Table 3-4
Definition of component bays for summary of data

principal component bay	*hydrographic-area 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 Bayá	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
á sediment data only

the role of the parameter in habitat determination, organism metabolism, or as an indicator of contamination, and which have the most extensive data bases. Average values are tabulated in Tables 3-5 through 3-10. For metals and even more so for trace organics, the water-phase data are usually at or below detection limits, so there is considerable noise and uncertainty in these data, a fact compounded by the relatively small number of samples. (We do not even present water-phase data for the trace-organic analytes. This data may be examined by consulting the main report, Ward and Armstrong, 1997a.) For sediment, the larger concentrations make their determination more reliable. One must weigh this improved accuracy against the fact that the sediment data base suffers even more from an inadequate number of independent measurements. In all of these tables, averages made up of a single measurement are expunged, and those based upon two or three measurements are flagged as being of questionable reliability.

For tissue data, the measurements are so scattered through the study area that little value is obtained by sorting into hydrographic areas. Instead, these data are averaged by major TNRCC Water Quality segment, and are presented in summary form in Table 3-11, for metal analytes and PCB's. Data for three organisms, representing the largest data sets, are given, *viz*., the oyster, blue

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Table 3-5
Period-of-record averages of indicator parameters
by component bay (see Table 3-4)
(Parameter abbreviations and units in Table 2-1)

component bay	*parameter*			
	WQSAL*	WQTEM*	WQDO*	WQDODEF*
Aransas Bay	24.6	22.4	8.12	-0.57
Copano Bay	14.5	22.2	8.55	-0.48
St Charles	14.3	23.1	8.50	-0.56
Mesquite	19.1	22.2	8.25	-0.38
Redfish	26.7	23.9	8.45	-1.13
Corpus Christi	28.7	22.8	7.77	-0.39
CCSC (bay)	29.0	22.1	7.62	-0.24
Inner Harbor	29.2	25.2	6.87	0.37
Nueces Bay	25.5	23.1	7.71	-0.21
Aransas Pass	27.4	22.8	8.07	-0.65
Causeway N	30.5	23.4	7.50	-0.30
Causeway S	32.8	24.6	7.75	-0.85
Laguna (King Ranch)	36.4	24.2	7.03	-0.21
Laguna (Baffin)	37.6	24.2	6.90	-0.17
Baffin Bay	37.5	24.1	7.14	-0.36
GOM inlet	31.1	22.3	7.55	-0.24

*measurements in upper 1 m

	WQPH	WQXTSS	WQFCOLI
Aransas Bay	8.20	33.5	6
Copano Bay	8.17	47.8	19
St Charles	8.18	44.1	55
Mesquite	8.21	56.7	6
Redfish	8.34	33.7	54
Corpus Christi	8.25	54.0	508
CCSC (bay)	8.19	62.8	4
Inner Harbor	8.03	31.0	260
Nueces Bay	8.09	218.7	52
Aransas Pass	8.28	36.0	4
Causeway N	8.28	23.1	22
Causeway S	8.23	31.5	48
Laguna (King Ranch)	8.23	23.0	2
Laguna (Baffin)	8.19	33.6	2
Baffin Bay	8.22	56.9	16
GOM inlet		23.2	62

Table 3-6
Period-of-record averages of nutrient and productivity parameters
by component bay (see Table 3-4)
(Parameter abbreviations and units in Table 2-1)

component bay	*parameter*			
	WQAMMN	WQNO3N	WQTOTP	WQSIO2
Aransas Bay	0.051	0.018	0.069	5.04
Copano Bay	0.064	0.486	0.133	9.15
St Charles	0.076	0.043	0.099	7.76
Mesquite	0.056	0.057	0.123	5.59
Redfish	0.068	0.064	0.054	3.63
Corpus Christi	0.079	0.035	0.066	2.63
CCSC (bay)	0.061	0.043	0.065	2.07
Inner Harbor	0.278	0.153	0.112	3.22
Nueces Bay	0.085	0.064	0.145	2.80
Aransas Pass	0.118	0.055	0.054	2.93
Causeway N	0.069	0.047	0.062	3.21
Causeway S	0.037	0.018	0.051	3.61
Laguna (King Ranch)	0.069	0.025	0.055	4.70
Laguna (Baffin)	0.068	0.031	0.051	4.90
Baffin Bay	0.061	0.020	0.157	7.15
GOM inlet	0.179	0.037	0.081	

	WQTOC	WQCHLA	WQPHEO
Aransas Bay	10.7	48.8	1.6
Copano Bay	15.8	13.2	1.6
St Charles	12.7	10.3	1.1
Mesquite	11.8	11.6	4.5
Redfish	9.33	3.8	1.2
Corpus Christi	11.3	7.1	1.7
CCSC (bay)	6.85	7.8	2.4
Inner Harbor	578	15.3	0.9
Nueces Bay	7.41	9.0	6.1
Aransas Pass	6.99	15.1	1.8
Causeway N	6.49	4.5	1.6
Causeway S	3.20	5.7	1.3
Laguna (King Ranch)	7.17	5.1	1.1
Laguna (Baffin)	7.05	9.8	1.6
Baffin Bay	11.5	12.4	1.1
GOM inlet	7.80	3.1	1.3

Table 3-7
Period-of-record average (with BDL=0) for component bays (see Table 3-4),
Conventional sediment quality parameters (Table 2-1)

Component bay	*Parameter:*		
	SEDAMMN	SEDKJLN	SEDTOTP
Aransas Bay	*	*	*
Copano Bay	*	1610	388
St Charles	*	444	211
Mesquite	0	460	413
Redfish	*	750	363
Corpus Christi	*	**	**
CCSC (bay)	117	1365	634
Inner Harbor	165	1302	488
Nueces Bay	*	**	**
Aransas Pass	**	50áá	190á
Oso Bay	*	*	*
Causeway N	*	*	*
Causeway S	*	*	*
Laguna (King Ranch)	*	4190	636
Laguna (Baffin)	*	*	*
Baffin Bay	*	1725	508
GOM inlet	42	277	639
	SEDTOC	SEDO&G	SEDVOLS
Aransas Bay	8.4	**	*
Copano Bay	8.8	1230	77200
St Charles	6.1	1570	24500
Mesquite	5.6	2560	160000
Redfish	10.0	452	17900
Corpus Christi	10.1	368	**
CCSC (bay)	3.9	387	92821
Inner Harbor	0.4	1151	68800
Nueces Bay	6.5	547	**
Aransas Pass	3.1	140áá	1á
Oso Bay	9.6	*	*
Causeway N	13.2	**	*
Causeway S	21.6	**	*
Laguna (King Ranch)	11.1	1008	75300
Laguna (Baffin)	7.1	*	*
Baffin Bay	10.5	913	105700
GOM inlet	3.6	454	27100

* no data
only 1(**), 2 (á), or 3(áá) measurements in period of record

Table 3-8
Period-of-record average (with BDL=0) of total metals in water,
by component bay (see Table 3-4).
Highest three concentrations for each metal in boldface

component bay	*metals:*				
	WQMETCDT	WQMETCUT	WQMETHGT	WQMETPBT	WQMETZNT
Aransas Bay	0.0	2.2	0.00	4.0	13.1
Copano Bay	**2.5**	**27.0**	**0.40**	0.5	35.0
St Charles	0.0	4.0	0.00	25.0	10.0
Mesquite	*	*	*	*	*
Redfish	**1.6**	**19.7**	0.08	**51.7**	20.0
Corpus Christi	0.0	2.8	0.00	11.9	**105.9**
CCSC (bay)	**2.2**	10.1	0.08	3.4	**63.0**
Inner Harbor	0.8	11.5	0.12	18.0	52.8
Nueces Bay	0.0	14.0	0.00	**100.0**	44.0
Aransas Pass	0.0	0.0	0.01	0.0	2.2
Causeway N	0.0	0.0	0.00	0.0	0.0
Causeway S	0.0	0.0	0.00	**70.0**	5.0
Laguna (King Ranch)	0.8	10.5	**0.33**	14.7	22.7
Laguna (Baffin)	0.0	0.0	0.00	8.0	5.4
Baffin Bay	**1.6**	**31.3**	**2.22**	36.2	**59.3**
GOM inlet	0.0	0.3	0.07	0.0	1.7

Table 3-9
Period-of-record average (with BDL=0) of sediment metals,
by component bays (see Table 3-4).
Highest three concentrations for each metal in boldface.

Component bay	*metals:* SEDMETAS	SEDMETCD	SEDMETCR	SEDMETCU	SEDMETHG
Aransas Bay	3.98	1.89	11.4	6.53	0.038
Copano Bay	**4.98**	**3.79**	**22.2**	8.51	0.036
St Charles	2.53	**5.00**	12.5	4.55	0.030
Mesquite	3.70	2.92	6.8	5.28	**0.158**
Redfish	3.53	0.68	9.2	6.47	0.029
Corpus Christi	**4.50**	0.89	18.6	9.81	0.083
CCSC (bay)	3.50	0.95	14.2	7.64	**0.145**
Inner Harbor	**6.33**	**16.41**	**36.1**	**37.39**	**1.097**
Nueces Bay	3.62	1.68	12.8	9.87	0.120
Aransas Pass	1.96	0.52	14.7	3.30	0.014
Oso Bay	2.45á	0.35á	14.5	10.13	0.060á
Causeway N	1.56	0.00	9.4	7.43	0.027
Causeway S	4.05	0.33	13.4	**14.81**	0.054
Laguna (King Ranch)	3.38	0.40	9.6	8.23	0.100
Laguna (Baffin)	3.20	0.31	7.5	4.59	0.036
Baffin Bay	4.09	1.22	19.6	**12.82**	0.088
GOM inlet	2.04	1.17	**27.4**	7.64	0.083

	SEDMETNI	SEDMETPB	SEDMETSE	SEDMETZN
Aransas Bay	6.67	9.14	0.31	31.3
Copano Bay	**10.25**	13.14	**0.60**	43.3
St Charles	5.51	6.17	**0.70**	25.5
Mesquite	3.75	6.87	**0.60**	26.5
Redfish	6.09	7.31	0.13	33.8
Corpus Christi	**10.58**	17.98	0.21	**73.7**
CCSC (bay)	8.59	16.02	0.53	59.3
Inner Harbor	**9.72**	**91.66**	**0.78**	**1484.6**
Nueces Bay	6.30	13.15	0.12	**166.5**
Aransas Pass	4.28	6.31	0.12	16.1
Oso Bay	3.67	14.00á	0.00á	56.2
Causeway N	3.98	7.33	0.05	21.7
Causeway S	7.79	**18.33**	0.56	46.8
Laguna (King Ranch)	6.21	10.86	0.40	30.4
Laguna (Baffin)	3.75	11.98	0.23	26.9
Baffin Bay	9.68	**30.84**	0.35	42.5
GOM inlet	8.03	14.15	0.40	29.0

á only 2 measurements in period of record

Table 3-10
Period-of-record average (with BDL=0) of sediment pesticides and PCB's, by component bays (Table 3-4)
Highest three concentrations for each analyte in boldface.

Component bay	SED-ALDR	SED-CHLR	SED-DIAZ	SED-DIEL	SED-LIND
Aransas Bay	**0.13**	**0.72**	**	0.13	0.02
Copano Bay	**0.25**	**1.53**	**1.25**	**0.19**	**0.14**
St Charles	0.10	0.50	0.00	0.10	0.00
Mesquite	0.08	0.33	0.00	0.12	0.00
Redfish	0.01	0.01	0.00	0.00	0.02
Corpus Christi	0.00	0.11	**	0.10	**0.08**
CCSC (bay)	0.00	0.00	0.00	0.00	0.00
Inner Harbor	0.00	0.71	0.00	**0.72**	0.00
Nueces Bay	0.08	0.27	*	0.08	0.03
Aransas Pass	0.08	0.00	*	0.02	0.00
Oso Bay	**	**	**	**	**
Causeway N	**	0.00á	*	**	**
Causeway S	**	0.00áá	*	**	**
Laguna (King Ranch)	0.00	0.00	0.00	0.00	0.00
Laguna (Baffin)	*	0.00	*	*	*
Baffin Bay	**0.25**	**5.00**	**1.67**	**0.75**	**0.25**
GOM inlet	0.00	0.00	**	0.00	0.00

Parameter:

Component bay	SED-TOXA	SED-XDDT	SED-DDT	SED-PCB
Aransas Bay	0.00	0.09	**0.15**	0.77
Copano Bay	**12.50**	0.24	**0.41**	1.83
St Charles	0.00	0.10	0.10	1.00
Mesquite	0.00	0.36	0.10	0.67
Redfish	0.00	0.00	0.01	**82.07**
Corpus Christi	0.00	**0.74**	**0.15**	0.48
CCSC (bay)	0.00	**0.97**	0.00	**17.00**
Inner Harbor	0.00	0.00	0.00	**48.96**
Nueces Bay	**2.50**	0.06	0.09	3.77
Aransas Pass	0.00	0.00	*	0.00
Oso Bay	**	**	**	**
Causeway N	0.00á	0.00á	*	0.00á
Causeway S	0.00áá	0.00áá	*	0.00áá
Laguna (King Ranch)	0.00	0.00	0.00	13.47
Laguna (Baffin)	0.00	0.00	*	0.00
Baffin Bay	**12.50**	**1.18**	**1.18**	15.00
GOM inlet	0.00	0.00	**	6.00

* no data
only 1(**), 2 (á), or 3(áá) measurements in period of record

Table 3-11
Period-of-record average (with BDL=0) of tissue metals and PCB's
in oyster, blue crab and black drum by major TNRCC Segments.
Highest two concentrations for each analyte in boldface.

Segment	*parameter* TxMETAS	TxMETCD	TxMETCU	TxMETHG	TxMETPB	TxMETZN	Tx-PCB
-Oyster (Organism Code 04), meat and liquor only-							
2463 Mesquite	0.909	0.802	17.1	0.00797	0.0466	98.5	*
2471 Aransas	**1.44**	0.724	17.8	0.0113	0.0527	206	*
2472 Copano	1.02	**1.31**	29.7	**0.0204**	0.0725	198	*
2481 Corpus Christi	**1.37**	0.86	21.5	0.0163	**0.122**	623	*
2482 Nueces	0.424	**2.47**	**41.7**	**0.0251**	0	**1440**	**0.175**
2483 Redfish	*	*	*	*	*	*	*
2484 Inner Harbor	0.62á	1.28á	**104**á	0.005á	**0.951**á	**1660****	*
2491 Upper Laguna	*	*	*	*	*	*	*
2492 Baffin	*	*	*	*	*	*	*
-Blue crab (Organism Code 10), total organism-							
2463 Mesquite	*	0.293	8.51	0	0	33	0
2471 Aransas	*	*	*	*	*	*	*
2472 Copano	*	*	*	*	*	*	*
2481 Corpus Christi	3.82	0.249	**17.5**	0.0417	0.0479	28.8	*
2482 Nueces	1.72áá	**0.416**áá	13.9áá	**0.0506**áá	0áá	26.6áá	*
2483 Redfish	2.96á	0.273á	**18.9**á	0.00615á	**0.196**á	23.3á	*
2484 Inner Harbor	1.76áá	0.288áá	10.7áá	**0.0448**áá	**0.542**áá	**33.1****	**0.018**á
2491 Upper Laguna	**10.4**	**0.536**	12.4	0.0285	0.0916	24.6	*
2492 Baffin	**5.82**	0.214	10.4	0.0196	0.0712	**45.4**	*
-Black drum (Organism Code 15), filets only-							
2463 Mesquite	*	*	*	*	*	*	á
2471 Aransas	0**	0**	0**	0.04**	0**	3.4**	**
2472 Copano	0á	0á	0á	**0.11**á	0á	**6.4**á	á
2481 Corpus Christi	0áá	0áá	0.367áá	0.06áá	0áá	4.7áá	áá
2482 Nueces	**0.463**	0	**0.407**	**0.153**	0	**5.34**	0.0058
2483 Redfish	*	*	*	*	*	*	*
2484 Inner Harbor	*	*	*	*	*	*	*
2491 Upper Laguna	*	0**	**1.4****	0.06**	0**	4.4**	**
2492 Baffin	0á	0áá	0.4áá	0.0763áá	0áá	4.37áá	á

* no data
only 1(**), 2 (á), or 3(áá) measurements in period of record

crab, and black drum. Analyte abbreviations use the second character, in Table 3-11 replaced with "x," to code the portion of the organism analyzed, but the element or compound code otherwise follows the same convention as Table 2-4.

The extent of vertical stratification in a parameter is frequently of concern in water-quality analysis. The intensity of vertical mixing in the Texas bays, and the resulting vertical homogeneity of the water column has been frequently remarked, e.g. Ward (1980a). With the data base assembled here, the extent of vertical stratification was analyzed for each variate for which coincident measurements at two depths were available, predominantly temperature, salinity and dissolved oxygen, and to a lesser extent nitrogen series, TOC, suspended solids and chlorophyll-a. Vertical stratification was computed as the vertical gradient in concentration between the two most widely separated measurements in the vertical for a given sample:

$$Dc/Dz$$

where Dc is the upper-to-lower difference in concentration, and Dz is the difference in elevation of the two measurements with z positive upwards. It must be emphasized that stratification is determined in its fluid-dynamics sense, and does not imply any "layering" of the water (which entails quantum changes in parameter values at an interface, i.e. singularities in stratification). Such "layering" and associated concepts, such as the notorious "salt wedge," are so rare and evanescent in Corpus Christi Bay that they are irrelevant to its general water-quality characteristics. The units of stratification are parameter units per unit depth, e.g. ppm per metre, and stratification is positive if concentration increases upward. Therefore, the normal density stratification implies a positive stratification in temperature and a negative stratification in salinity.

The vertical stratification in selected parameters is tabulated in Tables 3-12 through 3-19 for the component bays defined in Table 3-4. Stratification computations for each of the hydrographic-area segments are presented in the Technical Report (Ward and Armstrong, 1997a). Because stratification is a divided difference, it is even noisier than the concentration data upon which it is based. This computation is presented in two ways: the arithmetic average stratification in each component bay, with the associated standard deviation, and t__ percentage of the data exhibiting *positive* stratification. The predominance of stratification is manifested by a large value of gradient compared to the normal magnitude of concentration, and/or a predominance of sign. Since predominance of sign is based upon positive values of stratification, this excludes the occurrence of *zero* stratification. Therefore, one cannot infer that if positive stratification occurs r % of the time then negative stratification will occur (100 - r)% of the time, but rather that negative *or zero* stratification will occur (100 - r)% of the time. The general negative stratification in salinity and suspended solids, and the general positive stratification in temperature and dissolved oxygen are consistent with the physical processes controlling each of these (to anticipate the discussions of Chapter 4).

Table 3-12
Average stratification in salinity (WQSAL), ppt m^{-1}, by component bay

Component Bay	*no. obs*	*strat ppt/m*	*st dev ppt/m*	*percent positive*
Aransas Bay	538	-0.40	1.24	14
Copano Bay	486	-0.35	1.12	10
St Charles	75	-0.37	1.24	12
Mesquite	161	0.29	2.63	22
Redfish	263	-0.62	1.29	16
Corpus Christi	1719	-0.32	1.06	14
CCSC (bay)	430	-0.25	0.52	13
Inner Harbor	487	-0.21	0.50	23
Nueces Bay	404	-0.46	3.31	21
Aransas Pass	245	-0.13	0.87	14
Causeway N	223	-0.16	0.67	16
Causeway S	132	-0.14	1.06	33
Laguna (King Ranch)	310	-0.12	1.27	24
Laguna (Baffin)	106	-0.01	2.10	42
Baffin Bay	451	0.05	3.07	33

Table 3-13
Average stratification in temperature (WQTEMP), C m^{-1}, by component bay

Component Bay	*no. obs*	*strat C/m*	*st dev C/m*	*percent positive*
Aransas Bay	588	0.067	0.30	51
Copano Bay	488	0.119	0.48	45
St Charles	75	0.064	0.55	31
Mesquite	163	0.274	2.58	35
Redfish	266	0.104	0.32	59
Corpus Christi	1841	0.046	0.28	47
CCSC (bay)	473	0.031	0.09	60
Inner Harbor	498	0.058	0.14	76
Nueces Bay	399	0.081	0.70	32
Aransas Pass	260	0.019	0.09	47
Causeway N	226	0.045	0.16	48
Causeway S	146	0.120	0.14	75
Laguna (King Ranch)	308	0.047	0.82	54
Laguna (Baffin)	106	0.138	0.21	69
Baffin Bay	450	0.127	0.48	47

Table 3-14
Average stratification in DO deficit (WQDODEF), ppm m^{-1}, by component bay

Component Bay	*no. obs*	*strat ppm/m*	*st dev ppm/m*	*percent positive*
Aransas Bay	224	-0.24	0.46	21
Copano Bay	260	-0.20	0.42	18
St Charles	36	0.03	0.38	28
Mesquite	60	-0.14	0.35	27
Redfish	162	-0.25	0.45	21
Corpus Christi	751	-0.26	0.79	18
CCSC (bay)	268	-0.08	0.16	18
Inner Harbor	438	-0.19	0.21	8
Nueces Bay	186	-0.28	0.69	36
Aransas Pass	151	-0.04	0.16	28
Causeway N	123	-0.04	0.17	37
Causeway S	58	-0.14	0.16	17
Laguna (King Ranch)	131	-0.20	0.43	17
Laguna (Baffin)	42	-0.35	0.46	19
Baffin Bay	109	-0.20	0.45	31

Table 3-15
Average stratification in pH (WQpH), 10^{-3} pH m^{-1}, by component bay

Component Bay	*no. obs*	*strat 10^{-3}pH/m*	*st dev 10^{-3}pH/m*	*percent positive*
Aransas Bay	326	17.1	51	37
Copano Bay	343	22.5	79	32
St Charles	41	19.6	82	12
Mesquite	115	-4.4	109	17
Redfish	189	21.2	50	49
Corpus Christi	736	6.7	47	27
CCSC (bay)	204	8.2	17	60
Inner Harbor	404	9.3	22	53
Nueces Bay	193	19.9	110	26
Aransas Pass	155	7.2	29	39
Causeway N	125	0.2	46	32
Causeway S	88	5.4	38	41
Laguna (King Ranch)	144	4.5	51	22
Laguna (Baffin)	70	10.5	70	36
Baffin Bay	199	1.9	73	24

Table 3-16
Average stratification in ammonia (WQAMMN), 10^{-3} ppm m^{-1}, by component bay

Component Bay	*no. obs*	*strat 10^{-3}ppm/m*	*st dev 10^{-3}ppm/m*	*percent positive*
Aransas Bay	108	-1.4	15.9	31
Copano Bay	38	-1.6	29.8	32
St Charles		insufficient data		
Mesquite	27	-1.6	24.6	37
Redfish	17	-5.2	8.6	12
Corpus Christi	313	-0.6	39.6	32
CCSC (bay)	90	-0.5	11.8	30
Inner Harbor	82	-5.7	32.5	44
Nueces Bay	121	-4.6	45.0	36
Aransas Pass	49	-0.1	4.8	29
Causeway N	68	0.8	21.8	31
Causeway S	28	-0.1	2.3	32
Laguna (King Ranch)	126	-0.2	17.3	38
Laguna (Baffin)	31	-0.9	3.1	35
Baffin Bay	214	-2.7	15.5	29

Table 3-17
Average stratification in nitrates (WQNO3N), 10^{-3} ppm m^{-1}, by component bay

Component Bay	*no. obs*	*strat 10^{-3}ppm/m*	*st dev 10^{-3}ppm/m*	*percent positive*
Aransas Bay	108	1.65	22.2	36
Copano Bay	41	-42.40	186.0	10
St Charles	3	-111.00	130.0	0
Mesquite	27	13.00	29.3	56
Redfish	19	-14.10	380.0	11
Corpus Christi	306	0.77	12.8	32
CCSC (bay)	97	2.54	36.4	33
Inner Harbor	90	7.06	25.4	54
Nueces Bay	122	6.26	56.3	53
Aransas Pass	46	-3.24	12.3	20
Causeway N	66	-7.44	49.0	26
Causeway S	28	0.04	0.4	39
Laguna (King Ranch)	126	1.40	21.0	44
Laguna (Baffin)	31	-0.13	1.0	65
Baffin Bay	214	0.17	6.1	55

Table 3-18
Average stratification in chlorophyll-a (WQCHLA), 10^{-3}ppm/m, by component bay

Component Bay	*no. obs*	*strat 10^{-3}ppm/m*	*st dev 10^{-3}ppm/m*	*percent positive*
Aransas Bay		insufficient data		
Copano Bay		insufficient data		
St Charles		insufficient data		
Mesquite	13	-1312	855	0
Redfish		insufficient data		
Corpus Christi	129	-31	509	26
CCSC (bay)	44	-44	249	36
Inner Harbor		insufficient data		
Nueces Bay	116	-1025	2493	32
Aransas Pass	13	62	420	23
Causeway N	22	-100	620	45
Causeway S		insufficient data		
Laguna (King Ranch)		insufficient data		
Laguna (Baffin)		insufficient data		
Baffin Bay		insufficient data		

Table 3-19
Average stratification in proxy TSS (WQXTSS), ppm m^{-1}, by component bay

Component Bay	*no. obs*	*strat ppm/m*	*st dev ppm/m*	*percent positive*
Aransas Bay	146	-8.98	25.0	14
Copano Bay	91	-6.03	14.9	23
St Charles	18	-8.53	15.9	17
Mesquite	36	-27.30	48.0	14
Redfish	28	-4.94	7.2	11
Corpus Christi	552	-4.84	9.8	16
CCSC (bay)	98	-3.63	4.7	10
Inner Harbor	106	-2.05	5.6	25
Nueces Bay	33	-28.30	36.6	3
Aransas Pass	108	-1.69	4.0	20
Causeway N	43	-3.00	9.3	12
Causeway S	36	-0.73	3.6	25
Laguna (King Ranch)	20	-7.32	11.5	15
Laguna (Baffin)		insufficient data		
Baffin Bay	29	-5.76	15.3	24

3.2 Time trends in water and sediment quality

The second table of each pair of statistical analyses, e.g. Table 3-3, presents the Time Trend Analysis. This was approached by a linear regression of the (non-BDL) measurements versus time. The period of record, the period used for the time-trend analysis (which may differ from the former because BDL values are part of the measurement record but are excluded from the trend analysis), and the average observations per year entering the analysis all provide an indication of the validity of the trend analysis. Clearly, the shorter the period of time over which usable data are available, and the smaller the number of observations per year, the more limited the statistical validity of the trend analysis.

From the water- and sediment-quality "climate" viewpoint, the most important regression parameter is the slope. This is the average (in the least-squares sense) rate of increase (if positive) or decrease (if negative) in the magnitude of the water quality variate, in units of the analyte per year. It is the key indicator of a systematic change in that water- or sediment-quality variate. The intercept is the average value (least-squares sense) of the trend at the beginning of the period of analysis. Finally, the standard error of the estimate (SEE) in units of the variate and the residual variance (per cent) provide a measure of scatter about the trend line. The larger these two indicators, the greater the scatter about the trend line. These communicate both the extent of observed variability that may be systematic in time, and the uncertainty of the computed trend. It should also be noted, however, that a least-squares trend line is not judged by its explained variance (or linear correlation coefficient) because we are not seeking to *explain* the observed variability in a parameter only in terms of the passage of time. Indeed, considering the many sources of variation in the Corpus Christi system, we expect time to be a relatively minor contributor to variance in measured concentrations. Even if such a trend line "explains" only, say, 1 per cent of the variance of a constituent, it can still provide insight into long-term alterations in the water quality "climate" of the system.

Our concern with the scatter about the trend line is, rather, to be able to judge the "reality" of the computed trend. To this end, two additional parameters are provided in the Time Trend tables to qualify its computation, *viz*. the upper and lower 95% confidence bounds of the slope of the regression line. One must bear in mind that these confidence bounds presuppose, on average, a 1/20 failure rate (i.e., in which the real regression slope lies outside of the 95% bounds). Further, this calculation is subject to the assumption that the available data are an adequate sampling of the population. The confidence bounds measure some of this, in that the accuracy of the slope estimate degenerates, i.e., the confidence bounds become wider, as the scatter about the regression (SEE) increases, the number of data points decreases, and the spread in time of the data decreases. But a handful of data points spuriously clustered at both ends of the period of record can yield a high confidence in the slope, which one would dismiss as fictitious based upon his external knowledge about the normal variability of the water quality variate. In this respect, the behavior of the parameter in neighboring areas of the bay, and direct inspection of the data, should be used in determining whether to accept the statistical calculation of trend. We note also that this analysis does not distinguish between a statistically unresolvable trend and a trend of zero.

For our present purposes, the most important diagnostic is when both confidence bounds have the same sign, indicating that the real trend has that sign (with no worse than a 97.5% probability). In many instances, the confidence bounds have different signs, but one bound is of much greater absolute magnitude than the other, i.e. the confidence band is highly asymmetric about 0. A lower probability value would produce confidence bounds of the same sign. Therefore, as a supplement, confidence bounds corresponding to 80% probability were also computed. We define a *probable trend* to be one for which *both* of the 95% confidence bounds have the same sign. We emphasize that this entails a 1/40 failure rate (i.e., slope judged as one sign when it is in fact the other), so this is a very stringent definition of "probable." We define a *possible* trend as one in which both of the 80% confidence bounds have the same sign, i.e. a 1/10 risk of misjudging the sign of the trend.

The present analysis, based upon spatial aggregation of the data, has a distinct advantage in statistical interpretation compared to the usual problem of interpreting a trend analysis of a set of data. Here we have sorted the data into separate geographical segments, each one of which represents an *independent* data set for trend analysis. This not only provides insight into spatial variation in water quality in Corpus Christi Bay, but also the regional coherence of trends is a strong indicator of whether the trends are real or possibly may be some statistical artifact (including the 1/40 chance of a false significant slope occurring by random variation). In Figs. 3-44 through 3-62, the distribution of positive and negative trends for selected parameters is depicted graphically, by zones of "probable" trends, and "possible" trends, for selected parameters and regions of the study area.

3.3 Observations and discussion

Salinity is, of course, the central hydrographic and habitat variable of Corpus Christi Bay. We expect the long-term average salinities to exhibit a landward decline toward the sources of inflow. What is striking about the distributions in the CCBNEP study area is that the overall gradient in salinity runs from north to south across the study area, from lowest salinities in the Aransas-Copano system to highest salinities in Baffin Bay, but without dramatic local depression in regions of major inflow. In the upper section of Corpus Christi Bay, in particular, the gradient to the Nueces River inflow is quite flat. (Consonant with our philosophy of segregating the *facts* of the statistical analyses from their *interpretation*, we defer comments on probable causes and apparent associations with controlling variables to the discussions of Chapter 4.)

Within Corpus Christi Bay *per se*, Fig. 3-2, the highest average salinities occur dead center in the bay, and of course near the entrance to the Laguna Madre. Unlike the estuaries on the upper Texas coast, such as Galveston Bay (see Ward

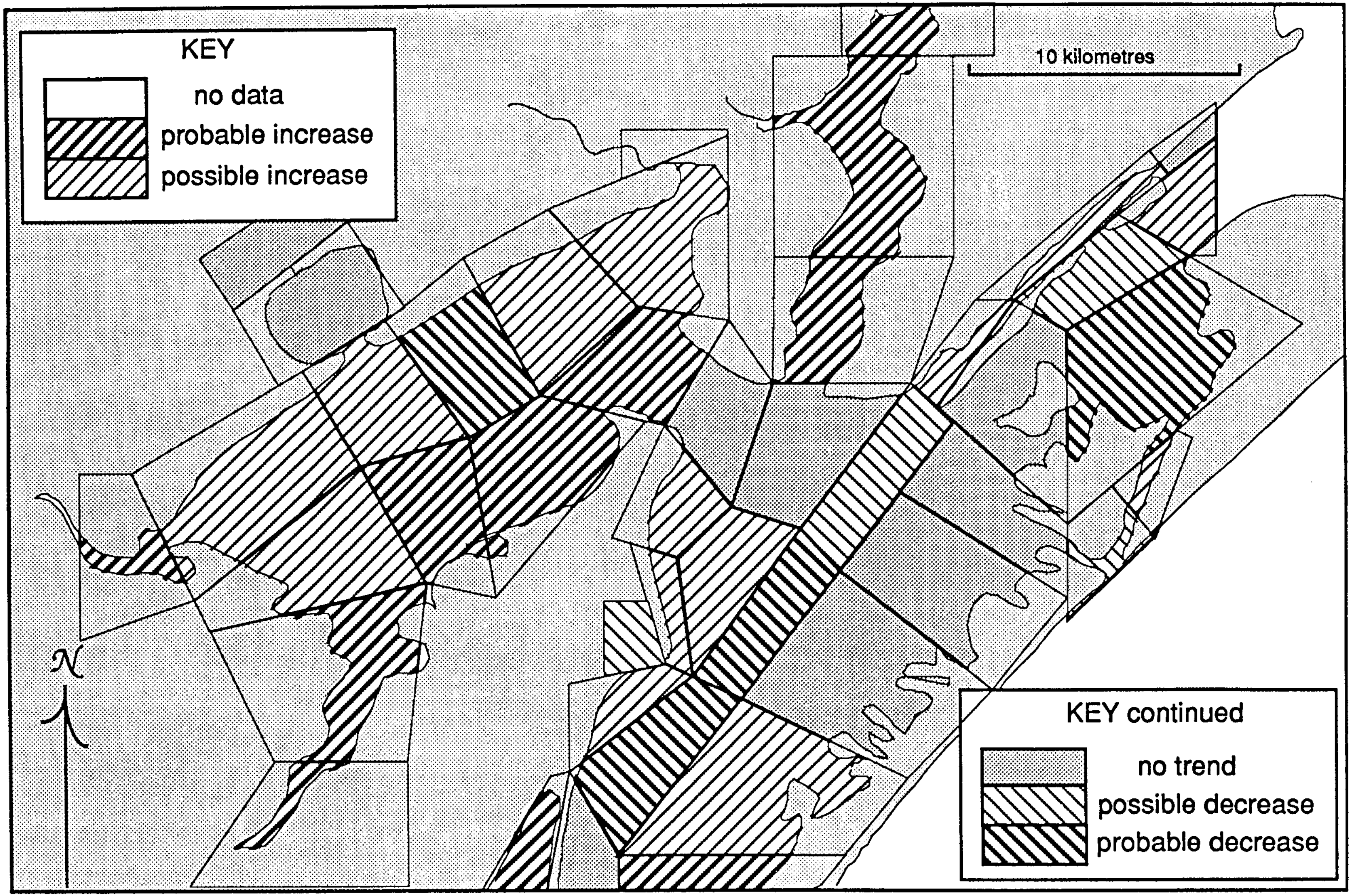

Figure 3-44. WQSAL in upper 1 m period-of-record time trends for Aransas-Copano system

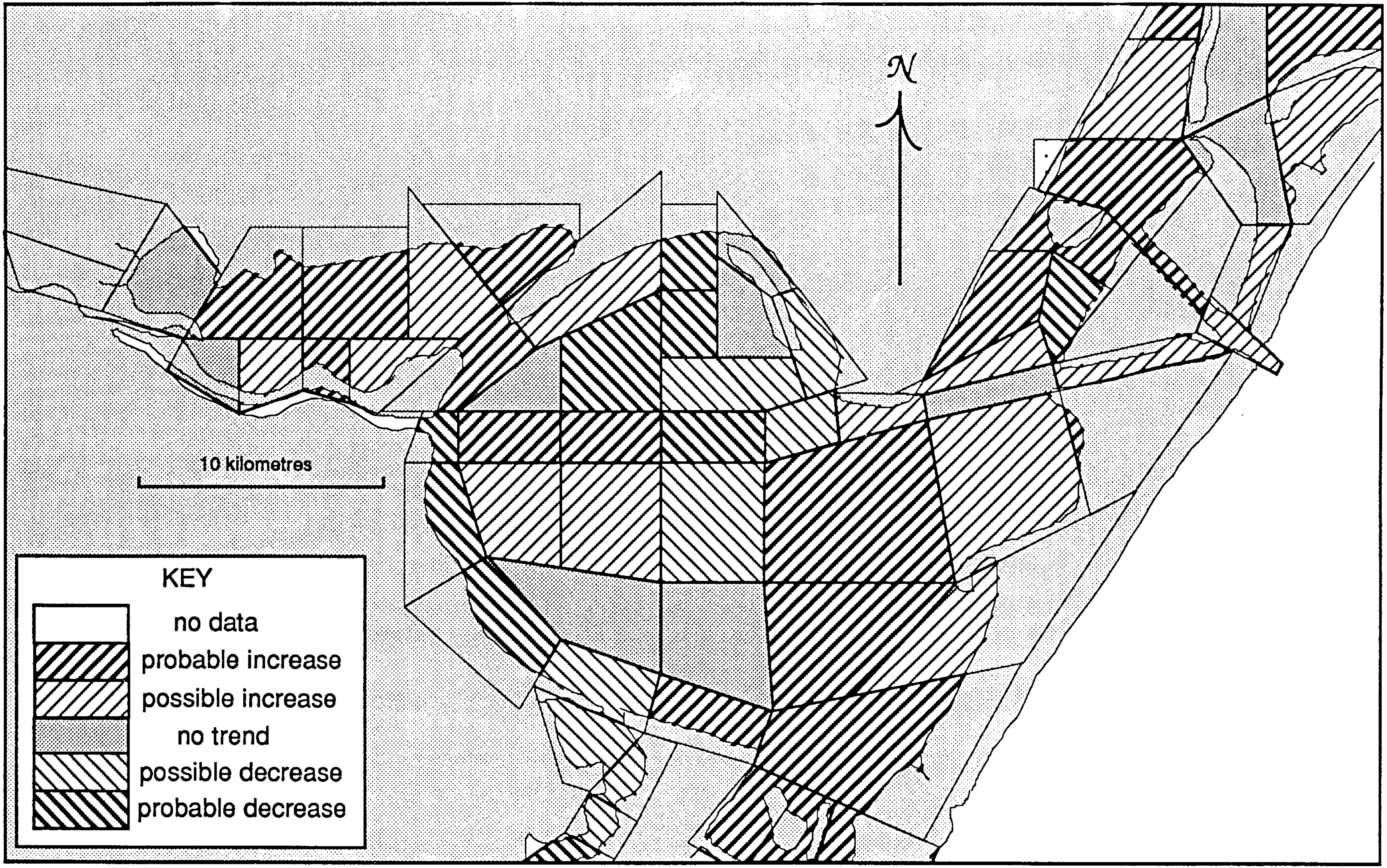

Figure 3-45. WQSAL in upper 1 m period-of-record time trends for Corpus Christi system

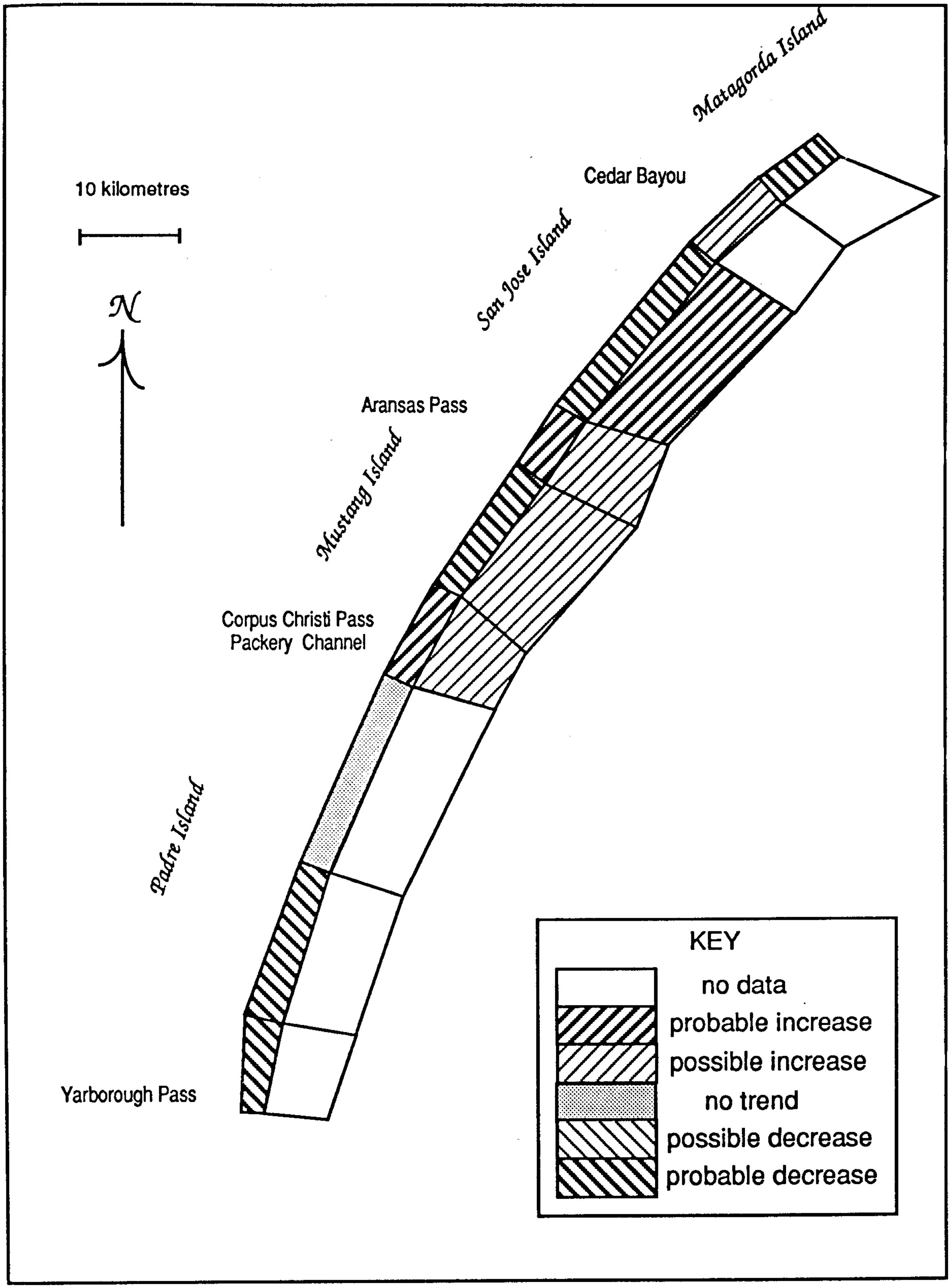

Figure 3-46. WQSAL in upper 1 m period-of-record trends for Gulf of Mexico

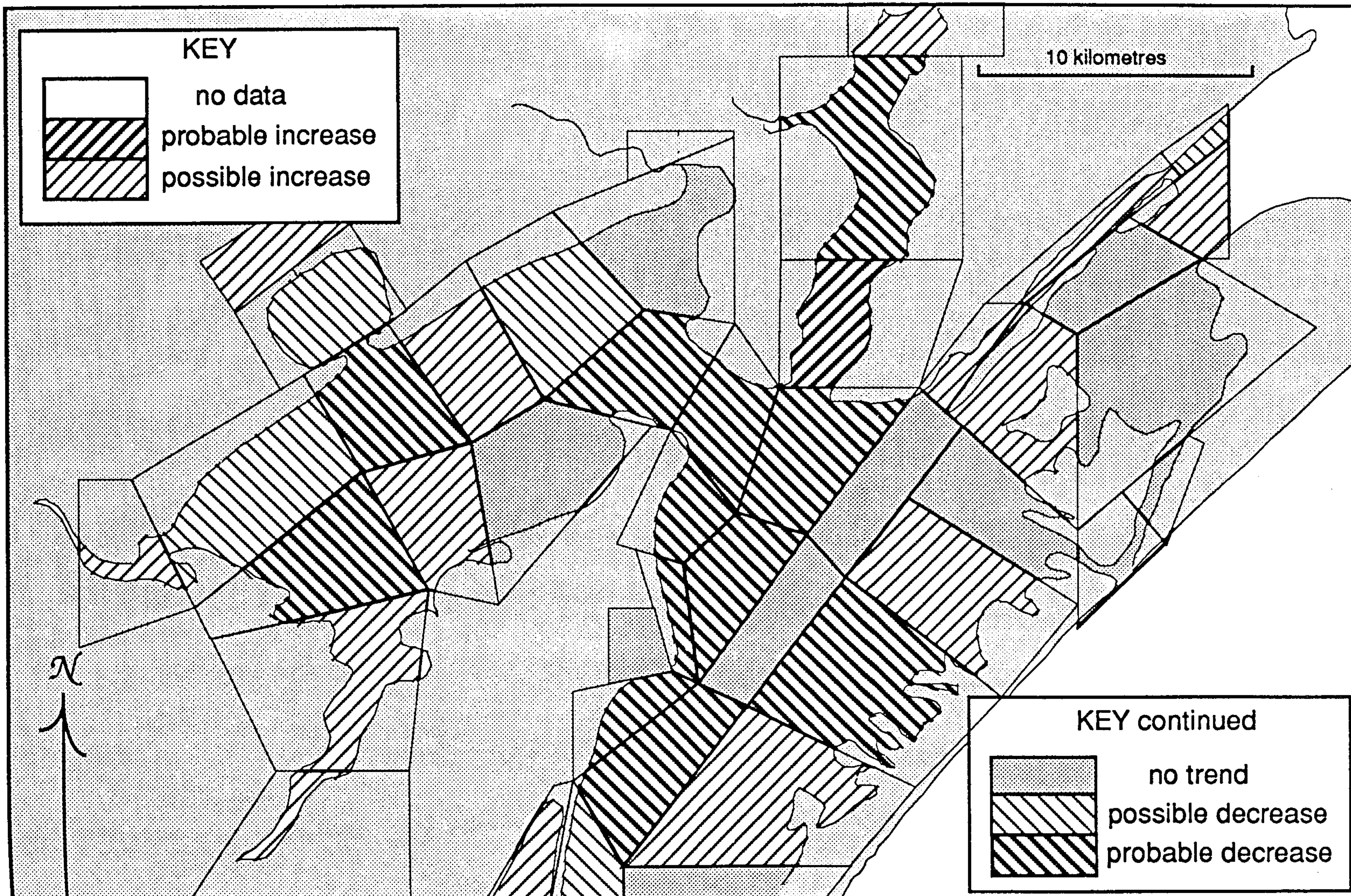

Figure 3-47. WQTEMP in upper 1 m period-of-record time trends for Aransas-Copano system

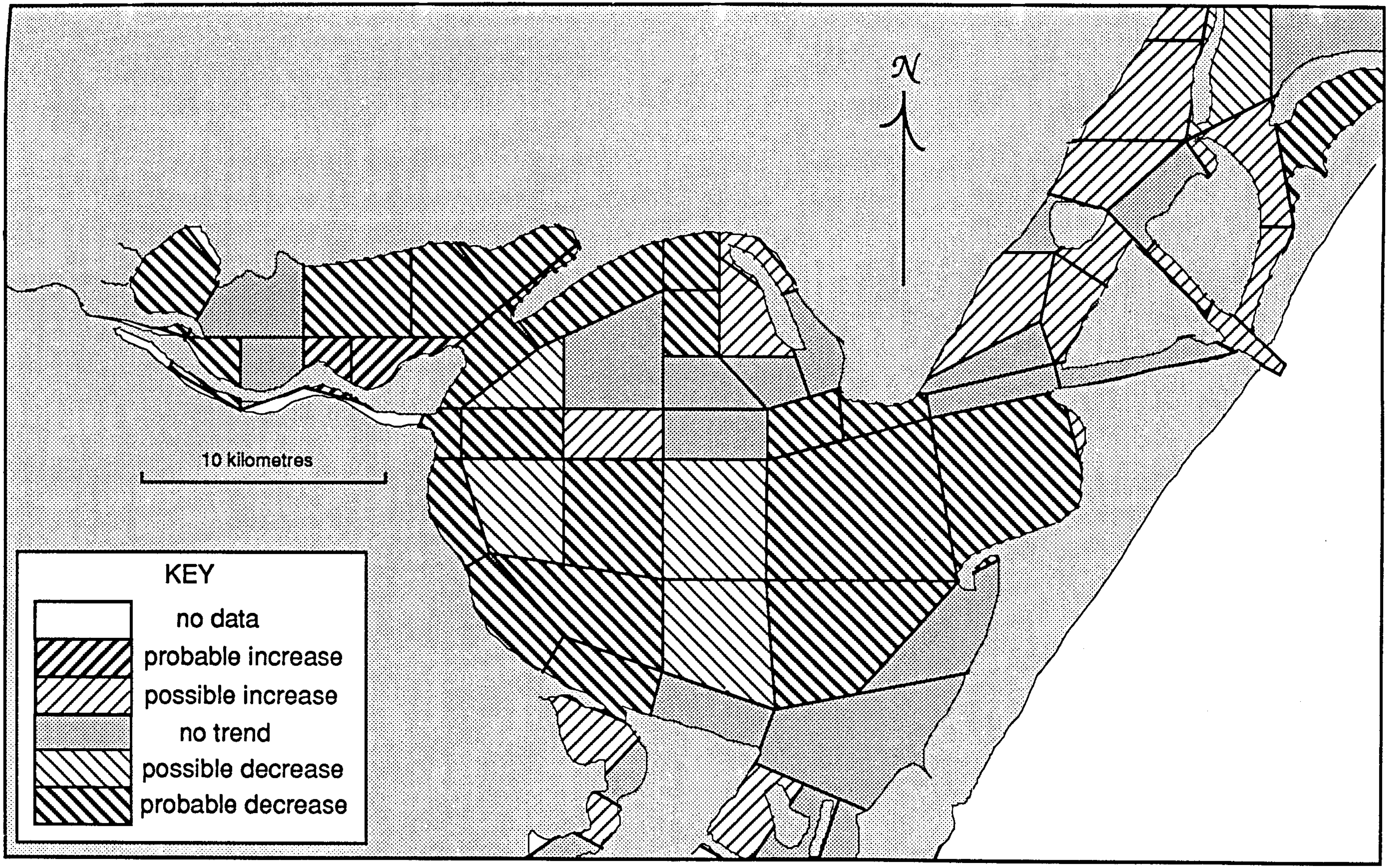

Figure 3-48. WQTEMP in upper 1 m period-of-record trends for Corpus Christi system

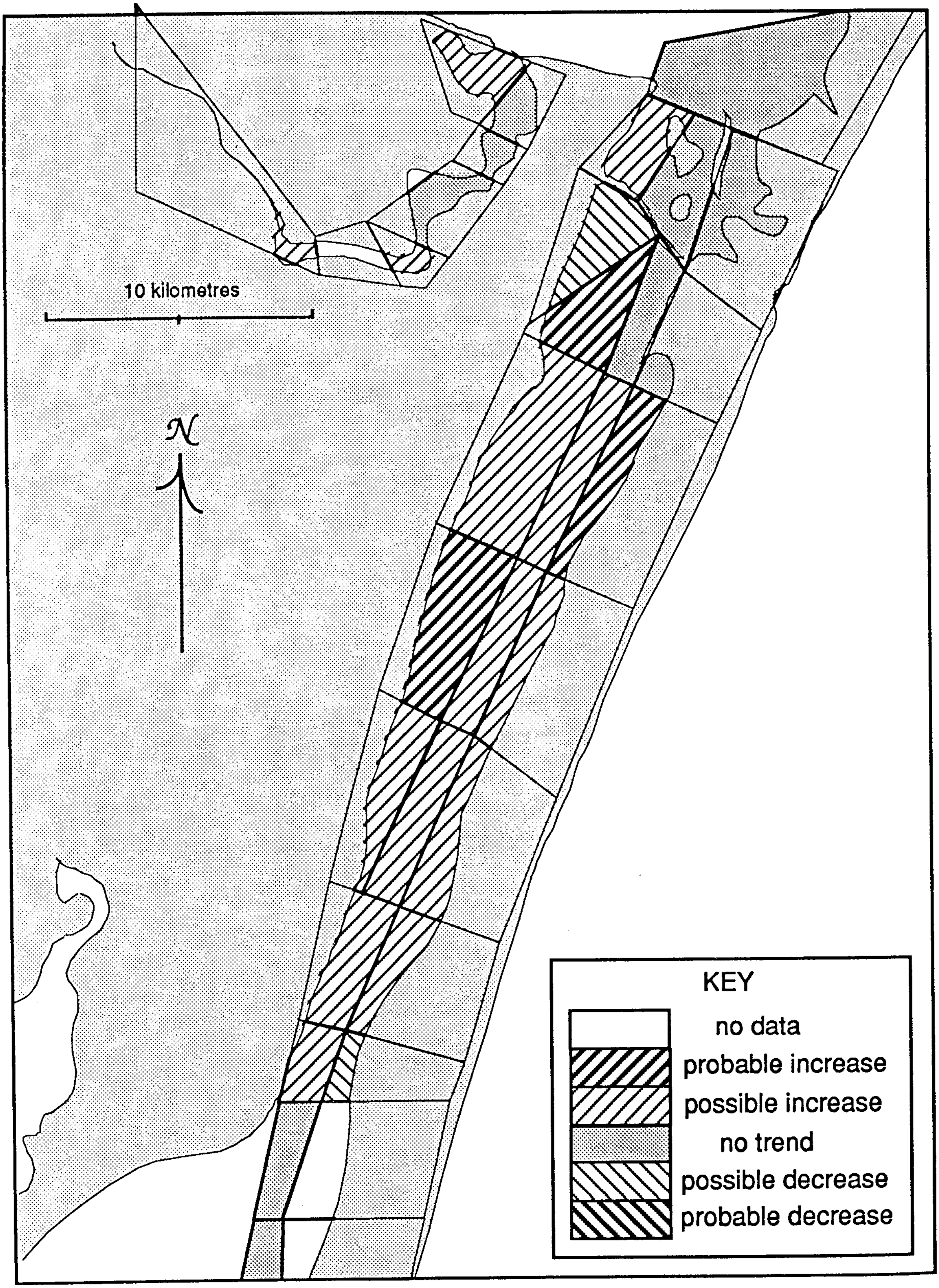

Figure 3-49. WQTEMP in upper 1 m period-of-record trends for Upper Laguna Madre

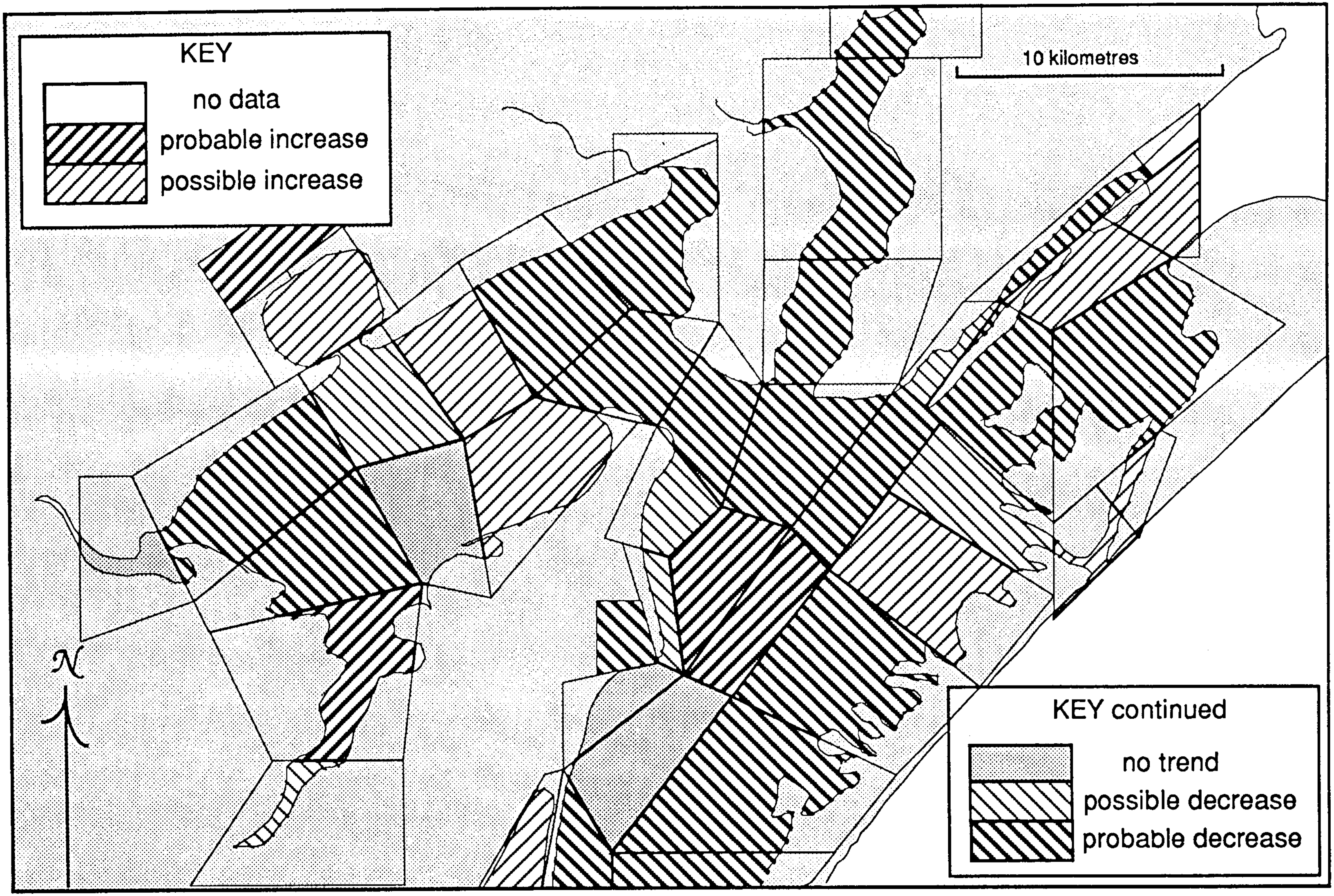

Figure 3-50. WQDODEF in upper 1 m period-of-record time trends for Aransas-Copano system

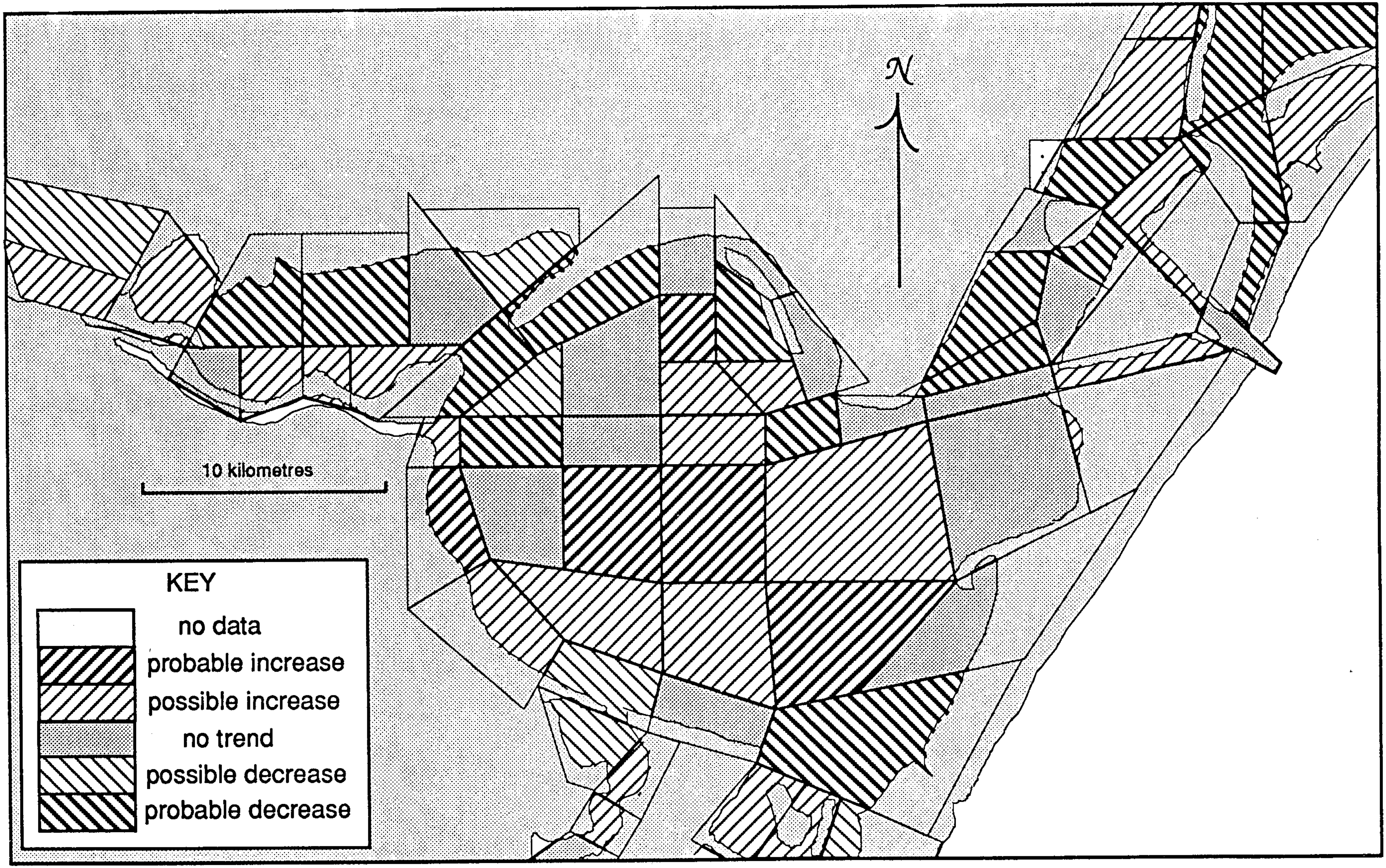

Figure 3-51. WQDODEF in upper 1 m period-of-record trends for Corpus Christi system

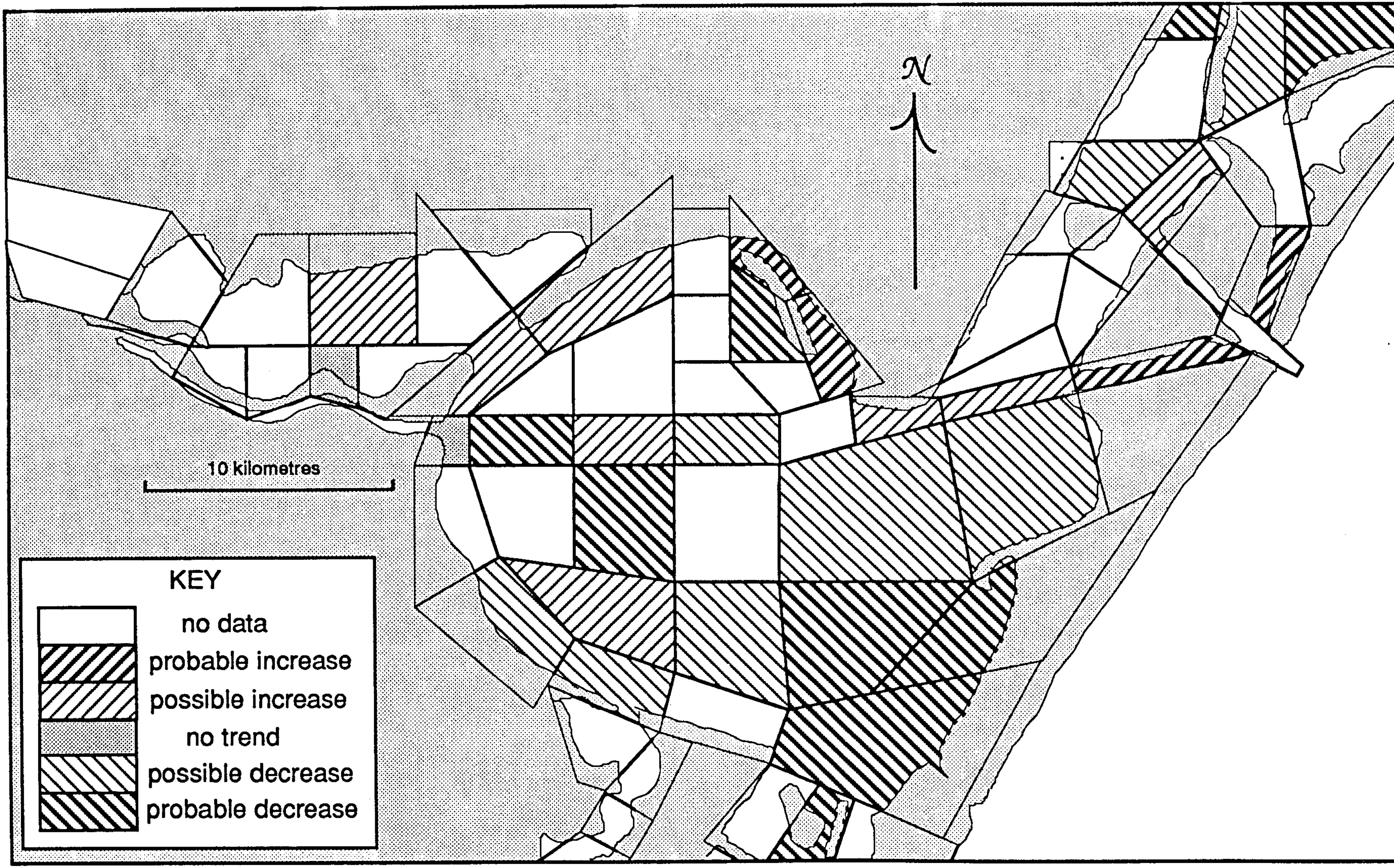

Figure 3-52. WQBOD5 period-of-record trends for Corpus Christi system

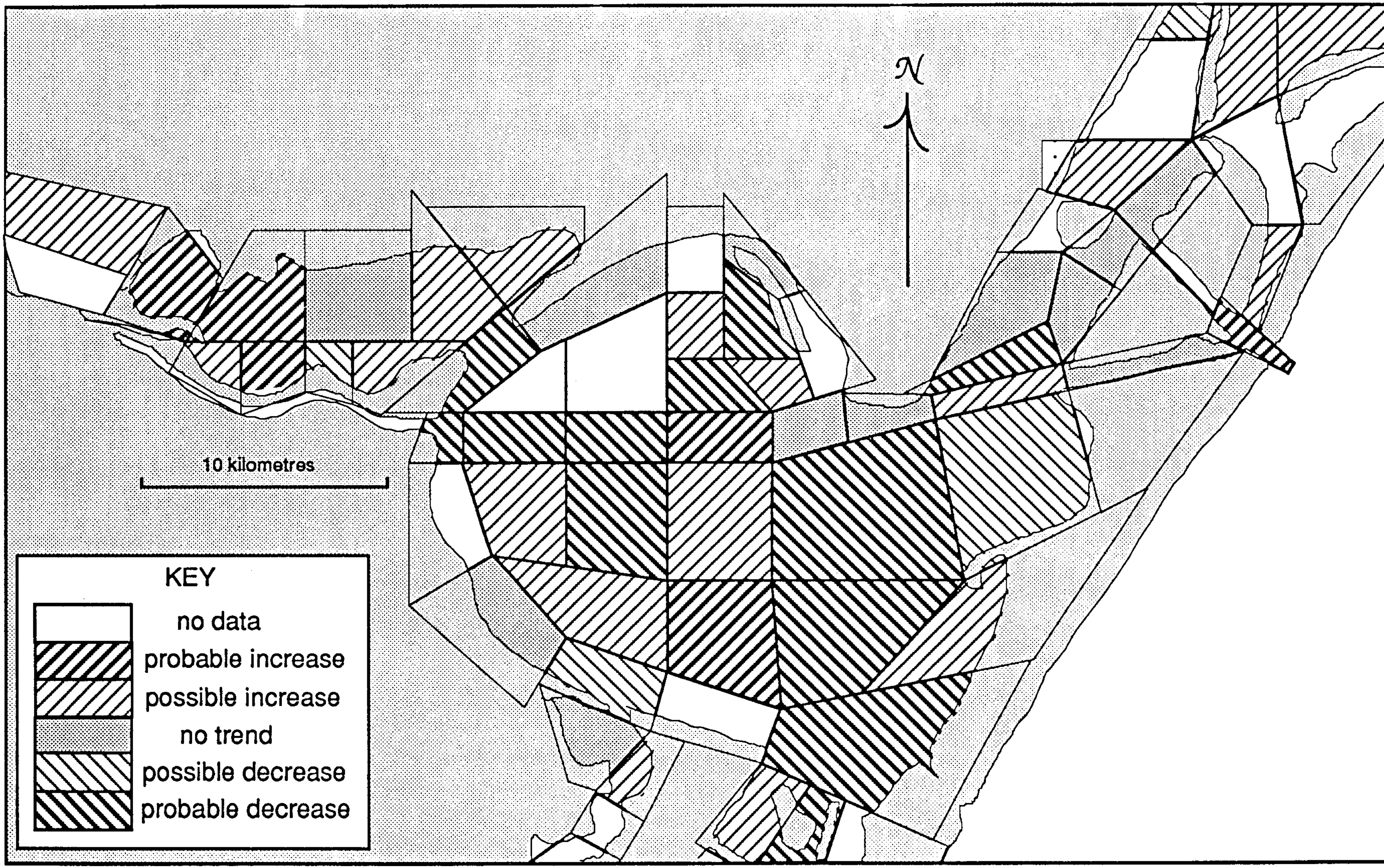

Figure 3-53. WQAMMN period-of-record trends for Corpus Christi system

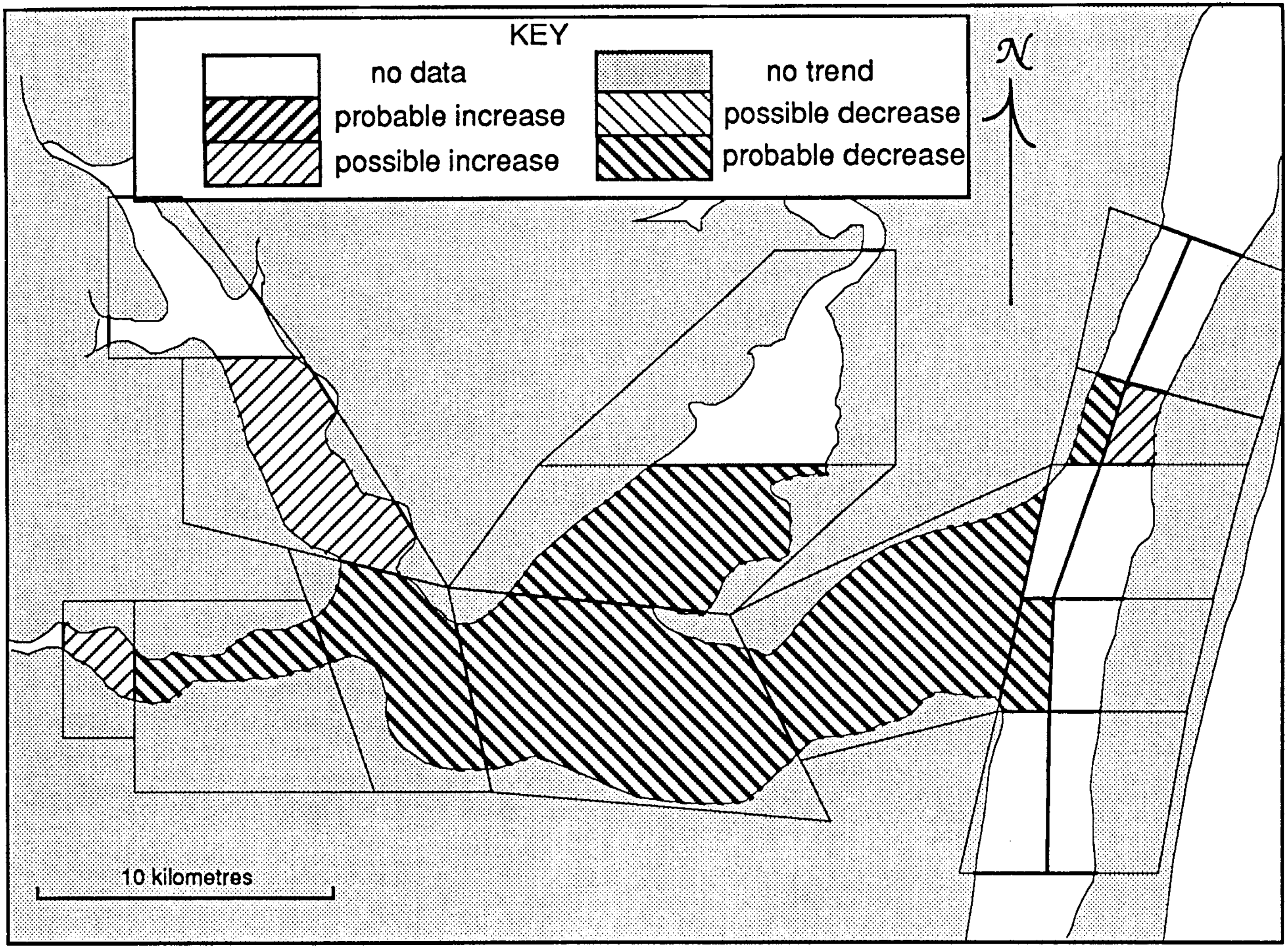

Figure 3-54. WQAMMN period-of-record time trends for Baffin Bay region

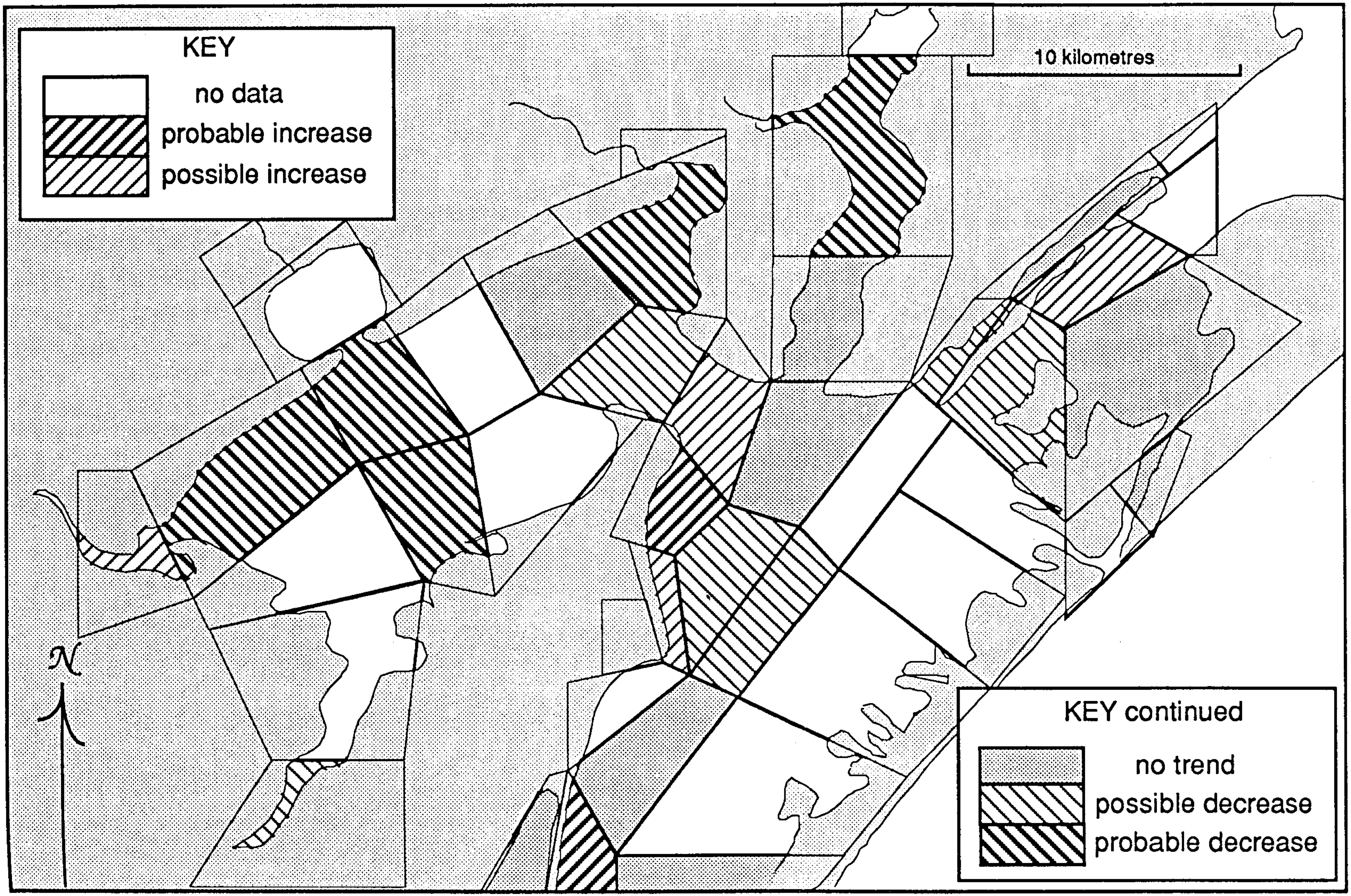

Figure 3-55. WQNO3N period-of-record time trends for Aransas-Copano system

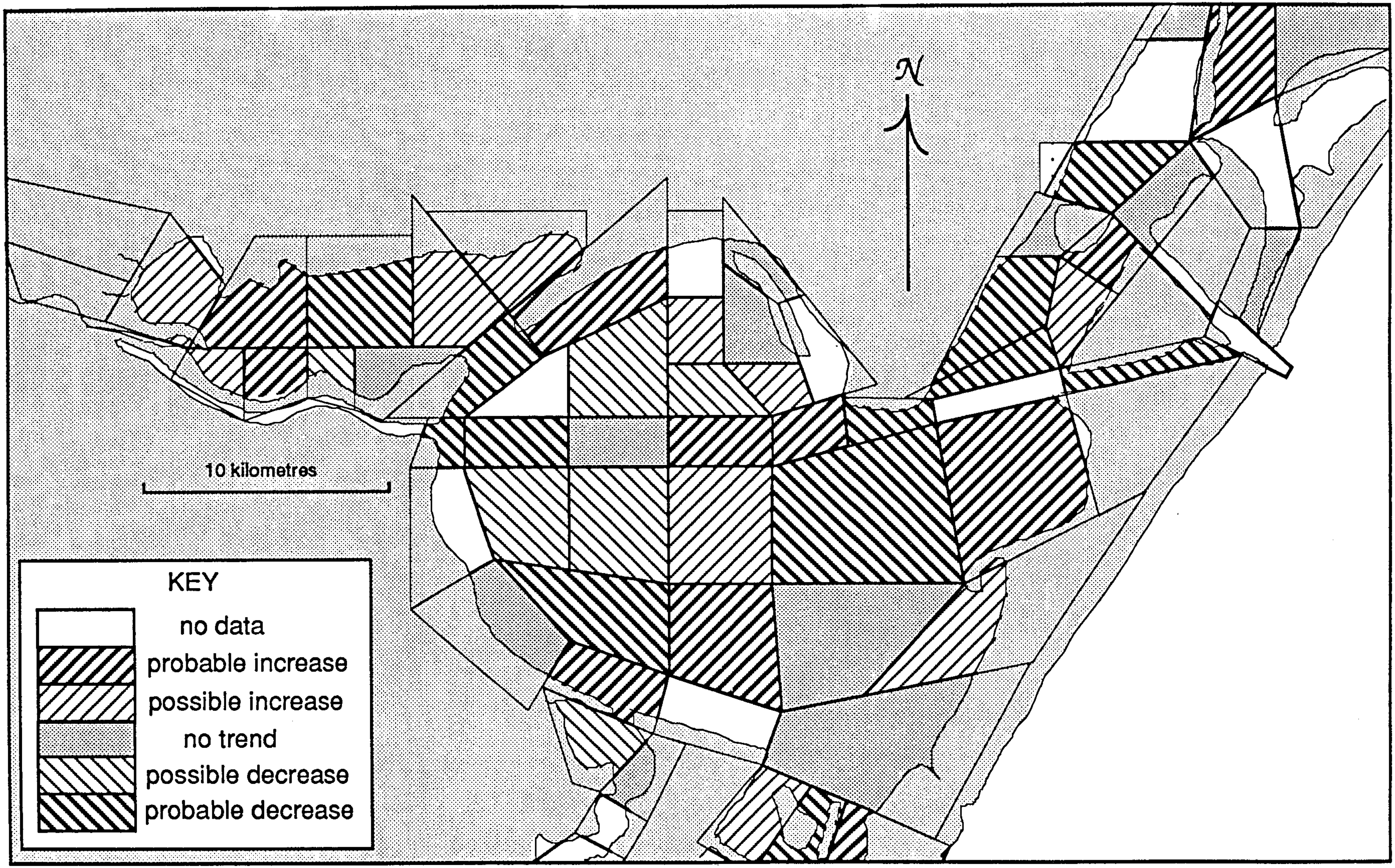

Figure 3-56. WQNO3N period-of-record trends for Corpus Christi system

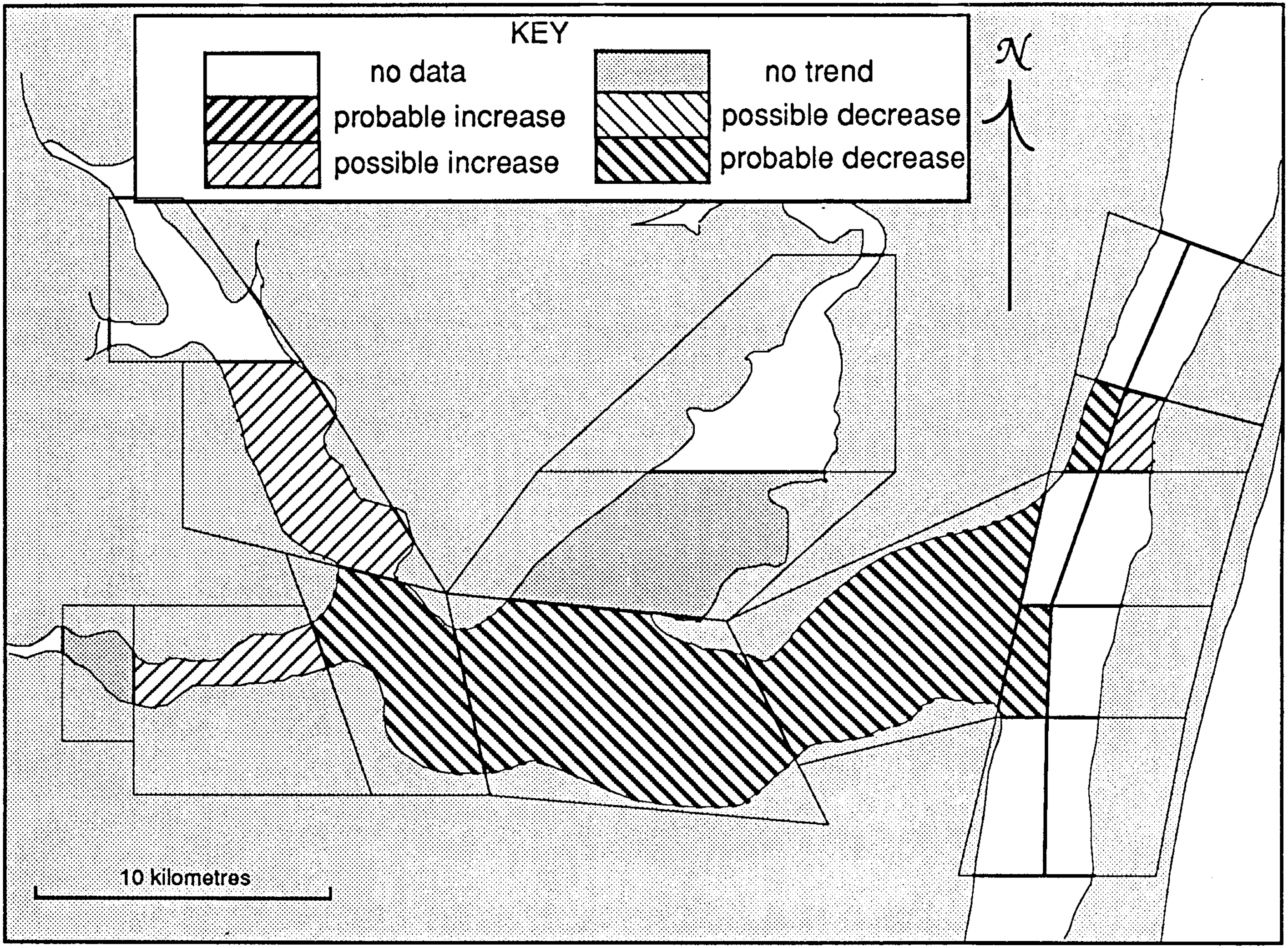

Figure 3-57. WQNO3N period-of-record time trends for Baffin Bay region

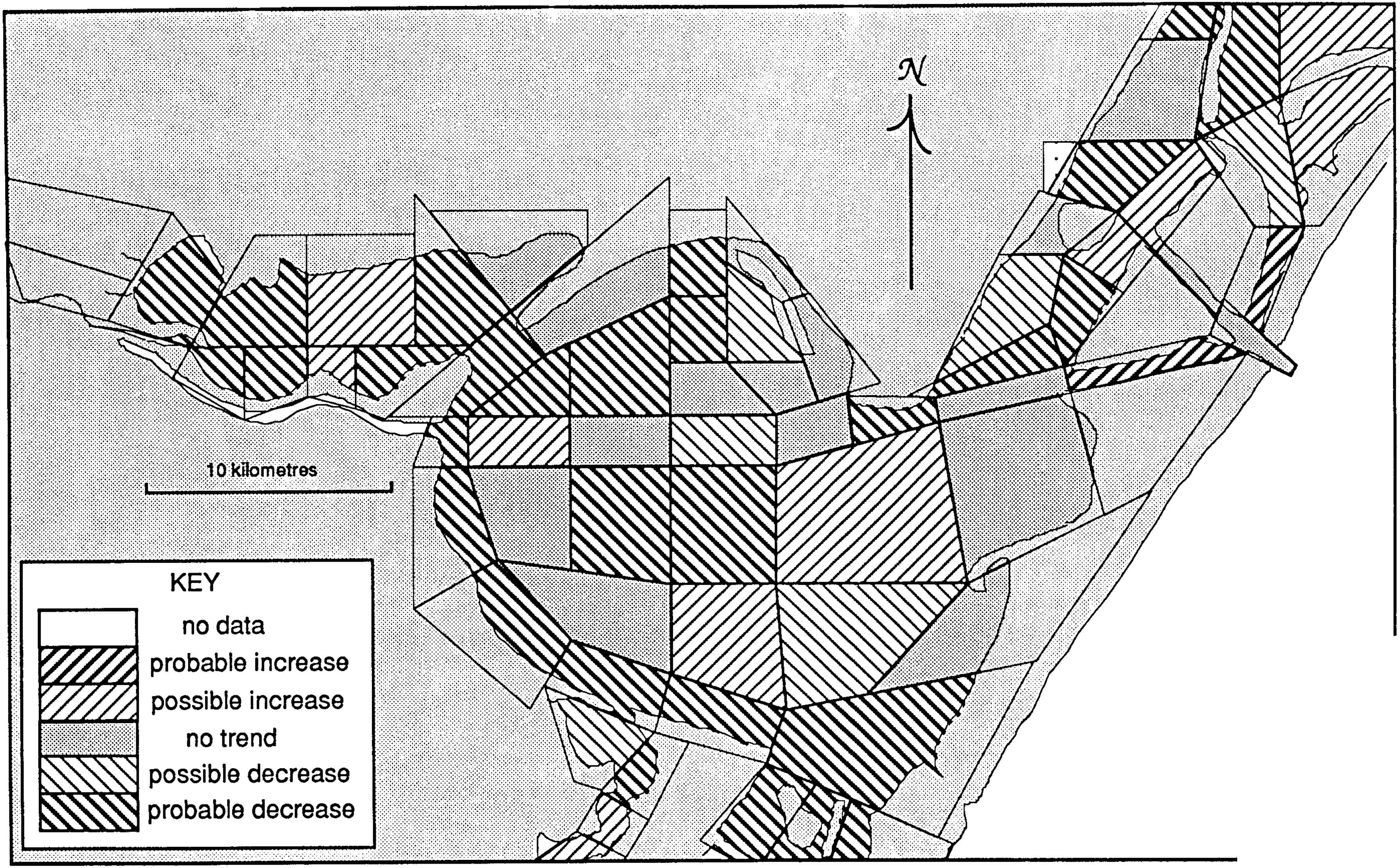

Figure 3-58. WQXTSS period-of-record trends for Corpus Christi system

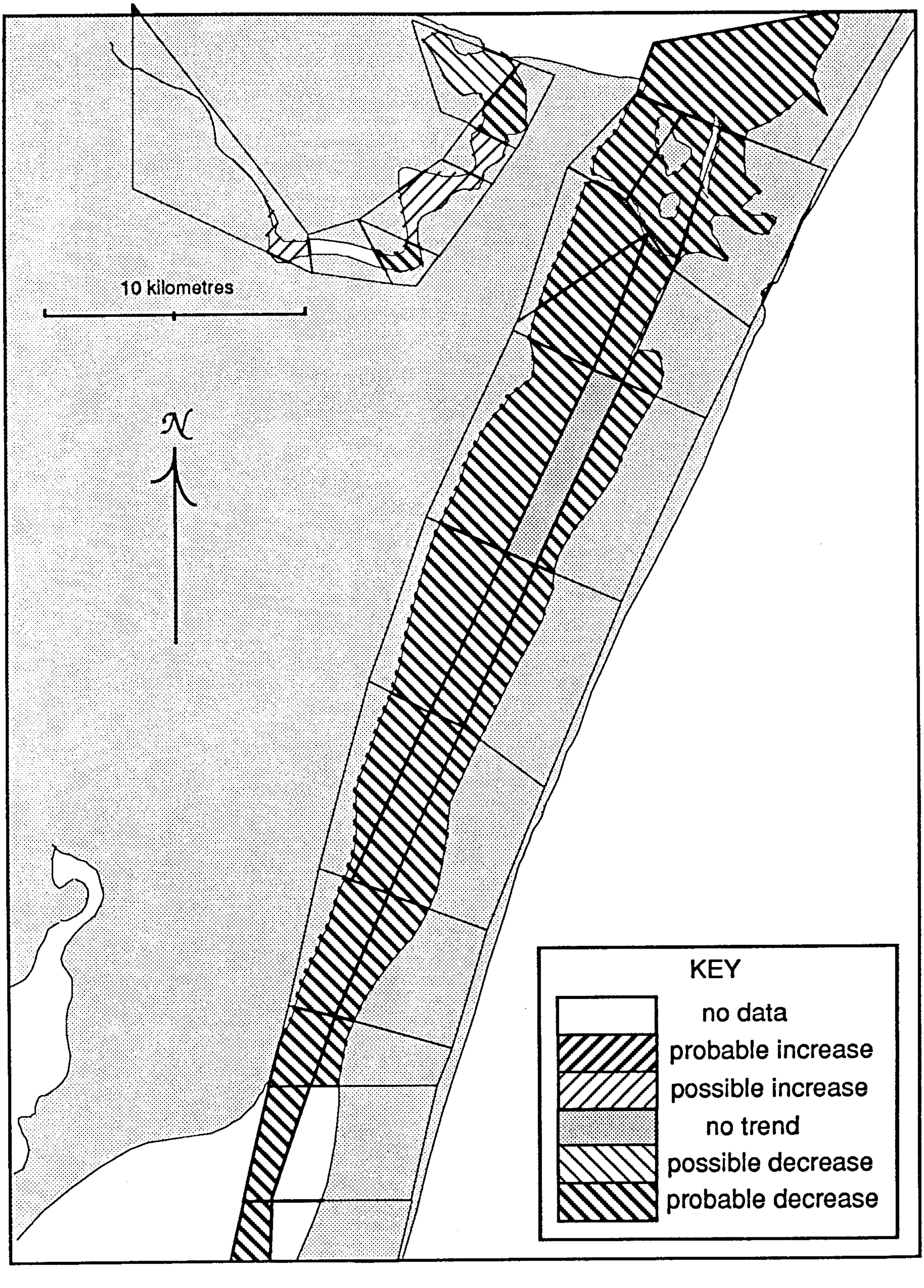

Figure 3-59. WQXTSS period-of-record trends for Upper Laguna Madre and Oso Bay

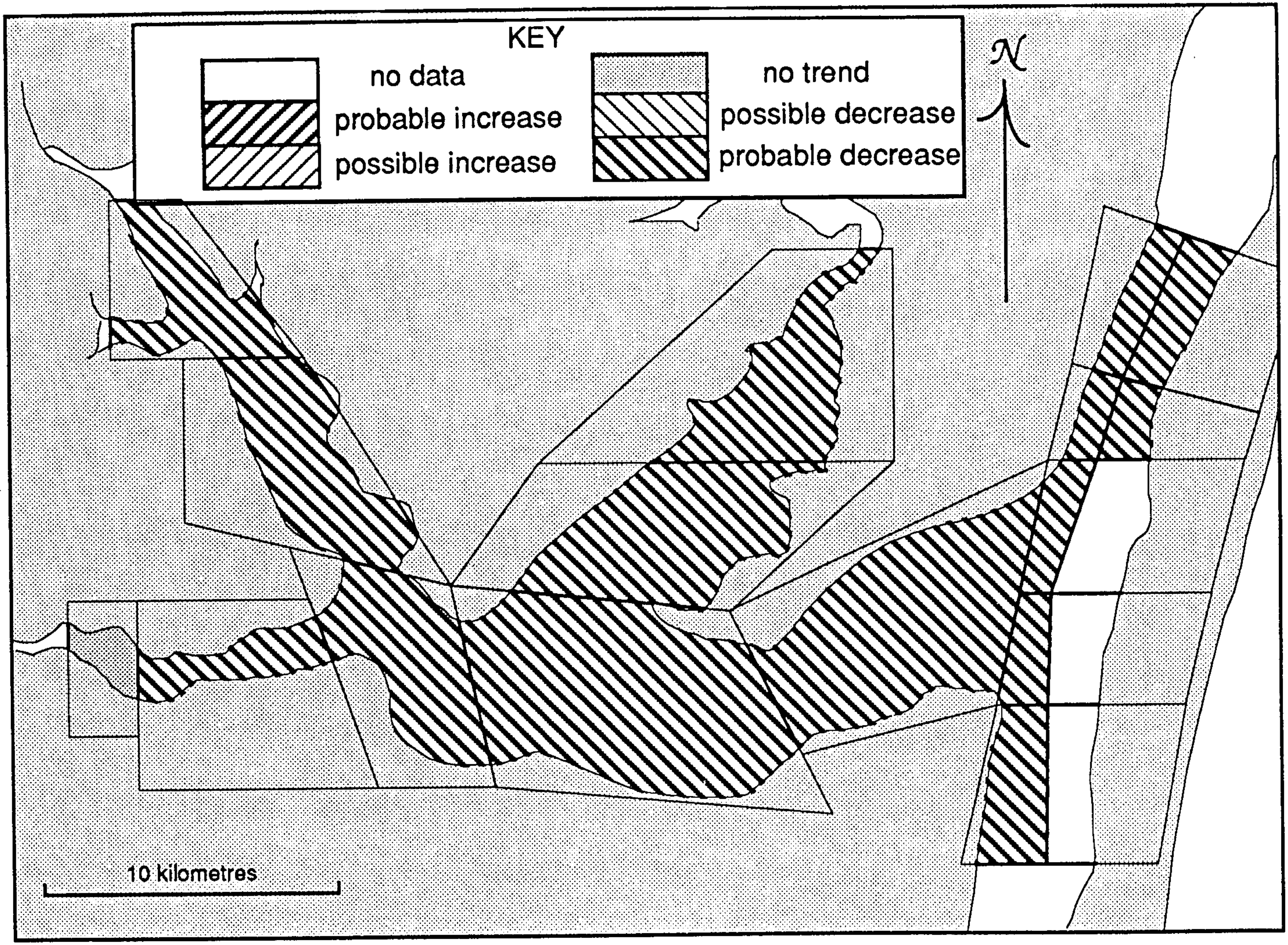

Figure 3-60. WQXTSS period-of-record time trends for Baffin Bay region

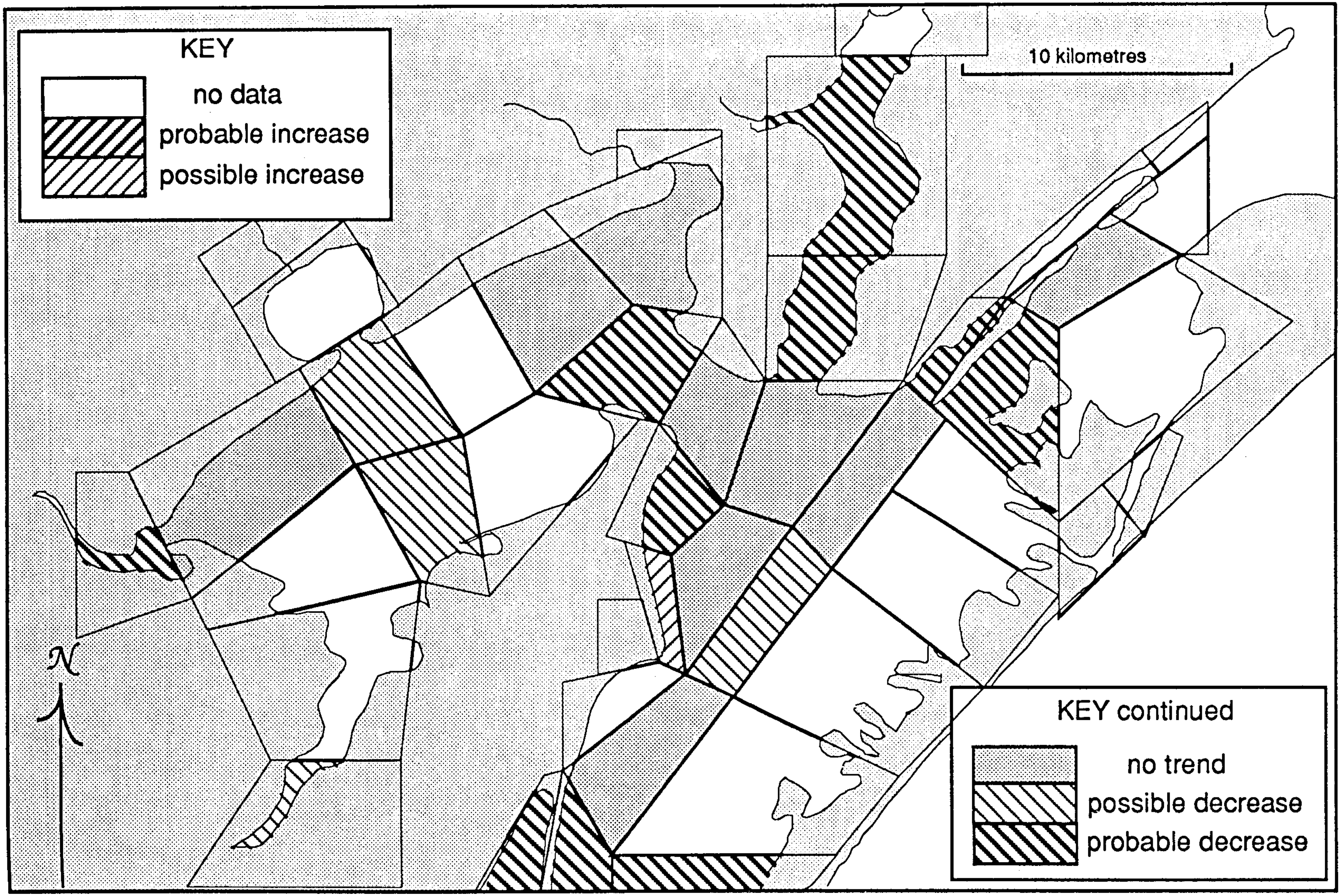

Figure 3-61. WQTOC period-of-record time trends for Aransas-Copano system

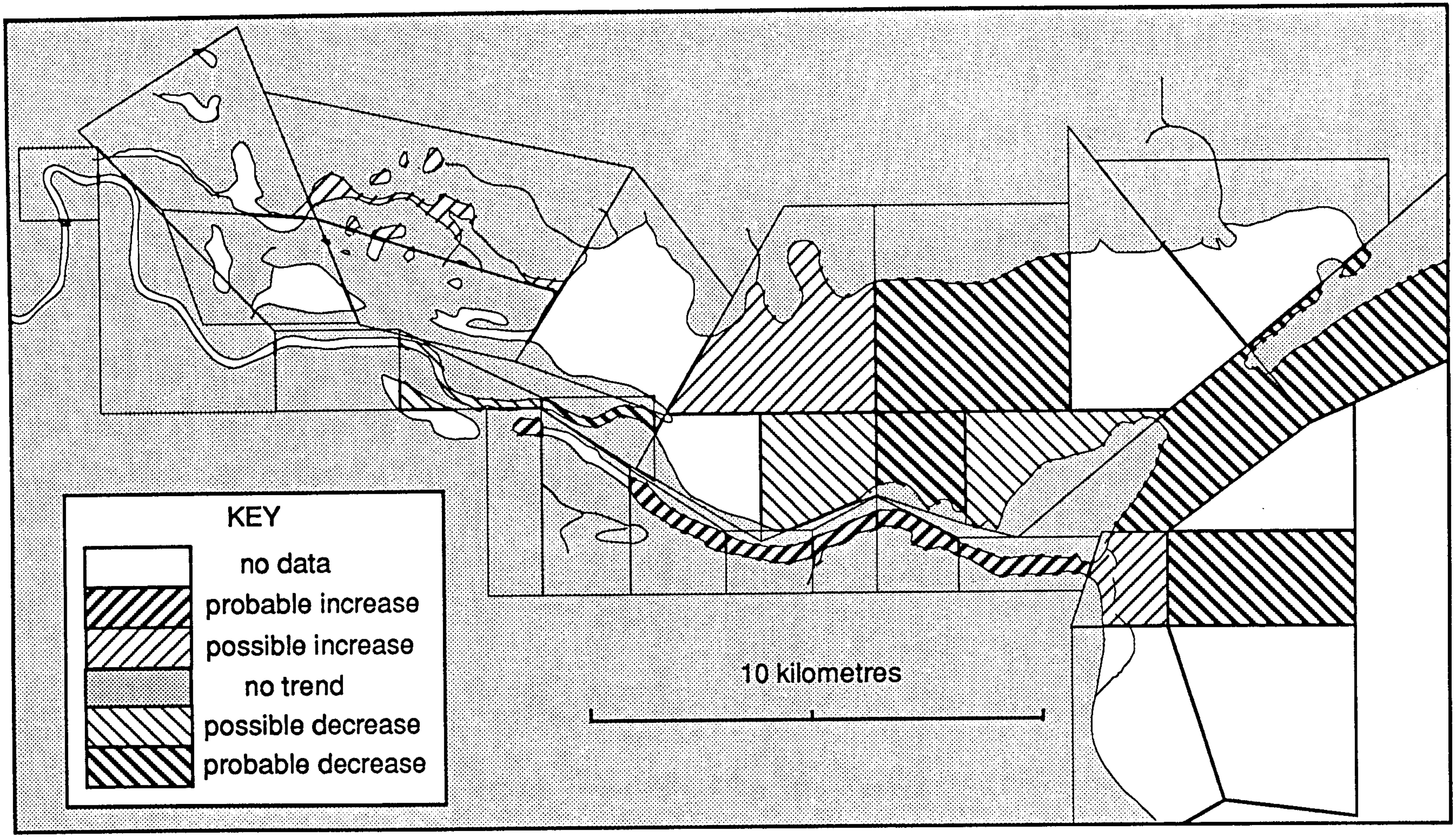

Figure 3-62. WQTOC period-of-record time trends for Nueces Bay region, including Inner Harbor

and Armstrong, 1992a), in Corpus Christi Bay there is no systematic elevation in mean salinity in association with the deepdraft ship channel. On the contrary, the mean salinities in the channel segments of Fig. 6-2 are consistent with the larger-scale gradients. Salinities in the Laguna and Baffin Bay generally exceed those of the adjacent Gulf by several ppt, and in the upper Laguna the GIWW seems to exhibit systematically lower salinities than those of the adjacent shallows. Perhaps surprisingly, there is no clear seasonal signal in salinity in the CCBNEP study-area system other than a proclivity for slightly higher salinities in the summer months, see Figs. 3-63 and 3-64. Only Nueces Bay exhibits a seasonal depression that could be characterized as an average freshet response, and this is a depression of only 7 ppt in June.

Average salinity stratification (Table 3-12) is remarkably uniform through the bay, given its noisy character, and is almost exclusively negative, as would be expected given the effect of salinity on buoyancy. In magnitude, the vertical (negative) salinity gradient is less than 0.5 /m nearly everywhere, and less than 0.3 /m throughout about half of the study area. By estuary standards, this is slight. Thus, the long-term average data support the general statement that the system is practically homogeneous in the vertical. The largest values of this (small) vertical gradient seem to occur in regions affected by inflow. There is no dependence of stratification on water depth evidenced in the long-term averages, in particular the deepdraft channel does not exhibit a rate of stratification different from the adjacent water. Reversed stratification does occur in the system (i.e., stratification in which the upper salinities exceed the lower), especially in the regions whose salinities exceed seawater. For the period of record, 10-20% of the time, stratification is positive in the upper bays. This illustrates the natural hydrographic variability of the Corpus Christi Bay environment.

Over the period of record, dating back in some segments to the early 1950’s, there emerge trends in salinity that are coherent and systematic, but with considerable regional variation in the study area. In the less saline components of the upper bay, i.e. Copano and its tributary inlets, and St. Charles Bay, Fig. 3-44, there has been general increasing trends of salinity. Averaged over those segments in Copano Bay with probable increasing trends, the rate of increase is 0.08 ppt/yr. There is no clear trend in Aransas Bay. In Corpus Christi Bay, the general trend is for increasing salinities, at a rate averaged over the open-bay segments with probable increasing trends of 0.05 ppt/yr, but there are exceptions, notably in those areas adjacent to urban development such as the shoreline of the City of Corpus Christi and the La Quinta Channel and Portland areas, where salinity is declining at about the same rate. In Nueces Bay, Fig. 3-45, where there is a trend, it is increasing, at an average rate of 0.25 ppt/yr. Adjacent to the JFK Causeway on the north, there is an increasing trend in salinity averaging 0.4 ppt/yr. In the lower bays, there is no clear systematic trend in salinity.

Water temperature is nearly uniform throughout the study area, varying generally less than 2 C over the entire system, except in winter and spring, when the range may be as large as 4 , the lower bays being of course warmer. Temperature, as expected, exhibits a prominent seasonal variation, Fig. 3-65,

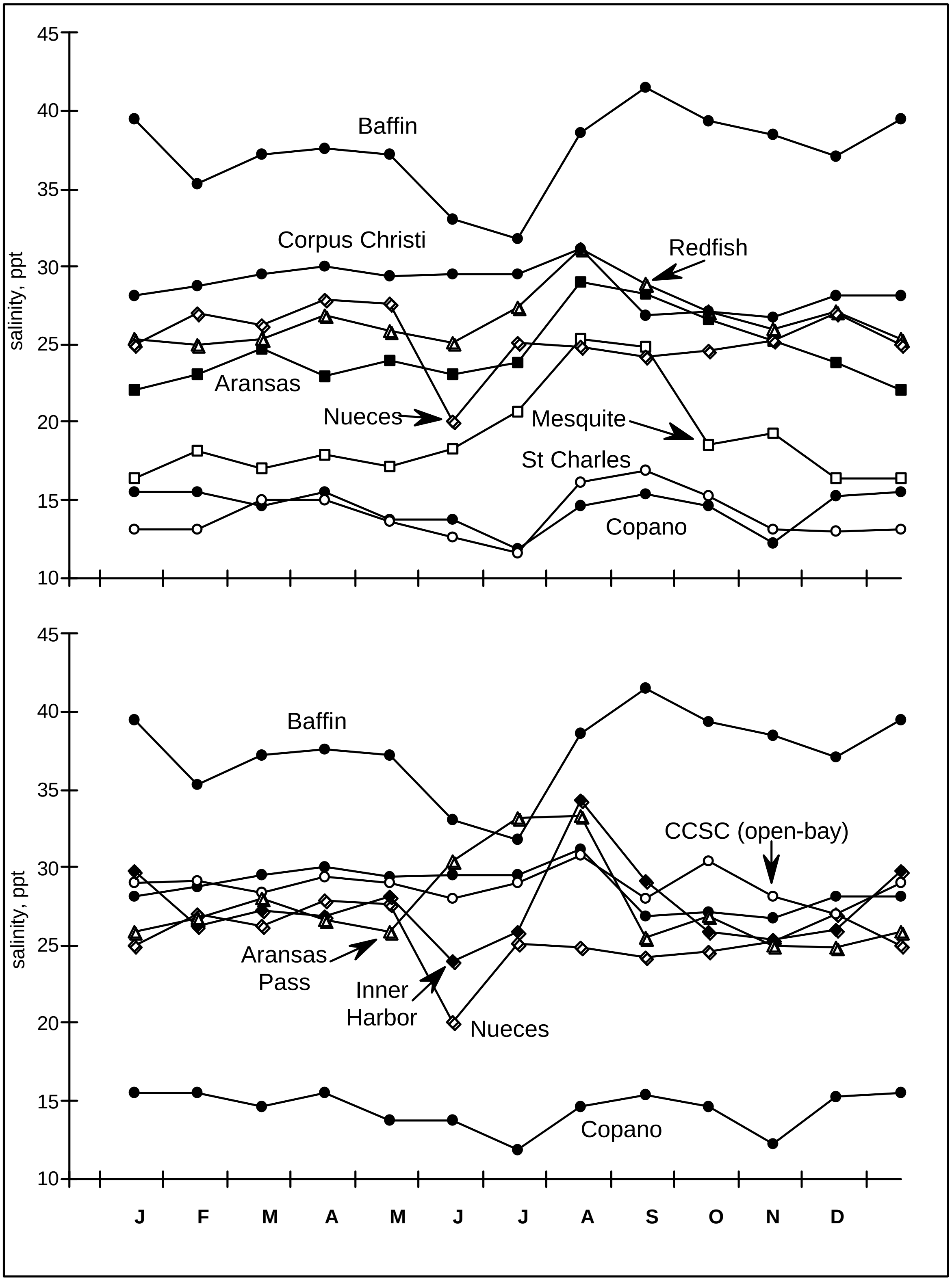

Figure 3-63. Period-of-record monthly-mean salinity (WQSAL), upper 1 m, principal bays (above) and Corpus Christi Bay region (below)

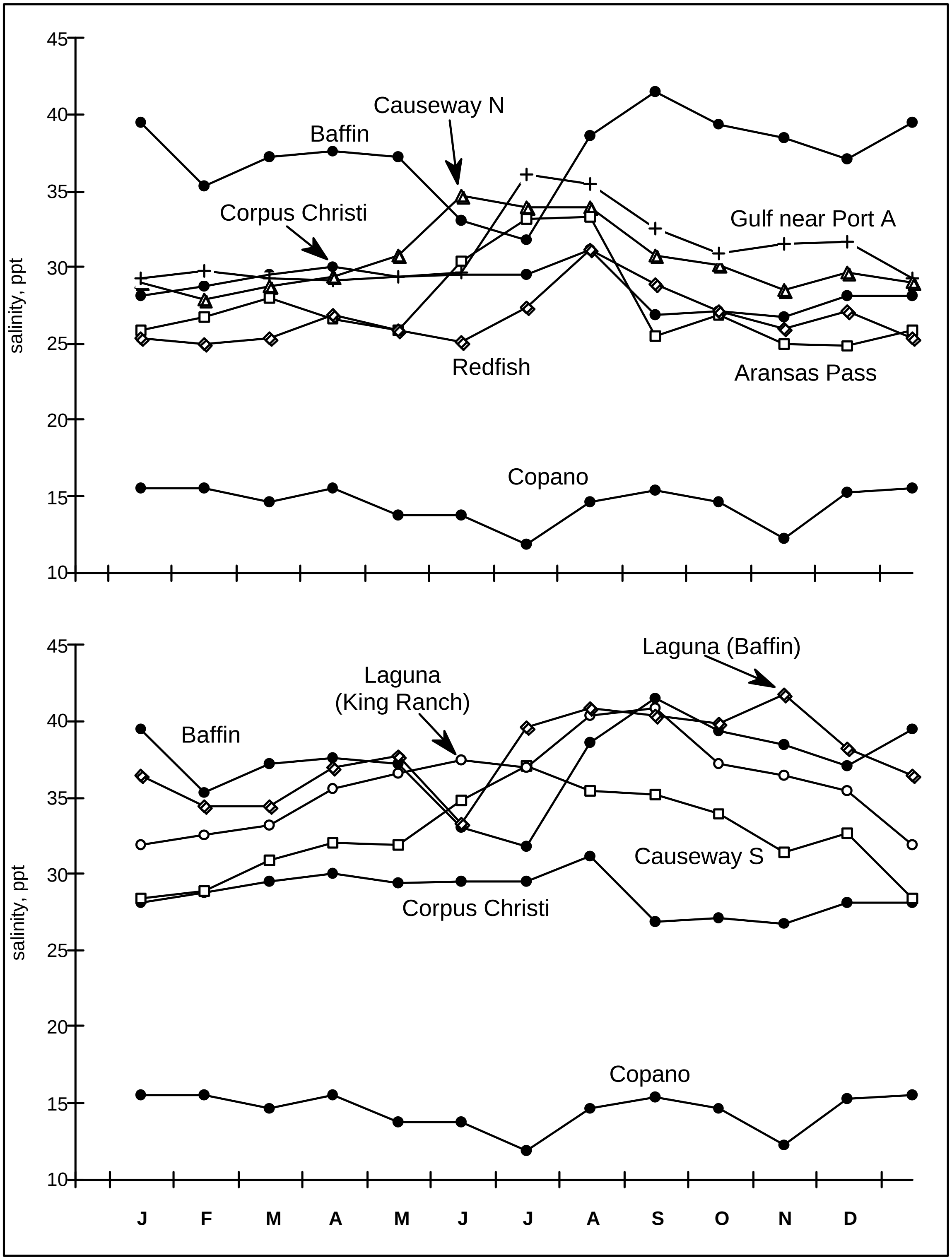

Figure 3-64. Period-of-record monthly-mean salinity (WQSAL), upper 1 m, barrier island region (above) and Upper Laguna region (below)

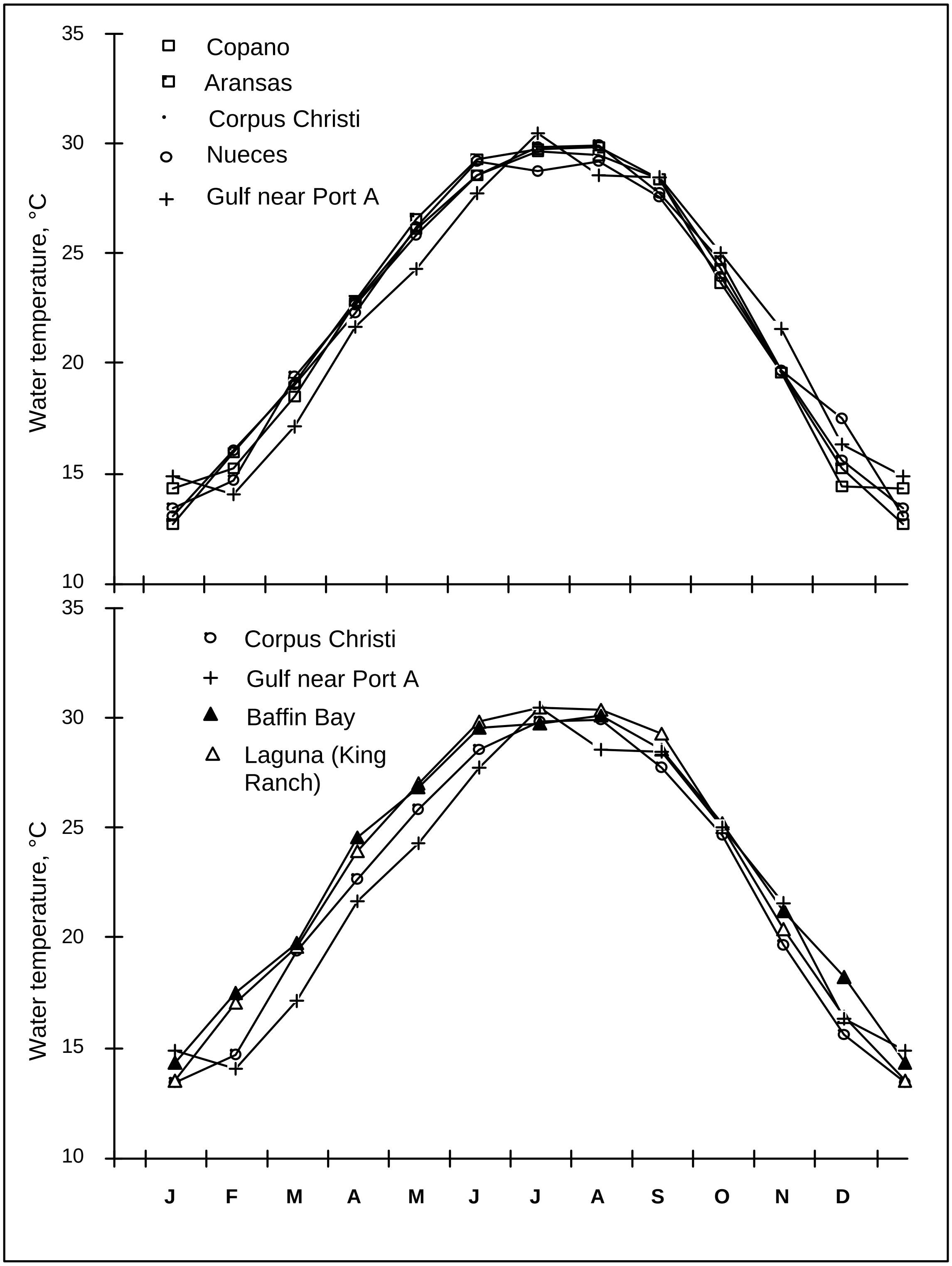

Figure 3-65. Period-of-record monthly-mean temperature (WQTEMP), upper 1 m, upper bays (above) and lower bays (below)

ranging from about 14 in winter to 30 in summer. Stratification in temperature (Table 3-13) is noisy and not well-developed, but generally negative, averaging 0.05-0.1 C/m, with most open-bay stations in Corpus Christi Bay less than 0.05 C/m. For the past two-three decades, there has been a general and substantial decline in water temperatures in the upper bays, especially in the open-bay segments, see Figs. 3-47 through 3-49. Averaged over all segments with a probable negative trend, this decline is roughly -0.1 C/yr in Corpus Christi Bay and -0.06 C/yr in Nueces Bay. There has been an increasing but less definite trend in the Upper Laguna, and no clear trends in the offshore areas, or in Baffin Bay.

As expected, there is little variation in pH in the system, from values approaching 8.5 in the open, more saline segments of the bay, to values around or slightly less than 8.0 near points of inflow (Table 3-5). There is a slight tendency toward a trend in pH in major segments of the system, declining in the open waters and increasing in the regions more affected by freshwater, on the order of 0.01 pH/yr. It is interesting to note that, though the period of record is shorter, there seems to be a decline in alkalinity in the system.

There is a pronounced annual signal in dissolved oxygen, e.g. Fig. 3-66, driven to a large extent by variation in solubility (see Section 2.1.2). We therefore focus more on the dissolved oxygen deficit to identify spatial and temporal trends. Average dissolved oxygen concentrations in the open bay are uniformly high. Near-surface values, Figs. 3-11 to 3-16, exceed saturation almost everywhere, and never are less than 1 ppm below saturation. The lowest mean DO values (highest deficit values) in the system are found primarily in the Inner Harbor, north-central sections of Corpus Christi Bay, and in the shallow waters of the Upper Laguna Madre. Stratification in DO deficit dominates DO stratification; that is, the vertical variation in salinity and temperature have an at-most secondary effect on vertical DO variation. The stratification in DO deficit is uniformly negative, Table 3-14, and on the order of 0.1 - 0.2 ppm/m. There appears to be no correlation with depth or with dredged ship channels.

For dissolved oxygen, the time trends are not clear. There is more of a tendency for increasing trends in DO than decreasing, but the statistical confidence is not particularly high, no doubt due to the high seasonal variability in DO resulting from solubility. Trends in DO deficit are somewhat better defined. In the Aransas-Copano system, deficit is declining, i.e. the DO climate is improving, Fig. 3-50, on the order of 0.03 ppm/yr. In Corpus Christi Bay overall the trends are a wash, Fig. 3-51, but there is a large area in the central region of the bay with coherent increasing values of deficit, on the order of 0.05 ppm/yr. The Inner Harbor, historically the site of greatest DO stress, does not exhibit any clear trend in DO or deficit. In the Laguna the trends are variable, while in Baffin Bay, where a trend in deficit emerges, it is declining (i.e., DO is improving).

The concentrations of total suspended solids generally increase toward points of inflow and regions of runoff through out the system, and are generally higher in the bays than in the Gulf of Mexico, Figs. 3-24 through 3-27. Stratification in TSS is pronounced, and decreases upward, Table 3-19. Though this is based upon the

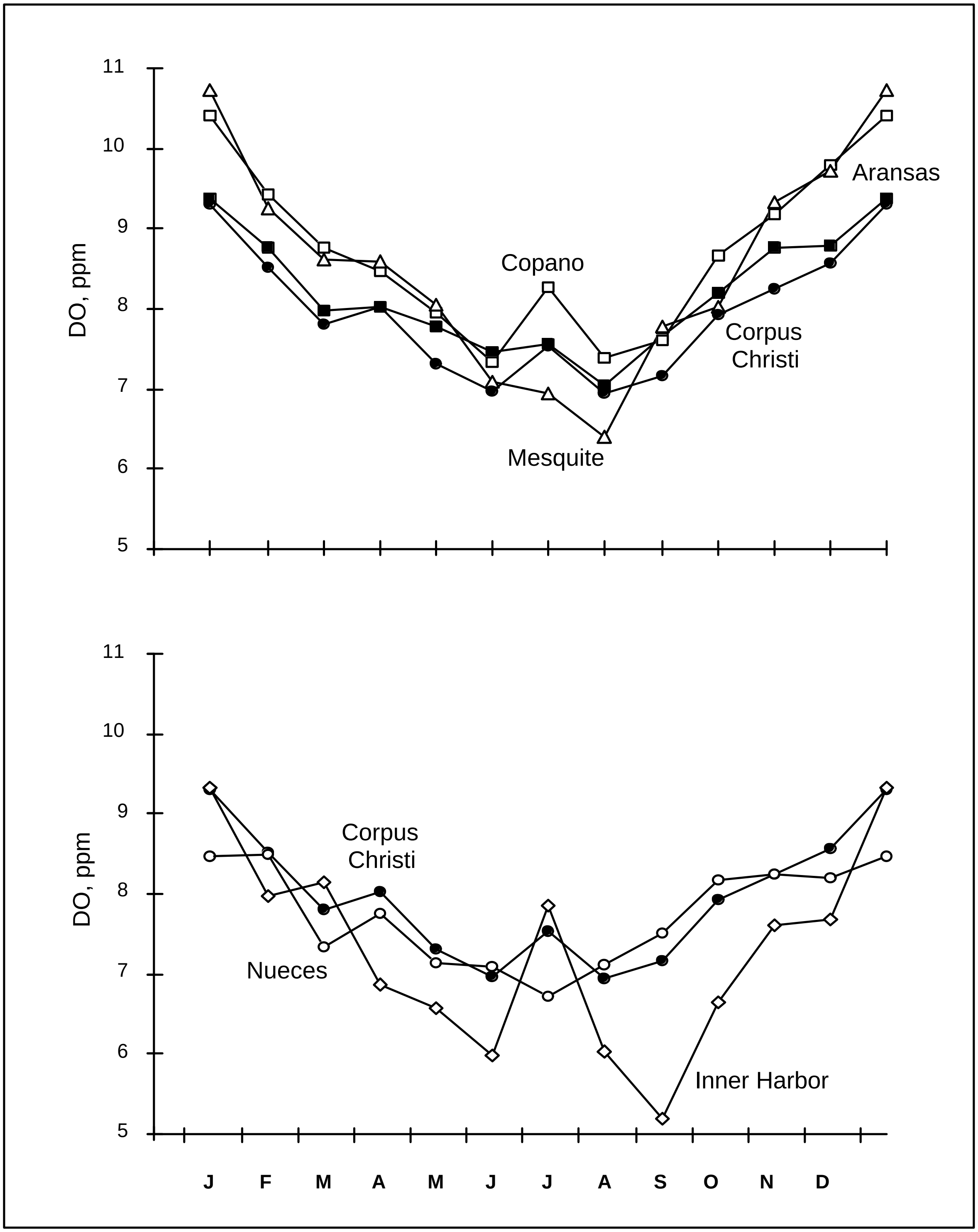

Figure 3-66. Period-of-record monthly-mean DO (WQDO) in upper 1 meter, upper bays (above), Nueces region (below)

proxy TSS data set (see Section 2.1.3), it is confirmed by the smaller data base of direct TSS measurements. The most remarkable feature of TSS in Corpus Christi Bay is the widespread declining trend throughout the study area. This declining trend increases in prominence from the upper bays to the lower. In Copano, the trends are up and down, and could be judged a wash. In Corpus almost all *probable* trends are negative, Fig. 3-58, prominently in Nueces Bay and along the south shore near the City of Corpus Christi. In the Upper Laguna and Baffin Bay (Figs. 3-59 and 3-60) probable declining trends occur *uniformly* throughout these systems. The mean rate of decline, averaged over those segments with a probable negative trend, is on the order of 0.5 ppm/yr increasing to 1 ppm/yr in the lower bays.

The spatial variation of BOD exhibits an expected pattern of uniformity in the open areas of each of the major bays of the system, and, also as expected, increases toward regions of waste discharge. What emerged from the data analysis that was unexpected is a general increase in BOD from the upper bays of Copano-Aransas, about 1.5-2.0, to the lower bays of the Laguna and Baffin, about 3-6 ppm. Unfortunately, BOD is no longer widely sampled, so it is not clear how well this pattern represents the present conditions. It is noteworthy that BOD is declining in the Aransas-Copano system, where deficit is improving. However, the reverse association occurs in Corpus Christi Bay, where BOD is declining in the open waters of the bay, Fig. 3-52, but deficit is increasing.

Fecal coliforms, Fig 3-29 and Table 3-5, are highest in the upper bays in proximity to sources of inflow and runoff, especially in urbanized areas. The highest average coliforms in the system occur in the nearshore segments from Corpus Christi Beach to Oso Bay, Fig. 3-29. Coliform data tend to be particularly "spiky," with many small values with rare, large values interspersed. The period of record average, and other statistics, therefore are especially sensitive to the intensity of sampling. It is perhaps no surprise, then, that time trends do not carry a high degree of statistical confidence. We note a predominance of increasing trends in the outer bays, *viz*. Copano and St. Charles Bay, Baffin Bay and the Upper Laguna.

The concentrations of nitrogen species are fairly uniform throughout the study area. Ammonia ranges from 0.06 - 0.08 ppm on average, see Figs. 3-17 and 3-18, and Table 3-6. Nitrate is noisier, with elevated values in regions influenced by runoff, especially Copano and Nueces Bays, Figs. 3-19 and 3-20. The highest concentrations of ammonia and nitrate occur in the Inner Harbor. Throughout the study area, ammonia tends to be slightly but systematically stratified with concentration decreasing upward in the water column, Table 3-16. The same is not true of nitrate, whose stratification is noisy and nonsystematic, Table 3-17. Where concentrations are high in ammonia and nitrates, the trends are generally declining. The prominent exception to this statement is the Inner Harbor, where ammonia is declining but nitrate does not show a clear trend. The decline in nitrogen species is particularly evident in the Baffin system, see Figs. 3-54 through 3-56.

Phosphorus is variable in concentration, and higher values occur in proximity to points of runoff, including Copano Bay, St. Charles Bay, Nueces Bay, Oso Bay, and the arms of Baffin Bay, Figs. 3-21 through 3-23, also Table 3-6. There is a widespread tendency for increasing phosphorus in the study area, but with low statistical confidence.

Generally total organic carbon values are about a factor of two higher in the upper bays than the lower, declining from 20-30 ppm in Copano to 5-15 ppm in Baffin and the Laguna, see Table 3-6, with a seasonal peak in early summer. Where concentrations are higher, the trend is declining. Therefore, declining trends are more prominent in Aransas-Copano, Nueces and the open waters of Corpus Christi Bay, but not in the lower bays, Figs. 3-61 and 3-62. The prominent exception to this is in the Inner Harbor, where average TOC is the highest in the study area, Table 3-6, and is increasing in time, Fig. 6-105. For chlorophyll-a, where data exists, the pattern seems to be one of higher concentrations in the shallower bays subject to runoff and inflow, Table 3-6. For the instances in which chlorophyll-a was sampled at two or more points in the vertical, the stratification is predominantly *negative*, i.e. decreasing in concentration up the water column, see Table 3-18. The paucity of data also obscures time trend analysis, but there is a tendency for declining chlorophyll-a concentrations in Copano Bay and some of the peripheral (nearshore) areas of the main body of Corpus Christi Bay.

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, 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 3-7, notably in Segment I12 (the same region that shows elevated water analyte values WQAMMN, see Table 3-6). For phosphorus in water, the 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, is not mimicked in the sediments. Rather, there appears to be a fair degree of homogeneity in sediment phosphorus 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 Table 3-6, the exceptions being depressed values in Nueces Bay, and much larger values (about an order of magnitude) in the Inner Harbor. For sediment TOC, however, the *lowest* values occur in the Inner Harbor, and the concentrations seem to *increase* southward across the study area, see Table 3-7 and Figs. 3-30 through 3-33. 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. Tables 3-6 and 3-7.

Whether there are time trends of nutrients in the sediments that are correlated with those in the water cannot be addressed as certainly because of the more limited data base for sediments. Recall that we require at least three points in time to report the results of a trend analysis; therefore, while the data base may support an estimate of the magnitude of sediment concentration, it may not be adequate to allow an estimate of the trend. (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 result do we feel justified in accepting its reality.) As examples, Tables 3-20 and 3-21 summarize the trend analyses for sediment phosphorus and TOC, organized by the component bay groupings of Table 3-4. Generally, only about ten percent of the hydrographic segments within these component bay groupings have the minimum data required to report a trend. These trends tend to be noisy and poorly defined. However, where probable trends can be extracted, they are declining and consistent with the water phase trends in the corresponding area.

Most hydrographic-area segments of the Corpus Christi Bay system have an inadequate data base for water-phase metals, even less data for organic compounds, and most of the data which exist are below detection limits. The component-bay averages for representative metals are given in Table 3-8. Generally, the areas sampled are those in which metals are expected to be encountered, namely the principal ship channels, the Inner Harbor and La Quinta Channel, and regions subjected to runoff from urban or industrialized areas, e.g. Fig 3-35. Elevated concentrations have indeed been detected in these regions. But we are unable to judge to what extent such concentrations might be dispersed through the system. With these limitations noted, the statistical behavior of metals can be summarized as follows:

- Elevated concentrations of arsenic (7-10 ppb) occur in Redfish Bay and adjacent Corpus Christi Ship Channel, and in Baffin Bay. The highest concentration in the system is found in Nueces Bay. There are no clear time trends in the system.

- Cadmium is generally less than 10 ppb through the system. The highest values in the study area by two orders of magnitude are in the La Quinta Channel and in Nueces Bay. There are no clear time trends in the system.

- Chromium is noisy. Occasional freak values of 50-90 ppb have been measured throughout the system, but it is difficult to ascribe any significance to these. The highest systematic values occur in the Inner Harbor, La Quinta Channel, and in Nueces Bay. The trend is probable and increasing in La Quinta Channel, and probable and declining in the Inner Harbor.

- Copper, like chromium, is spiky. Systematic elevated concentrations occur in the Inner Harbor (10-20 ppb) region, La Quinta Channel region (10-40 ppb), Baffin Bay (10-60 ppb), and Nueces Bay (20 ppb). There are no clear time trends.

Table 3-20
Summary of trend analysis for sediment phosphorus (SEDTOTP)
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr) by component bay (Table 3-4)

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 3-21
Summary of trend analysis for total organic carbon in sediment (SEDTOC)
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr) by component bay

component bay	*number segments*	*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		

- Elevated mercury concentrations (> 0.2 ppb) occur in La Quinta Channel, the Inner Harbor, Nueces Bay (again) and Baffin Bay. An extreme value of 1.7 ppb occurs in the King Ranch reach of the Upper Laguna, and an even more extreme value of 3.7 ppb at the mouth of Baffin Bay. There are no clear time trends.

- Nickel, like chromium, is spiky. The La Quinta Channel and Inner Harbor regions are systematically elevated in concentration (10-60 ppb), but the largest concentrations occurring in the system are in Redfish Bay adjacent to Harbor Island (130 ppb), the entrance of Oso Bay (200 ppb) and the Upper Laguna (100 ppb). There are no clear time trends.

- Lead is similar to mercury in its distribution, except that the highest values in the system are found in Nueces Bay and its entrance. The only probable trends in time are in the Inner Harbor, and are increasing.

- Zinc shows systematic elevated concentrations in the Inner Harbor, La Quinta Channel and Nueces Bay . High concentrations of zinc have also been observed in the Aransas River Mouth, Baffin Bay, the Laguna Madre and Oso Bay, but the data base in these areas is generally not as extensive. The only probable trends occur in the La Quinta Channel area and the Inner Harbor, the former increasing and the latter declining.

One impression that emerges from the survey of the individual metals is that, apart from the industrialized areas, there are isolated regions of the system that show unexpectedly high concentrations in most of the metals. One of these is the southeast corner of Nueces Bay (NB7 in Fig. 2-3). Unfortunately, this is the only segment in Nueces Bay that is regularly sampled for metals in water. Occasional sampling in other areas of Nueces Bay confirm a proclivity for high metals, which raises the question of whether this might be prevalent throughout the bay. Also, the mouth of the Aransas River, the mouth of Oso Bay, the Harbor Island area of Redfish Bay, and a point about midway in the King Ranch reach of the Laguna Madre show high concentrations of most of the metals. For most of these, the segments around the area are not sampled, so, as in Nueces Bay, it is not clear whether the elevated metals are isolated or representative of this entire region of the system. In the last case, however, the segment is I12 (Fig. 2-4) in and around the GIWW in the Upper Laguna. The segments both north and south of this region have also been sampled for metals, but do not exhibit the systematically high concentrations of I12.

In many respects, the distribution of metals in the sediments provide a better index to metal contamination than those in the water phase, because sediments are “carriers” of metals, sediments are less mobile than water so exhibit a more integrated response to metal loads, and concentrations are higher in sediments and therefore more reliably measured. For sediment metals, Table 3-9 and Figs. 3-36 through 3-43, the general statement can be made that the highest values, often by an order of magnitude, are found in the Inner Harbor sediments. 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

3-8. 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 3-8 (except for lead, whose concentrations in Copano are low). For specific metals, there are other regions of high concentration in sediments. Chromium is high in Corpus Christi Bay, copper in the offshore Gulf of Mexico, mercury in Mesquite Bay, and 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, in the latter 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 3-9 (and 3-8) 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 entire system, apart from the Inner Harbor.

For sediment metals, the data base allowing trend determinations is somewhat better than that for conventional parameters. Tables 3-22 and 3-23 are example trends summaries for copper and zinc. In the component bays (Table 3-4) of the system, where a trend can be reliably established in a sediment metal it is usually declining. For the Inner Harbor in particular, which was found to be the site of greatest metals concentrations, a probable declining trend is consistently indicated. There are important exceptions to this general statement, however. 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. Sediment zinc, whose concentrations are elevated in many areas, exhibits widespread *possible* increasing trends in large areas of the open waters of Corpus Christi Bay and Baffin Bay. The widespread coherence in this pattern over many segments argues for attaching more importance to it than would normally be ascribed to a single segment.

As noted earlier, the tissue data base proves to be too sparse for practical analysis. The three best data bases are represented in Table 3-11. 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 exhibits systematically elevated metals, with the highest mean tissue concentrations in the system for cadmium, copper, lead and zinc. (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. These distributions generally agree with the relative concentrations in the sediments, cf. Table 3-9, 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.

Table 3-22
Summary of trend analysis for copper in sediment (SEDMETCU)
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr) by component bay

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 3-23
Summary of trend analysis for zinc in sediment (SEDMETZN)
Fraction (percent) of segments with data, exhibiting indicated trend for BDL>0
and average of probable trends (ppm/yr) by component bay

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	

Blue crab data 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, and there are elevated arsenic concentrations in the Upper Laguna and Baffin Bay. 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.

From a statistical point-of-view, very little can be said about water-phase organics in the study area. The best-monitored pesticide is DDT, and the greatest data base is that assembled by proxying the principal isomer. Even at this, most areas of the bay do not have data, and those segments which do are most often below detection limits. 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, that in Nueces Bay. The situation is similar for the other organics, with only one or a few non-zero average values, and inadequate data to determine any trends or spatial variation.

The sediment phase of trace-organic analyses offers the same advantages over the water phase as is the case for metals. Even at this, the data base for complex organics in sediments is 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 3-10 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. Only one pesticide trend is evident, declining SED-XDDT in Copano Bay. PCB's follow a very different distribution in the system, with very high concentrations (as expected) in the Inner Harbor, and with (unexpectedly) high concentrations in Redfish Bay. No time trends are apparent. For PAH's, the Inner Harbor dominates the concentrations of most of the PAH's, but there are also consistent elevated concentrations of some of the PAH compounds in Nueces Bay, Copano Bay, and Mesquite Bay. One example is sediment napthalene in Fig. 3-43. 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.

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