5	0							
Oso Bay	3	0							
Aransas Pass	4	0							
Causeway N	3	0							
Causeway S	4	0							
Laguna (King)	13	0							
Laguna (Baffin)	6	0							
Baffin Bay	5	0							
GOM inlet	6	0							

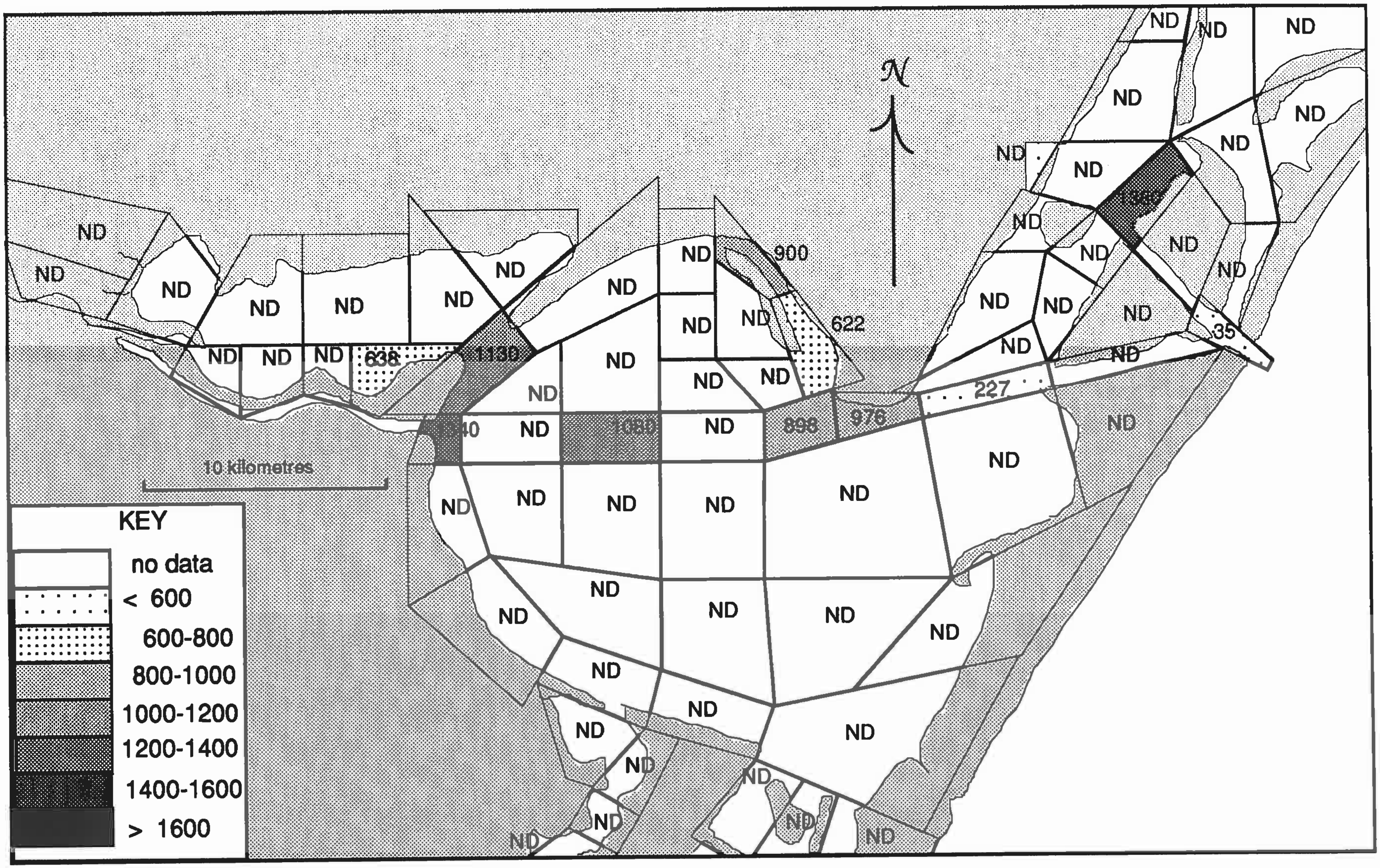


Figure 7-1. Period-of-record means of SEDKJLN for Corpus Christi system

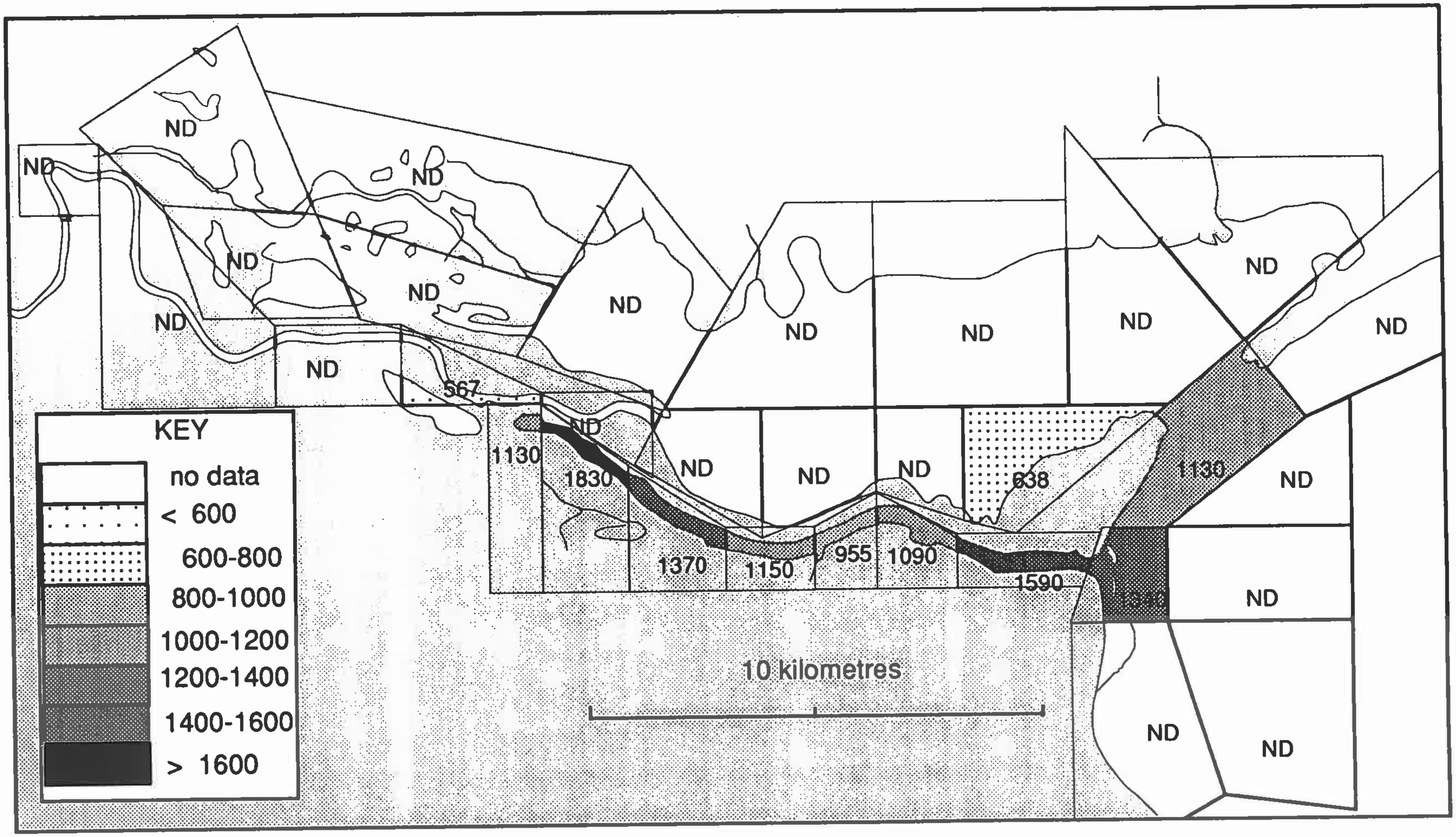


Figure 7-2. Period-of-record means of SEDKJLN for Nueces Bay region, including Inner Harbor

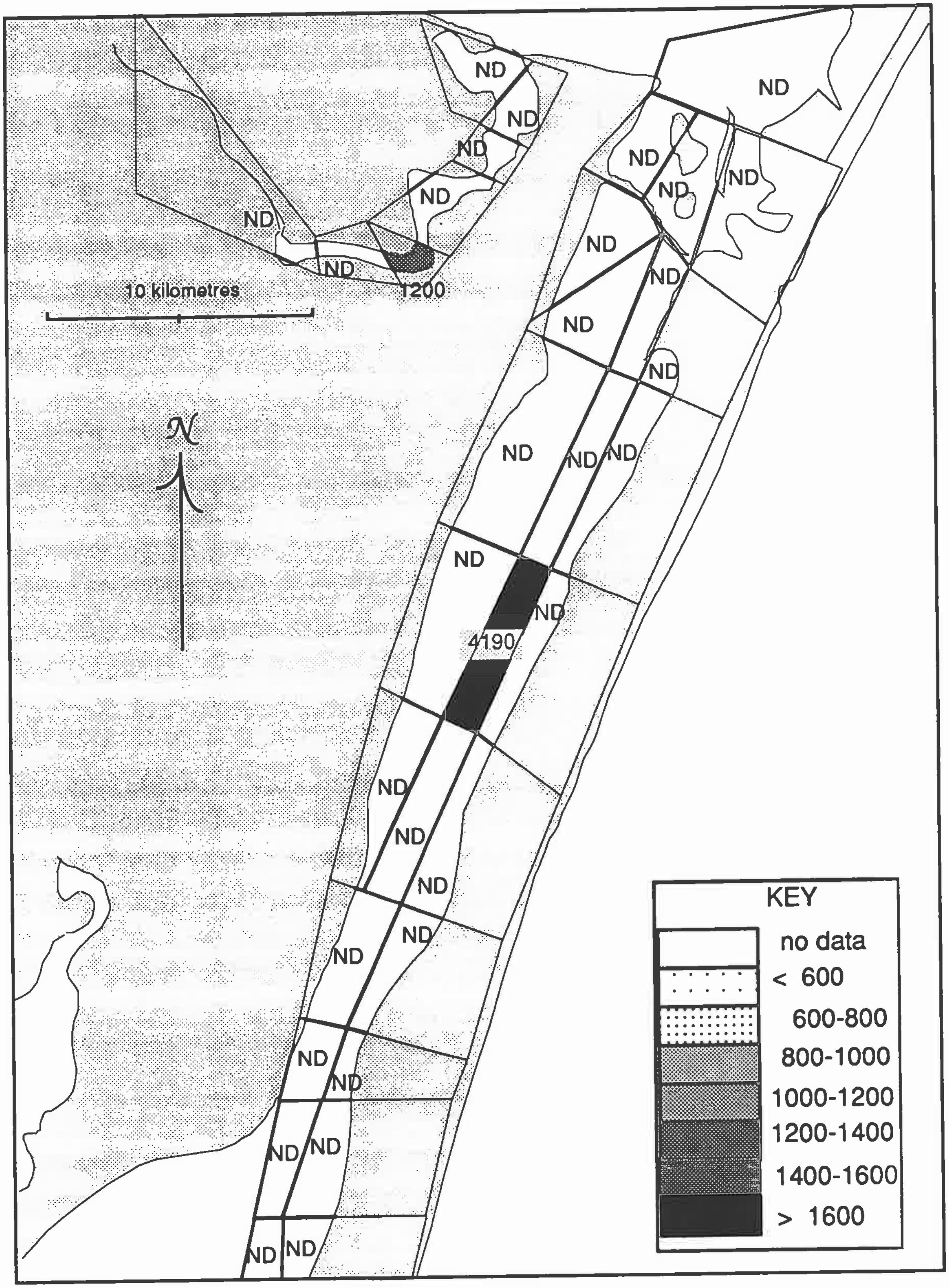


Figure 7-3. Period-of-record means of SEDKJLN for Upper Laguna Madre and Oso Bay

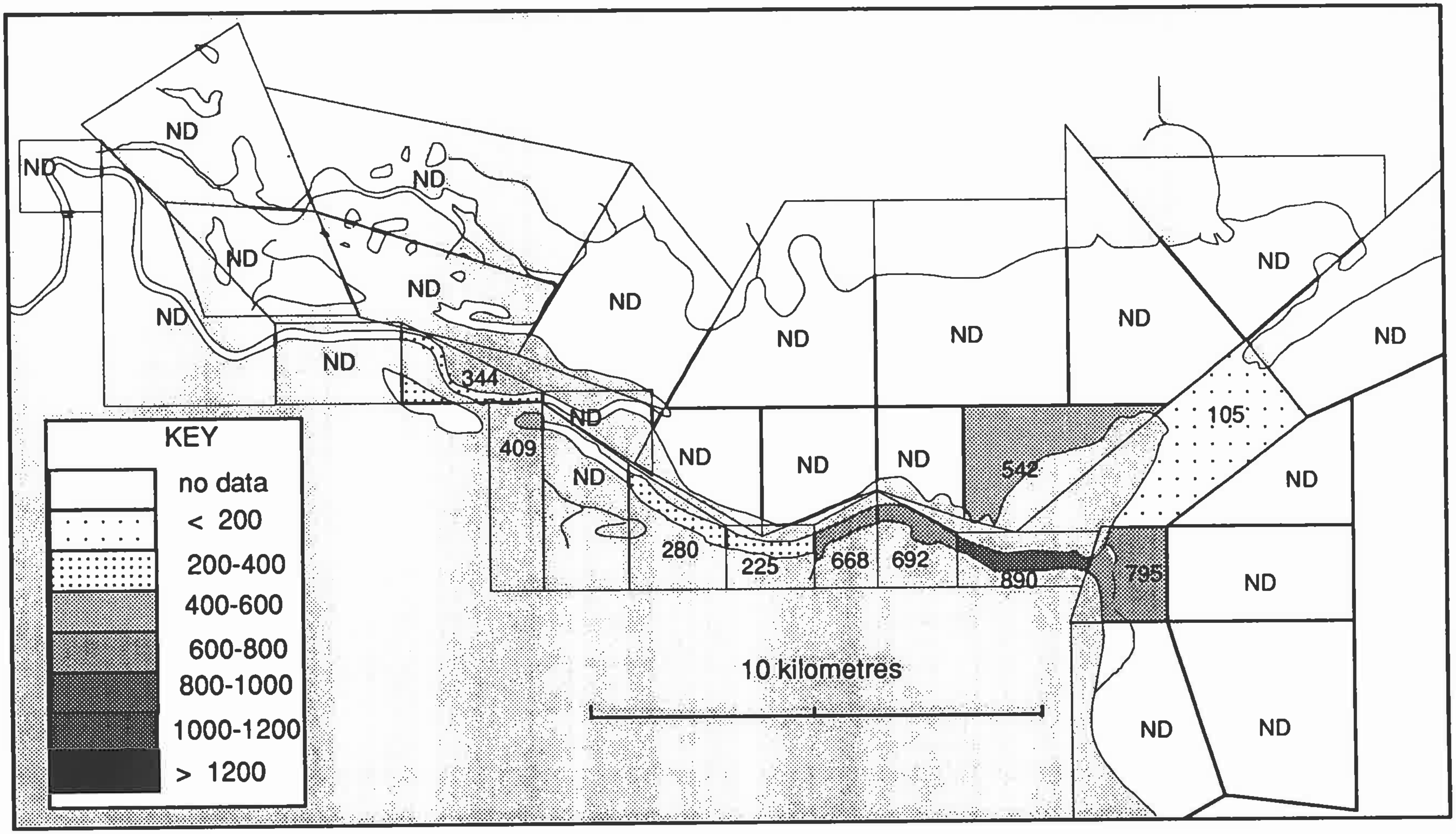


Figure 7-4. Period-of-record means of SEDTOTP for Nueces Bay region, including Inner Harbor

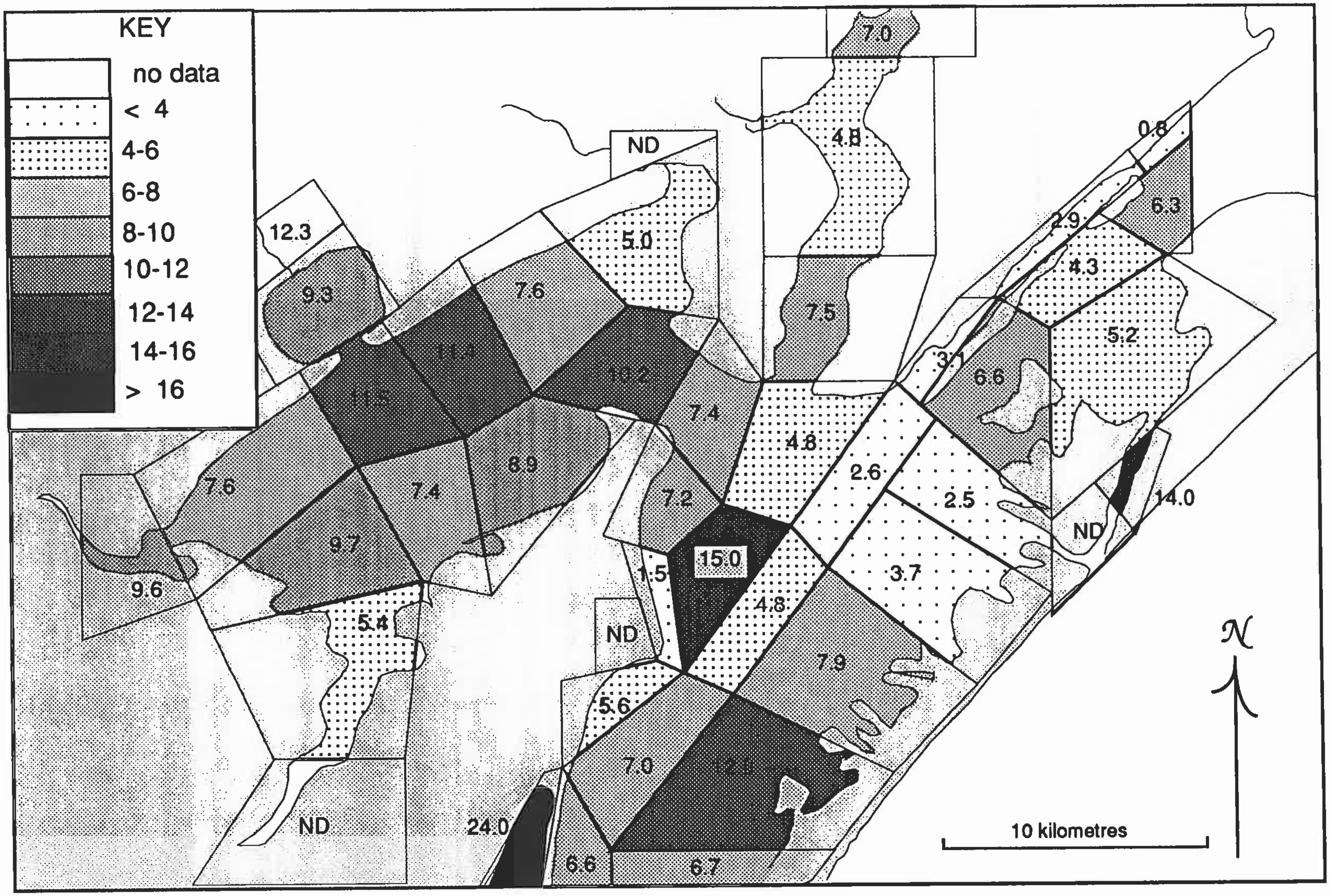


Figure 7-5. Period-of-record means of SEDTOC for Aransas-Copano system

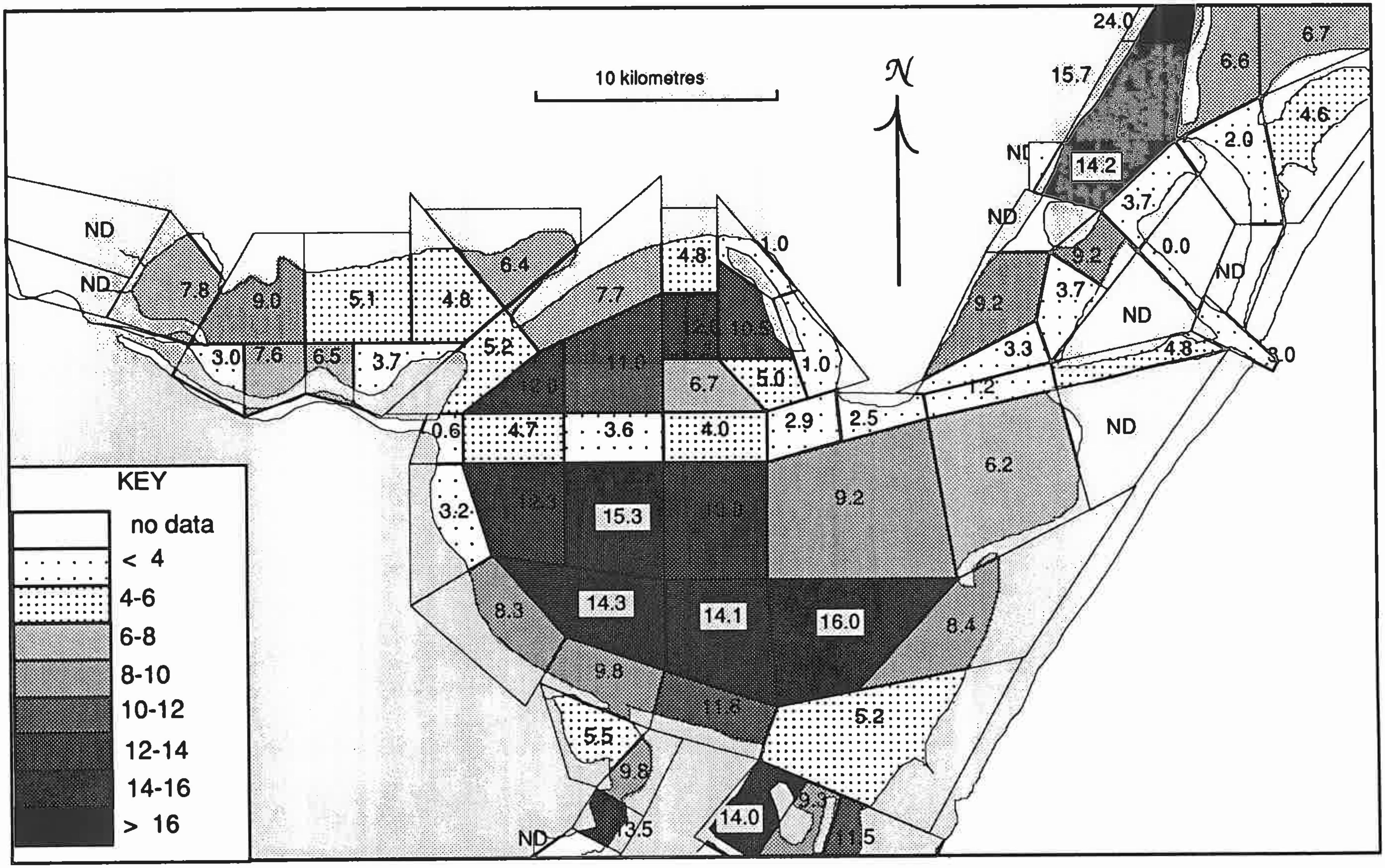


Figure7-6. Period-of-record means of SEDTOC for Corpus Christi system

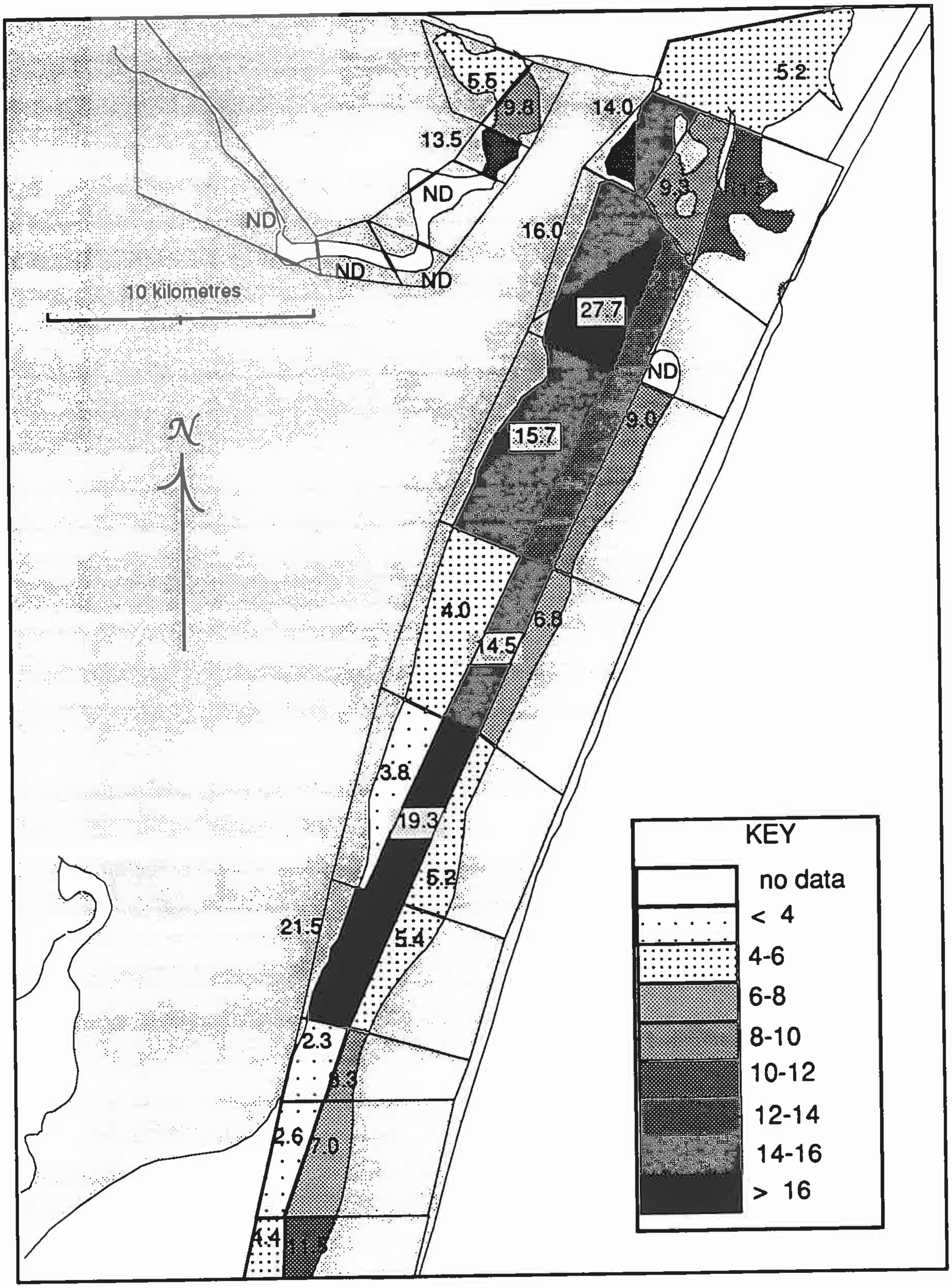


Figure 7-7. Period-of-record means of SEDTOC for Upper Laguna Madre and Oso Bay

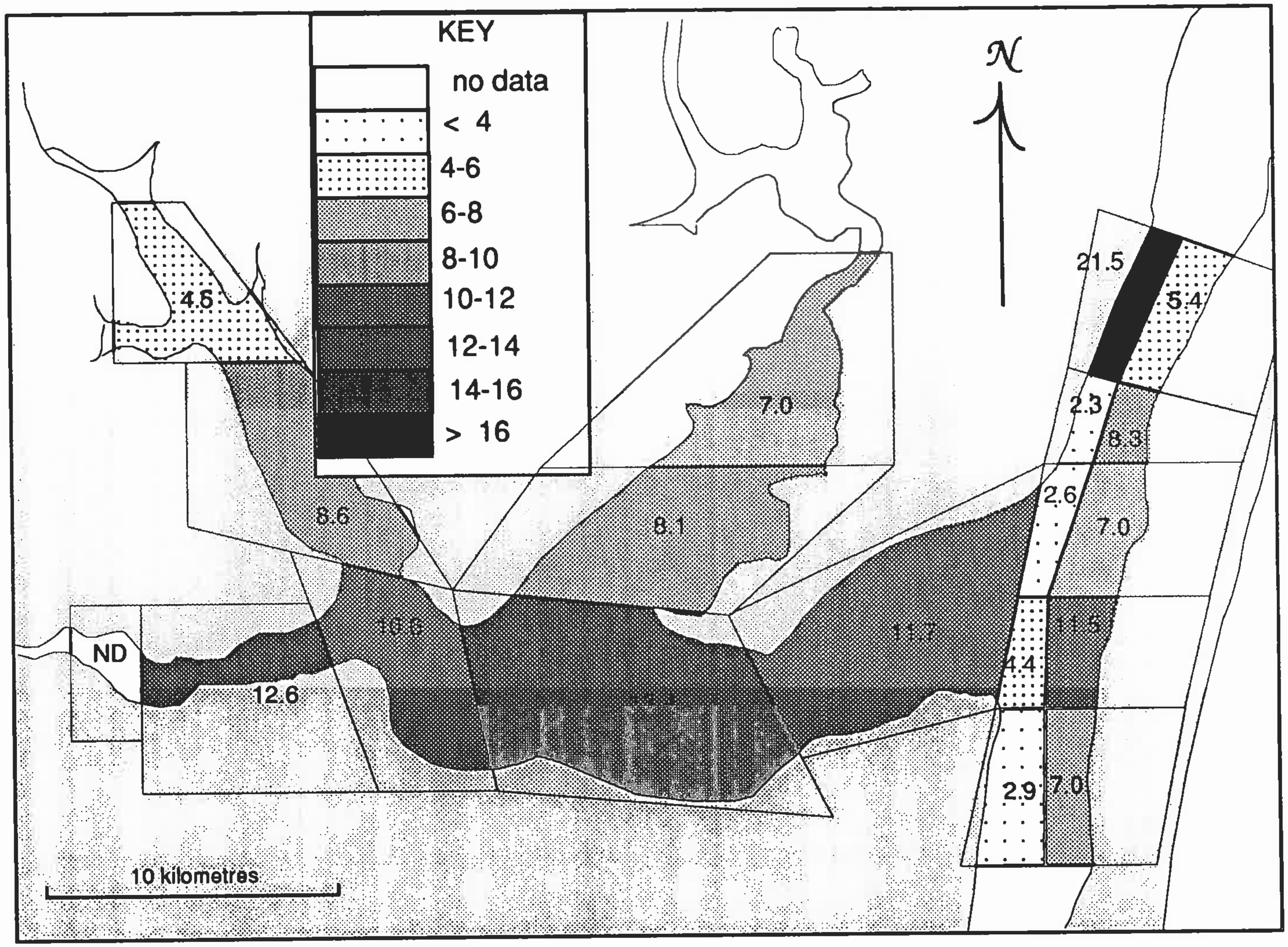


Figure 7-8. Period-of-record means of SEDTOC for Baffin Bay region

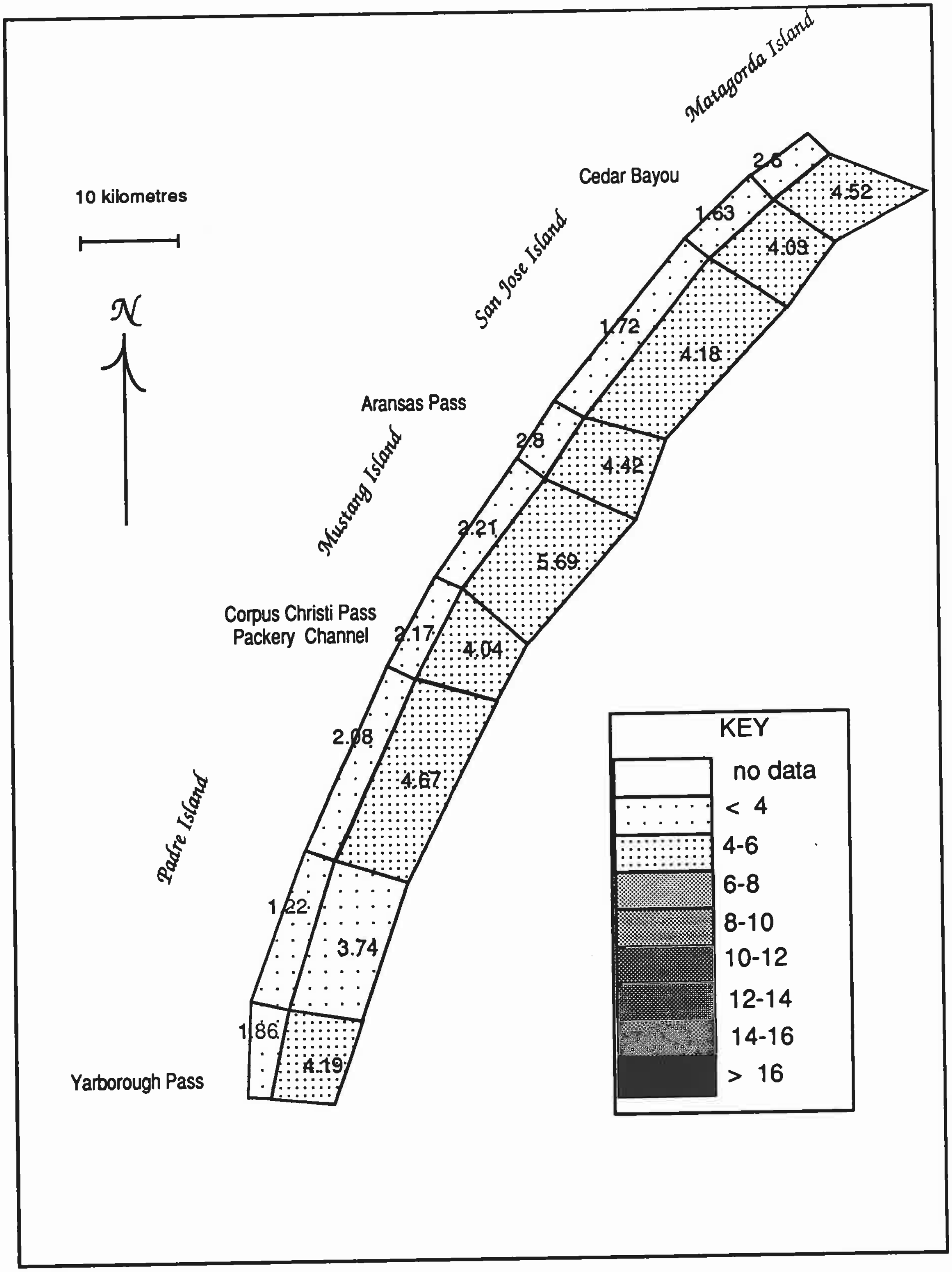


Figure 7-9. Period-of-record means of SEDTOC for Gulf of Mexico

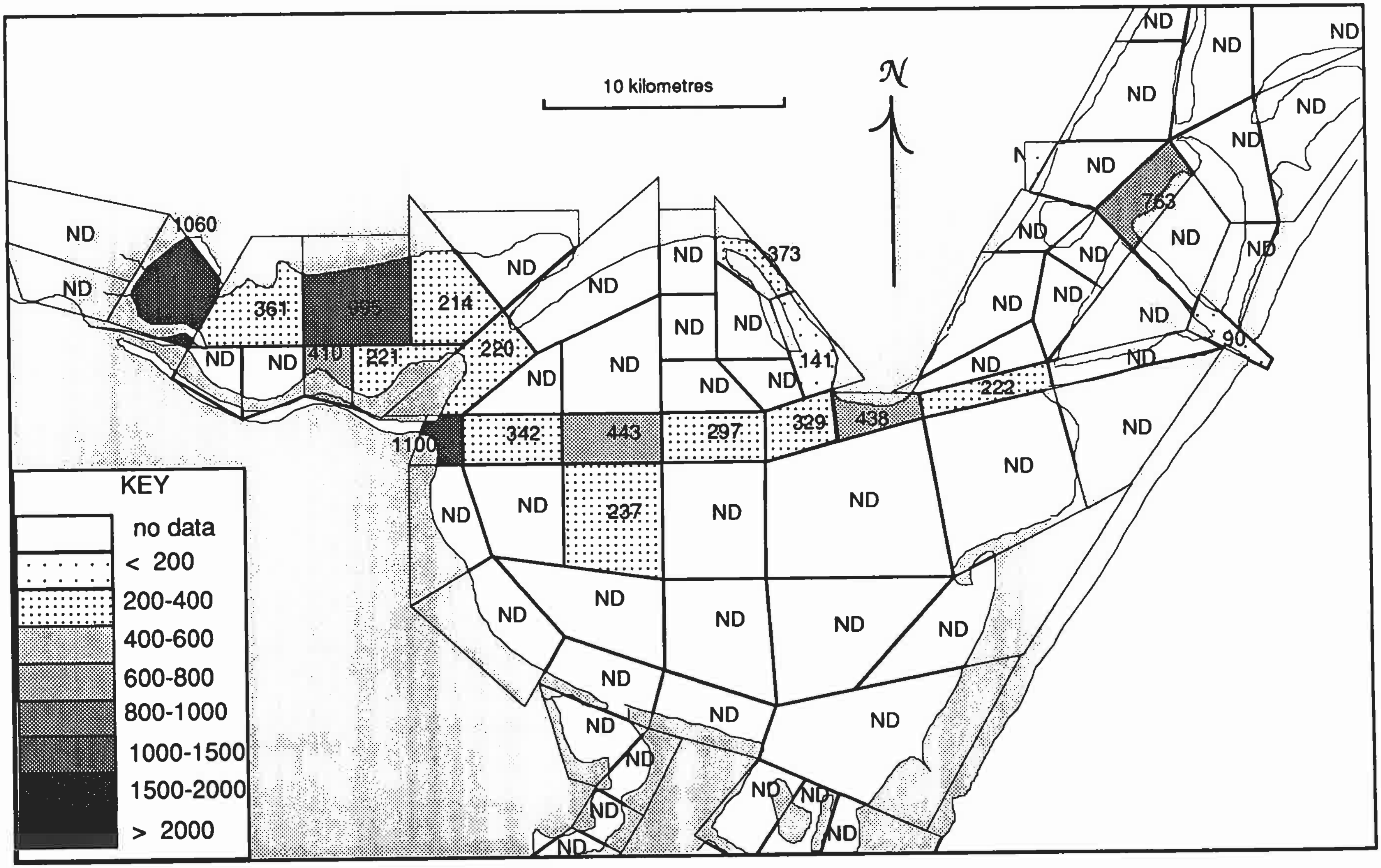


Figure 7-10. Period-of-record means of SEDO&G for Corpus Christi system

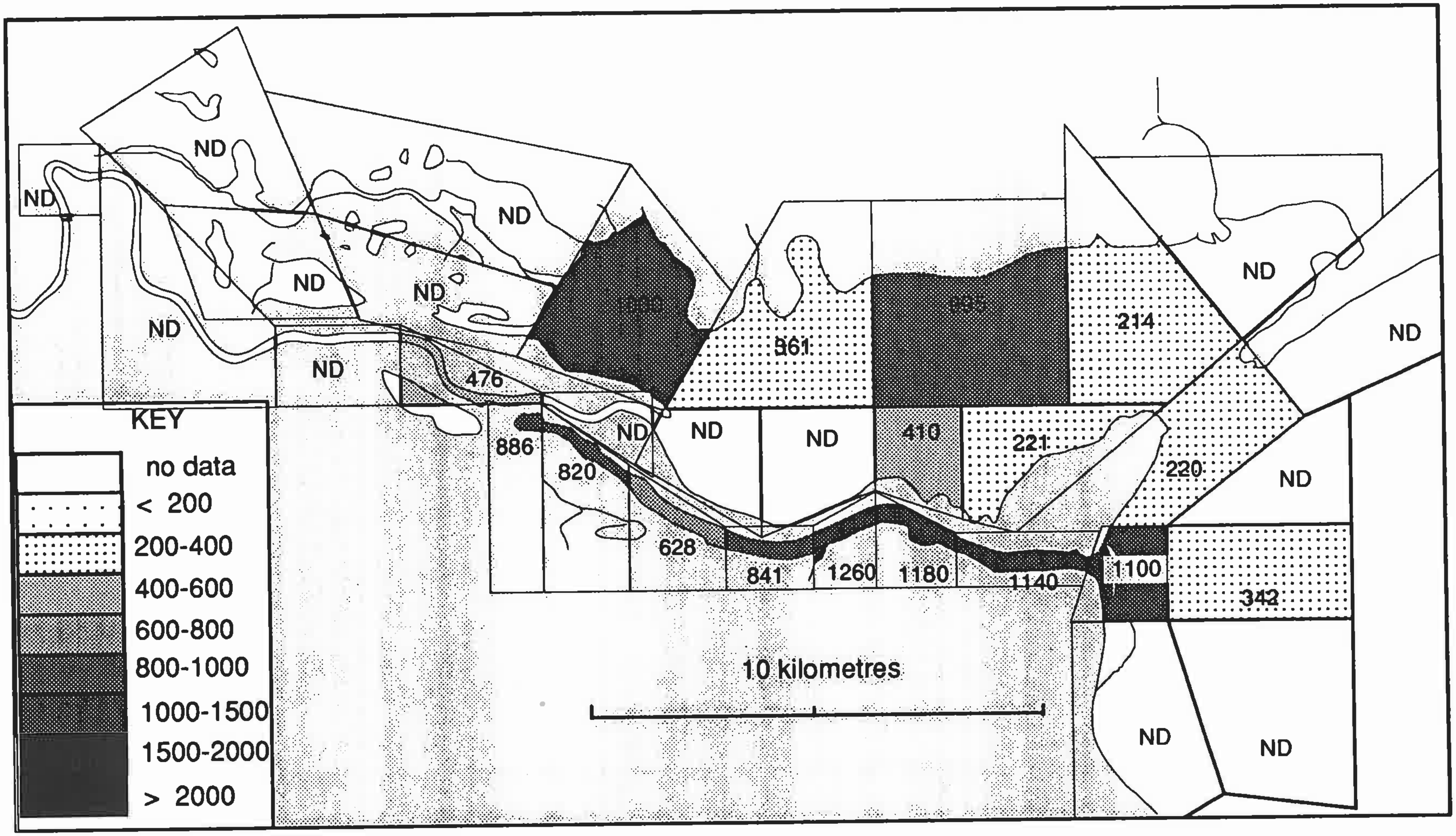


Figure 7-11. Period-of-record means of SEDO&G for Nueces Bay region, including Inner Harbor

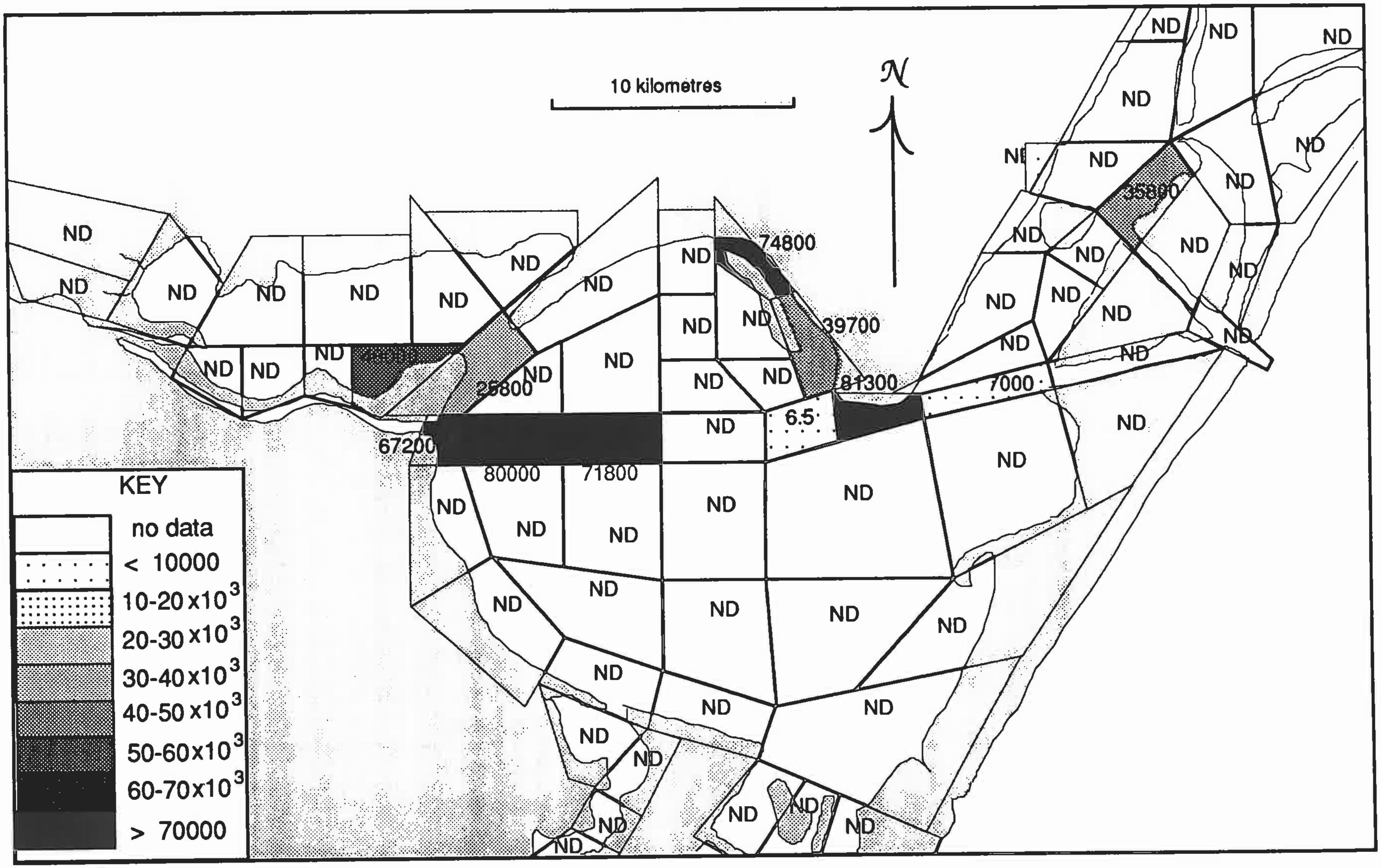


Figure 7-12. Period-of-record means of SEDVOLS for Corpus Christi system

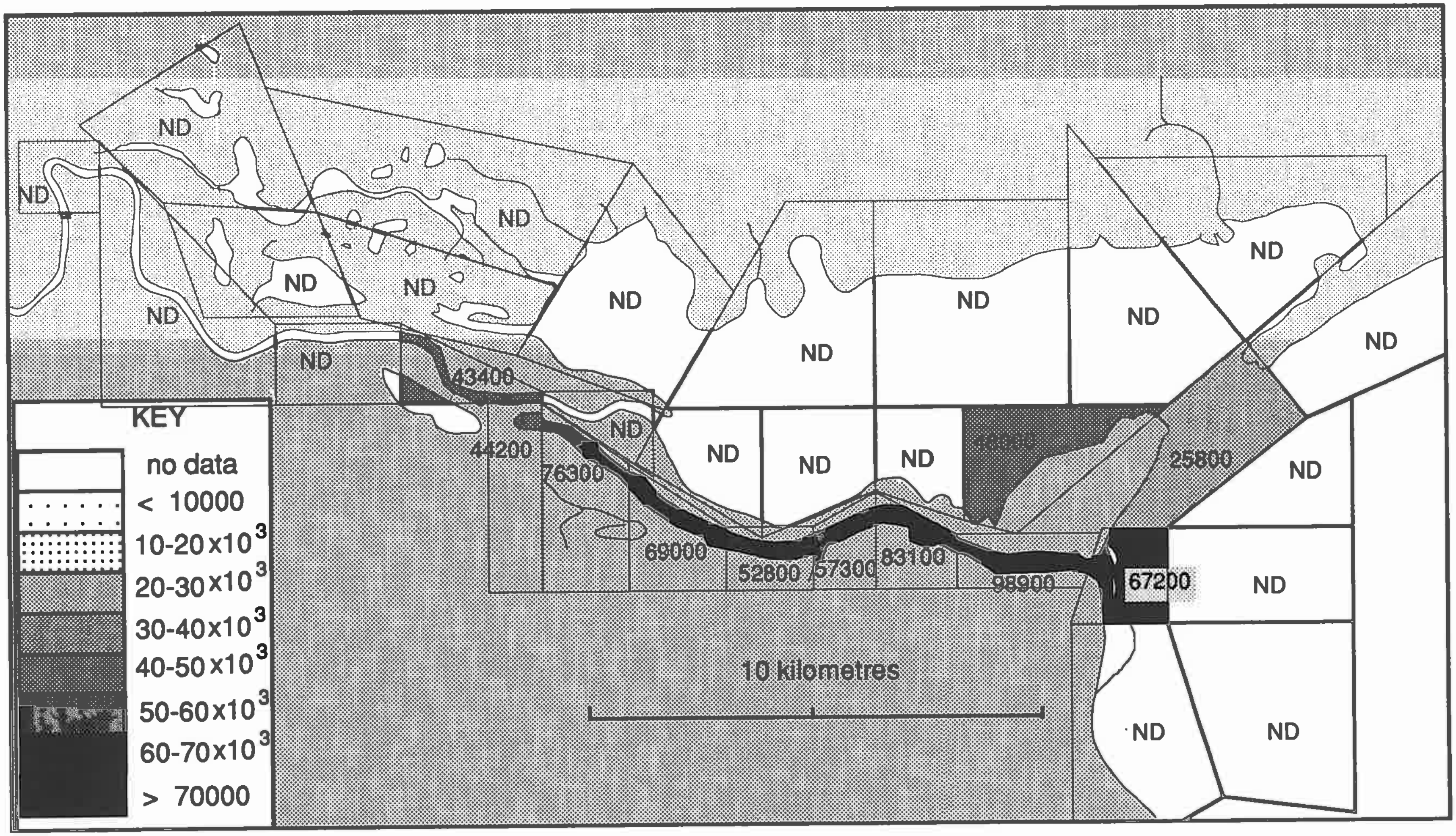


Figure 7-13. Period-of-record means of SEDVOLS for Nueces Bay region, including Inner Harbor

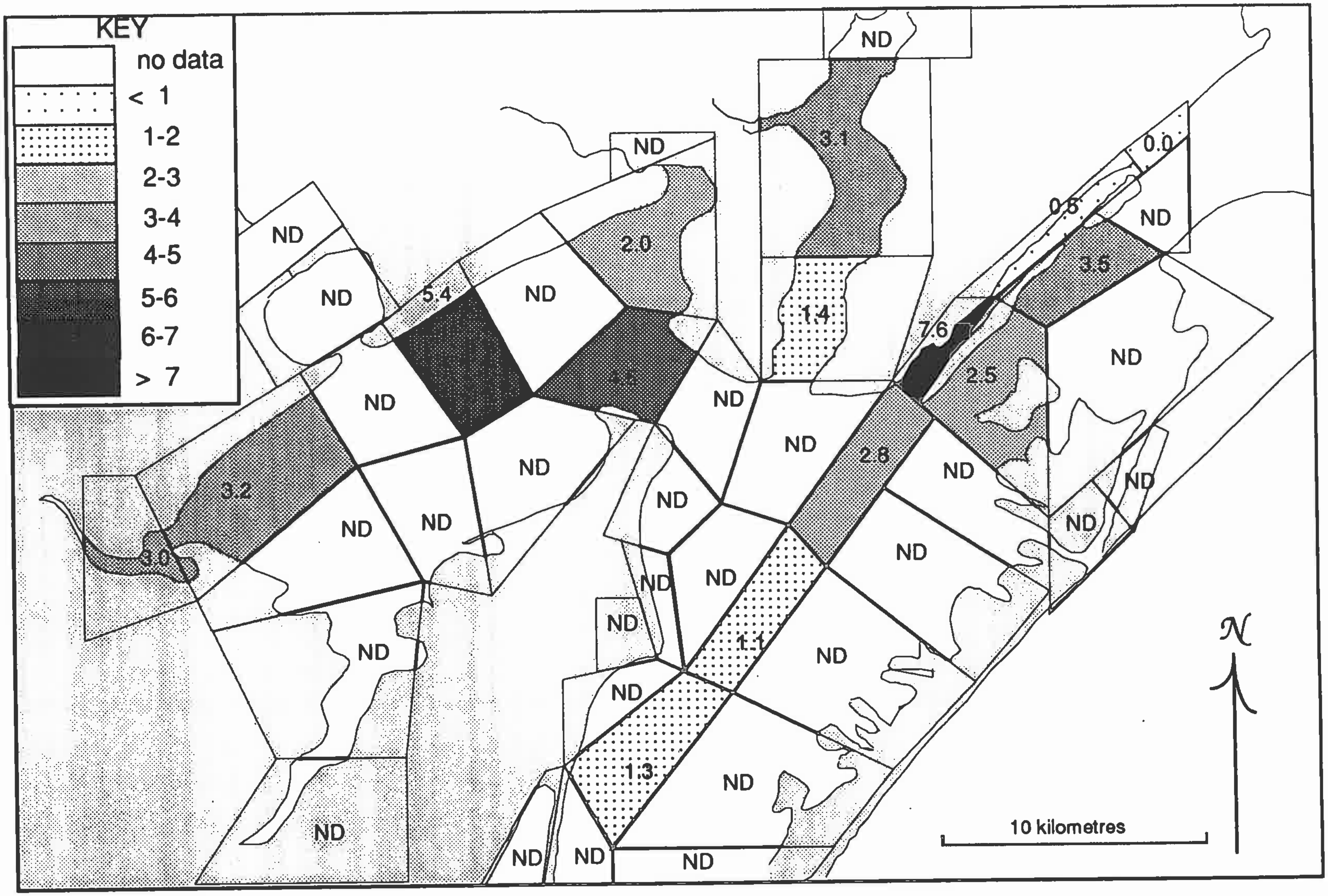


Figure 7-14. Period-of-record means of SEDMETAS for Aransas-Copano system

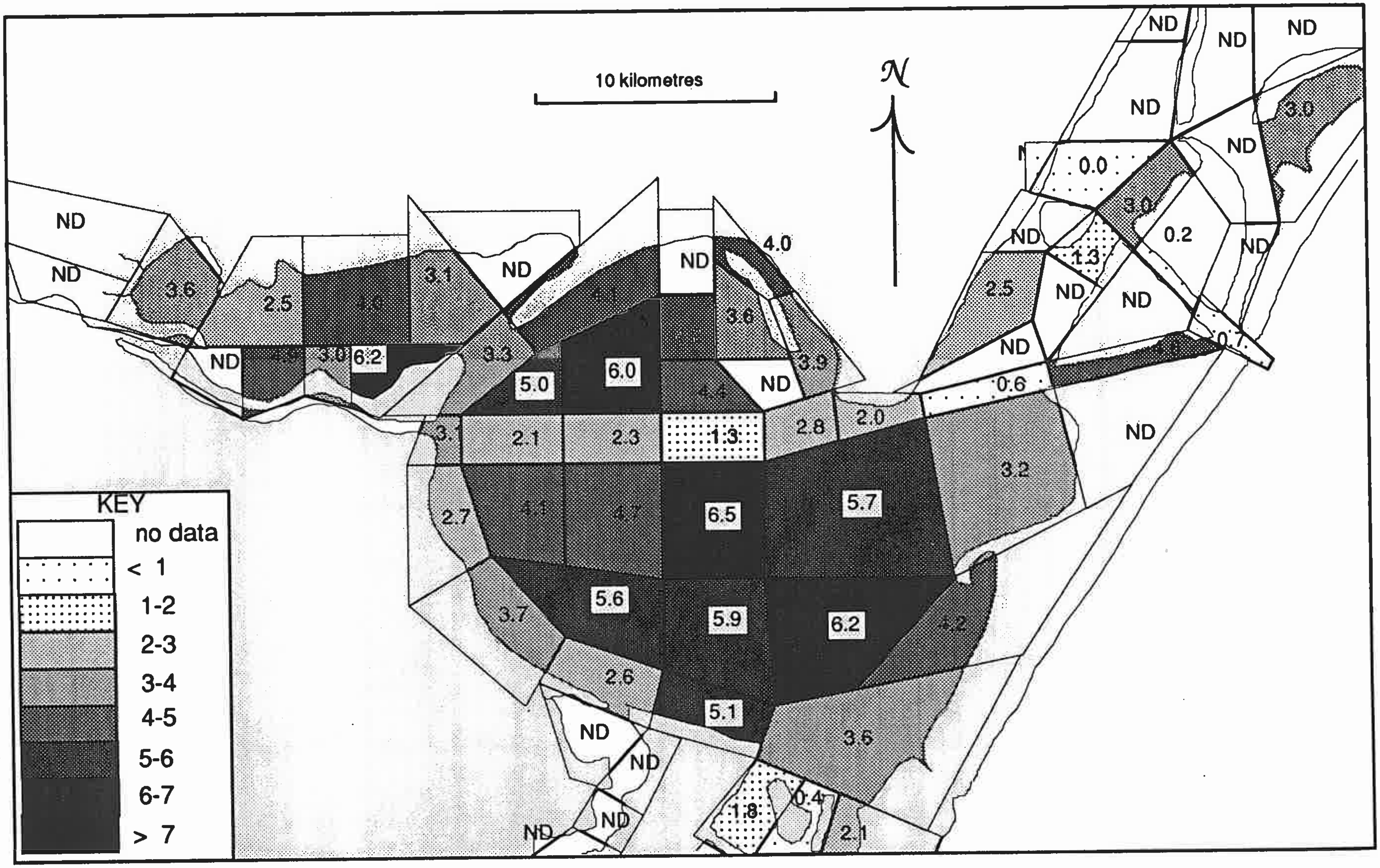


Figure 7-15. Period-of-record means of SEDMETAS for Corpus Christi system

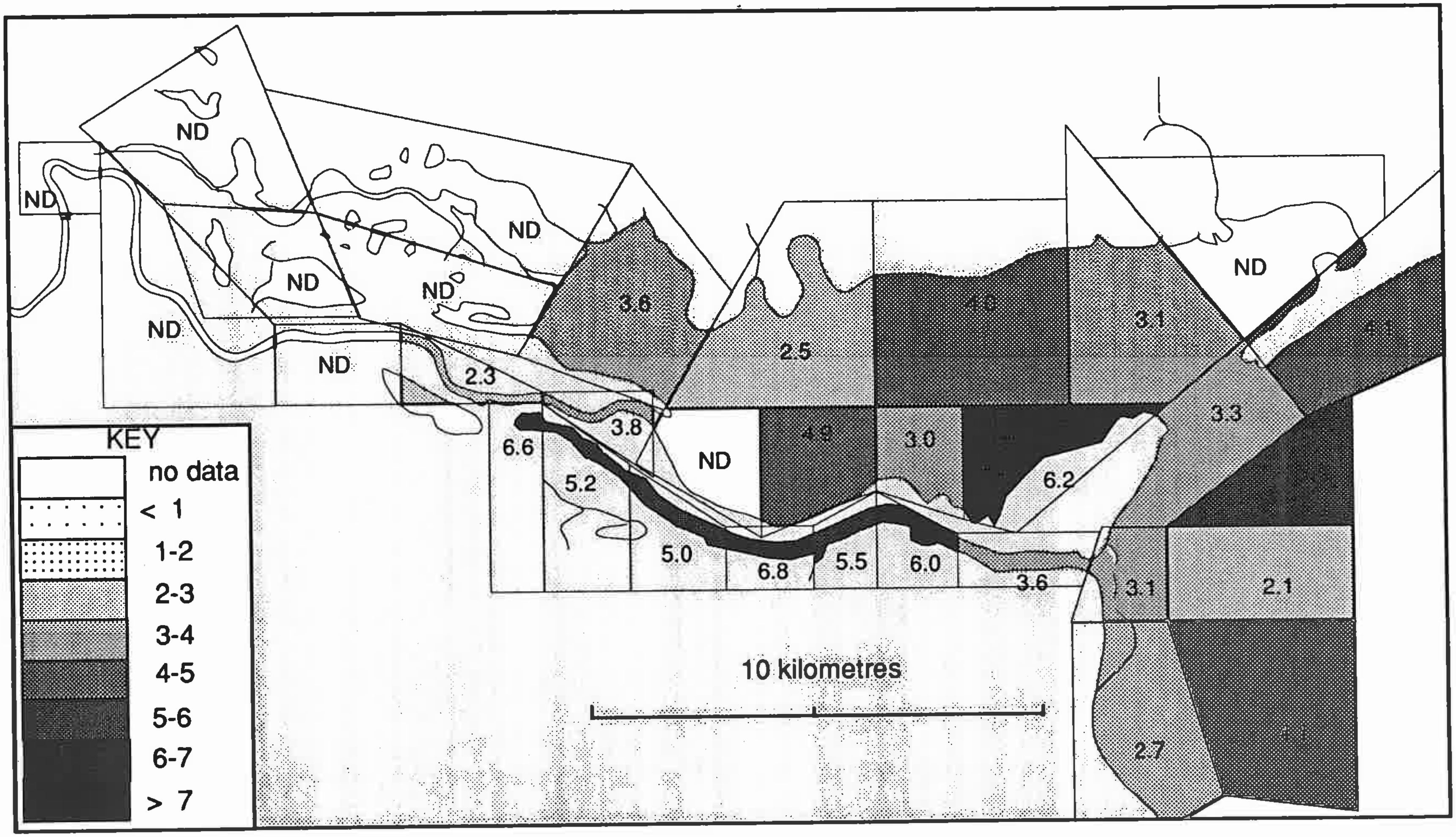


Figure 7-16. Period-of-record means of SEDMETAS for Nueces Bay region, including Inner Harbor

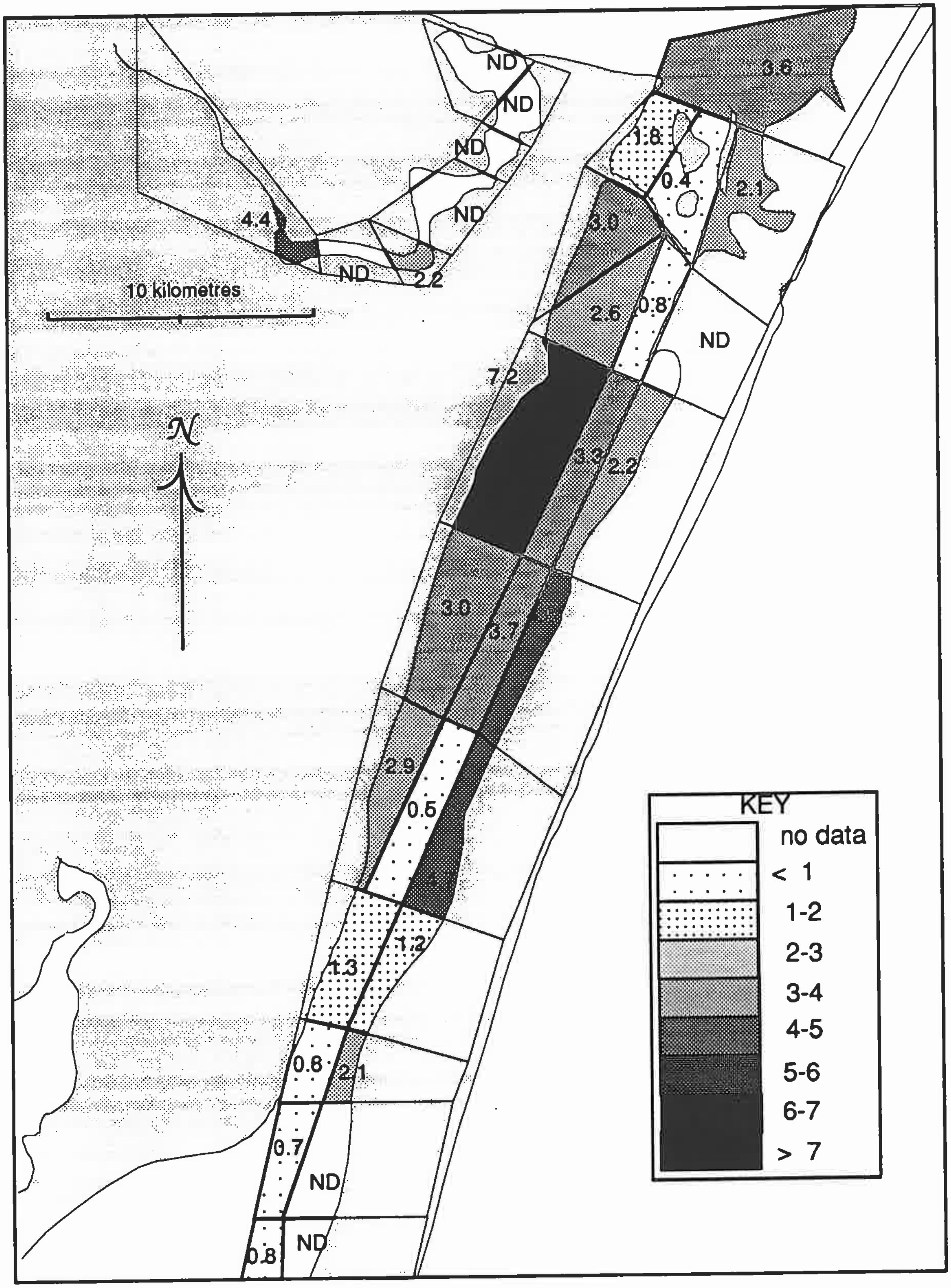


Figure 7-17. Period-of-record means of SEDMETAS for Upper Laguna Madre and Oso Bay

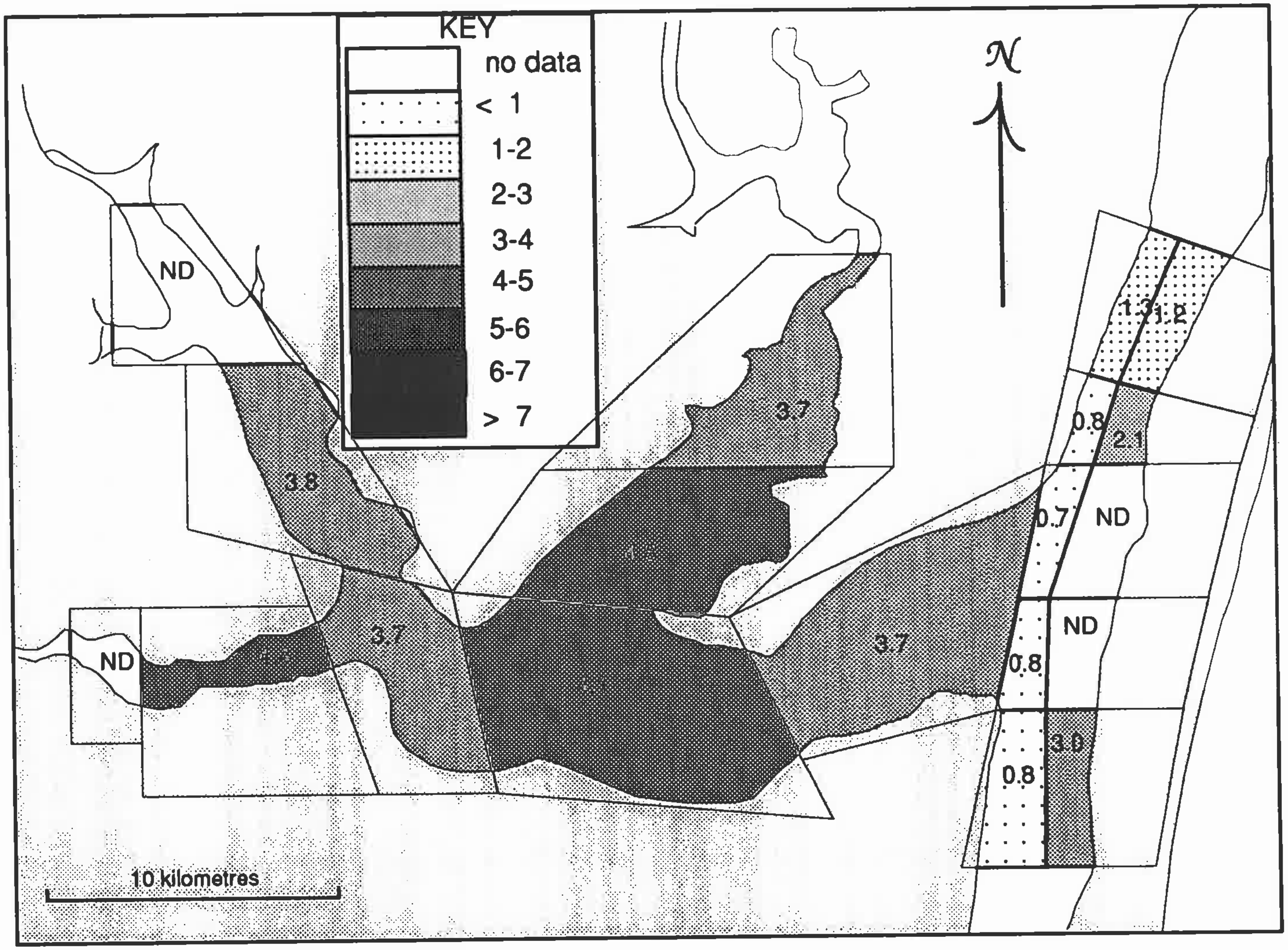


Figure 7-18. Period-of-record means of SEDMETAS for Baffin Bay region

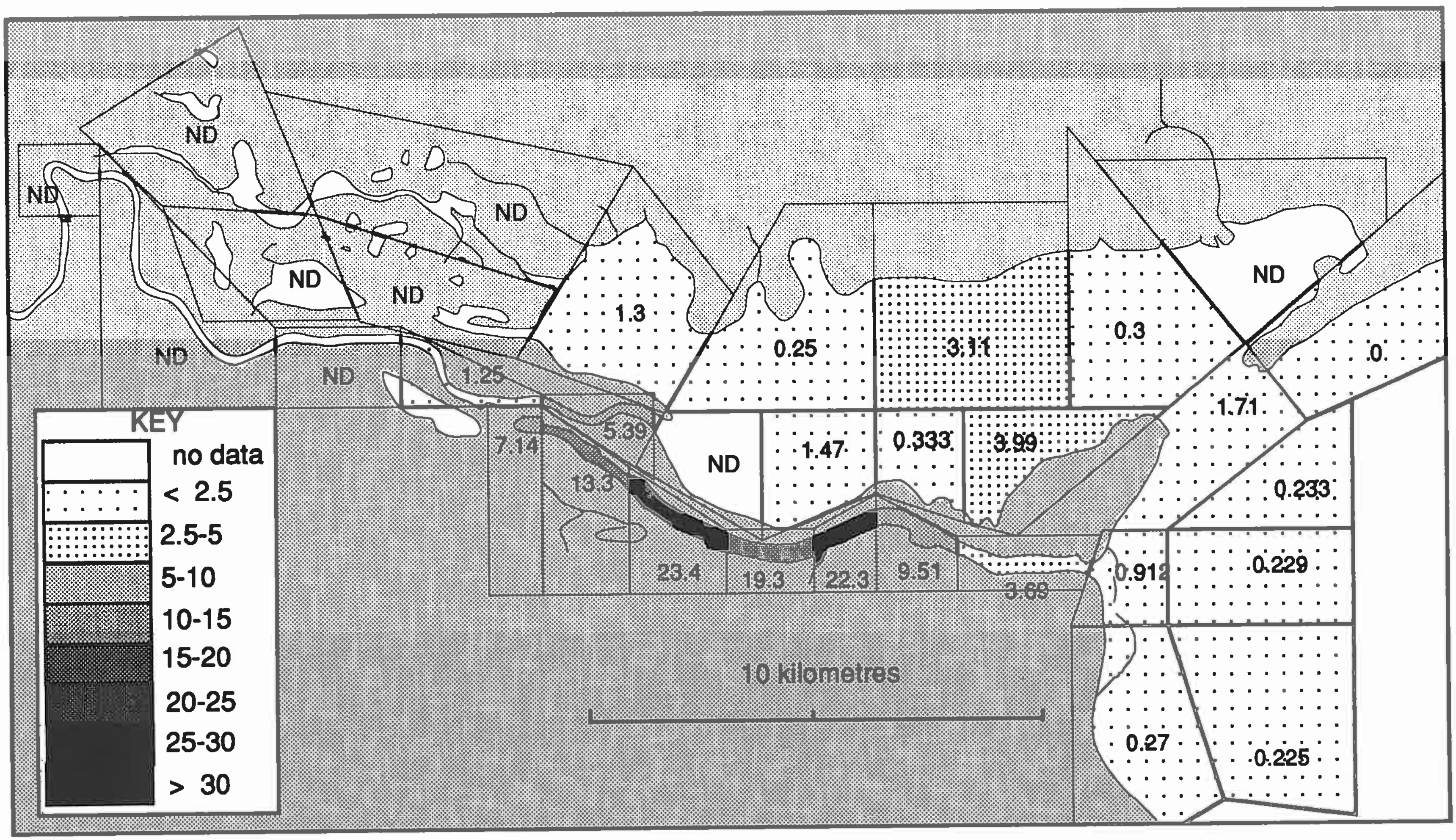


Figure 7-19. Period-of-record means of SEDMETCD for Nueces Bay region, including Inner Harbor

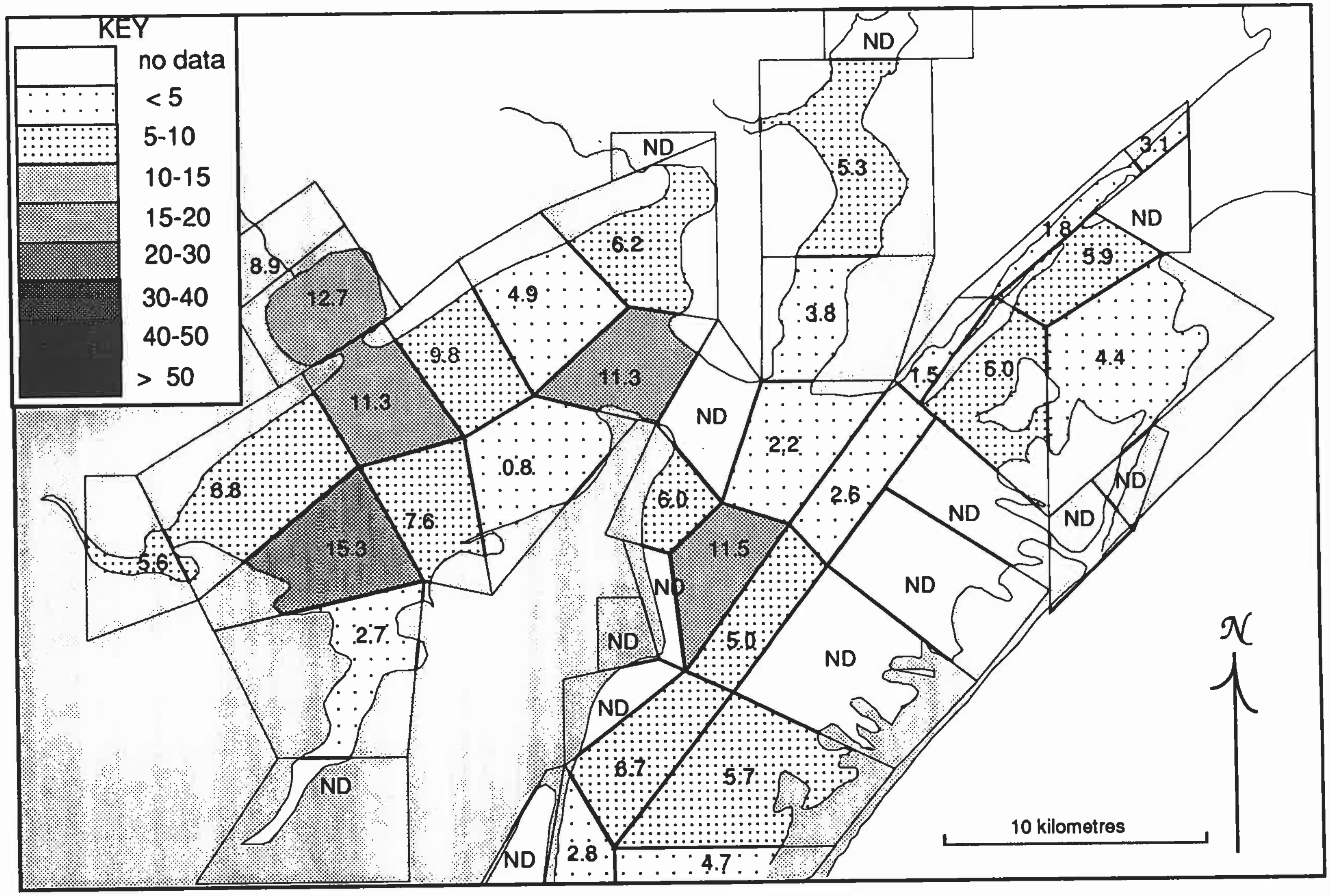


Figure 7-20. Period-of-record means of SEDMETCU for Aransas-Copano system

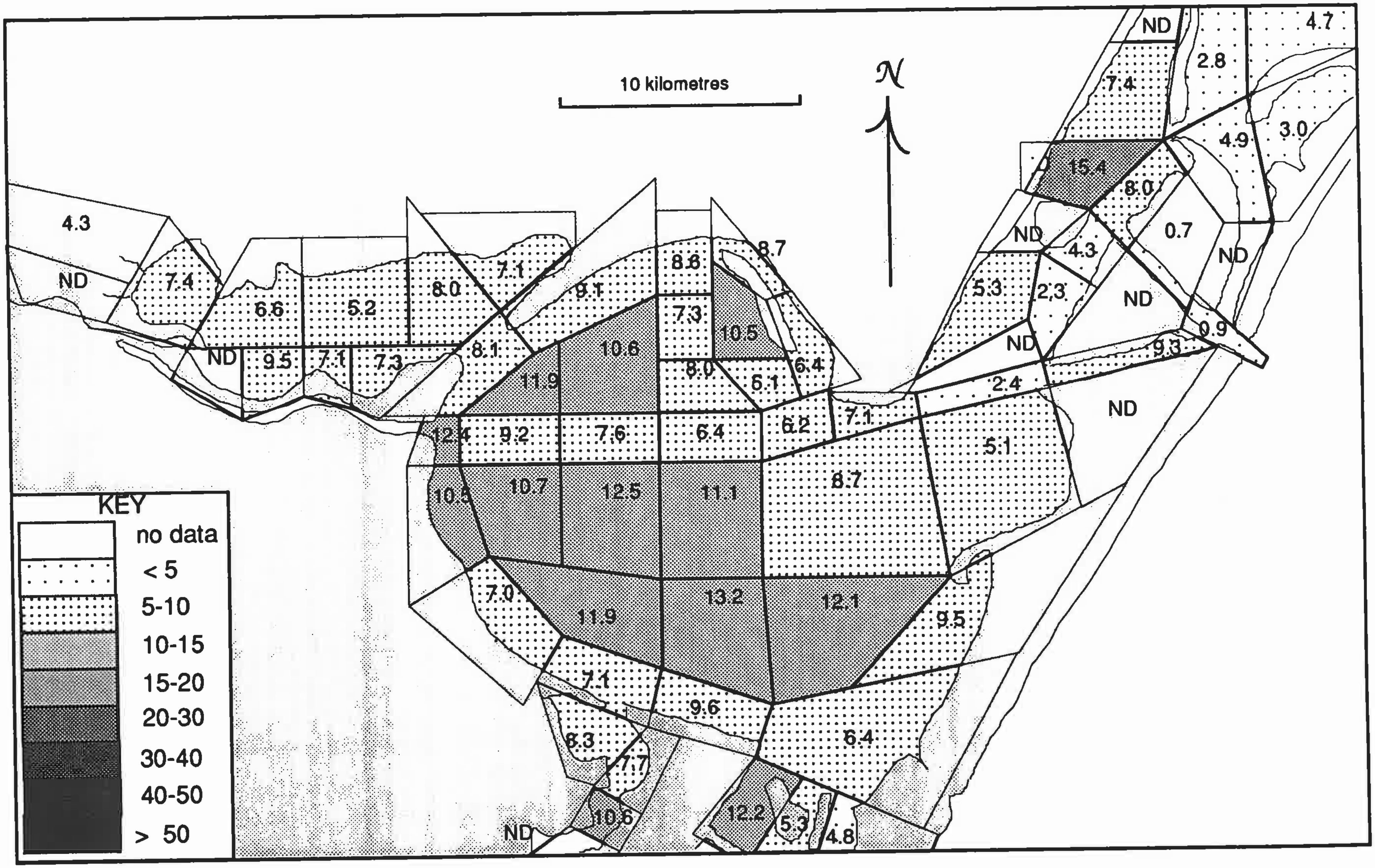


Figure 7-21. Period-of-record means of SEDMETCU for Corpus Christi system

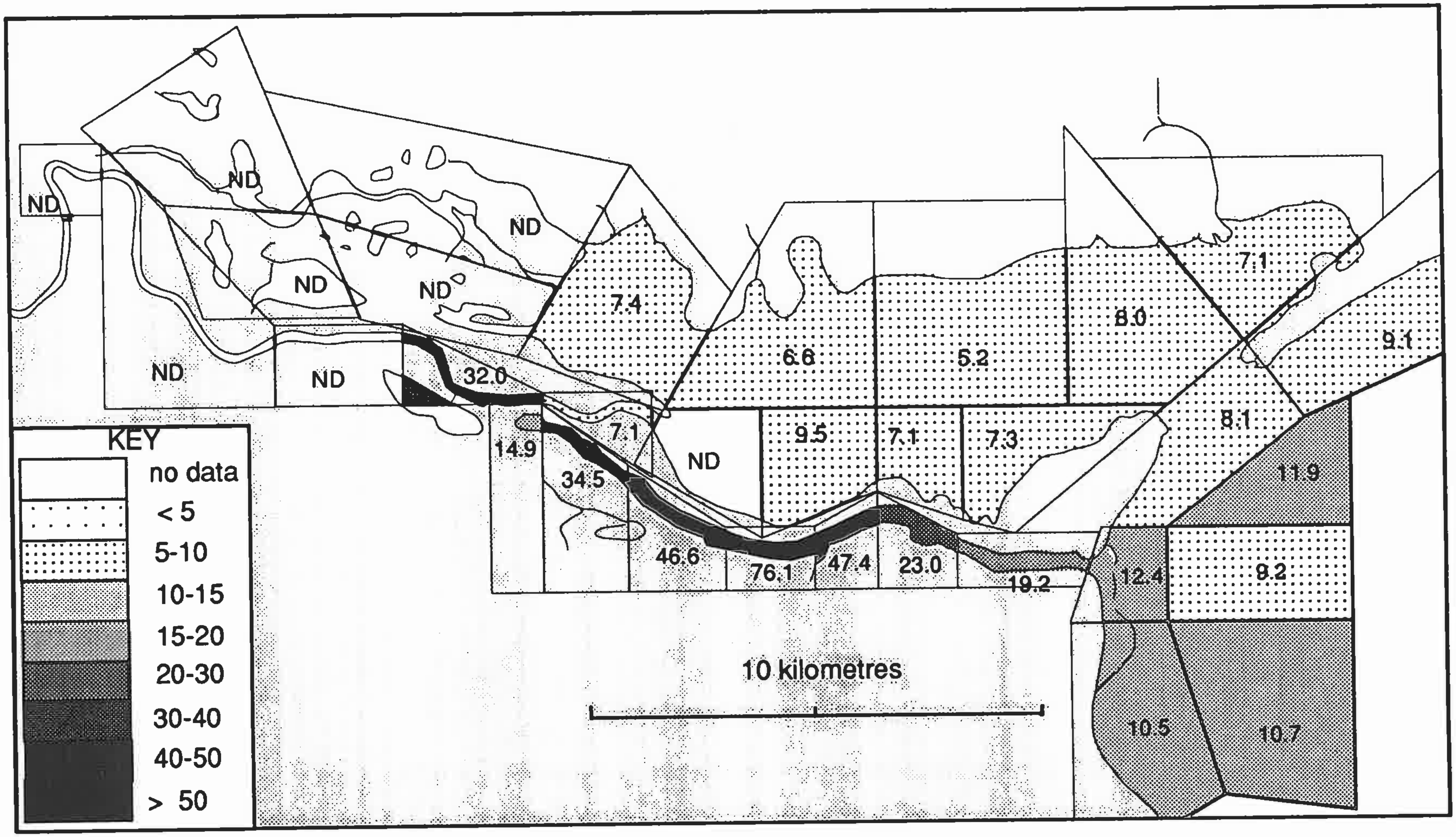


Figure 7-22. Period-of-record means of SEDMETCU for Nueces Bay region, including Inner Harbor

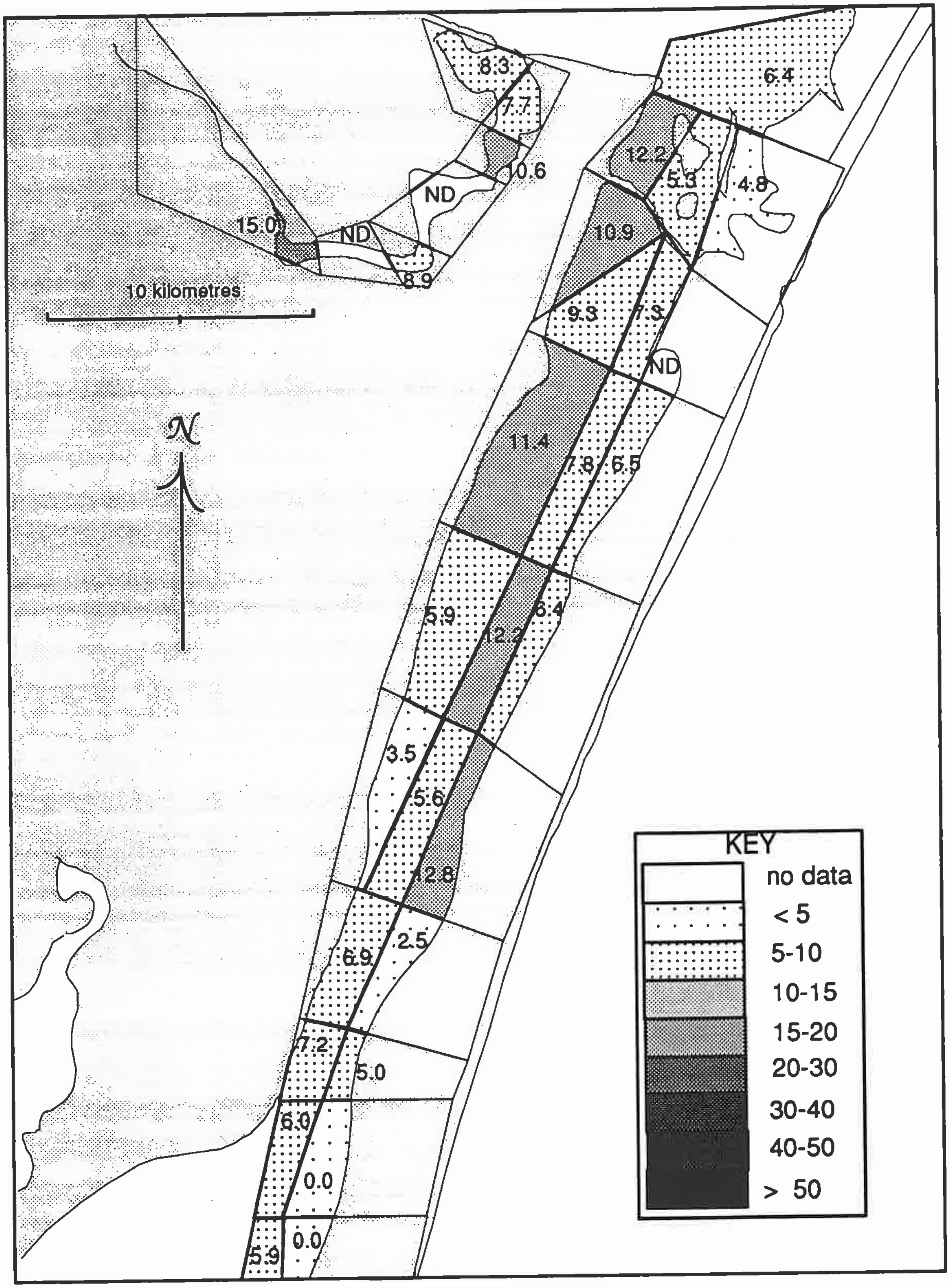


Figure 7-23. Period-of-record means of SEDMETCU for Upper Laguna Madre and Oso Bay

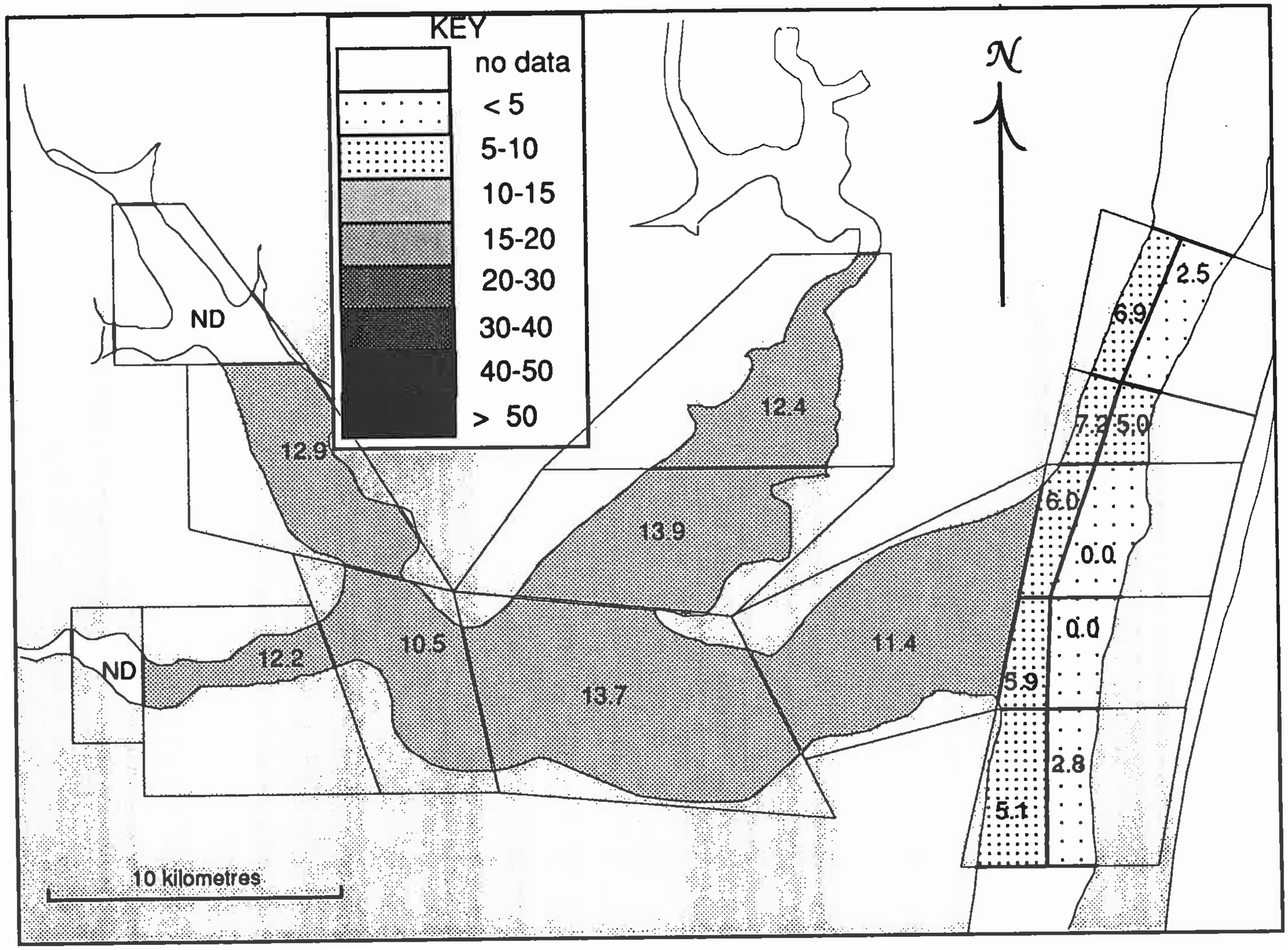


Figure 7-24. Period-of-record means of SEDMETCU for Baffin Bay region

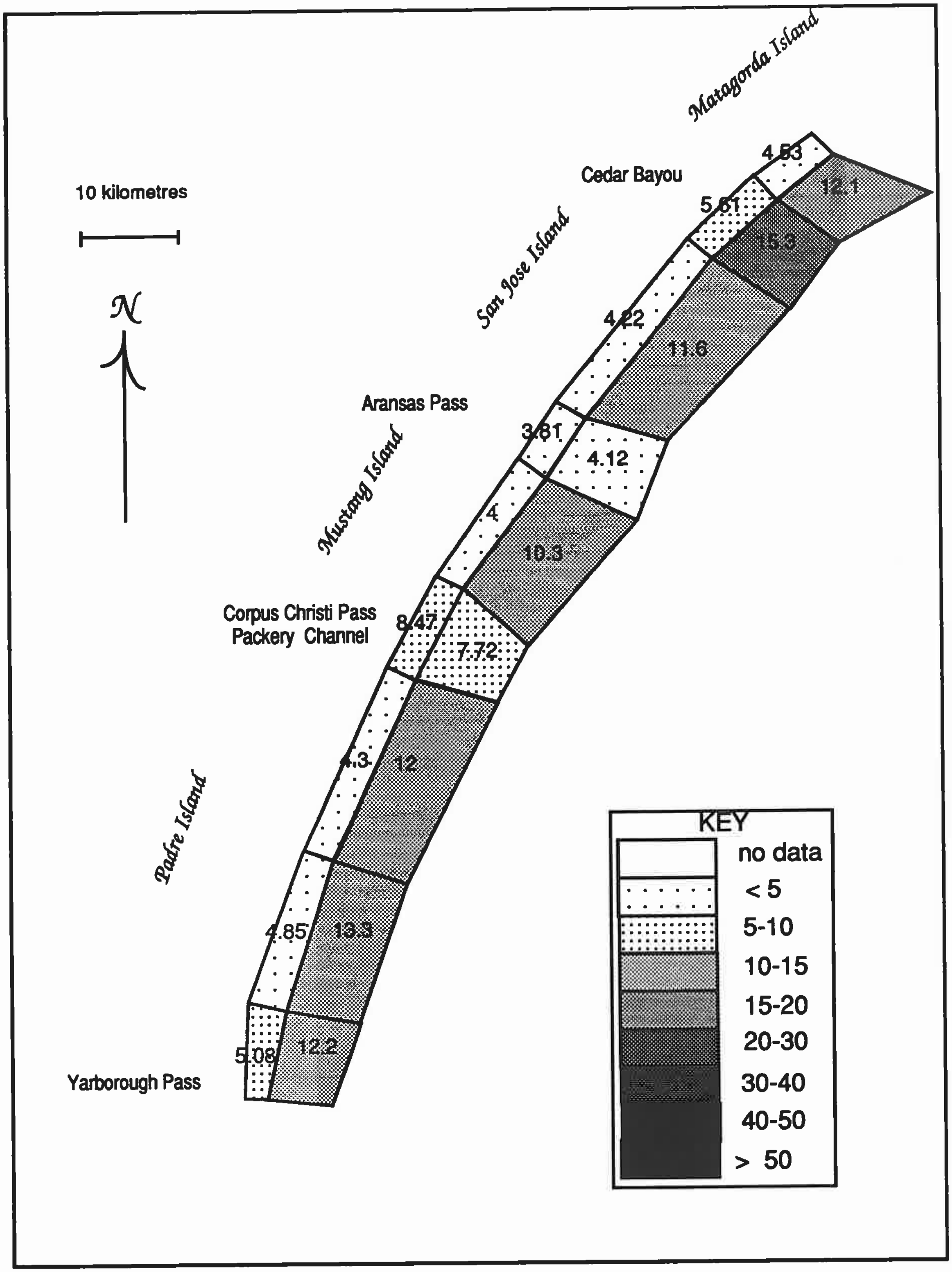


Figure 7-25. Period-of-record means of SEDMETCU for Gulf of Mexico

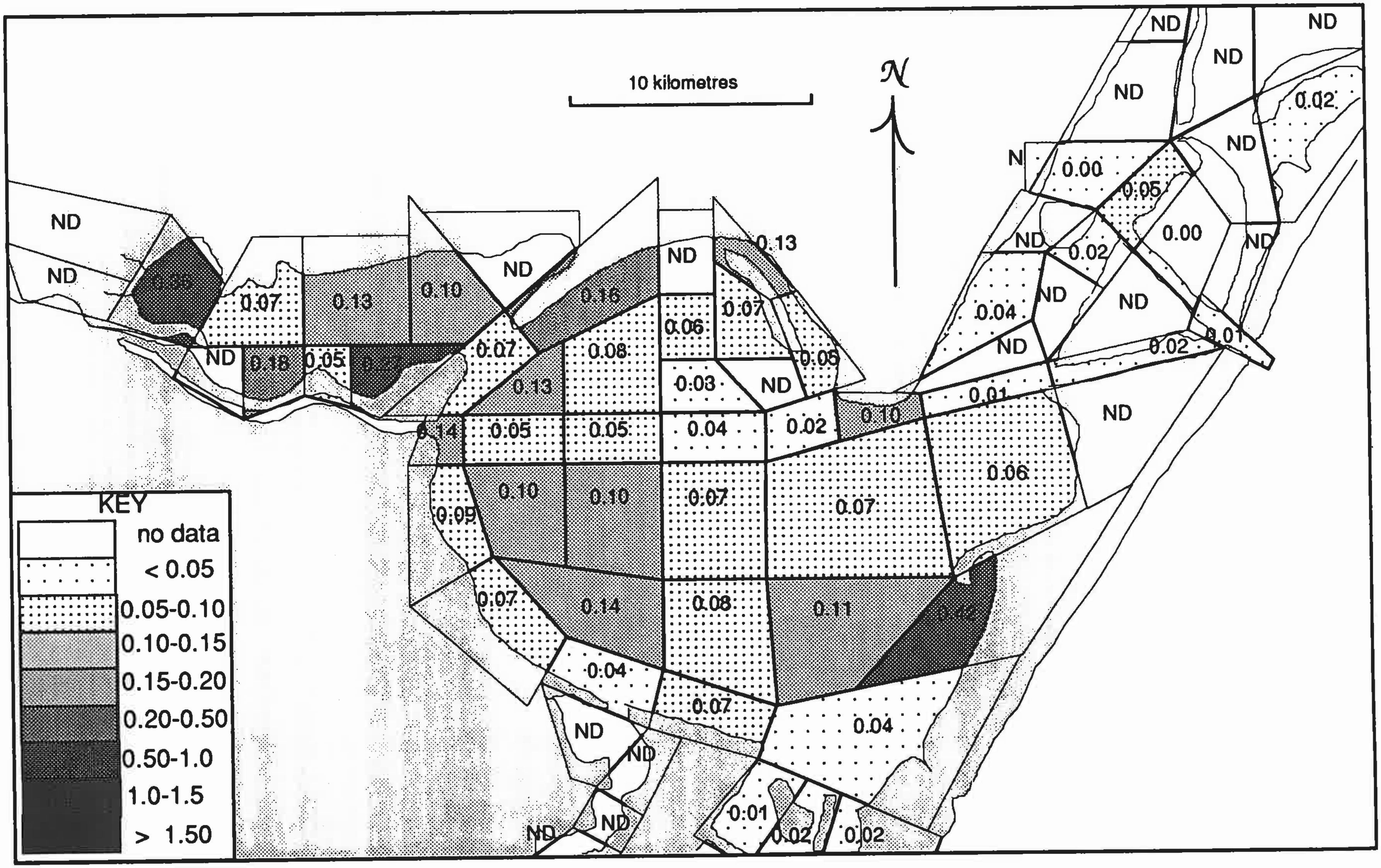


Figure 7-26. Period-of-record means of SEDMETHG for Corpus Christi system

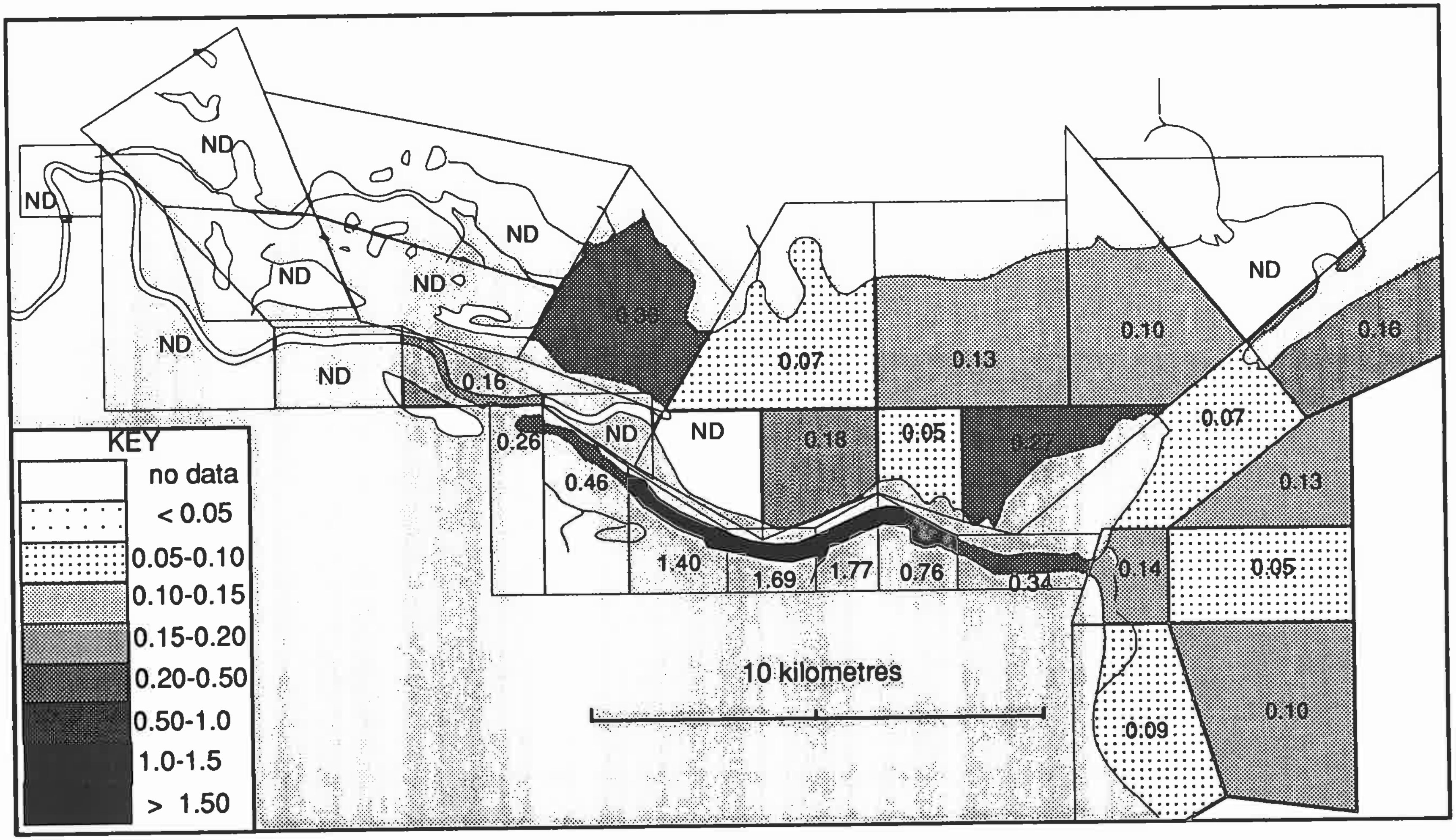


Figure 7-27. Period-of-record means of SEDMETHG for Nueces Bay region, including Inner Harbor

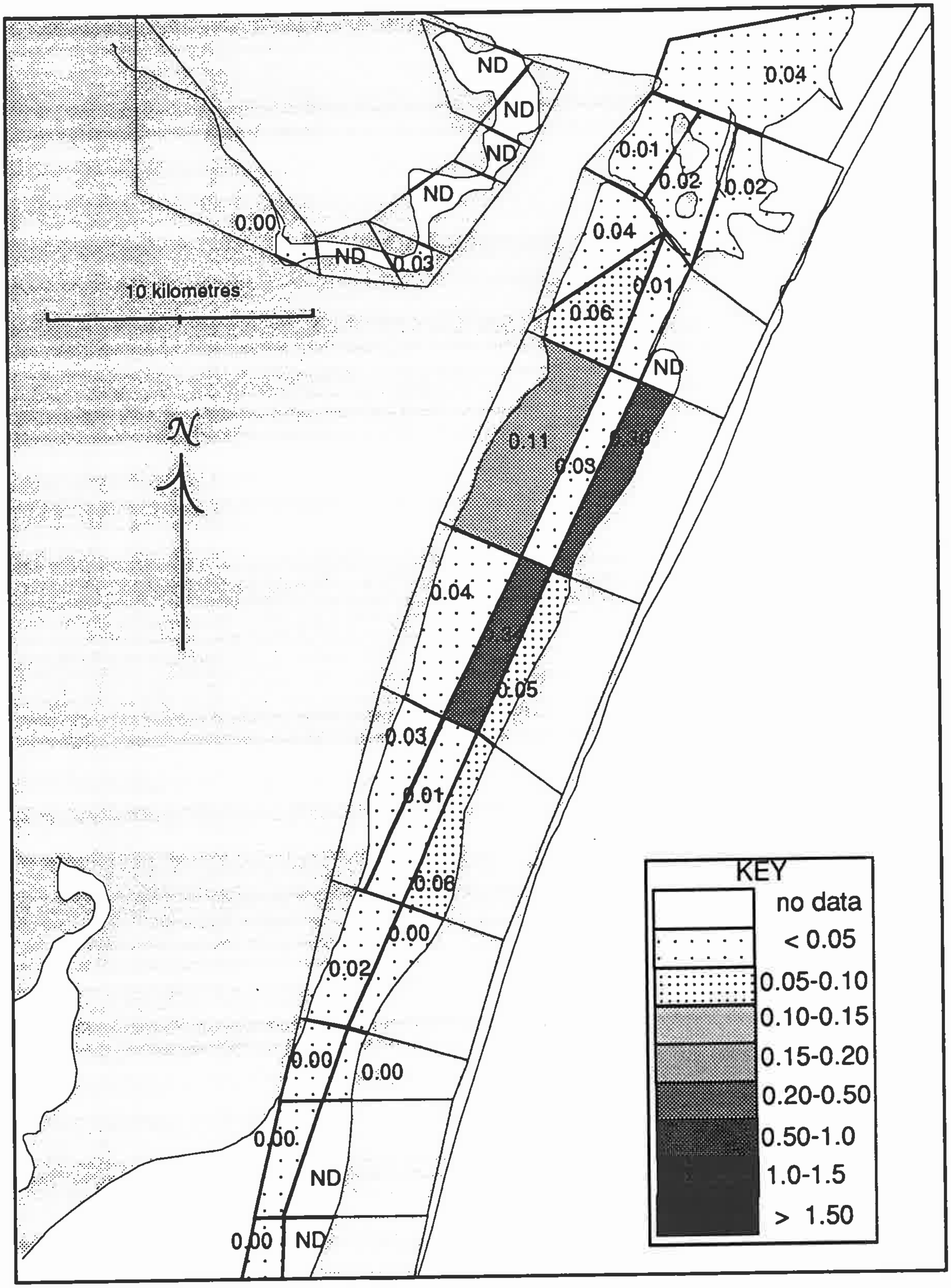


Figure 7-28. Period-of-record means of SEDMETHG for Upper Laguna Madre and Oso Bay

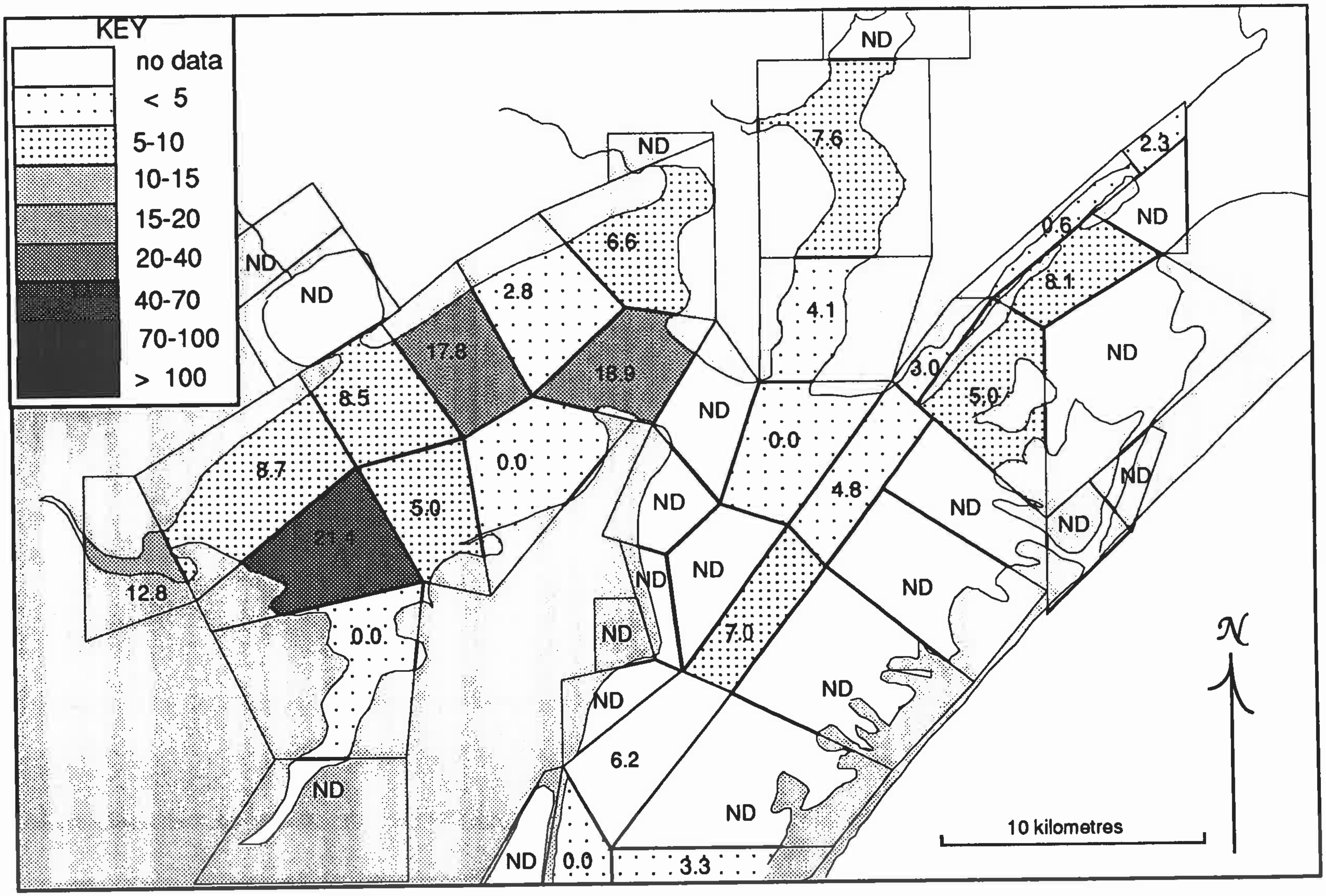


Figure 7-29. Period-of-record means of SEDMETPB for Aransas-Copano system

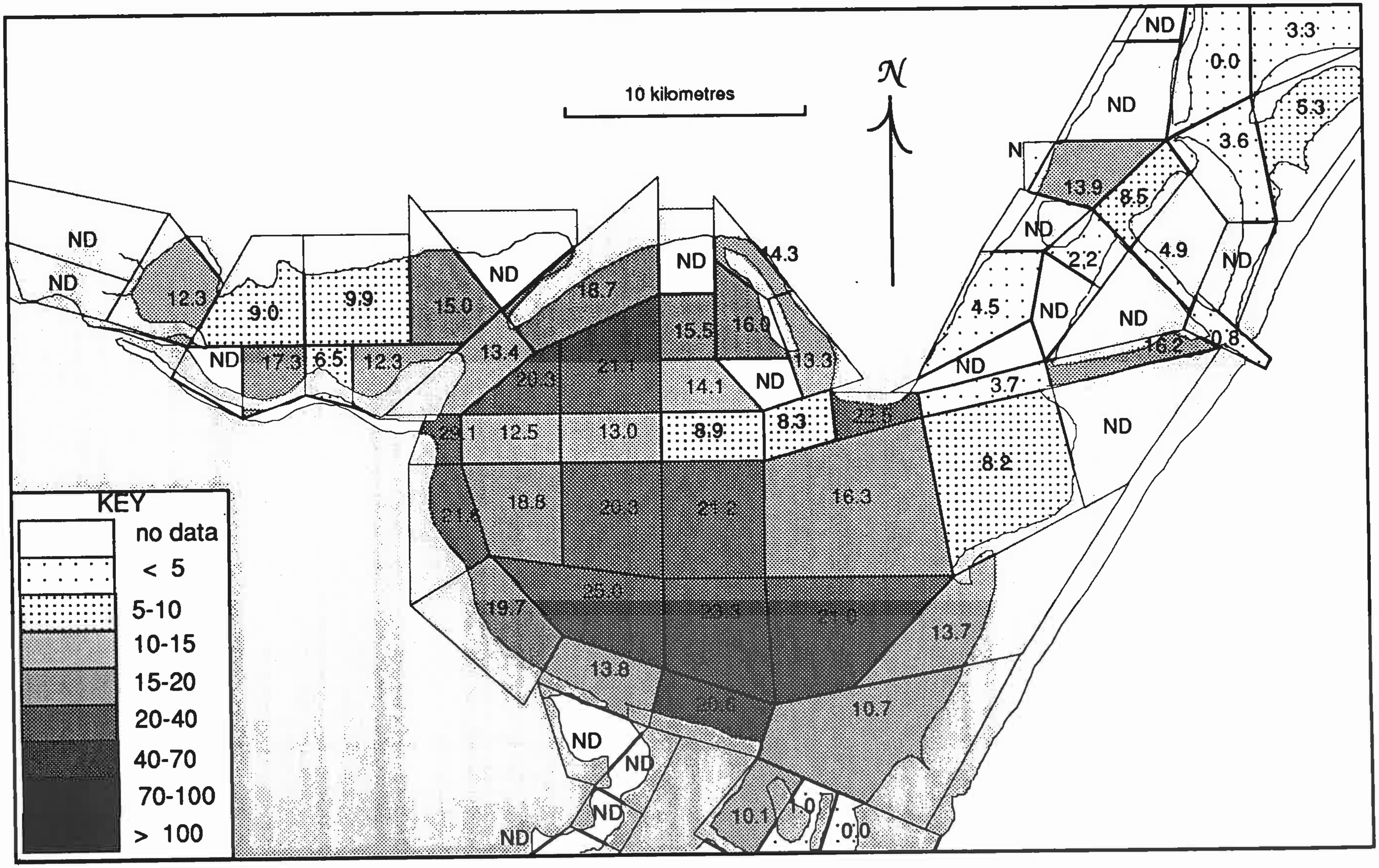


Figure 7-30. Period-of-record means of SEDMETPB for Corpus Christi system

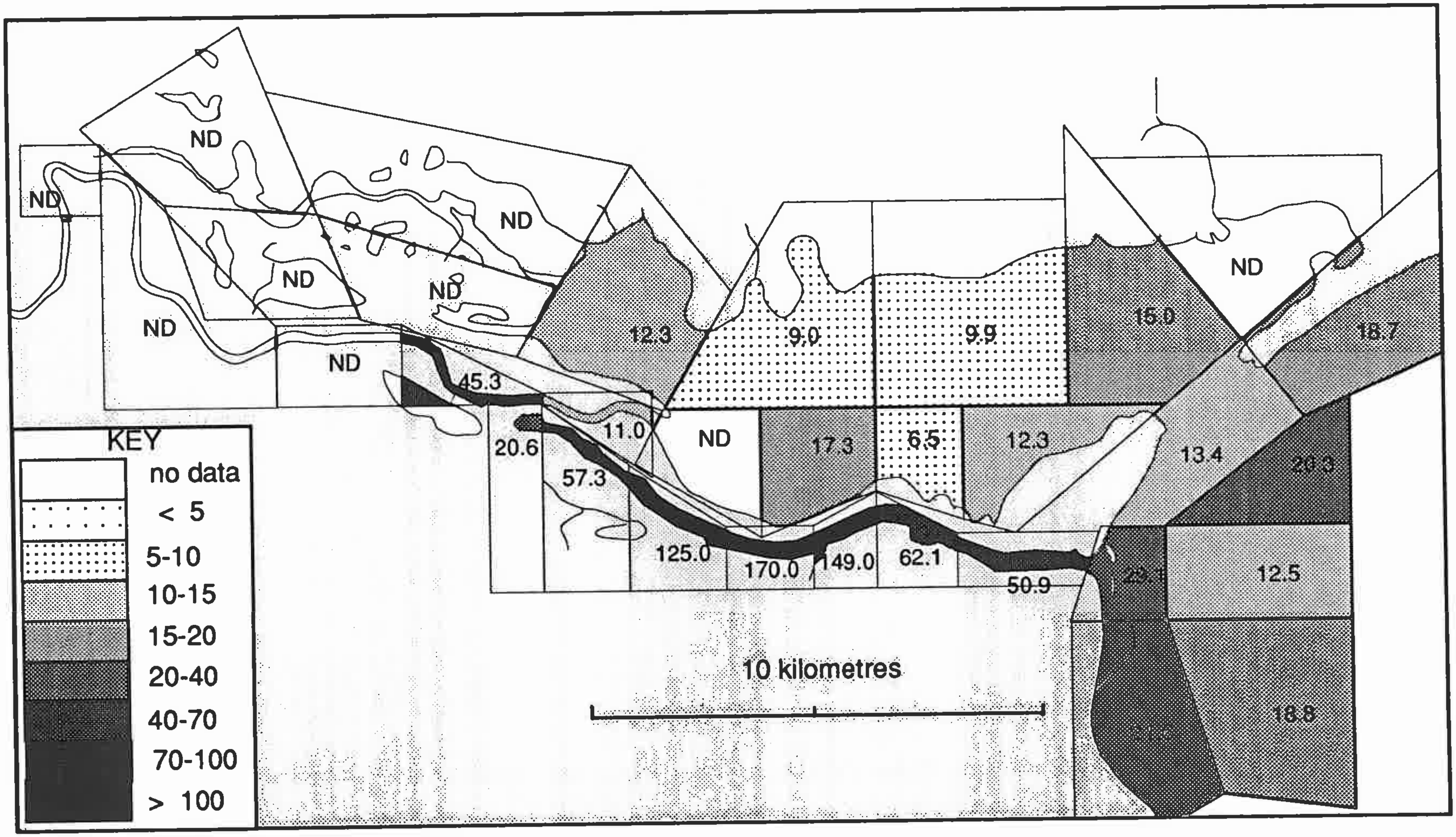


Figure 7-31. Period-of-record means of SEDMETPB for Nueces Bay region, including Inner Harbor

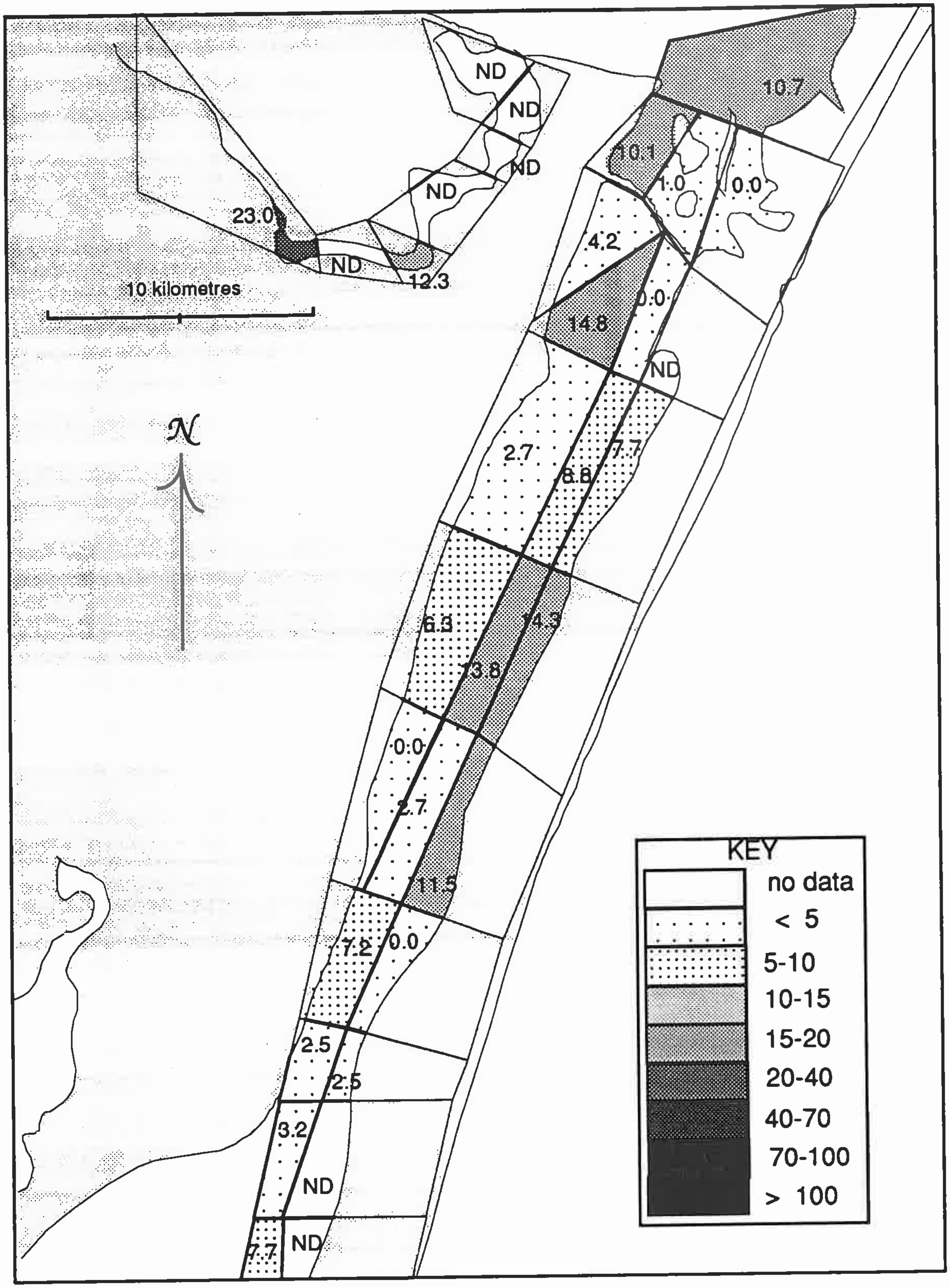


Figure 7-32. Period-of-record means of SEDMETPB for Upper Laguna Madre and Oso Bay

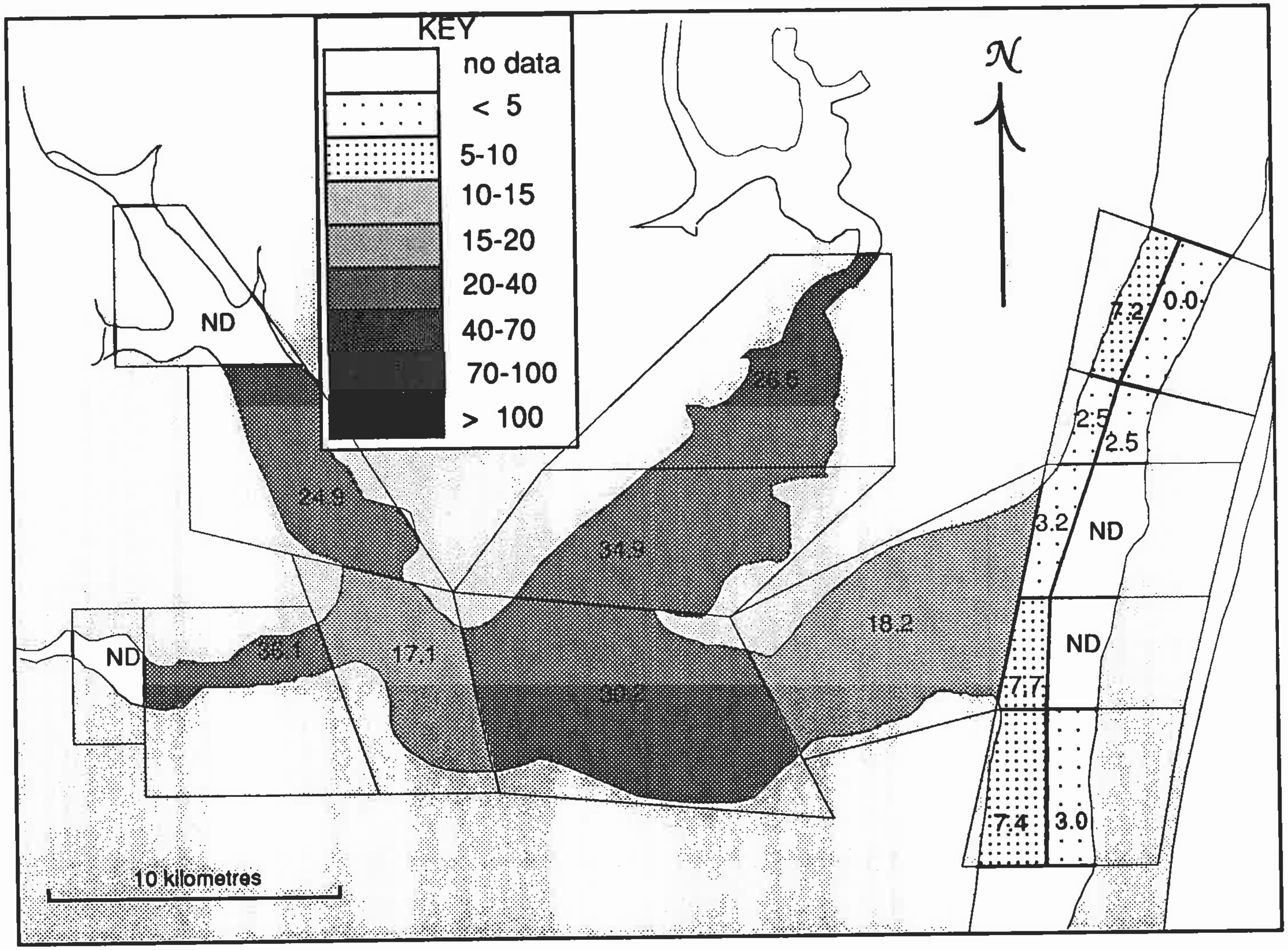


Figure 7-33. Period-of-record means of SEDMETPB for Baffin Bay region

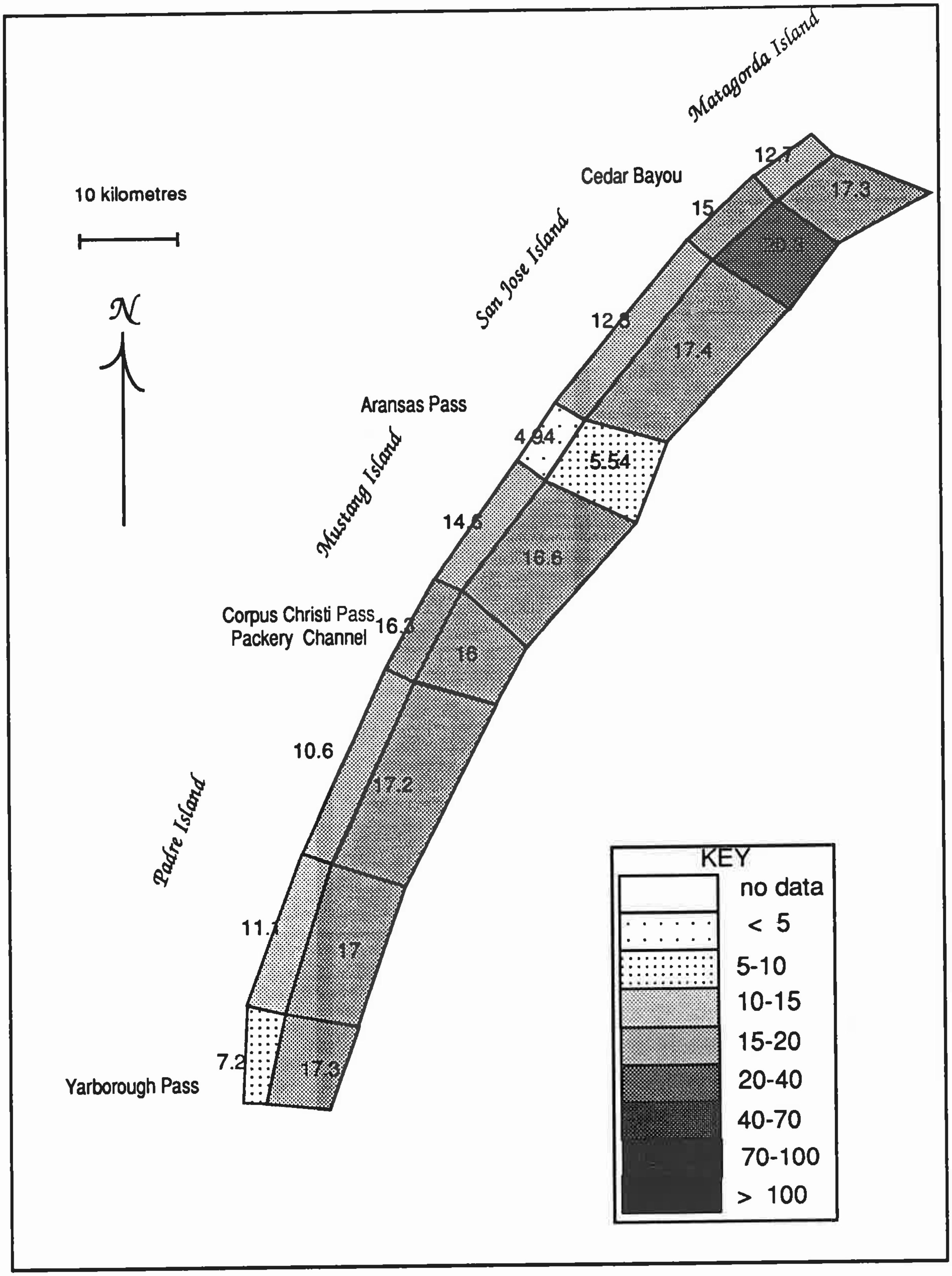


Figure 7-34. Period-of-record means of SEDMETPB for Gulf of Mexico

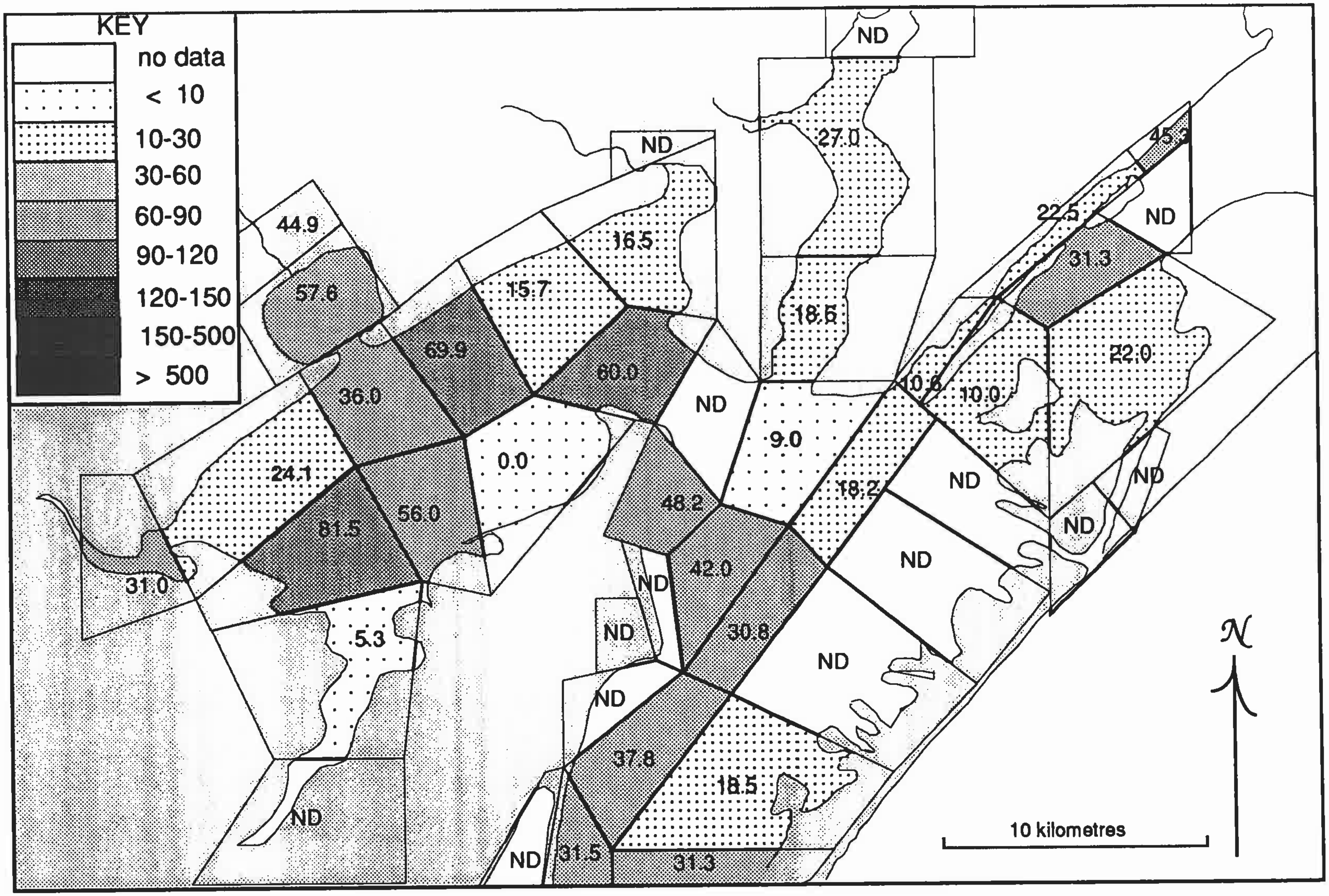


Figure 7-35. Period-of-record means of SEDMETZN for Aransas-Copano system

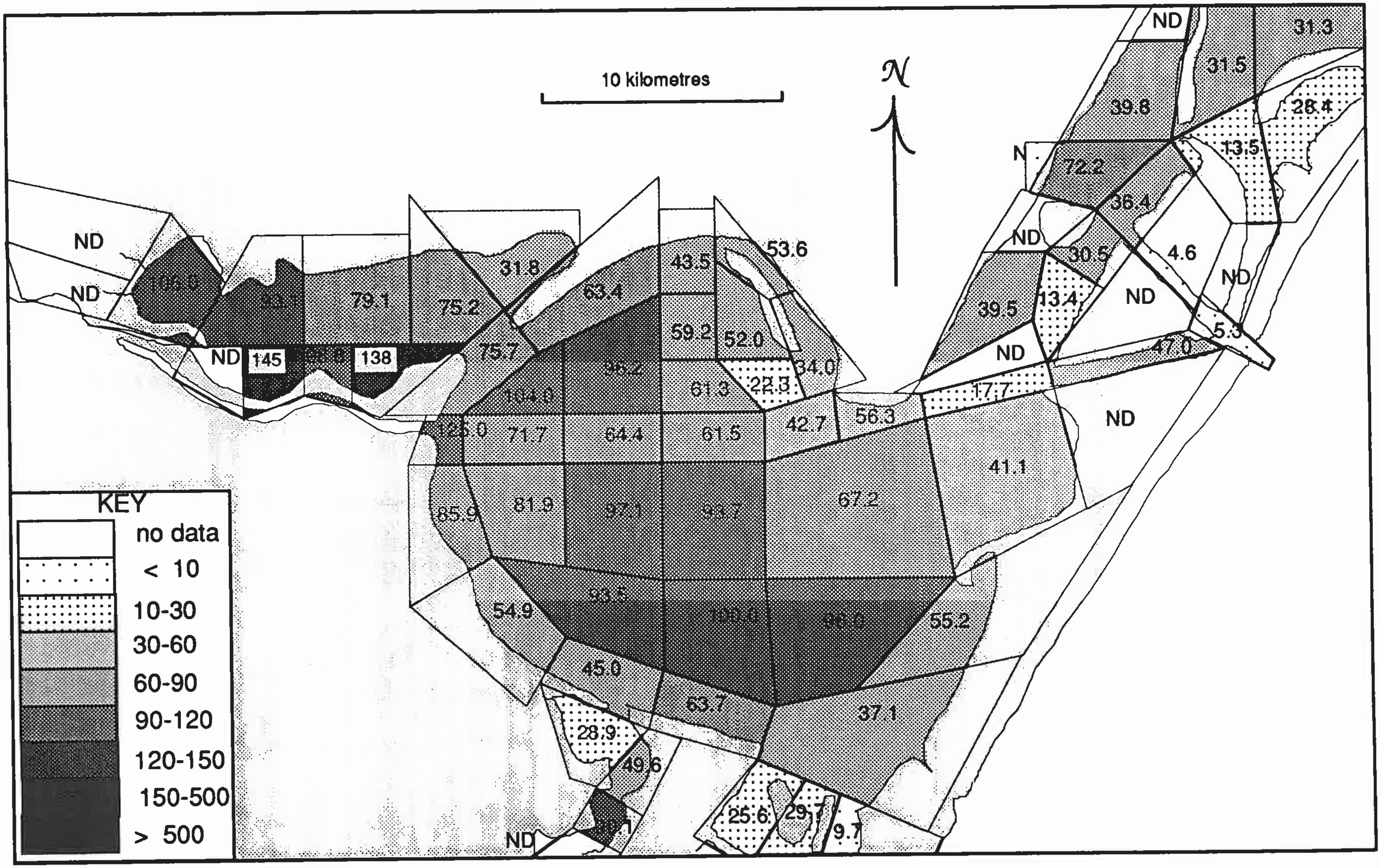


Figure 7-36. Period-of-record means of SEDMETZN for Corpus Christi system

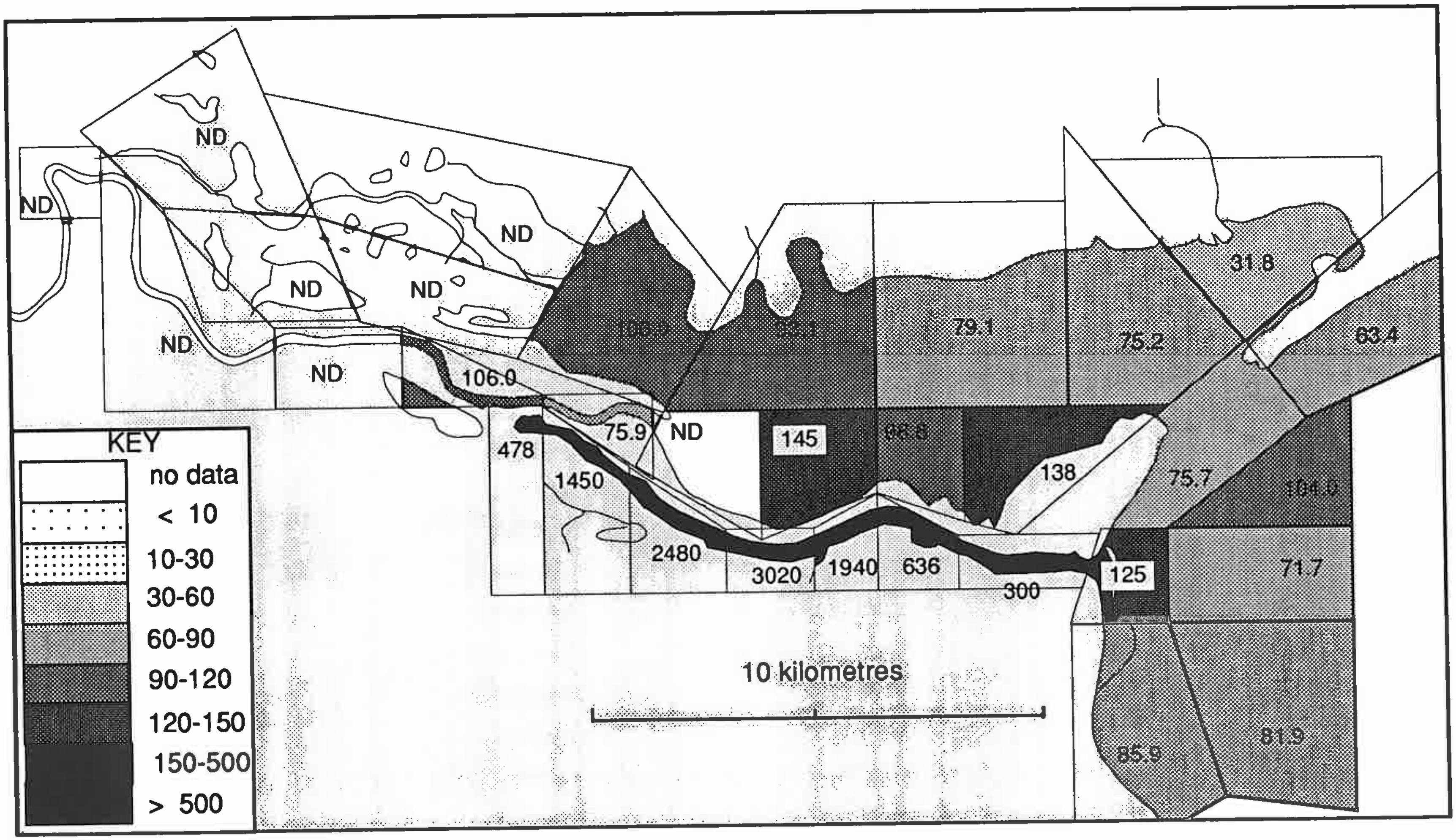


Figure 7-37. Period-of-record means of SEDMETZN for Nueces Bay region, including Inner Harbor

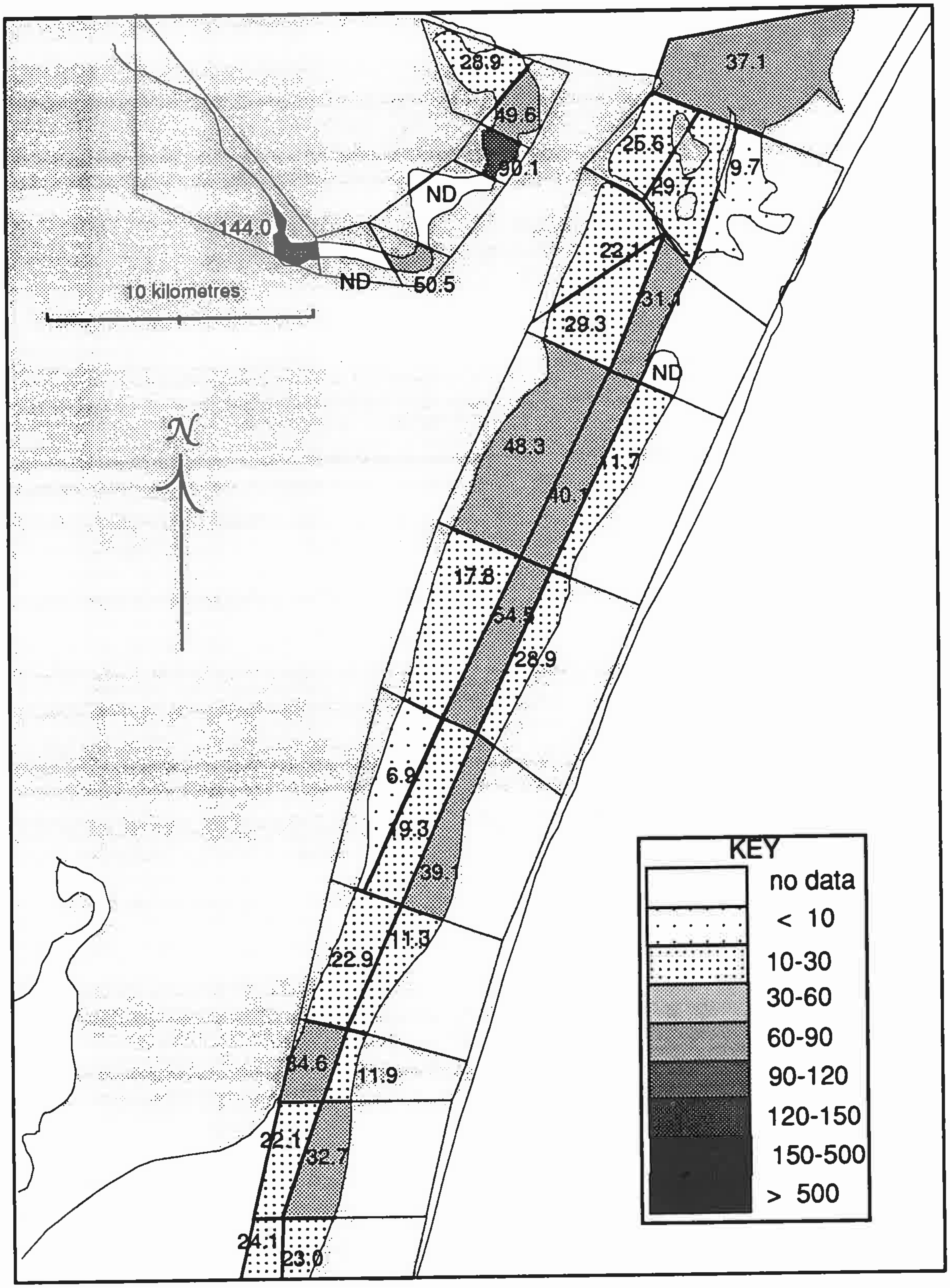


Figure 7-38. Period-of-record means of SEDMETZN for Upper Laguna Madre and Oso Bay

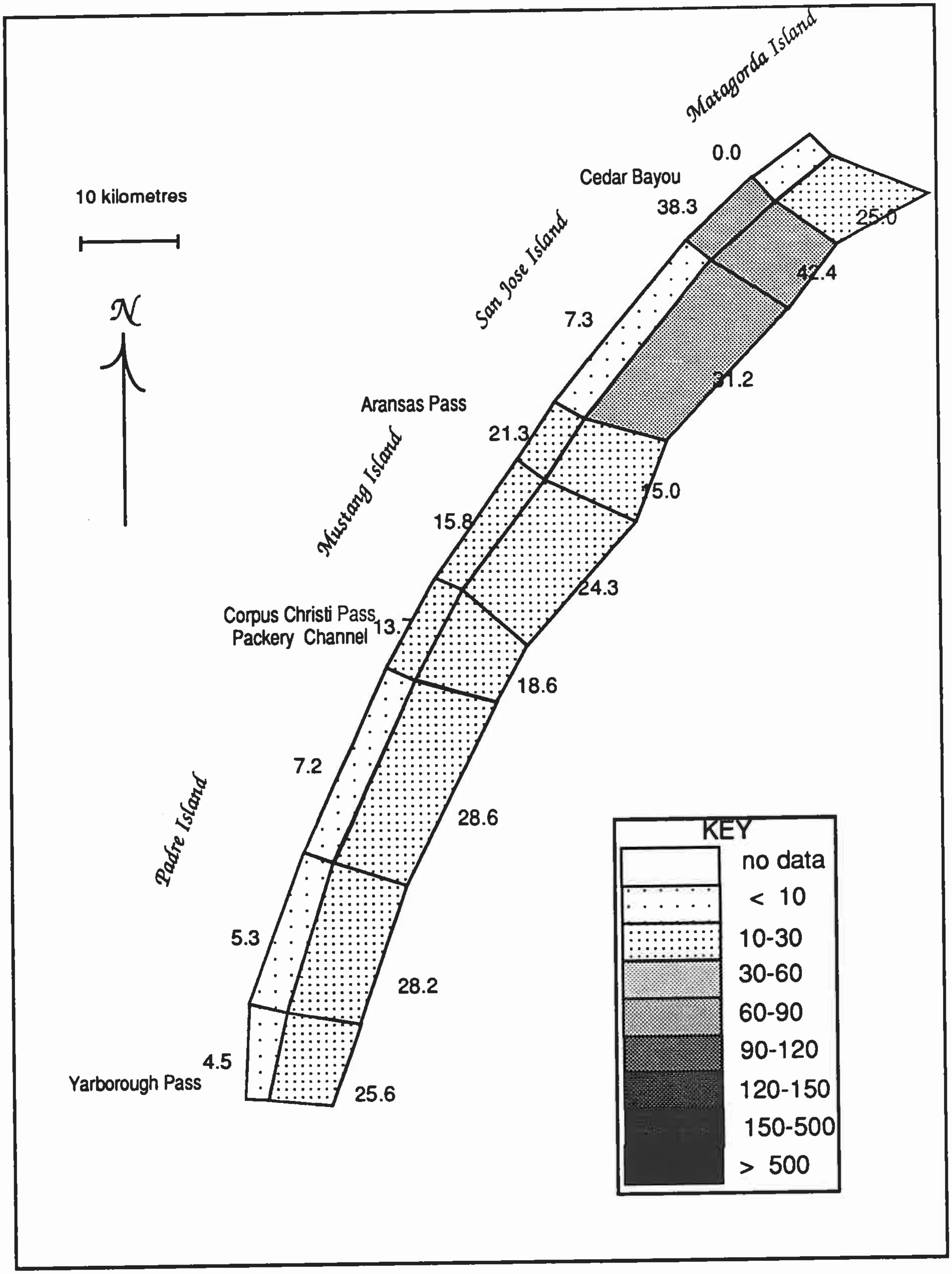


Figure 7-39. Period-of-record means of SEDMETZN for Gulf of Mexico

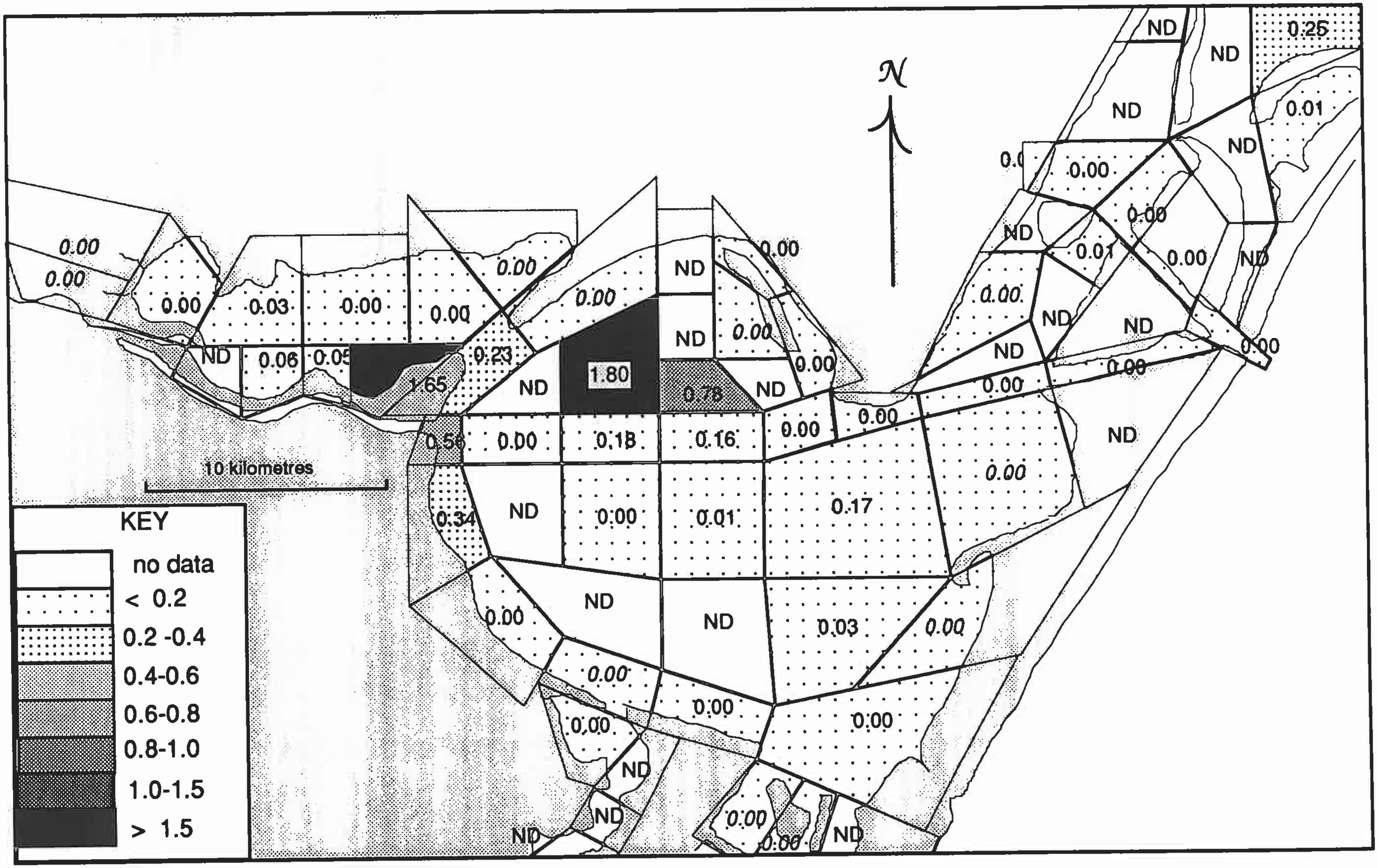


Figure 7-40. Period-of-record means of SED-XDDT for Corpus Christi system

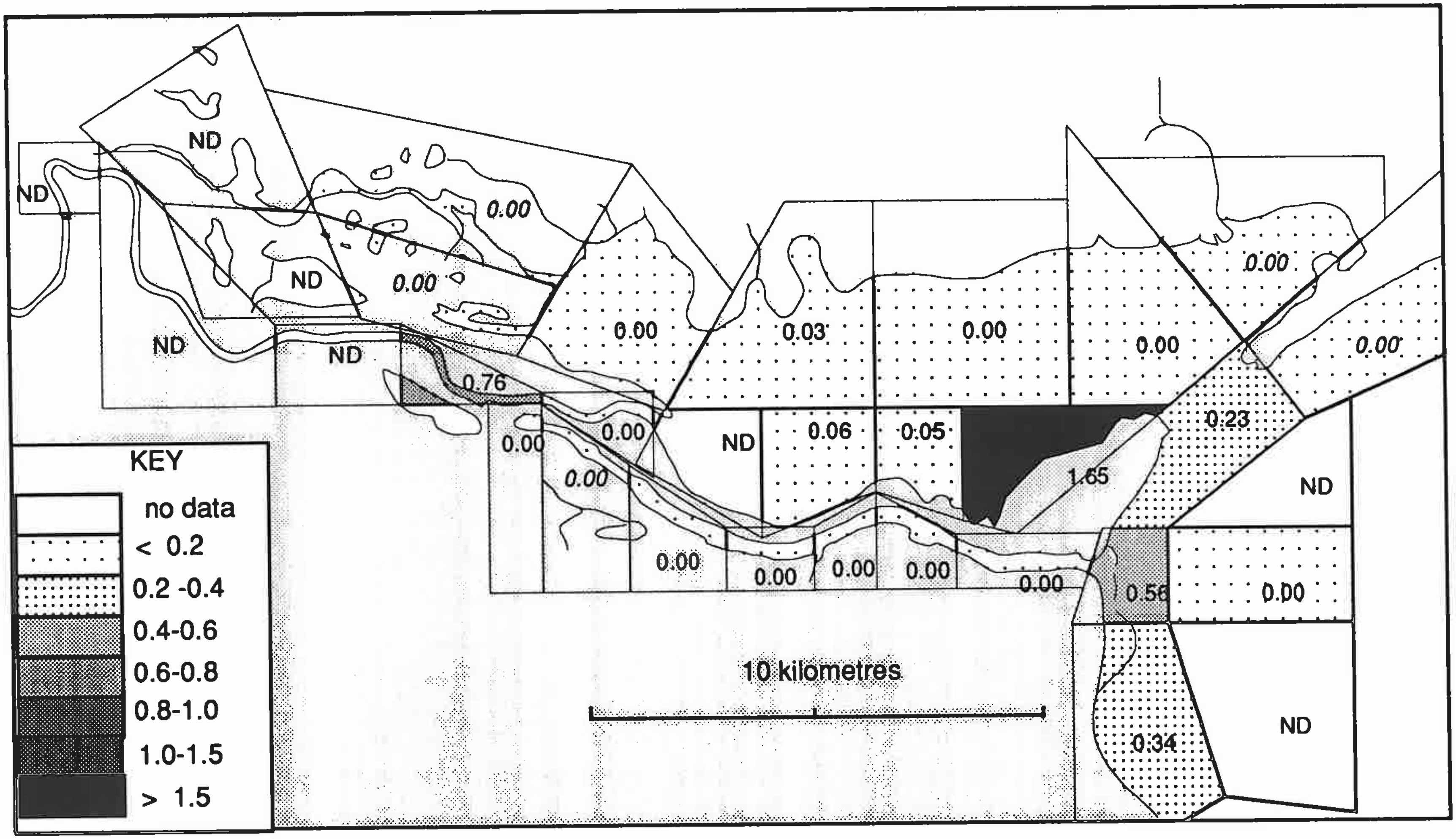


Figure 7-41. Period-of-record means of SED-XDDT for Nueces Bay region, including Inner Harbor

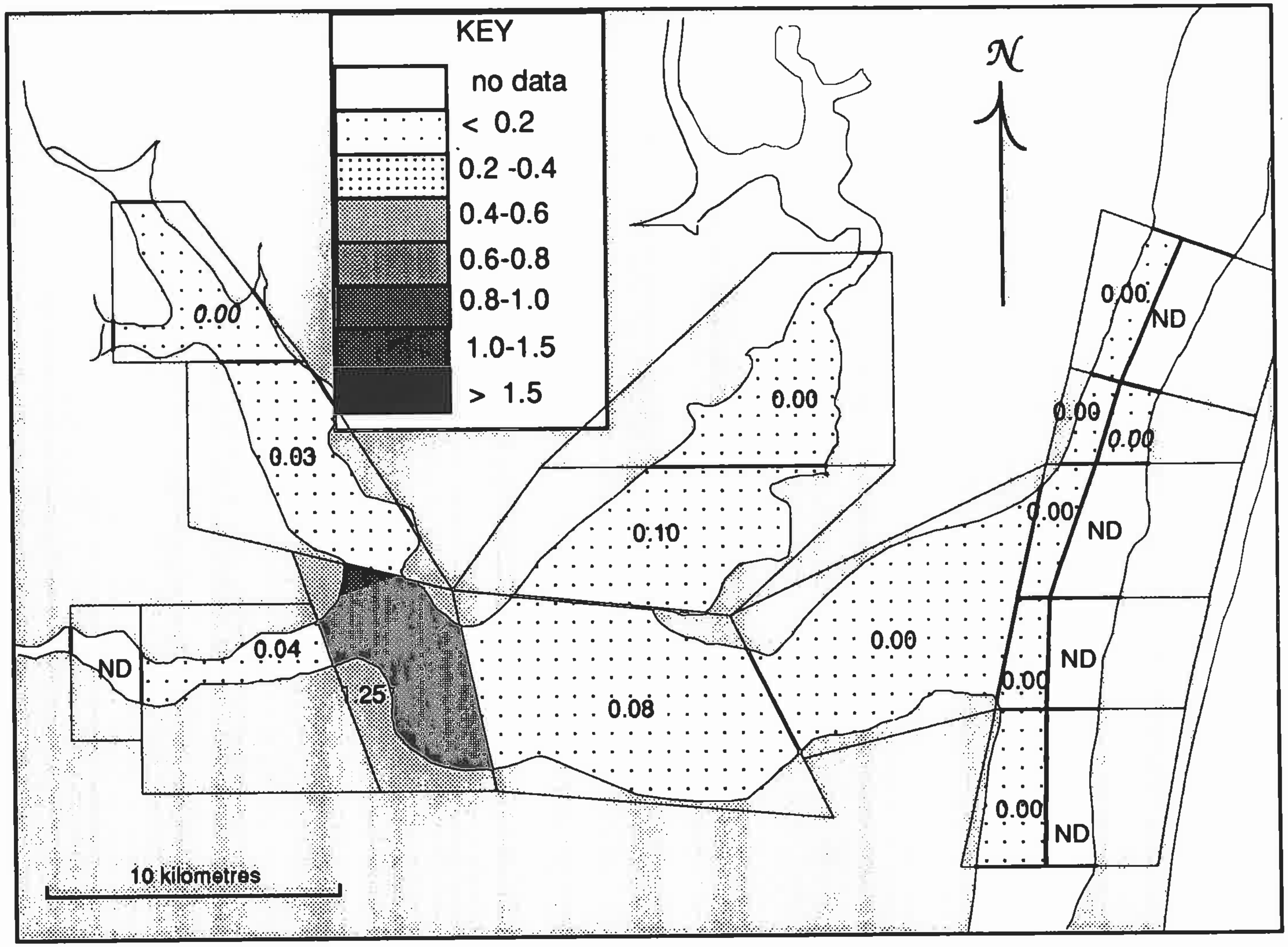


Figure 7-42. Period-of-record means of SED-XDDT for Baffin Bay region

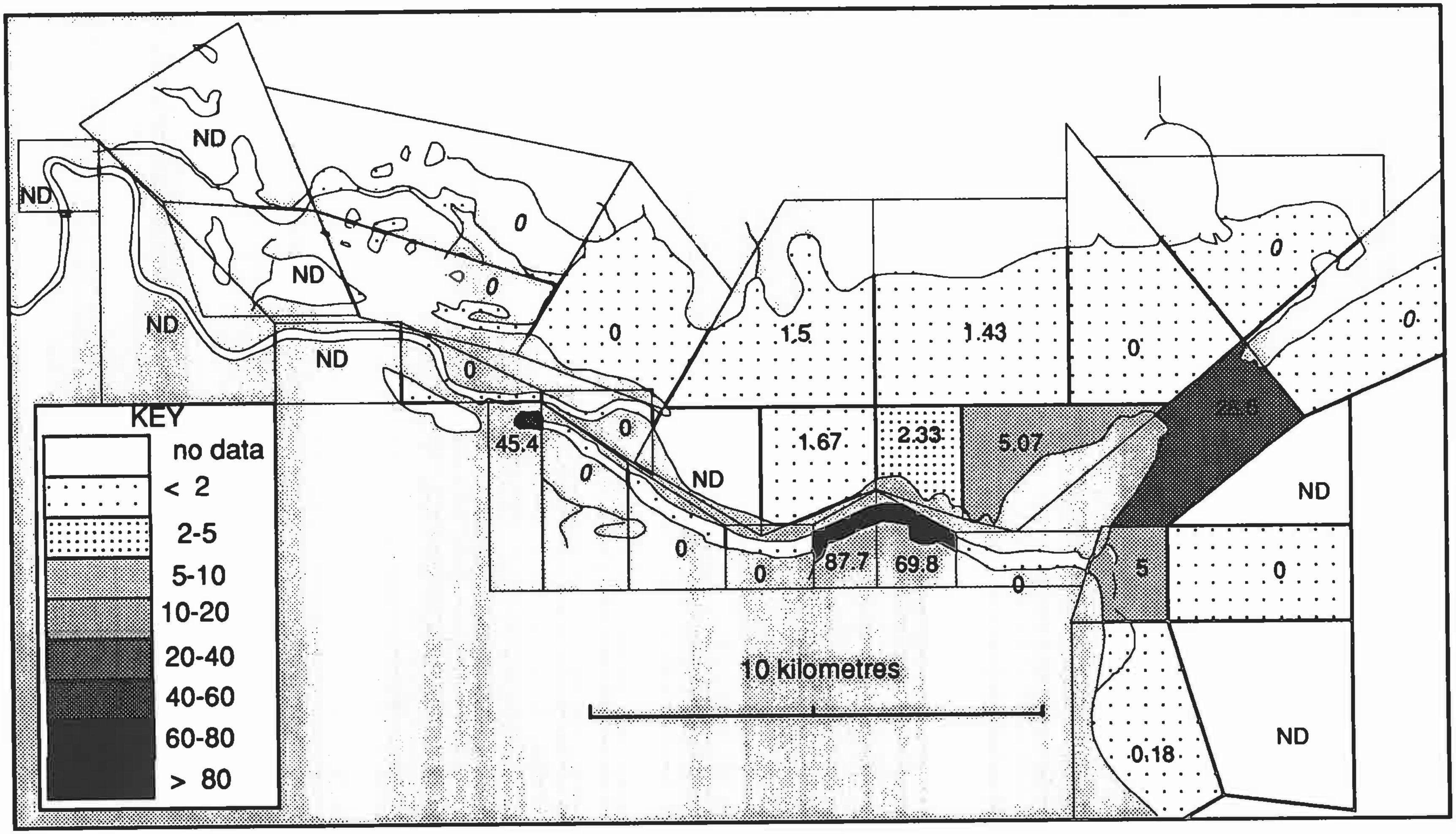


Figure 7-43. Period-of-record means of SED-PCB for Nueces Bay region, including Inner Harbor

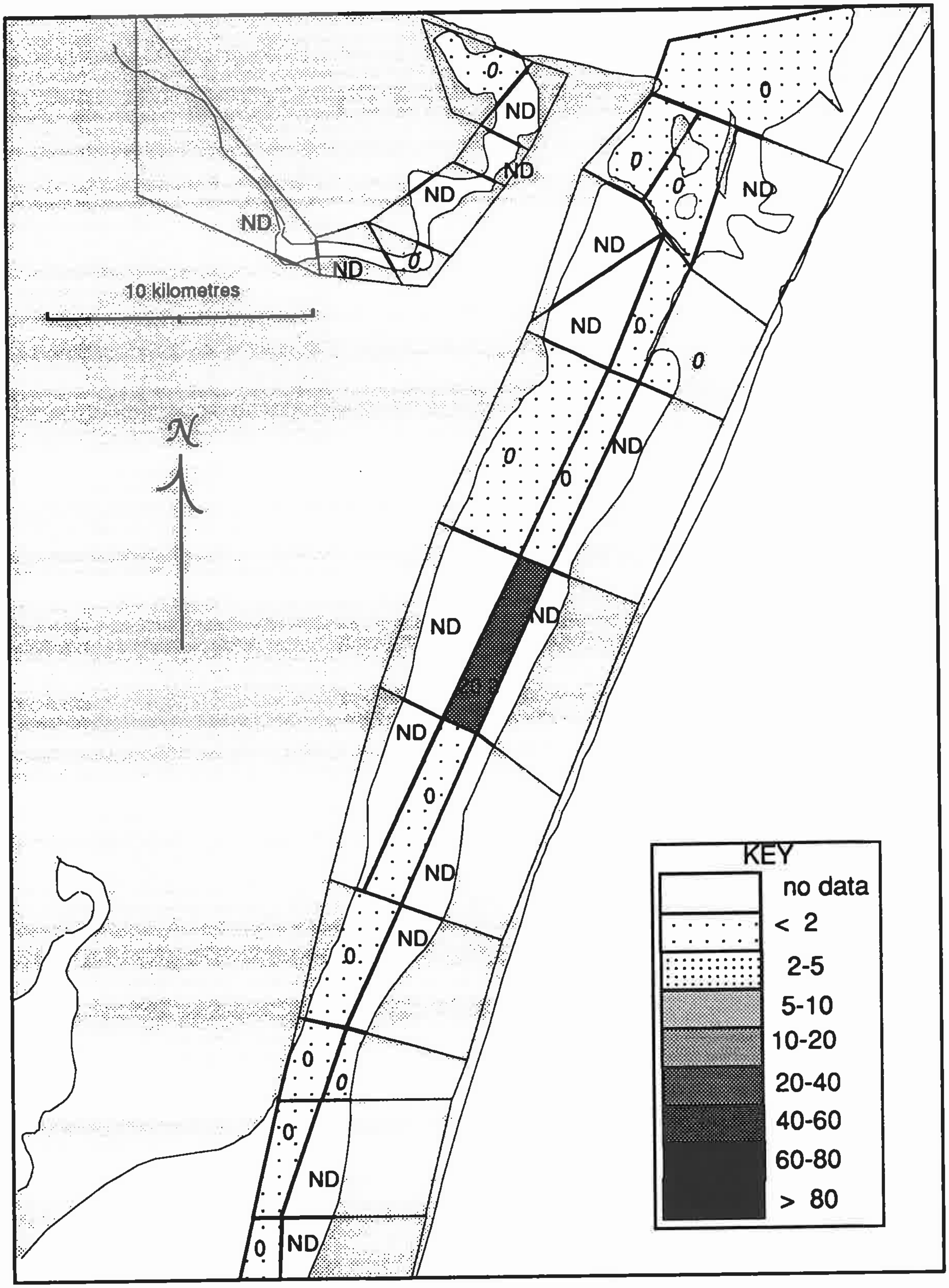


Figure 7-44. Period-of-record means of SED-PCB for Upper Laguna Madre and Oso Bay

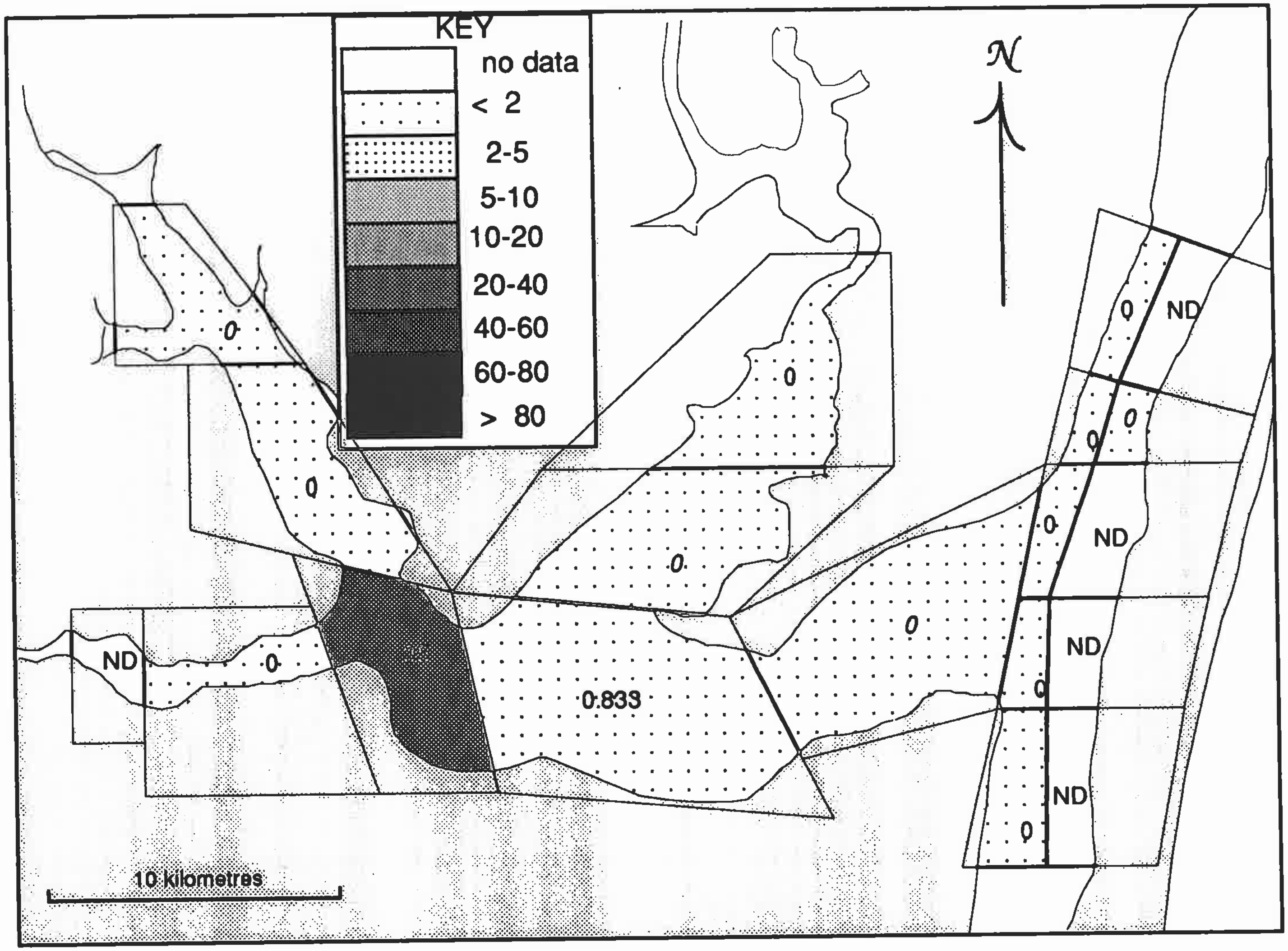


Figure 7-45. Period-of-record means of SED-PCB for Baffin Bay region

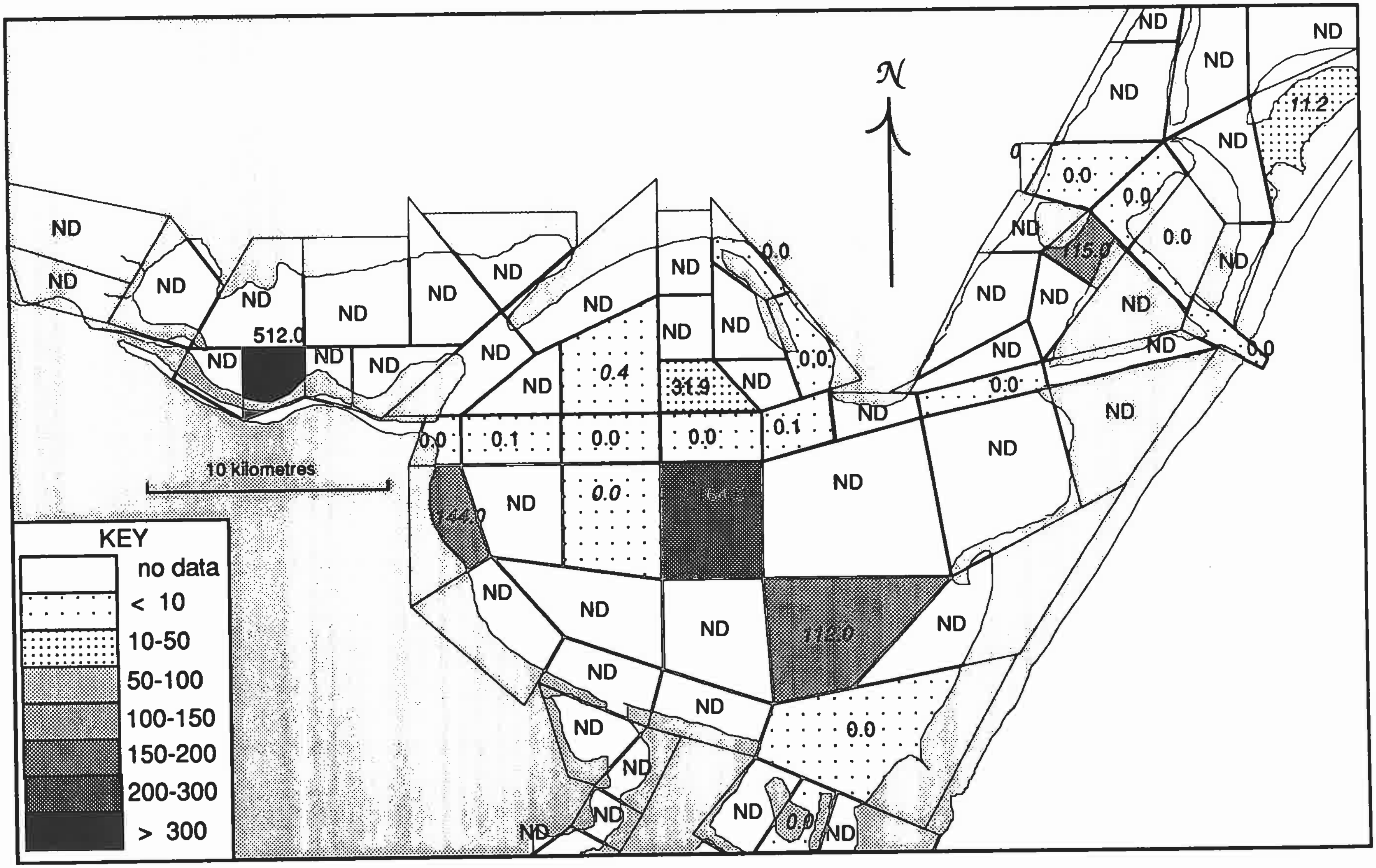


Figure 7-46. Period-of-record means of SED-PAH for Corpus Christi system

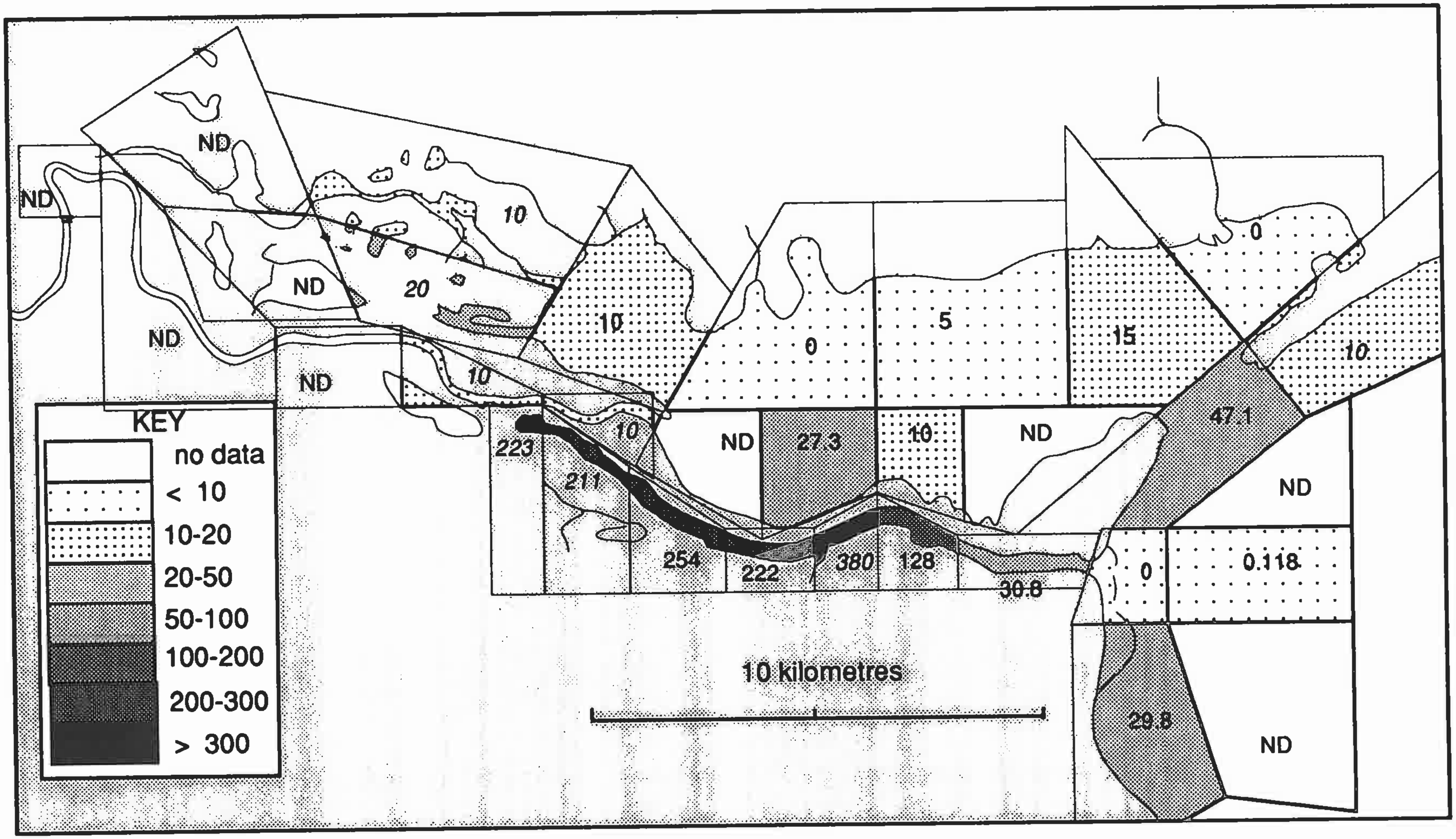


Figure 7-47. Period-of-record means of SED-BNZA for Nueces Bay region, including Inner Harbor

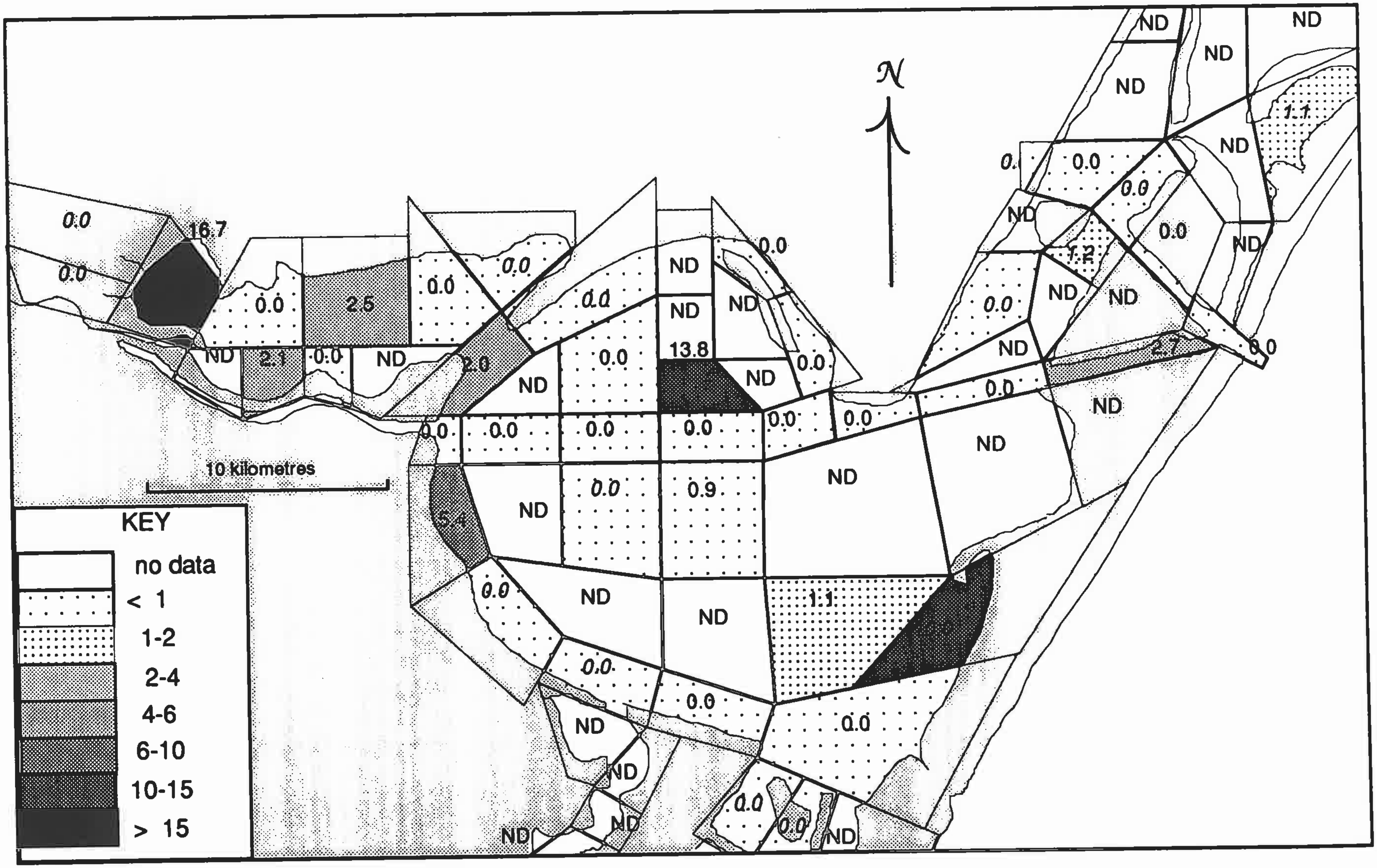


Figure 7-48. Period-of-record means of SED-NAPT for Corpus Christi system

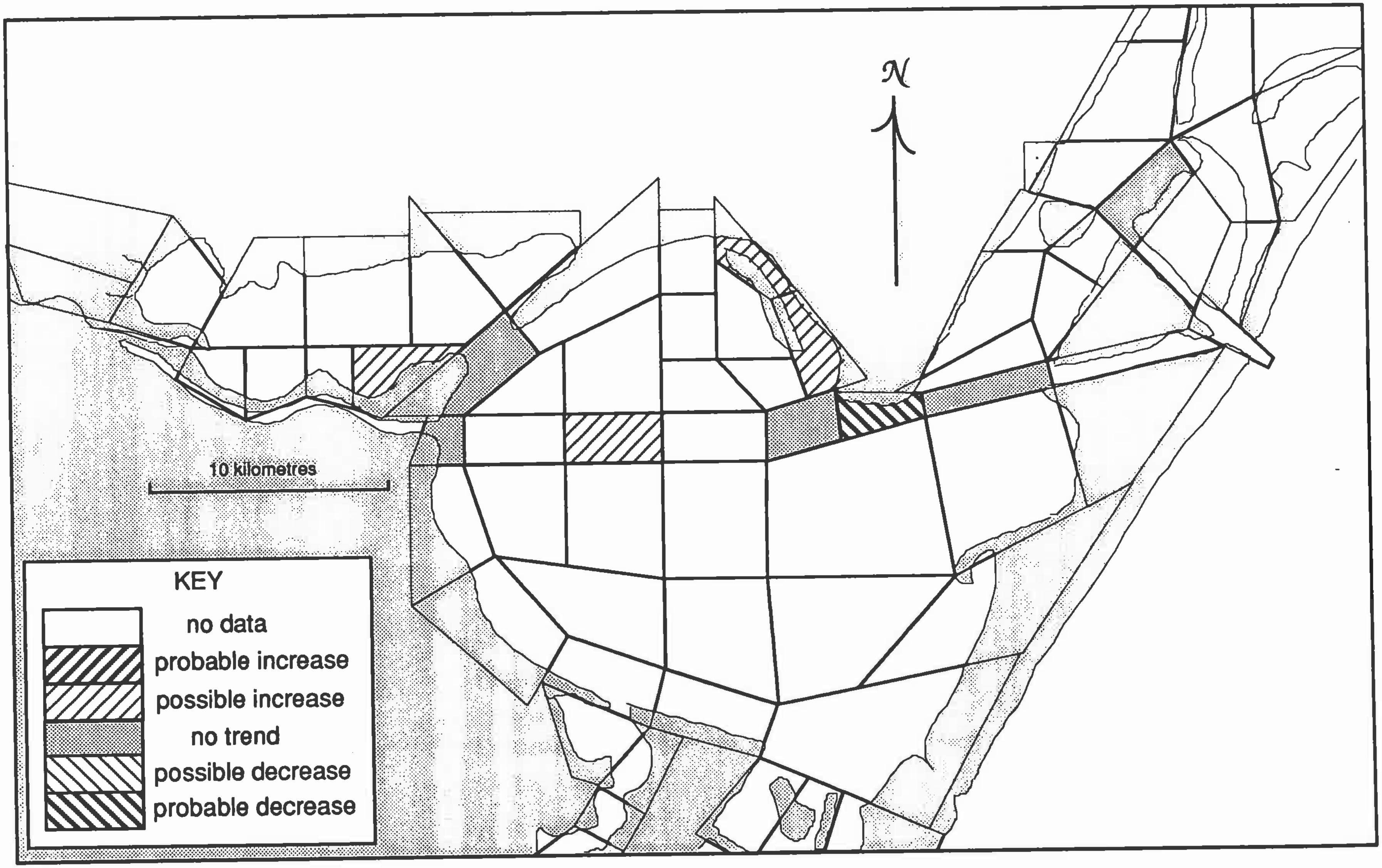


Figure 7-49. SEDKJLN period-of-record trends for Corpus Christi system

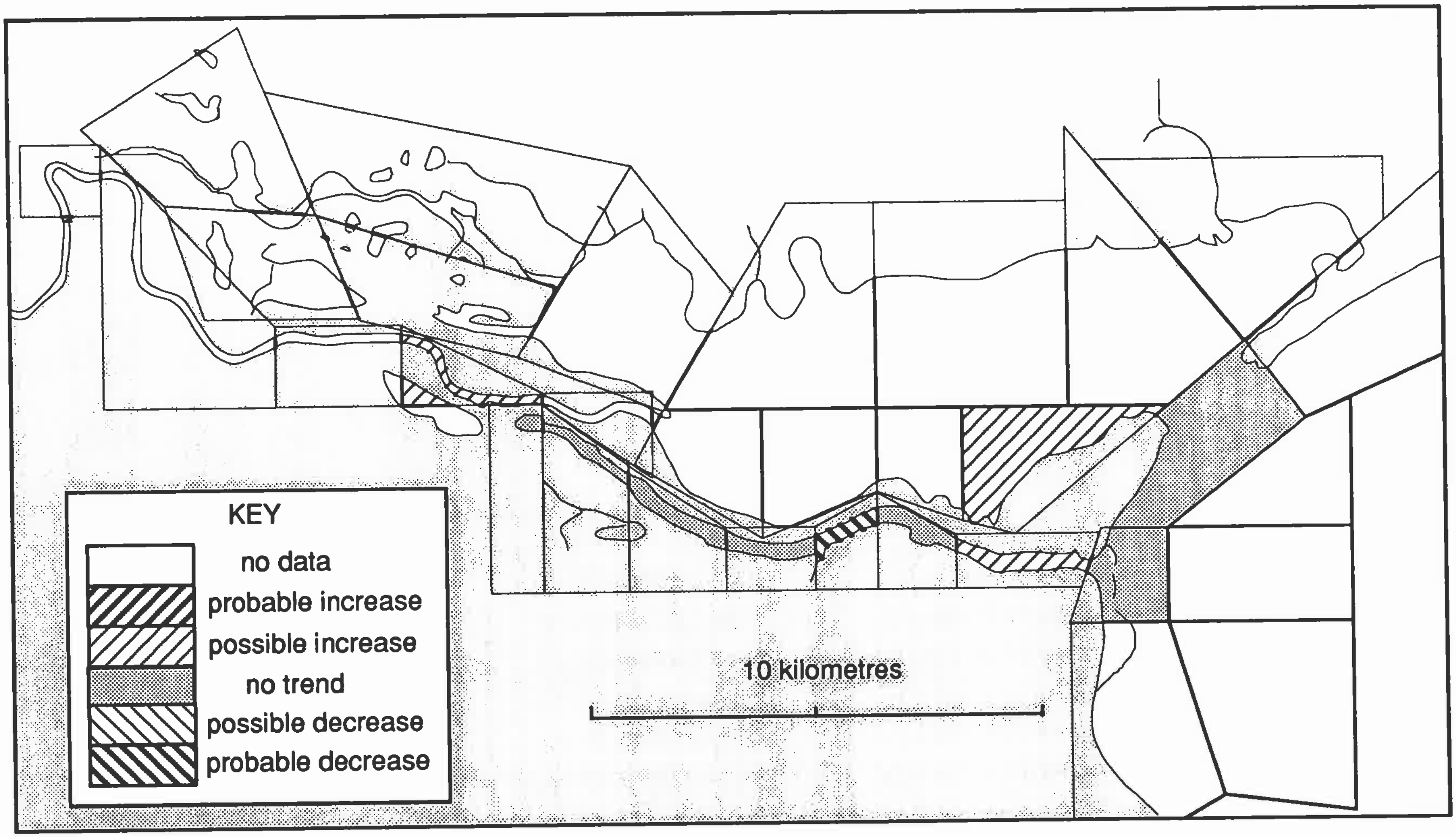


Figure 7-50. SEDKJLN period-of-record time trends for Nueces Bay region, including Inner Harbor

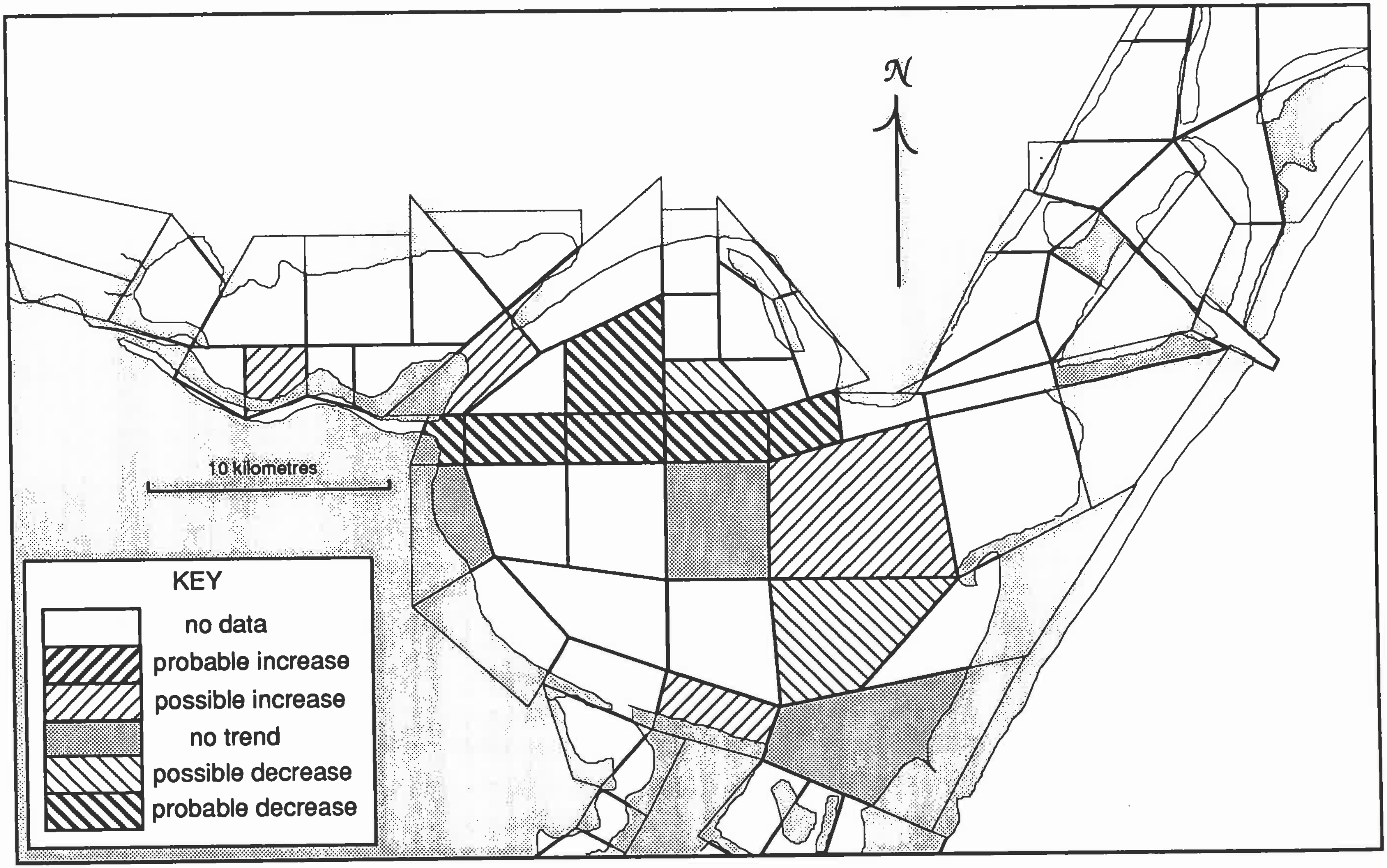


Figure 7-51. SEDTOC period-of-record trends for Corpus Christi system

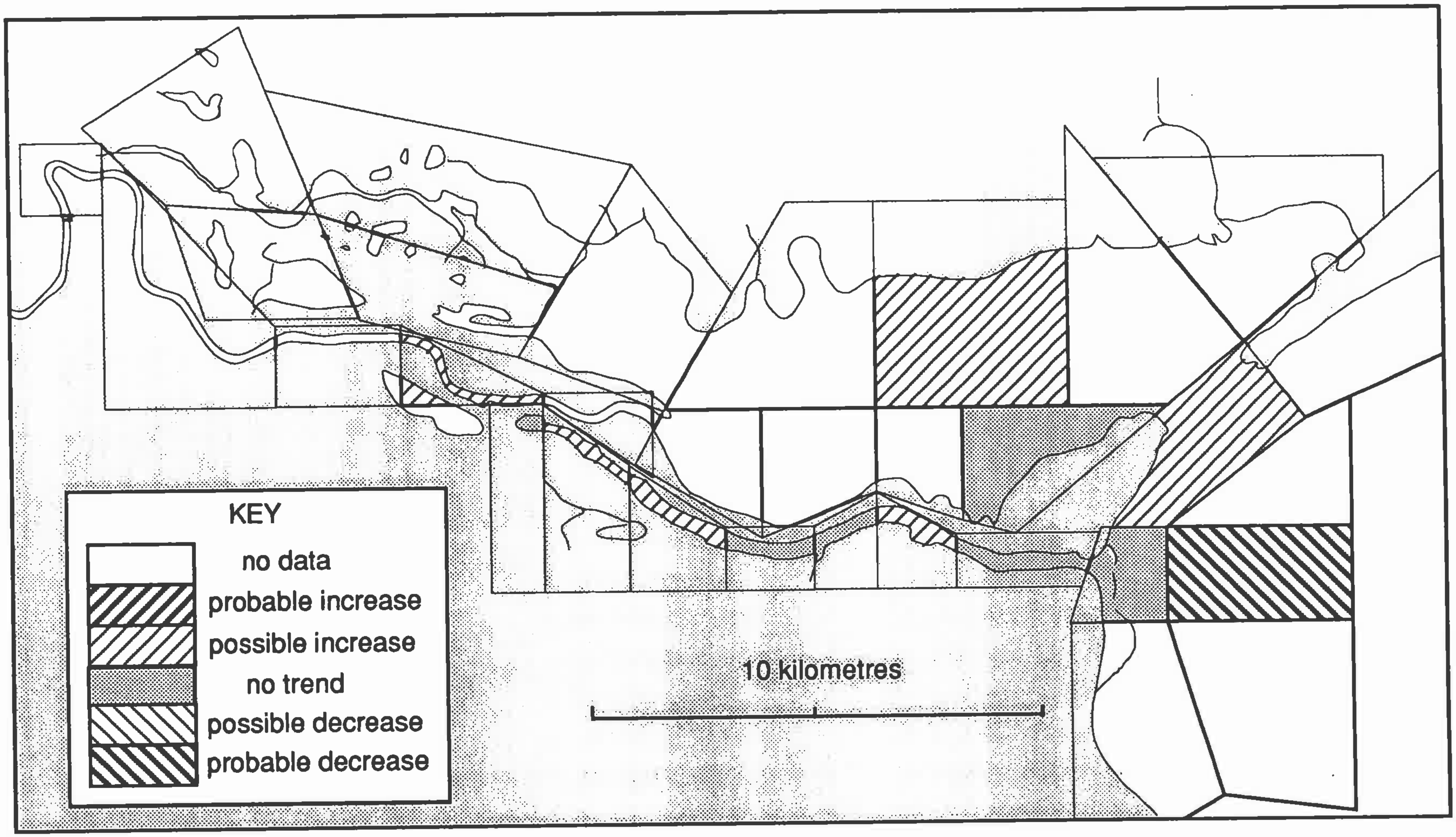


Figure 7-52. SEDO&G period-of-record time trends for Nueces Bay region, including Inner Harbor

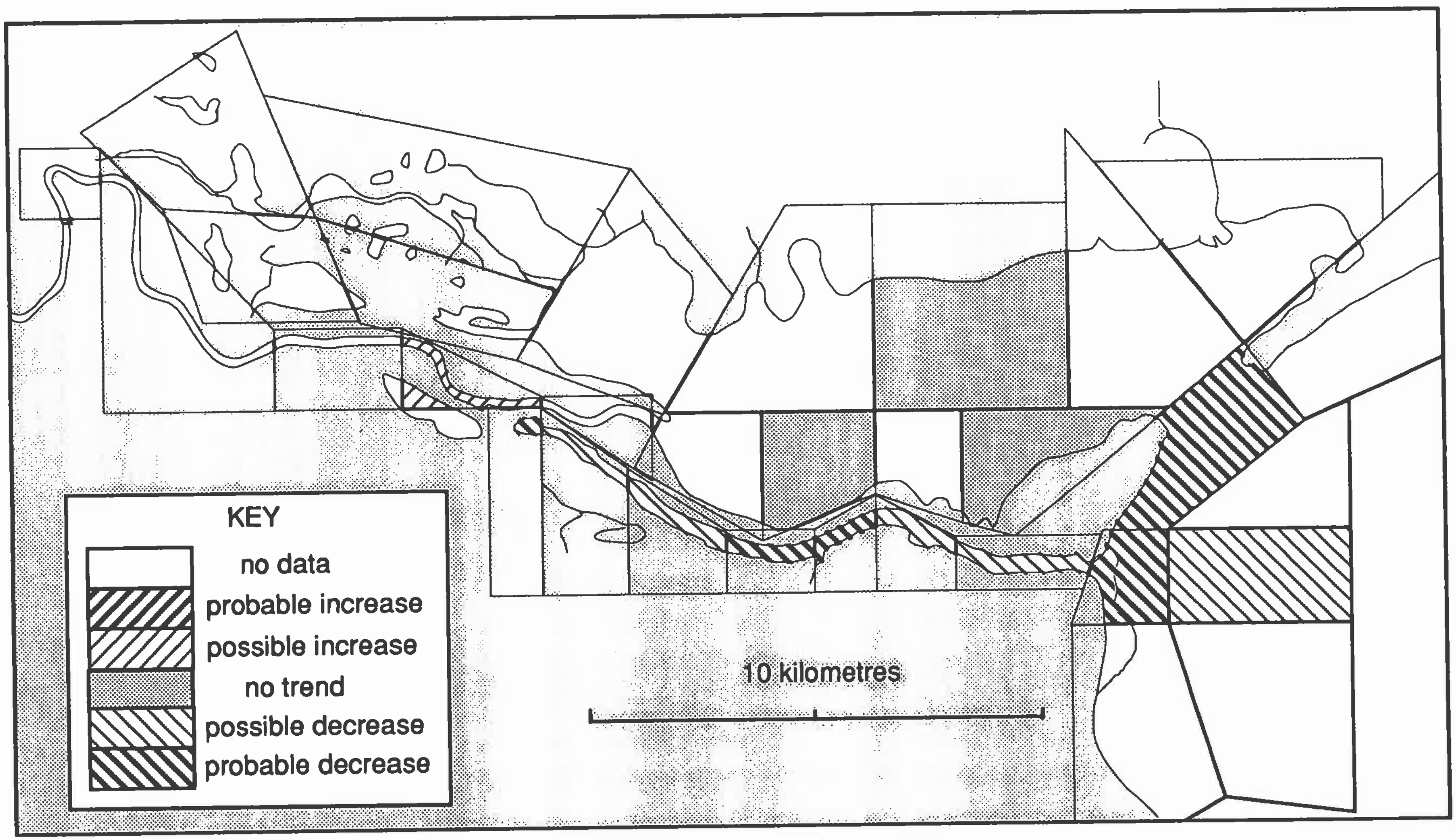


Figure 7-53. SEDMETCD period-of-record time trends for Nueces Bay region, including Inner Harbor

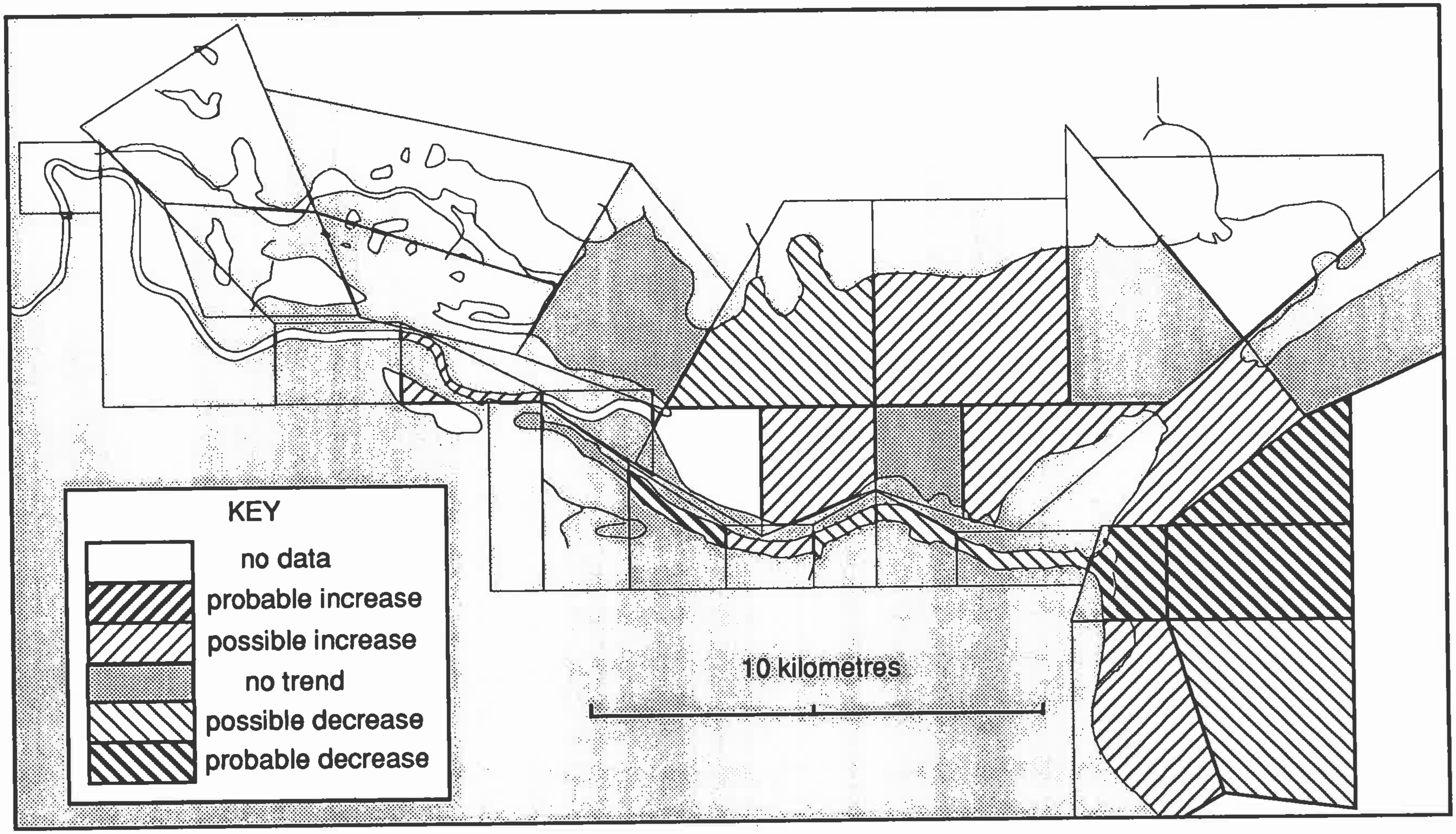


Figure 7-54. SEDMETCU period-of-record time trends for Nueces Bay region, including Inner Harbor

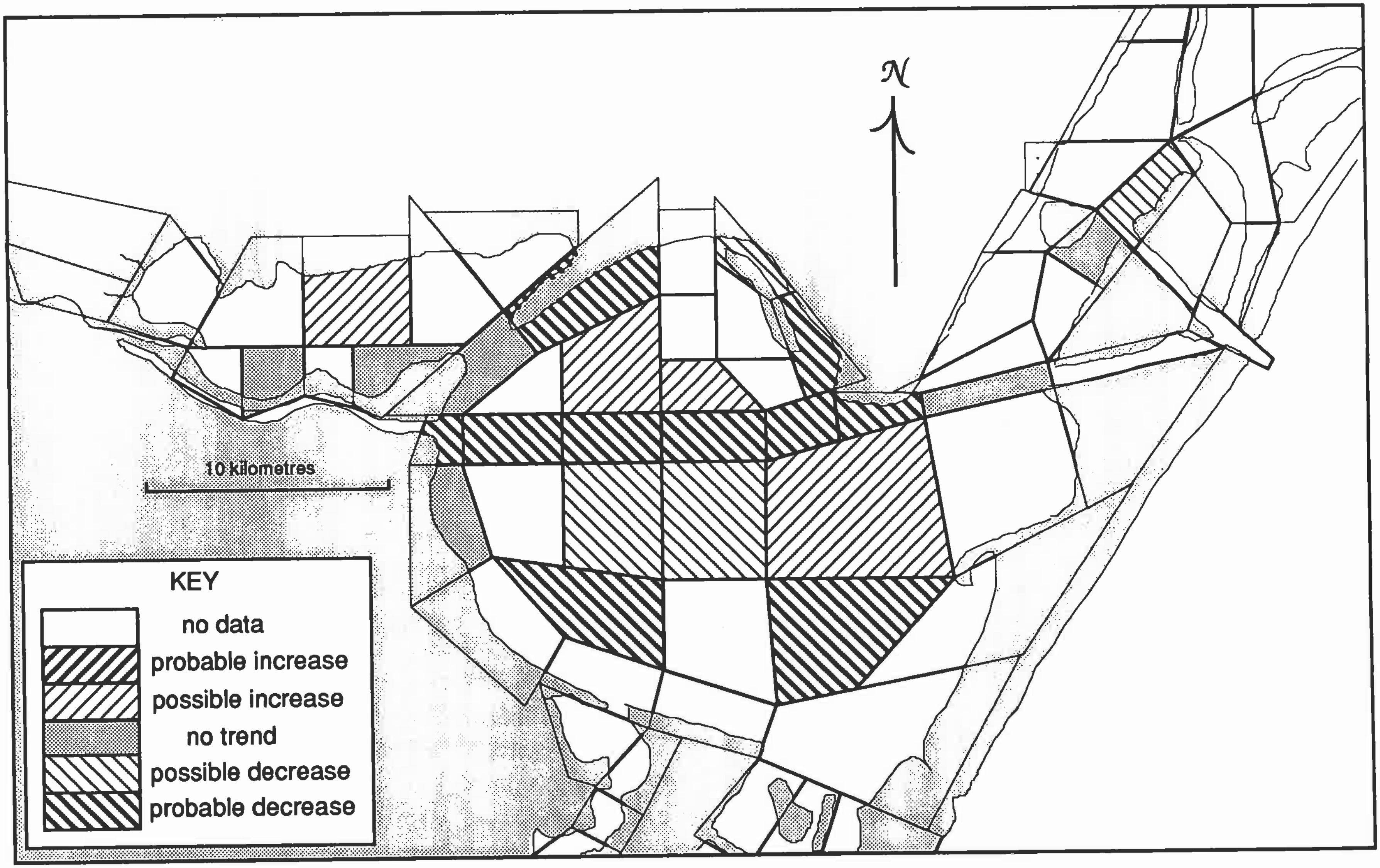


Figure 7-55. SEDMETHG period-of-record trends for Corpus Christi system

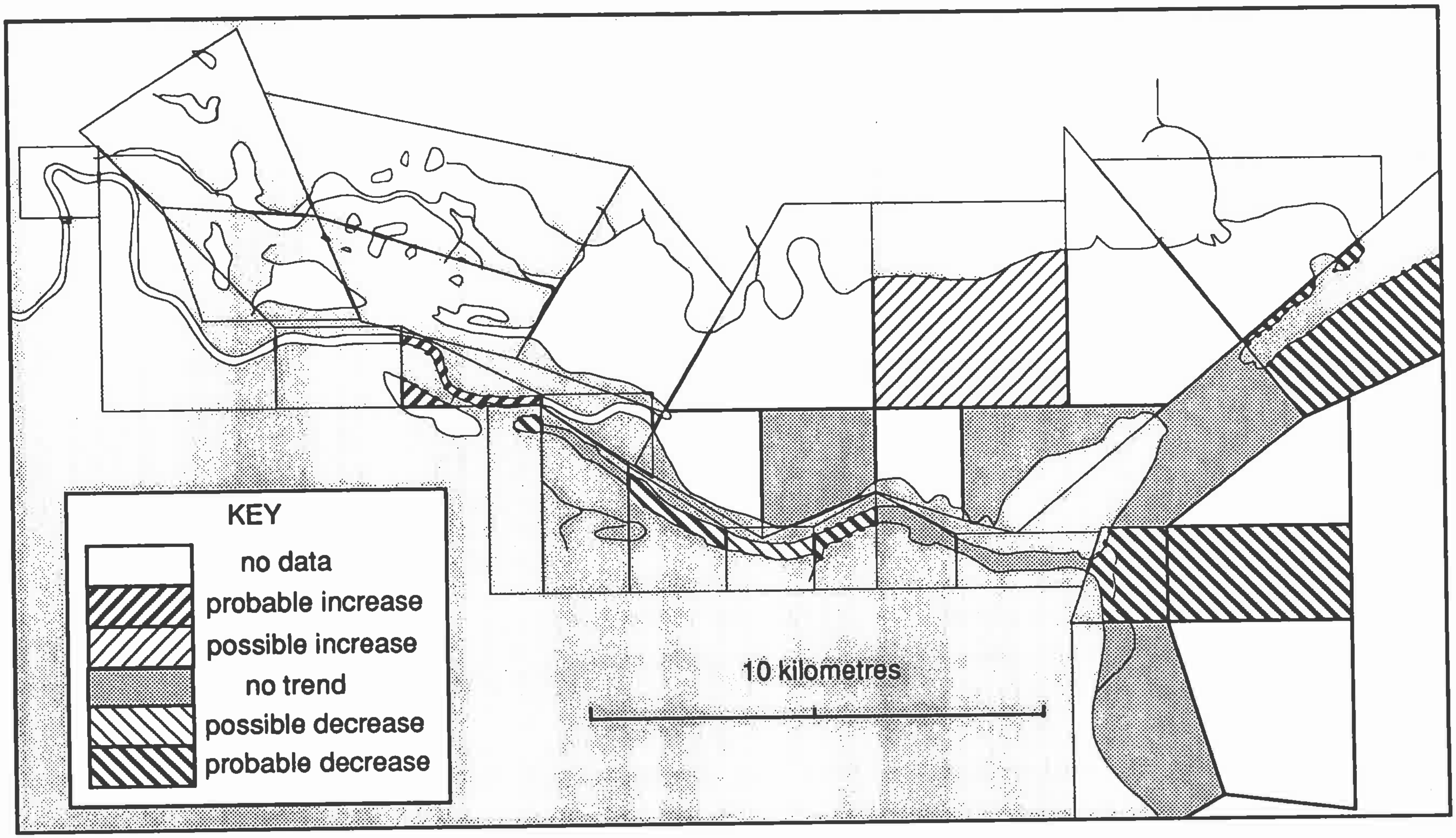


Figure 7-56. SEDMETHG period-of-record time trends for Nueces Bay region, including Inner Harbor

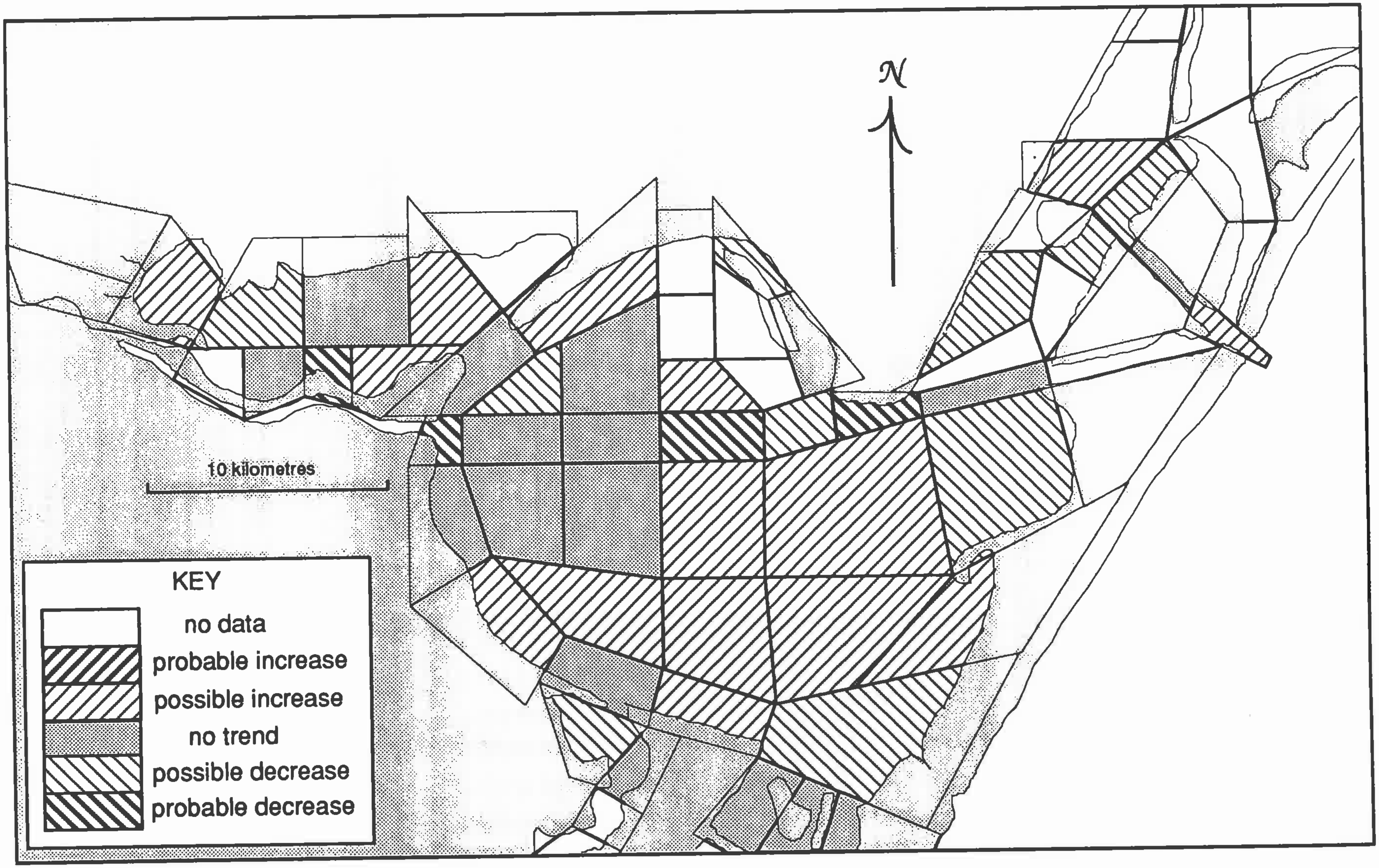


Figure 7-57. SEDMETZN period-of-record trends for Corpus Christi system

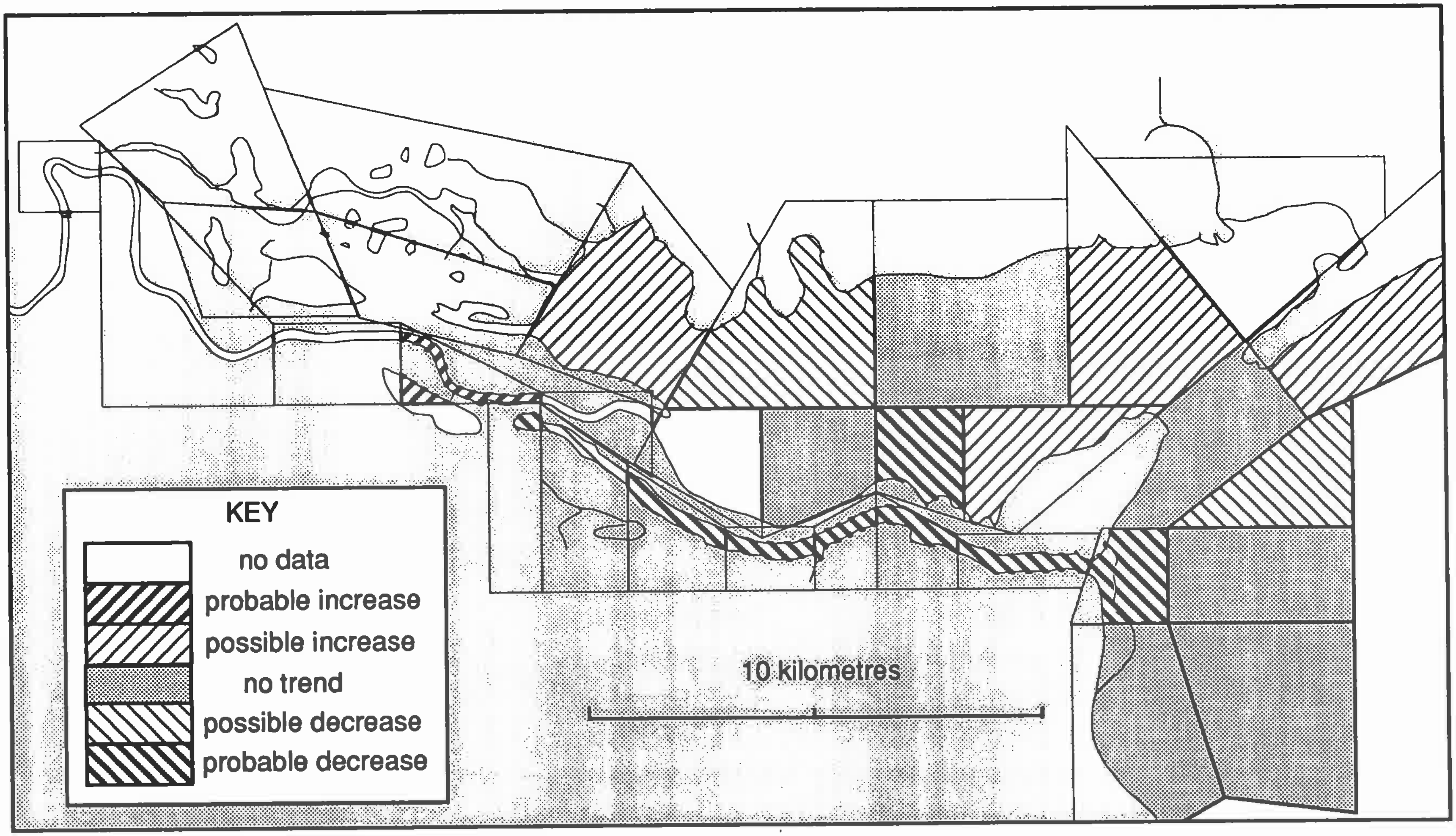


Figure 7-58 SEDMETZN period-of-record time trends for Nueces Bay region, including Inner Harbor

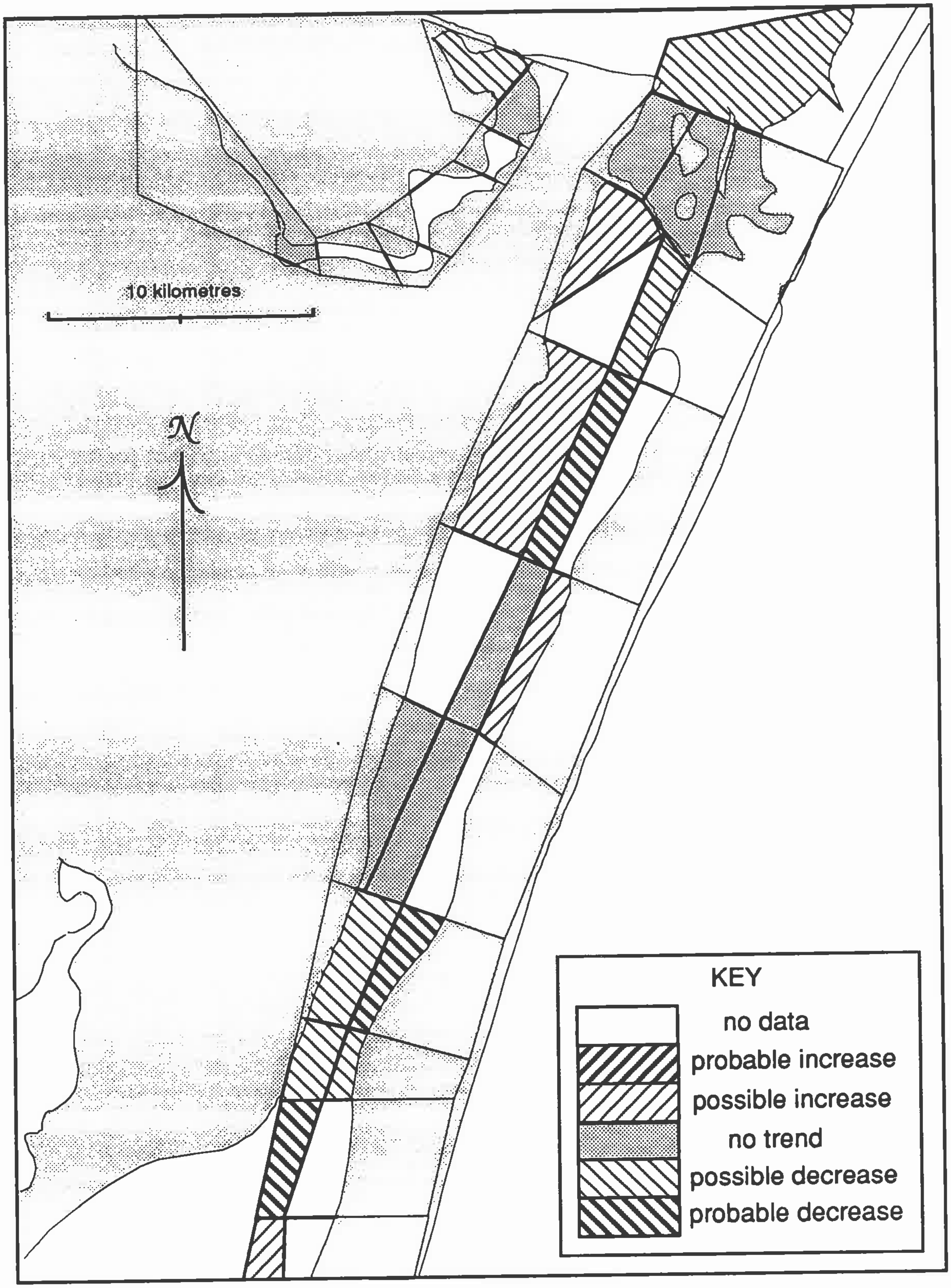


Figure 7-59. SEDMETZN period-of-record trends for Upper Laguna Madre and Oso Bay

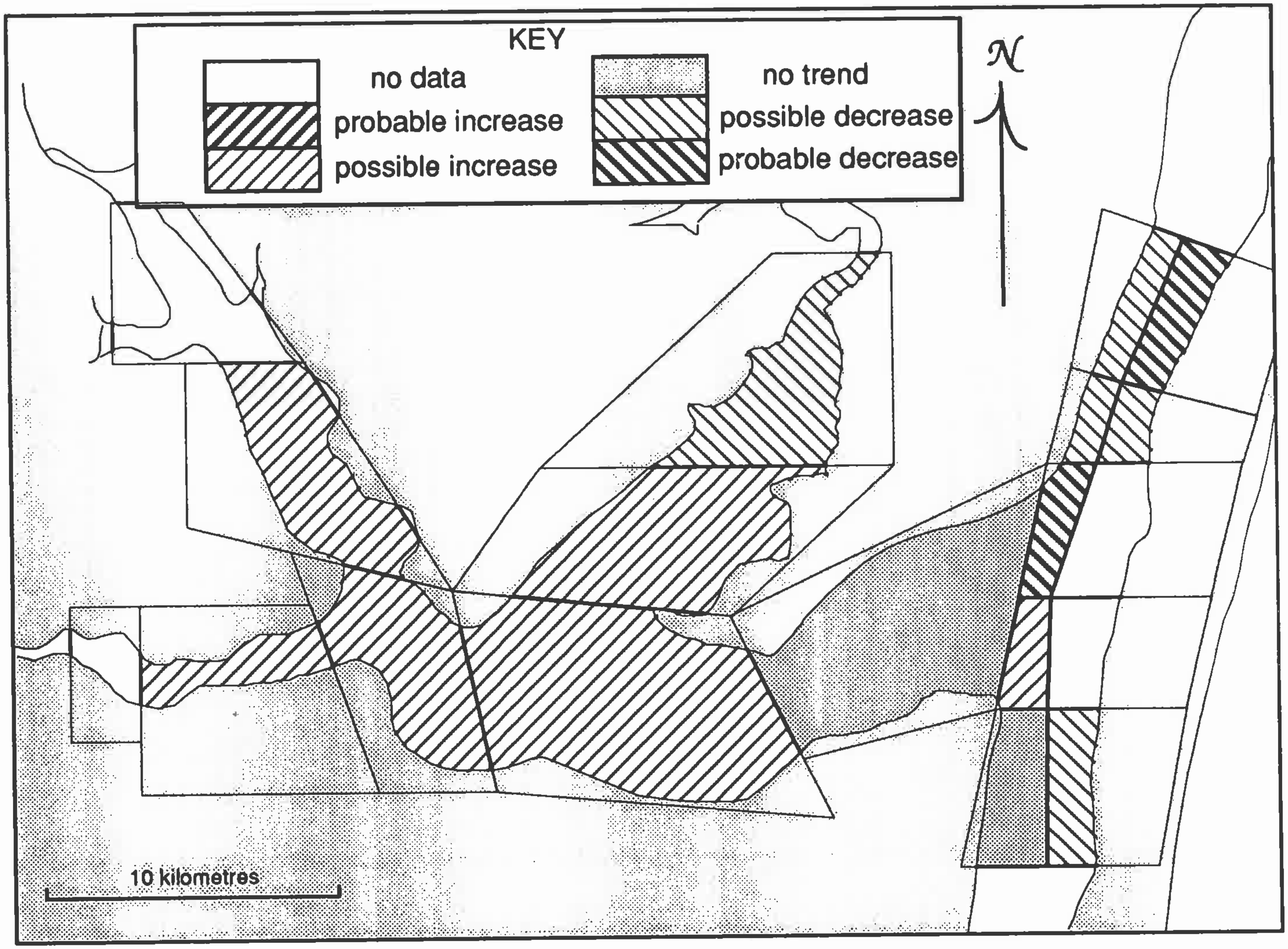


Figure7-60. SEDMETZN period-of-record time trends for Baffin Bay region

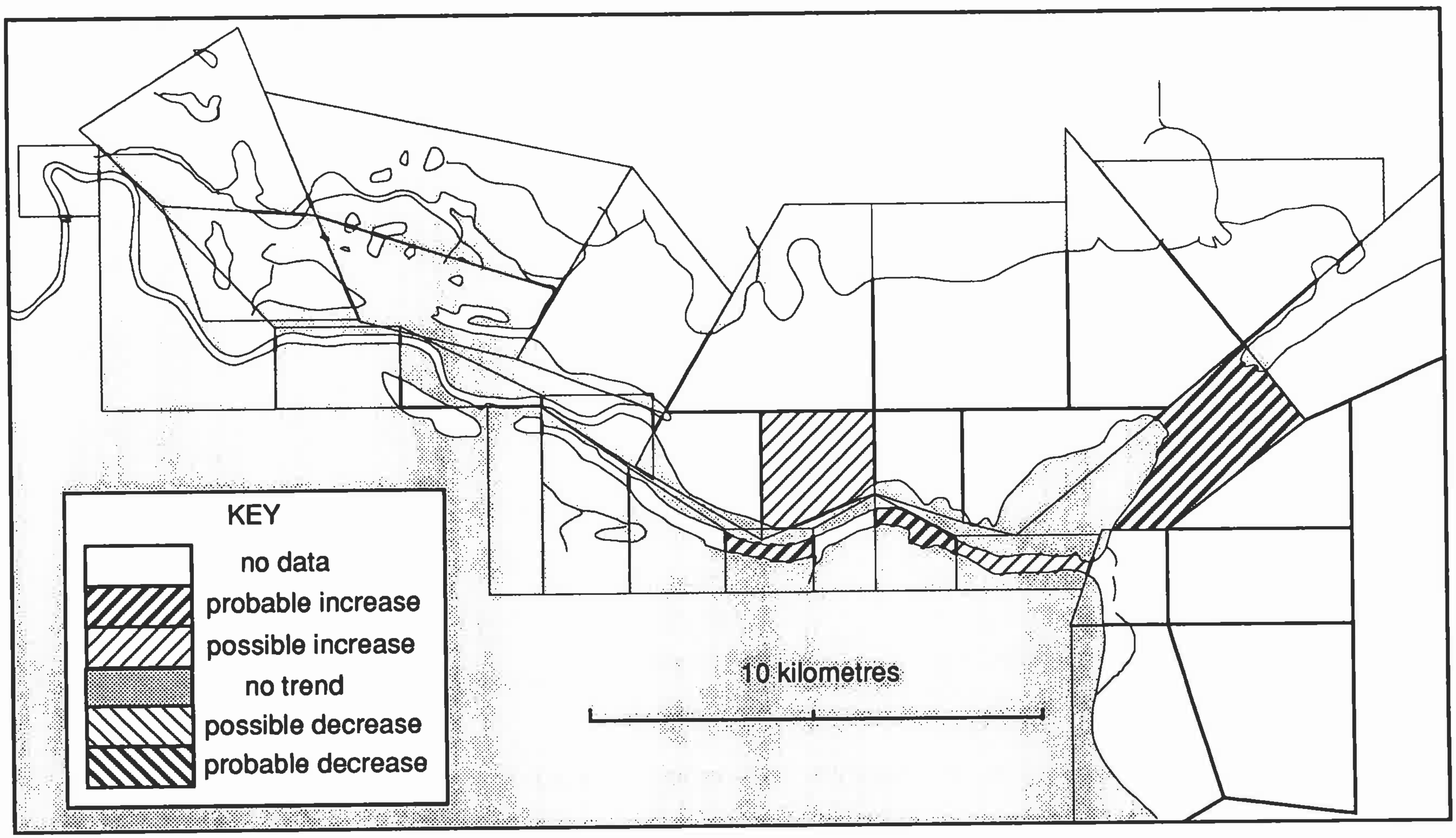


Figure 7-61. SED-BNZA period-of-record time trends for Nueces Bay region, including Inner Harbor

7.2 Observations

In one respect, the example statistical summaries of Tables 7-2 through 7-5 are misleading. This is that they give the impression that sediment data is widely available throughout the study area. In fact, among the conventional parameters, TOC (SEDTOC, Table 7-2) comprises the largest data base, and among the metals, zinc (SEDMETZN, Table 7-3) comprises the largest data base. For almost all of the other parameters, the spatial distribution of data is much sparser. For time-trend analysis, we require at least three measurements in order to perform a statistical analysis. Therefore, for those segments with only one or two measurements in the historical period of record, no time-trend results are presented. Consequently, the time-trend data are even sparser than the data for mean concentrations. The number of blank entries in Tables 7-4 and 7-5 are testimony to this. Of course, basing a time-trend inference on merely three data points in the period of record is aleatory in itself, statistical measures of confidence notwithstanding. Only if there is some degree of spatial coherence in the time-trend results do we feel justified in accepting its reality.

One would expect most of the conventional organic constituents in the sediment, e.g. total phosphorus, oil & grease, Kjeldahl nitrogen, and volatile solids, to correlate with the corresponding water analytes and to exhibit the same general pattern, particularly as elevated values in those regions loaded in waste discharges and runoff. This is not generally the case, however. Sediment ammonia (SEDAMMN) and Kjeldahl nitrogen (SEDKJLN) are systematically elevated in the Inner Harbor, Fig. 7-2, as is the corresponding water analytes. However, the highest concentrations in the system of SEDKJLN are found in Baffin Bay, Copano Bay and (especially) the King Ranch reach of the Laguna, Table 7-6, notably in Segment I12 (the same region that shows elevated water analyte values WQAMMN, see Table 6-2). For phosphorus, it will be recalled (e.g., Fig. 6-64) that there is a fairly systematic variation in the study area, with the lowest values of the water analyte in the main body of Corpus Christi and Aransas Bays, higher values in Baffin, Nueces and Copano, and the highest values in the system in the Inner Harbor. In the sediments, in contrast, there appears to be a fair degree of homogeneity throughout the study area, with somewhat *lower* values in the Inner Harbor. For TOC the contrast is even more striking. In the water column, TOC concentrations generally decrease southward across the study area in the main bays, from Copano to Baffin, see Fig. 6-66, the exceptions being depressed values in Nueces Bay, and much larger values (about an order of magnitude) in the Inner Harbor, Fig. 6-39. This is not the pattern for sediment concentrations, however. Instead, the *lowest* values of sediment TOC occur in the Inner Harbor, and the concentrations seem to *increase* southward across the study area, see Table 7-6 and Figs. 7-5 through 7-8. Nueces Bay in sediment as well as water evidences depressed values of TOC relative to the rest of the study area. Also, water- and sediment-phase TOC agree in showing higher values of the estuaries compared to the adjacent Gulf of Mexico, cf. Figs. 6-66 and 7-9. Curiously, the highest sediment concentrations of both oil & grease (SEDO&G) and volatile solids (SEDVOLS) occur in the Mesquite Bay area, Table 7-6. Recall that the GIWW segments are not included in the

Mesquite Bay definition, because they may be subject to nonrepresentative effects due to their proximity to land as well as channelization activity, so these elevated values of SEDO&G and SEDVOLS reflect only the open-water areas of this region.

For the metals, Table 7-7 and Figs. 7-14 through 7-39, the general statement can be made that the highest values, often by an order of magnitude, are found in the Inner Harbor sediments. The sole exception among the metals of Table 7-7 is nickel, for which the Inner Harbor concentrations are indeed elevated, but so also are those in the open bay areas of Corpus Christi, Baffin and Copano. This observation is in decided contrast to the case of water analytes, for which the Inner Harbor metals data is not particularly prominent, see Table 6-26. If one looks beyond the fact that the Inner Harbor dominates sediment metals, and examines the distribution in the remainder of the study area, Baffin and Copano are seen to be consistently high in metals concentrations. This is especially obvious for arsenic, cadmium, chromium, copper and nickel; it is interesting to note that this is also indicated in the water analytes of Table 6-26 (except for lead, whose concentrations in Copano are low). For specific metals, there are other regions of high concentration. Chromium is high in Corpus Christi Bay, copper in the offshore Gulf of Mexico (Fig. 7-25), mercury in Mesquite Bay, lead in Corpus Christi Bay and the Gulf of Mexico. There are also two regions of the study area that seem to have consistently elevated concentrations for most of the metals, namely Nueces Bay and the Upper Laguna, both adjacent to the Causeway and in the King Ranch reach. With respect to Nueces Bay, it should be noted that the definition of the Nueces Bay component as shown in Table 7-7 (and 6-26) excludes segment NB7 because it would not be representative of the open areas of Nueces Bay, yet this segment registers some of the highest average concentrations of metals in the system, apart from the Inner Harbor.

As was the case with water quality, the data base for complex organics is even more limited, due primarily to the small number of measurements but also because many are below detection limits (though not as great a proportion as with the water analytes). Table 7-8 summarizes the principal pesticides, as well as total PCB's. For all of the pesticides shown in this table, the highest concentrations, sometimes by an order of magnitude, are found in Baffin Bay. Almost equally high are those in Copano Bay, except for chlordane, dieldrin and DDT which are elevated nonetheless. In contrast, the concentrations of sediment pesticides in Nueces Bay are not especially high, except for toxaphene. PCB's follow a very different distribution, with very high concentrations (as expected) in the Inner Harbor, see Fig. 7-43, and with (unexpectedly) high concentrations in Redfish Bay. The high correlation of the sediment DDT in Baffin Bay (Fig. 7-42) with sediment PCB's (Fig. 7-45) raises the question of whether the latter may be an artifact due to misattribution of GC-MS peaks due to pesticides.

PAH's follow a very different distribution. First, and expectedly, the Inner Harbor dominates the concentrations of most of the PAH's, see Table 7-9. Second, there are also consistent elevated concentrations of some of the PAH compounds in Nueces Bay, Copano Bay, and Mesquite Bay. There is very little data on TBT's, and, as shown in Table 7-9, little can be said about their spatial distribution.

The paucity of good sediment records in the Corpus Christi Bay study area is especially demonstrated by the widespread lack of sufficient data to support a determination of trends. For conventional parameters, only a handful of trend results are available, as shown by Tables 7-10 through 7-14. A tendency for declining nitrogen in Corpus Christi Bay and the Inner Harbor (Table 7-10) is consistent with the declining trends determined for water-phase nitrogen (Tables 6-44 and 6-45). Similarly, the identifiable trends in sediment TOC, Table 7-12, are declining, consistent with the results for the water column, Table 6-51, cf. Fig. 7-51 and 6-104.

For metals, the data base allowing trend determinations is somewhat better than that for conventional parameters, Table 7-15 through 7-21. For the Inner Harbor, which was found to be the site of greatest metals concentrations, a probable declining trend is consistently indicated. Other trends throughout the system vary depending upon the specific metal, see Figs. 7-53 *et seq*. It is noteworthy that for Copano Bay, which shows among the highest concentrations in the study area (apart from the Inner Harbor) for chromium and nickel, also exhibits increasing probable trends for these metals, as well as for copper and zinc. Otherwise, in the principal components of the system, where a trend can be reliably established in a sediment metal it is generally declining. One exception is with sediment zinc, for which widespread *possible* increasing trends are indicated in large areas of the open waters of Corpus Christi Bay (Fig. 7-57) and Baffin Bay (Fig. 7-60). The widespread coherence in this pattern over many segments argues for attaching more importance to it than would be normally ascribed to a single segment.

On a baywide basis, little can be said about trends in organics, because the data base is so limited. Only one pesticide trend is evident, declining SED-XDDT in Copano. PCB's are highest in the Inner Harbor and do not evidence a trend, Table 7-23. BaP (SED-BNZA) is highest in the Inner Harbor and in Nueces Bay, and is trending upward in both areas, the former being a probable trend, see also Fig. 7-61.

8. TISSUE QUALITY

To include the acquisition and analysis of tissue data as a part of the present investigation has a certain logical appeal, in that most of the agencies engaged in the collection of tissue chemistry data are also those from which water/sediment chemistry data were sought, and in that some association might be expected of elevated body burdens in an organism with ambient sediment and water concentrations in the habitat of that organism. One might expect therefore that incorporating compilation and analysis of tissue data into the present project could potentially yield additional insight into the ambient environment of Corpus Christi Bay without substantially increasing or diverting the project effort. Unfortunately, both of these expectations proved false.

First, for all of the agencies that routinely acquire tissue data, that data is managed differently from the water and sediment chemistry data. Therefore, these data sets required special handling different from that of the water or sediment data. Second, for a specific chemical parameter, there is a greater range in what is measured and how it is reported in the tissue phase compared to water or sediment, and there is a corresponding lack of consistency among agencies (and sometimes within the same agency). This aggravated the compilation problems, and led to lack of intercomparability from data source to data source, and therefore a reduction in statistical inference power. This chapter summarizes this part of the effort and its results. Because this data proved to be sparse, noncomparable, and generally inconclusive—in short, more trouble than it was worth—this chapter is brief. Reference is made, however, to a companion CCBNEP report by Jensen et al. (1996) that uses these data to evaluate public health risks.

8.1 Tissue Data and its Compilation

Tissue body burden of a specific chemical or element is determined by first acquiring an organism from the estuary, excising a portion of that organism, mechanically homogenizing the excised portion, and performing a chemical analysis using generally the same protocols and analytical methodologies (see Section 2.6) as employed in a sediment or solids sample. The ultimate purpose of such analyses may be either (1) to determine flux of specific compounds or elements through the food chain; (2) to establish whether there is a public health risk entailed by consumption of that organism. Which objective is intending informs the entire procedure, from the initial organism to be sampled to the compounds chosen for analysis and how the results are presented. All of this entails a great range of variation in the nature of the data. Options are:

- element or chemical compound for analysis

- selection of organism:
  - one individual
  - multiple individuals
    - same species
    - various species

- organism portion to be analyzed:
  - whole organism
  - specific organ
  - edible portions ("filet")

- reporting convention:
  - wet-weight concentration
  - dry-weight concentration

There were no instances encountered in this compilation of analyses performed on specific organs, such as livers. Our data fell into the categories of either whole-organism or edible-portions ("filet"). For oysters, the two are equivalent: there was no instance encountered in which analyses was reported on an entire oyster, shell and all. There were a few instances (in the TNRCC SMN data base) in which tissue data were reported based upon a composite (probably a purée) of individuals of more than one species (the names of which were not noted). These data were not used in the present compilation. However, a scattering of analyses of more than one individual of the same species were reported, and were included in the compilation.

A wide range of chemical parameters were encountered. At the outset, we retained data for all of the chemical parameters in the data compilation, though it was clear that for most of them, the data resource was going to be too small to permit any reliable statistical analysis, particularly when further stratified in space and time. At a later stage, data sets that were simply too small to treat (i.e. one isolated measurement) were deleted. The exception was PCB's, in that we did not retain the individual PCB analyses, because there were too many that were non-interconvertible (reported by congenor number in some cases, Aroclor identifiers in others, and level of chlorination in yet other cases), instead retaining only the total-PCB determination. Table A-3 in the Appendix presents the complete list of chemical parameters retained in the tissue compilation.

For each chemical analyte, it is necessary to differentiate the organism sampled, whether the analysis was carried for the whole organism or filets, and whether the data is reported on a dry- or wet-weight basis. It should be noted that data from different organisms is fundamentally noncomparable. Accumulation of a compound in organism tissue is dependent upon the metabolism of the species, internal chemical transformation of the compound, activity of the species in a region of contamination, its activity in regions of noncontamination, its food sources and their respective exposures. Similarly, the concentration in the whole organism is fundamentally noncomparable to that in only the edible portion. The only two categories offering, in principle, a possibility of comparability are the wet-weight versus dry-weight reporting. These can be interconverted only if separate reporting is made of the moisture content of the tissue sample. Incredibly, most of the agencies providing tissue data do not report (and apparently do not analyze) tissue moisture content.

The same basic data structure was employed in the master data base compilation of tissue data as used for water and sediment quality, as described in Section 4.1 above, and the processing steps were basically the same as presented in Section 4.2. As with water and sediment parameters, the parameter is given a unique abbreviation used in tabular output and in the naming of data files. These are given in Table A-3 in the Appendix. We differentiated between dry-weight and wet-weight data, and between whole-organism and filet analyses by the leading characters in the parameter name. The general format for tissue parameter abbreviations is:

TXparam

All tissue data parameters begin with the letter "T." The second character X is one of:

S - whole-organism, wet weight
F - filet (edible portions only), wet weight
D - filet, dry weight

The remainder of the name "param" is either made up of the prefix "MET" followed by the (1-2 character) chemical abbreviation for the element, in the case of elemental analyses, or a hyphen followed by the compound abbreviation, in the case of volatile organic compounds. For example, TF-DDT represents the wet-weight concentration of total DDT in the edible tissue of an organism. No data were encountered of whole organism concentrations in dry weight so no separate identifier was necessary. (Actually, the USF&WS did report such data, but also provided proportion of moisture, so the results could be converted to wet-weight.)

The same basic data-record format was the same as for water and sediment data, see Section 4.3. That is, each data entry represents a point in time (to resolution of a day) and space (horizontal position), together with the measurement of parameter concentration, in a 50-byte record. The format of each record in the Derivative Data Files is:

DATE LATITUDE LONGITUDE ORG MEASRMT UNCRNTY PRJ

where DATE, LATITUDE AND LONGITUDE are 6-digit fields (YRMODA and the latitude/longitude coordinates are degrees/minutes/seconds), the sample depth is in meters, and MEASRMT is the measured value of the parameter (retaining three significant figures). The place for measurement uncertainty UNCRNTY is held in the record, to be consistent with the water/sediment data format, but separate establishment of appropriate uncertainties for the parameters in the tissue data set was beyond the scope of this effort. The most important difference between the tissue data records and those of the water/sediment data is that the depth field is replaced by an "organism field." Clearly, the depth from which an organism is captured is totally meaningless as any sort of explanatory or analytical variable (even if it were reported, which it is not). Therefore, this field is used to contain a code uniquely identifying the organism.

Organisms were identified by a two-digit code, presented in Table 8-1. It should be noted that some sampling agencies reported only a "common" name, without speciation. When we were confident of the species (e.g., blue crab or pink shrimp), the specific name was supplied, even if the sampling agency did not. In some cases, such as code 02 or 21, we have no idea.

A number of anomalies were encountered in the management of tissue data. These are detailed in the individual data-source reports in the accompanying report on the CCBNEP data base (Ward and Armstrong, 1997a), but it is useful to mention these here to give some indication of the effort necessary to put this data in a usable form. Probably, the two most important sources for tissue data were the TNRCC Statewide Monitoring Network and the Texas Department of Health, since both of these agencies have collected this sort of data for a number of years in the system. Other data sources included the OXYCHEM project in and around the La Quinta Channel, the Corps of Engineers, the NOS Status & Trends and Mussel Watch projects, and the EPA EMAP/REMAP project. Both of the last two federal projects maintain their tissue data in files in a completely different format than the water/sediment data, requiring separate retrievals and *ad hoc* de-coding and processing routines. Both the Corps and the OXYCHEM project had information in hardcopy only, that required manual keyboarding.

The entirety of the available tissue data from the TDH has been compiled into a hardcopy report. Despite the fact that this entailed a substantial keyboarding effort, there is no magnetic version of this data base. Therefore, this project had to manually keyboard the information from the hardcopy report (Ward and Armstrong, 1997a). Location of the organism collection site is given by state tract number. Each of these had to be individually identified and located on a map. A probable collection site, for which latitude/longitude were determined, was then assigned as the centroid of open water for fish and shrimp organisms, or the centroid of major reefs in the tract for oysters. Another problem encountered was the fact that only organic compounds above detection limits were reported in the TDH data. From the public-health viewpoint, this is appropriate. For the purposes of a status & trends analysis, however, the nondetects are of equal importance and need to be included in the data base. Unfortunately, several different suites of compounds are analyzed by TDH, and no records could be provided as to which were applied to a given sample. We finally elected to assume the minimum suite of analytes for all such analyses (see Ward and Armstrong, 1997a).

For the TNRCC tissue data, the greatest impediment to compiling the data is that no organism information is included in the TNRCC computer data base. That is, the date, station, analytes and measured concentrations for a tissue analysis are input into the system and could be retrieved for the present data compilation. But the species was not identified. Ultimately, this information had to be individually

Table 8-1
CODES FOR TISSUE ORGANISMS

Code	Common name	Specific name
00	unknown	no information provided
01	southern flounder	*Paralichthys lethostigma*
02	fin perch	unknown
03	speckled trout	
04	American oyster	*Crassostrea virginica*
05	hardhead catfish	*Arius felis*
06	gafftopsail catfish	*Bagre marinus*
07	Atlantic croaker	*Micropogonias undulatus*
08	brown shrimp	*Penaeus aztecus*
09	penaeid shrimp (undiff.)	*Penaeus spp.*
10	blue crab	*Callinectes sapidus*
11	toadfish	*Opsanus beta*
12	calico crab	*Eriphia gonagra*
13	shoalgrass	*Halodule wrightii*
14	sheepshead	*Archosargus probatocephalus*
15	black drum	*Pogonias cromis*
16	red drum (redfish)	*Sciaenops ocellatus*
17	clam	*Mercenaria*
18	menhaden	*Brevoortia patronus*
19	whiting	
20	white shrimp	*Penaeus setiferus*
21	sea catfish	
22	ladyfish	
23	alligator gar	
24	carp	*Cyprinus carpio*
25	pinfish	*Lagodon rhombiodes*
26	tarpon	*Megalops atlantica*
27	spot croaker (spot)	*Leistomus xanthurus*
28	mullet	*Mugil spp.*
29	stone crab	
30	Spanish mackerel	
31	pigfish	
32	longnose killifish	*Fundulus similis*
33	perch	unknown
34	spotted seatrout	*Cynoscion nebulosus*

determined by looking up the tag data for each tissue sample and manually entering the organism data into our data base. Even with this effort, for a significant proportion of the SMN tissue data the organism could not be identified. This information was retained in the present data base, though little use could be made of it in this analysis. This is the reason for the code 00 in Table 8-1. Additional information on problems and processing of all of the tissue data is given for the separate projects in Ward and Armstrong (1997a).

8.2 Data Base for Tissue in Corpus Christi Bay

All told, there are 8201 individual records of tissue/analyte/date/location from the Corpus Christi Bay study area, encompassing the period from 1977 to 1994. At first glance this might appear to be a workable amount of data, until one considers that it is divided among approximately 100 individual analytes, 34 individual species (including the no-information species), and one of the three noncomparable categories whole-organism wet-weight, filet wet-weight or filet dry-weight. A census of the data holdings by chemical parameter abbreviation (which separates whole organism, filet wet-weight and filet dry-weight) subdivided by the eleven primary organisms is given in Table 8-2. For the purpose of this census the primary organisms and their respective codes are taken to be:

southern flounder	01	black drum	15
speckled trout	03	red drum (redfish)	16
American oyster	04	white shrimp	20
brown shrimp	08	spot croaker (spot)	27
blue crab	10	spotted seatrout	34
sheepshead	14		

which arguably neglects the extensive toadfish and gar fisheries of the bay. Table 8-3 presents exactly the same information except with the census limited to the measurements above detection limits (and the parameters deleted for which no detectable concentrations occur in the data base). An inspection of Tables 8-2 and 8-3 discloses the following:

- By far, the greatest quantity of data has been taken for the metals analytes.
- The most-sampled organism is the American oyster, followed by the blue crab, followed by speckled trout, red drum and black drum.
- Brown shrimp and white shrimp, relatively speaking, are rarely sampled. One sample of each appears in the data base.
- Among the organics, the greatest data base is that of the pesticides, especially the common commercial mixtures such as chlordane and toxaphene, and that of PCB's.
- Most of the organics in the suite of analytes have never been detected in the tissues of organisms.
- The data base of detected PAH's and related hydrocarbons is negligible. For only a few, such as pyrene, have there been detects logged in the data.

The last observation may be as much due to bias in the sampling as to low concentrations, in that PAH's are analyzed about 1/15 times as often as pesticides.

The one organism for which whole-body and edible portions are equivalent is the oyster, since all of the sampling agencies involved here shuck the organism and analyze a blend of the meat and liquor. Moreover, there seems to be relative consistency in the moisture content of oysters, around 85% (R. Presley, TAMU, pers. comm. 1996; P. Jensen, EH&A, pers. comm. 1996). The one source of data including moisture determinations available to this project was that of the U.S. Fish & Wildlife Service (Corpus Christi Bay contaminants study), whose data for oysters show a mean moisture content of 84.5% with a standard deviation of 1.2% (see Project 27 in Ward and Armstrong, 1997a). With this relation, the data for oysters could be combined into one proxy data set of equivalent wet-weight concentrations, identified by the abbreviation prefix TO.

The above census is, of course, without regard to geographical distribution in the system. Figures 8-1 and 8-2 display the sites from which oysters for tissue analysis have been taken. Clearly, the majority of the data are from Nueces Bay and Aransas Bay. Even at that, the spatial dense is sparse. (There are no oyster sites in the Laguna or Baffin systems.) The next-best-sampled organism, blue crab, is depicted in Figs. 8-3 through 8-6. The blue crab is more ubiquitous than the oyster, and the samples are better distributed through the study area, but even at this the sampling density is low. For the other organisms, the sampling distributions through the study area are even sparser. Because of this low sampling density there was little merit in the sorting by hydrographic areas, since the vast majority of the segments will contain either 0 or 1 sample. Accordingly, the statistical analyses were limited to distribution by TNRCC segment.

The same protocols for data handling were observed for the tissue data as outlined in Chapter 4, except, as noted above, that sorting into hydrographic areas was deemed unnecessary, and that no screening for aberrant values was performed, both because the data are so sparse. Tables 8-4 and 8-5 present summary statistics for the entire aggregated study area, composited across all organisms, for the principal metals and organic analytes. The validity of a composite data base irrespective of the species is highly questionable, because the tissue concentrations will depend upon geographical exposure and the metabolism of each species. Some, like many finfish and shrimp, move large distances through the system, as well as through the nearshore Gulf, while others are territorial, like the black drum, and still others are sessile, like oysters. Some, like filter feeders and some top carnivores, will exhibit a greater degree of concentration, than others. On the other hand, some readers may wish a general indication of relative elevations of individual analytes in the study area, which would be provided by these tables.

Many of the same remarks concerning the water/sediment data, made in Chapter 5, apply as well to the tissue data, including the concerns with data management. Most of these do not warrant repeating here. However, it is worth pointing out that the first causative factor compromising the integrity of modern data bases discussed in Section 5.3.2, of poor data recovery procedures, is particularly painful with respect to tissue data. One of the more valuable data sets on tissue in the study area is the USF&WS contaminants project in the late 1980's (Barrera, et al., 1995), in which 37 sites from Baffin Bay and the Upper Laguna to Redfish Bay were sampled for biota, and tissue analyses performed for an extensive suite of metals and organics. Due apparently to a data-transfer bug, *all* of the organic analyses for the tissue samples were inadvertently deleted from the archival digital files attached to the report in diskettes. USF&WS advises that the only way to recover the lost data would be to go back to the raw lab sheets and completely re-keyboard them. Therefore, this valuable, comprehensive set of recent tissue data is not included in the present compilation.

Table 8-2
Census of tissue data holdings for principal organism codes
Organism codes defined in Table 8-1
Parameter codes defined in Table A-3 of Appendix

parameter:	organism codes: 1	3	4	8	10	14	15	16	20	27	34	all organisms
TDMETAG	0	0	81	0	0	0	0	0	0	0	0	81
TDMETAS	0	0	101	0	0	0	0	0	0	0	0	101
TDMETCD	0	0	101	0	0	0	0	0	0	0	0	101
TDMETCR	0	0	81	0	0	0	0	0	0	0	0	81
TDMETCU	0	0	101	0	0	0	0	0	0	0	0	101
TDMETHG	0	0	101	0	0	0	0	0	0	0	0	101
TDMETNI	0	0	101	0	0	0	0	0	0	0	0	101
TDMETPB	0	0	101	0	0	0	0	0	0	0	0	101
TDMETSE	0	0	101	0	0	0	0	0	0	0	0	101
TDMETZN	0	0	101	0	0	0	0	0	0	0	0	101
TD-ACEN	0	0	101	0	0	0	0	0	0	0	0	101
TD-ACENY	0	0	101	0	0	0	0	0	0	0	0	101
TD-ALDR	0	0	101	0	0	0	0	0	0	0	0	101
TD-BNZA	0	0	101	0	0	0	0	0	0	0	0	101
TD-CHRY	0	0	101	0	0	0	0	0	0	0	0	101
TD-DIEL	0	0	101	0	0	0	0	0	0	0	0	101
TD-ENDR	0	0	101	0	0	0	0	0	0	0	0	101
TD-FLRA	0	0	101	0	0	0	0	0	0	0	0	101
TD-FLRN	0	0	101	0	0	0	0	0	0	0	0	101
TD-HEPT	0	0	101	0	0	0	0	0	0	0	0	101
TD-HEPX	0	0	101	0	0	0	0	0	0	0	0	101
TD-LIND	0	0	101	0	0	0	0	0	0	0	0	101
TD-NAPT	0	0	101	0	0	0	0	0	0	0	0	101
TD-PDDD	0	0	101	0	0	0	0	0	0	0	0	101
TD-PDDE	0	0	101	0	0	0	0	0	0	0	0	101
TD-PDDT	0	0	101	0	0	0	0	0	0	0	0	101
TFMETAG	0	0	0	1	0	0	0	0	0	0	0	20
TFMETAS	1	7	12	1	14	3	19	12	0	0	0	89
TFMETCD	4	34	39	1	35	5	25	21	0	0	0	190
TFMETCR	0	0	0	1	0	0	0	0	0	0	0	20
TFMETCU	4	34	39	1	35	5	25	21	0	0	0	190
TFMETHG	4	35	39	1	35	5	24	21	0	0	0	190
TFMETNI	0	0	0	1	0	0	0	0	0	0	0	20
TFMETPB	4	34	39	1	35	5	25	21	0	0	0	190
TFMETZN	4	33	39	1	35	5	25	21	0	0	0	189
TF-ABHC	3	14	24	0	22	2	15	13	0	0	0	96

(continued)

Table 8-2
Census of tissue data holdings for principal organism codes
(continued)

parameter:	*1*	*3*	*4*	*8*	*10*	*14*	*15*	*16*	*20*	*27*	*34*	*all organisms*
					organism codes:							
TF-ACEN	0	0	6	0	0	0	0	0	0	0	0	6
TF-ACENA	0	0	6	0	0	0	0	0	0	0	0	6
TF-ALDR	3	14	24	1	22	2	15	13	0	0	0	113
TF-ANTHR	0	0	6	0	0	0	0	0	0	0	0	6
TF-BNZA	0	0	6	0	0	0	0	0	0	0	0	6
TF-BNZB	0	0	6	0	0	0	0	0	0	0	0	6
TF-BNZE	0	0	6	0	0	0	0	0	0	0	0	6
TF-BNZGP	0	0	6	0	0	0	0	0	0	0	0	6
TF-BNZK	0	0	6	0	0	0	0	0	0	0	0	6
TF-CHLR	3	14	24	0	22	2	15	13	0	0	0	96
TF-CHRYS	0	0	6	0	0	0	0	0	0	0	0	6
TF-DBANE	0	0	6	0	0	0	0	0	0	0	0	6
TF-DDD	3	14	24	0	22	2	15	13	0	0	0	96
TF-DDE	3	14	24	0	22	2	15	13	0	0	0	96
TF-DDT	3	14	24	0	22	2	15	13	0	0	0	109
TF-DIEL	3	14	24	1	22	2	15	13	0	0	0	113
TF-ENDO	3	14	24	0	22	2	15	13	0	0	0	96
TF-ENDR	3	14	24	1	22	2	15	13	0	0	0	113
TF-FLRA	0	0	6	0	0	0	0	0	0	0	0	6
TF-FLRN	0	0	6	0	0	0	0	0	0	0	0	6
TF-HEPT	3	14	24	1	22	2	15	13	0	0	0	113
TF-HEPX	3	14	24	1	22	2	15	13	0	0	0	113
TF-HEXA	0	0	6	0	0	0	0	0	0	0	0	6
TF-I123P	0	0	6	0	0	0	0	0	0	0	0	6
TF-LIND	3	14	24	1	22	2	15	13	0	0	0	113
TF-MTHX	3	14	24	0	22	2	15	13	0	0	0	96
TF-NAPT	0	0	6	0	0	0	0	0	0	0	0	6
TF-PCB	3	14	24	1	22	2	15	13	0	0	0	109
TF-PDDD	0	0	0	1	0	0	0	0	0	0	0	17
TF-PDDE	0	0	0	1	0	0	0	0	0	0	0	17
TF-PDDT	0	0	0	1	0	0	0	0	0	0	0	17
TF-PHNAN	0	0	6	0	0	0	0	0	0	0	0	6
TF-PYRN	0	0	6	0	0	0	0	0	0	0	0	6
TF-TOXA	3	14	24	1	22	2	15	13	0	0	0	113
TSMETAG	1	1	4	0	33	0	0	0	0	0	0	83
TSMETAS	1	1	5	0	53	0	1	0	1	2	0	140
TSMETCD	1	1	5	0	53	0	1	0	1	2	0	140

(continued)

Table 8-2
Census of tissue data holdings for principal organism codes
(continued)

parameter:	1	3	4	8	10	14	15	16	20	27	34	all organisms
	organism codes:											
TSMETCR	1	1	5	0	53	0	1	0	1	2	0	140
TSMETCU	1	1	5	0	53	0	1	0	1	2	0	140
TSMETHG	1	1	5	0	53	0	1	0	1	2	0	140
TSMETNI	1	1	4	0	51	0	0	0	0	0	0	101
TSMETPB	1	1	5	0	53	0	1	0	1	2	0	140
TSMETSE	0	0	4	0	33	0	0	0	0	0	0	95
TSMETZN	1	1	4	0	51	0	0	0	0	0	0	101
TS-124TC	0	0	0	0	0	0	0	0	0	0	0	7
TS-12DCB	0	0	0	0	0	0	0	0	0	0	0	7
TS-12DPH	0	0	0	0	0	0	0	0	0	0	0	7
TS-13DCB	0	0	0	0	0	0	0	0	0	0	0	7
TS-14DCB	0	0	0	0	0	0	0	0	0	0	0	7
TS-246TC	0	0	0	0	0	0	0	0	0	0	0	7
TS-24DCP	0	0	0	0	0	0	0	0	0	0	0	7
TS-24DMP	0	0	0	0	0	0	0	0	0	0	0	7
TS-24DNH	0	0	0	0	0	0	0	0	0	0	0	7
TS-24DNT	0	0	0	0	0	0	0	0	0	0	0	7
TS-26DNC	0	0	0	0	0	0	0	0	0	0	0	7
TS-26DNT	0	0	0	0	0	0	0	0	0	0	0	7
TS-2CLNP	0	0	0	0	0	0	0	0	0	0	0	7
TS-2NIPH	0	0	0	0	0	0	0	0	0	0	0	7
TS-33DCB	0	0	0	0	0	0	0	0	0	0	0	7
TS-3PCM	0	0	0	0	0	0	0	0	0	0	0	1
TS-4BRPE	0	0	0	0	0	0	0	0	0	0	0	7
TS-4C34	0	0	0	0	0	0	0	0	0	0	0	7
TS-4CLPE	0	0	0	0	0	0	0	0	0	0	0	7
TS-ABHC	1	1	0	0	2	0	0	0	0	2	1	32
TS-ACEN	1	1	0	0	18	0	0	0	0	0	0	28
TS-ACENA	1	1	0	0	0	0	0	0	0	0	0	10
TS-ALDR	1	1	0	0	20	0	0	0	0	2	1	60
TS-ANTHR	1	1	0	0	18	0	0	0	0	0	0	28
TS-B2CE	0	0	0	0	0	0	0	0	0	0	0	7
TS-B2CEN	0	0	0	0	0	0	0	0	0	0	0	7
TS-B2CM	0	0	0	0	0	0	0	0	0	0	0	7
TS-B2EPH	0	0	0	0	0	0	0	0	0	0	0	7
TS-BBHC	0	0	0	0	0	0	0	0	0	0	0	7
TS-BNZA	1	1	0	0	18	0	0	0	0	0	0	28
TS-BNZAA	0	0	0	0	0	0	0	0	0	0	0	7

(continued)

Table 8-2
Census of tissue data holdings for principal organism codes
(continued)

parameter:	organism codes: 1	3	4	8	10	14	15	16	20	27	34	all organisms
TS-BNZDE	0	0	0	0	0	0	0	0	0	0	0	7
TS-BNZGP	0	0	0	0	0	0	0	0	0	0	0	7
TS-BNZJ	0	0	0	0	0	0	0	0	0	0	0	7
TS-BNZK	0	0	0	0	0	0	0	0	0	0	0	7
TS-BUBZP	0	0	0	0	0	0	0	0	0	0	0	7
TS-CHLR	1	1	0	0	20	0	0	0	0	2	1	60
TS-CHLRC	0	0	0	0	2	0	0	0	0	2	1	28
TS-CHLRN	0	0	0	0	2	0	0	0	0	2	1	28
TS-CHLRT	0	0	0	0	2	0	0	0	0	2	1	28
TS-CHRY	0	0	0	0	18	0	0	0	0	0	0	18
TS-CHRYS	0	0	0	0	0	0	0	0	0	0	0	7
TS-CLPN	0	0	0	0	0	0	0	0	0	0	0	7
TS-DBANE	0	0	0	0	0	0	0	0	0	0	0	7
TS-DBHC	0	0	0	0	0	0	0	0	0	0	0	7
TS-DDD	0	0	0	0	0	0	0	0	0	0	0	28
TS-DDE	0	0	0	0	0	0	0	0	0	0	0	32
TS-DDT	0	0	0	0	2	0	0	0	0	2	0	36
TS-DIBUP	0	0	0	0	0	0	0	0	0	0	0	7
TS-DIEL	1	1	0	0	20	0	0	0	0	2	1	62
TS-DIETP	0	0	0	0	0	0	0	0	0	0	0	7
TS-DIMET	0	0	0	0	0	0	0	0	0	0	0	7
TS-DIN8	0	0	0	0	0	0	0	0	0	0	0	7
TS-DIPH	0	0	0	0	0	0	0	0	0	0	0	7
TS-ENDO	1	1	0	0	0	0	0	0	0	0	0	10
TS-ENDOS	0	0	0	0	0	0	0	0	0	0	0	7
TS-ENDR	1	1	0	0	2	0	0	0	0	2	1	42
TS-ENDRA	0	0	0	0	0	0	0	0	0	0	0	7
TS-FLRA	1	1	0	0	0	0	0	0	0	0	0	10
TS-FLRN	1	1	0	0	18	0	0	0	0	0	0	28
TS-HEPT	1	1	0	0	18	0	0	0	0	0	0	46
TS-HEPX	0	0	0	0	0	0	0	0	0	0	0	25
TS-HXCBU	0	0	0	0	0	0	0	0	0	0	0	7
TS-HXCCP	0	0	0	0	0	0	0	0	0	0	0	7
TS-HXCLB	0	0	0	0	2	0	0	0	0	2	1	39
TS-HXCLE	0	0	0	0	0	0	0	0	0	0	0	7
TS-I123P	0	0	0	0	0	0	0	0	0	0	0	7
TS-ISPHR	0	0	0	0	0	0	0	0	0	0	0	7
TS-LIND	1	1	0	0	20	0	0	0	0	2	1	60

(continued)

Table 8-2
Census of tissue data holdings for principal organism codes
(continued)

parameter:	organism codes: 1	3	4	8	10	14	15	16	20	27	34	all organisms
TS-MTHX	1	1	0	0	2	0	0	0	0	2	1	41
TS-NAPT	1	1	0	0	18	0	0	0	0	0	0	28
TS-NITRB	0	0	0	0	0	0	0	0	0	0	0	7
TS-NNNPR	0	0	0	0	0	0	0	0	0	0	0	7
TS-NNSM	0	0	0	0	0	0	0	0	0	0	0	7
TS-NNSP	0	0	0	0	0	0	0	0	0	0	0	7
TS-ODDD	0	0	0	0	2	0	0	0	0	2	1	29
TS-ODDE	0	0	0	0	2	0	0	0	0	2	1	29
TS-ODDT	0	0	0	0	2	0	0	0	0	2	1	29
TS-PCB	0	0	0	0	20	0	0	0	0	2	1	60
TS-PCP	1	1	0	0	0	0	0	0	0	0	0	10
TS-PDDD	1	1	0	0	20	0	0	0	0	2	1	50
TS-PDDE	1	1	0	0	20	0	0	0	0	2	1	50
TS-PDDT	1	1	0	0	20	0	0	0	0	2	1	50
TS-PHEN	1	1	0	0	0	0	0	0	0	0	0	3
TS-PHNAN	0	0	0	0	0	0	0	0	0	0	0	7
TS-PYRN	0	0	0	0	0	0	0	0	0	0	0	7
TS-T0XA	0	0	0	0	0	0	0	0	0	0	0	25
TS-TOXA	1	1	0	0	18	0	0	0	0	0	0	21
TS-TPHEN	1	1	0	0	0	0	0	0	0	0	0	10

Table 8-3
Census of tissue data holdings exceeding detection limits for principal organism codes

parameter:	1	3	4	8	10	14	15	16	20	27	34	all organisms
TDMETAG	0	0	81	0	0	0	0	0	0	0	0	81
TDMETAS	0	0	101	0	0	0	0	0	0	0	0	101
TDMETCD	0	0	101	0	0	0	0	0	0	0	0	101
TDMETCR	0	0	81	0	0	0	0	0	0	0	0	81
TDMETCU	0	0	101	0	0	0	0	0	0	0	0	101
TDMETHG	0	0	99	0	0	0	0	0	0	0	0	99
TDMETNI	0	0	101	0	0	0	0	0	0	0	0	101
TDMETPB	0	0	101	0	0	0	0	0	0	0	0	101
TDMETSE	0	0	101	0	0	0	0	0	0	0	0	101
TDMETZN	0	0	101	0	0	0	0	0	0	0	0	101
TD-ACEN	0	0	63	0	0	0	0	0	0	0	0	63
TD-ACENY	0	0	63	0	0	0	0	0	0	0	0	63
TD-ALDR	0	0	44	0	0	0	0	0	0	0	0	44
TD-BNZA	0	0	63	0	0	0	0	0	0	0	0	63
TD-CHRY	0	0	63	0	0	0	0	0	0	0	0	63
TD-DIEL	0	0	94	0	0	0	0	0	0	0	0	94
TD-ENDR	0	0	101	0	0	0	0	0	0	0	0	101
TD-FLRA	0	0	63	0	0	0	0	0	0	0	0	63
TD-FLRN	0	0	63	0	0	0	0	0	0	0	0	63
TD-HEPT	0	0	48	0	0	0	0	0	0	0	0	48
TD-HEPX	0	0	80	0	0	0	0	0	0	0	0	80
TD-LIND	0	0	87	0	0	0	0	0	0	0	0	87
TD-NAPT	0	0	63	0	0	0	0	0	0	0	0	63
TD-PDDD	0	0	92	0	0	0	0	0	0	0	0	92
TD-PDDE	0	0	100	0	0	0	0	0	0	0	0	100
TD-PDDT	0	0	72	0	0	0	0	0	0	0	0	72
TFMETAG	0	0	0	1	0	0	0	0	0	0	0	16
TFMETAS	1	0	4	1	3	2	10	0	0	0	0	38
TFMETCD	0	1	37	1	24	0	0	1	0	0	0	72
TFMETCR	0	0	0	1	0	0	0	0	0	0	0	19
TFMETCU	2	18	39	1	35	3	14	8	0	0	0	144
TFMETHG	4	35	11	1	35	5	24	21	0	0	0	159
TFMETNI	0	0	0	1	0	0	0	0	0	0	0	19
TFMETPB	0	1	1	0	2	0	0	0	0	0	0	18
TFMETZN	4	33	39	1	35	5	25	21	0	0	0	189
TF-ALDR	0	0	0	0	0	0	0	0	0	0	0	3
TF-CHLR	0	0	0	0	2	0	0	0	0	0	0	2

(continued)

Table 8-3
Census of tissue data holdings exceeding detection limits
(continued)

parameter:	*1*	*3*	*4*	*8*	*10*	*14*	*15*	*16*	*20*	*27*	*34*	*all organisms*
	organism codes:											
TF-DDE	0	5	4	0	4	0	1	0	0	0	0	14
TF-DDT	0	0	0	0	0	0	0	0	0	0	0	13
TF-HEPT	0	0	0	0	0	0	0	0	0	0	0	2
TF-HEPX	0	0	0	0	0	0	0	0	0	0	0	1
TF-PCB	3	14	24	1	22	2	15	13	0	0	0	109
TF-PDDD	0	0	0	0	0	0	0	0	0	0	0	1
TF-PDDE	0	0	0	0	0	0	0	0	0	0	0	7
TF-PDDT	0	0	0	0	0	0	0	0	0	0	0	9
TF-PYRN	0	0	6	0	0	0	0	0	0	0	0	6
TSMETAG	0	1	0	0	0	0	0	0	0	0	0	2
TSMETAS	1	0	4	0	34	0	1	0	0	0	0	86
TSMETCD	0	0	5	0	37	0	0	0	0	0	0	70
TSMETCR	0	1	5	0	34	0	1	0	1	2	0	96
TSMETCU	1	0	5	0	50	0	1	0	1	2	0	133
TSMETHG	0	0	4	0	28	0	1	0	1	2	0	93
TSMETNI	0	1	4	0	17	0	0	0	0	0	0	41
TSMETPB	1	0	2	0	6	0	0	0	1	2	0	34
TSMETSE	0	0	4	0	33	0	0	0	0	0	0	77
TSMETZN	1	1	4	0	51	0	0	0	0	0	0	101
TS-CHLR	0	0	0	0	0	0	0	0	0	0	0	1
TS-CHLRN	0	0	0	0	0	0	0	0	0	0	0	1
TS-DDD	0	0	0	0	0	0	0	0	0	0	0	3
TS-DDE	0	0	0	0	0	0	0	0	0	0	0	19
TS-DDT	0	0	0	0	0	0	0	0	0	0	0	1
TS-DIBUP	0	0	0	0	0	0	0	0	0	0	0	1
TS-DIEL	0	0	0	0	0	0	0	0	0	0	0	3
TS-ENDR	0	0	0	0	0	0	0	0	0	0	0	1
TS-FLRA	0	0	0	0	0	0	0	0	0	0	0	1
TS-HXCLB	0	0	0	0	0	0	0	0	0	1	0	3
TS-PCB	0	0	0	0	1	0	0	0	0	2	0	16
TS-PDDD	0	0	0	0	0	0	0	0	0	0	0	1
TS-PDDE	0	0	0	0	1	0	0	0	0	0	1	17
TS-PYRN	0	0	0	0	0	0	0	0	0	0	0	1
TS-TPHEN	1	1	0	0	0	0	0	0	0	0	0	3

Table 8-4
Systemwide summary statistics of tissue concentrations in all organisms
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. > DLs*	*% > DLs*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
TFMETAS	89	1.09E+00	3.10E+00	38	43	19	930723	4.66E-01	7.46E-01
TFMETCD	190	9.81E-01	1.00E+00	72	38	5.1	800505	3.72E-01	5.57E-01
TFMETCU	190	1.10E+01	1.30E+01	144	76	72	940818	8.35E+00	8.52E+00
TFMETHG	190	1.06E-01	8.30E-02	159	83	0.57	800708	8.85E-02	9.35E-02
TFMETPB	190	2.47E-01	3.00E-01	18	9	1	810316	2.34E-02	7.33E-01
TFMETZN	189	1.42E+02	4.00E+02	189	100	2500	940818	1.42E+02	1.42E+02
TF-ACEN	6								1.00E+00
TF-ALDR	117	1.18E-03	6.60E-04	3	3	0.0019	930720	3.03E-05	1.75E-03
TF-BNZA	6								1.00E+00
TF-CHLR	100	2.28E-01	3.00E-01	4	4	0.75	781130	9.13E-03	1.89E-02
TF-DDT	113	2.87E-03	1.80E-03	13	11	0.0082	920729	3.30E-04	9.53E-03
TF-DIEL	117								5.05E-03
TF-ENDO	96								1.00E-02
TF-ENDR	117								5.08E-03
TF-FLRN	6								1.00E+00
TF-NAPT	6								1.90E+01
TF-PCB	113	3.05E-02	1.40E-01	113	100	1.2	781130	3.05E-02	3.05E-02
TF-TOXA	113								1.00E-01
TSMETAS	140	3.24E+00	3.30E+00	86	61	23	890901	1.99E+00	2.44E+00
TSMETCD	140	4.57E-01	5.10E-01	70	50	3	890901	2.28E-01	3.58E-01
TSMETCU	140	8.90E+00	1.80E+01	133	95	190	890901	8.45E+00	8.58E+00
TSMETHG	140	1.02E-01	9.50E-02	93	66	0.43	890901	6.79E-02	1.94E-01
TSMETPB	140	1.22E+00	1.40E+00	34	24	7.7	771020	2.96E-01	1.34E+00
TSMETZN	101	1.09E+02	2.40E+02	101	100	1700	890901	1.09E+02	1.09E+02
TS-ACEN	28								5.58E+01
TS-ALDR	60								2.01E+01
TS-BNZA	28								5.58E+01
TS-CHLR	60	3.90E-02	0.00E+00	1	2	0.039	781130	6.50E-04	1.00E+02
TS-DDT	36	3.00E-02	0.00E+00	1	3	0.03	890815	8.33E-04	2.94E-02
TS-DIEL	62	7.20E-02	8.30E-03	3	5	0.081	770128	3.48E-03	1.95E+01
TS-ENDO	10								1.20E+02
TS-ENDR	42	3.50E-02	0.00E+00	1	2	0.035	790214	8.33E-04	2.86E+01
TS-FLRN	28								5.58E+01
TS-NAPT	28								5.58E+01
TS-PCB	60	1.71E-01	2.30E-01	16	27	1	781130	4.57E-02	3.09E+00
TS-TOXA	46								3.01E+01

Table 8-5
Systemwide summary time trends of tissue concentrations in all organisms
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*		*trend*
TFMETAS	840514	940818	840709	940818	3.8	2.73E-02	8.70E-01	3.14E+00	1.00	-3.20E-01	3.80E-01	poss
TFMETCD	800505	940818	800505	940818	5	-9.12E-02	1.30E+00	9.52E-01	0.90	-1.60E-01	-2.70E-02	prob
TFMETCU	800505	940818	800505	940818	10	-6.46E-01	1.40E+01	1.30E+01	0.95	-1.10E+00	-1.90E-01	prob
TFMETHG	800505	940818	800505	940817	11	1.66E-03	9.70E-02	8.27E-02	0.99	-1.20E-03	4.50E-03	poss
TFMETPB	800505	940818	810316	930723	1.5	-5.99E-02	7.90E-01	1.15E-01	0.15	-7.30E-02	-4.70E-02	prob
TFMETZN	800505	940818	800505	940818	13	-4.24E+00	1.60E+02	3.99E+02	1.00	-1.80E+01	9.10E+00	
TF-ACEN	801211	801211										
TF-ALDR	781130	930927	920729	930722	3.1	1.38E-03	2.80E-04	1.79E-04	0.07	-3.50E-03	6.30E-03	poss
TF-BNZA	801211	801211										
TF-CHLR	781130	930927	781130	840814	0.7	-7.07E-02	4.30E-01	2.26E-01	0.56	-3.10E-01	1.70E-01	
TF-DDT	781130	930927	910805	930723	6.6	7.41E-04	1.90E-03	1.79E-03	0.94	-1.20E-03	2.70E-03	poss
TF-DIEL	781130	930927										
TF-ENDO	800505	930927										
TF-ENDR	781130	930927										
TF-FLRN	801211	801211										
TF-NAPT	801211	801211										
TF-PCB	781130	930927	781130	930927	7.6	-5.90E-03	6.40E-02	1.36E-01	0.98	-1.30E-02	1.20E-03	poss
TF-TOXA	800505	930927										
TSMETAS	771020	930302	771020	930302	5.6	1.30E-01	1.80E+00	3.30E+00	0.99	-1.10E-01	3.70E-01	poss
TSMETCD	771020	930302	771020	890901	5.9	-3.34E-02	8.20E-01	5.05E-01	0.97	-7.90E-02	1.20E-02	poss
TSMETCU	771020	930302	771020	930302	8.7	3.94E-01	5.10E+00	1.84E+01	0.99	-4.00E-01	1.20E+00	poss
TSMETHG	771020	930302	771020	910723	6.8	3.76E-03	6.80E-02	9.39E-02	0.97	-6.70E-04	8.20E-03	poss
TSMETPB	771020	930302	771020	930302	2.2	-5.51E-02	1.70E+00	1.35E+00	0.95	-1.40E-01	3.20E-02	
TSMETZN	840823	930302	840823	930302	12	1.41E+01	4.90E+01	2.35E+02	0.99	-9.00E+00	3.70E+01	poss
TS-ACEN	830616	930302										
TS-ALDR	771020	930302										
TS-BNZA	830616	930302										
TS-CHLR	771020	930302	781130	781130	1							

(continued)

Table 8-5
(continued)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*		*trend*
TS-DDT	771020	910806	890815	890815	1							
TS-DIEL	770128	930302	770128	790214	1.5	1.47E-03	7.10E-02	8.16E-03	0.97	-1.10E-01	1.10E-01	
TS-ENDO	830616	930302										
TS-ENDR	771020	930302	790214	790214	1							
TS-FLRN	830616	930302										
TS-NAPT	830616	930302										
TS-PCB	750618	910806	750618	910806	0.99	-5.46E-03	2.10E-01	2.28E-01	0.98	-2.80E-02	1.70E-02	
TS-TOXA	830616	930302										

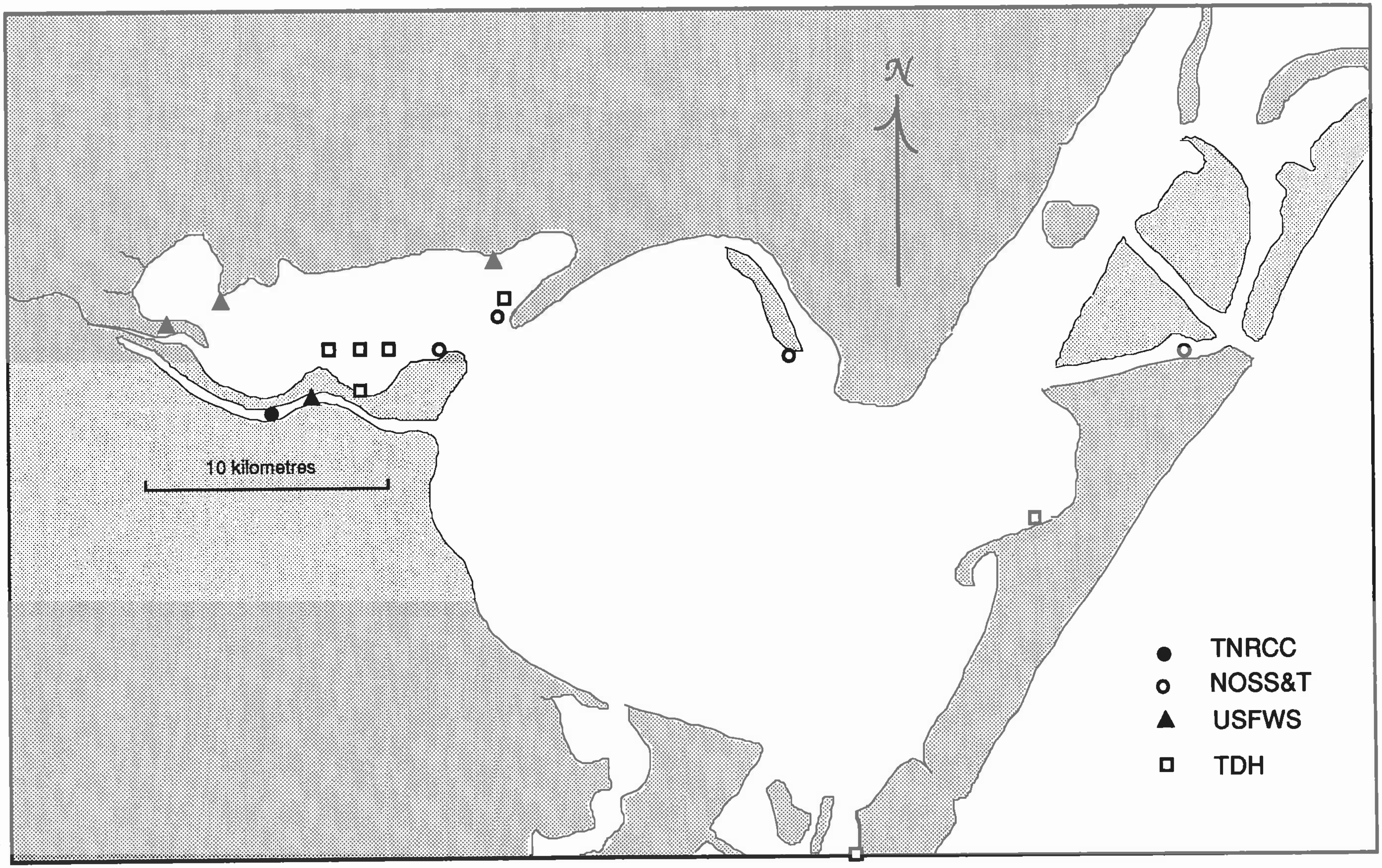


Figure 8-1. Sites of oyster samples in tissue data base, Corpus Christi Bay

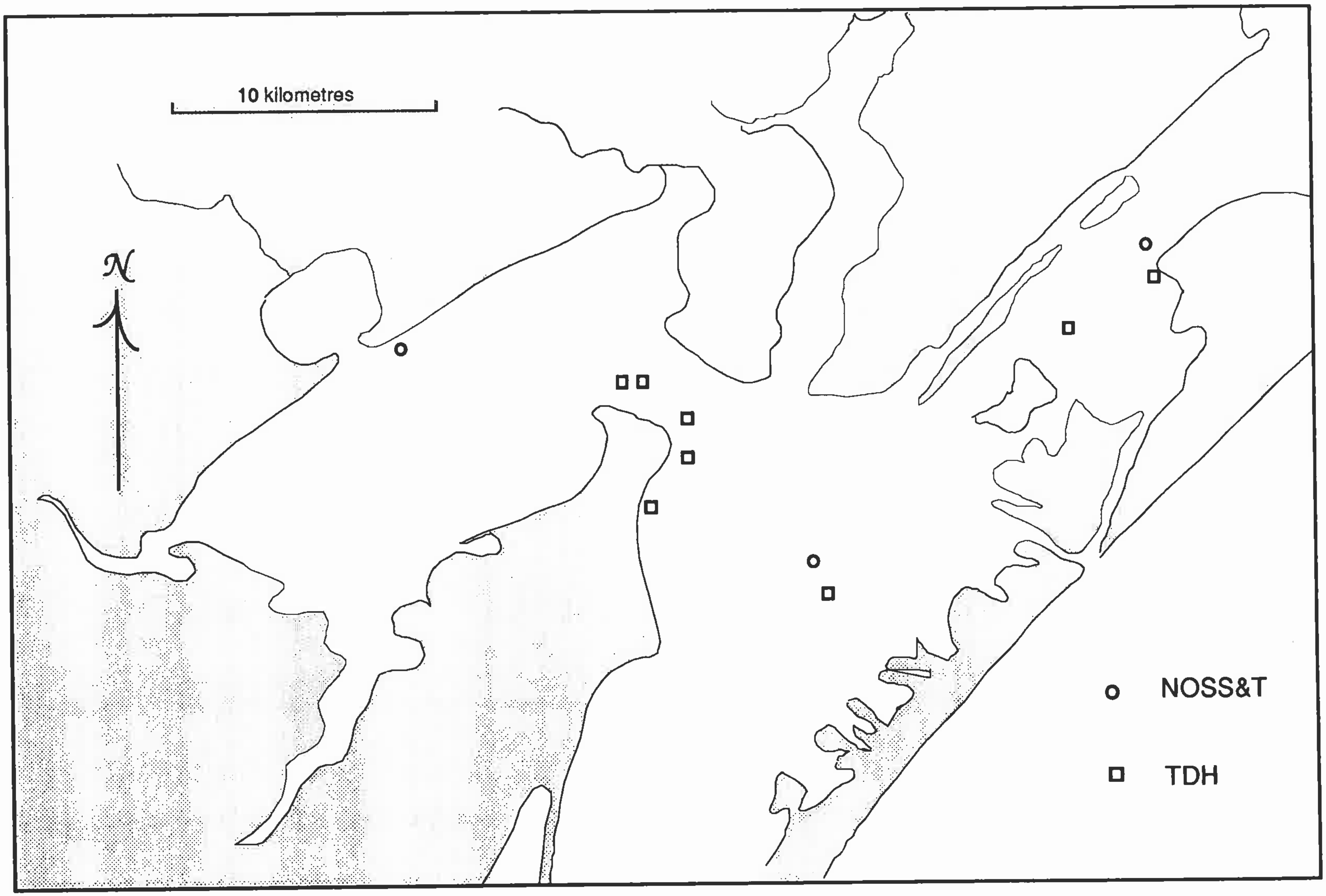


Figure 8-2. **Sites of oyster samples in tissue data base, Copano-Aransas Bay**

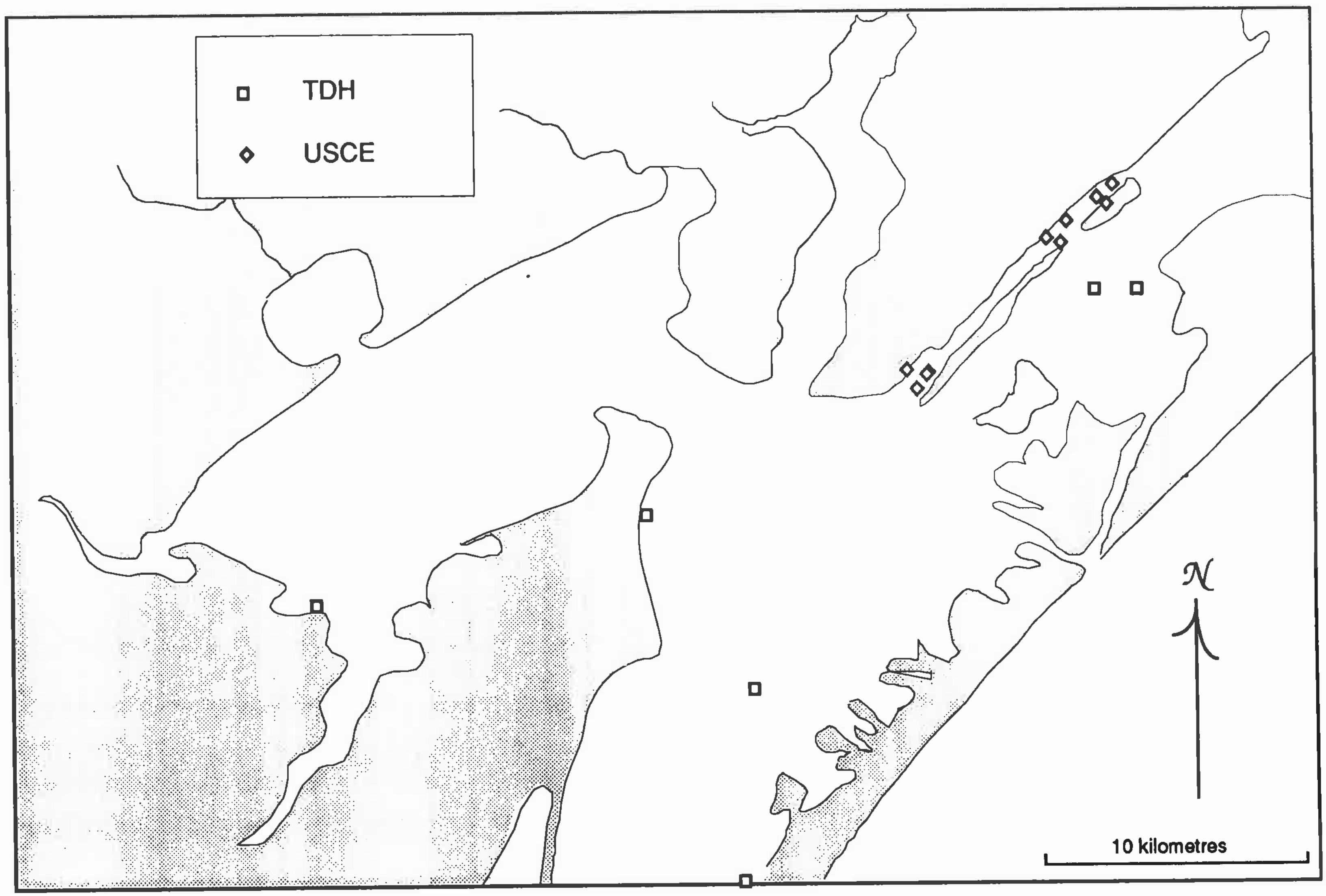


Figure 8-3. Sites of blue crab samples in tissue data base, Aransas-Copano Bay

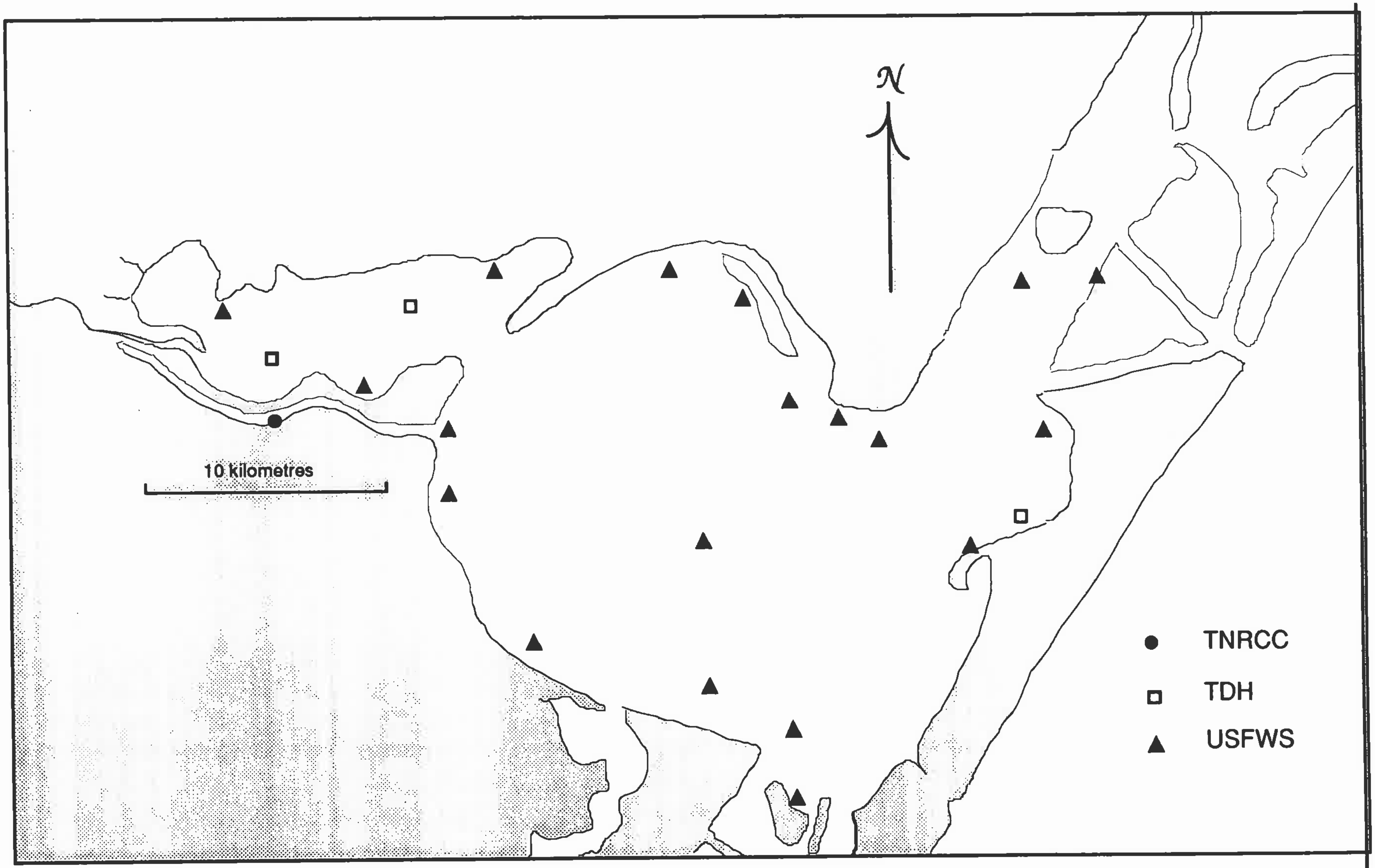


Figure 8-4. Sites of blue crab samples in tissue data base, Corpus Christi Bay

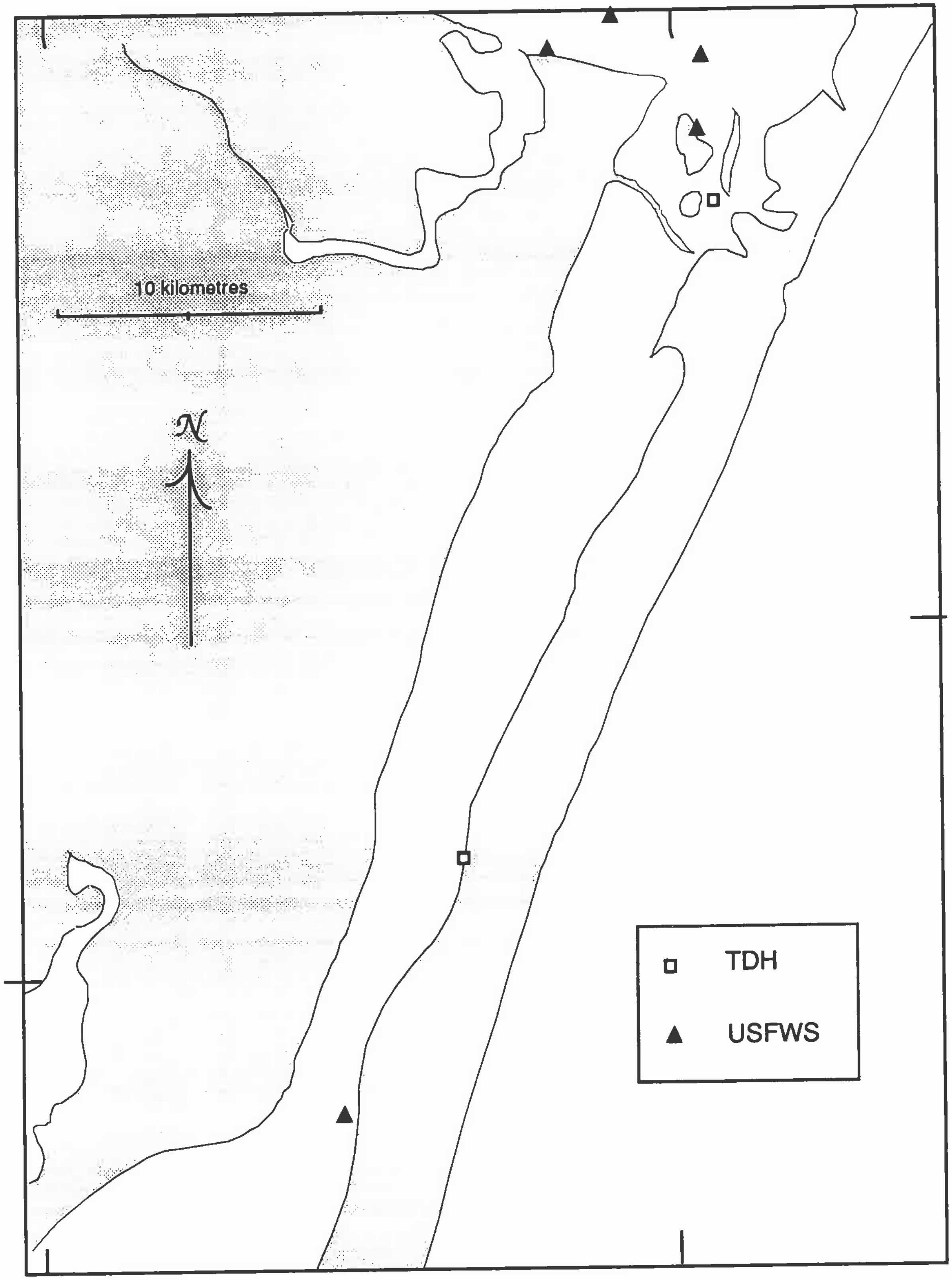


Figure 8-5. Sites of blue crab samples in tissue data base, Upper Laguna and Oso Bay

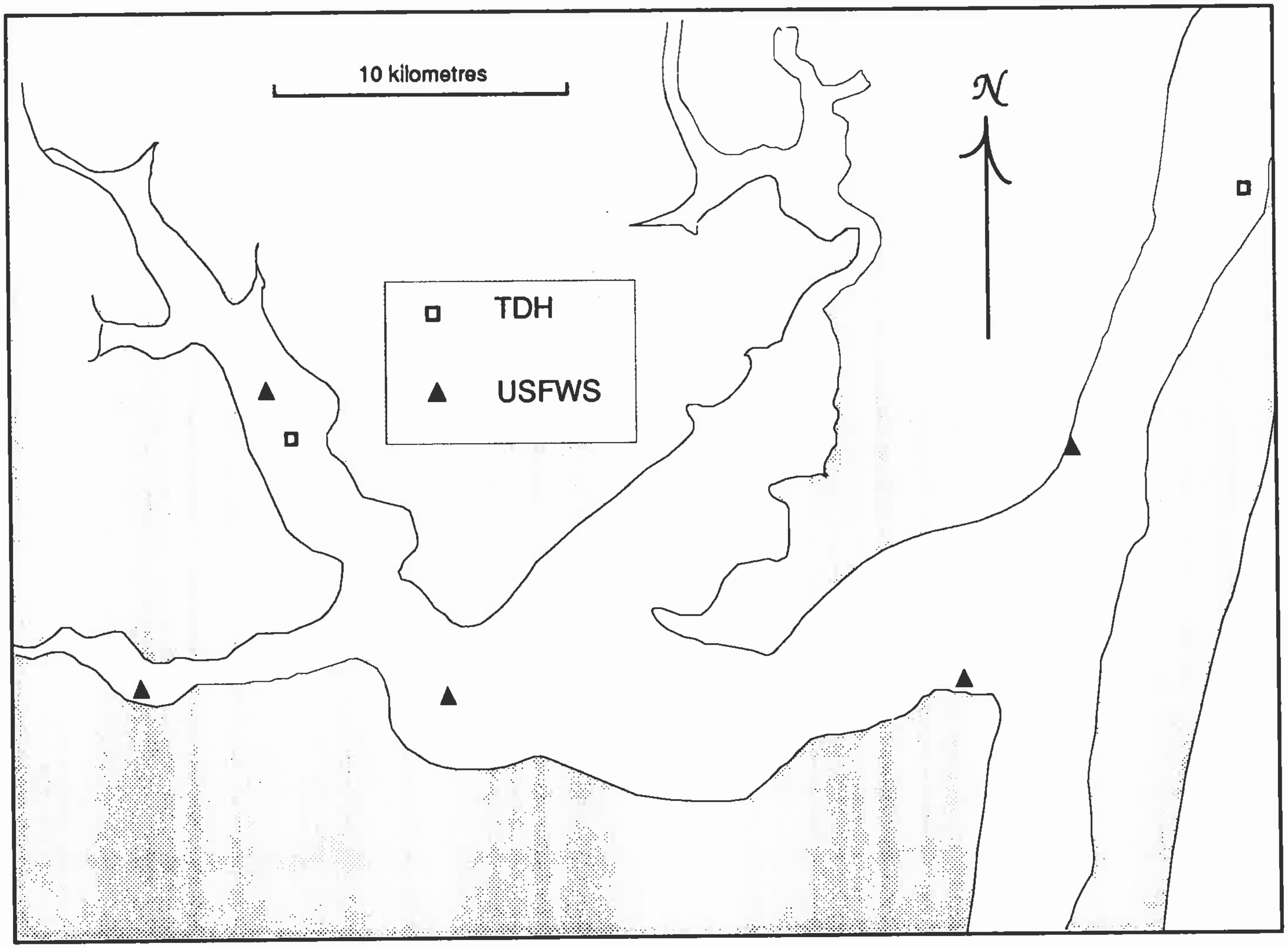


Figure 8-6. Sites of blue crab samples in tissue data base, Baffin Bay

8.3 Data analyses and observations

Statistical analyses for the more important organisms of Table 8-1 aggregated by TNRCC segment are presented in Appendix D. To save paper, only those segments/analytes are given for which data exist. Some readers may wonder about the general behavior of a specific analyte in a given species, independent of location in the bay. Particularly in view of the sparsity of data in space, a statistical composite of all oyster data, say, may be considered to provide some indication of the extent of tissue contamination within the study area. Such analyses are provided in Tables 8-6 *et seq*., for oyster, blue crab, speckled trout, red drum and black drum.

For oyster, Table 8-6 indicates elevated concentrations of some of the metals, notably arsenic, cadmium, copper and zinc. Some of the analytes exhibit declining trends with time. We note that attaching significance to any of these statistics without cognizance of their underlying geographical distribution is aleatory. For example, an oyster analysis from the open waters of Corpus Christi Bay in the 1970's pooled with an analysis from the Inner Harbor in the 1990's would display an apparent increasing time trend, but this would have no real validity. For this reason, Tables 8-6 *et seq*. should be interpreted with caution. Of course, for organisms that are ubiquitous and have a high degree of mobility in the system, the geographical pooling of Tables 8-6 *et seq*. has some value. Thus for crab (Tables 8-8 and 8-9) and speckled trout (Tables 8-10 and 8-11), the elevation of some metals and PCB's, and the possible increasing trends, may be indicative of real variability in these analytes.

To display statistical behavior with separation of geographical dependency, Tables 8-16 et seq. show statistics and time trends for the major metals analytes and PCB's, for three species with the greatest data base, oyster, blue crab and black drum, aggregated by the principal regional TNRCC segments, *viz*. Mesquite, Copano and Aransas Bays (the upper bays), Redfish, Corpus Christi and Nueces Bays (the central region) and the Upper Laguna and Baffin Bay (the lower bays).

For the oyster, the upper bays and the main body of Corpus Christi Bay show somewhat elevated concentrations of arsenic with no clear time trends. Nueces Bay exhibits systematically elevated metals. For cadmium (Table 8-17), copper (Table 8-18), lead (Table 8-20) and zinc (Table 8-21), the highest mean tissue concentrations are found in Nueces Bay. (This statement means apart from the Inner Harbor, but since the Inner Harbor tissue mean is based on only two samples it is not as statistically secure as those for Copano and Nueces Bay.) The second runner is Copano Bay for cadmium and copper, and it exceeds Nueces Bay slightly for mercury (Table 8-19). This conclusion generally agrees with the relative concentrations in the sediments, cf. Table 7-7, if the Inner Harbor and tertiary bays are discounted. (And, of course, there are no oyster samples from the lower bays.) Time trends are mixed both with respect to the analyte and with respect to geography. Some are statistically probable, but the small data bases still render them suspect.

Blue crab data, Tables 8-23 through 8-29, are generally much sparser than oyster data, and the conclusions are even more tenuous. Noise in the data no doubt obscures the relative magnitudes of the mean concentrations. Redfish Bay and Baffin show elevated levels of most metals. The high arsenic concentrations in the Upper Laguna and Baffin Bay should be especially noted. The data base would not support any trend determinations anywhere.

The black drum data is sparser yet, the data base for Nueces Bay being the only one even remotely adequate for statistical analysis. This does indicate some elevated metals concentrations, especially for mercury and zinc, and where a time trend can be resolved that is either possible or probable, it is increasing.

When one considers that the data base greatest for the species and analytes of Tables 8-16 *et seq.*, and is sparser yet for the remainder of the species and analytes, it becomes apparent why so little can be concluded concerning tissue concentrations in this system.

Table 8-6
Systemwide summary statistics for oyster (code 04)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
TOMETAS	118	1.24E+00	4.50E-01	109	92	1.40E-01	920715	1.40E-01	920715	2.40E+00	880715	1.15E+00	1.19E+00
TOMETCD	145	1.06E+00	6.90E-01	143	99	1.90E-02	920715	1.90E-02	920715	4.10E+00	800505	1.05E+00	1.05E+00
TOMETCU	145	2.43E+01	1.90E+01	145	100	3.00E+00	910715	3.00E+00	910715	1.90E+02	890901	2.43E+01	2.43E+01
TOMETHG	145	1.89E-02	1.40E-02	114	79	1.50E-03	870715	1.50E-03	870715	1.20E-01	890901	1.49E-02	2.01E-02
TOMETPB	145	1.17E-01	1.50E-01	104	72	2.80E-02	870715	2.80E-02	870715	1.40E+00	771020	8.36E-02	2.56E-01
TOMETZN	144	4.47E+02	4.50E+02	144	100	2.70E+01	910715	2.70E+01	910715	2.50E+03	940818	4.47E+02	4.47E+02
TO-ACEN	107	3.33E-03	2.90E-03	63	59	5.10E-04	910715	5.10E-04	910715	1.70E-02	880715	1.96E-03	5.91E-02
TO-ALDR	125	3.04E-04	3.60E-04	44	35	6.00E-06	890715	6.00E-06	890715	1.50E-03	900715	1.07E-04	5.29E-04
TO-BNZA	107	3.33E-03	2.90E-03	63	59	5.10E-04	910715	5.10E-04	910715	1.70E-02	880715	1.96E-03	5.91E-02
TO-CHLR	24			0	0								1.00E-02
TO-DIEL	125	5.12E-04	5.90E-04	94	75	1.90E-05	910715	1.90E-05	910715	3.40E-03	860715	3.85E-04	1.55E-03
TO-ENDO	24			0	0								1.00E-02
TO-ENDR	125	2.30E-06	1.50E-05	101	81	0.00E+00	860715	3.00E-06	910715	1.50E-04	920715	1.86E-06	1.15E-03
TO-FLRN	107	3.33E-03	2.90E-03	63	59	5.10E-04	910715	5.10E-04	910715	1.70E-02	880715	1.96E-03	5.91E-02
TO-NAPT	107	3.33E-03	2.90E-03	63	59	5.10E-04	910715	5.10E-04	910715	1.70E-02	880715	1.96E-03	1.07E+00
TO-TOXA	24			0	0								1.00E-01
TO-DDT	125	5.13E-04	7.00E-04	72	58	1.60E-05	930715	1.60E-05	930715	4.40E-03	890715	2.95E-04	2.23E-03
TO-PCB	24	4.38E-02	1.50E-01	24	100	0.00E+00	820125	4.40E-02	830310	7.70E-01	840712	4.38E-02	4.38E-02

Table 8-7
Systemwide summary time trends for oyster (code 04)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*		*trend*
TOMETAS	771020	940818	840709	940818	11	-2.66E-02	1.40E+00	4.42E-01	0.99	-6.80E-02	1.40E-02	
TOMETCD	771020	940818	771020	940818	8.5	-7.07E-02	1.80E+00	6.47E-01	0.88	-1.00E-01	-3.80E-02	prob
TOMETCU	771020	940818	771020	940818	8.6	-9.06E-02	2.50E+01	1.90E+01	1.00	-1.00E+00	8.50E-01	
TOMETHG	771020	940818	771020	930715	7.2	3.75E-05	1.90E-02	1.41E-02	1.00	-8.80E-04	9.60E-04	poss
TOMETPB	771020	940818	771020	930715	6.6	-2.99E-02	4.60E-01	1.39E-01	0.82	-4.20E-02	-1.80E-02	prob
TOMETZN	800505	940818	800505	940818	10	1.94E+00	4.30E+02	4.54E+02	1.00	-2.10E+01	2.50E+01	poss
TO-ACEN	801211	930715	860715	930715	9	-1.19E-03	7.80E-03	2.14E-03	0.54	-1.50E-03	-8.70E-04	prob
TO-ALDR	800505	930927	880715	920715	11	5.89E-06	2.90E-04	3.62E-04	1.00	-8.50E-05	9.70E-05	poss
TO-BNZA	801211	930715	860715	930715	9	-1.19E-03	7.80E-03	2.14E-03	0.54	-1.50E-03	-8.70E-04	prob
TO-CHLR	800505	930927										
TO-DIEL	800505	930927	860715	930715	13	-1.41E-04	8.90E-04	5.22E-04	0.80	-2.00E-04	-8.30E-05	prob
TO-ENDO	800505	930927										
TO-ENDR	800505	930927	860715	930715	14	2.14E-06	-3.70E-06	1.49E-05	0.93	5.70E-07	3.70E-06	prob
TO-FLRN	801211	930715	860715	930715	9	-1.19E-03	7.80E-03	2.14E-03	0.54	-1.50E-03	-8.70E-04	prob
TO-NAPT	801211	930715	860715	930715	9	-1.19E-03	7.80E-03	2.14E-03	0.54	-1.50E-03	-8.70E-04	prob
TO-TOXA	800505	930927										
TO-DDT	800505	930927	860715	930715	10	7.58E-06	4.90E-04	7.03E-04	1.00	-8.10E-05	9.60E-05	poss
TO-PCB	800505	930927	800505	930927	1.8	-7.27E-04	4.70E-02	1.53E-01	1.00	-2.30E-02	2.10E-02	

Table 8-8
Systemwide summary statistics for blue crab (code 10)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
TFMETAS	14	0.72	0.33	3	21	0.26	940817	0.26	940817	1	840822	0.154	0.547
TFMETCD	35	0.507	0.31	24	69	0.15	820810	0.15	820810	1.7	840725	0.347	0.437
TFMETCU	35	12	7.2	35	100	4.4	820810	4.4	820810	33	840725	12	12
TFMETHG	35	0.0729	0.04	35	100	0.02	820810	0.02	820810	0.18	940817	0.0729	0.0729
TFMETPB	35	0.7	0.1	2	6	0.6	840706	0.6	840706	0.8	820210	0.04	0.62
TFMETZN	35	40.9	12	35	100	1	800708	1	800708	57	840725	40.9	40.9
TF-ACEN	0												
TF-ALDR	22			0									0.002
TF-BNZA	0												0
TF-CHLR	22	0.0265	0.011	2	9	0.016	840814	0.016	840814	0.037	840814	0.00241	0.0115
TF-DDT	22			0									0.01
TF-DIEL	22			0									0.006
TF-ENDO	22			0									0.01
TF-ENDR	22			0									0.006
TF-FLRN	0												
TF-NAPT	0												
TF-PCB	22	0.0206	0.069	22	100	0	800708	0.15	840712	0.3	840725	0.0206	0.0206
TF-TOXA	22	0	0	0	0	0	0	0	0	0	0	0	0.1
TSMETAS	53	4.88	4.1	34	64	0.43	890901	0.43	890901	23	890901	3.13	3.48
TSMETCD	53	0.394	0.26	37	70	0.089	890901	0.089	890901	1.3	890901	0.275	0.403
TSMETCU	53	13.5	5.1	50	94	0.93	890901	0.93	890901	23	890901	12.8	13
TSMETHG	53	0.0444	0.022	28	53	0.012	890901	0.012	890901	0.097	890901	0.0235	0.0614
TSMETPB	53	0.584	0.2	6	11	0.36	890901	0.36	890901	0.9	771020	0.0661	1.98
TSMETZN	51	30.7	19	51	100	15	890901	15	890901	150	890901	30.7	30.7
TS-ACEN	18			0									20
TS-ALDR	20			0									0.18
TS-BNZA	18			0									20

(continued)

Table 8-8
(continued)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*BDL=DL*
TS-CHLR	20			0									0.902
TS-DDT	2			0									0.01
TS-DIEL	20			0									0.451
TS-ENDO	0												
TS-ENDR	2			0									0.0065
TS-FLRN	18			0									20
TS-NAPT	18			0									20
TS-PCB	20	0.035	0	1	5	0.035	781130	0.035	781130	0.035	781130	0.00175	9
TS-TOXA	18			0									10

Table 8-9
Systemwide summary time trends for blue crab (code 10)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*		*trend*
TFMETAS	840627	940817	840822	940817	0.3	-0.0692	0.95	0.0408	0.015	-0.18	0.041	poss
TFMETCD	800708	940817	800708	840822	5.8	0.0902	0.27	0.292	0.887	-0.021	0.2	poss
TFMETCU	800708	940817	800708	940817	2.5	-0.178	13	7.19	0.997	-1.3	0.89	
TFMETHG	800708	940817	800708	940817	2.5	0.00284	0.064	0.0399	0.974	-0.0031	0.0088	poss
TFMETPB	800708	940817	820210	840706	0.83							
TFMETZN	800708	940817	800708	940817	2.5	0.686	39	12	0.983	-1.1	2.5	poss
TF-ACEN												
TF-ALDR	800708	840814										
TF-BNZA												
TF-CHLR	800708	840814	840814	840814	2							
TF-DDT	800708	840814										
TF-DIEL	800708	840814										
TF-ENDO	800708	840814										
TF-ENDR	800708	840814										
TF-FLRN												
TF-NAPT												
TF-PCB	800708	840814	800708	840814	5.4	0.0124	-0.014	0.067	0.935	-0.0096	0.034	poss
TF-TOXA	800708	840814										
TSMETAS	771020	890901	781130	890901	3.2	0.209	2.7	4.11	0.992	-0.58	1	poss
TSMETCD	771020	890901	771020	890901	3.1	-0.0415	0.85	0.242	0.848	-0.074	-0.0087	prob
TSMETCU	771020	890901	771020	890901	4.2	0.661	7	4.75	0.856	0.2	1.1	prob
TSMETHG	771020	890901	771020	890901	2.4	-0.000983	0.055	0.0222	0.984	-0.0041	0.0021	
TSMETPB	771020	890901	771020	890901	0.51	-0.032	0.9	0.137	0.484	-0.075	0.011	poss
TSMETZN	840823	890901	840823	890901	10	-0.458	32	18.9	0.997	-2.7	1.8	

(continued)

Table 8-9
(continued)

Analyte	*Period of record*	*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*	*trend*
TS-ACEN	840823 841001									
TS-ALDR	771020 841001									
TS-BNZA	840823 841001									
TS-CHLR	771020 841001									
TS-DDT	771020 781130									
TS-DIEL	771020 841001									
TS-ENDO										
TS-ENDR	771020 781130									
TS-FLRN	840823 841001									
TS-NAPT	840823 841001									
TS-PCB	771020 841001	781130	781130	1						
TS-TOXA	840823 841001									

Table 8-10
Systemwide summary statistics for speckled trout (code 03)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
TFMETAS	7	0	0	0	0	0	0	0	0	0	0	0	0.443
TFMETCD	34	0.2	0	1	3	0.2	810317	0.2	810317	0.2	810317	0.00588	0.347
TFMETCU	34	0.889	1.2	18	53	0.3	801223	0.3	801223	4.5	800708	0.471	0.847
TFMETHG	35	0.159	0.11	35	100	0.04	820810	0.04	820810	0.57	800708	0.159	0.159
TFMETPB	34	1	0	1	3	1	810316	1	810316	1	810316	0.0294	0.9
TFMETZN	33	4.22	0.66	33	100	2.8	830608	2.8	830608	5.9	821109	4.22	4.22
TF-ACEN	0												
TF-ALDR	15			0	0								0.00193
TF-BNZA	0												
TF-CHLR	15			0	0								0.0107
TF-DDT	15			0	0								0.01
TF-DIEL	15			0	0								0.0058
TF-ENDO	14			0	0								0.01
TF-ENDR	15			0	0								0.0058
TF-FLRN	0												
TF-NAPT	0												
TF-PCB	15	0.0137	0.042	15	100	0	800708	0.04	781130	0.17	840713	0.0137	0.0137
TF-TOXA	14			0	0								0.1
TSMETAS	1			0	0								20
TSMETCD	1			0	0								0.2
TSMETCU	1			0	0								1
TSMETHG	1			0	0								5
TSMETPB	1			0	0								2
TSMETZN	1	11	0	1	100	11	930302	11	930302	11	930302	11	11

(continued)

Table 8-10
(continued)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*BDL=DL*
TS-ACEN	1			0	0								400
TS-ALDR	1			0	0								400
TS-BNZA	1			0	0								400
TS-CHLR	1			0	0								2000
TS-DDT	0												
TS-DIEL	1			0	0								400
TS-ENDO	1			0	0								400
TS-ENDR	1			0	0								400
TS-FLRN	1			0	0								400
TS-NAPT	1			0	0								400
TS-PCB	0												
TS-TOXA	1			0	0								400

Table 8-11
Systemwide summary time trends for speckled trout (code 03)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*		*trend*
TFMETAS	840514	940817										
TFMETCD	800708	940817	810317	810317	1							
TFMETCU	800708	940817	800708	940817	1.3	-0.067	1	1.15	0.97	-0.27	0.13	
TFMETHG	800708	940817	800708	940817	2.5	0.00509	0.14	0.107	0.99	-0.01	0.02	poss
TFMETPB	800708	940817	810316	810316	1							
TFMETZN	800708	940817	800708	940817	2.3	0.0592	4.1	0.64	0.95	-0.033	0.15	poss
TF-ACEN												
TF-ALDR	781130	840713										
TF-BNZA												
TF-CHLR	781130	840713										
TF-DDT	781130	840713										
TF-DIEL	781130	840713										
TF-ENDO	800708	840713										
TF-ENDR	781130	840713										
TF-FLRN												
TF-NAPT												
TF-PCB	781130	840713	781130	840713	2.7	0.00737	-0.013	0.0408	0.95	-0.012	0.027	poss
TF-TOXA	800708	840713										
TSMETAS	930302	930302										
TSMETCD	930302	930302										
TSMETCU	930302	930302										
TSMETHG	930302	930302										
TSMETPB	930302	930302										
TSMETZN	930302	930302	930302	930302	1							

(continued)

Table 8-11
(continued)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*	*trend*
TS-ACEN	930302	930302									
TS-ALDR	930302	930302									
TS-BNZA	930302	930302									
TS-CHLR	930302	930302									
TS-DDT											
TS-DIEL	930302	930302									
TS-ENDO	930302	930302									
TS-ENDR	930302	930302									
TS-FLRN	930302	930302									
TS-NAPT	930302	930302									
TS-PCB											
TS-TOXA	930302	930302									

Table 8-12
Systemwide summary statistics for red drum (code 16)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
TFMETAS	7			0	0								0.443
TFMETCD	34	0.2	0	1	3	0.2	810317	0.2	810317	0.2	810317	0.00588	0.347
TFMETCU	34	0.889	1.2	18	53	0.3	801223	0.3	801223	4.5	800708	0.471	0.847
TFMETHG	35	0.159	0.11	35	100	0.04	820810	0.04	820810	0.57	800708	0.159	0.159
TFMETPB	34	1	0	1	3	1	810316	1	810316	1	810316	0.0294	0.9
TFMETZN	33	4.22	0.66	33	100	2.8	830608	2.8	830608	5.9	821109	4.22	4.22
TF-ACEN	0			0	0								
TF-ALDR	15			0	0								0.00193
TF-BNZA	0												
TF-CHLR	15			0	0								0.0107
TF-DDT	15			0	0								0.01
TF-DIEL	15			0	0								0.0058
TF-ENDO	14			0	0								0.01
TF-ENDR	15			0	0								0.0058
TF-FLRN	0												
TF-NAPT	0												
TF-PCB	15	0.0137	0.042	15	100	0	800708	0.04	781130	0.17	840713	0.0137	0.0137
TF-TOXA	14			0	0								0.1
TSMETAS	1			0	0								20
TSMETCD	1			0	0								0.2
TSMETCU	1			0	0								1
TSMETHG	1			0	0								5
TSMETPB	1			0	0								2
TSMETZN	1	11	0	1	100	11	930302	11	930302	11	930302	11	11

(continued)

Table 8-12
(continued)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*BDL=DL*
TS-ACEN	1			0	0								400
TS-ALDR	1			0	0								400
TS-BNZA	1			0	0								400
TS-CHLR	1			0	0								2000
TS-DDT	0												
TS-DIEL	1			0	0								400
TS-ENDO	1			0	0								400
TS-ENDR	1			0	0								400
TS-FLRN	1			0	0								400
TS-NAPT	1			0	0								400
TS-PCB	0												0
TS-TOXA	1			0	0								400

Table 8-13
Systemwide summary time trends for red drum (code 16)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*		*trend*
TFMETAS	840514	940817										
TFMETAS	840514	940817										
TFMETCD	800708	940817	810317	810317	1							
TFMETCU	800708	940817	800708	940817	1.3	-0.067	1	1.15	0.969	-0.27	0.13	
TFMETHG	800708	940817	800708	940817	2.5	0.00509	0.14	0.107	0.987	-0.01	0.02	poss
TFMETPB	800708	940817	810316	810316	1							
TFMETZN	800708	940817	800708	940817	2.3	0.0592	4.1	0.64	0.951	-0.033	0.15	poss
TF-ACEN												
TF-ALDR	781130	840713										
TF-BNZA												
TF-CHLR	781130	840713										
TF-DDT	781130	840713										
TF-DIEL	781130	840713										
TF-ENDO	800708	840713										
TF-ENDR	781130	840713										
TF-FLRN												
TF-NAPT												
TF-PCB	781130	840713	781130	840713	2.7	0.00737	-0.013	0.0408	0.95	-0.012	0.027	poss
TF-TOXA	800708	840713										
TSMETAS	930302	930302										
TSMETCD	930302	930302										
TSMETCU	930302	930302										
TSMETHG	930302	930302										
TSMETPB	930302	930302										
TSMETZN	930302	930302	930302	930302	1							

(continued)

Table 8-13
(continued)

Analyte	*Period of record*	*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*	*trend*
TS-ACEN	930302 930302									
TS-ALDR	930302 930302									
TS-BNZA	930302 930302									
TS-CHLR	930302 930302									
TS-DDT										
TS-DIEL	930302 930302									
TS-ENDO	930302 930302									
TS-ENDR	930302 930302									
TS-FLRN	930302 930302									
TS-NAPT	930302 930302									
TS-PCB										
TS-TOXA	930302 930302									

Table 8-14
Systemwide summary statistics for black drum (code 15)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min*	*date*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
TFMETAS	19	0.509	0.36	10	53	0.22	940817	0.22	940817	1.5	940817	0.268	0.505
TFMETCD	25			0	0								0.304
TFMETCU	25	0.701	0.35	14	56	0.28	820924	0.28	820924	1.4	800708	0.392	0.654
TFMETHG	24	0.119	0.056	24	100	0.04	840725	0.04	840725	0.21	940817	0.119	0.119
TFMETPB	25			0	0								0.912
TFMETZN	25	5.12	1.4	25	100	3.2	840816	3.2	840816	8.5	840627	5.12	5.12
TF-ACEN	0												
TF-ALDR	15			0	0								0.002
TF-BNZA	0												
TF-CHLR	15			0	0								0.01
TF-DDT	15			0	0								0.01
TF-DIEL	15			0	0								0.006
TF-ENDO	15			0	0								0.01
TF-ENDR	15			0	0								0.006
TF-FLRN	0												
TF-NAPT	0												
TF-PCB	15	0.00153	0.0057	15	100	0	800708	0.023	820924	0.023	820924	0.00153	0.00153
TF-TOXA	15			0	0								0.1
TSMETAS	1	0.9	0	1	100	0.9	781130	0.9	781130	0.9	781130	0.9	0.9
TSMETCD	1			0	0								0.2
TSMETCU	1	1.9	0	1	100	1.9	781130	1.9	781130	1.9	781130	1.9	1.9
TSMETHG	1	0.03	0	1	100	0.03	781130	0.03	781130	0.03	781130	0.03	0.03
TSMETPB	1			0	0								0.4
TSMETZN	0												

No data for whole body organic analytes (TS-parameter)

Table 8-15
Systemwide summary time trends for black drum (code 15)
(Parameter abbreviation definitions in Appendix A-3)

Analyte	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start date)*	*standard error*	*residl varnc*	*95% conf bounds on slope*		*trend*
TFMETAS	840514	940817										
TFMETAS	840627	940817	940816	940817	3700	42.2	0.44	0.358	0.98	-180	260	poss
TFMETCD	800708	940817										
TFMETCU	800708	940817	800708	940817	0.99	-0.0262	0.96	0.318	0.82	-0.062	0.0093	poss
TFMETHG	800708	940817	800708	940817	1.7	0.00929	0.047	0.0253	0.20	0.0072	0.011	prob
TFMETPB	800708	940817										
TFMETZN	800708	940817	800708	940817	1.8	0.0816	4.5	1.29	0.90	-0.022	0.19	poss
TF-ACEN												
TF-ALDR	800708	840814										
TF-BNZA												
TF-CHLR	800708	840814										
TF-DDT	800708	840814										
TF-DIEL	800708	840814										
TF-ENDO	800708	840814										
TF-ENDR	800708	840814										
TF-FLRN												
TF-NAPT												
TF-PCB	800708	840814	800708	840814	3.7	-0.00123	0.0055	0.00556	0.94	-0.0042	0.0017	
TF-TOXA	800708	840814										
TSMETAS	781130	781130	781130	781130	1							
TSMETCD	781130	781130										
TSMETCU	781130	781130	781130	781130	1							
TSMETHG	781130	781130	781130	781130	1							
TSMETPB	781130	781130										
TSMETZN												

No data for whole body organic analytes (TS-parameter)

Table 8-16
Oyster (Code 04) arsenic in tissue (TOMETAS), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	20	0.909	0.22	20	100.00	0.59	870715	1.6	930715	0.909	0.909
Aransas	2471	20	1.44	0.42	20	100.00	0.65	870715	2.1	860715	1.44	1.44
Copano	2472	21	1.12	0.29	19	90.48	0.14	920715	1.7	860715	1.02	1.06
Corpus Christi	2481	46	1.44	0.43	44	95.65	0.5	840709	2.4	880715	1.37	1.39
Nueces	2482	7	0.594	0.26	5	71.43	0.26	940817	0.95	890901	0.424	0.567
Redfish	2483	0										
Inner Harbor	2484	2	1.24	0	1	50.00	1.2	890901	1.2	890901	0.62	0.87
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	860715	930715	860715	930715	2.9	0.082	0.67	0.151	0.45	0.045	0.12	prob
Aransas	2471	860715	930715	860715	930715	2.9	0.00503	1.4	0.421	1.00	-0.098	0.11	poss
Copano	2472	840626	920715	860715	920715	3.2	-0.0974	1.4	0.23	0.62	-0.16	-0.033	prob
Corpus Christi	2481	840706	930715	840709	930715	4.9	-0.00184	1.4	0.428	1.00	-0.068	0.064	
Nueces	2482	840712	940818	890901	940818	1	-0.1	0.79	0.0876	0.12	-0.17	-0.034	prob
Redfish	2483												
Inner Harbor	2484	771020	890901	890901	890901	1							
Upper Laguna	2491												
Baffin	2492												

Table 8-17
Oyster (Code 04) cadmium in tissue (TOMETCD),
status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	28	0.802	0.33	28	100	0.36	930715	1.9	920715	0.802	0.802
Aransas	2471	28	0.724	0.23	28	100	0.019	920715	1.1	860715	0.724	0.724
Copano	2472	25	1.31	0.51	25	100	0.44	920715	2.2	900715	1.31	1.31
Corpus Christi	2481	46	0.86	0.36	46	100	0.39	880715	1.9	870715	0.86	0.86
Nueces	2482	14	2.47	1	14	100	1.1	890901	4.1	800505	2.47	2.47
Redfish	2483	0										
Inner Harbor	2484	2	1.28	0.025	2	100	1.3	890901	1.3	771020	1.28	1.28
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	820810	930715	820810	930715	2.6	0.00364	0.78	0.329	1.00	-0.036	0.043	poss
Aransas	2471	820125	930715	820125	930715	2.4	-0.0443	0.97	0.185	0.63	-0.067	-0.021	prob
Copano	2472	820125	920715	820125	920715	2.4	0.0373	1.1	0.494	0.95	-0.033	0.11	poss
Corpus Christi	2481	840706	930715	840706	930715	5.1	-0.0739	1.2	0.322	0.80	-0.12	-0.029	prob
Nueces	2482	800505	940818	800505	940818	0.98	-0.133	3.2	0.792	0.61	-0.24	-0.029	prob
Redfish	2483												
Inner Harbor	2484	771020	890901	771020	890901	0.17							
Upper Laguna	2491												
Baffin	2492												

Table 8-18
Oyster (Code 04) copper in tissue (TOMETCU),
status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	28	17.1	6.9	28	100	3.5	910715	30	830621	17.1	17.1
Aransas	2471	28	17.8	8.5	28	100	3	910715	31	830927	17.8	17.8
Copano	2472	25	29.7	13	25	100	8.9	920715	54	880715	29.7	29.7
Corpus Christi	2481	46	21.5	10	46	100	8.8	840706	48	880715	21.5	21.5
Nueces	2482	14	41.7	16	14	100	23	830310	72	940818	41.7	41.7
Redfish	2483	0										
Inner Harbor	2484	2	104	87	2	100	17	771020	190	890901	104	104
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	820810	930715	820810	930715	2.6	-1.19	23	5.55	0.66	-1.9	-0.53	prob
Aransas	2471	820125	930715	820125	930715	2.4	-1.8	28	6.2	0.53	-2.6	-1	prob
Copano	2472	820125	920715	820125	920715	2.4	-0.0714	30	13.4	1.00	-2	1.8	
Corpus Christi	2481	840706	930715	840706	930715	5.1	0.39	20	10.3	0.99	-1	1.8	poss
Nueces	2482	800505	940818	800505	940818	0.98	2.53	28	10.3	0.42	1.2	3.9	prob
Redfish	2483												
Inner Harbor	2484	771020	890901	771020	890901	0.17							
Upper Laguna	2491					0							
Baffin	2492					0							

Table 8-19
Oyster (Code 04) mercury in tissue (TOMETHG),
status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	28	0.0112	0.0059	20	71	0.0018	870715	0.025	930715	0.00797	0.0137
Aransas	2471	28	0.0158	0.0061	20	71	0.0015	870715	0.027	880715	0.0113	0.0163
Copano	2472	25	0.0255	0.013	20	80	0.01	820125	0.064	870715	0.0204	0.0316
Corpus Christi	2481	46	0.0174	0.0076	43	93	0.0035	870715	0.031	880715	0.0163	0.0172
Nueces	2482	14	0.0351	0.032	10	71	0.01	830310	0.12	890901	0.0251	0.0294
Redfish	2483	0										
Inner Harbor	2484	2	0.01	0	1	50	0.01	771020	0.01	771020	0.005	0.02
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	820810	930715	860715	930715	2.9	0.000697	0.0091	0.00568	0.94	-0.00069	0.0021	poss
Aransas	2471	820125	930715	820125	930715	1.7	0.000552	0.012	0.0059	0.95	-0.00059	0.0017	poss
Copano	2472	820125	920715	820125	920715	1.9	-0.000587	0.03	0.0133	0.99	-0.0034	0.0022	
Corpus Christi	2481	840706	930715	840709	930715	4.8	-0.000292	0.019	0.00755	0.99	-0.0015	0.00088	
Nueces	2482	800505	940818	800505	890901	1.1	0.0055	0.012	0.0248	0.60	-0.0000087	0.011	poss
Redfish	2483												
Inner Harbor	2484	771020	890901	771020	771020	1							
Upper Laguna	2491												
Baffin	2492												

Table 8-20
Oyster (Code 04) lead in tissue (TOMETPB), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*BDL=DL*
Mesquite	2463	28	0.0652	0.025	20	71	0.028	870715	0.13	930715	0.0466	0.204
Aransas	2471	28	0.0737	0.027	20	71	0.029	890715	0.14	880715	0.0527	0.224
Copano	2472	25	0.0954	0.035	19	76	0.048	880715	0.18	910715	0.0725	0.213
Corpus Christi	2481	46	0.131	0.11	43	93	0.048	880715	0.7	840709	0.122	0.209
Nueces	2482	14			0	0					0	0.5
Redfish	2483	0										
Inner Harbor	2484	2	0.951	0.45	2	100	0.5	890901	1.4	771020	0.951	0.951
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	820810	930715	860715	930715	2.9	0.00677	0.046	0.021	0.70	0.0016	0.012	prob
Aransas	2471	820125	930715	860715	930715	2.9	0.00347	0.064	0.0257	0.93	-0.0028	0.0098	poss
Copano	2472	820125	920715	860715	920715	3.2	0.00942	0.07	0.0306	0.76	0.00091	0.018	prob
Corpus Christi	2481	840706	930715	840709	930715	4.8	-0.0121	0.19	0.109	0.96	-0.03	0.0058	poss
Nueces	2482	800505	940818										
Redfish	2483												
Inner Harbor	2484	771020	890901	771020	890901	0.17							
Upper Laguna	2491												
Baffin	2492												

Table 8-21
Oyster (Code 04) zinc in tissue (TOMETZN), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	28	98.5	35	28	100	28	910715	190	930715	98.5	98.5
Aransas	2471	28	206	180	28	100	27	910715	820	890715	206	206
Copano	2472	25	198	73	25	100	58	920715	350	880715	198	198
Corpus Christi	2481	46	623	220	46	100	140	890715	1000	880715	623	623
Nueces	2482	14	1440	470	14	100	870	890901	2500	940818	1440	1440
Redfish	2483	0										
Inner Harbor	2484	1	1660	0	1	100	1700	890901	1700	890901	1660	1660
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	820810	930715	820810	930715	2.6	-1.8	110	34.3	0.97	-5.9	2.3	
Aransas	2471	820125	930715	820125	930715	2.4	-5.72	240	179	0.99	-28	17	
Copano	2472	820125	920715	820125	920715	2.4	-3.05	220	72.3	0.98	-13	7.2	
Corpus Christi	2481	840706	930715	840706	930715	5.1	32.9	480	211	0.90	3.6	62	prob
Nueces	2482	800505	940818	800505	940818	0.98	39.7	1200	429	0.83	-16	96	poss
Redfish	2483												
Inner Harbor	2484	890901	890901	890901	890901	1							
Upper Laguna	2491												
Baffin	2492												

Table 8-22
Oyster (Code 04) PCB's in tissue (TO-PCB), status & trends statistics by major bay regions

Summary statistics

Bay	TNRCC seg	No.of obs	Avg >DL	Std devn >DL	No. >DLs	% > DLs	Min >0	date	Max	date	average with BDL=0	average with BDL=DL
Mesquite	2463	4	0	0	4	100						
Aransas	2471	6	0	0	6	100						
Copano	2472	5	0	0	5	100						
Corpus Christi	2481	3	0	0	3	100						
Nueces	2482	6	0.175	0.27	6	100	0.044	830310	0.77	840712	0.175	0.175
Redfish	2483	0										
Inner Harbor	2484	0										
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	TNRCC seg	Period of record		Start date	End date	avg obs /yr	slope (/yr)	intcp (at start)	stnd error	residl varnc	95% conf bounds on slope		trend
Mesquite	2463	820810	830622	820810	830622	4.6							
Aransas	2471	820125	930927	820125	930927	0.51							
Copano	2472	820125	840626	820125	840626	2.1							
Corpus Christi	2481	840706	840709	840706	840709	370							
Nueces	2482	800505	840712	800505	840712	1.4	0.0938	-0.075	0.231	0.75	-0.13	0.32	poss
Redfish	2483												
Inner Harbor	2484												
Upper Laguna	2491												
Baffin	2492												

Table 8-23
Blue crab (Code 10) arsenic in whole organism (TSMETAS), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	14	0	0		0	1					
Aransas	2471	0										
Copano	2472	0										
Corpus Christi	2481	14	3.82	1.8	14	100	1.5	890901	6.4	890901	3.82	3.82
Nueces	2482	3	1.72	0.32	3	100	1.5	890901	2.2	890901	1.72	1.72
Redfish	2483	2	2.96	0.55	2	100	2.4	890901	3.5	890901	2.96	2.96
Inner Harbor	2484	3	2.64	0.065	2	67	2.6	890901	2.7	781130	1.76	1.92
Upper Laguna	2491	5	10.4	7	5	100	3	890901	23	890901	10.4	10.4
Baffin	2492	5	5.82	0.86	5	100	4.6	890901	6.9	890901	5.82	5.82

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*	*trend*
Mesquite	2463	840823	841001									
Aransas	2471											
Copano	2472											
Corpus Christi	2481	890901	890901	890901	890901	14						
Nueces	2482	890901	890901	890901	890901	3						
Redfish	2483	890901	890901	890901	890901	2						
Inner Harbor	2484	771020	890901	781130	890901	0.19	0	2.7				
Upper Laguna	2491	890901	890901	890901	890901	5						
Baffin	2492	890901	890901	890901	890901	5						

Table 8-24
Blue crab (Code 10) cadmium in whole organism (TSMETCD), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	14	0.82	0.075	5	36	0.7	841001	0.9	841001	0.293	0.614
Aransas	2471	0										
Copano	2472	0										
Corpus Christi	2481	14	0.269	0.11	13	93	0.089	890901	0.47	890901	0.249	0.252
Nueces	2482	3	0.416	0.033	3	100	0.38	890901	0.46	890901	0.416	0.416
Redfish	2483	2	0.273	0.11	2	100	0.16	890901	0.39	890901	0.273	0.273
Inner Harbor	2484	3	0.433	0.13	2	67	0.3	771020	0.57	890901	0.288	0.355
Upper Laguna	2491	5	0.536	0.4	5	100	0.12	890901	1.3	890901	0.536	0.536
Baffin	2492	5	0.267	0.092	4	80	0.16	890901	0.41	890901	0.214	0.22

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*	*trend*
Mesquite	2463	840823	841001	841001	841001	5						
Aransas	2471					0						
Copano	2472					0						
Corpus Christi	2481	890901	890901	890901	890901	13						
Nueces	2482	890901	890901	890901	890901	3						
Redfish	2483	890901	890901	890901	890901	2						
Inner Harbor	2484	771020	890901	771020	890901	0.17	0	0.3				
Upper Laguna	2491	890901	890901	890901	890901	5						
Baffin	2492	890901	890901	890901	890901	4						

Table 8-25
Blue crab (Code 10) copper in whole organism (TSMETCU), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	14	10.8	3	11	79	5.7	841001	15	841001	8.51	9.59
Aransas	2471	0										
Copano	2472	0										
Corpus Christi	2481	14	17.5	4.6	14	100	7.4	890901	23	890901	17.5	17.5
Nueces	2482	3	13.9	3.7	3	100	11	890901	19	890901	13.9	13.9
Redfish	2483	2	18.9	2	2	100	17	890901	21	890901	18.9	18.9
Inner Harbor	2484	3	10.7	3.7	3	100	7.5	781130	16	890901	10.7	10.7
Upper Laguna	2491	5	12.4	3.9	5	100	7.7	890901	18	890901	12.4	12.4
Baffin	2492	5	10.4	6.3	5	100	0.93	890901	21	890901	10.4	10.4

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	840823	841001	840823	841001	100	39.5	7	2.72	0.83	-27	110	poss
Aransas	2471												
Copano	2472												
Corpus Christi	2481	890901	890901	890901	890901	14							
Nueces	2482	890901	890901	890901	890901	3							
Redfish	2483	890901	890901	890901	890901	2							
Inner Harbor	2484	771020	890901	771020	890901	0.25	0.682	7.7	0.761	0.04	-1.1	2.5	poss
Upper Laguna	2491	890901	890901	890901	890901	5							
Baffin	2492	890901	890901	890901	890901	5							

Table 8-26
Blue crab (Code 10) mercury in whole organism (TSMETHG), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	14			0	0					0	0.1
Aransas	2471											
Copano	2472											
Corpus Christi	2481	14	0.0531	0.021	11	79	0.018	890901	0.097	890901	0.0417	0.0481
Nueces	2482	3	0.0506	0.027	3	100	0.016	890901	0.082	890901	0.0506	0.0506
Redfish	2483	2	0.0123	0	1	50	0.012	890901	0.012	890901	0.00615	0.0212
Inner Harbor	2484	3	0.0448	0.015	3	100	0.024	890901	0.06	781130	0.0448	0.0448
Upper Laguna	2491	5	0.0285	0.011	5	100	0.018	890901	0.044	890901	0.0285	0.0285
Baffin	2492	5	0.0326	0.0077	3	60	0.026	890901	0.043	890901	0.0196	0.0316

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	840823	841001										
Aransas	2471												
Copano	2472												
Corpus Christi	2481	890901	890901	890901	890901	11							
Nueces	2482	890901	890901	890901	890901	3							
Redfish	2483	890901	890901	890901	890901	1							
Inner Harbor	2484	771020	890901	771020	890901	0.25	-0.00263	0.056	0.00529	0.12	-0.015	0.0099	
Upper Laguna	2491	890901	890901	890901	890901	5							
Baffin	2492	890901	890901	890901	890901	3							

Table 8-27
Blue crab (Code 10) lead in whole organism (TSMETPB), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	14			0	0					0	5
Aransas	2471											
Copano	2472											
Corpus Christi	2481	14	0.67	0	1	7	0.67	890901	0.67	890901	0.0479	0.419
Nueces	2482	3			0	0					0	0.4
Redfish	2483	2	0.391	0	1	50	0.39	890901	0.39	890901	0.196	0.396
Inner Harbor	2484	3	0.814	0.086	2	67	0.73	890901	0.9	771020	0.542	0.676
Upper Laguna	2491	5	0.458	0	1	20	0.46	890901	0.46	890901	0.0916	0.412
Baffin	2492	5	0.356	0	1	20	0.36	890901	0.36	890901	0.0712	0.391

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*	*trend*
Mesquite	2463	840823	841001			0						
Aransas	2471					0						
Copano	2472					0						
Corpus Christi	2481	890901	890901	890901	890901	1						
Nueces	2482	890901	890901									
Redfish	2483	890901	890901	890901	890901	1						
Inner Harbor	2484	771020	890901	771020	890901	0.17	0	0.9				
Upper Laguna	2491	890901	890901	890901	890901	1						
Baffin	2492	890901	890901	890901	890901	1						

Table 8-28
Blue crab (Code 10) zinc in whole organism (TSMETZN), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	14	33	9.2	14	100	23	841001	58	840823	33	33
Aransas	2471	0										
Copano	2472	0										
Corpus Christi	2481	14	28.8	9.7	14	100	15	890901	46	890901	28.8	28.8
Nueces	2482	3	26.6	3.8	3	100	23	890901	32	890901	26.6	26.6
Redfish	2483	2	23.3	5.3	2	100	18	890901	29	890901	23.3	23.3
Inner Harbor	2484	1	33.1	0	1	100	33	890901	33	890901	33.1	33.1
Upper Laguna	2491	5	24.6	8.8	5	100	16	890901	36	890901	24.6	24.6
Baffin	2492	5	45.4	52	5	100	15	890901	150	890901	45.4	45.4

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	840823	841001	840823	841001	130	-157	45	5.13	0.31	-220	-90	prob
Aransas	2471												
Copano	2472												
Corpus Christi	2481	890901	890901	890901	890901	14							
Nueces	2482	890901	890901	890901	890901	3							
Redfish	2483	890901	890901	890901	890901	2							
Inner Harbor	2484	890901	890901	890901	890901	1							
Upper Laguna	2491	890901	890901	890901	890901	5							
Baffin	2492	890901	890901	890901	890901	5							

Table 8-29
Blue crab (Code 10) PCB's in whole organism (TS-PCB), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	14			0	0					0	10
Aransas	2471	0										
Copano	2472	0										
Corpus Christi	2481	0										
Nueces	2482	0										
Redfish	2483	0										
Inner Harbor	2484	2	0.035	0	1	50	0.035	781130	0.035	781130	0.0175	0.0275
Upper Laguna	2491	0										
Baffin	2492	0										

Time trends

Bay	*TNRCC seg*	*Period of record*	*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*	*trend*
Mesquite	2463	840823 841001									
Aransas	2471										
Copano	2472										
Corpus Christi	2481										
Nueces	2482										
Redfish	2483										
Inner Harbor	2484	771020 781130	781130	781130	1						
Upper Laguna	2491										
Baffin	2492										

Table 8-30
Black drum (Code 15) arsenic in filet (TFMETAS), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	0										
Aransas	2471	1			0	0					0	0.5
Copano	2472	2			0	0					0	0.5
Corpus Christi	2481	3			0	0					0	0.5
Nueces	2482	11	0.509	0.36	10	91	0.22	940817	1.5	940817	0.463	0.508
Redfish	2483	0										
Inner Harbor	2484	0										
Upper Laguna	2491	0										
Baffin	2492	2			0	0					0	0.5

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463												
Aransas	2471	840725	840725										
Copano	2472	840627	840627										
Corpus Christi	2481	840706	840710										
Nueces	2482	840713	940817	940816	940817	3700	42.2	0.44	0.358	0.98	-180	260	poss
Redfish	2483												
Inner Harbor	2484												
Upper Laguna	2491												
Baffin	2492	840817	840817										

Table 8-31
Black drum (Code 15) cadmium in filet (TFMETCD), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	0										
Aransas	2471	1			0	0					0	0.4
Copano	2472	2			0	0					0	0.4
Corpus Christi	2481	3			0	0					0	0.4
Nueces	2482	15	0	0	0	0					0	0.253
Redfish	2483	0										
Inner Harbor	2484	0										
Upper Laguna	2491	1			0	0					0	0.2
Baffin	2492	3			0	0					0	0.4

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*	*trend*
Mesquite	2463											
Aransas	2471	840725	840725									
Copano	2472	840627	840627									
Corpus Christi	2481	840706	840710									
Nueces	2482	820923	940817									
Redfish	2483											
Inner Harbor	2484											
Upper Laguna	2491	800708	800708									
Baffin	2492	840816	840817									

Table 8-32
Black drum (Code 15) copper in filet (TFMETCU), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	0										
Aransas	2471	1			0	0					0	0.7
Copano	2472	2			0	0					0	0.7
Corpus Christi	2481	3	1.1	0	1	33	1.1	840706	1.1	840706	0.367	0.833
Nueces	2482	15	0.555	0.23	11	73	0.28	820924	1	940817	0.407	0.517
Redfish	2483											
Inner Harbor	2484											
Upper Laguna	2491	1	1.4	0	1	100	1.4	800708	1.4	800708	1.4	1.4
Baffin	2492	3	1.2	0	1	33	1.2	840816	1.2	840816	0.4	0.867

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463												
Aransas	2471	840725	840725										
Copano	2472	840627	840627										
Corpus Christi	2481	840706	840710	840706	840706	1							
Nueces	2482	820923	940817	820924	940817	0.92	0.0165	0.39	0.219	0.893	-0.019	0.052	poss
Redfish	2483												
Inner Harbor	2484												
Upper Laguna	2491	800708	800708	800708	800708	1							
Baffin	2492	840816	840817	840816	840816	1							

Table 8-33
Black drum (Code 15) mercury in filet (TFMETHG),
status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	0										
Aransas	2471	1	0.04	0	1	100	0.04	840725	0.04	840725	0.04	0.04
Copano	2472	2	0.11	0.01	2	100	0.1	840627	0.12	840627	0.11	0.11
Corpus Christi	2481	3	0.06	0.0082	3	100	0.05	840706	0.07	840710	0.06	0.06
Nueces	2482	14	0.153	0.048	14	100	0.06	840713	0.21	940817	0.153	0.153
Redfish	2483	0										
Inner Harbor	2484	0										
Upper Laguna	2491	1	0.06	0	1	100	0.06	800708	0.06	800708	0.06	0.06
Baffin	2492	3	0.0763	0.017	3	100	0.06	840817	0.099	840816	0.0763	0.0763

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463												
Aransas	2471	840725	840725	840725	840725	1							
Copano	2472	840627	840627	840627	840627	2							
Corpus Christi	2481	840706	840710	840706	840710	270	1.37	0.055	0.00408	0.25	-8.7	11	poss
Nueces	2482	820923	940817	820923	940817	1.2	0.0081	0.083	0.0236	0.24	0.0052	0.011	prob
Redfish	2483												
Inner Harbor	2484												
Upper Laguna	2491	800708	800708	800708	800708	1							
Baffin	2492	840816	840817	840816	840817	1100	-12.4	0.099	0.00408	0.06	-53	28	poss

Table 8-34
Black drum (Code 15) lead in filet (TFMETPB), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No. of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	0										
Aransas	2471	1			0	0					0	0.7
Copano	2472	2			0	0					0	1.8
Corpus Christi	2481	3			0	0					0	1.03
Nueces	2482	15			0	0					0	0.807
Redfish	2483	0										
Inner Harbor	2484	0										
Upper Laguna	2491	1			0	0					0	0.4
Baffin	2492	3			0	0					0	0.967

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*	*trend*
Mesquite	2463											
Aransas	2471	840725	840725									
Copano	2472	840627	840627									
Corpus Christi	2481	840706	840710									
Nueces	2482	820923	940817									
Redfish	2483											
Inner Harbor	2484											
Upper Laguna	2491	800708	800708									
Baffin	2492	840816	840817									

Table 8-35
Black drum (Code 15) zinc in filet (TFMETZN), status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	0										
Aransas	2471	1	3.4	0	1	100	3.4	840725	3.4	840725	3.4	3.4
Copano	2472	2	6.4	2.1	2	100	4.3	840627	8.5	840627	6.4	6.4
Corpus Christi	2481	3	4.7	0.67	3	100	4	840706	5.6	840710	4.7	4.7
Nueces	2482	15	5.34	1.3	15	100	3.8	940816	8.2	940817	5.34	5.34
Redfish	2483	0										
Inner Harbor	2484	0										
Upper Laguna	2491	1	4.4	0	1	100	4.4	800708	4.4	800708	4.4	4.4
Baffin	2492	3	4.37	0.94	3	100	3.2	840816	5.5	840817	4.37	4.37

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463												
Aransas	2471	840725	840725	840725	840725	1							
Copano	2472	840627	840627	840627	840627	2							
Corpus Christi	2481	840706	840710	840706	840710	270	123	4.3	0.204	0.093	-380	620	poss
Nueces	2482	820923	940817	820923	940817	1.3	0.0795	4.7	1.19	0.884	-0.052	0.21	poss
Redfish	2483												
Inner Harbor	2484												
Upper Laguna	2491	800708	800708	800708	800708	1							
Baffin	2492	840816	840817	840816	840817	1100	639	3.2	0.449	0.229	-3800	5100	poss

Table 8-36
Black drum (Code 15) PCB's in filet (TF-PCB),
status & trends statistics by major bay regions

Summary statistics

Bay	*TNRCC seg*	*No.of obs*	*Avg >DL*	*Std devn >DL*	*No. >DLs*	*% > DLs*	*Min >0*	*date*	*Max*	*date*	*average with BDL=0*	*average with BDL=DL*
Mesquite	2463	2			2	100						
Aransas	2471	1			1	100						
Copano	2472	2			2	100						
Corpus Christi	2481	3			3	100						
Nueces	2482	4	0.00575	0.01	4	100	0.023	820924	0.023	820924	0.00575	0.00575
Redfish	2483	0										
Inner Harbor	2484	0										
Upper Laguna	2491	1			1	100						
Baffin	2492	2			2	100						

Time trends

Bay	*TNRCC seg*	*Period of record*		*Start date*	*End date*	*avg obs /yr*	*slope (/yr)*	*intcp (at start)*	*stnd error*	*residl varnc*	*95% conf bounds on slope*		*trend*
Mesquite	2463	830622	830622	830622	830622	2							
Aransas	2471	840725	840725	840725	840725	1							
Copano	2472	840627	840627	840627	840627	2							
Corpus Christi	2481	840706	840710	840706	840710	270							
Nueces	2482	820923	840713	820923	840713	2.2	-0.00424	0.0077	0.00939	0.89	-0.041	0.032	
Redfish	2483												
Inner Harbor	2484												
Upper Laguna	2491	800708	800708	800708	800708	1							
Baffin	2492	840814	840814	840814	840814	2							

9. CONTROLS AND CORRELATES

Following the compilation of a comprehensive long-term data base for key water quality parameters, and the statistical analysis of that data base to characterize the spatio-temporal variation in water quality of the Corpus Christi Bay system, the next logical step is to attempt to infer cause-and-effect relations, either between the quality variables or between a given variable and external controls on the system. A thorough exploration of cause-and-effect hypotheses would exceed the resources of this project. Indeed, the prime objective of this project is to accomplish the data compilation, which will support such cause-and-effect studies by future researchers. Nevertheless, several straightforward evaluations are possible and useful in interpreting the results of the preceding chapters.

Generally, the processes affecting a water quality indicator may be categorized as kinetics and transport. Kinetics refers to the complex of processes that directly affect the concentration of the parameter at a point in space, including physico-chemical reactions and biological interactions, also referred to as "source-sink" processes. Transport refers to the complex of processes that affect point concentration by the movement of water masses. Transport includes the various mechanisms of circulation and dispersion responsible for the intermixing of estuary and Gulf waters (the so-called "flushing" of the estuary). The more prominent of these are reviewed in the first section below, with specific attention given freshwater inflow and density variation as controls.

Any waterborne property, including the water-quality indicators of this study, is affected by transport; the concern is the additional effect of kinetics and its relative magnitude compared to transport. A relative evaluation is based upon the rate coefficients governing the kinetics to which the property is subjected, and the proximity and significance of any boundary feature which creates a gradient in concentration within the system. Table 9-1 summarizes typical magnitudes for kinetic processes affecting important or representative water-quality parameters. The higher the kinetic rate, the more important kinetic processes are inclined to be, relative to transport processes. On the other hand, in the vicinity of a steep concentration gradient—e.g., in proximity to an outfall containing high concentrations of the parameter of concern—transport processes can become locally dominant. In the present context, the emphasis is on large-scale variations in the Corpus Christi Bay complex, not the small-scale neighborhoods of point sources.

From Table 9-1, it is apparent that salinity, mercury, and PCB's are virtually conservative, while DO, temperature, coliforms, PAH's and Aldrin are very reactive. Therefore, we would expect that the horizontal gradients of salinity and metals would be governed by boundary fluxes and internal transports, while DO, temperature, coliforms, etc., are more influenced by point processes and much less by boundary fluxes. This indeed is the case. Salinity, for example, is determined by the interplay of boundary fluxes—freshwater inflow and the Gulf of Mexico salinity regime—and the various mechanisms of internal hydrographic transport. Temperature and DO, on the other hand, are dominated by seasonal

TABLE 9-1
Typical rate coefficients for representative water quality parameters, from Ward and Armstrong (1992a)

parameter	*process*	*rate coefficient* (day^{-1})
salinity	increase by evaporation	0.002
temperature	radiation	0.3
dissolved oxygen	aeration	0.5
ammonia-nitrogen	nitrification	0.1
suspended particulates	settling	
fine sand, 100 μm		300
fine silt, 10 μm		5
medium clay, 1 μm		0.05
coliforms	die-off in open water	1
mercury	aquatic metabolism	0.001
PAH's	volatilization	1
DDT	volatilization	0.1
	hydrolysis	0.01
Aldrin	volatilization	1
PCB's	photolysis	0.01

meteorology—winds, air temperature, etc.—and much less by the effect of inflow and exchange with the Gulf of Mexico. (These nominal reaction rates, it should be noted, are with respect to the vertical-mean concentration. For such averaging, true conservative parameters, such as salinity and suspended sediment, and nearly conservative parameters, such as temperature, exhibit an *effective* reaction due to vertical transport processes, as characterized by the indicated rate coefficient. For example, evaporation, a volume flux of water from the upper boundary acts as an effective source of vertical-mean salinity.)

Kinetics and transport processes may be termed "internal controls" on water/sediment concentrations, in that they operate within the interior of the estuary fluid volume. In contrast, "external controls" are those physicochemical factors that are applied around the periphery of the estuary, creating internal responses that are manifested as distributions of water/sediment indicators. Alternative terms for these external controls are "external forcing" or "boundary conditions." Interpretation of the behavior of a water/sediment constituent in any watercourse requires knowledge of both internal controls and external controls. For an estuary, Corpus Christi Bay included, the transitional nature of the system makes external controls especially important.

9.1 External Controls

9.1.1 Overview

The two most important classes of external controls are hydrography and loadings. The former refers to the hydrodynamic forcing of the estuary. For convenience, we include climatological forcing in this category, because atmospheric variables achieve both climatological and hydrographic forcing. The latter refers to influxes of constituents that are indicators of water/sediment quality in their own right, or, through kinetic processes, have a direct influence on such indicators.

Hydrography of the Corpus Christi Bay system, like most estuaries, is principally governed by four physical factors: tides, meteorology, density currents and freshwater inflow. Each of these is highly variable in time and the character of the bay depends upon their relative predominance. Thus, the hydrography of the bay varies from season to season and year to year, and frequently on even abrupt time scales. The hydrography of Gulf coast estuaries is surveyed in Ward (1980a) and Ward and Montague (1996), and references therein, and the hydrography of Corpus Christi Bay in particular is addressed in TDWR (1981) and Orlando et al. (1993).

The most obvious marine influence is the tide. In the Texas Gulf coast area, the principal astronomical determinant for tidal variability is the declination of the moon. At great declination, the tide is predominantly diurnal and of maximum range, while at small declination, the diurnal component disappears so that the tide becomes semi-diurnal and of minimum range. Tidal range on the Gulf of Mexico shoreface in the vicinity of Corpus Christi Bay is typically on the order of 0.8 m during the diurnal mode of the tide. As the tide propagates into Corpus Christi Bay it is lagged in phase and attenuated in amplitude. The extreme constriction of the tidal passes reduces the tidal amplitude and significantly filters the semidiurnal component. Within the even more constricted areas of the interior bays, such as the Laguna Madre, even the diurnal component is significantly filtered. The tide is manifested in the inlets and lower segments of the bay as a progressive long wave. Within the bay, the effects of constraining physiography introduces a standing-wave component; indeed, in the open main body of Corpus Christi Bay, the tide becomes predominantly a standing wave.

These observations are relative to variation over a tidal cycle and do not represent the total excursion in water level in Corpus Christi Bay. During the cycle of lunar declination, there is also a storage and depletion of water within the system, with generally higher mean water levels during the semidiurnal phase, producing a fortnightly periodicity. In the Gulf there is a longer-term secular rise and fall in water levels, partly astronomical in origin, but mainly climatological. The seasonal meteorology leads to a characteristic annual variation in water levels along the nearshore Gulf of Mexico, bimodal along the Texas coast with maxima in spring and fall, and minima in winter and summer. The winter minimum and fall maximum dominate this pattern in the Corpus Christi region, with a net range on the order of 0.3 m, but with year-to-year variability in this range. Illustrative of the western Gulf secular variation is the long-term mean range in the *monthly mean* tide record at Galveston is from -2.8 to +1.8 ft NGVD (Harris, 1981), which includes both astronomical and meteorological effects. Further, meteorological systems can induce shorter term fluctuations in Gulf water levels, so-called "wind tides" described further below.

While the tide is the most obvious marine influence on Corpus Christi Bay, the most obvious freshwater influence is the inflows of the principal rivers. The predominant source of freshwater inflow to the main body of Corpus Christi Bay is the Nueces River, comprising the majority of inflow to the system. The freshwater inflow is responsible for the estuarine character of Corpus Christi Bay, in diluting ocean water and establishing a gradient in salinity across the system. Inflow has a twofold importance to this study, in that it is a primary control on transport and mixing, and is also an important source of external loadings. Inflow is also important analytically, because there is an extended detailed time record of measurements available for the system, which can in principle be combined with the water quality data of this project. The analysis and behavior of inflow are therefore treated in more detail in Section 9.1.2 below.

In addition to tides and inflows, the atmosphere (in which we include insolation) has a significant influence on Corpus Christi Bay. The atmosphere governs the heat budget of the estuary waters, and thus the magnitude and seasonal progression of water temperatures. Evaporation from the surface, controlled by humidity, temperature and wind, is a significant element in the water budget. From a hydrographic viewpoint, wind forcing is the most important meteorological influence. Due to the broad, shallow physiography of the bay, as well as the dynamic meteorological regimes of the area, the bay is very responsive to wind forcing. This response is manifested in three general ways: the development of windwaves, the generation of internal wind-driven circulations, and the excursions in water level. Windwaves are important from the standpoint of creating intense vertical mixing, and thus vertical near-homogeneity of waterborne constituents, especially in the shallow portions of the system. Windwaves also aerate the water column. Wind-driven circulations are to be expected due to the relatively steady prevailing winds in combination with the morphology of the bay, but there is little quantitative information available concerning theses circulations. (Their existence is predicted by dynamical models, but the accuracy of these predictions is dubious without field validation.) For other Texas estuaries such wind-driven circulations have been documented by observations, for instance in Galveston Bay and Sabine Lake.

Perhaps the most dramatic meteorological effect is that of denivellation, i.e. meteorologically forced variations in water level. Indeed, in Corpus Christi Bay, it is meteorology, not the tide, which is the dominant factor governing the day-to-day excursions in water level. Part of this is the general response of the northwestern Gulf of Mexico to the imposed windstress of southeasterly winds about the Bermuda High and northerlies associated with midlatitude synoptic disturbances, which is communicated through the inlets of Corpus Christi Bay. Within the bay, meteorological systems affect the water-level variation even more, mainly due to constrictions of land boundaries. Strong onshore winds can "setup" water levels in the upper bay. North winds, especially following vigorous frontal passages, can induce dramatic "setdown," and are capable of evacuating a significant portion of the bay volume in a few hours. (For bays on the upper Texas coast, with more open inlets, as much as half of the volume of the bay can be evacuated, see Ward, 1980a, 1980b.) Even modest weather systems significantly perturb water levels to the point that the astronomical tide is obliterated. This is especially true in the inland or isolated reaches of the bays, such as Copano Bay, Baffin Bay, and the Upper Laguna Madre.

The horizontal gradient in salinity in concert with variations in depth produce the fourth important component of estuarine circulation, the density current. This is one of the prime mechanisms for salinity intrusion into an estuary system, and is especially prominent in many dredged ship channels. Density currents are exhibited in two different forms: vertical shear in the horizontal current, and large-scale horizontal circulations. The vertical shearing density current is found particularly in deep channels that are laterally confined. A well-documented example on the Texas coast is the Houston Ship Channel above Morgans Point (see Ward and Armstrong, 1992a and references therein). Usually this kind of current is exposed by averaging vertical profiles of current velocity over a tidal cycle. This is the classical estuarine density current observed in these types of systems since the nineteenth century, whose mechanics is that of denser water underflowing and displacing lighter water. The resultant circulation is a tidal-mean influx from the sea into the estuary in the lower layer, and a return flow from the estuary to the sea in the upper layer.

The second kind of density current results from the absence of laterally confining boundaries, so that the return flow is completed in the horizontal plane, rather than in the vertical. This circulation is induced by the presence of a deep trough in open waters of an estuary, such as a talweg or dredged channel. In this case, the vertical-mean current is directed up (into) the estuary along the axis of the trough, and the return flow to sea takes place in the shallow open bay to either side. In a broad estuary with a natural bathymetry of deeper water near the center and shallower near the side, a combined circulation results with both horizontal and vertical shear, and with secondary circulations in a plane inclined intermediate between the vertical and the horizontal.

The above description of density currents did not refer to vertical stratification. Either kind of density current can occur even when the water-column salinity is homogeneous, because the driving force for density currents is the *horizontal* gradient. The confined density current, especially, will tend to develop salinity stratification, but if the vertical mixing processes are sufficiently intense, as they typically are in Corpus Christi Bay, the salinity can still be maintained nearly homogeneous in the vertical. More detailed information on estuarine density currents is given in Ward and Montague (1996). The potential rôle of a density current in Corpus Christi Bay is addressed in Section 9.2 below in the context of salinity intrusion.

9.1.2 Freshwater inflow

The principal direct riverine inflow to the Corpus Christi Bay Study Area system, including the upper bays of Copano and Aransas and the lower bays of Baffin and the Laguna is the Nueces River. In addition, there are several smaller rivers such as the Mission and Aransas Rivers, and numerous minor tributaries which drain the watershed of the study area and can be locally important as fresh water sources. These include Copano Creek, Oso Creek, Olmos Creek, San Fernando Creek, and Petronila Creek. The key word in the first sentence above is "direct" because an important indirect riverine inflow is the combined inflow of the San Antonio and Guadalupe Rivers, which does not enter the study area *per se*, but debouches into the next bay to the north, San Antonio Bay. There is free communication between this system and the Aransas-Copano system, through Ayres-Carlos-Mesquite Bays, and there is some indication that on a long-term basis this inflow has an effect on salinities in the upper part of the study area.

As noted above, the flow of the Nueces River is important to the hydrography of the main body of Corpus Christi Bay, and the variation of this river is central to the overall effect of inflow on the bay system (see TDWR, 1981). The Nueces is also the only riverine source for which an accurate history of gauge measurements exists. (Some of the other tributaries to the system, such as Oso Creek and the Mission River, are also gauged, but the proportion of their total watershed that is gauged is much lower than that for the Nueces.) Thus one problem in analyzing freshwater inflows to the overall system is the lack of measured streamflow.

For this study, we have utilized the work in a companion CCBNEP project, the Freshwater Inflow Status and Trends Study performed by the U.S. Geological Survey (Mosier et al., 1995). USGS subdivided the watershed of the CCBNEP study area into 17 distinct subwatersheds. For each of these, the HSPF model (essentially the Stanford Watershed Model, e.g., Singh, 1989) was applied. This is a numerical runoff computation utilizing inputs of soils, land use, precipitation, wind and air temperature to compute a complete surface water budget, from which daily streamflow in the drainage channel was calculated. USGS then combined these subwatersheds into watersheds for component bays of the study area, as follows:

Copano Bay	St. Charles Bay
Redfish Bay	Corpus Christi Bay*
Upper Laguna	Baffin Bay

* including the ungauged Nueces watershed downstream from Mathis

The simulated ("synthetic") inflow records from these six component watersheds together with the gauged flow in the Nueces at Mathis comprise the total inflow to the CCBNEP Study Area. (We note two exceptions to this statement. No accounting is made for runoff from the barrier islands to the bay, and the watershed draining into the south shoreline of Baffin Bay is not addressed. Neither of these are considered to be of importance to the overall freshwater inflow to the system.) USGS provided digital copies of the simulated daily flows for each of these component watersheds to this project. The reader is referred to the USGS report Mosier et al. (1995) for detailed information on application of the watershed model and analysis of the simulated data, as well as comparison to the Texas Water Development Board statistical model for nongauged areas TxRR (Longley, 1994).

Inflow into Corpus Christi Bay is highly variable, but the question is whether this variability has definite patterns. River flow in the Texas climate is governed by surface runoff from storm systems; this means the rivers are "flashy," exhibiting large, sudden excursions in flow. The daily flow of the Nueces, as a case in point, spans four orders of magnitude. One would therefore expect a seasonal variation, correlated with the usual climatological pattern of storms. But the details of each "season," each of which is in fact a series of quickflow spikes, will vary from year to year, and systematic variation can be extracted only by averaging over a long period of record. Flows on the upper Texas coast, e.g. the Trinity River (see Ward and Armstrong, 1992a), have a predominant pattern of an annual "flood" and an annual "drought," the flood being the spring freshet, which typically occurs in April and May, and the drought is the summer low-flow season typically extending from July through October. With distance down the Texas coast, the spring freshet diminishes in importance, due to reduced southward penetration by midlatitude disturbances. But a fall maximum, originating from tropical processes, such as the interplay of Gulf windflow with subtropical disturbances and from landfalling tropical depressions, becomes increasingly important with distance south. This is illustrated by the pattern of inflow in the Nueces.

Figure 9-1 shows the daily flow of the Nueces at Mathis averaged over the 26-year period 1968-1993. This period was employed because it corresponds to the period used by USGS for generating synthetic inflow hydrographs from the component watersheds. But this is a satisfactory data-analysis period because it encompasses the periods of most intense data collection of the water/sediment quality historical data base, cf. Figs. 5-80 *et seq*., and is also sufficiently long to encompass a range of variation in the controlling parameters. Figure 9-1 shows the degree of smoothing achieved by longer averaging windows. On a daily basis there is little year-to-year consistency, because the occurrence of quickflows within a given season is more-or-less random, and therefore the 26-year means of daily flows are clearly influenced by individual spikes of inflow occurring in the data record. When the daily flow record is further smoothed by a sliding 11-day window centered on a given day, the spikes are diminished, see the broken trace of Fig. 9-1, but the record is still subject to random surges. For most of the analyses of this study, we employed a monthly averaging period. In Fig. 9-1, the basic bimodal character of the seasonal Nueces inflow is apparent in the late spring and early fall maxima.

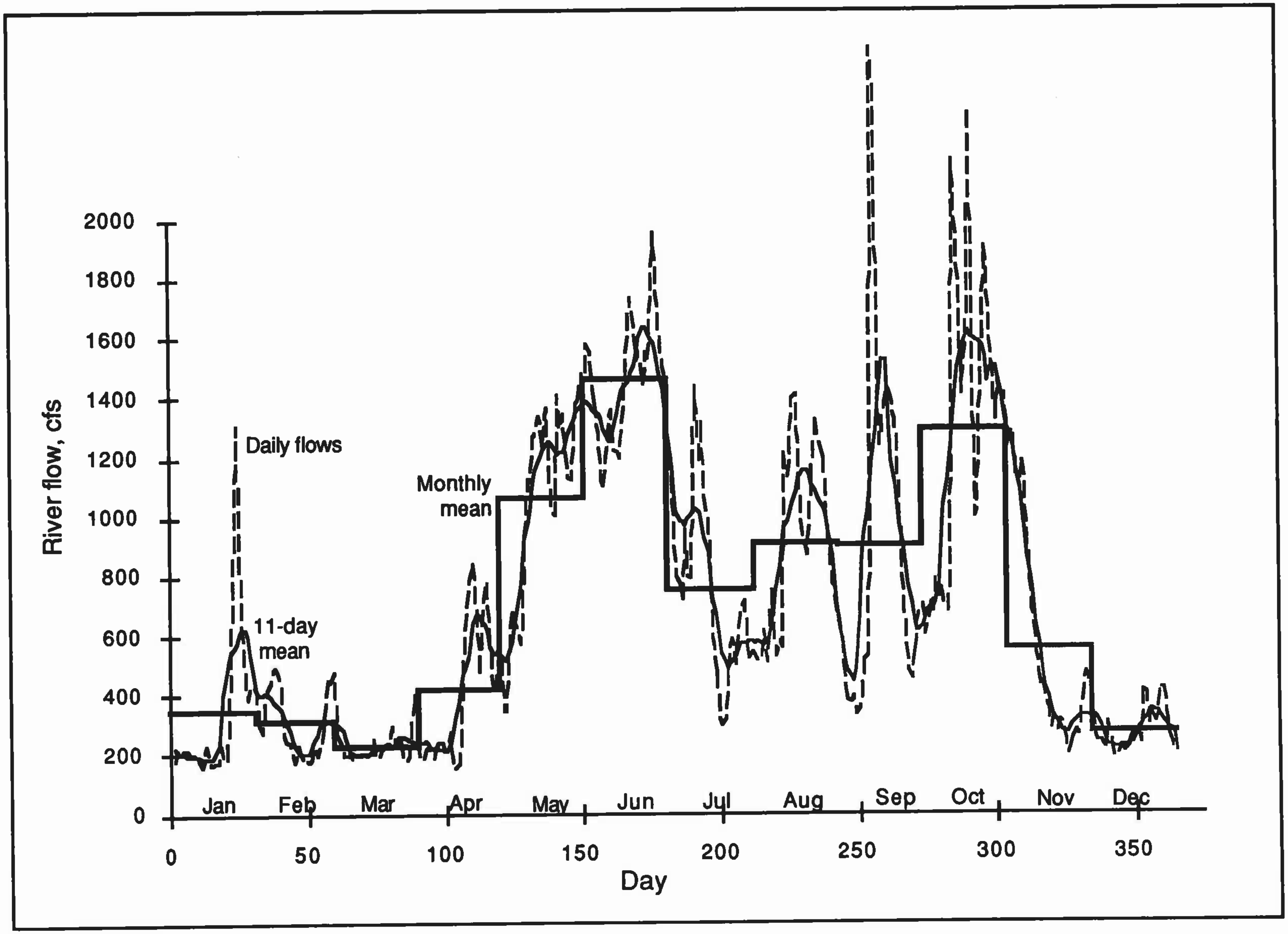


Figure 9-1. Nueces at Mathis, 1968-93, daily flow and longer-period averages

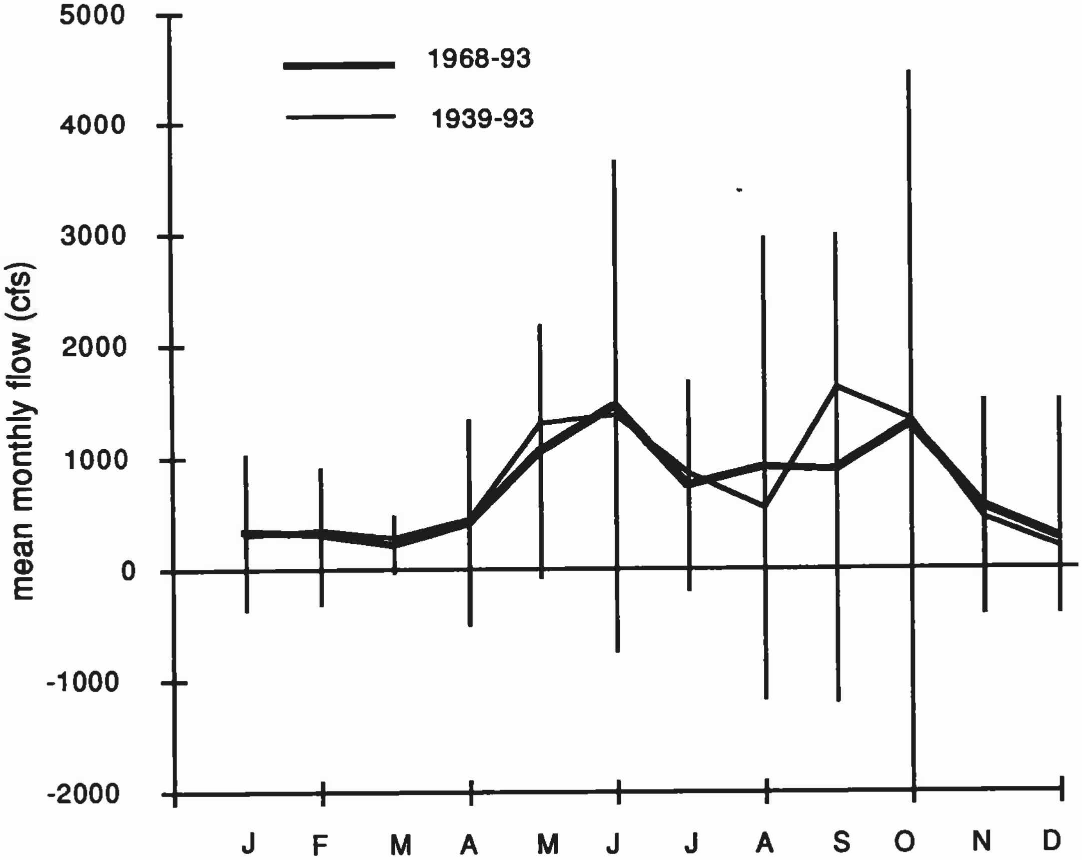
Additional features of the monthly averaged inflow record of the Nueces are shown in Fig. 9-2. In Fig. 9-2 (a), the study analysis period of 1968-1993 is compared to the longer gauge period of record of 1939-93. Despite the fact that the latter includes the 1964 drought of record and the extended drought of the 1950's, the mean annual monthly pattern is quite comparable to the 1968-93 study period. The variability of the Nueces is extreme even at a monthly averaging level, as evidenced by the standard deviation of the monthly means, shown by the vertical bars of Fig. 9-2 (a). Of course, negative values of monthly mean flow do not occur. The fact that the standard deviations extend into negative values indicates the skew in the data record toward more frequent occurrences of low monthly flows. As the monthly flow increases, so does the variance in the data record, as demonstrated by the plot of standard deviation versus monthly mean flow of Fig. 9-2 (b). This means that the coefficient of variation is fairly constant for the Nueces monthly data, and is high, about 175%. Table 9-2 presents the monthly mean and annual inflows for each of the component watersheds for the CCBNEP Study Area, including the gauged watershed of the Nueces. These same monthly flows are depicted graphically in Figs. 9-3 and 9-4, the former by individual watersheds and the latter by accumulated inflow from south to north.

The most important aspect of the year-to-year variation in annual discharge is how that is manifested in the occurrences of high flows. That is, the freshet is the central feature of the annual hydrograph. Some years exhibit a pronounced and extended freshet, while in other years freshets may be totally absent. Correspondingly, in some years the summer low-flow season may be shortened or even eliminated by unusual runoff, and in other years may be prolonged while the flows dwindle to nothing. To exhibit quantitatively the hydrologic behavior of inflows, the monthly-mean flow record for the 1968-93 period was analyzed for each of the component watersheds from the USGS simulations and the gauged flow of the Nueces. Figure 9-5 and Table 9-3 exhibit the mean annual inflow for each of the component watersheds over this period. As an approximate index to freshet behavior, it was postulated that a two-month sequence would capture the freshet in each of the watersheds, so for each year the highest two-month inflow was determined. This two-month average is also tabulated in Table 9-3. It is remarkable that for most of the inflow to the Study Area, these two months average half of the annual inflow, as shown in Fig. 9-6 and Table 9-3. The two-month average inflow for this maximal two-month sequence and the month in which it began are graphed in Figs. 9-7 and 9-8.

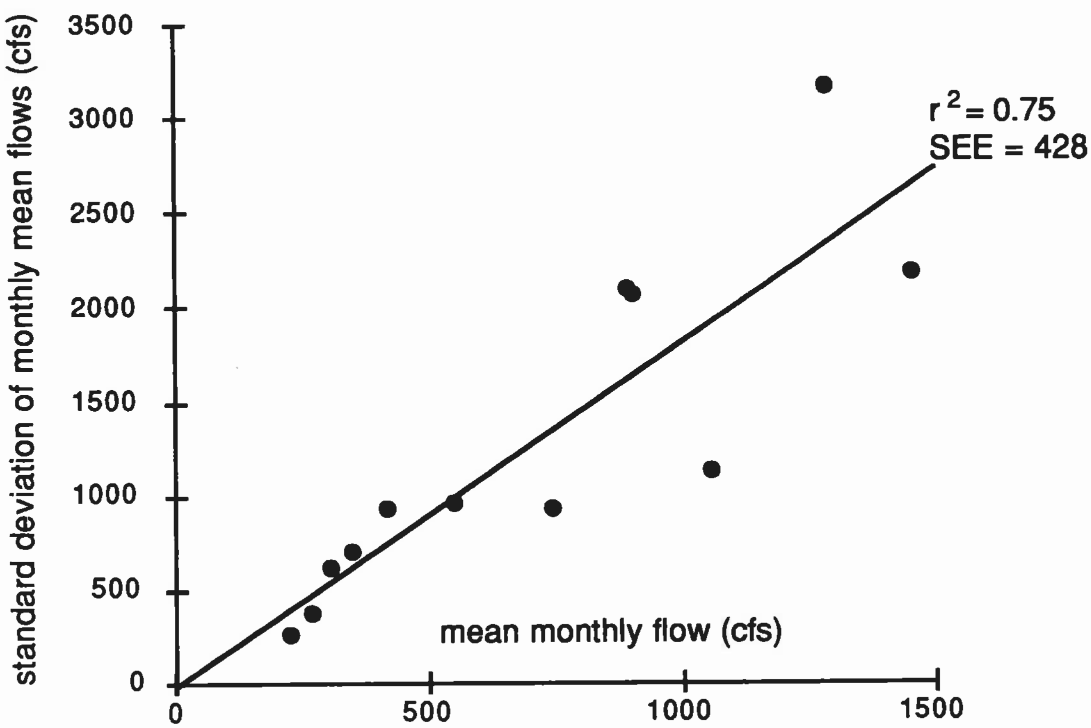
Several observations are noted from these analyses:

(1) The two most prolific sources of inflow are Copano Bay and the Nueces River, in that order. Corpus Christi Bay is a distant third. However, there is considerable year-to-year variation in the magnitude and order of the annual inflow. The highest inflow of the 1968-93 period occurred in 1971.

(2) According to the results of the USGS HSPF simulation, the gauged flow of the Nueces less diversions and return flows comprises on average about 75% of the



(a) Monthly flows, mean and standard deviation of mean



(b) Standard deviation of monthly mean flows versus mean flows

Figure 9-2. Nueces at Mathis, monthly mean flows

Table 9-2

Monthly mean flows (1968-93) for principal component watersheds in CCBNEP study area

	Baffin	*Upper Laguna*	*Corpus Christi*	*Nueces River**	*Redfish*	*Copano*	*St. Charles*	*Total*
J	141	4	150	347	15	791	113	1561
F	193	6	166	308	14	905	171	1763
M	46	4	95	227	9	441	66	888
A	29	2	80	419	9	279	29	847
M	73	5	180	1061	18	695	69	2101
J	242	12	338	1459	18	1513	97	3679
J	114	5	223	749	14	992	100	2197
A	108	6	169	905	13	479	40	1720
S	296	9	468	895	33	1988	224	3913
O	371	11	278	1288	21	1475	98	3542
N	76	4	124	551	13	690	118	1576
D	71	3	110	268	13	741	128	1334

Annual average flows

Baffin	*Upper Laguna*	*Corpus Christi*	*Nueces River**	*Redfish*	*Copano*	*St. Charles*	*Total*
147	6	198	706	16	916	104	2093

Fraction (percent) of total inflow to Study Area

Baffin	*Upper Laguna*	*Corpus Christi*	*Nueces River**	*Redfish*	*Copano*	*St. Charles*	*Total*
7	0	9	34	1	44	5	100

* At Mathis gauge, uncorrected for diversions and return flows

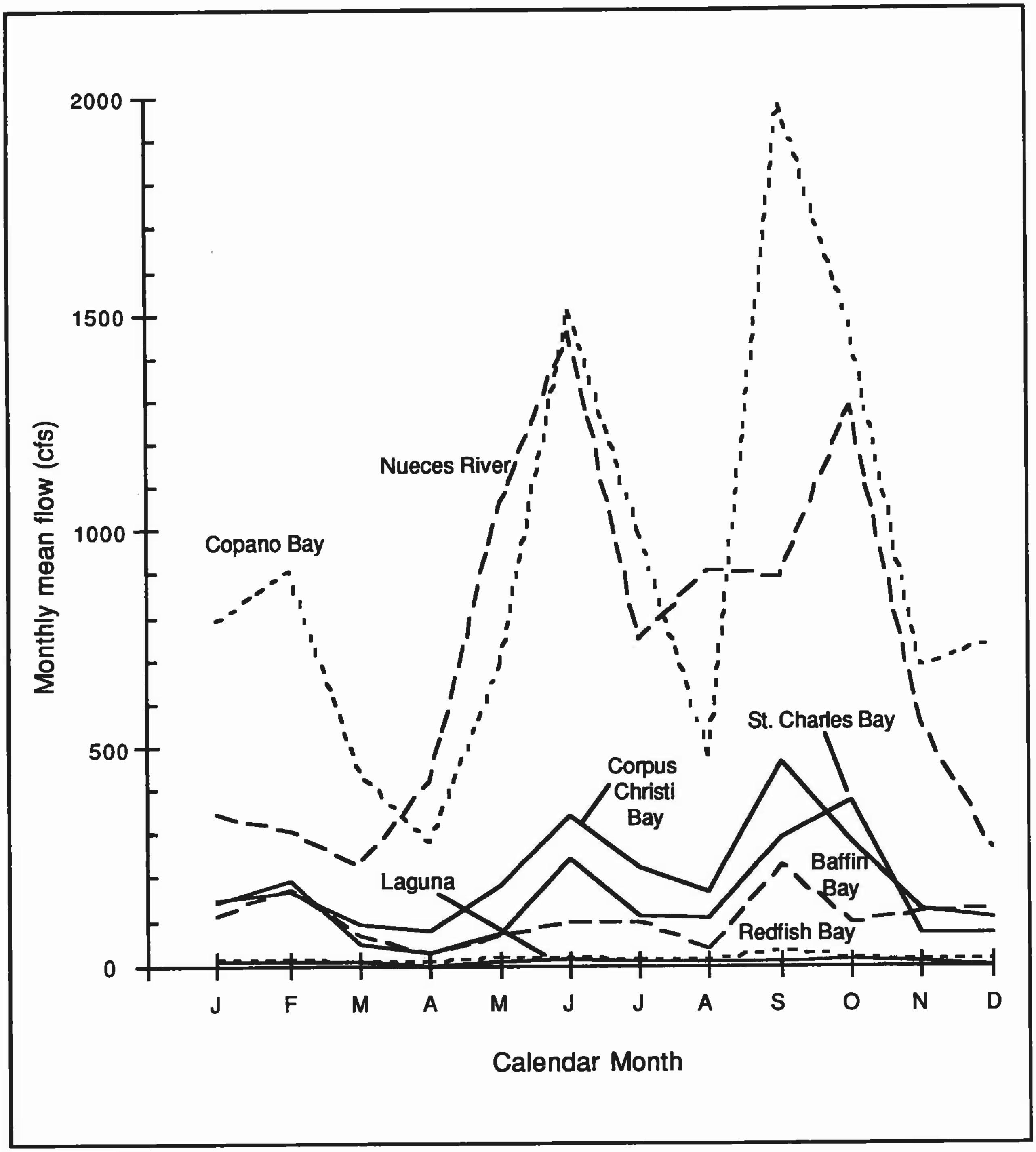


Figure 9-3. Monthly mean inflows (1968-93) for principal watersheds draining into Corpus Christi Bay Study Area

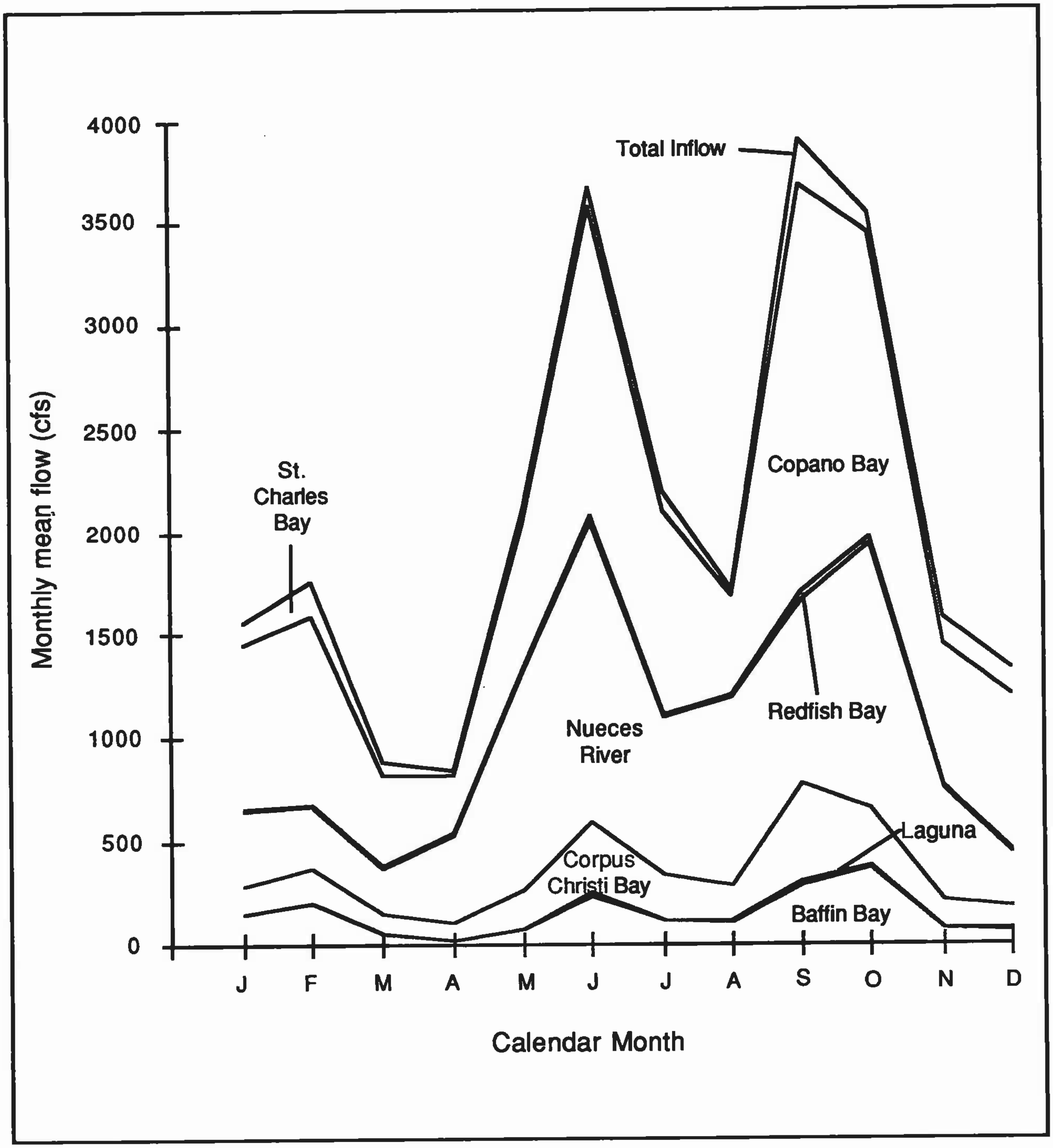


Figure 9-4. Monthly-mean inflows (1968-93) for principal watersheds draining into Corpus Christi Bay Study Area, accumulated from south to north.

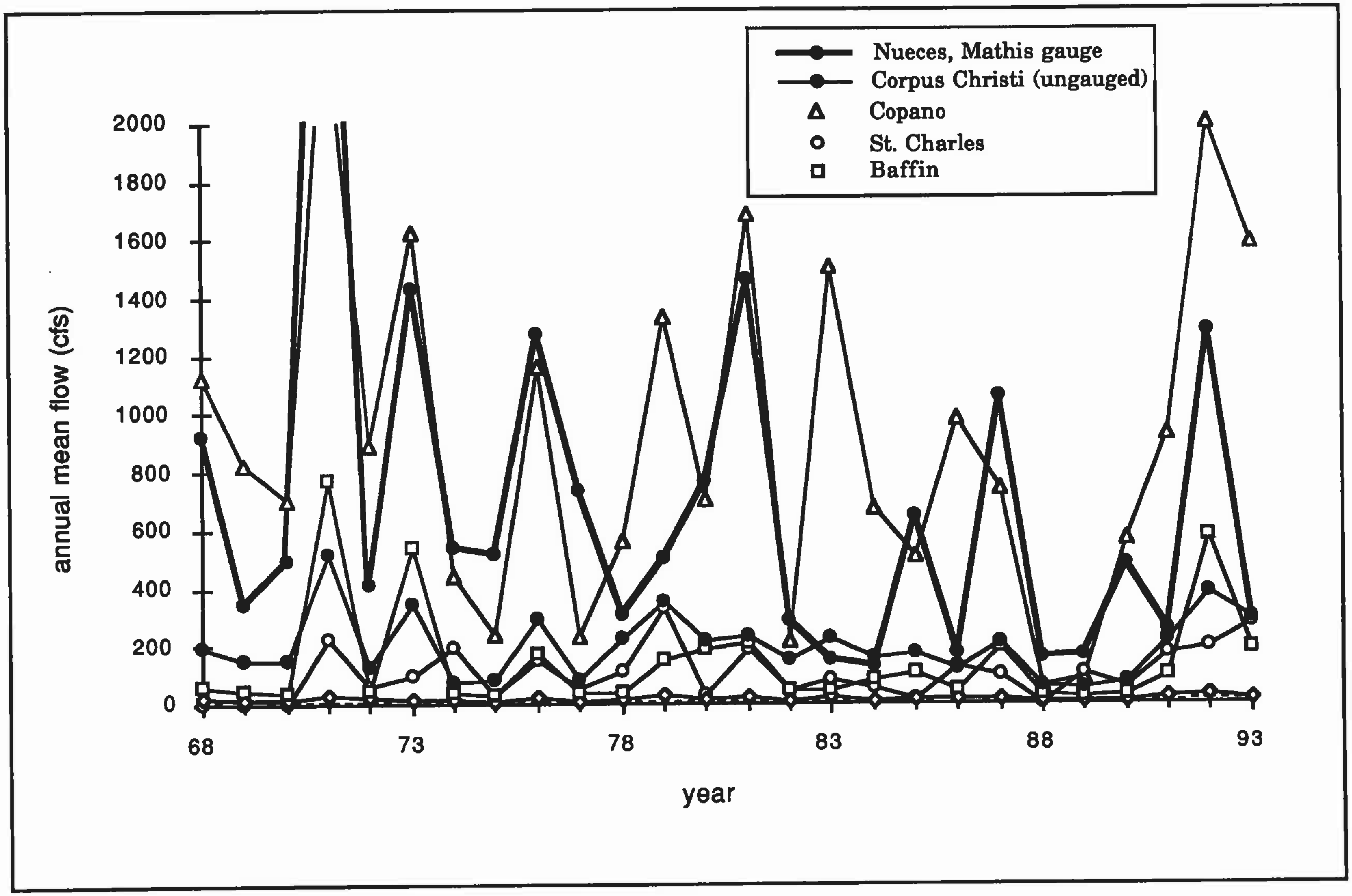


Figure 9-5. Annual mean flow for 1968-93 period by component watershed

Table 9-3
Annual inflow measures by component watershed, 1968-93, in cfs

	St Charles				Copano				Redfish			
year	*mean*	*freshet mean*	*first month*	*ratio*	*mean*	*freshet mean*	*first month*	*ratio*	*mean*	*freshet mean*	*first month*	*ratio*
68	1.2	7.1	4	1.00	1123	4118	5	0.61	19.7	45.7	5	0.39
69	0.1	0.5	11	1.00	827	2090	11	0.42	13.5	28.1	11	0.35
70	0.0	0.0	11	-	708	2377	9	0.56	18.3	66.0	9	0.60
71	226.8	597.0	11	0.44	2413	12558	9	0.87	31.7	120.5	9	0.63
72	63.3	195.1	4	0.51	895	2958	5	0.55	19.5	42.3	5	0.36
73	99.5	381.4	9	0.64	1625	4618	9	0.47	14.8	33.0	9	0.37
74	192.2	890.2	11	0.77	443	1255	9	0.47	13.6	31.3	5	0.38
75	26.9	127.4	8	0.79	240	813	9	0.57	10.1	20.5	8	0.34
76	148.0	515.7	11	0.58	1160	3159	11	0.45	22.1	40.7	11	0.31
77	51.8	149.6	5	0.48	230	813	1	0.59	9.9	16.0	4	0.27
78	115.5	532.2	9	0.77	562	2347	8	0.70	12.7	32.6	9	0.43
79	332.3	1189.2	8	0.60	1332	3617	8	0.45	27.8	71.2	8	0.43
80	29.1	130.5	8	0.75	705	2635	8	0.62	11.3	32.2	8	0.47
81	189.1	743.8	5	0.66	1687	3455	10	0.34	20.7	30.8	10	0.25
82	45.3	175.7	2	0.65	217	1129	2	0.87	6.1	13.6	2	0.37
83	85.2	250.3	9	0.49	1507	4984	9	0.55	19.4	44.0	6	0.38
84	52.3	225.7	10	0.72	671	2047	1	0.51	7.5	16.5	9	0.37
85	16.8	61.1	3	0.61	508	974	3	0.32	13.1	21.5	9	0.27
86	129.3	549.0	10	0.71	983	3038	10	0.51	12.4	23.2	9	0.31
87	96.1	219.4	6	0.38	742	1946	6	0.44	14.1	22.8	6	0.27
88	0.4	1.0	6	0.40	63	128	9	0.34	8.5	15.9	8	0.31
89	103.0	347.0	1	0.56	92	266	6	0.48	7.4	15.0	6	0.34
90	63.5	191.5	7	0.50	571	2051	7	0.60	10.1	15.5	2	0.26
91	175.9	435.4	11	0.41	927	2578	11	0.46	21.8	42.2	11	0.32
92	198.3	646.0	1	0.54	2001	6984	1	0.58	27.9	103.1	1	0.62
93	274.7	1297.7	2	0.79	1587	5412	5	0.57	15.3	35.9	2	0.39
mean	104.5	379.2	11*	0.63	916	3013	9*	0.54	15.7	37.7	9*	0.38

* Most frequent month

Table 9-3
(continued)

year	Nueces River mean	Nueces River freshet mean	Nueces River first month	Nueces River ratio	Corpus Christi mean	Corpus Christi freshet mean	Corpus Christi first month	Corpus Christi ratio	Baffin mean mean	Baffin freshet month	Baffin first	Baffin ratio
68	920	2502	5	0.45	198.2	656.9	5	0.55	62.8	208.4	5	0.55
69	344	1167	10	0.57	153.4	382.8	11	0.42	45.4	95.7	8	0.35
70	496	2103	5	0.71	153.4	356.0	9	0.39	38.8	73.4	5	0.31
71	3487	12887	9	0.62	517.2	2550.1	9	0.82	770.8	4218.6	9	0.91
72	409	1406	5	0.57	126.2	247.3	5	0.33	45.2	94.5	5	0.35
73	1431	4405	9	0.51	345.8	1021.2	9	0.49	537.8	2333.4	9	0.72
74	540	2021	8	0.62	75.6	132.5	5	0.29	37.3	60.4	2	0.27
75	516	1795	5	0.58	82.3	230.4	8	0.47	33.2	75.0	7	0.38
76	1276	3545	10	0.46	293.3	1003.0	6	0.57	173.6	433.9	11	0.42
77	735	3008	4	0.68	83.1	146.5	4	0.29	33.9	62.1	5	0.31
78	308	940	8	0.51	222.0	585.5	6	0.44	37.5	80.9	9	0.36
79	505	1995	5	0.66	351.2	1498.5	8	0.71	147.2	563.5	9	0.64
80	767	2760	8	0.60	215.4	1015.8	8	0.79	187.3	808.8	8	0.72
81	1458	5148	5	0.59	229.7	494.8	6	0.36	206.4	927.6	6	0.75
82	287	947	5	0.55	148.6	623.6	2	0.70	46.1	156.2	2	0.56
83	148	176	5	0.20	226.0	688.7	6	0.51	43.9	73.4	6	0.28
84	129	178	4	0.23	154.7	453.7	10	0.49	81.3	341.6	10	0.70
85	646	1620	10	0.42	174.5	348.7	9	0.33	102.8	317.4	10	0.51
86	175	387	11	0.37	117.4	255.2	11	0.36	48.4	119.8	11	0.41
87	1053	5010	6	0.79	210.2	534.1	6	0.42	194.9	521.1	5	0.45
88	158	197	7	0.21	58.7	137.1	9	0.39	28.0	60.0	9	0.36
89	166	199	7	0.20	53.7	74.9	8	0.23	21.7	40.7	8	0.31
90	481	1562	7	0.54	77.8	208.8	3	0.45	30.3	54.5	3	0.30
91	252	487	5	0.32	215.7	476.2	11	0.37	94.9	356.5	11	0.63
92	1283	3094	5	0.40	379.3	1459.1	1	0.64	576.9	3144.0	1	0.91
93	296				292.6	1369.9	5	0.78	190.1	1009.0	6	0.88
mean	703	2382	5*	0.49	198.3	652.0	8*	0.48	146.8	624.3	5,9*	0.51

* Most frequent month

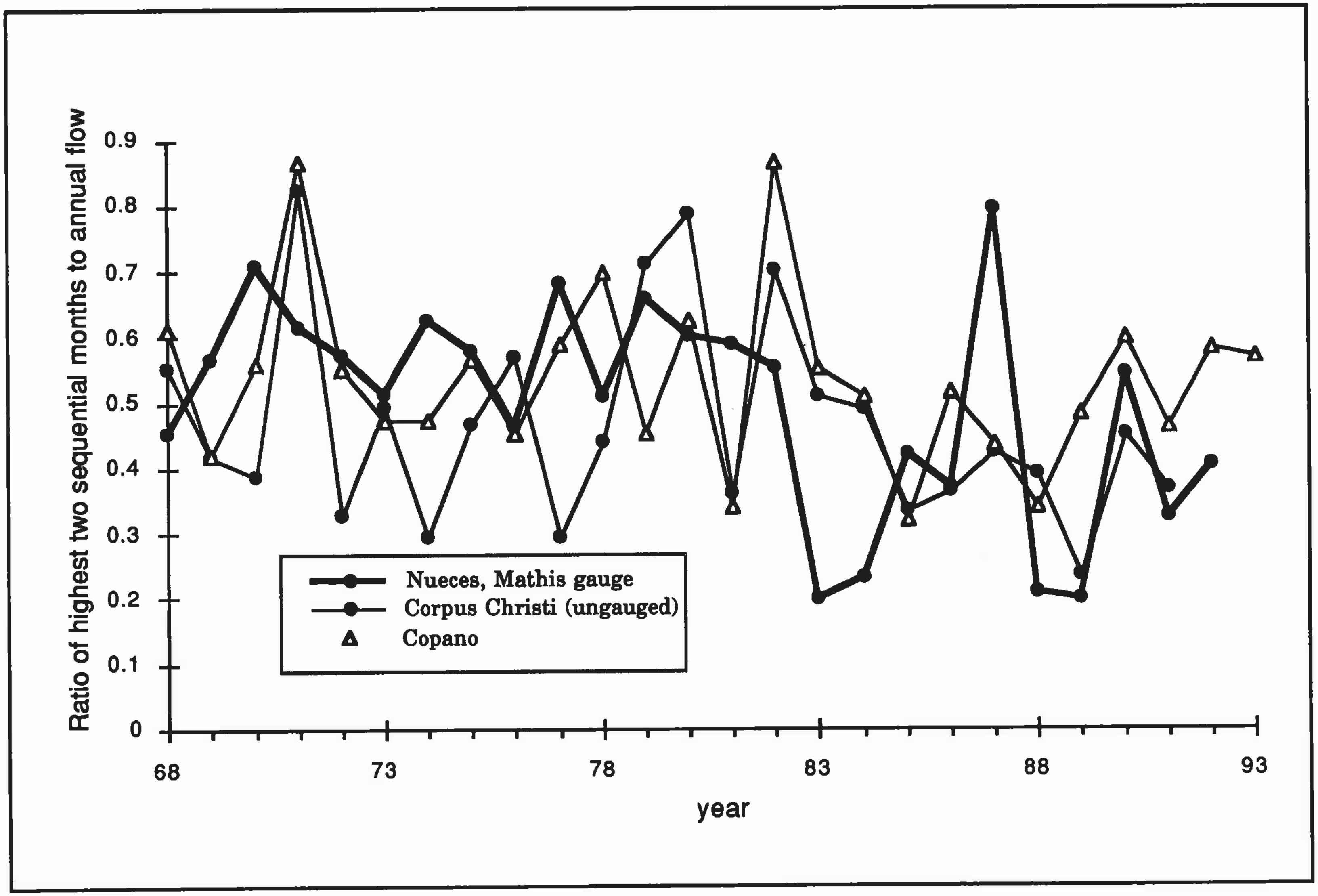


Figure 9-6. Proportion of annual flow in maximal two sequential months

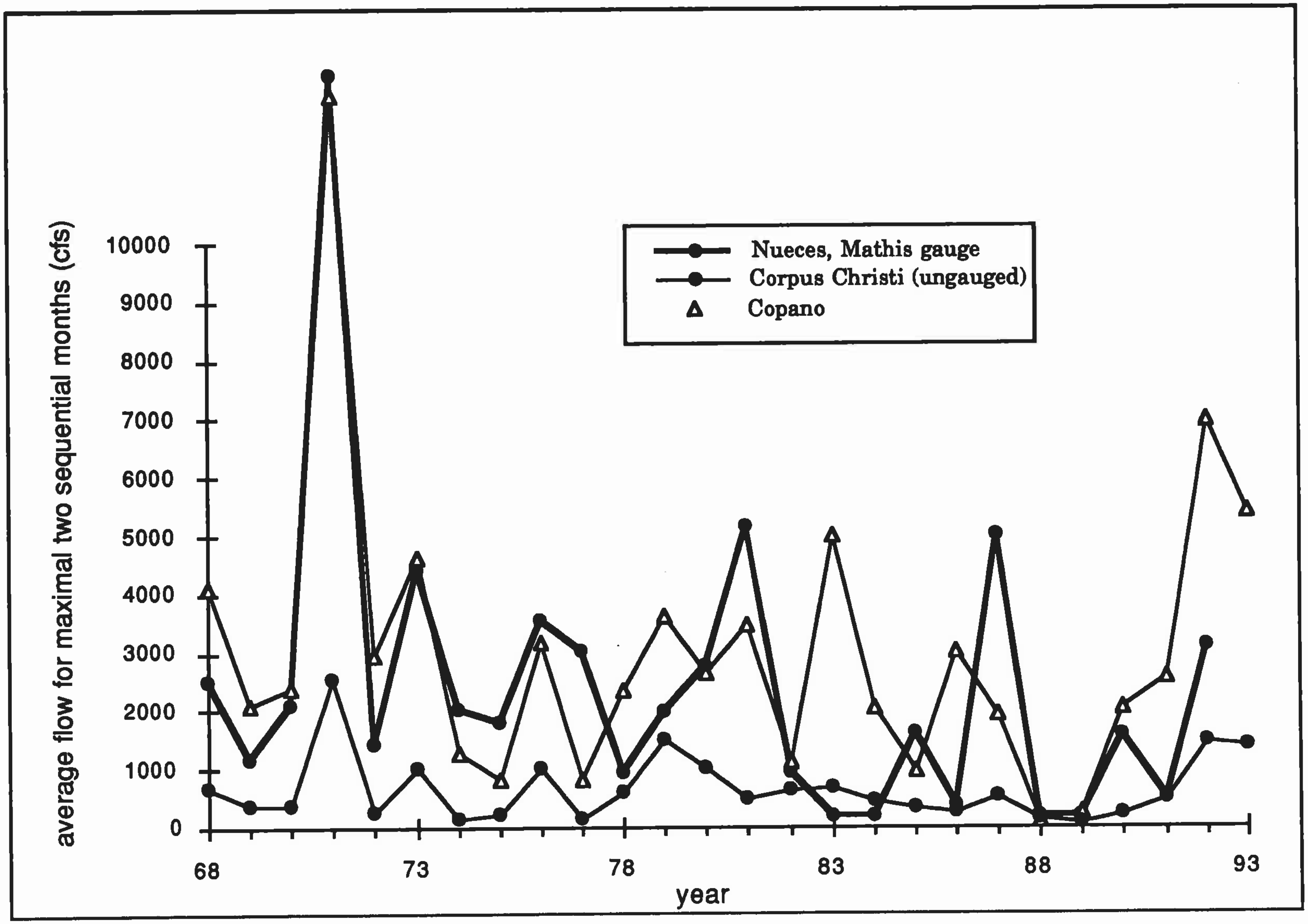


Figure 9-7. Historical variation of annual maximum flow in two sequential months

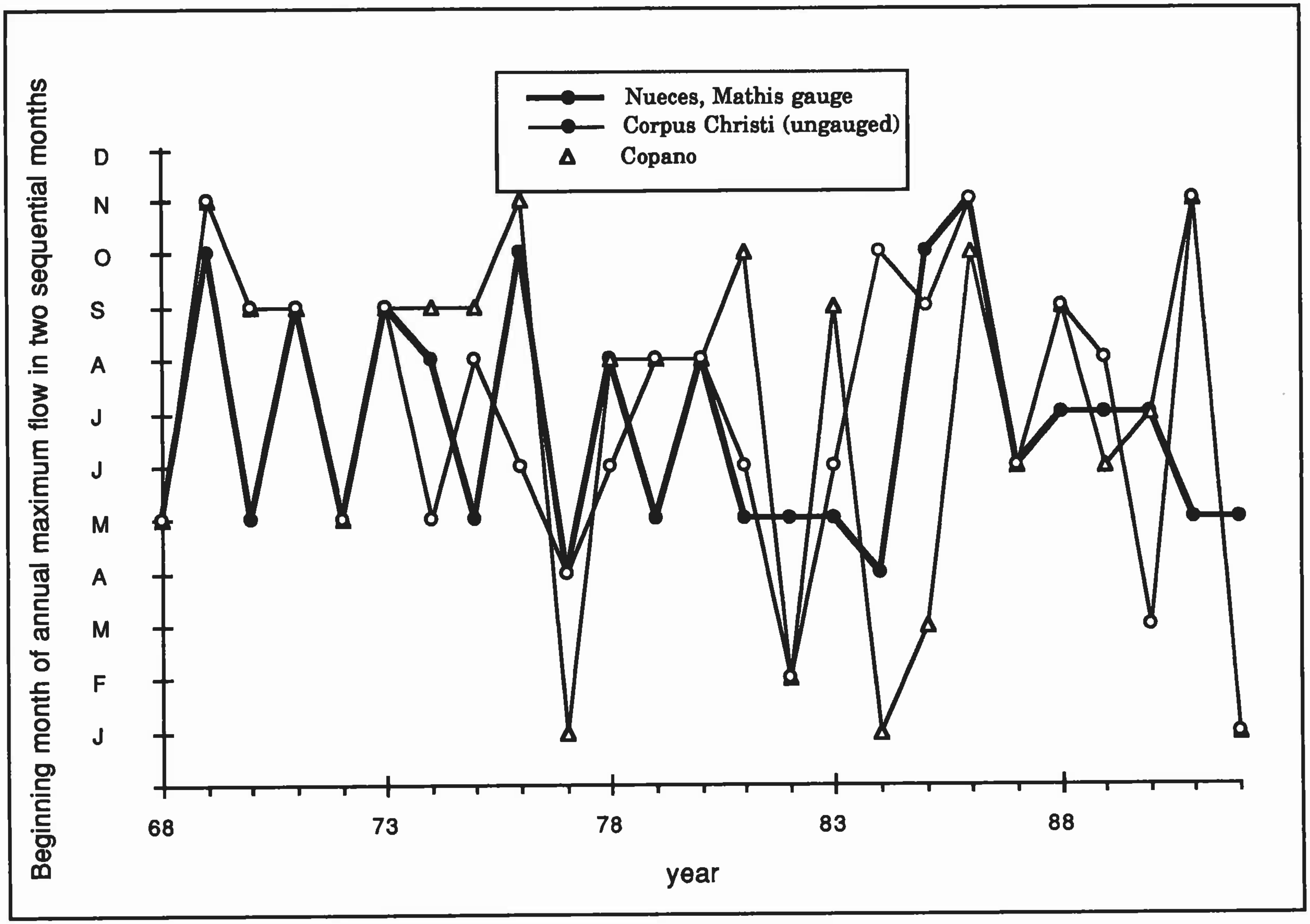


Figure 9-8. Historical variation of occurrence of annual maximum flow in two sequential months

total flow to Corpus Christi Bay *per se*. This is in general agreement with some ratios that have been promulgated recently (e.g., Copeland et al., 1994). Especially during drought periods, the Nueces proportion falls considerably below 50%.

(3) The small watersheds of Redfish Bay and the Upper Laguna render their inflows of negligible importance.

(4) The low runoff from the Baffin Bay watershed is evidence of the high aridity of this region of the Study Area.

(5) The fact that a two-month period is sufficient to "capture" the annual freshet demonstrates the flashy character of the inflows to the Corpus Christi Bay Study Area. (In contrast, for the Trinity River, Ward and Armstrong, 1992a, found that a 3-month "freshet" period—as defined here—was necessary to represent just over *half* of the annual flow of the river.)

(6) The annual flow is highly correlated with the spring "freshet," r=0.91 for Copano, r=0.98 for Nueces. High correlation is not unexpected given (5), but to be this high is unexpected and further reinforces the domination of the annual hydrographic by the freshet.

(7) For the main contributors (Copano, Nueces and Corpus Christi) there is a interannual spread of nearly two orders-of-magnitude in the freshet volume.

(8) The first month of the 2-month freshet period is most commonly late summer (August or September). The exception is the Nueces, whose freshet most commonly begins in the late spring. This emphasizes the fact that the hydroclimatology of the Nueces watershed is fundamentally different from that of the coastal plain, and tracks more closely that of the upper Texas coast.

9.1.3 Loadings

A detailed analysis of organic, nutrient, and contaminant loading to the Corpus Christi Bay system is now underway for the CCBNEP. Therefore, we do not have the advantage of quantitative results from this project for the present analyses. However, the qualitative variation in loadings over the past two to three decades is well known and suffices to anticipate responses of water and sediment quality. In summary, the influxes of conventional pollutants and most organics and metals as a mass load from both point source discharges and inflows have declined in recent years, since probably the 1970's, depending upon the specific contaminant and loading source.

Generally, loadings fall into two broad categories. Those with geographically focused sources of large magnitude are referred to as point sources. These typically originate as wastewater returns from industrial facilities or municipal sewage treatment plants. These are subject to direct regulation and are capable of being captured and "treated" by a combination of diversion, detention, filtration, and biochemical or chemical processing. In contrast, loadings whose points of origin are diffuse in space, perhaps continuous, are referred to as nonpoint sources. Typically, these involve complex interactions between the ultimate origin of the constituent and environmental flow paths, especially runoff processes in the aquatic phase or boundary layer flows in the atmosphere. The nonpoint source loadings of greatest concern in the Texas coastal environment are those transporting mobilized constituents from the watershed by storm runoff into the periphery of an estuary. Urban areas with large proportions of impervious cover and sources of contamination associated with city activities, suburban areas high in regions of artificial landscaping, rural regions modified for agricultural production with high-technology utilization of fertilizers and pesticides, rural regions with confined animal feeding operations (CAFO's) and rural areas modified for ranching are all considered to be potential sources of nonpoint source loadings. Rivers hold an ambiguous position in this categorization. As high-volume, geographically focused influx points, they would appear to be a point source. But because the loaded constituents originate from diffuse upstream sources, and because the river load is amenable neither to regulation nor to capture and treatment, from an administrative viewpoint it is usually considered a nonpoint source.

Reduction of the magnitude of point source loadings is a consequence of implementation of advanced waste treatment, driven by state and federal regulation. In the Texas coastal zone, as a general rule, improvements in waste treatment have progressed in time from the industrial sector to the municipal sector, and from the upper Texas coast to the lower. While passage of the 1972 Federal Water Pollution Control Act Amendments (PL 92-500) is usually taken to mark the beginning of this process, in Texas this was preceded by the state initiative Operation Clean Sweep of the Texas Water Quality Board, implemented in 1969. In the Houston area, where industrial and municipal dischargers are numerous, there has been accomplished a substantial reduction in total loadings, by an order of magnitude, as summarized by EPA (1980) and Powelson (1978). In the Corpus Christi Bay area a similar proportional reduction of loadings could be anticipated in the industrial wastewater discharges, and would be most evident in the regions of concentrated wastewater returns, e.g. the Inner Harbor and La Quinta Channel. Many of the point-source loads have high organic content, especially nitrogen. One consequence of advanced waste treatment is the shift of the nitrogen species in the discharge to the oxidized forms, *viz.* reduction of ammonia accompanied by an increase of nitrates. While wastewater treatment has improved in the municipal sector within the last two decades, the level of treatment is still below that achieved in the municipalities on the upper coast. With the growth of population and industry in the coastal zone, there has been a steady increase in the *volume* of return flows. In the Coastal Bend area, this is most evident in the municipal sector.

In those cases when data analysis has been performed of the loading of major Texas rivers, there has been found a general decline in mass loading of sediments and organics, considered to be a consequence of improved waste treatment, of improved land-management practices on the watershed, and of upstream impoundments. With respect to reservoirs and the concomitant entrapment of fine-grain sediments, because many nutrients and contaminants are associated with these finer particulates, these reservoirs are therefore considered to represent an effective sink of these constituents in the inflows. Unfortunately, the construction of most reservoirs, including Lake Corpus Christi on the Nueces, antedate the period of adequate record of riverborne chemical constituents, so the quantitative effect of these reservoirs on chemical loadings cannot be directly evaluated with a high level of reliability. For example, Ward and Armstrong (1992a) evaluated the historical silt and nitrate load on the Trinity, before and after closure of Lake Livingston (one of the more recent reservoirs in the state). While they found that both annual load and mean concentration of suspended sediments downstream from Livingston have fallen to one-third of their pre-lake level, they note that the TSS concentration exhibited a declining trend over the 20-year period prior to closure of the dam.

For the CCBNEP Study Area, there are relatively few results in the literature to draw upon. White and Calnan (1990) determined that the riverine suspended sediment load for the Nueces is much smaller for the period 1961-80 than for 1942-57, which was attributed to the construction of Wesley Seale Dam in 1958. Longley et al. (1994) compared nutrient and sediment loading from the watersheds into five major Texas bay systems, two of which, Aransas-Copano and Nueces-Corpus Christi are in the study area, finding that these two are lowest of the five in nitrogen, phosphorus and organic carbon loading, and among the lowest in sediment yield. The exception was the sediment yield from the Nueces watershed downstream from Mathis which was the highest of the watersheds analyzed (see Table 4.4.5 of Longley et al., 1994). No trends in these loadings are given.

9.2 Water and Sediment Quality Responses

9.2.1 Temperature

Temperature in Corpus Christi Bay is governed primarily by surface heat exchange, which imposes a strong seasonal signal, as shown in Fig. 6-57. Because of its smaller depths and limited exchange with the Gulf, the bays lead the Gulf by about a month in their response to seasonal heating and cooling. Therefore, in the spring to early summer, the bays are about 2-3°C warmer than the adjacent Gulf, then this relation is reversed in the fall. As noted in Chapter 6, stratification effects are nil, amounting on average to a fraction of a degree per meter positive upward (see Table 6-28). This is much too small to have any effect on buoyancy, so it is undoubtedly a result of the greater insolation near the water surface. Temperature generally increases with distance south across the study area, and is somewhat higher in the shallow tributaries and secondary bays compared to the open waters, see Figs. 6-7 through 6-11 and Fig. 6-57. This being said, these differences are minor, and the more accurate representation of temperature is that horizontal spatial structure is virtually absent. The lack of vertical stratification is an indicator of the vigorous vertical mixing which operates in Corpus Christi Bay and renders many variables vertically homogeneous. The strong seasonal variation and the lack of significant spatial structure are consistent with the domination of surface heat fluxes (so that boundary fluxes become much less important).

The one important exception to the lack of spatial structure in temperature is in Upper Nueces Bay, see Fig. 6-9. Segment NB7 (see Fig. 3-10) receives the cooling water discharge from the Central Power and Light Nueces Generating Station. This is a once-through fossil-fired steam-electric plant, which intakes cooling water from the adjacent Inner Harbor, Segment IH7. Presently, this SES is rated at 515 MW generating capacity and is permitted for a 21.9 m^3s^{-1} (775 cfs, 500 MGD) circulating flow (Mierschin, 1992). The actual generation and circulating flow is variable, depending upon the number of units in operation, load demand, and efficiency; a typical circulating flow is 18.4 m^3s^{-1} (650 cfs, 420 MGD). Ward (1982) compiled data on the heat rejection of this plant and the resulting thermal plume in Nueces Bay. The condenser temperature rise ranges nominally 4-10° C, and the resulting plume at 1°C (temperature rise over ambient) is about 200 ha (500 acres), ranging a factor of two about this value depending upon meteorology, especially wind direction. The effect of this heated water return is quite evident in the higher water temperatures in the south sections of Nueces Bay, Fig. 6-9.

One other major power plant of CP&L operates in the Corpus Christi Bay system, namely the Barney Davis Generating Station. Like the Nueces SES, Barney Davis is a fossil-fired steam-electric station with once-through cooling. Cooling water is drawn from the Upper Laguna Madre near Pita Island (Segment UL03) and discharged into Oso Bay (Segment OS3), at a circulating flow rate of nominally 19 m^3s^{-1} (670 cfs). Unlike the Nueces SES, the Barney Davis discharge is first detained in a shallow cooling pond of area 4.5×10^6 m^2 (1.77 sq mi), the net effect of which is to reduce the temperature rise upon discharge into Oso Bay to less than 1°C. Therefore, there is no elevated temperature in upper Oso Bay that can be attributed to this power station.

The most significant observation from the analyses of Chapter 6 is the long-period decline in water temperatures, especially within the open waters of Corpus Christi and Nueces Bays, and to a lesser extent within the upper bays of Copano and Aransas, see Table 6-39 and Figs. 6-75 through 6-79. Over the three-decade period of record, the net decline for those segments with a statistically probable trend (Table 6-39) is on the order of 2°C. It is noteworthy that a similar decline in water temperature, at about the same rate, was discovered in Galveston Bay (Ward and Armstrong, 1992a). Hypotheses offered by Ward and Armstrong (1992a) possibly explaining this observed decline are the following:

(1) Long-term alterations in climatology, e.g. declines in air temperature or increases in wind speed;

(2) Long-term alterations in water temperature of the Gulf of Mexico;

(3) Alterations in the intensity of interaction of Corpus Christi Bay with the adjacent Gulf of Mexico;

(4) Sampling bias toward the earlier months of summer in more recent years.

These cannot be tested within the scope of this project. We note that a cursory examination of the sampling dates in this Corpus Christi period of record indicates little support for (4). With respect to (2) it is interesting to observe that the nearshore waters of the Gulf evidence a probable *increasing* trend, Fig. 6-80. Since the waters of the Gulf are systematically cooler than those of the estuary, and since the nearshore waters are probably more influenced by thermodynamics of the surf zone, this observation does not eliminate (3), but certainly renders it more doubtful. Hypothesis (1) is considered the most probable. Recently Kim and North (1995) employed surface air temperatures compiled by Jones et al. (1986) by 5°x5° zones to examine trends in air temperature. Kim (1996) notes that one of these 5°x5° boxes representing the Texas coastal zone shows a negative trend (but does not provide any quantitative detail).

9.2.2 Salinity

Of all of the conventional water-quality indicators, salinity has probably been more in the public view in the Corpus Christi Bay system than in any of the other estuaries of Texas. This is due to its perceived link to freshwater inflow and the intense local concern with the supply of inflow to the bay. From a broader analytical standpoint, there is probably no variable that provokes as much frustration as salinity, because for this variable there is a clear, intuitive cause-and-effect association with freshwater inflow that refuses to emerge from the statistics. Many attempts have been made by past researchers to extract a salinity-inflow relationship by statistical analysis (e.g. TDWR, 1981, Longley, 1994), none of which have been satisfactory.

Salinity in Corpus Christi Bay *is* dependent upon freshwater inflow. Without freshwater inflow to the bay, the salinities would eventually acquire oceanic values. The fallacy is to conclude from this that there is a *direct* association between a given level of inflow and the salinity at a point in the bay. The other hydrographic mechanisms, such as tides, meteorology, and density currents, all govern the internal transports of waters of different salinities in the bay, and dictate how freshwater influences salinity. Further, the salinities present at the entrance to the bay are controlled by processes in the Gulf of Mexico, especially the effects of the freshwater plumes from river basins along the northwest coast, notably the Sabine, Neches and Mississippi. In this system, evaporation plays a major rôle in the salt budget, much more so than is the case in the estuaries of the upper Texas coast.

The nature of the problem is illustrated by the salinity data of Fig. 9-9, showing the association of salinities with gauged flow of the Nueces. The locations, NB5 in lower Nueces Bay and CCC7 in the Corpus Christi Ship Channel just out from the Inner Harbor (Fig. 3-9), are characteristic of open-bay areas but still close enough to the mouth of the Nueces to presumably respond to its inflow. While there is a discernible downward slope in the relation, as we would expect, the range of salinity encompasses a significant portion of the entire estuarine range,

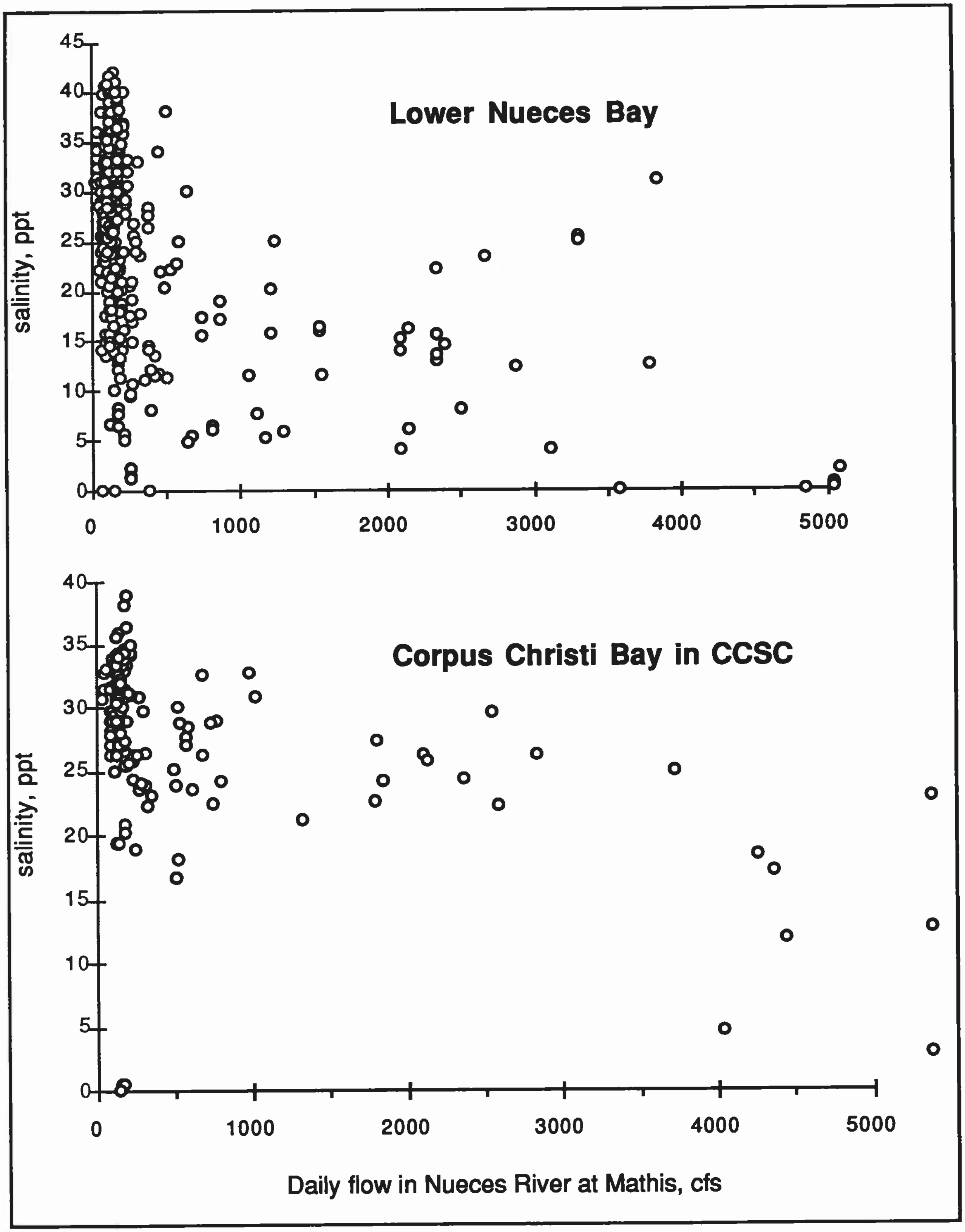


Figure 9-9. Salinity versus daily flow in two hydrographic segments, NB5 and CCC7. (Flows greater than 5000 cfs not shown.)

independent of the level of inflow. Put another way, for virtually any level of inflow (the exception being for the rare extremely high flow events) one encounters in the data a disquietingly wide range of salinity. Moreover, the relation of salinity with inflow displayed in this figure, such as it is, is eroded even more with distance from the Nueces.

This high variance is a quantitative demonstration of the complexity of the response of salinity in the bay to many factors, only one of which is freshwater inflow. First, there is a lag between the freshwater signal as measured at an inflow gauge and its effect on the bay. In addition to this lag, salinity in the bay responds more as an integrator of freshwater inflow, i.e. with a longer time scale of variation than that of the inflow itself. Moreover, the response of salinity is affected by the operative physical processes, e.g. tidal excursion, antecedent salinity gradients, semi-permanent circulation patterns and evaporation. Salinity extrusion, especially in Nueces Bay and Copano Bay is basically a mechanism of displacement by freshwater, and occurs rather rapidly when forced by freshets. Salinity intrusion, on the other hand, takes place by mixing and advection by tidal currents, interior circulations, and density currents, and intrusion into the inland or more isolated segments of the system (e.g. Baffin Bay and the Upper Laguna) generally requires a comparatively longer time.

The response of salinity as an integrator of the freshwater inflow signal can be accommodated to some degree by using a long-period average of inflow as the independent variable. Generally, the salinity at a point in the bay is better correlated with the average flow over the preceding several weeks. In Fig. 9-10 is shown the improvement in statistical association achieved by time averaging the river flow, for a range of averaging periods, at the same segments used in Fig. 9-9. While the explained variance can be nearly doubled (in this region of the bay) by this device, even with the optimal averaging not even 50% of the variance is explained by the relation to inflow. Further, the standard error of the regression is still more than 7-8 ppt, which means the regression predicts salinity at a 95% certainty within a 32 ppt range, i.e. about the normal range from fresh to oceanic. Moreover, in most areas of the open bay, the explained variance and standard error are even worse.

As observed above, the fallacy with this approach is the implicit assumption that there is a direct relation between salinity and inflow, which can therefore be extracted by the usual regression methods. Generally, the salinity at any point in the bay is in a state of dynamic response to the integrated resultant of present and earlier hydrological and hydrographic factors. The complete analysis of this behavior cannot be by statistical association alone but rather must take explicit account of the time-response character of the variates. Such an analysis is beyond the scope of the present study, but could employ either of: (1) time-series and system-identification methods; (2) detailed event-response analysis, including salt-budgeting and deterministic modeling. It is probable that similar methods may be necessary for other variates whose concentration in the bay is determined by boundary fluxes and internal transports, e.g. quasi-conservative parameters such as phosphorus and many metals.

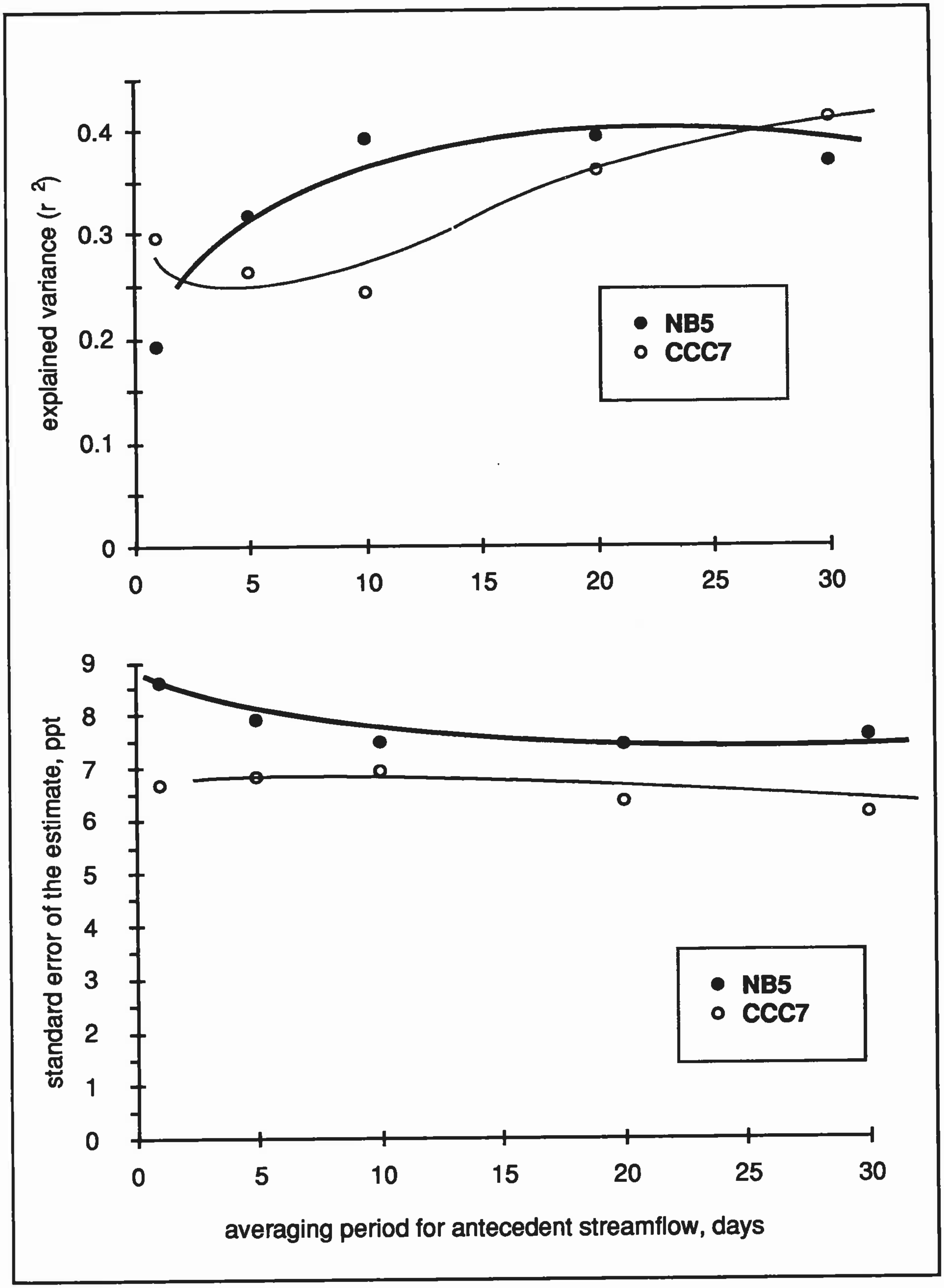


Figure 9-10. Statistical measures of regression quality versus averaging time of Nueces River flow, same data as Fig. 9-9

As noted in Chapter 6, the average salinity distribution in the Study Area is predominantly a north-to-south gradient of increasing salinity. This is undoubtedly the result of the diminishing freshwater inflow from Copano in the north to Baffin in the south, reinforced by increasing evaporation (and *net* evaporation, since precipitation also decreases from north to south). The effect of evaporation on the salt budget is amplified by the lack of exchange of the entire system with the ocean, especially for the lower bays of Baffin and the Upper Laguna, which do not exchange well even with the larger body of Corpus Christi Bay.

As remarkable as this north-to-south salinity gradient is, equally remarkable is the lack of a prominent gradient in salinity in those regions most affected by freshwater inflow. In Copano Bay, Fig. 6-1, which receives the greatest quantity of inflow, the average gradient in only about 4 ppt from the causeway to the mouths of the rivers. In Nueces Bay, even more surprisingly, the gradient from the mouth of the bay to the delta is flat, only a couple of ppt, Fig. 6-2. This is clear evidence that the effect of freshets in depressing salinity is relatively infrequent (no surprise from the hydrology of the Nueces River, discussed in the previous section) and short-lived. Another noteworthy feature of the mean salinity patterns is the absence of systematically higher salinities in the channel segments. This would suggest that, on average, the deepdraft ship channel has little additional effect on salinity intrusion. This is in direct contrast to the Houston Ship Channel in the Galveston system (Ward and Armstrong, 1992a). The reason for this is also rooted in the relative infrequency of freshets in the Corpus Christi Bay system. For a density current in a deep channel to develop, there must be a horizontal gradient in salinity. This gradient is regularly present in Galveston Bay, due to the inflow from the Trinity and San Jacinto Rivers. In Corpus Christi Bay, as shown by Fig. 6-2, the average gradient in the open bay is flat. Without such a gradient, density currents cannot develop, and the deep channel cannot become a favored pathway for salinity intrusion. When large freshets do occur, such gradients are developed and the density current becomes important in salinity intrusion, but such events are apparently so rare that they do not appear in the long-term statistics.

Trends in salinity are obscured because there is such relative constancy in salinity in the system, which makes the parameter susceptible to random variations. Despite this, regions of the study area exhibit defined trends, notably Copano Bay, St. Charles Bay, Nueces Bay and most of the open areas of Corpus Christi Bay, all of which show increasing salinities, see Figs. 6-69 through 6-71 and Table 6-38. The average rates of increase over those segments with a probable trend are: Copano, 0.081; St. Charles, 0.26; Nueces, 0.25; Corpus Christi, 0.047 ppt/yr. These are not trivial increases. Over two decades (say), these would translate to increases in average salinity of: Copano Bay, 1.6 ppt; Corpus Christi Bay, 1 ppt; and Nueces Bay, 5 ppt.

In seeking a possible explanation for these trends, the obvious control to examine is freshwater inflow. With respect to the gauged flow of the Nueces, a linear decreasing trend in the monthly mean flows is indeed disclosed, with rate 29 cfs per year. This trend line superposed on the time series of monthly flows is shown in Fig. 9-11. Inspection of the data indicates that the greatest contributor to the declining trend is the reduced frequency of occurrence of high-inflow events.

Similar trend analyses were carried out for the synthetic flows, developed by USGS (see Section 9.1.2 above), for Copano and Corpus Christi Bay watersheds, averaged by month. (Recall that Corpus Christi Bay watershed is defined to be all of its peripheral drainage area, including the Nueces watershed downstream from the gauge at Mathis.) In its status and trends study, USGS (Mosier et al., 1995) elected not to perform trend analyses on its synthetic hydrographs principally because such trend analyses would be a reflection of trends in precipitation (all other factors being static in the model). In the present context, we are not bound by such scruple, since a declining trend in inflow driven by such a trend in precipitation is still a declining trend in inflow. The resulting linear trends superposed on the monthly mean flow data are shown in Figs. 9-12 and 9-13. For Copano a barely resolvable declining trend emerged, of 5.1 cfs/yr, and for Corpus Christi Bay a declining trend of 16 cfs/yr.

To determine whether such a declining trend in inflow could be responsible for the increasing trend in salinity would require a detailed salt budget for the system, manifestly beyond the scope of the present study. Some judgements can be proffered based on magnitudes, however. By comparison of these inflow trends to their initial values in 1968, the respective reduction in annual inflow over the 1968-93 period would be about 14% for Copano Bay, 53% for Corpus Christi Bay, and 69% for the Nueces River (at Mathis). This is substantial.

While the decline in inflow is likely to be the explanation for the increasing trends in salinity, we note that there are other hypotheses which could be contributors as well:

(1) Increased salinities in the adjacent Gulf of Mexico;

(2) Altered interaction with the Gulf of Mexico;

(3) Altered volume and timing of freshwater inflow events to augment salinity intrusion;

(4) Sampling bias due to changing seasonality, geographical distribution or vertical profiling over time;

(5) Increased diversions and/or decreased return flows.

Some of these may be locally important, even if not important on a bay-wide or system-wide scale. There is no evidence of (1) based upon the trends analyses of this project (see Fig. 6-74). The volumes of diversion and return flow in Corpus Christi Bay are smaller by an order of magnitude than the trends in inflow, so (5) appears unlikely, except, again, in some specific localities. A cursory inspection of the sampling intensity does not reveal any obvious bias in the more recent data

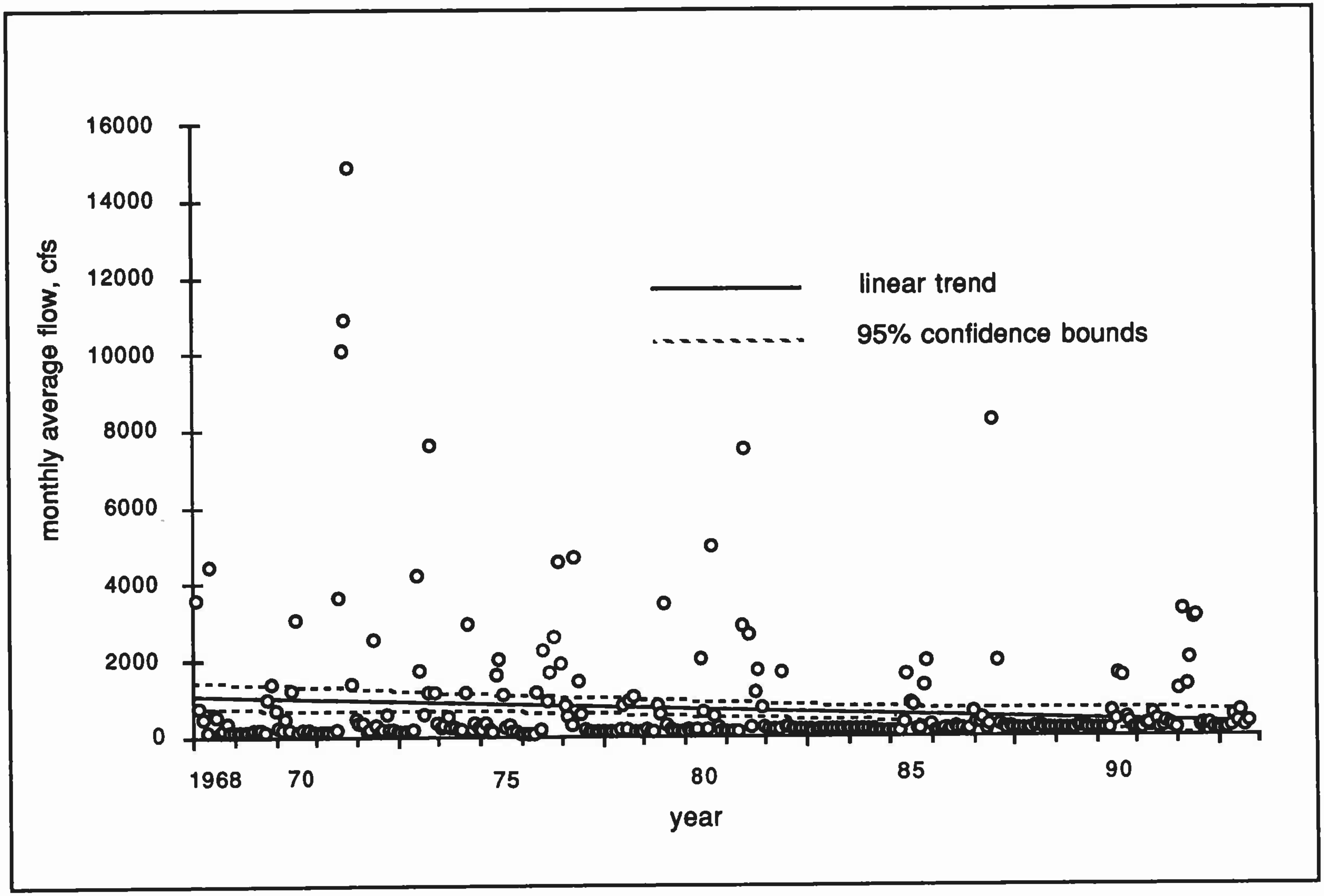


Figure 9-11. Monthly mean flow of Nueces at Mathis and linear trend line

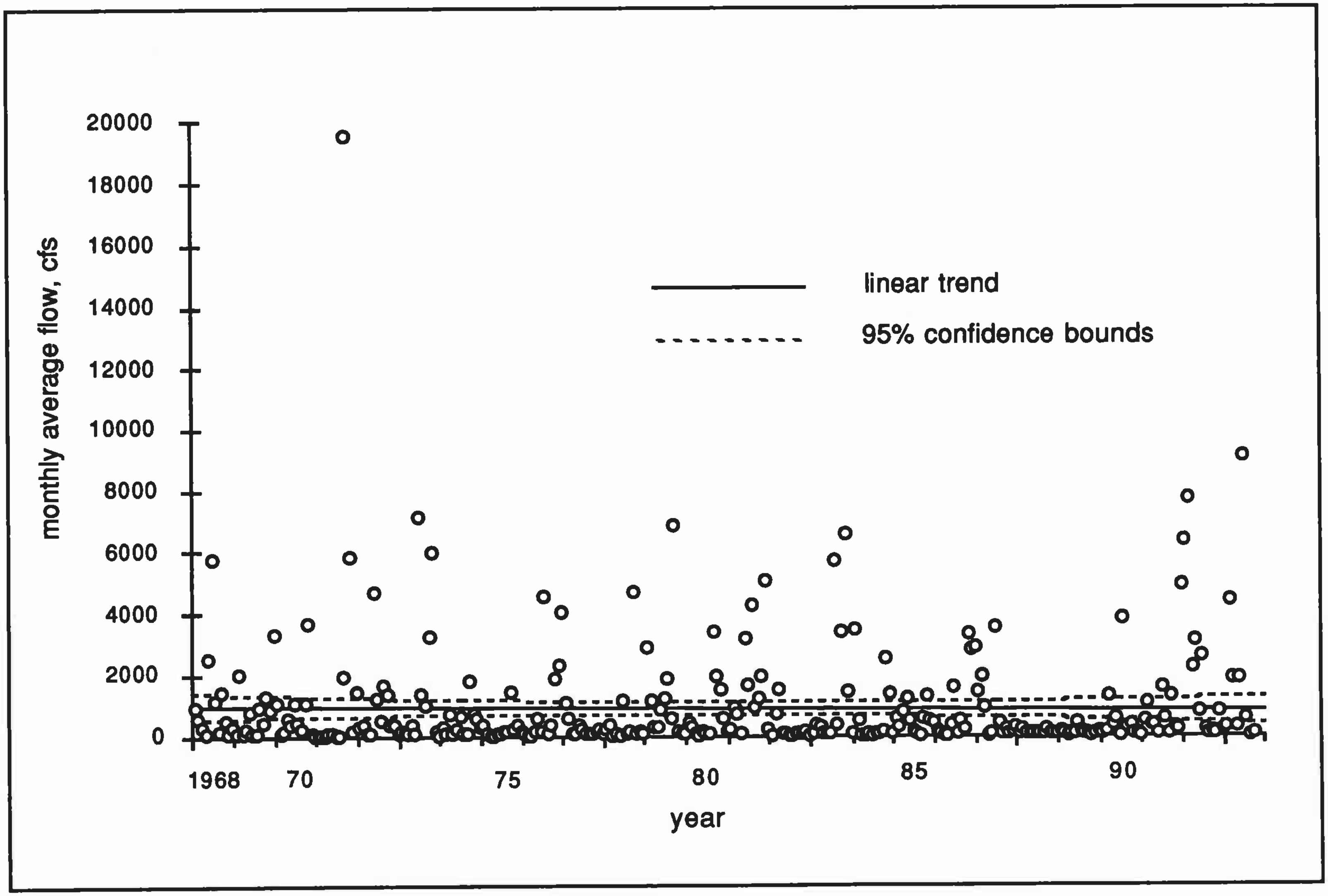


Figure 9-12. Monthly mean flow of Copano Bay watershed and linear trend line

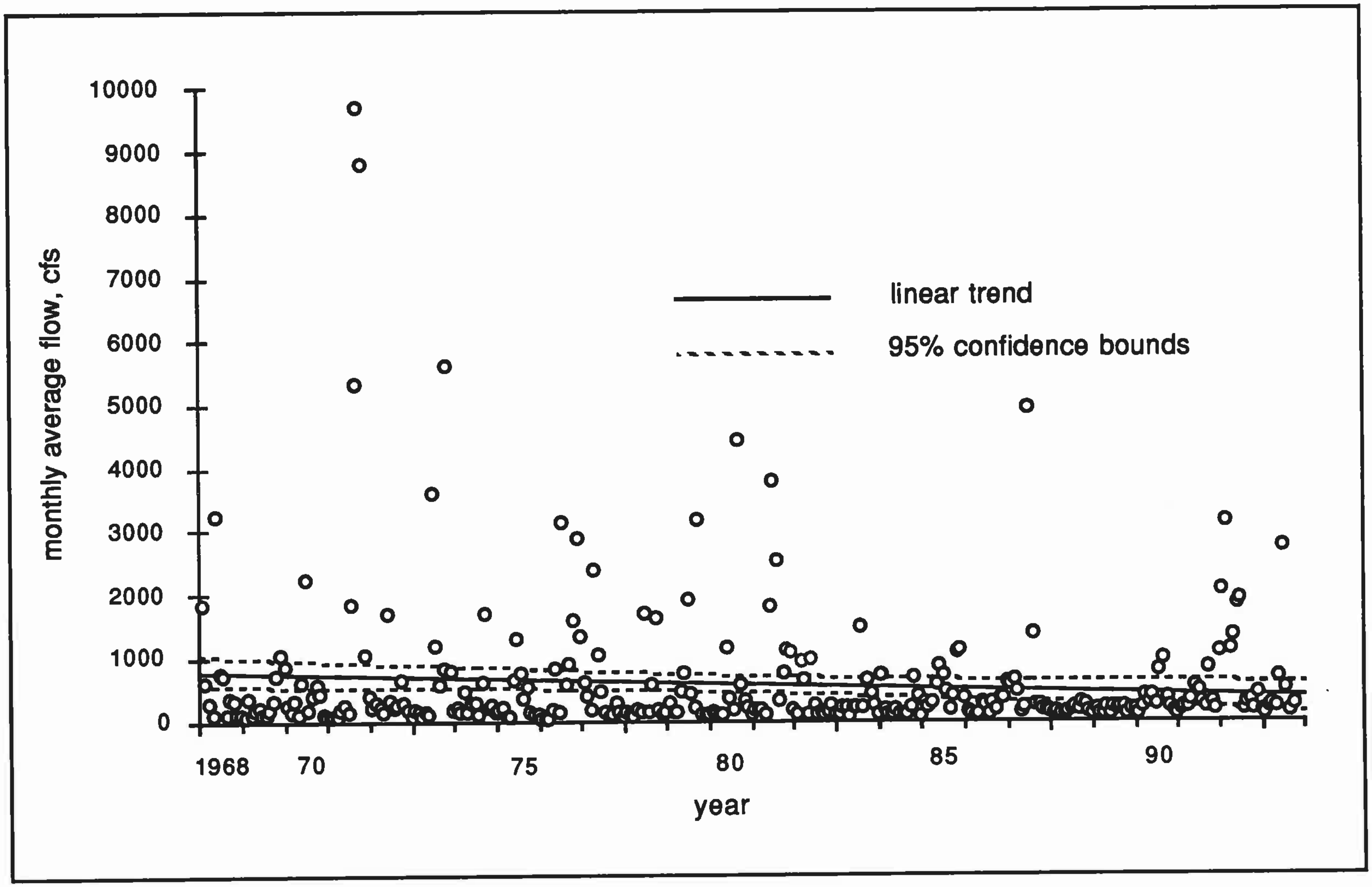


Figure 9-13. Monthly mean flow of Corpus Christi Bay watershed and linear trend line

compared to those of the 1970's, so (4) does not seem likely, at least on a baywide basis. In fact, one of the principal state programs, that of the Texas State Department of Health, has altered its sampling strategy to emphasize those conditions conducive to coliform violations, which implies that salinity data would be taken during or immediately after inflow events. If anything, this would entail a bias to lower salinities.

9.2.3 Dissolved oxygen

In the open bay, dissolved oxygen, like temperature, is most strongly affected by surface processes. A high degree of aeration is implied by the saturated conditions, which is consistent with surface-wave overtopping and vigorous vertical mixing. A relatively slight stratification in DO increasing upward, equivalently a stratification in DO deficit decreasing upward (Table 6-29), is consistent with oxygen consumption in the water column and in the bottom sediments, in conjunction with the influx of oxygen through the surface. There is no apparent correlation with depth in stratification through the system, though deeper water will evidence a greater top-to-bottom DO difference, since the gradient is multiplied by a greater depth. Even at this, the Inner Harbor, the greatest focus of oxygen-demanding waste loads in the system, averages only about 3 ppm top-to-bottom difference in DO.

Since the system is so near-saturation, systematic trends are difficult to discern. This is reflected in the statistical results, e.g. Table 6-41 and Figs. 6-81 through 6-86, which are mixed. One prominent exception is the outer bays, Copano, Aransas and Baffin, that show a systematic trend of declining DO deficit (i.e., increasing DO). One hypothesis for this trend could be as the result of improvements in waste treatment implemented by the communities on the shore of these bays. Other hypotheses include diminishing oxygen-demanding loads in runoff and altered kinetics within the bay waters themselves.

One aspect of DO behavior that is obscured by long-term statistical analyses is the prevalence of low-DO events, i.e. hypoxia. The potential impact of these events on the ecosystem may be far greater than their relative infrequency might suggest. For this reason, special attention was given to the occurrence of such depressed events by sorting and separately analyzing the data for concentrations below 2 ppm. The frequency of occurrence of such low-oxygen events in the data record, as a percent of all measurements, is summarized in Table 9-4 by hydrographic area and in Table 9-5 by component bay, following the same convention as Section 6.1. (A blank is entered in this table for those months not represented in the data record.) Only those hydrographic areas with a nonzero occurrence of low DO's in the period of record are shown in Table 9-4, so it is immediately apparent that the majority of segments in the system have never logged an occurrence of DO below 2 ppm. A quick inspection of this table shows, as expected, low DO events are much more a phenomenon of summer and the greatest systematic occurrence is in those areas affected by high organic loading and poor flushing, notably the Inner

Table 9-4
Monthly and total frequency of occurrence as percent (%) of dissolved oxygen (WQDO) values ≤ 2 ppm by hydrographic-area segment

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
A5	0	0	0	0	0	9.1	0	0	0	0	0	0	0.6
A6	0	0	0	0	0	0	0	0	0	0	0	7.1	0.7
A10	4.5	0	0	0	0	0	0	0	0	0	0	0	0.4
AL1	0	0	0	0	0	0	0	0	6.7	0	0	0	0.6
AL2	0	0	0	0	2.7	0	0	0	0	4.1	0	0	0.9
BF1	0	2.5	0	0	0	0	0	0	0	0	0	0	0.2
BF2	0	0	0	0	0	2.0	2.9	9.4	0	2.1	0	0	1.3
BF3	0	0	3.4	0	1.5	4.7	2.1	3.6	2.0	3.2	0	0	1.7
C01	0	0	0	0	0	0	0	3.8	0	0	0	0	0.4
C03	0	0	0	0	0	0	2.9	5.4	0	0	0	0	0.6
C04	0	0	0	0	0	0	2.8	3.2	0	2.9	0	0	1.1
C05	0	0	0	0	0	0	0	3.8	0	0	0	0	0.2
C06	0	0	0	0	0	0	2.8	7.7	1.8	5.5	0	0	1.5
C07	0	0	0	0	0	0	0	0	0	0	1.7	0	0.2
C09	0	0	0	0	0	0	0	0	0	3.9	0	0	0.4
C10	0	0	0	0	0	0	0	0	0	2.7	0	0	0.3
C11	0	0	0	0	0	0	0	1.5	0.7	0	0	0	0.2
C12	0	0	2.3	0	0	0	1.3	1.6	0	0	1.8	0	0.6
C14	0	0	0	0	0	1.4	1.9	2.8	0	0	0	1.6	0.5
C15	0	0	0	0	0	0	5.9	5.5	1.3	0.8	0	0	1.2
C16	0	0	0	0	0	0	0	0	0	10.0	0	0	1.1
C17	0	0	0	0	0	0	4.4	5.3	0	0	0	0	0.7
C21	0	0	0	0	0	0	0	0	0	2.7	0	0	0.3
CCC1	0	0	0	0	2.7	1.2	1.1	0	0	0	0	0	0.5
CCC3	0	0	0	0	0	0	0	4.1	0	2.4	0	0	0.5
CCC4	0	0	0	0	0	0	5.0	0	0	0	0	0	0.8
CCC6	0	0	0	0	0	0	0	0	0	1.7	0	0	0.2
CCC7	0	0	0	0	0	4.9	0	20.7	6.7	4.3	0	0	2.1
CCC8	0	0	0	0	0	3.4	3.7	2.8	12.9	1.5	0	0	1.8
CP02	0	0	0	0	2.3	0	0	0	0	0	0	0	0.3
CP07	0	0	0	0	0	0	0	0	0	2.3	0	0	0.3
CP08	0	0	0	0	0	3.6	0	0	0	0	0	0	0.3
CP09	0	0	0	0	0	0	0	0	4.3	0	0	0	0.3
GR2	0	0	0	0	2.7	0	0	3.7	0	0	0	0	0.5
I3	0	0	0	0	0	0	0	0	0	2.9	0	0	0.4
I5	0	0	0	0	2.7	0	0	0	0	0	0	0	0.4
I6	0	0	0	0	0	0	0	4.9	0	0	0	0	0.5
I7	0	0	0	0	0	0	0	0	0	0	2.4	0	0.2

(continued)

Table 9-4
(continued)

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
I9	0	0	0	1.9	0	0	0	0	0	0	0	0	0.2
I11	0	0	11.1	0	0	0	0	0	0	0	0	0	0.7
I12	0	0	0	0	0	0	0	2.6	0	0	0	0	0.3
I13	0	0	6.5	0	0	0	0	0	0	0	0	0	0.7
I14	0	0	37.5	0	0	0	0	0	6.3	0	0	0	3.3
I15	0	0	0	0	0	0	0	5.9	0	3.4	0	0	0.9
I16	0	0	0	0	0	7.7	0	0	0	0	0	0	1.6
I17	0	0	0	0	0	0	0	7.7	0	0	0	0	1.1
IH1	0	1.3	0	0	5.3	25.8	37.7	19.8	41.7	15.4	5.9	33.3	12.8
IH2				0				13.3				0	3.0
IH3	0	0	14.3	10.3		33.3	42.9	6.7		42.9	0	0	15.0
IH4	0			12.5	0	33.3		0		0		0	5.6
IH5	0	0	3.3	4.4	5.7	20.6	24.5	6.5	36.9	5.6	0	0	9.1
IH6	0	1.4	7.7	4.1	0	33.3	8.9	8.8	10.9	6.9	5.3	18.2	6.5
IH7	0	0	3.5	0.7	2.0	8.3	23.3	17.6	17.4	11.8	2.7	1.6	7.3
LQ1	0	0	1.2	0	0	0	3.2	2.0	0	0	0	0	0.6
LQ2	0	0	0	0	4.0	0	6.1	3.2	0	0	0	0	1.2
LS2	0	0	0	0	0	7.1	0	0	0	0	0	0	0.4
M2		0	0	0	0	6.7	0	0	0	0	0	0	1.3
NB5	0	0	0	0	0	0	2.3	0	2.7	0	0	0	0.4
NB6	0	0	4.5	0	0	0	0.9	0	0	0	0	0	0.4
NB7	0	0	12.0	0	0	0	0	0	0	2.4	0	0	0.9
NR1	0	0	31.8	0	0	0	0	0	0	18.2	0	0	7.0
NR3	0		44.4	12.1	27.3	10.0	0	0		14.3	35.7		17.5
NR4	0	0	0	0	0	0	0	0	11.8	0	0	0	1.2
NR5	0	0	0	0	0	0	15.4	0	0	0	0	0	1.7
OS1	0	11.1	0	0	0	0	0	0	0	0	22.2	0	3.9
OS3	0	0	20.0	0	0	0	0	0	0	0	0	0	1.7
PB1	0	0	0	0	4.0	0	0	0	0	0	0	0	0.6
PB2	0	6.3	0	0	0	0	0	0	0	0	0	0	0.5
RB2	0	0	0	0	0	0	0	0	7.7	5.9	0	0	1.8
RB9	0	20.0	0	0	0	0	4.3	13.6	0	3.2	5.6	0	3.3
SC1	0	0	0	0	0	4.8	0	0	0	0	0	0	0.6
SC3	0	0	0	0	1.4	0	2.6	0	0	0	0	0	0.4
UL02	0	0	12.5	0	0	0	0	0	4.5	0	0	0	1.3
UL03	0	0	0	0	2.4	0	10.0	6.7	11.1	9.1	2.9	0	4.0
UL05	0	0		0	0	6.7	0	0	0	0	0	0	1.7
UL06	0	0	7.1	0	3.7	6.3	0	7.1	0	0	0	0	1.9
GMI5	0	0	0	0	0	5.3	0	0	0	0	0	0	0.5
GMI6	0	0	0	0	0	1.9	0	0	0	0	0	0	0.2
GMO5	0	0	0	2.9	0	0	0	0	0	0	0	0	0.3
GMO7	0	0	2.9	0	0	0	0	0	0	0	0	0	0.3

Table 9-5
Monthly and total frequency of occurrence as percent (%) of dissolved oxygen (WQDO) values ≤ 2 ppm by principal component bay

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
Aransas Bay	0.4	0	2.9	0	0	0.6	0	1.0	0.5	0.3	0	0	0.6
Copano Bay	0	0	0	0	0.3	0.4	0	0	0.5	0.2	0	0	0.1
St Charles	0	0	0	0	0.7	0	1.3	0	0	0	0	0	0.2
Mesquite	0	0	0	0	0	0	0	0	0	0	0	0	0
Redfish	0	2.5	0	0	0	0	0.5	1.7	1.0	1.1	0.7	0	0.6
Corpus Christi	0	0	0	0	0	0.1	0.8	1.7	0.1	1.2	0.1	0.1	0.4
CCSC (bay)	0	0	0	0	0	1.0	1.0	5.0	1.3	1.7	0	0	0.7
Inner Harbor	0	0.5	5.8	4.6	2.6	25.8	27.5	10.4	26.7	13.8	2.8	7.6	8.5
Nueces Bay	0	0	0	0	0	0	0.4	0	0.5	0	0	0	0.1
Aransas Pass	0	0	0	0	0.7	0.3	0.4	0	0	0	0	0	0.1
Causeway N	0	0	0	0.6	0	0	0	0	0	0	0	0	0.1
Causeway S	0	0	3.1	0	0	0	0	0	1.1	0	0	0	0.3
Laguna (King)	0	0	5.2	0	0.5	1.0	0.8	1.7	1.3	1.0	0.2	0	1.0
Laguna (Baffin)	0	0	0	0	0	2.6	0	2.6	0	0	0	0	0.9
Baffin Bay	0	0.5	0.7	0	1.4	1.3	1.0	3.3	0.4	1.9	0	0	0.9
GOM inlet	0	0	0.5	0.5	0	1.2	0	0	0	0	0	0	0.2

Table 9-6
Monthly and total frequency of occurrence of dissolved oxygen (WQDO) values ≤ 0.5 ppm as percent (%) of the occurrence of hypoxic values (Table 9-4) by hydrographic-area segment

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
C15							0	14					7
CCC3								100		0			60
CCC7						50		83	100	0			69
IH1					100	50	35	41	50	58	100	100	52
IH3				17		50	100			83			57
IH5				0	50	29	46	33	38	25			35
IH6				67		25	20	29	29	50	0		33
IH7			67		0	0	23	46	50	22	0		30
NR1			80							0			57
NR3			100	50	67					33	80		65
UL03									100	0			38

Harbor, La Quinta Channel, Upper Laguna, especially along the King Ranch reach and near the JFK Causeway, Redfish Bay near Ingleside, and the nearshore of Corpus Christi Bay along the urbanized south shore.

What Tables 9-4 and 9-5 do not show is the depth occurrence of these low DO events and the frequency of occurrence of near-zero events, i.e. DO that is virtually zero. A direct inspection of the data indicates, again as expected, that very low DO's occur primarily in the measurements at depth, although in the 1960's and 1970's occasional profiles of DO in the Inner Harbor show depleted DO throughout the depth. With respect to near-zero events, defined to be a DO concentration ≤ 0.5 ppm, their occurrence as a fraction (percent) of the hypoxic events is summarized in Table 9-6 by hydrographic segment. To better focus this table, we include only those segments in which at least one such occurrence is logged in the period of record, and there are at least three measurements that are hypoxic (so that the relative frequency has some meaning). Again, the Inner Harbor is the predominant low-DO environment in the system.

These tables show hypoxia and near-zero occurrences as a fraction of the total data base or the fraction of the hypoxic events, respectively (requiring at least three independent measurements to compute such a fraction), to better scale the probable frequency of occurrence of such events. What is lost in this type of presentation is the magnitude of the raw numbers of such events, both hypoxic (DO $\leq$ 2) and near-zero (DO ≤ 0.5). These are summarized in Tables 9-7 and 9-8, segments being omitted if there are no occurrences in the data record.

What emerges from these tables is that hypoxia is relatively rare in the system, and the geographical regions of consistent occurrence are those enumerated above. Near-zero DO is rarer yet, being primarily confined to the Inner Harbor and Nueces River. In the time domain, most of the occurrences of hypoxia in the Corpus Christi Bay main body were logged in the 1960's and 1970's, especially in the Inner Harbor. In the outer bays of Copano, Aransas, the Upper Laguna and Baffin, most of the occurrences have been in the late 1980's and early 1990's.

Recently, the occurrence of near-bottom near-zero DO has been reported in the region north of the JFK Causeway (Montagna, pers. comm., 1996), Hydrographic Segment C14 (Fig. 3-11). These measurements are not included in the present compilation because they were received too late in the data-compilation process. However, by comparison with the rest of the data, this region evidences no proclivity for the occurrence of hypoxia, so we must regard this recent occurrence as probably localized and transient.

9.2.4 Suspended Solids and Turbidity

Suspended solids in Corpus Christi Bay have a close geographical association with regions of inflow and, to a lesser extent, with regions of shipping, see Figs. 6-33 through 6-37. The former is no doubt due to the riverine inflow and waste

Table 9-7
Number of hypoxia occurrences in data base, dissolved oxygen values ≤ 2 ppm by month and hydrographic-area segment

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
A5						1							1
A10	1												1
AL1									1				1
BF1		1											1
BF2								1		1			2
BF3					1		1	1		2			5
C01								1					1
C03								2					2
C04							1	1		2			4
C05								1					1
C06							1	1	1	2			5
C07											1		1
C10										2			2
C11								1	1				2
C12			1				1	1			1		4
C14							2	1					3
C15							6	7	1				14
C16										1			1
C17							1	2					3
CCC1					2	1							3
CCC3								3		2			5
CCC6										1			1
CCC7						2		6	5	3			16
CCC8						1	1	2	4	1			9
CP02					1								1
CP08						1							1
CP09									1				1
GR2								1					1
I3										1			1
I5					1								1
I6								2					2
I7											1		1
I9				1									1
I11			1										1
I12								1					1
I14									1				1
I15								1		1			2
I16						1							1
I17								3					3

(continued)

Table 9-7
(continued)

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
IH1		1			4	8	20	17	14	12	3	2	81
IH2								1					1
IH3			1	6		6	3	1		6			23
IH4				3		1							4
IH5			1	3	4	7	13	6	24	4			62
IH6				3		4	5	7	7	4	2	1	33
IH7			3	1	2	7	13	13	10	9	2		60
LQ1							2	1					3
LQ2					1		3	2					6
M2						1							1
NB5									2				2
NB6			1				1						2
NB7			3							1			4
NR1			5							2			7
NR3			4	4	3	1				3	5		20
NR4									2				2
NR5							2						2
OS1		1									2		3
OS3			1										1
PB1					1								1
PB2		1											1
RB2									1	1			2
RB9							1	3		1	1		6
SC1						1							1
SC3					1								1
UL02									1				1
UL03					1		1		3	2	1		8
UL05			1										1
UL06						1							1
Aransas Bay	1					1		4	1	1			8
Copano Bay					1	1			1				3
St Charles					1								1
Mesquite													0
Redfish							1	3	1	2	1		8
Corpus Christi							5	10	2	7	1		25
CCSC (bay)						2		9	5	6			22
Inner Harbor		1	5	16	10	33	54	45	55	35	7	3	264
Nueces Bay									2				2
Aransas Pass					2	1							3
Causeway N				1									1
Causeway S									1				1
Laguna (King)			2		1	1	1	2	4	3	1		15
Laguna (Baffin)						1		3					4
Baffin Bay		1			1		1	3		3			9

Table 9-8
Number of near-zero occurrences in data base, dissolved oxygen values ≤ 0.5 ppm by month and hydrographic-area segment

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
A10	1												1
AL1									1				1
BF1		1											1
BF2								1		1			2
BF3					1					2			3
C01								1					1
C03								2					2
C04							1			2			3
C06							1		1	1			3
C07											1		1
C10										2			2
C11									1				1
C12			1				1				1		3
C14							2	1					3
C15							6	6	1				13
C16										1			1
C17							1	2					3
CCC1					2	1							3
CCC3										2			2
CCC6										1			1
CCC7						1		1		3			5
CCC8						1	1	2	4	1			9
CP08						1							1
CP09									1				1
I3										1			1
I5					1								1
I6								2					2
I7											1		1
I9				1									1
I11			1										1
I14									1				1
I15										1			1
I16						1							1
I17								3					3
IH1						4	13	10	7	5			39
IH2								1					1
IH3				5		3		1		1			10
IH4				3		1							4
IH5			1	3	2	5	7	4	15	3			40
IH6				1		3	4	5	5	2	2		22
IH7			1	1	2	7	10	7	5	7	2		42

(continued)

Table 9-8
(continued)

segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*all*
LQ1							2	1					3
LQ2					1		3	2					6
M2						1							1
NB5									2				2
NB6							1						1
NB7										1			1
NR1			1							2			3
NR3				2	1	1				2	1		7
NR4									2				2
NR5							2						2
OS1											2		2
RB2									1	1			2
RB9								2		1	1		4
UL02									1				1
UL03					1		1			2	1		5
UL05			1										1
UL06						1							1
Aransas Bay	1												1
Copano Bay													0
St Charles													0
Mesquite													0
Redfish													1
Corpus Christi													1
CCSC (bay)										1			2
Inner Harbor				2	1	3	5	4	5	3	1		23
Nueces Bay													0
Aransas Pass					1								1
Causeway N													0
Causeway S													0
Laguna (King)													1
Laguna (Baffin)								1					1
Baffin Bay										1			1

discharges as sources of TSS, particularly very fine grained particulates that are easily maintained in suspension. The latter is probably due to resuspension by dredging activity and—especially—by ship traffic. Stratification in TSS is consistent and widespread, though not especially high, generally several ppm per m, decreasing upward. This vertical stratification is expected, for two reasons. First, because the particulates are subject to gravitational settling, there is expected to be an accumulation toward the bottom. Second, mobilization of bottom sediments are expected to be a primary source for suspended particulates, so the resultant concentrations will be greater near the source, *viz*. near the bed.

One of the surprising findings of this study is the general declining trend in suspended solids throughout the bay, see Table 6-50 and Figures 6-97 through 6-101. In the upper bays and the main body of Corpus Christi Bay, this rate of decline is on the order of 0.5 ppm/yr. This rate of decline over the past two decades has resulted in reducing TSS concentrations by approximately one-fourth. (This trend was based upon the proxy relations, by which turbidity measures were expressed as equivalent TSS. To verify that this trend was not a statistical artifact, separate trends were determined for TSS measurements and the individual turbidity measurements. All were found to be in basic agreement.) In the lower bays of the Upper Laguna and Baffin, the declining trend was even more prominent, being almost uniformly statistically probable, see Figs. 6-100 and 6-101, and at rate of decline over twice that of the upper bays. Over the period of record this has led to roughly *halving* the TSS concentrations in these bays. It is interesting to note that Ward and Armstrong (1992a) found exactly the same result in the analysis of data from Galveston Bay.

Hypotheses that could account for this decline are:

(1) Reductions in TSS loading due to advanced waste treatment;

(2) Reductions in TSS loading due to reductions in river inflow;

(3) Reductions in TSS loading due to declines in riverine transport, in turn a consequence of

  (a) reservoir construction

  (b) better land-use practices on the watersheds

  (c) natural modifications to watershed solids runoff;

(4) Reductions in TSS loading of peripheral runoff, due to alterations in land use around the bay;

(5) Declines in the mechanical resuspension of particulates within the bay;

(6) A laboratory artifact due to improved methods of filtration and analysis in the more recent data.

Among most workers (1) and (3a) would be considered the frontrunners by a considerable margin. This may explain the declines in Nueces and Corpus Christi Bay, but does not account for those in the upper and lower bays. Noting that there is a general association of regions of increasing salinity and regions of declining TSS in Corpus Christi, Nueces, Aransas and Copano Bays, and the probable effect of reduced inflow on salinity (see 9.2.2 above) lend weight to (2), perhaps in concert with (3b) or (3c). Again, this does not explain the substantial decline in the lower bays. Hypothesis (5) implies a longer-term climatological change, perhaps an alteration of wind predominance or windwave production.

In our view, the only one of these which lacks plausibility is (6). This is because actual TSS measurements make up a minority of the proxied data base, and the same decline is evidenced in the alternative measures of turbidity. It is too much of a stretch to claim methodological bias in all of these measures.

9.2.5 Nutrients and chlorophyll

Ammonia nitrogen is generally higher in regions affected by waste discharges, especially the Inner Harbor, while nitrate is typically highest in regions affected by runoff and inflow. Generally where these are high in concentration, they exhibit a declining trend. The exception to this statement is the occurrence of elevated nitrate in the Inner Harbor, which does not evidence a clear decline. Phosphorus is generally higher in regions affected by runoff, i.e. near the inflows of rivers and tributaries, but its distribution in the system is generally opposite to that of volume of flow, increasing in concentration from Copano in the north to Baffin in the south. Total organic carbon (TOC) is higher in the regions more influenced by inflows, namely the upper bays and Corpus Christi Bay, and in these systems the trend is toward declining concentrations. The sediments also exhibit declining trends of TOC in areas of higher concentrations, see Fig. 7-51.

Hypotheses explaining these observations include the following:

(1) The prominent source of ammonia is waste loads, and is declining due to improved waste treatment;

(2) Nitrate is introduced both in runoff and in waste loads, however improvements in waste treatment are not achieving a decline in nitrate in the Inner Harbor because the ammonia in the waste stream is being oxidized to nitrate;

(3) Declines in nitrate in the upper bays are due to reduced riverine loading, in turn a consequence of:

(a) reservoir construction

(b) better land-use practices on the watersheds

(4) TOC is declining due to reduced organic loads in the rivers;

(5) TOC is declining due to reduced biomass production in the open waters.

Whether (5) is a viable hypothesis could be judged by whether a similar trend is indicated for chlorophyll-a. Unfortunately, the data holdings are too sparse and noisy for reliable trend analysis. (In Nueces Bay, the trend are opposite, declining for TOC but increasing for chlorophyll-a.) It is noteworthy to contrast this situation with the analysis for Galveston Bay (Ward and Armstrong, 1992a), where a much more substantial data base for chlorophyll-a allowed determination of a general decline in concentration throughout the system.

9.2.6 Contaminants

The association of BOD concentration with waste discharge sources is evident in two respects: the geographical distribution of BOD, with higher concentrations in regions affected by inflows and waste discharges, and a tendency for decline in BOD concentrations over time in the same regions. Unfortunately, measurement of BOD seems to have gone out of fashion in recent years, so most of our knowledge about the distribution of BOD in the system applies only to the 1970's for most areas, and the early 1980's for the others. The high concentrations indicated in Baffin (Fig. 6-21) are based on data from the 1960's and 70's. Similarly, the declines in Inner Harbor values would probably be much more pronounced (and better defined) had we any data from the most recent decade. Thus while we do not need to look far for a causal hypothesis explicating the observed behavior of BOD in Corpus Christi Bay, since it is clearly a direct measure of organic loads, both from waste discharges and from peripheral runoff (including inflows), its association with more recent trends in the system, e.g. nutrients and increasing salinities, is unknown. Other alternative indicators of organic contaminants such as volatile suspended solids and oil & grease suffer from the same problems of limited measurements. Volatile suspended solids are high in the water and volatile solids are high in the sediment in the Inner Harbor. These are also high in Copano Bay and Nueces Bay. For VSS, however, the data record extends to the present, and evidences a probable declining trend almost everywhere in the system (where data exist).

Fecal coliforms exhibit lower concentrations in open-bay areas and higher concentrations in areas affected by inflow, runoff, and waste discharges, Table 6-20. High values are found in the nearshore regions along the urbanized south shore of Corpus Christi Bay. The most widespread trend is for increasing concentrations, but this is at a low level of statistical confidence. This would seem to run counter to the above hypotheses of improved waste treatment, and diminished runoff loads. Certainly, the noisy character of this measure erodes the statistical confidence in the analysis, and many of the apparent trends may be statistical artifacts. The obvious hypothesis of coliform behavior is that it is a highly transient indicator responding to environmental factors that operate on much shorter time frames than implicit in a long-term data base. This means that apparent statistical behavior of the data base may be more a function of where and when it is sampled than in any intrinsic variation of the parameter. The fact that coliforms respond to many variables other than human enteric wastes has been remarked by many investigators, as well. The observed behavior of coliforms might profit from detailed response-type analysis including storm events, hydrographic fluctuations, and postulated attrition kinetics; such an analysis is beyond the scope of this study.

Metals, in general, behave in a quasi-conservative manner in the water column (cf., Table 7-1) and their *variability* in Corpus Christi Bay would be expected to be high, in response to all of the factors effecting mass transport (analogous to that of salinity). This would make inferences difficult in itself. The problem is compounded by the relatively sparse data set and the great majority of measurements reported as "below detection limits," all of which translates to a high degree of uncertainty. It is clear, however, that the regions in and around the Inner Harbor exhibit consistently high metals in the water. Nueces Bay is a region consistently high in metals, in both the water column and the sediment, as are Baffin Bay, Copano Bay, a region of the Upper Laguna around Pita Island, the La Quinta Channel, and Redfish Bay near Aransas Pass.

The existence of the CP&L Nueces Generating Station means there is a direct transport of water from the Inner Harbor to Nueces Bay (see 9.2.1 above), in that the plant continuously circulates a flow at a nominal rate of 18 m^3s^{-1} (650 cfs), which is approximately equal to the mean inflow of the Nueces River (Table 9-3). One hypothesis for the elevated metals in Nueces Bay, therefore, is that they are due to this influx of water (and suspended sediments) from the Inner Harbor. This hypothesis cannot, however, be the entire explanation, because there are too many parameters whose concentrations are inconsistent between Nueces Bay and the Inner Harbor, such as ammonia, suspended solids, and lead, nor are the trends consistent. A second hypothesis is that the metals are associated with oil and gas activities, a feature which Nueces Bay has in common with Copano Bay and Baffin Bay. This may also be supported by the relatively high sediment concentrations of PAH's (Table 7-9) some of which, such as acenapthene, are not shared with the Inner Harbor. For the metals for which a reliable trend determination can be made, most are declining in the Inner Harbor. This is in general conformity to the hypothesis of improved water quality due to advanced waste treatment. One curious exception is lead in the water phase, which shows probable increasing trends consistently in all of the segments of the Inner Harbor. This statement is not true for the sediment metals, in that no positive trends are indicated in the Inner Harbor for any of the metals.

Elsewhere in the bay, metals data for the water phase are too sparse to allow general statements. In the sediments, the open deeper waters of Corpus Christi Bay tend to be higher in concentration than the nearshore waters for most metals. This seems to be obeyed as well in the other systems, especially Baffin, but is most obvious in Corpus Christi Bay because of the high range of concentrations. On the other hand, the deepest sections of Corpus Christi Bay, namely, the Corpus Christi Ship Channel hydrographic segments, are systematically lower in metals than the sediments to either side, see Figs. 7-15, 7-21, 7-26, 7-30, and 7-36. This general pattern offers clear evidence of the association of metals with sediments, especially the finer grain sediments, and how they are influenced by transport, deposition and dredging. Trends in sediment concentrations are inconsistent geographically and from metal to metal, so without further detailed analysis, it is difficult to determine possible causes. We note a general probable decline in mercury in the open bay waters, and some tendency for increasing zinc, especially in the Baffin and Corpus Christi systems, but this is statistically less reliable.

Two hypotheses regarding in the interaction of water and sediment metals, and their ultimate transport and fate are:

(1) The pathway of metals is to the sediments due to settling of solids and then to the overlying water by resuspension and reworking; that is, metals in the water column are driven principally by concentrations in the sediments and continual scour and resuspension;

(2) The pathway of metals is to the water column first, followed by transport with the main currents and settling with solids; that is, concentrations in the sediments are driven by the TSS-sorbed metals in the overlying water and zones of relative stagnation where settling is enhanced;

With respect to the observed distributions and probable sources, the following hypotheses are proffered:

(3) The principal sources of metals in Corpus Christi Bay are in the industrial and outer bay areas, in turn originating from

- (a) waste discharges
- (b) runoff from industrialized areas
- (c) shipping activity
- (d) oil & gas production activities

(4) The decline in metals concentrations in water and sediment results from advances in waste treatment, in turn from

- (a) reductions in TSS and the associated affinity of metals for fine-grained solids
- (b) assimilation and/or bonding during high-detention secondary treatment

(5) The decline in metals concentrations in water and sediment results from better runoff controls in the watershed;

(6) The decline in sediment metals in the Inner Harbor and trans-bay reach of the Corpus Christi Ship Channel is due to increased dredging, removing contaminated sediments from the bay system to upland or offshore sites, or sidecasting into areas remote from the channel; if the pathway is from sediments to water (1), this would imply a reduced concentration in the water column, as well.

These hypotheses are not mutually exclusive. Clearly, the observed decline in suspended solids and in many metals is considered to be more than just a statistical association, because there is a well-established physical relation in the affinity of metals for fine-grained solids. Therefore, any insight into the cause of the reduction in TSS would yield information on the dynamics of metals. The alternative pathways of (1) and (2) would be moot if the reduction in metals were tied to waste-treatment or runoff control, since the net effect of either pathway would ultimately be the same. On the other hand, (1) would imply maximum concentrations in areas of strong currents and intense shipping, perhaps offering an explanation for the higher concentrations of some metals in the Port Aransas Entrance Channel regions.

The sparse data base and rarity of measurements above detection levels prevent any statements about coherent behavior of pesticides, PAH's and PCB's in Corpus Christi Bay, other than a proclivity for higher concentrations in regions of increased urban activity, especially the Inner Harbor.

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 The data base

A primary objective of this study was the compilation of a digital data base composed of water-quality, sediment-quality and tissue-quality data, which was assembled from 30 data collection programs performed in Corpus Christi Bay. This compilation included data from the three most important ongoing monitoring programs in Corpus Christi Bay: the Texas Natural Resource Conservation Commission (TNRCC) Statewide (a.k.a., Stream, a.k.a. Surface-water) Monitoring Network (SMN), the Texas Parks and Wildlife Department hydrographic observations from its Coastal Fisheries program, and the hydrographic and biochemical data of the Texas Department of Health Seafood Safety (née Shellfish Sanitation) Division program. The important surveys and research projects sponsored by the Texas Water Development Board and maintained in its digitized Coastal Data System are included. This compilation also entailed keyboarding of other major data sets, many of which exist in limited hardcopy and are virtually unobtainable, including the Galveston District U.S. Corps of Engineers (USCE) O&M water and sediment surveys of the 1970's, data of the Texas Game Fish & Oyster Commission from the 1960's, the Reynolds-sponsored "baseline" surveys of the early 1950's, the Submerged Lands Project of the Bureau of Economic Geology, and the data collections by the now-defunct Ocean Science and Engineering Laboratory of Southwest Research Institute. Other entries in this compilation include research projects whose data are published only in limited technical reports or academic theses, all of which were keyboarded. A major data compilation effort of the project was devoted to determination of latitude/longitude coordinates based upon historical sampling station location information, so that all of the data could be unambiguously georeferenced. In addition to supporting the spatial-distribution analyses of this study, this georeferencing data will facilitate incorporation of the data base into GIS systems.

All told, the digital compilation is the most extensive and detailed long-term record of water and sediment quality ever assembled for Corpus Christi Bay. Each measurement record includes the date, sample depth, latitude and longitude of the sample station, measured variable, estimated uncertainty of measurement expressed as a standard deviation, and a project code identifying the origin of the data. For tissue data, the sample depth field is replaced by a code identifying the organism.

Spatial aggregation of the data was accomplished by two separate segmentation systems for Corpus Christi Bay, the TNRCC Water Quality Segmentation of 27 segments, and a system of 178 hydrographic segments devised by this project and designed to depict the effects of morphology and hydrography on water properties. (The 27 TNRCC segments include the original 15 specified by the Scope of Work, to which we added 5 classified segments and 7 unclassified.) Each segmentation system was codified by a network of nonoverlapping quadrilaterals by which the data records could be sorted using latitude/longitude coordinates of sampling stations.

Detailed statistical analyses were performed of 109 water-quality parameters and 83 sediment-quality parameters, in addition to several supplementary (e.g., DO deficit), screened (e.g., near-surface values), or transformed (e.g., proxied TSS) variables. Each statistical analysis included basic sampling density information, means and standard deviations, with three different treatments of measurements below detection limits (BDL), and a linear trend analysis over the period of usable record, with confidence limits on the slope. Therefore, statistical analyses addressing water/sediment quality were performed of about 200 parameters in about 200 (exactly, 27 + 178) different segments, a total of about 40,000 independent statistical analyses, since each parameter/segment comprises an independent data set. For tissue data, an even more extensive suite of analytes were compiled, but the statistical analyses were confined to a subset of these analytes because of the sparsity of the data base. In addition to sediment/parameter differentiation, tissue data had to be further separated according to organism, portion of organism analyzed (i.e., whole versus fileted), and reporting by dry- or wet-weight, each combination of which represented an independent statistical analysis. The results of these analyses are given in the Appendices to this report.

It is appropriate to note several deficiencies of this data set, as they relate to the interpretation of water and sediment quality, and as motivation for recommendations proffered in the concluding section. Despite the hundreds of thousands of separate measurements compiled in this study, from extensive and overlapping routine monitoring and survey programs by several state agencies and numerous special surveys, when these data are subdivided by specific parameters, each of which measures a different aspect of the water quality "climate," aggregated by region of the bay (segments) and distributed over time, the data record is seen to be rather sparse. Generally, Corpus Christi Bay is undersampled. This is relative to the high degree of variability of the bay. Unlike a lake or a river, which can be fairly stable in time and fairly homogeneous over large areas, an estuary such as Corpus Christi Bay is subject to a variety of external controls, all of which contribute to variation in space and time. The intermixing of fresh and oceanic waters imposes spatial gradients in both the horizontal and the vertical. The effects of tides, meteorologically driven circulations, and transient inflows all contribute to extreme variability in time. Superposed upon all of this are the time- and space-varying influences of human activities.

Adequacy of a data base is judged relative to the ability to resolve the various scales of variation, and therefore in this respect the data base for Corpus Christi Bay is sparse. Continuity in space of the data base is undermined by too few stations, and by inconsistency in the suite of measurements at different stations. Continuity in time is undermined by infrequent sampling, and the replacement of one parameter by another without sufficient paired measurements to establish a relation. Past and present sampling practice does not permit analysis of time scales of variation shorter than a few days. Ability to resolve long-term trends in the face of high intrinsic variability requires data over an extended period. The extant period of record for Corpus Christi Bay, with adequate continuity for trends analysis, extends back only to about 1965, except for some traditional parameters and for certain areas of the bay, for which the record can be extended back to the 1950's. As salinity and temperature are the most easily measured variables, they represent the densest and longest data record. For metals and for complex organics, the period of record may extend back only a decade or so. Many of these measurements are below detection limits. For sediment, the data base is even more limited, amounting to one sample per 50 square miles per year, and extending back in time at most to the 1970's.

Data management is generally poor. Reference is made to the conclusions of Ward and Armstrong (1992a) concerning data management practices and data loss in general. Most of the same problems encountered in the Galveston Bay Status & Trends Project were met in this one as well. A new mainframe data management system, and the link through the Internet have greatly improved the dissemination process at TNRCC relative to the situation five years ago. Also this agency is now observing paper-copy back-up for its holdings, so that errors or missing information can be tracked down. On the other hand there remain problems with the older data including data-entry errors, position errors, and incorporation of BOGAS measurements (see Sections 2.1 and 5.3.2) into the data base. The most pressing management problem for historical data in the Corpus Christi area, as well as in other areas of the Texas coast, is preservation of the older data. Much irreplaceable and invaluable information on the Corpus Christi Bay system has been lost.

10.2 The water and sediment "climate"

Salinity acts as a water mass tracer and general habitat indicator for Corpus Christi Bay waters whose concentration is primarily determined by boundary fluxes at the inflow points and at the inlets to the sea, and internal transport and mixing. It is technically a conservative parameter, but viewed from a water-column perspective, it behaves nonconservatively much of the time because of the major rôle evaporation plays in the bay's salt budget. In contrast to the estuaries on the upper Texas coast, substantial gradients across Corpus Christi Bay from the sea to the regions of inflow are not a normal feature of salinity structure. These gradients are on average rather flat. The most significant gradient of salinity in the project Study Area is, rather, from north to south, from Copano Bay to Baffin Bay. This is clearly the combined result of diminishing inflow with distance to the south and increasing evaporation. However, variability about the mean salinity is high, in some areas encompassing tens of parts per thousand, and exceeding seawater concentrations sometimes by large amounts, especially in the lower bays (the Upper Laguna and Baffin Bay). Vertical stratification of bay waters is slight, by estuarine standards, generally averaging less than 0.6 ppt/m, and averaging less than 0.3 ppt/m over about half of the study area, with no correlation with water depth. In particular, there is no apparent correlation between mean salinities and ship channels, suggesting that density currents as a mechanism of salinity intrusion are rarely important in Corpus Christi Bay.

This is consistent with the lack of horizontal salinity gradient along the ship channels.

While freshwater inflow is the ultimate control on salinity, inflow proves to be a poor statistical predictor of salinity, achieving less than 50% explained variance in those areas in proximity to sources of inflow, and even less elsewhere, even with long-term averaging of the inflow. This illustrates that the variability of salinity is influenced by factors other than simply the level of inflow.

In the bays generally more influenced by freshwater inflow, *viz.* the Copano system, the main body of Corpus Christi Bay and Nueces Bay, there has been a general increase in salinity over the three-decade period of record, on the order of 0.1 ppt per year. During the same period there has been a declining trend in monthly-mean inflow to these same bays, over 50% in Corpus Christi and Nueces Bays, less in Copano (which also logged a smaller increase in salinity). Our favored hypothesis (whose testing would require detailed salt budgeting for the system, and exceeded the scope of this study) is that this decline in mean inflow is responsible for the increase in salinity. No clear trends in salinity emerged for the Upper Laguna or Baffin Bay.

The parameter pH is rather uniform, with its higher values, in excess of 8, in the more saline regions of the bay, an expression of the high buffering capacity of sea water. Because of its variability within a rather narrow range, no reliable trends were detectable, though in the open waters of Corpus Christi there is a proclivity to declining values. It is noteworthy that the (smaller) data set for alkalinity shows statistically probable declining trends almost everywhere.

Temperature in Corpus Christi Bay is primarily controlled by surface fluxes, especially the seasonal heat budget, and much less—if at all—by peripheral boundary fluxes and internal transports. The horizontal gradient across the study area is from north to south, ranging 2-4°C. There is little systematic stratification, though on average a slight stratification on the order of 0.1°C/m is indicated. This stratification is due to near-surface heat absorption, rather than density effects. The seasonal signal is, of course, the principal source of variation in water temperature, ranging about 14 to 30°C from winter to summer. Over the three-decade period of record, water temperature in the upper bays and main body of Corpus Christi Bay, especially in the open waters, has declined at a nominal rate of 0.05°C/yr. There are no clear trends in the lower bays. It is interesting to note that the same decline in temperature, at approximately the same rate, was discovered in Galveston Bay (Ward and Armstrong, 1992a). Our favored hypothesis for this decline is an alteration in climate (e.g., air temperature, wind, cloud cover), though this could not be tested within the scope of this project.

Dissolved oxygen is generally high throughout the CCBNEP Study Area, averaging near (and above) saturation through most of the system, with frequent occurrence in the data record of substantial supersaturation. Exceptions to this are in poorly flushed tributaries and areas influenced by wasteloads, especially the Inner Harbor. These near-saturated conditions are a manifestation of the intense vertical mixing processes in Corpus Christi Bay, which enhance mechanical surface aeration, as well as a manifestation of photosynthetic productivity. The most important variation in DO is due to seasonal changes of solubility. In the open, well-aerated areas of the bay, vertical stratification is on the order of 0.1 ppm/m. This stratification is considered to be the result of DO influx across the surface in concert with water-column and sediment biochemical oxygen consumption. The occurrence of hypoxia (which we define to be DO $\leq$ 2 ppm) is rare, occurring at most in several percent of the data in a minority of regions of the bay and those in measurements near the bottom in deeper water. The exception is the Inner Harbor, where hypoxia has occurred in about one-fourth of the measurements, primarily near-bottom. We note a large area in the central region of Corpus Christi Bay with coherent increasing values of DO deficit, on the order of 0.05 ppm/yr.

Conventional water-phase organic contaminants as measured by BOD, oil & grease, VSS and volatile solids, are generally highest in the Inner Harbor. However, the data base is too limited for reliable trend determination. (In fact, the frequency of measurement of these parameters has declined in recent years.) In the open waters of Corpus Christi Bay, BOD seems to be declining, and wherever adequate data for analysis exist, VSS is declining. This is probably the result of the institution of advanced waste treatment. Analogous measures in the sediments, volatile solids and oil & grease, are not especially elevated, even in the Inner Harbor, but the highest concentrations in the system are found in the Mesquite-Carlos-Ayres Bay region.

Like all of the Texas bays, Corpus Christi is turbid. Long-term average suspended solids range 20-100 ppm throughout most of the Study Area, higher in the bays influenced by freshwater inflow, i.e. Nueces, Copano and Corpus Christi Bay, as well as in Baffin. Stratification in TSS is noisy, but on the order of 5 ppm/m declining upward, which is consistent with settling of larger particles to the bottom as well as a near-bottom source of particulates from scour of the bed sediments. The highest TSS concentrations and highest stratification are found in Nueces Bay.

The remarkable feature of TSS in Corpus Christi Bay is its decline throughout the system, increasing in significance from north to south in the Study Area. This is consistent with the findings for Galveston Bay (Ward and Armstrong, 1992a) but the rate of decline is about a factor of two to four smaller in Corpus Christi Bay. Still, it is sufficient to have reduced the average concentration by about 25% in the upper bays and by about 50% in the lower bays over the last two decades. This could be caused by several factors, including a general reduction of TSS loading to the bay or altered mobilization within the bay system itself. The usual hypotheses of improved waste treatment and/or TSS entrapment within reservoirs are not adequate to account for the substantial reductions in the lower bays, though they may explain the alterations in Nueces Bay.

Nitrogen and phosphorus nutrients in the water column are noisy and highly variable through the Corpus Christi Bay study area. Ammonia nitrogen is generally higher in regions affected by waste discharges, especially the Inner Harbor, while nitrate nitrogen and phosphorus are typically highest in regions affected by runoff and inflow. Generally where the nitrogen species are high in concentration, they exhibit a declining trend. No clear trends are apparent in the phosphorus data. In the sediment phase, concentrations of Kjeldahl nitrogen are elevated but not excessive in the Inner Harbor region, and the highest concentrations in the system occur in the Upper Laguna along the King Ranch. Sediment phosphorus is relatively uniform throughout the system with no relative elevation in the Inner Harbor or in areas affected by inflow.

The levels of concentration of total inorganic nitrogen in the water are about 0.1 ppm in most sections of the system, except much higher, around 0.5 ppm in Copano and in the Inner Harbor (the latter due to high ammonia concentrations). Total phosphorus in water is about 0.05 ppm through the system, except around 0.15 ppm in regions affected by tributary inflow, notably Nueces Bay, Copano Bay and Baffin Bay. These mean concentrations in Corpus Christi Bay are more-or-less typical of other Texas bays (e.g., Longley, 1994), though total inorganic nitrogen is about half the levels found in Galveston Bay and total phosphorus is about one-fourth (Ward and Armstrong, 1992a).

Generally water-phase TOC values are about a factor of two higher in the upper bays, decreasing from 20-30 ppm in Copano to 5-15 ppm in Baffin and the Laguna, with a seasonal peak in early summer. Much larger values (about an order of magnitude) are found in the Inner Harbor. Water-phase and sediment TOC distributions generally run counter to each other. TOC in sediments *increase* southward across the study area with the *lowest* values of sediment TOC in the Inner Harbor. Nueces Bay shows substantially depressed values of TOC in both water and sediment. There is a widespread declining trend in water-phase TOC at a rate sufficient to reduce the concentrations by about one-fourth over two decades. (The prominent exception to this is in the Inner Harbor, where average TOC is the highest in the study area, and is increasing in time.) Where sufficient sediment TOC data exist to establish a trend, this trend generally is also declining in time. Unfortunately, the data for chlorophyll-a is too sparse and noisy to determine whether any correlated time trends occur in it as well, so we cannot judge whether the decline in TOC is due to reduced primary production or to reduced loadings.

Contaminants such as coliforms, metals and trace organics (pesticides, PCB's) show elevated levels in regions of runoff and waste discharge, with generally the highest values in the Inner Harbor, and generally low values in the open bay waters. Given this general statement, some exceptional situations should be noted. The highest average coliforms in the system occur in the nearshore segments of Corpus Christi Bay from Corpus Christi Beach to Oso Bay. Much higher values are represented in the fecal coliforms in this region than the older total coliform determinations from the same area. Apart from the Inner Harbor, Nueces Bay is a region consistently high in metals, in both the water column and the sediment, as are Baffin Bay, Copano Bay, a region of the Upper Laguna around the Bird Islands, the La Quinta Channel, and Redfish Bay near Aransas Pass. We expect metals concentrations in both water and sediment to be closely linked to suspended sediments, which act as carriers for metals, but to also be influenced by local sources, and perhaps sources from the watersheds brought in by runoff. The only apparent commonality to all of these regions is concentrations of petroleum production facilities.

Curiously, while concentrations in the water phase of arsenic, cadmium (except for Nueces Bay), iron, mercury in the CCBNEP Study Area in general are substantially less than those in Galveston Bay, concentrations of copper, chromium, lead, manganese, nickel and zinc are about the same. Considering that Galveston Bay is a smaller area, is more directly influenced throughout by human activities, and is generally considered to have much higher point-source loads of metals, one would expect the Corpus Christi Bay study area to have lower concentrations. That it does not would suggest a source other than point source loadings for these metals. The metals copper, nickel and zinc, in particular, have elevated concentrations generally throughout Corpus Christi Bay where data exist (relative to the values presented in Moore and Ramamoorthy, 1984b, typifying "uncontaminated" coastal and marine waters). With respect to sediment metals, arsenic, cadmium, mercury, and zinc are on the same order as Galveston Bay, while copper, iron and lead are much lower (except for the Inner Harbor, which is similar to the upper Houston Ship Channel in all of these metals, save zinc, for which its sediments are an order of magnitude *higher* than those of the Houston Ship Channel).

The water-phase metals data were so sparse and noisy that reliable trends could not be generally established. For sediment metals in the principal components of the system, where a trend can be reliably established it is generally declining. For the Inner Harbor, which was found to be the site of greatest metals concentrations, a probable declining trend is consistently indicated. Other trends throughout the system vary depending upon the specific metal. It is noteworthy that Copano Bay, which shows among the highest concentrations in the study area (apart from the Inner Harbor) for chromium and nickel, also exhibits increasing probable trends for these metals, as well as for copper and zinc. Another exception to the general declining trends is sediment zinc, for which widespread *possible* increasing trends are indicated in large areas of the open waters of Corpus Christi Bay and Baffin Bay. However, the strength of these statements is blunted by the fact that metals data in the upper bays tends to be much older, with relatively little information from the most recent decade.

No definitive statements can be made about water-phase volatile organics such as pesticides and PAH's, because data is sparse, and very few measurements are uncensored, most being simply reported as below detection limits. For example, the best-monitored pesticide is DDT, for which most areas of the bay do not have data. Only four non-zero average values occur in the entire study area, two in the GIWW at Ayres Bay, one in Nueces Bay, and one in Baffin Bay. For toxaphene, only one non-zero value occurs, in Nueces Bay. The situation is similar for the other organics, with only one or a few non-zero values, and inadequate data to determine any trends or spatial variation.

The situation is a little better for sediment-phase data, but still most of the system is unsampled, and much of the data which do exist are below detection limits. The highest concentrations of the common pesticides are found in Baffin Bay and

Copano Bay. Concentrations of sediment pesticides in Nueces Bay are not especially high, except for toxaphene. PCB's and PAH's follow a very different distribution, with very high concentrations (as expected) in the Inner Harbor. Elevated concentrations of PCB's also occur in Redfish Bay. There are consistent elevated concentrations of some of the PAH compounds in Nueces Bay, Copano Bay, and Mesquite Bay, but not in the Upper Laguna.

10.3 Tissue quality

Considering the effort required to obtain, digitize and compile the tissue data for the CCBNEP study area, the information yield is disappointing. Pooling and analysis of the data are hampered by the noncomparable attributes of organism sampled, portion of organism analyzed (whole versus edible portions), and reporting convention (wet-weight versus dry-weight), in addition to the usual discriminants of analyte and geographical position. The most-sampled organism is the American oyster, with most samples from Nueces and Aransas Bays, followed by the blue crab, speckled trout, red drum and black drum. One sample each of brown shrimp and white shrimp appears in the entire data base. By far, the greatest quantity of analyses have been performed for the metals. Of the organic analytes, the greatest number of determinations have been performed for the pesticides, especially the common commercial mixtures such as chlordane and toxaphene, and for PCB's. Most of the organic analytes have never been detected in the tissues of organisms. In particular, the data base of *detected* PAH's and related hydrocarbons is negligible. For only a few, such as pyrene, have there been detects logged in the data.

For the oyster, the upper bays and the main body of Corpus Christi show somewhat elevated concentrations of arsenic with no clear time trends. Nueces Bay and Copano Bay exhibit systematically elevated metals in the tissue, Nueces Bay having the highest mean tissue concentrations for cadmium, copper, lead and zinc, and Copano Bay exceeding Nueces Bay slightly for mercury. This conclusion generally agrees with the relative concentrations in the sediments, if the Inner Harbor and tertiary bays are discounted. Blue crab data in Redfish Bay and Baffin Bay show elevated levels of most metals. Elevated arsenic concentrations in particular are noted in the Upper Laguna and Baffin Bay. Statistical analysis of the black drum data base was possible only for Nueces Bay, which indicated some elevated metals concentrations, especially for mercury and zinc, and where a time trend could be resolved, it is increasing. These statements notwithstanding, the limited data base in general renders any statistical judgments tenuous.

10.4 Problem areas

With the marshalling of the data of this project, one central concern is whether there are indicated any regions of the Corpus Christi Bay study area exhibiting degraded quality or exhibiting a trend of degradation that could bode an incipient problem. "Quality," of course, is a relative term; here it refers to the suitability of the watercourse to sustain biological activities and a viable ecosystem, and to support quality-limited human uses typical of the nature of the watercourse, e.g. recreation but (for an estuary) not water supply. This is quantified by standards and criteria applicable to Corpus Christi Bay. For water quality, the sources are the Texas Surface Water Standards (TWC, 1991) and the EPA "Gold Book" (EPA, 1986). These are summarized by parameter in Table 10-1. It should be noted that the Texas Standards, as *standards*, apply both to a parameter and to a region of the bay (specifically identified by its TNRCC segment), while the EPA criteria pertain to a parameter in the marine or estuarine environment, without regional specificity, and therefore subject to revision as warranted by local conditions and organisms. A similar qualification is necessary with respect to how the standards or criteria are applied. In many cases, our use here does not conform to how the standards are applied in regulatory practice. Thus, we flag the use of the term "violation" by which we mean simply that the point measurement exceeds (or, in the case of DO, is less than) the numerical criterion.

In the present context, we regard these criteria as convenient quantifications of parameter levels which *may* be indicative of degraded water quality. As our principal concern is the "present" quality of Corpus Christi Bay, we have focused on data collected since 1985. A comparison of the actual concentrations measured in the Corpus Christi Bay system with the criteria of Table 10-1 is given in Tables 10-2 through 10-7, for various classes of waterborne parameters. Tables 10-2 through 10-4, for temperature, dissolved oxygen and coliforms, further analyzes these comparisons on a monthly basis, since there is some reason to anticipate a seasonal exposure to violation of the standard.

For temperature, Table 10-2, the single instantaneous standard of 35°C (95°F) applies throughout the system. The first column to examine in Table 10-2 is the rightmost, for the entire data set for each segment, giving the frequency of exceedance of 35°C. Then the distribution by month should be examined, the frequencies of occurrence being relative to total data holdings for each month. One must recognize that the TNRCC temperature standard of 35°C is applied uniformly to the entire Texas coast, without cognizance of the natural gradient of increasing temperatures toward the south, a gradient to which the indigenous organisms would have presumably acclimated. Clearly, the shallow, poorly circulated sections of the Corpus Christi Bay system are most prone to higher temperatures, especially those in the lower bays, and violations occur, mainly in the summer, at a low rate–only a couple of percent. Only two regions have substantially higher frequencies of violation; these are in Nueces Bay and Oso Bay, both affected by return flows from power plants. Coupled with the general decline in water temperatures in time, this low frequency of violation indicates that hyperthermality is not a problem in Corpus Christi Bay.

The state standard for dissolved oxygen requires special comment. Prior to 1984, standards attainment was established by comparison with a surface measurement of DO. With the 1984 revisions, attainment was based upon a vertical profile of DO, either depth-integrated or "under conditions of density stratification, a composite sample collected from the mixed surface layer." This

Table 10-1
Standards and Criteria for Water Quality

parameter	*State of Texas Standard**	*EPA criterion (chronic) fresh*	*marine*
WATER QUALITY INDICATORS:			
Temperature (°F)	95		
Dissolved oxygen (mg/L)	5.0 4.0 in 2001, 2003 & 2492 3.0 in 2484	4[m]	
Fecal coliforms (org/100mL)	14[a] 200[a] in: 2001, 2003, 2101, 2484	126(406)[c]	14[s]
METALS (dissolved):			
Arsenic (μg/L)	78	190	36
Cadmium (μg/L)	10.02	1.1	9.3
Chromium (μg/L)		11	50
Chromium (hex) (μg/L)	50		
Copper (μg/L)	4.37	12	
Lead (μg/L)	5.6	3.2	5.6
Mercury (μg/L)	1.1	0.012	0.025
Nickel (μg/L)	13.2	96	7.1
Selenium(μg/L)	136	35	54
Silver (μg/L)	0.92	0.12	
Zinc (μg/L)	89	47	58

* for metals, the marine chronic standard is given
m one-day minimum
a 30-day geometric mean
s shellfish harvesting, median w/<10% exceeding 43
c light contact recreation, 406 single-sample max

Table 10-1
(continued)

parameter	*State of Texas Standard†*	*EPA criterion (chronic) fresh*	*marine*
PESTICIDES AND RELATED PARAMETERS:			
DDT, Total (μg/L)	0.001	0.0010 (1.1)**	0.0010 (0.13)
DDE, Total (μg/L)		0.0010 (1.1)	0.0010 (0.13)
DDD, Total (μg/L)		0.0010 (1.1)	0.0010 (0.13)
Chlordane, Total (μg/L)	0.004	0.0043 (2.4)	0.0040 (0.09)
Dieldrin (μg/L)	0.0019	0.0019	0.0019
Endosulfan (μg/L)	0.0087		
Endosulfan-I (μg/L)		0.056	0.0087
Endrin (μg/L)	0.0023	0.0023	0.0023
Toxaphene (μg/L)	0.0002	0.013	
Heptachlor (μg/L)	0.0036	0.0038	0.0036
Methoxychlor (μg/L)	0.03	0.03	0.03
PCB's, Total (μg/L)	0.03	0.014	0.030
Malathion (μg/L)	0.01	0.1	0.1
Parathion (μg/L)		0.04	0.04
2,4,5 Trichlorophenol	12		
Hexachlorobenzene (μg/L)		30	129
PAH, Total (μg/L)			300*
Napthalene (μg/L)		620	
Acenaphthene (μg/L)		520	500
Fluoranthene (μg/L)			16

† marine chronic standard
* acute toxicity
** instantaneous values in parentheses

Table 10-2
Violations of temperature standard (Table 10-1), upper 1 m, post-1984
Relative frequency (percent) by hydrographic area segment and month
(only segments logging violations are shown)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
A13	10.0	0	0	0	0	0	0	0	0	0	0	0	1.0
BF3	0	0	0	0	0	0	0	0	0	3.3	0	0	0.3
C14	0	0	0	0	0	0	2.4	5.6	0	0	0	0	0.6
C17	0	0	0	0	0	0	6.7	0	0	0	0	0	0.5
C25	*	0	0	0	0	50.0	*	25.0	0	0	0	0	3.5
GR2	0	0	0	0	0	0	0	8.3	0	0	0	0	0.5
I8	0	0	0	0	0	0	33.3	0	0	0	*	*	3.3
I13	0	0	0	0	0	0	0	0	0	14.3	0	0	1.1
NB1	0	0	0	0	0	0	8.3	0	0	0	0	0	0.6
NB6	0	0	0	0	0	0	18.6	0	3.4	0	0	0	7.8
NB7	0	0	0	0	0	0	11.8	0	8.5	0	0	0	4.2
ND4	0	0	0	0	0	4.0	0	0	0	0	0	0	0.3
OS5	0	*	0	0	0	0	66.7	0	0	0	0	0	7.1
OS7	0	0	0	0	0	0	12.5	0	0	0	0	0	1.2
UL02	0	0	0	0	0	0	0	0	14.3	0	0	0	1.5
UL03	0	0	0	0	0	0	0	0	9.1	0	0	0	0.8
UL05	0	0	0	0	0	9.1	0	0	7.7	0	0	0	2.9
UL07	0	0	0	0	0	0	33.3	0	0	0	0	0	2.0

* No data

Table 10-3
"Violations" of dissolved oxygen standard (Table 10-1), upper 1 m, post-1984
Relative frequency (percent) by hydrographic area segment and month
(only segments logging violations are shown)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
A1	0	0	0	0	0	0	0	33.3	50.0	0	0	0	4.3
A5	0	0	0	0	0	50.0	0	0	*	0	0	0	3.4
A6	0	0	*	0	0	16.7	*	0	33.3	0	0	0	3.4
A8	0	0	0	0	0	0	0	100.0	0	0	0	0	6.3
A9	0	0	50.0	0	0	0	0	50.0	0	0	0	0	7.1
A10	0	0	0	0	0	0	0	0	20.0	0	0	0	1.7
A11	0	0	0	0	11.1	0	33.3	0	0	0	0	0	3.2
A12	0	0	0	0	0	0	33.3	0	10.0	0	0	0	2.4
A13	0	0	0	0	0	0	0	0	12.5	0	0	0	1.6
AL1†	0	0	0	0	0	0	0	0	9.1	5.0	0	0	1.4
AL2†	0	0	0	0	4.3	5.9	0	10.0	5.6	0	0	0	2.0
BF1†	0	0	0	0	4.0	0	0	0	0	0	0	0	0.5
BF2†	0	0	0	0	7.7	0	37.5	22.2	0	5.9	0	0	4.7
BF3†	0	6.3	7.1	0	3.4	11.8	25.0	20.0	15.4	18.5	3.8	0	8.1
C01	0	0	0	0	0	0	0	50.0	0	*	0	*	5.3
C02	0	0	20.0	0	0	0	0	0	0	0	0	0	1.7
C03	0	0	50.0	33.3	0	0	*	0	16.7	0	0	0	7.7
C04	0	50.0	100.0	0	0	*	*	50.0	0	0	0	0	23.1
C06	*	100.0	0	0	*	*	*	0	*	*	0	*	11.1
C08	0	0	50.0	*	0	*	0	0	0	0	0	0	5.3
C09	0	0	0	0	4.2	5.0	12.5	0	5.9	3.3	9.1	0	3.3
C10	0	0	14.3	0	0	0	0	0	0	0	0	0	1.5

(continued)

* No data † DO standard = 4 ppm †† DO standard = 3 ppm

Table 10-3
"Violations" of dissolved oxygen standard (Table 10-1), upper 1 m, post-1984
(continued)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
C12	5.0	0	5.3	0	0	0	0	0	2.8	0	4.3	0	1.5
C14	5.3	0	13.3	2.7	3.1	0	5.6	0	5.0	0	0	0	3.0
C15	0	0	4.8	0	4.3	0	0	0	7.1	0	0	0	1.6
C17	0	0	7.1	0	0	0	0	0	7.7	0	0	0	1.4
C20	0	0	33.3	*	0	*	*	0	0	0	0	0	6.3
C23	50.0	0	33.3	20.0	0	0	*	0	0	0	0	0	8.1
C24	0	0	12.5	0	12.5	0	12.5	20.0	22.2	0	6.7	0	8.0
CB	0	0	0	0	0	9.1	25.0	66.7	0	0	0	0	5.2
CCC1	0	0	8.3	0	0	0	0	0	0	0	0	0	1.0
CCC3	0	0	8.3	0	0	0	0	0	0	0	0	0	0.8
CCC5	0	0	20.0	0	0	*	0	0	0	0	0	0	2.3
CCC6	0	16.7	*	0	0	0	0	0	*	0	0	0	2.7
CCC7	0	0	16.7	0	0	0	0	0	0	0	0	0	0.7
CCC8	0	0	50.0	12.5	20.0	0	0	0	25.0	0	0	0	6.6
CP01	0	0	*	0	0	0	0	*	0	14.3	0	0	3.7
CP02	0	0	0	0	11.8	0	0	16.7	4.8	0	0	0	4.5
CP03	0	0	0	0	0	7.7	0	0	0	0	0	0	0.8
CP04	0	0	0	0	0	33.3	25.0	0	0	0	0	0	2.9
CP07	0	0	0	0	0	0	0	0	0	25.0	0	0	2.2
CP08	0	0	0	0	0	14.3	0	0	6.3	9.1	0	0	3.1
EF	0	0	0	0	12.5	0	0	0	0	0	66.7	*	7.0
GR2†	0	0	0	14.3	5.0	0	0	0	12.5	0	8.3	0	4.3
HI1	0	0	0	50.0	0	0	0	0	0	0	0	0	4.5
HI2	0	0	0	0	0	0	0	50.0	0	0	0	14.3	3.3

(continued)

* No data † DO standard = 4 ppm †† DO standard = 3 ppm

Table 10-3
"Violations" of dissolved oxygen standard (Table 10-1), upper 1 m, post-1984
(continued)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
I2	0	0	0	0	0	0	50.0	100.0	0	0	0	0	5.4
I3	0	0	0	0	0	0	0	0	0	42.9	0	0	7.7
I6	0	0	0	0	0	0	25.0	0	0	0	0	0	1.8
I7	0	0	0	0	0	0	14.3	*	16.7	0	0	0	3.3
I8	0	0	0	0	0	0	33.3	0	0	0	*	*	3.3
I9	0	0	14.3	25.0	20.0	0	33.3	0	12.5	40.0	12.5	0	15.2
I10	*	0	0	0	0	0	0	0	33.3	*	*	0	6.3
I11	0	0	0	0	0	0	0	0	0	12.5	0	0	1.7
I12	0	0	0	14.3	0	0	0	22.2	0	0	37.5	0	7.8
I13	0	0	25.0	0	22.2	0	12.5	50.0	9.1	25.0	0	0	11.1
I14	0	20.0	50.0	0	10.0	33.3	20.0	0	23.1	0	11.1	0	14.1
I15	0	0	0	25.0	25.0	33.3	42.9	100.0	0	10.0	16.7	0	18.8
I16	50.0	33.3	25.0	0	42.9	11.1	0	0	0	0	50.0	0	20.8
I17	0	12.5	100.0	0	0	0	0	0	50.0	0	0	0	5.4
I18	*	0	*	0	0	0	*	0	0	0	50.0	50.0	9.1
IH1††	0	0	*	0	0	*	0	0	66.7	0	0	*	5.1
IH5††	0	0	*	0	0	*	0	0	50.0	0	0	*	2.6
IH6††	0	0	*	0	0	*	0	0	25.0	0	0	*	4.4
LS1†	*	0	0	*	0	0	0	100.0	*	0	*	0	7.7
LS2†	0	0	0	0	0	33.3	0	0	0	0	10.5	0	2.6
M2	0	0	0	0	0	15.4	50.0	0	50.0	0	0	0	6.5
MB1	0	0	0	11.1	0	0	0	*	0	0	0	0	1.0
MB2	0	0	0	0	0	0	14.3	0	5.9	0	0	0	2.1

(continued)

* No data   † DO standard = 4 ppm   †† DO standard = 3 ppm

Table 10-3
"Violations" of dissolved oxygen standard (Table 10-1), upper 1 m, post-1984
(continued)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
NB1	50.0	10.0	64.3	42.9	0	0	0	0	0	0	0	0	12.3
NB2	66.7	0	33.3	0	0	16.7	100.0	0	0	11.1	0	0	9.9
NB3	0	0	16.7	14.3	16.7	0	0	0	0	0	0	0	4.5
NB4	15.0	0	21.4	0	0	0	0	0	0	0	0	0	2.5
NB5	15.0	0	31.3	0	0	0	0	0	6.7	0	0	0	2.7
NB6	0	0	40.0	0	0	0	9.4	0	8.0	0	0	0	8.4
NB7	0	0	0	0	0	0	21.1	7.1	13.6	7.7	0	0	11.6
NB8	0	*	50.0	0	0	0	*	0	0	0	0	0	4.5
NB9	0	0	100.0	0	0	0	0	0	0	0	0	0	2.2
ND4	3.3	0	0	0	4.0	0	16.0	28.0	22.6	15.6	0	0	7.7
NR4	0	0	0	0	0	20.0	0	14.3	42.9	0	0	0	7.2
OS1	0	0	*	0	*	*	100.0	0	0	20.0	0	*	9.5
OS4	0	0	0	25.0	0	20.0	0	50.0	0	0	0	0	6.0
OS6	0	11.1	0	10.0	0	25.0	0	12.5	0	0	0	0	6.8
OS7	0	0	0	0	0	0	0	12.5	11.1	14.3	33.3	0	4.8
PB1	0	0	0	0	0	0	0	22.2	0	0	0	0	2.4
PB2	0	12.5	0	0	0	16.7	28.6	25.0	0	0	0	0	4.3
RB1	0	0	0	9.1	0	12.5	100.0	0	60.0	0	0	0	8.2
RB2	0	0	0	0	0	0	0	25.0	10.0	7.1	0	0	4.1
RB3	0	0	0	0	12.5	0	0	14.3	0	0	0	0	2.4
RB4	0	0	0	0	0	0	0	0	0	5.9	0	50.0	3.3
RB5	0	0	0	0	0	0	22.2	16.7	16.7	6.7	0	0	4.7
RB6	0	0	0	0	0	16.7	0	0	0	0	0	0	1.9
RB8	0	0	0	0	0	0	0	14.3	25.0	0	0	0	2.7

(continued)

* No data † DO standard = 4 ppm †† DO standard = 3 ppm

Table 10-3
"Violations" of dissolved oxygen standard (Table 10-1), upper 1 m, post-1984
(continued)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
SC2	0	0	0	0	5.0	0	7.1	30.0	9.1	6.7	0	0	5.0
SC3	0	0	0	0	4.3	14.3	0	14.3	0	0	0	0	3.0
UL01	33.3	0	0	0	0	20.0	0	0	0	28.6	0	0	9.1
UL02	0	0	33.3	0	9.1	11.1	0	25.0	14.3	0	0	0	7.7
UL03	66.7	0	0	16.7	47.1	15.4	75.0	75.0	44.4	60.9	20.0	0	37.1
UL04	0	0	*	0	25.0	*	0	0	0	0	0	0	2.3
UL05	0	0	100.0	0	0	0	0	33.3	0	0	0	0	2.9
UL06	0	14.3	33.3	12.5	30.8	25.0	83.3	37.5	44.4	12.5	50.0	16.7	30.1
UL07	0	0	0	0	16.7	0	0	0	7.7	0	0	0	3.9
UL08	0	0	50.0	12.5	40.0	60.0	100.0	100.0	25.0	0	0	50.0	26.8
UL09	20.0	0	16.7	0	0	28.6	0	37.5	0	25.0	0	0	12.0
UL10	0	0	0	0	0	0	16.7	0	16.7	0	0	0	4.0
UL11	100.0	100.0	*	*	0	*	100.0	100.0	*	0	*	0	40.0
GMI1	0.0	*	*	*	0.0	22.2	0.0	0.0	0.0	0.0	0.0	*	5.6
GMI2	0.0	0.0	0.0	0.0	0.0	9.5	33.3	20.0	6.7	0.0	0.0	0.0	9.3
GMI3	0.0	0.0	0.0	0.0	0.0	20.0	12.5	16.7	8.3	0.0	0.0	0.0	5.5
GMI4	0.0	0.0	0.0	0.0	0.0	25.0	13.3	35.7	27.3	0.0	0.0	0.0	10.3
GMI5	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	7.1	0.0	21.1	0.0	4.0
GMI6	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	*	0.9
GMI7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.9
GMI8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.6
GMO7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	1.3

* No data † DO standard = 4 ppm †† DO standard = 3 ppm

Table 10-4
"Violations" of fecal coliform standard (Table 10-1) post-1984
Relative frequency (percent) by hydrographic area segment and month
(only segments logging violations are shown)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
A1	3.4	0	5.9	0	0	*	*	*	*	0	3.8	0	2.2
A2	25.0	100.0	0	0	0	*	*	*	*	0	0	30.0	15.2
A3	0	0	5.6	0	0	*	*	*	*	8.3	0	0	2.1
A4	0	0	11.1	0	0	*	*	*	*	0	20.0	11.1	6.5
A6	25.0	0	12.5	0	0	*	*	*	*	0	0	12.5	9.5
A8	0	0	0	0	0	*	*	*	*	0	20.0	14.3	4.7
A10	0	0	0	0	0	*	*	*	*	8.3	0	5.9	2.2
A13	16.7	0	0	0	0	*	*	*	*	0	0	0	2.6
AR1†	*	*	*	0	0	*	*	*	0	0	0	*	0.0
BF3	0	50.0	*	0	0	*	0	0	*	0	0	*	5.6
C01	16.7	9.1	70.6	55.0	31.3	56.7	32.3	40.7	55.9	32.0	0	42.9	42.2
C02	0	13.3	25.0	41.7	30.0	62.5	35.7	46.2	0	35.7	40.0	30.8	31.2
C03	42.9	42.9	57.1	62.5	14.3	33.3	27.3	45.5	40.0	11.1	28.6	57.1	37.9
C12	0	0	0	0	0	*	0	*	*	0	8.3	0	1.4
C15	7.7	11.1	35.3	37.9	15.6	36.1	31.7	26.7	9.5	28.6	15.8	16.7	25.0
C17	20.0	16.7	0	0	0	*	0	*	*	0	0	0	5.6
C19	0	0	0	0	0	*	0	*	*	0	16.7	0	2.8
C20	0	0	0	0	0	*	0	*	*	0	16.7	0	2.8
CCC3	0	16.7	0	0	0	0	0	*	0	0	0	0	2.1
CCC4	0	0	0	0	0	*	0	*	*	0	16.7	0	2.8
CCC8	8.3	13.3	15.4	33.3	15.4	40.0	38.5	23.1	40.0	20.0	18.8	20.0	22.4
CP02	33.3	25.0	40.0	0	0	*	*	*	*	0	60.0	20.0	26.5
CP03	19.0	0	17.9	33.3	0	*	*	*	*	0	52.4	31.3	21.8

(continued)

* No data

† fecal coliform standard = 200 org/100 mL

Table 10-4
"Violations" of fecal coliform standard post-1984, relative frequency (percent)
(continued)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
CP04	0	0	15.0	0	0	*	*	*	*	0	21.4	9.1	7.8
CP05	14.3	0	11.1	0	0	*	*	*	*	0	28.6	16.7	11.4
CP06	0	0	33.3	0	*	*	*	*	*	0	0	0	10.5
CP10	6.3	0	10.5	0	0	*	0	0	*	6.7	0	0	3.7
I4	22.2	25.0	14.3	0	0	*	*	*	*	0	20.0	12.5	13.6
I6	0	0	0	7.7	0	*	0	*	*	0	0	0	1.0
I10	*	0	100.0	28.6	57.1	72.7	40.0	50.0	60.0	40.0	*	*	52.5
I12	0	0	*	0	100.0	*	0	0	*	0	0	*	5.9
IH1†	0	0	*	0	0	*	0	0	0	0	0	*	0.0
IH5†	0	0	*	0	50.0	*	0	0	0	0	0	*	5.3
IH6†	0	0	*	0	0	*	0	0	0	0	0	*	0.0
LQ1	0	*	50.0	0	*	0	0	*	0	*	0	100.0	18.2
LQ2	0	50.0	50.0	0	0	0	50.0	0	*	0	0	100.0	15.4
M2	0	0	16.7	16.7	0	33.3	*	*	*	14.3	0	50.0	14.3
MB1	9.1	20.0	10.0	0	50.0	*	0	*	0	16.7	0	33.3	11.8
MB2	7.1	0	25.0	0	*	*	*	*	*	0	0	20.0	6.9
NB2	40.0	14.3	20.0	0	50.0	*	*	*	*	50.0	33.3	0	25.7
NB4	0	*	*	100.0	*	*	100.0	*	*	*	100.0	*	80.0
NB5	0	0	*	25.0	0	*	0	0	*	0	33.3	*	12.5
NB6	16.7	14.3	16.7	0	0	*	*	*	*	50.0	33.3	0	18.9
NB7	12.5	15.0	33.3	25.0	42.9	*	0	0	*	25.0	36.4	7.7	23.5
NB8	60.0	50.0	20.0	100.0	0	*	*	*	*	25.0	33.3	25.0	39.4
NB9	16.7	18.2	27.3	25.0	0	*	*	*	*	25.0	16.7	0	17.6

(continued)

* No data

† fecal coliform standard = 200 org/100 mL

Table 10-4
"Violations" of fecal coliform standard post-1984, relative frequency (percent)

(continued)

Segment	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total data set*
NR1†	*	*	*	*	0	0	33.3	0	0	100.0	*	*	0.0
NR4†	50.0	25.0	0	25.0	33.3	50.0	100.0	0	0	0	0	50.0	25.9
OS1	100.0	100.0	*	100.0	*	*	*	100.0	100.0	100.0	100.0	*	100.0
OS6	0	0	*	62.5	*	*	0	66.7	0	0	100.0	50.0	42.9
OS7	50.0	50.0	*	16.7	*	*	*	66.7	*	0	0	0	29.4
PB1†	*	0	*	0	0	*	*	0	*	0	*	*	0
RB4	50.0	*	*	*	*	*	*	*	*	0	*	*	33.3
RB8	33.3	33.3	*	0	0	*	33.3	0	0	0	*	0	12.5
SC2	25.0	75.0	11.1	25.0	0	0	*	*	*	0	33.3	16.7	20.3
SC3	0	50.0	*	50.0	0	*	0	50.0	*	50.0	*	0	35.7
UL01	*	0	66.7	62.5	62.5	45.5	30.0	33.3	80.0	33.3	*	*	47.5
UL04	50.0	0	*	0	0	*	0	0	*	0	0	*	5.9
GMI6	*	0	*	25.0	*	*	*	*	*	0	*	*	14.3

* No data   † fecal coliform standard = 200 org/100 mL

Table 10-5
"Violations" of metals standards (Table 10-1) post-1984
Relative frequency (percent) by hydrographic area segment
(only segments are shown for which metals data exist)

segment	*wqmetagt*	*wqmetast*	*wqmetcdt*	*wqmetcrt*	*wqmetcut*	*wqmethgt*	*wqmetnit*	*wqmetpbt*	*wqmetset*	*wqmetznt*
C07	*	0	0	0	0	0	0	0	0	100.0
C08	*	0	0	0	0	0	0	0	0	100.0
C14	*	0	0	0	0	0	0	0	0	0
C18	*	0	0	0	0	0	0	0	0	100.0
C22	*	0	0	0	0	0	0	0	0	100.0
CBH	0	0	0	0	0	0	0	0	0	0
CCC2	*	0	0	0	0	0	0	0	0	0
CCC3	0	0	80.0	20.0	20.0	0	80.0	0	0	20.0
CCC4	0	0	0	0	0	0	0	0	0	0
CCC5	0	0	0	0	0	0	0	0	0	25.0
CCC6	0	0	0	0	8.7	0	0	0	0	21.7
CCC7	0	0	0	0	0	0	0	0	0	30.0
CCC8	0	0	0	0	28.6	0	16.7	0	0	16.7
HI1	0	0	0	0	0	0	0	0	0	0
I1	*	0	100.0	0	0	0	0	0	0	0
I2	*	0	100.0	0	0	0	0	0	0	0
I3	0	0	0	0	0	0	33.3	0	0	16.7
I4	0	0	6.1	0	0	0	48.5	0	0	12.1
I5	0	0	0	0	0	0	11.8	0	0	0
I6	*	0	0	0	0	0	0	0	0	0
I9	*	0	0	0	0	0	0	0	0	0
I10	*	0	0	0	0	0	0	0	0	0

(continued)

* No data

Table 10-5
Relative frequency (percent) of "violations" of metals standards
(continued)

segment	*wqmetagt*	*wqmetast*	*wqmetcdt*	*wqmetcrt*	*wqmetcut*	*wqmethgt*	*wqmetnit*	*wqmetpbt*	*wqmetset*	*wqmetznt*
I11	*	0	0	0	0	0	0	0	0	0
I13	*	0	0	0	0	0	0	0	0	0
I14	*	0	0	0	0	0	0	0	0	0
I15	*	0	0	0	0	0	0	0	0	0
I16	*	0	0	0	0	0	0	0	0	0
I17	*	0	0	0	0	0	0	0	0	0
I18	*	0	0	0	0	0	0	0	0	0
IH1	0	0	0	0	66.7	0	0	0	0	0
IH2	0	0	0	0	0	0	0	0	0	0
IH3	0	0	0	0	0	0	0	0	0	0
IH4	0	0	0	0	0	0	0	0	0	0
IH5	0	0	0	0	50.0	0	0	0	0	0
IH6	0	0	0	0	28.6	0	25.0	0	0	0
IH7	0	0	0	0	33.3	0	33.3	0	0	0
INL	0	0	0	0	0	0	0	0	0	0
LQ1	0	0	41.7	8.3	0	0	41.7	0	0	8.3
LQ2	0	0	54.5	18.2	18.2	9.1	54.5	0	0	18.2
NB7	0	0	25.0	0	50.0	0	0	50.0	0	25.0
RB3	0	0	0	0	0	0	0	0	0	0
RB8	0	0	0	0	0	0	0	0	0	0
GMI6	*	0	0	0	0	0	0	0	0	0
GMO6	*	0	0	0	0	0	0	0	0	0

* No data

Table 10-6
"Violations" of pesticide standards (Table 10-1) post-1984
Relative frequency (percent) by hydrographic area segment
(only segments are shown for which pesticides data exist)

segment	*WQ-245T*	*WQ-CHLR*	*WQ-DDD*	*WQ-DDE*	*WQ-DDT*	*WQ-XDDT*	*WQ-DIEL*
C07	*	0	*	*	*	0	*
C08	*	0	*	*	*	0	*
C14	*	0	*	*	*	0	*
C18	*	0	*	*	*	0	*
C22	*	0	*	*	*	0	*
CBH	*	0	*	*	*	0	*
CCC2	*	0	*	*	*	0	*
CCC3	*	0	*	*	*	0	0
CCC4	*	0	*	*	*	0	0
CCC5	*	0	*	*	*	0	*
CCC6	0	10	*	*	*	0	0
CCC7	*	0	*	*	*	0	*
CCC8	*	0	*	*	*	0	*
HI1	*	0	*	*	*	0	*
I1	*	0	*	*	*	100	*
I2	*	0	*	*	*	100	*
I3	*	0	*	*	*	0	*
I4	*	0	*	*	*	0	*
I5	*	0	*	*	*	0	*
I6	*	0	*	*	*	0	*
I9	*	0	*	*	*	0	*
I10	*	0	*	*	*	0	*
I11	*	0	*	*	*	0	*
I13	*	0	*	*	*	0	*
I14	*	0	*	*	*	0	*
I15	*	0	*	*	*	0	*
I16	*	0	*	*	*	0	*
I17	*	0	*	*	*	0	*
I18	*	0	*	*	*	0	*
IH1	*	0	*	*	*	0	*
IH2	*	0	*	*	*	0	*
IH3	*	0	*	*	*	0	*
IH4	*	0	*	*	*	0	*
IH5	0	0	*	*	*	0	0
IH6	*	0	*	*	*	0	*
IH7	*	0	*	*	*	0	*
INL	*	0	*	*	*	0	*
LQ1	*	0	*	*	*	0	0
LQ2	*	0	*	*	*	0	0
RB3	*	0	*	*	*	0	*
RB8	*	0	*	*	*	0	*
GMI6	*	0	*	*	*	0	*
GMO6	*	0	*	*	*	0	*

* No data

Table 10-6
"Violations" of pesticide standards (Table 10-1) post-1984
Relative frequency (percent) by hydrographic area segment
(continued)

segment	*WQ-ENDO*	*WQ-HEPT*	*WQ-MALA*	*WQ-MTHX*	*WQ-PARA*	*WQ-TOXA*
C07	*	*	*	*	*	0
C08	*	*	*	*	*	0
C14	*	*	*	*	*	0
C18	*	*	*	*	*	0
C22	*	*	*	*	*	0
CBH	*	*	*	*	*	0
CCC2	*	*	*	*	*	0
CCC3	0	0	*	0	*	0
CCC4	*	0	*	*	*	0
CCC5	*	*	*	*	*	0
CCC6	*	0	0	0	0	0
CCC7	*	*	*	*	*	0
CCC8	*	*	*	*	*	0
HI1	*	*	*	*	*	0
I1	*	*	*	*	*	0
I2	*	*	*	*	*	0
I3	*	*	*	*	*	0
I4	*	*	*	*	*	0
I5	*	*	*	*	*	0
I6	*	*	*	*	*	0
I9	*	*	*	*	*	0
I10	*	*	*	*	*	0
I11	*	*	*	*	*	0
I13	*	*	*	*	*	0
I14	*	*	*	*	*	0
I15	*	*	*	*	*	0
I16	*	*	*	*	*	0
I17	*	*	*	*	*	0
I18	*	*	*	*	*	0
IH1	*	*	*	*	*	0
IH2	*	*	*	*	*	0
IH3	*	*	*	*	*	0
IH4	*	*	*	*	*	0
IH5	*	0	0	0	0	0
IH6	*	*	*	*	*	0
IH7	*	*	*	*	*	0
INL	*	*	*	*	*	0
LQ1	0	0	*	0	*	0
LQ2	0	0	*	0	*	0
RB3	*	*	*	*	*	0
RB8	*	*	*	*	*	0
GMI6	*	*	*	*	*	0
GMO6	*	*	*	*	*	0

Table 10-7
"Violations" of PAH's and other organics standards (Table 10-1)
Relative frequency (percent) post-1984 by hydrographic area segment
(only segments are shown for which pesticides data exist)

segment	*WQ-ACEN*	*WQ-ENDR*	*WQ-FLRA*	*WQ-NAPT*	*WQ-PAH*	*WQ-PCB*	*WQ-HEXA*
C07	0	*	0	0	0	0	*
C08	0	*	0	0	0	0	*
C14	0	*	0	0	0	0	*
C18	0	*	0	0	0	0	*
C22	0	*	0	0	0	0	*
CBH	0	*	0	0	0	0	*
CCC2	0	*	0	0	0	0	*
CCC3	0	0	*	0	*	*	*
CCC4	0	*	0	0	0	0	*
CCC5	0	*	0	0	0	0	*
CCC6	0	0	0	0	0	0	0
CCC7	0	*	0	0	0	0	*
CCC8	0	*	0	0	0	0	*
HI1	0	*	0	0	0	0	*
I1	0	*	0	0	0	0	*
I2	0	*	0	0	0	0	*
I3	0	*	0	0	0	0	*
I4	0	*	0	0	0	0	*
I5	0	*	0	0	0	0	*
I6	0	*	0	0	0	0	*
I9	0	*	0	0	0	0	*
I10	0	*	0	0	0	0	*
I11	0	*	0	0	0	0	*
I13	0	*	0	0	0	0	*
I14	0	*	0	0	0	0	*
I15	0	*	0	0	0	0	*
I16	0	*	0	0	0	0	*
I17	0	*	0	0	0	0	*
I18	0	*	0	0	0	0	*
IH1	0	*	0	0	0	0	*
IH2	0	*	0	0	0	0	*
IH3	0	*	0	0	0	0	*
IH4	0	*	0	0	0	0	*
IH5	0	0	0	0	0	0	0
IH6	0	*	0	0	0	0	*
IH7	0	*	0	0	0	0	*
INL	0	*	0	0	0	0	*
LQ1	0	0	0	0	0	0	*
LQ2	0	0	0	0	0	0	*
RB3	0	*	0	0	0	0	*
RB8	0	*	0	0	0	0	*
GMI6	0	*	0	0	0	0	*
GMO6	0	*	0	0	0	0	*

* No data

was motivated by the increasing use of mathematical models in waste allocation, because these models predict vertical-mean DO rather than surface values. Since the numerical value of the DO standard concentration was unchanged, this revision amounted to a stringent upgrade in the DO standard. For present purposes, we use the older convention of the surface measurement as a basis for comparison, for simplicity and uniformity of analysis. Also, the standards given in Table 10-1 apply to 24-hour mean DO values, from which a further depression of 1 pm in instantaneous concentration is allowable. We do not make these distinctions in this evaluation, but rather compare the instantaneous near-surface values to those given in Table 10-1. (For simplicity, we also do not discriminate the data analysis by flow condition.)

Despite the fact that average DO is near saturation throughout the system, Table 10-3 shows that most areas of the bay have a violation frequency of the applicable standard of a couple of percent, almost always in the summer or early fall. There are scattered higher frequencies of violations, especially in proximity to sources of inflow and wasteloads. A prominent example is C04 out from the Inner Harbor. The violation frequency is even higher in the shallow, poorly-circulating areas near the barrier island, and is especially high in the Upper Laguna. While most of these probably evidence DO depletion due to oxygen-demanding organics, this is more properly regarded as a compounding of low antecedent DO's that are a result of natural hydrography, rather than evidence of excessive waste loading. The apparent contradiction between the observation that the system is at or above saturation much of the time, yet has a nonnegligible frequency of standard violation, 10-20% in some areas, is reconciled by noting that much of the year the standard is very close to the saturation concentration. Considering the high natural temperatures and salinities in these areas, the 5 ppm "standard" is only about 1 ppm below saturation, and occasional excursions of more than 1 ppm below saturation are not unexpected. (In fact, if one examines violations of a 4 ppm DO level instead, many of the 1-3% occurrences vanish, and most, including those in the Upper Laguna, are halved.)

It is difficult to judge whether such frequencies of "depressed" DO evidence a serious or systematic water quality problem, because there seems to be little basis for the appropriateness of the 5 ppm standard in this estuary. Like the 35°C TNRCC temperature standard, the DO standard is applied uniformly to most of the Texas bays from Sabine Lake to South Bay, without discrimination to account for the decreasing solubility with distance south. Certainly, there is a desirability for re-evaluating the applicability of the 5 ppm average DO standard to waters with such low solubility. We note that there is a prominent exception to the uniform application of the 5 ppm DO standard, that one bay is assigned a lower open-water DO standard by TNRCC, namely the 4 ppm standard for Galveston Bay.

The 5 ppm criterion does serve to caution that–whatever the appropriate standard may be–the clearance between physical saturation and the threshold level of DO entailing biological stress is small throughout much of the Corpus Christi Bay study area for a major portion of the year. These regions will therefore have a low assimilative capacity, and this should be carefully considered in any proposed waste discharges or increased wasteloading. Moreover, the time-trend analysis discloses increasing deficits in some of these same areas of low assimilative capacity, notably the Upper Laguna Madre and the open waters of Corpus Christi Bay south of the CCSC.

The state coliform standard strictly applies to a geometric mean of at least five samples "representative" of a 30-day period. The 14 col/100 mL criterion derives from the requirement for "oyster waters" (TWC, 1991, Section 307.7), which further limits the frequency in individual samples to no more than 10% over 43 col/100 mL. Our purpose here is not to strictly apply these conditions (indeed, the temporal density of most of the data will not allow computation of a 5-sample geometric mean within 30 days), but to use them as a guide to identify regions of potential bacterial contamination. The simple frequency of exceedance of the applicable numerical value is given in Table 10-4. Those areas with a frequency of occurrence of less than about 10% would probably vanish altogether if a geometric mean of several independent measurements could be made. The areas of concern to us are those exceeding 10%. These are primarily the upper bays in proximity to sources of inflow and runoff, especially in urbanized areas, specifically:

- Copano Bay near the mouths of inflows
- St. Charles Bay
- Nueces Bay and near its entrance in Corpus Christi Bay
- Corpus Christi Bay along the south shore from Corpus Christi Beach to Demit Island
- Bulkhead Flats and the Upper Laguna around the JFK Causeway
- Lower Oso Bay

If the raw data are screened for those sections exceeding 43 col/100 mL more than 10% of the time, these same areas emerge. While statistical trends in data as noisy and spikey as coliforms are difficult to establish reliably, the present analysis certainly provides no indication that the coliform concentrations are declining. (At the same time, it should be noted that these concentrations are considerably smaller than the standard for contact recreation, 200 col/100 mL.) All of these areas are presently closed for shellfish harvesting (Jensen et al. 1996). To the extent that these elevated coliform levels represent a problem area, the state has already implemented appropriate action.

The state standards for metals and pesticides strictly apply to the dissolved parameter. Those values given in Table 10-1 are the chronic marine criteria. The direct applicability of these and the EPA criteria for metals (which are developed for "acid-soluble" metal concentrations) to the Corpus Christi Bay data base is problematic, because there are so few measurements of dissolved fractions from Corpus Christi Bay (see Section 2.6), and these are generally below detection limits. Therefore, we have applied these criteria to the Corpus Christi Bay data base for "total" (i.e., unfiltered) metals, which will be greater in concentration than the "dissolved" metal by as much as an order of magnitude, depending upon the specific metal and the nature of suspended matter in the sample. The values in Table 10-1 are almost certainly too conservative applied in this way, but again our purpose is to use these to identify potential areas of concern, realizing that they may indicate a water-quality problem that does not exist. The order of applicability was the state standard when available, otherwise the EPA marine criterion if available, and the freshwater criterion otherwise. (The EPA values in Table 10-1 for mercury are especially stringent, as these are based upon final residue values for methylmercury rather than final chronic values for mercury -II, due to high biomagnification potential in certain fish and shellfish. Moreover, some of these EPA criteria, e.g. cadmium, lead, mercury, and nickel, are less than the detection limits in the data set.)

The violation frequency of of these criteria for total metals, based on measurements since January 1985, are summarized in Table 10-5. (Monthly breakdowns are not presented, because a seasonal effect is not expected and because the data are so sparse that too few measurements would be available for each month to be meaningful.) Inspection of this table immediately discloses the relative infrequency of violations of these criteria. Some metals are within the criteria limit everywhere, namely silver, arsenic and selenium, while others are violated in only one segment in the system, namely mercury and lead. The metal with the greatest frequency of violation is zinc, whose violations are fairly widespread within Corpus Christi Bay *per se*, especially in and around the CCSC and the La Quinta Channel. The La Quinta Channel and the adjacent CCSC near Ingleside (Segment CCC3) is a region of violations of several metals.

Ward and Armstrong (1992a) observed that in Galveston Bay metals concentrations in excess of the criteria are generally associated with shipping in the bay, i.e. along the Houston Ship Channel, in both its open-bay and landlocked reaches, along the GIWW, and in the turning basins. They added that this may be due in part to the concentration of urban activity and waste discharges in these same areas, but also to the fact that shipping regions are generally sampled more intensively due to dredging activity, thus allowing a greater opportunity for occasional high measurements. In the case of Corpus Christi Bay, not all, but the great majority of the water-phase metal samples have been taken from areas of shipping, including *all* of those since 1985, so we cannot draw any conclusions about the relative frequency of metals violations in these regions in comparison to other areas of the bay. However, the three metals with the highest frequency of violation in Table 10-5, namely zinc, copper and nickel, are also the three identified above as exhibiting elevated concentrations generally throughout Corpus Christi Bay (where data exist) relative to the values presented in Moore and Ramamoorthy (1984b). It is also interesting to recall that zinc concentrations in the sediments of the Inner Harbor are an order of magnitude larger than those in the Houston Ship Channel. This raises the speculation of whether the Inner Harbor could be the ultimate source for elevated zinc in the system. We also observe that high zinc levels have been found in some of the tissue analyses, notably oyster and black drum, especially in Nueces Bay.

We emphasize that dissolved metals—if we had a sufficient data base available—would exhibit lower frequencies of violations than these total-metals measurements. Even the applicability of dissolved standards such as those of Table 10-1 without taking account of the speciation of the metals is questionable. Therefore in terms of posing a threat to aquatic life, no strict conclusions can be

Table 10-8

Ranges of sediment metals (mg/kg) typifying "pollution" compiled from Thomas (1987), see also Baudo and Muntau (1990)

Element	*non-polluted*	*heavily polluted*
Total Hg	<1.0	>1.0
Pb	<90	>200
Zn	<90	>200
Fe	<17,000	>25,000
Cr	<25	>75
Cu	<25	>50
As	<3	>8
Cd		>6
Ni	<20	>50
Mn	<300	>500
Ba	<20	>60

drawn from the comparisons of Table 10-5, but it seems safe to judge that the possibility is unlikely.

Concentration ranges considered to be representative of heavy metal pollution compiled from the recent professional literature are presented in Table 10-08. These are, at very best, qualitative indicators, many being applicable strictly to freshwater rather than estuarine systems, but at least these serve as an indication of how the sediments in Corpus Christi Bay could be judged. By these criteria, copper throughout the system, and zinc in the Inner Harbor and Nueces Bay would be characterized as evidence of "heavy pollution."

With respect to pesticides and trace organics, the data base is even sparser. Violations since 1985 are shown in Tables 10-6 and 10-7. Violations of the criteria of Table 10-1 occur for only proxied DDT and chlordane, as follows:

parameter	*segment*	*violations / measurements*
DDT (extended: WQ-XDDT)	I1	2/2
	I2	2/2
chlordane (WQ-CHLR)	CCC6	2/20

Of course, virtually all measurements are below detection limits, hence the rarity of criteria violation.

For sediment, the information base for standards and criteria is not nearly so great as for water quality. First, the expression of sediment criteria for biological and human activities is still in the research and development stage. Second, what information is available applies only to a few pesticides and PAH's, and is tentative. The concentration in sediment of a contaminant does not properly characterize its potential biological effects, because these are modulated by the bioavailability of the constituent, which is in turn a function of the partitioning of the constituent between the particulate and interstitial water components of the sediment, and the make-up of the sediment itself. EPA has adopted the Equilibrium Partitioning approach to determination of sediment quality. The EqP model is a means of deriving equivalent sediment quality impacts from already-extant results for water quality, and in particular models the partitioning and bioavailability of the contaminant by its behavior with respect to sediment organic carbon. . The most promising method at present relies upon normalizing sediment concentration to organic carbon for hydrophobic organics (pesticides, PAH's, PCB's and related compounds) and normalizing sediment concentration to acid volatile sulfides (AVS) for metals, see Shea (1988), Di Toro et al. (1992), and Adams et al. (1992) for overviews. Although a general distribution of organic carbon in the bed sediments of Corpus Christi Bay has been compiled (Appendix C), the extreme heterogeneity of TOC requires that the contaminant and TOC analyses be performed on the same sample. Data on sediment AVS is not available, and, in any event, the method would require simultaneously extracted metals from the same sample. (We note that the utility of the AVS is much better demonstrated in freshwater systems than in estuaries, and will be of doubtful applicability in environments of high sediment oxidation.)

One implication of the EqP formulation is that for a given hydrophobic organic concentration in the sediment, regions with a lower TOC will have potentially enhanced bioavailability. While there is no indication in any of the sediment data that there are excessively high concentrations in the study area, we note that the regions of low sediment TOC, namely the upper bays and Nueces Bay, have evidenced elevated levels of some of the PAH's and are probably more susceptible to nonpoint source loadings of pesticides.

From a systemic point of view, the most significant potential problems affecting the bay as a whole are related to the parameters for which there is no regulatory standard or criterion of optimality, namely, suspended particulates, nutrients and salinity. With respect to the first two, the potential problem may not be too high a concentration, but too low. The statistical analyses of TSS in Corpus Christi Bay disclosed a decline widespread throughout the system, increasing in significance from north to south. The rate of decline is sufficient to have reduced the average concentration by about 25% in the upper bays and by about 50% in the lower bays over the last two decades. Suspended sediment is an intrinsic and important aspect of the Corpus Christi Bay environment; its decline is not necessarily beneficial.

Where inorganic nitrogen is higher in the system, declining trends were found to be typical, especially in the upper bays; no clear trend in phosphorus was evident. It is interesting to compare this result with Galveston Bay, for which declining trends were much more evident in the statistics (Ward and Armstrong, 1992a). This may be due to the fact that the concentrations of these nutrients are higher in Galveston Bay, inorganic nitrogen and phosphorus levels being respectively twice and four times those of Corpus Christi Bay, but it may also be due to the fact that the data base for Galveston Bay, especially considered on a areal basis, is much greater than that available to us in Corpus Christi Bay. A widespread declining trend was, however, determined in water-phase TOC at a rate sufficient to reduce the concentrations in the Corpus Christi Bay study area by about one-fourth over two decades. It is not clear from the data whether this indicates a decline in organic loading or a decline in productivity. More importantly, whether a decline in any of these nutrients is a problem or an improvement depends upon determining the optimum levels for Corpus Christi Bay. Much more research is needed on the total ecosystem to establish these optima.

As noted above, there is no regulatory standard or established optimal level for salinity. Salinity of Corpus Christi Bay has been a major source of controversy, especially within the past decade, because of its perceived value as a habitat indicator that also measures freshwater inflow. At this writing, the City of Corpus Christi water supply in the Nueces reservoirs of Choke Canyon and Lake Corpus Christi is threatened by a continuing drought, and the conflict between human water-supply requirements and the needs of the estuary ecosystem has been brought into sharp relief. One result of the present study, disclosing increasing trends in salinity that seem to be associated with declining trends in mean inflow, certainly suggests that salinity will continue to be at the center of management issues and strategies for this system, even after the current drought has abated. Certain areas of the system, notably Baffin Bay and the Upper Laguna Madre, are chronically hypersaline environments. This is the result of a combination of low freshwater inflow (as these areas are naturally arid) and poor exchange with Corpus Christi Bay and the Gulf of Mexico. Man's intervention cannot easily alter the former, but it can the latter, and, again, we can expect salinity to be a central issue in debates about physiographic alterations in this part of the study area.

10.5 Recommendations

The obvious recommendation to reduce the deficiencies identified in the Corpus Christi data base in Chapter 5 is to sample at more locations, more frequently, for more parameters. Clearly, the ability of any agency to accomplish this is dictated by available resources and the relative importance of that agency's missions (hence, allocation of resources). It seems of more immediate value to the development of a Comprehensive Management Plant for Corpus Christi Bay to present specific recommendations that will substantially improve the data base with little additional expenditures. Suggestions are offered in this section on alterations in procedures for monitoring in future programs to assist filling data gaps or repairing data deficiencies. Emphasis is on procedural modifications that can be implemented with little or no cost, and that will not interfere with the objectives of the primary agency but will greatly augment the value of the data.

10.5.1 Data-collection precepts

The primary requirement of any data collection program is to perform measurements targeted at the principal question or function that program addresses. For research studies, the data-collection strategy is tailored to the scientific hypothesis to be tested. Many state and federal agency programs have statutorily defined missions, that in turn dictate their sampling strategies. Therefore, to the extent that any given survey is properly designed to achieve its mission, our recommendations for its performance are superfluous. On the other hand, few programs can afford the investment of long-term, intensive data collection in a system such as Corpus Christi Bay. To address scientific and management questions that require such massive data bases, we must depend upon the use of data collected by different agencies for perhaps different purposes.

Each such data-collection agency must recognize that the value of its data transcends its immediate application in achieving the purpose of that agency. In this sense, data collection should be regarded as a collective enterprise, and its design should reflect a certain degree of scientific altruism, to ensure maximal utility of the data without unduly hampering the measurement procedures or project resources. It is in this spirit that we offer several concrete recommendations. In summary, these recommendations argue that data programs should be somewhat more careful, collect somewhat more measurements, and facilitate somewhat better their data dissemination, than strictly required for the mission at hand.

Ward and Armstrong (1992a) in addressing the problems of data collection in Galveston Bay proposed four precepts of data collection. They observe that it is the violation of these precepts which contribute to data deficiencies that are avoidable or correctable at little cost. These are repeated here, because they are equally applicable to the Corpus Christi Bay situation:

(I) Continuity of record in space and time should be of paramount importance.

(II) Benefit versus *incremental* cost should be a governing criterion for delineation of a suite of measurements.

(III) Basis for selection of parameters to be measured should include potential analyses the measurements will support as well as historical perspective of measurement continuity.

(IV) Recording and processing of the data ("data recovery") as well as archiving should be performed with great sensitivity to and avoidance of potential loss of information.

The reduction in space/time density of data collection within roughly the last decade has significantly diminished the utility of modern data collection at least for the types of analyses performed here. Precept I listed above emphasizes maintenance of continuity. Corpus Christi Bay, like each of the Texas estuaries, is a highly variable environment, subject to many external factors, each of which contributes a degree of "noise" in any measured parameter. To filter this noise, and expose variations in time and space, requires that sufficient independent measurements be available over the range of variation of the external factors. For time variability, continuity of data record is an all-important property of any data base. For space variability, a high density of sampling stations repeatedly sampled is necessary. (The actual intensity of sampling is determined by the intrinsic variability of the parameter of concern.)

Several data collection programs are underway simultaneously in Corpus Christi Bay. Yet these seem to be uncoordinated. The obvious reason is that each of the programs has a single, often narrow, objective, and the program is designed to meet that objective. Generally, a large investment is required to obtain the basic sample. This cost is dominated by operations: putting a sampling crew (and usually a boat) on a specific station, or installing an automatic data logger on a platform in the bay. Precept II advises that the incremental cost in acquiring additional measurements (including loss of efficiency) must be weighed against the cost of occupying the station, in specifying the suite of parameters to be obtained. Whether additional parameters have direct application in the project objective is unimportant; they may be peripheral or irrelevant to the objective of the project, but have great value for other objectives and therefore justify the small incremental cost for their acquisition. For example, when a water sample is pulled for coliform determination, the additional cost to measure salinity is negligible. Though salinity has no bearing on the use of the data for public health purposes, it would add to the general base of information on salinity structure, perhaps from a region that is poorly sampled otherwise. The same principle of incremental cost versus benefits should be considered in specifying laboratory analyses. Many procedures, e.g. mass spectrometry or grain-size by settling tube, are cost-loaded in technician training and sample preparation, and can admit additional parameters or greater resolution with minor incremental cost. Again, a certain altruistic philosophy is necessary in the sampling agency, to acquire measurements that may be superfluous to the immediate objective, but from which others will benefit.

Not only should sample programs be coordinated among themselves to maximize the total benefit, those programs should be coordinated with historical practice, as indicated by Precept III. Extending a past data record may be sufficient to justify including a parameter, even if modern analysis and technology suggest a more useful variate. In particular, when a new parameter is inducted into an ongoing survey to replace a less satisfactory parameter, measurements of both the new and the old parameters should be performed in order to establish (or falsify) the relation between them.

One might expect Precept IV to be so patently obvious that it need not even be stated. Any data collection program should include procedures of data screening and data-entry verification, from the original lab sheets to the digital data file. While this may seem trivially obvious, the occurrence of equally obvious errors in all of the state data bases (to say nothing of inobvious errors) indicates that present procedures are inadequate. We argue in Precept IV for a heightened awareness to the possibilities of data loss, even for the cultivation of agency paranoia. When the data entry is recent and the raw data sheets are still available, errors are easiest to detect and correct. Error correction at the data-entry step may very well track back to the recording and/or acquisition of data. This opportunity decays rapidly in time. For this reason, data entry should be performed in a timely manner, not months after the event.

Data-checking procedures represent the obverse face of Precept III. At present, in the culture of many of the agencies (including academic research projects) their implementation seems to be viewed as a redundant cost item in data acquisition, perhaps absorbing funds that might be better spent in a boat or diverting energies from more productive professional activities. Such a view is myopic, because the expense of data checking shrinks to negligibility compared to the unit cost of acquiring and analyzing a water sample. One can not afford to lose that considerable investment because of an errant keystroke. Moreover, the place that a water sample potentially holds in a space or time trend may be invaluable. Data checking is an absolutely indispensable investment to preserve the information in a measurement.

10.5.2 Data collection recommendations

The obvious recommendation to reduce the deficiencies identified in the Corpus Christi data base is to sample at more locations, more frequently, for more parameters. Clearly, the ability of any agency to accomplish this is dictated by available resources, and is more a matter of trade-offs to most efficiently meet that agency's mission. It seems of more immediate value to the development of a Comprehensive Management Plant for Corpus Christi Bay to present specific recommendations that will substantially improve the data base with little additional expenditures. Therefore, suggestions are offered below on alterations in monitoring procedures to assist filling data gaps or repairing data deficiencies, with emphasis on those that can be implemented with little or no cost, and that will not interfere with the objectives of the primary agency but will greatly augment the value of the data. In summary, data programs should be somewhat more careful, collect somewhat more measurements, and facilitate somewhat better their data dissemination, than strictly required for the mission at hand.

We re-emphasize that Corpus Christi Bay is a highly variable environment, subject to many external factors, each of which contributes a degree of "noise" in any measured parameter. To filter this noise, and expose variations in time and space, requires that sufficient independent measurements be available over the range of variation of the external factors. For time variability, continuity of data record is an all-important property of any data base. For space variability, a high density of sampling stations repeatedly sampled is necessary. Specific recommendations, as well as some amplification of these above precepts, are as follows:

(1) When the major investment of time and expense is to place a boat crew on station, a few *in situ* measurements should be standard procedures. Salinity should *always* be measured. If the crew is equipped with electrometric over-the-side probes, a vertical profile instead of a single depth should be routine. (Yet there are manifold examples of violation of this practice.) Some limited water sampling may also be simply accommodated, perhaps just surface grab samples for straightforward lab analyses. Notation should always be made of conditions, sampling location, and time and date. (This seems trivial, but there are numerous examples of omission of some or all of these.)

(2) We suggest that short lists be formulated of "recommended" parameters, to be included within suites of measurements of various classes (e.g, *in situ* parameters, non-fixed water samples, sediment sampling for chemical analysis, etc.), to provide guidance to anyone undertaking a sampling project.

(3) The same principle of incremental cost versus benefits should be considered in specifying laboratory analyses. Many procedures, e.g. mass spectrometry or grain-size by settling tube, are cost-loaded in sample preparation, and can admit additional parameters or greater resolution with minor incremental cost.

(4) Necessity for both continuity in time and continuity in space must be recognized, as well as the need for maintenance of a long period of sampling (Precepts I and III). There are numerous examples in the data record when a parameter is suspended from further measurement. In many cases, this has involved a replacement of the old parameter with a new one, e.g. JTU's replaced by NTU's. As another example, in recent years, there has been a shift of emphasis from rather gross and imprecise measurements such as BOD, oil & grease, volatile solids and total PAH's, to specific organic and hydrocarbon parameters. While the more precise measures are welcome, the termination of the record of the others is lamentable. When a new, more accurate parameter is considered to replace another, there should be a continuation of data for the older variable together with the new parameters to at least establish an empirical relation. It may be more important to continue the measurement of the older parameter, to preserve the continuity of record, even if the utility of that parameter is limited compared to the new one.

(5) One important implication of Precept I is that the density of independent measurements of a parameter should be commensurate with the space and time variability of that parameter. We note that the intratidal-diurnal scale of variability is virtually unsampled in Corpus Christi Bay by routine monitoring programs. The use of robot data collection, based on electrometric sensing and automatic data logging, has been instituted by the TWDB and, more recently, by Conrad Blucher Institute at Texas A&M University–Corpus Christi. We strongly recommend continuation of this work, but with increased attention given to Q/A procedures, data scrubbing and reconciliation, and drift control. *NB*, such data

acquisition should not replace routine sampling, since routine sampling provides far better spatial continuity than is practical to achieve with robot monitors.

(6) Some measure of suspended solids (e.g. turbidity) should be included in routine monitoring. For nutrients, metals, organic pesticides, PAH's or similar constituents that have an affinity for particulates, suspended solids *per se* should be routinely determined as part of the suite of measurements. Further, the analysis should include grain-size distribution or at least a simple filtration to determine partitioning of clays-and-finer and silts-and-coarser. (Technology such as a Coulter Counter can considerably improve resolution and precision, but can be expensive.)

(7) A ubiquitous deficiency of the sediment data base is that there are almost no paired measurements of chemistry and sediment texture (i.e., grain-size distribution). Analysis of the variability of many of the parameters of concern in environmental management, such as heavy metals and pesticides, must consider the grain-size fractions. We recommend that texture analysis be instituted as a routine aspect of any chemical analysis of a sediment sample. As laboratory analyses go, sediment texture is a cheap measurement. This is an excellent example of how the value of the data may be enhanced by a relatively economical additional measurement.

(8) Because of the future potential rôle sediment organic carbon may play in evaluating sediment chemistry with respect to a standard, presuming the EPA EqP approach (Adams et al, 1992) is adopted, we recommend that organic carbon be instituted as a routine aspect of any chemical analysis of sediment involving non-ionic organic contaminants, especially organohalogens.

(9) Too much information is sacrificed by the present practice of censoring analytical data. We recommend that chemical laboratories report both the actual instrumental determination and the computed detection limit. This will leave the decision to the user of the data of whether or how to use the instrumental value when it falls below the detection limit. Note that this recommendation requires no additional expense or action on the part of the laboratory, but rather dispenses with the last step of the reporting procedure of replacing instrumental values with the flag for "below detection limits." (With present procedures, the applicable detection limits should be reported already, independent of the magnitude of the instrumental result.)

10.5.3 Data management recommendations

(1) Data entry (i.e., transcription) errors are a prime cause of information loss, and any data-entry procedure should include a process of verification. It is perplexing that an agency will commit major funding to support field crews and state-of-the-art analytical equipment and analyses, then entrust the resulting data to unsupervised, nontechnical, poorly trained, and uncaring data-entry clerks.

(2) Any process that reduces or replaces measurements (including units conversions) may be losing data unless carefully performed. Precept IV urges a sensitivity to this potential, that seems to be largely lacking in present agency procedures. Replacing a series of raw measurements over time or space by an average, modifying the spatial position data, failing to preserve information on sampling time, position or conditions, or intermixing actual measurements with "estimated" (BOGAS) values without any means of separation, all represent losses of information, and are all practices that can be avoided with care and forethought. We recommend following the same philosophy observed here (see Section 4.1) of differentiating a source data base from a derivative data base. The raw data in original units with all supporting and ancillary information should be maintained as a source data file. Any alterations, including units conversions and averaging, should be implemented in a separate data base.

(3). We recommend that a clear separation be made between a data base that serves the archival function and a data base that is used for analytical purposes. One particularly ubiquitous practice is to combine measurements from one's own data collection with data drawn from other sources, perhaps subsampled or processed. At present, several agencies, e.g. TNRCC and TWDB, intermix such data in a single data base. This is ubiquitous because of the use of combined data bases in scientific analysis, exactly as carried out in this project. This intermixing may be compounded by further processing, e.g. averaging together. The danger lies in not maintaining a separate and uncorrupted file of the original measurements. We recommend adherence to the same principle of preservation of data integrity observed in this project. Agencies should differentiate between the data record of observations obtained by that agency, and a compiled data record of those and other external measurements, possibly further processed.

(4) We recommend the implementation of well-structured data management procedures utilizing modern computer capabilities, including streamlined access and dissemination protocols. Even small-scale research projects can take advantage of spreadsheet software for permanent data base maintenance. It is remarkable how many data sources for this study maintain data only have hard-copy field or laboratory sheets, or (worse) type the data without retaining a magnetic copy. We recommend multiple backups of the data files, utilizing robust formats (e.g. flat-ASCII files).

10.5.4 Data preservation and archiving recommendations

Data-dissemination problems transform themselves with the passage of time into data-preservation problems. The management of historical data needs a twofold thrust: the implementation of actions to improve preservation and dissemination of current data-collection programs, and institution of actions necessary to preserve existing data. The former was addressed in Section 10.5.3 above. In this section we consider the latter. With respect to data from past programs, the primary need is preservation, which must be based upon the recognition that older data can play a central rôle in water quality management. A secondary need is to transform the data into a more utilitarian format as soon as practicable.

In Section 5.3.3 above, seven factors were enumerated that are considered to contribute to the loss of historical data from Corpus Christi Bay. These apply not only to water/sediment quality data but to all categories of environmental data from the Corpus Christi Bay system. The important observation about all of these factors is that they are self-exacerbating and mutually reinforcing. The existence of only one or a few copies of a data set, and its possession by one or a few individuals increase the potential of loss due to natural or technological hazards. (These problems are particularly evidenced in the academic area, where each faculty member is responsible for the storage and tracking of his own materials, and there is little or no provision for preservation of those of a retired or resigned faculty.) Low priority of data management implies poor housing and careless data management practices, and increases the exposure to discard due to agency instability. All of these factors are continuing to work at present, and are creating the potential for further loss of data, which will be lamented in the future. In our view, the problem is critical.

The facile–and fatuous–recommendation to correct the situation would be to eliminate the above seven factors. We proffer the following specific recommendations, which we believe to be more pragmatic and to lie within the purview of the National Estuary Program or its participating agencies.

(1) All sponsored research projects (including consulting contracts and interagency contracts) should include a *requirement* for preparation of a data report documenting the *raw* measurements of the project. If a digitized version of the data base is part of the project, transmittal of a copy on an appropriate digital medium should also be required, with written (hard-copy) documentation of formats and software operation. Compliance with this requirement should be a condition for any future contracts. For public agencies, the data so transmitted should then be subjected to the requirement of public distribution given in (3) below.

(2) All projects internal to an agency, performed by an agency staff, involving observations and measurements should require preparation of a data report. If a digitized version of the data base is part of the project (which we recommend, but this may not always be practical), a copy on the appropriate digital medium should also be required, with written (hard-copy) documentation of formats and software operation. For public agencies, the data so transmitted should then be subjected to the requirement of public distribution given in (3) below.

(3) In public agencies, the release of the data report and digital copy should be made mandatory after a certain calendar period, e.g., six months. (If the data is still under review, it should be so marked, but being under review should not be used as a reason for delaying release.) Reimbursement for the expense of copying is appropriate, but the price should be reasonable. After all, the public has already paid for it once. Maximum advantage should be made of the Internet for dissemination.

(4) All agency files and materials should be marked with a destruction schedule by its originator. For measurements and raw data, at least, the files should be marked "permanent storage, not for destruction." In some agencies, smaller but equivalent words may be desirable.

(5) At least one hard-copy record of every data set should be maintained. This might be raw data sheets, or might be a print-out of a digital data record. Also, even when a data set exists in a digitized data-management format (e.g., a data base management software form such as Lotus or dBase), a separate version in general encoding format (e.g., ASCII) should be maintained.

(6) Data Inventory and Acquisition Projects should be sponsored as soon as practicable, either internal to an agency, or through external contract, to extend the present activity for Corpus Christi Bay, and to secure similar data sets for the other Texas embayments and for the Texas coast. In particular, holdings in the following agencies and sites should be retrieved, organized and, where appropriate, digitized:

- the Texas Parks and Wildlife Olmeto warehouse
- the U.S. Corps of Engineers: Galveston District, the Texas area offices and the Waterways Experiment Station
- the National Marine Fisheries Service laboratories in Galveston
- research universities in the Texas coastal zone
- private engineering and surveying companies

(7) Some centralized, cooperative data storage and management facility is needed, one which is divorced from the separate mission-oriented state and federal agencies. Emphasis should be on competence of staffing and an appropriate delineation of scope. The Texas Natural Resources Information System could become this entity, but it suffers from many problems, not the least of which is adequate and stable funding, which presently prevent its serving this function. This recommendation, of course, exceeds the jurisdiction of the CCBNEP agencies, but could profit from the strong unanimous support of these agencies. It is, however, the only long-range solution that is evident to us.

(8) Digital preservation technology has improved in recent years, and many of the long-term aging problems associated with re-writable magnetic media can now be avoided. In particular, we recommend preservation of historical data bases using CD-ROM technology, which is now sufficiently reliable and economical to be a viable alternative to tape. Again, the use of robust formats is preferable to software-specific or proprietary formats.

10.5.5 Recommendations for additional studies of water and sediment quality

On a more strategic level, regarding our understanding of water and sediment quality and information needed for effective management of the Corpus Christi Bay resources, we recommend the following:

(1) The data base assembled in this project is capable of many more analyses. In particular, it may be useful to examine the effects of varying temporal sample density on statistical bias, to normalize the data to uniform periods of record, and to carry out more sophisticated statistical examinations than could be mounted within the scope of this project. Detailed mass-budgeting studies are needed to determine the probable cause of the apparent declines in particulates and nutrients, perhaps in concert with hydrographic analyses or deterministic models, using the data base compiled in this project. Event-scenario analysis as well as time-series studies could both provide insight. This should be extended to include numerical modeling, as an "interpolator" in space and time.

(2) Additional analyses of chlorophyll-a and related measurements from Corpus Christi Bay, in association with *in situ* productivity studies are needed. These studies should include detailed examination of phytoplankton dynamics in Corpus Christi Bay, and its dependence on water quality.

(3) Metals remain a major concern. The present analysis was significantly delimited by the sparsity of data and the precision of measurement. Clearly, more and better measurements are necessary to assess and monitor this suite of variables. On the other hand, the investment in complex and demanding analyses does not at the moment seem highly critical to the management of Corpus Christi Bay, apart from the present state and federal activity in wasteload regulation. While monitoring should continue, we do not believe that merely intensifying that monitoring will yield information in proportion to investment. We recommend a research focus on:

- (a) improved measurement methodology, including relations with and among older methods, for interpretation of historical data, and better determination of precision and accuracy,
- (b) bioaccumulation of metals and trace organics,
- (c) detailed studies on kinetics and fluxes in carefully selected regions of the bay subject to identifiable and quantifiable controls, especially addressing the metals identified in this study as being elevated,
- (d) exploration of suitable tracers and their measurement, such as aluminum, to separate natural and anthropogenic sources of metals.

While information is needed on open-bay environments in general, the greater effort should be invested in those regions already manifesting a proclivity for elevated metals, i.e. in regions of runoff, inflow, waste discharges and shipping. We note that in the upper bays, Copano and Aransas in particular, recent data collection has been especially deficient.

(4) In an estuary as turbid as Corpus Christi Bay, the rôle of sediments in suspension and in the bed is quintessential. Every element of the sediment transport process is imperfectly understood, as manifested in our inability for quantification, from riverine loads to exchange with the Gulf, from scour and deposition on the estuary bottom to shoreline erosion. The affinity of many key pollutants for particulates, especially metals, and the dynamics of transport and exchange within the estuary, render an understanding of sediments absolutely indispensable to the management of water quality in general. This is compounded by the activity in Corpus Christi Bay of dredging, shoreline alteration, and trawling, as well as the declines in suspended sediments in recent years. In our view, sediment dynamics should be the focus of a renewed research effort in the bay, ranging from more detailed observation on grain-size spectrum and its effects, to biokinetic processes operating within the sediment itself.

(5) The observed decline in temperature is probably not a serious concern from the water-quality management standpoint, but additional examination of its cause, especially if of climatological origin, may provide insight into other processes. We recommend some modest examination of long-term variability in the climatological controls of the surface heat budget. Since the same trend in temperature was also discovered in Galveston Bay, this suggests that the scope of research should be extended to encompass the entire Texas coast.

(6) The salinity data base assembled in this project is the most comprehensive available for Corpus Christi Bay and will support analytical studies of salinity response heretofore not possible. In view of the mandatory releases from the Nueces River reservoirs, and the controversy surrounding the ecological value of these releases, detailed studies of the response of salinity to inflow events are highly recommended. In particular, it is recommended that salinity variability in Corpus Christi Bay be examined using sophisticated methods of time-series and response analysis to better delineate the rôle of inflow and other hydrographic factors on salinity. This would be valuable, not only because of the intrinsic importance of salinity as a hydrographic and ecological variable, but to yield insight into the time-response behavior of other, less intensely sampled parameters whose concentrations are dominated by internal transports.

(7) The significant observed increase in salinity underscores the gaps in our understanding of even as fundamental a parameter as this. While inflow has been identified as a probable causative factor, other elements of the salt budget, notably evaporative deficit and exchange with the Gulf of Mexico, could be of equal or greater importance. We recommend additional studies of the external controls on salinity. This could probably be most usefully pursued, at least at the outset, by detailed salt budgeting, combining the data base of the present study with the time-intense robot data records from TDWB and TAMU–CBI. Pursuant to this we recommend that the data records at TWDB be subjected to review and correction for drift, calibration error, and sensor faults, so to be available as a resource for such studies. As with nutrient and particulate loading, we believe event-scenario and time-series analysis to be the most promising approaches. There is also a place for hydrodynamic modeling, but only after the essential controls and responses of the system are much better defined.

(8) There seems to be little basis for the appropriateness of the 5 ppm standard in this estuarine system, given the low saturation concentrations at high temperatures and salinities. We recommend re-evaluating the applicability of the 5 ppm average DO standard to waters with such low solubility. (We note that there is a prominent exception to the uniform application of the 5 ppm DO standard along the Texas coast—that one bay is assigned a lower open-water DO standard by TNRCC—namely the 4 ppm standard for Galveston Bay.) At the same time, these low solubilities mean a concomitantly constrained assimilative capacity for oxygen-demanding constituents. While DO does not appear to be a problem in the study area at present, we recommend renewed research on the DO requirements of organisms, methods appropriate for evaluating assimilative capacity (for evaluation of waste discharges, particularly), and the factors leading to episodes of depressed DO in the study area, especially in poorly flushed regions.

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