CHAPTER 7: MARSH RESTORATION PROJECT: FISH ASSEMBLAGE STRUCTURE

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MARSH RESTORATION PROJECT: FISH ASSEMBLAGE STRUCTURE

INTRODUCTION

In July 1994, the New Jersey Department of Environmental Protection (NJDEP) issued the Final NJPDES Permit No. NJ0005622 ("Permit") for the Salem Station. In August 2001, the NJDEP renewed PSEG's Permit; with several Custom Requirements that advanced the restoration and monitoring measures required by the 1994 permit. Specific to marsh fish assemblage monitoring, the 2001 Permit required PSEG to develop and implement an Improved Biological Monitoring Work Plan (IBMWP). The IBMWP requires, among other things, the following studies:

> *Studies of habitat utilization by finfish will be conducted in restored wetlands and the results will be compared to those from reference wetlands. Four representative wetland restoration sites and two reference sites will be sampled from late spring through mid-fall in all years of the permit cycle.*
>
> *Two sampling methods will be employed, trawls and block nets. Trawl samples will be collected monthly at three stations within each marsh/adjacent study area: lower tidal creek, bay/marsh fringe (shoal), and deeper bay (>10 ft). At each of the three stations, three 2-minute tows will be conducted. Fish sampling in upper tidal creeks will employ block nets fished during daylight ebb tides on a monthly basis. All finfish will be identified to the lowest practical taxon and counted. The length of the target species will be measured in a subsample taken from each collection. Data on water temperature, dissolved oxygen, salinity, and turbidity also will be recorded at each sampling location.*

In addition to the IBMWP required monitoring, PSEG has continued weir monitoring of three habitat types within the Alloway Creek watershed to document changes in fish assemblage resulting from the restoration of *Phragmites*-dominated marsh.

The overall long-term objective of this research is to evaluate the effectiveness of restoration activities on faunal response with emphasis on the patterns and processes that control fish utilization and production for restored wetlands in Delaware Bay. More specifically, fish species composition, life history stage, and size are compared across habitat types (large and small marsh creeks) in restored and reference marshes. The target species are weakfish (*Cynoscion regalis*), white perch (*Morone americana*), spot (*Leiostomus xanthurus*), and bay anchovy (*Anchoa mitchilli*), although all fish species, as well as blue crabs (*Callinectes sapidus*), horseshoe crabs (*Limulus polyphemus*), painted turtles (*Chrysemys picta*), and diamondback terrapin turtles (*Malaclemys terrapin*) were included in sampling for a more complete understanding of restoration effects.

These studies of habitat utilization began in 1996 with the initiation of physical marsh restoration efforts, and this is the twelfth annual report in a long term monitoring project (PSE&G 1997-1999b; PSEG 2000-2008). The outline of this report was re-organized in 2007 to present results with a regional perspective. With this perspective, the fish assemblages, sampled in the restoration and reference sites monitored, can be more clearly described as part of respective ecological communities within the estuary. Accordingly, results from the Moores Beach

Reference Marsh and Commercial Township Restoration Site are summarized in the Lower Bay Region section of this report, reflecting the polyhaline (18-35 ppt) portion of the Delaware Estuary. The Mad Horse Creek Reference Marsh and Alloway Creek Restoration Site are summarized in the Upper Region section of this report, reflective of the oligohaline (0.5-5 ppt) portion of the Estuary. Sub-sections within site-specific summaries are as they have been in the previous annual reports.

MATERIALS AND METHODS

STUDY SITES AND SAMPLING FREQUENCY

The monitoring area encompasses two restoration and two reference tidal marsh sites arrayed along the New Jersey shore of Delaware Bay (Figure 7-1). These sites were sampled intensively once a month, from May through November, in daylight, and in coincident to the spring tides (Table 7-1). The intensively sampled sites included the Moores Beach Reference Marsh (Fig. 7-2a and b), the Commercial Township Restoration Site (Fig. 7-3a and b), the Mad Horse Creek Reference Marsh (Fig. 7-4), and the ACW Site, which includes the Alloway Creek (Fig. 7-5), and Mill Creek (Fig. 7-6) Sampling Areas. As previously described, based on their generalized salinity profiles and reference/restoration site characteristics the Moores Beach and Commercial Township sites were grouped into the Lower Bay Region; the Mad Horse Creek, Alloway Creek, and Mill Creek areas were grouped into the Upper Bay Region (Table 7-1). The restoration sites can also be divided broadly into two groups based on the nature of alteration: former salt hay farms adjacent to the lower bay and *Phragmites*-dominated sites adjacent to the upper bay. The Commercial Township Restoration Site, as a former salt hay farm, entailed the creation of higher order marsh creeks and the breaching of earthen dikes to allow a natural tidal inundation cycle to re-establish tidal exchange within the site. Moores Beach, located four miles southeast of the Commercial Township site, was designated as a reference site for the salt hay restoration site. The *Phragmites*-dominated restoration site included the Mill Creek and Alloway Creek areas. At these areas of the ACW site, restoration efforts are ongoing and include a range of measures to remove *Phragmites* and encourage the natural re-vegetation of *S. alterniflora* and other types of vegetation. Mad Horse Creek, located approximately 10 miles south of the ACW site, is the designated reference site for the *Phragmites*-dominated restoration sites. Mad Horse Creek has a minimal disturbance history, and probably represents the more natural marsh condition among the reference sites. Additionally, sampling of the two areas of the ACW site encompassed (within a single salinity/temperature and distance regime) stages of restoration including those dominated by *Phagmites*, areas undergoing restoration that were treated with herbicide, and reference areas dominated by *S. alterniflora.*

SAMPLING TECHNIQUES

Physical and chemical parameters were measured at the beginning of each sample, for all otter trawl and weir samples. From May to November 2008, temperature, dissolved oxygen concentration and salinity were measured with a calibrated hand-held salinity, temperature and oxygen meter (YSI Model 85), by lowering the probe into the water and recording near-surface values. Water transparency was measured by lowering a Secchi disc in the water column until it was no longer visible and recording the corresponding depth in 1.0 inch increments.

Large marsh creeks were sampled using a 4.9 m (16 ft.) semi-balloon otter trawl with 6.0 mm (0.25 inch) cod end mesh. At each site, two large marsh creeks were sampled at three locations: upper, lower, and mouth (e.g., Figure 7-2 a). Sampling took place around high tide, with three two-minute tows per station. The mouth of a creek was defined as its intersection with the next higher order creek. In general, the creek mouth trawling stations are subtidal and the lower and upper stations are shallow subtidal to intertidal. Start and end points for each trawl were recorded using Global Positioning System (GPS) co-ordinates to ensure that identical areas were sampled each month. Tow speed was 1.4 m/s (6 ft/s) and was measured using a Marsh-McBirney, Inc. model 201 flowmeter. All tows were against the current at a constant engine RPM of 1800 (90 hp Honda outboard on 24ft. Carolina Skiff) or 2500 (50 hp Honda outboard on 21ft. Carolina Skiff). Depth was measured at each site using a Hummingbird® Piranha Max 10 depth recorder. The ratio of towline to water depth was maintained at 5:1 with minor adjustments to compensate for current speed and tidal flow. A total of 504 otter trawls were made during the 2008 sampling season (Table 7-1).

The first 20 of each fish species, blue crabs, diamondback terrapins, horseshoe crabs, and painted turtles in each replicate tow were identified, enumerated, and measured separately to the nearest millimeter. Fork length (FL) was recorded for fish species with forked tails; total lengths (TL) were recorded for all other fish. Carapace width (CW) was measured for blue crabs and horseshoe crabs, and carapace length (CL) was recorded for diamondback terrapins and painted turtles. Tentative identifications were finalized and fish ages were determined using Wang and Kernehan (1979), Able and Fahay (1998) and PSE&G (1999a). Individual fishes not identifiable to species were preserved in 95% ethanol or 10% formalin and processed in the laboratory. All fish not preserved for laboratory identification and all turtles were returned to the water at the end of all sampling within a creek reach.

Small intertidal marsh creeks were sampled using weirs 1.8 m x 1.2 m x 1.2 m (6 ft. x 4 ft. x 4 ft.), with 4.5 m x 1.8 m (15 ft. x 6 ft.) wings, 0.175 mm (0.125 inch) mesh set at high tide and hauled at low tide when the creek was drained. At each small intertidal creek sampled, a net was stretched across the channel with support poles embedded vertically in the sediment. Wings were extended back onto the marsh surface from each end of the net, forming a funnel-shaped weir. Wing support poles were embedded in the sediment directly upstream and lashed to the net support poles, and the "leaded" net line was buried in the bottom sediment to eliminate gaps in the weir. Local topography occasionally prevented the complete draining of the small marsh creeks, therefore, any fish remaining in standing pools of water immediately in front of the net were seined into the weir. Fish and blue crabs were identified and enumerated, and up to 50 individuals per species per sample were measured, using the same techniques as for the trawl collections. A total of five sites were sampled monthly using weirs deployed during the day totaling 98 sets (Table 7-1).

DATA ANALYSIS

Species composition and abundances were calculated as percent frequency of occurrence (percent of samples containing each species), percent composition (proportion of individual species to the total number of fish collected), and catch-per-unit-effort (CPUE) (mean numbers of individuals collected per sample). Length frequency distributions were used to interpret age distributions for target species.

RESULTS AND DISCUSSION

LOWER BAY REGION

Physical and Chemical Parameters

Temperature

The pattern in mean water temperature observed in 2008 exhibited the typical seasonal pattern found in a temperate climate (Figure 7-7). Over the period of sampling, mean water temperatures increased from May through July, and then declined through November. Relative to the two Lower Bay Region sites, values were similar throughout the sampling season. Moores Beach values ranged from 10.1°C in November to 28.9°C in July; Commercial Township values ranged from 11.2°C in November to 29.3°C in July.

Salinity

The Lower Bay Region sites mean salinity values, as observed during the 2008 "Marsh Fish Assemblage" sampling season, are presented in Figure 7-7. Generally, over the period of sampling the average salinity in the Lower Bay Region increased from relatively low values in May to a seasonal plateau beginning in August, where values ranged from 21.1 to 22.8 ppt through the remainder of the season. Relative to the two Lower Bay Region sites of Moores Beach and Commercial Township, the mean values of salinity were generally similar. Moores Beach values ranged from 17.1 ppt in June to 22.8 ppt in October; Commercial Township ranged from 16.3 ppt in May to 22.7 ppt in August. The greatest difference in salinity occurred in June when Moores Beach was 1.2 ppt lower than Commercial Township; in all other months the difference was between 0.1 to 0.9 ppt.

Dissolved Oxygen

Monthly mean dissolved oxygen values for the 2008 sampling season are depicted in Figure 7-7. In general, mean dissolved oxygen decreased from May to the seasonal low in July, and then increased through November. Seasonal lows for the Moores Beach and Commercial Township sites occurred in July, at 3.7 and 5.4 mg/L, respectively. However, the seasonal high at Moores Beach occurred in November at 8.2 mg/L. At the Commercial Towship site the seasonal high was recorded in May at 8.6 mg/L. When comparing the values of Moores Beach and Commercial Township, their seasonal trends more or less mimic one another.

Moores Beach Reference Site

General Catch Composition

A total of 4,301 fish, representing 23 species and 16 families, was collected in 126 otter trawl collections and 14 weir sets from May through November 2008 in the Moores Beach reference site (Tables 7-1, 7-2 and 7-3). The species collected were composed primarily of transients (74%), i.e. those that spend a portion of their life history outside of the Delaware Bay, and secondarily of residents (26.0%), i.e. those that spend their entire life history in the Bay. In addition, two invertebrates, i.e., blue crab (n = 517) and horseshoe crab (12), and one reptile, i.e., diamondback terrapin (8), were included in the catches.

Large Marsh Creeks

A total of 1,473 fish, representing 19 species and 14 families, was collected in otter trawl collections during 2008 (Table 7-2 and 7-3). The total CPUE was 11.69. In the aggregate, four species comprised 92% of the total catch, and in order of decreasing abundance they were; Atlantic menhaden (46%), Atlantic croaker (28%), spot (13%), and bay anchovy (5%). While Atlantic menhaden was the most numerically abundant species, Atlantic croaker and spot were collected more frequently, with similarly high frequencies of occurrence in trawl collections of 40 and 38%, respectively. Bay anchovy occurred in 27% of the collections, Atlantic menhaden occurred in 24%, and striped bass occurred in 21% of the collections. No other species occurred in more than 9% of the collections. Striped bass was the only other species collected comprising > 1% of the total catch. Fish abundance in the large marsh creeks, as expressed by monthly catch-per-unit-effort (CPUE) for all fish collected by otter trawls, was highest in June with a monthly mean CPUE of 42.50, and CPUE's were ≤16.72 during the other months of sampling (Fig. 7-8). When viewed from a monthly perspective, species composition and predominance data illustrates a dynamic progression of species utilization underlying the aggregate data (Figure 7-9). Each of the following species comprised ≥51% of the total catch in their respective months; Atlantic menhaden in June, spot in July, and Atlantic croaker in October.

Small Marsh Creeks

A total of 2,828 fish, representing 10 species and seven families, was collected in weir sets during 2008 (Table 7-2 and 7-3). The total CPUE was 202.00. Two species comprised 99% of the total catch, and in order of decreasing abundance they were; mummichog (73%) and Atlantic silverside (26%). Mummichog occurred in all of the weir sets, and Atlantic silverside was taken in 64% of the sets. All other species occurred in ≤ 14% of the collections. Fish abundance in the small marsh creeks, as expressed by monthly catch-per-unit-effort (CPUE) for all fish collected by weir, was highest in August with a monthly mean CPUE of 518.00, and mummichog was the predominant species comprising 76% (Figure 7-8 and 7-9). Mummichog comprised 100% of the catch in May and June, and was the predominant species during all months of sampling. Atlantic silversides comprised 44% of the catch in September, in its highest month of occurrence (Figure 7-9).

Commercial Township Restoration Site

General Catch Composition

A total of 6,452 fish, representing 20 species and 15 families, was collected in 126 otter trawl collections and 14 weir sets from May through November 2008 in the Commercial Township restoration site (Tables 7-1, 7-2 and 7-4). The species collected were composed primarily of transients (65%), and secondarily of residents (35%). In addition, two invertebrates, i.e., blue crab (n = 385) and horseshoe crab (35), and one reptile, i.e., diamondback terrapin (8), were included in the catches.

Large Marsh Creeks

A total of 4,577 fish, representing 16 species and 11 families, was collected in otter trawl collections during 2008 (Table 7-2 and 7-4). The total CPUE was 36.33. Three species comprised 93% of the total catch, and in order of decreasing abundance they were; bay anchovy (54%), Atlantic croaker (22%), and spot (17%). All other species collected individually comprising ≤ 3% of the total fish catch. While, bay anchovy was the numerically abundant species, Atlantic croaker was the species most frequently taken, occurring in 59% of the trawl collections. Spot, bay anchovy, and weakfish, were represented in the catch at relatively high frequencies of 44, 38, and 23%, respectively. No other species occurred in more the 15% of the collections. Fish abundance in the large marsh creeks, decreased each month from May to July, followed by a seasonal high in August with a monthly mean CPUE of 73.17, CPUE decreased in September, then rose slightly in October and November (Figure 7-10). Spot was the predominant species in May and June comprising 57 and 46% of the catch, respectively. Bay anchovy was the predominant species in August, September and October, comprising 90, 96 and 97% of the catch, respectively. In July and November Atlantic croaker was the predominant species comprising 41 and 68 % of the catch, respectively (Figure 7-11).

Small Marsh Creeks

A total of 1,875 fish, representing nine species and six families, was collected in weir sets during 2008 (Table 7-2 and 7-4). The total CPUE was 133.93. Four species comprised 90% of the total fish catch, and in order of decreasing abundance they were; mummichog (45%), Atlantic silverside (19%), spot (15%), and bay anchovy (11%). Mummichog was taken in 86% of the weir sets, and Atlantic silverside occurred in 71% of the sets. Spot and black drum were taken in 50 and 43% of the sets, respectively. No other species occurred in more the 29% of the collections. Fish abundance in the small marsh creeks was highest in August with a monthly mean CPUE of 396.50 (Figure 7-10). Abundance was lowest in November, with a monthly mean CPUE of 14.50. Each of the following species comprised ≥52 % of the total catch in their respective months; spot in May and June, Atlantic silverside in July and September, and mummichog in August and November (Figure 7-11).

Target Species Accounts for the Lower Bay Region

Bay anchovy

In the large marsh creeks of the Lower Bay Region, bay anchovy comprised 5 and 54% of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in 27 and 38% of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach a total, of 73 individuals, was collected and their mean CPUE for the study period was 0.58. At Commercial Township a total, of 2,478, was taken and the CPUE was 19.67. Bay anchovy was collected at Moores Beach during all months except June. Bay anchovy abundance was highest in November at 1.72, and was intermediately high in May and August with CPUE's of 0.89 and 0.94, respectively. In all other months of sampling CPUE's were ≤0.28 (Figure 7-12). At Commercial Township, bay anchovy abundance was highest in August with a CPU of 65.61. Their abundance was secondarily high in October at 37.94; CPUE's were ≤20.67 in all other months of sampling. Individuals collected at Moores Beach ranged from 13 to 73 mm FL (Figure 7-13). All specimens collected in May were age 1+; all specimens collected in August and November were age 0+. Individuals collected at Commercial Township ranged from 18 to 88 mm FL (Figure 7-14). All specimens measured in May and June were age 1+. During July through November age 0+ were predominant comprising from 98 to 100% of the specimens measured. During July 60% of the specimens measured were 43 and 58 mm FL; in August 57% were 23 and 28mm; in September 68% were 28 and 33 mm; in October 52% were 33 and 38 mm; and in November 48% were 33 to 38mm.

In the small marsh creeks of the Lower Bay Region, two bay anchovy were collected at the Moores Beach Reference Site and 209 were taken at the Commercial Township Restoration Site (Tables 7-3 and 7-4). At the Moores Beach site, the mean CPUE for the study period for bay anchovy was 0.14. The fish were collected in October, the monthly mean CPUE was 1.00, and they were age 0+ at 48 and 58 mm FL (Figures 7-13 and 7-15). At the Commercial Township Restoration Site bay anchovy occurred in 29% of the weir collections. Bay anchovy was collected at Commercial Township only during September and October with CPUE's of 21.50 and 83.00, respectively. Individuals collected at Commercial Township ranged from 23 to 83 mm FL; age 0+ were predominant in both months. In September, 65% were 23 and 28 mm; and in October, 51% were 28 and 33 mm FL (Figures 7-13 and 7-14).

Spot

In the large marsh creeks of the Lower Bay Region, spot comprised 13 and 17% of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in 38 and 44% of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach, a total of 197 spot was collected, and their mean CPUE for the study period was 1.56. At Commercial Township, a total of 762 was taken and the CPUE was 6.05. At Moores Beach, spot abundance increased from 1.34 in May to a peak of 4.78 in July, and declined thereafter (Figure 7-16). Spot abundance was highest at Commercial Township in May with a CPUE of 30.22, and it steadily declined through November. Individuals collected at Moores Beach ranged from 23 to 163 mm TL , and all but one were age 0+ (Figure 7-17). During May, 46% of the specimens measured were 43 and 48 mm TL; in June, 37% were 63 and 68 mm; and in July 31% were 93 and 98 mm. Individuals collected at Commercial Township ranged from 23 to 163 mm TL, and all but nine were age 0+ (Figure 7-18). During May, 44% of the specimens measured were 43 and 48 mm TL; in June 39% were 63 to 73 mm; and in July 36% were 88 to 98 mm.

In the small marsh creeks of the lower bay region, spot comprised <1% and 15% of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in 14 and 50% of the respective weir collections (Tables 7-3 and 7-4). At Moores Beach, a total of 24 spot was collected, and their mean CPUE for the study period was 1.71. At Commercial Township, a total of 283 was taken and the CPUE was 20.21. Spot abundance was highest at Moores Beach in July with a CPUE of 8.00 (Figure 7-19). At Commercial Township, spot was most abundant in June with a CPUE of 70.50. Individuals collected at Moores Beach ranged from 93 to 133 mm TL (Figure 7-17). Individuals collected at Commercial Township ranged from 23 to 138 mm TL (Figure 7-18). All spot collected in the small marsh creeks of the lower bay region were age 0+.

Weakfish

In the large marsh creeks of the Lower Bay Region, weakfish comprised 1 and 3% of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in 9 and 23% of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach, a total of 17 individuals was collected, and their mean CPUE for the study period was 0.13. While at Commercial Township, a total of 140 was taken, and the CPUE was 1.11. At Moores Beach, weakfish was collected in July through October, with the peak in abundance occurring in August through September with identical CPUE's of 0.28 (Figure 7-20). However at Commercial Township, weakfish was collected June through September with a seasonal peak in abundance in June at 3.72, followed by a secondary peak at 3.50 in August. Individuals collected at Moores Beach ranged from 23 to 103 mm TL, and all were age 0+ (Figure 7-21). Individuals collected at Commercial Township ranged from 13 to 173 mm TL; all were age 0+ (Figure 7-22). During July, individuals ranging from 33 to 43 mm TL comprised 34% of the specimens measured; during August 57% of the individuals measured ranged from 28 to 43 mm TL. No weakfish were taken in the small marsh creeks of the Lower Bay Region.

White perch

In the large marsh creeks of the Lower Bay Region, white perch comprised <1% of the total catch at both the Moores Beach Reference and Commercial Township Restoration Sites, occurring in 7 and 11% of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach, a total of 9 individuals was collected and their mean CPUE for the study period was 0.07. At Commercial Township, a total of 30 was taken, and the CPUE was 0.24. At Moores Beach, white perch was collected in June, July, October, and November (Figure 7-23). The mean monthly CPUE was highest in June at 0.17. In months to follow, the CPUE decreased to 0.11. At Commercial Township, white perch was collected during all months of sampling, except September and October. Their abundance was highest during November at 0.83, abundance in all other months was ≤0.33. Individuals collected at Moores Beach ranged from 113 to 258 mm FL; all were age 1+ or older, possibly including individuals age 8+ (Figure 7-24). Individuals collected at Commercial Township ranged from 128 to 263 mm FL; all but one were age 1+ or older and maybe including individuals age 8+ (Figure 7-25).

In the small marsh creeks of the Lower Bay region, no white perch were caught at the Commercial Township Restoration Site. At Moores Beach Reference Site, one individual was collected, comprising <1% of the total catch, and the mean CPUE for the study period was 0.07. The mean monthly CPUE for September, the only month that white perch were collected was 0.5. The individual collected at Moores Beach was 198 mm FL (Table 7-3 and Figure 7-26).

Effects of Restoration at Lower Bay Salt Hay Farms

Abundance of all species collected in the large marsh creeks of the lower bay was 3.2 times greater at the Commercial Township Restoration Site (CPUE = 36.33) than at the Moores Beach Reference Site (11.69) (Tables 7-3 and 7-4; Figure 7-27). This difference was largely the result of the predominance of bay anchovy at the Commercial Township Site. If the bay anchovy contribution to total CPUE is subtracted from both sites, then the resulting aggregate CPUE's for all other species is more similar, 11.11 at Moores Beach and 16.66 at Commercial Township. The remaining difference in overall fish abundance may be attributed to the higher abundance of the target species, weakfish and spot, and the non-target species, Atlantic croaker and hogchoker at Commercial Township. The abundance of weakfish was 8 times greater at Commercial Township (1.11) than at Moores (0.13), and spot were four times more abundant, with respective CPUE's of 6.05 and 1.56. White perch were equally abundant at both sites, with respective CPUE's of 0.24 and 0.07. The abundance of the non-target species listed above ranged from 2 to 3 times higher at Commercial Township than at Moores Beach.

Fish species richness in trawls was similar at both sites with 19 species at Moores Beach and 16 at Commercial Township (Figure 7-27). There were 13 species common to both sites, though differing in rank order. Those species taken exclusively at one site or the other were incidental to infrequent captures represented by < 10 individuals. The top seven species at the two sites had six species in common; Atlantic croaker, spot, weakfish, Atlantic menhaden, bay anchovy, and hogchoker. Atlantic menhaden was ranked first at Moores Beach and fifth at Commercial Township; Atlantic croaker was ranked second at Moores Beach and Commercial Township; spot was ranked third at Moores Beach and Commercial Township; bay anchovy ranked fourth at Moores Beach and first at Commercial Township; weakfish ranked sixth at Moores Beach and fourth at Commercial Township; and hogchoker ranked seventh at Moores Beach and sixth at Commercial Township. Other species of note include striped bass which ranked fifth at Moores Beach and eighth at Commercial Township; and white perch which ranked eighth at Moores Beach and seventh at Commercial Township.

Abundance of all species collected in the small marsh creeks of the lower bay was generally similar at the Moores Beach Reference Site (CPUE = 202.00) and at the Commercial Township Restoration Site (133.93) (Tables 7-3 and 7-4; Figure 7-27). Fish species richness was similiar at both sites with ten species at Moores Beach and nine species at Commercial Township. There were seven species common to both sites, though differing somewhat in rank order. Mummichog and Atlantic silverside ranked first and second at both sites, respectively. Other species of note included spot ranking third at both Moores Beach and at Commercial, black drum ranking fourth at Moores Beach and seventh at Commercial, and bay anchovy ranking third at Commercial but only two individuals were taken at Moores Beach, Atlantic menhaden ranked fifth at Commercial, but was not taken at Moores Beach, and Atlantic croaker ranking sixth at Commercial, but it also was not taken at Moores Beach. The catches of the other species were ≤2 individuals, making their occurrences more or less incidental.

UPPER BAY REGION

Physical And Chemical Parameters

Temperature

The pattern in mean water temperature observed in 2008 exhibited the typical seasonal pattern found in a temperate climate (Figure 7-28). Over the period of sampling, in the upper bay region, mean water temperatures generally increased from May through July, and then generally declined through November. Monthly differences in mean water temperature among sites during the sampling season ranged from 0.4 °C in August to 2.5°C in September. Monthly regional low and high mean water temperature was not recorded consistently at any one site. Site-specific maximum and minimum values were recorded in July and November, respectively, at all sites. Mad Horse Creek minimum and maximum values ranged from 10.8 to 28.1°C; Alloway Creek ranged from 12.40 to 28.0 °C; Mill Creek ranged from 10.1 to 28.6 °C.

Salinity

The upper bay region mean salinity values, as observed during the 2008 "Marsh Fish Assemblage" sampling season, are presented in Figure 7-28. Mean salinity at Mad Horse Creek, a designated upper bay site but geographically intermediate, was always higher than the other two sample areas, ranging from a low of 8.2 ppt in May to a high of 15.1 ppt in October. Over the period of sampling at the Alloway Creek and Mill Creek areas, mean salinity values generally increased from May through October, then slightly decreased in November. Through the sampling period, mean salinity at Alloway Creek ranged from 2.9 ppt in May to 8.7 ppt in October, and at Mill Creek it ranged from 2.1 ppt in May to 7.5 ppt in October. Observed mean salinities were generally lowest at Mill Creek.

Dissolved Oxygen

Monthly upper bay region sites mean dissolved oxygen values for the 2008 sampling season are depicted in Figure 7-28. There were no clear overall trends in mean dissolved oxygen values at all three sites. At Mad Horse Creek values generally decreased from May to August, then increased to a seasonal high in November. In contrast the seasonal peak at Alloway Creek was reached in May, then values decreased through September and reached a secondary peak in October. The seasonal high mean dissolved oxygen value occurred in July at Mill Creek. At Mad Horse Creek, mean dissolved oxygen ranged from 5.4 to 9.0 mg/L; at Alloway Creek it ranged from 5.3 to 9.4 mg/L; and at Mill Creek it ranged from 5.2 to 10.2 mg/L.

Mad Horse Creek Reference Site

General Catch Composition

A total of 1,017 fish, representing 20 species and 12 families, was collected in 126 otter trawl collections and 14 weir sets from May through November 2008 in the Mad Horse Creek Reference Site (Tables 7-1, 7-2, and 7-5). Most species collected were transients (70%), i.e. those that spend a portion of their life history outside of the Delaware Bay, and the remaining species were residents (30%), i.e. those that spend their entire life history in the Bay. In addition, one invertebrate, i.e., blue crab (n = 463) and one reptile, i.e., diamondback terrapin (3), were included in the catches.

Large Marsh Creeks

A total of 900 fish, representing 19 species and 11 families, was collected in otter trawl collections during 2008 (Table 7-5). The total CPUE was 7.14. In the aggregate, six species comprised 85% of the total catch. Bay anchovy and spot comprised nearly half of the catch at 28 and 17%, respectively, and they were commonly taken, occurring in 52 and 35% of the trawl collections, respectively. The other four species of note were, in order of decreasing abundance, Atlantic menhaden (14%), white perch (11%), hogchoker (8%), and Atlantic croaker (7%). White perch were commonly taken occurring in 41% of the collections, however no other species occurred in >24% of the collections. Fish abundance in the large marsh creeks at the Mad Horse Creek site, as expressed by monthly catch-per-unit-effort (CPUE) for all fish collected by otter trawls, was highest in July with a CPUE of 10.22 (Fig. 7-29). A similar secondary peak was recorded in May at 10.00. As the aggregate data above indicated, bay anchovy was clearly predominant species. On a monthly basis, bay anchovy was the predominant species in September and October comprising 70 and 48% of the total catch, respectively. However in the other months, no species comprised > 38% of the catch (Figure 7-30).

Small Marsh Creeks

A total of 117 fish, representing seven species and seven families, was collected in weir sets during 2008 (Table 7-5). The total CPUE was 8.36. Two species comprised 86% of the total catch. They were mummichog (60%) and Atlantic menhaden (26%). Mummichog occurred in 57% of the weir sets, however Atlantic menhaden occurred in only 7% of the weir sets. Other species occurring in 21% of the collections were bay anchovy and naked goby. Fish abundance in the small marsh creeks at the Mad Horse Creek site, as expressed by monthly catch-per-unit-effort (CPUE) for all fish collected in weir sets, was highest in May at 24.00, secondarily high in November at 20.00, and relatively stable but lower during June through October, with CPUE's ranging from 0.50 to 7.00 (Fig. 7-29). Given the relatively low total catch (n=117), no clearly predominant species can be meaningfully identified (Figure 7-30).

Alloway Creek Watershed Restoration Site – Alloway Creek Sampling Area

General Catch Composition

A total of 1,192 fish, representing five species and five families, was collected in 42 weir sets from May through November 2008 in the Alloway Creek Sampling Area (Tables 7-1, 7-2 and 7-6). The representation of transient and resident species was two and three, respectively. In addition, one invertebrate, i.e., blue crab (n = 38) was included in the catches. The total CPUE was 28.38. Mummichog comprised 86% of the total catch, and occurred in 95% of the weir sets. Atlantic menhaden comprised 12% of the total catch, and occurred in 2% of the weir sets. All other species were represented by eight specimens or less, and occurred in no more than 10% of the sets. Fish abundance in the small marsh creeks at the Alloway Creek area, as expressed by monthly catch-per-unit-effort (CPUE) for all fish collected in weir sets, was highest in

September, with a CPUE of 64.33 (Fig. 7-31). During the other months of sampling, CPUE ranged from 3.50 to 38.67. In May, Atlantic menhaden comprised 64% of the catch. Mummichog was the predominant species for all other months at the Alloway Creek Sampling Area, comprising from 90 to 100% of the catch (Figure 7-32).

Alloway Creek Watershed Restoration Site – Mill Creek Sampling Area

General Catch Composition

A total of 7,748 fish, representing 21 species and 12 families, was collected in 126 otter trawl collections and 14 weir sets from May through November 2008 in the Mill Creek Sampling Area (Tables 7-1, 7-2, and 7-7). Most species collected were transients (57%), i.e. those that spend a portion of their life history outside of the Delaware Bay, and the remaining species were residents (43%), i.e. those that spend their entire life history in the Bay. In addition, one invertebrate, i.e., blue crab (n = 141) and two reptiles, i.e., diamondback terrapin (4), and painted turtle (1), were included in the catches.

Catch in Large Marsh Creeks

A total of 3,193 fish, representing 20 species and 11 families, was collected in otter trawl collections during 2008 (Table 7-7). The total CPUE was 25.34. Three species comprised 81% of the total catch. They were white perch (36%), bay anchovy (24%), and spot (21%). White perch, the most numerically abundant species, was also collected most frequently, occurring in 70% of the trawl collections. Spot and bay anchovy were taken in 63 and 51% of the collections, respectively. All other species individually comprised ≤ 8% of the catch, and occurred in ≤ 37% of the collections. Fish abundance in the large marsh creeks at the Mill Creek area, as expressed by monthly catch-per-unit-effort (CPUE) for all fish collected by otter trawls, was highest in June at 35.22; it declined thereafter to 14.11 in September; then increased to 25.94 in October (Fig. 7-33). Spot was the dominant species during the temporal peak in June, comprising 60% of the total catch (Figure 7-34). White perch was the predominant species in May and August, comprising 53 and 55% of the total catch, respectively. Two species comprised 56% of the total catch in October; they were white perch and bay anchovy at 31 and 25%, respectively.

Catch in Small Marsh Creeks

A total of 4,555 fish, representing 14 species and 12 families, was collected in weir sets during 2008 (Table 7-7). The total CPUE was 325.36. Mummichog comprised 81% of the total catch, and occurred in 100% of the weir sets. All other species individually comprised ≤ 7% of the catch. While collected in relatively low numbers, Atlantic silverside, white perch and brown bullhead were commonly taken, occurring in 79, 64 and 57%, respectively. Fish abundance in the small marsh creeks at the Mill Creek area was secondarily high in July with a CPUE of 757.00; it was highest in August at 786.00; and it decreased thereafter to 5.50 in November (Fig. 7-33). Mummichog was the predominant species during all months except May and October. During their months of predominance, they comprised from 72 to 96% of the catch (Figure 7-34). Atlantic menhaden comprised 80% in May, and no species comprised > 22% of the total catch in October.

Target Species Accounts for the Upper Bay Region

Bay Anchovy

In the large marsh creeks of the Upper Bay Region, bay anchovy comprised 28 and 24% of the total catch at the Mad Horse Creek Reference Site and Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 52 and 51% of the respective otter trawl collections (Tables 7-5 and 7-7). At Mad Horse Creek, a total, of 256 individuals, was collected and their mean CPUE for the study period was 2.03. At Mill Creek, a total of 752 was taken, and the CPUE was 5.97. Bay anchovy was collected in all months of sampling at Mad Horse, and abundance was highest in September with a CPUE of 4.50 (Figure 7-35). During the other months of sampling CPUE was ≤3.33. Similarly at Mill Creek, bay anchovy was collected in all months of sampling. Their abundance was highest at 13.06 during July, and the CPUE was ≤7.78 in the other months of sampling. Individuals collected at Mad Horse Creek ranged from 23 to 83 mm FL (Figure 7-36). All specimens collected in May and June were age 1+ and older. Age 0+ were predominant in July through September and November, comprising from 71 to 100% of the specimens measured. During October, when abundance was highest, age composition was equally divided between age 0+ and age 1+. Individuals 53 to 68 mm FL comprised 72% of the specimens measured in October. Individuals collected at Mill Creek ranged from 18 to 63 mm FL (Figure 7-37). All specimens measured in May and June were age 1+ and older. Age 0+ were predominant in July through November, comprising from 97 to 100% of the specimens measured. In July, when abundance was high at Mill Creek, specimens 28 and 33 mm FL comprised 72% of the specimens measured. In September, when abundance also was high at Mill Creek, specimens 33 and 48 mm FL comprised 80%.

No bay anchovy were collected in the small marsh creeks at the Alloway Creek Area of the Upper Bay Region during 2008. Bay anchovy comprised 3 and <1% of the total catch at the Mad Horse Creek Reference Site, and the Mill Creek Area within the Alloway Creek Restoration Site, respectively, occurring in 21 and 29% of the respective weir sets at both locations (Tables 7-5, 7-6 and 7-7). At Mad Horse Creek, a total of four individuals was collected, and their mean CPUE for the study period was 0.29. At the Mill Creek Area, a total 28 was collected, and the CPUE was 2.00. At Mad Horse Creek, bay anchovy were collected only in May and November with CPUE's of 0.50 and 1.50, respectively (Figure 7-38). At Mill Creek, bay anchovy were collected in July, September, and October, with the highest CPUE of 12.00 in October. Individuals collected at Mad Horse Creek ranged from 43 to 53 mm FL, and those individuals collected at Mill Creek ranged from 28 to 43 mm FL (Figures 7-36 and 7-37). Two of the bay anchovy collected in weir sets in the small marsh creeks of the Upper Bay Region were age 1+, all others were age 0+.

Spot

In the large marsh creeks of the Upper Bay Region, spot comprised 17 and 21% of the total catch at the Mad Horse Creek Reference and Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 35 and 63% of the respective otter trawl collections (Tables 7-5 and 7-7). At Mad Horse Creek, a total of 153 spot was collected and their mean CPUE for the study period was 1.21. At Mill Creek, a total of 659 was taken, and the CPUE was 5.23. At Mad Horse Creek, spot were collected in all months; CPUE was highest in May at 3.61, declining thereafter

(Figure 7-39). At Mill Creek, spot were collected during May through October. Abundance peaked in June at 21.22, and CPUE was ≤5.11 in the other months of their occurrence. Individuals collected at Mad Horse Creek ranged from 23 to 158 mm FL, and all but one specimen was age 0+ (Figure 7-40). Individuals collected at Mill Creek ranged from 23 to 163 mm FL, and all but seven individuals were age 0+ (Figure 7-41).

No spot were collected in the small marsh creeks at the Alloway Creek Area of the Upper Bay Region during 2008. Spot comprised 2 and <1% of the total catch at Mad Horse Creek Reference and Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 14 and 43% of the respective weir collections. At Mad Horse Creek, a total of two spot were collected and their mean CPUE for the study period was 0.14. Individuals collected at Mad Horse Creek were 33 and 118 mm TL, and were only collected in May and October with a monthly CPUE of 0.5 in both months. At Mill Creek in July through October a total of 39 spot was taken, and the CPUE was 2.79. Individuals collected at Mill Creek ranged from 68 to 148 mm TL; abundance was highest in July with a CPUE of 9.5; abundance was secondarily high in October with a CPUE of 7.00; and CPUE was ≤2.00 in all other months of occurrence (Figures 7-41 and 7-42).

Weakfish

In the large marsh creeks of the Upper Bay Region, weakfish comprised 3 and <1% of the total catch at the Mad Horse Creek Reference and Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 12 and 10% of the respective otter trawl collections (Tables 7-5 and 7-7). At Mad Horse Creek, a total of 23 weakfish was collected and their mean CPUE for the study period was 0.18. At Mill Creek, a total of 16 was taken, and the CPUE was 0.13. At Mad Horse Creek, weakfish were collected June through October, and the CPUE was highest in July at 0.39 (Figure 7-43). At Mill Creek, weakfish were collected July through October; CPUE was highest in July at 0.50. Individuals collected at Mad Horse Creek ranged from 18 to 153 mm FL (Figure 7-44). Individuals collected at Mill Creek ranged from 78 to 133 mm FL, (Figure 7-45). All weakfish measured were age 0+. No weakfish were taken in the small marsh creeks of the Upper Bay Region.

White perch

In the large marsh creeks of the Upper Bay Region, white perch comprised 11 and 36% of the total catch at the Mad Horse Creek Reference and the Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 41 and 70% of the respective otter trawl collections (Tables 7-5 and 7-7). At Mad Horse Creek, a total of 100 individuals were collected and their mean CPUE for the study period was 0.79. At Mill Creek, a total of 1,134 was taken, and the CPUE was 9.00. White perch were collected in all months of sampling at Mad Horse, and abundance was highest in May with CPUE of 1.72 (Figure 7-46). During the months to follow, CPUE decreased to a low of 0.11 in August, and then increased to similar secondary fall peaks of 1.22 and 1.44 during October and November, respectively, suggestive of a seasonally bimodal temporal distribution. At Mill Creek, white perch also were collected in all months of sampling. CPUE was high in May at 11.89, decreased to 5.60 in June, then rose to the seasonal high of 15.00 in August, declined to 2.61 in September, and then increased to a fall peak of 9.61 in November. Individuals collected at Mad Horse Creek ranged from 83 to 268 mm FL; all specimens measured were age 1+ or older, possibly including individuals age 8+ (Figure 7-47). During May, when abundance was highest, individuals 83 to 103 mm FL comprised 32% of the specimens measured. During October and November, when abundance was secondarily and similarly high, individuals 168 to 198 mm FL and 168 to 193 mm FL comprised 72 and 69% of the specimens measured, respectively. Individuals collected at Mill Creek ranged from 23 to 238 mm FL (Figure 7-48). Similar to Mad Horse Creek, age 1+ and older individuals appear to be predominant at Mill Creek. However unlike Mad Horse Creek, age 0+ individuals were represented in the Mill Creek catch. During May and November, when abundance was similarly high, individuals 23 to 83 mm FL (probably age 0+) comprised 41 and 31% of the specimens measured, respectively.

No white perch were collected in the small marsh creeks at the Mad Horse Creek Reference Site. In the small marsh creeks of the Upper Bay Region, white perch comprised <1 and 2% of the total catch at the Alloway and Mill Creek Areas within the Alloway Creek Restoration Site, respectively; occurring in 7 and 64% of the respective weir sets (Tables 7-5, 7-6 and 7-7). At the Alloway Creek Area, a total of five white perch was taken, and the CPUE was 0.12. At the Mill Creek Area, a total of 100 was collected, and the CPUE was 7.14 (Figure 7-49). At Alloway Creek, they were collected only in June, October, and November with respective CPUE's of 0.17, 0.50, and 0.17. At Mill Creek, white perch were collected in May through October. Their abundance was highest in July with a CPUE of 24.50, abundance was secondarily high in October at 12.00, and CPUE was ≤6.50 in the other months of their occurrence. Individuals collected at Alloway Creek ranged from 93 to 183 mm FL, and all were age 1+. Those collected at Mill Creek ranged from 48 to 163 mm FL, and were predominantly age 1+ (Figures 7-47, 7-48 and 7-50).

Effects of Restoration at Upper Bay *Phragmites*-Dominated Marshes

Abundance of all species collected in the large marsh creeks of the upper bay was 3.6 times greater at the Mill Creek Sampling Area of the ACW Site (CPUE = 25.34) than at the Mad Horse Creek Reference Site (CPUE = 7.14) (Tables 7-5 and 7-7; Figure 7-51). Even though white perch, spot, and bay anchovy were the predominant species at both sites, this difference in overall fish abundance was largely the result of their higher absolute abundance at the Mill Creek area. If the combined contribution of white perch, spot, and bay anchovy to the total CPUE is subtracted from both sites, then the resulting aggregate CPUE's for all other species are more similar, i.e., 3.11 at Mad Horse Creek and 5.14 at Mill Creek. The contribution to overall fish abundance at Mill Creek made by the other one target species, weakfish, was more dubious. Weakfish was slightly more abundant at Mad Horse Creek (0.18) than at Mill Creek (0.13).

Fish species richness was similar at Mad Horse Creek and at Mill Creek with 19 and 20 species, respectively (Figure 7-51). There were 16 species common to both sites, though differing in rank order. Those species taken exclusively at one site or the other were incidental captures represented by ≤2 individuals, with the exception of brown bullhead. They were taken only at Mill Creek where a total of 63 was collected comprising 2% of the total catch. White perch ranked first at Mill Creek and fourth at Mad Horse; and bay anchovy ranked first at Mad Horse and second at Mill Creek. While both sites are located in the "upper bay", they also are in the transitional portion of the estuary where generally freshwater and saltwater assemblages intermingle at the boundaries of their favored distributions. During 2008, this intermingling exhibited similarities and commonalities of note. The fish assemblage at the Mad Horse Creek site consisted of 14 transient, four estuarine resident and two freshwater resident species. Similarly at the Mill Creek area, the fish assemblage consisted of 12 transient, three estuarine resident and six freshwater resident species. A total of 12 transient species were common to both sites; three of the estuarine residents occurred at both sites; and one freshwater resident species were common to both sites. However, summer flounder, a species which is typically more associated with the higher salinity waters of the "lower bay", was taken exclusively at Mad Horse Creek. Similarly, carp and eastern silvery minnow, species which are typically more associated with the low or no salinity waters of the freshwater tidal river, were taken exclusively at Mill Creek.

Abundance of all species collected in the small marsh creeks of the upper bay was higher at both restoration sampling areas than at the Mad Horse Creek Reference Site. At Alloway Creek, the total CPUE (28.38) was 3.4 times greater than that at Mad Horse Creek (8.36), and at Mill Creek (325.36) it was 38.9 times greater (Tables 7-5, 7-6 and 7-7; Figure 7-51). These differences were driven by the disproportionate predominance of mummichog at both restoration areas. This was particularly notable at both Mill Creek and Alloway Creek where mummichog abundance was two orders of magnitude higher than at Mad Horse Creek. Like abundance, fish species richness was higher at Mill Creek than at the Mad Horse Creek Reference Site, with 14 and 7 species, respectively (Figure 7-51). Species richness at Alloway Creek was five, and similar to Mad Horse Creek. Four of seven species taken at Mad Horse Creek, i.e., mummichog, Atlantic silverside, Atlantic menhaden and naked goby, were common to both Alloway and Mill Creeks, and all species taken at Alloway Creek were common to Mill Creek. The typically ubiquitous bay anchovy was taken at both Mad Horse and Mill Creek, but were curiously absent from weir sets at Alloway Creek. There were six species taken only at Mill Creek, each comprised <1% of the total catch. Regarding species rank order, mummichog was first at all three sites; Atlantic menhaden was ranked second at all three sites; naked goby was ranked third at Mad Horse and Alloway Creek, but only one individual was caught at Mill Creek; bay anchovy was ranked fourth at Mad Horse, sixth at Mill Creek, but absent from Alloway Creek; and white perch was ranked fourth at Alloway and Mill Creek, but was absent from Mad Horse.

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Table 7-1. Summary of sampling efforts for the 2008 Marsh Fish Assemblage sampling season.

Site	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Site Totals
Lower Bay								
Moores Beach								
Trawl	18	18	18	18	18	18	18	126
Weir	2	2	2	2	2	2	2	14
Commercial Township								
Trawl	18	18	18	18	18	18	18	126
Weir	2	2	2	2	2	2	2	14
Upper Bay								
Mad Horse Creek								
Trawl	18	18	18	18	18	18	18	126
Weir	2	2	2	2	2	2	2	14
Mill Creek								
Trawl	18	18	18	18	18	18	18	126
Weir	2	2	2	2	2	2	2	14
Alloway Creek								
Weir	6	6	6	6	6	6	6	42
Monthy Totals								
Trawl	72	72	72	72	72	72	72	504
Weir	14	14	14	14	14	14	14	98
Combined	86	86	86	86	86	86	86	602

Table 7-2 Checklist of Delaware Bay Fauna collected from May 2008 to November 2008. Key: T = Tansient, R = Resident.

	Species	Common Name	Pattern of Utilizations
Invertebrates			
	Callinectes sapidus	Blue claw crab	R
	Limulus polyphemus	Horseshoe crab	T
Achiridae			
	Trinectes maculatus	Hogchoker	R
Anguillidae			
	Anguilla rostrata	American eel	T
Atherinopsidae			
	Menidia menidia	Atlantic silverside	T
Batrachoididae			
	Opsanus tau	Oyster toadfish	R
Carcharhinidae			
	Mustelus canis	Smooth dogfish	T
Clupeidae			
	Alosa aestivalis	Blueback herring	T
	Alosa mediocris	Hickory shad	T
	Alosa sapidissima	American shad	T
	Brevoortia tyrannus	Atlantic menhaden	T
	Dorosoma cepedianum	Gizzard shad	R
Cyprinidae			
	Cyprinus carpio	Common carp	R
	Hybognathus regius	Eastern silvery minnow	R
Cyprinodontidae			
	Cyprinodon variegatus	Sheepshead minnow	R
Emydidae			
	Chrysemys picta	Painted Turtle	R
Engraulidae			
	Anchoa mitchilli	Bay anchovy	T
Fundulidae			
	Fundulus luciae	Spotfin killifish	T
	Fundulus heteroclitus	Mummichog	R
	Fundulus majalis	Striped killifish	T
Gobiidae			
	Gobiosoma bosc	Naked goby	R
Ictaluridae			
	Ameiurus catus	White catfish	R
	Ameiurus nebulosus	Brown bullhead	R
	Ictalurus punctatus	Channel catfish	R
Moronidae			
	Morone americana	White perch	R
	Morone saxatilis	Striped bass	T
Mugilidae			
	Mugil curema	White mullet	T
Ophidiidae			
	Ophidion marginatum	Striped cusk eel	T
Paralichthyidae			
	Paralichthys dentatus	Summer flounder	T

Table 7-2. Continued.

Phycidae			
	Uropycis regia	Spotted hake	T
Pomatomidae			
	Pomatomus saltatrix	Bluefish	T
Sciaenidae			
	Bairdiella chysoura	Silver perch	T
	Cynoscion regalis	Weakfish	T
	Leiostomus xanthurus	Spot	T
	Mircopogonias undulatus	Atlantic croaker	T
	Pogonias cromis	Black drum	T
	Menticirrhus saxatilis	Northern kingfish	T
Serranidae			
	Centropristis striata	Black sea bass	T
Reptilia			
	Malaclemys terrapin	Diamondback terrapin	R

Table 7-3. Composite species composition, for large marsh creek (otter trawl) and small marsh creek (weir) collections, for Moores Beach from May to November 2008.

	Large Marsh Creeks				Small Marsh Creeks			
Species	Percent frequency of occurrence	Percent composition	Catch per unit effort	Total collected	Percent frequency of occurrence	Percent composition	Catch per unit effort	Total collected
Alosa mediocris	<1	<1	0.01	1	--	--	--	--
Anchoa mitchilli	**27**	**5**	**0.58**	**73**	**7**	**<1**	**0.14**	**2**
Anguilla rostrata	2	<1	0.02	2	--	--	--	--
Brevoortia tyrannus	24	46	5.34	673	--	--	--	--
Centropristis striata	<1	<1	0.01	1	--	--	--	--
Cynoscion regalis	**9**	**1**	**0.13**	**17**	--	--	--	--
Cyprinodon variegatus	--	--	--	--	14	<1	0.14	2
Fundulus heteroclitus	2	<1	0.02	3	100	73	147.07	2059
Fundulus luciae	--	--	--	--	7	<1	0.14	2
Fundulus majalis	--	--	--	--	7	<1	0.07	1
Gobiosoma bosc	2	<1	0.06	7	7	<1	0.07	1
Leiostomus xanthurus	**38**	**13**	**1.56**	**197**	**14**	**<1**	**1.71**	**24**
Menidia menidia	--	--	--	--	64	26	52.29	732
Micropogonias undulatus	40	28	3.33	419	--	--	--	--
Morone americana	**7**	**<1**	**0.07**	**9**	**7**	**<1**	**0.07**	**1**
Morone saxatilis	21	3	0.37	46	--	--	--	--
Mugil curema	<1	<1	0.01	1	--	--	--	--
Mustelus canis	<1	<1	0.01	1	--	--	--	--
Ophidion marginatum	<1	<1	0.01	1	--	--	--	--
Opsanus tau	<1	<1	0.01	1	--	--	--	--
Pogonias cromis	2	<1	0.02	2	7	<1	0.29	4
Pomatomus saltatrix	2	<1	0.02	3	--	--	--	--
Trinectes maculatus	7	1	0.13	16	--	--	--	--
Total Fish	--	--	11.69	1473	--	--	202.00	2828
Callinectes sapidus	71	18	2.62	330	79	6	13.36	187
Malaclemys terrapin	6	<1	0.06	8	--	--	--	--
Limulus polyphemus	6	<1	0.08	10	14	<1	0.14	2
Total all species	--	--	14.45	1821	--	--	215.50	3017

Table 7-4. Composite species composition, for large marsh creek (otter trawl) and small marsh creek (weir) collections, for Commercial Township from May to November 2008.

	Large Marsh Creeks				**Small Marsh Creeks**			
Species	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total collected**	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total collected**
Anchoa mitchilli	**38**	**54**	**19.67**	**2478**	**29**	**11**	**14.93**	**209**
Anguilla rostrata	2	<1	0.02	3	--	--	--	--
Brevoortia tyrannus	13	2	0.75	94	14	3	4.50	63
Cynoscion regalis	**23**	**3**	**1.11**	**140**	--	--	--	--
Cyprinodon variegatus	--	--	--	--	7	<1	0.07	1
Dorosoma cepedianum	<1	<1	0.01	1	--	--	--	--
Fundulus heteroclitus	--	--	--	--	86	45	60.64	849
Gobiosoma bosc	--	--	--	--	14	<1	0.14	2
Leiostomus xanthurus	**44**	**17**	**6.05**	**762**	**50**	**15**	**20.21**	**283**
Menidia menidia	--	--	--	--	71	19	25.50	357
Micropogonias undulatus	59	22	7.89	994	21	3	4.43	62
Morone americana	**11**	**<1**	**0.24**	**30**	--	--	--	--
Morone saxatilis	11	<1	0.15	19	--	--	--	--
Mustelus canis	<1	<1	0.01	1	--	--	--	--
Ophidion marginatum	<1	<1	0.01	1	--	--	--	--
Opsanus tau	2	<1	0.02	2	--	--	--	--
Paralichthys dentatus	2	<1	0.02	2	--	--	--	--
Pogonias cromis	2	<1	0.02	2	43	3	3.50	49
Trinectes maculatus	15	1	0.37	46	--	--	--	--
Urophycis regia	2	<1	0.02	2	--	--	--	--
Total Fish	--	--	36.33	4577	--		133.93	1875
Callinectes sapidus	46	5	1.81	228	79	8	11.21	157
Malaclemys terrapin	6	<1	0.06	8	--	--	--	--
Limulus polyphemus	8	<1	0.28	35	--	--	--	--
Total all species	--	--	38.48	4848	--	--	145.14	2032

Table 7-5. Composite species composition, for large marsh creek (otter trawl) and small marsh creek (weir) collections, for Mad Horse Creek from May to November 2008.

	Large Marsh Creeks				**Small Marsh Creeks**			
Species	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total collected**	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total collected**
Alosa aestivalis	<1	<1	0.01	1	--	--	--	--
Alosa mediocris	<1	<1	0.01	1	--	--	--	--
Ameiurus catus	2	<1	0.02	2	--	--	--	--
Anchoa mitchilli	**52**	**28**	**2.03**	**256**	**21**	**3**	**0.29**	**4**
Anguilla rostrata	2	<1	0.02	2	7	2	0.14	2
Bairdiella chrysoura	3	<1	0.06	7	--	--	--	--
Brevoortia tyrannus	21	14	1.02	128	7	26	2.14	30
Cynoscion regalis	**12**	**3**	**0.18**	**23**	--	--	--	--
Dorosoma cepedianum	<1	<1	0.01	1	--	--	--	--
Fundulus heteroclitus	--	--	--	--	57	60	5.00	70
Gobiosoma bosc	4	<1	0.04	5	21	5	0.43	6
Leiostomus xanthurus	**35**	**17**	**1.21**	**153**	**14**	**2**	**0.14**	**2**
Menidia menidia	3	3	0.21	27	14	3	0.21	3
Micropogonias undulatus	20	7	0.52	65	--	--	--	--
Morone americana	**41**	**11**	**0.79**	**100**	--	--	--	--
Morone saxatilis	18	3	0.21	27	--	--	--	--
Paralichthys dentatus	2	<1	0.02	2	--	--	--	--
Pogonias cromis	11	3	0.20	25	--	--	--	--
Pomatomus saltatrix	2	<1	0.02	2	--	--	--	--
Trinectes maculatus	24	8	0.58	73	--	--	--	--
Total Fish	--	--	7.14	900	--	--	8.36	117
Callinectes sapidus	73	22	2.00	252	86	64	15.07	211
Malaclemys terrapin	2	<1	0.02	3	--	--	--	--
Total all species	--	--	9.17	1155	--	--	23.43	328

Table 7-6. Composite species composition, for small marsh creek (weir) collections, for Alloway Creek area during May to November 2008.

	Small Marsh Creeks			
Species	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total collected**
Brevoortia tyrannus	2	12	3.52	148
Fundulus heteroclitus	95	86	24.50	1029
Gobiosoma bosc	10	<1	0.19	8
Menidia menidia	5	<1	0.05	2
Morone americana	**7**	**<1**	**0.12**	**5**
Total Fish	--	--	28.38	1192
Callinectes sapidus	43	3	0.90	38
Total all species	--	--	29.29	1230

Table 7-7. Composite species composition, for large marsh creek (otter trawl) and small marsh creek (weir) collections, for Mill Creek area from May to November 2008.

	Large Marsh Creeks				Small Marsh Creeks			
Species	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total collected**	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total collected**
Alosa sapidissima	<1	<1	0.01	1	--	--	--	--
Ameiurus nebulosus	31	2	0.50	63	57	<1	2.00	28
Anchoa mitchilli	**51**	**24**	**5.97**	**752**	**21**	**<1**	**2.00**	**28**
Anguilla rostrata	2	<1	0.03	4	14	<1	0.14	2
Bairdiella chrysoura	<1	<1	0.01	1	--	--	--	--
Brevoortia tyrannus	36	8	1.90	240	21	7	22.21	311
Cynoscion regalis	**10**	**<1**	**0.13**	**16**	--	--	--	--
Cyprinis carpio	4	<1	0.06	7	--	--	--	--
Dorosoma cepedianum	37	4	0.97	122	36	<1	1.93	27
Fundulus heteroclitus	<1	<1	0.01	1	100	81	264.43	3702
Gobiosoma bosc	--	--	--	--	7	<1	0.07	1
Hybognathus regius	<1	<1	0.01	1	7	<1	0.36	5
Ictalurus punctatus	<1	<1	0.01	1	--	--	--	--
Leiostomus xanthurus	**63**	**21**	**5.23**	**659**	**43**	**<1**	**2.79**	**39**
Menidia menidia	<1	<1	0.01	1	79	7	21.43	300
Micropogonias undulatus	34	4	1.06	133	7	<1	0.07	1
Morone americana	**70**	**36**	**9.00**	**1134**	**64**	**2**	**7.14**	**100**
Morone saxatilis	17	1	0.26	33	--	--	--	--
Pogonias cromis	2	<1	0.02	2	14	<1	0.71	10
Pomatomus saltatrix	6	<1	0.08	10	7	<1	0.07	1
Trinectes maculatus	7	<1	0.10	12	--	--	--	--
Total Fish	--	--	25.34	3193	--	--	325.36	4555
Callinectes sapidus	25	1	0.32	40	79	2	7.21	101
Chrysemys Picta	<1	<1	0.01	1	--	--	--	--
Malaclemys terrapin	3	<1	0.03	4	--	--	--	--
Total all species	--	--	25.70	3238	--	--	332.57	4656

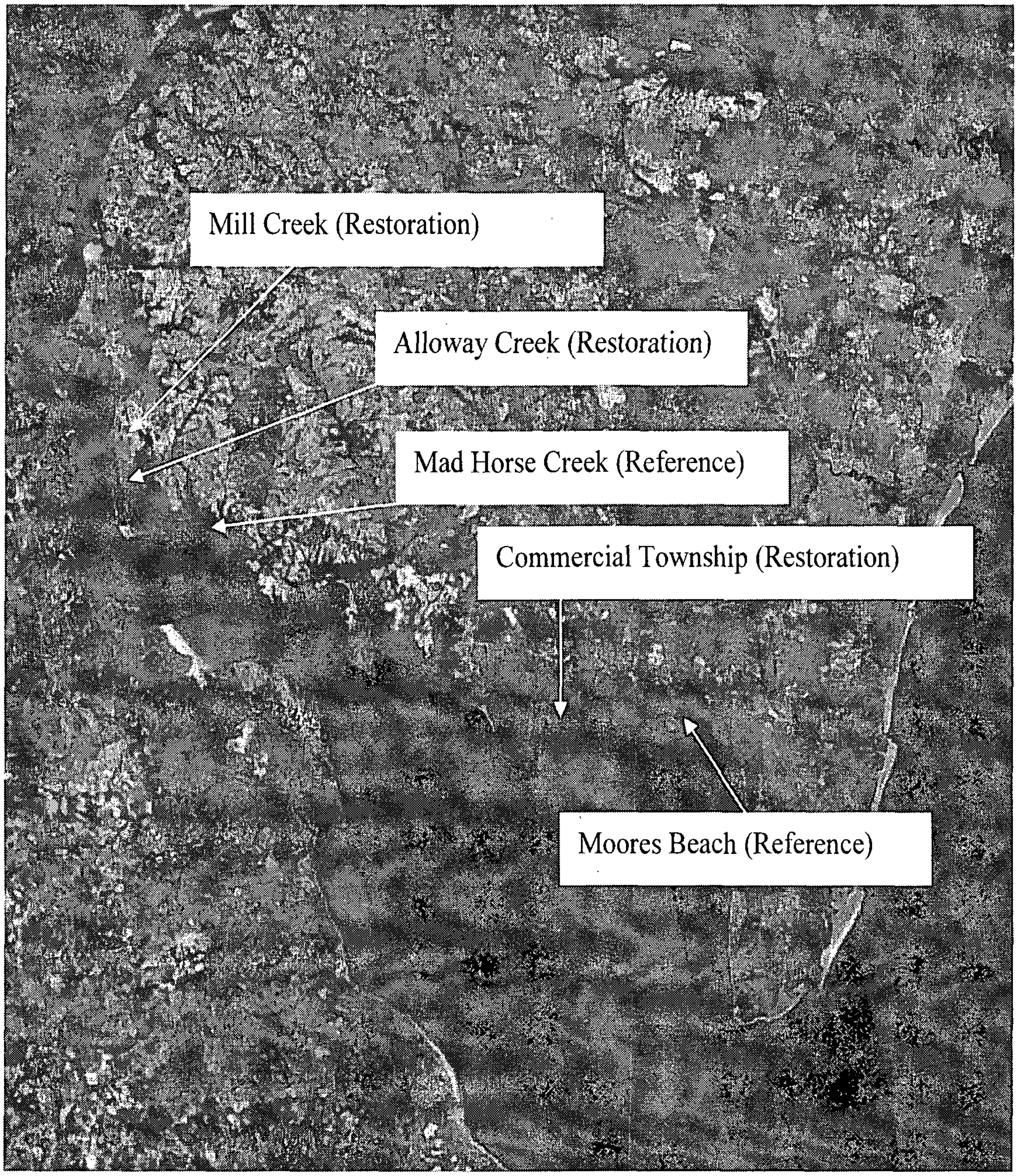


Figure 7-1. Restored and reference marsh study sites in Delaware Bay.

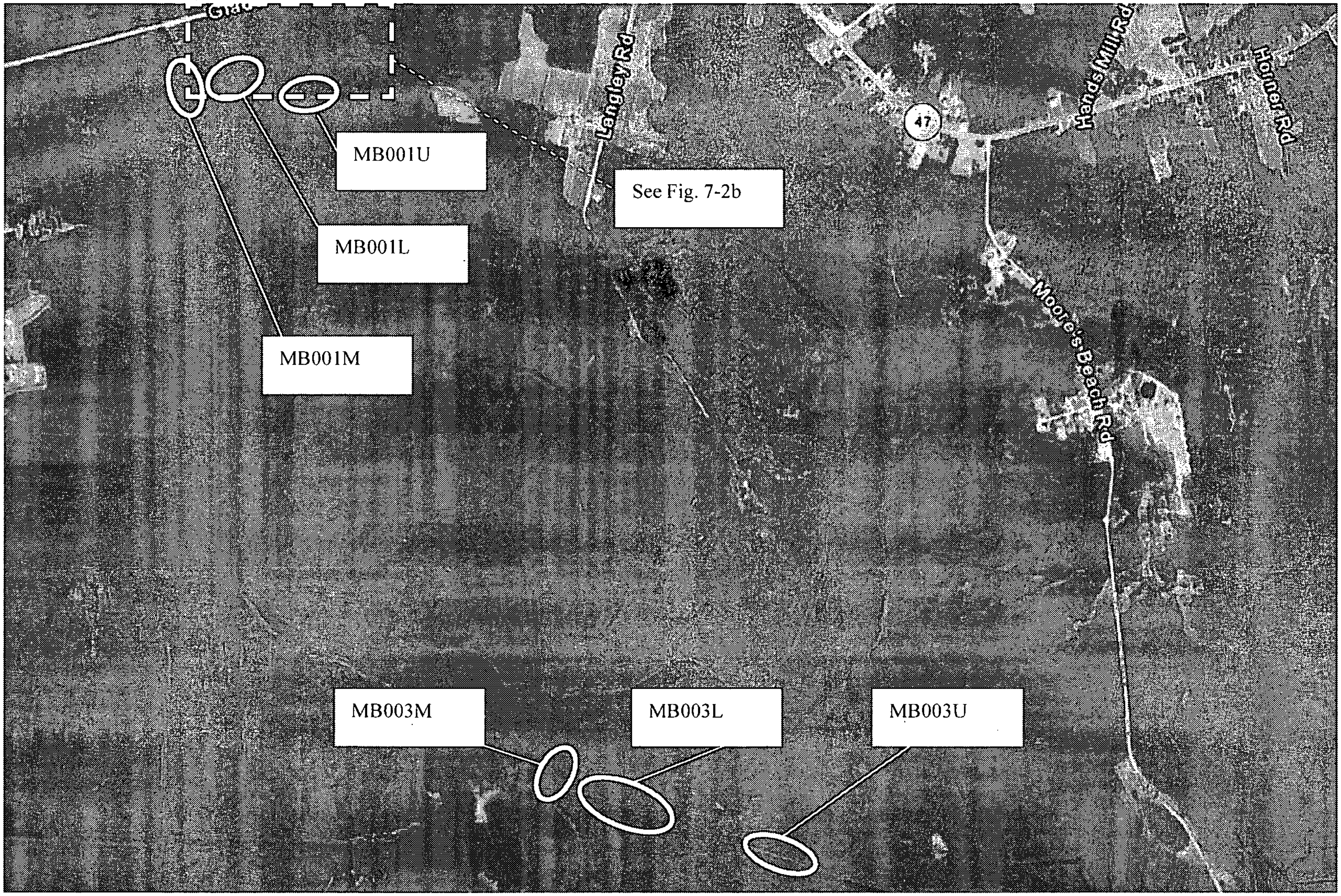


Figure 7-2a. Moores Beach sampling sites (reference) in Delaware Bay during 2008.

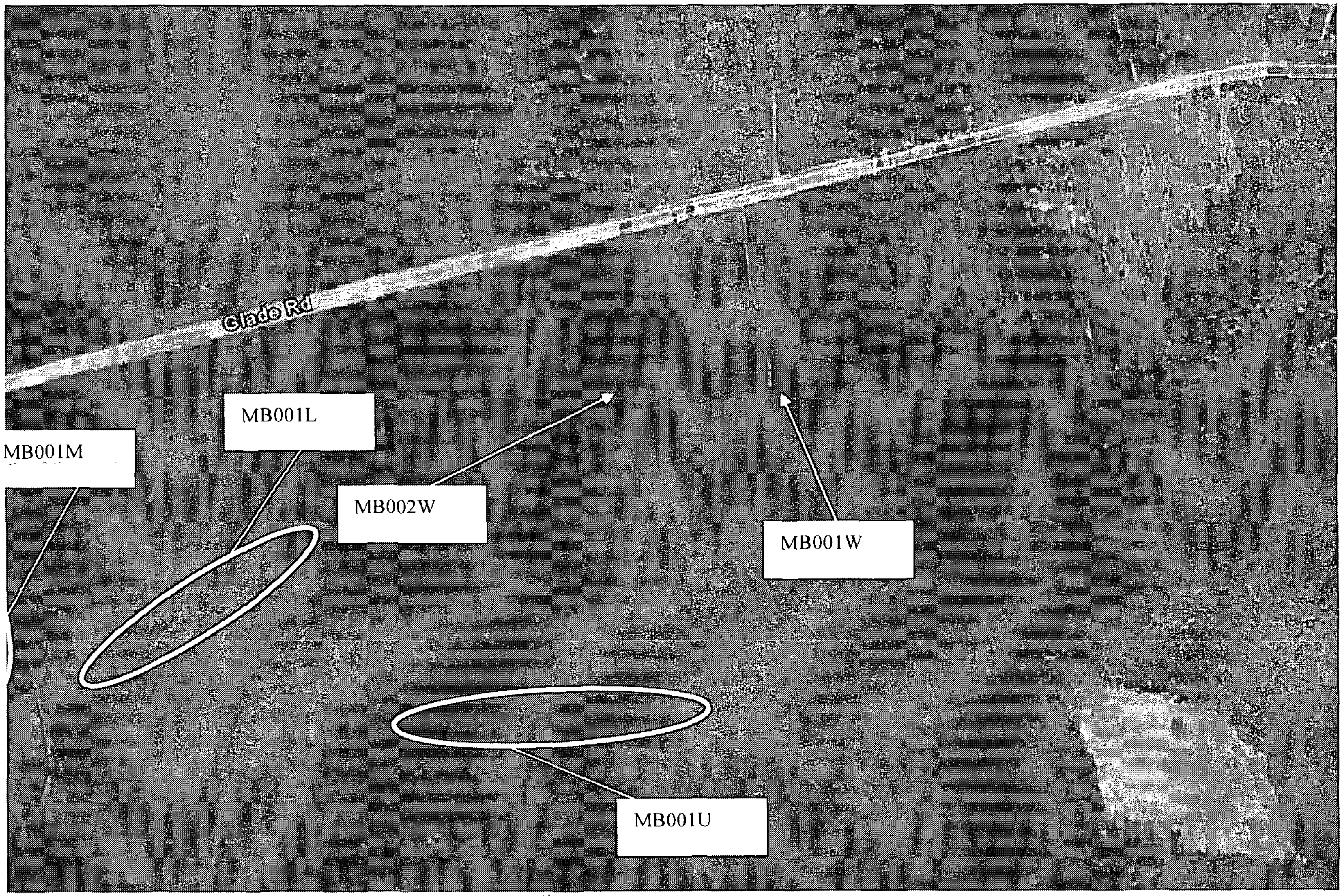


Figure 7-2b. Expanded view of small marsh creeks (weir) at the Moores Beach Reference Site in Delaware Bay during 2008.

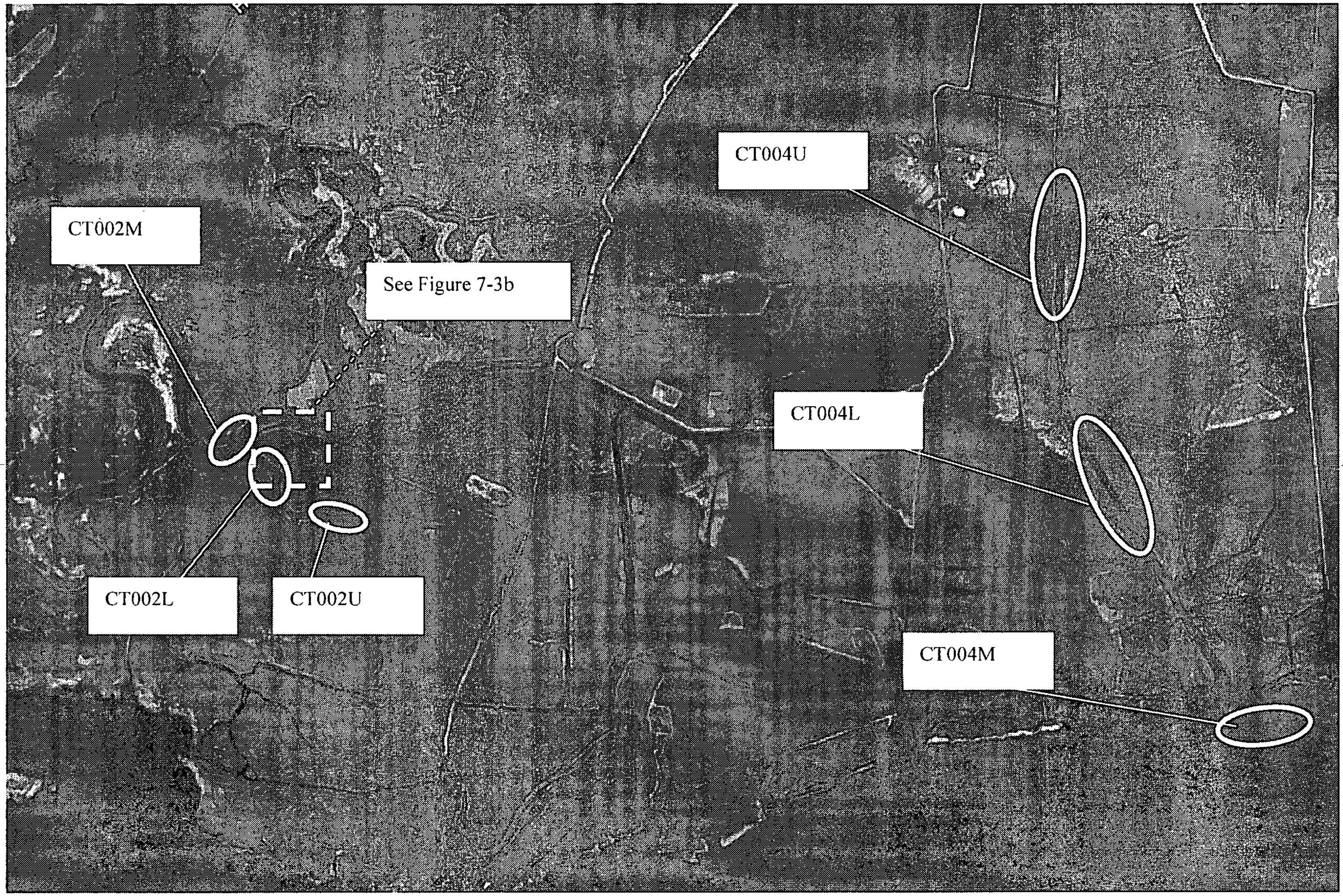


Figure 7-3a. Commercial Township sampling sites (restoration) in Delaware Bay during 2008.

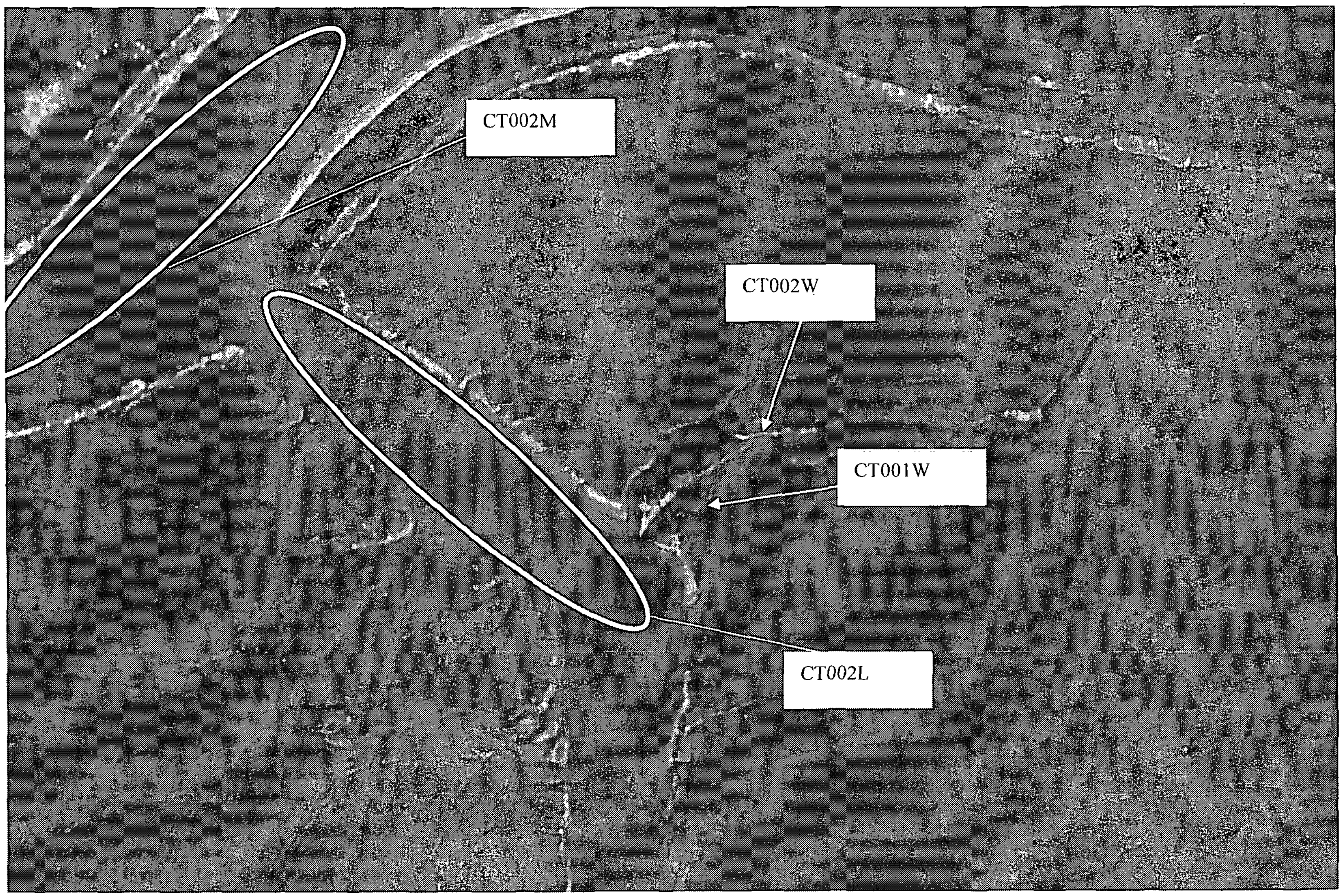


Figure 7-3b. Expanded view of small marsh creeks (weir) at the Commercial Township Restoration Site in Delaware Bay during 2008.

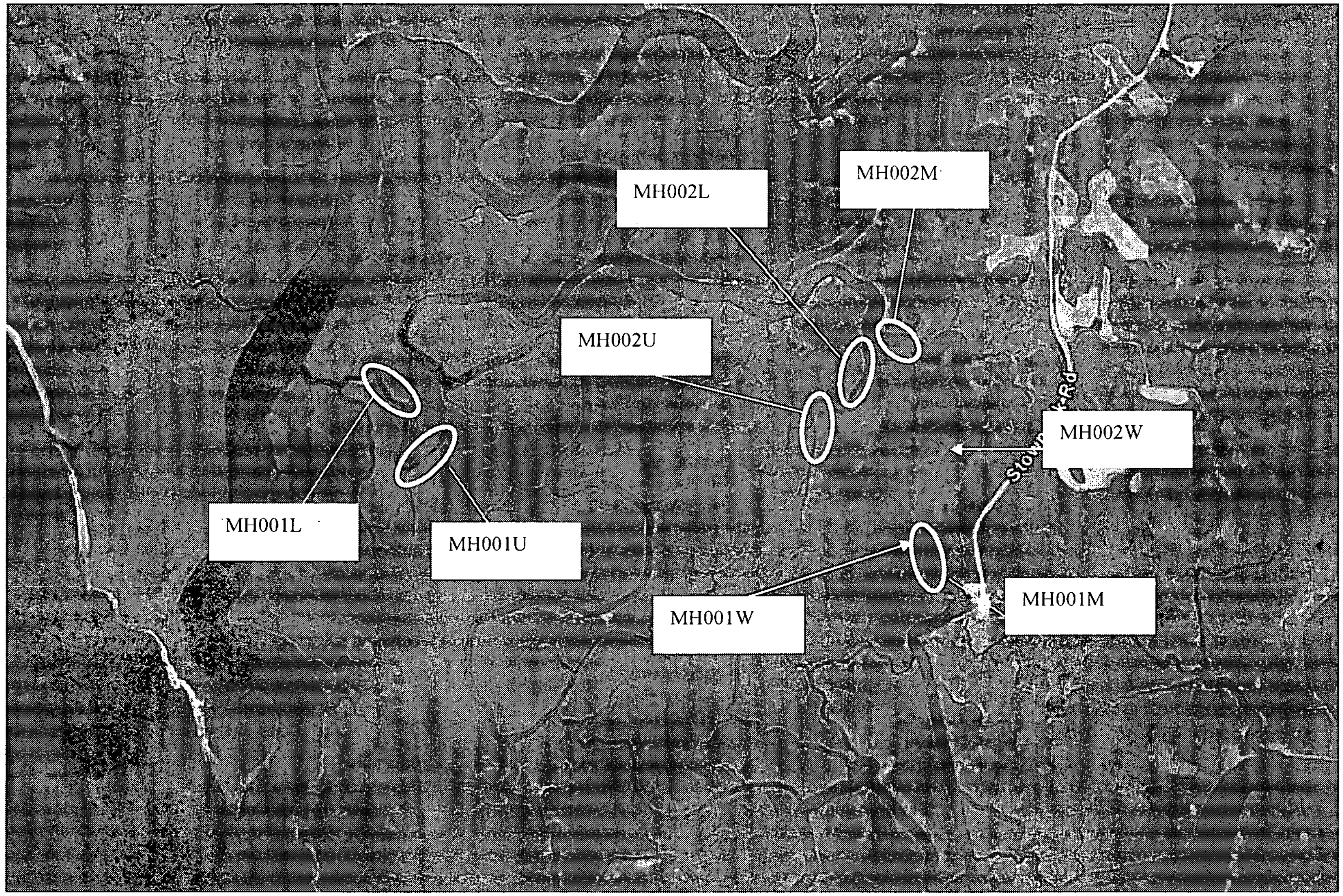


Figure 7-4. Mad Horse Creek sampling sites (reference) in Delaware Bay during 2008.

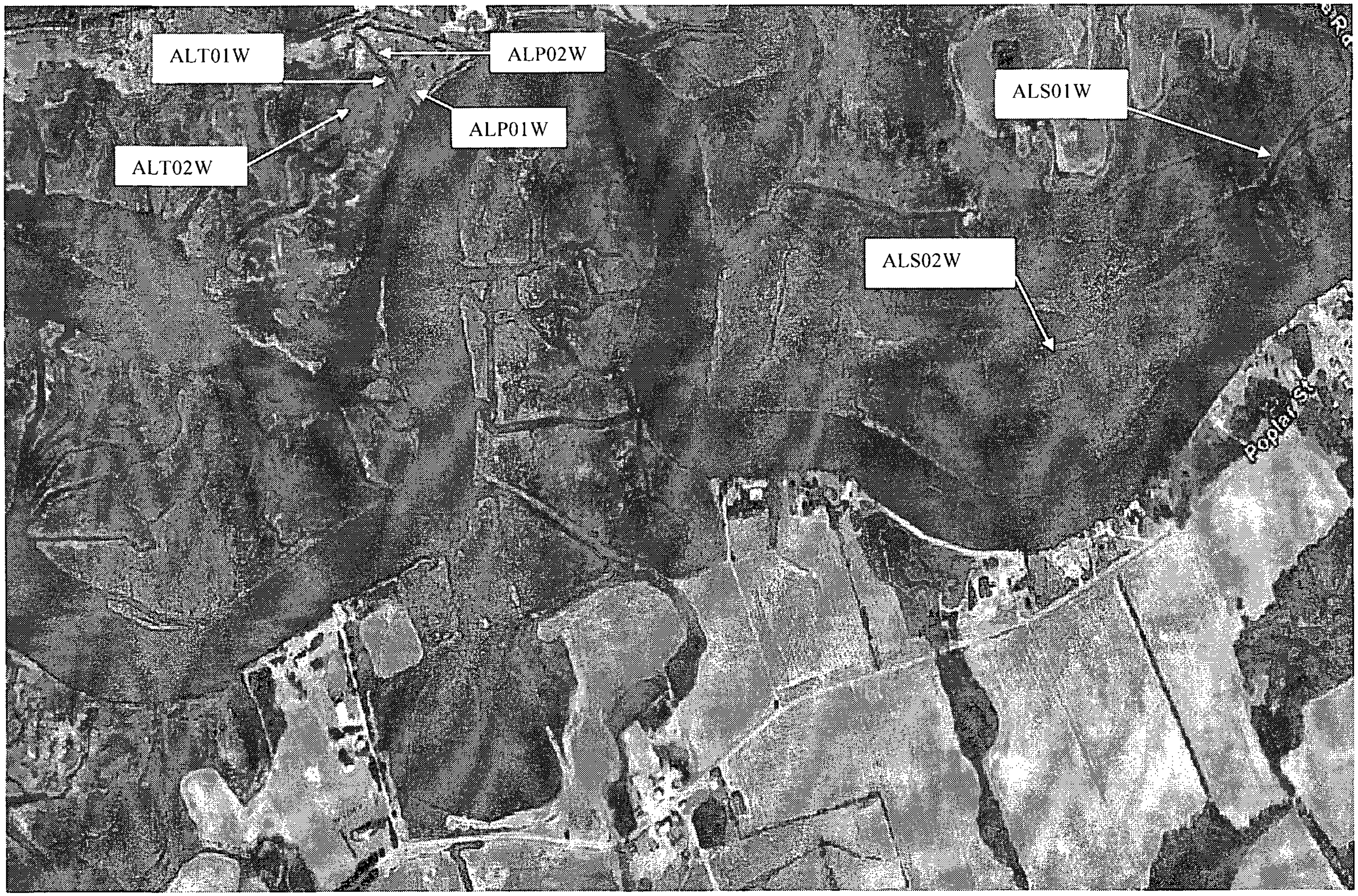


Figure 7-5. Alloway Creek sampling sites (restoration) in Delaware Bay during 2008.

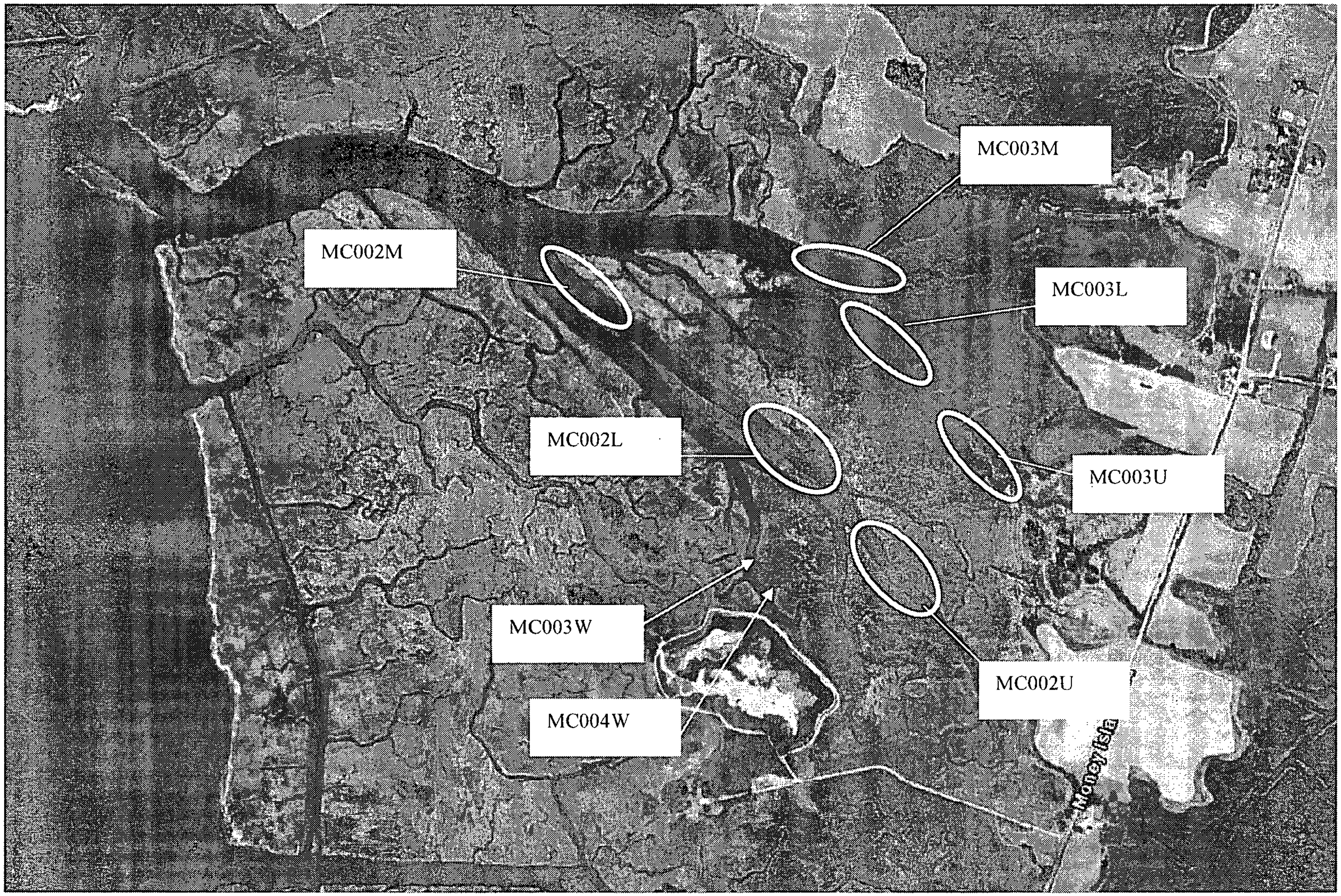


Figure 7-6. Mill Creek sampling (restoration) sites in Delaware Bay during 2008.

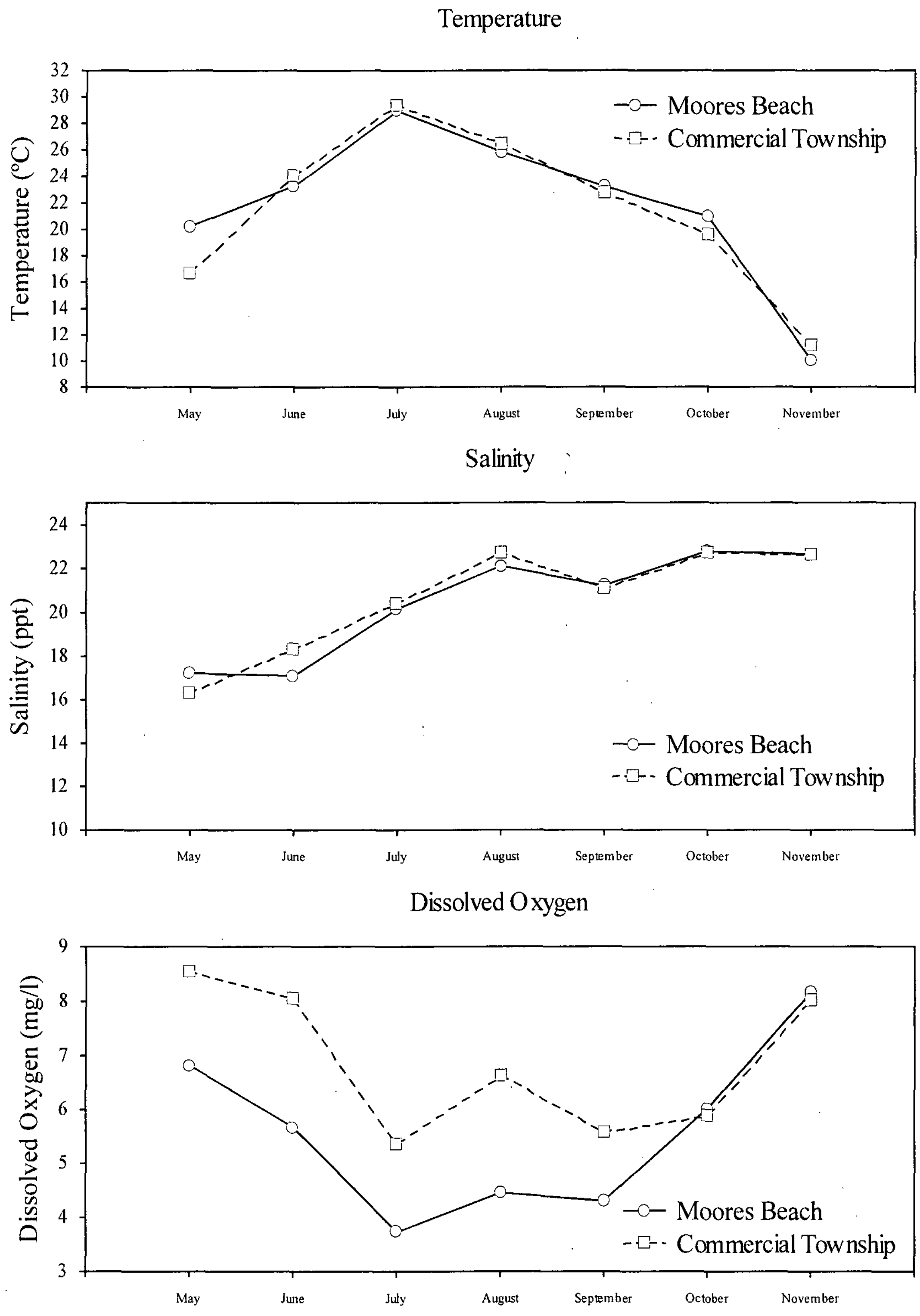
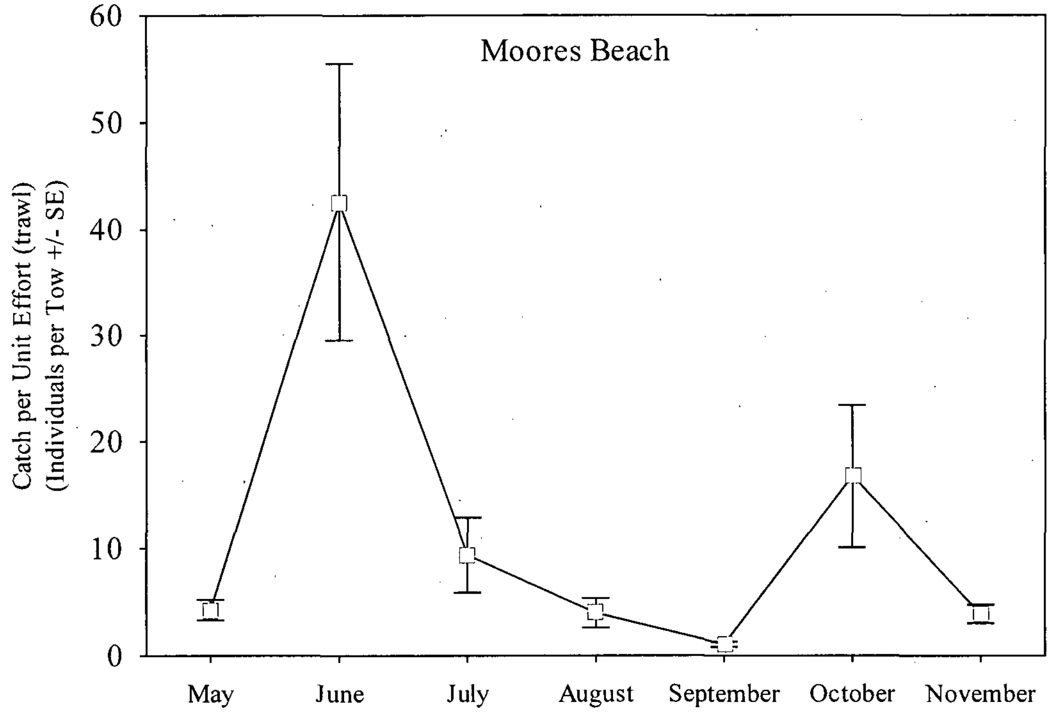


Figure 7-7. Selected physical parameters at regularly sampled sites in the Lower Delaware Bay Region during 2008.



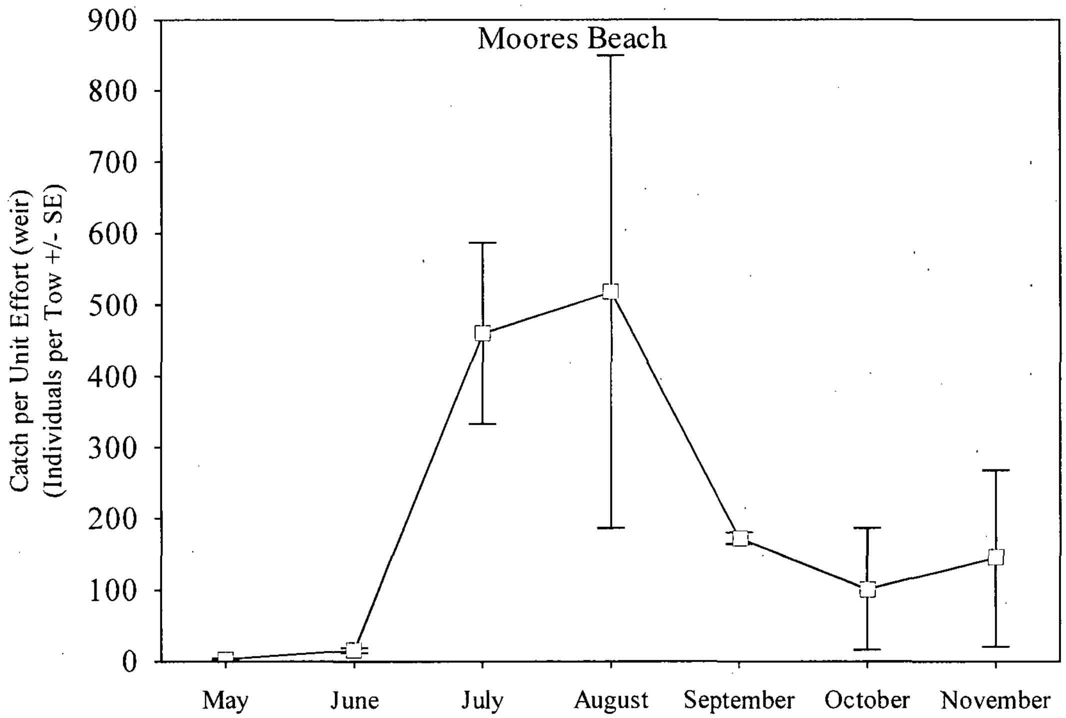


Figure 7-8. Monthly abundance for all fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach during 2008.

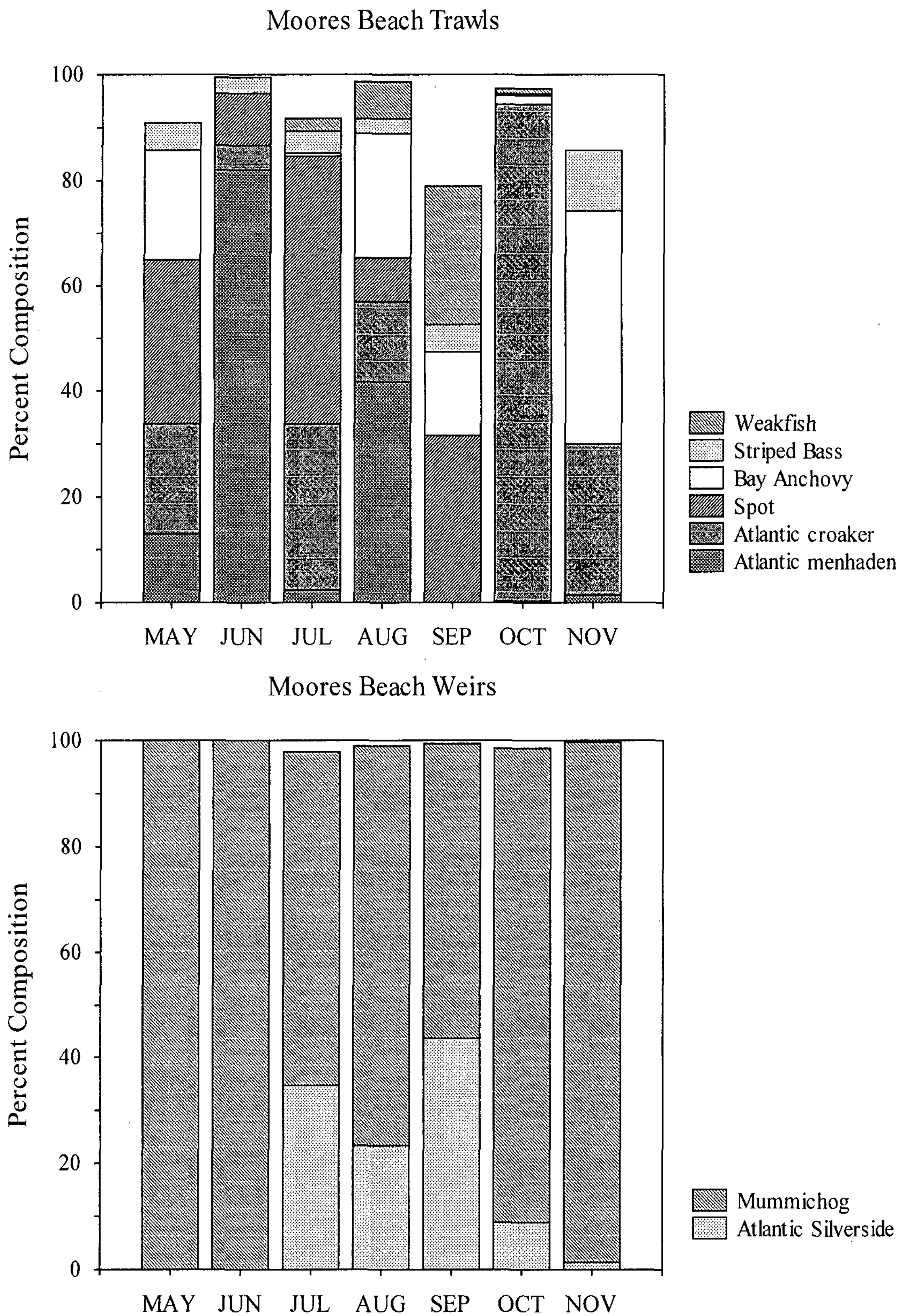


Figure 7-9. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Moores Beach during 2008.

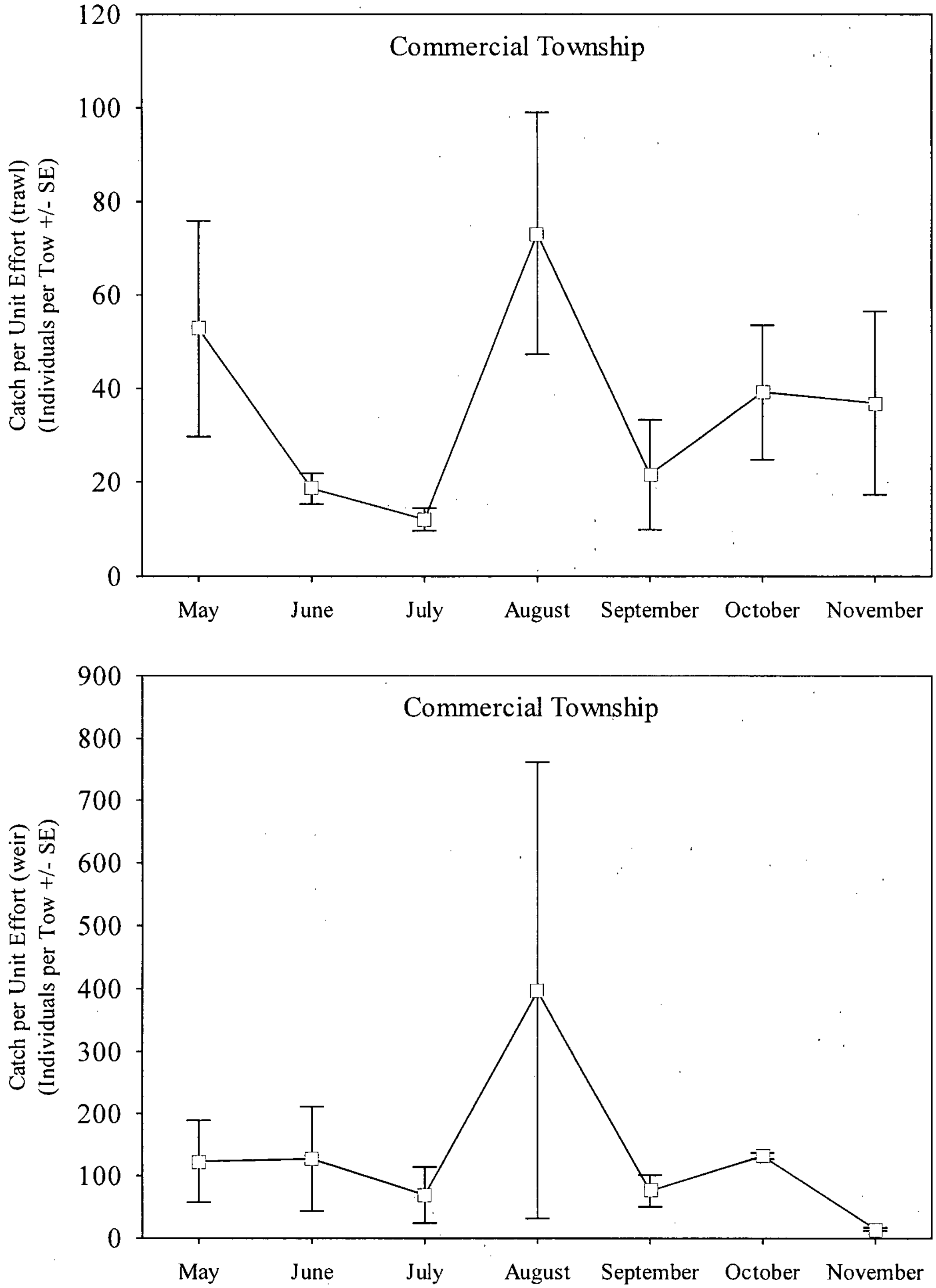


Figure 7-10. Monthly abundance for all fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township during 2008.

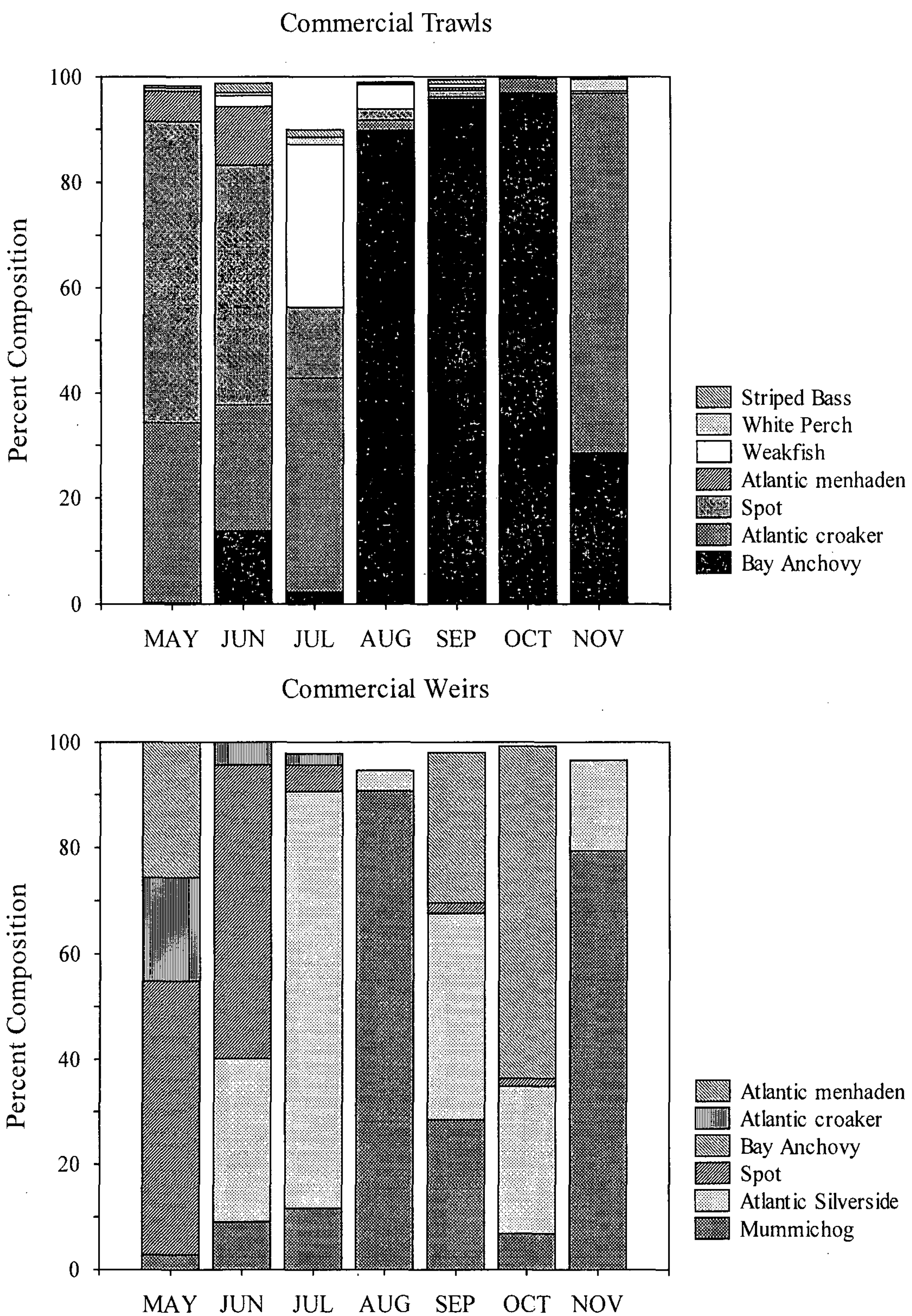


Figure 7-11. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Commercial Township during 2008.

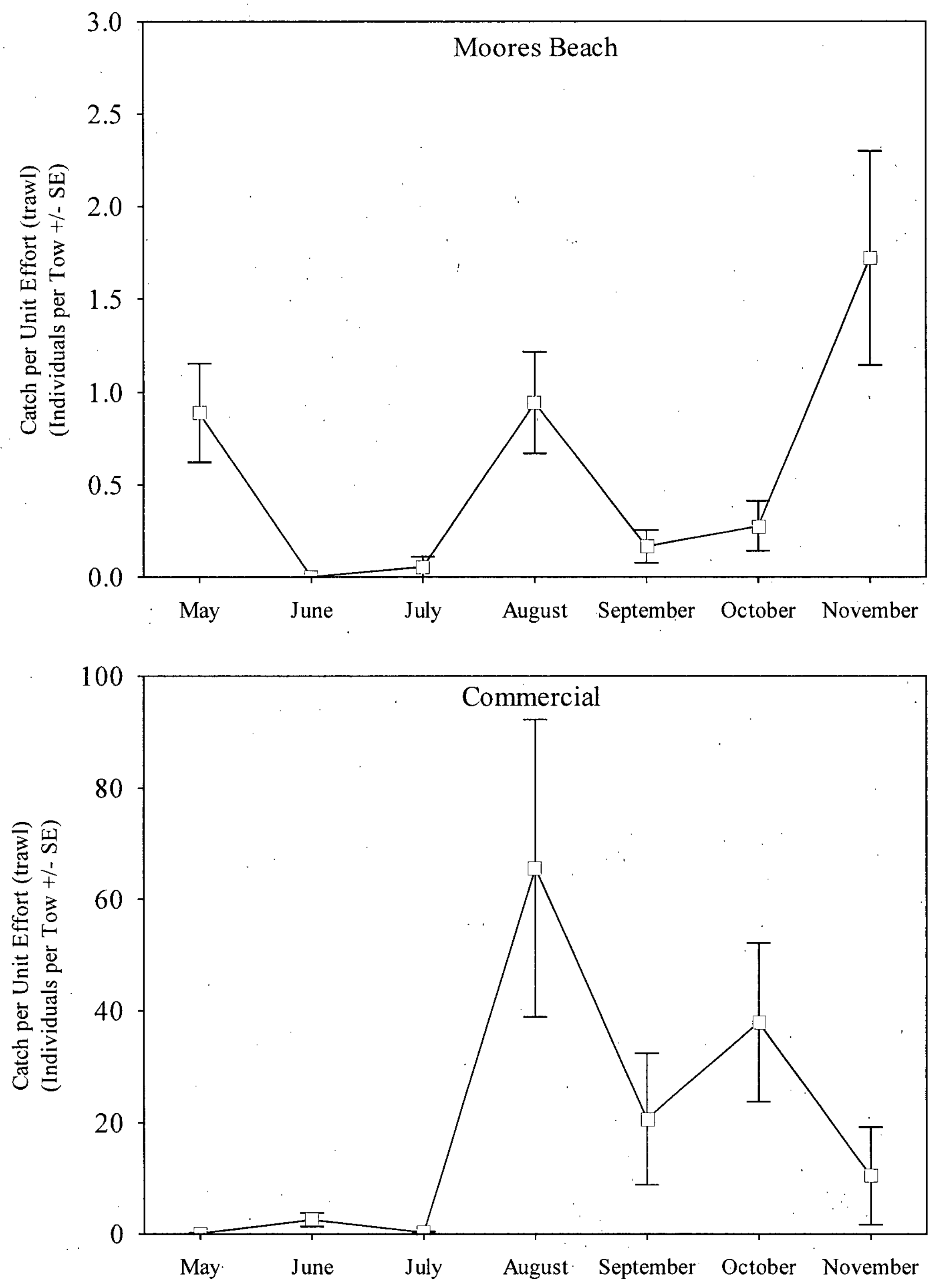


Figure 7-12. Monthly abundance for bay anchovy caught, in large marsh creeks with otter trawls, in the Lower Bay Region during 2008.

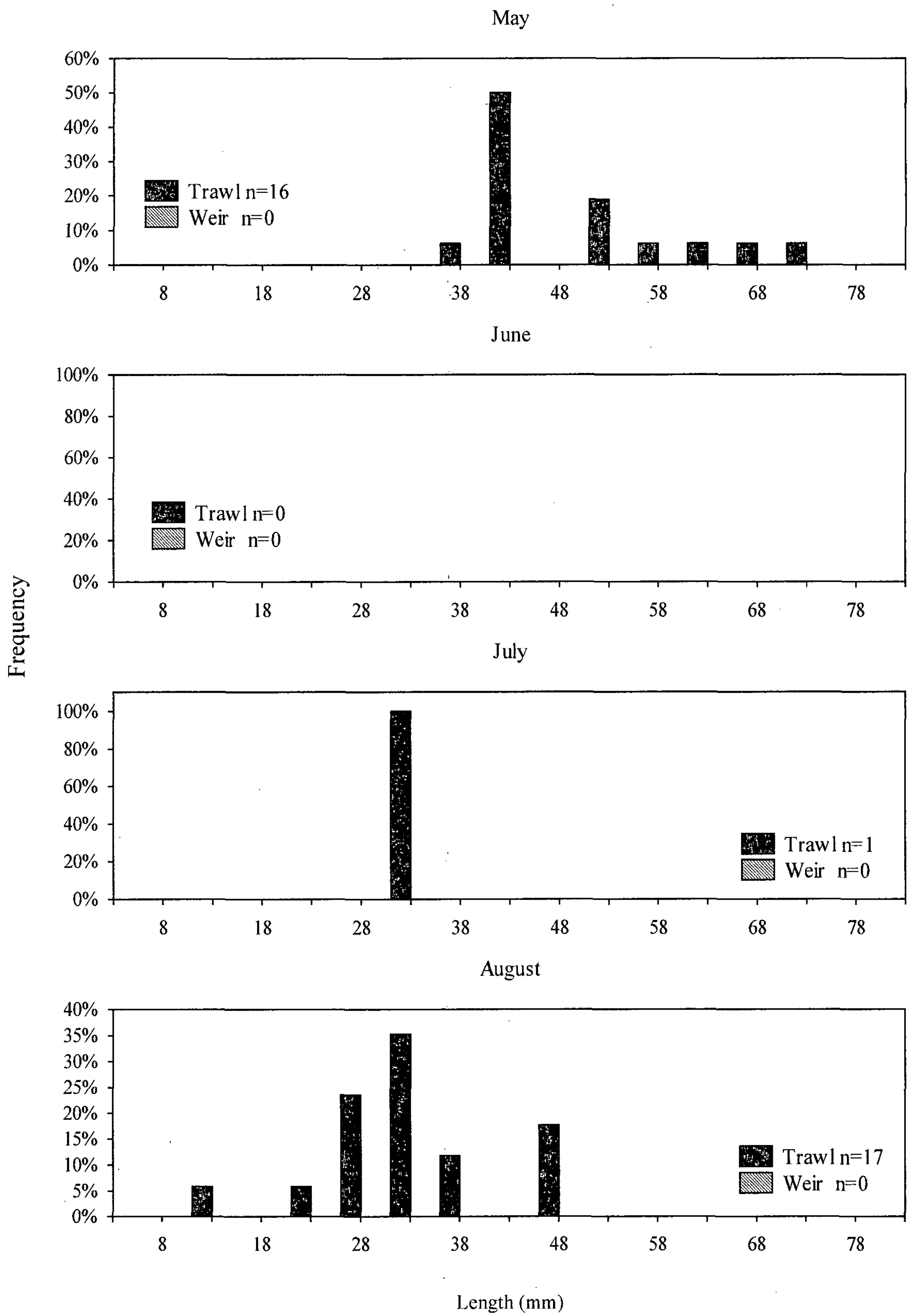


Figure 7-13. Size distribution of bay anchovy, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach in 2008.

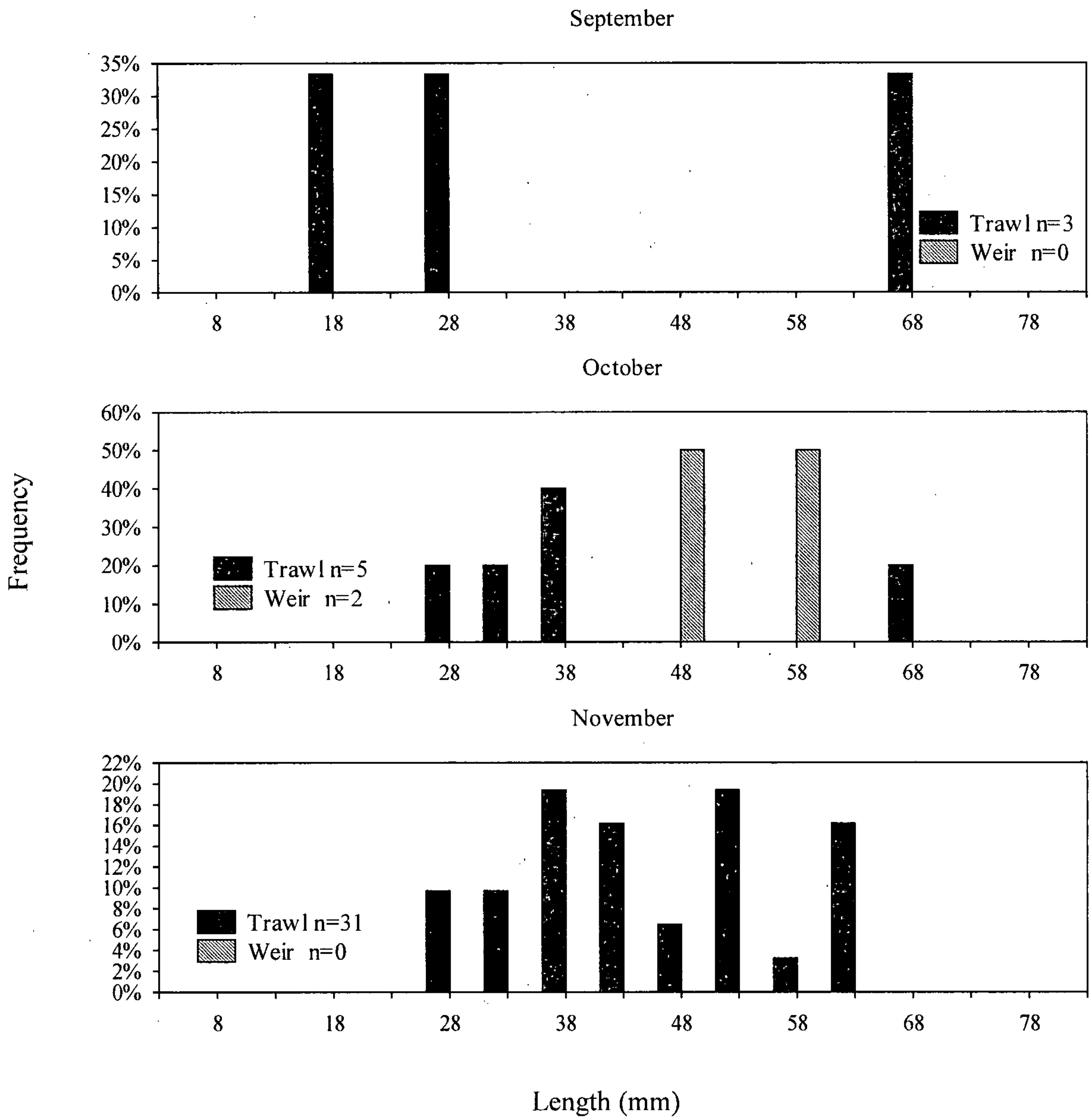


Figure 7-13. Continued.

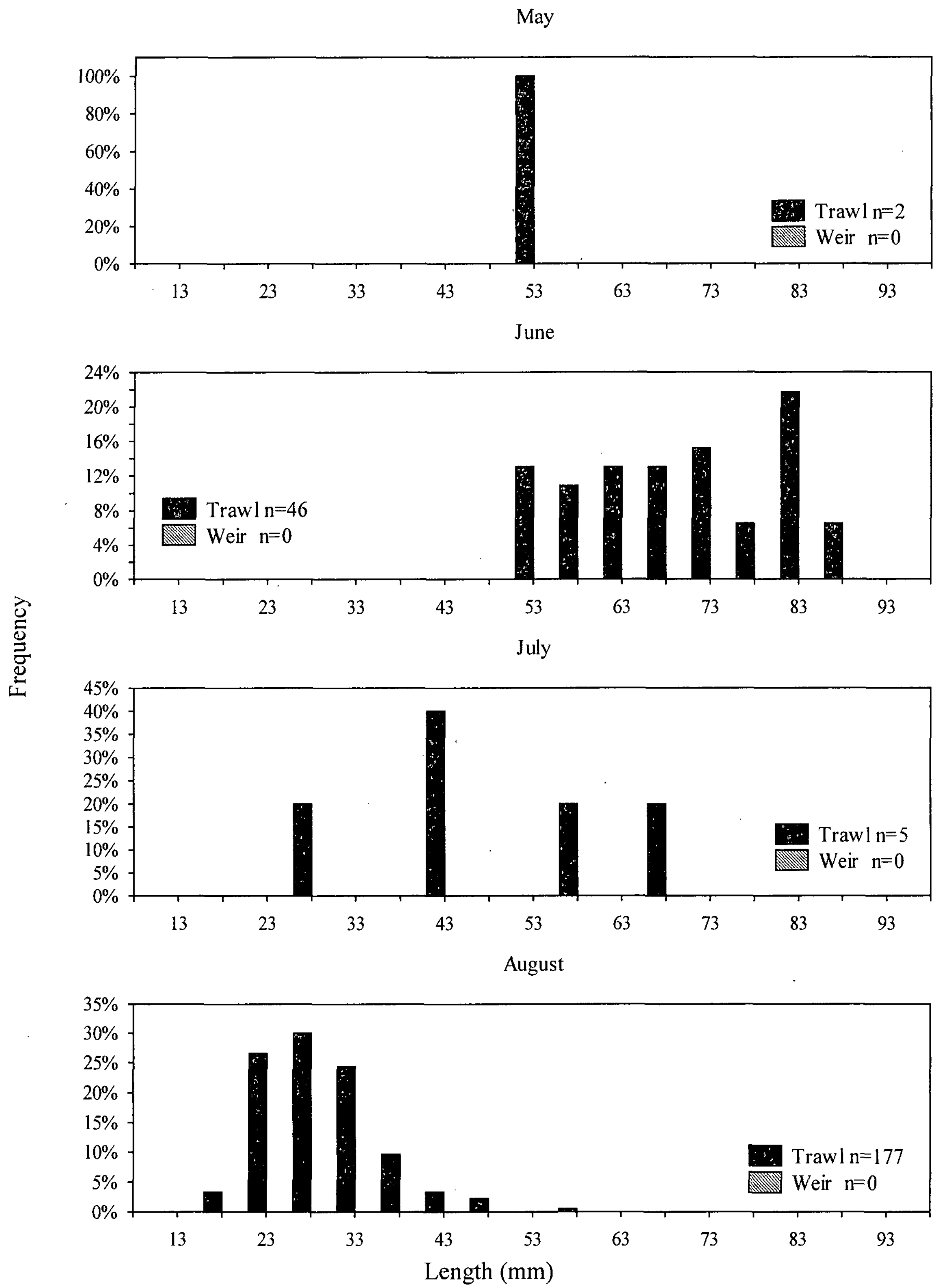
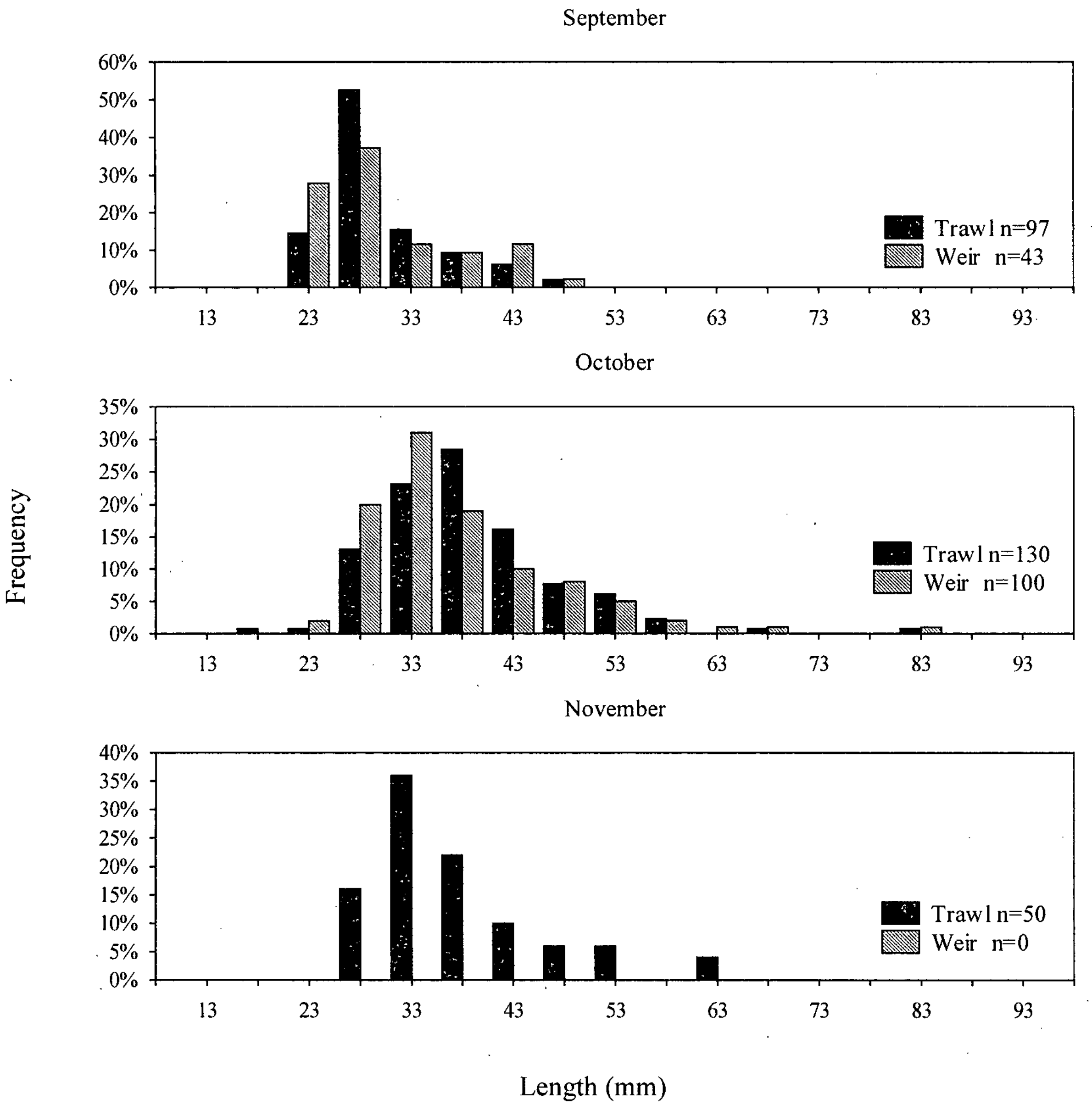


Figure 7-14. Size distribution of bay anchovy, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township in 2008.



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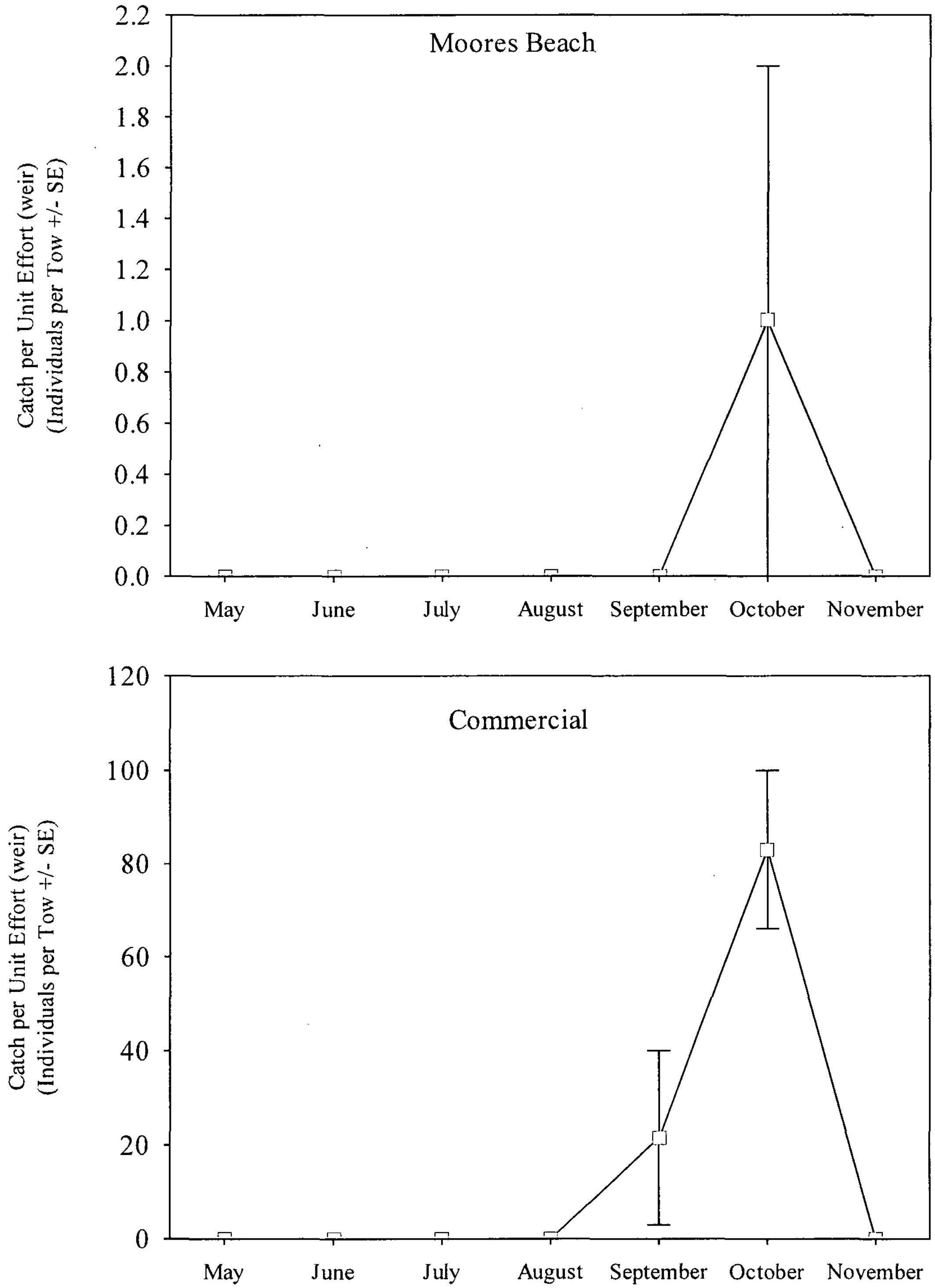


Figure 7-15. Monthly abundance for bay anchovy caught, in small marsh creeks with weirs, in the Lower Bay Region in 2008.

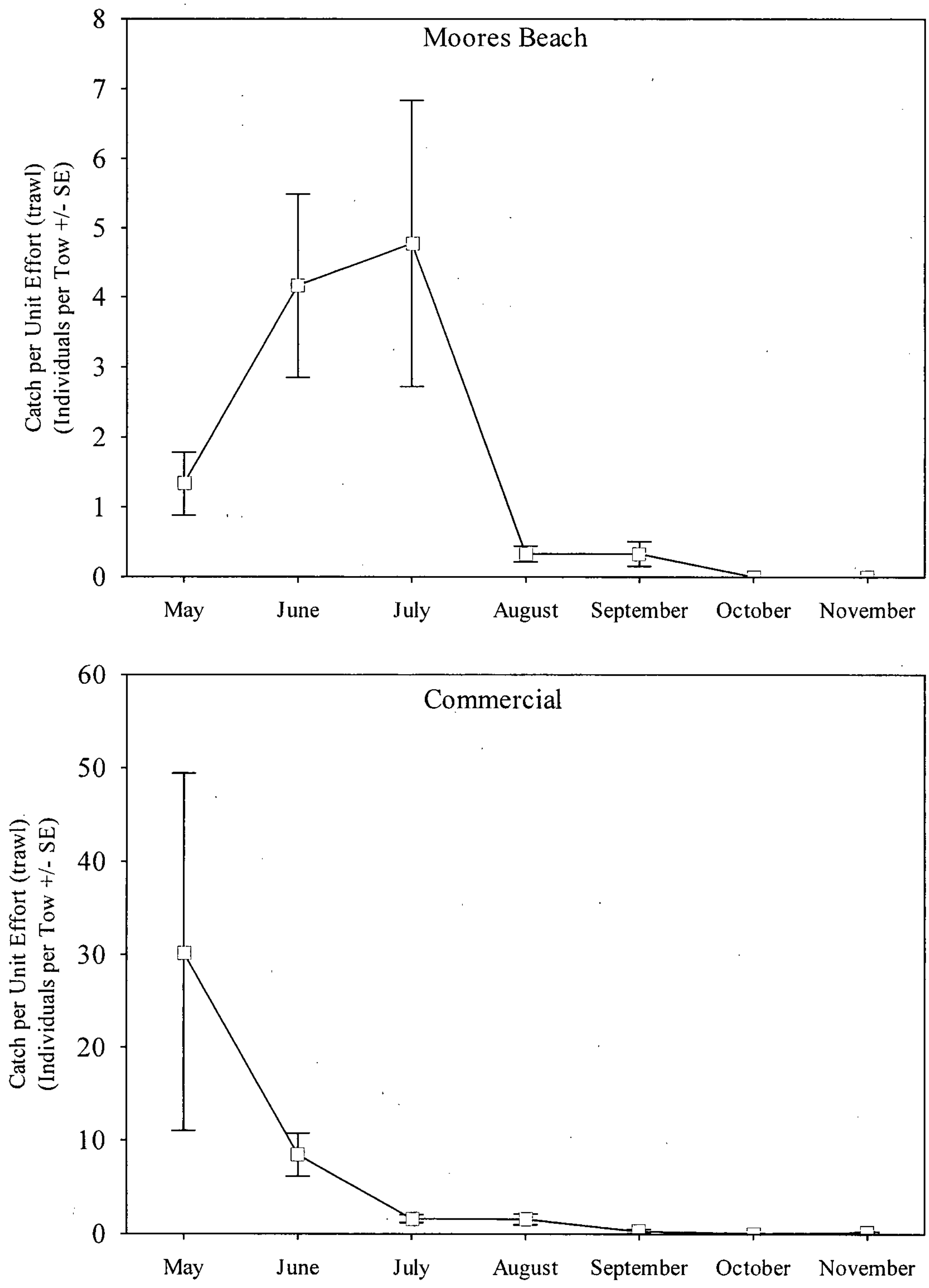


Figure 7-16. Monthly abundance for spot caught, in large marsh creeks with otter trawls, in the Lower Bay Region during 2008.

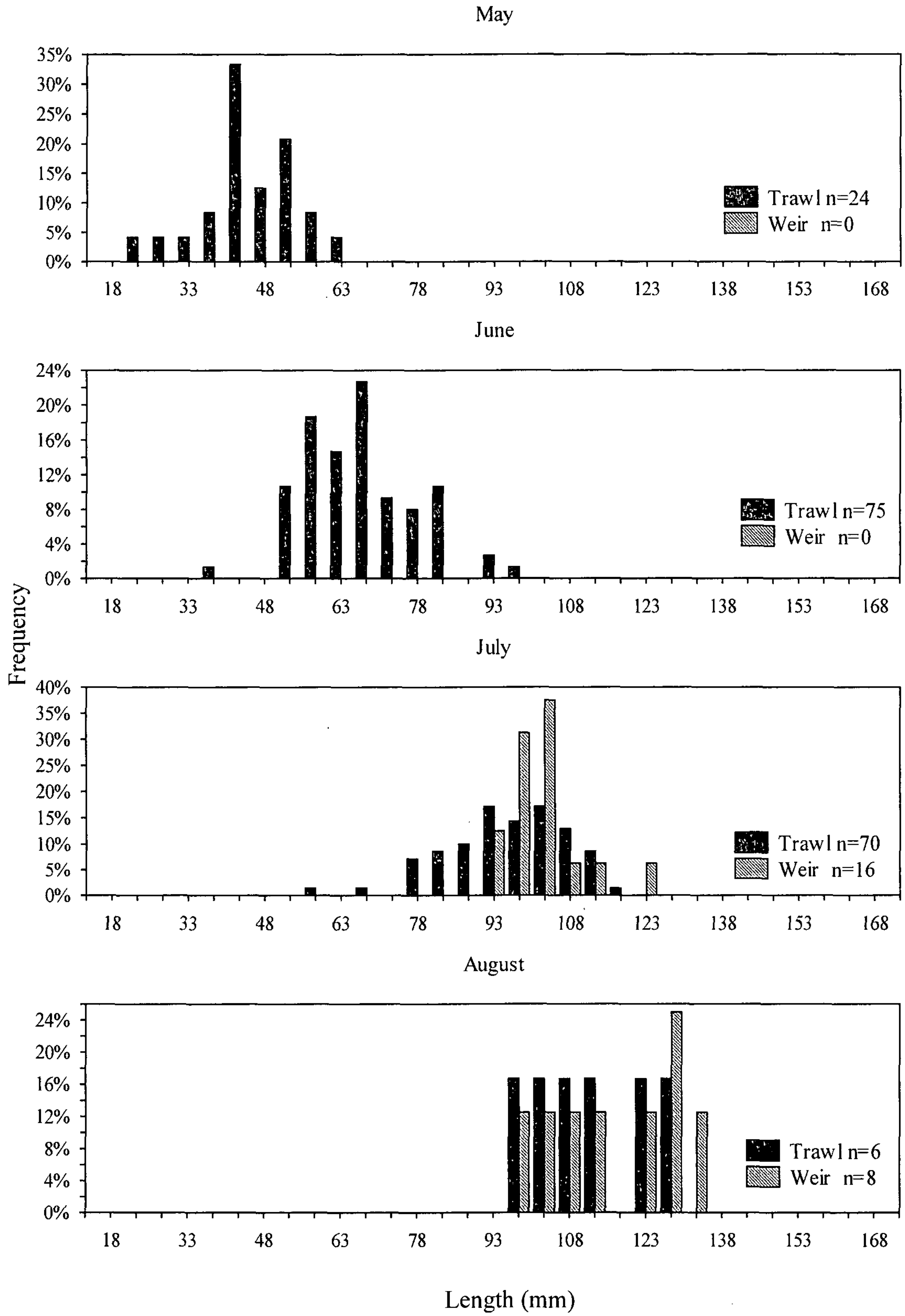


Figure 7-17. Size distribution of spot, from large marsh creeks (otter trawl) and small marsh creeks (weirs), at Moores Beach during 2008.

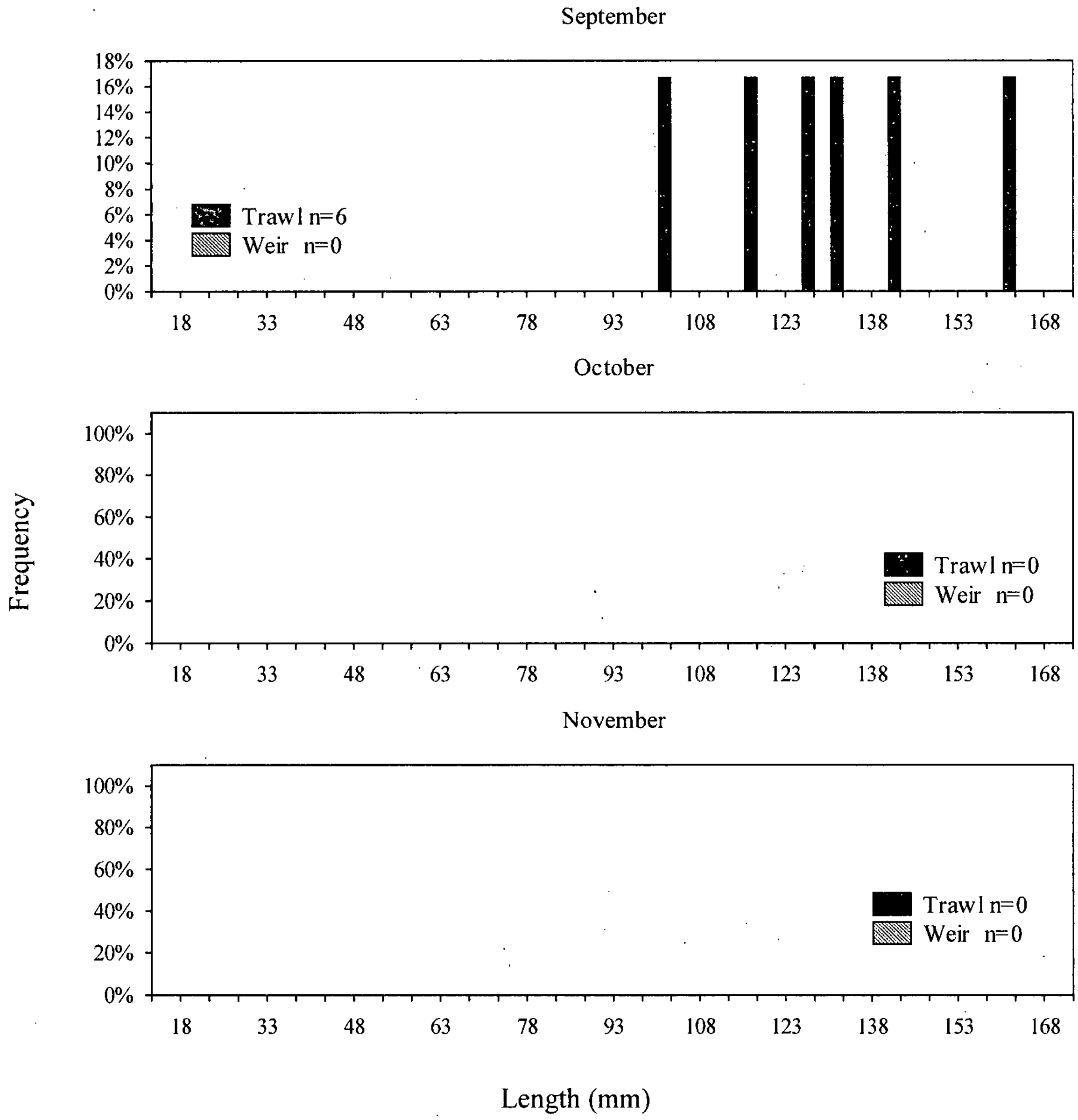


Figure 7-17. Continued.

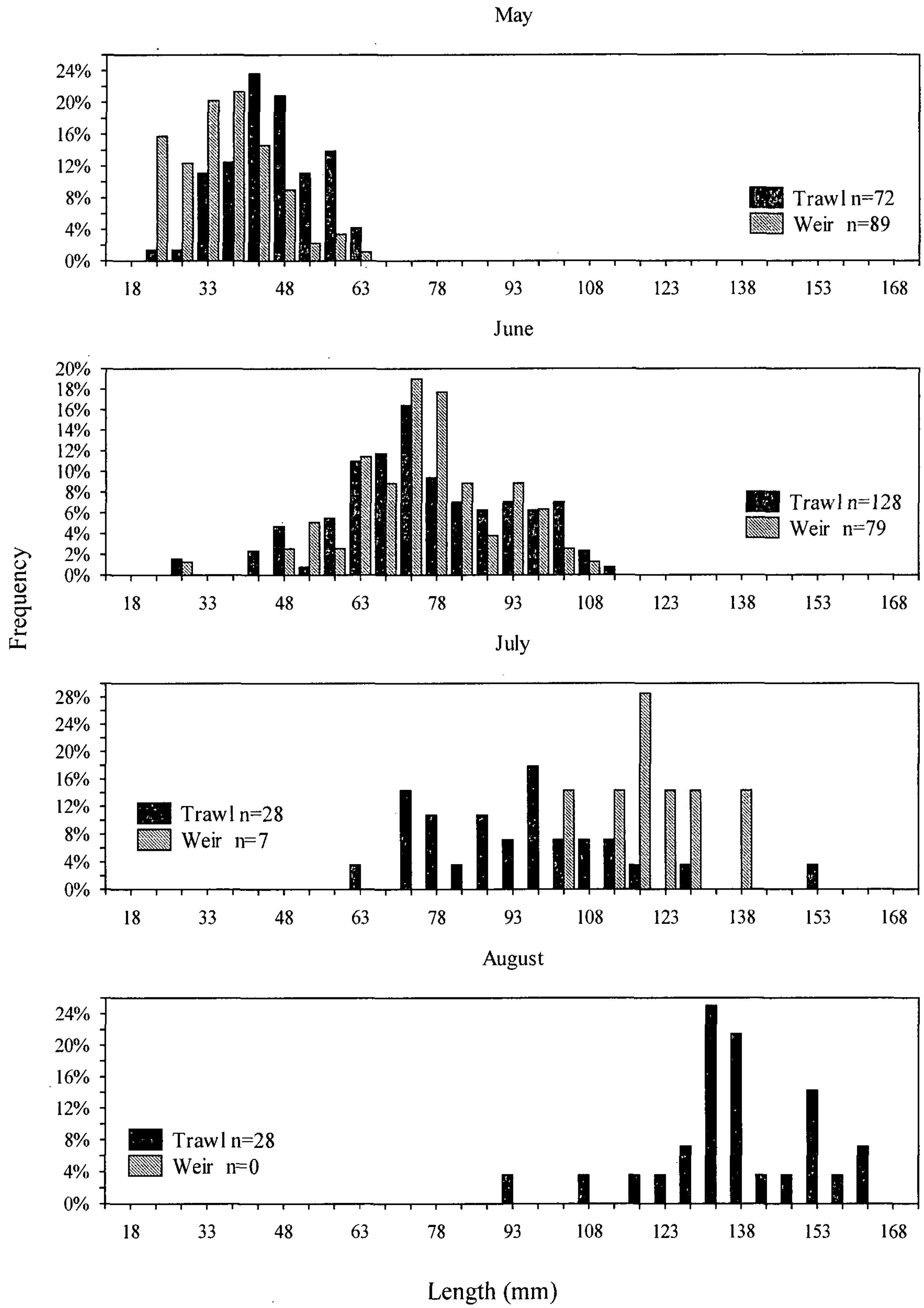


Figure 7-18. Size distribution of spot, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township in 2008.

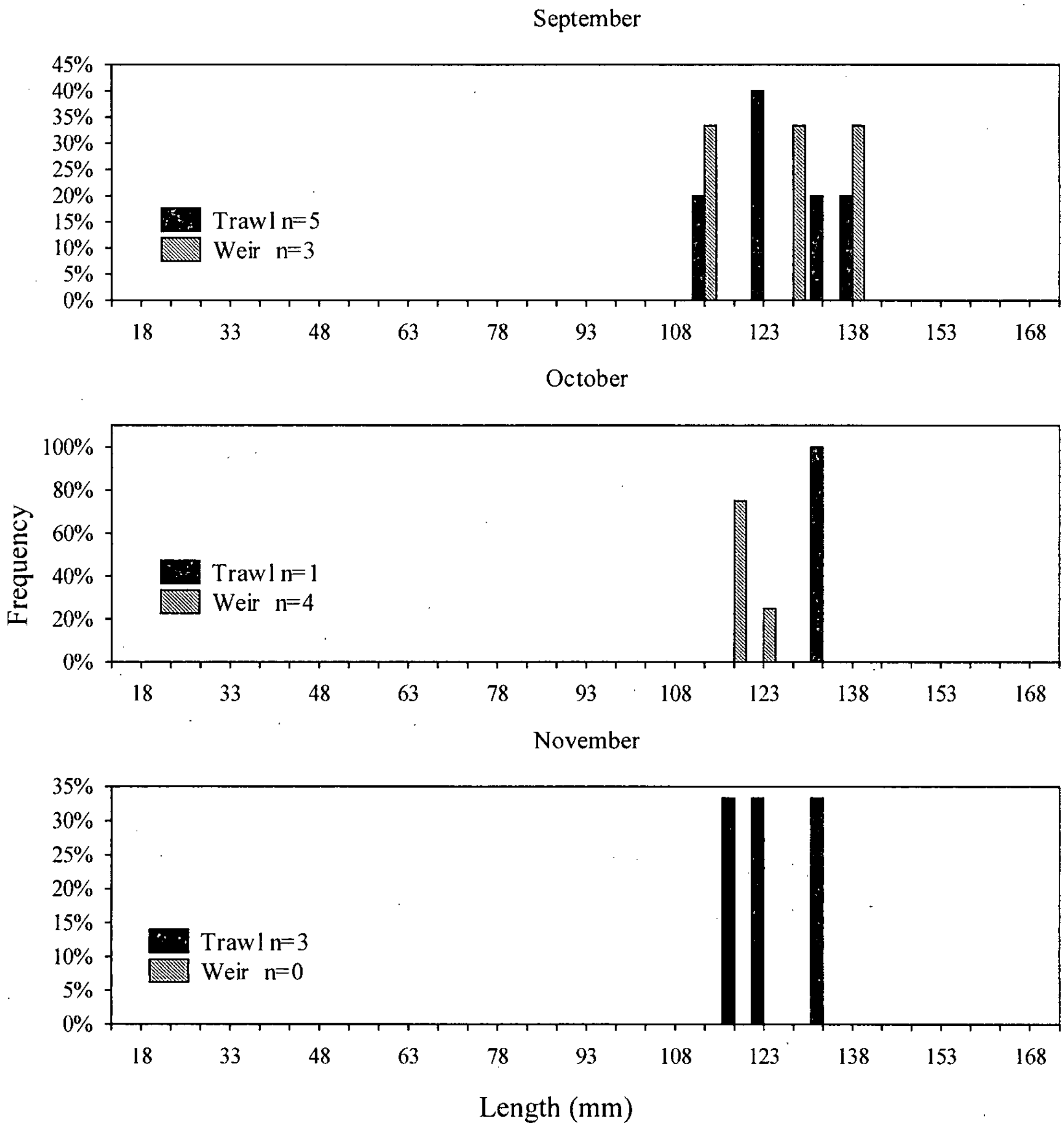


Figure 7-18. Continued.

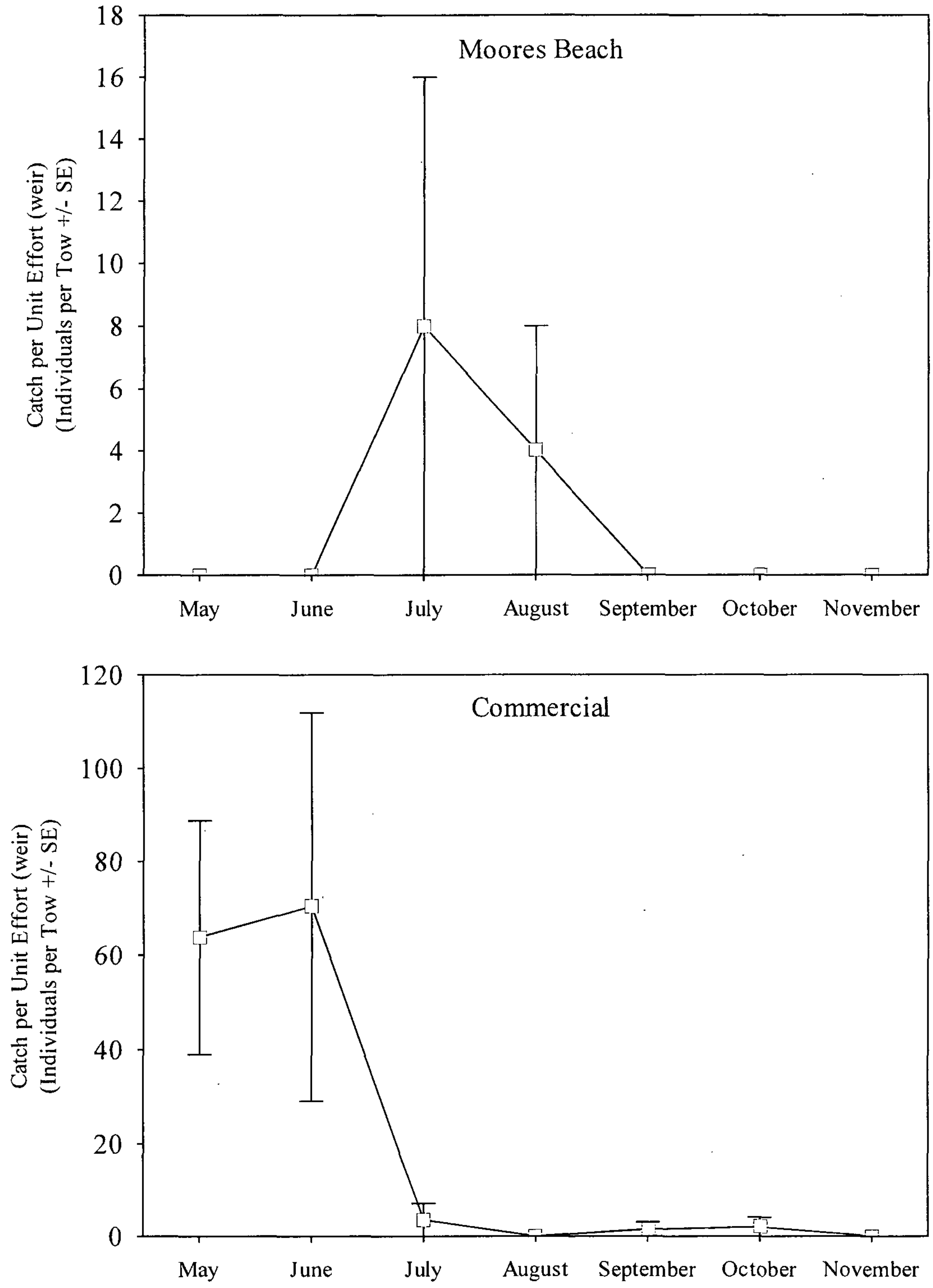


Figure 7-19. Monthly abundance for spot caught, in small marsh creeks with weirs, in the Lower Bay Region in 2008.

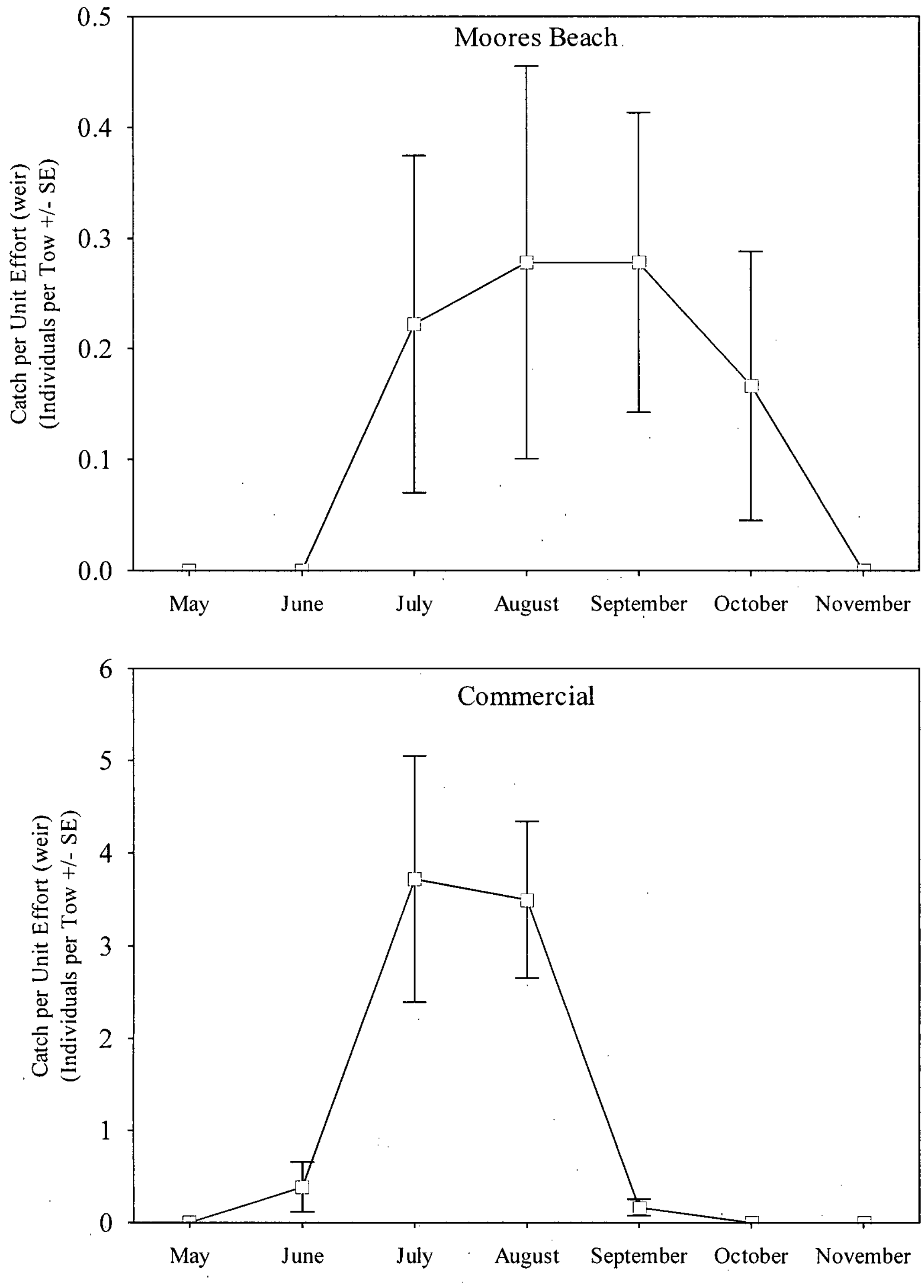


Figure 7-20. Monthly abundance for weakfish caught, in large marsh creeks with otter trawls, in the Lower Bay Region during 2008.

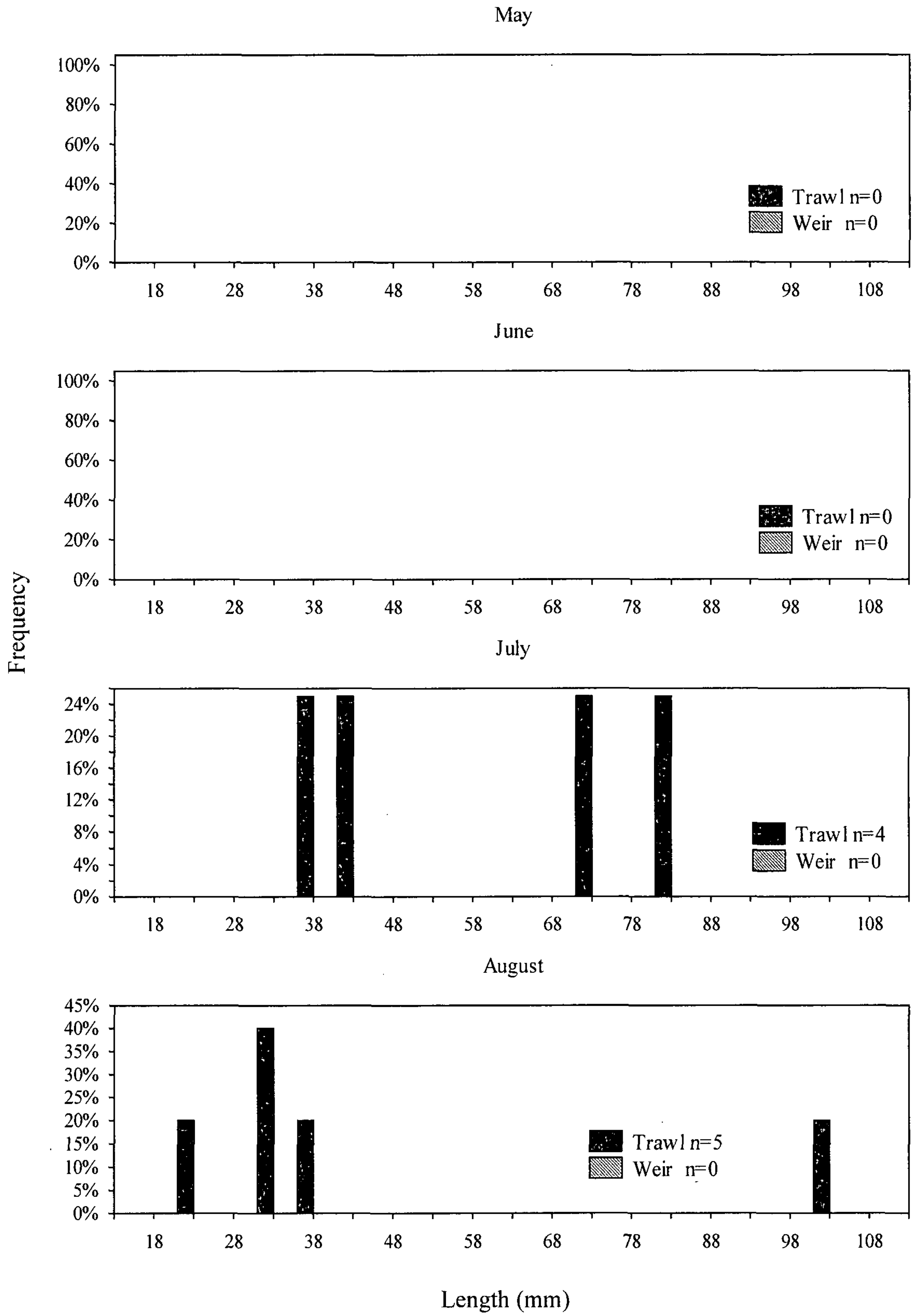


Figure 7-21. Size distribution of weakfish, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach during 2008.

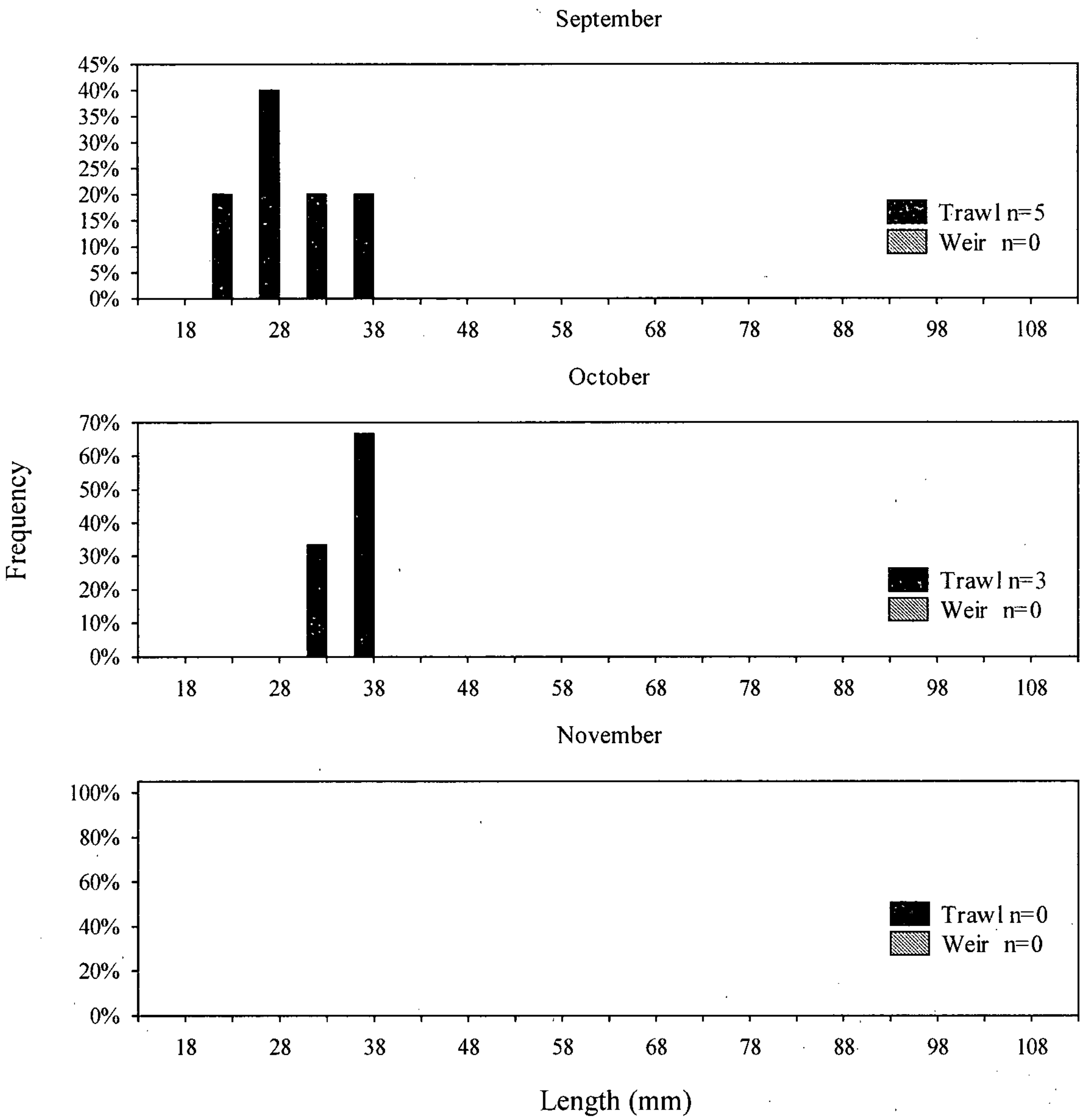


Figure 7-21. Continued.

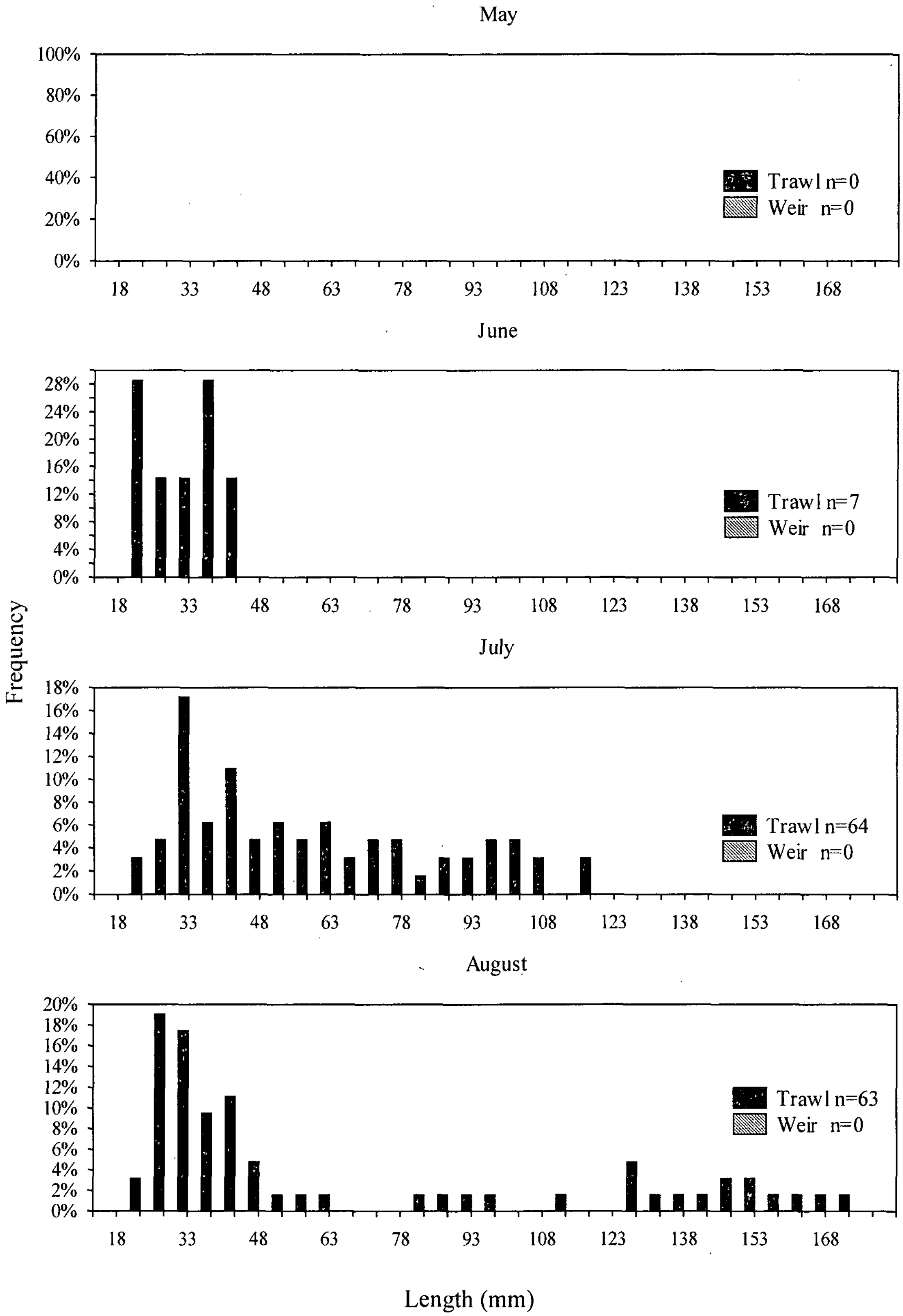


Figure 7-22. Size distribution of weakfish, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township during 2008.

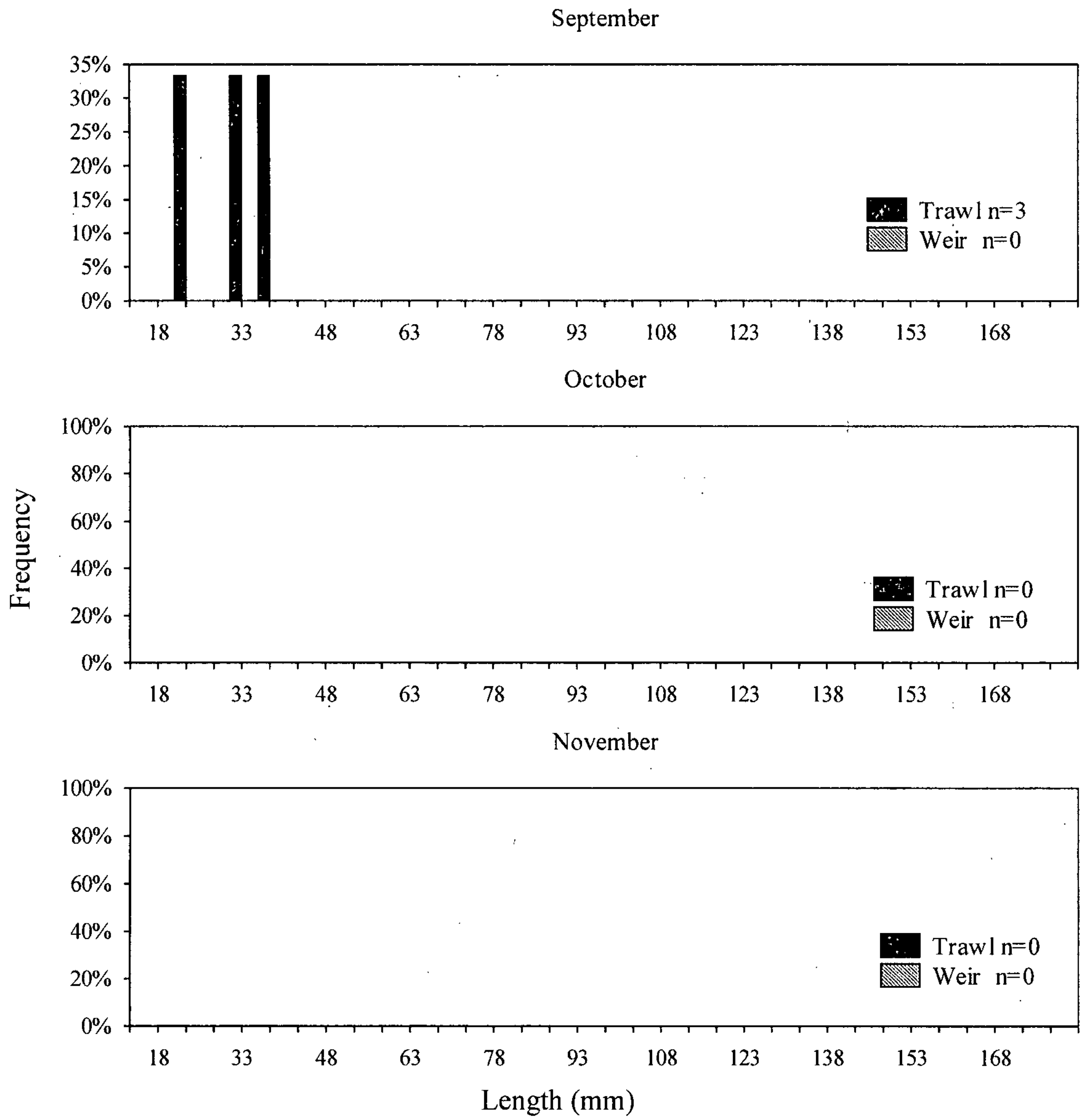


Figure 7-22. Continued.

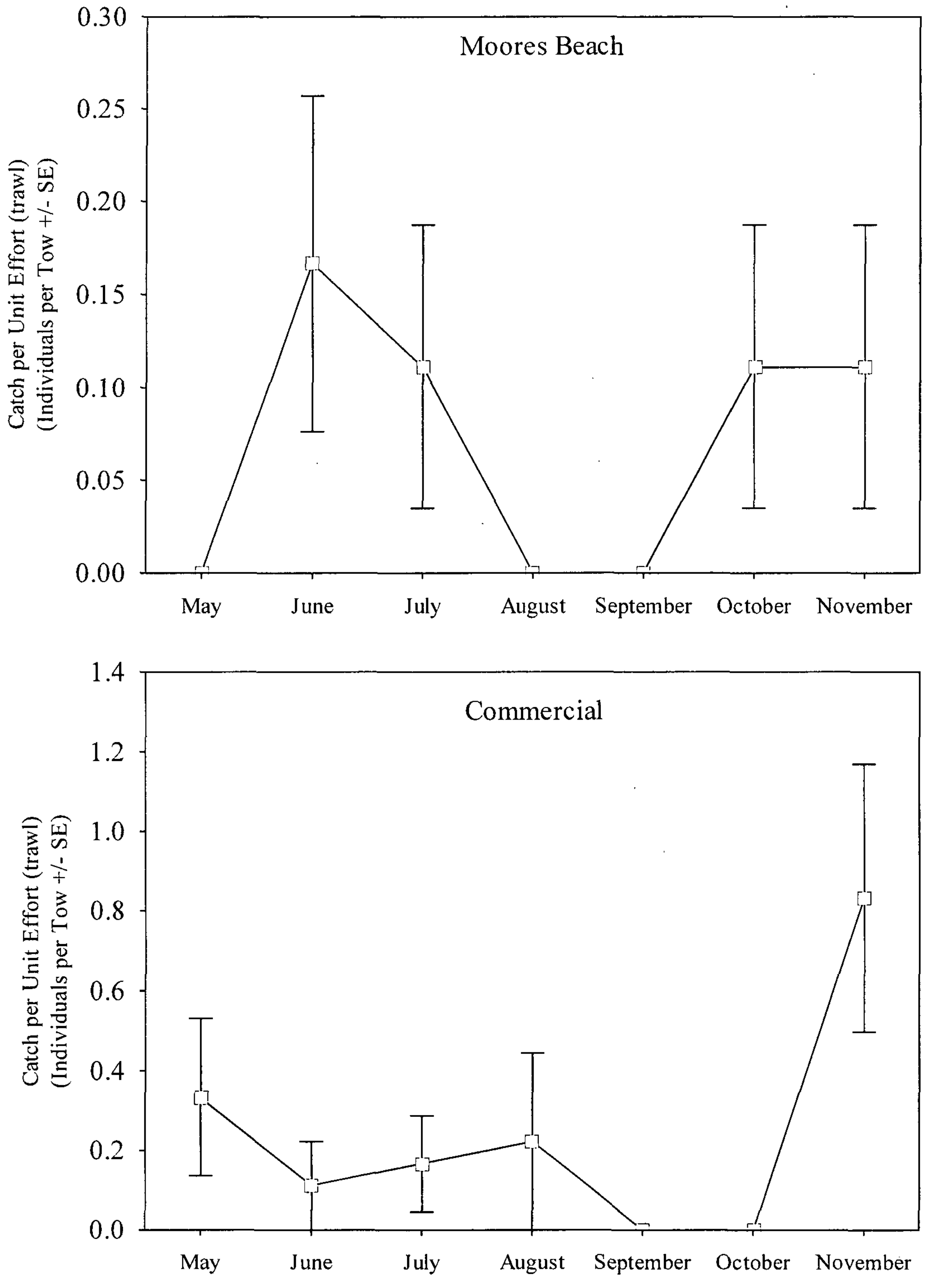


Figure 7-23. Monthly abundance for white perch caught, in large marsh creeks with otter trawls, the Lower Bay Region during 2008.

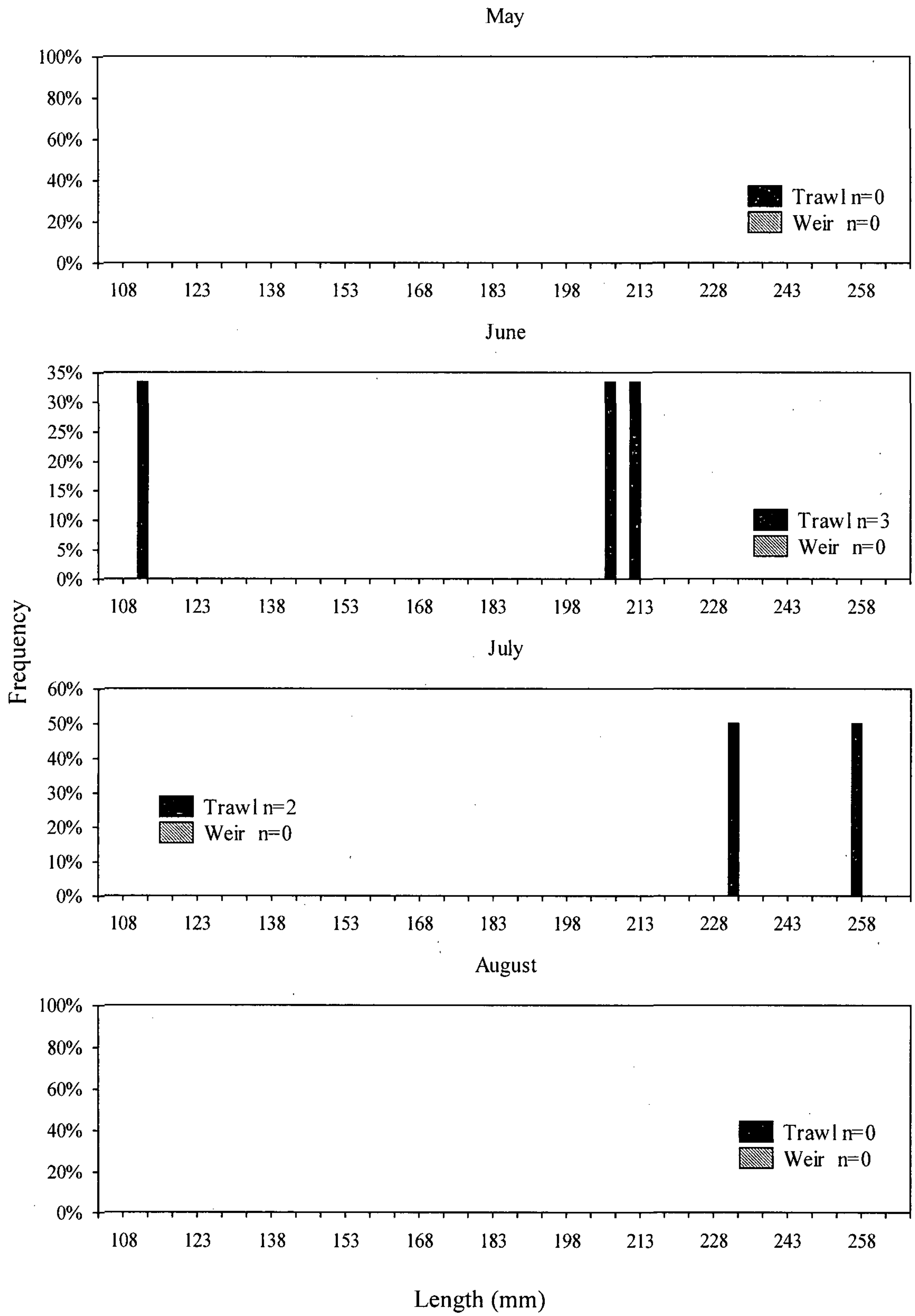


Figure 7-24. Size distribution of white perch, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach in 2008.

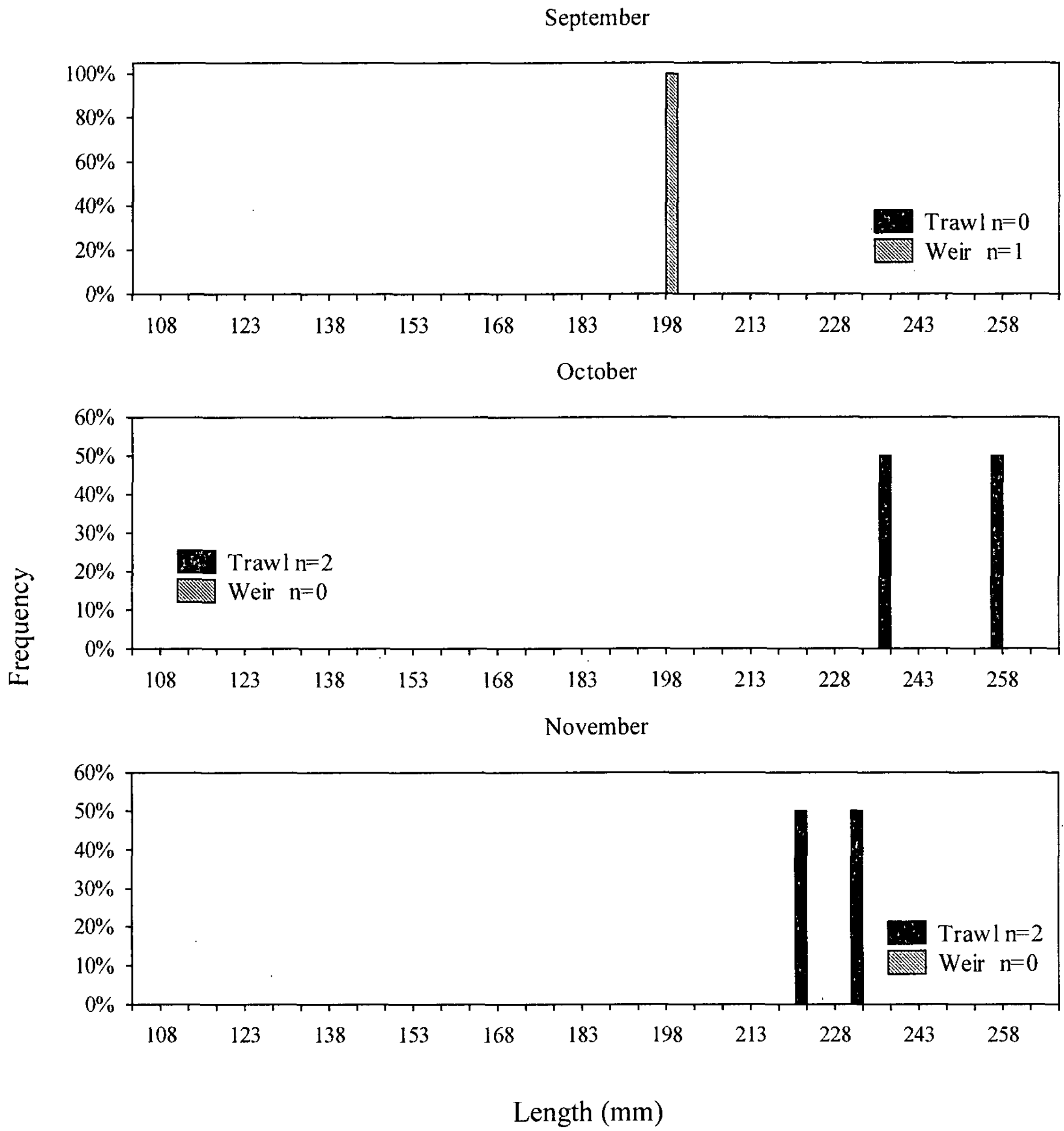


Figure 7-24. Continued.

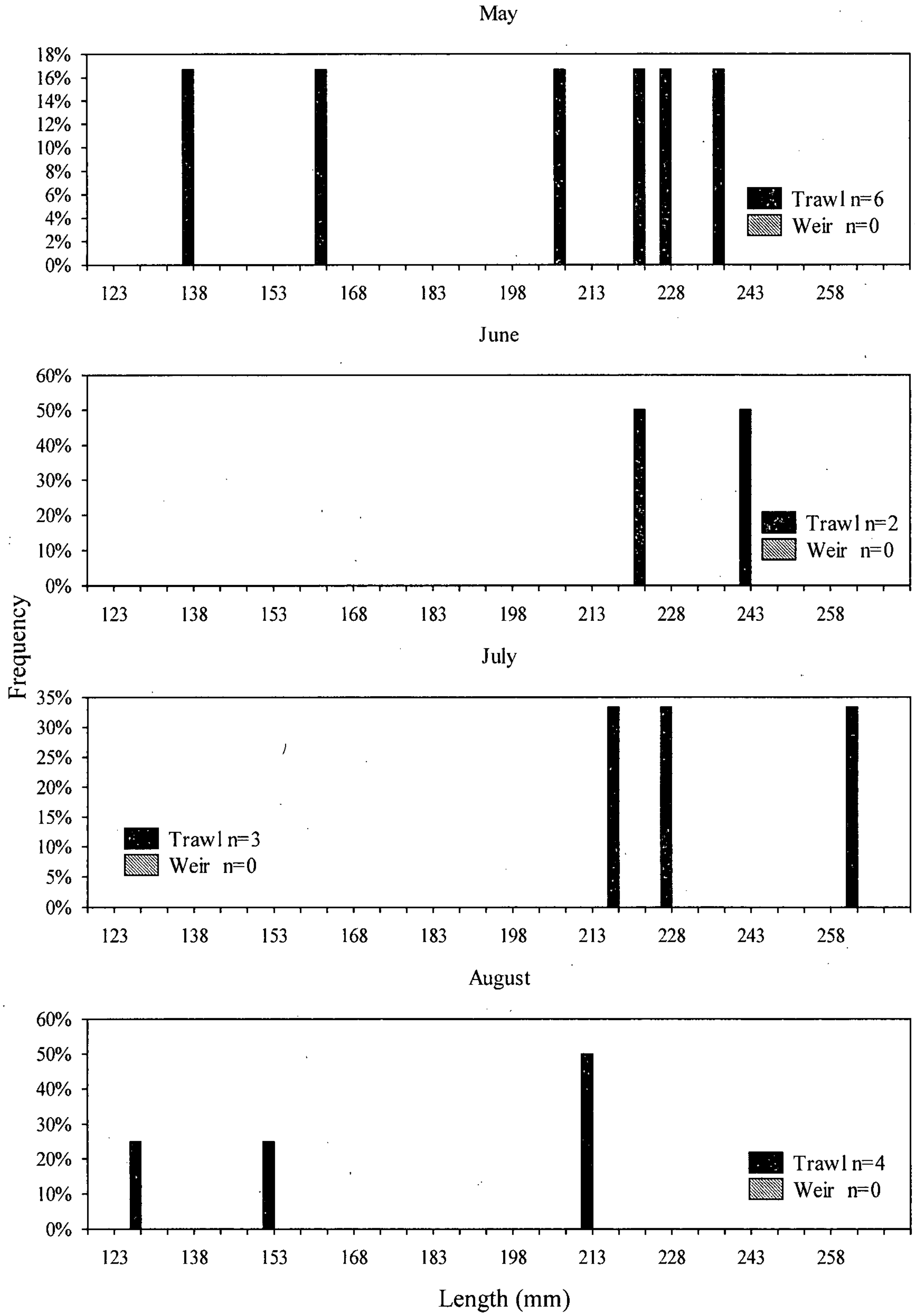
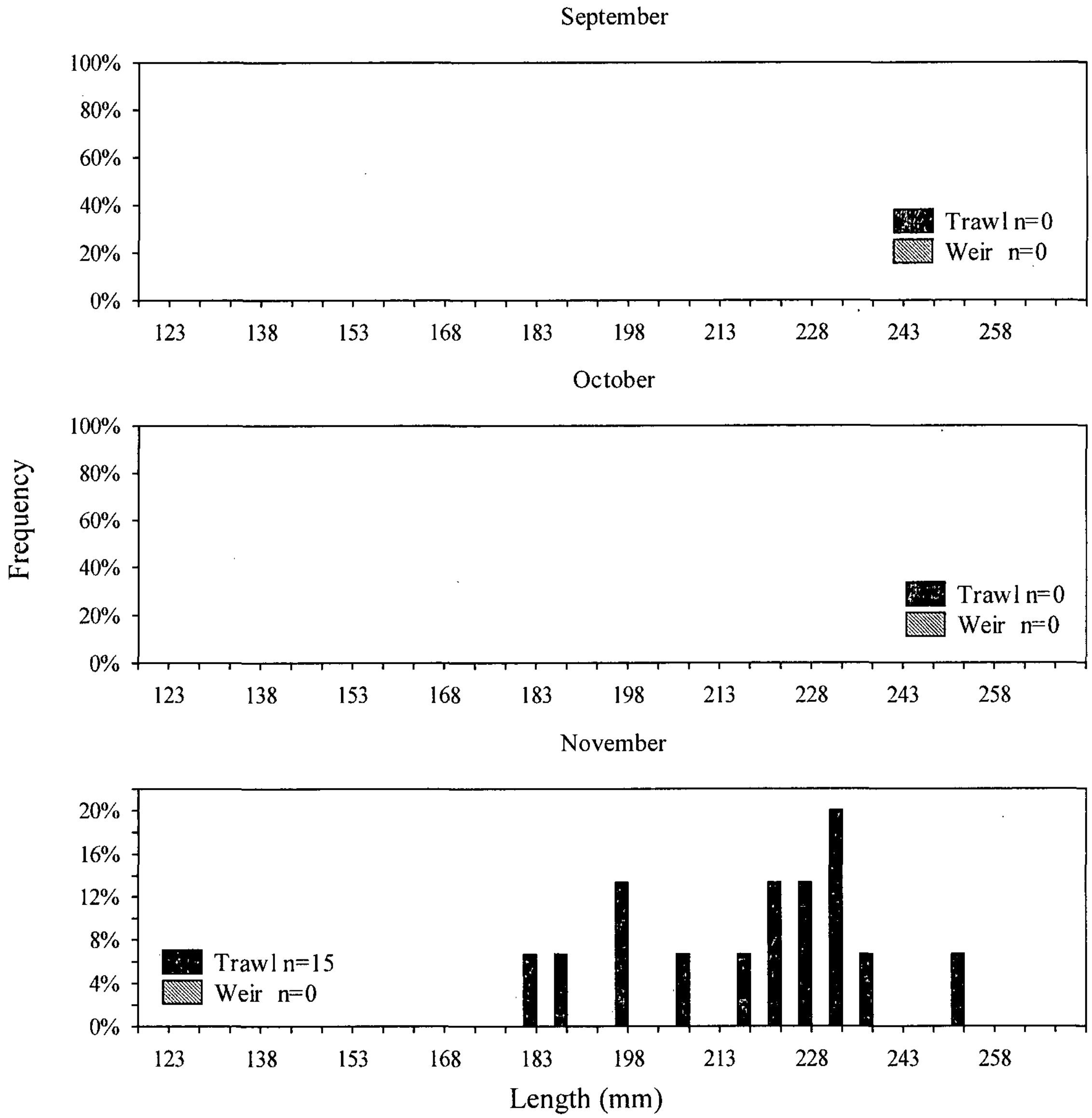


Figure 7-25. Size distribution of white perch, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township in 2008.



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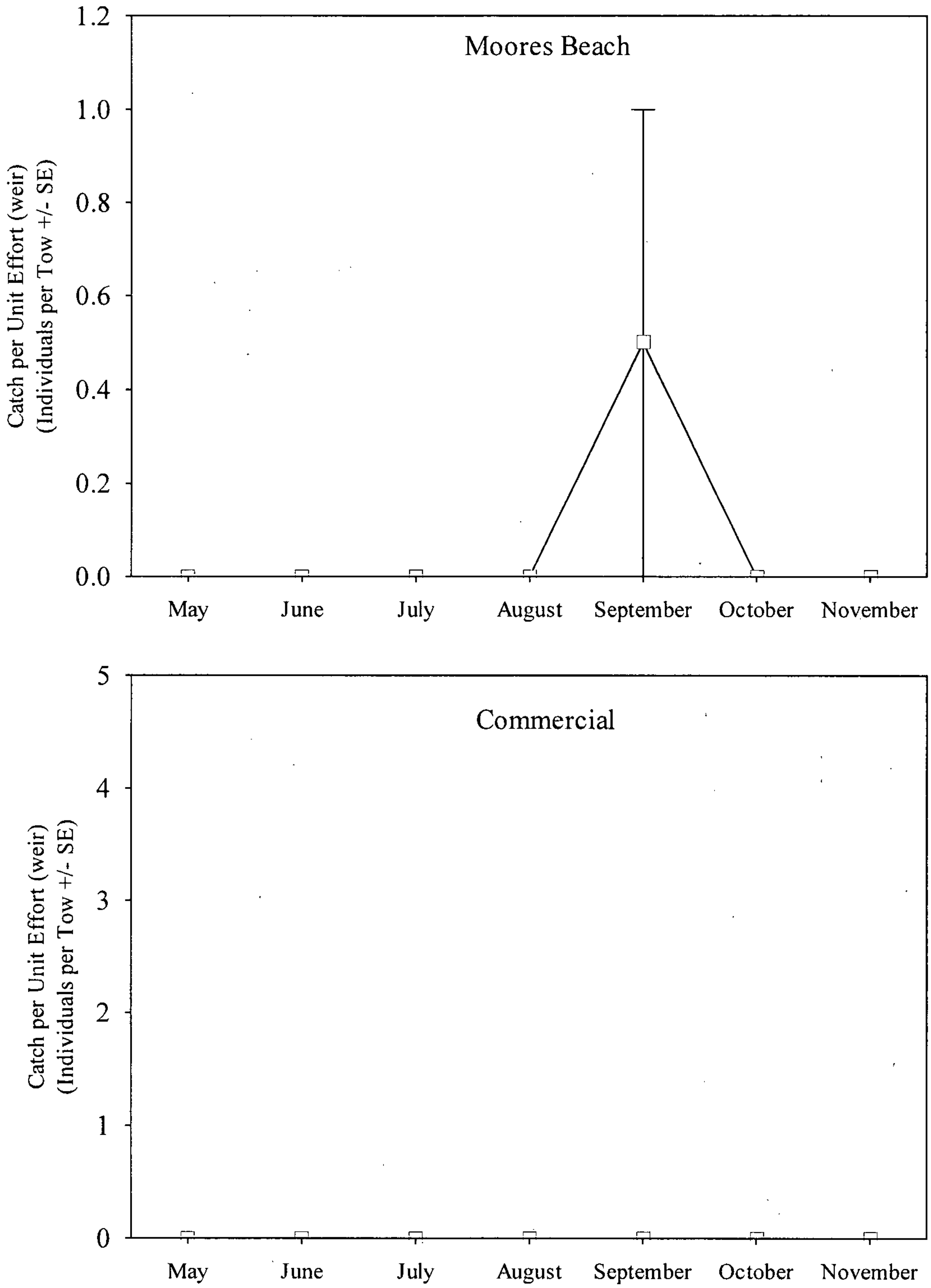


Figure 7-26. Monthly abundance for white perch caught in, small marsh creeks with weirs, in the Lower Bay Region in 2008.

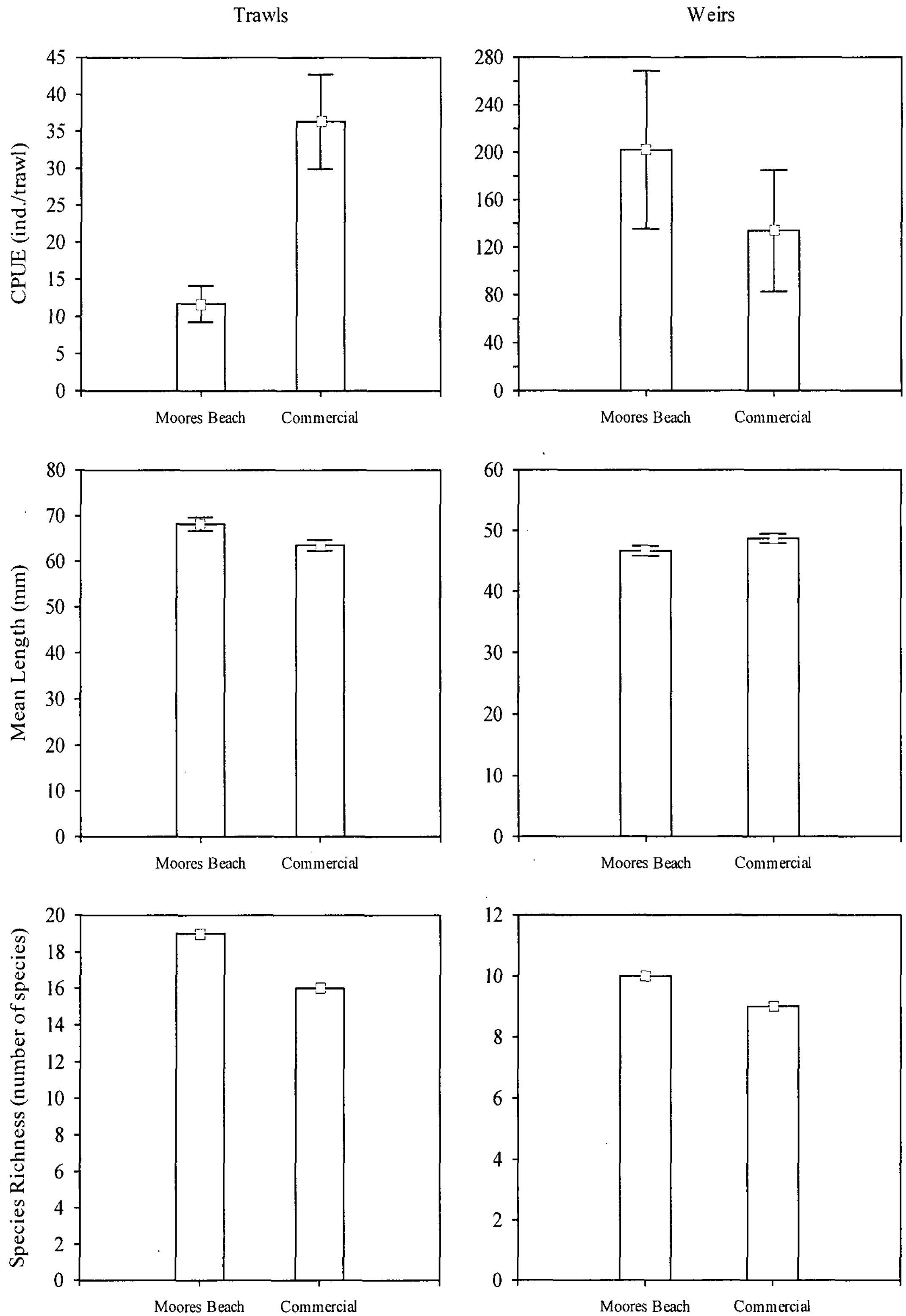


Figure 7-27. Comparisons of abundance, fish length, and species richness among reference (Moores Beach) and restored (Commercial Township) marshes from large and small creeks during 2008.

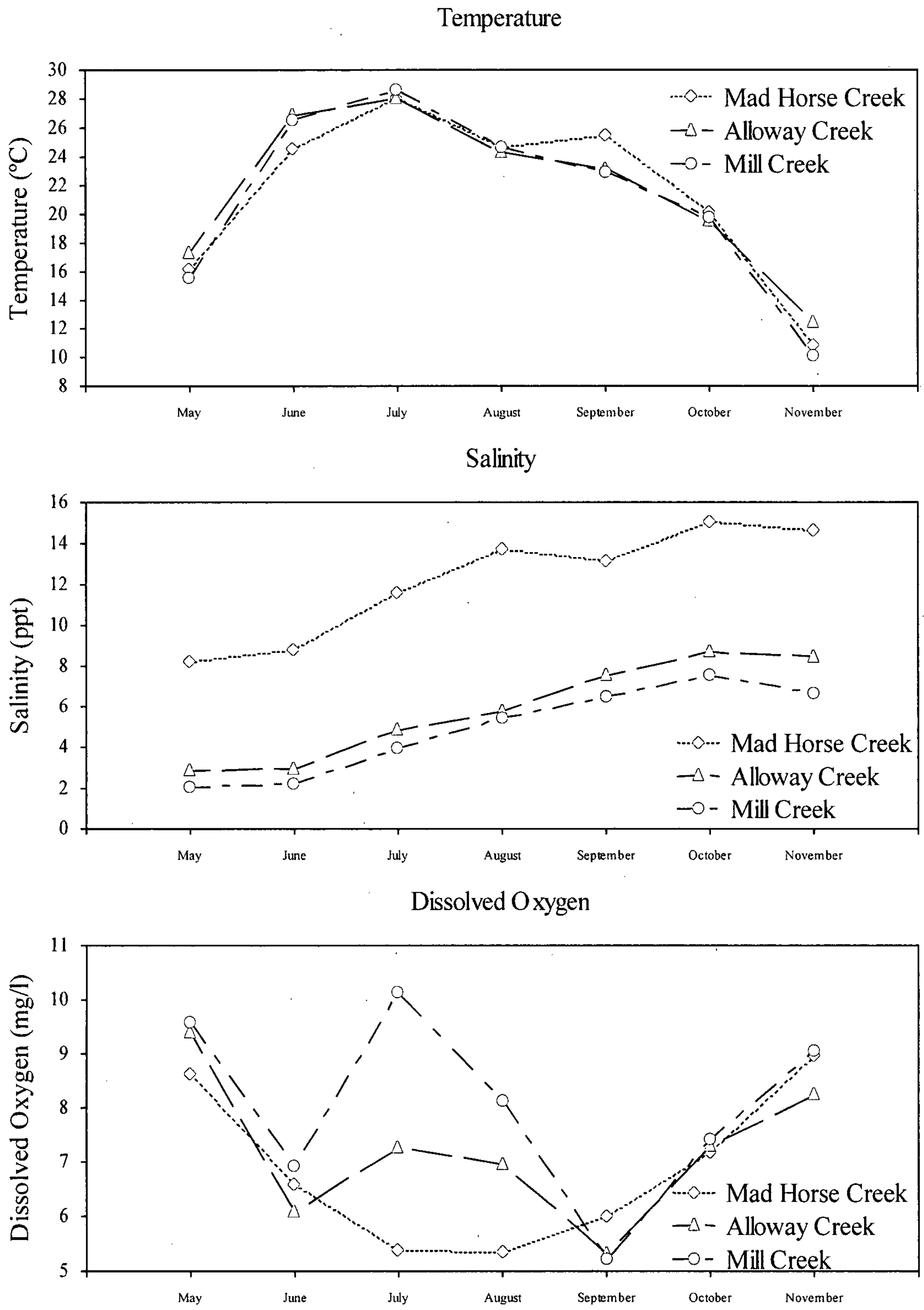


Figure 7-28. Selected physical parameters at regularly sampled sites in the Upper Delaware Bay Region during 2008.

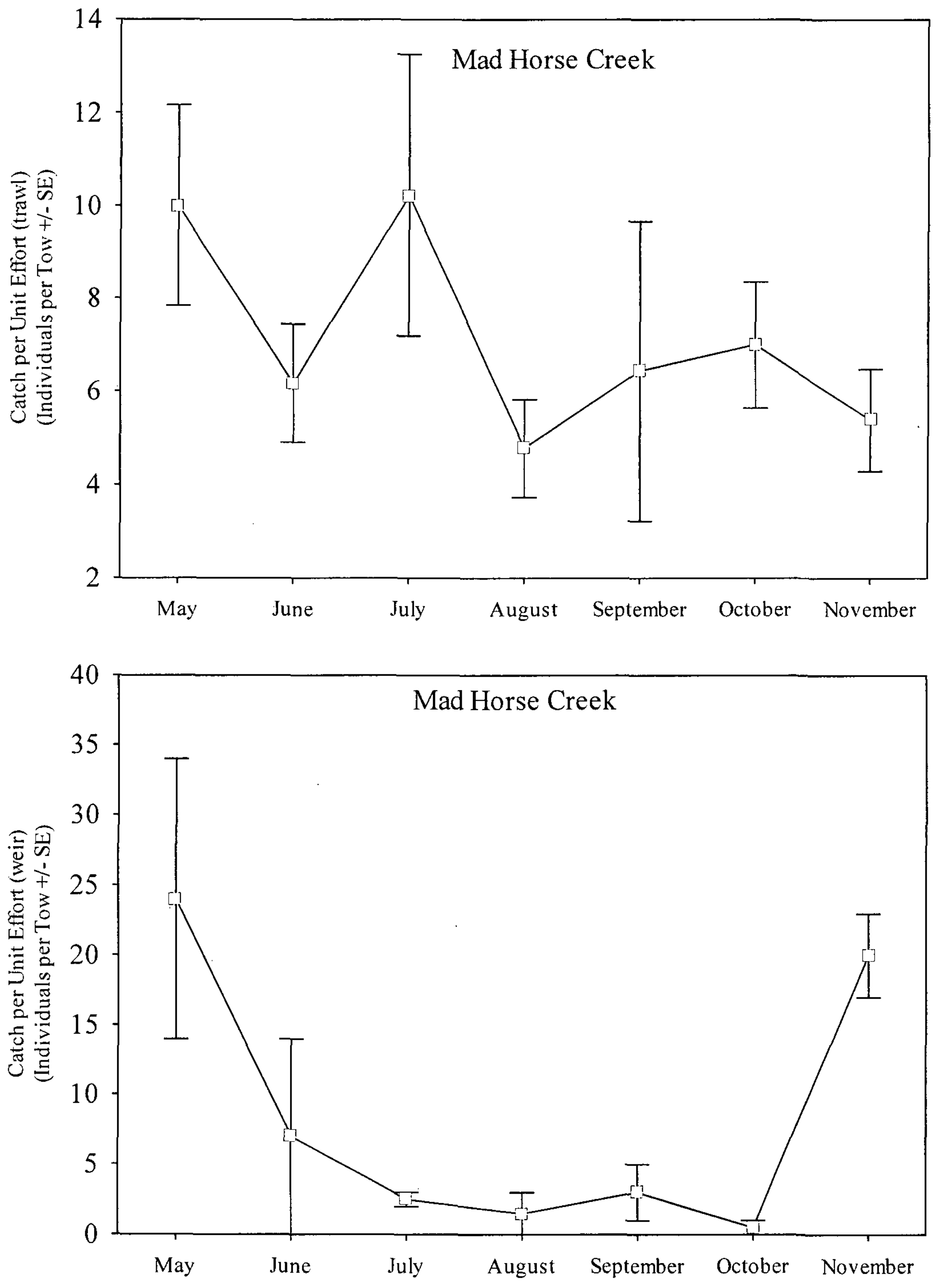


Figure 7-29. Abundance by month for all fish caught, in large marsh creeks (otter trawl) and in small marsh creeks (weir), at Mad Horse Creek during 2008.

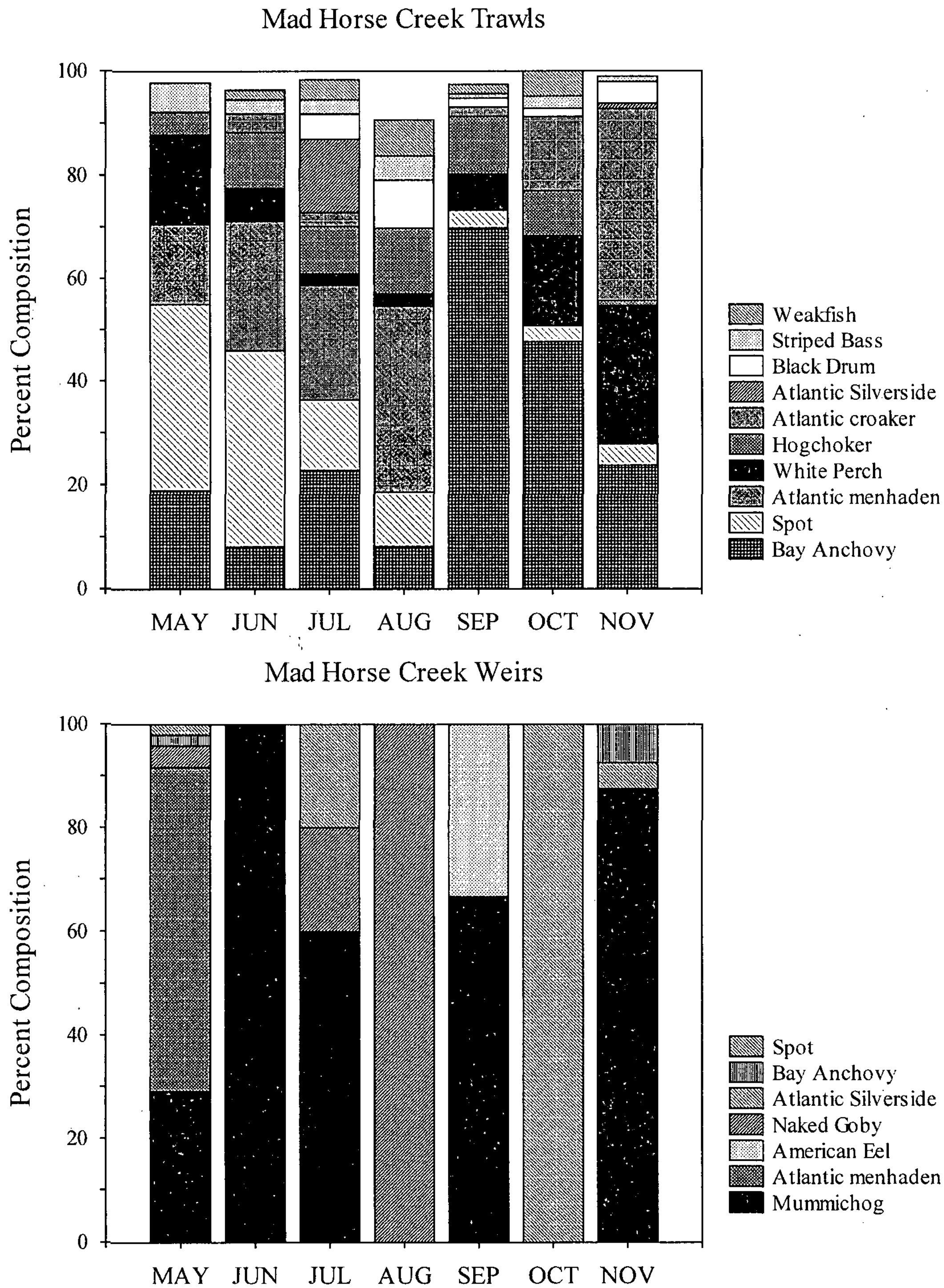


Figure 7-30. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Mad Horse Creek during 2008.

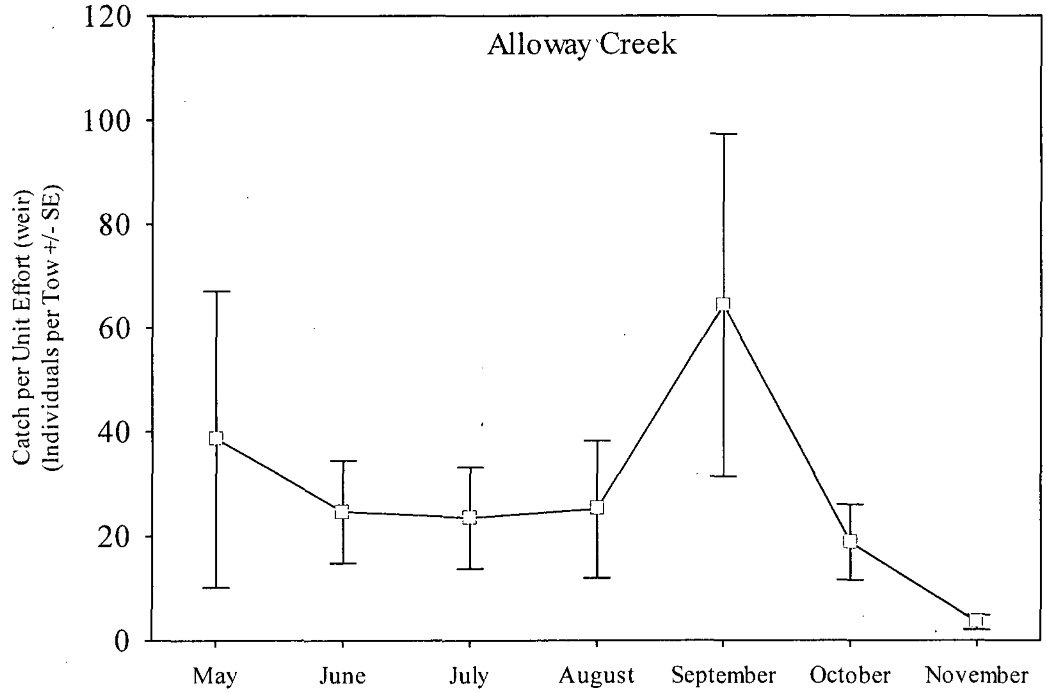


Figure 7-31. Monthly abundance for all fish caught, in small marsh creeks with weirs, at Alloways Creek during 2008.

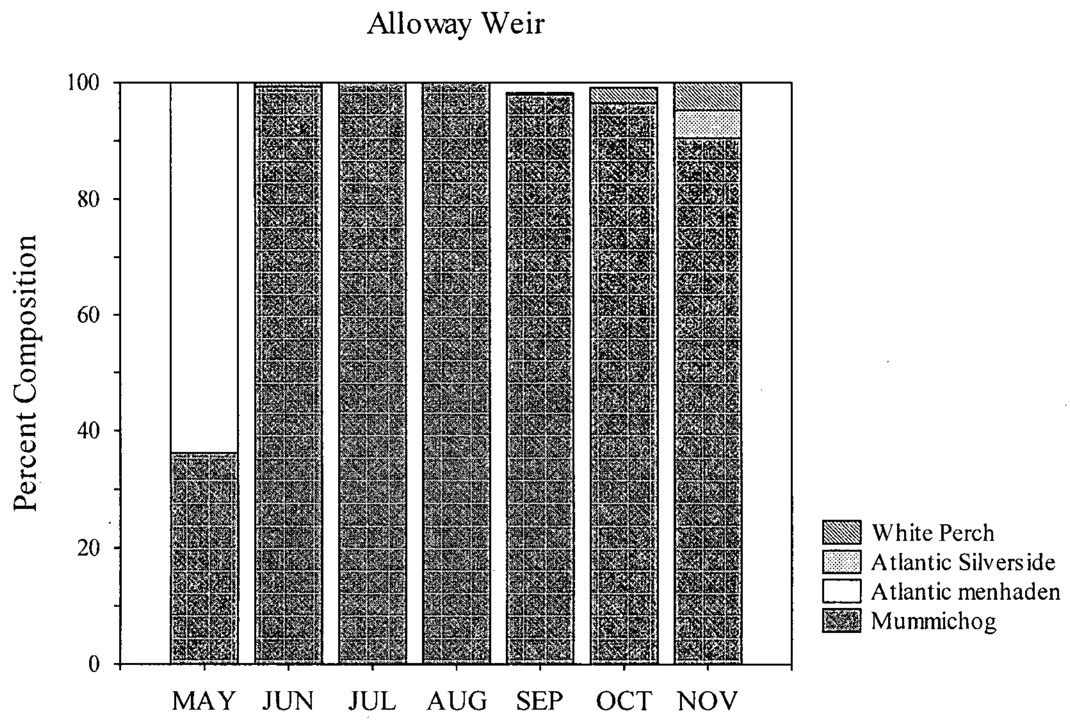


Figure 7-32. Monthly percent composition for fish caught, in small marsh creeks (weir), in Alloway Creek during 2008.

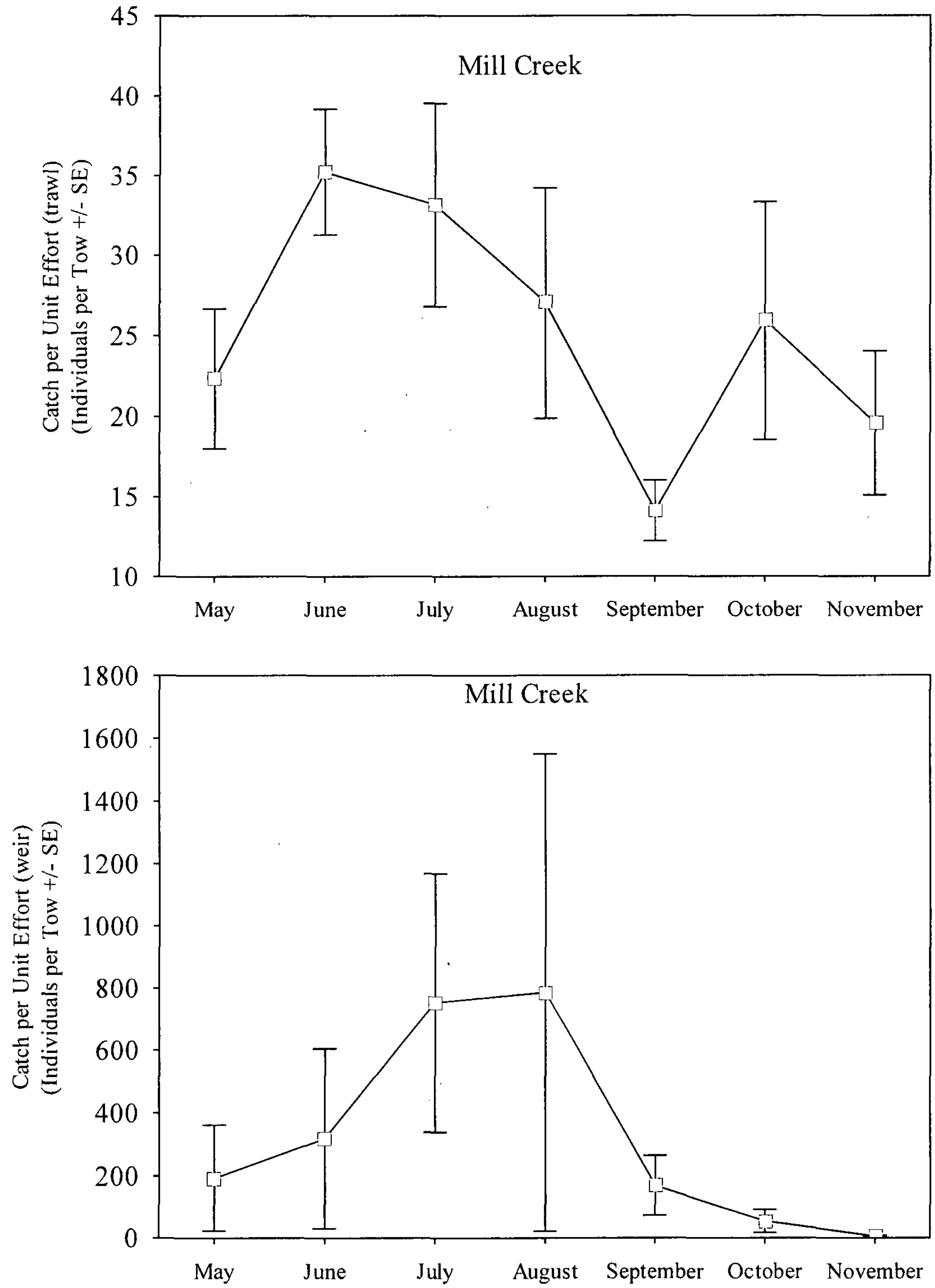


Figure 7-33. Abundance by month for all fish caught, in large marsh creeks (otter trawl) and in small marsh creeks (weir), at Mill Creek during 2008.

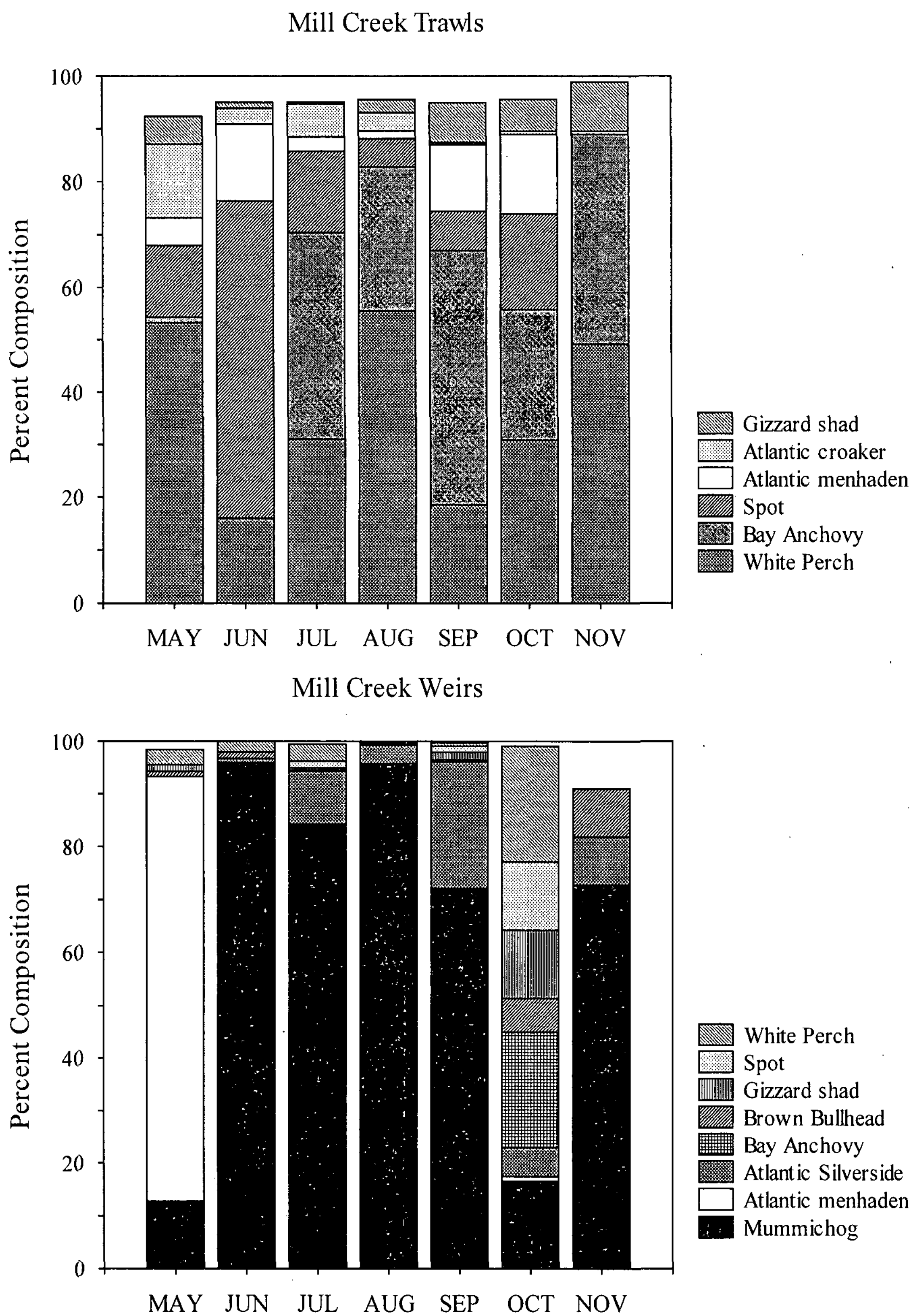
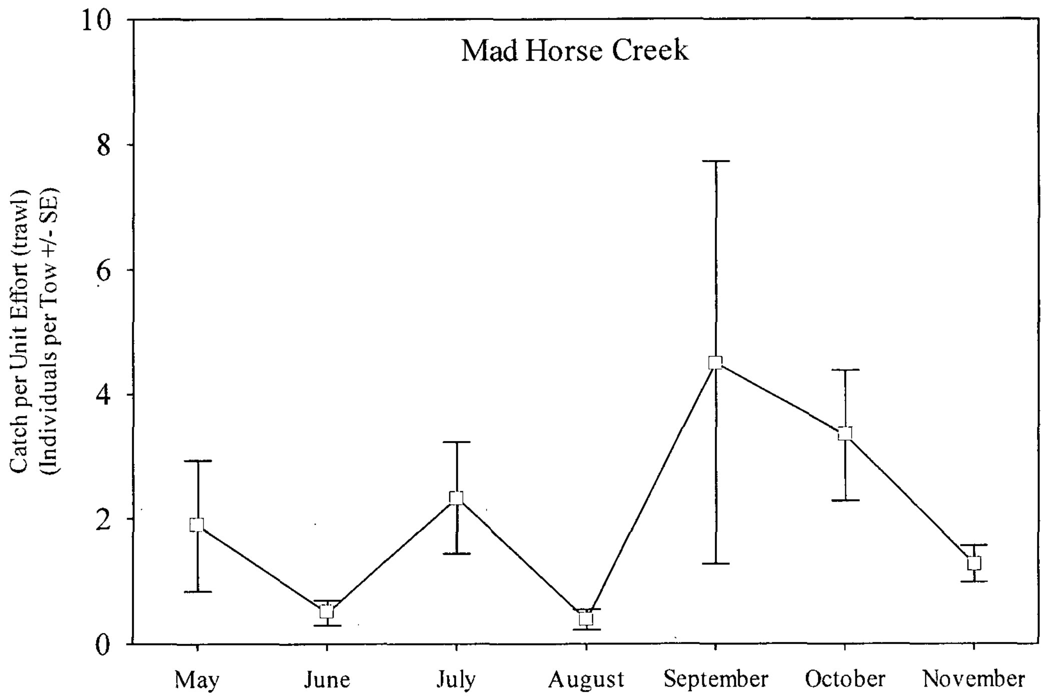


Figure 7-34. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Mill Creek during 2008.



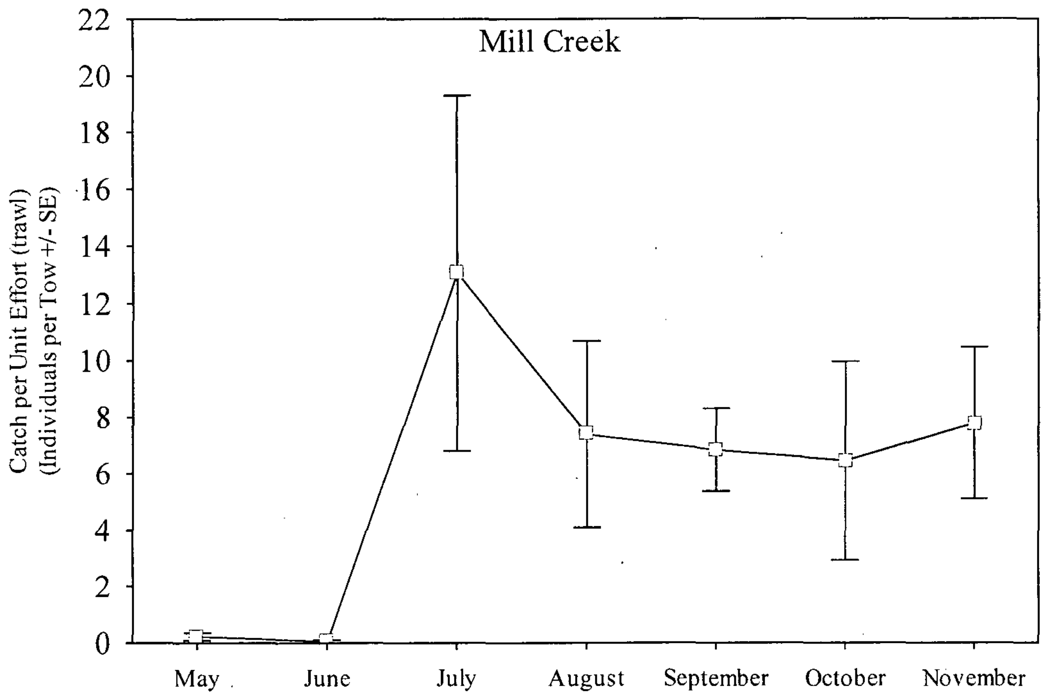


Figure 7-35. Monthly abundance for bay anchovy caught, in large marsh creeks with otter trawls, in the Upper Bay Region during 2008.

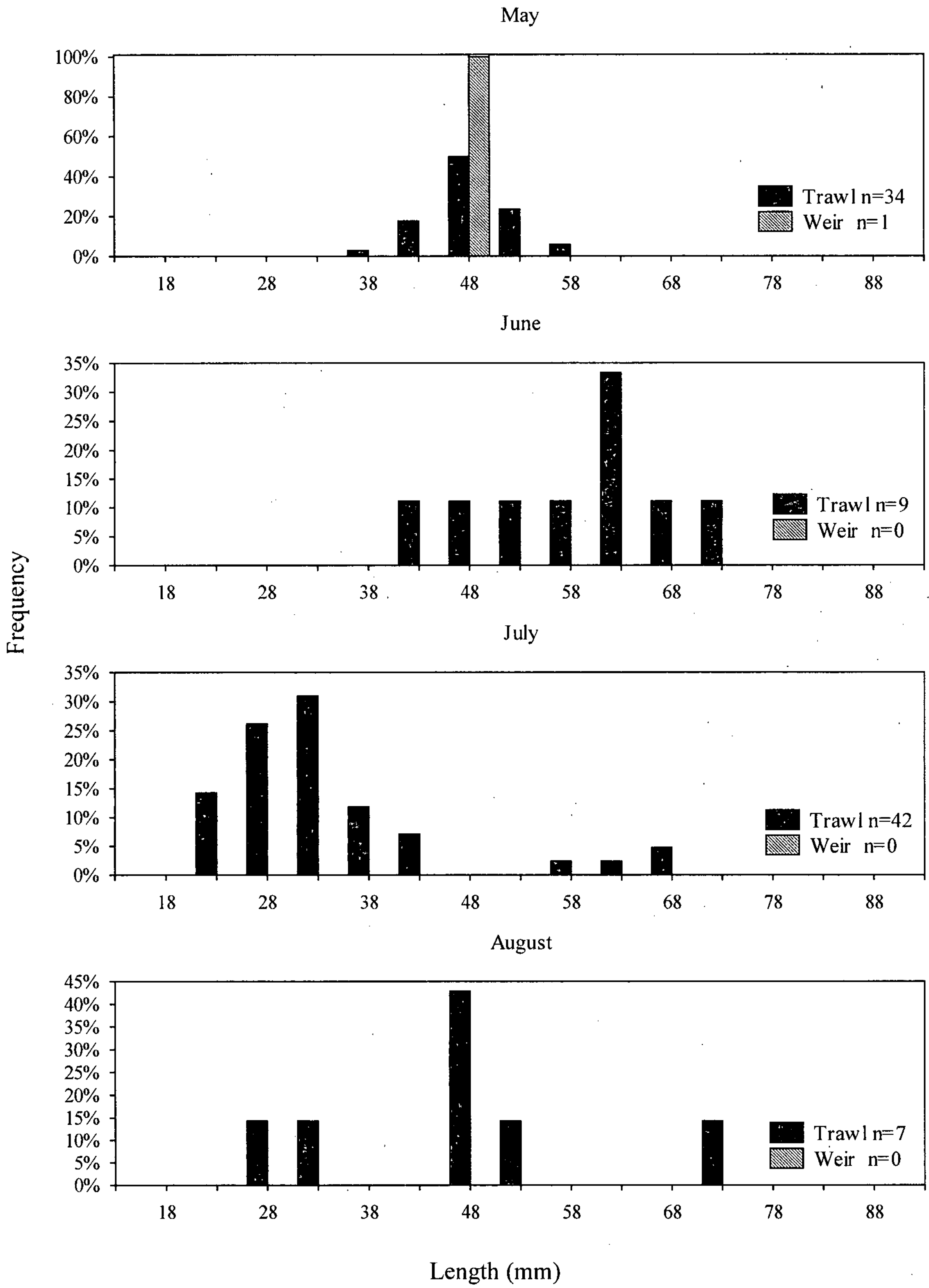


Figure 7-36. Size distribution of bay anchovy, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse Creek during 2008.

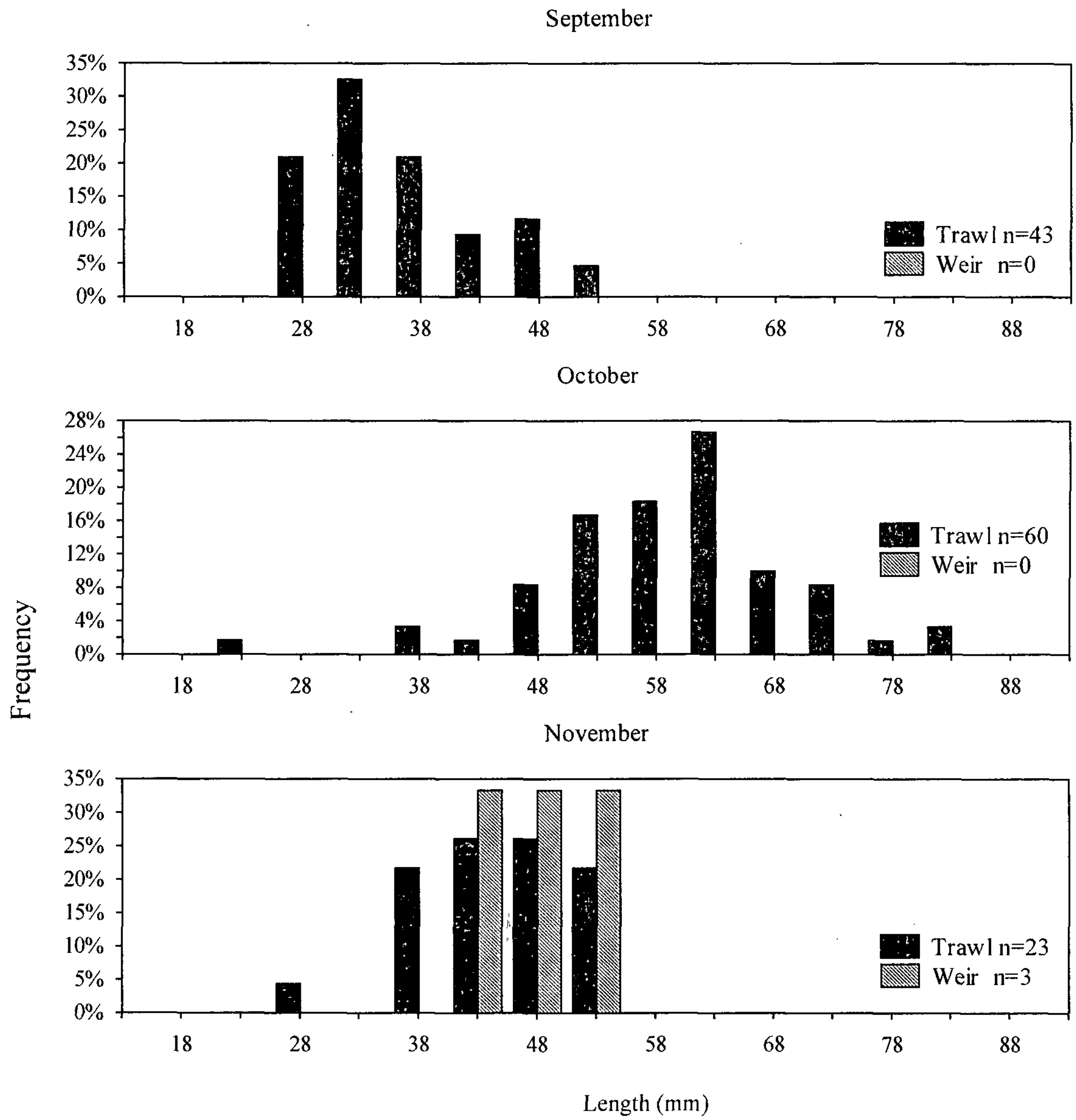


Figure 7-36. Continued.

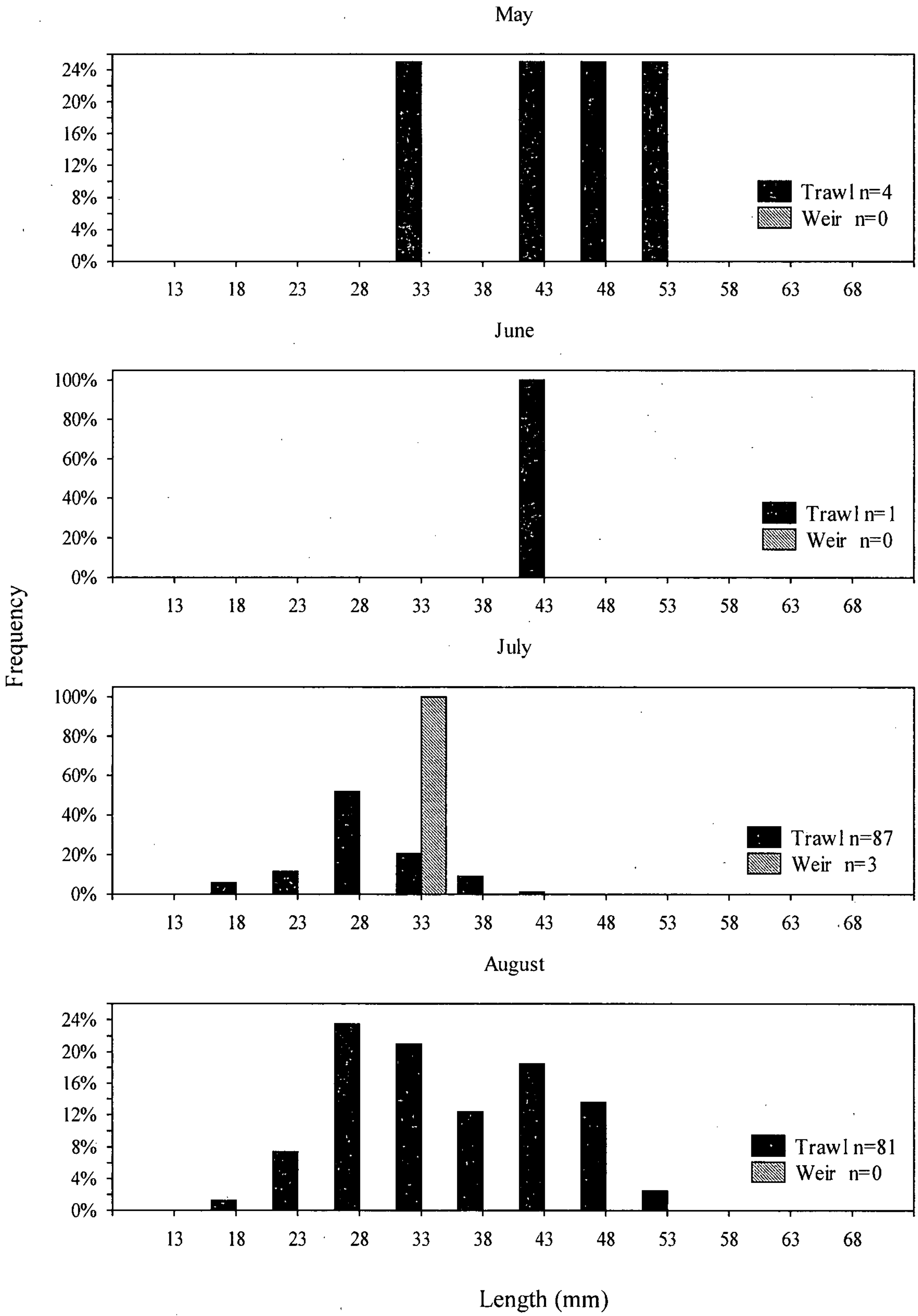


Figure 7-37. Size distribution of bay anchovy, collected in large marsh creeks (otter trawl) and small marsh creeks (weirs), at Mill Creek in 2008.

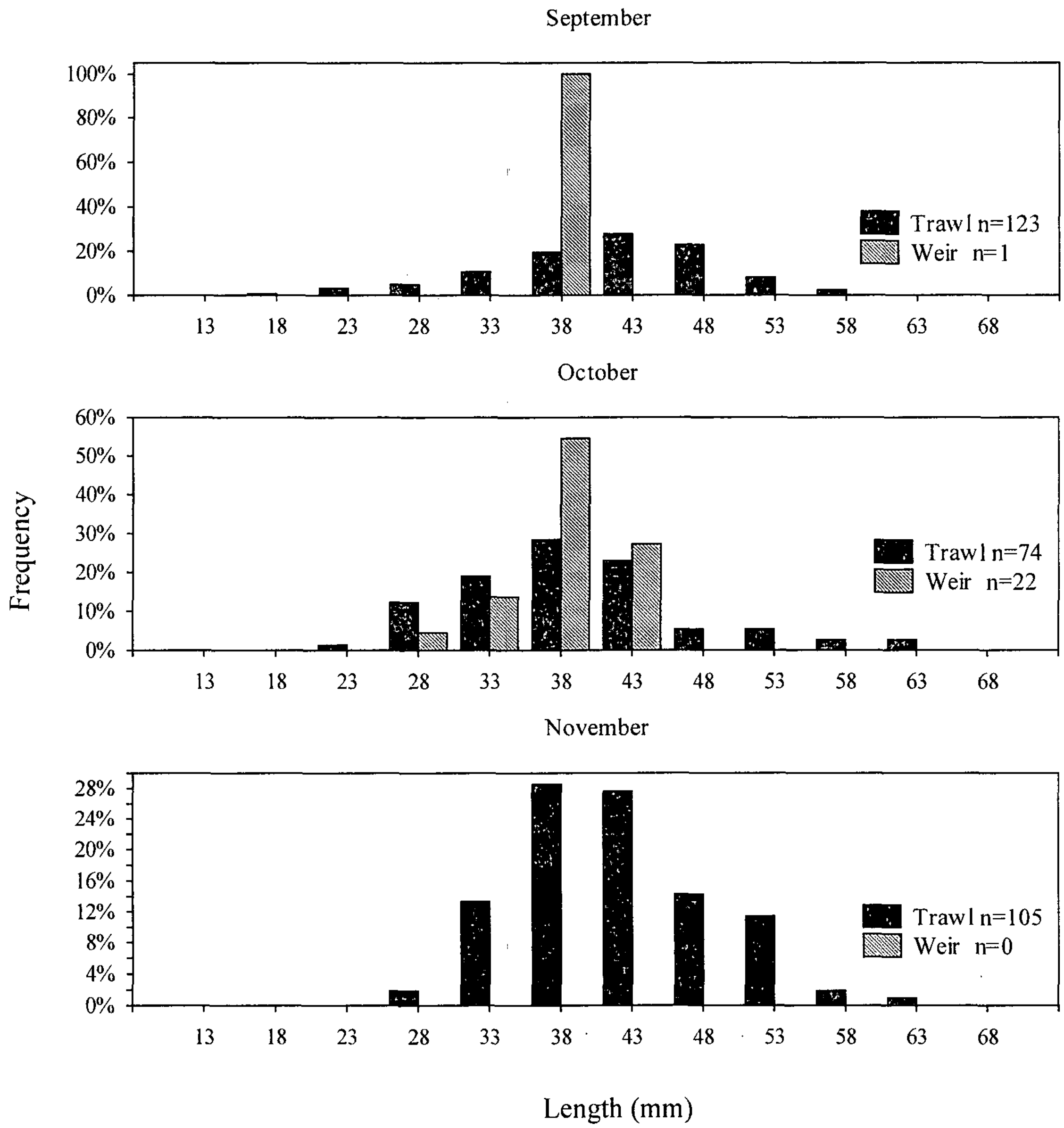


Figure 7-37. Continued.

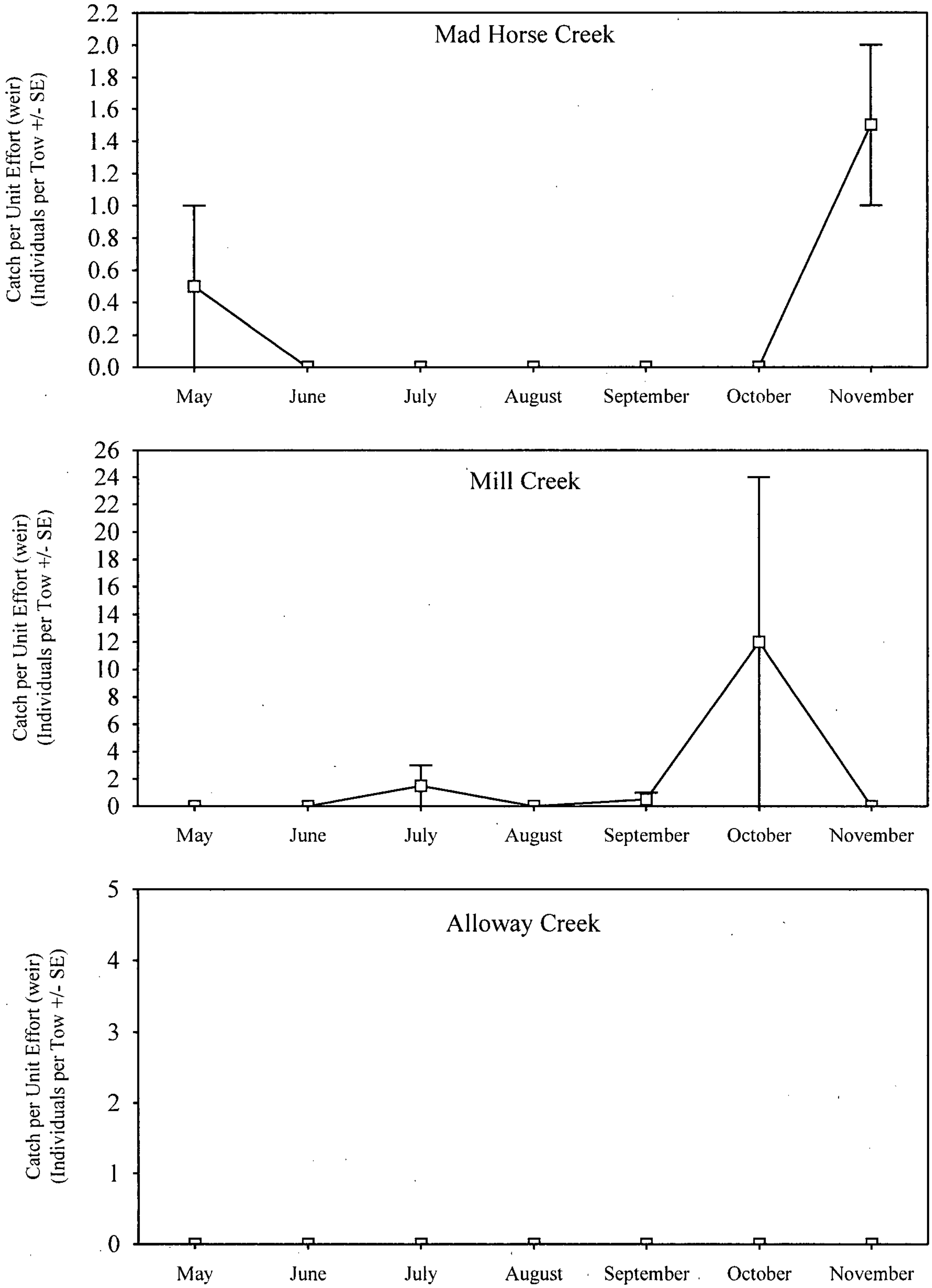


Figure 7-38. Monthly abundance for bay anchovy caught, in small marsh creeks with weirs, in the Upper Bay Region in 2008.

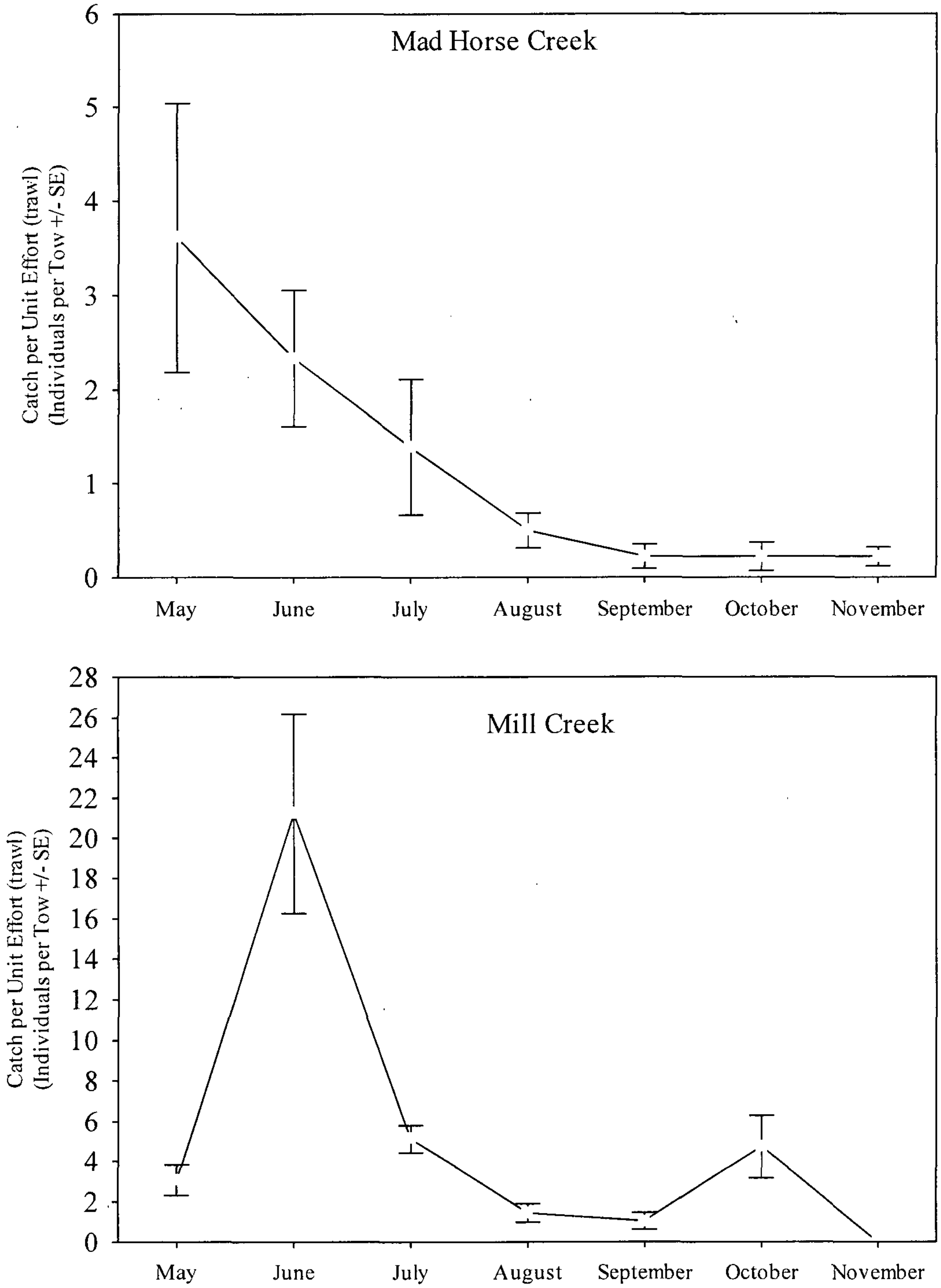


Figure 7-39. Monthly abundance for spot, collected in large marsh creeks with otter trawls, in the Upper Bay Region during 2008.

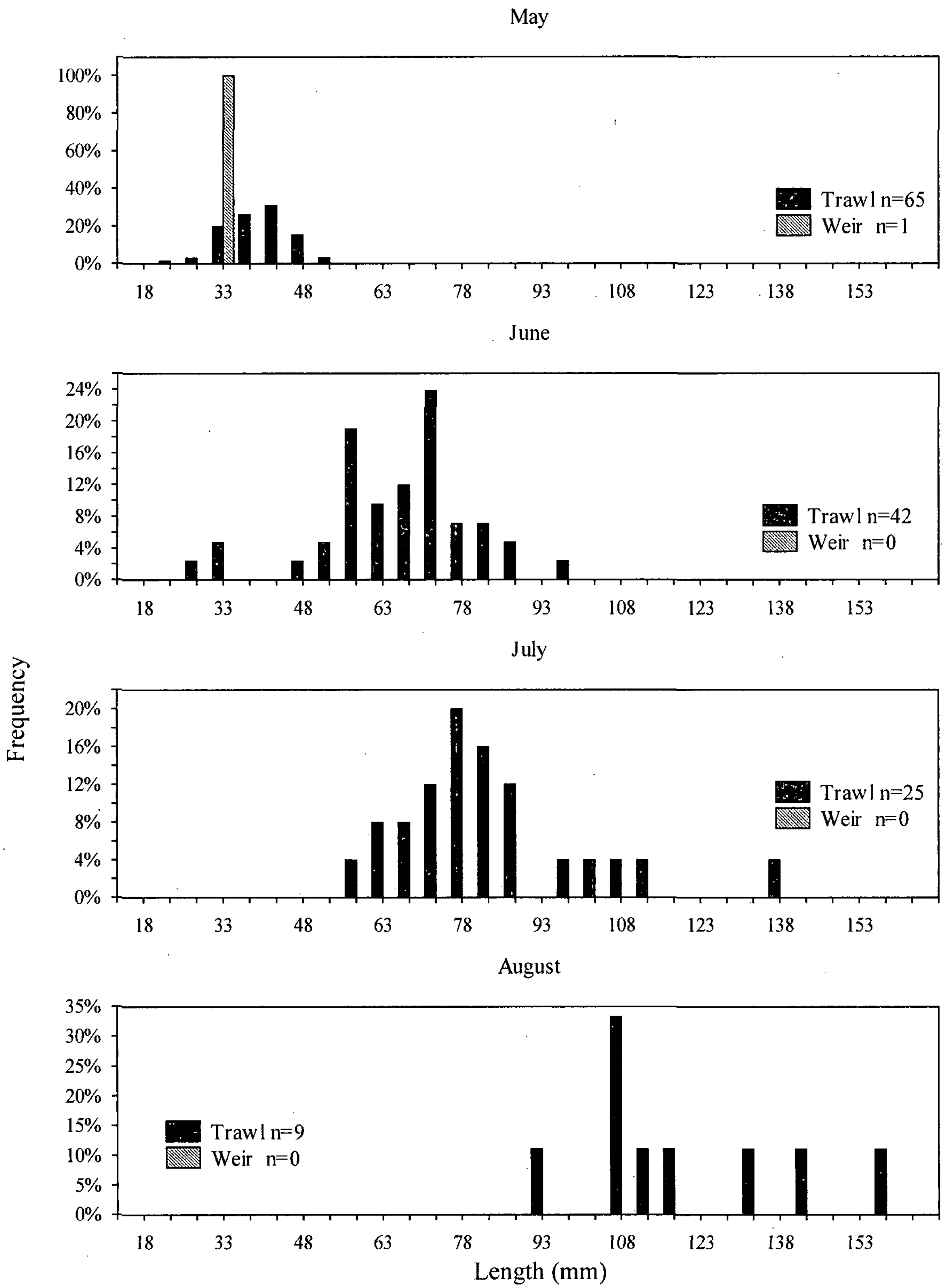
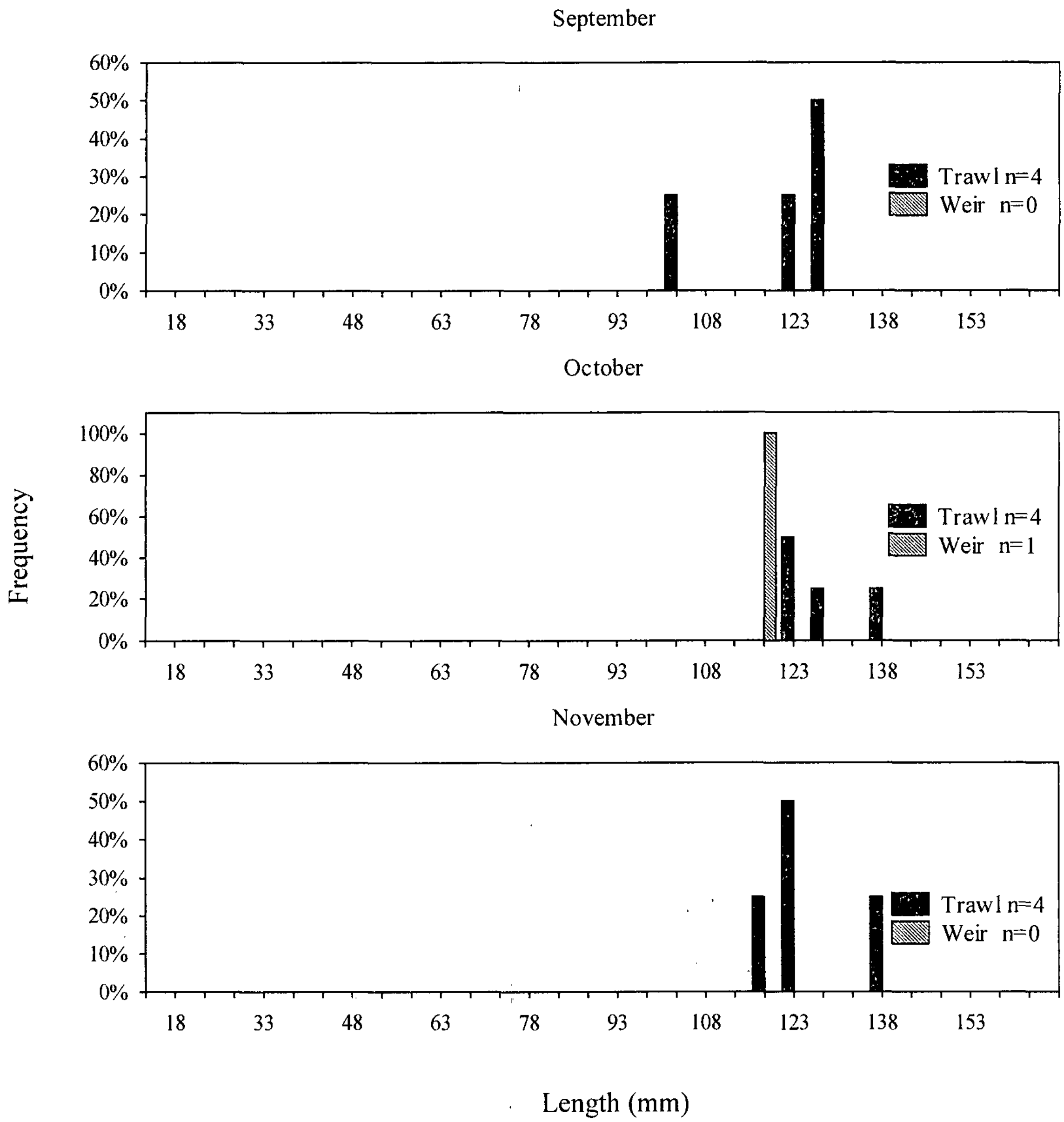


Figure 7-40. Size distribution of spot, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse Creek during 2008.



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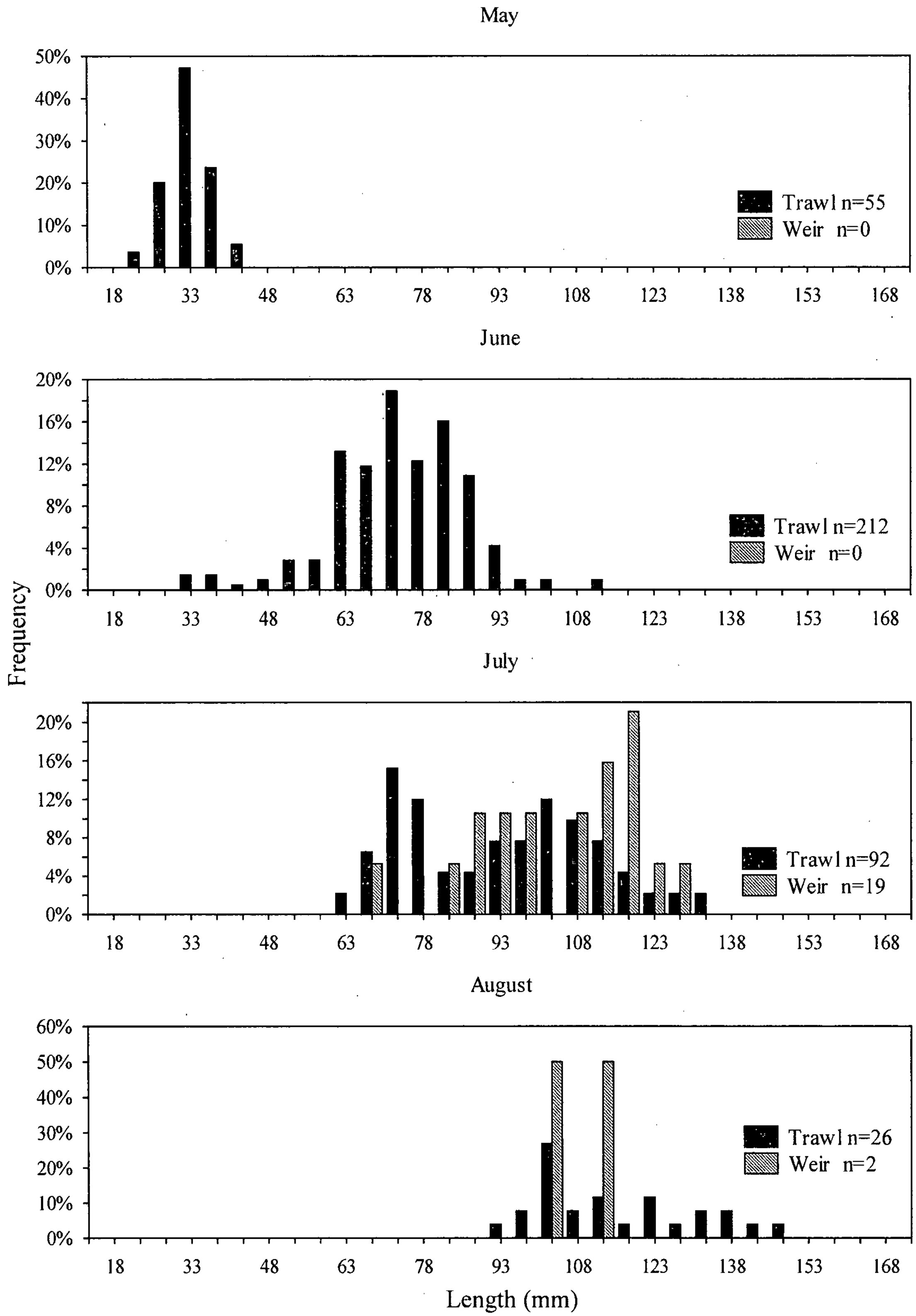
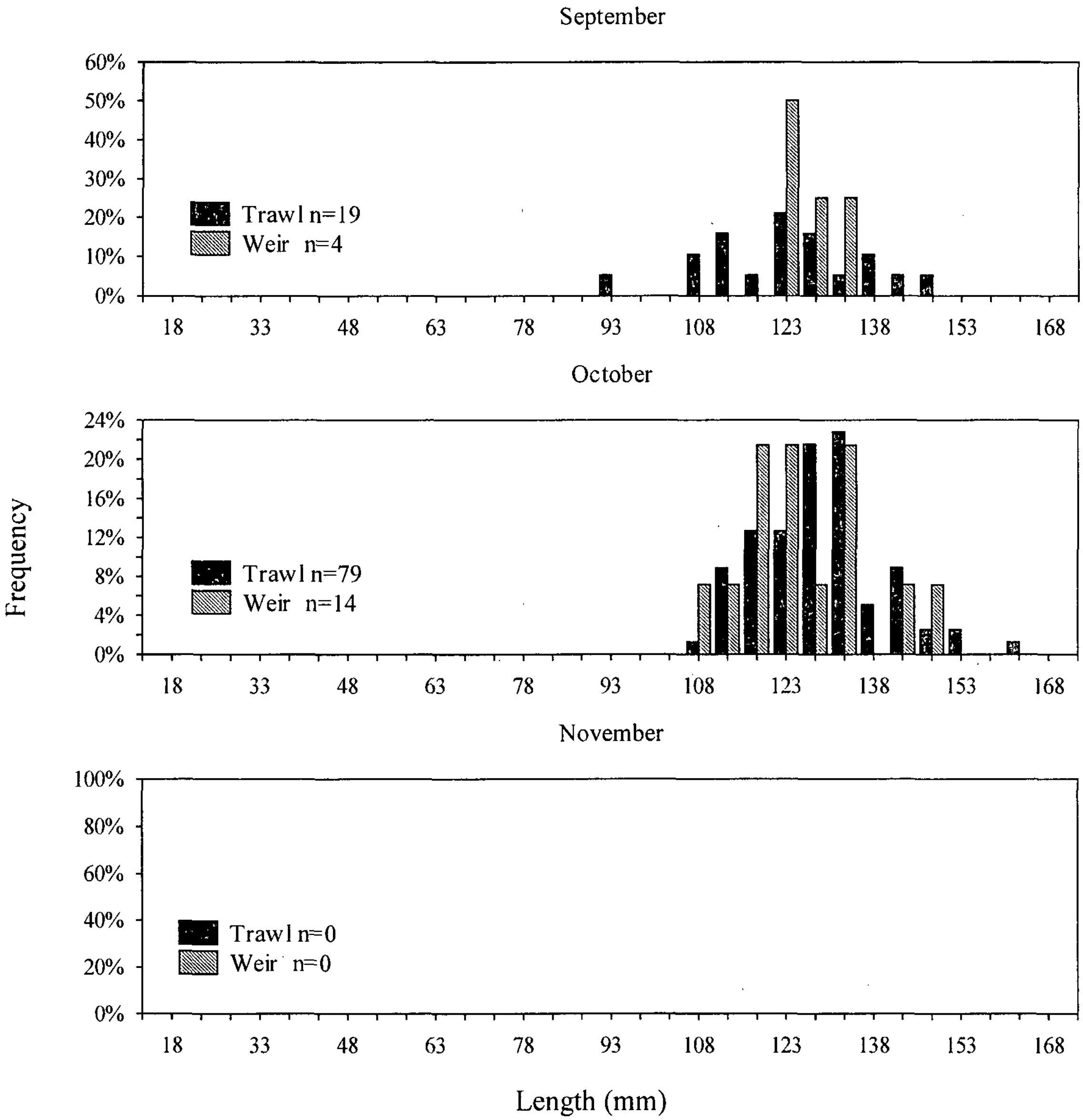


Figure 7-41. Size distribution of spot, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mill Creek during 2008.



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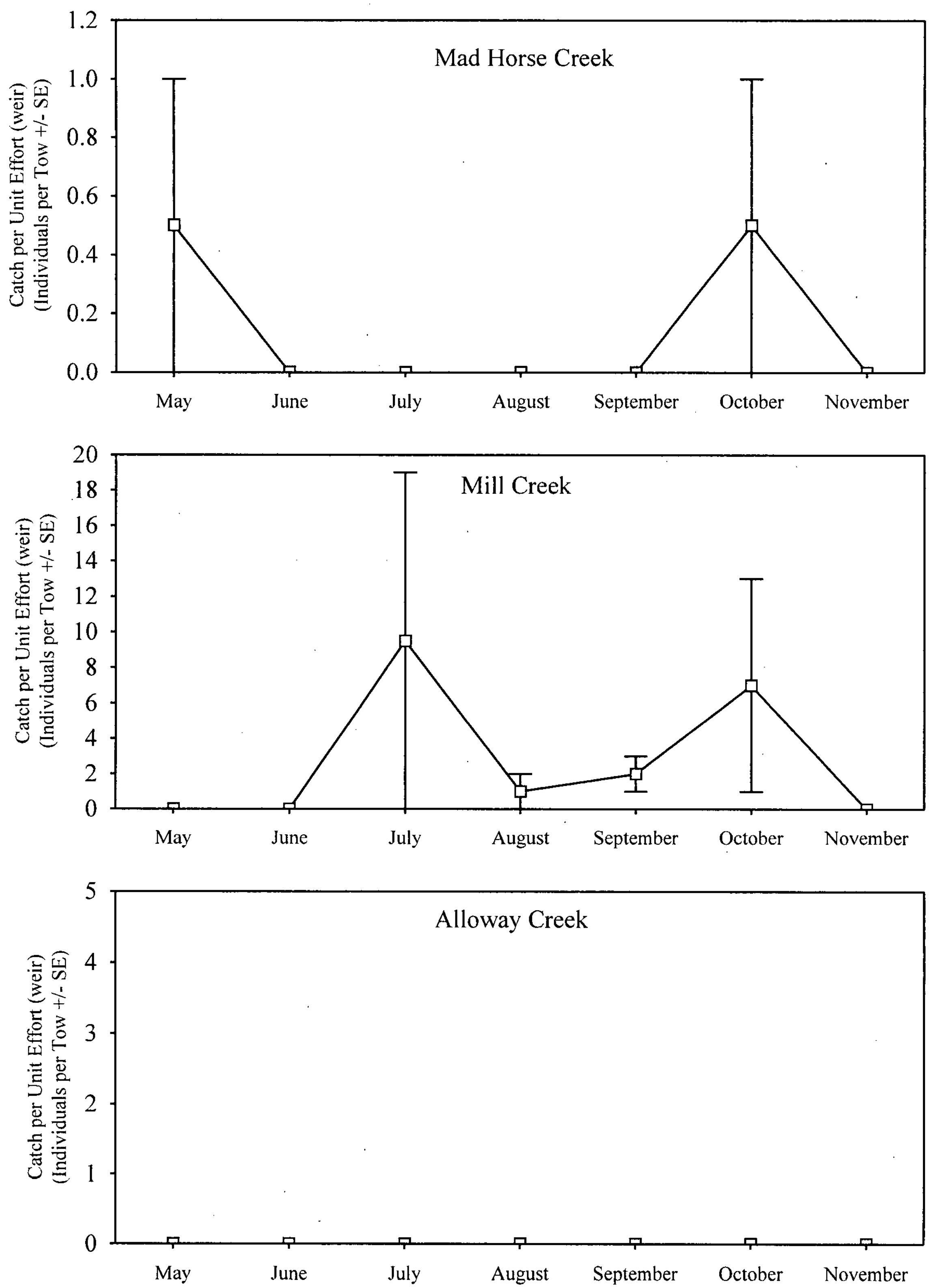


Figure 7-42. Monthly abundance for spot, collected in small marsh creeks (weir), in the Upper Bay Region during 2008.

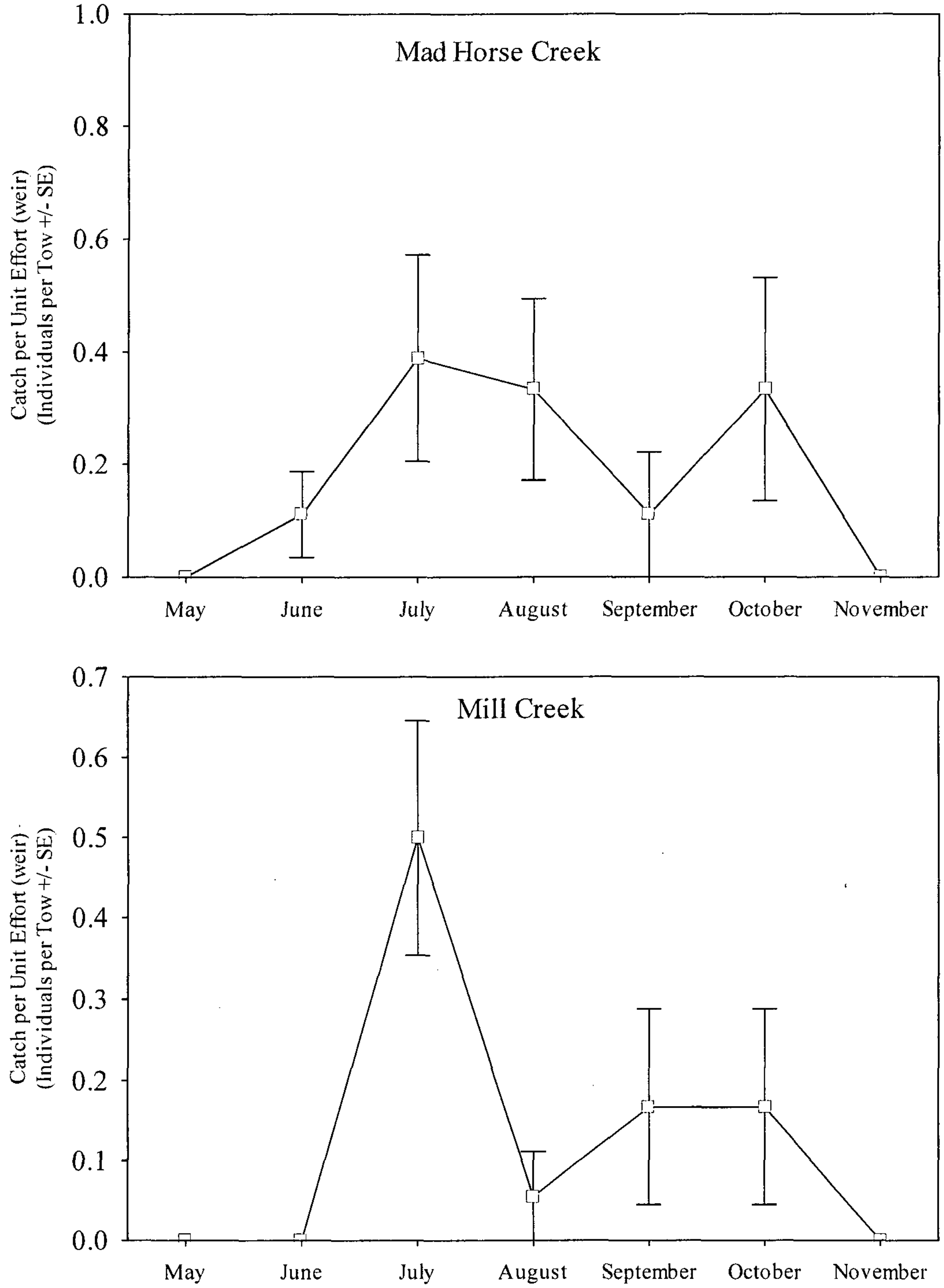


Figure 7-43. Monthly abundance for weakfish, collected in large marsh creeks with otter trawls, in the Upper Bay Region during 2008.

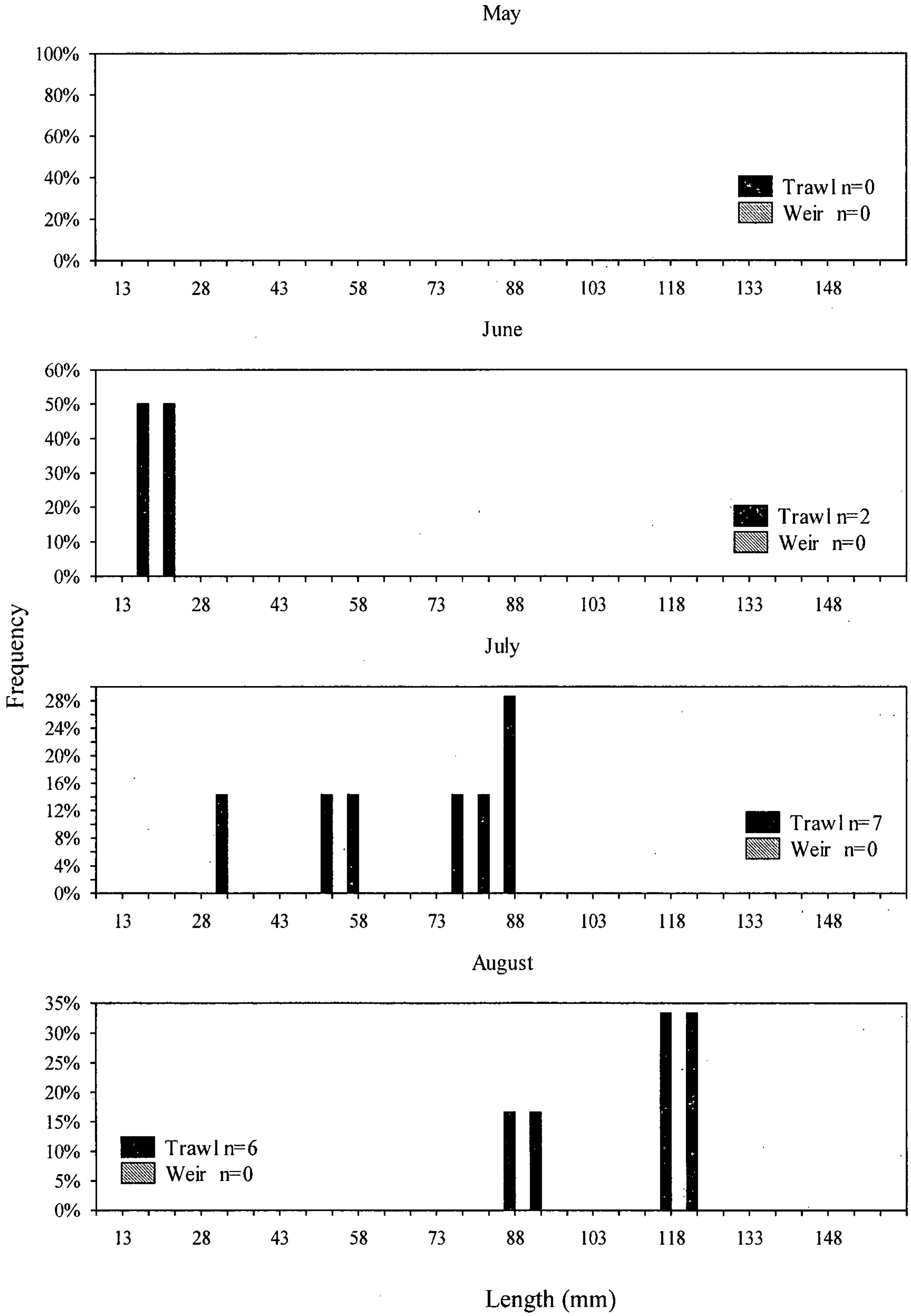
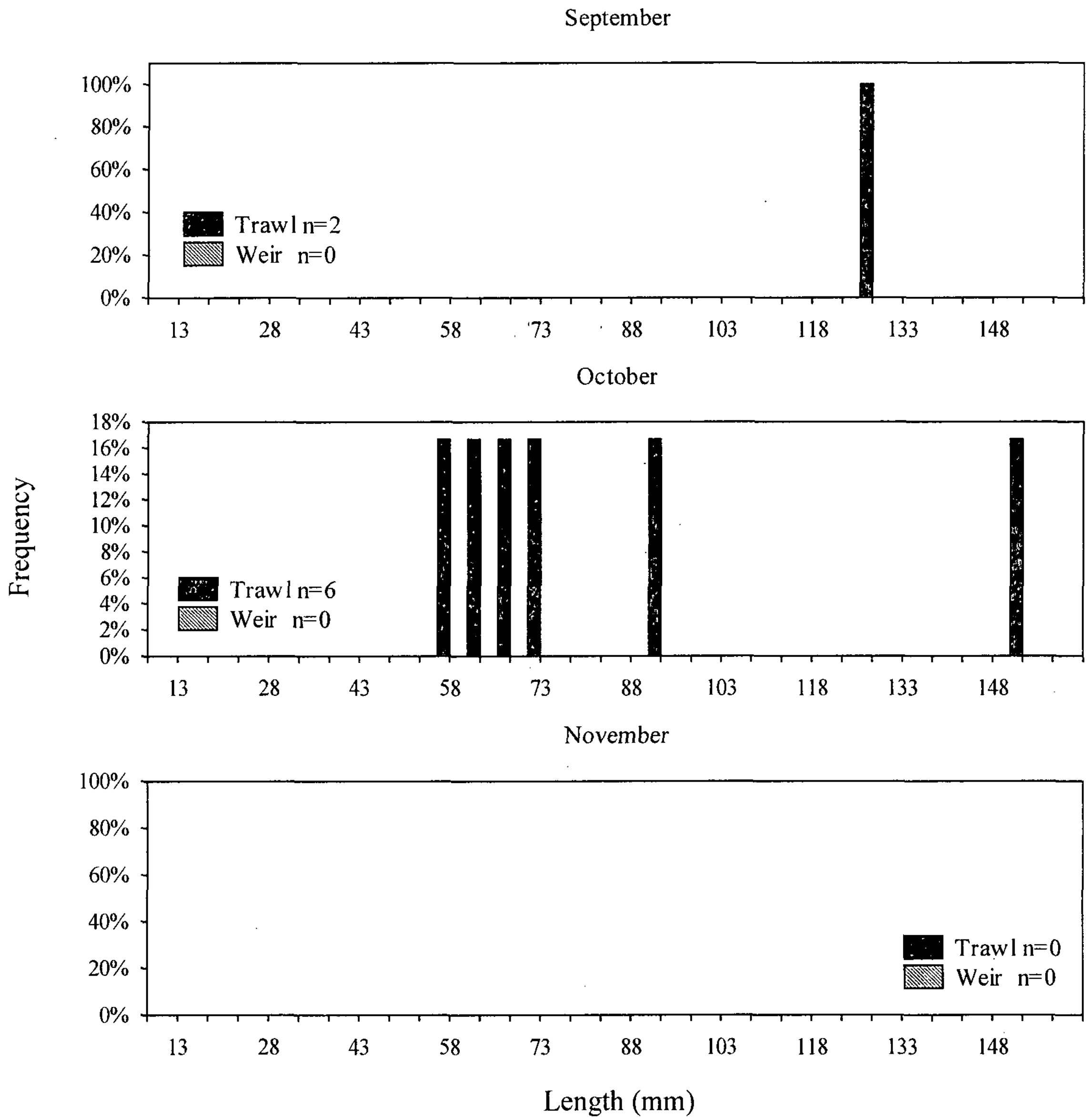


Figure 7-44. Size distribution of weakfish, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse Creek during 2008.



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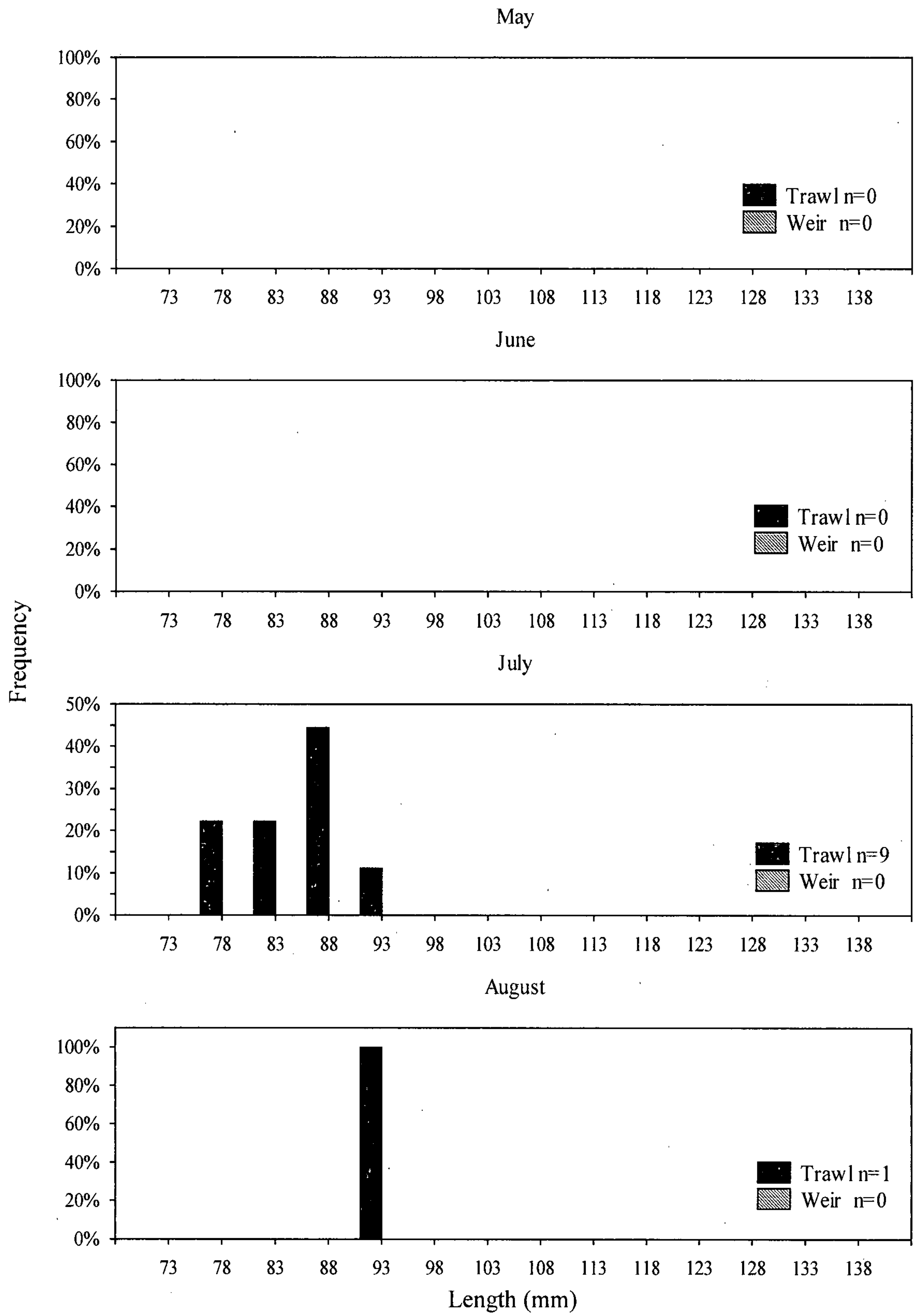
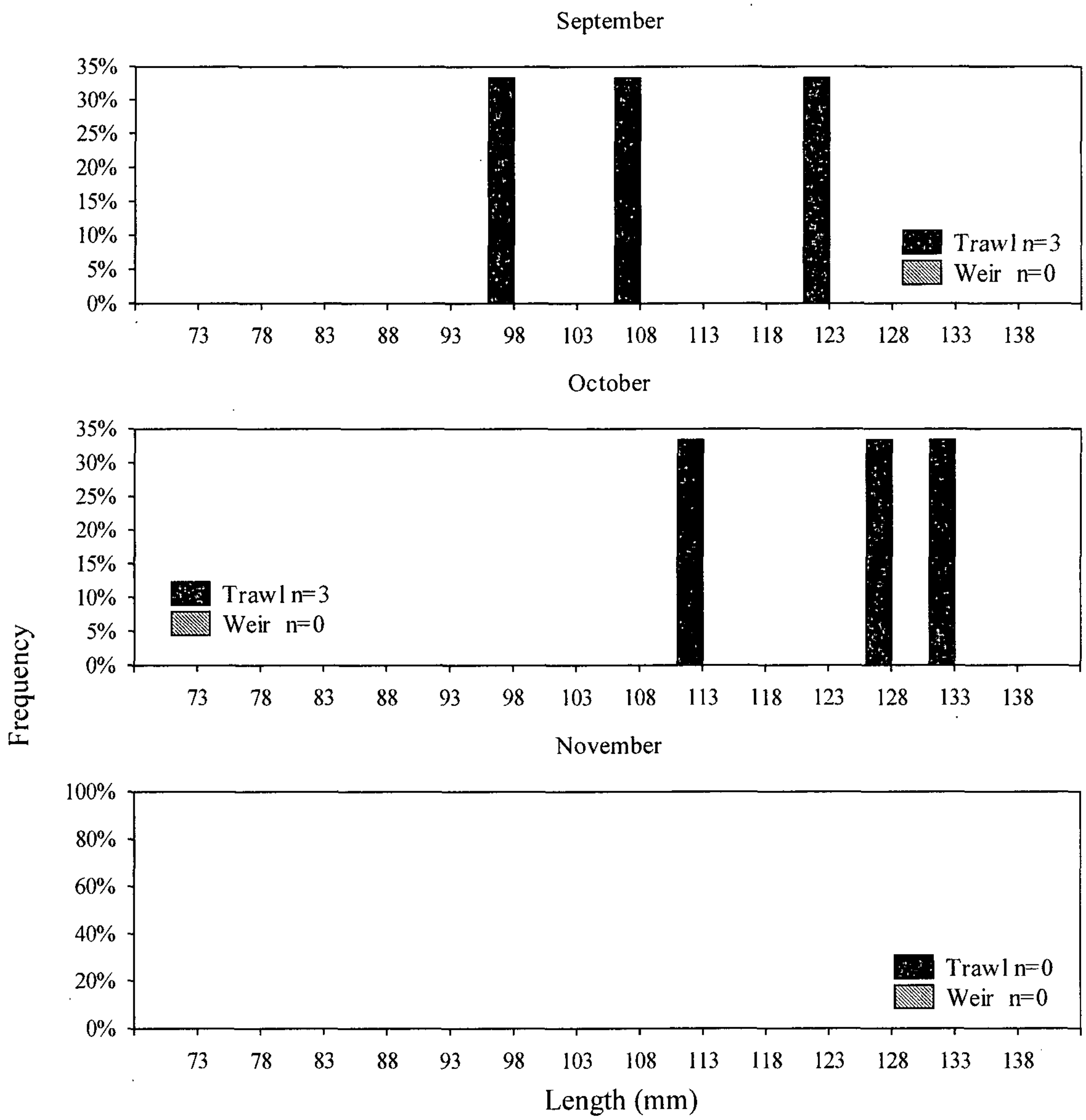


Figure 7-45. Size distribution of weakfish, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mill Creek during 2008.



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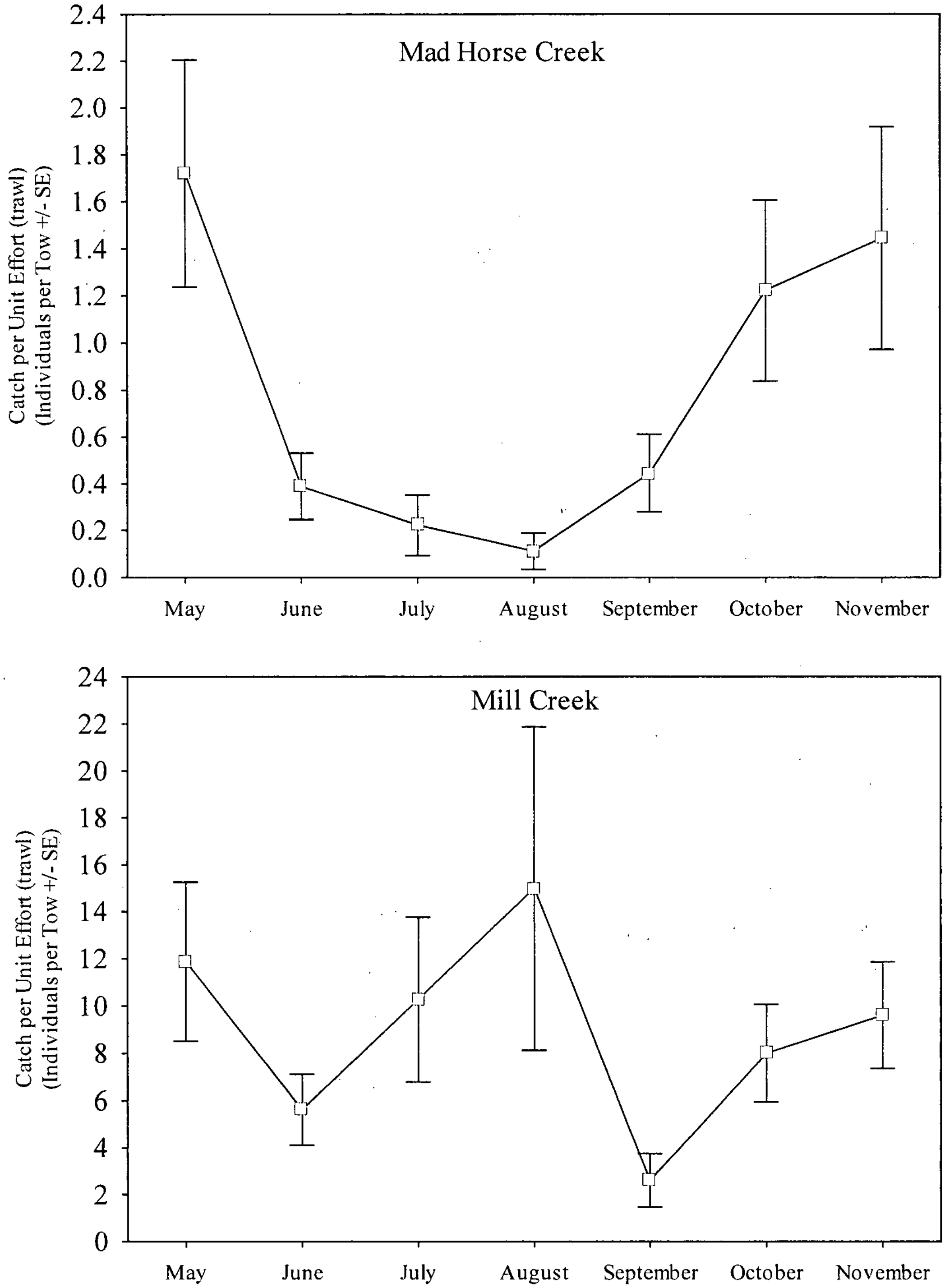


Figure 7-46. Monthly abundance for white perch, collected in large marsh creeks (otter trawl), in the Upper Bay Region during 2008.

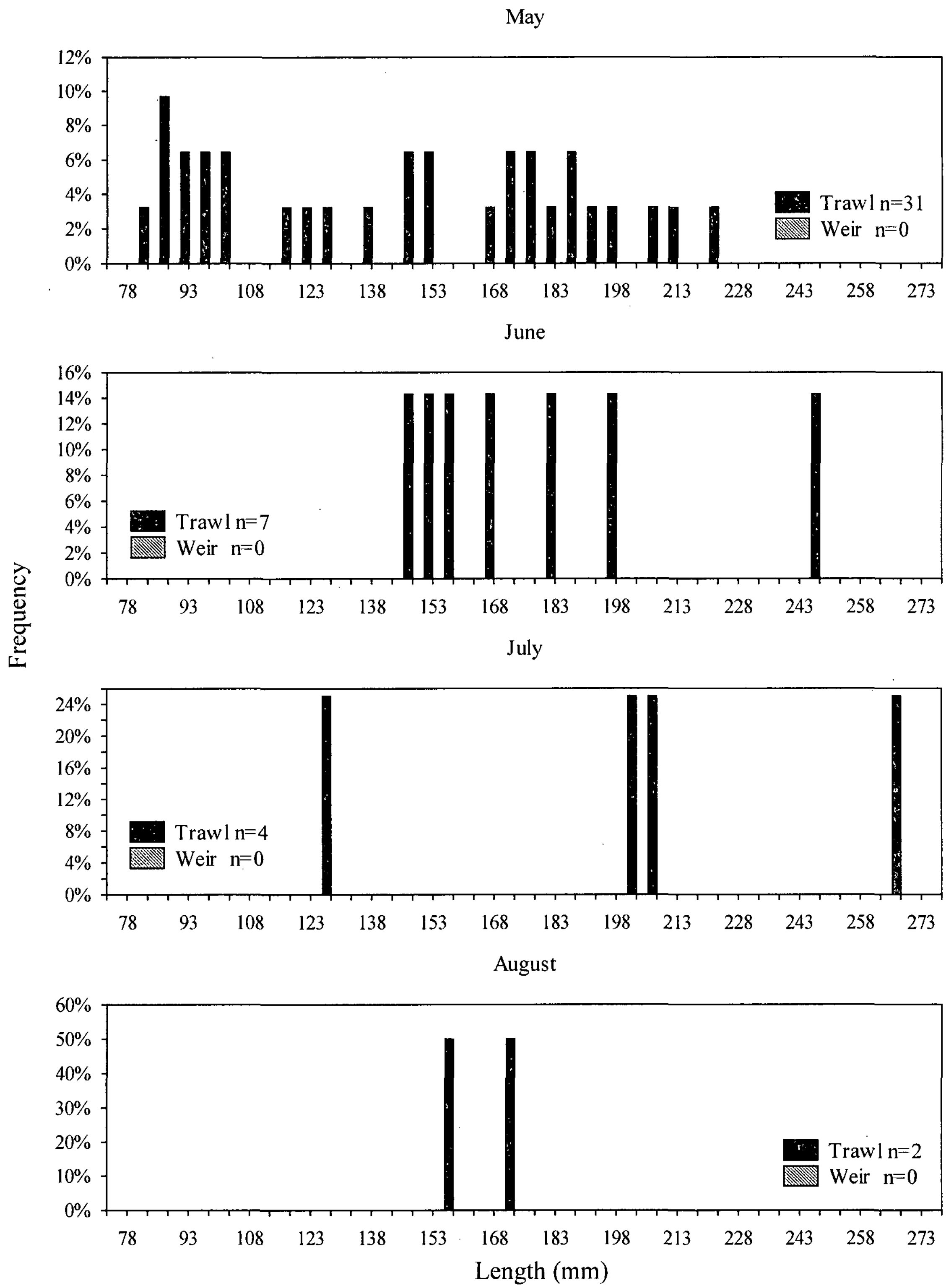
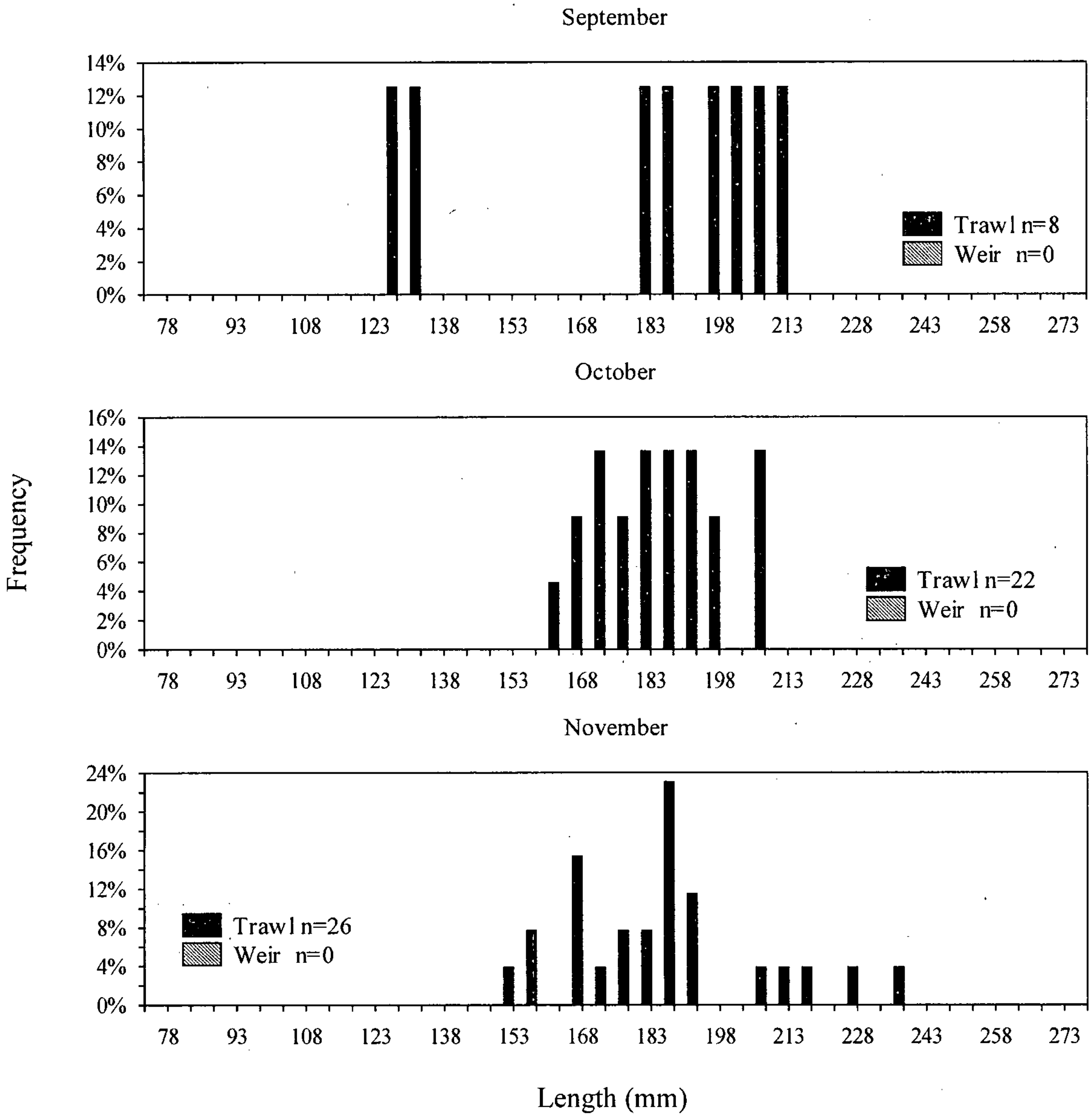


Figure 7-47. Size distribution of white perch, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse Creek during 2008.



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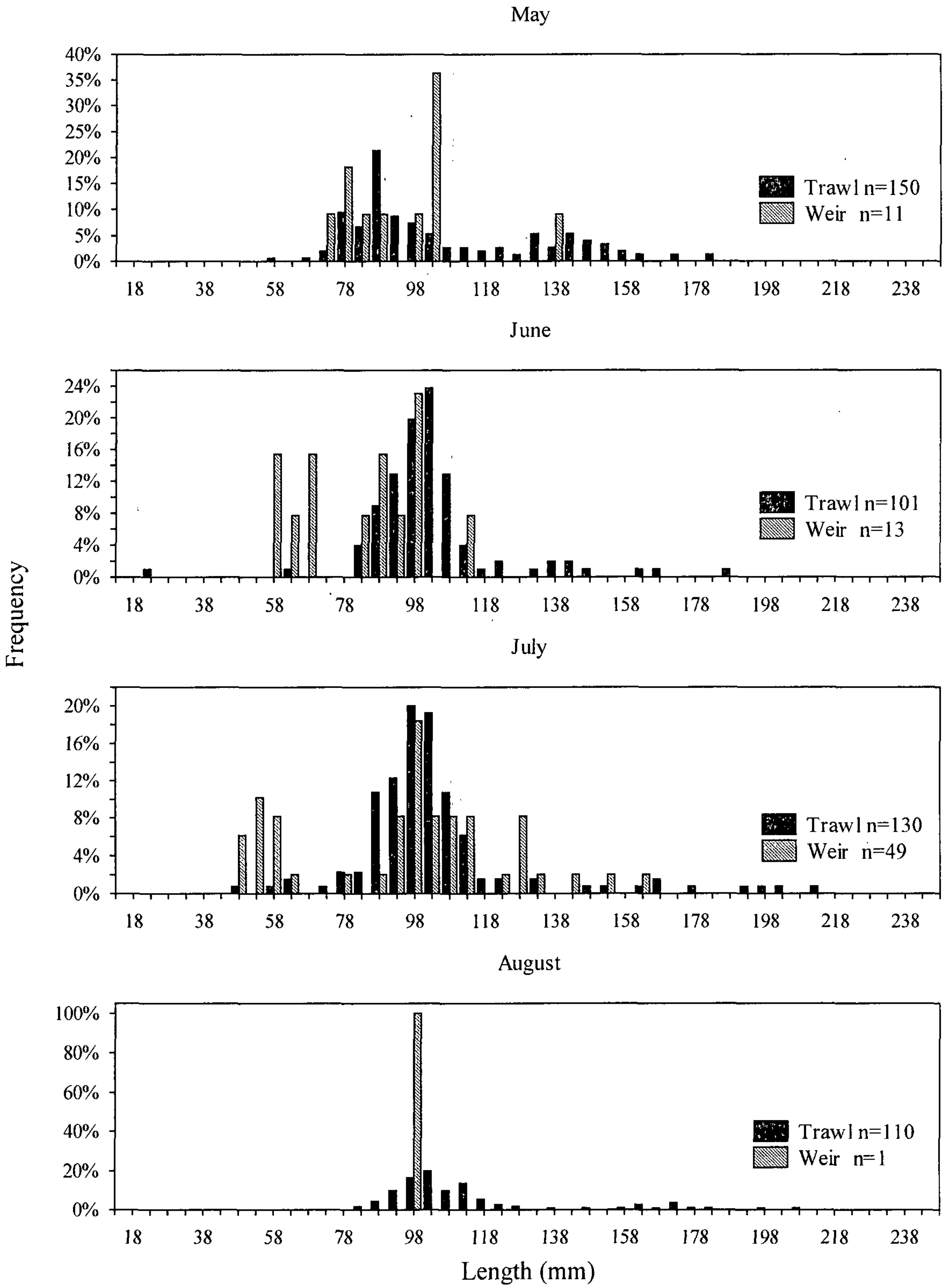

Figure 7-48. Size distribution of white perch, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mill Creek during 2008.

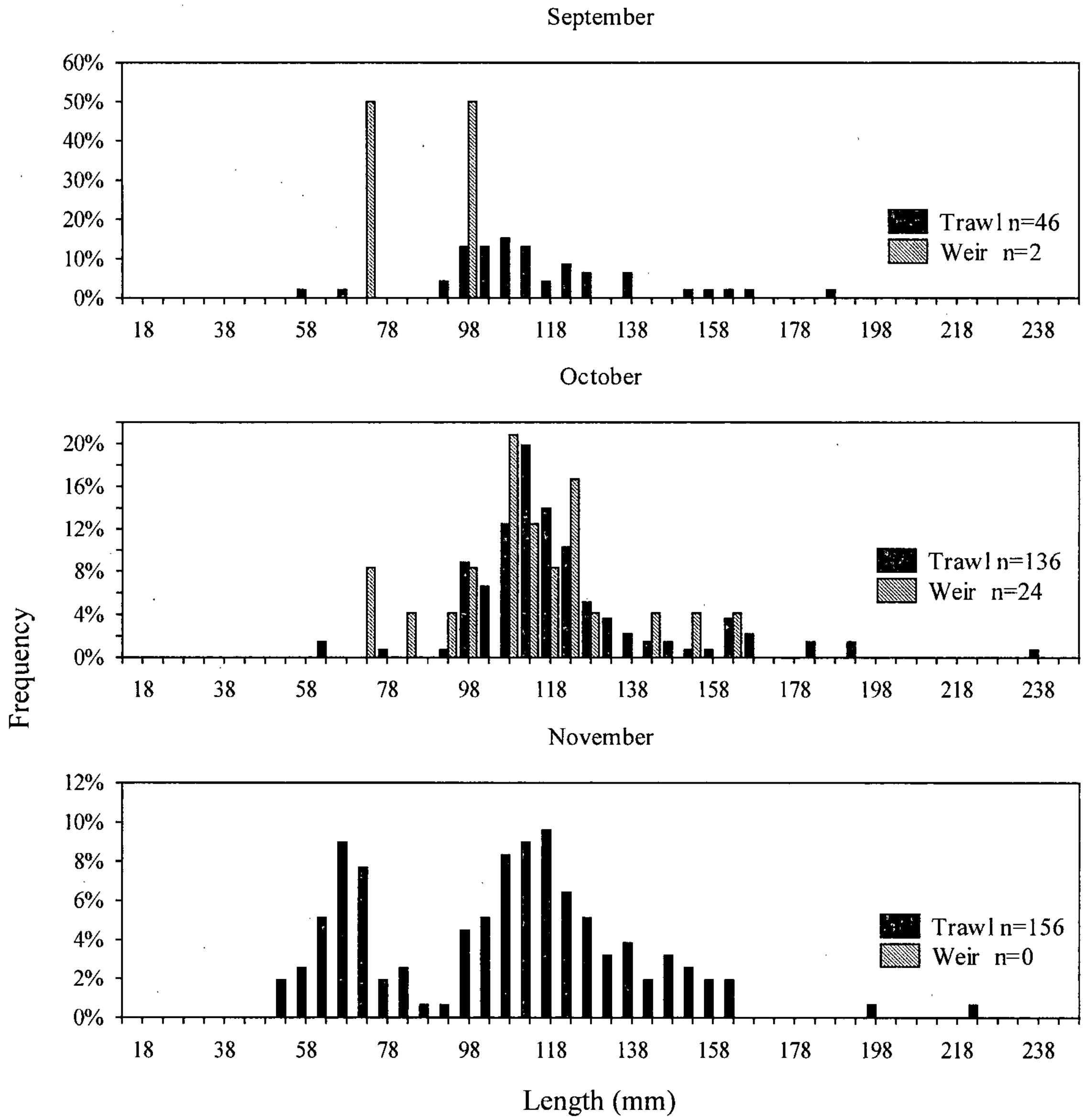

Figure 7-48. Continued.

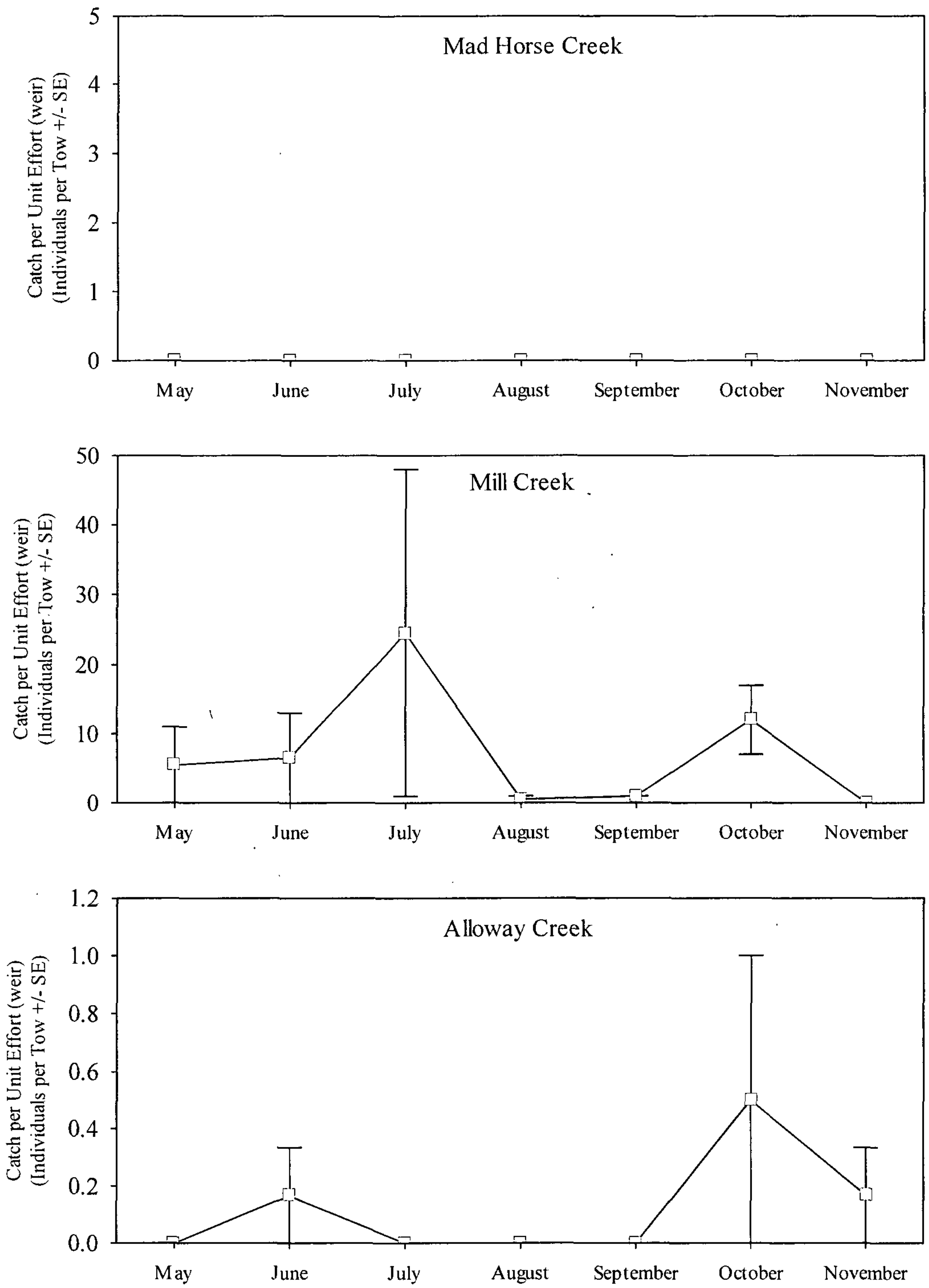

Figure 7-49. Monthly abundance for white perch, collected in small marsh creeks (weir), in the Upper Bay Region during 2008.

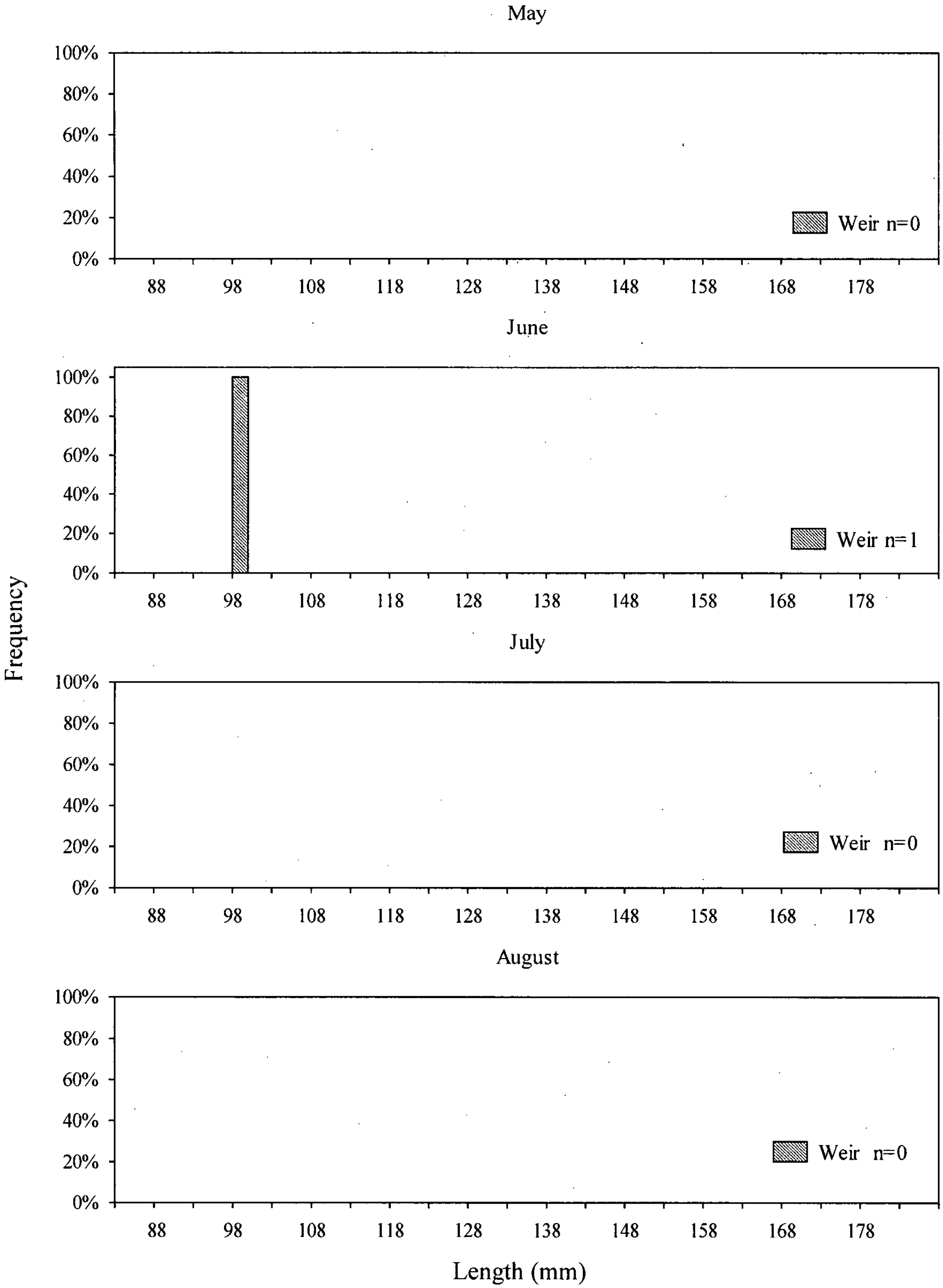

Figure 7-50. Size distribution of white perch, collected in small marsh creeks (weir) at Alloway Creek during 2008.

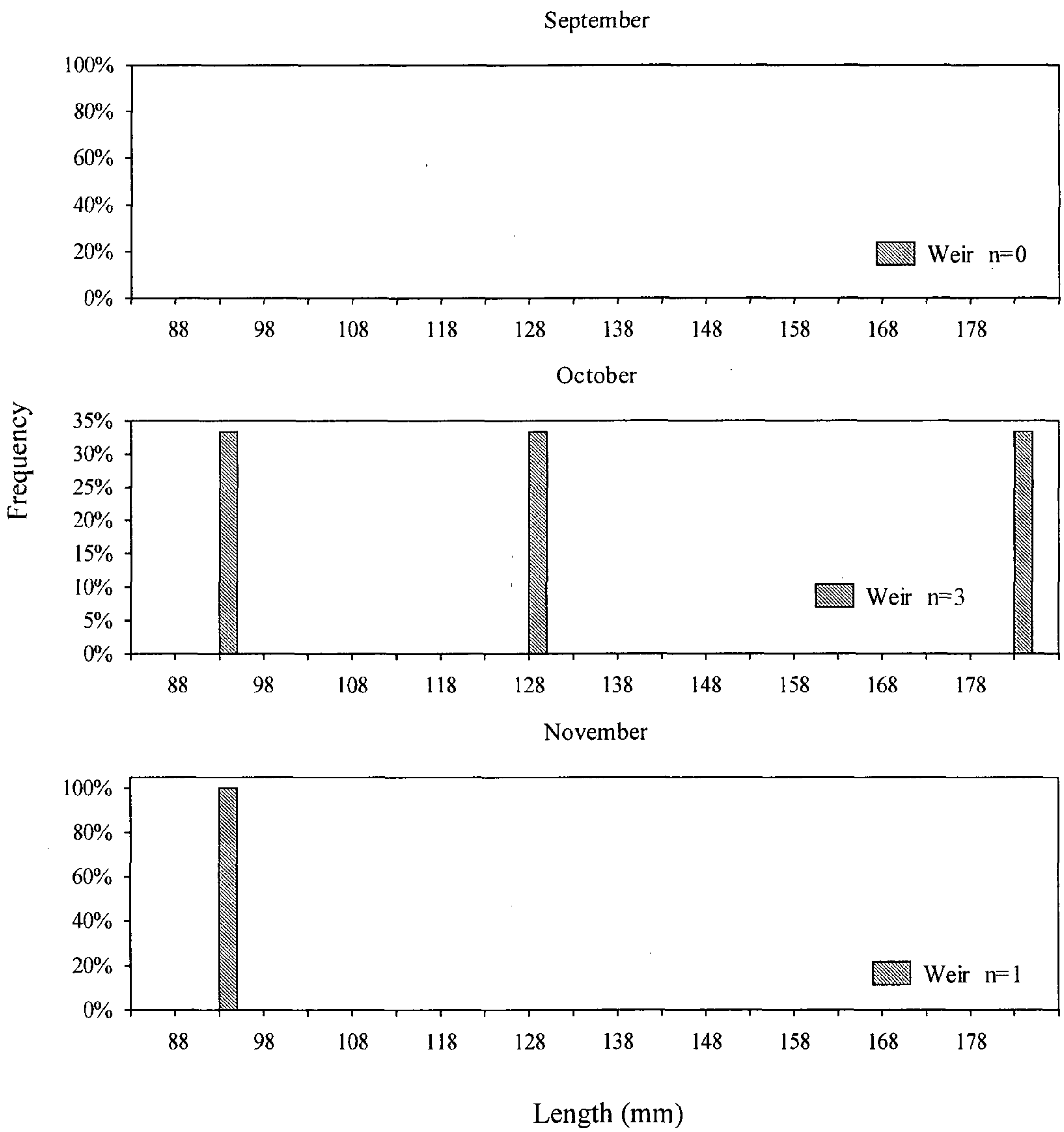

Figure 7-50. Continued.

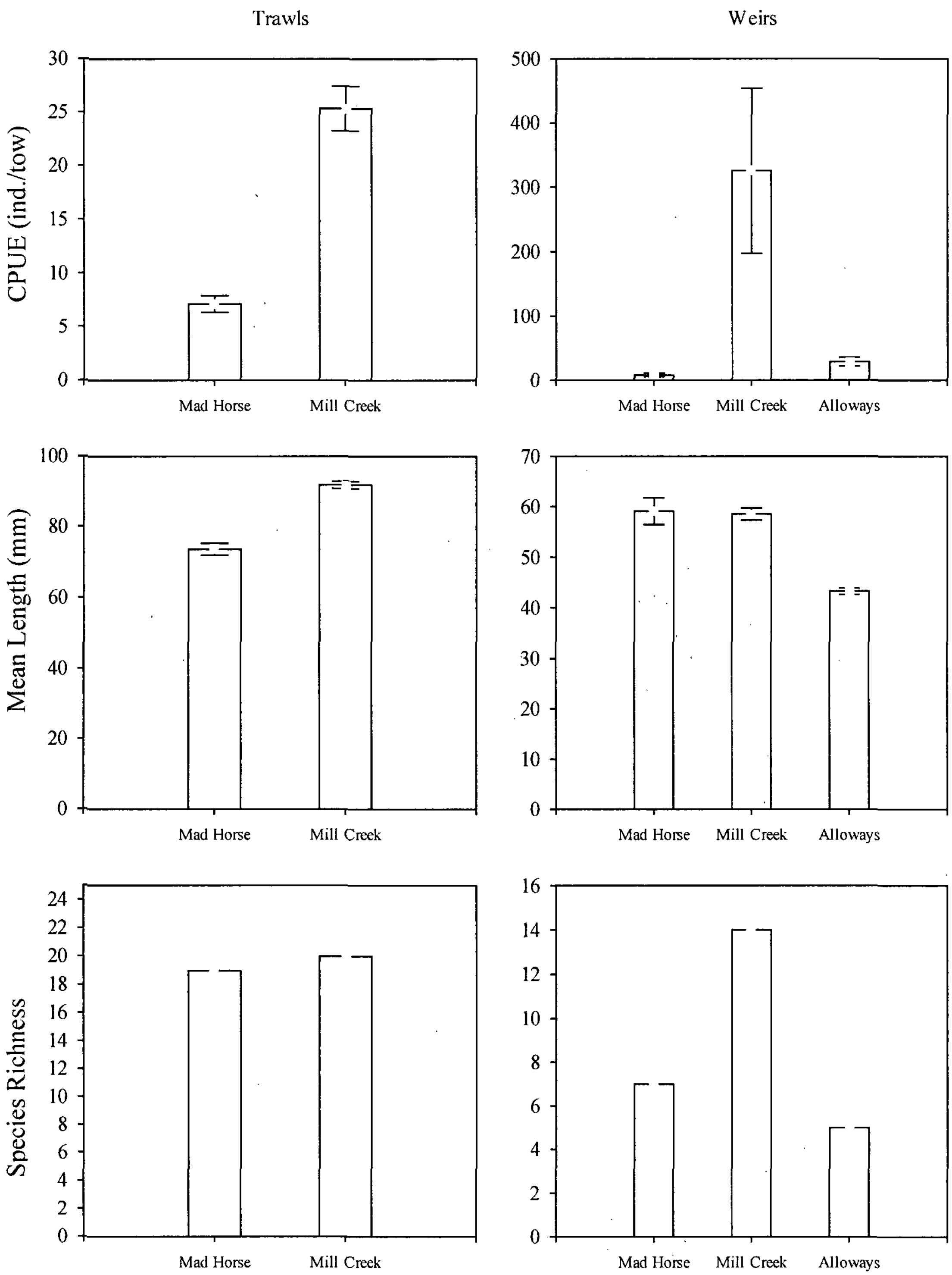

Figure 7-51. Comparisons of abundance, fish length, and species richness among restored (Alloway Creek and Mill Creek) and reference (Mad Horse Creek) marshes from large and small marsh creeks during 2008.

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INTRODUCTION

As a component of its Estuary Enhancement Program (EEP), Public Service Enterprise Group (PSEG) has initiated an Improved Biological Monitoring Program (IBMWP) for the Delaware Estuary pursuant to Special Condition Section G.6 of the 2001 NJPDES Permit (No. NJ0005622) for the Salem Generating Station. The IBMWP was prepared and amended by PSEG, reviewed by the Estuary Enhancement Program Advisory Committee and approved by the New Jersey Department of Environmental Protection (NJDEP).

In accordance with the IBMWP, vegetative and hydrogeomorphic monitoring was conducted in 2008 by PSEG. This monitoring included peak growing season (August) sampling at two reference marshes in New Jersey and four wetland restoration sites in New Jersey and Delaware. False color infrared (CIR) and true color aerial photographs were also acquired of the reference marshes and wetland restoration sites on September 8, 2008. These photographs were utilized to map the extent of the various vegetation cover types present on each of these sites.

MATERIALS AND METHODS

This section describes the materials and methods used in the collection of detrital production data in 2008 and subsequent data analysis. Elements of the 2008 work scope included:

- Collection of percent coverage, height and flowering status data within quadrats located along transects and within plots;
- Collection of macrophyte and litter samples;
- Processing (i.e., weighing) of macrophyte samples in the laboratory;
- Data analysis (e.g., mean, standard deviation, standard error) of percent cover, height and biomass data;
- Acquisition and interpretation of CIR and true color aerial photography.

SITE LOCATIONS

The locations of the EEP restoration sites and reference marshes are shown in Figure 8-1. CIR or true color aerial photography was acquired at all sites for the purpose of mapping the extent of the vegetation communities present. Field data collection in 2008 occurred in New Jersey at four sites: the Mad Horse Creek (MHC Reference Marsh) and Moores Beach West (MBW Reference Marsh) reference marshes; the Commercial Township Salt Hay Farm Wetland Restoration Site (CT Site); and the Alloway Creek Wetland Restoration Site (ACW Site). Field data collection also occurred at two wetland restoration sites in Delaware: The Rocks and Cedar Swamp. A brief description of each site is provided in the following paragraphs.

Reference Marshes

The two reference marshes selected in accordance with the IBMWP were MHC Reference Marsh and MBW Reference Marsh. MHC Reference Marsh is an oligohaline (salinity 0-5 ppt) marsh, most of which had not been previously used for salt hay farming operations. The 3,942-acre portion of the marsh selected as a reference site is considered to represent a good example of natural hydrology and drainage patterns, and represents a mature vegetative marsh community.

MBW Reference Marsh is a mesohaline (salinity 5-18 ppt) marsh that "naturally restored" following storm damage to its berms in 1972. By 1992, most of the areas that were in salt hay production in 1960 had been converted to low marsh dominated by *Spartina alterniflora.* The low marsh succession was accomplished by natural processes. The marsh area designated as the reference site encompasses approximately 1,264 acres.

Salt Hay Farm Wetland Restoration Sites

Three New Jersey salt hay farms, located in Commercial Township, Maurice River Township and Dennis Township, have been restored to normal daily tidal flow by PSEG under the EEP. The Dennis Township and Maurice River Township salt hay farm sites have reached their targeted coverage of *Spartina alterniflora* and other desirable marsh species, and are not included in this chapter of the 2008 Annual Report. Detrital production monitoring has continued at the CT Site, which is located in Cumberland County and contains 2,894 acres within the restoration boundary.

The CT Site is bounded to the east by the Village of Bivalve and the Maurice River, to the south by the Delaware Estuary, to the west by Dividing, Indian, and Hansey Creeks and to the north by rural properties and the Village of Port Norris. The restoration site is situated along the southern New Jersey shoreline of the Delaware Estuary at the northern margin of the Maurice River Cove, approximately 18 miles northwest of Cape May Point. For at least three generations, the area between Dividing Creek and the Maurice River had been farmed commercially; earthen dikes had been constructed to enhance the production of salt hay *(Spartina patens* and *Distichlis spicata).* As a result of storms during early 1996, a number of breaches in the perimeter dike occurred; despite attempts to repair these, much of the salt hay farming area was inundated during the 1996 growing season. However, salt hay farming was continued on some areas in the western portion of the site. The construction phase (dredging, dike breaching, etc.) of the wetland restoration was completed in the fall of 1997, returning daily tidal flows to the wetland restoration area of the site.

New Jersey *Phragmites* Dominated Sites

Two *Phragmites*-dominated sites in New Jersey, the ACW Site and the Cohansey River Watershed Wetland Restoration Site (CRW Site), have undergone restoration by PSEG under the EEP. The CRW Site has reached its targeted coverage of *Spartina alterniflora* and other desirable marsh species, and is not included in this chapter of the 2008 Annual Report. The ACW Site is a *Phragmites*-dominated site that had been historically diked and farmed. Based on a review of historical aerial photography, *Phragmites* originally became established on dike areas and then spread to the adjacent marshes. The ACW Site is located in Elsinboro and Lower Alloways Creek Townships, Salem County, NJ. The ACW Site encompasses approximately 3,096 acres that include the wetland restoration area and adjacent buffer. The wetland restoration area is comprised of approximately 1600 acres; *Phragmites* covered approximately 58.7 percent of the wetland restoration area in 1996, prior to initial restoration activities. The wetland restoration area is subject to tidal influence from the Delaware River, via Alloways Creek, Straight Ditch and Mill Creek. The ACW Site is bounded to the east by the Salem-Hancocks Bridge Road, to the north by the Fort Elfsborg-Hancocks Bridge Rd, tidal marsh and agricultural fields, to the west by the Delaware River, and to the south primarily by the Alloways Creek.

Delaware *Phragmites* Dominated Sites

Prior to 1999, five restoration sites were monitored in Delaware. PSEG selected to continue restoration activities at two of these sites, The Rocks and Cedar Swamp. Wetland restoration activities were initiated at these two Delaware *Phragmites*-dominated sites by the Delaware Department of Natural Resources and Environmental Control (DNREC) in 1995. A brief description of the pre-restoration conditions at each site based on interpretations of 1993 aerial photography is provided in the following paragraphs.

The restoration area at The Rocks is comprised of 736 acres and is located approximately 2.3 miles south of Silver Run and 4.0 miles southeast of Odessa in Appoquinimink Hundred, New Castle County, Delaware. This site is part of a continuous tidal marsh community, referred to as the Appoquinimink River-Blackbird Creek System, which extends north and south for several miles. The site is bounded to the east by the Delaware River, to the north by Appoquinimink River, to the west by Stave Landing Road and to the south by Blackbird Creek. Stave Landing Road provides access to The Rocks from the west. *Phragmites* covered 86.9 percent of the vegetated marsh plain in 1993 prior to the initiation of restoration activities by DNREC.

The restoration area at Cedar Swamp is comprised of 1,863 acres and is located approximately 2.6 miles south of The Rocks in Blackbird Hundred, New Castle County, Delaware. This site is bounded to the east by the Delaware Bay. To the north, the site is bounded by farmland and Cedar Swamp Road, and to the west and south the site is bounded by farmland, woodland, and contiguous tidal marsh. The boundary between the Delaware River and the Delaware Bay is located at the northeast side of the site, at Liston Point. Collins Beach Road provides access to a public boat ramp and parking area in the southeast corner of the site. Public access to the northern side of the site is available via Cedar Swamp Road. In addition to public hunting and wildlife observation, Cedar Swamp is used as an anchorage for commercial and recreational crabbing and fishing boats. Historically, the site was used for hunting and included a coastal recreation resort. *Phragmites* covered 71.3 percent of the wetland restoration area prior to the initiation of wetland restoration activities by DNREC.

AERIAL MAPPING

Aerial photography was acquired for all reference and restoration sites in New Jersey and Delaware on September 8, 2008. True color photographs were acquired of the MHC Reference Marsh, ACW Site, Cedar Swamp and The Rocks. CIR photographs were acquired of the MBW Reference Marsh and the CT Site. This photography was acquired at a nominal scale of 1:9600 (i.e., 1 in = 800 ft). The time of acquisition was selected to provide images of the sites at the end of the growing season during the mid-day period and at low tide.

Camera, Aircraft, and Film Type

To obtain the aerial photography, a Wild-RC30 camera with a Wild Universal Aviogon/4-S lens and a nominal focal length of 153 mm was flown in a Cessna Piper aircraft. Kodak Aerochrome III Infrared Film 1443, an infrared-sensitive, false color reversal film, was used for the CIR aerial photography. CIR photographic film is comprised of three layers (cyan, yellow and magenta) that are exposed in response to the characteristics of the light reflected from the earth's surface. Plant leaves reflect a significant amount of green energy and partially expose the yellow layer in addition to almost complete exposure of the cyan layer by the infrared - leaving the magenta layer and varying parts of the yellow layer with an image color ranging from magenta to red. The more green energy that is reflected by a given vegetation cover, the less yellow layer remains and the more magenta the images of that type appears. Because of species differences in leaf structure and chlorophyll content, separation of species dominated areas on CIR photography often can be based on this variation in red to magenta color. Since wet soil and water reflect little in the wavelengths that CIR film is sensitive to, these areas appear dark (unexposed) on the image. As a result, CIR aerial photography is particularly useful in mapping vegetative coverage on sites that are not fully vegetated.

Agfa AVIPHOT Color X100 PEI, a color negative film without color mask that is suitable for electronic image scanning for the reproduction of clean and saturated colors without additional color correction, was used for the true color aerial photography. This film is particularly useful for mapping vegetation types that are visually different during the peak growing season (e.g., *Spartina alterniflora* and *Phragmites australis*).

The aerial photography was acquired following standard specifications for stereo coverage. The forward overlap (overlap in the direction of flight) was 60 percent. The sidelap between overlapping parallel flight lines of vertical photography was 30 percent. Any series of two or more consecutive photographs within a flight line were not to be crabbed in excess of three (3) degrees relative to the plotted line of flight, and the differential crab between any two consecutive exposures within a flight line did not exceed three (3) degrees. The tilt within a single frame did not exceed three (3) degrees nor did the difference in tilt between two consecutive frames within flight lines exceed four (4) degrees. The average tilt for all negatives of the same nominal scale did not exceed one (1) degree.

Once the aerial photography was secured, the original photographic negatives were developed through automated processing equipment and RC paper contact prints (9in x 9in) and diapositives of each negative were produced. One set of film diapositives was printed from the original aerial photography using an automatic dodging printer having a flat platen on cut sheets of Kodak Aerographic Duplicating (ESTAR Thick Base) Film No. 4421. This set was used for the vegetation mapping photo interpretation process.

To allow for quick referencing of the aerial flight, an aerial photographic line index of the photography was produced utilizing minifications of each exposure and referencing photographs to each other using Adobe® Photoshop® software. The index references each flight line and exposure on the index map by site.

Geodetic Control

Available existing horizontal and vertical controls, as well as controls acquired in 1996, were used to establish geodetic control for the mapping. All external control (used to control the final network adjustment) was based entirely on first order stations as published by the National Geodetic Survey. Stations were located for photo-identifiability (e.g., targets were painted, where surfaces allow, with high visibility traffic paint). Where surfaces did not permit painting, targets consisted of weather-proof plastic material. Target legs measured 12 inches in width and seven feet in length.

GPS survey techniques were used for establishing photo control at these sites using ground-based rapid static procedures. Rapid static GPS uses dual-frequency receivers to occupy the stations for 8-15 minutes compared to 30-45 minutes using dual frequency receivers in a static mode and 60-75 minutes using single-frequency static methods. The accuracy of the GPS-derived orthometric heights is enhanced by occupying a number of existing benchmarks throughout the project area, and using *Geoid93*—geoidal height interpolation and modeling software from the National Geodetic Survey (NGS)—to model the undulations, or the separation of the modeled sea level surface (the geoid) from the idealized mathematical representation of the earth as an ellipsoid of revolution.

All GPS surveys were performed to exceed the first order horizontal specification (0.01 m + 10 ppm). A sufficient number of existing National Geodetic Reference System (NGRS) stations was used as external control. When the vertical control was done using static mode GPS, a sufficient number (at least 6) of well-distributed benchmarks was included in the network. These known orthometric heights were used along with geoid heights derived from *Geoid93* to obtain orthometric heights of all stations in the network. The network was designed so that loop closures may be analyzed for verification.

GPS data collected in the field were downloaded from the receivers to a computer and processed using the GP Survey® software package from Trimble Navigation, Ltd. The baseline processor is known as WAVE (Weighted Ambiguity and Vector Estimation), which is optimized for dual frequency data. This program checks the data as it is downloaded, allowing editing of items such as station name, height of instrument, and so forth. The data was processed in batch mode, with no operator interaction required. Only integer biased fixed solutions were used. The results were examined to identify suspect lines. When a baseline had a low ratio and/or a high reference variance, it was checked by loop closures. The network was designed to enable the verification of all lines. The results were sent by high-speed modem link for analysis by an experienced geodetic engineer. If any re-observations were required, theses were performed before the GPS crew left the site. Office processing consisted of analyzing the results to determine if any manual reprocessing was necessary. Results deemed acceptable were combined to form a network. This network was then adjusted by TRIMNET, a least squares adjustment package from Trimble Navigation, Ltd.

Aerotriangulation

Analytical aerotriangulation was performed for the CIR and true color aerial photography obtained in September 2008. The aerial film negatives were digitally scanned at 22.5 microns and the scanned images were used in the analytical aerotriangulation process on Socet Set® softcopy workstations utilizing Socet Set® Multi-Sensor Triangulation System (MST) software. Data capture was performed with the Automation Point Measurement program (APM). The identification and numbering of pass points and tie points between contiguous strips, was performed by the APM program. This data was then edited with the Interactive Point Measurement program (IPM). The editing process reduces the point residual error, point placement and the addition of ground control. The data was corrected for radial lens distortion and film deformation, and a non-airborne simultaneous adjustment was performed. The data was then exported into the program system BLUH to perform the data reduction and final adjustment. BLUH performs the automatic elimination of systematic image effects through the use of additional parameters. Simultaneous Adjustment was carried out and the data was exported into Socet Set® software for the stereo compilation process.

Stereo compilation

Stereo compilation was accomplished by the stereo digitizing of map elements, extracted from the 2008 CIR and true color aerial photography using precision analytical stereo plotting instruments. The aerial photographs were arranged in overlapping pairs, (commonly referred to as a stereo model) and were then mounted in a stereoplotter for compilation. The analytical solutions, aerial calibration, and geodetic control data, developed in the previous steps of the mapping process, were downloaded into the photogrammetric device and accurately registered to the photography. This process involves mathematically orienting the stereo model with the instrument to create a stereoscopic three dimensional image that the photogrammetrist interprets and compiles to build a vector land base of the mapping features as seen through the optics of the instrument. Such map features include:

- Center lines of channels between one and five feet in width;
- Edges of channels greater than five feet in width;
- Ponded areas;
- Dikes, dike breaches and internal berms; and
- Miscellaneous roadways.

Digital Elevation Models (DEM) were also developed to support the production of digital orthophotographs by taking a file containing break lines (digitized points that are connected by a line) which have been placed at all breaks in terrain, and mass points placed at strategic locations (tops, depressions, road intersections, and so forth) and linking them together to form the triangulated irregular network, or TIN. Generally, break lines will be shown at all terrain breaks, drains, tops of banks, ridges, valleys, bases of hills, edges of plateaus, road edges, and so forth. All vector information (map data) was tiled to match PSEG's existing tiling scheme (4,000 ft x 8,000 ft).

Digital Orthophotography

An Intergraph Digital Ortho Production System was used for generating digital orthophotography of the reference and restoration sites. The system includes the Zeiss/Intergraph PhotoScan PS1 digital transmissive scanner, six Intergraph workstations with JPEG Compression boards, and more than 40 gigabytes of disk storage capacity. The following steps comprise the general digital orthophoto workflow:

Scanning. Each diapositive was scanned three times using red, green, and blue filters. Each scan pass detects the film's emulsion layers that are sensitive to a corresponding spectral bandwidth. Scanning is performed in a manner that duplicates the film as it is exposed to maintain the relationships between the individual colors in the film.

DEM Production. Mass point and break lines were merged into blocks and the coordinate system, global origin and working units were set using Intergraph's MGE Terrain Modeler software package. A TIN surface model was developed for each site and, from that surface representation, a grid model was created at an appropriate interval to support orthorectification.

Image Orientations. After an exposure was scanned, the fiducial marks were measured using

Image Station Digital Orientation (ISDO) software to determine the Interior Orientation (IO) of the image. This step relates the scanned image to the USGS camera calibration report and determines the geometric relationship between the two. Residual errors are normally less than 10 microns for a diapositive. If the Root Mean Square Error (RMSE) was excessive, the exposure was re-scanned. If the error was repeated, the diapositive was rejected and remade.

The Exterior Orientation (EO) was performed by relating measured pug mark positions with the corresponding ground coordinates to determine the exact location of the camera at the time of exposure. Known as the space resection, this position consists of the X, Y, and Z coordinates of the camera and the three rotation angles that describe the tip, tilt, and yaw of the aircraft. Convergence statistics should not exceed National Map Accuracy Standards (NMAS) standards for the scale of photography.

Digital Orthorectification. Digital orthophoto processing is a reiterative process that combines input from photography, analytics, and a DEM. The Intergraph Image Station Rectifier (IISR) software mathematically calculates the true orthogonal position and brightness value for each pixel within the digital orthophoto. This is accomplished by differentially resampling the input data both spatially and radiometrically to calculate a new rectified pixel.

The central portion of every exposure from the stereo model was scanned and rectified. Using only the central portion of each exposure reduces the effect of vignetting (uneven exposure that results in darker margins around the diapositives). This is especially important with color infrared photography as it is very susceptible to change in exposure level. Following rectification, the coordinates of photo-identifiable points within the rectified image were compared to the actual ground coordinate of that point. The distance between the observed point and the true coordinate is used to quantify the accuracy of the orthophoto in terms of the NMAS for the mapping scale. These values were included with the result of the interior and exterior orientation analysis. The ortho image was also viewed against the vectorized break lines and other planimetric features to ensure correlation with the DEM file. Compiled features such as stream edges and road center lines are readily identifiable and were used to assess the overall accuracy of the orthophoto.

Mapsheet Generation and Output

Automated procedures were used to merge two or more overlapping images together and generate a specified mapsheet (4,000 ft in a north-south direction and 8,000ft in an east-west direction). Using the AutoOrtho (ISAO) software developed by Intergraph and TRIFID Corporation, digital imagery can be mosaiced, tone-matched, and feathered into a single continuous seam-free image that can be edge matched against the adjacent sheets to check for continuity of features and contrast. All digital orthophoto files were produced as Intergraph type 28 RGB 24-bit files with a standard color table attached to it so that plotting and display characteristics are consistent among the files.

Vegetation Mapping

Mapping of marsh vegetation types on the wetland restoration and reference sites utilized the 2008 CIR and true color aerial photography acquired for vector mapping and digital orthophotograph production. CIR photography is a three layer (cyan, yellow and magenta) film that has been widely used for crop and natural vegetation studies because image color formation is dependent upon reflected energy in the red and green portion of the visible spectrum as well as the near-infrared. An object that reflects only infrared energy will expose the cyan layer of the film, leaving the yellow and magenta layers that combine in a subtractive mixture to form a red image when viewed by transmitted light.

A team of scientists familiar with the vegetation and physical features of the reference and restoration sites interpreted the CIR and true color aerial photography by identifying color/texture characteristics (i.e., signatures) of the various cover types present. The various areas of species-dominated polygons or other site features (e.g., mud flats) identified on the CIR aerial photography were delineated digitally while viewing the orthophotograph on the computer monitor. On-screen digitizing of cover type boundaries was performed using AutoCAD LT 2005™. Each polygon mapped in this way was assigned an identifying code consisting of the year, cover type designation, and a sequential polygon number for that cover type. Thus, each polygon was given a unique alphanumeric identification that linked the polygon to an external Microsoft Access™ database. AutoCAD Map 2® Release 14.0 software was utilized to further process the data. The minimum mapping unit (MMU) employed for the digitizing effort was one acre. In order to be identified as a given cover type, it is generally necessary that the vegetative cover of the polygon exceed 30 percent. Thus areas mapped as "mud flat" may support vegetation below the 30 percent mapping threshold. This is consistent with the approach utilized by the USFWS in the preparation of NWI maps, where areas supporting less than 30 percent cover are identified as unvegetated (Tiner 1998).

Quantitative Geomorphologic Evaluation

A quantitative evaluation of the geomorphologic features was conducted based on the geomorphological mapping compiled from the September 2008 CIR and true color photography. The following parameters were determined as part of the quantitative geomorphologic evaluation:

- Channel classification (order)
- Determination of the total number of channels in each order
- Calculation of bifurcation ratio
- Channel frequency
- Total length (sinuous length)
- Total linear length
- Average channel length
- Channel length ratio
- Percent of total channel length
- Average channel sinuosity
- Drainage density

An approach to geomorphological classification of stream channels was developed by Horton (1945), who emphasized topographic characteristics of the drainage area and gave a hierarchical order to every channel in the drainage basin in his stream-ordering technique. The Horton method utilizes a "top-down" approach to determine the order of the drainage channels, where the smaller streams have lower-order numbers and the central channel is assigned the highest-order number.

Strahler (1957) modified the Horton system by starting the next highest order at the confluence of two tributaries of lower order. Strahler's method is based on the premise that, for a sufficiently large sample size, order number is directly proportional to relative watershed dimensions, channel size, and volume of stream discharge. Also, because the order number is a dimensionless value, two drainage basins of different sizes can be compared at corresponding points through the use of order numbers.

The analytical channel geomorphology tools of Horton (1945) and Strahler (1957), as referenced in Chow (1964, 1988) (order analysis) were developed for evaluating mature stream systems and to aid in the design of stream restoration projects. An implicit assumption of order analysis is that the evaluation is done for sites with comparable channel orders. While this technique is appropriate for mature stream systems, it is not as effective for rapidly developing (i.e., recently restored) salt marsh tidal channel systems in which the number and order of channels can change dramatically over a short time period.

The development of small channels through natural restoration processes dramatically changes the order number of the largest channels. The change in order number with channel development makes it extremely difficult to relate channel dimension with channel order. Because the number of small channels at a restoration site increases as the site matures, the classical channel ordering method makes it appear as if the number of large inlet channels also varies over time. This is because the increase in small channels causes the order number assigned to the largest channels to increase as well.

This increase in order number for the largest channels made comparison between years and among sites extremely difficult at the PSEG restoration sites. In some instances it was not possible to match channel size (dimensions) with channel order, since each channel system changed independently of other systems at a site, and among sites. As a result, it was impossible to track what was happening over time in the smaller channels. Knowing what was happening in the smaller channels was critical, since these small marsh channels provide pathways for tidal waters to access the marsh plain. Additionally, these small marsh channels provide conduits for fish access and detrital export. Therefore, analyzing changes of these small tidal channels is one of the most critical aspects for assessing restoration success.

To address the difficulties associated with application of the "top-down" channel order approach, the hydrogeomorphic analysis technique utilized for this project was modified to be more useful with a dynamic system. Using this hydrogeomorphic class technique ensures that the largest channels are always the lowest number (first class), and that increasing order numbers are assigned to the rapidly changing smaller channels.

Using the "bottom-up" approach, the main inlet from the Delaware Bay or other major water body (e.g. West Creek, Riggins Ditch) was designated a first-class channel. The procedures outlined below were then followed to determine the class designations of channels to be analyzed at each site.

(1) A second-class channel begins where a first-class channel splits into two separate, comparably sized double-lined channels (double-lined channels are greater than five ft wide). If one of these two channels is less than half the size of the other channel, the smaller channel becomes a second-class channel and the other remains a first-class channel.

(2) When a second-class channel splits, the above-stated procedure is applied to identify these branches as third class, fourth class, etc. This rule is only applicable to double-lined channels (i.e., greater than 5 ft wide).

(3) Any single-lined channel (i.e., less than 5 ft wide) coming off a double-lined channel is a third-class channel. However, if that double-lined channel is already a third-class channel or greater, then that single-lined channel will be one class higher than the double-lined channel it branches from.

(4) With any split of a single-lined channel, those two channels will be one class higher than the channel they are splitting from.

The method used to derive the geomorphological analysis of the reference marshes and wetland restoration sites utilizes the attributes of both AutoCAD® and Arc View® software. This software quantifies the number of channels of each order that occur on a site as well as derive the various length measurements that are utilized to characterize the channel systems on the sites, as described below:

Bifurcation Ratio (R_B). The bifurcation ratio, or R_B, is the ratio of the number of channels of one class to the number of channels of the next lower class.

$$R_B = N_n / N_{n-1}$$

Channel Frequency (F_C). The channel frequency, or F_C, is the number of channels for all classes (N_T) per unit area.

Total length (sinuous length) (L). The total sinuous length, or L, for channels in each class is the centerline length along the channel course from the start of a channel of one class to the beginning of the channel of next lower class.

Total linear length (straight line length) (SL). The straight line length, or SL, is the length for channels in each class measured as the straight line distance from the start of the channel of one class to the beginning of the channel of next lower class.

Average channel length ($L_{n\ avg}$). The average channel length, or $L_{n\ avg}$, is the total length of channels of a given class divided by the number of channels in that class.

$$L_{n\ avg} = L_n / N_n$$

Channel length ratio (R_L). The channel length ratio, or R_L, is the ratio of the average length of channels in one class to the average length of channels in the next higher class.

$$R_L = L_n / L_{n+1}$$

Percent of total channel length (%CL). The percent of total channel length, or %CL, provides information on the proportion of each channel class in the site. This value is calculated by dividing the total length of channels in one class (Ln) by the total length of channels of all classes (LT) and multiplying by 100%.

$$\%CL = L_n / L_T \times 100\%$$

Average channel sinuosity (S_{avg}). The average channel sinuosity, or S_{avg}, is the ratio of the average length of channels of a given class to the average straight line length for channels in that class.

$$S_{avg} = L_{n\ avg} / SL_{n\ avg}$$

Drainage density (D). The drainage density, or D, is the total length of channels of all classes divided by the area of the site.

VEGETATION TRANSECTS

Detrital production data were collected in August 2008 along transects located in New Jersey at the MHC Reference Marsh and MBW Reference Marsh (Figures 8-2 and 8-3, respectively); the CT Site (Figure 8-4); the ACW Site (Figure 8-5); and The Rocks and Cedar Swamp Sites in Delaware (Figures 8-6 and 8-7). Random quadrats (0.25 m^2) were located as described below along each of the transect alignments shown in these figures. Macrophyte production data were collected within these quadrats as described in the following sections. The original transects at the restoration sites and the reference marshes were established as part of the 1995 detrital production monitoring effort. Two of the reference site transects were relocated in 1996, MHC Reference Marsh Transect 3 (shown as MHT3A in Figure 8-2) and MBW Reference Marsh Transect 1 (shown as MBT1A in Figure 8-3). The former was relocated for a property access purpose; the latter to eliminate the excessive edge habitat that the original alignment traversed. The Rocks and Cedar Swamp transects were established for the 1999 sampling effort.

Each transect sampled in 2008 was divided into community segments, with each segment traversing a portion of the total transect length dominated by a given species. In the event that two or more species were determined to be co-dominants, the community segment was identified as such. This method is further discussed in the following section.

The collection of field data (e.g., percent aerial cover) and clipping of samples of macrophytes for laboratory processing occurred within the randomly selected quadrats located along the community segments of each transect. Each quadrat was identified by an alpha-numeric code designating its associated transect and sampling event, the type of data collected at the quadrat and its position along the transect. As an example, MHT1-08-OQ18 indicates that the quadrat was sampled along MHC Reference Marsh Transect 1 during 2008 (MHT1-08). The data collected was an ocular estimate of percent cover within the quadrat area (O), and the quadrat was the eighteenth sampled along the transect (Q18). Similarly, MHT1-08-CQ1 indicates that the quadrat was sampled along MHC Reference Marsh Transect 1 during 2008 (MHT1-08). In this instance, percent cover data were collected and the quadrat area was clipped for standing crop determinations (C). The quadrat was the first sampled along the transect (Q1).

The method for establishing the random location of the quadrats is as follows:

The transects at the wetland restoration sites were walked, recording the type, length and number of plant communities (i.e., community segments) and open water and mudflat areas crossed on an appropriate data sheet (Appendix A, Exhibit A-1). A Magellan Meridian® global position system (GPS) unit was utilized to determine the lengths of each plant community traversed and the locations of channels and other geomorphic features. The community designations determined as a result of this effort served as the basis for the selection of quadrat locations.

The appropriate number and location of quadrats sampled utilizing the appropriate data form (Appendix A, Exhibits A-2 and A-3) was determined as follows:

1. Two quadrats per dominant species type traversed along the transect (e.g., *Spartina patens* dominated, *Spartina alterniflora* dominated) were randomly located. Within these quadrats, standing crop collections ("clips") were made. To locate these clip quadrat locations, two community segments of the transect dominated by the same species were randomly selected from the total number of similarly dominated segments[1]. A quadrat location was then randomly selected within each segment.

2. Additional quadrats were randomly located along the transect length within which only ocular estimates of percent cover were made (i.e., "ocular" quadrats). The number of ocular quadrats was determined by multiplying three by the total number of biomass clip quadrats (maximum 22).

Clip and/or ocular quadrats were located one meter to the side of the transect alignment so as to avoid sampling areas that were previously walked over. The side (right/left) of the transect to which the quadrat was placed was alternated between sample points.

At the reference marshes, community data collected during the 1996 sampling effort were used to determine the appropriate number and location of quadrats to be sampled (according to the procedures outlined above) during the 2008 effort.

QUADRAT SAMPLING

Sampling within the 0.25 m^2 quadrats located along the transects as described above was

[1]In the event that only one transect segment was dominated by a given species, both clip quadrats were randomly located within that segment.

conducted utilizing the field procedures described below:

Percent Aerial Coverage

Within each 0.25 m^2 quadrat, the percent of plant foliar and stem aerial coverage (as viewed from above by an observer standing at a point adjacent to the quadrat) was visually estimated using the following percent coverage categories:

0% = open water or bare sediment
<1% = plants sparsely or very sparsely present
5% = plants covering from 1 to 10% of the area
15% = plants covering from 11 to 20% of the area
25% = plants covering from 21 to 30% of the area
35% = plants covering from 31 to 40% of the area
45% = plants covering from 41 to 50% of the area
55% = plants covering from 51 to 60% of the area
65% = plants covering from 61 to 70% of the area
75% = plants covering from 71 to 80% of the area
85% = plants covering from 81 to 90% of the area
95% = plants covering from 91 to 100% of the area

The process of determining the percent coverage for each species occurring in a quadrat first involved estimating of the total percent coverage of all plants within the 0.25 m^2 quadrat area. This total was then subdivided into individual percentages for each species within the quadrat and entered onto an appropriate data sheet (Appendix A - Exhibit 2 for clip quadrats; Exhibit 3 for ocular quadrats).

Canopy Height

Canopy height was determined for each species by measuring the height of a mid-sized plant occurring within the quadrat. These data were entered onto an appropriate data sheet (Appendix A - Exhibit 2 for clip quadrats; Exhibit 3 for ocular quadrats).

Flowering status

During each sampling event, plant species occurring within each quadrat were noted as being either flowering or non-flowering at the time of sampling. The flowering status was recorded on the appropriate data sheet (Appendix A - Exhibit 2 for clip quadrats; Exhibit 3 for ocular quadrats).

Above-ground Biomass Collection

A vertical photograph was taken of each clip quadrat area and all living and standing non-living vegetation within the quadrat was cut within 1 cm of the sediment, separated by species and placed in labeled paper bags. Unattached surface litter from within the quadrat area was also collected and placed in labeled paper bags. Samples were then transported to and processed in the laboratory as described below.

VEGETATION PLOTS

To supplement the collection of field data within quadrats along transects in 2008, additional 0.25 m^2 quadrat sampling was conducted within previously established 60 m x 60 m (3,600 m^2) "plots". These plots were located at each site during the initial years of restoration to collect macrophyte productivity data from areas appearing to be of relatively uniform species composition, coverage and height at the time of selection. The primary purpose of this supplemental sampling was to determine the peak live standing crop in areas that could be located on the peak growing season CIR and true color photography, since a 3,600 m^2 area appears as an approximately 0.2 cm^2 area (0.4 cm x 0.4 cm) on a 2X enlargement (1:4,800) of the 1:9,600 scale aerial photography. The number of plots located at each site and the dates these plots were established are as follows:

Site	Number of Plots	Date Established
MHC Reference Marsh	3	1996
MBW Reference Marsh	3	1996
Cedar Swamp Site	1	1997
The Rocks Site	1	1997
ACW Site	3	1999
CT Site	4	1999

The corners of these plots were marked with PVC pipes and located using Global Positioning System (GPS) methods to provide a permanent record of the sampling location. The locations of these plots at each site are shown in Figures 8-2 (MHC Reference Marsh), 8-3 (MBW Reference Marsh), 8-4 (CT Site), 8-5 (ACW Site), 8-6 (The Rocks Site), and 8-7 (Cedar Swamp Site).

Quadrat Locations

Each of the fifteen 3,600 m^2 plots listed above was stratified into nine 20 m x 20 m (400 m^2) sub-areas. One 0.25 m^2 quadrat was randomly located within each sub-area, for a total of 9 quadrats per plot. Each quadrat was identified by an alpha-numeric code designating the site, plot number and quadrat number. As an example, MHP1-08-CQ5 indicates that the quadrat was sampled within MHC Reference Marsh Plot 1 (MHP1) during 2008 (08). The quadrat area was clipped for standing crop determination (CQ) and it was the fifth sampled within the plot (5).

Quadrat Sampling

Percent coverage, height and flowering status data were collected in each quadrat as described previously and recorded on the appropriate data sheet (Appendix A – Exhibit A-4). Above ground biomass collection was performed as described previously. Samples were then transported to and processed in the laboratory as described below.

MACROPHYTE LABORATORY PROCESSING

In the laboratory, each sample was dried to a constant weight at 60° C. Following drying, the plant materials collected from each quadrat were weighed to the nearest 0.01g and entered onto the laboratory data sheet (Appendix A – Exhibit A-5). The data was then entered into a Microsoft ® EXCEL spreadsheet for subsequent statistical analysis.

RESULTS

COVER TYPE MAPPING

Cover Type Descriptions

The CIR and true color aerial photography acquired on September 8, 2008 was interpreted to map the extent of the various cover types present on the wetland restoration and reference sites at the time of peak standing crop. The cover types identified at the various sites were delineated by mapped polygons[2] representing areas of each site that are either dominated by listed species (i.e., vegetation community types) or represent identifiable land/water features (e.g., developed land, agricultural land, open water, mud flat). In areas where two or more species dominate a vegetation community, multiple species were listed.

The acreage and percent coverage of each individual cover type (e.g., species or group of species) for the reference marshes and the "wetland restoration area" of each wetland restoration site is provided in Tables 8-1 through 8-4. The wetland restoration area generally occurs within the overall "site boundary" and was determined based on the mapping of the tidal wetland/upland edges. These tables group the cover types under the following categories:

- *Spartina*/other desirable marsh vegetation;
- *Phragmites*-dominated vegetation;
- Non-vegetated marsh plain;
- Internal water areas;
- Open water; and
- Upland vegetation/miscellaneous cover categories

The extent of each cover category at each of the reference marshes and wetland restoration sites is shown in Appendix B, Figures B-1 to B-6. These figures also show the wetland restoration area boundaries for each site. General descriptions of the various cover categories that appear on these figures and the individual cover types that they represent are provided in the following paragraphs.

<u>*Spartina spp.* and Other Desirable Marsh Vegetation</u>

While restoration of *Spartina alterniflora* as a dominant species is desirable, there are numerous other species that contribute to estuarine productivity and are indicative of a fully functional marsh ecosystem. Such species include, but are not limited to: *Spartina cynosuroides, Spartina patens, Distichlis spicata, Scirpus robustus, Scirpus olneyi, Typha latifolia, Pluchea purpurascens, Acorus calamus, Eleocharis parvula,* and *Echinochloa walteri*. Areas that are predominated by *Spartina alterniflora* or another desirable marsh species are included in this category. Where other species are co-dominants with *Spartina alterniflora*, these species are also indicated in the type designation (e.g., *Spartina alterniflora/Amaranthus cannabinus*).

[2] The minimum polygon area for vegetation stands is approximately 1 acre.

Where sparse clumps of *Spartina alterniflora* occur in mud flat areas, these areas are designated in a similar manner (e.g., *Spartina alterniflora*/Mud flat). In the event that mud flat predominates an area, the order of the type name is reversed (i.e., Mud flat/*Spartina alterniflora*).

Spartina alterniflora

The *Spartina alterniflora* cover type represents areas that have developed "complete" coverage by this species. The percent coverage of the marsh plain by *Spartina alterniflora* in these areas generally ranges between 80 and 90 percent. This cover type represents both tall and short forms. The tall form reaches heights of between 120 and 200 cm and occurs along the margins of creeks, guts, channels, and in other areas that are subject to daily tidal inundation. Short form plants are generally 30 to 60 cm high and occur either in areas of higher marsh surface elevation or on the normally flooded marsh plain inland from the creek channels. In some cases other species, including *Spartina cynosuroides, Scirpus robustus*, and *Amaranthus cannabinus*, also occur as co-dominants in this community.

Salt Hay

The salt hay cover type represents areas of the Commercial Township Site vegetated with *Spartina patens, Distichlis spicata*, and *Juncus gerardii.* This cover type was present prior to the restoration of tidal flows to this site. These areas were actively managed for salt hay production, which involved, among other things, periodic inundation and mowing.

Spartina patens

The *Spartina patens* cover type is typically found in natural high-marsh areas that are at an elevation between mean high and mean higher high water (MHW and MHHW, respectively). These areas are usually dominated by *Spartina patens*.

High Marsh

The high marsh cover type includes a variety of coastal species that are generally found at an elevation above MHW. Depending on the particular location, it may contain *Spartina patens, Distichlis spicata, Iva frutescens, Baccharis halimifolia, Panicum virgatum*, and *Phragmites australis*.

Typha spp.

The *Typha* spp. cover type includes areas dominated by *Typha latifolia* and *Typha angustifolia*. These species generally occur in the lower-salinity areas of the estuary and have become established over large areas of the *Phragmites*-dominated sites following the application of a glyphosate-based herbicide with a surfactant.

Recovering Desirable Species Area

These areas, historically, were dominated by desirable marsh vegetation, (i.e., *Spartina alterniflora, Spartina cynosuroides*). In recent years, these areas have been severely damaged by foraging snow geese and muskrats, turning them primarily to mud flat.

Desirable Marsh Vegetation and *Phragmites*

Desirable Marsh Vegetation/*Phragmites* represents portions of each site that are dominated by a variety of desirable marsh species, and include *Phragmites* as a subdominant species. *Phragmites* may occur sparsely throughout the mapped area (Mixed Marsh) or as small isolated colonies that are below the mapping threshold. These areas are primarily within the *Phragmites*-dominated wetland restoration sites and usually represent areas that, prior to initial restoration activities, were monotypic stands of *Phragmites*.

***Phragmites*-Dominated Vegetation**

This cover category includes larger areas (>1 acre) dominated by living monotypic stands of *Phragmites* and areas treated with a glyphosate-based herbicide with a surfactant that have remaining dead culms present (e.g., areas that have not been burned).

Phragmites australis

Stands of *Phragmites* occur at both the reference marshes and the wetland restoration sites. At the reference marshes and salt hay farm restoration sites, this community is usually found as an isolated cover type in disturbed areas such as dikes, ditch and road edges, and on natural creek levees. At the *Phragmites*-dominated sites, the cover type had occurred over large areas of the marsh plain prior to the initiation of the restoration activities. Although *Phragmites* usually forms monotypic stands, species such as *Iva frutescens*, *Baccharis halimifolia*, and *Atriplex patula* may also be present in this community, especially along the upland edge.

Dead *Phragmites australis*

Monotypic stands of *Phragmites* that have been either treated with a glyphosate-based herbicide with a surfactant or subjected to salt water inundation are delineated as the dead *Phragmites australis* cover type. This type is included in the *Phragmites*-dominated vegetation category because the dead culms mask the underlying vegetation; therefore, the establishment of desirable marsh vegetation cannot be interpreted from the aerial photography. As these culms are removed by natural processes (e.g., storm tides, ice flows) or by mechanical means through continued restoration activities, the marsh plain will be exposed and these areas will likely become vegetated with *Spartina alterniflora* or other desirable naturally occurring marsh vegetation.

Non-Vegetated Marsh Plain

Various cover types within the marsh plain that are not vegetated[3] by macrophytes are included in this category.

Mud Flat

At the restoration sites, mud flat is primarily a transitional cover type that precedes the establishment of desirable vegetation. Mud flat areas that were exposed (i.e., not covered by water) at the time of the CIR and true color aerial photography were delineated as this cover type. During many high tides these areas are inundated. Sparse (< 30 percent cover) vegetation may be present that cannot be detected on the CIR or true color aerial photography. This vegetation may be dominated by *Phragmites* or *Spartina* spp. and other desirable naturally occurring marsh vegetation. Algal mats may also be present over much of the mud flat areas.

Algal Mat

Mud flats covered by cohesive mats of filamentous algae or a filamentous or gelatinous mat of cyanobacteria have been categorized as algal mat. This cover type is present over many areas, but is not always identifiable on the CIR or true color aerial photography because of differences in the sun's reflection off the marsh surface and sediment deposition onto the algal mat.

Wrack

In some areas, the marsh plain is covered by accumulated dead stems of marsh vegetation that that have been deposited by the tides, obscuring the marsh surface. These areas are delineated as the wrack cover type.

Internal Water Areas

Areas that were covered by surface water at the time of the aerial photography (low tide) were designated as open water. Open water includes the subtidal areas of tidal creeks, guts, channels, ditches, and areas of ponded water within the marsh. These areas generally do not support any significant vegetation.

Interior Channels

This cover type consists of interior channels greater than five feet wide and includes water areas within channels at the time of the aerial photography (low tide) as well as exposed channel mudflat areas between the low tide water line and the adjacent marsh plain.

[3] Areas considered to be non-vegetated may support sparse vegetative cover. To be mapped as vegetated, it is generally necessary that greater than 30 percent of the marsh surface be covered by macrophytes.

Ponded Water

The ponded water cover type represents areas within the reference marsh and wetland restoration sites that are hydrologically isolated and remain inundated at low tide.

Open Water

The open water category includes small portions of major water bodies (e.g., Delaware Bay, Alloways Creek) adjacent to the various restoration sites or reference marshes that occur within the site boundaries.

Upland Vegetation/Miscellaneous Cover Categories

Relatively small areas of upland vegetation and other non-marsh cover categories occur within the restoration area boundary at some sites. While the area of each of these is provided in the tables, they are generally mapped on the Figures in Appendix B as upland "buffer" areas.

Site Descriptions

Discussions of the cover type composition in 2008 at each of the reference marshes and wetland restoration sites are provided in this section. Reference marshes are discussed first, followed by the CT Site, the ACW Site and the Delaware *Phragmites*-dominated restoration sites.

Detailed information on cover type areas for the 2008 monitoring year are presented in Tables 8-1 through 8-4. The percentage of the total marsh area[4] for applicable cover types has been calculated and is included in these tables. Maps showing the 2008 vegetative cover of each reference marsh and wetland restoration site are provided in Appendix B. These maps correspond to the reference marsh and wetland restoration area cover type data presented in Tables 8-1 through 8-4 and show the areas of each site that are vegetated as per the categories below.

Reference Marshes

The extent of each cover category at the reference marshes was based on the interpretation of the 2008 CIR and true color aerial photography as shown in Figures B-1 (MHC Reference Marsh) and B-2 (MBW Reference Marsh) in Appendix B. The acreage of the vegetation cover categories and cover types mapped in 2008 within each of the reference marshes and the relative percent of the total marsh area that each type represents are summarized in Table 8-1.

A total of 74.2 percent of the MHC Reference Marsh was covered by *Spartina spp.* and Other

[4] The total marsh area excludes: 1) areas of each reference marsh and wetland restoration site that are above MHHW, as defined by vegetation interpretation; and 2) tidal wetland areas that were not affected by PSEG's wetland restoration activities at a given site. The latter includes areas that were outside of the salt hay farming dikes at the time of PSEG's acquisition of the site and areas landward of upland dikes that were constructed by PSEG as part of the wetland restoration designs for the sites.

Desirable Marsh Vegetation in 2008. *Spartina alterniflora* as the single dominant comprised 23.3 percent of the total marsh area. *Phragmites australis* dominated over areas representing 8.7 percent of the marsh plain in 2008. Interior Water Areas, primarily Channels, made up 15.2 percent.

A total of 81.0 percent of the MBW Reference Marsh was covered by *Spartina spp.* and Other Desirable Marsh Vegetation in 2008. *Spartina alterniflora* as the single dominant comprised 61.9 percent of the total marsh area. *Phragmites australis* dominated areas covered 3.5 percent of the marsh plain. Non-vegetated Marsh Plain and Internal Water Areas made up 3.6 percent and 7.4 percent, respectively, of this reference marsh.

Commercial Township Salt Hay Farm Restoration Site

The extent of each cover category and cover type at the CT Site based on the interpretation of the 2008 CIR aerial photography is shown in Figure B-3 in Appendix B. The acreage of the vegetation cover categories and cover types mapped within the CT Site and the relative percent of the total marsh area that each type represents are summarized in Table 8-2.

Spartina spp./Other Desirable Marsh Vegetation (50.8%) and Non-vegetated Marsh Plain (36.7%) were the dominant cover categories at the CT Site in 2008. Areas dominated by *Spartina alterniflora* represented the most extensive vegetated cover type (occurring over 44.7% of the restoration area). Mud Flat (22.3%) and Mud Flat/*Spartina alterniflora* (13.4%) were the most prevalent non-vegetated cover types. *Phragmites* Dominated Vegetation comprised 2.9 percent of the total marsh area and was also present within areas mapped as *Spartina* spp./Other Desirable Marsh Vegetation with *Phragmites* cover category (0.3%). Internal Water Areas were primarily Channels (7.5%) and Ponded Water (1.2%).

Alloway Creek Watershed *Phragmites* Dominated Wetland Restoration Site

The extent of each cover category at the ACW Site based on the interpretation of the 2008 true color aerial photography is shown in Figure B-4 in Appendix B. The acreage of the vegetation cover categories, cover types mapped and the relative percent of the total marsh area that each type represents are summarized in the Table 8-3.

Spartina spp./Other Desirable Marsh Vegetation comprised 74.7 percent of the total marsh area at the ACW Site in 2008. Individual cover types present within this cover category included: *Spartina alterniflora*/Desirable Mixed Marsh (41.4%), Desirable Mixed Marsh (26.3%), and Mixed Marsh (2.7%). The *Phragmites* Dominated Vegetation cover category represented 7.8 percent of the total marsh area, with monotypic *Phragmites australis* stands representing 3.1 percent, and *Phragmites australis* dominating with other vegetation types representing 4.7 percent. Also included in this cover category are areas of the ACW Site dominated by Dead *Phragmites australis,* representing 1.5 percent of the total marsh area. Non-vegetated Marsh Plain comprised 3.7 percent of the total marsh area. Areas covered by wrack accounted for most (2.5%) of these areas. Channels represent 13.7 percent of the ACW Site.

Delaware *Phragmites* Dominated Wetland Restoration Sites

The extent of each cover category at the Delaware *Phragmites* dominated wetland restoration sites based on the interpretation of the 2008 true color aerial photography is shown in Figures B-5 (The Rocks) and B-6 (Cedar Swamp) in Appendix B. The acreage of the vegetation cover categories and cover types mapped within each restoration site and the relative percent of the total marsh area that each type represents are summarized in Table 8-4.

The Rocks. *Spartina spp.*/Other Desirable Marsh Vegetation (85.9%) was the most extensive cover category at The Rocks Site in 2008. Individual cover types present within this cover category included: *Spartina alterniflora*/Desirable Mixed Marsh (65.9%), Desirable Mixed Marsh (10.4%), and Mixed Marsh (3.8%). The *Phragmites* Dominated Vegetation cover category represented 8.3 percent of the total marsh area, with monotypic *Phragmites australis* stands representing 3.4 percent, and *Phragmites australis* dominating with other types representing 4.9 percent. Also included in this cover category are areas dominated by Dead *Phragmites australis,* representing 1.5 percent of the total marsh area. Non-vegetated Marsh Plain comprised 1.1 percent of the total marsh area. Areas covered by wrack accounted for most (0.9%) of these areas. Internal Water Areas represent 4.2 percent of The Rocks Site, represented primarily by Channels (4.0%).

Cedar Swamp. *Spartina spp.*/Other Desirable Marsh Vegetation (82.7%) was the most extensive cover category at the Cedar Swamp Site in 2008. Individual cover types present within this cover category included: *Spartina alterniflora/Spartina cynosuroides* (37.1%), Desirable Mixed Marsh (18.1%), *Spartina alterniflora*/Desirable Mixed Marsh (8.4%), and *Spartina alterniflora* (7.9%). In addition, *Spartina* spp. /Other Desirable Marsh Vegetation with *Phragmites* represented 5.4 percent of this category, represented primarily by Mixed Marsh areas (4.7%). The *Phragmites* Dominated Vegetation cover category represented 5.3 percent of the total marsh area, with monotypic *Phragmites australis* stands representing 2.4 percent, and *Phragmites australis* dominating with other types representing 2.9 percent. Also included in this cover category are areas dominated by Dead *Phragmites australis,* representing 1.2 percent of the total marsh area. Non-vegetated Marsh Plain comprised 1.6 percent of the total marsh area. Areas covered by wrack accounted for most (1.3%) of these areas. Internal Water Areas represent 10.1 percent of the Cedar Swamp Site, represented primarily by Channels (10.1%).

GEOMORPHOLOGIC MAPPING

Maps showing existing hydraulic features on the restoration sites as interpreted from the September 2008 CIR and true color aerial photography of the reference marshes and wetland restoration sites are provided in Appendix C. Mapped features include:

- Center lines of channels between one and five feet in width;
- Edges of channels greater than five feet in width;
- Ponded areas;
- Dikes, dike breaches and internal berms; and
- Miscellaneous roadways.

These maps present the extent of channel systems and other water areas (e.g., ponded areas) as interpreted from the above-referenced photography for these sites. Comments regarding the mapping of the sites are provided in the following paragraphs.

Reference Marshes

The channel systems at the MHC and MBW Reference Marshes based on 2005 CIR and true color aerial photography are shown on Figures C-1 and C-2 in Appendix C. Data representing the 2005 geomorphological characteristics of these reference marshes are presented in Table 8-5.

Commercial Township Salt Hay Farm Wetland Restoration Site

The channel systems at the CT Site in 2008 are shown on Figure C-3 in Appendix C. Data representing the geomorphological characteristics of the CT Site are presented in Table 8-5.

Alloway Creek Watershed *Phragmites* Dominated Wetland Restoration Site

The channel systems at the ACW Site in 2008 are shown on Figure C-4 in Appendix C. Data representing the geomorphological characteristics of the ACW Site are presented in Table 8-5.

Delaware *Phragmites* Dominated Wetland Restoration Sites

The channel systems at The Rocks and Cedar Swamp sites in 2008 are shown on Figures C-5 and C-6 in Appendix C. Data representing the geomorphological characteristics of The Rocks and Cedar Swamp are presented in Table 8-5.

REFERENCE MARSH TRANSECT SAMPLING

Quadrat sampling was conducted during the peak (August) 2008 growing season at the MHC Reference Marsh and MBW Reference Marsh. Percent cover, species identification, flowering status, and height data were collected from both clip and ocular quadrats. Standing crop data (live standing and dead standing) and litter were collected from clip quadrats only.

The field and lab data representing the clip and ocular quadrats along the reference marsh transects during the peak season 2008 macrophyte sampling events are presented in Appendix D. The individual 2008 quadrat data, as well as the means, for percent cover, height (*Spartina alterniflora* and *Spartina cynosuroides*), live standing crop, dead standing crop, and litter for each transect and for all transects at each reference marsh are presented in Appendix D, Tables D-1 and D-2. For each site these means were calculated for: 1) *Spartina alterniflora* dominated[5] (S-d) quadrats, 2) non-*Spartina alterniflora* dominated (e.g., *Phragmites* dominated) quadrats, and 3) for all quadrats.

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[5] *Spartina alterniflora* dominated quadrats include those dominated by *Spartina cynosuroides*.

While the tables in Appendix D present all macrophyte field and laboratory data in detail, several tables have been prepared which summarize the reference marsh transect data collected during the peak growing season. Table 8-6 presents a summary of percent cover by dominance type (*Spartina alterniflora* dominated, non-*Spartina alterniflora* dominated, and all species) for all quadrats (clip and ocular). A summary of percent cover and standing crop data, from clip quadrats only is presented in Table 8-7. The mean percent cover (and mean standing crop), standard error of the mean, standard deviation, minimum, maximum, and number of quadrats for each dominance type are provided in both tables. In addition to the summaries by site, summaries by transect also have been prepared. Table 8-8 presents the means and measures of dispersion (standard error of the mean and standard deviation) by transect for percent cover, height, and standing crop. Data from both clip and ocular quadrats, as applicable, have been used in the calculations in Table 8-8.

Species Composition. *Spartina alterniflora* was the dominant species sampled along transects at the MHC Reference Marsh and MBW Reference Marsh in 2008, recorded in 70 and 92 percent of the quadrats sampled at each site, respectively. Additional species found to be present in the quadrats at the reference marshes are presented in Table 8-9.

Percent Cover. Peak season 2008 percent cover was estimated within all (ocular and clip) quadrats sampled at each reference marsh during the peak season sampling event. The total number of quadrats sampled and number of *Spartina* dominated (S-d) quadrats were as follows:

Site	Peak Season (#)
MHC Reference Marsh	72 (51 S-d)
MBW Reference Marsh	24 (22 S-d)

The mean percent coverage (± SE) for all quadrats in the 2008 sampling event at each reference marsh is graphically shown in Figure 8-8 and was as follows:

Site	Peak Season (%)
MHC Reference Marsh	50 (±2)
MBW Reference Marsh	36 (±2)

The mean percent cover for *Spartina alterniflora* dominated and non-*Spartina alterniflora* dominated quadrats is shown in Figure 8-8. Histograms illustrating the distribution of percent cover determinations for all *Spartina alterniflora* dominated quadrats sampled at the reference marshes are presented in Figures 8-9 and 8-10.

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at each reference marsh during the 2008 peak season sampling event. For *Spartina alterniflora* dominated quadrats (which include *Spartina alterniflora* and *Spartina cynosuroides),* the mean height (±SE) for the 2008 sampling event at each reference marsh was as follows:

Site	Peak Season (cm)
MHC Reference Marsh	100 (±4)
MBW Reference Marsh	95 (±5)

Heights of other species measured within quadrats during the 2008 peak season are presented in Tables D-1 and D-2 (Appendix D).

Flowering Status. Flowering *Spartina alterniflora* was present in 3 percent of the quadrats in which this species occurred along transects at the MHC Reference Marsh during the 2008 peak season sampling event. In comparison, flowering *Spartina alterniflora* was present in 4 percent of the quadrats in which this species occurred at the MBW Reference Marsh. The flowering status for plants within each quadrat sampled is provided in Tables D-1 and D-2 (Appendix D).

Live Standing Crop. Peak season 2008 live standing crop was determined for each reference marsh based on collections of standing living plant materials from clip quadrats along transects. The total number of clip quadrats as well as *Spartina* dominated (S-d) clip quadrats at each reference site were as follows:

Site	Peak Season (#)
MHC Reference Marsh	18 (11 S-d)
MBW Reference Marsh	6 (5 S-d)

The mean values (±SE) for live standing crop in *Spartina alterniflora* dominated quadrats, non-*Spartina alterniflora* dominated quadrats, and all quadrats sampled at each reference marsh in 2008 are presented in Table 8-7 and shown in Figure 8-11. The mean live standing crop for all quadrats was as follows:

Site	Peak Season (gdw/m^2)
MHC Reference Marsh	778 (±77)
MBW Reference Marsh	676 (±96)

Dead Standing Crop. Dead standing crop was determined for each reference marsh based on collections of standing dead plant materials from clip quadrats along transects. The mean values (±SE) for dead standing crop in *Spartina alterniflora* dominated quadrats, non-*Spartina alterniflora* dominated quadrats, and all quadrats sampled at each reference marsh in 2008 are presented in Table 8-7. The mean values (±SE) for dead standing crop for all quadrats at each reference marsh were as follows:

Site	Peak Season (gdw/m^2)
MHC Reference Marsh	12 (±12)
MBW Reference Marsh	33 (±28)

Litter. Plant litter biomass present on the marsh surface was determined based on collection of unattached dead plant materials within clip quadrats along transects at the reference marshes. The mean values (±SE) for litter in *Spartina alterniflora* dominated quadrats, non-*Spartina alterniflora* dominated quadrats, and all quadrats sampled at each reference marsh in 2008 are presented in Table 8-7. The mean values (±SE) for litter biomass in all quadrats at each reference marsh were as follows:

Site	Peak Season (gdw/m^2)
MHC Reference Marsh	107 (±33)
MBW Reference Marsh	125 (±38)

The above tabulations are based on the pooled data for all quadrats *(Spartina alterniflora* dominated and non-*Spartina alterniflora* dominated) in all transects at the reference marshes during the peak-growing season. The following sections present a summary of data from Tables D-1 and D-2 (Appendix D) for quadrats along transects at each reference marsh.

Mad Horse Creek Reference Marsh - Transects

The field and laboratory data representing the clip and ocular quadrats along the MHC Reference Marsh transects during the peak season 2008 macrophyte sampling events are presented in Table D-1, in Appendix D. The means for percent cover, species height (*Spartina alterniflora* dominated only), live standing crop, dead standing crop and litter for each transect are also presented on this table. These means were calculated independently for 1) *Spartina alterniflora* dominated quadrats along each transect, 2) other (e.g., *Phragmites* dominated) quadrats along each transect, and 3) for all quadrats along each transect. Means of each type also were calculated for the site as a whole (i.e., means of all quadrats along all transects). Tables 8-6, 8-7 and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop and litter biomass as previously described.

Species Composition. *Spartina alterniflora* was the dominant species present in quadrats sampled along transects at MHC Reference Marsh, occurring in 70 percent of the quadrats sampled. The percentage of quadrats in which *Spartina alterniflora* occurred along each transect was as follows: MHT1 (63 percent), MHT2 (100 percent), and MHT3 (100 percent). Additional species found to be present in the quadrats at MHC Reference Marsh were *Amaranthus cannabinus*, *Distichlis spicata*, *Scirpus robustus*, *Spartina patens* and *Spartina cynosuroides*.

Percent Cover. The mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation), for quadrats along each transect at MHC Reference Marsh during the 2008 peak growing season are presented in Table 8-8. Field data for each quadrat are presented in Table D-1 (Appendix D). The total number of quadrats (clip and ocular) along each transect was as follows:

Transect	Peak Season (#)
MHT1	24 (18 S-d)
MHT2	8 (4 S-d)
MHT3	40 (29 S-d)

The mean percent cover (± SE) for all quadrats along each transect in 2008, and for *Spartina alterniflora* dominated quadrats (shown graphically in Figure 8-12) only were as follows:

Transect	All Quadrats (%)	S-d Quadrats (%)
MHT1	43 (±4)	48(±3)
MHT2	50 (±9)	59 (±11)
MHT3	54 (±3)	57 (±4)

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at MHC Reference Marsh during the 2008 peak season sampling event. For *Spartina* dominated quadrats, the mean height (±SE) of *Spartina alterniflora* and/or *Spartina cynosuroides* was as follows:

Transect	Peak Season (cm)
MHT1	83 (±5)
MHT2	108 (±5)
MHT3	108 (±5)

Heights for all species of vegetation present in the quadrats in 2008 are presented in Table D-1.

Live Standing Crop. Live standing crop was determined for each transect at MHC Reference Marsh based on collections of living standing plant materials from clip quadrats along each transect. The number of clip quadrats along each transect was as follows:

Transect	Peak Season (#)
MHT1	6 (4 S-d)
MHT2	2 (1 S-d)
MHT3	10 (6 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2008 peak season sampling of MHC Reference Marsh transects, and for all *Spartina alterniflora* dominated clip quadrats, were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MHT1	620 (±141)	660 (±194)
MHT2	585 (±183)	768 (±n/a)
MHT3	911 (±91)	943(±133)

Mean live standing crop determinations for *Spartina alterniflora* dominated quadrats only sampled during the 2008 peak season are shown graphically in Figure 8-13.

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during the 2008 peak season sampling of MHC Reference Marsh transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MHT1	0 (±0)	0 (±0)
MHT2	108 (±108)	0 (±n/a)
MHT3	0 (±0)	0 (±0)

Litter. The mean values (±SE) for litter biomass in clip quadrats during the 2008 peak season sampling of MHC Reference Marsh transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MHT1	67 (±23)	47 (±31)
MHT2	52 (±4)	48 (±n/a)
MHT3	142 (±58)	193 (±90)

Moores Beach West Reference Marsh - Transects

The field and laboratory data representing clip and ocular quadrats along MBW Reference Marsh transects during the 2008 peak season macrophyte sampling events are presented in Table D-2, in Appendix D. The means for percent cover, species height (*Spartina alterniflora* dominated only), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. The means were calculated independently for: 1) *Spartina alterniflora* dominated quadrats along each transect, 2) other (e.g., *Phragmites* dominated) quadrats along each transect, and 3) for all quadrats along each transect. Means of each type also were calculated for the site as a whole (i.e., means of all quadrats along all transects). Tables 8-6, 8-7 and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop and litter biomass as previously described.

Species Composition. *Spartina alterniflora* was the dominant species present in quadrats sampled along transects at MBW Reference Marsh, occurring in 92 percent of the quadrats sampled in 2008. The percentage of quadrats in which *Spartina alterniflora* occurred along each transect was as follows: MBT1 (100 percent), MBT2 (100 percent), and MBT3 (100 percent). No other species occurred within the quadrats sampled.

Percent Cover. The mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation), for quadrats along each transect at MBW Reference Marsh during the 2008 peak growing season are presented in Table 8-8. Field data for each quadrat are presented in Table D-2. The total number of quadrats (clip and ocular) from which percent cover data were collected along each transect was as follows:

Transect	Peak Season (#)
MBT1	8 (7 S-d)
MBT2	8 (8 S-d)
MBT3	8 (7 S-d)

The mean percent cover (±SE) for all quadrats along each transect, and for all *Spartina alterniflora* dominated quadrats (shown graphically in Figure 8-12) were as follows:

Transect	All Quadrats (%)	S-d Quadrats (%)
MBT1	31 (±3)	33 (±3)
MBT2	38 (±3)	38 (±3)
MBT3	38 (±4)	41 (±3)

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at MBW Reference Marsh during the 2008 peak season sampling event. The mean height (±SE) for *Spartina* dominated quadrats (which included *Spartina alterniflora* and *Spartina cynosuroides*) at MBW Reference Marsh was as follows:

Transect	Peak Season (cm)
MBT1	102 (±10)
MBT2	102 (±7)
MBT3	82 (±6)

Live Standing Crop. Live standing crop was determined for each transect at MBW Reference Marsh based on collections of living standing plant materials from clip quadrats along each transect. The number of clip quadrats sampled along each transect in 2008 was as follows:

Transect	Peak Season (#)
MBT1	2 (1 S-d)
MBT2	2 (2 S-d)
MBT3	2 (2 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2008 peak season sampling of MBW Reference Marsh transects, and for all *Spartina alterniflora* dominated clip quadrats, were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MBT1	827 (±94)	921 (±n/a)
MBT2	599 (±172)	599 (±172)
MBT3	603 (±254)	603 (±254)

Live standing crop determinations for the 2008 peak season are shown graphically in Figure 8-13.

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during the 2008 peak season sampling of MBW Reference Marsh transects, and for all *Spartina alterniflora* dominated clip quadrats, were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MBT1	12 (±12)	24 (±n/a)
MBT2	71 (±71)	71 (±71)
MBT3	0 (±n/a)	0 (±n/a)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2008 peak season sampling of MBW Reference Marsh transects, and for all *Spartina alterniflora* dominated clip quadrats, were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MBT1	143 (±54)	197 (±n/a)
MBT2	36 (±36)	36 (±36)
MBT3	133 (±100)	133 (±100)

REFERENCE MARSH PLOT SAMPLING

The field and laboratory data representing clip quadrats within 60 m x 60 m plots during the peak season 2008 macrophyte sampling event are presented in Appendix E. The individual quadrat data as well as means for percent cover and live standing crop are presented in Tables E-1 (MHC Reference Marsh) and E-2 (MBW Reference Marsh). Summary data for each plot, and for each reference marsh are presented in Table 8-10. The summary data includes mean percent cover, live standing crop and dead standing crop as well as measures of dispersion (standard deviation, standard error of the mean, minimum and maximum). Because the plots were located to provide representative data for selected *Spartina alterniflora* dominated areas of each site, means and measures of dispersion have not been calculated for *Spartina alterniflora* dominated quadrats separately.

The percent cover and standing crop data for the MHC Reference Marsh and MBW Reference Marsh plots as a whole are presented here, followed by a discussion of individual plots within each location.

Percent Cover. Peak season 2008 percent cover was estimated within randomly sampled quadrats in three 60 m x 60 m plots located at each reference marsh. Since each plot contained nine (9) randomly located quadrats, the total number of percent cover estimates for each reference marsh was twenty-seven (27). The mean percent coverage (±SE) for all quadrats at each reference marsh was as follows:

Site	Peak Season (%)
MHC Reference Marsh	54 (±2)
MBW Reference Marsh	29 (±3)

Live Standing Crop. Peak season 2008 live standing crop was determined for each reference marsh based on collections of standing living plant materials from the 27 quadrats within each of the 60 m x 60 m plots at each of the reference marshes. The mean live standing crop (±SE) for all quadrats at each reference marsh was as follows:

Site	Peak Season (gdw/m^2)
MHC Reference Marsh	793 (±48)
MBW Reference Marsh	738 (±66)

The following sections present data for individual 60 m x 60 m plots at each reference marsh in 2008.

Mad Horse Creek Reference Marsh - Plots

Three 60 m x 60 m plots were sampled at MHC Reference Marsh in August 2008. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop. Individual quadrat data are presented in Table E-1.

Species Composition. *Spartina alterniflora* was the dominant species present in quadrats sampled in plots at MHC Reference Marsh, occurring in 96 percent of the quadrats sampled in 2008. The percentage of quadrats in which *Spartina alterniflora* occurred within each plot was as follows: MHP1 (100 percent), MHP2 (100 percent), and MHP3 (89 percent). Additional species found to be present in the quadrats at MHC Reference Marsh were *Spartina cynosuroides*, *Scirpus robustus*, *Spartina patens* and *Distichlis spicata*..

Percent Cover. The peak season 2008 mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum), for each plot are presented in Table 8-10. The mean percent cover (±SE) for each plot is graphically shown in Figure 8-14 and was as follows:

Plot	Peak Season (%)
MHP1	61 (±3)
MHP2	52 (±3)
MHP3	49 (±5)

Live Standing Crop. The peak season 2008 mean live standing crop as well as measures of distribution around the mean for each plot is presented in Table 8-10. The mean live standing crop (±SE) for each plot is graphically shown in Figure 8-15 and was as follows:

Plot	Peak Season (gdw/m^2)
MHP1	745 (±79)
MHP2	749 (±91)
MHP3	885 (±80)

Moores Beach West Reference Marsh - Plots

Three 60 m x 60 m plots were sampled at MBW Reference Marsh in August 2008. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop. Individual quadrat data are presented in Table E-2.

Species Composition. *Spartina alterniflora* was the dominant species present in quadrats sampled in plots at MBW Reference Marsh, occurring in 70 percent of the quadrats sampled in 2008. The percentage of quadrats in which *Spartina alterniflora* occurred within each plot was as follows: MBP1 (100 percent), MBP2 (100 percent), and MBP3 (100 percent).

Percent cover. The peak season 2008 mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum), for each plot are presented in Table 8-10. The mean percent cover (±SE) for each plot is graphically shown in Figure 8-14 and was as follows:

Plot	Peak Season (%)
MBP1	27 (±4)
MBP2	32 (±4)
MBP3	28 (±8)

Live standing crop. The peak season 2008 mean live standing crop as well as measures of dispersion for each plot are presented in Table 8-10. The mean live standing crop (±SE) for each plot is graphically shown in Figure 8-15 and were as follows:

Plot	Peak Season (gdw/m^2)
MBP1	649 (±75)
MBP2	728 (±99)
MBP3	839 (±158)

COMMERCIAL TOWNSHIP SALT HAY FARM WETLAND RESTORATION SITE TRANSECT SAMPLING

The field and laboratory data representing the clip and ocular quadrats along transects at the CT Site during the 2008 peak season macrophyte sampling event are presented in Table D-3 in Appendix D. The individual quadrat data, as well as the means for percent cover, height (*Spartina alterniflora* and *Spartina cynosuroides*), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. For each transect, these means were calculated independently for: 1) *Spartina alterniflora* dominated (S-d) quadrats, 2) other (e.g., *Phragmites* dominated) quadrats, and 3) the site as a whole. Tables 8-6, 8-7, and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop, and litter biomass as previously described. The mean percent cover and live standing crop for the 2008 peak growing season also are presented graphically in Figures 8-16 and 8-21, respectively.

Data were collected from both clip and ocular quadrats. Percent cover, species identification, flowering status and height data were collected from both clip and ocular quadrats; live standing crop, dead standing crop, and litter biomass were collected from clip quadrats only.

Species Composition. *Spartina alterniflora* was present in 75 percent of the quadrats sampled at the CT Site in 2008. The other quadrats sampled were located in mudflat areas of the marsh plain.

Percent Cover. Percent cover was estimated within all (ocular and clip) quadrats sampled at the sites during the 2008 peak season sampling event. A total of 32 quadrats were sampled along transects at the CT Site. The mean percent cover (±SE) for all quadrats during the 2008 peak season sampling event at the salt hay farm wetland restoration site (graphically shown in Figure 8-16) was 29% (±4%). Figure 8-17 shows the percent cover groupings for *Spartina alterniflora* dominated quadrats at the CT Site.

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at the site during the 2008 peak growing season sampling event. For *Spartina alterniflora* dominated quadrats (which include *Spartina alterniflora* and *Spartina cynosuroides),* the mean heights (±SE) at the CT Site in 2008 was 164cm (±5 cm). Heights for other species of vegetation present in the quadrats are presented in Table D-4.

Flowering Status. Flowering *Spartina alterniflora* was present in 72 percent of the quadrats in which this species occurred along transects at the CT Site during the 2008 peak season sampling event. The flowering status for plants within each quadrat sampled is provided in Table D-3.

Live Standing Crop. Peak season 2008 live standing crop was determined for the site based on collections of standing living plant materials from clip quadrats along the transects. The number of clip quadrats sampled along transects in 2008 was eight (8), all of which were *Spartina alterniflora* dominated. The mean value (±SE) for live standing crop at the CT Site is shown in Figure 8-21 and was 1,366 gdw/m^2 (±242 gdw/m^2).

Dead Standing Crop. Dead standing crop was determined for the site based on collections of standing dead plant materials from clip quadrats along transects. The mean values (±SE) for dead standing crop in *Spartina alterniflora* dominated quadrats, non-*Spartina alterniflora* dominated quadrats, and all quadrats sampled at the site in 2008 are presented in Table 8-7. There was no dead standing crop present during the 2008 sampling event.

Litter. The plant litter biomass present on the marsh surface was determined based on collection of unattached dead plant materials within clip quadrats along transects at the restoration site in 2008. The mean value (±SE) for litter biomass at the site was 41 gdw/m^2 (±19 gdw/m^2).

The above discussions are based on the pooled data for all quadrats at the CT Site during the peak growing season. The following sections present a summary of data from Appendix D, Table D-3 for quadrats along individual transects at the site.

CT Site - Transects

The field and laboratory data representing the clip and ocular quadrats along the Commercial Township Wetland Restoration Site transects during the peak season 2008 macrophyte sampling event are presented in Table D-3, in Appendix D. The means for percent cover, species height (*Spartina alterniflora* dominated only), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. These means were calculated independently for: 1) *Spartina alterniflora* dominated quadrats along each transect, 2) other (e.g., *Phragmites* dominated) quadrats along each transect, and 3) for all quadrats along each transect. Means of each type also were calculated for the site as a whole (i.e., means of all quadrats along all transects). Tables 8-6, 8-7 and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop and litter biomass as previously described.

Species Composition. *Spartina alterniflora* was present in 78 percent of the quadrats sampled along transects at the CT Site in 2008. The percentage of quadrats in which *Spartina alterniflora* occurred along each transect was as follows: CTT1 (100 percent), CTT2 (63 percent), CTT3 (75 percent) and CTT4 (75 percent).

Percent Cover. The mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation), for quadrats along each transect at the CT Site during the 2008 peak growing season are presented in Table 8-8. Field data for each quadrat are presented in Table D-3. The number of quadrats (clip and ocular) along each transect was as follows:

Transect	Peak Season (#)
CTT1	8 (8 S-d)
CTT2	8 (5 S-d)
CTT3	8 (6 S-d)
CTT4	8 (4 S-d)

The mean percent cover (±SE) for all quadrats along each transect, and for *Spartina alterniflora* dominated quadrats (shown graphically in Figure 8-22,) were as follows:

Transect	All Quadrats (%)	S-d Quadrats (%)
CTT1	48 (±2)	48 (±2)
CTT2	14 (±4)	23 (±2)
CTT3	30 (±8)	40 (±6)
CTT4	23 (±7)	40 (±3)

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at the CT Site during the 2008 peak season sampling event. For *Spartina* dominated quadrats, the mean height (±SE) of *Spartina alterniflora* and *Spartina cynosuroides* were as follows:

Transect	Peak Season (cm)
CTT1	173 (±3)
CTT2	128 (±0)
CTT3	173 (±12)
CTT4	175 (±4)

Live Standing Crop. Peak season 2008 live standing crop was determined for each transect at the site based on collections of living standing plant materials from clip quadrats along each transect. The number of clip quadrats along each transect was as follows:

Transect	Peak Season (#)
CTT1	2 (2 S-d)
CTT2	2 (2 S-d)
CTT3	2 (2 S-d)
CTT4	2 (2 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the peak season sampling of the CT Site transects, and for *Spartina alterniflora*-dominated quadrats only (shown graphically in Figure 8-24), were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
CTT1	2,127 (±486)	2,127 (±486)
CTT2	502 (±52)	502 (±52)
CTT3	1,527 (±74)	1,527 (±74)
CTT4	1,307 (±193)	1,307 (±193)

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during the 2008 peak season sampling of the CT Site transects, and for *Spartina alterniflora*-dominated quadrats only, were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
CTT1	0 (±0)	0 (±0)
CTT2	0 (±0)	0 (±0)
CTT3	0 (±0)	0 (±0)
CTT4	0 (±0)	0 (±0)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2008 peak season sampling of the CT Site transects, and for *Spartina alterniflora*-dominated quadrats only, were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
CTT1	117 (±1)	117 (±1)
CTT2	0 (±0)	0 (±0)
CTT3	45 (±29)	45 (±29)
CTT4	0 (±0)	0 (±0)

COMMERCIAL TOWNSHIP SALT HAY FARM WETLAND RESTORATION SITE PLOT SAMPLING

Four 60 m x 60 m plots were sampled at the CT Site in August 2008. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop. Individual quadrat data are presented in Appendix E, Table E-3.

Species Composition. *Spartina alterniflora* was present in 72 percent of the quadrats sampled within plots at the CT Site in 2008. The percentage of quadrats in which *Spartina alterniflora* occurred in each plot was as follows: CTP1 (33 percent), CTP2 (89 percent), CTP3 (78 percent) and CTP4 (89 percent).

Percent Cover. The 2008 peak season mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum), for the plots at each site are presented in Table 8-10. The mean percent cover for the plots at the CT Site (graphically shown in Figure 8-26) were as follows:

Transect	Peak Season (%)
CTP1	18 (±9)
CTP2	46 (±8)
CTP3	45 (±11)
CTP4	46 (±7)

Live Standing Crop. The 2008 peak season mean live standing crop as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum), for the plots at each site are presented in Table 8-10. The mean live standing crop for the plots at the CT Site (graphically shown in Figure 8-27) were as follows:

Transect	Peak Season (gdw/m^2)
CTP1	509 (±256)
CTP2	1,301 (±267)
CTP3	794 (±178)
CTP4	878 (±162)

ALLOWAY CREEK WATERSHED *PHRAGMITES* DOMINATED WETLAND RESTORATION SITE TRANSECT SAMPLING

The field and laboratory data representing the clip and ocular quadrats along transects at the ACW Site during the 2008 peak season macrophyte sampling event is presented in Table D-4, in Appendix D. The individual quadrat data, as well as the means for percent cover, height (*Spartina alterniflora* and *Spartina cynosuroides*), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. For each transect, these means were calculated independently for: 1) *Spartina alterniflora*-dominated (S-d) quadrats, 2) other (e.g., *Phragmites* dominated) quadrats, and 3) the site as a whole. Tables 8-6, 8-7, and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop, and litter biomass as previously described. The average percent cover and live standing crop for the peak growing season also are presented graphically in Figures 8-16 and 8-21, respectively.

Data were collected from both clip and ocular quadrats. Percent cover, species identification, flowering status and height data were collected from both clip and ocular quadrats; live standing crop, dead standing crop, and litter biomass were collected from clip quadrats only.

Species Composition. *Spartina alterniflora* was the most common dominant species present in quadrats sampled along transects at the ACW Site, occurring in 79 percent of the quadrats sampled. *Phragmites australis* was present in 32 percent of the quadrats. Other species occurring within quadrats included *Spartina cynosuroides, Echinochloa walteri, Amaranthus cannabinus, Cyperus strigosis, Scirpus validus, Scirpus robustus,* and *Polygonum punctatum, Pluchea purpurascens, Typha angustifolia, Peltandra virginica,* and *Eleocharis parvula.*

Percent Cover. Percent cover was estimated within all (ocular and clip) quadrats sampled at the sites during the 2008 peak season sampling event. A total of 56 quadrats were sampled along transects at the ACW Site. The mean percent cover (±SE) for all quadrats (graphically shown in Figure 8-16) were 40% (±3%). Figure 8-18 shows the percent cover groupings for *Spartina alterniflora* dominated quadrats at the ACW Site.

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at the site during the 2008 peak growing season sampling event. For *Spartina alterniflora* dominated quadrats (which include *Spartina alterniflora* and *Spartina cynosuroides),* the mean heights (±SE) at the ACW Site were 129 (±7). Heights for other species of vegetation present in the quadrats are presented in Table D-4.

Flowering Status. Flowering *Spartina alterniflora* was present in 34 percent of the quadrats in which this species occurred along transects at the ACW Site during the 2008 peak season sampling event. The flowering status for species within each quadrat at the ACW Site in 2008 is provided in Table D-4 (Appendix D).

Live Standing Crop. Peak season 2008 live standing crop was determined for the ACW Site based on collections of standing living plant materials from clip quadrats along transects. The number of clip quadrats along each transect was 14 (9 S-d). The mean value (±SE) for live standing crop for all quadrats is shown in Figure 8-21 and was 940 (±160) (gdw/m^2).

In addition to the mean live standing crop for all quadrats in the restoration sites, the mean live standing crop values for *Spartina alterniflora* dominated and non-*Spartina alterniflora* dominated quadrats were calculated and are presented in Table 8-7.

Dead Standing Crop. Peak season 2008 dead standing crop was determined based on collections of standing dead plant materials from clip quadrats along transects at the restoration sites. The mean value (±SE) for dead standing crop at the site was 10 (±10) (gdw/m^2).

Litter. The plant litter biomass present on the marsh surface in 2008 was determined based on collection of unattached dead plant materials within clip quadrats along transects at the restoration sites. The mean value (±SE) for litter biomass at the site was 54 (±13) (gdw/m^2).

The above discussions are based on the pooled data for all quadrats at the ACW Site during the peak growing season. The following sections present a summary of data from Appendix D, Table D-4 for quadrats along individual transects at the site. Savvy

ACW Site - Transects

The field and laboratory data representing the clip and ocular quadrats along the ACW Site transects during the peak season 2008 macrophyte sampling event are presented in Table D-4, in Appendix D. The means for percent cover, species height (*Spartina alterniflora* dominated only), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. These means were calculated independently for: 1) *Spartina alterniflora* dominated quadrats along each transect, 2) other (e.g., *Phragmites* dominated) quadrats along each transect, and 3) for all quadrats along each transect. Means of each type also were calculated for the site as a whole (i.e., means of all quadrats along all transects). Tables 8-6, 8-7 and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop and litter biomass as previously described.

Species Composition. *Spartina alterniflora* was present in 79 percent of the quadrats sampled along transects at the ACW Site in 2008. The percentage of quadrats in which *Spartina alterniflora* occurred along each transect was as follows: ACWT1 (88 percent), ACWT2 (81 percent), ACWT3 (75 percent) and ACWT4 (75 percent).

Percent Cover. The peak season 2008 mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation), for quadrats along each transect at the ACW Site are presented in Table 8-8. Field data for each quadrat are presented in Table D-4. The number of quadrats (clip and ocular) along each transect was as follows:

Transect	Peak Season (#)
ACWT1	8 (7 S-d)
ACWT2	16 (14 S-d)
ACWT3	16 (6 S-d)
ACWT4	16 (5 S-d)

The mean percent cover (±SE) for all quadrats along each transect, and for *Spartina alterniflora*-dominated quadrats only (shown graphically in Figure 8-22), were as follows:

Transect	All Quadrats (%)	S-d Quadrats (%)
ACWT1	44 (±5)	49 (±3)
ACWT2	43 (±5)	41 (±3)
ACWT3	48 (±6)	60 (±9)
ACWT4	27 (±2)	29 (±2)

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at the ACW Site during the 2008 peak season sampling event. For *Spartina* dominated quadrats, the mean height (±SE) of *Spartina alterniflora* and *Spartina cynosuroides* for each transect at the site was as follows:

Transect	Peak Season (cm)
ACWT1	113 (±12)
ACWT2	143 (±9)
ACWT3	96 (±9)
ACWT4	182 (±9)

Heights for other species of vegetation present in the quadrats are presented in Table D-4.

Live Standing Crop. Peak season 2008 live standing crop was determined for each transect at the site based on collections of living standing plant materials from clip quadrats along each transect. The number of clip quadrats along each transect was as follows:

Transect	Peak Season (#)
ACWT1	2 (2 S-d)
ACWT2	4 (3 S-d)
ACWT3	4 (2 S-d)
ACWT4	4 (2 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2008 peak season sampling of the ACW Site transects, and for *Spartina alterniflora*-dominated quadrats only (shown graphically in Figure 8-24), were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
ACWT1	784 (±103)	784 (±103)
ACWT2	1,307 (±529)	1,694 (±509)
ACWT3	656 (±85)	599 (±142)
ACWT4	935 (±157)	879 (±234)

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during the 2008 peak season sampling of the ACW Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
ACWT1	0 (±0)	0 (±0)
ACWT2	0 (±0)	0 (±0)
ACWT3	34 (±34)	0 (±0)
ACWT4	0 (±0)	0 (±0)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2008 peak season sampling of the ACW Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
ACWT1	88 (±13)	88 (±13)
ACWT2	92 (±25)	101 (±33)
ACWT3	53 (±21)	20 (±20)
ACWT4	0 (±0)	0 (±0)

ALLOWAY CREEK WATERSHED *PHRAGMITES* DOMINATED WETLAND RESTORATION SITE PLOT SAMPLING

Three 60 m x 60 m plots were sampled at the ACW Site in August 2008. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop. Individual quadrat data are presented in Appendix E, Table E-4.

Species Composition. *Spartina alterniflora* was the most common dominant species present in quadrats sampled within plots at the ACW Site, occurring in 81 percent of the quadrats sampled. The percentage of quadrats in which *Spartina alterniflora* occurred within each plot was as follows: ACWP1 (67 percent), ACWP2 (89 percent), and ACWP3 (89 percent).

Percent Cover. The peak season 2008 mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum), for the plots at each site are presented in Table 8-10. The mean percent cover for the plots at the ACW Site (graphically shown in Figure 8-26) was as follows:

Plot	Peak Season (%)
ACWP1	32 (±4)
ACWP2	48 (±6)
ACWP3	59 (±10)

Live Standing Crop. The peak season 2008 mean live standing crop as well as measures of dispersion for the plots at each site are presented in Table 8-10. The mean live standing crop for the plots at the ACW Site (graphically shown in Figure 8-27) were as follows:

Plot	Peak Season (gdw/m^2)
ACWP1	733 (±200)
ACWP2	773 (±110)
ACWP3	849 (±179)

DELAWARE *PHRAGMITES* DOMINATED WETLAND RESTORATION SITES TRANSECT SAMPLING

The field and laboratory data representing the clip and ocular quadrats along transects at The Rocks and Cedar Swamp Sites in Delaware during the 2008 peak season macrophyte sampling event are presented in Tables D-5 and D-6, in Appendix D. The individual quadrat data, as well as the means for percent cover, height (*Spartina alterniflora* and *Spartina cynosuroides*), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. For each transect, these means were calculated independently for: 1) *Spartina alterniflora*-dominated (S-d) quadrats, 2) other (e.g., *Phragmites* dominated) quadrats, and 3) the site as a whole. Tables 8-6, 8-7, and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop, and litter biomass as previously described. The average percent cover and live standing crop for the peak-growing season also are presented graphically in Figures 8-16 and 8-21, respectively.

Data were collected from both clip and ocular quadrats. Percent cover, species identification, flowering status and height data were collected from both clip and ocular quadrats; live standing crop, dead standing crop, and litter biomass were collected from clip quadrats only.

Species Composition. *Spartina alterniflora* and/or *Spartina cynosuroides* occurred within 85 percent of the quadrats sampled along transects at The Rocks Site in 2008. *Phragmites australis* was present in 21 percent of the quadrats. The vegetation cover at The Rocks Site is diverse, with fourteen other species occurring within the quadrats sampled.

Spartina alterniflora and/or *Spartina cynosuroides* occurred within 95 percent of the quadrats sampled along transects at the Cedar Swamp Site in 2008. *Phragmites australis* was present in 13 percent of the quadrats. Other species present at Cedar Swamp included *Scirpus robustus, Pluchea purpurascens, Iva frutescens, Polygonum punctatum*, *Atriplex patula*, and *Amaranthus cannabinus.*

Percent Cover. Percent cover was estimated within all (ocular and clip) quadrats sampled at the sites during the 2008 peak season sampling event. A total of 70 quadrats were sampled along transects at The Rocks Site and 64 quadrats were sampled at the Cedar Swamp Site. The mean percent cover (±SE) for all quadrats during the 2008 peak season sampling event at the Delaware *Phragmites* dominated wetland restoration sites (graphically shown in Figure 8-16) were as follows:

Site	Peak Season (%)
The Rocks	47 (±2)
Cedar Swamp	40 (±2)

Figures 8-19 and 8-20 show the percent cover groupings for *Spartina alterniflora* dominated quadrats at The Rocks and Cedar Swamp Sites, respectively.

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at the site during the peak growing season sampling event. For *Spartina alterniflora* dominated quadrats (which include *Spartina alterniflora* and *Spartina cynosuroides),* the mean height (±SE) for the 2008 sampling event at each Delaware *Phragmites* dominated restoration site was as follows:

Site	Peak Season (cm)
The Rocks	147 (±9)
Cedar Swamp	120 (±8)

Heights for all species of vegetation present in the quadrats are presented in Tables D-5 and D-6.

Flowering Status. Flowering *Spartina alterniflora* was present in 20 percent of the quadrats in which this species occurred along transects at The Rocks Site during the 2008 peak season sampling event. The flowering status for species within each quadrat at The Rocks Site in 2008 is provided in Table D-5 (Appendix D).

Flowering *Spartina alterniflora* was present in 2 percent of the quadrats in which this species occurred along transects at the Cedar Swamp Site during the 2008 peak season sampling event. The flowering status for species within each quadrat at the Cedar Swamp Site in 2008 is provided in Table D-6 (Appendix D).

Live Standing Crop. Peak season 2008 live standing crop was determined for each site based on collections of standing living plant materials from clip quadrats along transects. The number of clip quadrats along each transect was as follows:

Site	Peak Season (#)
The Rocks	18 (11 S-d)
Cedar Swamp	16 (12 S-d)

The mean value (±SE) for live standing crop at each site is shown in Figure 8-21 and was as follows:

Site	Peak Season (gdw/m^2)
The Rocks	1,083 (±181)
Cedar Swamp	882 (±153)

In addition to the mean live standing crop for all quadrats in the restoration site, the mean live standing crop values for *Spartina alterniflora* dominated and non-*Spartina alterniflora* dominated quadrats were calculated and are presented in Table 8-7.

Dead Standing Crop. Peak season 2008 dead standing crop was determined based on collections of standing dead plant materials from clip quadrats along transects at the restoration sites. The mean values (±SE) for dead standing crop were as follows:

Site	Peak Season (gdw/m^2)
The Rocks	14 (±14)
Cedar Swamp	131 (±46)

Litter. The peak season 2008 plant litter biomass present on the marsh surface was determined based on collection of unattached dead plant materials within clip quadrats along transects at the restoration sites. The mean value (±SE) for litter biomass at the sites was as follows:

Site	Peak Season (gdw/m^2)
The Rocks	29 (±11)
Cedar Swamp	216 (±50)

The above discussions are based on the pooled data for all quadrats at The Rocks and Cedar Swamp Sites during the peak growing season. The following sections present a summary of data from Appendix D, Tables D-5 and D-6 for quadrats along individual transects at each site.

The Rocks Site – Transects

The field and laboratory data representing the clip and ocular quadrats along The Rocks Site transects during the peak season 2008 macrophyte sampling event are presented in Table D-5, in Appendix D. The means for percent cover, species height (*Spartina alterniflora* dominated only), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. These means were calculated independently for: 1) *Spartina alterniflora* dominated quadrats along each transect, 2) other (e.g., *Phragmites* dominated) quadrats along each transect, and 3) for all quadrats along each transect. Means of each type also were calculated for the site as a whole (i.e., means of all quadrats along all transects). Tables 8-6, 8-7 and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop and litter biomass as previously described.

Species Composition. *Spartina alterniflora* and/or *Spartina cynosuroides* was present in 86 percent of the quadrats sampled along transects at The Rocks Site in 2008. The percentage of quadrats in which one or both of these species occurred along each transect was as follows: TRT1 (88 percent), TRT2 (100 percent), TRT3 (73 percent) and TRT4 (100 percent). Some of the quadrats sampled along TRT3 are dominated by *Spartina patens* and/or *Scirpus olneyi*. Most of the occurrence of *Phragmites australis* was evenly distributed throughout quadrats along TRT2 -TRT4, with this species occurring in 21 percent of the quadrats sampled along the transects.

Percent Cover. The mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation), for quadrats along each transect at The Rocks Site during the 2008 peak growing season are presented in Table 8-8. Field data for each quadrat are presented in Table D-5. The number of quadrats (clip and ocular) along each transect was as follows:

Transect	Peak Season (#)
TRT1	16 (14 S-d)
TRT2	16 (12 S-d)
TRT3	30 (19 S-d)
TRT4	8 (6 S-d)

The mean percent cover (±SE) for all quadrats along each transect, and for *Spartina alterniflora*-dominated quadrats only (shown graphically in Figure 8-23), were as follows:

Transect	All Quadrats (%)	S-d Quadrats (%)
TRT1	45 (±3)	45 (±3)
TRT2	41(±4)	44 (±5)
TRT3	51 (±4)	47 (±4)
TRT4	45 (±10)	50 (±11)

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at The Rocks Site during the 2008 peak season sampling event. For *Spartina* dominated quadrats, the mean height (±SE) of *Spartina alterniflora* and *Spartina cynosuroides* for each transect at the site was as follows:

Transect	Peak Season (cm)
TRT1	101 (±8)
TRT2	142 (±10)
TRT3	191 (±17)
TRT4	116 (±15)

Heights for other species of vegetation present in the quadrats are presented in Table D-5.

Live Standing Crop. Peak season 2008 live standing crop was determined for each transect at the site based on collections of living standing plant materials from clip quadrats along each transect. The number of clip quadrats along each transect was as follows:

Transect	Peak Season (#)
TRT1	4 (2 S-d)
TRT2	4 (3 S-d)
TRT3	8 (4 S-d)
TRT4	2 (2 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the peak season sampling of The Rocks Site transects, and for *Spartina alterniflora*-dominated quadrats only (shown graphically in Figure 8-25), were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
TRT1	890 (±259)	519 (±85)
TRT2	1,256 (±146)	1,114 (±49)
TRT3	1,217 (±378)	1,631 (±723)
TRT4	584 (±1)	584 (±1)

Dead Standing Crop. The peak season 2008 mean values (±SE) for dead standing crop in all clip quadrats during the peak season sampling of The Rocks Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
TRT1	0 (±0)	0 (±0)
TRT2	0 (±0)	0 (±0)
TRT3	0 (±0)	0 (±0)
TRT4	129 (±129)	129 (±129)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2008 peak season sampling of The Rocks Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
TRT1	0 (±0)	0 (±0)
TRT2	12 (±7)	16 (±8)
TRT3	51 (±22)	95 (±33)
TRT4	34 (±26)	34 (±26)

Cedar Swamp Site - Transects

The field and laboratory data representing the clip and ocular quadrats along the Cedar Swamp Site transects during the peak season 2008 macrophyte sampling event are presented in Table D-6, in Appendix D. The means for percent cover, species height (*Spartina alterniflora* dominated only), live standing crop, dead standing crop and litter biomass for each transect are also presented on this table. These means were calculated independently for: 1) *Spartina alterniflora* dominated quadrats along each transect, 2) other (e.g., *Phragmites* dominated) quadrats along each transect, and 3) for all quadrats along each transect. Means of each type also were calculated for the site as a whole (i.e., means of all quadrats along all transects). Tables 8-6, 8-7 and 8-8 provide summary information for percent cover, height, live standing crop, dead standing crop and litter biomass as previously described.

Species Composition. *Spartina alterniflora* and/or *Spartina cynosuroides* was present in 95 percent of the quadrats sampled along transects at the Cedar Swamp Site in 2008. The percentage of quadrats in which one or both of these species occurred along each transect was as follows: CST1 (94 percent), CST2 (92 percent), CST3 (100 percent) and CST4 (100 percent). All of the occurrences of *Phragmites australis* were within quadrats along CST2, with this species occurring in 13 percent of the quadrats sampled at the site.

Percent Cover. The mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation), for quadrats along each transect at the Cedar Swamp Site during the 2008 peak growing season are presented in Table 8-8. Field data for each quadrat are presented in Table D-6. The number of quadrats (clip and ocular) along each transect was as follows:

Transect	Peak Season (#)
CST1	16 (14 S-d)
CST2	24 (16 S-d)
CST3	16 (16 S-d)
CST4	8 (6 S-d)

The mean percent cover (±SE) for all quadrats along each transect, and for *Spartina alterniflora*-dominated quadrats only (shown graphically in Figure 8-23), were as follows:

Transect	All Quadrats (%)	S-d Quadrats (%)
CST1	43 (±2)	44 (±3)
CST2	35 (±3)	41 (±2)
CST3	51 (±3)	51 (±3)
CST4	31 (±4)	35 (±3)

Vegetation Height. The average height of each plant species present was measured for all (ocular and clip) quadrats sampled at the Cedar Swamp Site during the 2008 peak season sampling event. For *Spartina* dominated quadrats, the mean height (±SE) of *Spartina alterniflora* and *Spartina cynosuroides* for each transect at the site was as follows:

Transect	Peak Season (cm)
CST1	158 (±20)
CST2	122 (±12)
CST3	97 (±13)
CST4	91 (±5)

Heights for other species of vegetation present in the quadrats are presented in Table D-6.

Live Standing Crop. Peak season 2008 live standing crop was determined for each transect at the site based on collections of living standing plant materials from clip quadrats along each transect. The number of clip quadrats along each transect was as follows:

Transect	Peak Season (#)
CST1	4 (4 S-d)
CST2	6 (3 S-d)
CST3	4 (4 S-d)
CST4	2 (1 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2008 peak season sampling of the Cedar Swamp Site transects, and for *Spartina alterniflora*-dominated quadrats only (shown graphically in Figure 8-25), were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
CST1	1,619 (±326)	1,619 (±326)
CST2	631 (±187)	577 (±199)
CST3	649 (±183)	649 (±183)
CST4	630 (±46)	676 (±n/a)

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during the 2008 peak season sampling of the Cedar Swamp Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
CST1	200 (±123)	200 (±123)
CST2	182 (±83)	102 (±102)
CST3	0 (±0)	0 (±0)
CST4	103 (±103)	0 (±n/a)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2008 peak season sampling of the Cedar Swamp Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
CST1	394 (±135)	394 (±135)
CST2	178 (±50)	185 (±70)
CST3	185 (±96)	185 (±96)
CST4	34 (±12)	47 (±n/a)

DELAWARE *PHRAGMITES* DOMINATED WETLAND RESTORATION SITES PLOT SAMPLING

One 60 m x 60 m plot was sampled at both The Rocks and Cedar Swamp Sites in August 2008. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop. Individual quadrat data are presented in Appendix E, Tables E-5 and E-6.

Species Composition. *Spartina alterniflora* was the most common dominant species present in quadrats sampled within the plot at The Rocks Site, occurring in 56 percent of the quadrats sampled. Other species present were *Spartina patens, Spartina cynosuroides, Polygonum punctatum, Scirpus robustus, Scirpus pungens, Typha angustifolia* and *Amaranthus cannabinus.*

Spartina alterniflora was the most common dominant species present in quadrats sampled within the plot at the Cedar Swamp Site, occurring in all (100 percent) of the quadrats sampled. Other species present were *Spartina cynosuroides, Pluchea purpuresence,* and *Polygonum punctatum.*

Percent Cover. The peak season 2008 mean percent aerial cover as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum) for the plots at each site are presented in Table 8-10. The mean percent cover values for the plots at each site (graphically shown in Figure 8-26) were as follows:

Site	Peak Season (%)
The Rocks (TRP1)	65 (±8)
Cedar Swamp (CSP1)	58 (±6)

Live Standing Crop. The peak season 2008 mean live standing crop as well as measures of dispersion for the plots at each site are presented in Table 8-10. The mean live standing crop values for the plots at each site (graphically shown in Figure 8-27) were as follows:

Site	Peak Season (gdw/m^2)
The Rocks (TRP1)	1,773 (±216)
Cedar Swamp (CSP1)	738 (±81)

DISCUSSION

COVER TYPE MAPPING

Cover category and cover type mapping and area determinations were completed for two reference marshes and four wetland restoration sites in 2008. This mapping is presented as a series of six maps within Appendix B and detailed listings of the areas of the various cover types within the mapped cover categories are provided in Tables 8-1 through 8-4. The mapping represents wetland systems ranging from relatively stable reference marshes to sites at various phases of post-restoration development. The completion of the restoration of normal tidal inundation and drainage of the marsh at the CT Site has promoted the spread of the *Spartina alterniflora* communities at that site. Glyphosate-based herbicide with a surfactant applications at the ACW Site in New Jersey and Cedar Swamp and The Rocks in Delaware have maintained progress in controlling *Phragmites australis* at these sites and resulted in the expansion of *Spartina alterniflora* and other desirable marsh species as dominant species at these sites in 2008.

GEOMORPHOLOGIC MAPPING

Evidence of successful wetland restoration at the CT Site is provided by the quantitative analysis of 2008 geomorphology mapping. The drainage density in 2008 (1,150 ft/acre) was higher than found for the MBW Reference Marsh in 2005 (438 ft/acre). This drainage density is evidence of progress in the development of a natural channel systems since 2002, when the drainage density was 374 ft/acre. The channel frequency at the CT Site in 2008 (24.2 channels/acre) was also higher than that found in MBW Reference Marsh in 2005 (4.8 channels/acre). The drainage frequency data are a further indication of the progress in channel development that occurred since 2002, when the channel frequency was 3.7 channels/acre.

The drainage density at the MHC Reference Marsh in 2005 was 708 ft/acre. The drainage density value for the ACW Site in 2008 was 690 ft/acre. Drainage densities for the *Phragmites* dominated sites in Delaware ranged from 537 ft/acre at The Rocks to 602 ft/acre at Cedar Swamp. The drainage density for the ACW Site is below that of the MHC Reference Marsh. The Cedar Swamp Site and The Rocks Site are also below the MHC Reference Marsh.

The channel frequency for the MHC Reference Marsh in 2005 was 8.9 channels/acre. The channel frequency value for the ACW Site in 2008 was 10.2 channels/acre. The Rocks and Cedar Swamp 2008 channel frequencies were 8.6 channels/acre and 8.3 channels/acre, respectively.

ABOVE-GROUND NET PRIMARY PRODUCTION

Extensive studies of the net primary production of *Spartina alterniflora* have been conducted along the Atlantic and Gulf coasts of the United States. Mitsch and Gosselink (1993) provide a comparison of many of the measured values, ranging from 330 gdw/m^2/yr to 3,700 gdw/m^2/yr. Higher above-ground productivity is generally found in southern coastal plain marshes than those in northern latitudes. Turner (1976) states that this higher production is related to a greater influx of solar energy and a longer growing season. The relatively high productivity of some southern marshes may also be associated with higher nutrient import associated with sediments deposited by rivers of that region (White et al. 1978).

One of the methods that has been utilized to measure net primary production in tidal marshes is the Peak Standing Crop (PSC) Method. In the PSC Method, the average peak living standing crop over 2 or more consecutive years is used to represent annual net primary productivity (Hsieh 1997). Hsieh lists the following four assumptions relating to the use of the PSC Method:

1. There is no carry-over in living standing crop from one year to another.
2. There is no significant mortality during the growing season.
3. There is no significant growth after the peak of living standing crop.
4. There is no significant grazing.

Since the PSC Method does not account for growing season mortality or loss of live standing crop biomass due to tidal flux and decomposition, the estimates derived from the method are minimum production values. Mitsch and Gosselink (1993) list several primary production determinations for *Spartina alterniflora* marshes derived utilizing the PSC Method as follows:

	Kaswadji et al. (1990)	Kirby and Gosselink (1976)	Hopkinson et al (1980)	Shew et al (1981)
Peak Standing Crop ($gdw/m^2/yr$)	831 ± 41	903	754	242

White et al. (1978) list two additional peak above-ground biomass determinations in North Carolina and New Jersey as 1,320 gdw/m^2 and 1,592 gdw/m^2, respectively. Gross et al. (1991) sampled monthly in both short-form and tall-form *Spartina alterniflora* stands near Lewes, Delaware. They found live aboveground *Spartina alterniflora* during September to range from approximately 500 gdw/m^2 to 1,500 gdw/m^2 in short form and tall form stands, respectively.

Annual production estimates (gdw/m^2) were determined at both reference marshes and wetland restoration sites using the PSC Method. These estimates were derived utilizing data for all clip quadrats sampled along transects at each site in 2008 and from all quadrats sampled within permanent plots at each site in 2008.

MACROPHYTE PRODUCTION AT THE REFERENCE MARSHES

The MHC Reference Marsh and MBW Reference Marsh are both *Spartina alterniflora* dominated tidal wetland systems. At the end of the 2008 growing season, 74.2 percent of MHC and 83.8 percent of MBW was vegetated by *Spartina* spp. and other desirable marsh vegetation. Marsh production in terms of the mean dry weight of live standing macrophytes collected from *Spartina alterniflora*-dominated quadrats sampled along transects during the peak season of 2008 was 824 ±103 gdw/m^2 at MHC Reference Marsh and 665 ±116 gdw/m^2 at MBW Reference

Marsh. Values for quadrats sampled within the permanent plots established at each site were 793 ±48 gdw/m^2 at the MHC Reference Marsh and 738 ±66 gdw/m^2 at the MBW Reference Marsh. These production values are within the published ranges that are summarized above.

MACROPHYTE PRODUCTION AT COMMERCIAL TOWNSHIP SITE

At the end of the 2008 growing season, 50.3 percent of the CT Site was vegetated by *Spartina* spp. and other desirable marsh vegetation. Marsh production in terms of the mean dry weight of live standing macrophytes collected from *Spartina alterniflora* dominated quadrats along transects at the CT Site was 1,366 ±242 gdw/m^2. Mean dry weight of live standing macrophytes collected at the permanent plots throughout the site was 871 ±116 gdw/m^2. These production values are within the published ranges that are summarized above and are comparable to the production at the MBW Reference Marsh in 2008.

MACROPHYTE PRODUCTION AT ALLOWAY CREEK SITE

At the end of the 2008 growing season, 74.7 percent of the ACW Site was vegetated by *Spartina* spp. and other desirable marsh vegetation. Marsh production in terms of the mean dry weight of live standing macrophytes collected from *Spartina alterniflora* dominated quadrats along transects at the ACW Site was 1,067 ±223 gdw/m^2. Mean dry weight of live standing macrophytes collected at the permanent plots throughout the site was 785 ±93 gdw/m^2. These production values are within the published ranges that are summarized above and are comparable to the production at the MHC Reference Marsh in 2008.

MACROPHYTE PRODUCTION AT THE ROCKS AND CEDAR SWAMP SITES

At the end of the 2008 growing season, 85.9 percent of The Rocks Site was vegetated by *Spartina* spp. and other desirable marsh vegetation. Marsh production in terms of the mean dry weight of live standing macrophytes collected from *Spartina alterniflora* dominated quadrats along transects at The Rocks Site was 1,097 ± 280 gdw/m^2. Mean dry weight of live standing macrophytes collected at the permanent plots throughout the site was 1,773 ±216 gdw/m^2. These production values are within the published ranges that are summarized above, and comparable to the production at the MHC Reference Marsh in 2008.

At the end of the 2008 growing season, 82.7 percent of the Cedar Swamp Site was vegetated by *Spartina* spp. and other desirable marsh vegetation. Marsh production in terms of the mean dry weight of live standing macrophytes collected from *Spartina alterniflora* dominated quadrats along transects at the Cedar Swamp Site was 957 ±186 gdw/m^2. Mean dry weight of live standing macrophytes collected at the permanent plots throughout the site was 738 ±81 gdw/m^2. These production values are within the published ranges that are summarized above, and comparable to the production at the MHC Reference Marsh in 2008.

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Chapter 8 Tables

Table 8-1
2008 Reference Marsh Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Mad Horse Creek**		**Moores Beach West**	
	Acres	**Percent of Total Marsh** (a)	**Acres**	**Percent of Total Marsh** (a)
Spartina* spp./ Other Desirable Marsh Vegetation** ***w/o Phragmites				
Amaranthus cannabinus	0	0.0%	0	0.0%
A. cannabinus / Desirable Mixed Marsh	0	0.0%	0	0.0%
A. cannabinus / S. alterniflora	5	0.1%	0	0.0%
Spartina alterniflora	895	23.3%	783	61.9%
S. alterniflora / A. cannabinus	79	2.1%	0	0.0%
S. alterniflora / Beach	2	0.0%	1	0.1%
S. alterniflora / Chanel Banks	0	0.0%	0	0.0%
S. alterniflora / Dead *S. alterniflora*	0	0.0%	0	0.0%
S. alterniflora / Desirable Mixed Marsh	55	1.4%	2	0.2%
S. alterniflora / High Marsh	0	0.0%	0	0.0%
S. alterniflora / Mud Flat	95	2.5%	48	3.8%
S. alterniflora / Mud Flat / Wrack	4	0.1%	0	0.0%
S. alterniflora / Mud Flat / *A. cannabinus*	0	0.0%	0	0.0%
S. alterniflora / Salt Hay	0	0.0%	164	13.0%
S. alterniflora / S. cynosuroides	264	6.9%	0	0.0%
S. alterniflora / Wrack	1	0.0%	2	0.2%
S. alterniflora / Wrack / Mud Flat	0	0.0%	0	0.0%
Salt Hay *(S. patens; D.spicata; J. gerardii)*	0	0.0%	2	0.2%
Salt Hay / High Marsh	0	0.0%	3	0.3%
Salt Hay */ S. alterniflora*	0	0.0%	11	0.9%
S. cynosuroides	23	0.6%	0	0.0%
S. cynosuroides / Dead *P. australis*	0	0.0%	0	0.0%
S. cynosuroides / S. alterniflora	337	8.8%	0	0.0%
S. cynosuroides / Wrack	1	0.0%	0	0.0%
S. patens	1	0.0%	0	0.0%
S. patens / S. alterniflora	2	0.1%	0	0.0%
Amaranthus cannabinus	0	0.0%	0	0.0%
A. cannabinus / S. alterniflora	0	0.0%	0	0.0%
A. cannabinus / Desirable Mixed Marsh	0	0.0%	0	0.0%
Desirable Mixed Marsh	872	22.7%	0	0.0%
Desirable Mixed Marsh / Beach	0	0.0%	0	0.0%
Desirable Mixed Marsh / Mud Flat	22	0.6%	0	0.0%
Desirable Mixed Marsh / Mud Flat / Wrack	2	0.1%	0	0.0%
Desirable Mixed Marsh / Wrack	0	0.0%	0	0.0%
High Marsh Shrubs	26	0.7%	0	0.0%
High Marsh	3	0.1%	3	0.3%
High Marsh / Deciduous Forest	1	0.0%	2	0.1%
High Marsh / Dead Trees	0	0.0%	1	0.1%
High Marsh / Salt Hay	0	0.0%	1	0.1%
High Marsh / *S. alterniflora*	0	0.0%	1	0.1%
subtotal w/o Phragmites	2691	70.2%	1024	81.0%

Table 8-1
2008 Reference Marsh Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	Mad Horse Creek		Moores Beach West	
	Acres	Percent of Total Marsh (a)	Acres	Percent of Total Marsh (a)
w/ Phragmites				
Desriable mixed marsh / P. australis	1	0.0%	0	0.0%
S. alterniflora / P. australis	22	0.6%	0	0.0%
S. alterniflora / P. australis / Mud Flat	1	0.0%	0	0.0%
Salt Hay / Dead *P. australis*	0	0.0%	0	0.0%
S. cynosuroides / P. australis	14	0.4%	0	0.0%
S. cynosuroides / P. australis / Wrack	1	0.0%	0	0.0%
S. cynosuroides / P. australis / S. alterniflora	2	0.1%	0	0.0%
S. cynosuroides / S. alternoflora / P. australis	1	0.0%	0	0.0%
Mixed Marsh	91	2.4%	2	0.2%
Mixed Marsh / Beach	2	0.0%	2	0.2%
Mixed Marsh / Dead *P. australis*	0	0.0%	0	0.0%
Mixed Marsh / Developed Land	0	0.0%	0	0.0%
Mixed Marsh / Mud Flat	3	0.1%	0	0.0%
Mixed Marsh / Wrack	1	0.0%	0	0.0%
High Marsh / *P. australis*	12	0.3%	31	2.5%
High Marsh Shrubs / Mixed Marsh	1	0.0%	0	0.0%
subtotal w/ Phragmites	153	4.0%	36	2.8%
Subtotal	**2844**	**74.2%**	**1059**	**83.8%**
***Phragmites* Dominated Vegetation**				
Dead *P. australis* Dominant				
Dead *P. australis*	2	0.0%	0	0.0%
Dead *P. australis /* Mud Flat	0	0.0%	0	0.0%
Dead *P. australis /* Mixed Marsh	0	0.0%	0	0.0%
Dead *P. australis / P. australis*	0	0.0%	0	0.0%
Dead *P. australis /* Wrack	0	0.0%	0	0.0%
Dead *P. australis / S. alterniflora*	0	0.0%	0	0.0%
Subtotal	***3***	***0.1%***	***0***	***0.0%***
P. australis Dominant				
Phragmites australis	243	6.3%	5	0.4%
P. australis / Salt Hay	0	0.0%	0	0.0%
P. australis / High Marsh	0	0.0%	36	2.9%
P. australis / Dead *P. australis*	3	0.1%	0	0.0%
P. australis / Dead Trees	0	0.0%	3	0.2%
P. australis / Desirable Mixed Marsh	20	0.5%	0	0.0%
P. australis / High Marsh Shrubs	3	0.1%	0	0.0%
P. australis / Mud Flat	1	0.0%	0	0.0%
P. australis / Mud Flat / *S. alterniflora*	0	0.0%	0	0.0%
P. australis / Beach	1	0.0%	0	0.0%
P. australis / Mixed Marsh	1	0.0%	0	0.0%
P. australis / S. alterniflora	34	0.9%	0	0.0%
P. australis / S. alterniflora / S. cynosuroides	1	0.0%	0	0.0%
P. australis / S. cynosuroides	19	0.5%	0	0.0%
P. australis / S. cynosuroides / S. alterniflora	0	0.0%	0	0.0%
P. australis / Wrack	2	0.0%	0	0.0%
Subtotal	**329**	**8.6%**	**45**	**3.5%**

Table 8-1
2008 Reference Marsh Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	Mad Horse Creek		Moores Beach West	
	Acres	Percent of Total Marsh [a]	Acres	Percent of Total Marsh [a]
Non-vegetated Marsh Plain				
Mud Flat	9	0.2%	1	0.1%
Mud Flat / Desirable Mixed marsh	2	0.1%	0	0.0%
Mud Flat / Mixed Marsh	2	0.0%	1	0.1%
Mud Flat / *P. australis*	0	0.0%	0	0.0%
Mud Flat / *S. alterniflora*	27	0.7%	18	1.4%
Mud Flat / *S. alterniflora* / Wrack	0	0.0%	0	0.0%
Mud Flat / Beach	0	0.0%	3	0.3%
Mud Flat / Wrack	1	0.0%	0	0.0%
Mud Flat / Wrack / *S. alterniflora*	0	0.0%	0	0.0%
Mud Flat / Wrack / Mixed Marsh	0	0.0%	0	0.0%
Beach	3	0.1%	9	0.7%
Beach / Mixed Marsh	0	0.0%	5	0.4%
Beach / Mud Flat	0	0.0%	1	0.1%
Beach / *S. alterniflora*	1	0.0%	2	0.1%
Beach / *P. australis*	0	0.0%	0	0.0%
Wrack	16	0.4%	1	0.1%
Wrack / Desirable Mixed Marsh	0	0.0%	0	0.0%
Wrack / Desirable Mixed Marsh / Mud Flat	1	0.0%	0	0.0%
Wrack / Mixed Marsh	3	0.1%	0	0.0%
Wrack / Mud Flat	3	0.1%	0	0.0%
Wrack / Mud Flat / Mixed Marsh	0	0.0%	0	0.0%
Wrack / *S. alterniflora*	1	0.0%	2	0.2%
Wrack / *S. alterniflora* / Mud Flat	1	0.0%	0	0.0%
Wrack / *S. cynosuroides*	1	0.0%	0	0.0%
Wrack / *P. australis*	3	0.1%	0	0.0%
Subtotal	**77**	**2.0%**	**45**	**3.6%**
Internal Water Areas				
Channels	579	15.1%	87	6.9%
Ponded Water	3	0.1%	7	0.5%
Ponded Water / *S. alterniflora*	0	0.0%	0	0.0%
Ponded Water / Wrack	0	0.0%	0	0.0%
Subtotal	**582**	**15.2%**	**94**	**7.4%**
Open Water				
Delaware Bay	1	0.0%	21	1.6%
Upland Vegetation / Miscellaneous Cover Categories.				
Agricultural Land	25	--	15	--
Old Field	2	--	15	--
Old Field/Deciduous Forest	0	--	1	--
Deciduous Forest	64	--	33	--
Deciduous Forest / High Marsh	1	--	21	--
Deciduous Forest / High Marsh Shrubs	7	--	0	--
Developed Land	3	--	8	--
Dike	1	--	0	--
Road	3	--	1	--
Subtotal [b]	**105**	--	**95**	--
Total Marsh Area	**3835**	**100.0%**	**1264**	**100.0%**
Total Site Area	**3942**	--	**1359**	--

[a] *Includes water areas, but does not include upland developed land on the site.*

[b] Cover category subtotals may not reflect sum of individual cover type acreages due to rounding

Table 8-2
2008 Commercial Township Salt Hay Farm Wetland Restoration Site -
Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Commercial Township**	
	Acres	**Percent of Total Marsh**
***Spartina spp*./Other Desirable Marsh Vegetation**		
w/o P. australis		
Desirable Mixed Marsh	12	0.4%
HMS	2	0.1%
High Marsh	13	0.4%
High Marsh / Mud Flat	1	0.0%
Salt Hay (*S. patens*; *D. spicata*; *J.gerardii*)	1	0.0%
Salt Hay / Desirable Mixed Marsh	0	0.0%
Salt Hay / *S. alterniflora*	1	0.0%
Spartina alterniflora	1293	44.7%
S. alterniflora / Dead Trees	3	0.1%
S. alterniflora / Desirable Mixed Marsh	19	0.7%
S. alterniflora / Mud Flat	118	4.1%
S. alterniflora / Wrack	0	0.0%
S. patens	0	0.0%
subtotal w/o P. australis	*1463*	*50.5%*
w/ P. australis		
Desirable Mixed Marsh / P. australis	2	0.1%
High Marsh / *P. australis*	0	0.0%
Mixed Marsh	0	0.0%
Salt Hay / *P. australis*	0	0.0%
S. alterniflora / *P. australis*	7	0.2%
subtotal w/ P. australis	*9*	*0.3%*
Subtotal	**1472**	**50.8%**
***P. australis* Dominated Vegetation**		
P. australis Dominant		
Phragmites australis	54	1.9%
P. australis / Dead Trees / High Marsh	1	0.0%
P. australis / Dike	6	0.2%
P. australis / High Marsh	0	0.0%
P. australis / High Marsh / Shrubs	0	0.0%
P. australis / Mud Flat	0	0.0%
P. australis / *S. alterniflora*	23	0.8%
P. australis / Salt Hay	1	0.0%
subtotal - P. australis	*85*	*2.9%*
Subtotal	**85**	**2.9%**

Table 8-2
2008 Commercial Township Salt Hay Farm Wetland Restoration Site - Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Commercial Township**	
	Acres	**Percent of Total Marsh**
Non-Vegetated Marsh Plain		
Algal mat	5	0.2%
Beach	0	0.0%
Beach / Desriable Mixed Marsh	0	0.0%
Beach / Mud Flat	2	0.1%
Mud Flat	646	22.3%
Mud Flat / *P. australis*	0	0.0%
Mud Flat / Pond	0	0.0%
Mud Flat / Salt Hay		0.0%
Mud Flat/ *S. alterniflora*	389	13.4%
Mud Flat / Wrack	0	0.0%
Wrack	15	0.5%
Wrack / Desirable Mixed Marsh	1	0.0%
Wrack / Mud Flat	3	0.1%
Wrack / *S. alterniflora*	1	0.0%
Wrack / *P. australis*		0.0%
Subtotal	**1063**	**36.7%**
Internal Water Areas		
Channels (>5 ft. wide at low tide)	217	7.5%
Channel Mud Flat		0.0%
Ponded Water	34	1.2%
Ponded Water / *S. alterniflora*		0.0%
Subtotal	**251**	**8.7%**
Open Water		
Delaware Bay	22	0.7%
Upland Vegetation / Miscellaneous Cover Categories (b)		
Dike / *Phragmites australis*	3	0.1%
Subtotal (c)	**3**	**0.1%**
Total Site Area	**2895**	**100%**

(a) Areas listed are for portions of the site within the Wetland Restoration Area Boundary, as show Figures B-3 and B-4.

(b) Areas of upland / developed land listed, are in most cases due to annual variability in the mappi edge cover types and should not be interpreted as an effect of wetland restoration.

(c) Cover category subtotals may not reflect sum of individual cover type acreages due to roundin;

Table 8-3
2008 Alloway Creek Watershed Phragmites Dominated Wetland Restoration Site - Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Alloway Creek Watershed [a]**	
	Acres	**Percent of Total Marsh**
***Spartina* spp./ Other Desirable Marsh Vegetation**		
Desirable Mixed Marsh	421	26.3%
Desirable Mixed Marsh / Mud Flat	3	0.2%
Desirable Mixed Marsh / Wrack	6	0.4%
Echinochloa walteri	1	0.0%
Eleocharis spp. / S. alterniflora	0	0.0%
High Marsh	4	0.3%
High Marsh Shurbs	1	0.1%
Spartina alterniflora	22	1.4%
S. alterniflora / Desirable Mixed Marsh	663	41.4%
S. alterniflora / Desirable Mixed Marsh / Mud Flat	7	0.4%
S. alterniflora / Mud Flat	4	0.3%
Spartina cynosuroides	0	0.0%
Typha spp.	1	0.1%
subtotal w/o P. australis	*1134*	*70.9%*
w/ P. australis		
Desirable Mixed Marsh / *P. australis*	2	0.1%
Desirable Mixed Marsh / Dead *P. australis*	4	0.3%
Mixed Marsh	44	2.7%
Mixed Marsh / Mud Flat	4	0.3%
Mixed marsh / Dead *P. australis*	0	0.0%
Mixed Marsh / Wrack	5	0.3%
S. alterniflora / Dead *P. australis*	0	0.0%
S. alterniflora / P. australis	1	0.1%
subtotal w/ P. australis	61	3.8%
Subtotal [a]	**1195**	**74.7%**

Table 8-3
2008 Alloway Creek Watershed Phragmites Dominated Wetland Restoration Site - Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Alloway Creek Watershed** [a]	
	Acres	**Percent of Total Marsh**
P. australis **Dominated Vegetation**		
Dead P. australis Dominant		
Dead *P. australis*	4	0.2%
Dead *P. australis* / Desirable Mixed Marsh	1	0.1%
Dead *P. australis* / Mixed Marsh	4	0.2%
Dead *P. australis* / *P. australis*	15	0.9%
Subtotal	***23***	***1.5%***
P. australis Dominant		
Phragmites australis	50	3.1%
P. australis / Dead *P. australis*	1	0.0%
P. australis / Desirable Mixed Marsh	29	1.8%
P. australis / Mud Flat	0	0.0%
P. australis / *S. alterniflora*	23	1.4%
Subtotal	***102***	***6.4%***
Subtotal [a]	**125**	**7.8%**
Non-Vegetated Marsh Plain		
Mud Flat	11	0.7%
Mud Flat / Dead *P. australis*	0	0.0%
Mud Flat / Desirable Mixed Marsh	0	0.0%
Mud Flat / Mixed Marsh	3	0.2%
Mud Flat / *P. australis*	0	0.0%
Mud Flat / *S. alterniflora*	2	0.1%
Mud Flat / Wrack	1	0.1%
Wrack	12	0.7%
Wrack / Desirable Mixed Marsh	3	0.2%
Wrack / Mud Flat	14	0.9%
Wrack / Mud Flat / Desirable Mixed Marsh	1	0.1%
Wrack / Mud Flat / Mixed Marsh	1	0.0%
Wrack / Mixed Marsh	9	0.6%
Wrack / *P. australis*	0	0.0%
Wrack / *S. alterniflora*	0	0.0%
Subtotal	**59**	**3.7%**

Table 8-3
2008 Alloway Creek Watershed Phragmites Dominated Wetland Restoration Site - Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Alloway Creek Watershed** [a]	
	Acres	**Percent of Total Marsh**
Internal Water Areas		
Channels	219	13.7%
Subtotal	**219**	**13.7%**
Upland Vegetation / Miscellaneous Cover Categories		
Agricultural	0	0.0%
Deciduous Forest	0	0.0%
Developed	0	0.0%
Road	0	0.0%
Upland Island	1	0.1%
Subtotal	**2**	**0.1%**
Total Area	**1600**	**100.0%**

[a] Cover category subtotals may not reflect sum of individual acreages due to rounding.

Table 8-4
2008 Delaware Phragmites Dominated Wetland Restoration Sites - Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	The Rocks		Cedar Swamp	
	Acres	Percent of Total Marsh[(a)]	Acres	Percent of Total Marsh[(a)]
***Spartina spp.* / Other Desirable Vegetation**				
w/o P. australis				
Desirable Mixed Marsh	76	10.4%	338	18.1%
Desirable Mixed Marsh / Mud Flat	0	0.0%	2	0.1%
Desirable Mixed Marsh / Sand / Wrack	1	0.1%	0	0.0%
Desirable Mixed Marsh / Wrack	0	0.0%	0	0.0%
High Marsh	3	0.4%	0	0.0%
High Marsh Shrubs	2	0.3%	23	1.2%
High Marsh Shrubs / *P. australis*	0	0.0%	0	0.0%
High Marsh Shrubs / *S. alterniflora*	0	0.0%	1	0.0%
Salt Hay (*Spartina patens, Distichlis spicata, Juncus gerardii)*	3	0.4%	0	0.0%
Salt Hay / Desirable Mixed Marsh	3	0.4%	1	0.1%
Salt Hay / *S. alterniflora*	1	0.2%	0	0.0%
Salt Hay / *Scirpus olneyi*	0	0.0%	0	0.0%
Spartina alterniflora	5	0.7%	146	7.9%
S. alterniflora / Beach	0	0.0%	4	0.2%
S. alterniflora / Desirable Mixed Marsh	485	65.9%	157	8.4%
S. alterniflora / Mud Flat	2	0.3%	2	0.1%
S. alterniflora / S. cynosuroides	0	0.0%	691	37.1%
Spartina cynosuroides	1	0.2%	4	0.2%
S. cynosuroides / Desirable Mixed Marsh	0	0.1%	0	0.0%
S. cynosuroides / S. alterniflora	2	0.2%	70	3.8%
Scirpus olneyi	1	0.1%	0	0.0%
Scirpus punctatum	0	0.0%	2	0.1%
subtotal w/o P. australis	*587*	*79.8%*	*1441*	*77.4%*
w/ P. australis				
Desirable Mixed Marsh/ *P. australis*	2	0.3%	0	0.0%
Desirable Mixed Marsh/ Dead *P. australis*	13	1.8%	1	0.1%
Mixed Marsh	28	3.8%	87	4.7%
Mixed Marsh / Beach	0	0.0%	2	0.1%
Mixed Marsh / Dead *P. australis*	0	0.0%	6	0.3%
Mixed Marsh / Mud Flat	1	0.1%	4	0.2%
Mixed Marsh / *S. alterniflora*	0	0.0%	0	0.0%
Mixed Marsh / Wrack	0	0.0%	0	0.0%
S. alterniflora / P. australis	0	0.1%	0	0.0%
S. alterniflora / Mixed Marsh	0	0.0%	0	0.0%
S. cynosuroides / P. australis	0	0.0%	0	0.0%
Salt Hay / Mixed Marsh	0	0.0%	0	0.0%
subtotal w/ P. australis	*45*	*6.1%*	*100*	*5.4%*
Subtotal	**632**	**85.9%**	**1541**	**82.7%**
***P. australis* Dominated Vegetation**				
Dead P. australis Dominant				
Dead *P. australis*	3	0.4%	8	0.4%
Dead *P. australis* / Desirable Mixed Marsh	6	0.8%	0	0.0%
Dead *P. australis* / Mixed Marsh	0	0.0%	7	0.4%
Dead *P. australis* / Mud Flat	0	0.0%	0	0.0%
Dead *P. australis* / High Marsh Shrubs	0	0.0%	0	0.0%
Dead *P. australis / P. australis*	1	0.2%	6	0.3%
Dead *P. australis / P. australis / S. cynosuroides*	0	0.0%	0	0.0%
Dead *P. australis / P. australis* / Desirable Mixed Marsh	1	0.1%	0	0.0%
Dead *P. australis / S. alterniflora*	0	0.0%	0	0.0%
subtotal - Dead P. australis	*11*	*1.5%*	*22*	*1.2%*

Table 8-4
2008 Delaware Phragmites Dominated Wetland Restoration Sites - Cover Category Summary
PSEG Detrital Production Monitoring

Cover Category / Cover Type	The Rocks		Cedar Swamp	
	Acres	**Percent of Total Marsh**[(a)]	**Acres**	**Percent of Total Marsh**[(a)]
<u>*P. australis* Dominant</u>				
Phragmites australis	25	3.4%	45	2.4%
P. australis / Dead *P. australis*	0	0.0%	3	0.1%
P. australis / Dead *P. australis* / Wrack	0	0.0%	0	0.0%
P. australis / Desirable Mixed Marsh	9	1.2%	8	0.4%
P. australis / High Marsh	0	0.0%	0	0.0%
P. australis / Mixed Marsh	0	0.0%	0	0.0%
P. australis / Mud Flat	0	0.0%	0	0.0%
P. australis / Mud Flat / *S. alterniflora*	0	0.0%	0	0.0%
P. australis / *S. alterniflora*	12	1.6%	1	0.0%
P. australis / *S. alterniflora* / *S. cynosuroides*	0	0.0%	0	0.0%
P. australis / *S. cynosuroides*	4	0.5%	20	1.1%
P. australis / Wrack	1	0.1%	0	0.0%
P. australis / Wrack / *S. alterniflora*	0	0.0%	0	0.0%
<u>*subtotal - P. australis*</u>	<u>*51*</u>	<u>*6.9%*</u>	<u>*76*</u>	<u>*4.1%*</u>
Subtotal	**61**	**8.3%**	**98**	**5.3%**
Non-vegetated Marsh Plain				
Beach	0	0.0%	0	0.0%
Beach / Mixed Marsh	0	0.0%	1	0.1%
Beach / *S. alterniflora*	0	0.0%	0	0.0%
Mud Flat	0	0.0%	0	0.0%
Mud Flat / Desirable Mixed Marsh	0	0.0%	0	0.0%
Mud Flat / Mixed Marsh	0	0.0%	1	0.0%
Mud Flat / *P. australis*	0	0.0%	0	0.0%
Mud Flat / *S. alterniflora*	1	0.1%	1	0.0%
Mud Flat / Wrack	0	0.0%	1	0.1%
Wrack	5	0.7%	23	1.2%
Wrack / Dead *P. australis*	0	0.0%	0	0.0%
Wrack / Dead *P. australis* / *P. australis*	0	0.0%	0	0.0%
Wrack / Desirable Mixed Marsh	1	0.1%	0	0.0%
Wrack / Mixed Marsh	1	0.1%	0	0.0%
Wrack / *P. australis*	0	0.0%	0	0.0%
Wrack / *S. alterniflora*	0	0.0%	0	0.0%
Wrack / Mud Flat	0	0.0%	1	0.1%
Subtotal	**8**	**1.1%**	**29**	**1.6%**
Internal Water Areas				
Channels	30	4.0%	188	10.1%
Ponded Water	1	0.1%	0	0.0%
Subtotal	**31**	**4.2%**	**188**	**10.1%**
Open Water				
Appoquinimink River	3	0.5%	5	0.3%
Subtotal	**3**	**0.5%**	**5**	**0.3%**
Upland Vegetation / Miscellaneous Cover Categories				
Deciduous Forest	0	0.1%	1	0.0%
Developed Land	0	0.0%		0.0%
Subtotal [(b)]	**0**	**0.1%**	**1**	**0.0%**
Total Marsh Area	**736**	**100%**	**1863**	**100%**

[(a)] Includes water areas, but does not include upland developed land on the site.

[(b)] Cover category subtotals may not reflect sum of individual cover type acreages due to rounding.

TABLE 8-5
Channel Geomorphology for Reference Marshes and Restoration Sites

Site	Channel Class	Number of Channels	Sinuous Length (feet)	Average Length (feet)	Site Area (acres)	Drainage Density (ft/acre)	Channel Frequency	% of Total Channel Length	Length Ratio	Bifurcation Ratio	Average Channel Sinuosity
Mad Horse 2005	18	2	79	40			0.003	0.0%	1.2	--	1.0
	17	4	130	33			0.006	0.0%	0.8	2.0	1.1
	16	22	910	41			0.030	0.2%	0.9	5.5	1.1
	15	36	1597	44			0.050	0.3%	1.1	1.6	1.1
	14	57	2246	39			0.079	0.4%	0.9	1.6	1.1
	13	86	3962	46			0.119	0.8%	1.0	1.5	1.1
	12	91	4194	46			0.126	0.8%	0.9	1.1	1.2
	11	155	8340	54			0.215	1.6%	1.0	1.7	1.1
	10	236	12829	54			0.327	2.5%	1.0	1.5	1.2
	9	349	19793	57			0.484	3.9%	1.0	1.5	1.1
	8	601	34438	57			0.833	6.7%	0.9	1.7	1.1
	7	916	58897	64			1.270	11.5%	1.0	1.5	1.2
	6	1,175	75738	64			1.629	14.8%	0.9	1.3	1.2
	5	1,174	86941	74			1.627	17.0%	0.8	1.0	1.2
	4	954	86042	90			1.322	16.8%	0.6	0.8	1.2
	3	501	73952	148			0.694	14.5%	0.1	0.5	1.2
	2	27	28659	1061			0.037	5.6%	0.7	0.1	1.3
	1	8	12180	1523			0.011	2.4%	--	0.3	1.3
	Total	6,394	510926		721	708	8.863	100.0%			
Moore's Beach 2005	23	5	320	64			0.004	0.1%	1.6	--	1.1
	22	4	163	41			0.003	0.0%	0.6	0.8	1.1
	21	4	258	65			0.003	0.0%	0.9	1.0	1.0
	20	4	303	76			0.003	0.1%	1.2	1.0	1.2
	19	14	860	61			0.010	0.1%	1.2	3.5	1.1
	18	19	1006	53			0.014	0.2%	0.9	1.4	1.1
	17	35	2054	59			0.026	0.3%	0.9	1.8	1.1
	16	48	3000	63			0.035	0.5%	1.1	1.4	1.1
	15	72	3934	55			0.053	0.7%	0.9	1.5	1.1
	14	118	7542	64			0.087	1.3%	1.0	1.6	1.1
	13	145	8878	61			0.107	1.5%	0.9	1.2	1.1
	12	219	14237	65			0.161	2.4%	1.0	1.5	1.1
	11	323	21641	67			0.238	3.6%	1.0	1.5	1.1
	10	470	33097	70			0.346	5.6%	1.0	1.5	1.1
	9	577	41238	71			0.425	6.9%	0.9	1.2	1.1
	8	738	56707	77			0.543	9.5%	0.9	1.3	1.1
	7	857	69901	82			0.631	11.7%	0.9	1.2	1.1
	6	920	79205	86			0.677	13.3%	0.9	1.1	1.1
	5	848	77738	92			0.624	13.1%	0.8	0.9	1.1
	4	670	72863	109			0.493	12.2%	0.6	0.8	1.1
	3	353	67362	191			0.260	11.3%	0.2	0.5	1.1
	2	17	17517	1030			0.013	2.9%	0.5	0.0	1.3
	1	8	15413	1927			0.006	2.6%	--	0.5	1.2
	Total	6,468	595237		1,359	438	4.760	100.0%			

TABLE 8-5
Channel Geomorphology for Reference Marshes and Restoration Sites

Site	Channel Class	Number of Channels	Sinuous Length (feet)	Average Length (feet)	Site Area (acres)	Drainage Density (ft/acre)	Channel Frequency	% of Total Channel Length	Length Ratio	Bifurcation Ratio	Average Channel Sinuosity
Commercial Township 2008	44	4	308	77			0.0	0.0%	--	1.0	1.1
	43	4	117	29			0.0	0.0%	0.4	1.0	1.0
	42	4	169	42			0.0	0.0%	1.4	1.0	1.1
	41	4	236	59			0.0	0.0%	1.4	1.0	1.0
	40	4	448	112			0.0	0.0%	1.9	1.8	1.1
	39	7	380	54			0.0	0.0%	0.8	0.9	1.0
	38	6	260	43			0.0	0.0%	0.7	2.2	1.0
	37	13	606	47			0.0	0.0%	2.3	1.8	1.1
	36	23	763	33			0.0	0.0%	1.3	0.7	1.0
	35	16	411	26			0.0	0.0%	0.5	1.1	1.0
	34	18	718	40			0.0	0.0%	1.7	1.2	1.1
	33	21	1074	51			0.0	0.0%	1.5	1.2	1.1
	32	25	1471	59			0.0	0.0%	1.4	1.6	1.0
	31	40	1849	46			0.0	0.1%	1.3	1.4	1.0
	30	57	2238	39			0.0	0.1%	1.2	1.2	1.1
	29	68	2780	41			0.0	0.1%	1.2	1.0	1.0
	28	70	4268	61			0.0	0.1%	1.5	1.2	1.0
	27	87	3842	44			0.0	0.1%	0.9	1.4	1.0
	26	118	4846	41			0.0	0.1%	1.3	1.5	1.0
	25	175	6964	40			0.1	0.2%	1.4	1.4	1.0
	24	253	10585	42			0.1	0.3%	1.5	1.4	1.0
	23	347	14429	42			0.1	0.4%	1.4	1.2	1.0
	22	403	15675	39			0.1	0.5%	1.1	1.3	1.0
	21	535	22711	42			0.2	0.7%	1.4	1.4	1.0
	20	760	30607	40			0.3	0.9%	1.3	1.3	1.0
	19	1014	45314	45			0.3	1.4%	1.5	1.2	1.0
	18	1249	52582	42			0.4	1.6%	1.2	1.4	1.0
	17	1689	75054	44			0.6	2.2%	1.4	1.3	1.0
	16	2134	96290	45			0.7	2.9%	1.3	1.2	1.0
	15	2642	114069	43			0.9	3.4%	1.2	1.2	1.0
	14	3072	132967	43			1.1	4.0%	1.2	1.2	1.0
	13	3547	156244	44			1.2	4.7%	1.2	1.2	1.0
	12	4210	180028	43			1.5	5.4%	1.2	1.1	1.0
	11	4726	205693	44			1.6	6.2%	1.1	1.1	1.0
	10	5205	222901	43			1.8	6.7%	1.1	1.1	1.0
	9	5721	251774	44			2.0	7.5%	1.1	1.1	1.0
	8	6183	279568	45			2.1	8.4%	1.1	1.0	1.0
	7	6394	289738	45			2.2	8.7%	1.0	1.0	1.0
	6	6300	286406	45			2.2	8.6%	1.0	0.9	1.1
	5	5839	287071	49			2.0	8.6%	1.0	0.0	1.1
	4	4725	253757	54			1.6	7.6%	0.9	0.5	1.1
	3	2324	198698	85			0.8	6.0%	0.8	0.0	1.1
	2	41	47709	1164			0.0	1.4%	0.2	0.0	1.1
	1	9	32507	3612			0.0	1.0%	0.1	--	1.2
	Total	70,086	3,336,128		2,901	1,150	24.2	100.0%			

TABLE 8-5
Channel Geomorphology for Reference Marshes and Restoration Sites

Site	Channel Class	Number of Channels	Sinuous Length (feet)	Average Length (feet)	Site Area (acres)	Drainage Density (ft/acre)	Channel Frequency	% of Total Channel Length	Length Ratio	Bifurcation Ratio	Average Channel Sinuosity
Alloway Creek Watershed 2008	30	2	63	32			0.001	0.0%	--	0.5	1.01
	29	4	95	24			0.002	0.0%	1.5	1.0	1.03
	28	4	195	49			0.002	0.0%	2.1	0.5	1.03
	27	8	390	49			0.005	0.0%	2.0	0.9	1.08
	26	9	384	43			0.006	0.0%	1.0	0.9	1.07
	25	10	417	42			0.006	0.0%	1.1	1.7	1.06
	24	6	353	59			0.004	0.0%	0.8	0.8	1.10
	23	8	606	76			0.005	0.1%	1.7	1.0	1.05
	22	8	361	45			0.005	0.0%	0.6	0.7	1.06
	21	12	776	65			0.007	0.1%	2.2	1.0	1.13
	20	12	369	31			0.007	0.0%	0.5	0.7	1.02
	19	18	534	30			0.011	0.0%	1.4	0.5	1.04
	18	33	1373	42			0.021	0.1%	2.6	0.6	1.08
	17	59	2796	47			0.037	0.3%	2.0	0.6	1.09
	16	104	4498	43			0.065	0.4%	1.6	0.8	1.07
	15	130	5983	46			0.081	0.5%	1.3	0.7	1.07
	14	176	7997	45			0.110	0.7%	1.3	0.7	1.08
	13	237	11323	48			0.148	1.0%	1.4	0.7	1.09
	12	322	16613	52			0.201	1.5%	1.5	0.7	1.10
	11	448	23951	53			0.280	2.2%	1.4	0.6	1.09
	10	713	35543	50			0.445	3.2%	1.5	0.7	1.09
	9	988	49976	51			0.617	4.5%	1.4	0.7	1.10
	8	1449	75619	52			0.905	6.8%	1.5	0.8	1.09
	7	1899	106780	56			1.186	9.7%	1.4	0.8	1.10
	6	2334	134200	57			1.458	12.1%	1.3	0.9	1.12
	5	2592	155456	60			1.619	14.1%	1.2	1.0	1.10
	4	2579	178842	69			1.611	16.2%	1.2	1.3	1.10
	3	2004	183305	91			1.252	16.6%	1.0	24.7	1.12
	2	81	46414	573			0.051	4.2%	0.3	0.9	1.16
	1	94	60272	641			0.059	5.5%	1.3	--	1.18
	Total	16,343	1,105,485		1,601	690	10.208	100.0%			
The Rocks 2008	22	2	160	80			0.003	0.0%	---	1.0	1.0
	21	2	84	42			0.003	0.0%	0.5	0.5	1.0
	20	4	122	30			0.005	0.0%	0.7	0.7	1.1
	19	6	297	49			0.008	0.1%	1.6	1.0	1.1
	18	6	136	23			0.008	0.0%	0.5	0.3	1.0
	17	18	790	44			0.024	0.2%	1.9	0.9	1.0
	16	20	718	36			0.027	0.2%	0.8	0.5	1.0
	15	38	1909	50			0.052	0.5%	1.4	0.5	1.0
	14	79	3757	48			0.107	0.9%	0.9	0.9	1.1
	13	89	4108	46			0.121	1.0%	1.0	0.7	1.2
	12	130	6684	51			0.176	1.7%	1.1	0.6	1.1
	11	220	10067	46			0.299	2.5%	0.9	0.6	1.1
	10	362	15330	42			0.491	3.9%	0.9	0.7	1.1
	9	492	22141	45			0.668	5.6%	1.1	0.8	1.1
	8	641	30476	48			0.870	7.7%	1.1	0.8	1.1
	7	777	37411	48			1.054	9.5%	1.0	0.9	1.1
	6	892	44167	50			1.210	11.2%	1.0	0.9	1.1
	5	968	51564	53			1.313	13.0%	1.1	1.0	1.1
	4	941	59922	64			1.277	15.1%	1.2	1.5	1.1
	3	641	73451	115			0.870	18.6%	1.8	37.7	1.1
	2	17	13974	822			0.023	3.5%	7.2	1.1	1.3
	1	15	18603	1240			0.020	4.7%	1.5	---	1.4
	Total	6,360	395873		737	537	8.630	100.0%			

TABLE 8-5
Channel Geomorphology for Reference Marshes and Restoration Sites

Site	Channel Class	Number of Channels	Sinuous Length (feet)	Average Length (feet)	Site Area (acres)	Drainage Density (ft/acre)	Channel Frequency	% of Total Channel Length	Length Ratio	Bifurcation Ratio	Average Channel Sinuosity
Cedar Swamp 2008	36	3	39	13			0.002	0.0%	--	0.5	0.7
	35	6	384	64			0.003	0.0%	4.9	0.8	1.2
	34	8	378	47			0.005	0.0%	0.7	0.6	1.1
	33	13	573	44			0.008	0.1%	0.9	0.8	1.1
	32	17	888	52			0.010	0.1%	1.2	0.9	1.2
	31	18	1056	59			0.010	0.1%	1.1	0.7	1.1
	30	27	1605	59			0.016	0.2%	1.0	1.4	1.0
	29	20	1196	60			0.012	0.1%	1.0	1.0	1.1
	28	21	1392	66			0.012	0.1%	1.1	1.1	1.1
	27	19	1098	58			0.011	0.1%	0.9	0.7	1.1
	26	28	1662	59			0.016	0.2%	1.0	0.9	1.1
	25	31	2134	69			0.018	0.2%	1.2	0.7	1.1
	24	46	3345	73			0.027	0.3%	1.1	0.9	1.1
	23	49	3194	65			0.028	0.3%	0.9	0.7	1.1
	22	68	4344	64			0.039	0.4%	1.0	0.6	1.1
	21	116	6470	56			0.067	0.6%	0.9	0.7	1.1
	20	171	9682	57			0.099	0.9%	1.0	0.8	1.1
	19	223	11834	53			0.129	1.1%	0.9	0.7	1.1
	18	310	19158	62			0.179	1.8%	1.2	0.7	1.1
	17	423	25051	59			0.244	2.4%	1.0	0.8	1.1
	16	557	31470	56			0.322	3.0%	1.0	0.8	1.1
	15	680	38071	56			0.393	3.7%	1.0	0.8	1.1
	14	836	47183	56			0.483	4.5%	1.0	0.8	1.1
	13	987	55592	56			0.570	5.3%	1.0	0.9	1.1
	12	1160	69377	60			0.670	6.7%	1.1	0.9	1.1
	11	1263	71421	57			0.729	6.9%	0.9	1.0	1.1
	10	1282	75839	59			0.740	7.3%	1.0	1.0	1.1
	9	1287	75952	59			0.743	7.3%	1.0	1.1	1.1
	8	1156	80962	70			0.668	7.8%	1.2	1.1	1.1
	7	1083	78640	73			0.625	7.5%	1.0	1.1	1.1
	6	982	82259	84			0.567	7.9%	1.2	1.2	1.1
	5	827	81257	98			0.478	7.8%	1.2	1.5	1.1
	4	559	85048	152			0.323	8.2%	1.5	3.5	1.1
	3	162	58554	361			0.094	5.6%	2.4	54.0	1.4
	2	3	14510	4837			0.002	1.4%	13.4	3.0	1.0
	1	1	865	865			0.001	0.1%	0.2	0.0	1.0
	Total	14,442	1042483		1,732	602	8.341	100.0%			

TABLE 8-6
AERIAL COVER SUMMARY
2008 CLIP AND OCULAR QUADRAT TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

	Peak Season Percent Cover
Mad Horse Creek Reference Marsh	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	54%
Standard Error of Mean	3%
Standard Deviation	18%
Minimum	25%
Maximum	95%
Count (n)	51
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	41%
Standard Error of Mean	5%
Standard Deviation	23%
Minimum	0%
Maximum	80%
Count (n)	21
All Quadrats	
Mean	50%
Standard Error of Mean	2%
Standard Deviation	20%
Minimum	0%
Maximum	95%
Count (n)	72
Moores Beach West Reference Marsh	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	38%
Standard Error of Mean	2%
Standard Deviation	9%
Minimum	25%
Maximum	55%
Count (n)	22
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	16%
Standard Error of Mean	1%
Standard Deviation	1%
Minimum	15%
Maximum	16%
Count (n)	2
All Quadrats	
Mean	36%
Standard Error of Mean	2%
Standard Deviation	11%
Minimum	15%
Maximum	55%
Count (n)	24

TABLE 8-6
AERIAL COVER SUMMARY
2008 CLIP AND OCULAR QUADRAT TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

	Peak Season Percent Cover
Commercial Township Site	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	39%
Standard Error of Mean	3%
Standard Deviation	12%
Minimum	10%
Maximum	55%
Count (n)	23
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	2%
Standard Error of Mean	1%
Standard Deviation	4%
Minimum	0%
Maximum	10%
Count (n)	9
All Quadrats	
Mean	29%
Standard Error of Mean	4%
Standard Deviation	20%
Minimum	0%
Maximum	55%
Count (n)	32
Alloway Creek Site	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	44%
Standard Error of Mean	3%
Standard Deviation	15%
Minimum	25%
Maximum	92%
Count (n)	32
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	34%
Standard Error of Mean	5%
Standard Deviation	24%
Minimum	5%
Maximum	100%
Count (n)	24
All Quadrats	
Mean	40%
Standard Error of Mean	3%
Standard Deviation	20%
Minimum	5%
Maximum	100%
Count (n)	56

TABLE 8-6
AERIAL COVER SUMMARY
2008 CLIP AND OCULAR QUADRAT TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

	Peak Season Percent Cover
The Rocks Site	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	46%
Standard Error of Mean	2%
Standard Deviation	17%
Minimum	15%
Maximum	100%
Count (n)	51
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	48%
Standard Error of Mean	7%
Standard Deviation	29%
Minimum	5%
Maximum	101%
Count (n)	19
All Quadrats	
Mean	47%
Standard Error of Mean	2%
Standard Deviation	20%
Minimum	5%
Maximum	101%
Count (n)(c)	70
Cedar Swamp Site	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	44%
Standard Error of Mean	2%
Standard Deviation	11%
Minimum	26%
Maximum	66%
Count (n)	52
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	25%
Standard Error of Mean	4%
Standard Deviation	12%
Minimum	5%
Maximum	50%
Count (n)	12
All Quadrats	
Mean	40%
Standard Error of Mean	2%
Standard Deviation	14%
Minimum	5%
Maximum	66%
Count (n)	64

(a) Also includes *Spartina cynosuroides* dominated quadrats, when present.
(b) Includes quadrats dominated by *Spartina patens*.

TABLE 8-7
SUMMARY OF 2008 CLIP QUADRAT TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

	Percent Cover	Biomass: Live Standing gdw/m²	Live Standing lb/acre	Dead Standing gdw/m²	Litter gdw/m²	Total Standing gdw/m²	Total Biomass gdw/m²
Mad Horse Creek Reference Marsh							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	53%	824	7,353	0	126	824	951
Standard Error of Mean	6%	103	923	0	53		
Standard Deviation	18%	343	3,060	0	176		
Minimum	25%	355	3,170	0	0		
Maximum	75%	1320	11,777	0	588		
Count (n)	11	11	11	11	11		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	54%	705	2,909	31	76	736	812
Standard Error of Mean	13%	110	982	0	0		
Standard Deviation	18%	308	2,751	81	59		
Minimum	35%	291	2,599	0	0		
Maximum	80%	1,120	9,991	215	154		
Count (n)	7	7	7	7	7		
All Quadrats							
Mean	53%	778	6,941	12	107	790	897
Standard Error of Mean	4%	77	686	12	33		
Standard Deviation	18%	326	2,909	51	142		
Minimum	25%	291	2,599	0	0		
Maximum	80%	1,320	161	215	588		
Count (n)	18	18	18	18	18		
Moores Beach West Reference Marsh							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	41%	665	5,933	41	134	706	840
Standard Error of Mean	5%	116	1,037	34	48		
Standard Deviation	11%	260	2,318	68	96		
Minimum	25%	349	3,116	0	34		
Maximum	55%	921	8,215	142	233		
Count (n)	5	5	5	4	4		
Non-*Spartina alterniflora* dominated Quadrats Only							
Mean	15%	733	2,088	0	90	733	822
Standard Error of Mean	15%	733	6,536	0	90		
Standard Deviation	--	--	--	--	--		
Minimum	15%	733	6,536	0	90		
Maximum	15%	733	6,536	0	90		
Count (n)	1	1	1	1	1		
All Quadrats							
Mean	37%	676	6,033	33	125	709	834
Standard Error of Mean	6%	96	853	28	38		
Standard Deviation	15%	234	2,088	62	86		
Minimum	15%	349	3,116	0	34		
Maximum	55%	921	54	142	233		
Count (n)	6	6	6	5	5		

TABLE 8-7
SUMMARY OF 2008 CLIP QUADRAT TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

	Percent Cover	Biomass: Live Standing gdw/m²	Biomass: Live Standing lb/acre	Biomass: Dead Standing gdw/m²	Biomass: Litter gdw/m²	Biomass: Total Standing gdw/m²	Biomass: Total Biomass gdw/m²
Commercial Township Site							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	39%	1366	12,185	0	41	1,366	1,406
Standard Error of Mean	4%	242	2,158	0	19		
Standard Deviation	12%	684	6,103	0	54		
Minimum	15%	450	4,017	0	0		
Maximum	50%	2613	23,317	0	119		
Count (n)	8	8	8	8	8		
Non-*Spartina alterniflora* dominated Quadrats Only							
Mean	--	--	--	--	--	--	--
Standard Error of Mean	--	--	--	--	--		
Standard Deviation	--	--	--	--	--		
Minimum	--	--	--	--	--		
Maximum	--	--	--	--	--		
Count (n)	0	0	0	0	0		
All Quadrats							
Mean	39%	1,366	12,185	0	41	1,366	1,406
Standard Error of Mean	4%	242	2,158	0	19		
Standard Deviation	12%	684	6,103	0	54		
Minimum	15%	450	4,017	0	0		
Maximum	50%	2,613	71	0	119		
Count	8	8	8	8	8		
Alloway Creek Site							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	40%	1067	9,523	0	58	1,067	1,125
Standard Error of Mean	4%	223	1,988	0	19		
Standard Deviation	11%	668	5,964	0	56		
Minimum	25%	457	4,078	0	0		
Maximum	55%	2709	24,172	0	145		
Count (n)	9	9	9	9	9		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	24%	710	5,348	28	48	738	786
Standard Error of Mean	2%	65	577	0	0		
Standard Deviation	15%	414	3,694	62	45		
Minimum	5%	145	1,291	0	0		
Maximum	41%	1,287	11,484	138	94		
Count (n)	5	5	5	5	5		
All Quadrats							
Mean	34%	940	8,385	10	54	950	1,004
Standard Error of Mean	4%	160	1,429	10	13		
Standard Deviation	15%	599	5,348	37	50		
Minimum	5%	145	1,291	0	0		
Maximum	55%	2,709	125	138	145		
Count	14	14	14	14	14		

TABLE 8-7
SUMMARY OF 2008 CLIP QUADRAT TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

	Percent Cover	Biomass					
		Live Standing		Dead Standing	Litter gdw/m²	Total Standing	Total Biomass
		gdw/m²	lb/acre	gdw/m²		gdw/m²	gdw/m²
The Rocks Site							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	46%	1097	9,790	23	45	1,121	1,166
Standard Error of Mean	5%	280	2,499	23	17		
Standard Deviation	17%	929	8,289	78	56		
Minimum	15%	381	3,399	0	0		
Maximum	85%	3651	32,577	258	154		
Count (n)	11	11	11	11	11		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	48%	1,059	6,838	0	4	1,059	1,063
Standard Error of Mean	6%	210	1,874	0	0		
Standard Deviation	27%	474	4,231	0	4		
Minimum	16%	556	4,957	0	0		
Maximum	101%	1,682	15,009	0	8		
Count (n)	7	7	7	7	7		
All Quadrats							
Mean	47%	1,083	9,659	14	29	1,097	1,126
Standard Error of Mean	5%	181	1,612	14	11		
Standard Deviation	21%	766	6,838	61	48		
Minimum	15%	381	3,399	0	0		
Maximum	101%	3,651	161	258	154		
Count	18	18	18	18	18		
Cedar Swamp Site							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	45%	957	8,534	92	243	1,049	1,292
Standard Error of Mean	3%	186	1,658	50	62		
Standard Deviation	9%	644	5,744	174	216		
Minimum	35%	184	1,643	0	47		
Maximum	65%	2188	19,521	502	688		
Count (n)	12	12	12	12	12		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	18%	660	5,465	249	134	908	1,042
Standard Error of Mean	5%	259	2,311	96	71		
Standard Deviation	10%	518	4,622	192	143		
Minimum	5%	107	959	0	8		
Maximum	30%	1,359	12,127	442	301		
Count (n)	4	4	4	4	4		
All Quadrats							
Mean	38%	882	7,872	131	216	1,014	1,229
Standard Error of Mean	4%	153	1,366	46	50		
Standard Deviation	15%	613	5,465	186	202		
Minimum	5%	107	959	0	8		
Maximum	65%	2,188	143	502	688		
Count	16	16	16	16	16		

(a) Also includes *Spartina cynosuroides* dominated quadrats, when present
(b) Includes quadrats dominated by *Spartina patens.*

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m^2	Dead Standing gdw/m^2	Litter gdw/m^2
Mad Horse Creek Reference Marsh - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	48%	83	660	0	47
Standard Error of Mean	3%	5	194	0	31
Standard Deviation	14%	23	388	0	62
Count (*n*)	18	18	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	28%	--	541	0	107
Standard Error of Mean	11%	--	250	0	3
Standard Deviation	27%	--	353	0	4
Count (*n*)	6	--	2	2	2
All Quadrats					
Mean	43%	--	620	0	67
Standard Error of Mean	4%	--	141	0	23
Standard Deviation	19%	--	345	0	57
Count (*n*)	24	--	6	6	6
Mad Horse Creek Reference Marsh - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	59%	108	768	0	48
Standard Error of Mean	11%	5	--	--	--
Standard Deviation	22%	11	--	--	--
Count (*n*)	4	4	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	41%	--	402	215	57
Standard Error of Mean	14%	--	--	--	--
Standard Deviation	28%	--	--	--	--
Count (*n*)	4	--	1	1	1
All Quadrats					
Mean	50%	--	585	108	52
Standard Error of Mean	9%	--	183	108	4
Standard Deviation	25%	--	259	152	6
Count (n)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA
BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m^2	Dead Standing gdw/m^2	Litter gdw/m^2
Mad Horse Creek Reference Marsh - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	57%	108	943	0	193
Standard Error of Mean	4%	5	133	0	90
Standard Deviation	19%	27	325	0	220
Count (*n*)	29	34	6	6	6
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	48%	--	863	0	65
Standard Error of Mean	6%	--	129	0	39
Standard Deviation	19%	--	258	0	78
Count (*n*)	11	--	4	4	4
All Quadrats					
Mean	54%	--	911	0	142
Standard Error of Mean	3%	--	91	0	58
Standard Deviation	19%	--	287	0	182
Count (n)	40	--	10	10	10
Moores Beach West Reference Marsh - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	33%	102	921	24	197
Standard Error of Mean	3%	10	--	--	--
Standard Deviation	8%	27	--	--	--
Count (*n*)	7	7	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	15%	--	733	--	90
Standard Error of Mean	--	--	--	--	--
Standard Deviation	--	--	--	--	--
Count (*n*)	1	--	1	1	1
All Quadrats					
Mean	31%	--	827	12	143
Standard Error of Mean	3%	--	94	12	54
Standard Deviation	10%	--	133	17	76
Count (*n*)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m^2	Dead Standing gdw/m^2	Litter gdw/m^2
Moores Beach West Reference Marsh - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	38%	102	599	71	36
Standard Error of Mean	3%	7	172	71	36
Standard Deviation	9%	19	243	100	51
Count (*n*)	8	8	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	--	--	--	--	--
Standard Error of Mean	--	--	--	--	--
Standard Deviation	--	--	--	--	--
Count (*n*)	0	--	0	0	0
All Quadrats					
Mean	38%	--	599	71	36
Standard Error of Mean	3%	--	172	71	36
Standard Deviation	9%	--	243	100	51
Count (*n*)	8	--	2	2	2
Moores Beach West Reference Marsh - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	41%	82	603	0	133
Standard Error of Mean	3%	6	254	0	100
Standard Deviation	9%	16	359	0	141
Count (*n*)	7	8	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	16%	--	--	--	--
Standard Error of Mean	--	--	--	--	--
Standard Deviation	--	--	--	--	--
Count (*n*)	1	--	0	0	0
All Quadrats					
Mean	38%	--	603	0	133
Standard Error of Mean	4%	--	254	0	100
Standard Deviation	12%	--	359	0	141
Count(n)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA
BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m^2	Dead Standing gdw/m^2	Litter gdw/m^2
Commercial Township Site - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	48%	173	2127	0	117
Standard Error of Mean	2%	3	486	0	1
Standard Deviation	5%	8	688	0	2
Count (*n*)	8	8	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	--	--	--	--	--
Standard Error of Mean	--	--	--	--	--
Standard Deviation	--	--	--	--	--
Count (*n*)	0	--	0	0	0
All Quadrats					
Mean	48%	--	2127	0	117
Standard Error of Mean	2%	--	486	0	1
Standard Deviation	5%	--	688	0	2
Count (*n*)	8	--	2	2	2
Commercial Township Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	23%	128	502	0	0
Standard Error of Mean	2%	0	52	0	0
Standard Deviation	4%	0	73	0	0
Count (*n*)	5	5	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	0%	--	--	--	--
Standard Error of Mean	0%	--	--	--	--
Standard Deviation	0%	--	--	--	--
Count (*n*)	3	--	0	0	0
All Quadrats					
Mean	14%	--	502	0	0
Standard Error of Mean	4%	--	52	0	0
Standard Deviation	12%	--	73	0	0
Count (*n*)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m²	Dead Standing gdw/m²	Litter gdw/m²
Commercial Township Site - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	40%	173	1527	0	45
Standard Error of Mean	6%	12	74	0	29
Standard Deviation	15%	29	104	0	41
Count (*n*)	6	6	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	0%	--	--	--	--
Standard Error of Mean	0%	--	--	--	--
Standard Deviation	0%	--	--	--	--
Count (*n*)	2	--	0	0	0
All Quadrats					
Mean	30%	--	1527	0	45
Standard Error of Mean	8%	--	74	0	29
Standard Deviation	22%	--	104	0	41
Count (*n*)	8	--	2	2	2
Commercial Township Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	40%	175	1307	0	0
Standard Error of Mean	3%	4	193	0	0
Standard Deviation	6%	8	273	0	0
Count (*n*)	4	4	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	5%	--	--	--	--
Standard Error of Mean	3%	--	--	--	--
Standard Deviation	6%	--	--	--	--
Count (*n*)	4	--	0	0	0
All Quadrats					
Mean	23%	--	1307	0	0
Standard Error of Mean	7%	--	193	0	0
Standard Deviation	19%	--	273	0	0
Count (*n*)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m²	Dead Standing gdw/m²	Litter gdw/m²
Alloway Creek Watershed Site - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	49%	113	784	0	88
Standard Error of Mean	3%	12	103	0	13
Standard Deviation	7%	33	146	0	19
Count (*n*)	7	7	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	15%	--	--	--	--
Standard Error of Mean	--	--	--	--	--
Standard Deviation	--	--	--	--	--
Count (*n*)	1	--	0	0	0
All Quadrats					
Mean	44%	--	784	0	88
Standard Error of Mean	5%	--	103	0	13
Standard Deviation	13%	--	146	0	19
Count (*n*)	8	--	2	2	2
Alloway Creek Watershed Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	41%	143	1694	0	101
Standard Error of Mean	3%	9	509	0	33
Standard Deviation	10%	34	882	0	57
Count (*n*)	14	14	3	3	3
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	53%	--	145	0	65
Standard Error of Mean	48%	--	--	--	--
Standard Deviation	67%	--	--	--	--
Count (*n*)	2	--	1	1	1
All Quadrats					
Mean	43%	--	1307	0	92
Standard Error of Mean	5%	--	529	0	25
Standard Deviation	20%	--	1058	0	50
Count (*n*)	16	--	4	4	4

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m^2	Dead Standing gdw/m^2	Litter gdw/m^2
Alloway Creek Watershed Site - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	60%	96	599	0	20
Standard Error of Mean	9%	9	142	0	20
Standard Deviation	22%	23	200	0	29
Count (*n*)	6	6	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	42%	--	713	69	87
Standard Error of Mean	8%	--	128	69	8
Standard Deviation	24%	--	181	97	11
Count (*n*)	10	--	2	2	2
All Quadrats					
Mean	48%	--	656	34	53
Standard Error of Mean	6%	--	85	34	21
Standard Deviation	24%	--	169	69	42
Count (*n*)	16	--	4	4	4
Alloway Creek Watershed Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	29%	182	879	0	0
Standard Error of Mean	2%	9	234	--	0
Standard Deviation	5%	20	330	--	0
Count (*n*)	5	5	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	26%	--	991	0	0
Standard Error of Mean	3%	--	296	0	0
Standard Deviation	9%	--	419	0	0
Count (*n*)	11	--	2	2	2
All Quadrats					
Mean	27%	--	935	0	0
Standard Error of Mean	2%	--	157	0	0
Standard Deviation	8%	--	315	0	0
Count (*n*)	16	--	4	4	4

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m^2	Dead Standing gdw/m^2	Litter gdw/m^2
The Rocks Site - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	45%	101	519	0	0
Standard Error of Mean	3%	8	85	0	0
Standard Deviation	11%	32	120	0	0
Count (*n*)	14	15	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	48%	--	1262	0	0
Standard Error of Mean	8%	--	346	0	0
Standard Deviation	11%	--	489	0	0
Count (*n*)	2	--	2	2	2
All Quadrats					
Mean	45%	--	890	0	0
Standard Error of Mean	3%	--	259	0	0
Standard Deviation	11%	--	518	0	0
Count (*n*)	16	--	4	4	4
The Rocks Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	44%	142	1114	0	16
Standard Error of Mean	5%	10	49	0	8
Standard Deviation	17%	35	84	0	14
Count (*n*)	12	12	3	3	3
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	34%	--	1682	0	0
Standard Error of Mean	8%	--	--	--	--
Standard Deviation	17%	--	--	--	--
Count (*n*)	4	--	1	1	1
All Quadrats					
Mean	41%	--	1256	0	12
Standard Error of Mean	4%	--	146	.0	7
Standard Deviation	17%	--	293	0	14
Count (*n*)	16	--	4	4	4

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m^2	Dead Standing gdw/m^2	Litter gdw/m^2
The Rocks Site - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	47%	191	1631	0	95
Standard Error of Mean	4%	17	723	0	33
Standard Deviation	17%	79	1445	0	65
Count (*n*)	19	22	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	57%	--	803	0	7
Standard Error of Mean	10%	--	177	0	1
Standard Deviation	33%	--	354	0	2
Count (*n*)	11	--	4	4	4
All Quadrats					
Mean	51%	--	1217	0	51
Standard Error of Mean	4%	--	378	0	22
Standard Deviation	24%	--	1070	0	63
Count (*n*)	30	--	8	8	8
The Rocks Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	50%	116	584	129	34
Standard Error of Mean	11%	15	1	129	26
Standard Deviation	26%	40	1	183	36
Count (*n*)	6	7	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	28%	--	--	--	--
Standard Error of Mean	23%	--	--	--	--
Standard Deviation	32%	--	--	--	--
Count (*n*)	2	--	0	0	0
All Quadrats					
Mean	45%	--	584	129	34
Standard Error of Mean	10%	--	1	129	26
Standard Deviation	27%	--	1	183	36
Count (*n*)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA
BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m²	Dead Standing gdw/m²	Litter gdw/m²
Cedar Swamp Site - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	44%	158	1619	200	394
Standard Error of Mean	3%	20	326	123	135
Standard Deviation	9%	73	652	246	270
Count (*n*)	14	14	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	36%	--	--	--	--
Standard Error of Mean	0%	--	--	--	--
Standard Deviation	0%	--	--	--	--
Count (*n*)	2	--	0	0	0
All Quadrats					
Mean	43%	--	1619	200	394
Standard Error of Mean	2%	--	326	123	135
Standard Deviation	9%	--	652	246	270
Count (*n*)	16	--	4	4	4
Cedar Swamp Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	41%	122	577	102	185
Standard Error of Mean	2%	12	199	102	70
Standard Deviation	9%	49	345	176	121
Count (*n*)	16	16	3	3	3
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	23%	--	685	263	171
Standard Error of Mean	5%	--	365	134	86
Standard Deviation	13%	--	631	232	149
Count (*n*)	8	--	3	3	3
All Quadrats					
Mean	35%	--	631	182	178
Standard Error of Mean	3%	--	187	83	50
Standard Deviation	13%	--	459	204	122
Count (*n*)	24	--	6	6	6

TABLE 8-8
SUMMARY OF 2008 CLIP and OCULAR QUADRAT DATA BY TRANSECT
PSEG EEP DETRITAL MONITORING PROGRAM

	Peak Season				
			Biomass		
	Percent Cover	Height (a) (cm)	Live Standing gdw/m²	Dead Standing gdw/m²	Litter gdw/m²
Cedar Swamp Site - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	51%	97	649	0	185
Standard Error of Mean	3%	13	183	0	96
Standard Deviation	12%	51	367	0	192
Count (*n*)	16	16	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	--	--	--	--	--
Standard Error of Mean	--	--	--	--	--
Standard Deviation	--	--	--	--	--
Count (*n*)	0	--	0	0	0
All Quadrats					
Mean	51%	--	649	0	185
Standard Error of Mean	3%	--	183	0	96
Standard Deviation	12%	--	367	0	192
Count (*n*)	16	--	4	4	4
Cedar Swamp Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	35%	91	676	0	47
Standard Error of Mean	3%	5	--	--	--
Standard Deviation	7%	13	--	--	--
Count (*n*)	6	6	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	20%	--	583	207	22
Standard Error of Mean	10%	--	--	--	--
Standard Deviation	14%	--	--	--	--
Count (*n*)	2	--	1	1	1
All Quadrats					
Mean	31%	--	630	103	34
Standard Error of Mean	4%	--	46	103	12
Standard Deviation	10%	--	66	146	17
Count (*n*)	8	--	2	2	2

(a) Height calculations include values for *S. alterniflora* and *S. cynosuriodes* from Spartina-dominated quadrats only.
(b) Also includes *Spartina cynosuroides* dominated quadrats, when present.
(c) Includes quadrats dominated by *Spartina patens.*

Table 8-9
2008 Species Occurrence At Reference Marshes
PSEG Detrital Production Monitoring

Species [a]	Reference Marsh	
	Mad Horse Creek	Moores Beach West
Amaranthus cannabinus	X*	
Distichlis spicata	X*	
Phragmites australis	X*	
Scirpus robustus	X*	
Spartina alterniflora	X*	X*
Spartina cynosuroides	X*	X
Spartina patens	X*	

[a] Species listed were present within quadrats along sampling transects.
* Present as a dominant (>20 percent relative cover) in some quadrats.

TABLE 8-10
SUMMARY OF 2007 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent	Live Standing Biomass	
	Cover	gdw/m2	lb/acre
Mad Horse Creek Reference Marsh			
Plot 1 (MHP1)			
Mean	61%	745	6,643
Standard Error of Mean	3%	79	704
Standard Deviation	10%	237	2,112
Minimum	45%	546	4,872
Maximum	75%	1,289	11,500
Count (n)	9	9	
Plot 2 (MHP2)			
Mean	52%	749	6,680
Standard Error of Mean	3%	91	811
Standard Deviation	8%	273	2,434
Minimum	45%	469	4,187
Maximum	65%	1,212	10,814
Count (n)	9	9	
Plot 3 (MHP3)			
Mean	49%	885	7,892
Standard Error of Mean	5%	80	711
Standard Deviation	16%	239	2,132
Minimum	15%	508	4,532
Maximum	65%	1,164	10,386
Count (n)	9	9	
All Plots			
Mean	54%	793	7,072
Standard Error of Mean	2%	48	428
Standard Deviation	13%	249	2,224
Minimum	15%	469	4,187
Maximum	75%	1,289	11,500
Count (n)	27	27	

TABLE 8-10
SUMMARY OF 2007 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent Cover	Live Standing Biomass gdw/m2	Live Standing Biomass lb/acre
Moores Beach West Reference Marsh			
Plot 1 (MBP1)			
Mean	27%	649	5,788
Standard Error of Mean	4%	75	666
Standard Deviation	13%	224	1,997
Minimum	15%	284	2,535
Maximum	55%	1,056	9,425
Count (n)	9	9	
Plot 2 (MBP2)			
Mean	32%	728	6,491
Standard Error of Mean	4%	99	883
Standard Deviation	13%	297	2,649
Minimum	1%	225	2,003
Maximum	45%	1,242	11,084
Count (n)	9	9	
Plot 3 (MBP3)			
Mean	28%	839	7,482
Standard Error of Mean	8%	158	1,407
Standard Deviation	23%	473	4,221
Minimum	5%	251	2,241
Maximum	65%	1,619	14,440
Count (n)	9	9	
All Plots			
Mean	29%	738	6,587
Standard Error of Mean	3%	66	589
Standard Deviation	17%	343	3,061
Minimum	1%	225	2,003
Maximum	65%	1,619	14,440
Count (n)	27	27	

TABLE 8-10
SUMMARY OF 2007 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent Cover	Live Standing Biomass	
		gdw/m2	lb/acre
Commercial Township Site			
Plot 1 (CTP1)			
Mean	18%	509	4,543
Standard Error of Mean	9%	256	2,283
Standard Deviation	28%	768	6,850
Minimum	0%	0	0
Maximum	55%	1,656	14,771
Count (n)	9	9	
Plot 2 (CTP2)			
Mean	46%	1,301	11,608
Standard Error of Mean	8%	267	2,382
Standard Deviation	24%	801	7,147
Minimum	0%	0	0
Maximum	85%	2,912	25,981
Count (n)	9	9	
Plot 3 (CTP3)			
Mean	45%	794	7,082
Standard Error of Mean	11%	178	1,589
Standard Deviation	33%	534	4,766
Minimum	0%	0	0
Maximum	85%	1,531	13,664
Count (n)	9	9	
Plot 4 (CTP4)			
Mean	46%	878	7,836
Standard Error of Mean	7%	162	1,448
Standard Deviation	20%	487	4,344
Minimum	0%	0	0
Maximum	75%	1,453	12,966
Count (n)	9	9	
All Plots			
Mean	39%	871	7,767
Standard Error of Mean	5%	116	1,034
Standard Deviation	28%	695	6,204
Minimum	0%	0	0
Maximum	85%	2,912	25,981
Count (n)	36	36	

TABLE 8-10
SUMMARY OF 2007 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent Cover	Live Standing Biomass gdw/m2	Live Standing Biomass lb/acre
Alloway Creek Watershed Site			
Plot 1 (ACWP1)			
Mean	32%	733	6,537
Standard Error of Mean	4%	200	1,782
Standard Deviation	12%	599	5,345
Minimum	15%	0	0
Maximum	50%	1,773	15,823
Count (n)	9	9	
Plot 2 (ACWP2)			
Mean	48%	773	6,892
Standard Error of Mean	6%	110	986
Standard Deviation	18%	331	2,957
Minimum	16%	394	3,518
Maximum	75%	1,537	13,717
Count (n)	9	9	
Plot 3 (ACWP3)			
Mean	59%	849	7,579
Standard Error of Mean	10%	179	1,597
Standard Deviation	31%	537	4,791
Minimum	15%	0	0
Maximum	100%	1,642	14,647
Count (n)	9	9	
All Plots			
Mean	46%	785	7,003
Standard Error of Mean	5%	93	833
Standard Deviation	24%	485	4,329
Minimum	15%	0	0
Maximum	100%	1,773	15,823
Count (n)	27	27	

TABLE 8-10
SUMMARY OF 2007 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent Cover	Live Standing Biomass	
		gdw/m2	lb/acre
The Rocks Site			
Plot 1 (TRP1)			
Mean	65%	1,773	15,823
Standard Error of Mean	8%	216	1,925
Standard Deviation	24%	647	5,774
Minimum	36%	681	6,074
Maximum	100%	2,737	24,421
Count (n)	9	9	
Cedar Swamp Site			
Plot 1 (CSP1)			
Mean	58%	738	6,587
Standard Error of Mean	6%	81	726
Standard Deviation	18%	244	2,178
Minimum	36%	410	3,660
Maximum	85%	1,209	10;786
Count (n)	9	9	

Chapter 8 Figures

PSEG ESTUARY ENHANCEMENT PROGRAM

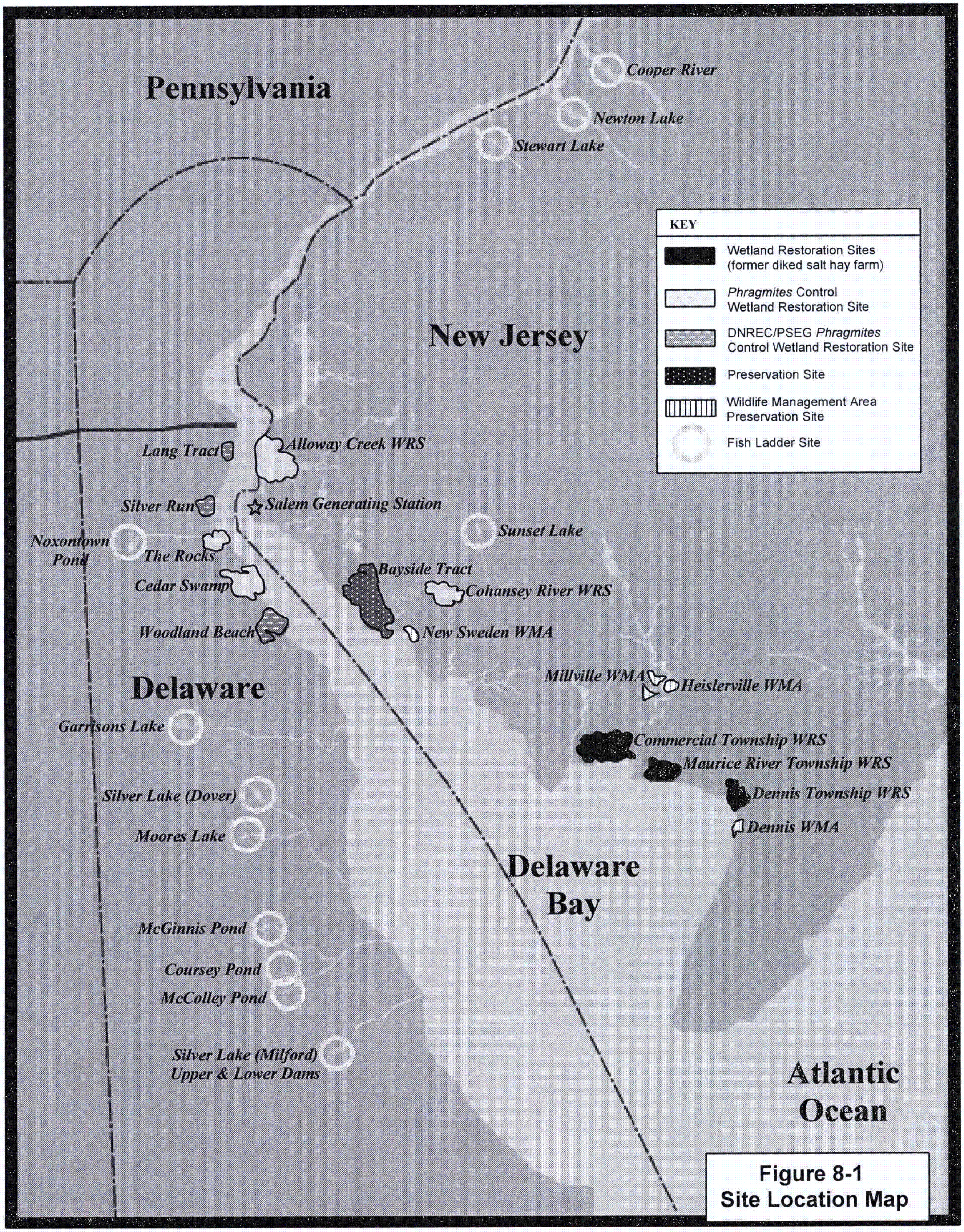
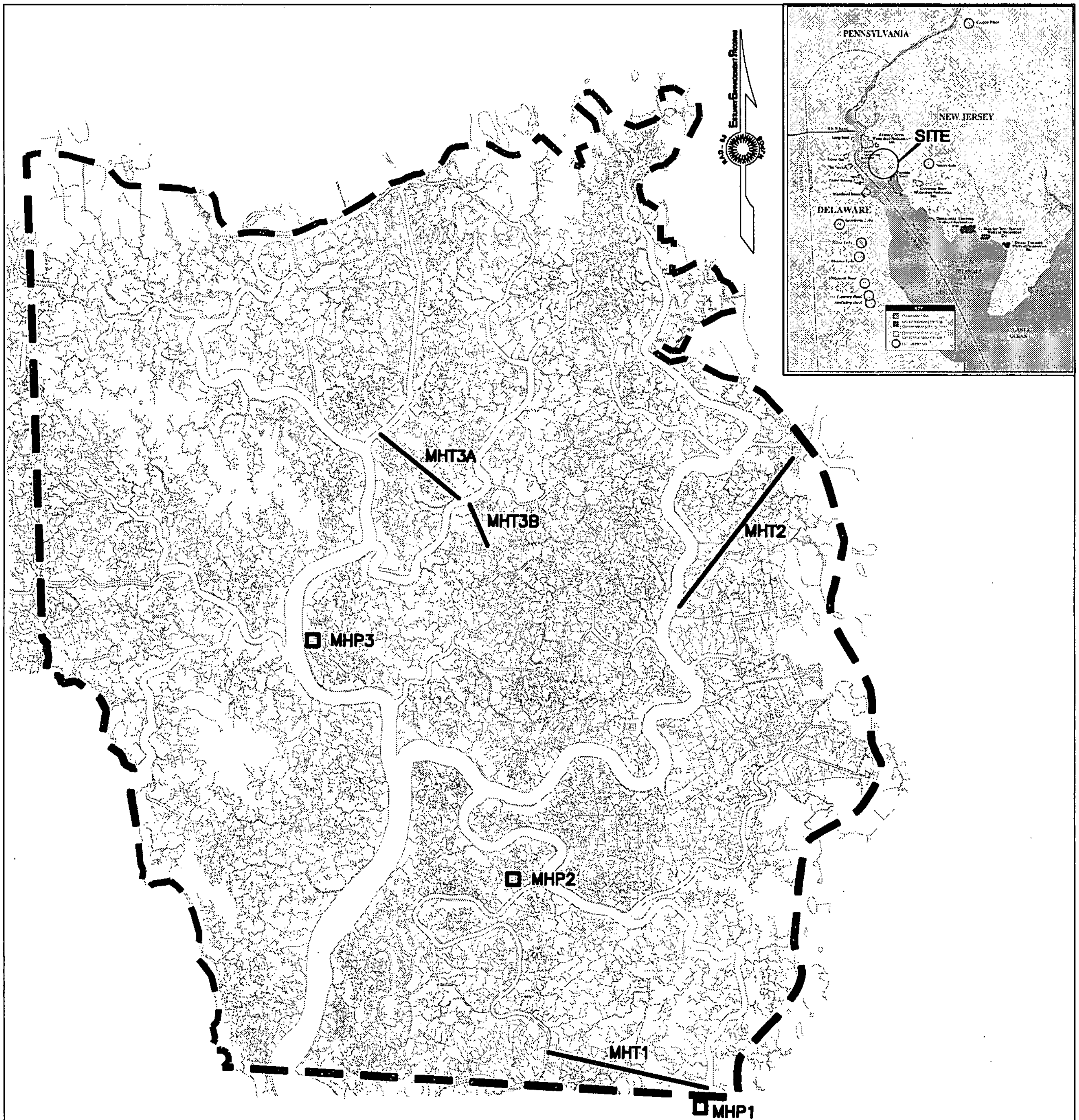


Figure 8-1
Site Location Map



NOTE:

MHT1	MAD HORSE CREEK VEGETATION TRANSECT 1
MHT2	MAD HORSE CREEK VEGETATION TRANSECT 2
MHT3	MAD HORSE CREEK VEGETATION TRANSECT 3
MHP1	MAD HORSE CREEK VEGETATION PLOT 1
MHP2	MAD HORSE CREEK VEGETATION PLOT 2
MHP3	MAD HORSE CREEK VEGETATION PLOT 3

LEGEND

- SITE BOUNDARY
- EXISTING SURFACE WATER FEATURE
- TRANSECT
- 60m x 60m PLOT

FEET 0 1200 2400 3600
METERS 0 600 1200

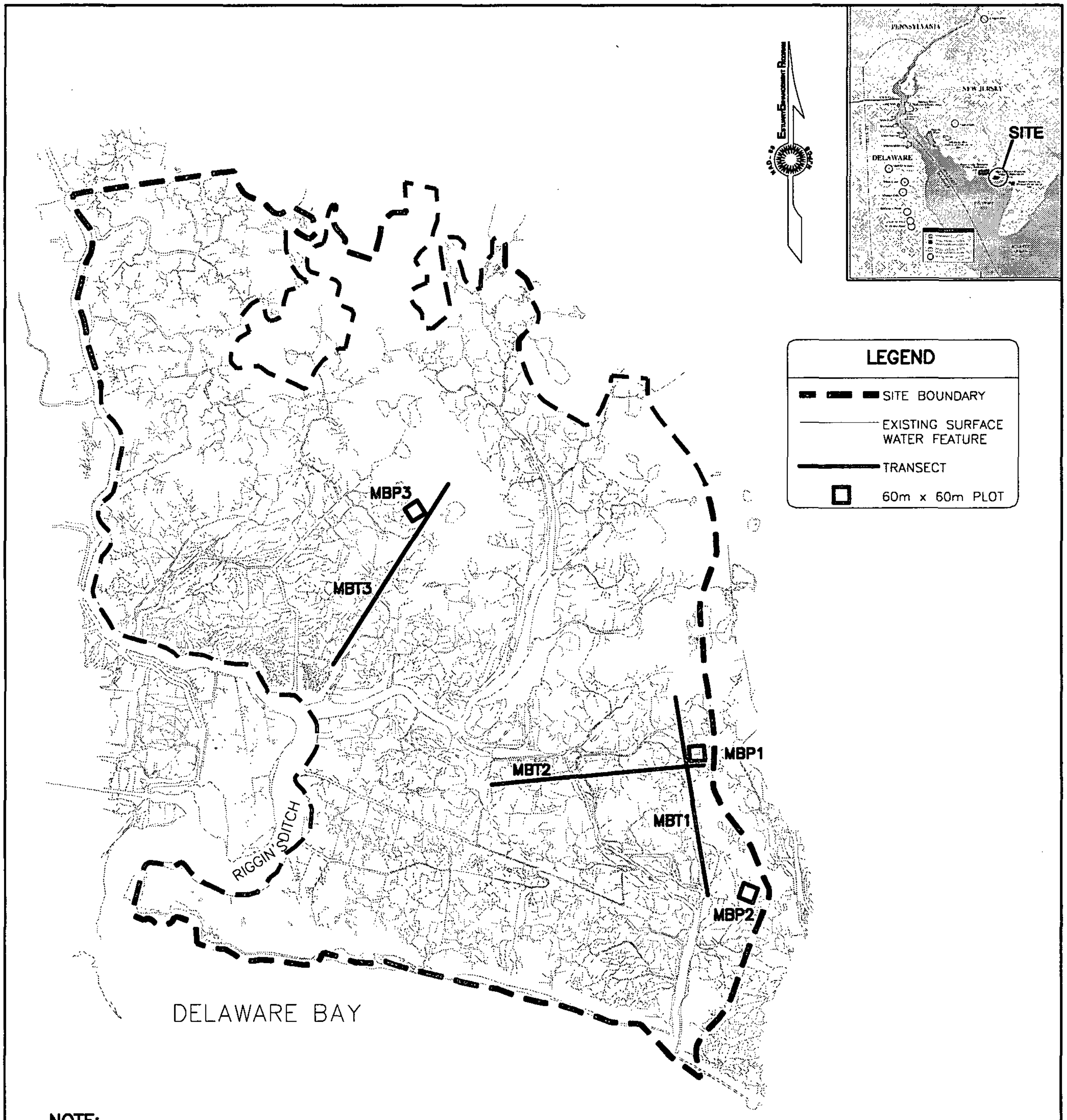
URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure 8-2

MADHORSE CREEK REFERENCE MARSH
2008 VEGETATION MONITORING
TRANSECTS AND PLOTS
LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08_MH_TRA CHECKED RLH EXAMINED RLH



NOTE:

MBT1 MOORES BEACH VEGETATION TRANSECT 1
MBT2 MOORES BEACH VEGETATION TRANSECT 2
MBT3 MOORES BEACH VEGETATION TRANSECT 3
MBP1 MOORES BEACH VEGETATION PLOT 1
MBP2 MOORES BEACH VEGETATION PLOT 2
MBP3 MOORES BEACH VEGETATION PLOT 3

FEET 0 900 1800 2700
METERS 0 400 800

URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure 8-3

MOORES BEACH REFERENCE MARSH

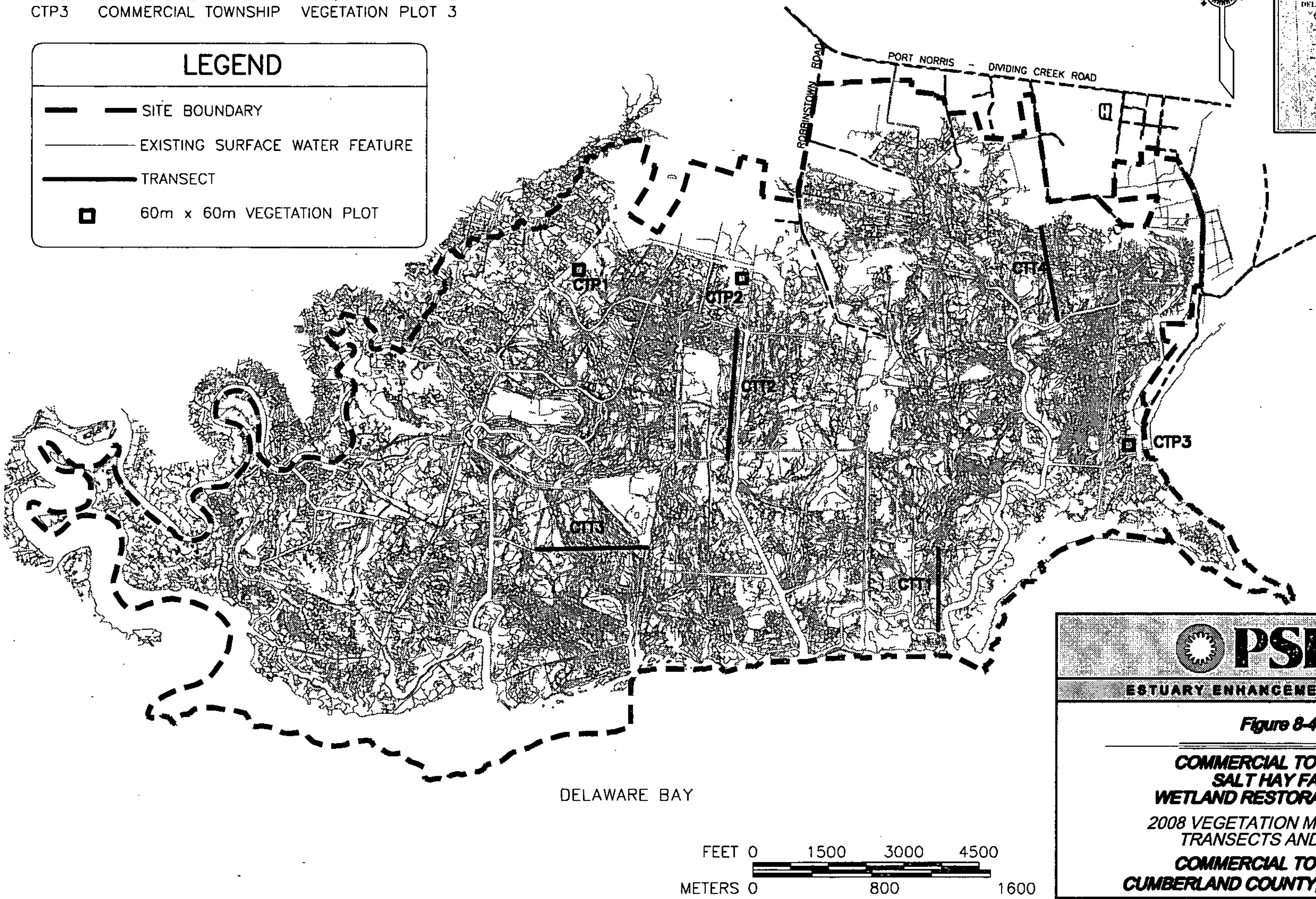
2008 VEGETATION MONITORING TRANSECTS AND PLOTS

MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08_MB_TRA CHECKED RLH EXAMINED RLH

NOTE:

CTT1 COMMERCIAL TOWNSHIP VEGETATION TRANSECT 1
CTT2 COMMERCIAL TOWNSHIP VEGETATION TRANSECT 2
CTT3 COMMERCIAL TOWNSHIP VEGETATION TRANSECT 3
CTT4 COMMERCIAL TOWNSHIP VEGETATION TRANSECT 4
CTP1 COMMERCIAL TOWNSHIP VEGETATION PLOT 1
CTP2 COMMERCIAL TOWNSHIP VEGETATION PLOT 2
CTP3 COMMERCIAL TOWNSHIP VEGETATION PLOT 3



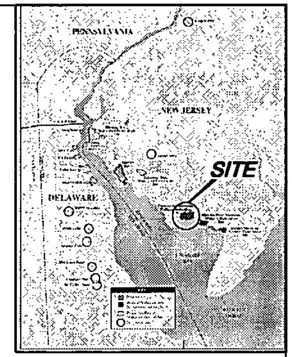


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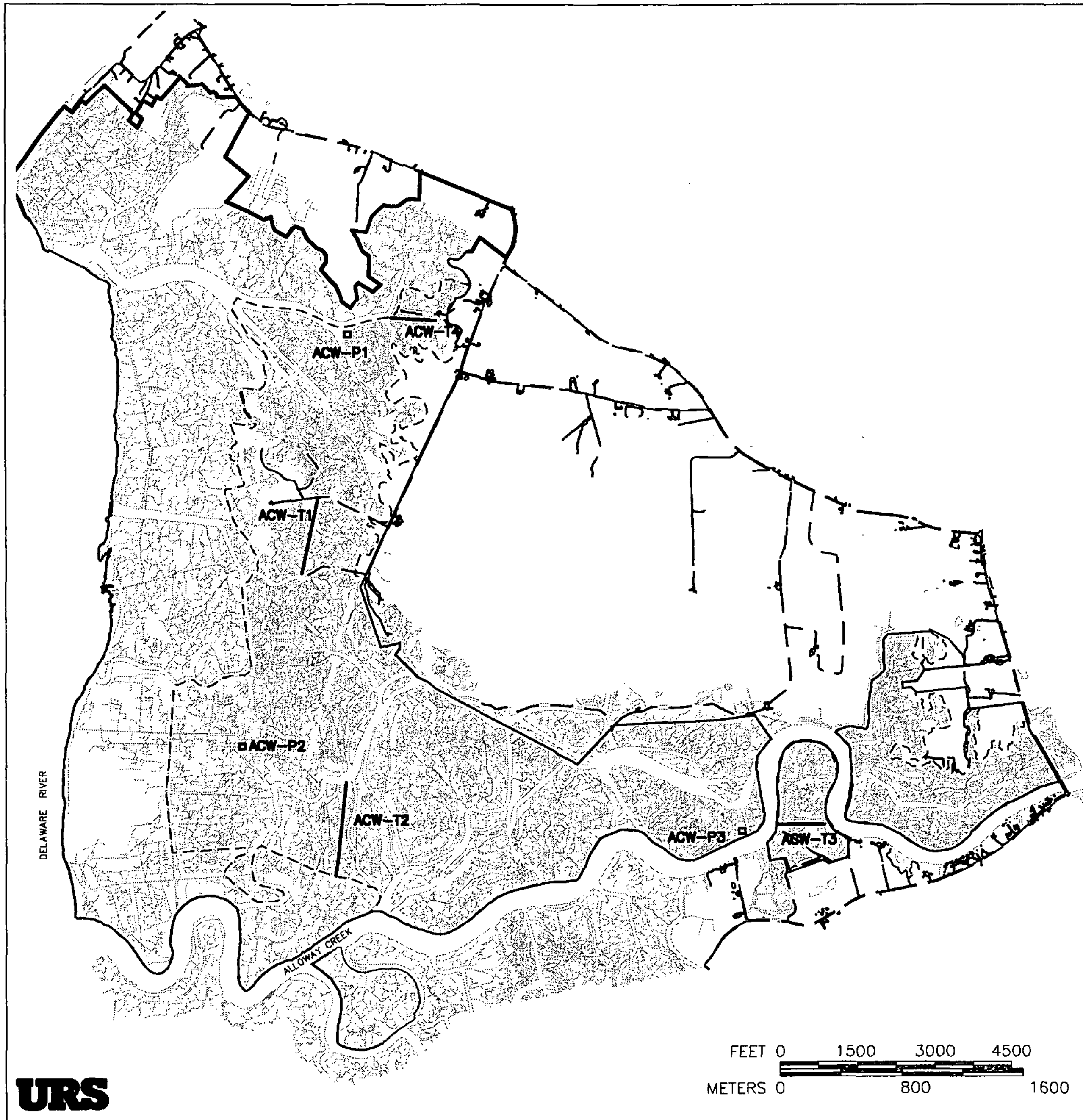
Figure 8-4

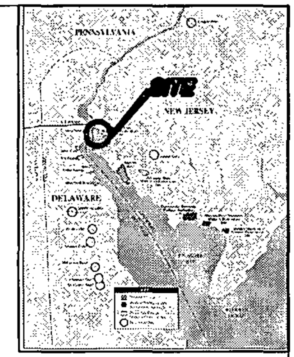
COMMERCIAL TOWNSHIP SALT HAY FARM WETLAND RESTORATION SITE

2008 VEGETATION MONITORING TRANSECTS AND PLOTS

COMMERCIAL TOWNSHIP CUMBERLAND COUNTY, NEW JERSEY

CADD	JL	DATE	APR 20, 2009	SCALE	AS SHOWN
FILE	08_CT_TRA	CHECKED	RLH	EXAMINED	RLH





LEGEND

- SITE BOUNDARY
- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS
- TRANSECT
- 60 x 60m PLOT

NOTE:

ACWT1 ALLOWAY CREEK WATERSHED TRANSECT 1
ACWT2 ALLOWAY CREEK WATERSHED TRANSECT 2
ACWT3 ALLOWAY CREEK WATERSHED TRANSECT 3
ACWT4 ALLOWAY CREEK WATERSHED TRANSECT 4
ACWP1 ALLOWAY CREEK WATERSHED VEGETATION PLOT 1
ACWP2 ALLOWAY CREEK WATERSHED VEGETATION PLOT 2
ACWP3 ALLOWAY CREEK WATERSHED VEGETATION PLOT 3

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ESTUARY ENHANCEMENT PROGRAM

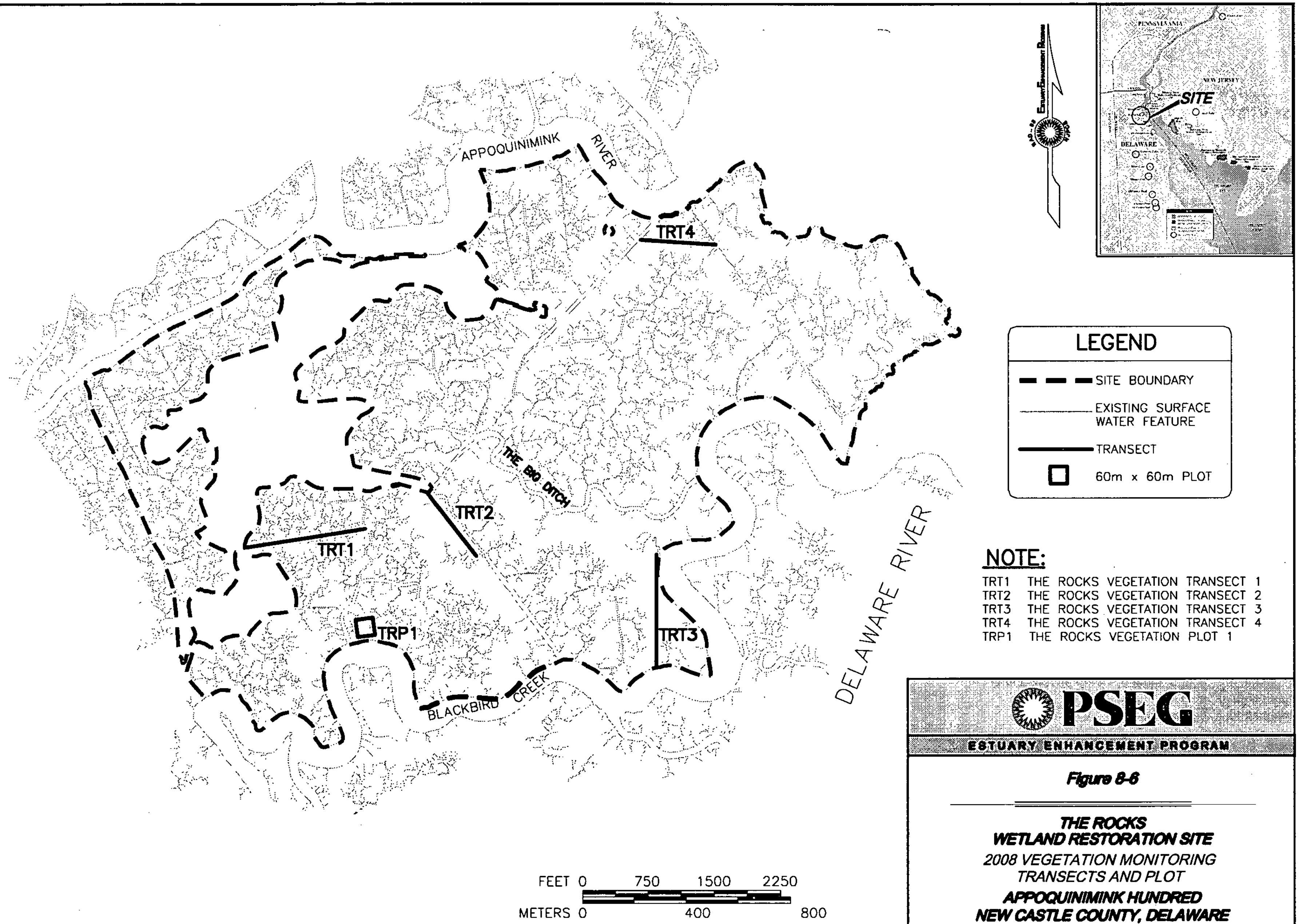
Figure 8-5

ALLOW CREEK SITE
WATERSHED WETLAND RESTORATION SITE

2008 VEGETATION MONITORING
TRANSECTS AND PLOTS

ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08 ACW TRA CHECKED RLH EXAMINED RLH



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ESTUARY ENHANCEMENT PROGRAM

Figure 8-6

THE ROCKS
WETLAND RESTORATION SITE
2008 VEGETATION MONITORING
TRANSECTS AND PLOT
APPOQUINIMINK HUNDRED
NEW CASTLE COUNTY, DELAWARE

CADD	JL	DATE	APR 20, 2009	SCALE	AS SHOWN
FILE	DB_TR_TRA	CHECKED	RLH	EXAMINED	RLH

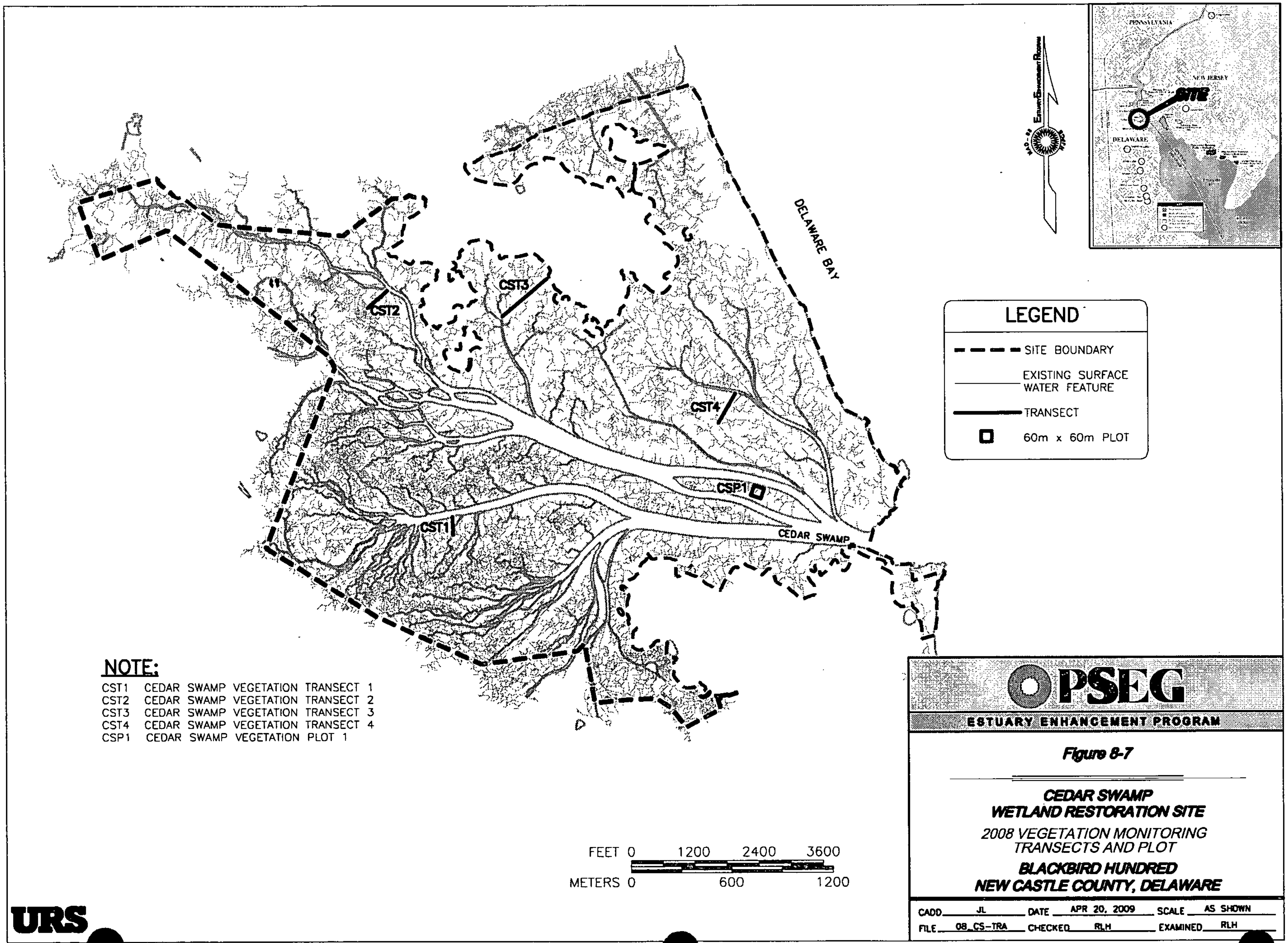


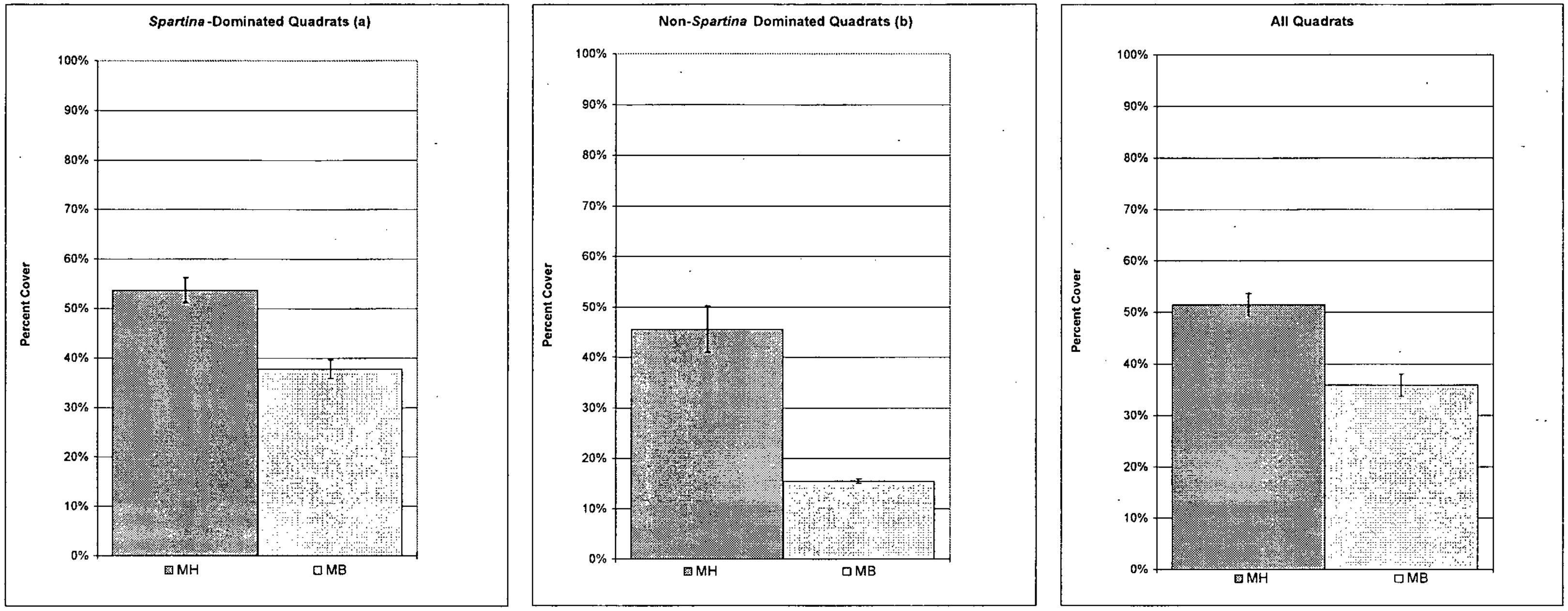
Figure 8-7

CEDAR SWAMP WETLAND RESTORATION SITE

2008 VEGETATION MONITORING TRANSECTS AND PLOT

BLACKBIRD HUNDRED NEW CASTLE COUNTY, DELAWARE

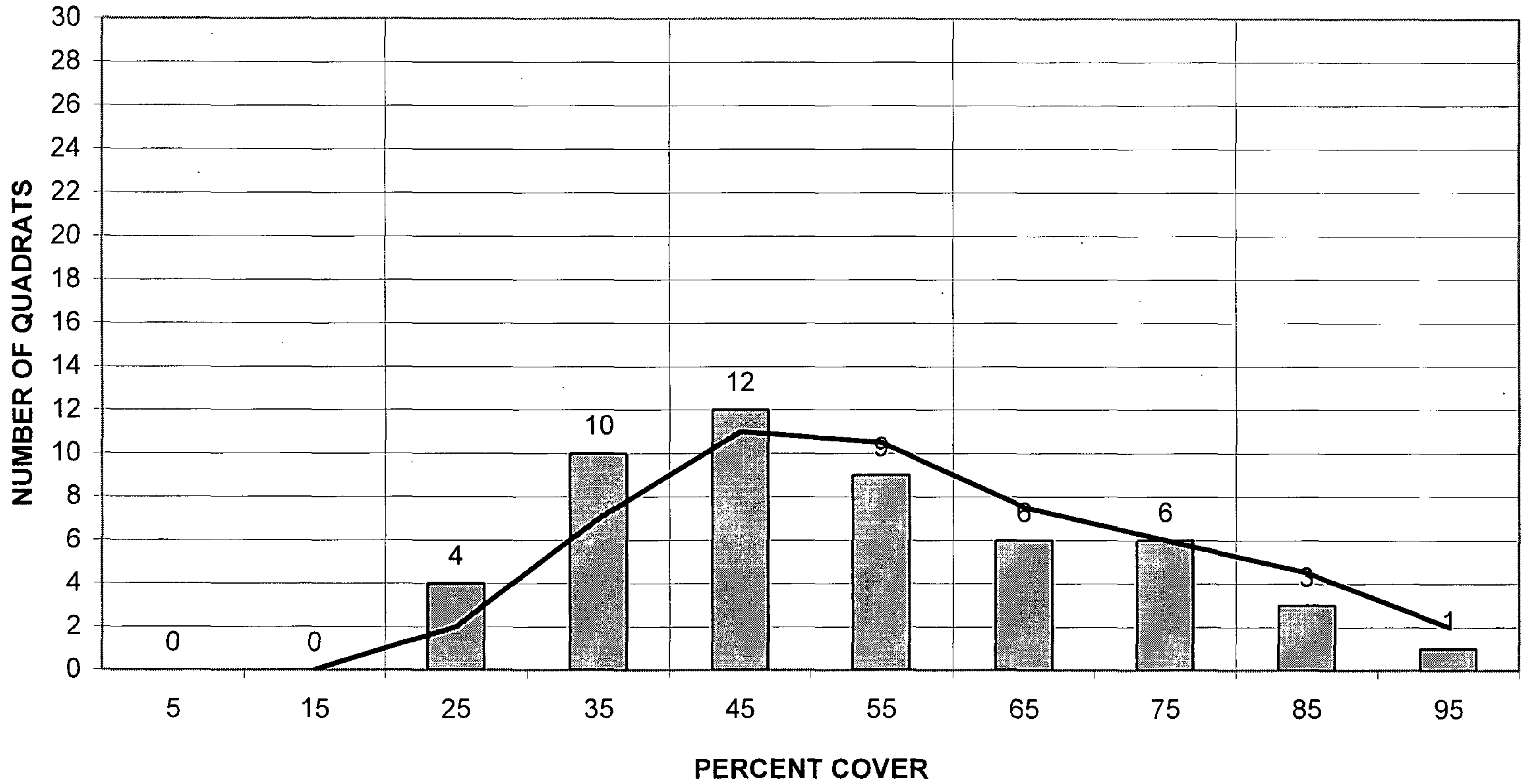
FIGURE 8-8
MEAN PERCENT COVER
2008 REFERENCE MARSH TRANSECT DATA



(a) Also includes *Spartina cynosuroides* dominated quadrats, when present.
(b) Includes quadrats dominated by *Spartina patens*, if present.
Error bar represents +/- one Standard Error of the Mean.

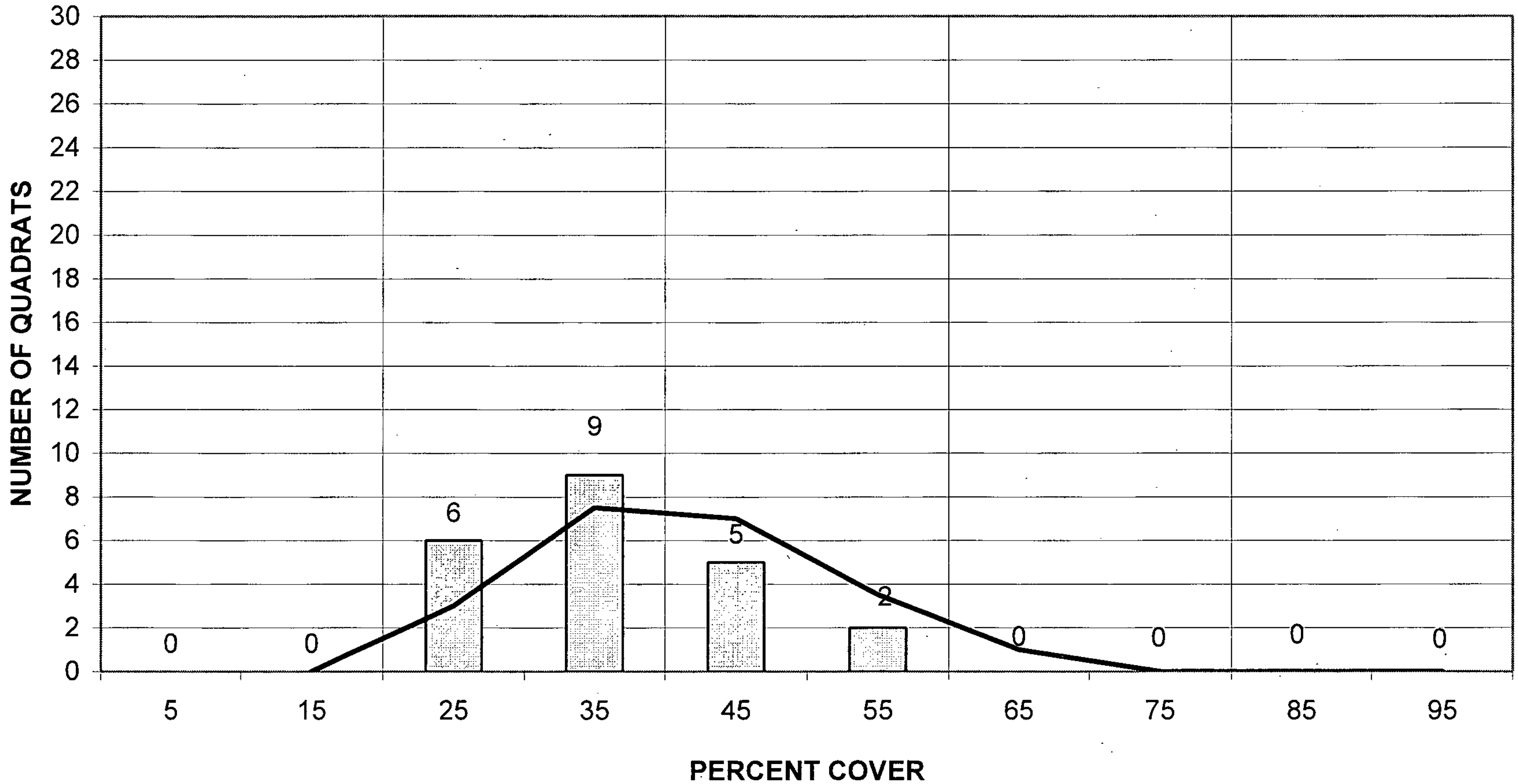
MH = Mad Horse Creek Reference Marsh
MB = Moores Beach West Reference Marsh

FIGURE 8-9
2008 PERCENT COVER GROUPINGS
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
MAD HORSE CREEK REFERENCE MARSH TRANSECTS



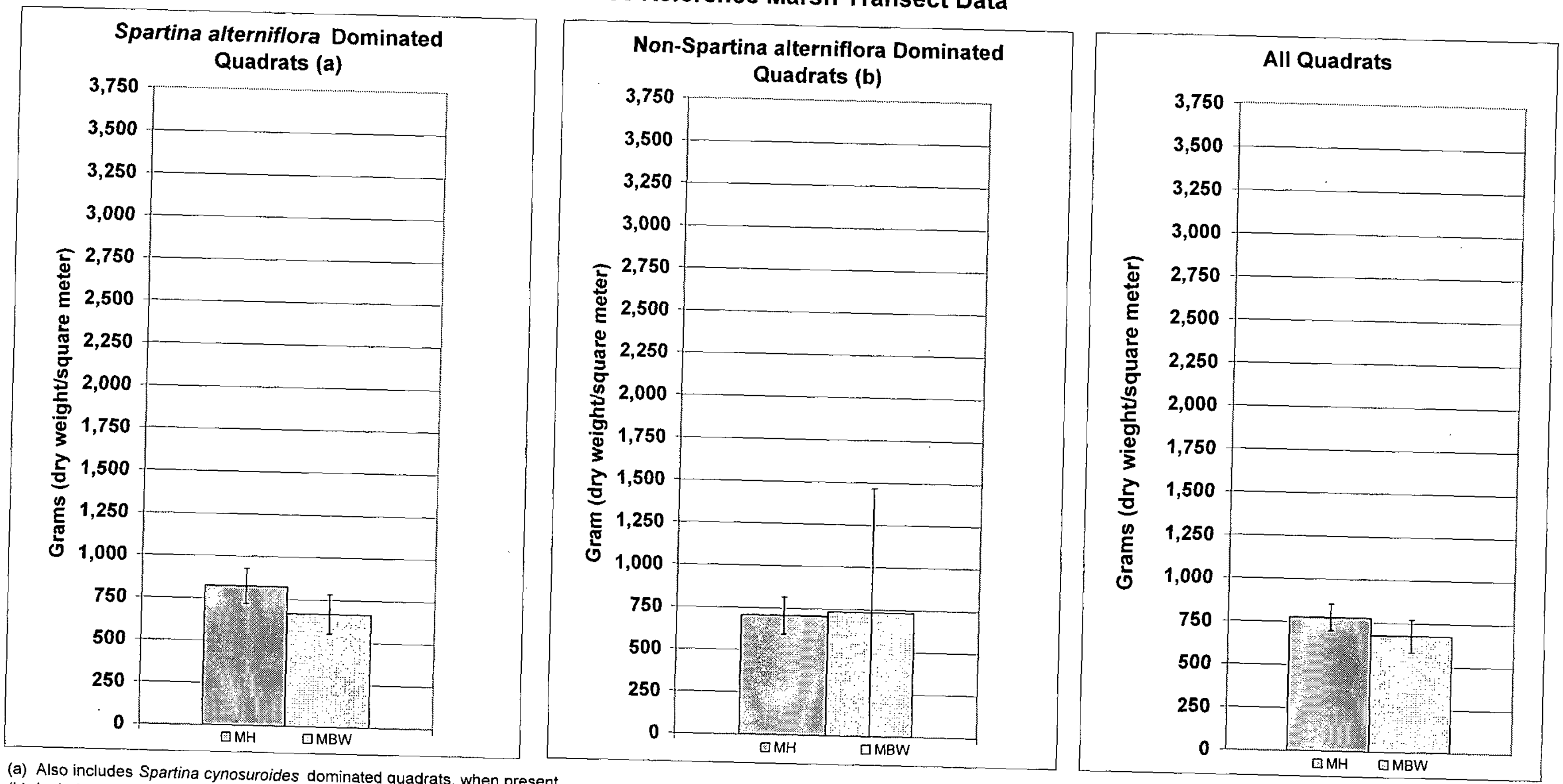
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-10
2008 PERCENT COVER GROUPINGS
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
MOORES BEACH WEST REFERENCE MARSH TRANSECTS



(a) Includes *S. cvnosuroides* dominated

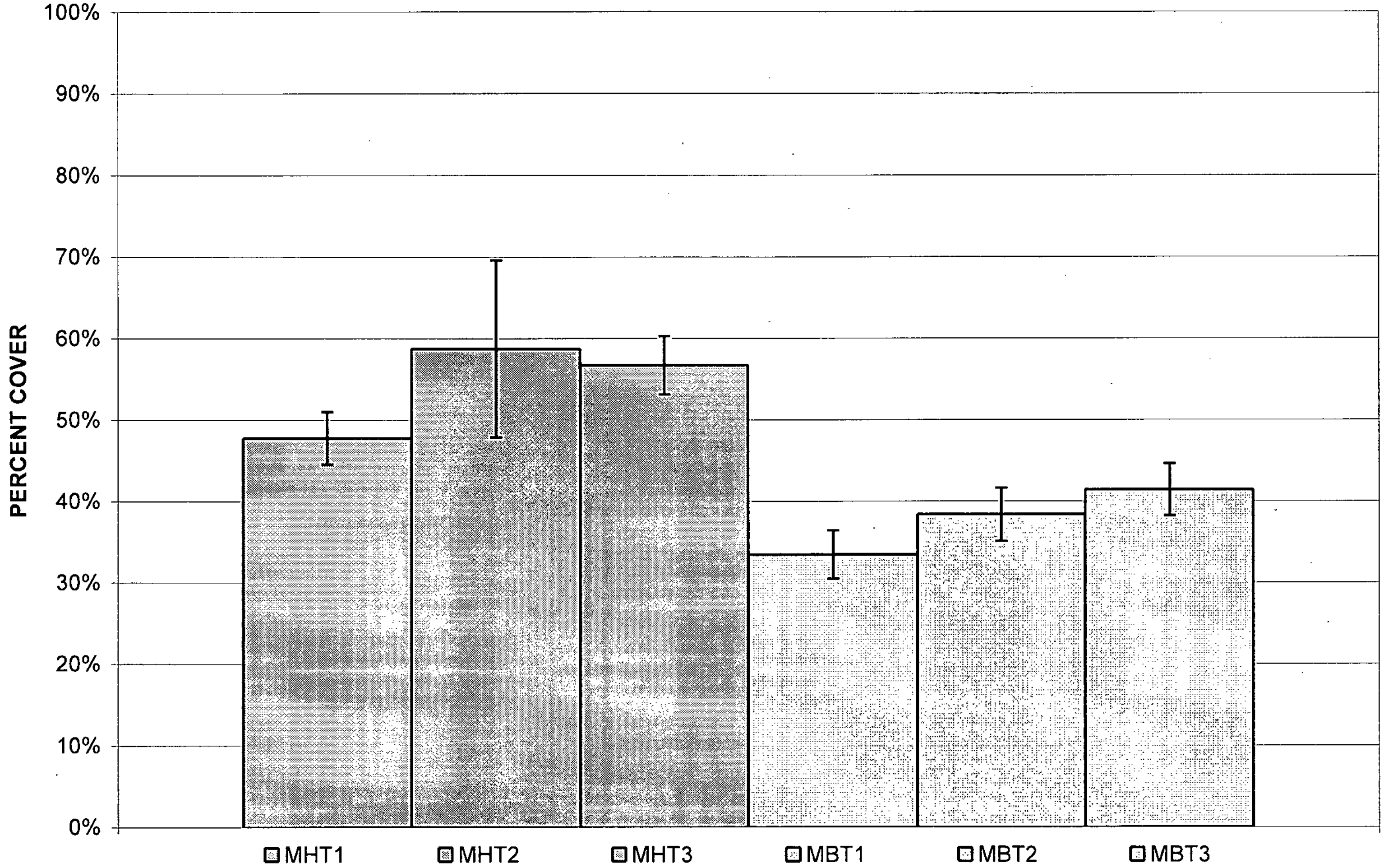
Figure 8-11
Mean Live Standing Crop
2008 Reference Marsh Transect Data



(a) Also includes *Spartina cynosuroides* dominated quadrats, when present.
(b) Includes quadrats dominated by *Spartina patens*, if present.
Error bar represents +/- one Standard Error of the Mean.

MH = Mad Horse Creek Reference Marsh
MBW = Moores Beach West Reference Marsh

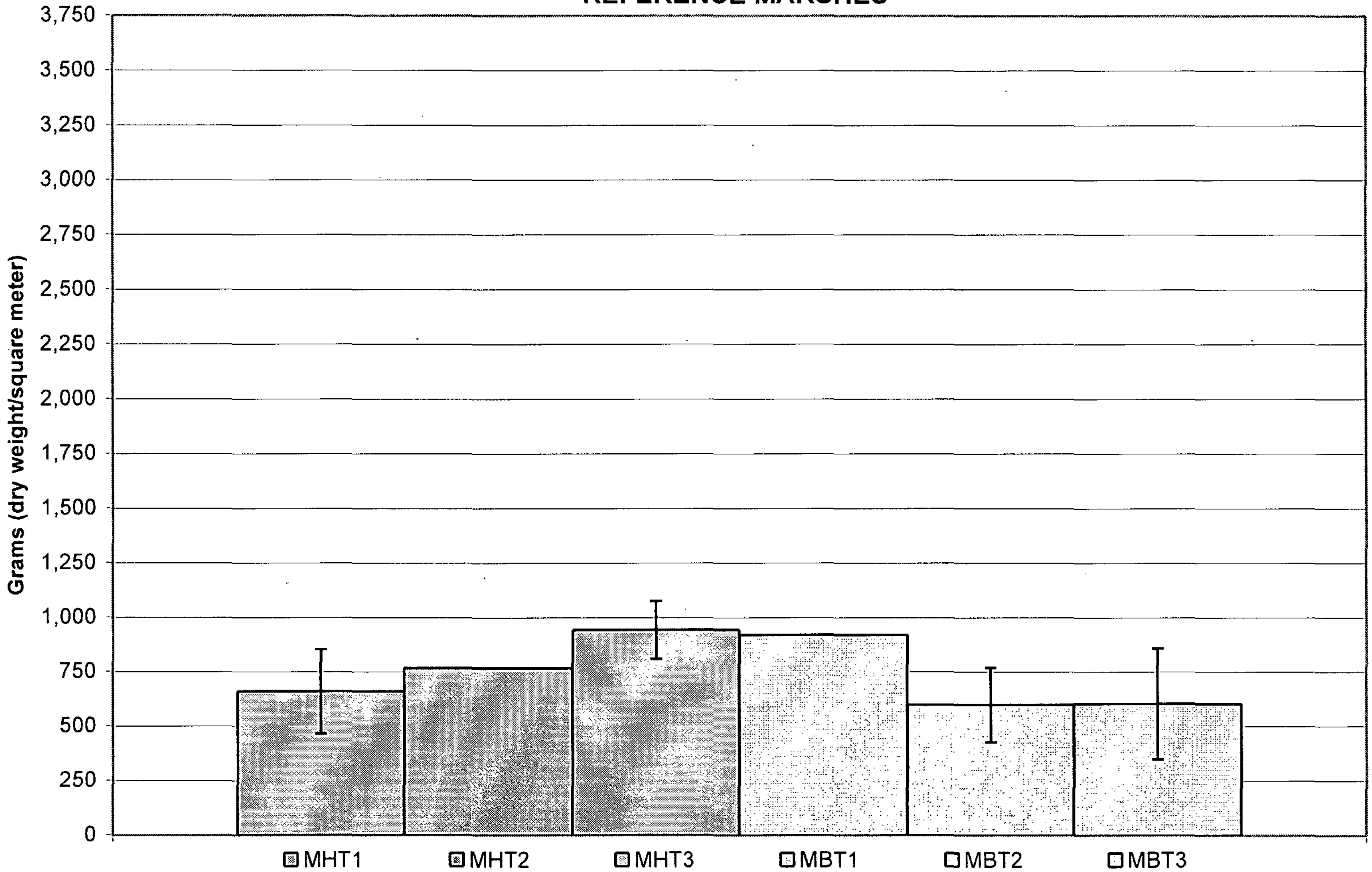
FIGURE 8-12
2008 MEAN PERCENT COVER by TRANSECT
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
REFERENCE MARSHES



(a) Includes *S. cynosuroides* dominated quadrats.
Error bar represents +/- one Standard Error of the Mean.

MH = Mad Horse
MB = Moores Beach West
T1 = Transect 1

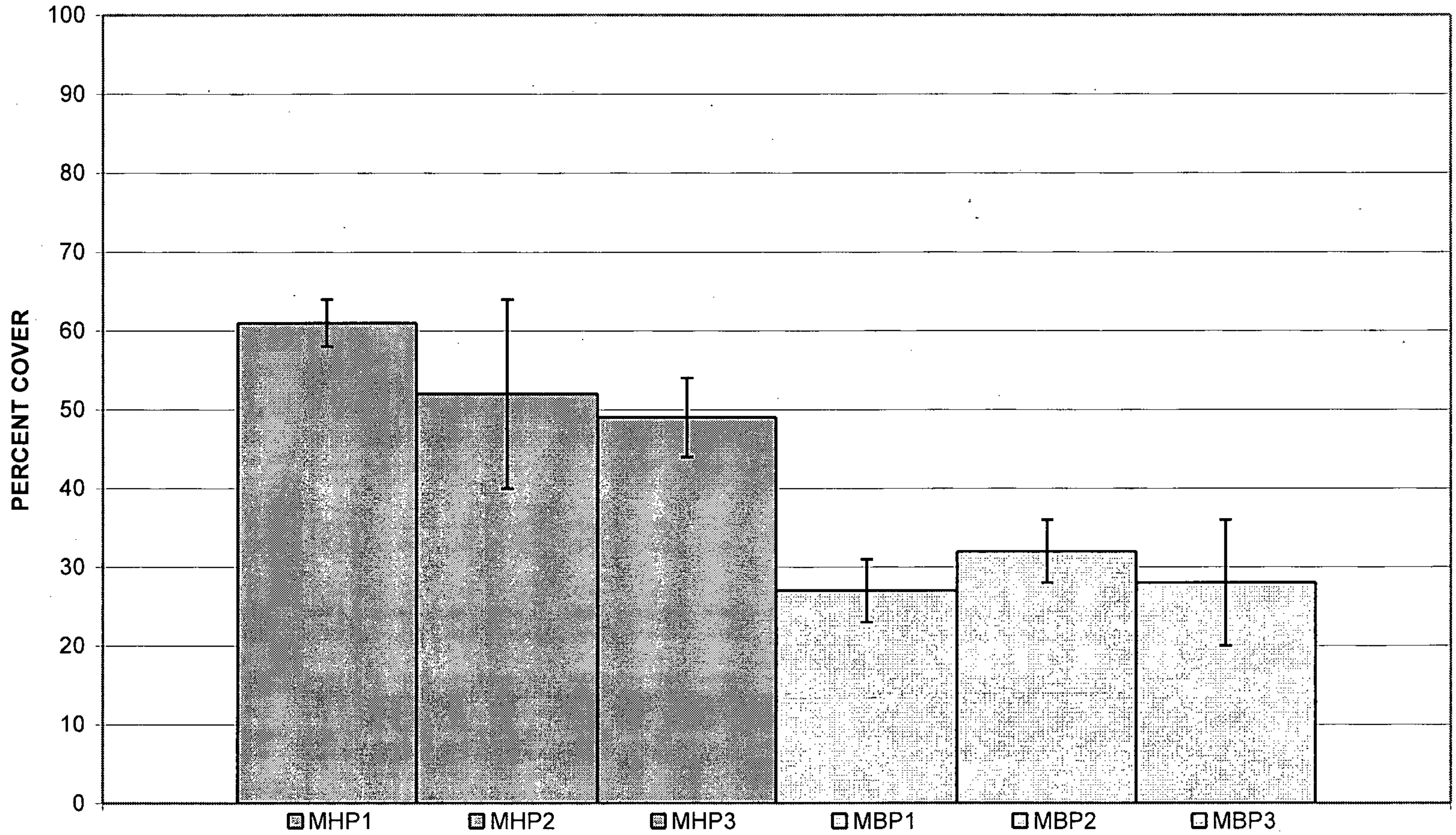
FIGURE 8-13
2008 MEAN LIVE STANDING CROP by TRANSECT
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
REFERENCE MARSHES



(a) Includes *S. cynosuroides* dominated quadrats.
Error bar represents +/- one Standard Error of the Mean.

MH = Mad Horse
MB = Moores Beach West
T1 = Transect 1

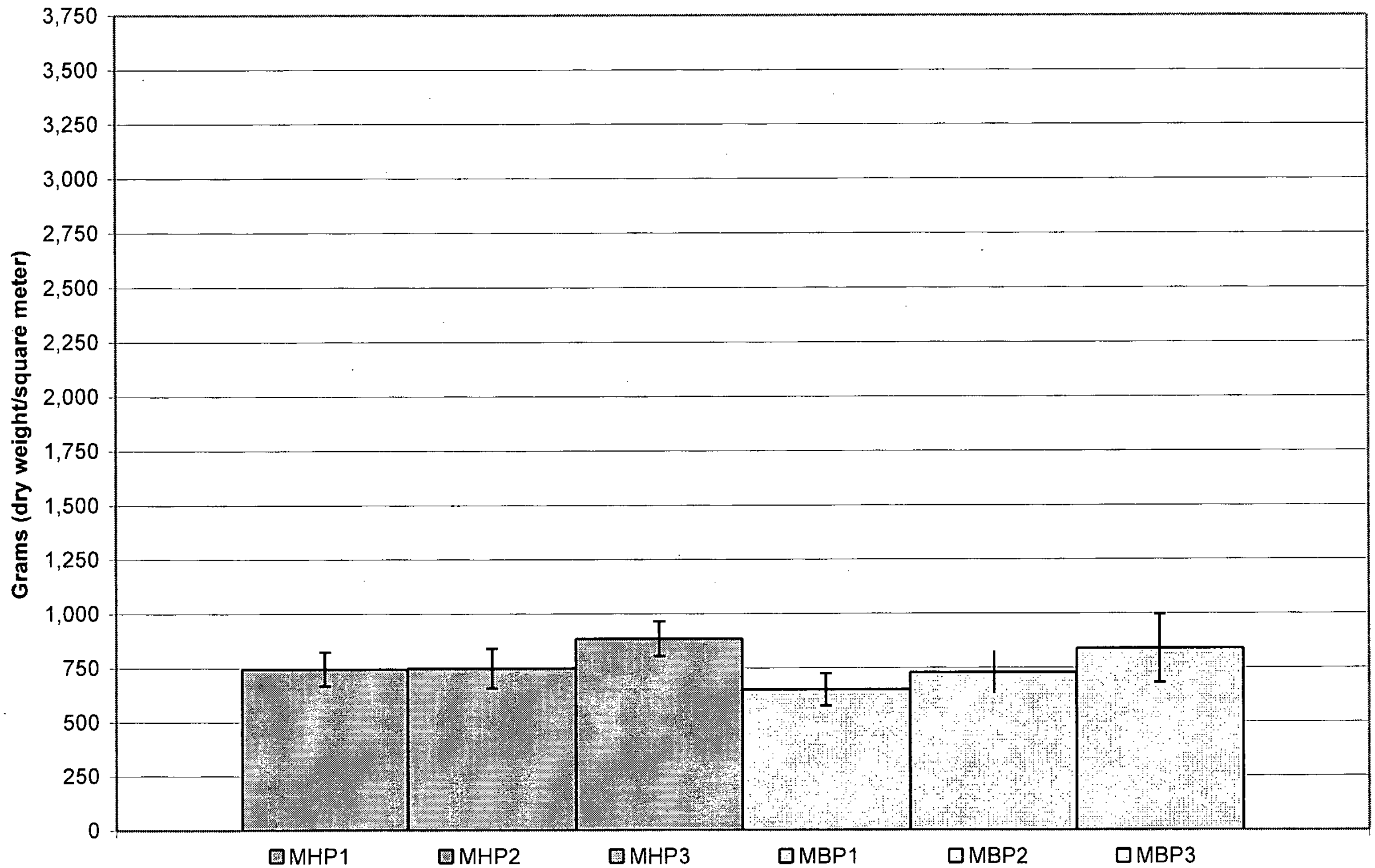
FIGURE 8-14
2008 MEAN PERCENT COVER 60x60 METER PLOTS
REFERENCE MARSHES



MH = Mad Horse
MB = Moores Beach West
P1 = Plot 1

Error bar represents +/- one Standard Error of the Mean.

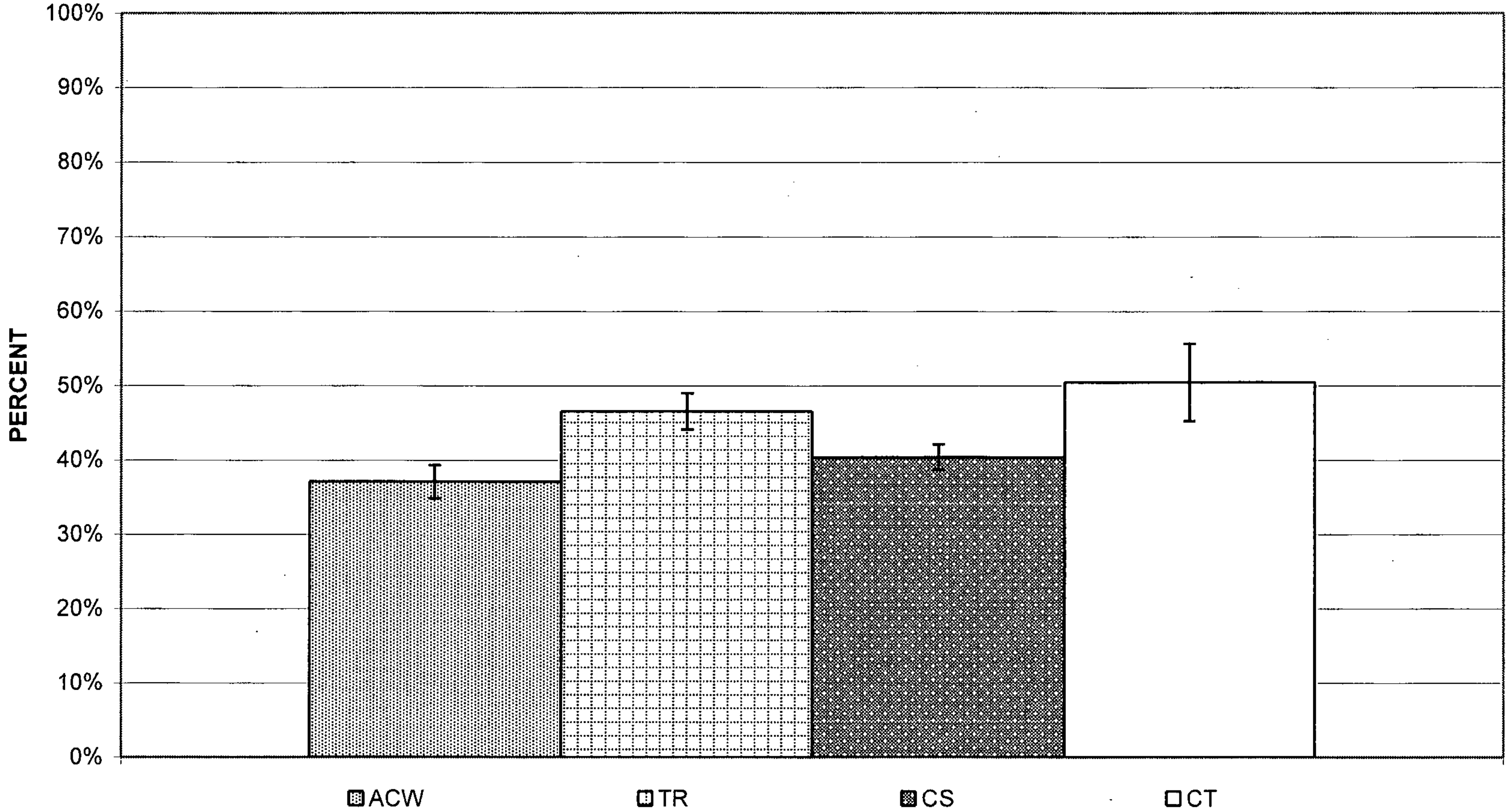
FIGURE 8-15
2008 MEAN LIVE STANDING CROP 60x60 METER PLOTS
REFERENCE MARSHES



Error bar represents +/- one Standard Error of the Mean.

MH = Mad Horse
MB = Moores Beach West
P1 = Plot 1

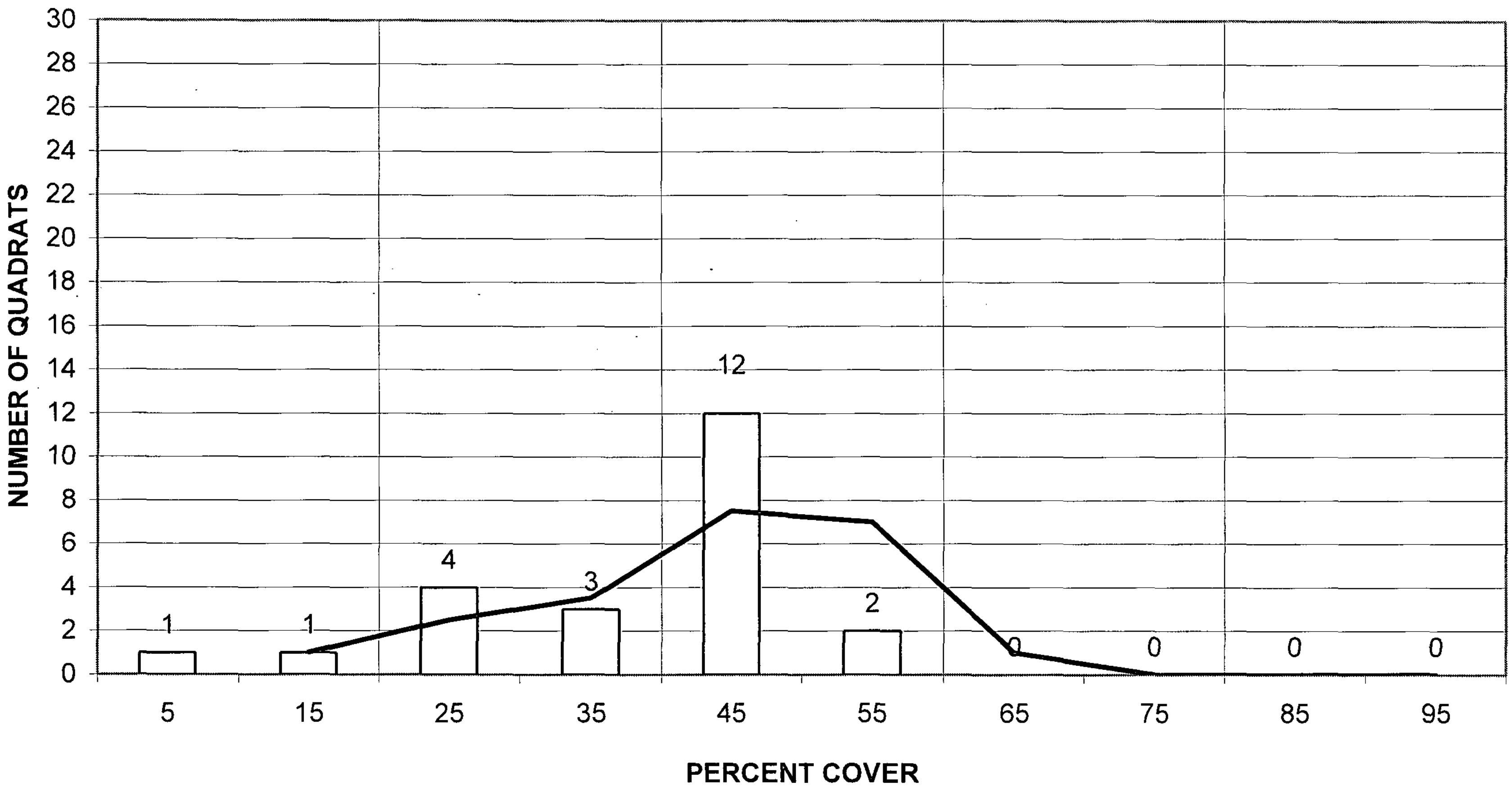
FIGURE 8-16
MEAN PERCENT COVER
2008 RESTORATION SITE TRANSECT DATA



- Error bar represents +/- one Standard Error of the Mean.

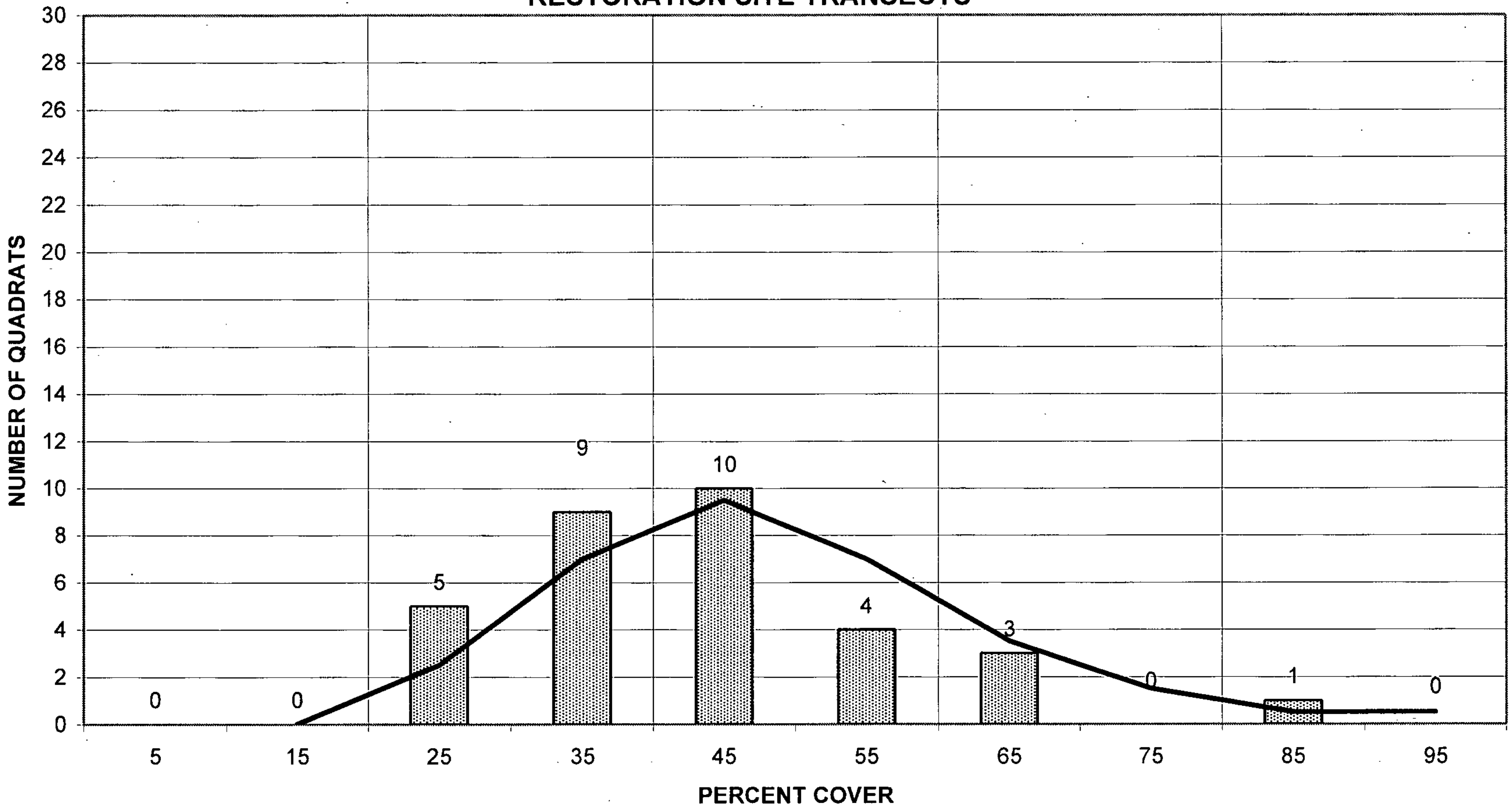
CT = Commercial Township Site
TR = The Rocks
CS = Cedar Swamp
ACW = Alloway Creek Site

FIGURE 8-17
2008 PERCENT COVER GROUPINGS
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
COMMERCIAL TOWNSHIP SALT HAY FARM WETLAND RESTORATION SITE TRANSECTS



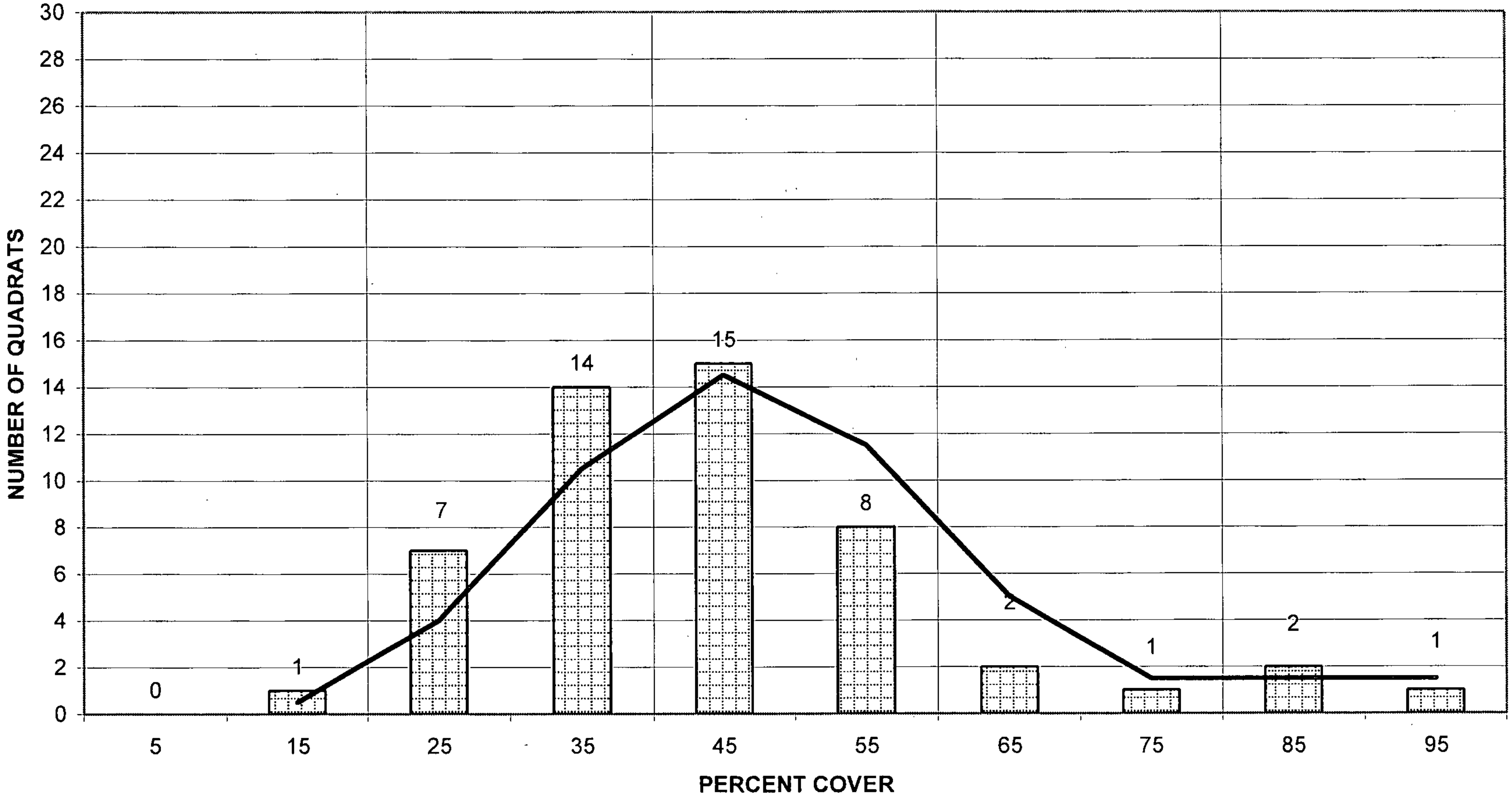
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-18
2008 PERCENT COVER GROUPINGS
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
ALLOWAY CREEK WATERSHED PHRAGMITES DOMINATED WETLAND
RESTORATION SITE TRANSECTS



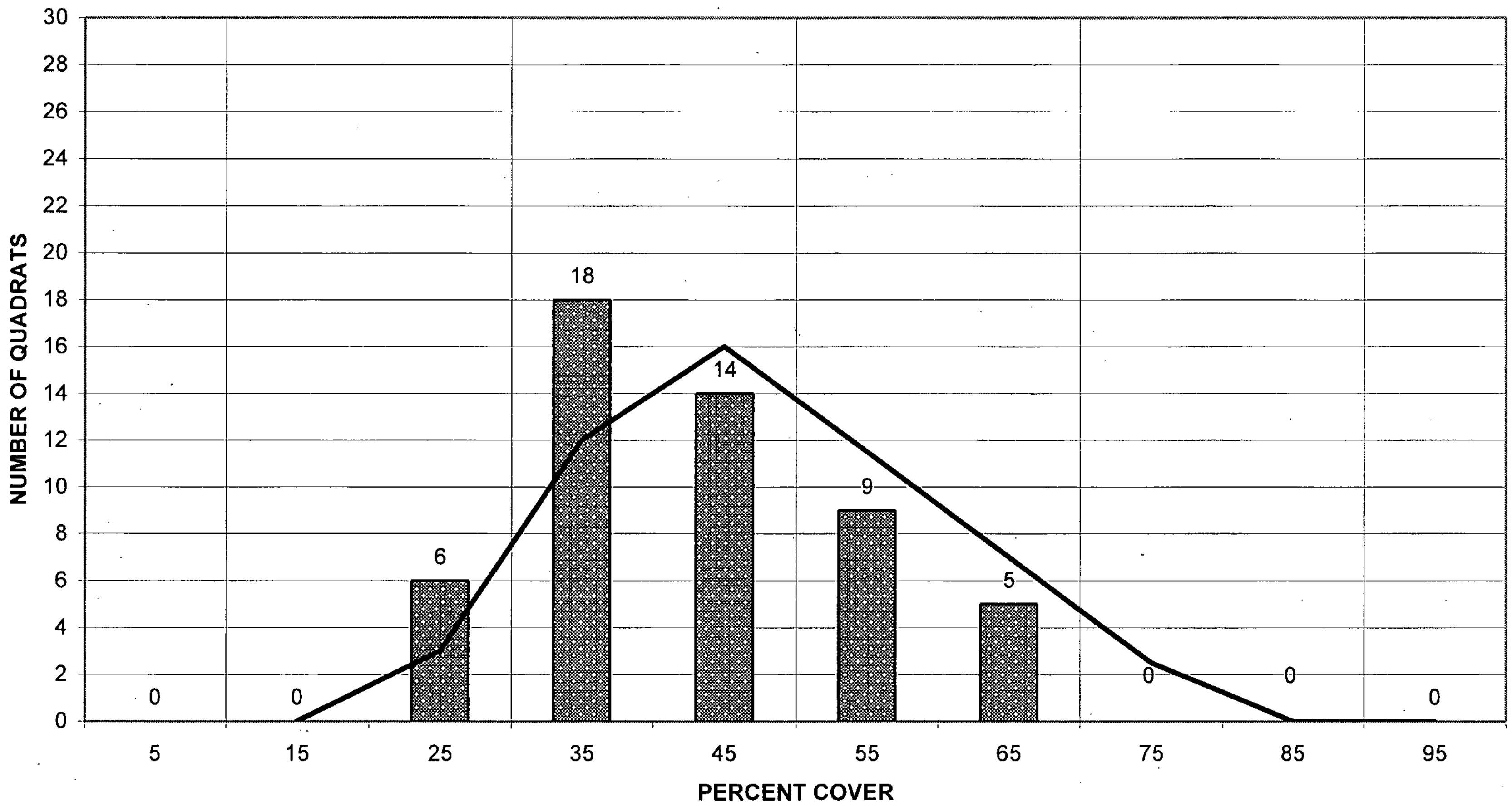
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-19
2008 PERCENT COVER GROUPINGS
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
THE ROCKS PHRAGMITES DOMINATED WETLAND RESTORATION SITE TRANSECTS



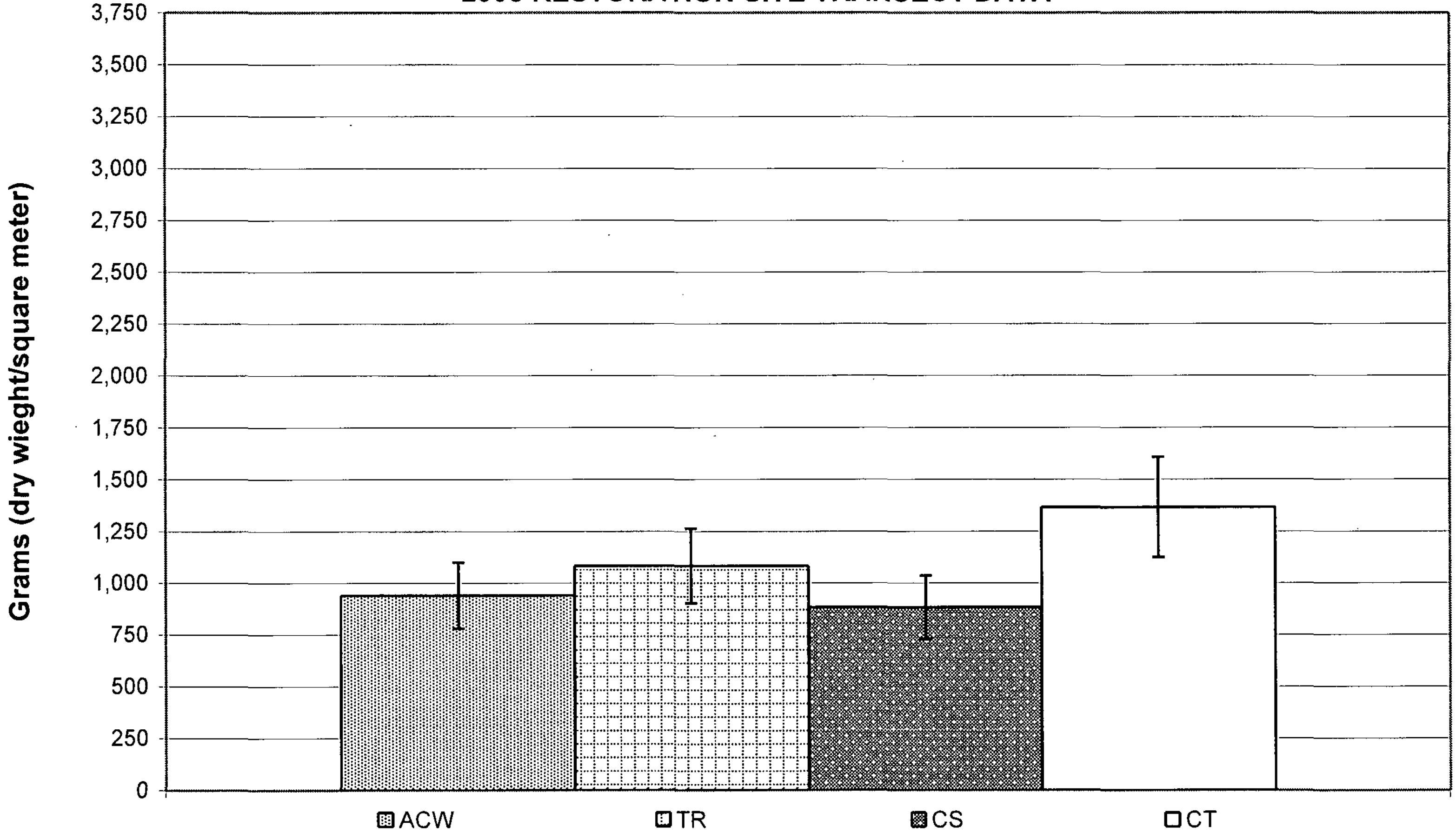
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-20
2008 PERCENT COVER GROUPINGS
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
CEDAR SWAMP PHRAGMITES DOMINATED WETLAND RESTORATION SITE TRANSECTS



(a) Includes *S. cynosuroides* dominated quadrats, when present.

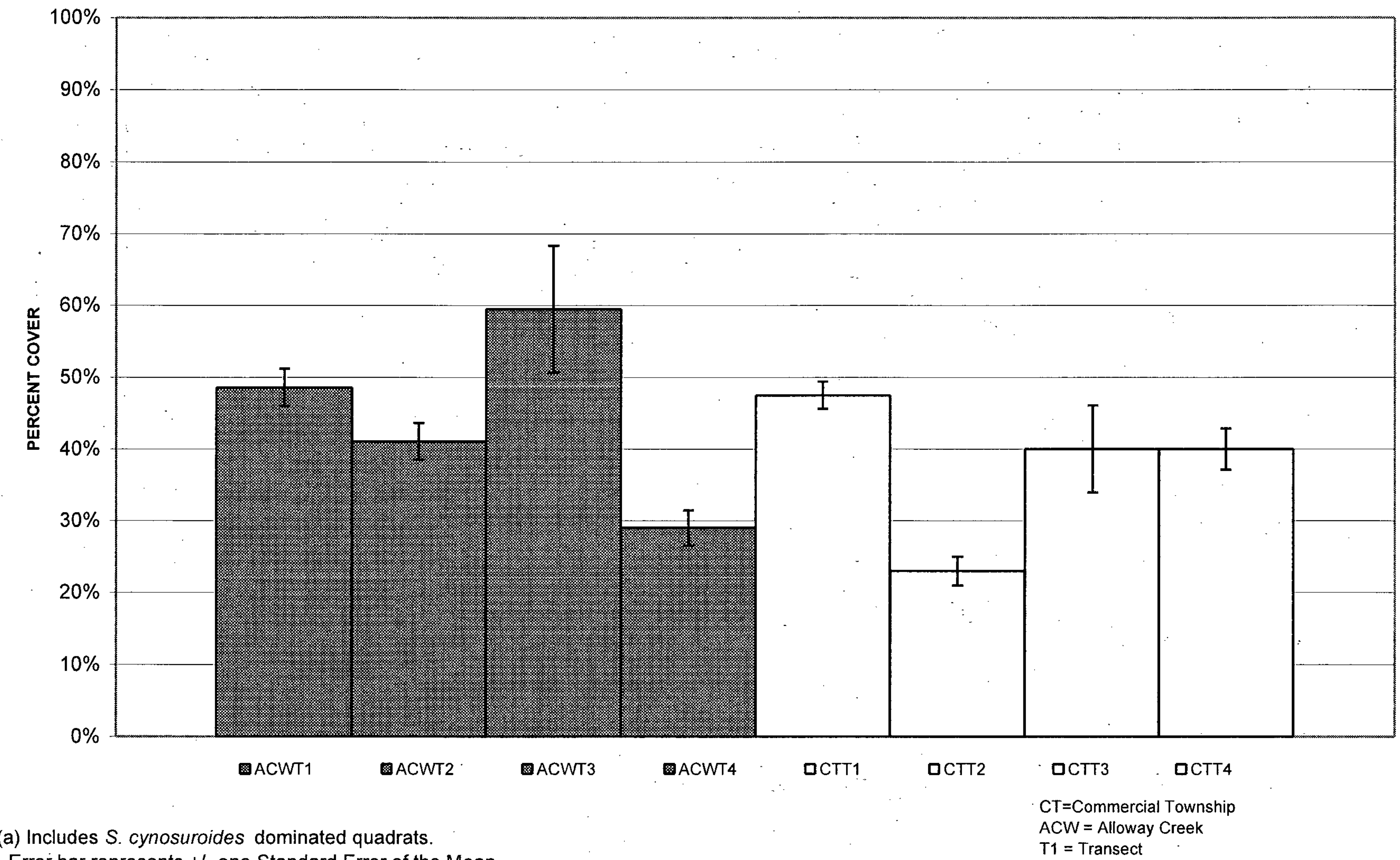
FIGURE 8-21
MEAN LIVE STANDING CROP
2008 RESTORATION SITE TRANSECT DATA



CT = Commercial Township Site
TR = The Rocks
CS = Cedar Swamp
ACW = Alloway Creek Site

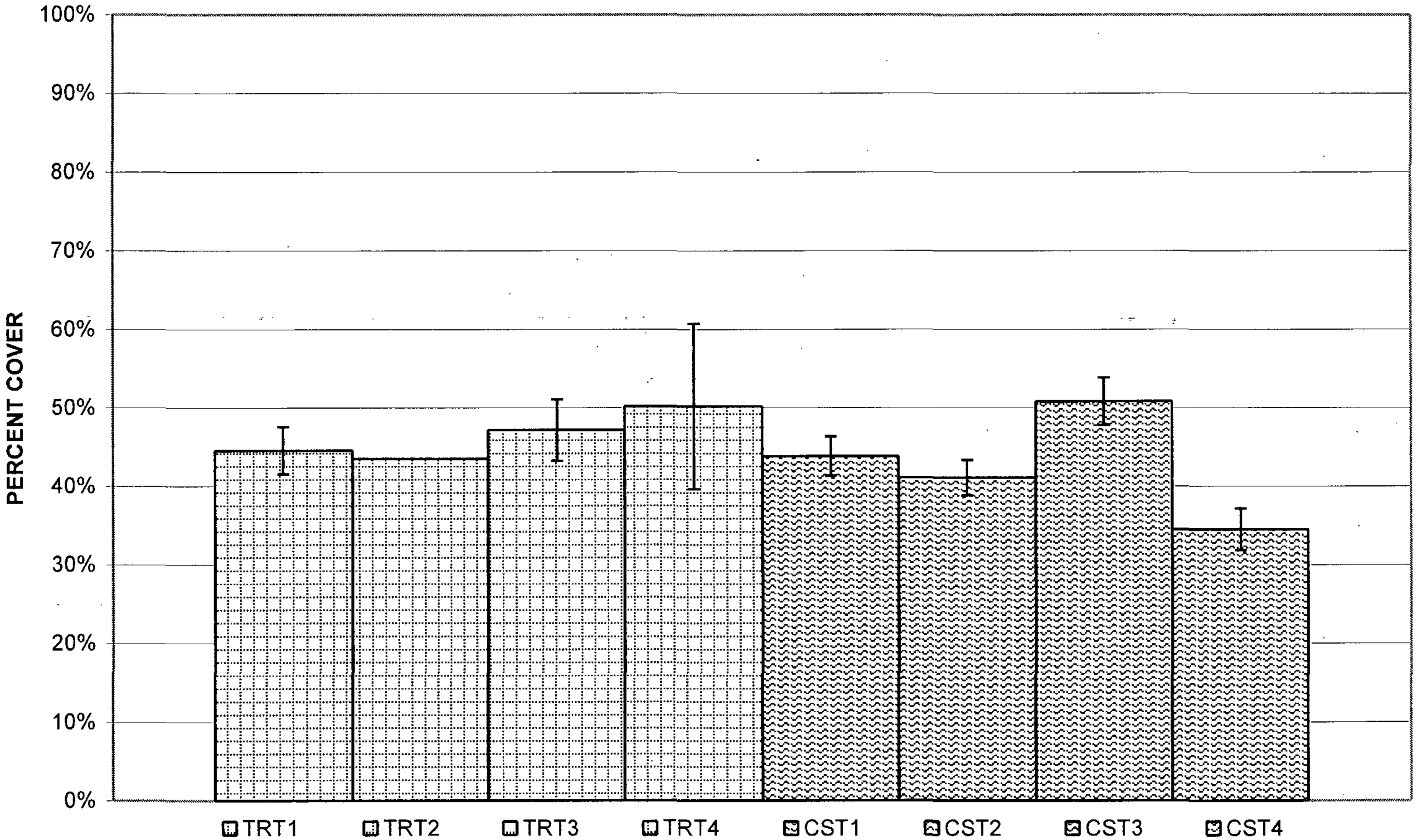
- Error bar represents +/- one Standard Error of the Mean.

FIGURE 8-22
2008 MEAN PERCENT COVER by TRANSECT
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
NEW JERSEY WETLAND RESTORATION SITES



(a) Includes *S. cynosuroides* dominated quadrats.
- Error bar represents +/- one Standard Error of the Mean.

FIGURE 8-23
2008 MEAN PERCENT COVER by TRANSECT
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
DELAWARE WETLAND RESTORATION SITES

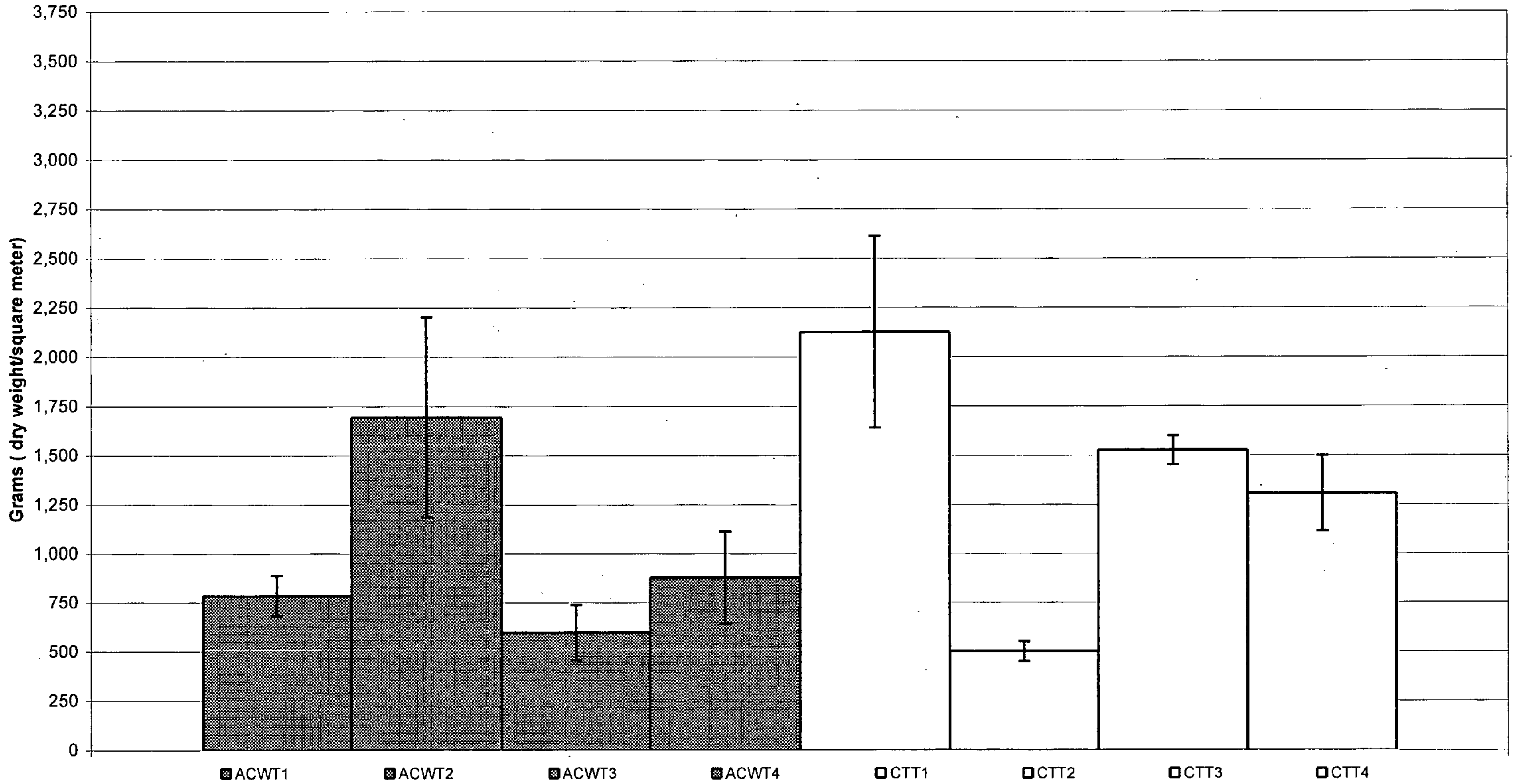


(a) Includes S. cynosuroides dominated quadrats.
Error bar represents +/- one Standard Error of the Mean.

TR = The Rocks
CS = Cedar Swamp

T1 =Transect 1

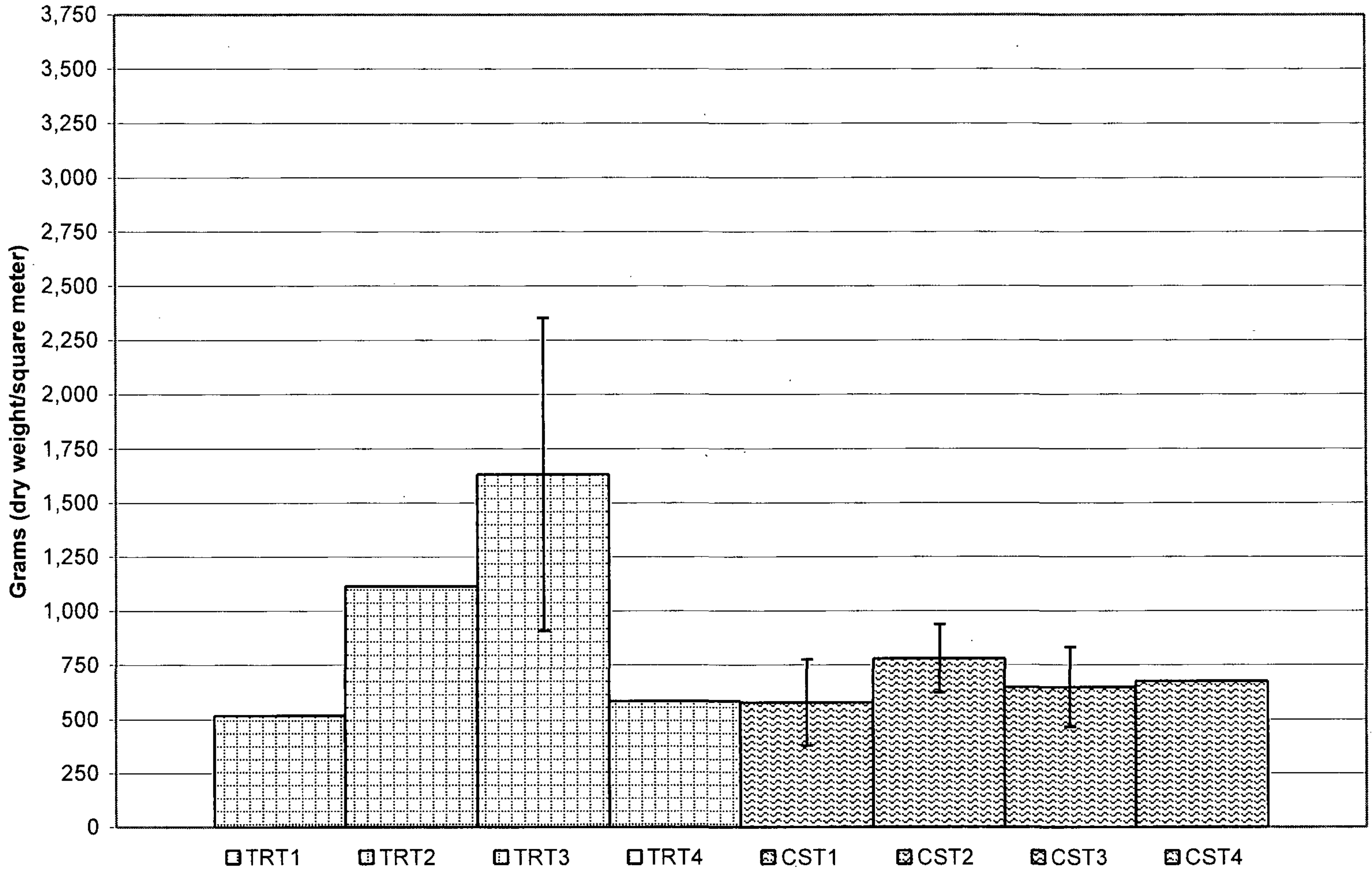
FIGURE 8-24
2008 MEAN LIVE STANDING CROP by TRANSECT
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
NEW JERSEY WETLAND RESTORATION SITES



CT=Commercial Township
ACW = Alloway Creek
T1 = Transect

(a) Includes *S. cynosuroides* dominated quadrats.
Error bar represents +/- one Standard Error of the Mean.

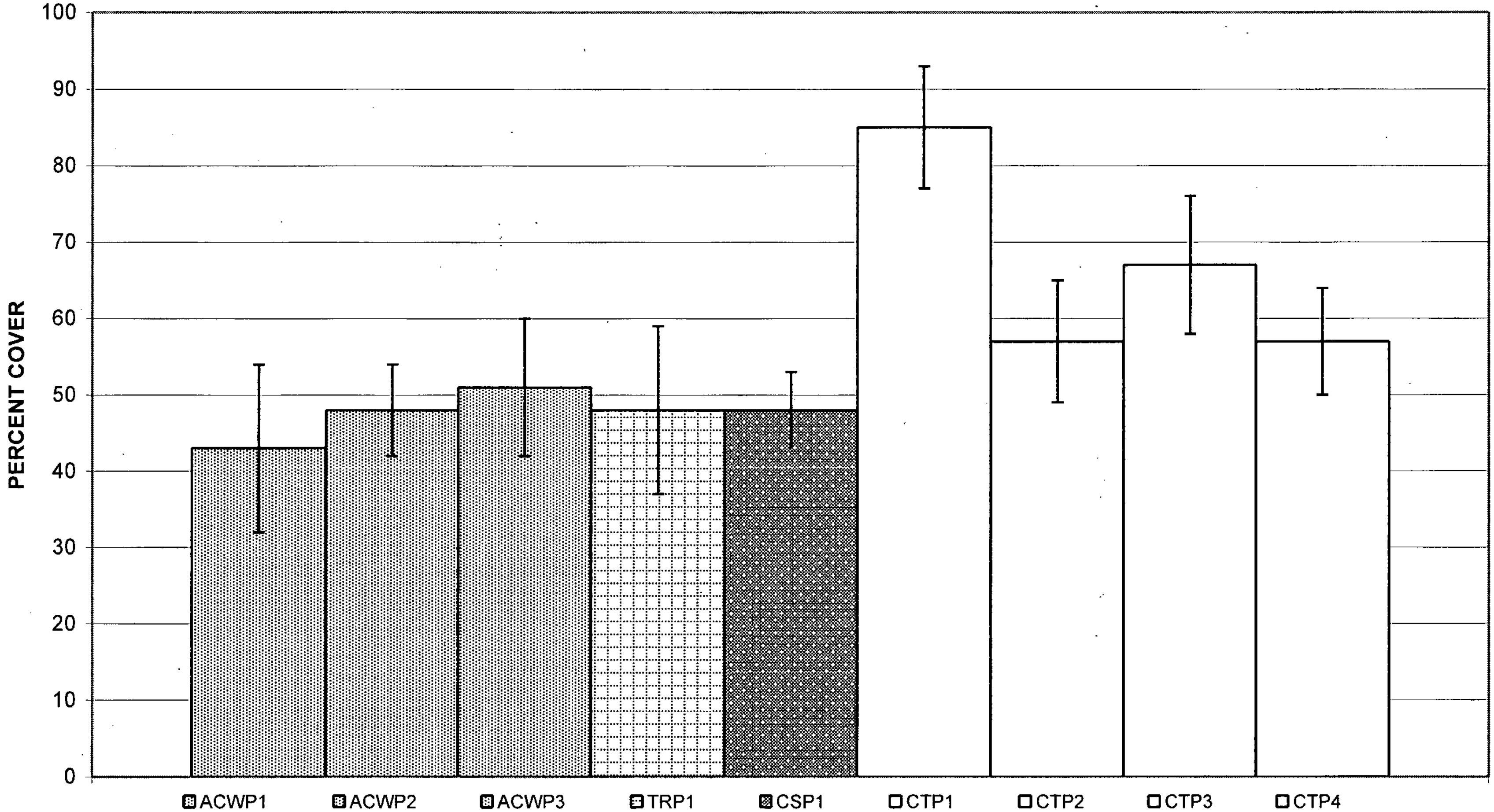
FIGURE 8-25
2008 MEAN LIVE STANDING CROP by TRANSECT
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
DELAWARE WETLAND RESTORATION SITES



(a) Includes S. cynosuroides dominated quadrats.
Error bar represents +/- one Standard Error of the Mean.

TR = The Rocks
CS = Cedar Swamp
T1 =Transect 1

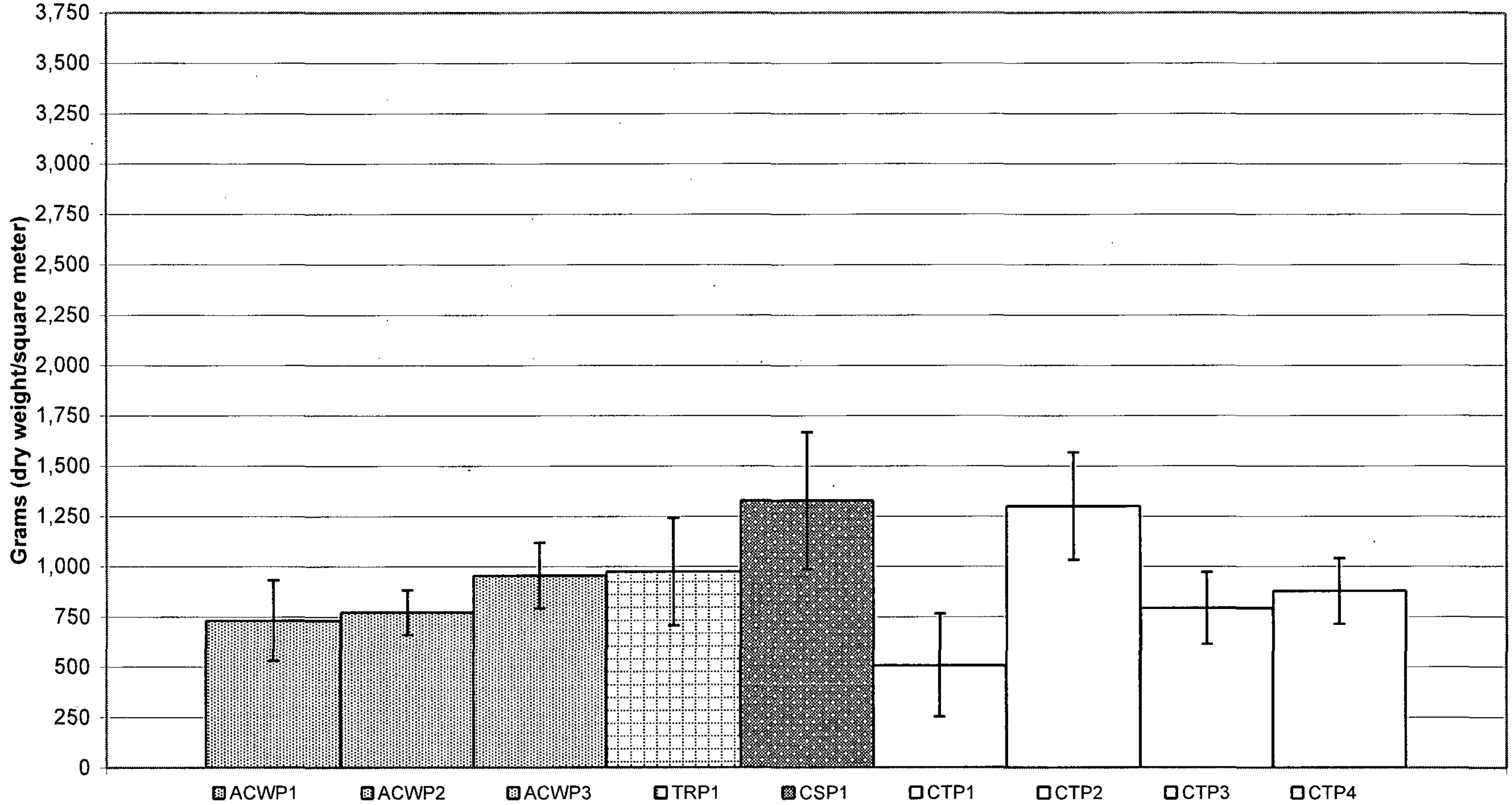
FIGURE 8-26
2008 MEAN PERCENT COVER 60x60 METER PLOTS
WETLAND RESTORATION SITES



Error bar represents +/- one Standard Error of the Mean.

CT=Commercial Township
TR = The Rocks
CS = Cedar Swamp
ACW = Alloway Creek Site
P1 = Plot 1

FIGURE 8-27
2008 MEAN LIVE STANDING CROP 60x60 METER PLOTS
WETLAND RESTORATION SITES



Error bar represents +/- one Standard Error of the Mean.

CT=Commercial Township TR = The Rocks
CS = Cedar Swamp
ACW = Alloway Creek Site P1 = Plot 1

Appendix A
Macrophyte Field Data Sampling Data Sheets

EXHIBIT A-1
VEGETATION TRANSCT DATA SHEET
PSEG EEP DETRITAL MONITORING

Site:____________ ____________ **Transect:** ____________ **Date:** ____________

Investigators:________________________ **Compass Reading:**____________

*Weather Conditions:*________________________

Pole #1
Pole #2
Pole #3
Pole #4
Pole #5

Notes:

Community type (No.) / Segment No.	Start - End (m)	Length (m)	Return Start - End (m)	Selected Clip Plots (dist from segment) / Selected Ocular Plots (dist from end)

Total number of vegetation communities = ________

Total number of 0.25 m^2 clip plots (number of vegetation communities X 2) = ________

Total number of 0.25 m^2 ocular quadrats (number of clip plots X 3; up to 22) = ________

Total transect length = ________ meters

Dominant Plant Community	No. Community Segments	Selected Community Segment / length (m)		Segment No. / Distance to quadrat (m)	

EXHIBIT A-2
CLIP QUADRAT DATA SHEET
PSEG EEP DETRITAL MONITORING

Site:____________ ________ **Photo No.:**________ **Date:** ____________
Investigators: ________________ Weather Conditions: ____________
Transect:__________ **Quadrat:** ________ **Distance (m):** ________
Side of transect (L or R):____________ Water Depth (cm): ____________
Notes:

Species	Percent Cover	Height (cm)	Flowering (Y/N)	Number of Bags			
				Live	Dead	Litter	Sort
Total Percent Cover							

EXHIBIT A-3

OCULAR QUADRAT DATA SHEET
PSEG EEP VEGETATION MONITORING

Date: ______________ **Site:** ________________ **Transect:** ______________ **Investigators:** ________________

Quadrat No.	Distance from end (m)	Total % Cover	Species {% cover / height (cm) / flowering (y/n)}														
			% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__	% / ht. /__

Note: Locate odd number quadrats on the left side of the transect and even number quadrats on the right side.

EXHIBIT A-4

VEGETATION PLOT DATA SHEET

PSEG EEP VEGETATION MONITORING

Site:_______________________ **Date:** ________

Investigators:_______________ Weather Conditions:________________________

Plot:_______________

Notes:

Quadrat ID	Distance north (m)	Distance east (m)	Species {% cover / height (cm) / flowering (y/n)}														Number of Bags			
			% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	% / ht ./__	Live	Dead	Litter	Sort

EXHIBIT A-5
LAB DATA SHEET FOR CLIP QUADRAT VEGETATION
PSEG EEP VEGETATION MONITORING

Quadrat ID	Date	Species	Live (g)	Dead Standing (g)	Litter (g)

Species abbreviations

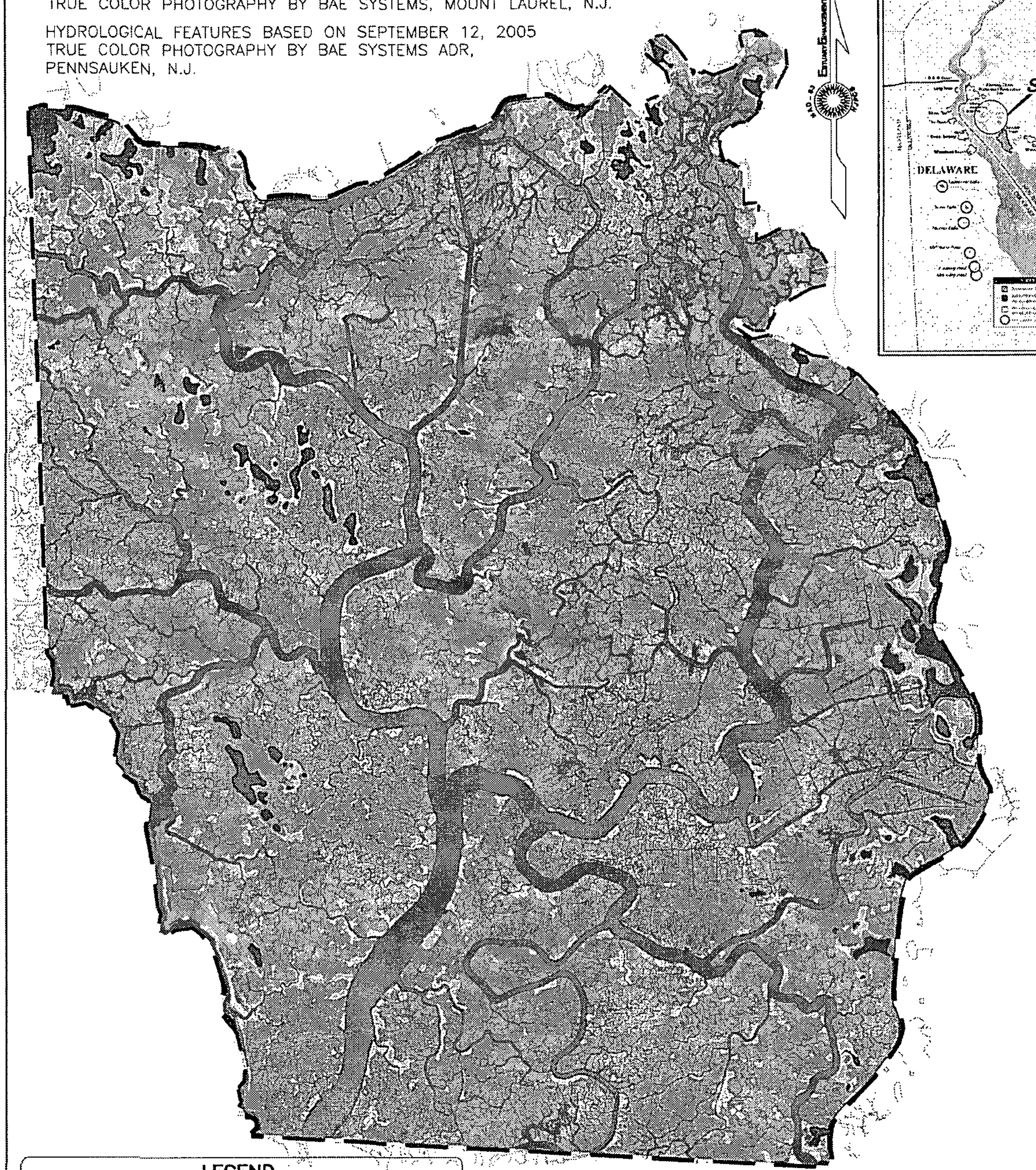
AA = arrow arum - *Pelatandra virginica*
AC = water hemp - *Amaranthus cannabinus*
BJ = Blue joint - *Calamagrostis canadenis*
DS = spike grass - *Distichlis spicata*
JG = black grass - *Juncus gerardii*
PA = common reed - *Phragmites australis*
PP = salt marsh fleabane - *Pluchea purpurascens*
PUNC = dotted smartweed - *Polygonum punctatum*
PV = Switch grass - *Panicum virgatum*
SA = smooth cordgrass - *Spartina alterniflora*
SC = big cordgrass - *Spartina cynosuroides*
SO = Three square - *Scirpus olneyi*
SP = salt hay grass - *Spartina patens*
SR = salt marsh bulrush - *Scirpus robustus*
SS = seaside goldenrod - *Solidago sempervirens*
SV = soft stem bulrush - *Scirpus validus*
TA = narrow-leaf cattail - *Typha angustifolia*
TL = broad leaf cattail - *Typha latifolia*
WM = walter's millet - *Echinochloa walteri*

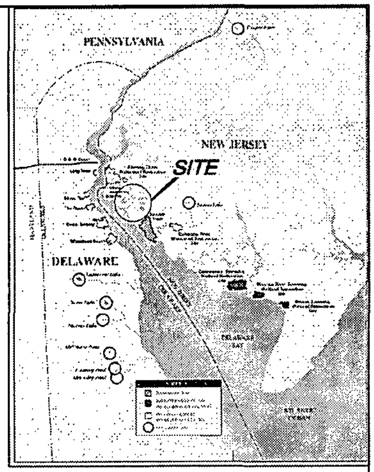
Appendix B
Vegetation Cover Category Maps

MAP SOURCE:

VEGETATION FEATURES BASED ON SEPTEMBER 8, 2008
TRUE COLOR PHOTOGRAPHY BY BAE SYSTEMS, MOUNT LAUREL, N.J.

HYDROLOGICAL FEATURES BASED ON SEPTEMBER 12, 2005
TRUE COLOR PHOTOGRAPHY BY BAE SYSTEMS ADR,
PENNSAUKEN, N.J.





LEGEND

- SITE BOUNDARY
- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS

VEGETATIVE COVER CATEGORIES

- *Spartina*/OTHER DESIRABLE MARSH VEGETATION
- DESIRABLE MARSH VEGETATION/*Phragmites*
- *Phragmites* DOMINATED VEGETATION
- DEAD *Phragmites australis*
- NON-VEGETATED MARSH PLAIN
- PONDED WATER
- CHANNEL
- OPEN WATER
- BUFFER AREA

FEET 0 1200 2400 3600
METERS 0 600 1200

URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

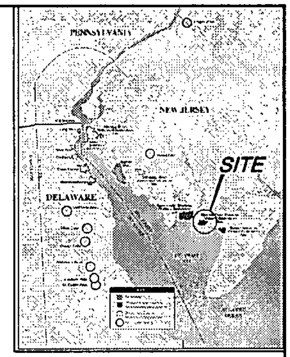
Figure B-1

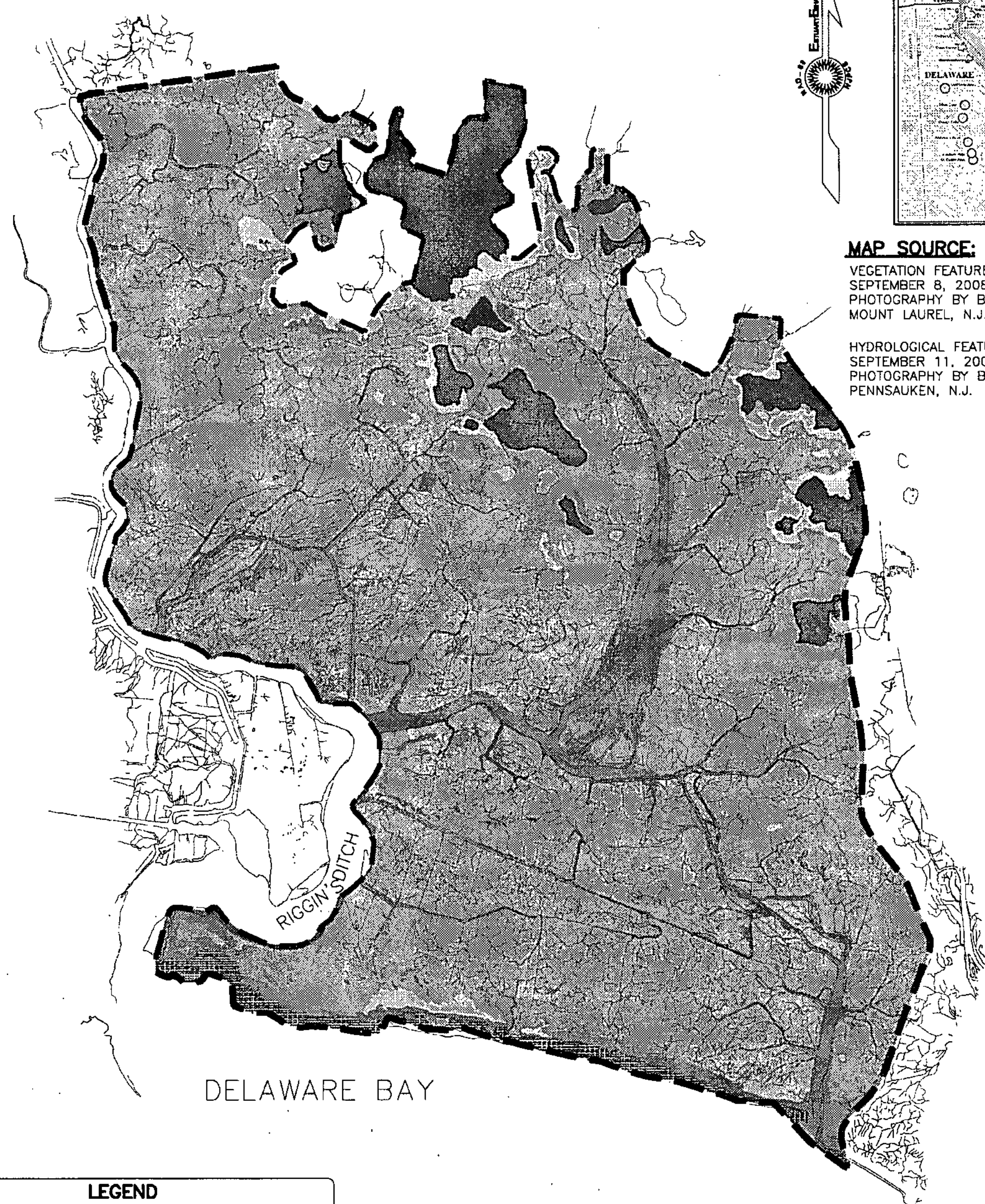
MADHORSE CREEK REFERENCE MARSH

2008 VEGETATION FEATURES

LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD	JL	DATE	APR 20, 2009	SCALE	AS SHOWN
FILE	08_MH_VEG	CHECKED	RLH	EXAMINED	RLH





MAP SOURCE:

VEGETATION FEATURES BASED ON SEPTEMBER 8, 2008 CIR AERIAL PHOTOGRAPHY BY BAE SYSTEMS, MOUNT LAUREL, N.J.

HYDROLOGICAL FEATURES BASED ON SEPTEMBER 11, 2005. CIR AERIAL PHOTOGRAPHY BY BAE SYSTEMS ADR, PENNSAUKEN, N.J.

LEGEND

- SITE BOUNDARY
- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS

VEGETATIVE COVER CATEGORIES

- *Spartina*/OTHER DESIRABLE MARSH VEGETATION
- DESIRABLE MARSH VEGETATION/*Phragmites*
- *Phragmites* DOMINATED VEGETATION
- Dead *Phragmites australis*
- NON-VEGETATED MARSH PLAIN
- PONDED WATER
- CHANNEL
- OPEN WATER
- BUFFER AREA
- RECOVERING DESIRABLE SPECIES AREA

FEET 0 900 1800 2700

METERS 0 400 800

URS

PSEG

ESTUARY ENHANCEMENT PROGRAM

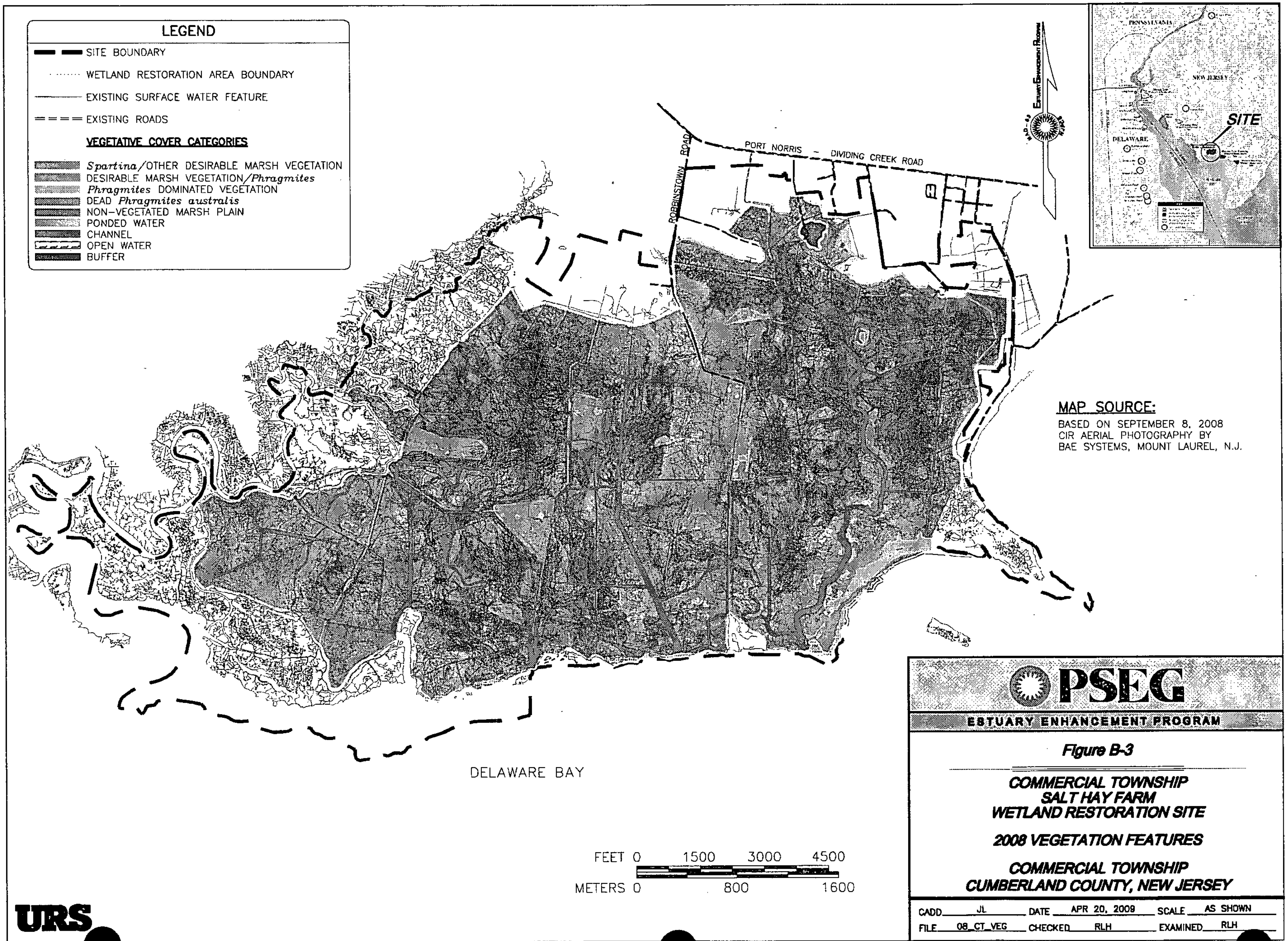
Figure B-2

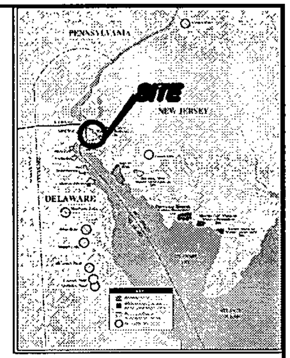
MOORES BEACH REFERENCE MARSH

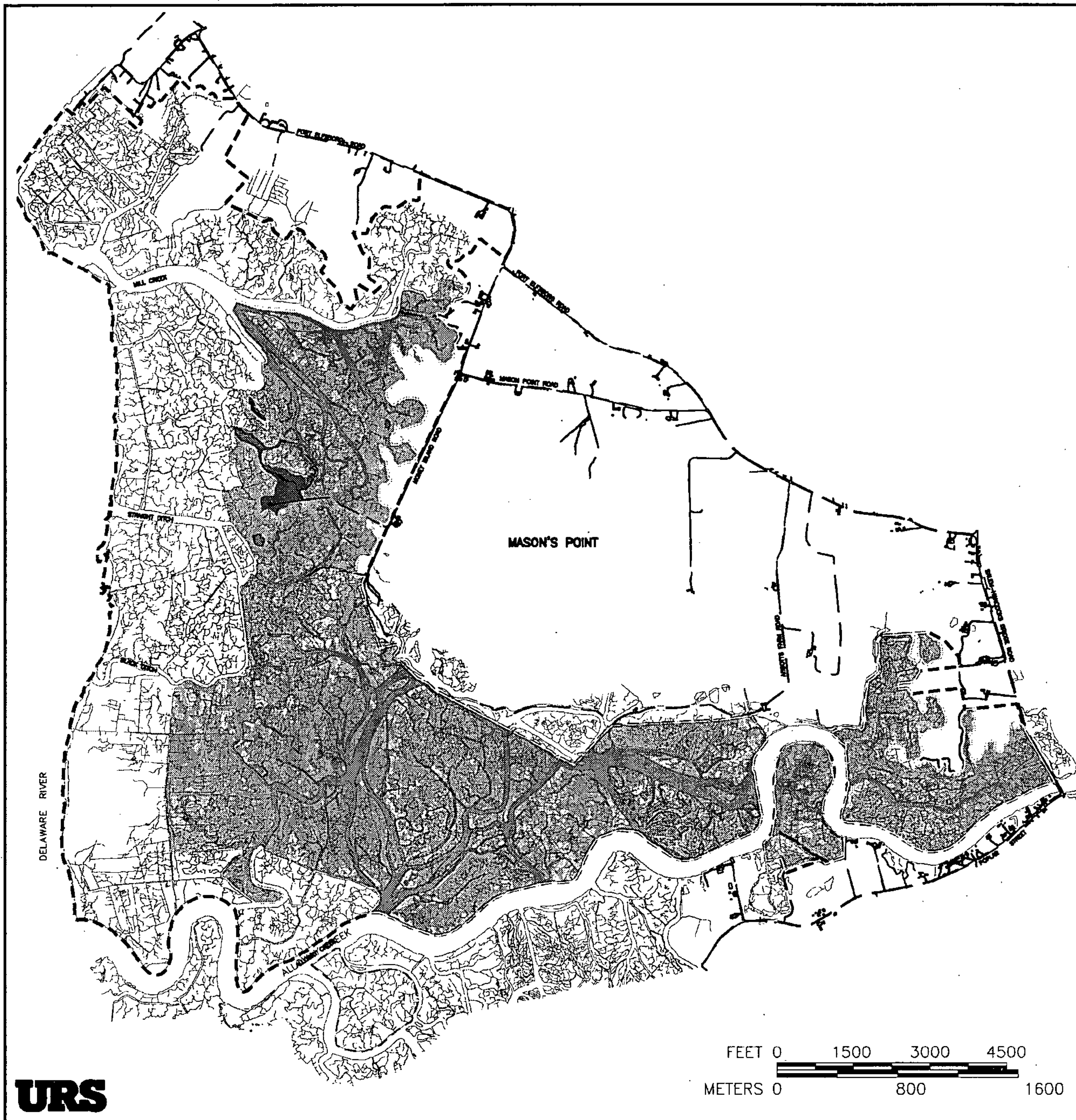
2008 VEGETATION FEATURES

MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD JL	DATE APR 20, 2009	SCALE AS SHOWN
FILE 08_MB_VEG	CHECKED RLH	EXAMINED RLH


LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATEGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
DESIRABLE MARSH VEGETATION/Phragmites
Phragmites DOMINATED VEGETATION
DEAD Phragmites australis
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
BUFFER
PORT NORRIS - DIVIDING CREEK ROAD
ROBBINSTOWN ROAD
PENNSYLVANIA
NEW JERSEY
DELAWARE
SITE
MAP SOURCE:
BASED ON SEPTEMBER 8, 2008
CIR AERIAL PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.
DELAWARE BAY
FEET 0 1500 3000 4500
METERS 0 800 1600
URS
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure B-3
COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE
2008 VEGETATION FEATURES
COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY
CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08_CT_VEG CHECKED RLH EXAMINED RLH





LEGEND

- SITE BOUNDARY
- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS

VEGETATIVE COVER CATEGORIES

- *Spartina*/OTHER DESIRABLE MARSH VEGETATION
- DESIRABLE MARSH VEGETATION/*Phragmites*
- *Phragmites* DOMINATED VEGETATION
- DEAD *Phragmites australis*
- NON-VEGETATED MARSH PLAIN
- PONDED WATER
- CHANNEL
- OPEN WATER
- BUFFER AREA

MAP SOURCE:

BASED ON SEPTEMBER 8, 2008
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.

URS

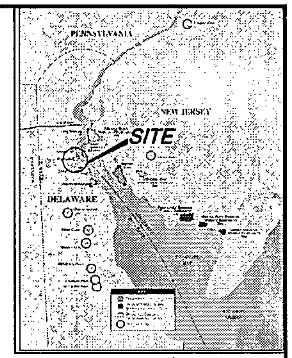
PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure B-4

ALLOWAY CREEK WATERSHED
WETLAND RESTORATION SITE

2008 VEGETATION FEATURES
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD	JL	DATE	APR 20, 2009	SCALE	AS SHOWN
FILE	08 ACW VEG	CHECKED	RLH	EXAMINED	RLH



LEGEND

- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS

VEGETATIVE COVER CATEGORIES

- *Spartina*/OTHER DESIRABLE MARSH VEGETATION
- DESIRABLE MARSH VEGETATION/*Phragmites*
- *Phragmites* DOMINATED VEGETATION
- DEAD *Phragmites australis*
- NON-VEGETATED MARSH PLAIN
- PONDED WATER
- CHANNEL
- OPEN WATER
- BUFFER AREA

MAP SOURCE:

BASED ON SEPTEMBER 8, 2008
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.

FEET 0 750 1500 2250
METERS 0 400 800

URS

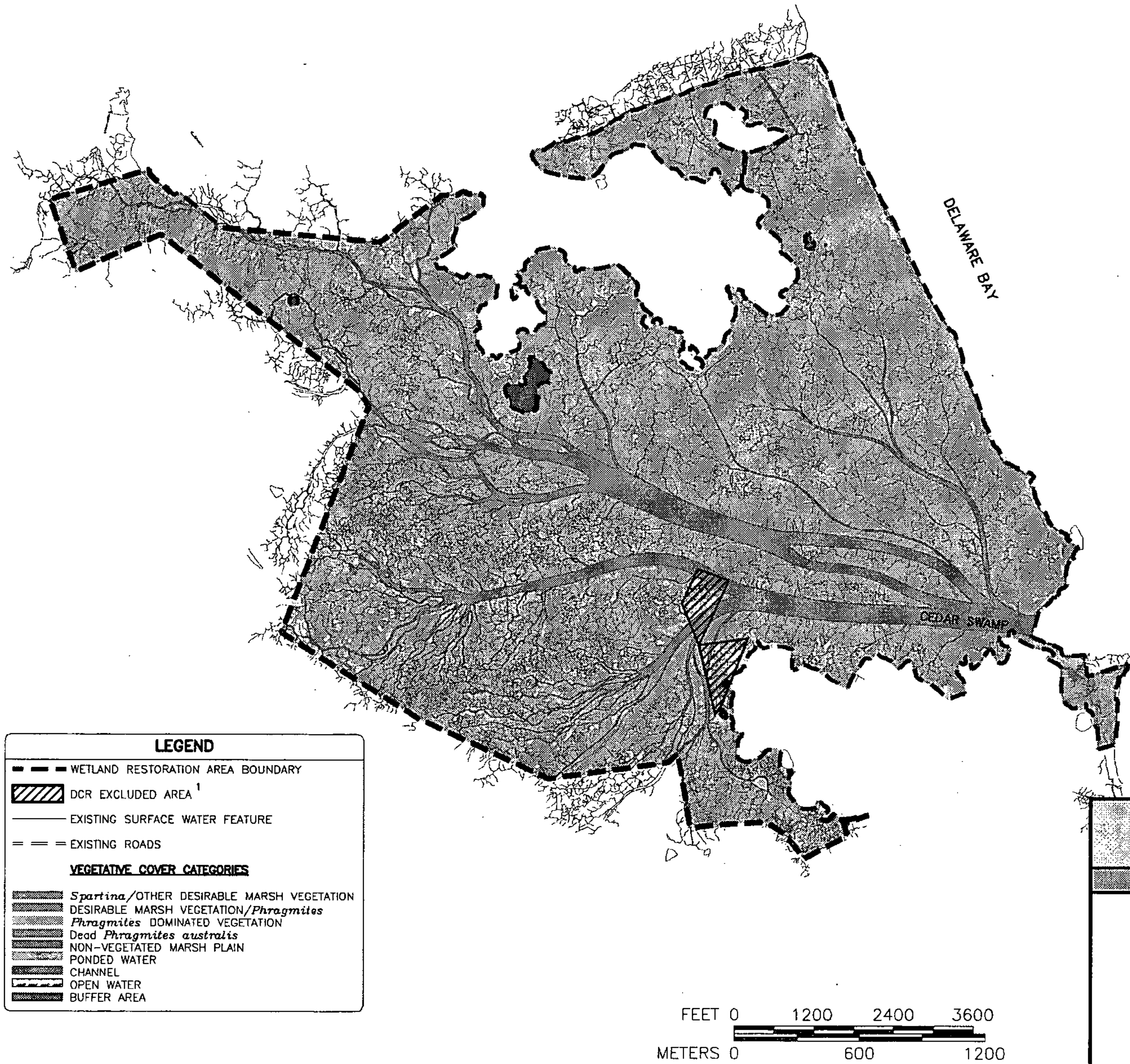
PSEG
ESTUARY ENHANCEMENT PROGRAM

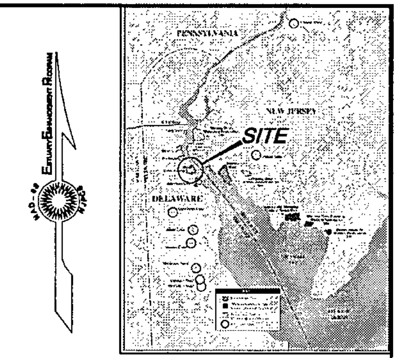
Figure B-5

THE ROCKS
WETLAND RESTORATION SITE

2008 VEGETATION FEATURES
APPOQUINIMINK HUNDRED
NEW CASTLE COUNTY, DELAWARE

CADD	JL	DATE	APR 20, 2009	SCALE	AS SHOWN
FILE	08_TR_VEG	CHECKED	RLH	EXAMINED	RLH





NOTE:

1. CROSS-HATCHED AREA NOT SUBJECT TO DECLARATIONS OF RESTRICTIONS AND COVENANTS.

MAP SOURCE:

BASED ON SEPTEMBER 8, 2008 TRUE COLOR PHOTOGRAPHY BY BAE SYSTEMS, MOUNT LAUREL, N.J.

URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure B-6

**CEDAR SWAMP
WETLAND RESTORATION SITE**

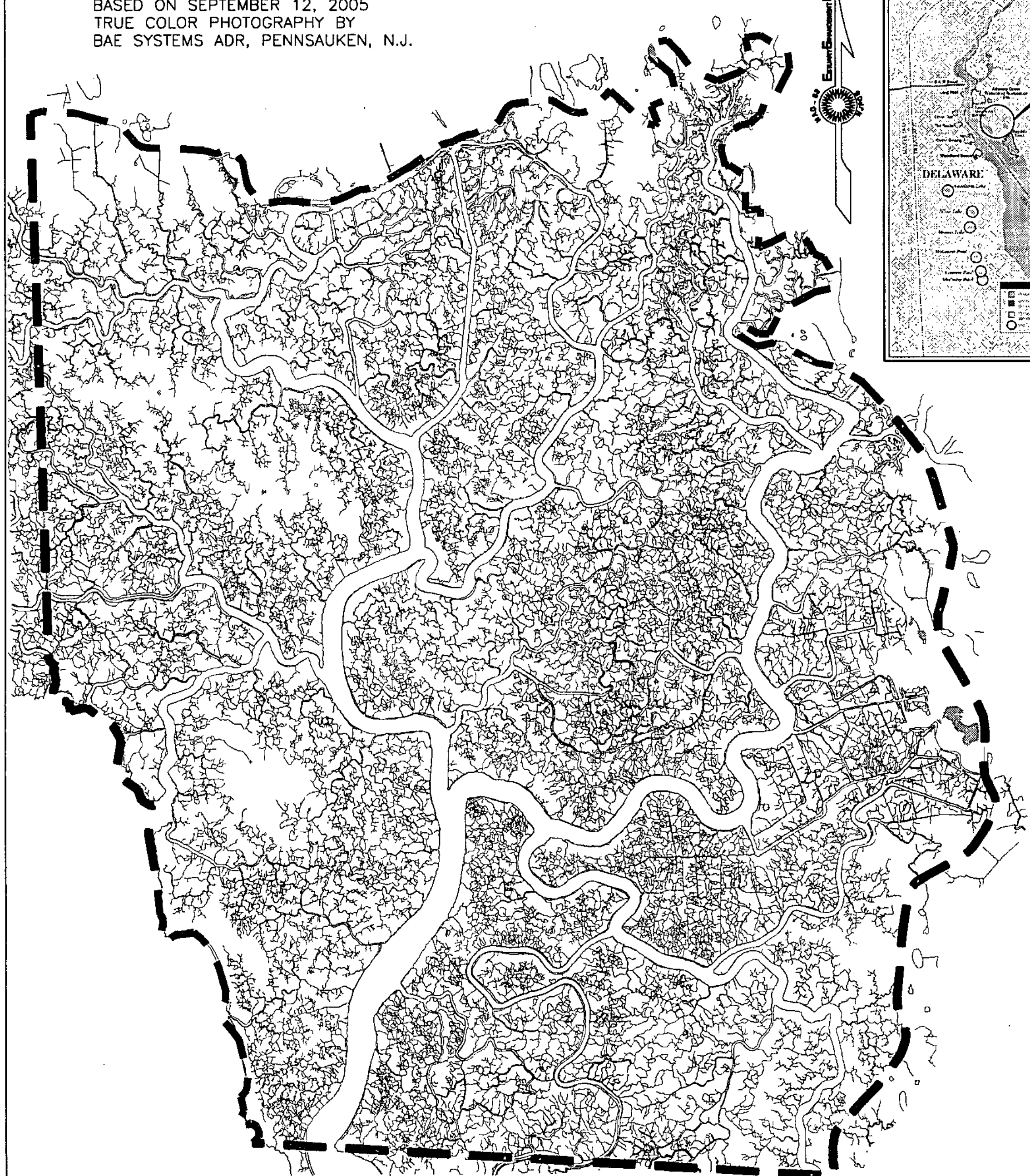
2008 VEGETATION FEATURES

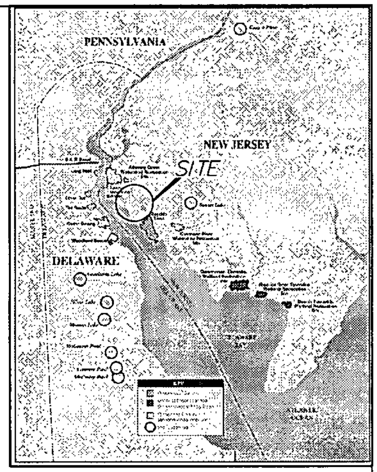
**BLACKBIRD HUNDRED
NEW CASTLE COUNTY, DELAWARE**

CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08_CS-VEG CHECKED RLH EXAMINED RLH

Appendix C
Geomorphologic Maps

MAP SOURCE:
BASED ON SEPTEMBER 12, 2005
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.





LEGEND

- SITE BOUNDARY
- EXISTING SURFACE WATER FEATURE
- PONDED AREAS

FEET 0 1200 2400 3600
METERS 0 600 1200

URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

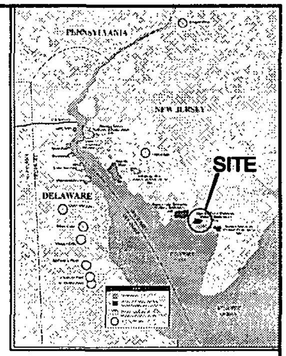
Figure C-1

MADHORSE CREEK REFERENCE MARSH

2005 HYDROLOGICAL FEATURES

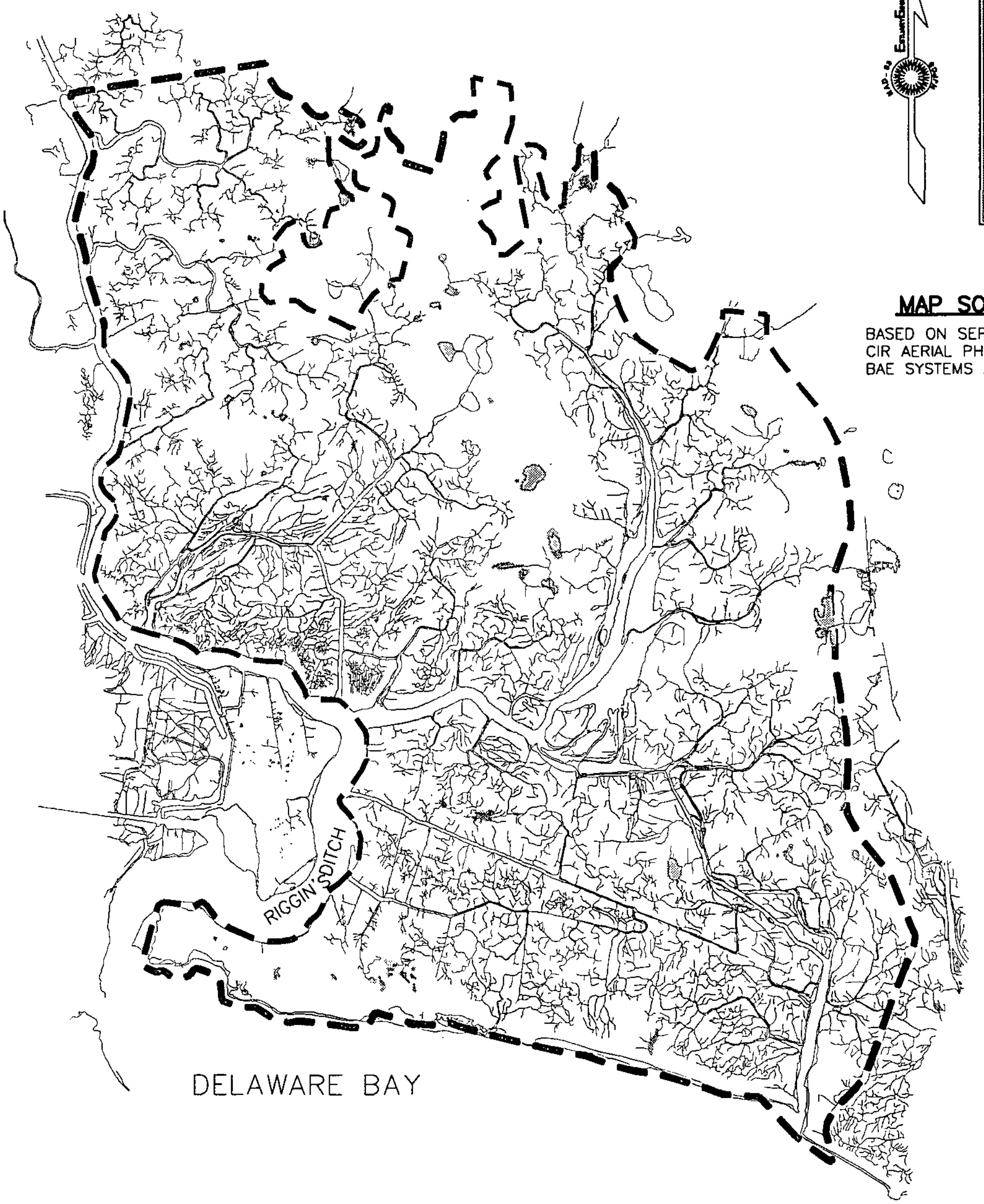
LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08_MH_HYD CHECKED RLH EXAMINED RLH



MAP SOURCE:

BASED ON SEPTEMBER 11, 2005
CIR AERIAL PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.



LEGEND

- SITE BOUNDARY
- EXISTING SURFACE WATER FEATURE
- PONDED AREAS

FEET 0 900 1800 2700
METERS 0 400 800

URS

PSEG

ESTUARY ENHANCEMENT PROGRAM

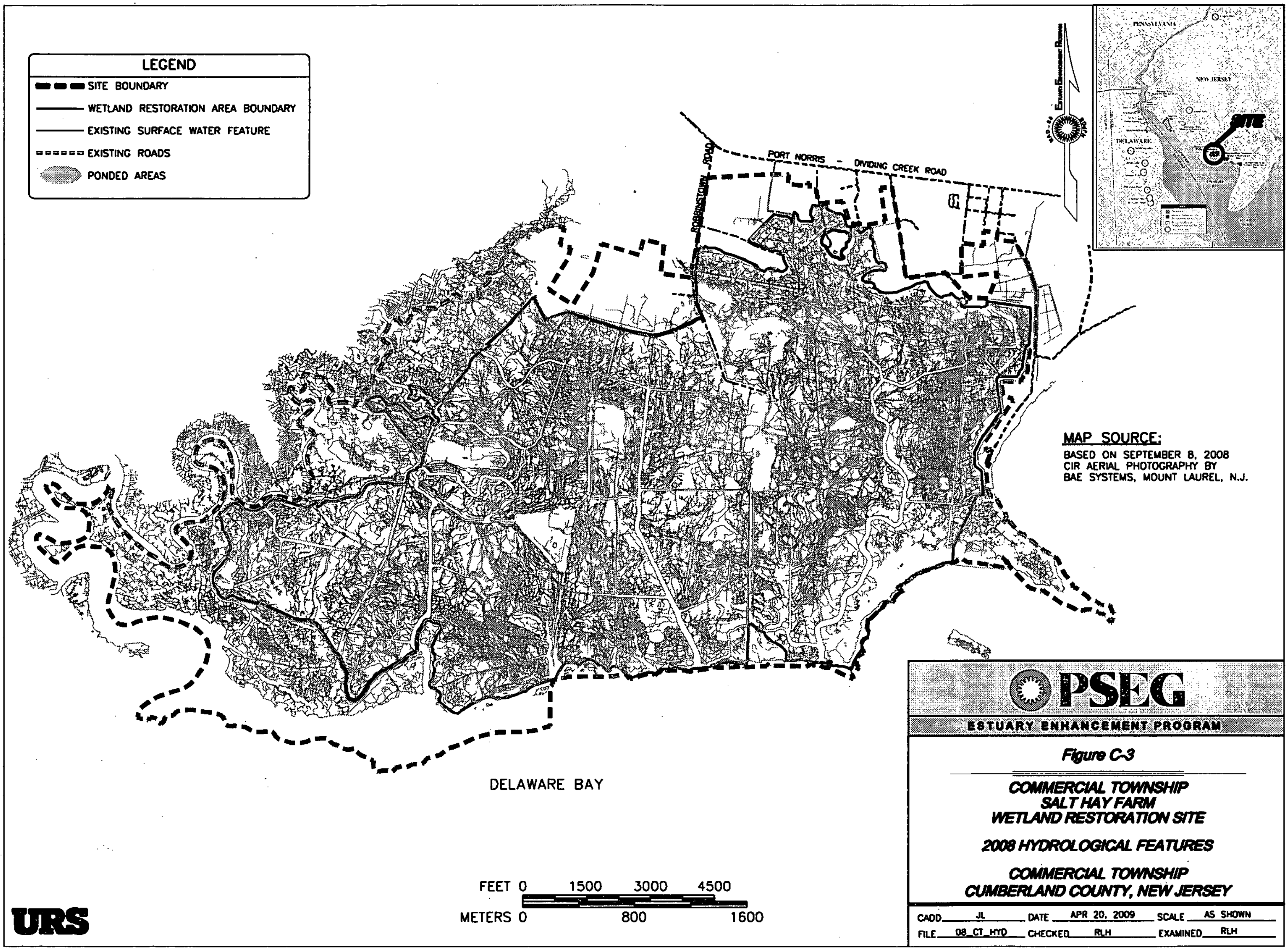
Figure C-2

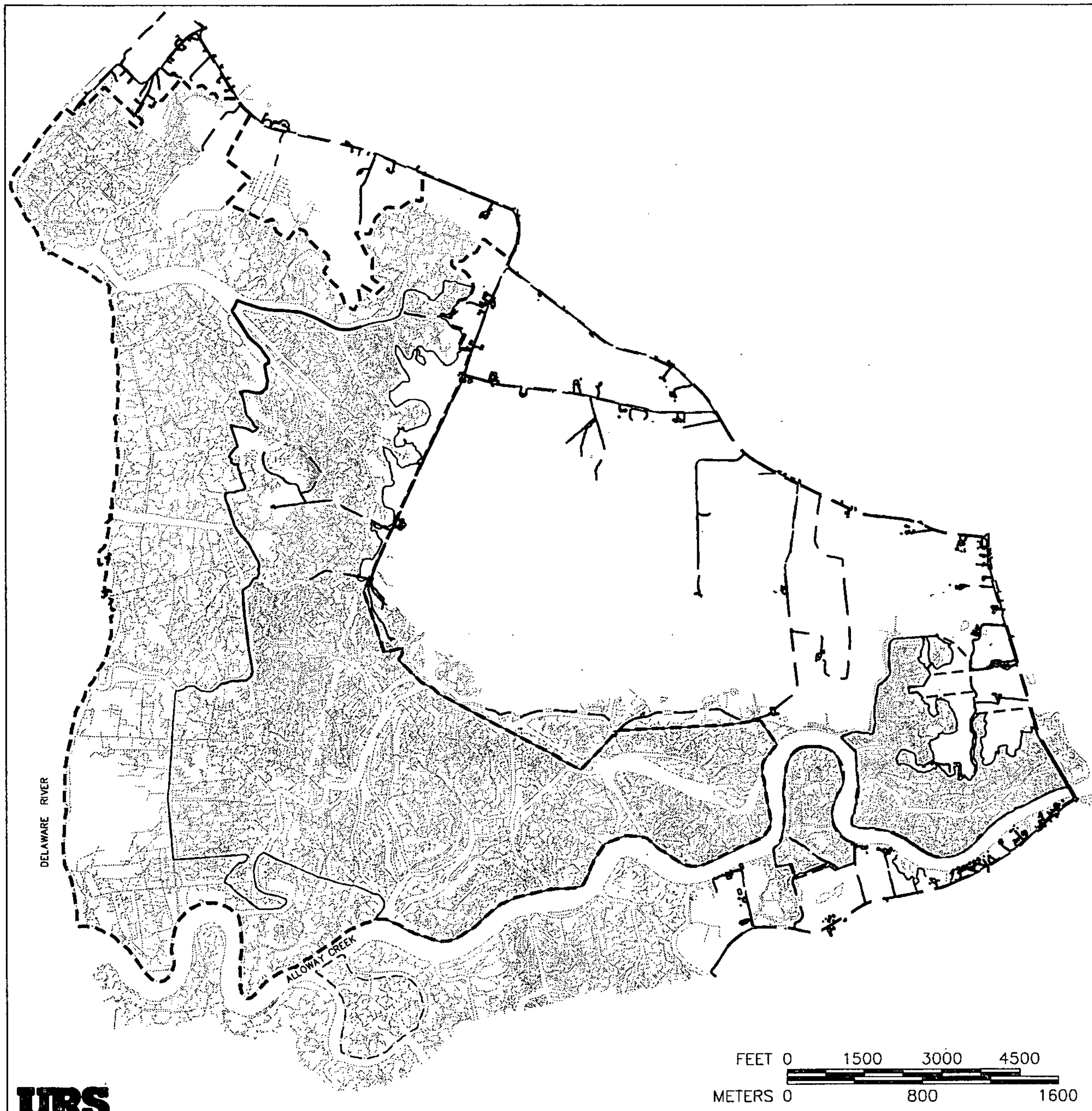
MOORES BEACH REFERENCE MARSH

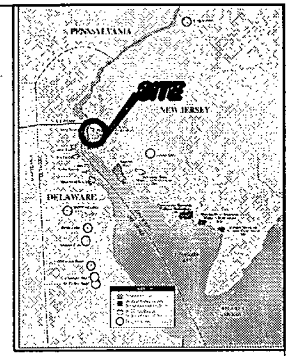
2005 HYDROLOGICAL FEATURES

MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD JL	DATE APR 20, 2009	SCALE AS SHOWN
FILE 08_MB_HYD	CHECKED RLH	EXAMINED RLH


LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
PONDED AREAS
PORT NORRIS - DIVIDING CREEK ROAD
ROBBINSTOWN ROAD
MAP SOURCE:
BASED ON SEPTEMBER 8, 2008
CIR AERIAL PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.
DELAWARE BAY
FEET 0 1500 3000 4500
METERS 0 800 1600
URS
PENNSYLVANIA
NEW JERSEY
DELAWARE
SITE
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure C-3
COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE
2008 HYDROLOGICAL FEATURES
COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY
CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08_CT_HYD CHECKED RLH EXAMINED RLH





LEGEND

- SITE BOUNDARY
- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS
- PONDED AREA

MAP SOURCE:

BASED ON SEPTEMBER 8, 2008
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.

URS

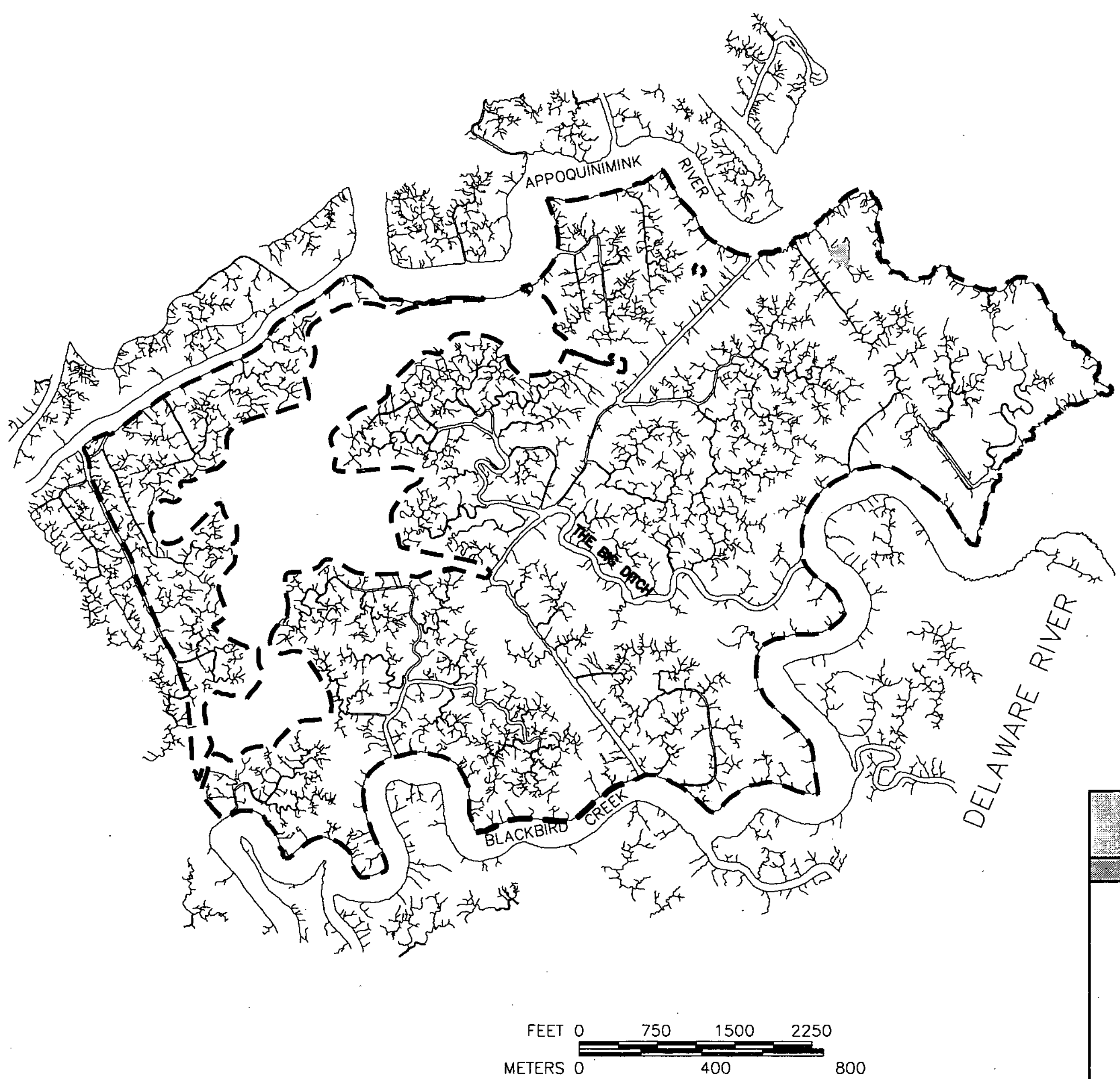
PSEG
ESTUARY ENHANCEMENT PROGRAM

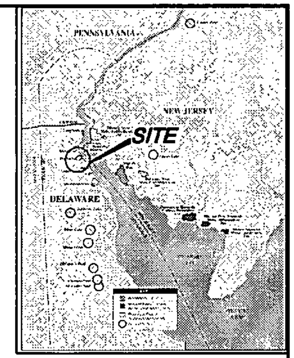
Figure C-4

ALLOWAY CREEK SITE
WATERSHED WETLAND RESTORATION SITE

2008 HYDROLOGICAL FEATURES
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD	JL	DATE	APR 20, 2009	SCALE	AS SHOWN
FILE	08 ACW HYD	CHECKED	RLH	EXAMINED	RLH





LEGEND

- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS
- PONDED AREAS

MAP SOURCE:

BASED ON SEPTEMBER 8, 2008
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.

URS

PSEG

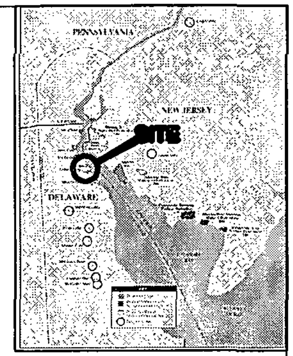
ESTUARY ENHANCEMENT PROGRAM

Figure C-5

THE ROCKS
WETLAND RESTORATION SITE

2008 HYDROLOGICAL FEATURES
APPOQUINIMINK HUNDRED
NEW CASTLE COUNTY, DELAWARE

CADD	JL	DATE	APR 20, 2009	SCALE	AS SHOWN
FILE	08_TR_HYD	CHECKED	RLH	EXAMINED	RLH



NOTE:

1. CROSS-HATCHED AREA NOT SUBJECT TO DECLARATIONS OF RESTRICTIONS AND COVENANTS.

MAP SOURCE:

BASED ON SEPTEMBER 8, 2008
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.

LEGEND

- WETLAND RESTORATION AREA BOUNDARY
- DCR EXCLUDED AREA[1]
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS
- PONDED AREAS

FEET 0 1200 2400 3600
METERS 0 600 1200

PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure C-6

CEDAR SWAMP
WETLAND RESTORATION SITE

2008 HYDROLOGICAL FEATURES

BLACKBIRD HUNDRED
NEW CASTLE COUNTY, DELAWARE

CADD JL	DATE APR 20, 2009	SCALE AS SHOWN
FILE 08_CS-HYD	CHECKED RLH	EXAMINED RLH

URS

Appendix D
Macrophyte Quadrat Data - Transects

Table D-1
MAD HORSE CREEK REFERENCE MARSH
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Mad Horse Creek-08- Transect 3B 8/14/08										
MHT3B-08-OQ1	228	*S. alterniflora*	55%	98%	107	N				
		A. cannabinus	1%	2%	40	Y				
MHT3B-08-OQ2	225	*S. alterniflora*	35%	100%	144	N				
MHT3B-08-CQ1	215	*S. alterniflora*	35%	100%	130	N	810	7226	0	271
MHT3B-08-OQ3	210	*S. alterniflora*	25%	96%	55	N				
		A. cannabinus	1%	4%	46	N				
MHT3B-08-CQ2	199	*S. alterniflora*	55%	98%	162	N	1050	9368	0	135
		A. cannabinus	1%	2%	107	Y	23	204	0	0
MHT3B-08-OQ4	193	*S. alterniflora*	45%	96%	147	N				
		P. australis	1%	2%	119	N				
		Dead P. australis	1%	--	--	--				
MHT3B-08-OQ5	189	*S. alterniflora*	10%	14%	94	N				
		A. cannabinus	25%	36%	117	Y				
		P. australis	35%	50%	159	Y				
MHT3B-08-OQ6	184	*S. alterniflora*	10%	14%	74	N				
		A. cannabinus	35%	50%	176	Y				
		P. australis	25%	36%	125	Y				
MHT3B-08-CQ3	181	*A. cannabinus*	45%	60%	131	Y	992	8854	0	161
		S. alterniflora	30%	40%	125	Y	328	2923	0	0
MHT3B-08-OQ7	180	*S. alterniflora*	35%	41%	86	N				
		A. cannabinus	45%	53%	109	Y				
		P. australis	5%	6%	111	N				
MHT3B-08-CQ4	169	*P. australis*	25%	56%	145	Y	579	5163	0	154
		S. alterniflora	5%	11%	130	N	164	1468	0	0
		A. cannabinus	15%	33%	115	Y	119	1062	0	0
MHT3B-08-CQ5	157	*S. alterniflora*	35%	54%	109	N	557	4967	0	588
		A. cannabinus	25%	38%	128	Y	592	5286	0	0
		P. australis	5%	8%	115	Y	88	784	0	0
MHT3B-08-CQ6	150	*P. australis*	70%	88%	185	Y	622	5550	0	106
		S. alterniflora	5%	6%	99	N	444	3965	0	0
		A. cannabinus	5%	6%	121	Y	53	476	0	0
MHT3B-08-OQ8	149	*S. alterniflora*	15%	27%	99	N				
		A. cannabinus	5%	9%	129	Y				
		P. australis	35%	64%	155	Y				
MHT3B-08-OQ9	135	*S. alterniflora*	45%	90%	104	N				
		A. cannabinus	5%	10%	106	Y				
		Dead P. australis	5%	--	--	--				
MHT3B-08-OQ10	129	*S. alterniflora*	55%	58%	92	N				
		A. cannabinus	5%	5%	92	Y				
		S. patens	35%	37%	169	N				
MHT3B-08-OQ11	112	*S. alterniflora*	65%	76%	43	N				
		A. cannabinus	15%	17%	64	Y				
		Dead P. australis	5%	--	--	--				
		D. spicata	1%	1%	29	N				
MHT3B-08-OQ12	105	*S. alterniflora*	85%	99%	75	N				
		D. spicata	1%	1%	67	N				
MHT3B-08-OQ13	82	*S. alterniflora*	75%	100%	118	N				
MHT3B-08-OQ14	80	*S. alterniflora*	55%	98%	121	N				
		A. cannabinus	1%	2%	64	N				
MHT3B-08-OQ15	77	*S. alterniflora*	55%	98%	91	N				
		Dead P. australis	1%	--	--	--				
MHT3B-08-OQ16	71	*S. alterniflora*	55%	69%	122	N				
		P. australis	20%	25%	122	Y				
		Dead P. australis	5%	--	--	--				
MHT3B-08-OQ17	51	*S. alterniflora*	35%	76%	111	N				
		S. robustus	10%	22%	109	N				
		Dead S. robustus	1%	--	--	--				
MHT3B-08-OQ18	35	*S. alterniflora*	25%	56%	93	N				
		A. cannabinus	20%	44%	109	Y				
MHT3B -08- Mean Spartina dominated Quadrats (b)			61%		108		1110	9903	0	289
MHT3B -08- Mean Non-Spartina dominated Quadrats (b)			64%		--		991	8841	0	130
MHT3B-08- Mean All Quadrats			61%		--		1070	9549	0	236
Site Mean Spartina dominated Quadrats (b)			54%		100		824	7353	0	126
Site Mean Non-Spartina dominated Quadrats (b)			41%		--		705	6293	31	66
Site Mean All Quadrats			50%		--		778	6941	12	107

Table D-2
MOORES BEACH REFERENCE MARSH
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Moores Beach-08- Transect 1 8/16/08										
MBT1-08-OQ1	546	*S. alterniflora*	35%	97%	74	N				
		Dead S. alterniflora	1%	--	--	--				
MBT1-08-CQ1	476	*S. alterniflora*	15%	100%	83	N	733	6536	0	90
MBT1-08-OQ2	297	*S. alterniflora*	20%	80%	102	N				
		Dead S. alterniflora	5%	--	--	--				
MBT1-08-OQ3	283	*S. alterniflora*	25%	96%	91	N				
		Dead S. alterniflora	1%	--	--	--				
MBT1-08-OQ4	222	*S. alterniflora*	25%	96%	100	N				
		Dead S. alterniflora	1%	--	--	--				
MBT1-08-CQ2	184	*S. alterniflora*	35%	97%	146	N	921	8215	0	197
		Dead S. alterniflora	1%	--	--	--	0	0	24	0
MBT1-08-OQ5	28	*S. alterniflora*	35%	88%	88	N				
		Dead S. alterniflora	5%	--	--	--				
MBT1-08-OQ6	5	*S. alterniflora*	45%	100%	124	N				
MBT1-08- Mean Spartina dominated Quadrats (b)			33%		102		921	8215	24	197
MBT1-08- Mean Non-Spartina dominated Quadrats (b)			15%		--		733	6536	0	90
MBT1-08- Mean All Quadrats			31%		--		827	7375	12	143
Moores Beach-08- Transect 2 8/16/08										
MBT2-08-OQ1	652	*S. alterniflora*	55%	100%	83	N				
MBT2-08-OQ2	509	*S. alterniflora*	25%	83%	98	N				
		Dead S. alterniflora	5%	--	--	--				
MBT2-08-OQ3	467	*S. alterniflora*	35%	97%	140	N				
		Dead S. alterniflora	1%	--	--	--				
MBT2-08-CQ1	464	*S. alterniflora*	45%	98%	112	N	770	6874	0	72
		Dead S. alterniflora	1%	--	--	--	0	0	142	0
MBT2-08-OQ4	241	*S. alterniflora*	35%	100%	110	Y				
MBT2-08-CQ2	230	*S. alterniflora*	25%	100%	88	N	427	3807	0	0
MBT2-08-OQ5	341	*S. alterniflora*	35%	88%	86	N				
		Dead S. alterniflora	5%	--	--	--				
MBT2-08-OQ6	53	*S. alterniflora*	35%	88%	101	N				
		Dead S. alterniflora	5%	--	--	--				
MBT2-08- Mean Spartina dominated Quadrats (b)			38%		102		599	5341	71	36
MBT2-08-Mean Non-Spartina dominated Quadrats (b)			0%		--		0	0	0	0
MBT2-08- Mean All Quadrats			38%		--		599	5341	71	36
Moores Beach-08- Transect 3 8/16/08										
MBT3-08-OQ1	715	*S. alterniflora*	35%	100%	80	N				
MBT3-08-OQ2	676	*S. alterniflora*	15%	94%	35	N				
		S. cynosuroides	1%	6%	35	N				
MBT3-08-OQ3	619	*S. alterniflora*	20%	67%	90	N				
		S. cynosuroides	10%	33%	103	N				
MBT3-08-CQ1	429	*S. alterniflora*	45%	100%	52	N	858	7652	0	233
MBT3-08-OQ4	410	*S. alterniflora*	45%	100%	87	N				
MBT3-08-CQ2	238	*S. alterniflora*	55%	100%	67	N	349	3116	0	34
MBT3-08-OQ5	140	*S. alterniflora*	25%	71%	82	N				
		Dead P. australis	10%	--	--	--				
MBT3-08-OQ6	120	*S. alterniflora*	30%	67%	93	N				
		Dead P. australis	15%	--	--	--				
MBT3-08- Mean Spartina dominated Quadrats (b)			41%		82		603	5384	0	133
MBT3-08 - Mean Non-Spartina dominated Quadrats (b)			16%		--		0	0	0	0
MBT3-08- Mean All Quadrats			38%		--		603	5384	0	133

Site Mean Spartina dominated Quadrats (b)		38%		95		665	5933	33	107
Site Mean Non-Spartina dominated Quadrats (b)		16%		--		733	6536	0	90
Site Mean All Quadrats		36%		--		676	6033	28	104

Table D-3
COMMERCIAL TOWNSHIP SALT HAY FARM WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Commercial Township-08- Transect 1 8/15/08										
CTT1-08-OQ1	211	*S. alterniflora*	40%	100%	170	Y				
CTT1-08-OQ2	188	*S. alterniflora*	45%	100%	163	Y				
CTT1-08-OQ3	185	*S. alterniflora*	45%	100%	175	Y				
CTT1-08-OQ4	52	*S. alterniflora*	55%	100%	185	Y				
CTT1-08-OQ5	36	*S. alterniflora*	45%	100%	174	Y				
CTT1-08-CQ1	18	*S. alterniflora*	45%	100%	164	Y	2613	23317	0	119
CTT1-08-OQ6	9	*S. alterniflora*	55%	100%	180	Y				
CTT1-08-CQ2	6	*S. alterniflora*	50%	100%	180	Y	1641	14641	0	116
CTT1-08- Mean Spartina dominated Quadrats (b)			48%		173		2127	18979	0	117
CTT1-08- Mean Non-Spartina dominated Quadrats (b)			0%		--		0	0	0	0
CTT1-08- Mean All Quadrats			48%		--		2127	18979	0	117
Commercial Township-08- Transect 2 8/17/08										
CTT2-08-OQ1	586	*S. alterniflora*	25%	100%	128	Y				
CTT2-08-OQ2	483	*S. alterniflora*	25%	100%	128	Y				
CTT2-08-OQ3	395	Mud Flat	0%	--						
CTT2-08-OQ4	141	Mud Flat	0%	--						
CTT2-08-OQ5	97	Mud Flat	0%	--						
CTT2-08-CQ1	13	*S. alterniflora*	15%	100%	129	Y	553	4937	0	0
CTT2-08-CQ2	3	*S. alterniflora*	25%	100%	128	N	450	4017	0	0
CTT2-08-OQ6	1	*S. alterniflora*	25%	100%	128	Y				
CTT2-08- Mean Spartina dominated Quadrats (b)			23%		128		502	4477	0	0
CTT2-08- Mean Non-Spartina dominated Quadrats (b)			0%		--		0	0	0	0
CTT2-08- Mean All Quadrats			14%		--		502	4477	0	0
Commercial Township-08- Transect 3 8/15/08										
CTT3-08-CQ1	428	*S. alterniflora*	45%	100%	177	Y	1601	14281	0	73
CTT3-08-OQ1	417	*S. alterniflora*	45%	100%	180	Y				
CTT3-08-CQ2	405	*S. alterniflora*	45%	100%	202	Y	1454	12970	0	16
CTT3-08-OQ2	390	*S. alterniflora*	45%	100%	195	Y				
CTT3-08-OQ3	224	Mud Flat	0%	--						
CTT3-08-OQ4	214	Mud Flat	0%	--						
CTT3-08-OQ5	101	*S. alterniflora*	10%	100%	120	Y				
CTT3-08-OQ6	34	*S. alterniflora*	50%	100%	165	Y				
CTT3-08- Mean Spartina dominated Quadrats (b)			40%		173		1527	13625	0	45
CTT3-08- Mean Non-Spartina dominated Quadrats (b)			0%		--		0	0	0	0
CTT3-08- Mean All Quadrats			30%		--		1527	13625	0	45
Commercial Township-08- Transect 4 8/17/08										
CTT4-08-OQ1	241	Mud Flat	0%	--						
CTT4-08-OQ2	223	Mud Flat	0%	--						
CTT4-08-OQ3	146	*S. alterniflora*	10%	100%	160	Y				
CTT4-08-OQ4	140	*S. alterniflora*	10%	100%	160	Y				
CTT4-08-OQ5	50	*S. alterniflora*	35%	100%	170	Y				
CTT4-08-OQ6	27	*S. alterniflora*	35%	100%	170	Y				
CTT4-08-CQ1	16	*S. alterniflora*	45%	100%	187	Y	1114	9936	0	0
CTT4-08-CQ2	8	*S. alterniflora*	45%	100%	174	Y	1499	13379	0	0
CTT4-08- Mean Spartina dominated Quadrats (b)			40%		175		1307	11657	0	0
CTT4-08- Mean Non-Spartina dominated Quadrats (b)			5%		--		0	0	0	0
CTT4-08- Mean All Quadrats			23%		--		1307	11657	0	0
Site Mean Spartina dominated Quadrats (b)			39%		164		1366	12185	0	41
Site Mean Non-Spartina dominated Quadrats (b)			2%		--		0	0	0	0
Site Mean All Quadrats			29%		--		1366	12185	0	41

Table D-4
ALLOWAY CREEK WATERSHED PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Alloway Creek Watershed-08- Transect 1 8/19/08										
ACWT1-08-OQ1	446	*S. alterniflora*	35%	100%	161	Y				
ACWT1-08-OQ2	362	*S. alterniflora*	45%	90%	72	N				
		A. cannabinus	5%	10%	69	N				
ACWT1-08-OQ3	336	*S. robustus*	15%	100%	120	Y				
ACWT1-08-CQ1	219	*S. alterniflora*	35%	78%	82	N	637	5684	0	101
		A. cannabinus	5%	11%	76	Y	17	150	0	0
		S. robustus	5%	11%	119	N	27	244	0	0
ACWT1-08-OQ4	190	*S. alterniflora*	35%	70%	120	N				
		S. robustus	15%	30%	161	N				
ACWT1-08-OQ5	136	*S. alterniflora*	55%	100%	141	Y				
ACWT1-08-CQ2	62	*S. alterniflora*	55%	100%	91	N	888	7919	0	75
ACWT1-08-OQ6	35	*S. alterniflora*	45%	90%	124	Y				
		A. cannabinus	5%	10%	75	Y				
ACWT1-08- Mean Spartina dominated Quadrats (b)			49%		113		784	6999	0	88
ACWT1-08- Mean Non-Spartina dominated Quadrats (b)			15%		--		0	0	0	0
ACWT1-08- Mean All Quadrats			44%		--		784	6999	0	88
Alloway Creek Watershed-08- Transect 2 8/12/08										
ACWT2-08-OQ1	537	*S. alterniflora*	35%	78%	107	N				
		Dead *S. alterniflora*	10%	--	--	--				
ACWT2-08-OQ2	503	*S. alterniflora*	35%	97%	106	N				
		Dead *S. alterniflora*	1%	--	--	--				
ACWT2-08-OQ3	476	*S. alterniflora*	45%	100%	165	N				
ACWT2-08-OQ4	449	*S. alterniflora*	45%	98%	111	N				
		A. cannabinus	1%	2%	93	Y				
ACWT2-08-CQ1	385	*S. alterniflora*	40%	87%	141	N	951	8486	0	123
		A. cannabinus	5%	11%	107	N	32	287	0	0
		S. robustus	1%	2%	140	N	135	1203	0	0
ACWT2-08-OQ5	318	*S. alterniflora*	45%	100%	151	Y				
ACWT2-08-CQ2	289	*S. alterniflora*	5%	100%	131	Y	145	1291	0	65
		(Channel)	0%	--						
ACWT2-08-OQ6	270	*S. alterniflora*	25%	100%	137	Y				
ACWT2-08-OQ7	175	*S. alterniflora*	35%	100%	162	Y				
ACWT2-08-OQ8	171	*S. alterniflora*	25%	100%	150	Y				
ACWT2-08-OQ9	152	*S. alterniflora*	45%	100%	132	Y				
ACWT2-08-OQ10	89	*S. alterniflora*	35%	100%	133	Y				
		Dead *S. alterniflora*	5%	--	--	--				
ACWT2-08-OQ11	60	*S. alterniflora*	55%	96%	107	N				
		Dead *S. alterniflora*	1%	--	--	--				
		S. robustus	1%	2%	104	Y				
ACWT2-08-OQ12	56	Wrack	100%	100%						
ACWT2-08-CQ3	19	*S. cynosuroides*	55%	100%	234	Y	2709	24172	0	145
ACWT2-08-CQ4	9	*S. cynosuroides*	35%	100%	163	Y	1255	11200	0	37
ACWT2-08- Mean Spartina dominated Quadrats (b)			41%		143		1694	15116	0	101
ACWT2-08- Mean Non-Spartina dominated Quadrats (b)			53%		--		145	1291	0	65
ACWT2-08- Mean All Quadrats			43%		--		1307	11660	0	92

Table D-4
ALLOWAY CREEK WATERSHED PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Alloway Creek Watershed-08- Transect 3 8/12/08										
ACWT3-08-OQ1	273	*S. alterniflora*	65%	100%	91	N				
ACWT3-08-OQ2	244	*P. australis*	25%	100%	131	Y				
		Dead P. australis	1%	--	--	--				
ACWT3-08-CQ1	180	*P. australis*	35%	88%	160	Y	772	6885	0	79
		S. alterniflora	5%	13%	56	N	69	615	0	0
		Dead P. australis	1%	--	--	--	0	0	138	0
ACWT3-08-OQ3	232	*S. alterniflora*	15%	38%	81	N				
		P. australis	25%	63%	173	Y				
ACWT3-08-OQ4	205	*P. australis*	15%	75%	235	Y				
		P. purpurascens	5%	25%	40	N				
ACWT3-08-OQ5	193	*S. alterniflora*	45%	69%	95	N				
		A. cannabinus	5%	8%	90	Y				
		S. robustus	15%	23%	103	Y				
ACWT3-08-CQ2	210	*S. alterniflora*	35%	100%	98	N	457	4078	0	0
ACWT3-08-OQ6	149	*P. australis*	45%	75%	157	Y				
		S. cynosuroides	15%	25%	93	N				
ACWT3-08-OQ7	105	*S. alterniflora*	85%	92%	84	N				
		A. cannabinus	1%	1%	103	Y				
		S. robustus	1%	1%	124	Y				
		T. angustifolia	5%	5%	123	N				
ACWT3-08-OQ8	94	*P. australis*	35%	100%	203	Y				
ACWT3-08-CQ3	66	*P. australis*	15%	100%	163	Y	585	5221	0	94
ACWT3-08-OQ9	81	*S. alterniflora*	5%	12%	130	N				
		P. australis	35%	85%	176	Y				
		T. angustifolia	1%	2%	103	N				
ACWT3-08-OQ10	76	*S. alterniflora*	5%	13%	61	N				
		P. australis	35%	88%	174	Y				
ACWT3-08-OQ11	39	*S. alterniflora*	65%	98%	68	N				
		P. australis	1%	2%	73	N				
ACWT3-08-OQ12	15	*S. alterniflora*	5%	5%	73	N				
		Wrack	95%	95%	--					
ACWT3-08-CQ4	118	*S. alterniflora*	35%	100%	137	N	740	6604	0	40
ACWT3-08- Mean Spartina dominated Quadrats (b)			60%		96		599	5341	0	20
ACWT3-08- Mean Non-Spartina dominated Quadrats (b)			42%		--		713	6360	69	87
ACWT3-08- Mean All Quadrats			48%		--		656	5851	34	53

Table D-4
ALLOWAY CREEK WATERSHED PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Alloway Creek Watershed-08- Transect 4 8/18/08										
ACWT4-08-OQ1	246	*S. alterniflora*	15%	94%	155	Y				
		Peltandra virginica	1%	6%	55	N				
ACWT4-08-OQ2	243	*S. alterniflora*	15%	94%	160	Y				
		P. virginica	1%	6%	70	N				
ACWT4-08-OQ3	237	*S. alterniflora*	25%	100%	158	Y				
ACWT4-08-OQ4	196	*S. alterniflora*	1%	2%	98	N				
		Scirpus validus	5%	11%	119	Y				
		Cyperus strigosis	1%	2%	50	Y				
		Eleocharis parvula	35%	80%	4	N				
		E. walteri	1%	2%	80	Y				
		S. robustus	1%	2%	103	N				
ACWT4-08-OQ5	189	*S. alterniflora*	35%	100%	198	Y				
ACWT4-08-CQ1	217	*S. alterniflora*	25%	100%	198	Y	1112	9924	0	0
ACWT4-08-OQ6	176	*S. alterniflora*	35%	100%	192	Y				
ACWT4-08-OQ7	161	*S. alterniflora*	1%	4%	150	Y				
		E. walteri	25%	96%	134	Y				
ACWT4-08-OQ8	123	*S. alterniflora*	15%	71%	140	N				
		P. virginica	5%	24%	58	N				
		P. punctatum	1%	5%	48	Y				
ACWT4-08-CQ2	116	*S. alterniflora*	25%	100%	163	Y	645	5754	0	0
ACWT4-08-OQ9	105	*S. alterniflora*	15%	75%	143	N				
		P. virginica	5%	25%	75	N				
ACWT4-08-OQ10	101	*S. alterniflora*	35%	95%	118	Y				
		P. virginica	1%	3%	65	N				
		A. cannabinus	1%	3%	100	Y				
ACWT4-08-CQ3	64	*E. walteri*	15%	75%	170	Y	621	5536	0	0
		P. australis	5%	25%	68	Y	74	660	0	0
ACWT4-08-CQ4	60	*E. walteri*	35%	95%	165	Y	1138	10154	0	0
		P. australis	1%	3%	212	Y	140	1251	0	0
		S. alterniflora	1%	3%	128	N	9	79	0	0
ACWT4-08-OQ11	54	*E. walteri*	15%	68%	146	Y				
		S. robustus	1%	5%	155	Y				
		T. latifolia	5%	23%	218	N				
		P. australis	1%	5%	260	Y				
ACWT4-08-OQ12	45	*E. walteri*	5%	23%	150	Y				
		P. australis	15%	68%	230	Y				
		P. punctatum	1%	5%	150	N				
		S. cynosuroides	1%	5%	190	Y				
ACWT4-08- Mean Spartina dominated Quadrats (b)			29%		182		879	7839	0	0
ACWT4-08- Mean Non-Spartina dominated Quadrats (b)			26%		--		991	8840	0	0
ACWT4-08- Mean All Quadrats			27%		--		935	8339	0	0
Site Mean Spartina dominated Quadrats (b)			44%		129		1067	9523	0	58
Site Mean Non-Spartina dominated Quadrats (b)			34%		--		710	6338	28	48
Site Mean All Quadrats			40%		--		940	8385	10	54

Table D-5
THE ROCKS PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
The Rocks-08- Transect 1 8/20/08										
TRT1-08-OQ1	404	*S. alterniflora*	25%	63%	81	N				
		S. robustus	15%	38%	102	Y				
TRT1-08-CQ1	397	*S. alterniflora*	35%	69%	65	N	376	3350	0	0
		S. pungens	15%	29%	94	Y	27	244	0	0
		P. punctatum	1%	2%	28	Y	31	276	0	0
TRT1-08-OQ2	382	*S. alterniflora*	35%	78%	77	N				
		S. robustus	5%	11%	110	N				
		P. punctatum	5%	11%	89	Y				
TRT1-08-OQ3	373	*S. alterniflora*	45%	96%	90	N				
		S. robustus	1%	2%	87	Y				
		P. punctatum	1%	2%	50	Y				
TRT1-08-OQ4	359	*S. alterniflora*	55%	100%	110	N				
TRT1-08-OQ5	320	*S. alterniflora*	45%	100%	81	N				
TRT1-08-OQ6	274	*S. alterniflora*	35%	97%	65	N				
		P. australis	1%	3%	93	N				
TRT1-08-OQ7	263	*S. alterniflora*	35%	97%	79	N				
		A. cannabinus	1%	3%	83	Y				
TRT1-08-OQ8	260	*S. alterniflora*	25%	93%	87	Y				
		P. punctatum	1%	4%	65	Y				
		A. cannabinus	1%	4%	115	Y				
TRT1-08-OQ9	238	*S. alterniflora*	55%	92%	118	N				
		A. cannabinus	5%	8%	120	Y				
TRT1-08-OQ10	152	*S. alterniflora*	5%	13%	90	N				
		S. cynosuroides	35%	88%	174	Y				
TRT1-08-OQ11	103	*S. alterniflora*	65%	100%	135	Y				
TRT1-08-CQ2	95	*S. alterniflora*	35%	70%	125	Y	543	4847	0	0
		A. cannabinus	15%	30%	110	Y	61	541	0	0
TRT1-08-OQ12	45	*S. alterniflora*	25%	93%	145	Y				
		P. punctatum	1%	4%	89	Y				
		A. cannabinus	1%	4%	90	Y				
TRT1-08-CQ3	8	*T. angustifolia*	55%	100%	196	Y	1608	14346	0	0
TRT1-08-CQ4	3	*T. angustifolia*	35%	88%	188	Y	903	8055	0	0
		P. purpurascens	5%	13%	25	Y	13	117	0	0
TRT1-08- Mean Spartina dominated Quadrats (b)			45%		101		519	4629	0	0
TRT1-08- Mean Non-Spartina dominated Quadrats (b)			48%		--		1262	11259	0	0
TRT1-08- Mean All Quadrats			45%		--		890	7944	0	0

Table D-5
THE ROCKS PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
The Rocks-08- Transect 2 8/16/08										
TRT2-08-CQ1	307	*S. alterniflora*	75%	88%	111	Y	1179	10523	0	23
		P. punctatum	5%	6%	52	Y	10	93	0	0
		A. patula	5%	6%	70	Y	13	112	0	0
TRT2-08-OQ1	296	*S. alterniflora*	5%	9%	67	Y				
		P. punctatum	50%	91%	109	Y				
TRT2-08-OQ2	281	*S. alterniflora*	45%	100%	143	Y				
TRT2-08-OQ3	272	*S. alterniflora*	40%	89%	121	Y				
		A. patula	5%	11%	97	Y				
TRT2-08-OQ4	251	*S. alterniflora*	50%	91%	125	Y				
		P. punctatum	5%	9%	84	Y				
TRT2-08-CQ2	227	*S. alterniflora*	55%	100%	187	Y	1034	9228	0	24
TRT2-08-OQ5	203	*S. alterniflora*	35%	78%	149	Y				
		P. punctatum	5%	11%	86	Y				
		P. australis	5%	11%	123	Y				
TRT2-08-OQ6	201	*S. alterniflora*	10%	25%	139	N				
		P. australis	30%	75%	150	Y				
TRT2-08-OQ7	193	*S. alterniflora*	20%	57%	103	N				
		P. australis	15%	43%	126	Y				
TRT2-08-OQ8	177	*S. alterniflora*	30%	86%	171	Y				
		P. australis	5%	14%	100	N				
TRT2-08-OQ9	173	*S. alterniflora*	45%	100%	84	Y				
TRT2-08-OQ10	115	*S. alterniflora*	5%	19%	102	N				
		P. purpurascens	1%	4%	56	Y				
		T. latifolia	20%	77%	134	Y				
TRT2-08-CQ3	88	*S. cynosuroides*	10%	63%	194	Y	1566	13971	0	0
		P. australis	5%	31%	158	Y	115	1030	0	0
		P. purpurascens	1%	6%	27	Y	1	8	0	0
TRT2-08-OQ11	60	*P. punctatum*	1%	3%	32	Y				
		T. latifolia	5%	14%	120	Y				
		S. robustus	5%	14%	106	Y				
		S. cynosuroides	25%	69%	140	Y				
TRT2-08-OQ12	7	*P. purpurascens*	1%	4%	45	Y				
		S. cynosuroides	25%	96%	196	Y				
TRT2-08-CQ4	2	*S. cynosuroides*	15%	100%	170	Y	1104	9849	0	0
TRT2-08- Mean Spartina dominated Quadrats (b)			44%		142		1114	9935	0	16
TRT2-08- Mean Non-Spartina dominated Quadrats (b)			34%		--		1682	15009	0	0
TRT2-08- Mean All Quadrats			41%		--		1256	11203	0	12

Table D-5
THE ROCKS PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m^2	Litter gdw/m^2
			Aerial	Relative			gdw/m^2	lb/acre		
The Rocks-08- Transect 3 8/16/08										
TRT3-08-OQ1	390	*S. cynosuroides*	40%	62%	300	Y				
		P. punctatum	25%	38%	116	Y				
TRT3-08-CQ1	359	*S. robustus*	1%	2%	174	N	86	768	0	58
		S. cynosuroides	55%	98%	270	Y	1563	13948	0	0
TRT3-08-OQ2	390	*S. cynosuroides*	55%	98%	280	Y				
		S. robustus	1%	2%	140	Y				
TRT3-08-OQ3	390	*S. cynosuroides*	5%	11%	170	N				
		S. alterniflora	40%	89%	170	N				
TRT3-08-OQ4	390	*S. cynosuroides*	15%	43%	140	Y				
		S. alterniflora	20%	57%	130	N				
TRT3-08-OQ5	390	*S. cynosuroides*	35%	78%	340	Y				
		S. alterniflora	10%	22%	136	N				
TRT3-08-CQ2	329	*S. robustus*	1%	2%	120	N	56	501	0	154
		S. cynosuroides	45%	98%	350	Y	3595	32076	0	0
TRT3-08-OQ6	390	*S. cynosuroides*	55%	98%	250	Y				
		P. punctatum	1%	2%	61	Y				
TRT3-08-OQ7	390	*S. alterniflora*	55%	98%	171	Y				
		P. australis	1%	2%	51	N				
TRT3-08-OQ8	390	*S. alterniflora*	25%	100%	64	N				
TRT3-08-OQ9	390	*S. alterniflora*	85%	94%	74	N				
		Unknown	5%	6%	71	Y				
TRT3-08-OQ10	390	*S. alterniflora*	75%	99%	99	Y				
		Unknown	1%	1%	76	Y				
TRT3-08-CQ3	251	*S. patens*	10%	38%	55	N	91	808	0	145
		P. australis	1%	4%	104	Y	32	288	0	0
		S. olneyi	5%	19%	91	Y	83	739	0	0
		S. cynosuroides	20%	77%	179	Y	636	5678	0	0
TRT3-08-OQ11	390	*S. cynosuroides*	45%	98%	235	Y				
		P. Purpurascens	1%	2%	2	N				
TRT3-08-OQ12	390	*S. cynosuroides*	35%	97%	185	Y				
		P. purpurascens	1%	3%	12	Y				
TRT3-08-OQ13	390	*S. cynosuroides*	30%	86%	137	Y				
		P. punctatum	5%	14%	38	Y				
TRT3-08-CQ4	204	*S. patens*	85%	84%	69	N	312	2785	0	4
		S. cynosuroides	1%	1%	125	N	21	188	0	0
		S. olneyi	15%	15%	96	Y	222	1984	0	0

Table D-5
THE ROCKS PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
The Rocks-08- Transect 3 8/16/08 - cont.										
TRT3-08-CQ5	202	*S. olneyi*	5%	19%	104	Y	46	406	0	21
		S. cynosuroides	20%	77%	153	N	319	2842	0	0
		P. purpurascens	5%	19%	17	N	1	7	0	0
		P. australis	1%	4%	97	N	16	143	0	0
TRT3-08-OQ14	390	*S. robustus*	5%	5%	104	Y				
		P. punctatum	1%	1%	42	Y				
		S. patens	70%	77%	79	N				
		S. olneyi	15%	16%	112	Y				
TRT3-08-CQ6	169	*S. olneyi*	30%	86%	112	Y	641	5717	0	8
		S. patens	5%	14%	74	N	10	91	0	0
TRT3-08-OQ15	390	*P. purpurascens*	5%	17%	49	Y				
		S. patens	5%	17%	88	N				
		S. olneyi	20%	67%	119	Y				
TRT3-08-OQ16	390	*P. punctatum*	1%	1%	54	Y				
		S. patens	95%	94%	46	N				
		S. olneyi	5%	5%	104	N				
TRT3-08-OQ17	390	*P. punctatum*	10%	11%	82	Y				
		S. patens	80%	84%	71	N				
		S. olneyi	5%	5%	94	N				
TRT3-08-OQ18	390	*S. olneyi*	25%	100%	134	Y				
TRT3-08-OQ19	390	*P. purpurascens*	5%	14%	36	Y				
		S. patens	5%	14%	92	N				
		S. olneyi	25%	71%	122	Y				
TRT3-08-OQ20	390	*S. cynosuroides*	15%	58%	99	N				
		S. alterniflora	5%	19%	117	Y				
		P. australis	1%	4%	48	N				
		P. purpurascens	5%	19%	31	Y				
TRT3-08-OQ21	390	*S. cynosuroides*	25%	71%	188	Y				
		P. australis	5%	14%	132	N				
		Solidago sempervirens	5%	14%	132	N				
TRT3-08-OQ22	390	*S. cynosuroides*	25%	96%	189	Y				
		P. punctatum	1%	4%	67	Y				
TRT3-08-CQ7	85	*S. olneyi*	30%	54%	129	Y	467	4165	0	8
		S. patens	20%	36%	94	N	165	1474	0	0
		P. punctatum	5%	9%	85	Y	43	383	0	0
		P. purpurascens	1%	2%	38	Y	1	5	0	0
TRT3-08-CQ8	6	*S. sempervirens*	20%	57%	91	N	422	3762	0	8
		S. cynosuroides	15%	43%	221	Y	906	8087	0	0
TRT3-08- Mean Spartina dominated Quadrats (b)			47%		191		1631	14551	0	95
TRT3-08- Mean Non-Spartina dominated Quadrats (b)			57%		--		803	7160	0	7
TRT3-08- Mean All Quadrats			51%		--		1217	10856	0	51

Table D-5
THE ROCKS PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
The Rocks-08- Transect 4 8/16/08										
TRT4-08-OQ1	214	*S. cynosuroides*	55%	100%	156	Y				
TRT4-08-OQ2	205	*S. cynosuroides*	15%	60%	75	Y				
		E. walteri	5%	20%	66	Y				
		P. australis	5%	20%	84	N				
TRT4-08-CQ1	149	*S. cynosuroides*	30%	73%	138	Y	390	3483	0	59
		Dead *P. australis*	5%	--	--	--	0	0	258	0
		P. purpurascens	1%	2%	30	Y	1	7	0	0
		S. alterniflora	5%	9%	70	N	192	1715	0	0
TRT4-08-CQ2	92	*S. patens*	15%	33%	62	N	39	344	0	8
		S. cynosuroides	30%	67%	85	N	547	4877	0	0
TRT4-08-OQ3	67	*S. cynosuroides*	5%	100%	130	Y				
TRT4-08-OQ4	37	*S. cynosuroides*	15%	30%	86	N				
		P. australis	15%	30%	82	N				
		Dead *P. australis*	5%	--	--	--				
		A. patula	15%	30%	62	Y				
TRT4-08-OQ5	35	*S. cynosuroides*	20%	50%	121	N				
		E. walteri	10%	25%	64	Y				
		P. australis	5%	13%	139	N				
		A. patula	5%	13%	65	Y				
TRT4-08-OQ6	20	*S. cynosuroides*	30%	60%	169	Y				
		E. walteri	10%	20%	112	N				
		P. australis	10%	20%	188	Y				
TRT4-08- Mean Spartina dominated Quadrats (b)			50%		116		584	5213	129	34
TRT4-08- Mean Non-Spartina dominated Quadrats (b)			28%		--		0	0	0	0
TRT4-08- Mean All Quadrats			45%		--		584	5213	129	34

Site Mean Spartina dominated Quadrats (b)		46%		147		1097	9790	23	45
Site Mean Non-Spartina dominated Quadrats (b)		48%		--		1059	9453	0	4
Site Mean All Quadrats		47%		--		1083	9659	14	29

Table D-6
CEDAR SWAMP PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Cedar Swamp-08- Transect 1 8/15/08										
CST1-08-OQ1	99	*S. alterniflora*	50%	89%	106	N				
		Dead S. alterniflora	5%	--	--	--				
		A. cannabinus	1%	2%	59	Y				
CST1-08-CQ1	84	*S. alterniflora*	55%	100%	102	N	880	7853	0	173
CST1-08-OQ2	78	*S. alterniflora*	50%	98%	118	N				
		Dead. S. alterniflora	1%	--	--	--				
CST1-08-OQ3	76	*S. alterniflora*	55%	96%	111	N				
		Dead S. alterniflora	1%	--	--	--				
		A. cannabinus	1%	2%	120	Y				
CST1-08-OQ4	71	*S. alterniflora*	45%	98%	121	N				
		Dead. S. alterniflora	1%	--	--	--				
CST1-08-OQ5	70	*S. alterniflora*	35%	97%	111	N				
		Dead. S. alterniflora	1%	--	--	--				
CST1-08-OQ6	68	*S. alterniflora*	35%	97%	108	N				
		Dead. S. alterniflora	1%	--	--	--				
CST1-08-CQ2	65	*S. alterniflora*	35%	100%	113	N	1261	11251	0	156
CST1-08-OQ7	56	*S. alterniflora*	20%	57%	110	N				
		S. robustus	15%	43%	116	N				
CST1-08-OQ8	33	*S. robustus*	5%	11%	135	N				
		S. cynosuroides	40%	89%	172	Y				
CST1-08-OQ9	28	*S. robustus*	35%	97%	121	N				
		S. cynosuroides	1%	3%	141	N				
CST1-08-OQ10	27	*S. robustus*	35%	97%	136	Y				
		A. patula	1%	3%	69	N				
CST1-08-OQ11	21	*S. cynosuroides*	45%	100%	278	Y				
CST1-08-CQ3	17	*S. cynosuroides*	35%	85%	250	Y	1967	17550	0	558
		Dead S. cynosuroides	5%	--	--	--	0	0	299	0
		S. robustus	1%	2%	186	N	179	1595	0	0
CST1-08-CQ4	14	*S. cynosuroides*	40%	80%	280	Y	2019	18016	0	688
		Dead S. cynosuroides	5%	--	--	--	0	0	502	0
		S. robustus	5%	10%	169	N	169	1505	0	0
CST1-08-OQ12	1	*S. cynosuroides*	20%	77%	264	Y				
		A. patula	5%	19%	165	N				
		Dead S. cynosuroides	1%	--	--	--				
CST1-08- Mean Spartina dominated Quadrats (b)			44%		158		1619	14443	200	394
CST1-08- Mean Non-Spartina dominated Quadrats (b)			36%		--		0	0	0	0
CST1-08- Mean All Quadrats			43%		--		1619	14443	200	394

Table D-6
CEDAR SWAMP PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m²	Litter gdw/m²
			Aerial	Relative			gdw/m²	lb/acre		
Cedar Swamp-08- Transect 2 8/13/08										
CST2-08-OQ1	119	*S. alterniflora*	45%	100%	98	Y				
CST2-08-CQ1	116	*S. robustus*	4%	9%	108	N	77	688	0	196
		P. australis	1%	2%	118	N	58	515	0	0
		S. alterniflora	40%	89%	115	N	695	6201	0	0
CST2-08-OQ2	113	*S. alterniflora*	35%	78%	109	N				
		S. cynosuroides	5%	11%	175	Y				
		S. robustus	5%	11%	125	Y				
CST2-08-CQ2	112	*S. alterniflora*	30%	67%	90	N	620	5527	0	59
		S. robustus	10%	22%	111	Y	96	859	0	0
		P. purpurascens	5%	11%	35	N	2	20	0	0
CST2-08-OQ3	111	*S. alterniflora*	25%	71%	95	N				
		S. robustus	10%	29%	120	N				
CST2-08-OQ4	107	*S. alterniflora*	25%	71%	86	N				
		S. robustus	10%	29%	120	N				
CST2-08-OQ5	105	*S. alterniflora*	10%	38%	99	N				
		S. cynosuroides	5%	19%	172	N				
		S. robustus	10%	38%	113	N				
		P. purpurascens	1%	4%	18	N				
CST2-08-OQ6	100	*S. cynosuroides*	35%	100%	18	Y				
CST2-08-OQ7	83	*S. cynosuroides*	50%	91%	182	Y				
		S. robustus	5%	9%	139	N				
CST2-08-OQ8	82	*S. cynosuroides*	50%	91%	180	Y				
		S. robustus	5%	9%	135	N				
CST2-08-OQ9	79	*S. cynosuroides*	40%	89%	180	Y				
		S. robustus	5%	11%	130	N				
CST2-08-CQ3	74	*S. cynosuroides*	30%	83%	132	N	99	886	0	301
		Dead *S. cynosuroides*	5%	--	--	--	0	0	306	0
		S. robustus	1%	3%	97	Y	85	757	0	0
CST2-08-OQ10	74	*S. cynosuroides*	30%	83%	132	N				
		S. robustus	1%	3%	97	N				
		Dead *S. cynosuroides*	5%	--	--	--				
CST2-08-OQ11	62	*S. cynosuroides*	10%	40%	158	N				
		S. robustus	10%	40%	196	N				
		Dead *S. cynosuroides*	5%	--	--	--				
CST2-08-OQ12	60	*S. cynosuroides*	25%	83%	184	Y				
		Dead *S. cynosuroides*	5%	--	--	--				
CST2-08-CQ4	54	*S. cynosuroides*	5%	100%	102	N	107	959	0	203
CST2-08-OQ13	45	*S. cynosuroides*	25%	96%	180	Y				
		Dead *S. cynosuroides*	1%	--	--	--				
CST2-08-CQ5	25	*P. australis*	5%	60%	245	Y	573	5117	0	301
		Dead *P. australis*	15%	--	--	--	0	0	442	0
		S. robustus	1%	20%	162	N	15	137	0	0
CST2-08-OQ14	21	*S. cynosuroides*	15%	60%	250	Y				
		Dead *S. cynosuroides*	10%	--	--	--				
CST2-08-CQ6	13	*P. australis*	15%	94%	244	Y	1359	12127	0	8
		Dead *P. australis*	1%	--	--	--	0	0	346	0
CST2-08-OQ15	9	*S. cynosuroides*	10%	67%	120	Y				
		Dead *S. cynosuroides*	5%	--	--	--				
CST2-08-OQ16	3	*S. alterniflora*	25%	71%	87	N				
		S. robustus	5%	14%	145	Y				
		I. frutescens	5%	14%	93	N				
CST2-08-OQ17	2	*S. alterniflora*	55%	100%	81	N				
CST2-08-OQ18	0	*S. cynosuroides*	5%	10%	110	N				
		I. frutescens	5%	10%	91	N				
		A. patula	40%	80%	88	Y				
CST2-08- Mean Spartina dominated Quadrats (b)			41%		122		577	5151	102	185
CST2-08- Mean Non-Spartina dominated Quadrats (b)			23%		--		685	6113	263	171
CST2-08- Mean All Quadrats			35%		--		631	5632	182	178

Table D-6
CEDAR SWAMP PHRAGMITES DOMINATED WETLAND RESTORATION SITE
PEAK SEASON 2008 TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m^2	Litter gdw/m^2
			Aerial	Relative			gdw/m^2	lb/acre		
Cedar Swamp-08- Transect 3 8/18/08										
CST3-08-OQ1	365	*S. alterniflora*	55%	100%	73	N				
CST3-08-OQ2	338	*S. alterniflora*	65%	100%	81	N				
CST3-08-CQ1	289	*S. alterniflora*	65%	100%	63	N	356	3180	0	101
CST3-08-OQ3	288	*S. alterniflora*	65%	100%	66	N				
CST3-08-CQ2	256	*S. alterniflora*	45%	100%	56	N	309	2759	0	117
CST3-08-OQ4	247	*S. alterniflora*	35%	97%	61	N				
		P. australis	1%	3%	81	N				
CST3-08-OQ5	205	*S. alterniflora*	45%	100%	61	N				
CST3-08-OQ6	186	*S. alterniflora*	35%	100%	63	N				
CST3-08-OQ7	182	*S. alterniflora*	35%	64%	68	N				
		P. australis	15%	27%	109	N				
		P. punctatum	5%	9%	42	Y				
CST3-08-OQ8	164	*S. alterniflora*	50%	91%	57	N				
		P. punctatum	5%	9%	31	Y				
CST3-08-OQ9	122	*S. alterniflora*	65%	100%	61	N				
CST3-08-CQ3	84	*S. cynosuroides*	45%	100%	160	Y	928	8279	0	51
CST3-08-OQ10	80	*S. cynosuroides*	45%	98%	198	Y				
		Dead S. cynosuroides	1%	--	--	--				
CST3-08-OQ11	41	*P. punctatum*	1%	2%	58	Y				
		S. cynosuroides	65%	98%	144	N				
CST3-08-CQ4	10	*S. cynosuroides*	35%	100%	170	N	1002	8938	0	470
CST3-08-OQ12	9	*S. cynosuroides*	35%	100%	174	N				
CST3-08- Mean Spartina dominated Quadrats (b)			51%		97		649	5789	0	185
CST3-08- Mean Non-Spartina dominated Quadrats (b)			0%		--		0	0	0	0
CST3-08- Mean All Quadrats			51%		--		649	5789	0	185
Cedar Swamp-08- Transect 4 8/15/08										
CST4-08-OQ1	199	*S. alterniflora*	35%	88%	82	N				
		P. purpurascens	5%	13%	51	Y				
CST4-08-OQ2	122	*S. alterniflora*	35%	85%	90	N				
		P. purpurascens	1%	2%	38	Y				
		Dead S. alterniflora	5%	--	--	--				
CST4-08-OQ3	92	*S. alterniflora*	25%	83%	104	N				
		Dead S. alterniflora	5%	--	--	--				
CST4-08-OQ4	45	*S. alterniflora*	25%	96%	78	N				
		Dead S. alterniflora	1%	--	--	--				
CST4-08-OQ5	17	*S. alterniflora*	25%	83%	80	N				
		Dead S. alterniflora	5%	--	--	--				
CST4-08-OQ6	14	*S. alterniflora*	5%	50%	72	N				
		Dead S. alterniflora	5%	--	--	--				
CST4-08-CQ1	160	*S. alterniflora*	35%	88%	110	N	666	5946	0	47
		P. purpurascens	5%	13%	60	Y	10	88	0	0
CST4-08-CQ2	28	*S. alterniflora*	15%	50%	90	N	583	5206	0	22
		Dead S. alterniflora	15%	--	--	--	0	0	207	0
CST4-08- Mean Spartina dominated Quadrats (b)			35%		91		676	6033	0	47
CST4-08- Mean Non-Spartina dominated Quadrats (b)			20%		--		583	5206	207	22
CST4-08- Mean All Quadrats			31%		--		630	5620	103	34

Site Mean Spartina dominated Quadrats (b)	44%		120		957	8534	92	243
Site Mean Non-Spartina dominated Quadrats (b)	25%		--		660	5886	249	134
Site Mean All Quadrats	40%		--		882	7872	131	216

(a) Quadrat numbers ending in "OQ##" indicate ocular quadrats, those ending in "CQ##" indicate clip quadrats.
(b) Spartina dominated quadrats include those dominated by S. alterniflora and/or S. cynosuroides.

Appendix E
Macrophyte Quadrat Data - Plots

Table E-1
MAD HORSE CREEK REFERENCE MARSH
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m^2	lb/acre	gdw/m^2	gdw/m^2
Mad Horse Creek - Plot 1 8/21/08									
MHP1-08-VP1	*Spartina alterniflora*	65%	100%	102	N	688	6141	0	76
MHP1-08-VP2	*S. alterniflora*	45%	100%	96	N	631	5630	0	147
MHP1-08-VP3	*S. alterniflora*	65%	92%	134	N	780	6961	0	27
	Scirpus robustus	1%	1%	103	N	2	14	0	0
	Spartina cynosuroides	5%	7%	198	Y	507	4525	0	0
MHP1-08-VP4	*S. alterniflora*	65%	100%	119	N	704	6283	0	59
MHP1-08-VP5	*S. alterniflora*	75%	100%	102	N	602	5368	0	455
MHP1-08-VP6	*S. alterniflora*	45%	90%	102	N	516	4600	0	284
	S. robustus	5%	10%	119	N	89	795	0	0
MHP1-08-VP7	*S. alterniflora*	45%	75%	97	N	519	4629	0	204
	Distichlis spicata	15%	25%	59	N	27	243	0	0
MHP1-08-VP8	*S. alterniflora*	65%	100%	114	N	967	8626	0	306
MHP1-08-VP9	*S. alterniflora*	55%	100%	105	N	669	5973	0	315
Mean for Plot		61%		117		745	6643	0	208
Mad Horse Creek - Plot 2 8/20/08									
MHP2-08-VP1	*S. alterniflora*	55%	100%	106	N	694	6188	0	86
MHP2-08-VP2	*S. alterniflora*	25%	42%	101	N	869	7757	0	130
	S. robustus	35%	58%	121	N	338	3012	0	0
MHP2-08-VP3	*S. alterniflora*	45%	100%	110	N	616	5497	0	270
MHP2-08-VP4	*S. alterniflora*	65%	100%	97	N	469	4187	0	380
MHP2-08-VP5	*S. alterniflora*	45%	100%	67	N	708	6319	0	3
MHP2-08-VP6	*S. alterniflora*	45%	100%	61	N	531	4738	0	34
MHP2-08-VP7	*S. alterniflora*	35%	58%	122	N	1017	9073	0	129
	S. robustus	25%	42%	143	N	195	1741	0	0
MHP2-08-VP8	*S. alterniflora*	45%	100%	80	N	694	6194	0	66
MHP2-08-VP9	*S. alterniflora*	25%	56%	91	N	570	5090	0	179
	S. robustus	15%	33%	111	N	28	253	0	0
	D. spicata	5%	11%	63	N	8	69	0	0
Mean for Plot		52%		93		749	6680	0	142
Mad Horse Creek - Plot 3 8/20/08									
MHP3-08-VP1	*S. alterniflora*	25%	63%	74	N	576	5139	0	133
	D. spicata	15%	38%	39	Y	33	293	0	0
MHP3-08-VP2	*S. alterniflora*	25%	42%	83	N	507	4523	0	86
	Spartina patens	35%	58%	51	N	187	1667	0	0
MHP3-08-VP3	*S. alterniflora*	35%	100%	77	N	508	4532	0	60
MHP3-08-VP4	*S. alterniflora*	65%	100%	126	N	1135	10129	0	60
MHP3-08-VP5	*S. alterniflora*	55%	92%	122	N	955	8518	0	194
	S. cynosuroides	5%	8%	162	Y	209	1868	0	0
MHP3-08-VP6	*S. alterniflora*	55%	100%	105	N	947	8452	0	130
MHP3-08-VP7	*S. alterniflora*	45%	90%	111	N	896	7995	0	181
	S. cynosuroides	5%	10%	173	Y	142	1264	0	0
MHP3-08-VP8	*S. cynosuroides*	15%	75%	197	Y	1054	9407	236	264
MHP3-08-VP9	*S. alterniflora*	45%	74%	132	N	453	4045	0	145
	S. cynosuroides	15%	25%	203	Y	343	3063	0	0
	S. robustus	1%	2%	124	N	14	129	0	0
Mean for Plot		49%		124		885	7892	26	139
Mean for Site		54%		112		793	7072	9	163

Table E-2
MOORES BEACH REFERENCE MARSH
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m^2	lb/acre	gdw/m^2	gdw/m^2
Moores Beach - Plot 1 8/17/08									
MBP1-08-VP1	*S. alterniflora*	35%	100%	103	N	683	6090	0	80
	Dead P. australis	<1%	--	--	--	0	0	47	0
MBP1-08-VP2	*S. alterniflora*	55%	100%	121	N	1056	9425	0	346
	Dead P. australis	5%	--	--	--	0	0	267	0
MBP1-08-VP3	*S. alterniflora*	25%	100%	96	N	571	5098	0	47
	Dead S. alterniflora	<1	--	--	--	0	0	121	0
MBP1-08-VP4	*S. alterniflora*	35%	100%	104	N	833	7429	0	35
	Dead S. alterniflora	<1	--	--	--	0	0	55	0
MBP1-08-VP5	*S. alterniflora*	25%	100%	142	N	762	6797	0	369
	Dead P. australis	5%	--	--	--	0	0	115	0
MBP1-08-VP6	*S. alterniflora*	15%	100%	90	N	284	2535	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	158	0
MBP1-08-VP7	*S. alterniflora*	25%	100%	98	N	443	3951	0	0
	Dead S. alterniflora	<1	--	--	--	0	0	56	0
MBP1-08-VP8	*S. alterniflora*	15%	100%	100	N	576	5136	0	0
	Dead S. alterniflora	<1	--	--	--	0	0	128	0
MBP1-08-VP9	*S. alterniflora*	15%	100%	150	N	631	5632	0	0
	Dead S. alterniflora	<1	--	--	--	0	0	74	0
Mean for Plot		27%		111		649	5788	113	97
Moores Beach - Plot 2 8/17/08									
MBP2-08-VP1	*S. alterniflora*	45%	100%	92	N	566	5051	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	28	0
MBP2-08-VP2	*S. alterniflora*	35%	100%	90	N	600	5350	0	72
	Dead S. alterniflora	5%	--	--	--	0	0	69	0
MBP2-08-VP3	*S. alterniflora*	45%	100%	120	N	968	8637	0	0
	Dead S. alterniflora	<1	--	--	--	0	0	197	0
MBP2-08-VP4	*S. alterniflora*	35%	100%	90	N	744	6642	0	0
	Dead S. alterniflora	<1	--	--	--	0	0	235	0
MBP2-08-VP5	*S. alterniflora*	35%	100%	101	N	1242	11084	0	48
	Dead S. alterniflora	5%	--	--	--	0	0	30	0
MBP2-08-VP6	*S. alterniflora*	35%	100%	81	N	787	7022	0	133
	Dead S. alterniflora	5%	--	--	--	0	0	119	0
MBP2-08-VP7	*S. alterniflora*	35%	100%	90	N	505	4506	0	0
	Dead S. alterniflora	<1	--	--	--	0	0	125	0
MBP2-08-VP8	*S. alterniflora*	1%	100%	85	N	225	2003	0	0
	Dead S. alterniflora	35%	--	--	--	0	0	377	0
MBP2-08-VP9	*S. alterniflora*	25%	100%	110	N	910	8123	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	357	0
Mean for Plot		32%		97		728	6491	171	28

Table E-2
MOORES BEACH REFERENCE MARSH
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m^2	lb/acre	gdw/m^2	gdw/m^2
Moores Beach - Plot 3 8/16/08									
MBP3-08-VP1	*S. alterniflora*	15%	100%	79	N	424	3782	0	175
	Dead S. alterniflora	25%	--	--	--	0	0	989	0
MBP3-08-VP2	*S. alterniflora*	65%	100%	97	N	1281	11425	0	380
MBP3-08-VP3	*S. alterniflora*	15%	100%	92	N	903	8055	0	101
	Dead S. alterniflora	5%	--	--	--	0	0	210	0
MBP3-08-VP4	*S. alterniflora*	5%	100%	87	N	251	2241	0	489
	Dead S. alterniflora	25%	--	--	--	0	0	1127	0
MBP3-08-VP5	*S. alterniflora*	35%	100%	102	N	1619	14441	0	207
MBP3-08-VP6	*S. alterniflora*	25%	100%	86	N	786	7011	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	550	0
MBP3-08-VP7	*S. alterniflora*	20%	100%	110	N	793	7073	0	388
	Dead S. alterniflora	25%	--	--	--	0	0	45	0
MBP3-08-VP8	*S. alterniflora*	5%	100%	68	N	275	2453	0	398
MBP3-08-VP9	*S. alterniflora*	65%	100%	65	N	1217	10859	0	141
Mean for Plot		28%		92		839	7482	325	253
Mean for Site		29%		100		738	6587	203	126

Table E-3
COMMERCIAL TOWNSHIP SALT HAY FARM WETLAND RESTORATION SITE
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m²	lb/acre	gdw/m²	gdw/m²
Commercial Township - Plot 1 8/15/08									
CTP1-08-VP1	Mud Flat	0%	--	--	--	0	0	0	0
CTP1-08-VP2	Mud Flat	0%	--	--	--	0	0	0	0
CTP1-08-VP3	*S. alterniflora*	55%	100%	172	Y	1573	14037	0	147
CTP1-08-VP4	*S. alterniflora*	55%	100%	145	N	1354	12076	0	11
CTP1-08-VP5	Mud Flat	0%	--	--	--	0	0	0	0
CTP1-08-VP6	Mud Flat	0%	--	--	--	0	0	0	0
CTP1-08-VP7	*S. alterniflora*	55%	100%	122	Y	1656	14771	0	0
CTP1-08-VP8	Mud Flat	0%	--	--	--	0	0	0	0
CTP1-08-VP9	Mud Flat	0%	--	--	--	0	0	0	0
Mean for Plot		18%		146		509	4543	0	18
Commercial Township - Plot 2 8/15/08									
CTP2-08-VP1	*S. alterniflora*	35%	100%	151	Y	1051	9376	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	63	0
CTP2-08-VP2	*S. alterniflora*	35%	100%	148	N	1531	13655	0	0
	Dead S. alterniflora	1%	--	--	--	0	0	278	0
CTP2-08-VP3	*S. alterniflora*	45%	100%	110	N	1806	16116	0	0
	Dead P. australis	5%	--	--	--	0	0	93	0
CTP2-08-VP4	*S. alterniflora*	35%	100%	155	Y	678	6045	0	29
CTP2-08-VP5	*S. alterniflora*	45%	100%	145	N	1460	13028	0	0
	Dead P. australis	5%	--	--	--	0	0	123	0
	Dead S. alterniflora	5%	--	--	--	0	0	228	0
CTP2-08-VP6	*S. alterniflora*	85%	100%	127	N	1192	10632	0	524
CTP2-08-VP7	Mud Flat	0%	--	--	--	0	0	0	0
CTP2-08-VP8	*S. alterniflora*	65%	100%	185	N	2912	25981	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	312	0
CTP2-08-VP9	*S. alterniflora*	65%	100%	102	N	1080	9638	0	269
	Dead P. australis	5%	--	--	--	0	0	162	0
Mean for Plot		46%		140		1301	11608	140	91
Commercial Township - Plot 3 8/15/08									
CTP3-08-VP1	*S. alterniflora*	65%	100%	183	N	788	7027	0	70
	Dead S. alterniflora	5%	--	--	--	0	0	171	0
CTP3-08-VP2	*S. alterniflora*	65%	100%	165	N	1208	10774	0	112
	Dead S. alterniflora	5%	--	--	--	0	0	321	0
CTP3-08-VP3	*S. alterniflora*	65%	100%	164	N	660	5889	0	54
	Dead S. alterniflora	5%	--	--	--	0	0	390	0
CTP3-08-VP4	*S. alterniflora*	25%	100%	162	N	1310	11690	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	468	0
	Dead P. australis	1%	--	--	--	0	0	455	0
CTP3-08-VP5	*S. alterniflora*	25%	100%	152	Y	722	6437	0	0
CTP3-08-VP6	Mud Flat	0%	--	--	--	0	0	0	0
CTP3-08-VP7	*S. alterniflora*	75%	100%	92	N	925	8255	0	224
CTP3-08-VP8	*S. alterniflora*	85%	100%	141	N	1531	13664	0	35
CTP3-08-VP9	Mud Flat	0%	--	--	--	0	0	0	0
Mean for Plot		45%		151		794	7082	201	55

Table E-3
COMMERCIAL TOWNSHIP SALT HAY FARM WETLAND RESTORATION SITE
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m^2	lb/acre	gdw/m^2	gdw/m^2
Commercial Township - Plot 4 8/15/08 (Grasshopper)									
CTP4-08-VP1	*S. alterniflora*	45%	100%	121	N	1453	12966	0	29
	Dead S. alterniflora	5%	--	--	--	0	0	55	0
CTP4-08-VP2	*S. alterniflora*	45%	100%	107	N	532	4750	0	180
	Dead S. alterniflora	5%	--	--	--	0	0	372	0
CTP4-08-VP3	*S. alterniflora*	45%	100%	92	Y	1359	12129	0	0
CTP4-08-VP4	*S. alterniflora*	45%	100%	109	N	644	5748	0	76
	Dead S. alterniflora	5%	--	--	--	0	0	117	0
CTP4-08-VP5	Mud Flat	0%	--	--	--	0	0	0	0
CTP4-08-VP6	*S. alterniflora*	65%	100%	130	N	1251	11161	0	0
CTP4-08-VP7	*S. alterniflora*	45%	100%	105	N	633	5648	0	50
	Dead S. alterniflora	5%	--	--	--	0	0	53	0
CTP4-08-VP8	*S. alterniflora*	45%	100%	103	N	740	6601	0	37
CTP4-08-VP9	*S. alterniflora*	75%	100%	80	N	1291	11518	0	0
Mean for Plot		46%		106		878	7836	66	41
Mean for Site		39%		133		871	7767	102	51

Table E-4
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m^2	lb/acre	gdw/m^2	gdw/m^2
Alloway Creek Watershed - Plot 1 8/18/08									
ACWP1-08-VP1	*S. alterniflora*	25%	93%	220	Y	1311	11700	0	0
	P. punctatum	1%	4%	110	Y	7	59	0	0
	A. cannabinus	1%	4%	140	Y	24	212	0	0
ACWP1-08-VP2	*S. alterniflora*	25%	96%	190	Y	943	8410	0	0
	P. punctatum	1%	4%	120	Y	0	1	0	0
ACWP1-08-VP3	*S. alterniflora*	25%	100%	213	Y	1072	9565	0	0
ACWP1-08-VP4	Wrack	50%	50%	--	--	0	0	0	0
	Mud Flat	0%	--	--	--	0	0	0	0
ACWP1-08-VP5	*P. australis*	15%	100%	360	Y	1773	15823	0	105
ACWP1-08-VP6	*S. alterniflora*	35%	100%	112	N	463	4133	0	237
ACWP1-08-VP7	*S. alterniflora*	25%	96%	140	N	538	4801	0	0
	A. cannabinus	1%	4%	80	Y	6	50	0	0
	Dead S. alterniflora	5%	--	--	--	0	0	120	0
ACWP1-08-VP8	Wrack	50%	50%	--	--	0	0	0	0
	Mud Flat	0%	--	--	--	0	0	0	0
ACWP1-08-VP9	*S. robustus*	5%	16%	140	Y	76	677	0	156
	S. alterniflora	25%	81%	125	N	377	3360	0	0
	Peltandra virginica	1%	3%	66	N	5	41	0	0
Mean for Plot		32%		167		733	6537	13	55

Table E-4
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m^2	Litter gdw/m^2
		Aerial	Relative			gdw/m^2	lb/acre		
Alloway Creek Watershed - Plot 2 8/12/08									
ACWP2-08-VP1	*S. alterniflora*	40%	89%	97	N	641	5720	0	221
	A. cannabinus	5%	11%	154	Y	269	2397	0	0
ACWP2-08-VP2	*S. alterniflora*	25%	45%	100	N	550	4909	0	126
	A. cannabinus	30%	55%	121	Y	203	1814	0	0
ACWP2-08-VP3	*S. alterniflora*	20%	27%	80	N	366	3263	0	188
	P. australis	55%	73%	211	Y	511	4560	0	0
	Dead P. australis	1%	--	--	--	0	0	44	0
ACWP2-08-VP4	*S. alterniflora*	30%	67%	100	N	395	3522	0	48
	S. robustus	5%	11%	100	Y	39	348	0	0
	A. cannabinus	10%	22%	110	Y	158	1414	0	0
ACWP2-08-VP5	*S. alterniflora*	30%	86%	96	Y	466	4159	0	81
	A. cannabinus	5%	14%	96	Y	48	431	0	0
ACWP2-08-VP6	*S. alterniflora*	45%	82%	94	N	362	3231	0	182
	A. cannabinus	10%	18%	90	Y	32	287	0	0
ACWP2-08-VP7	*S. alterniflora*	15%	94%	90	Y	742	6618	0	0
	P. purpurascens	1%	7%	13	Y	3	27	0	0
ACWP2-08-VP8	*S. alterniflora*	20%	57%	90	N	457	4073	0	129
	A. cannabinus	15%	43%	140	Y	173	1540	0	0
ACWP2-08-VP9	*S. alterniflora*	30%	43%	156	N	1293	11535	0	34
	S. robustus	30%	43%	137	Y	218	1943	0	0
	A. cannabinus	5%	7%	121	Y	26	228	0	0
	P. punctatum	5%	7%	43	Y	1	10	0	0
Mean for Plot		48%		102		773	6892	5	112

Table E-4
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m²	lb/acre	gdw/m²	gdw/m²
Alloway Creek Watershed - Plot 3 8/12/08									
ACWP3-08-VP1	*S. alterniflora*	65%	100%	136	N	1290	11511	0	80
ACWP3-08-VP2	*S. alterniflora*	15%	50%	128	Y	554	4941	0	190
	S. robustus	15%	50%	123	Y	131	1166	0	0
ACWP3-08-VP3	*S. alterniflora*	25%	25%	115	Y	378	3376	0	0
	A. cannabinus	1%	1%	67	Y	6	52	0	0
	Wrack	74%	74%	--	--	0	0	0	0
ACWP3-08-VP4	*S. alterniflora*	25%	100%	143	Y	934	8330	0	0
ACWP3-08-VP5	*S. alterniflora*	65%	100%	148	Y	1642	14647	0	0
ACWP3-08-VP6	Wrack	100%	100%	--	--	0	0	0	0
ACWP3-08-VP7	*S. alterniflora*	15%	100%	121	N	329	2934	0	0
ACWP3-08-VP8	*S. alterniflora*	55%	100%	136	Y	1253	11179	0	0
ACWP3-08-VP9	*S. alterniflora*	75%	100%	124	N	1129	10077	0	72
Mean for Plot		59%		134		849	7579	0	38
Mean for Site		46%		131		785	7003	6	68

Table E-5
THE ROCKS WETLAND RESTORATION SITE
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing	Litter
		Aerial	Relative			gdw/m²	lb/acre	gdw/m²	gdw/m²
The Rocks - Plot 1 8/19/08									
TRP1-08-VP1	*S. alterniflora*	35%	97%	91	Y	677	6040	0	29
	P. punctatum	1%	3%	68	Y	4	34	0	0
TRP1-08-VP2	*S. alterniflora*	45%	100%	111	Y	1150	10259	0	73
TRP1-08-VP3	*S. alterniflora*	50%	91%	112	N	2122	18933	0	46
	S. cynosuroides	5%	9%	134	N	167	1489	0	0
TRP1-08-VP4	*S. alterniflora*	55%	96%	110	Y	1120	9992	0	70
	P. punctatum	1%	2%	81	Y	4	39	0	0
	A. cannabinus	1%	2%	163	Y	68	606	0	0
TRP1-08-VP5	*S. cynosuroides*	40%	89%	147	Y	1717	15322	0	0
	S. robustus	5%	11%	141	Y	75	669	0	0
TRP1-08-VP6	*S. alterniflora*	45%	69%	96	N	1314	11724	0	95
	Typha angustifolia	20%	31%	142	Y	744	6641	0	0
TRP1-08-VP7	*S. cynosuroides*	10%	10%	142	Y	268	2389	0	189
	Spartina patens	90%	90%	75	N	2469	22033	0	0
TRP1-08-VP8	*S. patens*	95%	95%	51	N	1810	16151	0	98
	Scirpus pungens	5%	5%	63	N	119	1063	0	0
TRP1-08-VP9	*S. patens*	30%	35%	70	N	188	1675	0	71
	S. cynosuroides	50%	59%	123	N	1825	16283	0	0
	S. puingens	5%	6%	141	N	120	1069	0	0
Mean for Plot		65%		116		1773	15823	0	74
Mean for Site		65%		116		1773	15823	0	74

Table E-6
CEDAR SWAMP WETLAND RESTORATION SITE
PEAK SEASON 2008 60 X 60 M PLOT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

Quadrat No. (a)	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m^2	Litter gdw/m^2
		Aerial	Relative			gdw/m^2	lb/acre		
Cedar Swamp - Plot 1 8/13/08									
CSP1-08-VP1	*S. alterniflora*	75%	100%	58	N	600	5356	0	336
CSP1-08-VP2	*S. alterniflora*	75%	100%	51	N	800	7133	0	98
CSP1-08-VP3	*S. alterniflora*	25%	63%	85	N	626	5586	0	124
	Pluchea purpurascens	15%	38%	22	Y	51	458	0	0
CSP1-08-VP4	*S. alterniflora*	55%	100%	70	N	589	5255	0	134
CSP1-08-VP5	*S. alterniflora*	65%	100%	66	N	796	7105	0	127
CSP1-08-VP6	*S. alterniflora*	85%	100%	84	N	1209	10786	0	74
CSP1-08-VP7	*S. alterniflora*	35%	97%	57	N	408	3639	0	129
	Dead P. australis	5%	--	--		0	0	524	0
	P. punctatum	1%	3%	40	N	2	21	0	0
CSP1-08-VP8	*S. alterniflora*	55%	100%	68	N	567	5062	0	208
	Dead P. australis	1%	--	--		0	0	67	0
CSP1-08-VP9	*S. alterniflora*	25%	63%	69	N	921	8219	0	68
	Dead P. australis	<1%	--	--		0	0	128	0
	S. cynosuroides	15%	38%	102	N	74	662	0	0
Mean for Plot		58%		71		738	6587	80	144
Mean for Site		58%		71		738	6587	80	144

Salem/ Hope Creek Environmental Audit – Post-Audit Information

Question #: ECO-6 **Category:** Ecology

Statement of Question: Please provide the following documents that were made available during the Salem and HCGS License Renewal Environmental Audit in response to Pre-Audit Question # ECO-6.

A Attachment #1 – 1994 Biological Monitoring Work Plan

B Attachment #2 – 2006 Improved Biological Monitoring Work Plan

Response: The documents requested are being provided.

List Attachments Provided:

A EA Engineering, Science, and Technology. *Work Plan for the Biological Monitoring of the Delaware Estuary Under Salem's New Jersey Pollutant Discharge Elimination System Permit, Part I.* Prepared for Public Service Electric and Gas Company Estuary Enhancement Program. October 1994. [Note: Parts II and III, which contain Study Plans for additional and optional monitoring are also included.]

B Letter from PSEG Nuclear, LLC (T. Joyce) to NJDEP (D. Chanda) regarding Salem Generating Station NJPDES Permit No. NJ0005622, Custom Requirement G.6, Improved Biological Monitoring Program Work Plan (IBWMP) (forwarding enclosures including a proposed revision to Section 2.1.2 in the IBWMP, "Fish Utilization of Restored Wetlands"). March 6, 2006.

batch# 286
part# 3580-A

Work Plan for the Biological Monitoring of the Delaware Estuary Under Salem's New Jersey Pollutant Discharge Elimination System Permit

Part I

Prepared for

Public Service Electric and Gas Company
Estuary Enhancement Program
P.O. Box 236
Trailer 80 M/C N33
End of Buttonwood Road-Artificial Island
Hancocks Bridge, New Jersey 08038

Prepared by

EA Engineering, Science, and Technology
The Maple Building
3 Washington Center
Newburgh, New York 12550

and

Lawler, Matusky & Skelly Engineers
One Blue Hill Plaza
Pearl River, New York 10965

October 1994

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CONTENTS (Continued)

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1. INTRODUCTION

This report presents Public Service Electric and Gas Company's (PSE&G's) Work Plan for a Biological Monitoring Program of the Delaware Estuary and adjacent environs to address specific issues related to the operation of PSE&G's Salem Generating Station. Salem's New Jersey Pollutant Discharge Elimination System (NJPDES) Permit (No. NJ0005622), issued on 20 July 1994, requires that PSE&G shall

> "...develop and implement a biological monitoring program for the Delaware Estuary. The biological monitoring program shall include comprehensive thermal monitoring and performance of a biothermal assessment on the Representative Important Species (RIS); bay-wide abundance monitoring; impingement and entrainment monitoring; abundance monitoring for ichthyoplankton and juvenile blueback herring in connection with fish ladder sites, detrital production monitoring, and residual pesticide monitoring (in salt hay impoundments); and such other special monitoring studies including effects of sound deterrents as may be required by the Department."

The study plans described herein are designed to address these requirements.

For convenience, the various studies comprising the Work Plan can be loosely grouped into four broad categories:

1. Wetlands restoration and enhancement
2. Elimination of impediments to fish migration
3. Sound deterrent feasibility study
4. Biological monitoring.

Each of these categories and the associated studies therein are described in the following sections. The results of these studies will be summarized in an annual report to be submitted to the New Jersey Department of Environmental Protection and Energy (NJDEPE) within 6 months of the completion of all sampling in each year.

A

2. WETLANDS RESTORATION AND ENHANCEMENT

2.1 BACKGROUND

The NJPDES Permit for the Salem Generating Station contains Special Conditions under which PSE&G will restore and enhance up to 10,000 acres of tidal wetlands which are presently degraded due to diking or *Phragmites* invasion. The premise behind this request is that these restored areas will approach typical wetland function and generate new energy and habitat for the aquatic communities in the Estuary.

The purpose of the group of studies contained within this chapter is to document the results of the wetland restoration and enhancement activities undertaken by PSE&G. For the restored wetlands, this monitoring will address the production of detritus in the restored and enhanced areas and, in addition, monitoring of the salt hay farms will be conducted to assess the possible release of pesticides (especially DDT) from these areas. Overall, the results of these monitoring activities can be used as part of the evaluation process to determine the success of the wetland restoration and enhancement activities.

2.2 DETRITAL PRODUCTION MONITORING

2.2.1 Introduction

2.2.1.1 Objectives of Study

In addition to developing and implementing management plan(s) for the wetland restoration sites (Special Conditions 3d, 3e, 3f, and 3g), PSE&G is required to monitor (Special Condition 6) the progress of those management plans in meeting the goals of the 1994 Final NJPDES Permit. The goal of the restoration/enhancement program is to restore natural salt marsh wetlands on selected salt hay farms, other impoundments, and *Phragmites*-dominated degraded wetland sites. The key measure of the success of the program is the re-establishment of natural salt marsh plant associations typically dominated by *Spartina* spp.

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The next permitting cycle will be greatly facilitated by the ability of PSE&G to clearly and unequivocally demonstrate its Estuary Enhancement Program successes. The detrital production monitoring study will document the distribution, species, biomass and changes in the plant communities, and allow for demonstration of successful succession of community types toward that of other natural functioning salt marshes in the region as result of restoration activities.

Specifically, Special Condition 6(a) requires monitoring of "...detrital production..." The macrophyte assemblages in wetlands decompose to form the detrital complex, a major component of the estuarine food web. The quantity and quality of detrital production is expected to change as the plant community composition shifts during restoration. The goal of the Estuary Enhancement Program restoration is to cause a shift in the physical and chemical character of the restoration sites and an associated transition in the vegetation community to resemble that observed in natural functioning salt marshes in the area. Actual site restoration is not likely to begin until 1996 following engineering and design activities; plant assemblages at some restored sites will likely begin to resemble those of reference sites 3-4 years later (i.e., 1999-2000). Similarly, the character of detritus produced by some these restored wetlands is also expected to begin to resemble that of natural functioning salt marshes in the area in the same timeframe. Therefore, the detrital production monitoring study will focus on documenting the transition of the plant community in these restoration sites until such time as the plant assemblages, and associated detritus, approach that of natural salt marsh sites. The detrital monitoring study will provide species lists for the vascular vegetation present, information on the distribution of discrete species assemblages (plant communities), relative abundance of the species and communities, quantitative data on the composition of the dominant plant communities, quantitative data on density and standing stock biomass of dominant species, and comparable information on identified species of special interest in the restored wetlands.

These data will be used to document the first steps in the change of the energy base of the marsh-dependent estuarine ecosystem, that is, the shift in community composition associated with the wetland restoration. This information will be valuable for documenting the

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creditable restored wetland acreage for Permit compliance, in establishing the general environmental benefits of the Estuary Enhancement Program, and in documenting the specific benefits of restoration to wetland dependant fish and wildlife.

In addition, the importance of algal communities will be evaluated. Organisms may utilize marsh macrophytes as a food source by direct ingestion of tubers and aboveground vegetation, or by consuming associated fungal, bacterial, and algal growth. Algae inhabit both the bottom muds (edaphic algae) and grass, stems, and other aerial structures (epiphytic algae) in salt marshes (Blum 1968; Van Raalte et al. 1976).

2.2.1.2 Rationale for this Study

Vacular Plants

The detrital production monitoring study is an important component of the Work Plan to document the success of PSE&G's Estuary Enhancement Program plan. One of the goals of the Estuary Enhancement Program is conversion of existing diked and degraded estuarine marsh areas dominated by *Spartina patens* and *Phragmites australis* to part of a tidally connected *Spartina alterniflora* marsh, widely recognized as an important component of the estuarine food web. As a result, vegetation monitoring is necessary to document the existing plant community composition and characteristics, and document the shift from the current community composition to the proposed condition. This information will also be useful in documenting the effects the restoration has had on the production, biomass, and stem density of the selected tidal marshes.

Edaphic and Epiphytic Algae

Algal production is important for three reasons: (1) the season of active primary production in temperate zone salt marshes is extended, (2) algae have less structural tissue than grasses and, therefore, are more suitable as a direct energy source for consumer organisms, and (3) production may be highest before the new *Spartina* association becomes established during restoration. Benthic algae can make a significant contribution to overall ecosystem primary production on an annual basis (Van Raalte et al. 1976). Jones (1980) and Stowe and Gosselink (1985) estimated that epiphytic growth on salt marsh macrophytes can produce organic matter at rates comparable to those of edaphic salt marsh algae.

2.2.1.3 Historical Foundation

Numerous studies exist concerning the vegetation associations of tidal salt marshes. While many of these studies and documents are of a general nature, several have a more specific application to the Delaware Estuary and specific parcels and will be used as part of the background data used to establish a baseline for the vegetation present within this habitat area. Information available in PSE&G's Estuary Enhancement Program library will be reviewed for additional pertinent information for inclusion in this baseline. Any historical quantitative data found will be compared to the existing vegetation communities and their distributions. This comparison may provide insight as to how the communities have changed in recent time. In addition, in a dynamic environment such as the Delaware Estuary, the information may be useful in understanding patterns in temporal and spatial variations.

A quantitative baseline for the species of concern is in the process of being completed for several of the proposed restoration sites. This information will be used as a reference for future efforts, providing additional useful information for this monitoring study.

2.2.2 Proposed Study Design

2.2.2.1 Study Duration and Geographic Extent

This monitoring study will continue throughout the 5-year duration of the NJPDES Permit. The geographic range of this study will include specific tidal marsh areas and their associated landward buffers along the New Jersey coast of the Delaware Bay from Salem County in the north to Cape May County in the south. This is the portion of the Estuary in which salinity and tidal conditions are generally conducive to the growth and propagation of the plant

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species of interest and their associated communities. Areas to be selected for restoration are characterized as having the appropriate elevation relative to high tide, the presence of desirable colonizing propagules, and a recent history as a functioning tidal salt marsh area.

2.2.2.2 Sampling Frequency

The sampling frequency at each restoration site will consist of two sampling periods each year for a total of 5 years with at least 100 samples collected per sampling period at each site. Sampling will be conducted at four reference natural marsh sites, two *Phragmites* restoration sites, one impoundment restoration, and three salt hay farm restoration sites selected to be representative of the range of restoration and natural salt marsh sites in Cape May, Cumberland, and Salem counties. Sampling efforts will occur during the growing season, one in the spring (e.g., early June near the beginning of the growing season) and another in late summer (e.g., early September near the end of the growing season). Once the dikes have been breached, this frequency of field visits will provide insight into changes in local site conditions, such as the effects of wave action/inundation and the resultant reworking of sediment. The frequency proposed should also facilitate early identification of large and small scale spatial successes and failures, which should produce useful information for other restoration sites. Specific cross applications may include modifications to engineering designs, tidal channel sediment control, water velocity, or the need for planting in selected habitat types, among other details. The frequency of sampling will also be sufficient to monitor the progression of vegetation changes throughout the life of the Permit.

2.2.2.3 Sampling Intensity and Locations

Aerial false-color infrared photographs and other geo-referenced mapped information (at 1 in. = 500 ft) will be used to define the distribution of vegetation community types (e.g., salt hay, cordgrass, *Phragmites*, scrub, woodlands, etc.) relative to candidate restoration sites. Corrected infrared aerial photographs produced annually will facilitate the community mapping effort. Marsh community areas will be mapped from these photos each year so as to distinguish among the different community types and document the transition of 9 these communities during the Permit period. To the extent practical, this mapping effort should strive to distinguish large areas dominated by a single species (e.g., *Phragmites* stands, *Spartina patens* high marsh, *Spartina alterniflora* low marsh) from intermixed areas of the same communities with a highly interrelated distribution, and from more diverse communities (e.g., shrub areas on tidal margins).

While only the first year's aerial photograph information would be used to establish the permanent transects, annual mid-summer aerial photographic surveys will be used to measure the spatial patterns of change associated with the marsh restoration. While it would be desirable to conduct this measurement using digital image processing techniques, it is not clear that such an approach would be sensitive to annual changes other than vegetative conversion of large areas. As an alternative, overlay analysis may be desirable to demonstrate patterns of change and quantify areas influenced.

This vegetative community information from the first annual survey will be the basis for selection of the sampling locations. A stratified-random sampling design will be used to map existing features of the plant communities present at each site. This information will also be used to identify up to four reference sites on the Delaware Estuary located within the geographic range of the restoration sites. Criteria for selection of these reference sites will include at a minimum: sites which appear to function presently as natural salt marshes; sites with no indication of previous human alteration, disturbance, or restoration activity; and sites reflecting the range of salinity and tidal conditions anticipated at the restoration sites.

Permanent monitoring transects, each approximately 500 m in length, will be established in areas representative of the dominant communities and maintained throughout the life of the NJPDES Permit. Two transect types will be established to provide information on the growth characteristics of individual plant species and plant community variability across ecotones associated with topographic and hydrologic features (e.g., tidal creek to marsh flat, marsh flat to upland).

Transect Type I

Transects through homogeneous stands of vegetation (e.g., *Spartina patens*) will be used to accurately describe the characteristics of major vegetative cover types. The number of transects per vegetative community type will be based on the relative proportion of each of the dominant community types identified at a given site during the first aerial photograph plant cover interpretation effort described above. Subsequent sampling efforts will occur along the same transects, unless annual photo-interpretation efforts indicate that this approach would be a mistake. This approach will facilitate analysis of changes from one sampling period to the next. Along each of 10 transects, 10 randomly selected 1-m square quadrats will be selected and percent ground covered will be estimated using the Braun-Blanquet cover estimation technique (Brower and Zar 1977). At a subsample of these quadrats (e.g., 1 from each of the 10 transects), all aboveground biomass, including dead material, will be clipped and collected for laboratory analysis. This material will be sorted into live and dead material (at time of collection) and weights for each fraction and the total will be obtained during laboratory processing. The relative importance of each fraction will be analyzed using the Smalley technique (APHA 1992). Additional qualitative observations will be made relative to species composition and percent cover of the species of concern and their associated communities in the immediate vicinity of each transect.

Transect Type II

The second transect type will be set across transition zones where different plant types are distributed along hydrologic or topographic gradients. Sampling across such ecotones will be conducted to describe the community shifts associated with these habitat features at a finer level of detail than the Type I transect permits. Quadrat locations will be selected to be representative of the proportion of the habitat distributed along the transect gradient. The transect sampling approach for characterizing ecotones is similar to that proposed for the homogeneous community types, except a greater proportion of quantitative samples (at least three per transect as opposed to one) will be necessary to accurately characterize the variability along these gradients and the locations of the actual plots will not be randomly located. The length of these transects will be based on the length of the transition zone. The number of transects at each site will depend on the complexity of the hydrology, topography, and vegetative cover; at least one transect will be set across each identified major type of transition zone. This effort will provide quantitative information to characterize plant species gradations along these features. These data will be useful in documenting the mechanism of community shifts and will also help to document the effects of the restoration on unique and important transition areas including mudflats, tidal channels, upland/wetland edge, etc.

Edaphic and Epiphytis Algae

To determine the production of edaphic algae available to the food chain, sediment samples will be collected monthly. Monitoring would be conducted at four reference natural marsh sites, two *Phragmites* restoration sites, one impoundment restoration, and three salt hay farm restoration sites selected to be representative of the range of restoration and natural salt marsh sites in Cape May, Cumberland, and Salem counties. At each selected restoration site, replicate samples will be collected along the permanent transects within each major vegetation habitat type and major transition zones as described above. Chlorophyll analysis will follow standard procedures outlined by Lorenzen and Jefferey (1980) and Standard Methods. Analysis of chlorophyll in sediments will be used to evaluate of the effect of dominant marsh macrophytes and location within the marsh (e.g., low marsh, high marsh, creek channel) on edaphic algae production.

This sampling effort will begin prior to marsh restoration activities, and will continue annually for the duration of the permit. Monitoring the selected sites prior to restoration will provide a baseline characterization of algal community production. Monitoring during and subsequent to restoration will document temporal and spatial trends and the progress of the transition of the restoration sites to natural functioning *Spartina*-dominated salt marshes.

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2.2.2.4 Laboratory Processing

Vascular Plants

The vegetation samples collected from selected quadrats as described above will be processed and weighed using widely accepted scientific procedures. Stems will be counted to establish number per m^2. Samples will be weighed, both before and after drying, to the nearest 0.1 g. Wet weight samples will be shaken dry before weighing. Dry weight samples will be dried for 24 hours at 105°C (Brower and Zar 1977). Due to variations of water content among various taxa, dry weights are usually considered more meaningful measures of biomass; however, the comparisons of wet weights throughout the duration of the study will provide information pertaining to the vigor of the various species collected.

Edaphic and Epiphytic Algae

To determine the contribution of organic matter by epiphytic algae, replicate samples will be collected at the same intervals and locations as sediment samples for edaphic algae. Algal growth on the macrophytes will be removed by wiping a measured surface area of stems with fiber-filters, and rinsing with de-ionized water. The rinsate and filter will then be extracted with acetone and measured for chlorophyll following standard methods. Results from the chlorophyll analysis will be evaluated to estimate the contribution of organic matter by epiphytic growth on dominant macrophyte species and in various locations within the marsh. In addition, aliquots of this material will be collected at each sampling site twice annually to coincide with vascular plant sampling efforts. Aliquots will be placed in light-dark bottles for measurements of oxygen and respiration measurements over a 24-hour period. This information will be useful for measuring algal production and microbial respiration.

2.2.2.5 Data Analysis

The quadrats for which data on biomass, density, and diversity are collected will be extrapolated to the overall site based on the percent cover information gathered from

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transects. Inter- and intra-site variability will also be estimated. This approach allows the cost-effective collection of substantial quantitative data under pre-restoration, implementation, and post-restoration phases of the restoration management plans in order to assess vegetation variability, changes, and trends related to restoration activities. Data from reference sites will also allow comparison of restored sites to existing functional salt marsh sites. Comparisons will also be possible with existing data from previous wetland restoration sites on Delaware Bay.

Vegetation species lists will be created for each habitat type at restoration sites. Data characterizing the identity and percent composition of the plant communities will be generated in the field. Data on number of stems, species diversity, and biomass will be based on laboratory data. This information will be compared to the results of other studies in the Delaware Estuary or other similar environments. Annual data will be used to describe the progression of vegetation patterns from pre-restoration baseline conditions to natural functioning salt marsh and to assess the success of this transition in the plant community as required by PSE&G's NJPDES Permit. This analysis will provide a quantitative measure of the community that exists at the end of the Permit cycle and a comparison to the community that existed before the issuance of the NJPDES Permit.

Numerous metrics have been presented in the scientific literature for describing diversity, stability, and dynamic interactions of biotic communities. They have been applied with varying levels of success to evaluate degraded ecosystems, sources of environmental stress, and recovery. Two commonly used diversity and community similarity indices will be generated as tools to measure changes in the vegetation community structure during the monitoring period. The two diversity indices recommended for use are Simpson's index and Shannon's diversity index (Brower and Zar 1977). Simpson's index takes into account the number of species, the total number of individuals present, and the proportion of the total that each species represents. The Shannon diversity index uses logarithmic transformation of data on species abundances within samples taken from a larger community to determine species diversity. Two community similarity indices, Morisita's index and Horn's index (Brower and Zar 1977) are recommended to provide quantitative information allowing the

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comparison of two or more separate community locations, or the same location across a time series. Morisita's index is based on Simpson's index of dominance, while Horn's index is an information-theoretic index based on the Shannon diversity index. While a variety of more sophisticated tools are available (e.g., discrimination analysis), the ordination approach outlined above is expected to be sufficient for the purpose of documenting the type of community change anticipated by the scientific community.

In addition to these indices, the quantitative data collected, including percent cover, density, and biomass values, will be evaluated using non-parametric and parametric statistical methods. These statistical tools are expected to be used for confirmation of trends and patterns.

2.2.2.6 Quality Assurance/Quality Control

Standardized sampling, analytical, and auditing procedures based on commonly accepted scientific methods will be developed and subject to review of the Monitoring Advisory Committee. Procedures will be implemented to assure that the data are consistently and accurately collected and that the data collection protocol can be easily replicated in future years or by other investigators. Data acquisition, laboratory processing, data entry, analysis, and production of reports will be subjected to standardized review procedures to control experimental and procedural errors. Results of data analysis will also be interpreted consistent with accepted scientific practice to assure that conclusion as to the progress and success of restoration efforts are scientifically supportable and defensible.

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2.3 RESIDUAL PESTICIDE RELEASE MONITORING

2.3.1 Introduction

2.3.1.1 Objectives of the Study

Historical insect control in impounded salt marshes used for the production of harvestable hay traditionally involved the application of pesticides. In 1972, the use of DDT in such an application was banned. However, this compound and its metabolites, DDE and DDD, have a relatively long life in the environment, including impounded wetlands. Concern has been expressed that residual pesticides such as DDT may be released from the formerly impounded wetlands once the dikes surrounding the wetlands are breached as part of wetland restoration.

The purpose of the residual pesticide release monitoring study is to evaluate the potential release of pesticides from the formerly impounded wetlands. To achieve this objective, it is recommended that in addition to the analytical monitoring to be performed subsequent to dike breaching, analytical data be collected to further characterize baseline conditions prior to dike breaching. These baseline data would supplement preliminary data collection efforts previously performed by PSE&G in April and August 1993.

2.3.1.2 Rationale for this Study

The Salem NJPDES Final Permit includes the requirement to "...develop and implement a biological monitoring program...including residual pesticide release monitoring (in salt hay impoundments)." This monitoring plan is designed to address that Permit requirement.

2.3.1.3 Historical Foundation

PSE&G has performed two previous studies (EA 1993a,b) that included analysis of pesticides in diked salt hay marshes in Cumberland and Cape May counties in New Jersey. The first 16 study (EA 1993a), conducted in April 1993, was designed to provide comparative data for sediments within diked areas and sediments in comparable undiked reference areas. For this study, sediments were analyzed for EPA's Target Compound List for pesticides. Of all pesticides analyzed, p,p'-DDT, p,p'-DDD, and p,p'-DDE were the only pesticides consistently detected. Detected concentrations of p,p'-DDT, p,p'-DDD, and p,p'-DDE were found in both the diked salt hay marshes and the undiked reference marshes, with slightly higher concentrations in some of the diked marshes. Methoxychlor, which was the only other pesticide detected, was detected in one of the sediment samples from an undiked reference marsh, but was not detected in any of the diked marshes. Pesticide concentrations in sediments were well below NJDEPE soil and sediment action levels. There was minimal correlation between pesticide concentration and sample boring depth, with slightly higher concentrations found in surficial sediments. A quantitative assessment of site-specific ecological risks performed as part of this study demonstrated that measured concentrations of p,p'-DDT, p,p'-DDD, and p,p'-DDE were below concentrations expected to cause risks to indigenous organisms.

The second study (EA 1993b), conducted in August 1993, analyzed for p,p'-DDT, p,p'-DDD, and p,p'-DDE in surface water from diked salt hay fields and surface water and sediments from Delaware Bay in the vicinity of the diked salt hay fields. These pesticides were not detected in any of the Delaware Bay sediment samples. One of the Delaware Bay surface water samples had detected concentrations of p,p'-DDE and one diked salt marsh surface water sample had detected concentrations of p,p'-DDT and p,p'-DDD.

2.3.2 Proposed Study Design

The residual pesticide release monitoring study will include baseline data collection to characterize conditions prior to dike breaching, in addition to analytical monitoring to be performed subsequent to dike breaching. These baseline data will supplement preliminary data collection efforts previously performed by PSE&G.

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Baseline analyses and pesticide monitoring after dike breaching will be performed on sediment and surface water samples. Pesticides in the environment, including p,p'-DDT, p,p'-DDD, and p,p'-DDE, have a very low water solubility and are bound to sediment particles. Since organic carbon in sediments binds pesticides and mediates bioavailability of these compounds, total organic carbon will be measured in all sediment samples. Measurement of total organic carbon will allow normalization of bulk sediment chemical data to organic carbon. Total suspended solids will be measured in all surface water samples to allow quantification of suspended particulate matter in the water column.

Sediment samples will be collected from creeks potentially affected by breaching of dikes in the three confined salt marshes targeted for restoration and from a creek in an unconfined marsh area used as a reference site for a previous PSE&G pesticide study (EA 1993a). Surface water samples will be collected as mid-depth grab samples from the same study areas that sediment samples are being collected.

2.3.2.1 Study Duration and Geographic Extent

Study areas identified for the residual pesticide study are creeks potentially affected by the transport of sediment subsequent to breaching of dikes in the three confined marsh areas and a creek in an unconfined marsh area to be used as a reference site. The diked salt hay farms are located in Cumberland and Cape May counties. The proposed reference site for the residual pesticide monitoring study is an undiked marsh located along the east bank of the Maurice River near East Point Road. In the unlikely event that the selection of final locations for dike breaching prevents use of this site as a reference due to potential impacts from breaching, another marsh will be substituted as a reference site.

The confined marsh creeks and the reference marsh creek will be sampled initially as part of the baseline characterization. Sampling for the baseline characterization will take place during a single collection effort prior to dike breaching. Baseline analytical data for the creeks, which were not sampled during any of the previous PSE&G studies, will be critical for monitoring potential transport of pesticides from the restored marshes. Without baseline 18 data, it will not be possible to completely segregate potential changes resulting from dike breaching from background pesticide concentrations. Subsequent residual pesticide monitoring will focus on creeks potentially affected by dike breaching.

2.3.2.2 Sampling Frequency

Baseline Characterization

A single intensive sampling effort will be conducted prior to dike breaching to allow a baseline characterization of pesticide concentrations. Timing for this collection is dependent upon the final schedule for dike breaching.

Pesticide Monitoring

Monitoring subsequent to dike removal will take place immediately after dike breaching and will occur at the rate of once a week for the first 4 weeks subsequent to dike breaching and once every 4 weeks for the next 8 weeks, for a total of 6 sampling events.

2.3.2.3 Sampling Intensity and Locations

Study areas proposed for the residual pesticide study are creeks potentially affected by the transport of sediment subsequent to dike breaching and a creek in the unconfined marsh area to be used as a reference site. Creek samples from the confined marshes will be collected in the vicinity of the breached dikes. An attempt will be made to collect all sediment samples from areas of comparable substrate within the confined and unconfined marsh creeks. Locations of dike breaching have not yet been determined. Sampling locations will be surveyed in the field and located using a global positioning system.

Study areas designated for sampling and numbers of samples recommended for collection from each area are described below for the two phases of the monitoring study.

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Baseline Characterization

It is critical that the baseline data are sufficient to adequately characterize present conditions, since these data will be the benchmark for all monitoring subsequent to dike breaching. Sediment samples will be collected at depths of 0-0.5 ft. Surface water samples will be collected at mid-depth. The baseline sampling effort will include the following samples:

BASELINE		
Study Area	Surface Water	Sediment
Reference Marsh Creek	1	1
Confined Marsh Creeks	10	10
Quality Assurance/Quality Control Samples		
Rinsate blank	1	1
MS	---	1
MSD	---	1
Field duplicate	1	1
TOTAL NO. SAMPLES	13	15

Pesticide Release Monitoring

This phase of the monitoring study will begin immediately after dike breaching. Based on results of earlier PSE&G studies, the highest pesticide concentrations will be found in the surficial sediments, therefore, sediment samples will be collected at depths of 0-0.5 ft. The six pesticide monitoring events will include the following samples:

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MONITORING AFTER DIKE BREACHING				
Study Area	Surface Water	Sediment	No. of Sampling Events	Total No. of Samples
Reference Marsh Creek	1	1	6	12
Confined Marsh Creeks	6	6	6	72
Quality Assurance/Quality Control Samples				
Rinsate blank	1	1	6	12
MS	---	1	6	6
MSD	---	1	6	6
Field duplicate	1	1	6	12
TOTAL NO. SAMPLES	9	11		120

2.3.2.4 Sampling Gear and General Deployment

Access to all sampling locations will be by boat. Sediment samples will be collected using a stainless steel Ponar grab sampler. Sediment samples will be homogenized in dedicated stainless steel bowls using dedicated stainless steel spoons. Samples will be placed in clean glass sample jars, taking care to avoid collection of macroinvertebrates that could complicate the sample matrix.

Water samples will be collected with clean sample collection bottles at mid-depth in shallow water or with a Teflon-lined Van Dorn bottle in deeper areas. Water samples will be collected prior to sediment sample collection at each location to avoid collection of resuspended particulate material resulting from sediment sampling.

2.3.2.5 Laboratory Processing

Surface water samples will be measured for pesticides and total suspended solids. Sediment grab samples will be analyzed for pesticides and total organic carbon. During previous studies, sediments and surface waters in confined and unconfined salt marshes and Delaware Bay were analyzed for all pesticides on EPA's Contract Laboratory Program (CLP) Target

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Analyte List. The only pesticides detected with any consistency were p,p'-DDT and its metabolites, p,p'-DDD and p,p'-DDE. Baseline samples collected prior to dike removal will be analyzed for EPA's CLP 8/91 SOW (U.S. EPA 1990) Target Compound List for pesticides, which include the following:

α-BHC	Endosulfan I	p,p'-DDT
β-BHC	Dieldrin	Methoxychlor
δ-BHC	p,p'-DDE	Endrin ketone
γ-BHC (Lindane)	Endrin	Endrin aldehyde
Heptachlor	Endosulfan II	α-Chlordane
Aldrin	p,p'-DDD	γ-Chlordane
Heptachlor epoxide	Endosulfan sulfate	Toxaphene

If these analyses confirm results of preliminary analyses conducted in 1993, pesticide monitoring subsequent to dike removal will be restricted to p,p'-DDT, p,p'-DDD, and p,p'-DDE. All samples will be extracted, cleaned, and analyzed using standard EPA methodology. Samples will be analyzed for pesticides using a modified version of EPA's CLP 8/91 SOW (U.S. EPA 1991). This method utilizes gas chromatography with electron capture detector for analysis of halogenated hydrocarbon pesticides. The proposed method modification increases the volume of sample extracted and decreases the final extract volume for injection on the gas chromatograph, which allows reporting of results at a lower quantitation limit. When detected, pesticides will be confirmed by second column confirmation. Total organic carbon will be analyzed for sediment samples using SW-846 Method 9060 (U.S. EPA 1986). Total suspended solids will be measured in surface water samples using EPA Method 160.2 for total nonfilterable residue (U.S. EPA 1979).

2.3.2.6 Data Analysis

Prior to data analysis, a randomly selected 10 percent subset of all laboratory data will be audited according to EPA CLP protocols. Audited analytical data will be statistically evaluated using analysis of variance. Non-parametric analysis will be performed to detect

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any statistically significant differences between baseline pesticide concentrations in potentially impacted creeks and pesticide concentrations in those creeks subsequent to dike removal.

2.3.2.7 Quality Assurance/Quality Control

Field Quality Assurance/Quality Control

Sample collection will be performed by qualified field personnel familiar with the site. The accuracy of sampling locations will be ensured by surveying and using a global positioning system for locating sampling stations. Sediment samples will be collected using a stainless steel Ponar grab sampler. Water samples will be collected using a Teflon-lined Van Dorn bottle fitted with Teflon tubing. Both the Ponar and the Van Dorn bottle will be decontaminated between samples, according to NJDEPE guidance, to prevent cross-contamination. A field logbook will be maintained to record sample collection data.

Rinsate blanks will be prepared in the field after use of non-dedicated sampling equipment to evaluate the effectiveness of equipment decontamination. Non-dedicated sampling equipment scheduled for use in this monitoring are the stainless steel Ponar and the Teflon-lined Van Dorn bottle. Rinsate blank samples will be prepared by decontaminating the Ponar sampler or the Van Dorn bottle and collecting the final rinse of analyte-free water in appropriate sample containers. Rinsate blanks will be collected once per sampling event. Field duplicates will be collected for both water and sediment. Duplicate samples, which are collocated field samples, will be used to evaluate matrix homogeneity, as well as sample collection, handling, preparation, and analysis techniques. All samples will be stored and shipped on ice in sealed coolers in accordance with NJDEPE guidance and will be handled under chain-of-custody procedures.

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Laboratory Quality Assurance/Quality Control

Laboratory quality assurance/quality control will include use of standards, laboratory method blanks, extraction duplicates, and spiked samples. These will be used for instrument calibration, evaluation of potential laboratory contamination, and identification of potential matrix interferences. Laboratory quality assurance/quality control results will be used as a measure of laboratory performance; they will not be used to adjust analytical results for samples. Prior to data analysis, a randomly selected 10 percent subset of all laboratory data will be audited according to EPA CLP protocol.

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3. ELIMINATION OF IMPEDIMENTS TO FISH MIGRATION

3.1 BACKGROUND

Under the Special Conditions of Salem's NJPDES Permit, PSE&G will construct and maintain five fish ladders in tributaries of the Delaware Estuary which presently contain impediments to fish migration. The intent of installing these fish ladders is to provide increased access to spawning and nursery habitat for two river herring species (alewife and blueback herring). The river herring produced by the availability of this additional habitat should add to the food resources for larger predatory animals in the Estuary as well as to the harvestable stock available to commercial and recreational fishermen. As part of the study described herein, the utilization of the five installed fish ladders by adult river herring will be assessed. In addition, the spawning success and juvenile production resulting from these migrating adults will be documented. Overall, the results of these monitoring activities can be used as part of the evaluation process to determine the success of fish ladder installations.

3.2 ABUNDANCE MONITORING - BLUEBACK HERRING AND ALEWIFE

3.2.1 Introduction

3.2.1.1 Objective of Study

The objective of the fish ladder abundance monitoring is to evaluate the effectiveness of fish ladders in successfully passing upstream migrating alewife and blueback herring (collectively referred to as river herring) and subsequently contributing to the number of juvenile river herring in Delaware Bay. Two components required to meet the objective of this monitoring study are to document that: (1) adults utilize the fish ladders, and (2) successful reproduction and subsequent recruitment to the juvenile life stage occurs. These data can be used to evaluate the effectiveness of the five fish ladders in terms of recruiting river herring to the population.

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3.2.1.2 Rationale for this Study

Installing fish ladders provides access to additional spawning and rearing habitats, therefore, the number of juvenile river herring produced from the Delaware Bay stock potentially will be increased. The documentation of upstream passage of river herring over the dams proves that fish ladders are successful in providing herring populations access to spawning and rearing habitat that is currently unavailable. This would potentially be a benefit of the restoration program. However, the real benefit is not just in providing access to these habitats, but in establishing that river herring using the ladders are successfully spawning and that their offspring are recruiting to the juvenile life stage, at which time they migrate downstream into Delaware Bay or the ocean. If successful reproduction and recruitment to the juvenile life stage can be established, it will be clearly demonstrated that the installation of fish ladders has benefited river herring populations of the Delaware Bay, which is one of the objectives of the restoration program.

3.2.1.3 Historical Foundation

Several studies have been designed to assess passage and migration of river herring in other systems. For example, Tyus (1974) measured movement and spawning of alewives in North Carolina. Movements of fish during the spawning season were determined by sampling one 8-hour period in each successive 2-day block of time. In this study, fish were collected and counted in large removable traps which fish moving towards the lake must pass through. Results from each intensive collection period were extrapolated for the season as a whole. Dominy (1973) determined rates of passage of alewives by using a glass-bottomed viewing box. Observers counted alewives passing the measuring location for 10 minutes each hour for a 10-hour interval during the spring migration season. Several techniques were used to estimate seasonal migration. Versar, Inc. (1990) conducted studies in District of Columbia watersheds in order to document spatial and temporal reproductive activities of alosids. A biweekly electrofishing stream survey and a biweekly gillnetting survey at mainstem locations were conducted through the spring season.

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3.2.2 Proposed Study Design

3.2.2.1 Study Duration and Geographic Extent

Abundance monitoring for river herring will be initiated in the spring following installation of the fish ladders. Monitoring will be initially conducted at each of the five sites where fish ladders are installed. It is anticipated that the fish ladders will be installed in the first 2 years of the Estuary Enhancement Program, therefore, the abundance monitoring at the fish ladders will be implemented in the third year of the Estuary Enhancement Program. After successful passage, spawning, and recruitment to the juvenile life stage has been documented for 2-3 years at each of the five sites, the abundance monitoring can be eliminated or focused only on adult passage.

The geographic extent of the abundance monitoring at the fish ladders is difficult to define given the lack of data on where river herring spawning will occur upstream of the dams. The monitoring of actual herring passage will occur at the five fish ladders. However, it is required that successful spawning and larval recruitment to the juvenile life stage also be documented. Consequently, during the first year of monitoring, it will be necessary to conduct some reconnaissance surveys to determine likely spawning areas. This information will help to define the geographic limits of the monitoring. At a minimum, the impoundment formed by the dam will be included in the monitoring. Because river herring are likely to use tributaries to the impoundment for spawning or rearing, some tributaries will be included in the geographic scope.

3.2.2.2 Sampling Frequency

Sampling will be conducted from mid-spring through early fall. River herring migrate upstream to spawn beginning in April and the migration continues through May. Migration is tied to water temperature. In the Delaware River, Smith (1971) reported spawning of blueback herring occurred when water temperatures were between 15 and 22°C, while alewife spawning occurred slightly later at temperatures of 12-25°C (Wang and Kernehan

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1979). Thus, adult passage monitoring will begin by the time the water temperature reaches 12°C to make sure the start of the migration is monitored. Upstream migration monitoring will conclude when the temperature reaches 21°C or no fish are observed migrating for a period of 1 week. Each day that sampling is scheduled, periodic visual observations will be made to determine if there is a population of herring downstream of the dam that could potentially use the ladder. These visual observations may be supplemented by active collection (e.g., seine or electroshocking) as appropriate.

3.2.2.3 Sampling Intensity

Abundance monitoring for adult river herring passage at fish ladders will be conducted 3 days each week at each of the five ladders. Sampling will be conducted between dawn and dusk because this is the time that river herring are most actively migrating. Because a single observer will be used at each fish ladder, counts will be made for three 10-minute intervals each hour to minimize error and safety hazards associated with eye fatigue. Fish migrations are known to be sporadic and monitoring less than 3 days per week could result in a failure to detect large schools of herring using the fish ladders. Many of the larger fish passage facilities (e.g., mainstem Connecticut River and Susquehanna River) provide total counts of migration by counting upstream migrants every day. However, because total counts of the number of river herring using the ladders being monitored as part of the Estuary Enhancement Program is not required, 3 days of sampling each week is sufficient to detect variability and trends in passage that may be of interest. The 3-day sampling protocol will be used only to provide an estimate of the fish passing on those days. An estimate of the total number of herring using the ladder is not required in the Permit and will not be derived based on this level of sampling effort.

Larval sampling will be conducted biweekly. Sampling will occur over an approximate 8-week period corresponding to the upstream migration period. In each of the five impoundments, samples will be collected at two areas within the main area of the impoundment and one sample at each of the primary tributaries to the impoundment. In most cases, this should provide 3-4 samples.

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Juvenile sampling will be conducted monthly in July, August, and September. In each of the five impoundments, 3-5 sampling locations will be identified. These sampling locations may or may not correspond to the sampling locations for larval herring. Sampling locations will be predominantly located in coves or other shallow areas as juvenile herring are not typically found in the deeper open areas of impoundments before their out-migration.

3.2.2.4 Sampling Gear and General Deployment

Sampling gear will differ depending on the three life stages (adult, larval, and juvenile) to be sampled as part of this monitoring study. Several options exist to sample the adults passing upstream via the fish ladders. The most common way of monitoring the number of fish that utilize fish ladders is through direct observation. If the fish ladders are relatively small and water clarity is good, it may be possible to count the migrating river herring at the exit of the fish ladder. The exit of the fish ladder would be painted white to facilitate observation. If it proves beneficial, a video camera can be used to record fish passage instead of having observers on site. The advantage of video is, if there are not many fish passing upstream via the ladder, the video can be screened in fewer hours than is required to have personnel at the site observing the fish. The downside of video is that they are subject to vandalism and may not work well for large numbers of fish. It is possible that a sampling program that utilizes both of these methods could be effectively implemented.

If it is not possible to count upstream migrating herring with direct observation, a method of capturing the herring that use the fish ladder will be developed. The exact capture method will be developed on a site-specific basis to match the dimensions of the fish ladder exit and the hydraulic conditions at the exit of the ladder. It may be possible to attach a trap net to the trash racks that are located at the exit of the fish ladders. An alternative would be to construct a floating live pen that is attached to the exit. The downside to these techniques is that the fish have to be handled and some mortality could result from this handling.

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A different alternative is to use electronic counters installed at the exit of the fish ladders to estimate the number of herring using the ladders. Electronic counters are an attractive option if an estimate of the number of herring using the ladders during the entire migration season is an objective. Because the electronic counters operate remotely, personnel would only be required to calibrate the system and download data. The disadvantages of electronic counters are that it is not possible to distinguish between alewives and blueback herring and that if large numbers of fish are simultaneously using the ladders, the accuracy of the counts are reduced. Similar to the use of video, there is a potential for vandalism.

To collect egg and larval herring, a plankton net will be used. The plankton net will be towed through representative lengths of potential spawning and rearing areas. The catch of different length samples can be quantified on a catch-per-unit-effort (catch per volume sampled) basis if comparisons among or within sites are desired at a later point in time.

To sample juvenile herring, a combination of beach seining and electrofishing will be used. Beach seining is a highly effective method of sampling juvenile clupeids provided there are suitable places to use a large (greater than 200 ft) beach seine. Electrofishing is less effective in collecting juvenile clupeids, but is the best sampling method in areas that cannot effectively be sampled by seining. A combination of these two methods will be used to determine the abundance of juvenile herring.

3.2.2.5 Laboratory Processing

The adult herring observed or collected will not require processing other than enumeration by species and subsequently will be handled as little as possible. The juvenile herring collected as part of this monitoring will be identified, counted, measured for length, and weighed in the field. Because juvenile alewife and blueback herring are difficult to distinguish based on external characteristics, a subset of 25 juveniles will be identified from each sample.

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Because juvenile herring are difficult to handle without descaling and subsequent mortality, only the subset of 25 will be weighed and measured. Therefore, no laboratory processing is required for adult or juvenile samples.

The egg and larval fish samples will require laboratory processing, thus they will be preserved in the field and processed in the laboratory. The egg and larvae samples will be sorted and only the river herring will be subject to further processing. It may be necessary to split the samples based on sample volume and only identify and count a subset of the herring eggs and larvae. The processing will include the number of herring by life stage (egg and larval) for each sample.

3.2.2.6 Data Analysis

Data analysis will be both qualitative and quantitative and consist of three components corresponding to each of the three life stages sampled as part of this study. For migrating adults, the analysis will consist of estimating (from count data) the total number of herring using the ladders for days the ladders were sampled. The hours in which the majority of fish used the ladder will be determined to help structure future sampling efforts. For example, if 80 percent of the fish migrated during a 4-hour time block (e.g., immediately after sunrise), future sampling, if required, could be limited to that time period.

Both larval and juvenile sampling will provide quantitative estimates of abundance based on catch-per-unit-effort. Comparisons among sites and years can be based on catch-per-unit-effort or other statistics computed from catch-per-unit-effort data. Analysis of the egg and larval samples will be limited to determining abundance of river herring in the samples and the distribution of river herring across the sampling locations. The abundance estimates will be based on volumetric estimates of the number of herring per cubic meter. Trends in abundance over the spawning season could also be calculated to help structure future monitoring efforts.

The analysis of the juvenile samples will be similar to the egg and larval samples, except that abundance will be calculated on a catch per area or unit of time basis rather than on a volumetric basis. Juvenile sampling will provide information relative to distribution and size of the river herring which could be analyzed to help structure future sampling programs.

3.2.2.7 Quality Assurance/Quality Control

Quality assurance/quality control procedures will be implemented for the collection and processing of the samples. The data recording and processing techniques will be standardized to minimize investigator error. A quality assurance/quality control manual specific to this monitoring study will be developed prior to initiating sampling.

4. SOUND DETERRENT FEASIBILITY STUDY

4.1 BACKGROUND

Under Salem's NJPDES Permit Special Conditions, PSE&G will conduct a study "...to assess the feasibility of deterring fish from the area in front of the cooling water system intake structure through the use of underwater speakers or sound projectors." Although designed to reduce impingement rates, concern has been raised over possible adverse effects that the sound system might have on fish migrating through the vicinity of Salem. If the sound levels are sufficiently high to induce avoidance out in the Estuary, then natural migratory patterns could be disrupted. As a result of this concern, an assessment of the potential detrimental effects of this system on fish species in the Delaware Estuary will be conducted. The study described herein will provide the information for just such an assessment.

4.2 POTENTIAL DETRIMENTAL EFFECTS OF SOUND DETERRENCE SYSTEM ON MIGRATORY FISHES

4.2.1 Introduction

4.2.1.1 Objective of Study

As part of the overall Work Plan, PSE&G will examine the feasibility of using sound to deter fish from the intake. Part of this study involves an assessment of the potential for detrimental effects on fish species. The study described below is designed to determine whether or not sound deterrents act as a barrier to normal fish migration in the vicinity of Salem.

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4.2.1.2 Rationale for this Study

An assessment of potential detrimental effects of sound deterrent devices on fish is specifically required by the 1994 NJPDES Permit. However, the exact nature of the study is not defined. It appears that the primary concern is whether or not sound from the deterrent devices blocks the normal upriver and downriver migrations of fish, especially for striped bass, American shad, blueback herring, and alewife.

A study of the potential detrimental effects of sound will be undertaken only after:

- Test installation of sound deterrent devices at Salem has demonstrated an effectiveness

- Physical delineation of the sound field demonstrates that the frequencies which elicit avoidance behavior are detectable above ambient sound levels at distances of more than one-fourth the river width at Salem.

Failure to meet these conditions indicates that either the devices will not be used or that the effects are so localized that migratory access would likely not be hindered. If these conditions are met, then a study will need to be conducted.

4.2.1.3 Historical Foundation

There is no historical precedent for this study in the Delaware Estuary.

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4.2.2 Proposed Study Design

4.2.2.1 Study Duration and Geographic Extent

If required, a 1-year study will be conducted during the first year after successful demonstration of the effectiveness of sound in reducing impingement. It is assumed that this will be 1996.

4.2.2.2 Sampling Frequency

The sampling will be conducted twice during the year: once during the spring immigration period and once during the fall emigration period. The exact timing will be based on the occurrence of striped bass, American shad, blueback herring, and alewife in field and onsite samples.

4.2.2.3 Sampling Intensity and Locations

A hydroacoustic study of fish distribution across the river will be conducted to define the extent of exclusion. A series of hydroacoustic transects upriver and downriver with the sound generating devices turned on and off will be used to demonstrate the potential for exclusion.

4.2.2.4 Sampling Gear and General Deployment

A series of four across-river hydroacoustic transects, starting 0.5 mi downriver and ending 0.5 mi upriver from Salem, will be sampled using two boats. Continuous across-river tracings of hydroacoustic targets will be made. The transects will be sampled twice: once with the devices operating and once with the devices turned off.

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4.2.2.5 Field and Laboratory Processing

The number of hydroacoustic targets per unit volume along each transect will be recorded.

4.2.2.6 Data Analysis

Rigorous statistical testing of the results would be difficult. It is recommended that plots of hydroacoustic targets per unit volume across the river be used for the assessment. If no biologically significant differences in across-river distribution are detected between periods when the deterrent is operating and when it is not, then it may be concluded that the deterrent devices have no detrimental effect. A report summarizing the study findings will be produced at the end of the study.

4.2.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an acceptable outgoing quality level (AOQL) of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

5. BIOLOGICAL MONITORING

Operation of the Salem Generating Station can affect the aquatic communities of the Delaware Estuary through three primary routes:

1. Withdrawal of cooling water from the Estuary can result in the loss of macroinvertebrates and the early life stage of fish through entrainment (i.e., passage of smaller organisms through the Station's cooling water system along with the water).

2. Withdrawal of cooling water from the Estuary can also result in the loss of juvenile and adult fish through impingement (i.e., entrapment of larger organisms against the traveling screens at the Station's intake).

3. Discharge of heated effluent into the Estuary can result in exposure of organisms in the Estuary to elevated temperatures with the possibility of adverse consequences.

The study plans presented herein are designed to address the potential for adverse environmental impacts resulting from each of these three types of effect.

5.1 BIOLOGICAL MONITORING OF THE DELAWARE BAY AND RIVER

5.1.1 Background

A primary concern involving operation of the Salem Generating Station is the effect of entrainment and impingement losses on the abundance of selected fish and macroinvertebrate species within the Delaware Estuary. Because all entrainment, and most impingement, losses occur during the early life stages (eggs, larvae, and early juveniles), this concern has been focused on the effects of Salem's operation on the abundance of juvenile fish produced in the

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Estuary each year. If there has been no reduction in the production of juvenile fish due to the operation of Salem, then any changes in the adult stock must be due to other factors and unrelated to Salem's operation.

In addition to concerns over effects of entrainment and impingement losses on fish populations, the possible localized reduction in the abundance of macrozooplankton (opossum shrimp and scuds) in the vicinity of Salem's intake was also an issue. If this occurs, the availability of food to support larval and juvenile fishes in the area could be potentially affected. Although there is no evidence that such a local reduction is occurring, the available data do not allow an in-depth assessment. Therefore, an important component of this biological monitoring plan will be a study to assess whether or not there has been a depletion in the abundance of either opossum shrimp or scuds in the vicinity of Artificial Island which could be attributed to the operation of Salem.

In Appendix H of their comments on the NJPDES Draft Permit (PSE&G 1991), PSE&G undertook an extensive examination of several indices of abundance for juvenile fish within the Delaware Estuary. In this analysis, two indices were selected as most appropriate due to their geographic and temporal coverage. The Delaware Department of Natural Resources and Environmental Conservation (DNREC) Small Trawl Survey, conducted in the Delaware portion of Delaware Bay since 1980, provides indices of juvenile abundance for marine species, such as bay anchovy and weakfish, which use Delaware Bay as spawning and/or nursery habitat. The NJDEPE Beach Seine Survey, conducted in the tidal portion of the Delaware River since 1980, provides indices of juvenile abundance for some anadromous and freshwater species that utilize this portion of the River as juvenile nursery habitat. To date, neither of these two indices provides any evidence of an effect of Salem's operations. In fact, since Salem began operation, these indices have shown increases for most of the RIS. Given the importance of these indices of juvenile abundance in assessing potential impacts of Salem's cooling water withdrawals, an important component of the Biological Monitoring will be the continuation and expansion of these two surveys to provide indices which can be used to further assess the potential impacts of Salem's operation.

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5.1.2 Bay-Wide Trawl Survey

5.1.2.1 Introduction

Objectives of Study

The relative abundance of juvenile finfish within the Delaware Estuary from the mouth of Delaware Bay to the Chesapeake and Delaware Canal (C&D Canal) will be monitored. These data will be used to construct an annual index of abundance which conforms to the Delaware DNREC Small Trawl Survey. The focus of this survey will be on bay anchovy, spot, and weakfish. By monitoring changes in the index over time, general trends in population abundance may be assessed.

Rationale for this Study

NJDEPE has indicated that the abundance indices derived from the existing bay-wide trawl program will help form the basis for their future decisions as to whether or not Salem is having an adverse environmental impact requiring further mitigation on the part of PSE&G.

Historical Foundation

Beginning in 1980, and continuing through the present, the abundance of juvenile fish within the Delaware portion of the Delaware Bay and lower Delaware River has been monitored by the Delaware DNREC Juvenile Trawl Survey. DNREC uses the mean or geometric mean of their catch as an indicator of population abundance. By monitoring trends in the index over time, general trends in population abundance may be assessed.

From 1980 through 1988, the DNREC Small Trawl Sampling Program was conducted from Primehook Beach (River Mile [RM] 6) to the C&D Canal (RM 59). In September 1989, the survey was extended farther upriver (RM 78) to encompass the area up to the Delaware/ Pennsylvania state line (near Wilmington, Delaware). This survey is conducted on a monthly

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basis from April through October of each year using a 4.9-m otter trawl towed for 10 minutes against the tide. In the lower region of the Estuary (RM 6-59), 34 samples were collected during a 7-month period of each year, yielding 238 samples per year. In 1989, the addition of six collections in the RM 60-78 region increased the total to 40 samples per month, yielding 280 samples per year. The most important use of the DNREC data has been in the development of abundance indices for the juveniles of such marine species as bay anchovy, spot, and particularly, weakfish.

The primary purpose of the DNREC Juvenile Trawl Survey and associated abundance indices is to provide advanced warning of serious population decline. In general, current abundance, or abundance over some selected set of years, is compared to average abundance during some historical period to screen for downward trends. Analysis of variance (ANOVA) or Statistical Process Control (Montgomery 1985) procedures may be used to evaluate the results.

5.1.2.2 Proposed Study Design

Study Duration and Geographic Extent

The far-field bottom trawl survey will be conducted each year from 1995 through 1999. Samples shall be collected from both the Delaware and New Jersey sides of the Estuary from the mouth of Delaware Bay (River Kilometer [RKM] 0) to the Delaware-Pennsylvania state line (RKM 126). Selection of monitoring stations will be done from the regions of Delaware Bay not sampled by DNREC.

Sampling Frequency

To be compatible with the DNREC program, samples will be collected once per month from May through October.

Sampling Intensity and Locations

PSE&G will sample up to 40 fixed stations per sampling event. Provided that DNREC continues to sample as in the past, PSE&G will sample the locations shown in Figure 5-1.

Sampling Gear and General Deployment

A 16-ft (4.9-m) otter trawl with 1.5-in. stretch mesh body, 1.25-in. stretch mesh codend, and 0.5-in. stretch mesh codend inner liner will be used to collect bottom samples. Tows will be of 10-minute duration against the tide of a speed of approximately 3 knots. Details of deployment are given in Section 5.4.2.2 of Appendix I of PSE&G's 316(b) Demonstration.

Field and Laboratory Processing

All finfish and blue crabs collected will be identified in the field. From each sample, the fork length (to nearest mm) will be recorded for up to 100 specimens of each target species (as per Section 5.4.2.3 of Appendix I to PSE&G's 316[b] Demonstration). If more than 100 individuals of a target species are captured, a random subsample of 100 individuals will be selected.

The following physicochemical parameters will be measured at the surface and bottom with each collection: water temperature, dissolved oxygen, and salinity. The depth of the sample, bottom depth, and Secchi disk transparency will be recorded with each sample.

Data Analysis

The mean and geometric mean catch-per-unit-effort shall be computed in a manner comparable to that computed by DNREC. Each annual abundance index will be added to a control chart. The mean and standard deviation of species catch for each sampling event will be incorporated into an annual summary report.

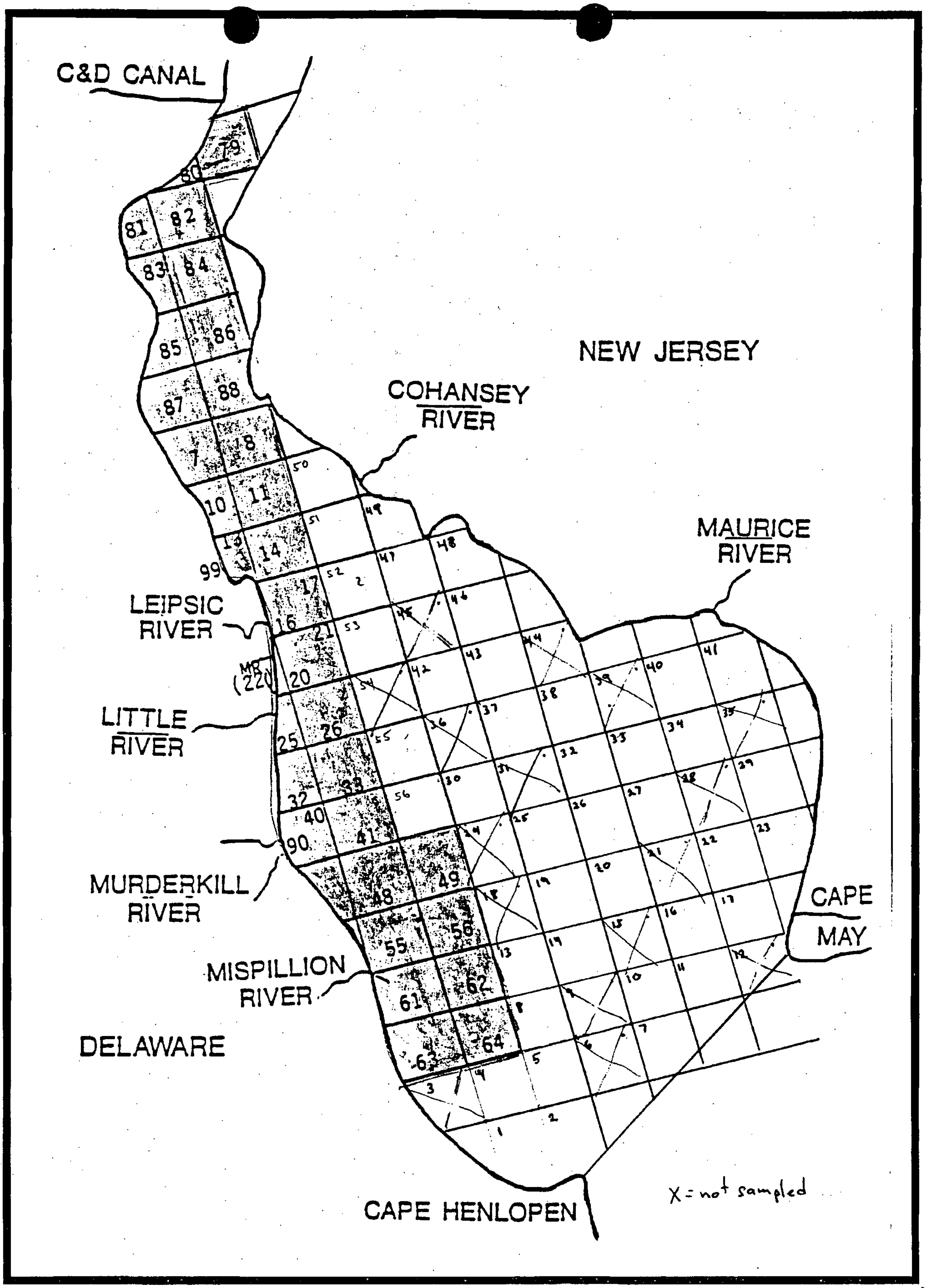

Figure 5-1. Far-field proposed bottom trawl sampling stations.

Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

5.1.3 Beach Seine Survey

5.1.3.1 Introduction

Objective of Study

The relative abundance of young-of-year finfish species will be monitored within the shallow, near-shore waters of the Delaware Estuary. These data will be used to construct indices of abundance of white perch, striped bass, American shad, alewife, and blueback herring which conform to the NJDEPE abundance indices.

By monitoring changes in the index over time, general trends in population abundance may be assessed.

Rationale for this Study

NJDEPE has indicated that these abundance indices will form the basis for their future decisions as to whether or not Salem is having an adverse environmental impact requiring further mitigation on the part of PSE&G.

Historical Foundation

Beginning in 1980 and continuing to the present, the State of New Jersey has conducted a survey of fish abundance on an annual basis within the tidal Delaware River from the C&D Canal upstream to Trenton. The focus of their survey is to monitor the abundance of juvenile striped bass in the shore zones of this area, however, the abundance of other species of fish is recorded allowing calculation of annual abundance indices.

Sampling is conducted using a 100-ft × 6-ft beach seine constructed from 0.375-in. bar mesh netting. The net is deployed perpendicular to shore from a small boat. Once fully extended, the seine is hauled into shore in a semicircular path.

By 1987, after several changes in the sampling program design, a relatively consistent program had evolved. In this program, samples were taken from 16 fixed stations twice a month from mid-July through mid-November. Two seine hauls were made at each station during each sampling event. The 16 stations were allocated among three regions:

- ***Region I***—Brackish, tidal water extending from the springtime saltwater/freshwater interface to the Delaware Memorial Bridge.
- ***Region II***—Brackish to fresh tidal water extending from the Delaware Memorial Bridge to the Schuylkill River at the Philadelphia Naval Yard.
- ***Region III***—Tidal freshwater from Philadelphia to the fall line at Trenton.

Six stations were sampled within Regions I and III, while four stations were sampled within Region II.

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In 1991, after a review of data collected on the previous 10 years and statistical analysis, the beach seine sampling program was substantively modified. Principal changes included: (1) sampling at both fixed and random stations, (2) optimizing effort among regions, i.e., concentrating 50 percent of the effort in Region II, (3) eliminating replicate samples, and (4) restricting the sampling season from August through October.

The primary purpose of the NJDEPE beach seine survey and associated abundance indices is to provide advanced warning of any serious population declines. As with the DNREC trawl survey, the hypothesis tested is that the current abundance, or abundance over some selected set of years, is not significantly lower than the average abundance during some historical period. ANOVA or Statistical Process Control procedures may be used to evaluate the indices.

5.1.3.2 Proposed Study Design

Study Duration and Geographic Extent

The beach seine survey will be conducted each year from 1995 through 1999.

Sampling Frequency

Sampling will be conducted twice per month from August through October.

Sampling Intensity and Locations

It is PSE&G's intent to sample up to 40 seine haul stations per sampling event. If all historically sampled stations are sampled, PSE&G will reallocate its sampling effort to regions of the Estuary below the Delaware Memorial Bridge.

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Sampling Gear and General Deployment

Samples will be collected using a 100-ft × 6-ft beach seine constructed from 0.375-in. bar mesh netting. The net will be deployed perpendicular to shore from a small boat. Once fully extended, the seine will be hauled into shore in a semicircular path against the tide.

Field and Laboratory Processing

All finfish and blue crab specimens will be identified in the field. For each haul, the fork length (to nearest mm) will be recorded for up to 100 specimens of each target species. If more than 100 of a target species are captured, a random subsample of 100 individuals will be selected.

The following physicochemical parameters will be taken with each collection: water temperature, dissolved oxygen, and salinity.

Data Analysis

The mean and geometric mean catch-per-unit-effort will be computed in a manner comparable to that computed by NJDEPE. Each annual abundance index will be added to a control chart. The mean and standard deviation of catch per sampling event for each species will be included in an annual summary report.

Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records. 46

5.2 PLANT EFFECTS MONITORING

5.2.1 Background

Routine monitoring of entrainment and impingement losses at Salem has been ongoing since Salem began operation in 1978. The proposed entrainment and impingement monitoring described in this Work Plan represents a continuation of this routine monitoring. The extent of the thermal plume from Salem has also been the subject of considerable prior study by PSE&G. Recent modeling studies have suggested that the effects of this thermal plume are relatively minor and of little consequence. The studies proposed in this document are designed to verify the recent modeling efforts.

5.2.2 Thermal Monitoring

5.2.2.1 Introduction

Objectives of Thermal Monitoring Program

The proposed thermal monitoring program includes intensive monitoring of temperature and salinity in the near- and far-field areas periodically occupied by the thermal plume.
The continuous database, to be collected over a 6-month period, will provide an extensive empirical record of the thermal plume under a wide range of environmental conditions through all phases of tidal mixing for use in verification of the mathematical model used to predict the characteristics of the plume under selected conditions. This updated characterization of the thermal plume will be used in the biothermal assessment (Section 5.3.2) to help document maintenance of the balanced, indigenous community and protection and propagation of shellfish, fish, and other invertebrate wildlife. This data and the associated hydrothermal assessment will be required for a new determination by NJDEPE on continuance of a Section 316(a) variance at the end of the current Permit period.

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Rationale for Thermal Monitoring Program

The Section 316(a) variance granted as part of this Final Permit will terminate at the expiration of this Permit. If requested at that time, NJDEPE will make another determination relative to continuance of the variance after a review of "...the nature of the thermal discharge or the aquatic population associated with the Station...."

The Salem 316(a) Demonstration and Supplements submitted by PSE&G since 1974 have demonstrated that the area of the thermal plume with the most potential to affect the protection and propagation of shellfish, fish, and other vertebrate wildlife is the near-field zone of initial mixing. These demonstrations have relied on a variety of empirical data and modeling exercises which have presented a generally consistent description of the near-field zone and supported the issuance of a variance under Section 316(a) of the Clean Water Act from the dimensional limits on the far-field thermal plume defined by the 1.5°F isotherm. The 1994 NJPDES Permit for the Salem Generating Station agreed with the conclusions of PSE&G's most recent 316(a) Supplement (Appendix F of PSE&G 1993) and NJDEPE's consultant (Versar 1989) that the current thermal discharge is protective of the balanced, indigenous community and was, therefore, consistent with requirements for a variance from more stringent thermal discharge limits. The Final Permit includes Special Condition 6 in Part IV-B/C which requires, among other monitoring programs, "...comprehensive thermal monitoring...."

The proposed near- and far-field monitoring programs will expand the empirical database with intensive monitoring of the temperature, distribution, and frequency of occurrence of the plume for additional model verification and to support an updated predictive biothermal assessment. The results of the model verification and the updated assessment will be submitted as part of the NJPDES Permit renewal application to support continuance of the Section 316(a) variance.

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Historical Foundation

PSE&G has used three methods, including physical and mathematical models and field thermal surveys, to characterize Salem's thermal plume. Physical and mathematical models have been used to facilitate assessment of potential impacts under conditions that can rarely be captured in the field; empirical data, on the other hand, have been used to calibrate and verify predictive models.

PSE&G filed a Section 316(a) Demonstration in 1974 and Supplements in 1975 and 1979 supported by predictive physical modeling of Salem's thermal plume (Pritchard and Carpenter 1968). The thermal plume, defined by the instantaneous 1.5°F increase above ambient predicted by this physical model, extended upstream at the end of flood tide approximately 31,000 ft and downstream at the end of ebb tide approximately 41,000 ft under projected worst-case operating and summer receiving water conditions.

In 1982, PSE&G conducted thermal plume mapping surveys on several dates to collect empirical data on the dynamics of the thermal plume with two units in operation. These surveys indicated that for the given operating, meteorologic, and tidal conditions at the time of the surveys, the 1.5°F isotherm extended approximately 13,200 ft upstream at maximum flood tide and 12,800 ft downstream at maximum ebb tide. These empirical data are valuable for calibration and verification of thermal models. However, their utility can be somewhat limited for directly assessing the potential effects of a thermal discharge into tidal estuaries because they reflect only conditions at the particular time of the survey, transect data are rarely synoptic, ambient temperature can generally not be clearly defined in the presence of the thermal discharge, and locating the outer edge of the dynamic plume at the instant tidal flow reverses the direction of the plume is virtually impossible.

PSE&G's Comments (1991) on the Draft 1990 Permit summarized these earlier studies and presented more detailed mathematical modeling (UDHKDEN) of the near-field portion of the plume. This near-field plume was characterized as having higher temperatures (typically 9°F or more above ambient) and higher discharge-induced velocities (2 fps or more). Although

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this portion of the plume was predicted (PSE&G 1991) to have some potential for biothermal effects on the RIS, the probability of significant effects was low and the affected area was very small (from 0.09 to 0.00007 percent of the Estuary). Data from the 1982 field surveys were used to calibrate this model.

In its 1993 Comments on the 1993 Draft Permit, PSE&G presented another analysis of the characteristics of the near- and far-field plumes using state-of-the-art mathematical models, CORMIX and RMA-10, respectively. These models were used to predict the distribution of temperatures in the near-field portion of the plume and the overall length (to the 1.5°F isotherm) of the thermal plume. These models were used to predict the distribution of temperatures that would exist in the absence of Salem's discharge, and then to predict the water temperatures in the Estuary, taking into account the effects of Salem's thermal discharge. The 1993 far-field model yielded maximum plume lengths between 30,000 and 40,000 ft under conditions of minimal heat loss to the atmosphere, comparable to the 1968 physical model. The 1991 and 1993 near-field models predicted similar temperature distributions within the near-field plume.

5.2.2.2 Proposed Thermal Monitoring Study Design

Study Duration and Geographic Extent

The thermal monitoring study of the waters in the Delaware Estuary influenced by the Salem thermal discharge plume is proposed to take place during May-October 1996. This period was selected as the first year following the approval of the work plan by NJDEPE. The 6-month study duration will allow thermal observations over a wide range of meteorological, runoff, and tidal conditions including the period of peak summer ambient water temperatures. The thermal monitoring program will include studies focused on two segments of the thermal plume in order to address near- and far-field issues.

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Within the framework of the Section 316(a) variance, the region of importance for the RIS biothermal assessment is the near-field region, in or just beyond the zone of plume rise from the discharge pipes to the surface. Within this portion of the plume, the 19°F design discharge delta-temperature undergoes an initial 50 percent reduction. CORMIX modeling has indicated that the plume reaches the surface within 230-300 ft and that the delta-temperature is reduced to approximately 50 percent of the initial discharge value within 90-300 ft of reaching the surface (i.e., within 310-600 ft of the discharge pipe). For the purpose of this study, the near-field region is defined as 1,000 ft upstream and downstream from the discharge location in order to assure that the study area encompasses the isotherm of the 50 percent reduction in delta temperature.

Historical studies have indicated that the edge of the plume, as defined by the 1.5°F isotherm, extends 12,000-38,000 ft upstream and downstream depending on meteorological, runoff, and tidal conditions. The median plume extension predicted by the RMA-10 model was 29,000 ft during a flood tide and 30,000 ft during an ebb tide. The 1982 field surveys documented plume conditions which extended a distance less than or equal to these predicted median values. Placing thermographs within the far-field plume region for 6 months will allow compilation of temperature statistics over a wider range of conditions. The resultant temperature distribution could provide verification for the previously predicted frequency distribution of plume extensions. The far-field study region is defined for purposes of this Work Plan as an area 10,000-38,000 ft upstream and downstream of the discharge, i.e., the area which has been predicted to typically enclose the 1.5°F isotherm.

Sampling Frequency and Locations

Near-Field Thermographs

Four near-field thermograph moorings will be deployed during the May-October period. Each location will consist of a near surface and mid-depth thermograph. One thermograph location will be just beyond the plume rise to surface in the ebb and flood tide direction (along plume centerline approximately 400 ft from the discharge). The second pair of

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thermographs will be at the same ebb/flood distance upstream and downstream as the first pair but located farther offshore. Based on previous near-field modeling, an additional 400-ft distance offshore would be expected to place the thermograph in a similar temperature regime as the 1,000-ft longitudinal boundaries of the near-field region. The thermographs would be serviced on a monthly basis. A time-series temperature record at 1-hour intervals will be processed from the thermograph data at each station.

In addition to the thermographs during this 6-month period, a tide gauge will be installed to monitor tidal velocity and direction in the vicinity of the transition from the near- to far-field zone. This data will be used in conjunction with thermograph data to evaluate tidal influence on the distribution of the thermal mixing zone.

Near-Field Plume Mapping

Six monthly thermal plume mapping surveys will be conducted during the May-October period. Each survey will consist of a set of vertical temperature and conductivity profiles and horizontal surface temperature transects. The surveys will be conducted at four times over a tidal cycle. The vertical profiles will be arranged within a 16-station grid on approximately 250-ft centers which would provide coverage of the 1,000-ft near-field region. The vertical data will be collected with a profiler which records a continuous surface to bottom temperature-conductivity-depth record. This will allow a large number of vertical profiles to be recorded in a time efficient manner. Continuous horizontal surface temperature transects will be set at approximately the same 250-ft intervals upstream and downstream as the vertical profiles.

Far-Field Thermographs

Four thermograph moorings will be deployed within the 10,000- to 38,000-ft zone associated with the 1.5°F isotherm during the 6-month May-October thermal monitoring study period. Each location will have a surface and mid-depth thermograph. An examination of existing observed and predicted plume maps indicates that 12,000- and 30,000-ft distances would be

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appropriate. The distance from shore would be selected to place the thermographs along the centerline of the plume as depicted in the historical surveys. The offshore plume distance is greater in the downstream than the upstream direction, but does not reach the shipping channel. A time-series temperature record at a 1-hour interval will be processed from the thermograph data at each station.

Sampling Gear

There are a variety of thermographs available for long-term deployment. A thermograph should be selected which has an accuracy of 0.1°C and records to solid state memory. Available memory should allow a 5-minute sampling interval for periods exceeding the proposed 30-day servicing interval.

The mooring installations will require Coast Guard approval, which may impact the size and type of buoys selected. A 6-month deployment in a dynamic estuarine environment requires a substantial mooring design. A subsurface buoy is used to maintain tension on the mooring cable such that the thermographs remain at a fixed depth relative to the bottom. A marker buoy would also be placed at the surface.

The vertical profiles will be sampled using a profiler such as the SEACAT SBE 19-03. This instrument is lowered/raised through the water column while recording a continuous data record of temperature, conductivity, and depth (pressure sensor) to solid state memory. The instrument has an accuracy of 0.01°C and a resolution of 0.001°C. The use of a profiler allows data collection at a large number of vertical stations within a short period of time.

Boat positioning during the plume mapping survey will be determined with a global positioning system which can provide location accuracy to within ±1 m. The vertical station grid can be programmed into the system, allowing the boat operator to return to the same transect on subsequent surveys.

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Data Analysis

Thermographs

The thermograph data will be processed into 1-hour values and stored in the project database as a time-series record at each station. Appropriate summary tables, figures, and statistics will be developed. A frequency distribution of the temperature data at each location would provide direct input to the biothermal RIS assessment. Data analysis techniques including Fourier transforms and filtering can be used to identify daily and tidal components associated with natural or station-induced effects. A detailed analysis of the spatial and temporal difference between stations provides information on natural longitudinal temperature gradients within the study region and estimates of ambient temperature. Estimates of ambient temperature will be based on analysis of temperatures recorded by the most upstream and downstream thermographs at the time of maximum ebb before slack tide and maximum flood before slack tide, respectively. This would allow the thermograph data to be presented as delta-temperatures associated with the plume. Far-field delta temperatures will be important if issues associated with state water quality standards are raised during the next permitting process.

Near-Field Plume Mapping

The temperature data collected over the vertical station grid will be used to develop a three-dimensional representation of the near-field plume. Data presentations will include cross-sectional profiles and cumulative volume-temperature statistics. The near-field temperature data can be used to confirm CORMIX predictions of the extent of bottom contact and spatial distribution following plume rise to surface. Data analysis will be coordinated with the biothermal assessment task to ensure that data presentations contain the necessary supporting thermal information in a usable format.

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Modeling

The development of an extensive empirical thermal database creates an opportunity to examine the verification of the previous near- and far-field modeling. In 1993, the near-field region was modeled with CORMIX. It is proposed that the near-field be remodeled with CORMIX or the most appropriate "state-of-the-art" three-dimensional plume model available at the time of these analyses (i.e., 1996-1997). A near-field model re-verified using this extensive empirical database would provide a tool to address with greater certainty plume scenarios arising from plant-induced or natural conditions beyond the range observed in the empirical surveys. The plume model could also be used to better define the cumulative volume-temperature relationship and extend the relationship beyond the limits of the 16-station sampling grid assuming a linear or known non-linear relationship.

In 1993, PSE&G presented far-field modeling based upon the three-dimensional finite element RMA-10 model. Execution of this previously calibrated model for the 6-month thermal monitoring period would provide additional model verification. Time-series temperature data at fixed locations and depths within the plume region provide an excellent dataset for model verification. The proposed far-field monitoring program focuses on compiling a frequency distribution of temperatures associated with the longitudinal extent of the plume. The far-field model would allow this longitudinal information to be extended laterally to provide cumulative area-temperature relationships.

Quality Assurance/Quality Control

Manufacturer's recommendations will be followed pertaining to the frequency and procedures for thermograph calibration. Calibration records will be maintained on each instrument.

Data processing procedures will be established which will examine the integrity of each station's data relative to expected temperature ranges and previously observed differences between stations. The continuity of the data record between two different instruments which were exchanged during a monthly servicing is also an important quality check point.

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5.2.3 Thermal Assessment for Representative Important Species

5.2.3.1 Introduction

Objective of this Study

The objective of this study plan is to provide an updated predictive biothermal assessment to be submitted with PSE&G's NJPDES Permit renewal application at the end of the current 5-year Permit period in support of a request for re-issuance of a Section 316(a) variance. The predictive biothermal assessment was most recently updated as part of PSE&G's September 1993 Comments on the 1993 Draft NJPDES Permit based on laboratory thermal effects data, life history information, and mathematical hydraulic models of the near-field (CORMIX) and far-field (RMA-10) thermal plume which existed at the time.
A comprehensive thermal plume monitoring program in compliance with Final NJPDES Permit Special Condition 6.(a) (Part IV-B/C, Page 26) has been proposed as part of this Work Plan (Section 5.2.2). Data collected during the plume monitoring program will be used to validate and update the two thermal plume models. These revised models will be used as the basis for updating the predictive biothermal assessment. The conclusions of the 1993 predictive biothermal assessment relative to assuring "...the protection and propagation of the balanced indigenous population [community]," under the Section 316(a) Determination (Final NJPDES Permit Special Condition 11, Part IV-B/C, Page 31) will be reviewed and, where appropriate, modified and refined to account for refinements in the physical characteristics of the plume predicted by the updated models.

Historical Foundation and Rationale

PSE&G originally filed a Type II (predictive) Section 316(a) Demonstration with EPA for Salem in 1974. This Demonstration was supplemented in 1975 and 1978 with Type III Demonstrations which combine predictive and empirical assessment techniques. Versar, Inc. (1989), as consultant to NJDEPE, reviewed the Demonstration and Supplements. Although this review identified nine deficiencies in four of the categories of biothermal data presented,

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Versar ultimately concluded that the adverse effects from Salem's thermal discharge "...were small and localized and not a major source of impact" and "...therefore, did not need to be reduced to protect the balanced, indigenous population." In the Fact Sheet for the 1990 Draft NJPDES Permit, NJDEPE agreed with this conclusion that adverse effects would be restricted to a few species under extreme temperature conditions and in a very localized area. In comments on the 1990 Draft NJPDES Permit (PSE&G 1991, Appendix F) and again in comments on the 1993 Draft NJPDES Permit, PSE&G provided updated supplemental Type III Demonstrations which addressed the Versar (1989) comments.

These Demonstrations and Supplements have utilized three distinct methods to predict and describe the mixing characteristics, shape, temperature and velocity distributions, and occurrence frequency of the thermal plume. These methods include physical and mathematical models, as well as empirical field surveys, which NJDEPE concluded in its Response to Comments Document in the Final 1994 NJPDES Permit "... have generally provided consistent information on the overall dimensions of the thermal plume." However, NJDEPE has required a "comprehensive [robust] thermal monitoring program" and performance of a new biothermal assessment for the RIS using the best scientific methods and technical knowledge available to assess the effects of the cooling system.

5.2.3.2 Proposed Study Design

If the plume monitoring program indicates that the configuration, temperature, or frequency distribution of the plume are substantially different than previously described, the biothermal assessment will be revised to address the potential effects of these differences on the RIS. Revisions will also take into account relevant new thermal effects data for the RIS and an updated characterization of the range of station operating conditions observed historically and during the period of this Permit which may influence the plume characteristics. This predictive assessment will focus on the warmer portions of the plume where the greatest potential for thermal effects to aquatic organisms is likely to occur, that is the near-field area predicted by CORMIX and the transition to RMA-10 models. The biothermal assessment will be presented as a Supplemental 316(a) Demonstration, patterned after Appendix F of

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PSE&G's September 1993 Comments. This Supplement will emphasize predictive methods to demonstrate protection and propagation of the balanced, indigenous population as represented by the RIS, supplemented, as appropriate, by empirical information (Section 5.1) to demonstrate, "no prior appreciable harm" to the balanced, indigenous population.

This assessment would be performed during Year 4 of the Permit for inclusion in the permit renewal application, as well as to take maximum advantage of data generated by the thermal monitoring (Section 5.2.2) and other relevant studies.

5.2.4 Entrainment Abundance Monitoring

5.2.4.1 Introduction

Objective of Study

Onsite entrainment abundance monitoring will be conducted in the circulating water system. The objective of this study is to estimate the total annual abundance of fish and macroinvertebrates entrained through the circulating water system at Salem Units 1 and 2.

Rationale for this Study

This study is specifically required by the 1994 NJPDES Permit. Estimates of entrainment losses form the basis for a number of indices and measures used for assessing Salem's impact on the Delaware Estuary's fish and macroinvertebrate populations. Annual losses monitored over time may be used as an index of population abundance, while losses expressed as equivalent adults may be used for assessing production losses and long-term changes in population dynamics.

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Historical Foundation

Since 1977, entrainment samples at Salem have been collected, typically at circulating water system intake bays 11A or 12B or at discharge standpipes 12 or 22. Individual samples are pumped, via a Neilsen 15.2-cm fish pump, into a net-in-tank "abundance chamber." The abundance chamber consists of a 1-m plankton net with 0.5-mm mesh mounted inside a tank. The tank serves to buffer turbulence inside the net and reduce damage to the collected organisms. Pumping rates generally do not exceed 2.0 m^3/minute with a total sample volume of 50-100 m^3.

Over the years, entrainment sampling schedules have varied considerably. From August 1977 through April 1978, samples were taken monthly from September through May and twice per month from June through August. In May 1979, the schedule was changed to once per month in March, April, October, and November; twice per month in May, August, and September; and four times per month in June and July. During this period, samples were collected once every 4 hours during each 24-hour collection period. In June 1980, after a series of Monte Carlo simulation studies, the program was further modified to consist of four samples per day with samples taken every fourth day. This program was maintained through 1982. Currently, entrainment abundance samples are collected from intake bays 22A or 12B three times per day, one day per week, during each month of the year (January-December).

5.2.4.2 Proposed Study Design

Study Duration and Geographic Extent

Entrainment abundance monitoring will be conducted from 1995 through 1999.

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Sampling Frequency

Entrainment abundance monitoring will be conducted 3 days per week from April through September, and 1 day per week from October through March during 1996 and 1997. During the remaining years, entrainment sampling will remain at the current level of one sample per week during the entire year.

Sampling Intensity and Locations

Up to six samples will be collected during each 24-hour period. The proposed sampling program will yield 624 samples per year during 1996 and 1997, and 312 samples per year in the remaining years. Samples will be collected from intake bays 22A or 12B.

Sampling Gear and General Deployment

Sampling methods will be the same as used since 1977. Individual samples will be pumped, via a Neilsen 15.2-cm (or equivalent) fish pump, into a net-in-tank "abundance chamber." The abundance chamber will consist of a 1-m plankton net with 0.5-mm mesh mounted inside a tank. Pumping rates will not exceed 2.0 m^3/minute with a total sample volume of 50-100 m^3.

Field and Laboratory Processing

Ichthyoplankton and macroinvertebrate samples will be preserved for processing in the laboratory. Once in the laboratory, species and life stages will be counted and identified. In addition, total length for fish target species larvae and juveniles, head-telson length for opossum shrimp, and rostrum-telson length for scud will be measured to the nearest millimeter for up to 50 individuals of each species and life stage per sample.

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Data Analysis

The total annual number entrained and corresponding 95 percent confidence limits will be computed for each of the target species. The results will be incorporated into an annual report which summarizes the volume of water sampled, plant operating conditions, and environmental conditions for each sample.

Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

5.2.5 Impingement Abundance Monitoring

5.2.5.1 Introduction

Objective of Study

The objective of this study is to estimate the total number of each species of fish impinged at Salem Units 1 and 2 and to estimate their initial survival.

Rationale for this Study

Impingement monitoring is specifically required by the 1994 NJPDES Permit. Estimates of impingement losses form several important measures for assessing the effects of Salem on the Delaware Estuary fish population. Annual impingement numbers may be used to form an index of population abundance and are essential for computing conditional mortality rates.

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Historical Foundation

Impingement samples have been collected at Salem since the startup of Unit 1 in 1977. This program collects fish from the combined fish- and trash-trough screenwash by diverting the screenwash discharge into the north or south fish counting pools. On flooding tides, the north pool is used, while on ebbing tides the south pool is used. At a minimum, 1 minute of flow is diverted into the counting pools, although under light detritus conditions, samples of longer duration are occasionally taken. The average diversion duration has been approximately 3 minutes.

After diverting the screenwash, the pool is drained through the gate, valve, or pump, depending on the tidal stage. When the water depth drops to approximately 0.3 m, fish are collected with a dip net and placed in a bucket.

For each sample, the date, start time, and end time are recorded, as are the number of circulators and traveling screens in operation, screen speed, tidal stage and elevation, sky condition, wind direction, wave height, and air temperature. Water temperature and salinity in the pool are also measured.

Fish are sorted by species and the total number, weight, minimum and maximum length, and length frequencies are recorded. The condition of each fish is recorded as live, damaged, or dead.

Since the start of impingement monitoring in May 1977, the sampling frequency has varied considerably. During 1977 through June 1978, fewer than 98 samples were taken per month. Beginning in July 1978 until December 1983, the number increased substantially; typically 250-350 samples were collected each month. After 1983, there was an attempt to stratify the sampling effort. Typically 20-30 samples per month were taken from November through April and 50-100 from May through October. After March 1988, sampling continued at a level of approximately 48-54 samples per month throughout the year.

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Impingement collection efficiency studies were also conducted to determine, by size class of fish, the percentage of impinged fish not recovered during the spraywashing and fish collection procedures. These studies were conducted with blueback herring, bay anchovy, white perch, weakfish, spot, and Atlantic croaker. Dead fish were stained with rose bengal, measured to the nearest 5 mm, and stored in containers labeled by size increment. For testing, approximately 100 specimens of a species were selected and counted from the available size increments. A composite sample of one or more species was then released in front of the traveling screen. A recovery sample was taken by diverting a minimum 12-minute flow of screenwash water into the counting pool. The number returned by size interval was then evaluated.

5.2.5.2 Proposed Study Design

Study Duration and Geographic Extent

Impingement monitoring will be conducted from 1995 through 1999.

Sampling Frequency

Sampling will continue on a year-round basis; data collected will include species abundance, length frequency measurements, and initial percent survival.

Sampling Intensity and Locations

Impingement abundance monitoring will be conducted 3 days per week, with up to 10 samples collected per 24-hour period during 1996 and 1997. During the remaining years, impingement sampling will be conducted 1 day per week. Samples will be collected at the north or south collection pools, depending on the discharge direction.

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Sampling Gear and General Deployment

Sampling methods used for this program will be comparable to the impingement abundance monitoring program conducted at Salem since 1977. A total of 1- to 3-minute screenwash flow will be diverted to the appropriate counting pool (north on ebb, south on flood). When the water level drops to approximately 0.3 m, fish will be collected with a dip net and placed in a bucket.

Field and Laboratory Processing

For each sample, the date, start and end times, number of circulators, number of traveling screens in operation, screen speed, tidal stage, tidal elevation, sky condition, wind direction, wave height, air temperature, water temperature, and salinity will be measured and recorded. Fish will be sorted by species and the length and condition (live, dead, or damaged) of each fish recorded. Additionally, the weight of the smallest and largest individual of each species will be recorded.

Data Analysis

The total annual impingement and corresponding 95 percent confidence limits will be computed for each target species. These results will be incorporated into an annual report summarizing the findings of the study. This report will include the volume of water sampled, plant operating conditions, and environmental conditions.

Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

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batch # 287
part # 3580-B

Study Plans for Additional Biological Monitoring of the Delaware Estuary to be Conducted by Public Service Electric and Gas Company

Part II

Prepared for

Public Service Electric and Gas Company
Estuary Enhancement Program
P.O. Box 236
Trailer 80 M/C N33
End of Buttonwood Road-Artificial Island
Hancocks Bridge, New Jersey 08038

Prepared by

EA Engineering, Science, and Technology
The Maple Building
3 Washington Center
Newburgh, New York 12550

and

Lawler, Matusky & Skelly Engineers
One Blue Hill Plaza
Pearl River, New York 10965

October 1994

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CONTENTS (Continued)

3

1. INTRODUCTION

This report presents plans for additional studies which Public Service Electric and Gas Company (PSE&G) will conduct during the present 5-year Permit period for Salem's New Jersey Pollutant Discharge Elimination System (NJPDES) Permit. These studies complement those described in the Permit Work Plan and are designed to address key issues and questions which are expected to arise during the next permit application period. Many of the issues addressed in these study plans were previously raised by New Jersey Department of Environmental Protection and Energy (NJDEPE) and their consultants during the review of Salem's 316(b) Demonstration or by various commentors on the draft Permit, especially the U.S. Environmental Protection Agency (EPA). The intent of the studies proposed herein is to provide information which can be used to address these issues should they arise again during the next permit cycle.

For convenience, these additional study plans are grouped into three broad categories:

1. Biological Monitoring of the Delaware Bay and River
2. Habitat Restoration Monitoring
3. Refinement of Estimates of Conditional Mortality.

Each of the study plans is discussed in detail in the following chapters.

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2. BIOLOGICAL MONITORING OF THE DELAWARE BAY AND RIVER

2.1 MACROINVERTEBRATE MONITORING

2.1.1 Introduction

2.1.1.1 Objective of Study

The macroinvertebrate sampling program is designed to investigate the potential for near-field depletion effects. This study will look for a statistically lower concentration of opossum shrimp in the immediate vicinity of Salem Generating Station relative to other, i.e., far-field, regions of the Estuary.

2.1.1.2 Rationale for this Study

The Permit does not require this study. Such a study would, however, be useful in addressing future concerns of regulatory agencies. During the initial review of the Salem 316(b) Demonstration and during the permitting process, questions were raised as to whether or not Salem was reducing the populations of macroinvertebrates, especially opossum shrimp, in the immediate vicinity of Salem. If this is the case, the forage base for local fish populations may be reduced, bringing concomitant reductions in growth and survival.

2.1.1.3 Historical Foundation

Although opossum shrimp have been sampled extensively throughout the Delaware Estuary, there is no historical precedent for a study of local depletion in the immediate vicinity of Salem. A study conducted by Walker (1989) used an epibenthic sled to sample seven stations along the length of the river. This study found no statistical difference in mean concentration among all stations. The sampling location nearest to Salem was located at the C&D Canal.

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2.1.2 Proposed Study Design

2.1.2.1 Study Duration and Geographic Extent

A study of local depletion can be completed within a single year. It is recommended that this study be conducted early within the 5-year Permit period, preferably during 1995 or 1996. This will provide time to conduct the test in subsequent years if, for any reason, the study cannot be completed.

Versar, Inc., in its review of the Salem 316(b) Demonstration, believed that there was a potential for local depletion within an area of ± 10 mi from Salem. Therefore, restricting the study area to ± 10 mi or less from Salem should be sufficient to test Versar's claim.

2.1.2.2 Sampling Frequency

In order to collect sufficient samples to be reasonably certain (≥ 80 percent probability) of detecting a 25 percent or greater difference in mean concentrations between the near- and far-field areas, at least eight sampling events with a total of 26 samples per event must be collected. (See Section 2.1.2.3 for distribution of sampling effort within each event.) A total of 208 samples will be collected.

Because the life cycle of opossum shrimp is very short, with adults producing several generations over the May through September growing season, the effects of local depletion should appear rapidly and be especially apparent by late in the growing season— after the compounded effects of cropping on several generations has accumulated. To insure sufficient numbers of organisms throughout the study, sampling should commence in mid-August and be conducted weekly through the middle of October.

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2.1.2.3 Sampling Intensity and Locations

Each 10-mi region of river extending north and south of Salem will be divided in half to form near- and far-field study areas. The near-field region is the single 10-mi stretch of river centered at Salem, while the far-field region is the two 5-mi reaches above and below the 10-mi reach. Thirteen randomly chosen samples will be collected from the near-field and 13 from the far-field regions during each sampling event, for a total of 26 samples per event.

2.1.2.4 Sampling Gear and General Deployment

Samples will be collected with a 0.5-m diameter plankton net mounted on an epibenthic sled. Tows will be made at approximately 1.3-1.9 knots in the direction of tidal flow; tow duration will be approximately 5 minutes. Flowmeters will be used to determine the total volume of water filtered.

2.1.2.5 Field and Laboratory Processing

Macroinvertebrate samples will be preserved for processing in the laboratory. Once in the laboratory, the number of opossum shrimp per tow will be determined. Subsampling techniques may be used if large numbers of individuals are taken.

The following physicochemical parameters shall be taken with each collection: water temperature, dissolved oxygen, salinity, and Secchi disk transparency.

2.1.2.6 Data Analysis

A randomized block analysis of variance (ANOVA) shall be used to test for statistical differences between the near- and far-field regions. The model should include WEEK as a

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random effect, LOCATION as a fixed effect, and a WEEK × LOCATION interaction effect. The results of this analysis will be incorporated into a report summarizing the macroinvertebrate sampling findings.

2.1.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities shall undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the program work plan. Data files resulting from this study will be inspected following procedures designed to ensure an acceptable outgoing quality level (AOQL) of ≥0.1 percent.

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3. HABITAT RESTORATION MONITORING

3.1 DETRITAL FLUX MONITORING

3.1.1 Introduction

3.1.1.1 Objectives of Study

Flux studies will be conducted to determine the export of organic matter and nutrients from restoration sites and reference salt marsh sites, and to demonstrate whether restored sites function similarly to other natural salt marsh sites in the Delaware River Estuary.

3.1.1.2 Rationale for this Study

This study will supplement the Detrital Production Monitoring (Work Plan, Section 2.2), required by the Final NJPDES Permit, demonstrating the availability of marsh detrital production to the food chain both in the marsh and in the open waters of the Estuary.

Early hypothesis of coastal ecosystem processes suggested that a key role of marshes was in the export of particulate matter derived from vascular plants to estuarine and coastal waters. A significant fraction of estuarine and coastal fish and shellfish production is considered to be dependent on marsh-based detrital production (Adam 1990). A major factor in the availability of detrital production to the food chain is the tidal flux of materials between the marsh and adjacent open waters. Organic matter may enter or leave the marsh in the form of fish and invertebrates; floating, suspended, or bed load detritus; and dissolved material. Scientific research on the flux of nutrients and organic matter in and out of marshes has demonstrated a wide range of flux rates depending on the hydrology and meteorological conditions at a given site. Flux rates can vary seasonally and annually at a given site with studies demonstrating some sites to be net exporters of organic matter and nutrients and others being net importers.

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The aggregated food chain model, which was formulated as the basis for estimating the number of acres of wetlands to be restored as part of the Estuary Enhancement Program, assumes that detrital production in the marshes is available to fish and invertebrates at higher levels of the food chain which reside in the marsh seasonally or for most of the year.
In addition, this primary production is also available to other estuarine and coastal inhabitants that only infrequently enter the marsh in the form of exported dissolved and particulate organic matter and nutrients or through forage fish and invertebrates which do utilize the marsh. This study will be used to document whether the restored marsh sites function as a source of food production for the estuarine food chain, similar to natural salt marshes (reference sites) in the Delaware River Estuary.

3.1.2 Proposed Study Design

3.1.2.1 Study Duration and Geographic Extent

These studies will be conducted over three 1-year intervals. The first phase will be initiated 1 year prior to the beginning of marsh restoration activities, allowing documentation of baseline conditions and incorporating seasonal variation in mean sea level. The flux monitoring will continue for a second 1-year interval follow initiation of restoration activities. The third year of monitoring will begin at such time as the Detrital Production Monitoring (Work Plan, Section 2.2) indicates that the vegetation community at the restored sites resembles that at the reference sites. Sampling sites will include at least two *Phragmites* restorations, one impoundment restoration, one salt hay farm restoration, and two reference sites. Reference sites will be selected to be representative of the geography and the physical and chemical range of conditions at the restoration sites.

3.1.2.2 Sampling Locations and Frequency

Specific sampling locations will include the mouths of two or three representative tidal creeks at each site. Water and detrital samples will be collected monthly over one full tidal cycle.

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Separate composite samples will be collected during two consecutive flood and ebb tide phases.

3.1.2.3 Sampling Methods

One of the most important components of detrital flux study will be the measurement of water exchange. Scientific studies have utilized several methods to determine water exchange, including current meter measurements, estimation from tide height and hypsographic curves, and modeling, which have been reviewed and summarized by Nixon (1980). For this study, a combination of these methods is recommended. For each of the three study phases, at selected discharge channels, the stage-discharge relationship will be established for flood and ebb tide using channel cross-section dimensional measurements and empirical measurement of discharge. In addition, a continuous 6-month record of current velocity (analyzed at hourly intervals) will be obtained from a fixed location in each channel, along with simultaneous relative water surface elevation. The continuous current and water surface elevation database will be calibrated against the stage-discharge relationship in order to model the seasonal and longer-term exchange of water between the marsh and the open estuary.

The second component of the detrital flux study is the measurement of organic and nutrient constituents of the water flowing into and out of the marsh, including particulate (POM) and dissolved (DOM) organic matter, nitrogen, and phosphorus. Methods for collection and analysis of DOM and uncertainties associated with such flux measurements have been outlined in Boon (1975 and 1978), Kjerfve et al. (1978), and Kjerfve and Proehl (1979); similar methods will be used for this study. Particulate matter may be further divided into gross and fine. Gross POM includes large floating "rafts" of vegetation mainly in the form of shoots, while fine POM includes smaller pieces of suspended matter. Detrital bed load typically consists of a combination of gross and fine material. Macrodetritus (gross POM) will be collected with skimmer nets anchored at predetermined sites following methods outlined in Dame (1982). Water samples will be collected at the surface and near bottom at

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each location. Nitrogen (total, organic, ammonia, nitrate, and Kjeldahl) and phosphorous (total, dissolved, and orthophosphate) will be measured in both whole water samples and POM, as appropriate.

Bacterial carbon conversion efficiencies have been found to be linked with nutrient concentrations (Benner et al. 1988). Several authors (Haines and Hanson 1979; Newell et al. 1983) reported that the addition of inorganic nitrogen to salt marsh water increased rates of degradation and conversion efficiencies of *Spartina* detritus. Nutrient concentrations will be monitored in waters flowing into and out of the marsh to estimate net flux.

Flux measurements from restored marshes will be compared to those for reference sites and among pre-, initial, and late restoration sampling intervals to evaluate differences and changes in exchange rates.

3.2 FISH AND MACROINVERTEBRATE UTILIZATION OF RESTORED WETLANDS

3.2.1 Introduction

3.2.1.1 Objectives of Study

The objective of this monitoring study is to quantify fish and macroinvertebrate use of the restored wetland areas. This monitoring will include a variety of habitat types common to both restored and undisturbed wetland areas. Because the sampling methods that will be employed to conduct this monitoring will collect a large variety of fishes and macroinvertebrates in addition to the target species, the objective will be to evaluate the fish and macroinvertebrate communities that exploit wetland habitat and not be necessarily limited to the target species. Including non-target species as part of the objective will provide a more complete framework for assessing the success of the restoration programs.

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3.2.1.2 Rationale for this Study

Habitat utilization studies are important in terms of establishing the premise that the restored wetlands are being utilized by the fish and macroinvertebrate communities in abundances similar to undisturbed wetlands. This monitoring study would help document the assumptions presented in the Permit Application relative to the function of wetlands as important larval, juvenile, and/or adult fish habitat for the species at issue, as well as for the entire Delaware Bay fish and macroinvertebrate community. A central theme in the Permit Application was that the restored wetlands would provide additional high quality habitat for the target species.

3.2.1.3 Historical Foundation

As in the case of most estuaries (Haedrich 1983), Delaware Bay supports a wide variety of fish species and life stages, many of which are seasonal transients (Wang and Kernehan 1979). Few studies have been designed to describe community structure and interaction in northeastern tidal wetlands. Rountree and Able (1992) conducted a large effort in southern coastal New Jersey to describe the community structure and nursery function of wetland surface, intertidal creek, and subtidal creek subhabitat in a mesohaline salt marsh. Results from this study strongly suggest that this region is an important nursery ground for large numbers of marine species, including the lady crab as well as bluefish, mullet, Atlantic needlefish, summer flounder, and Atlantic herring. Several adult seasonal transients occurred in tidal creeks as adults. These included the horseshoe crab, sticklebacks, bay anchovy, and weakfish. Bozeman and Dean (1980) measured fall and winter populations of larval fish in a South Carolina intertidal creek. Results indicate that extensive southeastern tidelands are important nursery grounds during the winter for spot, Atlantic croaker, and Atlantic menhaden. Larvae of many species of fish migrate into the estuarine intertidal creeks during the winter (Croaker 1965; Thayer et al. 1974).

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3.2.2 Proposed Study Design

3.2.2.1 Study Duration and Geographic Extent

This study will be initiated in the first year of PSE&G's Estuary Enhancement Program and continue through the 5-year Permit period. The first year of the study will serve to collect baseline data, because most of the restoration process will not yet have been initiated at many of the sites. This study period should also be sufficient to document an increase in fish and selected macroinvertebrate abundance from a wetland that is in transition from being a disturbed wetland to a wetland that is restored to its natural state. The sampling program is likely to be refined after the initial 1 or 2 years of sampling as the data are analyzed and other data needs are identified.

Because fish and macroinvertebrate populations vary significantly from year to year as a function of a variety of biotic and abiotic factors, this monitoring study will include reference sites. Reference sites will closely match the site to be restored in terms of size, salinity, tidal fluctuation, elevation and other physical parameters. The reference sites will serve as benchmarks that will allow evaluation of the degree of restoration success.

The geographic extent of the study is somewhat difficult to define in that the study will evaluate selected wetlands throughout the Delaware Bay to monitor the success of restoration at individual sites. The locations of the sample sites could theoretically be distributed throughout the Delaware Bay, but this may or may not be possible given the distribution of sites to be restored and candidate reference sites. In either case, the results will be applied to all restored sites that match the characterized sites of one of the restored sites included in the monitoring program. It is not the intent of this monitoring program to sample at all of the restored wetland sites at a sufficient level of effort to independently compare fish and macroinvertebrate abundance against fish and macroinvertebrate abundance of the reference sites.

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3.2.2.2 Sampling Frequency

For purposes of sampling, wetland habitat can be partitioned into several important and contiguous subhabitats: (1) irregularly flooded wetland including wetland ponds, (2) regularly flooded intertidal wetland surface, (3) intertidal wetland creeks, (4) subtidal wetland creeks, and (5) bay wetland fringe (Rountree and Able 1992). Because the species at issue would not be abundant in irregularly flooded wetland and regularly flooded intertidal wetland surface, these subhabitats can be eliminated from the sampling program. Some life stages of the target species may occupy regularly flooded intertidal wetland surface on a flood tide, but they can be sampled from the other habitats that would be used to access the wetland surface. At least some of the species at issue would be expected to be abundant in the other three habitat types. However, to help reduce the number of samples, intertidal and subtidal creeks will not be distinguished and most of the samples will likely be collected from subtidal creeks. The subtidal creeks sampled in the restored and reference sites will be of similar size in terms of length and width. In a general sense, samples will be collected from two habitat types, bay/wetland fringe and tidal creeks.

For each type of restored wetland (e.g., salt hay farms, *Phragmites*-dominated wetland), a sufficient number of sample wetlands to represent the range of salinity, tidal conditions, and other important physical parameters will be included in the monitoring study. Representative wetlands is an important component of this monitoring study because the results will be applied to the other wetlands that resemble the studied wetland in the interpretation of the results. It is not necessary to have a different reference site for each restored site as long as the physical characteristics are similar. At a minimum, the initial sampling years will include four sites to be restored (including salt hay farms or polyhaline marshes and *Phragmites*-dominated or oligohaline marshes) and two reference sites (one oligohaline and one polyhaline).

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As an option, it may be prudent to conduct some minimal sampling effort at additional restored sites to allow more confidence in the extrapolation of conclusions made from the more intensely sampled wetlands. The level of sampling effort may be reduced to sampling only subtidal creeks as they drain during the ebb tide. The exact number of restored wetlands included in the study will be determined based on the site selection process for restoration. If this part of the study is initiated, the sampling effort would occur in either the fourth or fifth year of the Estuary Enhancement Program.

The sampling program will be limited to those months that the target species are present even though the fish and macroinvertebrate communities as a whole will be included in the analyses. The target species principally utilize the marshes during periods when the water is relatively warm (>10°C). Therefore, sampling will occur from early April through mid-November.

3.2.2.3 Sampling Intensity

Sampling intensity will differ according to the different types of gear and habitats being sampled. The sampling program is outlined below for blocknets and trawling. Details regarding the sampling gear are provided in Section 3.2.2.4. Samples will always be collected from reference and restored sites, if possible, to provide the proper basis for comparisons of fish and macroinvertebrate abundance.

- **Blocknets (Fish Weirs)**—The primary sampling method to document utilization of fishes and macroinvertebrates in tidal creeks, which are arguably the most important habitats in the marshes for fish, will be blocknets. Blocknets will be fished during the daylight ebb tide on a semimonthly basis. This would result in 15 samples being collected at each blocknet sampling location.

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Because there is sufficient data to suggest that species composition and abundance vary between day and night samples (Bozeman and Dean 1980; Miller and Dunn 1980), special sampling will be conducted to evaluate this phenomenon in the Delaware Bay. The blocknets will be fished over consecutive ebb tides for a 2-day period (2 day and 2 night samples), once each in May, July, and September. This study will be conducted at one oligohaline and one polyhaline marsh.

- **Trawl Sampling**—Trawl samples will be collected monthly at four sites; upper tidal, lower tidal creek, bay/marsh fringe (shoal), and deeper bay (> 10 ft), within each of the tidal tributary systems. At each of the four locations, four 2-minute tows will be conducted.

3.2.2.4 Sampling Gear and General Deployment

Several different types of sampling gear will be used to collect macroinvertebrates and fish larvae, subadults, and adults. One of the primary areas to be sampled is intertidal creeks where a weir sampling device patterned after Rountree and Able (1992) will be used. A weir collection device will be effective in collecting fish and larger macroinvertebrates that are moving in and out of tidal creeks with the tide. Seines will be used to collect fish that are present in the tidal creeks during low tides. Fish weirs will be set within 1 hour of the end of the flood tide and will be fished throughout the ebb tide. Fish moving out of the tidal creeks will be captured. Seining will be conducted at standardized areas within the tidal creeks.

Small otter trawls (10- to 16-ft headrope) will be used to sample tidal tributaries and bay/wetland fringe. Trawl samples will be standardized by the time of the trawl and the catch will be expressed on a catch-per-unit-effort basis. Fish samples in other wetland habitats will be collected in a standardized manner, using gear that efficiently samples in a variety of yet to be determined habitat types.

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Larval fish and macroinvertebrate samples will be collected with a standard 0.5-m plankton net towed or held in place for a set duration. The sampling intensity will be similar to that described for blocknets. Oblique tows will be used in all areas of sufficient size. Surface and bottom tows may be used in more confined areas. All sampling protocols will be standardized to allow comparisons within and among sites.

3.2.2.5 Laboratory Processing

Laboratory processing will be required for most of the samples collected as part of this monitoring program. As much of the processing as possible for adult and juvenile fish will be conducted in the field. However, it is likely that at least subsamples from the weir collections will be preserved in 10 percent formalin and processed in the laboratory. Samples will be sorted in the field or laboratory to remove all the individuals of the target species or rare species. If subsampling is required, the subsample will consist of the species remaining after the rare and target species have been removed. For a subset of each species, length and weight will be measured.

The samples collected in plankton nets will be preserved in buffered formalin in labeled polyethylene jars in the field and a histological dye added to appropriate samples to facilitate organism removal in the laboratory. Organisms will be removed with the aid of a dissecting microscope in the laboratory and preserved in 75 percent ethanol. If organism numbers are excessive, a subsampling method will be utilized to reduce the number of organisms to be sorted and identified. The organisms will then be identified to the lowest practical taxon and enumerated. An alternative would be to identify all non-target species to the generic level, which would reduce the amount of effort required to process the samples and at the same time retain much of the information required from the samples.

3.2.2.6 Data Analysis

Data analysis will be focused on comparisons of the data obtained from the reference sites with data obtained from the restored sites. There will be two basic levels of data analysis.

The first level of analysis will focus on the relative abundance and distribution of only the target species. These comparisons will be based on catch-per-unit-effort by gear types within similar habitat types among the reference and restored wetlands. The analyses will be conducted separately for each tide stage (ebb or flood) and for day and night samples.

The second level of analysis will involve species in addition to the target species and be based on community assessments. Parameters such as diversity, richness, similarity coefficients, and trophic composition will be examined for similarities between reference and restored sites, as well as between tidal tributaries and subtidal creeks.

These analyses will be incorporated into a report that includes methods, results, and a discussion of the abundance and distribution of fishes and macroinvertebrates in restored and reference marshes. Recommendations for the following year's sampling effort will also be included in the report.

3.2.2.7 Quality Assurance/Quality Control

Quality assurance/quality control procedures will be implemented for the collection and processing of the samples. The data recording and processing techniques will be standardized to minimize investigator error. A quality assurance/quality control manual specific to this monitoring study will be developed prior to initiating sampling.

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4. REFINEMENT OF ESTIMATES OF CONDITIONAL MORTALITY

4.1 DISTRIBUTION AND RECRUITMENT SURVEY

4.1.1 Introduction

4.1.1.1 Objective of Study

This study will estimate the relative distribution (D-factors) and relative recruitment timing (R-factors) with emphasis on bay anchovy, weakfish, spot, and striped bass. These two groups of factors are critical input to the Empirical Transport Model (ETM); the results of this study will be used as input to revised model runs with more recent data. This study will need to be conducted in conjunction with the Gear Comparison Study (Section 4.2).

4.1.1.2 Rationale for this Study

This study is not required by the Permit, but is in response to EPA's comments on the Draft Permit in which they requested NJDEPE require PSE&G "...to verify the fish population models being used...." In addition, this information would be required in order to update estimates of conditional mortality which might be required during the next permit renewal cycle.

4.1.1.3 Historical Foundation

Several of PSE&G's assessment models require estimates of the distribution of organisms throughout the Estuary and recruitment patterns, i.e., the temporal occurrence of organisms within the Estuary. One such model, the ETM, requires estimates of the proportion of the population (by life stage) in defined segments of the Estuary over time. The temporal distribution of eggs is used to establish the timing of cohort recruitment. The Exploitation Rate Model used for opossum shrimp and scud also utilizes information on distribution, as well as size composition data, to estimate the relative population size and mortality rates. 20

A program conducted by PSE&G in 1981 and 1982 was used for all of these modeling purposes. This program had two major components: a bottom/pelagic trawl program and an ichthyoplankton/macroinvertebrate program.

The 1981-1982 bay-wide bottom/pelagic trawl program divided the Estuary from RKM 0 to RKM 117 into 16 strata, eight bottom (lower 0.627 m of water column) and eight mid-water (remainder of water column). Bottom samples were collected using a 16-ft (4.9-m) semi-balloon otter trawl equipped with a 17-ft headrope, 21-ft footrope, net body of 1.5-in. stretch mesh, 1.25-in. stretch mesh codend, and a 0.5-in. stretch mesh inner liner. Bottom trawls were towed at an average speed of 3 knots for 10 minutes. Pelagic samples were collected with a 1.8- × 1.4-m pelagic trawl. This net was 4.6-m long with a 0.313-in. (0.79-cm) body mesh and 0.25-in. (0.635-cm) codend liner. A total of 70 sampling stations per program per collection period were allocated using a Neyman allocation procedures (i.e., number of samples proportional to the expected variance). Trawl sampling was conducted three times per month from June through September and twice per month in May and October.

The 1981-1982 ichthyoplankton/macroinvertebrate sampling divided the Estuary from RKM 0 to RKM 117 into eight strata. Sampling was conducted monthly in April and October, twice in September, and three times monthly from May through August. Samples were collected during daylight with a 0.5-m diameter, 0.5-mm mesh, conical plankton net fitted with a 1-pint screened (0.5-mm bolting cloth) plastic codend and a depressor to ensure proper fishing attitude. A single oblique tow was conducted in a stepwise manner (3-m steps) from near surface to near bottom. Tows were made at 1.3-1.9 knots in the direction of tidal flow and each took 4-6 minutes, not including retrieval time (about 1 minute). Samples were processed for both ichthyoplankton and macroinvertebrates. From 64 to 70 samples were collected during each sampling event.

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4.1.2 Proposed Study Design

4.1.2.1 Study Duration and Geographic Extent

The distribution and recruitment survey will be conducted in 1995 and 1997. Two separate studies, a bottom and pelagic finfish study and an ichthyoplankton and macroinvertebrate study will be conducted. Both studies will sample from the mouth of the Estuary to a point just upriver of the Delaware Memorial Bridge (RKM 117).

4.1.2.2 Sampling Frequency

Bottom and pelagic trawling will be conducted three times per month from June through September and twice per month in May and October. The ichthyoplankton/macroinvertebrate study will sample monthly in April and October, twice in September, and three times monthly from May through August.

4.1.2.3 Sampling Intensity and Locations

The bottom and pelagic finfish study will allocate 70 samples per collection event among the eight sampling regions from RKM 0 to RKM 117, with each region having two sampling strata (surface and bottom). The ichthyoplankton/macroinvertebrate study will allocate a total of 70 samples among the eight regions from RKM 0 to RKM 117. Both programs will use historical data to develop a Neyman allocation procedure for sample allocation.

4.1.2.4 Sampling Gear and General Deployment

Bottom samples will be collected using a 16-ft (4.9-m) semi-balloon otter trawl equipped with a 17-ft headrope, 21-ft footrope, net body of 1.5-in. stretch mesh, 1.25-in. stretch mesh codend, and a 0.5-in. stretch mesh inner liner. Bottom trawls will be towed at an average

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speed of 3 knots for 10 minutes. Pelagic samples are to be collected with a 1.8- × 1.4-m fixed frame pelagic trawl. This net will measure 4.6-m long with a 0.313-in. (0.79-cm) body mesh and 0.25-in. (0.635-cm) codend liner.

The ichthyoplankton/macroinvertebrate samples will be collected during daylight with a 0.5-m diameter, 0.5-mm mesh, conical plankton net fitted with a 1-pint screened (0.5-mm bolting cloth) plastic codend and depressor. A single oblique tow will be conducted in a stepwise manner (3-m steps) from near surface to near bottom. Tows will be made at 1.3-1.9 knots in the direction of tidal flow for a duration of 4-6 minutes (exclusive of retrieval time). Samples will be processed for both ichthyoplankton (eggs, prolarvae, postlarvae, and juveniles) and macroinvertebrates.

4.1.2.5 Field and Laboratory Processing

All finfish and blue crab specimens will be identified in the field. For each tow, the fork length to the nearest millimeter will be recorded for up to 100 specimens of each target species (as per the Salem 316[b] Demonstration). If more than 100 individuals of a target species are captured, a random subsample of 100 individuals will be selected.

Ichthyoplankton and macroinvertebrate samples will be preserved for processing in the laboratory. Once in the laboratory, individuals will be identified to species and life stage, and counted. Total length for target species ichthyoplankton, head-telson length for opossum shrimp, and rostrum-telson length for scud will be measured to the nearest millimeter for up to 50 individuals of each target species and life stage per sample.

The following physicochemical parameters will be measured with each collection: water temperature, dissolved oxygen, salinity, and Secchi disk transparency.

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4.1.2.6 Data Analysis

D-factors and R-factors will be computed from the data following the procedures described in the Salem 316(b) Demonstration. Complete program listings are provided in the Addendum to Appendix I, Volume 2. The results of this analysis will be incorporated into a report summarizing the study findings and into a database for use in ETM computations.

4.1.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

4.2 GEAR COMPARISON STUDY

4.2.1 Introduction

4.2.1.1 Objective of Study

The objective of the Gear Comparison Study is to establish, in a statistically rigorous manner, the functional relationship between the relative probability of avoiding capture and such factors as turbidity and fish length for various life stages of bay anchovy and juvenile weakfish. Given this functional relationship, an appropriate scaling factor can be computed and applied to individual sample density data in establishing a more accurate spatial distribution of these species within the Delaware Estuary.

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4.2.1.2 Rationale for this Study

This study is not required by the 1994 NJPDES Permit. It is, however, a beneficial adjunct to the distribution (D-factor) study which could be used to revise estimates of conditional mortality based on the ETM.

4.2.1.3 Historical Foundation

One of the primary assumptions of the ETM, the model used for determining the proportion of the weakfish and bay anchovy populations lost to entrainment and impingement at Salem, is that sampling gear efficiency is the same throughout the Estuary. PSE&G had reason to doubt that this assumption was being met, and in 1990, conducted a study designed to test the hypothesis of equal gear efficiency.

The 1990 study employed a 6- × 4-ft fixed-frame pelagic trawl and a 10- × 10-ft Cobb trawl which were fished simultaneously in a paired-tow fashion in the River and lower Bay. With each collection, bay anchovy and juvenile weakfish were enumerated and length-frequency data recorded on a randomly selected subsample of up to 200-500 specimens. Turbidity measurements were also recorded for each sample.

For bay anchovy, the results indicated that relative catches were 7.8, 29.6, and 43.2 times greater in the River than in the lower Bay for 10-20, 20-30, and 30-40 mm size groups, respectively. No bay anchovy greater than 40 mm were taken in the lower Bay with the fixed frame net, although they were collected with the Cobb trawl. Too few weakfish were collected during the study to reach any conclusion. The results of the study were interpreted as a turbidity effect on catchability. As water increased in clarity near the mouth of the Bay, avoidance increased, especially for larger individuals. The D-factors used in the ETM were adjusted accordingly. The overall effect was to increase the size of the population in the lower Bay, thereby decreasing the proportion of the population potentially vulnerable to entrainment or impingement at Salem.

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PSE&G intends to repeat this gear comparison study to verify and expand its 1990 results, especially with respect to weakfish. The primary difference in sampling protocol between the 1990 investigation and this study occurs in the selection of study location. In the 1990 study, sampling occurred in two discrete regions, one in the river near Salem and one in the lower Bay offshore of Broadkill Beach. This study proposes to stratify sampling by turbidity (10-in. Secchi reading depths) to ensure sampling a broad spectrum of turbidity conditions. Three depth strata, at <15 ft, 15-30 ft, and >30 ft, will be sampled. A sample size of nine replicates per gear, depth, and location combination will be used.

4.2.2 Proposed Study Design

4.2.2.1 Study Duration and Geographic Extent

The Gear Comparison Study will be conducted once during the 5-year Permit period, preferably during 1996 (the period between the two distribution factor studies). The geographic range for this study will extend from the more turbid waters in the upper Bay or lower River to the clearer oceanic waters near the Bay's mouth (Figure 4-1).

4.2.2.2 Sampling Frequency

The Gear Comparison Study is composed of two separate studies, one for analyzing turbidity effects and a second for analyzing depth effects. Sampling for both studies will coincide with the occurrence of species and life stages targeted for analysis using the ETM. For bay anchovy and weakfish, most testing will be conducted during late July and August.

4.2.2.3 Sampling Intensity and Locations

For the turbidity effects study, five strata will be defined on the basis of average Secchi disk turbidity—10-20 in., 20-30 in., 30-40 in., 40-50 in., and >50 in. Within each stratum, five stations will be sampled; six replicate samples will be taken at each of the stations. A total of 150 paired samples will be collected.

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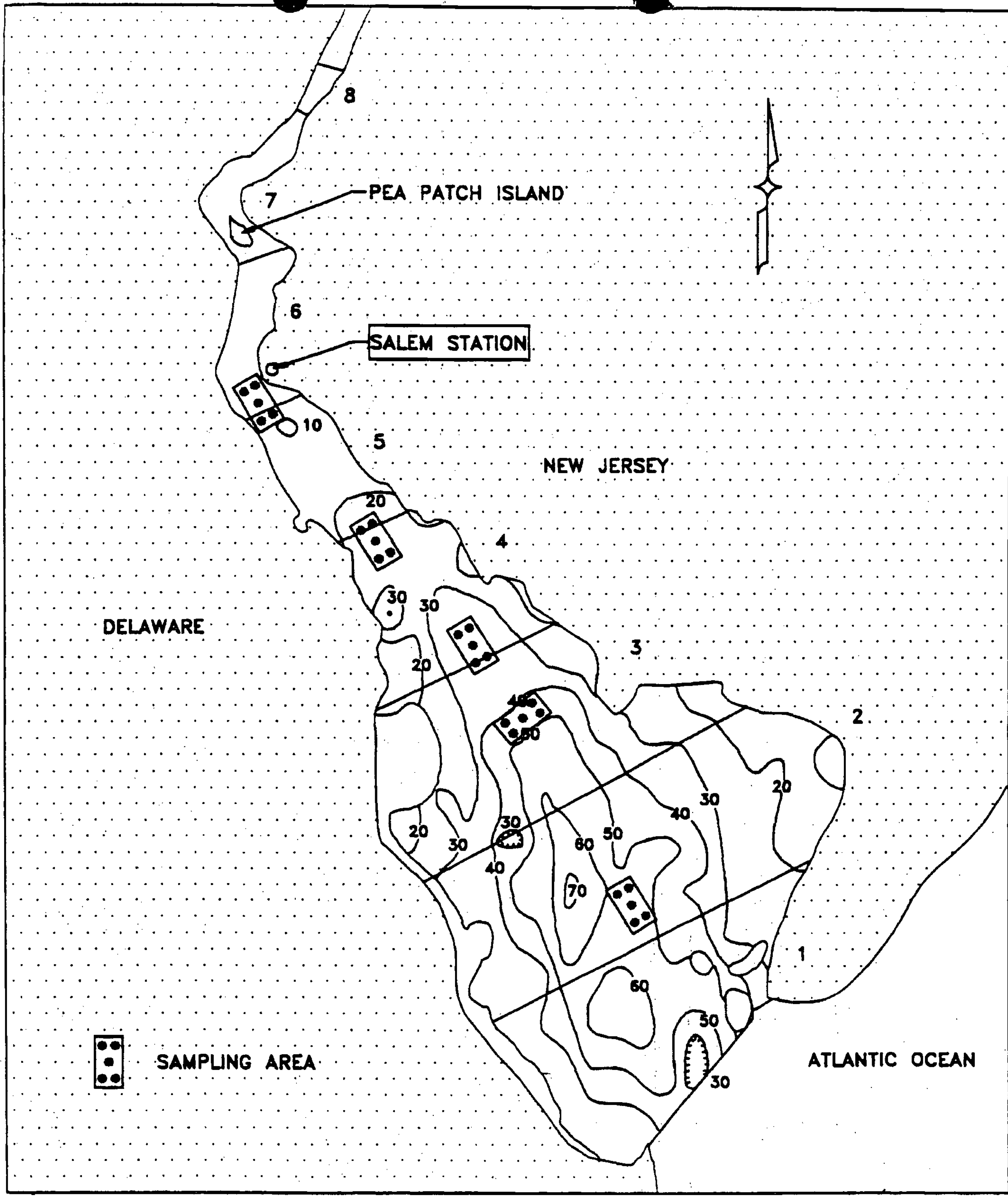

Figure 4-1. Conceptual depiction of sampling areas along average summer Secchi gradient within the Delaware Estuary. ETM regions within the Salem 316(b) study area are indicated.

For the depth effects study, a single lower Bay location will be selected. The selected sampling area will be in an area with an overall depth of >45 ft and a water clarity of ≥40 in., as measured with a Secchi disk. Three depth strata, at <15 ft, 15-30 ft, and >30 ft, will be established. A sample size of nine replicates per gear, depth, and location combination will be used for a total 27 sample pairs. The entire study should be completed within as short a time period as possible in order to reduce the influence of temporal changes in turbidity.

4.2.2.4 Sampling Gear and General Deployment

The design of the gear comparison study will be similar in many aspects to the previous gear comparison study. As in the 1990 study, the gears employed will be the 6- × 4-ft fixed-frame pelagic trawl and a 10- × 10-ft Cobb trawl which will be fished simultaneously in a paired-tow fashion. Tows will be of 10-minute duration, set with the tide, and at a speed of approximately 4.4 fps as measured by a current meter. A flowmeter will be affixed within the forward position of the body of each net to permit determination of the volume filtered.

With each collection, bay anchovy and juvenile weakfish will be enumerated and length-frequency data recorded on a randomly selected subsample of up to 200-500 specimens. In addition, a Secchi disk reading will be taken and a water sample will be retained (on ice) for subsequent turbidity measurements by turbidimeter. Light penetration will be measured with a photometer at a minimum of 1-ft intervals from the surface to the bottom. Smaller depth increments (0.5 ft) may be necessary in the surface waters.

4.2.2.5 Field and Laboratory Processing

All bay anchovy, weakfish, striped bass, and spot individuals collected will be identified in the field. For each tow, the fork length (to nearest mm) will be recorded for up to 100 individuals of each of these species. If more than 100 of a target species are captured, a random subsample of 100 individuals will be selected.

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4.2.2.6 Data Analysis

The results of this study will be used to describe the functional relationship between the relative probability of capture and two independent variables, turbidity and fish length, for each species. In addition, the results of this study will be used to explore how these functional relationships might change with depth. A report summarizing all study findings will be produced at the conclusion of the program.

4.2.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

4.3 W-FACTOR STUDY

4.3.1 Introduction

4.3.1.1 Objective of Study

The objective of the W-factor study is to estimate the ratio of density of fish in Salem's intake to the density of fish in a cross-sectional portion of the river directly in front of the intake. W-factor coefficients are required by the ETM, which has been used to estimate the conditional mortality rate for many of the target fish species. The results of this study will be used as input to revised model runs with more recent data.

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4.3.1.2 Rationale for this Study

This program is not required by the NJPDES Permit, but is in response to EPA's comments on the Draft Permit in which they requested NJDEPE require PSE&G "...to verify the fish population models being used...." In addition, this information would be required in order to update estimates of conditional mortality which might be required during the next permit renewal cycle. If the W-factor study were not conducted during the 1995-1999 period, values from the 1980s would be used. Use of these coefficients would likely not be challenged unless major operational changes occur, such as decreased intake screen mesh size or installation of effective sound deterrent device. As such changes are contemplated, the affected ETM input parameters must be revised.

4.3.1.3 Historical Foundation

One of PSE&G's assessment models, the ETM, requires an estimate of the abundance of organisms in the power plant intake water relative to their average abundance in an idealized cross-section of the river in front of Salem. A program conducted in 1981 and 1982 was used to estimate these coefficients. This program had two major components, a bottom and pelagic trawl program and an ichthyoplankton program.

For the bottom and pelagic trawl program, three depth strata, surface, mid-depth, and bottom, were established. Within these depth strata, six surface, five mid-depth, and five bottom river zones were established. Sampling consisted of one near-plant zone from each depth strata paired with one randomly selected river zone sample from the same depth. A total of three sets of paired samples were taken during each sampling event. A 16-ft (4.9-m) otter trawl was used to sample the bottom regions, while a 1.2- × 1.8-m fixed-frame trawl was used to sample mid-water regions. Sampling was conducted twice a month during May and October and three times a month during June-September. All sampling was conducted during daylight hours.

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The basic design of the ichthyoplankton program was similar to that of the bottom and pelagic trawl program. The primary differences were the lack of depth stratification and the collection of both night and day samples. Vertical tows using a 0.5-m plankton net from the single near-plant zone were paired with a single sample from each of the five river zones. One set of the five sample pairs was collected during daylight hours, while another was taken during hours of darkness. Sampling took place three times during June, three times during July, and once during August.

4.3.2 Proposed Study Design

4.3.2.1 Study Duration and Geographic Extent

The W-factor study should be conducted in 1995 and 1997 to estimate these coefficients for the ETM. Because the anticipated changes in plant operating characteristics resulting from sound deterrents, modified fish baskets, and mesh size are not expected to alter the W-factors for ichthyoplankton, only the finfish portion of the study should be repeated.

4.3.2.2 Sampling Frequency

Finfish sampling will be conducted twice a month during May and October and three times a month during June-September.

4.3.2.3 Sampling Intensity and Locations

For the finfish trawl program, three depth strata, surface, mid-depth, and bottom, will be established. Stratification will be as defined for the 1981-1982 program, i.e., within the three depth strata, six surface, five mid-depth, and five bottom river zones will be established. Sampling will consist of one near-plant zone from each depth stratum paired with one randomly selected river zone sample from the same stratum. A total of three sets of paired samples will be taken during each sampling event.

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4.3.2.4 Sampling Gear and General Deployment

A 4.9-m otter trawl will used to sample the bottom regions, while a 1.2- × 1.8-m fixed-frame trawl will be used to sample mid-water regions. All finfish sampling will be conducted during daylight hours.

4.3.2.5 Field and Laboratory Processing

All specimens will be counted and measured in the field. After processing, all fish and macroinvertebrates will be returned to the water.

4.3.2.6 Data Analysis

Two different methods of computing W-ratios will be used. The first computes the density of each stratum (or zone) by averaging the calculated densities (number collected divided by the volume sampled) of all samples within the zone. The second method computes the density by dividing the total number collected by the total sample volume. Details of the computations are provided in Appendix I of the Salem 316(b) Demonstration (Pages 2.2-21 through 2.2-23). The results of this analysis will be incorporated into a report summarizing the study findings and into a database for use in the ETM computations.

4.3.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤0.1 percent, i.e., one rejected record per 1,000 records.

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4.4 THERMAL MORTALITY STUDY

4.4.1 Introduction

4.4.1.1 Objective of Study

The objective of this study is to estimate the thermal component of entrainment mortality for each life stage of weakfish. Thermal mortality is defined as the fraction of each life stage and species killed as the result of the combined effects of ambient plus delta (through-plant) temperatures exclusive of mechanical and biocide effects.

4.4.1.2 Rationale for this Study

This program is not required by the Permit. Mortality due to thermal stresses is, however, a necessary input for calculating through-plant entrainment losses. Although estimates have been developed for each of the target species, the estimates for weakfish were based on extremely limited data. In addition, there is at least some indication that the derived thermal mortality curve may be an inaccurate description of responses for this species and it was subject to some criticism by technical reviewers during the permitting process.

4.4.1.3 Historical Foundation

One major component of through-plant mortality is thermal mortality. This is the incremental mortality that results from exposure to elevated temperatures during plant passage. This component is generally estimated from laboratory studies of responses to various combinations of acclimation temperature, exposure temperature, and exposure duration. Of particular concern to PSE&G is the response of weakfish prolarvae, postlarvae, and entrainable juveniles. Although such studies were conducted by PSE&G during the 1970s, few tests were performed for weakfish under the appropriate test conditions.

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Experiments from 1974 through 1984 were conducted using a two-chambered tubular apparatus constructed of 40-mm ID transparent PVC tubing. Temperature increases were 7.5°C and 15°C during 1974-1977, 10°C and 14°C in 1978, and 10°C and 18°C in 1979-1981. Maximum exposure duration was 9.7 minutes. Cooling to ambient (collection) temperature occurred within seconds. After exposure, organisms were held in 1.9-liter battery jars in a controlled temperature water bath maintained within ±2°C of ambient. Most tests were conducted with a 48-hour latent holding period; a few tests had a 24- or 96-hour holding period.

4.4.2 Proposed Study Design

4.4.2.1 Study Duration and Geographic Extent

Thermal mortality studies will be conducted during 2 of the 5 study years. For present purposes, it is assumed that these years are 1996 and 1998.

4.4.2.2 Sampling Frequency

Studies need to be conducted during the period of abundance for the weakfish life stages of interest. Therefore, studies will be conducted during June, July, and August.

4.4.2.3 Sampling Intensity and Locations

Laboratory experiments will be conducted to estimate the temperature response relationships for weakfish prolarvae, postlarvae, and entrainable juveniles. Tests will be designed to span the range of expected exposure times (i.e., through-plant transit times), discharge temperatures, and acclimation temperatures (i.e., ambient temperatures during periods of occurrence) expected to be encountered by these life stages when entrained at Salem. Optimally, a range of discharge temperatures will be selected to induce partial mortalities between 10 and 90 percent. Two replicates of at least 15 individuals each will be used for each test.

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4.4.2.4 Sampling Gear and General Deployment

Tests will be conducted in insulated aquaria. Fluctuations during the test will controlled to 0.1-0.3°C or less throughout the duration of the exposure. Following the test, specimens will be held for up to 48 hours at the acclimation temperature and salinity.

4.4.2.5 Field and Laboratory Processing

Test specimens will be fed twice daily. Tanks will be inspected at 0, 2, 4, 8, 12, 24, and 48 hours after the test. At each inspection, the number of live, damaged, and dead will be recorded.

4.4.2.6 Data Analysis

Probit or logit regression analysis will be used to develop thermal response curves involving exposure temperature, acclimation temperature, and exposure duration for each life stage. These models, in turn, will be used to estimate through-plant entrainment losses and conditional mortality rates. These results will be incorporated into a report summarizing the study findings.

4.4.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of $\leq$0.1 percent, i.e., one rejected record per 1,000 records.

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batch # 288
part # 3580-C

Study Plans for Optional Biological Monitoring of the Delaware Estuary Which Could be Conducted by Public Service Electric and Gas Company

Part III

Prepared for

Public Service Electric and Gas Company
Estuary Enhancement Program
P.O. Box 236
Trailer 80 M/C N33
End of Buttonwood Road-Artificial Island
Hancocks Bridge, New Jersey 08038

Prepared by

EA Engineering, Science, and Technology
The Maple Building
3 Washington Center
Newburgh, New York 12550

and

Lawler, Matusky & Skelly Engineers
One Blue Hill Plaza
Pearl River, New York 10965

October 1994

CONTENTS

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CONTENTS (Continued)

3

1. INTRODUCTION

This report presents plans for optional studies which Public Service Electric and Gas Company (PSE&G) could conduct during the present 5-year Permit period for Salem's New Jersey Pollutant Discharge Elimination System (NJPDES) Permit. These studies complement those described in the Permit Work Plan and those described as additional studies. These optional study plans are designed to address other issues and questions which could arise during the next permit application period. Many of the issues addressed in these study plans were previously raised by the New Jersey Department of Environmental Protection and Energy (NJDEPE) and their consultants during the review of Salem's 316(b) Demonstration or by various commentors on the draft permit, especially the U.S. Environmental Protection Agency (EPA). However, none of them are expected to be major issues. The intent of the studies proposed herein is to provide information which can be used to address these issues should they arise again during the next permit cycle.

For convenience, these optional study plans are grouped into three broad categories:

1. Biological Monitoring of the Delaware Bay and River
2. Habitat Restoration Monitoring
3. Refinement of Estimates of Conditional Mortality.

Each of the study plans is discussed in the following chapters.

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2. BIOLOGICAL MONITORING OF THE DELAWARE BAY AND RIVER

2.1 NEAR-FIELD TRAWL SURVEY

2.1.1 Introduction

2.1.1.1 Objective of Study

The relative abundance of juvenile finfish in the Delaware River in the vicinity of the Salem Nuclear Generating Station (±10 mi) will be monitored. This program will provide data for comparison to data collected in PSE&G's 1970-1982 and 1988-present sampling programs. The objective of this comparison will be to assess whether or not the operation of Salem has had an adverse effect on the fish community in the vicinity of Artificial Island.

2.1.1.2 Rationale for this Study

This study is not required by the 1994 NJPDES Permit. However, as this is the only program providing any extent of pre-operational data, it may be in PSE&G's best interest to continue the monitoring. During the Permit renewal process, the issue was raised (by the Delaware Department of Natural Resources and Environmental Conservation) that the effect of Salem needed to be assessed relative to the pre-operational population levels. Although PSE&G argued that the effects could be seen (if they occurred at all) during the post-operational period, this argument may be raised again in the future.

It should be noted, however, that the near-field trawl data as an index of abundance is somewhat limited. The Salem near-field study area is relatively small and subject to considerable environmental variation which affects fish abundance. Salinity, and consequently fish abundance, exhibits wide fluctuations as a consequence of seasonal and annual changes in freshwater flow.

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2.1.1.3 Historical Foundation

During the periods 1970-1982 and 1988-present, PSE&G collected samples in the vicinity of Artificial Island (±10 mi) to monitor juvenile fish abundance. Generally, this sampling extends over the period January-December, however, inclement weather and river icing precluded sampling in January and/or February of certain years. During 1981 and 1982, sampling was scheduled only for the period from May through October.

Bottom samples are collected using a 16-ft (4.9-m) semi-balloon otter trawl equipped with a 17-ft headrope, 21-ft footrope, net body of 1.5-in. stretch mesh, 1.25-in. stretch mesh codend, and a 0.5-in. stretch mesh inner liner. Bottom trawls are towed at an average speed of 3 knots against the tide for 10 minutes. During 1981-1982, additional samples were collected in this region with a 1.8- × 1.4-m pelagic trawl as part of PSE&G's bay-wide sampling. This net was 4.6-m long with a 0.313-in. (0.79-cm) body mesh and 0.25-in. (0.635-cm) codend liner.

Prior to program changes after 1978, the Artificial Island region trawl program was very consistent, sampling 22 fixed regions on a biweekly schedule. One onshore and one offshore trawl was taken from each region during each sampling event.

In 1979, the sampling program was radically altered to encompass the entire Delaware Bay, first using a systematic sampling design in 1979 and 1980 and then a stratified random sampling design beginning in 1981. For the systematic sampling design, stations remained fixed throughout the 2-year period with only six stations sampled in the plant vicinity (River Kilometer [RKM] 64-97). During 1980 and 1981, a completely random, i.e., randomized for each event, station selection program was adopted. During this period, six samples were collected from the surface stratum and four samples were collected from the bottom stratum during each sampling event.

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2.1.2 Proposed Study Design

As the pre-1979 dataset provides the longest continuum of data collected in a consistent manner, PSE&G intends to return to the sampling design and methods used during that period. Abundance indices will be prepared for bay anchovy, blueback herring, alewife, American shad, striped bass, white perch, weakfish, spot, and Atlantic croaker.

2.1.2.1 Study Duration and Geographic Extent

The near-field trawl survey will be conducted each year from 1995 through 1999.

2.1.2.2 Sampling Frequency

Samples will be collected twice per month from May through October.

2.1.2.3 Sampling Intensity and Locations

Up to 22 fixed stations within ±5 mi of the station will be sampled during each sampling event. The optimal program would sample the same stations as sampled during 1970-1982 (Table 2-1). Some or all of the 22 stations for this study could be substituted with the bay-wide trawl survey stations (Section 2.1), however, some loss of comparability would occur.

2.1.2.4 Sampling Gear and General Deployment

Bottom samples will be collected using a 16-ft (4.9-m) otter trawl with 1.5-in. stretch mesh body, 1.25-in. stretch mesh codend, and 0.5-in. stretch mesh codend inner liner. The net will be towed on the bottom for 10 minutes against the tide.

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TABLE 2-1 PUBLIC SERVICE ELECTRIC AND GAS COMPANY 1970-1978 NEAR-FIELD SAMPLING REGIONS

Zone	Southern	Western	Eastern	Northern
NW-2	Line from the entrance to the C&D Canal to the western boundary of the shipping channel.	Delaware shore.	Pea Patch Island and the western boundary of the shipping channel.	Line from New Castle to Buoy 5D.
NW-1	Cable area on east side of Reedy Island; and line from northern tip of Reedy Island to a point on the western boundary of the shipping channel 700 yd above Buoy 5R.	Delaware shore	Reedy Island and western boundary of the shipping channel.	Line from the entrance to the C&D Canal to the western boundary of the shipping channel.
NE-2	Line from the southern tip of Hickory Island (at mouth of Salem River) to eastern boundary of shipping channel (across from Buoy 5N.	Eastern boundary of shipping channel.	New Jersey shore.	Line from Pennsville to Buoy 6D.
NE-1	Line from Elsinboro Point to a point on the eastern boundary of the shipping channel 1,500 yd below Buoy N2N.	Eastern boundary of shipping channel.	New Jersey shore.	Line from southern tip of Hickory Island (mouth of Salem River) to eastern boundary of shipping channel (across channel from Buoy 5N).
SW-2	Line from Delaware Point to a point on the western boundary of the shipping channel 400 yd below Buoy R6L.	Delaware shore.	Western boundary of shipping channel.	Line from mouth of Ray's Ditch to point on the western boundary of the shipping channel 1,000 yd below Buoy 1B.
SW-1	Line from Bakeoven Point to Buoy 42.	Delaware shore.	Western boundary of shipping channel.	Line from Delaware Point to a point on the western boundary of the shipping channel 400 yd below Buoy R6L.
SE-3	Line from 500 yd above mouth of Mad Horse Creek to a point on the eastern boundary of the shipping channel 400 yd below Buoy R6L.	Eastern boundary of shipping channel.	New Jersey shore.	Line from Hope Creek Jetty to Buoy R8L.
SE-2	Line from Arnold Point to a point on the eastern boundary of the shipping channel 1 mi below Buoy R4L.	Eastern boundary of shipping channel.	New Jersey shore.	Line from 500 yd above mouth of Mad Horse Creek to a point on the eastern boundary of the shipping channel 400 yd below Buoy R6L.
SE-1	Line from Dunks Point tower to Buoy 42.	Eastern boundary of shipping channel.	New Jersey shore.	Line from Arnold Point to a point on the eastern boundary of the shipping channel 1 mi below Buoy R4L.
SE-0	Line from Sea Breeze to Ship John Shoal.	Eastern boundary of shipping channel.	New Jersey shore.	Line from Dunks Point tower to Buoy 42.
W-1	Line from Ray's Ditch to Hope Creek Jetty.	Delaware shore.	Western boundary of shipping channel to Buoy 1B, to southern tip of Reedy Island Dike.	Line from lower break to light at southern tip of Reedy Island Dike.
W-2	Line from lower break to light at southern tip of Reedy Island Dike.	Delaware shore.	Reedy Island Dike.	Line from mouth of Augustine Creek to point on Reedy Island Dike, 1,000 yd below light below break in Reedy Island Dike.
W-3	Line from mouth of Augustine Creek to point on Reedy Island Dike, 1,000 yd below light below break in Reedy Island Dike.	Delaware shore.	Reedy Island Dike.	Cable area east of Reedy Island.

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TABLE 2-1 (Continued)

Zone	Southern	Western	Eastern	Northern
E-1	Line from Hope Creek Jetty to Buoy R8L.	Eastern boundary of shipping channel.	New Jersey shore.	Line from western tip of Sunken Ships to a point on the eastern boundary of the shipping channel 1,500 yd below Buoy R2B.
E-2	Line from western tip of Sunken Ships to a point on the eastern boundary of the shipping channel 1,500 yd below Buoy R2B.	New Jersey shore (Artificial Island).	Eastern boundary of shipping channel.	Line from point 1,500 yd north of the southern tip of Artificial Island to a point on the eastern boundary of the shipping channel 100 yd above Buoy R2R.
E-3	Line from point 1,500 yd north of the southern tip of Artificial Island to a point on the eastern boundary of the shipping channel 100 yd above Buoy R4B.	Eastern boundary of shipping channel.	New Jersey shore.	Line from point 2,000 yd south of northern tip of Artificial Island to a point on the eastern boundary of the shipping channel 100 yd above Buoy R2R.
E-4	Line from point 2,000 yd south of northern tip of Artificial Island to a point on the eastern boundary of the shipping channel 100 yd above Buoy R2R.	Eastern boundary of shipping channel.	New Jersey shore.	Line from north tip of Artificial Island to a point on the eastern boundary of the shipping channel 1,000 yd above Buoy N4R.
E-5	Line from north tip of Artificial Island to a point on the eastern boundary of the shipping channel 1,000 yd above Buoy N4R.	Eastern boundary of shipping channel.	New Jersey shore.	Line from point 400 yd south of Straight Ditch to a point on the eastern boundary of the shipping channel 100 yd above Buoy N6R.
E-6	Line from point 400 yd south of Straight Ditch to a point on the eastern boundary of the shipping channel 100 yd above Buoy N6R.	Eastern boundary of shipping channel.	New Jersey shore.	Line from Elsinboro Point to a point on eastern boundary of shipping channel 1,500 yd below Buoy N2N.
RIE-1	Line from southern tip of Reedy Island Dike to Buoy 1B.	Reedy Island Dike.	Western boundary of shipping channel.	Line south of flashing green 2.5-second light on Reedy Island Dike to a point on the western boundary of the shipping channel 100 yd south of Buoy C1R.
RIE-2	Line south of flashing green 2.5-second light on Reedy Island Dike to a point on the western boundary of the shipping channel 100 yd south of Buoy C1R.	Reedy Island Dike.	Western boundary of shipping channel.	Line from northern tip of Reedy Island to a point on the western boundary of the shipping channel 1,000 yd above Buoy 5R.
SSC	Ring of Sunken Ships	Line from western tip of Sunken Ships to southern tip of Artificial Island.	Ring of Sunken Ships	New Jersey shore (Artificial Island).

2.1.2.5 Field and Laboratory Processing

All finfish and blue crab specimens will be identified in the field. For each tow, the fork length (to nearest mm) will be recorded for up to 100 specimens of each target species (as per the Salem 316[b] Demonstration). If more than 100 individuals of a target species are captured, a random subsample of 100 individuals will be selected.

The following physicochemical parameters will be measured with each collection: water temperature, dissolved oxygen, salinity, and Secchi disk transparency.

2.1.2.6 Data Analysis

The primary purpose of the PSE&G juvenile near-field survey and associated abundance indices is to provide advance warning of any major changes in habitat usage in the vicinity of Salem. In general, the hypothesis that the current abundance, or abundance over some selected set of years, is not significantly lower than the average abundance during some historical period. Analysis of Variance or Statistical Process Control procedures may be used to evaluate the indices. For each survey, the mean and geometric mean catch-per-unit-effort will be computed in a manner comparable to that previously utilized by PSE&G.

2.1.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study plan. Data files resulting from this study will be inspected following procedures designed to ensure an acceptable outgoing quality level (AOQL) of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

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2.2 THERMAL MONITORING

2.2.1 Objectives of Study

The proposed optional thermal monitoring studies are designed to provide analysis of the far-field thermal plume (1.5°F isotherm) in greater detail than would otherwise be required for the Biothermal Assessment in the Work Plan. These studies will be coordinated with the chronic mixing zone studies being developed for the Effluent Characterization studies required in the Permit.

2.2.2 Rationale for this Study

The thermal monitoring program proposed in the Work Plan (Section 5.2.2) was formulated to support the RIS biothermal assessment. As a result, plume mapping is confined to the near-field 1,000-ft region. The far-field monitoring was limited to placing thermographs along the plume centerline. In the hydrothermal analysis associated with obtaining the present permit, great attention was given to the longitudinal extent of the thermal plume. The placement of these thermographs will provide information on the duration and magnitude of the plume at far-field locations which will be compared to the frequency distribution of plume lengths developed with the RMA-10 Model.

It remains unclear the intent of the "comprehensive thermal monitoring" requirement in the Final NJPDES Permit. The proposed thermal monitoring field program does not address the full lateral/spatial extent of the plume (1.5°F isotherm). In the proposed modeling for the Work Plan, the use of the thermograph data for additional verification of the 3-dimensional RMA-10 model was discussed. The subsequent execution of RMA-10 would provide information on lateral plume dimensions. However, to obtain this type of information directly from field observations, the thermal monitoring program will need to be expanded.

2.2.3 Proposed Study Design

There are two studies which will compliment the Work Plan proposed thermal monitoring study: the placement of additional thermographs or performing a comprehensive 3-dimensional temperature/dye tracer survey. The cost of doubling the thermograph work plan for 16 additional thermographs at 8 locations for 6 months, is approximately half the cost of performing a comprehensive temperature/dye tracer survey at the Salem site.

2.2.3.1 Increased Thermograph Monitoring

Additional thermographs will be placed at locations in the Delaware Estuary to expand the thermograph grid in the lateral dimension. At the far-field locations, up to three mooring strings will be placed within the plume region extending out to the channel. Thermographs will also be placed at locations to monitor the plume in Delaware waters or the nature of plume reversals near slack water.

2.2.3.2 Tracer Dye Study

In addition to thermal monitoring the present permit requires dilution studies to be conducted for the determination of acute and chronic mixing zones for toxicity as part of the Effluent Characterization Permit Condition. In the Request for Proposal to develop work plans for these dilution studies (RFP No. MC-10) performing a comprehensive 3-dimensional temperature/dye tracer survey is a desirable alternative. If the study is performed during acceptable critical conditions, the resultant plume maps will be used directly for defining dilution associated with the chronic mixing zone. A survey of this type would, however, more logically belong as part of the thermal monitoring program. The overlapping requirements of the dilution study and thermal monitoring work plans need to be resolved before finalizing the program design.

A 3-dimensional temperature/dye tracer study will be a significant addition to the empirical database for the Salem Generating Station. A properly conducted field program will include 12 surveys in both the near- and far-field regions for both dye and temperature. Dye will need to be injected for several tidal cycles before the intensive surveys in order to account for plume build-up in both the near- and far-field. The absolute minimum injection period will be 5 days. This will provide a 5 ppb discharge concentration which will assure the resolution necessary to track a 100-fold dilution (0.2°F resolution relative to the 19°F delta-T). The use of dye will allow delta-Ts to be determined throughout the plume region relative to a spatially variable ambient temperature.

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3. HABITAT RESTORATION MONITORING

3.1 DETRITAL CHARACTERIZATION STUDY

3.1.1 Introduction

3.1.1.1 Objectives of Study

The premise of the restoration plan formulated as part of the Estuary Enhancement Program is that an increase in the quality of marsh vegetation, and acreage of functioning wetlands, will yield an increase in quality of detritus available to support the estuarine food web, and thus an increase in estuarine trophic production. The assumptions and basis of this premise are described in detail in PSE&G's Phase I, Appendix Q (1993) and Phase II, Appendix Q-1 (1994) Comments on the Draft Permit. This monitoring plan is designed to test the assumption that detrital production from restored salt marsh sites will eventually be similar in quality and quantity to that from other functional natural salt marsh sites in the Delaware Estuary and that this additional production will be similarly available to higher trophic levels of the salt marsh/estuarine ecosystem.

Planned restoration of wetlands includes the breaching of dikes, opening agricultural impoundments, eradication of *Phragmites* which is considered low quality marsh vegetation, and re-establishment of *Spartina* which is considered higher quality marsh vegetation. Breaching of dikes and opening impoundments will re-establish tidal influence on the composition of wetland vegetation and allow a transition to a natural functional wetland. This alteration is expected to increase nutrient and detrital exchange between the marsh at these sites and the open estuary.

Shifts in dominant marsh vegetation as a result of restoration efforts should in turn produce a change in the type and quality of detritus. The Detrital Production Monitoring Study that is part of the Work Plan will document the changes in wetland vegetation communities, the primary source of wetland-based detritus, associated with wetland restoration. The objective

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of this monitoring study is to characterize the change in quality and quantity of detrital production associated with the change in vegetation. Monitoring conducted prior to restoration activities at selected sites will provide baseline characterization of detrital production. Monitoring, conducted at that point in time when the vegetative community and associated detritus in the restored sites resembles that observed in the reference sites, will provide data for analysis of changes or trends in the characteristics of the associated detritus production.

3.1.1.2 Rationale for this Study

Monitoring of detrital production is specifically required under Special Condition 6(a) of the Final NJPDES Permit. This study will offer a unique opportunity for measurement of changes in the characteristics of detritus in response to marsh restoration and management. Data from the study will be utilized to determine the contribution of organic matter from wetlands to the detritus-based food chain in the wetland/estuarine system. This information can then be evaluated in conjunction with results from the Detrital Flux Monitoring Study (Additional Study Plans, Section 3.1), Fish and Macroinvertebrate Utilization of Restored Wetlands Study (Additional Study Plans, Section 3.2), and Food Habits of Fish in Restored Wetlands Study (Optional Study Plans, Section 3.2) to provide insight into the system response to restoration and management of the wetlands.

3.1.1.3 Historical Foundation

A simple aggregated food chain model has been used to describe the salt marsh dependent component of the detrital-based food chain of the Delaware Estuary. The aggregated food chain model was used to calculate the acres of wetland to be restored to offset Salem-related losses of fish and invertebrates, and forms the basis for the Estuary Enhancement Program as defined by the NJPDES Permit (PSE&G Phase I, Appendix Q [1993]; Phase II, Appendix Q-1 [1994] Comments. A review of methods for calculating marsh primary productivity and production estimates for Atlantic and Gulf coast salt marshes from Maine to Louisiana were also presented in Appendix Q. For the aggregated food chain model, estimates of annual net 15 aboveground primary production from vascular salt marsh plants and edaphic algae were derived from studies by Roman and Daiber (1984) and Gallagher and Daiber (1974) at two Delaware Estuary salt marsh sites. Ignoring the significant below ground production available from growth of roots and rhizomes, the aggregated food chain model used these aboveground estimates as a conservative basis for calculating trophic production through the detrital complex (decomposing plant material, bacteria, fungi, protozoa, and other microzoa) up to second and third consumer levels of the food chain.

The studies proposed herein for detrital characterization, in conjunction with those for detrital production (Work Plan, Section 2.2), will serve as a basis for documenting restoration success as measured by establishment at restored sites of primary production and detrital production rates similar to other natural functioning salt marshes of the Delaware Estuary.

The breaching of dikes and restoration of marshes is expected to produce a shift in the species composition of wetland vegetation and the composition of the resulting detritus at these sites. Because numerous factors can influence the plant community transition from pre- to post-restoration at a given site, the exact length of time this process will take is difficult to predict. However, based on previous restoration projects, it is estimated that within 3 years following physical restoration of a degraded wetland, the marsh will likely be making a substantial contribution of productivity to the estuarine food webs similar to other natural marsh sites.

3.1.2 Proposed Study Design

As stated, the objective of the Detrital Characterization Study is to determine the quality of detritus produced at restored salt marsh sites relative to pre-restoration conditions and other reference marsh sites. To accomplish this, this study plan will include two primary tasks: determination of decomposition rates of marsh vegetation and characterization of detrital composition.

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3.1.2.1 Decomposition Rates of Wetland Vegetation

The justification for the conversion of *Phragmites*-dominated wetlands to *Spartina*-dominated salt marsh is the generally accepted understanding that *Spartina* provides greater food and habitat value for aquatic and terrestrial faunal communities. *Spartina* is believed to provide higher quality detritus because faster degradation rates produce smaller detrital particles with greater surface area for supporting secondary production within this detrital complex.

Monitoring will be conducted at a subsample of four of the candidate restoration sites. The sites selected for detrital monitoring will be representative of the types of restoration strategies (e.g., two *Phragmites* sites, one impoundment, one salt hay farm site, and two reference natural salt marsh sites) and the range of hydrological and physical conditions (e.g., elevation and salinity) across all restoration sites. Each site will be monitored during two periods: (1) prior to any restoration activities at any of the sites, and (2) at such time that the Detrital Production Monitoring Study indicates that the restored sites have begun to resemble the appropriate reference sites.

The decomposition rates of the marsh vegetation will be determined over two 18-month periods (i.e., pre-restoration and post-restoration) beginning near the peak of the growing season (e.g., late July) using litter bags. Samples of stems and leaves from up to two dominant plant species will be collected at each of the selected restoration sites and placed in separate litter bags constructed of fiberglass window screen. Approximately 108 bags will be prepared (e.g., triplicate samples × 2 species × 18 months) for each selected monitoring site. The bags will be sealed, oven dried, and weighed. Bags will then be staked out on the marsh surface in various habitat types (e.g., low marsh, high marsh, and creek bank) at each of the selected monitoring sites. At monthly sampling intervals, three bags from each habitat type and vegetation type per site will be removed, oven dried, and weighed. Following determination of dry weight, monthly samples from each site will be analyzed for caloric and ash content.

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Decomposition rates for the year and for each monthly interval will be calculated for each site, habitat, and vegetation type. The results of this study will be evaluated to determine if decomposition rates are similar between restored and reference sites, and if differences exist between the pre- and post-restoration monitoring periods at each of the selected sites. The caloric and ash content values will be analyzed to determine the change in structural composition and caloric value over time, and differences among sites and dominant vegetation types. The caloric and ash content values will provide a measure of the quality of the decomposing vegetation as a food source to higher trophic levels.

3.1.2.2 Detritus Composition Study

The Detritus Composition Study will provide measurements of the quality of produced detritus as a food and energy source for higher trophic levels. This task will include analysis of structural plant material, total organic carbon, nutrients, caloric, ash, and chlorophyll content of the detritus. As a measure of the proportion of detritus composed of refractory structural plant material, samples will be analyzed for cellulose and lignin. The nutrient analysis will provide a measure of the nitrogen (total, organic, ammonia, nitrate, and Kjeldahl), phosphorus (total and orthophosphate), and sulfur (sulfate and sulfide) content of the detrital matter which, in combination with the organic carbon and caloric content, will characterize the value of the detritus as a food source. Chlorophyll analysis will include chlorophylls and phaeophytin, and will determine the ratio of chlorophyll associated with live and dead plant material.

Samples will be collected each year during the early growing season (early June) and late growing season (late September), similar to the Detrital Production Monitoring (Work Plan, Section 2.2). The same restoration and reference sites, and during the same years as described above for the decomposition rates study (Section 3.1.2.1), will be sampled for this component of the study. At each site, approximately 25 random samples will be collected from the surface of the marsh distributed among the major habitat types (e.g., low marsh, high marsh, creek bank, and subtidal creek bed) and along the same fixed transects established for the Detrital Production Monitoring (Work Plan, Section 2.2).

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3.2 FOOD HABITS OF FISH IN RESTORED WETLANDS

3.2.1 Introduction

3.2.1.1 Objective of Study

The objective of this monitoring study is to establish a direct link between the forage base produced in the restored wetlands and four target species (bay anchovy, weakfish, spot, and white perch) that utilize those restored wetlands. Because the target species are known to exploit the food resources of highly productive marsh areas during at least some life stages, establishing this link will demonstrate that the restored marshes are enhancing the fisheries resources of Delaware Estuary. In addition, this study may also afford insight into the relative value of the restored wetland habitats. This objective will be met by comparing the stomach contents of fish collected in the marsh to the forage base available in the various marsh habitats. If the stomach content of the target species is comprised of some subset of the prey organisms that are collected in the marsh and these organisms were consumed while the fish was in the marsh, the direct link between the restored marsh to the target species will have been demonstrated.

3.2.1.2 Rationale for this Study

The results of the food habits monitoring would provide pertinent data to substantiate the arguments presented in Permit Application relative to the function of marshes as important foraging and nursery areas for fishes and macroinvertebrates. The data obtained from the food habits study combined with the data from the marsh utilization study could provide strong evidence that the target species are deriving a clear bioenergetic benefit from the restored marshes. Marsh habitats can be extremely important in terms of providing an easily obtainable, high quality food source that benefits many species from a bioenergetics standpoint, which increases survival rates for those species. The results of this monitoring will provide a direct assessment of whether or not the restored marshes are providing a food

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base which is exploited by the target species. If the restored marshes are being used as foraging areas by the target species, it demonstrates that the restored marshes are functioning as undisturbed marshes with respect to the food web.

3.2.1.3 Historical Foundation

Based on a review of available scientific literature, PSE&G has established that the diet of all target species include wetland-associated prey organisms. For example, both juvenile and adult bay anchovies can be found in abundance in marsh creeks (Rountree and Able 1992; Smith et al. 1984). Young anchovies prey predominantly on clam larvae and copepods (Carr and Adams 1973). Field studies have indicated that the diet of adult anchovies shifts to larger macrozooplankters (i.e., mysids, cladocerans, and crab zoea) and is supplemented by small mollusks and detritus (Darnell 1958; Smith et al. 1984).

Additionally, spot are seasonal residents of marsh creeks (Weinstein 1983) and utilize these areas to feed and grow (Weinstein and Walters 1981). Studies of spot food habits in the Chesapeake Bay (Homer and Boynton 1978; Homer et al. 1980) indicated that spot are obligate bottom feeders whose diets vary with feeding area. Polychaetes, mollusks, and copepods were the preferred food items in a diet that also included mysids, amphipods, isopods, and detrital material. All indications are that spot are opportunistic feeders able to utilize a wide variety of food items available in marsh creeks (CRC 1991).

Finally, both weakfish and white perch are seasonally abundant in estuaries and utilize marsh areas as both young (CRC 1991; Wang and Kernehan 1979) and adults (Rountree and Able 1992). Both species are predatory and, as such, have varying food habits with age. Larval white perch feed on copepods, cladocerans, and rotifers (Seltzer-Hamilton et al. 1981). Juvenile white perch preferentially feed on mysids and other benthic invertebrates; older white perch become piscivorous benthic predators (CRC 1991). Larval weakfish in Delaware Bay feed primarily on copepods, polychaetes, and pelagic invertebrate eggs,

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showing a preference for larger food items with increased size (Goshorn and Epifanio 1991). In the Delaware Estuary, older weakfish prey on a wide variety of invertebrates and fishes (Grecay 1990; Taylor 1987).

3.2.2 Proposed Study Design

3.2.2.1 Study Duration and Geographic Extent

This monitoring study will be initiated after restoration of the sites has begun and continue through the end of the 5-year Permit period. Baseline food habitats of the target species from reference sites or restored sites do not have to be documented for this study because documenting a change in food habits is not directly related to the fact that the target species exploit the food resources of the restored wetland. The objective is to establish that the restored marshes provide a food base that is exploited by the target species.

The monitoring program should last several years because exploitation of the marsh food base may be related to abundance and species of prey items available. Relative abundance of prey items may change as the restored marsh approaches a natural state, and result in a change in the food habits of some species. If a favored prey type becomes more abundant as the marsh is restored, linking the food habits of a target species to the marsh could be easier and better established. It would also be advantageous to compare the food habits of the target species from restored and reference marshes during the fifth year of the Estuary Enhancement Program when the restored marshes should most resemble the reference marshes. If the food habits (and prey base) were similar, it would be a clear indication that the restored marshes are benefitting the target species in the same fashion and extent as the reference marshes.

The geographic extent of this study will be limited to the four sites that are being restored. The sites will include both salt hay farms and *Phragmites*-dominated marshes that are targeted for restoration. Towards the end of the 5-year Permit period, it may be advantageous to collect some food habit data from each of the marshes being restored if it is

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not possible to demonstrate that the target species are exploiting the food resources in each of the four marshes being studied. If this link can be convincingly demonstrated in each of the four marshes, there should be no reason to monitor each of the restoration sites individually.

3.2.2.2 Sampling Frequency

This monitoring program will be conducted when the target species are abundant in the marshes at the juvenile and/or adult life stage. Food habits of larval fish are not currently included as part of the study. Most of the target species should be abundant between April and early November.

3.2.2.3 Sampling Intensity and Locations

Because food habits are related to body size for many species (CRC 1991; Goshorn and Epifanio 1991; Homer et al. 1980), sampling will be conducted monthly from April through early November to adequately document the food habits of individuals of various sizes. Samples collected as part of the Fish and Macroinvertebrate Monitoring of the Restored Wetlands (Additional Studies) would be used for these analyses and no additional sampling for the target species is proposed.

3.2.2.4 Sampling Gear and General Deployment

Two pieces of data are required to link the food habits of the target species to the forage base of the marsh: prey items of the target species and prey items available in the marsh. The target species will be collected with blocknets or trawls.

Prey availability will be determined through a combination of the prey items collected in the trawl or blocknet, macroinvertebrate samples collected with a standard plankton net, and ponar samples. Ponar samples will only be used if there is reason to expect a large benthic component in the diet of one or more of the target species. Oblique plankton net tows will

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be used where possible. If ponar samples are required, five ponar samples will be collected from each location. It will likely be necessary to augment the data collected from the Fish and Macroinvertebrate Monitoring of the Restored Wetlands (Additional Studies) in terms of defining the available food base.

3.2.2.5 Laboratory Processing

Stomach contents and relative fullness will be determined for 25 individuals of each species in three or four predetermined size categories each year (total of 75-100 individuals per target species per year). The predetermined size categories will be based on the fish sizes reported in the literature in which there has been a documented shift in prey species or prey size from smaller sized individuals. The fish will be placed on ice in the field and transported to the laboratory where the stomachs will be removed and preserved. The stomach contents will be identified to the lowest practical taxon. It is likely that some organisms will have to be processed in the laboratory.

The prey availability samples collected with the ponar or plankton net will be preserved in the field in buffered formalin and a histological dye will be added to facilitate the sorting process. If organism numbers are excessive, a subsampling method will be used to reduce the time it takes to sort and identify each sample.

3.2.2.6 Data Analysis

Data analysis will include comparing the stomach contents of the fish collected with the prey base collected. There are several techniques of examining the relative contribution of prey items to the overall food habits of the fish or in relation to the availability of prey (e.g., Pielou's evenness index, various electivity indices). These statistics can be calculated for biomass or abundance of the prey items in the stomach and/or environment. An appropriate statistic will be identified and evaluated when detailed work plans are prepared. The various statistics each have their strengths and weaknesses and these will be outlined in the detailed study work plan.

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Both diet composition and stomach fullness will be analyzed separately for each predetermined size group of the target species. A broader scale analysis might be used to categorize the type of prey items consumed. Prey items could be classified as microzooplankton, macrozooplankton, benthos, fish, detritus, etc., to generally describe the foraging habits of the target species.

3.2.2.7 Quality Assurance/Quality Control

Quality assurance/quality control procedures will be implemented for the collection and processing of the samples. The data recording and processing techniques will be standardized to minimize investigator error. A quality assurance/quality control manual specific to this monitoring study program will be developed prior to initiating sampling.

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4. REFINEMENT OF ESTIMATES OF CONDITIONAL MORTALITY

4.1 MARK-RECAPTURE STUDY

4.1.1 Introduction

4.1.1.1 Objective of Study

The objective of the mark-recapture study is to obtain an estimate of the number of Age 0 white perch in the tidal portion of the Delaware Estuary. A population estimate for Age 0 fish is required as an input to the Empirical Impingement Model.

4.1.1.2 Rationale for this Study

This program is not required by the 1994 Permit, but is in response to EPA's comments on the Draft Permit in which they requested that NJDEPE require PSE&G "...to verify the fish population models being used...." In addition, this information would be required in order to update estimates of conditional mortality which might be required during the next permit renewal cycle. Considering the age of the existing data on white perch population size and the potential changes in conditional mortality rates from changes in sound deterrents, fish baskets, and mesh size, a re-evaluation of this parameter is warranted.

4.1.1.3 Historical Foundation

Historically, PSE&G has used the Empirical Impingement Model to assess the fraction of the white perch population in the Delaware Estuary lost to impingement at Salem. The Empirical Impingement Model requires three primary data inputs: the number of fish impinged, the natural or total mortality rate, and the initial population size.

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During 1980 and 1981, PSE&G conducted a mark-recapture experiment to estimate the population size of white perch in the upper Delaware Estuary. Age 0 white perch were collected using a 4.9-m otter trawl during November-December and marked with fin clips indicating one of eight river zones. The eight zones extended upriver from Artificial Island (RKM 72) to near Bristol (RKM 190). After a 10-minute holding period, marked fish were released back into the river near the original capture site. During the recapture phase from January through mid-May, sampling effort was allocated among the eight zones according to the observed abundance. Additional recapture collections were made at various industrial intakes in the area. In order to achieve a ±50 percent confidence limit around the population estimates, an initial target of 5,000 fish to be marked and 18,000 fish to be examined for marks was set. These mark and recapture targets were established based on information provided by Robson and Regier (1964). Throughout the mark-recapture experiment, Age 0 white perch were held in the laboratory to estimate marking mortality and mark retention.

4.1.2 Proposed Study Design

4.1.2.1 Study Duration and Geographic Extent

A mark-recapture program will be conducted in 1995 and 1997. Marking and recapture of Age 0 white perch will be conducted from Artificial Island (RKM 72) to near Bristol (RKM 190).

4.1.2.2 Sampling Frequency

The marking phase of this study will be conducted from November through December. Capture of fish to be marked will continue daily throughout the entire 2-month period or until 5,000 fish are marked. The recapture phase will be conducted daily during January

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through mid-May. The goal will be to examine approximately 18,000 Age 0 white perch for marks. Sampling may terminate prior to mid-May if it is demonstrated that the resulting population estimates have a confidence interval of less than ±50 percent.

4.1.2.3 Sampling Intensity and Locations

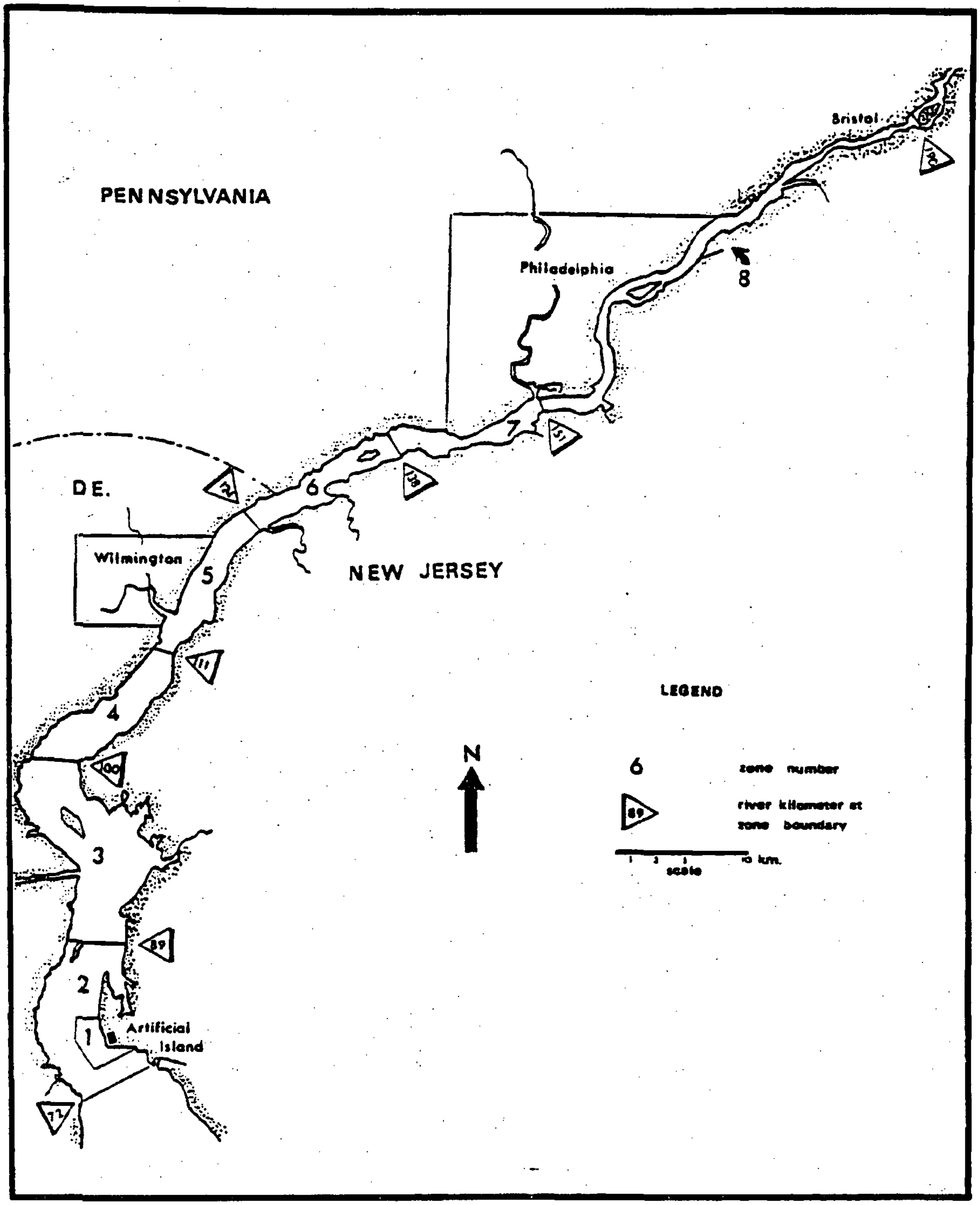
Eight zones extending upriver from Artificial Island (RKM 72) to near Bristol (RKM 1980), patterned after the 1980-1981 mark-recapture study, will be used (Figure 4-1). In the early stages of the marking phase, sampling effort will be equally allocated among all eight regions. As distribution patterns become better defined, sampling effort may be re-allocated to maximize the number of fish caught. During the recapture phase, sampling effort will be allocated among the eight zones in accordance with the observed abundance. Additional recapture collections will be made at various industrial intakes in the area.

4.1.2.4 Sampling Gear and General Deployment

Although any sampling gear yielding uninjured specimens may be used, previous experience suggests that a 4.9-m otter trawl is effective. Any gear or deployment method used will be designed to reduce stress on young fish. During the recapture phase, any collection method will be acceptable, including impingement samples.

4.1.2.5 Field and Laboratory Processing

During the mark phase, Age 0 white perch will be identified and then marked. Fin clips or binary coded wire tags unique to the region of capture will be used. After marking, fish will be held for at least 10 minutes. Those individuals exhibiting signs of stress will not be released. The remaining fish will be released back into the river near the original capture site.



PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM 316(b) STUDY

Figure 4-1. Location of white perch mark-recapture zones in the Delaware River.

To identify Age 0 white perch during the recapture phase, the following procedure will be used. First, all specimens of less than the monthly length maxima listed below will be counted and examined for marks. Next, scale samples will be obtained from fish that are in the size range overlapping Ages 0 and 1. Finally, after the scales have been read, the estimated number of Age 1 fish will be subtracted from the total number of fish examined.

Month	Maximum Length (mm fork length)	Length Range for Scale Sample
January	109	100-109
February	113	104-113
March	117	108-117
April	121	112-121

Throughout the mark-recapture experiment, Age 0 fish will be held in the laboratory to estimate marking mortality and mark retention. At least 200 marked and 200 control specimens will be used to initiate the tests.

4.1.2.6 Data Analysis

The Age 0+ population size will be estimated using the Schaefer, or stratified Petersen, method, as appropriate (Chapman and Junge 1966; Ricker 1975).

4.1.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

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4.2 MECHANICAL ENTRAINMENT MORTALITY STUDY

4.2.1 Introduction

4.2.1.1 Objective of Study

The objective of this study is to estimate the mechanical component of entrainment mortality for each life stage of the target species. Mechanical mortality is defined as the fraction of each life stage and species lost as the result of through-plant passage when ambient plus delta-temperatures are too low to induce thermal mortality.

4.2.1.2 Rationale for this Study

This program is not required by the 1994 NJPDES Permit. It is, however, a necessary input for calculating through-plant entrainment losses. The values used for the Salem 316(b) Demonstration were based on limited, often non-site-specific, data and were subject to criticism by technical reviewers. This alone suggests that the study be continued. If intake screen mesh size is changed from the existing 0.375-in. square mesh, thereby altering the size distribution of fish passing through the plant, new mechanical mortality coefficients might be required.

4.2.1.3 Historical Foundation

To calculate entrainment losses at Salem, an estimate of the through-plant mortality (or survival) rate is required. This mortality rate is often divided into three separate components: mechanical mortality, thermal mortality, and biocide mortality. Mechanical mortality represents the incremental mortality resulting from physical abrasion, shear forces, and pressure effects during plant passage, exclusive of the other two components.

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Studies of entrainment survival at Salem began in 1977, but it was not until 1981 that the sampling intensity was great enough to yield statistically adequate numbers of the target species. During 1981 and 1982, sampling occurred four times monthly in June and July, twice monthly in May and August, and once during September and October. At least six pairs of intake-discharge samples were collected during each sampling event.

Beginning in late 1980, a low velocity flume replaced the previously used larval table for collecting entrainment survival samples. The low velocity flume is a modification of the larval table designed to increase the volume of water sampled. While the larval table system normally filters approximately 5 m^3 in a 10-minute sample, the low velocity flume is capable of filtering approximately 75 m^3 in a 10-minute sample. The low velocity flume uses the same frame as the larval table (8.1- × 1.2- × 0.9-m) and the same drain system. The most significant modification is the elimination of the table collection box and the substitution of a 4.5-m long, 0.5-m diameter net of 505-μm mesh attached at the point of water entry.

Entrainment survival samples were taken at both the intake and discharge. Mortality among specimens collected at the intake represents gear-induced and natural mortality. At the end of the sample collection, specimens were carefully removed from the low velocity flume and transported to an onsite laboratory facility where they were held for up to 96 hours. Laboratory-held specimens were fed twice daily.

A series of collection efficiency and mortality component studies was also conducted. By holding a known quantity of specimens in the laboratory, releasing them into the net directly, and pumping them into the net, estimates of mortality due to holding and handling may be ascertained.

4.2.2 Proposed Study Design

4.2.2.1 Study Duration and Geographic Extent

The study will be conducted in 1995 and 1997 at Salem.

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4.2.2.2 Sampling Frequency

Sampling for mechanical mortality will be conducted four times monthly in June and July, twice monthly in May and August, and once during September and October. At least six pairs of intake-discharge samples will be collected during each sampling event.

4.2.2.3 Sampling Intensity and Locations

Samples will be paired: one sample from the intake and one sample from the discharge. A target of 300 intake and discharge specimens for each species and life stage will be set.

4.2.2.4 Sampling Gear and General Deployment

A low velocity flume, or equivalent device, capable of sampling at least 7.5 m^3 will be used to collect intake and discharge samples.

Collection efficiency and mortality component studies will also be conducted. Control specimens will be held in the laboratory and known quantities of live organisms will be introduced into the sampling device. If sampled specimens pass through a pump, then the mortality component test must be able to distinguish between net-induced mortality and pump-induced mortality.

4.2.2.5 Field and Laboratory Processing

At the end of each sample collection, specimens will be carefully removed from the sampling device and transported to an onsite laboratory facility where they will be held for up to 48 hours. Held individuals will be fed twice daily. Specimens will be examined at time intervals of 0, 2, 4, 8, 12, 24, and 48 hours. The number of live, damaged, and dead specimens will be recorded. Physicochemical factors, such as water temperature and salinity, will also be measured with each sample.

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4.2.2.6 Data Analysis

Differences between control and experimental tests will be conducted using appropriate tests, such as Fisher's Exact Test, χ^2, or a G-Test. Average survival rates and associated 95 percent confidence limits will be calculated for entrained target species by life stage. Investigations into factors influencing survival rates, such as water temperature and salinity, will also be conducted. These results will be incorporated into a report summarizing the findings of the study.

4.2.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

4.3 LATENT IMPINGEMENT MORTALITY STUDY

4.3.1 Introduction

4.3.1.1 Objective of Study

The objective of this study will be to assess the delayed effects (up to 96 hours) of impingement on mortality rates for target species. The results of this study will be used in conjunction with the Impingement Abundance Study (Work Plan, Section 5.2.5) to update estimates of impingement loss for the target species at Salem.

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4.3.1.2 Rationale for this Study

This program is not required by the 1994 NJPDES Permit. It is, however, a necessary input for calculating through-plant impingement losses. Although values developed for the Salem 316(b) Demonstration could be used, anticipated changes to the intake fish baskets, screen mesh size, and the installation of sound deterrent devices might render these values obsolete.

4.3.1.3 Historical Foundation

Delayed mortality (measured to 96 hours) may be a significant component of impingement mortality. In order to estimate the contribution of delayed mortality, PSE&G conducted a series of tests during 1977-1982. Initially, all latent mortality studies were conducted at the Ichthyological Associates Delaware laboratory facility. Beginning in 1981, some tests, especially bay anchovy and herring tests, were conducted at Salem. Control specimens were held in the laboratory throughout the study.

Impingement latent mortality tests were conducted as fish and test tanks were available. Samples were generally collected at least weekly throughout the year. All impinged specimens used in the latent mortality tests were taken from the fish collection pools. A maximum of 20 fish per test tank were held; control sample sizes generally equaled the maximum loading factor for a specific sized test tank.

Tests at the Delaware facility were conducted with temperature-controlled recirculated water in 190-L (50-gal) oval tanks equipped with removable screened dividers and in 81-L (22-gal) circular tanks. Holding water was a mixture of seawater and freshwater adjusted to ambient river conditions in the vicinity of Artificial Island. Water was changed when pH, dissolved oxygen, or ammonia did not meet the water quality criteria for the Delaware River.

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4.3.2 Proposed Study Design

4.3.2.1 Study Duration and Geographic Extent

Latent mortality sampling will be conducted at Salem each year during the period 1995 through mid-1997.

4.3.2.2 Sampling Frequency

Impingement latent mortality tests samples will be collected at least weekly throughout the year.

4.3.2.3 Sampling Intensity and Locations

All impinged specimens used in the latent mortality tests, except handling controls, will be taken from the fish collection pools. Control specimens will be wild fish captured in the Salem vicinity.

4.3.2.4 Sampling Gear and General Deployment

Test specimens will be held in temperature-controlled tanks with recirculated water. Tanks similar in size and configuration to the previously used 190-L (50-gal) oval tanks equipped with removable screened dividers and 81-L (22-gal) circular tanks are recommended. Holding water will be a mixture of seawater and freshwater adjusted to ambient river conditions in the vicinity of Artificial Island. Water will be changed when pH, dissolved oxygen, or ammonia do not meet the water quality criteria for the Delaware River. A maximum of 20 fish per test tank will be held; control sample sizes will be equal to or less than the maximum loading factor for a specific sized test tank.

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4.3.2.5 Field and Laboratory Processing

Environmental factors, such as water temperature and salinity, will be measured with each sample. Test individuals will be examined at time intervals of 0, 2, 12, 24, 48, 72, and 96 hours. The number of live, damaged, and dead specimens will be recorded. For white perch, the loss of equilibrium condition will also be noted.

4.3.2.6 Data Analysis

Differences between control and experimental tests will be examined using appropriate tests, such as Fisher's Exact Test, χ^2, or a G-Test. Average survival rates and associated 95 percent confidence limits will be calculated for impinged target species by age class and month. The effects of water temperature and salinity on latent mortality will also be investigated. These results will be incorporatred into a report summarizing the findings of the study.

4.3.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

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4.4 AGE COMPOSITION STUDY

4.4.1 Introduction

4.4.1.1 Objective of Study

The objective of this study will be to estimate the age class composition of target species impinged at Salem. This information will be combined with estimates of impingement abundance and mortality to estimate the number of each age of each target species lost to impingement at Salem. The age of impinged organisms must be known in order to express losses in terms of equivalent adults.

4.4.1.2 Rationale for this Study

This program is not required by the 1994 NJPDES Permit. The information generated by this study is, however, a necessary input for calculating impingement losses. Considering the age of the existing data on age class composition and the potential changes resulting from changes in sound deterrents, fish baskets, and mesh size, re-evaluation of this parameter is warranted.

4.4.1.3 Historical Foundation

An important consideration in the computation of the conditional impingement mortality rate is the age of the impinged fish. For most species at Salem, this presents little difficulty as they are easily identified as Age 0+ by their relatively small size. However, for bay anchovy and white perch, several different age classes may be involved. It has, therefore, been necessary to obtain estimates of the age composition of impinged individuals of these two species. This was accomplished in 1981-1982 through the examination of annular marks on scales or otoliths.

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4.4.2 Proposed Study Design

4.4.2.1 Study Duration and Geographic Extent

Scale/otolith samples from impinged bay anchovy, blueback herring, alewife, and white perch will be collected during 1995-1999.

4.4.2.2 Sampling Frequency

Samples will be collected as part of the impingement abundance monitoring program.

4.4.2.3 Sampling Intensity and Locations

Samples will be collected at the north or south collection pools, depending on the discharge direction.

4.4.2.4 Sampling Gear and General Deployment

The impingement collections for each of the targeted species will be separated into 10-mm length strata and up to 30 randomly chosen scales and/or otoliths per length stratum per month will be selected for analysis.

4.4.2.5 Field and Laboratory Processing

In the laboratory, scales and otoliths will be examined for annular marks. Two independent readers will be used to make age determinations. Readings not in agreement will be resolved by a third reading or the sample will be discarded. An age-length key will be constructed and will be used to assign an age to all measured specimens taken in impingement samples.

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4.4.2.6 Data Analysis

The length-at-age data will be used to construct an age-length key for each species for each month. The resulting age-length keys will be used to assign age designations to the individuals collected in the impingement abundance monitoring study. Results of this study will be incorporated into a final report and made available annually for calculation of impingement losses.

4.4.2.7 Quality Assurance/Quality Control

A quality assurance program will be implemented for all phases of the field, laboratory, and data handling activities to ensure that the work products meet high standards of accuracy. Field and laboratory activities will undergo periodic audits of the performance of the respective crews to ensure compliance with the standard operating procedures and the study work plan. Data files resulting from this study will be inspected following procedures designed to ensure an AOQL of ≤ 0.1 percent, i.e., one rejected record per 1,000 records.

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Thomas P. Joyce
Site Vice President - Salem

PSEG Nuclear LLC
P.O. Box 236, Hancocks Bridge, NJ 08038-1236
tel: 856.339.2086 fax: 856.339.2956

PSEG
Nuclear LLC

CERTIFIED MAIL

March 6, 2006
EEP06040

Mr. David Chanda
Director, Division of Fish and Wildlife
New Jersey Department of Environmental Protection
PO Box 400
501 East State Street, 3rd Floor
Trenton, NJ 08625-0400

Dear Mr. Chanda:

SALEM GENERATING STATION NJPDES PERMIT NO. NJ0005622
CUSTOM REQUIREMENT G.6
IMPROVED BIOLOGICAL MONITORING WORK PLAN (IBWMP)

PSEG Nuclear, LLC hereby submits the attached revision to the current IBMWP for the department's review and approval. This proposed revision reflects minor adjustments to Section 2.1.2 of the IBMWP, "Fish Utilization of Restored Wetlands," and all other sections of the IBMWP remain unchanged.

These proposed changes to the IBMWP were discussed with the Estuary Enhancement Program Advisory Committee (EEPAC) and members of your Department on February 21, 2006 (Enclosure 1). As summarized during the February 21st web cast/teleconference, PSEG has been collecting data for 10 years on fish utilization of several wetland restoration sites that meet the vegetative success criteria and now proposes to focus the required monitoring on the remaining restoration sites that have not yet met the vegetative success criteria (Enclosure 2). This approach to reduce monitoring of fish utilization on restoration sites meeting the success criteria is consistent with the NJDEP-approved program for monitoring of vegetative cover and will reduce the impact on aquatic organisms resulting from monthly sample collection.

As indicated by comments on the proposed change submitted by two EEPAC members subsequent to the conference call (Enclosure 3), there is general recognition by our scientific advisors that a reduction in monitoring for sites demonstrating success is appropriate.

We request your approval of the proposed changes to the IBMWP by April 1, 2006, to support initiation of the Spring 2006 field program. Should you have any questions about this proposed modification to the IBMWP, please feel free to contact Jeff Pantazes, Manager of Permitting and Technical Services, at (856) 878-6920, or Ken Strait, Manager of the Estuary Enhancement Program, at (856) 878-6929.

Sincerely,

Thomas P. Joyce
Site Vice President - Salem

Enclosures (4)

C J. Pantazes – PSEG (w/o)
P. Patterson – NJDEP (w/ enclosure)
S. Rosenwinkel – NJDEP (w/ enclosure)
EEPAC Members (via e-mail)

KAS/mk

BC: S. LaBruna
T. O'Neill
D. Benyak
J. Grant
J. Balletto
C. McAuliffe
K. Strait
B. Evans
J. Valeri
File#170.121

PSEG Nuclear LLC

Salem Generating Station
NJPDES Permit No. NJ0005622

Custom Requirement G.6
Improved Biological Monitoring Program Work Plan

PSEG Services Corporation
Estuary Enhancement Program

March 1, 2006

EEP06040

1.0 INTENT

The NJPDES Permit (No. NJ0005622) for the Salem Generating Station contains several Custom Requirements. Custom Requirement G.6 (a) calls for the permittee to:

> "...develop and implement an improved biological monitoring program under this renewal permit. This biological monitoring program shall include, at a minimum: abundance monitoring for adult and juvenile passage of river herring as well as stocking in connection with the eight fish ladder sites; improved impingement and entrainment monitoring; review and discussion as to the appropriateness of Atlantic silverside as a representative important species; improved bay-wide abundance monitoring; continued detrital production monitoring (including vegetative cover mapping, quantitative field sampling and geomorphology); continued study of fish utilization of restored wetlands; and other special monitoring studies as may be recommended by the EEPAC and/or the Department and subsequently required by the Department."

2.0 MONITORING PROGRAMS

2.1 Wetlands Restoration and Enhancement

2.1.1 Vegetative Cover and Geomorphology Mapping

Vegetative cover at the wetland restoration sites will be monitored using a combination of aerial photography and field sampling methodologies. Aerial photography will be conducted annually to map changes in the vegetative communities and the geomorphology associated with the restoration process. Annual field sampling will also be conducted on representative wetland restoration sites to assess changes in community abundance and composition for vascular plants.

Annual mapping of the vegetative communities and geomorphology will occur on all wetland restoration sites that have not met the vegetative success criteria defined in the applicable site-specific Management Plan. The representative wetland restoration sites selected for vegetative field sampling will include at least one restored salt hay farm, until all formerly impounded restoration sites meet the vegetative success criteria, and formerly *Phragmites*–dominated restoration sites that have not met the vegetative success criteria defined in the applicable site-specific Management Plan. Annual mapping of the vegetative communities and vegetative field sampling will also continue on the Moores Beach reference marsh until all formerly impounded sites meet the applicable vegetative success criteria; and on the Mad Horse Creek reference marsh until all formerly *Phragmites*-dominated restoration sites meet the applicable vegetative success criteria. Mapping of the geomorphology on the Moore's Beach and Mad Horse Creek reference marshes will only be conducted during 2003.

Quantitative field sampling of the vascular vegetation will be conducted during the peak growing season, in quadrats located along fixed transects at each study site. The sampling will consist of percent cover, vegetation height, and calculation of above ground biomass for the vascular plants.

2.1.2 Fish Utilization of Restored Wetlands

Studies of habitat utilization by finfish will be conducted in representative wetland restoration sites and the results will be compared to those from reference marshes. Sampling will be conducted in one site representative of each type of restoration (formerly diked or formerly *Phragmites*-dominated) plus the comparable reference marsh for that restoration type (Moores Beach West or Mad Horse Creek, respectively) until all sites of that restoration type meet the final vegetative success criteria. The specified representative wetland restoration sites and reference marshes will be sampled monthly from late spring through mid-fall.

Two sampling methods will be employed, trawls and block nets. At each site, two marsh creeks will be sampled at three locations with an otter trawl: upper tidal creek, lower tidal creek and creek mouth. At each of the three stations, three 2-minute tows will be conducted. Block nets will also be deployed at two locations on each site to sample intertidal creeks draining into one of the creeks sampled with the trawl. Block net sampling will occur during daylight ebb tides. All finfish will be identified to the lowest practical taxon and counted. The length of the target species will be measured in a subsample taken from each collection. Data on water temperature, dissolved oxygen, salinity, and turbidity also will be recorded at each sampling location.

2.2 Adult and Juvenile River Herring Monitoring at Fish Ladder Sites

Use of the eight installed fish ladders by blueback herring and alewife will be monitored to document adult utilization of the fish ladders in all years of the permit period. In addition, two new fish ladders located in New Jersey and two new fish ladders located in Delaware will be installed during the permit period. Monitoring upstream migration at these new sites will begin in the spring immediately following installation.

Monitoring of adult fish passage will be conducted at a minimum of three days per week beginning when water temperatures first reach 9°C and ending when water temperatures first reach 21°C. Adult monitoring will be conducted by using traps installed at the exit of the ladders. All fish collected will be identified and enumerated, and returned to the impoundment as appropriate. Ancillary data will be recorded, including water elevation, water clarity, conductivity, dissolved oxygen, pH and temperature of both the ponds and spill pools.

To avoid impacting the reproductive success of migrating herring, monitoring for adult passage will be discontinued at sites where the target of 5 adult river herring per impoundment acre is achieved by passage alone for two consecutive years. Ponds at which adult monitoring is discontinued will be re-assessed for continuing adult passage after 3 years.

In impoundments where a target adult density of 5 fish per acre will not be achieved by adult passage alone, adult passage through the fish ladder will be supplemented with the trapping and transfer ("stocking") of adult river herring from other nearby source waters. The availability of adult river herring for stocking, and uncertainty concerning the size and duration of annual spawning runs, may impact the ability to achieve the 5 adult fish per acre target in each impoundment. PSEG will continue to conduct supplemental stocking of individual impoundments each year, when adequate numbers of adult river herring are available from other nearby water sources, until the target of 5 adult fish per acre is achieved in each specific impoundment. Impoundments where the fish ladders have passed at least 5 adult river herring per acre for two consecutive years will not be stocked in subsequent years.

Juvenile river herring production will be monitored by electrofishing once per month from September through November in each year of the permit period for those impoundments in which juvenile production has not yet been documented.

To quantify juvenile river herring emigration resulting from fish ladder use, a pilot study to test new techniques to monitor juvenile out-migration will be conducted at a selected fish ladder site in 2003. If acceptable non-destructive techniques can be identified, expanded juvenile out-migration monitoring at representative sites (that have a documented presence of juveniles) will be conducted during 2004. The delayed onset of juvenile out-migration monitoring is appropriate to allow the adult run to become fully established and self-sustaining. Data collected during the juvenile out-migration study will include enumeration by species, water elevation, water clarity, conductivity, dissolved oxygen, pH and temperature of both the ponds and spill pools.

2.3 River Abundance Monitoring

The focus of these studies will be on four priority Representative Important Species (RIS), which are: weakfish (*Cynoscion regalis*), bay anchovy (*Anchoa mitchilli*), white perch (*Morone americana*), and striped bass (*M. saxatilis*), as well as continued monitoring of other species as specified in the historical Biological Monitoring Work Plan. These species are spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), American shad (*Alosa sapidissima*), blueback herring (*A. aestivalis*), and alewife (*A. pseudoharengus*). Atlantic silverside (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and bluefish (*Pomatomis saltatrix*) will also be identified and counted for abundance monitoring.

2.3.1 River Bottom Trawl Survey

The relative abundance of finfish and blue crabs will be determined by employing 10-minute tows of a 4.9-m otter trawl in the Delaware Estuary. Forty samples will be collected once per month from April through November, conditions permitting, at random stations allocated among eight sampling strata between the mouth of the

Delaware Bay and the Delaware Memorial Bridge in all years of the permit period. During three intensive years (2002, 2003, and 2004) of the NJPDES permit period, an additional 30 samples will be collected once per month from April through November, conditions permitting, at random stations allocated among six strata between the Delaware Memorial Bridge and near the Fall Line in Trenton, NJ. Fish and blue crabs collected will be identified to the lowest practicable taxonomic level, sorted by species, and counted. The length distribution of target species will be determined in a representative subsample of each target species. Lengths will be measured to the nearest millimeter. In addition, sampling information as well as water temperature, dissolved oxygen, salinity, and water clarity will be recorded for each sample.

2.3.2 River Ichthyoplankton Survey

The relative abundance of ichthyoplankton will be determined by employing 5-minute stepwise oblique tows (surface to bottom) of a 1-m plankton net (500 micron mesh) in the Delaware Estuary. Ninety samples will be collected twice per month from April through July, conditions permitting, at random stations allocated among fourteen sampling strata between the mouth of the Delaware Bay and near the Fall Line at Trenton, New Jersey during the three intensive years identified above. Specimens collected will be identified to the lowest practical taxon and life stage, and counted. In addition, total length will be measured to the nearest millimeter for a representative subsample of each target species and life stage per sample. Sampling information, as well as water temperature, dissolved oxygen, salinity, and turbidity, will be recorded for each sample.

2.3.3 River Pelagic Trawl Survey

The relative abundance of juvenile fish and blue crabs will be determined by employing 10 minute tows of a 4' x 6' pelagic frame trawl at randomly selected depth strata within the Delaware Estuary. Eighty samples will be collected once per month from April through November, conditions permitting, at random stations allocated among fourteen sampling strata between the mouth of the Delaware River and near the Fall Line at Trenton, New Jersey during the three intensive years identified above. Specimens collected will be identified to the lowest practical taxon and counted. The length distribution of target species will be determined in a representative subsample of each target species. Lengths will be measured to the nearest millimeter. Sampling information, as well as water temperature, dissolved oxygen, salinity, and turbidity, will be recorded for each sample.

2.3.4 Beach Seine Survey

Finfish and blue crabs will be sampled by deploying a 100-ft x 6-ft beach seine in the near shore waters of the Delaware Estuary. Forty samples will be collected once per month in June and November; and twice per month in July through October, conditions permitting, at fixed stations between the mouth of the Delaware River to the Chesapeake and Delaware Canal in each year of the permit period. These fixed stations will be the same as those stations randomly selected originally at the initiation of the beach seine survey in the 1995 BMWP.

Finfish and blue crabs collected will be identified to the lowest practicable taxon and counted. Length measurements will be determined in a representative subsample of each target species. Sampling information, as well as water temperature, dissolved oxygen, and salinity, will be recorded for each sample.

Beach seine data for the region between the Chesapeake and Delaware Canal and near the Fall Line in Trenton will be provided by the NJDEP Division of Fish and Wildlife ("NJFW"). PSEG will provide funding to the NJFW for the conduct of these surveys in each year of the permit period. The NJFW will modify its existing Delaware River Striped Bass Recruitment Survey to collect representative length measurements for all of PSEG's target species. The NJDEP and PSEG will exchange data generated in their respective programs; however, the results of upriver seine efforts will not be included in the PSEG annual reports discussed in Section 3.0.

2.4 Plant Effects Monitoring

2.4.1 Entrainment Abundance Monitoring

To estimate the number and size distribution of ichthyoplankton entrained, abundance samples will be collected over 24-hour periods with a pump. In all years of the permit cycle, sampling will be conducted three days per week at a frequency of seven samples per day during January through March and August through December (non-peak entrainment periods), conditions permitting. In addition, sampling will be conducted four days per week at a frequency of fourteen samples per day during the period April through July (peak entrainment periods), conditions permitting. Specimens collected will be identified to the lowest practical taxon and life stage, and counted. In addition, total length will be measured to the nearest millimeter for a representative subsample of each target species and life stage per sample. For each sample, additional data collected will include circulator status (on/off), air temperature, water temperature, and salinity.

2.4.2 Impingement Abundance Monitoring

To estimate the number and size distribution of target species impinged, collections of traveling screen wash water will be made on three days per week during all years of the permit cycle. Ten samples will be collected per 24-hour period, conditions permitting.

All fish collected will be sorted by species and counted, and the condition (live, dead, or damaged) of each specimen will be recorded. Length of each specimen will be measured for a subset of each target species, along with the total aggregate weight for all specimens of each species and condition code. For each sample, additional data collected will include circulator status (on/off), air temperature, water temperature, and salinity.

3.0 REPORTING SCHEDULE

The data from each year's monitoring activities will be summarized and discussed in an annual progress report that will be submitted to the NJDEP by June 30 of the following year.

ENCLOSURE 1

Salem Hope Creek
GENERATING STATIONS

EEPAC Web Cast Conference

February 21, 2006

AGENDA

- **Welcome**
- **PSEG Updates**
- **EEPAC Member Updates**
- **2006 Marsh Fish Sampling Program**
- **Pre-Publication Manuscript:**
  "Long Term Response Of Fishes To Restoration Of Former Salt Hay Farms: Multiple Measures Of Restoration Success" by Dr. K. Able et. al.
- **Proposed Changes to IBMWP**
- **June 2006 Meeting**

Marsh Fish Sampling Program For 2006 Field Season

- **2005 Biological Monitoring Program Annual Report in preparation**
- **Field sampling season begins April 1st**
- **Current program includes sampling on four (4) representative wetland restoration sites plus two (2) reference marshes**
  - Wetland Sites: Dennis, Commercial, Cohansey (Brown's Run), & Alloway (Mill Creek)
  - Reference Marshes: Moores Beach West & Mad Horse Creek
- **Dennis Twp. and Cohansey River Sites have met vegetative success criteria**
- **10 years of marsh fish assemblage data for successfully restored sites**
  - Draft manuscript summarizes response of fishes on restored salt hay farms

Salem Hope Creek 3

"Long Term Response Of Fishes To Restoration Of Former Salt Hay Farms: Multiple Measures Of Restoration Success" by Dr. K. Able et. al.

Salem Hope Creek 4

EEP06042

Improved Biological Monitoring Work Plan - Background

Required by Custom Requirement G.6.a of Salem's 2001 NJPDES Permit

Outlines EEP monitoring programs

- Vegetation Cover and Geomorphology Mapping
- Fish Utilization of Restored Wetlands
- Adult and Juvenile River Herring Monitoring At Fish Ladder Sites
- River Bottom Trawl Survey
- River Ichthyoplankton Survey
- River Pelagic Trawl Survey
- Beach Seine Survey
- Entrainment Abundance Monitoring
- Impingement Abundance Monitoring

Reviewed by EEPAC and approved NJDEP

Salem Hope Creek GENERATING STATIONS 5

Improved Biological Monitoring Work Plan – Revision History

Original IBMWP reviewed by MAC/MPAC/EEPAC and submitted in April 2002

Proposed changes reflecting optimal entrainment sampling allocation (per Custom Requirement G.9.b.i) reviewed with EEPAC and submitted to the NJDEP in June 2002

- Revision approved by the NJDEP in July 2003

Proposed changes to reduce adult passage monitoring at fish ladders that successfully pass river herring reviewed with EEPAC and submitted to the NJDEP in December 2003

- Revision approved by NJDEP in May 2004

Salem Hope Creek GENERATING STATIONS 6

Improved Biological Monitoring Work Plan – Proposed Revision

Proposed Revision to the Fish Utilization of Restored Wetlands section of the IBMWP:

- Reduces monitoring to one representative salt hay farm site, one representative *Phragmites* site, and attendant reference marshes for these restoration types until all sites of a restoration type meet success criteria
  - Consistent with IBMWP approach to vegetation cover monitoring
- Changes allocation of trawl stations from lower tidal creek, bay marsh fringe, and deep bay to upper tidal creek, lower tidal creek and creek mouth
  - Consistent with field program

Improved Biological Monitoring Work Plan – Original Text

"Studies of habitat utilization by finfish will be conducted in restored wetlands and the results will be compared to those from reference wetlands. Four representative wetland restoration sites and two reference sites will be sampled from late spring through mid-fall in all years of the permit cycle.

Two sampling methods will be employed, trawls and block nets. Trawl samples will be collected monthly at three stations within each marsh/adjacent study area: lower tidal creek, bay/marsh fringe (shoal), and deeper bay (>10 ft). **At each of the three stations, three 2-minute tows will be conducted. Fish sampling in upper tidal creeks will employ block nets fished during daylight ebb tides on a monthly basis. All finfish will be identified to the lowest practical taxon and counted. The length of the target species will be measured in a subsample taken from each collection. Data on water temperature, dissolved oxygen, salinity, and turbidity also will be recorded at each sampling location."**

Improved Biological Monitoring Work Plan – Revised Text

"Studies of habitat utilization by finfish will be conducted in representative wetland restoration sites and the results will be compared to those from reference marshes. Sampling will be conducted in one site representative of each type of restoration (formerly diked or formerly *Phragmites*-dominated) plus the comparable reference marsh for that restoration type (Moores Beach West or Mad Horse Creek, respectively) until all sites of that restoration type meet the final vegetative success criteria. **The specified representative wetland restoration sites and reference marshes will be sampled from late spring through mid-fall.**

Two sampling methods will be employed, trawls and block nets. Trawl samples will be collected monthly at three stations within each marsh/adjacent study area: upper tidal creek, lower tidal creek and creek mouth. **At each of the three stations, three 2-minute tows will be conducted. Fish sampling in upper tidal creeks will employ block nets fished during daylight ebb tides on a monthly basis. All finfish will be identified to the lowest practical taxon and counted. The length of the target species will be measured in a subsample taken from each collection. Data on water temperature, dissolved oxygen, salinity, and turbidity also will be recorded at each sampling location."**

Salem Hope Creek GENERATING STATIONS

9

"Long Term Response of Fishes and Invertebrates To Restoration Of Former Salt Hay Farms: Multiple Measures Of Restoration Success"

K.W. Able
T.M. Grothues
S.M. Hagan
D.M. Nemerson*
M.E. Kimball
G. Taghon

Marine Field Station
Institute of Marine and Coastal Sciences Rutgers University
800 c/o 132Great Bay Boulevard
Tuckerton, NJ 08087-2004

*National Aquarium in Baltimore
Pier 3/501 E Pratt Street
Baltimore, MD 21202-3194

Multiple Measures of Restoration Success

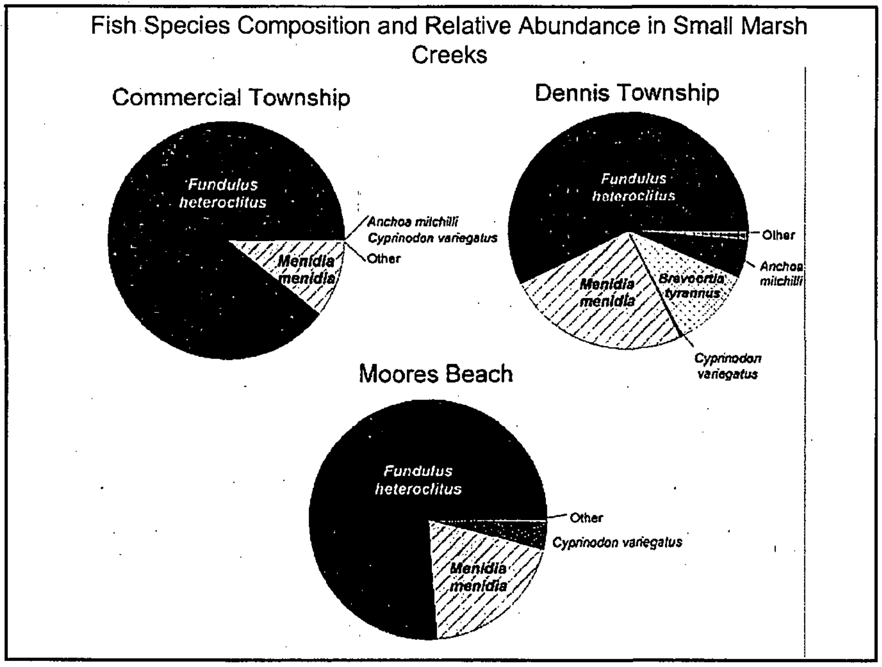
- Structural Attributes
  - Species Composition
  - Abundance
  - Assemblage structure
- Functional Attributes
  - Feeding
  - Growth
  - Survival
  - Production

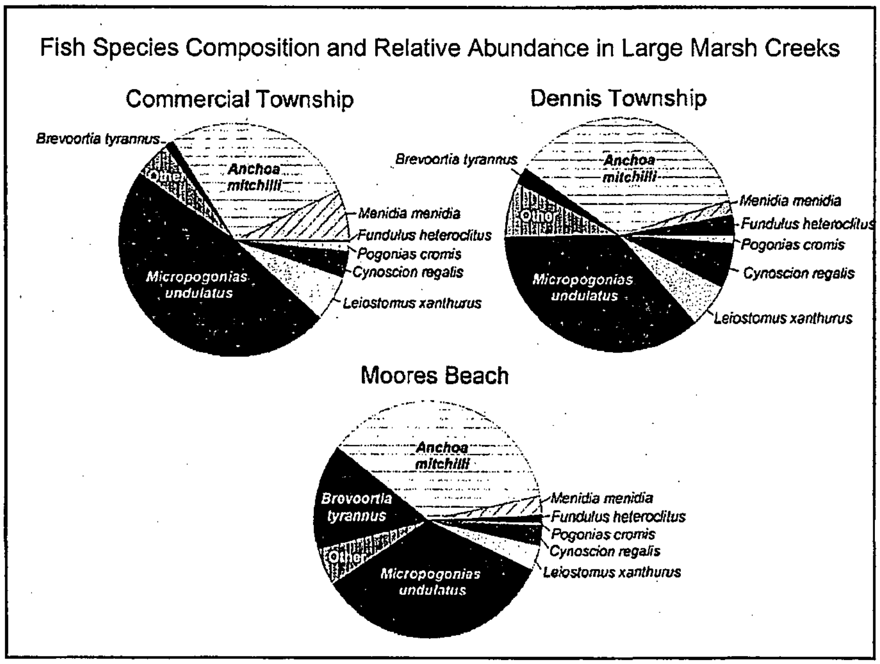
Multiple Measures of Restoration Success

- Methods
  - Up to 10 years of comparisons between restored (Dennis Township and Commercial Township) and reference (Moores Beach) marshes
  - Across several taxa
    - Fishes
    - Blue crabs
    - Horseshoe crabs
    - Diamondback terrapins
    - Benthic invertebrates
  - Based on monthly (May-November) intertidal (weir) and subtidal (otter trawl) sampling.
  - "Special projects" in some years
    - e.g. fish diet, condition, growth

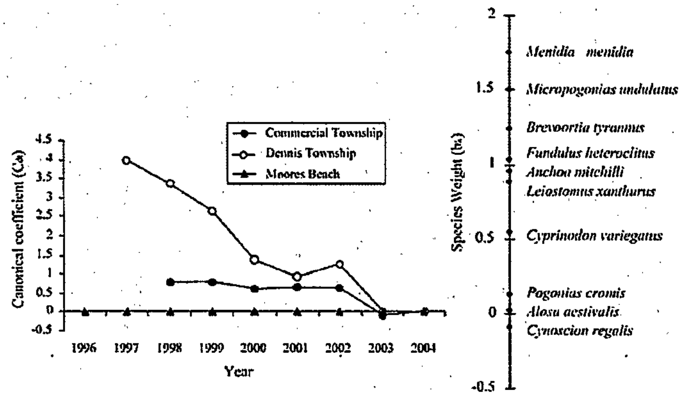
Substantial Documentation

- Two Major Synthesis
  1. Linkages between marshes and Delaware bay and river.
  2. Restoration Success in Former salt hay farms
- Peer-reviewed publications (13) on salt hay farm restoration
- RU thesis (1) and Dissertation (2)

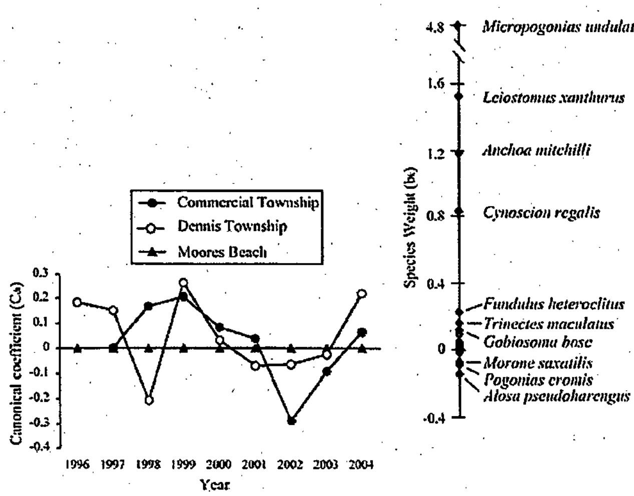

Fish Species Composition and Relative Abundance in Small Marsh Creeks
Commercial Township
Fundulus heteroclitus
Anchoa mitchilli
Cyprinodon variegatus
Other
Menidia menidia
Dennis Township
Fundulus heteroclitus
Other
Anchoa mitchilli
Brevoortia tyrannus
Menidia menidia
Cyprinodon variegatus
Moores Beach
Fundulus heteroclitus
Other
Cyprinodon variegatus
Menidia menidia


Fish Species Composition and Relative Abundance in Large Marsh Creeks
Commercial Township
Brevoortia tyrannus
Other
Anchoa mitchilli
Menidia menidia
Fundulus heteroclitus
Pogonias cromis
Cynoscion regalis
Leiostomus xanthurus
Micropogonias undulatus
Dennis Township
Brevoortia tyrannus
Anchoa mitchilli
Other
Menidia menidia
Fundulus heteroclitus
Pogonias cromis
Cynoscion regalis
Leiostomus xanthurus
Micropogonias undulatus
Moores Beach
Anchoa mitchilli
Brevoortia tyrannus
Other
Menidia menidia
Fundulus heteroclitus
Pogonias cromis
Cynoscion regalis
Leiostomus xanthurus
Micropogonias undulatus

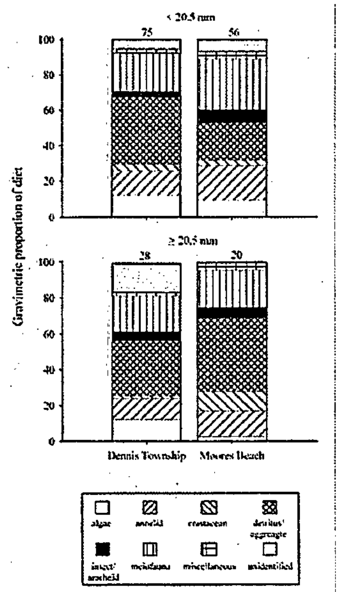
Fish Assemblage Structure in Small Marsh Creeks



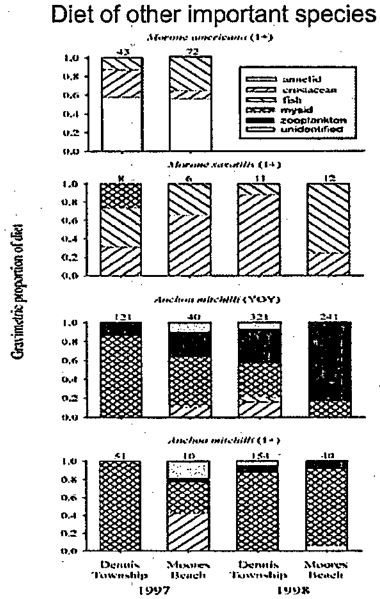
Fish Assemblage Structure in Large Marsh Creeks



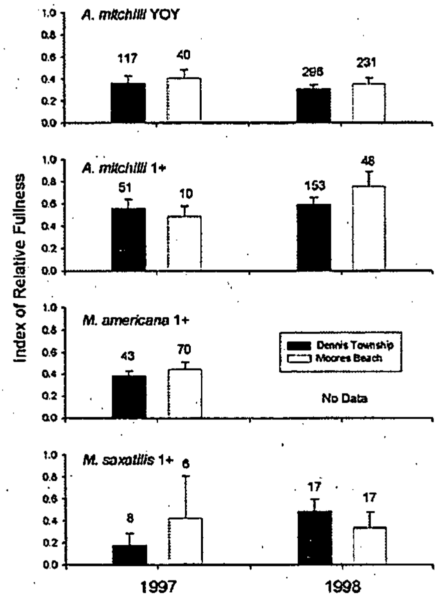
Diet of *Fundulus heteroclitus* by size



Diet of other important species



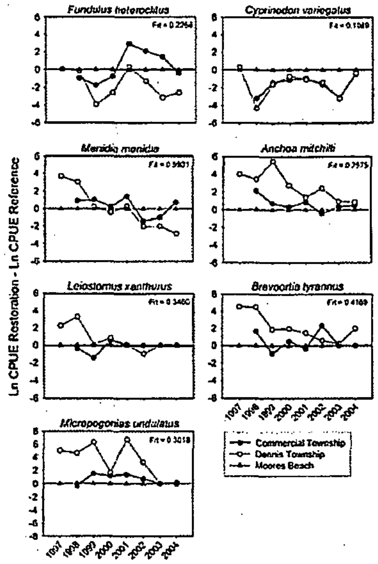
Stomach Fullness



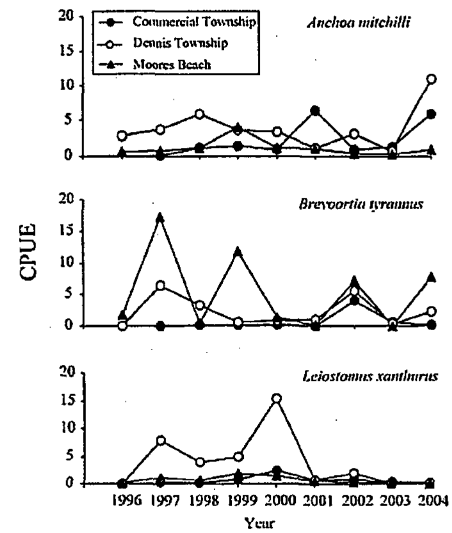
Summary
Multiple Measures of Restoration Success

Structural Attributes	Success Ratio
Species Composition	9/9
Abundance	15/15
Assemblage structure	9/9
Functional Attributes	
Feeding	3/3
Growth	5/5
Condition	3/3
Survival	8/8
Production	1/1

Comparative Fish Abundance in Small Marsh Creeks



Comparative Fish Abundance in Large Marsh Creeks



ENCLOSURE 2

Estuary Enhancement Program Advisory Committee (EEPAC)
Supplemental Webcast
February 21, 2006
14:30 – 15:30

Meeting Summary

Attendees

Ken Able - RUMFS
Brenda Evans - PSEG
Tom Grothues -RUMFS
Ed Houde - EEPAC
Ron Kneib - EEPAC
Bill Mitsch - EEPAC
Glenn Nickerson - EEPAC
Tom Noji - EEPAC
Jeff Pantazes – EEPAC/PSEG
Gina Petruzelli - RUMFS
Susan Rosenwinkel - NJDEP
Ken Strait – PSEG
Joe Shissler - EEPAC
Shawn Shotzberger –PSEG/AKRF
Anthony Totah - EEPAC
Don Wilkinson – NJDEP

Notes

J. Pantazes introduced the web meeting by identifying the participants and thanking them for their time. He then provided a brief status update of several PSEG activities, including the recent submittal of the NJPDES Permit renewal application and the anticipated merger with Exelon. Lastly, he confirmed the dates of May 31 and June 1 for the spring EEPAC meeting.

K. Strait briefly described changes to the Improved Biological Monitoring Work Plan (IBMWP) that PSEG is requesting. These changes are supported by K. Able's findings, which have been synthesized in a manuscript monograph. K. Strait then introduced K. Able and his team at Rutgers University Marine Field Station (RUMFS) to summarize the findings.

K. Able reviewed a number of slides presenting summary data from the manuscript and more recent data from 2005. With respect to a variety of metrics, including fish assemblage, fish diet composition, fish production, and the abundance indices of other species (e.g. diamondback terrapin, horseshoe crabs, macroinvertebrates), among others, the salt hay farm restoration sites are performing similarly to the reference site. Canonical analysis indicated that the fish assemblages and structures within restoration sites (Dennis and Commercial) have converged on those of the Moore's Beach reference site. R. Kneib asked about the large percentage of bay anchovy and menhaden in the Dennis fish assemblage charts. T. Grouthues and K. Able indicated that this species abundance was driven by a few catches with large numbers of specimens. Because bay anchovy and menhaden are schooling species, the collection of a single large school can skew the results.

E. Houde inquired as to whether there were also similarities in fish age structure, biomass, and size. K. Able responded that the results for age structure and biomass are likely very similar between the reference site and the restored sites, however the RUMFS analysis used general size class as a surrogate for these metrics. E. Houde also inquired about the variability of the data. T. Grothues responded that the data from the restoration sites tended to be less variable than the data from the reference sites. J. Pantazes inquired as to whether the manuscript could be provided to the EEPAC. K. Able responded affirmatively, with the caveat that it has not yet been submitted to a peer reviewed journal for publication, and could change after review.

K. Strait provided a brief history of the IBMWP and previous revisions to it. The two past revisions to the IBMWP were reviewed with the EEPAC and approved by the NJDEP. K. Strait then presented PSEG's proposed changes – namely reducing monitoring to one restoration site and one reference site per restoration type (i.e. *Phragmites* and salt hay farms) until all sites of a type have met their success criteria and reallocating trawl stations as identified in the IBMWP to reflect the field program. It was explained that this change is consistent with the vegetation monitoring program, and similar to the recent change in fish ladder monitoring (reduction of effort at successful sites).

E. Houde questioned what PSEG expected to gain by the reduction of effort. K. Strait responded that PSEG has successfully completed all restoration efforts at the Dennis Township site, that additional monitoring data from this site has no practical application, and that PSEG would continue to monitor Commercial Township until it was successfully restored. K. Strait suggested that some reduced frequency of monitoring could be conducted (e.g. every five years) to verify that the sites remained successful, but that interannual variability would limit the utility of the data collected. K. Able agreed that such a reduced monitoring frequency would only allow comparison to the reference site in the same year, and would not allow a long term assessment of potential continued changes to the restoration sites on a yearly basis. J. Shissler suggested that, to a large extent, faunal success is directly related to vegetative success. From this perspective, vegetative response could be used as a surrogate for faunal response. G. Nickerson inquired about other metrics such as shorebird surveys that might be used to track restoration success. D. Wilkinson suggested that the data from NJDEP aerial survey were too spatially and temporally variable to use as site-specific metric for restoration success tracking.

S. Rosenwinkel stated that the NJDEP expects that the EEP efforts to taper off as restoration is completed. She inquired as to the timing of this proposed change to the IBMWP. K. Strait responded that PSEG is targeting April 1, 2006 for an approval date, to coincide with the start of the 2006 field season. To expedite the EEPAC review process, J. Pantazes offered to send a package of materials to the EEPAC for comment, including the slides from the webcast, a brief meeting summary, the RUMFS manuscript, and a copy of the revised IBMWP.

J. Pantazes thanked webcast participants and adjourned the webcast/conference call.

ENCLOSURE 3

Estuary Enhancement Program Advisory Committee (EEPAC) Comments on Proposed Changes to IBMWP March 6, 2006

-----Original Message-----
From: Thomas Noji [mailto:Thomas.Noji@noaa.gov]
Sent: Friday, February 24, 2006 11:32 AM
To: Pantazes, Jeffrey J.
Subject: Re: EEPAC Proposed IBMWP Modification

Jeff,

The more I thought about your proposals, the more I think that they are reasonable. The key is to justify that monitoring sites are representative of the larger area of concern. Ken's fish data are useful. It might be just as useful (or more so) to compare other factors such as hydrography, riverine input, etc., to show that the areas are comparable.

The issue (raised by someone on the line) of natural / external forces influencing environmental variables and fish at the monitoring sites thereby obscuring human-induced changes is legitimate. However reducing the number of monitoring sites need not necessarily be a concern in this respect, presuming that the sites have similar properties and are affected by natural / external stressors (climate, weather, etc.) in the same or nearly the same manner. In contrast, if the external stressor is local in nature (e.g. contamination), then it may have local effects, which may not be characteristic for the larger area.

Again, the key is to demonstrate that your monitoring sites are representative of a larger stratum, and that your monitoring sites are not subject to strong local forcing.

Tom
[Thomas Noji, Ph.D
Ecosystem Processes Division
NOAA, NMFS, NEFSC
James J. Howard Marine Sciences Laboratory]

-----Original Message-----
From: RTK Consulting [mailto:ron@rtkconsulting.com]
Sent: Friday, February 24, 2006 5:34 PM
To: Pantazes, Jeffrey J.
Subject: RE: EEPAC Proposed IBMWP Modification

Jeff -

Given the information provided in Ken Able's presentation on fish utilization of the restored sites (convergence of restored sites with reference sites) and the fact that some restored sites (e.g. Dennis Twnshp) have met the success criteria, I see no reason to object to the proposed changes to reduce the fish utilization monitoring of restored wetlands (section 2.1.2 in the improved biological monitoring work plan). Also, there seems to be no reason to object to the minor change in statement about the location of the samples (upper, lower and creek mouth) to achieve consistency with the field sampling program.

I did want to clarify my comment about potentially monitoring the restored sites in some way with a longer interval (5 yr sampling interval). PSEG has invested a lot in the marsh restoration effort and I have a growing appreciation for the value of long-term datasets for monitoring ecosystem responses. In order to be able to continue using the benefits of the restoration work as a justification for future permits to continue plant operations (if that is a desirable goal), it seems to make some sense to propose a level of ongoing monitoring. From a completely selfish scientific perspective, I would very much like to know how stable the structure and function of the restored marshes remains over time. At the same time, I have always appreciated the fact that Bay-wide environmental changes, which are not under the control of PSEG can impact the future directions taken by these systems. Also, from the company's perspective, there should be an endpoint to responsibility for the systems.

Still, would there be some future value realized in public relations or in continuing to claim positive environmental benefits of the restoration effort without some level of monitoring to demonstrate that environmental dividends from this investment continued to accrue in the public interest? Perhaps it would be enough to use vegetative cover and geomorphology as Joe Shistler suggested to provide this level of monitoring. But I think a more direct measure of the animal communities using the marshes eliminates the need to continually defend the 'if you build it, they will come' assumption.

Cheers,
Ron

[Ronald T. Kneib, Ph.D
University of Georgia, Marine Institute
Sapelo Island, GA 31327]