2-Intertidal and Nearshore Benthos

Introduction

A major objective of the Biological Monitoring Program (BMP) is the detection of changes in intertidal benthic assemblages as a consequence of fill operations. Inherent limitations in the power of sampling programs to detect less than dramatic changes in fishery resources underscore the general reliance on quantitatively sampling benthos in order to infer impacts on fishery resources. Impacts to beach infauna are expected to include reduced abundance and altered community structure. While there are no standard sampling programs for collecting this type of information, guidelines found in Cochran (1963), Morrisey et al. (1992), and Nelson (1993) have been followed. Likewise, recommendations concerning statistical design found in Saila et al. (1976), Cohen (1988), and Underwood (1992) were applied to the study. Emphasis is placed on detecting both short-term and long-term impacts to abundance, biomass, and assemblage structure along a gradient from intertidal to subtidal depths.

Examination of nourishment impacts to New Jersey beaches is complicated by the relative paucity of quantitative studies of beach infauna along the mid-Atlantic coast. In a review of infaunal zonation on high-energy beaches McLachlan and Jaramillo (1995) reported no studies between North Carolina and southern New England. Fortunately, McDermott (1983) has described the distribution of southern New Jersey beach infauna as part of a study of the surf zone food web. New Jersey beach infauna were dominated by the polychaete *Scolelepis squamata*, the wedge clam *Donax variabilis*, the mole crab *Emerita talpoida*, the ribbon worm (Rhynchocoela) *Micura leidyi*, and a variety of haustoriid amphipods. McDermott has previously reported the distribution of both *S. squamata* (McDermott, 1979) and the nephtyid polychaete *Nepthys bucera* (McDermott, 1987) from the same site. Croker (1970) provides a faunal list of intertidal macrofauna from Long Island that is very similar to that of McDermott (1983). The benthic assemblage described in these reports is essentially identical to these and others reported for U.S Atlantic coast beaches (McLachlan and Jaramillo, 1995).

In addition to the paucity of reports concerning the quantitative distribution of beach infauna, there are virtually no studies of beach nourishment impacts to intertidal infauna north of the Carolinas. Both Nelson (1985 and 1993) and Hackney et al. (1996) have extensively reviewed the literature and neither report studies for this region. The closest study is that of Jaramillo et al. (1987) who followed the recovery of a New England sandy beach after intense erosion. In general, both Nelson (1985 and 1993) and Hackney et al. (1996) categorized nourishment impacts to beach infauna as short-term with recovery times ranging from 2 to 7 months. Subsequent studies by Jutte et al. (1999a and 1999b) in South Carolina arrived at a similar estimate (3 to 6 months). The longest recovery times reported for nourished beaches occur when there is a poor match between fill materials and the original substrate. For instance, Reilly and Bellis (1983) reported that recovery took more than a year for some species on a North Carolina beach where substantial amounts of silts and clays were present in the fill.

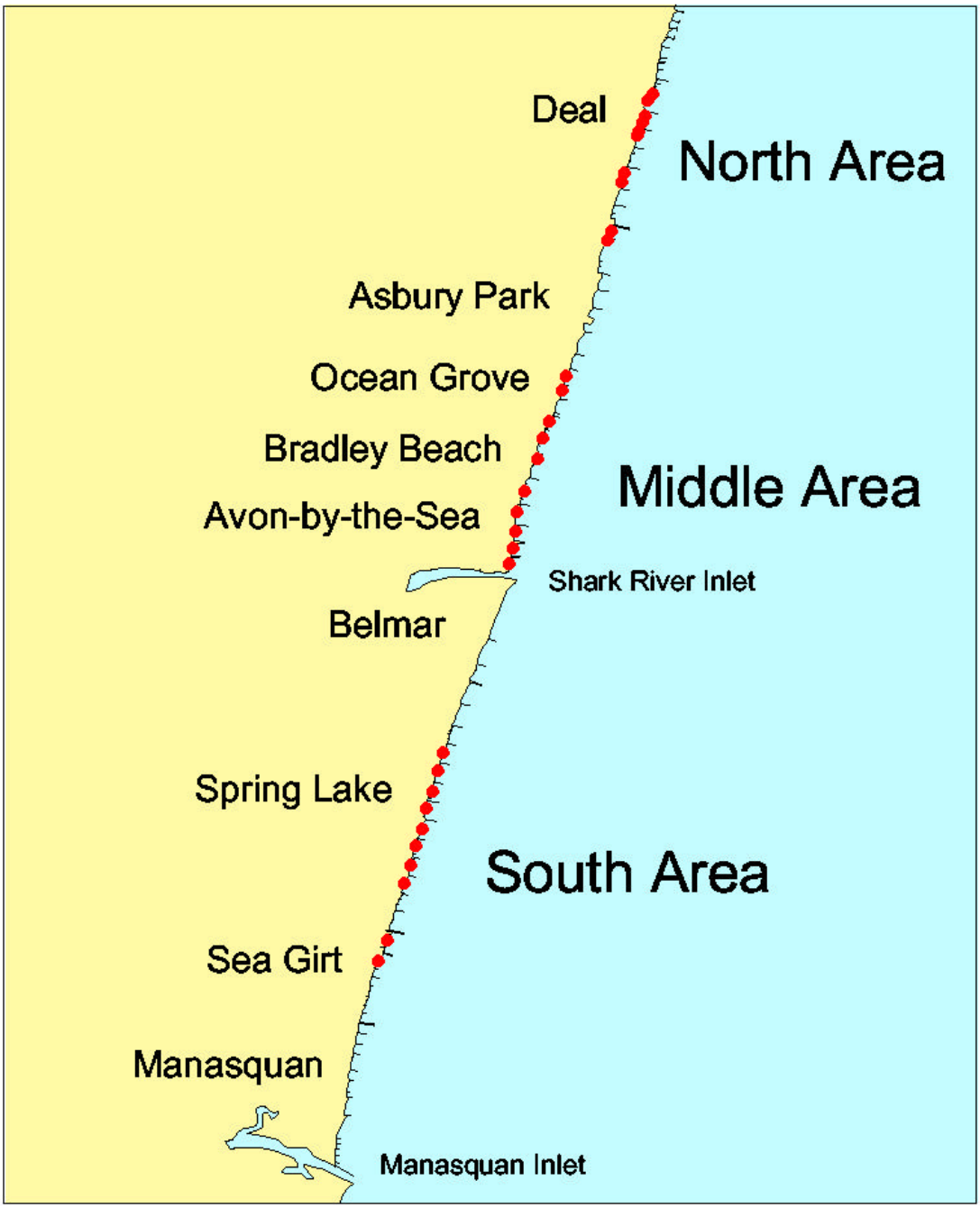

Figure 2-1. Intertidal and Nearshore benthos sampling locations.

Table 2-1. Summary Biological Results for Intertidal and Nearshore Infauna

Area / Data / Depth	Total			South			Middle			North		
	MLW	**MLW-1m**	**Nearshore**	**MLW**	**MLW-1m**	**Nearshore**	**MLW**	**MLW-1m**	**Nearshore**	**MLW**	**MLW-1m**	**Nearshore**
Total Taxa	80	80	225	57	54	173	42	48	137	41	45	158
Total Animals	81691	50827	298999	25633	16360	125827	38963	16581	35669	17095	17886	137503
Total Biomass (g)	779.68	502.87	32906.64	380.61	165.78	8554.47	236.32	184.55	17030.50	162.76	152.54	7321.67
Average Taxa/Sample*	2.6	2.5	14.3	2.7	2.4	15.9	2.6	2.5	13.0	2.5	2.7	14.2
Average Abundance/m^2	11503	7272	632	10552	7097	721	16583	7262	250	7373	7458	883
Average Biomass (g/m^2)	150.60	97.14	99.72	220.56	96.07	77.77	136.94	106.94	154.82	94.31	88.40	66.56
Annelid	107.69	75.58	1.44	150.40	75.22	1.40	105.71	81.58	1.02	66.95	69.93	1.88
Crustacea	21.36	19.10	9.05	29.39	15.79	9.03	11.78	24.47	14.57	22.91	17.05	3.54
Mollusc	20.73	0.63	88.97	39.87	0.41	67.16	18.12	0.40	138.96	4.19	1.07	60.79
Echinoderm	-----	4.21	---	---	4.21	---	---	---	---	---	---	0.00
Miscellaneous	0.80	0.42	0.27	0.87	0.42	0.17	1.26	0.48	0.27	0.26	0.35	0.35
% Annelid	72.12	77.90	10.12	68.19	78.30	5.53	77.19	76.29	5.71	70.98	79.11	19.11
% Crustacean	15.41	19.54	24.33	13.32	16.44	26.56	8.61	22.88	23.87	24.29	19.29	22.56
% Mollusc	11.92	0.67	63.50	18.07	0.43	66.97	13.23	0.38	68.62	4.44	1.21	54.91
% Echinoderm	-----	4.38	0.00	---	4.38	0.00	---	---	0.01	---	---	0.00
% Miscellaneous	0.53	0.43	2.07	0.39	0.44	0.94	0.92	0.45	1.80	0.28	0.40	3.49

*Intertidal sample = $44cm^2$; Nearshore sample = $0.1m^2$

Appendix Table 2-1. Mean Low Water Station Locations

Area	Station No.	Depth	Latitude	Longitude
South	1	MLW	40° 08.006	74° 01.665
South	2	MLW	40° 08.139	74° 01.621
South	3	MLW	40° 08.588	74° 01.465
South	4	MLW	40° 08.743	74° 01.402
South	5	MLW	40° 08.960	74° 01.343
South	6	MLW	40° 09.064	74° 01.376
South	7	MLW	40° 09.263	74° 01.273
South	8	MLW	40° 09.397	74° 01.251
South	9	MLW	40° 09.579	74° 01.085
South	10	MLW	40° 09.701	74° 01.115
Middle	21	MLW	40° 11.377	74° 00.554
Middle	22	MLW	40° 11.478	74° 00.527
Middle	23	MLW	40° 11.568	74° 00.509
Middle	24	MLW	40° 11.798	74° 00.440
Middle	25	MLW	40° 12.004	74° 00.426
Middle	26	MLW	40° 12.198	74° 00.361
Middle	27	MLW	40° 12.454	74° 00.285
Middle	28	MLW	40° 12.545	74° 00.216
Middle	29	MLW	40° 12.803	74° 00.097
Middle	30	MLW	40° 12.936	74° 00.056
North	41	MLW	40° 14.091	73° 59.724
North	42	MLW	40° 14.147	73° 59.672
North	43	MLW	40° 14.588	73° 59.610
North	44	MLW	40° 14.645	73° 59.576
North	45	MLW	40° 14.982	73° 59.480
North	46	MLW	40° 15.019	73° 59.470
North	47	MLW	40° 15.080	73° 59.408
North	48	MLW	40° 15.100	73° 59.351
North	49	MLW	40° 15.296	73° 59.414
North	50	MLW	40° 15.340	73° 59.353

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Acarina (LPIL)													
Actiniaria (LPIL)													
Ampelisca abdita				2486		226							
Ampharetidae (LPIL)													
Amphipoda (LPIL)									226				
Amphiporeia gigantea													
Ampithoe valida						226							
Ancistrosyllis hartmanae													
Archiannelida Family A				339									
Ascidiacea (LPIL)													
Bivalvia (LPIL)								226	226				
Bodotriidae (LPIL)					226								
Branchiopoda (LPIL)													
Calyptraeidae (LPIL)													
Cancer irroratus													
Capitellidae (LPIL)													
Chiridotea tuftsi													
Cirratulidae (LPIL)				1695									
Cladocera (LPIL)													
Corophium tuberculatum													
Crangon septemspinosa													
Crepidula (LPIL)								904					
Crepidula fornicata													
Crepidula plana							226						
Decapoda (LPIL)			226										
Decapoda Reptantia (LPIL)													
Dipolydora socialis													
Donax variabilis										301			339
Echinoidea (LPIL)													
Emerita talpoida	226	291		678	226	1582	226	452		881	678	678	904
Eteone longa										226			

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Eurythoe complanata													
Gammaridae (LPIL)					226								
Gammarus annulatus		226			452								
Gastropoda (LPIL)									226				
Gemma gemma													
Goneplacidae (LPIL)													
Goniada teres												226	
Haustoriidae (LPIL)													
Haustorius canadensis							226			226			226
Haustorius sp. A		226											
Haustorius sp. C													
Hesionidae (LPIL)		226											
Hirudinea (LPIL)		1582											
Jassa falcata								226			226		226
Levinsenia gracilis						301							
Litocorsa antennata						226							
Lumbrineridae (LPIL)							226						
Mactridae (LPIL)								452					
Magelona annulata													
Magelona papillicornis													
Mediomastus ambiseta	226			565		226							
Melitidae (LPIL)													
Microphthalmus (LPIL)				226									
Microphthalmus aberrans		226		16046									
Microphthalmus hartmanae													
Microphthalmus sp. G					603	565			339			396	
Micropthalmus listensis													
Mysella planulata													
Mysidacea (LPIL)													
Mytilidae (LPIL)							226						
Mytilus edulis	517	1098	1281	19210	226	452	1456	5368	2769		7860		678

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Nephtyidae (LPIL)													
Nephtys (LPIL)				226	226								
Nephtys bucera													
Nereidae (LPIL)	226												
Neverita duplicata								226					
Nucula proxima													
Oligochaeta (LPIL)	3229	10270	9379	5914	226	1130		1582	452			452	
Ophiurodea (LPIL)							226						
Ostracoda (LPIL)											226		
Ovalipes ocellatus													
Ovalipes stephensoni													
Parahaustorius (LPIL)													
Parahaustorius attentuatus			226					452					
Parahaustorius holmesi													
Parahaustorius longimerus													
Parandalia ocularis													
Paraonidae (LPIL)													
Paraprionospio pinnata						226							
Pelecypoda (LPIL)		226			226	226							
Petricola pholadiformis													226
Phoxocephalidae (LPIL)													
Phyllodoce arenae							226						
Phyllodocidae (LPIL)													
Pisionidae (LPIL)													
Polydora (LPIL)													
Polygordius (LPIL)				21470		226		753		339			
Portunidae (LPIL)													
Prionospio (LPIL)				565									
Protodrilidae (LPIL)					9221								
Protodriloides (LPIL)												1565	2863
Protohaustorius (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Pseudunciola obliquua													
Rhynchocoela (LPIL)	18956	22781	21154	11006	28792	6464	18419	8226	28815	7300	32680	3858	42330
Sabellaria vulgaris								226					
Sabellidae (LPIL)	226												
Scolelepis squamata	17477	2325	17091	7741	1898	7619	57133	13741	18306	6253	83507	8861	32815
Sipuncula (LPIL)													
Spionidae (LPIL)	226		339		226	226				226	932		
Spisula solidissima									226	226			
Stenothoidae (LPIL)							226						
Streblospio benedicti													
Tellina agilis													
Tharyx acutus						226							
Turbellaria (LPIL)													
Turbonilla (LPIL)													226
Unciola irrorata								226					
Xanthidae (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Acarina (LPIL)									226				
Actiniaria (LPIL)													
Ampelisca abdita						226							
Ampharetidae (LPIL)													
Amphipoda (LPIL)		226											
Amphiporeia gigantea						226							
Ampithoe valida													
Ancistrosyllis hartmanae													
Archiannelida Family A				2599									
Ascidiacea (LPIL)								226					
Bivalvia (LPIL)								339					
Bodotriidae (LPIL)													
Branchiopoda (LPIL)									339				
Calyptraeidae (LPIL)													
Cancer irroratus										226			
Capitellidae (LPIL)	226												
Chiridotea tuftsi													
Cirratulidae (LPIL)				226									
Cladocera (LPIL)													
Corophium tuberculatum													
Crangon septemspinosa								226					
Crepidula (LPIL)													
Crepidula fornicata													
Crepidula plana													
Decapoda (LPIL)													
Decapoda Reptantia (LPIL)													
Dipolydora socialis													
Donax variabilis									1130			226	226
Echinoidea (LPIL)								452					
Emerita talpoida				339	226				904			1130	226
Eteone longa													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Eurythoe complanata													
Gammaridae (LPIL)													
Gammarus annulatus													226
Gastropoda (LPIL)													
Gemma gemma				226									
Goneplacidae (LPIL)													
Goniada teres													
Haustoriidae (LPIL)													
Haustorius canadensis													301
Haustorius sp. A		377											
Haustorius sp. C	226												
Hesionidae (LPIL)									377				
Hirudinea (LPIL)													
Jassa falcata								452					
Levinsenia gracilis													
Litocorsa antennata													
Lumbrineridae (LPIL)													
Mactridae (LPIL)													
Magelona annulata						226							
Magelona papillicornis						452							
Mediomastus ambiseta				678		904							
Melitidae (LPIL)													226
Microphthalmus (LPIL)	904	226		226	452				1130				
Microphthalmus aberrans		678		1921									
Microphthalmus hartmanae													
Microphthalmus sp. G					1582	1130			1017				
Micropthalmus listensis					226								
Mysella planulata													
Mysidacea (LPIL)						226							
Mytilidae (LPIL)													
Mytilus edulis	565	362	226	226	226	226	1040	452	961		1883		283

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Nephtyidae (LPIL)				904									
Nephtys (LPIL)													
Nephtys bucera		452	226	3164									
Nereidae (LPIL)													
Neverita duplicata													
Nucula proxima													
Oligochaeta (LPIL)	2983	8447	4068	7752	735	1453		904	633	537		226	
Ophiurodea (LPIL)													
Ostracoda (LPIL)													
Ovalipes ocellatus		226	226			226					226	226	
Ovalipes stephensoni								226					
Parahaustorius (LPIL)													
Parahaustorius attentuatus		452	283	0		396	226	452			904	271	
Parahaustorius holmesi													
Parahaustorius longimerus				226		226			226		226		
Parandalia ocularis													
Paraonidae (LPIL)						226							
Paraprionospio pinnata						226							
Pelecypoda (LPIL)	452		226										
Petricola pholadiformis													
Phoxocephalidae (LPIL)					226								
Phyllodoce arenae								226					
Phyllodocidae (LPIL)													
Pisionidae (LPIL)													
Polydora (LPIL)													
Polygordius (LPIL)								226					
Portunidae (LPIL)								226					
Prionospio (LPIL)													
Protodrilidae (LPIL)					872								
Protodriloides (LPIL)											1017	1157	879
Protohaustorius (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Pseudunciola obliquua													
Rhynchocoela (LPIL)	4407	36989	5831	13899	15006	9341	5452	9176	14848	3541	37200	1968	12972
Sabellaria vulgaris								226					
Sabellidae (LPIL)													
Scolelepis squamata	13598	3792	678	25350	829	16724	16975	7707	10735	13583	61296	1507	27996
Sipuncula (LPIL)						226							
Spionidae (LPIL)	226	226									396		
Spisula solidissima													
Stenothoidae (LPIL)													
Streblospio benedicti													
Tellina agilis							226	3616					
Tharyx acutus													
Turbellaria (LPIL)													
Turbonilla (LPIL)													
Unciola irrorata													
Xanthidae (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Acarina (LPIL)													
Actiniaria (LPIL)													
Ampelisca abdita				1130									
Ampharetidae (LPIL)												226	
Amphipoda (LPIL)				226									226
Amphiporeia gigantea													
Ampithoe valida													
Ancistrosyllis hartmanae													
Archiannelida Family A													
Ascidiacea (LPIL)													
Bivalvia (LPIL)								226					
Bodotriidae (LPIL)													
Branchiopoda (LPIL)													
Calyptraeidae (LPIL)													
Cancer irroratus													
Capitellidae (LPIL)													
Chiridotea tuftsi													
Cirratulidae (LPIL)				1130							226		
Cladocera (LPIL)													
Corophium tuberculatum													
Crangon septemspinosa													
Crepidula (LPIL)													
Crepidula fornicata													
Crepidula plana								226					
Decapoda (LPIL)												226	
Decapoda Reptantia (LPIL)													
Dipolydora socialis													
Donax variabilis													226
Echinoidea (LPIL)													
Emerita talpoida		339		3842		377		226		452		226	301
Eteone longa													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Eurythoe complanata													
Gammaridae (LPIL)													
Gammarus annulatus													
Gastropoda (LPIL)									226				
Gemma gemma													
Goneplacidae (LPIL)													
Goniada teres													
Haustoriidae (LPIL)													
Haustorius canadensis							452					226	
Haustorius sp. A													
Haustorius sp. C	452			226						339			
Hesionidae (LPIL)													
Hirudinea (LPIL)		226											
Jassa falcata							226		226				
Levinsenia gracilis													
Litocorsa antennata													
Lumbrineridae (LPIL)													
Mactridae (LPIL)													
Magelona annulata													
Magelona papillicornis													
Mediomastus ambiseta						226							
Melitidae (LPIL)													
Microphthalmus (LPIL)	452	452	339	1507		452	7458			678	1582		
Microphthalmus aberrans		226		1281									
Microphthalmus hartmanae													
Microphthalmus sp. G					226	452	2260	1582	452				
Micropthalmus listensis													
Mysella planulata									226				
Mysidacea (LPIL)													
Mytilidae (LPIL)												226	
Mytilus edulis	414	3239	226		226	452	1065	735	1780		1306	226	452

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Nephtyidae (LPIL)						226							
Nephtys (LPIL)													
Nephtys bucera				23278									
Nereidae (LPIL)				678									
Neverita duplicata													
Nucula proxima								452					
Oligochaeta (LPIL)	2863	6167	3968	6360	509	979	339	2147	1017	2345	1582	352	
Ophiurodea (LPIL)													
Ostracoda (LPIL)													
Ovalipes ocellatus											226	226	
Ovalipes stephensoni								226					
Parahaustorius (LPIL)							226						
Parahaustorius attentuatus			226			226	226						
Parahaustorius holmesi													
Parahaustorius longimerus						226					452		
Parandalia ocularis		678											
Paraonidae (LPIL)													
Paraprionospio pinnata													
Pelecypoda (LPIL)		226											
Petricola pholadiformis													
Phoxocephalidae (LPIL)													
Phyllodoce arenae													
Phyllodocidae (LPIL)													
Pisionidae (LPIL)													
Polydora (LPIL)						226							
Polygordius (LPIL)													
Portunidae (LPIL)													
Prionospio (LPIL)													
Protodrilidae (LPIL)					1657								
Protodriloides (LPIL)											1808	576	226
Protohaustorius (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Pseudunciola obliquua													
Rhynchocoela (LPIL)	52364	21018	334864	6228	79552	25176	30761	51166	10780	4420	17718	3763	16475
Sabellaria vulgaris								377					
Sabellidae (LPIL)													
Scolelepis squamata	32946	14790	11639	3209	4294	15086	22776	19798	8955	10820	34375	10170	2192
Sipuncula (LPIL)													
Spionidae (LPIL)						226			226	226	565		
Spisula solidissima											452		
Stenothoidae (LPIL)													
Streblospio benedicti												226	
Tellina agilis													
Tharyx acutus													
Turbellaria (LPIL)													
Turbonilla (LPIL)													
Unciola irrorata													
Xanthidae (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Acarina (LPIL)													
Actiniaria (LPIL)										226			
Ampelisca abdita				10170									
Ampharetidae (LPIL)													
Amphipoda (LPIL)			226									226	
Amphiporeia gigantea													
Ampithoe valida													
Ancistrosyllis hartmanae													
Archiannelida Family A				452									
Ascidiacea (LPIL)													
Bivalvia (LPIL)								226					
Bodotriidae (LPIL)													
Branchiopoda (LPIL)													
Calyptraeidae (LPIL)									226				
Cancer irroratus													
Capitellidae (LPIL)													
Chiridotea tuftsi													
Cirratulidae (LPIL)				226									
Cladocera (LPIL)													
Corophium tuberculatum				226									
Crangon septemspinosa													
Crepidula (LPIL)													
Crepidula fornicata													
Crepidula plana													
Decapoda (LPIL)			226						226			226	
Decapoda Reptantia (LPIL)	226												
Dipolydora socialis										226			
Donax variabilis									1394				
Echinoidea (LPIL)													
Emerita talpoida					226							226	
Eteone longa													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Eurythoe complanata													
Gammaridae (LPIL)													
Gammarus annulatus													
Gastropoda (LPIL)												226	
Gemma gemma													
Goneplacidae (LPIL)									226				
Goniada teres													
Haustoriidae (LPIL)	226	226	226				226				226		
Haustorius canadensis							226						
Haustorius sp. A													
Haustorius sp. C		226		678						226			
Hesionidae (LPIL)													
Hirudinea (LPIL)													
Jassa falcata							226				226	226	
Levinsenia gracilis													
Litocorsa antennata													
Lumbrineridae (LPIL)													
Mactridae (LPIL)													
Magelona annulata													
Magelona papillicornis													
Mediomastus ambiseta				3239									
Melitidae (LPIL)													
Microphthalmus (LPIL)		339	452		678				7684				
Microphthalmus aberrans				1055									
Microphthalmus hartmanae													
Microphthalmus sp. G									452				
Micropthalmus listensis					1017								
Mysella planulata													
Mysidacea (LPIL)													
Mytilidae (LPIL)										226			
Mytilus edulis	1130	301	264	226	339	226	1384	791	1424	226	904		226

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Nephtyidae (LPIL)													
Nephtys (LPIL)													
Nephtys bucera			226										
Nereidae (LPIL)													
Neverita duplicata													
Nucula proxima													
Oligochaeta (LPIL)	8023	8616	7307	3192	8990	3588		1921	1921	3917	283		
Ophiurodea (LPIL)		226											
Ostracoda (LPIL)											226		
Ovalipes ocellatus		226	226							226		226	
Ovalipes stephensoni								226					
Parahaustorius (LPIL)						226							
Parahaustorius attentuatus		226	226	226		377		396	339				
Parahaustorius holmesi										603			
Parahaustorius longimerus						339			226		339		
Parandalia ocularis													
Paraonidae (LPIL)													
Paraprionospio pinnata													
Pelecypoda (LPIL)	226	226			226								
Petricola pholadiformis													
Phoxocephalidae (LPIL)													
Phyllodoce arenae													
Phyllodocidae (LPIL)				226									
Pisionidae (LPIL)			226										
Polydora (LPIL)													
Polygordius (LPIL)									452	226		226	
Portunidae (LPIL)					226				226				
Prionospio (LPIL)													
Protodrilidae (LPIL)													
Protodriloides (LPIL)											1485	765	
Protohaustorius (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Pseudunciola obliquua													
Rhynchocoela (LPIL)	25131	7634	20114	1288	19074	17226	14419	6202	18261	18177	18419	4428	7142
Sabellaria vulgaris					226			2712					
Sabellidae (LPIL)													
Scolelepis squamata	37674	1921	7639	1808	452	1356	12505	2612	27233	19888	40205	5569	3013
Sipuncula (LPIL)													
Spionidae (LPIL)		226			226	226					377		
Spisula solidissima									226				
Stenothoidae (LPIL)													
Streblospio benedicti													
Tellina agilis								1537					
Tharyx acutus													
Turbellaria (LPIL)													
Turbonilla (LPIL)													
Unciola irrorata													
Xanthidae (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Acarina (LPIL)													
Actiniaria (LPIL)										226			
Ampelisca abdita													
Ampharetidae (LPIL)													
Amphipoda (LPIL)				678		226		226				226	
Amphiporeia gigantea													
Ampithoe valida													
Ancistrosyllis hartmanae													
Archiannelida Family A													
Ascidiacea (LPIL)													
Bivalvia (LPIL)							226						
Bodotriidae (LPIL)													
Branchiopoda (LPIL)													
Calyptraeidae (LPIL)								226					
Cancer irroratus													
Capitellidae (LPIL)													
Chiridotea tuftsi							226						
Cirratulidae (LPIL)													
Cladocera (LPIL)							226						
Corophium tuberculatum				66670									
Crangon septemspinosa													
Crepidula (LPIL)													
Crepidula fornicata										226			
Crepidula plana								226					
Decapoda (LPIL)			226										
Decapoda Reptantia (LPIL)													
Dipolydora socialis													
Donax variabilis												226	452
Echinoidea (LPIL)													
Emerita talpoida		517		41132		1582		839		904		339	377
Eteone longa													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Eurythoe complanata													
Gammaridae (LPIL)													
Gammarus annulatus				226									
Gastropoda (LPIL)							226						
Gemma gemma													
Goneplacidae (LPIL)													
Goniada teres													
Haustoriidae (LPIL)										226			
Haustorius canadensis													
Haustorius sp. A													
Haustorius sp. C		452											
Hesionidae (LPIL)													
Hirudinea (LPIL)		4219											
Jassa falcata													
Levinsenia gracilis													
Litocorsa antennata													
Lumbrineridae (LPIL)													
Mactridae (LPIL)													
Magelona annulata													
Magelona papillicornis													
Mediomastus ambiseta				2712									
Melitidae (LPIL)													
Microphthalmus (LPIL)	226	1959	2034		791			1356		565	2185	791	
Microphthalmus aberrans	753	1808								904	1808		
Microphthalmus hartmanae													
Microphthalmus sp. G					678	10848		226	2712			1582	
Micropthalmus listensis													
Mysella planulata													
Mysidacea (LPIL)													
Mytilidae (LPIL)										226			
Mytilus edulis	716	497	509		603	565	778	527	1092		2283	226	1413

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Nephtyidae (LPIL)					226								
Nephtys (LPIL)													
Nephtys bucera			226	452	226							226	
Nereidae (LPIL)													
Neverita duplicata													
Nucula proxima													
Oligochaeta (LPIL)	1220	3917	28499	4045	1840	10622		3340	20453	226	339	452	
Ophiurodea (LPIL)	226												
Ostracoda (LPIL)													
Ovalipes ocellatus												226	
Ovalipes stephensoni													
Parahaustorius (LPIL)													
Parahaustorius attentuatus			226					226			226		
Parahaustorius holmesi													
Parahaustorius longimerus											678	226	
Parandalia ocularis													
Paraonidae (LPIL)													
Paraprionospio pinnata						226							
Pelecypoda (LPIL)													
Petricola pholadiformis													
Phoxocephalidae (LPIL)													
Phyllodoce arenae													
Phyllodocidae (LPIL)													
Pisionidae (LPIL)													
Polydora (LPIL)													
Polygordius (LPIL)					226						226		
Portunidae (LPIL)													
Prionospio (LPIL)													
Protodrilidae (LPIL)													
Protodriloides (LPIL)											1808	1469	339
Protohaustorius (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW	MLW
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Pseudunciola obliquua									226				
Rhynchocoela (LPIL)	10260	4153	31527	27472	17538	18464	3819	9818	2938	4520	4158	8814	4746
Sabellaria vulgaris								226					
Sabellidae (LPIL)													
Scolelepis squamata	9266	10120	362	12600	7784	3519	4696	21108	2656	6441	24159	8661	30184
Sipuncula (LPIL)						226							
Spionidae (LPIL)										226	979		
Spisula solidissima								226					
Stenothoidae (LPIL)													
Streblospio benedicti													
Tellina agilis													
Tharyx acutus													
Turbellaria (LPIL)						904							
Turbonilla (LPIL)													
Unciola irrorata													
Xanthidae (LPIL)													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Acarina (LPIL)									226				
Actiniaria (LPIL)													
Ampelisca abdita													
Ampharetidae (LPIL)													
Amphipoda (LPIL)					226							226	
Amphiporeia gigantea													
Ampithoe valida				226									
Ancistrosyllis hartmanae												226	
Archiannelida Family A													
Ascidiacea (LPIL)													
Bivalvia (LPIL)								452					
Bodotriidae (LPIL)													
Branchiopoda (LPIL)													
Calyptraeidae (LPIL)								226					
Cancer irroratus													
Capitellidae (LPIL)													
Chiridotea tuftsi													
Cirratulidae (LPIL)					226								
Cladocera (LPIL)													
Corophium tuberculatum													226
Crangon septemspinosa													
Crepidula (LPIL)													
Crepidula fornicata													
Crepidula plana													
Decapoda (LPIL)												226	
Decapoda Reptantia (LPIL)								226		226			
Dipolydora socialis													
Donax variabilis												226	226
Echinoidea (LPIL)													
Emerita talpoida									226				1130
Eteone longa													

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Eurythoe complanata					226								
Gammaridae (LPIL)													
Gammarus annulatus				226									
Gastropoda (LPIL)											226		
Gemma gemma													
Goneplacidae (LPIL)													
Goniada teres													
Haustoriidae (LPIL)		226						452		226			
Haustorius canadensis													
Haustorius sp. A													
Haustorius sp. C		226								226			
Hesionidae (LPIL)													
Hirudinea (LPIL)	1733												
Jassa falcata									226				
Levinsenia gracilis													
Litocorsa antennata													
Lumbrineridae (LPIL)													
Mactridae (LPIL)													
Magelona annulata													
Magelona papillicornis													
Mediomastus ambiseta													
Melitidae (LPIL)													
Microphthalmus (LPIL)		1582	1733		6272				3345	678			
Microphthalmus aberrans	9718									2260			
Microphthalmus hartmanae	1356	4068											
Microphthalmus sp. G					4972				6504				
Micropthalmus listensis					904								
Mysella planulata													
Mysidacea (LPIL)													
Mytilidae (LPIL)													
Mytilus edulis	1620	339	377		226	226	1243	377	1758		1893	226	2893

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Nephtyidae (LPIL)													
Nephtys (LPIL)		226											
Nephtys bucera		226					226						
Nereidae (LPIL)													
Neverita duplicata													
Nucula proxima													
Oligochaeta (LPIL)	9847	27472	27075	13379	12982	1876		8023	2518	7006	678	226	
Ophiurodea (LPIL)													
Ostracoda (LPIL)													
Ovalipes ocellatus		226		4068		226		301		226	226	301	
Ovalipes stephensoni													
Parahaustorius (LPIL)						226					226		
Parahaustorius attentuatus		226	339	2938	226	226	339	283					
Parahaustorius holmesi													
Parahaustorius longimerus					226						678	226	
Parandalia ocularis													
Paraonidae (LPIL)			226										
Paraprionospio pinnata													
Pelecypoda (LPIL)		226											
Petricola pholadiformis													226
Phoxocephalidae (LPIL)													
Phyllodoce arenae													
Phyllodocidae (LPIL)													
Pisionidae (LPIL)			2514										
Polydora (LPIL)													
Polygordius (LPIL)													
Portunidae (LPIL)													
Prionospio (LPIL)													
Protodrilidae (LPIL)					226								
Protodriloides (LPIL)											1187	2147	
Protohaustorius (LPIL)			226										

Appendix Table 2-2. Abundance of Intertidal Taxa (Numbers of Animals/m^2) (Continued)

Area	North	North	North	North	North	North	North	North	North	North	North	North	North
Depth	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1	MLW-1
Taxon (LPIL) Date	May-94	Sept.- 94	May-95	Sept.- 95	May-96	Sept.- 96	May-97	Sept.- 97	May-98	Sept.- 98	May-99	Sept.- 99	May-00
Pseudunciola obliquua													
Rhynchocoela (LPIL)	25515	10283	12136	7955	14283	2583	3842	2430	5175	10396	29244	4226	3221
Sabellaria vulgaris													
Sabellidae (LPIL)													
Scolelepis squamata	26829	17063	1130	11865	7533	2687	13861	872	6360	7797	27436	5133	34849
Sipuncula (LPIL)													
Spionidae (LPIL)		226									490		
Spisula solidissima		226									226		
Stenothoidae (LPIL)													
Streblospio benedicti													
Tellina agilis								226			226		
Tharyx acutus													
Turbellaria (LPIL)													
Turbonilla (LPIL)													
Unciola irrorata													
Xanthidae (LPIL)					226								

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2)

Taxa / Area / Date	South May-95	South Sept.- 95	South May-96	South Sept.- 96	South May-97	South Sept.- 97	South May-98	South Sept.- 98	South May-99	South Sept.- 99	South May-00
Acanthohaustorius (LPIL)			10	50		70					
Acanthohaustorius intermedius											
Acanthohaustorius millsi	48	119	55	251	236	477	235	611	337	384	318
Acarina (LPIL)											
Actiniaria (LPIL)			10	10		40		10	120		
Albunea paretii						10					
Americamysis bigelowi				10		70	10				
Americhelidium americanum	13	18	20			10	30	10	10		10
Ampelisca (LPIL)						10					
Ampharete (LPIL)		50	28								
Ampharete americana	30	20	50		22						
Ampharete finmarchica			50								
Ampharetidae (LPIL)	15	58	23		40	56	15	10	208	15	470
Amphipoda (LPIL)	10		10	10	10						
Ampithoe (LPIL)				20							
Ampithoe longimana											
Ampithoe valida				20							
Anadara ovalis						150					
Ancinus depressus											
Aoridae (LPIL)											
Apoprionospio pygmaea								10			
Archiannelida Family A			10								
Arcidae (LPIL)											
Aricidea (LPIL)						20					
Aricidea catherinae											
Asabellides oculata					35	228	160		90	104	998
Ascidiacea (LPIL)											
Astarte castanea						338					
Asteroidea (LPIL)		50				140					
Balanoglossus (LPIL)											10
Bathyporeia (LPIL)				120							
Bathyporeia parkeri			10		41		10		10	20	

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	South May-95	South Sept.- 95	South May-96	South Sept.- 96	South May-97	South Sept.- 97	South May-98	South Sept.- 98	South May-99	South Sept.- 99	South May-00
Bathyporeia quoddyensis							10	30	30		38
Bivalvia (LPIL)						50	20	15			90
Bodotriidae (LPIL)											
Callinectes (LPIL)						10					
Callinectes similis						10					
Calyptraea centralis											
Calyptraeidae (LPIL)						80					
Cancer irroratus											
Capitella capitata			10						200		
Capitellidae (LPIL)									20	10	
Carazziella hobsonae			10								
Caulleriella sp. J									10		
Chaetozone (LPIL)		10									
Chiridotea tuftsi	178	10	59	133	194		75	102	71	22	24
Cirratulidae (LPIL)		10	10			10	10		40		20
Corophium (LPIL)						20					
Corophium acutum											
Corophium insidiosum											
Corophium tuberculatum						10				10	
Crangon septemspinosa		10		10		17		10			
Crepidula (LPIL)											
Crepidula fornicata						70					
Crepidula plana						128		10			
Cumacea (LPIL)											
Decapoda (LPIL)											
Decapoda Reptantia (LPIL)		10									
Diastylidae (LPIL)							10				
Diastylis sculpta								10			
Diopatra cuprea											
Dipolydora commensalis									10		
Dipolydora socialis	10		10								
Dispio uncinata	26	64	23	42			18	190	55	250	18

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	South May-95	South Sept.- 95	South May-96	South Sept.- 96	South May-97	South Sept.- 97	South May-98	South Sept.- 98	South May-99	South Sept.- 99	South May-00
Donax variabilis			10	30	20		468	1003	367	95342	10836
Echinarachnius parma									10		
Echinoidea (LPIL)			20			30					
Edotea triloba	34	10	25	20		13	30		15		110
Elasmopus levis											
Emerita talpoida		10				10				10	
Ensis directus	10					10					20
Erichthonius rubricornis			10								
Eusarsiella zostericola											
Euspira heros										10	
Gammaridae (LPIL)				10		20	10				10
Gammarus (LPIL)	10	90	10	10			24		10		
Gammarus annulatus	30	42	20			30			10	630	50
Gastropoda (LPIL)				10		30					
Glycera (LPIL)						18				10	
Glycera americana	10										
Glycera capitata											
Glycera dibranchiata											
Glycera sp. E										10	
Glyceridae (LPIL)											
Glycinde solitaria											
Haminoea solitaria						10					
Harmothoe imbricata									20		
Haustoriidae (LPIL)	14	30	32	45	34	48	30	10	20	48	20
Hemipodus roseus											
Hippomedon sp. C											
Hydrobiidae (LPIL)											
Hydrozoa (LPIL)										10	
Hypereteone heteropoda								10			
Idotea balthica		40									
Idotea sp. A				10							
Idoteidae (LPIL)		10									

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	South May-95	South Sept.- 95	South May-96	South Sept.- 96	South May-97	South Sept.- 97	South May-98	South Sept.- 98	South May-99	South Sept.- 99	South May-00
Ilyanassa trivittata		10				20			10		
Isaeidae (LPIL)			10								
Ischyroceridae (LPIL)		10									
Isopoda (LPIL)											
Jassa falcata		30			10		20	20			
Jassa marmorata											
Leucon americanus											
Libinia dubia						100					
Lineidae (LPIL)					20	15		20			
Lumbrineridae (LPIL)											
Lysianassidae (LPIL)	37	10	77					10			
Macoma (LPIL)											
Macoma yoldiformis			30								
Mactra fragilis										18	
Magelona (LPIL)			10							10	
Magelona papillicornis	2133	1861	579	2196	52	89	23	10	50	21	10
Magelonidae (LPIL)					10						
Majidae (LPIL)						40				10	
Mancocuma stellifera					10				12		
Marenzellaria viridis						28					
Mediomastus (LPIL)						10	10				
Mediomastus ambiseta											
Mediomastus californiensis							10				
Melita (LPIL)						10					
Mulinia lateralis					18	30					
Mya arenaria							110				
Mysella planulata									10	47	
Mysidacea (LPIL)				10	30						
Mysidae (LPIL)		10	10	13	10	60	10				
Mytilidae (LPIL)				10							
Mytilus edulis	37	20	231	33	94	30	147		163	13	79
Naticidae (LPIL)			10								10

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	South May-95	South Sept.- 95	South May-96	South Sept.- 96	South May-97	South Sept.- 97	South May-98	South Sept.- 98	South May-99	South Sept.- 99	South May-00
Neomysis americana						171		10			
Neopanope sayi						10					
Nephtyidae (LPIL)	10	10		10		34	10	10	10		
Nephtys (LPIL)			10							10	
Nephtys bucera	16	33	18		15	17	10		20	10	60
Nephtys picta	25	10	10			10	10	20		27	65
Nereidae (LPIL)				10							
Nereididae (LPIL)								10			
Nereis succinea						15					30
Neverita duplicata	10					25					
Nucula proxima								20	50	15	20
Odostomia gibbosa						733					
Oedocerotidae (LPIL)											
Oligochaeta (LPIL)		10	10	15		30			40		10
Onuphidae (LPIL)						20					
Onuphis eremita		17	10			24	15			33	20
Orbinia americana	10										10
Ostraoda (LPIL)											
Ovalipes (LPIL)											
Ovalipes ocellatus	10	10		20		10		10	10	10	
Ovalipes stephensoni										10	
Owenia fusiformis											
Oxyurostylis smithi									10		10
Paguridae (LPIL)				10	10	31					
Pagurus (LPIL)	30		23	10		23	10	20			65
Pagurus longicarpus								10			
Pagurus politus	10	10				30			10		
Palaemonidae (LPIL)						10					
Parahaustorius (LPIL)											
Parahaustorius attenuatus			20	20	90			35	26	30	48
Parahaustorius longimerus										20	
Parametopella cypris											

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	South May-95	South Sept.- 95	South May-96	South Sept.- 96	South May-97	South Sept.- 97	South May-98	South Sept.- 98	South May-99	South Sept.- 99	South May-00
Paranaitis speciosa					10						
Paraonidae (LPIL)											
Paraonis fulgens	17										
Paraprionospio pinnata			10								
Pectinaria gouldii						10					
Pelecypoda (LPIL)	10	10	54	30							
Petricola pholadiformis										20	50
Pherusa affinis						10					
Pholadidae (LPIL)	10										
Photis macrocoxa											
Phoxocephalidae (LPIL)											
Phyllodoce (LPIL)						10					
Phyllodoce arenae	20	10				29			20	10	28
Phyllodocidae (LPIL)											
Pitar morrhuanus									10	10	
Podocopida (LPIL)											
Politilana polita											
Polydora cornuta											
Polygordius (LPIL)		10		10			10	18		37	15
Polynoidae (LPIL)			10			60					
Portunidae (LPIL)						10					
Protohaustorius (LPIL)			25	10		30	130				
Protohaustorius sp. B	82	102	53	50	37	399	165	138			
Protohaustorius wigleyi									270	388	269
Psammonyx nobilis	107	207	1400	110	570	365	73	140	515	392	1215
Pseudoleptocuma minor				23	10		18				10
Pseudunciola obliquua		35						15			
Pyramidellidae (LPIL)						10					
Rhepoxynius hudsoni								10			
Rhynchocoela (LPIL)	28	15	20	24	20	25	14	10	28	14	20
Sabellaria vulgaris		10				251					
Scolelepis squamata					15	25	25	305	90	10	

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	South May-95	South Sept.- 95	South May-96	South Sept.- 96	South May-97	South Sept.- 97	South May-98	South Sept.- 98	South May-99	South Sept.- 99	South May-00
Scoloplos rubra					10						
Sigalionidae (LPIL)						10		10			
Siliqua costata	13						20		15		27
Solen (LPIL)			10								
Solenidae (LPIL)											
Spio (LPIL)	100										
Spio pettiboneae										10	
Spio setosa							215		50		10
Spiochaetopterus oculatus		10				10				15	
Spionidae (LPIL)	10		15	43	10	47	10	14	135	13	10
Spiophanes bombyx	10	15	15	17	30	95	71	25	180	10	44
Spisula solidissima	94	144	20	120	17	700	33	321	105	93	33
Stenothoe minuta				10							
Sthenelais (LPIL)						13					
Sthenelais limicola	13	10			10				20	10	
Sthenolepis sp. A											
Streblospio benedicti		10	15								
Syllis gracilis											
Tanaidacea (LPIL)		10									
Tanaissus psammophilus		100			10				10		
Tectonatica pusilla						10				20	
Tellina agilis	156	135	1472	361	230	213	73	78	233	200	464
Tellinidae (LPIL)				20		120					
Tharyx acutus		10						10			
Turbellaria (LPIL)		10								20	
Turbonilla (LPIL)						23			10	30	
Turbonilla interrupta											30
Unciola (LPIL)	10					10					
Unciola irrorata			10				10				10
Unciola serrata											
Upogebiidae (LPIL)											
Xanthidae (LPIL)											

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	Middle May-95	Middle Sept.- 95	Middle May-96	Middle Sept.- 96	Middle May-97	Middle Sept.- 97	Middle May-98	Middle Sept.- 98	Middle May-99	Middle Sept.- 99	Middle May-00
Acanthohaustorius (LPIL)		15		33		35	20	15			
Acanthohaustorius intermedius	10										
Acanthohaustorius millsi	46	43	27	61	134	141	220	307	68	356	129
Acarina (LPIL)											
Actiniaria (LPIL)			320						33	10	
Albunea paretii											
Americamysis bigelowi		10		15	10	31		10			
Americhelidium americanum	10	14	10	10	10			15		10	
Ampelisca (LPIL)											
Ampharete (LPIL)		35	10								
Ampharete americana	15	53	10								
Ampharete finmarchica											
Ampharetidae (LPIL)	10	17	10	10	20	1155	40	10	32	23	10
Amphipoda (LPIL)				10							
Ampithoe (LPIL)		10									
Ampithoe longimana		10									
Ampithoe valida											
Anadara ovalis											
Ancinus depressus											10
Aoridae (LPIL)											
Apoprionospio pygmaea											
Archiannelida Family A											
Arcidae (LPIL)											
Aricidea (LPIL)											
Aricidea catherinae											
Asabellides oculata					20	92	135		109	120	
Ascidiacea (LPIL)										30	
Astarte castanea						145	20				
Asteroidea (LPIL)						10		15			
Balanoglossus (LPIL)											
Bathyporeia (LPIL)											
Bathyporeia parkeri	10				25		10				

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	Middle May-95	Middle Sept.- 95	Middle May-96	Middle Sept.- 96	Middle May-97	Middle Sept.- 97	Middle May-98	Middle Sept.- 98	Middle May-99	Middle Sept.- 99	Middle May-00
Bathyporeia quoddyensis							10				
Bivalvia (LPIL)					10	50	10	10	20		10
Bodotriidae (LPIL)		10									
Callinectes (LPIL)											
Callinectes similis											
Calyptraea centralis											
Calyptraeidae (LPIL)				20		40					
Cancer irroratus											
Capitella capitata											
Capitellidae (LPIL)											
Carazziella hobsonae											
Caulleriella sp. J											
Chaetozone (LPIL)											
Chiridotea tuftsi	35	24	29	40	238	10	27	36	48	10	10
Cirratulidae (LPIL)			10	10							
Corophium (LPIL)											
Corophium acutum											
Corophium insidiosum											
Corophium tuberculatum											
Crangon septemspinosa		10		15	10	15					
Crepidula (LPIL)						30					
Crepidula fornicata											
Crepidula plana						26		40			
Cumacea (LPIL)											
Decapoda (LPIL)											
Decapoda Reptantia (LPIL)											
Diastylidae (LPIL)											
Diastylis sculpta											
Diopatra cuprea							10				
Dipolydora commensalis											
Dipolydora socialis								20			
Dispio uncinata	24	68	28	351	15		18	133	30	365	15

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	Middle May-95	Middle Sept.- 95	Middle May-96	Middle Sept.- 96	Middle May-97	Middle Sept.- 97	Middle May-98	Middle Sept.- 98	Middle May-99	Middle Sept.- 99	Middle May-00
Donax variabilis	30	30			54	518	1538	102	177	14320	1002
Echinarachnius parma											
Echinoidea (LPIL)			10			10				10	
Edotea triloba	10	10	13	10	10	10	15		25		10
Elasmopus levis											
Emerita talpoida		20		10							
Ensis directus		10							10		
Erichthonius rubricornis											
Eusarsiella zostericola							10				
Euspira heros								10			
Gammaridae (LPIL)									10		13
Gammarus (LPIL)	10	15	13				73		40		15
Gammarus annulatus	43	10	15				473		10	190	20
Gastropoda (LPIL)				10							
Glycera (LPIL)						28				10	
Glycera americana											
Glycera capitata											
Glycera dibranchiata									10		
Glycera sp. E											
Glyceridae (LPIL)						40					
Glycinde solitaria											
Haminoea solitaria											
Harmothoe imbricata											
Haustoriidae (LPIL)	15	10	10	26	60	10	18		10	10	
Hemipodus roseus											
Hippomedon sp. C									10		
Hydrobiidae (LPIL)						20					
Hydrozoa (LPIL)											
Hypereteone heteropoda				10							
Idotea balthica										10	
Idotea sp. A											
Idoteidae (LPIL)							10				

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	Middle May-95	Middle Sept.- 95	Middle May-96	Middle Sept.- 96	Middle May-97	Middle Sept.- 97	Middle May-98	Middle Sept.- 98	Middle May-99	Middle Sept.- 99	Middle May-00
Ilyanassa trivittata											
Isaeidae (LPIL)											
Ischyroceridae (LPIL)			10								
Isopoda (LPIL)	10										
Jassa falcata	10		10		10		10		10	15	
Jassa marmorata					13						
Leucon americanus			10								
Libinia dubia											
Lineidae (LPIL)			10		20	10		10		10	
Lumbrineridae (LPIL)											
Lysianassidae (LPIL)	10						10				10
Macoma (LPIL)											
Macoma yoldiformis			18								
Mactra fragilis										35	
Magelona (LPIL)										10	
Magelona papillicornis	933	1331	167	2595	123	150	15	10	15	30	20
Magelonidae (LPIL)					10						
Majidae (LPIL)											
Mancocuma stellifera					10						
Marenzellaria viridis											
Mediomastus (LPIL)				10						10	
Mediomastus ambiseta											
Mediomastus californiensis											
Melita (LPIL)											
Mulinia lateralis					35					25	
Mya arenaria											
Mysella planulata										40	
Mysidacea (LPIL)		10									
Mysidae (LPIL)		10		10	23	40					
Mytilidae (LPIL)				15							
Mytilus edulis	16		71	45	49	20	143		162	97	27
Naticidae (LPIL)									10		

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	Middle May-95	Middle Sept.- 95	Middle May-96	Middle Sept.- 96	Middle May-97	Middle Sept.- 97	Middle May-98	Middle Sept.- 98	Middle May-99	Middle Sept.- 99	Middle May-00
Neomysis americana		10				36		10			
Neopanope sayi											
Nephtyidae (LPIL)	25	10		17		85	10	13	10		
Nephtys (LPIL)										10	
Nephtys bucera	13	30	15	10	10	24	40			10	10
Nephtys picta							30	13	13	17	10
Nereidae (LPIL)				20							
Nereididae (LPIL)						10		10			
Nereis succinea											
Neverita duplicata						10				10	
Nucula proxima							10		10		
Odostomia gibbosa						40					
Oedocerotidae (LPIL)											
Oligochaeta (LPIL)			10							10	
Onuphidae (LPIL)						20					
Onuphis eremita						20	10		10	10	10
Orbinia americana									20		
Ostraoda (LPIL)							10				
Ovalipes (LPIL)											
Ovalipes ocellatus		10	10	10				15	10		
Ovalipes stephensoni											
Owenia fusiformis						10					
Oxyurostylis smithi									10	10	
Paguridae (LPIL)				30		14					
Pagurus (LPIL)			10	10		37	10				
Pagurus longicarpus						20		40			
Pagurus politus							10		15		
Palaemonidae (LPIL)											
Parahaustorius (LPIL)											
Parahaustorius attenuatus	20		20		50		10				
Parahaustorius longimerus	20			10							
Parametopella cypris											

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa \ Area / Date	Middle May-95	Middle Sept.- 95	Middle May-96	Middle Sept.- 96	Middle May-97	Middle Sept.- 97	Middle May-98	Middle Sept.- 98	Middle May-99	Middle Sept.- 99	Middle May-00
Paranaitis speciosa											
Paraonidae (LPIL)				10							
Paraonis fulgens											
Paraprionospio pinnata											
Pectinaria gouldii				10		10					
Pelecypoda (LPIL)		10	20	33							
Petricola pholadiformis											
Pherusa affinis											
Pholadidae (LPIL)											
Photis macrocoxa											
Phoxocephalidae (LPIL)											
Phyllodoce (LPIL)						20					
Phyllodoce arenae		10		10		16					
Phyllodocidae (LPIL)						10					10
Pitar morrhuanus											
Podocopida (LPIL)											
Politilana polita											
Polydora cornuta				10							
Polygordius (LPIL)							10	15		10	
Polynoidae (LPIL)						10					
Portunidae (LPIL)											
Protohaustorius (LPIL)											
Protohaustorius sp. B	18	41	27	39		211	98	79			
Protohaustorius wigleyi									31	257	30
Psammonyx nobilis	4760	530	20	180	1243	102	115	70	415	275	
Pseudoleptocuma minor			10	10	10		16				10
Pseudunciola obliquua		10								10	
Pyramidellidae (LPIL)											
Rhepoxynius hudsoni					10					10	
Rhynchocoela (LPIL)	40	24	22	34	20	80	46	16	28	35	
Sabellaria vulgaris						81					
Scolelepis squamata					59	49	23	60	20		

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	Middle May-95	Middle Sept.- 95	Middle May-96	Middle Sept.- 96	Middle May-97	Middle Sept.- 97	Middle May-98	Middle Sept.- 98	Middle May-99	Middle Sept.- 99	Middle May-00
Scoloplos rubra											
Sigalionidae (LPIL)							10				
Siliqua costata	10						18		20		
Solen (LPIL)											
Solenidae (LPIL)							10		10		
Spio (LPIL)									15		
Spio pettiboneae											
Spio setosa				10							
Spiochaetopterus oculatus		10		20		15		10		20	
Spionidae (LPIL)	14	10		63	10	26	10	20	10	20	10
Spiophanes bombyx	50	13		18	10	35	60	17	24		
Spisula solidissima	32	133	13	220	10	552	23	735	98	26	15
Stenothoe minuta											
Sthenelais (LPIL)									10		
Sthenelais limicola		10			20				10		
Sthenolepis sp. A										10	
Streblospio benedicti		20							30		
Syllis gracilis										10	
Tanaidacea (LPIL)											
Tanaissus psammophilus		10	20								
Tectonatica pusilla										10	
Tellina agilis	39	63	424	278	161	156	36	20	221	108	109
Tellinidae (LPIL)				10			10				
Tharyx acutus											
Turbellaria (LPIL)				10							
Turbonilla (LPIL)						13				15	10
Turbonilla interrupta											
Unciola (LPIL)							10				
Unciola irrorata				10					10		
Unciola serrata				10							
Upogebiidae (LPIL)						10					
Xanthidae (LPIL)											

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa \ Area / Date	North May-95	North Sept.- 95	North May-96	North Sept.- 96	North May-97	North Sept.- 97	North May-98	North Sept.- 98	North May-99	North Sept.- 99	North May-00
Acanthohaustorius (LPIL)				30							
Acanthohaustorius intermedius											
Acanthohaustorius millsi	30	40	23	78	58	91	116	288	79	226	1221
Acarina (LPIL)		10									
Actiniaria (LPIL)			20				10				
Albunea paretii											
Americamysis bigelowi		20		53		15					
Americhelidium americanum	10	22	13	20	17					30	18
Ampelisca (LPIL)											10
Ampharete (LPIL)		125	30								
Ampharete americana	30	346	20		15						
Ampharete finmarchica			10								
Ampharetidae (LPIL)	20	118	20	34	27	3750	30	10	59		256
Amphipoda (LPIL)						20					
Ampithoe (LPIL)											
Ampithoe longimana											
Ampithoe valida				10							
Anadara ovalis						10					
Ancinus depressus											
Aoridae (LPIL)				30							
Apoprionospio pygmaea											
Archiannelida Family A											
Arcidae (LPIL)				10		50					
Aricidea (LPIL)			20					10			
Aricidea catherinae						10					
Asabellides oculata					10	3429	10		123	65	524
Ascidiacea (LPIL)						10					
Astarte castanea						547	15				
Asteroidea (LPIL)						33					
Balanoglossus (LPIL)											
Bathyporeia (LPIL)											
Bathyporeia parkeri	10	10			10					10	

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	North May-95	North Sept.- 95	North May-96	North Sept.- 96	North May-97	North Sept.- 97	North May-98	North Sept.- 98	North May-99	North Sept.- 99	North May-00
Bathyporeia quoddyensis								10			
Bivalvia (LPIL)					20	50	15		20		
Bodotriidae (LPIL)	10										
Callinectes (LPIL)											
Callinectes similis											
Calyptraea centralis						50					
Calyptraeidae (LPIL)						51					
Cancer irroratus						15					
Capitella capitata				10					10		
Capitellidae (LPIL)				10							
Carazziella hobsonae											
Caulleriella sp. J											
Chaetozone (LPIL)											
Chiridotea tuftsi	23	180	18	47	162	10	33	70	60	47	110
Cirratulidae (LPIL)			13	10			10	10	10		10
Corophium (LPIL)		10									10
Corophium acutum											10
Corophium insidiosum			20								
Corophium tuberculatum											
Crangon septemspinosa		10		10	10	18		10			
Crepidula (LPIL)											
Crepidula fornicata						50					
Crepidula plana						102					
Cumacea (LPIL)											10
Decapoda (LPIL)											10
Decapoda Reptantia (LPIL)		10									
Diastylidae (LPIL)											
Diastylis sculpta											
Diopatra cuprea						10					
Dipolydora commensalis											
Dipolydora socialis						10					
Dispio uncinata	22	68	62	192	10		20	251	55	840	60

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	North May-95	North Sept.- 95	North May-96	North Sept.- 96	North May-97	North Sept.- 97	North May-98	North Sept.- 98	North May-99	North Sept.- 99	North May-00
Donax variabilis	10		10	20	18	1910	69	263	71	84883	25689
Echinarachnius parma											
Echinoidea (LPIL)			10								
Edotea triloba	10	10	32	20	30	10			10		10
Elasmopus levis								10			
Emerita talpoida						10				10	
Ensis directus		10							10	10	
Erichthonius rubricornis											
Eusarsiella zostericola											
Euspira heros										10	
Gammaridae (LPIL)		10									
Gammarus (LPIL)	10	196	13				50		18		10
Gammarus annulatus	40	617	25			100	20		40	24	240
Gastropoda (LPIL)			10	10		13			10		
Glycera (LPIL)						10					
Glycera americana											
Glycera capitata										20	
Glycera dibranchiata				10		10		10			
Glycera sp. E										20	
Glyceridae (LPIL)											
Glycinde solitaria				310							
Haminoea solitaria											
Harmothoe imbricata											
Haustoriidae (LPIL)	10	10		24	12	15	25	27	10	10	
Hemipodus roseus		10									
Hippomedon sp. C											
Hydrobiidae (LPIL)											
Hydrozoa (LPIL)											
Hypereteone heteropoda				30							
Idotea balthica											
Idotea sp. A				10							
Idoteidae (LPIL)											

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	North May-95	North Sept.- 95	North May-96	North Sept.- 96	North May-97	North Sept.- 97	North May-98	North Sept.- 98	North May-99	North Sept.- 99	North May-00
Ilyanassa trivittata											
Isaeidae (LPIL)											
Ischyroceridae (LPIL)		10		10							
Isopoda (LPIL)											
Jassa falcata		10	20	30		10	10		10	10	
Jassa marmorata											
Leucon americanus											
Libinia dubia											
Lineidae (LPIL)						10		10			
Lumbrineridae (LPIL)										10	
Lysianassidae (LPIL)	10										
Macoma (LPIL)			12								
Macoma yoldiformis			47								
Mactra fragilis											
Magelona (LPIL)						20			10	10	
Magelona papillicornis	36	1538	497	3547	28	194	10	10	23	24	17
Magelonidae (LPIL)					10						
Majidae (LPIL)						25					
Mancocuma stellifera					30						
Marenzellaria viridis											
Mediomastus (LPIL)				20							10
Mediomastus ambiseta											10
Mediomastus californiensis											
Melita (LPIL)											
Mulinia lateralis					10	13				10	
Mya arenaria											
Mysella planulata										53	
Mysidacea (LPIL)		10									
Mysidae (LPIL)		30	10	20	10	46					10
Mytilidae (LPIL)			230	30							
Mytilus edulis	60		316	37	86	14	59		656	10	469
Naticidae (LPIL)											

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	North May-95	North Sept.- 95	North May-96	North Sept.- 96	North May-97	North Sept.- 97	North May-98	North Sept.- 98	North May-99	North Sept.- 99	North May-00
Neomysis americana		10				50		30			
Neopanope sayi											
Nephtyidae (LPIL)	15	20		18	10	139		15	13		
Nephtys (LPIL)											
Nephtys bucera	10	10	15	10	17	24	10	15	18		43
Nephtys picta		10					23	15	17	15	25
Nereidae (LPIL)											
Nereididae (LPIL)						10		10			
Nereis succinea											
Neverita duplicata											
Nucula proxima						20	10		10		10
Odostomia gibbosa						20					
Oedocerotidae (LPIL)			10								
Oligochaeta (LPIL)			127				23	10	10		
Onuphidae (LPIL)						18					
Onuphis eremita		10								20	
Orbinia americana									10	20	10
Ostraoda (LPIL)											
Ovalipes (LPIL)								10			
Ovalipes ocellatus		20		10		10		40		10	
Ovalipes stephensoni											
Owenia fusiformis											
Oxyurostylis smithi									10	10	17
Paguridae (LPIL)						240					
Pagurus (LPIL)		10			10	33		20		10	10
Pagurus longicarpus					20	10		10			
Pagurus politus		10		10			10		10		
Palaemonidae (LPIL)											
Parahaustorius (LPIL)				10	10						
Parahaustorius attenuatus	10		15	20	17		10		20		10
Parahaustorius longimerus				20	15				10		
Parametopella cypris						10					

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa \ Area / Date	North May-95	North Sept.- 95	North May-96	North Sept.- 96	North May-97	North Sept.- 97	North May-98	North Sept.- 98	North May-99	North Sept.- 99	North May-00
Paranaitis speciosa											
Paraonidae (LPIL)					10						
Paraonis fulgens		10						10		10	
Paraprionospio pinnata											
Pectinaria gouldii						10				10	
Pelecypoda (LPIL)			43	10							
Petricola pholadiformis									20	10	10
Pherusa affinis						13					
Pholadidae (LPIL)											
Photis macrocoxa			10								
Phoxocephalidae (LPIL)		10									
Phyllodoce (LPIL)											
Phyllodoce arenae		13		15		28					40
Phyllodocidae (LPIL)						60					
Pitar morrhuanus											
Podocopida (LPIL)											10
Politilana polita				15					10		10
Polydora cornuta		10	10								
Polygordius (LPIL)		30					190	10	11	37	
Polynoidae (LPIL)			10			17					
Portunidae (LPIL)		10									
Protohaustorius (LPIL)	20			10							
Protohaustorius sp. B		25	13	37	20	16	10	33			
Protohaustorius wigleyi									47	52	50
Psammonyx nobilis	10			65	127	114	10	10	460	17	
Pseudoleptocuma minor			10	17	12		12	10	10		10
Pseudunciola obliquua		15			10						
Pyramidellidae (LPIL)											
Rhepoxynius hudsoni						10					
Rhynchocoela (LPIL)		20	35	47	18	129	31	26	37	20	23
Sabellaria vulgaris			10		10	270					
Scolelepis squamata					45	77	26	302	17		10

Appendix Table 2-3. Abundance of Nearshore Taxa (Numbers of Animals/m^2) (Continued)

Taxa / Area / Date	North May-95	North Sept.- 95	North May-96	North Sept.- 96	North May-97	North Sept.- 97	North May-98	North Sept.- 98	North May-99	North Sept.- 99	North May-00
Scoloplos rubra											10
Sigalionidae (LPIL)						15					
Siliqua costata	40						15		26		
Solen (LPIL)											
Solenidae (LPIL)									10		
Spio (LPIL)									25		10
Spio pettiboneae											
Spio setosa									10		20
Spiochaetopterus oculatus						10		13			
Spionidae (LPIL)	180	10	10	87	20	18	10	23	10	60	10
Spiophanes bombyx		10	10	37		13	30	28	20	10	30
Spisula solidissima		98	15	228	10	1283	20	1446	41	23	37
Stenothoe minuta			10			10					
Sthenelais (LPIL)											
Sthenelais limicola	10							10	10		
Sthenolepis sp. A											
Streblospio benedicti				10							
Syllis gracilis											
Tanaidacea (LPIL)											
Tanaissus psammophilus			23								
Tectonatica pusilla									10	25	10
Tellina agilis	178	108	886	760	114	178	47	50	219	178	253
Tellinidae (LPIL)					70	270	20				
Tharyx acutus										10	
Turbellaria (LPIL)		10		10		33				10	10
Turbonilla (LPIL)					10	43			30	10	
Turbonilla interrupta											
Unciola (LPIL)				10				10			
Unciola irrorata											10
Unciola serrata											
Upogebiidae (LPIL)				10							
Xanthidae (LPIL)											10

Appendix Table 2-4. Analysis of Variance (ANOVA) Results- Biannual Data

Abundance

Source	SS	DF Num	F Ratio	Prob>F
Area	0.2517	2	0.1954	0.8234
Depth	9.0020	2	6.9895	0.0029
Date	5.9236	17	0.5411	0.9105
Area*Depth	9.9736	4	3.8719	0.0068
Area*Date	11.4866	34	0.5246	0.9793
Depth*Date	20.0506	34	0.9158	0.6026
Area*Depth*Date	67.7672	68	1.5476	0.0030
Error	1615.0668	2508		

Biomass

Source	SS	DF Num	F Ratio	Prob>F
Area	2.7671	2	0.7845	0.4644
Depth	11.6698	2	3.3086	0.0486
Date	58.9712	17	1.9670	0.0457
Area*Depth	4.4041	4	0.6243	0.6467
Area*Date	0.0063	34	0.0001	1.0000
Depth*Date	10.8594	34	0.1811	1.0000
Area*Depth*Date	539.9615	68	4.5026	<.0001
Error	4422.9992	2508		

Intertidal Taxa

Source	SS	DF Num	F Ratio	Prob>F
Area	0.0238	2	0.1680	0.8464
Depth	0.1203	1	0.5860	0.4587
Date	3.9672	12	1.4767	0.2471
Area*Depth	0.3036	2	2.9083	0.0740
Area*Date	1.6974	24	1.3551	0.2311
Depth*Date	2.4642	12	3.9345	0.0021
Area*Depth*Date	1.2526	24	2.1353	0.0011
Error	55.2893	2262		

Nearshore Taxa

Source	SS	DF Num	F Ratio	Prob>F
Area	0.6690	2	2.7218	0.0901
Date	4.9318	10	4.0130	0.0040
Area*Date	2.4579	20	4.8294	<.0001
Error	7.5578	297		

Appendix Table 2-5. Abundance of Monthly Intertidal Taxa (Numbers of Animals/m^2) from 1997

Taxon	South May-97	South Jun-97	South Jul-97	South Aug-97	South Sep-97	South Oct-97	South Nov-97	Middle May-97	Middle Jun-97	Middle Jul-97	Middle Aug-97	Middle Sep-97	Middle Oct-97	Middle Nov-97
Ancylidae (LPIL)											75			
Aoridae (LPIL)									75					
Bivalvia (LPIL)												151	75	
Caprellidae (LPIL)						75								
Chiridotea tuftsi			75											
Cirratulidae (LPIL)									75					
Crepidula (LPIL)					301									
Donax variabilis		151							301					
Emerita talpoida	75						829							226
Haustoriidae (LPIL)		151							301					
Haustorius canadensis	75							151	226					
Jassa falcata		75			75			75						
Lumbrineridae (LPIL)	75													
Mactridae (LPIL)					301									
Manocuma stelliffera										151				
Mediomastus ambiseta		150		301					75					
Nephtys (LPIL)					75	75								
Neverita duplicata					75									
Oligochaeta (LPIL)		8739	12581	5650	527	1055		151	4520	3390	753	1657	8211	170931
Ophiuroidea (LPIL)	75											75		
Ovalipes stephensoni			301	75						151	226			
Parahaustorius attenuatus			226	151				151		151	904			
Phyllodoce arenae	75													
Polychaeta (LPIL)							75							75
Polygordius (LPIL)					753									527
Rhynchocoela (LPIL)	51980	90701	37365	19813	20265	7232	8965	17854	142757	54767	16649	60649	24709	829
Sabellaria vulgaris					75							75		
Scolelepis squamata	78874	98310	92208	7985	38646	9417	6316	50247	70286	21771	7609	39776	41584	
Streblospio benedicti		75												

Appendix Table 2-6. Abundance of Monthly Intertidal Taxa (Numbers of Animals/m^2) from 1999-2000

Area	South	South	South	South	South	South	South	South	South	South	South	South	South
Taxa / Date	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00
Amphipoda (LPIL)				226									
Amphiporeia virginiana		226											
Aoridae (LPIL)						226							
Ascidiacea (LPIL)													
Bivalvia (LPIL)													
Capitellidae (LPIL)									226				
Cirratulidae (LPIL)													
Crepidula plana								226					
Donax variabilis		678	678	452		226							452
Echinoidea (LPIL)				226									
Emerita talpoida	678		735	226	565	8023	1017	678	678			791	1243
Gammarus (LPIL)		226											
Gastropoda (LPIL)			226										
Haustorius canadensis						452	226	226					
Hippidae (LPIL)													
Jassa falcata													226
Levinsenia gracilis												226	
Lumbrineridae (LPIL)													
Microphthalmus (LPIL)		904											
Microphthalmus aberrans			226										
Microphthalmus sp. G				527	791								
Mytilus edulis	9944	961	603	678			226	226			339	904	527
Nephtys bucera													
Oligochaeta (LPIL)			452			226							
Ostracoda (LPIL)	226												
Ovalipes ocellatus				226									
Parahaustorius attenuatus		226											
Parahaustorius longimerus													
Paraonidae (LPIL)								226					
Petricola pholadiformis							226						
Pleustidae (LPIL)							226						

Appendix Table 2-6. Abundance of Monthly Intertidal Taxa (Numbers of Animals/m^2) from 1999-2000 (Continued)

Taxa / Area / Date	South May-99	South Jun-99	South Jul-99	South Aug-99	South Sep-99	South Oct-99	South Nov-99	South Dec-99	South Jan-00	South Feb-00	South Mar-00	South Apr-00	South May-00
Polygordius (LPIL)						603	226				226		
Protodriloides (LPIL)		2204	2147	490	3119	377	2034	1130	339	1130	678	565	2411
Pseudunciola obliquua						226							
Rhynchocoela (LPIL)	29945	24973	28325	44823	9906	452	3880	3560	1220	1639	7865	6177	37403
Scolelepis squamata	101248	9537	44115	62640	20076	10260	84637	21809	452	12340	2938	1695	34013
Sipuncula (LPIL)						904	1017						
Spionidae (LPIL)	1220	678											
Spisula solidissima							226						
Streblospio benedicti													
Tellina (LPIL)			226										
Tubificidae (LPIL)									226				
Turbonilla interrupta											226		226

Appendix Table 2-6. Abundance of Monthly Intertidal Taxa (Numbers of Animals/m^2) from 1999-2000 (Continued)

Area	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle
Taxa Date	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00
Amphipoda (LPIL)													226
Amphiporeia virginiana													
Aoridae (LPIL)													
Ascidiacea (LPIL)				339									
Bivalvia (LPIL)											226		
Capitellidae (LPIL)													
Cirratulidae (LPIL)	226												
Crepidula plana													
Donax variabilis		1130	565	226		301							226
Echinoidea (LPIL)													
Emerita talpoida		226		1657		226	904				226		452
Gammarus (LPIL)													
Gastropoda (LPIL)													
Haustorius canadensis				226	339	226							
Hippidae (LPIL)		226											
Jassa falcata													
Levinsenia gracilis													
Lumbrineridae (LPIL)										226			
Microphthalmus (LPIL)		791											
Microphthalmus aberrans													
Microphthalmus sp. G							452						
Mytilus edulis	1243	1507	226	452	226	226		226		226	226		452
Nephtys bucera										226			
Oligochaeta (LPIL)	904	565	226	42036	829								
Ostracoda (LPIL)													
Ovalipes ocellatus	226	226			452								
Parahaustorius attenuatus													
Parahaustorius longimerus	452	565		226									
Paraonidae (LPIL)													
Petricola pholadiformis						226						452	
Pleustidae (LPIL)													

Appendix Table 2-6. Abundance of Monthly Intertidal Taxa (Numbers of Animals/m^2) from 1999-2000 (Continued)

Taxa / Area / Date	Middle May-99	Middle Jun-99	Middle Jul-99	Middle Aug-99	Middle Sep-99	Middle Oct-99	Middle Nov-99	Middle Dec-99	Middle Jan-00	Middle Feb-00	Middle Mar-00	Middle Apr-00	Middle May-00
Polygordius (LPIL)						226							
Protodriloides (LPIL)	904	3616	2034	2882	1281		226						226
Pseudunciola obliquua													
Rhynchocoela (LPIL)	18231	7646	8701	4351	12694	396	565	3729	452	1492	1672	2373	15519
Scolelepis squamata	33448	11451	52477	9097	47460	22012	768	904	452	1492	2373	4927	3352
Sipuncula (LPIL)							565						
Spionidae (LPIL)	678							226				226	
Spisula solidissima	452	226				226	226						
Streblospio benedicti					226								
Tellina (LPIL)													
Tubificidae (LPIL)													
Turbonilla interrupta													

Appendix Table 2-7. Biomass Composition of Monthly Infaunal Samples 1997

97May	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 21	Station 22	Station 23	Station 24	Station 25	Station 26
Annelid	5.38	94.44	99.72	99.13	99.99	99.59	96.92	35.34	98.47	99.94	99.99	98.07
Crusteacea	94.23	-----	-----	-----	-----	-----	-----	64.47	-----	0.03	-----	1.93
Mollusc	0.10	2.78	0.01	-----	-----	0.12	2.84	0.19	0.72	0.03	-----	-----
Echinoderm	-----	-----	-----	0.29	-----	-----	-----	-----	-----	-----	-----	-----
Misc	0.29	2.78	0.27	0.58	-----	0.29	0.24	-----	0.81	-----	0.01	-----
97June	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelid	99.60	99.83	98.72	99.80	98.81	96.28	94.72	99.61	96.38	99.18	97.56	99.89
Crusteacea	-----	-----	-----	-----	-----	-----	-----	-----	2.17	-----	0.01	-----
Mollusc	0.39	0.12	-----	0.01	-----	2.11	0.96	0.24	1.07	0.03	1.90	-----
Echinoderm	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Misc	-----	0.05	1.28	0.19	1.19	1.60	4.33	0.15	0.38	0.79	0.53	0.11
97July	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelid	20.00	100.00	33.33	99.46	98.87	98.77	99.26	-----	0.83	99.81	5.59	96.49
Crusteacea	40.00	-----	-----	0.41	-----	1.22	-----	99.81	98.35	0.10	94.10	2.89
Mollusc	20.00	-----	33.33	-----	-----	-----	-----	0.19	-----	-----	-----	-----
Echinoderm	0.00	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Misc	20.00	-----	33.33	0.12	1.13	0.01	0.74	-----	0.83	0.10	0.31	0.62
97Aug	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelid	0.01	99.80	1.36	97.45	50.13	99.08	0.99	0.07	78.06	0.08	-----	99.80
Crusteacea	94.73	-----	98.49	-----	-----	-----	27.21	84.78	21.86	16.35	99.87	-----
Mollusc	5.25	-----	-----	-----	49.69	-----	71.80	15.07	-----	83.42	-----	-----
Echinoderm	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Misc	0.01	0.20	0.15	2.55	0.18	0.92	0.01	0.07	0.08	0.15	0.13	0.20
97Sept	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelid	12.28	99.28	7.25	99.98	99.31	53.09	99.87	-----	98.74	99.71	99.78	2.16
Crusteacea	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	96.38
Mollusc	87.68	-----	92.68	-----	-----	-----	-----	100.00	0.18	-----	-----	0.02
Echinoderm	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Misc	0.04	0.72	0.08	0.02	0.69	46.91	0.13	0.00	1.08	0.29	0.22	1.45

Appendix Table 2-7. Biomass Composition of Monthly Infaunal Samples 1997

97Oct	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 21	Station 22	Station 23	Station 24	Station 25	Station 26
Annelid	98.41	99.55	99.44	99.93	99.90	96.43	99.39	98.72	95.28	99.97	99.66	99.94
Crusteacea	-----	0.15	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusc	-----	-----	-----	-----	-----	-----	0.01	-----	-----	-----	-----	-----
Echinoderm	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Misc	1.59	0.30	0.56	0.07	0.10	3.57	0.60	1.28	4.72	0.03	0.34	0.06
97Nov	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelid	98.78	10.03	66.37	47.75	-----	31.10	-----	0.22	96.77	45.33	55.74	-----
Crusteacea	-----	89.81	33.48	51.25	-----	68.68	-----	99.55	-----	53.33	-----	-----
Mollusc	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	43.93	-----
Echinoderm	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Misc	1.22	0.15	0.15	1.00	-----	0.22	-----	0.22	3.23	1.33	0.33	100.00

Appendix Table 2-8. Biomass Composition of Monthly Infaunal Samples 1999-2000

99May	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 21	Station 22	Station 23	Station 24	Station 25	Station 26
Annelida	15.92	91.64	99.33	97.01	97.39	96.45	70.49	98.36	99.27	92.66	58.73	95.08
Crustacea	82.71	6.71	-----	-----	0.01	-----	28.14	0.70	-----	5.50	40.23	4.60
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	1.35	1.58	0.21	0.39	1.99	3.23	1.15	0.50	0.72	0.59	-----	0.02
Other Taxa	0.02	0.07	0.45	2.60	0.61	0.32	0.23	0.44	0.02	1.25	1.04	0.29
99June	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	86.69	96.66	-----	96.65	49.66	91.24	67.38	97.24	99.82	25.27	40.18	6.33
Crustacea	-----	-----	35.05	-----	0.23	0.09	32.47	0.49	-----	68.95	59.53	93.63
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	8.27	1.82	64.92	1.02	49.66	8.54	0.15	1.45	-----	5.76	0.06	-----
Other Taxa	5.05	1.52	0.03	2.33	0.46	0.13	-----	0.82	0.18	0.02	0.23	0.04
99July	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	88.23	52.89	11.21	69.06	0.04	96.23	99.96	99.23	99.93	99.86	99.88	31.36
Crustacea	-----	47.05	87.51	30.34	99.89	-----	-----	-----	-----	-----	-----	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	11.68	-----	0.35	-----	-----	2.52	-----	0.70	-----	-----	-----	68.34
Other Taxa	0.09	0.06	0.94	0.60	0.06	1.25	0.04	0.07	0.07	0.14	0.12	0.30
99Aug	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	69.58	47.45	76.97	98.78	88.02	99.89	99.50	97.63	2.96	99.67	0.56	-----
Crustacea	-----	-----	0.51	-----	11.77	-----	-----	-----	71.85	-----	99.06	35.39
Echinodermata	1.13	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	27.21	49.63	21.09	-----	-----	-----	-----	-----	23.62	-----	-----	64.60
Other Taxa	2.08	2.92	1.43	1.22	0.22	0.11	0.50	2.37	1.57	0.33	0.37	-----
99Sept	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	60.31	88.53	93.81	99.25	21.78	99.68	83.40	99.74	99.24	59.67	15.18	25.21
Crustacea	36.94	-----	-----	-----	77.45	-----	15.59	-----	-----	39.44	79.27	50.99
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	-----	-----	-----	-----	-----	-----	0.19	-----	-----	-----	-----	-----
Other Taxa	2.75	11.47	6.19	0.75	0.76	0.32	0.83	0.26	0.76	0.89	5.55	23.80

Appendix Table 2-8. Biomass Composition of Monthly Infaunal Samples 1999-2000

99Oct	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 21	Station 22	Station 23	Station 24	Station 25	Station 26
Annelida	87.92	32.74	1.51	8.18	0.75	9.84	97.46	6.84	99.69	97.87	17.41	100.00
Crustacea	12.05	66.45	98.23	91.82	99.25	90.16	-----	73.74	-----	-----	70.49	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	-----	-----	0.04	-----	-----	-----	2.48	19.41	-----	1.65	-----	-----
Other Taxa	0.03	0.81	0.22	-----	-----	-----	0.06	0.00	0.31	0.48	12.10	-----
99Nov	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	18.95	99.22	99.48	99.96	99.94	99.38	80.63	100.00	100.00	91.63	-----	73.54
Crustacea	75.38	0.59	0.26	-----	-----	0.35	-----	-----	-----	-----	96.74	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	3.56	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.87	-----
Other Taxa	2.11	0.19	0.26	0.03	0.06	0.27	19.37	-----	-----	8.37	2.39	26.46
99Dec	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	77.54	98.69	93.50	7.99	98.39	-----	22.16	-----	-----	-----	100.00	-----
Crustacea	-----	-----	6.16	90.38	1.38	100.00	-----	-----	-----	-----	-----	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	17.85	-----	-----	1.63	-----	-----	-----	100.00	-----	-----	-----	-----
Other Taxa	4.62	1.31	0.33	-----	0.22	-----	77.84	-----	-----	-----	-----	100.00
00Jan	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	49.43	100.00	86.91	3.57	10.65	32.43	100.00	-----	-----	-----	-----	-----
Crustacea	-----	-----	-----	91.64	88.26	-----	-----	-----	-----	-----	-----	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Other Taxa	50.57	-----	13.09	4.79	1.09	67.57	-----	100.00	-----	-----	-----	-----
00Feb	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	-----	99.44	97.22	4.83	100.00	100.00	99.53	100.00	99.73	99.09	-----	95.96
Crustacea	-----	-----	-----	95.17	-----	-----	-----	-----	-----	-----	-----	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.59
Other Taxa	100.00	0.56	2.78	-----	-----	-----	0.47	-----	0.27	0.91	100.00	0.45

Appendix Table 2-8. Biomass Composition of Monthly Infaunal Samples 1999-2000

00Mar	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 21	Station 22	Station 23	Station 24	Station 25	Station 26
Annelida	99.72	98.35	99.84	97.89	97.36	82.29	99.96	48.24	99.48	98.08	98.53	96.86
Crustacea	-----	-----	-----	-----	-----	-----	-----	51.60	-----	-----	-----	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	0.07	0.54	-----	-----	2.55	13.67	-----	-----	-----	1.26	1.47	-----
Other Taxa	0.21	1.11	0.16	2.11	0.10	4.04	0.04	0.16	0.52	0.66	-----	3.14
00Apr	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	31.82	94.19	99.75	60.80	8.71	-----	91.30	99.93	13.45	99.08	99.60	99.85
Crustacea	-----	-----	-----	39.14	91.26	-----	-----	-----	86.04	-----	-----	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	-----	-----	-----	-----	-----	74.13	-----	-----	-----	-----	-----	0.03
Other Taxa	68.18	5.81	0.25	0.06	0.03	25.87	8.70	0.07	0.51	0.92	0.40	0.11
00May	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 21**	**Station 22**	**Station 23**	**Station 24**	**Station 25**	**Station 26**
Annelida	99.42	99.88	99.83	96.56	50.10	59.69	99.82	83.17	99.90	95.50	64.04	98.77
Crustacea	-----	-----	-----	0.35	49.12	40.15	-----	-----	-----	-----	35.81	-----
Echinodermata	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mollusca	0.02	-----	0.11	0.44	0.57	-----	-----	6.93	-----	4.05	0.06	-----
Other Taxa	0.56	0.11	0.06	2.65	0.21	0.16	0.18	9.90	0.10	0.45	0.09	1.23

Table 2-2. Relative Abundance and Occurrence of Dominant Intertidal Taxa

Area / Taxa	Total		South		Middle		North	
	Abund.	**Occur.**	**Abund.**	**Occur.**	**Abund.**	**Occur.**	**Abund.**	**Occur.**
Rhynchocoela (LPIL)	51.44	35.64	44.27	36.15	66.24	36.03	36.55	34.74
Scolelepis squamata	34.87	30.00	45.35	30.38	26.80	30.26	35.11	29.36
Oligochaeta (LPIL)	8.32	16.45	4.62	12.95	4.37	18.21	19.01	18.21
Mytilus edulis	1.60	14.15	2.38	13.97	0.82	12.82	1.89	15.64
Protodriloides (LPIL)	0.82	6.07	1.26	6.03	0.37	6.03	1.02	6.15
Corophium tuberculatum	0.45	0.17	---	---	<0.01	0.13	1.69	0.38
Microphthalmus (LPIL)	0.42	2.99	0.04	1.15	0.24	2.82	1.17	5.00
Emerita talpoida	0.38	4.40	0.35	6.41	0.11	2.56	0.84	4.23
Microphthalmus sp. G	0.36	2.09	0.15	2.44	0.07	1.54	1.08	2.31
Microphthalmus aberrans	0.22	0.64	0.06	0.90	0.41	1.41	0.20	0.98
Polygordius (LPIL)	0.16	0.60	0.49	1.15	0.01	0.38	0.01	0.26
Spionidae *(LPIL)*	0.12	2.82	0.03	1.41	0.09	1.67	0.07	1.97
Parahaustorius attentuatus	0.08	2.95	0.05	2.44	0.13	2.18	0.08	2.52
Donax variabilis	0.04	1.15	0.07	1.15	0.02	0.64	0.05	0.98
Ovalipes ocellatus	0.01	0.77	0.03	1.79	0.09	1.67	0.04	1.41
Parahaustorius longimerus	0.01	0.64	0.03	1.28	0.03	0.77	0.02	0.90
Haustorius sp. C	<0.01	0.26	0.03	1.28	0.02	0.51	0.02	0.68
Pisionidae (LPIL)	---	---	<0.01	0.13	0.25	1.03	0.07	0.38

*Taxa in **bold** excluded from final analyses (see text)

Table 2-3. Relative Abundance and Occurrence of Dominant Nearshore Infauna

Area / Taxa	Total		South		Middle		North	
	Abund.	**Occur.**	**Abund**	**Occur**	**Abund**	**Occur**	**Abund**	**Occur**
Donax variabilis	74.84	46.97	77.90	47.27	48.56	50.00	78.85	43.64
Magelona papillicornis	5.75	60.00	5.40	63.64	13.79	60.91	3.99	55.45
Tellina agilis	3.60	100.00	4.12	100.00	5.13	98.18	2.73	100.00
Spisula solidissima	2.11	64.85	1.11	61.82	5.19	67.27	2.23	65.45
Acanthohaustorius millsi	2.03	80.61	2.15	89.09	3.81	80.91	1.45	71.82
Psammonyx nobilis	1.94	36.36	2.37	57.27	6.77	30.00	0.29	21.82
Ampharetidae (LPIL)	1.88	37.58	0.27	30.91	3.40	37.27	2.97	44.55
Asabellides oculata	1.33	26.06	0.65	26.36	0.69	21.82	2.13	30.00
Dispio uncinata	0.98	59.09	0.46	55.45	2.62	66.36	1.03	55.45
Mytilus edulis	0.92	53.64	0.56	56.36	1.26	46.36	1.15	58.18
Chiridotea tuftsi	0.55	61.21	0.59	66.36	1.15	60.00	0.36	57.27
Protohaustorius sp. B	0.47	41.52	0.76	60.00	1.16	43.64	0.04	20.91
Gammarus annulatus	0.40	21.21	0.45	21.82	0.84	19.09	0.25	22.73
Protohaustorius wigleyi	0.36	16.36	0.59	20.91	0.81	18.18	0.04	10.00
Astarte castanea	0.29	8.18	0.16	5.45	0.33	8.18	0.40	10.91
Scolelepis squamata	0.23	20.30	0.17	13.64	0.31	20.91	0.27	26.36
Rhynchocoela (LPIL)	0.22	58.79	0.11	60.91	0.68	57.27	0.20	58.18
Spiophanes bombyx	0.11	26.67	0.16	33.64	0.22	24.55	0.04	21.82
Ampharete americana	0.08	10.00	0.04	15.45	0.06	5.45	0.13	9.09
Nephtys bucera	0.06	27.27	0.07	30.91	0.13	23.64	0.04	27.27
Neomysis americana	0.06	8.48	0.10	8.18	0.06	7.27	0.03	10.00
Parahaustorius attenuatus	0.05	14.55	0.07	17.27	0.14	11.82	0.02	14.55
Nephtys picta	0.05	19.70	0.05	21.82	0.08	14.55	0.03	22.73
Edotea triloba	0.04	16.06	0.06	21.82	0.06	13.64	0.02	12.73
Americhelidium americanum	0.03	19.70	0.03	24.55	0.05	13.64	0.03	20.91
Pagurus (LPIL)	0.03	11.52	0.03	12.73	0.04	7.27	0.03	14.55
Americamysis bigelowi	0.03	8.79	0.02	6.36	0.08	10.91	0.02	9.09
Phyllodoce arenae	0.03	11.82	0.04	17.27	0.03	7.27	0.02	10.91
Polygordius (LPIL)	0.03	10.00	0.02	10.91	0.02	6.36	0.03	12.73
Pseudoleptocuma minor	0.02	15.45	0.02	11.82	0.05	12.73	0.02	21.82

*Taxa in **bold** excluded from final analyses (see text)

Table 2-4. Analysis of Variance (ANOVA) Results- Biannual Data*

MLW Abundance

Source	SS	DF	F Ratio	Prob>F
Area	3.1826	2	2.5465	0.0993
Date	3.4631	12	0.4618	0.9178
Area*Date	94.5518	24	6.3045	**<.0001**
Error	706.7598	1131		

MLW -1m Abundance

SS	DF	F Ratio	Prob>F
1.1604	2	0.7558	0.4805
7.7220	12	0.8383	0.6134
48.1442	24	2.6131	**<.0001**
868.2349	1131		

Nearshore Abundance

SS	DF	F Ratio	Prob>F
1.3305	2	3.2160	0.0615
11.7774	10	5.6939	0.0005
13.4224	20	3.2446	**<.0001**
61.4319	297		

MLW Biomass

Source	SS	DF	F Ratio	Prob>F
Area	4.6118	2	1.2794	0.2965
Date	55.3450	12	2.5589	0.0242
Area*Date	256.4352	24	5.9281	**<.0001**
Error	2038.5013	1131		

MLW-1m Biomass

SS	DF	F Ratio	Prob>F
0.4076	2	0.0977	0.9073
50.5510	12	2.0194	0.0690
1998.2297	24	3.9594	**<.0001**
2359.3130	1131		

Nearshore Biomass

SS	DF	F Ratio	Prob>F
2.4063	2	2.5778	0.1009
11.0007	10	2.3584	0.0491
28.2761	20	3.0292	**<.0001**
138.6197	297		

MLW Taxa

Source	SS	DF	F Ratio	Prob>F
Area	0.5899	2	0.2429	0.7862
Date	9.0502	12	0.6211	0.8038
Area*Date	77.3406	24	2.6539	**<.0001**
Error	1373.3420	1131		

MLW-1m Taxa

SS	DF	F Ratio	Prob>F
5.0113	2	1.9086	0.1701
70.4679	12	4.4732	0.0009
65.5492	24	2.0805	**<.0001**
1484.7667	1131		

Nearshore Taxa

SS	DF	F Ratio	Prob>F
148.5077	2	3.5970	0.0463
1434.5596	10	6.9498	0.0001
912.7890	20	2.2110	**<.0024**
6130.6000	297		

Table 2-5. Correlations Between Taxa and MDS Axes*

	Axis	
Taxon	**1**	**2**
Ampelisca abdita	-0.010	-0.265
Archiannelida (LPIL)	-0.027	-0.240
Corophium tuberculatum	0.021	-0.120
Donax variabilis	**-0.402**	**0.790**
Emerita talpoida	0.373	-0.284
Hirudinea (LPIL)	0.100	-0.238
Magelona papilicornis	**-0.920**	**0.622**
Mediomastus ambiseta	-0.039	-0.237
Microphthalmus aberrans	0.122	**-0.439**
Microphthalmus hartmanae	0.055	-0.164
Microphthalmus sp. G	0.350	-0.285
Micropthalmus listensis	0.162	-0.130
Oligochaeta (LPIL)	**0.516**	**-0.811**
Parahaustorius longimerus	0.023	-0.078
Parahaustorius attentuatus	0.063	-0.114
Polygordius (LPIL)	-0.102	0.103
Protodriloides (LPIL)	0.367	-0.094
Rhynchocoela (LPIL)	**0.903**	**-0.836**
Scolelepis squamata	**0.930**	**-0.740**

*Values in bold considered to be significant correlations

Table 2-6. Analysis of Variance (ANOVA) Results - Monthly Data - 1997

Abundance

Source	SS	DF Num	F Ratio	Prob>F
Area	0.0974	1	0.1047	0.7572
Date	3.8805	6	0.6954	0.6649
Area*Date	14.8796	6	2.6664	0.0160
Error	221.3548	238		

Biomass

Source	SS	DF Num	F Ratio	Prob>F	Power
Area	0.8438	1	0.3453	0.5782	0.0507
Date	60.0846	6	4.0975	0.0550	0.0616
Area*Date	18.4138	6	1.2557	0.2788	0.4897
Error	581.6682	238			

Taxa Richness

Source	SS	DF Num	F Ratio	Prob>F	Power
Area	0.0003	1	0.0128	0.9137	0.0500
Date	0.1583	6	1.0855	0.4616	0.0530
Area*Date	0.2138	6	1.4662	0.1905	0.5646
Error	5.7861	238			

Table 2-7. Analysis of Variance (ANOVA) Results - Monthy Data 1999-2000

Abundance

Source	SS	DF Num	F Ratio	Prob>F
Area	5.5938	1	7.3749	0.0188
Date	30.3031	12	3.3293	0.0236
Area*Date	67.9997	12	7.4709	<0.0001
Error	335.2552	442		

Biomass

Source	SS	DF Num	F Ratio	Prob>F
Area	8.9809	1	4.3961	0.5790
Date	71.4768	12	2.9254	0.0375
Area*Date	179.2814	12	7.3377	<0.0001
Error	899.9482	442		

Taxa Richness

Source	SS	DF Num	F Ratio	Prob>F
Area	0.2184	1	9.6768	0.0090
Date	1.7601	12	6.5001	0.0014
Area*Date	0.9594	12	3.5432	<0.0001
Error	9.9738	442		

Table 2-8. Benthic Recovery Rate Estimates

Area	Year	Parameter	Regression Line*	Time to Recovery (Days)	p Value	r^2 value
South	1997	Abundance	X = 2.85207 + 0.00301Y	49	0.0059	0.63
South	1997	Biomass	X = 2.86079 + 0.00352Y	38	0.0145	0.55
South	1997	Taxa Richness	X = 2.89811 + 0.00448Y	23	0.0072	0.63
Middle	1999	Abundance	X = 1.60700 + 0.00736Y	189	0.0026	0.24
Middle	1999	Biomass	X = 1.13418 + 0.01056Y	176	0.0016	0.26
Middle	1999	Taxa Richness	X = 2.47089 + 0.00316Y	178	0.0002	0.36

* X = ArcSine-Square Root of % Recovery (100% = 3) and Y = days

Table 2-9. Representative Infaunal Abundances for Atlantic Coast Sandy Beaches.

Reference	Site	Abundance/m^2
Larsen and Doggett (1990)	Southern Maine	0-25,000
Sameoto (1969)	Cape Cod, MA	3,000
McDermott (1983)	Avalon Beach, NJ	42,000-86,000
This Study	Asbury Park - Manasquan Inlet , NJ	9,531-14,773
Matta (1977)	Duck, NC	30-800
Diaz and DeAlteris (1982)	Duck, NC	2,300
Dexter (1969)	Morehead City, NC	60
Van Dolah et al. (1994)	Folly Beach, SC	1,000-22,000
Jutta et al. (1999ab)	Myrtle Beach, SC	1,000-25,000
Knott et al. (1983)	Murrells Inlet, SC	1,500-3,200
Gorzelany and Nelson (1987)	Melbourne Beach, FL	1,000-4,200

Table 2-10. Summary of Beach Nourishment Recovery Rate Estimates

Reference	Site	Recovery rate (months)
Reilly and Bellis (1983)	Bogue Banks, NC	>12[sc]
Van Dolah et al. (1994)	Folly Beach, SC	2-3
Jutta et al. (1999ab)	Myrtle Beach, SC	6
Gorzelany and Nelson (1987)	Melbourne Beach, FL	<1*
Salomon and Naughton (1984)	Panama City, FL	2
Rakocinski et al. (1996)	Perdido Bay, FL	>12[sc]

[sc]Substantial amounts of silts and clays present

*No impact detected

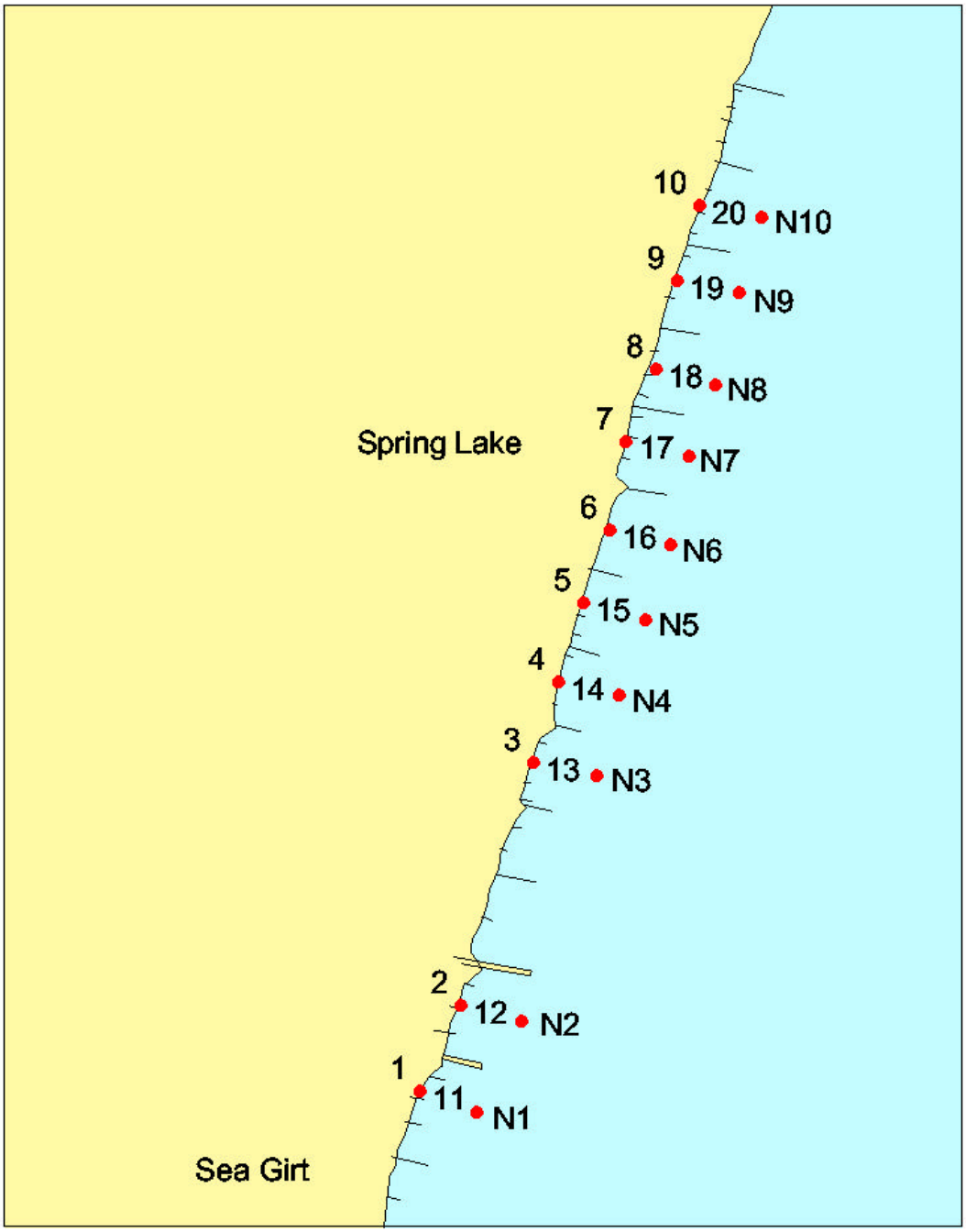

Figure 2-2. Intertidal and Nearshore benthos sampling locations in the South Area.

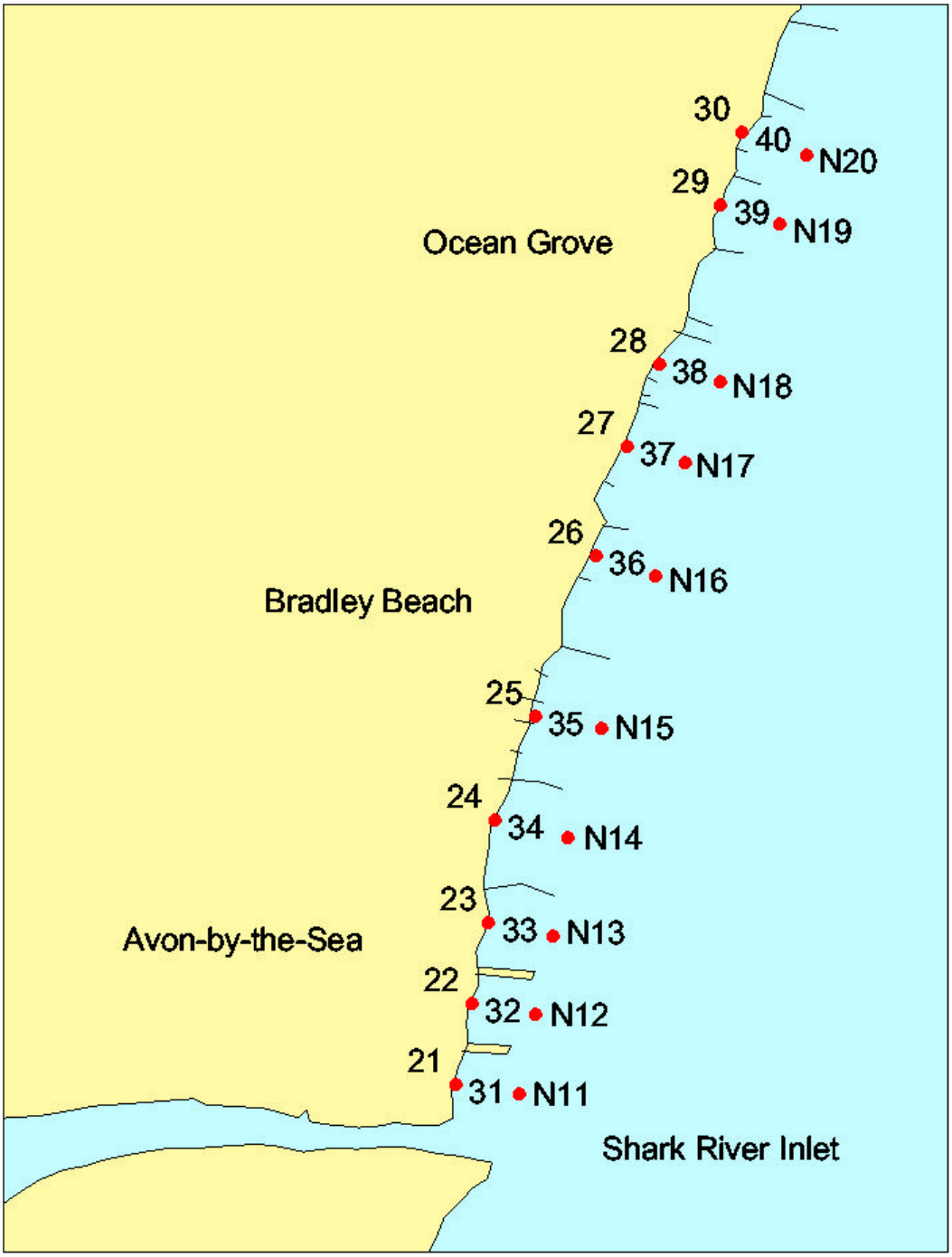

Figure 2-3. Intertidal and Nearshore benthos sampling locations in the Middle Area.

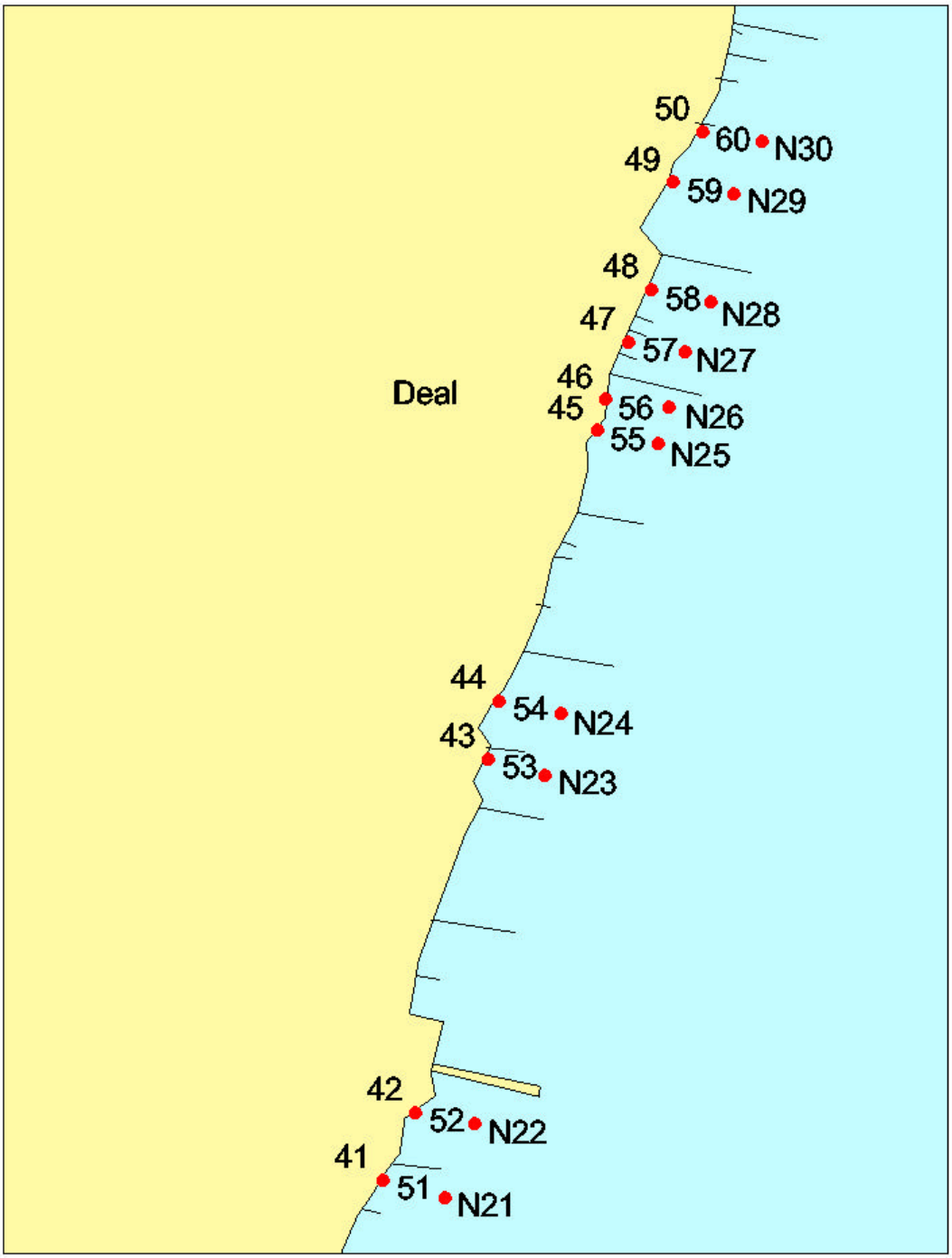

Figure 2-4. Intertidal and Nearshore benthos sampling locations in the North Area.

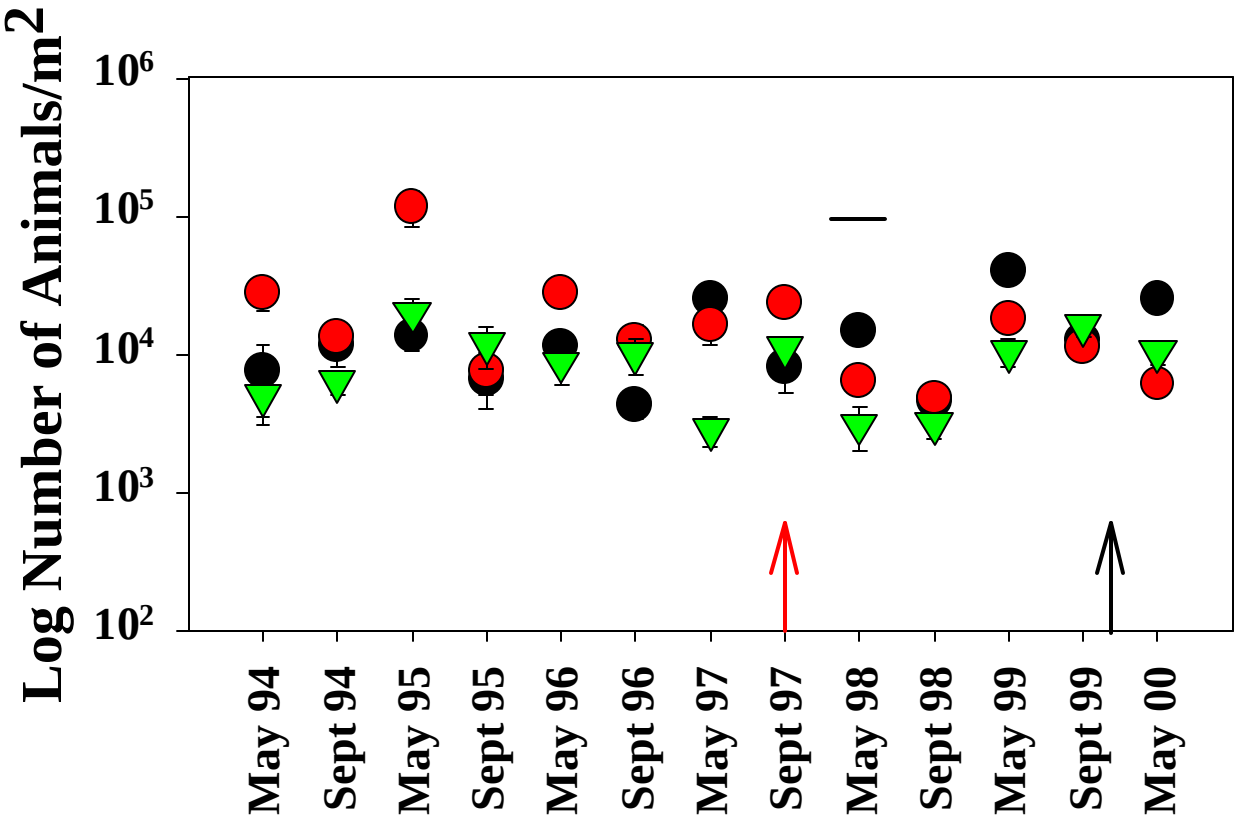

Figure 2-5. Mean Low Water Abundance (No. Animals/m^2±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

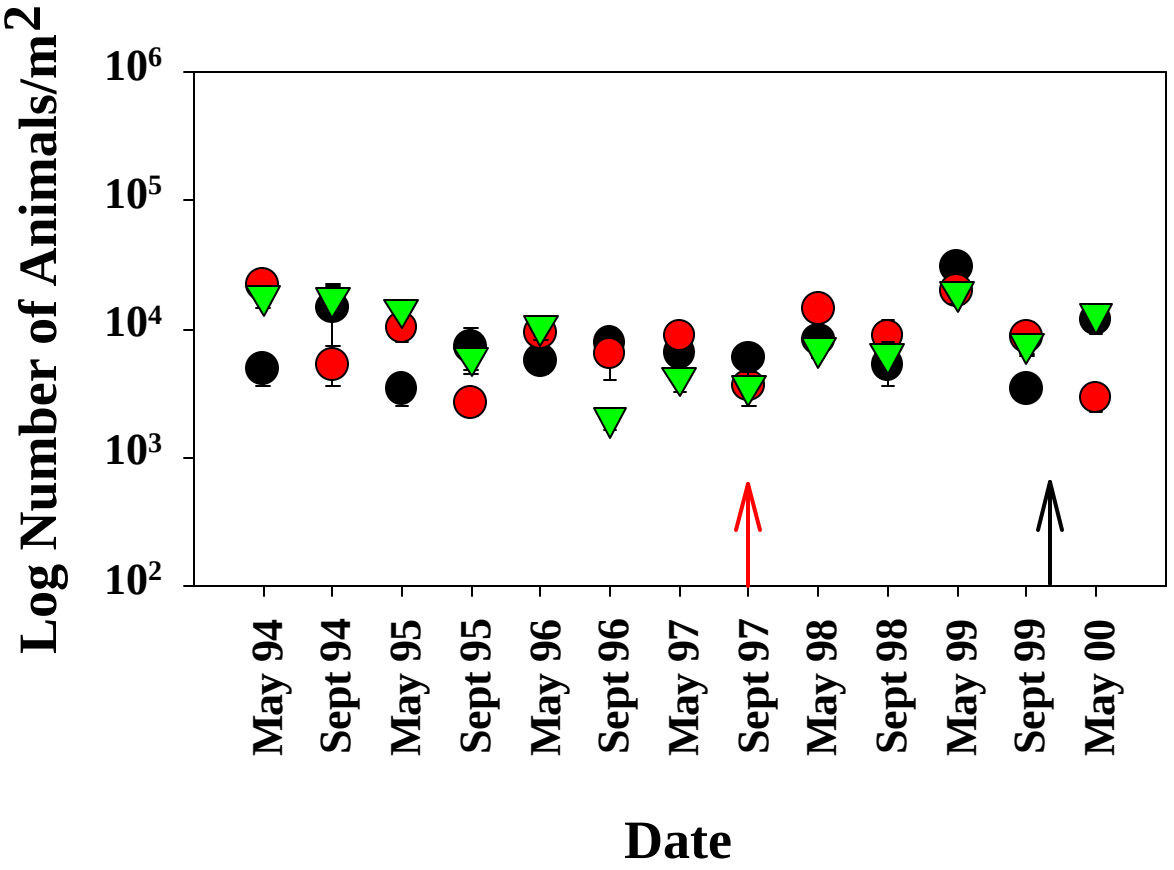

Figure 2-6. Mean Low Water –1m Abundance (No. Animals/m^2 ± SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

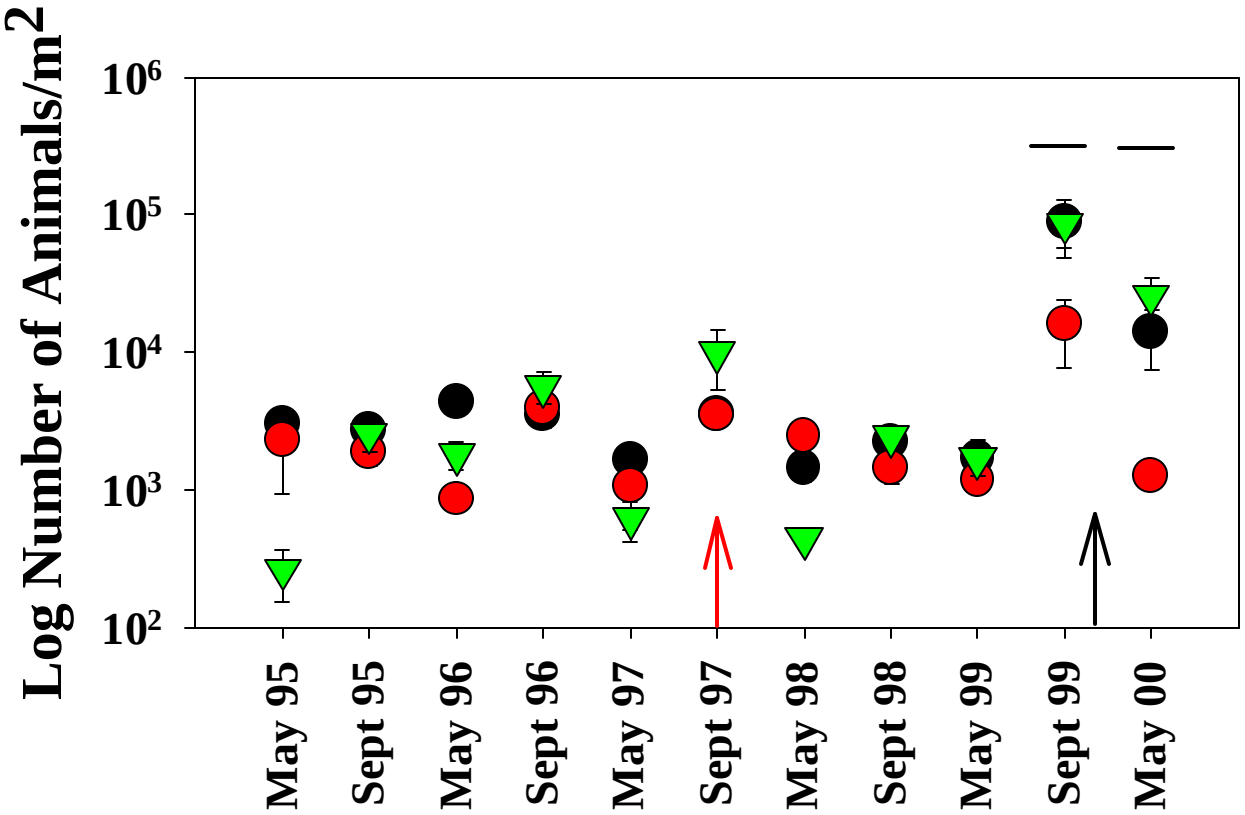

Figure 2-7. Nearshore Abundance (No. Animals/m^2 ±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

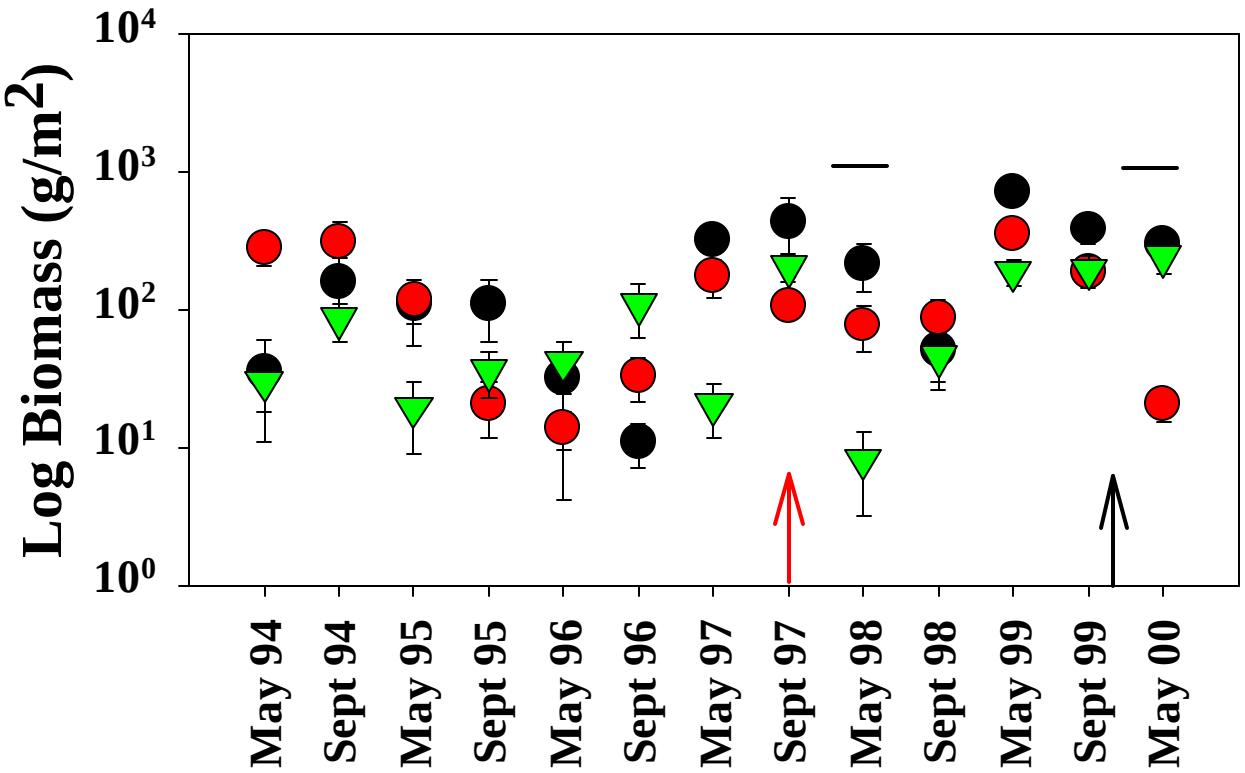

Figure 2-8. Mean Low Water Biomass (Grams/m^2±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

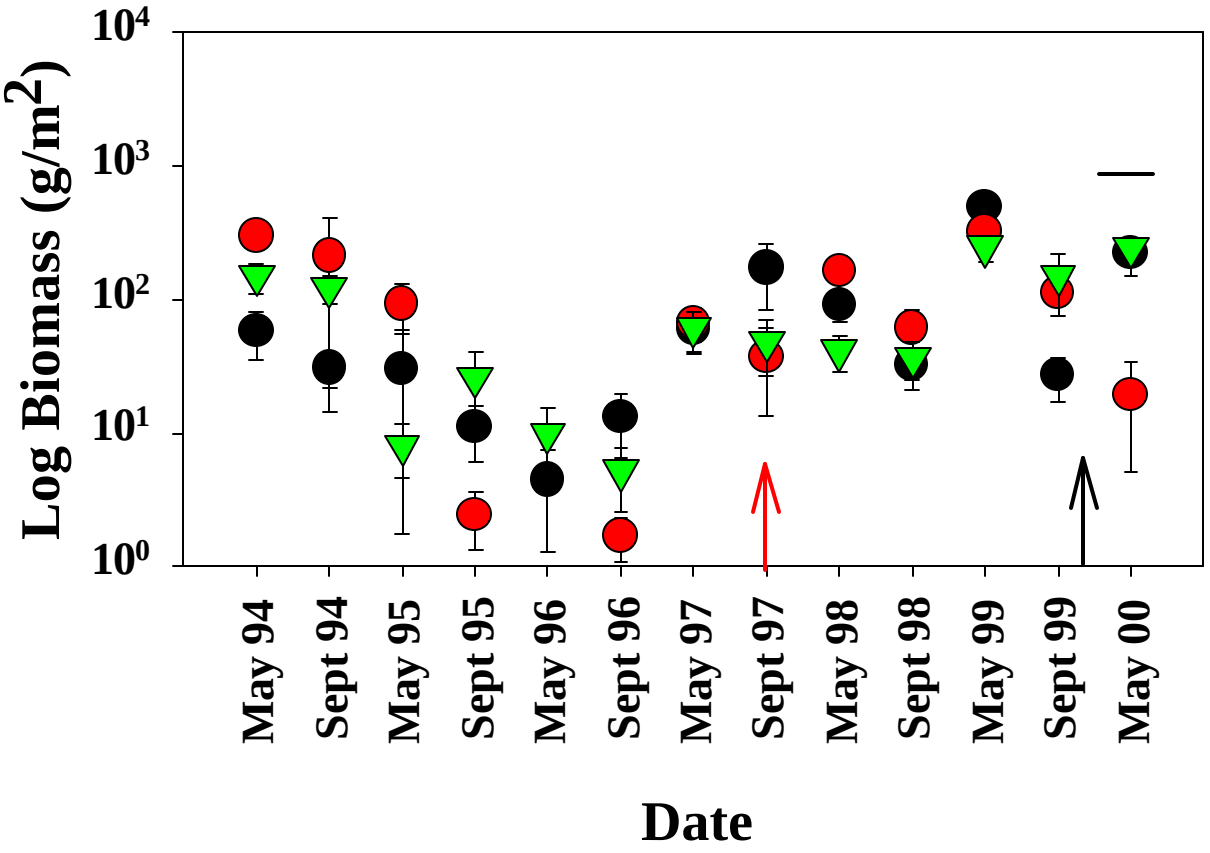

Figure 2-9. Mean Low Water –1m Biomass (Grams/m^2±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

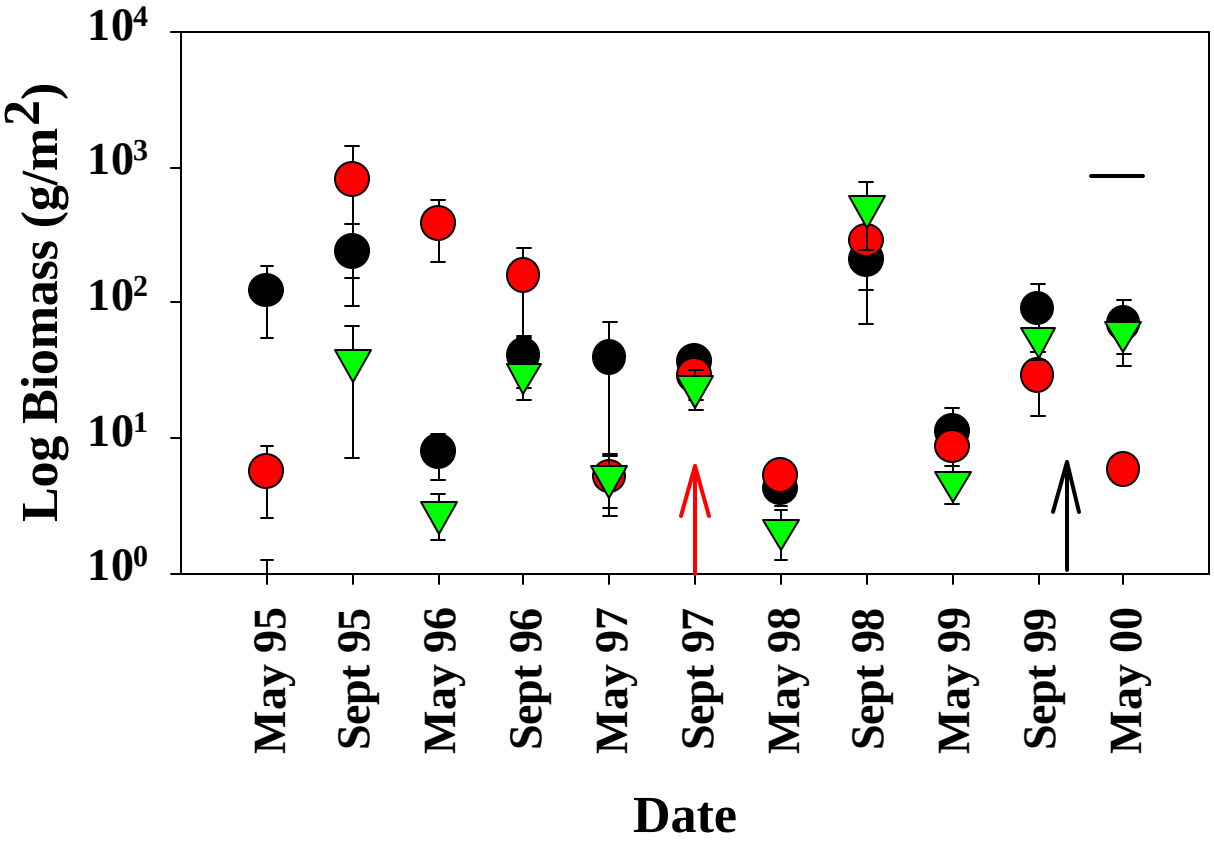

Figure 2-10. Nearshore Biomass (Grams/m^2±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

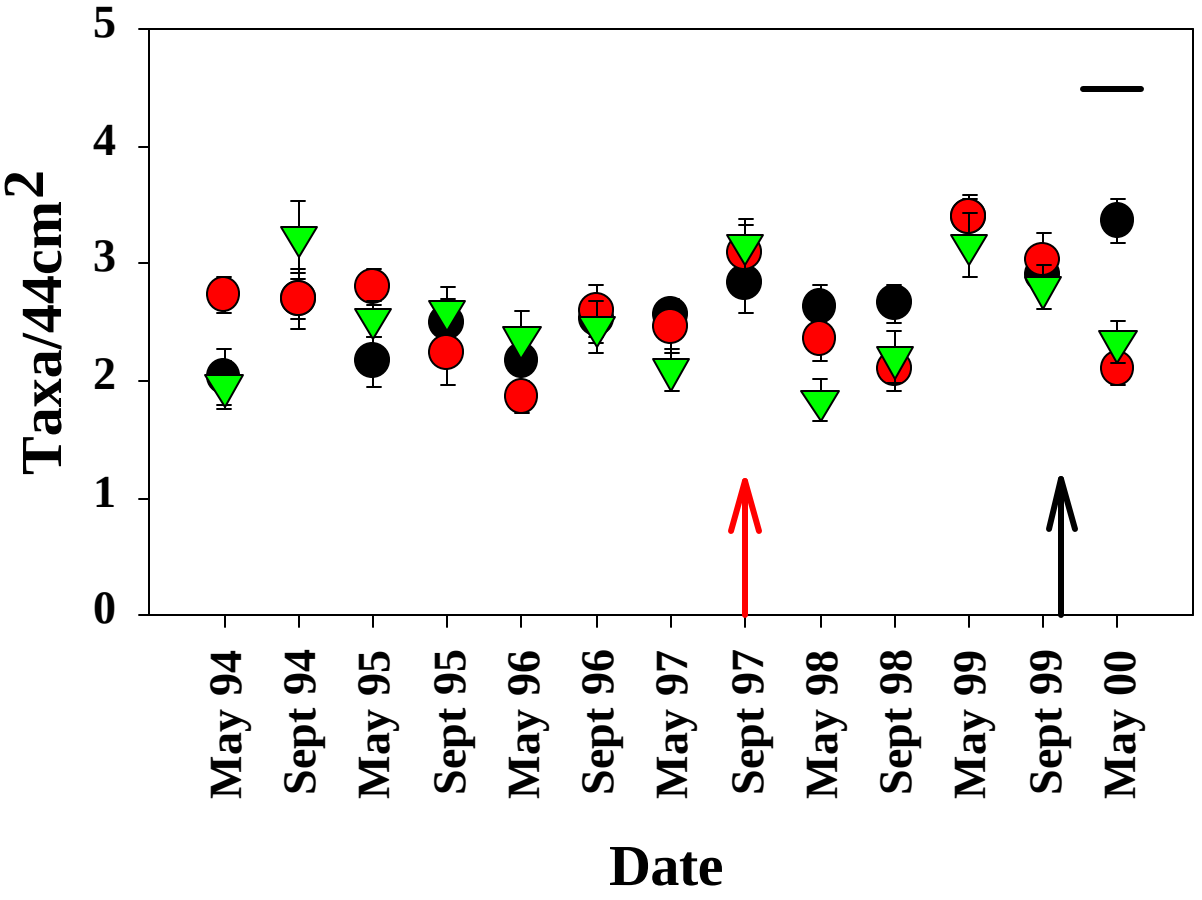

Figure 2-11. Mean Low Water Taxa Richness (Taxa/44cm^2 $\pm$SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

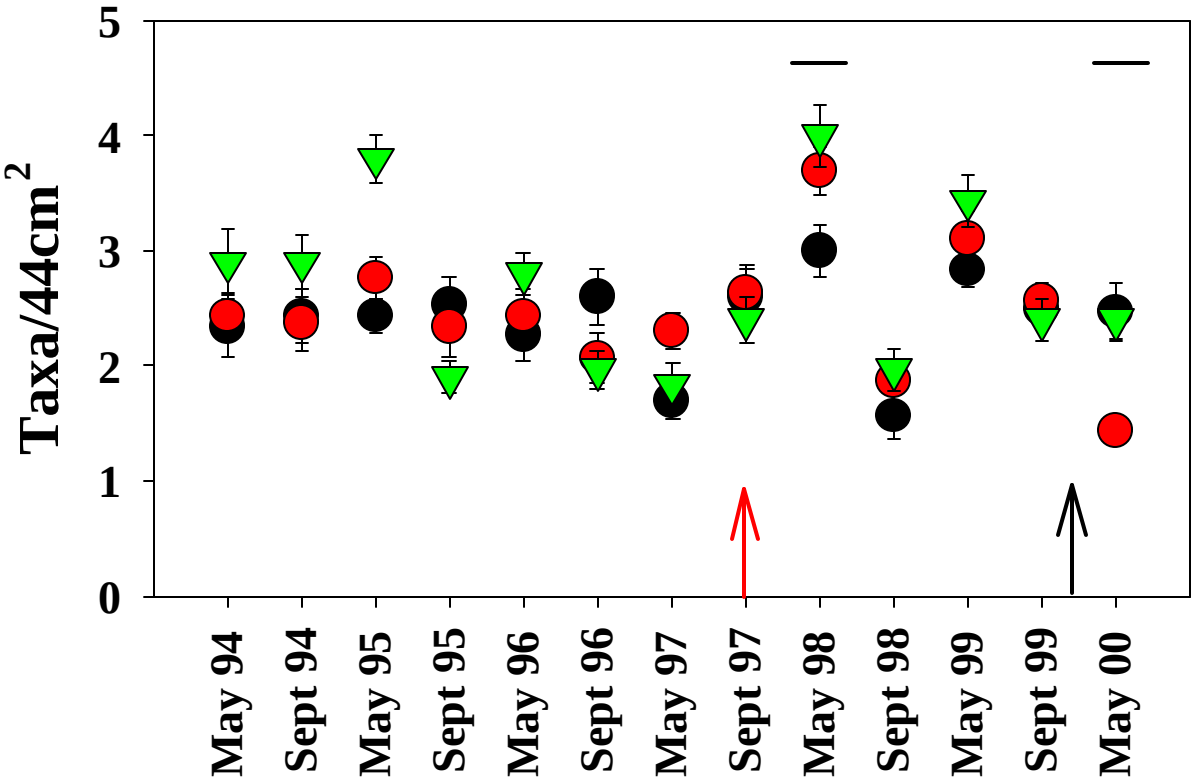

Figure 2-12. Mean Low Water –1m Taxa Richness (Taxa/44cm^2±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

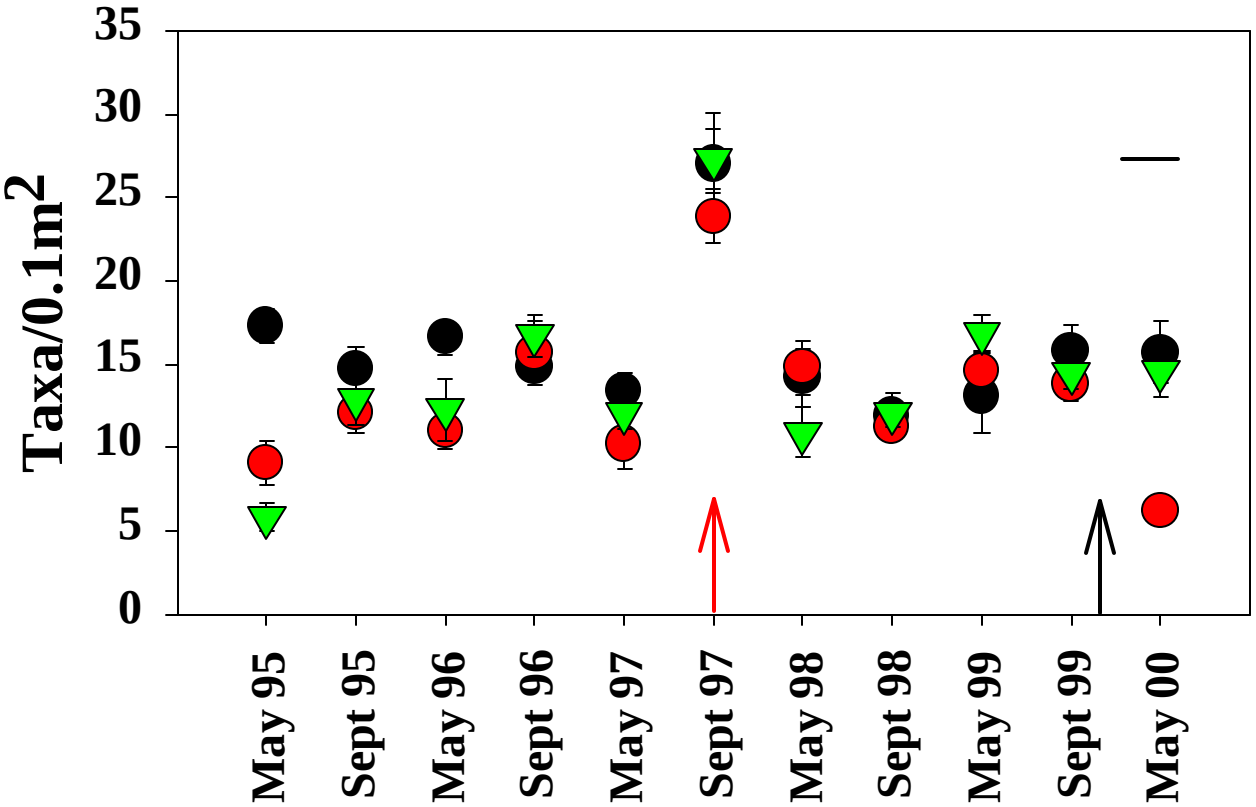

Figure 2-13. Nearshore Taxa Richness (Taxa/0.1m^2±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Red arrow indicates South Area nourished; Black arrow indicates Middle Area nourished; Bar indicates a significant ($p<0.0125$) linear contrast between means.

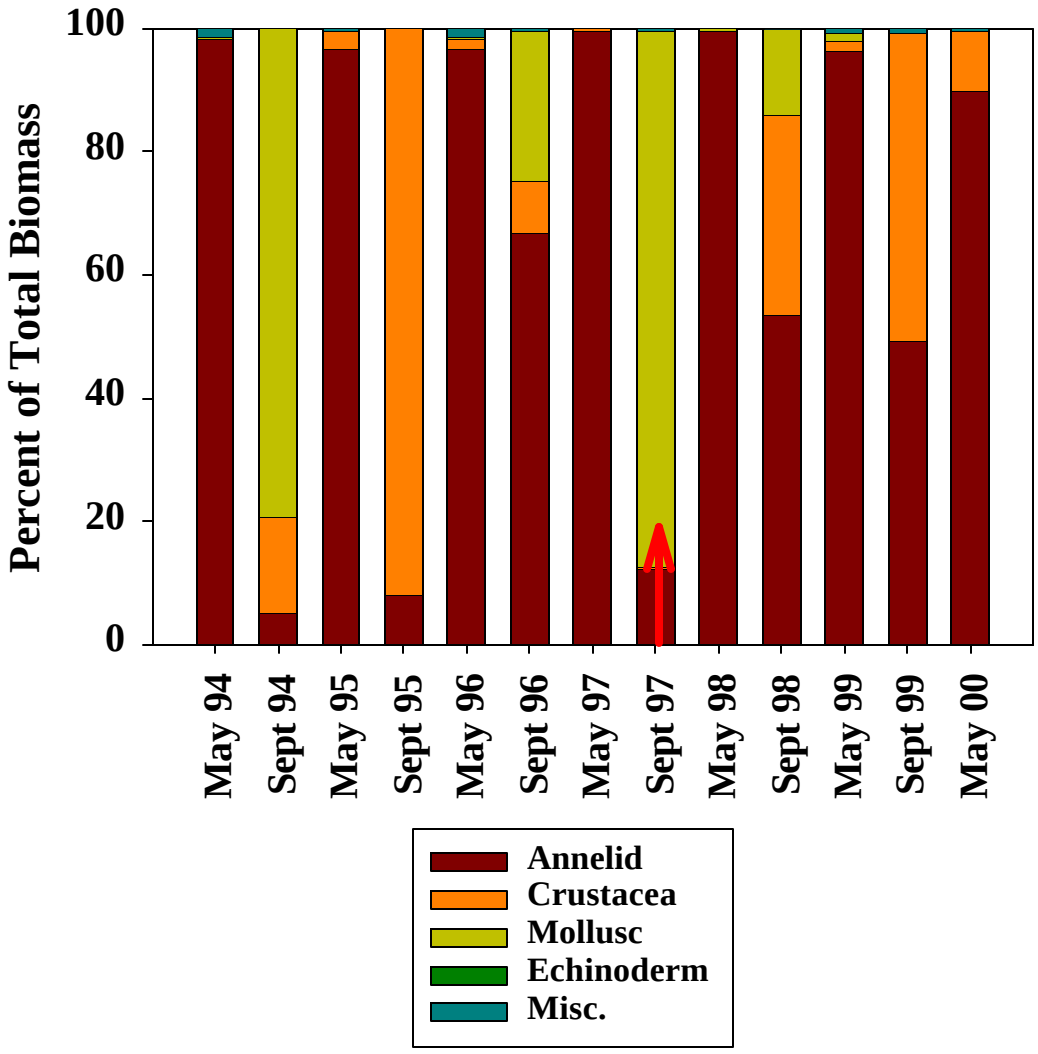

Figure 2-14. MLW Benthos Biomass Composition – South Area. Arrow indicates when nourishment occurred.

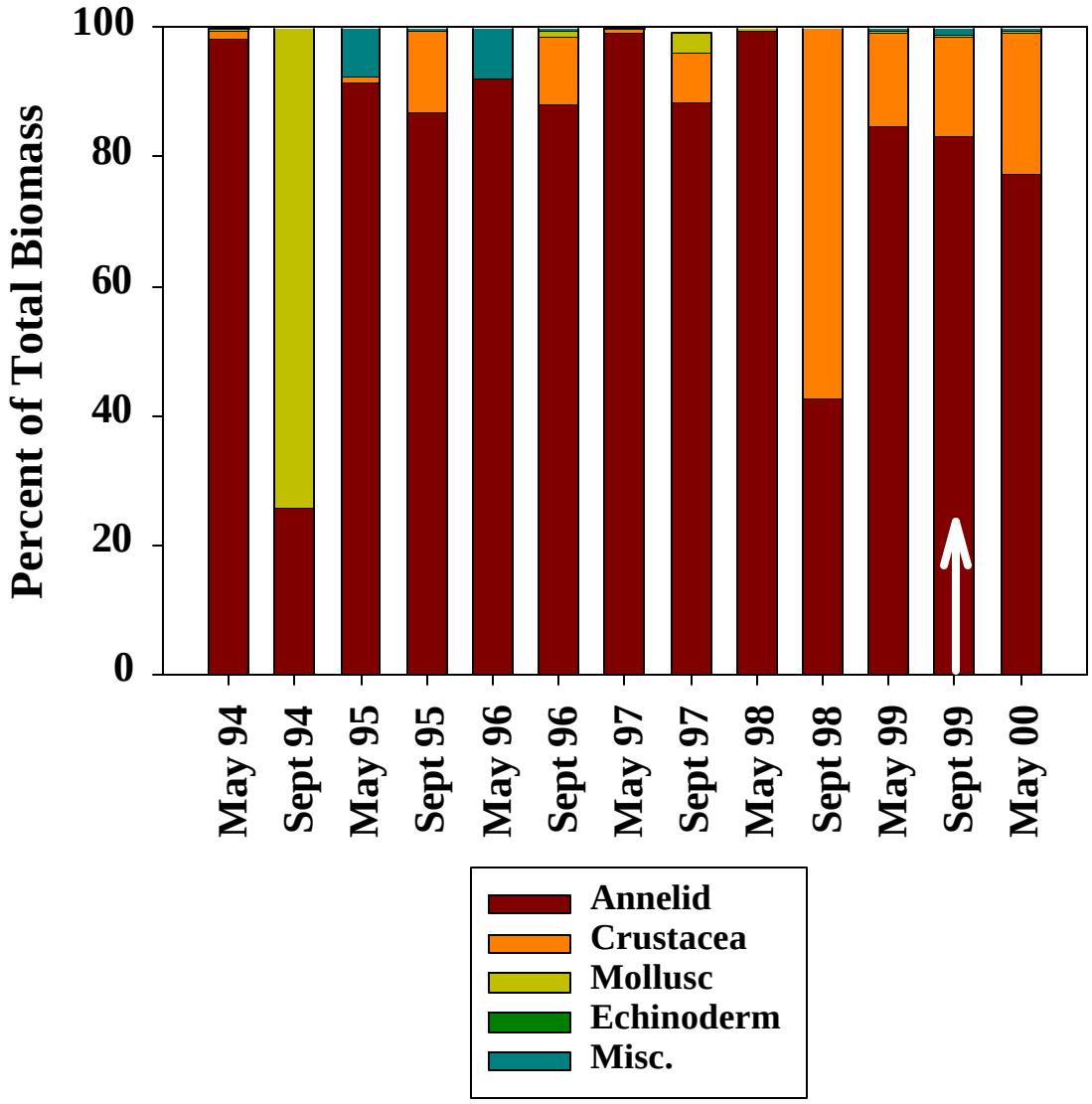

Figure 2-15. MLW Benthos Biomass Composition – Middle Area. Arrow indicates when nourishment occurred.

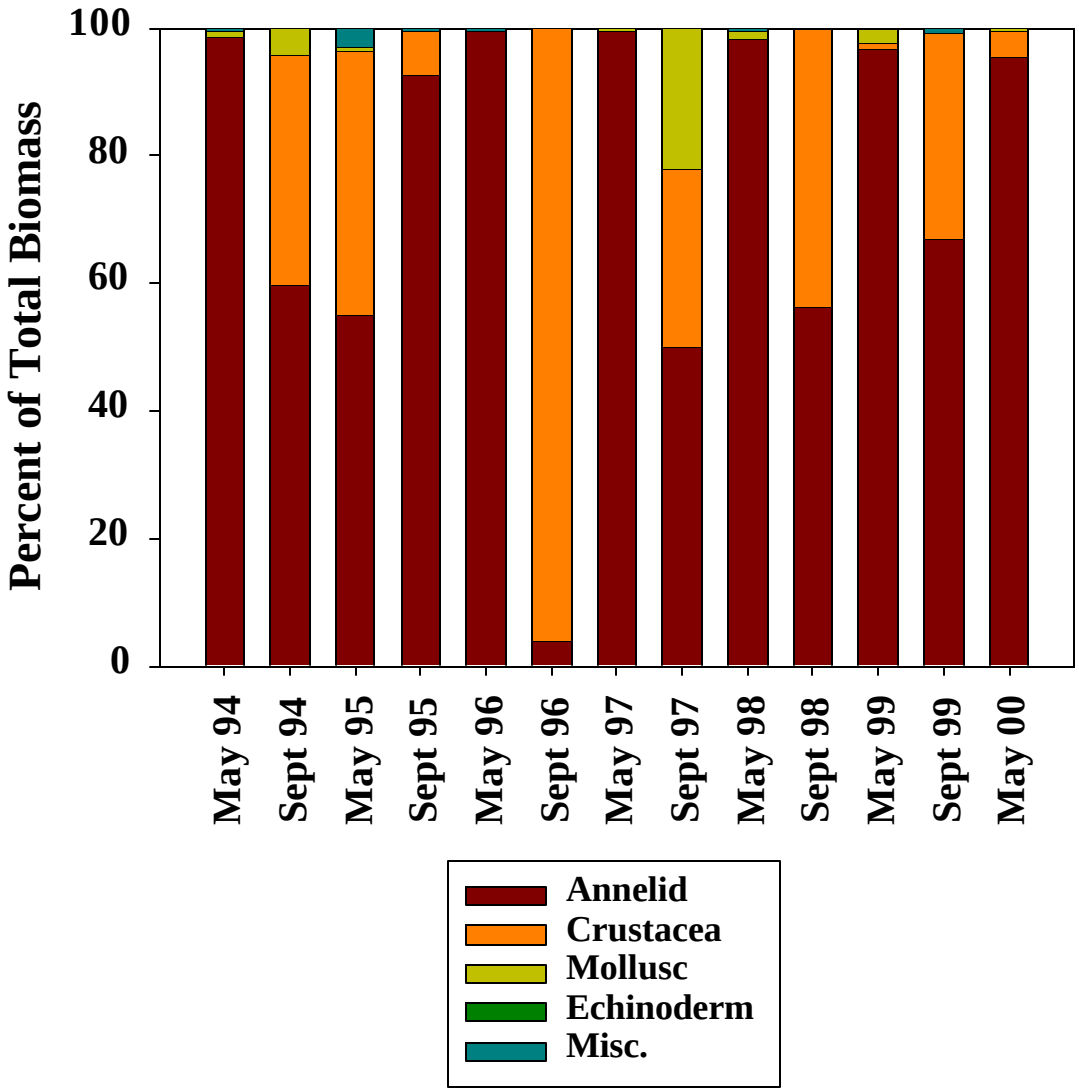

Figure 2-16. MLW Benthos Biomass Composition - North Area.

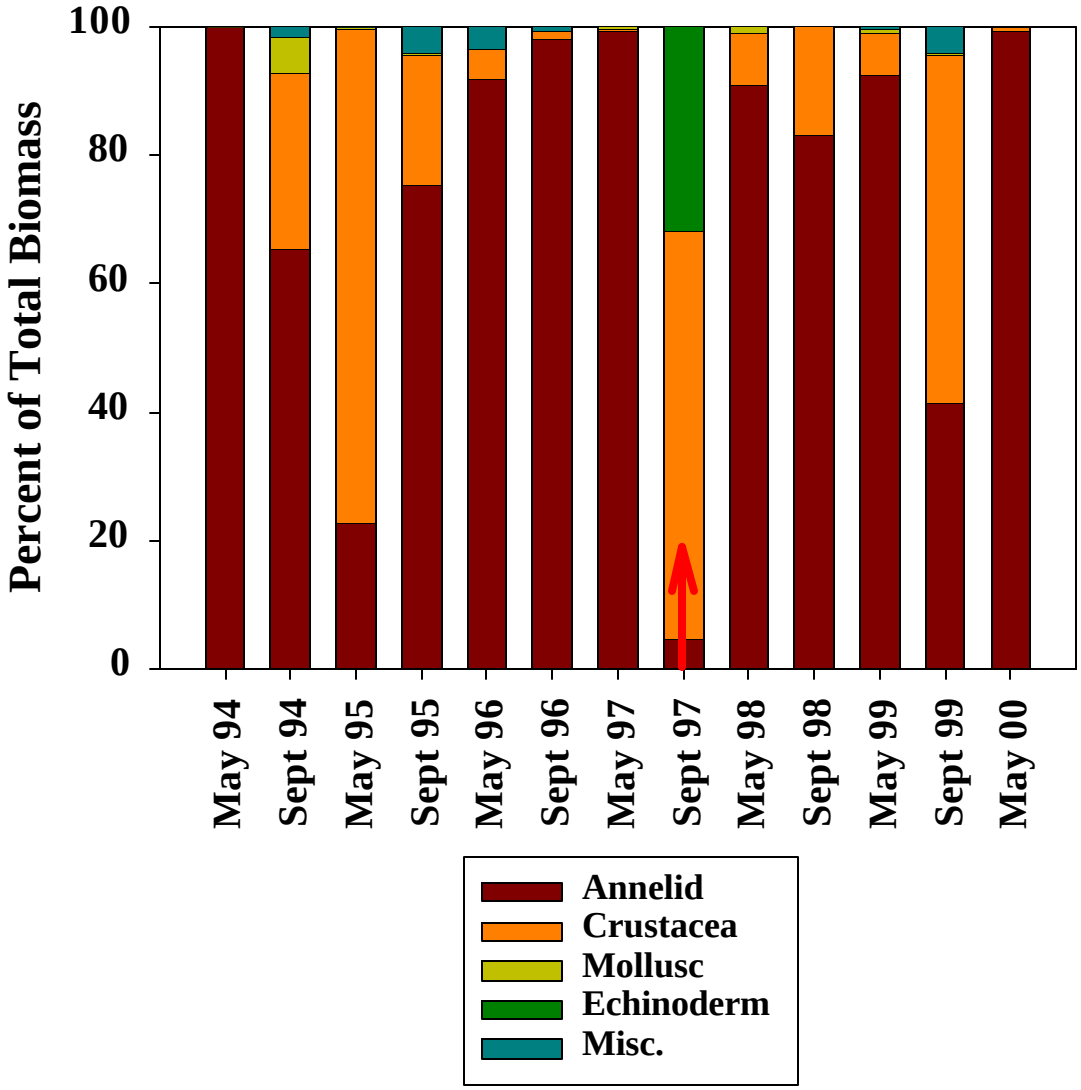

Figure 2-17. MLW-1m Benthos Biomass Composition- South Area. Arrow indicates when nourishment occurred.

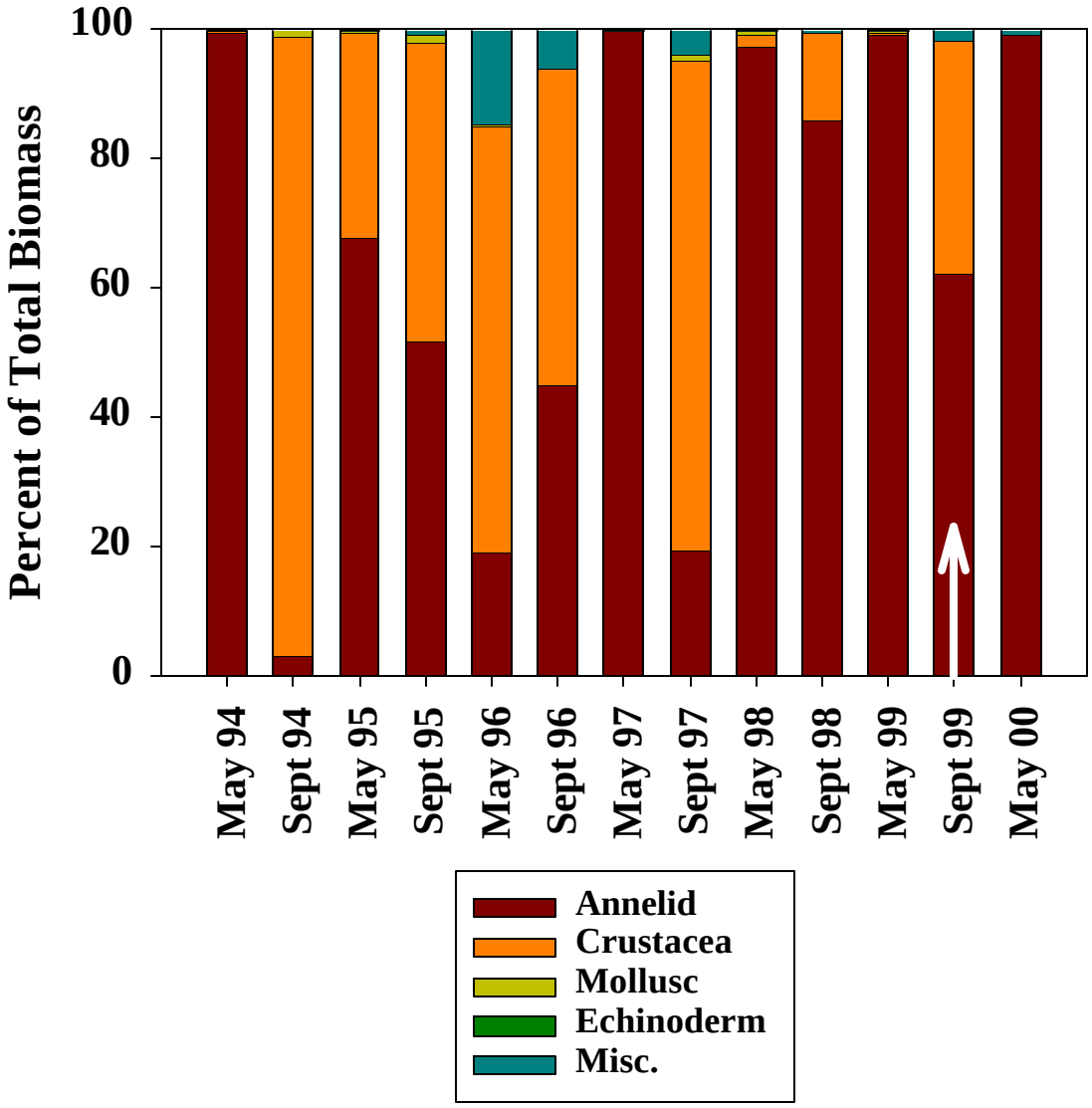

Figure 2-18. MLW-1m Benthos Biomass Composition- Middle Area. Arrow indicates when nourishment occurred.

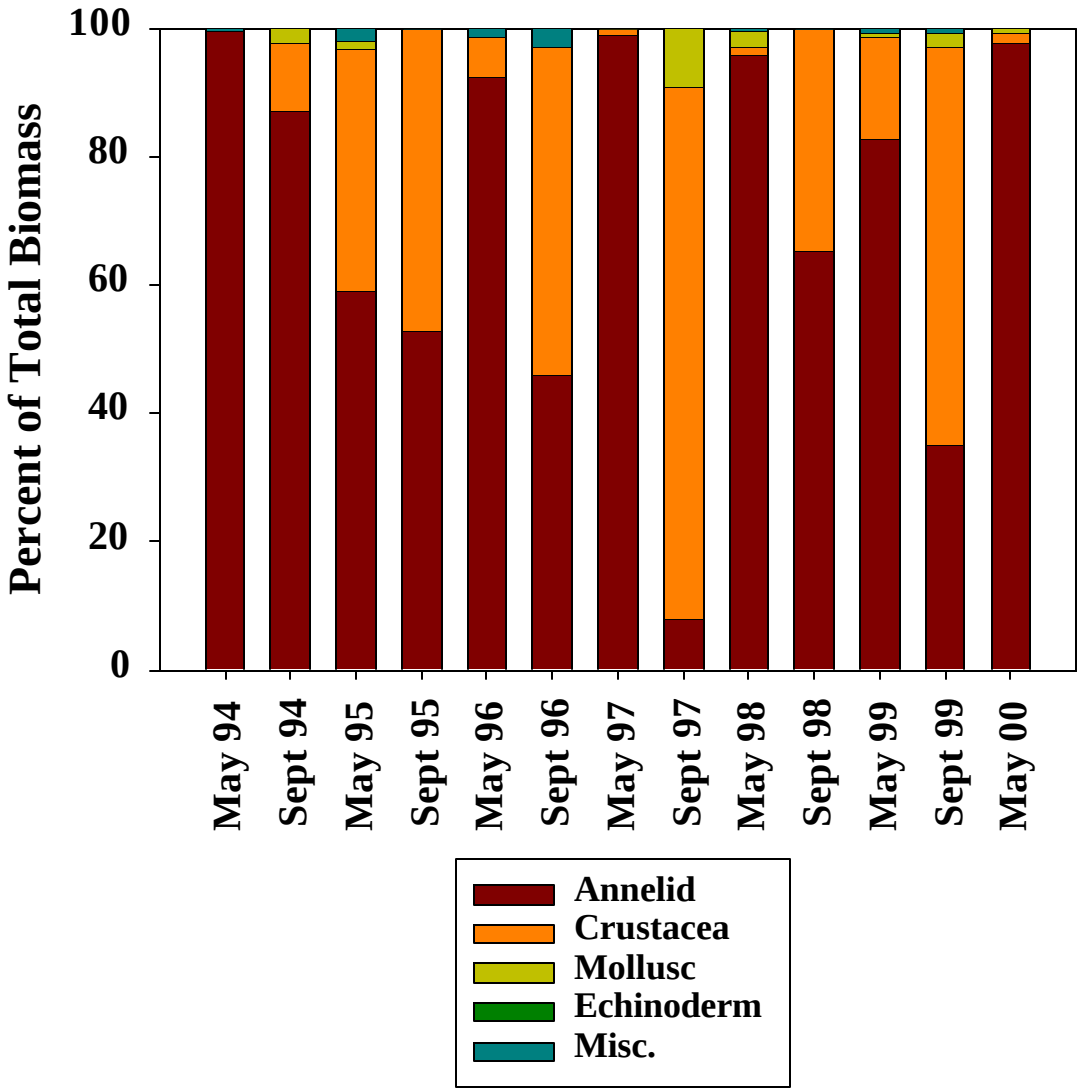

Figure 2-19. MLW-1m Benthos Biomass Composition- North Area.

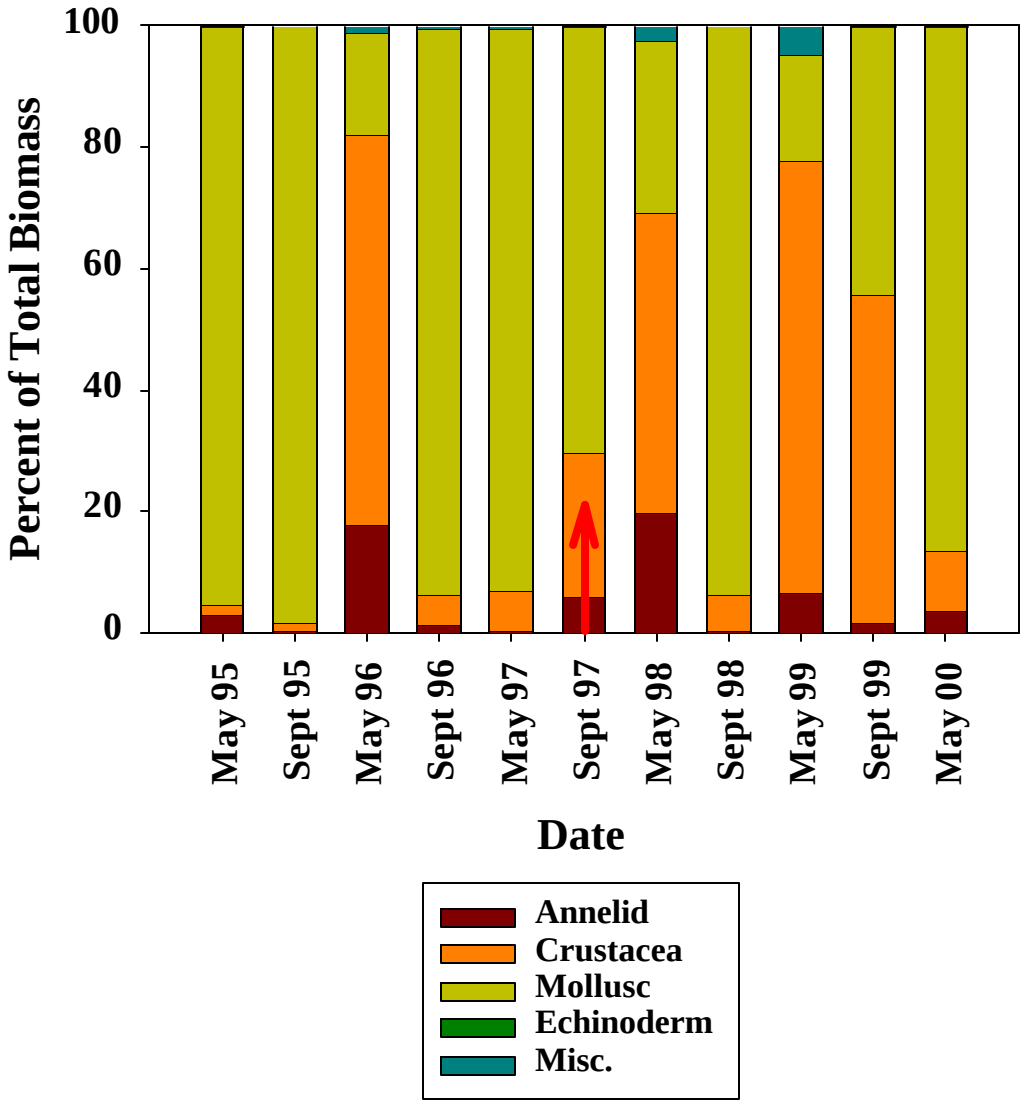

Figure 2-20. Nearshore Benthos Biomass Composition - South Area. Arrow indicates when nourishment occurred.

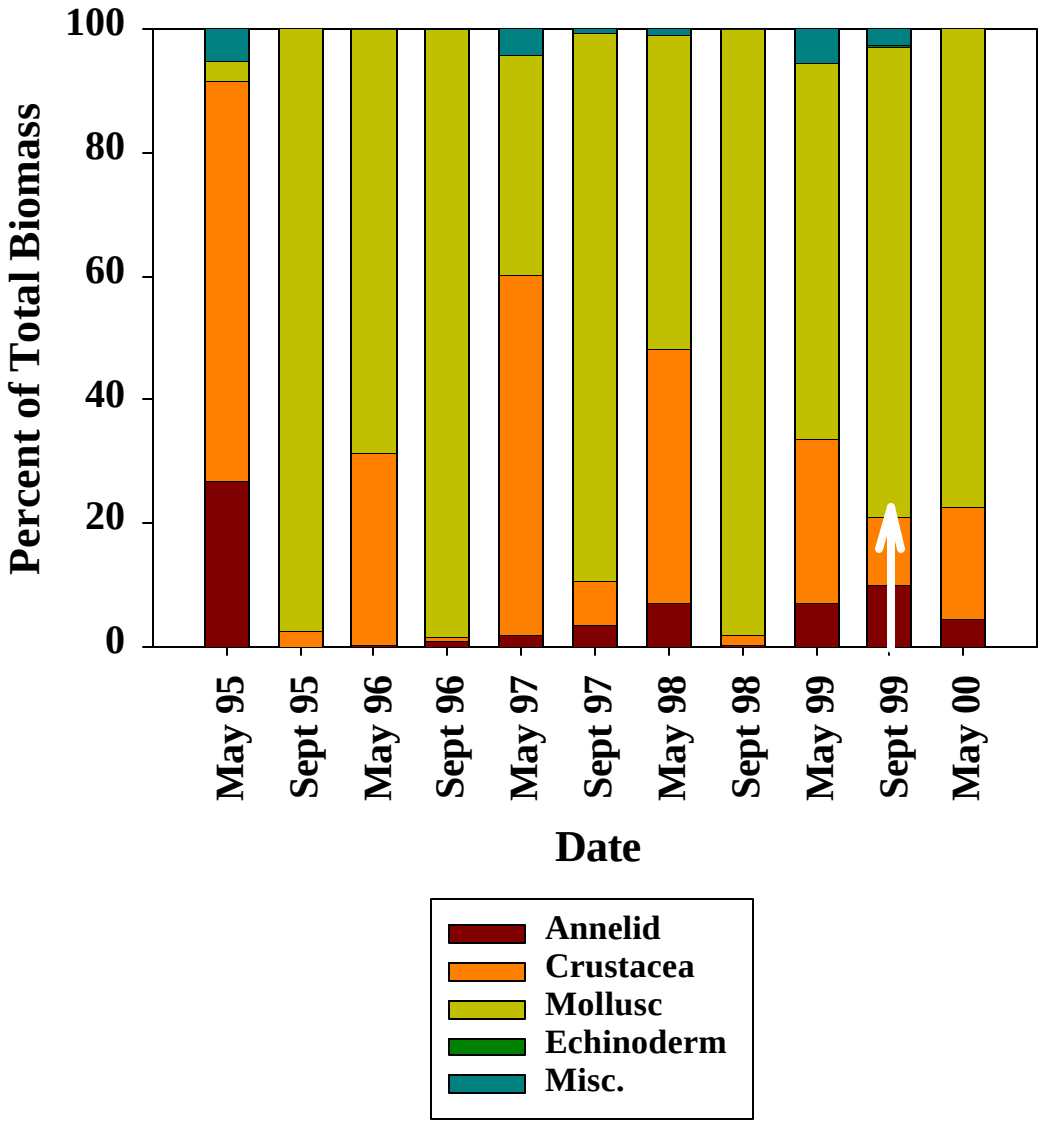

Figure 2-21. Nearshore Benthos Biomass Composition - Middle Area. Arrow indicates when nourishment occurred.

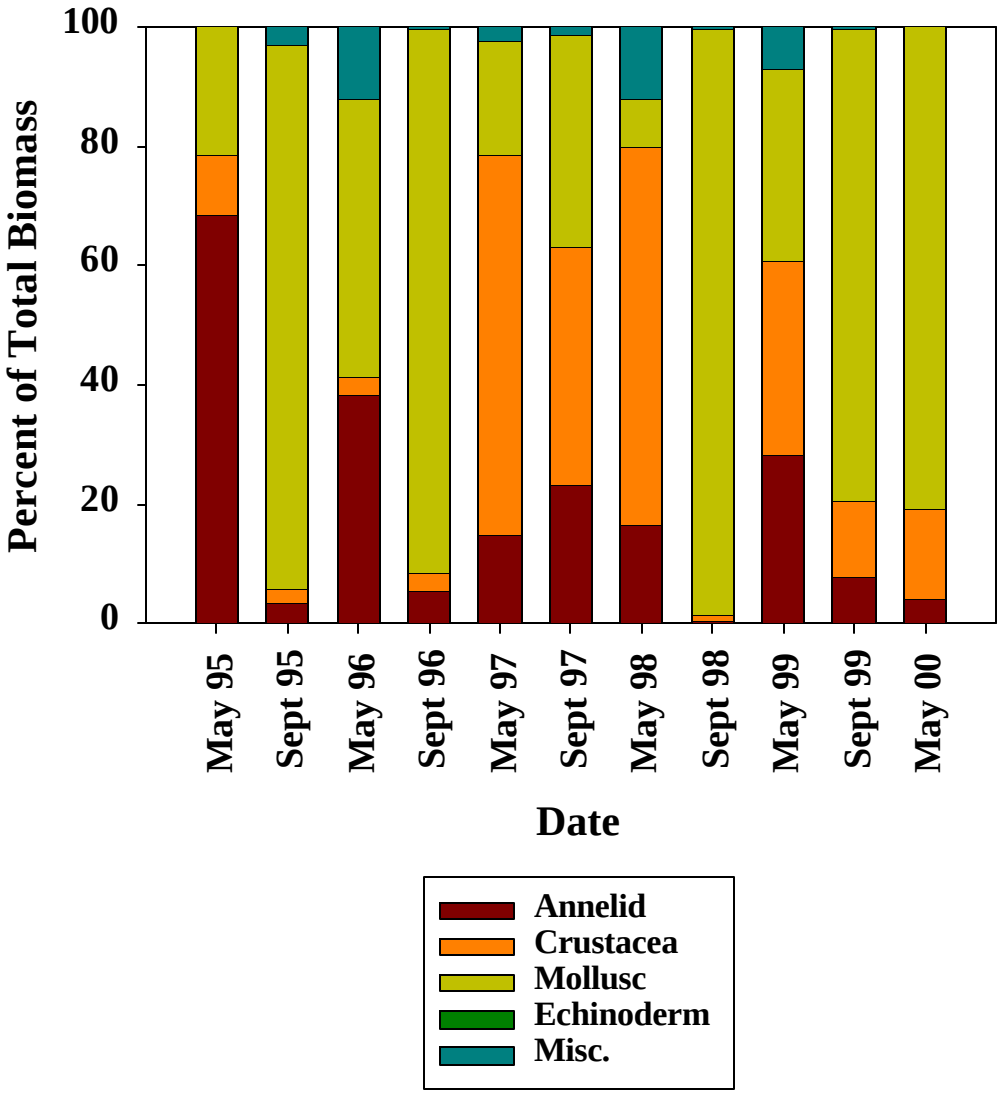

Figure 2-22. Nearshore Benthos Biomass Composition - North Area.

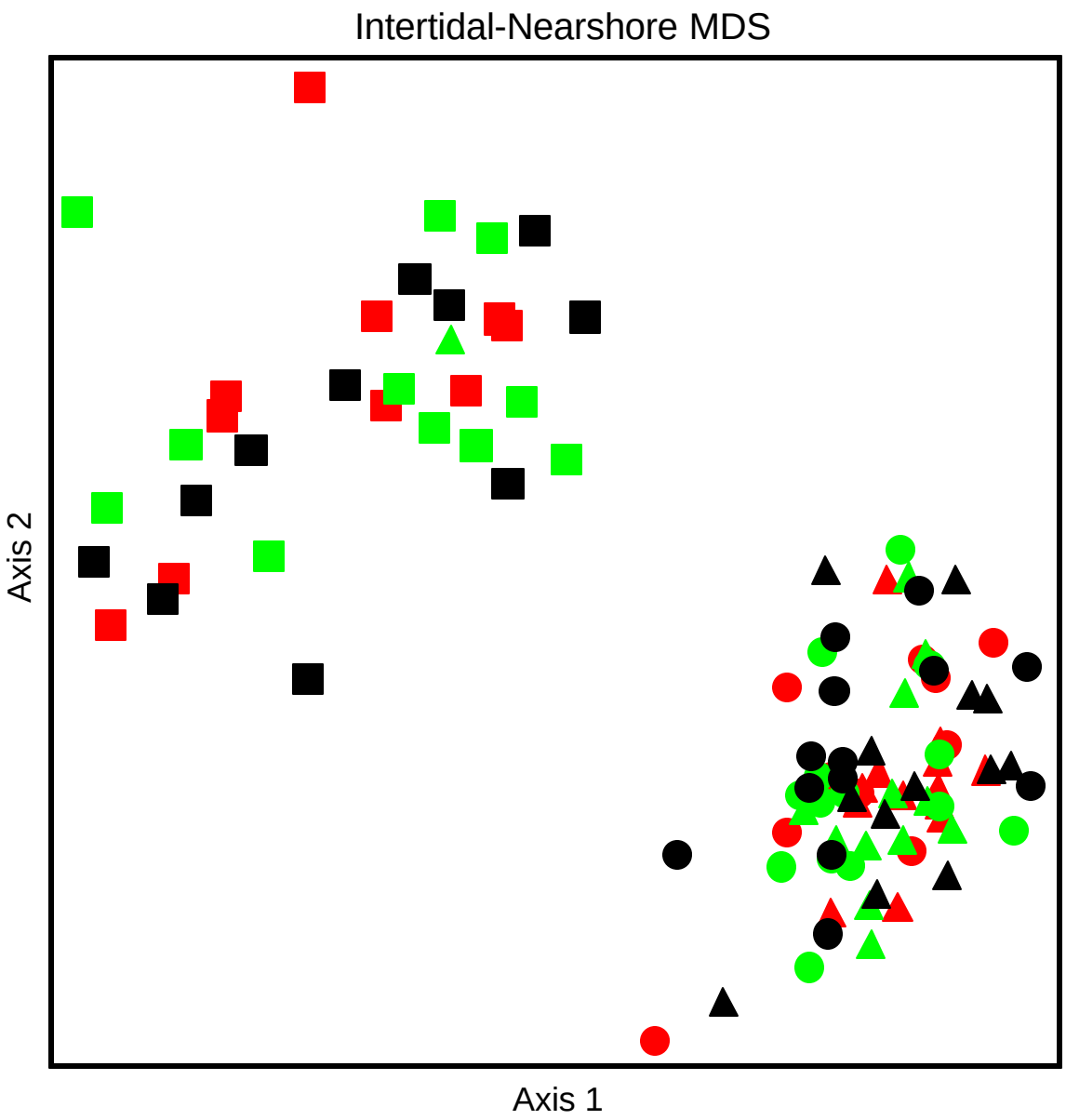

Figure 2-23. Intertidal-Nearshore Infaunal NMDS Results. Black = South Area, Red = Middle Area, Green = North Area; Triangle = MLW, Circle = MLW-1m. Square = Nearshore. Stress = 0.13.

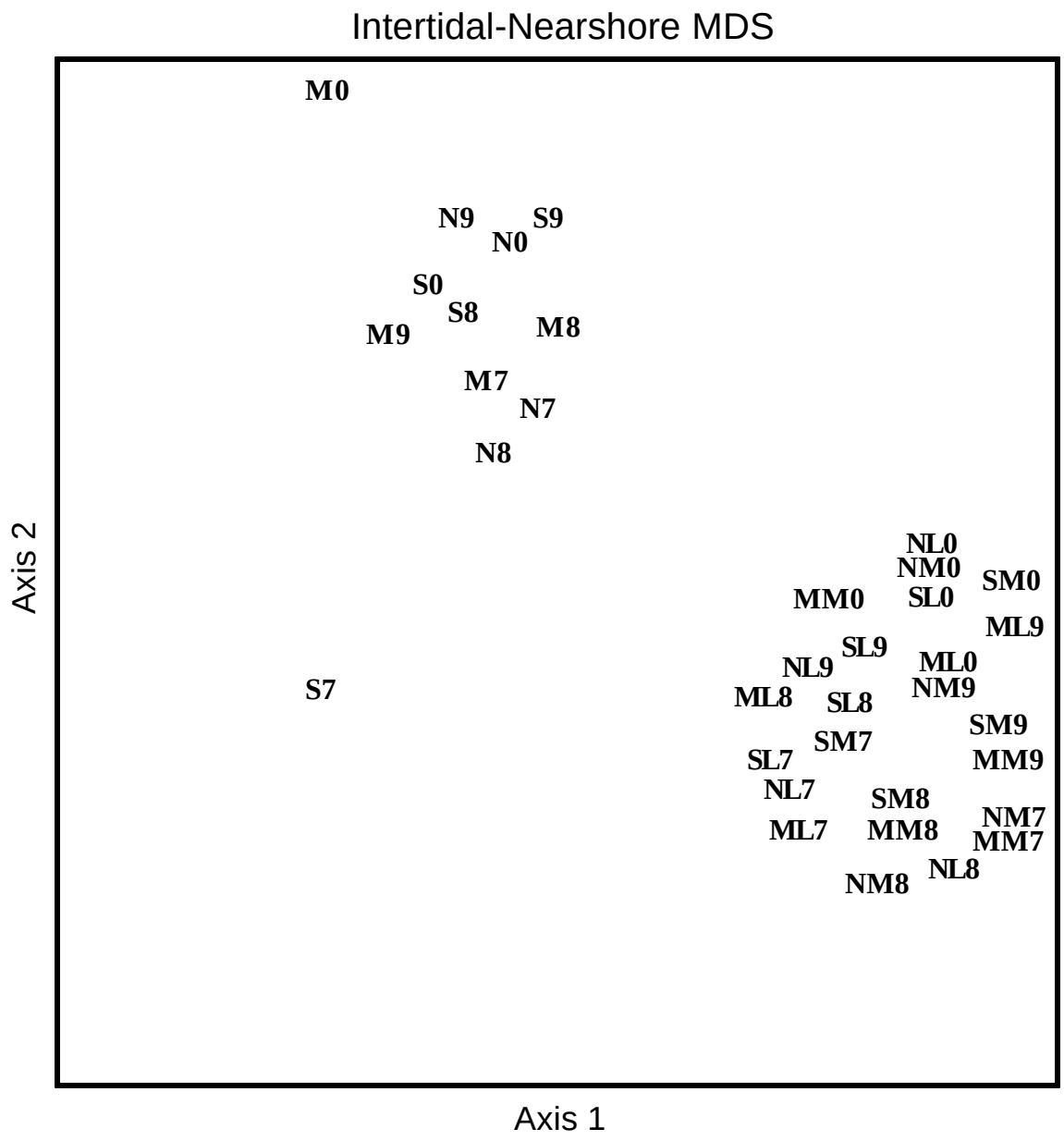

Figure 2-24. NMDS Results from Intertidal-Nearshore Samples During and Immediately After Nourishment. Nearshore Data: S= South, M= Middle. N=North; 7=Sept 1997, 8=May 1998. 9 = Sept. 1999, 0=May 2000. Intertidal Data: S = South, 1st M = Middle, N= North, 2nd M= MLW, L= MLW-1m: 7=Sept 1997, 8=May 1998. 9 = Sept. 1999, 0=May 2000. Stress = 0.13.

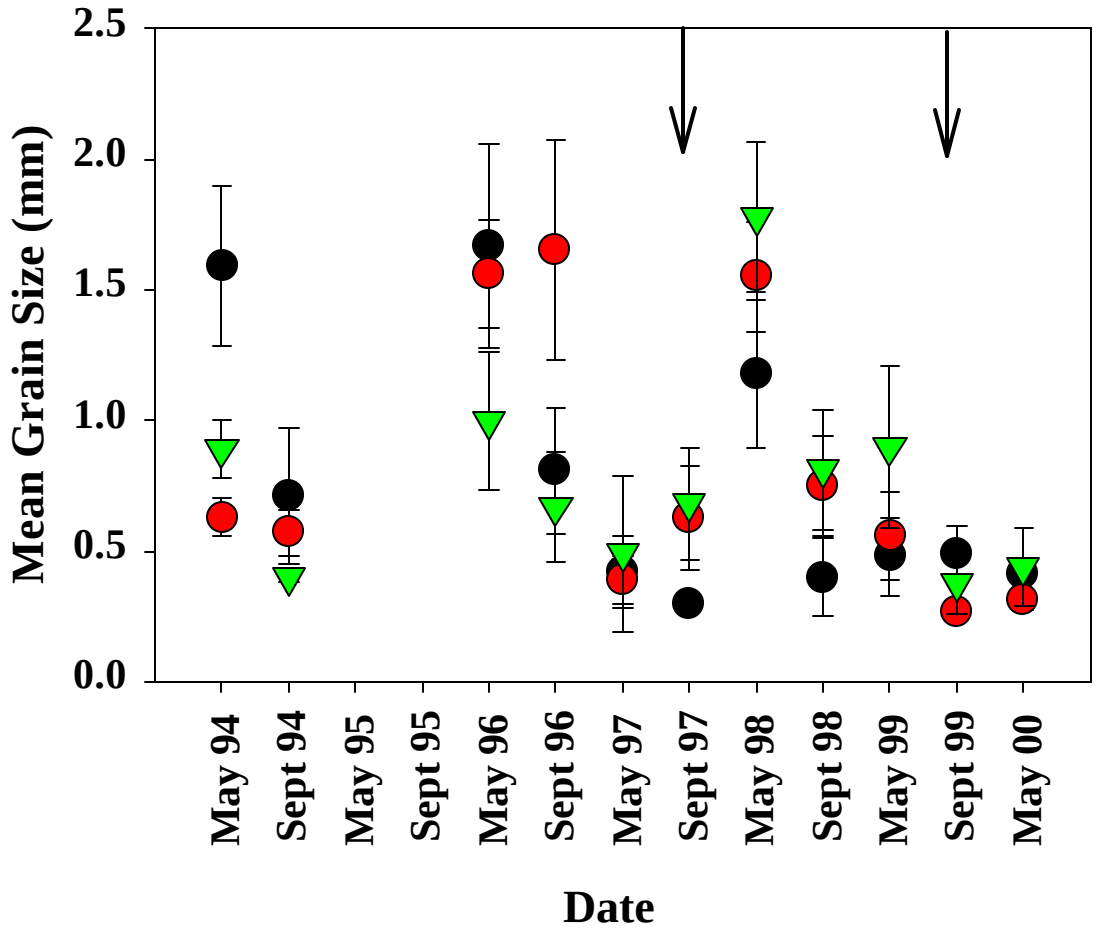

Figure 2-25. Mean Low Water Mean Grain Size (mm±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Arrows indicate when nourishment occurred (1st = South, 2nd = Middle).

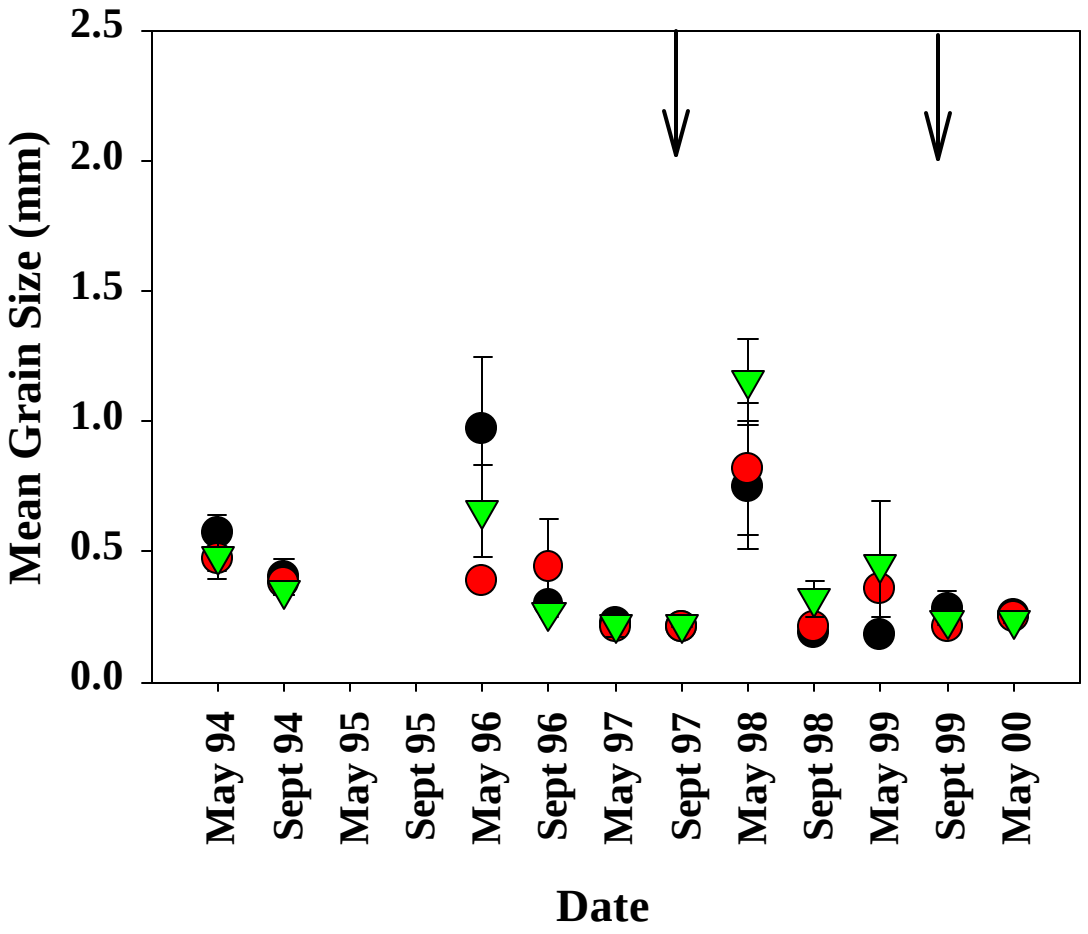

Figure 2-26. Mean Low Water –1m Mean Grain Size (mm±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Arrows indicate when nourishment occurred (1st = South, 2nd = Middle).

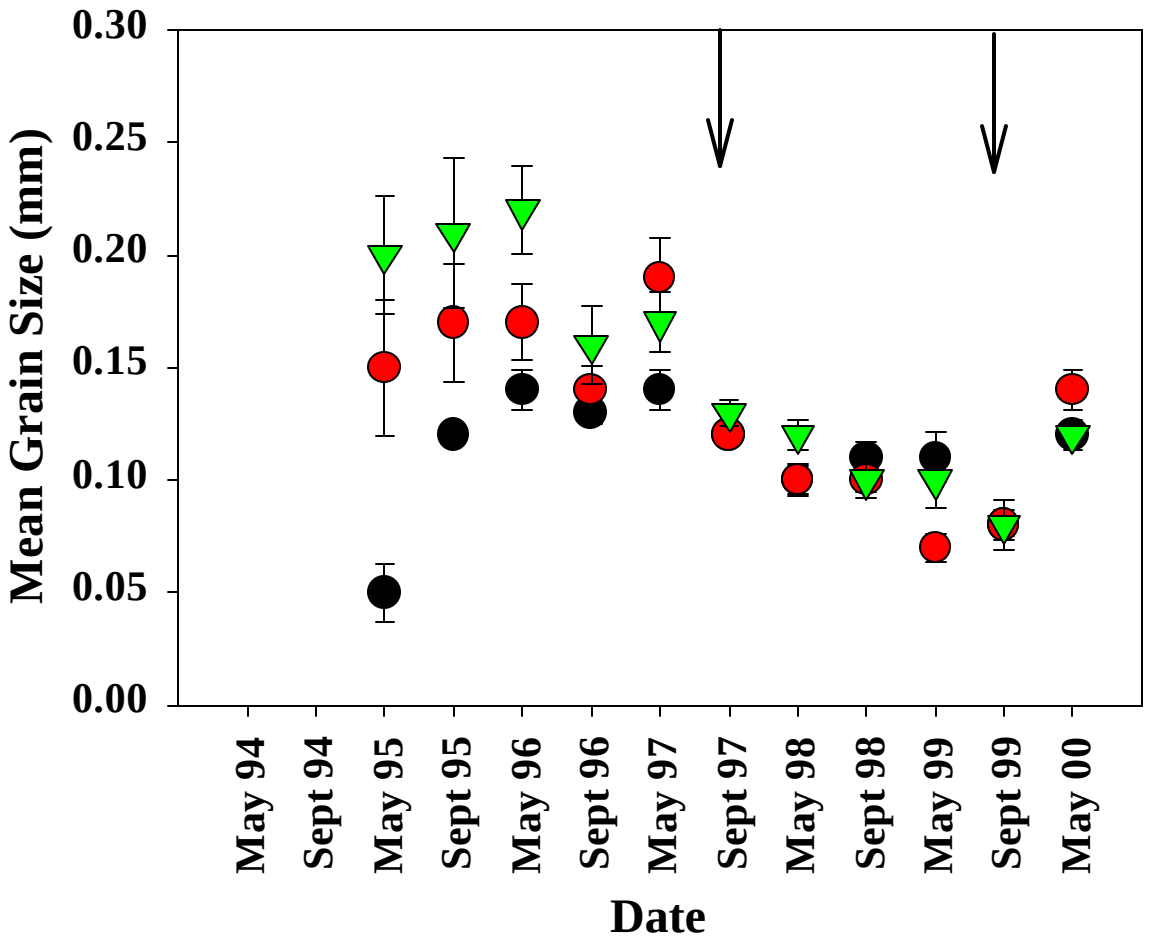

Figure 2-27. Nearshore Mean Grain Size (mm±SE) by Date. Black Circles = South Area, Red Circles = Middle Area, Green Triangles = North Area; Arrows indicate when nourishment occurred (1st = South, 2nd = Middle).

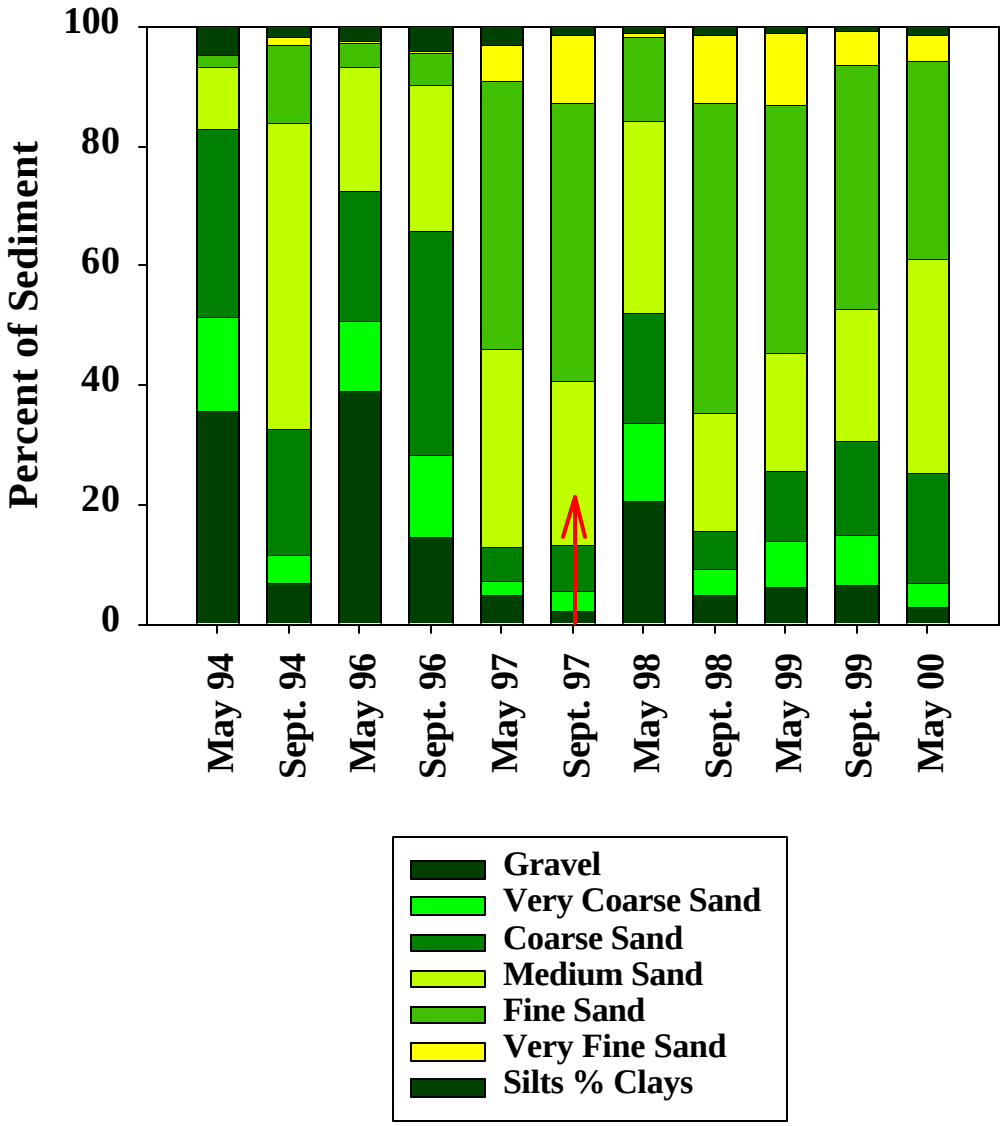

Figure 2-28. MLW Sediment Composition - South Area. Arrow indicates when nourishment occurred.

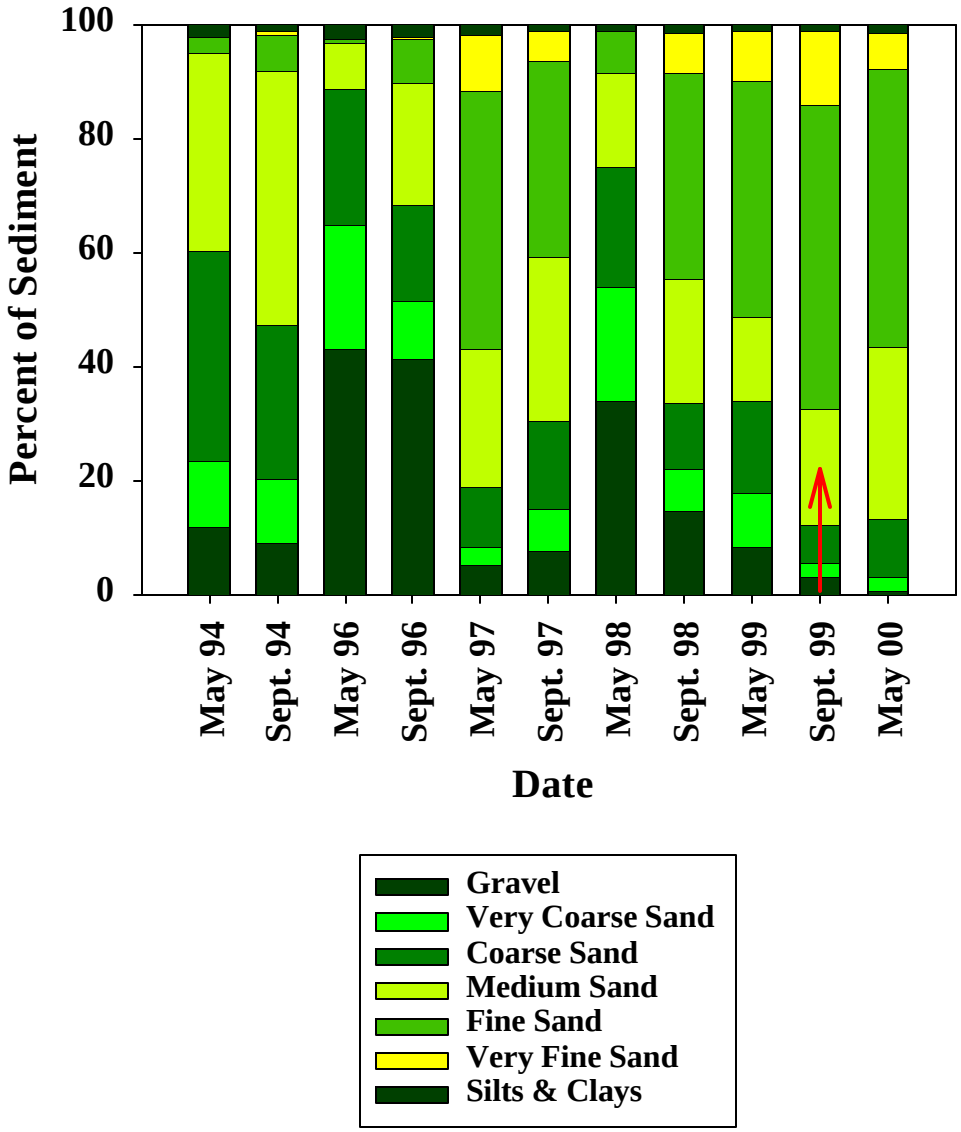

Figure 2-29. MLW Sediment Composition - Middle Area. Arrow indicates when nourishment occurred.

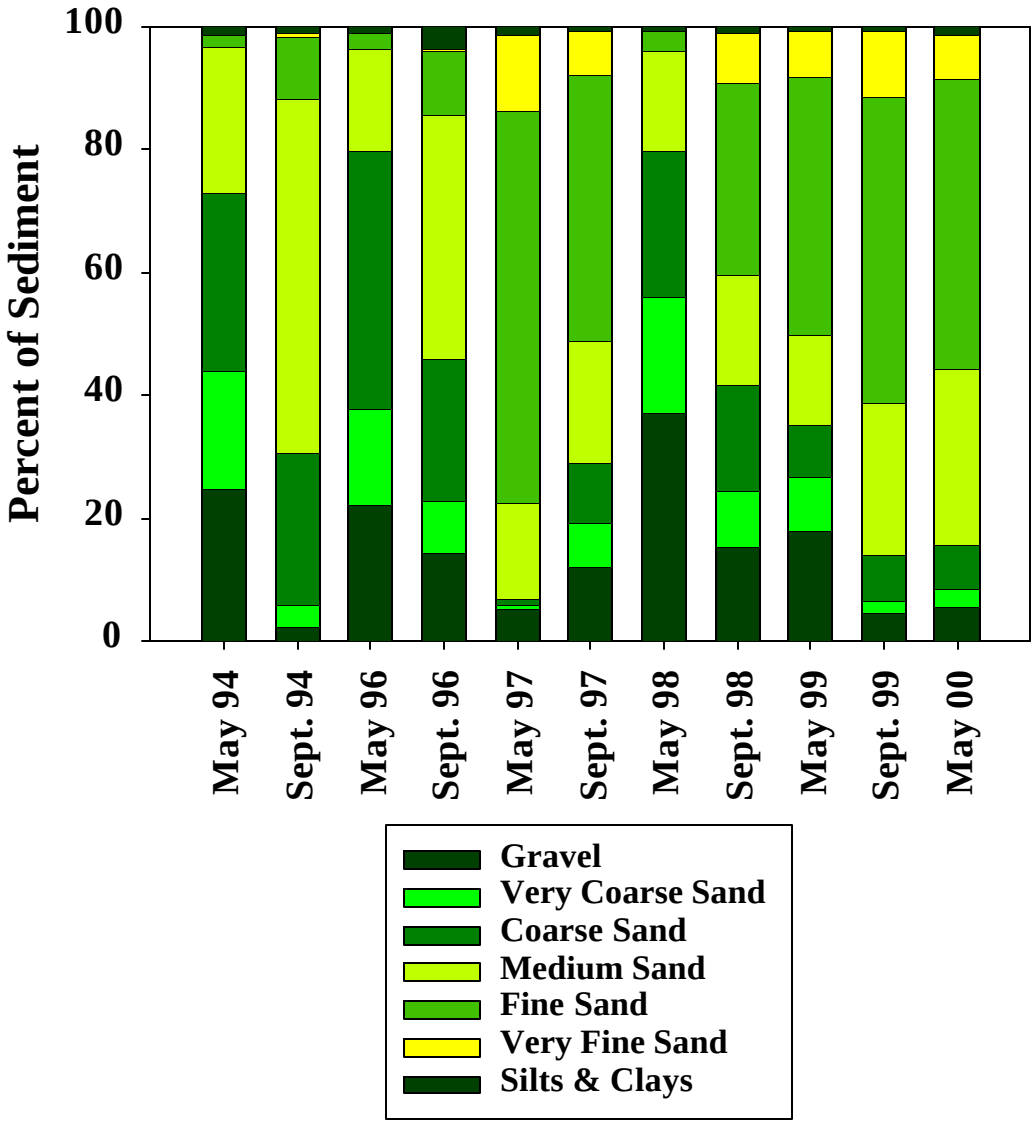

Figure 2-30. MLW Sediment Composition - North Area.

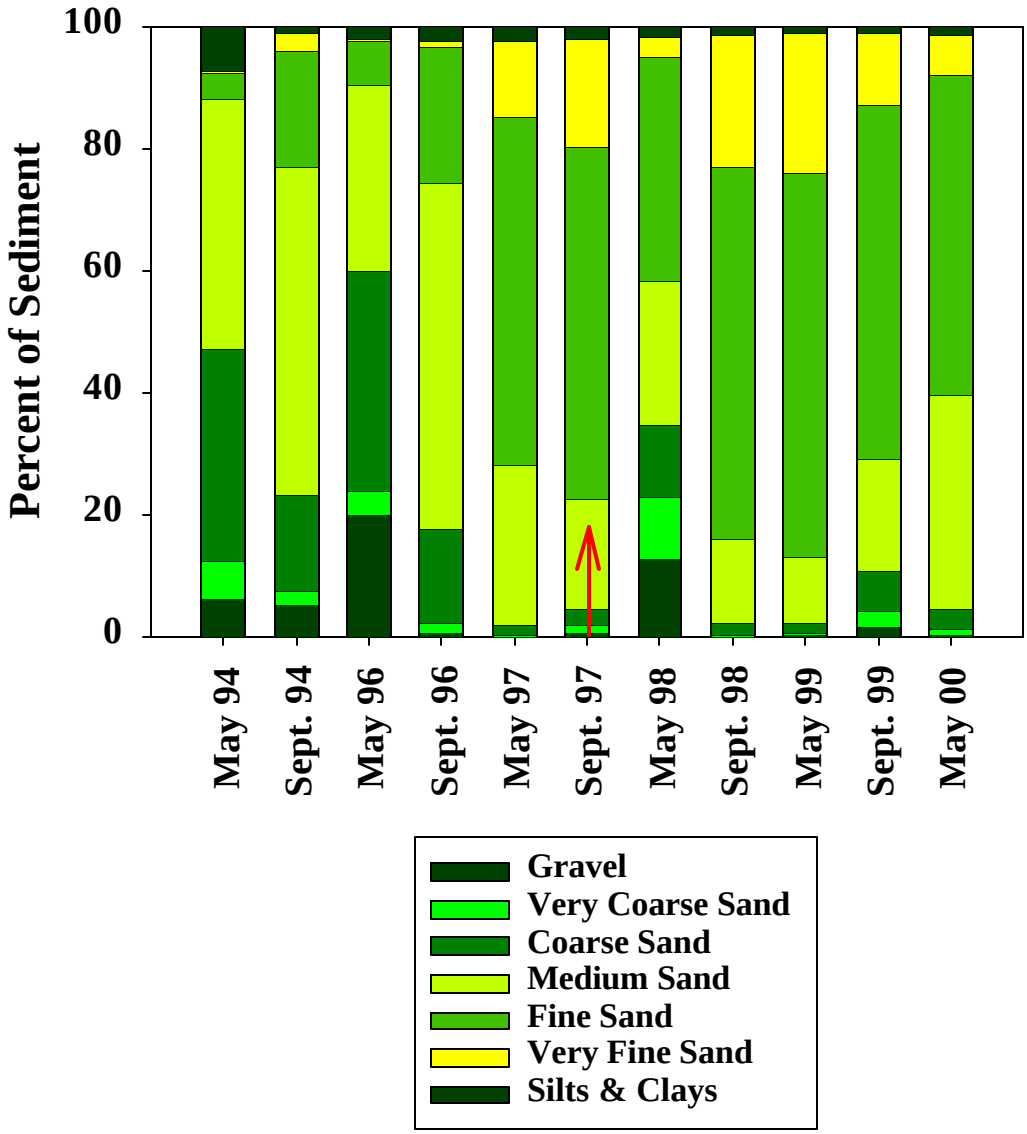

Figure 2-31. MLW-1m Sediment Composition- South Area. Arrow indicates when nourishment occurred.

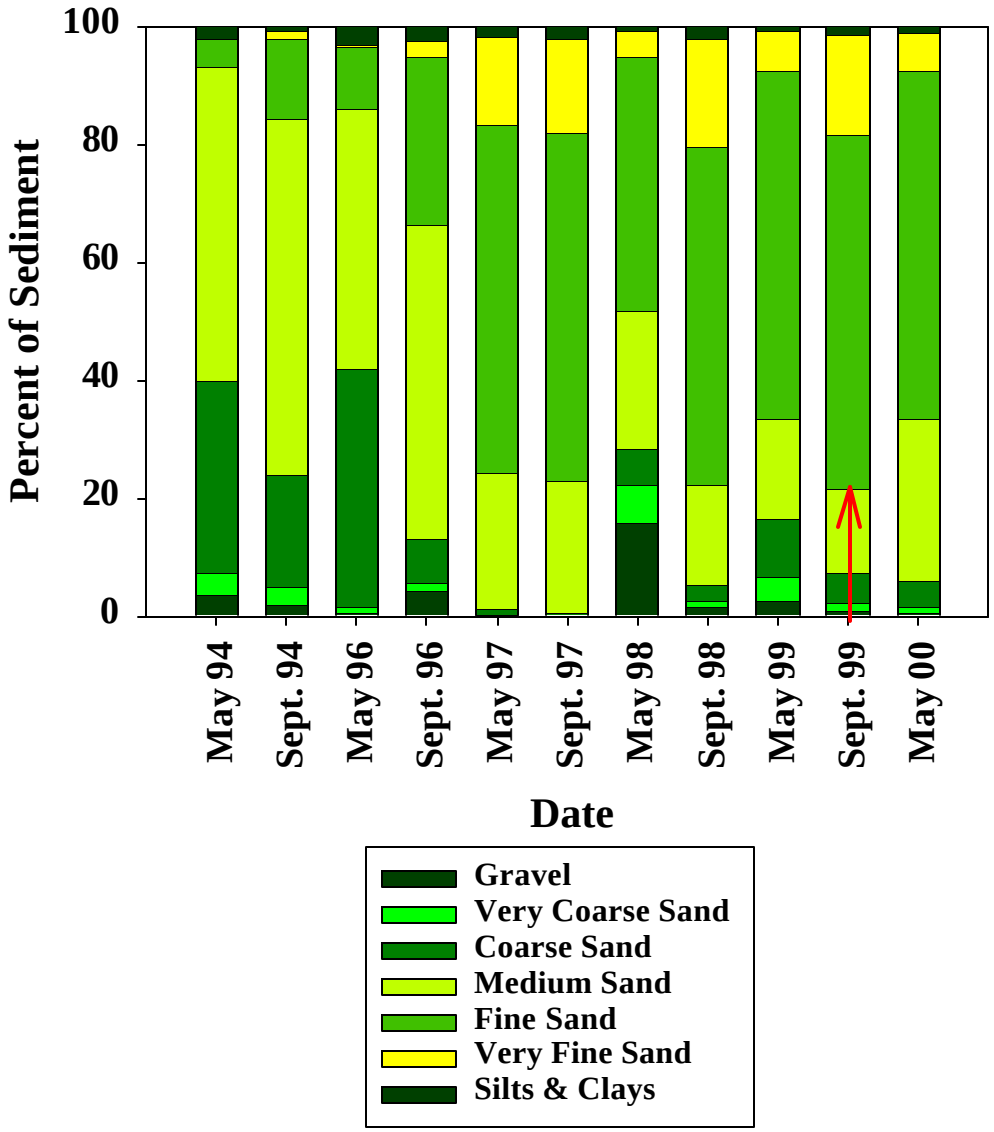

Figure 2-32. MLW-1m Sediment Composition- Middle Area. Arrow indicates when nourishment occurred.

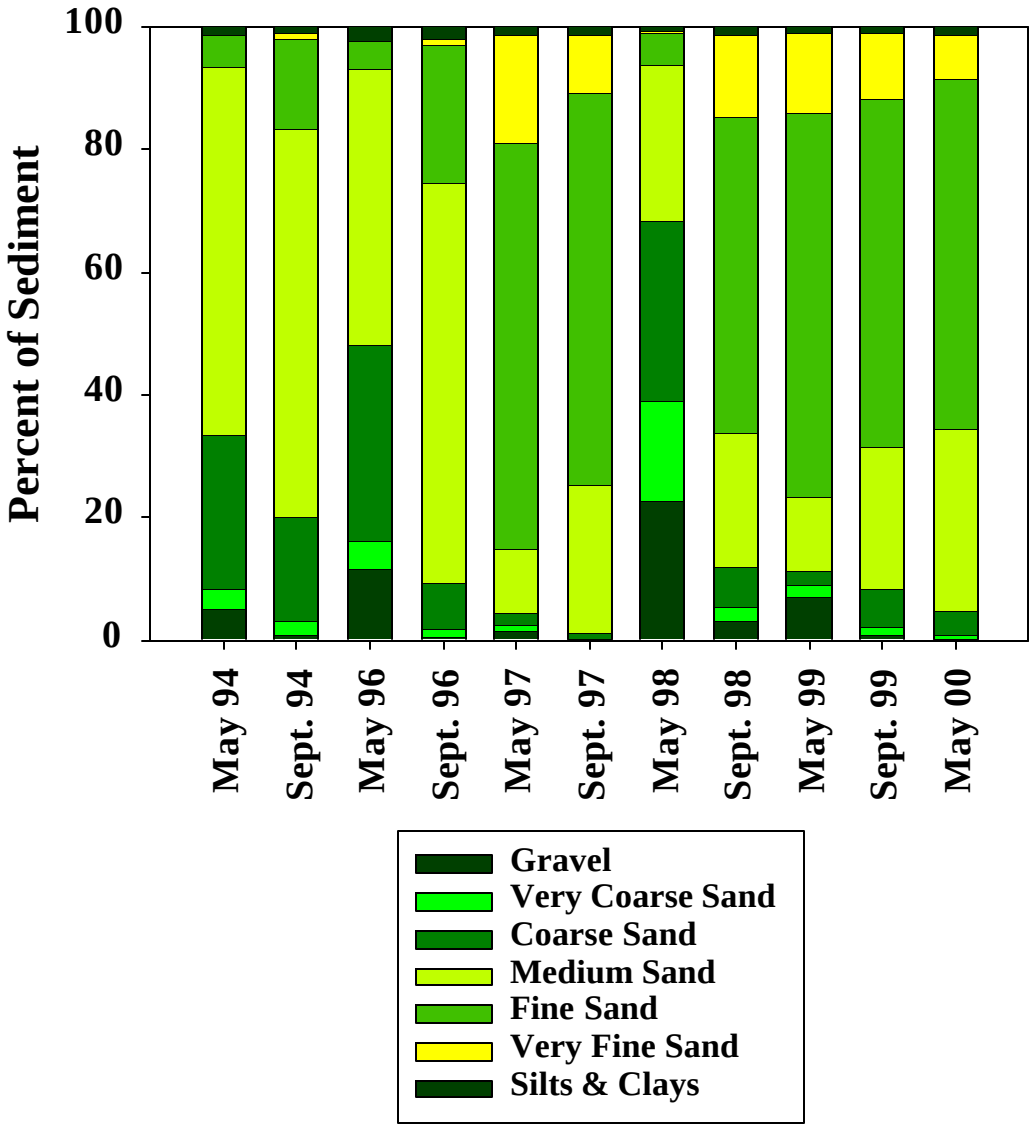

Figure 2-33. MLW-1m Sediment Composition- North Area.

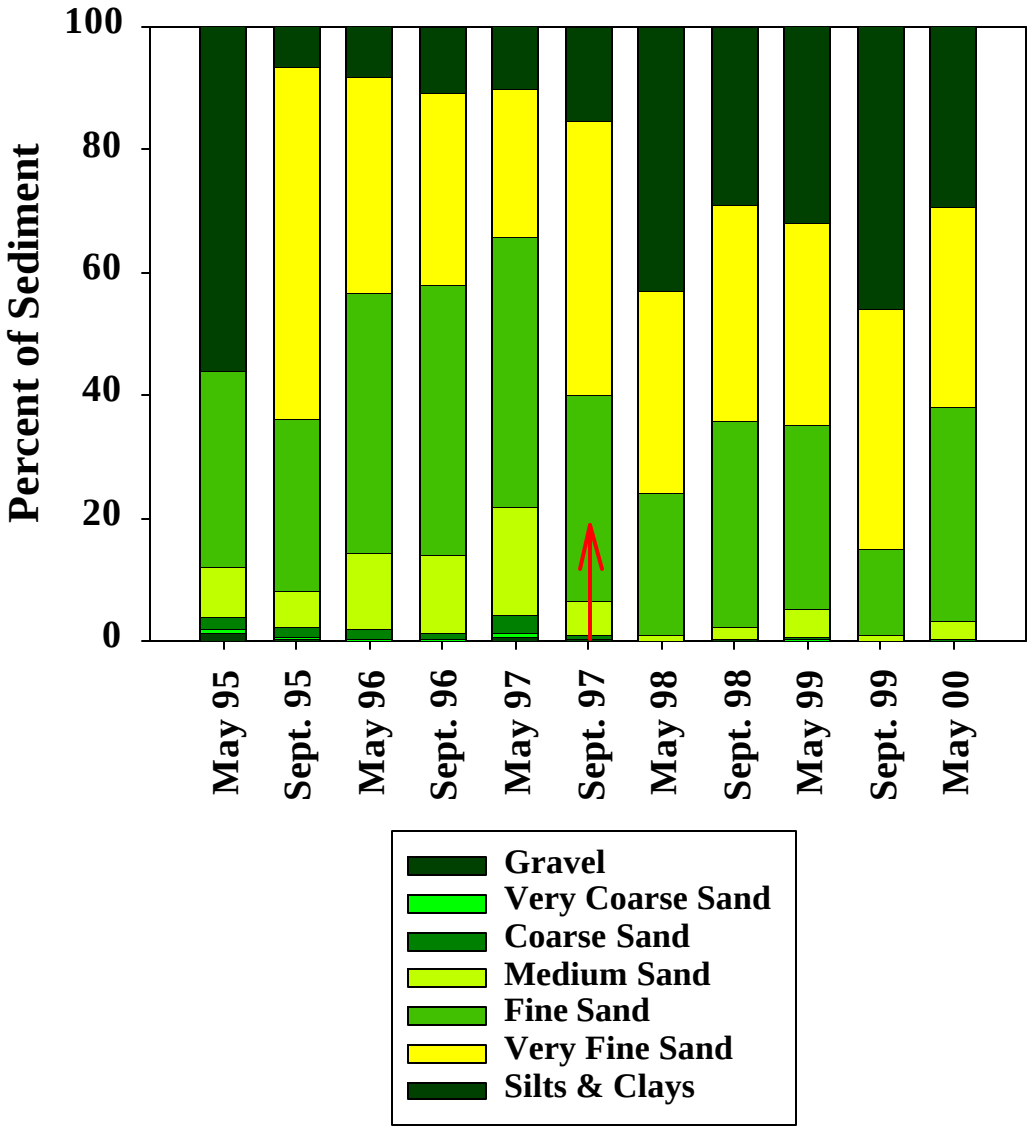

Figure 2-34. Nearshore Sediment Composition - South Area. Arrow indicates when nourishment occurred.

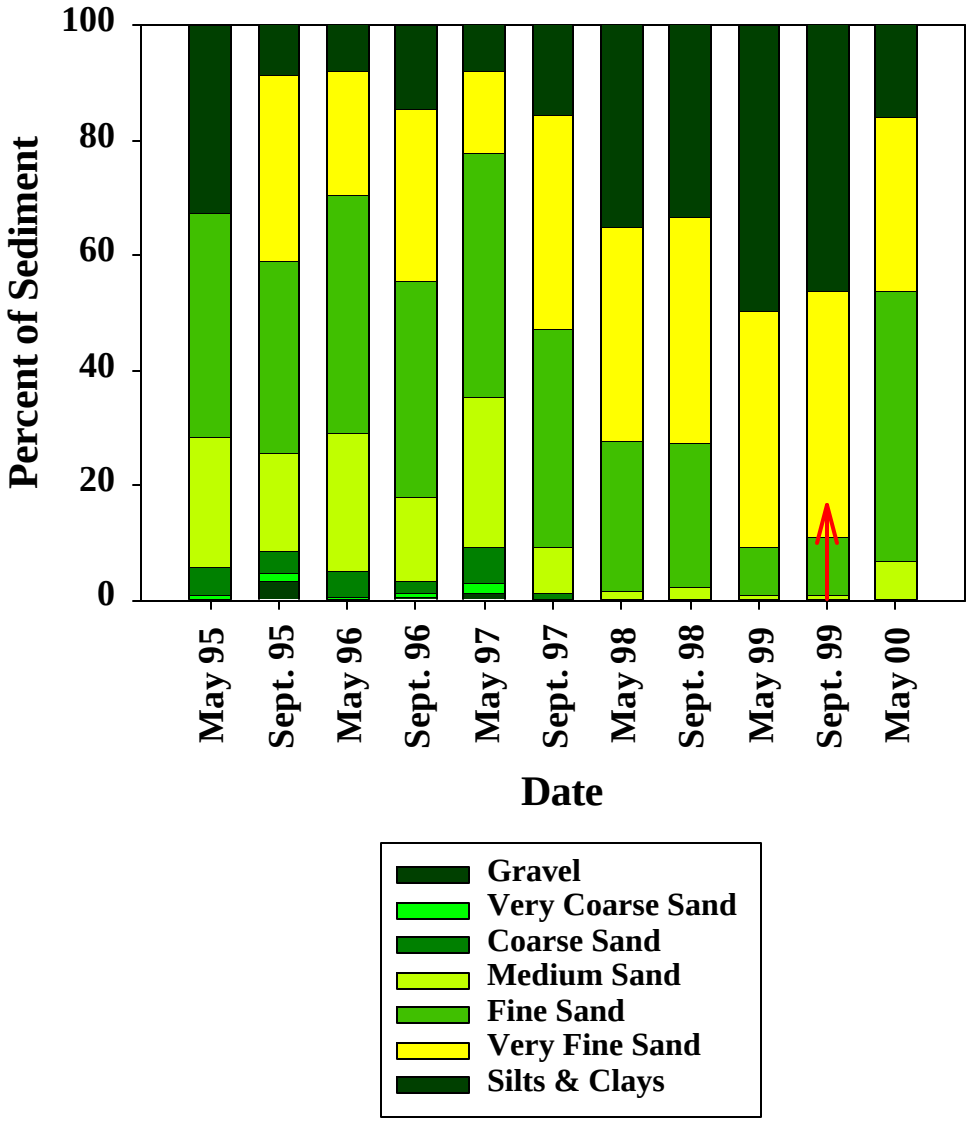

Figure 2-35. Nearshore Sediment Composition - Middle Area. Arrow indicates when nourishment occurred.

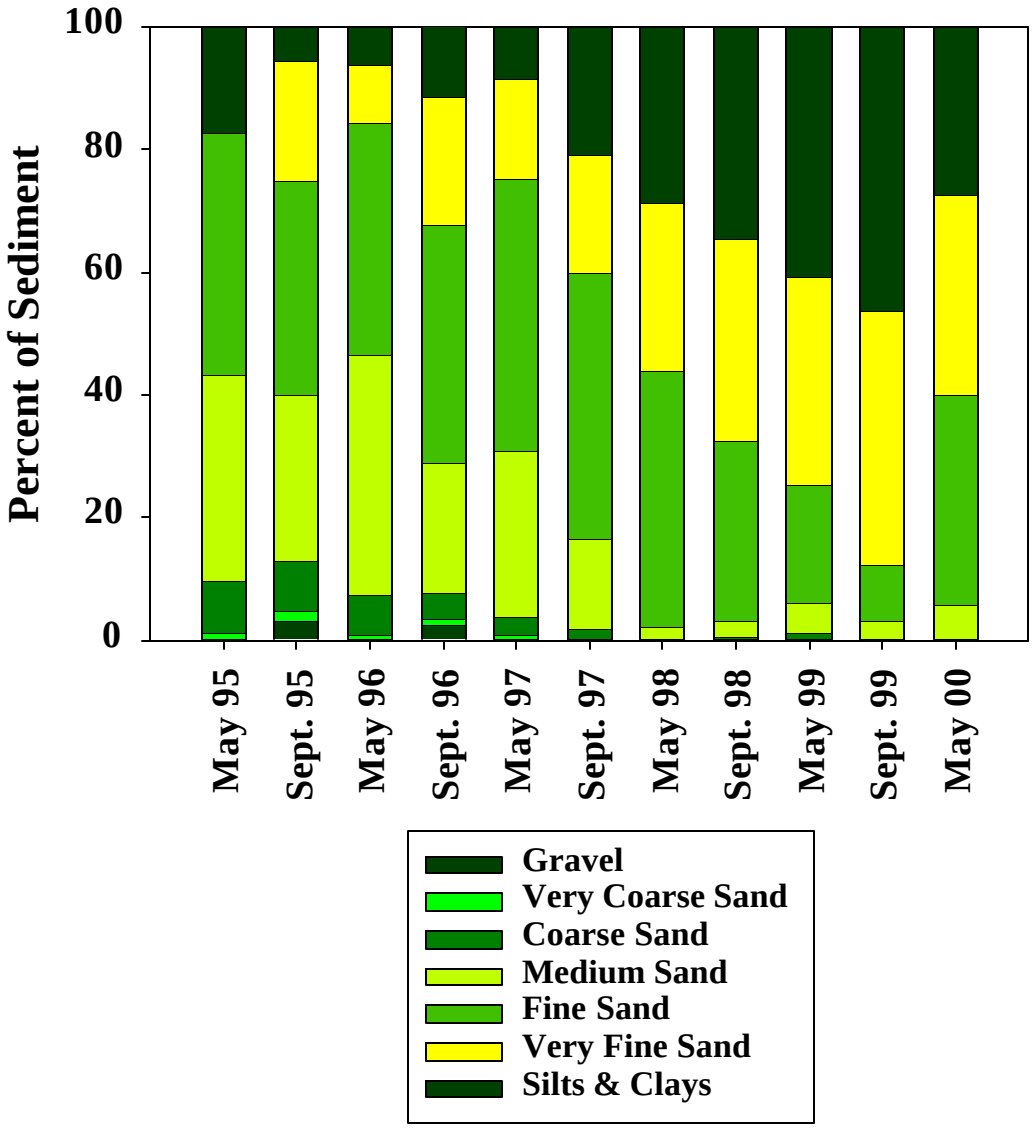

Figure 2-36. Nearshore Sediment Composition - North Area.

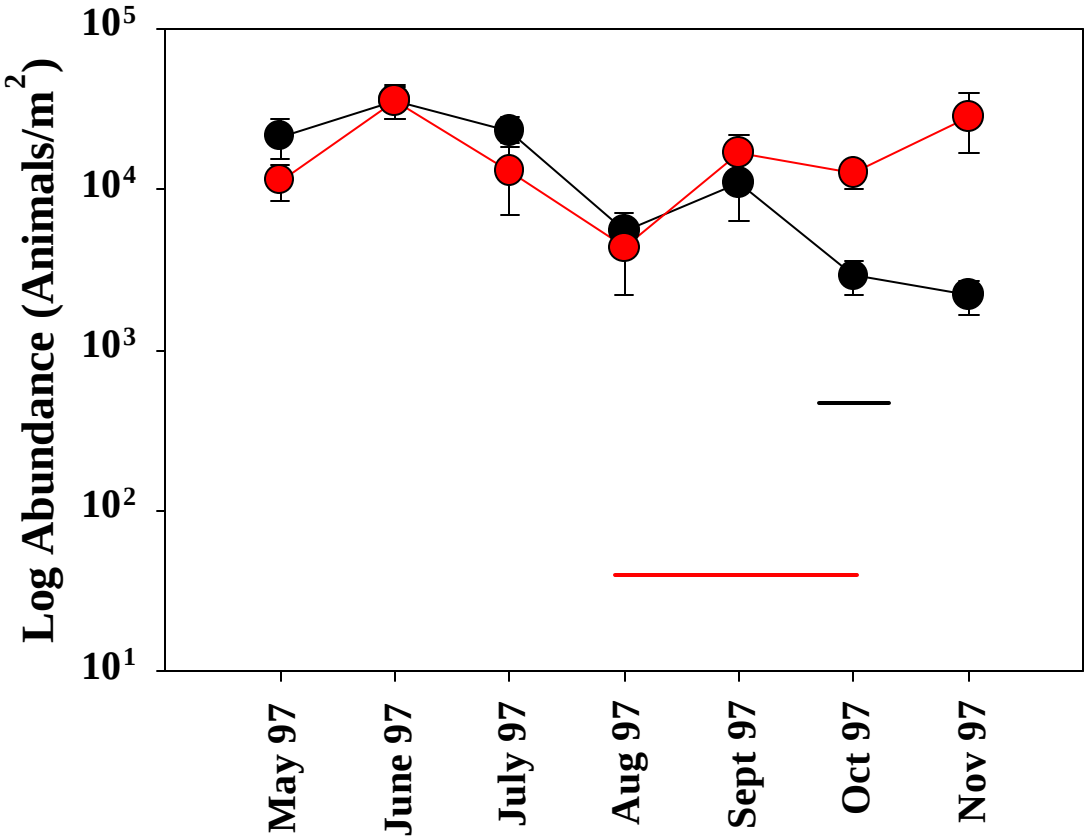

Figure 2-37. Monthly Abundance (No. Animals/m^2 ±SE) for 1997. Red Circles = South Area, Black Circles = Middle Area, Red line indicates time during which South Area MLW Stations 1-6 were nourished; Bar indicates a significant ($p<0.0167$) linear contrast between means.

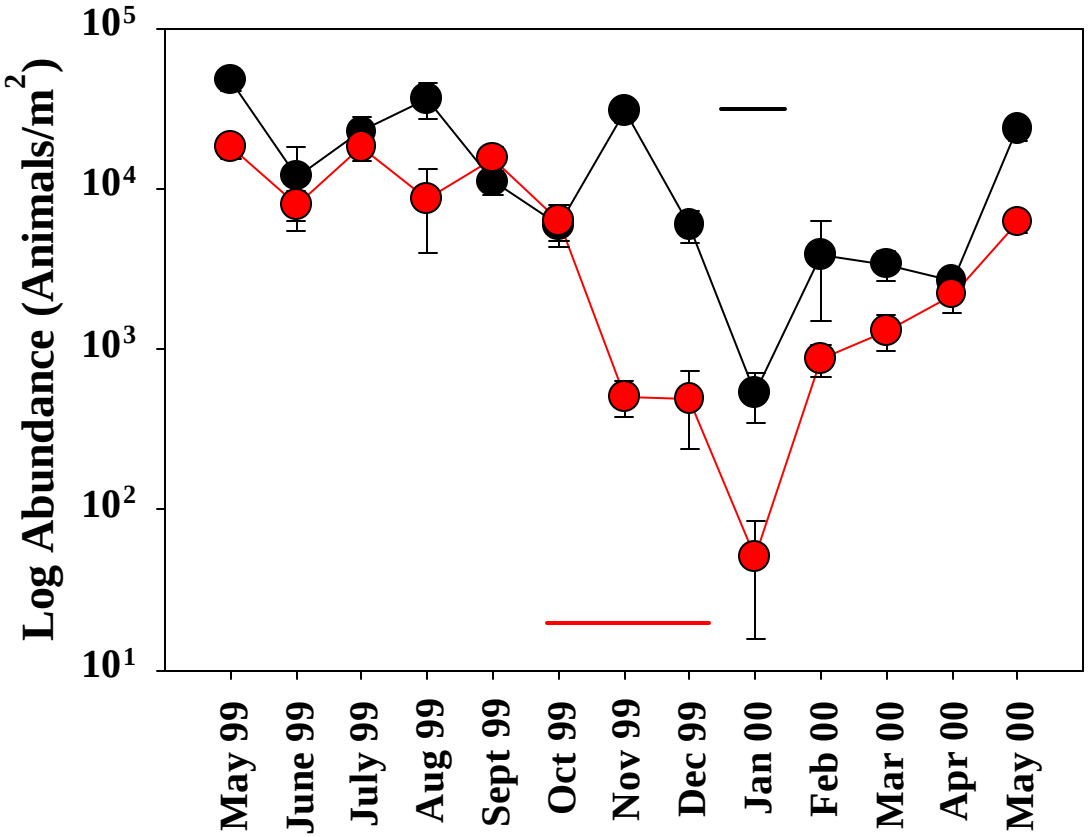

Figure 2-38. Monthly Abundance (No. Animals/m^2±SE) for 1999. Red Circles = South Area, Black Circles = Middle Area, Red line indicates time during which Middle Area MLW Stations 21-26 were nourished; Bar indicates a significant ($p<0.0167$) linear contrast between means.

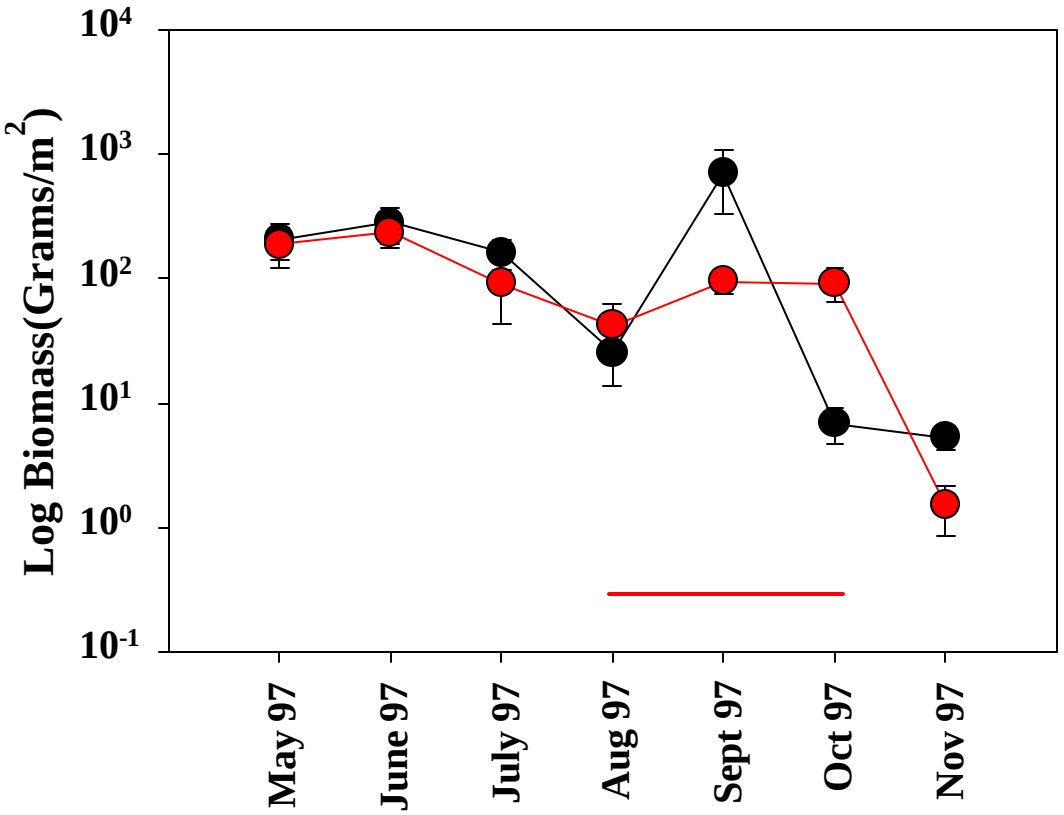

Figure 2-39. Monthly Biomass (Grams/m^2±SE) for 1997. Red Circles = South Area, Black Circles = Middle Area, Red line indicates time during which South Area MLW Stations 1-6 were nourished; Bar indicates a significant ($p<0.0167$) linear contrast between means.

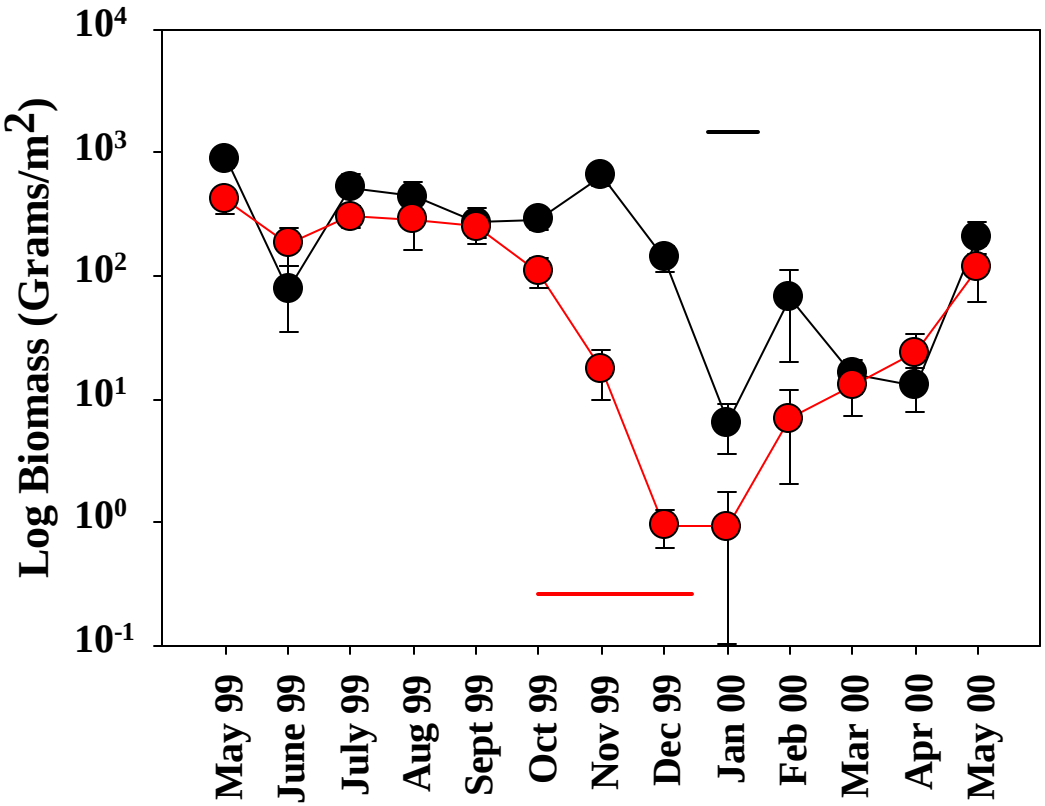

Figure 2-40. Monthly Biomass (Grams/m^2±SE) for 1999. Red Circles = South Area, Black Circles = Middle Area, Red line indicates time during which Middle Area MLW Stations 21-26 were nourished; Bar indicates a significant ($p<0.0167$) linear contrast between means.

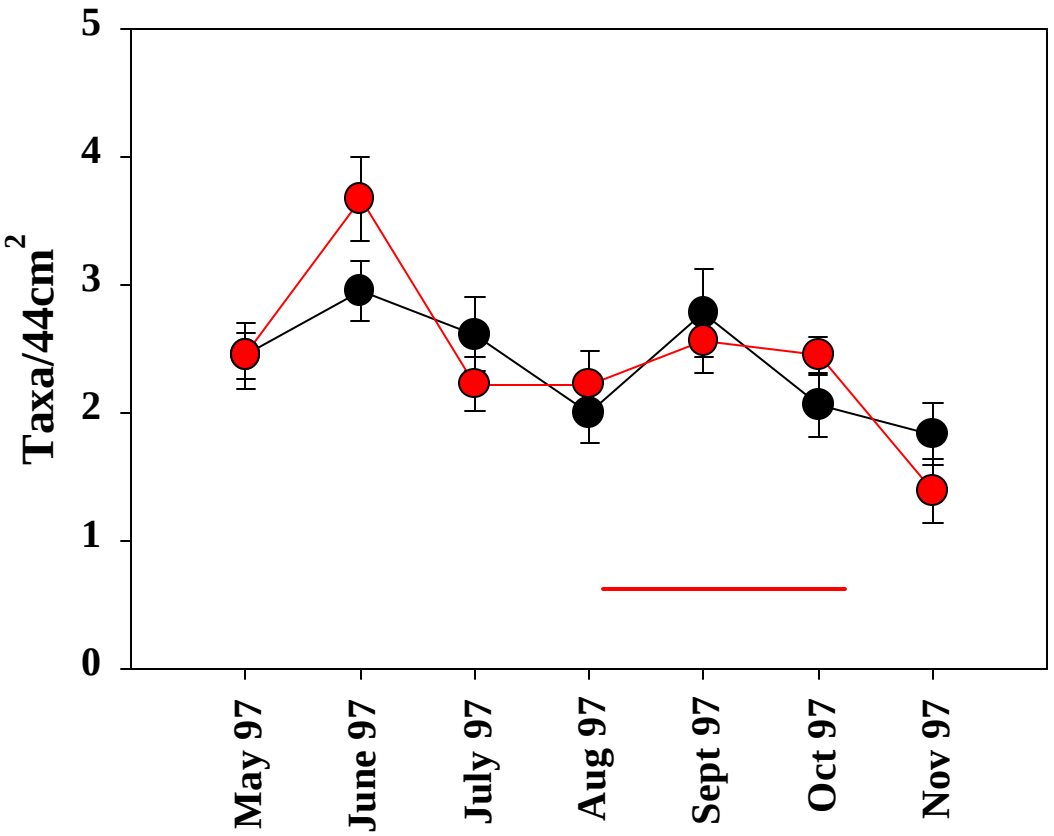

Figure 2-41. Monthly Taxa Richness (Taxa/44cm^2±SE) for 1997. Red Circles = South Area, Black Circles = Middle Area, Red line indicates time during which South Area MLW Stations 1-6 were nourished; Bar indicates a significant ($p<0.0167$) linear contrast between means.

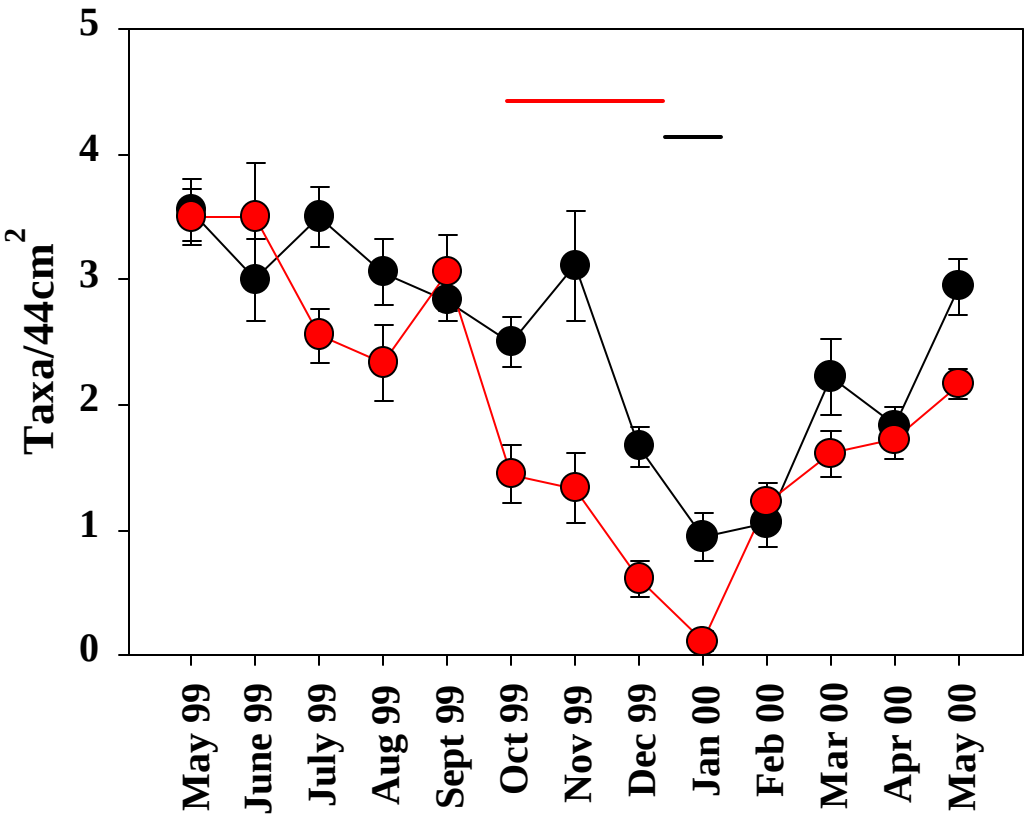

Figure 2-42. Monthly Taxa Richness (Taxa/44cm^2 ± SE) for 1999. Red Circles = South Area, Black Circles = Middle Area, Red line indicates time during which Middle Area MLW Stations 21-26 were nourished; Bar indicates a significant ($p<0.0167$) linear contrast between means.

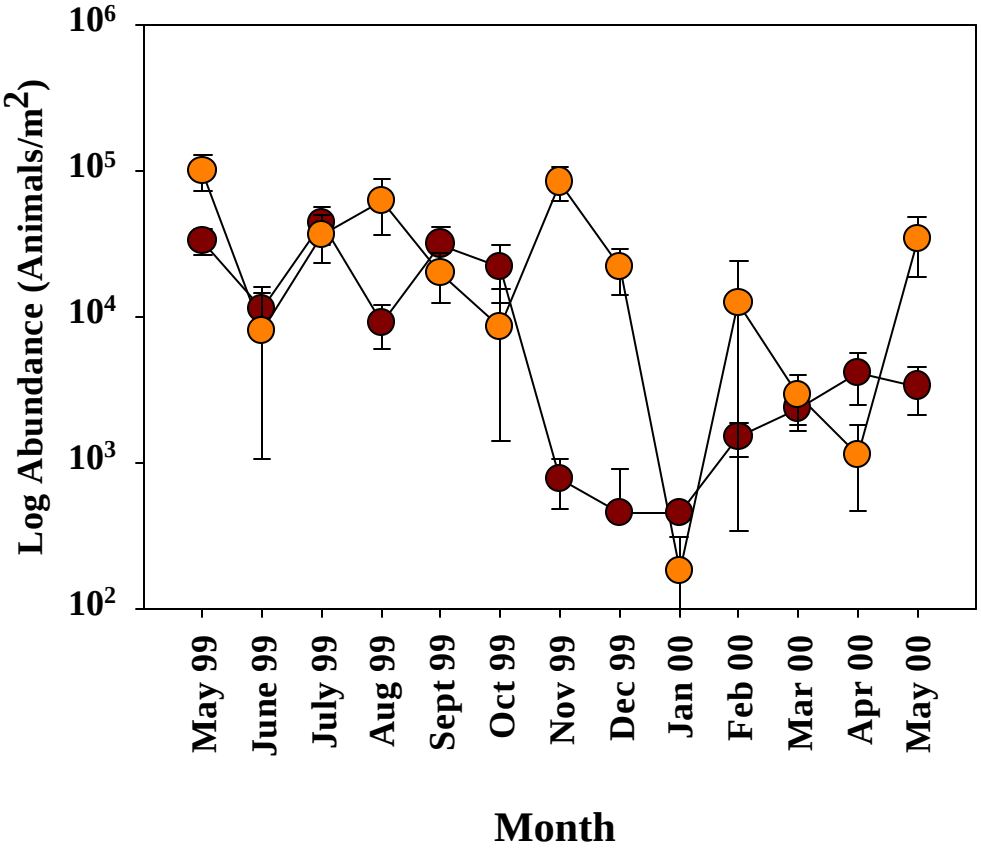

Figure 2-43. Monthly Abundance (Animals/m^2±SE) of *Scolelepis squamata*: 1999-2000. Orange = South Area (reference), Brown = Middle Area (nourished).

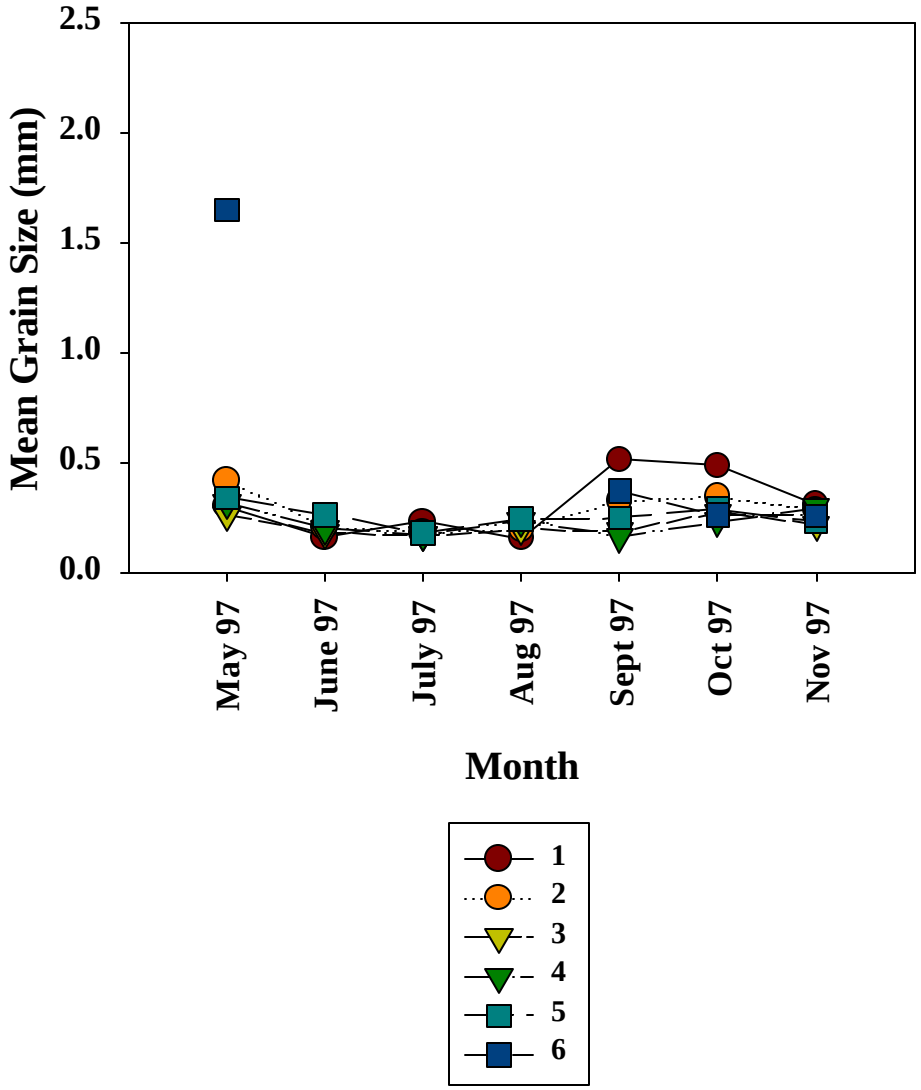

Figure 2-44. Monthly Sediment Mean Grain Size (±SE) for South Area 1997.
Numbers = MLW Stations.

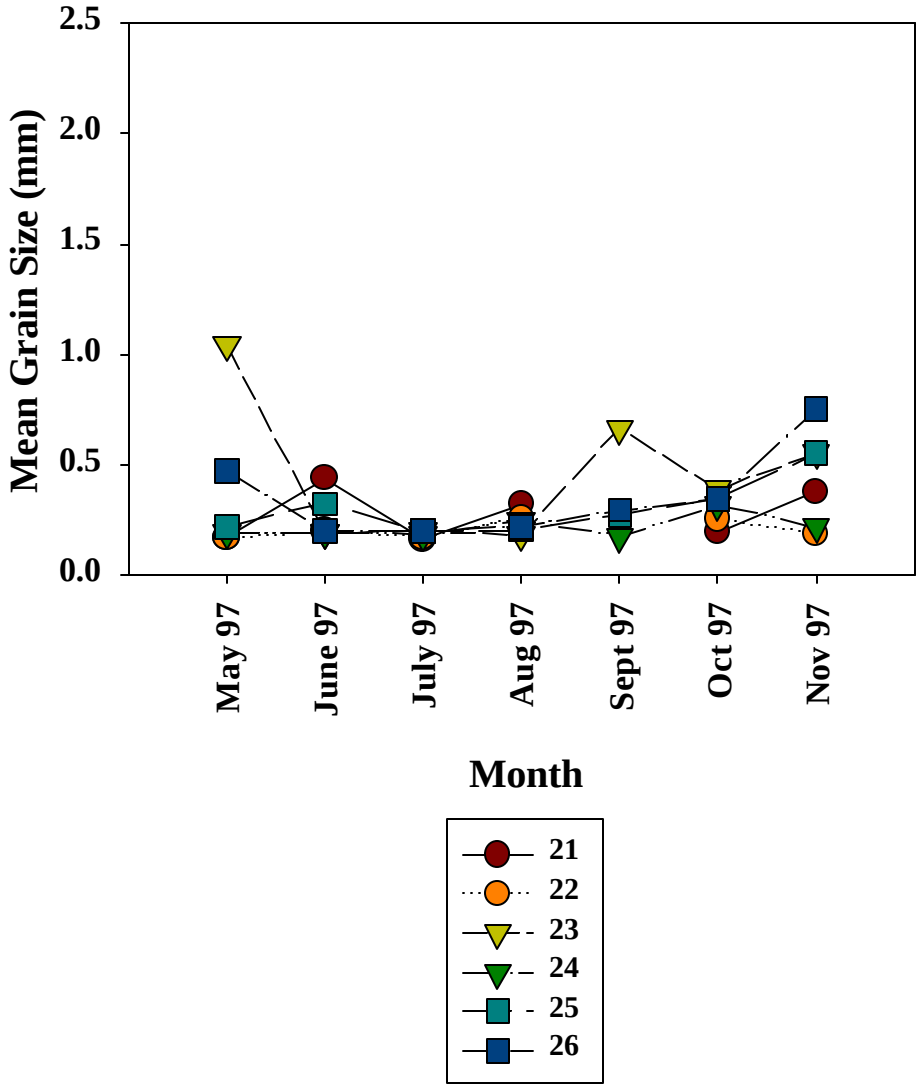

Figure 2-45. Monthly Sediment Mean Grain Size (±SE) for Middle Area 1997.
Numbers = MLW Stations.

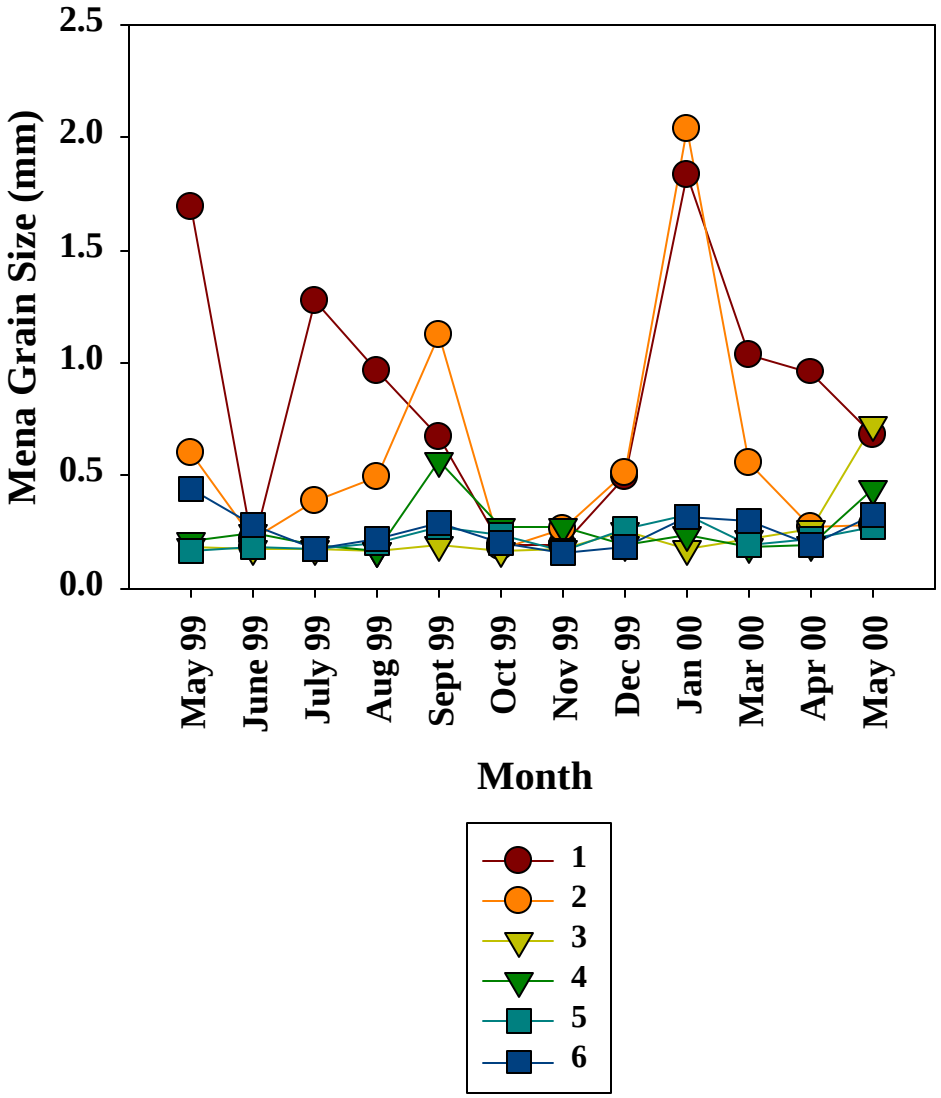

Figure 2-46. Monthly Sediment Mean Grain Size (±SE) for South Area 1999.
Numbers = MLW Stations.

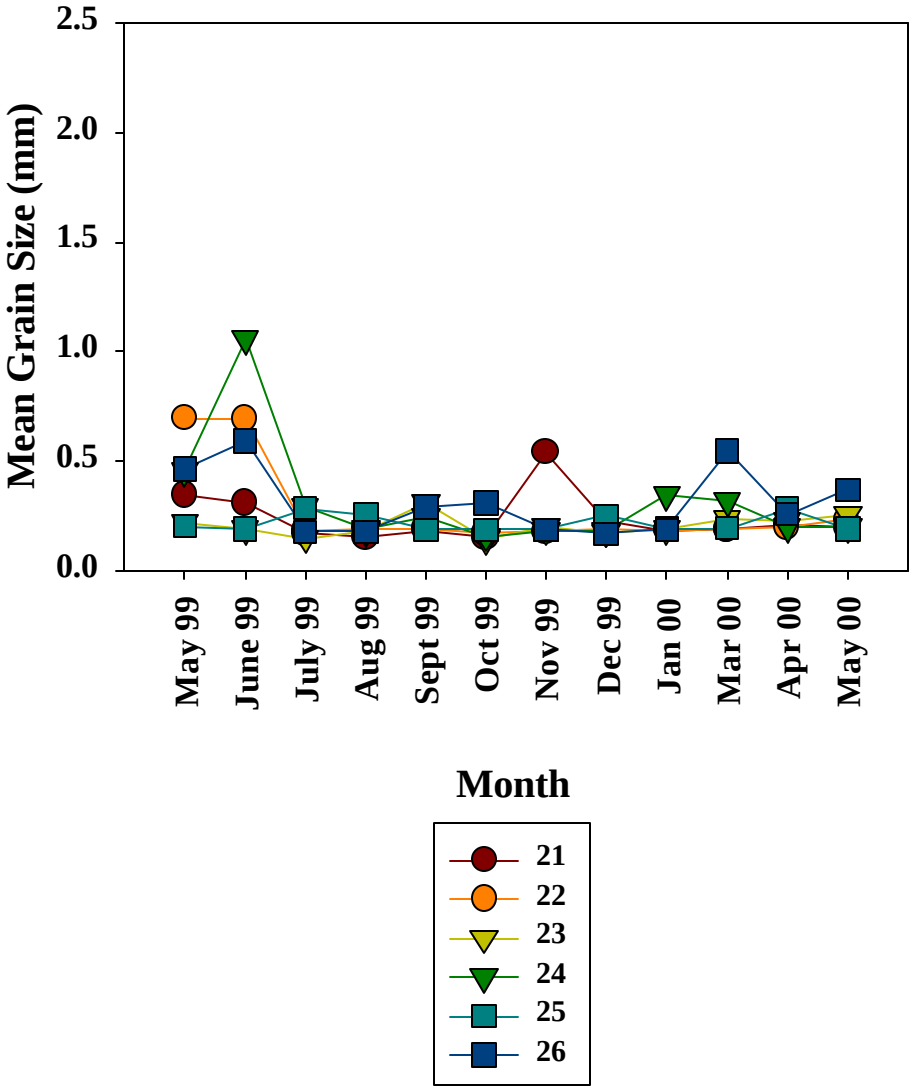

Figure 2-47. Monthly Sediment Mean Grain Size (±SE) for Middle Area 1999.
Numbers = MLW Stations.

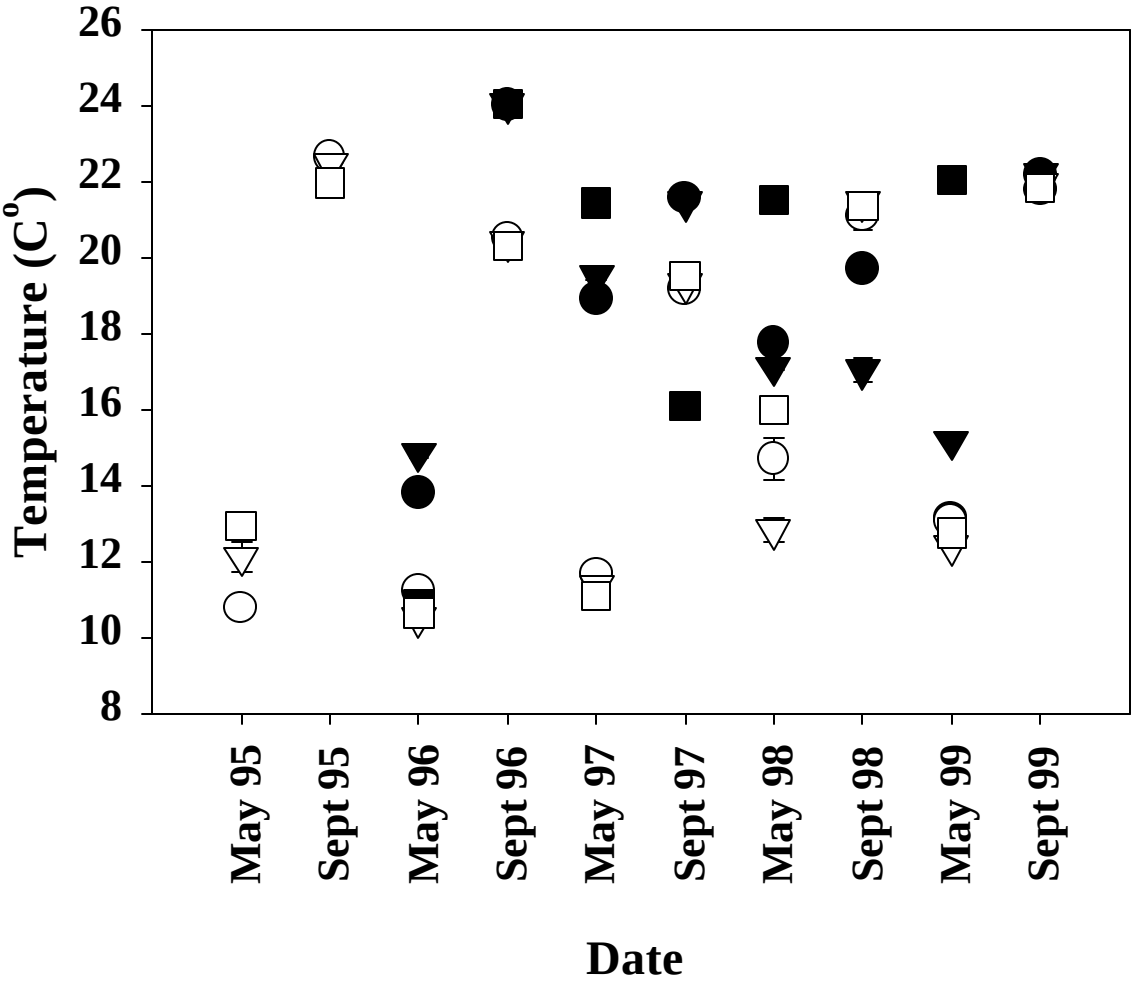

Figure 2-48. Surfzone and Nearshore Bottom Water Temperature (Mean C^o ±SE). Filled symbols = Surfzone, Open symbols = Nearshore Bottom water; Circle = South Area, Inverted Triangle = Middle Area, Square = North Area.

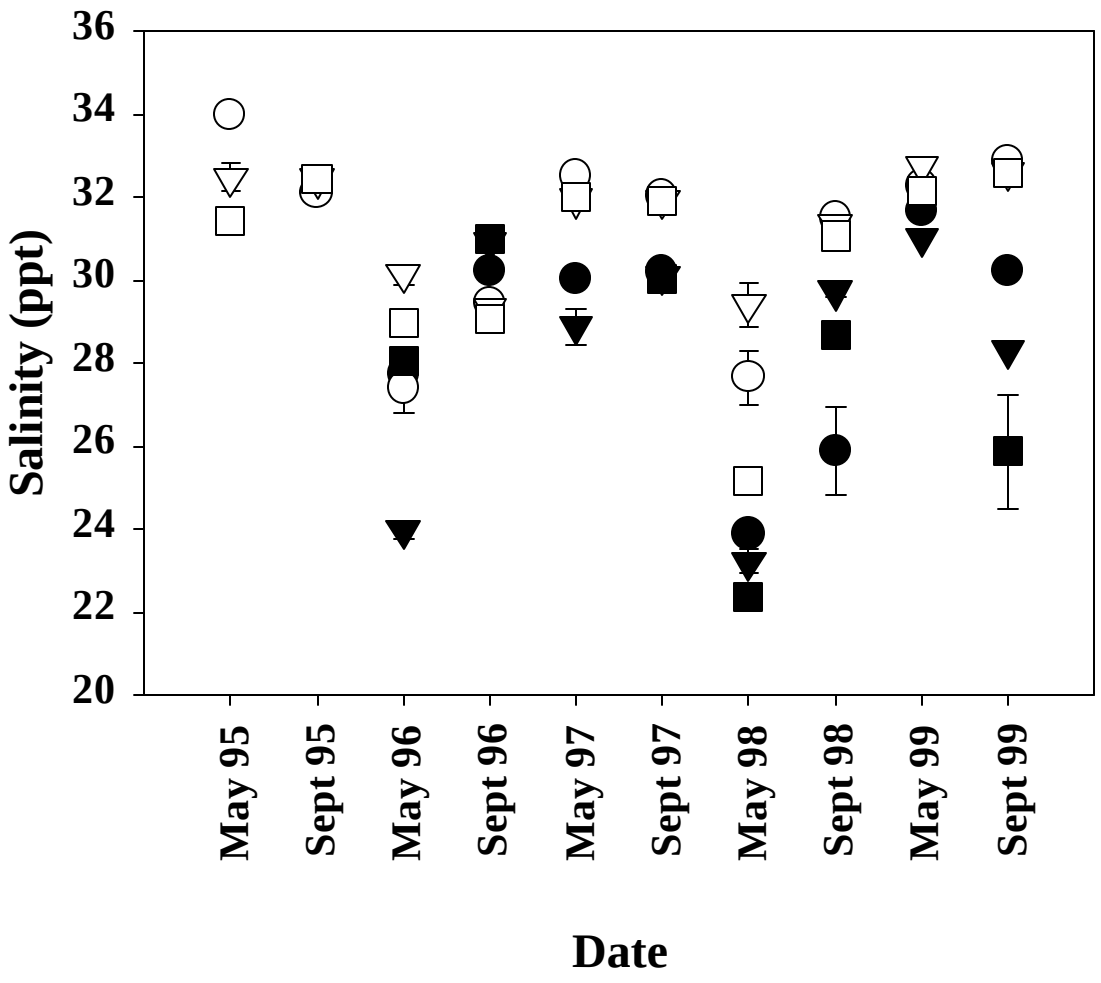

Figure 2-49. Surfzone and Nearshore Bottom Water Salinity (Mean ppt ±SE). Filled symbols = Surfzone, Open symbols = Nearshore Bottom water; Circle = South Area, Inverted Triangle = Middle Area, Square = North Area.

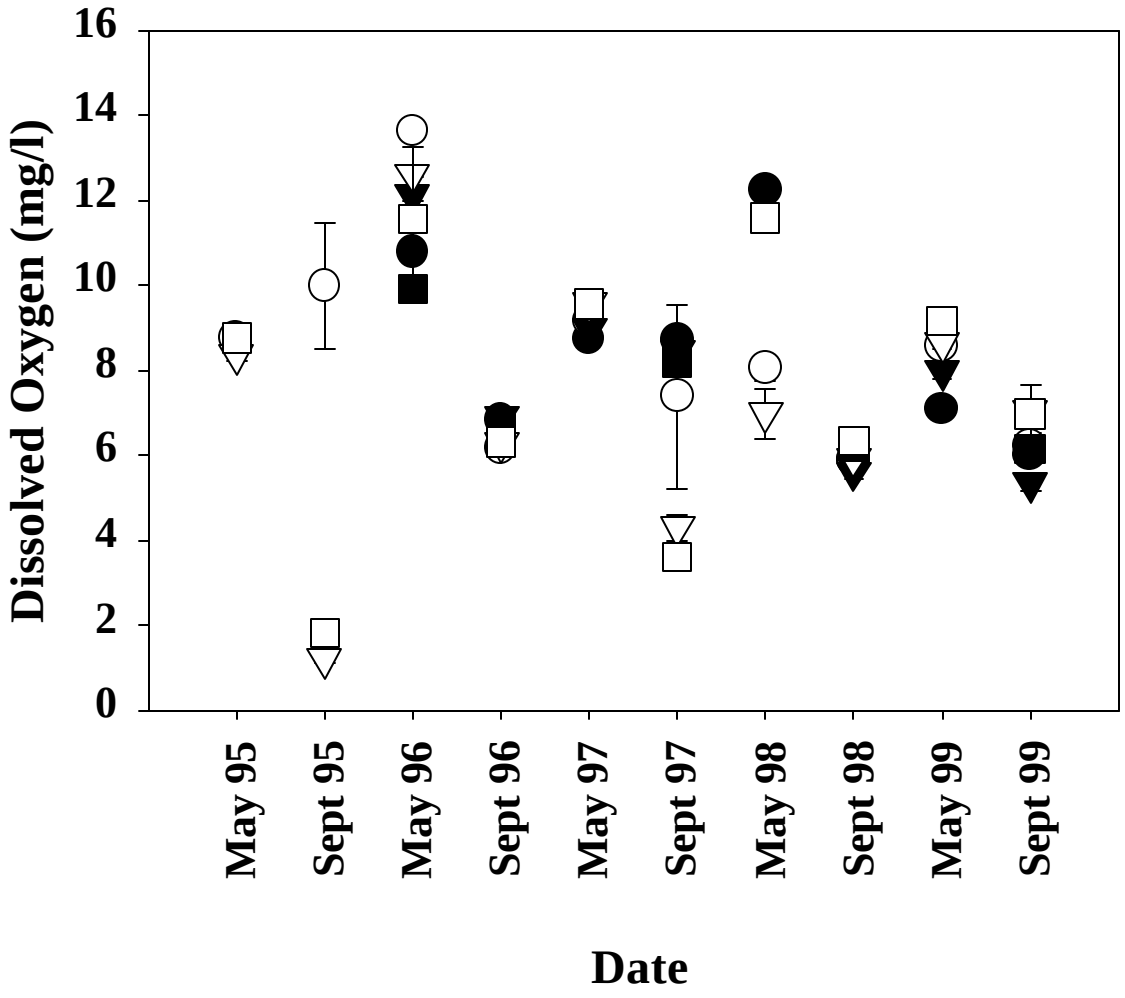

Figure 2-50. Surfzone and Nearshore Bottom Water Dissolved Oxygen Concentrations (Mean mg/l ±SE). Filled symbols = Surfzone, Open symbols = Nearshore Bottom water; Circle = South Area, Inverted Triangle = Middle Area, Square = North Area.

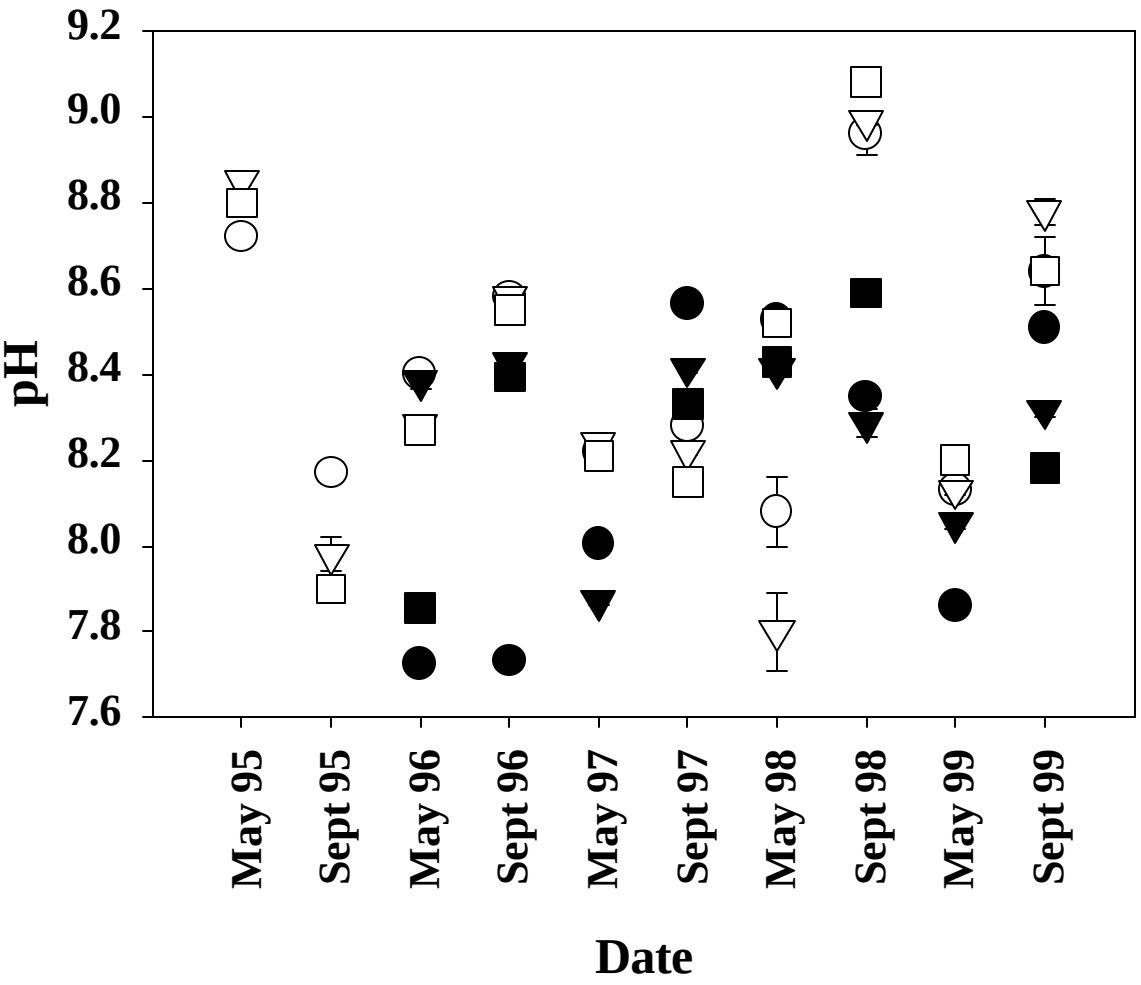

Figure 2-51. Surfzone and Nearshore Bottom Water pH (Mean±SE). Filled symbols = Surfzone, Open symbols = Nearshore Bottom water; Circle = South Area, Inverted Triangle = Middle Area, Square = North Area.

Likewise, Rakocinski et al. (1996) found delayed recovery of infaunal assemblages at a nourished
beach and shallow inshore habitats in Perdido Key, Florida where there were substantial amounts of silts and clays in the fill material. Peterson et al. (2000) have examined impacts of beach nourishment to large beach infauna (*Emerita*, *Donax* and the ghost crab *Ocypode*) at Bogue Sound, North Carolina. The presence of a substantial amount of silts and clays as well as shell hash in the fill materials resulted in infaunal abundances still being reduced 2.5 months after nourishment.

Methods

Monitoring Plan and Overall Execution: Sampling of intertidal benthos took place in two phases. In the first phase, samples were collected twice a year (spring and fall) at 10 sites within each of three areas and at two depths: 2 seasons x 3 areas/season x 10 sites/area x 2 stations/site x 3 cores/station for a total of 360 samples/year. Target areas were South Area, Middle Area, and North Area (Figure 2-1); and station depths were Mean Low Water (MLW) and MLW-1m (Figures 2-2 to 2-4). Station locations for MLW are provided in Appendix Table 2-1.

Replicate samples were collected at 1-2 m intervals with 7.5 cm PVC coring tubes to a depth of 10-15 cm, and a 0.5 mm sieve was used to separate infauna from the sediment. The monitoring plan also called for 120 sediment samples (one per infauna station per season) taken with a 5 cm, PVC coring tube to a depth of 10-15 cm, which were processed for grain-size distribution. Sampling began in June 1994 and was completed in May 2000. The second phase was initiated only when nourishment operations began. In 1997 the first six stations of both the nourished beach (South Area) and one of the reference areas (Middle Area) were sampled at MLW in June, July, August, October, and November (1997). In 1999-2000, when the Middle Area was nourished, the same stations were sampled, but the South Area acted as reference. As will be discussed later, the South Area had recovered sufficiently to serve as a reliable reference site. Samples were taken on a monthly schedule between June 1999 and April 2000. When combined with data from the May and September collections for the same stations, these samples permit a detailed temporal analysis of potential impacts and recovery ranging over a period of seven (1997) to thirteen (1999-2000) months.

Although sampling of nearshore benthos was not part of the original study design, this component was added in 1995 to extend characterization efforts far enough off the beach to capture potential impacts related to changes in profiles resulting from filling operations. Nearshore stations were located along the pre-construction 5.0-6.5 m depth contour, which generally lies just seaward of the terminal points of the existing groin field (Figures 2-2 to 2-4). Characterization of the nearshore benthos also enhanced interpretation of surf zone fish food habits data. Nearshore samples were collected with a single Smith-McIntyre grab (0.1 m^2) sample directly seaward of each intertidal site/station set, yielding a total of 30 samples per sampling date (3 areas x 10 sites/area x 1 sample/site). Each site was sampled twice a year (May and September) beginning in

1995 and ending in May 2000. A sample for sediment texture analysis was also taken at each sampling point.

The monitoring plan was executed as planned for all years (1994-2000) except for the loss of a few samples in May 1994, when sediment texture samples were lost in the field from site 25 (MLW of the fifth transect at Middle area), and all samples from September 1995 collections. Infauna and sediment samples from Middle area Stations 23 and 33 were also misplaced in September 1998. While the sample losses were unfortunate, the effect on the monitoring program was minimal. Correlations between sediment type and infauna abundance are either non-significant or weak for the remaining samples. Thus, interpretations of the infauna data are not impaired by the decrease in sediment data. Otherwise, all infaunal and sediment samples were taken on schedule for both phases (biannual and monthly) of the project.

Field and Laboratory Methods: The biannual samples (Phase 1) were collected during daytime, spring low tides during May and September of each year. The time of sampling was standardized to permit the most efficient use of field time and to reduce the influence of tidal migrations on taxa abundances (Jones et al. 1998).

Two to three days were required to collect all the samples during each sampling event. The groins were used to guide the distribution of the 10 sites in each sample area, with the goal being to sample the entire area as evenly as practicable. The South Area, which is between Philadelphia Blvd. and Remsen Ave., has 13 groins, which yields 12 inter-groin spaces (Figure 2-2). One sampling site was located near the center of each space, except for the two spaces near the storm-water outlet from Wreck Pond, which were excluded to avoid potential influences from the discharge. This sampling area encompasses 3.7 km of coastline, and the typical distance between transects is 300 m. The Middle Area, which is between Washington Ave. and Seaview Ave., has 12 groins, which yields 11 inter-groin spaces (Figure 2-3). One site was located near the center of each of these 11 spaces, except for the one space near the storm-water outlet from Fletcher Lake, which was excluded to avoid potential influences from the discharge. The sampling area covers 3.3 km of coastline, and the typical distance between sites is 300 m. The North sampling area, which covers 3.4 km between Cedar Ave. and Roosevelt Ave., has 12 groins, which yields 11 inter-groin spaces, but sampling in this area was not as straightforward as in the others (Figure 2-4). The portion near Neptune Ave. (2 inter-groin spaces) could not be sampled because there was no sandy beach during low tide. Furthermore, the groins are not distributed as evenly nor area as uniform in size as in the other areas. As a result, it was necessary to put two sites in two of the inter-groin spaces to provide 10 sites in this area. Distances between sites ranged from 100-220 m. Sampling occurred near the center of each inter-groin space to minimize the influence that groins might have on the immediately adjacent benthic community. In some cases, however, sites were moved away from the center to avoid derelict groins or storm-water outfalls.

Stations were initially located within each area based on standard land survey methods. A base station, usually in the South Area, was established using a transit, Philadelphia rod, and maps of street elevations (height above MLW) prepared by Coastal Planning and Engineering,

Inc. The elevation of the boardwalk above MLW was determined using the transit, rod, and elevation of the street as a reference. The elevation
of the beach at the base of the boardwalk was then determined by subtracting the elevation of the boardwalk from the height of the boardwalk above the beach. The transit and rod were then used to locate MLW along the beach face, and the location was marked for that day with a stake. The depth of the water at the stake was used to locate MLW at other locations (i.e., if water depth was 10 cm at the stake at a given time, we assumed other 10 cm deep locations in the study area were also MLW). The sampling crew communicated with an observer at the base station via a cellular phone to obtain information about the depth of water relative to MLW. After several years experience with this method, it was noted that equal levels of accuracy could be obtained basing station locations on beach structure and depth relative to time and tidal height. Specifically, it was found that a small beach step was present at all sites at the Mean Low Water (MLW) mark. Beach steps are common on coarse sandy beaches; the crest of the step is generally associated with the Mean Low Water level (Bauer and Allen, 1995). Using this structure to site the MLW station, the MLW-1m station could be easily determined by depth relative to the depth of water over the MLW station. Thus, if there were 10 cm of water over the MLW station, the MLW-1m station was located at depth of 110 cm. When this procedure was tested against the transect level method in Spring and Fall 1996, no substantive differences could be detected between the two methods.

Infaunal samples were preserved in the field with buffered 10% formalin. In the laboratory at Barry A. Vittor & Associates, Inc. (BVA), Mobile, Alabama, samples were stained with 1% Rose Bengal and transferred to 70% isopropyl alcohol. Organisms were then separated from the remaining debris by flotation and hand picking, identified by experienced taxonomists, and enumerated. Quality assurance and control measures included randomly selecting 10% of the samples and reconstituting with the original debris and repeating the entire separation, identification, and enumeration process. The quality assurance plan used by BVA calls for all samples processed by a particular sorter to be redone if a random audit of 10% of that sorter's work shows any samples to differ by more than 5% from the original results. For this project, all discrepancies were within 5%. The taxonomists previously worked on several projects from the area and verified each other's identifications. When differences of opinion occurred or when significant doubt remained, outside specialists examined the specimens. BVA performed a review of all taxonomic identifications at the request of WES in 1997 and existing discrepancies were rectified. Identifications were made to the lowest practical identification level (LPIL) when not to the species level. Wet-weight biomass was determined to 0.01 mg after grouping the specimens by class within each station and after blotting to remove excess liquid.

Sediment samples were transferred to whirl-pack bags in the field. Between Spring 1994 and Fall 1995, all sediment samples were processed by Tierra Consulting, Inc. of Mobile, Alabama. The samples were thoroughly mixed in a stainless bowl and a 30-50 g subsample was washed with deionized water, dried and weighed. Coarse and fine fractions of the subsample were separated through a 4-phi sieve (0.0625 mm). Sediment texture of the coarse fraction was determined at 1-phi intervals using nested sieves (-2 to 4-phi, 4.00 to 0.0625 mm)

on a Ro-Tap apparatus. The weight of material collected on each sieve was recorded and used to compute mean and median grain size,
and percentages by phi interval. No formal analyses of the fine fractions were done. After Fall 1995, all intertidal sediments were analyzed by Wetlands and Coastal Ecology Branch (U.S. Army Engineer Research Development Center). The only change in sample processing was the replacement of physical sieving of the sediments using the Ro-Tap apparatus by a wet-sieving technique. There is no discernable difference in the results produced by the two techniques. Nearshore sediment texture samples were analyzed in a similar manner with the exception that the fine fractions (silts and clays) were explicitly measured using a flotation technique (pipette method).

Water quality data were collected with a HydroLab® sensor during different components of the sampling program. Data reported here were compiled from values obtained during surf zone ichthyoplankton and beach seine sampling as well as nearshore infaunal sampling. Data include water temperature (^{o}C), salinity (ppt), dissolved oxygen (mg/l), and pH. Turbidity (NTU) was also measured but will be reported in Chapters 5 and 7.

Descriptive and Statistical Analyses: Numerical abundance, biomass, and taxa richness data were analyzed using Analysis of Variance (ANOVA) employing a two-way repeated measures design with sampling date as the repeated measure. Prior to testing, all data were converted to a per-m^2 basis, examined for normality and homogeneity of variance, and transformed (log (x+1)) where appropriate. Because multiple analyses were performed on data from each depth, it was necessary to adjust p values for multiple tests using the Bonferroni correction ($p = 0.5/n$ where n = number of tests). Since a total of nine tests were analyzed (abundance, biomass, and taxa richness at MLW, MLW-1m, and Nearshore), a p value of 0.006 was necessary to indicate the presence of a statistically significant difference.

If a significant difference ($p<0.006$) was not detected for an effect, an *a posteriori* statistical power of the test was calculated. A power level of 75-80% was assumed to be necessary to indicate that no statistical difference was present. Where the interaction factor (e.g., Area x Date) was significant ($p<0.006$), main effects could not be directly interpreted (Zar, 1996). In these cases, linear contrasts were performed on appropriate pairs of means. Because the significance level for interpreting contrasts was also calculated using the Bonferroni correction for multiple tests it was necessary to restrict the number of tests performed to conserve power. Tests were restricted to data from sampling periods during and immediately after nourishment: September 1997, May 1998, September 1999 and May 2000. Since a total of four comparisons were made for each parameter, a p value of <0.0125 was required for statistical significance. In all but one case, reference area means were compared to that of the nourished area. For instance, the first comparison was between South Area MLW September 1997 and the data for MLW of the remaining two areas. The only exception to this procedure was for taxa richness data from MLW in May 2000. Since, there was no obvious difference between the Middle (Nourished) and one of the reference (North Area) means (Figure 2-11), but there was between these two values and that of the South Area (Reference), the Middle and North Area values were compared to that of the South Area. Where differences were detected

among main or interaction effects, the arithmetic means and standard errors were plotted. Taxonomic distributions of biomass and sediment texture data were examined graphically but not statistically analyzed.

Patterns in community species composition were examined using the multivariate ordination technique Nonmetric Multidimensional Scaling (NMDS). NMDS utilizes a ranking protocol to remove nonlinear trends in the same way ranking is used to remove non-normality in nonparametric ANOVA's. Since ordination techniques are sensitive to the impact of rare species, only taxa contributing between 0.5% (intertidal) and 1.0% (nearshore) of abundance from any area were incorporated into the analyses. The difference in selection criteria used for samples from the different depths was due to the low number of taxa in intertidal samples. Abundances were logarithmically transformed (log x+1) to reduce the influence of high dominance by one or more taxa. Prior to estimation of the contributions of individual taxa, the list of LPIL taxa was consolidated to remove duplicative listings. For instance, the mole crab was listed both as *Emerita talpoida* and *Emerita* (LPIL). These data were consolidated to form the single taxonomic listing *Emerita talpoida*. In this fashion, the intertidal taxa list was reduced to 80 taxa and the nearshore list to 225 taxa.

Temporal patterns in recovery of abundance, biomass, and taxa richness from monthly samples were examined by linear regression. Individual station data were expressed as a percentage of reference values for each date; after arcsin-square root transformation, data were regressed against time (days) since completion of nourishment. Outliers were identified by visual examination of residual plots and removed.

Results

Biannual Infaunal Abundance: A total of 132,518 individuals (average density = 9,388/m^2) were collected from the intertidal zone and an additional 298,999 animals (632/m^2) from the nearshore subtidal (Table 2-1). The apparent anomaly between total numbers of animals collected and average abundance is due to differences in sample size. In the nearshore, a total of 3 m^2 were collected during each sampling (3 areas x 10 stations x 1 sample x 0.1m^2/sample), whereas only 0.79 m^2 was collected during each intertidal sampling (3 areas x 10 transects x 2 depths x 3 samples x 0.0044m^2/sample)

The highest intertidal abundances occurred at MLW of the Middle Area (38,963 individuals, average = 16,583/m^2) and the lowest at MLW-1m of the South Area (16,360 individuals, average = 7,097/m^2). Nearshore abundances were highest at the North Area (137,503 individuals, average 883/m^2) and lowest at the South Area (35,669 individuals, average = 250/m^2).

Intertidal abundance was dominated by three taxa: Rhynchocoela (LPIL), the spionid polychaete *Scolelepis squamata*, and Oligochaeta (LPIL). Rhynchocoels were the overall numerical dominant providing 51% of all animals collected, while the other two taxa supplied 35% and 8%, respectively (Table 2-2). Rhynchocoels comprised over 66% of all Middle Area

infauna but only 37% and 44%, respectively, of the North and South Areas. The most abundant taxa also occurred most frequently (Table 2-2). Percent occurrence (% of samples where a taxon was present) was very similar for all three dominants in all areas. Rhynchocoels were present in slightly more than 36% of all samples, while *S. squamata* and Oligochaeta (LPIL) occurred in 30% and 16%, respectively, of all samples. Oligochaetes were particularly important at the North Area where they made up 19% of the assemblage. The blue mussel, *Mytilus edulis,* was also present in 14% of all samples and comprised more than 1% of all animals collected. This taxon, a dominant on the hard substrate rocky groins along the beach, is dislodged by heavy wave action and accumulates on the beach, hence their presence in the intertidal samples. Since these animals are not indigenous to beach sands they were not included in subsequent analyses. The polychaete *Protodriloides* (LPIL) made up almost 1% of all animals collected and was found in 6% of the samples. It was most abundant at the North and South areas. The amphipod *Corophium tuberculatum*, the polychaete *Microphthalmus* (LPIL), *E. talpoida*, and *Microphthalmus* sp. G all contributed approximately 1% of total abundance in the North Area but not to overall intertidal abundance. The remaining taxa made up less than 1% of total abundance but were present in 1% or more of all samples overall or at one of the three area (Table 2-2). Of these taxa, only Spionidae (LPIL) was excluded from further analyses on the assumption that it was comprised mostly of damaged or small specimens of *S. squamata.*

Nearshore samples were overwhelmingly dominated (74%) by the wedge clam, *Donax variabilis* (Table 2-3). The second most abundant taxon, the polychaete *Magelona papillicornis*, comprised almost 6% of total abundance, while the clams *Tellina agilis* and *Spisula solidissima* contributed 3.6% and 2.1% respectively. Other taxa contributing approximately 1% or more to total abundance included the amhipods *Acanthohaustorius millsi* and *Psammonyx nobilis* and the polychaetes *Dispio uncinata* and *Asabellides oculata.* The taxon Ampharetidae (LPIL) was excluded from further analyses because it most likely represents small or damaged specimens of another dominant, *Ampharete americana,* or a mixture of species. *M. edulis* was excluded for reasons previously described. The remaining dominant taxa either contributed 1% or more to the abundance within a specific area or were present in 10% or more of the samples (Table 2-3). It is worth noting that most of the intertidal dominants are present in this list but in lower abundance or frequency of occurrence.

ANOVA of the abundance data revealed a significant ($p < 0.006$) interaction effect (Area x Date) at all three depths and as a result none of the other effects are interpretable (Table 2-4). Linear contrasts of the selected interaction means indicated a significant difference ($p<0.0125$) between Middle Area MLW values and those of the reference sites in May 1998, however values at this site were higher than the reference areas and are not believed to represent an impact response (Figure 2-5). No significant ($p>0.00125$) linear contrast was found for MLW-1m abundances in May 2000, although abundance at this time appears to be lower at the nourished area than the reference areas (Figure 2-6). A significant ($p<0.00125$) linear contrast was found however, for Nearshore abundance in May 2000 (Figure 2-7). Abundance was lower in the nourished area than the reference areas. In the case of both the MLW-1m and Nearshore abundances, the May 2000 values are well within the range of

normal values for unimpacted conditions. For instance, the abundance at MLW-1m in May 2000 was nearly identical to values at the South Area in
May 1995, the Middle Area in September 1995 and the North Area in September 1996 (Figure 2-6). Likewise, Middle Area Nearshore abundance in May 2000 was similar to previous May values at this area and actually higher than three of the previous May values for the North Area, the only completely unimpacted site in the study (Figure 2-7).

Biannual Infaunal Biomass: More than 12 kg of wet-weight biomass was found in the intertidal samples and nearly 33 kg in the nearshore samples (Table 2-1). MLW samples averaged over 150 g/m^2, MLW-1m samples averaged 97 g/m^2 and nearshore samples averaged 99 g/m^2. As with abundance, the apparent anomaly between total and average biomass/m^2 in intertidal and nearshore biomass comparisons is the result of differences in sample size. South Area MLW had the highest average biomass with over 220 g/m^2 and North Area Nearshore the lowest with 67 g/m^2. Annelids composed 72% of total MLW biomass and 78% of MLW-1m biomass. Intertidal mollusc biomass was almost entirely composed of blue mussels (*Mytilus edulis*) washed off of the surrounding jetties rather than true members of the sandy beach infauna. When intertidal biomass is recalculated excluding the mussels, annelids comprised 83% and 78% of MLW and MLW-1m biomass, respectively and crustaceans made up an additional 16%-20%. Nearshore biomass was dominated by the molluscs *Tellina agilis* and *Spisula solidissima* making up 63.5% of the total (Table 2-1). Annelids contributed 10% and crustaceans made up 24% of nearshore biomass.

ANOVA for total wet-weight biomass detected a significant ($p < 0.006$) interaction effect (Area x Date) for all three depths and as a result none of the other effects are interpretable (Table 2-4). Linear contrasts of during and immediately post-nourishment means indicated a significant difference ($p<0.0125$) between the nourished beach (South Area) and reference beaches in May 1998 for MLW (Figure 2-8) and Middle Area (nourished) and reference areas at all three depths in May 2000 (Figures 2-9 and 2-10). As in the abundance data, the difference between nourished and reference biomass in May 2000 represents an impact, however, the values are no lower than many of those from unimpacted conditions. Specifically, equivalent or lower biomass values were encountered at Middle Area MLW in September 1995 and again in May 1996, at the South Area in May 1994 and September 1996, and at the North Area in May of 1994, 1995, 1997 and 1998 (Figure 2-8). Biomass at MLW-1m of the nourished site was equal to or higher than that reported in the entire period between September 1995 and September 1996 (Figure 2-9). It was also equal to values reported from the South Area during September 1994, 1998, and 1999. In the nearshore, Middle Area biomass in 2000 was equal to or greater than that for the same area in May of all years except 1996 (Figure 2-10). It was also equal to or greater than that of South or North Area values in May 1996.

Biannual Infaunal Taxa Richness: Although diversity was not explicitly included as a test parameter in the original study design, this does not preclude its examination. Prior to examination, however, it is important to review the inherent limitations imposed by the study design. First and foremost, Jaramillo et al. (1995) have indicated that at a minimum of 4 m^2 is

required to account for 95% of all taxa present on most beaches. Since this level of effort exceeded the resources available, diversity
comparisons will of necessity be relative. Likewise, since the number of taxa collected is a function of sample area, direct comparisons cannot be made between intertidal and nearshore sites due to the difference in gear types used in sampling. Taxa richness (number of taxa/sample) was selected as the test measure since diversity indices such as the Shannon-Weiner Index have been shown to be inadequate in analysis of beach nourishment projects (Nelson, 1985; Wilber and Stern, 1992). Such indices also should not be tested with parametric statistics due to an absence of information on their underlying mathematical distributions (Norris and Georges, 1993).

A grand total of the 80 LPIL taxa were collected at both intertidal depths and 225 in the nearshore zone (Table 2-1). Total numbers of taxa at intertidal depths tended to be higher at MLW-1m than MLW and decrease in value among areas along a gradient from south to north. This pattern was not present in the nearshore data where there was no pattern among areas.

As with abundance and biomass, ANOVA's for taxa richness among intertidal and nearshore data had significant ($p<0.006$) interaction effects (Table 2-4). Linear contrasts of MLW data indicated a difference among areas during the second fill operation, however the difference does not appear to be directly related to nourishment (Figure 2-11). Taxa richness was found to be higher at the South (reference) Area than either the Middle (nourished) or North (reference) Areas. Linear contrasts of both MLW-1m and Nearshore data indicated taxa richness were significantly ($p<0.0125$) lower at the Middle Area (nourished) than either reference area in May 2000 (Figures 2-12 and 2-13). Again, the low values were within the range of values encountered during non-impacted periods of time. At MLW-1m, values of taxa richness equal to that of at the nourished site in May 2000 occurred at the South Area in September 1998. In the nearshore, May 2000 values were equal to those occurring at the North Area in May 1995.

Biannual Biomass Composition: Biomass composition (% of total biomass) varied among areas, depths, and sample dates. Annelids dominated biomass at both intertidal depths particularly in the spring (Figures 2-14 to 2-16). Crustacean biomass was generally second most important and was most prevalent in fall collections. Mollusc biomass was only dominant occasionally and then only in fall collections. Since most of this biomass was made up of *M. edulis* it's contribution can be considered to be minimal. Biomass composition appears to have been altered at the South Area during it's nourishment (September 1997) as evidenced by higher than normal proportions of molluscs at MLW and echinoderms at MLW-1m. There was no indication of a change in biomass composition after this time period or at anytime during the nourishment of the Middle Area in 1999 (Figures 2–17 to 2-19). Nearshore biomass was dominated by molluscs followed, in order of importance, by crustaceans and annelids (Figures 2-20 to 2-22). Molluscs were generally most dominant in fall collections while crustaceans and annelids were most dominant in the spring. There is no indication of a change in biomass composition associated with nourishment operations.

Biannual Species Composition: Patterns in species composition were explored using the ordination technique Nonmetric Multi-Dimensional Scaling (NMDS). Ordination of data from all three depths was successful (Figure 2-23) with stress, a measure of "goodness of fit", low at a value of 0.125 (Clarke and Warwick, 1994). A stress value of 0.20 or greater indicates that the data cannot be interpreted (Clarke and Warwick, 1994). Data ordinated almost entirely based on depth; the intertidal samples ordinated high on Axis 1 while the nearshore samples ordinated high on Axis 2 (Figure 2-23). There were no apparent differences between intertidal depths or areas within depths. Taxa positively and significantly ($r^2 \geq 0.4$) correlated with Axis 1 (i.e., those characteristic of the intertidal stations) included Rhynchocoela (LPIL), *Scolelepis squamata*, and Oligochaeta (LPIL) (Table 2-5). Taxa positively and significantly ($r^2 \geq 0.4$) correlated with Axis 2 (i.e., those characteristic of the nearshore stations) included *Donax variabilis* and *Magelona papillicornis*.

In order to detect temporal changes in species composition, especially those potentially associated with nourishment, two further analyses were employed. First, NMDS was performed on data for each depth separately, however, none of the results could be interpreted (stress>0.20). A second strategy was then employed, plotting the original NMDS results but excluding data points from periods of time when no nourishment was occurring. Specifically, only data from September 1997, May 1998, September 1999 and May 2000 were plotted (Figure 2-24). Examination of these data indicated several cases where a change in species composition was associated with nourishment. In September, South Area MLW samples differed from those of the Middle (Reference) Area**.** This pattern was repeated in September 1999 and May 2000 when samples and both Middle Area (Nourished) MLW and MLW-1m differed from the South Area (Reference). Examination of the individual species data for these time periods (Appendix Tables 2-2) suggests that the generally lower total abundance and taxa richness at these times are responsible for the observed differences rather than a change in the presence, absence, or relative abundance of any given taxon. In the nearshore samples, data from the South Area in September 1997 (during nourishment) and Middle Area in May 2000 (after nourishment) were different from the other samples collected during those time periods (Figure 2-24). Examination of individual species data (Appendix Table 2-3) indicates that abundance of *Donax variabilis* was most responsible for these differences. *Donax* was absent from the South Area samples in September 1997 while in May 2000 there were ten-times fewer clams in the Middle Area than either of the reference areas.

Biannual Sediment Texture: Sediment texture data were not contrasted statistically, however, average values are presented in this section. There were three distinct trends associated with the sediment composition results: depth, seasonal, and interannual (Figures 2-25 to 2-36). The most striking and consistent difference occurred between depths with finer sediments being associated with increased depth. The mean grain size (MGS) at MLW ranged between 0.27 mm and 1.78 mm with most values (28 out of 33) being greater than 0.40 mm (Figure 2-25). At MLW-1m MGS ranged from 0.18 mm to 1.16 mm with only 11 of 33 values greater than 0.40 mm (Figure 2-26), while in the Nearshore sediment MGS ranged between 0.05 mm to 0.22 mm (Figure 2-27). These differences are also reflected in the

proportions of individual grain size fractions. For example, in Spring 1996 more than 72% of MLW sediment at the South Area was
composed of gravels and coarse to very coarse sands (Figure 2-28). Sediments at MLW-1m for this area contained only 60% of these materials while nearshore sediments contained less than 2% (Figure 2-31 and 2-34).

The next most pronounced difference among sediments was associated with the season of collection; sediments were generally coarser in the spring than in the fall. The coarseness of sediments in the spring reflects the general cycle of beach sediment erosion and deposition; erosion is most common during the winter and spring when strong storms are most frequent (Nordstrom, 1975). Large amounts of fine-grained sediments are removed from the beaches leaving relatively coarse sediments, while during the relatively mild summer months, fine sediments are deposited. This pattern is not absolute since the frequency and intensity of storm activity can change from year-to-year. During mild winters there may be no appreciable change in beach sediments.

The pattern of seasonally alternating coarseness in grain size was most pronounced in the MLW samples from the South Area (Figure 2-25). South Area MGS was far lower in spring than fall of 1994, 1996, and again in 1998. Similar results were found at South MLW-1 in 1996 and 1998 (Figure 2-27) and among North Area Nearshore sediments from 1996 to 1999 (Figure 2-28). These changes are also seen in the distribution of individual grain size fractions. For example, in 1994 the South Area MLW spring samples had a cumulative total of >50% very coarse sands and gravel, while in the fall, the cumulative total was approximately 10% (Figure 2-28). Similar patterns are present during most years for all depths and areas (Figures 2-29 to 2-36).

Interannual variation occurred in both the pattern of seasonal differences and in longer-term changes in sediment texture. The 1997 data are the most striking example of interannual differences in sediment composition. Sediments at both intertidal depths during May 1997 were finer than previous fall samples (September 1996) and as fine or finer than the succeeding September samples (Figures 2-25 to 2-26). A similar anomaly occurred in 1999 when all but Middle Area MLW-1m intertidal sediments were as fine or finer than the previous or succeeding fall. Presumably these results are due to relatively mild winters. The “fining” of the sediments does not appear to be related to beach nourishment activities since neither dredging or sand placement had begun in either case (May 1997 and May 1999). In addition, the effect was detected at all areas and not just the one designated for nourishment. Seasonal variation in sediment texture was present but less consistent in the Nearshore data. Spring sediments were as fine or finer than subsequent fall samples at the South Area in 1996 and 1998 and at the Middle Area in 1998 and 1999 (Figures 2-34 and 2-35). Spring samples were consistently coarser than fall samples in the North Area (Figure 2-36).

Sediment texture also varied between years. Intertidal sediments were particularly coarse in May of 1994, 1996, and 1998 with fine materials (silts, clays and fine and very fine sands) being more prevalent beginning in May 1997 (Figures 2-25 and 2-26). This pattern was

far more pronounced in the nearshore data where fine materials increased in proportion to other sediment fractions from May 1996 to September 1999. This pattern was reversed in May 2000 when silts, clays, and very fine sands declined in proportion to the other sediment fractions (Figures 2-34 to 2-36).

Likewise, a previously noted tendency for nearshore sediments to become progressively coarser along a South to North gradient (USACE, 1999) proved to be ephemeral. Between May 1995 and September 1997, fine sediment fractions, such as the fine and very fine sands, decreased in importance with increasing distance from Manasquan Inlet (Figures 2-34 to 2-36). The degree of difference between areas became progressively less over time, until they were roughly equal in May 1998. Afterwards, all three areas appear to follow similar trends and had nearly equal proportions of fine materials.

Monthly Infaunal Abundance: Data from the monthly samples were processed and analyzed in an identical fashion to that described for the biannual samples. Analysis of Variance for the 1997 data detected a significant ($p<0.017$) area by month interaction (Table 2-6). Linear contrasts of September, October, and November means found a significant ($p<0.017$) difference only in October, although nourished beach (South Area) abundances were lower than the reference area (Middle Area) in both October and November (Figure 2-37). Regression of monthly abundance (expressed as a percentage of reference values) produced a significant result; r^2-value = 0.633 and ANOVA p = 0.0059 (Table 2-8). Estimated time for recovery of abundance based on this regression was 49 days.

Monthly abundance data for 1999-2000 yielded relatively high values during the spring and summer months, declining values during the winter, and lowest values in January (Figure 2-38). Analysis of Variance detected a significant ($p<0.017$) area by month interaction (Table 2-7). Of the three pairs of means tested (January, March and May), only the January data showed a significant difference ($p<0.017$). Abundance at the South Area (reference) was higher than that of the nourished Middle Area (Figure 2-38). Linear regression of the 1999-2000 abundance data produced a significant regression ($p=0.0026$), although the r^2 value was only 0.24 (Table 2-8). The estimated time to recovery was 189 days or approximately 6.5 months.

Monthly Infaunal Biomass: Monthly biomass for 1997 monthly samples followed the same pattern as abundance with values declining with the onset of fall. ANOVA failed to detected any significant ($p<0.017$) differences (Table 2-6), however, power values were too low for all three effects (Area, Date, and Area x Date Interaction) to interpret the results. Highest biomass was present at the nourished area in September (Figure 2-39). This high value is attributable to the presence of two unidentified bivalves possibly washed onto the beach during the nourishment process (Appendix Table 2-5). The lowest biomass was found at the reference area in November while nourished area biomass was also low in both October and November. Regression of monthly biomass (expressed as a percentage of reference values) also produced a significant result; r^2-value = 0.547 and ANOVA p = 0.0145 (Table 2-8). Estimated time for recovery of total biomass based on this regression was 38 days.

Monthly biomass for 1999-2000 also displayed a summer peak and winter low; lowest values occurred in January (Figure 2-40). ANOVA detected a significant ($p<0.017$) area by month interaction and of the three dates tested only January showed a significant linear contrast ($p<0.017$) (Table 2-7). Biomass was higher at the reference area than the nourished site at this time (Figure 2-40). Linear regression of the 1999-2000 biomass data produced a significant regression ($p=0.0016$) although the r^2 value was only 0.24 (Table 2-8). Estimated time for recovery of total biomass based on the regression was 176 days or roughly 6 months.

Monthly Infaunal Taxa Richness: Taxa richness values for both sets of monthly data (1997 and 1999-2000) matched those of the abundance and biomass data with peak values in summer and lowest values in January (Figures 2-41 and 2-42). No significant differences ($p>0.017$) were found in the ANOVA of the 1997 data, however, statistical power was too low to interpret the results (Table 2-6). Regression of monthly taxa richness produced a significant ANOVA result ($p = 0.0072$), with an r^2 value of 0.616 (Table 2-8). Estimated time for recovery of taxa richness based on this regression was 23 days. ANOVA of the 1999-2000 data produced a significant interaction effect and subsequent linear contrasts found only the January comparison to be significant ($p<0.017$). As with abundance and biomass, taxa richness was lower at the nourished beach than the reference beach (Figure 2-39). Linear regression of the 1999-2000 data produced a significant regression ($p=0.0002$), but with a low r^2 value ($r^2=0.36$). Estimated time for recovery of total biomass based on this regression was 178 days or roughly 6 months (Table 2-8).

Monthly Infaunal Biomass Composition: In 1997, annelids dominated infaunal biomass in both areas during most collection periods. Crustaceans and molluscs dominated a few stations in August and again in November (Appendix Table 2-7). There was no obvious association between nourishment and the numbers of stations dominated by a particular taxonomic group or the extent to which a taxonomic group dominated biomass at a given station. For instance, in October 1997, when disturbance should have been at its peak, annelids comprised more than 95% of biomass at all stations in both areas. At the end of nourishment in November 1997 both areas had two stations dominated by annelids, two or three dominated by crustaceans, and one station with no biomass.

In 1999-2000, most stations in both areas were dominated by annelids between May and November 1999 (Appendix Table 2-8). In December 1999, stations at the reference beach (South Area) continued to be dominated by annelids while at the nourished beach (Middle Area), two stations had no biomass, one was dominated by annelids, one by molluscs, and two by miscellaneous taxa. The following January, four of the six nourished stations had no biomass, one was dominated by annelids and the remaining station was dominated by miscellaneous taxa. Annelids, crustaceans, and molluscs each dominated two reference area stations. During the remainder of the study (February 2000 to May 2000), annelids were dominant at the majority of stations in both areas. These results indicate a nourishment impact lasting from December 1999 to January 2000 with recovery complete by February 2000. While biomass composition results cannot be analyzed in the same fashion (linear regression) as abundance, biomass, and taxa richness data, a conservative estimate can be made by calculating

the time between completion of nourishment at the first station to be disturbed (September 27, 1999) and the February sampling (February 19, 2000) when recovery appears to have been complete. This calculation resulted in a recovery time of 145 days or approximately 4.8 months, a value close to the 176 day recovery estimate for total biomass.

Monthly Infaunal Species Composition: Because of the small number of taxa involved, NMDS could not be performed on the monthly infaunal samples. Instead, potential changes in species composition are assessed by directly examining taxa abundances (Appendix Tables 2-5 and 2-6). During 1997, rhynchocoels, *Scolelepis squamata*, and oligochaetes were the most abundant taxa at both sites and in all time periods (Appendix Table 2-5). There was no obvious change in species composition or the abundance of the dominant taxa related to nourishment.

In 1999-2000, rhynchocoels, *S. squamata*, *Protodriloides* (LPIL), oligochaetes and *Emerita talpoida* were the most abundant taxa (Appendix Table 2-8). Changes associated with nourishment included the absence of *Protodriloides* (LPIL) until May 2000 after nourishment and a reduction in the abundance of *S. squamata* relative to the reference area between November and December (Figure 2-43).

Monthly Infaunal Sediment Composition: During the 1997 nourishment, sediments at both the nourished beach (South Area) and reference beach (Middle Area) were characterized by mean grain sizes less than 0.5 mm throughout the study period (Figures 2-44 and 2-45). There was no obvious difference in sediment texture after nourishment. The same is true for the 1999-2000 nourishment (Figures 2-46 and 2-47). Mean grain sizes were generally less than 0.5 mm at both the nourished beach (Middle Area) and reference beach (South Area), although higher values were found at Station 1 (South Area) in May and July of 1999 and January of 2000. High values were also found at Station 2 in September 1999 and January 2000. There was no change in sediment texture associated with the 1999 nourishment.

Water Quality Data: Water quality parameters varied seasonally and among depths. As might be expected, water temperatures were higher in September than May of all years and generally 1-3 C^o higher in the surfzone than in nearshore bottom waters (Figure 2-48). There were no consistent differences among areas and no obvious project-related effects during either dredging operation. Salinity varied among seasons and depths with lowest values occurring during May sampling periods (Figure 2-49). Salinity was usually 2-4 ppt lower in the surfzone than in nearshore bottom waters. Like the temperature results, there were no consistent differences among areas and no obvious changes due to dredging operations. Dissolved oxygen concentrations were similar in both the surfzone and nearshore bottom waters during spring sampling periods, but up to 4 mg/l lower in the nearshore waters during fall collections (Figure 2-50). This was particularly evident in September 1995 and again in September 1997. Comparatively low dissolved oxygen concentrations were also measured in bottom waters at the offshore borrow areas in September 1997 (See Chapter 8). There does not appear to be a relationship between the low values and nourishment since similar values were found in both nourished and unnourished areas and even lower values had been present when no nourishment

was going on (September 1995). Varying over a range of less than one unit, pH was generally higher in September than May sampling periods (Figure 2-51). There were no consistent differences among areas or depths, and no apparent changes related to either dredging operation.

Discussion

Infaunal assemblages of high-energy sandy beaches are dominated by two different types of organisms: small interstitial forms including rhynchocoels, oligochaetes, and hesionid and protodile polychaetes, and large mobile forms such as the mole crab, *Emerita talpoida*, the wedge clam *Donax variabilis*, and the polychaete *Scolelepis squamata* (McLachlan and Jaramillo, 1995). Interstitial forms tend to dominate numerical abundance while the larger organisms dominate biomass. Infauna are distributed intertidally among three to four zones although is difficult to precisely assign assemblages to individual zones because of the mobile nature of both the organisms and their environment. Species such as *Emerita talpoida* and *Donax variabilis* undergo diurnal and seasonal migrations (Bowman and Dolan, 1985; Ellers, 1995a,b), while the interstitial taxa are susceptible to being dislodged from the sediment by wave action or moved by bedload transport.

On the U.S. Atlantic coast the uppermost or supralittoral zone is dominated by air-breathing crustaceans such as taltrid amphipods (also known as beach-hoppers) and ocypodid (ghost) crabs (McLachlan and Jaramillo, 1995). Between the drift line and midtide level is the littoral or swash zone, an area dominated by isopods, haustoriid amphipods and polychaetes such as *Scolelepis squamata.* Below midtide lies the sublittoral zone where *Emerita*, *Donax*, and a variety of haustoriid amphipods typify the benthic assemblage. On some beaches (macrotidal dissipative), littoral zone benthos may be further subdivided into assemblages associated with the resurgence and saturation zones described by Salvat (1964, 1967) (McLachlan, 1990 and Raffaelli, et al., 1991). Beyond the beach, both McLachlan et al. (1984) and Fleischack and de Freitas (1989) have identified benthic assemblages associated with the area of breaking waves (breaker zone) and a nearshore zone beyond the breakers. Assemblages of these zones are characterized by the decreasing representation of beach fauna and increasing importance of fauna characteristic of offshore waters.

The distribution of beach infauna is controlled by physical factors, particularly wave energy and tidal range (McLachlan, 1990), as manifested in beach morphology (Wright and Short, 1984; Short, 1991). Different combinations of wave energy and tidal range produce characteristic beach types which can be classified by their slope and the average height of incoming waves (Masselink and Short (1993). Beach slope and wave height, in turn, have been identified as the two factors associated the most with different beach assemblages (McLachlan 1990; McArdle and McLachlan 1991, 1992). Wave height is important because it is a measure of wave energy: the higher the wave energy, the more stressed and therefore less diverse and abundant the infaunal assemblage (McLachlen, 1983). Beach slope is important because beaches with steep slopes have a relatively small swash zone and species such as *Emerita* and *Donax* which "ride" the tides in the swash zone (Bowman and Dolan, 1985;

Ellers, 1995ab) may not have sufficient scope for feeding and thus be unable to establish large populations (Leber, 1982b). Lateral features of beach morphology also influence assemblage structure. McLachlan and Hesp (1984) have shown that meiofauna, macrofauna, and nekton were distributed in different manners along the cusps and horns of a cuspate beach. Meiofauna were concentrated along the sides of the rip current, macrofauna in the cusp center, and nekton near the head of the rip currents.

Sediment texture, which is largely determined by the wave environment, can be a factor, although it is more difficult to detect unless the change in grain size is relatively large. Dexter (1969) and Leber (1982b) sampled beaches in the vicinity of Morehead City, North Carolina, but found relatively different assemblages. Dexter sampled a fine and medium sand beach dominated by haustoriid amphipods, while Leber found a medium sand beach to be dominated by *Emerita* and *Donax*. McLachlan (1996) has found that placement of coarse sands associated with mine tailings on a sandy beach in South Africa altered both beach morphology and the intertidal fauna. Species associated with the naturally occurring fine sands were replaced by larger, more robust fauna. In Uruguay, Defeo et al. (1997) have noted that the distribution of fine and coarse sands have substantial impacts on the distribution of species of the isopod genus *Exocirolana*.

Species composition in the study area was similar to that of other New Jersey and Atlantic coast beaches, although the relative dominance of individual taxa differed (Table 2-9). In an examination of sandy beach infauna in Maine, Larsen and Doggett (1990) found three different assemblages. Corresponding closely to temperature discontinuities, two assemblages were found north of Mount Desert; the northernmost was characterized by opheliid and paraoniid polychaetes and the other by oligochaetes and nepthyid and orbiniid polychaetes. The third and southernmost assemblage was dominated by *Scolelepis squamata* and the amphipods *Amphiporeia virginica* and *Haustorius canadensis*. This southernmost assemblage was the only one representing exposed (high-energy) beaches while the more northerly assemblages represent protected or low-energy beaches. Croker et al. (1975) and Croker (1977) described a similar distribution in southwestern Maine and New Hampshire. Amhipods dominated the more exposed sites, while polychaetes tended to be most abundant in areas with less direct exposure to wave action. In a study of sandy beach infauna near Avalon, New Jersey, McDermott (1983) reported *Scolelepis squamata* as the overall dominant followed by *Donax variabilis*, *Emerita talpoida*, *Amphiporeia virginica*, *Micrura leidyi* (a rhynchocoel), and the haustoriid amphipod *Haustorius canadensis*. Five other haustoriids were also present at the site. Croker (1970) has reported the same assemblage from sandy beaches of Long Island, New York. As previously noted, Dexter (1969) has described a North Carolina beach community dominated (in order) by haustoriids, *Donax*, and *Scolelepis*, while Leber (1982b), working in the same general area, found *Emerita*, two species of *Donax*, and haustoriids to be most abundant. Diaz and DeAlteris (1982) reported similar distributions for a beach at Duck, North Carolina. In a study of a South Carolina beach Knott et al. (1983) found *Scolelepis* and haustoriid amphipods accounted for 63% of all animals present with *Donax* abundant in two of three sampling transects.

Intertidal infauna in the project reach of the present study were dominated by interstitial rhynchocoels, oligochaetes, hesionid and protodile polychaetes, and larger forms such as *Emerita talpoida, Scolelepis squamata* and *Nepthys bucera* (Table 2-2). The interstitial forms dominated abundance while the large forms dominated biomass. *Scolelepis* was unique in that it was dominant in both abundance and biomass. As previously mentioned, large numbers of the blue mussel, *Mytilus edulis*, were also present in the samples but were excluded from consideration since they were not true beach infauna. Nearshore fauna were dominated by the larger forms with *Donax variabilis* being especially abundant (Table 2-3). The tendency for *Donax* to be most abundant in the nearshore rather than intertidally may be a function of beach slope.

As noted in a previous report (USACE, 1999), the distribution of intertidal infauna in the study area was patchy with "hot-spots" of high abundance and/or biomass occurring unpredictably. High numerical abundances were generally associated with interstitial infauna such as rhynchocoels, enchytraeid oligochaetes, and archiannelids. These small animals live on and between sand grains and are routinely redistributed by wave action. Concentrations of suspended meiofauna can be considerable with up to a third of the total consisting of interstitial forms (e.g., Bell and Sherman 1980; Hagerman and Rieger 1981). Between 1994 and 1996 total assemblage numerical abundance was generally highest at MLW of the Middle Area in spring, however this pattern dissipated after 1996 (Figure 2-5). Peaks in abundance coincided with high rhynchocoel densities. There was no predictable difference in abundance among areas or seasons at the other depths. "Hot-spots" of biomass seemed to correspond to high densities of the mole crab *Emerita* and occasionally to abundance of *Scolelepis* in the intertidal and *Donax* in the nearshore. Both *Emerita* and *Donax* migrate up and down the swash zone during a tide so how many animals are encountered may vary with the time of sampling. Highest abundances of *Emerita* are associated with low wave energy and low tides (Bowman and Dolan 1985). Seasonally both abundance and biomass displayed peak values in the summer and fall and lowest values in mid-winter. This pattern has also been noted in Florida (Salomon and Naughton, 1984), South Carolina (Van Dolah et al., 1994; Jutte et al., 1999b), and North Carolina (Leber, 1982b; Reilly and Bellis, 1983).

While abundance values are low compared to those of McDermott (1983) at Avalon Beach, NJ, they are similar to densities reported from other Atlantic coast beaches (Table 2-9). It should also be noted that the present study encompasses a much larger stretch of beach and longer time period than that of McDermott (1983) and as a result incorporates a higher degree of spatial and temporal variability.

During the 1997 nourishment operation, no deleterious impacts to the intertidal assemblages were detected. The biannual (long-term) samples showed no indication of a difference in abundance between the nourished beach (South Area) and either of the reference areas (Figures 2-5 to 2-6). Biomass results were very similar with little predictable pattern in seasonal or geographic distribution from the biannual samples (Figures 2-8 to 2-9). Monthly data indicated very high biomass in September but low values afterwards (Figure 2-39). Diversity, as measured by taxa richness, did not appear to differ among areas or seasons and no

impact was detected associated with nourishment (Figures 2-11 to 2-12). Likewise, no dramatic differences could be detected in either biomass composition or species composition. Biomass was dominated either by annelids (mostly *Scolelepis*) or crustaceans (mostly *Emerita*) but without a distinct pattern of spatial or temporal distribution (Figures 2-14; 2-17; 2-20). The only changes in biomass composition associated with nourishment appeared to be the stranding of a few large bivalves on the nourished site immediately after nourishment. Likewise, there were no consistent differences in species composition among areas, depths or dates and no apparent change in assemblage structure following nourishment (Appendix Tables 2-2 and 2-5). The only discernable change in the nearshore assemblage was the temporary disappearance of *Donax variabilis* (Appendix Table 2-3).

During the 1999 nourishment operation, there were clear but short-lived impacts to abundance, biomass, and taxa richness at all three depths. Abundance and biomass, in particular, were still lower at the placement area than the reference sites as late as May 2000. Short-term (monthly) sampling at MLW indicated that the most severe impacts occurred in the period November 1999 to January 2000. Values began to reach reference site values only between February and April 2000 (Figures 2-38; 2-40; 2-42). The same pattern was evidenced in the abundance of *Scolelepis squamata* (Figure 2-43). Biomass composition did not change in respect to nourishment during this period. Changes in species composition in the intertidal zone were related to declines in abundance and taxa richness rather than an altered assemblage structure. In the nearshore there was no difference in species composition during nourishment, but afterwards abundances of *Donax* and *Asabellides oculata* were lower in the nourished area than the reference sites. Despite the continuing lower abundance and biomass in May 2000 and the occasional differences in the abundance of individual species, these results were within the range of values reported during unimpacted conditions. Based on the 6.5 month estimate for recovery time, approximately 80% of the nourishment area had already recovered and only the portion nourished after mid-November (Stations 21-23) was still impacted.

Results of both the long-term (biannual) and short-term (monthly) sampling are consistent with previous studies of beach nourishment impacts. Impacts tend to be most severe to small relatively immobile species, those unable to burrow through the overburden of new sand (e.g., Maurer et al. 1978). Impacts during the present study were most apparent to densities of rhynchocoels, oligochaetes, and the polychaete *Scolelepis squamata* (e.g., Figure 2-40). Fortunately, these taxa generally have high reproductive rates, wide dispersal capabilities, and can recover in short periods of time. Larger, more mobile taxa which can burrow through the new sediment or avoid the disturbance by migrating out of the area are generally less impacted by sediment deposition. Hayden and Dolan (1974) examined the impact of beach nourishment on the mole crab, *Emerita talpoida*, and found that while crab abundance declined in the immediate proximity of the nourishment there was no evidence of mortality; crab abundance recovered within a few weeks. The authors hypothesized that the crabs migrated out of the immediate area during the disturbance but rapidly colonized the site after the disturbance was over. Schoeman et al. (2000) have conducted manipulative experiments on beach infauna and reported that defaunated sediments were colonized within two weeks.

Literature reviews of beach nourishment impacts to beach infauna (Nelson, 1985, 1993 and Hackney et al., 1996) categorize impacts as short-term with recovery times ranging from 2 to 7 months. For instance, Saloman and Naughton (1984) reported infaunal recovery within 5-6 weeks of nourishment at Panama City, Florida. Studies by Van Dolah et al. (1994) and Jutte et al. (1999a,b) report recovery periods of 3 to 6 months for nourished beaches in South Carolina. The longest estimated recovery times for beach nourishment monitoring studies occurred when the silt/clay content of fill materials was higher than that of the natural beach. Reilly and Bellis (1983) reported that recovery took more than a year for some species on a North Carolina beach. Recovery was not complete until the silts and clays had been dissipated by wave action. Rakocinski et al. (1996) also found delayed recovery of infaunal assemblages due to the presence of substantial amounts of silts and clays in fill material used for a nourished beach and shallow inshore habitats in Perdido Key, Florida. Jaramillo et al. (1987) followed the natural recovery of a New England sandy beach after intense erosion and found that it took nearly three years for sand to accrete to pre-disturbance levels. During this time, polychaetes dominated the infauna; amphipod abundances did not reach pre-disturbance levels until a year later. Likewise, Peterson et al. (2000) found that the presence of finer than normal sediments and large amounts of shell hash in fill materials resulted in delayed recovery of large fauna such as *Emerita, Donax* and the ghost crab *Ocypode*. This study was further complicated by the fact that placement occurred during the late spring-early summer when filling could be expected to interfere with recruitment.

Estimates of recovery time in the present study, 2 months for the 1997 nourishment and 6.5 months for the 1999 operations, are precisely in the range of values found where there was a good match between fill materials and natural beach sediments (Table 2-10). The difference in recovery rates between the two nourishment operations seems most likely due to when placement was finished. The 1997 operation was completed by early October, whereas the 1999 nourishment was not completed until mid-December. Infaunal populations decline precipitously between November and January (e.g., Figure 2-40), suggesting that in 1997 there was enough time for colonization to be completed before the onset of the decline. In 1999, nourishment was not completed until a decline was well underway with the repercussion that there were insufficient animals available to fully colonize the disturbed sediments. The similarity between the results of this program and those of previous studies indicate that the findings will be applicable to subsequent renourishment operations at these sties and to similar projects in the New York-New Jersey area.

The principal conclusions from this portion of the study are as follows:

1) The intertidal infaunal assemblage was dominated by rhynchocoels, the polychaetes *Scolelepis squamata, Protodriloides* (LPIL), and *Microphthalmus* spp., oligochaetes, the mole crab *Emerita talpoida*, as well as a number of haustoriid amphipods.

2) The nearshore infaunal assemblage included many of the same taxa, but was dominated by the wedge clam, *Donax variabilis*, the polychaete *Magelona papillicornis*, the clams *Spisula solidissima* and *Tellina agilis*, and the amphipods *Acanthohaustorius millsi* and *Psammonyx nobilis*, and the polychaete *Asabellides oculata.*

3) Infaunal assemblages of intertidal and nearshore beach environments were similar in species composition and abundance to those reported elsewhere on the Atlantic Coast. Abundance was somewhat lower than that reported for beaches in Southern New Jersey.

4) Intertidal abundances were highest in the summer and lowest in mid-winter.

5) Intertidal sediments varied between depths, seasons, and years. Mean grain size declined with depth and was generally highest in the spring.

6) Beach nourishment resulted in short-term declines in abundance, biomass, and taxa richness.

7) Recovery of intertidal assemblages was complete within 2-6.5 months of the conclusion of filling. Differences in the rate of recovery were most likely due to differences in when nourishment was complete. Sites where filling did not conclude until the low point in the seasonal cycle of infaunal abundance took the longest to recover.

8) Recovery rates are similar to those reported from other studies, particularly where the grain size of the fill material matched that of the beaches to be nourished.

9) There is no evidence of long-term impacts of beach nourishment operations on intertidal or nearshore infaunal assemblages.

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