IXTOC OIL SPILL ASSESSMENT
FINAL REPORT
APPENDICES (SECTION NINE)

Prepared for:

Bureau of Land Management
Contract No. AA851-CTO-71

Submitted by:

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March 19, 1982

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TABLE 9-1

GROUP I[a] AROMATICS IN SEDIMENTS

(Concentration: $ng \cdot g^{-1}$)

SAMPLE STATION	DATE	N	2-C_1N	1-C_1N	C_2N	C_3N	C_4N	BP	ACEN	F	C_1F	C_2F	C_3F	P	C_1P	C_2P	C_3P	C_4P	DBT	C_1DBT	C_2DBT	C_3DBT
S52	DEC. 1979	0.2	0.4	0.2	1.6	1.0	0.2	0.1	ND	0.2	ND	ND	ND	1.0	1.6	1.0	0.8	0.4	0.3	0.2	0.4	1.1
N39	DEC. 1979	ND	0.4	ND	2.7	2.7	0.1	0.1	ND	0.2	0.1	0.1	0.2	2.5	4.5	2.6	2.0	1.1	ND	0.2	0.3	0.1
M35	DEC. 1979	ND	ND	ND	ND	ND	0.5	ND	ND	ND	ND	ND	ND	8.3	2.9	ND	ND	ND	ND	ND	ND	ND
N38	DEC. 1979	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.4	ND	ND	ND	ND	ND	ND	ND	ND
S51	DEC. 1979	0.3	1.6	0.7	4.6	3.4	0.6	0.3	ND	0.8	0.5	ND	ND	5.1	ND	ND	ND	ND	ND	ND	ND	3.2
M37	DEC. 1979	0.3	1.6	1.0	5.2	6.1	1.5	0.2	0.2	0.6	0.4	ND	ND	4.4	ND	1.0	0.3	ND	0.5	0.1	ND	1.5
N38	DEC. 1980	0.9	1.5	ND	ND	ND	ND	0.3	ND	0.3	ND	ND	ND	2.5	2.4	1.6	0.7	ND	ND	ND	ND	ND
S51	DEC. 1980	3.4	-	-	1.6	ND	ND	0.3	1.2	0.7	0.4	ND	ND	6.6	7.5	5.8	7.9	2.4	ND	0.6	1.0	ND
S54	DEC. 1979	0.1	0.5	0.2	1.6	0.9	ND	0.1	ND	0.1	0.1	ND	ND	0.7	ND	0.5	0.1	ND	ND	ND	ND	ND
N19	DEC. 1980	0.1	0.1	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND	0.3	0.2	0.1	ND	ND	ND	ND	ND	ND
S31	DEC. 1979	0.1	0.1	0.1	0.2	0.1	ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	0.3
G05	DEC. 1980	7.7	1.5	1.6	7.5	1.8	2.6	0.9	ND	0.6	0.8	ND	9.3	8.0	16	25	23	5.1	2.1	1.6	4.0	2.4
M05	DEC. 1979	0.3	0.5	ND	ND	ND	ND	ND	ND	0.3	0.3	ND	ND	5.7	13	1.3	0.4	ND	1.1	ND	ND	ND
S53	DEC. 1980	0.5	0.9	0.2	1.4	0.6	ND	0.2	0.1	0.6	ND	ND	ND	3.8	2.8	2.3	1.4	0.5	0.5	0.4	0.5	ND
PA2	DEC. 1979	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.4	0.2	2.2	0.9	5.2	5.9	0.9	ND	0.6	9.8	8.2
M21	DEC. 1979	0.1	0.4	0.2	1.3	1.0	ND	0.1	ND	0.1	ND	ND	ND	0.7	ND	0.5	ND	ND	ND	0.1	0.2	0.5
N37	DEC. 1980	0.1	0.1	ND	0.1	0.1	ND	ND	ND	0.1	ND	ND	ND	0.3	0.3	0.3	0.2	0.1	ND	ND	ND	ND
S50	DEC. 1979	0.1	0.1	0.1	0.3	ND	ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND
M04	DEC. 1979	0.1	0.9	0.3	0.8	0.4	ND	ND	ND	ND	ND	ND	ND	2.3	1.0	0.8	ND	ND	0.5	ND	ND	ND
N40	DEC. 1980	0.4	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.7	2.1	0.9	0.9	ND	ND	0.1	0.2	ND
S49	DEC. 1980	4.9	16	1.5	11	6.3	1.9	1.1	3.2	3.2	0.8	1.0	ND	25	26	22	12	1.6	ND	1.3	2.7	ND
S04	DEC. 1980	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	5.2	3.3	ND	ND	ND	ND	ND	ND
S04	DEC. 1980	1.1	0.4	0.1	ND	ND	ND	0.3	ND	0.1	ND	ND	ND	3.0	6.3	5.8	3.4	ND	ND	ND	ND	ND
S06	DEC. 1979	ND	6.0	2.5	21	14	1.5	0.7	0.7	1.8	1.3	ND	ND	8.3	13	7.5	2.8	ND	ND	0.6	ND	ND
N03	DEC. 1980	9.6	3.8	3.1	15	13	5.7	1.0	0.2	1.6	1.7	ND	ND	22	39	30	20	9.2	3.6	2.5	5.3	8.1
N04	DEC. 1980	ND	4.2	2.0	14	13	4.1	0.9	0.3	2.0	1.8	ND	ND	24	63	23	11	ND	ND	2.1	2.7	1.9
G02	DEC. 1980	5.9	2.9	2.1	16	18	1	1.1	0.2	1.6	3.2	6.6	14	13	31	45	42	18	3.1	4.0	12	13
S52	DEC. 1980	0.2	0.2	0.1	0.4	0.2	0.1	0.1	ND	0.1	0.1	0.1	0.2	1.1	0.9	1.3	0.2	0.1	0.1	ND	0.1	0.1
S54	DEC. 1980	1.1	4.3	0.7	5.0	1.2	ND	0.3	0.8	0.8	ND	ND	ND	7.8	8.5	5.3	1.4	ND	ND	ND	ND	ND
S05	DEC. 1980	3.5	6.2	0.7	6.6	ND	ND	0.5	1.2	1.5	ND	ND	ND	21	24	14	ND	ND	ND	ND	ND	ND
G04	DEC. 1980	3.5	1.2	0.6	6.1	6.0	2.2	ND	ND	1.0	0.6	1.9	9.3	6.6	17	19	25	10	2.6	2.0	5.6	4.4
ANC	AUG. 1979	1.5	1.0	ND	3.2	4.4	2.8	0.2	ND	0.3	0.3	2.4	2.2	3.9	11	8.6	7.6	5.9	0.5	0.6	1.3	1.8
M14	DEC. 1979	ND	ND	ND	ND	2.1	ND	ND	0.4	ND	ND	ND	ND	4.1	ND	4.2	ND	ND	ND	0.9	ND	ND
N39	DEC. 1980	ND	ND	ND	ND	2.1	ND	ND	ND	ND	ND	2.5	8.1	3.3	6.3	5.2	2.5	2.1	1.5	ND	1.0	1.8
S31	DEC. 1980	5.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16	ND	ND	ND	17	15	ND	1.6	7.8	55
S33	DEC. 1980	ND	ND	ND	ND	0.2	ND	ND	ND	ND	ND	ND	ND	0.4	ND	0.5	ND	ND	ND	ND	ND	3.1
M35	DEC. 1980	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	ND	ND	8.3	ND	ND	ND	ND	ND	ND	ND	ND

NP = Naphthalene
BP = Biphenyl
ACEN = Acenaphthene
F = Fluorene
P = Phenanthane
DBT = Dibenzothiophene

[a]Related to petroleum sources.

TABLE 9-2

GROUP II[a] AROMATICS

(Concentration: $ng \cdot g^{-1}$)

SAMPLE STATION	DATE	FLU	PYR	C_1-PYR	BZA	CHR	C_1-CHR	BZA	BFZ(a)	BZF(e)	PER
S52	DEC. 1979	1.3	2.1	0.8	0.6	1.0	1.0	2.3	1.2	0.6	4.3
N39	DEC. 1979	5.8	6.4	7.1	3.6	5.1	5.3	19.0	7.6	4.8	25.0
M35	DEC. 1979	26.0	43.0	18.0	14.0	15.0	4.9	52.0	25.0	13.0	85.0
N38	DEC. 1979	15.0	27.0	ND	5.6	9.6	ND	21.0	10.0	5.5	59.0
S51	DEC. 1979	7.1	10.0	12.0	3.7	5.9	3.5	16.0	7.7	5.3	16.0
M37	DEC. 1979	4.0	5.6	5.0	1.6	1.5	0.4	3.9	1.8	1.1	5.2
N38	DEC. 1980	4.9	8.9	7.4	2.3	2.4	1.8	5.7	3.1	3.7	17.0
S51	DEC. 1980	16.0	27.0	26.0	9.3	11.0	15.0	29.0	15.0	15.0	57.0
S54	DEC. 1979	1.3	1.8	1.7	0.8	1.2	0.8	3.8	1.6	1.0	3.6
N19	DEC. 1980	0.5	0.8	0.5	0.2	0.3	0.1	0.6	0.1	0.2	0.3
S31	DEC. 1979	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
G05	DEC. 1980	14.0	18.0	30.0	6.0	14.0	6.3	26.0	9.6	12.0	61.0
M05	DEC. 1979	6.8	13.0	10.0	4.5	4.3	1.3	22.0	9.9	6.6	28.0
S53	DEC. 1980	7.3	11.0	6.8	3.6	3.7	2.8	11.0	4.4	3.6	22.0
PA2	DEC. 1979	3.5	2.9	1.2	1.9	3.2	1.1	5.3	2.2	1.3	0.9
M21	DEC. 1979	0.3	0.5	ND	0.2	0.3	0.1	0.8	0.2	0.1	1.0
N37	DEC. 1980	0.5	1.0	0.7	0.3	0.3	0.3	0.7	0.4	0.4	3.1
S50	DEC. 1979	ND	0.1	ND	ND	ND	ND	ND	ND	ND	0.1
M04	DEC. 1979	2.9	4.3	4.1	1.9	2.4	0.9	8.3	3.0	2.7	11.0
N40	DEC. 1980	4.3	7.8	5.0	1.2	1.1	0.6	2.5	1.0	0.7	6.1
S49	DEC. 1980	38.0	68.0	63.0	23.0	22.0	20.0	49.0	22.0	20.0	91.0
S04	DEC. 1980	9.5	16.0	14.0	5.6	8.6	4.0	28.0	11.0	8.4	37.0
S04	DEC. 1980	12.0	19.0	ND	7.2	7.8	ND	22.0	9.1	6.4	31.0
S06	DEC. 1979	12.0	20.0	25.0	9.6	11.0	13.0	31.0	14.0	10.0	40.0
N03	DEC. 1980	33.0	39.0	50.0	19.0	22.0	31.0	80.0	27.0	18.0	120.0
N04	DEC. 1980	28.0	31.0	31.0	9.7	14.0	7.4	35.0	13.0	8.7	57.0
G02	DEC. 1980	17.0	25.0	42.0	11.0	15.0	27.0	31.0	17.0	9.5	95.0
S52	DEC. 1980	1.6	2.4	0.2	0.1	0.1	0.1	0.3	0.1	0.1	0.7
S54	DEC. 1980	11.0	20.0	15.0	5.5	6.3	3.9	13.0	5.9	4.8	18.0
S05	DEC. 1980	35.0	61.0	53.0	19.0	21.0	11.0	50.0	21.0	16.0	77.0
G04	DEC. 1980	7.7	9.6	21.0	5.1	7.9	14.0	14.0	7.8	6.1	34.0
ANC	AUG. 1979	3.6	5.3	11.0	2.2	6.5	9.9	20.0	5.7	2.2	20.0
M14	DEC. 1979	10.0	16.0	7.0	2.6	2.1	1.9	13.0	8.1	ND	3.6
N39	DEC. 1980	7.7	8.2	14.0	4.6	11.0	7.9	29.0	11.0	7.5	10.0
S31	DEC. 1980	7.3	4.3	16.0	ND	19.0	31.0	ND	ND	ND	ND
S33	DEC. 1980	0.4	0.5	ND	ND	0.5	0.7	0.5	0.4	ND	ND
M35	DEC. 1980	11.0	20.0	7.1	ND	7.5	1.5	19.0	12.0	ND	5.3

FLU = Fluoranthene
PYR = Pyrene
BZA = Benz(a)anthracene
CHR = Chrysene
BZF = Benzofluoranthene
BZP = Benzopyrene
PER = Perylene

[a]Related to combustion sources.

Table 9-3

GROUP I[a] AROMATICS IN SHRIMP

Concentration ($ng \cdot g^{-1}$)

SAMPLE STATION	DATE	N	2-C_1N	1-C_1N	C_2N	C_3N	C_4N	BP	ACEN	F	C_1F	C_2F	C_3F	P	C_1P	C_2P	C_3P	C_4P	DBT	C_1DBT	C_2DBT	C_3DBT
Y04	NOV. 1979	0.9	1.1	0.9	19.0	31.0	25.0	ND	1.3	2.7	3.3	4.4	4.3	12.0	13.0	7.2	1.7	ND	2.2	3.1	2.4	0.9
W05	DEC. 1979	5.3	2.2	1.9	28.0	47.0	66.0	ND	1.0	2.3	7.5	21.0	34.0	16.0	29.0	35.0	37.0	17.0	4.0	9.1	12.0	6.4
W07	SEPT. 1979	0.4	0.7	0.4	7.9	21.0	31.0	0.3	0.3	1.1	3.8	10.0	16.0	3.5	17.0	35.0	35.0	11.0	1.3	5.6	12.0	7.4
M24	DEC. 1980	3.1	2.6	1.1	11.0	9.3	4.3	1.1	0.2	0.9	1.9	2.1	ND	3.9	6.1	3.4	0.8	ND	1.0	1.0	1.4	0.6
W07	JAN. 1980	ND	ND	ND	ND	0.7	1.5	ND	ND	ND	ND	ND	ND	2.9	2.2	1.1	0.6	ND	ND	ND	ND	ND
W06	NOV. 1979	0.3	1.2	0.7	41.0	160.0	110.0	1.0	0.6	1.9	22.0	48.0	59.0	22.0	67.0	61.0	38.0	21.0	5.7	22.0	20.0	8.4
W06	AUG. 1979	0.2	0.6	1.0	26.0	33.0	ND	0.3	0.3	0.4	ND	ND	ND	3.2	0.9	ND	ND	ND	7.2	ND	ND	ND
W06	SEPT. 1979	30.0	7.2	3.2	12.0	2.3	ND	1.5	ND	0.5	ND	ND	ND	4.6	4.0	7.2	4.9	ND	ND	3.4	15.0	15.0
X07	SEPT. 1979	9.3	2.7	1.0	1.1	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Y04	OCT. 1979	4.8	1.3	1.9	23.0	32.0	16.0	0.2	1.2	4.5	4.9	ND	ND	17.0	12.0	2.9	ND	ND	2.8	ND	ND	ND
M04	DEC. 1980	1.6	1.2	ND	3.2	ND	ND	ND	0.4	ND	ND	ND	ND	4.8	1.5	0.5	ND	ND	ND	ND	ND	ND
M05	DEC. 1980	2.6	2.0	ND	5.4	2.0	0.9	0.2	0.5	0.3	0.8	ND	ND	3.7	1.3	1.5	ND	0.5	0.4	0.3	1.0	0.3
S46	DEC. 1980	2.5	ND	0.9	ND	2.8	ND	0.9	0.8	0.9	ND	ND	2.5	12.0	8.4	4.6	ND	ND	1.5	1.1	0.9	0.9
G03	DEC. 1980	4.0	1.5	0.9	2.9	1.0	ND	0.3	ND	0.3	0.3	0.2	0.2	2.0	1.3	0.2	ND	ND	ND	ND	0.4	ND
M36	DEC. 1980	3.1	0.9	0.8	5.0	5.8	3.9	0.8	0.2	0.4	1.5	2.0	0.8	4.9	7.5	5.2	0.8	ND	1.0	1.2	2.4	0.3
W06	NOV. 1979	4.4	3.0	3.5	44.0	45.0	36.0	ND	0.7	1.8	0.9	5.6	11.0	6.8	8.7	9.9	14.0	1.1	1.2	2.2	ND	ND
W07	OCT. 1979	4.6	5.9	4.1	91.0	170.0	120.0	2.4	0.6	2.5	7.9	5.3	1.8	7.1	10.0	4.9	1.0	0.3	3.4	3.3	1.6	0.5

N = Naphthalene
BP = Biphenyl
ACEN = Acenaphthene
F = Fluorene
P = Phenanthane
DBT = Dibenzothiophene

[a]Related to petroleum sources

Table 9-4

GROUP II[a] AROMATICS IN SHRIMP

Concentration ($ng \cdot g^{-1}$)

SAMPLE											
STATION	DATE	FLU	PYR	C_1PYR	BZA	CHR	C_1CHR	BZF	BZP(a)	BZP(e)	PER
Y04	NOV. 1979	4.1	3.9	ND	0.7	ND	ND	ND	ND	ND	ND
W05	DEC. 1979	9.6	14.0	16.0	3.1	5.5	1.4	3.5	0.9	1.6	0.7
W05	SEPT. 1979	1.2	1.4	6.4	ND	2.0	4.2	0.7	ND	ND	ND
M24	DEC. 1980	2.0	2.1	0.7	0.3	0.7	ND	ND	ND	ND	ND
W07	JAN. 1980	1.1	0.5	ND	ND	ND	ND	ND	ND	ND	ND
W06	NOV. 1979	7.9	8.0	2.0	2.3	5.9	3.1	3.2	1.5	1.7	3.1
W06	AUG. 1979	1.0	0.9	ND	ND	ND	ND	ND	ND	ND	ND
W06	SEPT. 1979	3.5	3.9	ND	ND	ND	ND	ND	ND	ND	ND
X07	SEPT. 1979	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Y04	OCT. 1979	4.6	4.1	ND	ND	ND	ND	ND	ND	ND	ND
M04	DEC. 1980	0.9	1.0	ND	ND	ND	ND	ND	ND	ND	ND
M05	DEC. 1980	0.2	0.8	ND	ND	ND	ND	ND	ND	ND	ND
S46	DEC. 1980	1.2	3.3	ND	ND	ND	ND	ND	ND	ND	ND
G03	DEX. 1980	0.9	0.8	ND	ND	ND	ND	ND	ND	ND	ND
M36	DEC. 1980	1.5	1.7	0.8	0.4	0.4	ND	ND	0.6	ND	ND
W06	NOV. 1979	1.5	3.1	1.1	ND	ND	ND	ND	ND	ND	ND
W07	OCT. 1979	1.0	1.3	0.3	ND	ND	ND	ND	ND	ND	ND

FLU = Fluoranthene
PYR = Pyrene
BZA = Benz(a)anthracene
CHR = Chrysene
BZF = Benzofluoranthene
BZP = Benzopyrene
PER = Perylene

[a]Related to combustion sources.

Table 9-5

GROUP I[a] AROMATICS IN PETROLEUM
(Concentration $\mu g \cdot g^{-1}$ oil)

SAMPLE	N	2-C,N	1-C,N	C2N	C3N	C4N	BP	ACEN	F	C_1F	C_2F	C_3F	P	C_1P	C_2P	C_3P	C_4P	DBT	C_1DBT	C_2DBT	C_3DBT
7908-I4C-1001	ND	ND	ND	46	220	260	ND	ND	4.5	62	170	390	46	370	600	590	310	110	370	900	750
7911-B03-1001	0.7	6.1	5.1	66	92	60	1.2	0.2	2.5	11	23	30	14	42	52	47	7.4	3.1	8.2	10	4.3
7911-B02-1002	12	96	72	720	930	680	15	5.2	25	99	200	230	86	290	330	310	120	26	61	69	26
7911-P02-1001	160	780	580	3600	4000	2300	110	ND	33	200	430	730	120	660	920	870	490	160	310	660	570
8012-T01-1001	ND	ND	ND	ND	16	31	ND	ND	ND	ND	41	31	14	200	280	240	ND	ND	180	500	350
8004-E02-1001	5.1	ND	ND	ND	6.8	18	ND	ND	ND	ND	100	250	3.5	140	650	810	370	3.6	720	1400	1200
7912-P12-1001	1.3	ND	0.7	56	220	220	ND	ND	4.7	47	120	210	33	240	330	280	170	79	230	580	400
7911-B04-1001	2.3	41	33	780	1500	1300	9.8	3.0	49	180	440	600	230	750	910	880	170	66	150	200	93
7911-B04-1001	440	2000	1300	8400	9400	7000	250	ND	220	980	2300	2900	830	2700	3600	4400	2700	230	750	1100	830
8004-E0T-1001	10	1.0	ND	4.0	140	360	ND	ND	ND	44	310	820	26	550	1800	1800	790	27	610	2700	2500
7908-Q03-1001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	990	2900	2500	360	ND	930	4700	4000
7908-Q01-1001	23	ND	ND	ND	7.0	ND	ND	ND	ND	1.0	130	600	14	1100	1800	1800	980	6.0	500	2900	2600
7911-P20-1001	4.7	ND	ND	ND	46	41	ND	ND	ND	16	170	530	100	590	1400	1600	900	24	500	2200	2100
7911-B04-1002	16	58	44	1200	3200	3300	14	9.0	66	530	1500	2300	580	2500	3600	4000	1900	70	440	980	650
8012-T02-1001	31	ND	ND	65	250	160	ND	ND	ND	35	150	430	91	590	690	840	880	70	500	1300	1200
8012-T05-1001	32	9.0	ND	110	470	590	ND	ND	ND	110	500	1300	110	1200	2600	2400	1200	130	1400	4600	3900
8012-T03-1001	13	ND	ND	27	24	ND	11	ND	17	ND	24	53	38	73	110	100	32	66	44	190	170
7911-P12-1001	0.8	0.5	0.4	4.4	17	20	ND	ND	0.7	5.9	33	71	5.0	72	190	240	140	6.9	55	310	300
7908-Q02-1001	2.0	ND	ND	ND	ND	33	ND	ND	ND	ND	46	140	5.7	240	620	690	300	1.4	38	150	130
7909-R23-6001	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	0.3	0.9	2.9	4.2	2.2	ND	0.7	6.6	7.3

N = Naphthalene
BD = Biphenyl
ACEN = Acenaphthene
F = Fluorene
P = Phenanthrene
DBT = Dibenzothiophene
Cn = n methyl substitutions

[a]Related to petroleum sources.

Table 9-6

AROMATIC HYDROCARBONS IN PETROLEUM GROUP II[a]

Concentration ($\mu g \cdot g^{-1}$)

SAMPLE	FLU	PYR	CPYR	BZA	CHR	C_1CHR	BZF	BZP(a)	BZP(e)	PER
7908-I4C-1001	17	23	100	47	ND	84	ND	ND	ND	ND
7911-B03-1001	3.9	5.6	11	2.3	3.3	ND	ND	ND	ND	ND
7911-B02-1002	27	32	ND	13	37	ND	23	6.7	16	26
7911-P02-1001	27	16	180	26	10	48	ND	ND	ND	68
8012-T01-1001	ND	ND	ND	12	5.0	ND	ND	ND	ND	ND
8004-E02-1001	6.4	19	94	79	ND	150	ND	19	5.2	ND
7912-P12-1001	8.0	4.4	ND	ND	ND	ND	ND	4.6	4.2	4.3
7911-B04-1001	72	98	200	45	63	43	22	ND	20	17
7911-B04-1001	190	240	1400	62	220	750	200	53	130	200
8004-E05-1001	11	25	240	ND	ND	410	ND	ND	21	34
7908-Q03-1001	ND	ND	51	130	ND	220	ND	ND	ND	ND
7908-Q01-1001	40	30	160	190	ND	370	4.0	4.0	42	53
7911-P20-1001	57	60	210	57	220	360	52	56	96	23
7911-B04-1002	230	290	840	71	ND	360	180	76	84	100
8012-T02-1001	18	60	420	59	ND	290	33	150	60	53
8012-T05-1001	41	56	390	270	ND	480	58	74	ND	ND
8012-T03-1001	34	33	77	48	220	18	66	120	ND	ND
7911-P12-1001	3.1	5.0	57	14	220	36	5.5	3.6	20	1.8
7908-Q02-1001	3.2	5.9	140	ND	170	200	17	ND	35	ND
7909-R23-6001	0.1	0.1	ND	ND	ND	1.4	ND	ND	ND	ND

FLU = Fluoranthene
PYR = Pyrene
BZA = Benz(a)anthracene
CHR = Chrysene
BZF = Benzofluoranthene
BZP = Benzopyrene
PER = Perylene

[a]Related to combustion sources.

Table 9-7

GROUP I AND GROUP II AROMATICS IN SORBENT PADS
(Concentration $\mu g \cdot g^{-1}$ oil)

GROUP I[a]

SAMPLE	N	2-C,N	1-C,N	C2N	C3N	C4N	BP	ACEN	F	C_1F	C_2F	C_3F	P	C_1P	C_2P	C_3P	C_4P	DBT	C_1DBT	C_2DBT	C_3DBT
7911-S46-7001	ND	0.1	0.1	ND	3.0	ND	ND	ND	0.2	1.2	6.9	5.8	6.0	21	24	26	11	ND	4.6	30	322
7911-S27-7001	15	11	5.6	41	40	4.5	2.6	2.3	5.5	2.5	7.0	15	45	57	95	100	26	7.3	25	140	140
7911-M25-7001	1.7	1.0	0.8	4.5	0.5	ND	ND	ND	ND	ND	5.3	ND	4.6	43	15	17	3.7	0.4	3.9	26.0	44
7911-S21-7001	0.6	0.5	0.3	2.2	2.1	ND	0.1	0.2	0.2	ND	ND	ND	1.6	1.7	3.2	4.0	1.1	0.2	0.6	5.2	5.4

GROUP II[b]

SAMPLE	FLU	PYR	CPYR	BZA	CHR	C_1CHR	BZF	BZP(a)	BZP(O)	PER
7911-S46-7001	3.4	3.4	7.1	0.9	5.6	4.7	2.8	1.3	2.0	2.3
7911-S27-7001	20	28	19	5.2	21	21	17	10	ND	15
7911-M25-7001	6.8	7.1	3.5	1.9	6.6	6.6	7.0	2.1	1.0	3.5
7911-S21-7001	1.0	0.9	0.5	0.2	1.1	1.1	0.8	0.4	0.2	1.4

N = Naphthalene
BD = Biphenyl
ACEN = Acenaphthene
F = Fluorene
P = Phenanthrene
DBT = Dibenzothiophene
Cn = n methyl substitutions

[a]Related to petroleum sources.
[b]Related to combustion sources.

Sampling Inventory and Status Key for Tables 8-8 through 8-11

Analysis Type

UV = UV/Spectrofluorometry (UV/F)

GC = Gas Chromatography (FSCGC)

GCMS = Gas Chromatography/Mass Spectrometry (GC/MS)

IS1 = Stable Isotope Analysis of the f1

IS2 = Stable Isotope Analysis of the f2

IS12 = Stable Isotope Analysis of Combined f1 and f2

ISA = Stable isotope Analysis of the Asphaltene fraction

TOC = Total Organic Carbon Analysis

Symbols

\+ = Analysis Completed

\- = No analysis

TABLE 9-8

OIL SAMPLE INVENTORY AND STATUS

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
7908-CM1-1001	MALAQUITE31AUG79	-	+	-	-	-	-	-	-
7908-CM2-1001	MALAQUITE29AUG79	-	+	-	+	+	-	-	-
7908-I4C-1001	STX-M-4C	-	+	+	+	+	-	+	-
7908-I5A-1001	STX-C-5A	-	+	-	+	+	-	+	-
7908-Q01-1001	2604-9709-790812	-	+	+	-	-	-	-	-
7908-Q02-1001	2640-9728-790813	-	+	+	-	-	-	-	-
7908-Q03-1001	2604-9709-790814-001	-	+	+	-	-	-	-	-
7908-Q04-1001	2740-9710-790814	-	+	-	-	-	-	-	-
7908-Q05-1001	2805-9650-790814-001	-	+	-	+	+	-	-	-
7909-I03-1001	STX-03	-	+	-	-	-	-	-	-
7910-I17-1001	STX-17	-	-	-	-	-	-	-	-
7911-B01-1001	S.BIG SHELL 14NOV79	-	+	-	+	+	-	+	-
7911-B02-1001	BURMAAGATE5NOV#1	-	+	+	+	+	-	+	-
7911-B02-1002	BURMAAGATE5NOV#2	-	+	+	+	+	-	+	-
7911-B03-1001	RPI#1SJI 9NOV79	-	+	+	+	+	-	+	-
7911-B04-1001	SANJOSE#2 12NOV79	-	+	+	+	+	-	+	-
7911-B04-1002	E.BEACH A 11NOV79	-	+	+	-	-	-	-	-
7911-B05-1001	P5N0AA0511/19/79	-	+	-	+	+	-	-	-
7911-B06-1001	CGPORT BAUER8NOV79	-	+	-	+	+	-	-	-
7911-B07-1001	ATN0AA10 9NOV79	-	+	-	+	+	-	+	-
7911-P01-1001	11-19-79-PS-N0AA-01	-	+	-	-	-	-	-	-
7911-P02-1001	11-19-79-PS-N0AA-02	-	+	+	+	+	-	+	-
7911-P06-1001	11-20-79-PS-N0AA-06	-	+	+	+	+	-	+	-
7911-P09-1001	11-20-79-PS-N0AA-09	-	+	-	+	+	-	+	-
7911-P11-1001	11-20-79-PS-N0AA-11	-	-	-	-	-	-	-	-
7912-P12-1001	12-01-79-PS-N0AA-12	-	+	+	+	+	-	+	-
7912-P17-1001	12-04-79-PS-N0AA-17	-	+	-	-	-	-	-	-
7912-P19-1001	12-04-79-PS-N0AA-19	-	+	-	-	-	-	-	-
7912-P20-1001	12-05-79-PS-N0AA-20	-	+	+	+	+	-	+	-
7912-P24-1001	12-05-79-PS-N0AA-24	-	+	-	+	+	-	+	-
8004-E01-1001	ERN01-042080-1645-00	-	+	-	-	-	-	-	-
8004-E02-1001	ERN01--041780-1345-0	-	+	+	-	-	-	-	-
8004-E03-1001	ERN01-041880-1300-00	-	+	-	-	-	-	-	-
8004-E04-1001	ERN01-041780-0945-00	-	+	-	-	-	-	-	-
8004-E05-1001	ERN01-042080-1100-00	-	+	+	-	-	-	-	-

TABLE 9-8 (CONT.)

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
8012-M21-1111	DA01-M21-0380	-	-	-	-	-	-	-	-
8012-M24-1181	DA01-M24-0299	-	-	-	-	-	-	-	-
8012-M25-1121	DA01-M25-0320	-	-	-	-	-	-	-	-
8012-M25-1122	DA01-M25-0321	-	-	-	-	-	-	-	-
8012-M28-1111	DA01-M28-0383	-	-	-	-	-	-	-	-
8012-M36-1471	DA01-M36-0257	-	-	-	-	-	-	-	-
8012-N09-1071	DA01-N9-0081	-	-	-	-	-	-	-	-
8012-N18-1181	DA01-N18-0164	-	-	-	-	-	-	-	-
8012-N18-1182	DA01-N18-0165	-	-	-	-	-	-	-	-
8012-S05-1341	DA01-S05-0607	-	-	-	-	-	-	-	-
8012-S27-1081	DA01-S27-0604	-	-	-	-	-	-	-	-
8012-S52-1231	DA01-S52-0790	-	-	-	-	-	-	-	-
8012-T01-1001	T1-1	-	+	+	-	-	-	-	-
8012-T02-1001	T2-1	-	+	+	-	-	-	-	-
8012-T03-1001	T3-1	-	+	+	-	-	-	-	-
8012-T04-1001	T4-2	-	+	-	-	-	-	-	-
8012-T05-1001	T5-2	-	+	+	-	-	-	-	-
8012-T06-1001	T6	-	-	-	-	-	-	-	-

TABLE 9-9

TISSUE SAMPLE INVENTORY AND STATUS

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
7907-W09-5010	29089157790723570910	+	-	-	-	-	-	-	-
7907-X04-5011	28189630790723570510	+	+	-	-	-	-	-	-
7907-X04-5012	28259618790723571097	+	-	-	-	-	-	-	-
7907-X05-5020	28169532790723573811	+	-	-	-	-	-	-	-
7907-X08-5021	28249226790723574010	+	-	-	-	-	-	-	-
7907-X08-5022	28459244790725572910	+	-	-	-	-	-	-	-
7907-Y03-5020	27349703790723572611	+	-	-	-	-	-	-	-
7907-Z03-5030	26119706790725571810	+	-	-	-	-	-	-	-
7908-W06-5010	29309422790830570910	+	+	+	-	-	-	-	-
7908-W06-5020	29199416790822571510	+	-	-	-	-	-	-	-
7908-W06-5030	29349419790822570410	+	-	-	-	-	-	-	-
7908-W07-5010	29379352790823570710	+	+	-	-	-	-	-	-
7908-X05-5020	28169540790809573310	+	-	-	-	-	-	-	-
7908-Y03-5011	2WG2741970179082 23A1	+	-	-	-	-	-	-	-
7908-Y03-5012	19WG2739970279082 23A	+	-	-	-	-	-	-	-
7908-Y03-5013	24WG2739970279082 23A	+	+	-	-	-	-	-	-
7908-Y03-5014	30WG2745970279082 23A	+	-	-	-	-	-	-	-
7908-Y03-5015	36WG2749970079082 33A	+	-	-	-	-	-	-	-
7908-Y03-5016	41WG2749970079082 33A	-	-	-	-	-	-	-	-
7908-Y03-5017	36WG2749970079082 33A	+	-	-	-	-	-	-	-
7908-Y03-5021	28WG2745970279082 23A	+	-	-	-	-	-	-	-
7908-Y03-5022	29WG2745970279082 23A	+	-	-	-	-	-	-	-
7908-Y03-5023	33WG2743970479082 23A	+	-	-	-	-	-	-	-
7908-Y04-5010	51WG2750965579082 33A	+	-	-	-	-	-	-	-
7908-Y04-5021	50WG2750965579082 33A	+	-	-	-	-	-	-	-
7908-Y04-5022	27509654790806571810	+	-	-	-	-	-	-	-
7908-Z04-5021	26029657790827573110	+	-	-	-	-	-	-	-
7908-Z04-5022	26089642790815574610	+	-	-	-	-	-	-	-
7908-Z04-5023	26349657790817573810	+	-	-	-	-	-	-	-
7909-W06-5011	29239434790912570910	+	-	-	-	-	-	-	-
7909-W06-5012	29119454790904570910	+	+	-	-	-	-	-	-
7909-W06-5021	29319406790923571310	+	+	+	-	-	-	-	-
7909-W07-5011	29399344790907570510	+	+	+	-	-	-	-	-
7909-W07-5012	29439340790918570510	+	+	-	-	-	-	-	-
7909-X04-5020	28029603790911574410	+	+	-	-	-	-	-	-

TABLE 9-9 (CONT.)

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
7909-X05-5010	28309557790912571610	+	-	-	-	-	-	-	-
7909-X05-5020	28309530790910572710	+	-	-	-	-	-	-	-
7909-X07-5020	28439305790911573110	+	+	+	-	-	-	-	-
7909-Y04-5011	27539651790912571810	+	-	-	-	-	-	-	-
7909-Y04-5012	27509656790910571810	+	-	-	-	-	-	-	-
7909-Z03-5020	26509714790907573110	+	-	-	-	-	-	-	-
7909-Z04-5021	26089644790917574410	+	+	-	-	-	-	-	-
7909-Z04-5022	26219638790926575110	+	-	-	-	-	-	-	-
7910-W06-5010	29309423791003571310	+	+	-	-	-	-	-	-
7910-W06-5020	29319406791001571310	+	-	-	-	-	-	-	-
7910-W07-5011	29389344791018571110	+	+	-	-	-	-	-	-
7910-W07-5012	29429340791001570710	-	-	-	-	-	-	-	-
7910-W07-5020	29419313791002570911	+	+	+	-	-	-	-	-
7910-X01-5010	28499522791029570910	+	-	-	-	-	-	-	-
7910-X04-5010	28119627791011570710	+	+	-	-	-	-	-	-
7910-Y04-5010	27429642791003573710	+	+	+	-	-	-	-	-
7910-Y04-5020	27559636791017572710	+	+	-	-	-	-	-	-
7910-Z03-5010	26049704791016572410	+	-	-	-	-	-	-	-
7911-W06-5011	29129436791108571110	+	+	+	-	-	-	-	-
7911-W06-5012	29129447791121571311	+	+	+	-	-	-	-	-
7911-Y03-5011	27019711791121572211	+	-	-	-	-	-	-	-
7911-Y03-5012	27129718791116571611	+	-	-	-	-	-	-	-
7911-Y04-5011	27439651791107572710	+	-	-	-	-	-	-	-
7911-Y04-5012	27439651791107570910	+	+	+	-	-	-	-	-
7911-Z03-5021	26379700791121573711	+	-	-	-	-	-	-	-
7911-Z03-5022	26349704791101572711	+	-	-	-	-	-	-	-
7911-Z03-5030	26059704791102572011	+	-	-	-	-	-	-	-
7912-W05-5010	29049505791207571111	+	+	+	-	-	-	-	-
7912-W07-5010	29349354791214570911	+	+	-	-	-	-	-	-
7912-X08-5020	28139246791205576911	+	-	-	-	-	-	-	-
8001-W07-5011	29219327800123571611	+	+	-	-	-	-	-	-
8001-W07-5012	29379355800114570511	+	+	-	-	-	-	-	-
8001-W07-5013	29409323800115570911	+	+	+	-	-	-	-	-
8001-W07-5020	29379309800115571111	+	-	-	-	-	-	-	-
8001-X09-5020	28179124800121577311	+	-	-	-	-	-	-	-
8001-X10-5010	28589043800122570911	+	+	-	-	-	-	-	-

TABLE 9-9 (CONT.)

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
8012-G01-5021	DA01-G01-0815	+	+	-	-	-	-	-	-
8012-G03-5011	DA01-G03-0836	+	+	+	-	-	-	-	-
8012-M04-5021	DA01-M04-0464	+	+	+	-	-	-	-	-
8012-M05-5021	DA01-M05-0443	+	+	+	-	-	-	-	-
8012-M14-5011	DA01-M14-0423	+	-	-	-	-	-	-	-
8012-M15-5011	DA01-M15-0403	+	+	-	-	-	-	-	-
8012-M21-5011	DA01-M21-0361	+	-	-	-	-	-	-	-
8012-M24-5011	DA01-M24-0298	+	+	+	-	-	-	-	-
8012-M25-5010	DA01-M25-0319	+	-	-	-	-	-	-	-
8012-M26-5010	DA01-M26-0341	+	-	-	-	-	-	-	-
8012-M28-5011	DA01-M28-0382	+	-	-	-	-	-	-	-
8012-M35-5011	DA01-M35-0277	+	+	-	-	-	-	-	-
8012-M35-5021	DA01-M35-0278	-	-	-	-	-	-	-	-
8012-M36-5021	DA01-M36-0227	+	+	+	-	-	-	-	-
8012-M37-5011	DA01-M37-0226	+	+	-	-	-	-	-	-
8012-N03-5021	DA01-N3-0124	+	-	-	-	-	-	-	-
8012-N04-5021	DA01-N04-0791	+	-	-	-	-	-	-	-
8012-N09-5011	DA01-N09-0060	+	-	-	-	-	-	-	-
8012-N18-5011	DA01-N18-0163	+	-	-	-	-	-	-	-
8012-N19-5001	DA01-N19-0206	-	-	-	-	-	-	-	-
8012-N19-5010	DA01-N19-0185	+	+	-	-	-	-	-	-
8012-N32-5011	DA01-N32-0205	+	+	-	-	-	-	-	-
8012-N37-5011	DA01-N37-0080	-	-	-	-	-	-	-	-
8012-N37-5011	DA01-N37-0082	-	-	-	-	-	-	-	-
8012-N38-5011	DA01-N38-0020	+	+	-	-	-	-	-	-
8012-N39-5021	DA01-N39-0102	+	+	-	-	-	-	-	-
8012-N40-5011	DA01-N40-0040	+	+	-	-	-	-	-	-
8012-S04-5021	DA01-S04-0627	+	+	-	-	-	-	-	-
8012-S05-5021	DA01-S05-0606	+	-	-	-	-	-	-	-
8012-S15-5010	DA01-S15-0687	+	+	-	-	-	-	-	-
8012-S18-5011	DA01-S18-0787	+	+	-	-	-	-	-	-
8012-S21-5011	DA01-S21-0647	+	-	-	-	-	-	-	-
8012-S26-5011	DA01-S26-0585	+	-	-	-	-	-	-	-
8012-S31-5011	DA01-S31-0546	+	-	-	-	-	-	-	-
8012-S43-5011	DA01-S43-0667	+	-	-	-	-	-	-	-
8012-S46-5011	DA01-S46-0707	+	+	+	-	-	-	-	-

TABLE 9-9 (CONT.)

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
8012-S49-5011	DA01-S49-0505	+	-	-	-	-	-	-	-
8012-S49-5021	DA01-S49-0504	+	+	-	-	-	-	-	-
8012-S50-5011	DA01-S50-0525	+	+	-	-	-	-	-	-
8012-S50-5021	DA01-S50-0526	-	-	-	-	-	-	-	-
8012-S51-5021	DA01-S51-0484	+	+	-	-	-	-	-	-
8012-S52-5011	DA01-S52-0727	+	-	-	-	-	-	-	-
8012-S52-5021	DA01-S52-0789	+	+	-	-	-	-	-	-
8012-S53-5010	DA01-S53-0747	+	+	-	-	-	-	-	-
8012-S54-5021	DA01-S54-0767	+	-	-	-	-	-	-	-

TABLE 9-10

SEDIMENT SAMPLE INVENTORY AND STATUS

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
7908-ANA-6001	ANI-08-29-79-01	-	+	-	-	-	-	-	-
7908-ANB-6001	ANI-08-29-79-07	-	+	-	-	-	-	-	-
7908-ANC-6001	ANI-08-29-79-11	-	+	+	+	+	-	-	-
7908-AND-6001	ANI-08-30-79-03	-	-	-	-	-	-	-	-
7908-ANE-6001	ANI-08-30-79-10	-	+	-	-	-	-	-	-
7909-R15-6001	RIX-13-F085	+	+	-	-	-	-	-	-
7909-R16-6001	RIX-16-F086	+	-	-	-	-	-	-	-
7909-R17-6001	RIX-17-F089	+	-	-	-	-	-	-	-
7909-R18-6001	RIX-18-F092	+	+	-	-	-	-	-	-
7909-R19-6001	RIX-19-F095	+	-	-	-	-	-	-	-
7909-R20-6001	RIX-20-F098	+	-	-	-	-	-	-	-
7909-R21-6001	RIX-21-F102	+	+	-	-	-	-	-	-
7909-R23-6001	RIX-23-S012	+	+	+	-	-	+	-	-
7909-R24-6001	RIX-24-F113	+	-	-	-	-	-	-	-
7909-R25-6001	RIX-25-F116	+	+	-	-	-	-	-	-
7909-R26-6001	RIX-26-F119	+	-	-	-	-	-	-	-
7909-R27-6001	RIX-27-F122	+	-	-	-	-	-	-	-
7909-R28-6001	RIX-28-F125	+	-	-	-	-	-	-	-
7909-R30-6001	RIX-30-F134	+	-	-	-	-	-	-	-
7911-M20-6001	L-11-30-79-25	+	+	-	-	-	-	-	-
7911-M21-6001	L-11-30-79-23	+	+	+	-	-	+	-	-
7911-M23-6001	L-11-30-79-17	+	-	-	-	-	-	-	-
7911-M24-6001	L-11-30-79-5	+	+	-	-	-	-	-	-
7911-M25-6001	L-11-30-79-3	+	+	-	-	-	-	-	-
7911-M26-6001	L-11-30-79-1	+	+	-	-	-	-	-	-
7911-M28-6001	L-11-30-79-21	+	-	-	-	-	-	-	-
7911-M35-6001	L-11-30-79-13	+	+	+	-	-	+	-	+
7911-S06-6001	L-11-19-79-19	+	+	+	-	-	+	-	-
7911-S12-6001	L-11-18-79-45	+	-	-	-	-	-	-	-
7911-S13-6001	L-11-18-79-44	+	-	-	-	-	-	-	-
7911-S14-6001	L-11-18-79-39	+	-	-	-	-	-	-	-
7911-S15-6001	L-11-18-79-37	+	-	-	-	-	-	-	-
7911-S16-6001	L-11-18-79-11	+	-	-	-	-	-	-	-
7911-S17-6001	L-11-18-79-9	+	-	-	-	-	-	-	-
7911-S18-6001	L-11-18-79-1	+	-	-	-	-	-	-	-

TABLE 9-10 (CONT.)

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
7911-S19-6001	L-11-18-79-3	+	+	-	-	-	-	-	-
7911-S21-6001	L-11-17-79-42	+	+	-	-	-	-	-	-
7911-S22-6001	L-11-17-79-34	+	-	-	-	-	-	-	-
7911-S23-6001	L-11-17-79-36	+	+	-	-	-	-	-	-
7911-S25-6001	L-11-17-79-30	+	-	-	-	-	-	-	-
7911-S26-6001	L-11-17-79-19	+	+	-	-	-	+	-	-
7911-S27-6001	L-11-17-79-21	+	+	-	-	-	-	-	-
7911-S29-6001	L-11-17-79-15	+	+	-	-	-	-	-	-
7911-S30-6001	L-11-17-79-7	+	-	-	-	-	-	-	-
7911-S31-6001	L-11-17-79-9	+	+	+	-	-	+	-	-
7911-S33-6001	L-11-17-79-2	+	+	+	-	-	+	-	-
7911-S34-6001	L-11-17-79-1	+	+	-	-	-	-	-	-
7911-S36-6001	L-11-17-79-11	+	-	-	-	-	-	-	-
7911-S38-6001	L-11-17-79-11	-	-	-	-	-	-	-	-
7911-S40-6001	L-11-17-79-23	+	-	-	-	-	-	-	-
7911-S43-6001	L-11-17-79-40	+	-	-	-	-	-	-	-
7911-S46-6001	L-11-18-79-30	+	-	-	-	-	-	-	-
7911-S47-6001	L-11-18-79-35	+	+	-	-	-	-	-	-
7911-S48-6001	L-11-18-79-41	+	+	-	-	-	-	-	-
7911-S50-6001	L-11-16-79-9	+	+	+	-	-	+	-	+
7911-S52-6001	L-11-18-79-19	+	+	-	-	-	-	-	+
7911-S53-6001	L-11-18-79-21	+	+	+	+	-	-	-	+
7911-S54-6001	L-11-19-79-11	+	+	+	-	-	+	-	+
7911-S9B-6001	L-11-19-79-3	+	-	-	-	-	-	-	-
7912-M04-6001	L-12-2-79-17	+	+	+	-	-	+	-	-
7912-M05-6001	L-12-2-79-15	+	+	+	+	-	-	-	-
7912-M09-6001	L-12-1-79-31	+	-	-	-	-	-	-	-
7912-M10-6001	L-12-1-79-23	+	-	-	-	-	-	-	-
7912-M11-6001	L-12-1-79-25	+	-	-	-	-	-	-	-
7912-M14-6001	L-12-1-79-11	+	+	+	-	-	+	-	-
7912-M15-6001	L-12-1-79-13	+	+	-	-	-	-	-	-
7912-M17-6001	L-12-1-79-7	+	+	-	-	-	-	-	-
7912-M19-6001	L-12-1-79-1	+	+	-	-	-	-	-	-
7912-M31-6001	L-12-1-79-15	+	+	-	-	-	-	-	-
7912-M33-6001	L-12-1-79-27	+	-	-	-	-	-	-	-
7912-M36-6001	L-12-2-79-29	+	+	-	-	-	-	-	+

TABLE 9-10 (CONT.)

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
7912-M37-6001	L-12-2-79-3	+	+	+	+	-	-	-	+
7912-N03-6001	L-12-7-79-11	-	-	-	-	-	-	-	-
7912-N04-6001	L-12-7-79-13	+	-	-	-	-	-	-	-
7912-N09-6001	L-12-8-79-20	-	-	-	-	-	-	-	-
7912-N11-6001	L-12-9-79-11	+	+	-	-	-	-	-	-
7912-N13-6001	L-12-9-79-17	+	+	-	-	-	-	-	-
7912-N15-6001	L-12-9-79-23	+	-	-	-	-	-	-	-
7912-N17-6001	L-12-9-79-29	-	-	-	-	-	-	-	-
7912-N19-6001	L-12-9-79-35	+	-	-	-	-	-	-	-
7912-N20-6001	L-12-9-79-33	+	-	-	-	-	-	-	-
7912-N21-6001	L-12-9-79-41	+	-	-	-	-	-	-	-
7912-N23-6001	L-12-10-79-03	+	-	-	-	-	-	-	-
7912-N25-6001	L-12-9-79-47	+	+	-	-	-	-	-	-
7912-N26-6001	L-12-7-79-5	-	-	-	-	-	-	-	-
7912-N27-6001	L-12-7-79-3	+	+	-	-	-	-	-	-
7912-N32-6001	L-12-9-79-37	+	-	-	-	-	-	-	-
7912-N37-6001	L-12-8-79-18	+	+	-	-	-	-	-	-
7912-N38-6001	L-12-9-79-3	+	+	+	+	+	-	-	+
7912-N39-6001	L-12-8-79-11	+	+	+	-	-	+	-	+
7912-N40-6001	L-12-8-79-28	+	+	-	-	-	-	-	+
7912-PA1-6001	L-12-13-79-01	+	-	-	-	-	-	-	-
7912-PA2-6001	L-12-13-79-02	+	+	+	-	-	+	-	-
7912-PA3-6001	L-12-13-79-03	+	-	-	-	-	-	-	-
7912-PA4-6001	L-12-13-79-04	+	+	-	-	-	-	-	-
7912-PA5-6001	L-12-13-79-05	+	-	-	-	-	-	-	-
7912-S01-6001	L-12-2-79-9	+	-	-	-	-	-	-	-
7912-S49-6001	L-12-1-79-41	+	+	-	-	-	-	-	+
7912-S51-6001	L-12-2-79-3	+	+	+	-	-	+	-	+
8012-G01-6001	DA01-G01-0814	-	+	-	-	-	-	-	-
8012-G02-6001	DA01-G02-0816	-	+	+	-	-	-	-	-
8012-G03-6001	DA01-G03-0835	-	+	-	-	-	-	-	-
8012-G04-6001	DA01-G04-0000	-	+	+	+	+	-	-	-
8012-G05-6001	DA01-G05-0000	-	+	+	+	-	-	-	-
8012-G06-6001	DA01-G06-0000	-	+	-	+	+	-	-	-
8012-M04-6001	DA01-M04-0463	+	+	-	-	-	-	-	+
8012-M05-6001	DA01-M05-0442	+	+	-	-	-	-	-	+

TABLE 9-10 (CONT.)

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
8012-M14-6001	DA01-M14-0422	+	-	-	-	-	-	-	-
8012-M15-6001	DA01-M15-0402	+	+	-	-	-	-	-	+
8012-M21-6001	DA01-M21-0360	+	+	-	-	-	-	-	+
8012-M24-6001	DA01-M24-0297	+	-	-	-	-	-	-	+
8012-M25-6001	DA01-M25-0318	+	-	-	-	-	-	-	+
8012-M26-6001	DA01-M26-0340	+	+	-	-	-	-	-	+
8012-M28-6001	DA01-M28-0381	+	-	-	-	-	-	-	+
8012-M35-6001	DA01-M35-0276	+	+	+	+	+	-	-	+
8012-M36-6001	DA01-M36-0246	+	+	-	+	+	-	-	+
8012-M37-6001	DA01-M37-0225	+	+	-	-	-	-	-	+
8012-N03-6001	DA01-N3-0123	+	+	+	-	-	-	-	+
8012-N04-6001	DA01-N4-0143	+	+	+	-	-	-	-	+
8012-N09-6001	DA01-N09-0059	+	+	-	-	-	-	-	+
8012-N18-6001	DA01-N18-0162	+	-	-	-	-	-	-	+
8012-N19-6001	DA01-N19-0184	+	+	+	-	-	+	-	+
8012-N32-6001	DA01-N32-0204	+	-	-	-	-	-	-	+
8012-N37-6001	DA01-N37-0079	+	+	+	-	-	+	-	+
8012-N38-6001	DA01-N38-0019	+	+	+	-	-	+	-	+
8012-N39-6001	DA01-N39-0101	+	+	+	-	-	+	-	+
8012-N40-6001	DA01-N40-0039	+	+	+	-	-	-	-	+
8012-S04-6001	DA01-S04-0626	+	+	+	-	-	-	-	+
8012-S05-6001	DA01-S05-0605	+	+	+	-	-	-	-	+
8012-S15-6001	DA01-S15-0686	+	-	-	-	-	-	-	+
8012-S15-6002	DA01-S15-0788	-	-	-	-	-	-	-	-
8012-S18-6001	DA01-S18-0786	+	-	-	-	-	-	-	+
8012-S21-6001	DA01-S21-0646	+	+	-	-	-	-	-	+
8012-S26-6001	DA01-S26-0584	+	-	-	-	-	-	-	+
8012-S27-6001	DA01-S27-0565	+	-	-	-	-	-	-	+
8012-S31-6001	DA01-S31-0545	+	-	+	+	+	-	-	+
8012-S43-6001	DA01-S43-0666	+	-	-	-	-	-	-	+
8012-S46-6001	DA01-S46-0706	+	-	-	-	-	-	-	+
8012-S49-6001	DA01-S49-0503	+	+	+	-	-	-	-	+
8012-S50-6001	DA01-S50-0524	+	+	-	-	-	-	-	+
8012-S51-6001	DA01-S51-0483	+	+	+	+	+	-	-	+
8012-S52-6001	DA01-S52-0726	+	+	+	-	-	+	-	+
8012-S53-6001	DA01-S53-0746	+	+	+	-	-	-	-	+
8012-S54-6001	DA01-S54-0766	-	+	+	-	-	-	-	+

TABLE 9-11

SORBENT PAD SAMPLE STATUS AND INVENTORY

SAMPLE ID	ALTERNATE ID	UV	GC	GCMS	IS1	IS2	IS12	ISA	TOC
7911-M25-7001	LH-11-30-79-M025	-	+	+	+	-	-	-	-
7911-M26-7001	LH-11-30-79-M026	-	+	-	-	-	-	-	-
7911-S15-7001	LH-11-18-79-S015	-	+	-	-	-	-	-	-
7911-S21-7001	LH-11-17-79-S021	-	+	+	+	-	-	-	-
7911-S27-7001	LH-11-17-79-S027	-	+	+	+	-	-	-	-
7911-S46-7001	LH-11-18-79-S046	-	+	+	+	-	-	-	-
7912-N20-7001	LH-12-9-79-N020	-	+	-	-	-	-	-	-
7912-N26-7001	LH-12-7-79-N026	-	+	-	-	-	-	-	-
7912-N27-7001	LH-12-7-79-N027	-	+	-	-	-	-	-	-

TABLE 9-12

SUMMARY OF SAMPLES ANALYZED

			NUMBER	PERCENT
CHEMISTRY SAMPLES				
Oil Samples	1979	Collected	30	100.0
		GC analysis	28	93.3
		GC/MS analysis	13	43.3
		Stable isotope analysis	18	60.0
	1980	Collected	23	100.0
		GC analysis	10	43.5
		GC/MS analysis	6	26.1
		Stable isotope analysis	0	0.0
Sediment Samples	1979	Collected	99	100.0
		UV analysis	89	89.9
		GC analysis	52	52.5
		GC/MS analysis	21	21.2
		TOC analysis	11	11.1
		Stable isotope analysis	19	19.2
	1980	Collected	44	100.0
		UV analysis	36	81.8
		GC analysis	31	70.5
		GC/MS analysis	19	43.2
		TOC analysis	36	81.8
		Stable isotope analysis	12	27.3
Tissue Samples	1979	Collected	65	100.0
		UV analysis	63	96.9
		GC analysis	22	33.8
		GC/MS analysis	10	15.4
	1980	Collected	51	100.0
		UV analysis	46	90.2
		GC analysis	24	47.1
		GC/MS analysis	7	13.7
Sorbent Pad Samples	1979	Collected	9	100.0
		UV analysis	0	0.0
		GC analysis	9	100.0
		GC/MS analysis	4	44.4
		Stable isotope analysis	4	44.4
	1980	Collected	0	-

TABLE 9-12 (Cont.)

			NUMBER	%
BIOLOGY SAMPLES	1979	Collected	72 (12 strains x 6 replicates)	100.0
		Analyzed	72 (12 strains x 6 replicates)	100.0
	1980	Collected	240 (40 strains x 6 replicates)	100.0
		Analyzed	240 (40 strains x 6 replicates)	100.0
SUPPORT WORK				
Grain Size Analysis	1979	Collected	72 (12 strains x 6 replicates)	100.0
		Analyzed	72 (12 strains x 6 replicates)	100.0
	1980	Collected	240 (40 strains x 6 replicates)	100.0
		Analyzed	240 (40 strains x 6 replicates)	100.0

9.2 Grain Size Analysis--Geomet Technologies

SECTION ONE

INTRODUCTION, SCOPE OF WORK

This report contains the procedures used for sediment particle size analysis performed at the request of Energy Resources Co. Inc. (ERCO; purchase order number 15813-8325).

Sediment samples were collected in conjunction with chemical and biological sampling in the Gulf of Mexico, December 1980 (cruise DA01). GEOMET Technologies, Inc. received the samples on January 7, 1981 and began the analysis soon after ERCO's examination and approval of the procedures (GTI 1981).

The particle size analysis has been taken largely from Buchanan and Kain (1971), Ingram (1971), and Galehouse (1971), with adaptations from various other sources. This analysis is the more traditional one; the coarse fraction (sand) is separated into component size classes with a series of sieves, and the fine fraction (silt and clay) is separated into component, size classes by the pipette method. Gravel (particles greater than 2 millimeters in diameter) was not separated but was reported as percent of the total sample weight.

Size classes were in 1/2-phi intervals from -1 (2.00-mm diameter particles) to +6 phi (0.016-mm diameter particles). Particles ranging in size from +6 to +10 phi (0.016 to 0.001-mm in diameter) were separated into 1-phi interval size classes. The weight composition of particles over 10 phi (finer than 0.001 mm in diameter) was estimated by extrapolation.

SECTION TWO

PROCEDURES

All steps in the sample analysis are described below.

A. Preliminary

1. Sample Inventory

1.1 Inventory the samples and record each on the Sample Progress Log. A copy of the completed inventory is provided in Appendix A.

1.2 Prepare a set of data sheets for each sample. A sample set of data sheets appears in Appendix B.

2. Quality Control Sample Selection

As part of the quality assurance program, 5 percent of the samples were chosen for replicate analysis. Replicate sample analysis provides a measure of the variability of the methods used in this analysis. A complete replicate analysis was not possible, however, on clean sands because the entire sample was needed for the first analysis. In these instances, the pipette (fine fraction) analysis was run twice from the same sample. This will provide some measure of variability of the more sensitive portion of the overall technique.

Other quality assurance measures include in-house monitoring of the technicians' work by the project manager and quality control officer, as well

as data checks spelled out in the rest of this report. The steps used to pick the samples for replicate analysis are given below.

2.1 From the random numbers table in Rohlf and Sokal (1969), choose a series of 3-digit numbers and record them on a sheet of paper.

2.2 Each of the sediment samples has a unique 3-digit number; match the random numbers, in order, to the sample inventory. Record those that correspond until a list of 12 corresponding numbers has been found.

2.3 Draw up a separate set of sample data sheets and a Sample Progress Log for those samples.

Replicate samples chosen were:

M05-0428	M05-0437	N39-0090	
M25-031	M25-0310	S05-0590	
N09-0054		S43-0649	S43-0658
N18-0148	N18-0154		

3. Sample Splitting

The samples were examined and it was found that some needed subsampling. Buchanan and Kain (1971) suggest a sample size which contains 25 grams of silt and clay and Galehouse (1971) suggests a sample size with approximately 10 grams of clay. The purpose of the subsampling performed here was to approximate these guidelines. Only the finer textured samples were split since the coarser ones were not expected to exceed the silt and clay weight guideline. The finer textured samples (silt/clay or muddy samples) were split by an adaptation of the one described in Folk (1974). The muddy sediments dry into a brick, so they must be subsampled while moist.

3.1 Transfer all but the mud samples from the Whirlpak to a 600-ml beaker or 16-oz jar. See Step 3.4 below for mud samples.

3.2 Label the beaker or jar with the sample identification number.

3.3 Place the samples in a 40° C oven until dry.

3.4 The mud samples are to be split right away. Empty a sample into a jar and mix thoroughly with a spatula.

3.5 With the spatula, take aliquots at random and place into a 600-ml beaker. The beaker can be set on a triple-beam balance. Enough sample should be taken to approximate 10 grams of clay.

Note: Be sure to take a second sample from those designated for replicate sample analysis.

3.6 Record the date, your initials, and the words "wet split" in the "sample split" column of the Sample Progress Log for all samples subsampled as in Steps 3.4 and 3.5 above.

3.7 Return the unused portion of all samples to a jar, and mark with its sample identification number.

3.8 Record the date, your initials, and the words "not split" in the "sample split" column of the Sample Progress Log for all samples not subsampled.

B. Sediment Particle Size Analysis

1. Sample Pretreatment: Digestion

1.1 Put 100 ml of 6 percent hydrogen peroxide in beakers with sandy samples.

1.2 Put a small quantity (5-10 ml) of 30 percent hydrogen peroxide in beakers containing mud samples. Add the hydrogen peroxide slowly to avoid bubbling-over.

1.3 Let the samples stand overnight.

1.4 Add a small quantity of additional hydrogen peroxide to test for the presence of additional organic matter. Continue adding small amounts of hydrogen peroxide if organic matter is still present.

1.5 When no more vigorous bubbling occurs, place the sample on a hot plate and bring to a brief boil.

1.6 After the digestion, add water to the samples, if necessary, to prevent drying out, and cover until ready for the next process. Note: any water used in this or subsequent steps of this procedure must be deionized water.

1.7 After the completion of a day's batch of samples, record the date and your initials in the "digested" column of the Sample Progess Log.

2. Sample Pretreatment: Salt Removal

2.1 Set up the Buchner funnel and suction apparatus. Use a 12.5-cm diameter funnel and Whatman No. 50 filter paper.

2.2 Wash the sample onto the pre-moistened filter in the Buchner funnel and rinse thoroughly under gentle suction. Be sure that the filter paper lies flat before pouring the sample.

2.3 With a spatula and a squirt bottle of water, scrape and wash the sandy samples off the filter and into a 300-ml labeled beaker. Use as little water as possible but remove as much of the fine sediment fraction as practicable. Sandy samples will be dried.

2.4 Scrape and wash the mud samples into prelabeled 16-oz. wide-mouth jars. Approximately 200 ml of water can be used for this purpose. These samples will not be dried.

2.5 After the completion of a day's batch of samples, record the date and your initials in the "salt removed" column of the Sample Progress Log.

2.6 Place the sandy samples in a 40° C oven and dry overnight. Cover the mud samples until ready for the next process.

2.7 Remove the sandy samples from the 40° C oven and allow to equilibrate for one hour.

2.8 Put the sandy samples into pre-labeled metal weigh-boats and weigh to the nearest tenth of a milligram. Record the weight in the "treated sample gross weight" columns of the sample data sheet.

2.9 Empty the sandy samples into 16-oz. wide-mouth jars and weigh the empty metal weigh-boats. Record this weight in the "treated sample boat weight" columns of the sample data sheet.

2.10 After the completion of a day's batch of dry weight determinations of the sandy samples, record the date and your initials in the "dried and weighed" column of the Sample Progress Log. Enter in this column the letters "ND" (not determined) for mud samples that were not dried and weighed.

3. Sample Pretreatment: Dispersal

3.1 To all samples add (or bring up to, in the case of the mud samples) 200 ml of water.

3.2 With a volumetric pipette, add to each sample a quantity of 10 percent sodium hexametaphosphate solution, in millilitres, equal to the estimated clay content, in grams. Be sure to mix the

solution thoroughly before use. Record the quantity (in volume) of dispersant added on the sample data sheet. Record the dispersant weight corresponding to the volume used. The paragraph at the end of this section describes the method of standardizing the dispersant.

3.3 Stir the sediment with the drill and stirring attachment for two minutes.

3.4 Let the samples stand overnight.

3.5 Transfer the sample to the blender cup and mix for 1 to 5 minutes (the finer sediments are mixed longer).

3.6 The samples are then transferred from the blender cup to the sieve in the next process.

Determining the Weight of Dispersant

When a new batch of sodium hexametaphosphate is made up, make sure it is thoroughly mixed before proceeding with this analysis.

With a volumetric pipette, measure out five separate 20-ml aliquots of the solution and put into pre-weighed aluminum boats. Rinse the pipette with an additional aliquot of deionized water and drain this into the appropriate boat. Next, treat the samples exactly as the regular pipette aliquots taken to estimate silt and clay weights (see Sections 6.9 and 6.10 below). The five weights are then averaged. Record all calculations and place in project folder.

4. Wet Sieving (Separation of Coarse and Fine Fractions)

4.1 Set up the wet-sieving apparatus. This consists of a large Buchner funnel to hold the sieve, a ringstand to hold the Buchner funnel, and squirt bottles filled with deionized water.

4.2 Pre-label some large (at least 1-litre capacity) plastic bottles which will hold the sample's fine fraction.

4.3 Place the appropriate bottle under the funnel and then pour the sample from the blender cup into the 63-micron sieve mounted in the funnel.

4.4 Wash the sediment retained on the sieve with water until all fine material has passed through. Do not allow the contents of the catch bottle to exceed 1,000 ml.

Note: If the amount exceeds 1,000 ml, then put the bottle in a 40° C oven to evaporate off the excess.

4.5 After washing, remove the sieve from the funnel and place in an oven set at 40° C.

4.6 Wash the Buchner funnel of trapped sediment and remove and cap the plastic bottle containing the fine fraction.

4.7 After the coarse fraction in the sieve has dried, remove and transfer the sand to a pre-labeled plastic boat. Work over a large piece of glossy paper to collect spilled sediment.

Note: to speed up the drying process, the bulk of the sand can be removed and put into a pre-labeled plastic boat before putting the sieve into the oven. After drying, the balance is put into the same boat.

4.8 Return the coarse fraction to the oven to allow it to dry thoroughly.

4.9 After the completion of a day's batch of dispersals and wet sievings, enter the date and your initials in the appropriate column of the Sample Progress Log.

5. Coarse Fraction Analysis

5.1 Remove the coarse fraction samples from the 40° C oven and allow them to equilibrate for one hour.

5.2 Weigh the samples to the nearest 0.1 mg and record the weight in the "gross coarse fraction weight" space of the sample data sheet.

5.3 Prepare the stack of sieves. Be sure they are in ascending numerical order, from top to bottom:

10, 14, 18, 25, 35, 45, 60, 80, 120, 170, 230, bottom pan (U.S.A. Series numbers).

There should be 11 sieves and a bottom pan.

5.4 Empty a sample into the top sieve and put the cover on the stack.

5.5 Place the sieve stack into the sieve shaker and make sure the top plate rim is flush with the upper carrying plate. Set the sieve shaker timer for 10 minutes.

Note: Once daily, the hammer drop distance should be checked (1 5/16 $\pm$ 1/16 inch) and if not correct, adjust as per the Operation. Maintenance, and Parts Manual.

5.6 Pre-label and pre-weigh 11 plastic boats and weigh the empty sample boat. Enter these weights, to the nearest tenth of a milligram, in the appropriate columns of the sample data sheet. Record the empty sample boat weight in the "gross coarse fraction boat weight" space.

5.7 When the time is up, remove the sieve stack and empty the contents of each into the pre-labeled, pre-weighed plastic boats.

Note: When emptying the sieves, work over a large sheet of glossy paper to catch spilled sediments and sediment dislodged while tapping the sieve. See page 33 of Folk (1974) for a sieve-emptying technique.

Do not use the brass wire brush on the number 120, 170, or 230 sieves. Use only the nylon brush, and gently so as not to stretch the wire mesh.

5.8 Empty the contents of the bottom pan into the corresponding sample's fine fraction bottle. Note on the sample data sheet if an excessive amount of material (>1-2 gm) is in the bottom pan.

5.9 Weigh each boat to the nearest 0.1 mg and record the weights in the appropriate columns of the sample data sheets.

5.10 Examine each fraction and note the relative proportion of shell and clumped material and record on the sample data sheet.

Note: If aggregates appear, then refer to Folk (1974), page 34 for the method of estimating percent aggregation. If a fraction has over 25 percent aggregated, and if the fraction contains a significant portion (>1 gm) of the total weight, then the sample will have to be re-dispersed (Step 3.5 above; add some of the top liquid from the sample's fine fraction, mix in the blender, and proceed through the analysis). Note on the sample data sheet that the sample had to be re-dispersed.

5.11 Perform data check as described in Section C.1 before discarding samples.

5.12 After the completion of the day's batch of dry sievings, enter the date and your initials in the appropriate column of the Sample Progress Log.

6. Fine Fraction Analysis: Constant-Temperature Water Bath Assembly

6.1 Assemble the following equipment for the constant-temperature water bath:

1 65-gallon insulated tank (Frigid Units, Inc. MT-500)
1 equipment rack to straddle the tank
1 1,000-W heating element (Thermo-Quartz QHL 12-7)

1 Temperature Controller (YSI model 63RC)
1 temperature sensor (YSI no. 633)
1 circulating water pump and 4 feet of plastic tubing
1 mercury thermometer (ASTM 93 C, +0.1° C)
1 Scanning Tele-Thermometer (YSI model 477)
3 temperature probes (YSI no. 403)
1 recorder (YSI model 80A)
2 1-litre graduated cylinders

6.2 The constant-temperature water bath is set up and stabilized before beginning the fine fraction analysis. Place the tank at a convenient height and fill with water.

6.3 Place the equipment rack on the tank and secure the circulating water pump with a ringstand and clamp. The pump intake should be well below the water level but not so low that when the cylinders are put in the tank the level rise does not wet the electrical portion of the pump.

6.4 Put the plastic tubing over the pump outflow tube and place the tubing along the bottom corner of the tank. The purpose of the tube is to direct the water flow to the side of the tank opposite the pump intake. This will set up a gentle circulation throughout the tank. Secure the tube with some lead weights.

6.5 Place the heating element under the pump intake but above the tank bottom. Secure to the equipment rack.

6.6 Put the Temperature Controller on the equipment rack and connect the heating element.

6.7 Set a graduated cylinder filled with distilled water into the water bath. Put the temperature sensor into the cylinder and connect it to the Temperature Controller.

6.8 Set up the Scanning Tele-Thermometer; put one probe in the cylinder with the temperature sensor, and another in a cylinder situated at the opposite end of the water bath. A third probe is set up to monitor air temperature.

6.9 Connect the recorder to the Scanning Tele-Thermometer.

6.10 Turn all the equipment on and set the Temperature Controller so that the heating element is on. When the temperature reaches 24° C, adjust the Temperature Controller so that the relay opens (turning off the heating element).

6.11 Adjust position of the recorder stylus and check the calibration of the Scanning Tele-Thermometer.

6.12 Let the recorder run continuously to monitor the temperature in the water bath for at least two days before beginning the pipette analysis. The temperature should not vary by more than 1° C.

7. Fine Fraction Analysis

7.1 Empty the contents of the bottle holding the fine fraction into a 1-litre, graduated cylinder. Be sure to get all sediment particles out of the bottle, but do not exceed the 1,000-ml limit.

Note: If the 1,000-ml limit is exceeded, return the sample to its bottle and place it, with the top off, into a 40° C oven. Leave it in until it has evaporated down below 1,000 ml.

7.2 Put the sample in the constant-temperature water bath. Let the sample stand overnight and check for flocculation (see page 70 of Galehouse, 1971). Take any of the suggested steps to correct the problem.

7.3 Prepare all materials needed for the pipette analysis. Check the temperature of the water bath with a calibrated mercury thermometer. The temperature should be between 23 and 24° C. Set up the vacuum pump and volumetric pipette (20 ml), then check clock and timing mechanism. Pre-weigh and pre-label enough 50-ml aluminum boats.

7.4 Mix the sample, by either inverting end over end (stopped cylinders) or by pushing the stirring rod up and down (regular cylinders), for two minutes.

7.5 Begin timing as soon as the cylinder is upright or just after the last stroke of the stirring rod, and at 10 seconds insert the pipette to a depth of 20 centimeters. After 20 seconds have elapsed, begin drawing up the 20-ml aliquot.

Note: The 20-ml aliquot (and all subsequent ones) should be taken within 10 seconds.

7.6 Empty the pipette sample into one of the pre-labeled and pre-weighed aluminum boats and then take a 10- to 20-ml sample of water for rinsing and drain this into the same boat.

7.7 Take the water bath temperature with a mercury thermometer and enter on the sample data sheet.

7.8 Take the seven additional 20-ml aliquots according to the schedule below (taken in part from Galehouse 1971):

For ϕ finer than	Withdrawal Depth (cm)	Elapsed Time for 24° C
4.0	20	20s
4.5	20	1m 44s
5.0	15	2m 36s
5.5	10	3m 27s
6.0	10	6m 55s
7.0	10	27m 39s
8.0	5	55m 18s
9.0	5	3h 41m
	reshake	
10.0	5	14h 45m

7.9 At the end of the day, shake the samples again for two minutes. The last aliquot will be extracted after sitting overnight.

7.10 At the end of 14 hours and 45 minutes, take the last aliquot.

Note: Record the temperature at the end of the analysis. If a change greater than one degree is noted, the sample will have to be redone.

7.11 All samples are dried overnight in a 90° C oven. Put them into a 105° C oven for at least 24 hours after that.

7.12 Allow the boats to equilibrate to room temperature for one hour and weigh them to the nearest 0.1 mg. Record the weights in the appropriate columns of the sample data sheet.

7.13 Before discarding the remaining sample, proceed to the next step and make sure it is not one of the predesignated replicate analysis sand samples. If it is, repeat Steps 7.4 through 7.12 and enter the results on the replicate sample data sheets.

7.14 Perform data check as described in Section C.2 below.

C. Quality Control Checks

1. Sieve Loss Check

Some loss of sediment is expected (usually less than 1 gram). An unusually high loss, though, can be an indication of a weighing error.

1.1 On the sample data sheet, perform the subtractions of all the particle size classes and sum them up. (This is the final coarse fraction weight.)

1.2 Subtract the coarse fraction boat weight from the gross coarse fraction weight. (This is the initial coarse fraction weight.)

1.3 Subtract the final from the initial coarse fraction weight. This difference, plus the estimated silt/clay fraction in the bottom pan, should be no more than 1-2 grams.

1.4 If this difference is significantly greater than 2 grams, and cannot be explained by a heavy bottom pan sample, as required to be noted in B.5.8 above, then reweigh the individual fractions.

2. Total Fine Fraction Weight Check

This check monitors the pipette analysis, which is sensitive to temperature and operator technique.

2.1 Calculate the estimated fine fraction weight by subtracting the actual coarse fraction weight from the initial sample weight.

Note: This check cannot be performed on mud samples since no initial weight was obtained.

2.2 Calculate the actual fine fraction weight by first subtracting the boat weight from the gross weight of the initial pipette aliquot. Then multiply by 50, and finally subtract the dispersant weight.

2.3 Compare the estimated fine fraction weight and the actual one. The actual weight should only be a few grams less than the estimated one. This difference can be somewhat greater than 2 grams in very muddy samples, however, but this does serve as a check for gross weighing errors.

2.4 If the actual weight is much less than the estimated weight, the sample should be rechecked to see if it had been properly dispersed (see Section 7.2). The first pipette sample (20 second) may have to be retaken if the dispersion checks out.

3. Individual Fine Fraction Weight Checks

3.1 Calculate the individual aliquot net weights by subtracting boat from gross weight.

3.2 Compare all the aliquot net weights. They should be in decreasing magnitude, from the first to last sample.

3.3 If there are exceptions then apply the following test: subtract the weight that increases from the one immediately preceding it. If the difference is less than 2 milligrams (0.002), then it is within normal equipment error providing that very little sediment was expected in the affected weight class. The amount expected can be estimated by observing the weight classes around the affected one. If their values are close, i.e., within 20 milligrams, then the amount expected is small. If, on the other hand, the weight class was expected to be significant (greater than 20 milligrams), then the questionable aliquot will have to be reweighed. If the weight checks out, then the sample should be retaken.

3.4 If an increase in the time sequence of aliquot weights is much greater than 2 milligrams, then the boat should be reweighed or the sample retaken.

4. Keypunching Check

4.1 The individual size class weights as calculated on the sample data sheet for the coarse fraction (see 1.1 above) can be compared directly

with the computer program output size class weights (the intermediate output of the reformatting program). The keypunching can be assumed to be correct for all those that match. Any discrepancies may be traced to either a keypunch or hand calculation error.

4.2 The fine fraction weight, as calculated on the sample data sheet (see 2.2 above), should be compared to the sum of the silt and clay weights reported on the intermediate computer program output. Again, any discrepancies may be traced to either a keypunch or hand calculation error.

D. Statistical Parameters of Grain Size

1. Statistical Formulas for Grain Size

A good reference for the description and merits of some of the various grain size statistics is given in Folk and Ward (1957).

The program used to calculate the wide range of statistics given in this report was provided by Dr. S.A. Bloom of the University of Florida. His program has been extensively modified by GTI, however, to accommodate the extra size classes needed in the present project. Dr. Bloom's program is a part of a larger package of programs to analyze benthic communities, a description of which can be found in Bloom, Santos, and Field (1977).

The formulas used to calculate the various parameters are given below. The phi (ϕ) values used in the formulas are interpolated by the computer program from a plot of straight lines connecting points in a cumulative frequency curve.

1.1 Central Concern Formulas

a. Mean: $\phi 50$
b. Sorting coefficient: $(\phi 84-\phi 16)/2$
c. Skewness: $(\phi 75-\phi 25)/2-\phi 50$
d. Kurtosis: $(\phi 95-\phi 5)/(2.44[\phi 75-\phi 25])$

1.2 Moderately Peripheral Formulas

a. Mean: $(\phi 25 + \phi 50 + \phi 75)/3$
b. Sorting coefficient: $(\phi 95 - \phi 5)/3.3$
c. Skewness: $([\phi 84 + \phi 16] - 2\phi 50)/(\phi 84 - \phi 16)$
d. Kurtosis: same as 1.1.d.

1.3 Extreme Peripheral Formulas

a. Mean: $(\phi 16 + \phi 50 + \phi 84)/3.0$
b. Sorting coefficient: $(\phi 95 - \phi 5)/6.6 + (\phi 84 - \phi 16)/4$
c. Skewness: $(\phi 16 + \phi 84 - 2\phi 50)/(2[\phi 84 - \phi 16])+$
$(\phi 5 + \phi 95 - 2\phi 50)/(2[\phi 95 - \phi 5])$
d. Kurtosis: Same as 1.1.d.

2. Suggested Verbal Scales for the Description of Grain Size Statistics

The following scales are taken from Folk (1974).

2.1 For sorting (inclusive Graphic Standard Deviation):

<0.35 ϕ = very well sorted
0.35 - 0.50 ϕ = well sorted
0.50 - 0.71 ϕ = moderately well sorted
0.71 - 1.00 ϕ = moderately sorted
1.00 - 2.00 ϕ = poorly sorted
2.00 - 4.00 ϕ = very poorly sorted
>4.00 ϕ = extremely poorly sorted

2.2 For skewness (inclusive Graphic Skewness):

+1.00 to +0.30 = strongly fine-skewed
+0.30 to +0.10 = fine-skewed
+0.10 to -0.10 = near-symmetrical
-0.10 to -0.30 = coarse-skewed
-0.30 to -1.00 = strongly coarse-skewed

2.3 For Kurtosis (Graphic Kurtosis):

<0.67 = very platykurtic
0.67 - 0.90 = platykurtic
0.90 - 1.11 = mesokurtic
1.11 - 1.50 = leptokurtic
1.50 - 3.00 = very leptokurtic
>3.00 = extremely leptokurtic

E. Equipment List and Calibration Schedules

Following is a list of the major equipment used in the analysis. Calibration procedures are described.

1. Sieve Shaker

RO-TAP Testing Sieve Shaker, Model B, W.S. Tyler, Incorporated. Calibration: hammer drop is adjusted, as per Operation, Maintenance, and Parts Manual, before use and periodically checked during operation.

2. Sieves

U.S. Standard Sieve Series, A.S.T.M. E-11 specifications, W.S. Tyler, Company (8-inch diameter brass nesting sieves with top cover and bottom pans). Sieves are periodically checked for signs of mesh distortion.

3. Ovens

a. THELCO, model numbers 18 and 28

b. STABIL-THERM, Blue M Electric Company
c. IMPERIAL II, LAB-LINE Instruments, Inc.

Calibration: Temperature is checked daily with a top-mounted mercury thermometer, 1° C divisions, and adjusted as necessary.

4. Balances

SARTORIUS, model numbers 2462 and 2432, Brinkman Instruments, Inc.

Calibration: the scale is zeroed at least daily. Weekly, the scales are checked with a set of laboratory standards (Class S specifications of the National Bureau of Standards, manufactured by the Fisher Scientific Company). Standards are 1, 5, 50, and 100 grams. The balances are always adjustable to less than 0.0001 gram deviation from these standards. All calibration activity is noted on the Balance Calibration Log.

5. Thermometers

YSI Model 47 Scanning Tele-Thermometer

Calibration: period checks with a mercury thermometer factory calibrated to $\pm$0.1° C. The temperature difference is recorded once daily in the YSI-47 Calibration Log.

F. References

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9.3 Biological Assessment LGL Ecological Research

9.3.1.1 Introduction

During the December 1980 LGL/ERCO cruise following the Ixtoc I oil spill in the Bay of Campeche, Mexico, benthic infaunal samples were collected at 40 stations along the south Texas outer continental shelf. Twelve of these stations had been visited previously as part of the South Texas Outer Continental Shelf (STOCS) baseline studies program by the Bureau of Land Management as well as by the mid-spill Regional Response Team (RRT). Data from these twelve stations were used to compare pre-spill, mid-spill and post-spill conditions. Macroinfaunal community studies at these twelve stations are discussed in detail in Section 4. The remaining 28 stations had not been sampled for macroinfauna prior to the December 1980 cruise. Two of these 28 stations were immediately adjacent to the site of the 1979 collision and fire of the oil tanker Burmah Agate, and will be treated in Appendix 9.3.2. A summary of findings from the other 26 stations (called "new" stations herein to avoid confusion) is presented in the following sections. No historical infaunal data are available to the authors for any of the new stations, thus precluding comparisons with pre- and mid-spill conditions (Donald Harper, pers. comm., December 1981).

The 26 new stations were scattered throughout the region in which the twelve previously sampled stations were located. Fifteen of the new stations lay shoreward of the shallowest of the twelve STOCS/RRT/LGL-ERCO stations (10 m depth), providing collections from the 4.5 m to 9 m depth range, which was not sampled in earlier programs (Table 9-13, Figure 9-1). The twelve previously sampled stations and 26 new stations form a more-or-less synoptic group of samples from the same geographic region. This discussion therefore emphasizes similarities and differences within the set of 38 stations, viewed as a single collection rather than as two artificially separated data sets.

9.3.1.2 Methods and Approaches

Methods used for sample collection and analysis and data analysis for the 26 new stations were identical to those used for the twelve previously sampled stations. The 26 new stations yielded a total of 156 grab samples for laboratory analysis of macroinfauna. Please refer to Section 4.2 for a complete discussion of methods. The data set for twelve previously sampled stations plus 26 new stations included 15,646 individuals; a minimum cutoff of 1% (156 individuals) was used arbitrarily to define numerically dominant taxa for community summary graphics. This cutoff level was selected in the interests of consistency (18 taxa included) with previous analyses of the entire 1976-1980 data set, which also used a 1% cutoff for community summary graphics and which also included 18 taxa, (Figure 4-9). Presence/absence descriptions were believed to benefit from the inclusion of a larger number of taxa, and therefore we used a cutoff level of 0.1% (15 individuals) to provide consistency (88 taxa included) with previous presence/absence analyses (which included 72 numerically dominant taxa at a cutoff level of 0.2%, Figures 4-48 and 4-49).

Table 9-13. Station location and depth.

Station	Latitude	Longitude	Depth (m)
S-4	26°39'12"	96°48'48"	55
S-5	26°39'00"	97°00'00"	37
S-15	26°03'12"	97°08'00"	9
S-18	26°19'24"	97°05'30"	18
S-21	26°23'30"	97°12'30"	9
S-26	26°38'30"	97°12'24"	18
S-27	26°38'12"	97°17'12"	9
S-31	26°47'54"	97°20'12"	9
S-43	26°23'30"	97°12'42"	4.5
S-46	26°10'00"	97°09'48"	4.5
M-14	27°18'18"	97°15'00"	18
M-15	27°18'18"	97°19'42"	9
M-21	27°32'24"	97°13'30"	9
M-4	27°17'00"	96°48'42"	55
M-5	27°17'12"	96°59'00"	37
M-24	27°40'48"	97°02'24"	18
M-25	27°41'24"	97°08'12"	9
M-26	27°41'24"	97°08'30"	4.5
M-28	27°32'24"	97°13'54"	4.5
N-3	27°41'12"	96°30'30"	55
N-4	27°49'00"	96°33'42"	37
N-9	28°16'18"	96°28'18"	9
N-18	28°00'00"	96°43'24"	18
N-19	28°01'54"	96°51'30"	9
N-32	28°02'12"	96°51'48"	4.5
N-37	28°17'30"	96°28'42"	4.5

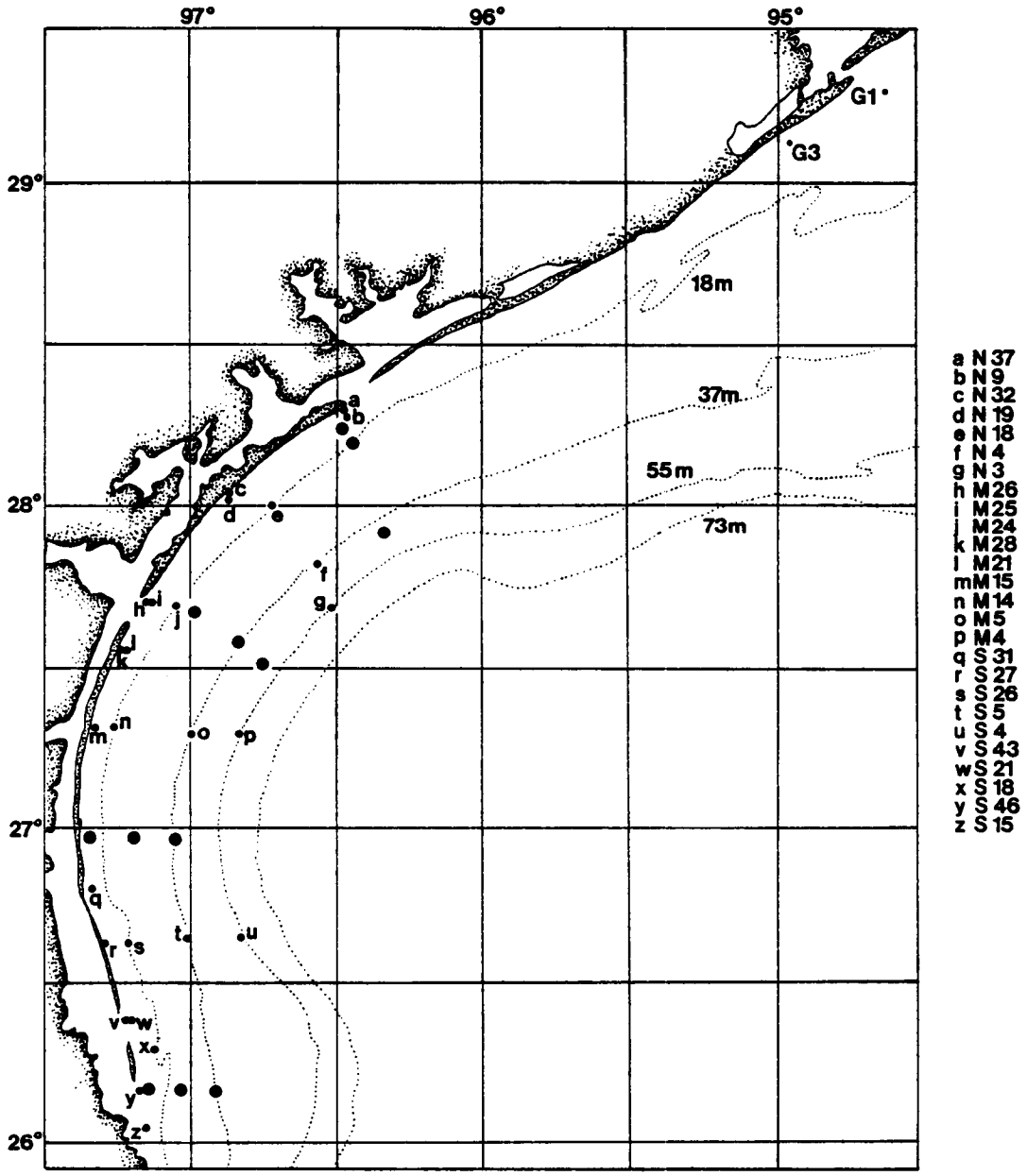


Figure 9-1. Map of 1980 LGL/ERCO stations (small dots identified by letter, legend at right) and Burmah Agate stations (G1 & G3); STOCS/RRT/LGL-ERCO (large dots, added for convenience) (see Fig 4-1 for STOCS/RRT/LGL-ERCO station codes).

9.3.1.3 Results

LGL identified 208 taxa of macroinfaunal invertebrates in the 156 samples from the 26 new stations (Table 9-14). A total of 12,300 individual organisms were present in the samples from the new stations, averaging 473 individuals per station. In comparison, samples from the twelve previously sampled stations included 127 macroinfaunal taxa consisting of 3,346 organisms, averaging 279 individuals per station. Taken together, all 38 stations included 222 taxa, comprised of 15,646 individuals. The greater average number of individuals per station among new stations was largely due to the samples being collected from the middle (M) and southern (S) series of shallow and nearshore stations; for example, samples from new stations S-18, S-26, and S-31 occupied first, second, and third place (respectively) in terms of numbers of taxa, and second, first, and third place (respectively) in terms of numbers of individuals (Table 9-15). New stations located at comparable depths to the twelve previously sampled stations produced roughly equivalent numbers of individuals (Figure 9-2).

Most of the taxa identified at the twelve previously sampled stations in 1980 were also present at the new stations. The great majority of taxa were quite rare. For example, 87 of the 222 taxa in samples from all 38 stations were represented by five or fewer individuals, and 41 taxa were represented by only a single individual. Only 27 taxa included more than 100 individuals.

Cluster analysis based upon relative abundance of taxa was performed using all taxa at all 38 stations together (Figure 9-3). Four distinct groups were evident at a similarity index level of 0.85. Three of the groups matched the nearshore, intermediate, and offshore sets of stations recognized in Figure 4-58 (q.v.). For example, the offshore set elucidated by cluster analysis performed on just the 1980 data from the twelve previously sampled stations included the outer stations of Transects I and II (Stations I-2 and II-2). Cluster analysis on all 38 stations again separated Stations I-2 and II-2 from the other twelve previously sampled stations, but included two adjacent new stations (N-3 and M-4) in the cluster. Similarly, the intermediate cluster indicated by analysis of 1980 data from the twelve previously sampled stations included four stations (II-4, III-1, III-5, and IV÷5); cluster analysis on all 38 stations again grouped these four stations together along with four nearby new stations (N-4, M-5, S-4, and S-5). The nearshore cluster derived from 1980 data from the 12 previously sampled stations included six stations (I-4, I-1, II-1, III-4, IV÷4, and IV-1); cluster analysis on all 38 stations once again grouped these six stations together, but also included seven other nearshore new stations (N-9, N-18, M-14, M-21, M-24, S-18, and S-26). A fourth group of 13 stations emerged from the cluster analysis on all 38 stations together. This fourth group consisted solely of new stations located in shallow water (station depths 4.5 m and 9 m).

Distinct faunal differences were evident from one group of stations to the next. The shallow cluster of stations had the highest relative diversity ($H' = 3.27$) and second highest evenness indices ($V' = 0.64$). Due in part to the inclusion of the greatest number of stations (13), the shallow group included 144 taxa comprised of 7,437 individuals (averaging

Table 9-14. Taxonomic checklist for 1980 LGL/ERCO samples from 26 new stations. Equivalent University of Texas (STOCS) names are in parentheses.

PHYLUM CNIDARIA
- CLASS Hydrozoa
  - Suborder Gymnoblastea
    - Tubularidae
      - *Ectopleura grandis* (*Tubularia* sp.--UT)
  - Suborder Calyptoblastea
    - Campanulinidae
      - *Lovenella grandis*
- CLASS Anthozoa
  - Order Pennatulacea
    - *Virgularia mirabilis* (sea pen, unid.--UT)
    - Renillidae
      - *Renilla mulleri*
  - Order Zoanthidea
    - *Palythoa texaensis*
  - Order Ceriantharia
    - Ceriantharian (unid.)

PHYLUM NEMERTINEA
- Miscellaneous nemerteans (unid.)

PHYLUM NEMATODA
- Miscellaneous nematodes (unid.)

PHYLUM PHORONIDA
- Miscellaneous phoronids (unid.)

PHYLUM MOLLUSCA
- CLASS Gastropoda
  - Vitrinellidae
    - *Cyclostremiscus pentagonus*
    - *Vitrinella floridana*
  - Melanellidae
    - *Liostraca bilineata*
  - Aclididae
    - *Bermudaclis* sp.
  - Naticidae
    - *Natica pusilla*
    - *Polynices duplicatus*
    - *Sinum perspectivum*
  - Columbellidae
    - *Anachis avara*
    - *Anachis obesa*
  - Nassariidae
    - *Nassarius acutus*
  - Olividae
    - *Oliva sayana*
    - *Olivella dealbata*
  - Turridae
    - *Kurtziella cerinella*

Table 9-14 (cont'd)

Terebridae
Terebra protexta
Pyramidellidae
Odostomia acutidens
Turbonilla interrupta
Cylichnidae
Cylichnella bidentata
Retusidae
Volvulella persimilis
Volvulella texasiana
Aglajidae
Aglaja sp. nov.

CLASS Scaphopoda
Siphonodentaliidae
Cadulus carolinensis
Dentaliidae
Dentalium eboreum

CLASS Pelecypoda
Nuculidae
Nucula aegeensis
Nuculanidae
Nuculana acuta
Nuculana concentrica
Arcidae
Anadara ovalis
Anadara transversa
Lucinidae
Lucina amiantus
Ungulinidae
Diplodonta cf. *punctata*
Tellinidae
Macoma tenta
Macoma sp.
Tellina aequistriata
Tellina sybaritica
Tellina versicolor
Semelidae
Abra aequalis
Veneridae
Chione clenchi
Chione grus
Dosinia discus
Pitar cordatus
Petricolidae
Petricola pholadiformis
Corbulidae
Corbula caribaea
Corbula dietziana
Gastrochaenidae
Gastrochaena hians

Table 9-14 (cont'd)

PHYLUM ANNELIDA
CLASS Polychaeta
Polynoidae
Lepidasthenia maculata
Eulepethidae
Grubeulepis mexicana
Sigalionidae
Sthenelais limicola
Palmyridae
Bhawania goodei
Amphinomidae
Linopherus ambigua
Phyllodocidae
Eteone lactea
Phyllodoce mucosa
Pilargiidae
Cabira incerta
Litocorsa stremma
Pilargis berkelyae
Sigambra bassi
Sigambra tentaculata
Hesionidae
Gyptis brevipalpa
Syllidae
Exogone dispar
Exogone verugera
Nereidae
Nereis cf. *grayii*
Nereis lamellosa
Nereis micromma (Nereidae [*Nicon*] sp. A--UT)
Nereis succinea
Nereis sp. D
Nephtyidae
Aglaophamus verrilli
Nephtys incisa
Nephtys picta
Glyceridae
Glycera americana
Glycera sp. A
Goniadidae
Goniada littorea
Ophioglycera sp.
Eunicidae
Marphysa sp. A
Onuphidae
Diopatra cuprea
Onuphis sp. A
Onuphis sp. B
Onuphis sp. C
Lumbrineridae
Lumbrineris cruzensis (*L.* cf. *magalhaensis*--UT)
Lumbrineris ernesti (*L. tenuis*--UT)

Table 9-14 (cont'd)

Lumbrineris januarii
Lumbrineris sp. nov. (L. parvepedata--UT)
Ninoe nigripes
Arabellidae
Arabella iricolor
Drilonereis magna
Dorvilleidae
Schistomeringos rudolphi
Spionidae
Apoprionospio pygmaea
Laonice cirrata
Malacoceros sp.
Paraprionospio pinnata
Prionospio cirrobranchiata (Minuspio cirrifera--UT)
Prionospio cristata
Prionospio steenstrupi
Scolelepis sp.
Spiophanes bombyx
Magelonidae
Magelona cincta
Magelona longicornis
Magelona pettiboneae
Magelona phyllisae
Magelona sacculata
Cirratulidae
Chaetozone corona (C. setosa--UT)
Tharyx marioni
Tharyx setigera
Heterospionidae
Heterospio longissima
Cossuridae
Cossura delta
Orbiniidae
Haploscoloplos foliosus
Haploscoloplos fragilis
Scoloplos rubra
Paraonidae
Aricidea finitima
Aricidea fragilis
Aricidea taylori
Aricidea sp.
Paraonides lyra
Paraonis gracilis
Opheliidae
Armandia agilis
Armandia maculata
Capitellidae
Mediomastus californiensis
Notomastus hemipodus
Notomastus cf. latericeus
Maldanidae
Asychis carolinae

Table 9-14 (cont'd)

Clymenella torquata
Oweniidae
Owenia fusiformis
Sabellaridae
Sabellaria vulgaris vulgaris
Pectinariidae
Pectinaria gouldii
Ampharetidae
Ampharete acutifrons
Ampharete parvidentata
Isolda pulchella
Melinna maculata
Terebellidae
Loimia viridis
Pista quadrilobata
Polycirrus cf. carolinensis
Sabellidae
Chone filicaudata

PHYLUM SIPUNCULA
Phascolion sp.
Miscellaneous sipunculids (unid.)

PHYLUM ARTHROPODA
CLASS Crustacea
SUBCLASS Ostracoda
Miscellaneous ostracods (unid.)
SUBCLASS Malacostraca
Order Mysidacea
Bowmaniella brasiliensis
Bowmaniella cf. portoricensis
Mysidopsis bigelowi
Order Cumacea
Cyclaspis varians
Cyclaspis sp. B
Eudorella monodon
Oxyurostylis sp.
Order Tanaidacea
Apseudes sp. A
Kalliapseudes sp.
Typhlapseudes sp.
Order Isopoda
Anthuridae
Xenanthura brevitelson
Idoteidae
Edotea montosa
Sphaeromatidae
Ancinus depressus
Order Amphipoda
Caprellidae
Paracaprella pusilla
Ampeliscidae

Table 9-14 (cont'd)

- *Ampelisca agassizi*
- *Ampelisca verrilli*
- *Ampelisca* sp. B
- *Ampelisca* sp.

Oedicerotidae
- *Monoculodes nyei* (*Monoculodes* sp. B--UT)
- *Synchelidium americanum*

Corophiidae
- *Grandidierella* sp.
- *Neomegamphopus* sp.
- *Photis melanicus* (*Photis* sp. B--UT)

Lysianassidae
- *Hippomedon* cf. *serratus*

Bateidae
- *Batea* sp.

Synopiidae
- *Tiron tropakis*

Liljeborgiidae
- *Listriella barnardi*
- *Listriella* sp. A

Phoxocephalidae
- *Trichophoxus floridanus* (*Paraphoxus epistomus*--UT)

Haustoriidae
- *Acanthohaustorius millsi*
- *Platyischnopus* sp.
- *Protohaustorius bousfieldi*

Amphilochidae
- Amphilochid sp. A

Order Decapoda

Penaeidae
- *Trachypenaeus constrictus*

Sicyoniidae
- *Sicyonia dorsalis*

Sergestidae
- *Acetes americanus*

Pasiphaeidae
- *Leptochela serratorbita*

Alpheidae
- *Alpheus* sp. A
- *Alpheus* sp. B
- *Automate* sp.

Ogyrididae
- *Ogyrides limicola*

Processidae
- *Processa* sp.

Paguridae
- *Pagurus* cf. *bullisi*

Albuneidae
- *Albunea paretii*

Leucosiidae
- *Persephona crinita*
- *Persephona mediterranea*

Table 9-14. (cont'd)

Majidae
Libinia emarginata
Xanthidae
Hexapanopeus angustifrons
Goneplacidae
Chasmocarcinus mississippiensis
Speocarcinus lobatus
Pinnotheridae
Pinnixa cf. *retinens*
Pinnixa sp.

PHYLUM ECHINODERMATA
CLASS Ophiuroidea
Amphiuridae
Micropholis atra
Ophiactidae
Hemipholis elongata
CLASS Echinoidea
Order Clypeasteroida
Melitidae
Mellita quinquiesperforata
Order Spatangoida
Schizasteridae
Moira atropos
CLASS Holothuroidea
Order Dendrochirotida
Cucumariidae
Pentamera pulcherrima
Thione mexicana
Order Apodida
Synaptidae
Protankyra cf. *benedeni*

Table 9-15. Numbers of taxa and individuals, by station.

Station No.	No. of Taxa	No. of Individuals
M-4	15	85
M-5	12	61
M-14	31	665
M-15	59	428
M-21	52	612
M-24	29	366
M-25	52	592
M-26	50	574
M-28	66	701
N-3	29	57
N-4	25	100
N-9	35	253
N-18	40	335
N-19	40	305
N-32	34	239
N-37	43	493
S-4	27	88
S-5	23	138
S-15	46	385
S-18	101	989
S-21	57	665
S-26	75	1114
S-27	59	702
S-31	68	912
S-43	57	766
S-46	44	675

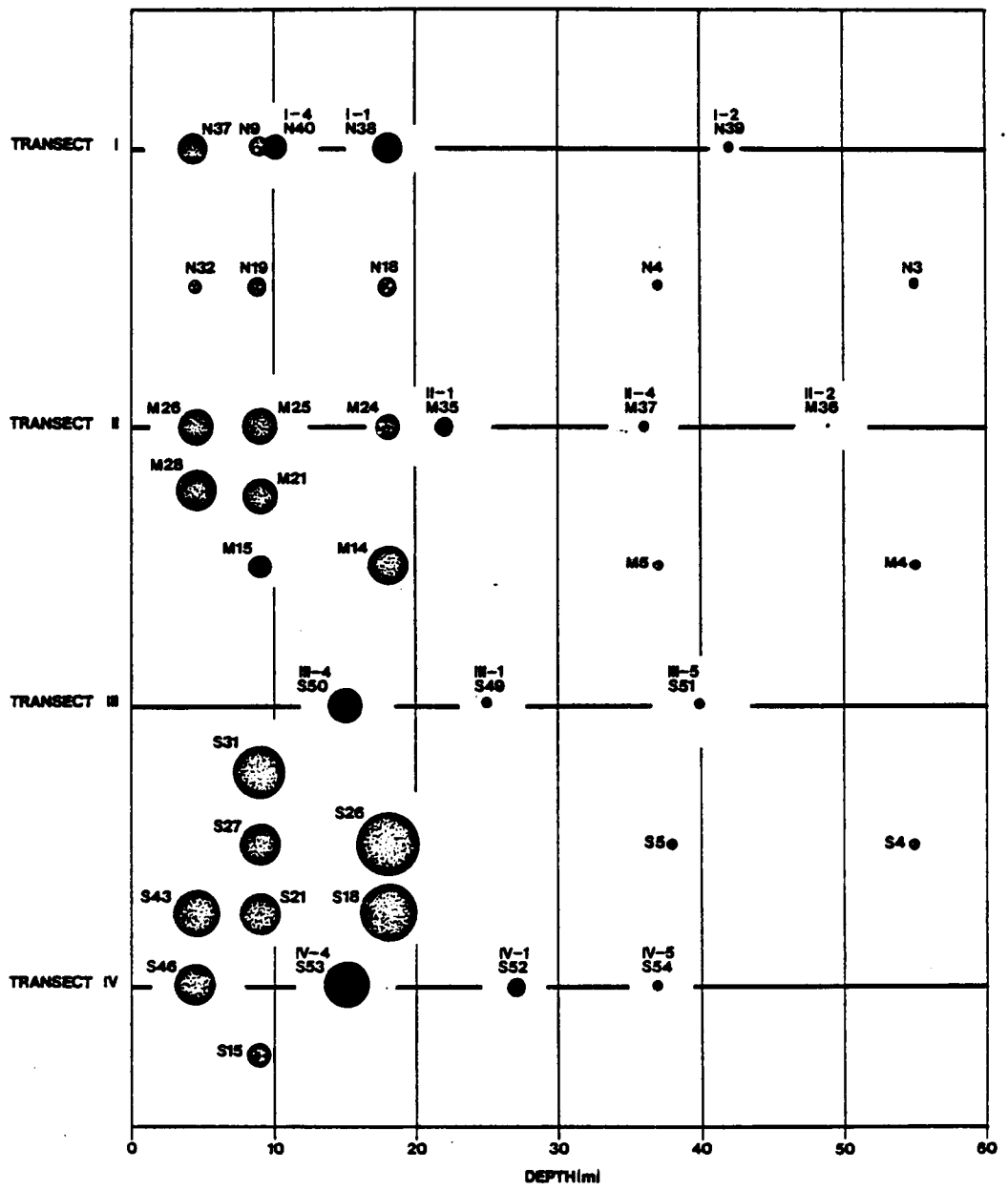


Figure 9-2. Schematic map of station locations and depths; circle diameter is directly proportional to macroinfaunal abundance: 1 mm - 100 individuals.

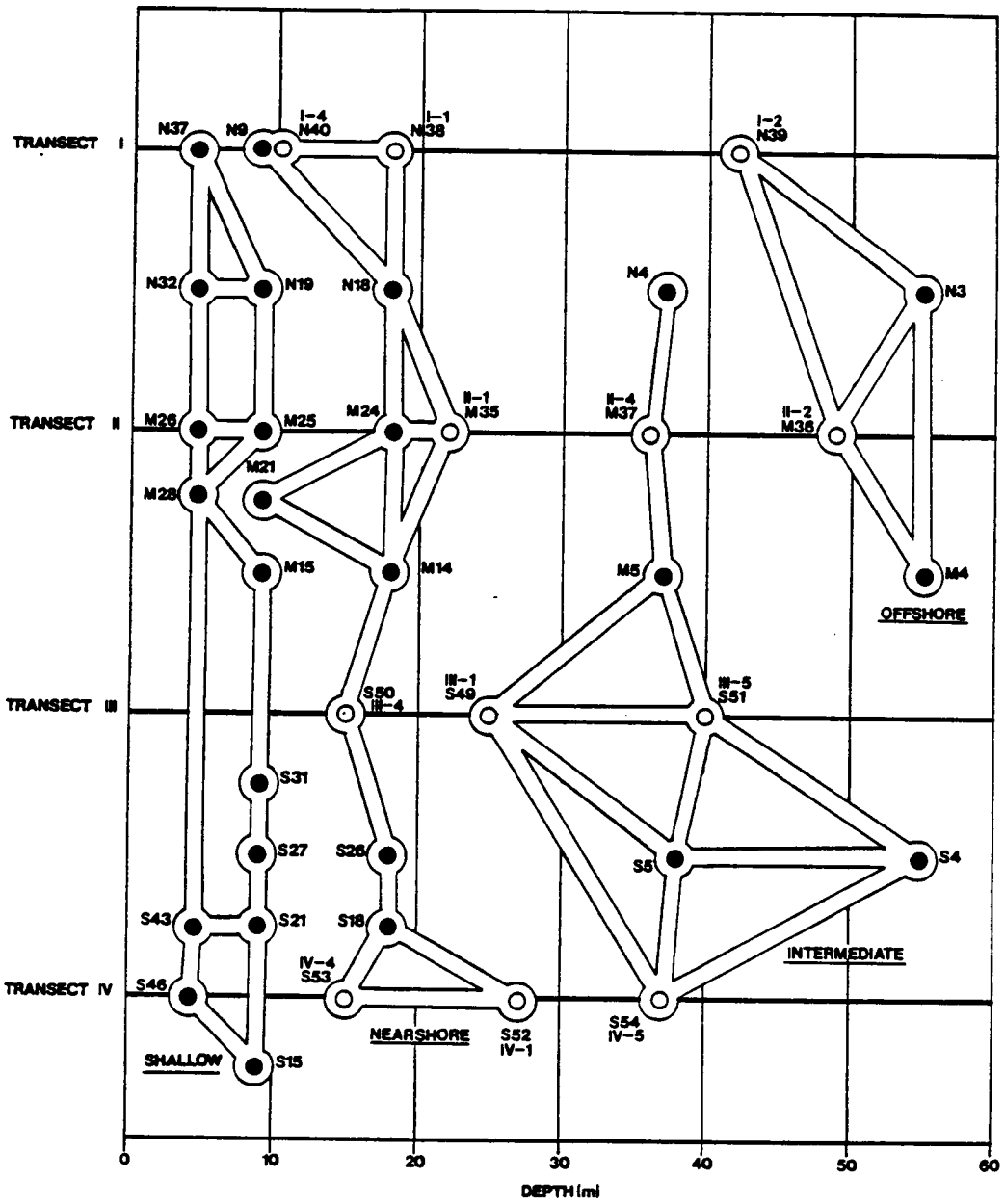


Figure 9-3. Schematic map of station groupings derived from cluster analysis of taxa abundance, at a similarity index level of 0.85; solid dots = "new" stations.

11.1 taxa and 527 organisms per station). The numerically dominant organism was the spionid polychaete Apoprionospio pygmaea, followed by the lumbrinerid polychaete Lumbrineris sp. nov. and the naticid gastropod Natica pusilla . The most abundant organisms in the shallow cluster were carnivorous and omnivorous polychaetes, deposit-feeding polychaetes, and gastropods, in order of decreasing abundance (Figure 9-4).

A presence/absence association listing based on average depth of collection (Table 9-16) indicated that most numerically dominant taxa found within the shallow cluster of stations were also present at the nearshore cluster of stations lying to the seaward of the shallow cluster, with a few exceptions (e.g. the haustoriid amphipods Acanthohaustorius millsi and Protohaustorius bousfieldi, the sphaeromatid isopod Ancinus depressus, the tanaid Kalliapseudes sp. A, the magelonid polychaete Magelona sp., the spionid polychaete Scolelepis sp., and the pennatulacean octocoral Virgularia mirabilis). Stations within the shallow cluster had coarse, sandy sediment (Figure 9-5).

The nearshore cluster of 13 stations had sediment ranging from sand to roughly even mixtures of sand, silt, and clay (Figure 9-6). The nearshore cluster was ranked third in overall diversity (H' = 3.16), and shared fourth in evenness with the intermediate cluster (V' = 0.59). As in the shallow cluster of stations, the combining of a large number of stations resulted in the inclusion of many taxa (177) and individuals (7,227). Each station averaged 13.6 taxa and 556 individuals. Stations ranged in depth from 9-22 m except for Station IV-1, a deeper (27 m) sandy site near shore, discussed extensively in Section 4. The numerically dominant organism was the naticid gastropod Natica pusilla, followed closely by the spionid polychaete Paraprionospio pinnata, the magelonid polychaete Magelona phyllisae, the lumbrinerid polychaete Lumbrineris sp. nov., and the holothuroid Protankyra cf. benedeni. Protankyra was found in large numbers only at two stations, however (N-18 and I-1). The most abundant groups of organisms in the nearshore cluster were carnivorous and/or omnivorous polychaetes, followed closely by deposit feeding polychaetes and by gastropods (Figure 9-4).

Many of the numerically dominant taxa found in the intermediate and offshore clusters of stations were typically represented at stations in the nearshore and shallow clusters. In contrast, a distinct suite of taxa was wholly restricted to the shallow and nearshore clusters; i.e. these species were never represented in collections from the intermediate and offshore clusters (Table 9-16).

The intermediate cluster included eight stations, all having fine silty-clay sediment (Figure 9-7). This cluster had the lowest diversity (H' = 2.65) of any of the four clusters, and the lowest evenness index (V' = 0.59, as for the nearshore cluster). Only 59 taxa comprised of 742 individuals were identified in samples from the eight stations in the intermediate cluster, an average of 7.4 taxa and 93 individuals per station. Six of the eight stations in the intermediate cluster ranged in depth from 36-40 m, while one shallower station (III-1 at 25 m depth) and one deeper station (S-4 at 55 m) were also included within the group.

The intermediate cluster was dominated by two polychaetes, the spionid Paraprionospio pinnata and the nephtyid Nephtys incisa. Roughly

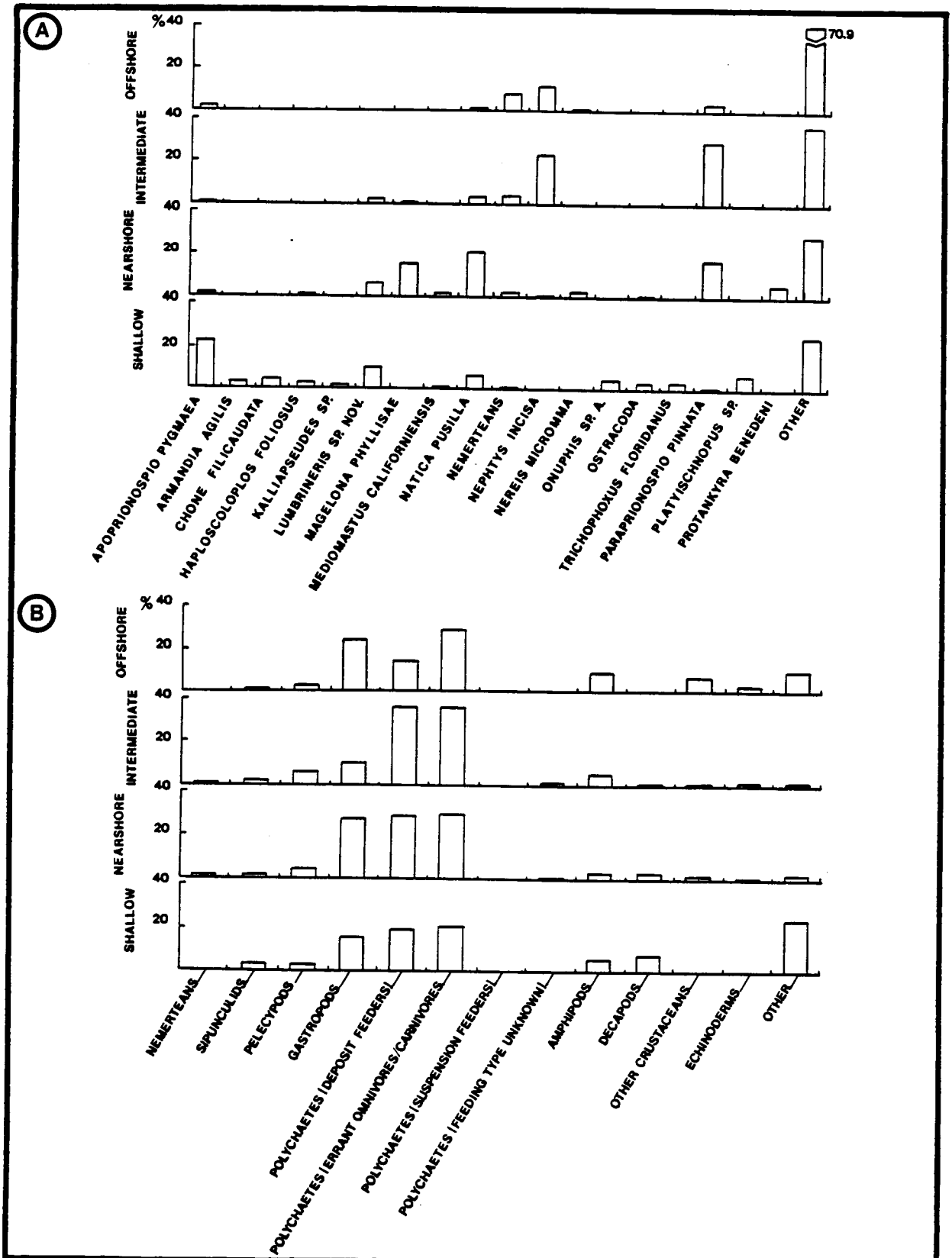


Figure 9-4. Relative proportions of numbers of individuals of numerically dominant taxa (A) (1% cutoff) and major groups of taxa (B), by cluster group, in percentages.

Table 9-16. Presence/absence associations by cluster group of stations and by depth (0.1% cutoff; see text for explanation).

	CLUSTER GROUP			
	Shallow	Nearshore	Intermediate	Offshore
Acanthohaustorius millsi	+			
Ancinus depressus	+			
Kalliapseudes sp.	+			
Magelona cf. sacculata	+			
Protohaustorius bousfieldi	+			
Scolelepis sp.	+			
Virgularia mirabilis	+			
Armandia agilis	+	+		
Chone filicaudata	+	+		
Glycera americana	+	+		
Grubeulepis mexicana	+	+		
Haploscoloplos foliosus	+	+		
Haploscoloplos fragilis	+	+		
Isolda pulchella	+	+		
Albunea paretii	+	+		
Litocorsa stremma	+	+		
Lovenella grandis	+	+		
Lucina amiantus	+	+		
Macoma tenta	+	+		
Magelona cincta	+	+		
Magelona pettiboneae	+	+		
Ampelisca sp.	+	+		
Monoculodes nyei	+	+		
Nassarius acutus	+	+		
Nereis succinea	+	+		
Nucula aegeensis	+	+		
Ogyrides limicola	+	+		
Onuphis sp. B	+	+		
Orbiniidae	+	+		
Pagurus bullisi	+	+		
Trichophous floridanus	+	+		
Photis melanicus	+	+		
Platyischnopus sp.	+	+		
Prionospio cristata	+	+		
Anachis obesa	+	+		
Renilla mulleri	+	+		
Anadara transversa	+	+		
Spiophanes bombyx	+	+		
Synchelidium americanum	+	+		
Tharyx marioni	+	+		
Aglaophamus verrilli	+	+		
Abra aequalis	+	+	+	
Heterospio longissima	+	+	+	

....cont'd

Table 9-16 (cont'd)

	CLUSTER GROUP			
	Shallow	Nearshore	Intermediate	Offshore
Hexapanopeus angustifrons		+		
Protankyra cf. benedeni		+		
Goniada littorea	+	+	+	
Pseudeurythoe ambigua	+	+	+	
Ampelisca agassizi	+	+	+	
Onuphis sp. A.	+	+	+	
Sipunculids	+	+	+	
Lepidasthenia maculata		+		
Clymenella torquata		+		
Maldanidae	+	+	+	
Mediomastus californiensis	+	+	+	
Xenanthura brevitelson		+		
Aricidea sp.	+	+		+
Cyclaspis sp. B.	+	+		+
Corbula caribaea	+	+	+	+
Ampelisca verrilli	+	+	+	+
Diopatra cuprea	+	+	+	+
Aricidea taylori	+	+	+	+
Ostracoda	+	+	+	+
Magelona phyllisae	+	+	+	+
Paraonis gracilis	+	+	+	+
Paraprionospio pinnata	+	+	+	+
Armandia maculata	+	+	+	+
Apoprionospio pygmaea	+	+	+	+
Micropholis atra	+	+	+	+
Apseudes sp. A.	+	+	+	+
Lumbrineris ernesti	+	+	+	+
Natica pusilla	+	+	+	+
Nemerteans	+	+	+	+
Nephtys incisa	+	+	+	+
Sigambra tentaculata	+	+	+	+
Nereis micromma	+	+	+	+
Speocarcinus lobatus	+	+	+	+
Nereis sp. D.	+	+	+	+
Lumbrineris januarii		+	+	
Notomastus cf. latericeus	+	+	+	+
Lumbrineris sp. nov.	+	+	+	+
Vitrinella floridana		+	+	
Nuculana acuta		+	+	
Cossura delta		+	+	+
Alpheus sp. A.		+	+	+
Ninoe nigripes		+	+	+
Magelona longicornis		+	+	+

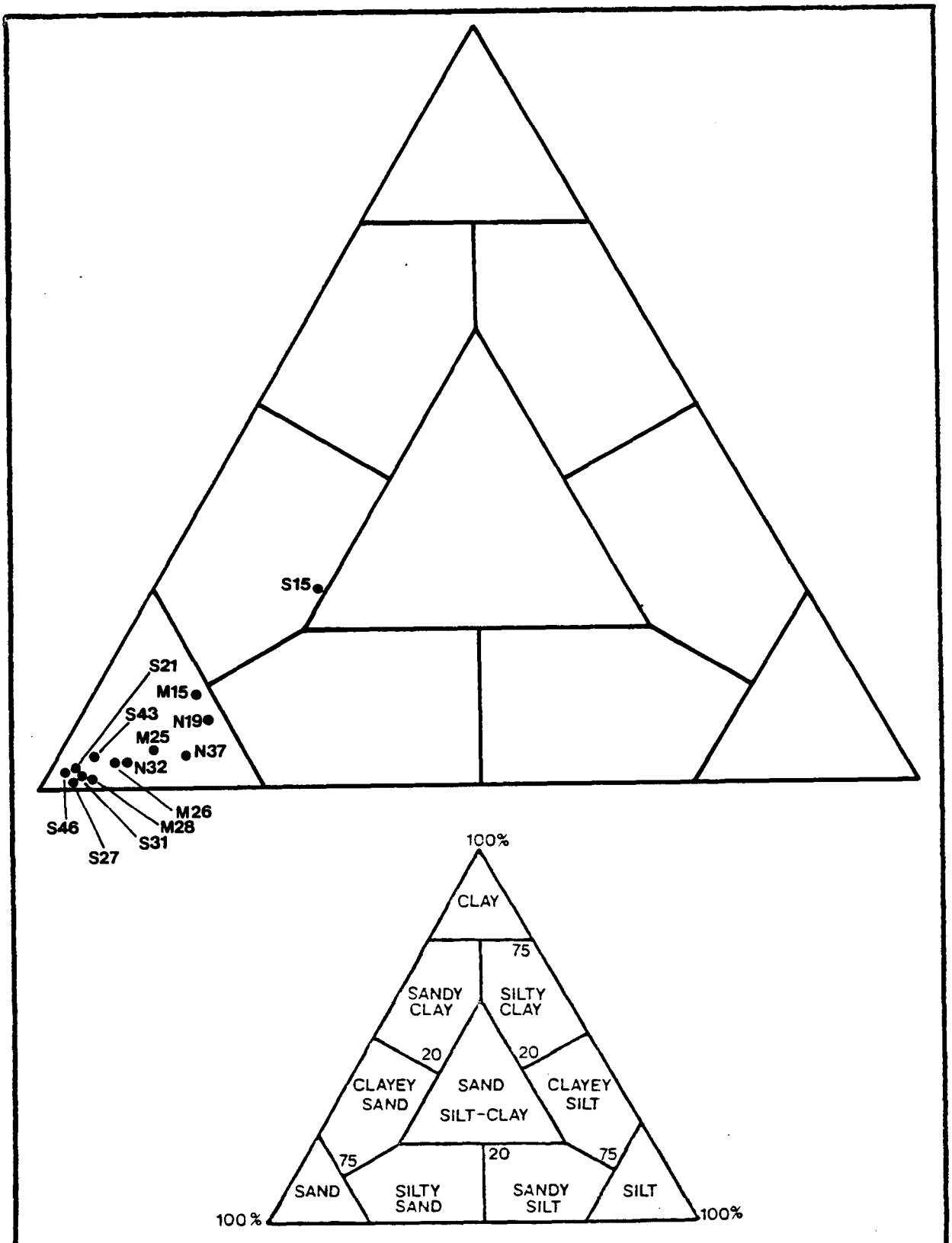
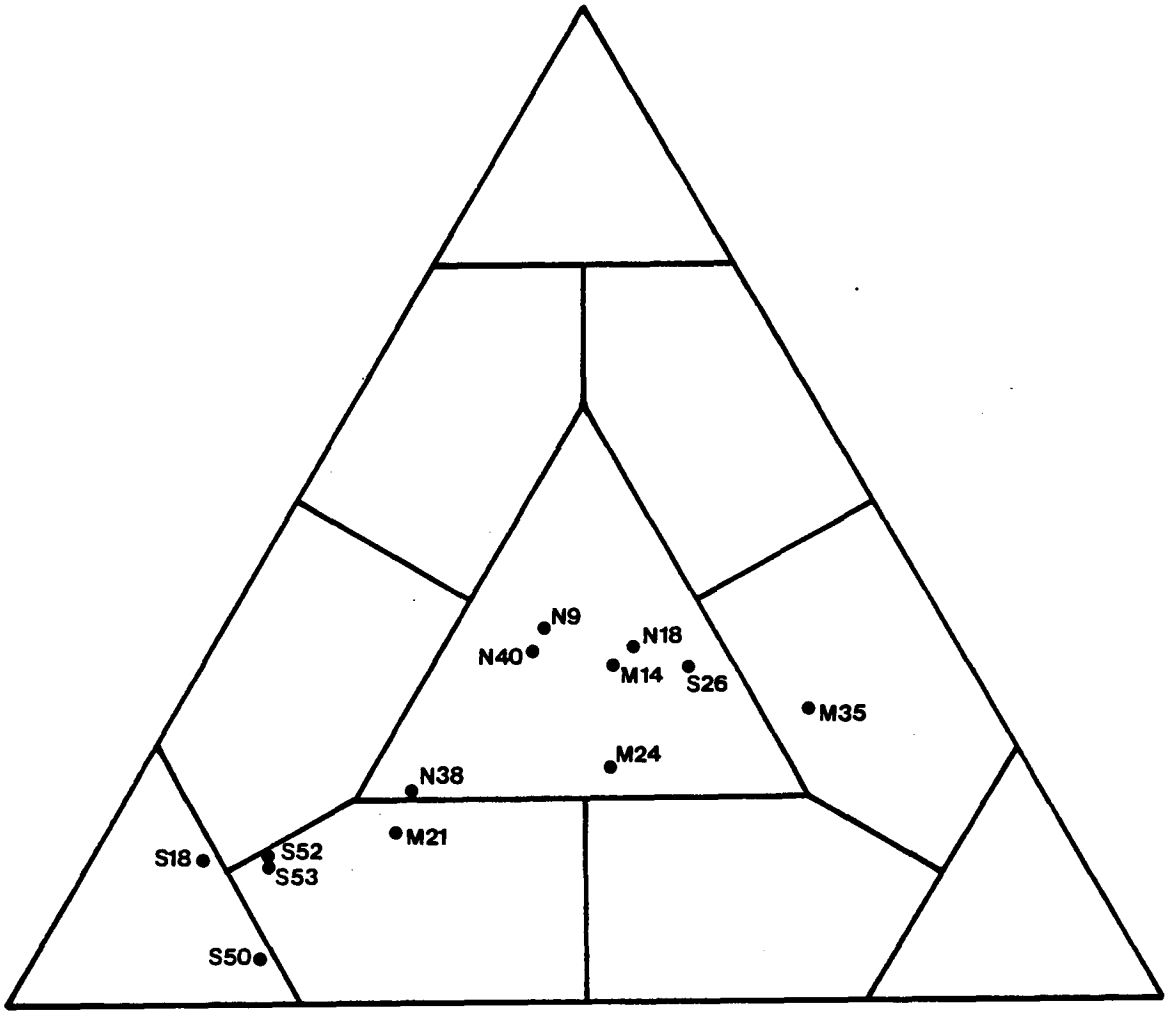


Figure 9-5. Sediment characterization for shallow cluster stations.



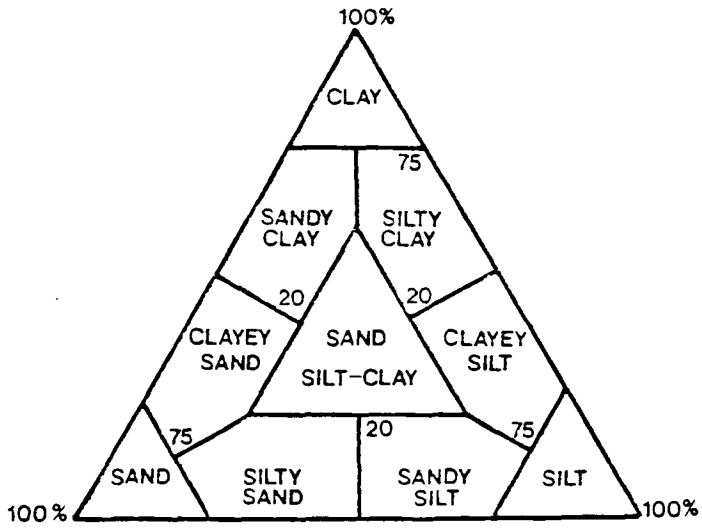


Figure 9-6. Sediment characterization for nearshore cluster stations.

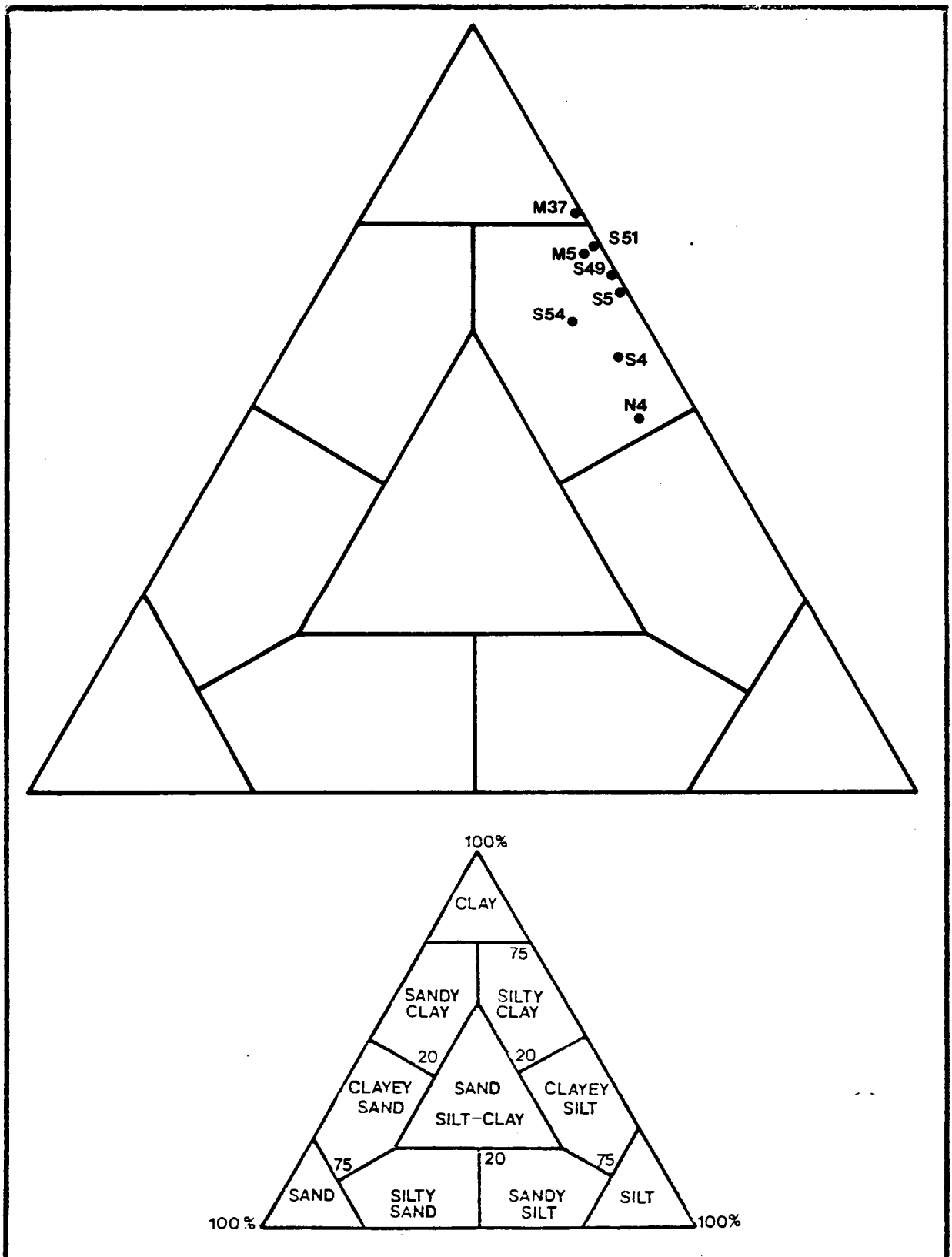


Figure 9-7. Sediment characterization for intermediate cluster stations.

half the numerically dominant taxa which were present within the shallow and nearshore clusters were absent from the intermediate cluster (Table 9-16). However, several taxa which were present in the samples from the intermediate cluster of stations were not found in the offshore cluster. The most important of these (from a numerical standpoint) was the capitellid polychaete Mediomastus californiensis. The most abundant groups within the intermediate cluster of stations were carnivorous and/or omnivorous errant polychaetes and deposit-feeding polychaetes (equally common) and gastropods (Figure 9-4).

The offshore cluster of four stations ranged in depth from 42-55 m. Stations within the offshore cluster had fine sediment made of approximately equal proportions of silt and clay, with the exception of Station N-39, the shallowest of the four, which had an added proportion of sand (Figure 9-8). Only 49 taxa (12.3 per station) were identified in samples from these stations, comprised of 227 individuals, averaging 57 individuals per station, the lowest value of the four clusters. Diversity was second highest (H' = 3.21), and evenness highest of the four cluster groups of stations (V' = 0.73). The numerically dominant organism was the nephtyid polychaete Nephtys incisa, followed by miscellaneous unidentified nemerteans and by the spionid polychaete Paraprionospio pinnata. The most common groups of taxa were carnivorous and/or omnivorous polychaetes, gastropods, and deposit feeding polychaetes, in that order (Figure 9-4). The largest fraction of uncommon or rare taxa was represented within this cluster; 71% of the individuals identified in these samples are grouped as "other" in Figure 9-4, indicating that their taxa did not satisfy the minimum 1% cutoff for numerically dominant taxa. Four taxa present at these deeper stations were not found in the shallowest cluster, though they were present in the intermediate and nearshore samples: the alpheid shrimp Alpheus sp. A, the magelonid polychaete Magelona longicornis, the lumbrinerid polychaete Ninoe nigripes, and the cossurid polychaete Cossura delta (Table 9-16).

9.3.1.4 Discussion

The macroinfaunal data from the 26 new stations would not be expected *a priori* to differ substantively from the data collected in 1980 from the twelve previously sampled STOCS/RRT/LGL-ERCO stations described in Section 4. All 38 stations were sampled in identical fashion within a single eleven-day period in December 1980, and the spatial distribution of the two sets of stations resembled a grid across the south Texas shelf in which new stations and previously sampled stations were intermixed. Compared to the 1980 samples from twelve previously sampled stations, the 26 new stations had more taxa present (208 as opposed to 127) and, of course, more individuals (12,300 as opposed to 3,346). Viewed from another standpoint, sampling the 26 new stations provided information on 208 taxa, while increasing the data set to include twelve additional stations only raised the total number of taxa to 222. On the average, more individuals were collected per station among the 26 new stations than among the 12 previously sampled stations (473 as opposed to 279). This difference was due to primarily to the inclusion of 13 new shallow stations (4.5 m and 9 m deep) and several nearshore stations (18 m deep,

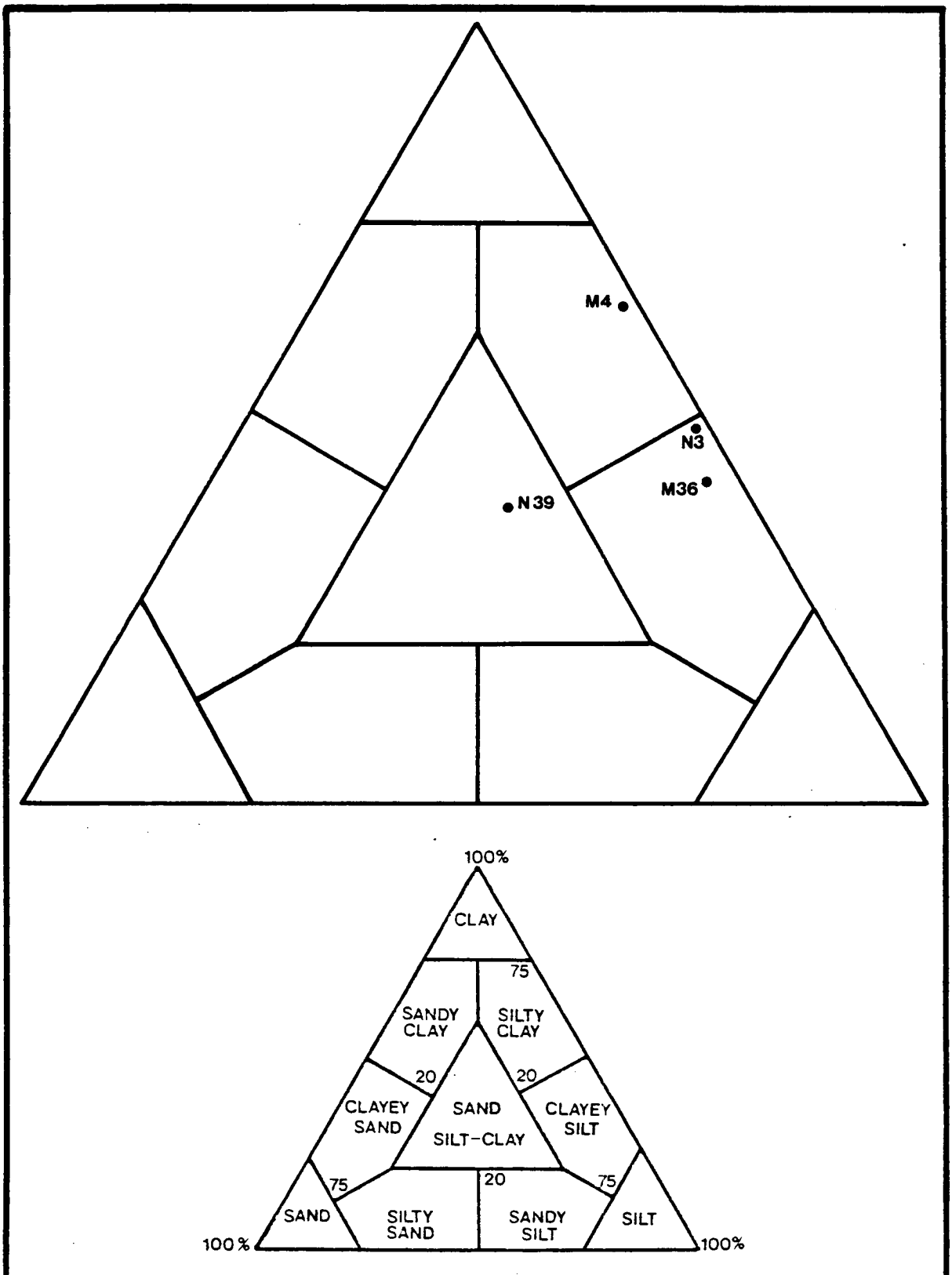


Figure 9-8. Sediment characterization for offshore cluster stations.

near the southernmost transect) which had very high densities of macroinfaunal animals.

Taken as a single group of samples, the fauna of the 38 stations consisted primarily of polychaetes (about half the animals collected), with deposit feeders and carnivores and/or omnivores present in roughly equal numbers. Gastropods accounted for another fourth of the collection, followed by miscellaneous decapods, amphipods, pelecypods, and sipunculids in that order, ranging in abundance from about 2% to 5% of the total. Flint and Holland (1980) described the fauna of a series of stations lying along Transect 2; three of their stations (#1, at 22 m; #2 at 36 m, and #3 at 49 m) fall within the depth range of the stations described above. Their results indicated that polychaetes were also the dominant organisms at those three stations (81.6%, 67.7%, and 67.4%, respectively) followed by amphipods (6.2% - 10.7%) and other crustaceans, pelecypods (0.3% - 7.7%), and gastropods (1.9% - 2.9%).

Cluster analysis on all 38 stations together at the 0.85 similarity index level reproduced the pattern described in Section 4 for the twelve previously sampled stations in 1980 as well as for earlier collections. The twelve previously sampled stations had been divided in the 1980 twelve-station analysis into three cluster groups: an offshore which was composed of two stations, an intermediate group which included four stations, and a nearshore group which included six stations. Addition of 26 new stations to the 1980 analysis did not alter this pattern; within offshore, intermediate, and nearshore cluster groups, the twelve previously sampled stations occupied the same relative positions. Thirteen of the new stations were added to these three cluster groups (two to the offshore, four to the intermediate, and seven to the nearshore), more or less filling in the spatial gaps between the twelve previously sampled stations.

The remaining 13 new stations were grouped by cluster analysis into a single shallow assemblage of stations at 4.5 m and 9 m depths. This assemblage could be further subdivided into northern and southern components at a slightly lower similarity index level (0.82), separating the southern shallow stations with high macroinfaunal densities from the northern stations with lower densities. However, to provide a more comprehensive overview this north-south division was deemphasized in favor of the broader grouping. The shallow assemblage of stations was characterized by high average abundance, by the presence of a number of numerically dominant taxa not collected at other stations, and by the presence of many taxa seen in the shallow cluster group.

Nearly all of the numerically dominant taxa identified in the intermediate and offshore clusters were also present in the shallow and nearshore cluster groups. This set of taxa may be considered ubiquitous within the study area, occurring at stations of all depths. In other words, the deepest stations were not characterized by a particularly distinct group of organisms limited to those sites. It seems reasonable to assume that even the deepest stations did not lie wholly within a faunal province of animals restricted only to deeper water, although a few taxa were present only at the offshore stations. On the other hand, approximately half the numerically dominant taxa were present only in shallow and nearshore cluster stations, indicating that a definite set of

shallow-water, sand-associated taxa could be delineated. Not surprisingly, at least a few of these taxa were found only at the 4.5 m and 9 m stations, suggesting a depth limitation, since they were not found in any of the 10 m samples.

The number of taxa collected per station was at its highest value (13.6) in the nearshore group of stations, and at its lowest in the intermediate group (7.4), but was higher at both ends of the depth distribution (11.0 in the shallow group, and 12.3 in the offshore group). The number of individuals per station showed a striking decrease with increasing depth (527 and 556 in the shallow and nearshore clusters, and 93 and 57 in the intermediate and offshore clusters, respectively). Consequently, the average number of individuals per taxon showed a monotonic decrease with increasing depth (47.6, 40.9, 12.6, and 4.7 for shallow, nearshore, intermediate, and offshore, respectively). Although the number of taxa present at inshore stations was not substantially greater than at offshore stations, each taxon was represented by progressively fewer individuals (an order of magnitude fewer, comparing shallow to offshore clusters).

Flint and Holland's Station #1 would fall within the nearshore cluster described above, based upon average station depth; Station #2 within the intermediate cluster; and Station #3 within the offshore cluster. While the relative order of major taxonomic groups within these clusters was quite similar to that given by Flint and Holland, the proportions were a bit different--e.g., 59.3%, 72.6%, and 43.1% polychaetes, respectively--as one might expect, since Flint and Holland's work was based upon a series of repeated visits to each station between January 1976 and September 1977, whereas the present description is based solely on a single sampling. A tendency for the percentage of polychaetes to decrease with increasing depth was described by Flint and Holland; the 1980 data from the 38 stations showed a substantial drop in proportion of polychaetes between the intermediate and offshore stations, but the highest value at the intermediate stations. Flint and Holland also described a gradual rise in proportions of gastropods with increasing depth. The 1980 sampling did not reflect this trend, due primarily to very spotty appearance of one taxon (Natica pusilla).

Flint and Holland also cited a cluster (which they called Group I) of ubiquitous taxa present at all six of their stations: Paraprionospio pinnata, Cossura delta, Sigambra tentaculata, and Nephtys incisa; these taxa were all also present in 1980 samples from the shallow, nearshore, intermediate, and offshore clusters, except for Cossura delta, which was not found in the shallow samples. Lumbrineris sp. nov. ("Lumbrineris parvapedata") was found by Flint and Holland to be absent at Station #1, most common at Station #2, and present in decreasing abundance farther offshore; the 1980 data showed Lumbrineris sp. nov. to be most common in the shallow cluster, and to decrease sharply in abundance in the offshore cluster. Paraonis sp. A was indicated by Flint and Holland to be most abundant at Stations #3 and #4 (49 m and 78 m, respectively), and absent from Station #1 (22 m); the time-series data from the twelve previously sampled stations also confirmed that this taxon was most common at Station IV-5 (37 m) and at deeper stations.

Flint and Holland's shallow water (Group II) taxa "occurred in high densities only at the shallower stations," (i.e. between 22 m and 49 m), and would thus span the 1980 nearshore, intermediate, and offshore clusters of stations. These shallow water taxa were dominated by Mediomastus californiensis, Magelona phyllisae, Nereis micromma ("Nereid [Nicon] sp. A"), and Ampelisca agassizi. The 1980 data showed Mediomastus californiensis and Magelona phyllisae present in shallow and intermediate stations, most common in the nearshore group of stations, and absent from the offshore cluster; Nereis micromma present in all four cluster groups but common (over 1% of total abundance) only in the nearshore stations; and Ampelisca agassizi present only in the shallow, nearshore, and intermediate stations and absent from the offshore stations.

Flint and Holland's Group III organisms were described as occurring "regularly in collections from mid-depth," i.e. from Station #2, #3, and #4. The most common of these organisms included Magelona longicornis (most abundant at Station #3); Eudorella monodon (most common at Station #2); Kalliapseudes sp. ("Kalliapseudes sp. A") (Station #3 only); Apseudes sp. A (most common at Station #2); Notomastus cf. latericeus (most common at Station #2); Corbula swiftiana (most common at Stations #2 and #3); Abra aequalis (approximately equal in percentage abundance at Stations #2-#5); Hyala sp. A (most common at Station #2); and Automate evermanni (most common at Stations #3-#6). Magelona longicornis was among the taxa not present in the shallow cluster of 1980 samples, but no other numerically dominant taxa showed such clear patterns of depth preference in the 1980 samples taken as a whole. However, when time series data for the 12 previously sampled stations were reviewed (see Section 4), several of these taxa showed positive correlations in abundance with percentages of fine particles (i.e. offshore stations): Eudorella monodon, Magelona longicornis, and Hyala sp. A. Figure 4-49 emphasised the increased frequency with depth of Hyala sp. A and Eudorella monodon.

9.3.1.5 Summary and conclusions

1. The data set described in this appendix includes 12,300 individuals of 208 macroinfaunal taxa at 26 stations not previously sampled for biological parameters.

2. These 26 new stations were sampled during the same time period during December 1980 as were twelve nearby stations previously sampled for macroinfauna in the South Texas Outer Continental Shelf (STOCS) program; the two data sets were merged and described as a single group of 38 stations.

3. When all 38 stations were considered, 15,646 individuals representing 222 taxa collected in 1980 made up the data set.

4. Most taxa were quite rare, represented by only one or a few individuals.

5. The most common organisms were polychaetes, followed in order of relative abundance by gastropods, decapods, amphipods, and pelecypods. Approximately half the polychaetes were deposit feeders, and the other half were carnivores and/or omnivores. Although the set of stations spanned a depth range of from 4.5 m to 55 m, this general pattern was rather constant from shallow to deeper stations, despite changes in the individual taxa present.

6. Cluster analysis divided the stations into four groups: A shallow-water group of 13 stations, a nearshore group of 13 stations, an intermediate group of eight stations, and an offshore group of four stations.

7. The shallow stations were characterized by sandy sediment; high diversity and evenness; a large suite of taxa including some distinctive forms not found in other groups; and high densities of macroinfauna, in terms of numbers of individuals per station and per taxon.

8. The nearshore stations were characterized by sediment ranging from fairly sandy to roughly equal proportions of sand, silt, and clay; somewhat lower diversity than the shallow stations; the lowest evenness of any of the four groups of stations; a large number of taxa, many of which were shared with the shallow stations but not with the other two station groups; and high densities of macroinfauna in terms of numbers of individuals per station and per taxon.

9. The intermediate stations were characterized by fine sediment tending toward silty clay; the lowest diversity of any of the four groups of stations; relatively low evenness; fewer than half the number of taxa present at the shallow and nearshore stations, most of which were shared with the other three groups of stations; and low macroinfaunal densities in terms of numbers of individuals per station and per taxon.

10. The offshore stations were characterized by fine sediment of roughly equal proportions of silt and clay; relatively high diversity; relatively high evenness; the fewest taxa of any of the four groups of stations but the second highest number of taxa per station; and the lowest macroinfaunal densities of any of the four groups of stations, both in terms of numbers of individuals per station and per taxon.

9.3.2.1 Introduction

During the December 1980 LGL/ERCO cruise following the Ixtoc I oil spill in the Bay of Campeche, Mexico, benthic infaunal samples were collected at 40 stations along the south Texas outer continental shelf. Twelve of these stations had been visited previously in the South Texas Outer Continental Shelf (STOCS) baseline studies program by the Bureau of Land Management and by the mid-spill Regional Response Team (RRT), and the data could therefore be used to provide comparisons of pre-spill, mid-spill and post-spill conditions. Macroinfaunal community studies at these twelve stations were discussed in detail in Section 4. The remaining 28 stations had not been sampled for macroinfauna prior to the December 1980 cruise. Two of these 28 stations were immediately adjacent to the site of the 1979 collision and fire of the oil tanker Burmah Agate. A discussion of the other 26 "new" stations may be found in Appendix 9.3.1. A summary of findings from the two Burmah Agate sites is presented in the following sections. No historical infaunal data are available for the two Burmah Agate stations, thus precluding comparisons with pre- and mid-spill conditions (Don Harper, pers. comm., December 1981).

No oil from the Ixtoc I spill was detected in benthic samples from any of the stations, including the two Burmah Agate sites (Sections 2 and 3). However, residues of oil from the Burmah Agate spill were detected in samples from the two stations (G-1 at a depth of 12 m, and G-3 at a depth of 10 m), but not from any of the other 38 stations sampled in 1980 (pers. comm. Paul Boehm, November 1981).

In the absence of historical data for G-1 and G-3, any assessment of the possible effects of the Burmah Agate must depend upon comparisons of conditions at impacted sites with non-impacted sites. Two such stations were selected to act as a posteriori "control" sites: Station I-4 (= N-40) at a depth of 10 m, and Station N-9 at a depth of 9 m. Both stations were located toward the northwestern boundary of the STOCS study area, geographically closest to the Burmah Agate site (Figure 9-1), and most nearly matched G-1 and G-3 in depth (Figure 9-2) and sediment type (Figures 4-67 [December 1980 sample], 9-6, and 9-9). Furthermore, I-4 and N-9 were members of the same cluster based on abundance of numerically dominant taxa (Figure 9-3), indicating a substantial degree of biological similarity between them.

While the selection of "control" sites facilitates comparisons, the reader should be aware that there are a number of restrictions upon the use of this method; perhaps the most serious restriction is that the choice of "controls" may be inappropriate but cannot be altered to conform to preconceived beliefs once the results are available. The word "control" is thus used advisedly, and retained in quotations marks to indicate that no true controls existed. This matter is treated in further detail in Section 9.3.4, Discussion.

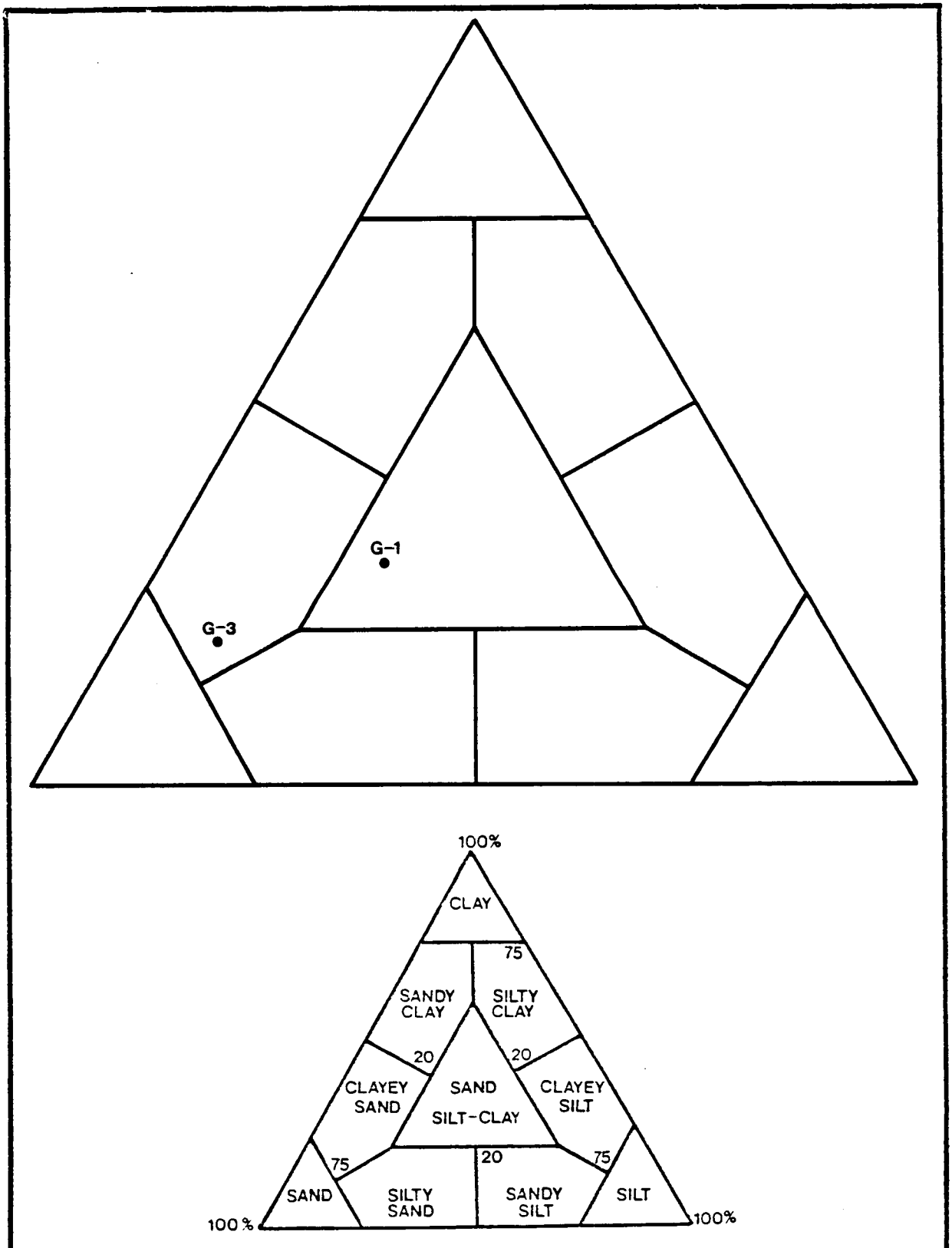


Figure 9-9. Sediment characterization for Burmah Agate stations.

9.3.2.2 Methods and Approaches

Methods used for sample collection and analysis and data analysis for the two Burmah Agate stations were identical to those used for the other 38 stations described in Section 4 and Appendix 9.3.1. A total of twelve grab samples were taken at the two Burmah Agate stations for laboratory analysis of macroinfauna. Please refer to Section 4.2 for a complete discussion of methods.

9.3.2.3 Results

LGL identified 51 taxa of macroinvertebrates in samples from the two Burmah Agate stations (Table 9-17). A total of 495 individual organisms were present in the samples, averaging 248 individuals per station, or 9.7 individuals per taxon. Only three taxa found at the Burmah Agate sites were not collected by LGL at any other site: samples from Station G-3 included two callianassid mud shrimps (Callianassa acanthochirus and C. latispina) and the cumacean Oxyurostylis salinoi. Other taxa found in the taxonomic checklist for the Burmah Agate site also appear in Tables 4-2 and 9-14. By comparison, the two "control" stations had a total of 649 individuals comprised of 52 taxa, for an average of 12.5 individuals per taxon. The complete set of samples from all four stations included 80 taxa.

Despite similar numbers of taxa present at the Burmah Agate sites vs. the "control" sites, relatively few taxa were present at both sets of stations. Twenty-three taxa (29% of 80) were held in common between the two sets of stations (i.e. found at at least one Burmah Agate station and at least one "control" station), and only seven taxa were present at all four stations. When both Burmah Agate stations were grouped together, the clear numerical dominant was the polychaete Magelona phyllisae, followed by sipunculids, the polychaete Nereis micromma, and nemerteans (Figure 9-10). In terms of numbers, the most important groups of organisms were deposit feeding polychaetes, sipunculids, and errant carnivorous and/or omnivorous polychaetes (Figure 9-11).

Taken separately, G-1 had far fewer taxa than did G-3 (17 vs. 46, respectively, or 37%) and fewer individuals (136 vs. 359, respectively, or 38%). Only twelve taxa (24% of 51) were held in common between the two Burmah Agate stations. The taxa at G-1 were for the most part a subset of the much larger group of taxa found at G-3; only five of the 17 taxa at G-1 were not also collected at G-3: the shrimp Alpheus sp. B, the polychaetes Notomastus cf. latericeus and Magelona longicornis, miscellaneous unidentified maldanid polychaetes, and the pelecypod Chione clenchi. These taxa were represented by a total of only five individuals. Station G-1 averaged 8 individuals per taxon; Station G-3 averaged 7.8 individuals per taxon.

Stations N-9 and I-4 were more similar to one another in terms of numbers of taxa (34 vs. 32, respectively) and numbers of individuals (253 vs. 396, respectively). Nonetheless, considerable heterogeneity existed between the two stations. Only 14 taxa (27% of 52) were held in common

Table 9-17. Taxonomic checklist for Burmah Agate and "control" stations.

	Burmah Agate		"Control"	
	G-1	G-3	N-9	I-4
Abra equalis		+	+	
Aglaophamus verrilli		+		
Alpheus sp. A			+	
Alpheus sp. B	+			
Ampelisca sp. B		+		
Anemones (misc. unid.)	+	+		
Albunea paretii			+	
Anachis obesa			+	
Anadara ovalis			+	
Anadara transversa			+	
Apoprionospio pygmaea			+	
Armandia maculata				+
Asychis carolinae		+		
Cabira incerta				+
Calappidae (misc. unid.)			+	
Callianassa acanthochirus		+		
Callianassa latispina		+		
Ceratonereis irritabilis				+
Ceriantharian (unid.)		+		
Chasmocarcinus mississippiensis			+	+
Chione clenchi	+			
Corbula caribaea	+	+	+	
Cossura delta				+
Diopatra cuprea		+	+	+
Glycera americana		+		+
Gyptis brevipalpa				+
Haploscoloplos foliosus		+		
Hemipholos elongata		+		
Hexapanopeus angustifrons		+	+	
Lepidasthenia maculata		+		
Linopherus ambigua		+		
Lucina amiantus		+		+
Lumbrineris ernesti	+	+	+	+
Lumbrineris sp. nov.	+	+	+	+
Macoma tenta			+	
Magelona cincta		+	+	+
Magelona longicornis	+			
Magelona phyllisae	+	+	+	+
Magelona cf. sacculata		+		
Maldanidae (misc. unid.)	+			
Marphysa sp.			+	
Micropholis atra	+	+	+	
Mediomastus californiensis				+
Minuspio cirrifera			+	
Monoculodes sp. B			+	
Mysidopsis bigelowi			+	
Nassarius acutus			+	+
Natica pusilla			+	+

Table 9-17 (cont'd)

	Burmah Agate		"Control"	
	G-1	G-3	N-9	I-4
Nemerteans (misc. unid.)	+	+		+
Nereis micromma	+	+	+	+
Nephtys incisa	+	+		
Nereis succinea		+		+
Ninoe nigripes	+	+	+	+
Notomastus cf. latericeus	+			+
Nucula aegeensis				+
Nuculana acuta				+
Nuculana concentrica				+
Ogyrides limicola		+	+	+
Onuphis sp. A		+		
Owenia fusiformis		+		
Oxyurostylis salinoi		+		
Paraprionospio pinnata	+	+	+	+
Paguridae (misc. unid.)		+		
Pagurus bullisi		+	+	
Petricola pholadiformis			+	
Phascolion sp.		+		
Phyllodoce mucosa		+		
Pinnixa sp.		+		
Polyodontes lupina				+
Scolelepis sp.		+		
Sigambra tentaculata		+		+
Sipunculida (misc. unid.)	+	+	+	+
Speocarcinus lobatus		+	+	
Squilla empusa		+		
Sthenelais limicola		+		
Terebra protexta		+		+
Tharyx marioni			+	+
Thyone mexicana			+	
Upogebia affinis		+		
Vitrinella floridana				+

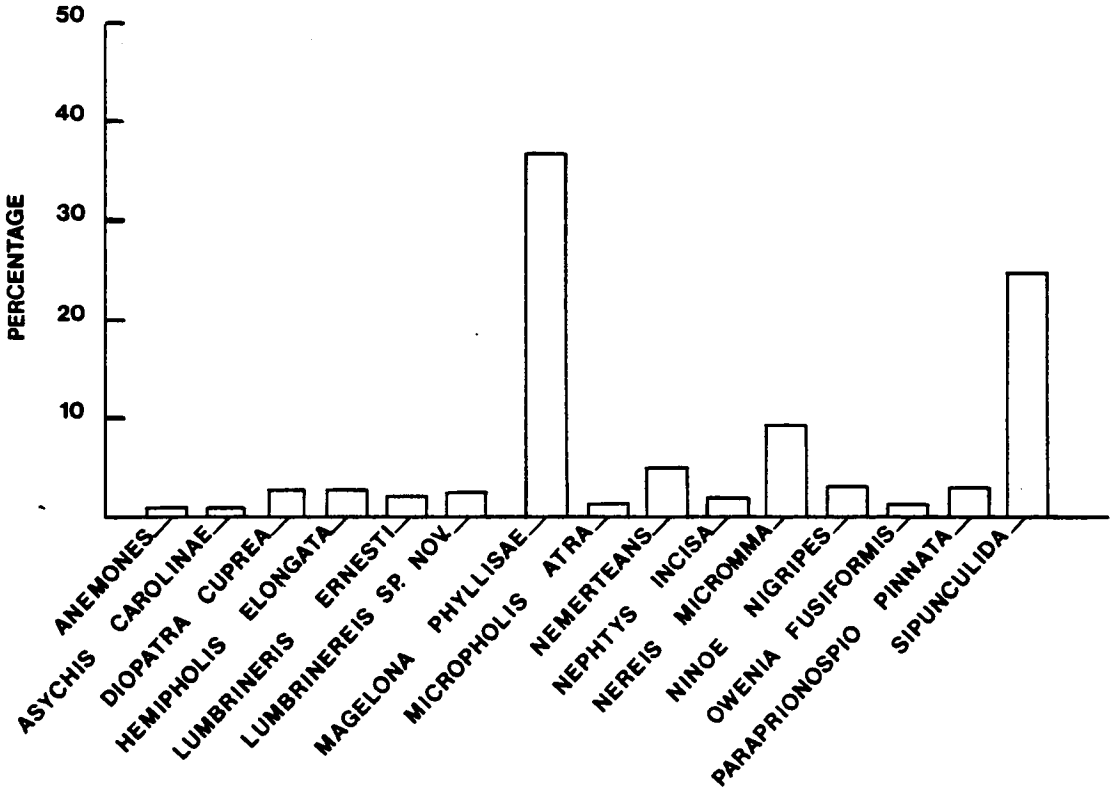


Figure 9-10. Relative proportions of numbers of individuals of numerically dominant taxa at Burmah Agate stations.

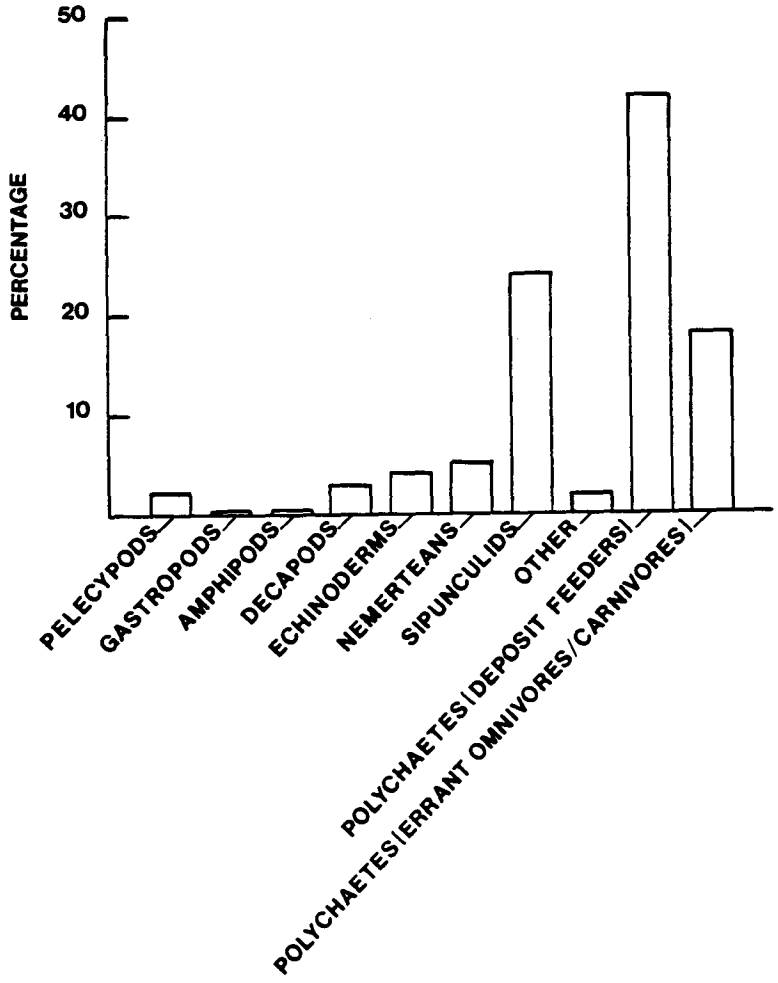


Figure 9-11. Relative proportion of major groups of taxa at Burmah Agate stations.

between the two "control" stations. Station N-9 averaged 7.4 individuals per taxon, while Station I-4 averaged 12.4 individuals per taxon.

The sediments at G-1, N-9, and I-4 were all somewhat sandy in texture (46% sand, 36% sand, and 37% sand, respectively) with the remainder being made up of approximately equal proportions of silt and clay. Station G-3 had sediment which was substantially coarser than that at the other three stations (70% sand), with remaining fractions of approximately equal amounts of silt and clay (Figures 4-67, 8-7, and 8-9).

The numerical dominant at Station G-1 was the polychaete Magelona phyllisae, which accounted for fully one-third of the individuals collected. Other fairly common taxa included the "catch-all" groups of nemerteans and sipunculids (not identified to species) and the polychaetes Nereis micromma, Ninoe nigripes, and Paraprionospio pinnata, in decreasing order of abundance. The most important groups of organisms were deposit feeding polychaetes (41% of 136 total individuals), omnivorous and/or carnivorous polychaetes (23%), sipunculids (18%), nemerteans (11%), and ophiuroids (4%). Diversity (H') and evenness (V') for G-1 were 2.07 and 0.64, respectively.

The numerical dominant at Station G-3 was Magelona phyllisae, again representing one-third of the total. Sipunculids were also common, though nemerteans made up a smaller proportion of the total. Other numerical dominants included the polychaetes Nereis micromma and Diopatra cuprea, and the ophiuroid Hemipholis elongata. The most important groups of organisms were deposit-feeding polychaetes (42% of 359 total individuals), sipunculids (25%), omnivorous and/or carnivorous polychaetes (16%), pelecypods (5%), decapods and ophiuroids (4% each). Diversity (H') and evenness (V') for G-3 were 2.47 and 0.56, respectively.

The numerical dominant at Station N-9 was Magelona phyllisae (one-fifth of the total), followed by the gastropod Natica pusilla, the polychaete Apoprionospio pygmaea, the xanthid brachyuran Hexapanopeus angustifrons, the polychaete Lumbrineris sp. nov., and the ophiuroid Micropholis atra, in decreasing order of relative abundance. The most important groups of organisms were deposit-feeding polychaetes (43% of 253 individuals), gastropods (19%), decapods (17%), omnivorous and/or carnivorous polychaetes (8%), and ophiuroids, pelecypods, and sipunculids (4% each). Diversity (H') and evenness (V') for N-9 were 2.67 and 0.67, respectively.

The numerical dominant at Station I-4 was Magelona phyllisae, which represented one fourth of the total. Other numerically important taxa included Paraprionospio pinnata, Natica pusilla, sipunculids, nemerteans, and Nereis micromma (Figure 4-11). Deposit-feeding polychaetes dominated I-4, followed by gastropods (Natica), errant omnivorous and/or carnivorous polychaetes, and sipunculids in 1980 (Figure 4-12). Diversity (H') and evenness (V') for I-4 were 2.28 and 0.59, respectively.

9.3.2.4 Discussion

The most striking difference between the four stations was the low number of individuals and taxa present at Station G-1, which was immediately adjacent to the site of the Burmah Agate spill. The number of individuals does appear to be unusually low (136) compared to the two "control" stations (253 and 396), or to the other two stations within the shallow and nearshore clusters lying along the northern transect (458 and 493, Figure 9-3). Both "control" stations were members of a cluster whose lowest value was observed at Station N-9, and whose average was 556. Similarly, the number of taxa collected at Station G-1 (17) was substantially lower than that at any of the four shallow and nearshore stations along the northern transect (range = 32 to 45). Whereas five other stations within the nearshore cluster had fewer taxa collected, all of these five stations lay at depths greater than 36 m, where numbers of individuals and numbers of taxa showed marked declines (Section 4).

The value for diversity at G-1 was also toward the lower end of the scale compared to the two "control" stations, but low diversity indices were not at all unusual for stations near the northern inshore end of the STOCS grid. For example, Stations M-14 and M-24, both members of the same cluster group as the two "control" stations (Appendix 9.3.1), had H' values of 1.58 and 1.77, respectively. Nevertheless, at both M-14 and M-24, these relatively low H' scores were accompanied by higher abundances (665 and 366, respectively) and numbers of taxa (31 and 29, respectively). Station N-37, the shallowest station (4.5 m deep) along the northernmost transect, had H' and V' values of 1.98 and 0.43, respectively, but 43 taxa and 493 individuals. Evenness at G-1 (0.64) lay between the values for the two "control" stations (0.59 and 0.67). On the whole, the nearshore cluster (to which the two "control" stations belonged) ranged in diversity from 1.58 to 2.70 and evenness from 0.40 to 0.67, except for two highly diverse southern stations (S-18 <H' = 3.52, V' = 0.72, 101 taxa and 989 individuals> and S-52 <H' = 3.21, V' = 0.76, 49 taxa and 293 individuals>). Therefore, the diversity and evenness indices observed at G-1 were not outside the range spanned by other presumably non-impacted stations and cannot be considered unusual, given the restrictions of the data set.

The number of individuals and the diversity index for samples from Station G-3 were intermediate between values for both at the two "control" stations, while the number of taxa at G-3 was higher than at either of the "control" stations, but intermediate between values for the other two stations in the shallow and nearshore clusters in the northern transect. Evenness for Station G-3 collections was slightly lower than at N-9 or I-4, but still higher than values at two of the four shallow and nearshore cluster stations in the northern transect. Consequently, none of the community summary statistics for Station G-3 were outside the range spanned by other non-impacted stations.

It was not possible to determine whether or not the spill was responsible for any observed differences between G-1 and any other station(s), however. In order to assign differences to their proper causes would require much more information than is presently available. For example, the relative quantity of petroleum which contacted the

benthos is not known for either impacted site. In addition, there is a variable background level of petroleum hydrocarbons present throughout the Gulf of Mexico (see Gallaway 1981 for a review). This background represents the remnants of previous spills (major and minor) which can only rarely be traced to their original source due to extensive weathering. As a result, there is a tendency among environmental scientists to treat this background as "noise," carrying little useful toxicological information. However, historical events at a given location--e.g. any one of the sites treated in this study--may have affected present biological conditions in completely unknown fashion. With present technology there is no way to evaluate these effects in most cases, and, in fact, they may be best considered yet another uncontrolled environmental variable from the standpoint of cause-and-effect analysis.

Implicit in the definition of a "control" is that it is possible to identify and quantify differences between locations or treatments. For most natural marine systems, this assumption is virtually never satisfied. Had either of the Ixtoc I or Burmah Agate spills been predictable before they happened, it might have been possible to select control and impact sites based on similarity of fauna and equivalent exposure to subsequent environmental influences. This is, of course, the basis of an experimental ecological approach, and not the stuff from which damage assessments are made. Consequently, the stations chosen a posteriori as examples of presumably comparable unimpacted areas may have been inappropriate, although the choices were based on our best judgment as to similarity of sediment types, distance offshore, depth, and proximity to the spill location.

It is important to point out that once the choice as to which stations to compare had been made, it would have been entirely improper to alter this choice subsequently. In other words, there would be a strong element of circularity in attempting to select "control" stations based upon information after the fact. For example, if the "control" stations had differed greatly from the two impacted sites, one could either retain the choice (thereby ensuring that effects would appear to have been present) or reject the choice in favor of more similar stations (thereby ensuring that effects would be difficult to perceive). Neither approach is defensible scientifically.

Station G-1 lies in an area which has been highly disturbed in recent years. Station G-1 is located within the entrance channel to Galveston Bay at the intersection of four navigational safety fairways for large ships. While some of the vessel traffic bound for Houston via the Houston Ship Channel may follow the Intracoastal Waterway, a large portion of the vessels travel through the Galveston entrance. As of 1978, the Channel was the third largest seaport in the United States, and housed the greatest concentration of petrochemical industries in the world, spawning over 350 waste discharges into the channel, and, ultimately, into Galveston Bay and the adjacent ocean (Texas DPW 1980). The bottom may well experience significant turbulence from passing vessels. In addition, the entrance and shipping channels immediately inshore of G-1 are heavily dredged, and the dredge spoil from this operation dumped in a large area several km from Station G-1. Other dredge spoil deposit zones no longer in use surround the station. It would not be unreasonable to expect this station to be subject to physical effects from dredging (see Allen and Hardy, 1980

for a review) and heavy ship traffic, as well as to major physical and biological effects from such a large adjacent estuarine system.

It is entirely possible that the fauna of G-1 may have been relatively sparse (both in terms of numbers of individuals and taxa) compared to G-3 or N-9 or I-4 before the spill--or that G-1 might have been much richer than any of the other stations before the spill. The authors are not aware of any macroinfaunal samples collected at the same location immediately before the spill, and therefore must leave the issue unsettled.

Within the 38 stations sampled in 1980 which did not receive any oil from the Burmah Agate, there was also a great deal of variability in numbers of individuals and taxa, even between stations at the same depth with very similar sediment. For example, Stations N-9, N-19, M-25, M-21, M-15, S-31, S-27, S-21, and S-15 were all 9 m deep, and show a range in numbers of individuals from 912 to 253 and numbers of taxa from 40 to 68 (Figure 8-2, Table 8-15). However, adjacent stations frequently were very similar in these parameters, with N-9 and I-4 having quite equivalent numbers of taxa (34 and 32, respectively) and fairly similar numbers of individuals. Despite this perhaps somewhat superficial similarity, though, these two stations shared only 14 taxa in common, while the two Burmah Agate sites shared twelve taxa in common. Throughout the study, high variability (between stations and between replicate grabs within stations) was the rule rather than the exception.

The major taxa were quite similar at all four sites. The numerically dominant organism was the polychaete Magelona phyllisae, an opportunistic species "found in a variety of environments including estuarine waters" (Flint and Holland 1980), but might be most common in areas having 50%-60% sand (Flint and Rabalais 1980). The polychaete Nereis micromma, commonly found with Magelona phyllisae (Flint and Rabalais 1980) was abundant at three sites and uncommon at the fourth. Nemerteans and sipunculids were common at all four stations. Some of the more obvious differences included large numbers of the spionid polychaete Paraprionospio pinnata at only one of the four sites (IV-1) and its apparent substitution by another spionid (Apoprionospio pygmaea) at N-9, the other "control" site. High abundances were noted for the gastropod Natica pusilla at "control" stations but not at either Burmah Agate site. Paraprionospio pinnata was very common at many of the southern nearshore stations, but less common to the north of the STOCS area. Apoprionospio pygmaea apparently favors sandier, shallower locations (e.g. N-9, and the adjacent inshore station N-37, where it was the numerical dominant with 268 individuals), as it was very abundant only in the shallow cluster of stations described in Appendix 9.3.1. The spotty appearance of Natica is not viewed as particularly significant, since Natica was present or absent in unpredictable fashion at a number of other stations unaffected by Burmah Agate oil, and seemed to be present in large numbers wherever it appeared.

9.3.2.5 Summary and conclusions

1. The data set described in this appendix includes 495 individuals of 51 macroinfaunal taxa at two stations

not previously sampled for biological parameters, but known to have received oil from the Burmah Agate spill in November 1979.

2. The two Burmah Agate stations were sampled during the same time period during December 1980 as were 38 other stations not previously sampled for macroinfauna, and which did not receive oil from the Burmah Agate spill; two of these non-impacted stations were chosen on the basis of depth, sediment, and location to serve for biological community comparisons with the two impacted stations.

3. The two impacted stations differed greatly from one another in terms of numbers of individuals and taxa present, with the station nearest the spill (G-1) having far fewer individuals and taxa than the station (G-3) farther away.

4. Neither diversity nor evenness indices at either impacted station were considered abnormally low or high compared to values at the two comparison sites or to other adjacent stations in the STOCS study area.

5. The numbers of individuals and taxa present at G-1 appeared to be quite low compared to those at the other, more distant impacted site or to the two comparison sites and to other adjacent stations in the STOCS study area.

6. Due to the lack of pre-spill samples from the two impacted stations, it is not possible to state with certainty that there was any effect of the spill upon the benthic infaunal community.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.