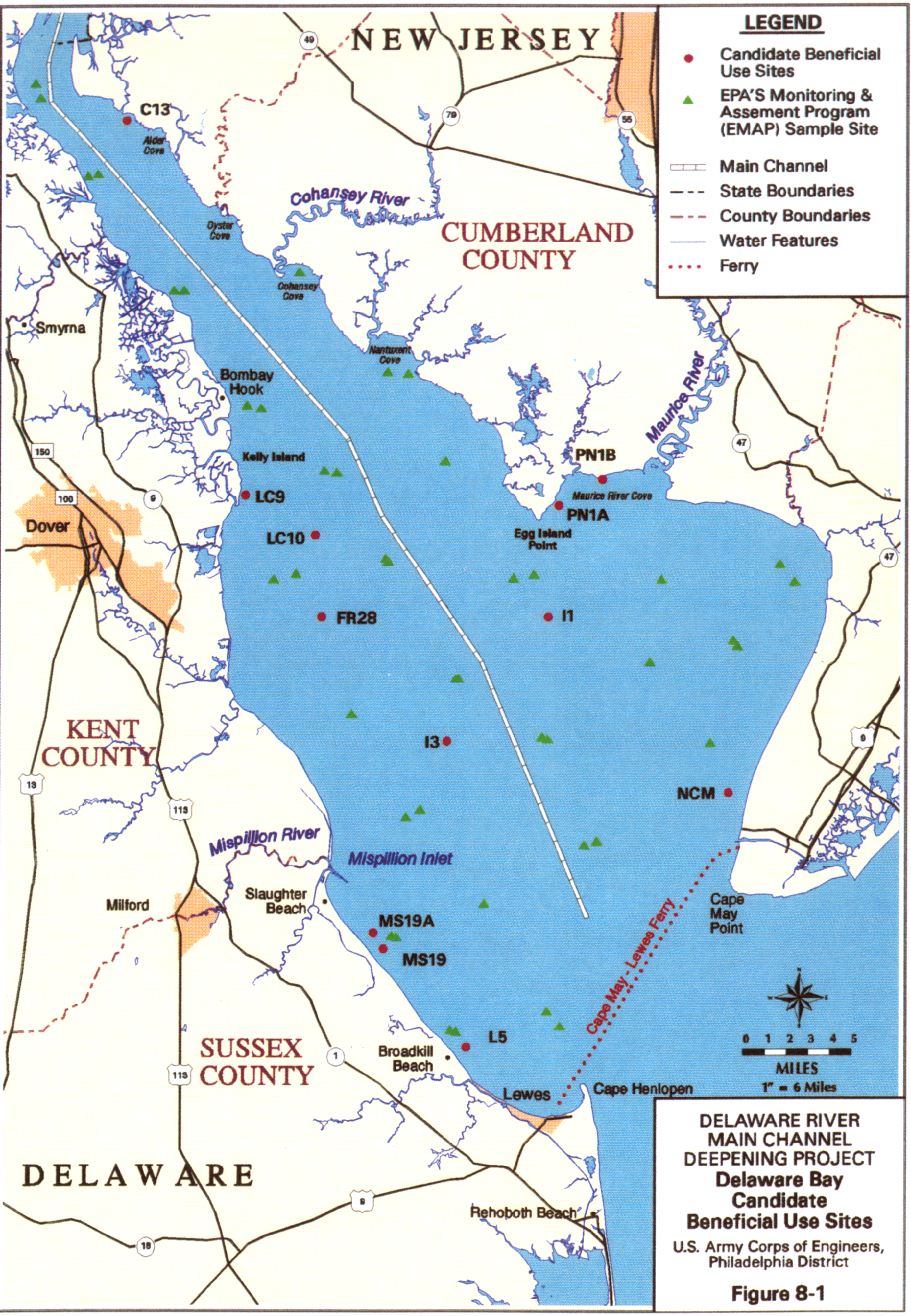
8.0 Benthic Habitat Investigations

8.1 Beneficial Use Site Investigations

Eleven candidate beneficial use sites were identified in Delaware Bay (Table 8-1, Figure 8-1). Options for beneficial use sites which were investigated include sand stockpiling in the bay for future beach replenishment activities along Delaware Bay shorelines, wetlands restoration and protection against erosion, and island creation to provide habitat. During Phase I of this study, data were collected on benthic macroinvertebrate resources at each candidate site to characterize the site and assess overall habitat quality (Greeley-Polhemus 1994a). Sampling procedures focused on measuring the overall diversity and density of the benthic community and included a survey of commercially or recreationally important species such as oysters, clams, blue crabs, and horseshoe crabs. On the basis of the Phase I report, four of the candidate beneficial use sites were selected that satisfied project needs, including cost, and minimize impacts to benthic resources. During Phase II, additional data were collected on the four sites to further characterize habitat quality. A twelfth site, MS-19B, was later added in 1995 and evaluated by Verser, Inc. (Chaillou and Weisberg. 1995).

Table 8-1. Candidate beneficial use sites

Site Name	Acreage	Beneficial Option
FR 28	500	Sand Stock Pile
L5	500	Sand Stock Pile
LC10	500	Sand Stock Pile
MS19A	500	Sand Stock Pile
MS19B	500	Sand Stock Pile
NCM	500	Sand Stock Pile
I1	250	Island Creation
I3	250	Island Creation
C13	250	Island Creation
LC9	350	Wetland Creation
PN1A	250	Wetland Creation
PN1B	250	Wetland Creation



DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT

Delaware Bay Candidate Beneficial Use Sites

U.S. Army Corps of Engineers, Philadelphia District

Figure 8-1

8.2 Evaluation of Benthic Resources of Candidate Beneficial Use Sites

Twelve sites were compared to background conditions in the Delaware Bay to determine any particular attributes that would assist in the beneficial use site selection process. The candidate sites were evaluated on the basis of four attributes: (1) physical characteristics, (2) presence of "unique" species, i.e., species which were not collected at other sites or in the surrounding Delaware Bay, (3) presence of commercially or recreationally important species, and (4) condition of the benthic macroinvertebrate community.

8.2.1 Physical Characteristics

Candidate sites were consistently shallower than the average for the rest of Delaware Bay, which is most likely attributed to the fact that the candidate sites are nearshore and away from the navigation channel (Table 8-2). Average channel depth exceeds 15 m; the deepest station of the candidate sites was 7.9 m at site I3.

The candidate sites were almost evenly divided according to mud or sand sediment type (seven sites versus five sites) (Table 8-2). Seven of the sites were significantly muddier than the average for the surrounding Delaware Bay. Only two sites, I1 and I3, were significantly sandier. Sites I1, I3, MS19A, and MS19B had sandy substrates at all sampling stations; site PN1B had a muddy substrate. All other sites were a combination of mud and sand sediment types.

Among the candidate sites, the percentage of total organic content tended to increase relative to silt-clay content (Table 8-2). The sandiest sites (silt-clay content less than 20%) had total organic content values less than 2%.

The candidate sites were predominantly polyhaline (salinity of 18 - 30 ppt), similar to the surrounding Delaware Bay (Table 8-2). The one exception was site C13, which was mesohaline (salinity of 5 -18 ppt). Only site MS19B, which is located in the lower bay, was significantly saltier (30.7 ppt) than the average for the surrounding Delaware Bay (23.4 ppt), though salinity differences may be largely affected by the stage in tide which they are measured. All sites were well-oxygenated and met state water quality standards of 5 ppm. Sites LC9, LC10, and NCM had significantly higher average bottom temperatures than the surrounding Delaware Bay. The maximum temperature of 30.1 C was measured at site LC9. Surface and bottom water quality measurements were very similar at each site, indicating a well-mixed system.

8.2.2 Presence of Unique Species

Evaluating potential effects on biodiversity of a system is an important aspect of environmental assessments associated with federal actions (CEQ 1993). One way to assess potential effects on biodiversity at a site is to identify whether any species are unique or abundant only at that site within those sites sampled.

A total of 248 species were found at either the candidate sites or in the surrounding Delaware Bay. Of those, 35 were unique to a particular candidate site (Table 8-3).

Ten of the 12 candidate sites contained at least one species that was collected only at that site. Site L5 contained 10 species not found in the other collections, which was the highest among the candidate sites. Sites C13 and PN1B were the only sites that contained no unique species.

Of the unique species that were found, none were so important as to preclude the placement of dredged material at the site. The majority of unique species fell into one of four categories:

- Of the 35 species, three are epifaunal taxa that are not well sampled by benthic infaunal gear. Their collection at individual sites is likely an artifact of attachment to surface debris.

- Five are abundant marine organisms that were collected at Delaware Bay sites near the Atlantic Ocean. Examples of these species are Notocirrus spiniferus and Aricidea fragilis, both large polychaete worms, and Paranthus rapiformis, commonly known as the onion anenome. All three species were found at site MS19B, which is located close to the mouth of the Delaware Bay.

- Another seven species are close relatives of other species on the taxa list that we believe are unique because of differences in taxonomic uncertainties among the laboratories that processed the samples.

- Sixteen species were so rare at the site (abundance < $2.0/m^2$) that it is unlikely to be an important or unique habitat for the species.

Of the remaining four species (Pagurus annulipes, Kurtziella cerina, Almyracuma proximoculi, and Pagurus annulipes), one each was found at L5 (in 1993 only), I1, PN1A (in 1994 only), and LC10 (in 1994 only). None of these taxa are considered rare in Delaware Bay (Watling and Maurer 1973).

Table 8-2. Means of physical parameters at candidate sites (standard error in parentheses). Shaded values are significantly different from background values observed in the Delaware Bay.

	C13	FR28	L5		LC9		LC10		PN1A		MS19A	MS19B	NCM	PN1B	I1	I3	Back-ground
			93	94	93	94	93	94	93	94							
Depth (m)	4.3 (0.3)	4.1 (0.1)	4.3 (0.2)	5.4 (0.1)	1.2 (0.1)	2.1 (0.2)	3.2 (0.2)	3.7 (0.2)	2.0 (0.3)	1.3 (0.1)	3.4 (0.1)	3.1 (0.2)	5.6 (0.3)	0.9 (0)	5.7 (0.2)	4.3 (1.3)	6.9 (0.7)
Silt-clay Content (%)	74 (12)	43 (2)	39 (7)	62 (4)	79 (11)	87 (5)	49 (8)	82 (1)	75 (14)	65 (13)	19 (3)	16 (2)	38 (12)	83 (8)	15 (<1)	4 (1)	23 (4)
Total Organic Content (%)	8.36 (1.76)	2.34 (0.13)	3.28 (0.46)	4.28 (0.27)	8.94 (1.77)	12.94 (0.61)	3.51 (0.83)	5.67 (0.38)	10.10 (1.97)	8.22 (2.22)	2.10 (0.17)	0.92 (0.05)	5.01 (1.27)	12.86 (3.19)	1.78 (0.12	1.08 (0.12)	
Surface DO (ppm)	8.7 (0.3)	7.8 (0.1)	9.1 (0.3)	8.4 (0.2)	5.7 (0.2)	6.2 (0.3)	8.8 (0.2)	6.8 (0.2)	6.6 (0.8)	6.5 (0.3	8.2 (0.2)	8.9 (0.4)	7.3 (0.1)	6.6 (0.1)	14.6 (0.5)	8.4 (0.1)	7.3 (0.2)
Bottom DO (ppm)	7.9 (0.3)	7.6 (0.1)	8.2 (0.2)	7.7 (0.1)	5.7 (0.2)	NM	8.4 (0.2)	5.7 (0.1)	6.0 (0)	NM	7.8 (0.1)	9.1 (0.6)	7.2 (0.1)	NM	12.5 (0.7)	8.5 (0.2)	6.5 (0.2)
Surface Salinity (ppt)	11.2 (0.1)	25.1 (0.1)	28.9 (0.2)	24.3 (0.4)	22.0 (0.3)	14.7 (0.5)	21.9 (0.8)	14.8 (0.5)	20.9 (0.1)	18.1 (0.1)	28.4 (0.2)	29.3 (0.4)	25.3 (0.4)	19.3 (0.2)	21.4 (0.7)	27.5 (0.2)	22.1 (1.1)
Bottom Salinity (ppt)	11.1 (0.2)	25.0 (<0.1)	28.1 (0.2)	24.3 (0.5)	21.6 (0.2)	NM	21.9 (0.8)	15.3 (0.3)	20.5 (0)	NM	28.2 (0.1)	30.7 (0.7)	25.6 (0.4)	NM	22.0 (0.4)	27.3 (0.2)	23.4 (0.9)
Surface Temperature (°C)	25.3 (0.4)	25.9 (0.3)	26.6 (0.4)	22.5 (0.4)	29.9 (0.5)	27.6 (0.2)	28.1 (0.3)	27.9 (0.2)	25.2 (0.2)	25.2 (0.1	26.3 (0.4)	24.5 (0.1)	26.7 (0.3)	24.8 (0.1)	23.6 (0.2)	25.7 (0.4)	24.9 (0.2)
Bottom Temperature (°C)	25.4 (0.4)	25.5 (0.2)	25.1 (0.3)	22.2 (0.4)	29.0 (0.3)	NM	27.3 (0.2)	27.7 (0.2)	24.0 (0)	NM	25.5 (0.3)	24.4 (0.1)	26.3 (0.3)	NM	23.4 (0.2)	24.3 (0.2)	24.5 (0.3)

Table 8-3. Abundance (#/m^2) of species found only at single sites

	C13	FR28	L5		LC9		LC10		PN1A		MS19A	MS19B	NCM	PN1B	I1	I3
			93	94	93	94	93	94	93	94						
Cnidaria : Hydrozoa Hydrozoa								0.48								
Cnidaria : Anthozoa Paranthus rapiformis												0.57				
Platyhelminthes : Turbellaria Planaridae				1.60												
Annelida : Polychaeta Aricidea fragilis												6.25				
Capitella capitata							1.44									
Clymenella torquata			9.13													
Notocirrus spiniferus												0.57				
Opheliidae											1.44					
Paranaitis speciosa												0.57				
Pherusa affinis			0.48	1.2												
Phyllodoce groenlandica															0.54	
Podarke obscura			1.92													
Tharyx setigera																0.96
Annelida : Hirudinea Hirudinea			0.48													
Mollusca : Gastropoda Bittium alternatum																0.48
Crepidula maculosa												0.57				
Kurtziella cerina															18.82	
Nudibranchia						0.48										
Urosalpinx cinerea				0.40												
Mollusca : Bivalvia Geukensia demissa				0.48												
Pandora gouldiana															0.54	
Tellina tenella															1.08	
Tellina versicolor		0.96														
Arthropoda : Cumacae Almyracuma proximoculi										5.77						

Table 8-3. (Continued)

	C13	FR28	L5		LC9		LC10		PN1A		MS19A	MS19B	NCM	PN1B	I1	I3
			93	94	93	94	93	94	93	94						
Arthropoda : Isopoda Idotea balthica											0.48					
Arthropoda : Amphipoda Aeginina longicornis			6.73													
Gammarus palustris						1.44										
Lysianopsis alba															0.54	
Microdeutopus gryllotalpa			5.77													
Paraphoxus spp.											60.58					
Arthropoda : Decapoda Emerita talpoida			0.48													
Ovalipes ocellatus													0.48			
Pagurus acadianus								0.48								
Pagurus annulipes								2.88								
Panopeus herbstii															30.11	
Total Number of Species	0	1	10		2		2		1		3	6	1	0	6	2

8.2.3 Presence of Commercially or Recreationally Important Species

Sites containing high abundances of commercially or recreationally important species are generally considered to be less preferable as beneficial use sites than sites with low abundances. Eleven of the 12 sites contained at least one species of commercial or recreational value, but only eight of those 11 sites contained infaunal species (Table 8-4).

Infaunal species are immobile and at greater risk from placement of dredged material than surface dwelling taxa that can migrate from the affected area. Of the eight sites, five contained *Mercenaria mercenaria* (northern quahog) but abundance was fairly low, less than $4.0/m^2$). Softshell clams were collected at sites LC9 and PN1A, but only in 1994. Atlantic surf clams were found only at site I3.

8.2.4 Benthic Community Response Measures

8.2.4.1 Biodiversity

None of the candidate sites had a significantly greater species richness or diversity than background conditions for the Delaware Bay across all four habitats (mesohaline/mud, mesohaline/sand, polyhaline/mud, and polyhaline/sand) (Tables 8-5 through 8-8). Site MS19B had the greatest mean number of species (18.45/sample) in any habitat. Site PN1A had the fewest mean number of species for either polyhaline habitat but it was only low in 1993; values for this site increased by a factor of two in 1994. Site MS19B also had the highest Shannon-Wiener index (3.19). Site LC9 had the lowest Shannon-Wiener index (0.34), significantly lower than the background condition, and was consistently low across both habitat and sampling years.

8.2.4.2 Abundance

Only two sites, MS19A and LC9, had a significantly higher benthic macroinvertebrate density than the surrounding Delaware Bay. In both cases, greater abundance resulted from an overwhelming abundance of a single species, rather than from an increased abundance of a balanced community. At site MS19A, total abundance was dominated by amphipods (96%), primarily *Ampelisca*, an opportunistic species. For site LC9, bivalves contributed almost 95% of the abundance in either mud or sand habitat in 1993, but the proportion was considerably lower in 1994. *Mulinia lateralis*, an opportunistic bivalve, was the dominant species.

Sites LC10 and PN1A had a considerably lower abundance than the surrounding Delaware Bay, but differences for both sites were habitat and year specific.

Table 8-4. Mean abundance (#/m^2) of commercial and recreational species collected at each of the candidate sites

	FR28	L5		LC9		LC10		PN1A		MS19A	MS19B	NCM	PN1B	I1	I3
		93	94	93	94	93	94	93	94						
Northern quahog *Mercenaria mercenaria*	2.40					1.44	0.48				0.57	3.85		3.76	
Atlantic surfclam *Spisula solidissima*															58.65
Softshell clam *Mya arenaria*					30.29				14.42						
Knobbed whelk *Busycon carica*			0.40							1.44					
Blue crab *Callinectes sapidus*							0.48	3.85		3.37		0.96	48.08		
Horseshoe crab *Limulus polyphemus*	29.33	0.96	0.40	6.87	18.75	3.37	0.48	0.96	5.77	92.31		6.25			

Table 8-5. Mean benthic macroinvertebrate condition in the mesohaline/mud habitat within candidate sites (standard error in parentheses). Shaded values are significantly different from background values observed in Delaware Bay.

	C13	Background
Number of Species (#/sample)	5.44 (0.65)	11.00 (1.73)
Shannon-Wiener Index	1.88 (0.17)	2.42 (0.22)
Percent of Abundance as Opportunist Species	33.76 (6.18)	23.78 (6.92)
Percent of Abundance as Equilibrium Species	10.37 (6.11)	0.14 (0.10)
Total Abundance (#/m^2)	374 (80)	2,915 (686)
Amphipod Abundance (#/m^2)	119 (39)	389 (85)
Bivalve Abundance (#/m^2)	20 (4)	127 (57)
Polychaete Abundance (#/m^2)	52 (10)	1,430 (477)
N	16	15

Table 8-6. Mean benthic macroinvertebrate condition in the mesohaline/sand habitat within candidate sites (standard error in parentheses). Shaded values are significantly different from background values observed in Delaware Bay.

	C13	Background
Number of Species (#/sample)	5.50 (0.29)	14.50 (1.85)
Shannon-Wiener Index	2.11 (0.11)	2.83 (0.25)
Percent of Abundance as Opportunist Species	49.12 (10.21)	57.30 (6.88)
Percent of Abundance as Equilibrium Species	0	1.39 (0.52)
Total Abundance (#/m^2)	308 (45)	3,006 (1,055)
Amphipod Abundance (#/m^2)	29 (6)	81 (36)
Bivalve Abundance (#/m^2)	10 (10)	1,483 (902)
Polychaete Abundance (#/m^2)	149 (40)	559 (138)
N	4	12

Table 8-7. Mean benthic macroinvertebrate condition in polyhaline/mud habitats within candidate sites (standard error in parentheses). Shaded values are significantly different from background values observed in Delaware Bay.

	FR28	L5		LC9		LC10		PN1A		PN1B	NCM	Back-ground
		93	94	93	94	93	94	93	94			
Number of Species (#/sample)	15.05 (0.39)	15.00 (1.21)	11.45 (0.47)	7.20 (0.37)	8.55 (0.49)	13.31 (0.83)	12.30 (0.41)	5.50 (0.39)	10.69 (1.01)	8.05 (0.75)	16.80 (1.12)	17.50 (1.68)
Shannon-Wiener Index	2.68 (0.04)	2.48 (0.06)	2.22 (0.08)	0.36 (0.07)	1.01 (0.10)	2.55 (0.10)	2.31 (0.05)	1.99 (0.14)	1.41 (0.16)	1.25 (0.16)	2.67 (0.11)	2.43 (0.15)
Percent of Abundance as Opportunist Species	64.59 (1.83)	52.78 (3.11)	63.01 (2.70)	96.69 (0.67)	31.89 (4.44)	21.54 (2.79)	58.21 (2.02)	27.85 (5.51)	31.56 (5.65)	57.92 (8.05)	8.50 (2.69)	66.17 (6.61)
Percent of Abundance as Equilibrium Species	0.38 (0.09)	1.43 (0.64)	0.15 (0.06)	0	0.39 (0.10)	0.23 (0.16)	0.16 (0.06)	0	0.37 (0.21)	0	2.48 (0.42)	0.04 (0.03)
Total Abundance (#/m²)	3,939 (201)	6,434 (1,403)	3,108 (206)	37,234 (5,035)	16,089 (1,874)	1,833 (190)	4,540 (272)	383 (104)	11,081 (1,685)	7,705 (2,235)	3,474 (348)	5,771 (1,225)
Amphipod Abundance (#/m²)	767 (83)	2,256 (655)	768 (161)	1,421 (1,101)	37 (11)	375 (70)	242 (31)	165 (98)	736 (204)	4,185 (2,124)	1,053 (273)	144 (31)
Bivalve Abundance (#/m²)	2,129 (129)	2,712 (576)	1,538 (71)	35,051 (4,709)	4,662 (1,190)	113 (29)	916 (142)	0	2,709 (644)	886 (260)	125 (18)	508 (226)
Polychaete Abundance (#/m²)	268 (17)	133 (31)	38 (6)	45 (5)	421 (177)	977 (97)	1,562 (100)	29 (11)	216 (53)	109 (21)	1,452 (165)	2,790 (958)
N	20	12	44	20	40	16	40	16	16	20	20	12

Table 8-8. Mean benthic macroinvertebrate condition in the polyhaline/sand habitat within candidate sites (standard error in parentheses). Shaded values are significantly different from background values observed in Delaware Bay.

	FR28	L5		LC9	LC10	PN1A		MS19A	MS19B	NCM	I1	I3	Back-ground
		93	94	93	93	93	94						
Number of species (#/sample)	13.20 (0.53)	14.11 (0.55)	13.75 (1.55)	7.75 (0.41)	12.79 (0.52)	5.50 (0.87)	11.25 (1.25)	13.30 (0.58)	21.48 (0.79)	13.05 (0.83)	18.45 (0.78)	8.85 (0.49)	23.86 (1.06)
Shannon-Wiener Index	2.79 (0.06)	2.28 (0.10)	1.99 (0.09)	0.34 (0.05)	2.61 (0.08)	1.59 (0.54)	2.18 (0.11)	1.32 (0.07)	3.19 (0.06)	2.40 (0.16)	2.63 (0.14)	1.69 (0.21)	2.85 (0.08)
Percent of Abundance as Opportunist Species	56.83 (2.14)	65.14 (3.43)	75.92 (1.01)	97.30 (0.52)	23.80 (2.30)	47.51 (19.56)	80.28 (1.22)	69.23 (3.20)	39.43 (2.45)	17.30 (6.17)	44.16 (4.34)	1.44 (0.85)	44.90 (2.98)
Percent of Abundance as Equilibrium Species	0.17 (0.10)	1.40 (0.28)	0	0.05 (0.05)	0.35 (0.13)	0	3.59 (1.62)	0.05 (0.01)	4.54 (0.49)	2.19 (0.96)	0.54 (0.16)	3.57 (0.72)	0.79 (0.16)
Total Abundance (#/m²)	2,394 (104)	3,873 (398)	3,510 (90)	30,767 (3,773)	1,644 (125)	6,716 (6,364)	2,082 (388)	26,549 (2,040)	6,825 (795)	5,063 (2,302)	2,935 (549(	2,462 (374)	7,934 (792)
Amphipod Abundance (#/m²)	575 (49)	1,824 (203)	250 (83)	861 (528)	275 (31)	6,490 (6,407)	10 (10)	25,451 (2,041)	2,134 (446)	3,891 (2,294)	1,235 (547)	1,738 (433)	1,563 (474)
Bivalve Abundance (#m/²)	1,055 (92)	1,187 (173)	2,630 (179)	29,214 (3,507)	162 (22)	0	1,240 (168)	429 (87)	1,424 (122)	167 (38)	190 (23)	163 (19)	588 (50)
Polychaete Abundance (#/m²)	175 (15)	126 (11)	48 (18)	48 (8)	801 (64)	111 (53)	548 (245)	79 (12)	2,117 (297)	626 (85)	1,032 (93)	251 (19)	4,530 (507)
N	20	28	4	8	24	4	4	40	40	20	20	20	95

8.2.4.3 Life History Strategy Measures

Disturbed habitats are often characterized by a predominance of relatively short-lived, tolerant species (opportunistic species) with relatively high reproductive and recruitment rates (Boesch 1973, 1977; Pearson and Rosenberg 1978; Rhoads et al. 1978; Dauer 1991, 1993; Dauer et al. 1992). Disturbed sites tend to be recolonized initially and quickly by opportunistic species. In contrast, undisturbed or unstressed habitats are often characterized by large, relatively long-lived species (equilibrium species) that are slow to recolonize when the habitat has been disturbed (Warwick. 1986; Dauer. 1993). Thus, candidate sites with a high frequency of equilibrium taxa and a low frequency of opportunistic taxa would be the poorest candidates to recover quickly from dredging impacts.

Seven sites had a higher frequency of equilibrium species than background conditions in Delaware Bay. Site MS19B had the greatest percentage of equilibrium species (4.5%). Sites PN1A and L5 had a significantly greater frequency of equilibrium species, but the differences were habitat and year-specific.

Three sites had more opportunistic species than background conditions in Delaware Bay. Site LC9 contained the highest percentage, averaging 97% in 1993.

8.2.4.4 Large Organisms

Sites containing higher abundances of large individuals are generally indicative of long-lived established benthic communities that will require a longer period to recover from stress (Warwick 1986; Dauer 1993). The number or percentage of large organisms (>2 cm) could not be compared between the candidate beneficial use sites and the background conditions in the bay because animal size was not measured in the EMAP sampling program. Among the candidate sites, sites MS19B and MS19A had the greatest number of species with body lengths exceeding 2 cm, 16 and 15 species respectively (Table 8-9). This was at least twice as high as at any other site. PN1A, PN1B, and C13 had the lowest number of species with large individuals.

MS19B was also the site with the highest percentage of large individuals within species. Approximately 91% of razor clams (*Ensis directus*) at site MS19B were large individuals, substantially higher than the seven other sites where it was found. Large individuals of *Glycera americana* were also found at site MS19B in percentages of total individuals approximately three to eight times greater than six other sites where it was collected. Of the 15 species with large individuals at site MS19A, only *Ensis directus* had a percentage greater than 10%.

Table 8-9. Percent of organisms greater than 2 cm (sites where smaller specimens were also found are indicated with zeros; species for which no specimens greater than 2 cm were found are not listed)

Species Group-Species Name	C13	FR28	L5		LC9		LC10		PN1A		MS19A	MS19B	NCM	PN1B	I1	I3
			93	94	93	94	93	94	93	94						
Cnidaria : Anthozoa																
Actiniaria				2.1				0		0		0	0			
Nemertinea																
Cerebratulus lacteus		2.5		0	6.0	1.5	9.2	2.5	20.0				0	5.0		
Nemertinea	0	2.5	0	2.1			0		0		7.5	0	0	0	0	0
Annelida : Polychaeta																
Aricidea fragilis												5.0				
Asabellides oculata												15.6				
Clymenella torquata			2.5													
Diopatra cuprea										10.9		10.0				
Drilonereis spp.											2.5					
Eumida sanguinea															5.0	
Glycera americana		2.5	21.3	4.2			2.5			0	2.5	20.0	7.5		5.0	
Glycera capitata		0		4.2			0				2.5					0
Glycera dibranchiata		2.5			30.7		2.5	7.5	0			12.5	2.5	7.5	15.0	
Glycera spp.				0	0		0		0						0.5	
Goniadidae		0	0		0		0		0		2.5		0	0	0	0
Leitoscoloplos robustus												34.5				
Marenzelleria viridis	15.0															
Nephtys incisa			7.5										5.0			
Nephtys spp.				0												10.0
Nephtys picta				0							7.5		0			6.3
Nereis spp.	2.5				0	2.5	0				7.5				0	
Notocirrus spiniferus												2.5				
Opheliidae											5.0					
Orbinia ornata			0								2.5		0			
Orbiniidae													0	2.5		

Table 8-9. (Continued)

Species Group-Species Name	C13	FR28	L5		LC9		LC10		PN1A		MS19A	MS19B	NCM	PN1B	I1	I3
			93	94	93	94	93	94	93	94						
Paraprionospio pinnata				0								10.0				
Pectinaria gouldi		0	2.5				0				2.5	5.0	0		0	
Pherusa affinis			0	2.1												
Polychaeta		0		0		2.5				0	0		0			
Polydora cornuta												1.3				
Prionospio spp.		2.5	2.5							0	0					
Scoletoma tenuis												1.3				
Scoloplos rubra				2.1				5.5		5.0		2.5				0
Scoloplos spp.		15.0	2.5	2.1	3.6	0	9.4		0		0		5.0	0	2.1	0
Spiochaetopterus costarum							0					61.9	0		0	
Spiophanes bombyx			0												10.0	0
Terebellidae		0	0							0			5.0	0		
Annelida : Hirudinea																
Hirudinea			2.5													
Mollusca : Gastropoda																
Busycon carica				0							7.5					
Crepidula convexa		0					0	0			2.5		0		0	
Crepidula fornicata											2.5		0		0	
Eupleura caudata		0									0	2.5			0	
Ilyanassa obsoleta				0	0	1.5	0	2.7	0	0				0		
Mollusca : Bivalvia																
Anadara ovalis			0										0		5.0	
Ensis directus		12.5	0	6.3			7.5	5.50			17.5	90.6	17.5		25.0	28.8
Mya arenaria						0.6				0						
Spisula solidissima																5.7
Yoldia limatula		0	0	0.7								0				
Arthropoda : Merostomata																
Limulus polyphemus		7.5	0	0	0	0	2.5	2.5	0	0	0		7.5			

Table 8-9. (Continued)

Species Group-Species Name	C13	FR28	L5		LC9		LC10		PN1A		MS19A	MS19B	NCM	PN1B	I1	I3
			93	94	93	94	93	94	93	94						
Arthropoda : Decapoda																
Cancer irroratus													0			10.0
Crangon septemspinosa	0	0	0	0	0.7	2.5	0	0	0	0	0	2.5	0	0	0	0
Eurypanopeus depressus		0					0	0			2.5				0	
Pagurus spp.		0					0	2.5		0	0	0	0		0	0
Rhithropanopeus harrisi	2.5	0	0		0		0				0		0		0	
Echinodermata : Holothuroidea																
Holothuroidea					0	2.1					0				0	
Total Number of Species with Organisms >2 cm	3	8	7	8	4	7	6	7	1	2	15	16	7	3	8	5

8.3 Assessment of Potential Impacts

8.3.1 General

No significant differences were found between any candidate site and background conditions in Delaware Bay that would preclude its selection as a beneficial use site. Therefore, no significant local effect will occur to benthic resources of Delaware Bay due the use of any of these sites as either wetland restorations or sand stockpiles.

There are a variety of potential effects associated with the placement of dredged material on top of benthic communities in estuarine environments. The most immediate of these effects is burial (Hirsch et al. 1978). The extent and magnitude of burial effects are dependent upon the thickness and composition of the emplaced dredged material. Many benthic infauna, particularly siphonate suspension feeders and deep-dwelling fauna, are able to migrate vertically to pre-existing sediment depths (Maurer et al. 1978; Saila et al. 1972; Schafer 1972; Shulenberger 1970). Vertical migrations approaching 3 feet and more have been documented from a variety of fauna, demonstrating a large adaptive ability to recover from burial. Benthic fauna with more limited abilities for vertical migrations in emplaced sediments will experience significant mortalities; however, the immediate changes in benthic community composition, abundance, and biomass caused by these mortalities are typically short-term impacts. Horizontal migration of benthic fauna from unimpacted areas and larval resettlement can bring about rapid recolonization of areas that have been disturbed by the emplacement of dredged materials (Ranasinghe, and Richkus 1993; Van Dolah et al. 1984; Mauer et al. 1978; Oliver et al. 1977). Initially, recolonization is dominated by opportunistic species whose reproductive capacity is large, and whose environmental requirements are often flexible enough to allow then to occupy disturbed areas (Boesch and Rosenberg 1981; McCall 1977). With additional time (months to several years), and if environmental conditions permit, the initial surface dwelling opportunistic species will be replaced by benthic species representing a more mature community.

The ultimate recovery of benthic communities from the emplacement of dredged material is dependent upon the type of dredged material emplaced and the extent and magnitude of any modifications of the existing environmental habitat. Existing regulations and practices extremely limit the emplacement of dredged material containing contaminants at concentrations that are potentially toxic to biota; therefore, acute and chronic toxic responses limiting the recovery of affected benthic communities are normally not a concern. Habitat modification is a concern in those cases where the dredged material represents a sediment type significantly different from existing sediments (Mauer et al. 1978). Changing from a muddy sediment habitat to a coarse sand sediment habitat will significantly change the composition of the benthic assemblage at a site. Changing from a muddy-sand to a sandy-mud will have less severe impacts. These changes are not necessarily undesirable and their influence on the estuary as a whole are most likely negligible; however, they are potential changes.

The emplacement of dredged material may also modify habitat by changing water depth. At the sand stockpile sites, the amount of dredged material targeted for placement may raise the height of the substrate by as much as 5 feet. Changes in the depth of subtidal sediments of 3 feet are likely to cause little change in the composition, abundance, and biomass of benthic communities that are deeper than about 9 feet. Most of the Delaware Estuary contains a heterotrophic benthos dependent upon planktonic autotrophic production for food (Frithsen et al. 1991). Small changes in water depth are likely not to favor significant benthic autotrophy by diatoms or macrophytes due to the extremely turbid nature of the estuary. Changes in the depth of subtidal sediments that are shallower than 6 feet may affect benthic communities due to greater exposure to physical stress caused by waves and surface currents. These physical effects may be most significant during storms when significant amounts of energy can be transferred from the surface to the sediments.

The loss of the benthic community due to dredged material disposal would be expected to be a short-term adverse impact. The Corps has constructed twenty-three underwater berms for storm attenuation or beach nourishment throughout the United States (Landin, 1992). For example, results of detailed studies of benthic recovery and fish use on a berm constructed at Dauphin Island, Alabama, indicated rapid benthic recovery. Fish use of the area also was reported as greater than in surrounding waters. The benthic recovery and greater fish use are related to slope, configuration, and orientation of the berm in the current (Landin, 1992).

Long-term impacts would likely result from the use of the sites as sand sources for future beach nourishment projects if the area is subjected to repeated disturbances. A regularly disturbed bottom would not necessarily provide the same abundance or species composition as the present site condition. However, these impacts would occur to relatively small portions of the sandpiles at a frequency of every 5 to 10 years.

8.3.2 Site Specific Impacts at Selected Beneficial Use Sites

8.3.2.1 Wetland Restoration Sites

PNIA and LC-9 are the beneficial use sites that were selected for wetland restoration/shore protection. The benthic communities of these sites, which cover about 225 acres, would be eliminated and the bottom would be changed from subtidal to intertidal wetland, averaging about +5 feet MLW. These sites were among those having the poorest quality benthic communities. They were characterized by a considerably less diverse assemblage than the background benthic communities in Delaware Bay. Compared to other candidate sites, they contained a higher abundance of opportunistic species, which are typical of disturbed environments. LC-9 was characterized by a different species composition between the two years it was sampled, which is a further indication of its unstable benthic community. LC-9 and PN1A (as well as PN1B) also had the lowest percent of equilibrium taxa among all of the candidate sites.

8.3.2.2 Sand Stockpiles

The beneficial use sites that were selected for sand stockpiles are L-5 and MS-19B. These sites would be covered with sand, changing the average depth from -8.0 feet MLW to about -3.0 feet MLW. The present substrate of L-5 has significantly more silt/clay content than MS-19B (51% vs. 16%). A change to a total sand substrate at L-5 will have a greater likelihood to change the benthic community that is present than at MS-19B which presently has essentially a sand substrate. It is likely that both benthic communities will change since they are both less than 6 feet and will be subjected to greater exposure to physical stress caused by waves and surface currents. As mentioned, these effects may be most significant during storms when significant amounts of energy can be transferred from the surface to the sediments. L-5 is similar in quality to LC-9 and PN1A as described above. Site MS-19B had one of the highest quality benthic communities among the 12 potential beneficial use sites, and would be expected to sustain greater impacts due to the lower recovery potential of its benthic macroinvertebrate community. Species richness was highest among the candidate sites at MS19B. It contained a higher abundance of equilibrium species, which are typically indicative of a stable, diverse, mature community, than the background benthic communities of the Delaware Bay. Site MS19B also contained the highest frequencies of individuals and the greatest number of species with body length greater than 2 cm, again indicative of a stable, mature assemblage, as well as infaunal species having commercial/recreational value. Although MS-19 has a higher quality benthic community than the other 12 sites that were evaluated, there were no significant differences found between it and the background conditions of the Delaware Bay that would preclude its use.

No significant differences were found between any candidate site and background conditions in Delaware Bay that would preclude its selection as a beneficial use site. Therefore, no significant impact will occur to either the diversity or overall populations of benthic resources due the use of any of these sites as either wetland restorations or sand stockpiles.