Pre-Construction Shorebird Monitoring at Kelly Island Wetland Restoration Site, Port Mahon Environmental Restoration Site and Broadkill Beach Sand Placement Site, Spring 2001, Delaware River Main Channel Deepening Project

Final Report prepared for the U.S. Army Corps of Engineers
By Brian A. Harrington and Sea McKeon
Manomet Center for Conservation Sciences
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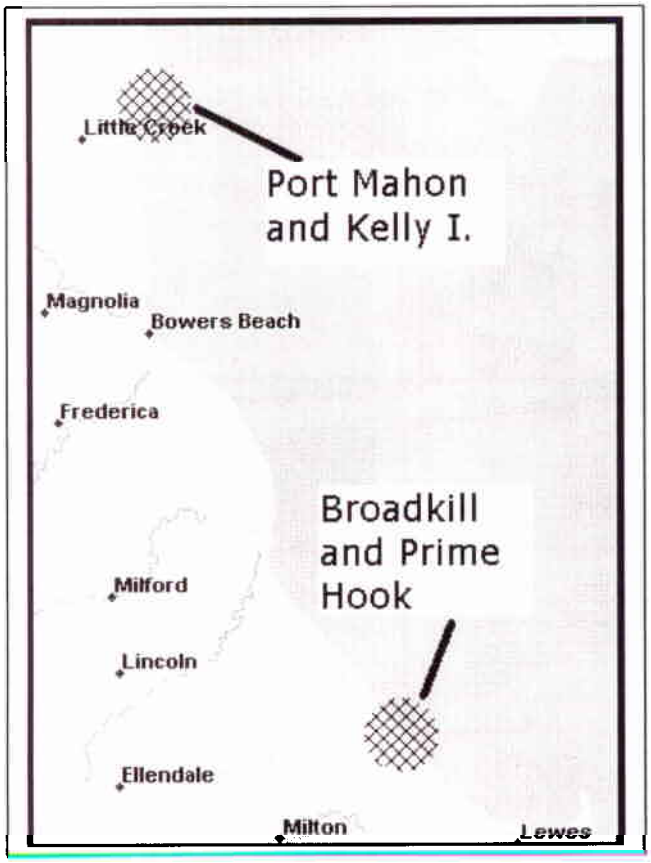
Introduction

Delaware Bay is recognized as one of the most critical stopovers worldwide for shorebirds migrating from their wintering grounds in Central and South America to their Arctic and Subarctic breeding grounds (WHSRN). Each spring shorebirds arrive by the hundreds of thousands on their staging grounds along the Delaware Bay to fuel up for the last leg of their northward journey. Their stopover coincides with the peak of horseshoe crab spawning. The millions of horseshoe crab eggs laid in the sand along bayshore beaches comprise an important food source for the migrants. Previous studies have called attention to apparent declines in the numbers of several shorebird species on their staging grounds (Howe et al. 1989, Clark et al. 1993, Harrington 1995) and point to the importance of habitat protection in the conservation of these species (Myers et al. 1987).

Figure 1. Location of study areas covered in this report.



The Army Corps of Engineers is proposing to use dredged material from deepening the Delaware River Federal Navigation Channel for shoreline restoration, including a restoration project at Kelly Island. Another project proposes sand placement at Broadkill beach and Port Mahon.

Shoreline beaches on Delaware Bay are known to attract high numbers of shorebirds. In order to determine whether the shoreline restoration projects will benefit migratory shorebirds, it is necessary to collect and analyze quantitative and qualitative baseline data on shorebird use of the sites prior to construction. This report summarizes baseline work completed during May and June 2001. Principal emphasis was on documenting usage by shorebirds at the locations proposed for restoration, and in one case (Prime Hook), at a comparable abutting location not slated for restoration. Rapid assessments also were made of common invertebrate animals in the same areas.

METHODS

A. Birds

Migratory shorebird surveys were conducted at four locations on the Delaware coast during May 2001 (Figure 1). Bird surveys were made with binoculars and a 20x telescope, and were conducted from vantage points that caused minimal disturbance to birds along the shoreline. Counting focused mostly on shoreline habitats, but flight-line counts of shorebirds moving between shoreline and nearby marshland habitats also were made near Port Mahon. Each shoreline section was divided into 25-31 subsections and marked. Counts were kept for each subsection. Bird species names, codes, and binomial names are shown in Table 1.

Table 1. Species codes, common and binomial names used in this report.

Code	Common name	Binomial name
BBPL	Black-bellied Plover	*Pluvialus squatarola*
PIPL	Piping Plover	*Charadrius melodus*
SEPL	Semipalmated Plover	*C. semipalmatus*
KILL	Killdeer	*C. vociferus*
BNST	Black-necked Stilt	*Himantopus mexicanus*
GRYE	Greater Yellowlegs	*Totanus melanoleuca*
LEYE	Lesser Yellowlegs	*T. flavipes*
WILL	Willet	*Catoptrophorus semipalmatus*
SPSA	Spotted Sandpiper	*Actitis macularia*
RUTU	Ruddy Turnstone	*Arenaria interpres*
REKN	Red Knot	*Calidris canutus*
SAND	Sanderling	*C. alba*
SESA	Semipalmated Sandpiper	*C. pusilla*
LESA	Least Sandpiper	*C. munitilla*
DUNL	Dunlin	*C. alpina*
DOSP	Dowitcher spp.[a]	*Limnodromus* spp.

[a] All or almost all were Short-billed Dowitchers

Knowing what tidal stage is best for counting shorebirds is important to designing sequel studies. Between two and eight shoreline surveys were made at each location each week. Shorebirds were counted at predicted mid-tide times (roughly half way between low and high tides) on each day that counts were made. A second count also was made either 3 hr before or 3 hr after the predicted mid-tide time, i.e. at approximately the time of predicted low or high tide. Correlation analysis was used to describe overall relationships between counts made at mid- versus low tide, and between counts made at mid- versus high tides. Analysis of Variance (SAS Institute 1999) was used to compare counts between the 4 study areas.

The methodology of the shoreline surveys closely followed that used by The Nature Conservancy and Manomet Center for Conservation Sciences for shorebird monitoring at Port Mahon in 1997 and 1999. The study areas (Appendix 1) are as follows:

1. Kelly Island (proposed for restoration): This area extends north along the shoreline from the mouth of the Mahon River for about 1.6 km to Deepwater Point.
2. Port Mahon (proposed restoration site): the area is a 1 km stretch of shoreline just south of the mouth of the Mahon River where Port Mahon Road runs parallel to the Delaware Bay.
3. Broadkill Beach (proposed for restoration): The study area is a 4.4 km stretch of shoreline from Arizona Avenue south to the end of the paved road.
4. Prime Hook Beach: An equivalent area of habitat similar to Broadkill Beach was surveyed as a future control site.

The study areas on Port Mahon and Broadkill beaches were divided into linear sections and marked. Similar linear segments were measured on Kelly Island and Prime Hook Beach. Marker locations were also GPS-located for future reference (see Appendix 1).

To assess the levels of shorebird use of marshlands proximate to the study beaches, we counted birds moving between the marsh and the shore during peak migration weeks. These surveys were made near the north end of the Port Mahon study site for 10 minutes at dawn and/or dusk, times when shorebirds are expected to be moving to and from roosting sites.

B. Invertebrate animals.

At each of the 4 study locations (at the tideline in transect 1,10, 20, and 25), core samples were collected during visits to the study sites after May 15th. Samples were sorted with a standard 1 mm screen to identify macro-invertebrate taxa. Fifty-two samples were assessed. Cores were collected on site, screened in the field, and washed with salt water into suitable containers marked for date and location, refrigerated, and sorted within 36 hours.

Invertebrates were identified as follows:

Gastropods and bivalves to genus (or better)
Amphipods and polychaete worms to family (or better)
Shrimps to genus (or better)
Crabs to genus (or better)
Insects and spiders to order (or better)
Scarce invertebrates (occurrence < 5% by head count) to class.

Results

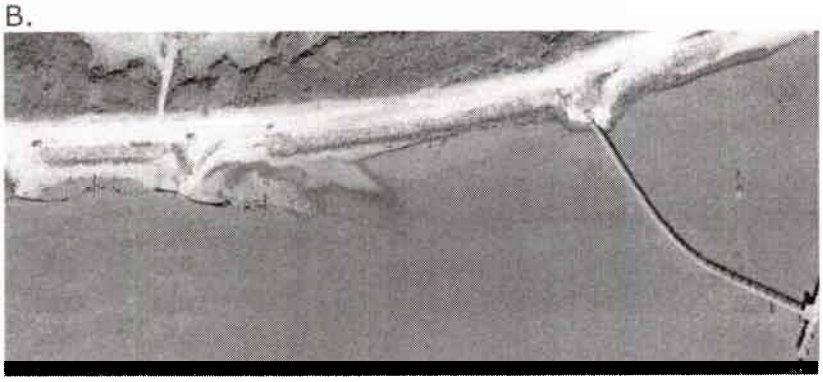
Part I. Site descriptions.

A. **Port Mahon.** The shoreline at Port Mahon is highly eroded and has been extensively affected by human efforts to fortify the shoreline against erosion. Natural shoreline substrates are sand (or marsh peat in some areas) on higher sections of the beach and unconsolidated mud at lower tide locations. The vestiges of remaining sand beach are littered with rock, cement blocks, and other materials that historically were used in attempts to control erosion. As shown (Figure 1), little beach remains exposed at high tides, leaving little habitat for foraging or resting birds and little material suitable for nesting horseshoe

Figure 1. Port Mahon Road showing (A) meeting point of Port Mahon Road and the Delaware Bay shoreline at 39.175°N; 75.409° W and (B) eroded shoreline, coastal armament, and petroleum dock.

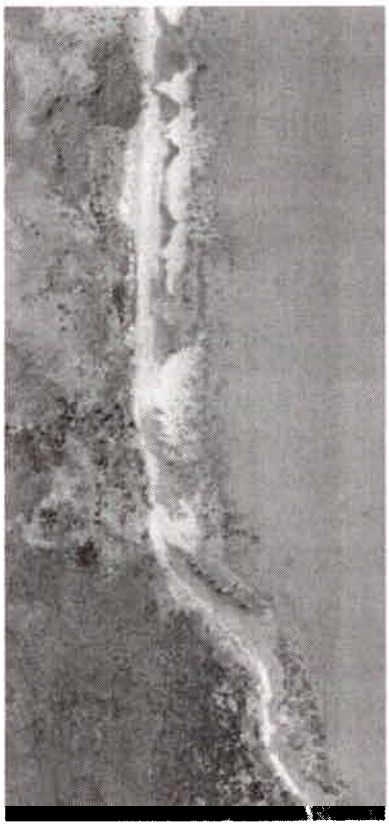
A.

B.



crabs, many of which become trapped in rocks and other erosion-control materials. Note that more intertidal mud exists on the unarmored section of shoreline south of Port Mahon Rd. (top photo, left side).

Figure 2. Section of Kelly Island shoreline showing eroded shoreline and marshland behind the shore.



B. Kelly Island.

Kelly Island is immediately north of Port Mahon, and also is slated as an environmental restoration site. The Kelly Island shoreline is substantially eroded, with some sections having a thin, sandy beach near the high tide line (Figure 2, see top section of photograph), and other sections having an eroded marsh peat shoreline. Mud is the principal substrate in the lower tidal reaches.

Because little sand remains on the Kelly Island shore, there is little habitat for horseshoe crab nesting, and so it is not a key feeding area for shorebirds during May. On the other hand, the shoreline of Kelly Island is difficult for people to access, and so it is little disturbed, and serves shorebirds well as a resting area.

C. **Prime Hook and Broadkill Beaches.**

These beaches, close to the mouth of Delaware Bay, are about 20 miles from the Port Mahon/Kelly Island locations. The bayshore in the Prime Hook region has much more extensively developed (wider) beaches than shorelines farther up the bay, and so provide better substrates for nesting horseshoe crabs. Beaches fronting the Broadkill community have groins built in efforts to control sand erosion. Sections of the beach that are less populated by people provide good potential foraging areas to shorebirds during the May and early June migration period, as do nearshore, intertidal sandflats. In

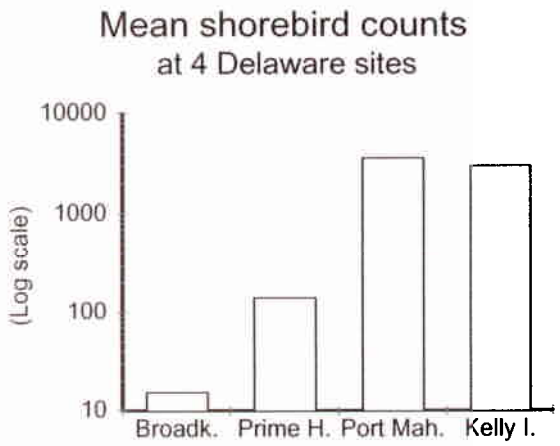
Figure 3. Beach development in the Broadkill/ Prime Hook region.

addition, banks of marsh peat are sometimes exposed in eroded sections of beach (more so on the Prime Hook than the Broadkill section), which can provide good shorebird foraging and roosting habitat.

Part II. Bird studies.

A. Results, Overall shorebird counts.

Figure 4. Mean counts of shorebirds at the four Delaware coastal study sites.



Counts of shorebirds were substantially and significantly ($P<0.001$) higher at the Port Mahon/Kelly Island pair of sites versus the Broadkill/Prime Hook pair of sites (Figure 4, note the log scale).

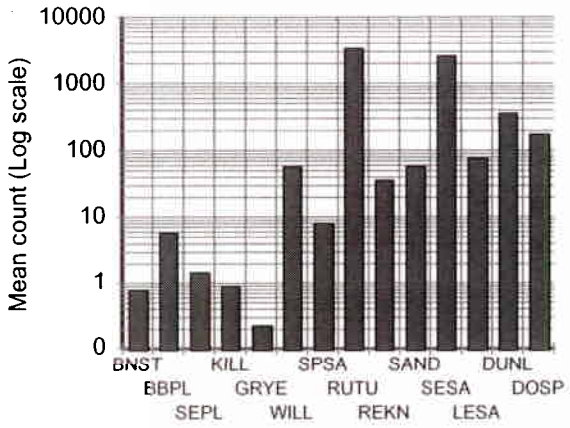
The overall numbers of shorebirds using the PAIRED study sites differed only slightly (and nonsignificantly) within the pair of locations near Port Mahon and within the pair near Prime Hook. Mean number of shorebirds counted at the Mahon pair was 3561 and 2965 versus 140 and 15 at the Prime Hook/Broadkill pair.

Table 2. Total shorebirds counted at 4 Delaware locations, Spring 2001.

Species Counted	Kelly Island	Port Mahon	Broadkill Beach	Primehook
Black-necked Stilt	0	5	0	2
Black-bellied Plover	39	0	0	12
Semipalmated Plover	3	10	0	0
Killdeer	0	6	0	2
Greater Yellowlegs	0	2	0	0
Willet	356	147	1	0
Spotted Sandpiper	31	26	4	10
Ruddy Turnstone	16443	13121	41	418
Red Knot	144	133	12	31
Sanderling	39	34	22	420
Semipalmated Sandpiper	5917	16636	57	357
Least Sandpiper	409	266	0	0
Dunlin	1672	1496	0	0
Dowitcher sp.	1379	168	0	9

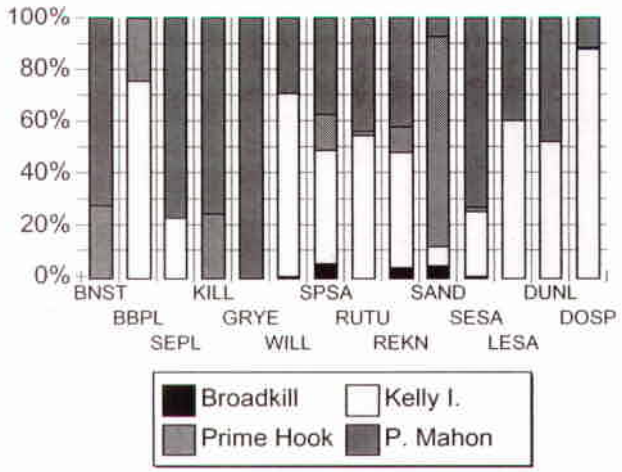
The relative abundance of the various species during the whole study is shown in Table 2 and Figure 5. Two species (Ruddy Turnstone and Semipalmated Sandpiper) far outnumbered other species (88% of the grand mean); the two next most common species (Dunlin and dowitchers) comprised only 8% of the mean.

Figure 5. Relative abundance of shorebird taxa on 4 Delaware Bay beaches, Delaware, May 2001 (note log scale). See Table 1 for species codes and names.



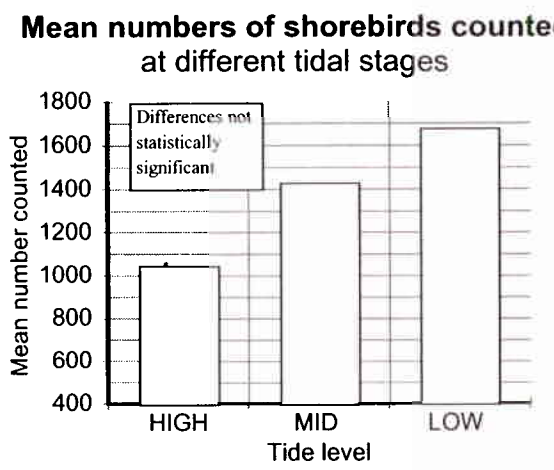
Most species were found at the four study sites in numbers that were commensurate to the totals of all shorebirds counted at the sites, but a few stand out as having skewed occurrence (Figure 6). For example, 70% of the Willets were found at Kelly Island (where slightly less than half of all shorebirds were counted). More than half of the Sanderlings were counted at Prime Hook, where only a small fraction of all shorebirds were counted. Most (>70%) of the Semipalmated Sandpipers were found at Port Mahon, whereas most of the Least Sandpipers (>60%) and dowitchers (> 88%) were at Kelly Island. In some other species, for example Killdeer or Black-bellied Plover, the percentages look skewed, but too few were found to make meaningful site comparisons. Finally, in only two species, Willet and Semipalmated Sandpiper, were the mean counts statistically significantly different ($P < 0.05$) among the four locations.

Figure 6. Relative occurrence of shorebird taxa at 4 Delaware Bay shore locations, Delaware, May 2001. See Appendix 4 for species names and codes.



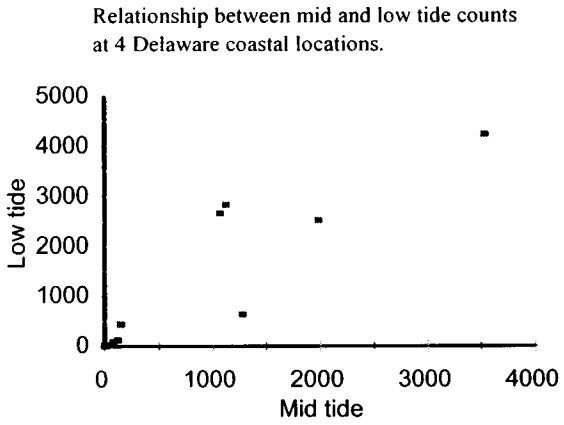
B. Results, counts in relation to tides.

Figure 7.



Numbers of shorebirds counted tended to be lower at high tides than at low tides (Figure 7), but the difference was significant only at Port Mahon; in aggregate there was no significant difference of mean counts made at low, mid, or high tide. However, given the large difference of numbers counted at the 3 locations we would not expect to find differences of the means of counts combined from all sites.

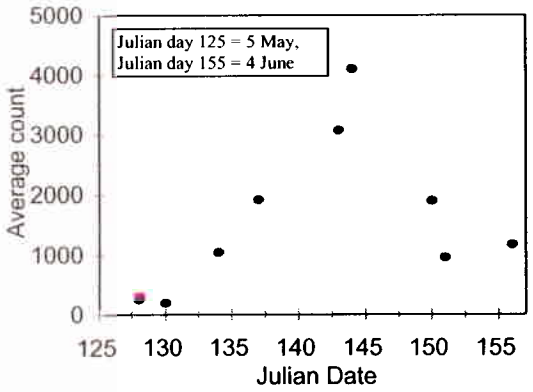
Figure 8. Correlation between mid- and low tide counts (r=0.91).



We found a close correlation between counts made at low tides versus mid-tides (Figure 8, r=0.91); the correlation between counts made at mid- and high tides was somewhat lower (r=0.77).

The overall results show the best time for counting is at lowest tides. The results also suggest that some shorebirds may use habitats away from the beaches during higher tidal phases.

Figure 9. Mean combined counts of shorebirds by date at Port Mahon and Kelly Island.



C. Results, Migration chronology.

The chronology of the 2001 Spring shorebird migration at the study shows a noticeable build-up beginning between May 10th and 14th (Julian dates 130-134, Figure 9).

Numbers then increased steadily until May 25th (Julian day 145) before declining sharply between then and May 30th.

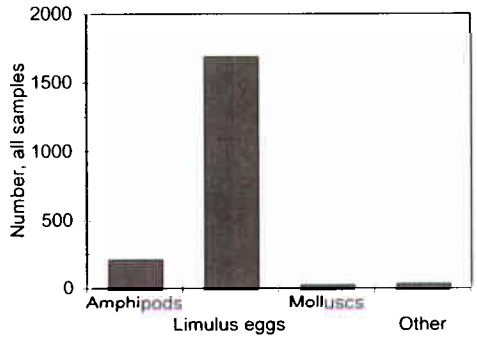
Two species, Ruddy Turnstone and Semipalmated Sandpiper, predominated in the counts, and showed similar patterns.

D. Flight-line counts. Dawn and dusk observations (detailed in Appendix 2) did not reveal any strong pattern of movement into and out of marshlands (Table 3). In part this was due to insufficient sampling effort. Most flying shorebirds were moving along the coast; the small numbers moving towards or away from the shoreline followed the course of the Mahon River.

Table 3. Dawn and dusk counts of shorebirds flying along the Delaware Bay shoreline and up/down the Mahon River, May 2001. See Appendix 4 for species names and codes.

	RUTU	SESA	DOSP	Total
Dawn, upstream	27	0	42	69
Dawn, downstream	64	32	6	102
Dusk, upstream	51	6	14	71
Dusk, downstream	12	0	0	12
				254
Dawn, coast sw	322	260	0	582
Dawn, coast ne	643	1668	58	2369
Dusk, coast sw	262	1133	48	1443
Dusk, coast ne	188	122	2	312
				4706

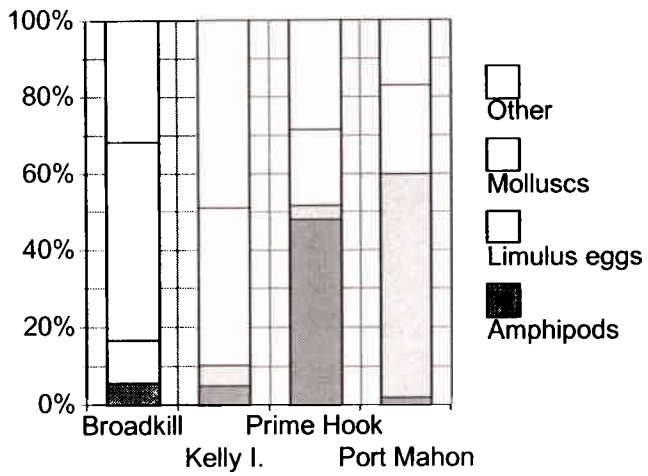
Figure 10. Relative counts of invertebrates in 4 Delaware Bay study areas, May 2001.



Part III. Invertebrate results.

The most common "invertebrate" found in the sampling were horseshoe crab (*Limulus polyphemus*) eggs (Figure 10); the next most common invertebrates were amphipods, mostly of the genera *Gammarus* and *Haustorius*. Other forms of potential invertebrate shorebird food were relatively scarce.

Figure 11. Relative occurrence (based on mean counts) by four invertebrate categories in four Delaware Bay study sites, May 2001.



Because the goal of the invertebrate sampling was to simply characterize the types present, any quantitative evaluation of the samples collected could well be inaccurate. However, crude comparisons of the percentages of each category found in the different study locations (Figure 11) suggest that there are differences in the invertebrate assemblage between the sites. This was especially evident for the most abundant item, the *Limulus* eggs.

Discussion

This project was oriented to provide baseline information on shorebird use of three areas proposed for environmental restoration on the Delaware Bay shore. An additional area (Prime Hook) where no restoration is planned also was also evaluated with hopes that 'before' and 'after' studies could be made of a restored and an abutting 'unrestored' site. The premise underlying this design was that the Prime Hook site would act as a 'control' in comparisons that would be made after restoration efforts were completed.

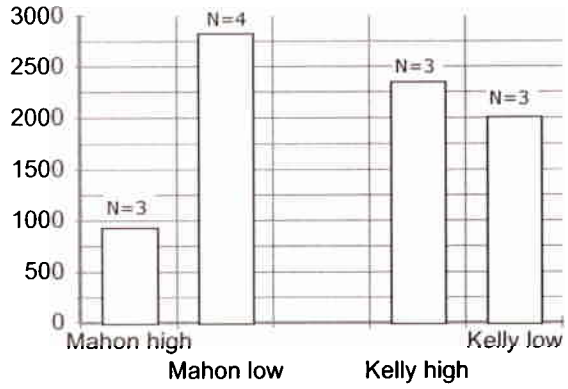
We believe that the bird counts from May/June 2001 provide a good basis for describing the numbers of shorebirds using the 4 shoreline sections. The counts at the southern (Broadkill/Prime Hook) location were similar to each other, and the northern counts (Port Mahon/Kelly Island) were similar to each other. In contrast, the northern pair of sites had much higher counts than the southern pair.

It is important to stress that our counts do not necessarily represent other Delaware Bay shoreline beaches or other habitats such as impoundments behind the beaches. We have included a single graph in Appendix 3 to reinforce this statement; it shows dramatically different species composition in impoundment versus beachfront habitats from some brief survey work completed in 1997. It also shows very different species ratios on beachfront habitats than we found in the 2 areas studied in May 2001. Although we cannot evaluate the causes underlying these differences, we believe that they are derived from differences in the ways that shorebirds are using different habitats (e.g. mudflats of impoundments versus sandy beaches), and from differences of the food resources in those habitats.

The level of invertebrate sampling that we were able to collect was insufficient to reliably quantify differences of the invertebrate animal populations between the sites, but it is clear that horseshoe crab eggs were far and away the most available food item, and that they were apparently more abundant at Port Mahon than at the other three locations. A more quantitative evaluation would be needed to verify this.

Figure 12

Mean shorebird counts at high and low tides at Port Mahon and Kelly Island



Field time also was inadequate for documenting activities of shorebirds, including prey selection, while they were being counted. But it was clear that for most species Kelly Island was used principally as a roosting site whereas the other three areas were used primarily as foraging sites. If Kelly Island was used principally for roosting, we would expect greater numbers of shorebirds to have been counted there at times when foraging habitats were restricted or inaccessible, i.e. during high tides. We have only limited samples for evaluating this, and they show the expected pattern (Figure 12); however, the differences are not statistically significant, perhaps due to the small sample sizes.

Ideally the pairs of sites we selected for this work would have been identical with respect to bird numbers, species composition, activity budgets of the birds, and accessibility of prey populations. This, of course, was not the case (Table 4). Perhaps the most important disparity was the difference of

Table 4. Estimated similarity of key habitat components within two pairs of Delaware Bay shoreline habitats (see Appendix one for location information).

	Comparable bird numbers?	Comparable bird foraging activities	Comparable invertebrates	Similar substrates	Comparable human activity
Port Mahon/Kelly Island	yes	no	no	no	no
Prime Hook/Broadkill	yes	yes	marginally ?	yes	no

foraging activities between the Port Mahon and the Kelly Island restoration sites. It remains to be seen whether this difference will be maintained after restoration work is completed, i.e. whether Kelly Island will continue to be principally used by shorebirds as a roosting site or whether alterations to it will make it an attractive foraging site. Another consideration is human activity at the sites. As shown (Table 4), human activities were not

comparable between the two sites at both the northern and the southern locations. The Port Mahon site is substantially more accessible to human activities than the Kelly Island restoration site; this did not appear to be a major issue in 2001 with respect to numbers of birds counted. However, human activities may have contributed to the lower counts at the Broadkill versus Prime Hook locations, but we had insufficient data to analyze for this.

Recommendations.

Based on our work in 2001, we believe that work in later phases of this project can be improved by:

- Increased design and time given to the invertebrate sampling, including observations from locations heavily used by shorebirds (but not necessarily appropriate as study sites for comparing effects of restoration activities), for example foraging habitats at the mouth of the Mispilllion River. (Goal would be to better understand characteristics of heavily used locations to improve restoration design) [work would require an additional, full-time field hand]
- Collection of data on shorebird foraging rates and success rates [would require an additional half-time field hand]
- Collection of data on numbers of birds foraging/not foraging during each count series (relatively small increased time requirement)
- Collection of data on shorebird prey preferences [work would need to commence 3 weeks prior to major shorebird arrival period, and continue through mid-June, and would require an additional half-time field hand].

Literature cited

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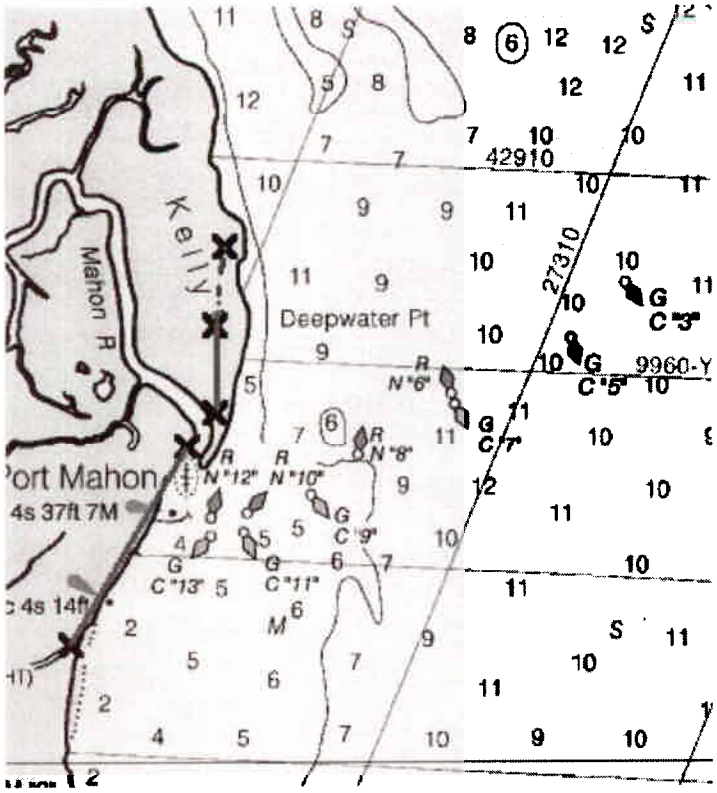
Appendix 1. Locations of four Delaware study sites evaluated for shorebird usage, May/June 2001.

A. Port Mahon and Kelly Island sites; solid lines show shorebird count locations in proposed restoration area, and dotted line shows count locations (12 transects) north of proposed restoration location.



B. Broadkill and Prime Hook sites.

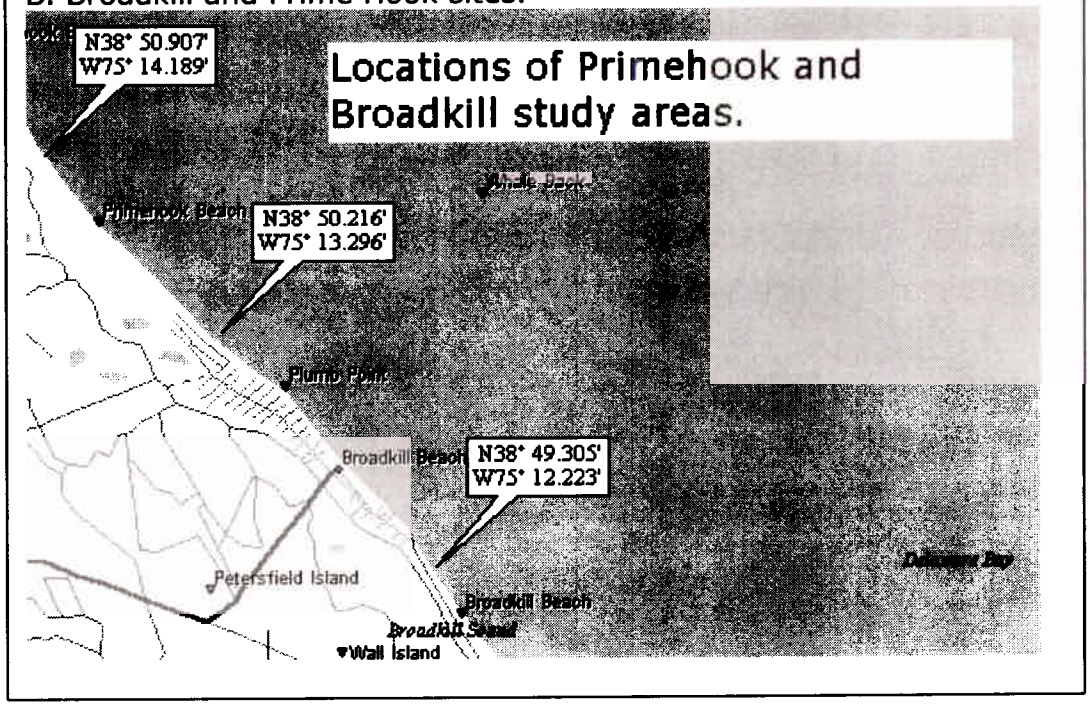


Table A1. Locations of transect markers.

Port Mahon Rd.

	Deg. north	Deg. west	min North	Min West
1	39.17518	75.40942	10.51	24.57
2	39.17559	75.40884	10.54	24.53
3	39.17596	75.40832	10.56	24.50
4	39.17638	75.40790	10.58	24.47
5	39.17689	75.40753	10.61	24.45
6	39.17720	75.40726	10.63	24.44
7	39.17766	75.40691	10.66	24.41
8	39.17814	75.40654	10.69	24.39
9	39.17859	75.40614	10.72	24.37
10	39.17905	75.40577	10.74	24.35
11	39.17952	75.40539	10.77	24.32
12	39.17999	75.40502	10.80	24.30
13	39.18044	75.40464	10.83	24.28
14	39.18091	75.40426	10.85	24.26
15	39.18137	75.40389	10.88	24.23
16	39.18185	75.40349	10.91	24.21
17	39.18231	75.40314	10.94	24.19
18	39.18278	75.40275	10.97	24.16
19	39.18324	75.40238	10.99	24.14
20	39.18370	75.40203	11.02	24.12
21	39.18419	75.40176	11.05	24.11
22	39.18472	75.40157	11.08	24.09
23	39.18525	75.40139	11.12	24.08
24	39.18578	75.40121	11.15	24.07
25	39.18630	75.40096	11.18	24.06
26	39.18679	75.40064	11.21	24.04
27	39.18725	75.40028	11.23	24.02
28	39.18772	75.39990	11.26	23.99
29	39.18818	75.39952	11.29	23.97
30	39.18866	75.39917	11.32	23.95
31	39.18913	75.39884	11.35	23.93

Kelly Island

	Deg. north	Deg. west		
1	39.19164	75.39620	11.50	23.77
2	39.19219	75.39637	11.53	23.78
3	39.19271	75.39634	11.56	23.78
4	39.19323	75.39627	11.59	23.78
5	39.19377	75.39606	11.63	23.76
6	39.19432	75.39601	11.66	23.76
7	39.19480	75.39606	11.69	23.76
8	39.19533	75.39606	11.72	23.76
9	39.19585	75.39594	11.75	23.76
10	39.19641	75.39609	11.78	23.77
11	39.19694	75.39630	11.82	23.78
12	39.19737	75.39670	11.84	23.80
13	39.19793	75.39686	11.88	23.81
14	39.19848	75.39687	11.91	23.81
15	39.19902	75.39681	11.94	23.81
16	39.19956	75.39681	11.97	23.81
17	39.20010	75.39673	12.01	23.80
18	39.20062	75.39670	12.04	23.80
19	39.20119	75.39651	12.07	23.79
20	39.20161	75.39643	12.10	23.79
21	39.20192	75.39635	12.12	23.78
22	39.20243	75.39613	12.15	23.77
23	39.20304	75.39533	12.18	23.72
24	39.20363	75.39525	12.22	23.72
25	39.20395	75.39534	12.24	23.72

Broadkill

1	38.82174	75.20362	49.3044	12.22
2	38.88217	75.20407	52.9302	12.24
3	38.82277	75.20464	49.3662	12.28
4	38.82318	75.20497	49.3908	12.30
5	38.82370	75.20551	49.422	12.33
6	38.82414	75.20606	49.4484	12.36
7	38.82455	75.20663	49.473	12.40
8	38.82492	75.20708	49.4952	12.42
9	38.82543	75.20763	49.5258	12.46
10	38.82589	75.20811	49.5534	12.49
11	38.82647	75.20879	49.5882	12.53
12	38.82701	75.20944	49.6206	12.57
13	38.82741	75.20991	49.6446	12.59
14	38.82790	75.21063	49.674	12.64
15	38.82861	75.21156	49.7166	12.69
16	38.82930	75.21231	49.758	12.74
17	38.83013	75.21342	49.8078	12.81
18	38.83070	75.21387	49.842	12.83
19	38.83116	75.21440	49.8696	12.86
20	38.83167	75.21499	49.9002	12.90
21	38.83215	75.21544	49.929	12.93
22	38.83265	75.21595	49.959	12.96
23	38.83314	75.21638	49.9884	12.98
24	38.83359	75.21705	50.0154	13.02
25	38.83404	75.21756	50.0424	13.05
26	38.83450	75.21811	50.07	13.09
27	38.83503	75.21877	50.1018	13.13
28	38.83549	75.21946	50.1294	13.17
29	38.83590	75.22009	50.154	13.21
30	38.83647	75.22090	50.1882	13.25
31	38.83690	75.22147	50.214	13.29

Prime Hook

1	38.83778	75.22286	50.2668	13.37
2	38.83827	75.22367	50.2962	13.42
3	38.83882	75.22470	50.3292	13.48
4	38.83928	75.22527	50.3568	13.52
5	38.83990	75.22606	50.394	13.56
6	38.84023	75.22656	50.4138	13.59
7	38.84054	75.22693	50.4324	13.62
8	38.84095	75.22743	50.457	13.65
9	38.84132	75.22801	50.4792	13.68
10	38.84165	75.22843	50.499	13.71
11	38.84211	75.22922	50.5266	13.75
12	38.84251	75.22977	50.5506	13.79
13	38.84310	75.23040	50.586	13.82
14	38.84355	75.23094	50.613	13.86
15	38.84400	75.23162	50.64	13.90
16	38.84457	75.23223	50.6742	13.93
17	38.84496	75.23265	50.6976	13.96
18	38.84551	75.23336	50.7306	14.00
19	38.84606	75.23398	50.7636	14.04
20	38.84623	75.23472	50.7738	14.08
21	38.84659	75.23455	50.7954	14.07
22	38.84701	75.23502	50.8206	14.10
23	38.84751	75.23547	50.8506	14.13
24	38.84797	75.23590	50.8782	14.15
25	38.84851	75.23642	50.9106	14.19

Appendix 2. Dawn and dusk counts of shorebirds moving along the Delaware Bay shoreline at Port Mahon, and counts of shorebirds moving up and down the Mahon River, May 2001. (Species codes are shown in Table 1).

8 May. The dusk survey along Port Mahon Rd. had 3 large flocks of RUTU moving north along the coastline, and some 45 SBDO moving upstream along the Mahon River (northwest).

14 May, Kelly Island. The 10 minute mud flat survey yielded very little: 4 LESA at mid-tide and a flock of 30 DUNL at high tide.

17 May, Port Mahon. The 10-min marsh scan revealed 4 GRYE, 6 SBDO, 130+ DUNL

23 May, Port Mahon marsh scan, 10 min. Flying sw along shoreline, 70 SESA, 42 RUTU, 17 SBDO, 13 DUNL. Courtship flights, 4 WILL.

Dusk scan. RUTU: 214 se along shore
72 nw along shore
12 downstream along Mahon R.
38 Upstream along Mahon R.

SBDO: 48 se along shoreline
2 nw along shore
14 upstream along Mahon R.

SESA: 320+ se along shoreline
54 nw along shoreline

24 May, Dawn scan. RUTU: 322 se along coast
64 downstream along Mahon R.
SESA: 1025 nw along shore (apparently from impoundment)
14 se along coast
SBDO 32 downstream along Mahon R.
9 NW from impoundments
BBPL 6 flying high NE, from inland.

30 May, Dawn scan. RUTU: 643 moving N along coast
27 nw along Mahon R.
SBDO: 49 N. along coast
43 nw up Mahon R.
SESA: 1341 N. along coast
246 S. along coast
6 downstream along Mahon R.

Mid-day scan: GRYE: 6 nw along shore

WILL: 4 displaying

31 May, Dusk.

RUTU: 48 sw along coast
24 ne along coast
13 upstream along Mahon R.

SESA 542 sw along coast
6 upstream along Mahon R.

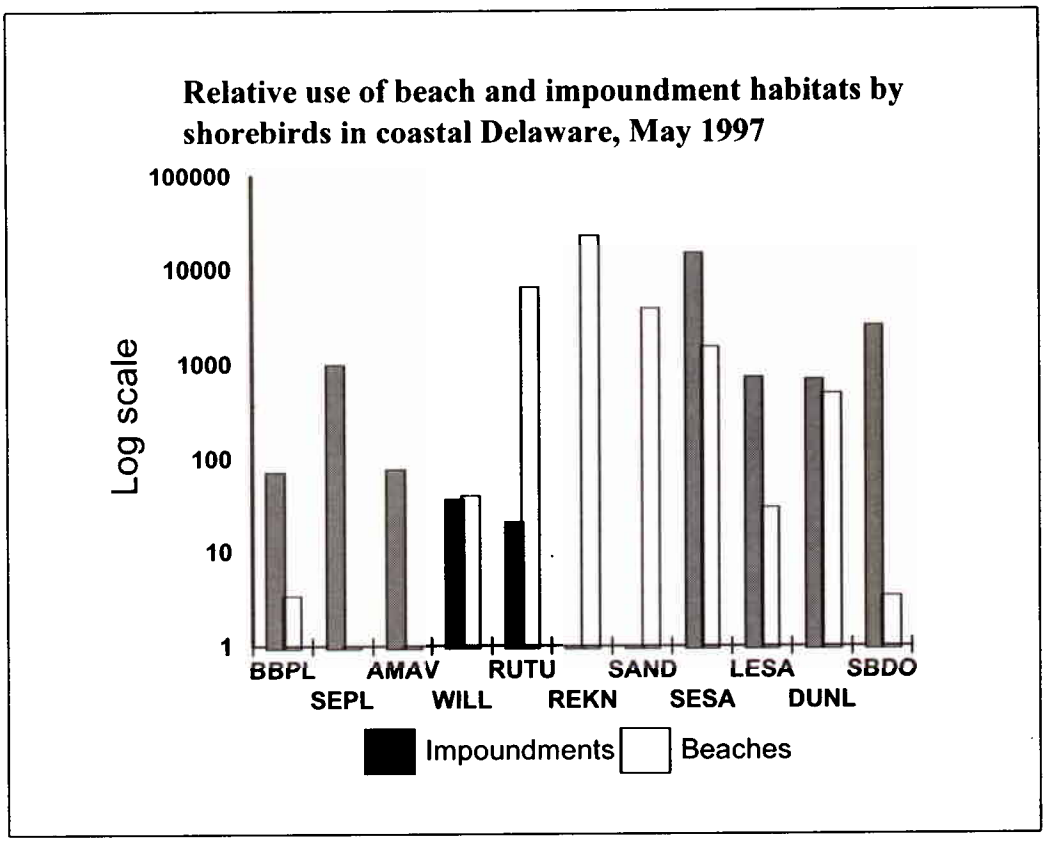
5 June, 10-min Marsh scan

WILL: 6 displaying
SBDO: 6 flying north

Dusk Survey

SESA: 271 sw along coast
68 ne along coast
RUTU: 104 ne along coast

Appendix 3.


Relative use of beach and impoundment habitats by shorebirds in coastal Delaware, May 1997
Log scale
100000
10000
1000
100
10
1
BBPL
SEPL
AMAV
WILL
RUTU
REKN
SAND
SESA
LESA
DUNL
SBDO
Impoundments
Beaches