PSEG

Estuary Enhancement Program

Public Service Enterprise Group Biological Monitoring Report 2006 Annual Report

2006 BIOLOGICAL MONITORING PROGRAM ANNUAL REPORT
EXECUTIVE SUMMARY

IMPINGEMENT ABUNDANCE MONITORING

Impingement abundance and initial survival sampling at the circulating water intake structure was conducted by diverting timed subsamples of flow from combined fish and trash troughs into fish counting pools. Sampling was scheduled during three 24-hour collection events per week from January through December. A total of 1,560 samples were collected. Sample duration can vary with fish and detritus abundance, and ranged from one to eight minutes, with 59% of the collections in 2006 being two minutes or greater. Individual finfish and blue crabs were collected from the pools by dip net and categorized as "live", "dead", or "damaged". Debris (vegetative matter) was examined for fish and any found were included in the collection. Specimens were sorted by condition category and species, and were counted, weighed, and measured. Ancillary parameters, including weight of detritus in the subsampled water volume, pump and screen conditions, tide, weather, water temperature and salinity, were measured during every sampling event.

A total of 56,876 finfish and 12,979 blue crabs were taken in 1,560 samples (total sample time of 2,591 minutes) during 2006. Findings specific to target finfish species include:

- Blueback herring (*Alosa aestivalis*). A total of 474 individuals were taken from 146 of 1,560 samples. Abundance was highest in March, with a secondary peak in February; individuals were collected January through April, August, and October through December. The proportion of live individuals on an annual basis was 96%.

- Alewife (*A. pseudoharengus*). A total of 45 individuals were taken from 33 of 1,560 samples. Abundance was highest in March; individuals were collected February through May, September, October, and December. The proportion of live individuals on an annual basis was 93%.

- American shad (*A. sapidissima*). A total of 75 individuals were taken from 60 of 1,560 samples. Abundance was highest in March, with a secondary peak in November; individuals were collected February through April and October through December. The proportion of live individuals on an annual basis was 95%.

- Atlantic menhaden (*Brevoortia tyrannus*). A total of 822 individuals were taken from 356 of 1,560 samples. Abundance was highest in May; individuals were collected in all months of 2006. The proportion of live individuals on an annual basis was 74%.

- Bay anchovy (*Anchoa mitchilli*). A total of 3,782 individuals were taken from 859 of 1,560 samples. Catches were similarly high in March and April; individuals were collected in all months of 2006. The proportion of live individuals on an annual basis was 87%.

- Atlantic silverside (*Menidia menidia*). A total of 876 individuals were taken from 363 of 1,560 samples. Abundance was highest in December; individuals were collected in all months of 2006. The proportion of live individuals on an annual basis was 95%.

- White perch (*Morone americana*). A total of 6,735 individuals were taken from 994 of 1,560 samples. Abundance was highest in March; individuals were collected in all months of 2006. The proportion of live individuals on an annual basis was 92%.

- Striped bass (*M. saxatalis*). A total of 191 individuals were taken from 127 of 1,560 samples. Abundance was highest in March; individuals were collected in all months of 2006 except May. The proportion of live individuals on an annual basis was 97%.

- Bluefish (*Pomatomus saltatrix*). A total of 139 individuals were taken from 118 of 1,560 samples. Abundance was highest in September; individuals were collected April through October. The proportion of live individuals on an annual basis was 78%.

- Weakfish (*Cynoscion regalis*). A total of 6,423 individuals were taken from 512 of 1,560 samples. Abundance was highest in August; individuals were collected in February, and June through December. The proportion of live individuals on an annual basis was 93%.

- Spot (*Leiostomus xanthurus*). A total of 194 individuals were taken from 84 of 1,560 samples. Abundance was highest in March; individuals were also collected in April, June, July, and December. The proportion of live individuals on an annual basis was 95%.

- Atlantic croaker (*Micropogonias undulatus*). A total of 26,254 individuals were taken from 1,476 of 1,560 samples. Abundance was highest in June, but was generally high in January, May, July, November, and December; individuals were collected in all months of 2006. The proportion of live individuals on an annual basis was 95%.

ENTRAINMENT ABUNDANCE MONITORING

Entrainment abundance sampling was conducted in the Salem Generating Station's circulating water intake structure by pumping river water out of the intake bay of Circulating Water Pumps 12B or 22A into a plankton net having a 0.5-mm mesh. A typical sample filtered 50 m^3 of intake water. During the months of January through March and August through December, routine entrainment sampling was scheduled during three 24-hour events per week with seven collections at approximately equal intervals during each event. During the months of April through July, intensive entrainment sampling occurred during four events scheduled each week with 14 samples scheduled at equal intervals during each event. Each event monitored a complete diel period encompassing two tidal cycles. A total of 1,687 out of 1,687 scheduled entrainment abundance samples were collected during 2006. Each concentrated sample was preserved, and the ichthyoplankton identified. For each species collected, the life stage was determined, the total number counted, and the lengths of a subsample were measured.

During the 2006 Salem Entrainment Abundance Monitoring program, totals of 67,049 fish eggs, 71,095 larvae, 13,706 juveniles, and 224 adults representing at least 38 species were collected in 1,687 entrainment abundance samples, with 85,740.1 m^3 of sample water filtered. Results specific to the target species are discussed in phylogenic order:

- <u>Blueback herring</u> - A total of three juvenile blueback herring was taken during January and March.

- <u>Alewife</u> – A total of 18 alewife including 16 larvae and two juveniles, was collected during January, and May through July. Alewife abundance was highest in July with larvae being the predominant lifestage.

- <u>Atlantic menhaden</u> - A total of 4,294 Atlantic menhaden, including 1,960 larvae and 2,333 juveniles, was taken during all months other than August and September. The abundance of Atlantic menhaden was highest in March, with larvae and juveniles being similarly predominant.

- <u>Bay anchovy</u> - A total of 86,985 bay anchovy, including 66,798 eggs, 17,482 larvae, 2,523 juveniles and 182 adults was collected during all months. Bay anchovy were most abundant in June, with eggs being the predominant lifestage.

- <u>*Menidia*</u> spp. – A total of 2,296 *Menidia* spp., including 167 eggs, 2,086 larvae, 33 juveniles, and 10 adults, was collected during the months of February, April through September, and December. *Menidia* spp. were most abundant in June, with larvae being predominant.

- <u>White perch</u> - A total of 472 white perch larvae was collected during July.

- Striped bass - A total of 468 striped bass, including 34 eggs, 415 larvae and 19 juveniles, was collected during April through July. Striped bass were most abundant in May, with larvae being the predominant lifestage.

- *Morone* spp**.** - A total of 95 *Morone* spp. larvae was collected during the months of May through July. *Morone* spp. were most abundant in July.

- Weakfish - A total of 603 weakfish, including 46 eggs, 373 larvae and 184 juveniles, was collected during the months of May through September. Weakfish were most abundant in August, with larvae being predominant.

- Spot - one spot larva was collected in May.

- Atlantic croaker - A total of 9,012 Atlantic croaker, including 630 larvae and 8,382 juveniles, was collected in all months. Atlantic croaker was most abundant in October, with juveniles being the predominant lifestage.

- Sciaenidae - A total of one sciaenid (weakfish/Atlantic croaker) larvae was collected during July.

BOTTOM TRAWL PROGRAM

The 2006 bottom trawl effort was conducted within the Delaware River Estuary from the mouth of the Delaware Bay to just north of the Delaware Memorial Bridge (rkm 0-117) at 40 randomly selected stations allocated from sampling Zones 1-8. The number of sampling stations designated within each of the eight sampling zones was allocated using a Neyman allocation procedure based on the proportional area of each zone and historical fisheries data. One daytime bottom trawl event was completed at each station each month from April through November 2006 using a 4.9m (16-ft) semi-balloon otter trawl. Eight monthly surveys were completed, resulting in the collection of 320 bottom trawls. Target species for this project were alewife, American shad, Atlantic menhaden, blueback herring, bay anchovy, Atlantic silverside, striped bass, white perch, bluefish, Atlantic croaker, spot, weakfish, and blue crab (*Callinectes sapidus*). All finfish and blue crabs were identified to the lowest practicable taxonomic level, enumerated, and recorded on field data sheets. Length measurements for all target species were recorded to the nearest millimeter. Surface, mid-depth and bottom water quality were recorded for each sample as well as pertinent field observations such as water clarity, weather, and tidal stage.

In the 320 bottom trawls that were completed in 2006, 38,934 specimens (35,163 finfish and 3,771 blue crabs) were collected. Total catch per unit effort (CPUE) was 121.7 for all zones. The results for target species were as follows:

- Alewife: One specimen was collected during the bottom trawl effort accounting for less than one percent of the total finfish catch. It was collected in Zone 4 in April. The CPUE for alewife was <0.1.

- American shad: Three specimens were caught in bottom trawls, comprising less than one percent of the total finfish catch. They were taken in May and October catches in Zones 4, 7 and 8. The CPUE for American shad was <0.1.

- Atlantic croaker: A total of 13,528 specimens were captured in bottom trawls, accounting for 38.5% of the total finfish collected. They were found in all zones and were relatively evenly distributed. The largest catch was in November and the second largest was in June. These two months accounted for 51.6% of the Atlantic croaker caught in 2006. The CPUE for Atlantic croaker was 42.3.

- Atlantic menhaden: Twenty Atlantic menhaden were collected during the 2006 Baywide bottom trawl effort, representing less than one percent of the total finfish catch. They were found in Zones 2-5 and 7-8 during May, June and August through November. The CPUE for Atlantic menhaden was 0.1.

- Atlantic silverside: No Atlantic silverside was collected during the bottom trawl effort.

- Bay anchovy: A total of 11,857 specimens were captured during the 2006 Baywide bottom trawl effort comprising 33.7% of the total finfish catch. Bay anchovy were captured in every sampling month, but approximately 49% of them were found in July and November. They were taken in every zone, but most of them (98%) were taken in Zones 1-5. The CPUE for bay anchovy was 37.1.

- Blueback herring: One specimen was collected during the bottom trawl effort accounting for less than one percent of the total finfish catch. It was collected in Zone 5 during June. The CPUE for blueback herring was <0.1.

- Spot: A total of 102 specimens were captured in bottom trawls, comprising 0.3% of the total finfish collected. Most of them were captured from July through September with none caught in April and June and a single fish taken in May, October and November. The CPUE for spot was 0.3.

- Striped bass: A total of 20 specimens were collected during the bottom trawl effort, accounting for less than one percent of the total finfish collected. Striped bass were taken in Zones 4-8 and were split up relatively evenly. They were captured in every sampling month, except May, and were evenly distributed throughout. CPUE for striped bass was 0.1.

- Weakfish: A total of 2,185 specimens were caught in bottom trawls, representing 6.2% of the total finfish catch. Weakfish were collected in all eight zones and were evenly distributed throughout. They were captured in every month sampled. Most of them were found from July through September. The CPUE for weakfish was 6.8.

- White perch: A total of 598 specimens were captured during the bottom trawl effort, comprising 1.7% of the total finfish catch. White perch were present in all eight zones, except Zone 1, but were most abundant in Zones 6-8. They were taken in all months and were most abundant in April and November. The CPUE for white perch was 1.9.

- Blue crab: A total of 3,771 specimens were collected in all eight zones. They were most abundant in Zones 4-6 and were captured in every month with the heaviest catches in September through November. The CPUE for blue crab was 11.8.

BAYWIDE BEACH SEINE PROGRAM

The Baywide Beach Seine Survey was conducted on a monthly basis in June and November, and twice monthly from July through October 2006. During the design phase of the study in 1995, the perimeter of the Delaware Bay from Cape May, NJ (rkm 0) to the lower Delaware River at the Chesapeake and Delaware Canal (rkm 100) was divided into 32 equal-length regions. Each region was further partitioned into 0.1-nautical mile segments. One fixed station was established within each of the 32 regions. Eight additional stations were established at bay front locations adjacent to PSEG marsh restoration sites. These 40 fixed stations have been annually sampled since 1995. The gear was a 100- x 6-ft (30.5- x 1.8-m) bagged haul seine with a 1/4-inch (6.25 mm) nylon mesh, identical to the gear employed by New Jersey Department of Environmental Protection (NJDEP) in their beach seine program conducted upstream of the present study. The seine was set at high tide by boat from the shore and pulled in the direction of the prevailing tidal current, wind or surf as conditions required, resulting in the most effective deployment of the gear. Water quality parameters, including water temperature, salinity, dissolved oxygen and water clarity were measured with each collection.

The Baywide Beach Seine Survey yielded 13,271 individuals of 50 finfish species from 400 samples. Atlantic silverside and bay anchovy represented 61.6% of the catch. Half (25 of 50) of the species taken were represented by 10 or fewer specimens. Of the target species only Atlantic silverside, bay anchovy, Atlantic croaker, white perch and striped bass were taken during all sampling events, in all regions and at all beach types.

Findings specific to target species include:

- American shad. A total of 48 American shad was taken in beach seine collections in 2006. American shad was taken during the first three sampling events and in all regions except rkm 0-20 and 41-60.

- Atlantic menhaden. A total of 432 Atlantic menhaden was taken, comprising 3.3% of the 2006 seine catch. They were collected during all sampling events except during the second half of October; abundance was highest during the second half of June. Although taken in all regions, Atlantic menhaden abundance was highest in region rkm 81-100.

- Bay anchovy. A total of 3,210 bay anchovy was taken, comprising 24.2% of the 2006 seine catch. Bay anchovy was collected during all sampling events; abundance was highest during the second half of August. Bay anchovy was most abundant in region rkm 61-80.

- Atlantic silverside. A total of 4,963 Atlantic silverside was taken, comprising 37.4% of the 2006 seine catch. Atlantic silverside was collected during all sampling events; abundance was highest during the second half of August. Atlantic silverside catches were highest in region rkm 0-20.

- White perch. A total of 639 white perch was taken in the 2006 seine catch. Individuals were taken during all collection events; abundance was highest in the second half of July. White perch abundance was highest in regions rkm 61-80.

- Striped bass. A total of 451 striped bass was taken in the 2006 seine catch. Individuals were taken during all collection events; abundance was highest during the first half of July. Striped bass were most abundant in region rkm 61-80.

- Bluefish. A total of 144 bluefish was taken in the 2006 seine catch. Bluefish was taken during all sampling events except the first half of November and were most abundant during the first half of September. They were most abundant in region rkm 0-20.

- Weakfish. A total of 375 weakfish was taken in the 2006 seine catch. Their abundance was highest during the second half of July. Weakfish were most abundant in regions rkm 21-40.

- Spot. A total of 158 spot was taken in the 2006 seine catch. They were most abundant during the second half of July and in region rkm 0-20.

- Atlantic croaker. A total of 1,040 Atlantic croaker was taken in the 2006 seine catch. Individuals were taken during all collection events; abundance was highest in the second half of October. Atlantic croaker was most abundant in region rkm 21-40.

FISH LADDER MONITORING

PSEG Nuclear LLC (PSEG) has constructed and maintains fish ladders on Delaware River estuary tributaries for spawning run restoration of the alewife (*Alosa pseudoharengus*) and the blueback herring (*Alosa aestivalis*), collectively known as river herring. Alaska Steeppass fish ladders have been constructed at twelve sites: Sunset Lake, Stewart Lake, Newton Lake, and Cooper River Lake in New Jersey, and Noxontown Pond, Silver Lake (Dover), Silver Lake (Milford), McGinnis Pond, Coursey Pond, McColley Pond, Garrisons Lake and Moores Lake in Delaware.

Adult passage monitoring, employing a fish ladder exit trap net, occurred from March 29 to June 8, 2006. No sampling of adult passage was conducted at Moore's Lake, McGinnis Pond, Coursey's Pond, and McColley Pond during 2006. These four fish ladders have consistently passed adult herring and monitoring was discontinued to avoid potentially impacting spawning behavior. No stocking occurred during 2006 due to the limited availability of adult herring for trap and transfer.

The following lists the number of adult herring counted, counted passing through the ladder, stocked, and total spawning run adult herring, for each of the eight monitored fish ladder sites:

Ladder Location	Counted	Counted Passing	Stocked	Total Into Pond
Noxontown Pond	**1**	**0**	**0**	**0**
Garrisons Lake	**22**	**21**	**0**	**21**
Silver Lake (Dover)	**117**	**115**	**0**	**115**
Silver Lake (Milford)	**4**	**3**	**0**	**3**
Cooper R. Lake	**3**	**3**	**0**	**3**
Newton Lake	**0**	**0**	**0**	**0**
Stewart Lake	**7**	**5**	**0**	**5**
Sunset Lake	**62**	**62**	**0**	**62**

In 2006, adult river herring migrated upstream to spawn in the creeks, spillpools, and ponds beginning in mid-March and the runs continued through early June. As expected, the adult herring movement appeared to be associated with rising creek water temperature and sunny days. The occurrence of adult herring at the fish ladder sites generally coincided with reported spawning temperatures.

FISH ASSEMBLAGE MONITORING

To evaluate the faunal response to salt marsh restoration in Delaware Bay, fish assemblages are monitored in small and large creek habitats of reference and restored marshes in upper and lower regions of the bay. Sampling was conducted monthly from May to November 2006 with otter trawls (4.9 m headrope, 6 mm mesh) in large marsh creeks (1.2 – 2.8 m mean depth at high tide) and with weirs (1.8 x 1.2 x 1.2 m with 4.5 x 1.2 m wings, 0.175 mm mesh) in small intertidal marsh creeks draining the marsh surface.

In the Lower Bay Region, totals of 126 trawl tows and 14 weir sets were conducted at the Moores Beach Reference Site, and 123 trawl tows and 14 weir sets were conducted at the Commercial Township Restoration Site. At the Moores Beach Site, a total of 24 fish species was collected; of these, 25% were considered residents of salt marshes and 75% were transients. In the large marsh creek habitat, fish abundance was highest in October, and Atlantic croaker was the predominant species. In the small marsh creek habitat, fish abundance was highest in August, and mummichog (*Fundulus heteroclitus*) was the predominant species. At the Commercial Township Site, a total of 25 fish species was collected; of these, 28% were considered residents of salt marshes and 72% were transients. In the large marsh creek habitat, fish abundance was highest in August and secondarily high in November. Bay anchovy and Atlantic croaker were the predominant species. In the small marsh creek habitat, fish abundance was highest in June, and mummichog was the predominant species. In the large marsh creek habitats of the Lower Bay Region, total fish abundance was higher at the Commercial Township Restoration Site than at the Moores Beach Reference Site, resulting from the disproportionate catches of Atlantic croaker and bay anchovy. As to other target species, weakfish also was more abundant at the Commercial Site, while white perch and spot were equally abundant at both sites.

In the large marsh creek habitats of the Lower Bay Region, fish species richness was similar at both sites, with over 80% of the species in common. The two sites shared five species ranking in the top seven at each site. In the small marsh creek habitats of the Lower Bay Region, total fish abundance was higher at the Moores Beach Reference than at the Commercial Township Restoration Site. Fish species richness was equal at the two sites, with five of eight species in common.

In the Upper Bay Region, totals of 126 trawl tows and 14 weir sets were conducted at the Mad Horse Creek Reference Site; in the Alloway Creek Restoration Site totals of 117 trawl tows and 14 weir sets were conducted at the Mill Creek Sampling Area, and 42 weir sets were conducted at Alloway Creek Sampling Area. At the Mad Horse Creek Site, a total of 23 fish species was collected; of these, 39% were considered residents of salt marshes and 61% were transients. In the large marsh creek habitat, fish abundance was highest in November, and white perch was the predominant species. In the small marsh creek habitat, fish abundance was highest in November, and mummichog was the predominant species. At the Mill Creek Sampling Area, a total of 21 fish species was

collected; the representation of resident and transient species was essentially equal. In the large marsh creek habitat, fish abundance fluctuated monthly. White perch was the predominant species in most months (4 of 7). However, bay anchovy, Atlantic croaker and brown bullhead (*Ameiurus nebulosus*) were predominant or co-predominant in the other months. In the small marsh creek habitat, fish abundance was highest in July, and mummichog was the predominant species. At the Alloway Creek Sampling Area, a total of 10 fish species was collected; resident and transient species were equally represented. In this small marsh creek weir sampling, fish abundance was highest in July, and mummichog was the predominant species.

In the large marsh creek habitats of the Upper Bay Region, total fish abundance was higher at the Mill Creek Sampling Area of the Alloway Creek Restoration Site than at the Mad Horse Creek Reference Site, resulting not from the predominance of one or two species, but rather reflecting an assemblage-wide contribution to higher abundance at Mill Creek. The two target species, white perch and bay anchovy, made a significant contribution to this abundance. In the large marsh creek habitats of the Upper Bay Region, fish species richness was higher at the Mad Horse Creek Reference Site, but the Mill Creek Area did show a 60% overlap in species commonality. Regarding species rank order, the two sites shared the same top three species, i.e., white perch, bay anchovy and Atlantic croaker. In the small marsh creek habitats of the Upper Bay Region, total fish abundance was higher at both restoration sampling areas than at the Mad Horse Creek Reference Site. The target species, with the exception of bay anchovy, made little contribution to this higher abundance. Like abundance, fish species richness was higher at the Alloway and Mill Creek Areas than at the Mad Horse Creek Reference Site. All species taken at Mad Horse Creek were common to both Alloway and Mill Creeks, and all species taken at Alloway Creek were common to Mill Creek.

VEGETATIVE COVER AND GEOMORPHOLOGY MONITORING

Vegetative cover monitoring is performed annually during the peak growing season at the reference marshes and all restoration sites that have not met the final success criteria as follows:

- Commercial Township Salt Hay Farm Wetland Restoration Site (CT Site)
- Moores Beach West Reference Marsh (MBW)
- Alloways Creek *Phragmites*-dominate Wetland Restoration Site (ACW Site)
- The Rock *Phragmites*-dominate Wetland Restoration Site (The Rocks)
- Cedar Swamp *Phragmites*-dominate Wetland Restoration Site (Cedar Swamp)
- Mad Horse Creek Reference Marsh (MHC)

To evaluate production of these marshes, cover type mapping and field sampling is conducted to assess community abundance and composition for vascular plants. During 2006, geomorphological monitoring was conducted at all four restoration sites to assess changes associated with the restoration process.

Analyses of the 2006 vegetative cover type mapping indicates that *Spartina alterniflora* and other desirable marsh species is the dominant cover type at all four restoration sites

and the two reference marshes. *S. alterniflora* comprised approximately 86 and 72 percent of the MBW and MHC reference marshes, respectively. At the three *Phragmites*-dominated restoration sites, *S. alterniflora* and other desirable vegetation ranged between nearly 71 to 82 percent the total marsh at the restoration sites. Approximately 48% of the CT Site marsh was mapped as *S.alterniflora* during 2006.

Other cover type categories evaluated at the restoration sites and reference marshes include *Phragmites*-dominated vegetation, non-vegetated marsh plain, internal water areas and open water. Non-vegetated marsh plain comprised approximately 40 percent of the CT Site.

Quantitative monitoring and sampling of the vascular vegetation provides data on percent cover, vegetation height, and a calculation of above ground biomass for the vascular plants. *S.alterniflora* was the most common dominant species present at the reference marshes and restoration sites. For each site, means were calculated for *Spartina* spp. dominated quadrats, non-*Spartina* spp. dominated quadrats, and for all quadrats.

Geomorphology monitoring during the 2006 season indicated that drainage densities (linear feet of channel/acre of marsh) ranged from 414 ft/acre to 523 ft/acre at the *Phragmites*-dominated restoration sites, and 877 ft/acre at the CT Site.

CHAPTER 1 - BIOLOGICAL MONITORING ANNUAL REPORT

INTRODUCTION

This report summarizes results of ongoing ecological monitoring programs conducted by PSEG Nuclear, LLC (PSEG, formerly PSE&G) of New Jersey. These studies are being conducted in relation to the operation of the Salem Generating Station (SGS), a two-unit nuclear power plant. The basis for conducting these studies is the New Jersey Pollutant Discharge Elimination System (NJPDES) Permit No. NJ0005622 issued by the New Jersey Department of Environmental Protection (NJDEP), with an effective date of September 1, 1994. This permit allows the SGS to discharge cooling water into the Delaware River in accordance with NJPDES Regulations N.J.A.C. 7:14A-1 et. Seq.. In 2001, the NJPDES Permit for the SGS was renewed with an effective date of August 1, 2001. Custom requirement G.6 of the renewed permit provided for the continuation and expansion of the studies included in the report.

STUDY AREA

The Delaware Estuary is a continuum of environments: freshwater, tidal fresh water, tidal brackish water and marine. The characteristics of these varying environments determine species composition and abundance, temporal and spatial distribution, functional dynamics and resiliency of the population and communities in this system.

The study area extends from the mouth of the Bay to River Mile 211, just south of the fall line in Trenton, NJ. Approximately 308 square miles of tidal marshes surround the Estuary, which play a significant role in water exchange and retention, and in chemical and biological functions within the system. An important interactive component of the Estuary is the contiguous ocean water of the Middle Atlantic Bight (Cape Cod to Cape Hatteras), which exists outside the entrance to the Bay. Pape and Garvine (1982) established that bottom ocean water from at least 40 km offshore is involved in residual flows into the Bay.

The Delaware Bay is composed of three regions: a shallow flats area on the New Jersey side, a central channel and alternating shoals with zones of deep water on the Delaware side. The deep water ranges from 12 - 90 feet with a deep hole reaching 143 feet at the mouth of the Bay off Lewes, DE. The deep zone is interspersed with long, finger like shoals 0 - 12 feet deep, which radiate out to the west and north from the mouth of the Bay. Broad expanses of shallow flats from 9-17 feet deep extend from the deeper water to the shoreline. Beyond the shoreline and extending up the many tidal creek tributaries are wide expanses of salt marsh.

The water movements within the Delaware Estuary affect the occurrence, distribution, and abundance of organisms both directly (as a result of net water transport, turbulent mixing, and exchange of water among the system's components) and indirectly (as a result of its influence on biologically important water quality parameters such as salinity, temperature, dissolved oxygen, and turbidity). Tidal circulation, freshwater discharge from the drainage basin and upstream impoundments, wind-induced flushing, and salinity-induced density gradients are major forces that influence the water circulation patterns in the system and result in its highly dynamic physical and chemical environment.

Tidal transport of water between the ocean and the Delaware Estuary dominates flow and circulation throughout the Estuary (Polis and Kupferman, 1973). The total flux during each tidal cycle, 11.02 billion cubic yards, is equivalent to about 23- 24 percent of the standing volume of the Estuary measured at mean tide level. Tidal flow past the Salem Station is approximately 448,000 to 472,000 cubic feet per second.

Current speed and direction throughout the Delaware Estuary are primarily dominated by the tide. Surface tidal currents generally are directed along the longitudinal axis of the Estuary except in near shore areas of river bends and coves. At maximum ebbing or flooding tide, local currents at any point within the Estuary may reach speeds of 3.3 to 4.3 feet per second (Polis and Kupferman, 1973).

Salinity in the Delaware Estuary varies from fresh water at Trenton (River Mile 132), to typical ocean water concentrations of about 34 parts per thousand on the continental shelf off the mouth of Delaware Bay. Variables such as freshwater discharge, tidal phase, basin morphology, and meteorological conditions affect salinity. In the vicinity of Salem, salinity ranges seasonally from about 0.5 to 20 parts per thousand.

SALEM GENERATING STATION

Location

Salem Generating Station is located on a peninsula known as Artificial Island on the eastern shore of the Delaware Estuary, 50 miles northwest of the mouth of the Bay and 30 miles southwest of Philadelphia, PA. Artificial Island was created from the deposition of dredge spoil material by the Army Corps of Engineers during the first half of the last century. It is bordered by the River on two sides and by extensive marshes and uplands on the other two sides. The Salem Units 1 and 2 are identical pressurized -water reactors; each with a net rated electrical output of 1,162 Mwe. Units 1 and 2 began commercial operation in 1977 and 1981, respectively.

The Station was sited on the Delaware Estuary to take advantage of the large volume of relatively low temperature cooling water. This once through cooling water is used to condense the steam produced by the Units during the process of electric generation. The rated flow for both units with all twelve pumps operating is 3,168 million gallons per day. Under Special Condition IV-B/C.H. I of the 1994 NJPDES Permit, Salem is limited to "...a monthly average rate not to exceed 3,024 million gallons per day". Water is withdrawn from the River through a shoreline intake structure divided into 12 intake bays. Each bay is 11.5 feet wide at the entrance with a designed water depth ranging from 31 - 50 feet depending on tide (and factors influencing tides). This configuration results in an average intake bay entrance design velocity of 0.87 feet per second at mean high tide and 1.0 foot per second at mean low tide.

Intake System

The traveling screens are equipped with buckets to catch most impinged organisms and prevent them from becoming re-impinged. Each screen basket base is fitted with a lip, which creates a water-filled bucket. The screens rotate continuously to minimize the time during which organisms

may be impinged. Estuarine organisms are captured in the water-filled buckets at the base of each ascending screen panel to prevent re-impingement. The buckets are emptied into a sluiceway (part of the fish return system) behind the screens, which return the fish to the Estuary north of the circulating water intake system (CWS) intake on flood tide and south of the CWS intake on ebb tide, to prevent re-impingement.

In June of 1996, PSE&G, in compliance with Special Condition IV-B/C.H.2 of the 1994 NJPDES permit, completed the installation of six newly modified traveling screens into the Unit 2 intake system. Composite material was used in place of stainless steel for the construction of the fish buckets. This reduced the weight of each screen by 100 pounds (6,200 pounds total). Composite material was also used to construct the individual basket frames, further saving weight. The lighter weight has enabled the maximum speed of the traveling screens to double from 17.5 to 35 feet per minute. The leading edge of the bucket is formed into a hydrodynamic inward bending shape that eliminates turbulence in the bucket, which could damage fish. New screen mesh with a flat smooth mesh face and 0.25 x 0.5-inch openings has been installed. The size of the wire in the mesh was reduced from 12 down to 14 gauge, increasing the open area by 25 percent. Mounting and structural hardware for the basket have been relocated behind the new screen mesh. Eight spray nozzles were added to the inside spray wash headers to provide a more efficient and even spray pattern. Debris shields were added to the above the spray nozzles to keep them free of debris. Fish and debris trough flap seals were redesigned to maintain a closer fit to the traveling screens. All of these modifications were designed to improve fish survival on the traveling screens.

<u>Discharge</u>

Both CWS water and service water systems (SWS) water are discharged through six 10-foot diameter pipes (3 per unit) which extend 500 feet into the Estuary. Water depth at the discharge is approximately 31 feet to the centerline of the pipe. When Salem is operating at full load, approximately 16 billion BTU/hr are released into the Estuary. The discharge pipes were designed to minimize the thermal effect on the Estuary by maintaining the discharge velocity at about 10 feet per second.

Heated effluent from the cooling water discharge is characterized by a difference in temperature (.T) from the ambient River water and results in a thermal plume. The .T normally varies from approximately 15°F to 21°F depending upon the CWS flow. Thus, the discharge water temperature can range from about 45°F in winter to about 100°F in summer. The .T is reduced by approximately one-half between the time the CWS water is discharged through the pipes until it reaches the surface approximately 40-50 seconds later. This is due to the fact that the water discharged (at 10 feet per second) is turbulently mixed with ambient River water. During this time, the plume buoyantly rises in the water column. The characteristics of the thermal plume are determined by convective spread, mass transport by ambient currents, diffusion and dispersion, and loss of heat to the atmosphere. These processes are affected by the temporal and spatial variations within tidal cycles, meteorological conditions, and plant operations

MONITORING PROGRAMS

Special Condition IV-B/C.H.6 (a) of the 1994 NJPDES Permit required PSEG to develop and implement a biological monitoring program for the Delaware Estuary. The results presented herein are from programs conducted per the approved 2000 Biological Monitoring Work Plan.

This report contains a separate section for each of the Biological Monitoring Work Plan (BMWP) programs that were performed during 2006. Programs discussed include; fish utilization of restored wetlands, elimination of impediments to fish migration, bay-wide trawl survey, beach seine survey, entrainment abundance monitoring, and impingement abundance monitoring.

CHAPTER 2: IMPINGEMENT MONITORING

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IMPINGEMENT MONITORING

INTRODUCTION

Impingement monitoring is conducted annually as stipulated in the New Jersey Pollutant Discharge Elimination System (NJPDES) permit issued for the Salem Generating Station (SGS). The specified monitoring was performed in 2006 as described in the Procedures Manual for Biological Monitoring Program for the Delaware Estuary (PSEG 2002). The objectives of this monitoring program are to estimate the temporal occurrence and abundance of each fish species impinged at Salem Units 1 and 2, and to estimate their initial survival. These estimates are important parameters for assessing the effects of Salem on the Delaware Estuary's fish populations.

During 2006, there were refueling and maintenance outages at Salem Unit 2 from October 11 through November 2, 2006, when a reduced number of circulating water pumps were in service. However, during the remainder of the year, 87% of the impingement samples were collected when 11 or 12 circulating pumps were in operation. This chapter presents the overall results of sampling and specific findings regarding the occurrence of SGS finfish target species: blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic menhaden (*Brevoortia tyrannus*), bay anchovy (*Anchoa mitchilli*), Atlantic silverside (*Menidia menidia*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), and Atlantic croaker (*Micropogonias undulatus*).

MATERIALS AND METHODS

Impingement abundance sampling during 2006 was scheduled three days per week during January through December. Sampling consisted of ten (10) samples taken at approximately 2½-hr intervals during each 24-hr period. The 24-hr sampling event provided for monitoring over a complete diel period and two full tidal cycles. The three 24-hr periods were chosen randomly within the seven-day weekly sampling time frame. During 2006, all of the 1,560 scheduled samples were collected.

Organisms impinged on the continuously rotating traveling screens at Salem are lifted from the river in water-filled buckets or troughs fitted at the bottom of each screen panel (Figure 2-1). These buckets provide a temporary environment during the vertical transport of the screen, and are designed to prevent most organisms from falling back into the screen well and becoming re-impinged. As the bucket travels over the head or top sprocket, organisms slide onto the screen face and are spray-washed into the fish trough by a low-pressure spray. The screen continues its downward movement and debris on the screen mesh is washed into the debris trough by a high-pressure wash. These fish and debris troughs converge and discharge to the Delaware River either to the north or south of the circulating water intake structure depending on tidal current direction to reduce re-impingement. To collect impingement samples, a timed sub-sample of total flow from the converged fish and debris troughs was diverted into the appropriate north or south fish counting pool (Figure 2-2) as dictated by tide and trough discharge direction. Sample

duration ranged from one to eight minutes, and was dependent largely on specimen and detrital abundance. Sample duration was two minutes or greater for 59% of the collections in 2006. At the end of the timed interval, trough flow was returned to the river discharge mode, and the sample was allowed a five-minute acclimation period before the pool was drained. As the pool was drained, debris (vegetative matter) was examined for finfish and blue crab, and any found were included in the collection. The condition of the specimens collected was determined according to the following criteria:

Live -	Swimming vigorously, no apparent orientation problems, behavior normal
Dead -	No vital signs, no body or opercular movement, no response to gentle probing
Damaged -	Struggling or swimming on side, evidence or indication of abrasion or laceration

Specimens in each category were sorted by species, and the total number and weight of each was determined. All specimens or a representative subsample (at least 100 specimens) of each species, drawn equally from each condition category, if possible, were measured to the nearest millimeter. Weights were determined to the nearest 0.1 g with an Acculab® Model 121 electronic scale.

The following parameters were recorded with all samples: the number of pumps and screens in operation, screen speed, tidal stage and elevation, air temperature, sky condition, wind direction, wave height, water temperature, and salinity. Air and water temperatures were measured with a field thermometer, and salinity was measured using a refractometer. Detritus taken with the sample was weighed to the nearest 0.1 kg with a Chatillon® suspended scale.

RESULTS AND DISCUSSION

Collection totals of 56,876 finfish of 61 species and 37 families, and 12,979 blue crab were taken in 1,560 samples (2,591 min sampled) at the Salem CWIS during 2006 (Table 2-1). All SGS designated finfish target species were taken, and summaries on the period of occurrence and abundance (expressed as a density in terms of the number/million cubic meters of intake water or $n/10^6m^3$), initial survival (species catches of < 5 individuals in a given month are not considered in the discussion), and length for each of these species are presented below in phylogenetic order. Target species include: blueback herring, alewife, American shad, Atlantic menhaden, bay anchovy, Atlantic silverside, white perch, striped bass, bluefish, weakfish, spot, and Atlantic croaker.

Blueback herring - A total of 474 specimens was taken in impingement samples during 2006; collection frequency was 146 out of 1,560 samples (Table 2-1). They were collected during January through April, August, and October through December (Figure 2-4). During their period of occurrence, monthly mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 3.0 to 9.5 ppt, respectively (Figure 2-3). Blueback herring were most abundant in March

with a mean density of 283.06, and secondarily abundant in February with a density of 101.03 (Figure 2-4). During the other months in which they occurred, densities were ≤22.52. Annual percent live and dead was 96 and 4, respectively; monthly (≥ 5 specimens taken) initial survival ranged from 77% in April to 98% in March (Tables 2-1 and 2-2). Length range was 48-173 mm FL, and >95% of individuals measured were ≤ 98 mm FL (Figure 2-5).

Alewife - A total of 45 specimens was taken; collection frequency was 33 out of 1,560 samples (Table 2-1). They were collected during February through May, September, October and December (Figure 2-6). During their period of occurrence, monthly mean water temperatures and salinities ranged from 6.1 to 21.4ºC and from 4.5 to 9.5 ppt, respectively (Figure 2-3). Alewife were most abundant in March with a mean density of 21.07 (Figure 2-6). In the other months of their occurrence, densities ranged from 0.53 in October, to 5.14 in April. Annual percent live and dead was 93 and 7, respectively; monthly (≥ 5 specimens taken) initial survival ranged from 91% in March to 100% in April and December (Tables 2-1 and 2-2). Length range was 33-118 mm FL, and all but two of the individuals measured were ≤ 98 mm (Figure 2-7).

American shad - A total of 75 specimens was taken; collection frequency was 60 out of 1,560 samples (Table 2-1). They were collected during February though April, and October through December (Figure 2-8). During their period of occurrence, monthly mean water temperatures and salinities ranged from 6.1 to 16.5ºC and from 3.9 to 9.5 ppt, respectively (Figure 2-3). As described above, American shad exhibited two periods of occurrence/abundance, with a late winter/early spring peak in March at a monthly mean density of 18.32 and a fall peak in November at 11.67(Figure 2-8). During the other months in which they occurred, densities were ≤8.56. Annual percent live, dead, and damaged was 95, 4, and 1, respectively; monthly (≥ 5 specimens) initial survival ranged from 78% in October to 100% in December and March (Tables 2-1 and 2-2). Length range was 63-198 mm FL, and 72% of all individuals measured were ≤ 98 mm (Figure 2-9).

Atlantic menhaden – A total of 822 specimens was taken; collection frequency was 356 out of 1,560 samples (Table 2-1). They were collected during all months of 2006 when monthly mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 1.9 to 9.5 ppt, respectively (Figures 2-3 and 2-10). Atlantic menhaden were most abundant in May with a density of 233.03 (Figure 2-10). During the other months in which they occurred, monthly mean densities ranged from 2.65 in November to 82.64 in June. Annual percent live, dead, and damaged was 74, 24, and 2, respectively; monthly (≥ 5 specimens) initial survival ranged from 13% in August to 95% in March (Tables 2-1 and 2-2). Length range was 28-283 mm FL, and >95% of the individuals measured were ≤ 98 mm FL (Figure 2-11).

Bay anchovy - A total of 3,782 specimens was taken; collection frequency was 859 out of 1,560 samples (Table 2-1). They were collected during all months of 2006 when monthly mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 1.9 to 9.5 ppt, respectively (Figures 2-3 and 2-12). Bay anchovy exhibited three periods of abundance; a spring period of highest abundance when monthly mean densities in March and April were similarly high at 877.57 and 834.88, respectively, and two intermediate peaks in summer (June) and fall (November) with mean densities of 305.59 and 335.89, respectively (Figure 2-12).. During all

other months, density ranged from 1.02 in January to 152.70 in May. Annual percent live and dead was 87 and 12, respectively; monthly (≥ 5 specimens) initial survival ranged from 65% in August to 92% in April (Tables 2-1 and 2-2). Length range was 23 to 98 mm FL, however individuals ranging from 48 to 83 mm FL comprised >90% of the subsample measured (Figure 2-13).

Atlantic silverside - A total of 876 specimens was taken; collection frequency was 363 out of 1,560 samples (Table 2-1). They were collected during all months of 2006, when monthly mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 1.9 to 9.5 ppt, respectively (Figures 2-3 and 2-14). Atlantic silverside were most abundant in December with a mean density of 198.03 (Figure 2-14). Smaller peaks of abundance occurred in February and September, with densities of 97.74 and 64.22, respectively. In the other months of their occurrence, density ranged from 3.88 in June to 47.76 in November. Annual percent live and dead was 95 and 5, respectively; monthly (≥ 5 specimens) initial survival ranged from 56% in July to 100% in March and April (Tables 2-1 and 2-2). The length range was 38-123 mm FL, however individuals ranging from 58 to 98 mm FL comprised >94% of the subsample measured (Figure 2-15).

White perch - A total of 6,735 specimens was taken; collection frequency was 994 out of 1,560 samples (Table 2-1). They were collected during all months of 2006, when monthly mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 1.9 to 9.5 ppt, respectively (Figure 2-3 and 2-16). White perch were generally abundant during fall and winter months, with the highest monthly mean density of 1,486.74 occurring in March (Figure 2-16). During the other months of this aforementioned seasonal abundance, densities ranged from 675.03 in December to 972.31 in January. During the other months of their occurrence, densities ranged from 4.51 in August to 273.16 in April. Annual percent live, dead, and damaged was 92, 2, and 6, respectively; monthly (≥ 5 specimens) initial survival ranged from 38% in June to 95% in April (Tables 2-1 and 2-2). Length range was 33-253 mm FL, and specimens ranging from 58 to 108 mm FL comprised >70% of the individuals measured (Figure 2-17). Modal lengths (frequency > 10) ranged from 58 mm FL in January and March to 108 mm FL in October.

Striped bass - A total of 191 specimens was taken; collection frequency was 127 out of 1,560 samples (Table 2-1). They were collected in all months of 2006, except May, when monthly mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 1.9 to 9.5 ppt, respectively (Figure 2-3 and 2-18). Striped bass were most abundant in March when the mean density was 67.79 (Figure 2-18). In other months of their occurrence, monthly mean density ranged from 0.55 in June to 20.47 in January. Annual percent live, dead, and damaged was 97, 1, and 2, respectively; monthly (≥ 5 specimens) initial survival ranged from 67% in August to 100% in January, February, April, September, November and December (Tables 2-1 and 2-2). Length range was 33-418 mm FL, and >86% of all individuals measured were ≤98 mm (Figure 2-19). The modal length in March, the month of highest abundance, was 78 mm.

Bluefish **-** A total of 139 specimens was taken; collection frequency was 118 out of 1,560 samples (Table 2-1). They were collected from April through October, when monthly mean water temperatures and salinities ranged from 13.5 to 25.6ºC and from 1.9 to 9.5 ppt,

respectively (Figures 2-3 and 2-20). Bluefish abundance was highest in September, when the mean density was 34.40 (Figure 2-20). Monthly mean densities in the other months of occurrence ranged from 0.86 in April to 12.20 in June. Annual percent live, dead, and damaged was 78, 17, and 5, respectively; monthly (≥ 5 specimens) initial survival ranged from 60% in October to 86% in June (Tables 2-1 and 2-2). Length range was 43-403 mm FL, and >89%of all individuals measured were ≤103 mm (Figure 2-21).

Weakfish - A total of 6,423 specimens was taken; collection frequency was 512 out of 1,560 samples (Table 2-1). They were collected in February and June through December, when monthly mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 1.9 to 9.0 ppt, respectively (Figures 2-3 and 2-22). Weakfish abundance was highest in August with a monthly mean density of 1,825.46 (Figure 2-22). Secondary peaks in abundance were recorded in July and September with densities of 550.74 and 700.06, respectively. In the remaining months of their occurrence, mean density ranged from 0.82 in February to 85.96 in June. Annual percent live and dead was 93 and 7, respectively; monthly (≥ 5 specimens) initial survival ranged from 67% in June to 97% in October (Tables 2-1 and 2-2). Length range was 28-148 mm TL, however individuals ranging from 43 to 68 mm TL comprised >74% of the subsample measured (Figure 2-23). Modal lengths increased from 43 mm TL in June to 58 mm TL in September.

Spot - A total of 194 specimens was taken; collection frequency was 84 out of 1,560 samples (Table 2-1). They were collected in March, April, June, July and December, when monthly mean water temperatures and salinities ranged from 7.5 to 24.6ºC and from 1.9 to 9.5 ppt, respectively (Figure 2-3 and 2-24). Spot were most abundant in March, when monthly mean density was 123.67 (Figure 2-24). In other months of their occurrence, density ranged from 1.72 in December, to 34.25 in April. Annual percent live, dead, and damaged was 95, 2, and 3, respectively; monthly (≥ 5 specimens) initial survival ranged from 71% in June to 100% in July (Tables 2-1 and 2-2). Initial survival was 99% in March, when 135 of 194 total were taken. Length range was 48-178 mm TL; and specimens ranging from 108 to 148 mm comprised >78% of the individuals measured (Figure 2-25).

Atlantic croaker - A total of 26,254 specimens was taken; collection frequency was 1,476 out of 1,560 samples (Table 2-1). They were collected in all months of 2006, when mean water temperatures and salinities ranged from 6.1 to 25.6ºC and from 1.9 to 9.5 ppt, respectively (Figures 2-3 and 2-26). Atlantic croaker exhibited two distinct periods of relatively high abundance; a late spring /early summer period (i.e. May, June and July), when mean density ranged from 1,870.49 in July to 3,403.07 in June, and a s late fall/winter period (i.e. November, December and January), when mean densities ranged from1,773.36 in November to 2,971.06 in December (Figure 2-26). During other months of occurrence, densities ranged from 18.35 in September to 707.24 in October. Annual percent live and dead was 95 and 5, respectively; monthly (≥ 5 specimens) initial survival ranged from 87% in January to 98% in October (Tables 2-1 and 2-2). Length range was 18-388 mm TL; individuals ranging from 38 to 108 mm TL comprised >79% of the subsample measured (Figure 2-27). During the aforementioned periods of abundance, modal lengths ranged from 48 mm TL in May to 73 mm TL in July and from 43 mm TL in November to 58 mm TL in January.

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Table 2-1
Annual catch statistics of finfish and blue crab taken in impingement sampling at the
Salem Generating Station circulating water intake structure, January through December 2006

Number of samples = 1,560
Total minutes sampled = 2,591
Total pump volume sampled (cubic meter) = 18,681,949
Detritus mean density (kg/million cubic meters) = 693.88

Species		Collection Frequency	Initial Percent			Total Number Collected	Mean density (n / 10^6 m^3)
			Live	Dead	Damaged		
Blue crab	*Callinectes sapidus*	911	100			12979	694.73
Lampreys - Petromyontidae							
Sea lamprey	*Petromyzon marinus*	4	100			4	0.21
Sturgeons - Acipenseridaee							
Atlantc sturgeon	*Acipenser oxyrhynchus*	1	100			1	0.05
Freshwater eels – Anguillidae							
American eel	*Anguilla rostrata*	74	83	7	10	82	4.39
Herrings – Clupeidae							
American shad	*Alosa sapidissima*	60	95	4	1	75	4.01
Blueback herring	*Alosa aestivalis*	146	96	4		474	25.37
Alewife	*Alosa pseudoharengus*	33	93	7		45	2.41
Atlantic herring	*Clupea harrengus*	4	100			4	0.21
Atlantic menhaden	*Brevoortia tyrannus*	356	74	24	2	822	44.00
Gizzard shad	*Dorosoma cepedianum*	221	93	2	5	419	22.43
Anchovies - Engraulidae							
Striped anchovy	*Anchoa hepsetus*	2	100			2	0.11
Bay anchovy	*Anchoa mitchilli*	859	87	12		3782	202.44
Mudminnows - Umbridae							
Eastern mudminnow	*Umbra pygmaea*	1	100			1	0.05
Carps and minnows - Cyprinidae							
Eastern silvery minnow	*Hybognathus regius*	35	90	1	9	87	4.66
Bullhead catfishes - Ictaluridae							
Channel catfish	*Ictalurus punctatus*	24	58	4	38	24	1.28
White catfish	*Ameiurus catus*	4	25		75	4	0.21
Brown bullhead	*Ameiurus nebulosus*	2	50		50	2	0.11
Toadfishes - Batrachoididae							
Oyster toadfish	*Opsanus tau*	39	100			54	2.89
Cods - Gadidae							
Red hake	*Urophycis chuss*	41	100			202	10.81
Spotted hake	*Urophycis regia*	344	99	1		4994	267.32
Silver Hakes - Merlucciidae							
Silver hake	*Merluccius bilinearis*	3	100			3	0.16
Cusk-eels - Ophidiidae							
Striped cusk-eel	*Ophidion marginatum*	48	98		2	59	3.16
Needlefishes - Belonidae							
Atlantic needlefish	*Strongylura marina*	2	100			2	0.11
Killifishes - Cyprinodontidae							
Mummichog	*Fundulus heteroclitus*	9	100			9	0.48
Striped killifish	*Fundulus majalis*	33	100			62	3.32
Silversides - Atherinidae							
Atlantic silverside	*Menidia menidia*	363	95	5		876	46.89
Stickleback - Gasterosteidae							
Threespine stickleback	*Gasterosteus aculeatus*	2	100			2	0.11
Pipefishes - Syngnathidae							
Northern pipefish	*Syngnathus fuscus*	43	96	2	2	46	2.46
Lined seahorse	*Hippocampus erectus*	1	100			1	0.05
Searobins - Triglidae							
Northern searobin	*Prionotus carolinus*	164	98	2		445	23.82

Table 2-1. Continued

Species		Collection Frequency	Initial Percent			Total Number Collected	Mean density (n / 10^6 m^3)
			Live	Dead	Damaged		
Temperate Basses - Percichthyidae							
White perch	*Morone americana*	994	92	2	6	6735	360.51
Striped bass	*Morone saxatilis*	127	97	1	2	191	10.22
Sea Basses - Serranidae							
Black sea bass	*Centropristis striata*	8	80	20		10	0.54
Sunfishes - Centrarchidae							
Bluegill	*Lepomis macrochirus*	59	97		3	73	3.91
Pumpkinseed	*Lepomis gibbosus*	3	100			3	0.16
Largemouth bass	*Micropterus salmoides*	1	100			1	0.05
White crappie	*Pomoxis annularis*	1	100			1	0.05
Perches – Percidae							
Yellow perch	*Perca flavescens*	20	100			21	1.12
Bluefishes – Pomatomidae							
Bluefish	*Pomatomus saltatrix*	118	78	17	5	139	7.44
Jacks – Carangidae							
Crevalle jack	*Caranx hippos*	2	100			2	0.11
Lookdown	*Selene vomer*	3	100			3	0.16
Porgies – Sparidae							
Sheepshead	*Archosargus probatocephalus*	2	100			2	0.11
Drums - Sciaenidae							
Weakfish	*Cynoscion regalis*	512	93	7		6423	343.81
Silver perch	*Bairdiella chrysoura*	128	97	3		229	12.26
Spot	*Leiostomus xanthurus*	84	95	2	3	194	10.38
Northern kingfish	*Menticirrhus saxatilis*	48	99	1		69	3.69
Atlantic croaker	*Micropogonias undulatus*	1476	95	5		26254	1405.31
Black drum	*Pogonias cromis*	4	100			4	0.21
Butterflyfishes - Chaetodontidae							
Spotfin butterflyfish	*Chaetodon ocellatus*	25	100			27	1.45
Wrasses - Labridae							
Tautog	*Tautoga onitis*	1	100			1	0.05
Stargazers – Uranoscopidae							
Northern stargazer	*Astroscopus gattatus*	1	100			1	0.05
Combtooth Blennies - Blenniidae							
Feather blenny	*Hypsoblennius hentz*	1	100			1	0.05
Gobies - Gobiidae							
Naked goby	*Gobiosoma bosc*	23	100			28	1.50
Sleepers - Eleotridae							
Fat sleeper	*Dormitator maculatus*	1	100			1	0.05
Butterfishes – Stromateidae							
Butterfish	*Peprilus triacanthus*	19	91	9		34	1.82
Lefteye flounders - Bothidae							
Smallmouth flounder	*Etropus microstomus*	11	100			14	0.75
Summer flounder	*Paralichthys dentatus*	58	97	1	2	146	7.82
Windowpane	*Scophthalmus aquosus*	89	100			200	10.71
Righteye flounders - Pleuronectidae							
Winter flounder	*Pleuronectes americanus*	27	94	6		33	1.77
American soles - Achiridae							
Hogchoker	*Trinectes maculatus*	787	100			3451	184.72
Toungefishes - Cynoglossidae							
Blackcheek toungefish	*Symphurus plagiusa*	1	100			1	0.05
Puffers – Tetraodontidae							
Northern puffer	*Sphoeroides maculatus*	1	100			1	0.05

Table 2-2
Monthly percentages live (L), dead (D), and damaged (D*) for target species taken in impingement sampling at the Salem Generating Station circulating water intake structure during 2006. n = number of individuals sampled. Values represent initial observed condition.

	Blueback herring				**Alewife**				**American shad**			
Month	n	L	D	D*	n	L	D	D*	n	L	D	D*
January	22	91	9									
February	123	94	6		4	100			2	100		
March	309	98	2		23	91	9		20	100		
April	13	77	23		6	100			10	90		10
May					4	75	25					
June												
July												
August	1		100									
September					1	100						
October	2	50	50		1	100			9	78	22	
November	3	100							22	95	5	
December	1	100			6	100			12	100		
Total	474				45				75			

	Atlantic menhaden				**Bay anchovy**				**Atlantic silverside**			
Month	n	L	D	D*	n	L	D	D*	n	L	D	D*
January	4	50	50		1	100			39	95	5	
February	7	71	29		32	81	19		119	96	4	
March	73	95	5		958	91	9		18	100		
April	38	87	5	8	975	92	5	3	5	100		
May	322	85	15		211	70	25	5	11	73	27	
June	149	84	16		551	79	21		7	57	43	
July	79	68	28	4	52	71	29		9	56	44	
August	88	13	84	3	69	65	35		42	86	12	2
September	33	52	45	3	88	78	22		112	89	11	
October	14	71	29		79	80	20		79	94	4	2
November	5	40		60	633	91	9		90	94	6	
December	10	80	10	10	133	85	15		345	99	1	
Total	822				3782				876			

Table 2-2. Continued.
Monthly percentages live (L), dead (D), and damaged (D*) for target species taken in impingement sampling at the Salem Generating Station circulating water intake structure during 2006. n = number of individuals sampled. Values represent initial observed condition.

	White perch				**Striped bass**				**Bluefish**			
Month	n	L	D	D*	n	L	D	D*	n	L	D	D*
January	950	93	2	5	20	100						
February	894	90	1	9	9	100						
March	1623	94	2	4	74	99		1				
April	319	95	1	4	10	100			1			100
May	41	85	2	12					2	50	50	
June	13	38	24	38	1	100			22	86	14	
July	38	66	5	29	6	83		17	15	73	27	
August	10	80	20		6	67	33		24	83	17	
September	14	71		29	9	100			60	81	12	7
October	334	93		7	18	94		6	15	60	27	13
November	1323	91	2	7	24	100						
December	1176	94	1	5	14	100						
Total	6735				191				139			

	Weakfish				**Spot**				**Atlantic croaker**			
Month	n	L	D	D*	n	L	D	D*	n	L	D	D*
January									2169	87	8	5
February	1	100							448	90	8	2
March					135	99	1		603	91	7	2
April					40	85	3	13	139	96	2	2
May									3679	96	4	
June	155	67	33		7	71	29		6136	95	5	
July	873	89	11		9	100			2965	96	4	
August	4046	94	6						242	94	5	1
September	1221	96	4						32	94	3	3
October	121	97	3						1323	98	2	
November	4	75	25						3342	96	4	
December	2	50	50		3	100			5176	96	4	
Total	6423				194				26254			

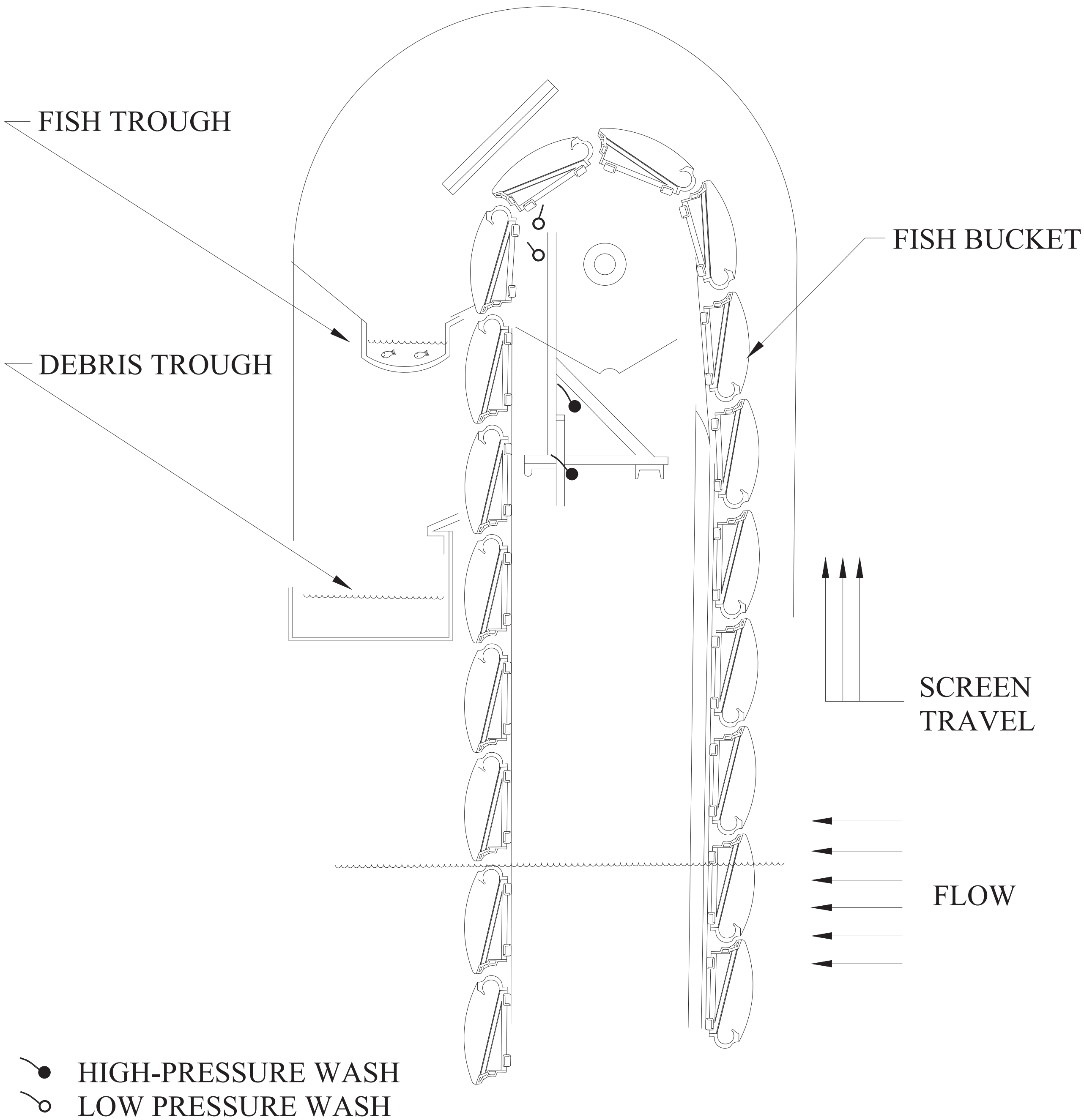


Figure 2-1. Ristroph modified traveling screen.

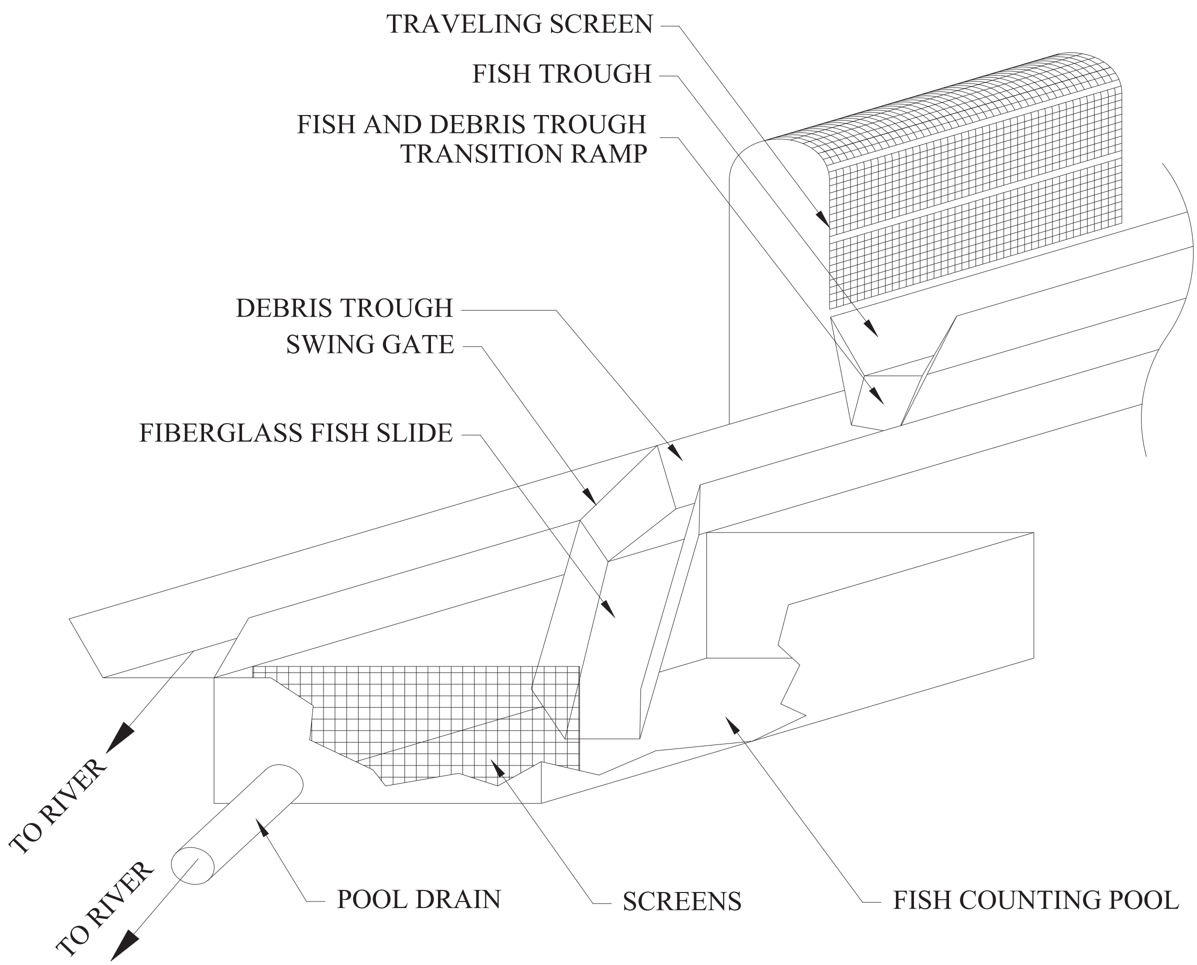


Figure 2-2. Fish counting pool.

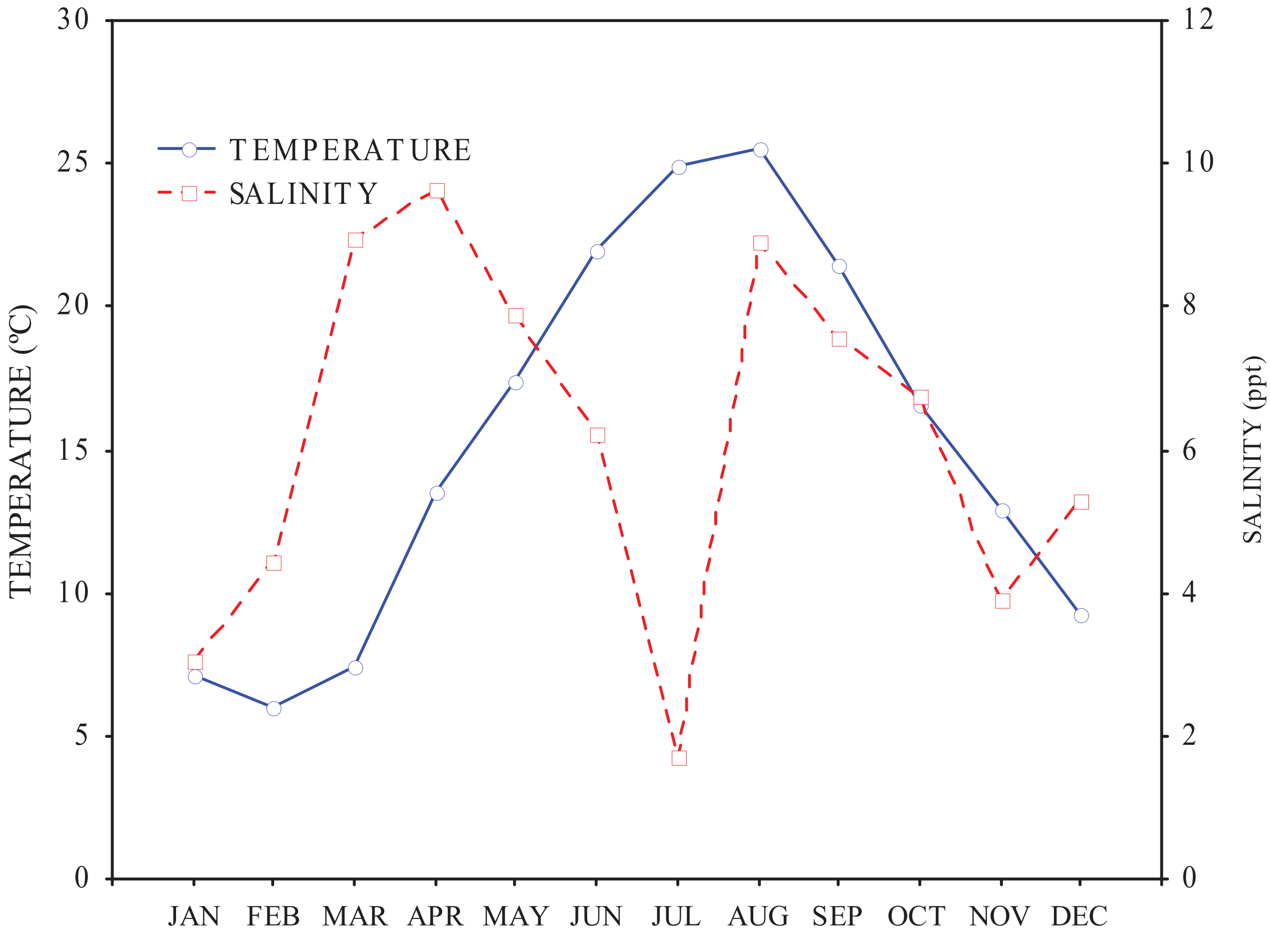


Figure 2-3. Salinity and temperature (mean) by month as observed during 2006 impingement sampling.

BLUEBACK HERRING

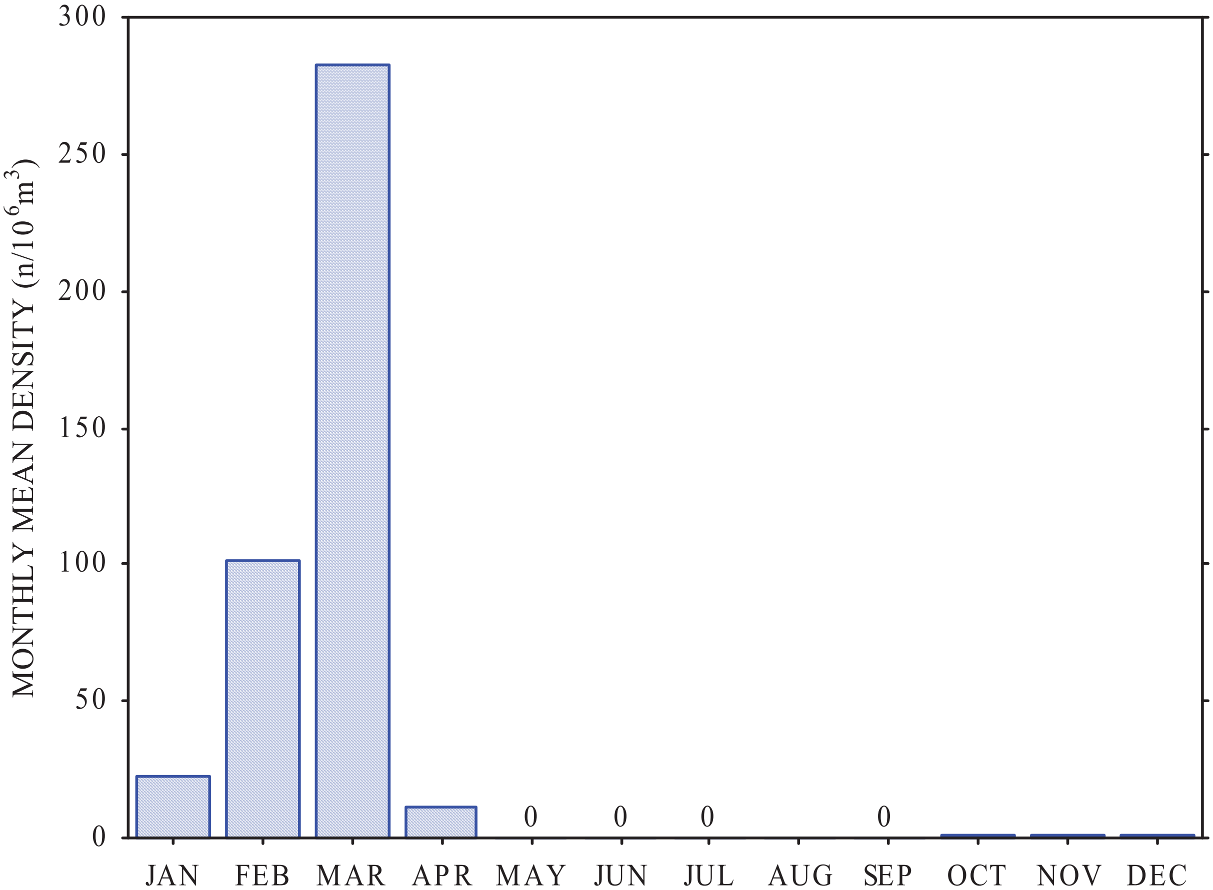


Figure 2-4. Monthly mean density (n/10^6 meters^3) of blueback herring taken in impingement sampling at the Salem circulating water intake structure during 2006.

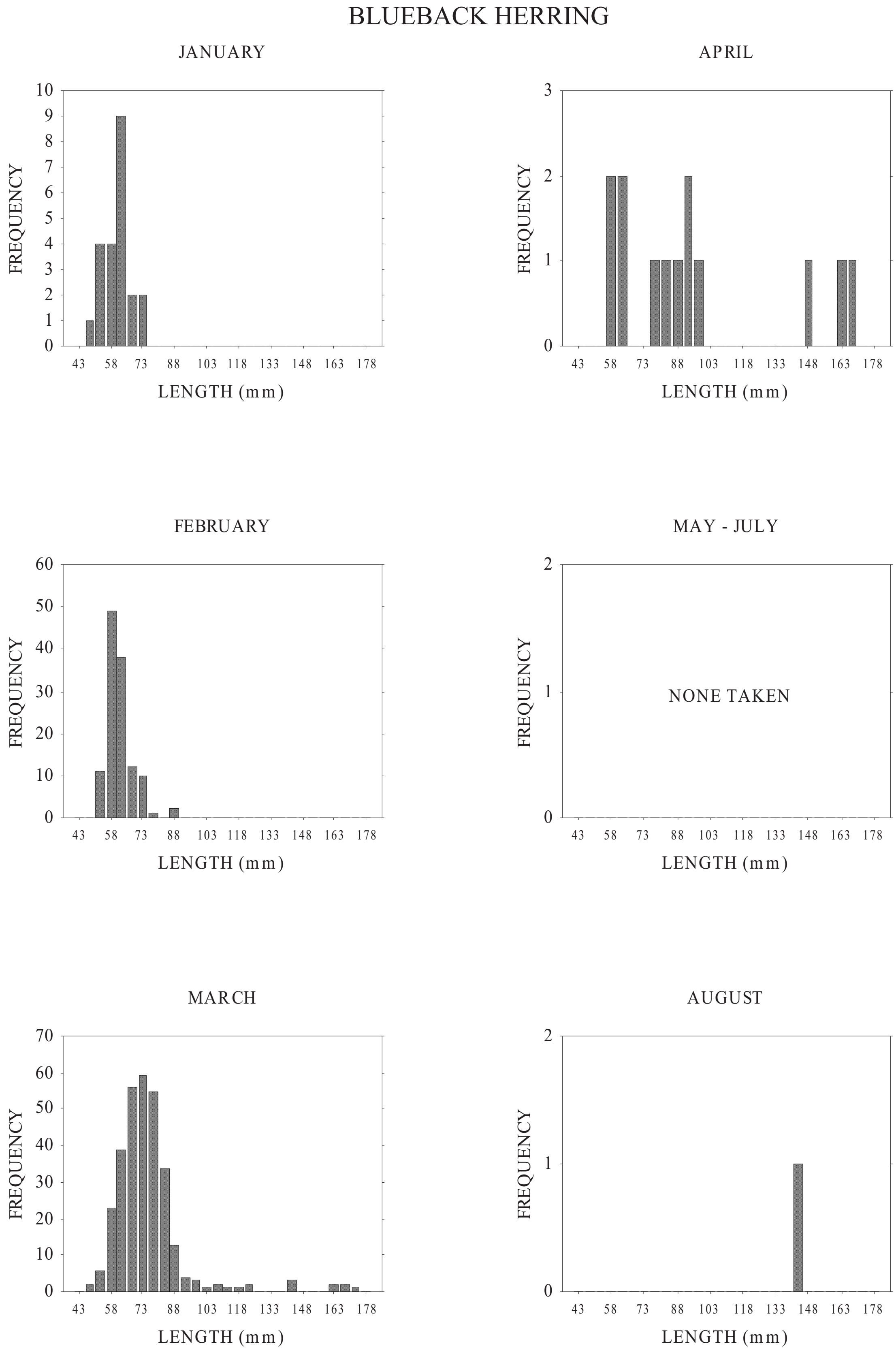
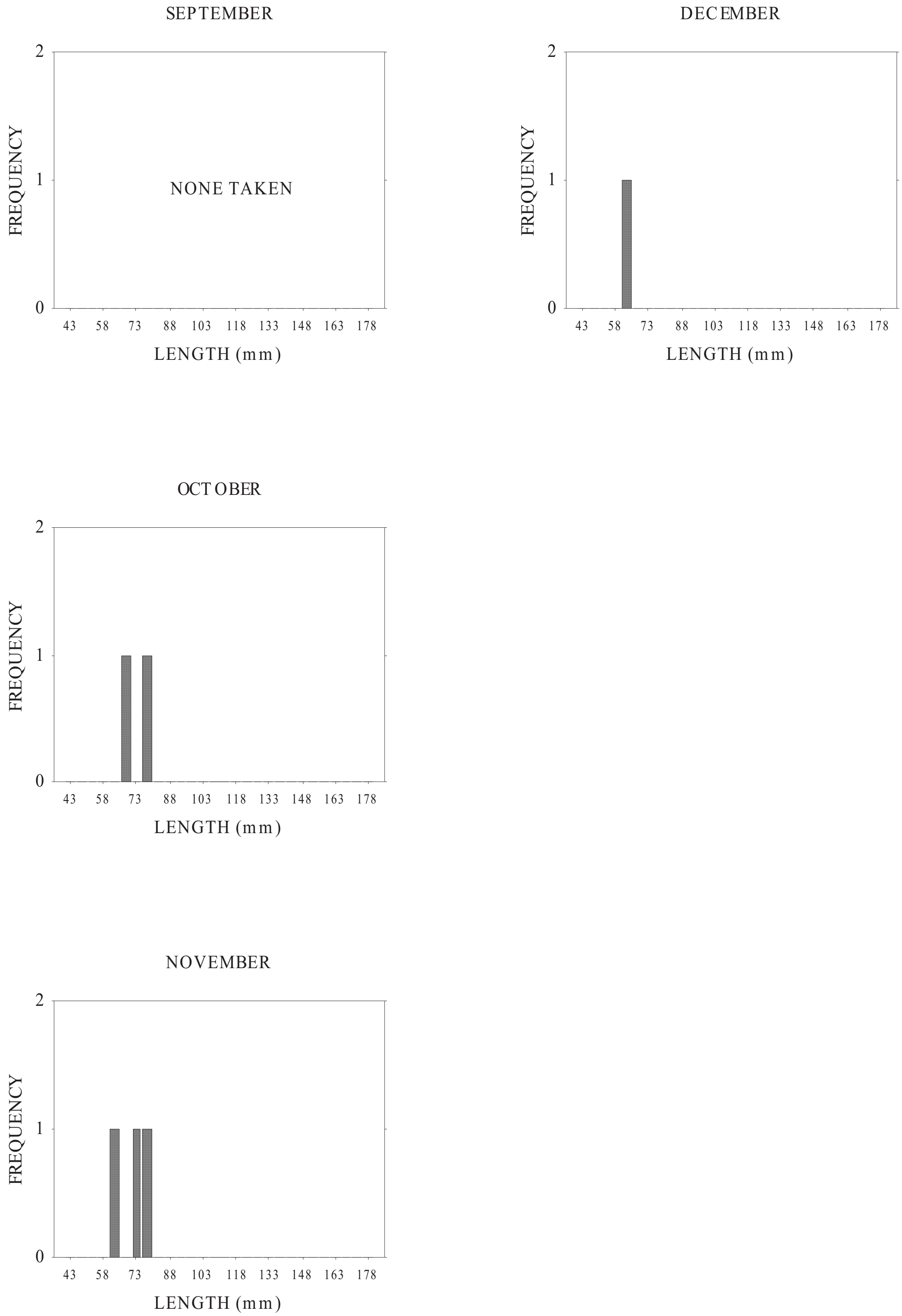


Figure 2-5. Length frequency of blueback herring taken in impingement sampling at the Salem circulating water intake structure during 2006.

BLUEBACK HERRING



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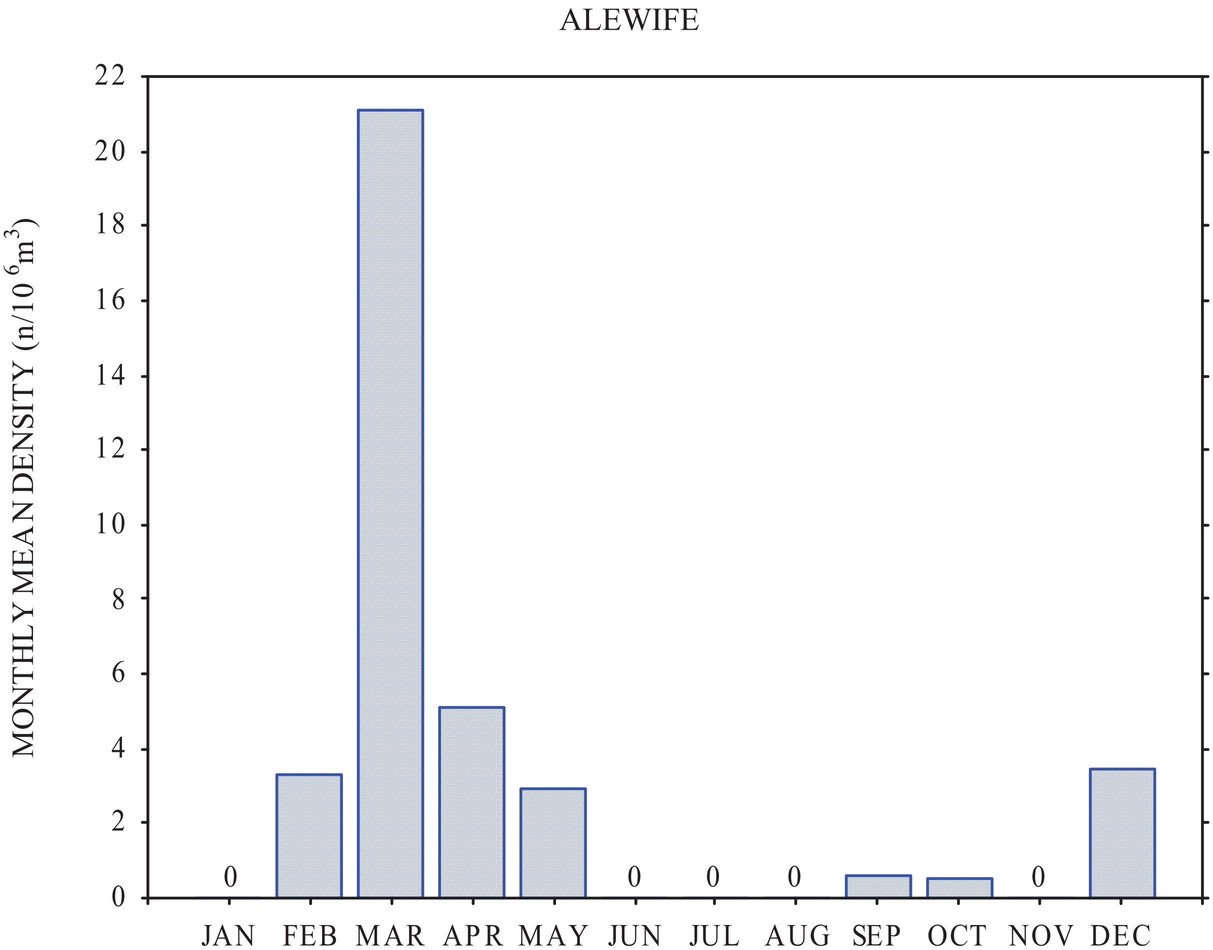


Figure 2-6. Monthly mean density (n/10^6 meters^3) of alewife taken in impingement sampling at the Salem circulating water intake structure during 2006.

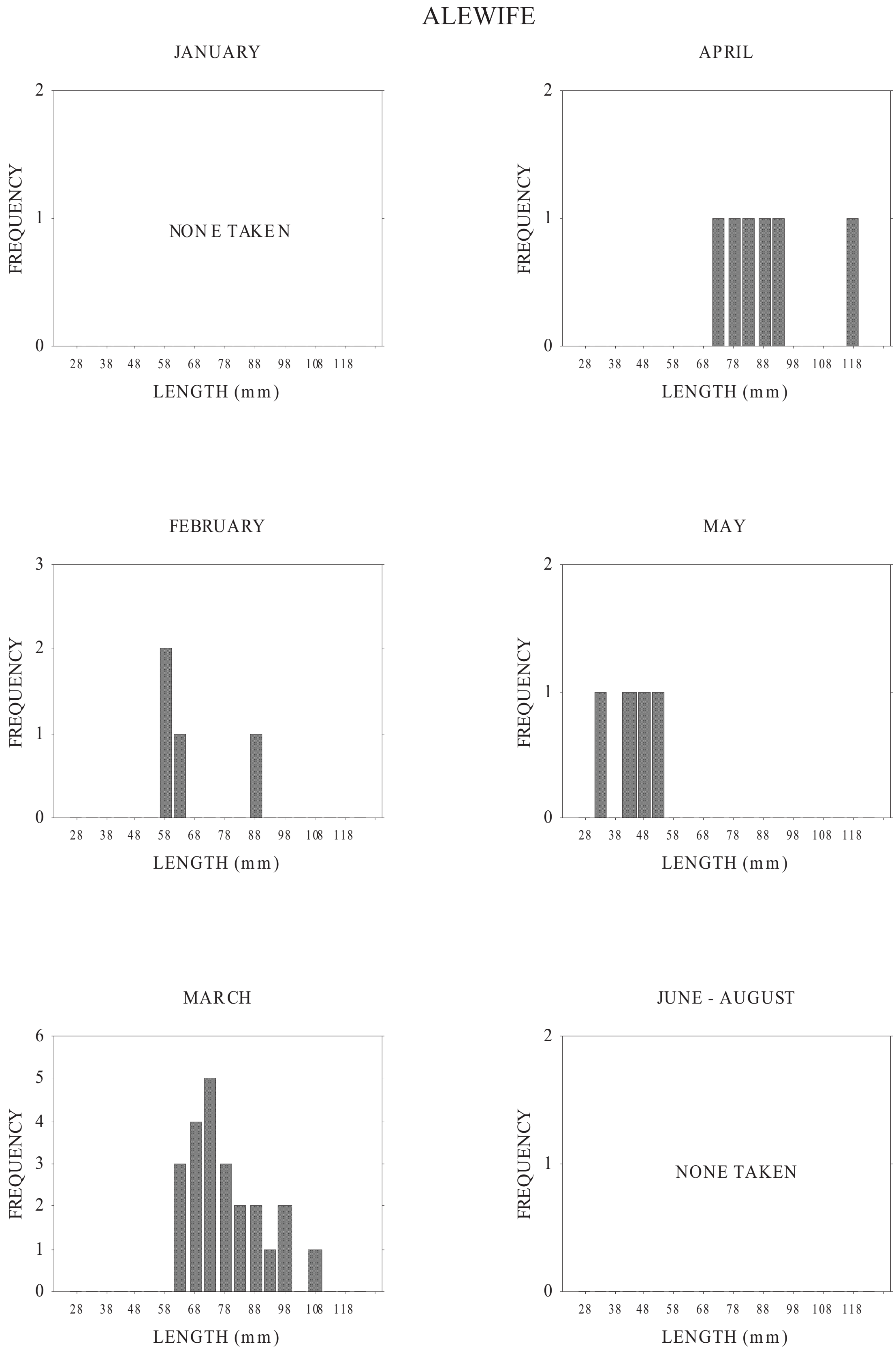
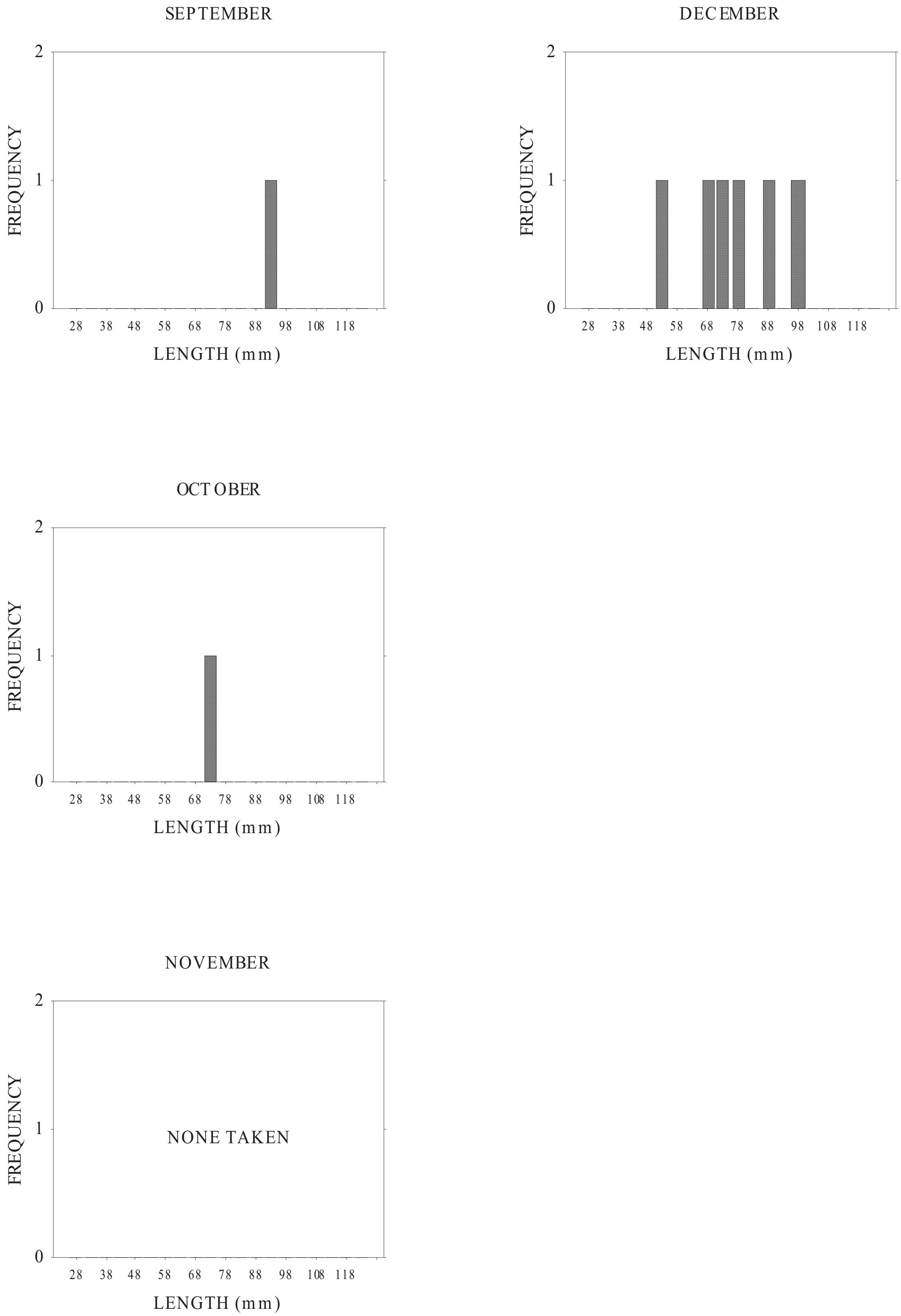


Figure 2-7. Length frequency of alewife taken in impingement sampling at the Salem circulating water intake structure during 2006.

ALEWIFE



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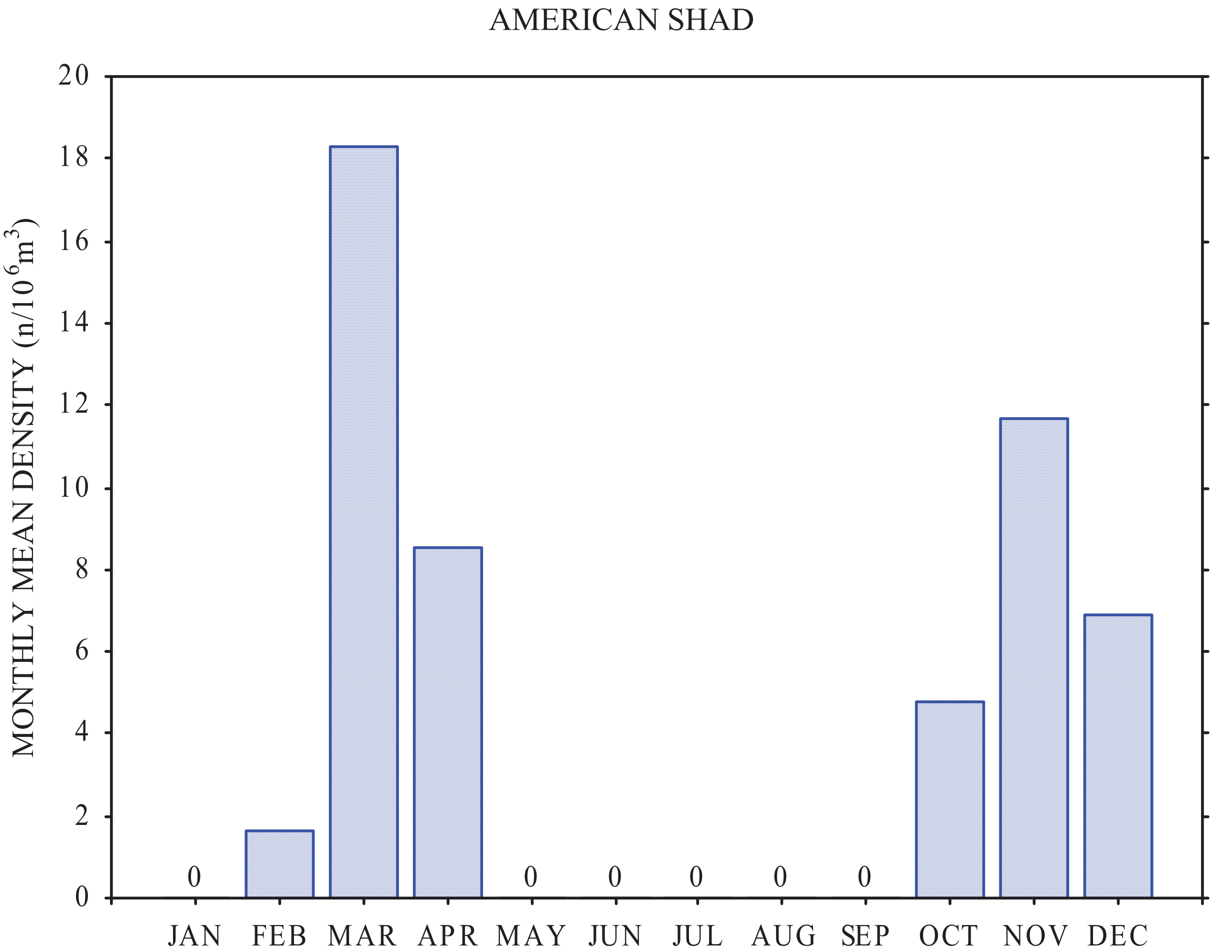


Figure 2-8. Monthly mean density ($n/10^6$ meters^3) of American shad taken in impingement sampling at the Salem circulating water intake structure during 2006.

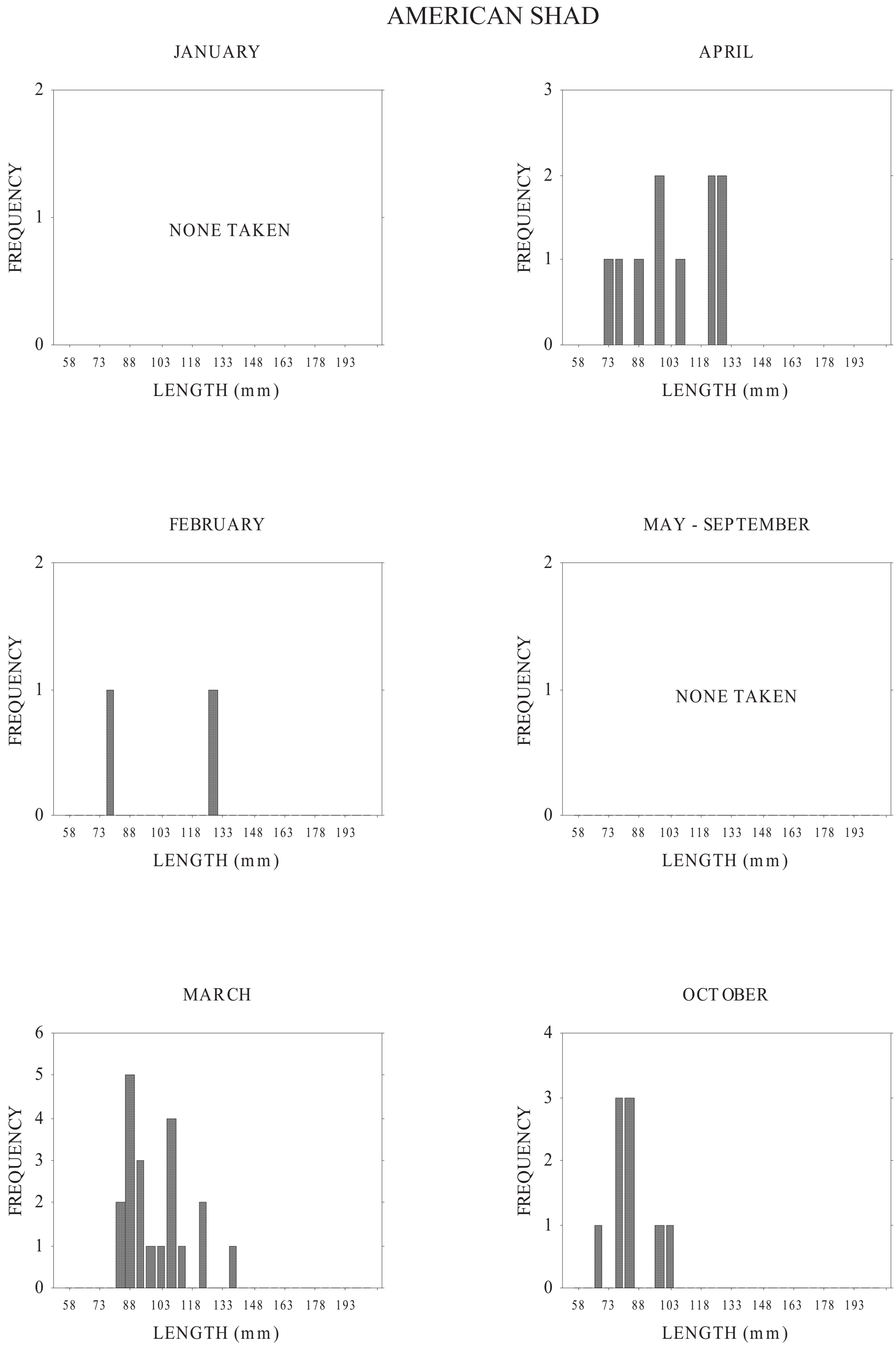
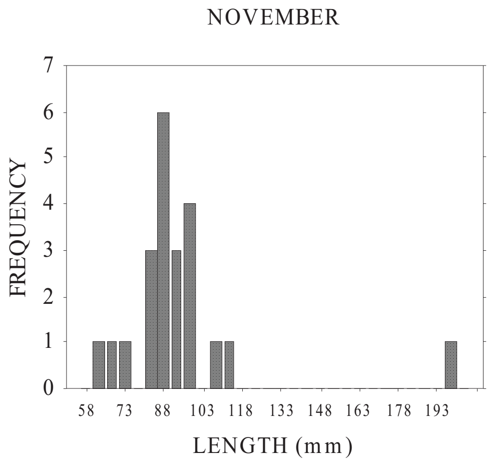


Figure 2-9. Length frequency of American shad taken in impingement sampling at the Salem circulating water intake structure during 2006.

AMERICAN SHAD



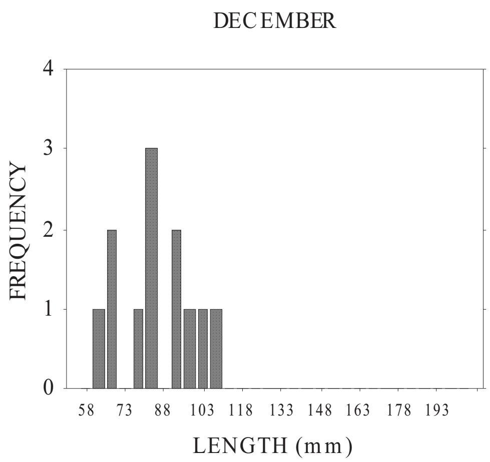


Figure 2-9. Continued.

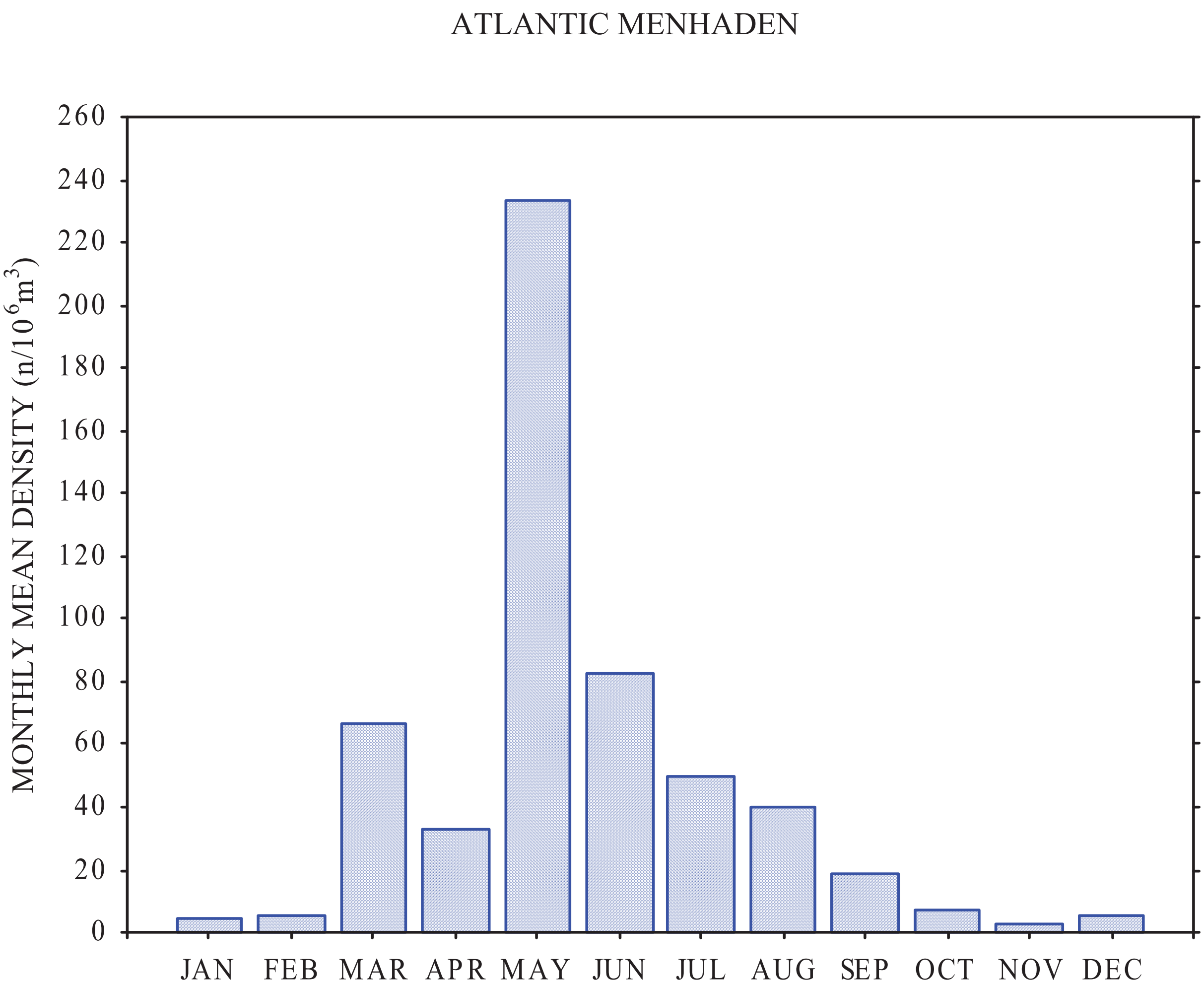


Figure 2-10. Monthly mean density (n/10^6 meters^3) of Atlantic menhaden taken in impingement sampling at the Salem circulating water intake structure during 2006.

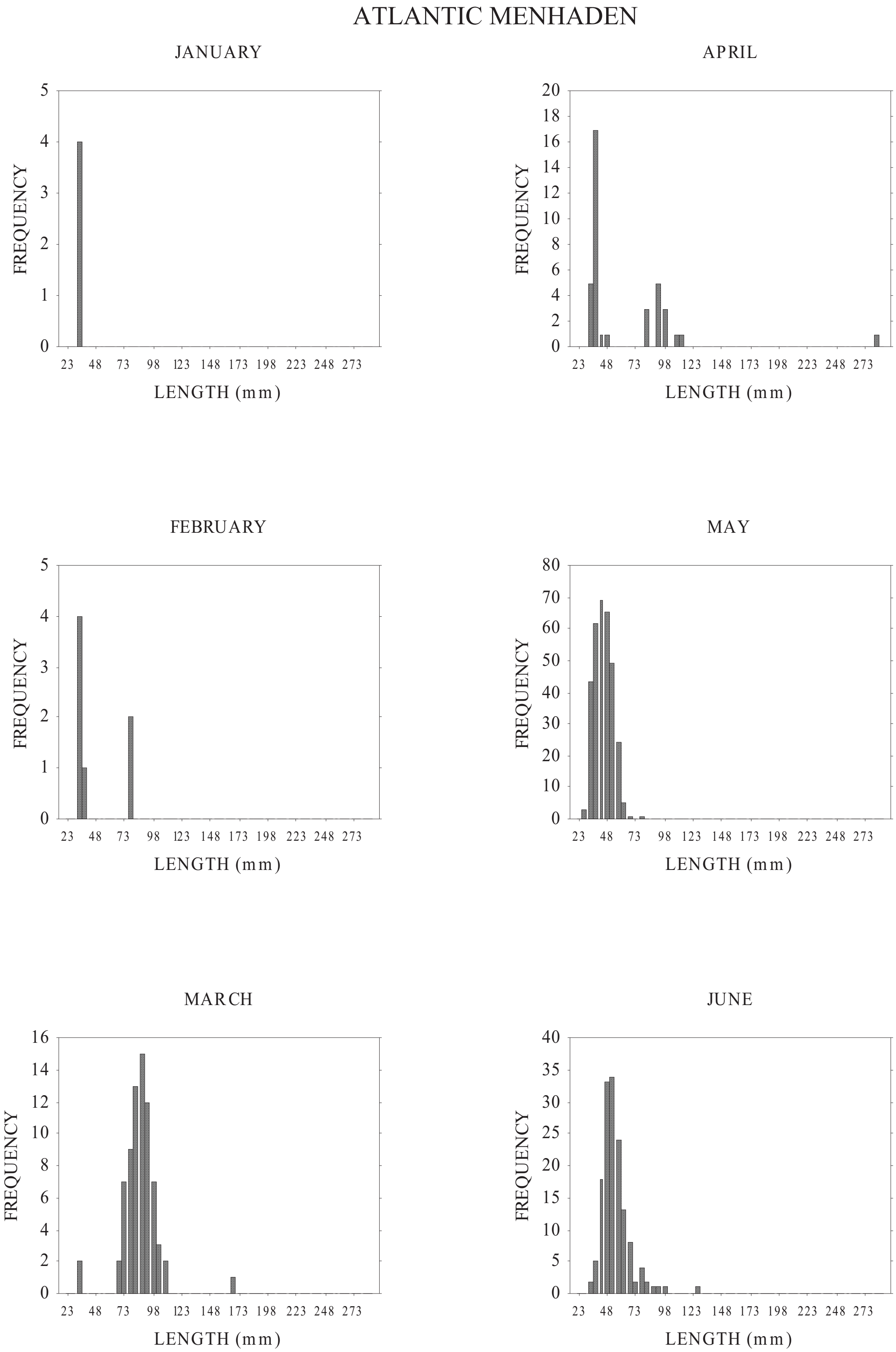


Figure 2-11. Length frequency of Atlantic menhaden taken in impingement sampling at the Salem circulating water intake structure during 2006.

ATLANTIC MENHADEN

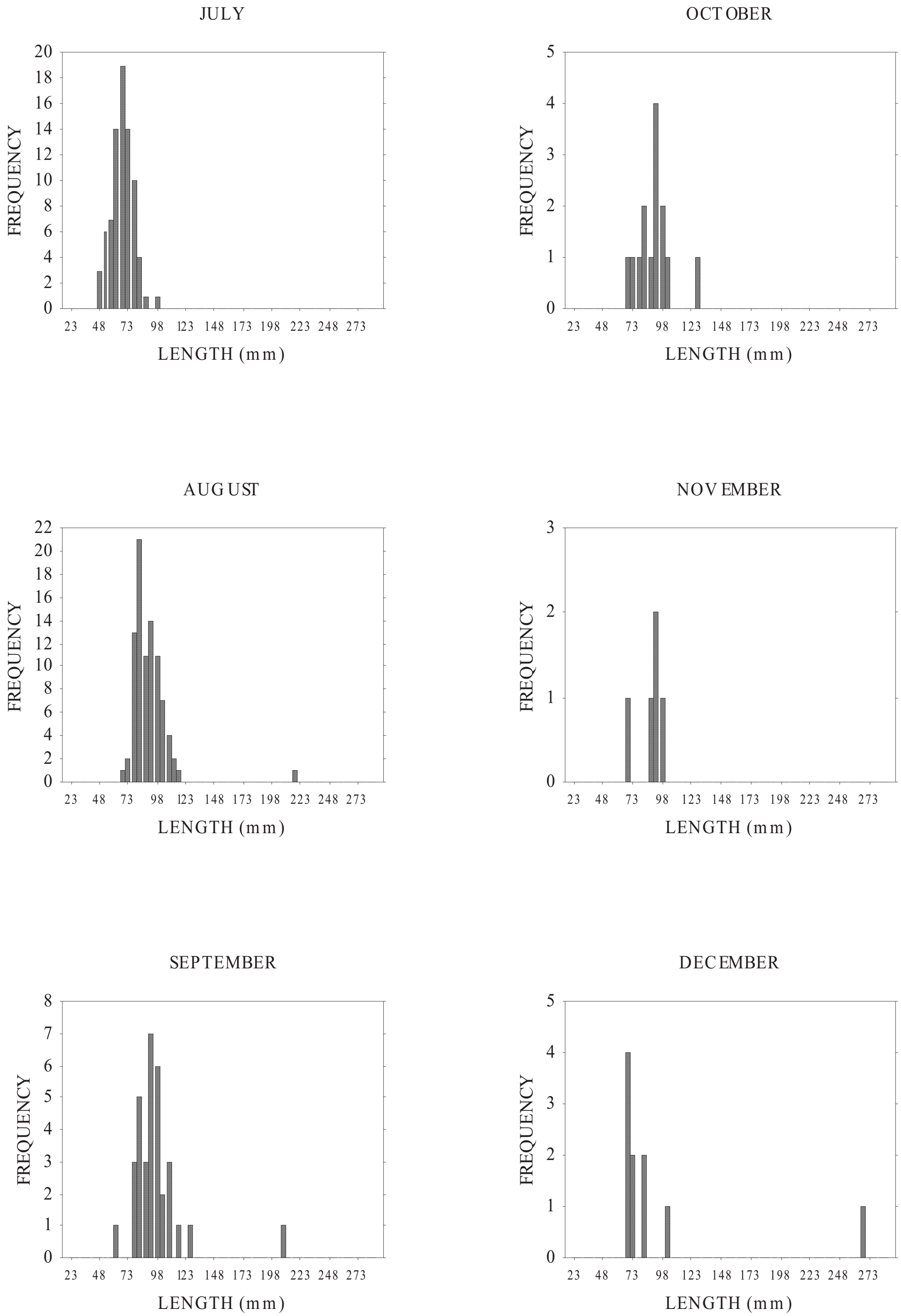


Figure 2-11. Continued.

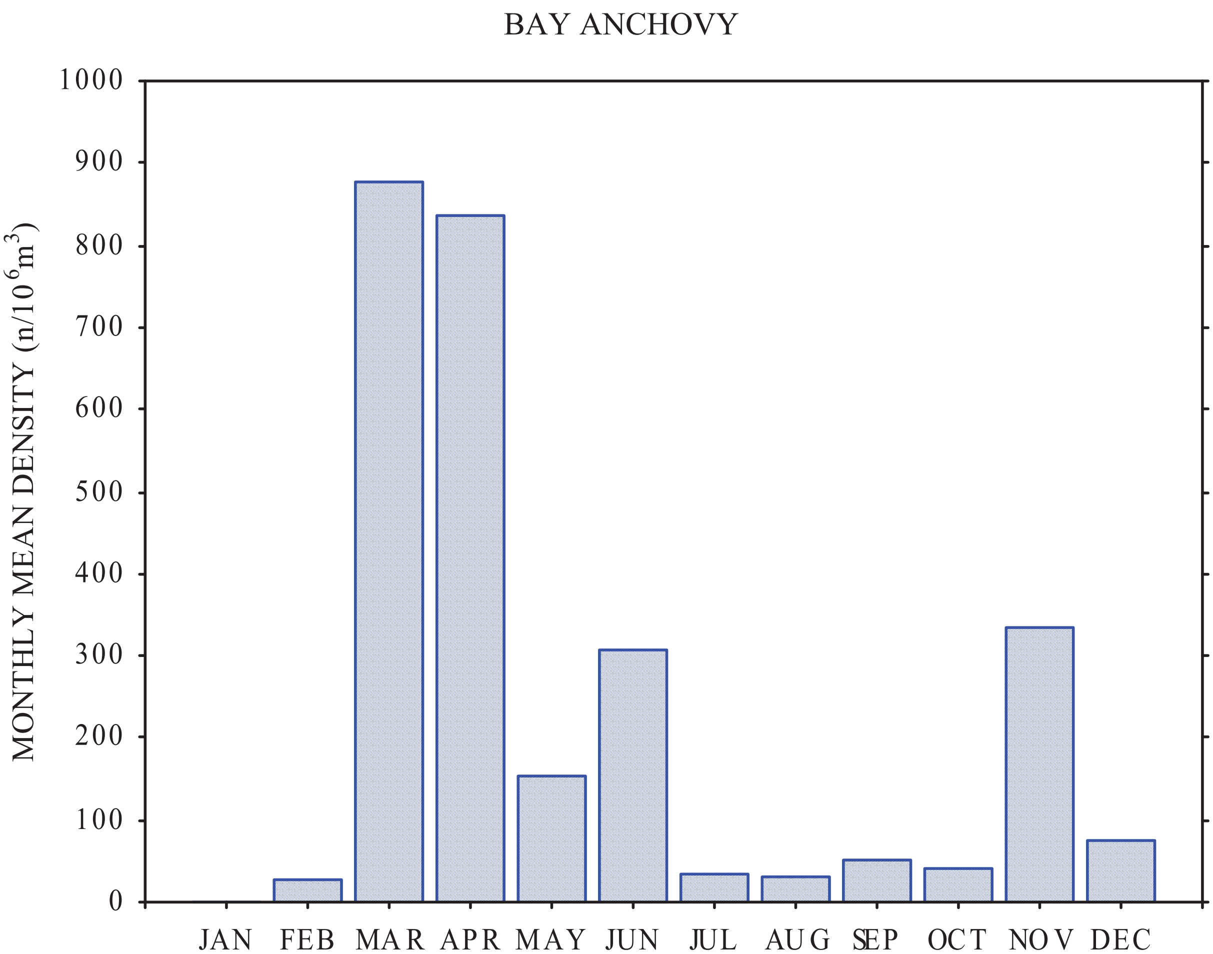


Figure 2-12. Monthly mean density (n/10^6 meters^3) of bay anchovy taken in impingement sampling at the Salem circulating water intake structure during 2006.

BAY ANCHOVY

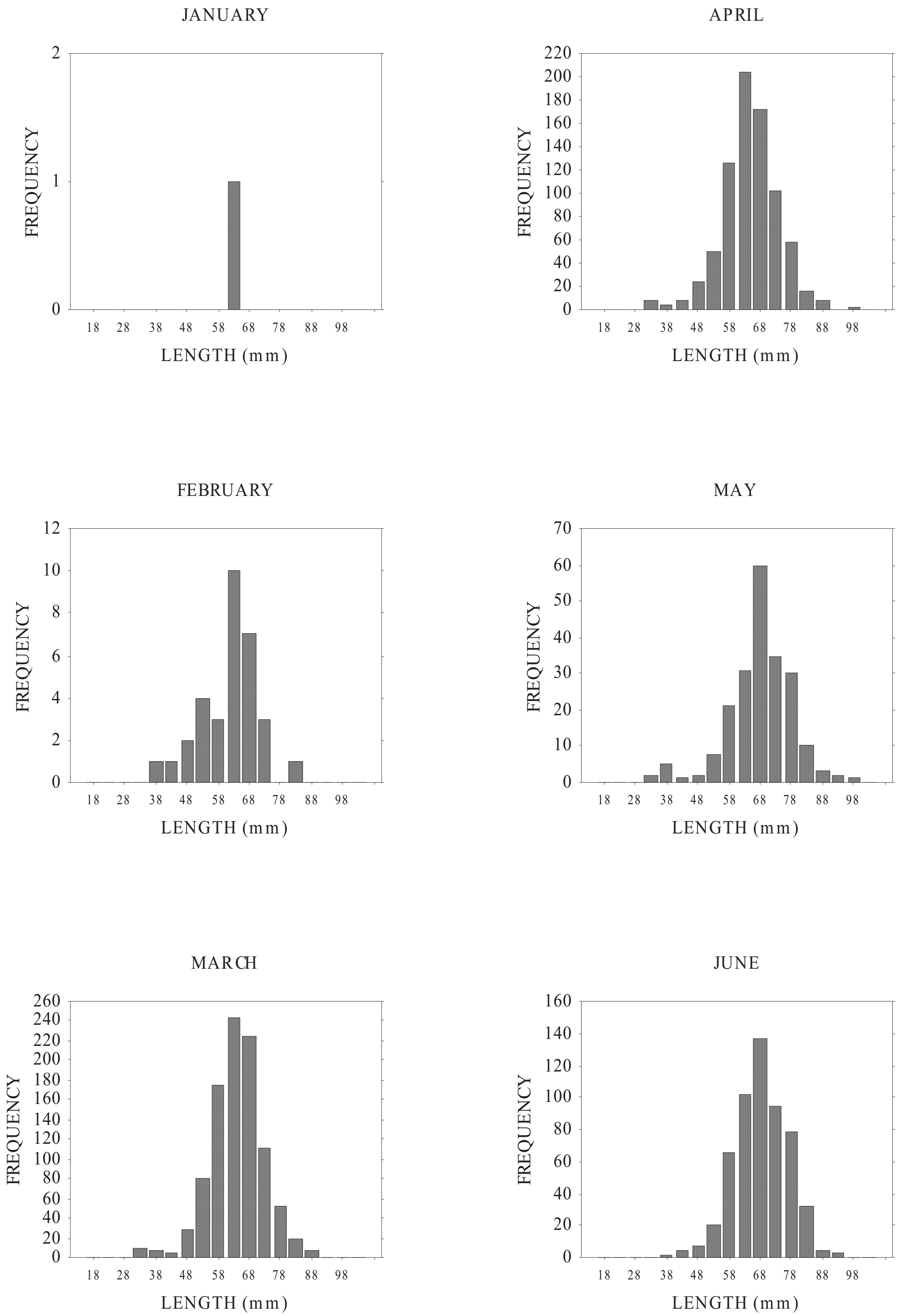


Figure 2-13. Length frequency of bay anchovy taken in impingement sampling at the Salem circulating water intake structure during 2006.

BAY ANCHOVY

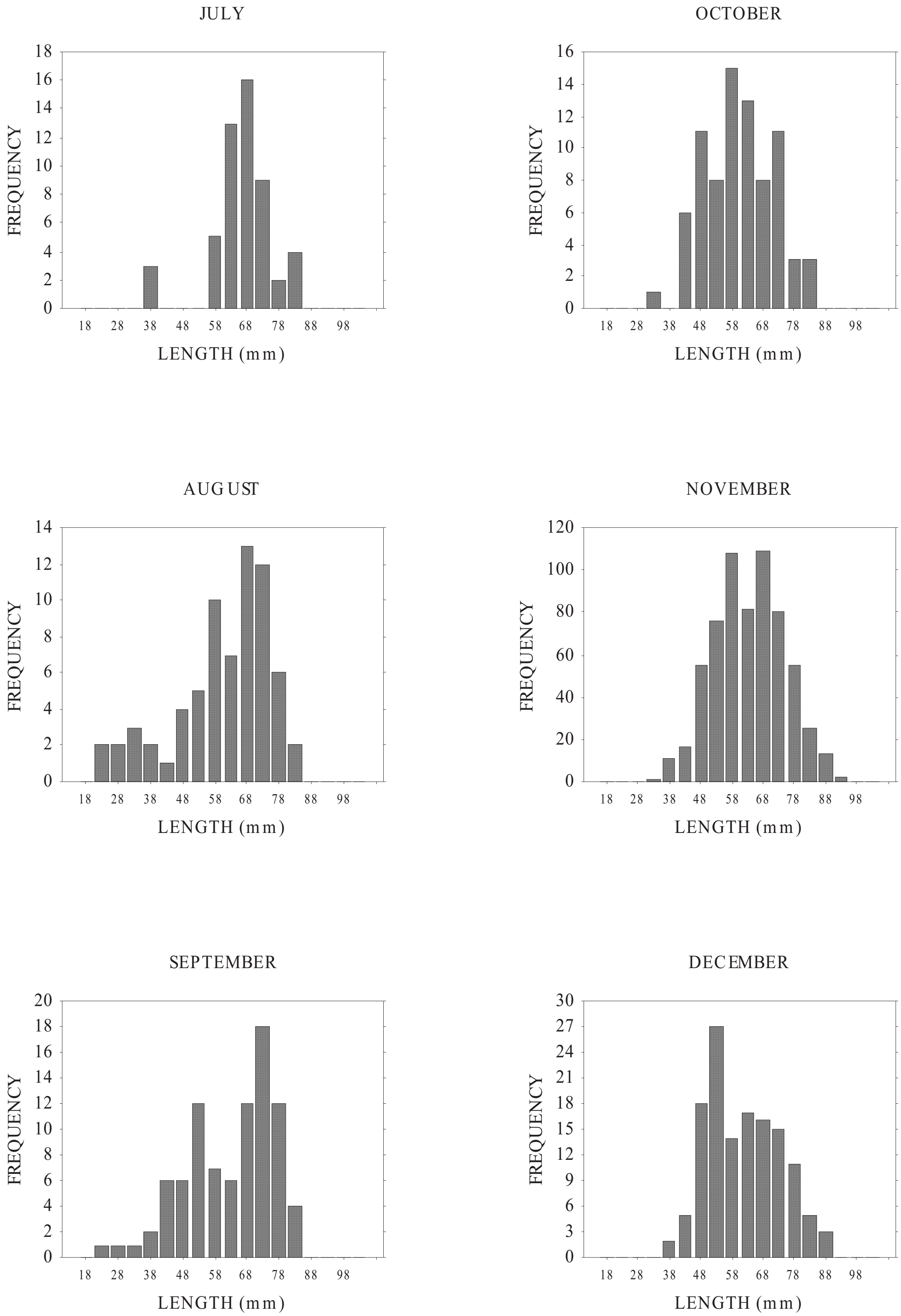


Figure 2-13. Continued.

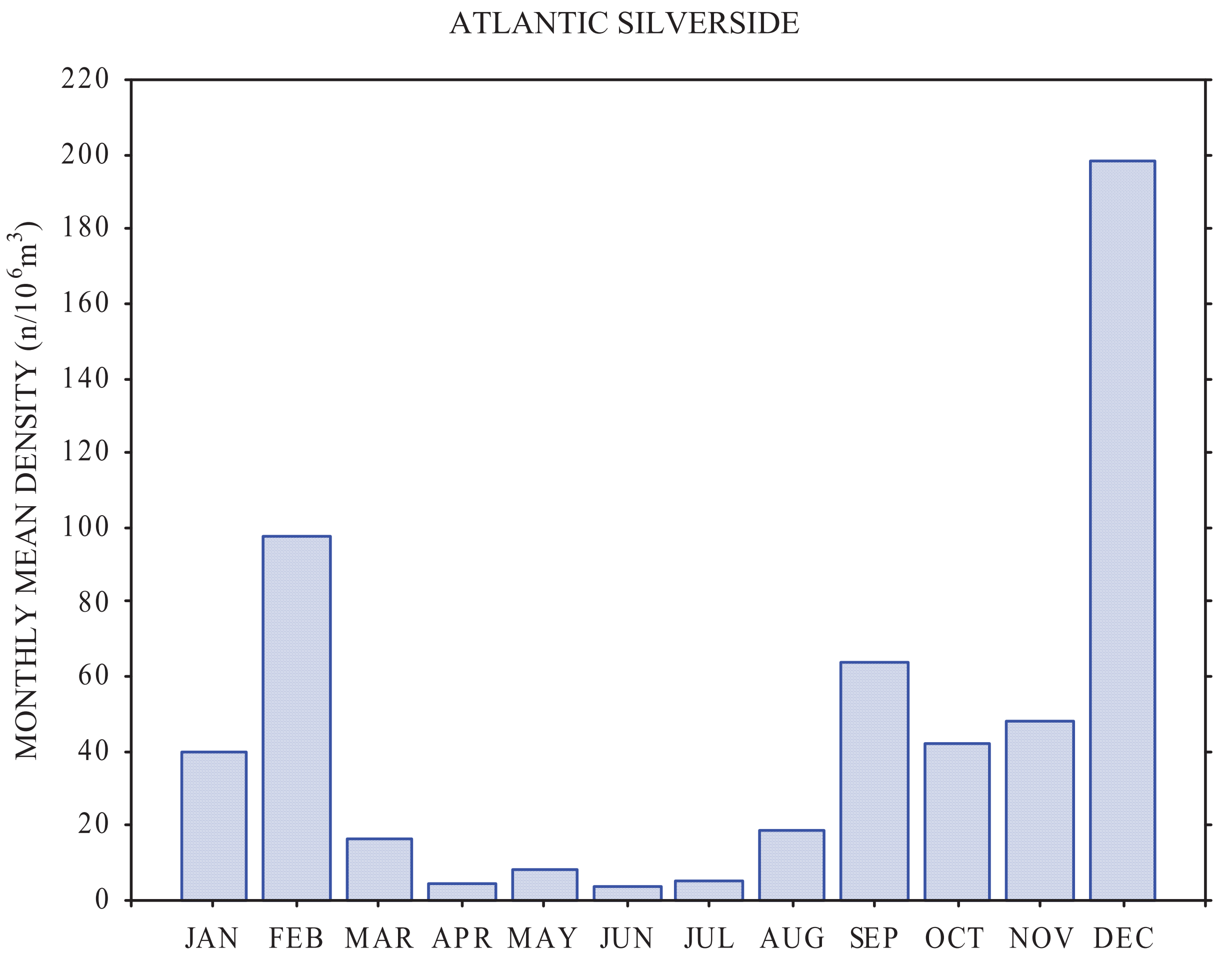


Figure 2-14. Monthly mean density (n/10^6 meters^3) of Atlantic silverside taken in impingement sampling at the Salem circulating water intake structure during 2006.

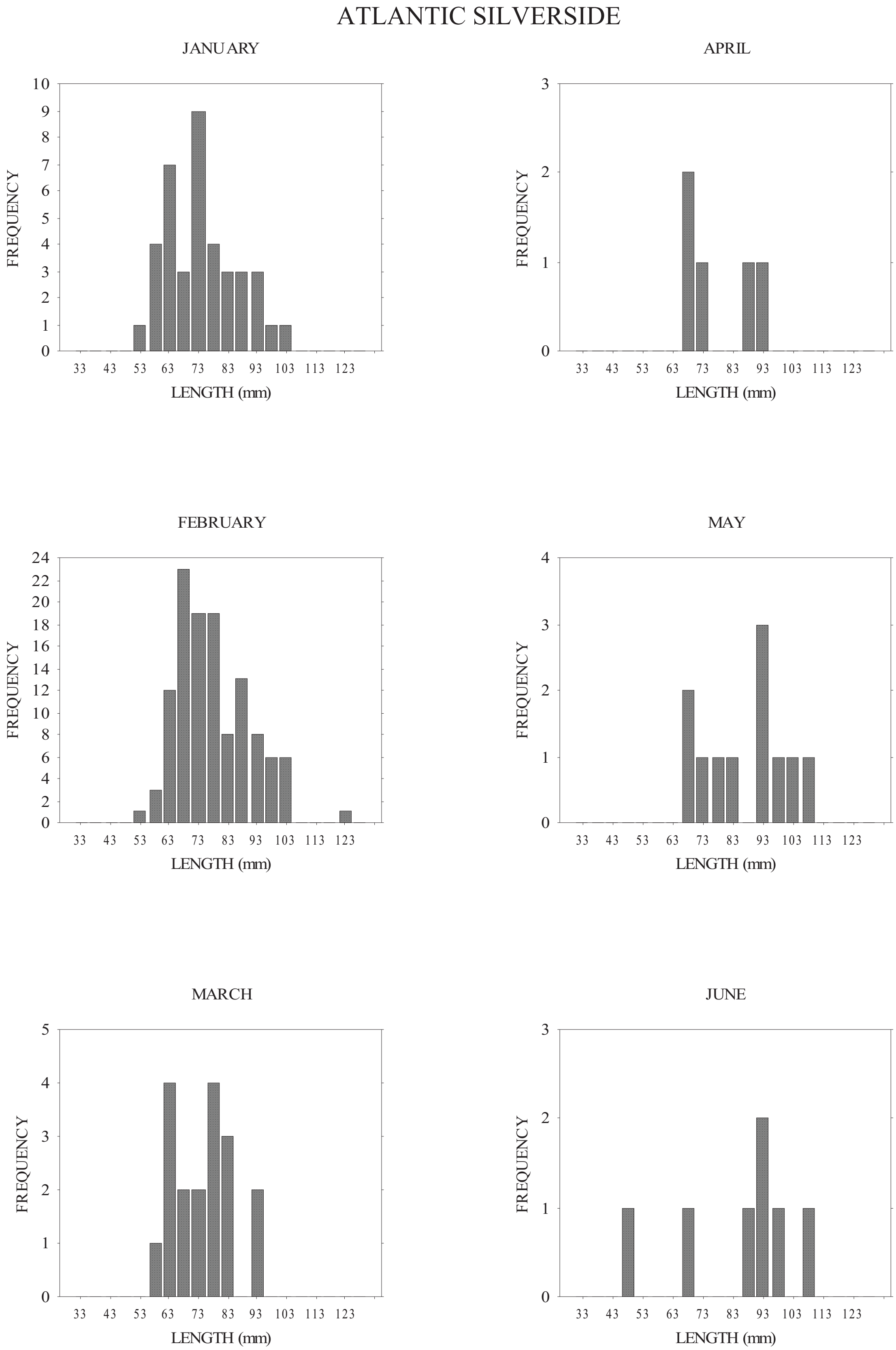


Figure 2-15. Length frequency of Atlantic silverside taken in impingement sampling at the Salem circulating water intake structure during 2006.

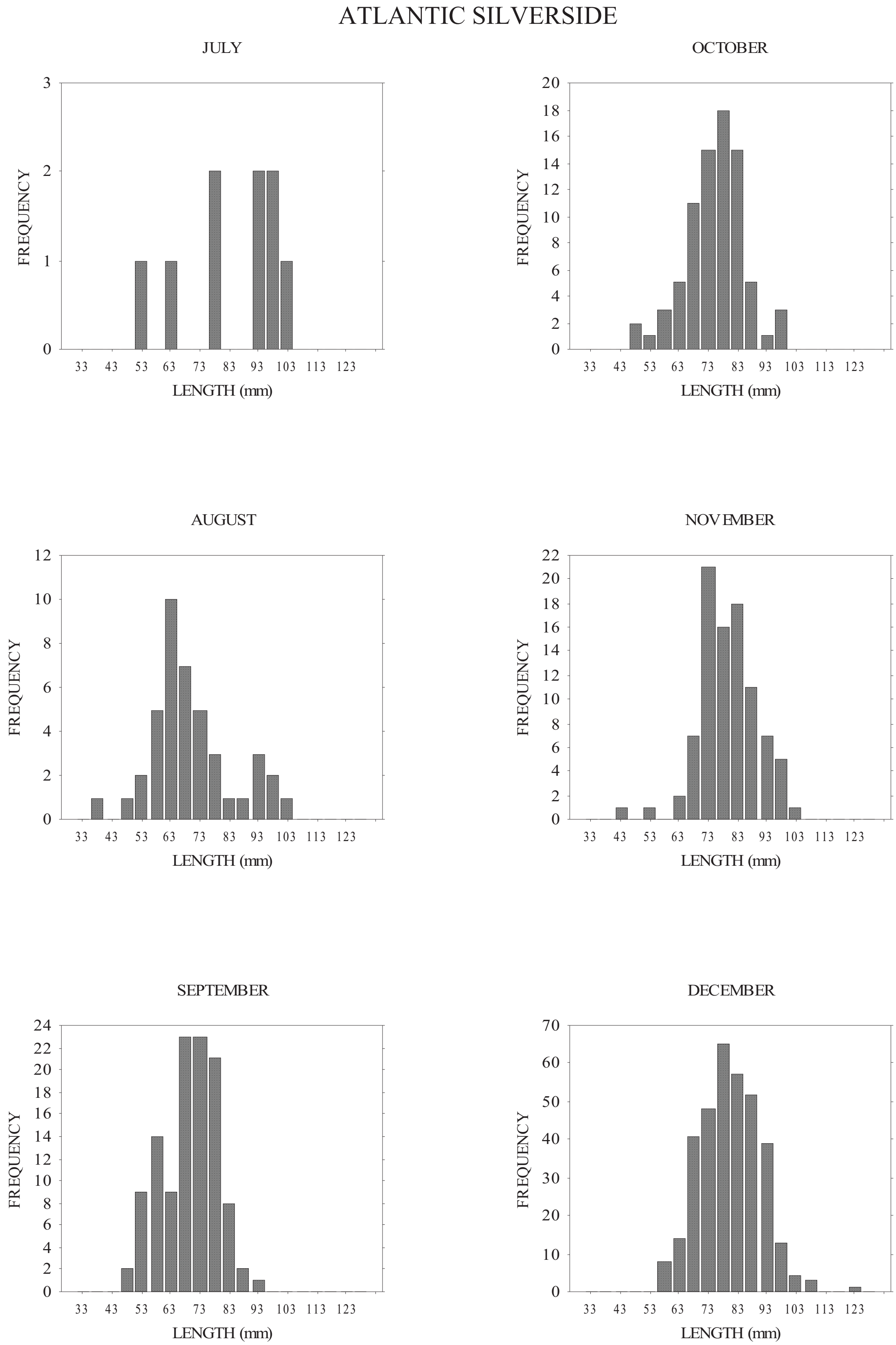


Figure 2-15. Continued.

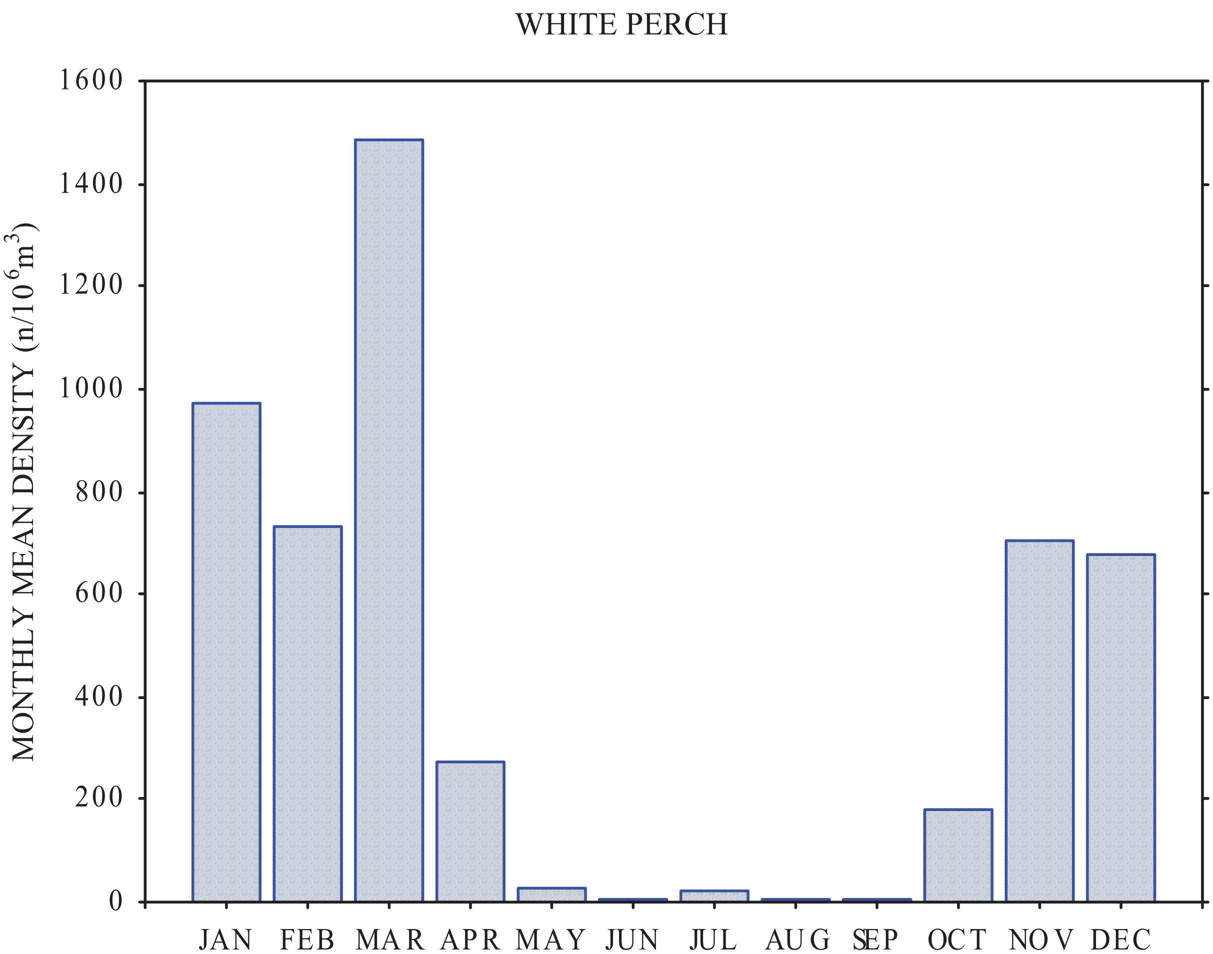


Figure 2-16. Monthly mean density (n/10^6 meters^3) of white perch taken in impingement sampling at the Salem circulating water intake structure during 2006.

WHITE PERCH

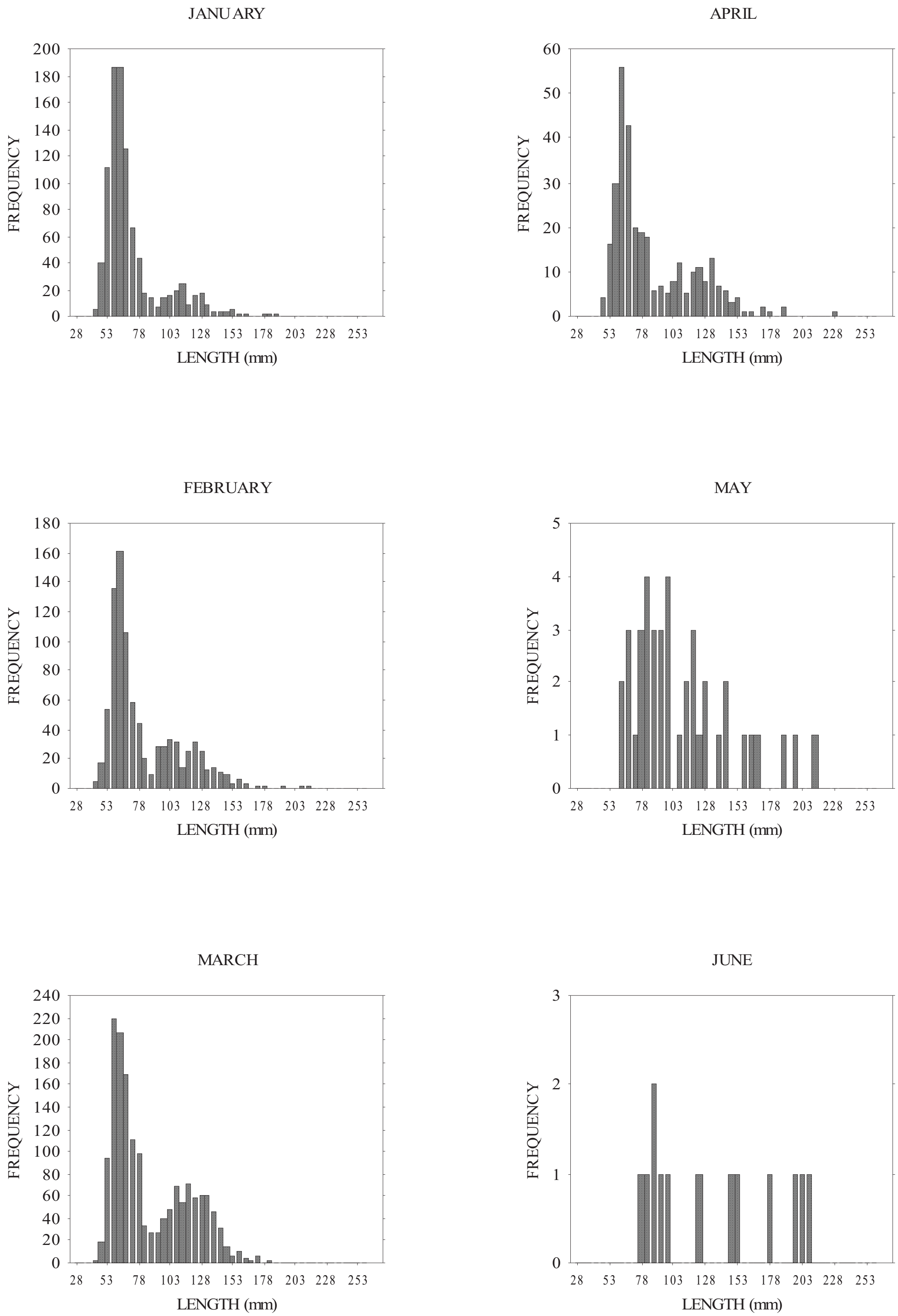


Figure 2-17. Length frequency of white perch taken in impingement sampling at the Salem circulating water intake structure during 2006.

WHITE PERCH

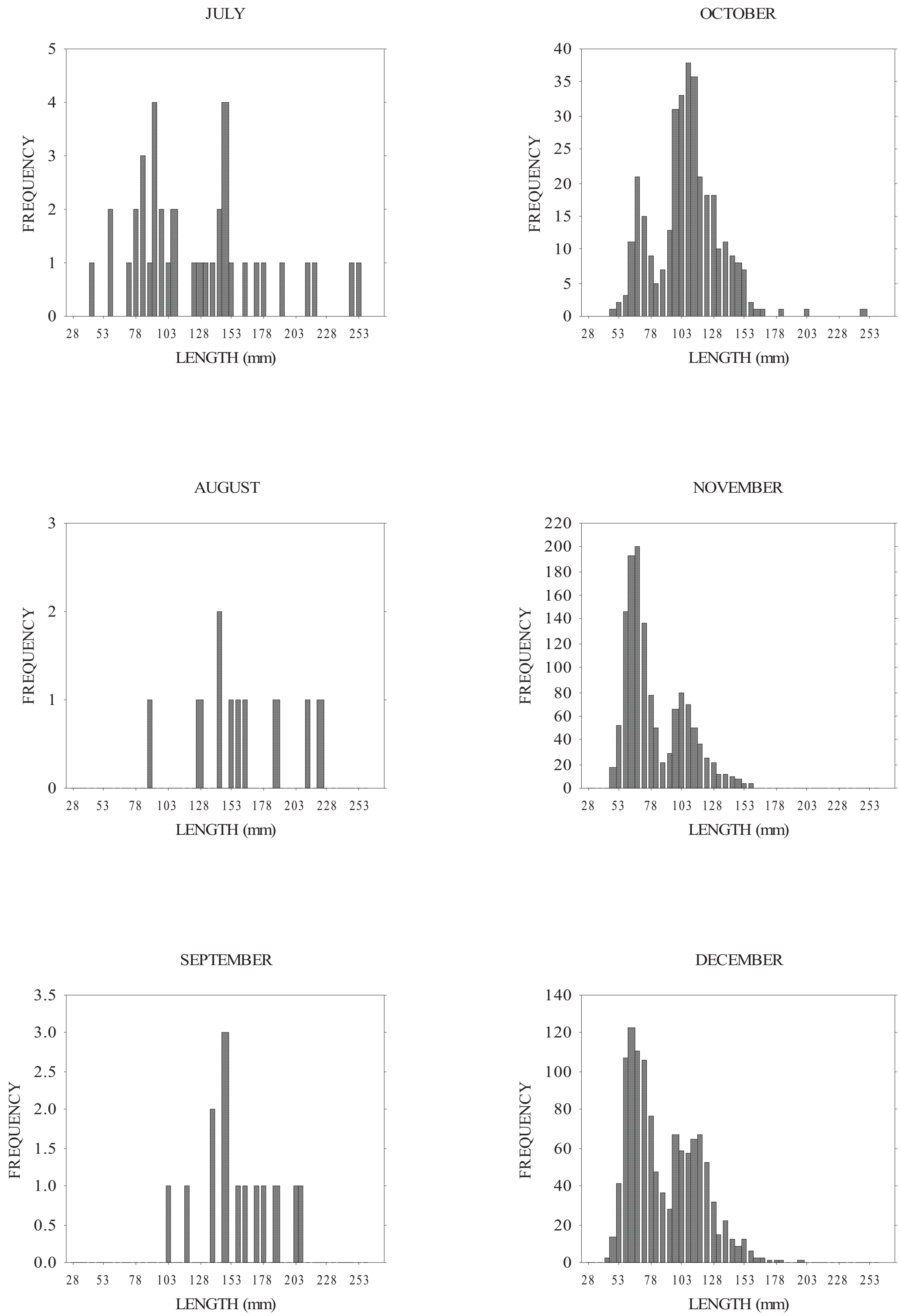


Figure 2-17. Continued.

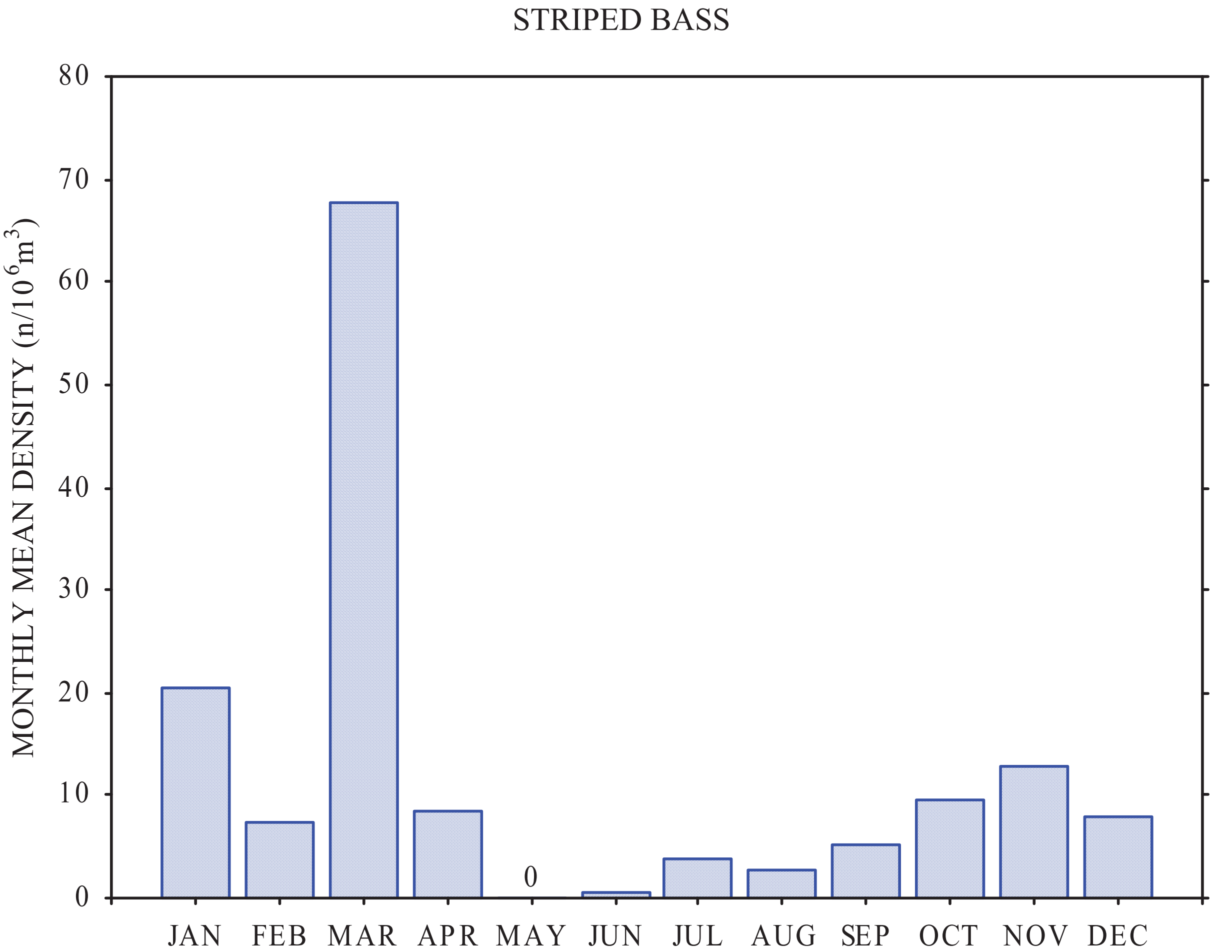


Figure 2-18. Monthly mean density (n/10^6 meters^3) of striped bass taken in impingement sampling at the Salem circulating water intake structure during 2006.

STRIPED BASS

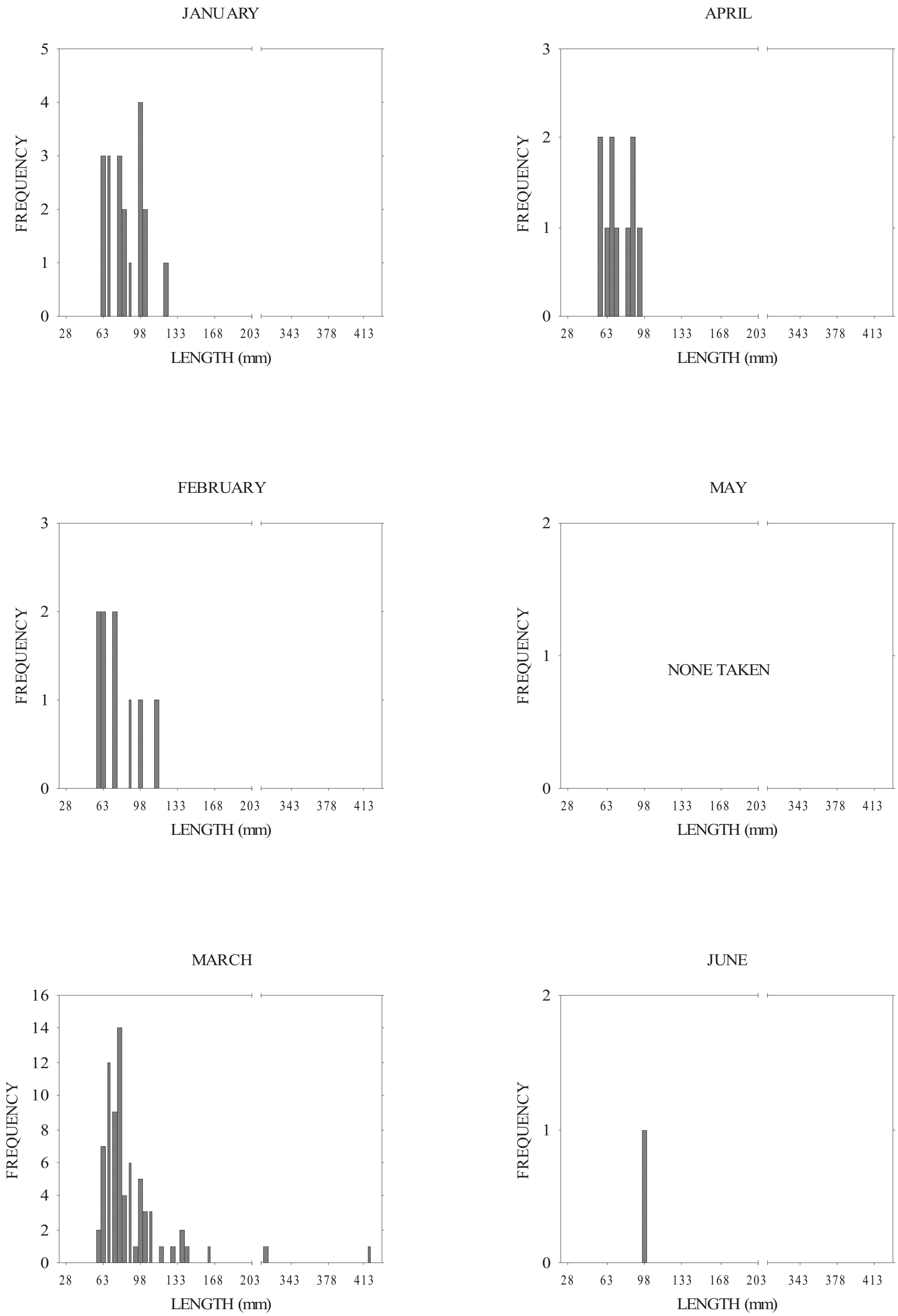


Figure 2-19. Length frequency of striped bass taken in impingement sampling at the Salem circulating water intake structure during 2006.

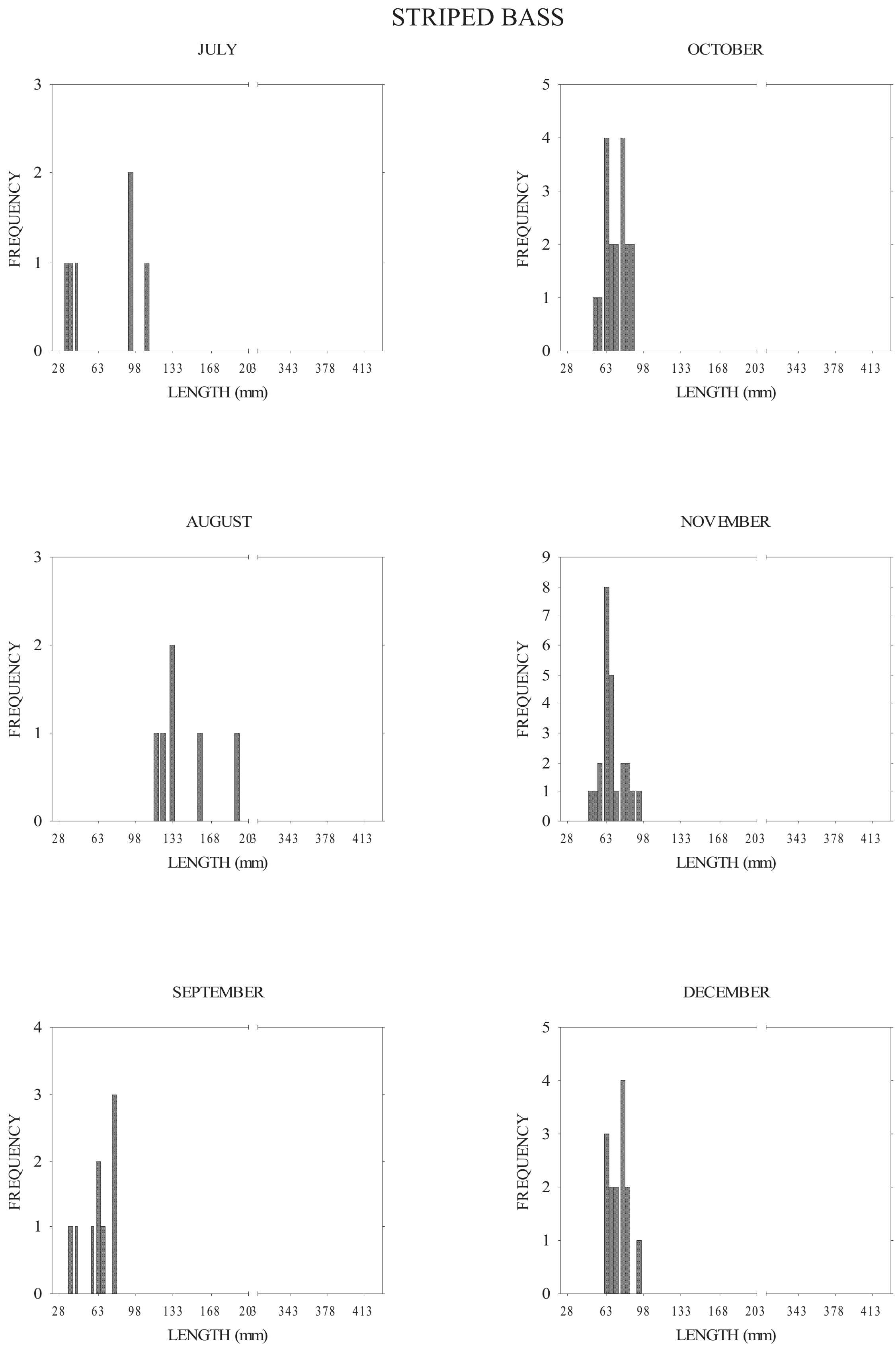


Figure 2-19. Continued.

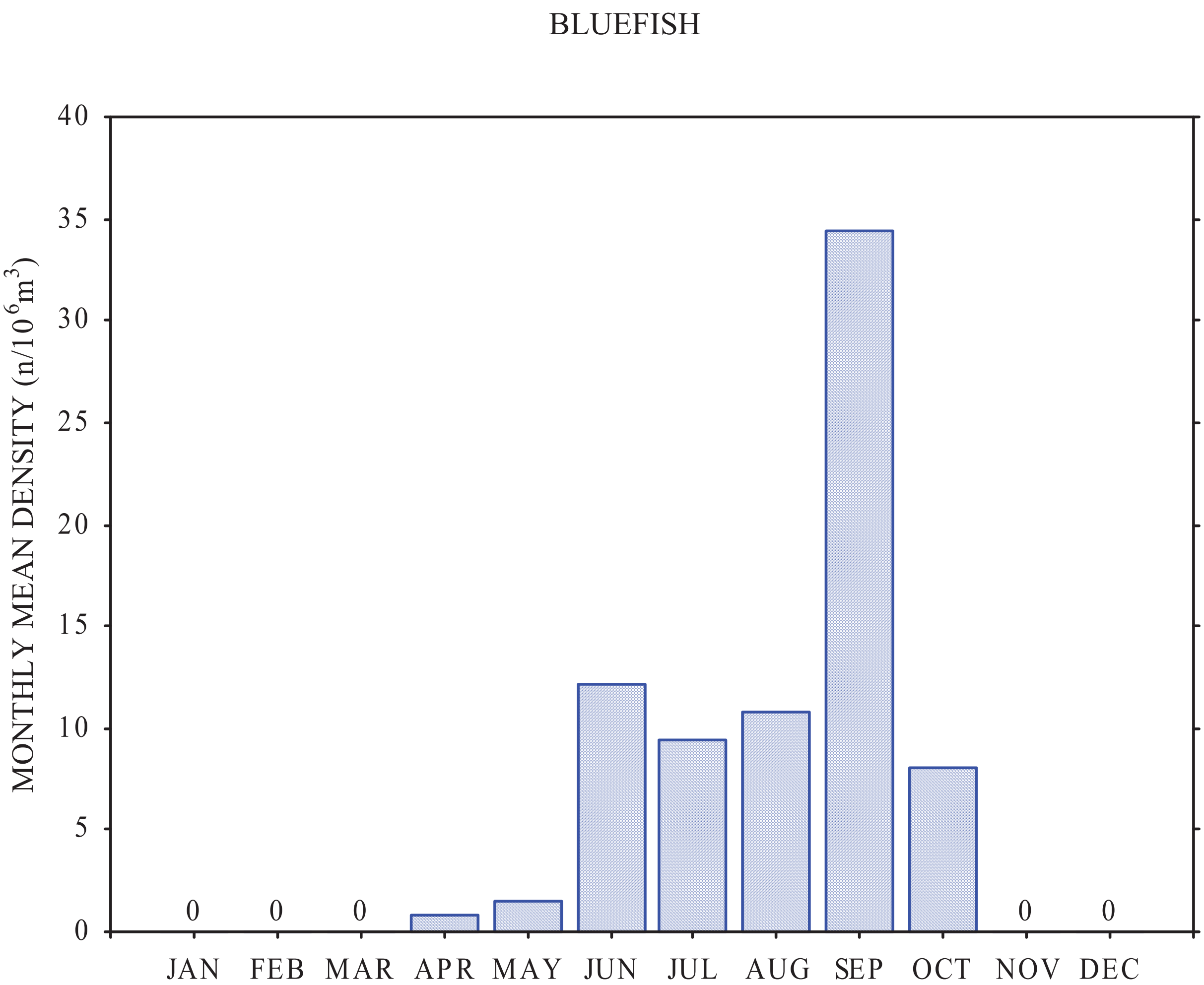


Figure 2-20. Monthly mean density (n/10^6 meters^3) of bluefish taken in impingement sampling at the Salem circulating water intake structure during 2006.

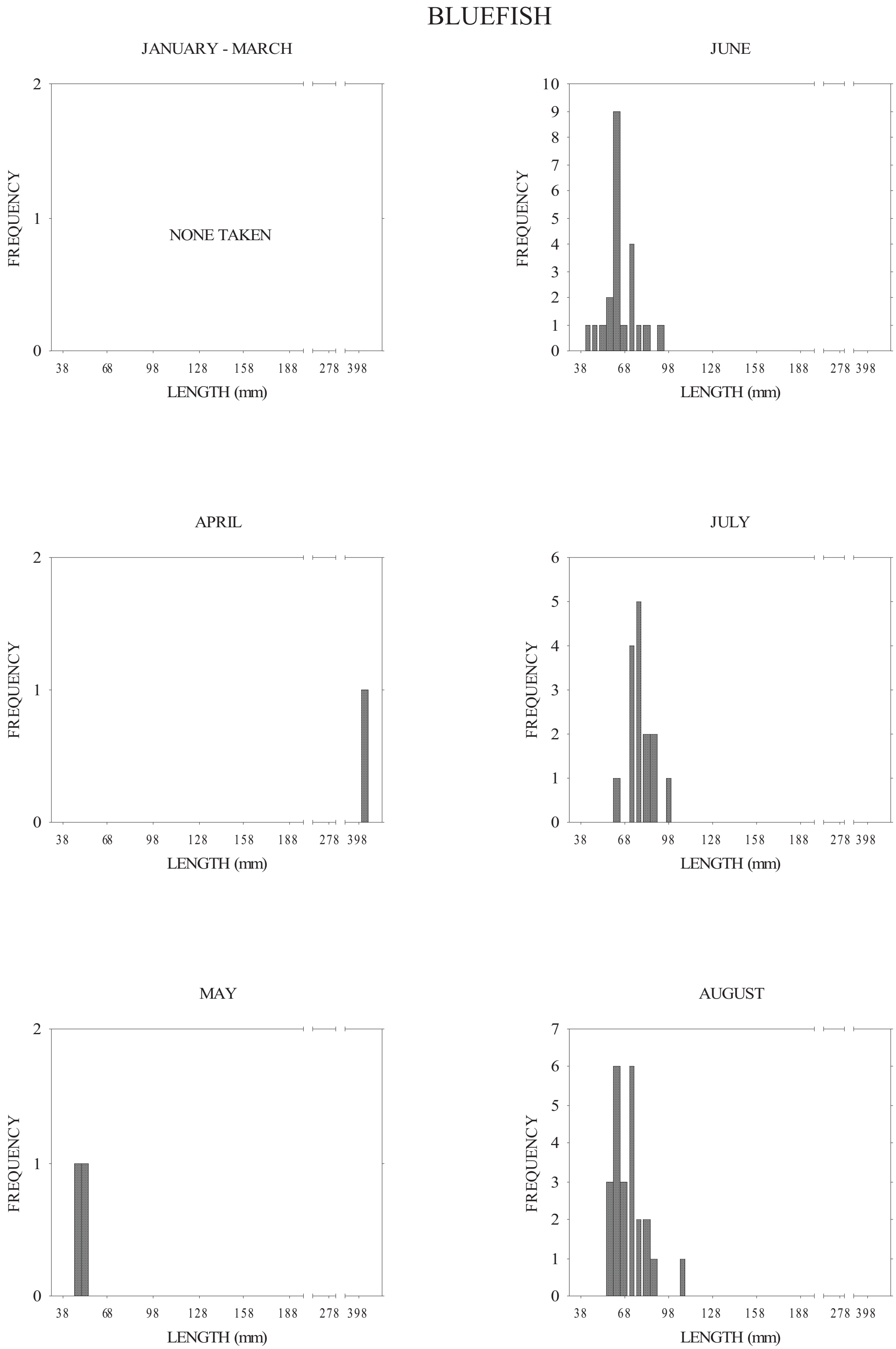


Figure 2-21. Length frequency of bluefish taken in impingement sampling at the Salem circulating water intake structure during 2006.

BLUEFISH

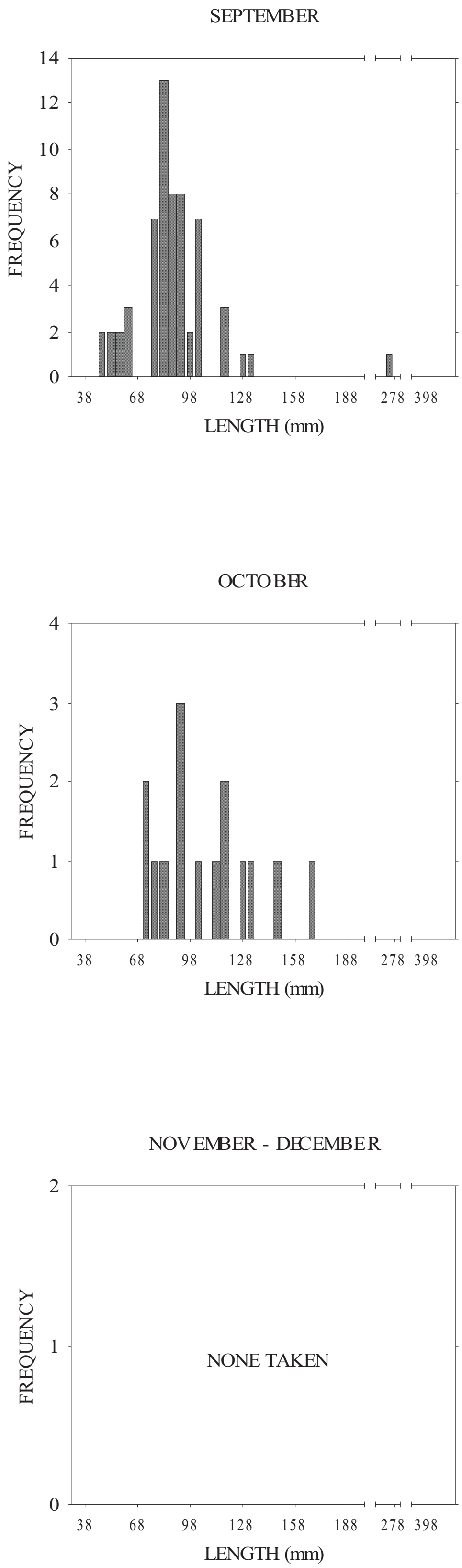


Figure 2-21. Continued.

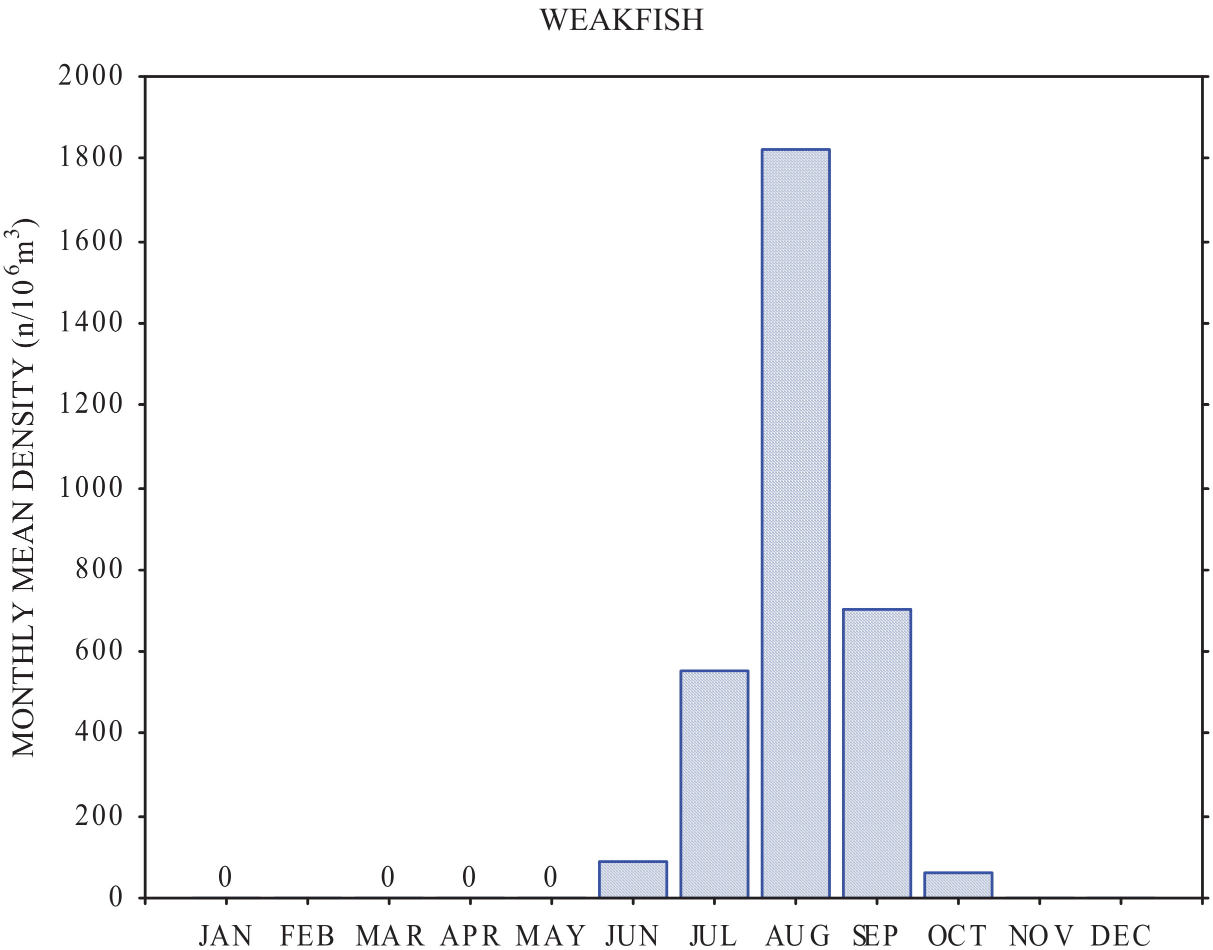


Figure 2-22. Monthly mean density (n/10^6 meters^3) of weakfish taken in impingement sampling at the Salem circulating water intake structure during 2006.

WEAKFISH

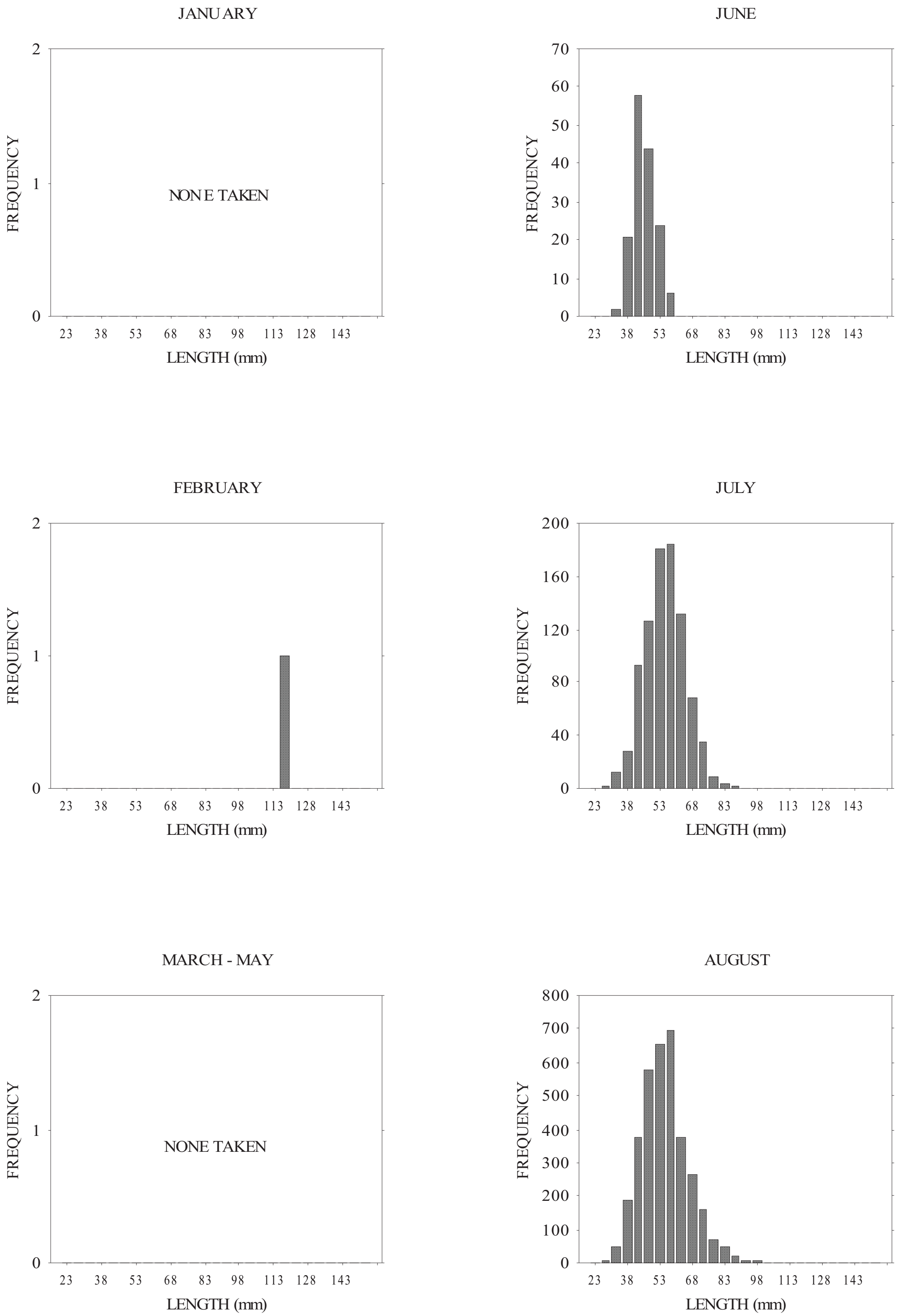


Figure 2-23. Length frequency of weakfish taken in impingement sampling at the Salem circulating water intake structure during 2006.

WEAKFISH

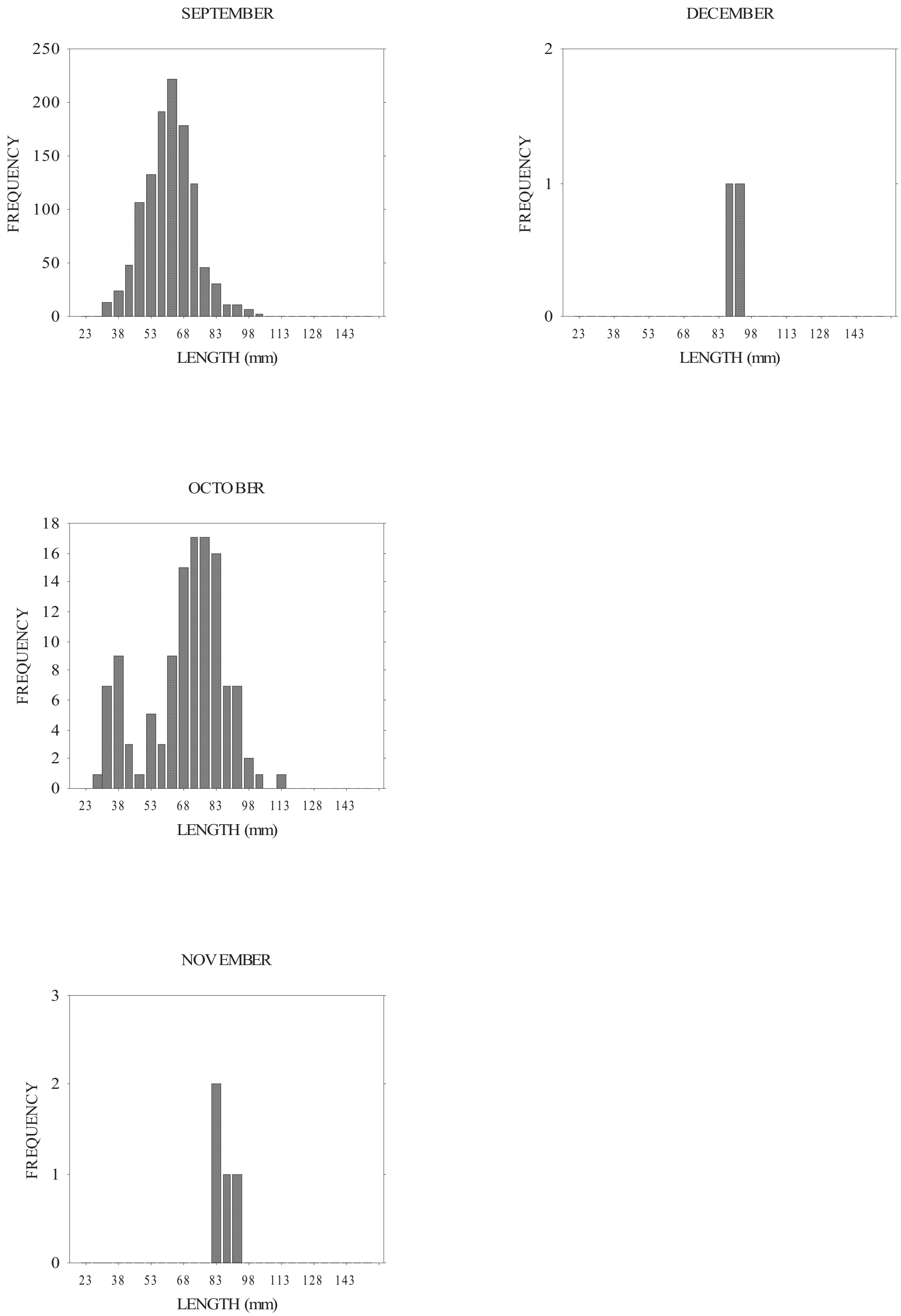


Figure 2-23. Continued.

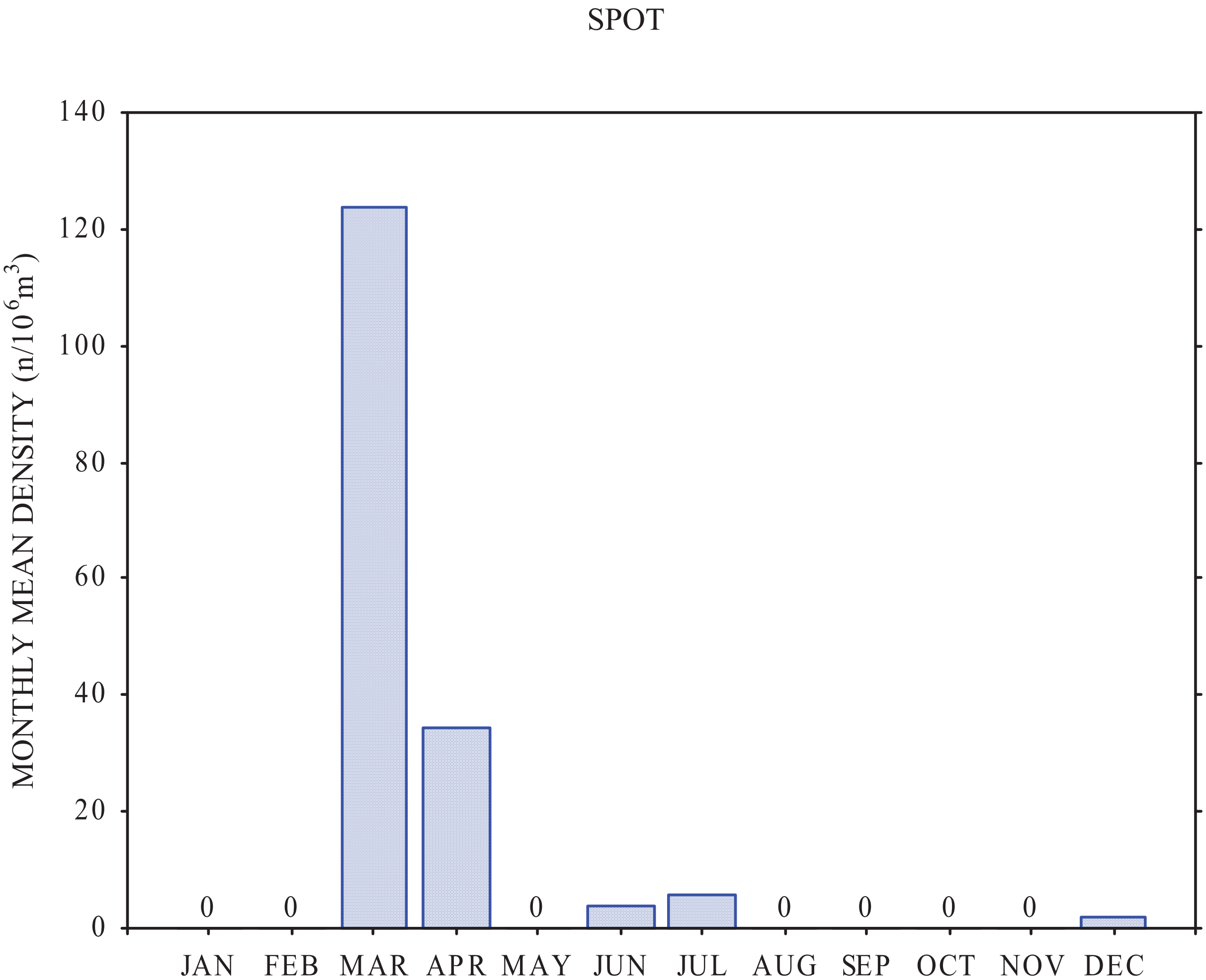


Figure 2-24. Monthly mean density (n/10^6 meters^3) of spot taken in impingement sampling at the Salem circulating water intake structure during 2006.

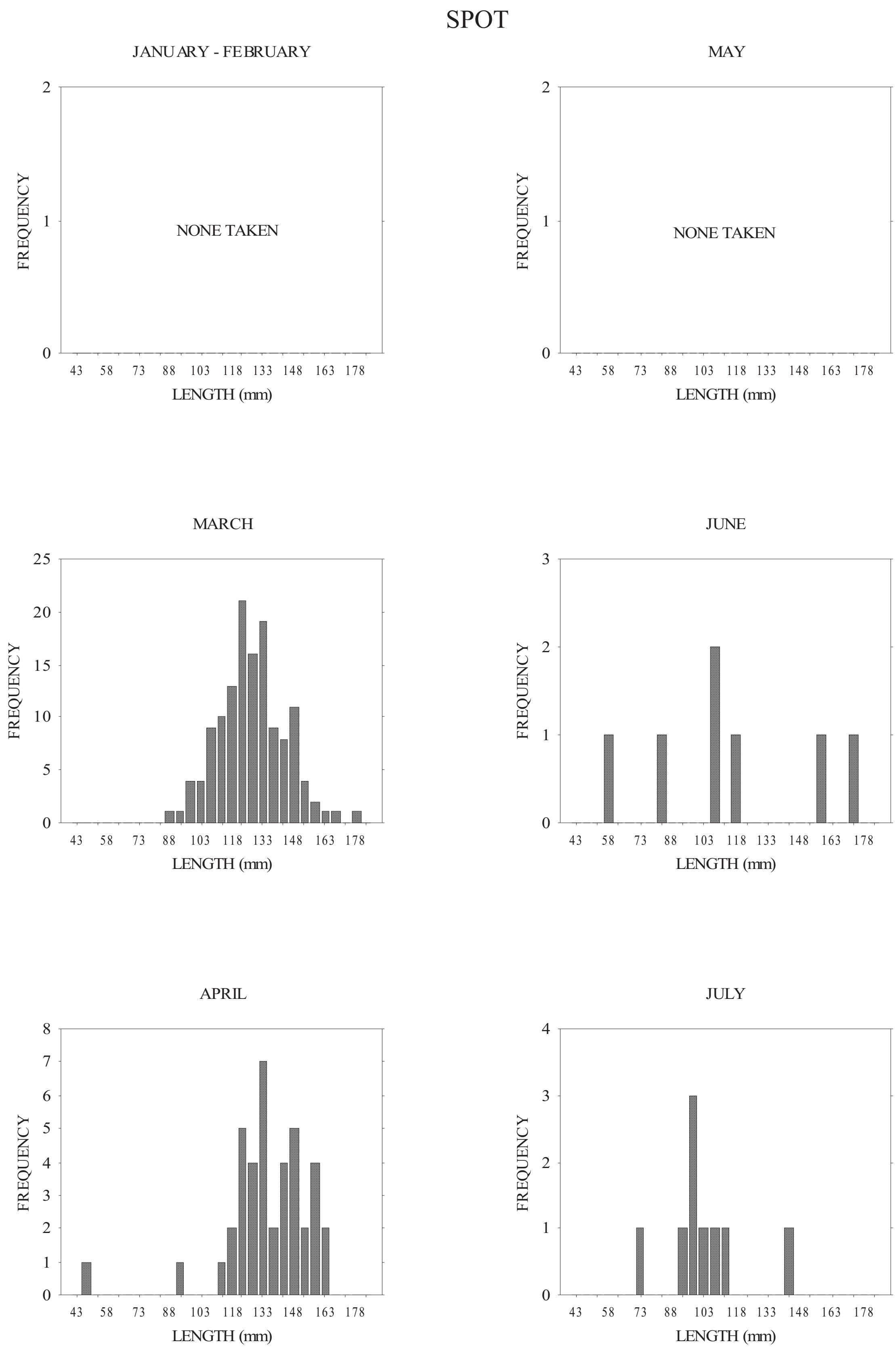


Figure 2-25. Length frequency of spot taken in impingement sampling at the Salem circulating water intake structure during 2006.

SPOT

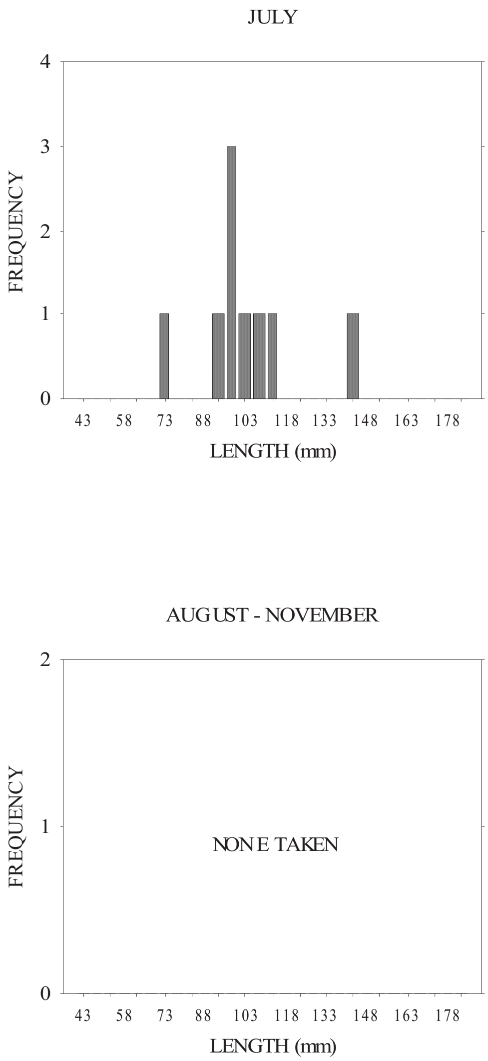


Figure 2-25. Continued.

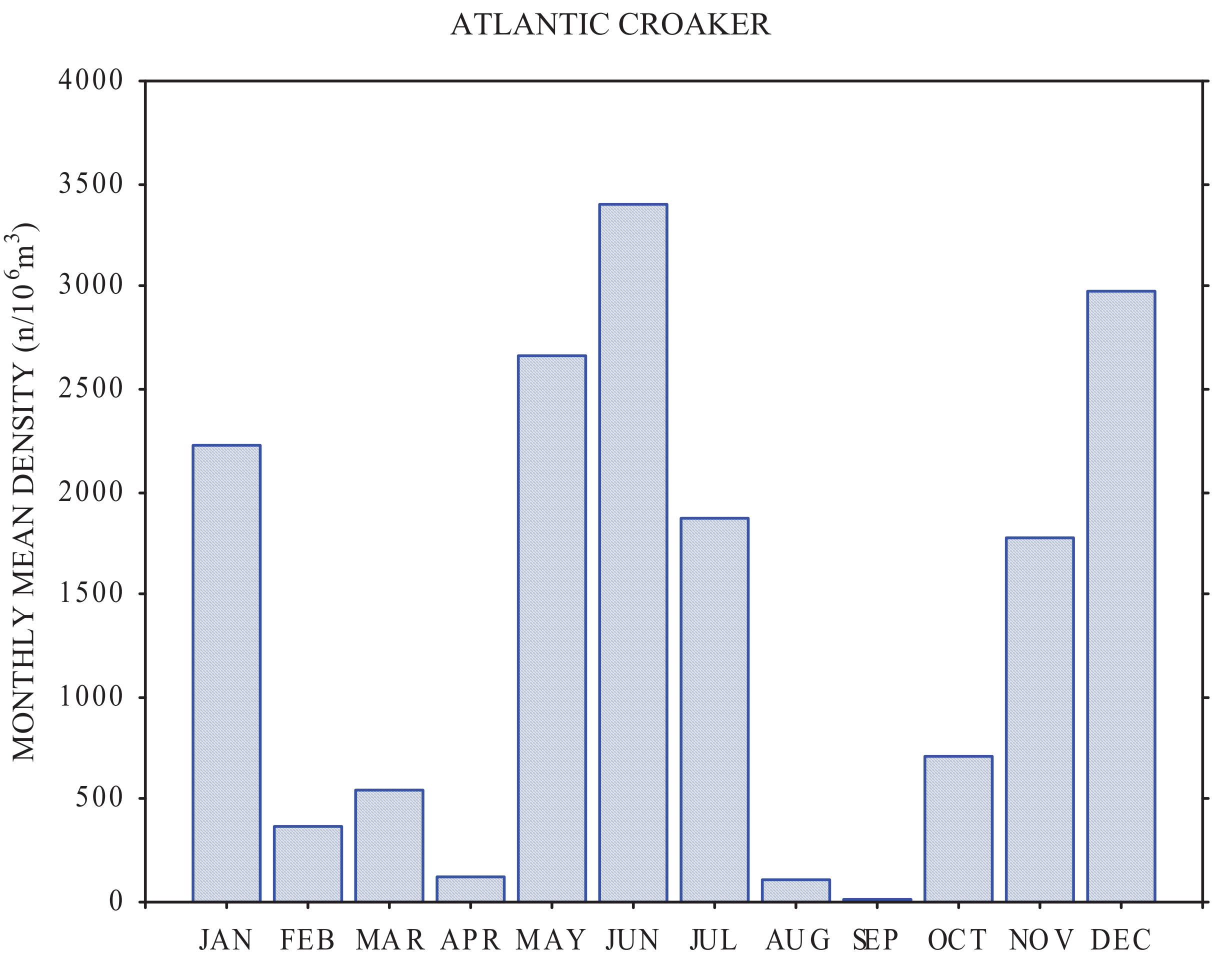


Figure 2-26. Monthly mean density (n/10^6 meters^3) of Atlantic croaker taken in impingement sampling at the Salem circulating water intake structure during 2006.

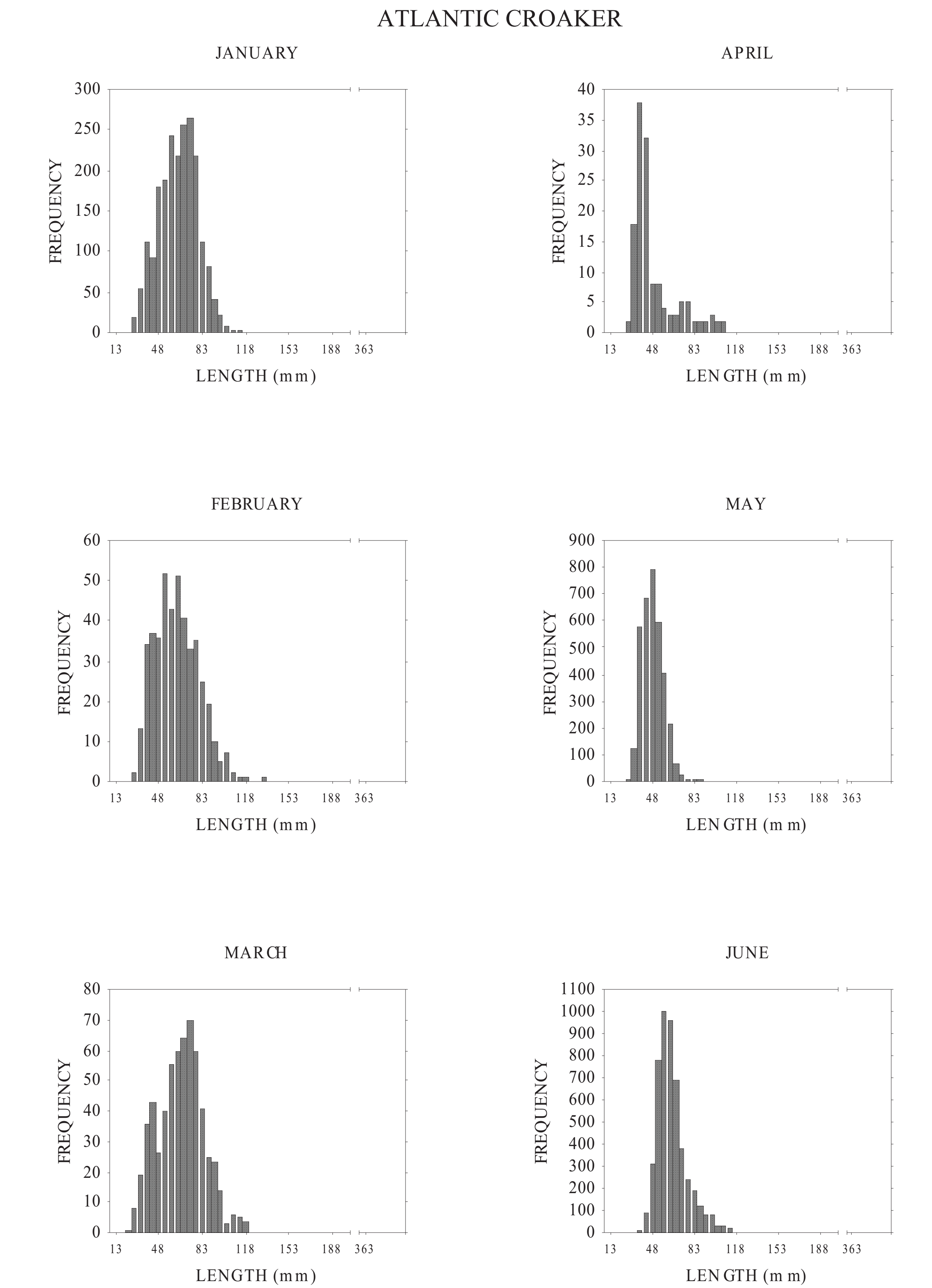


Figure 2-27. Length frequency of Atlantic croaker taken in impingement sampling at the Salem circulating water intake structure during 2006.

ATLANTIC CROAKER

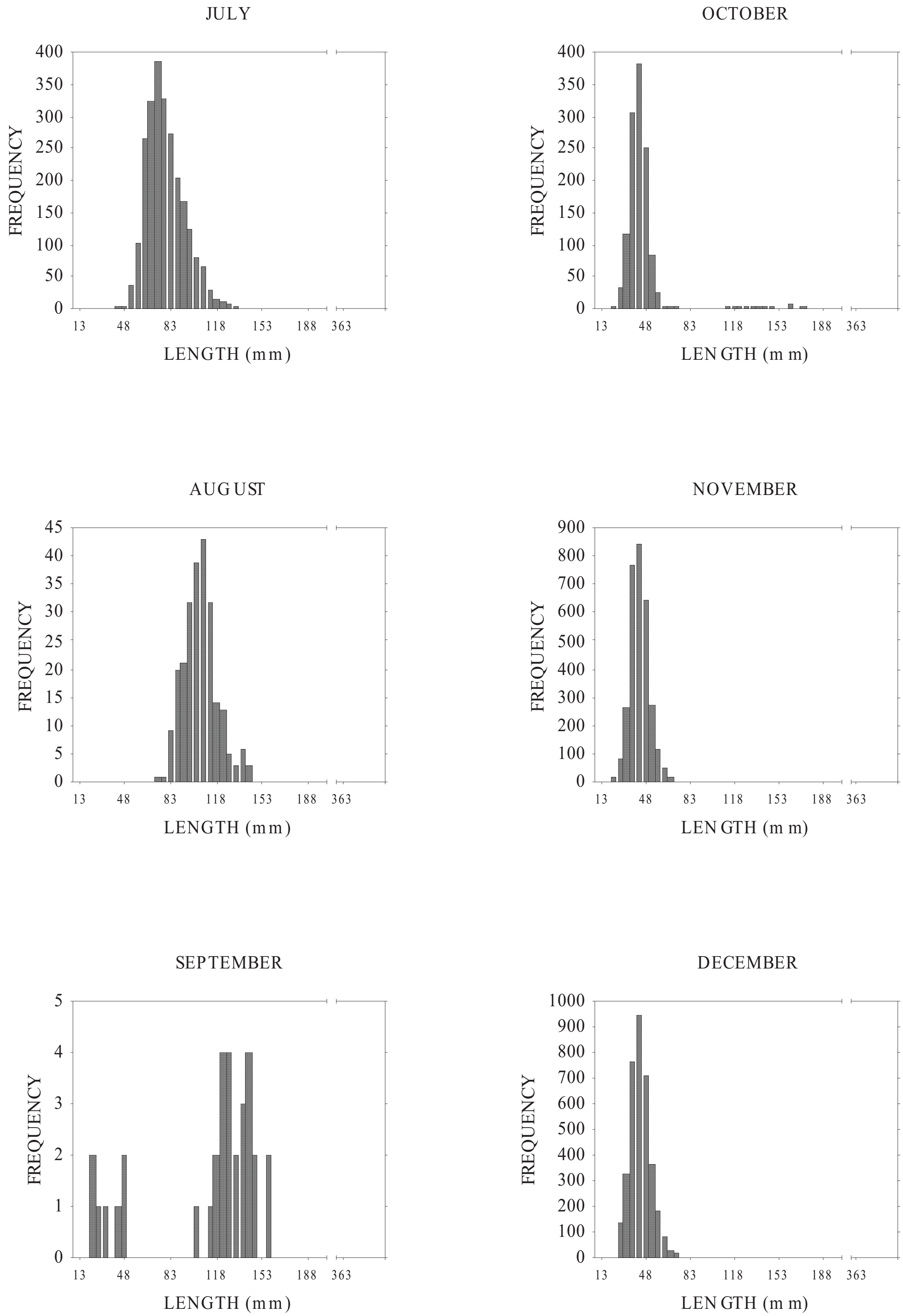


Figure 2-27. Continued.

CHAPTER 3: ENTRAINMENT ABUNDANCE

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ENTRAINMENT ABUNDANCE

INTRODUCTION

Entrainment monitoring is conducted annually as stipulated by the New Jersey Department of Environmental Protection in the New Jersey Pollutant Discharge Elimination System permit for Salem Generating Station, and will continue through the term of the permit. The specified monitoring was performed as described in the Procedures Manual for Biological Monitoring Program for the Delaware Estuary (PSEG 2002). The objective of this monitoring program is to produce accurate density estimates of fish entrained through the Circulating Water Intake System (CWIS) at Salem Units 1 and 2.

This chapter presents the overall results of sampling and specific findings for the year 2006 regarding the occurrence of the Salem finfish target species: blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic menhaden (*Brevoortia tyrannus*), bay anchovy (*Anchoa mitchilli*), Atlantic silverside (*Menidia menidia*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), and Atlantic croaker (*Micropogonias undulatus*). These species were defined in the Salem 316(b) Demonstration (PSE&G 1999).

MATERIALS AND METHODS

In 2006, entrainment abundance sampling was divided into two periods of frequency and intensity. During the months of January through March and August through December, routine entrainment sampling was scheduled during three 24-hour events per week with seven collections taken at approximately equal intervals during each event. During the months of April through July, intensive entrainment sampling occurred during four events scheduled each week with 14 samples scheduled at equal intervals during each event. Each event monitored a complete diel period encompassing two tidal cycles. All scheduled entrainment abundance samples were collected during 2006.

During each 24-hour sampling event, samples were collected at the midpoint of the water column in the intake bay of circulating water pump 12B or 22A, using the Paco (Model 52-6013-21-342000) fish pump and the entrainment abundance chamber (Figures 3-1, 3-2 and 3-3). The fish pump used for sampling was a 6-inch (15.2-cm), single-port impeller, centrifugal pump, and the abundance chamber consisted of a 260-gallon (1-m^3) cylindrical tank containing a 1.0-m diameter, 0.5-mm mesh, conical plankton net within which the sample was concentrated. The abundance chamber was filled with water during sampling, and cushioned the captured fish specimens against mechanical damage. The sample rate was approximately 1.0 m^3/minute. Sample volume and flow rate were determined using a Sparling Envirotech flowmeter (Model 115). Flowmeter calibration was checked and maintained within factory specifications on a monthly basis throughout 2006. Samples were preserved immediately in a 10 percent formalin/rose-bengal solution. During each sample, the following parameters were recorded: water temperature, salinity, tidal elevation and stage, and the number of circulating water pumps

and traveling screens in operation. Water temperature was measured with a field thermometer, and salinity was measured using a refractometer.

In the laboratory, all fish specimens were washed in freshwater, removed from the sample detritus, transferred to isopropanol, and identified to the lowest practicable taxonomic level, usually to species. Some specimens could not be identified to species because of the lack of identifying characteristics. Specimens that were in good condition but possessed no distinguishing characteristics were listed as ‘unidentified’ at the family level, while specimens in such poor physical condition that no genus or family level identification could be made were designated as 'unidentifiable fish'.

Each specimen's life stage was determined (i.e. egg, larva, juvenile, or adult) in accordance with the procedures manual (PSEG 2002), and the total number of each was recorded. For each species, the length of up to 50 specimens of each life stage, except eggs, was measured to the nearest 1 mm. Total length (TL) was used for all larvae and those juveniles and adults without forked tails. Fork length (FL) was used for those juveniles and adults with forked tails.

Densities are expressed as number per 100 cubic meters ($n/100m^3$). A volume-weighted mean density was calculated by dividing the total number of specimens in the samples by the total sample volume filtered during a given time period. Entrainment abundance and physical-chemical data were summarized by month and/or year. Sample collection and processing procedures are described in greater detail in the Procedures Manual for Biological Monitoring Program for the Delaware Estuary (PSEG 2002).

Only those fish designated as target species in the Salem 316(b) demonstration (PSE&G 1999) will be discussed in this section. Graphic presentations of abundance and length frequency data were prepared for those target species represented by at least ten total specimens of all life stages collected.

RESULTS AND DISCUSSION

Totals of 67,049 fish eggs, 71,095 larvae, 13,706 juveniles, and 224 adults representing at least 38 species were collected in 1,687 entrainment abundance samples, with 85,740.1 m^3 of sample water filtered during 2006 (Table 3-1). Specimens of at least ten of the twelve target species were collected. They were: blueback herring, alewife, Atlantic menhaden, bay anchovy, Atlantic silverside, white perch, striped bass, weakfish, spot, and Atlantic croaker. Monthly mean temperatures ranged from 6.0 to 25.5°C, and salinities from 1.7 to 9.7 ppt (Figure 3-4). A summary of collection data is presented below by phylogenic order for each target taxon.

Blueback herring - A total of three juvenile (≥20 mm) blueback herring was taken in entrainment abundance samples at Salem during January and March of 2006 (Table 3-1). The monthly mean densities ($n/100m^3$) were 0.02 in January and 0.04 in March, when the mean water temperature and salinities were 7.1 and 7.4°C and 3.0 and 8.9 ppt, respectively. The lengths of the individuals collected were 58 mm during January, and 60 and 64 mm during March.

Alewife - A total of 18 alewife, including 16 larvae and two juveniles, was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). Specimens representing at least one of these life stages were collected during January, and May through July (Figure 3-5). The abundance of alewife was highest in July with larvae being the predominant lifestage.

Alewife larvae (<20 mm) were taken during May, June, and July when water temperatures and salinities ranged from 17.4 to 25.0°C and 1.7 to 7.9 ppt, respectively (Figures 3-4 and 3-5). The annual mean density (n/100m^3) was 0.02 (Table 3-1). The monthly mean densities were 0.05 in May, 0.02 in June, and 0.06 in July (Figure 3-5).

The alewife juveniles (≥20 mm) were collected during January when mean water temperature and salinity was 7.1°C and 3.0 ppt, respectively (Figures 3-4 and 3-5). The annual mean density (n/100m^3) was <0.01 (Table 3-1). The monthly mean density was 0.04 (Figure 3-5).

Based on the specimens measured, the alewife collected during the 2006 entrainment abundance studies ranged in length from 3 to 56 mm (Figure 3-6). During January, individuals measured 55 and 56 mm. During May, June, and July, individuals ranged from 3 to 10 mm (Figure 3-6).

Additionally, a total of 20 unidentifiable herring larvae (Clupeidae) was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). The measurable fish, collected in February and May to July, were 3 to 28 mm in length. These fish may be river herring, gizzard shad (*Dorosoma cepedianum*), Atlantic menhaden, or Atlantic herring (*Clupea harengus*), but due to subtleties of known diagnostic taxonomic characters and the damaged condition of specimens, these individuals were not identifiable to species.

Atlantic menhaden - A total of 4,294 Atlantic menhaden, including one egg, 1,960 larvae and 2,333 juveniles, was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). Specimens representing at least one of these life stages were collected during all months other than August and September (Figure 3-7). The abundance of Atlantic menhaden was highest in March, with larval and juveniles lifestages being equally predominant.

The Atlantic menhaden egg was collected in June when the mean water temperature was 22.0°C, and salinity was 6.2 ppt (Figures 3-4 and 3-7). The annual mean density (n/100m^3) was <0.01 (Table 3-1). The monthly mean density was 0.01 (Figure 3-7).

Atlantic menhaden larvae (<30 mm) were taken during all months except August and September, when water temperatures and salinities ranged from 6.0 to 25.0°C and 1.7 to 9.7 ppt, respectively (Figures 3-4 and 3-7). The annual mean density (n/100m^3) was 2.29 (Table 3-1). The monthly mean densities were highest in March at 16.26, 7.12 in April, 3.24 in February and ≤0.98 during the other months of occurrence (Figure 3-7).

Atlantic menhaden juveniles (≥30 mm) were collected during January through June, and November and December, when mean water temperatures and salinities ranged from 6.0 to 22.0°C and 3.0 to 9.7 ppt, respectively (Figures 3-4 and 3-7). The annual mean density (n/100m^3) was 2.72 (Table 3-1). The monthly mean density (n/100m^3) was highest in March at

15.41, 11.05 in February, 5.53 and 3.44 in April and May, respectively, and was ≤0.83 during the other months of occurrence (Figure 3-7).

Based on the specimens measured, the Atlantic menhaden collected during the 2006 entrainment abundance studies ranged in length from 5 to 53 mm (Figure 3-8). During February through May, individuals from 20 to 40 mm comprised 94% of the total specimens measured. During this period, the modal lengths ranged from 29 to 32 mm. During the others months of occurrence, modes of distribution ranged from 22 to 26 mm.

Bay anchovy - A total of 86,985 bay anchovy, including 66,798 eggs, 17,482 larvae, 2,523 juveniles and 182 adults, was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). Specimens representing at least one of these life stages were collected in all months (Figure 3-9). Bay anchovy were most abundant in June, with eggs being the predominant lifestage.

Bay anchovy eggs were collected during the months of April through September when mean water temperatures ranged from 13.5 to 25.5°C, and salinity ranged from 1.7 to 9.7 ppt, respectively (Figures 3-4 and 3-9). The annual mean density ($n/100m^3$) was 77.91 (Table 3-1). The monthly mean density of eggs was highest in June at 327.09. It was 135.92 in May, and was ≤46.26 in other months in which they were taken (Figure 3-9).

Bay anchovy larvae (<20 mm) were collected during the months of May through October when mean water temperatures and salinities ranged from 16.6 to 25.5°C, and 1.7 to 8.9 ppt, respectively (Figures 3-4 and 3-9). The annual mean density ($n/100m^3$) was 20.39 (Table 3-1). Monthly mean density was highest in June at 92.94, intermediately high in July at 39.62 and was ≤14.96 during the other months of occurrence (Figure 3-9).

Bay anchovy juveniles (≥20 mm) were collected during all months except May, when mean water temperatures and salinities ranged from 6.0 to 25.5°C and from 1.7 to 9.7 ppt, respectively (Figures 3-4 and 3-9). Annual mean density ($n/100m^3$) was 2.94 (Table 3-1). The monthly mean density of juveniles was highest in July at 12.81 and intermediately high in August and September at 5.83 and 5.37. Densities were ≤1.65 during the other months of occurrence (Figure 3-9).

Bay anchovy adults were taken during the months of March through July, and November with an annual mean density of 0.21 (Table 3-1 and Figure 3-9). Monthly mean densities ranging from 0.04 to 0.89 (Figure 3-9). Monthly mean water temperatures and salinities ranged from 7.4 to 25.5°C and from 1.7 to 9.7 ppt, respectively (Figure 3-4).

Based on the subsample of the specimens measured, the bay anchovy collected during the 2006 entrainment abundance studies ranged in length from 3 to 89 mm, and 95% were 3 to 30 mm (Figure 3-10). Modal lengths in June, July, and August, the months of relatively high bay anchovy abundance, were 8 and 12 mm in June and August, respectively, and the distribution was bi-modal at 10 and 18 mm in July.

***Menidia* spp.** – A total of 249 Atlantic silversides, including 45 eggs, 184 larvae, 11 juveniles and 9 adults, was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). Additionally, 11 inland silversides (*Menidia beryllina)*, including 2 eggs, 8 larvae, and 1 juvenile; 117 rough silverside eggs (*Membras martinica*); and 1,919 *Menidia* spp. (*Menidia/Membras* spp.), including 3 eggs, 1,894 larvae, 21 juveniles, and 1 adult; were identified. These silversides were combined in the following discussion and graphic presentations. This combination was prompted by the distributional overlap, the subtleties of diagnostic and taxonomic features, and the compromised condition of collected specimens. Hence, the summary presented below includes the aggregate total of 2,296 *Menidia* spp., including 167 eggs, 2,086 larvae, 33 juveniles, and 10 adults. Specimens representing at least one of the above listed life stages were collected during all months except January, March, October, and November (Figure 3-11). *Menidia* spp. was most abundant in June, with larvae being the predominant lifestage.

Menidia spp. eggs were collected during May through August when mean water temperatures and salinities ranged from 17.4 to 25.5°C and 1.7 to 8.9 ppt, respectively (Figures 3-4 and 3-11). The annual mean density (n/100m^3) was 0.19 (Table 3-1). The monthly mean density of eggs was similar in the months of May, June, and July at 0.55, 0.35, and 0.42 and 0.06 in August (Figure 3-11).

Menidia spp. larvae (<15 mm) were collected during May through September when mean water temperatures and salinities ranged from 17.4 to 25.5°C and 1.7 to 8.9 ppt, respectively (Figures 3-4 and 3-11). The annual mean density (n/100m^3) was 2.43 (Table 3-1). The monthly mean density of larvae was similarly high in May and June at 6.21 and 6.41, and was ≤ 3.86 in the other months of occurrence (Figure 3-11).

Menidia spp. juveniles (≥15 - 20 mm) were taken during May through August when the mean water temperatures and salinities ranged from 17.4 to 25.5°C and 1.7 to 8.9 ppt, respectively (Figures 3-4 and 3-11). The annual mean density (n/100m^3) was 0.04 (Table 3-1). The monthly mean densities were highest in June at 0.15 and were ≤ 0.05 in the other months of occurrence (Figure 3-11).

Menidia spp. adults (>20 mm) were taken during the months of February, April, June through August, and December when the mean water temperatures and salinities ranged from 6.0 to 25.5°C and 1.7 to 9.7 ppt, respectively (Figures 3-4 and 3-11). The annual mean density (n/100m^3) was 0.01 (Table 3-1). The monthly mean density was highest in December at 0.05 (Figure 3-11).

Based on the specimens measured, the *Menidia* spp. collected during the 2006 entrainment abundance studies ranged in length from 3 to 70 mm; however 98 % of those measured were from 3 to 15mm (Figure 3-12). In the months of highest abundance, May through July, the modal length was 5 mm.

White perch - A total of 472 white perch larvae (<20 mm) was taken in entrainment abundance

samples at Salem during 2006 (Table 3-1). They were collected during the month of July when mean water temperature and salinity was 25.0ºC and 1.7 ppt (Figures 3-4 and 3-13). The annual mean density (n/100m^3) was 0.55 (Table 3-1). The monthly mean density was 4.06 (Figure 3-13).

Based on the specimens measured, the white perch larvae collected during the 2006 entrainment abundance studies ranged in length from 3 to 19 mm; however 90% of those individuals ranged from 3 to 10 mm (Figure 3-14). The modal length was 4 mm.

Striped bass - A total of 468 striped bass, including 34 eggs, 415 larvae and 19 juveniles, was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). Specimens representing at least one of these life stages were collected during the months of April through July (Figure 3-15). Striped bass were most abundant in May, with larvae being the predominant lifestage.

Striped bass eggs were collected during April and May when mean water temperatures were 13.5 and 17.4°C and salinities were 9.7 and 7.9 ppt, respectively (Figures 3-4 and 3-15). The annual mean density (n/100m^3) was 0.04 (Table 3-1). The monthly mean densities of eggs in April and May were 0.06 and 0.21, respectively (Figure 3-15).

Striped bass larvae (<20 mm) were taken during May, June and July, when water temperatures and salinities ranged from 17.4 to 25.0°C and 1.7 to 7.9 ppt, respectively (Figures 3-4 and 3-15). The annual mean density (n/100m^3) was 0.48 (Table 3-1). The monthly mean densities were 1.96, 0.40, and 0.98 in May, June and July, respectively (Figure 3-15).

Striped bass juveniles (≥20 mm) were collected during June and July when mean water temperatures were 22.0 and 25.0°C and salinities were 6.2 and 1.7 ppt, respectively (Figures 3-4 and 3-15). The annual mean density (n/100m^3) was 0.02 (Table 3-1). The monthly mean densities in June and July were 0.05 and 0.11, respectively (Figure 3-15).

Based on the specimens measured, the striped bass collected during the 2006 entrainment abundance studies ranged in length from 4 to 45 mm. Individuals ranging from 5 to 18 mm comprised 93 % of the sample., In May, June and July, the modal lengths were 6, 17, and 12 mm, respectively (Figure 3-16).

***Morone* spp.** - A total of 95 *Morone* spp. larvae (<20 mm) was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). They were collected during the months of May through July when mean water temperatures and salinities ranging from 17.4 to 25.0ºC and from 1.7 to 7.9 ppt, respectively (Figures 3-4 and 3-17). The annual mean density (n/100m^3) was 0.11 (Table 3-1). The highest monthly mean density of 0.62 occurred in July, and densities were ≤0.16 during the other months of occurrence (Figure 3-17).

Based on the specimens measured, the *Morone* spp. larvae collected during the 2006 entrainment abundance studies ranged in length from 3 to 14 mm; however 52% of those individuals ranged from 5 to 7 mm (Figure 3-18). The modal lengths in July, the month of highest abundance, were 6 and 7 mm.

Weakfish - A total of 603 weakfish, including 46 eggs, 373 larvae and 184 juveniles, was taken in entrainment abundance samples at Salem during 2006 (Table 3-1). Specimens representing at least one of these life stages were collected during the months of May through September (Figure 3-19). Weakfish were most abundant in August, with larvae being the predominant lifestage.

The weakfish eggs were collected in May through July when mean water temperatures and salinities ranged from 17.4 to 25.0ºC and from 1.7 to 7.9 ppt, respectively (Figures 3-4 and 3-19). The annual mean density ($n/100m^3$) was 0.05 (Table 3-1). The monthly mean density was highest in June at 0.27, and was 0.03 and 0.06 in May and July respectively (Figure 3-19).

Weakfish larvae (<10.5 mm) were taken during June through September, when water temperatures and salinities ranged from 21.4 to 25.5°C and 1.7 to 8.9 ppt, respectively (Figures 3-4 and 3-19). The annual mean density ($n/100m^3$) was 0.44 (Table 3-1). The monthly mean densities were similarly high in June and August at 1.67 and 1.73 respectively, and were ≤0.57 during the other months of occurrence (Figure 3-19).

Weakfish juveniles (≥10.5 mm) were collected during the months of June through September, when water temperatures and salinities ranged from 21.4 to 25.5°C and 1.7 to 8.9 ppt, respectively (Figures 3-4 and 3-19). The annual mean density ($n/100m^3$) was 0.21 (Table 3-1). The highest monthly mean density of 0.95 occurred in August, and densities were ≤0.57 during the other months of occurrence (Figure 3-19).

Based on the specimens measured, the weakfish collected during the 2006 entrainment abundance studies ranged in length from 3 to 49 mm (Figure 3-20). During June, July and August, 66% of the individuals ranged from 4 to 10 mm. The modal lengths during these months were 5, 9 and 10 mm respectively.

Spot – One spot larva was collected in entrainment abundance monitoring samples at Salem during May, 2006 (Table 3-1). The annual density ($n/100m^3$) was <0.01, the monthly density was 0.01, and mean monthly water temperature and salinity were 17.4°C and 7.9 ppt, (Figure 3-4). The larva was 3 mm.

Atlantic croaker - A total of 9,012 Atlantic croaker, including 630 larvae and 8,382 juveniles, was collected in entrainment abundance monitoring samples at Salem during 2006 (Table 3-1). Specimens were collected in all months (Figure 3-21). Atlantic croaker was most abundant in October, with juveniles being the predominant life stage.

Atlantic croaker larvae (<11 mm) were collected during the months of February, and June through December at mean water temperatures and salinities ranging from 6.0 to 25.5°C and 1.7 to 8.9 ppt, respectively (Figures 3-4 and 3-21). The annual mean density ($n/100m^3$) was 0.73 (Table 3-1). The monthly mean density was highest in October at 8.52, and was intermediately high at 4.06 in September. Densities were ≤0.50 during the other months of occurrence (Figure 3-21).

Atlantic croaker juveniles (≥11 mm) were taken during all months of 2006 at water temperatures and salinities ranging from 6.0 to 25.5°C and from 1.7 to 9.7 ppt, respectively (Figures 3-4 and 3-21). The annual mean density ($n/100m^3$) was 9.78 (Table 3-1). Monthly mean densities were similarly high in October and November at 65.40, and 55.90, respectively. During the other months of occurrence, densities were ≤17.02 (Figure 3-21).

Based on the specimens measured, the Atlantic croaker collected in the 2006 entrainment abundance samples ranged in length from 4 to 93 mm, and 92% of those individuals measured were from 7 to 30 mm (Figure 3-22). In October, the month of highest Atlantic croaker abundance, the modal length was 12 mm (Figure 3-22).

Sciaenidae - One sciaenid (weakfish/Atlantic croaker) larva was collected in entrainment abundance monitoring samples at Salem during July, 2006 (Table 3-1). The monthly density ($n/100m^3$) was <0.01 and mean monthly water temperature and salinity were 25.0°C and 1.7 ppt, (Figure 3-4). The larva was 7 mm.

LITERATURE CITED

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Public Service Enterprise Group (PSEG). 2002. Procedures Manual for Biological Monitoring Program for the Delaware Estuary.

Table 3-1				
Annual summary of finfish species, number collected, and mean density, taken in entrainment abundance collections at the Salem Generating Station Circulating Water Intake Structure, during January through December 2006				
Number of Samples = 1,687				
Total volume filtered (cubic meters) = 85,740.1				
Lifestage	Common name	Scientific name	Number	Density (n/100m³)
Eggs	Unidentifiable egg		2	<0.01
	Atlantic menhaden	*Brevoortia tyrannus*	1	<0.01
	Bay anchovy	*Anchoa mitchilli*	66,798	77.91
	Rough silverside	*Membras martinica*	117	0.14
	Unidentifiable silverside	Antherinidae	3	<0.01
	Inland silverside	*Menidia beryllina*	2	<0.01
	Atlantic silverside	*Menidia menidia*	45	0.05
	Striped bass	*Morone saxatilis*	34	0.04
	Weakfish	*Cynoscion regalis*	46	0.05
	Naked goby	*Gobiosoma bosc*	1	<0.01
Larvae	Unidentifiable larvae		48	0.06
	American eel	*Anguilla rostrata*	89	0.10
	Unidentifiable herring	Clupeidae	20	0.02
	Alewife	*Alosa pseudoharengus*	16	0.02
	Atlantic herring	*Clupea harengus*	2	<0.01
	Atlantic menhaden	*Brevoortia tyrannus*	1,960	2.29
	Bay anchovy	*Anchoa mitchilli*	17,482	20.39
	Unidentifiable minnow	Cyprinidae	200	0.23
	Carp	*Cyprinus carpio*	2	<0.01
	Unidentifiable sucker	*Catostomidae*	1	<0.01
	Quillback	*Carpiodes cyprinus*	75	0.09
	White sucker	*Catostomus commersoni*	1	<0.01
	Channel catfish	*Ictalurus punctatus*	1	<0.01
	Unidentifiable killifish	*Fundulus* spp.	17	0.02
	Mummichog	*Fundulus heteroclitus*	4	<0.01
	Striped killifish	*Fundulus majalis*	1	<0.01
	Unidentifiable silverside	Antherinidae	1,894	2.21
	Inland silverside	*Menidia beryllina*	8	0.01
	Atlantic silverside	*Menidia menidia*	184	0.21
	Northern pipefish	*Syngnathus fuscus*	2	<0.01
	White perch/striped bass	*Morone* spp.	95	0.11
	White perch	*Morone americana*	472	0.55
	Striped bass	*Morone saxatilis*	415	0.48
	Unidentifiable sunfish	Centrarchidae	1	<0.01
	Yellow perch	*Perca flavescens*	1	<0.01
	Unidentifiable drum	Sciaenidae	1	<0.01
	Weakfish	*Cynoscion regalis*	373	0.44
	Silver perch	*Bairdiella chrysoura*	9	0.01
	Spot	*Leiostomus xanthurus*	1	<0.01
	Atlantic croaker	*Micropogonias undulatus*	630	0.73

Table 3-1				
Lifestage	Common name	Scientific name	Number	Density (n/100m³)
	Tautog	*Tautoga onitis*	2	<0.01
	Naked goby	*Gobiosoma bosc*	46,975	54.79
	Green goby	*Microgobius thalassinus*	7	0.01
	Smallmouth flounder	*Etropus microstomus*	1	<0.01
	Summer flounder	*Paralichthys dentatus*	30	0.03
	Windowpane	*Scophthalmus aquosus*	1	<0.01
	Winter flounder	*Pleuronectes americanus*	3	<0.01
	Hogchoker	*Trinectes maculatus*	71	0.08
Juveniles	Unidentifiable juvenile		1	<0.01
	American eel	*Anguilla rostrata*	13	0.02
	Blueback herring	*Alosa aestivalis*	3	<0.01
	Alewife	*Alosa pseudoharengus*	2	<0.01
	Atlantic menhaden	*Brevoortia tyrannus*	2,333	2.72
	Bay anchovy	*Anchoa mitchilli*	2,523	2.94
	Spotted hake	*Urophycis regia*	11	0.01
	Atlantic needlefish	*Strongylura marina*	2	<0.01
	Mummichog	*Fundulus heteroclitus*	6	0.01
	Unidentifiable silverside	Antherinidae	21	0.02
	Inland silverside	*Menidia beryllina*	1	<0.01
	Atlantic silverside	*Menidia menidia*	11	0.01
	Northern pipefish	*Syngnathus fuscus*	33	0.04
	Striped bass	*Morone saxatilis*	19	0.02
	Weakfish	*Cynoscion regalis*	184	0.21
	Silver perch	*Bairdiella chrysoura*	3	<0.01
	Northern kingfish	*Menticirrhus saxatilis*	2	<0.01
	Atlantic croaker	*Micropogonias undulatus*	8,382	9.78
	Naked goby	*Gobiosoma bosc*	64	0.07
	Green goby	*Microgobius thalassinus*	3	<0.01
	Smallmouth flounder	*Etropus microstomus*	3	<0.01
	Summer flounder	*Paralichthys dentatus*	76	0.09
	Winter flounder	*Pleuronectes americanus*	7	0.01
	Hogchoker	*Trinectes maculatus*	1	<0.01
	Blackcheek tonguefish	*Symphurus plagiusa*	2	<0.01
Adults	Bay anchovy	*Anchoa mitchilli*	182	0.21
	Striped cusk-eel	*Ophidion marginata*	1	<0.01
	Unidentifiable silverside	Antherinidae	1	<0.01
	Atlantic silverside	*Menidia menidia*	9	0.01
	Northern pipefish	*Syngnathus fuscus*	5	0.01
	Silver perch	*Bairdiella chrysoura*	1	<0.01
	Naked goby	*Gobiosoma bosc*	25	0.03
Summary	Eggs		67,049	78.20
	Larvae		71,095	82.92
	Juveniles		13,706	15.99
	Adults		224	0.26

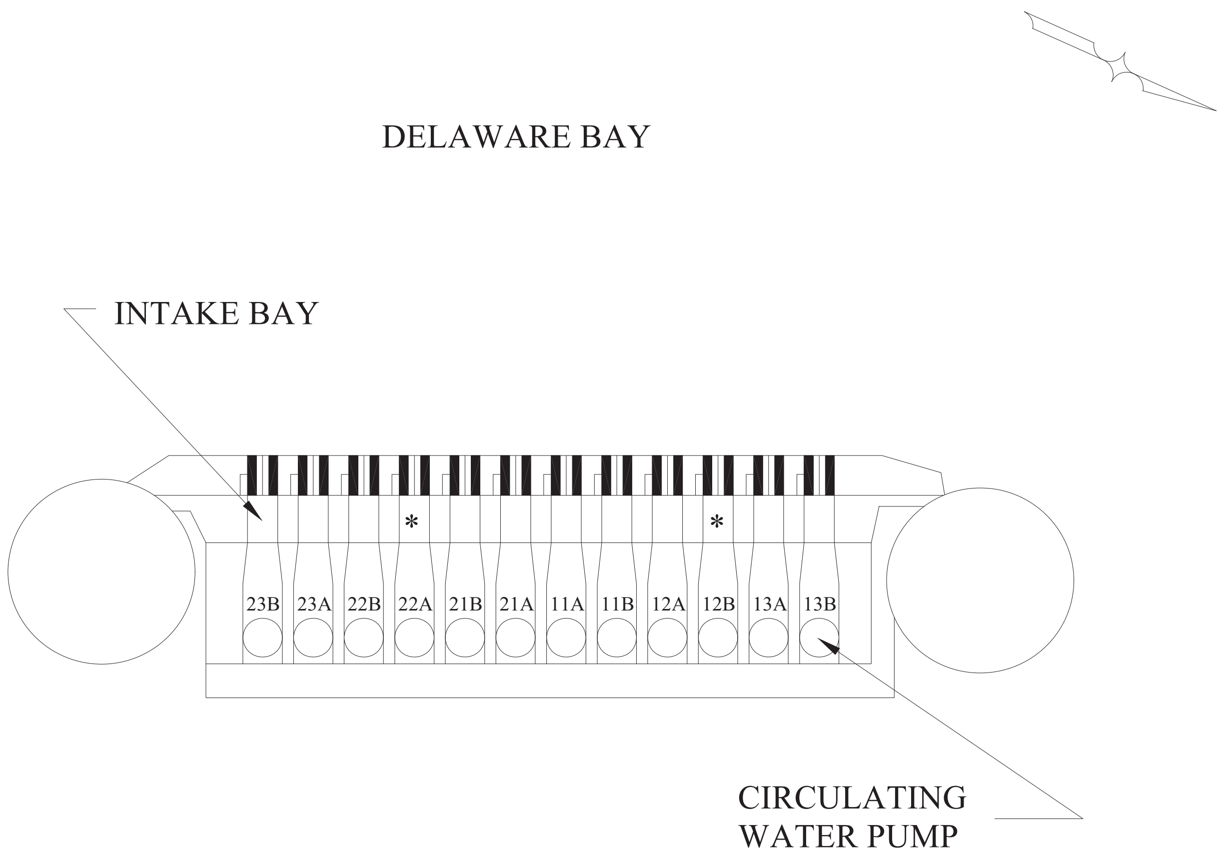

Figure 3-1. Schematic of Salem Generating Station circulating water intake structure with entrainment abundance sampling locations indicated by *.

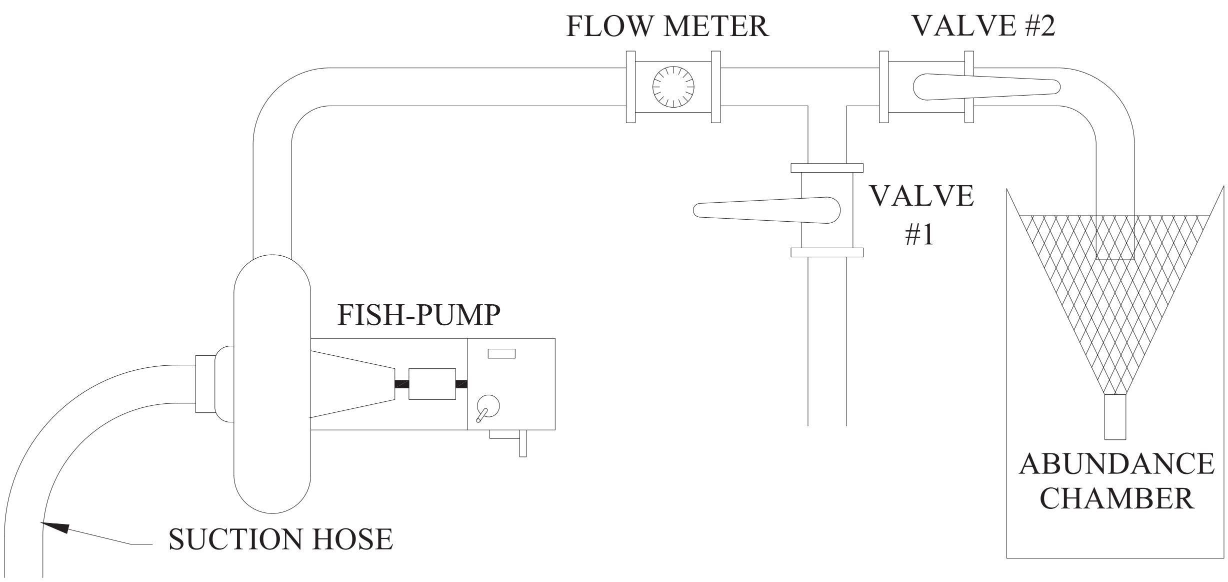

Figure 3-2. Plankton pump and abundance chamber used in entrainment sampling.

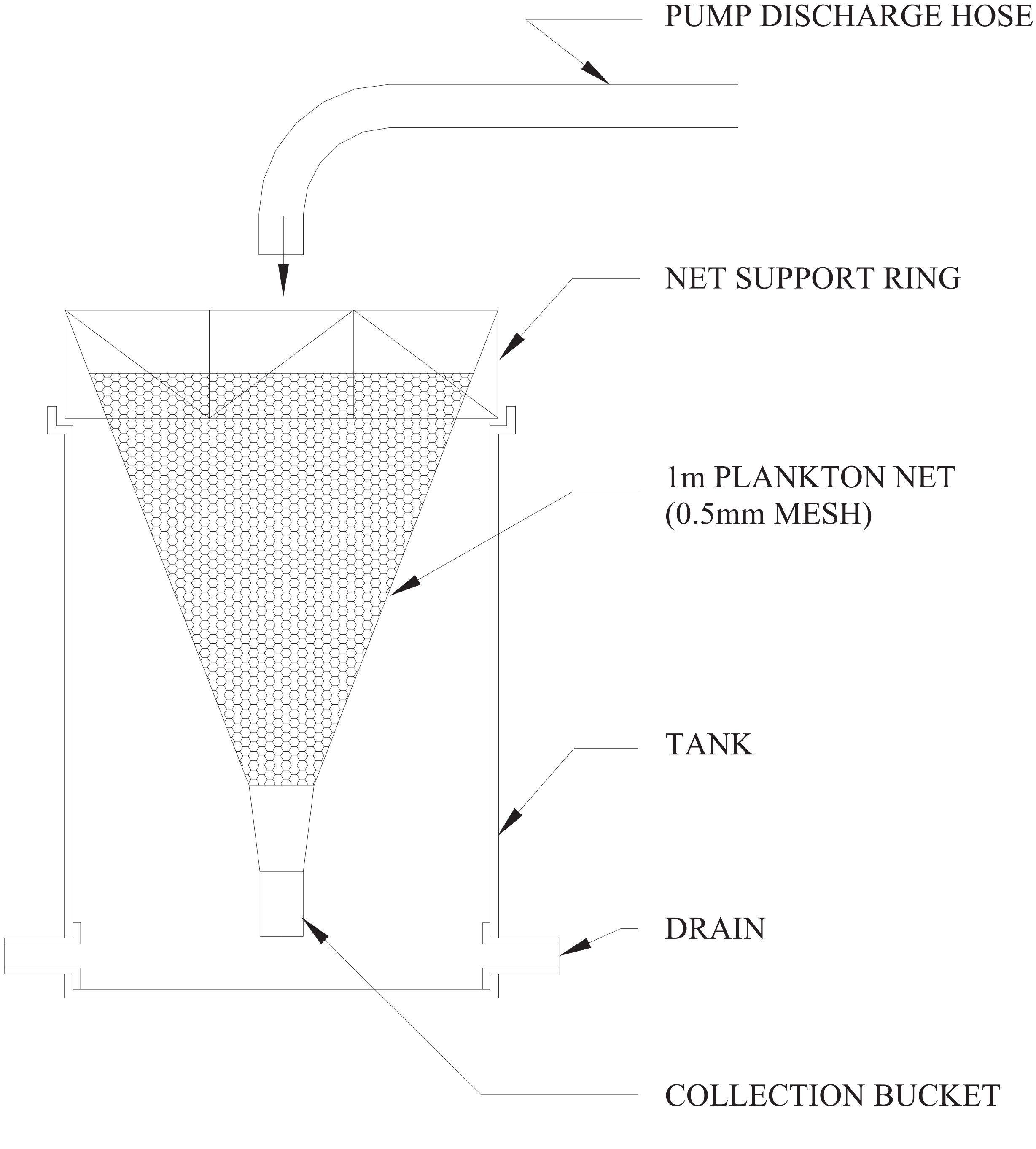

Figure 3-3. Cut away view showing entrainment collection net inside abundance chamber.

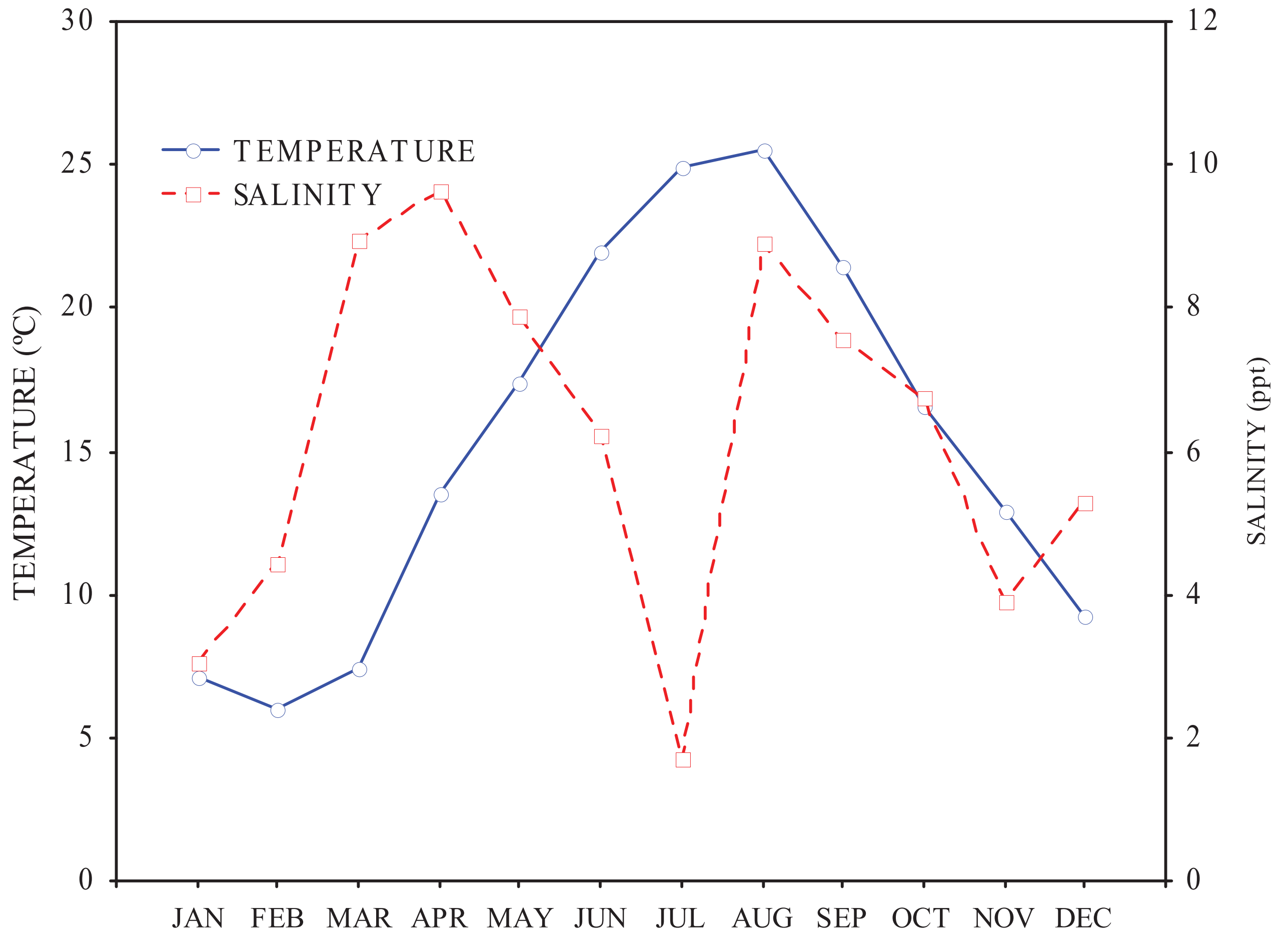

Figure 3-4. Salinity and temperature (mean) by month as observed during 2006 impingement sampling.

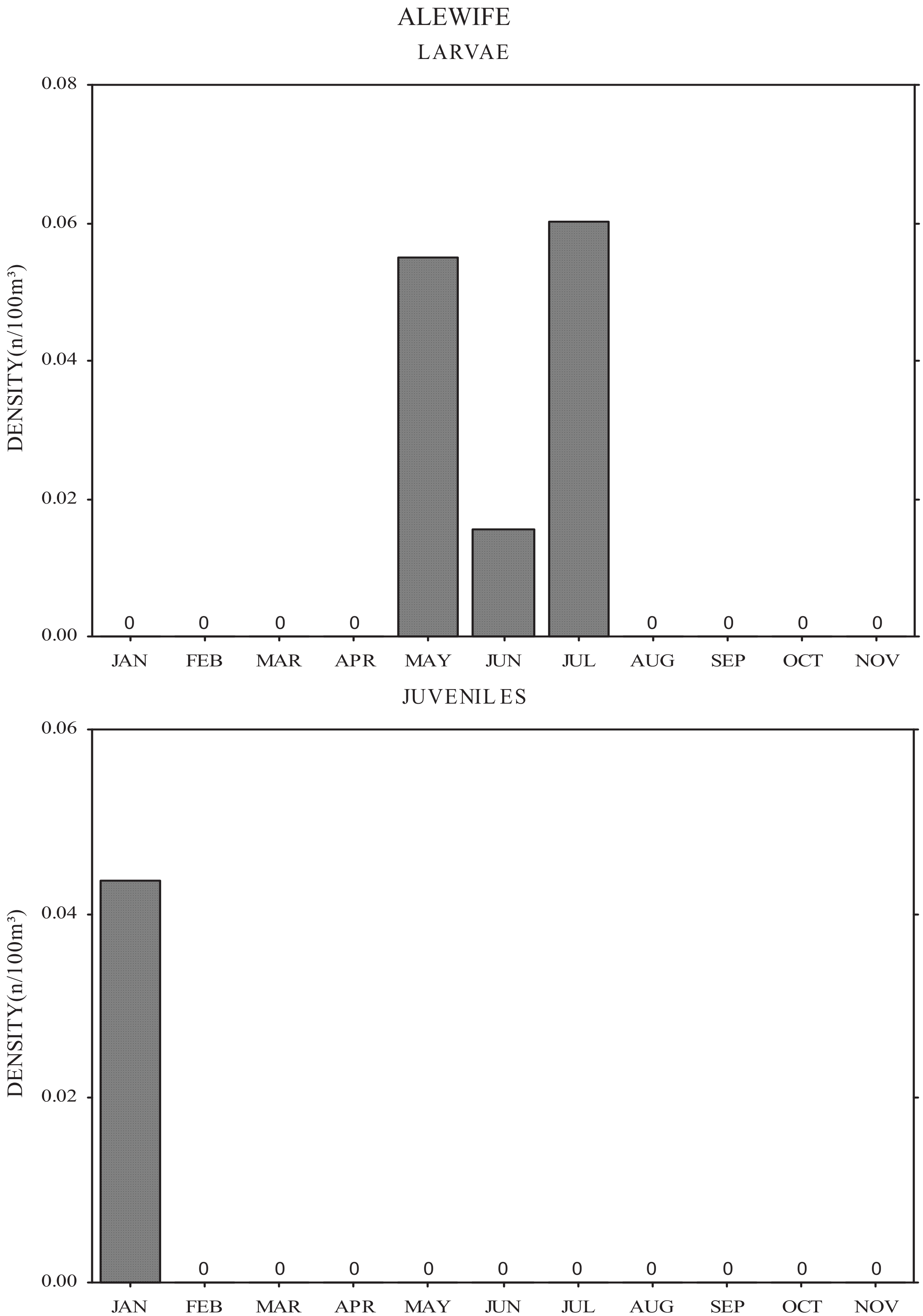

Figure 3-5. Monthly mean density (n/100m^3) of alewife larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2006.

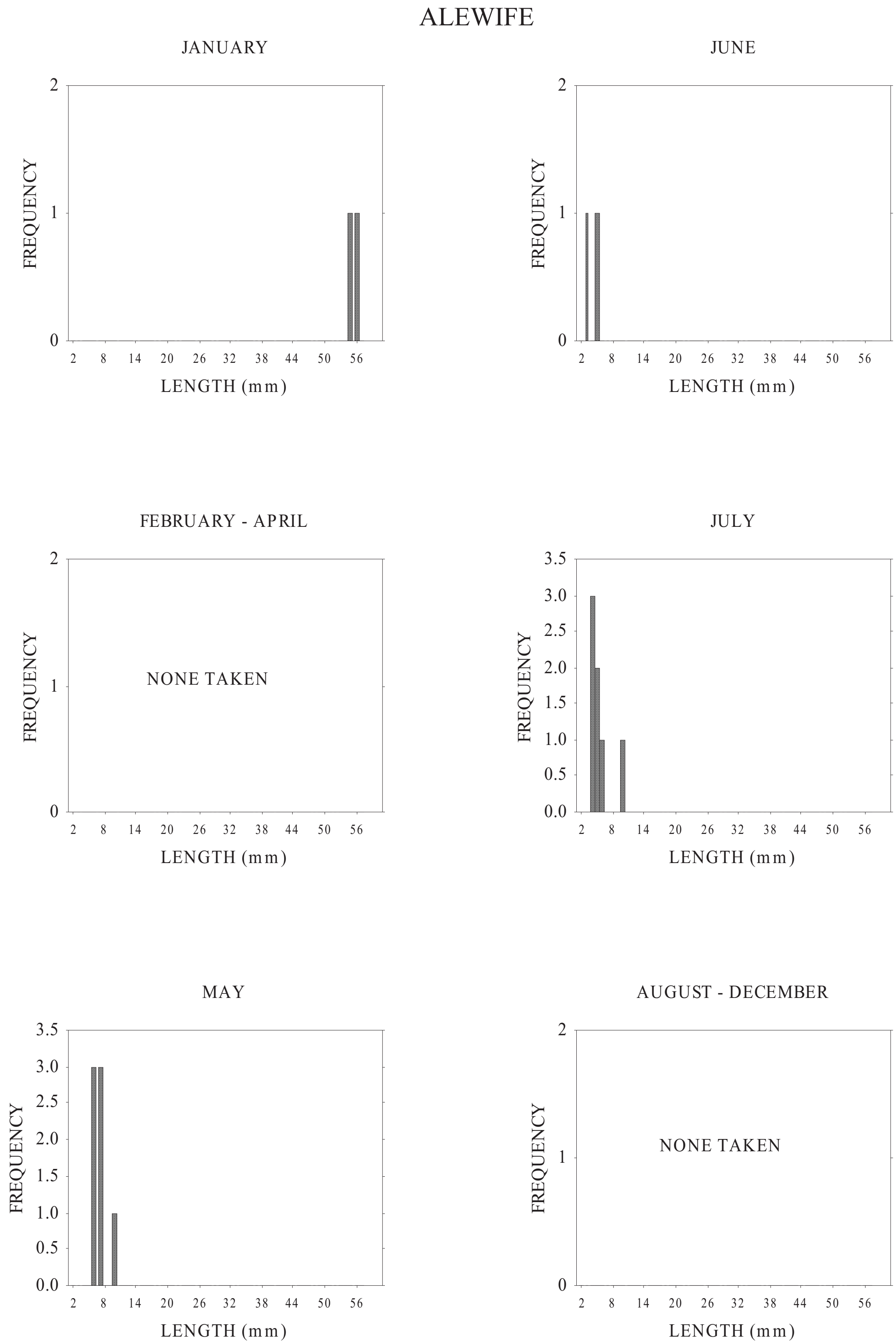

Figure 3-6. Length frequency of alewife taken in entrainment sampling at the Salem circulating water intake structure during 2006.

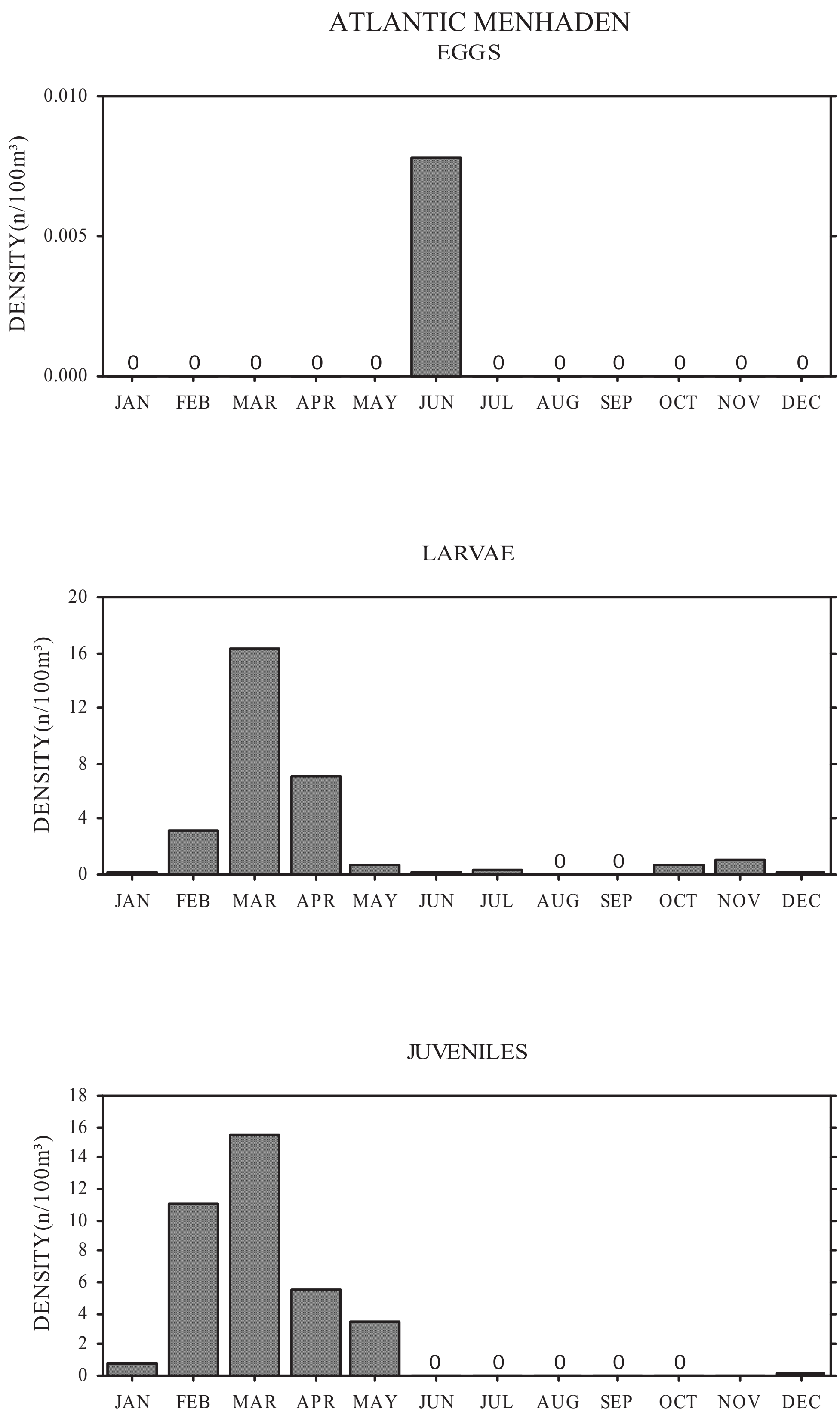

Figure 3-7. Monthly mean density (n/100m^3) of Atlantic menhaden eggs, larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2006.

ATLANTIC MENHADEN

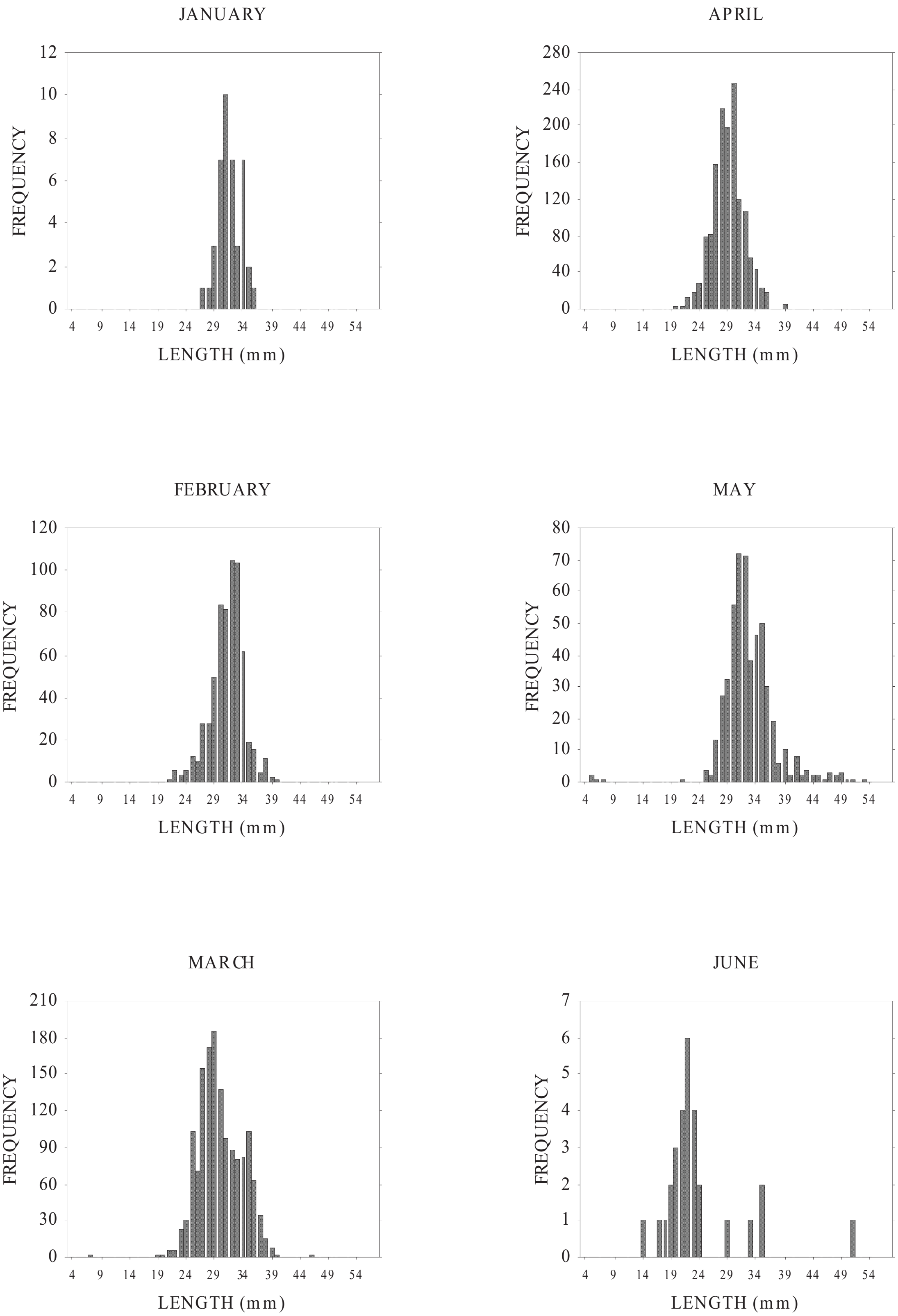

Figure 3-8. Length frequency of Atlantic menhaden taken in entrainment sampling at the Salem circulating water intake structure during 2006.

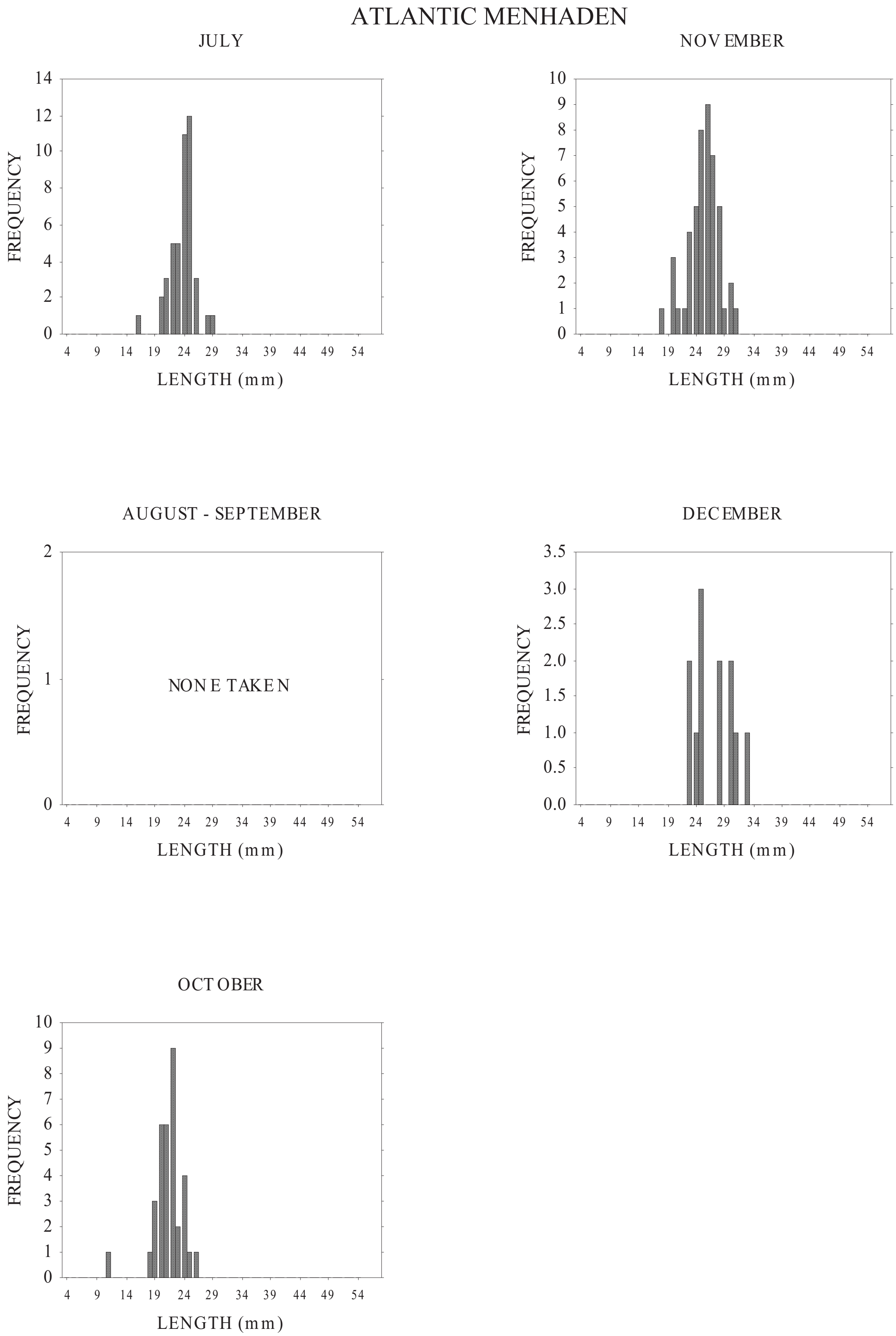

Figure 3-8. Continued.

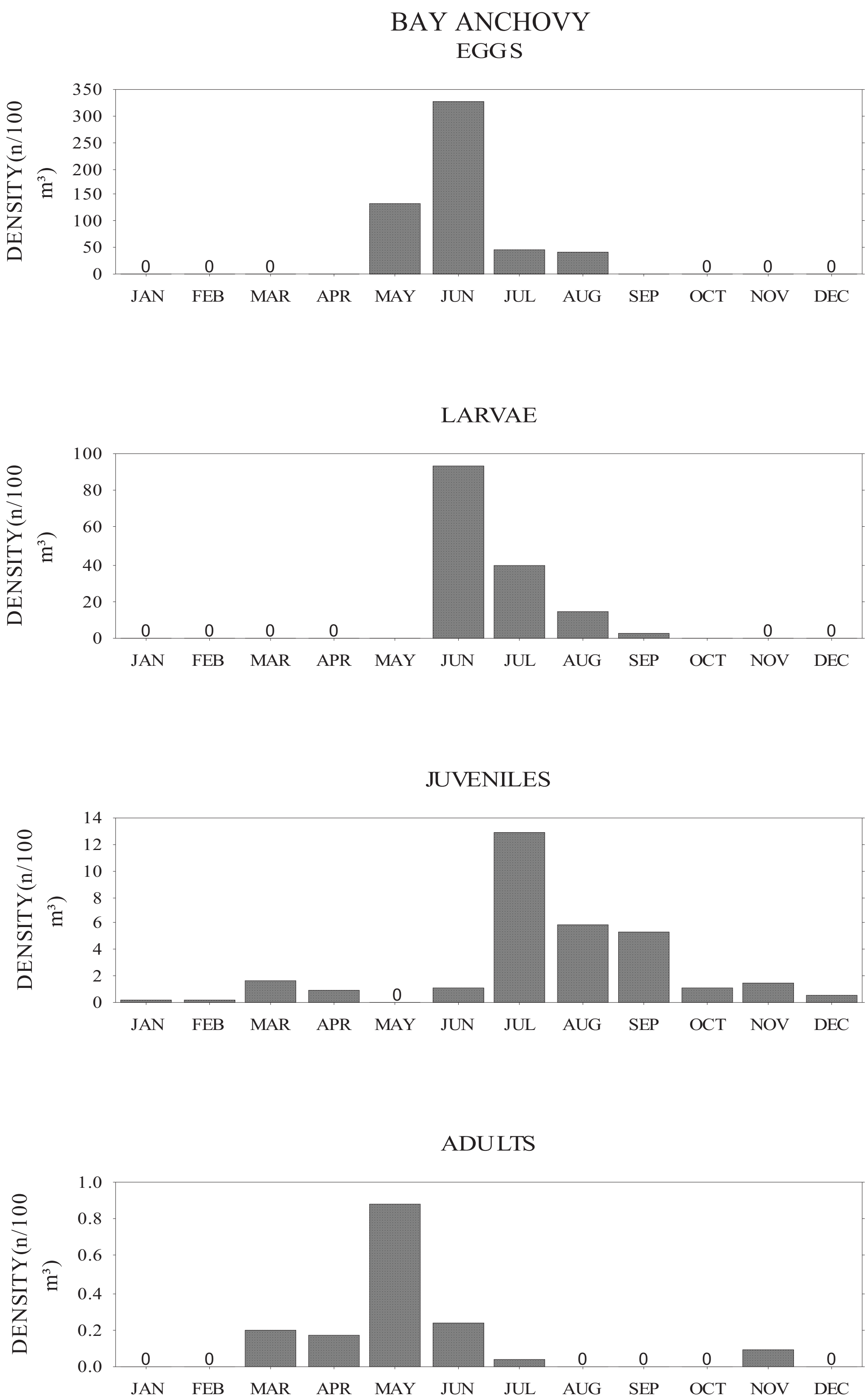

Figure 3-9. Monthly mean density (n/100m^3) of bay anchovy eggs, larvae, juveniles and adults taken in entrainment sampling at the Salem circulating water intake structure during 2006.

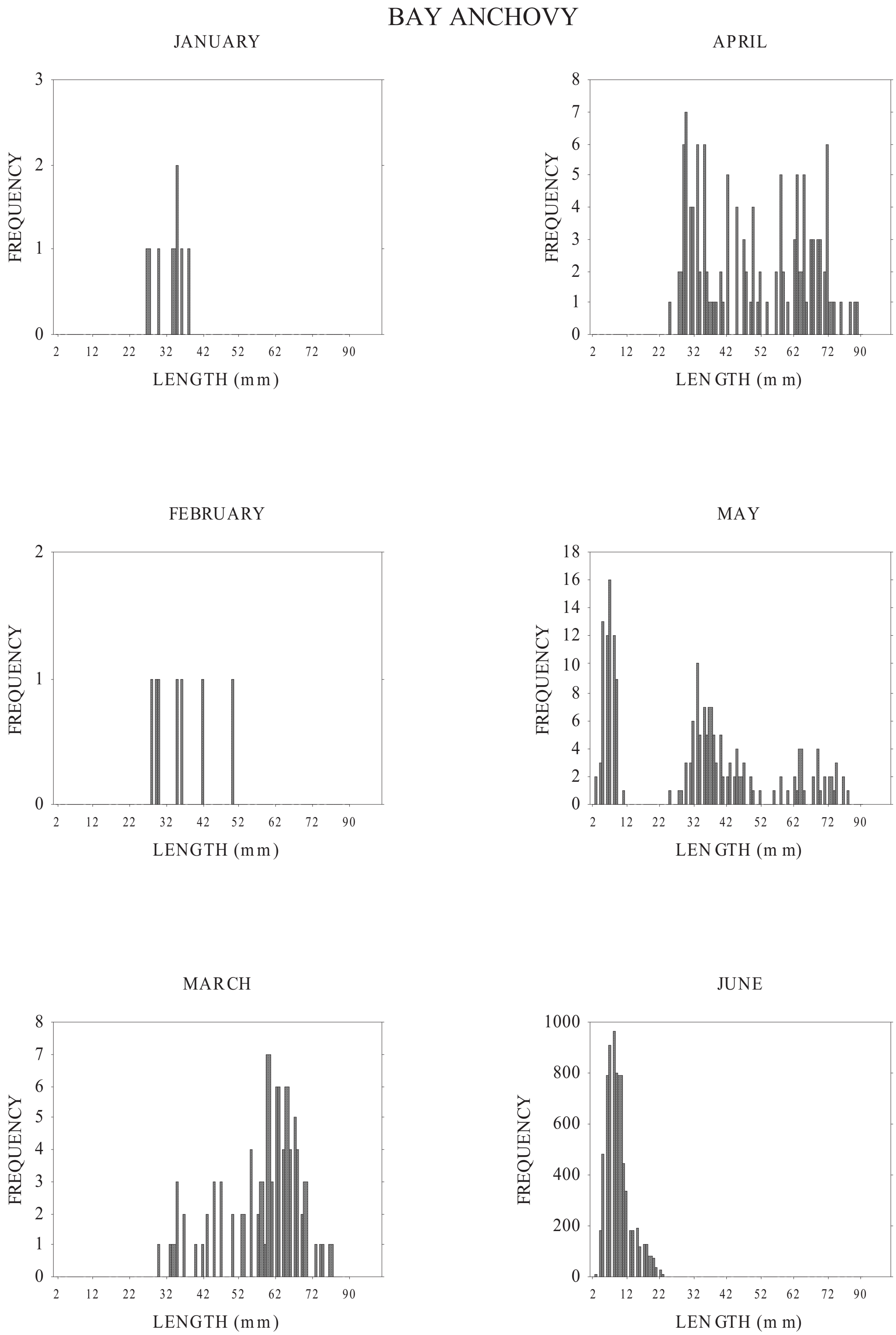

Figure 3-10. Length frequency of bay anchovy taken in entrainment sampling at the Salem circulating water intake structure during 2006.

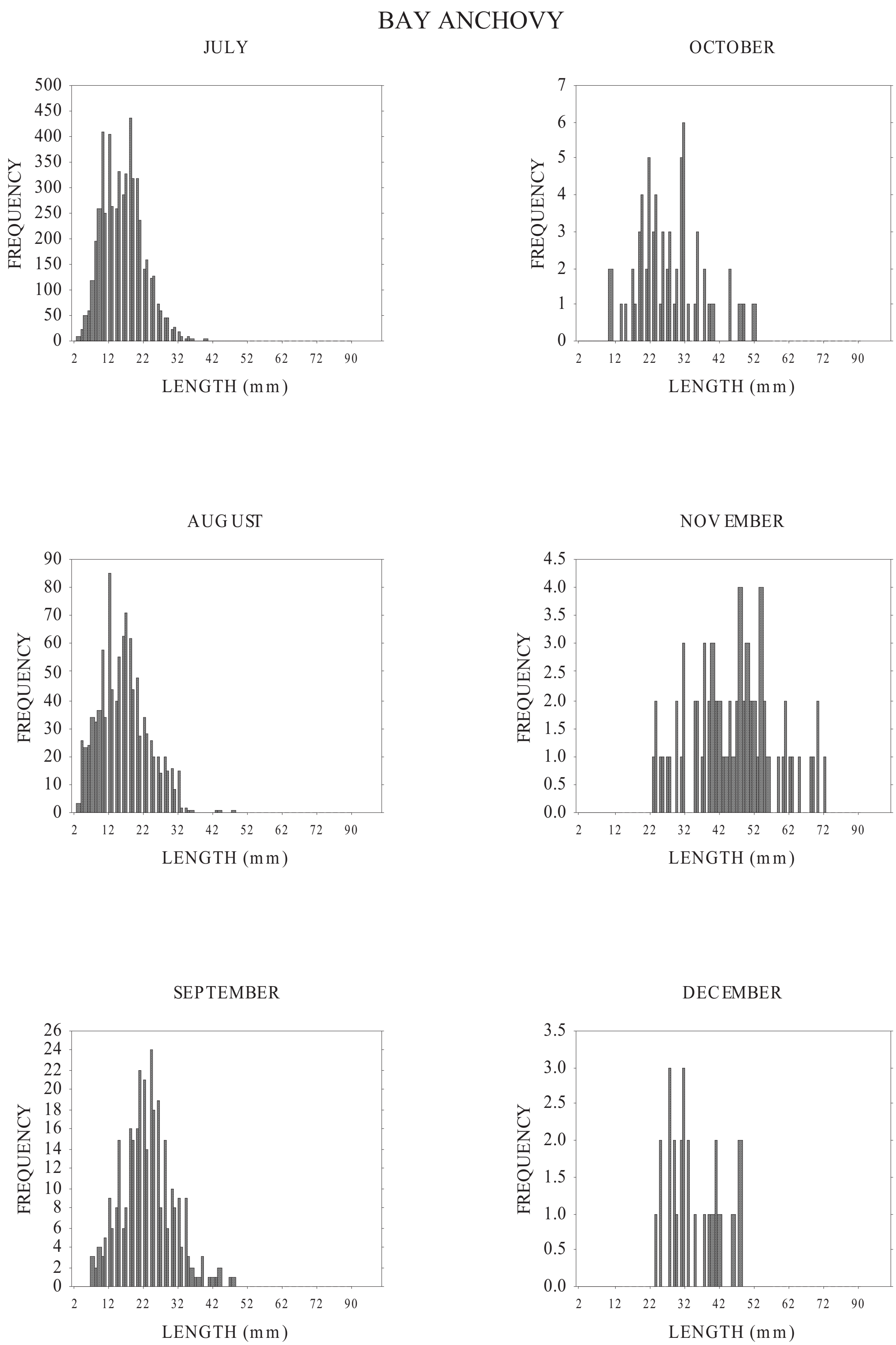

Figure 3-10. Continued.

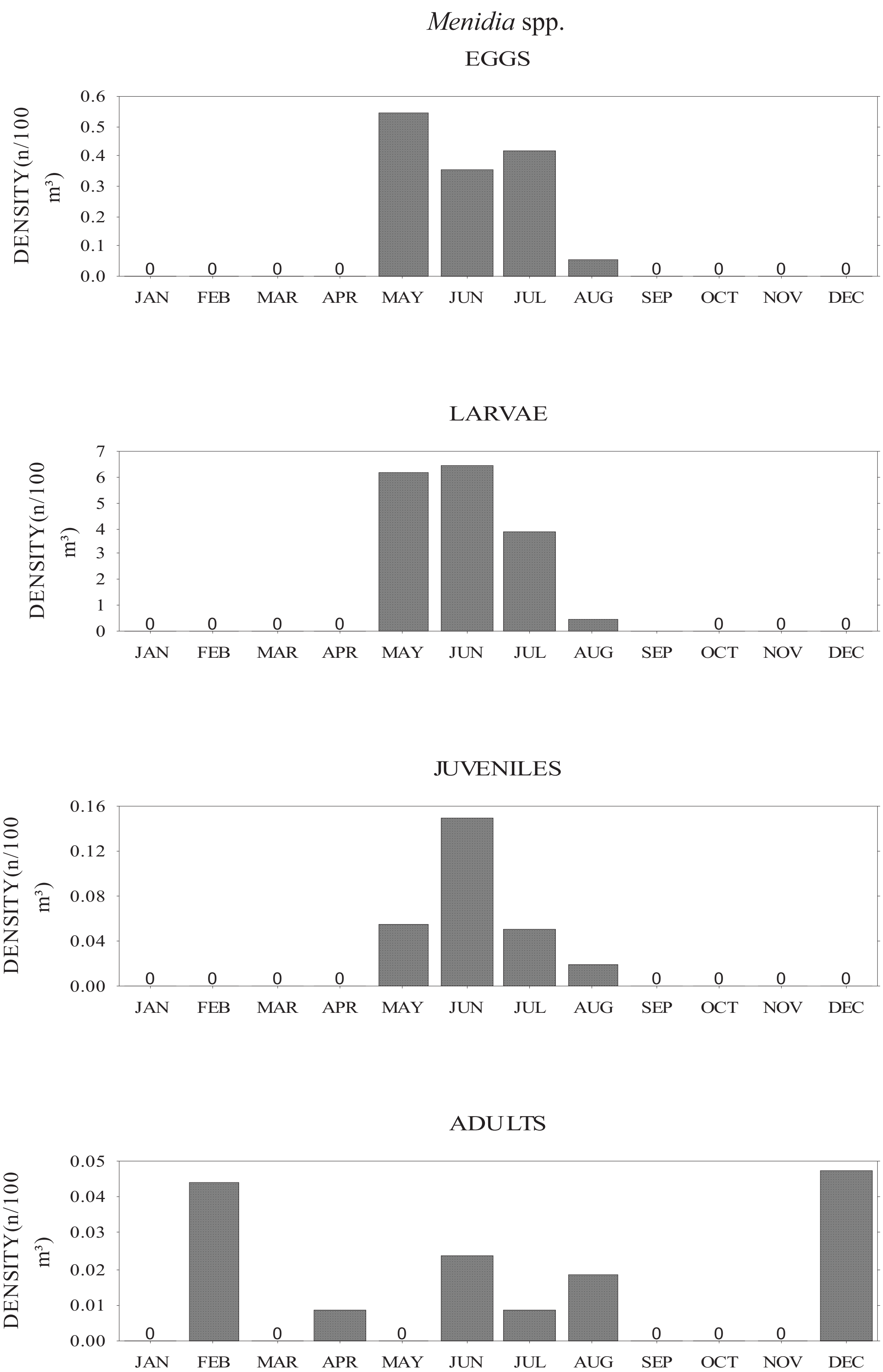

Figure 3-11. Monthly mean density (n/100m^3) of *Menidia* spp. eggs, larvae, juveniles and adults taken in entrainment sampling at the Salem circulating water intake structure during 2006.

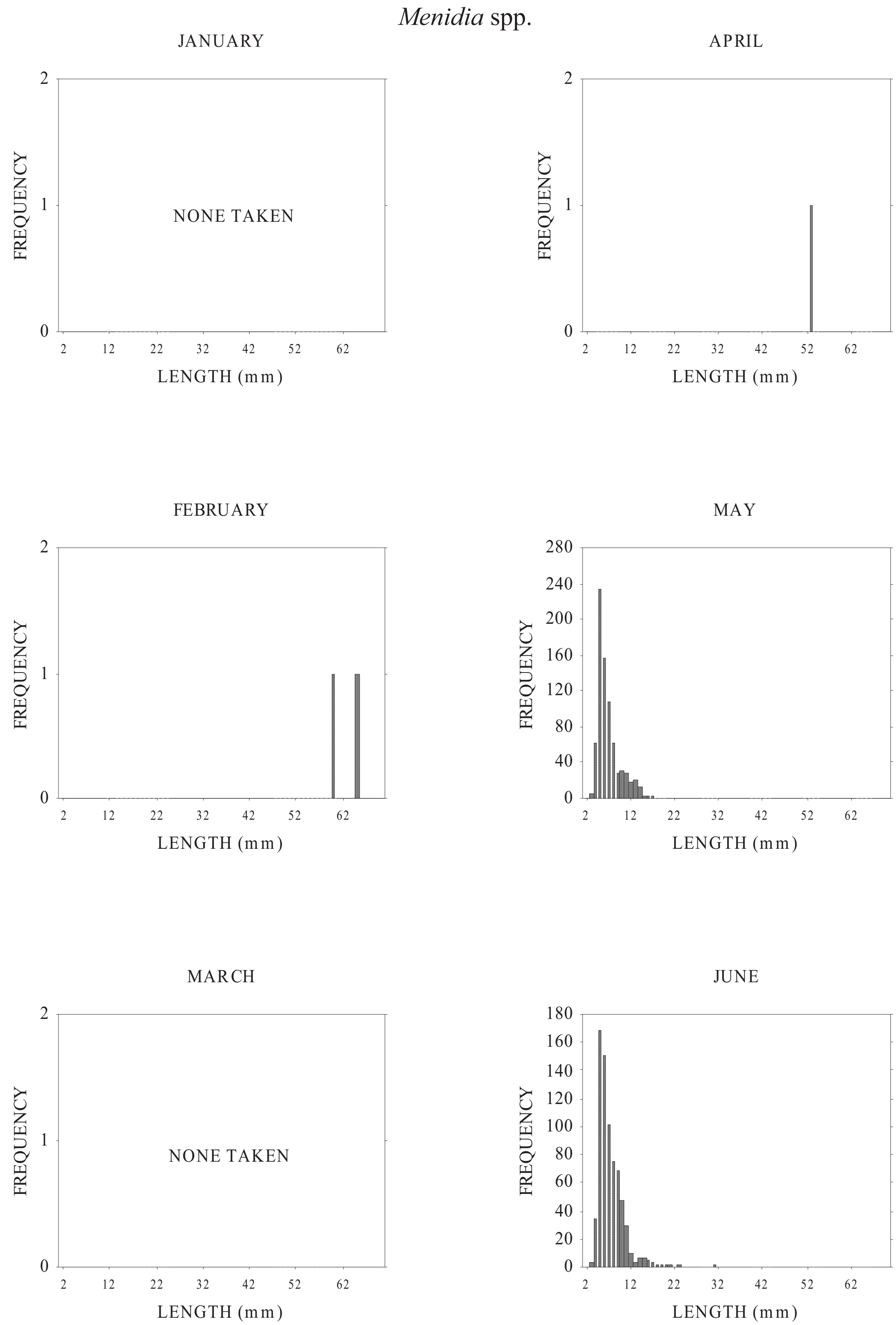

Figure 3-12. Length frequency of *Menidia* spp. taken in entrainment sampling at the Salem circulating water intake structure during 2006.

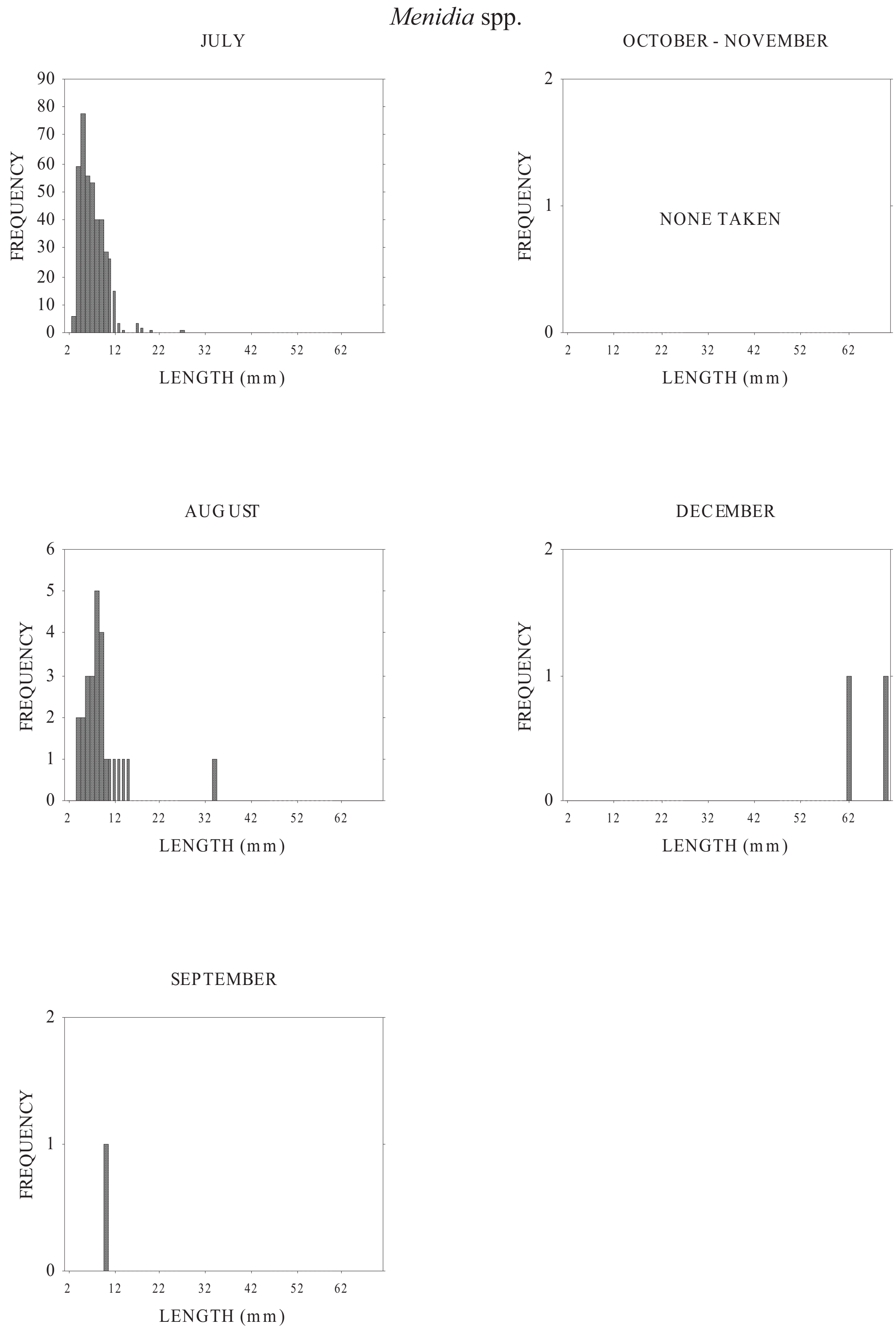

Figure 3-12. Continued.

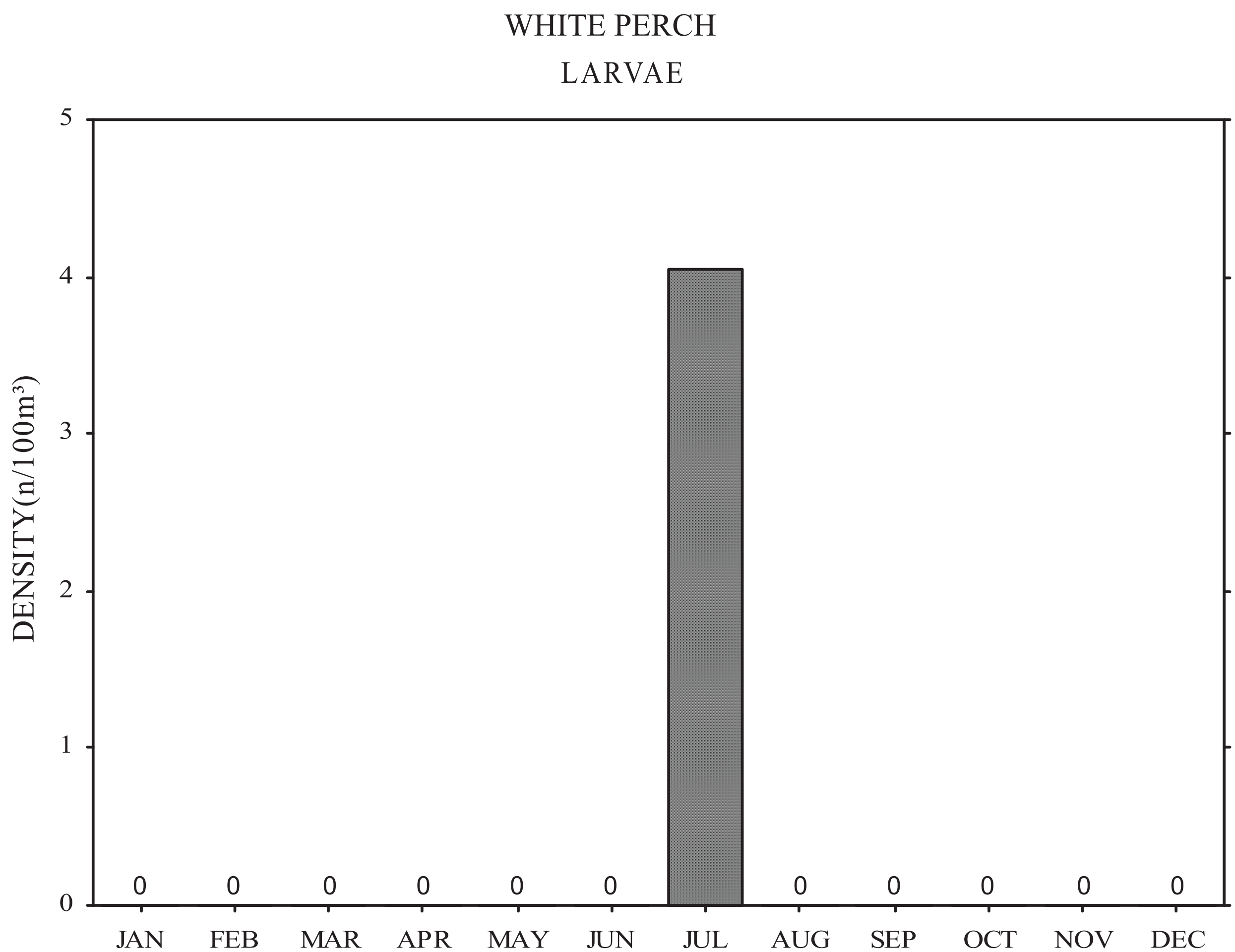

Figure 3-13. Monthly mean density (n/100m^3) of white perch larvae taken in entrainment sampling at the Salem circulating water intake structure during 2006.

WHITE PERCH

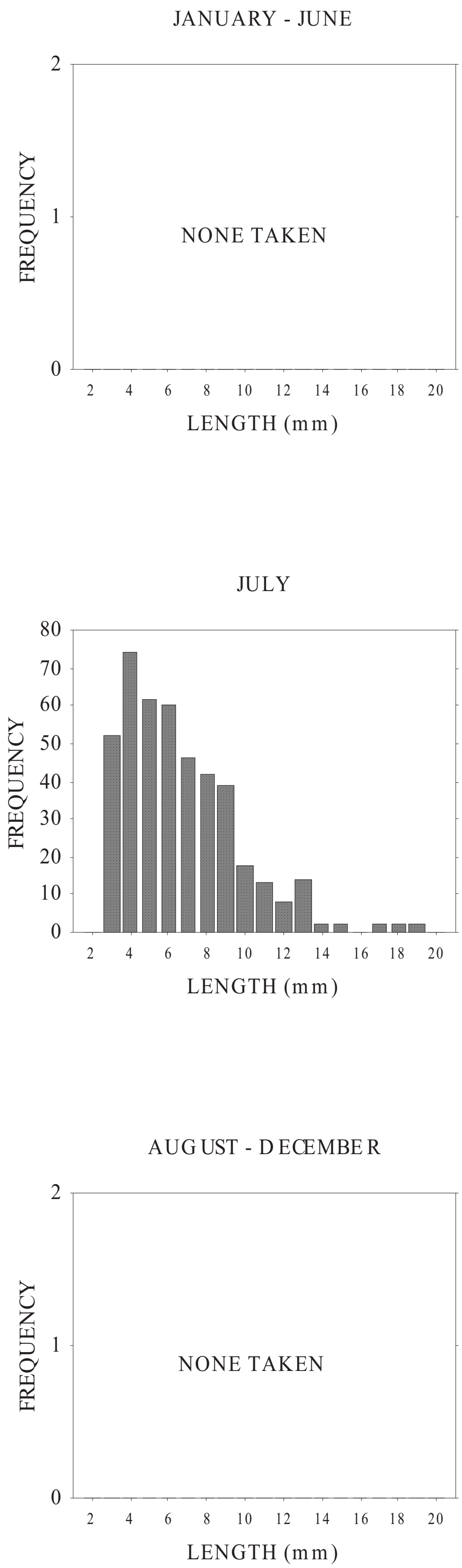

Figure 3-14. Length frequency of white perch taken in entrainment sampling at the Salem circulating water intake structure during 2006.

STRIPED BASS

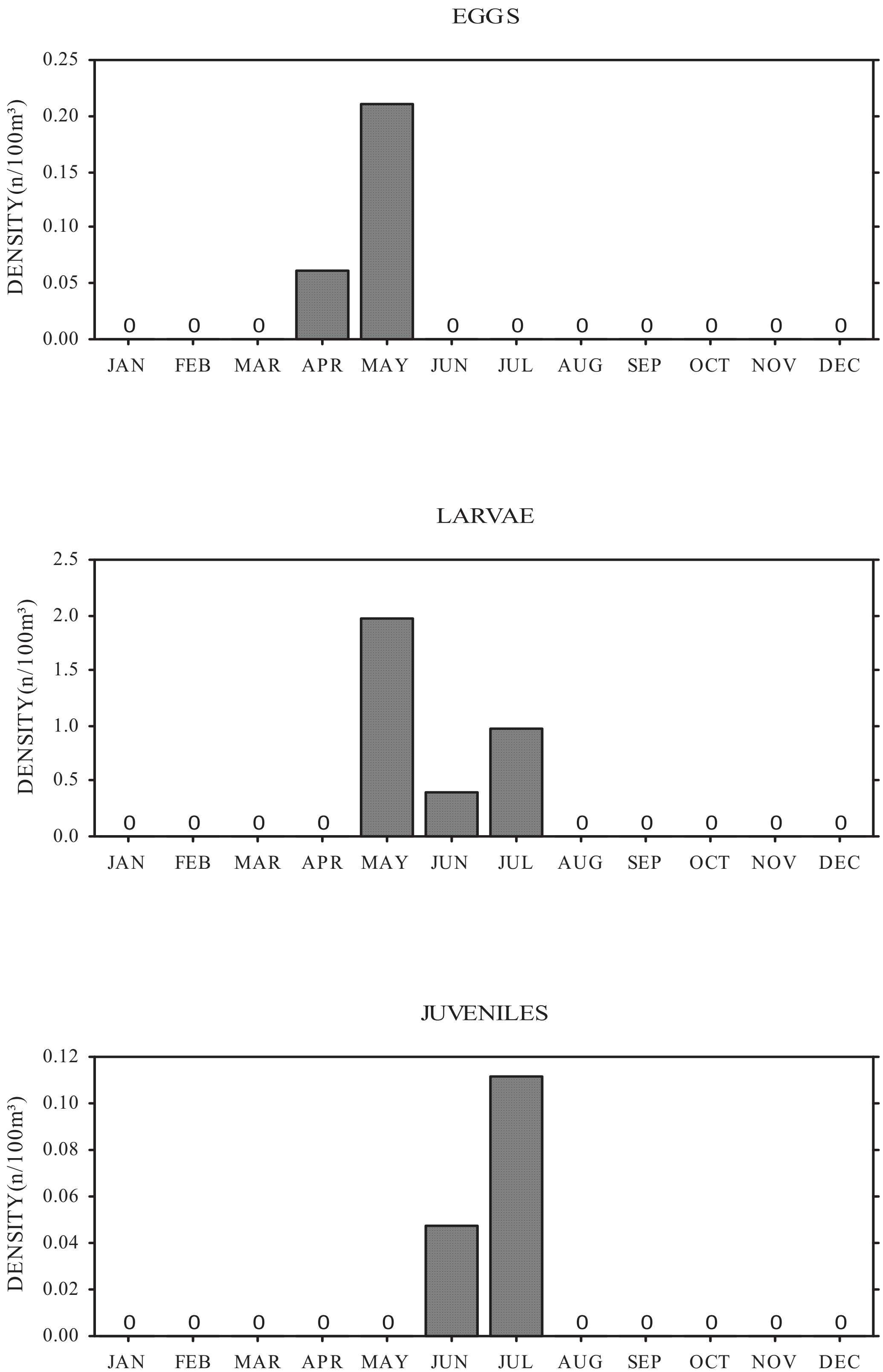

Figure 3-15. Monthly mean density (n/100m^3) of striped bass eggs, larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2006.

STRIPED BASS

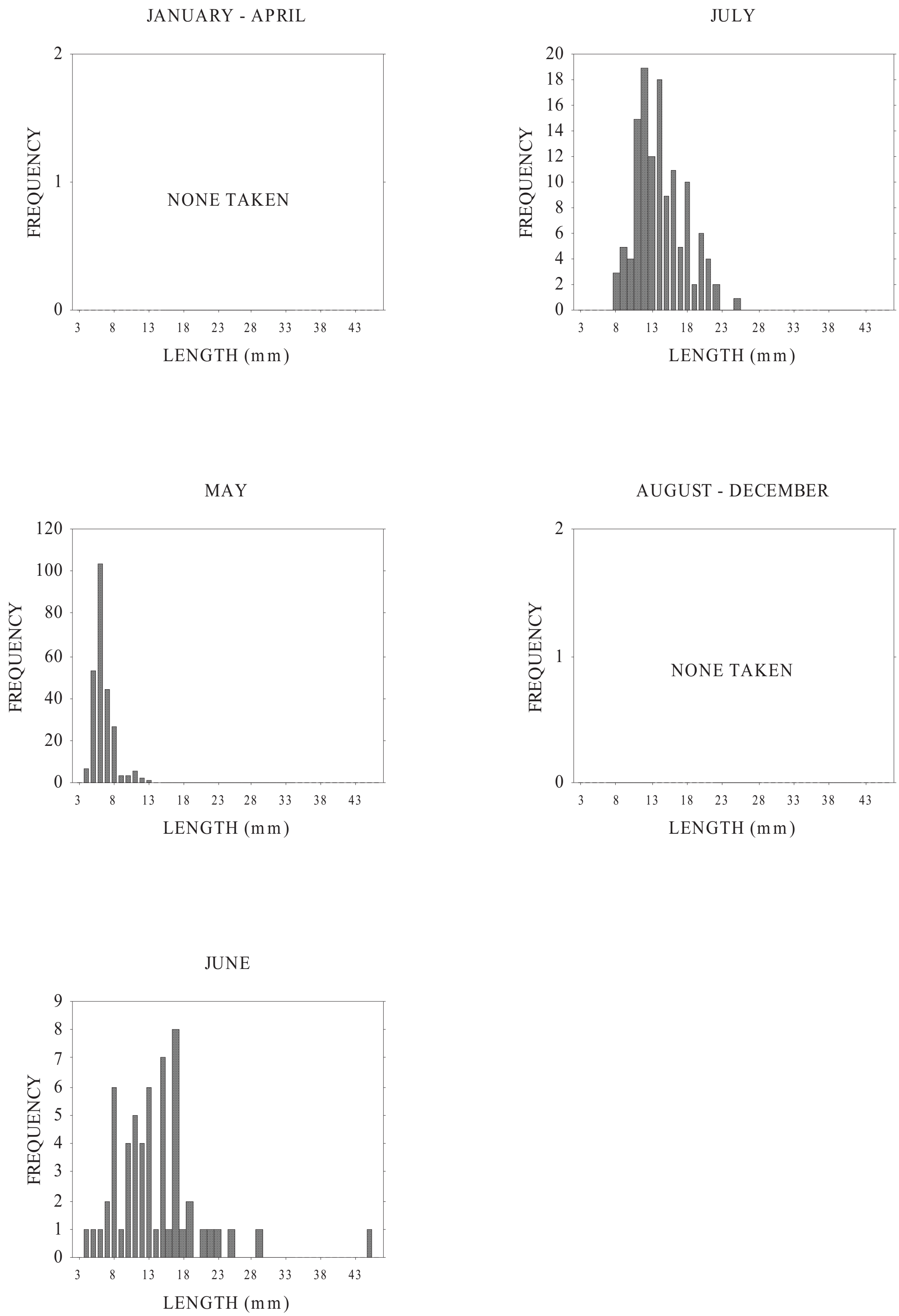

Figure 3-16. Length frequency of striped bass taken in entrainment sampling at the Salem circulating water intake structure during 2006.

Morone spp.

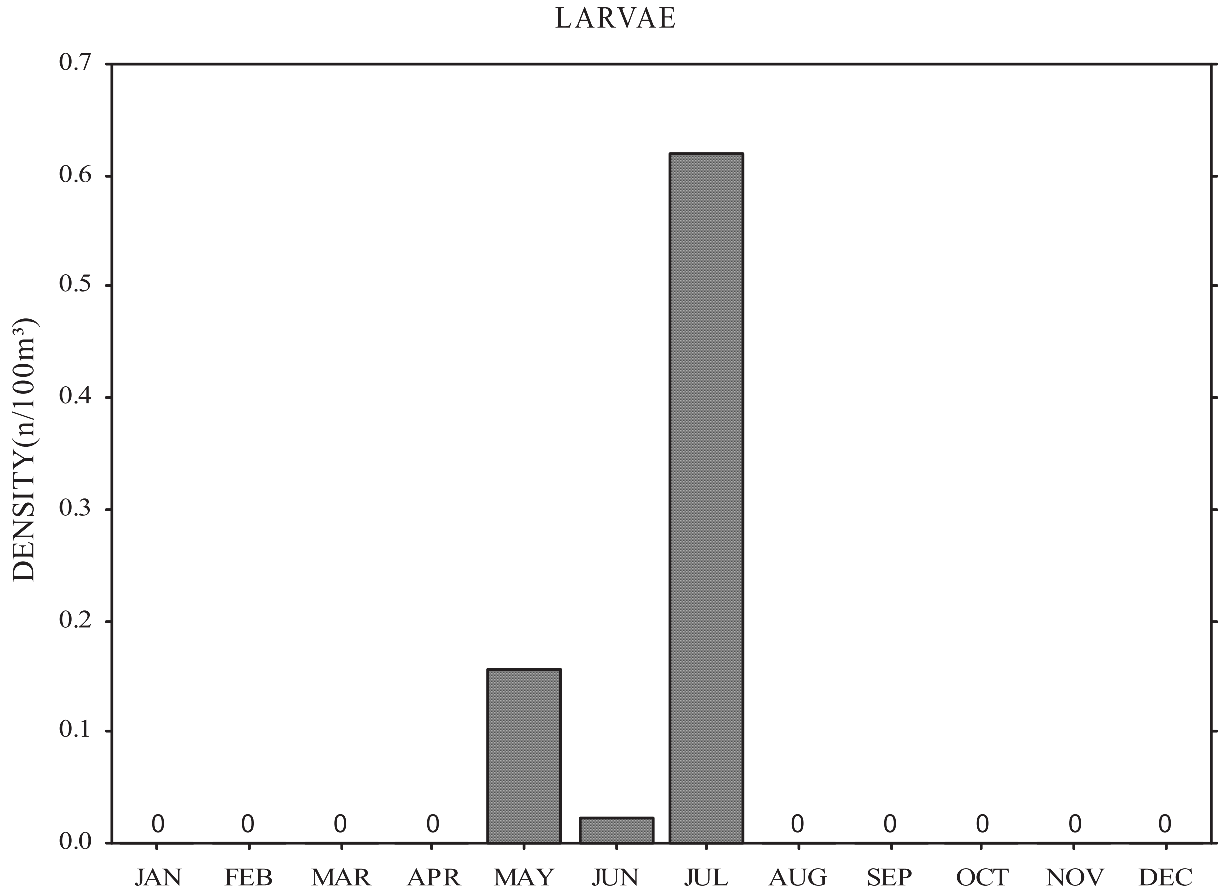

Figure 3-17. Monthly mean density (n/100m^3) of *Morone* spp. larvae taken in entrainment sampling at the Salem circulating water intake structure during 2006.

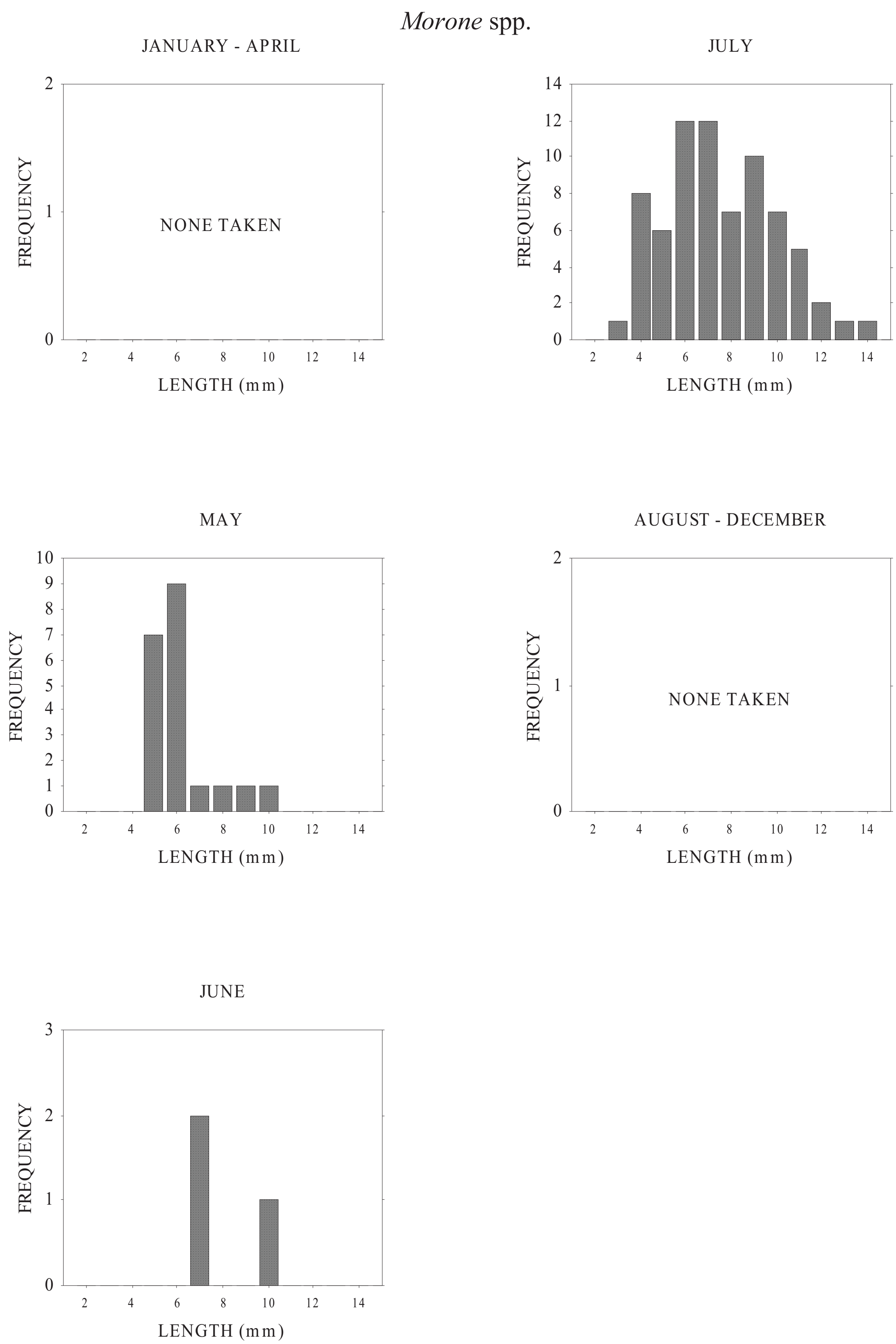

Figure 3-18. Length frequency of *Morone* spp. taken in entrainment sampling at the Salem circulating water intake structure during 2006.

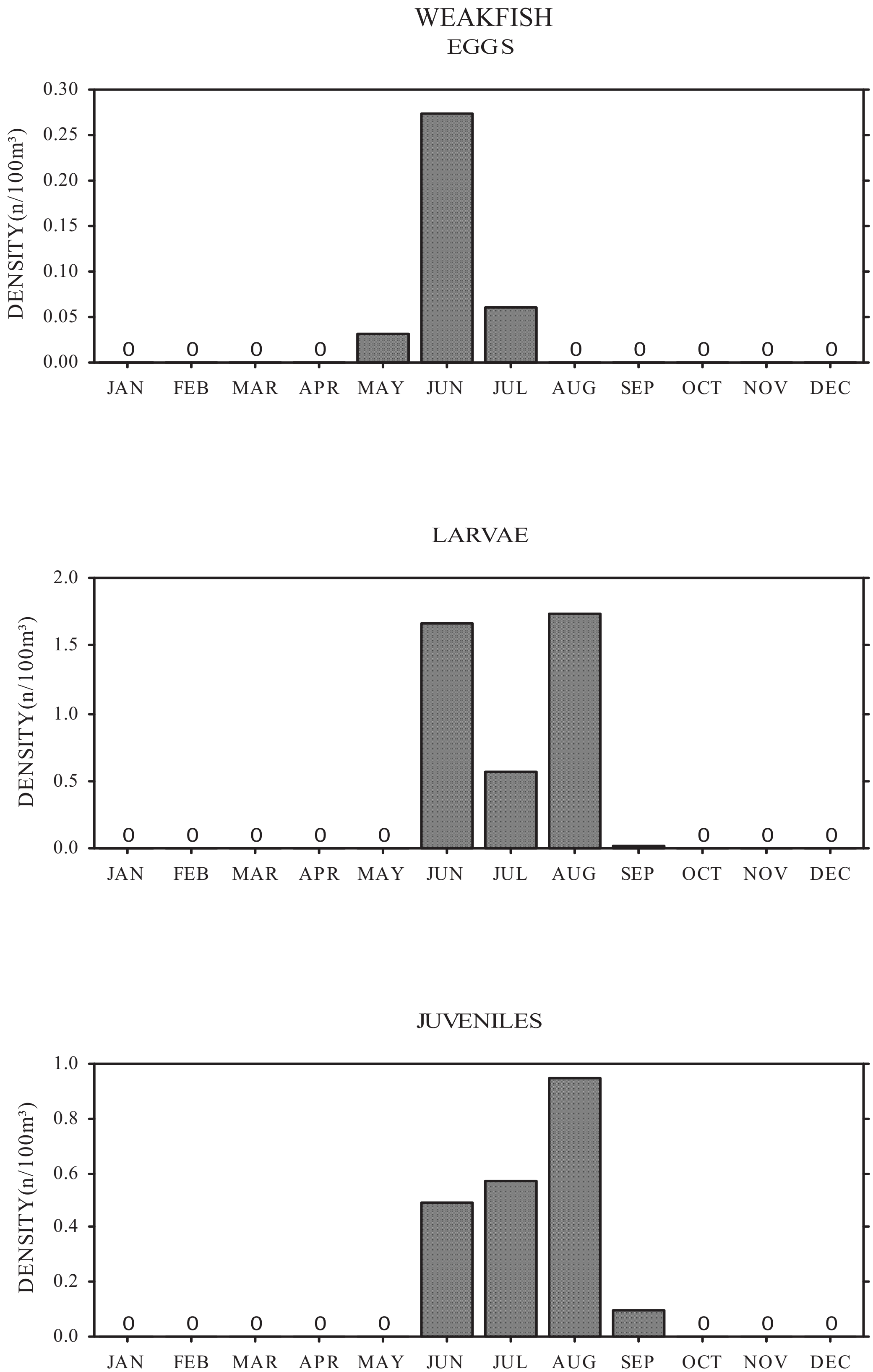

Figure 3-19. Monthly mean density (n/100m^3) of weakfish eggs, larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2006.

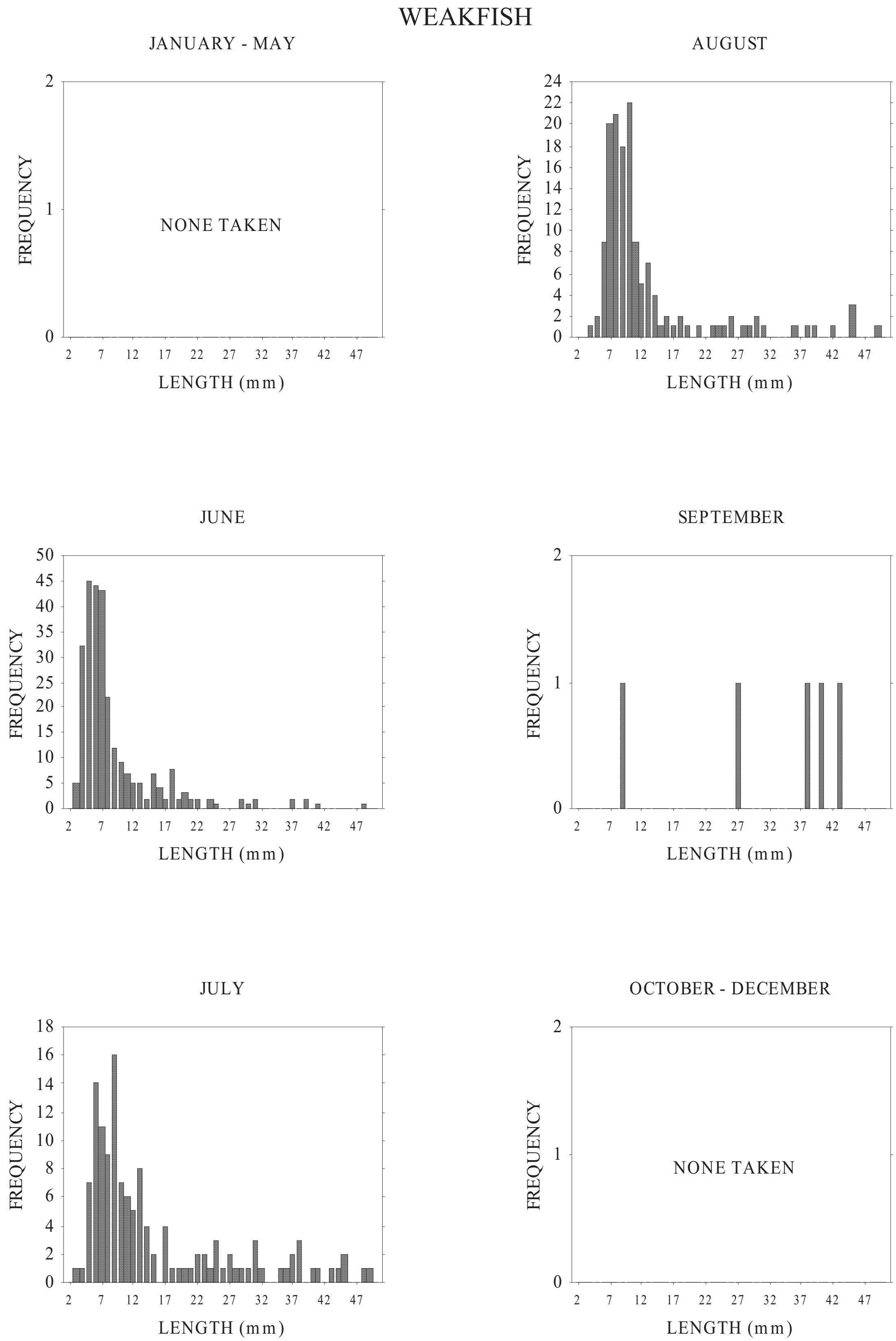

Figure 3-20. Length frequency of weakfish taken in entrainment sampling at the Salem circulating water intake structure during 2006.

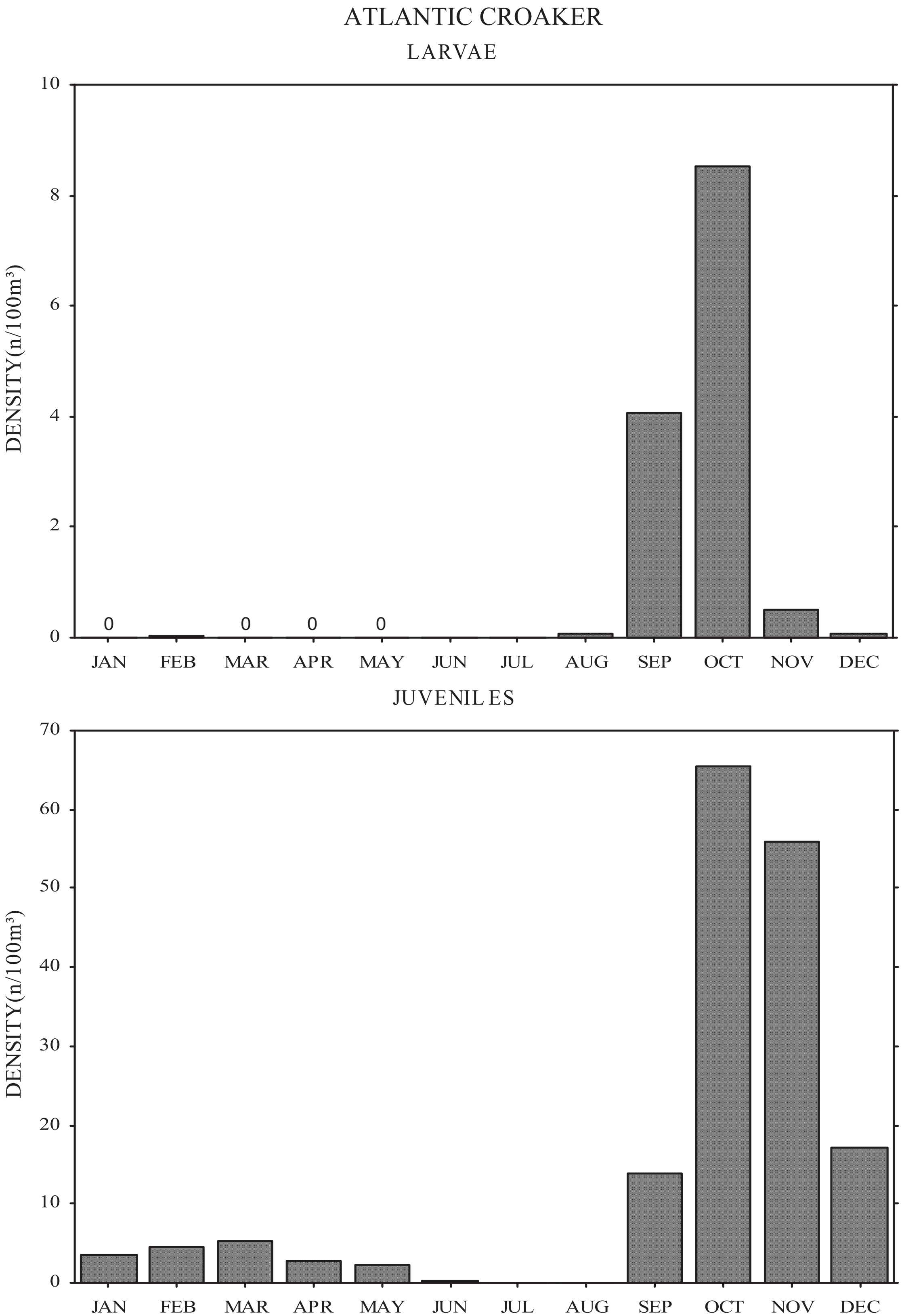

Figure 3-21. Monthly mean density (n/100m^3) of Atlantic croaker larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2006.

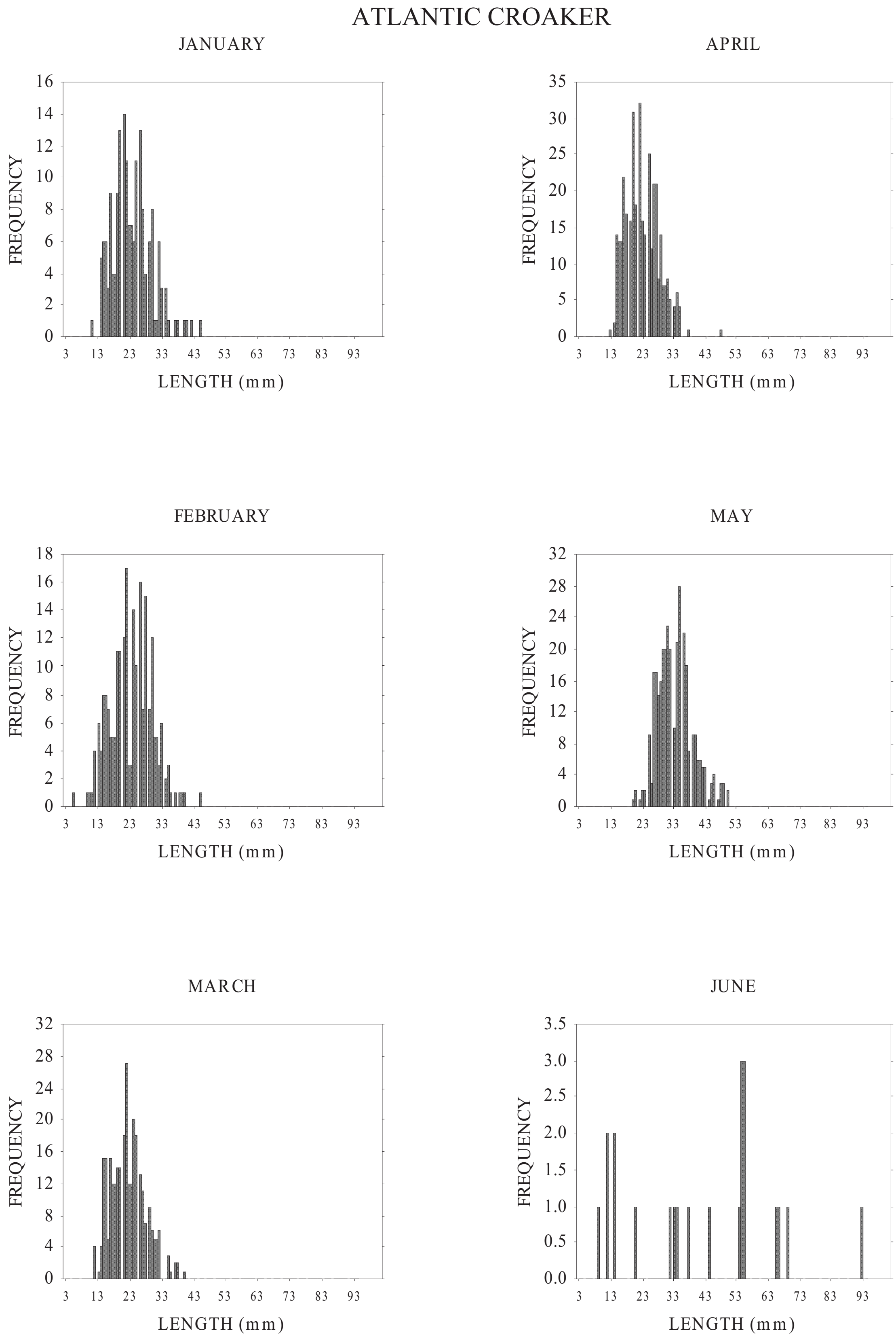

Figure 3-22. Length frequency of Atlantic croaker taken in entrainment sampling at the Salem circulating water intake structure during 2006.

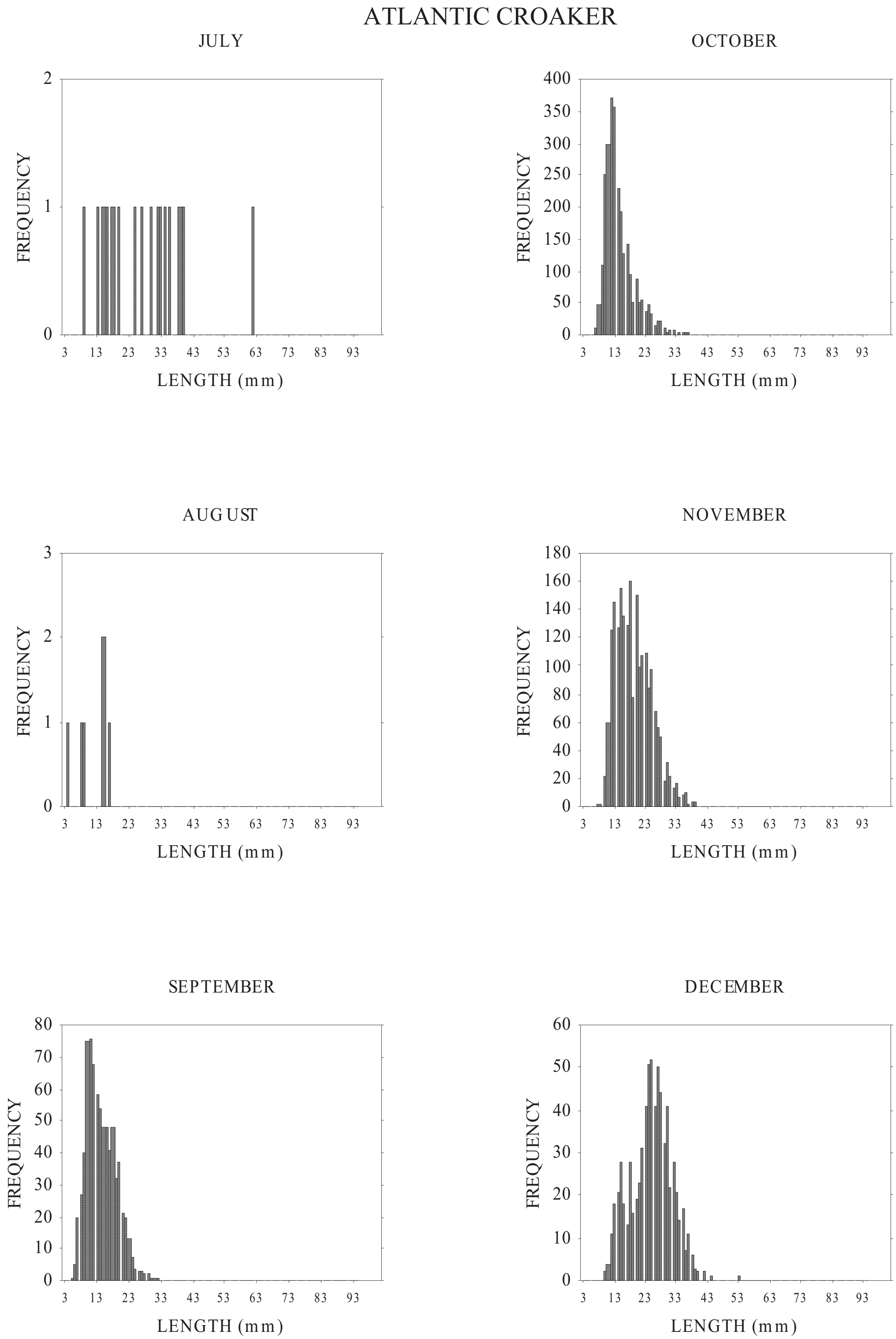

Figure 3-22. Continued.

CHAPTER 4: FINFISH MONITORING PROGRAM

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INTRODUCTION

The PSEG Nuclear, LLC bottom trawl effort during 2006 was conducted within the Delaware Bay and River once per month from April through November at 40 stations using a 4.9-m semi-balloon otter trawl. The objective of this trawling effort is to provide representative abundance indices for the target species.

This chapter discusses the overall results of the sampling efforts of the 2006 Bottom Trawl Monitoring Program, and the catch information related to the thirteen target species. The focus of this study was to provide abundance data for the fish species, bay anchovy (*Anchoa mitchilli*), alewife (*Alosa pseudoharengus)*, American shad (*A. sapidissima*), Atlantic menhaden (*Brevoortia tyrannus*), blueback herring (*A. aestivalis*), Atlantic silverside (*Menidia menidia)*, striped bass (*M. saxatilis)*, white perch (*Morone americana*), bluefish (*Pomatomus saltatrix*), Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), and weakfish (*Cynoscion regalis*), and the invertebrate species, blue crab (*Callinectes sapidus*) in the project area. Results of the bottom trawl sampling effort for the Baywide trawl programs conducted from 1995 through 2005 have been summarized in previous reports (PSE&G 1996, PSE&G 1997, PSE&G 1998, PSE&G 1999, PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006).

BOTTOM TRAWL EFFORT

Materials and Methods

The 2006 bottom trawl effort study area extended from the mouth of the Delaware Bay, rkm 0, to just north of the Delaware Memorial Bridge, rkm 117.

The study area was divided into eight zones (Figure 4-1). Zones 1, 2, and 3 (lower bay) are near the mouth of the bay. Zones 4, 5, and 6 are located in the 'middle' bay. Zones 7 and 8 (upper bay) are in the lower Delaware River.

Bottom trawl sampling (daytime only) was conducted once per month from April through November, for a total of eight trawling events. Daylight was defined as the period from one hour after sunrise to one hour before sunset.

Forty trawls were collected monthly during 2006 from randomly selected stations. These stations were distributed among the eight zones for a total of 320 samples. The number of stations within each zone was allocated using a Neyman allocation program that was based on the proportional area of each zone and on historical fishery data. The allocation of trawls per zone was as follows**:**

River Zone	Number of Trawls Per Zone
1	4
2	6
3	8
4	6
5	4
6	4
7	4
8	4

The primary sampling stations were randomly selected from a list of all available stations in each zone by a computer algorithm program. Alternate stations were also allocated in case a primary station could not be sampled due to navigational hazards, commercial fishing equipment, commercial shipping activity, etc.

Bottom trawls were collected with a 4.9-m (16-ft) semi-balloon otter trawl, manufactured by NETCO in Memphis, Tennessee and described as follows:

> "A 16-ft semi-balloon trawl: 17' headrope; 21' footrope; net made of nylon netting of the following size mesh and thread; 1½" stretch (3/4" square) mesh No. 9 thread body; 1¼" stretch (5/8" square) mesh No. 15 thread codend, fully rigged with four 2" I.D. net rings at top and bottom

> for lazy line and purse rope; inner liner of ½" stretch (¼"square) mesh No. 63 knotless nylon netting inserted and hogtied in codend; head and footropes of 3/8"-diameter poly-Dacron net rope with legs extended 3' and galvanized wire rope thimbles spliced in at each end; six 1½" x 2½" sponge floats spaced evenly on bosom of head rope; net treated in green net dip; trawl doors are 24" in length and 12" in width; doors are made of ¾" marine ply board, 1¼" x 1¼" straps and braces and ½" x 2" bottom shoe runner; 3/16" chain bridle, lap links and 5/16" swivels at the head of each bridle."

Trawl stations were located using an onboard GPS receiver that had been preprogrammed with each station's waypoint (latitude and longitude). The station depths were monitored with an onboard depth sounder.

Trawls were towed for ten minutes at 6 ft/sec. against the direction of the tide. A towline to water depth ratio of 10:1 was used to ensure that the trawl maintained contact with the bottom. Predicted tidal stages were determined using **Tides and Currents for Windows™** (version 2.5b) nautical software program and/or *Eldridge Tide and Pilot Book 2006* (Eldridge Tide and Pilot Book 2006). At each station, predicted tidal currents were visually verified by the crew prior to starting each tow. The tow speed was monitored with an electronic flowmeter with on-deck readout and/or engine rpm.

At the completion of each tow, the net was emptied into a collection container to prepare for sample processing. All finfish and blue crabs were transferred to the sorting table for identification to the lowest practicable taxonomic level (i.e., species). All species were identified, enumerated, and recorded on field data sheets. The subsampling procedure described in the procedures manual (PSEG 2002b) was not used because subsampling was not necessary during the 2006 bottom trawl effort. Any unidentifiable specimens were preserved in 10% formalin and returned to the laboratory for species identification.

Length measurements were recorded for all target finfish species and carapace width measurements were recorded for blue crabs. When the count for a target species was less than 100, measurements were recorded for each specimen. When the number of specimens for a target species exceeded 100, a representative subsample of 100 specimens was measured. Total length (TL) to the nearest millimeter was measured for fish with square or rounded caudal fins (tip of the snout to the tip of the longest caudal ray). Fork length (FL) to the nearest millimeter was measured for fish with emarginate or forked caudal fins (tip of the snout to the caudal fork). Carapace width to the nearest millimeter (shell point to point) was measured for blue crabs. Live fish and crabs were returned to the water as quickly as possible.

Water quality measurements for water temperature (°C), dissolved oxygen (DO) in milligrams per liter (mg/L), and salinity in parts per thousands (ppt) were recorded at surface, mid-depth and bottom depths at each trawl station. Surface measurements were recorded at stations where the depth was less than 10 ft. The primary meter used to

measure these parameters was the YSI-85 DO/Conductivity/Salinity/Temperature Meter. The YSI-55 DO/Temperature Meter and the YSI-30 Conductivity/Salinity/Temperature Meter were used as backups. Field crews also recorded water clarity (by Secchi disk), weather conditions, station depths, and tidal stage (ebb/flood/slack) at each trawl station.

Results and Discussion

Physical/Chemical Parameters

Trends in physical and chemical parameters recorded in the Delaware Baywide bottom trawl effort zones during 2006 were generally consistent with those results reported in previous study years (PSE&G 1996, PSE&G 1997, PSE&G 1998, PSE&G 1999 PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006).

Surface, mid-depth and bottom water temperatures varied by season, station depth, and river kilometer at all sampling stations in 2006. Mean bottom water temperatures increased throughout the spring and early summer, peaked in August and decreased monthly through November (Figure 4-2). Temperature ranges varied from lows of 13.9-16.1 °C in April-May and 11.4-12.8 °C in October-November to highs of 22.7-30.0 °C in June through September. The lowest mean water temperature was recorded during November (11.4 °C) and the highest mean water temperature was recorded in August (30.0 °C).

The temperature gradient pattern in 2006 was slightly more variable than it has been in previous years (PSE&G 1996, PSE&G 1997, PSE&G 1998, PSE&G 1999 PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). In 2006, bottom water temperatures ranged from 1-9 °C among the eight sampling zones within each sampling period. In 2005, bottom water temperatures ranged from 2-9 °C among the eight sampling zones within each monthly period. In 2004, bottom water temperatures ranged from 3-9 °C among the fourteen zones (current eight lower zones plus six upper zones sampled in 2002-2004) sampled within each monthly period. In 2003, bottom water temperatures ranged from 4-8 °C and in 2002 ranged from 2-7 °C. The greatest temperature gradient in 2006 was recorded in October with 8.6 °C between Zones 7 and 8. The least temperature gradient was recorded in September with 1.2 °C between Zones 4 and 8.

Zone 1 had the coldest water during April, May and July. Zone 2 had the coldest water in June and August. Zone 8 had the coldest water in September and October, and Zone 4 had the coldest water in November. Zone 7 had the warmest water during June, August and October. Zone 6 had the warmest water in April, July and November. Zone 4 had the warmest water in September and Zone 8 had the warmest water in May.

In 2006, the mean bottom salinity distribution was relatively consistent with the data from previous years (PSE&G 1996, PSE&G 1997, PSE&G 1998, PSE&G 1999 PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006), as it varied by month and by zone from April through November (Figure 4-3).

Salinity increased from April into May in Zones 1, 2, and 6-8, and decreased in Zones 3-5. Salinity then decreased into June in Zones 1-3, 5 and 7-8, and increased in Zones 4 and 6. In July, the salinity decreased in Zones 2-8, and increased in Zone 1. The salinity then increased into August in Zones 2-6 and 8, and went down in Zones 1 and 7. In September, salinity decreased in Zones 2, 4 and 5, but increased in Zones 1, 3 and 6-8. Salinity decreased from September into October in Zones 3 and 5-8, and increased in Zones 1, 2 and 4. The salinity then declined in November in Zones 1, 2, 4 and 6-8, went up in Zone 5 and remained the same in Zone 3. The seasonal increase from the spring to the fall, which is characteristic of mid-Atlantic estuaries (Moyle and Cech 1988), was not as evident in 2006, 2005, 2004 and 2003 as it was in previous years (PSE&G 1996, PSE&G 1997, PSE&G 1998, PSE&G 1999 PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006).

Zone 1 exhibited the highest mean bottom salinity (28.8 ppt) in October for any zone in any month. The water in the areas closest to the mouth of the bay (Zones 1, 2 and 3) is nearly marine and its salinity was consistently ≥ 23 ppt for all eight months. The water in Zones 4, 5 and 6 becomes gradually less saline from south to north. Zone 4 was always the fourth highest (18.9-24.3 ppt) in salinity, except during October (third highest). Zone 5 was always the fifth highest (14.1-20.2 ppt), and Zone 6 was the sixth highest (6.3-14.3 ppt). The water in the river areas (Zones 7 and 8) is nearly fresh and was consistently the least saline of the eight zones throughout the program. The salinity in Zone 7 ranged from 2.1 (August) to 9.3 (May). Zone 8 exhibited salinities between 0.2 (July) and 2.3 ppt (May). Variation among Zones 1 to 8 was relatively consistent from month to month (Figure 4-3). It was lowest in May, with a range of 2.3 to 27.9 ppt, and highest in July with a range of 0.2 to 28.4 ppt.

Monthly zone variations of mean bottom DO readings for the eight zones were higher in 2006 (Figure 4-4) than in 2005 in April, July, August and October, but lower for May, June, September and November. During the eight months of sampling, the gradient among zones ranged from 1.0 mg/L (both May and September) to 3.2 mg/L (August). Mean bottom DO concentrations throughout all sampling zones ranged from 6.2 to 11.7 mg/L. Overall, the bottom DO concentrations in the eight zones were similar to the historical values recorded during previous study years (PSE&G 1996, PSE&G 1997, PSE&G 1998, PSE&G 1999 PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006), and represent a well-mixed, oxygenated estuary (Moyle and Cech 1988).

Catch Composition

During the 2006 Baywide bottom trawl effort, 35,163 finfish from 60 species and 3,771 blue crabs were collected in 320 trawl samples (Table 4-1). Approximately 80.5% (28,320) of the total finfish catch was comprised of target species fish. Atlantic croaker (38.5%) and bay anchovy (33.7%) dominated the total catch. The remaining ten target finfish species collectively represented 8.3% of the total finfish catch.

A total of 6,843 specimens were collected of 48 non-target finfish species. This represented 19.5% of the total finfish catch. The most abundant non-target finfish species was hogchoker (Table 4-1). The only other relatively abundant (>200 fish caught) non-target species were spotted hake and red hake.

Total abundance for target species and others by zone across all months shows dominance of bay anchovy in Zones 1, 3 and 4, (Figure 4-5). Atlantic croaker was the most abundant species in Zones 2, and 5-8. Bay anchovy was the second most abundant species in Zone 2 and hogchoker was the second most abundant species in Zones 7 and 8.

Mean species composition (MSC) and catch per unit effort (CPUE) were calculated by zone and by month for the 2006 sampling season (Figure 4-6). Mean species composition by month is the number of species caught in a month over all zones divided by the number of zones. MSC by zone is the number of species caught in a zone over all months divided by the number of months. Mean CPUE by month is the average CPUE in a month over all zones divided by the number of zones. Mean CPUE by zone is the average CPUE in a zone over all months divided by the number of months.

MSC by month (Figure 4-6) was lowest in June, and highest in September. MSC by zone (Figure 4-6) was the lowest in Zone 8, and the highest in Zone 4.

Mean monthly CPUE (Figure 4-6) was lowest in May after decreasing by 45% from April. It then increased through May and June and into July, when the CPUE was almost 2.5 times higher than May. In August, the CPUE decreased 45%. It then steadily increased through September, October and into November, which had the highest monthly mean, rising to 2.75 times higher than August. The peak in July was due to high abundance of Atlantic croaker in Zones 6-8 and high bay anchovy numbers in Zones 2-5. The November peak was related to high abundance of Atlantic croaker in Zones 2-5 and 7-8, and high bay anchovy numbers in Zone 3 (Tables 4-2 through 4-9).

Mean CPUE was lowest in Zone 1 and highest in Zone 8 (Figure 4-6). Target species tended to have the higher species-specific CPUE in all zones, but hogchoker also had a high species-specific CPUE in Zones 6-8 (Tables 4-2 through 4-9). Bay anchovy had the highest CPUE for Zones 1, 3 and 4. Atlantic croaker had the highest CPUE in Zones 2 and 5-8.

The highest CPUE for blue crab was in Zone 6. Two other zones, out of the eight sampled, had high blue crab mean CPUE. They were Zones 4 and 5. The blue crab catch varied from month to month rising to peaks in September and November (Tables 4-2 through 4-9).

Figure 4-7 outlines MSC and CPUE by month for each zone. Species composition in 2006 was highest in Zone 4 and lowest in Zone 8. The variance of the species composition among all eight zones in 2006 was similar to the variance of the species composition among the same eight zones in 2005.

Length-frequency data are provided for all target fish species in Figures 4-8 through 4-18. Descriptions of the thirteen target species (including blue crab) are presented below. Spatial and temporal distributions are discussed where appropriate. Table 4-1 provides abundance catch by zone for each species while Tables 4-2 through 4-9 provide a monthly catch for each species by zone. More detailed descriptions of the life histories of the target species, except for Atlantic menhaden and bluefish, are described in Appendix C, Attachments C-1 through C-9, C-12 and C-14 of the Salem 316 (b) Demonstration (PSE&G 1999).

Alewife

One alewife was collected in the 2006 program, which was much less than the number caught in the same eight zones in 2005 (25), 2004 (32), 2003 (70), 2001 (42) and 2000 (15). However, it is similar to the number caught (3) in the same eight zones in 2002 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). The alewife caught in 2006 was found in Zone 4 in April and was probably a yearling (Figure 4-8).

American shad

Three American shad were collected in the 2006 Baywide bottom trawl effort. This is consistent with earlier years of this study. For example, thirteen fish were taken from the same eight zones in 1999, none in 2000, eight in 2001, five in 2002, eight in 2003, ten in 2004 and three in 2005 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). The American shad caught in 2006 were caught in May and October. They were located in Zones 4, 7 and 8. The two American shad that were caught in May were probably yearlings and the one caught in October was probably a young-of-the-year (Figure 4-9).

Atlantic croaker

Atlantic croaker was the most abundant fish species collected in 2006 representing 38.5% of the total finfish catch with 13,528 specimens captured. They were taken in all zones, but were more evenly distributed than they have been in past studies (PSE&G 1997, PSE&G 1998, PSE&G 1999, PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). Approximately 32.9% of the total Atlantic croaker catch was found in Zone 8, 14.3% in Zone 7, 14.1% in Zone 5, 10.7% in Zone 2, 10.3% in Zone 3 and 10.0% in Zone 6, 6.2% in Zone 4 and 1.5% in Zone 1. The seasonal Atlantic croaker catch in 2006 was distributed relatively evenly among all months. However, the largest catch was in November (32.2%) and the second largest catch was in June (19.3%). Only April and September yielded less than 1,000 fish, but several hundred were still captured in these two months. This seasonal pattern is consistent with the 2002 study where a large portion (20.6%) of the yearly catch was taken in June. It is inconsistent with the 1996 through 2001 and 2003 through 2005 data when most of the Atlantic croaker were taken in the later months of the studies. (PSE&G 1997, PSE&G 1998, PSE&G 1999, PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). It should also be noted that the 2006 Atlantic croaker catch was similar to the 2005 (11,062), 2004 (10,026) and 2003 (9,501) catches from the same eight zones, but only amounted to about 65.6 % of the 2002 catch from the same eight zones. Only a small number of adult fish were taken as is shown in the length-frequency distribution graphs presented in Figure 4-10. This is consistent with the data from past years (PSE&G 1997, PSE&G 1998, PSE&G 1999, PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006).

Atlantic menhaden

In 2006, twenty Atlantic menhaden were collected. This is closer to the number of fish caught in the same eight zones in 2000 (15), 2001 (10) and 2003(1), 2004 (29) and 2005 (4). However, it is much less than the 286 taken in the same eight zones in 2002 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). The Atlantic menhaden captured in 2006 were found in Zones 2-5 and 7-8. There were young-of-the-year (YOY) found in May and October, adults in June and August, and a mixture of YOY and older fish in September and November (Figure 4-11).

Atlantic silverside

No Atlantic silverside were collected during the 2006 Baywide bottom trawl effort. In the same eight zones, six were caught in 2005, 27 were collected in 2003, 11 were captured

in 2002, and only two were taken in 2001. None were captured in 2000 and 2004 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006).

Bay anchovy

Bay anchovy occur throughout Delaware Bay and are seasonally abundant from the lower Delaware River up to Wilmington, DE (rkm 120), and Philadelphia, PA (rkm 150). O'Herron et al. (1994) reported that bay anchovy was the fourth most abundant species, representing 10.1% of the overall catch, in an extensive survey of the Delaware River Estuary, ranging from the C & D Canal to Trenton, NJ.

Historically, bay anchovy is one of the most abundant species of the mid-Atlantic region estuaries and, in previous years, they represented the largest or second largest number of fish caught in the Baywide bottom trawl effort (PSE&G 1997, PSE&G 1998, PSE&G 1999, PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). In 2006, bay anchovy accounted for the second largest number of fish caught (11,857; 33.7% of the total finfish). This was only approximately 67% of the 2005 catch (17,776), 25% of the 2004 catch (48,286) and 58% of the 2002 catch (20,396) from the same eight zones. The 2006 catch was only about 15% more than the 2003 (10,314) and 2001 (10,351) catches, and almost twice the 2000 catch (6,233) from the same eight zones. The bay anchovy captured in 2006 were found in every sampling month, but approximately 49% of them were found in July (23.5%) and November (25.8%). They were taken in every zone, but most of them (98%) were taken in Zones 1-5.

Yearlings and adults dominated the length-frequency distribution of bay anchovy from April through June, 2006 (Figure 4-12). In July, the YOY fish appeared in the catches in great numbers. The YOY and yearling/adults demonstrated separate frequency cycles (peaks) from July through September, and finally overlapped in October and November. Although separate peaks are represented in the last two months of the program, it is difficult to determine where the YOY frequency cycle ends and the adult frequency cycle begins. This pattern is somewhat consistent with data from previous years' programs, which exhibited similar seasonal length-frequency distributions (PSE&G 1996, PSE&G 1997, PSE&G 1998, PSE&G 1999 PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006).

Blueback herring

One blueback herring was collected in 2006. This is much less than the number captured in 2005 (19), but more similar to the number caught in 2004 (8), 2003 (5), 2002 (9), 2001 (3) and 2000 (3) from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003,

PSEG 2004, PSEG 2005, PSEG 2006). The blueback herring caught in 2006 was found in Zone 5 during June and was probably an adult (Figure 4-13).

Bluefish

Five bluefish were taken in the 2006 Baywide bottom trawl effort, which was similar in number to the four collected from the same eight zones in 2005, five in 2004, 10 in 2003, 13 in 2002, 19 in 2001 and 17 in 2000 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). The bluefish caught in 2006 were found in Zones 2-4 and Zone 8 from July through September. The three caught in July and September were all YOY, but the one caught in August was probably a yearling (Figure 4-14).

Spot

The spawning season of spot along the Atlantic coast varies, extending possibly from mid-October through mid-March (Warlen and Chester 1985, Flores-Coto and Warlen 1993). In 2006, 102 spot were collected, which is only about 10% of the 2005 catch (1,002) and 24% of the 2000 catch (424) from the same eight zones. The 2006 catch was approximately 2.5 times the 2004 (42) catch, more than nine times the 2003 (11) catch, twice the 2002 (52) catch and 8.5 times the 2001 (12) catch from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). Spot were found in Zones 1-6 in 2006 with the greatest numbers in Zone 2. Most of them were captured from July through September with none caught in April and June and a single fish taken in May, October and November. Figure 4-15 demonstrates the presence of YOY in all six months in which spot were caught, except for the probable presence of a yearling in May and adults in July.

Striped bass

In 2006, 20 striped bass were collected, which is the lowest number caught in the last six years (2005, 201 caught; 2004, 79 caught; 2003, 269 caught; 2002, 88 caught; 2001, 318 caught; 2000, 45 caught) from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). Weisberg and Burton (1993) deduced that striped bass larvae spawned in the upper Delaware River in the late 1980s and early 1990s were possibly from a recovering native population. However, the species still represented only 0.1% of the total finfish catch in the 2006 Baywide bottom trawl effort, which was about the same as the 0.2% of the total finfish catch that striped bass accounted for in 2005, 0.2% in 2004, 0.7% in 2003, the 0.2% in 2002, the 1.1% in 2001

and the 0.3% in 2000 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006).

Striped bass were taken in Zones 4-8 and were split up relatively evenly. They were captured in every sampling month, except May, and were evenly distributed throughout. Striped bass YOY fish appeared to be totally absent from the 2006 catches, except for possibly one in August. Yearlings and/or older specimens were present all of the months in which striped bass were found (Figure 4-16).

Weakfish

The total catch for weakfish in the 2006 survey was 2,185, accounting for 6.2% of the total finfish catch and representing the fourth largest number of fish caught. This number is comparable to the annual weakfish catches from the same eight zones in 2004 (2,964), 2003 (1,672), 2002 (2,035) and 2000 (1,623), but significantly less than the catches in 2005 (7,644) and 2000 (5,261). Weakfish were found in all eight zones and were much more evenly distributed than they have been in the last six years (PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). Weakfish were collected in every month. Most of them were taken from July through September (83.7%).

The spawning season for weakfish extends from mid May through early August in the lower Delaware Bay and Indian River Bay (Wang and Kernehan 1979). Connaughton and Taylor (1996) reported spawning in Delaware Bay between mid May and early July or August. The appearance of YOY fish was responsible for the great increase in the catch totals from July through September (Figure 4-17). These smaller fish were a substantial part of the weakfish collections in these three months and added significantly to the catches in October and November.

White perch

Wang and Kernehan (1979) note that white perch is one of the most abundant resident species of the Delaware River Estuary. O'Herron et al. (1994) reported that white perch was the second most abundant species representing 20.6% of the overall catch. Adult white perch are typically semi-anadromous, making their upriver spawning migration in the spring and returning to the lower reaches of the estuary in the fall where they overwinter (Mansueti 1961).

Five hundred ninety-eight white perch were collected in 2006 accounting for approximately 1.7% of the total finfish catch. This was less than the 904 caught in 2005, 1,447 captured in 2004, the 3,037 taken in 2003 and the 800 sampled in 2000 from the same eight zones. But, it was more than the 478 collected in 2001 and about the same as

the 574 in caught in 2002 from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). White perch were found in all eight zones, except Zone 1. Approximately 83.6% of the white perch collected were located in Zones 6-8 with the most observed in Zone 8.

White perch were collected in every month. The most productive months were April and November. More moderate numbers were found in May, July, and October. The least productive months were June, August and September. In 2006, YOY were not recruited to the gear (possibly one in August) until October and November (Figure 4-18).

Blue crab

The blue crab catch for 2006 (3,771) was the largest catch taken from the same eight zones in the last seven years (2000-2006). It was more than twice the next largest catch in 2000 (1,831) and almost six times the smallest catch in 2003 (658) from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006). In 2006, blue crabs were caught in all eight zones. Most of them (86.7%) were captured in Zones 4-6. Blue crabs were collected in all months. Most of them (89.8%) were found from September through November with the heaviest catch occurring in November.

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Bottom Trawl Effort Tables

Table 4-1
PSEG Estuary Enhancement Program
Total catch collected by zone using a bottom trawl,
April through November 2006

Family	Common Name	Scientific Name	BZ-1	BZ-2	BZ-3	BZ-4	BZ-5	BZ-6	BZ-7	BZ-8	Total
PORTUNIDAE											
	BLUE CRAB (BLUECLAW)	CALLINECTES SAPIDUS	3	94	160	912	909	1448	187	58	3771
CARCHARHINIDAE											
	SMOOTH DOGFISH	MUSTELUS CANIS	13	9	6	4					32
RAJIDAE											
	CLEARNOSE SKATE	RAJA EGLANTERIA	6	5	1	2					14
	LITTLE SKATE	RAJA ERINACEA			1						1
MYLIOBATIDAE											
	BULLNOSE RAY	MYLIOBATIS FREMINVILLEI			2						2
	COWNOSE RAY	RHINOPTERA BONASUS		1							1
ANGUILLIDAE											
	AMERICAN EEL	ANGUILLA ROSTRATA					3	36	34	51	124
CONGRIDAE											
	CONGER EEL	CONGER OCEANICUS			1						1
ENGRAULIDAE											
	STRIPED ANCHOVY	ANCHOA HEPSETUS	1	29		1					31
	BAY ANCHOVY	ANCHOA MITCHILLI	480	1061	6432	2865	791	140	87	1	11857
CLUPEIDAE											
	ATLANTIC MENHADEN	BREVOORTIA TYRANNUS		2	10	3	3		1	1	20
	BLUEBACK HERRING	ALOSA AESTIVALIS					1				1
	ALEWIFE	ALOSA PSEUDOHARENGUS				1					1
	AMERICAN SHAD	ALOSA SAPIDISSIMA				1			1	1	3
	ATLANTIC HERRING	CLUPEA HARENGUS HARENGUS		1		3	1				5
ICTALURIDAE											
	CHANNEL CATFISH	ICTALURUS PUNCTATUS						1	4	122	127
	WHITE CATFISH	AMEIURUS CATUS							3	4	7
	BROWN BULLHEAD	AMEIURUS NEBULOSUS							2		2
BATRACHOIDIDAE											
	OYSTER TOADFISH	OPSANUS TAU	1		2	8	40	33			84
GADIDAE											
	SPOTTED HAKE	UROPHYCIS REGIA	33	599	68	39	45	336	121	1	1242
	SILVER HAKE	MERLUCCIUS BILINEARIS	1	2							3
	RED HAKE	UROPHYCIS CHUSS	6	276	2		2	2			288
OPHIDIIDAE											
	STRIPED CUSK-EEL	OPHIDION MARGINATA	2	5	2	6	7	30			52

Table 4-1 (continued)
PSEG Estuary Enhancement Program
Total catch collected by zone using a bottom trawl,
April through November 2006

Family	Common Name	Scientific Name	BZ-1	BZ-2	BZ-3	BZ-4	BZ-5	BZ-6	BZ-7	BZ-8	Total
POMATOMIDAE											
	BLUEFISH	POMATOMUS SALTATRIX		1	2	1				1	5
SPARIDAE											
	SCUP	STENOTOMUS CHRYSOPS	57	50	36	26	18	1			188
SCIAENIDAE											
	WEAKFISH	CYNOSCION REGALIS	137	571	270	160	341	448	234	24	2185
	SILVER PERCH	BAIRDIELLA CHRYSOURA	6	50	21	6	18	8			109
	SPOT	LEIOSTOMUS XANTHURUS	4	77	10	1	9	1			102
	NORTHERN KINGFISH	MENTICIRRHUS SAXATILIS	1	11	14	6	4	22	24		82
	ATLANTIC CROAKER	MICROPOGONIAS UNDULATUS	205	1452	1394	833	1905	1356	1939	4444	13528
	BLACK DRUM	POGONIAS CROMIS				1	1				2
URANOSCOPIDAE											
	NORTHERN STARGAZER	ASTROSCOPUS GUTTATUS					2				2
GOBIIDAE											
	NAKED GOBY	GOBIOSOMA BOSC				1	2	1	1		5
	GOBIIDAE SP.	UNIDENTIFIED GOBIIDAE			1						1
STROMATEIDAE											
	BUTTERFISH	PEPRILUS TRIACANTHUS	53	7	63	42		1			166
BOTHIDAE											
	SUMMER FLOUNDER	PARALICHTHYS DENTATUS	1	3	2	2	3	1			12
	WINDOWPANE	SCOPHTHALMUS AQUOSUS	11	9	11	5	3	12	2		53
PLEURONECTIDAE											
	WINTER FLOUNDER	PLEURONECTES AMERICANUS				1					1
SOLEIDAE											
	HOGCHOKER	TRINECTES MACULATUS	26	179	56	279	194	243	1351	1685	4013
	BLACKCHEEK TONGUEFISH	SYMPHURUS PLAGIUSA		9	5	15	8	9	1		47
TETRAODONTIDAE											
	STRIPED BURRFISH	CHILOMYCTERUS SCHOEPFI				1	1				2
CARANGIDAE											
	ATLANTIC MOONFISH	SELENE SETAPINNIS		1	1	1					3
	PERMIT	TRACHINOTUS FALCATUS		1							1

Table 4-1 (continued)
PSEG Estuary Enhancement Program
Total catch collected by zone using a bottom trawl,
April through November 2006

Family	Common Name	Scientific Name	BZ-1	BZ-2	BZ-3	BZ-4	BZ-5	BZ-6	BZ-7	BZ-8	Total
HAEMULIDAE											
	PIGFISH	ORTHOPRISTIS CHRYSOPTERA				1					1
BLENNIIDAE											
	FEATHERED BLENNY	HYPSOBLENNIUS HENTZI				1					1
SYNGNATHIDAE											
	LINED SEAHORSE	HIPPOCAMPUS ERECTUS		1		2					3
	NORTHERN PIPEFISH	SYNGNATHUS FUSCUS		5	2	3	2	1			13
TRIGLIDAE											
	NORTHERN SEAROBIN	PRIONOTUS CAROLINUS	5	7	4	15	8	8	1		48
	STRIPED SEAROBIN	PRIONOTUS EVOLANS	4	4		3	10				21
PERCICHTHYIDAE											
	WHITE PERCH	MORONE AMERICANA		12	5	72	9	81	162	257	598
	STRIPED BASS	MORONE SAXATILIS				3	4	3	6	4	20
SERRANIDAE											
	BLACK SEA BASS	CENTROPRISTIS STRIATA			1	4	6	1	1		13
CYPRINIDAE											
	EASTERN SILVERY MINNOW	HYBOGNATHUS REGIS							1		1
CENTRARCHIDAE											
	SMALLMOUTH BASS	MICROPTERUS DOLOMIEU			1						1
	PUMPKIN SEED	LEPOMIS GIBBSOUS								1	1
BOTHIDAE											
	SMALLMOUTH FLOUNDER	ETROPUS MICROSTOMUS	8	5	4	6	3	1			27
DASYATIDAE											
	SOUTHERN STINGRAY	DASYATIS AMERICANA	1								1
SQUALIDAE											
	SPINY DOGFISH	SQUALUS ACANTHIAS	1	1							2
TRICHIURIDAE											
	ATLANTIC CUTLASSFISH	TRICHIURUS LEPTURUS		1			3				4
SYNODONTIDAE											
	INSHORE LIZARDFISH	SYNODUS FOETENS			1						1
MUGILIDAE											
	WHITE MULLET	MUGIL CUREMA	1								1
ACIPENSERIDAE											
	ATLANTIC STURGEON	ACIPENSER OXYRHYNCHUS	1								1
		TOTAL CATCH	1068	4541	8591	5336	4356	4224	4163	6655	38934

Table 4-2
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 1 using a bottom trawl
April - November 2006

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
ATLANTIC CROAKER						116	31	58	**205**	**6.41**
ATLANTIC STURGEON					1				**1**	**0.03**
BAY ANCHOVY		5		1	8		465	1	**480**	**15.00**
BLUE CRAB (BLUECLAW)							1	2	**3**	**0.09**
BUTTERFISH				5	48				**53**	**1.66**
CLEARNOSE SKATE		1	1	3		1			**6**	**0.19**
HOGCHOKER						22		4	**26**	**0.81**
NORTHERN KINGFISH						1			**1**	**0.03**
NORTHERN SEAROBIN	4							1	**5**	**0.16**
OYSTER TOADFISH	1								**1**	**0.03**
RED HAKE	6								**6**	**0.19**
SCUP				56	1				**57**	**1.78**
SILVER HAKE	1								**1**	**0.03**
SILVER PERCH						3	3		**6**	**0.19**
SMALLMOUTH FLOUNDER					3	3	1	1	**8**	**0.25**
SMOOTH DOGFISH	1			9		3			**13**	**0.41**
SOUTHERN STINGRAY						1			**1**	**0.03**
SPINY DOGFISH	3								**3**	**0.09**
SPOT						4			**4**	**0.13**
SPOTTED HAKE	9	1		15	4			4	**33**	**1.03**
STRIPED ANCHOVY					1				**1**	**0.03**
STRIPED CUSK-EEL						2			**2**	**0.06**
STRIPED SEAROBIN						4			**4**	**0.13**
SUMMER FLOUNDER				1					**1**	**0.03**
WEAKFISH		30		19	2	36	38	12	**137**	**4.28**
WHITE MULLET							1		**1**	**0.03**
WINDOWPANE	1		2	2	1	2	1	2	**11**	**0.34**
Total Finfish Collected	26	37	3	111	69	198	541	85	**1070**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	6.5	9.3	0.8	27.8	17.3	49.5	135.3	21.3	**33.4**	

Table 4-3
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 2 using a bottom trawl
April - November 2006

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
ATLANTIC CROAKER				73	390	156	162	671	**1452**	**30.25**
ATLANTIC CUTLASSFISH				1					**1**	**0.02**
ATLANTIC HERRING	1								**1**	**0.02**
ATLANTIC MENHADEN						1	1		**2**	**0.04**
ATLANTIC MOONFISH						14			**14**	**0.29**
BAY ANCHOVY	13	10		189	285	327	93	144	**1061**	**22.10**
BLACKCHEEK TONGUEFISH						1	1	7	**9**	**0.19**
BLUE CRAB (BLUECLAW)					41	27	23	3	**94**	**1.96**
BLUEFISH					1				**1**	**0.02**
BUTTERFISH				2	4		1		**7**	**0.15**
CLEARNOSE SKATE	5								**5**	**0.10**
COWNOSE RAY				1					**1**	**0.02**
HOGCHOKER	5		3	6	14	26	19	106	**179**	**3.73**
LINED SEAHORSE				1					**1**	**0.02**
NORTHERN KINGFISH				1		2	6	2	**11**	**0.23**
NORTHERN PIPEFISH	1			1	1	1	1		**5**	**0.10**
NORTHERN SEAROBIN	4			1	1			1	**7**	**0.15**
PERMIT				1					**1**	**0.02**
RED HAKE	276								**276**	**5.75**
SCUP			15	28	7				**50**	**1.04**
SILVER HAKE	2								**2**	**0.04**
SILVER PERCH		2		7		31	2	8	**50**	**1.04**
SMALLMOUTH FLOUNDER			2			1	2		**5**	**0.10**
SMOOTH DOGFISH				2	3	1	3		**9**	**0.19**
SPINY DOGFISH	1								**1**	**0.02**
SPOT		1		29	35	12			**77**	**1.60**
SPOTTED HAKE	591	3		1	2			2	**599**	**12.48**
STRIPED ANCHOVY					28	1			**29**	**0.60**
STRIPED CUSK-EEL	3					2			**5**	**0.10**
STRIPED SEAROBIN					1	2	1		**4**	**0.08**
SUMMER FLOUNDER		1		1	1				**3**	**0.06**
WEAKFISH	4			213	190	136	10	18	**571**	**11.90**
WHITE PERCH	1							11	**12**	**0.25**
WINDOWPANE	7		2						**9**	**0.19**
Total Finfish Collected	914	17	22	558	1004	741	325	973	**4554**	
Trawls per Month	6	6	6	6	6	6	6	6	**48**	
Total CPUE	152.3	2.8	3.7	93.0	167.3	123.5	54.2	162.2	**94.9**	

Table 4-4
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 3 using a bottom trawl
April - November 2006

Common Name	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Total**	**CPUE**
ATLANTIC CROAKER		173	3	37	108	14	57	1002	**1394**	**21.78**
ATLANTIC MENHADEN		9						1	**10**	**0.16**
ATLANTIC MOONFISH						1			**1**	**0.02**
BAY ANCHOVY	14	216	84	1820	425	221	968	2684	**6432**	**100.50**
BLACKCHEEK TONGUEFISH								5	**5**	**0.08**
BLACK SEA BASS				1					**1**	**0.02**
BLUE CRAB (BLUECLAW)	3	25	2		3	4	16	107	**160**	**2.50**
BLUEFISH				1	1				**2**	**0.03**
BULLNOSE RAY					2				**2**	**0.03**
BUTTERFISH		2	2	49	1	3	6		**63**	**0.98**
CLEARNOSE SKATE		1							**1**	**0.02**
CONGER EEL								1	**1**	**0.02**
GOBIIDAE			1						**1**	**0.02**
HOGCHOKER	2		1	1	5	25	5	17	**56**	**0.88**
INSHORE LIZARDFISH				1					**1**	**0.02**
LITTLE SKATE								1	**1**	**0.02**
NORTHERN KINGFISH							1	14	**15**	**0.23**
NORTHERN PIPEFISH	1								**1**	**0.02**
NORTHERN SEAROBIN				4					**4**	**0.06**
OYSTER TOADFISH	1	1							**2**	**0.03**
RED HAKE	2								**2**	**0.03**
SCUP		1		1	19	11	4		**36**	**0.56**
SILVER PERCH			2	2	2	1	8	6	**21**	**0.33**
SMALLMOUTH BASS				1					**1**	**0.02**
SMALLMOUTH FLOUNDER	1				1	2			**4**	**0.06**
SMOOTH DOGFISH		2	2	2					**6**	**0.09**
SPOT				4		6			**10**	**0.16**
SPOTTED HAKE	45	1						22	**68**	**1.06**
STRIPED CUSK-EEL								2	**2**	**0.03**
SUMMER FLOUNDER			1			1			**2**	**0.03**
WEAKFISH	1	49	29	58	44	25	37	27	**270**	**4.22**
WHITE PERCH								5	**5**	**0.08**
WINDOWPANE	2		1			8			**11**	**0.17**
Total Finfish Collected	72	480	128	1982	611	322	1102	3894	**8591**	
Trawls per Month	8	8	8	8	8	8	8	8	**64**	
Total CPUE	9.0	60.0	16.0	247.8	76.4	40.3	137.8	486.8	**134.2**	

Table 4-5
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 4 using a bottom trawl
April - November 2006

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
ALEWIFE	1								**1**	**0.02**
AMERICAN SHAD		1							**1**	**0.02**
ATLANTIC CROAKER	79	14	9	1	58	123	72	477	**833**	**17.35**
ATLANTIC HERRING	3								**3**	**0.06**
ATLANTIC MENHADEN						1		2	**3**	**0.06**
ATLANTIC MOONFISH						1			**1**	**0.02**
BAY ANCHOVY	1516	37	154	348	122	147	329	212	**2865**	**59.69**
BLACK DRUM								1	**1**	**0.02**
BLACKCHEEK TONGUEFISH								15	**15**	**0.31**
BLACK SEA BASS		1	1			1	1		**4**	**0.08**
BLUE CRAB (BLUECLAW)	12	42	1	2	2	157	21	675	**912**	**19.00**
BLUEFISH						1			**1**	**0.02**
BUTTERFISH		1	1	36		4			**42**	**0.88**
CLEARNOSE SKATE		1					1		**2**	**0.04**
CREVALLE JACK						1			**1**	**0.02**
FEATHER BLENNY							1		**1**	**0.02**
HOGCHOKER	2	7		2	5	28	15	220	**279**	**5.81**
LINED SEAHORSE		1	1						**2**	**0.04**
NAKED GOBY			1						**1**	**0.02**
NORTHERN KINGFISH					1	5			**6**	**0.13**
NORTHERN PIPEFISH	1				1		1		**3**	**0.06**
NORTHERN PUFFER									**0**	**0.00**
NORTHERN SEAROBIN	8	4	1	1	1				**15**	**0.31**
OYSTER TOADFISH				2	1		4	1	**8**	**0.17**
PIGFISH						1			**1**	**0.02**
SCUP		1	1	6	14	3	1		**26**	**0.54**
SILVER PERCH							5	1	**6**	**0.13**
SMALLMOUTH FLOUNDER			1					4	**5**	**0.10**
SMOOTH DOGFISH					2	2			**4**	**0.08**
SPOT								1	**1**	**0.02**
SPOTTED HAKE	13	25						1	**39**	**0.81**
STRIPED ANCHOVY				1					**1**	**0.02**
STRIPED BASS							2	1	**3**	**0.06**
STRIPED BURRFISH					1				**1**	**0.02**
STRIPED CUSK-EEL								6	**6**	**0.13**
STRIPED SEAROBIN					1	2			**3**	**0.06**
SUMMER FLOUNDER		1				1	1		**3**	**0.06**
WEAKFISH		7	6	10	36	69	22	10	**160**	**3.33**
WHITE PERCH								72	**72**	**1.50**
WINDOWPANE		3				2			**5**	**0.10**
WINTER FLOUNDER				1					**1**	**0.02**
Total Finfish Collected	1634	145	177	410	245	549	476	1699	**5335**	
Trawls per Month	6	6	6	6	6	6	6	6	**48**	
Total CPUE	272.3	24.2	29.5	68.3	40.8	91.5	79.3	283.2	**111.1**	

Table 4-6
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 5 using a bottom trawl
April - November 2006

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN EEL						1	2		**3**	**0.09**
ATLANTIC CROAKER		2	7	132	64	88	424	1188	**1905**	**59.53**
ATLANTIC CUTLASSFISH				3					**3**	**0.09**
ATLANTIC HERRING	1								**1**	**0.03**
ATLANTIC MENHADEN		2			1				**3**	**0.09**
BAY ANCHOVY	154	24	39	396	147	11	9	11	**791**	**24.72**
BLACKCHEEK TONGUEFISH								8	**8**	**0.25**
BLACK DRUM						1			**1**	**0.03**
BLACK SEA BASS	1					1	4		**6**	**0.19**
BLUEBACK HERRING			1						**1**	**0.03**
BLUE CRAB (BLUECLAW)	14	6	20	8	55	481	120	205	**909**	**28.41**
HOGCHOKER	5	4	3	3		61	45	73	**194**	**6.06**
NAKED GOBY						1		1	**2**	**0.06**
NORTHERN KINGFISH						1	3		**4**	**0.13**
NORTHERN PIPEFISH	1						1		**2**	**0.06**
NORTHERN SEAROBIN	3	4					1		**8**	**0.25**
NORTHERN STARGAZER					1		1		**2**	**0.06**
OYSTER TOADFISH		6			2	9	6	17	**40**	**1.25**
RED HAKE	1	1							**2**	**0.06**
SCUP			2	1		15			**18**	**0.56**
SILVER PERCH				1		14	2	1	**18**	**0.56**
SMALLMOUTH FLOUNDER							3		**3**	**0.09**
SPOT				3	1	4	1		**9**	**0.28**
SPOTTED HAKE	6	4	28			1	2	4	**45**	**1.41**
STRIPED BASS					1	1	1	1	**4**	**0.13**
STRIPED BURRFISH					1				**1**	**0.03**
STRIPED CUSK-EEL						2	4	1	**7**	**0.22**
STRIPED SEAROBIN						10			**10**	**0.31**
SUMMER FLOUNDER					1	1	1		**3**	**0.09**
WEAKFISH		5	16	35	132	132	19	2	**341**	**10.66**
WHITE PERCH							5	4	**9**	**0.28**
WINDOWPANE	2				1				**3**	**0.09**
Total Finfish Collected	188	58	116	582	407	835	654	1516	**4356**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	47.0	14.5	29.0	145.5	101.8	208.8	163.5	379.0	**136.1**	

Table 4-7
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 6 using a bottom trawl
April - November 2006

Common Name	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Total**	**CPUE**
AMERICAN EEL		8	4	4		5	6	9	**36**	**1.13**
ATLANTIC CROAKER	6	13	85	860	131	32	97	132	**1356**	**42.38**
BAY ANCHOVY	1		9	37	81	1	3	8	**140**	**4.38**
BLACKCHEEK TONGUEFISH						2	1	6	**9**	**0.28**
BLACK SEA BASS		1							**1**	**0.03**
BLUE CRAB (BLUECLAW)	12	54	11	32	10	602	178	549	**1448**	**45.25**
BUTTERFISH							1		**1**	**0.03**
CHANNEL CATFISH				1					**1**	**0.03**
HOGCHOKER	55	27	37	16	15	2	50	41	**243**	**7.59**
NAKED GOBY								1	**1**	**0.03**
NORTHERN KINGFISH						11	10	1	**22**	**0.69**
NORTHERN PIPEFISH								1	**1**	**0.03**
NORTHERN SEAROBIN	3	3	2						**8**	**0.25**
OYSTER TOADFISH		5	10	1		9	8		**33**	**1.03**
RED HAKE	2								**2**	**0.06**
SCUP			1						**1**	**0.03**
SILVER PERCH		1		3		1	1	2	**8**	**0.25**
SMALLMOUTH FLOUNDER	1								**1**	**0.03**
SPOT				1					**1**	**0.03**
SPOTTED HAKE	278	32	25					1	**336**	**10.50**
STRIPED BASS				1		1		1	**3**	**0.09**
STRIPED CUSK-EEL			1	8	2	9	10		**30**	**0.94**
SUMMER FLOUNDER			1						**1**	**0.03**
WEAKFISH		1	1	347	75	17	7		**448**	**14.00**
WHITE CATFISH									**0**	**0.00**
WHITE PERCH	26			2	1		4	48	**81**	**2.53**
WINDOWPANE	10	1	1						**12**	**0.38**
Total Finfish Collected	394	146	188	1313	315	692	376	800	**4224**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	98.5	36.5	47.0	328.3	78.8	173.0	94.0	200.0	**132.0**	

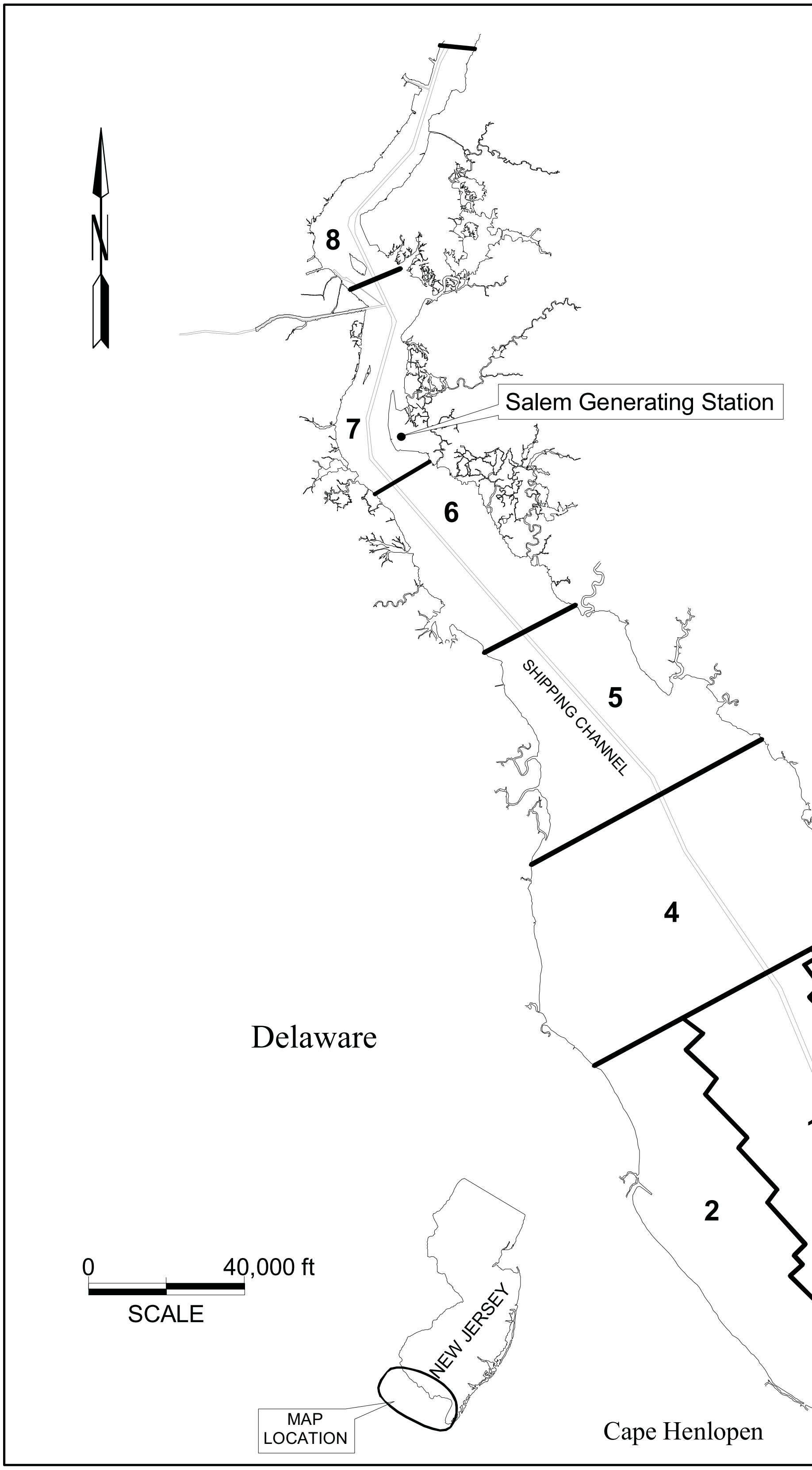
Table 4-8
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 7 using a bottom trawl
April - November 2006

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN EEL	1		8	2		19	2	2	**34**	**1.06**
AMERICAN SHAD		1							**1**	**0.03**
ATLANTIC CROAKER	28	45	456	328	279	91	180	532	**1939**	**60.59**
ATLANTIC MENHADEN			1						**1**	**0.03**
BAY ANCHOVY	7	74				1	4	1	**87**	**2.72**
BLACKCHEEK TONGUEFISH							1		**1**	**0.03**
BLACK SEA BASS	1								**1**	**0.03**
BLUE CRAB (BLUECLAW)	2		5	3	14	71	49	43	**187**	**5.84**
BROWN BULLHEAD	2								**2**	**0.06**
CHANNEL CATFISH				4					**4**	**0.13**
HOGCHOKER	242	10	150	186	87	455	124	97	**1351**	**42.22**
NAKED GOBY					1				**1**	**0.03**
NORTHERN KINGFISH						3	21		**24**	**0.75**
NORTHERN SEAROBIN	1								**1**	**0.03**
SPOTTED HAKE	115	6							**121**	**3.78**
STRIPED BASS	2		1	1	1	1			**6**	**0.19**
WEAKFISH				1	179	48	6		**234**	**7.31**
WHITE CATFISH	3								**3**	**0.09**
WHITE PERCH	50	12	10	30	11	21	12	16	**162**	**5.06**
WINDOWPANE	2								**2**	**0.06**
Total Finfish Collected	456	148	631	555	572	710	399	691	**4162**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	114.0	37.0	157.8	138.8	143.0	177.5	99.8	172.8	**130.1**	

Table 4-9
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 8 using a bottom trawl
April - November 2006

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN EEL	5	4	20	7	2	8	1	4	**51**	**1.59**
AMERICAN SHAD							1		**1**	**0.03**
ATLANTIC CROAKER	241	1028	2057	424	44	61	289	300	**4444**	**138.88**
ATLANTIC MENHADEN		1							**1**	**0.03**
BAY ANCHOVY						1			**1**	**0.03**
BLACKBANDED SUNFISH									**0**	**0.00**
BLUE CRAB (BLUECLAW)	1	2			2	10	37	6	**58**	**1.81**
BLUEFISH						1			**1**	**0.03**
CHANNEL CATFISH	28	24	15	3		7	15	30	**122**	**3.81**
EASTERN SILVERY MINNOW	1								**1**	**0.03**
HOGCHOKER	463	196	206	120	64	167	398	71	**1685**	**52.66**
PUMPKINSEED		1							**1**	**0.03**
SPOTTED HAKE	1								**1**	**0.03**
STRIPED BASS	1				1		2		**4**	**0.13**
WEAKFISH						24			**24**	**0.75**
WHITE CATFISH	2			1			1		**4**	**0.13**
WHITE PERCH	124	29	1	33	7	3	35	25	**257**	**8.03**
Total Finfish Collected	867	1285	2299	588	120	282	779	436	**6656**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	216.8	321.3	574.8	147.0	30.0	70.5	194.8	109.0	**208.0**	

Bottom Trawl Effort Figures



Zone	Typical Number of Bottom Trawls per Sampling Event
1	4
2	6
3	8
4	6
5	4
6	4
7	4
8	4

Public Service Enterprise Group	Figure 4-1 Delaware Bay Sampling Zones

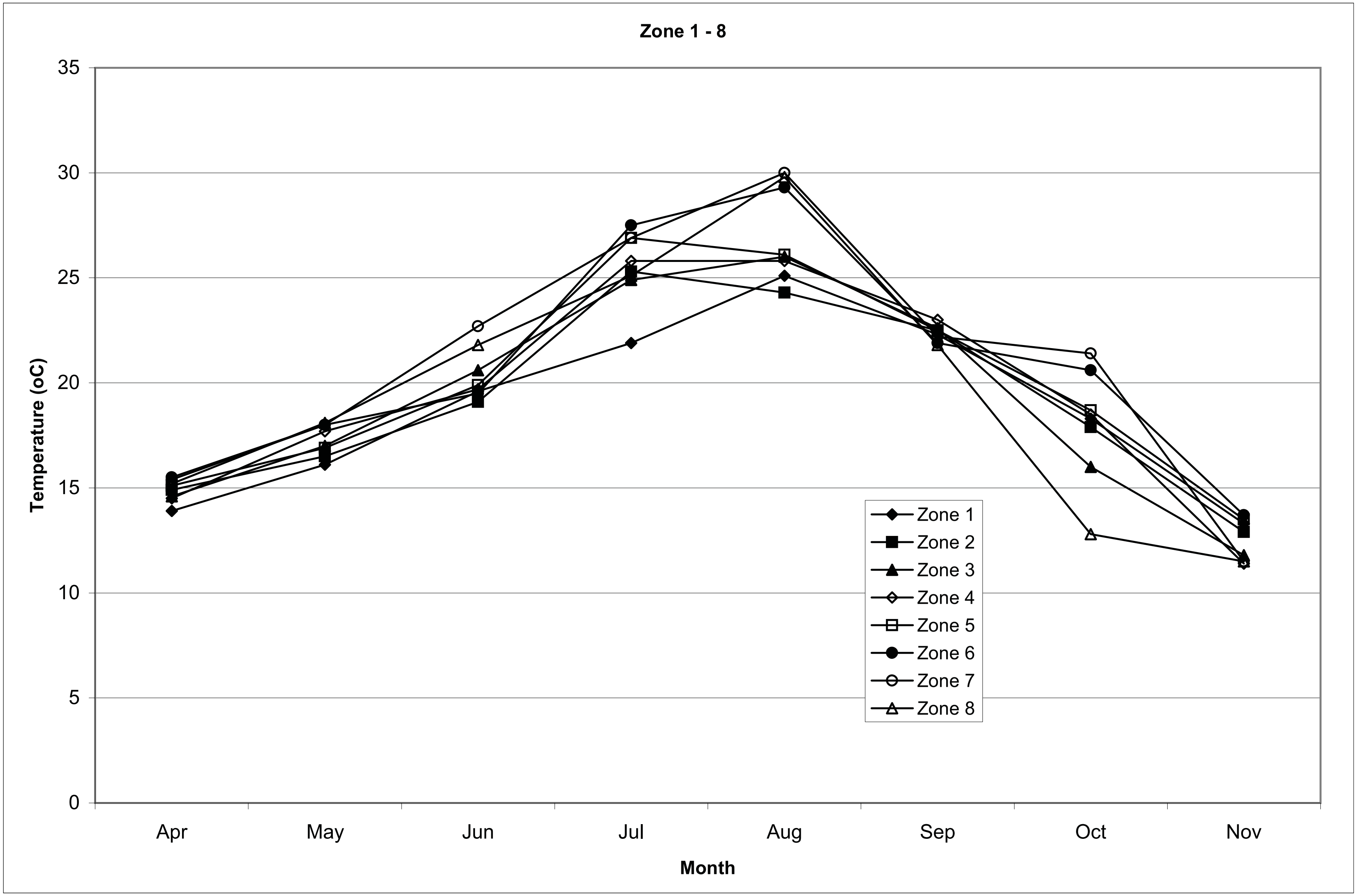


Figure 4-2 Spatial and temporal distribution of mean bottom water temperature observed during the Bottom Trawl Effort, April - November, 2006

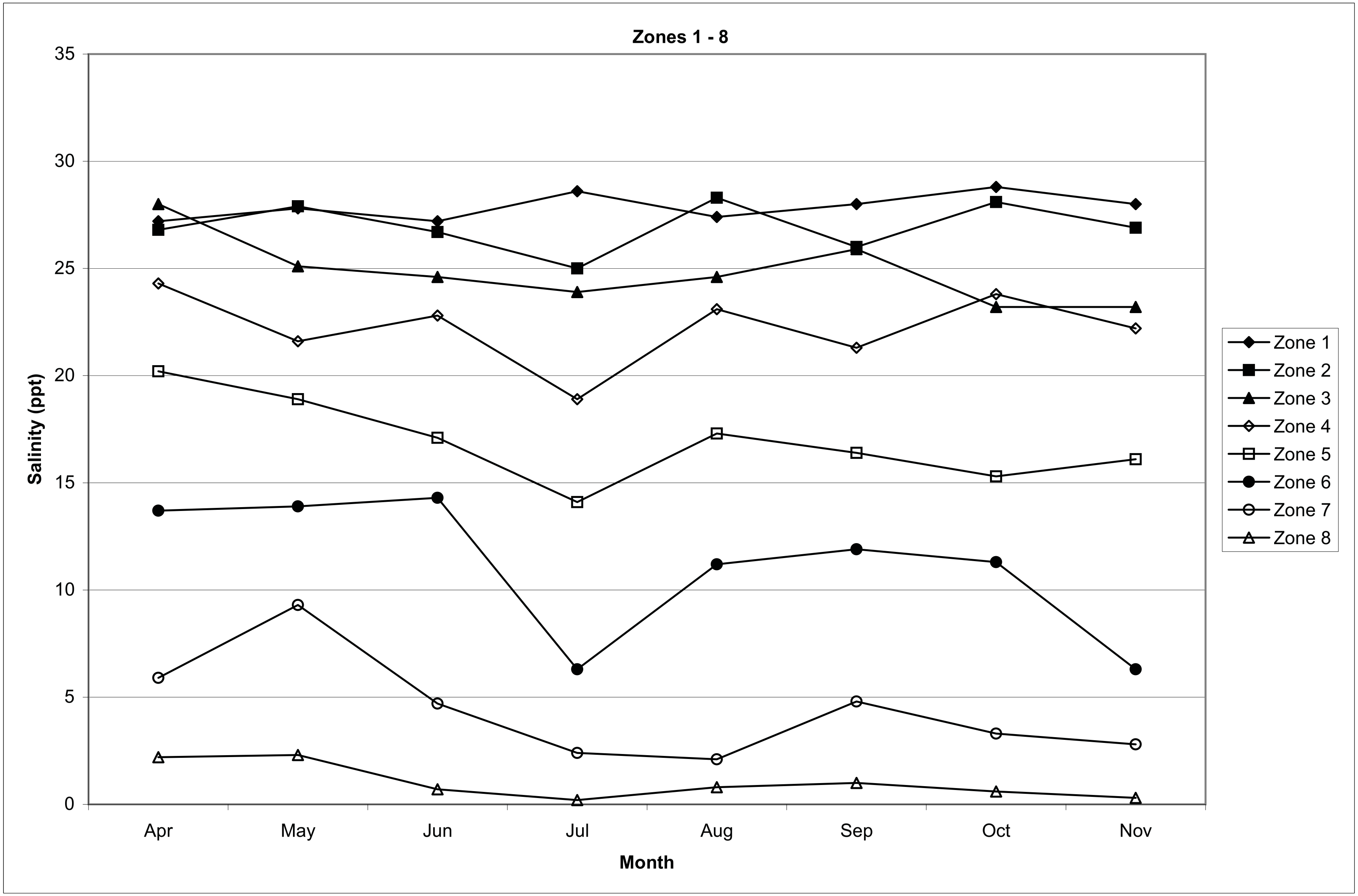


Figure 4-3 Spatial and temporal distribution of mean bottom salinity observed during the Bottom Trawl Effort, April - November 2006

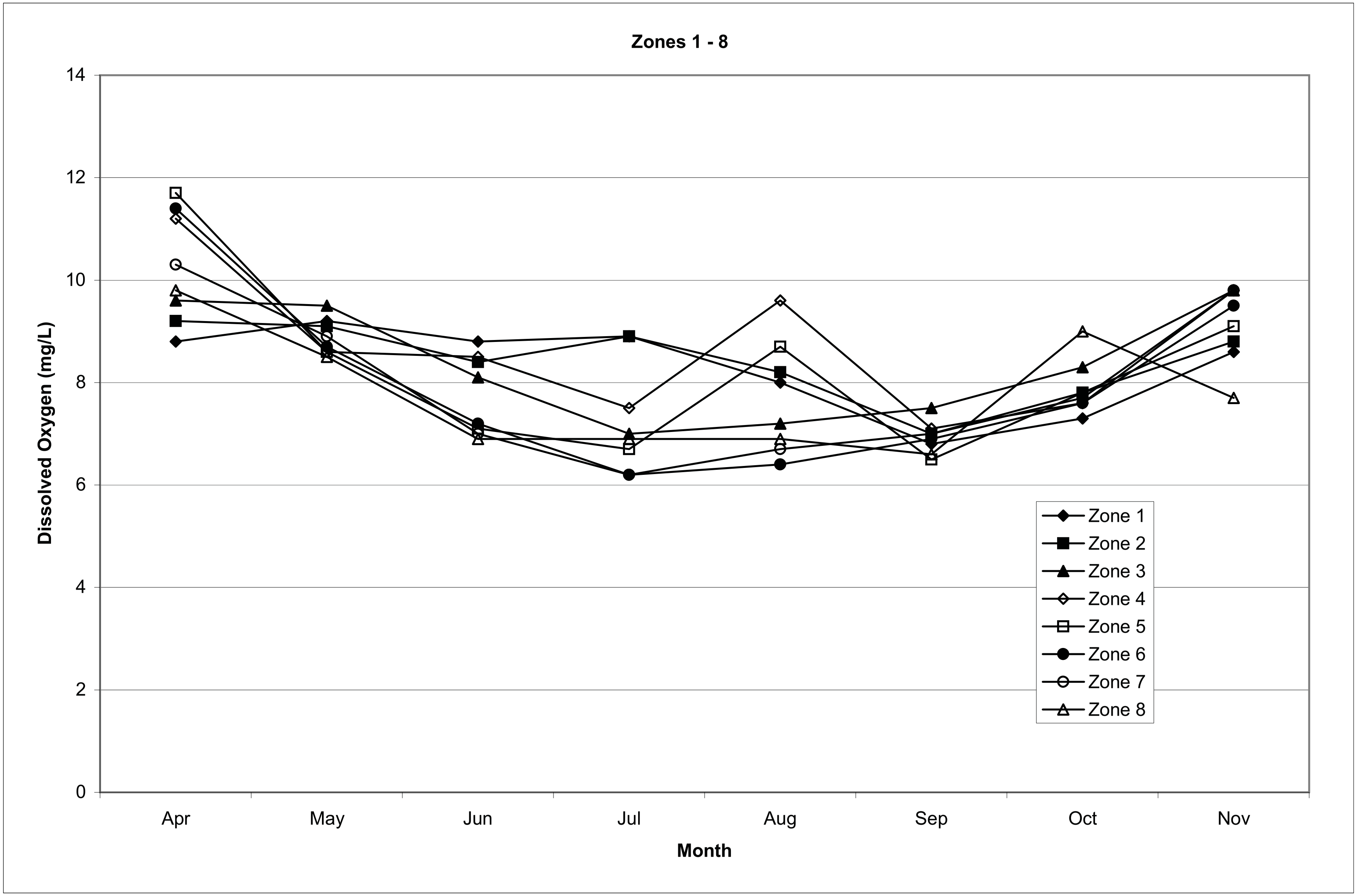


Figure 4-4 Spatial and temporal distribution of mean bottom dissolved oxygen observed during the Bottom Trawl Effort, April - November 2006

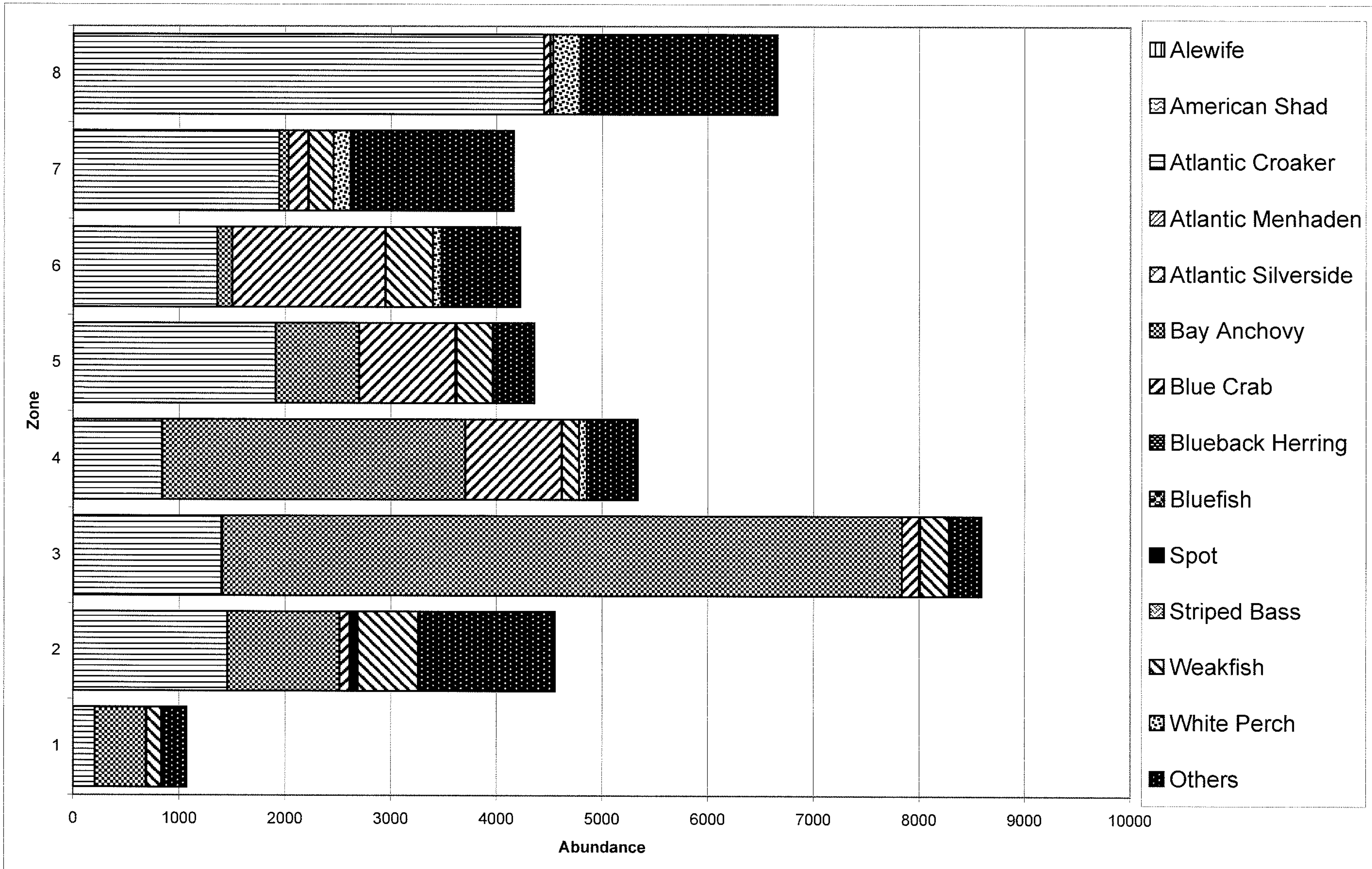
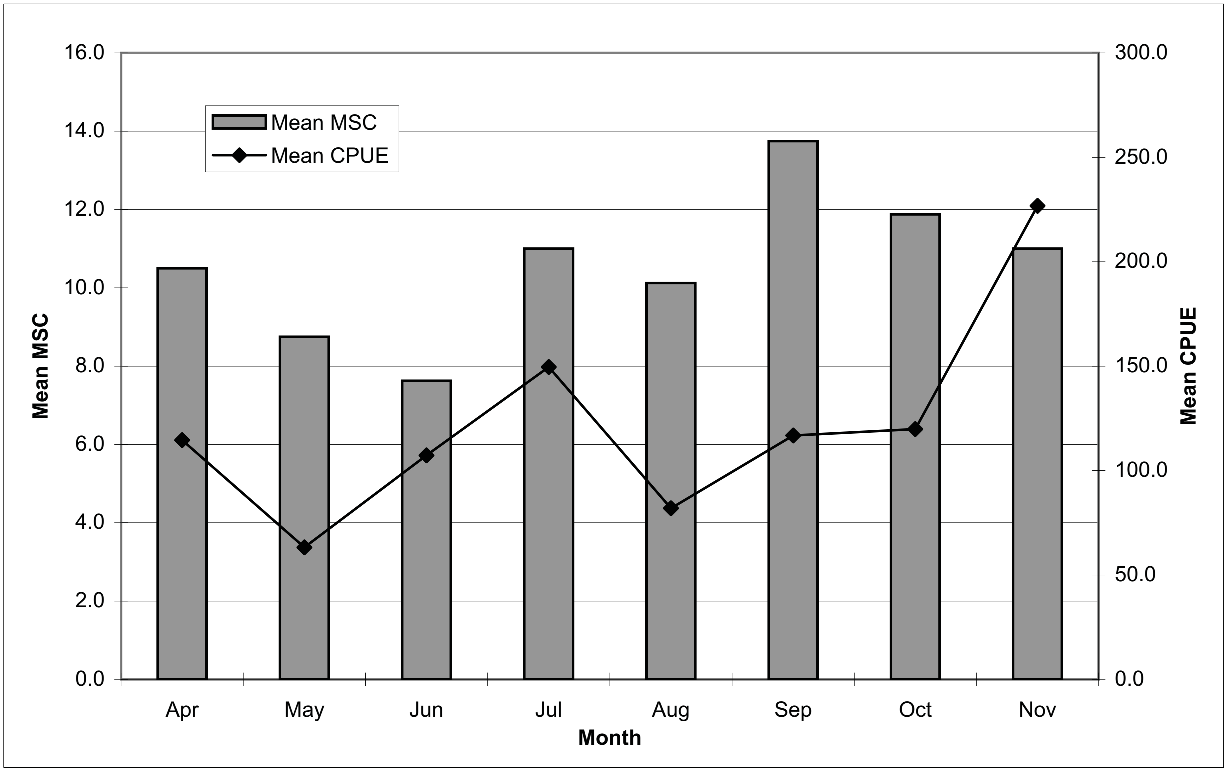
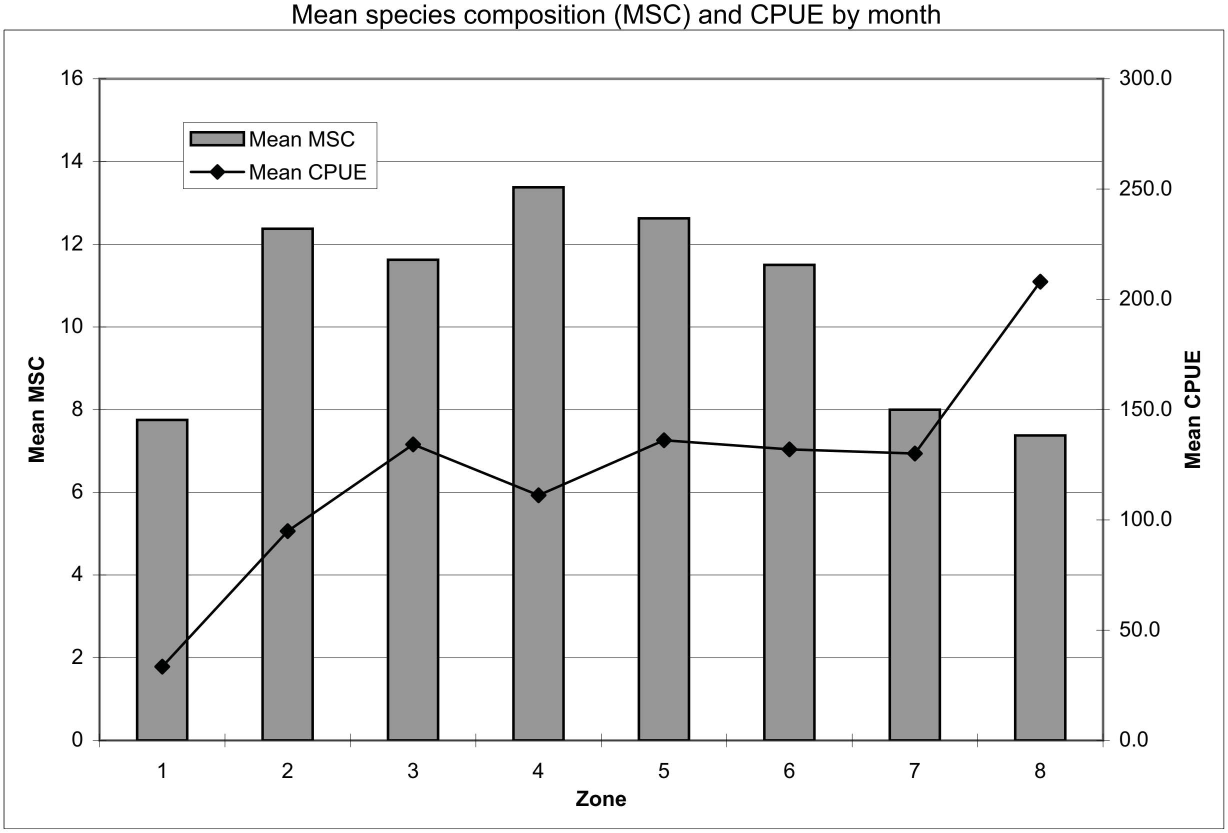


Figure 4-5 Total abundance by zone for target species and others caught during the Bottom Trawl Effort, April - November 2006



Mean species composition (MSC) and CPUE by month



Mean species composition (MSC) and CPUE by zone

Figure 4-6 Mean species composition (MSC) and catch per unit effort (CPUE) by zone and by month for all species caught during the Bottom Trawl Effort, April - November 2006

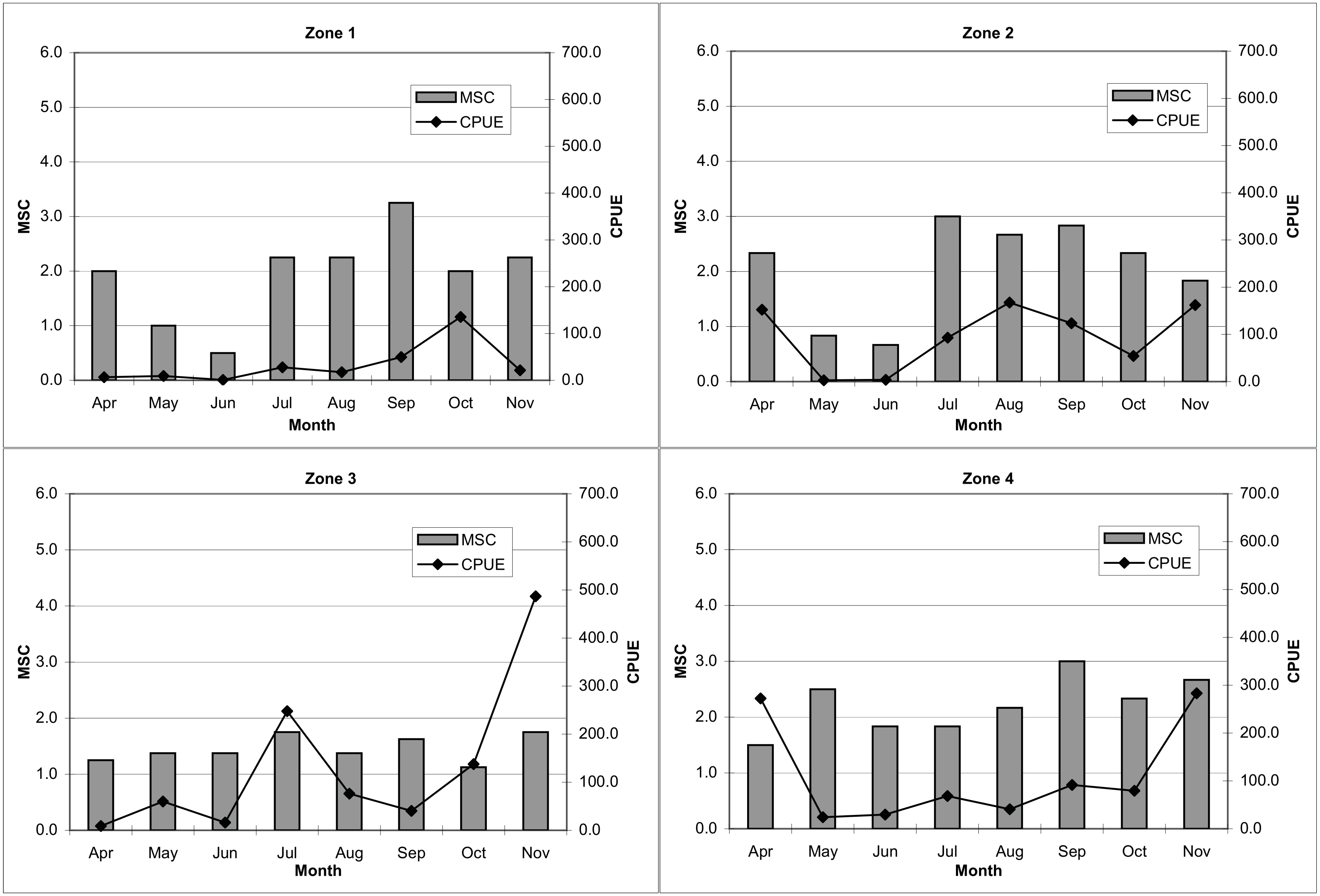


Figure 4-7 Mean species composition (MSC) and catch per unit effort (CPUE) by month for each zone during the Bottom Trawl Effort, April - November 2006

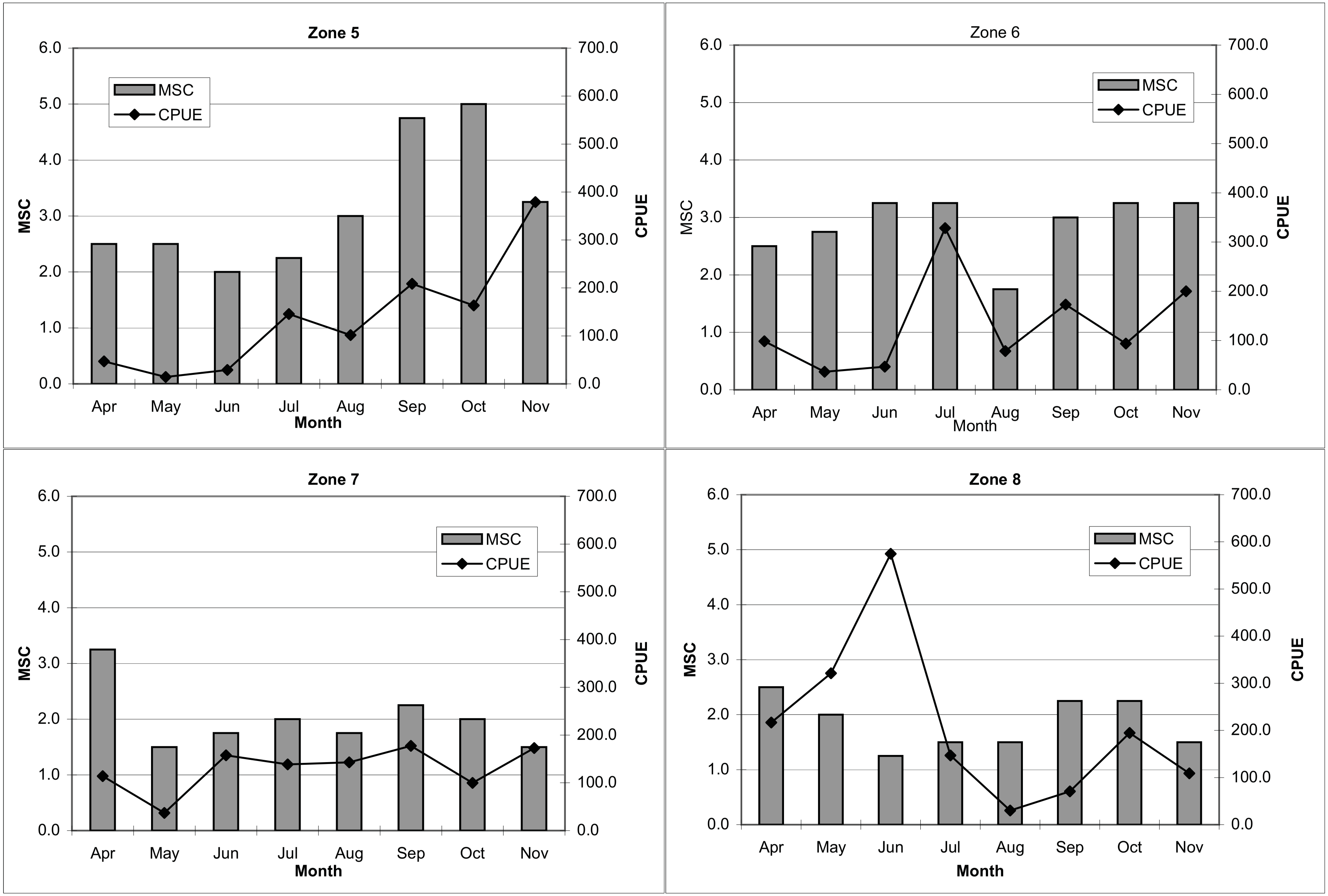


Figure 4-7 (continued) Mean species composition (MSC) and catch per unit effort (CPUE) by month for each zone during the Bottom Trawl Effort, April - November 2006

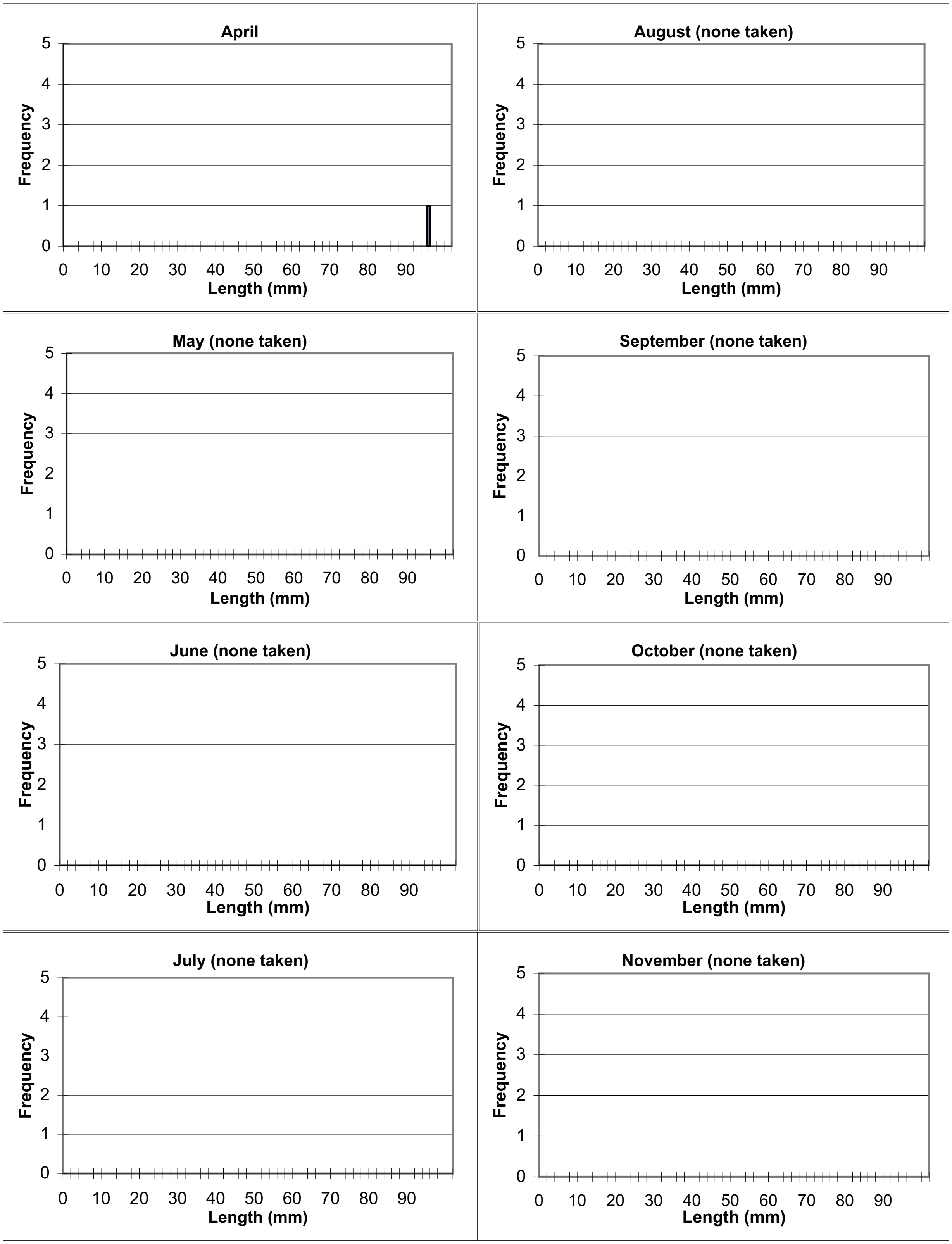


Figure 4-8 Length-frequency distribution of alewife by month during the Bottom Trawl Effort, April - November 2006

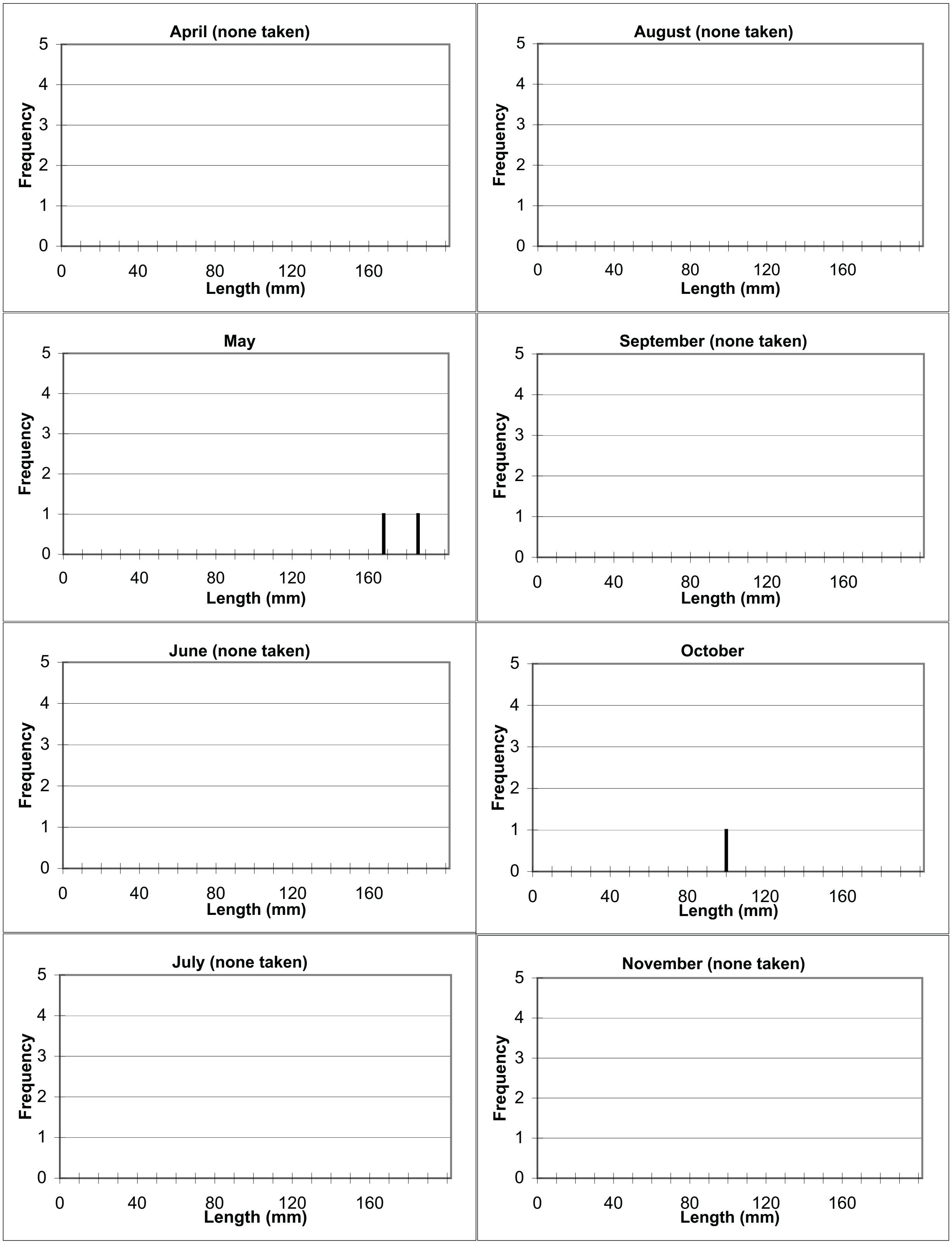


Figure 4-9 Length-frequency distribution of American shad by month during the Bottom Trawl Effort, April - November 2006

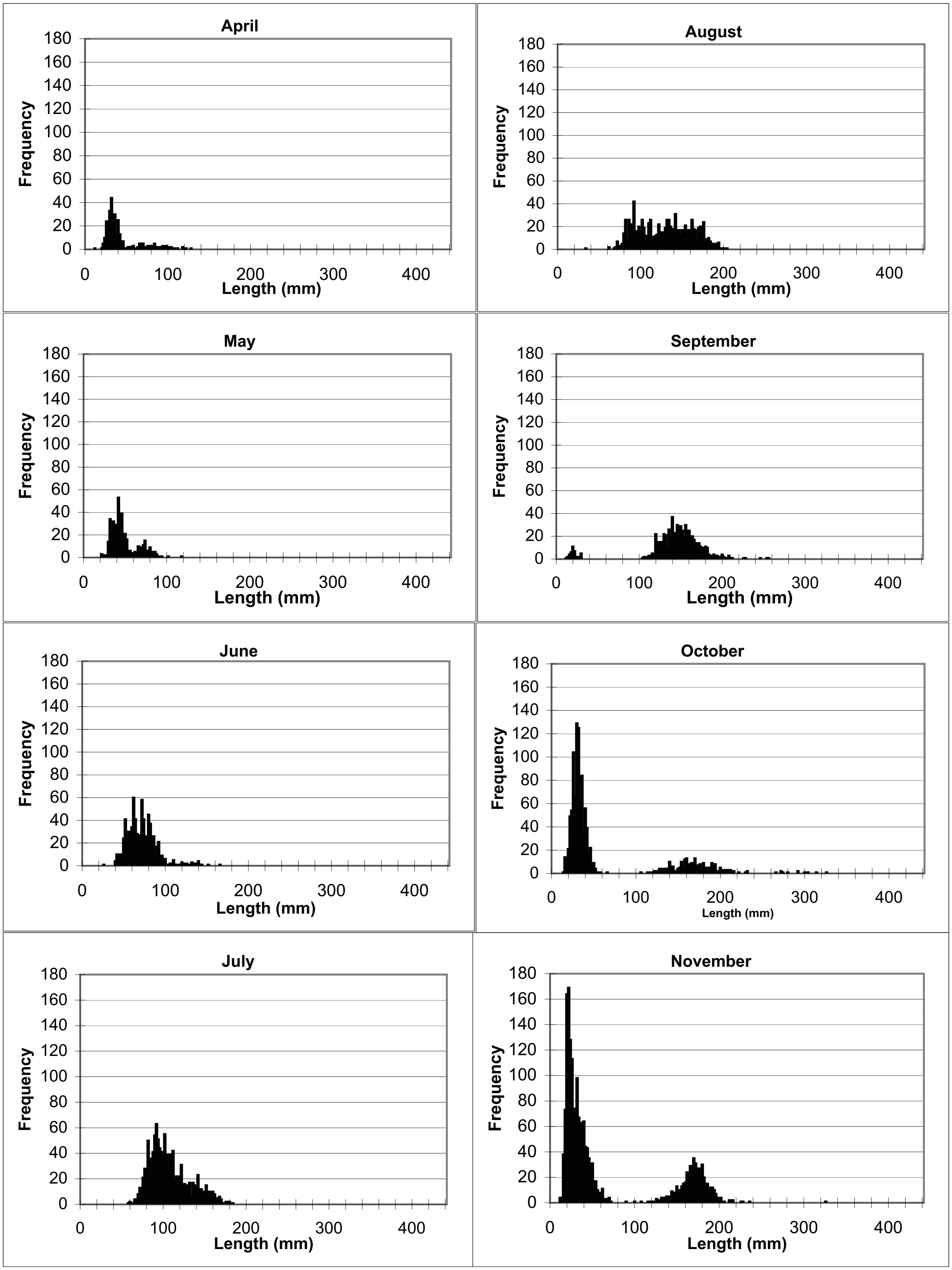


Figure 4-10 Length-frequency distribution of Atlantic croaker by month during the Bottom Trawl Effort, April - November 2006

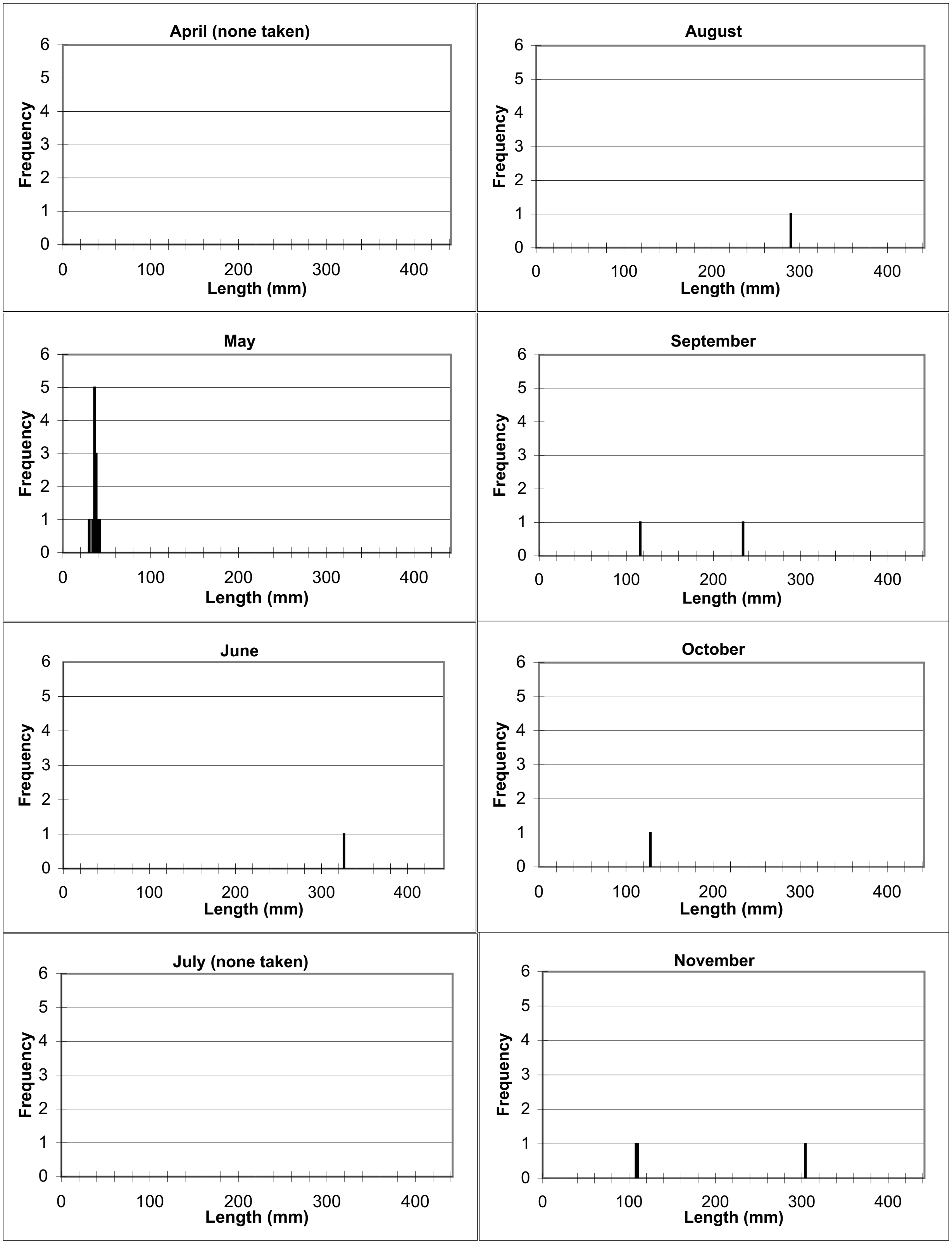


Figure 4-11 Length-frequency distribution of Atlantic menhaden by month during the Bottom Trawl Effort, April - November 2006

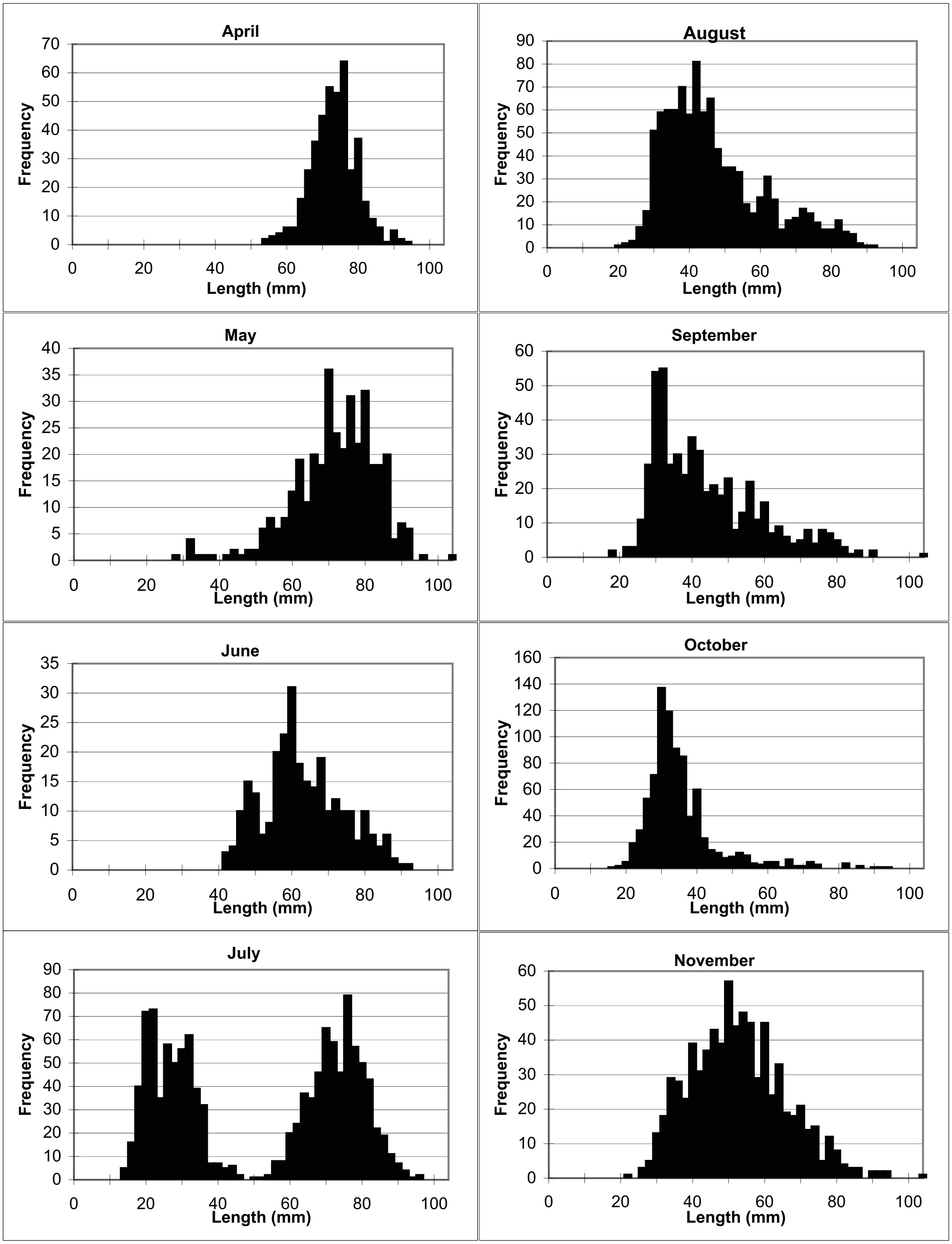


Figure 4-12 Length-frequency distribution of bay anchovy by month during the Bottom Trawl Effort, April - November 2006

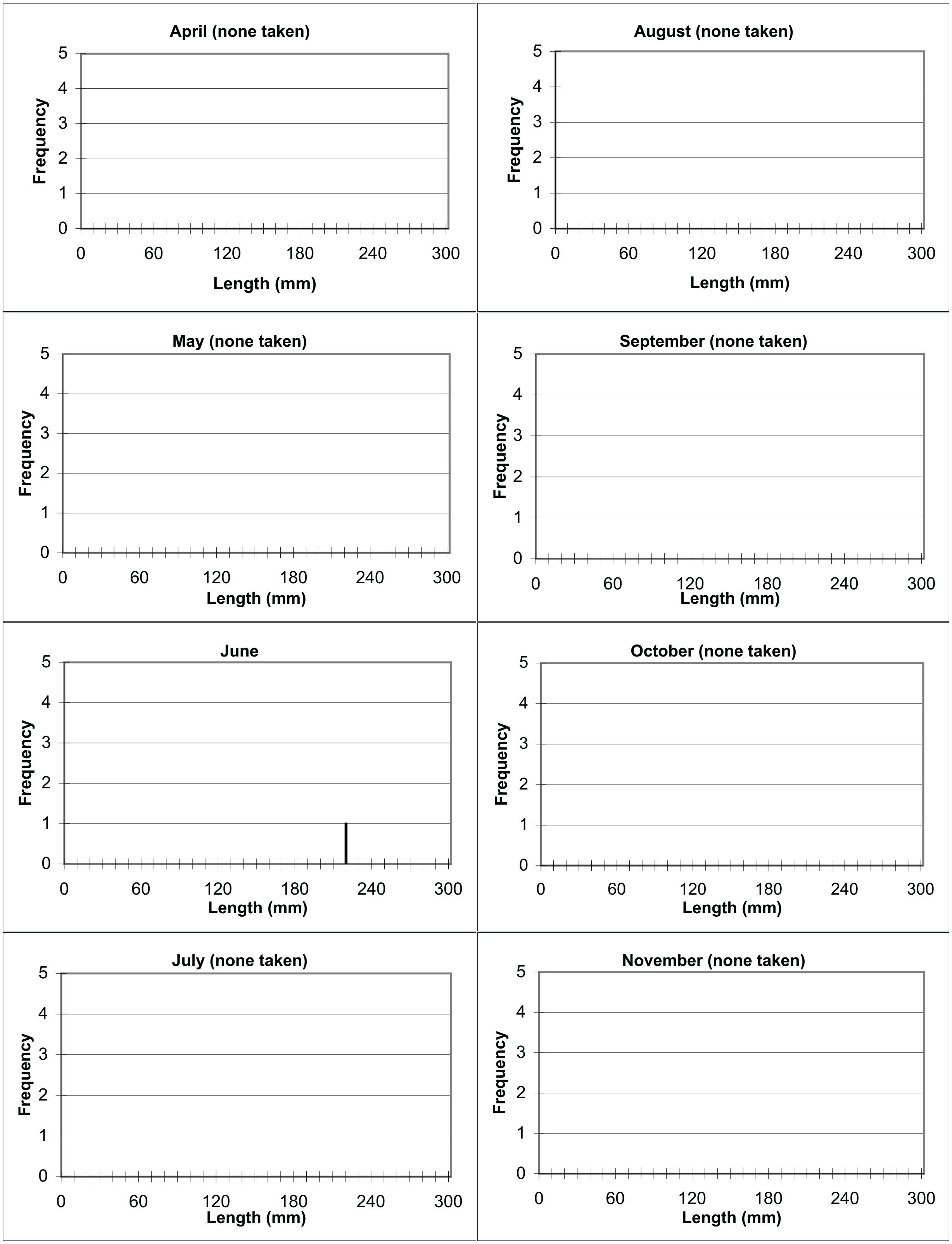


Figure 4-13 Length-frequency distribution of blueback herring by month during the Bottom Trawl Effort, April - November 2006

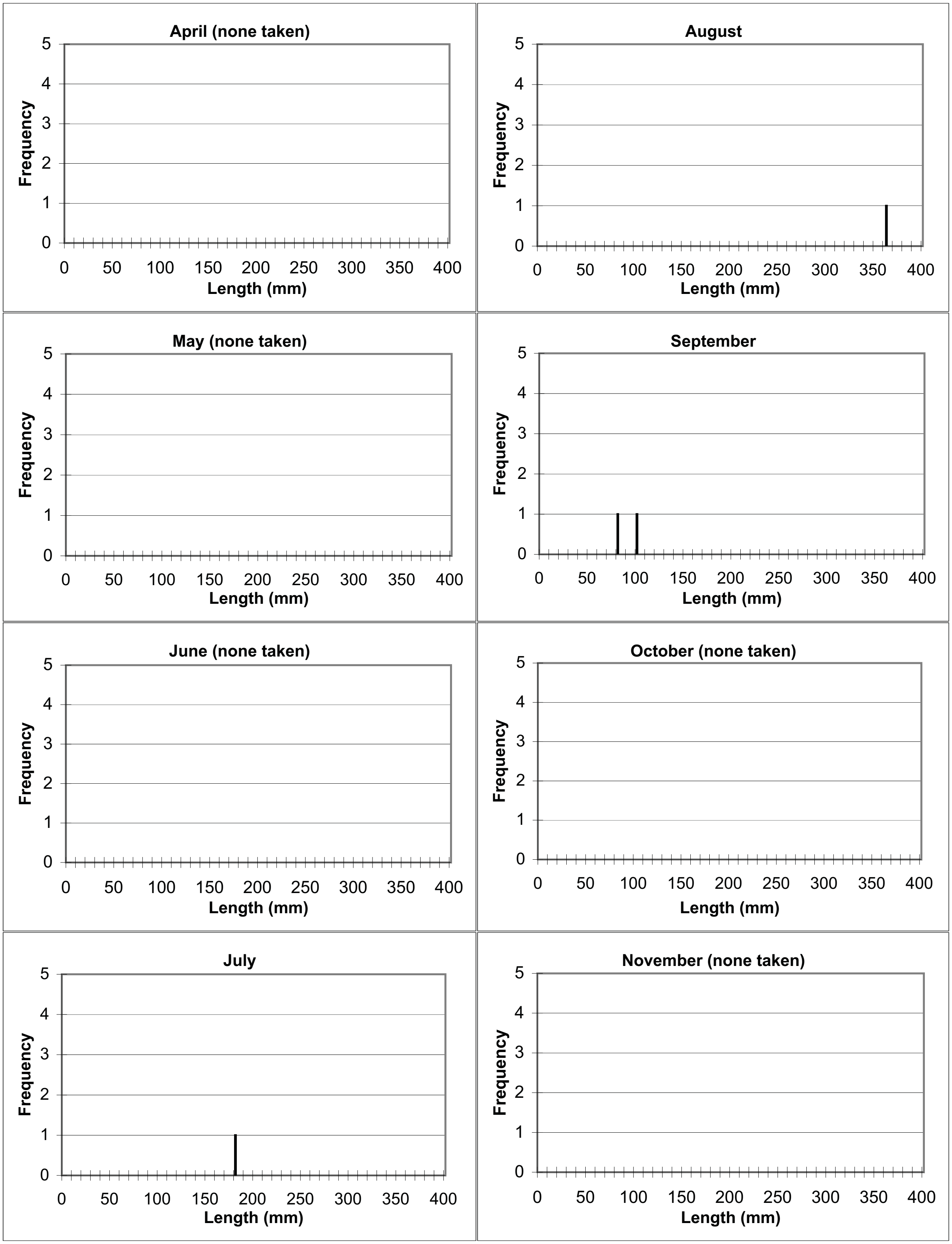


Figure 4-14 Length-frequency distribution of bluefish by month during the Bottom Trawl Effort, April - November 2006

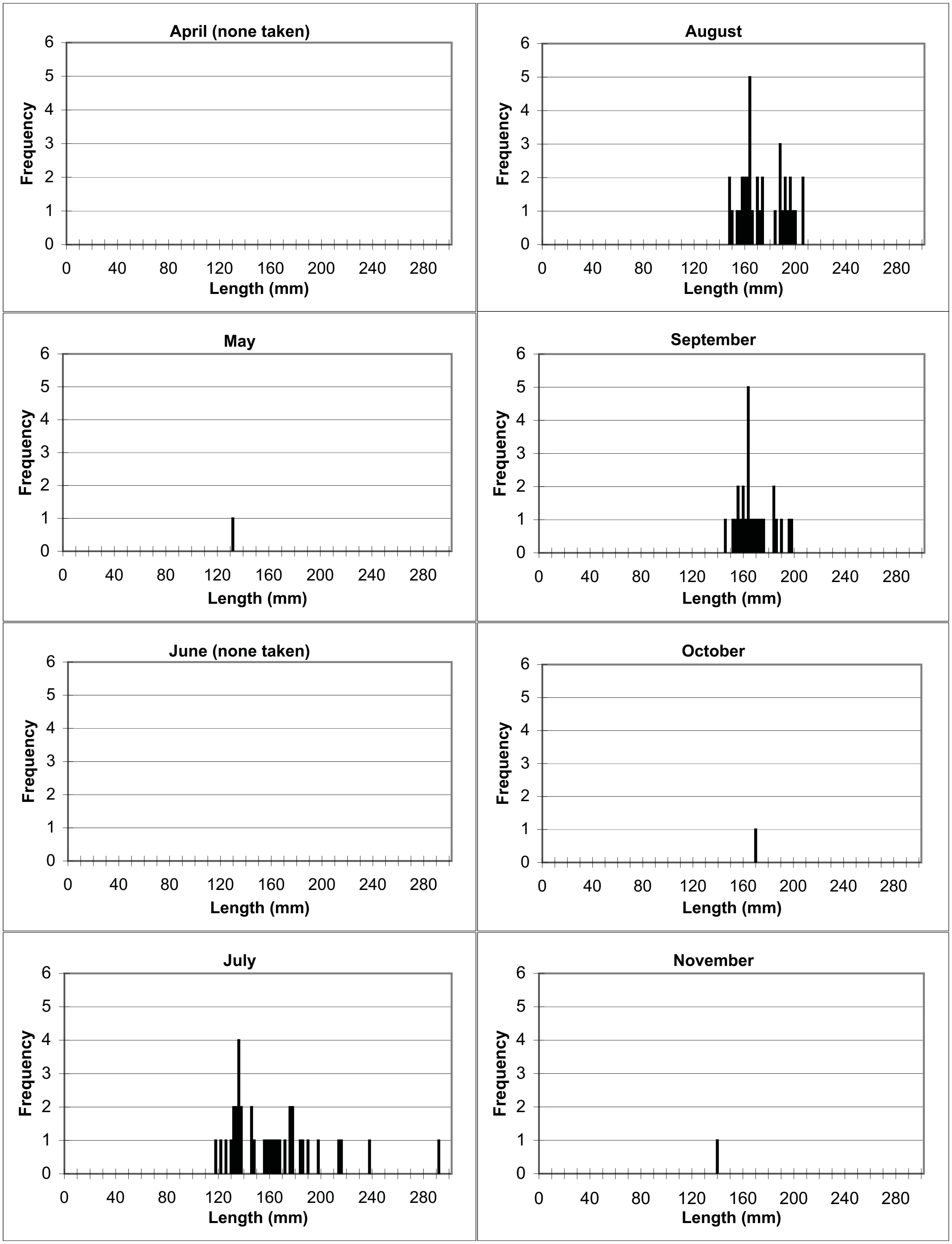


Figure 4-15 Length-frequency distribution of spot by month during the Bottom Trawl Effort, April - November 2006

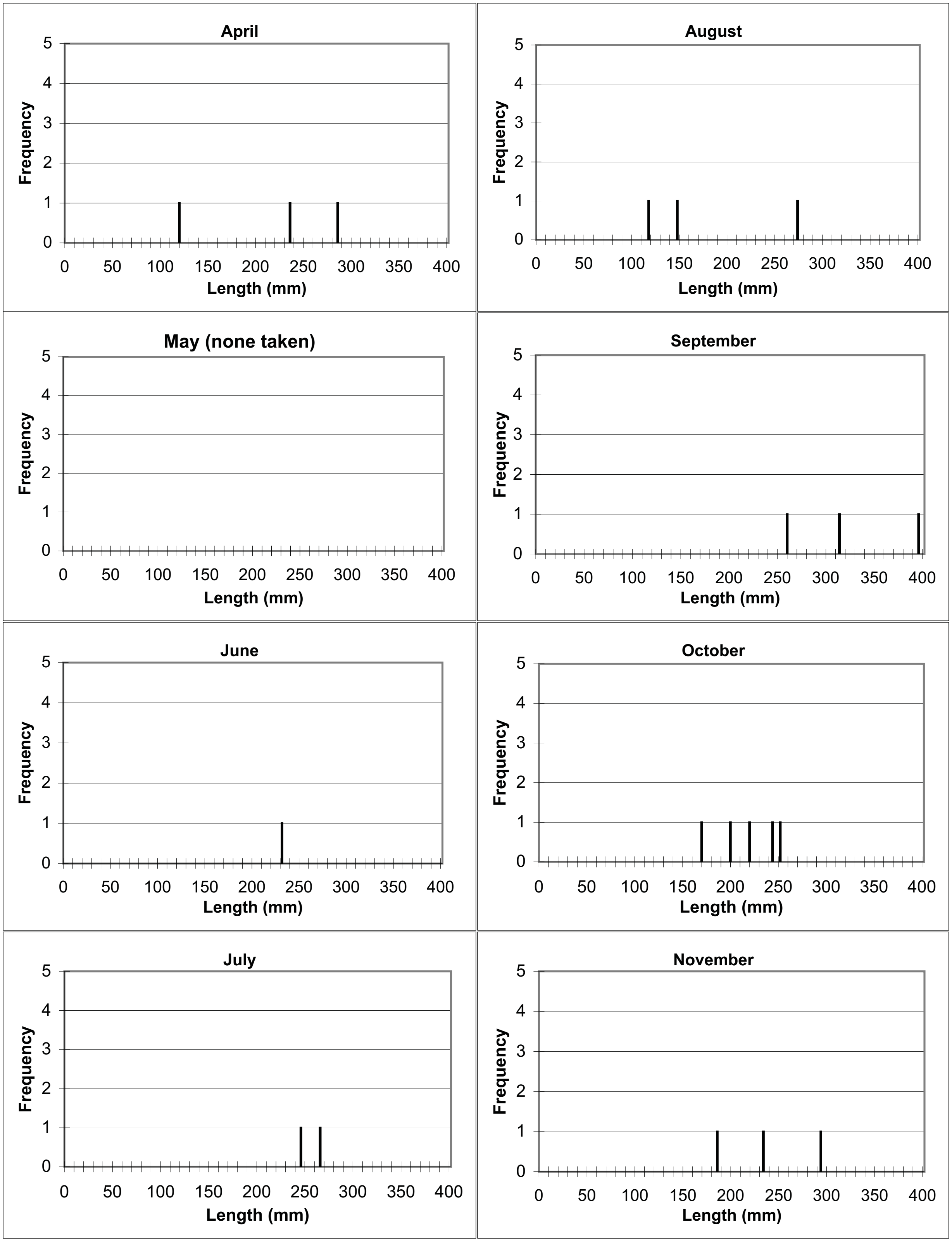


Figure 4-16 Length-frequency distribution of striped bass by month during the Bottom Trawl Effort, April - November 2006

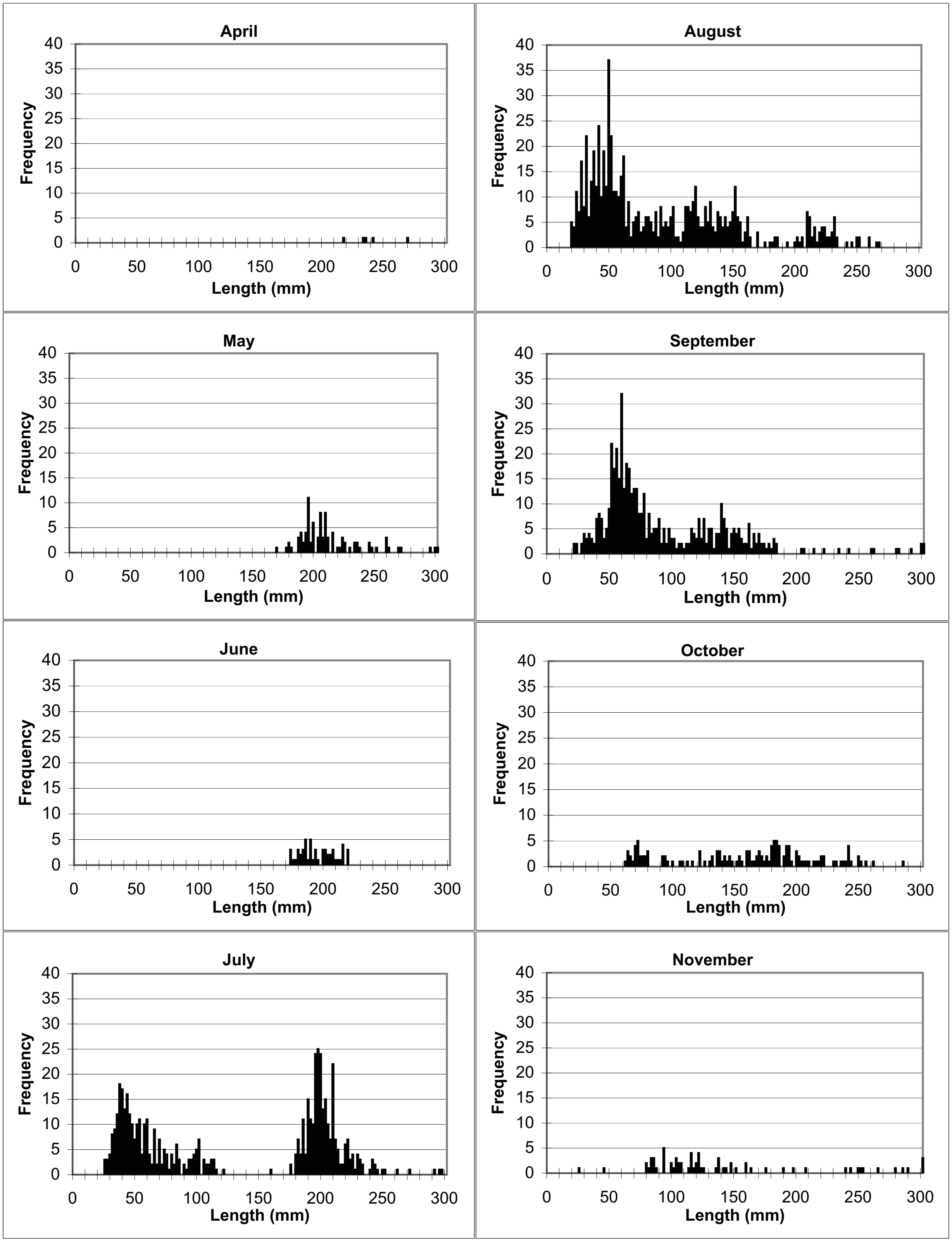


Figure 4-17 Length-frequency distribution of weakfish by month during the Bottom Trawl Effort, April - November 2006

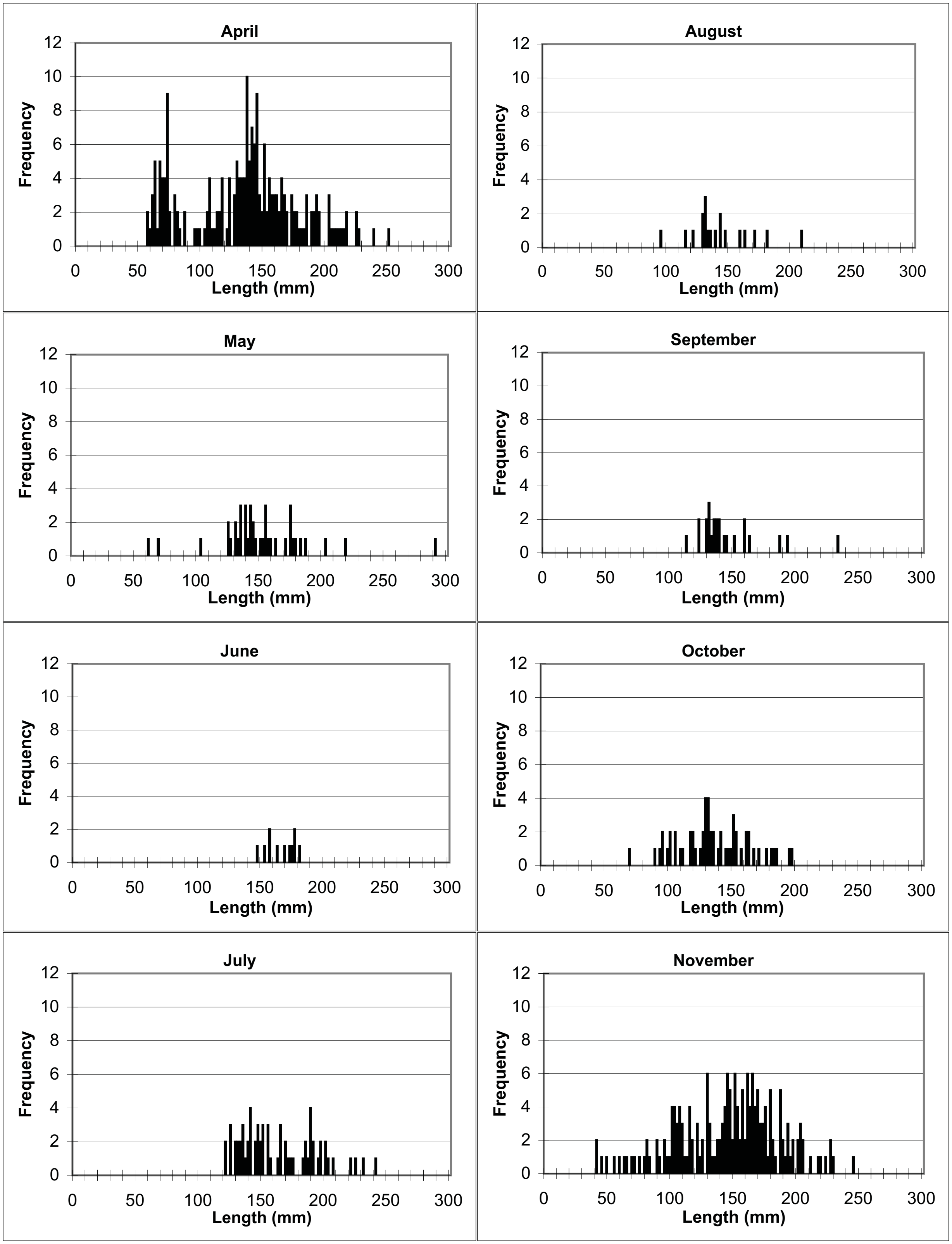


Figure 4-18 Length-frequency distribution of white perch by month during the Bottom Trawl Effort, April - November, 2006

CHAPTER 5: BAYWIDE BEACH SEINE

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BAYWIDE BEACH SEINE

INTRODUCTION

A number of annual survey programs collect empirical data on the relative abundance of finfish of the Delaware River estuary. Among various finfish studies that have been conducted over the past several decades is the Delaware River Striped Bass Recruitment Study conducted by the New Jersey Department of Environmental Protection (NJDEP). This annual survey, initiated in 1980, entails beach seine sampling throughout the tidal Delaware River from the Chesapeake and Delaware Canal to the fall line at Trenton, New Jersey. While the number of sampling stations has varied over the years, presently 32 stations are sampled with a 100-ft (30.5-m) beach seine on a monthly frequency in June and November, and semimonthly during July through October. Whereas the focus of this survey is to monitor the year-class strength of striped bass (*Morone saxatilis*), relevant abundance data is obtained for other species such as white perch (*Morone americana*), blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*), which similarly utilize the shallows within this portion of the River as part of their principal nursery grounds during this temporal period.

PSEG's Baywide Beach Seine Survey was initiated in 1995 to complement the NJDEP seine survey, providing sampling beyond the geographical boundaries of the respective study area to more fully characterize target species abundance and distribution patterns within the estuary. To enhance compatibility with the results being generated from the existing agency sampling program, the sampling gear and deployment procedures for the Baywide Beach Seine Survey were developed following the methods described in Baum (1994), and through personal communications with the principal investigator, Mr. Thomas Baum of NJDEP.

This report constitutes the twelfth-year progress report for the Baywide Beach Seine Survey. It presents the overall results of sampling and provides discussion regarding the occurrence of the Salem Generating Station finfish target species: blueback herring, alewife, American shad (*Alosa sapidissima*), Atlantic menhaden (*Brevoortia tyrannus*), bay anchovy (*Anchoa mitchilli*), Atlantic silverside (*Menidia menidia*), white perch, striped bass, bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), and Atlantic croaker (*Micropogonias undulatus).*

MATERIALS AND METHODS

Beach seine sampling was conducted during daylight once per month in June and November, and twice per month during July through October. Daylight is defined as the period one hour after sunrise to one hour before sunset. Samples were taken at 40 fixed stations in the Delaware Bay and lower River (Figure 5-1). Sampling at all stations was conducted within the period of two hours before to two hours after high slack water specific to that particular location. Sampling at high water increases the probability that individuals collected are more likely to be bay front, shore zone residents rather than marsh tributary transients.

Station spatial distribution was based on a partitioning of the overall study area shoreline into 32 equal-length regions. During the design phase of the study in 1995, the perimeter of the Delaware Bay from Cape May, NJ (rkm 0) to the lower Delaware River at the Chesapeake and Delaware Canal (rkm 100) was divided into 32 equal-length regions. Each region was further partitioned into 0.1-nautical mile segments. One fixed station was established within each of the 32 regions. Eight additional stations were established at bay front locations adjacent to PSEG marsh restoration sites. These 40 fixed stations (identifiable by latitude/longitude coordinates and flagged, labeled markers) have been sampled annually since 1995.

Seine hauls were taken with a 100- x 6-ft (30.5- x 1.8-m) bagged haul seine with a 1/4-inch (6.25 mm) nylon mesh, identical to the gear employed by NJDEP in the beach seine program conducted upstream of the present study. The seine is set perpendicularly from shore, by boat, until the bag is reached, at which time the remainder of the net is set in an arc-like fashion back to shore. The direction of the set was chosen relative to prevailing tidal current, wind and surf conditions to produce the most effective net deployment. The standard sampling effort was a single haul at each station.

With each collection, finfish were identified to the lowest practical taxonomic level (usually species), counted, and measured. A subsample of 100 specimens of each target species was measured to the nearest mm. Fork length (FL) was measured for all species with emarginated or forked caudal fins; for other species, total length (TL) was measured.

Surface measurements of water temperature (ºC), salinity (ppt) and dissolved oxygen (mg/ℓ) were recorded with each collection, as were water clarity (secchi depth), tidal stage, wave height, and weather conditions. Water quality parameters were measured with an YSI Model 85 OCST meter.

Catch results are summarized by sampling period, river kilometer (rkm) region and "beach type". The data are expressed in terms of total number taken; percent of total catch and mean number of specimens per seine haul. Sampling periods were each of the monthly or twice-monthly collection events; regions were defined as 20-rkm sections measured up the centerline of the estuary; and "beach types" were determined after qualitative assessments of the bottom type within the intertidal zone at the deployment location at each station. For graphic presentation purposes, species' length data was partitioned into 5-mm intervals.

RESULTS AND DISCUSSION

PHYSICAL AND CHEMICAL PARAMETERS

Temperature

The pattern in water temperature observed in 2006 exhibited the typical seasonal pattern found in a temperate climate (Figure 5-2a). Over the period of sampling, mean shore zone water temperature increased from the initial value of 25.6ºC during the second half of June to the seasonal maximum of 28.3°C during the first half of August. Mean temperature decreased to 19.0°C in the first half of October and continued to decline to the season low of 10.0°C during the first half of November.

The longitudinal differences across this lower 100 rkm of the estuary ranged from 0.6 to 8.3°C during the biweekly sampling periods (Figure 5-2b). The smallest and largest differences within sampling periods occurred during the first half of August and the second half of October, respectively.

Salinity

The overall range and mean values of salinity, as observed in the shore zone during the 2006 beach seine sampling season, are presented in Figure 5-3a. It is important to note that during the entire 2006 beach seine sampling season the freshwater discharge in Delaware River, as measured at the Trenton, NJ gauging station, was high, ranging from 111.3 (August) to 366.7 (June) percent of normal (www.state.nj.us/drbc/data.htm) . Within that context and considering the relatively restricted temporal window provided by the five-month sampling season, salinity levels exhibited in 2006 were most likely seasonally "typical" for higher than average flow. It is important to note that during June 24-28 a number of powerful storms caused “flash flooding and record to near record flood crests” (www.state.nj.us/drbc/Flood_Website/events.htm#2006). Mean values by sampling period ranged from 11.8 to 18.6 ppt, minimum values were 0.3 to 5.9 ppt, and maximum levels were 26.3 to 29.3 ppt.

The longitudinal gradient in salinity during the sampling periods was relatively stable throughout the entire season with the differences between minimum and maximum regional means ranging from 19.6 ppt in the first half of August to 24.2 ppt in the second half of June (Figure 5-3b).

Dissolved Oxygen

The Delaware Bay generally is considered to be well oxygenated throughout the year, and the high degree of tidal-driven mixing results in a nearly homogeneous vertical distribution of dissolved oxygen in the water column (PSE&G 1984). Smith (1987) and Michels (1995) concluded that dissolved oxygen levels in the Delaware Bay are not limiting to normal finfish species distributions. The minimum dissolved oxygen value, measured during the study period, of 4.6 mg/ℓ was recorded at Station 4 during the second half of July. Mean dissolved oxygen by

sampling period ranged from 7.0, during the first half of August, to 10.9 mg/ℓ, during the first half of July (Figure 5-4a).

Regional mean dissolved oxygen concentrations are depicted in Figure 5-4b. During a given sampling period, the greatest regional difference of 3.4 mg/ℓ was recorded during both sampling events in July. The greatest difference in mean dissolved oxygen within a region was recorded in region rkm 0-20 with a range of 6.0 mg/ℓ. The smallest difference in mean dissolved oxygen within a region was recorded in region rkm 41-60 with a range of 3.6 mg/ℓ.

CATCH COMPOSITION

Totals of 13,271 specimens of 50 finfish species and 336 blue crab (*Callinectes sapidus*) were collected in the 400 seine samples during 2006 (Table 5-1). Atlantic silverside was the most abundant species taken in the seine catch (n=4,963), comprising 37.4 percent of the annual sample (Table 5-2). Historically, Atlantic silverside has been predominant in the shore zone of the lower Delaware Estuary (Daiber 1954; DeSylva *et al.* 1962; PSEG 1996-2006). Bay anchovy, with a catch of 3,210 specimens, ranked second and comprised 24.2 percent of the catch. Atlantic croaker (1,040) and silver perch (717) individually represented less than 10 percent and greater than 5 percent of the total catch at 7.8 and 5.4, respectively. White perch, striped bass, Atlantic menhaden, weakfish, striped killifish, spot, bluefish and hogchoker were species which individually represented less than 5 percent and at least one percent of the total catch. Half, (25 of 50), of the species taken were represented by 10 or fewer specimens. A total of six species was taken during all 10 sampling events; 10 species were taken in all regions; 15 species were taken at all beach types. Only 5 species were collected during all sampling periods, in all regions and at all beach types: Atlantic silverside, bay anchovy, Atlantic croaker, white perch and striped bass. These species may be characterized as the ubiquitous core of this seasonal baywide, shore zone community in 2006.

The component of the seine catch composition represented by the target species temporally, regionally and relative to beach type is provided in Tables 5-2, 5-3 and 5-4, respectively. Temporally, from the first half of July through the first half of November, Atlantic silverside was the predominant target species comprising from 20.8 to 59.3 percent of the catch (Table 5-2). Although ranking second overall, bay anchovy was the most abundant species during the second half of June with 28.2 percent of the catch, and then secondarily abundant to Atlantic silverside during the remainder of the sampling year comprising from 16.6 to 38.2 percent of the catch. Other target species which comprised more than 10 percent in any given sampling period included Atlantic menhaden, white perch, striped bass and Atlantic croaker. Atlantic menhaden was the second most abundant target species during the second half of June comprising 23.1 percent of the catch. It comprised < 5 percent of the catch in sampling periods thereafter. Similarly, white perch was ranked second and third in the two July sampling periods, respectively, and comprised 17.9 and 15.8 percent of the catch, respectively. It comprised < 5 percent of the catch in all others periods. Atlantic croaker was ranked third among target species in the second half of June and the first half of July, comprising 14.8 and 15.0 percent of the catch, and was the second most abundant target species taken during the second half of October

comprising 30.4 percent of the total catch. Blueback herring and alewife were not collected during the 2006 sampling season.

Regionally, Atlantic silverside was the predominant species in the three regions rkm 0-60 comprising from 42.6 to 48.4 percent of the regional catch, and was secondarily abundant in the regions rkm 61-100 (Table 5-3). Bay anchovy was the predominant species in the two regions rkm 61-100, representing 46.2 and 45.7 percent, respectively. They were ranked second to Atlantic silverside in regions rkm 21-60. Atlantic menhaden, white perch and Atlantic croaker were the only other target species to comprise > 10 percent of the catch in a given sampling region. Atlantic menhaden comprised 11.7 percent in rkm 81-100. In two regions rkm 41-80, white perch comprised 10.3 and 10.7 percent of the catch. Atlantic croaker comprised 13.3 percent of the catch in rkm 21-40.

At the five beach types, Atlantic silverside was the predominant target species at the sand, sand/peat, and peat/mud beach types comprising from 34.4 to 47.6 percent of the total catch, and was secondarily abundant at the peat and mud beaches at 24.8 and 21.0 percent, respectively (Table 5-4). Bay anchovy was the predominant target species at the peat beaches comprising 52.0 percent of the catch, and was secondarily abundant at the sand, sand/peat, and peat/mud beaches, comprising from 12.4 to 28.6 percent. Atlantic croaker was the most abundant species for the mud beach type with 36.3 percent and comprised 5.0 to 10.9 for the remaining beach types. White perch was the only other target species to comprise more than 10 percent of the catch at a given beach type (sand/peat).

SPECIES RICHNESS AND NUMERIC ABUNDANCE

As a result of the predominance of the Atlantic silverside and bay anchovy (61.6 percent of the catch), the measure of numeric abundance relative to time, region and beach type largely reflects the pattern of occurrence of these species across these gradients. Overall finfish abundance in the shore zone, as measured by mean catch per haul, was relatively high during the first half of the sampling season, i.e., through the second half of August, with the mean catches ranging from 29.8 during the second half of June to 61.1 during the second half of August (Figure 5-5a). During the second half of the sampling season, finfish abundance decreased and remained relatively stable, with mean catches ranging from 26.9 during the first half of September to 19.7 during the first half of October. Regionally, finfish abundance was similarly high in the two regions rkm 0-20 and 61-80 with mean catches per haul of 41.3 and 41.5, respectively (Figure 5-5b). Abundance was lowest in region rkm 81-100 with a mean catch of 9.7. Relative to beach type, abundance was highest at the peat beaches with mean catches of 60.9 (Figure 5-5c). Abundance was intermediately high at the sand, sand/peat and mud beach type with mean catches of 38.2, 37.8 and 42.1, respectively. The mean catch per haul for the peat/mud beach type was the lowest at 10.9.

Over the sampling season, species richness (N) ranged from 14 in the first half of November to 31 in both sampling events in August; richness was ≥20 in all but two sampling periods (Figure

5-5a). Regionally, species richness was highest in rkm 0-20 with 38 species taken (Figure 5-5b). Species richness generally was progressively lower in regions rkm 21-40, 41-60 and 61-80 with 34, 26 and 25 species, respectively. Richness was lowest (N=3) in rkm 81-100; the lower salinity of this reach of the study area generally is not tolerated by most marine species, but was too high for the occurrence of most freshwater species. Relative to beach type, species richness was highest at the sand beaches with 43 species taken (Figure 5-5c). At the other beach types, richness was similar ranging from 23 to 28.

SPECIES ACCOUNTS

The following species accounts present the sampling results specific to each of the SGS target finfish species. These data summaries describe periods of occurrence, temporal and spatial abundance patterns, size distribution and inferred age composition. Graphic presentations of abundance and length-frequency data were prepared for those target species represented by at least ten specimens collected.

American shad

A total of 48 American shad was taken in this study during 2006 (Table 5-1). American shad was collected from June through July; abundance was highest in the second half of July with a mean catch of 1.1 per haul (Figure 5-6a). All but one American shad were age 0+ from the 2006 year class; age 0+ ranged from 59 to 103 mm FL; the age 1+ individual from the 2005 year class was 185 mm FL (PSE&G 1999a, Fig 5-7). American shad was taken in all regions except rkm 0-20 and was most abundant in region rkm 61-80 with a mean catch of 0.3 per haul (Figure 5-6b). Relative to beach type, American shad were taken at the sand/peat, peat and peat/mud beach types, but were most abundant at the sand/peat beach type at 0.4 (Table 5-4 and Figure 5-6c).

Atlantic menhaden

During 2006, a total of 432 Atlantic menhaden was taken, comprising 3.3 percent of the total catch (Table 5-1, 5-2). They were taken in all sampling periods except the second half of October, and were most abundant during the second half of June, with a mean catch of 6.9 specimens per haul, comprising 23.1 percent of the catch during that period (Table 5-2 and Figure 5-8a). Atlantic menhaden ranged in length from 34 to 283 mm FL (Figure 5-9), and all except one were age 0+ (Able and Fahay 1998). Although taken in all regions, Atlantic menhaden was most abundant in region rkm 61-80 with a mean catch of 2.3 and least abundant in rkm 0-20 at ≤ 0.1 per haul (Figure 5-8b). Mean catches in the other regions ranged from 0.4 to 1.3. The abundance of Atlantic menhaden was highest at sand/peat beach types with a mean catch of 1.9 per haul, and similarly low at the peat and mud beach types with mean catches of 0.5 per haul (Figure 5-8c).

Bay anchovy

A total of 3,210 bay anchovy was taken, comprising 24.2 percent of the 2006 seine catch (Tables 5-1 and 5-2). As a characteristically ubiquitous species within the study area, bay anchovy was taken during all sampling periods, in all regions, and at all beach types (Figure 5-10). Bay anchovy abundance was highest during the second half of August with a mean catches per haul of 23.0 (Figure 5-10a). Bay anchovy were intermediately abundant during the second half of June, the second half of July, the first half of August and the first half of November with mean catches per haul ranging from 8.0 to 9.8. Their abundance was lowest during the first half of July with a mean catches per haul of 3.7. Bay anchovy ranged in length from 22 to 98 mm FL (Figure 5-11), including individuals age 0+ and older (PSE&G 1999a). Based on the sub sample measured, age 1+ and older were the predominant age group during the first three sampling periods, comprising 100.0, 99.0 and 73.0 percent, respectively. The modal length, during the June and July sampling periods, increased from 53 to 58 mm FL. Thereafter, age 0+ of the 2006 year-class was predominant comprising from 87 to 100 percent of the catch, with modal lengths ranging from 38 mm in the first half of August to 53 mm during October and November. Overall, age 0+ individuals comprised about 74 percent of the species' catch. Bay anchovy abundance was highest in the region rkm 61-80 with a mean catch of 19.2 per haul, and similarly low in all other regions with mean catches ranging from 4.0 to 5.3 (Figure 5-10b). Bay anchovy abundance was similarly high at the sand, peat and peat/mud beach types with mean catches ranging from 9.0 to 10.4 specimens per haul (Figure 5-10c). In the other beach types the mean catches ranged from 4.4 to 9.5.

Atlantic silverside

Atlantic silverside was the most abundant species collected during 2006 with a total of 4,963 specimens taken and comprised 37.4 percent of the total catch (Table 5-1 and 5-2). As one of the ubiquitous core species group, Atlantic silverside was taken during all sampling periods, in all regions, and at all beach types (Figure 5-12). During the first sampling period the mean catch of Atlantic silverside was the lowest of the season at 4.1 per haul, but their abundance generally increased through the second half of August to their seasonal peak of 26.0 per haul (Figure 5-12a). Thereafter, the mean catch declined ranging from 9.8 to 15.9 specimens per haul. Atlantic silverside ranged in length from 25 to 120 mm FL (Figure 5-13), including individuals age 0+ to potentially age 2 (Conover and Ross 1982). Although age composition for this species is difficult to infer from length data alone, it appears that age 1+ (2005 year class) was the predominate age class during the first collection period, with a modal length of 73 mm FL and comprising 85 percent of the catch (Able and Fahay 1998). Thereafter, age 0+ were predominant in each collection period comprising from 73 to 100 percent. From the first half of July through the second half of August, the modal length generally increased from 58 to 73 mm TL. During the remaining sampling periods, modal length stabilized at 68 or 73 mm TL. Atlantic silverside abundance was similarly high in rkm regions 0-20 and 21-40, with mean ctaches of 18.2 and 17.1, respectively (Figure 5-12b). They exhibited a pattern of declining abundance in a progression up estuary with mean catches ranging from 2.4 to 9.4. Atlantic silverside was most abundant at the sand/peat beach type with a catch per haul of 18.0, intermediately high at the

sand (14.6) and peat/mud (12.5) beach types and lowest at the peat beach type 4.5 specimens per haul (Figure 5-12c).

White perch

A total of 639 white perch was taken in the 2006 seine program (Table 5-1). As one of the ubiquitous core species group, white perch was taken during all sampling periods, in all regions, and at all beach types (Figure 5-14). The relatively high catch was unexpected since the principal summer nursery and feeding grounds occur in the tributaries to the Estuary and in the Delaware River above the upstream limits of the study area. By contrast, the NJDEP seine effort in the river upstream has yielded, with essentially the same level of effort, annual catches of 1,808 – 13,791 white perch over the past 13 years 1993-2006 (Baum 1993-1996; Baum et al. 1997-2006; Baum, pers. comm. pending., preliminary 2006 catch data).

White perch abundance was highest during the second half of July with a catch per haul of 7.6 and secondarily high (5.7) during the first half of July (Figure 5-14a). The second half of June (1.2) was the only other sampling event to have a catch per unit effort greater than 1.0. White perch ranged in length from 48 to 354 mm FL (Figure 5-15), including individuals age 0+ to potentially age 6+ or older (Clark 1998). The predominant age groups appear to be age 1+ and potentially 2+, occurring during the first three sampling periods including June and July. Thereafter, the length frequency distribution is unremarkable reflecting scattered unitary frequencies. White perch exhibited a pattern of increasing abundance in a progression up the estuary through rkm 61-80 (Figure 5-14b). Their abundance was highest in regions rkm 61-80 with a mean catch of 4.4 per haul and secondarily abundant in regions rkm 41-60 with a catch per haul of 2.3. White perch was most abundant at sand/peat beaches with a mean catch of 4.2 and secondarily high at the sand beaches with a mean catch of 1.3; all other beach types represented ≤0.7 (Figure 5-14c).

Striped bass

During 2006, a total of 451 striped bass was taken (Table 5-1). As one of the ubiquitous core species group, striped bass was taken during all sampling periods, in all regions, and at all beach types (Figure 5-16). Striped bass abundance increased from 1.1 specimens per haul in the second half of June to the seasonal peak of 4.3 during the first half of July, lowered to a secondary high of 3.4 during the second half of July, and then generally decreased for the remainder of the sampling season, with the mean catches ranging from 0.1 to 1.0 per haul (Figure 5-16a). Striped bass ranged in length from 53 to 632 mm FL (Figure 5-17), including individuals age 0+ to potentially age 5+ (Baum et al. 2004). Most specimens collected (61.7 percent) ranged from 118 to 188 mm FL, and the modal length was 153 mm FL. Specimens age 1+ and older comprised 96 percent of the total catch. Striped bass was most abundant in region rkm 61-80 with a mean catch of 3.3 per haul, and similarly less abundant in all other regions with mean catches of < 1.0 per haul (Figure 5-16b). Striped bass was most abundant at the sand/peat beach type with a mean catch of 3.3, secondarily abundant at the peat/mud beaches with a mean catch of 1.2 per haul and least abundant at the peat beaches with a mean catch of ≤ 0.1 (Figure 5-16c).

Bluefish

During 2006, a total of 144 bluefish was taken (Table 5-1). Bluefish was taken during all sampling periods except the first half of November, in all regions, and at all beach types (Figure 5-18). Their abundance was highest during the first half of September with 1.3 specimens per haul (Figure 5-18a). In all other sampling periods in which bluefish was taken, the catch per haul never exceeded > 0.5. Bluefish ranged in length from 50 to 190 mm FL (Figure 5-19); all were age 0+ and the modal lengths were 78 and 93 mm (Able and Fahay 1998). Bluefish was most abundant in region rkm 0-20 with a mean catch per haul of 0.8, decline to 0.2 in rkm 21-40 and steadily increased up river to a catch per haul of 0.5 in rkm 81-100 (Figure 5-18b). Bluefish was most abundant at the sand beach type with a mean catch of 0.5, mean catches at the other beaches ranged to 0.3 (Figure 5-18c).

Weakfish

During 2006, a total of 375 weakfish was taken (Table 5-1). Weakfish was taken during all sampling periods through the first half of October, in all regions except 81-100 and at all beach types (Figure 5-20). Weakfish abundance increased from 0.5 specimens per haul during the second half of June to the seasonal peak of 3.9 during the second half of July, and then generally decreased to a seasonal low of 0.1 in the first half of October (Figure 5-20a). This trend is reflective of their seasonal movement offshore during the fall and exodus from the estuary by late October/early November. Weakfish ranged in length from 20 to 328 mm TL (Figure 5-21). Ninety six percent of the individuals were age 0+ (2006 year class; Michels 1997). During the second half of July, when 45 percent of the total catch was taken, the modal length was 63 mm TL. Weakfish was most abundant in the region rkm 21-40 with a mean catch of 1.5 per haul. They were intermediately abundant in rkm 0-20 at 1.0 per haul, and catch in the other rkm regions was ≤ 0.7 (Figure 5-21b). Weakfish was most abundant at the peat/mud beach type with a mean catch of 2.8, was intermediately abundant at the mud beach type with 1.9, and was least abundant at sand/peat beaches with 0.4 specimens per haul (Figure 5-21c).

Spot

A total of 158 spot was taken in 2006 (Table 5-1). Spot was taken during all sampling periods through the first half of September, in all regions, and at all beach types (Figure 5-22). Their abundance increased from 0.1 per haul at the beginning of the sampling season to a season high of 1.4 specimens per haul in the second half of July. Abundance decreased to 0.8 during both events in August and continued to decline to ≤ 0.1 during the first half of September (Figure 5-22a). Spot ranged in length from 40 to 228 mm TL, and were predominantly age 0+ (Figure 5-23;.Able and Fahay 1998, PSEG 1984). Spot was most abundant in rkm region 0-20 with a mean catch per haul of 0.9; was intermediately abundant in rkm region 41-60 with a mean catch of 0.7; and was least abundant in rkm regions 61-80 and 81-100 with mean catches of ≤ 0.1 per haul (Figure 5-22b). The mud beach type had the highest mean catch of spot at 1.0 per haul (Figure 5-22c). Spot was least abundant at the sand/peat and peat beach types with mean catches per haul of ≤ 0.1.

Atlantic croaker

During 2006, Atlantic croaker was the third most abundant species taken with a total of 1,040 specimens (Table 5-1). As one of the ubiquitous core species group, Atlantic croaker was taken during all sampling periods, in all regions, and at all beach types (Figure 5-24). It was most abundant during the second half of October with 7.4 specimens per haul; was similarly intermediate in abundance from the second half of June through all of July with catches per haul of 4.4, 4.8 and 4.3, respectively; and was lowest in abundance at 0.1 during the first half of September (Figure 5-24a). They ranged in length from 15 to 256 mm TL (Figure 5-25). Based on the subsample measured, 60 percent of the individuals were 1+. During the first six events through the first half of September, all individuals taken, except two, were age 1+ (2005 year-class) with modal lengths increasing from 78 mm in the second half of June to 128 mm in the second half of August (PSEG 1984). During the second half of September age 0+ specimens represented 89 percent of the catch; an increasing percentage of age 0+ continued through the remainder of the sampling season culminating at 100 percent during the first half of November. The modal length was 23 mm from the second half of September through the second half of October. Atlantic croaker was taken in all rkm regions; was most abundant in the region rkm 21-40 with a mean catch of 4.7 per haul (Figure 5-24b). Mean catch in the other regions ranged from 2.5 to 0.6 per haul. Mean catches of Atlantic croaker was highest at the mud beach type with a catch per haul of 15.3 and lowest at the peat beach type with a mean catch of 1.0 per haul.

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Table 5-1. Number of finfish and blue crab, by sampling period, taken by seine in the Delaware Bay and River during 2006.

SPECIES		JUN 16-30	JUL 1-15	JUL 16-31	AUG 1-15	AUG 16-31	SEP 1-15	SEP 16-30	OCT 1-15	OCT 16-31	NOV 1-15	TOTAL
Southern stingray	*Dasyatis Americana*	0	0	0	1	0	0	0	0	0	0	1
American eel	*Anguilla rostrata*	14	9	8	1	1	0	0	0	1	1	35
American shad	*Alosa sapidissima*	1	2	45	0	0	0	0	0	0	0	48
Hickory shad	*Alosa mediocris*	0	0	0	1	0	0	0	0	0	0	1
Atlantic menhaden	*Brevoortia tyrannus*	275	62	17	31	7	10	13	16	0	1	432
Gizzard shad	*Dorosoma cepedianum*	0	1	1	0	0	1	0	3	3	7	16
Striped anchovy	*Anchoa hepsetus*	2	0	0	6	19	43	19	1	1	0	91
Bay anchovy	*Anchoa mitchilli*	336	149	318	330	921	206	154	187	219	390	3210
Inshore lizardfish	*Synodus foetens*	0	0	0	0	0	0	0	1	0	0	1
Carp	*Cyprinus carpio*	1	1	0	0	0	0	1	0	0	0	3
Channel catfish	*Ictalurus punctatus*	8	24	5	2	0	0	0	0	0	0	39
White catfish	*Ameiurus catus*	1	0	0	0	3	0	0	0	0	0	4
Spotted hake	*Urophycis regia*	0	0	0	0	0	0	0	0	11	3	14
White hake	*Urophycis tenuis*	0	0	0	0	0	0	0	0	0	1	1
Striped cusk-eel	*Ophidion marginata*	0	0	0	1	0	0	0	0	0	0	1
Halfbeak	*Hyporhamphus unifasciatus*	6	0	1	0	2	0	0	0	0	0	9
Atlantic needlefish	*Strongylura marina*	3	0	0	1	0	0	1	1	0	0	6
Sheepshead minnow	*Cyprinodon variegates*	0	0	0	0	0	0	0	4	0	0	4
Mummichog	*Fundulus heteroclitus*	6	2	3	7	3	0	0	3	0	8	32
Spotfin killifish	*Fundulus luciae*	0	0	0	0	1	0	0	0	0	0	1
Striped killifish	*Fundulus majalis*	30	12	113	70	82	4	20	11	17	14	373
Rainwater killifish	*Lucania parva*	0	0	0	0	0	0	0	1	0	0	1
Inland silverside	*Menidia beryllina*	0	0	0	0	0	0	0	0	1	0	1
Atlantic silverside	*Menidia menidia*	162	265	504	429	1038	635	504	468	391	567	4963
Northern pipefish	*Syngnathus fuscus*	0	0	0	1	1	0	0	0	0	0	2
White perch	*Morone Americana*	49	228	303	6	5	6	8	5	16	13	639
Striped bass	*Morone saxatilis*	45	170	135	41	12	19	4	11	7	7	451
Bluespotted sunfish	*Enneacanthus gloriosus*	0	1	0	0	0	0	0	0	0	0	1
Bluefish	*Pomatomus saltatrix*	18	21	16	10	7	52	16	3	1	0	144
Crevalle jack	*Caranx hippos*	0	0	0	0	1	2	0	0	0	0	3
Pompano	*Trachinotus carolinus*	1	5	4	3	3	0	2	1	0	0	19

SPECIES		JUN 16-30	JUL 1-15	JUL 16-31	AUG 1-15	AUG 16-31	SEP 1-15	SEP 16-30	OCT 1-15	OCT 16-31	NOV 1-15	TOTAL
Lookdown	*Selene vomer*	0	1	1	1	0	0	0	0	0	0	3
Permit	*Trachinotus falcatus*	0	1	3	7	5	10	1	2	0	0	29
Pigfish	*Orthopristis chrysoptera*	0	0	2	3	13	0	0	0	0	0	18
Weakfish	*Cynoscion regalis*	19	43	155	62	41	10	41	4	0	0	375
Silver perch	*Bairdiella chrysoura*	35	20	4	486	145	7	13	6	0	1	717
Spot	*Leiostomus xanthurus*	4	34	56	31	31	2	0	0	0	0	158
Northern kingfish	*Menticirrhus saxatilis*	0	0	7	27	25	11	19	5	6	2	102
Southern kingfish	*Mentcirrhus americanus*	0	0	0	0	1	1	7	0	0	0	9
Atlantic croaker	*Micropogonias undulatus*	177	192	170	71	38	2	42	47	296	5	1040
Black drum	*Pogonias cromis*	0	0	0	2	5	0	0	0	0	0	7
Striped mullet	*Mugil cephalus*	0	0	1	0	0	7	0	0	1	0	9
White mullet	*Mugil curema*	0	1	2	5	10	44	19	9	2	0	92
Northern stargazer	*Astroscopus guttatus*	0	0	0	0	1	0	0	0	0	0	1
Smallmouth flounder	*Etropus microstomus*	0	0	0	1	0	0	0	0	0	0	1
Summer flounder	*Paralichthys dentatus*	0	1	0	1	2	2	0	0	0	0	6
Winter flounder	*Pleuronectes americanus*	0	11	0	0	0	0	0	0	0	0	11
Hogchoker	*Trinectes maculatus*	0	20	39	66	18	0	1	0	0	0	144
Northern puffer	*Sphoeroides maculatus*	0	0	0	0	1	0	0	0	0	0	1
Striped burrfish	*Chilomycterus schoepfi*	0	0	2	0	0	0	0	0	0	0	2
TOTAL		1193	1276	1915	1704	2442	1074	885	789	973	1020	13271
Bluecrab	*Callinectes sapidus*	22	23	51	71	100	37	10	11	8	3	336

Table 5-2. Percent composition, by sampling period, for finfish taken in the 2006 baywide seine survey (Target species in bold).

SPECIES	JUN 16-30	JUL 1-15	JUL 16-31	AUG 1-15	AUG 16-31	SEP 1-15	SEP 16-30	OCT 1-15	OCT 16-31	NOV 1-15	TOTAL
Atlantic silverside	**13.6**	**20.8**	**26.3**	**25.2**	**42.5**	**59.1**	**56.9**	**59.3**	**40.2**	**55.6**	**37.4**
Bay anchovy	**28.2**	**11.7**	**16.6**	**19.4**	**37.7**	**19.2**	**17.4**	**23.7**	**22.5**	**38.2**	**24.2**
Atlantic croaker	**14.8**	**15.0**	**8.9**	**4.2**	**1.6**	**0.2**	**4.7**	**6.0**	**30.4**	**0.5**	**7.8**
Silver perch	2.9	1.6	0.2	28.5	5.9	0.7	1.5	0.8		0.1	5.4
White perch	**4.1**	**17.9**	**15.8**	**0.4**	**0.2**	**0.6**	**0.9**	**0.6**	**1.6**	**1.3**	**4.8**
Striped bass	**3.8**	**13.3**	**7.0**	**2.4**	**0.5**	**1.8**	**0.5**	**1.4**	**0.7**	**0.7**	**3.4**
Atlantic menhaden	**23.1**	**4.9**	**0.9**	**1.8**	**0.3**	**0.9**	**1.5**	**2.0**		**0.1**	**3.3**
Weakfish	**1.6**	**3.4**	**8.1**	**3.6**	**1.7**	**0.9**	**4.6**	**0.5**			**2.8**
Striped killifish	2.5	0.9	5.9	4.1	3.4	0.4	2.3	1.4	1.7	1.4	2.8
Spot	**0.3**	**2.7**	**2.9**	**1.8**	**1.3**	**0.2**					**1.2**
Bluefish	**1.5**	**1.6**	**0.8**	**0.6**	**0.3**	**4.8**	**1.8**	**0.4**	**0.1**		**1.1**
Hogchoker		1.6	2.0	3.9	0.7		0.1				1.1
Northern kingfish			0.4	1.6	1.0	1.0	2.1	0.6	0.6	0.2	0.8
White mullet		0.1	0.1	0.3	0.4	4.1	2.1	1.1	0.2		0.7
Striped anchovy	0.2			0.4	0.8	4.0	2.1	0.1	0.1		0.7
American shad	**0.1**	**0.2**	**2.3**								**0.4**
Channel catfish	0.7	1.9	0.3	0.1							0.3
American eel	1.2	0.7	0.4	0.1	<0.1				0.1	0.1	0.3
Mummichog	0.5	0.2	0.2	0.4	0.1			0.4	<0.1	0.8	0.2
Permit		0.1	0.2	0.4	0.2	0.9	0.1	0.3			0.2
Pompano	0.1	0.4	0.2	0.2	0.1		0.2	0.1			0.1
Pigfish			0.1	0.2	0.5						0.1
Gizzard shad		0.1	0.1	<0.1	<0.1	0.1	<0.1	0.4	0.3	0.7	0.1
Spotted hake									1.1	0.3	0.1
Winter flounder		0.9									0.1
Halfbeak	0.5		0.1		0.1						0.1
Southern kingfish					<0.1	0.1	0.8				0.1
Striped mullet			0.1			0.7			0.1		0.1
Black drum				0.1	0.2						0.1
Atlantic needlefish	0.3			0.1			0.1	0.1			<0.1
Summer flounder		0.1		0.1	0.1	0.2					<0.1
White catfish	0.1				0.1						<0.1
Sheepshead minnow								0.5			<0.1
Carp	0.1	0.1					0.1				<0.1
Crevalle jack					<0.1	0.2					<0.1
Lookdown		0.1	0.1	0.1							<0.1
Northern pipefish				0.1	<0.1						<0.1
Striped burrfish			0.1								<0.1
Southern stingray				0.1							<0.1
Hickory shad				0.1							<0.1
Inshore lizardfish								0.1			<0.1
White hake										0.1	<0.1
Striped cusk-eel				0.1							<0.1
Spotfin killifish					<0.1						<0.1
Rainwater killifish								0.1			<0.1
Inland silverside									0.1		<0.1
Bluespotted sunfish		0.1									<0.1
Northern stargazer					<0.1						<0.1

Smallmouth flounder				0.1							<0.1
Northern puffer					<0.1						<0.1

Table 5-3. Percent composition, by river kilometer region, for finfish taken in the 2006 baywide seine survey (Target species in bold).

SPECIES	0-20	21-40	41-60	61-80	81-100	TOTAL
Atlantic silverside	**44.0**	**48.4**	**42.6**	**17.3**	**25.1**	**37.4**
Bay anchovy	**11.9**	**15.1**	**18.0**	**46.2**	**45.7**	**24.2**
Atlantic croaker	**2.7**	**13.3**	**5.9**	**6.1**	**6.5**	**7.8**
Silver perch	23.0	1.1	0.2			5.4
White perch	**0.3**	**0.9**	**10.3**	**10.7**	**2.1**	**4.8**
Striped bass	**0.5**	**1.5**	**3.8**	**8.0**	**0.7**	**3.4**
Atlantic menhaden	**0.1**	**3.5**	**1.6**	**5.5**	**11.7**	**3.3**
Weakfish	**2.5**	**4.2**	**3.2**	**1.4**		**2.8**
Striped killifish	1.8	5.4	3.0	0.5		2.8
Spot	**2.3**	**0.6**	**3.3**	**0.2**	**0.3**	**1.2**
Bluefish	**2.0**	**0.4**	**1.1**	**0.9**	**4.8**	**1.1**
Hogchoker		2.3	2.1	0.1		1.1
Northern kingfish	1.9	0.5	0.9	0.2		0.8
White mullet	2.4	0.4	0.4			0.7
Striped anchovy	1.0	0.3	1.4	0.5	0.3	0.7
American shad		**0.1**	**0.7**	**0.8**	**0.3**	**0.4**
Channel catfish		<0.1		1.0		0.3
American eel	0.1	0.5	0.3	0.1	0.3	0.3
Mummichog	0.1	0.4	0.3	0.1		0.2
Permit	0.5	0.3	0.1			0.2
Pompano	0.4	0.1	0.1			0.1
Pigfish	0.6	<0.1				0.1
Gizzard shad	<0.1		0.1	0.2	1.7	0.1
Spotted hake	0.4	<0.1				0.1
Winter flounder	0.4					0.1
Halfbeak	<0.1	<0.1	0.3			0.1
Southern kingfish	0.1	0.2				0.1
Striped mullet	0.2	<0.1				0.1
Black drum	<0.1	<0.1	0.2	<0.1		<0.1
Atlantic needlefish	<0.1	<0.1	0.2			<0.1
Summer flounder	0.2	<0.1				<0.1
Sheepshead minnow	<0.1	0.1				<0.1
White catfish				0.1		<0.1
Carp			0.1	<0.1	0.3	<0.1
Crevalle jack		<0.1		<0.1		<0.1
Lookdown	0.1					<0.1
Northern pipefish	0.1					<0.1
Striped burrfish	0.1					<0.1
Bluespotted sunfish				<0.1		<0.1
Hickory shad	<0.1					<0.1
Inland silverside				<0.1		<0.1
Inshore lizardfish				<0.1		<0.1
Northern puffer		<0.1				<0.1
Northern stargazer		<0.1				<0.1
Rainwater killifish		<0.1				<0.1
Smallmouth flounder	<0.1					<0.1
Southern stingray	<0.1					<0.1
Spotfin killifish			0.1			<0.1

Striped cusk-eel	<0.1					<0.1
White hake	<0.1					<0.1

Table 5-4. Percent composition, by beach type, for finfish taken in the 2006 baywide seine survey (Target species in bold).

SPECIES	SAND	SAND/PEAT	PEAT	PEAT/MUD	MUD	TOTAL
Atlantic silverside	**38.3**	**47.6**	**24.8**	**34.4**	**21.0**	**37.4**
Bay anchovy	**23.6**	**12.4**	**52.0**	**28.6**	**10.3**	**24.2**
Atlantic croaker	**5.0**	**6.0**	**5.7**	**10.9**	**36.3**	**7.8**
Silver perch	11.1	<0.1	0.5	2.2	0.8	5.4
White perch	**3.3**	**11.1**	**1.9**	**1.7**	**0.7**	**4.8**
Striped bass	**1.6**	**8.8**	**0.4**	**3.3**	**1.2**	**3.4**
Atlantic menhaden	**2.7**	**5.1**	**2.9**	**3.0**	**1.2**	**3.3**
Weakfish	**2.2**	**1.2**	**4.8**	**6.8**	**4.4**	**2.8**
Striped killifish	2.7	3.6	0.1	4.0	4.6	2.8
Spot	**2.0**	**0.2**	**0.2**	**0.5**	**2.3**	**1.2**
Bluefish	**1.4**	**0.5**	**1.9**	**0.4**	**0.7**	**1.1**
Hogchoker	<0.1	<0.1	2.0	0.6	11.7	1.1
Northern kingfish	1.2	0.3	0.1	1.0	0.8	0.8
White mullet	1.3	<0.1	0.1	0.7		0.7
Striped anchovy	0.9	0.5	0.7		1.2	0.7
American shad		**1.1**	**0.5**	**0.2**		**0.4**
Channel catfish	0.2	0.8	0.1		0.1	0.3
American eel	0.2	0.2	0.4	0.5	0.2	0.3
Mummichog	0.2	0.1	0.3	0.5	0.8	0.2
Permit	0.4	0.1		0.2		0.2
Pompano	0.3	<0.1		0.1	0.1	0.1
Pigfish	0.3	<0.1				0.1
Gizzard shad	0.1	0.1	0.3			0.1
Spotted hake	0.2					0.1
Winter flounder	0.2					0.1
Halfbeak	0.1	0.1	0.1			0.1
Southern kingfish	<0.1				0.8	0.1
Striped mullet	0.1				0.1	0.1
Black drum	0.1		0.1	0.1		0.1
Atlantic needlefish	<0.1	<0.1	0.1	0.1		<0.1
Summer flounder	0.1			0.1		<0.1
Sheepshead minnow	<0.1			0.2		<0.1
White catfish	<0.1	<0.1				<0.1
Carp	<0.1		0.1			<0.1
Crevalle jack		<0.1			0.1	<0.1
Lookdown	<0.1					<0.1
Northern pipefish	<0.1					<0.1
Striped burrfish	<0.1					<0.1
Bluespotted sunfish		<0.1				<0.1
Hickory shad	<0.1					<0.1
Inland silverside	<0.1					<0.1
Inshore lizardfish	<0.1					<0.1
Northern puffer					0.1	<0.1
Northern stargazer					0.1	<0.1
Rainwater killifish					0.1	<0.1
Smallmouth flounder	<0.1					<0.1
Southern stingray	<0.1					<0.1
Spotfin killifish			0.1			<0.1

Striped cusk-eel	<0.1					<0.1
White hake	<0.1					<0.1

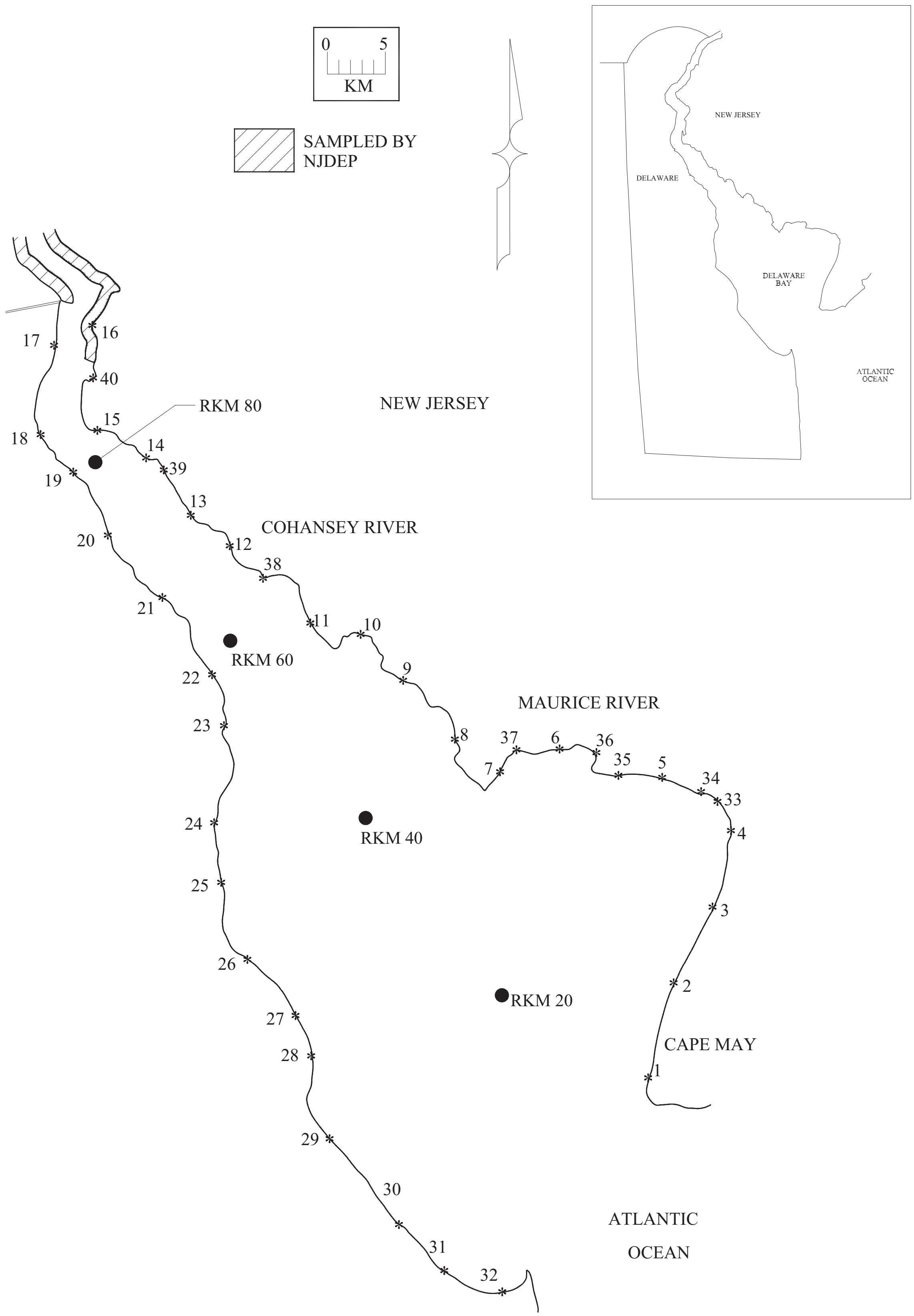
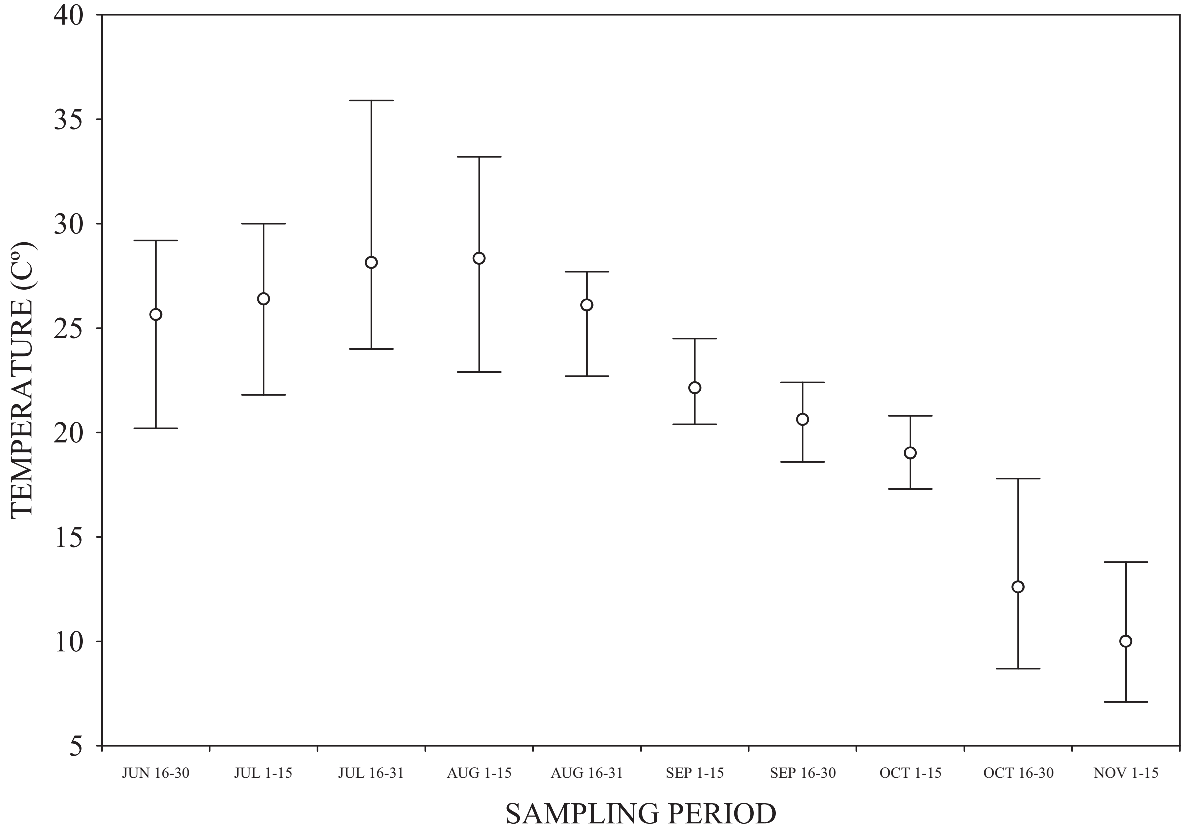


Figure 5-1 Baywide beach seine station locations.

(a)



(b)

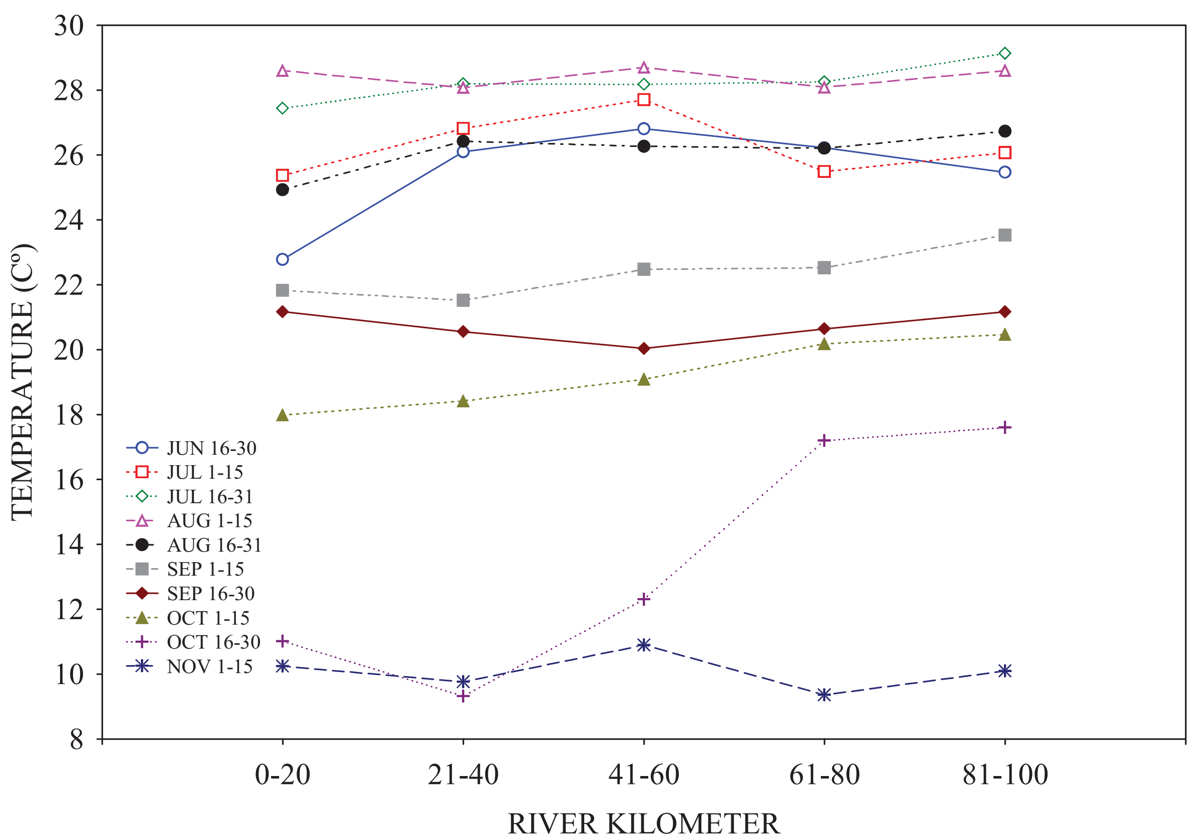
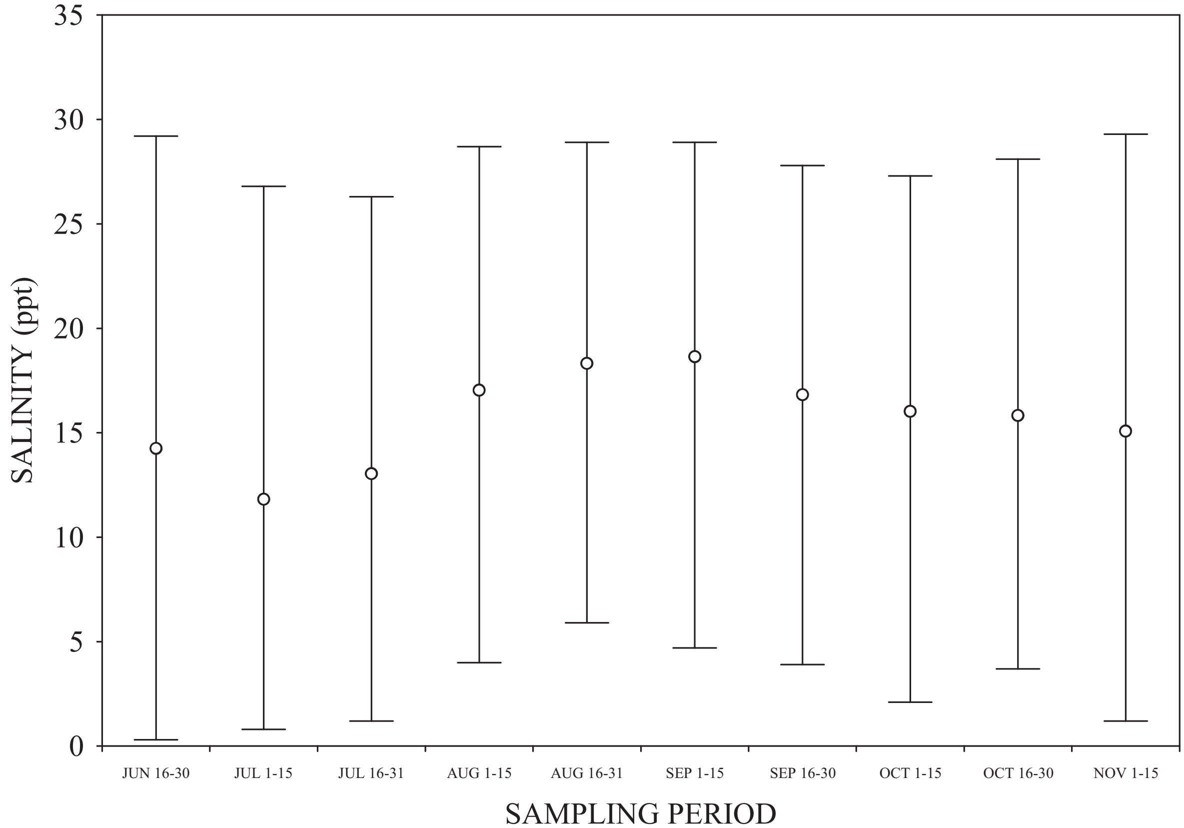


Figure 5-2. Mean temperature by sampling period (a) showing minimum and maximum values, and by river kilometer (b) as observed during the 2006 baywide seine survey.

(a)



(b)

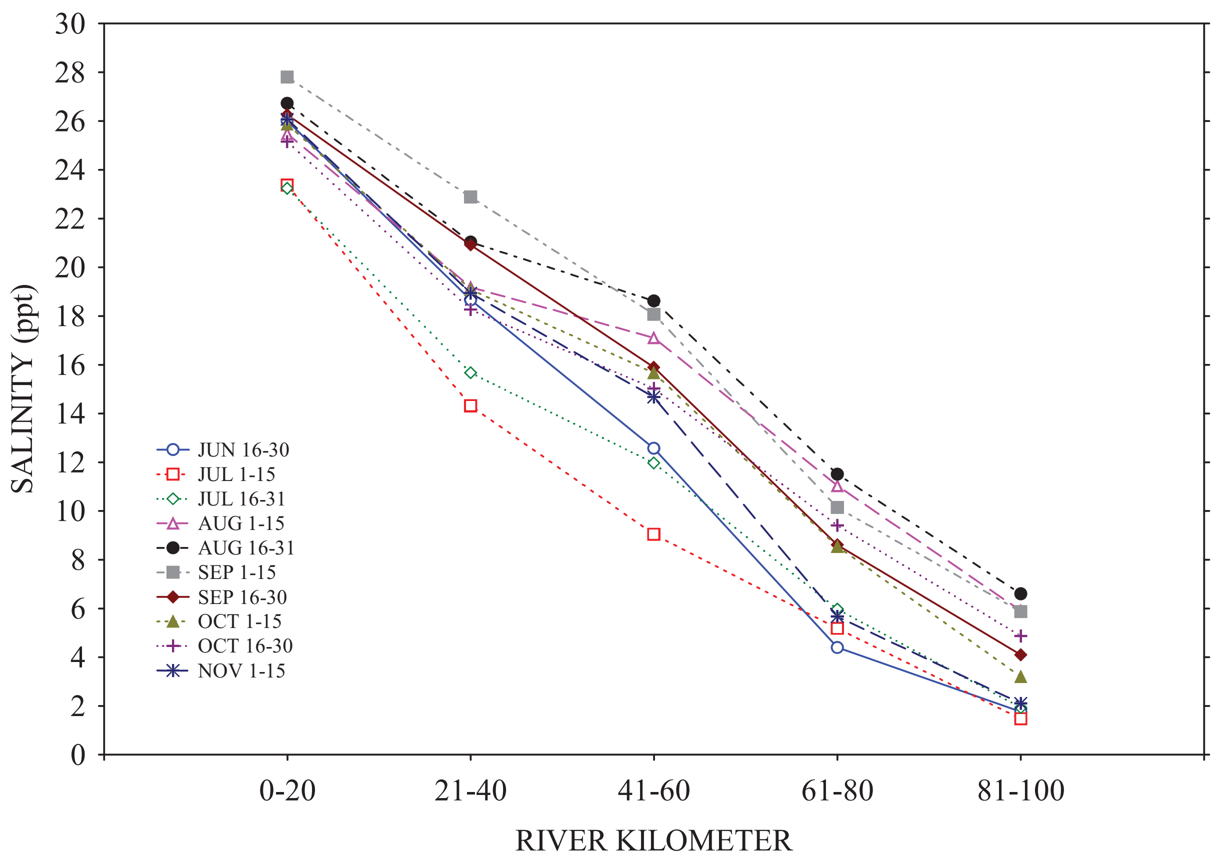
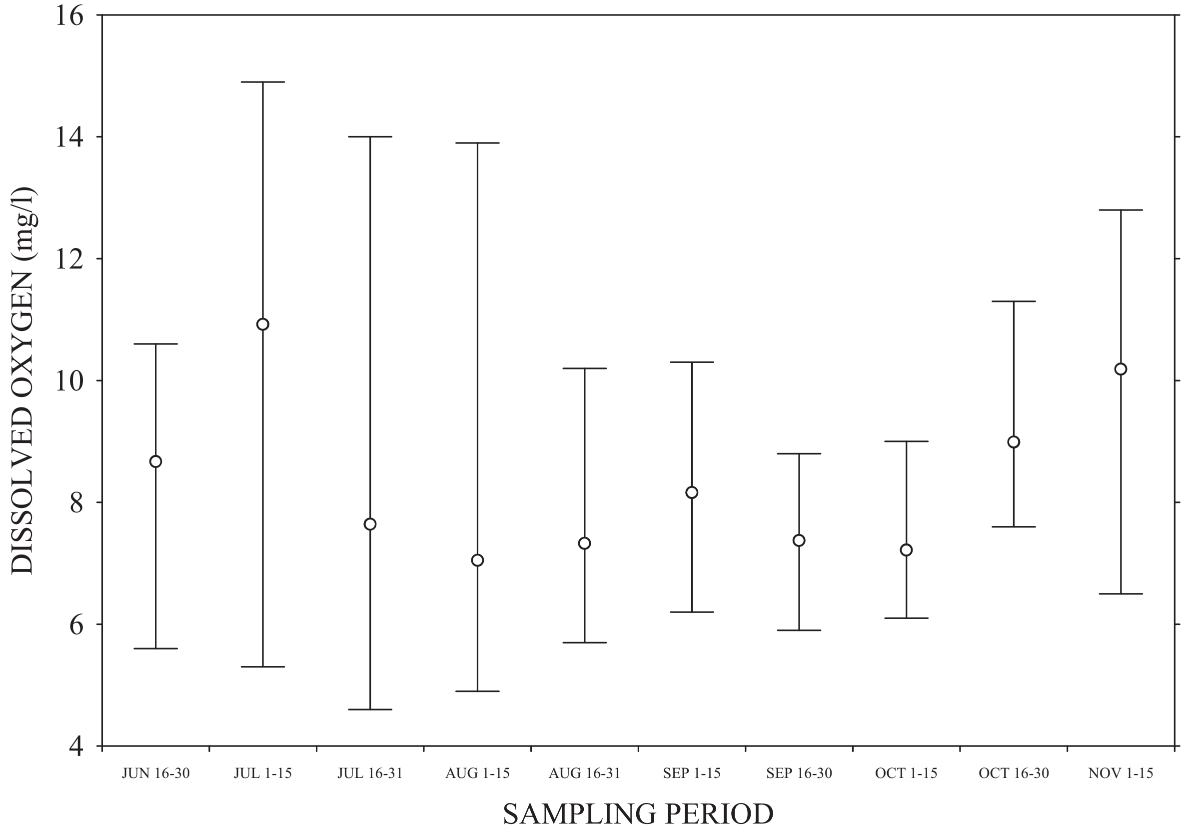


Figure 5-3. Mean salinity by sampling period (a) showing minimum and maximum values, and by river kilometer (b) as observed during the 2006 baywide seine survey.

(a)



(b)

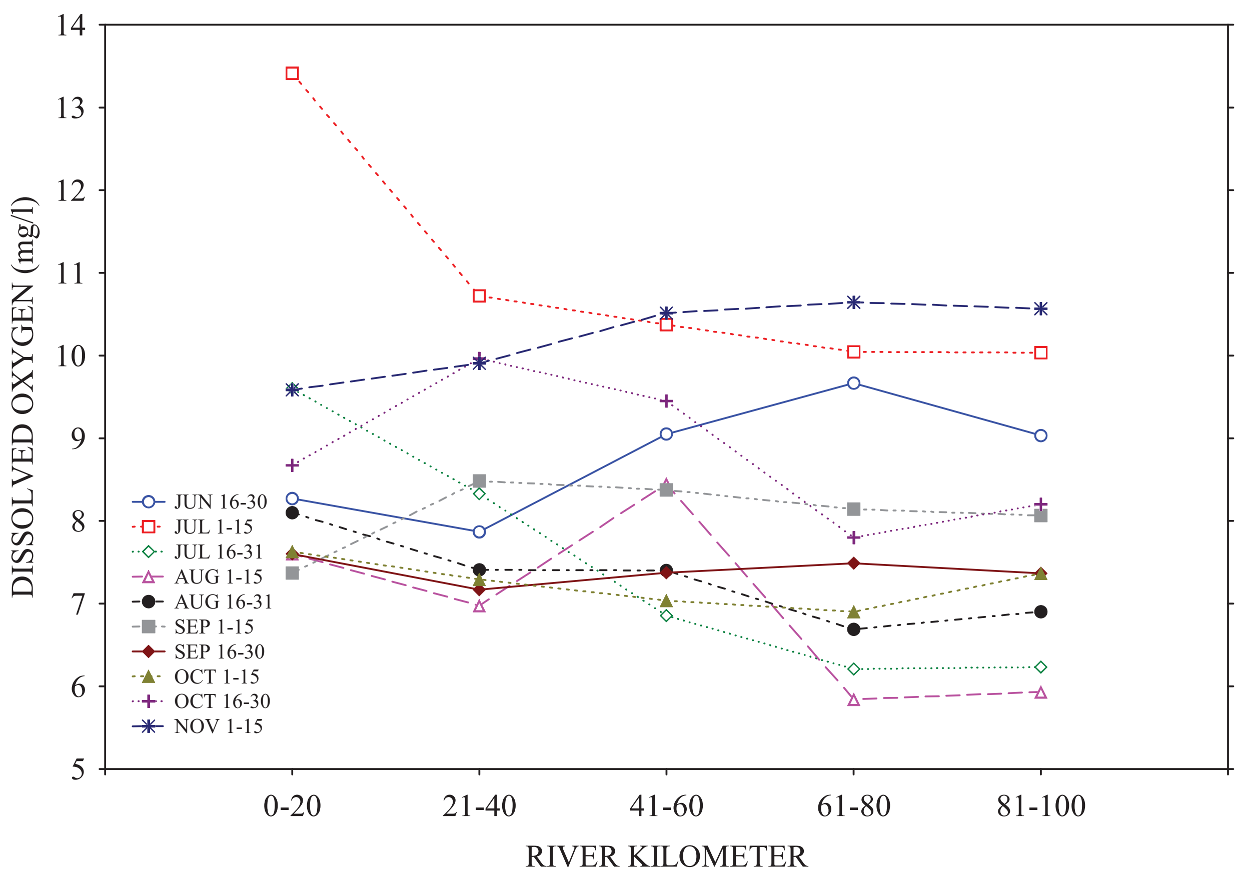


Figure 5-4. Mean dissolved oxygen by sampling period (a) showing minimum and maximum values, by river kilometer (b) as observed during the 2006 baywide seine survey.

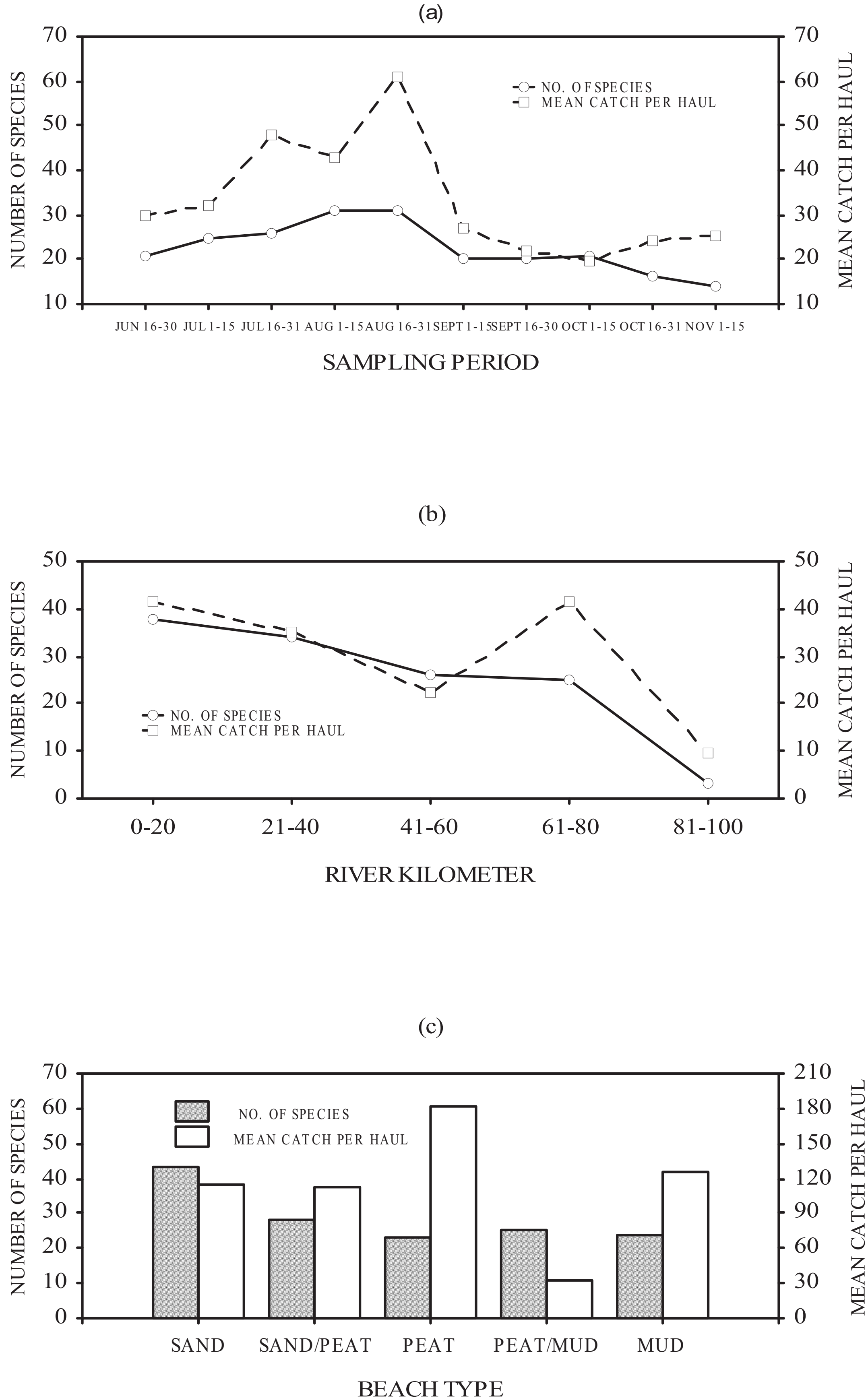


Figure 5-5. Mean abundance and species richness by sampling period (a), river kilometer (b), and beach type (c) as observed during the 2006 baywide seine survey.

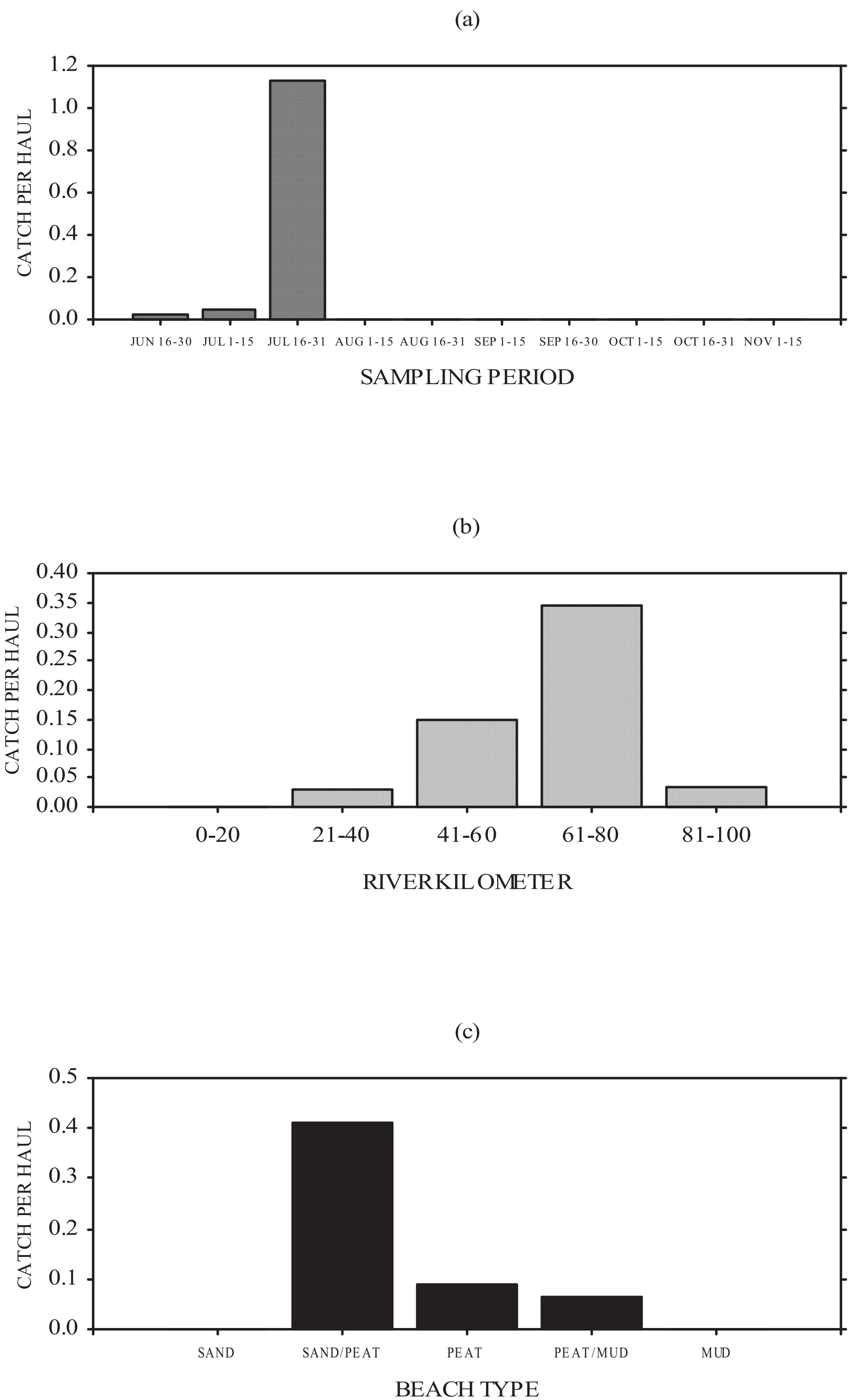


Figure 5-6. Mean catch per haul of American shad by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2006 baywide seine survey.

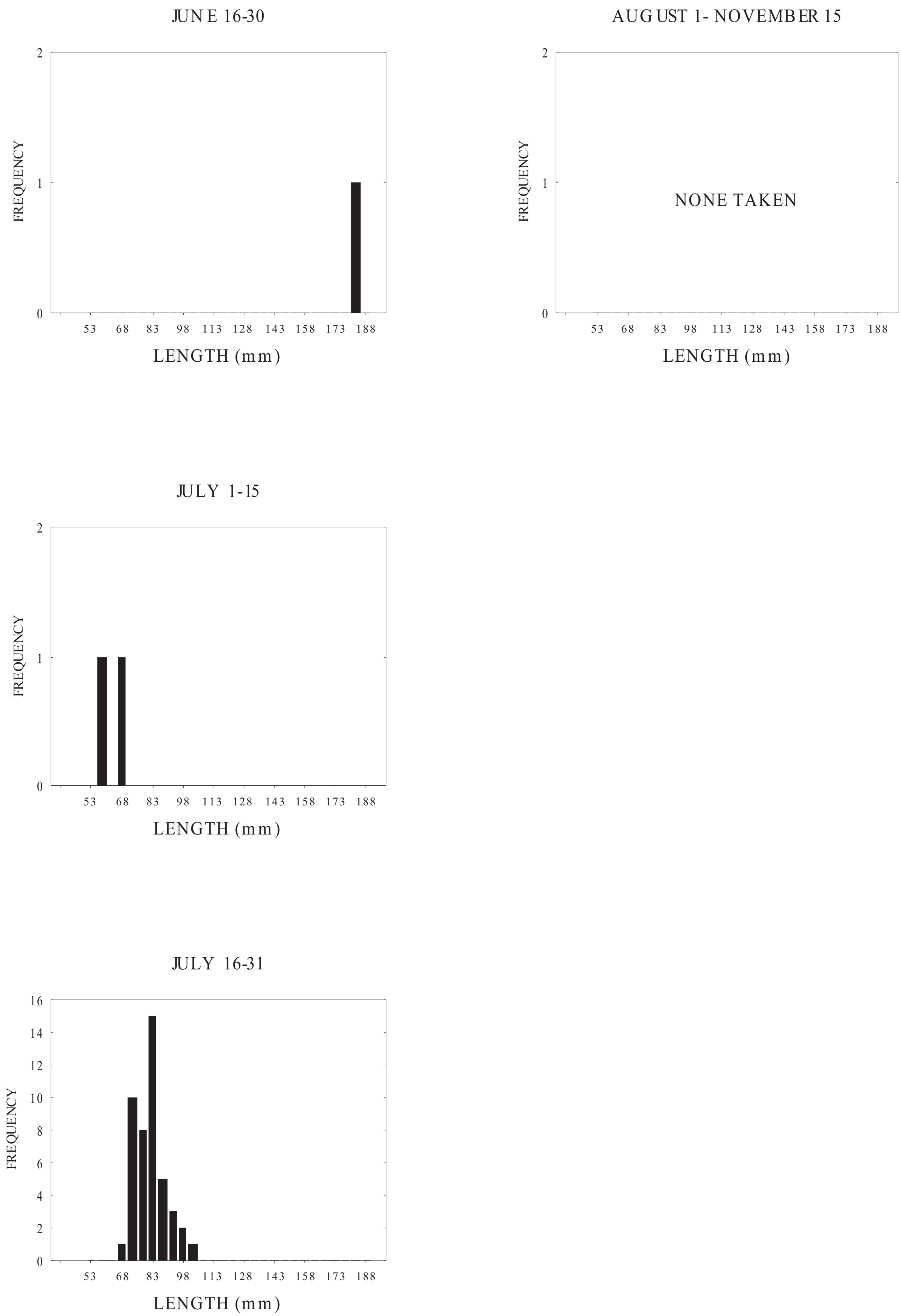


Figure 5-7. Length-frequency distribution by sampling period for American shad taken during the 2006 baywide seine survey.

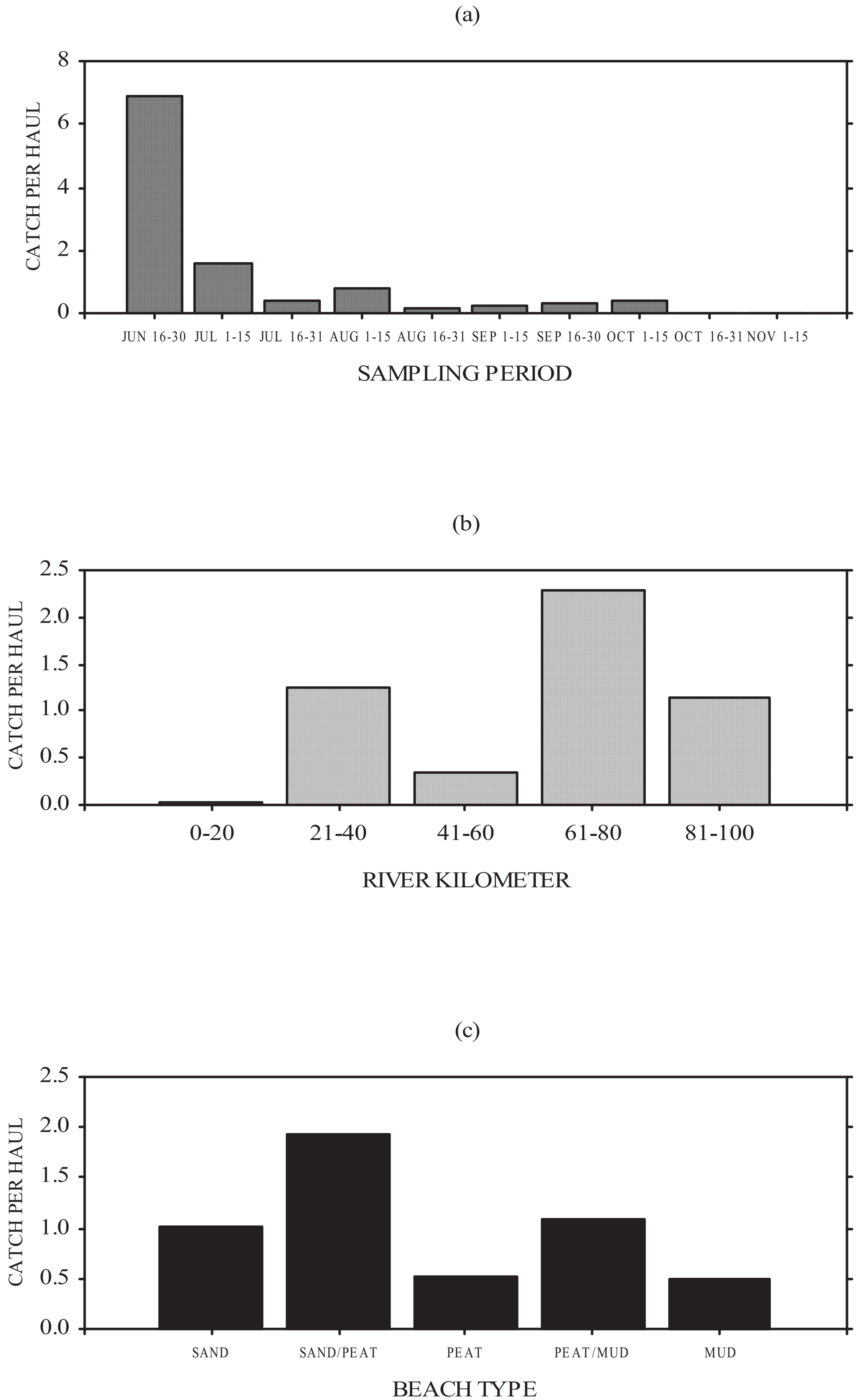


Figure 5-8. Mean catch per haul of Atlantic menhaden by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2006 baywide seine survey.

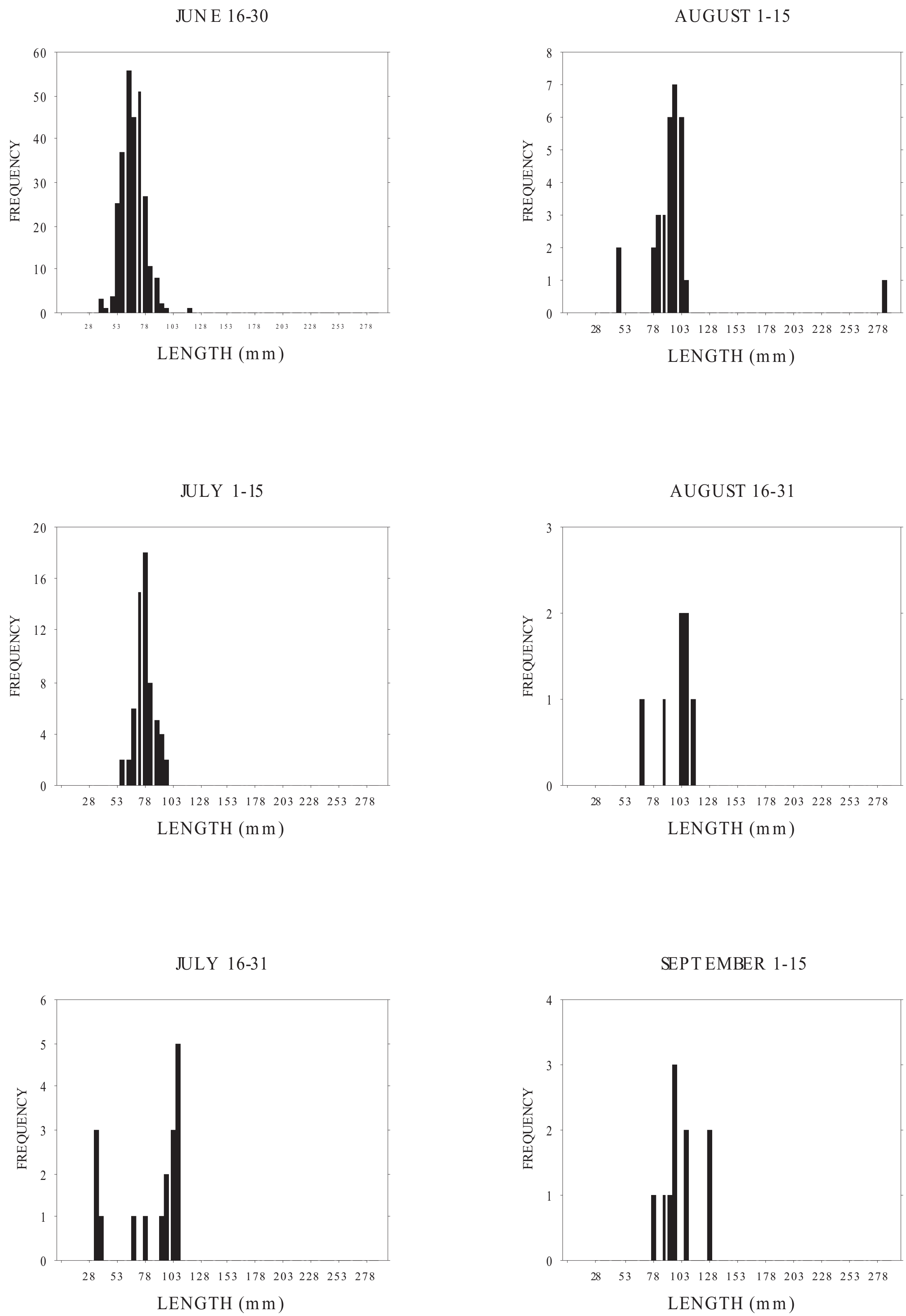
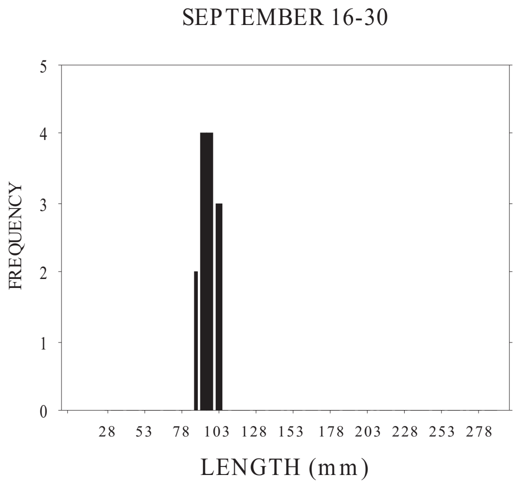
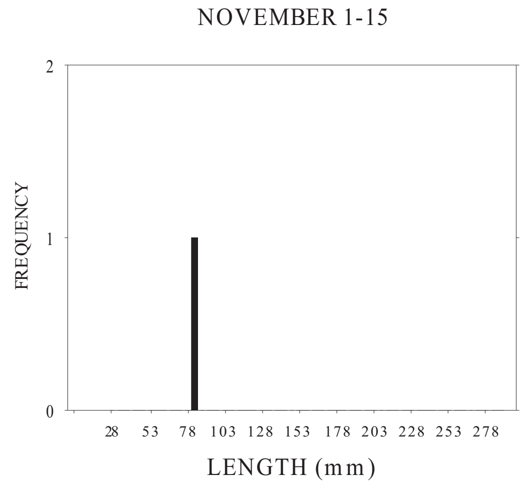
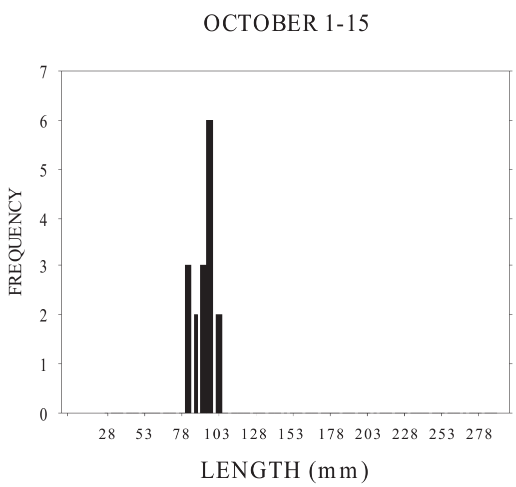


Figure 5-9. Length-frequency distribution by sampling period for Atlantic menhaden taken during the 2006 baywide seine survey.







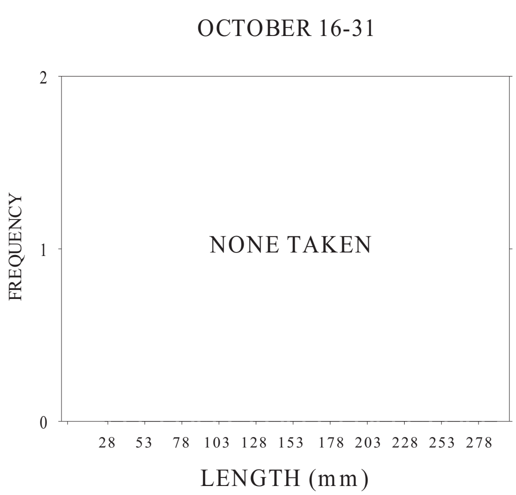


Figure 5-9. Continued.

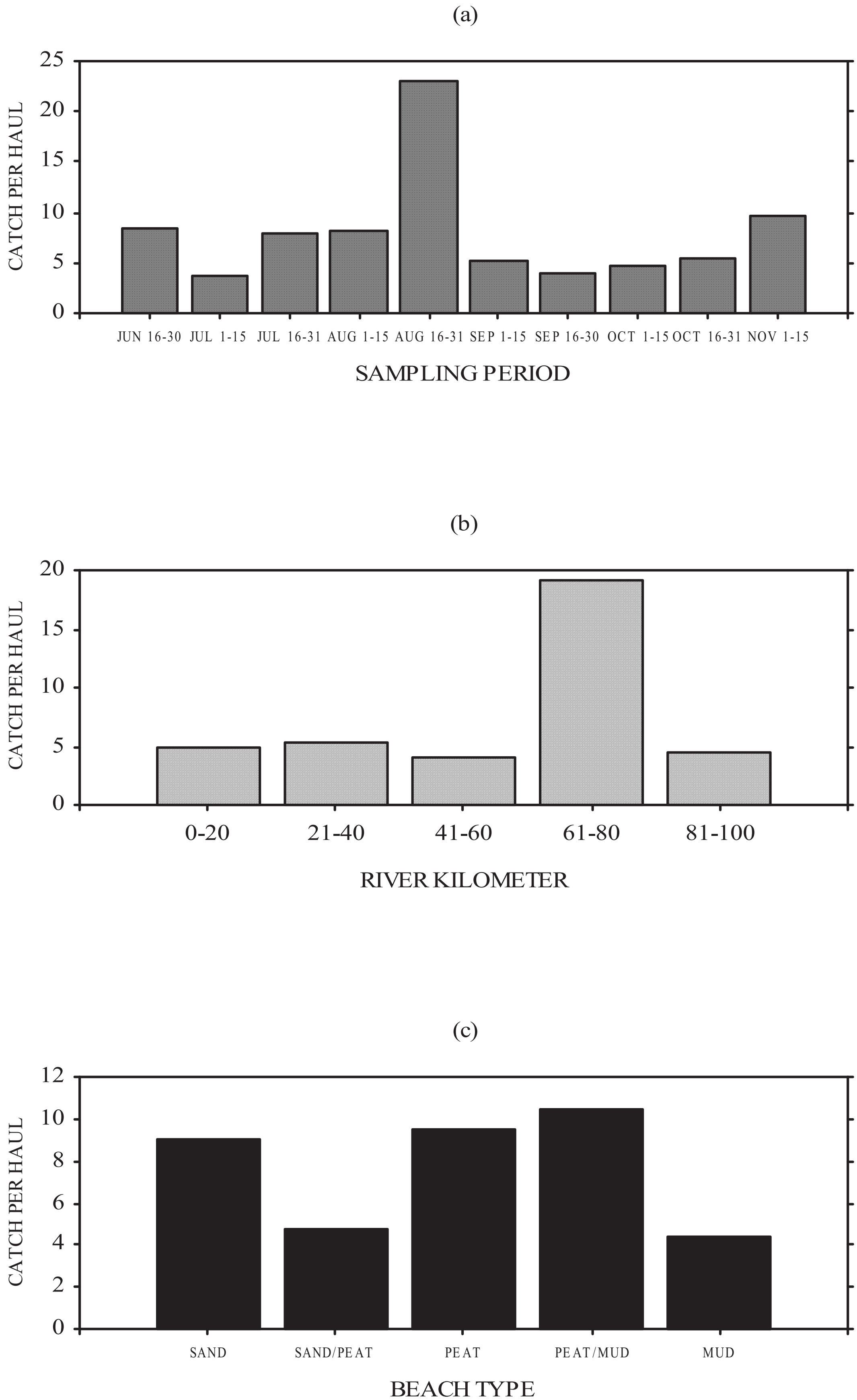


Figure 5-10. Mean catch per haul of bay anchovy by sampling period (a), river kilometer (b), and beach type (c) as observed during the 2006 baywide beach seine survey.

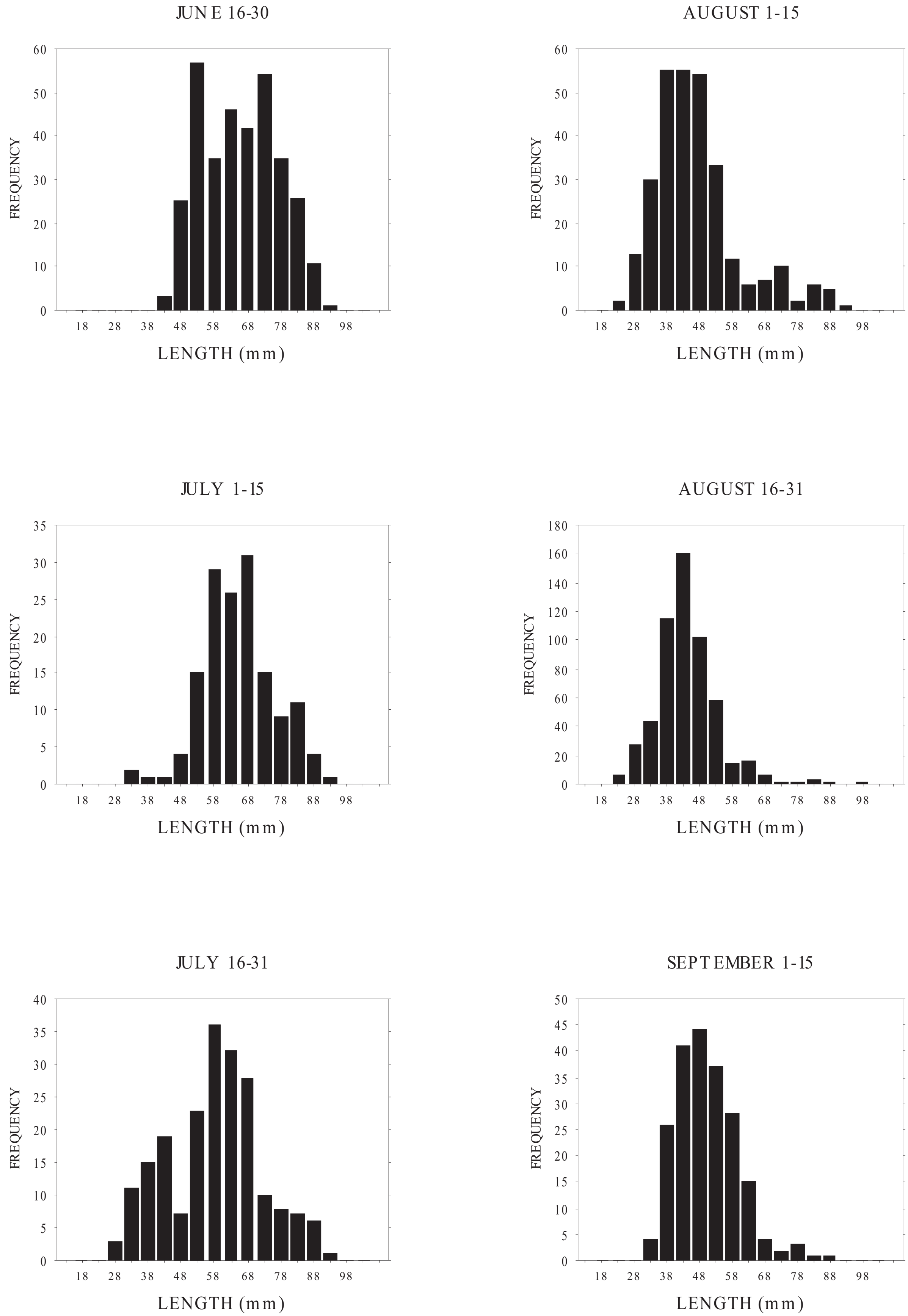
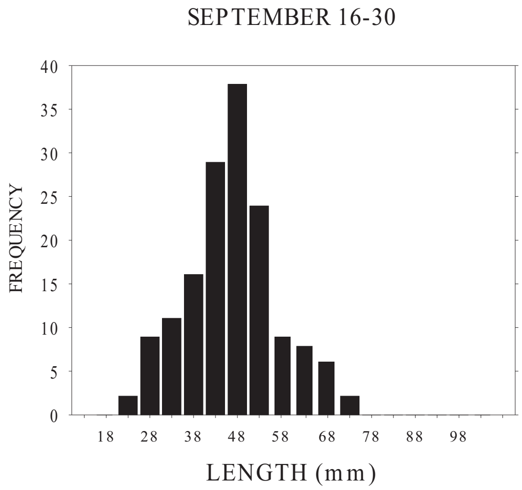
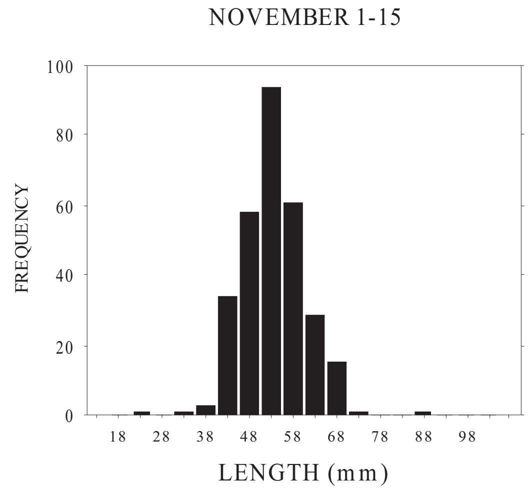
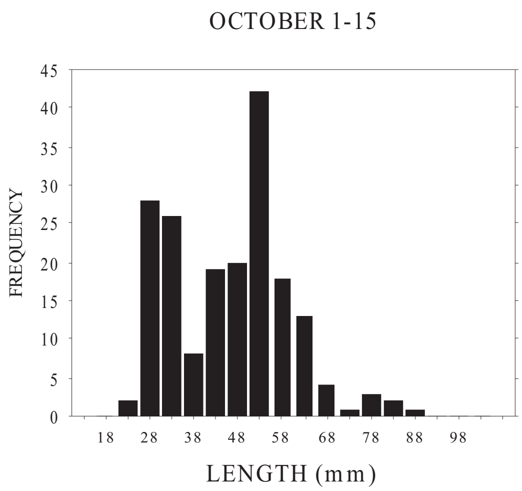


Figure 5-11. Length-frequency distribution by sampling period for bay anchovy taken during the 2006 baywide seine survey.







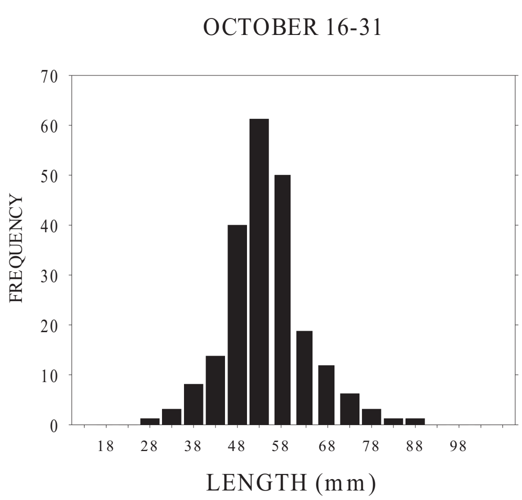


Figure 5-11. Continued.

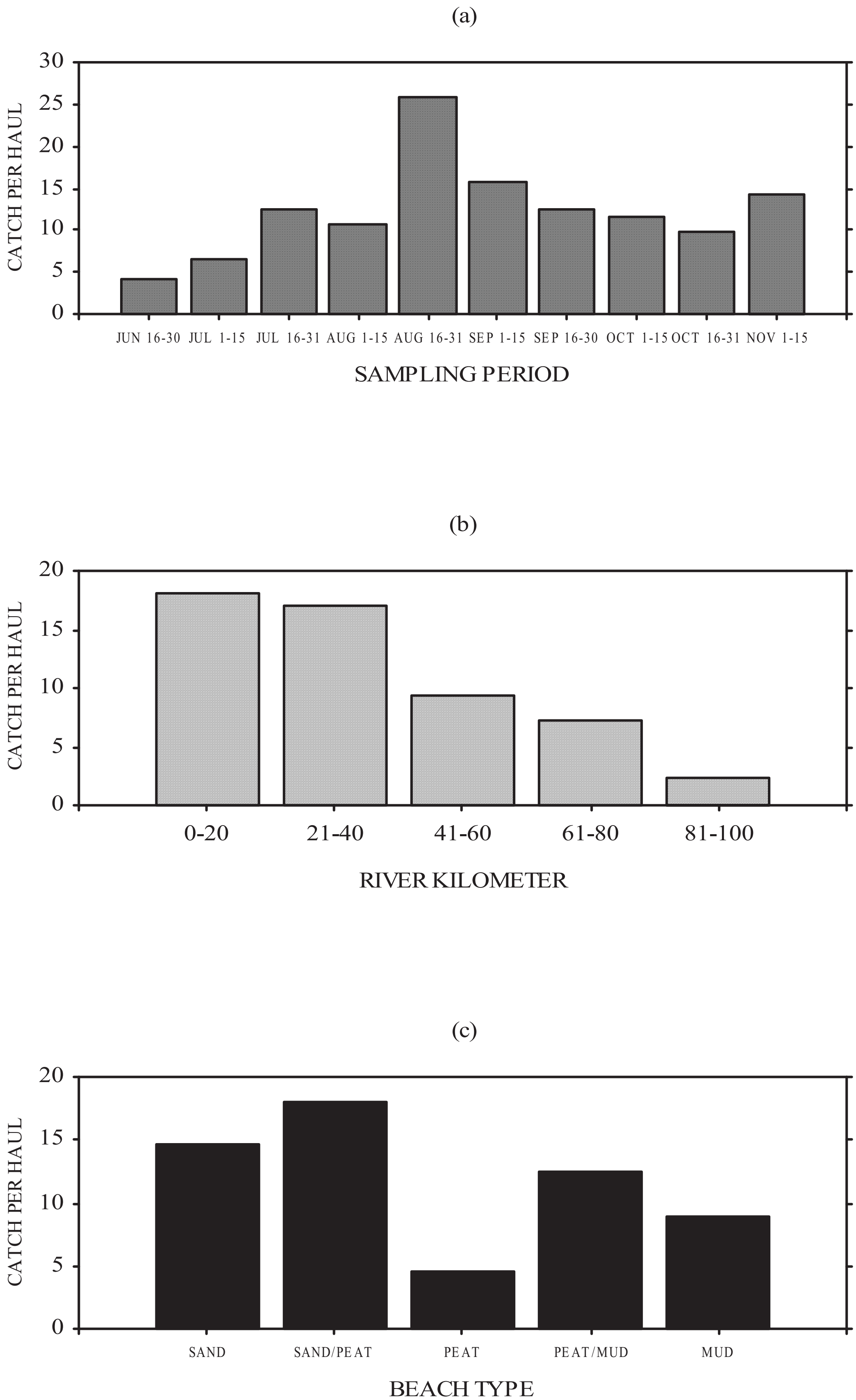


Figure 5-12. Mean catch per haul of Atlantic silverside by sampling period (a), river kilometer (b), and beach type (c) as observed during the 2006 baywide beach seine survey.

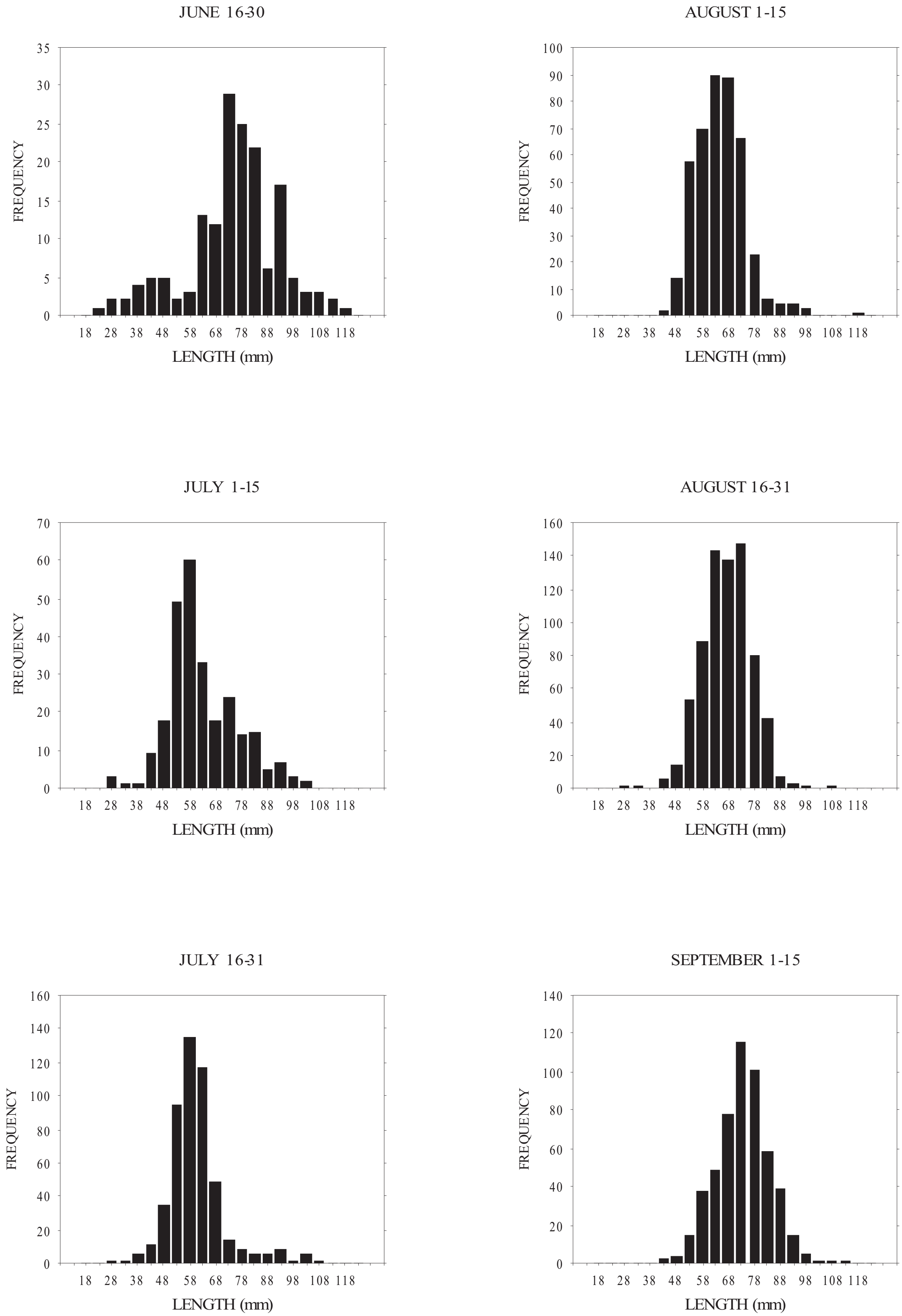
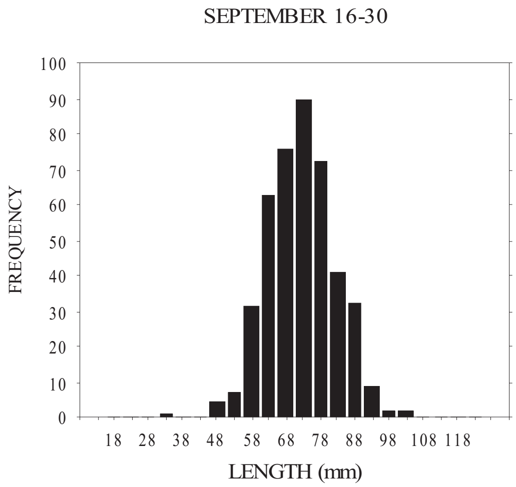
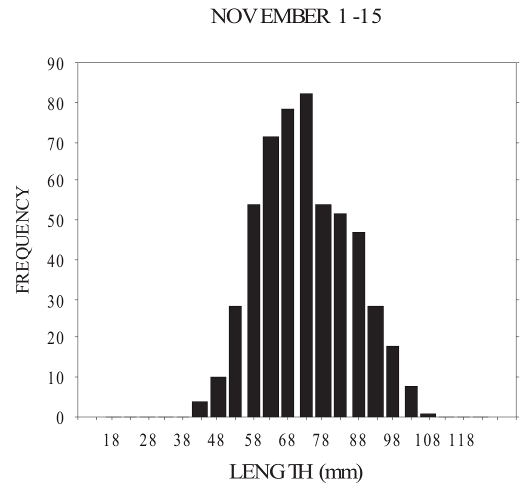
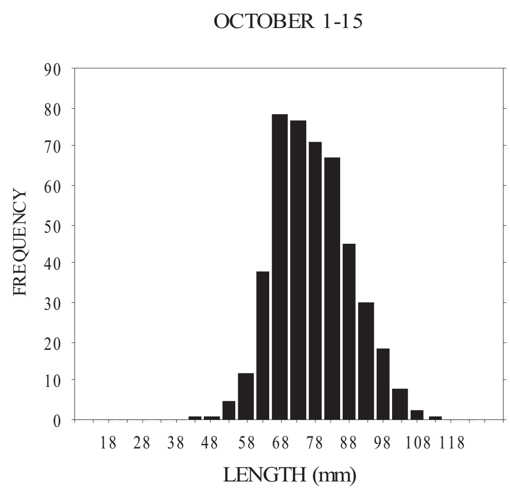


Figure 5-13. Length-frequency distribution by sampling period for Atlantic silverside taken during the 2006 baywide seine survey.







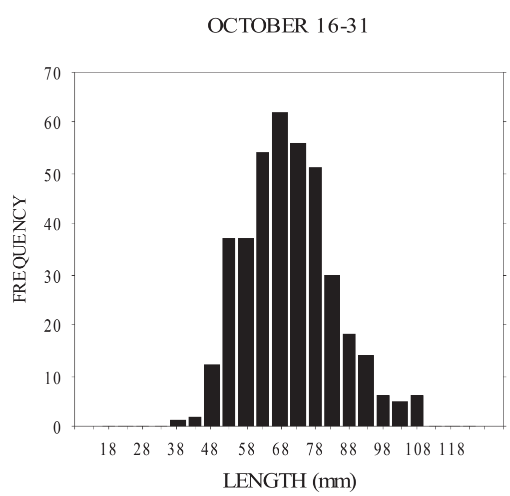
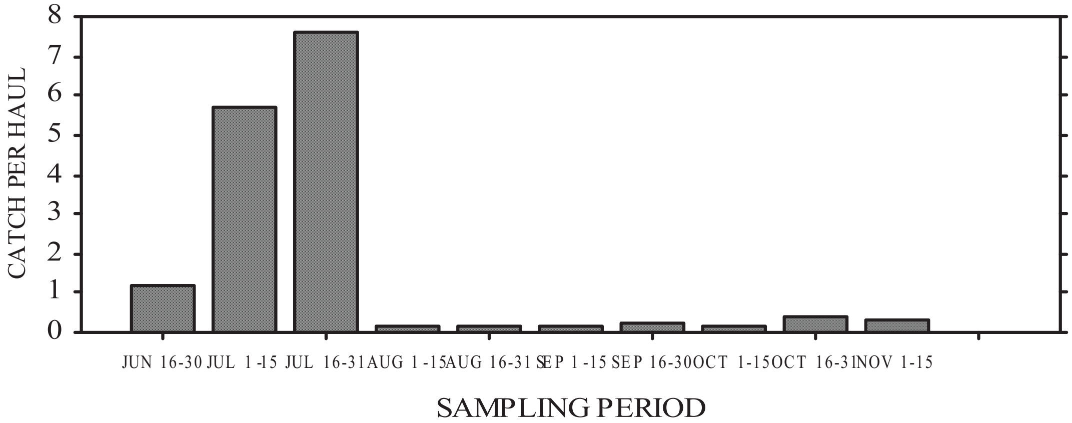


Figure 5-13. Continued.

(a)



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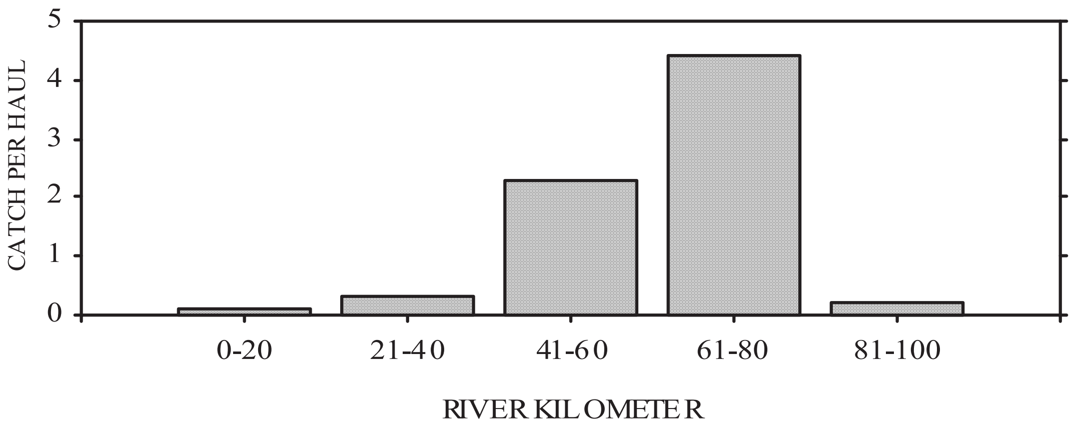

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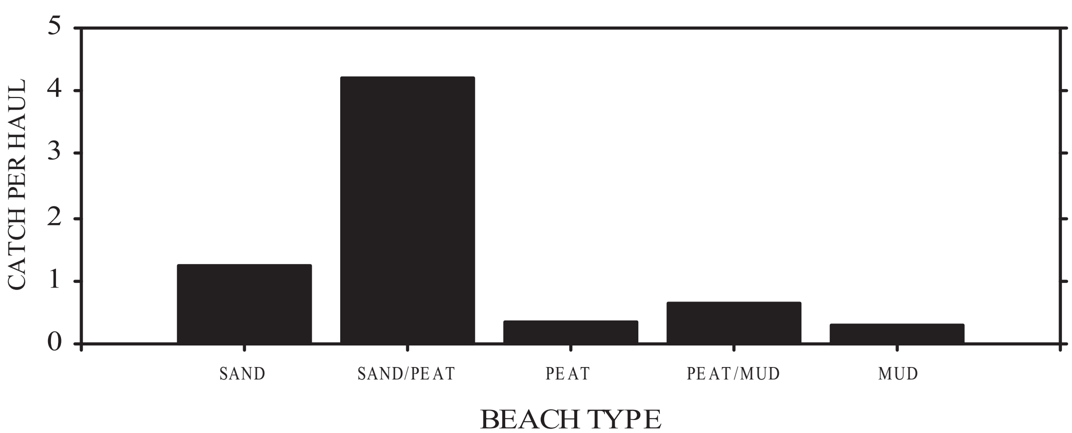


Figure 5-14. Mean catch per haul of white perch by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2006 baywide seine survey.

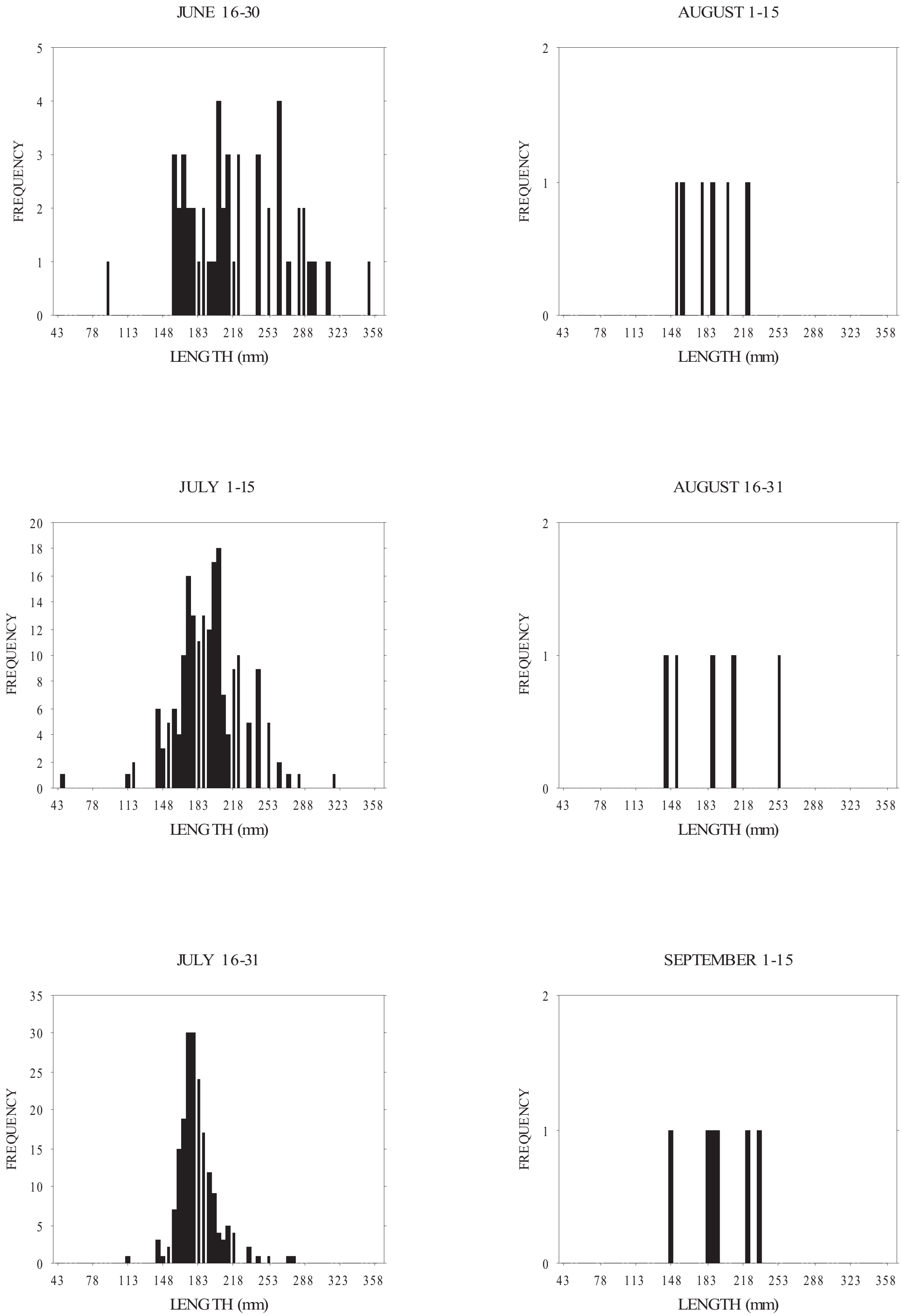
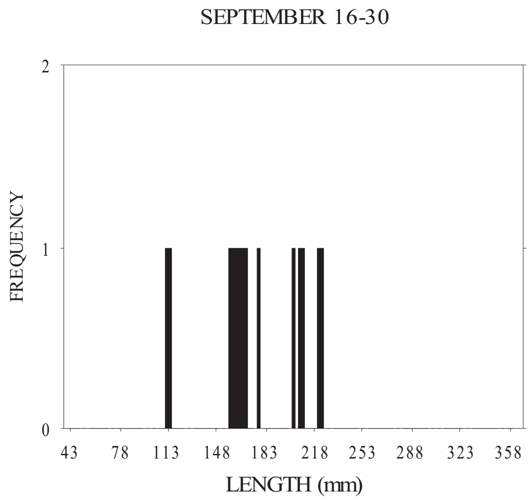
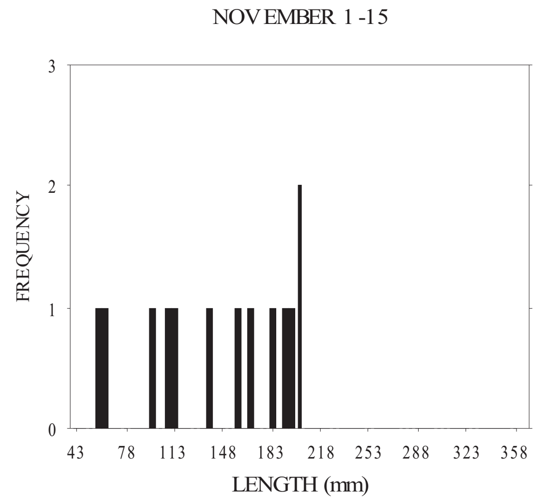
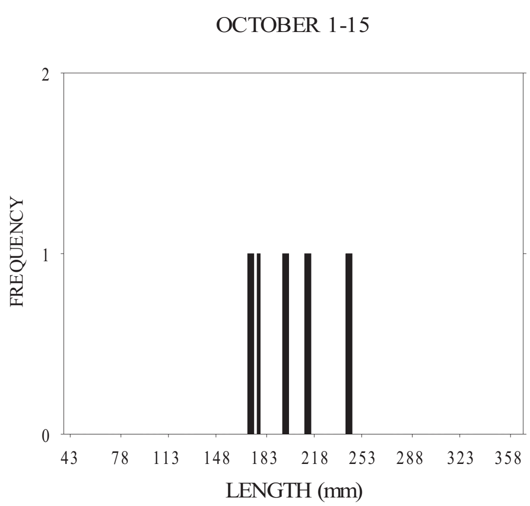
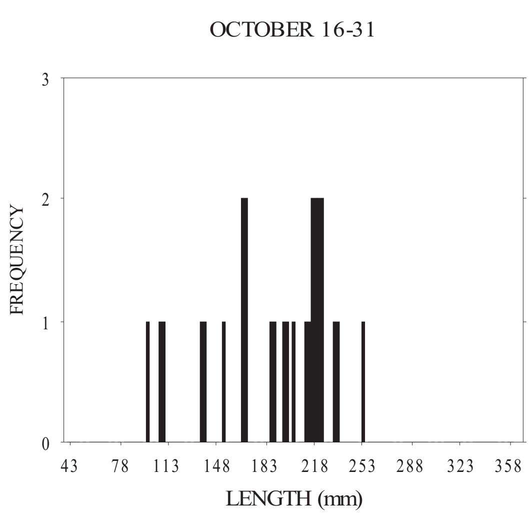


Figure 5-15. Length-frequency distribution by sampling period for white perch taken during the 2006 baywide seine survey.









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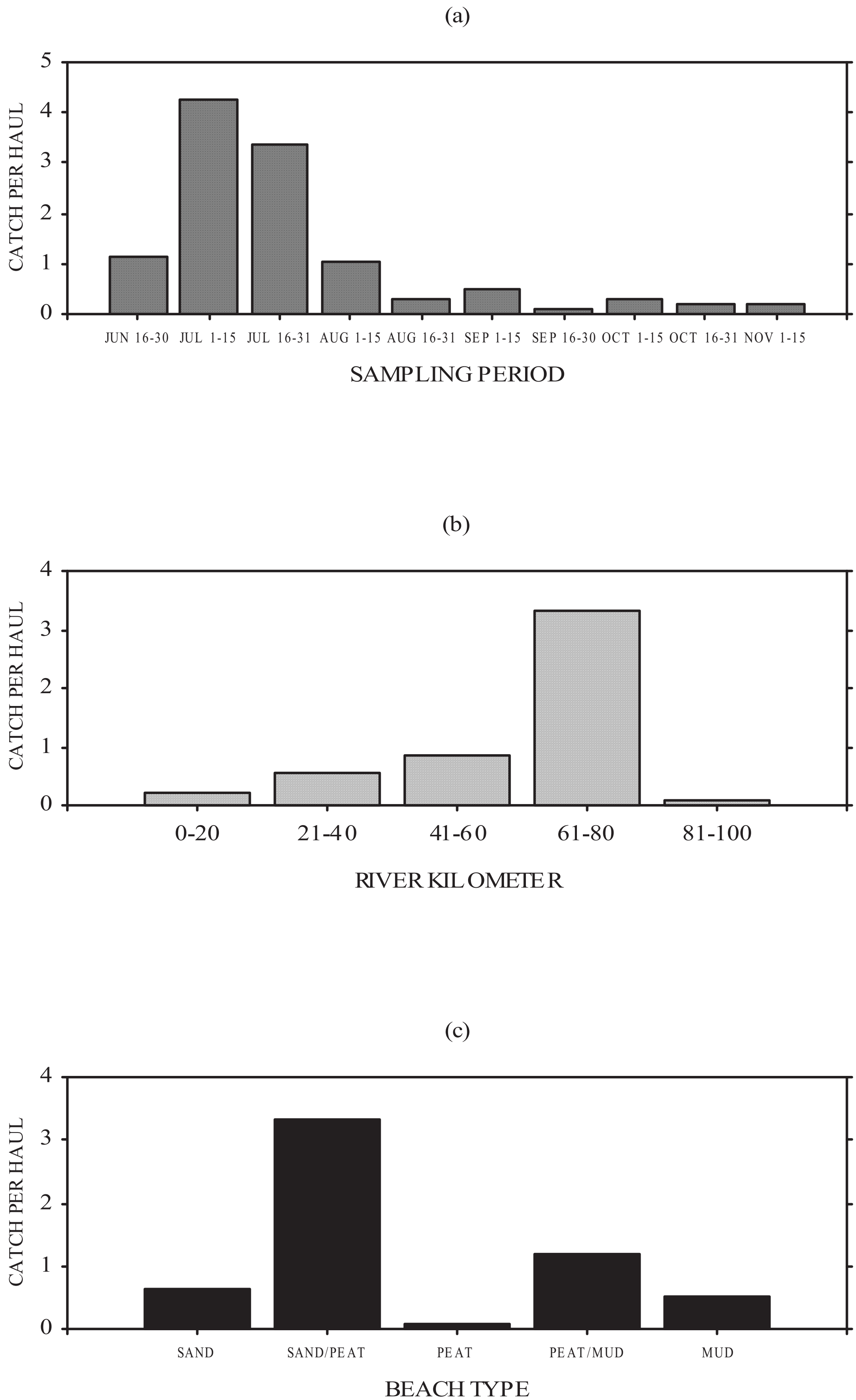


Figure 5-16. Mean catch per haul of striped bass by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2006 baywide seine survey.

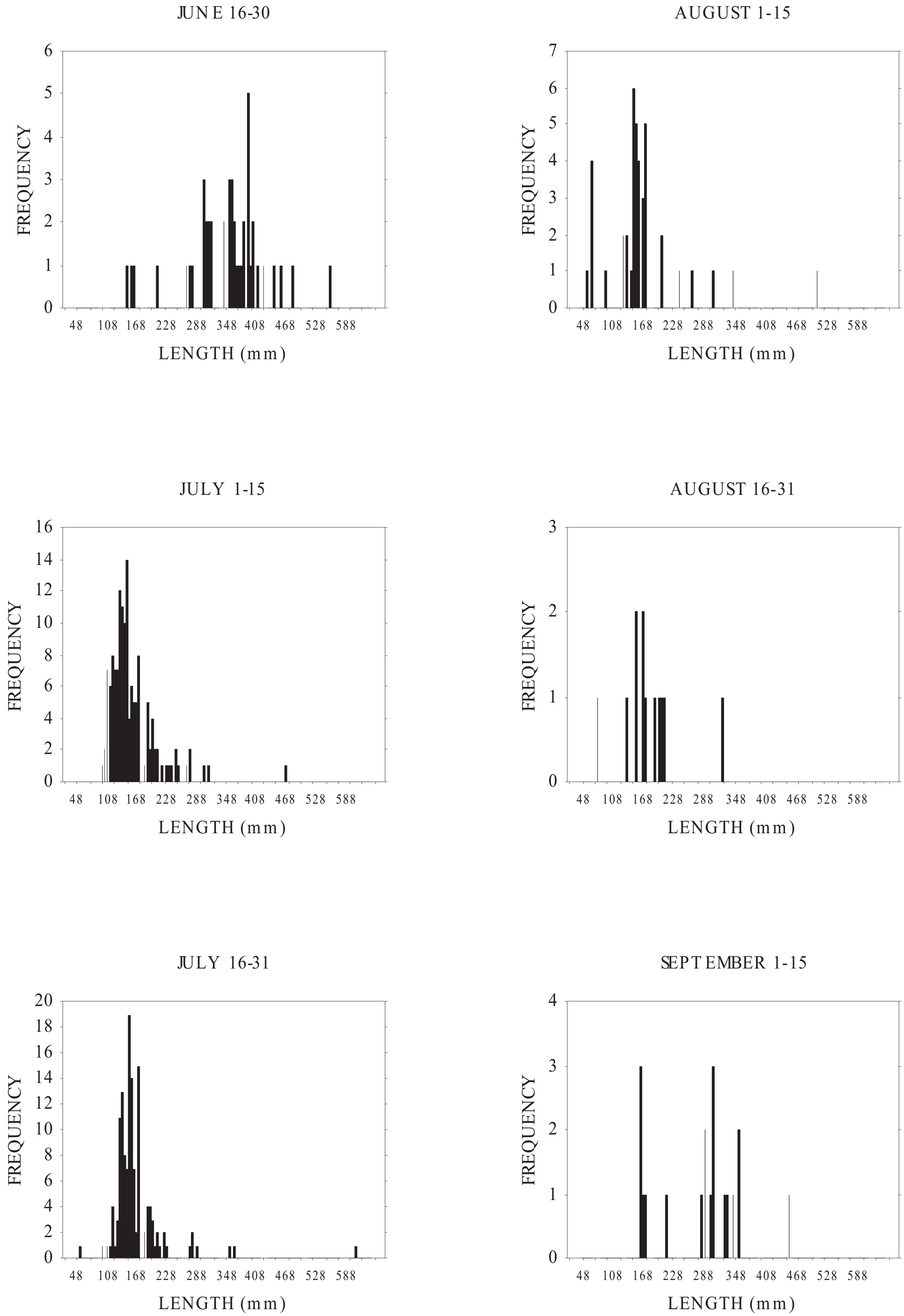


Figure 5-17. Length-frequency distribution by sampling period for striped bass taken during the 2006 baywide seine survey.

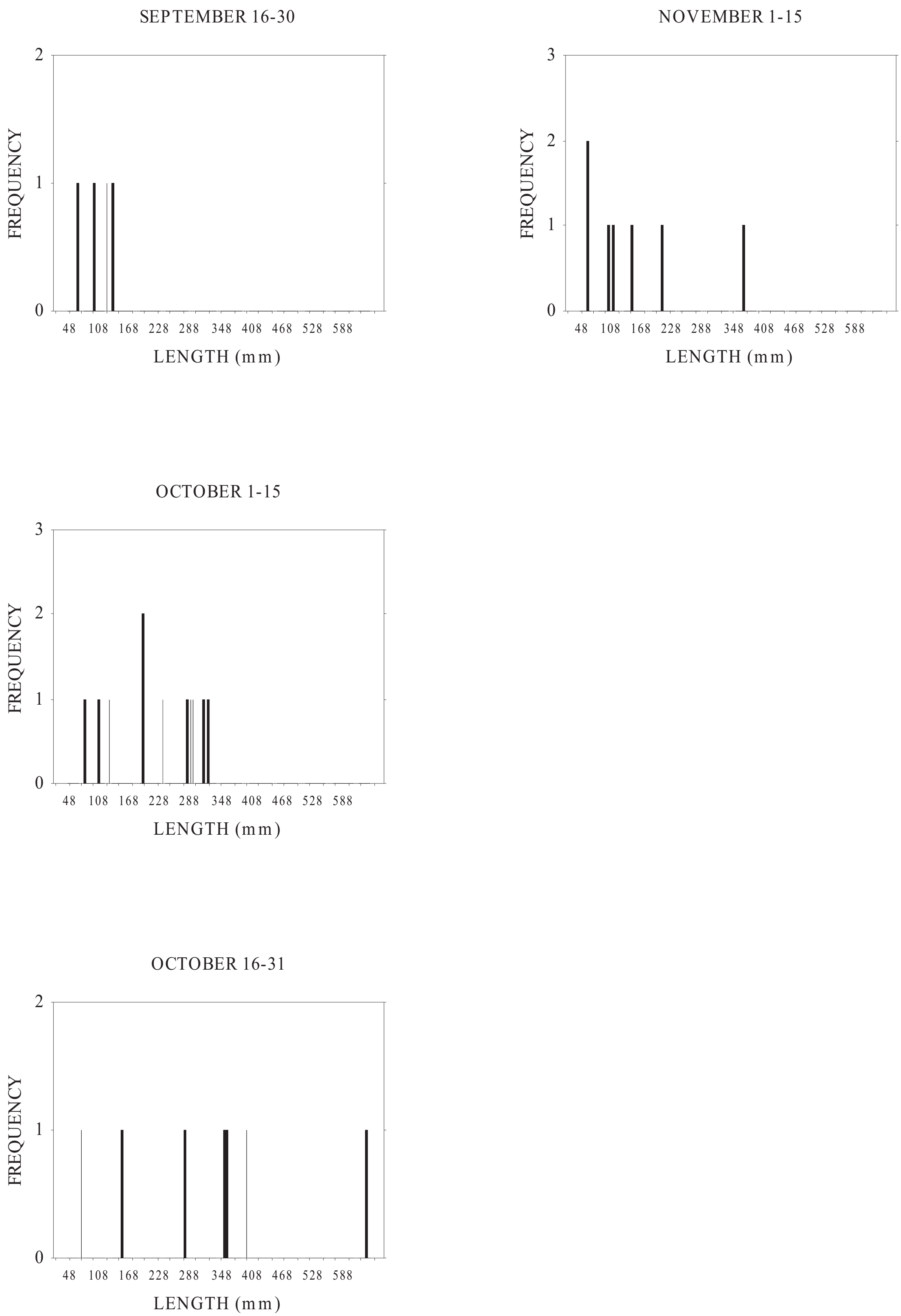
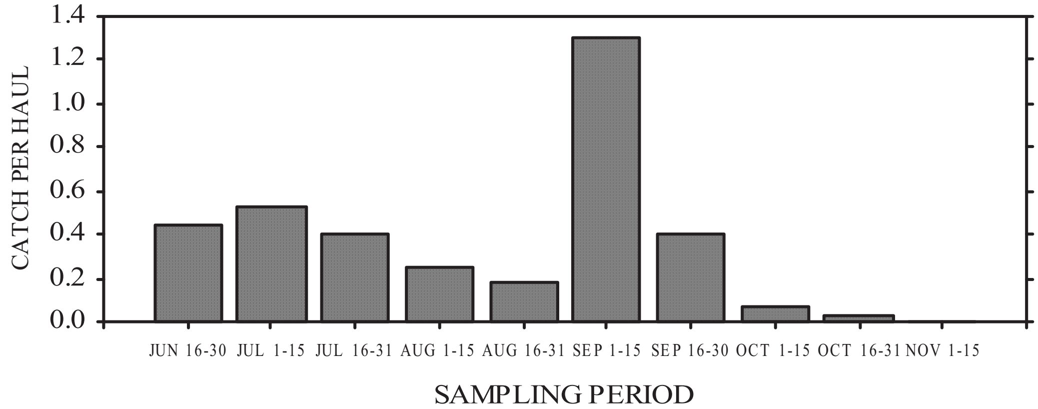


Figure 5-17. Continue.

(a)



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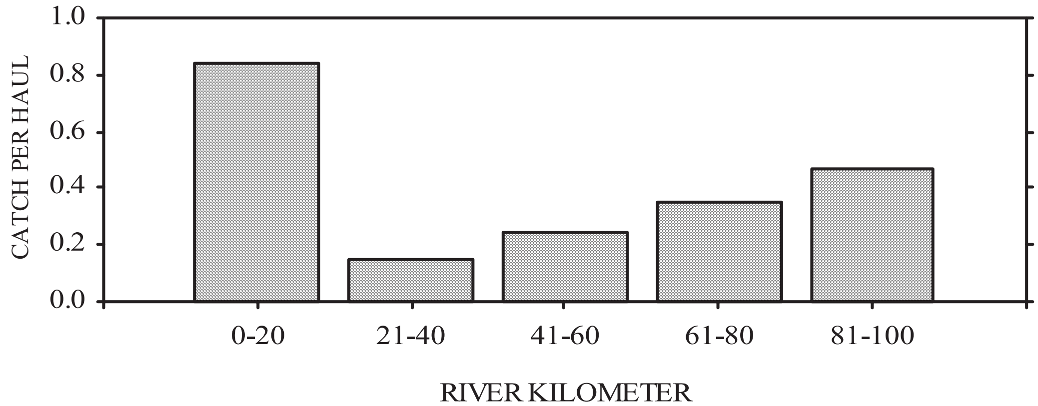


(c)

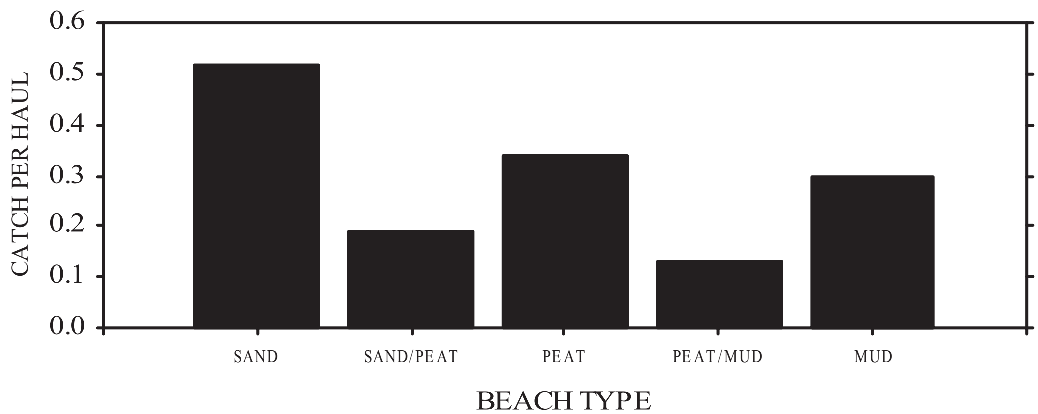


Figure 5-18. Mean catch per haul of bluefish by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2006 baywide seine survey.

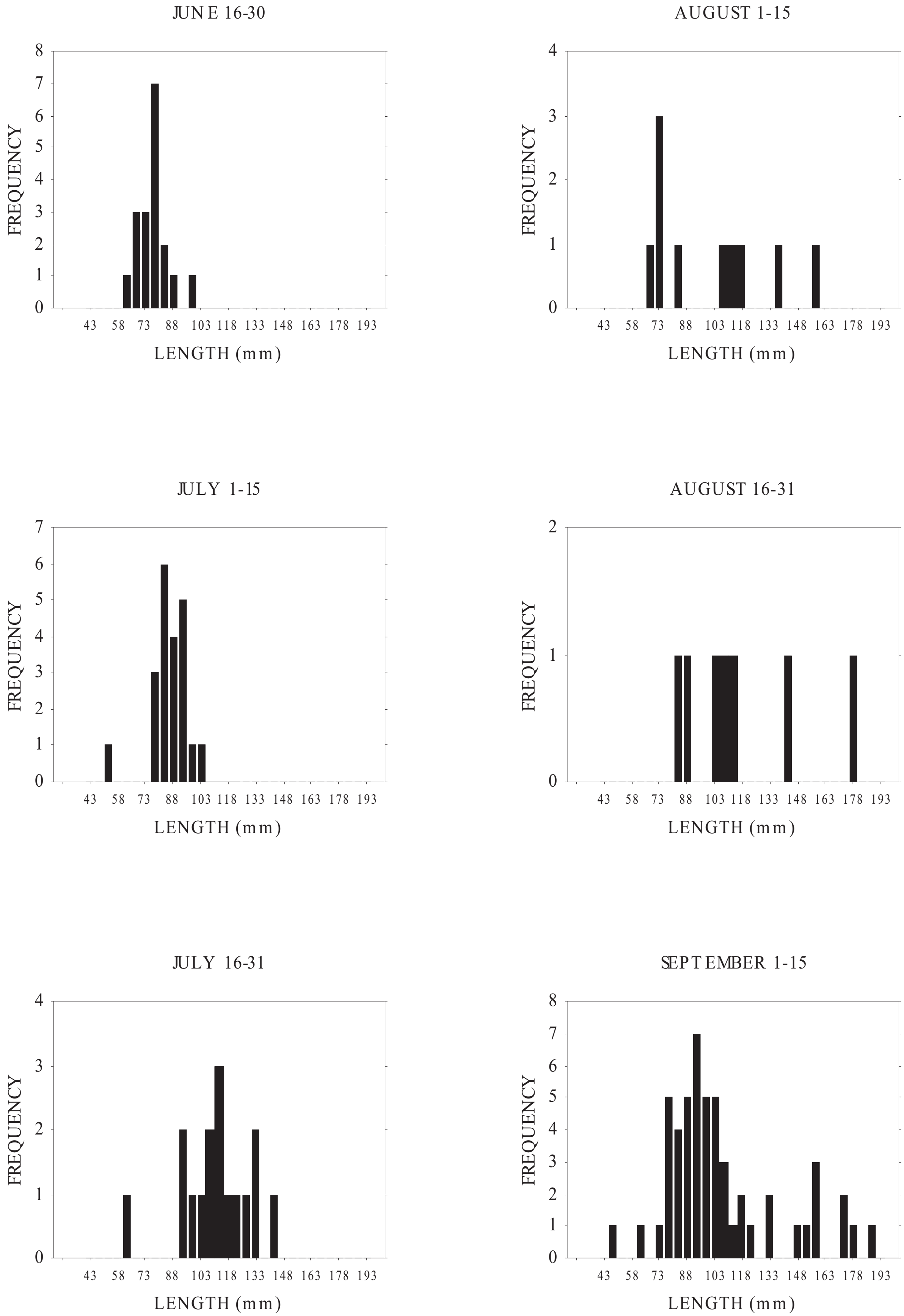
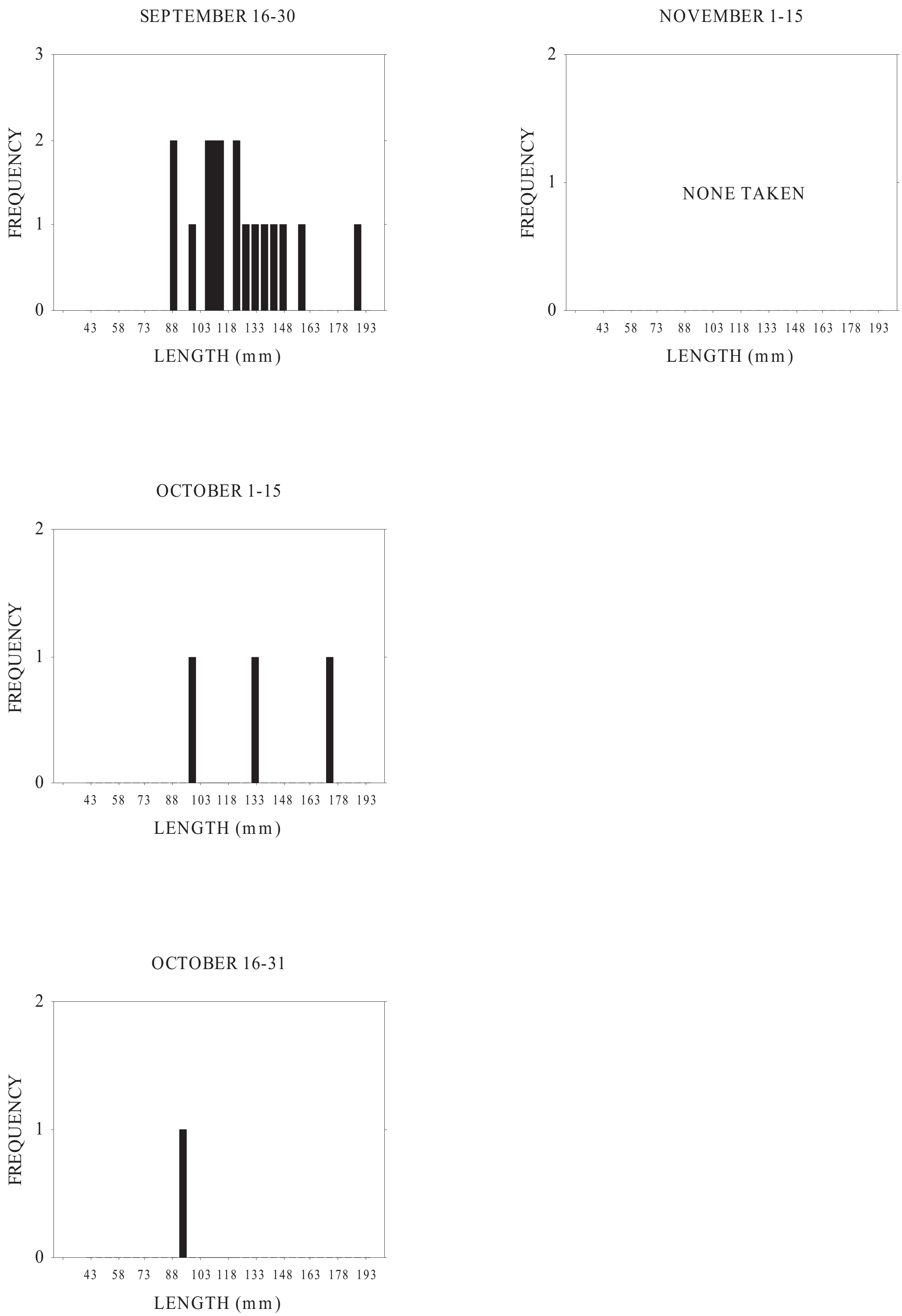


Figure 5-19. Length-frequency distribution by sampling period for bluefish taken during the 2006 baywide seine survey.



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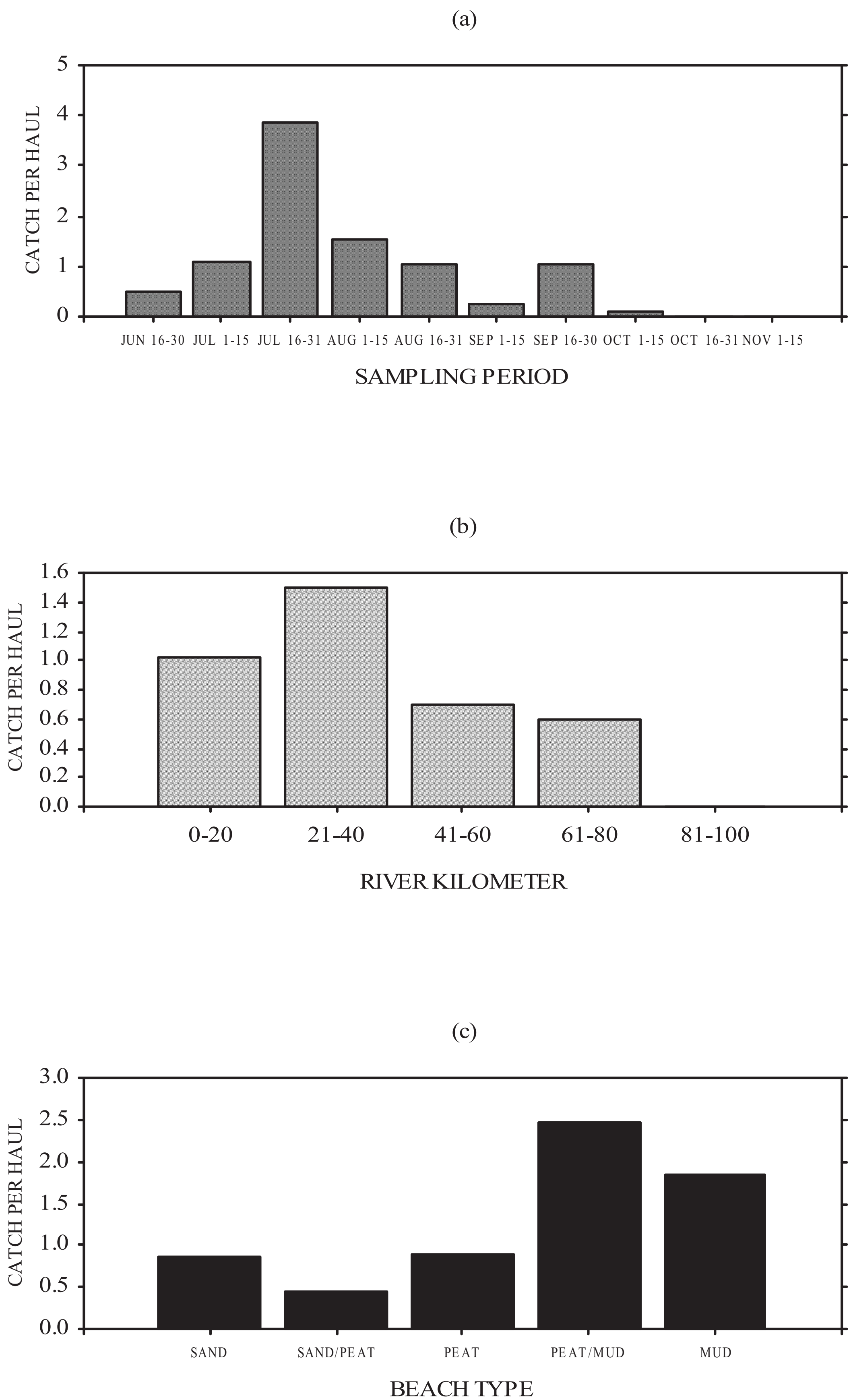


Figure 5-20. Mean catch per haul of weakfish by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2006 baywide seine survey.

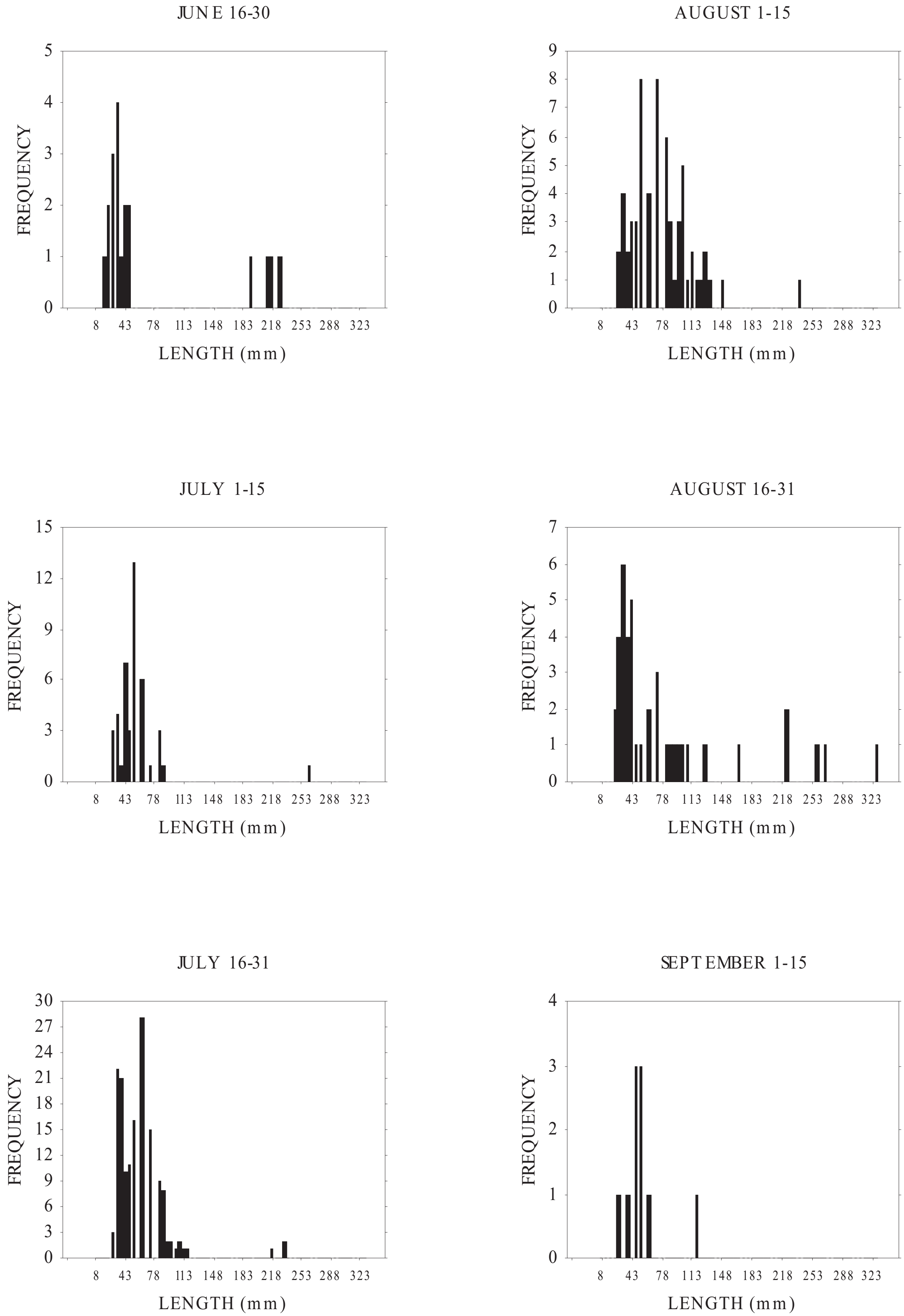
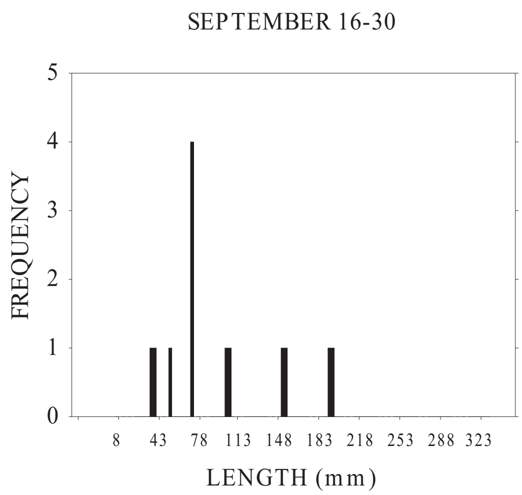
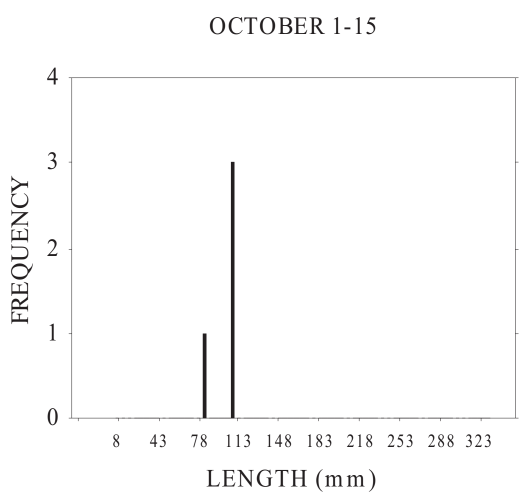
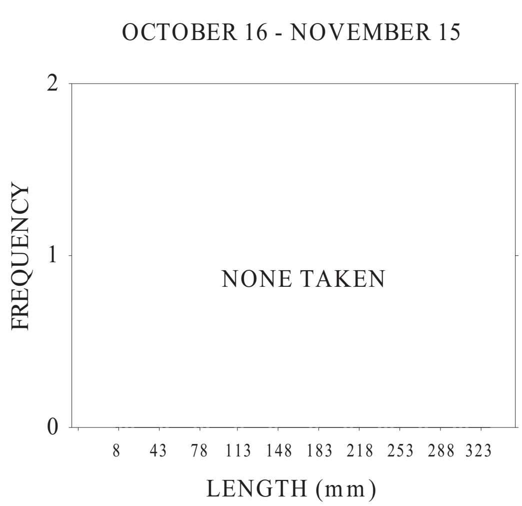


Figure 5-21. Length-frequency distribution by sampling period for weakfish taken during the 2006 baywide seine survey.







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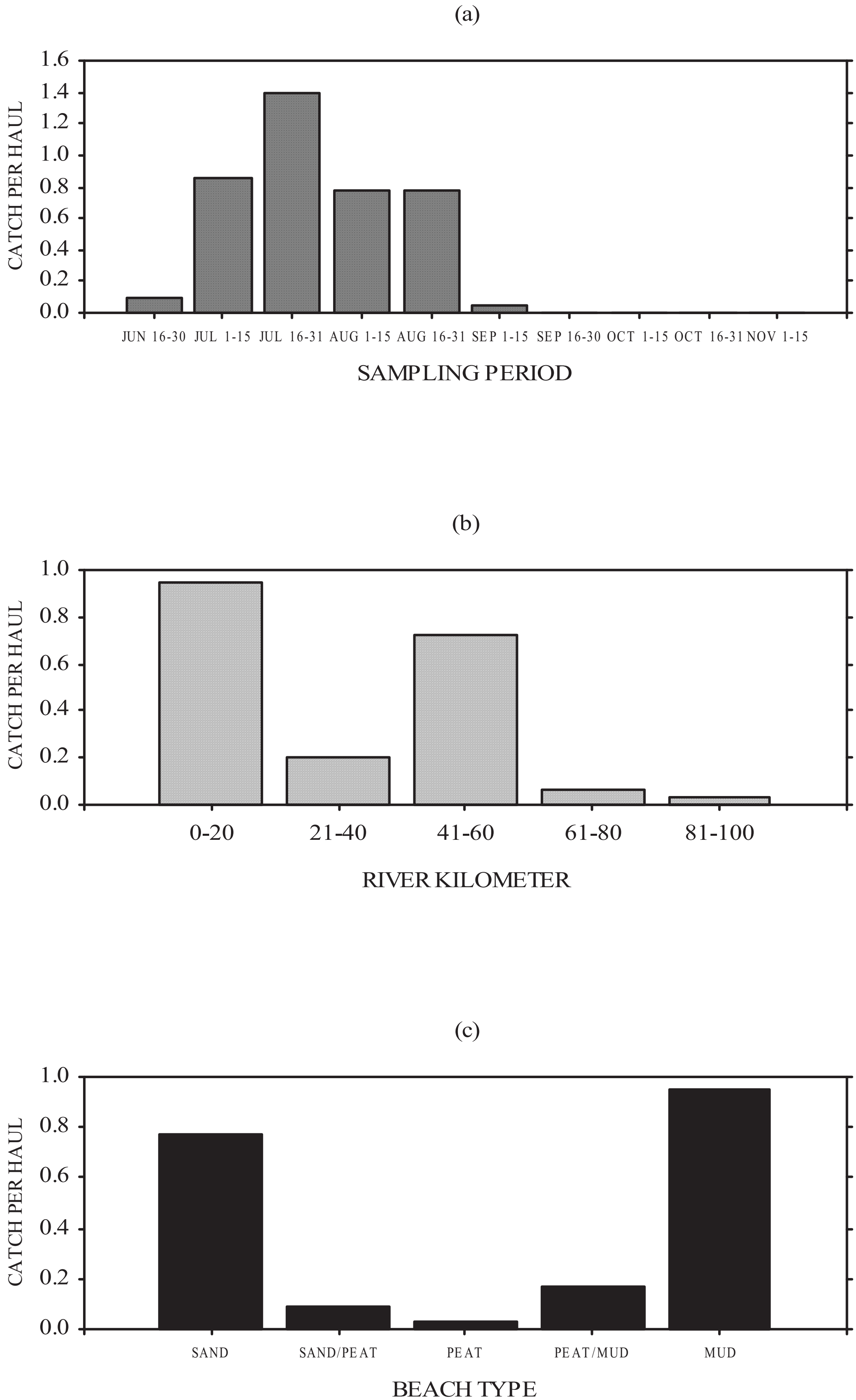


Figure 5-22. Mean catch per haul of spot by sampling period (a), river kilometer (b) and beach type (c), as observed during the 2006 baywide seine survey.

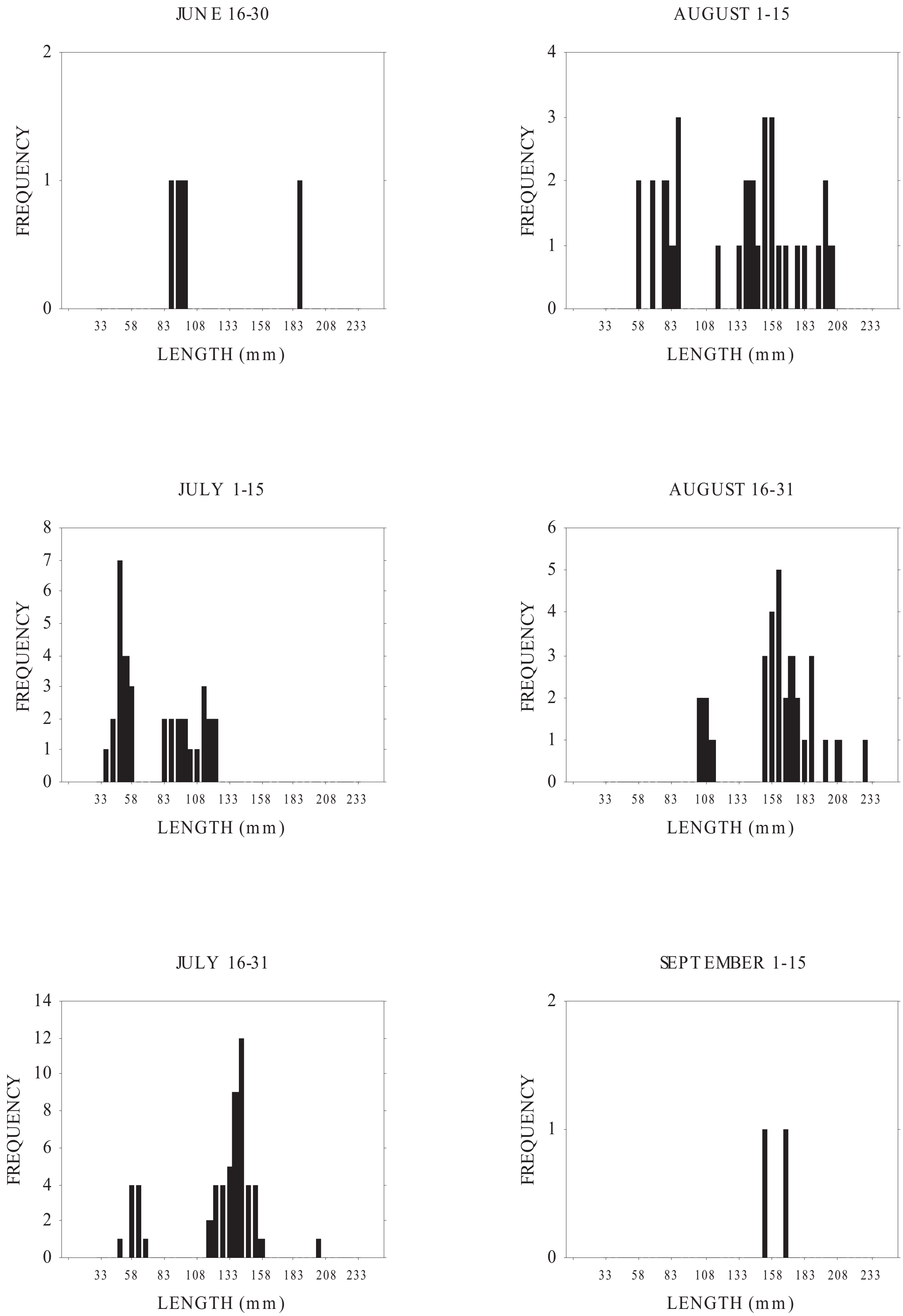
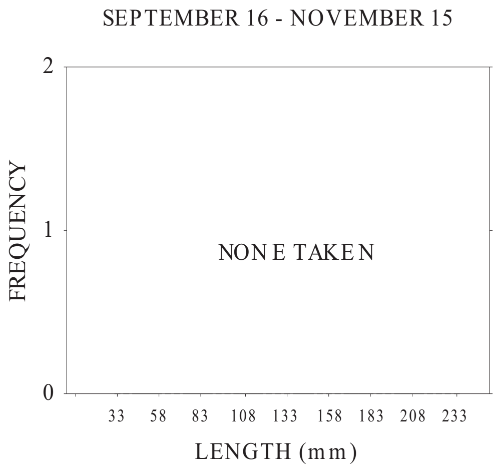


Figure 5-23. Length-frequency distribution by sampling period for spot taken during the 2006 baywide seine survey.



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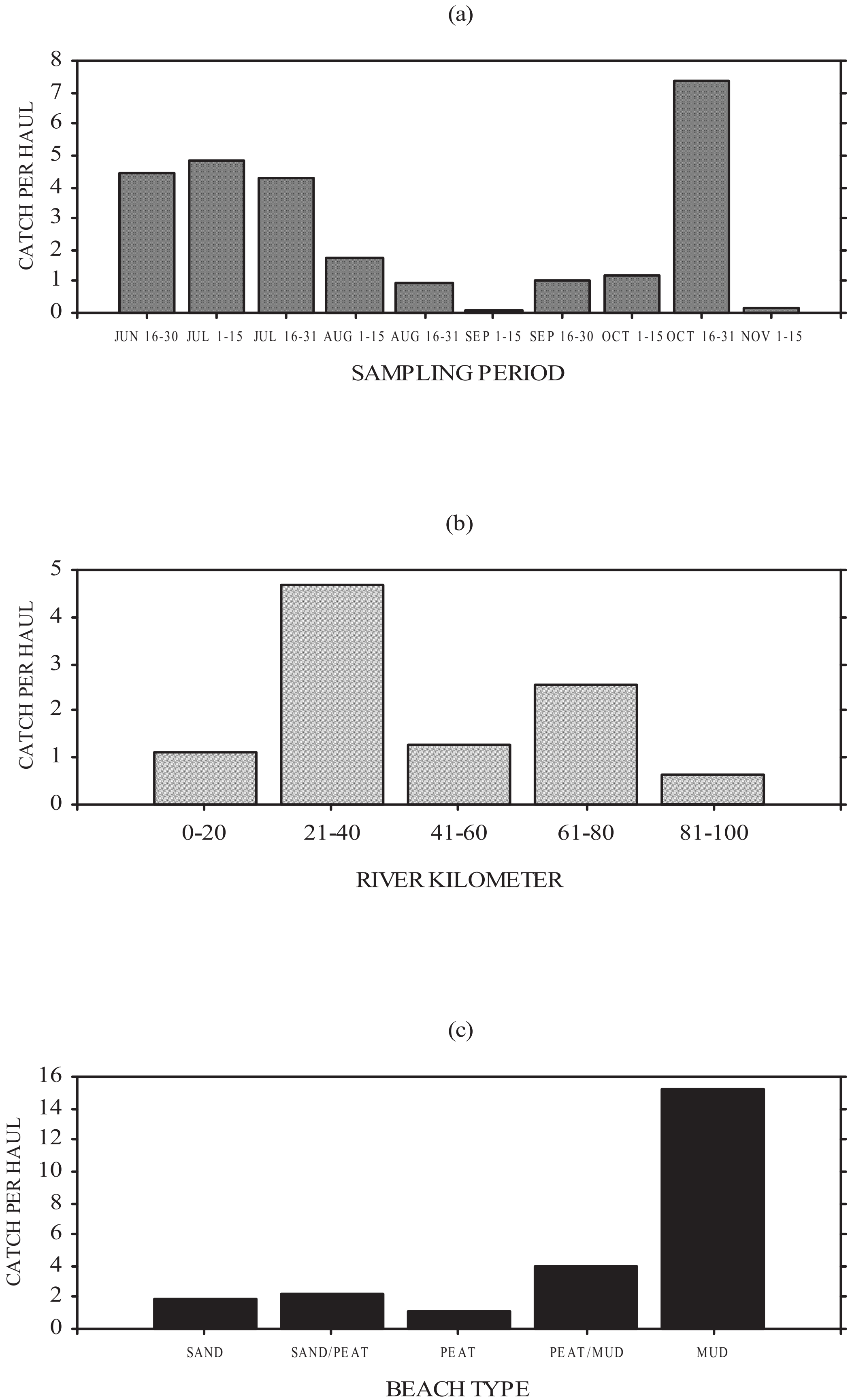


Figure 5-24. Mean catch per haul of Atlantic croaker by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2006 baywide seine survey.

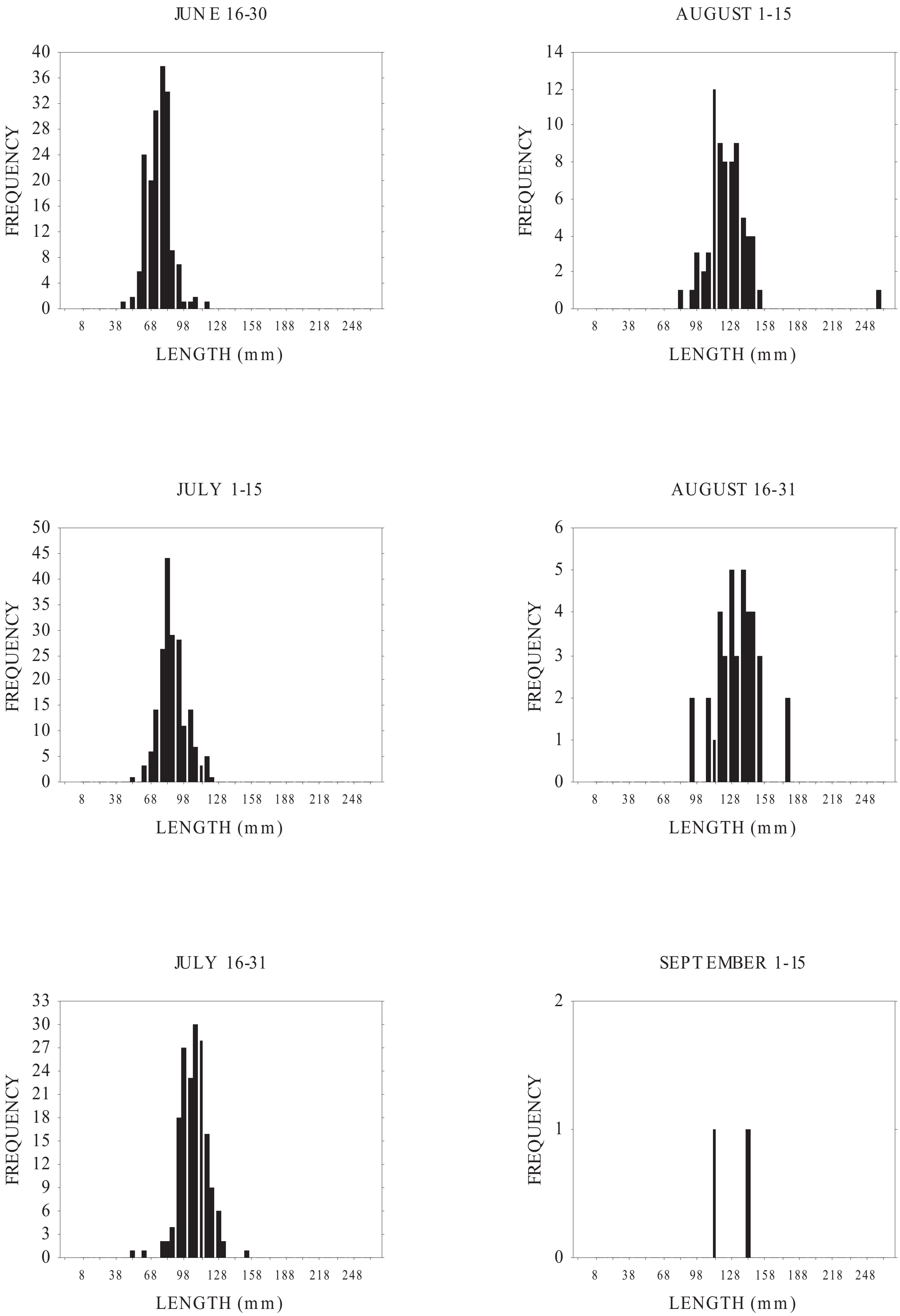
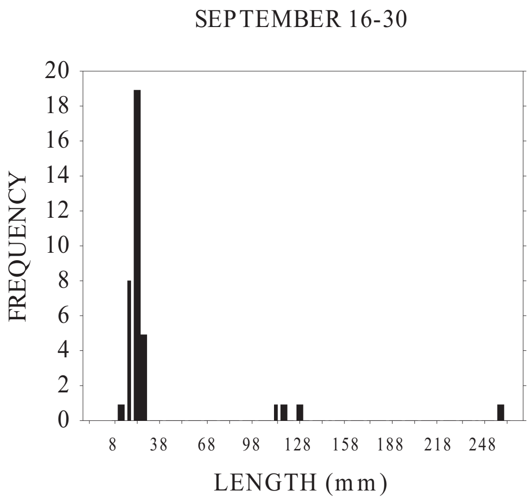
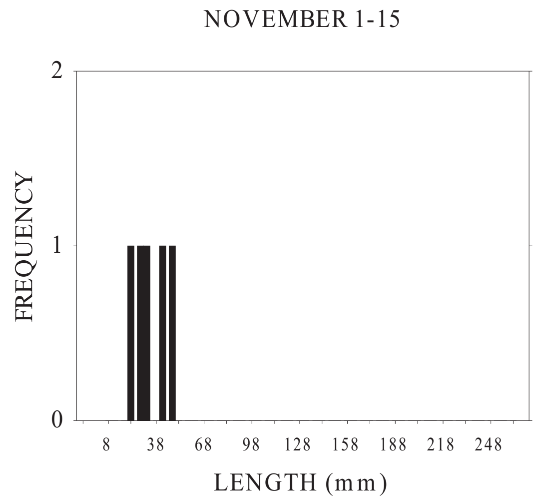
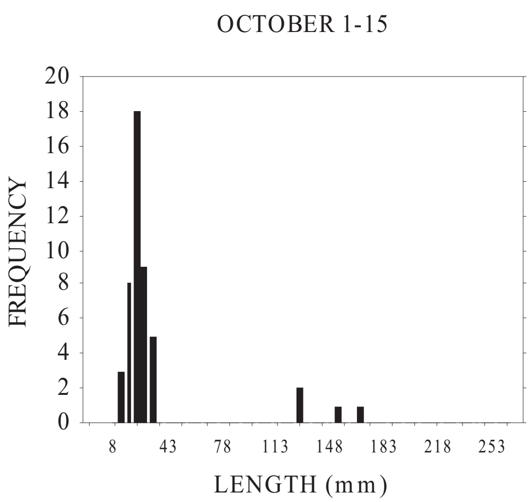


Figure 5-25. Length-frequency distribution by sampling period for Atlantic croaker taken during the 2006 baywide seine survey.







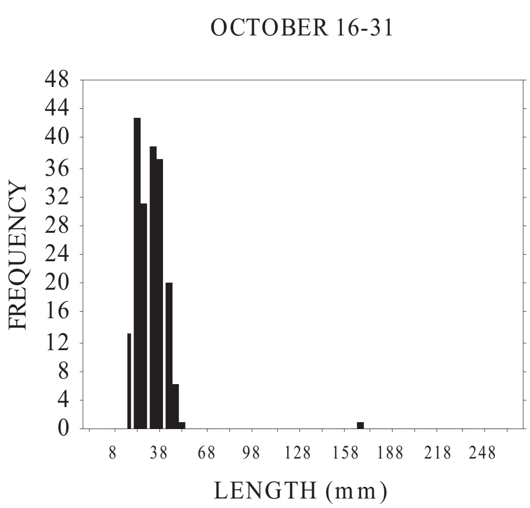


Figure 5-25. Continued.

Appendix 5-1. Region (rkm) and beach-type designations for the 40 beach seine stations**.**

Station #	Region (rkm)	Beach Type
1	0 - 20	Sand
2	0 – 20	Sand
3	0 - 20	Sand
4	21 - 40	Sand/Peat
5	21 – 40	Sand/Peat
6	21 – 40	Mud
7	21 – 40	Peat
8	41 – 60	Sand
9	41 – 60	Sand
10	41 – 60	Peat
11	41 – 60	Sand
12	61 – 80	Sand/Peat
13	61 – 80	Sand/Peat
14	61 – 80	Peat
15	61 – 80	Sand
16	81 - 100	Sand
17	81 - 100	Peat
18	61 – 80	Sand/Peat
19	61 – 80	Sand
20	61 – 80	Sand/Peat

Station #	Region (rkm)	Beach Type
21	61 – 80	Sand
22	41 – 60	Sand/Peat
23	41 – 60	Peat
24	41 – 60	Peat
25	21 - 40	Mud
26	21 – 40	Sand
27	21 – 40	Sand
28	21 - 40	Peat/Mud
29	0 – 20	Sand
30	0 – 20	Sand
31	0 – 20	Sand
32	0 - 20	Sand
33	21 - 40	Peat
34	21 – 40	Peat/Mud
35	21 – 40	Sand/Peat
36	21 – 40	Peat/Mud
37	21 - 40	Peat
38	41 – 60	Sand/Peat
39	61 – 80	Peat
40	81 - 100	Peat

CHAPTER 6: FISH LADDER MONITORING

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FISH LADDER MONITORING

6.1 INTRODUCTION

PSEG Nuclear LLC (PSEG), as a Special Condition of its NJPDES Permit (1995) (No. NJ0005622, Part IV-B/C Special Conditions, H.4), was required to construct and maintain five fish ladders on Delaware River estuary tributaries for spawning run restoration of the alewife (*Alosa pseudoharengus*) and the blueback herring (*Alosa aestivalis*), collectively known as river herring. Site evaluation studies conducted in 1994 and 1995 resulted in the initial selection of five impoundments for construction of fish ladders: Silver Lake, McGinnis Pond, McColley Pond, in Delaware and Cooper River Lake, and Sunset Lake in New Jersey. Silver Lake in Dover, McGinnis Pond near Frederica, and McColley Pond near Milford drain to the Delaware Bay (Figures 6-1, 6-4, 6-6, 6-8; Table 6-1). Construction of Alaska Steeppass fish ladders at these three locations was completed in 1996. Sunset Lake in Bridgeton, New Jersey (Figures 6-1, 6-13; Table 6-1); drains to the Delaware Bay. Construction of Alaska Steeppass fish ladder at Sunset Lake was completed in 1997. Cooper River Lake in Camden, New Jersey, drains into the Delaware River (Figures 6-1, 6-10; Table 6-1). Construction of an Alaska Steeppass fish ladder at this site was completed in 1998.

Even though these five initial sites satisfied the 1995 permit requirements, PSEG, using PSEG funds escrowed to DNREC as a result of a settlement agreement, subsequently installed fish ladders at three additional sites in Delaware. These sites are Coursey Pond, Garrisons Lake, and Moores Lake. Coursey Pond is near Frederica, Delaware and drains into Delaware Bay (Figures 6-1, 6-7; Table 6-1). Construction of the Alaska Steeppass fish ladder at Coursey Pond was completed in 1997. In early 1999, two Alaska Steeppass fish ladders were installed at Garrisons and Moores lakes near Dover and Cheswold, Delaware, respectively (Figures 6-1, 6-3, 6-5; Table 6-1); both of these impoundments drain to the Delaware Bay. In 2004 additional fish ladders were added in Noxontown Pond near Odessa and Silver Lake in Milford, Delaware and Newton and Stewart lakes south of Camden, NJ (Figure 6-1, 6-2, 6-9, 6-11, and 6-12 and Table 6-1).

Components of PSEG's Improved Biological Monitoring Work Plan (IBMWP) require monitoring for adult and juvenile river herring use at certain of these sites. Study objectives are to: 1) quantify the adult river herring use of the fish ladders and 2) to document year-class development by sampling for juveniles in the impoundments. To avoid impacting the reproductive success of migrating herring, monitoring of adult passage has been discontinued at sites where the target of 5 adult herring per impoundment acre was achieved by passage alone.

A supplemental stocking program was initiated in the spring 1998 to provide a target number of at least five spawning run adult fish per impoundment surface area. This stocking element is dependent on the availability of adult river herring and is conducted to augment the remnant herring runs at selected sites by promoting optimal adult spawning activity within these targeted impoundments, which should accelerate the rate of increase in spawning run size in subsequent years. The stocking program should yield additional juvenile production, which after a four-year maturation period at sea,

would result in a greater number of adult herring returning to that fish ladder site in subsequent years. No stocking occurred during 2005 or 2006 due to the limited availability of adult herring for trap and transfer.

In 2006 no sampling of adult passage was conducted at Moores Lake, McGinnis Pond, Coursey Pond, and McColley Pond. These four fish ladders have consistently passed adult herring. Allowing the spawning run fish to freely enter the pond without holding in the fish traps or being pilfered from the traps would allow more spawning activity in the ponds.

Monthly electroshocking was not performed during September through November 2006 as production has been documented in all twelve impoundments.

6.2 MATERIALS AND METHODS

SPILLPOOL MONITORING

Spillpool temperatures were monitored three days per week starting February 10, 2006 in advance of opening the fish ladders. This monitoring was conducted to ensure that when the temperature reached 7.0 °C that the fish ladders were opened and that at 8.0 °C the monitoring of the fish ladder passage commenced.

ADULT PASSAGE SAMPLING

Spawning of river herring in the tributaries to Delaware Bay and the lower River is reported to occur at water temperature ranges of 12.0-22.5°C for alewife and 15.0-24.0°C for blueback herring, (Smith, 1971; Wang and Kernehan, 1979). Jones (1999) reported alewives arriving at Wagamons at 9-11°C and blueback herring arriving at 13-20°C. Adult passage sampling is scheduled to begin when water temperature in the spill pool reaches 8°C. In 2006, traps were set at Noxontown and Silver Lake (Dover) fish ladder sites on March 29. Traps were set at Garrisons Lake and Silver Lake (Milford) on March 31. Sunset Lake, Newton Pond, and Stewart Lake sampling commenced on April 4 and Cooper River Lake sampling commenced on April 11, when water temperatures reached and remained at or above 8ºC. Table 6-2 describes the fish ladder operation and maintenance activities for the twelve sites.

Although the study design required sampling at each site for a minimum of five days per week with a minimum of four hours of sampling per pond per day, sampling since 2002 has been continuous (24 hour) at most sites. This was achieved by leaving the exit trap in place and visiting each site one or more times each day to enumerate catch and release the herring into the impoundment. The six Delaware traps were modified in 2001 to minimize holding mortality by limiting confining areas within each trap and incorporating K-less® knotless netting (Figures 6-14 through 6-17). The additional two traps added in Delaware are similarly constructed. The fish ladder at Cooper River Lake continues to be inaccessible for downstream monitoring purposes at high tide. A modified commercial trap net was employed at the upper end of the fish ladder extending into the lake (Figure 6-18).

Adult herring use of the fish ladders was monitored with a fish trap placed at the exit (upper end) of the fish ladder (Figures 6-14 through 6-17). The fish trap was secured to the trash bars at the exit of the fish ladder and positioned so that it extended into the pond. At Coursey Pond and McColley Pond, a reducer was placed at the outlet of the fish ladder to standardize the exit opening and the fish trap was attached to the reducer. At Silver Lake, a fish diversion curtain constructed of weighted, clear vinyl strips, was suspended across the lower end of the spill pool at the start of the spawning run to guide adult herring to the entrance of the fish ladder (Figure 6-19). At Moores Lake a temporary aluminum fish diversion flume was employed to direct fish to the entrance of the fish ladder (Figure 6-20).

The adult passage sampling sequence commenced when the fish trap was secured to the face of the fish ladder. Upon subsequent arrival at the site, the fish trap was checked for fish. Any catch was identified to species, enumerated, and the herring released into the pond; other species taken (e.g., gizzard shad, white perch) were released back to the spill pool. Next, the spill pool and tail water areas below the dam were observed for the presence of adult herring and any indication of spawning activity; polarized glasses were used to facilitate these observations. Cast netting and/or dip netting was occasionally employed to confirm observations and species identification; this activity was limited to minimize disturbance to the adult herring.

Additionally, impoundment and spill pool water quality parameters were measured at a minimum of once per day. Water temperature, conductivity, and dissolved oxygen were measured using a Yellow Springs Instruments (YSI) Model 85; an Oaklon® Model pHTestr 2 was used to measure pH; both instruments were calibrated daily to ensure accuracy. Water clarity was measured with a standard 20 cm (8-in) secchi disk. Meteorological conditions (e.g., sky conditions, weather) were also noted.

Hourly temperature monitoring was initiated at all sites using "TidbiT" temperature loggers. Loggers were used in each of the spillpools and placed to minimize disturbance by the public.

Sampling at all sites was discontinued on June 9th, at which time water temperatures exceeded 26ºC (Figures 6-21 and 6-22) and no herring had been observed for a period of one week.

STOCKING

A goal of establishing at least five adult river herring per surface acre of impoundment, through the adult passage or by the stocking program, was based on recommendations from researchers in New England and Canada. Target stocking numbers were as follows:

Impoundment	Acreage	@5/acre	Target number of herring
Noxontown Pond	158.6	793	793
Garrisons Lake	86.0	430	430
Silver Lake (Dover)	157.8	789	1,000
Moores Lake	27.0	135	135
McGinnis Pond	31.3	157	157
Coursey Pond	58.1	291	291
McColley Pond	49.0	245	245
Silver Lake (Milford)	28.5	143	143
Cooper River Lake	179.4	897	1,000
Newton Lake	41.0	205	205
Stewart Lake	45.0	225	225
Sunset Lake	77.6	388	1,000

The supplemental stocking is dependent on the availability of adult river herring in the spillpool of impoundments with installed fish ladders or from other nearby sources. Adult herring are not trapped in the spillpools when only low numbers are present. Adult herring are typically taken from local tributaries and spillpools using cast nets. Fish are transferred from the point of capture to the release site in a specially outfitted transport tank. Only vigorous adults are counted as stocked; the few fish that loose equilibrium are stocked but not counted. For the eight Delaware sites, an effort is made to utilize adults from the site-specific spill pool. Adult herring for supplemental stocking in the New Jersey impoundments were originally trapped at the Union Lake dam on the Maurice River; however, the NJDEP Bureau of Fresh Water Fisheries stipulated in 2004, that fish to be stocked should be obtained from the spillpools immediately below the water control structures of the targeted impoundment. That condition removed Union Lake as a source for spawning run herring to stock.

Due to the low numbers of river herring present in the impoundment spillpools during 2006, no fish were trapped and transferred

JUVENILE SAMPLING

Juvenile monitoring is no longer performed as production has been documented in all twelve impoundments.

Historically, monthly electroshocker sampling during September through November was used to assess juvenile river herring occurrence at each of the twelve impoundments. The primary goal of this sampling was to provide evidence of successful post-larval herring development. A Smith-Root Model 2.5-GPP portable electro-fisher unit with two UAA-4 umbrella anode arrays was used for electroshocking. The electroshocker unit

was operated in pulsed DC at 120 pulses per second and typically at 6-8 amps. The standard sampling duration was 1200 sec (20 min) of electroshocker operation at each impoundment. Effort was directed to the open water of the impoundments where experience has shown the highest probability of encountering juvenile herring. Fish are counted each time the foot switch is pressed. The count of small numbers of fish is exact. Estimates of larger numbers of fish are made in 10, 25, 50, 100, 150, and 200 fish increments. When herring were encountered in considerable numbers, electroshocking was briefly interrupted to limit the stress on the fish.

With each collection, a subsample of specimens of each herring species was measured for fork length, to the nearest millimeter. Several specimens of each species from each impoundment were retained for QA/QC of the speciation.

6.3 RESULTS

SPILLPOOL MONITORING

Spillpools were observed and spillpool temperatures were monitored manually. Spillpool temperatures were also collected using a “TidbiT” temperature logger at some spillpools. Representative water temperature data for Delaware and New Jersey pond spillpools is presented in Figures 6-21 and 6-22.

ADULT PASSAGE MONITORING AND STOCKING

Adult passage monitoring during 2006 spanned the period March 29th to June 9th, during which time a total of 12,235.25 hours of fish ladder trap net sampling was conducted. The following table lists the sampling hours specific to each site:

Fish Ladder Site	Hours Sampled
Noxontown Pond	1,727.58
Garrisons Lake	1,680.83
Silver Lake (Dover)	1,723.92
Moores Lake	N/A
McGinnis Pond	N/A
Coursey Pond	N/A
McColley Pond	N/A
Silver Lake (Milford)	1,682.17
Cooper River Lake	770.50
Newton Lake	1,481.92
Stewart Lake	1,577.58
Sunset Lake	1,586.75
Total	12,235.25

The daily catches of adult herring at each of the twelve fish ladder sites during 2006 are listed in Table 6-3. The range and peak periods of occurrence of each herring species, along with corresponding spill pool water temperatures at each site are described in

Table 6-4. The number of pre-spawn herring passed into each of the impoundments is presented in Table 6-5. The following briefly summarizes the trap net catch and stocking effort at each site:

- Trap net sampling at Noxontown Pond yielded 1 dead alewife and no blueback herring. The alewife was taken on April 18, 2006. Trap tampering was very common. No alewife or blueback herring were stocked into Noxontown Pond from the spillpool.

- Trap net sampling at Garrisons Lake yielded 1 dead alewife and 21 live blueback herring. The alewife was taken from April 20, 2006. The blueback herring were taken from April 14 through May 8. Trap tampering was very common with numerous people dipping fish out of the trap. No alewife or blueback herring were stocked into Garrisons Lake from the spillpool.

- Trap net sampling at Silver Lake (Dover) yielded 3 alewife and 112 blueback herring. The alewives were taken from March 29 through March 31, 2006. The blueback herring were taken April 3 through May 26. Trap tampering was also common with several people trying to fowl hook fish from the trap. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at Silver Lake (Milford) yielded no alewife and three live and one dead blueback herring the blueback herring were taken from April 29 through May 7, 2006. Trap tampering and vandalism was common with the trap being destroyed four times over the sampling season. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at Cooper River Lake yielded one alewife and two blueback herring. The alewife was taken on April 15, 2006. The blueback herring were taken on May 12, 2006. No herring were obtained from the spillpool for stocking into the lake.

- Trap net sampling at Newton Lake yielded no alewife or blueback herring in 2006. Occasional tampering with the trap was observed. Debris in the net was common. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at Stewart Lake yielded five live and two dead alewife and no blueback herring. The alewife were taken from April 4, 2006 to April 19, 2006. Debris in the trash bars was a common occurrence. No alewife or blueback herring were stocked from the spillpool.

- Sampling at Sunset Lake yielded seven alewife and 55 live blueback herring. The alewife were taken April 11, 2006 through May 3, 2006. The blueback herring were taken from April 12 through May 13, 2006. Trap tampering was common by individuals collecting herring for bait or other fish for food. Seining in the second spillpool yielded no herring for stocking into Sunset Lake.

No trap net sampling was conducted in 2006 at the Moores Lake, McGinnis Pond, Coursey Pond and McColley Pond fish ladders. Physical chemistries were collected

and the ladder was checked and cleaned on the days when sampling occurred at other fish ladders.

JUVENILE SAMPLING

No juvenile sampling was conducted in 2006.

6.4 DISCUSSION

ADULT USE OF THE FISH LADDERS

In 2006, adult river herring migrated into freshwater to spawn in the creeks, spillpools, and ponds beginning in early March continuing through early June. As expected, the adult herring movement appeared to be associated with rising creek water temperature and sunny days. As evidenced in Table 6-4 the occurrence of adult herring at the fish ladder sites generally coincides with reported spawning temperatures of between 12.0-22.5°C for alewife (Wang and Kernehan, 1979)) and 15.0-24.0°C for blueback herring (Smith, 1971. However, in sampling since 1996 pre-spawning blueback herring were observed at temperatures as high as 26.7°C. Most herring movement was observed during the middle part of the day, on sunny days, with warming temperatures, which is consistent with observations by Leim and Scott (1966). Very little herring movement was observed on overcast days or at night. A summary of monitoring results at each of the fish ladder sites over the period of study (1996-2006) is presented in Table 6-6. A summary of all of the species utilizing the fish ladders is presented in Tables 6-7 and 6-8.

Short duration sampling was conducted in 2001, 2002, 2003, and 2004 to determine the temporal distribution of herring passage through the fish ladders. Results from sampling, on days when few or no herring moved through the ladder, were removed. A lack of 2002, 2003, and 2004 data is due to very few herring utilizing the ladder during the days when short duration sampling was conducted. The resulting distribution shown in Table 6-9 is similar to the results found by Jones (1999) at Wagamons Pond. Herring generally began to move up the fish ladder about 0900 hours and continued to use the ladder through approximately 2100 hours.

Noxontown Pond

The Noxontown Pond fish ladder, installed early in 2004 appears to be functioning properly. The pond has a heavy algae and organic debris load which fouls the net. One dead alewife was taken in the trap in 1728 hours of sampling in 2006. The bridge where the water control structure and ladder are located is a favorite fishing spot and the ladder and trap are very easily accessible and are often subject to pilfering and occasional vandalism.

Garrisons Lake

The Garrisons Lake fish ladder, installed early in 1999 appears to be functioning properly. The trap at Garrisons Lake also suffers from a high debris loading of vegetation and trash which requires daily cleaning to ensure that the flow through the ladder is sufficient to pass herring. The State of Delaware was conducting dredging operations near the spillway for much of the sampling period. The 21 Blueback herring which passed during 1681 hours of sampling in 2006 were 4.9% of the target goal of 430.

Silver Lake (Dover)

Entrance modifications initiated in 1996 appear to have directed the flow from the ladder into the stream channel. The fish diversion curtain also appears to be effective, as the number of herring passed through the ladder has increased since its use began in 1998 (Table 6-6). The 115 adult herring counted passing the fish ladder yields 11.5% of the target goal of 1,000. In the 2001, 2002, and 2003, sampling seasons, stocked fish were released in mid-pond, west of the causeway, in an effort to provide immediate access to spawning habitat (Figure 6-4). In 2006 no herring were stocked into Silver Lake in Dover.

Moores Lake

The fish ladder at Moores Lake, also installed in 1999, appears to be functioning properly. A wooden weir at the exit of the spill pool apron renders the fish ladder inaccessible at the lower portions of the tide. Substantial spawning was observed in 1999 and 2000 throughout the spill pool area. In 2001 a temporary concrete diversion flume was installed by PSEG on the dam apron to guide the spawning run fish from the gap in the wooden weir to the entrance of the fish ladder. In 2002 the concrete diversion flume was replaced by a temporary aluminum flume. The flumes appear to have been successful passing 690, 682, 652, 697 herring in 2001, 2002, 2003, and 2004 as compared to 95 and 78 in 1999 and 2000 (Table 6-6). No Adult Sampling was conducted at Moores Lake in 2006. The dam where the water control structure and ladder are located is a favorite fishing spot and the ladder is easily accessible and is subject to occasional vandalism.

McGinnis Pond

Velocities within the structure and the entrance configuration allowed some fish to pass in 1996 and 1997. In early 1998, modifications were made to the fish ladder to lower velocities. While no herring passed earlier in that season, after the modifications to the ladder, 25 adult blueback herring were observed exiting the fish ladder. Permanent modifications to this fish ladder were completed in early 1999. No adult sampling was conducted in 2006. The situation of herring not being able to reach the McGinnis spillpool has been addressed by annual stream cleaning which was conducted again in 2006 to remove woody debris that routinely blocks and diverts the stream. In 2006, spawning run herring were seldom observed in the spillpool and the stream below McGinnis Pond which is similar to 2003 and 2004, a marked contrast to many of the previous years.

Coursey Pond

River herring approaching the Coursey Pond fish ladder appeared to follow the bridge abutment to the entrance of the fish ladder. If they did not encounter the fish ladder or chose not to use it they moved in a counter clockwise direction around the spillpool. Herring appeared to have the opportunity to pass the fish ladder entrance each time they circled. Some herring were observed spawning among the rocks (rip rap) in the spillpool. In 2006 no adult sampling was conducted, however, during the collection of water quality data and cleaning of the fish ladder large numbers of blueback herring were observed in the spillpool.

McColley Pond

Appropriate velocities continue within the structure and the entrance was accessible to fish throughout the tidal cycle. River herring approaching the McColley Pond fish ladder appeared to follow the bridge abutment to the entrance of the fish ladder. If they did not encounter the fish ladder or chose not to use it they moved in a counter clockwise direction around the spillpool. Herring appeared to have the opportunity to pass the fish ladder entrance each time they circled. In 2006 no adult sampling was conducted, however, during the collection of water quality data and cleaning of the fish ladder large numbers of blueback herring were observed in the spillpool.

Silver Lake (Milford)

The Silver Lake (Milford) fish ladders, installed early in 2004 appear to be functioning properly. The lower ladder in a small concrete dam is generally inaccessible by the public during the herring season. Debris obstructing this ladder was common and required routine removal. The upper ladder and trap are easily accessible and are subject to continual vandalism with the trap destroyed on several occasions. Pilfering from the trap is common. Three live and one dead blueback herring were collected in 1682 hours of sampling.

Cooper River Lake

The fish ladder was installed in 1998. In 770 hours of trap sampling one adult alewife and two adult blueback herring were taken at the Cooper River Lake fish ladder in 2006. At higher tidal elevations, spawning run herring are able and known to pass through the water control structure tide gates. High precipitation and flows may have limited the use of the ladder. The trap was damaged on several occasions when the water control structure was lifted to lower the lake levels prior to storm events. Stocking of fish into Cooper River Lake was limited by NJDEP's request that fish stocked into a pond come only from the stream and spillpool below the impoundment and that fish should not be moved in from another stream.

Newton Lake

The Newton Lake fish ladder, installed late spring in 2004, appears to be functioning properly. The fish ladder is located in a generally inaccessible area beneath the roadway. High tides and flows limited access to allow for net planning and deployment.

Sampling in 2006 utilized a net similar to the Cooper River net to allow accessibility at high tide and to limit the accessibility to the public. No herring were taken in 1482 hours of sampling. Newton Lake appears to have a heavy debris load which routinely obstructed the net. Sampling in 2007 will utilize a modified net to limit the area where debris can accumulate and block the net. A small amount of tampering with the net was observed.

Stewart Lake

The Stewart Lake fish ladder, installed late spring in 2004, appears to be functioning properly. The ladder and trap are easily accessible to the public. Large heavy debris in the form of tree limbs, firewood and heavy wooden dunnage left in the pond and under the bridge routinely plugged the entrance to the fish ladder. In 2006 during 1578 hours of sampling five live and two dead alewives were taken.

Sunset Lake

Engineering changes were initiated in 1998 to reduce fish ladder velocities and, subsequent to the changes, one alewife and one blueback herring were taken at the exit of the Sunset Lake fish ladder. The occurrence of other fish in the ladder indicated that the ladder was operating with appropriate water velocities. Permanent engineering changes were completed for the 1999 spawning season. The lower end of the fish ladder is now 18 to 24 inches above the bottom due to erosion of the sediment due to flows from the fish ladder and the bypass flow. The 63 adult herring that were counted passing through the fish ladder during 1587 hours of sampling during 2006 yields 6.3% of the target goal of 1,000. High precipitation and flows may have limited the use of the ladder and certainly limited the availability of spawning run adult fish to stock. Some pilferage from the trap was observed and reported. The trap was commonly found tipped up in a condition where herring could bypass the trap and enter the pond uncounted.

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Table 6-1. Characterization of the twelve fish ladders sites.

	Noxontown Pond	Garrisons Lake	Silver Lake (Dover)
Size (acres)	158.6	85.9	157.8
Length (miles)	1.99	0.76	1.71
Perimeter (miles)	7.03	2.19	4.52
Maximum Depth (feet)	8.0	4.0	9.0
Mean Depth (feet)	4.0	1.3	4.0
Receiving Waters	Appoquinimink River, drains to the Delaware Bay	Leipsic River, drains into the Delaware Bay	Saint Jones River, drains into Delaware Bay
Distance from Delaware Bay (miles)	9.65	12.57	13.33
Impoundment Watershed Size (acres)	6,110	10,752	20,480
Tributaries of the Impoundment	The main stem of the impounded creek flows from Wiggins Pond	Willis Branch, Leipsic River from Massey's Mill Pond, and two small unnamed branches	Forked Branch McKee Run and an unnamed branch
Combined Tributary Length (miles)	7.93	8.03	29.25
Shoreline	Natural, bulkhead, wooded, and turf	Natural, wooded	Natural, bulkhead, small beach
Bottom Types	Sand and mud	Mud	Sand and mud
Surrounding Land Use	Residential, forested and farm lands	Residential, forested and farm lands	Urban and agricultural
Predominant Vegetation	Spatterdock	Spatterdock	Swamp Loosestrife, Water Willow, and Spatterdock
Water Quality	Eutrophic, tannins	Eutrophic, tannins	Eutrophic, tannins
Notes		DNREC dredging occurred in 2006	

Table 6-1. Continued.

	Moores Lake	**McGinnis Pond**	**Coursey Pond**
Size (acres)	27.1	31.3	58.1
Length (miles)	0.76	0.76	0.72
Perimeter (miles)	1.87	2.16	2.48
Maximum Depth (feet)	5.0	9.0	4.0
Mean Depth (feet)	2.6	4.4	2.0
Receiving waters	Isaac Branch drains into Saint Jones River, drains into Delaware Bay	Hudson Branch, drains into Spring Creek, drains into the Murderkill River, drains into the Delaware Bay	Murderkill River, drains into the Delaware Bay
Distance from Delaware Bay (miles)	11.30	11.66	12.06
Impoundment Watershed Size (acres)	11,776	7,040	14,579
Tributaries of the Impoundment	Drainage from Wyoming Lake	Hudson Branch and two unnamed branches	Murderkill River from Killen Pond and Spring Branch
Combined Tributary Length (miles)	1.52	2.75	11.81
Shoreline	Natural, bulkhead, small beach	Natural, heavily wooded	Natural, heavily wooded
Bottom Types	Sand and mud	Sand and Mud	Sand and Mud
Surrounding Land Use	Urban and agricultural	Rural, forested and farm lands	Rural, forested and farm lands
Predominant Vegetation	Spatterdock	Swamp Loosestrife and Spatterdock Elodea, and Lyngbya (algae)	Swamp Loosestrife, Spatterdock,
Water Quality	Eutrophic, tannins	Eutrophic, tannins	Eutrophic, tannins
Notes			

Table 6-1. Continued.

	McColley Pond	Silver Lake (Milford)	Cooper River Lake
Size (acres)	49.0	28.5	179.35
Length (miles)	1.14	0.49	4.53
Perimeter (miles)	3.34	1.56	9.57
Maximum Depth (feet)	6.0	10.0	10.0
Mean Depth (feet)	2.9	4.2	3.5
Receiving Waters	Brown's Branch, drains into the Murderkill River, drains into the Delaware Bay	Mispillion River, drains into the Delaware Bay	Cooper River, drains into the Delaware River
Distance from Delaware Bay (miles)	11.68	12.80	2.95
Impoundment Watershed Size (acres)	6,080	17,326	23,680
Tributaries of the Impoundment	Browns Branch and an unnamed branch	Mispillion River from Haven Lake	No tributaries within the lake, Wallworth Lake and Evans Pond drain into Cooper River Lake
Combined Tributary Length (miles)	21.15	34.56	8.94
Shoreline	Natural, heavily wooded	Natural, bulkhead, riprap, turf, and wooded	Urban and parkland
Bottom Types	Sand and Mud	Sand and Mud	Mud, sand, and rubble
Surrounding Land Use	Rural, forested and farm lands	Urban and residential	Urban and parkland
Predominant Vegetation	Swamp Loosestrife and Spatterdock	Spatterdock	Spatterdock
Water Quality	Eutrophic, tannins	Eutrophic, tannins	Eutrophic
Notes			

Table 6-1. Continued.

	Newton Lake	**Stewart Lake**	**Sunset Lake**
Size (acres)	41.0	45.0	77.60
Length (miles)	2.87 (two branches)	1.17 (two branches)	0.67
Perimeter (miles)	6.03	4.39	2.10
Maximum Depth (feet)	5.0	6.5	9.0
Mean Depth (feet)	1.8	4.8	3.5
Receiving waters	Newton Creek drains into the Delaware River	Woodbury Creek drains into the Delaware River	Cohansey River, drains into the Delaware Bay
Distance from Delaware Bay (miles)	2.31	3.4	20.38
Impoundment Watershed Size (acres)	2,332	2,897	29,248
Tributaries of the Impoundment	Newton Creek and Peter Creek	Hester's Branch and Woodbury Creek	A spring fed tributary from Mary Elmer Lake and the Cohansey River
Combined Tributary Length (miles)	1.91	4.23	34.15
Shoreline	Urban and parkland	Urban and parkland	Natural, wooded, some bulkhead and hard shore, small beaches
Bottom Types	Mud	Mud and sand	Sand and mud stumps in upper reaches
Surrounding Land Use	Urban, parkland, and residential	Urban, parkland, and residential	Parkland and residential
Predominant Vegetation	Spatterdock	Spatterdock	Spatterdock
Water Quality	Eutrophic	Eutrophic	Eutrophic, tannins
Notes	Two sewage plant spills into Newton Lake were said to have occurred in the summer of 2006 with locals reporting large fish kills.		

Table 6-2. Operations and Maintenance Log for the twelve fish ladder sites during 2006.

Date		Action
1/5/2006		Delaware Juvenile bypass's closed
1/14/2006		New Jersey Ladders inspected for ice damage
2/14/2006		Spillpool temperature sampling and ladder inspection begins
2/16/2006		Delaware Ladders inspected
2/18/2006		New Jersey ladders inspected.
3/4/2006		Delaware fish ladders inspected and opened
3/9/2006		New Jersey fish ladders inspected and opened
3/17/2006		Attempted to set Delaware traps, prevented by high flows.
3/21/2006		Set traps and monitoring at five of the Delaware sites. Clean fish ladders at Moores, Courseys, and McColleys ponds.
3/28/2006		Flooding rains delay installation of New Jersey Traps
3/29/2006		Clean fishladders and set traps at Newton Pond and Stewart Lake.
3/30/2006		Clean fish ladder and set Sunset Lake trap
4/7/2006		Trap Set at Cooper River
4/8/2006		Silver Lake curtain deployed
4/21/2006		Delaware Fish Ladders checked
5/3/2006		New Jersey Fish Ladders checked
5/12/2006		Delaware Fish Ladders checked
5/22/2006		Delaware Fish Ladders checked
6/3/2006		New Jersey Fish Ladders checked, debris removed from Newton Lake and Cooper River ladders
6/8/2006		Cooper River Trap removed and Ladder closed
6/9/2006		Delaware Traps Removed
6/9/2006		Newton, Stewart, and Sunset traps removed.
6/17/2006		New Jersey Fish Ladders checked
6/27/2006		Newton, Stewart, and Sunset ladders closed and bypasses opened.
6/28/2006		Delaware Fish Ladders checked and Ladders closed
7/5/2006		Silver Lake Curtain removed, Delaware Ladders checked
7/17/2006		Delaware Fish Ladders checked
8/2/2006		New Jersey Fish Ladders checked
8/17/2006		Delaware Fish Ladders checked
9/5/2006		New Jersey Fish Ladders checked
9/23/2006		Delaware Fish Ladders checked
10/8/2006		New Jersey Fish Ladders checked
10/29/2006		Delaware Fish Ladders checked
11/12/2006		New Jersey Fish Ladders checked
11/24/2006		Delaware Fish Ladders checked
12/1/2006		Delaware juvenile bypasses opened, bypasses are inspected and cleaned every 2-3 days until bypasses are closed.
12/29/2006		Delaware juvenile bypasses closed
Note		The Delaware and New Jersey fish ladders and bypass facilities (closed for the season) are checked occasionally over the winter.
Note		Cooper River Lake fish ladder will be inspected weekly throughout the year as part of the Camden County Parks inspection of the water control structure.

Table 6-3. Number of adult herring collected in fish ladder trap sampling at the twelve fish ladder sites in 2006 with number alive and (number dead).

	Noxontown Pond		Garrisons Lake		Silver Lake (Dover)		Moores Lake		McGinnis Pond		Coursey Pond		McColley Pond		Silver Lake (Milford)	
Date	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**
3/29/2006																
3/30/2006																
3/31/2006					1											
4/1/2006																
4/2/2006					2											
4/3/2006																
4/4/2006																
4/5/2006						1										
4/6/2006																
4/7/2006																
4/8/2006																
4/9/2006																
4/10/2006																
4/11/2006																
4/12/2006																
4/13/2006																
4/14/2006																
4/15/2006				2												
4/16/2006																
4/17/2006																
4/18/2006	(1)															
4/19/2006																
4/20/2006			(1)													
4/21/2006																
4/22/2006																
4/23/2006																
4/24/2006																
4/25/2006																
4/26/2006																
4/27/2006																
4/28/2006																
4/29/2006																
4/30/2006																
5/1/2006						1										1
5/2/2006																(1)
5/3/2006																

Table 6-3. Continued.

	Noxontown Pond		Garrisons Lake		Silver Lake (Dover)		Moores Lake		McGinnis Pond		Coursey Pond		McColley Pond		Silver Lake (Milford)	
Date	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**
5/4/2006				5		26										
5/5/2006						49										
5/6/2006																
5/7/2006						12										
5/8/2006						5										2
5/9/2006				14												
5/10/2006						1										
5/11/2006																
5/12/2006						11										
5/13/2006																
5/14/2006						(2)										
5/15/2006																
5/16/2006																
5/17/2006																
5/18/2006																
5/19/2006						1										
5/20/2006																
5/21/2006																
5/22/2006																
5/23/2006						1										
5/24/2006																
5/25/2006																
5/26/2006						2										
5/27/2006																
5/28/2006						2										
5/29/2006																
5/30/2006																
5/31/2006																
6/1/2006																
6/2/2006																
6/3/2006																
6/4/2006																
6/5/2006																

Table 6-3. Continued.

	Noxontown Pond		Garrisons Lake		Silver Lake (Dover)		Moores Lake		McGinnis Pond		Coursey Pond		McColley Pond		Silver Lake (Milford)	
Date	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**	**Alewife**	**Blueback Herring**
6/6/2006																
6/7/2006																
Alive	0	0	0	21	3	112									0	3
Removed	0	0	0	0	0	0									0	0
Dead	1	0	1	0	0	2									0	1
Total	1	0	1	21	3	114									0	4

number dead = ( )
number removed for stocking = [ ]

Table 6-3. Continued.

	Cooper River Lake		Newton Lake		Stewart Lake		Sunset Lake	
Date	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring
4/4/2006								
4/5/2006								
4/6/2006					2			
4/7/2006								
4/8/2006								
4/9/2006								
4/10/2006								
4/11/2006					(2)		1	
4/12/2006								
4/13/2006							1	1
4/14/2006								
4/15/2006								1
4/16/2006	1							
4/17/2006								
4/18/2006					1			
4/19/2006					1		2	
4/20/2006								
4/21/2006					1			
4/22/2006								
4/23/2006								
4/24/2006								1
4/25/2006								1
4/26/2006								
4/27/2006								
4/28/2006								1
4/29/2006								
4/30/2006								2
5/1/2006								
5/2/2006								
5/3/2006							3	
5/4/2006								
5/5/2006								
5/6/2006								
5/7/2006								1
5/8/2006								
5/9/2006								
5/10/2006								4

Table 6-3. Continued.

	Cooper River Lake		Newton Lake		Stewart Lake		Sunset Lake	
Date	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring
5/11/2006								
5/12/2006								2
5/13/2006		2						
5/14/2006								
5/15/2006								42
5/16/2006								
5/17/2006								
5/18/2006								
5/19/2006								
5/20/2006								
5/21/2006								
5/22/2006								
5/23/2006								
5/24/2006								
5/25/2006								
5/26/2006								
5/27/2006								
5/28/2006								
5/29/2006								
5/30/2006								
5/31/2006								
6/1/2006								
6/2/2006								
6/3/2006								
6/4/2006								
6/5/2006								
6/6/2006								
6/7/2006								
6/8/2006								
Alive	1	2	0	0	5	0	7	56
Removed	0	0	0	0	0	0	0	0
Dead	0	0	0	0	2	0	0	0
Total	1	2	0	0	7	0	7	56

number dead = ( )
number removed for stocking = [ ]

Table 6-4. Range and peak periods of occurrence for alewife and blueback herring as observed in trap net sampling, with corresponding spill pool water temperatures (°C), at the eight fish ladder sites monitored in 2006.

Species	Noxontown Pond	Garrisons Lake	Silver Lake (Dover)	Silver Lake (Milford)	Cooper River Lake	Newton Lake	Stewart Lake	Sunset Lake
Alewife								
Period of occurrence	4/18	4/20	3/31-4/2		4/16		4/6-4/21	4/11-5/4
Temperature range (°C)	19.1	19.6	13.9-14.2		16.0		18.3-19.3	15.1-20.4
Peak occurrence	4/18	4/20						
Temperature (°C)	19.1	19.6						
Blueback Herring								
Period of occurrence		4/15-5/9	4/5-5/28	5/1-5/8	5/13			4-13-5/15
Temperature range (°C)		17.6-21.5	13.1-23.8	16.7-19.2	20.5			16.9-22.1
Peak occurrence		5/4-5/9	5/4-5/8					5/15
Temperature (°C)		17.6-21.5	19.1-22.8					18.6

Table 6-5. Number of spawning run adult herring counted passing in the eight impoundments monitored in 2006.

	Noxontown Pond		Garrisons Lake		Silver Lake (Dover)		Silver Lake (Milford)		Cooper River Lake		Newton Lake		Stewart Lake		Sunset Lake	
Date	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback
March 26-April 1					3											
April 2-8						1							2			
April 9-15				2											2	2
April 16-22									1				3		2	
April 23-29																3
April 30-May 6				5		76		1							3	2
May 7-13				14		29		2		2						7
May 14-20						1										42
May 21-27						3										
May 28-June 3						2										
June 4-10																
Total Spawners	0	0	0	21	3	112	0	3	1	2	0	0	5	0	7	56
Total Herring	0		21		115		3		3		0		5		63	
Target Number	793		430		1,000		143		1,000		205		225		1,000	
Percent	0		4.9		11.5		2.1		0.3		0		2.2		6.3	

Table 6-6. Summary of annual herring monitoring results at the twelve fish ladder sites during 1996-2006.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.		No.	Min.	No.	Units	No.	Days	No.
Noxontown Pond												
2004	1,415				No Sampling		60		No Sampling		No Sampling	
Alewife		0						0				
Blueback		0		23				0				
Alosa spp.		0						0				
2005	1,948				No Sampling		60		No Sampling		No Sampling	
Alewife		5						0				
Blueback		0						7				
Alosa spp.		0						0				
2006	1,728				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife		1										
Blueback		0										
Alosa spp.		0										

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.		No.	Min.	No.	Units	No.	Days	No.
Garrisons Lake												
1999	1,320				20		94.5		No Sampling		No Sampling	
Alewife		5				0		0				
Blueback		34		318		0		0				
Alosa spp.		0				5		67				
2000	1,312				20		60.4		No Sampling		No Sampling	
Alewife		12				0		0				
Blueback		58		48		0		0				
Alosa spp.		0				0		0				
2001	2,254				No Sampling		60.3		No Sampling		No Sampling	
Alewife		0						0				
Blueback		4		473				0				
Alosa spp.		0						0				
2002	2,183				No Sampling		60.0		No Sampling		No Sampling	
Alewife		0						0				
Blueback		3		432				0				
Alosa spp.		0						0				
2003	2,154				No Sampling		61.1		No Sampling		No Sampling	
Alewife		13						0				
Blueback		18						0				
Alosa spp.		0						0				
2004	2,037				No Sampling		60		No Sampling		No Sampling	
Alewife		8						0				
Blueback		15		37				0				
Alosa spp.		0						0				
2005	1,940				No Sampling		60		No Sampling		No Sampling	
Alewife		1						0				
Blueback		0						0				
Alosa spp.		0						0				
2006	1,681				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife		1										
Blueback		21										
Alosa spp.		0										

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
Silver Lake (Dover)												
1996	78				20		268.0		5		No Sampling	
Alewife		0				0		0		0		
Blueback		4		84		0		0		0		
Alosa spp.		0				6		0		0		
1997	112				20		137.3		4		No Sampling	
Alewife		0				0		0		0		
Blueback		7				0		0		0		
Alosa spp.		0				0		0		0		
1998	1,082				20		147.4		3		No Sampling	
Alewife		2				0		0		0		
Blueback		111		713		0		5		0		
Alosa spp.		0				1		0		0		
1999	1,368				20		66.5		No Sampling		No Sampling	
Alewife		11				0		0				
Blueback		152		687		0		0				
Alosa spp.		0				3		0				
2000	2,079				20		64.7		No Sampling		No Sampling	
Alewife		2				0		0				
Blueback		63		419		0		0				
Alosa spp.		0				0		0				
2001	2,234				No Sampling		60.0		No Sampling		No Sampling	
Alewife		14						0				
Blueback		137		993				25				
Alosa spp.		0						0				
2002	2,151				No Sampling		63.1		No Sampling		No Sampling	
Alewife		18						0				
Blueback		121		865				3				
Alosa spp.		0						0				

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
Silver Lake (Dover)												
2003	2,139						62.6					
Alewife		13			No Sampling			0	No Sampling		No Sampling	
Blueback		18		201				2				
Alosa spp.		0						0				
2004	2,038						60					
Alewife		55			No Sampling			0	No Sampling		No Sampling	
Blueback		128		79				0				
Alosa spp.		0						0				
2005	1,940						60					
Alewife		0			No Sampling			0	No Sampling		No Sampling	
Blueback		76						4				
Alosa spp.		0						0				
2006	1,724											
Alewife		3			No Sampling		No Sampling		No Sampling		No Sampling	
Blueback		114										
Alosa spp.		0										

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
Moores Lake												
1999	1,104				20		73.4		No Sampling		No Sampling	
Alewife		9				0		2				
Blueback		86		271		0		76				
Alosa spp.		0				0		0				
2000	2,080				20		60.1		No Sampling		No Sampling	
Alewife		5				0		0				
Blueback		73		70		0		71				
Alosa spp.		0				30		0				
2001	2,229				No Sampling		81.5		No Sampling		No Sampling	
Alewife		21						1				
Blueback		669						0				
Alosa spp.		0						0				
2002	2,112				No Sampling		62.3		No Sampling		No Sampling	
Alewife		28						0				
Blueback		654						0				
Alosa spp.		0						0				
2003	2,163				No Sampling		61.9		No Sampling		No Sampling	
Alewife		72						0				
Blueback		606						0				
Alosa spp.		0						0				
2004	2,040				No Sampling		60		No Sampling		No Sampling	
Alewife		255						0				
Blueback		457						8				
Alosa spp.		0						0				
2005	No Sampling				No Sampling		60		No Sampling		No Sampling	
Alewife								0				
Blueback								0				
Alosa spp.								0				
2006	No Sampling				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife												
Blueback												
Alosa spp.												

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
McGinnis Pond												
1996	79				20		225.0		3		No Sampling	
Alewife		0				0		0		0		
Blueback		1		32		0		20		0		
Alosa spp.		0				6		0		0		
1997	110				20		87.3		3		No Sampling	
Alewife		0				0		0		0		
Blueback		2				0		114		0		
Alosa spp.		0				5		0		0		
1998	1,032				20		139.6		3		76	
Alewife		0				0		0		0		0
Blueback		25		211		0		398		0		0
Alosa spp.		0				2		0		0		44
1999	1,368				20		74.8		No Sampling		No Sampling	
Alewife		13		5		0		0				
Blueback		35		166		0		1				
Alosa spp.		0				5		8				
2000	2,083				20		64.0		No Sampling		No Sampling	
Alewife		6				0		0				
Blueback		27		200		0		718				
Alosa spp.		0				1		0				
2001	2,229				No Sampling		60.7		No Sampling		No Sampling	
Alewife		4						0				
Blueback		95		241				244				
Alosa spp.		0						0				
2002	2,162				No Sampling		65.0		No Sampling		No Sampling	
Alewife		18						0				
Blueback		756						899				
Alosa spp.		0						0				

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
McGinnis Pond												
2003	2,159				No Sampling		64.6		No Sampling		No Sampling	
Alewife		2						0				
Blueback		23		22				0				
Alosa spp.		0						0				
2004	2,042				No Sampling		60		No Sampling		No Sampling	
Alewife		101						0				
Blueback		125						2,221				
Alosa spp.		0						0				
2005	1,945				No Sampling		60		No Sampling		No Sampling	
Alewife		4						0				
Blueback		212						19				
Alosa spp.		0						0				
2006	No Sampling				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife												
Blueback												
Alosa spp.												

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
Coursey Pond												
1997	105				20		128.8		3		No Sampling	
Alewife		0				0		0		0		
Blueback		30				0		12		0		
Alosa spp.		0				1		1		0		
1998	1,097				20		124.1		3		No Sampling	
Alewife		11				0		0		0		
Blueback		477		156		0		144		0		
Alosa spp.		0				1		0		0		
1999	729				20		60.1		No Sampling		No Sampling	
Alewife		257				0		56				
Blueback		845				0		26				
Alosa spp.		0				13		7				
2000	2,084				20		63.0		No Sampling		No Sampling	
Alewife		48				0		7				
Blueback		736				0		28				
Alosa spp.		0				14		4				
2001	2,277				No Sampling		61.0		No Sampling		No Sampling	
Alewife		63						10				
Blueback		1,336						62				
Alosa spp.		0						0				
2002	2,160				No Sampling		60.0		No Sampling		No Sampling	
Alewife		309						5				
Blueback		1,222						124				
Alosa spp.		0						0				
2003	2,161				No Sampling		61.8		No Sampling		No Sampling	
Alewife		128						0				
Blueback		218						7				
Alosa spp.		0						0				

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
Coursey Pond												
2004	2,018				No Sampling		60		No Sampling		No Sampling	
Alewife		188						0				
Blueback		96						20				
Alosa spp.		0						0				
2005	No Sampling				No Sampling		60		No Sampling		No Sampling	
Alewife								0				
Blueback								81				
Alosa spp.								0				
2006	No Sampling				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife												
Blueback												
Alosa spp.												

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
McColley Pond												
1996	82				20		214.4		3		No Sampling	
Alewife		3				0		0		0		
Blueback		112		8		0		24		1		
Alosa spp.		0				8		0		0		
1997	102				20		164.2		3		No Sampling	
Alewife		1				0		1		0		
Blueback		176				0		131		0		
Alosa spp.		0				4		1		0		
1998	1,074				20		88.1		3		76	
Alewife		16				0		0		0		0
Blueback		543		7		0		1,061		0		0
Alosa spp.		0				6		0		0		48
1999	728				20		61.8		No Sampling		No Sampling	
Alewife		147				0		0				
Blueback		975		11		0		300				
Alosa spp.		0				28		189				
2000	2,112				20		62.2		No Sampling		No Sampling	
Alewife		42				0		0				
Blueback		1,208				0		715				
Alosa spp.		0				17		0				
2001	2,260				No Sampling		72.5		No Sampling		No Sampling	
Alewife		32						0				
Blueback		886						92				
Alosa spp.		0						0				
2002	2,185				No Sampling		62.4		No Sampling		No Sampling	
Alewife		119						0				
Blueback		813						688				
Alosa spp.		0						0				

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
McColley Pond												
2003	2,160				No Sampling		62.8		No Sampling		No Sampling	
Alewife		74						0				
Blueback		154						1				
Alosa spp.		0						0				
2004	2,041				No Sampling		60		No Sampling		No Sampling	
Alewife		350						0				
Blueback		329						928				
Alosa spp.		0						0				
2005	No Sampling				No Sampling		60		No Sampling		No Sampling	
Alewife								0				
Blueback								649				
Alosa spp.								0				
2006	No Sampling				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife												
Blueback												
Alosa spp.												

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
Silver Lake (Milford)												
2004	695				No Sampling		60		No Sampling		No Sampling	
Alewife		0						0				
Blueback		0						0				
Alosa spp.		0						0				
2005	1,943				No Sampling		60		No Sampling		No Sampling	
Alewife		3						0				
Blueback		59						29				
Alosa spp.		0						0				
2006	1,682				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife		0										
Blueback		4										
Alosa spp.		0										

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
Cooper River Lake												
1998	47				20		110.9		4			
Alewife		3				0		0		0	No Sampling	
Blueback		0		766		0		0		0		
Alosa spp.		0				41		15,000		0		
1999	114				20		62.0					
Alewife		0				0		19	No Sampling		No Sampling	
Blueback		1		1,069		62		12,375				
Alosa spp.		0				0		0				
2000	656				20		60.4					
Alewife		1		23		0		12	No Sampling		No Sampling	
Blueback		3		941		0		3,417				
Alosa spp.		0				70		4,419				
2001	1,058						60.6					
Alewife		2			No Sampling			105	No Sampling		No Sampling	
Blueback		0		1,071				24,222				
Alosa spp.		0						0				
2002	1,499						60.8					
Alewife		10			No Sampling			0	No Sampling		No Sampling	
Blueback		1		840				438				
Alosa spp.		0						0				
2003	2,142						61.2					
Alewife		4			No Sampling			158	No Sampling		No Sampling	
Blueback		9						6,448				
Alosa spp.		0						0				
2004	1,584						60					
Alewife		0			No Sampling			0	No Sampling		No Sampling	
Blueback		0						0				
Alosa spp.		0						0				

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
Cooper River Lake												
2005	1,489				No Sampling		60		No Sampling		No Sampling	
Alewife		3						0				
Blueback		4						2,209				
Alosa spp.		0						0				
2006	770				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife		1										
Blueback		2										
Alosa spp.		0										

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
Newton Lake												
2004	NS				No Sampling		60		No Sampling		No Sampling	
Alewife								8				
Blueback								825				
Alosa spp.								0				
2005	1,487				No Sampling		60		No Sampling		No Sampling	
Alewife		1						0				
Blueback		0						399				
Alosa spp.		0						0				
2006	1,482				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife		0										
Blueback		0										
Alosa spp.		0										

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
Stewart Lake												
2004	NS				No Sampling		60		No Sampling		No Sampling	
Alewife								0				
Blueback								7				
Alosa spp.								0				
2005	1,655				No Sampling		60		No Sampling		No Sampling	
Alewife		17						0				
Blueback		3						1,134				
Alosa spp.		0						0				
2006	1,578				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife		7										
Blueback		0										
Alosa spp.		0										

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	Adult		Adult		Larvae		Juveniles		Juveniles		Juveniles	
Effort	Hrs.	No.		No.	Units	No.	Min.	No.	Units	No.	Days	No.
Sunset Lake												
1997	269				20		82.0		3		No Sampling	
Alewife		0				0		0		0		
Blueback		0		50		0		0		0		
Alosa spp.		0				0		0		0		
1998	266				20		132.6		3		No Sampling	
Alewife		0				0		0		0		
Blueback		6		1,045		0		1,301		0		
Alosa spp.		1				3		0		0		
1999	1,382				20		60.8		No Sampling		No Sampling	
Alewife		44		3				10				
Blueback		16		892				202				
Alosa spp.						1						
2000	1,920				20		61.3		No Sampling		No Sampling	
Alewife		17		71		0		0				
Blueback		15		430		0		335				
Alosa spp.		0				6		00				
2001	2,420				No Sampling		103.9		No Sampling		No Sampling	
Alewife		16						0				
Blueback		179		1,370				0				
Alosa spp.		0						0				
2002	2,260				No Sampling		61.3		No Sampling		No Sampling	
Alewife		87		254				0				
Blueback		279		756				1683				
Alosa spp.		0						0				
2003	2,011				No Sampling		60.3		No Sampling		No Sampling	
Alewife		15						0				
Blueback		49		969				173				
Alosa spp.		0						0				
2004	1,769				No Sampling		60		No Sampling		No Sampling	
Alewife		0						0				
Blueback		1		126				189				
Alosa spp.		0						0				

Table 6-6. Continued.

Sampling Element	Fish Ladder Sampling		Herring Stocking		Bongo Net		Electro-shocking		Surface/ Push Trawl		Spill pool Sampling	
Life Stage	**Adult**		**Adult**		**Larvae**		**Juveniles**		**Juveniles**		**Juveniles**	
Effort	**Hrs.**	**No.**		**No.**	**Units**	**No.**	**Min.**	**No.**	**Units**	**No.**	**Days**	**No.**
Sunset Lake												
2005	1,706				No Sampling		60		No Sampling		No Sampling	
Alewife		1						0				
Blueback		1						256				
Alosa spp.		0						0				
2006	1,587				No Sampling		No Sampling		No Sampling		No Sampling	
Alewife		7										
Blueback		56										
Alosa spp.		0										

Table 6-7. Summary of species and numbers collected in adult passage monitoring at four Delaware fish ladder sites during 2006.

Species	**Noxontown Pond**	**Garrisons Lake***	**Silver Lake (Dover)***	**Silver Lake (Milford)***
Alewife	1	1	3	
Banded Killifish	3			
Black Crappie	5	19	6	
Blueback Herring		21	114	4
Bluegill	96	48	19	16
Brown Bullhead	82	21	2	6
Carp	1	1	1	
Channel Catfish	1	1	1	
Gizzard Shad	41	543	984	1
Golden Shiner	64	10		10
Hybrid Striped Bass	1			
Largemouth Bass	6	1		1
Pumpkinseed	187	2		2
Red-eared Sunfish	3			
Silvery Minnow	7			
Striped Killifish	1			
White Catfish	3	2	1	
White Perch	452	659	30	
Yellow Bullhead	1			
Yellow Perch	1			1
Total	956	1,329	1,161	54

* Sampling net frequently vandalized.

Table 6-8. Summary of species and numbers collected in adult passage monitoring at four New Jersey fish ladder sites during 2006.

Species	**Cooper River Lake**	**Newton Lake**	**Stewart Lake**	**Sunset Lake***
Alewife	1		7	7
Black Crappie	4	1	15	
Blueback Herring	2			55
Bluegill		9	461	41
Bowfin				
Brown Bullhead	1		47	
Brown Trout			1	
Carp	1		10	
Chain Pickeral				1
Channel Catfish			1	
Gizzard Shad	3		18	494
Golden Shiner		1	114	13
Green Sunfish			2	
Largemouth Bass	1		24	
Pumpkinseed		4	98	1
White Perch	10	1	75	
White Sucker			2	
Yellow Perch		1	19	2
Total	23	17	895	587

*sampling net frequently vandalized.

Table 6-9. Temporal sampling of spawning run herring at three fish ladders, during 2001.

	Moores Lake			Coursey Pond			McColley Pond				
Time	4/24/01	4/25/01	5/7/01	4/23/01	4/24/01	4/25/01	4/23/01	4/24/01	4/25/01	5/7/01	Average
7:30											
8:00											
8:30											
9:00											
9:30											
10:00								0.33			0.33
10:30	10.33	4.75			19.00	1.50		0.33			7.18
11:00	10.33	4.75			19.00	1.50		0.33			7.18
11:30	10.33	4.75			19.00	1.50		21.45		2.04	9.51
12:00	10.33	4.75			6.40	1.50		21.45		2.04	7.41
12:30	10.33	2.09	3.40		6.40	13.00		21.45	3.47	2.04	7.52
13:00	10.33	2.09	3.40		6.40	13.00		21.45	3.47	2.04	7.52
13:30	11.00	2.09	3.40		6.40	13.00		21.45	3.47	2.04	7.60
14:00	11.00	2.09	3.40		6.40	13.00		21.45	3.47	2.04	7.60
14:30	11.00	2.09	3.40		6.40	13.00	3.63	21.45	3.47	2.04	7.16
15:00	11.00	2.09	3.40		6.40	13.00	3.63	21.45	3.47	2.04	7.16
15:30	11.00	2.09	3.40	3.57	6.40	13.00	3.63	21.45	3.47	2.04	6.80
16:00	11.00	2.09	3.40	3.57	6.40	13.00	3.63	21.45	3.47		7.56
16:30	11.00	2.09	3.40	3.57			3.63	21.45	3.47		6.94
17:00		2.09		3.57			3.63				3.10
17:30		2.09		3.57			3.63				3.10
18:00				3.57			3.63				3.60
18:30				3.57			3.50				3.54
19:00				16.50			3.50				10.00
19:30				16.50			5.50				11.00
20:00				1.50			5.50				3.50
20:30				1.50			3.00				2.25
21:00							3.00				3.00
22:00											
22:30											
23:00											
23:30											
0:00											

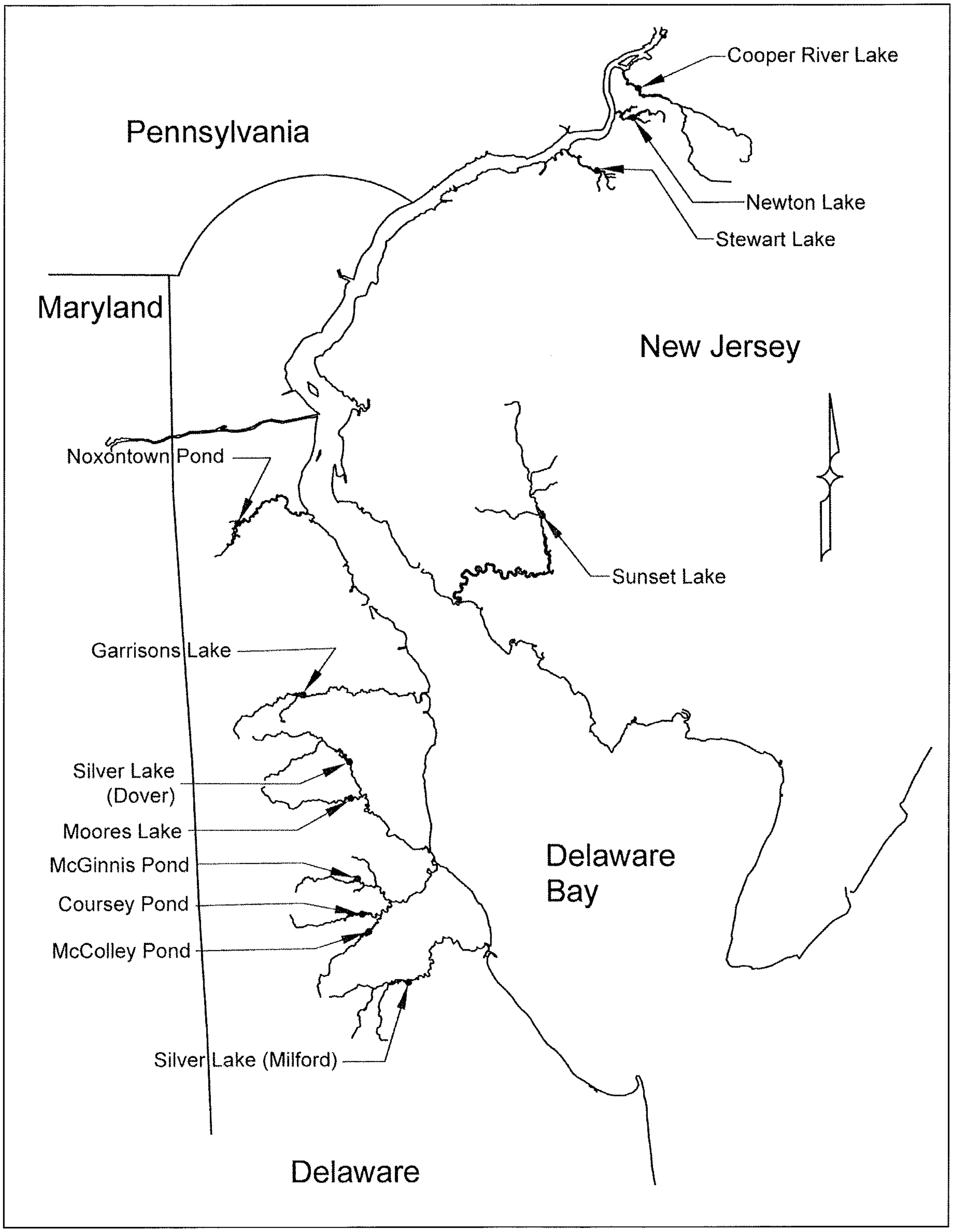

Figure 6-1. Map depicting the locations of the twelve PSEG fish ladders within the Delaware River estuary.

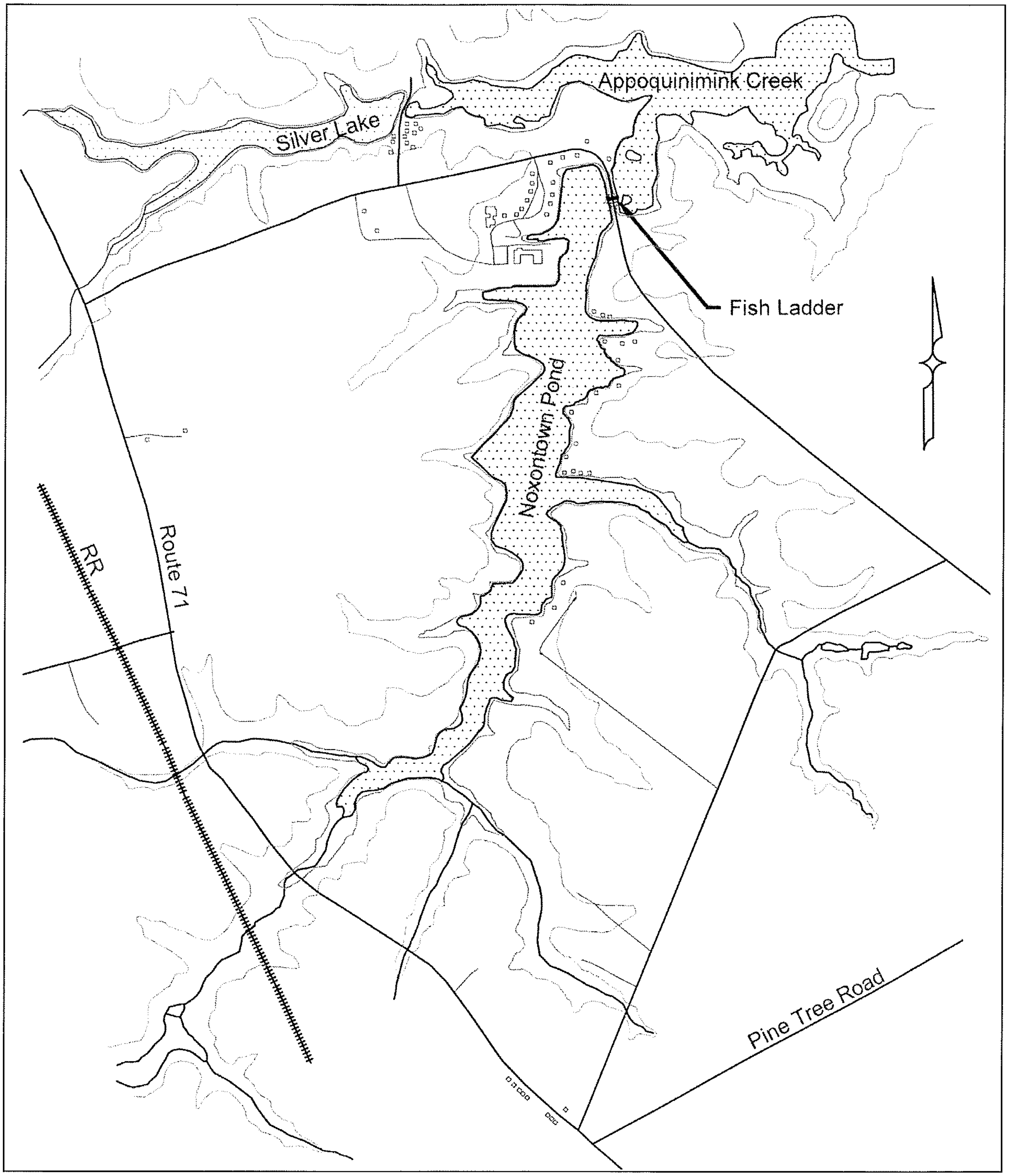

Figure 6-2. Noxontown Pond on the Appoquinimink River, in Odessa, DE.

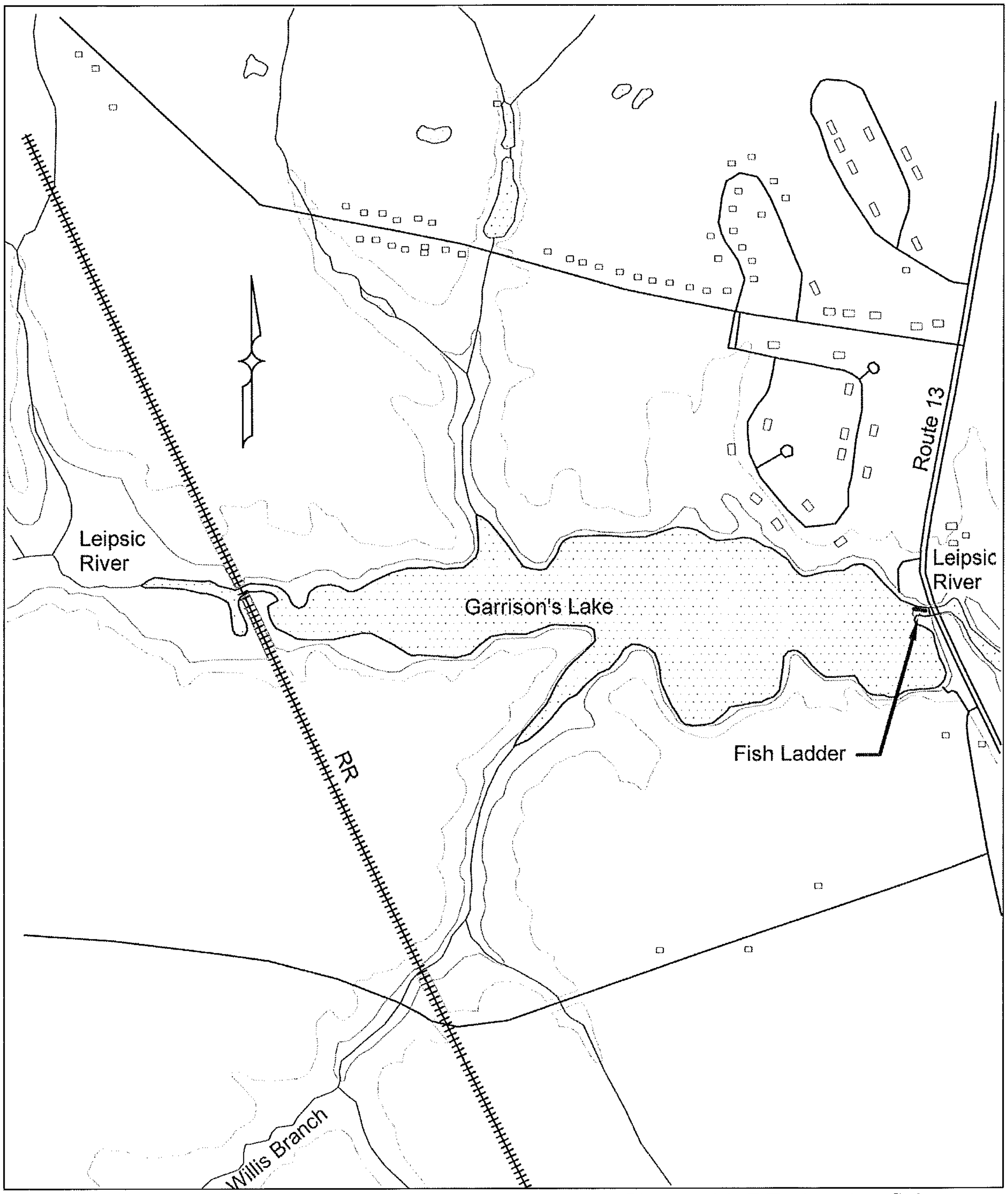

Figure 6-3. Garrisons Lake on the Leipsic River, near Cheswold, DE showing fish ladder.

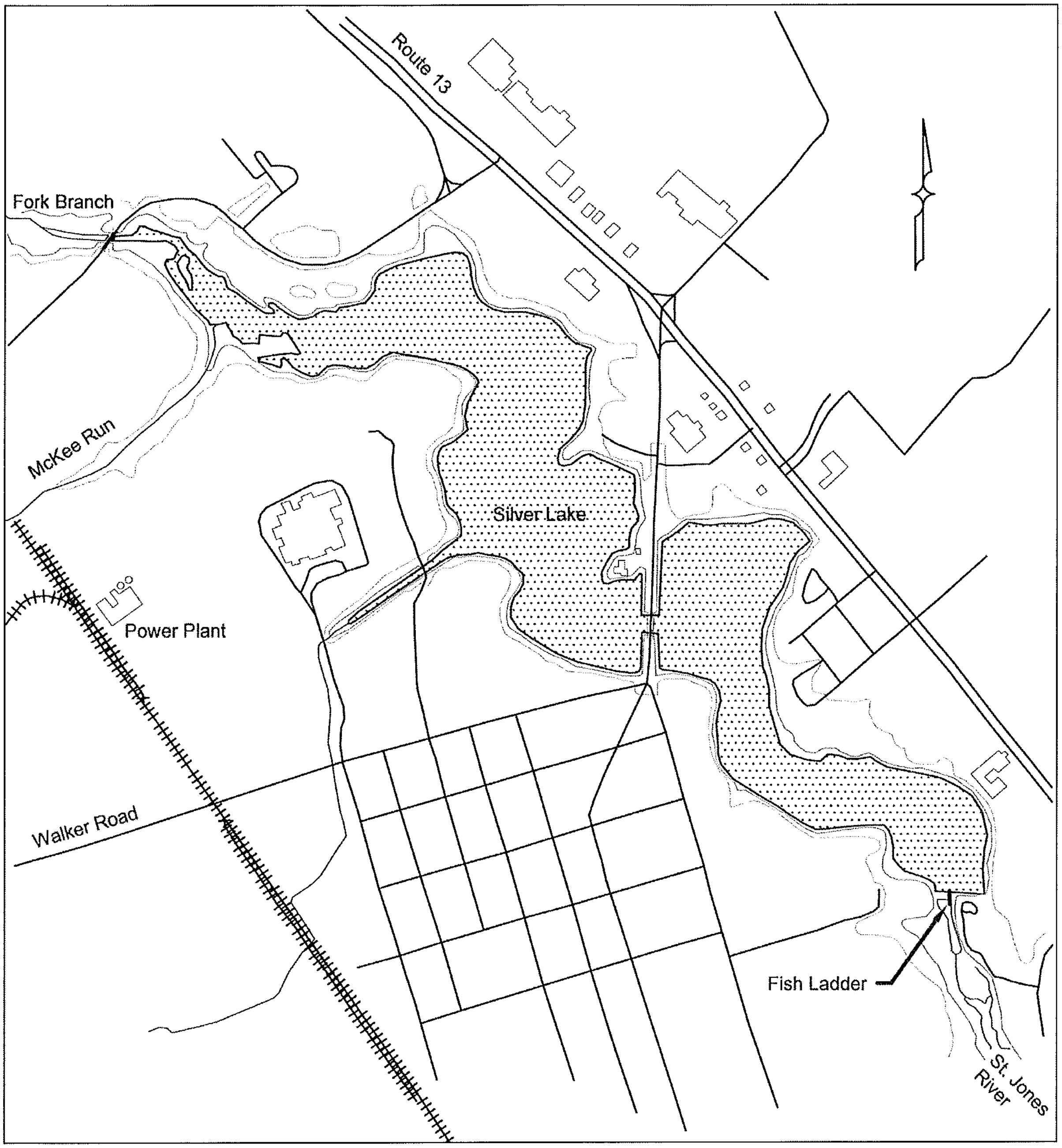

Figure 6-4. Silver Lake on the St Jones River, in Dover, DE.

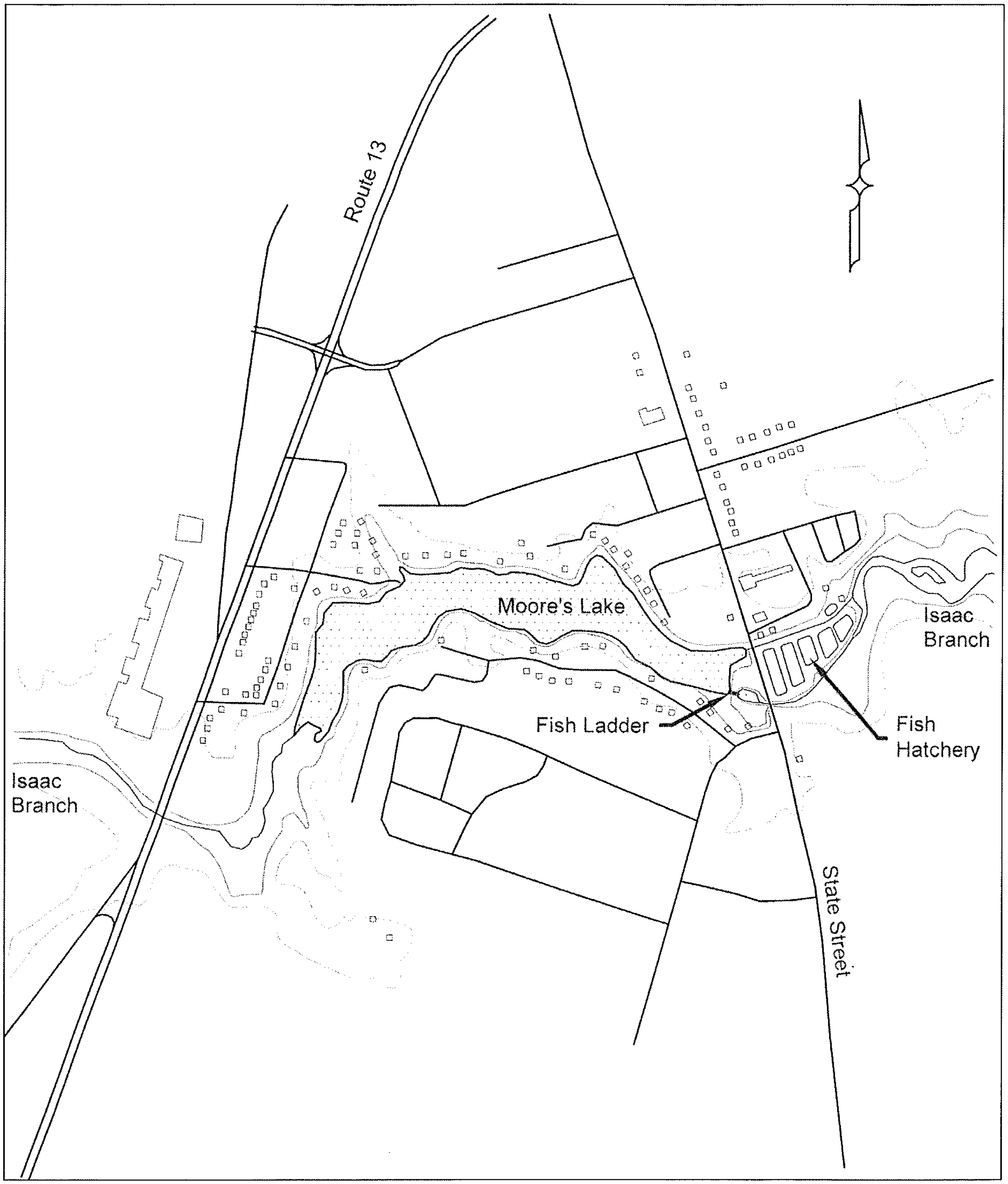

Figure 6-5. Moores Lake on Isaacs Branch, a tributary to the St. Jones River, near Dover, DE.

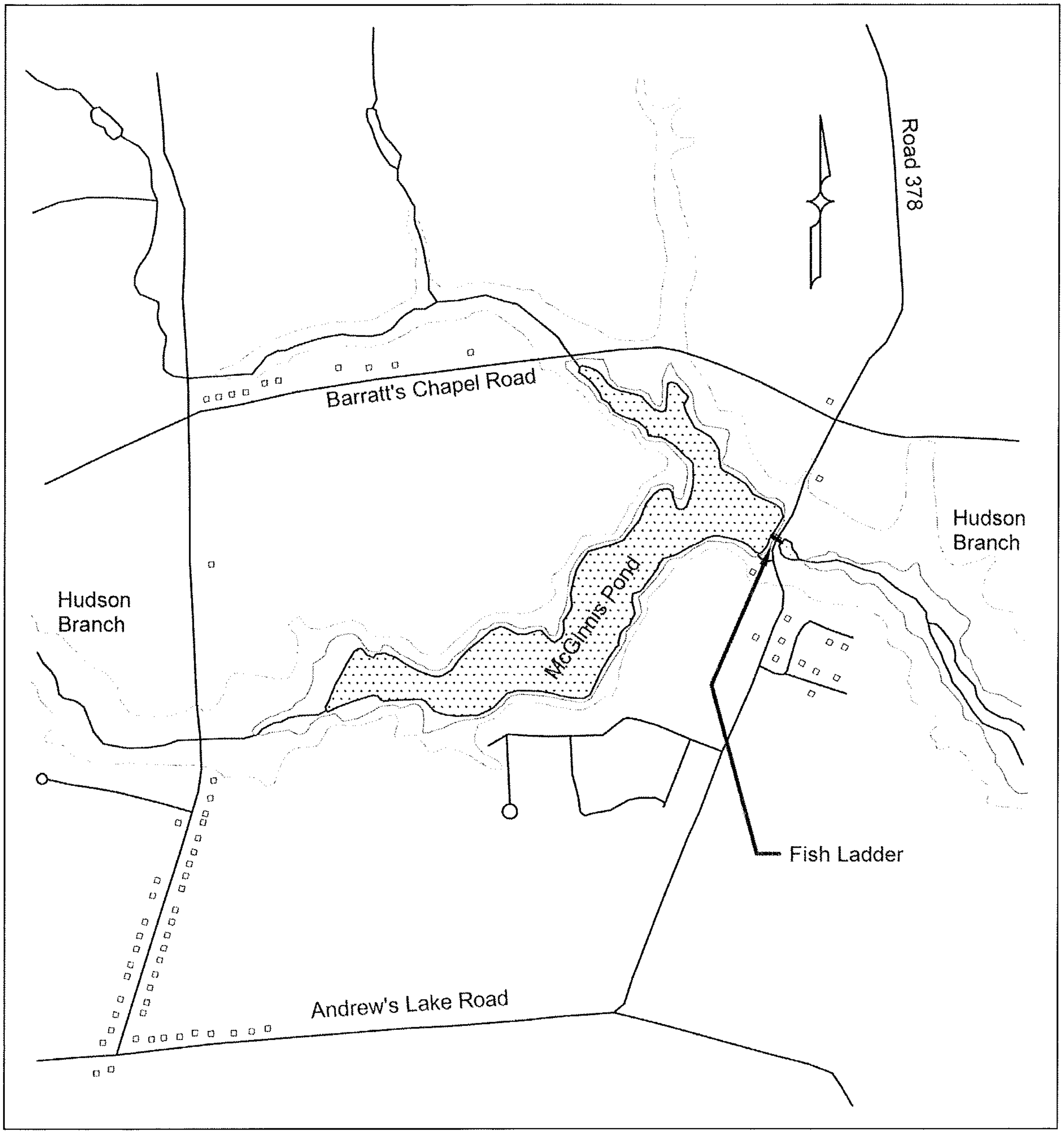

Figure 6-6. McGinnis Pond on Hudson Branch, a tributary of the Murderkill River, near Frederica, DE.

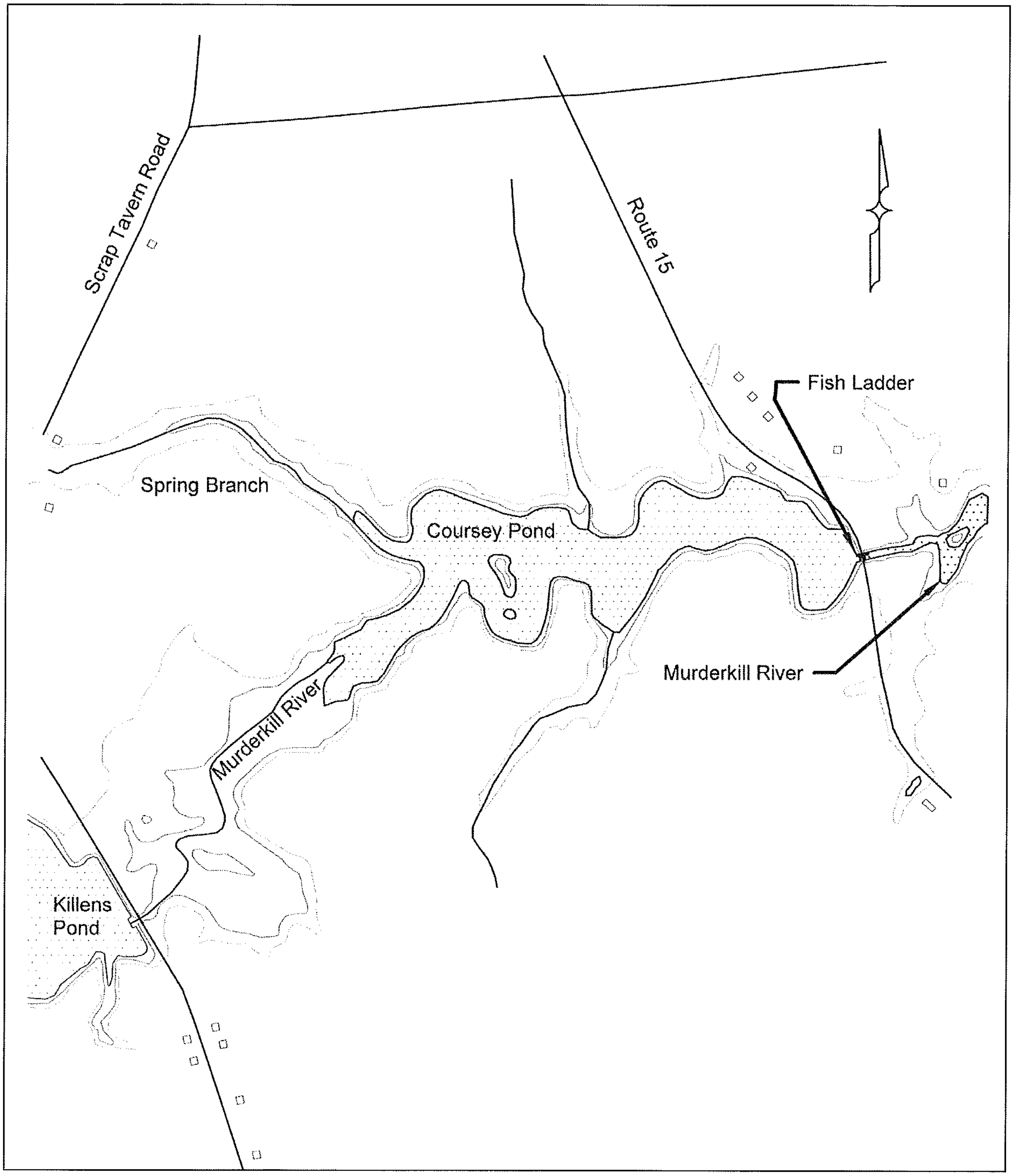

Figure 6-7. Coursey Pond on the Murderkill River, near Frederica, DE.

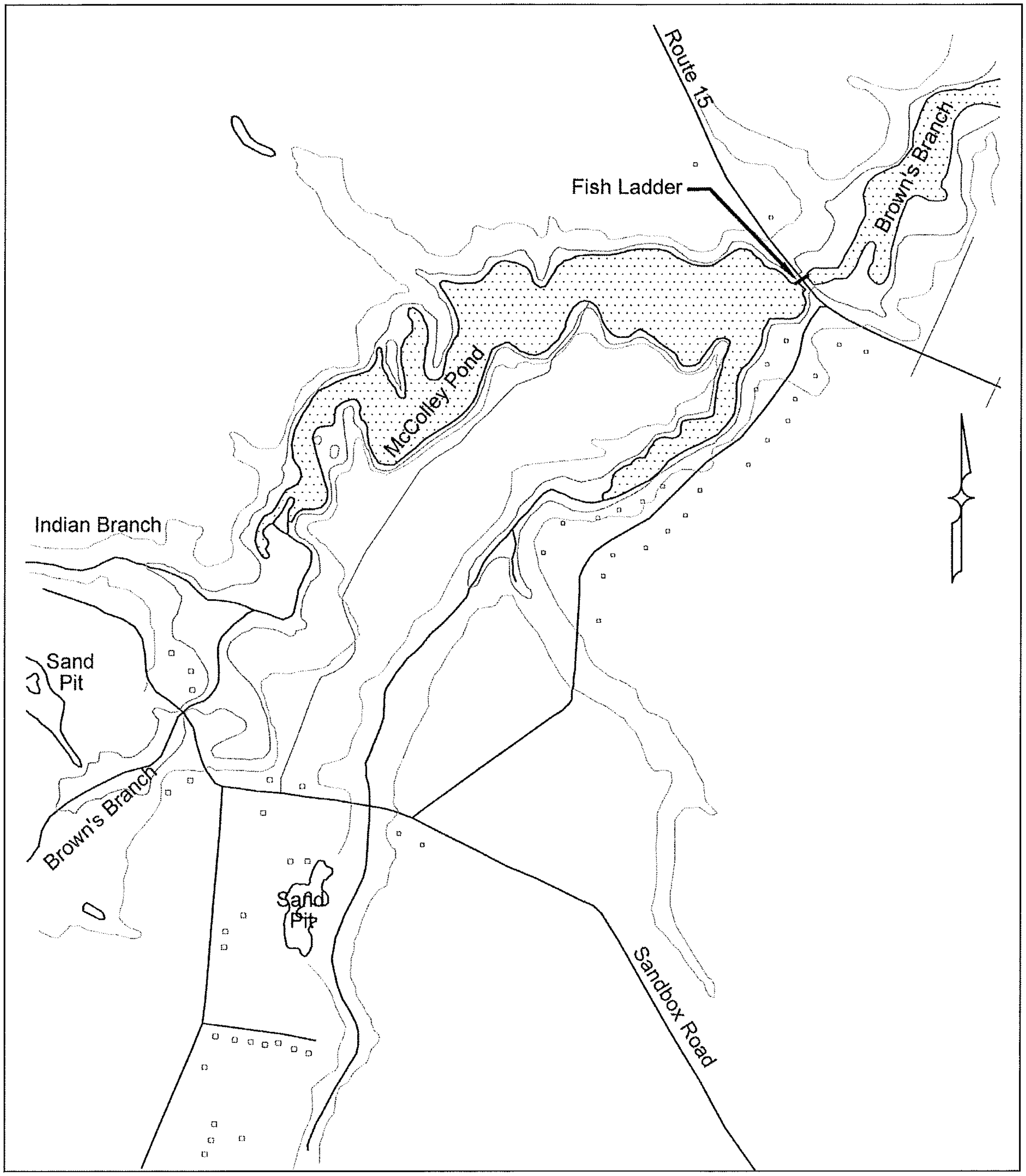

Figure 6-8. McColley Pond on Brown's Branch, a tributary to the Murderkill River, near Milford, DE.

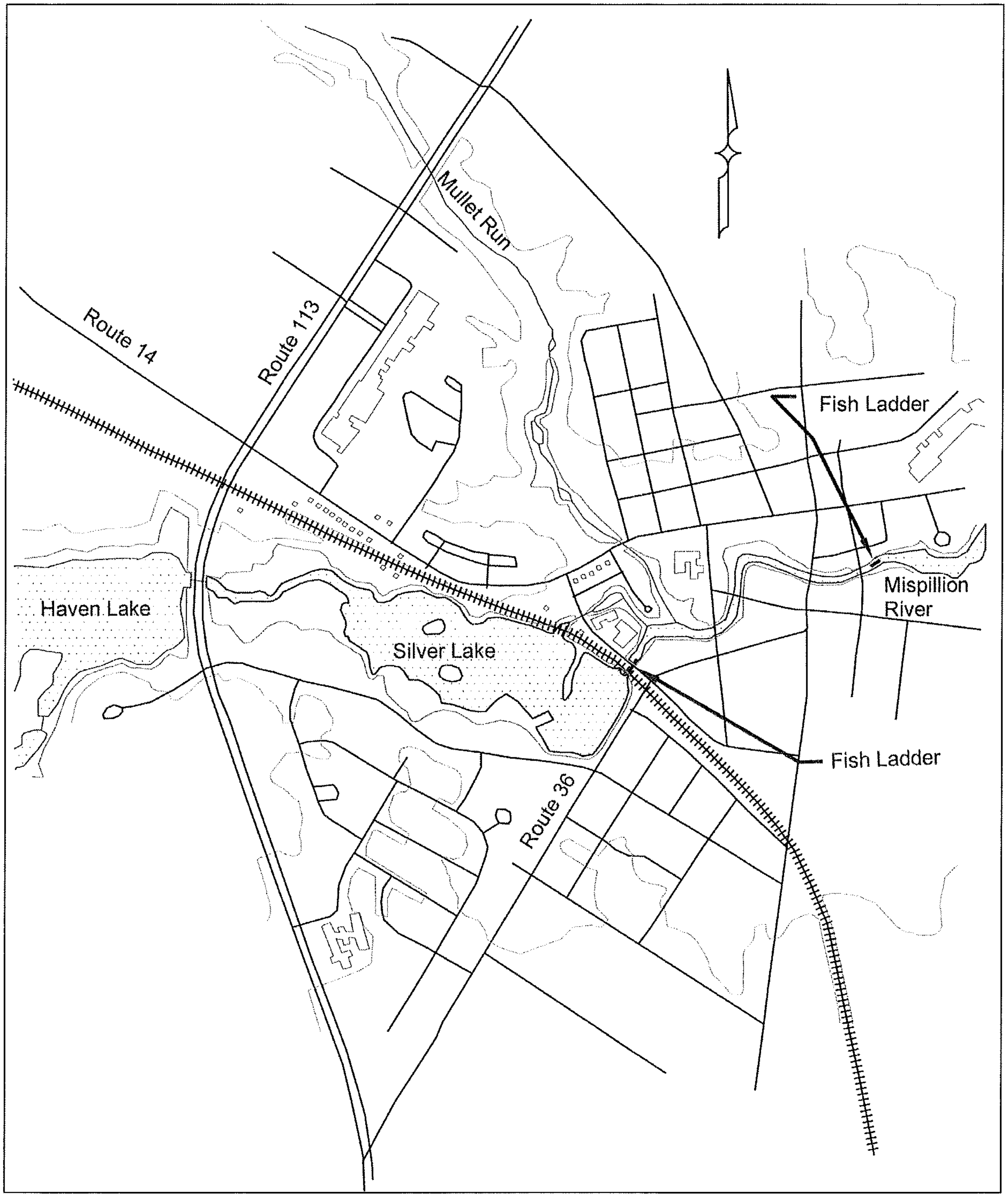

Figure 6-9. Silver Lake on the Mispillion River, in Milford, DE, showing the two fish ladders.

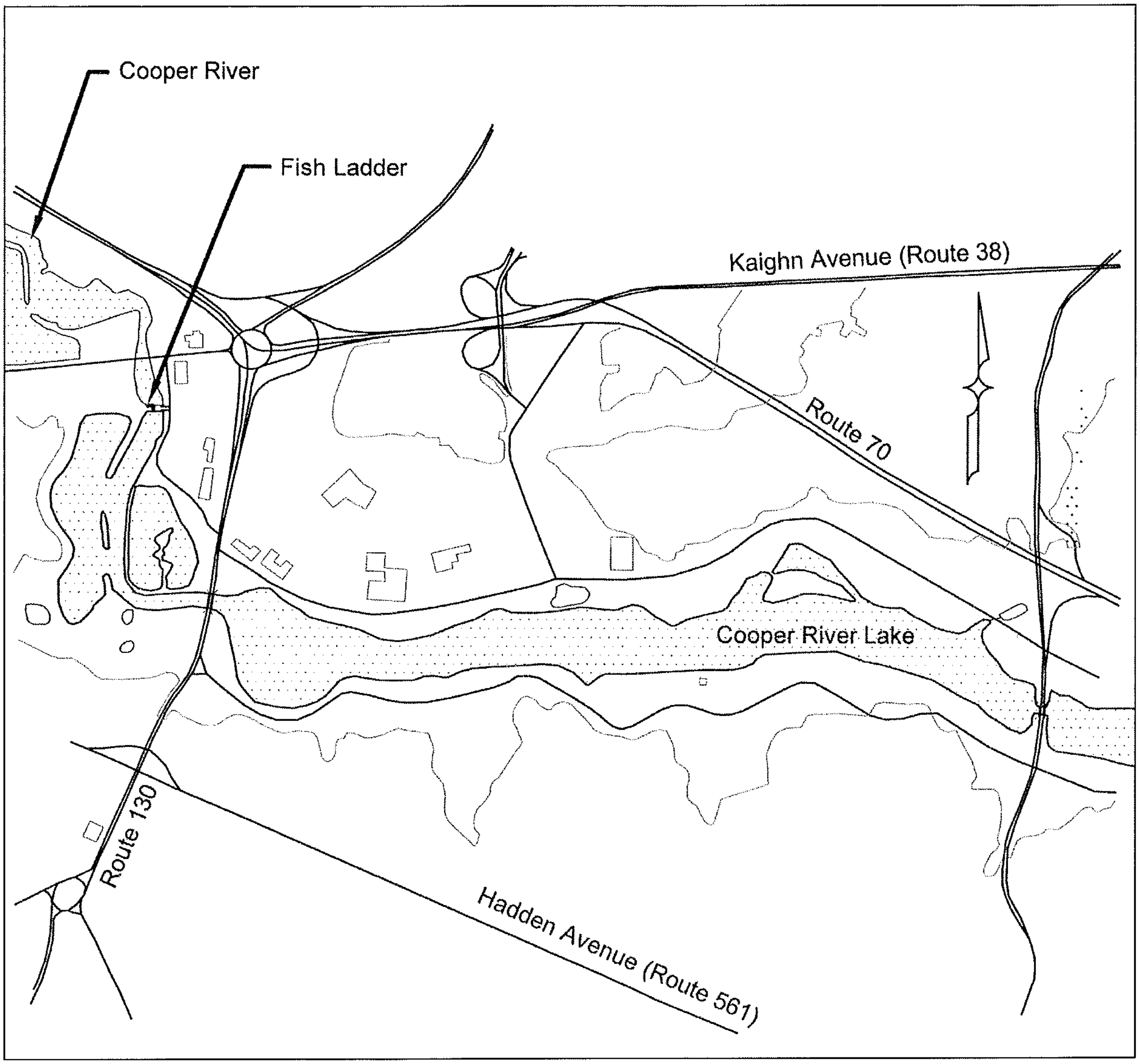

Figure 6-10. Cooper River Lake, an impoundment of the Cooper River, in Camden, NJ.

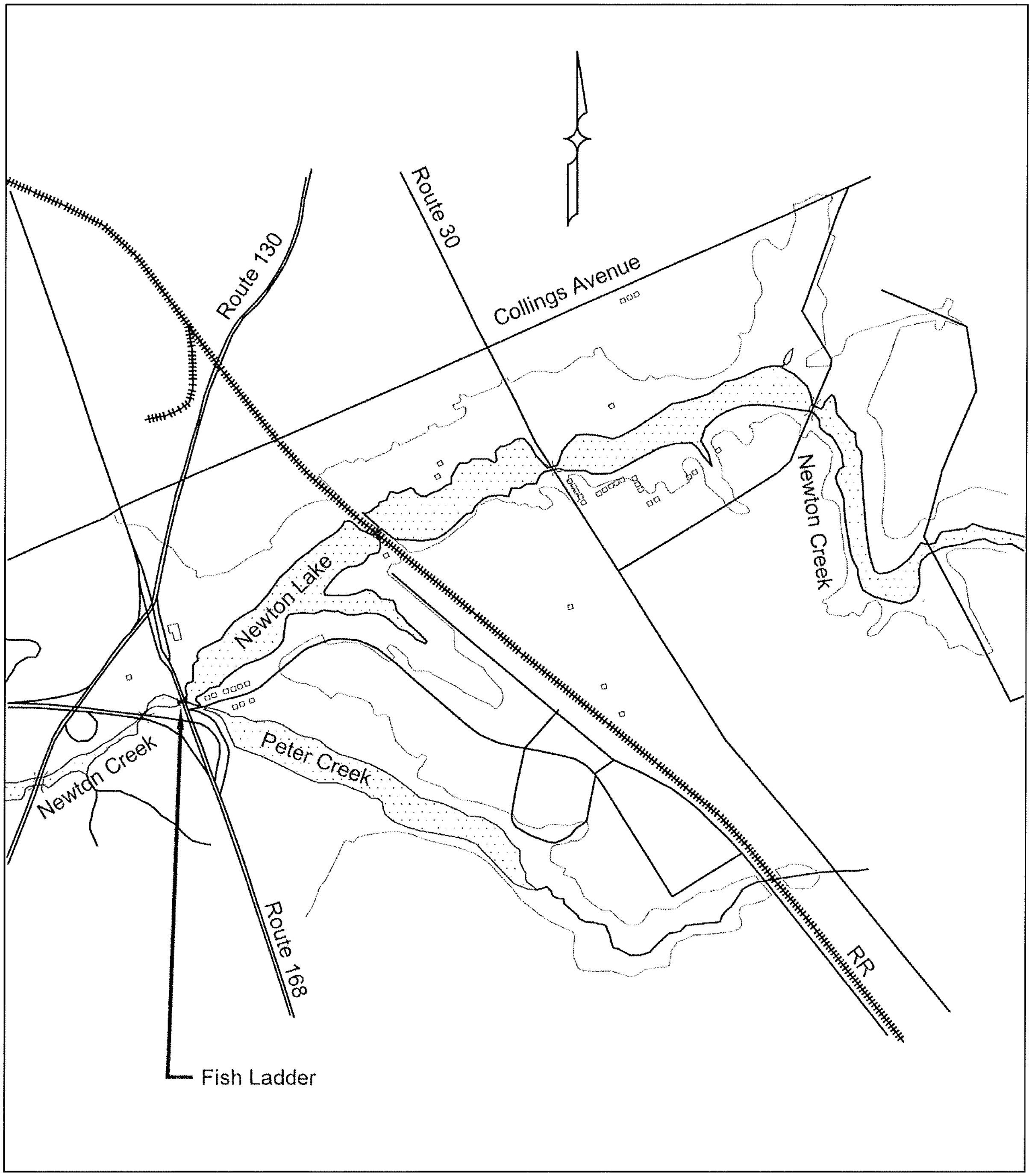

Figure 6-11. Newton Lake, an impoundment of Newton Creek, in Oaklyn, NJ.

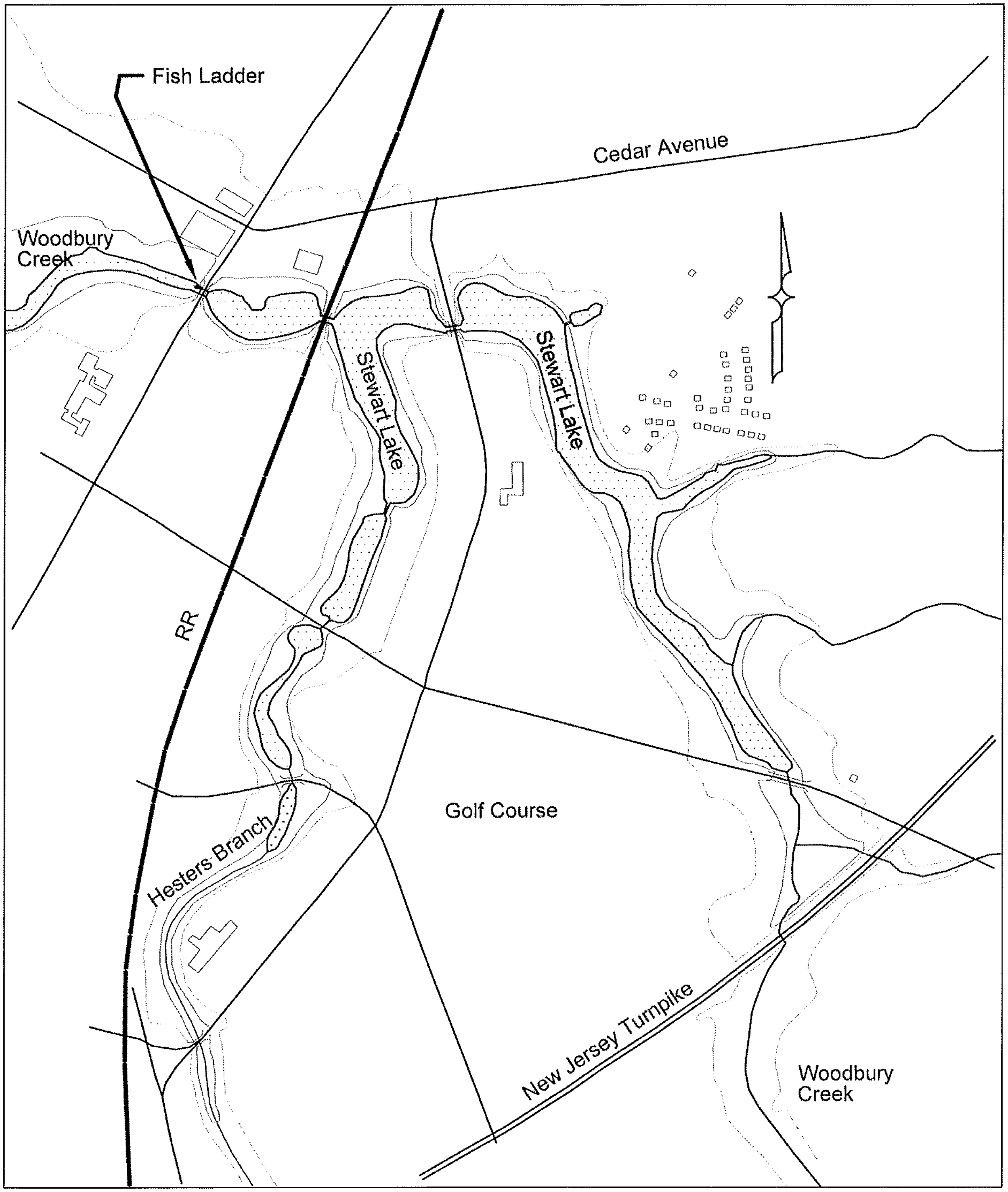

Figure 6-12. Stewart Lake, and impoundment of Woodbury Creek, in Woodbury, NJ.

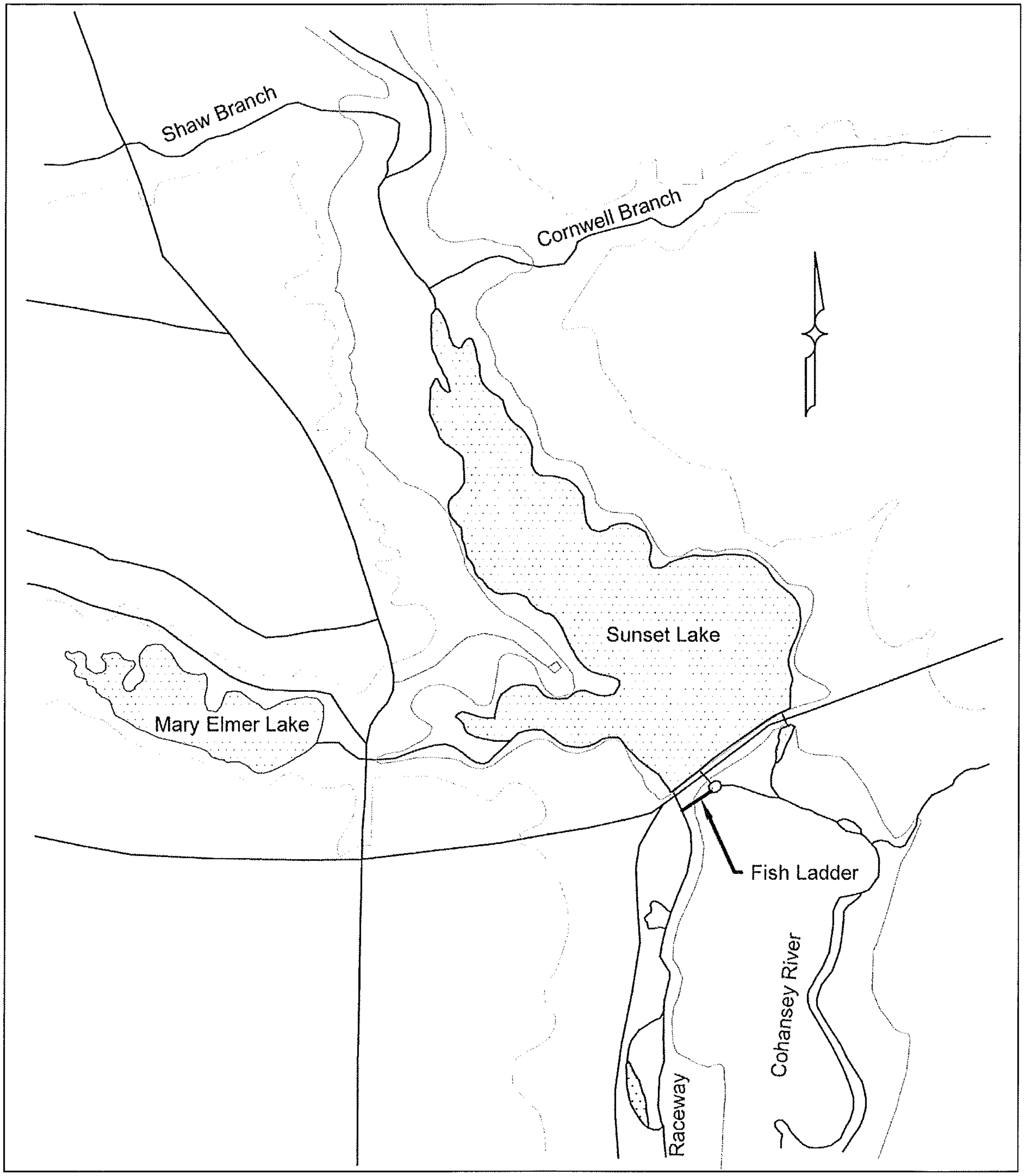

Figure 6-13. Sunset Lake on the Cohansey River, in Bridgeton, NJ.

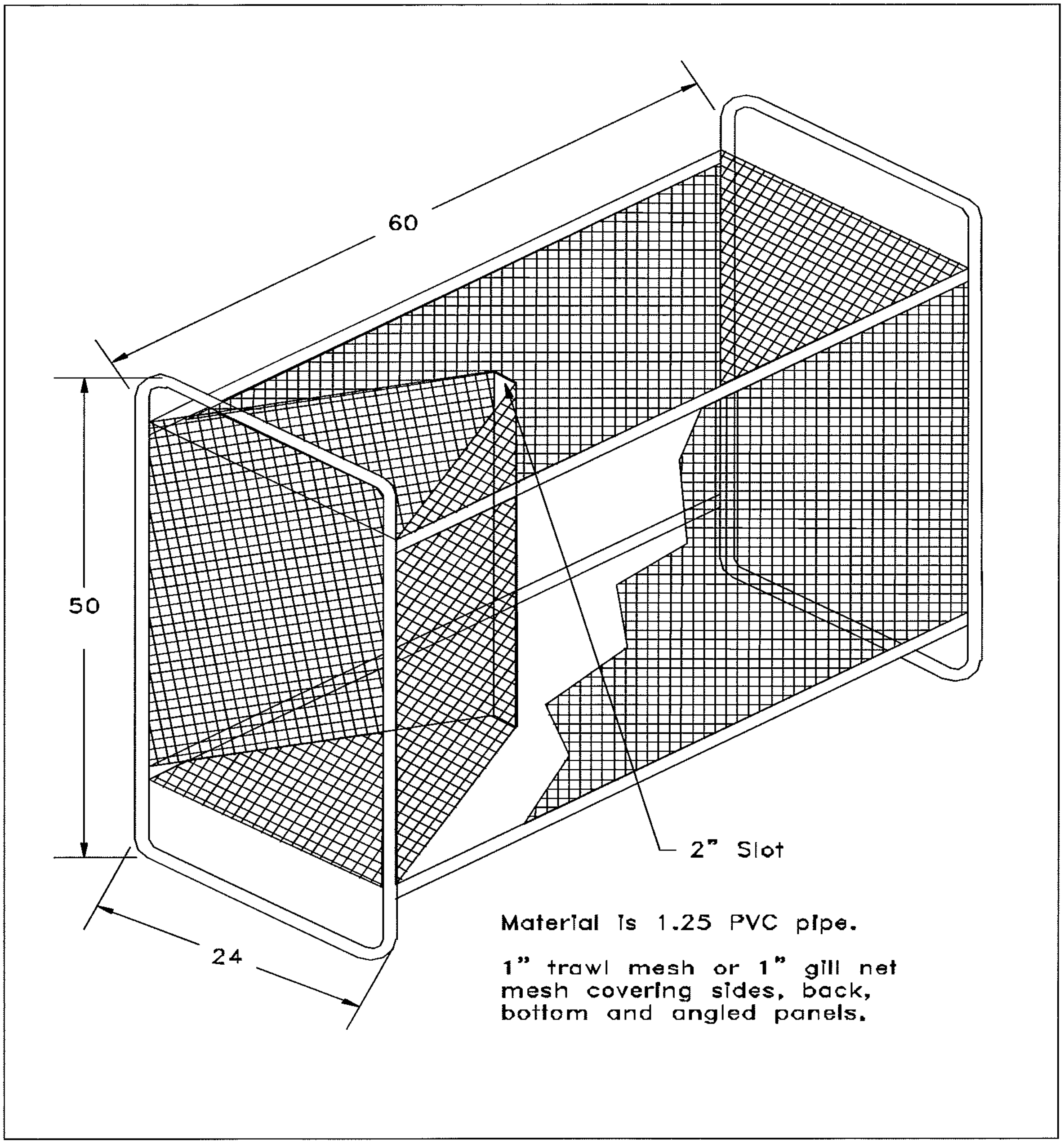

Figure 6-14. Generalized fish trap used to collect fish at the exit (upper end) of the fish ladders.

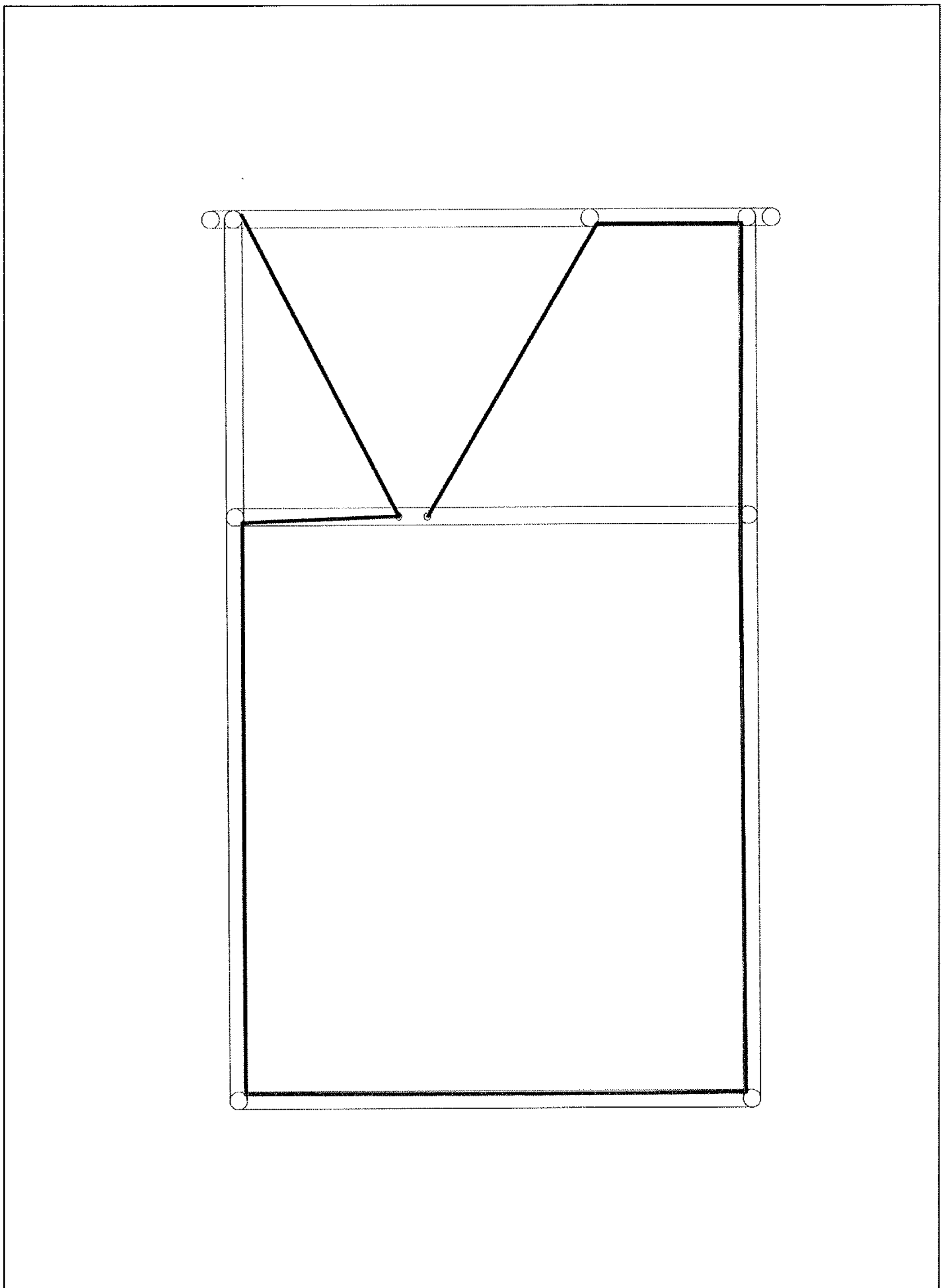

Figure 6-15. Plan view of Noxontown fish trap used to collect fish at the exit (upper end) of the fish ladder.

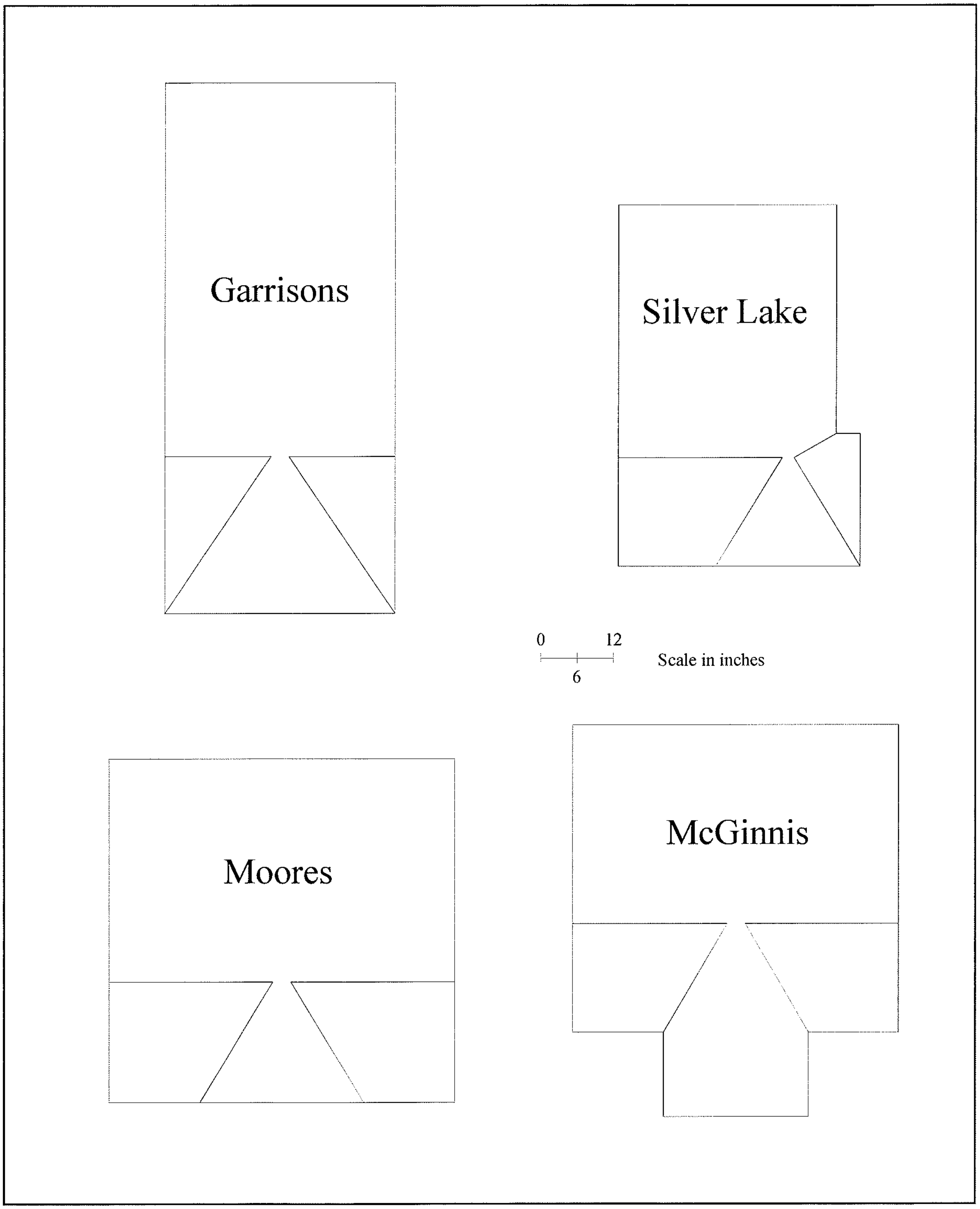

Figure 6-16. Plan views of four fish traps used to collect fish at the exit (upper end) of the fish ladders.

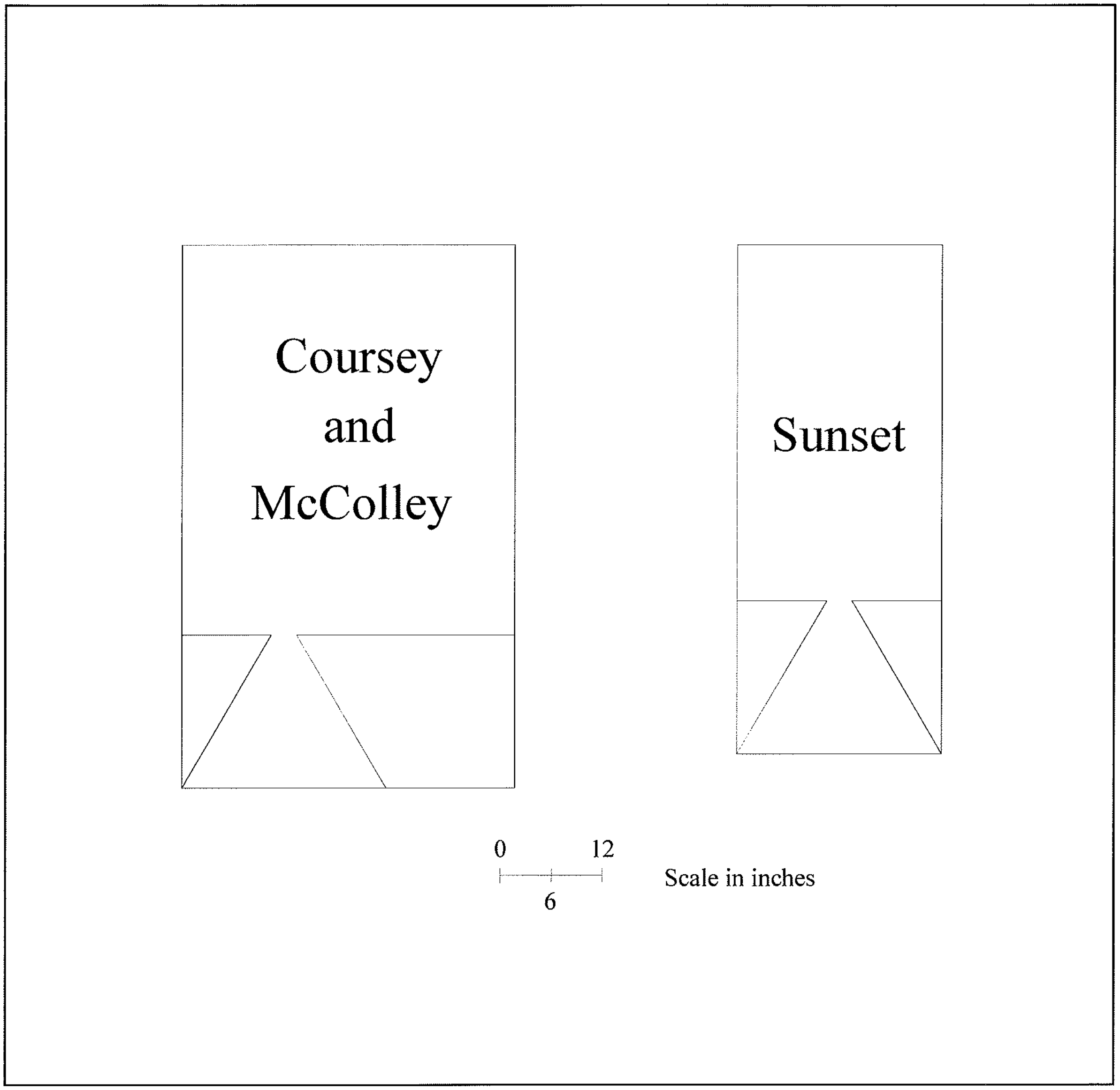

Figure 6-17. Plan views of two fish traps used to collect fish at the exit (upper end) of the fish ladders.

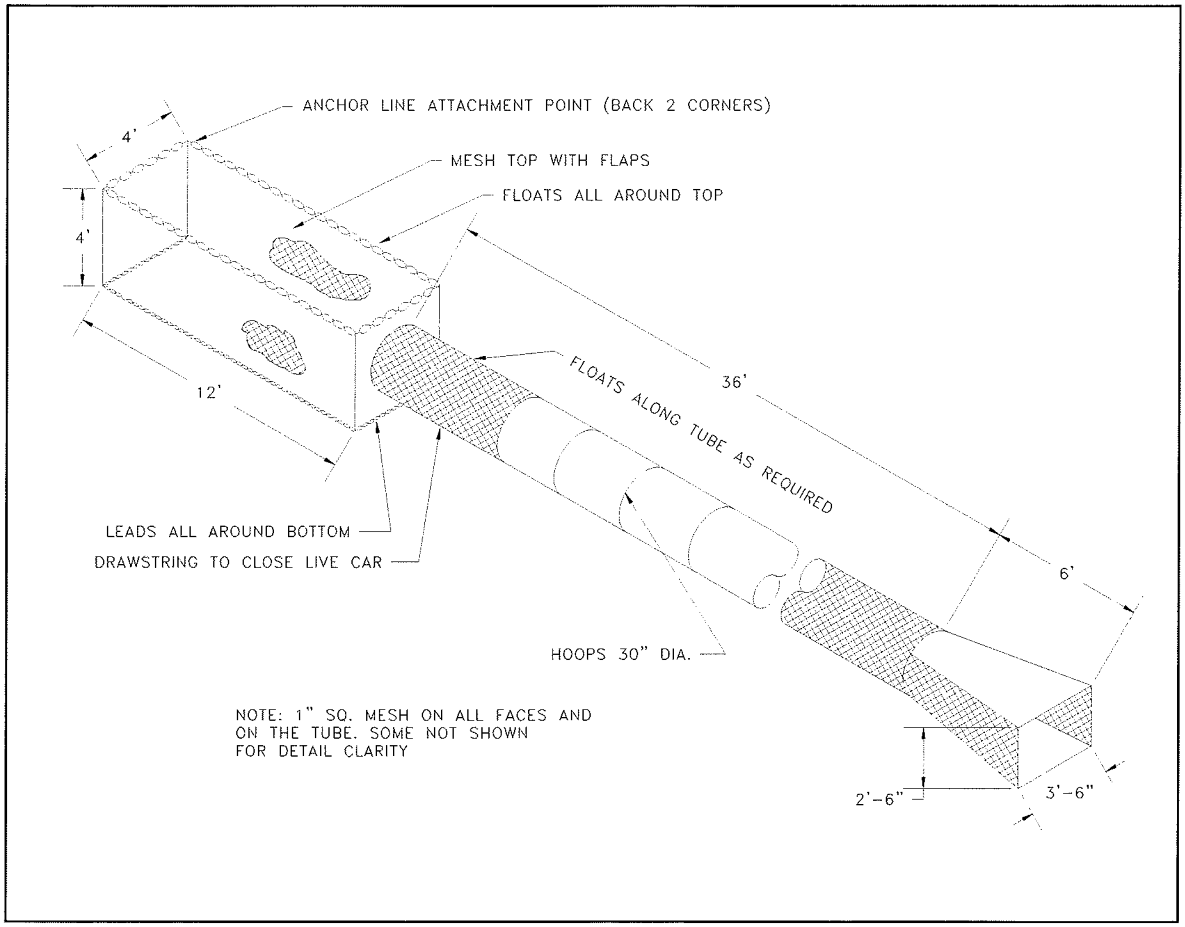

Figure 6-18. Modified commercial fish trap used to collect fish at the exit (upper end) of the Cooper River Lake fish ladder.

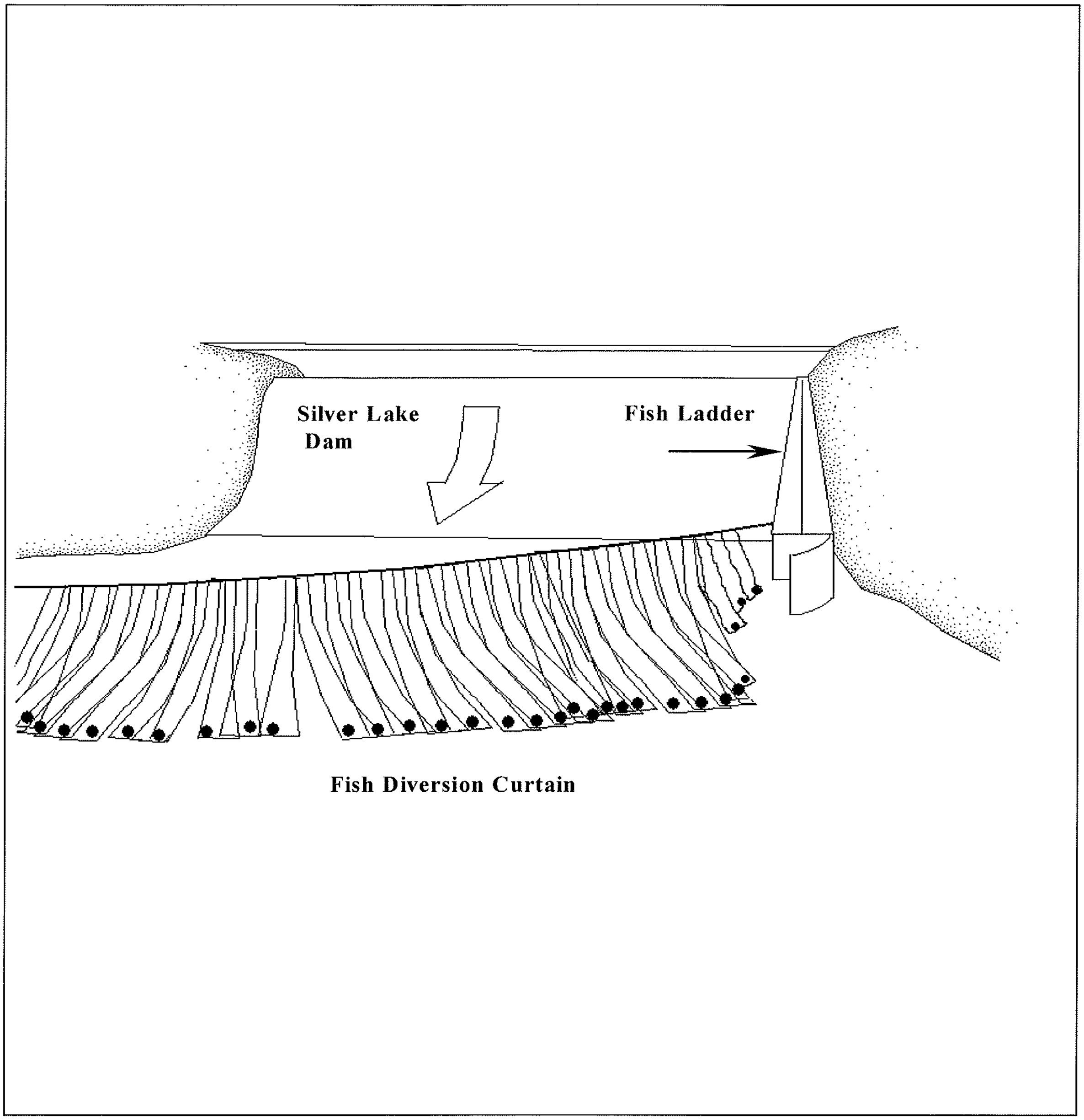

Figure 6-19. Fish diversion curtain at the Silver Lake fish ladder.

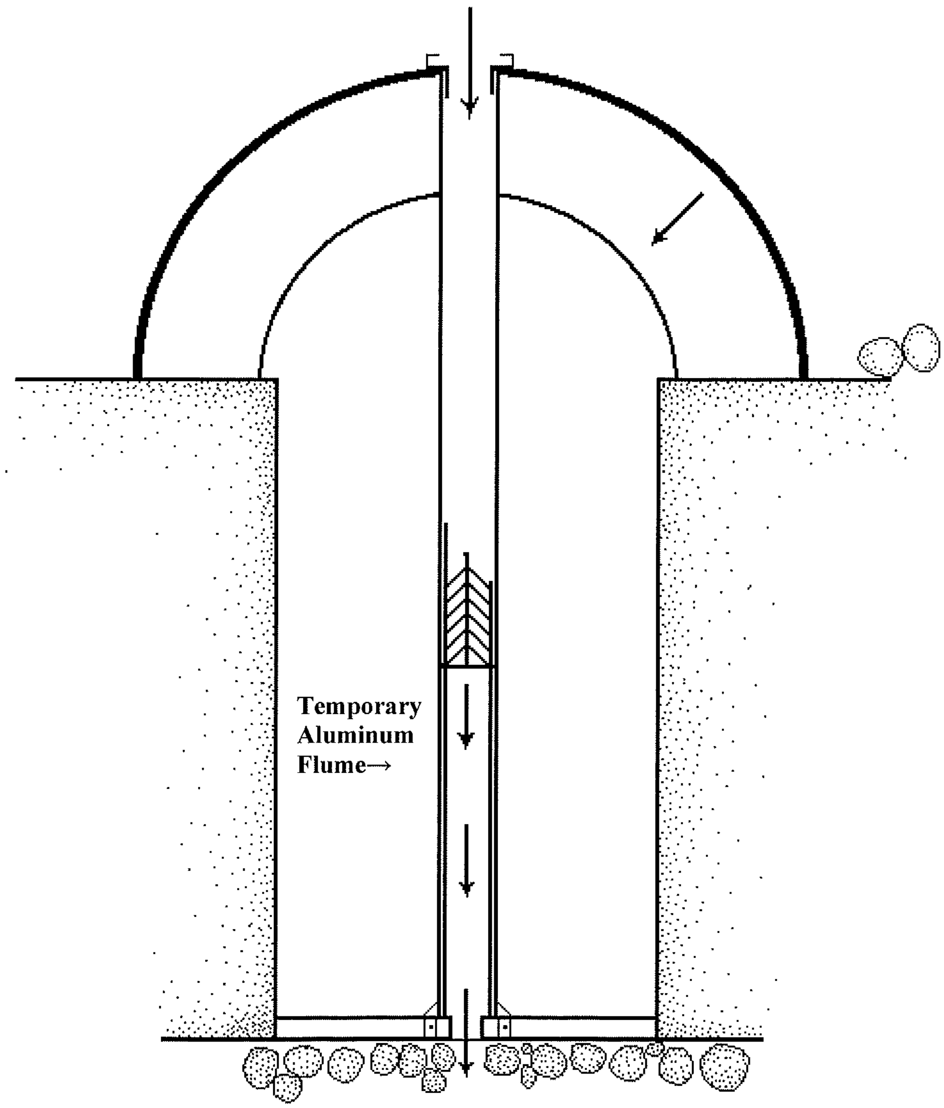

Figure 6-20. Fish diversion flume at Moores Lake fish ladder.

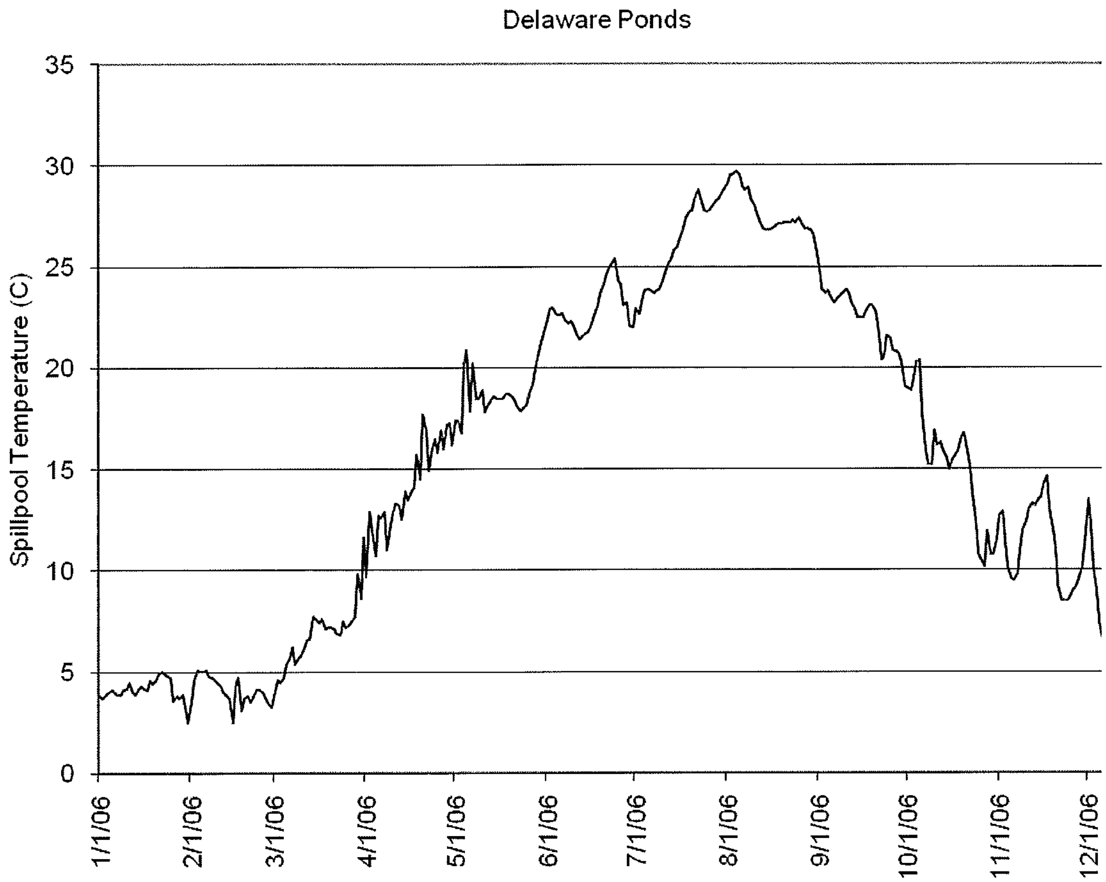

Figure 6-21. Water temperatures (°C) at Delaware Pond Spillpools during January 1, 2006 through December 31, 2006.

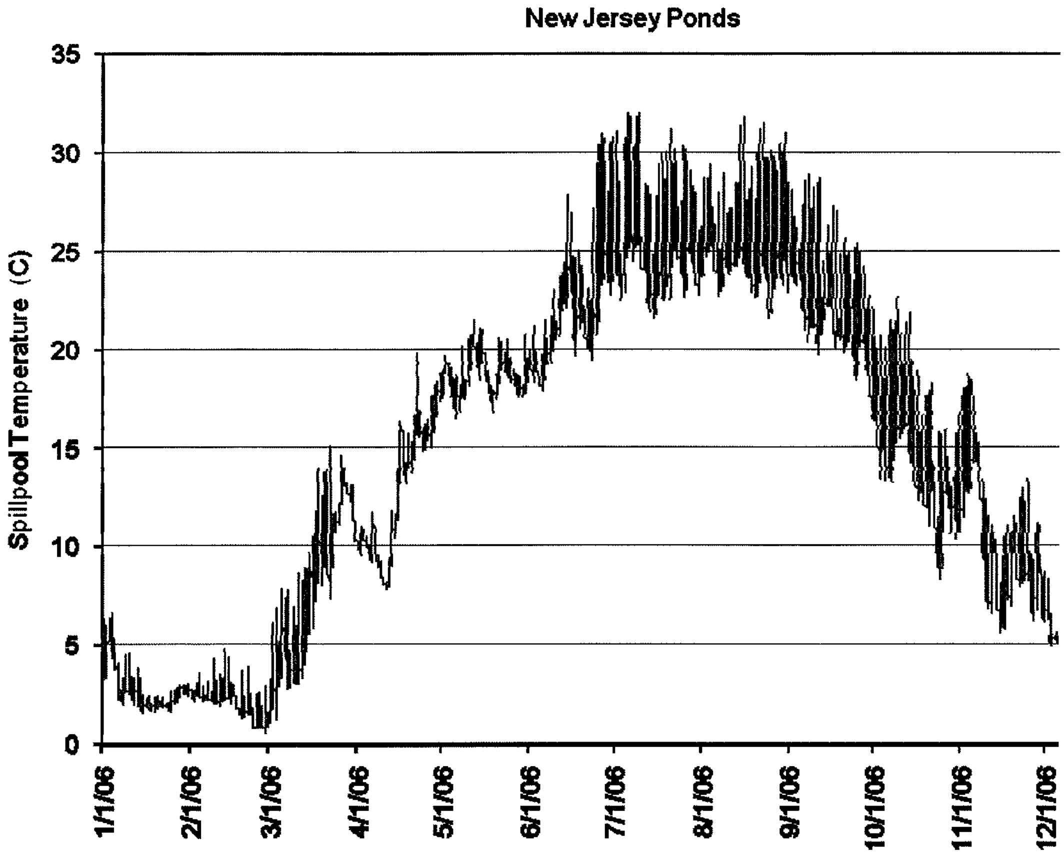

Figure 6-22. Water temperatures (°C) at New Jersey Pond Spillpools during January 1, 2006 through December 31, 2006.

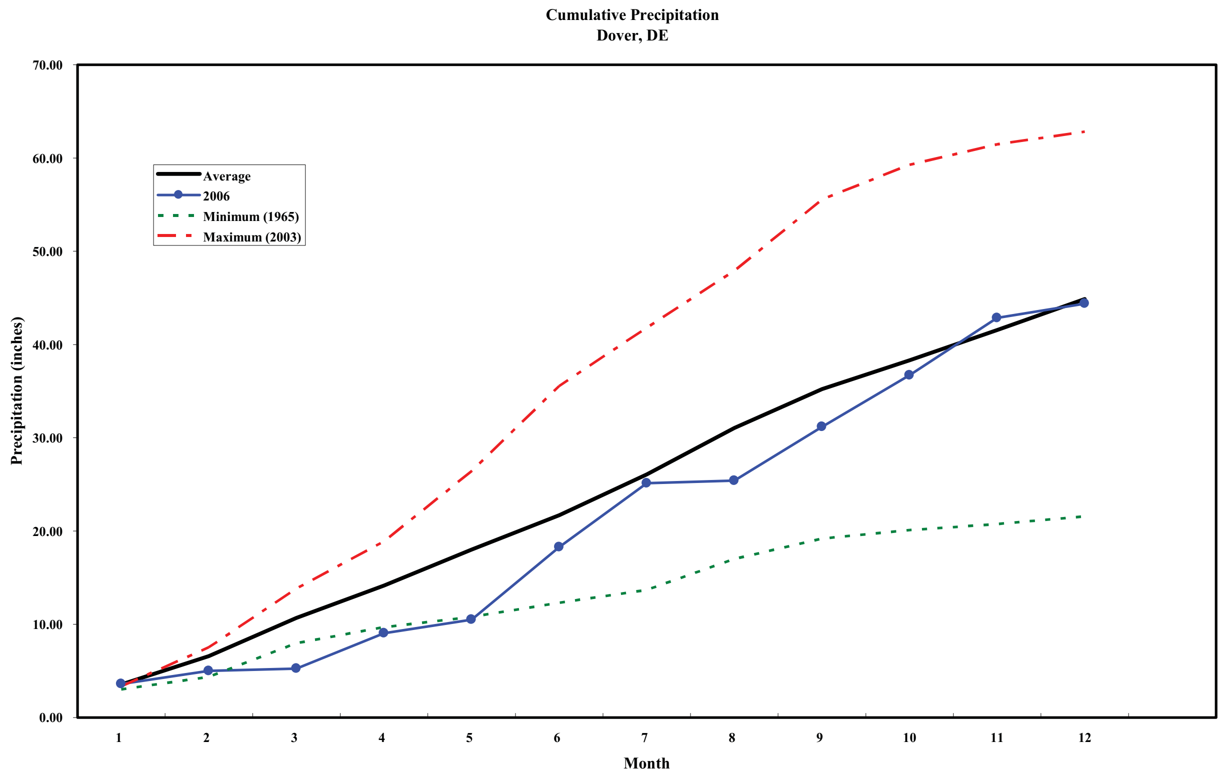

Figure 6-23. Cumulative precipitation for 2006 with 1922-2006 average from data collected by Del DOT in Dover, DE.

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*), 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 eleventh annual report in a long term monitoring project (PSE&G 1997-1999b). The outline of this report has been re-organized, and results are presented 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 and Commercial Township Restoration Sites are summarized in the Lower Bay Region section of

this report, reflecting the polyhaline (18-35 ppt) portion of the Delaware Estuary, and the Mad Horse Creek Reference, and Mill Creek and Alloways Creek Restoration Sites 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 new moon (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 Alloways Creek Watershed (ACW) Restoration Sites, which includes the Alloways 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 sites 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 sites included the Mill Creek area and portions of the Alloways Creek site. At these sites, 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 2006, 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 492 otter trawls were made during the 2006 sampling season (Table 7-1).

The first 20 of each fish species, blue crabs, diamondback terrapins, and horseshoe crabs 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. 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 2006 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 26.8°C in July; Commercial Township values ranged from 9.4°C in November to 27.0°C in July.

Salinity

The Lower Bay Region sites mean salinity values, as observed during the 2006 "Marsh Fish Assemblage" sampling season, are presented in Figure 7-7. It is important to note that from June 24-28 a number of powerful storms caused "flash flooding and record to near record flood crests" and may impact the mean salinity within the sampling sites (www.state.nj.us/drbc/Flood_Website/events.htm#2006). Generally, over the period of sampling the average salinity in the Lower Bay Region decreased from May to the seasonal low in June, increased to the seasonal high in September, and decreased 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 12.2 ppt in June to 20.8 ppt in September; Commercial Township ranged from 14.8 ppt in June and July to 20.4 ppt in September. The greatest difference in salinity occurred in June when Moores Beach was 2.6 ppt lower than Commercial Township; in all other months the difference was between 0.1 to 1.3 ppt.

Dissolved Oxygen

Monthly mean dissolved oxygen values for the 2006 sampling season are depicted in Figure 7-7. In general, mean dissolved oxygen decreased from May to the seasonal low in August, and then increased to the seasonal high in October. Seasonal lows and highs for both sites occurred in August and October, respectively. Moores Beach values ranged from 3.6 mg/L to 8.1 mg/L; Commercial Township values ranged from 5.0 mg/L to 9.9 mg/L. When comparing the values of Moores Beach and Commercial Township, their seasonal trends mimic one another but Moores Beach values were an average of 1.5 mg/L lower than Commercial Township values.

Moores Beach Reference Site

General Catch Composition

A total of 4,899 fish, representing 24 species and 16 families, was collected in 126 otter trawl collections and 14 weir sets from May through November 2006 in the Moores Beach reference site (Tables 7-1, 7-2 and 7-3). The species collected were composed primarily of transients (75.0%), i.e. those that spend a portion of their life history outside of the Delaware Bay, and secondarily of residents (25.0%), i.e. those that spend their entire life history in the Bay. In addition, two invertebrates, i.e., blue crab (n = 1,487) and horseshoe crab (2), and one reptile, i.e., diamondback terrapin (7), were included in the catches.

Large Marsh Creeks

A total of 1,359 fish, representing 23 species and 15 families, was collected in otter trawl collections during 2006 (Table 7-2 and 7-3). The total CPUE was 10.79. In the aggregate, six species comprised 91% of the total catch, and in order of decreasing abundance they were; Atlantic croaker (61%), Atlantic silverside (8%), Atlantic menhaden (6%), spotted hake (6%), bay anchovy (6%), and hogchoker (4%). Atlantic croaker, the most numerically abundant species, was also collected most frequently, occurring in 56% of the trawl collections. No other species occurred in more than 25% of the collections. White perch and mummichog were 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 seasonally bimodal at the Moores Beach site (Fig. 7-8). Abundance was highest in October with a monthly mean CPUE of 30.28, and Atlantic croaker was the predominant species comprising 91% (Figure 7-9). There was a secondary peak in July at 13.22, and Atlantic silverside was the predominant species comprising 37%.

Small Marsh Creeks

A total of 3,540 fish, representing eight species and six families, was collected in weir sets during 2006 (Table 7-2 and 7-3). The total CPUE was 252.86. Two species comprised 99% of the total catch, and in order of decreasing abundance they were; mummichog (84%) and Atlantic silverside (15%). Mummichog occurred in 86% of the weir sets, and Atlantic silverside was taken in 43% of the sets. No other species occurred in more the 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 608.00, and mummichug was the predominant species comprising 85% (Figure 7-8 and 7-9). Abundance was

intermediately high in July and September at 384.00 and 352.00, respectively. Mummichug comprised 94% of the catch in July and 56% in September; Atlantic silverside comprised 44% in September (Figure 7-9).

Commerical Township Restoration Site

General Catch Composition

A total of 3,979 fish, representing 25 species and 18 families, was collected in 123 otter trawl collections and 14 weir sets from May through November 2006 in the Commercial Township restoration site (Tables 7-1, 7-2 and 7-4). The species collected were composed primarily of transients (72.0%), and secondarily of residents (28.0%). In addition, one invertebrate, i.e., blue crab (n = 700) and one reptile, i.e., diamondback terrapin (6), were included in the catches.

Large Marsh Creeks

A total of 3,209 fish, representing 24 species and 17 families, was collected in otter trawl collections during 2006 (Table 7-2 and 7-4). The total CPUE was 26.09. Three species comprised 94% of the total fish CPUE, and in order of decreasing abundance they were; bay anchovy (47%), Atlantic croaker (41), and weakfish (6). White perch, Atlantic silverside, and hogchoker were the only other species collected comprising > 1% of the total fish catch. Just as bay anchovy and Atlantic croaker were similarly abundant, they also were collected at similar frequencies, occurring in 50 and 67% of the trawl collections, respectively. No other species occurred in more the 23% of the collections. Fish abundance in the large marsh creeks, increased each month from May to the high in August with a monthly mean CPUE of 69.78, and bay anchovy was the predominant species comprising 98% (Figure 7-10 and 7-11). CPUE decreased in September to 20.39, leveled at 19.94 in October, and then increased to 37.28 in November; suggestive of a fall/winter peak after sampling was completed for 2006. Atlantic croaker was the dominant species from September through November with 77%, 78%, and 76%, respectively (Figure 7-11).

Small Marsh Creeks

A total of 770 fish, representing eight species and five families, was collected in weir sets during 2006 (Table 7-2 and 7-4). The total CPUE was 55.00. Two species comprised 96% of the total fish catch, and in order of decreasing abundance they were; mummichog (76%) and Atlantic silverside (20). Mummichog occurred in all (100%) of the weir sets, and Atlantic silverside was taken in 71% of the sets. No other species occurred in more the 21% of the collections. Fish abundance in the small marsh creeks was highest in June with a monthly mean CPUE of 146.00, and mummichug was the predominant species comprising 94% (Figure 7-10 and 7-11). Abundance generally decreased thereafter.

Target Species Accounts for the Lower Bay Region

Bay anchovy

In the large marsh creeks of the Lower Bay Region, bay anchovy comprised 6 and 47% of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in 25 and 50% of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach a total, of 78 individuals, was collected and their mean CPUE for the study period was 0.62. At Commercial Township a total, of 1,524, was taken and the CPUE was 12.39. Bay anchovy abundance was highest, at Moores Beach, in July with a CPUE of 2.56, thereafter the CPUE was ≤0.72 (Figure 7-12). Bay anchovy was similarly abundant at Commercial Township in July with a CPUE of 3.89; however, bay anchovy abundance at Commercial peaked in August at 67.78. In the sampling months to follow, CPUE was ≤8.00. Individuals collected at Moores Beach ranged from 23 to 53 mm FL; all but one specimen were age 0+ (Figure 7-13). During July when >50% of the total catch was taken, individuals 28 and 33 mm FL comprised 81% of the specimens measured. Individuals collected at Commercial Township ranged from 13 to 88 mm FL (Figure 7-14). All specimens measured in May and June were age 1+. During July all were age 0+, and individuals 28 and 33 mm FL comprised 79% of the specimens measured. During each month August through November, all specimens measured but one were age 0+. In August and September, 52 % of specimens measured were 33 and 38mm, and 23 and 28mm, respectively. In October and November, 61% of specimens measured were 33 and 38mm, and 43 and 53mm, respectively.

In the small marsh creeks of the Lower Bay Region, bay anchovy comprised <1 and 1% of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in 14 and 21% of the respective weir sets (Tables 7-3 and 7-4). At Moores Beach, a total of 11 individuals was collected, and their mean CPUE for the study period was 0.79. While at Commercial Township, a total of five was taken, and the CPUE was 0.36. Bay anchovy abundance was highest at Moores Beach in October with a CPUE of 4.00 (Figure 7-15). Bay anchovy abundance was highest at Commercial in September at 2.00. Individuals collected at Moores Beach ranged from 38 to 53 mm FL, and all were age 0+ (Figure 7-13). Individuals collected at Commercial Township ranged from 33 to 48 mm FL, and all were age 0+ (Figure 7-14).

Spot

In the large marsh creeks of the Lower Bay Region, spot comprised <1% of the total catch at both the Moores Beach Reference and Commercial Township Restoration Sites, occurring in five and six percent of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach, a total of six individuals were collected and their mean CPUE for the study period was 0.05. At Commercial Township, a total of 10 were taken and the CPUE was 0.08. Spot abundance was highest at Moores Beach in July with a CPUE of 0.17 (Figure 7-16). At Commercial Township, spot was similarly abundant in all months of their occurrence (May through July, and September) with CPUE's ranging from 0.11 to 0.17. Individuals collected at Moores Beach ranged from 58 to 183 mm TL (Figure 7-17). Individuals collected at Commercial Township ranged from 43 to 188 mm TL (Figure 7-18).

In the small marsh creeks of the Lower Bay Region, one spot was collected at the Moores Beach Reference Site and none was taken at the Commercial Township Restoration Site, (Tables 7-3 and 7-4). At Moores Beach, their mean CPUE for the study period was 0.07. The fish was collected in September, the monthly mean CPUE was 0.50, and it was 198 mm TL (Figures 7-19 and 7-17).

Weakfish

In the large marsh creeks of the Lower Bay Region, weakfish comprised one and six percent of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in four and 23% of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach, a total, of seven individuals, was collected, and their mean CPUE for the study period was 0.06. While at Commercial Township, a total, of 185, was taken, and the CPUE was 1.50. At Moores Beach, weakfish was collected only in July and August with mean monthly CPUE's of 0.06 and 0.33, respectively (Figure 7-20). However at Commercial Township, weakfish was collected June through September and abundance peaked in July at 7.61. Individuals collected at Moores Beach ranged from 18 to 278 mm TL; all but one specimen were age 0+ (Figure 7-21). Individuals collected at Commercial Township ranged from 18 to 228 mm TL; all but one specimen were age 0+ (Figure 7-22). During July when the most weakfish were collected, individuals ranging from 38 to 68 mm TL comprised 64% of the specimens measured.

In the small marsh creeks of the Lower Bay Region, no weakfish were collected at the Moores Beach Reference Site, and two were collected at the Commercial Township Restoration Site, (Tables 7-3 and 7-4). At Commercial Township, their mean CPUE for the study period was 0.14. The fish were collected in June; the monthly mean CPUE was 1.00, and they were 13 and 18 mm TL (Figures 7-23 and 7-22).

White perch

In the large marsh creeks of the Lower Bay Region, white perch comprised three and one percent of the total catch at the Moores Beach Reference and Commercial Township Restoration Sites, respectively, occurring in 15 and 22% of the respective otter trawl collections (Tables 7-3 and 7-4). At Moores Beach, a total of 45 individuals was collected and their mean CPUE for the study period was 0.36. Similarly at Commercial Township, a total of 48 was taken, and the CPUE was 0.39. At Moores Beach, white perch was collected in all months of sampling (Figure 7-24). The mean monthly CPUE was highest in November at 0.89. In months prior, the CPUE generally fluctuated, ranging from 0.06 to 0.50. At Commercial Township, white perch was collected during all months of sampling as well. Their abundance was relatively low during May through September with CPUE's ranging from 0.07 to 0.28, it peaked in October at 1.28, and then declined to 0.50 in November. Individuals collected at Moores Beach ranged from 48 to 288 mm FL; all but two specimens were age 1+ or older, possibly including individuals age 8+ (Figure 7-25). Individuals collected at Commercial Township ranged from 153 to 278 mm FL; probably all were age 1+ or older and maybe including individuals age 8+ (Figure 7-26). No white perch were taken in the small marsh creeks of the Lower Bay Region.

Effects of Restoration at Lower Bay Salt Hay Farms

Abundance of all species collected in the large marsh creeks of the lower bay was 2.4 times greater at the Commercial Township Restoration Site (CPUE = 26.09) than at the Moores Beach Reference Site (10.79) (Tables 7-3 and 7-4; Figure 7-27). This difference is the result of the predominance of Atlantic croaker and bay anchovy at the Commercial Township Site. If the Atlantic croaker and bay anchovy contributions to total CPUE are subtracted from both sites, then the resulting aggregate CPUE's for all other species are very similar, 3.54 at Moores Beach and 2.88 at Commercial Township. The contribution made by the target species bay anchovy to overall fish abundance at Commercial can be further demonstrated by subtracting only the Atlantic croaker CPUE from both sites. This results in an aggregate CPUE at Moores Beach of 4.16 and at Commercial of 15.27. The abundance of weakfish was 25 times greater at Commercial (1.50) than at Moores (0.06), while white and spot were equally abundant at both sites. The respective CPUE's for white perch were 0.39 and 0.36, and for spot they were 0.08 and 0.05.

Fish species richness in trawls was similar at both sites with 24 species at Moores Beach and 25 at Commercial Township (Figure 7-27). There were 21 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 one or two individuals. The top seven species at the two sites had five species in common; Atlantic croaker, bay anchovy, Atlantic silverside, white perch and hogchoker. Atlantic croaker was ranked first at Moores Beach and second at Commercial Township; bay anchovy ranked fifth at Moores Beach and first at Commercial Township; and Atlantic silverside ranked second at Moores Beach and sixth at Commercial Township. Other species of note include white perch which ranked seventh at Moores Beach and fourth at Commercial Township; Atlantic menhaden which ranked third at Moores Beach and eighth at Commercial Township; weakfish which ranked tenth at Moores Beach and third at Commercial Township; and spot which ranked twelfth at Moores Beach and tenth at Commercial Township.

Abundance of all species collected in the small marsh creeks of the lower bay was 4.6 times greater at the Moores Beach Reference Site (CPUE = 252.86) than at the Commercial Township Restoration Site (55.00) (Tables 7-3 and 7-4; Figure 7-27). Fish species richness was the same at both sites with eight species (Figure 7-26). There were five species common to both sites, though differing somewhat in rank order. Mummichog and Atlantic silverside ranked first and second, respectively, at both sites. They occurred in essentially the same relative abundance at Moores Beach and Commercial sites, with mummichog comprising 84 and 76% of the total catches, respectively, and Atlantic silverside comprising 15 and 20%, respectively. The catches of the other species were ≤11 individuals, making their occurrences more or less incidental.

UPPER BAY REGION

Physical And Chemical Parameters

Temperature

The pattern in mean water temperature observed in 2006 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 declined through

November. Relative to the three upper bay region sites, values were similar throughout the sampling season with monthly differences of 0.4 to 2.4°C. Mad Horse Creek minimum and maximum values ranged from 14.2°C in November to 27.3°C in August; Alloways Creek ranged from 13.4 °C in November to 28.0 °C in July; Mill Creek ranged from 13.0 °C in August to 27.8°C in July.

Salinity

The upper bay region mean salinity values, as observed during the 2006 "Marsh Fish Assemblage" sampling season, are presented in Figure 7-28. It is important to note that from June 24-28 a number of powerful storms caused "flash flooding and record to near record flood crests along many streams and rivers throughout the basin" and may impact the mean salinity within the sampling sites (www.state.nj.us/drbc/Flood_Website/events.htm#2006). Mad Horse Creek, a designated upper bay site but geographically intermediate, fluctuated the greatest in mean salinity ranging from a low of 5.7 ppt in July to a high of 11.6 ppt in August. A salinity gradient was evident across the upper bay region sites, with higher values at sites closer to the mouth of the bay (Mad Horse Creek) and lower values up the bay (Alloways Creek and Mill Creek). Alloways Creek ranged from 1.2 ppt in July to 5.7 ppt in August; Mill Creek ranged from 0.8 in July and November to 4.7 ppt in August. Lowest mean salinities were observed at Mill Creek.

Dissolved Oxygen

Monthly upper bay region sites mean dissolved oxygen values for the 2006 sampling season are depicted in figure 7-28. In general, mean dissolved oxygen decreased from May to seasonal lows in June and July, and then increased through November. Mad Horse Creek ranged from 4.0 mg/L in June to 7.7 mg/L in November; Alloways Creek ranged from 5.2 mg/L in July to 8.3 mg/L in November; Mill Creek ranged from 4.9 mg/L in July to 7.7 mg/L in September.

Mad Horse Creek Reference Site

General Catch Composition

A total of 1,149 fish, representing 23 species and 14 families, was collected in 126 otter trawl collections and 14 weir sets from May through November 2006 in the Mad Horse Creek Reference Site (Tables 7-1, 7-2, and 7-5). Most species collected were transients (60.9%), i.e. those that spend a portion of their life history outside of the Delaware Bay, and the remainder were residents (39.1%), i.e. those that spend their entire life history in the Bay. In addition, one invertebrate, i.e., blue crab (n = 847) and one reptile, i.e., diamondback terrapin (8), were included in the catches.

Large Marsh Creeks

A total of 1,062 fish, representing 23 species and 14 families, was collected in otter trawl collections during 2006 (Table 7-5). The total CPUE was 8.43. In the aggregate, four species comprised 92% of the total catch, and in order of decreasing abundance they were; white perch (46%), bay anchovy (24%), Atlantic croaker (18%), and hogchoker (4%). White perch, the most numerically abundant species, was also collected most frequently, occurring in 75% of the trawl

collections. Accordingly, less abundant species, bay anchovy, Atlantic croaker and hogchoker, were taken less frequently, occurring 43, 52 and 14% of the collections, respectively. No other species comprised more than 2% of the total catch, or occurred in more the 10% 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 relatively stable during the period May through October, with CPUE's ranging from 5.17 to 8.44 (Fig. 7-29). However, abundance peaked in November with a monthly mean CPUE of 19.94, and white perch was the predominant species comprising 52% (Figure 7-30).

Small Marsh Creeks

A total of 87 fish, representing seven species and seven families, was collected in weir sets during 2006 (Table 7-5). The total CPUE was 6.21. Four species comprised 94% of the total catch, and in order of decreasing abundance they were; mummichog (57%), bay anchovy (14), Atlantic menhaden (13), and white perch (10). Mummichog occurred in 64% of the weir sets, white perch in 36%, bay anchovy in 21%, Atlantic silverside in 14% and hogchoker in 14%. 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 relatively stable during the period May through October, with CPUE's ranging from 2.50 to 6.50 (Fig. 7-29). However, abundance peaked in November with a monthly mean CPUE of 19.50 , and mummichug was the predominant species with 74% (Figure 7-30).

Alloway Creek Watershed Restoration Site – Alloway Creek Sampling Area

General Catch Composition

A total of 1,207 fish, representing 10 species and nine families, was collected in 42 weir sets from May through November 2006 in the Alloway Creek Sampling Area (Tables 7-1, 7-2 and 7-6). The representation of transient and resident species was equal with five species of each. In addition, one invertebrate, i.e., blue crab (n = 122) were included in the catches. The total CPUE was 28.74. Mummichog comprised 98% of the total catch, and occurred in 88% of the weir sets. All other species were represented by 10 specimens or less, and occurred in no more than 14% of the sets. Fish abundance in the small marsh creeks at the Alloway Creek site, as expressed by monthly catch-per-unit-effort (CPUE) for all fish collected in weir sets, was highest in July, with a CPUE of 105.00 (Fig. 7-31). During the other months of sampling, CPUE ranged from 9.67 to 29.50. Mummichug was the predominant species for all months at the Alloways Creek Sampling Area ranging from 89% in October to 100% in August (Figure 7-32).

Alloway Creek Watershed Restoration Site – Mill Creek Sampling Area

General Catch Composition

A total of 4,921 fish, representing 21 species and 13 families, was collected in 117 otter trawl collections and 14 weir sets from May through November 2006 in the Mill Creek Sampling Area (Tables 7-1, 7-2, and 7-7). The representation of transient and resident species was more or less equal with 10 and 11 species, respectively. In addition, one invertebrate, i.e., blue crab (n = 227) were included in the catches.

Catch in Large Marsh Creeks

A total of 3,006 fish, representing 19 species and 11 families, was collected in otter trawl collections during 2006 (Table 7-7). The total CPUE was 25.69. In the aggregate, four species comprised 92% of the total catch, and in order of decreasing abundance they were; white perch (43%), bay anchovy (23), Atlantic croaker (22), and brown bullhead (4). White perch, the most numerically abundant species, was also collected most frequently, occurring in 81% of the trawl collections. Conversely, Atlantic croaker, which comprised less than a quarter of the total catch, was taken in 75% of the collections. While similarly less abundant species, bay anchovy and brown bullhead, were taken less frequently, occurring in 54 and 29% of the collections, respectively. 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, fluctuated monthly from lower CPUE's ranging from 14.77 to 25.00 to higher values ranging from 29.87 to 34.83 (Fig. 7-33). However given the inherent variability of the data, abundance may have been more stable than the graphic would suggest. The dominant species during the temporal peaks was white perch during May and September through November, and Atlantic croaker during June and July, and bay anchovy during August (Figure 7-34).

Catch in Small Marsh Creeks

A total of 1,915 fish, representing 14 species and 11 families, was collected in weir sets during 2006 (Table 7-7). The total CPUE was 136.79. Three species comprised 90% of the total catch, and in order of decreasing abundance they were; mummichog (82%), bay anchovy (4%) and brown bullhead (4%). Mummichog occurred in all of the weir sets, brown bullhead in 57% and bay anchovy in 29%. Fish abundance in the small marsh creeks at the Mill Creek area was highest in July, with a CPUE of 447.50, and white perch was the predominant species comprising 99% (Fig. 7-33 and 7-34). During the other months of sampling, CPUE ranged from 31.50 to 195.00 (Figure 7-33).

Target Species Accounts for the Upper Bay Region

Bay Anchovy

In the large marsh creeks of the Upper Bay Region, bay anchovy comprised 24 and 23% of the total catch at the Mad Horse Creek Reference and Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 43 and 54% of the respective otter trawl collections (Tables 7-5 and 7-7). At Mad Horse Creek, a total, of 254 individuals, was collected and their mean CPUE for the study period was 2.02. At Mill Creek, a total of 702 was taken, and the CPUE was 6.00. Bay anchovy abundance at Mad Horse was similarly high in August and November with CPUE's of 4.72 and 5.33, respectively (Figure 7-35). During the other months of sampling CPUE was ≤1.22. At Mill Creek, bay anchovy abundance also peaked in August at 26.33, but no fall spike was recorded as CPUE was ≤7.67 in the other months of sampling. Individuals collected at Mad Horse Creek ranged from 13 to 83 mm FL (Figure 7-36). All specimens collected in May and June were age 1+ and older. During August and November, when abundance was high, age 0+ individuals ≤48 and 63 mm FL, respectively, comprised 94 and 82% of the specimens measured, respectively. Individuals collected at Mill Creek ranged from 18 to 78 mm FL (Figure 7-37). All but one specimen measured in June was age 1+ and older. However during the period August through November, age 0+ specimens were predominant, comprising from 93 to 100% of the individuals measured. In August when

abundance was highest at Mill Creek, specimens 23 and 28 mm FL comprised 50% of the specimens measured. Thereafter, the length of predominant groups increased suggestive either of growth from within the study area or recruitment from outside the area.

In the small marsh creeks of the Upper Bay Region, bay anchovy comprised 14, <1 and 4% of the total catch at the Mad Horse Creek Reference Site, and Alloway and Mill Creek Areas within the Alloway Creek Restoration Site, respectively, occurring in 21, 2 and 29% of the respective weir sets (Tables 7-5, 7-6 and 7-7). At Mad Horse Creek, a total of 12 individuals was collected, and their mean CPUE for the study period was 0.86. At the Alloway Creek Area, one bay anchovy was taken, and the CPUE was 0.02. However at the Mill Creek Area, a total 77 was collected, and the CPUE was 5.50. At Mad Horse Creek, bay anchovy were collected only in May, October and November with CPUE's of 0.50, 0.50, and 5.00, respectively (Figure 7-38). At Alloway Creek, they were collected only in July with CPUE of 0.17. At Mill Creek, bay anchovy were collected only in October and November with CPUE's of 11.00 and 27.00, respectively. Individuals collected at Mad Horse Creek ranged from 23 to 63 mm FL, the specimen collected At Alloway Creek was 33 mm FL, and those individuals collected at Mill Creek ranged from 28 to 58 mm FL (Figures 7-36, 7-37 and 7-39). All bay anchovy collected in weir sets in the small marsh creeks of the Upper Bay Region were age 0+.

Spot

In the large marsh creeks of the Upper Bay Region, spot comprised <1 and 3% of the total catch at the Mad Horse Creek Reference and Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 3 and 24% of the respective otter trawl collections (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 0.03. At Mill Creek, a total of 88 was taken, and the CPUE was 0.75. At Mad Horse Creek, spot were collected only in May and June with CPUE's of 0.06 and 0.17, respectively (Figure 7-40). At Mill Creek, spot were collected in all months of sampling except November, and abundance peaked in June at 4.27. CPUE was ≤0.54 in the other months of their occurrence. Individuals collected at Mad Horse Creek during June were 93 and 103 mm FL, and were probably age 1+ (Figure 7-41). Individuals collected at Mill Creek ranged from 33 to 168 mm FL, (Figure 7-42). In June when spot abundance was highest at Mill Creek, all but one specimen measured were age 1+. No spot were taken in the small marsh creeks of the Upper Bay Region.

Weakfish

In the large marsh creeks of the Upper Bay Region, weakfish comprised 1 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 6 and 3% of the respective otter trawl collections (Tables 7-5, 7-6, and 7-7). At Mad Horse Creek, a total, of nine individuals, was collected and their mean CPUE for the study period was 0.07. At Mill Creek, a total of 6 was taken, and the CPUE was 0.05. At Mad Horse Creek, weakfish were collected only in July, August and September with CPUE's of 0.06, 0.33 and 0.11, respectively (Figure 7-43). At Mill Creek, weakfish were collected only in August and September with CPUE's of 0.11 and 0.22, respectively. Individuals collected at Mad Horse Creek were between 73 and 133 mm FL (Figure 7-44). Individuals collected at Mill Creek ranged from 68 to 103 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 46 and 43% of the total catch at the Mad Horse Creek Reference and Mill Creek Area of the Alloway Creek Restoration Sites, respectively, occurring in 75 and 81% of the respective otter trawl collections (Tables 7-5, 7-6, and 7-7). At Mad Horse Creek, a total of 485 individuals was collected and their mean CPUE for the study period was 3.85. At Mill Creek, a total of 1,305 was taken, and the CPUE was 11.15. White perch abundance at Mad Horse was highest in November with CPUE of 10.33 (Figure 7-46). During the prior months of sampling CPUE was ≤3.50. At Mill Creek, white perch abundance is suggestive of a seasonally bimodal temporal distribution. CPUE declines from 10.69 in May, the first month of sampling, to relatively low summer values ranging from 2.33 to 6.67, then increases to a fall peak of 24.61 in October before decreasing to 12.71 in November. Individuals collected at Mad Horse Creek ranged from 48 to 283 mm FL; all but five specimens measured were age 1+ or older, possibly including individuals age 8+ (Figure 7-47). Individuals collected at Mill Creek ranged from 53 to 233 mm FL (Figure 7-48). Similar to Mad Horse Creek, very few individuals measured were age 0+; possibly as few as 12.

In the small marsh creeks of the Upper Bay Region, white perch comprised 10, 1 and 3% of the total catch at the Madhorse Creek Reference Site, and Alloway and Mill Creek Areas within the Alloway Creek Restoration Site, respectively; occurring in 36, 12 and 29% of the respective weir sets (Tables 7-5, 7-6 and 7-7). At Mad Horse Creek, a total of nine individuals was collected, and their mean CPUE for the study period was 0.64. At the Alloway Creek Area, a total of 10 white perch was taken, and the CPUE was 0.24. However at the Mill Creek Area, a total 67 was collected, and the CPUE was 4.79. At Mad Horse Creek, white perch abundance was highest in September with a CPUE of 2.00 (Figure 7-49). At Alloway Creek, they were similarly abundant in July and October with respective CPUE's of 0.50. At Mill Creek, white perch abundance was highest in October with a CPUE of 25.50; CPUE was ≤6.00 in the other months of their occurrence. Individuals collected at Mad Horse Creek ranged from 83 to 168 mm FL; those collected at Alloway Creek ranged from 88 to 148 mm FL, and those collected at Mill Creek ranged from 63 to 208 mm FL (Figures 7-47, 7-48 and 7-50). All white perch collected in weir sets in the small marsh creeks of the Upper Bay Region were age 1+ and older.

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

Abundance of all species collected in the large marsh creeks of the upper bay was 3.0 times greater at the Mill Creek Sampling Area of the ACW Site (CPUE = 25.69) than at the Mad Horse Creek Reference Site (CPUE = 8.43) (Tables 7-5 and 7-7; Figure 7-51). This difference was not the result of the predominance of one or two species, but rather reflected an assemblage-wide contribution to higher abundance at Mill Creek. The three predominant species at both sites, white perch, bay anchovy and Atlantic croaker, were 2.9, 3.0, and 3.7 times more abundant, respectively, at Mill Creek. The comparison of aggregate CPUE's for all other species also indicates that abundance was 2.8 times higher at Mill Creek. The contribution to overall fish abundance at Mill Creek made by the other two target species, weakfish and spot, was more dubious because of relatively small catches. Weakfish, with <10 specimens collected at either site, was 1.5 times more abundant at Mad Horse Creek (0.07) than at Mill Creek (0.05), while spot were 23.7 times more abundant at Mill Creek (0.75) than at Mad Horse Creek (0.03).

Fish species richness was higher at Mad Horse Creek with 23 species than at Mill Creek with 19 species (Figure 7-51). There were 14 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 <10 individuals. The top three species in abundance at both sites, white perch, bay anchovy and Atlantic croaker, were ranked first, second and third, respectively, at both sites and comprised 88% of the total catch at both sites. While both sites are located in the "upper bay", they also are in the transitional portion the estuary where generally freshwater and saltwater assemblages intermingle at the boundaries of their favored distributions. This intermingling may be evidenced in two ways: 1.) the relative ranking within sites and 2.) the absence/presence from sites. Hogchoker, an estuarine resident species, was ranked fourth at Mad Horse Creek and tied for twelfth at Mill Creek, while the brown bullhead, a freshwater resident species, was tied for fourteenth at Mad Horse and fourth at Mill Creek. Species which are typically more associated with the higher salinity waters of the "lower bay", including northern kingfish, toadfish, summer flounder, windowpane, and blackcheek tonguefish, were taken exclusively at Mad Horse Creek. Similarly, species which are typically more associated with the low or no salinity waters of the freshwater tidal river, including carp, eastern silvery minnow, green sunfish and black crappie, 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 Alloways Creek, the total CPUE (28.74) was 4.6 times greater than that at Mad Horse Creek (6.21), and at Mill Creek it (136.79) was 22.0 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 Mill Creek where mummichog abundance was two orders of magnitude higher than at Mad Horse Creek. Like abundance, fish species richness was higher at Alloway and Mill Creeks with 10 and 14 species, respectively, than at the Mad Horse Creek Reference Site with seven species (Figure 7-51). All species taken at Mad Horse Creek were common to both Alloway and Mill Creeks, and all species taken at Alloway Creek were common to Mill Creek. The absence of the recently ubiquitous Atlantic croaker from weir sets at Mad Horse Creek is both remarkable and unexplained. There were four species taken only at Mill Creek, but their occurrence was incidental as they were represented by a solitary individuals. Regarding species rank order, mummichog was first at all three sites; bay anchovy was ranked second at Mad Horse and Mill Creek, but ranked tied for seventh at Alloway; Atlantic menhaden was ranked third, fifth and sixth at Mad Horse, Alloway and Mill Creek, respectively; and white perch was ranked fourth, second and fifth at Mad Horse, Alloway and Mill Creek, respectively. The other two target species, weakfish and spot, were not taken in weir sets in the Upper Bay Region.

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Table 7-1. Summary of sampling efforts for the 2006 Marsh Fish Assemblage sampling season.

SITE	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Site Totals
Lower Bay								
Moores Beach								
Trawls	18	18	18	18	18	18	18	126
Weirs	2	2	2	2	2	2	2	14
Commercial Township								
Trawls	15	18	18	18	18	18	18	123
Weirs	2	2	2	2	2	2	2	14
Upper Bay								
Mad Horse Creek								
Trawls	18	18	18	18	18	18	18	126
Weirs	2	2	2	2	2	2	2	14
Mill Creek Area								
Trawls	13	15	18	18	18	18	17	117
Weirs	2	2	2	2	2	2	2	14
Alloways Creek Area								
Weirs	6	6	6	6	6	6	6	42
Monthly Totals								
Trawls	64	69	72	72	72	72	71	492
Weirs	14	14	14	14	14	14	14	98
Combined	78	83	86	86	86	86	85	590

Table 7-2 Checklist of Delaware Bay fauna collected from May 2006 to November 2006. Key: T = Transient, R = Resident.

	Species	Common Name	Pattern of Utilizations
Invertebrates			
	Callinectes sapidus	blue claw crab	R
	Limulus polyphemus	horseshoe crab	T
Anguillidae			
	Anguilla rostrata	American eel	T
Atherinidae			
	Menidia menidia	Atlantic silverside	T
Batrachoididae			
	Opsanus tau	oyster toadfish	R
Bothidae			
	Paralichthys dentatus	summer flounder	T
	Scopthalmus aquosus	windowpane	T
Centrarchidae			
	Lepomis cyanellus	green sunfish	R
	Pomoxis nigromaculatus	black crappie	R
Clupeidae			
	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
Cynoglossidae			
	Symphurus plagiusa	blackcheek tonguefish	T
Cyprinodontidae			
	Cyprinodon variegatus	sheepshead minnow	R
	Fundulus heteroclitus	mummichog	R
	Fundulus majalis	striped killifish	T
Engraulidae			
	Anchoa mitchilli	bay anchovy	T
Gadidae			
	Uropycis regia	spotted hake	T
Gobiidae			
	Gobiosoma bosc	naked goby	R
Ictaluridae			
	Ameiurus catus	white catfish	R
	Ameiurus nebulosus	brown bullhead	R
	Ictalurus punctatus	channel catfish	R
Mugilidae			
	Mugil curema	white mullet	T
Ophidiidae			
	Ophidion marginatum	striped cusk eel	T
Percichthyidae			
	Morone americana	white perch	R
	Morone saxatilis	striped bass	T

Table 7-2. Continued.

	Species	Common Name	Pattern of Utilizations
Pleuronectidae			
	Pleuronectes americanus	winter flounder	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
Soleidae			
	Trinectes maculatus	hogchoker	R
Syngnathidae			
	Syngnathus fuscus	northern pipefish	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 2006.

	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	--	--	--	--
Anchoa mitchilli	**25**	**6**	**0.62**	**78**	**14**	**<1**	**0.79**	**11**
Anguilla rostrata	3	<1	0.03	4	--	--	--	--
Bairdiella chrysoura	3	<1	0.03	4	--	--	--	--
Brevoortia tyrannus	8	6	0.67	84	14	<1	0.14	2
Cynoscion regalis	**4**	**1**	**0.06**	**7**	**--**	**--**	**--**	**--**
Cyprinodon variegatus	--	--	--	--	7	<1	0.07	1
Fundulus heteroclitus	4	2	0.17	22	86	84	213.36	2987
Fundulus majalis	1	<1	0.01	1	7	<1	0.07	1
Gobiosoma bosc	4	1	0.06	7	--	--	--	--
Leiostomus xanthurus	**5**	**<1**	**0.05**	**6**	**7**	**<1**	**0.07**	**1**
Menidia menidia	13	8	0.83	104	43	15	38.21	535
Menticirrhus saxatilis	2	<1	0.02	2	--	--	--	--
Micropogonias undulatus	56	61	6.63	835	14	<1	0.14	2
Morone americana	**15**	**3**	**0.36**	**45**	**--**	**--**	**--**	**--**
Morone saxatilis	12	1	0.15	19	--	--	--	--
Ophidion marginatum	1	<1	0.01	1	--	--	--	--
Opsanus tau	2	<1	0.02	2	--	--	--	--
Paralichthys dentatus	2	<1	0.02	2	--	--	--	--
Pleuronectes americanus	1	<1	0.01	1	--	--	--	--
Pogonias cromis	2	<1	0.02	2	--	--	--	--
Syngnathus fuscus	1	<1	0.01	1	--	--	--	--
Trinectes maculatus	9	4	0.40	50	--	--	--	--
Urophycis regia	6	6	0.64	81	--	--	--	--
Total Fish	**--**	**--**	**10.79**	**1359**	**--**	**--**	**252.86**	**3540**
Callinectes sapidus	77	50	10.94	1379	86	3	7.71	108
Limulus polyphemus	2	<1	0.02	2	--	--	--	--
Malaclemys terrapin	6	<1	0.06	7	--	--	--	--
Total All Species	**--**	**--**	**21.80**	**2747**	**--**	**--**	**260.57**	**3648**

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 2006.

	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	**50**	**47**	**12.39**	**1524**	**21**	**1**	**0.36**	**5**
Anguilla rostrata	7	<1	0.09	11	--	--	--	--
Bairdiella chrysoura	7	<1	0.11	13	21	1	0.79	11
Brevoortia tyrannus	7	<1	0.11	13	--	--	--	--
Cynoscion regalis	**23**	**6**	**1.50**	**185**	**7**	**<1**	**0.14**	**2**
Cyprinodon variegatus	--	--	--	--	14	<1	0.21	3
Dorosoma cepedianum	1	<1	0.01	1	--	--	--	--
Fundulus heteroclitus	1	<1	0.01	1	100	76	41.93	587
Gobiosoma bosc	1	<1	0.02	2	--	--	--	--
Leiostomus xanthurus	**6**	**<1**	**0.08**	**10**	**--**	**--**	**--**	**--**
Menidia menidia	7	1	0.15	18	71	20	11.21	157
Menticirrhus saxatilis	3	<1	0.03	4	--	--	--	--
Micropogonias undulatus	67	41	10.82	1331	7	<1	0.07	1
Morone americana	**22**	**1**	**0.39**	**48**	**--**	**--**	**--**	**--**
Morone saxatilis	3	<1	0.04	5	--	--	--	--
Mugil curema	1	<1	0.01	1	--	--	--	--
Ophidion marginatum	1	<1	0.01	1	--	--	--	--
Opsanus tau	1	<1	0.01	1	--	--	--	--
Paralichthys dentatus	2	<1	0.02	3	--	--	--	--
Pogonias cromis	3	<1	0.03	4	14	1	0.29	4
Pomatomus saltatrix	1	<1	0.01	1	--	--	--	--
Symphurus plagiusa	2	<1	0.02	2	--	--	--	--
Syngnathus fuscus	2	<1	0.02	2	--	--	--	--
Trinectes maculatus	12	1	0.21	26	--	--	--	--
Urophycis regia	2	<1	0.02	2	--	--	--	--
Total Fish	--	--	**26.09**	**3209**	--	--	**55.00**	**770**
Callinectes sapidus	80	13	3.98	490	93	21	15.00	210
Malaclemys terrapin	4	<1	0.05	6	--	--	--	--
Total All Species	--	--	**30.12**	**3705**	--	--	**70.00**	**980**

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 2006.

	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	2	<1	0.02	2	--	--	--	--
Ameiurus catus	1	<1	0.01	1	--	--	--	--
Ameiurus nebulosus	1	<1	0.01	1	--	--	--	--
Anchoa mitchilli	**43**	**24**	**2.02**	**254**	**21**	**14**	**0.86**	**12**
Anguilla rostrata	5	1	0.05	6	7	1	0.07	1
Bairdiella chrysoura	6	1	0.08	10	--	--	--	--
Brevoortia tyrannus	5	1	0.07	9	14	13	0.79	11
Cynoscion regalis	**6**	**1**	**0.07**	**9**	**--**	**--**	**--**	**--**
Dorosoma cepedianum	2	<1	0.02	3	--	--	--	--
Fundulus heteroclitus	6	2	0.15	19	64	57	3.57	50
Gobiosoma bosc	2	<1	0.02	2	7	2	0.14	2
Ictalurus punctatus	2	<1	0.02	3	--	--	--	--
Leiostomus xanthurus	**3**	**<1**	**0.03**	**4**	**--**	**--**	**--**	**--**
Menidia menidia	2	<1	0.02	3	14	2	0.14	2
Menticirrhus saxatilis	1	<1	0.01	1	--	--	--	--
Micropogonias undulatus	52	18	1.51	190	--	--	--	--
Morone americana	**75**	**46**	**3.85**	**485**	**36**	**10**	**0.64**	**9**
Morone saxatilis	10	2	0.13	16	--	--	--	--
Opsanus tau	1	<1	0.01	1	--	--	--	--
Paralichthys dentatus	1	<1	0.01	1	--	--	--	--
Scophthalmus aquosus	1	<1	0.01	1	--	--	--	--
Symphurus plagiusa	1	<1	0.01	1	--	--	--	--
Trinectes maculatus	14	4	0.32	40	--	--	--	--
Total Fish	**--**	**--**	**8.43**	**1062**	**--**	**--**	**6.21**	**87**
Callinectes sapidus	82	35	4.54	572	100	76	19.64	275
Malaclemys terrapin	7	<1	0.06	8	--	--	--	--
Total All Species	**--**	**--**	**13.03**	**1642**	**--**	**--**	**25.86**	**362**

Table 7-6. Composite species composition, for small marsh creek (weir) collections, for Alloway Creek area during May to November 2006.

	Small Marsh Creeks			
Species	**Percent frequency of occurrence**	**Percent composition**	**Catch per unit effort**	**Total Collected**
Ameiurus nebulosus	2	<1	0.10	4
Anchoa mitchilli	**2**	**<1**	**0.02**	**1**
Anguilla rostrata	2	<1	0.02	1
Brevoortia tyrannus	5	<1	0.05	2
Dorosoma cepedianum	2	<1	0.02	1
Fundulus heteroclitus	88	98	28.05	1178
Gobiosoma bosc	2	<1	0.02	1
Menidia menidia	14	1	0.17	7
Micropogonias undulatus	5	<1	0.05	2
Morone americana	**12**	**1**	**0.24**	**10**
Total Fish	**--**	**--**	**28.74**	**1207**
Callinectes sapidus	50	9	2.90	122
Total All Species	**--**	**--**	**31.64**	**1329**

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 2006.

	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**
Ameiurus nebulosus	29	4	1.02	119	57	4	5.29	74
Anchoa mitchilli	**54**	**23**	**6.00**	**702**	**29**	**4**	**5.50**	**77**
Anguilla rostrata	7	<1	0.08	9	7	<1	0.07	1
Bairdiella chrysoura	1	<1	0.01	1	--	--	--	--
Brevoortia tyrannus	19	2	0.44	52	21	2	2.29	32
Cynoscion regalis	**3**	**<1**	**0.05**	**6**	**--**	**--**	**--**	**--**
Cyprinis carpio	5	<1	0.06	7	7	<1	0.07	1
Dorosoma cepedianum	21	1	0.31	36	29	2	2.21	31
Fundulus heteroclitus	2	<1	0.03	3	100	82	111.79	1565
Gobiosoma bosc	--	--	--	--	7	<1	0.07	1
Hybognathus regius	1	<1	0.01	1	--	--	--	--
Ictalurus punctatus	2	<1	0.03	4	7	<1	0.07	1
Leiostomus xanthurus	**24**	**3**	**0.75**	**88**	**--**	**--**	**--**	**--**
Lepomis cyanellus	1	<1	0.01	1	--	--	--	--
Menidia menidia	--	--	--	--	43	3	4.14	58
Micropogonias undulatus	75	22	5.61	656	14	<1	0.36	5
Morone americana	**81**	**43**	**11.15**	**1305**	**29**	**3**	**4.79**	**67**
Morone saxatilis	7	<1	0.08	9	7	<1	0.07	1
Pomatomus saltatrix	3	<1	0.03	3	7	<1	0.07	1
Pomoxis nigromaculatus	1	<1	0.01	1	--	--	--	--
Trinectes maculatus	2	<1	0.03	3	--	--	--	--
Total Fish	**--**	**--**	**25.69**	**3006**	**--**	**--**	**136.79**	**1915**
Callinectes sapidus	37	3	0.77	90	86	7	9.79	137
Total All Species	**--**	**--**	**26.46**	**3096**	**--**	**--**	**146.57**	**2052**

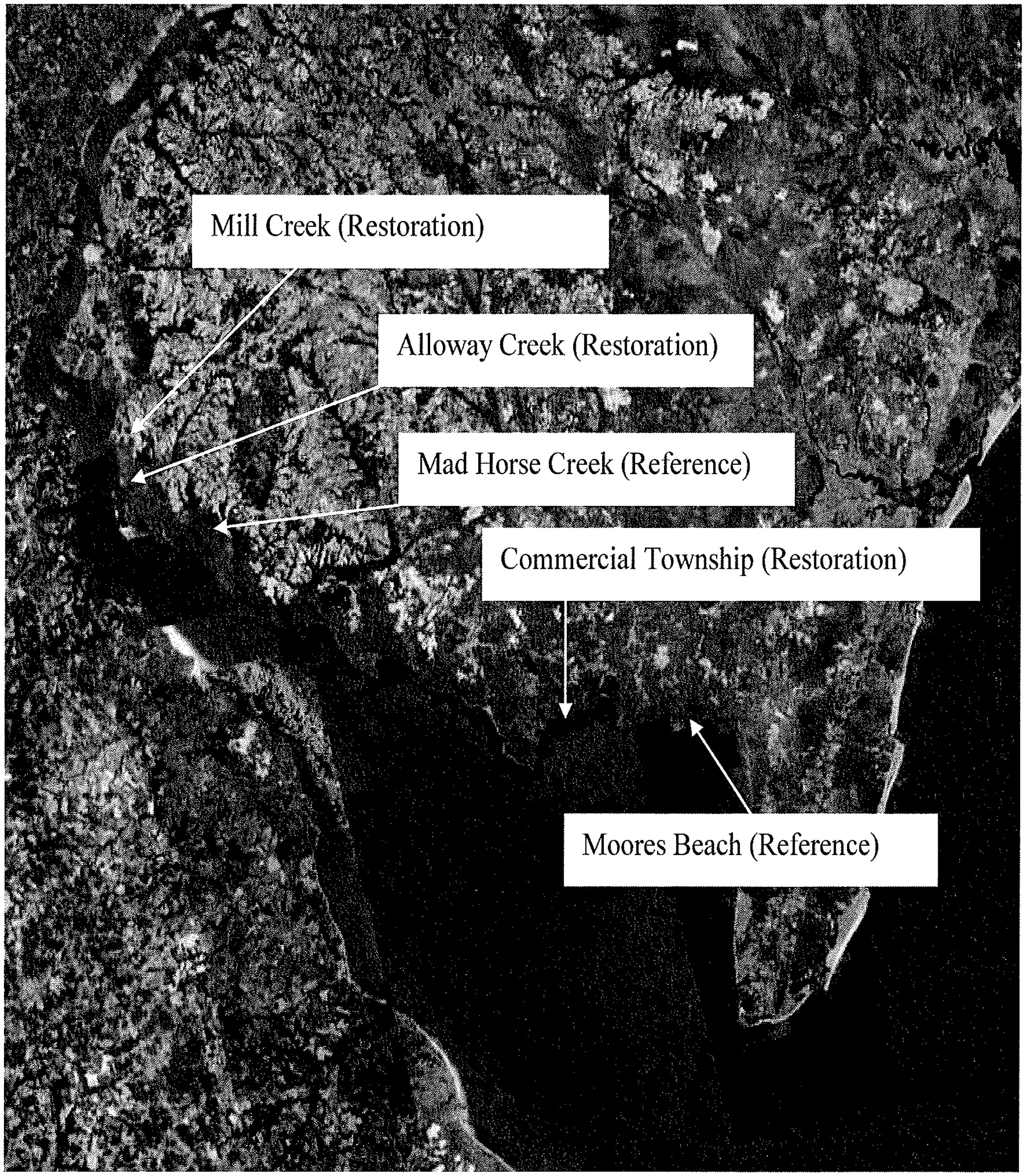


Figure 7-1. Restored and reference marsh study sites in Delaware Bay.

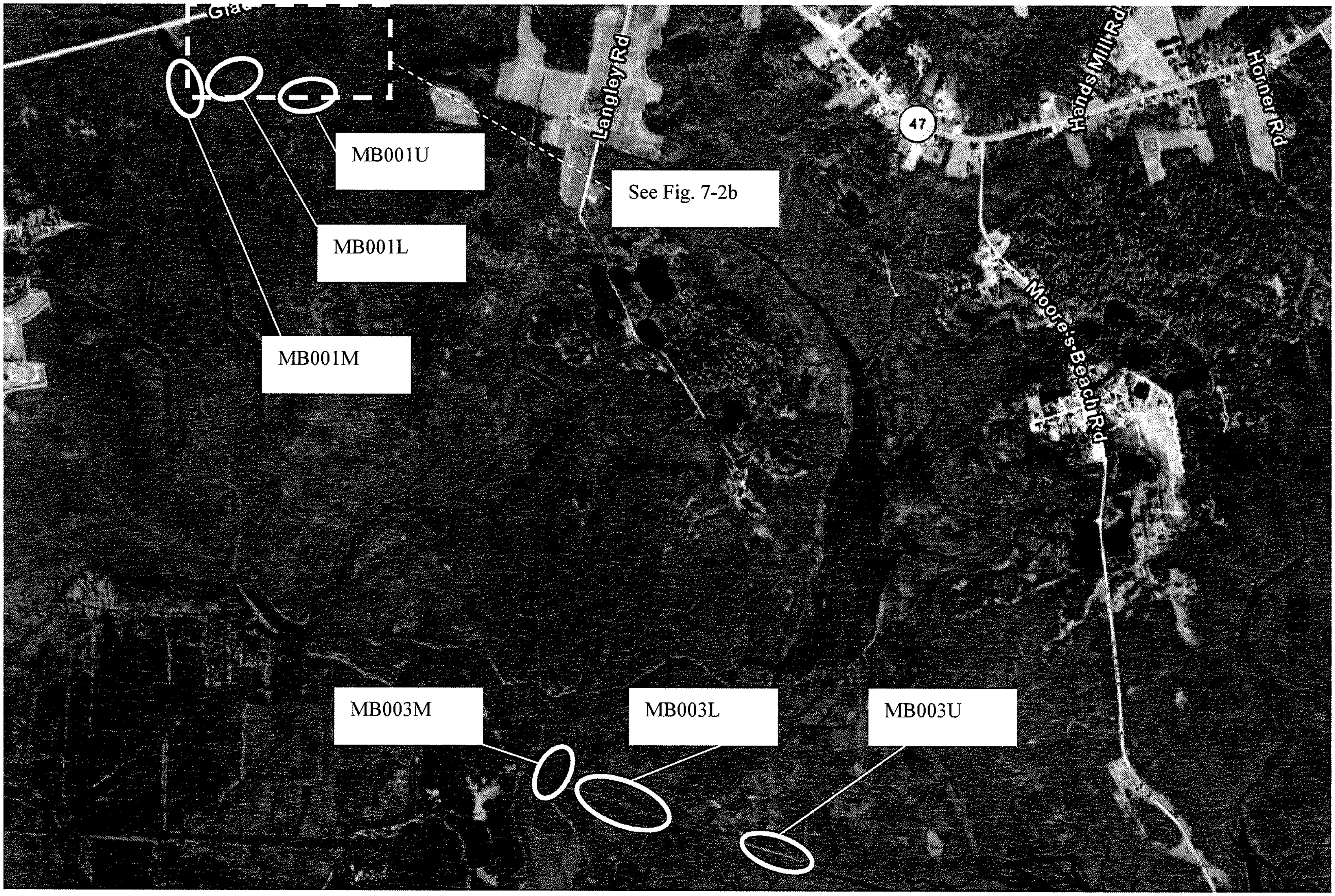


Figure 7-2a. Moores Beach sampling sites (reference) in Delaware Bay during 2006.

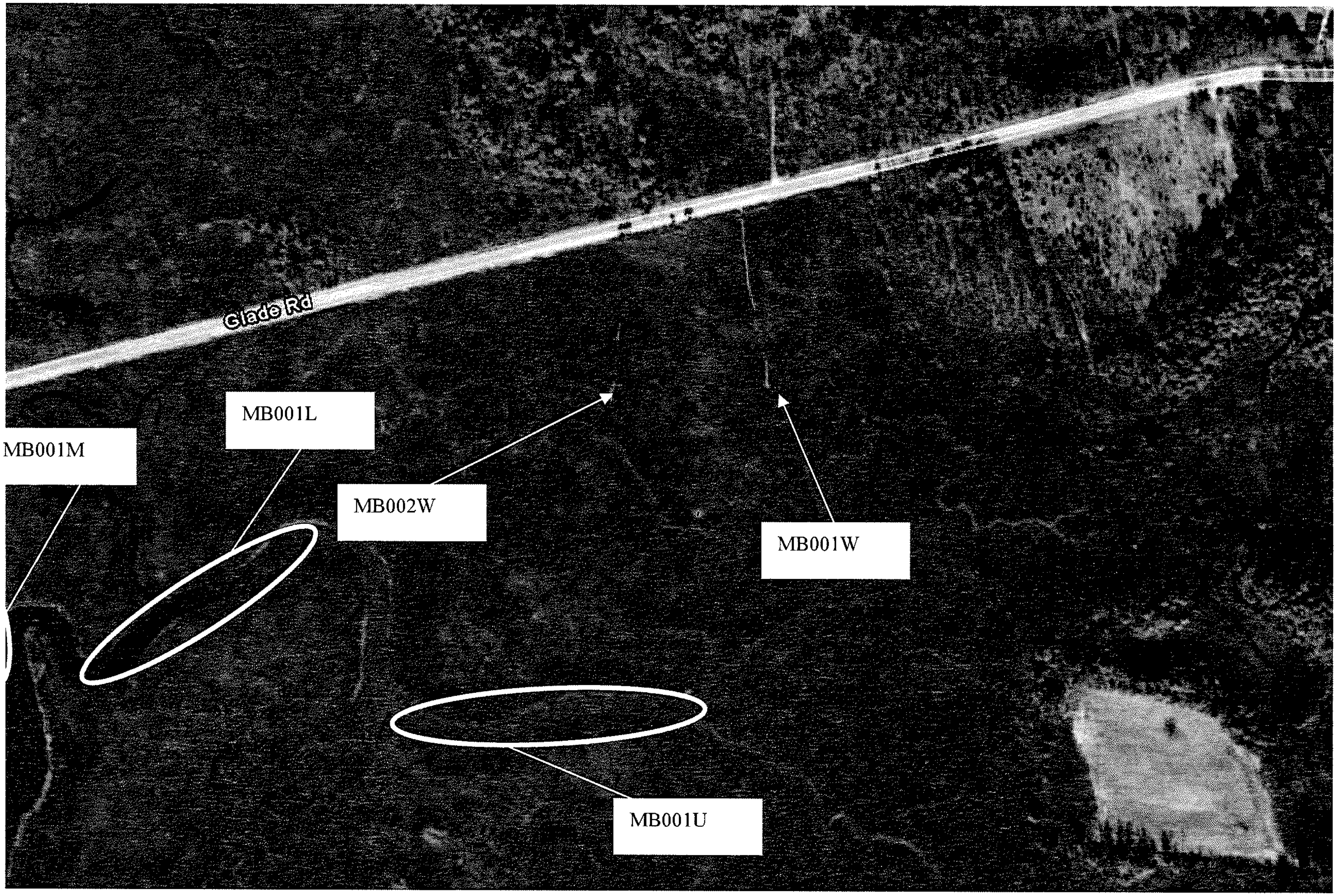


Figure 7-2b. Expanded view of small marsh creeks (weir) at the Moores Beach Reference Site in Delaware Bay during 2006.

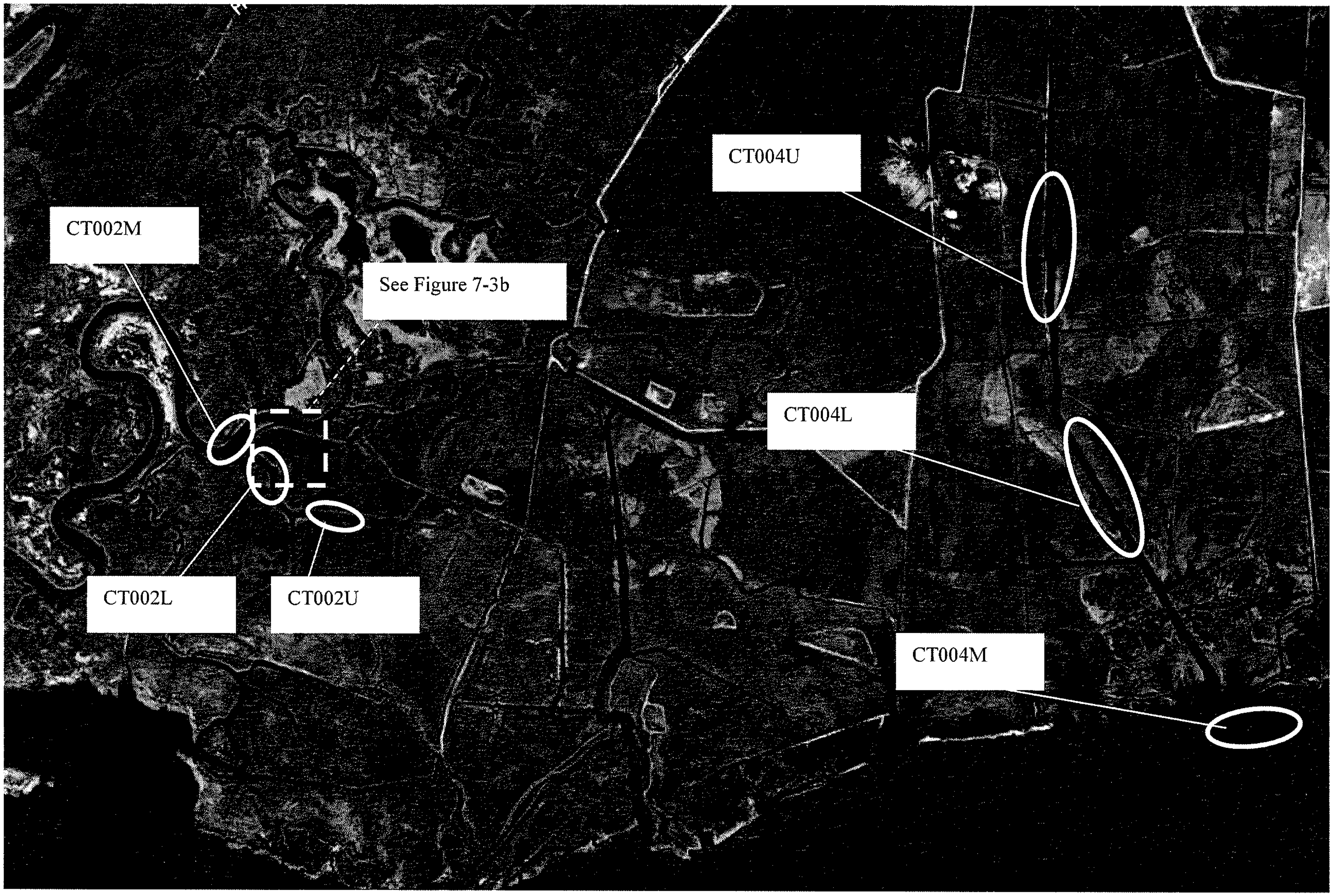


Figure 7-3a. Commercial Township sampling sites (restoration) in Delaware Bay during 2006.

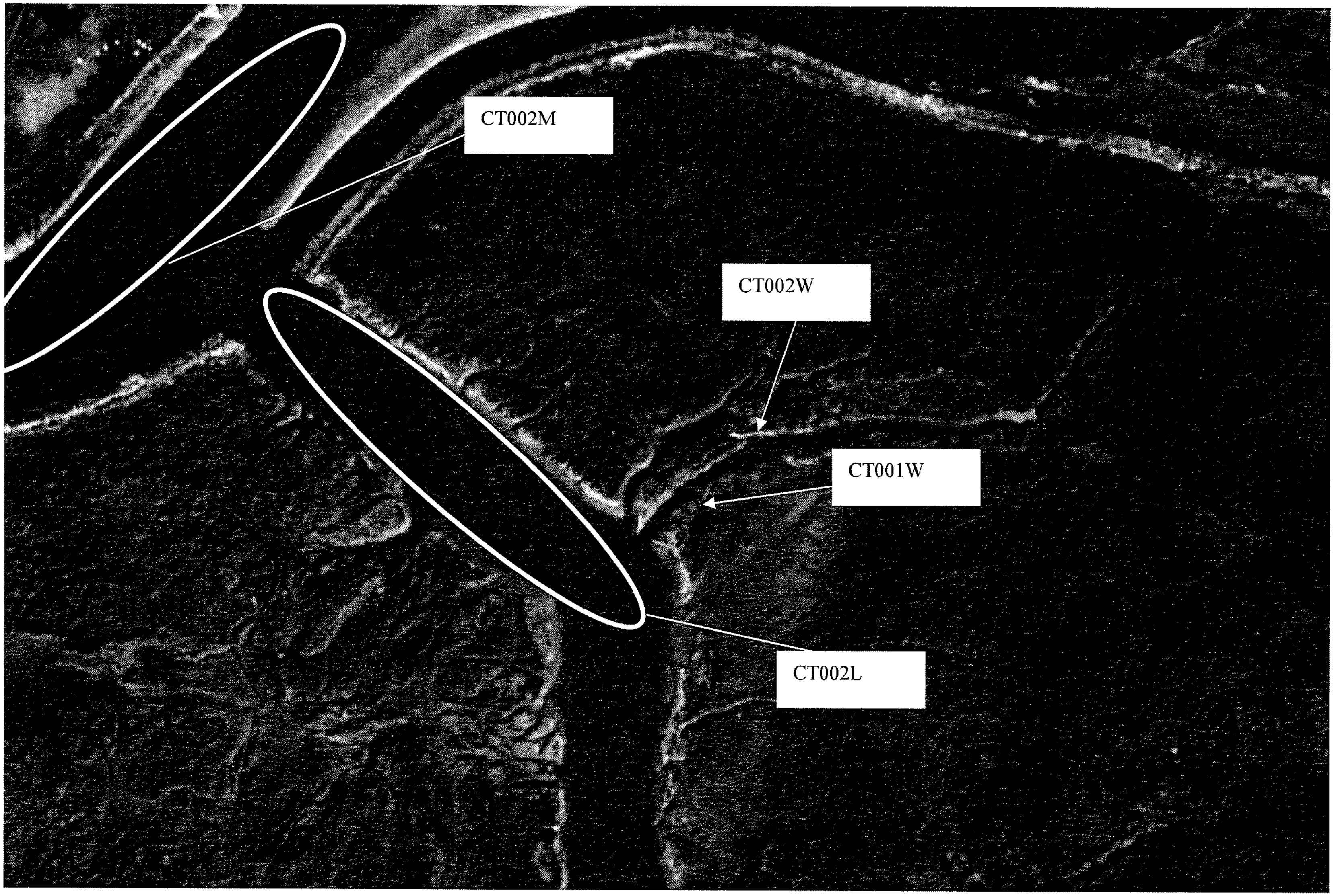


Figure 7-3b. Expanded view of small marsh creeks (weir) at the Commercial Township Restoration Site in Delaware Bay during 2006.

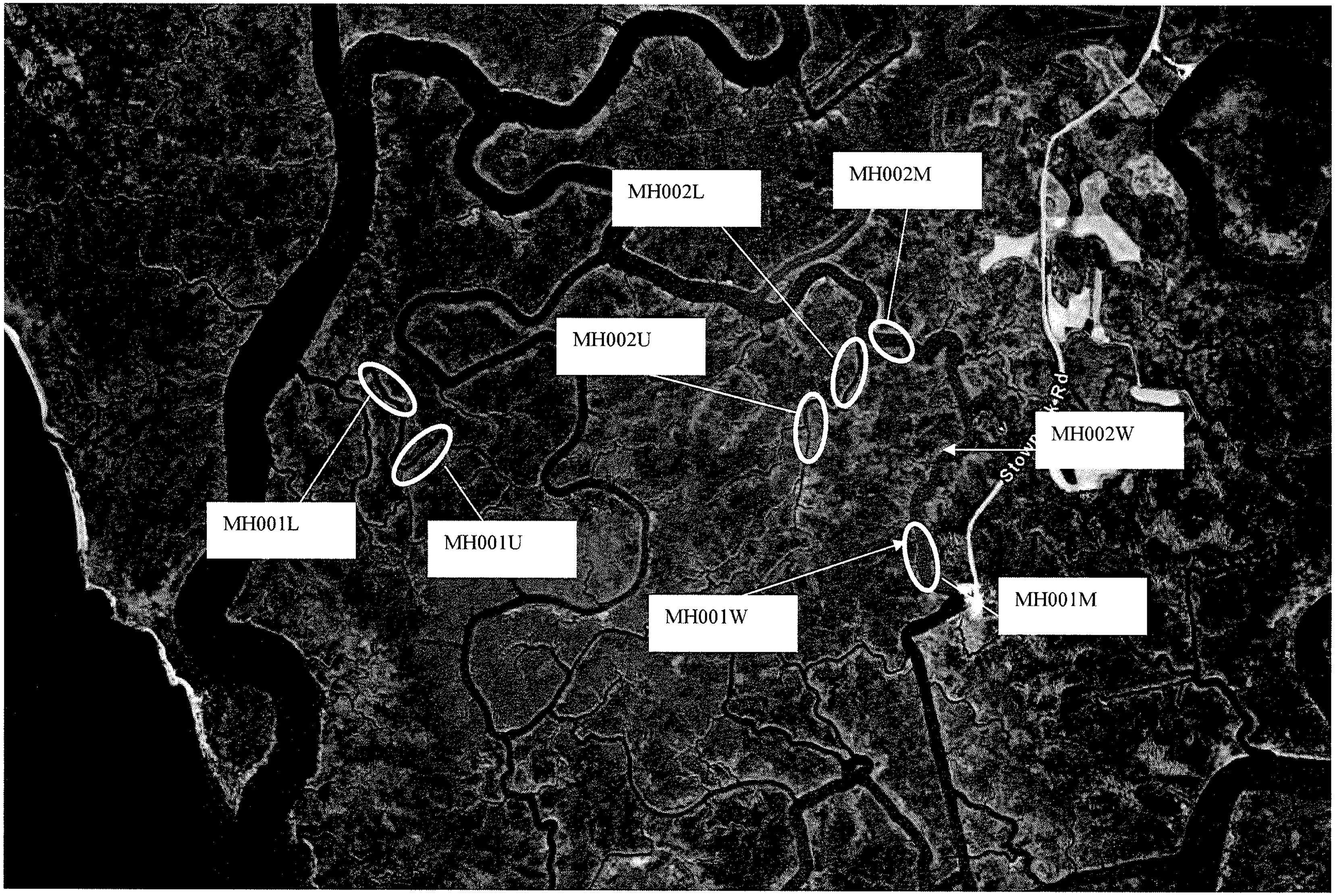


Figure 7-4. Mad Horse Creek sampling sites (reference) in Delaware Bay during 2006.

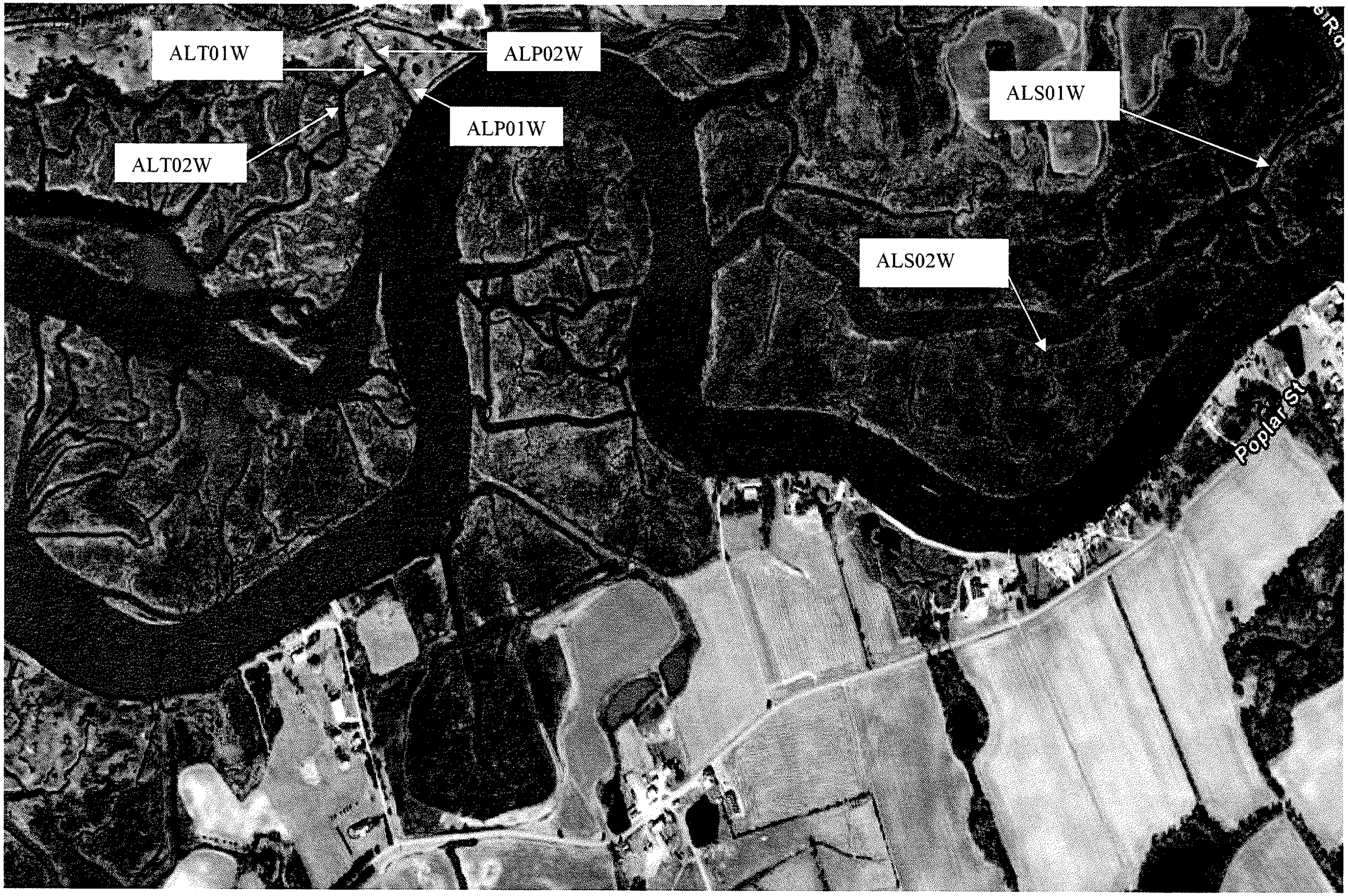


Figure 7-5. Alloways Creek sampling sites (restoration) in Delaware Bay during 2006.

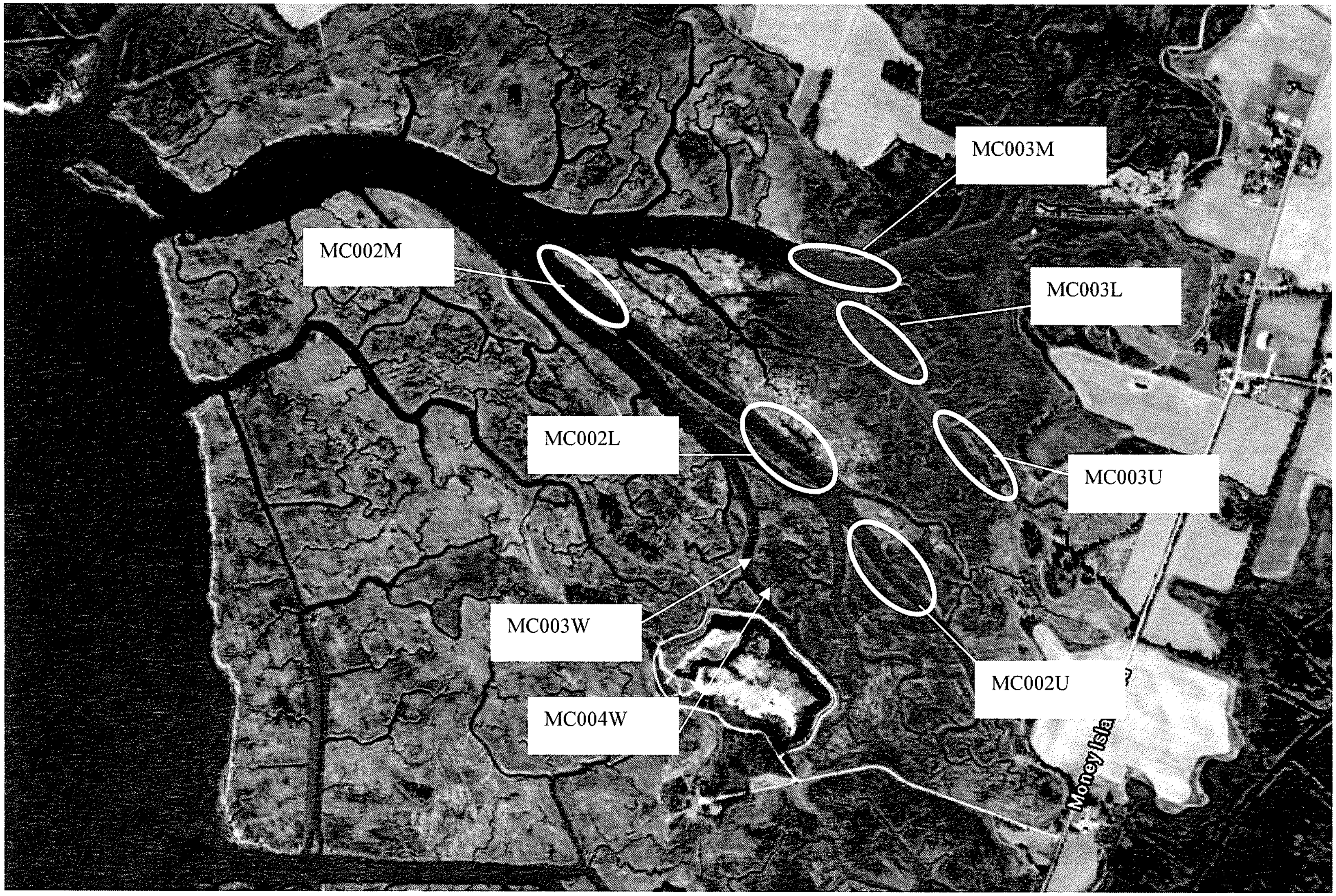


Figure 7-6. Mill Creek sampling (restoration) sites in Delaware Bay during 2006.

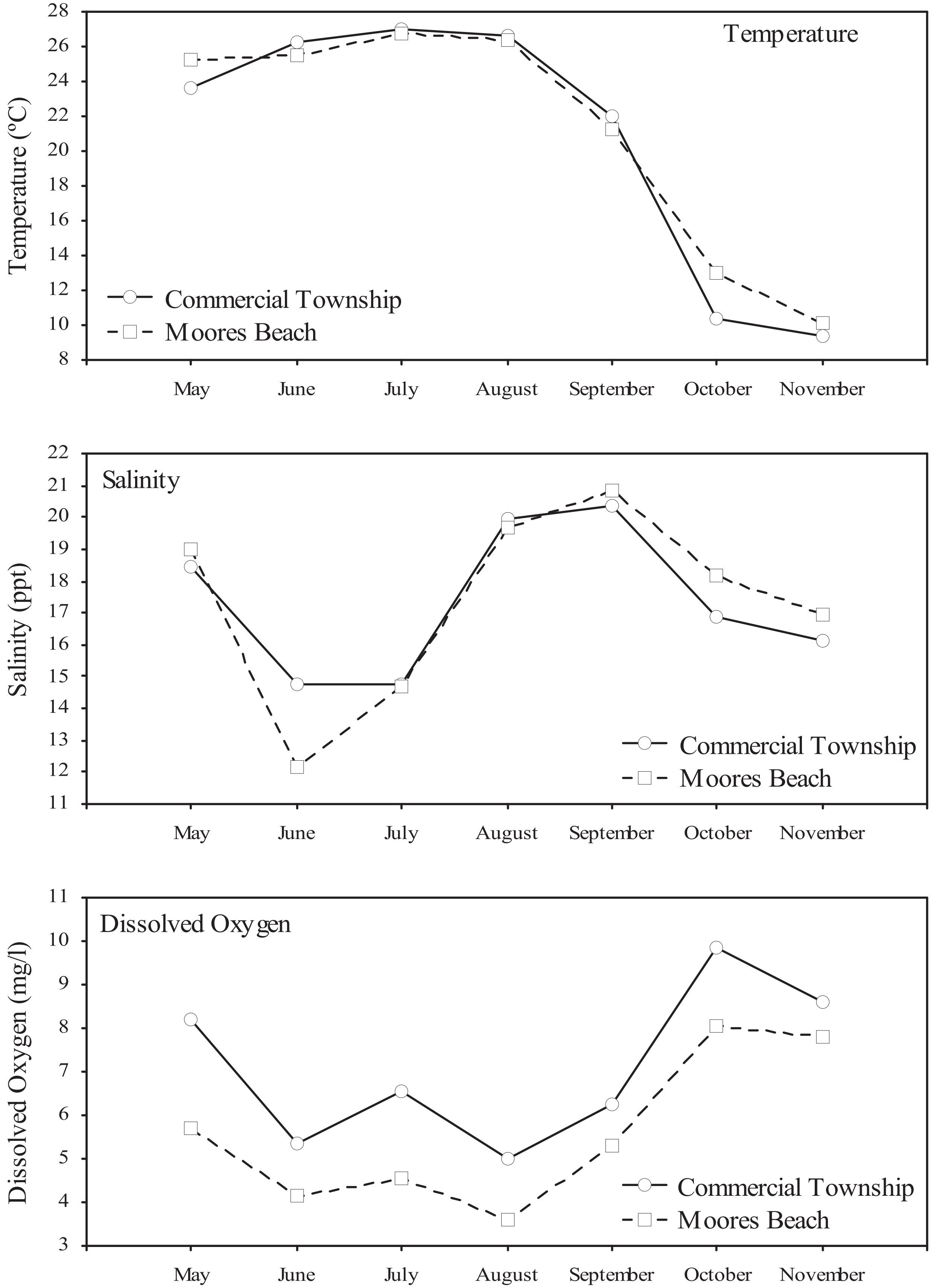


Figure 7-7. Selected physical parameters at regularly sampled sites in the Lower Delaware Bay Region during 2006.

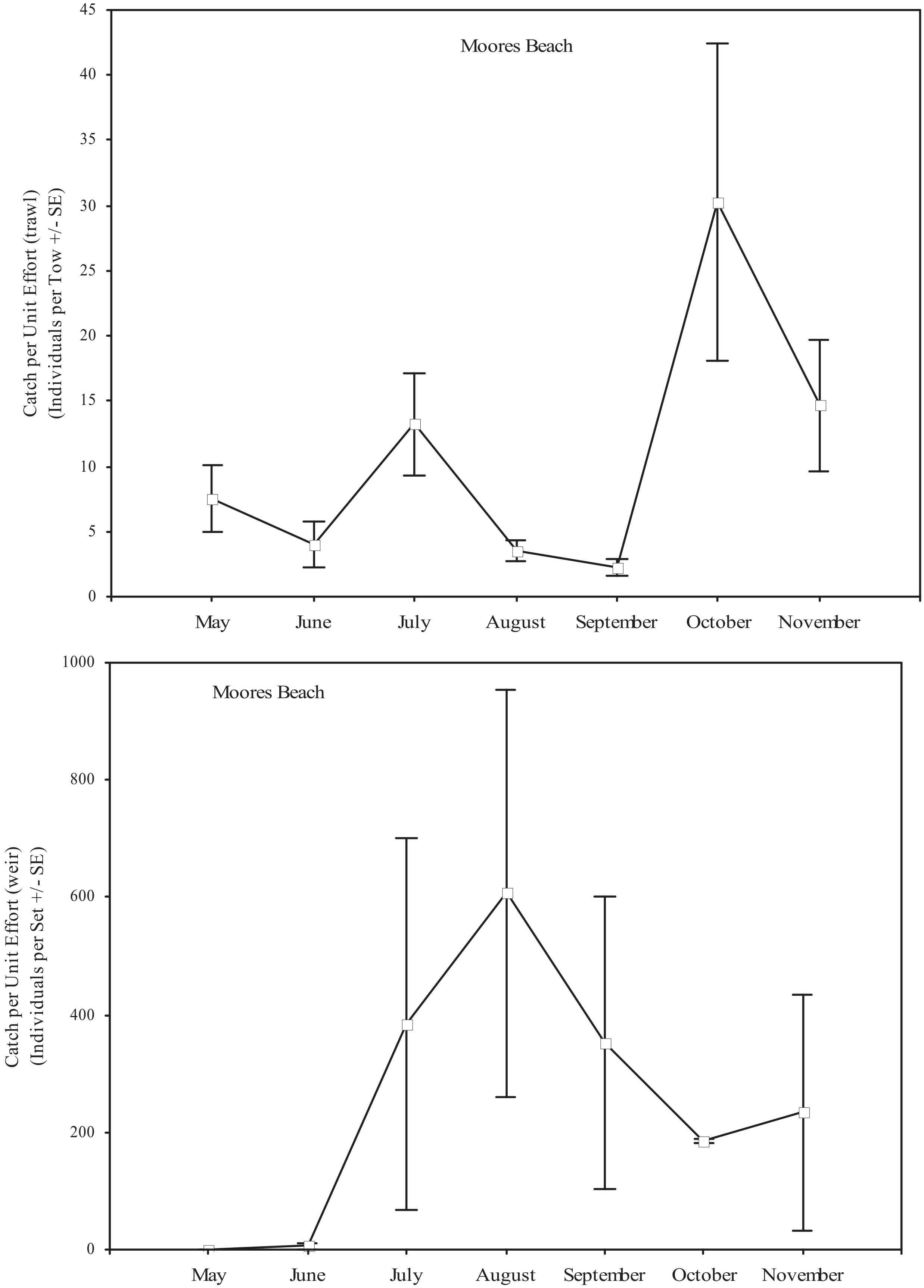


Figure 7-8. Monthly abundance for all fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach during 2006.

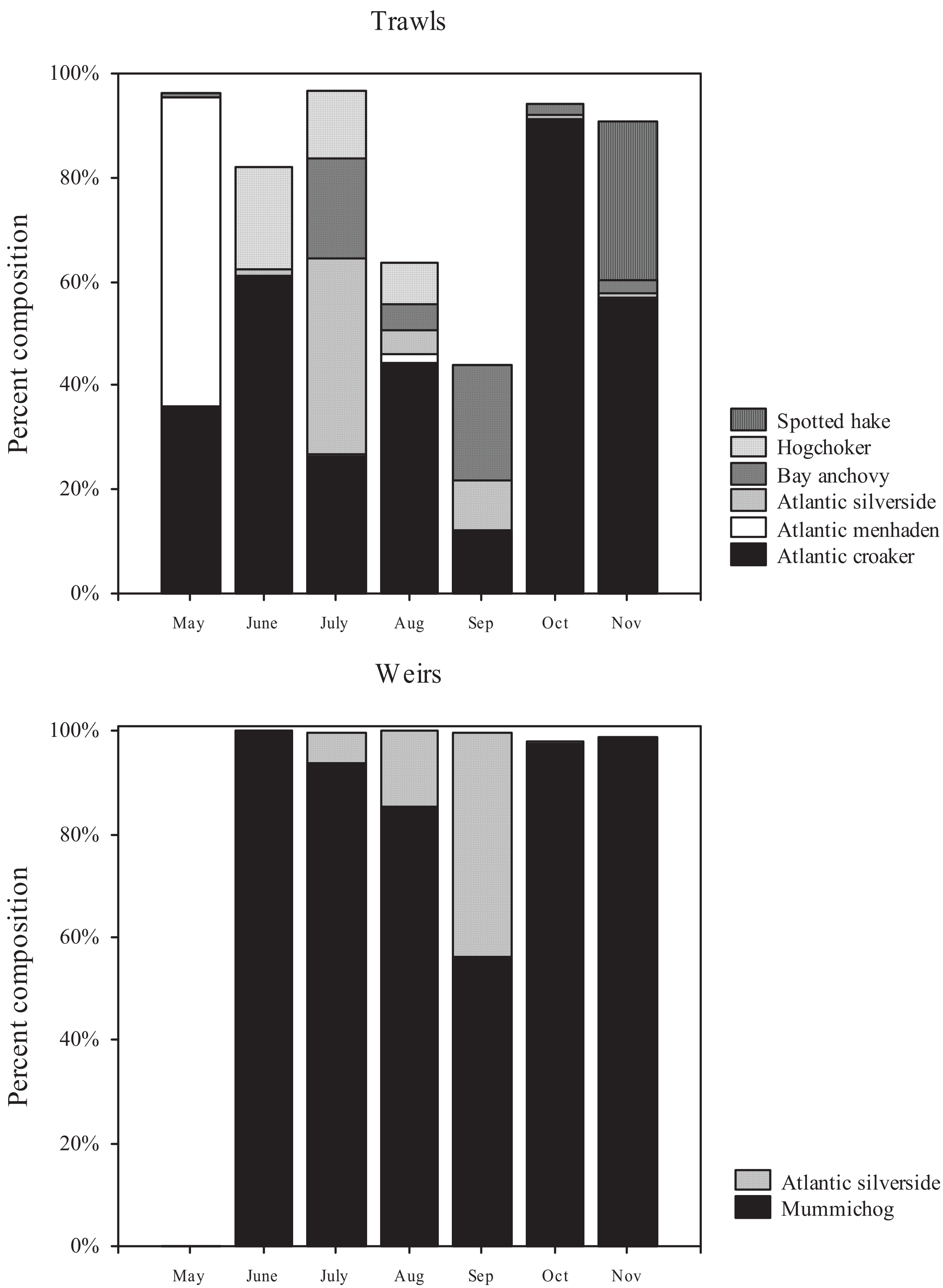
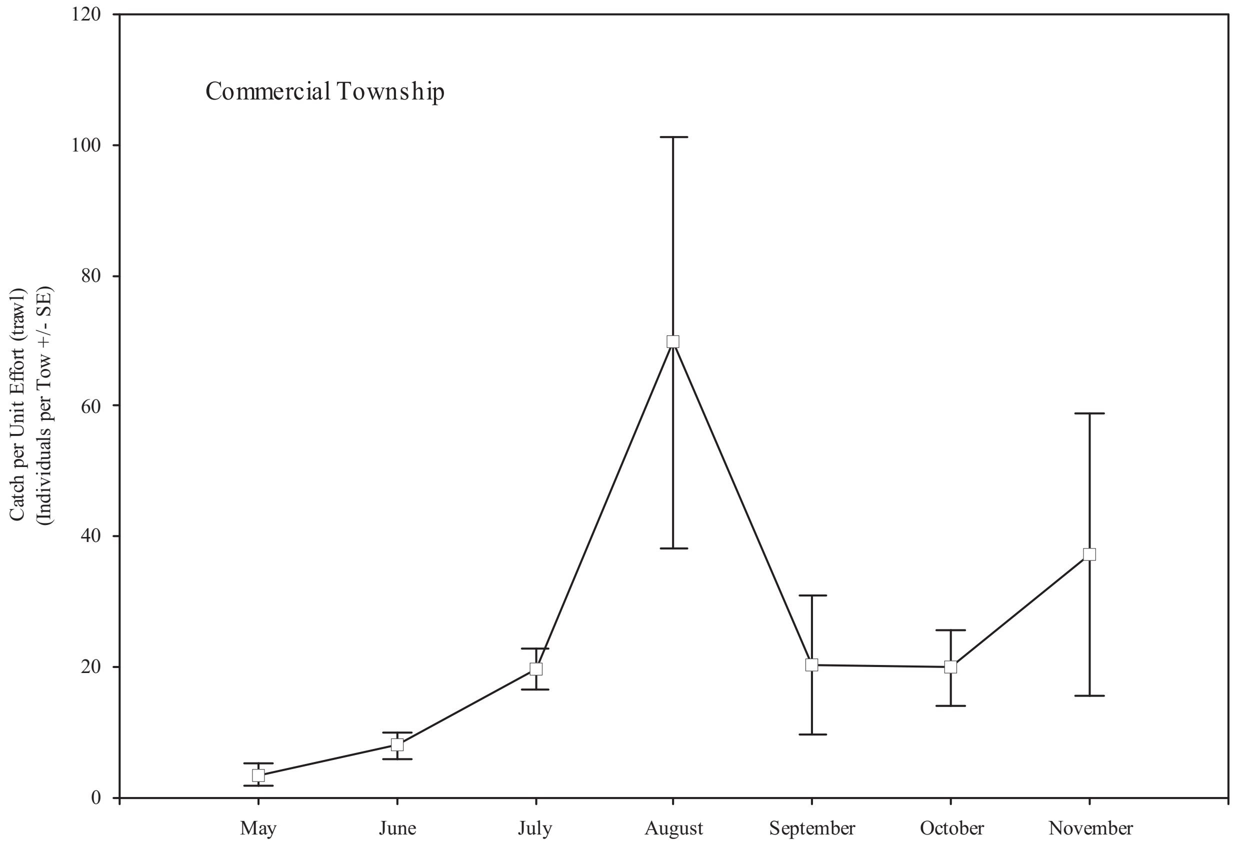


Figure 7-9. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Moores Beach during 2006.



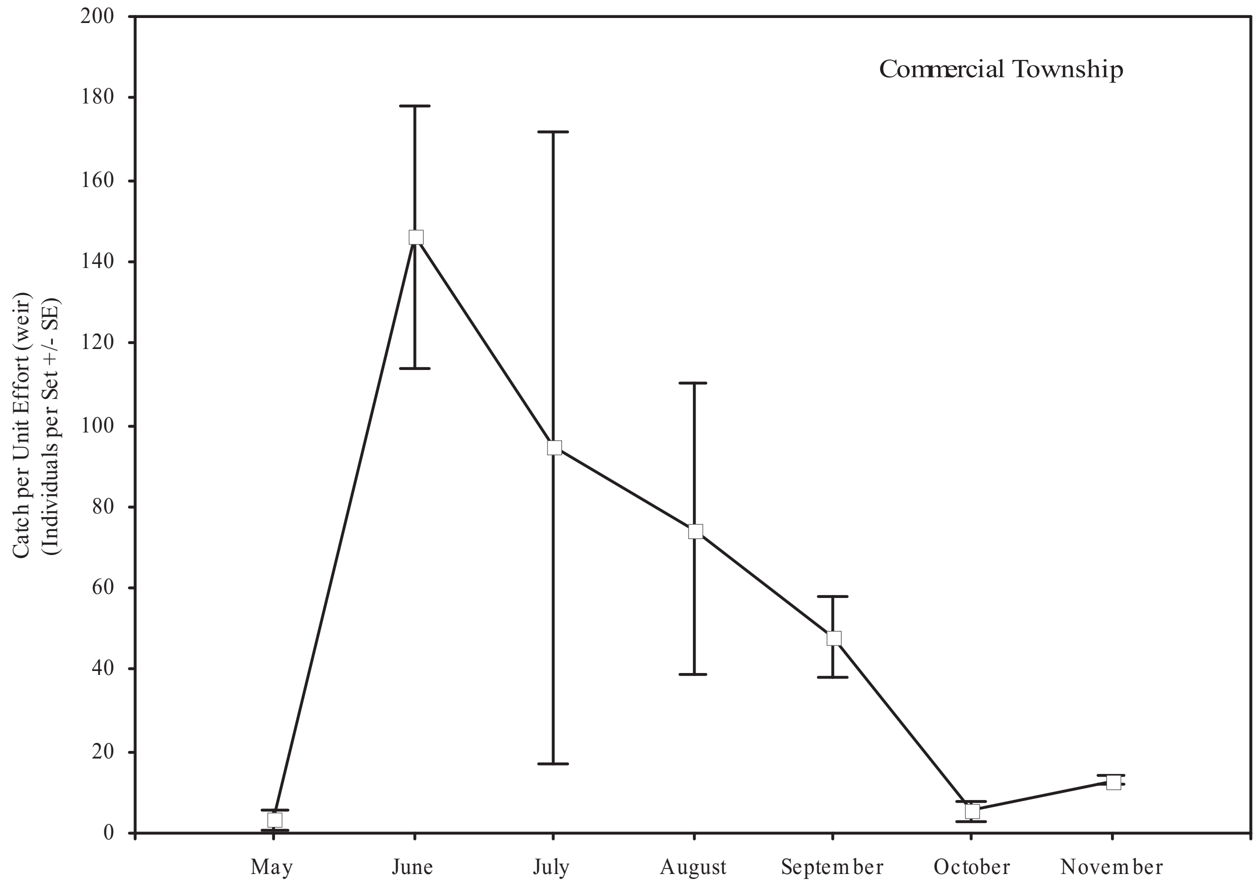


Figure 7-10. Monthly abundance for all fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township during 2006.

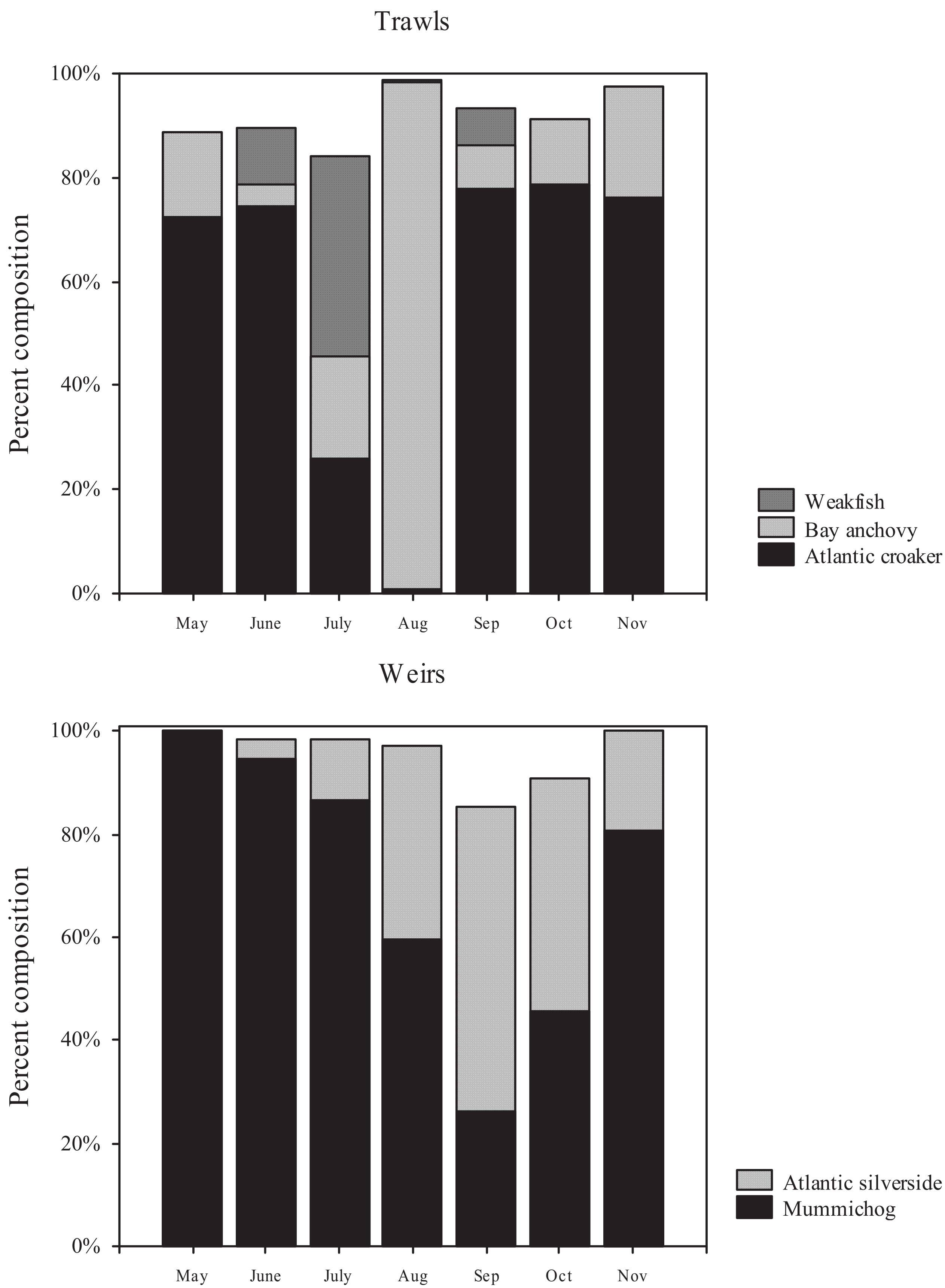


Figure 7-11. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Commercial Township during 2006.

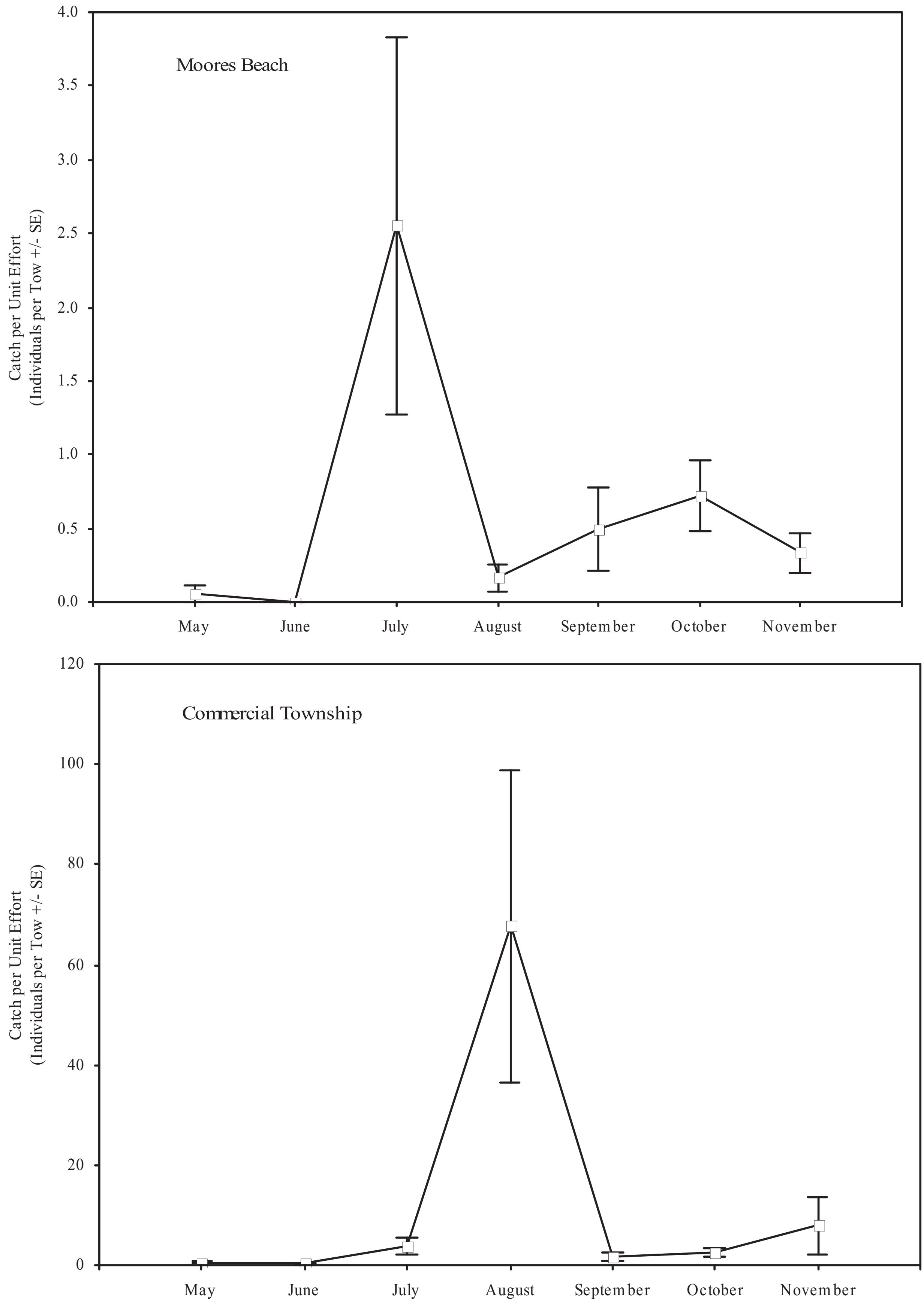


Figure 7-12. Monthly abundance for bay anchovy caught, in large marsh creeks with otter trawls, in the Lower Bay Region during 2006.

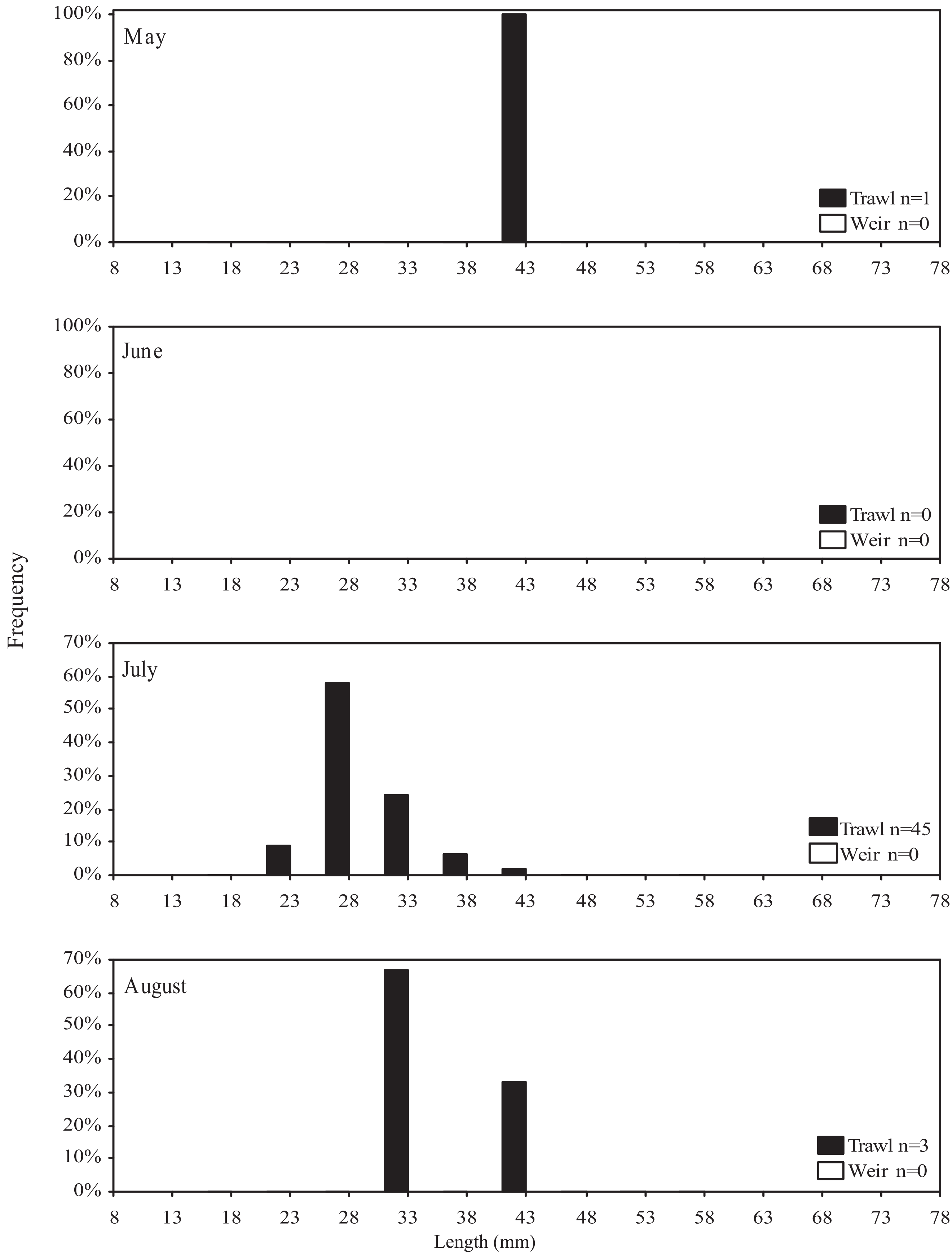


Figure 7-13 Size distribution of bay anchovy, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach in 2006.

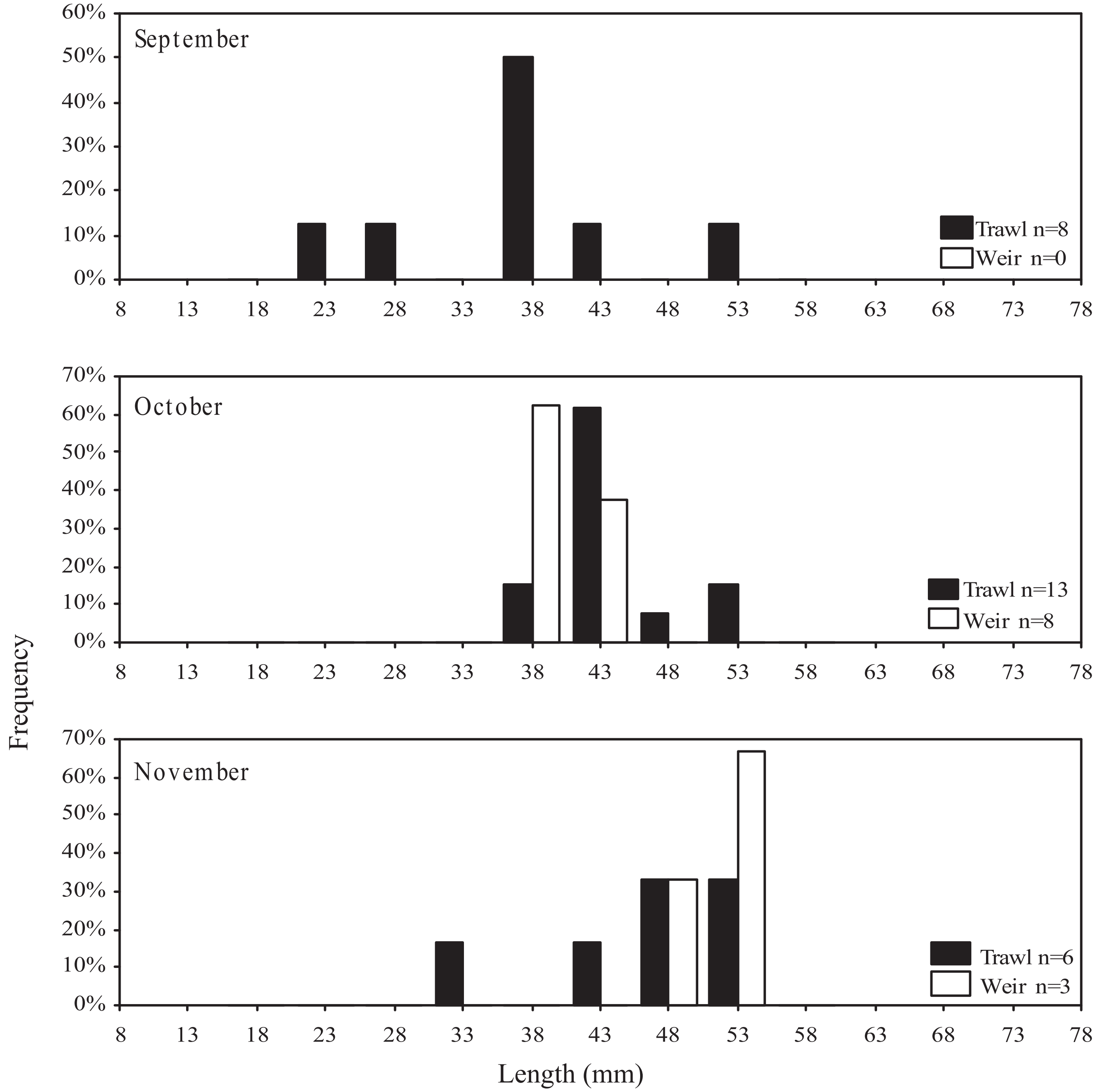


Figure 7-13. Continued.

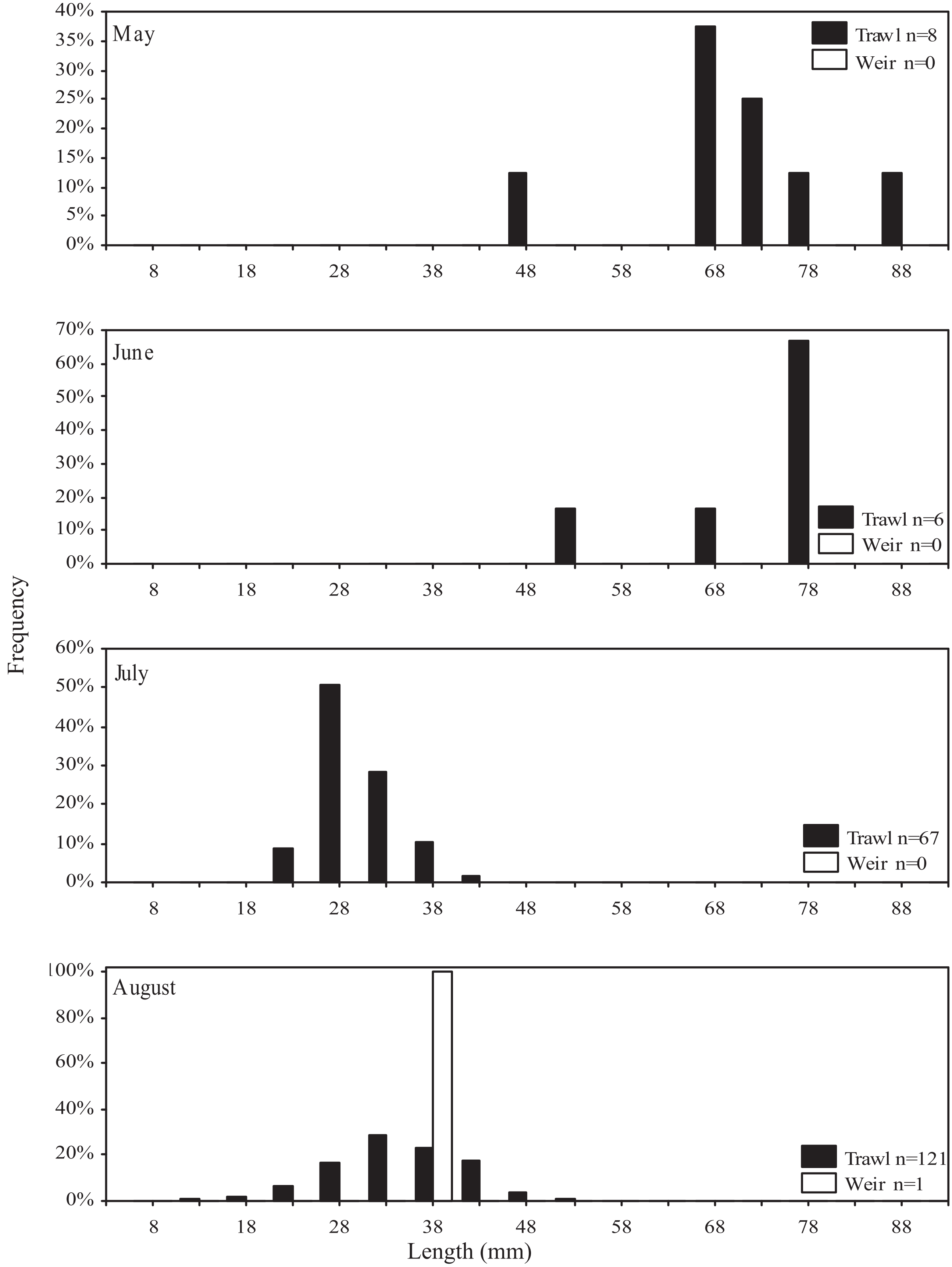
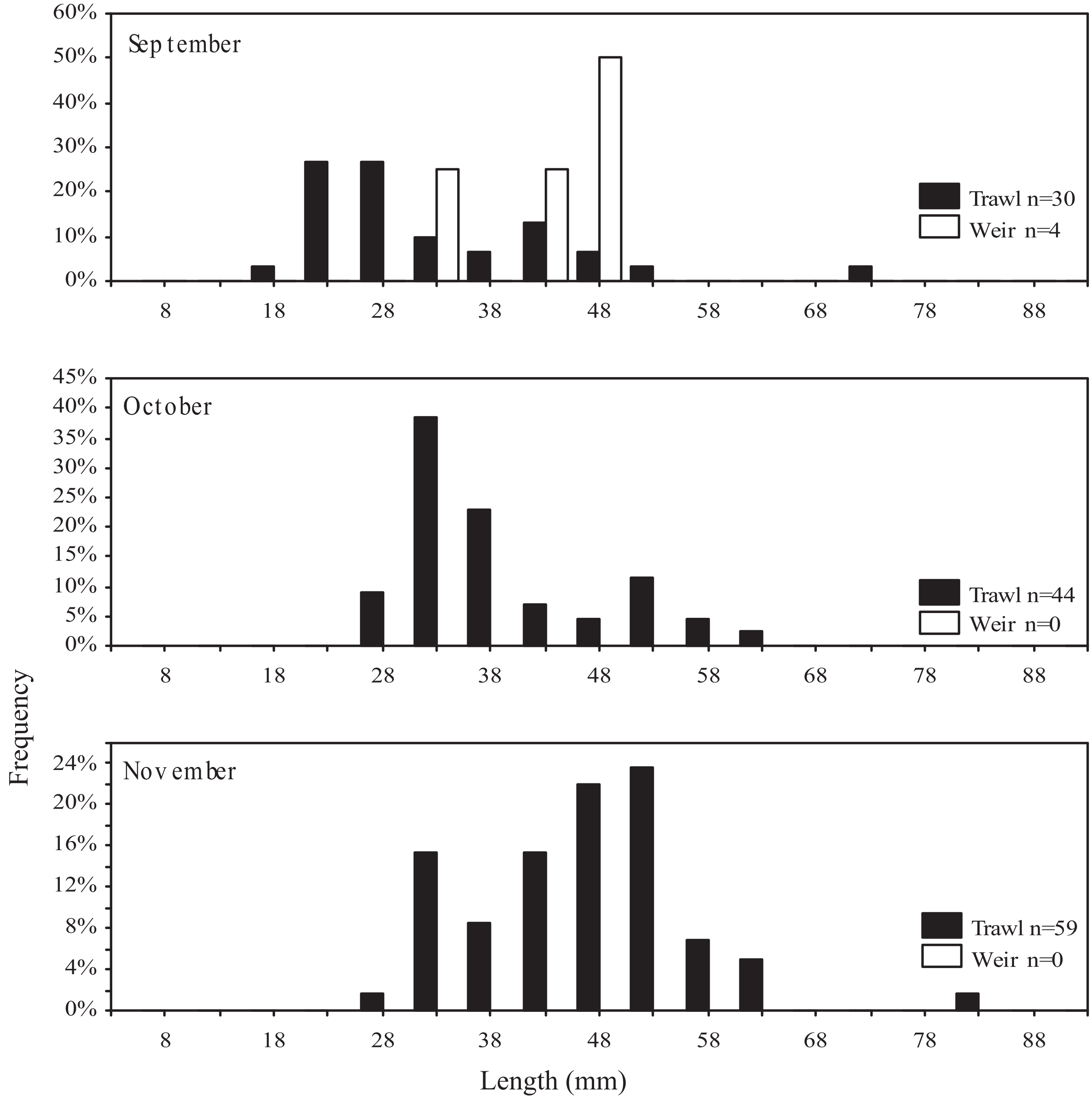


Figure 7-14. Size distribution of bay anchovy, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township in 2006.



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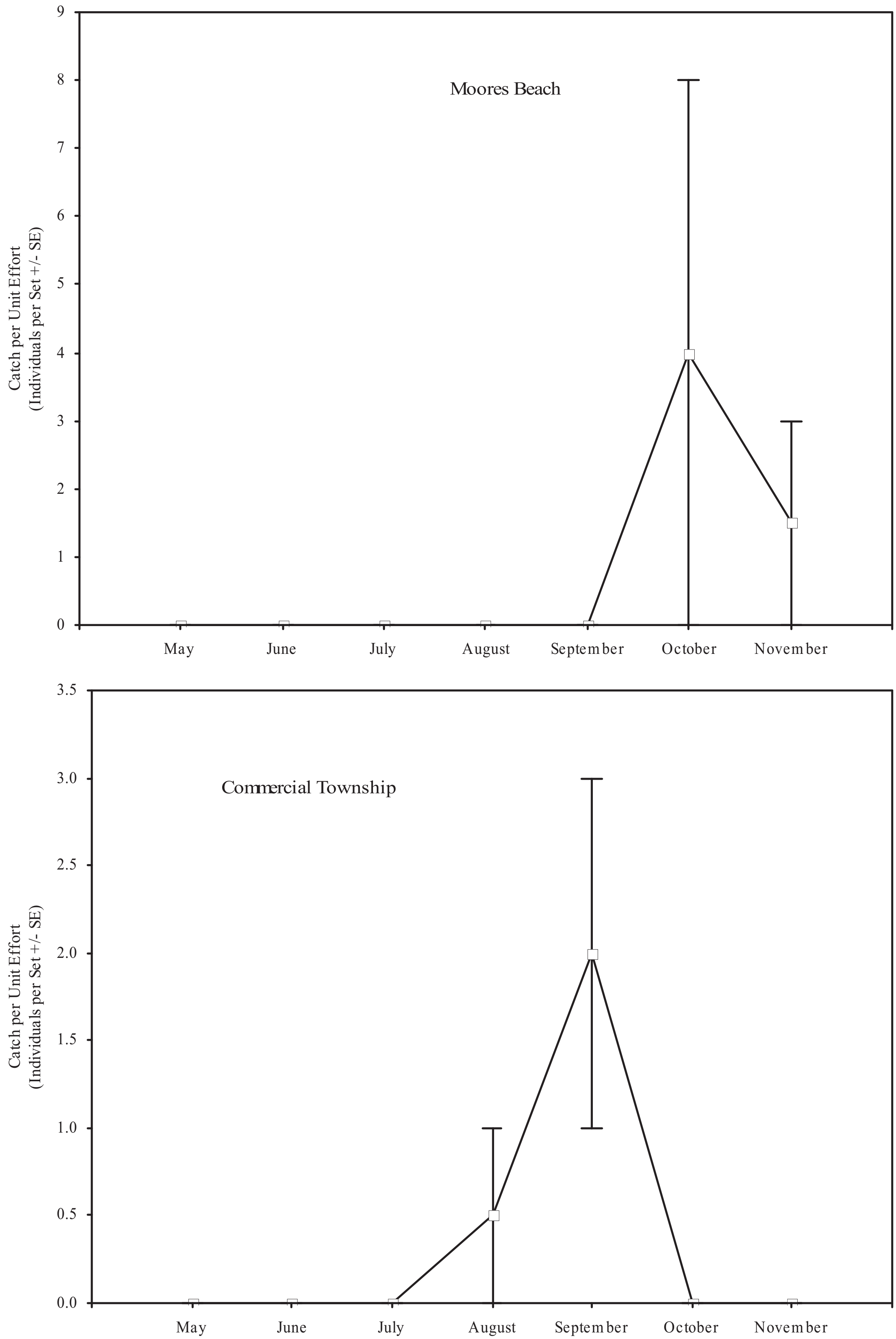


Figure 7-15. Monthly abundance for bay anchovy caught, in small marsh creeks with weirs, in the Lower Bay Region in 2006.

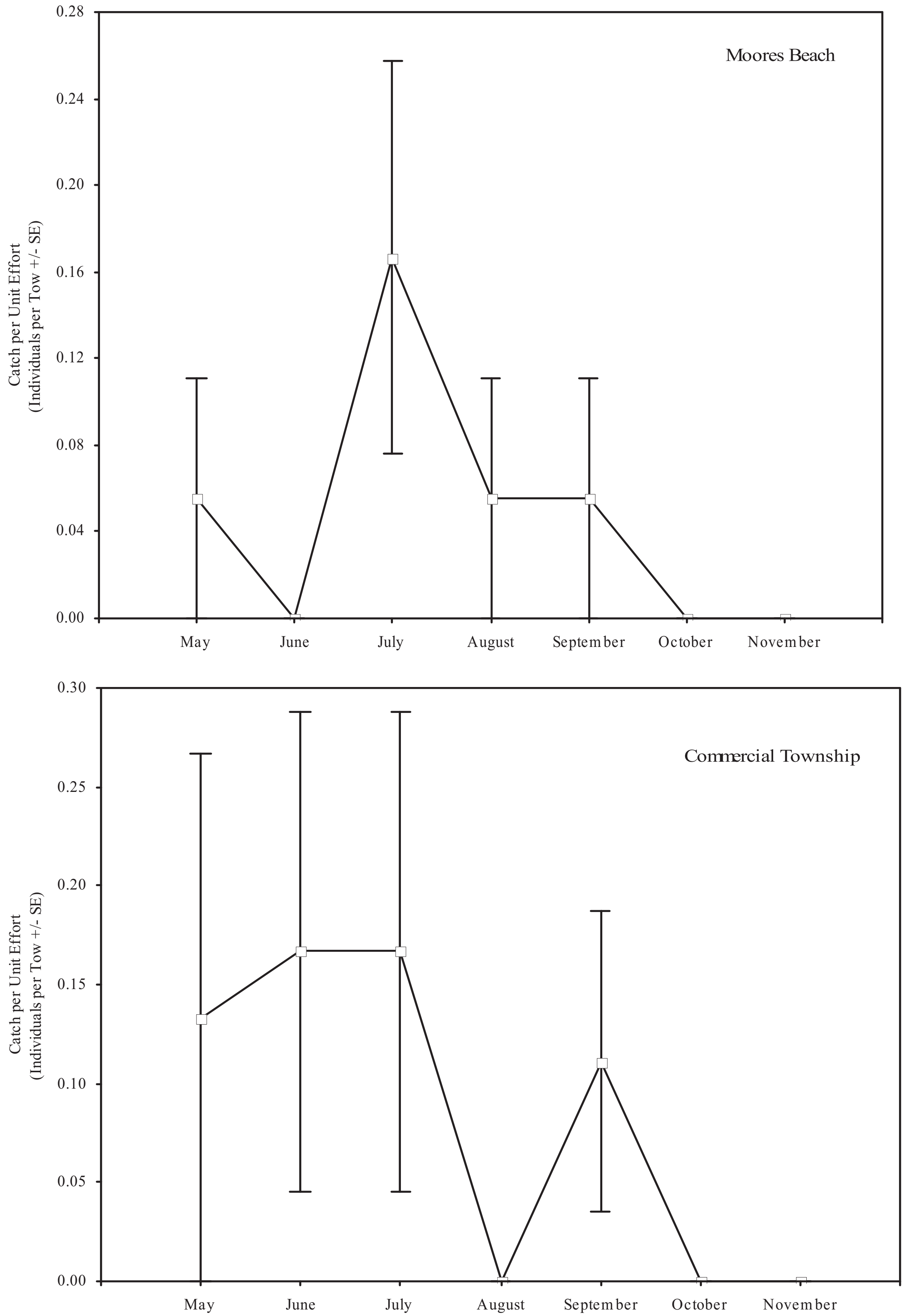


Figure 7-16. Monthly abundance for spot caught, in large marsh creeks with otter trawls, in the Lower Bay Region during 2006.

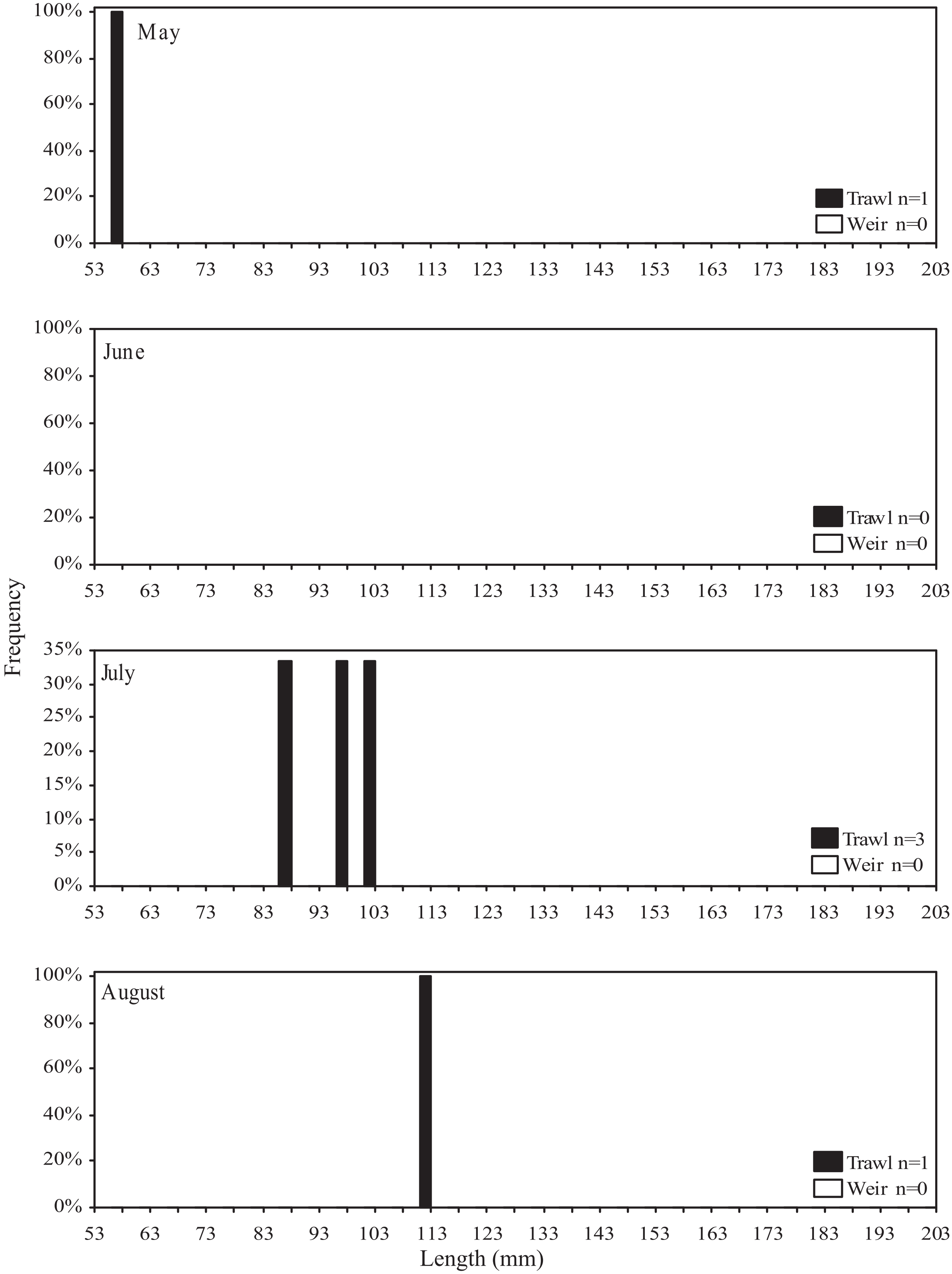
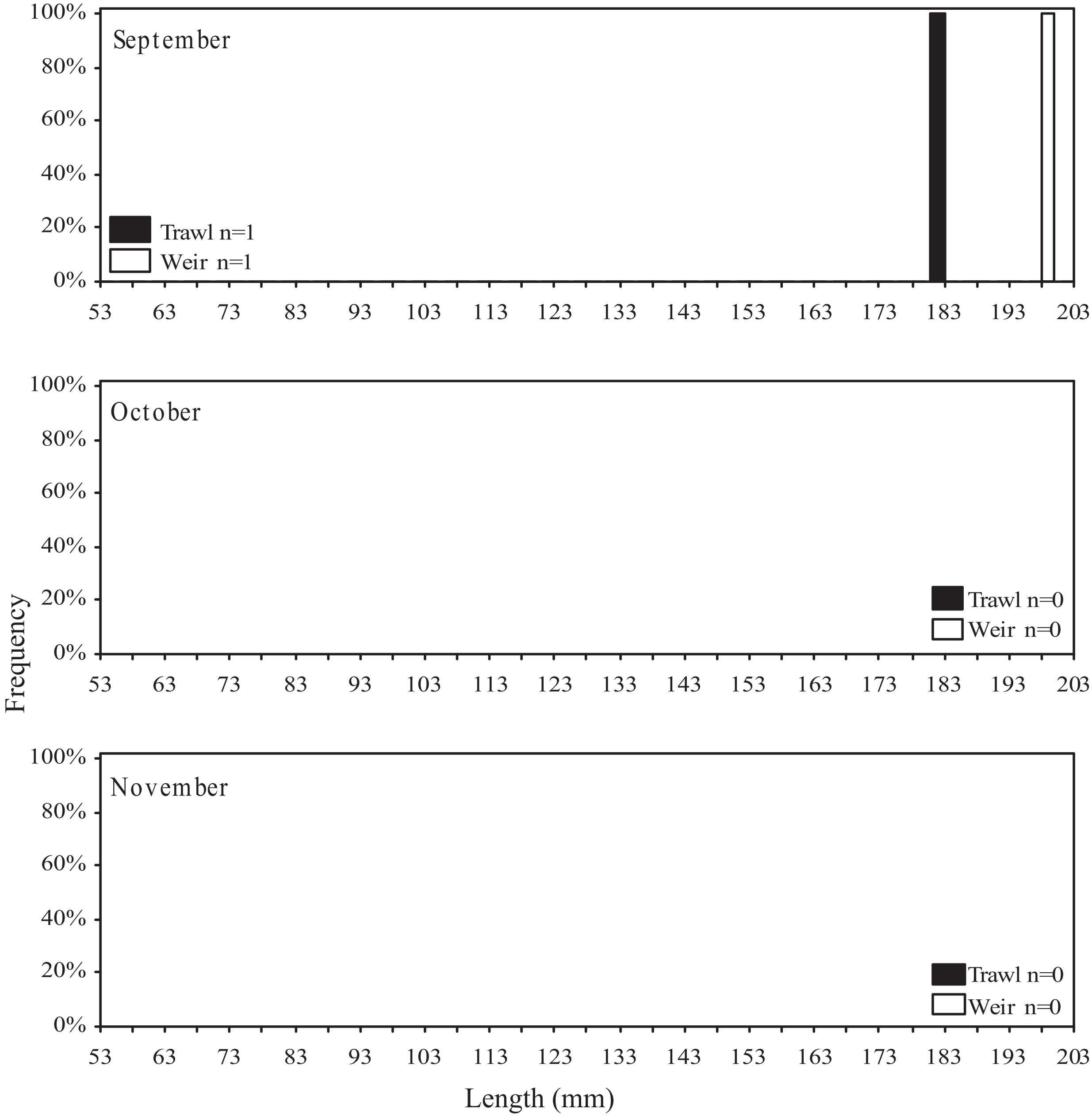


Figure 7-17. Size distribution of spot, from large marsh creeks (otter trawl) and small marsh creeks (weirs), at Moores Beach during 2006.



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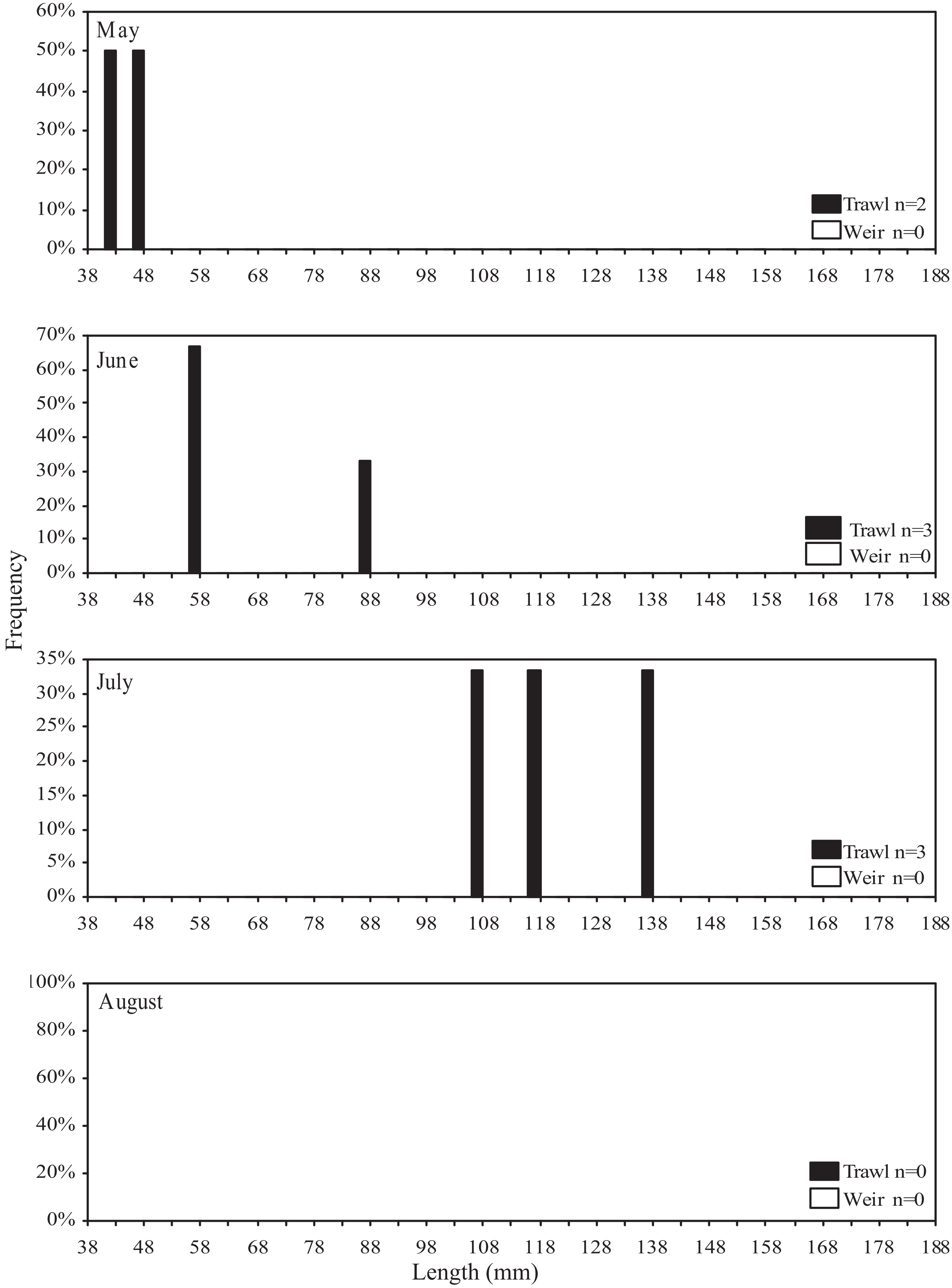
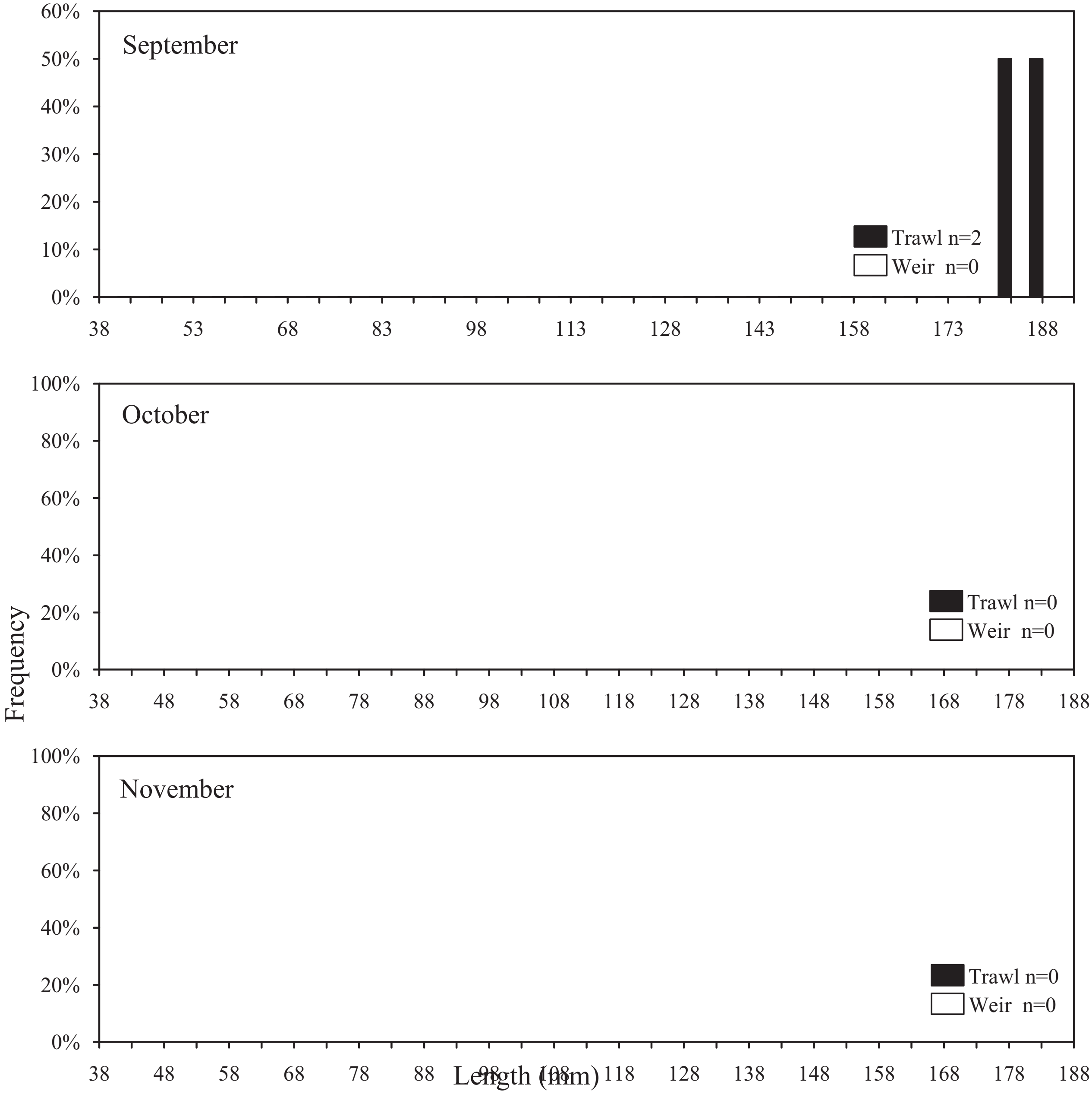


Figure 7-18. Size distribution of spot, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township in 2006.



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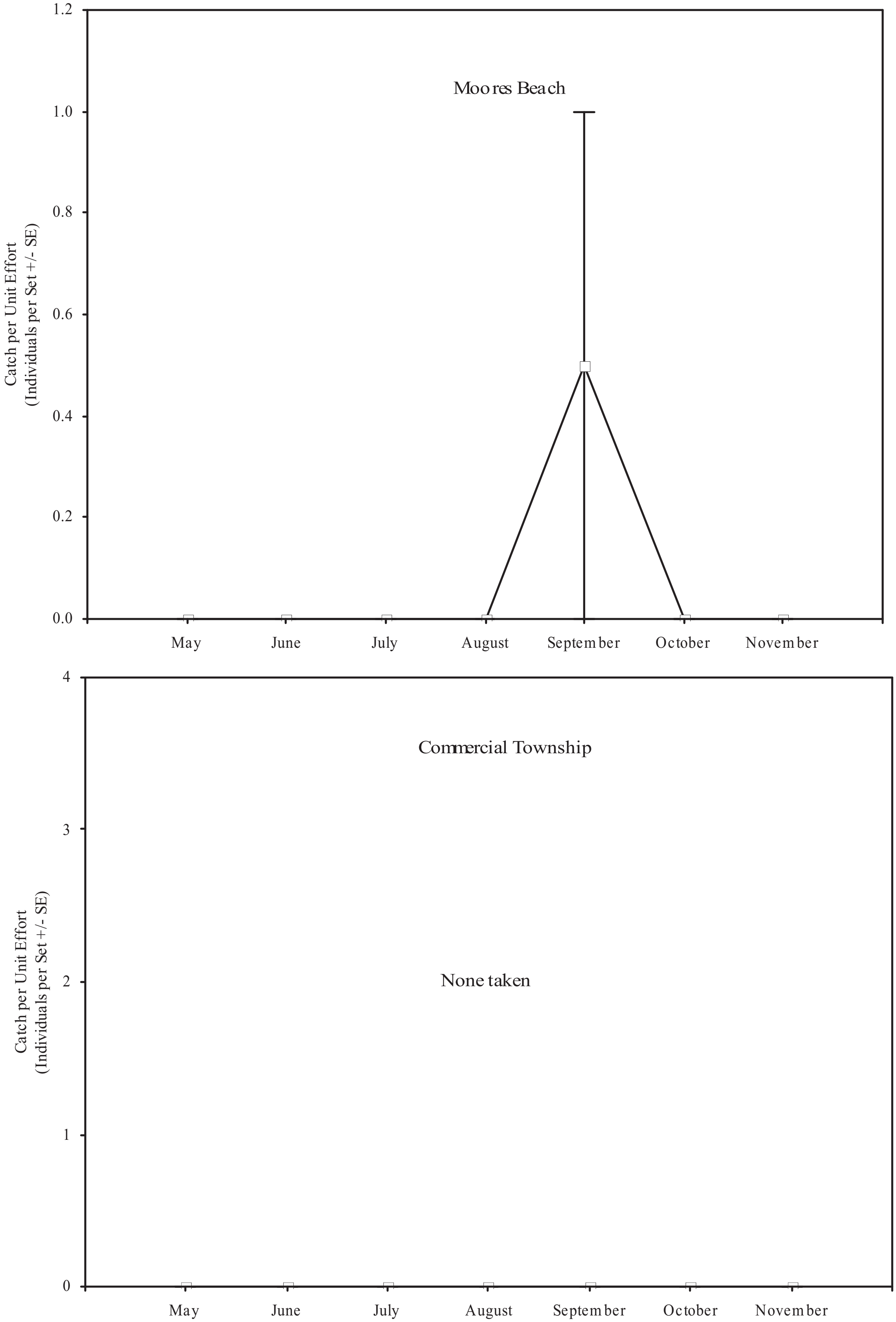
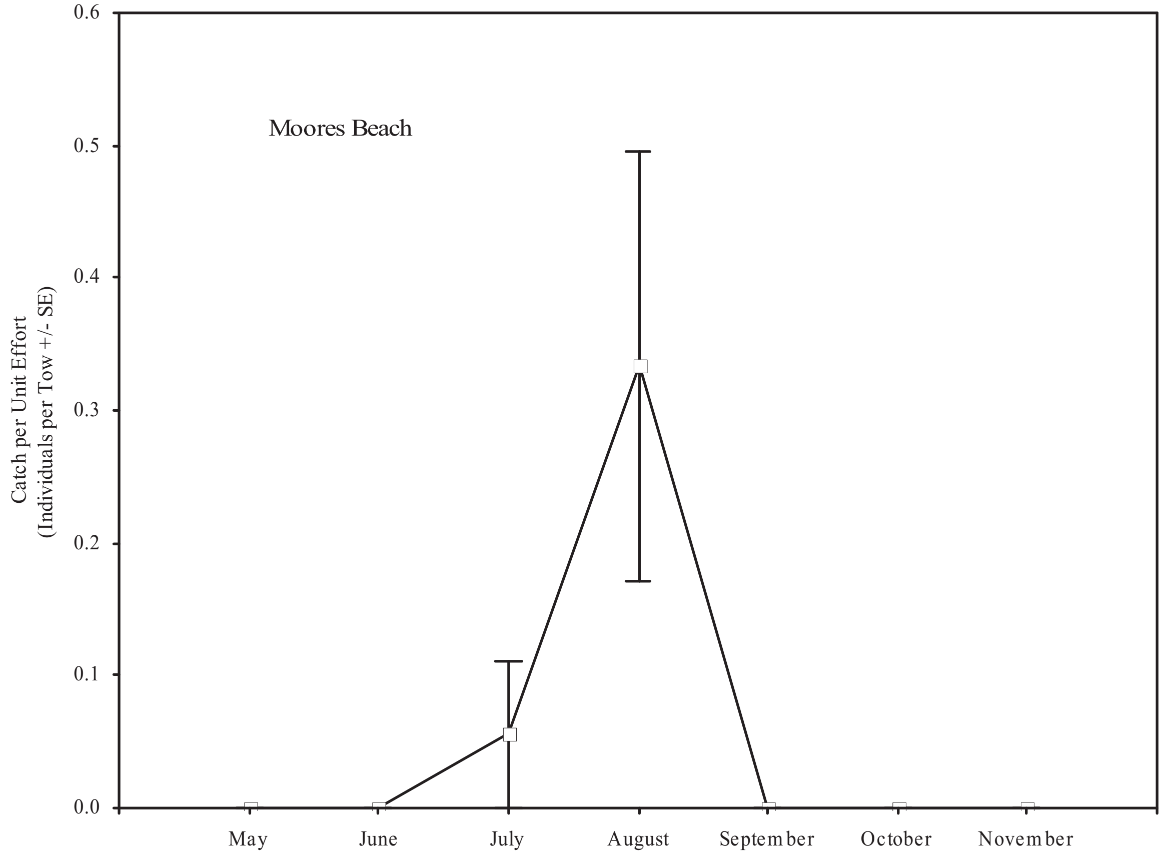


Figure 7-19. Monthly abundance for spot caught, in small marsh creeks with weirs, in the Lower Bay Region in 2006.



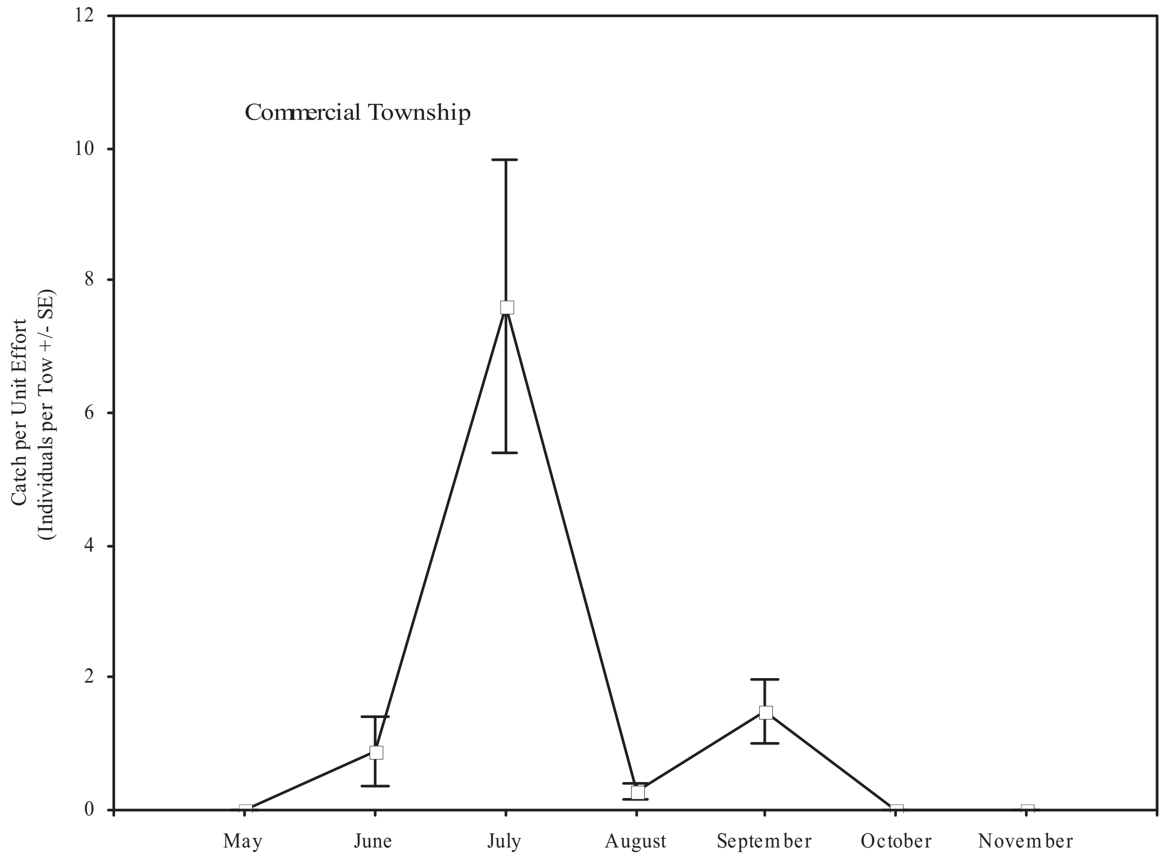


Figure 7-20. Monthly abundance for weakfish caught, in large marsh creeks with otter trawls, the Lower Bay Region during 2006.

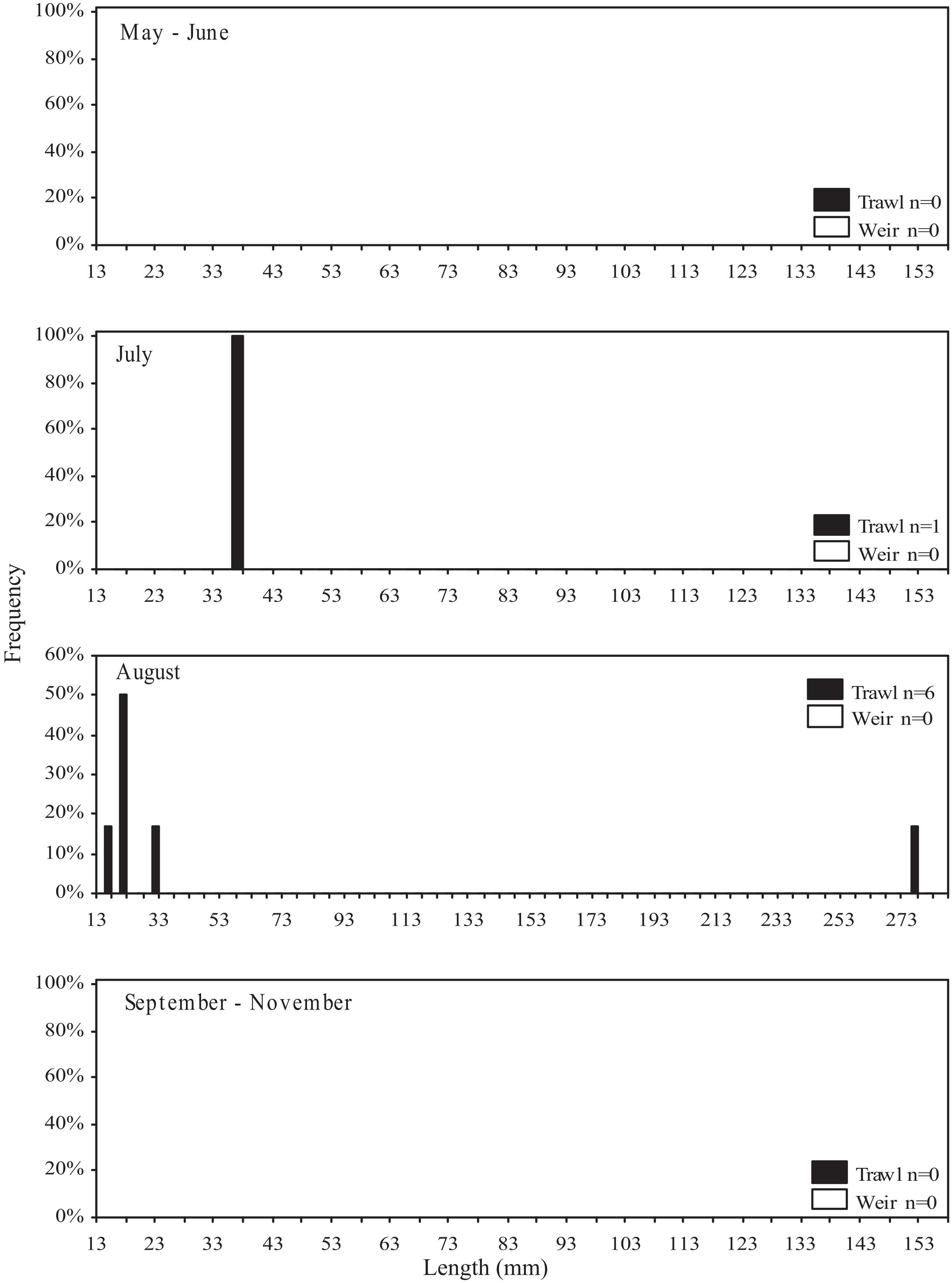


Figure 7-21. Size distribution of weakfish, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach during 2006.

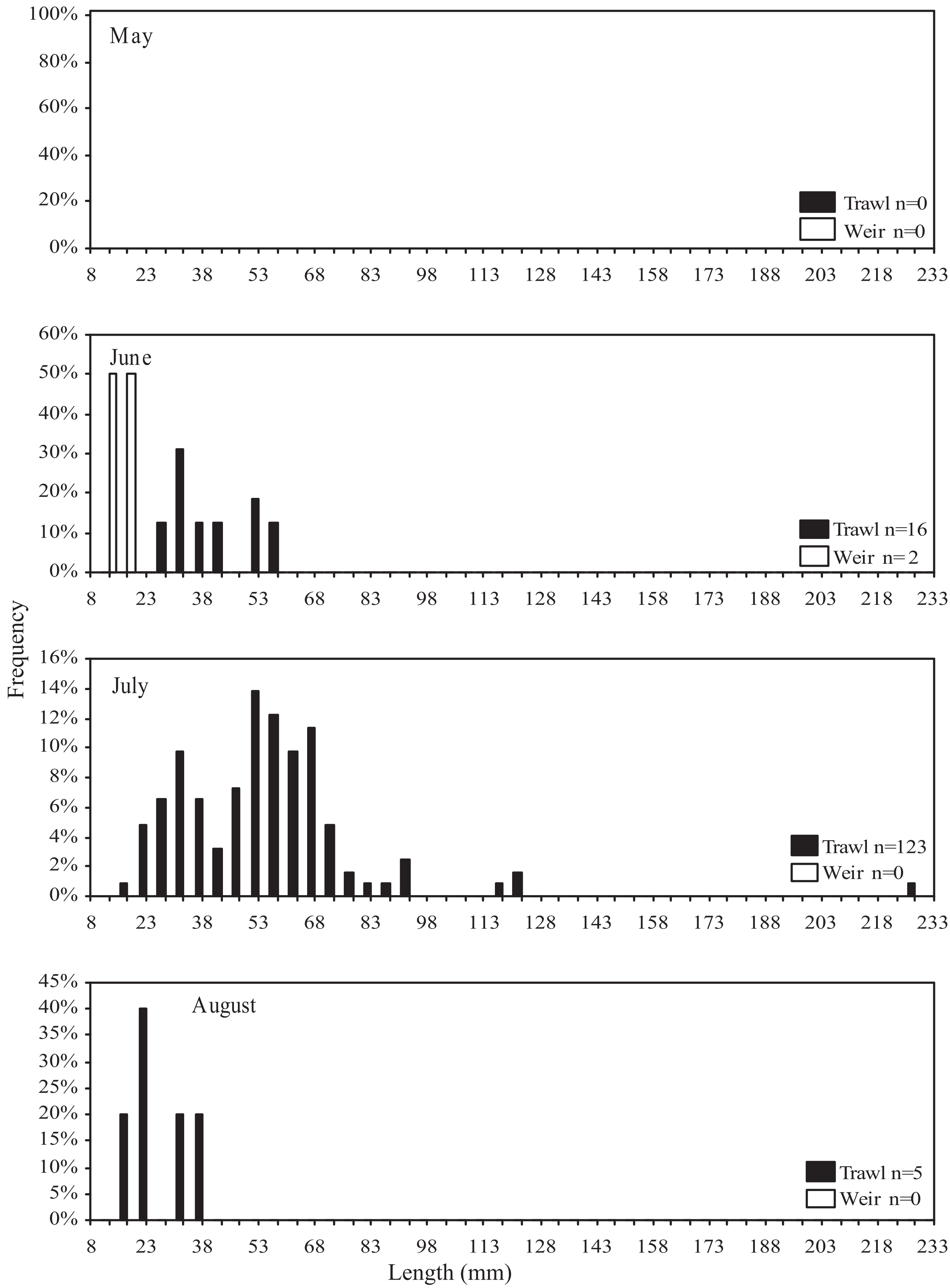
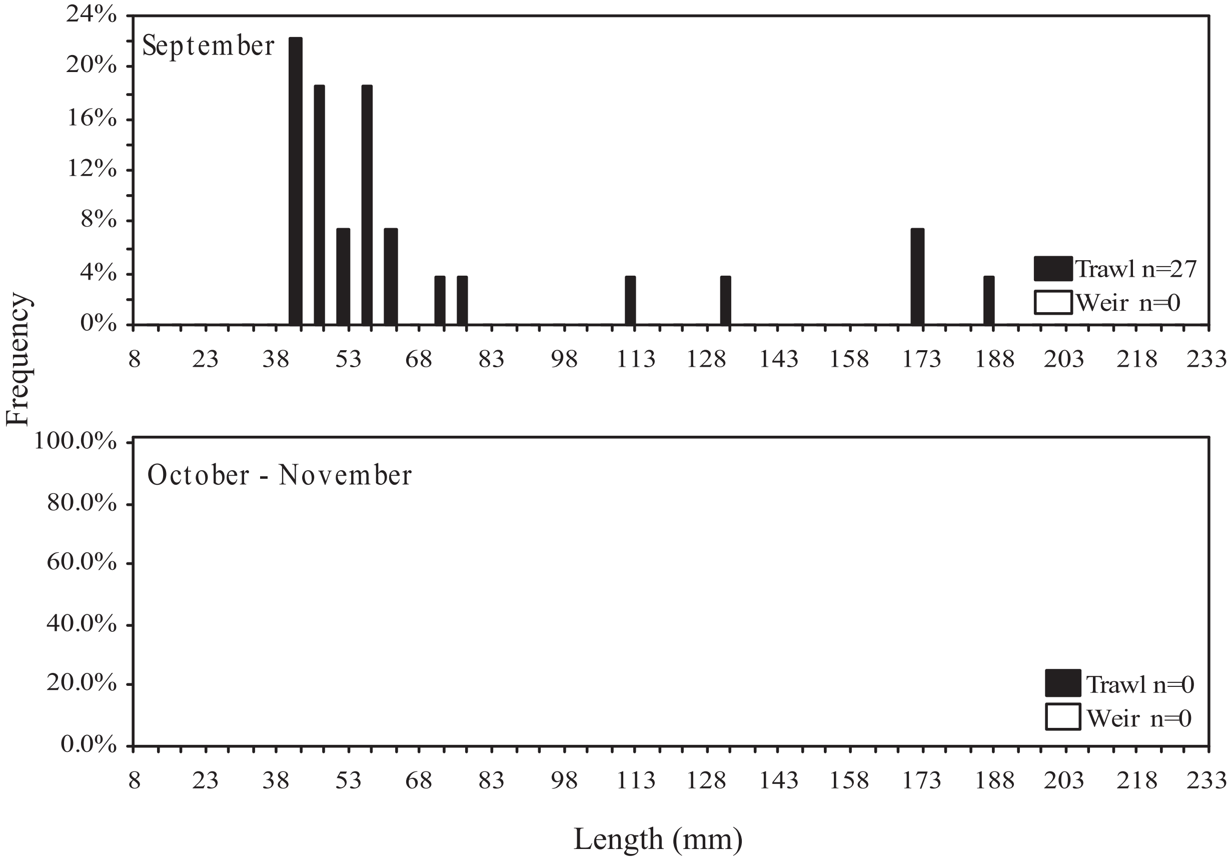


Figure 7-22. Size distribution of weakfish, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township during 2006.



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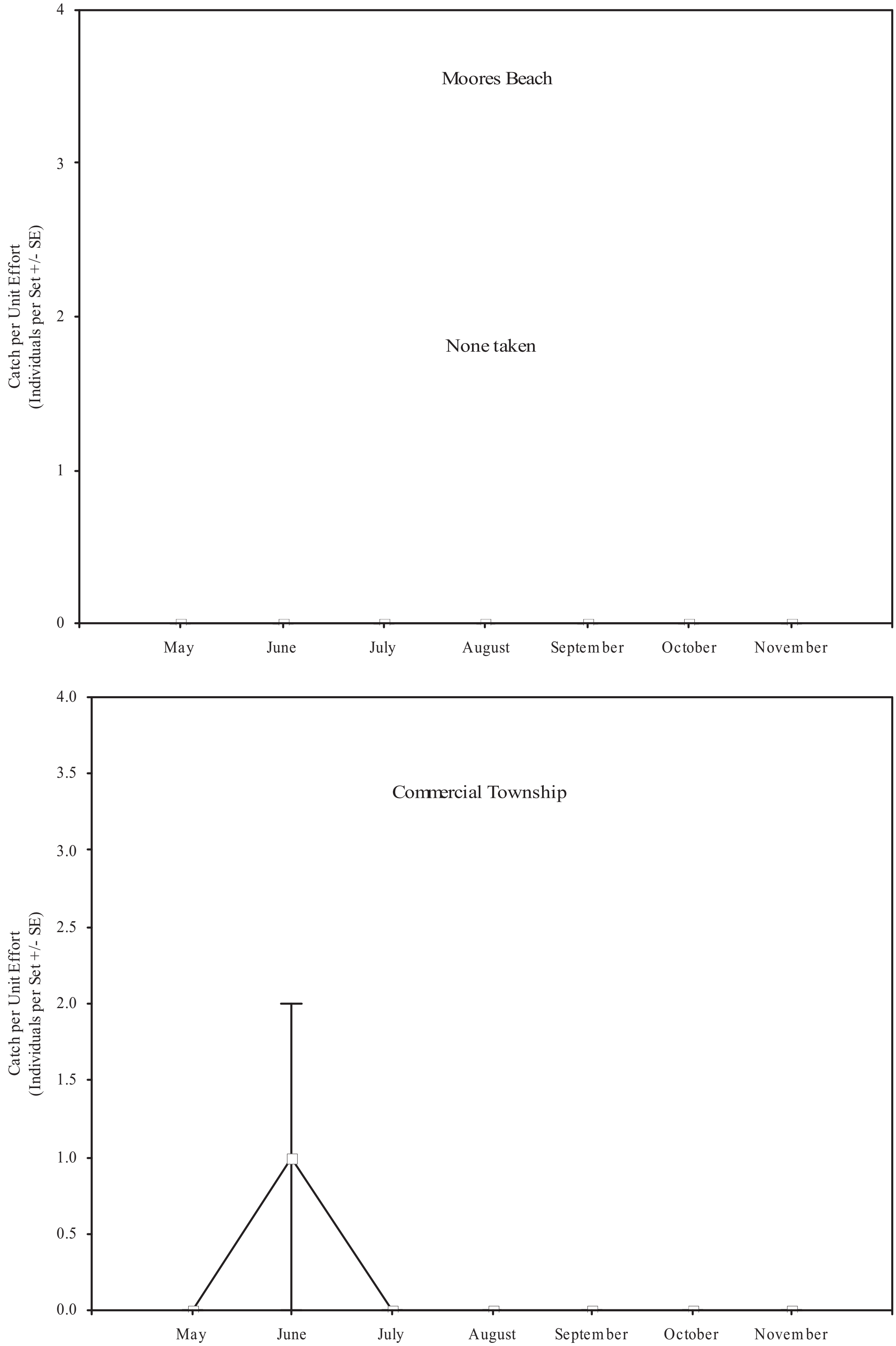


Figure 7-23. Monthly abundance for weakfish caught, in small marsh creeks with weirs, in the Lower Bay Region in 2006.

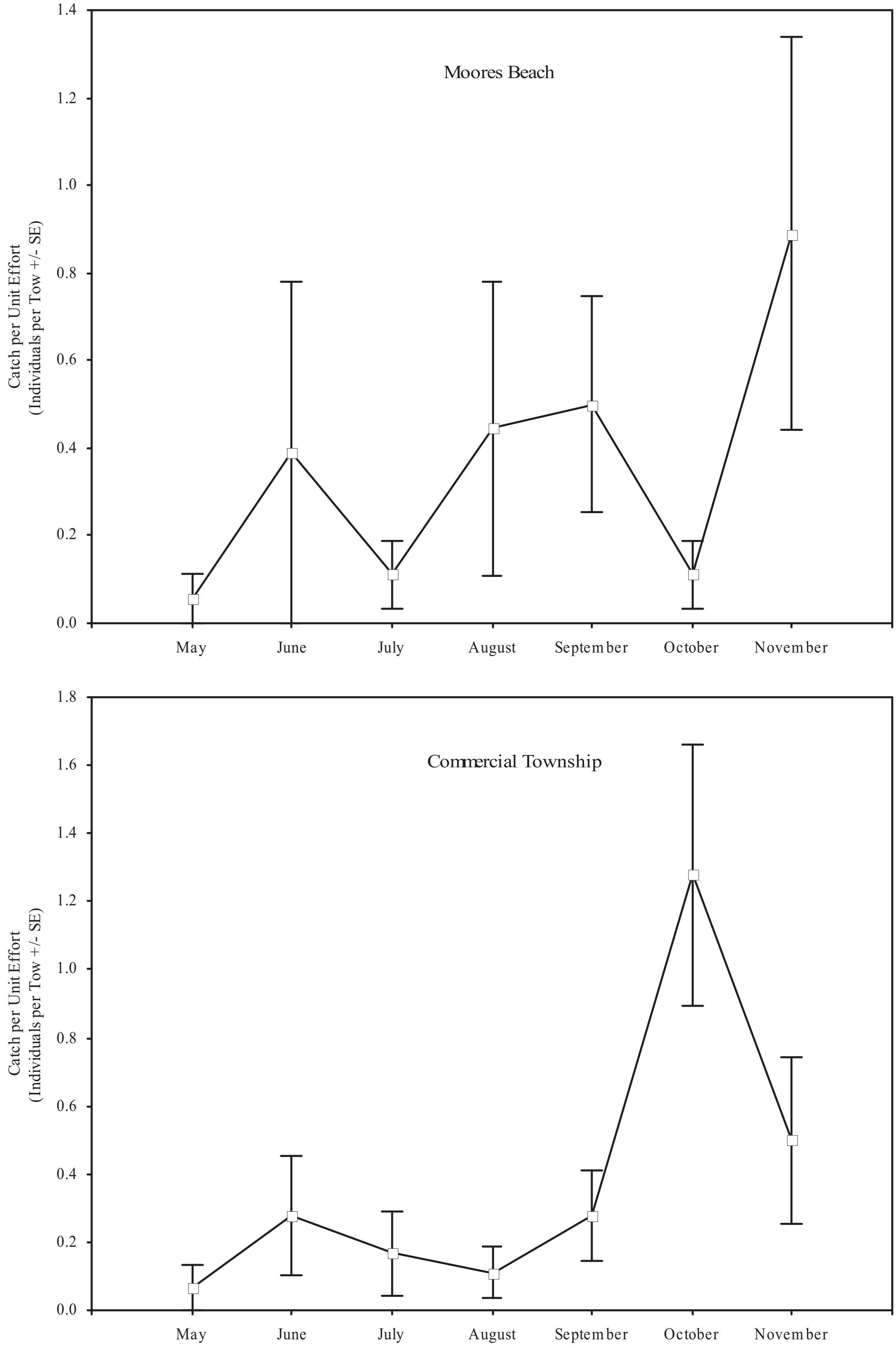


Figure 7-24. Monthly abundance for white perch caught in, large marsh creeks with otter trawls, the Lower Bay Region during 2006.

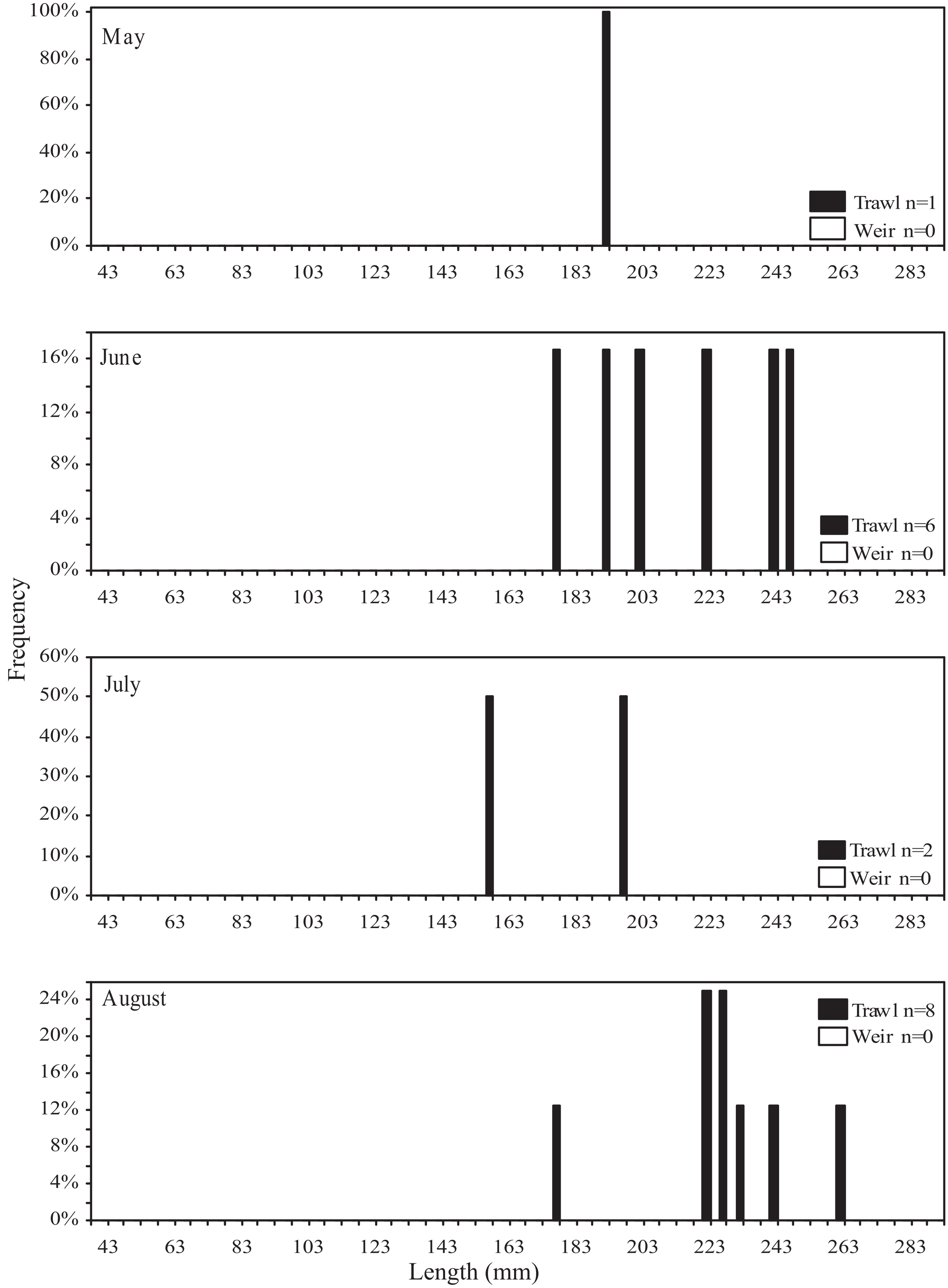
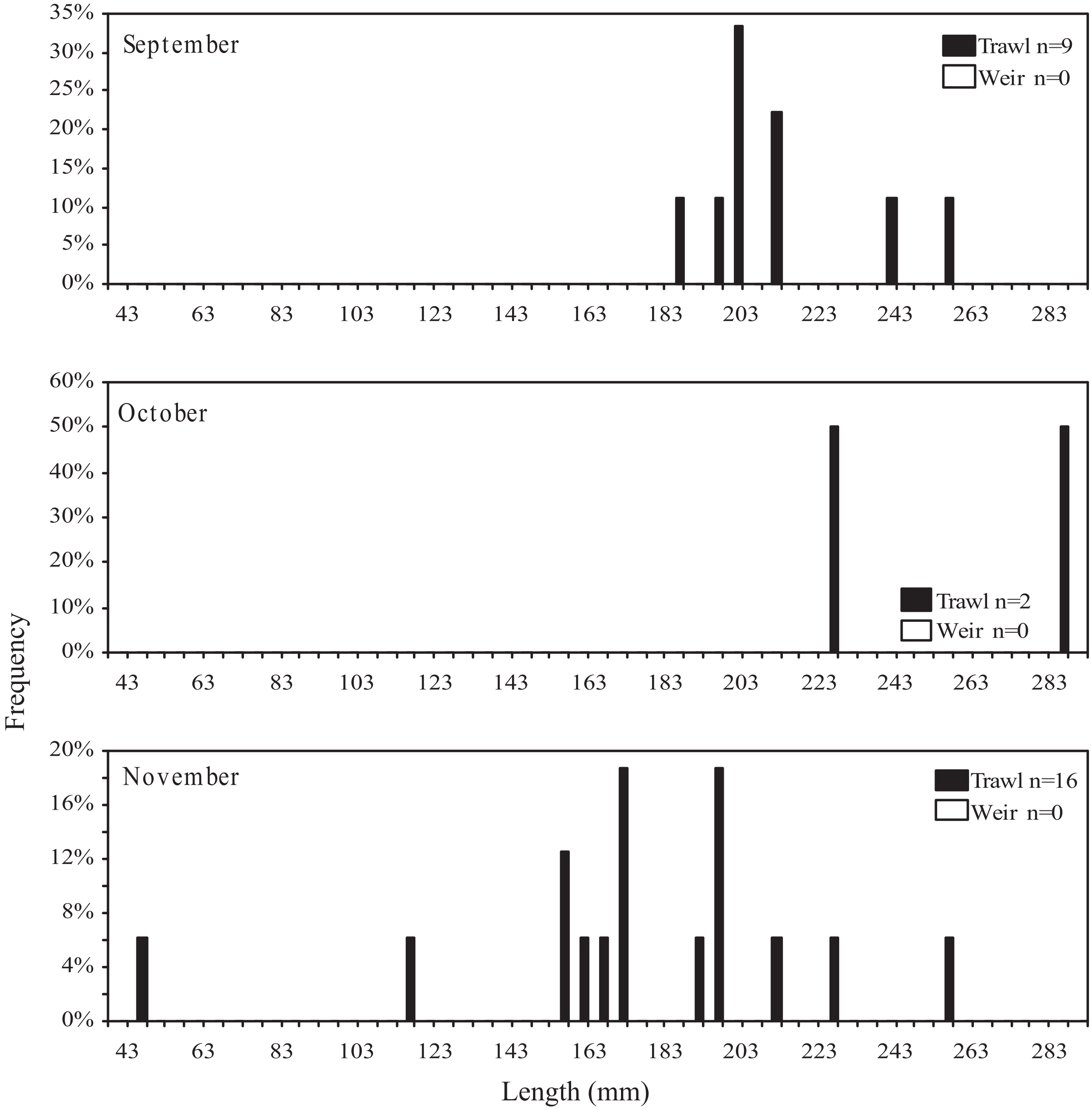


Figure 7-25. Size distribution of white perch, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Moores Beach in 2006.



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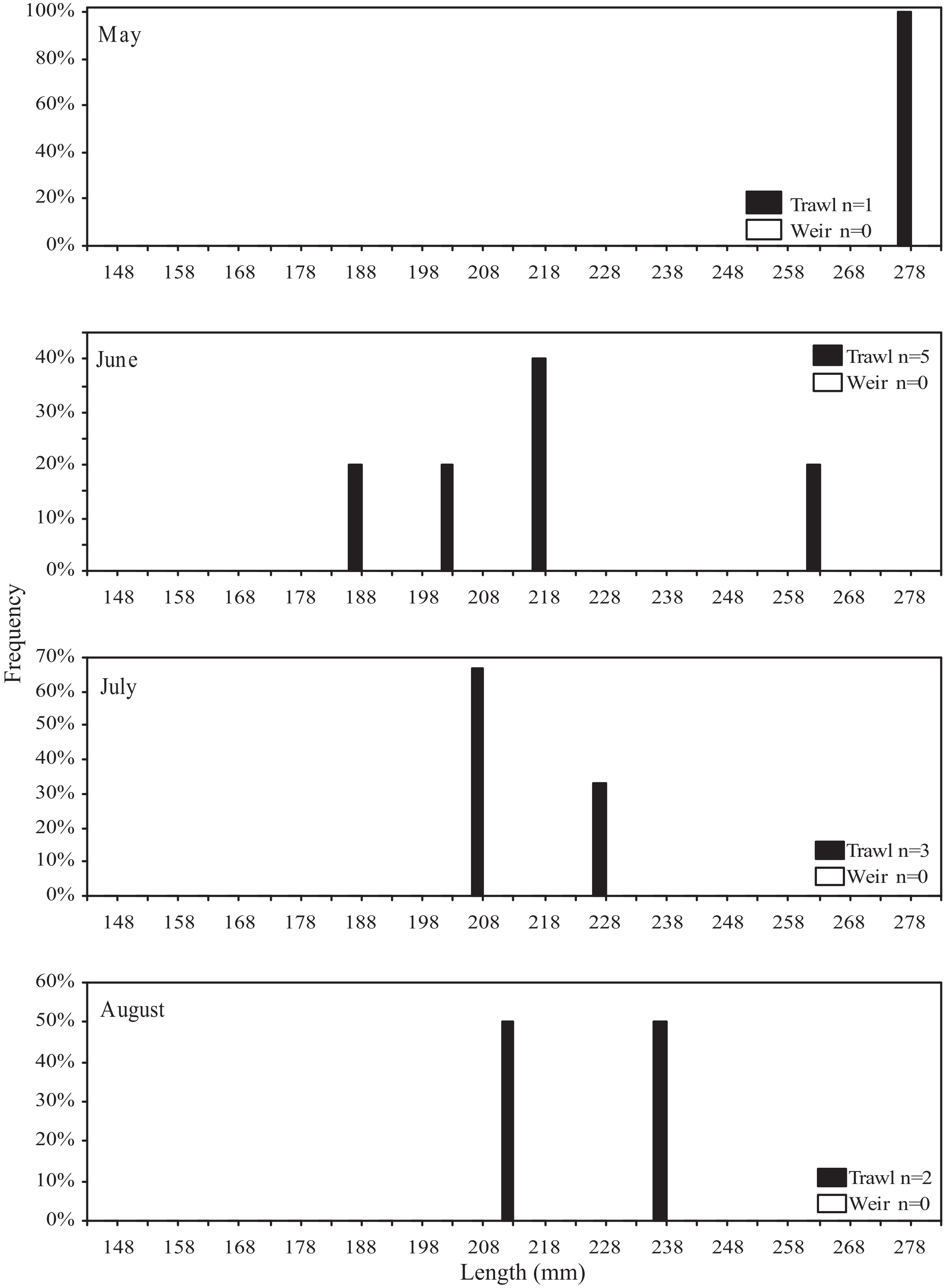


Figure 7-26. Size distribution of white perch, from large marsh creeks (otter trawl) and small marsh creeks (weir), at Commercial Township in 2006.

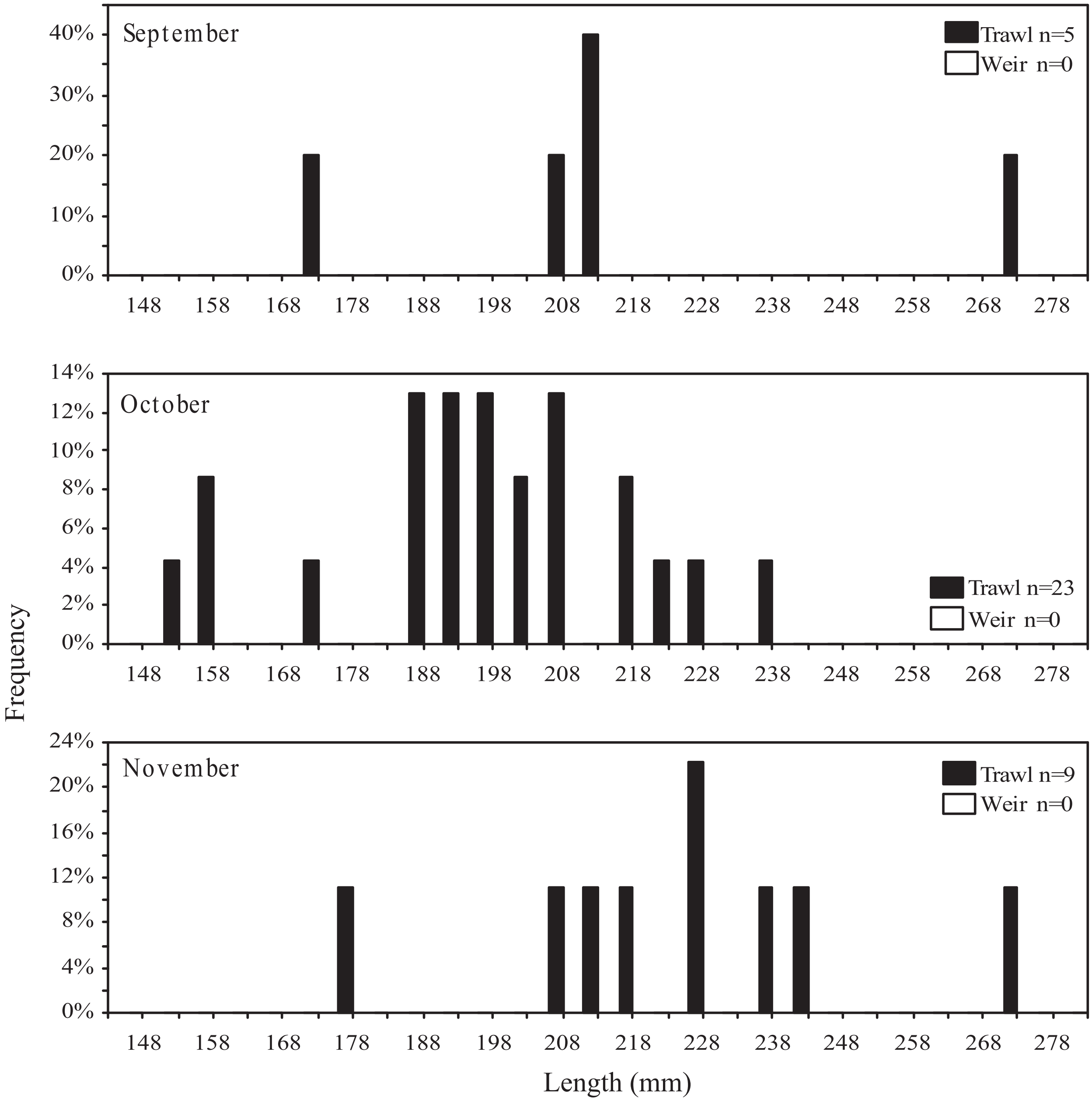


Figure 7-26. Continued.

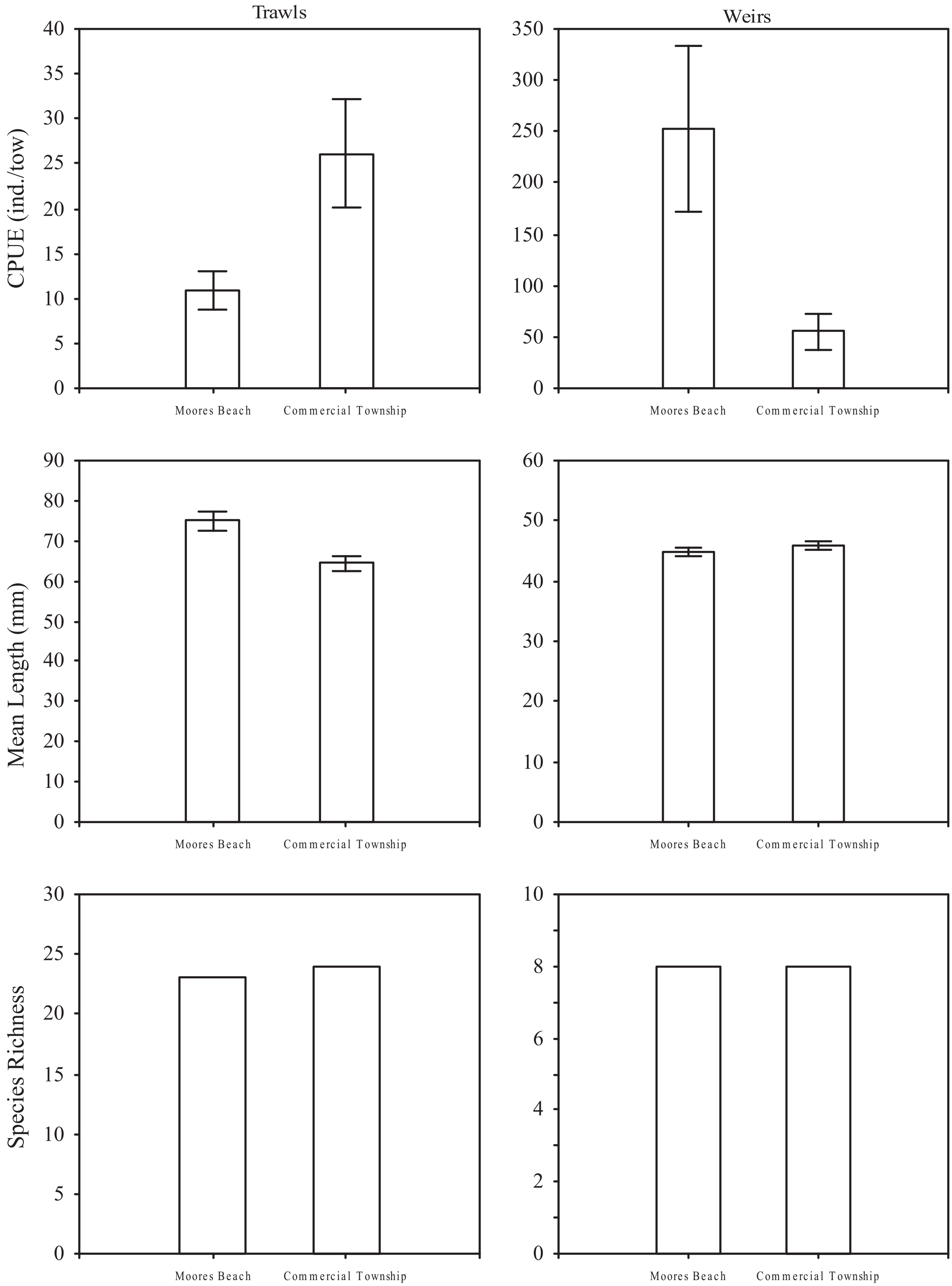


Figure 7-27. Comparisons of abundance, fish length, and species richness among reference (Moores Beach) and restored (Commercial Township) marshes from large and small creeks during 2006.

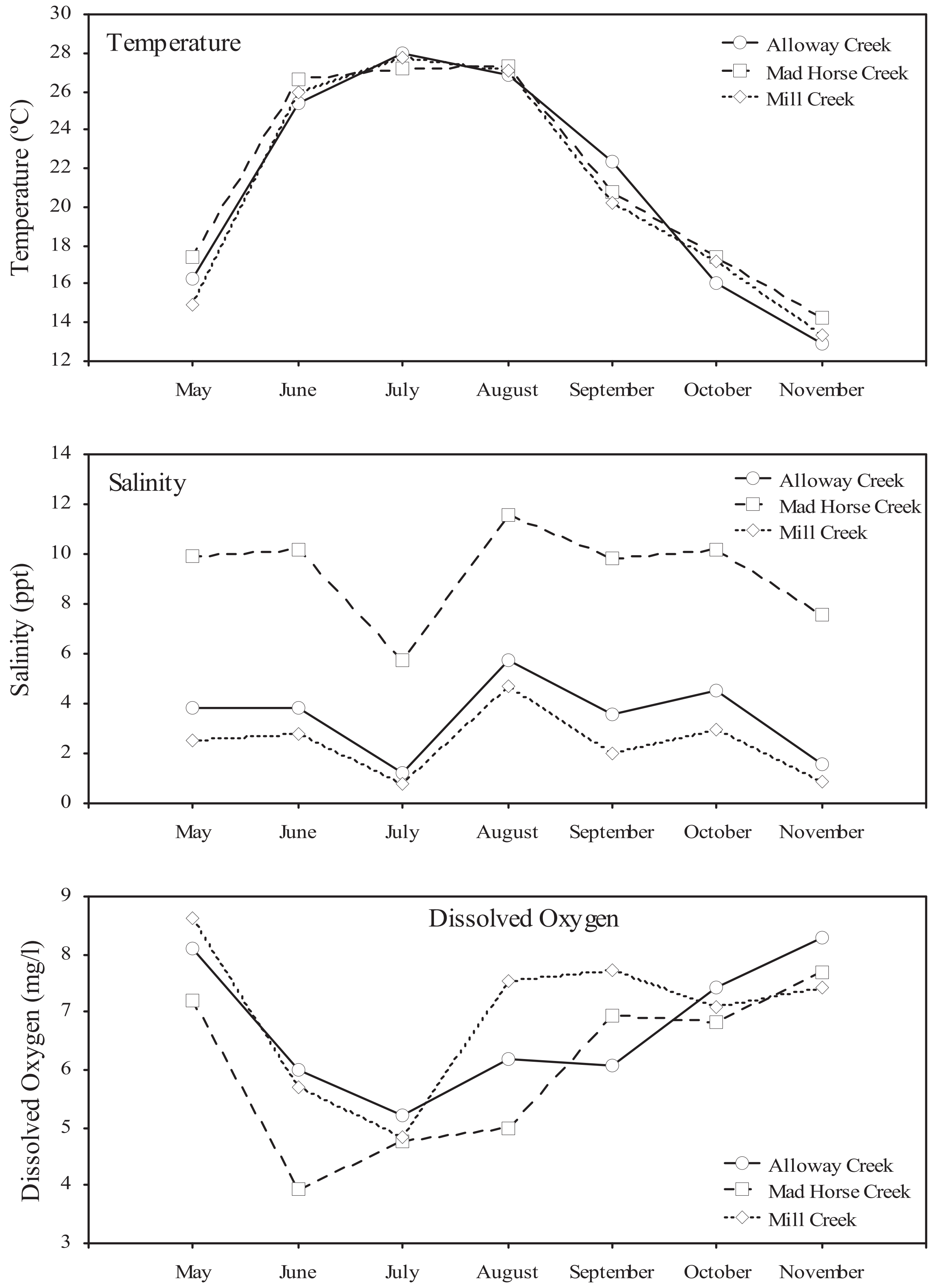


Figure 7-28. Selected physical parameters at regularly sampled sites in the Upper Delaware Bay Region during 2006.

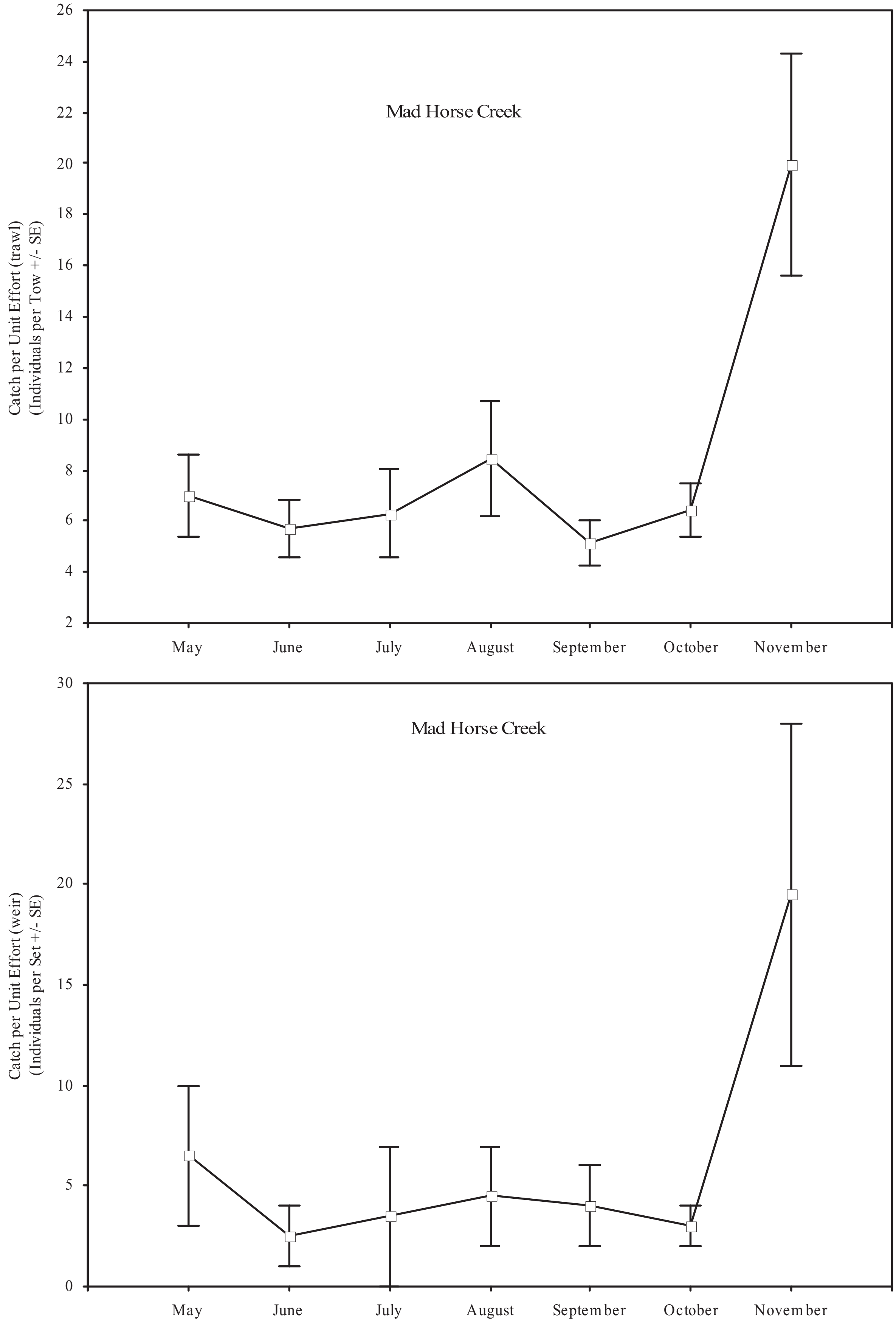


Figure 7-29. Abundance by month for all fish caught, in large marsh creeks (otter trawl) and in small marsh creeks (weir), at Mad Horse Creek during 2006.

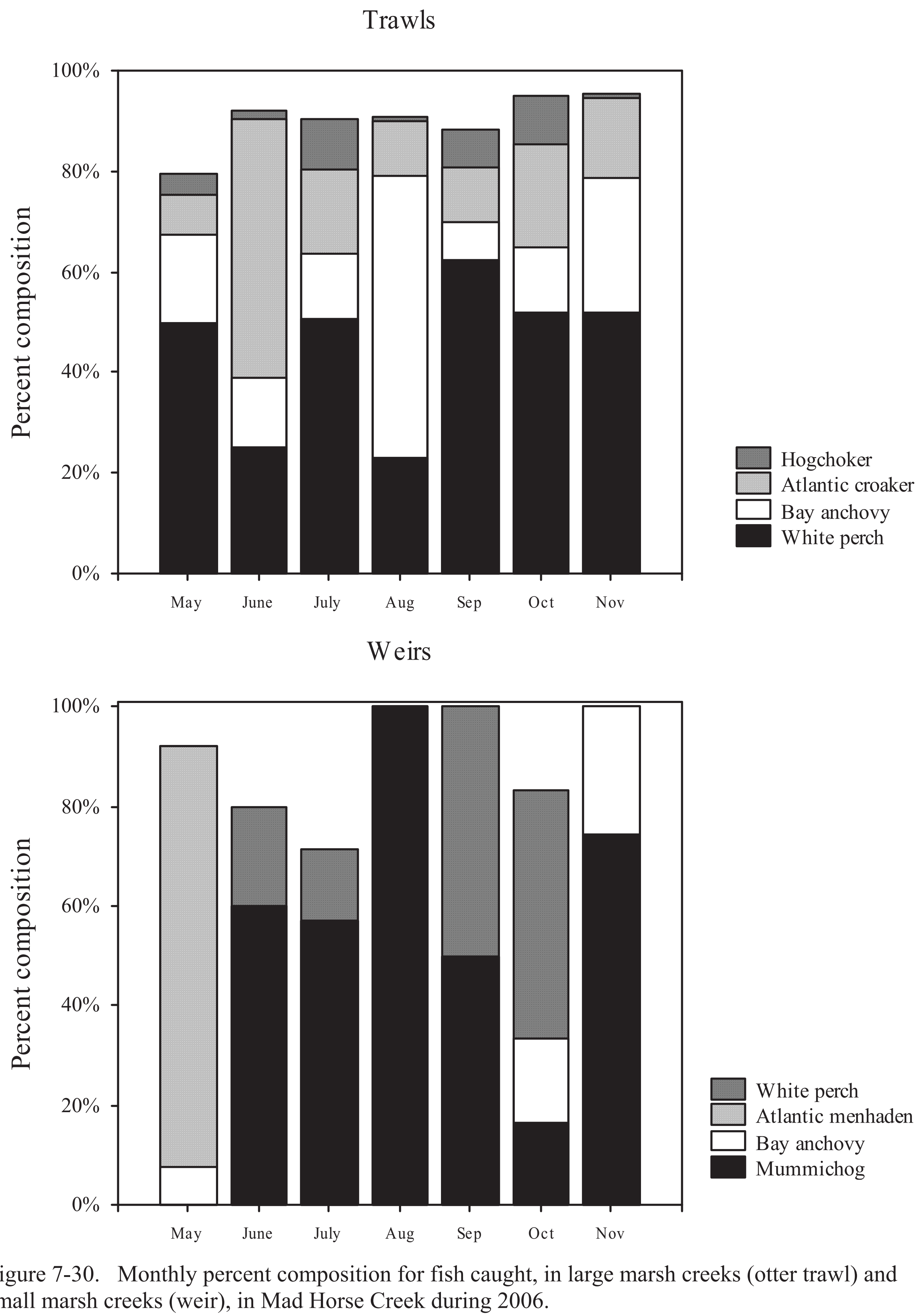


Figure 7-30. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Mad Horse Creek during 2006.

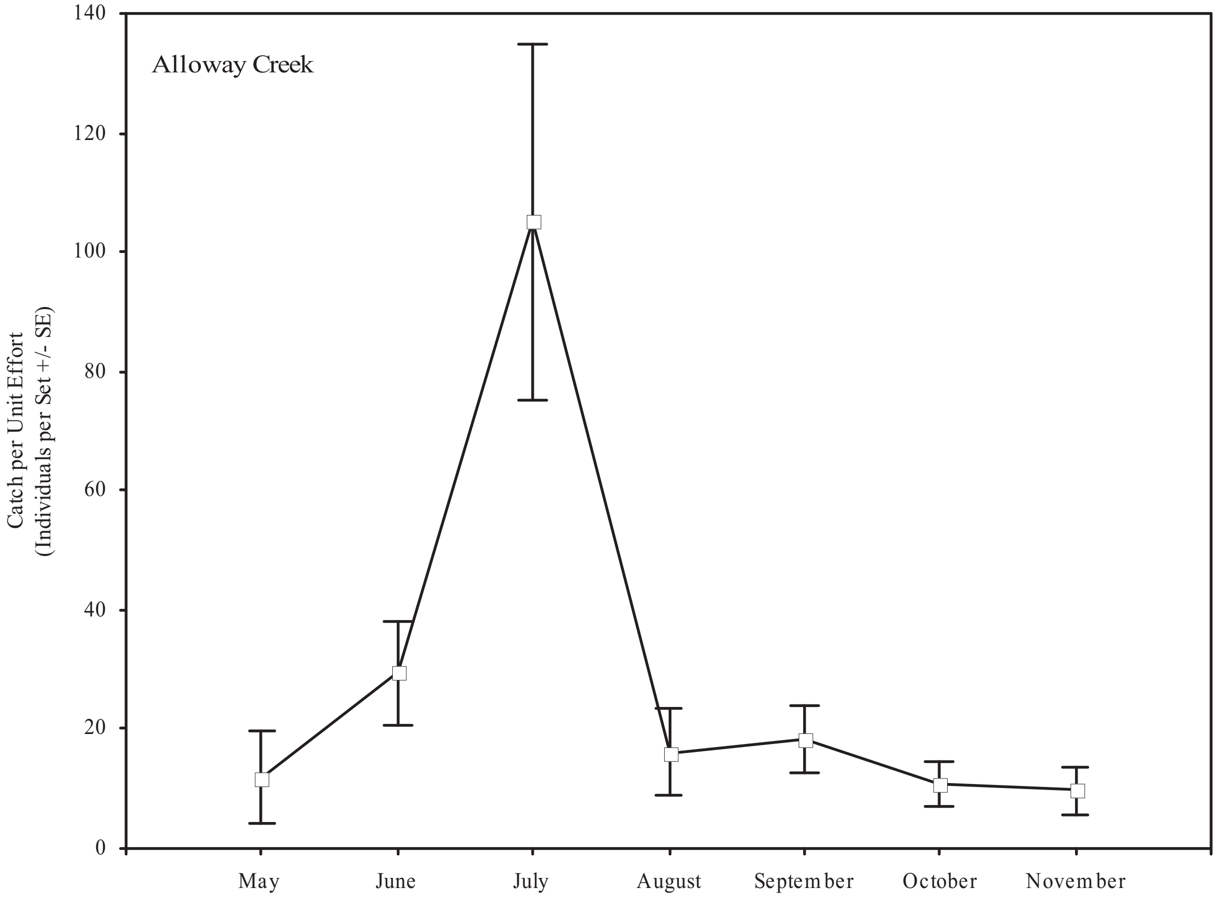


Figure 7-31. Monthly abundance for all fish caught, in small marsh creeks with weirs, at Alloways Creek during 2006.

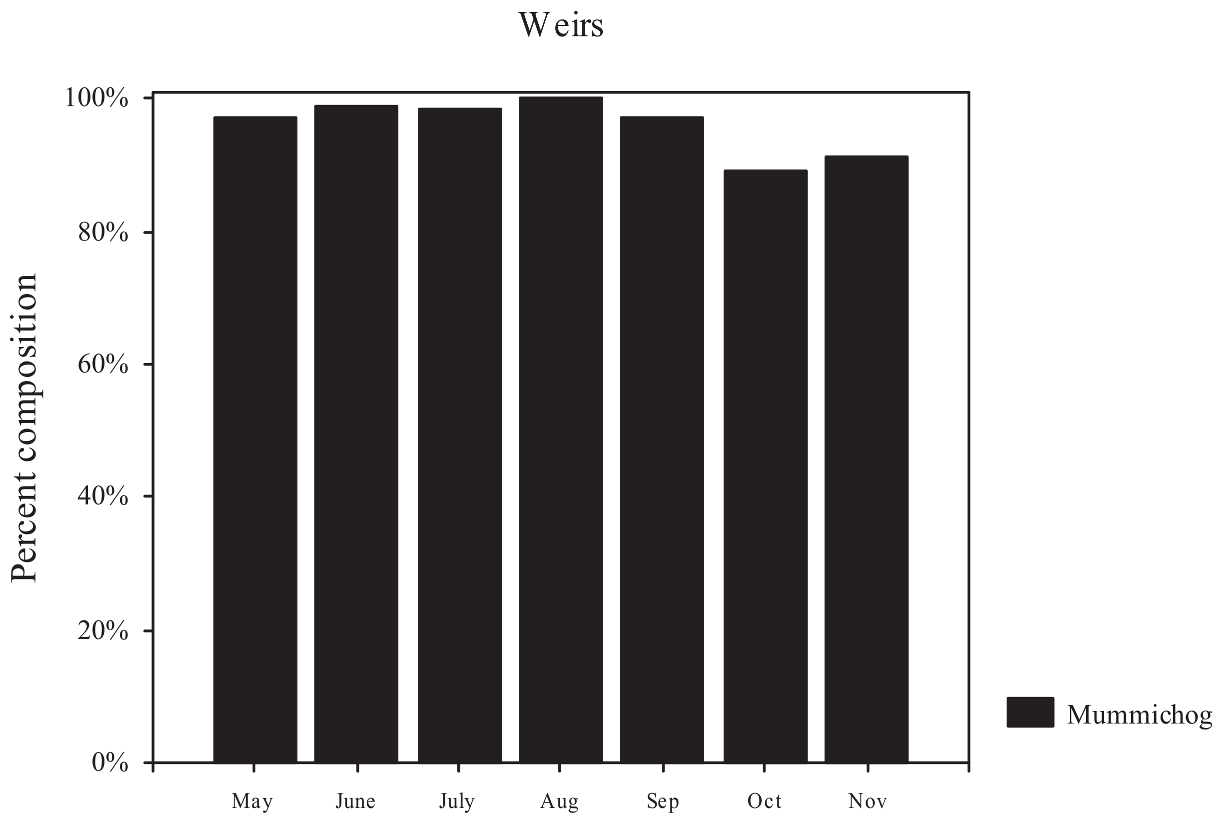


Figure 7-32. Monthly percent composition for fish caught, in small marsh creeks (weir), in Alloways Creek during 2006.

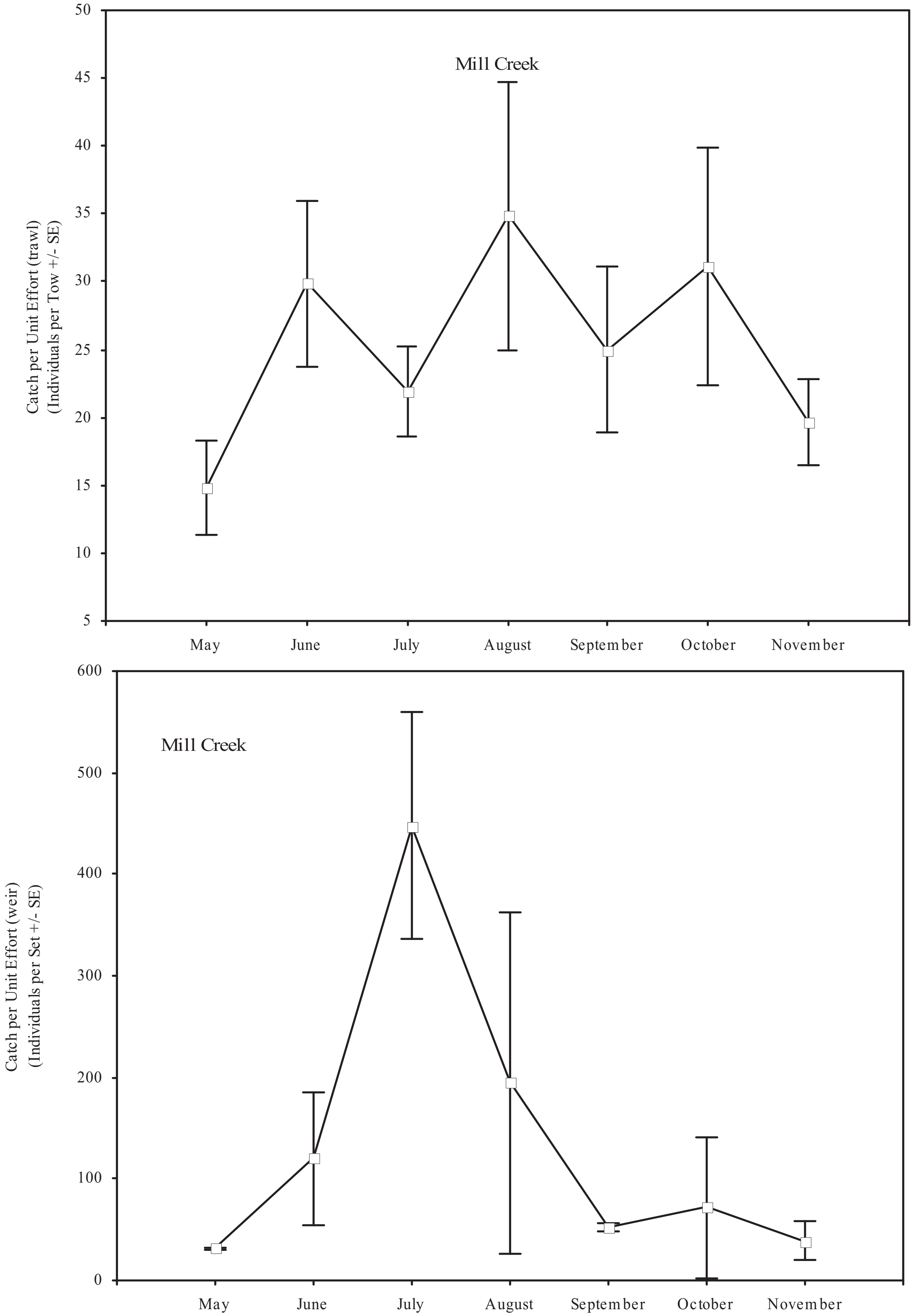
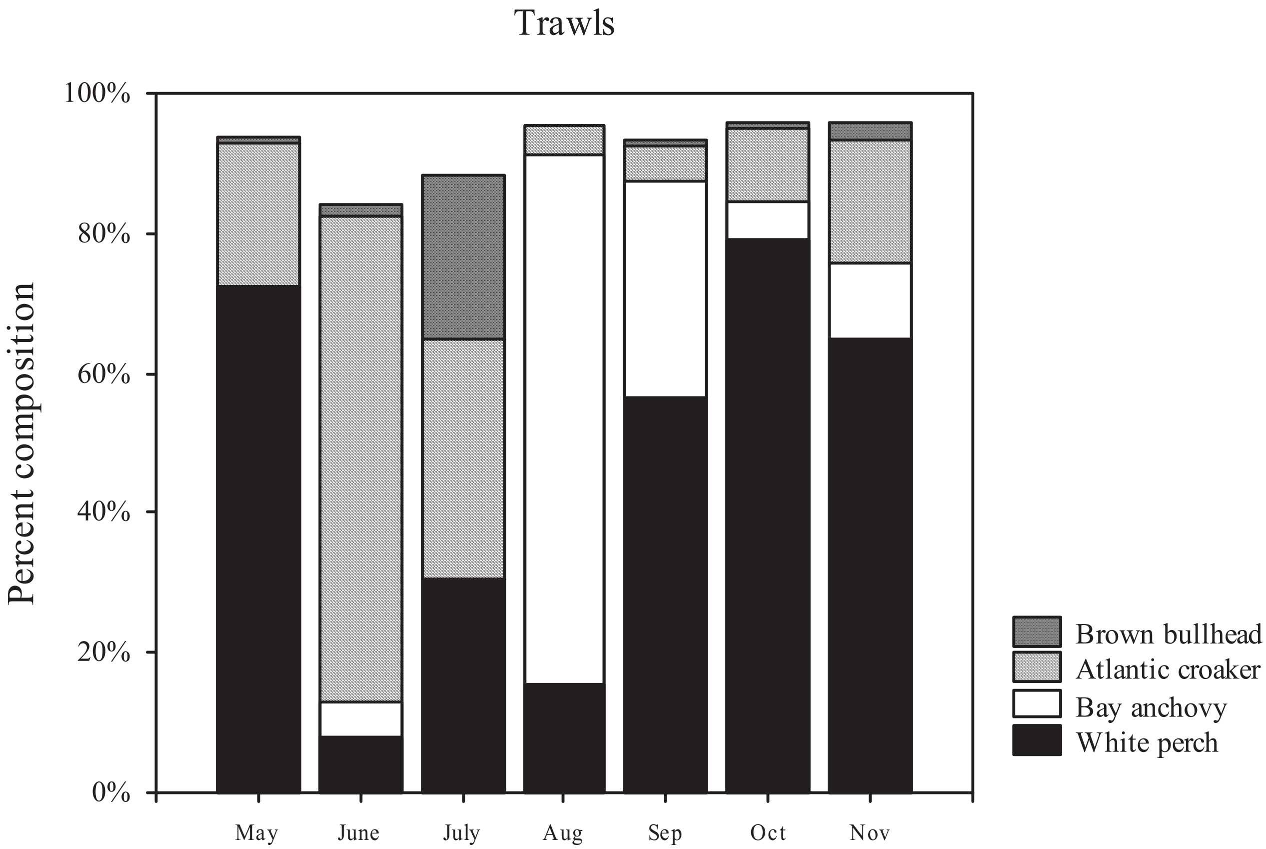


Figure 7-33. Abundance by month for all fish caught, in large marsh creeks (otter trawl) and in small marsh creeks (weir), at Mill Creek during 2006.



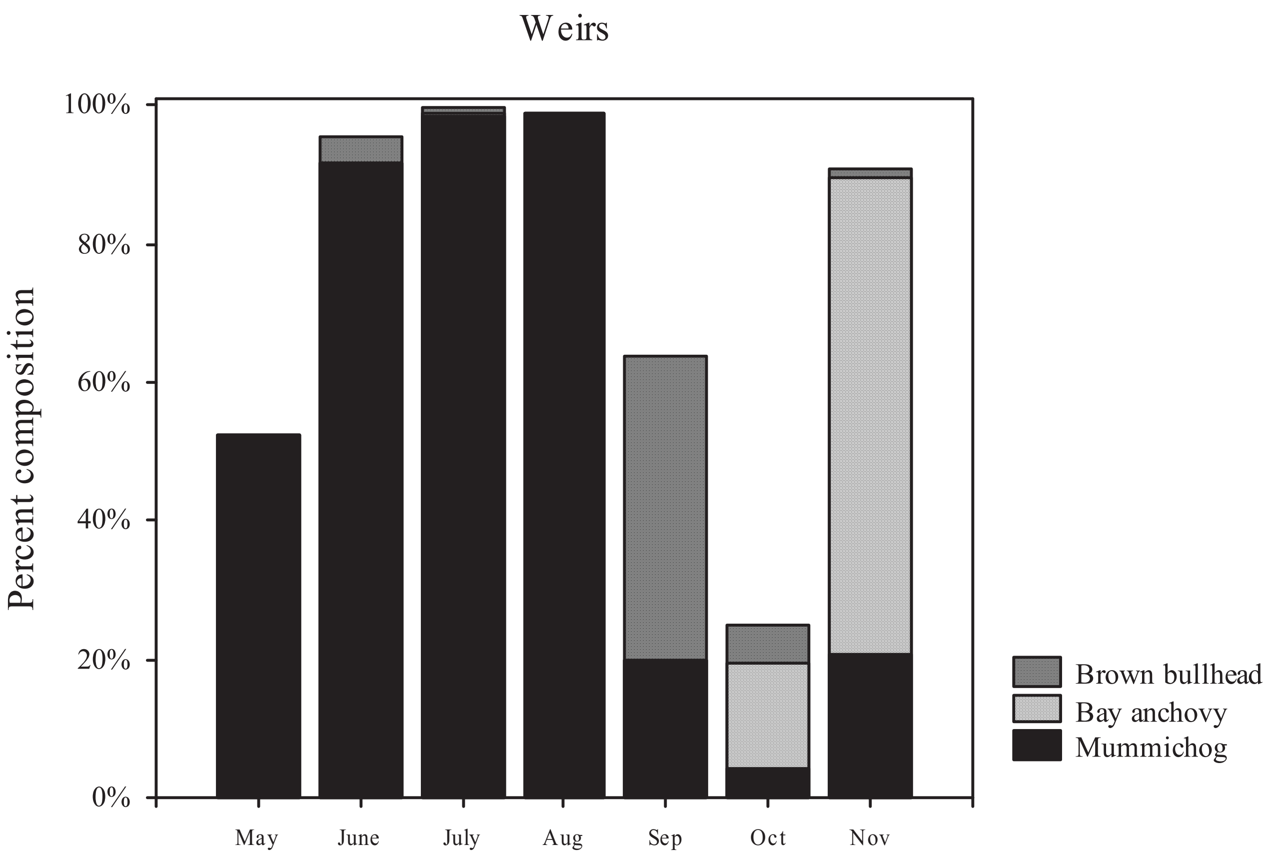


Figure 7-34. Monthly percent composition for fish caught, in large marsh creeks (otter trawl) and small marsh creeks (weir), in Mill Creek during 2006.

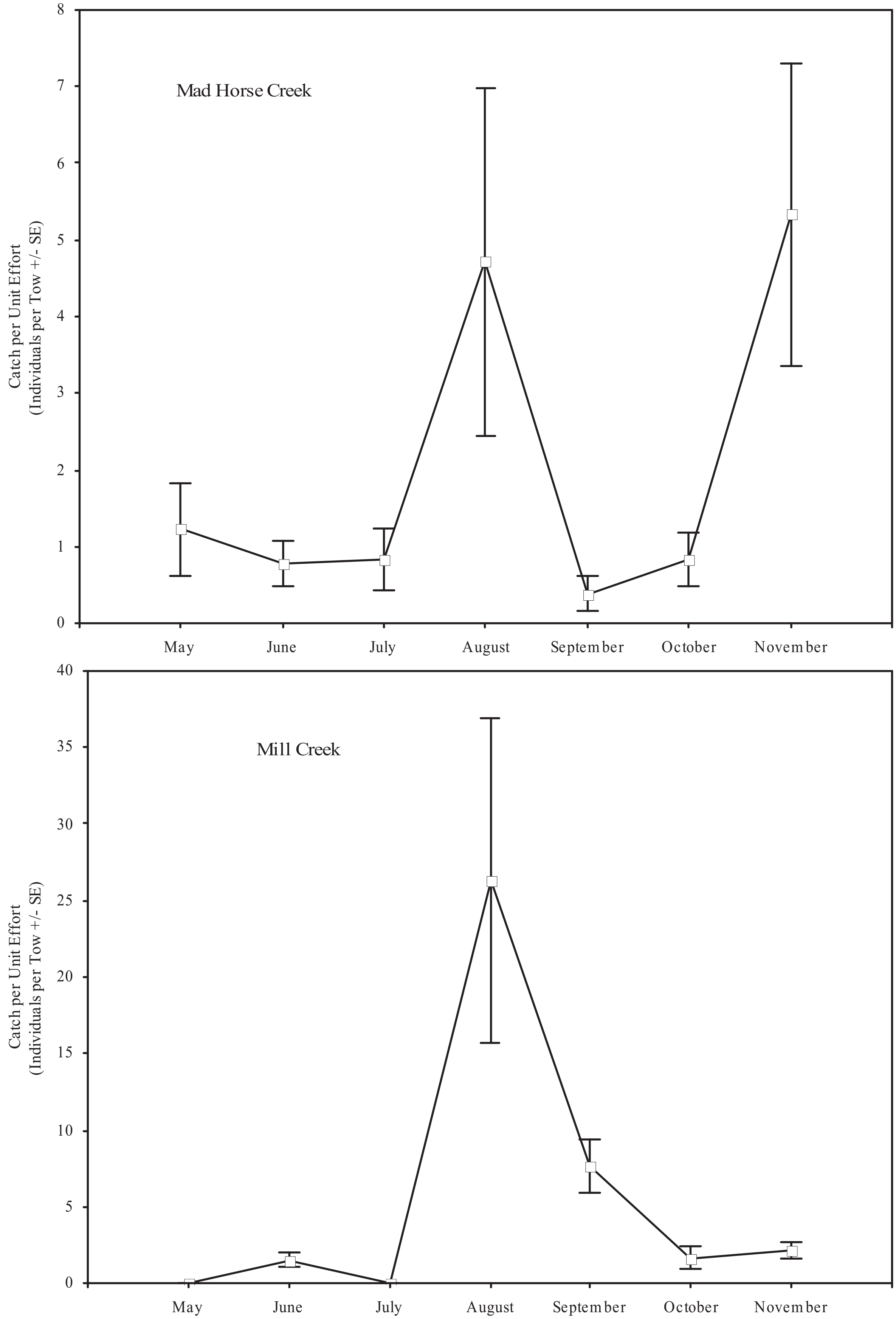


Figure 7-35. Monthly abundance for bay anchovy caught, in large marsh creeks with otter trawls, in the Upper Bay Region during 2006.

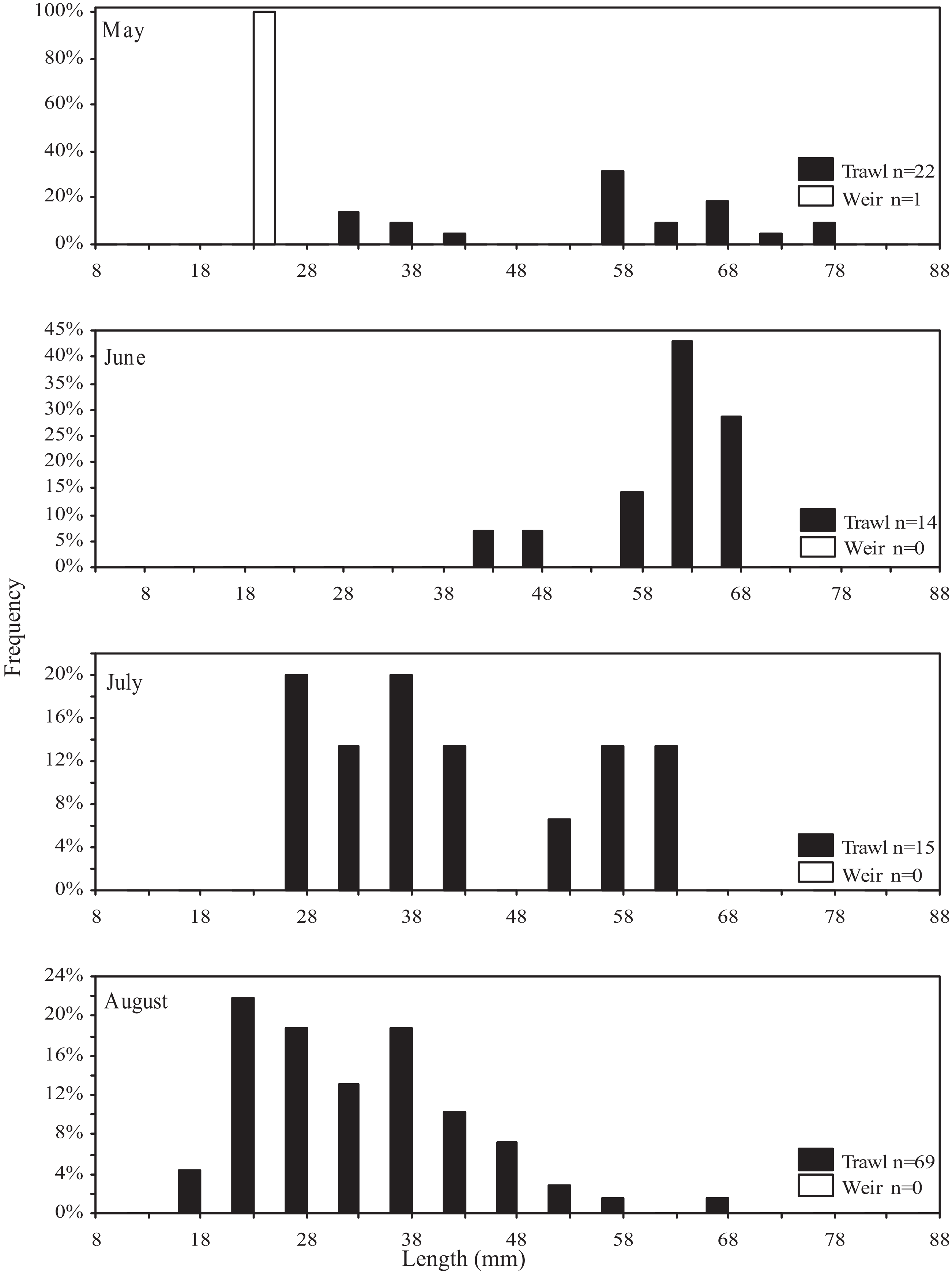


Figure 7-36. Size distribution of bay anchovy, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse during 2006.

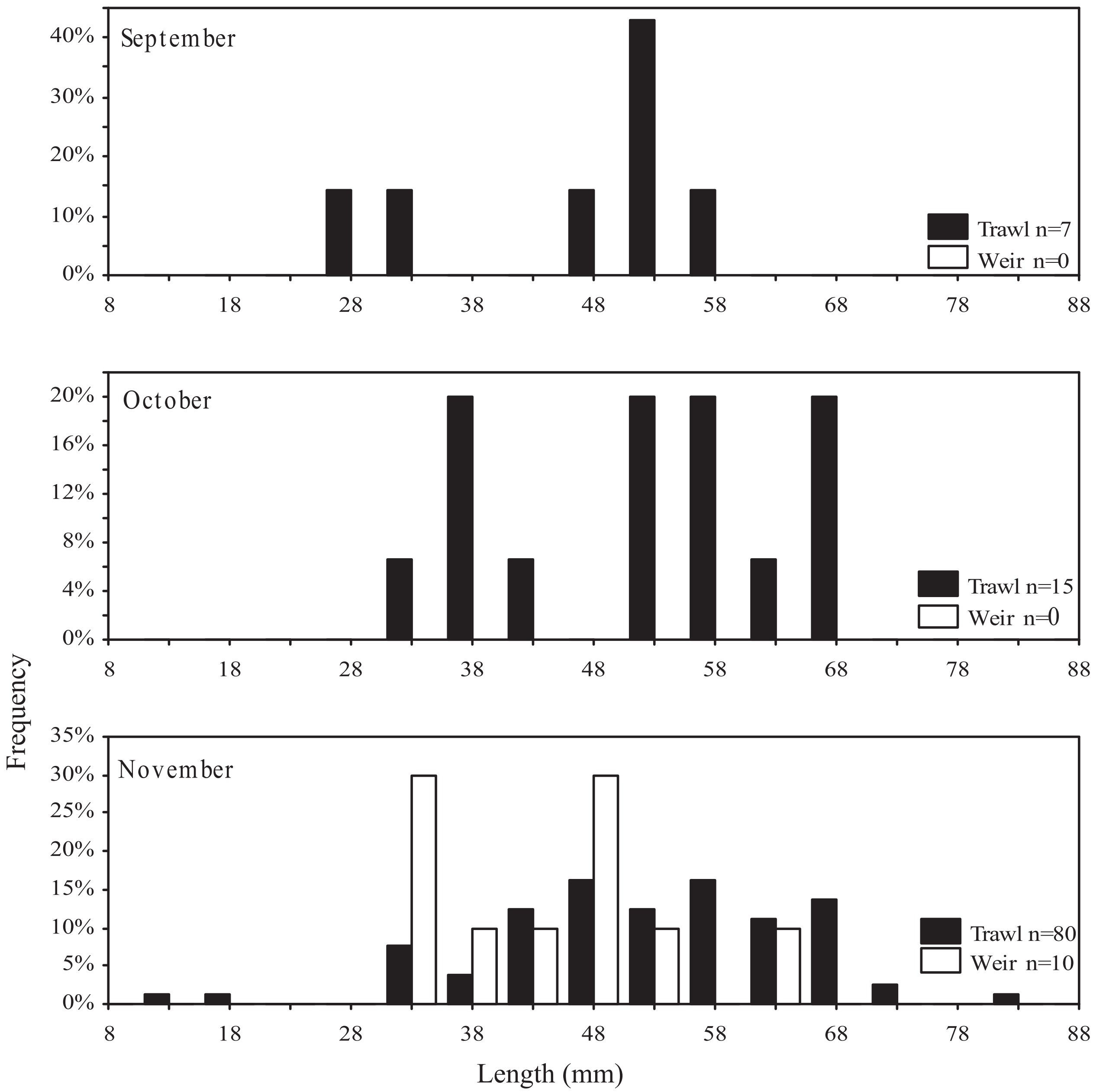


Figure 7-36. Continued.

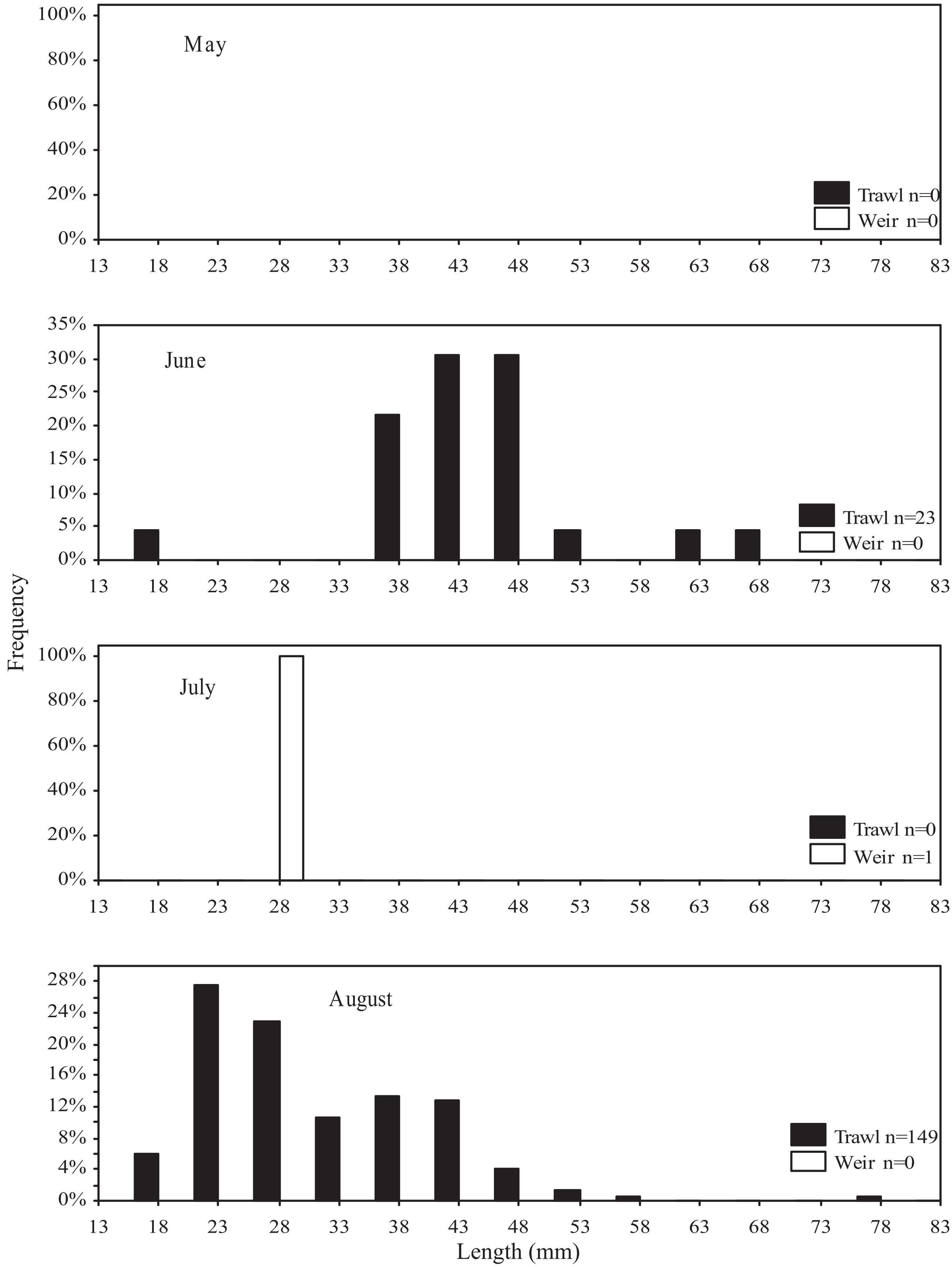
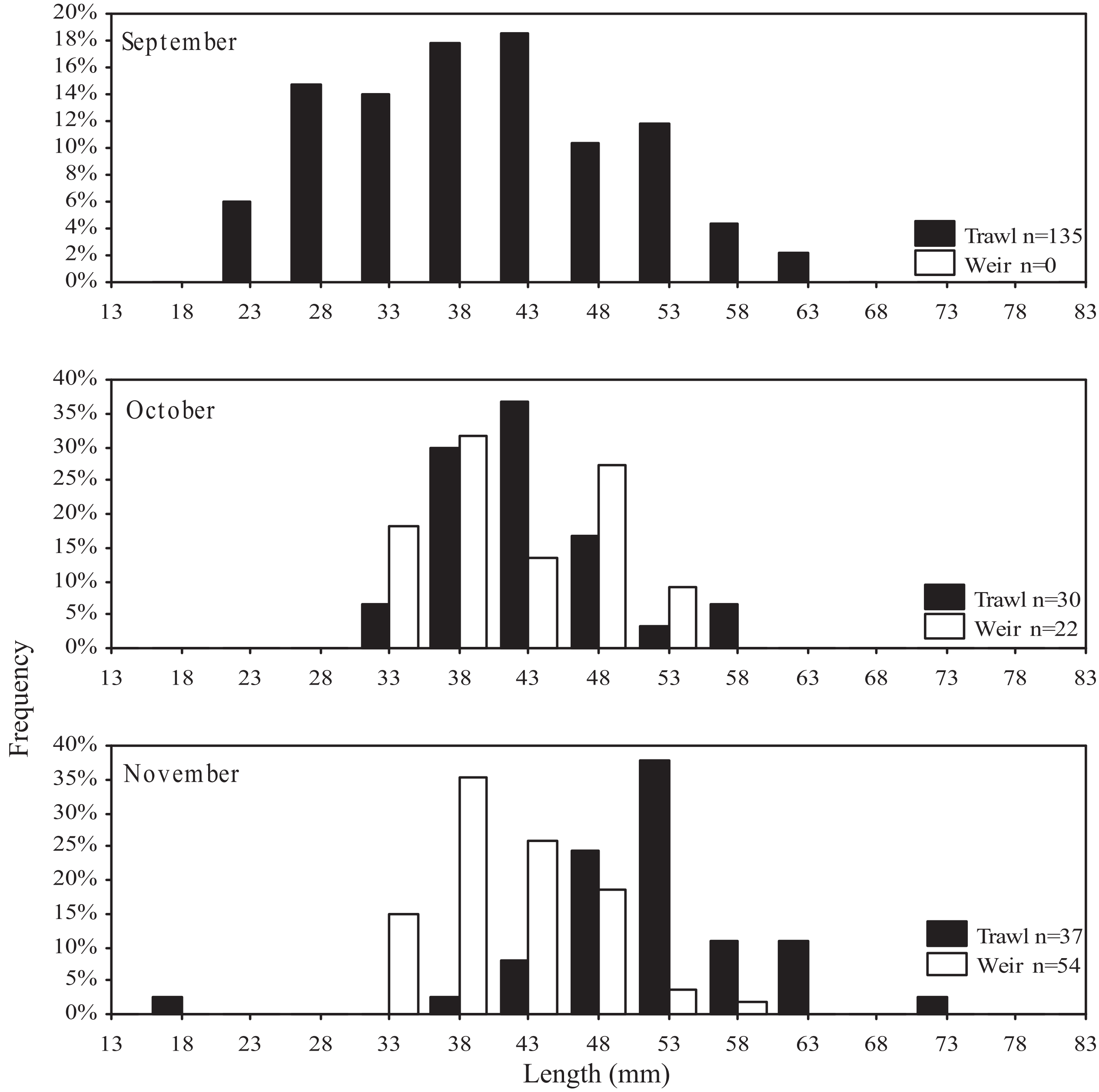


Figure 7-37. Size distribution of bay anchovy, collected in large marsh creeks (otter trawl) and small marsh creeks (weirs), at Mill Creek in 2006.



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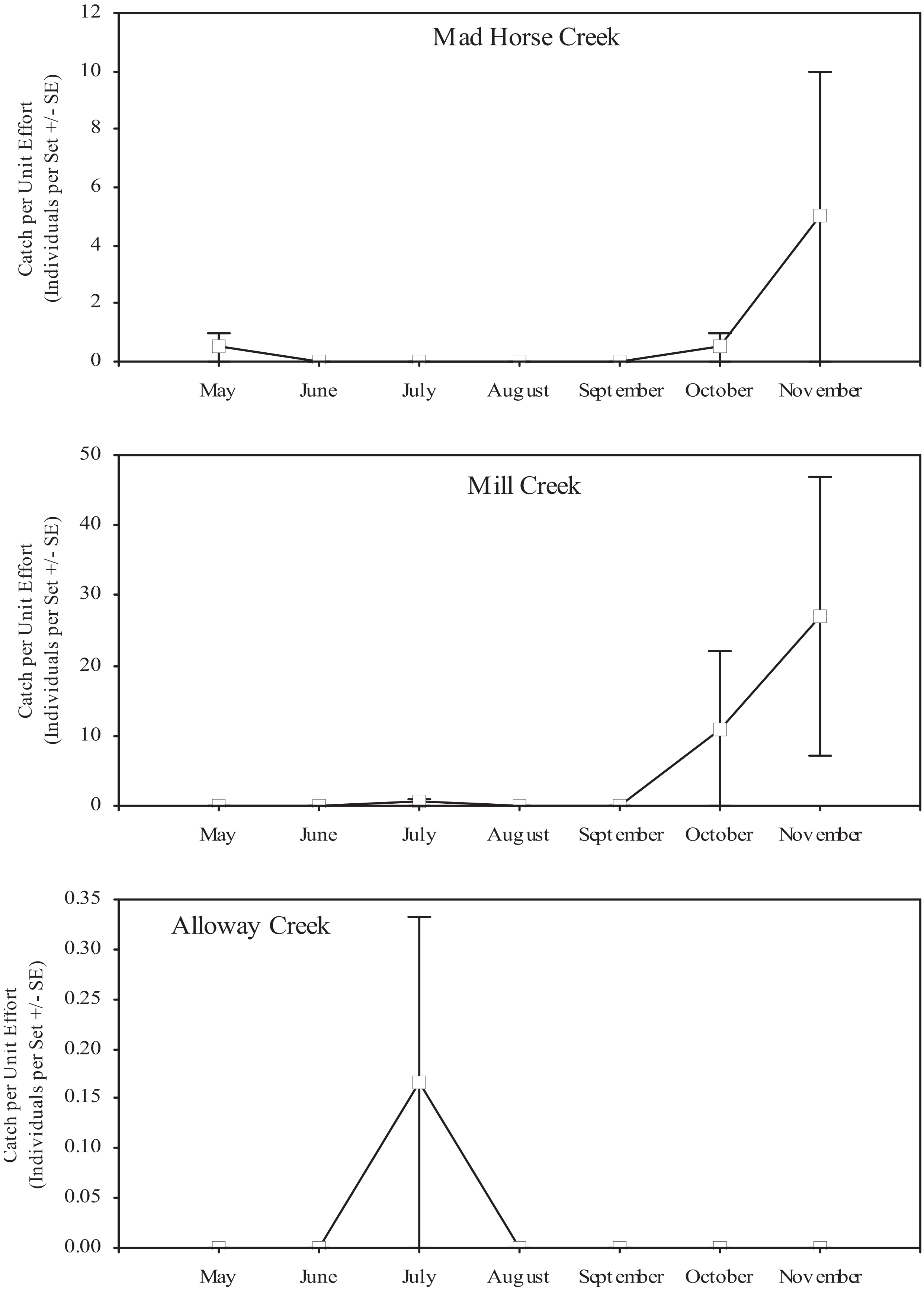


Figure 7-38. Monthly abundance for bay anchovy caught, in small marsh creeks with weirs, in the Upper Bay Region in 2006.

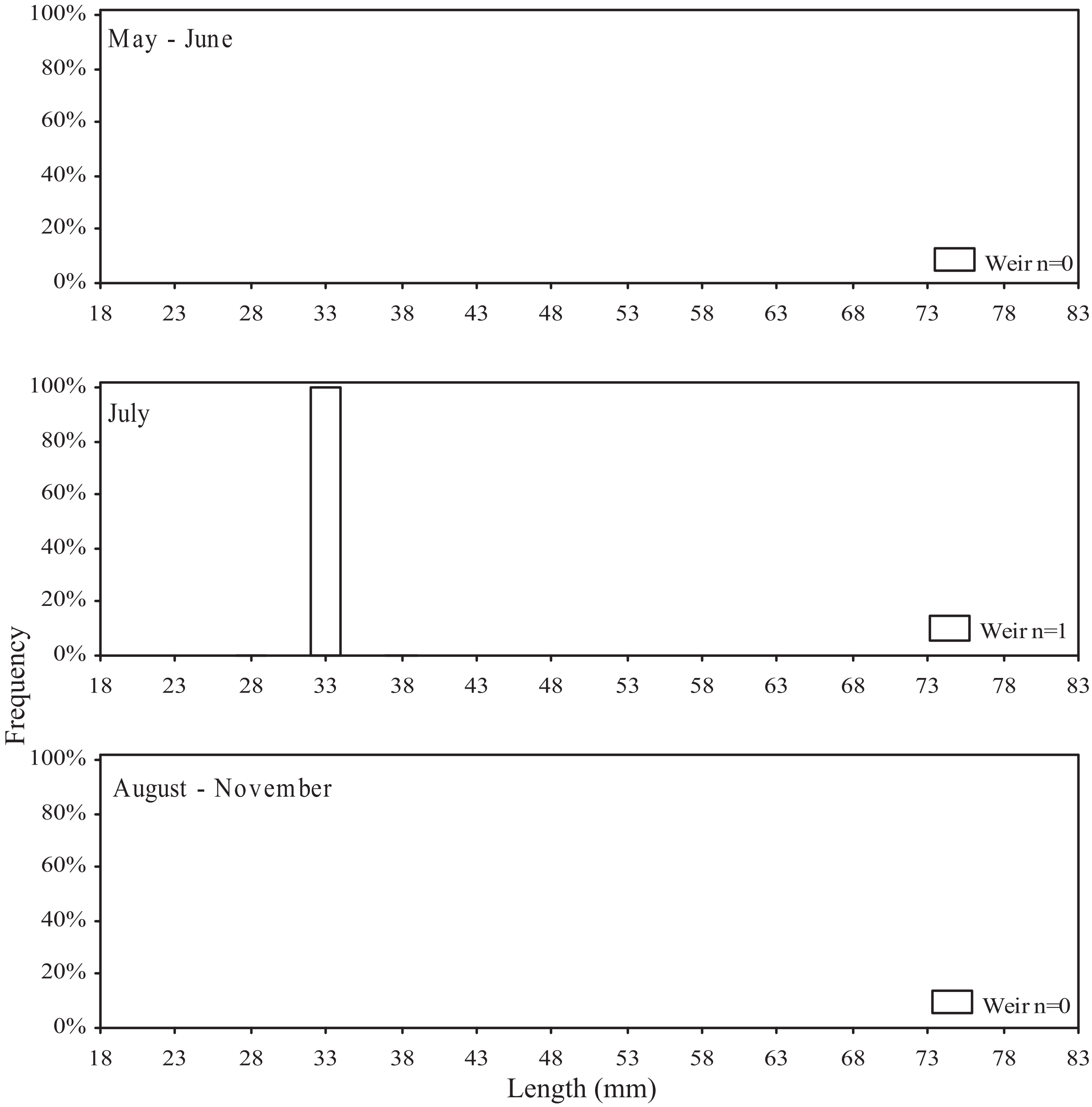


Figure 7-39. Size distribution of bay anchovy from small marsh creeks (weir) at Alloway Creek during 2006.

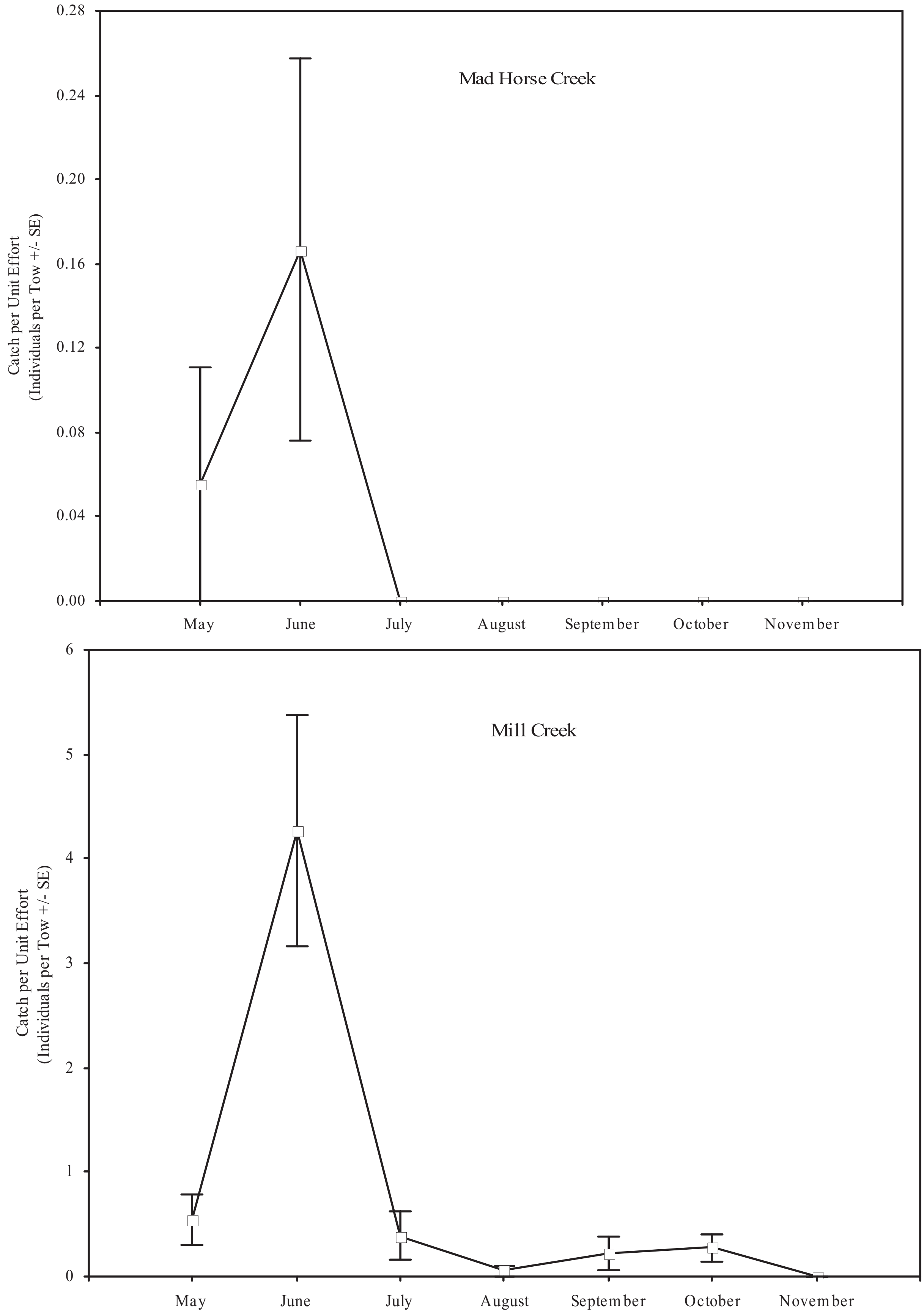


Figure 7-40. Monthly abundance for spot caught, collected in large marsh creeks with otter trawls, in the Upper Bay Region during 2006.

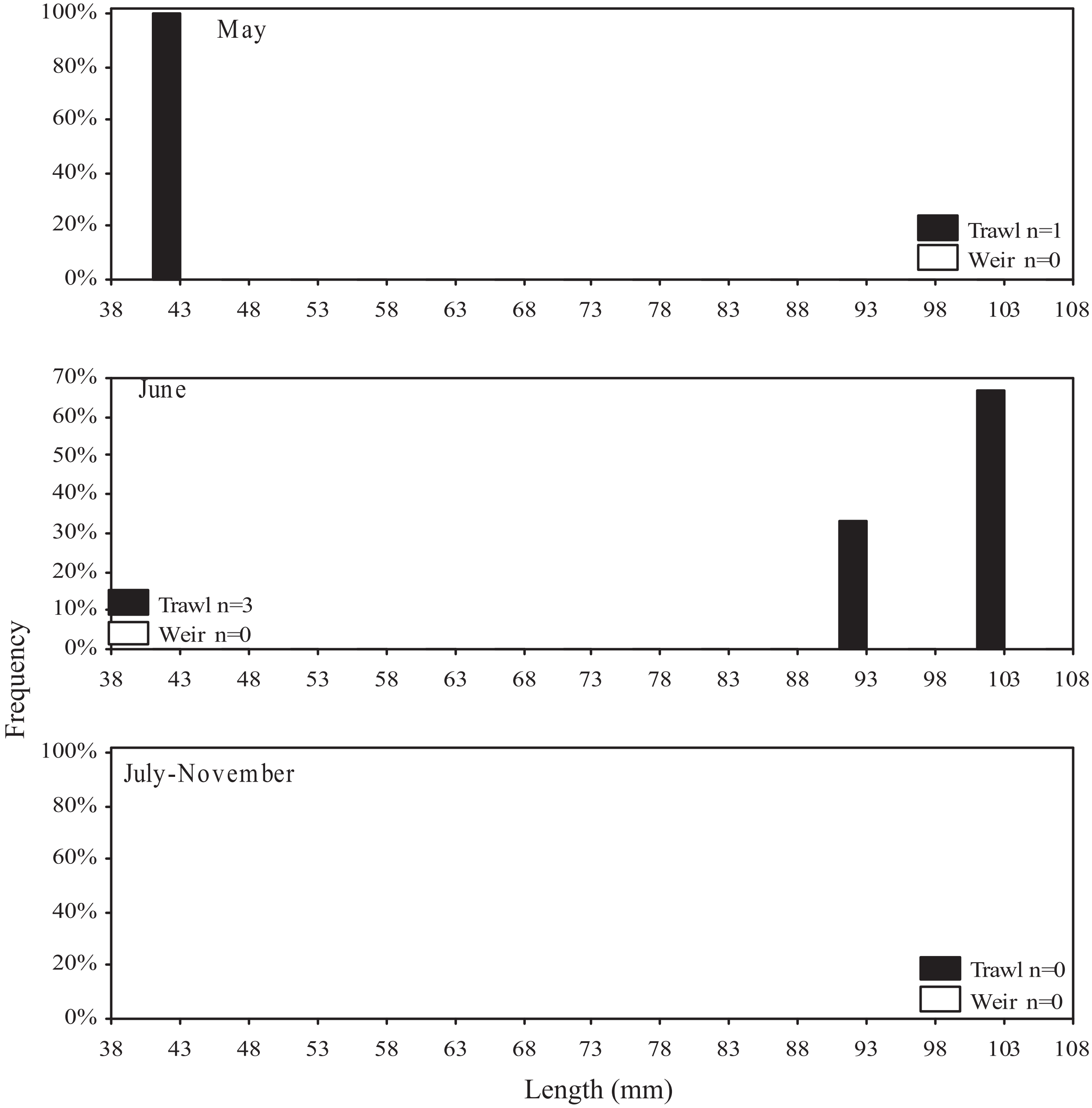


Figure 7-41. Size distribution of spot, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse Creek during 2006.

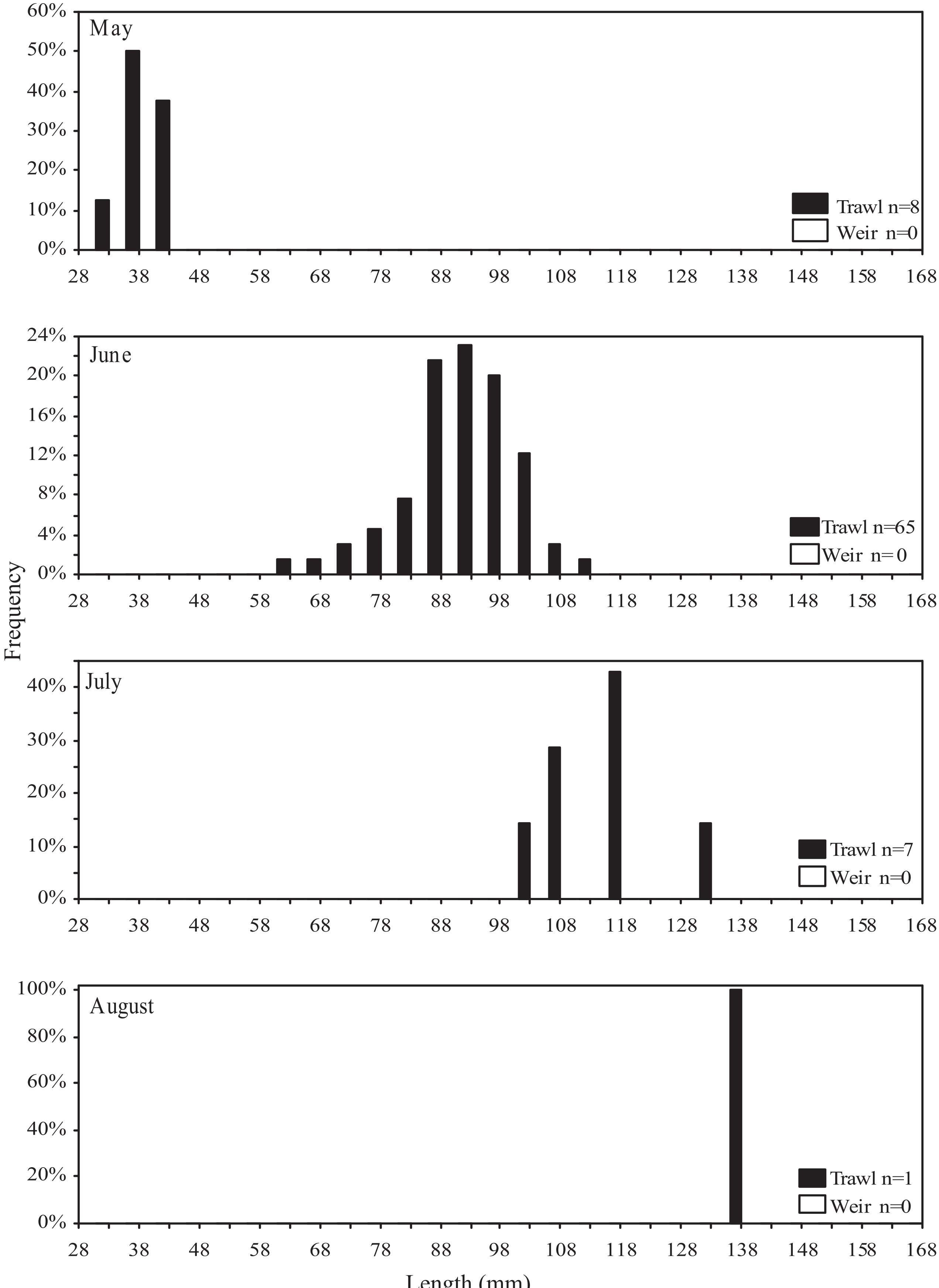
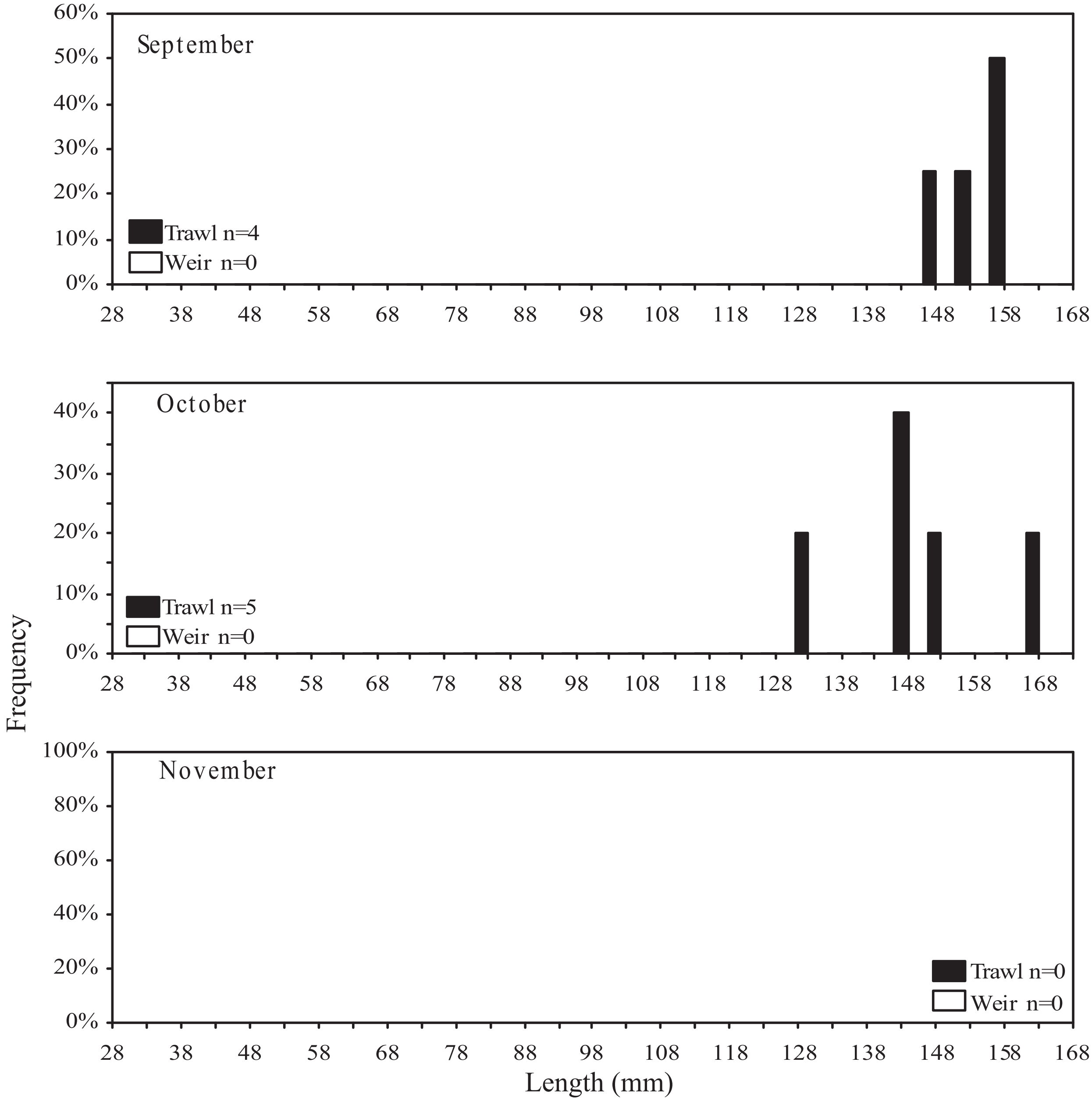


Figure 7-42 Size distribution of spot, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mill Creek during 2006.



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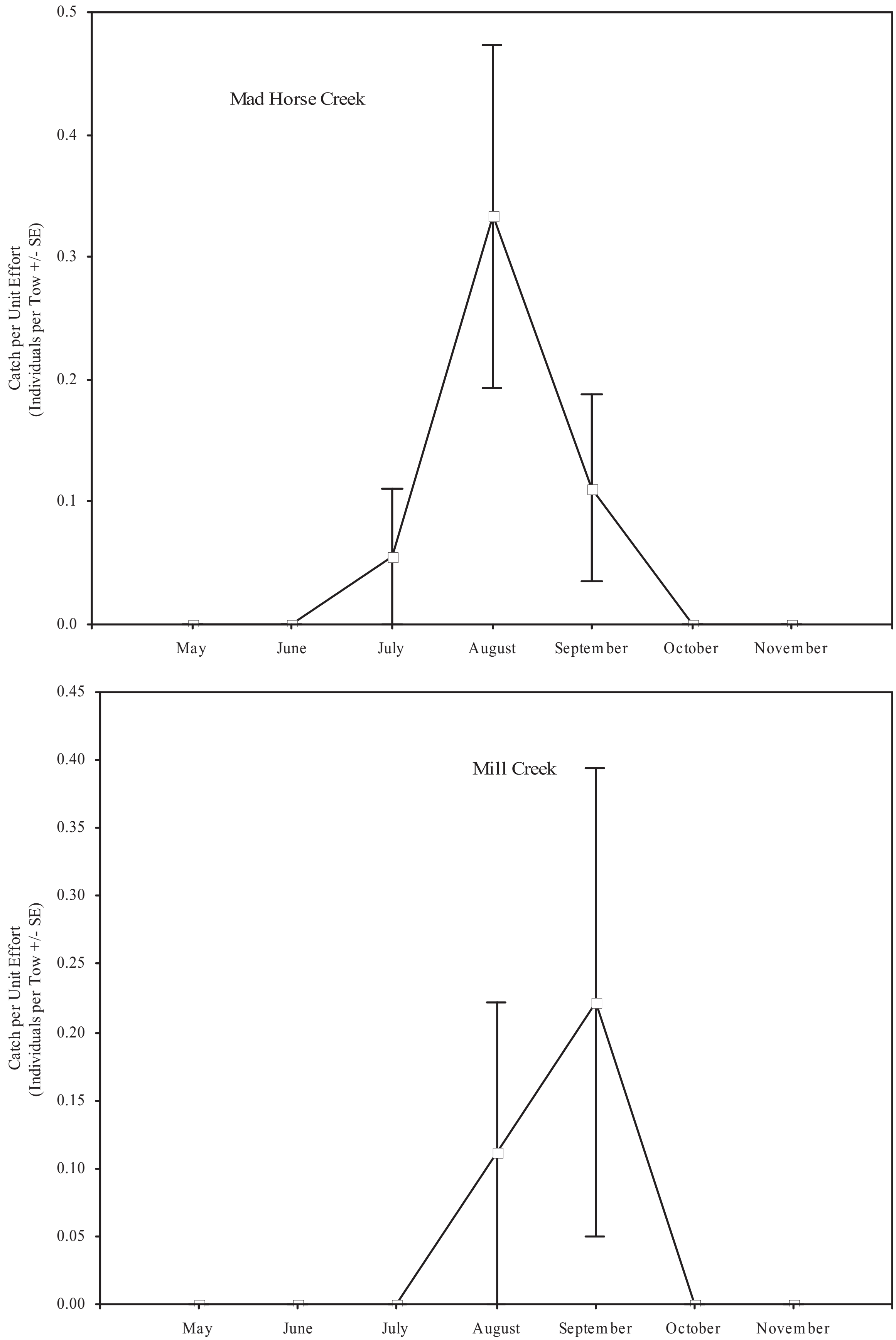


Figure 7-43. Monthly abundance for weakfish, collected in large marsh creeks with otter trawls, in the Upper Bay Region during 2006.

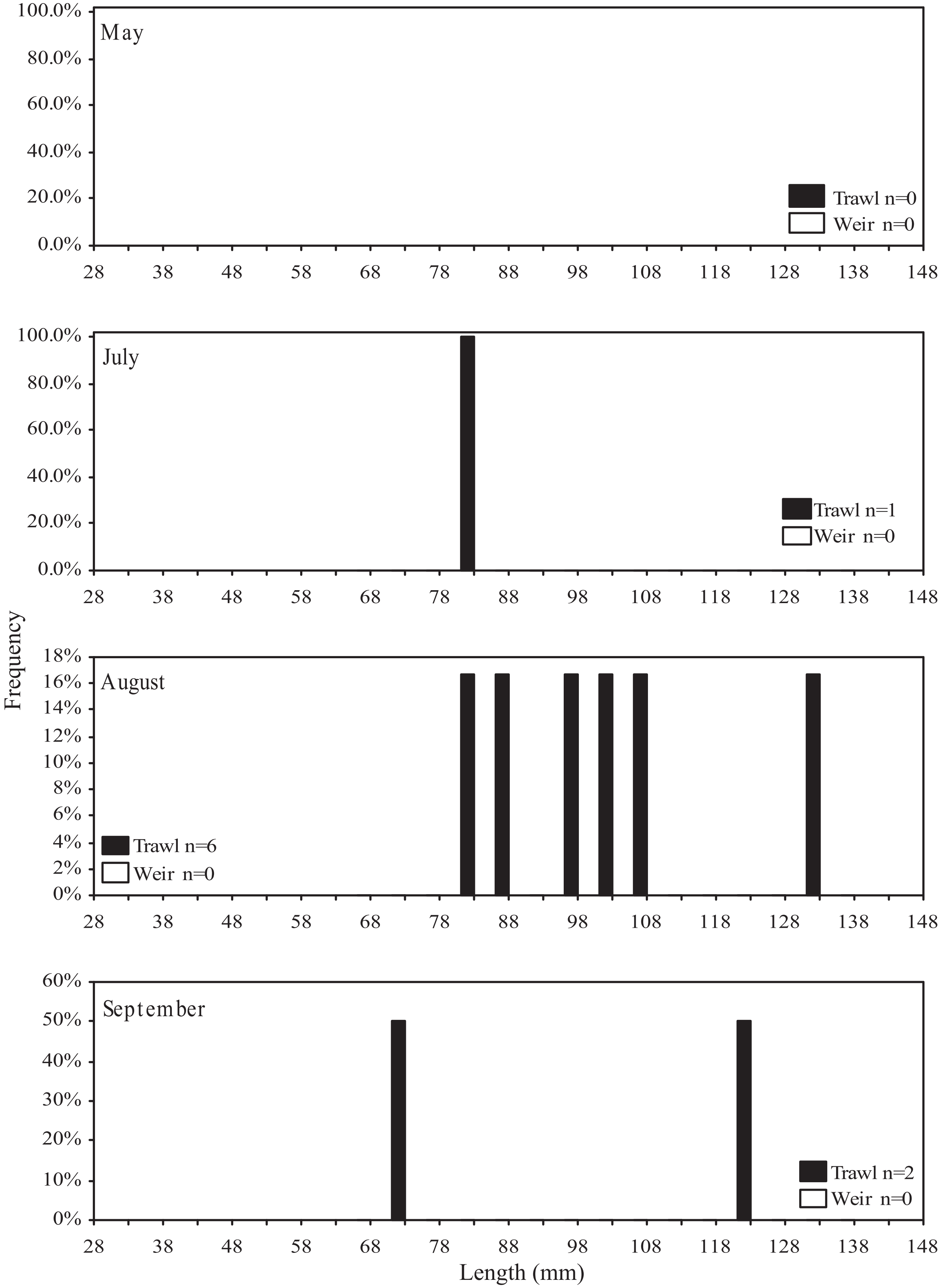


Figure 7-44. Size distribution of weakfish, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse Creek during 2006.

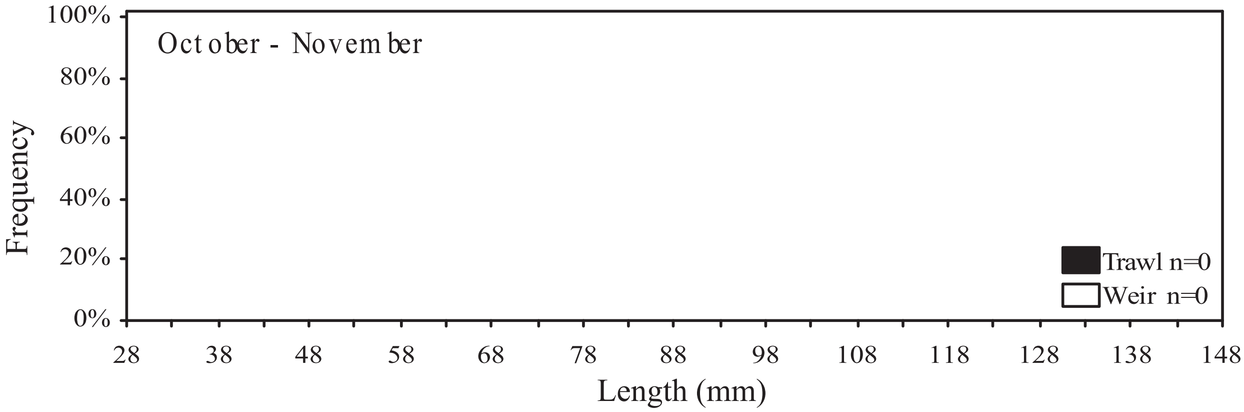


Figure 7-44. Continued.

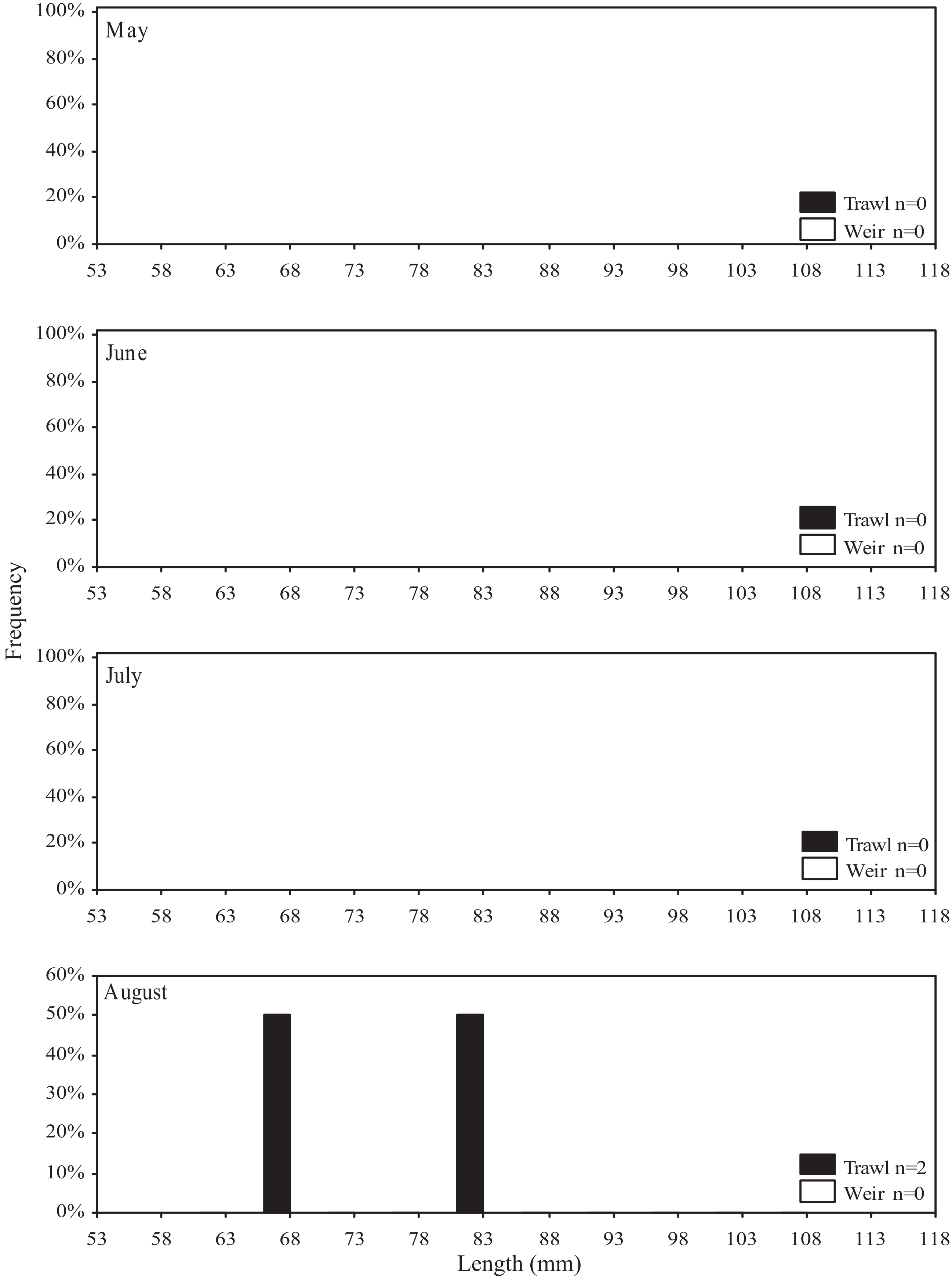


Figure 7-45. Size distribution of weakfish, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mill Creek during 2006.

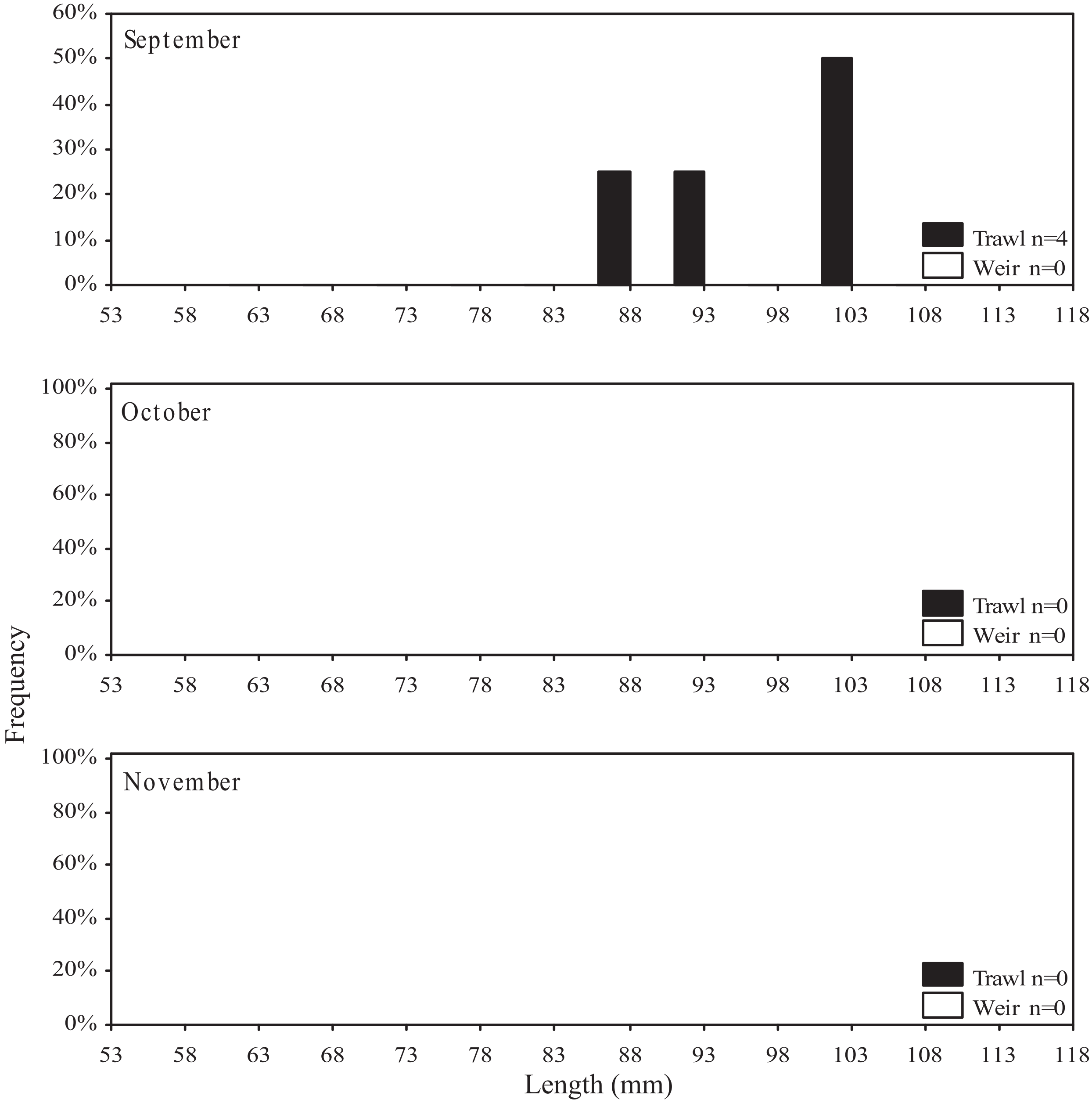
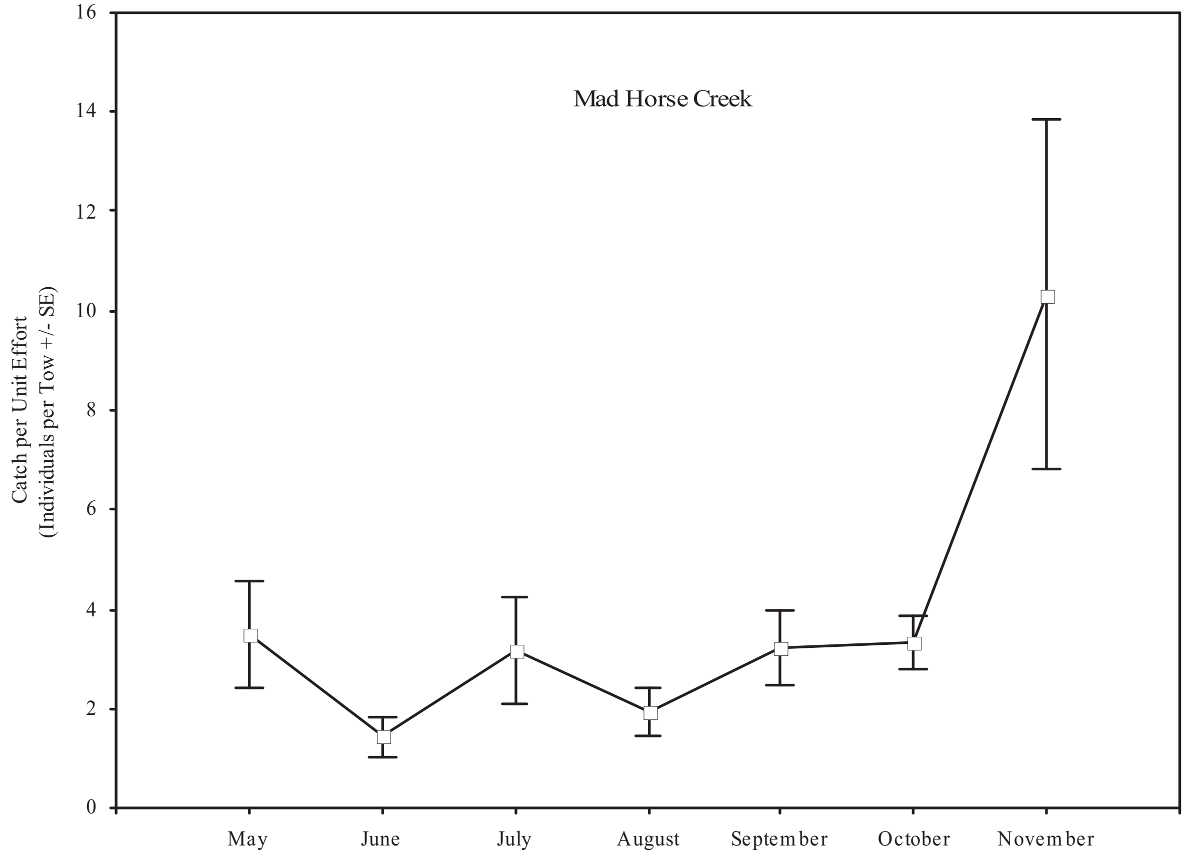


Figure 7-45. Continued.



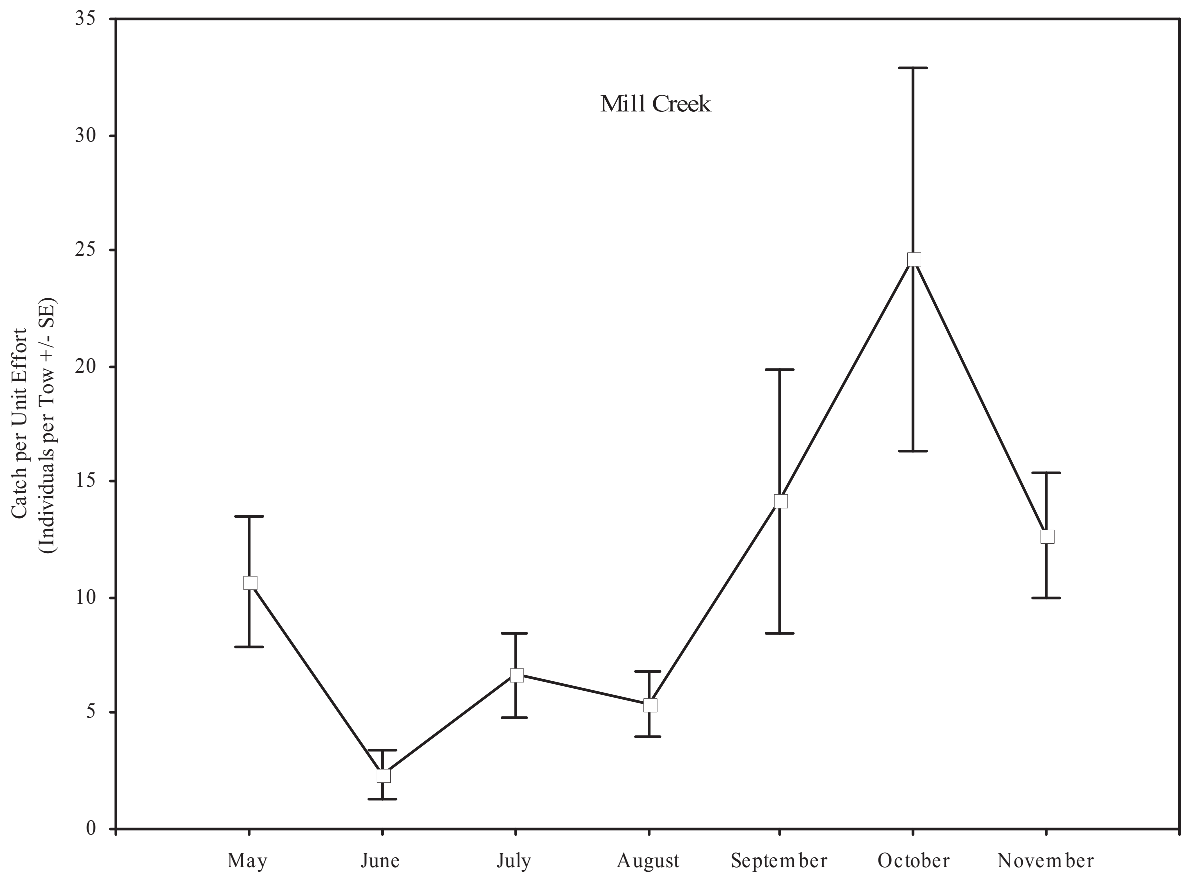


Figure 7-46. Monthly abundance for white perch, collected in large marsh creeks (otter trawl), in the Upper Bay Region during 2006.

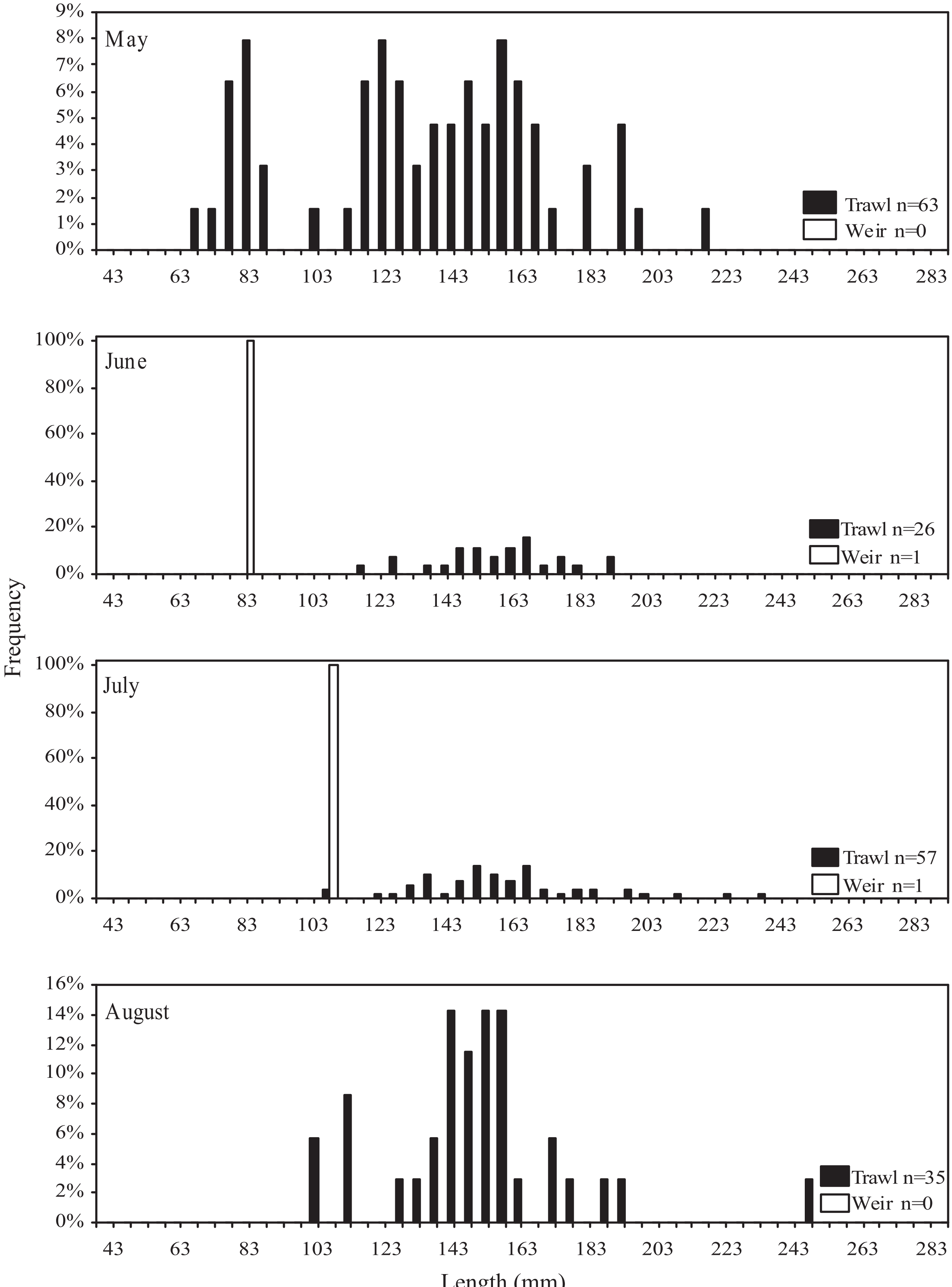


Figure 7-47. Size distribution of white perch, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mad Horse Creek during 2006.

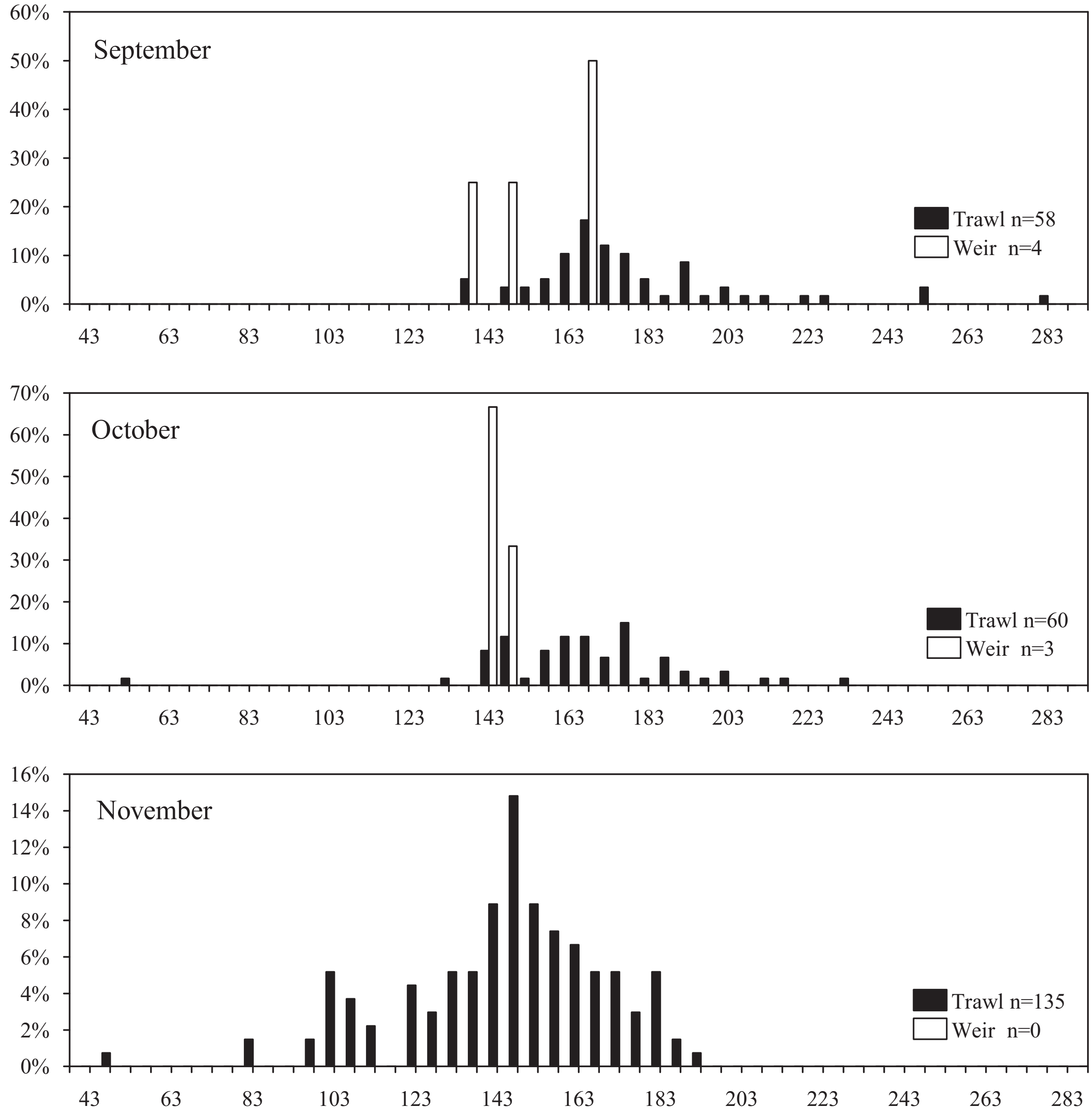


Figure 7-47. Continued.

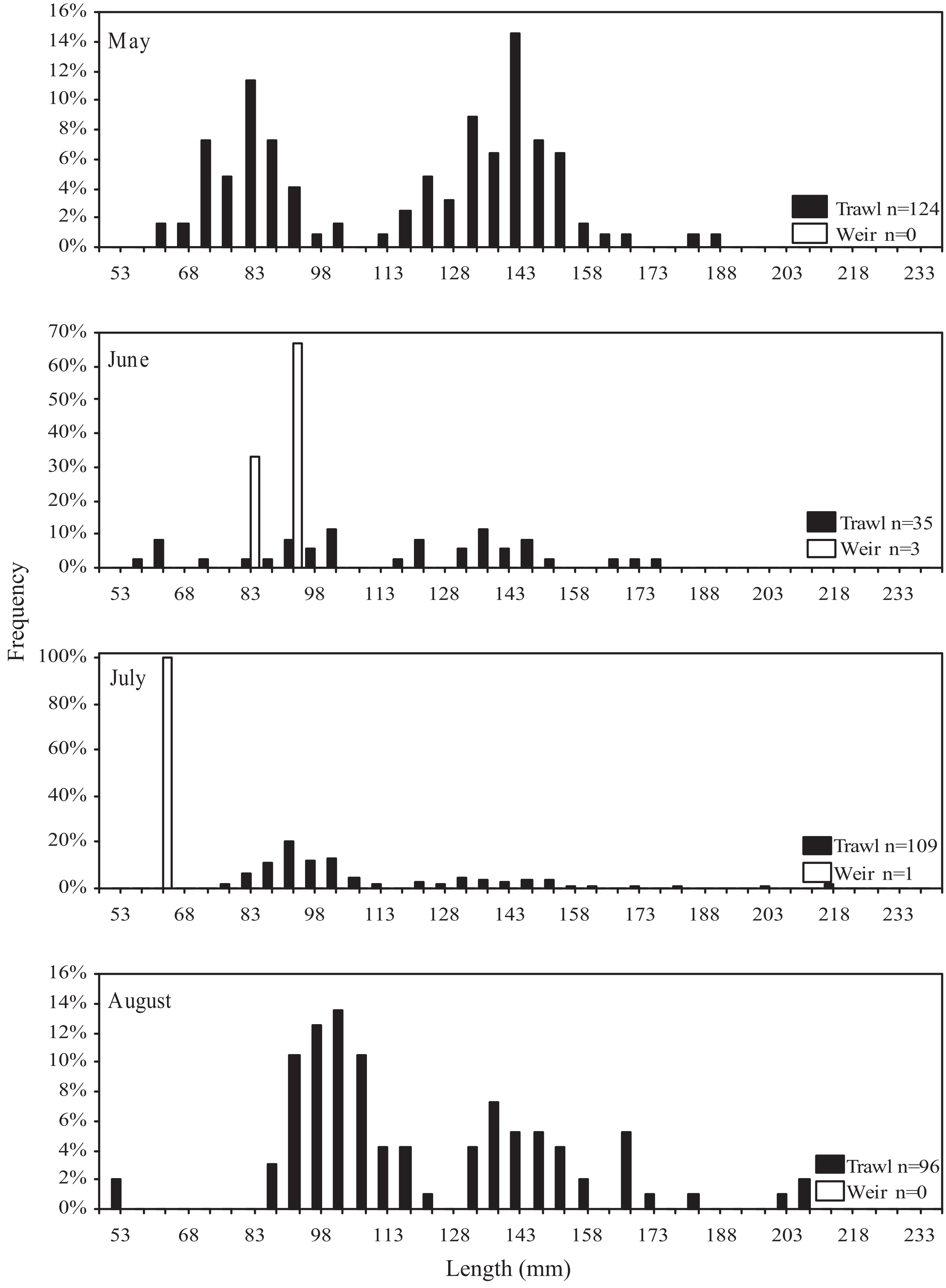


Figure 7-48. Size distribution of white perch, collected in large marsh creeks (otter trawl) and small marsh creeks (weir), at Mill Creek during 2006.

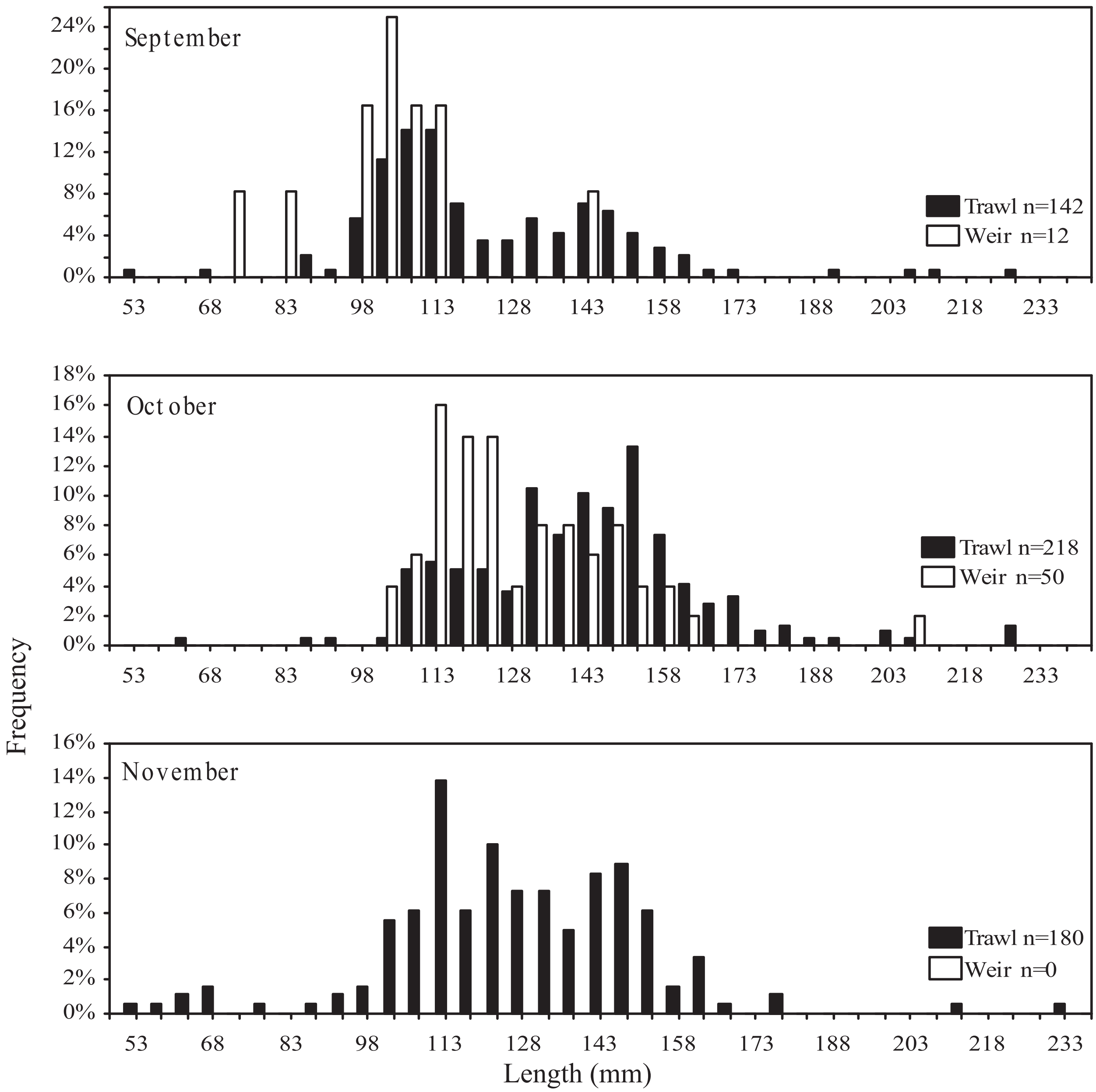


Figure 7-48. Continued.

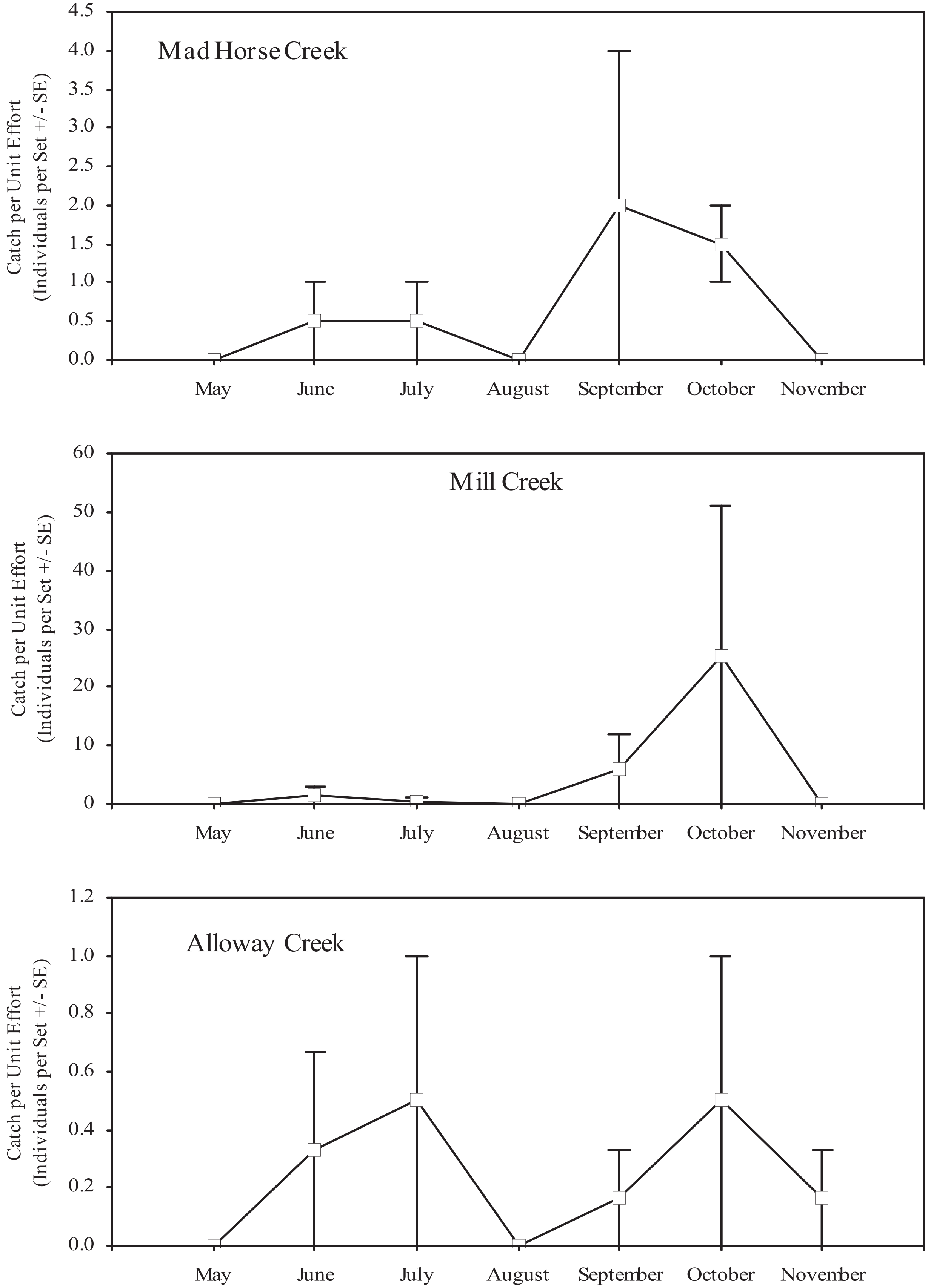


Figure 7-49. Monthly abundance for white perch, collected in small marsh creeks (weir), in the Upper Bay Region during 2006.

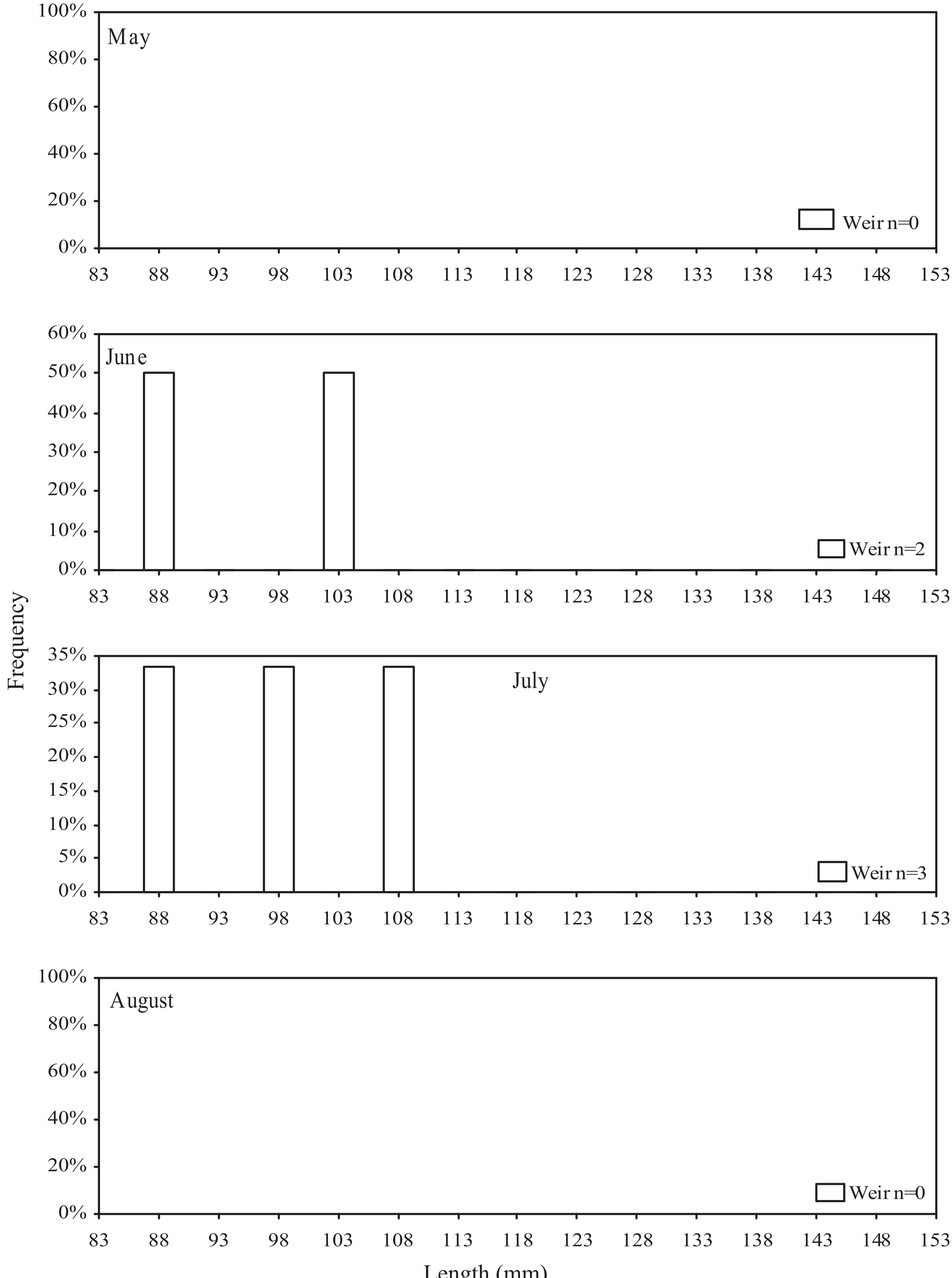


Figure 7-50. Size distribution of white perch, collected in small marsh creeks (weir) at Alloway Creek during 2006.

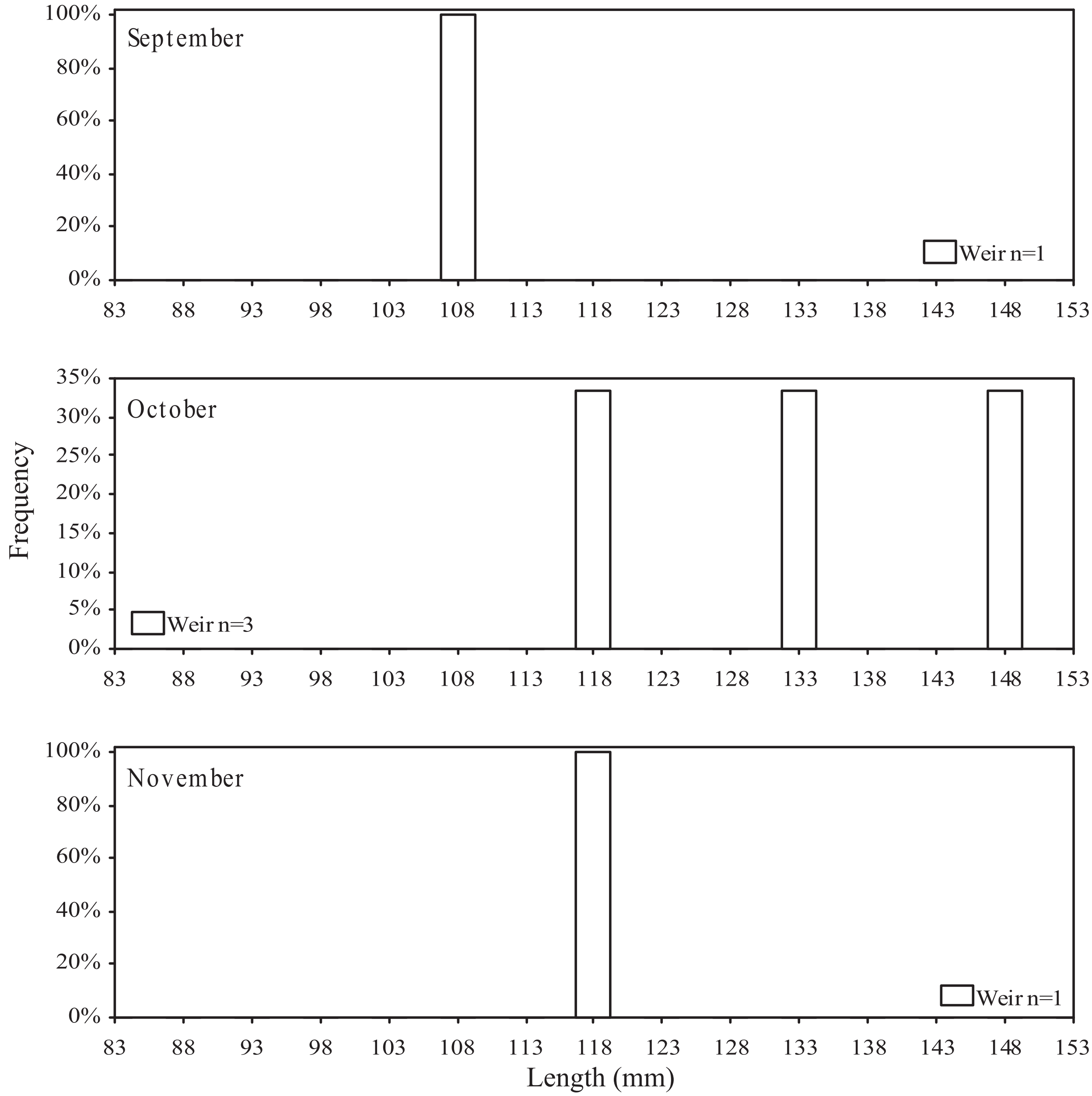


Figure 7-50. Continued.

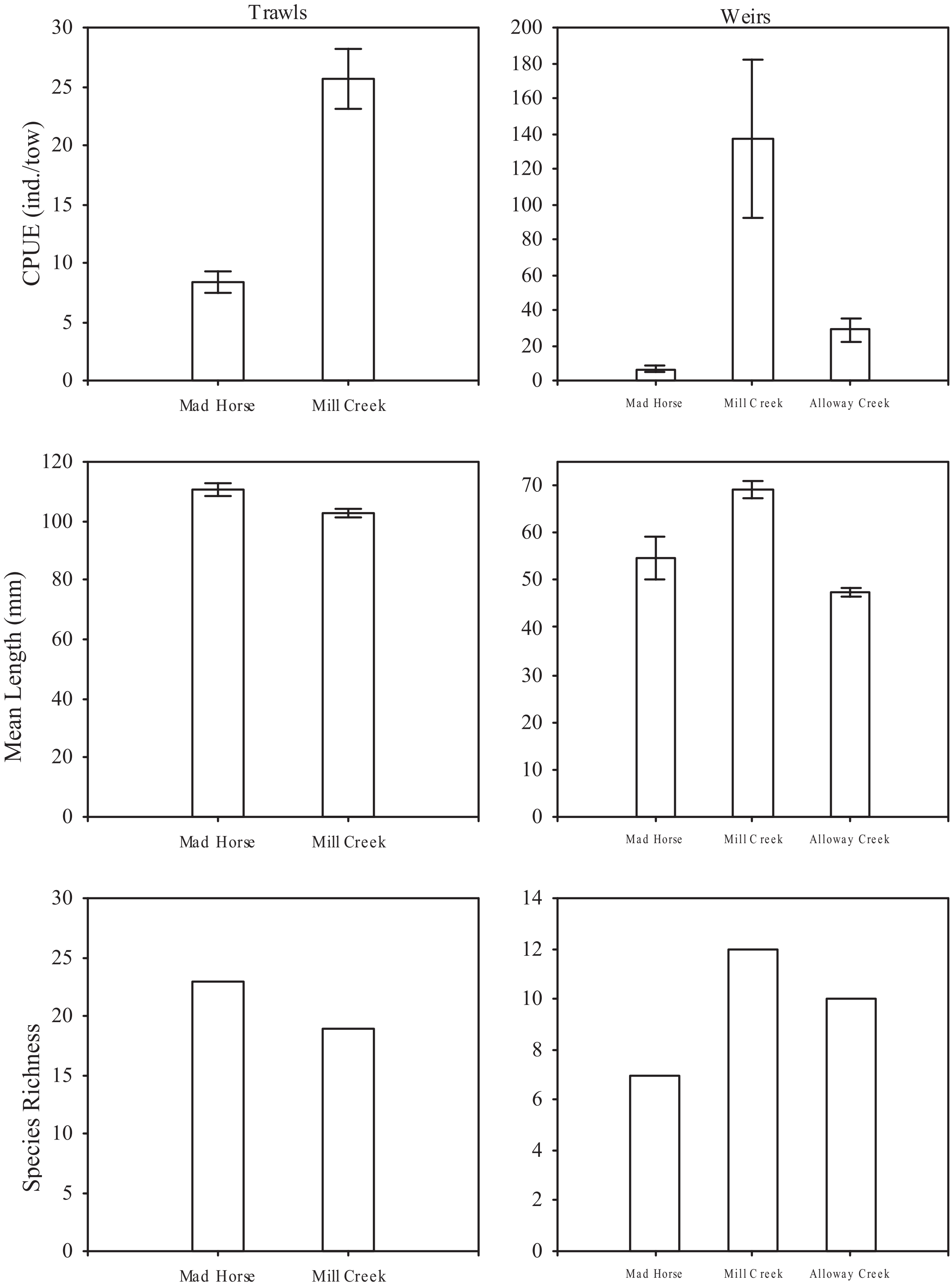


Figure 7-51. Comparisons of abundance, fish length, and species richness among restored (Alloways Creek and Mill Creek) and reference (Mad Horse Creek) marshes from large and small marsh creeks during 2006.

CHAPTER 8

DETRITAL PRODUCTION MONITORING

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APPENDIX E - MACROPHYTE QUADRAT DATA - PLOTS

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 2006 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 October 3, 2006. 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 2006 and subsequent data analysis. Elements of the 2006 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 present 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 and true color aerial photography was acquired for the purpose of mapping the extent of the vegetation communities present at the sites. Field data collection in 2006 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 (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. In 2006, most (71.8 percent) of the marsh area was vegetated with *Spartina* spp. and other desirable naturally occurring marsh vegetation. As described in Table 8-1, this site also included a substantial area of internal water areas, 16.2 percent of the marsh area in 2006.

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 encompassed approximately 1,185 acres, most of which (86.1 percent of the marsh area) were vegetated with *Spartina* spp. and other desirable naturally occurring marsh vegetation in 2006.

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 2006 Annual Report. Detrital production monitoring has continued at the Commercial Township Salt Hay Farm Wetland Restoration Site (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 Maurice River Township, 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 Township Cove, approximately 18 miles northwest of Cape May Point. For at least three generations, the area between Dividing Creek and the Maurice River Township 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 2006 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 bound 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 737 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 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 71.7 percent of the wetland restoration area prior to the initiation of wetland restoration activities by DNREC.

AERIAL MAPPING

True color and CIR aerial photography was acquired for all reference and restoration sites in New Jersey and Delaware on October 3, 2006. 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 111 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. 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 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, they could be performed before the GPS crew leaves the site. Office processing consists of analyzing the results to determine if any manual reprocessing is 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 aerial photography obtained in October 2006. 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 2006 CIR 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 centerlines 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 2006 CIR 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.

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 a 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.

A team of scientists familiar with the vegetation and physical features of the reference and restoration sites interpreted the CIR 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 2000™. 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 October 2006 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., > 5 ft wide).

(3) Any single-lined channel (i.e., <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.

$$\mathbf{L}_{n\ avg} = L_n / N_n$$

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 2006 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 2006 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, MHT1-06-OQ18 indicates that the quadrat

was sampled along MHC Reference Marsh Transect 1 (MHT1-06) during 2006. 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, MHT1-06-CQ1 indicates that the quadrat was sampled along MHC Reference Marsh Transect 1 during 2006 (MHT1-06). 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 2006 effort.

QUADRAT SAMPLING

Sampling within the 0.25 m^2 quadrats located along the transects as described above was conducted utilizing the field procedures described below:

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

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.

VEGETATION PLOTS

To supplement the collection of field data within quadrats along transects in 2006, additional 0.25 m^2 quadrat sampling was conducted within three 60 m x 60 m "plots". These plots were selectively located at each reference marsh to collect macrophyte productivity data from areas appearing to be of relatively uniform species composition, coverage and height (Figures 8-2 and 8-3). Four plots were located at the CT Site, while three plots were located at the ACW Site (Figure 8-4 and 8-5). One plot was located at The Rocks Site and at the Cedar Swamp Site in Delaware (Figures 8-6 and 8-7). 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 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.

Quadrat Locations

Each of the fourteen 3,600 m^2 plot areas (60 m x 60 m) listed above was stratified into nine 400 m^2 sub-areas (20 m x 20 m). 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, MHP1-06-CQ5 indicates that the quadrat was sampled within MHC Reference Marsh Plot 1 (MHP1) during 2006 (06). 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^o C. Following drying, the plant materials collected from each quadrat were weighed to the nearest 0.01 g and entered onto the laboratory data sheet (Appendix A – Exhibit A-5). The data was then entered into an EXCEL spreadsheet for subsequent statistical analysis.

RESULTS

COVER TYPE MAPPING

Cover Type Descriptions

The CIR and true color aerial photography acquired on October 3, 2006 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;
- Desirable marsh vegetation/*Phragmites*
- *Phragmites*-dominated vegetation;
- Non-vegetated marsh plain;
- Internal water areas;
- Open water; and
- Upland/developed land.

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.

Spartina spp. and Other Desirable Marsh Vegetation

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 *Echinachloa walteri*. Areas that are predominated by *Spartina alterniflora* or another desirable marsh species are included in this

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

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*). 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.

Mixed Marsh

The mixed marsh cover includes a mixture of desirable naturally occurring marsh vegetation and *Phragmites*, with no individual species dominating over large-enough areas to be interpreted as species-dominated polygons. Species that may be found in this community type include *Spartina alterniflora, Spartina cynosuroides, Typha latifolia, Typha angustifolia, Scirpus robustus, Scirpus olneyi, Echinochloa walteri, Atriplex patula* and *Phragmites* (usually a stunted growth form). This cover type developed over large areas of the Delaware *Phragmites*-dominated sites in 1997 after treatment with a glyphosate-based herbicide with a surfactant, in 1995 and burning in 1996. *Phragmites* remains as a co- or sub-dominant species in mixed marsh areas, occurring in small (<1 acre) colonies or as individual plants within areas of desirable vegetation.

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*

At the *Phragmites*-dominated wetland restoration sites in New Jersey and Delaware, areas mapped as Desirable Marsh Vegetation/*Phragmites* represent portions of each site that are vegetated with a variety of desirable marsh species, as well as *Phragmites*. Desirable species occurring in these areas include those listed above. *Phragmites* is also a co- or sub-dominant species within areas mapped as this category. 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* has been reduced in dominance as a result of the spray and burn treatments that have occurred at these sites, but remains a component of the vegetation community present in the years immediately following treatment.

***Phragmites*-Dominated Vegetation**

This cover category includes larger areas (>1 acre) dominated by living monotypic stands of *Phragmites* and areas treated with a glyhosate-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 were treated with a glyphosate-based herbicide with a surfactant but were not burned 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; however, no algal mats were detected on the 2006 CIR or true color aerial photography.

Beach Community

Sand beaches and other unvegetated sandy areas are included in this cover type. These areas are mainly associated with the Delaware Bayshore.

Wrack

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

[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.

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.

Channels

This cover type represents unvegetated areas within tidal creeks at the wetland restoration sites and includes channels with water present at the time the photography was acquired (low tide).

Channel Bank

The channel bank cover type represents unvegetated exposed channel banks within tidal creeks present at the time the photography was acquired (low tide).

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.

Site Descriptions

Discussions of the cover type composition in 2006 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 2006 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 2006 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

[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.

Tables 8-1 through 8-4 and show the areas of each site that are vegetated as per the categories below.

- Areas mapped as ***Spartina*-Dominated/Other Desirable Marsh Vegetation** represent portions of each site that are dominated by species such as *Spartina alterniflora, Spartina patens, Scirpus robustus, Typha angustifolia, Typha latifolia, Echinochloa walteri, Amaranthus cannabinus,* and *Peltandra virginica*. *Phragmites* is not a dominant in these areas.
    - At the *Phragmites*-dominated wetland restoration sites in New Jersey and Delaware, areas mapped as **Desirable Marsh Vegetation/*Phragmites*** represent portions of each site that are vegetated with a variety of desirable marsh species, as well as *Phragmites* and/or Dead *Phragmites*. Desirable species occurring in these areas include those listed above. The wetland restoration sites have this category divided into 2 sub-categories; *Phragmites* co-dominant or sub-dominant, and dead *Phragmites* co-dominant or sub dominant. These occur as small colonies (< 1 acre) or as individual plants within areas of desirable marsh vegetation. The cover types that are represented within these areas include all of the types listed in Tables 8-3 and 8-4 that include *Phragmites or* Dead *Phragmites* as an identified species, regardless of its relative dominance in the type (e.g., areas listed as *Spartina alterniflora/* Dead *Phragmites* as well as areas listed as *Spartina alterniflora/Typha* spp*./Phragmites*).

- Areas mapped as ***Phragmites*-Dominated** represent larger areas (>1 acre) of living, monotypic stands of *Phragmites* as well as areas treated with a glyhposate-based herbicide with a surfactant that have remaining dead culms. This mapping category is divided into 2 sub-categories. Dominant Dead *Phragmites* having stands of dead culms following treatment and dominant *Phragmites* having living stands which may be full growth (untreated) or regrowth following treatment with a glyhposate-based herbicide with a surfactant.

- Areas mapped as **Non-Vegetated Marsh Plain** include mud flats, with or without sparse (< 30 percent cover) vegetation; inundated forest areas prior to revegetation; dredged material (high marsh creation areas); and areas covered by *Phragmites* wrack.

- Areas mapped as **Internal Water Areas** include areas of non-vegetated marsh plain that remain inundated with ponded water at low tide as well as non-vegetated channels. The latter includes both the water covered portions of Channels at low tide as well as Channel Banks that were exposed at low tide.

- Areas mapped as **Open Water** represent small portions of major water bodies within the site and wetland restoration area boundaries.

Reference Marshes

The extent of each cover category at the reference marshes was based on the interpretation of the 2006 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 2006 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. *Spartina* spp./Other Desirable Marsh Vegetation comprised the majority of the marsh plain at both reference marshes. This cover category ranged from 71.8 percent of the total marsh plain at MHC Reference Marsh to 86.1 percent of the total marsh plain at MBW Reference Marsh. Within this cover category, *Spartina alterniflora* was the predominant cover type at both the MHC Reference Marsh and the MBW Reference Marsh.

A total of 71.8% of the MHC Reference Marsh was covered by *Spartina spp.* and Other Desirable Marsh Vegetation in 2006. *Spartina alterniflora*, as a single dominant or with other desirable co-dominants, represented most of this coverage (55.6%). *Spartina cynosuroides*, as a single dominant or with other desirable co-dominants, represented an additional 5.9% of this total. *Phragmites australis* dominated over areas representing 10.4% of the marsh plain in 2006. Interior Water Areas, primarily Channels and Channel Banks, made up 16.2%.

A total of 86.1% of the MBW Reference Marsh was covered by *Spartina spp.* and Other Desirable Marsh Vegetation in 2006. *Spartina alterniflora*, as a single dominant or with other desirable co-dominants, represented most of this coverage (82.1%). *Phragmites australis* dominated over areas representing 3.7% of the marsh plain. Non-vegetated Marsh Plain and Internal Water Areas made up 1.8% and 7.9%, 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 2006 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 (47.7%) and Non-vegetated marsh plain (39.8%) were the dominant cover categories at the CT Site in 2006. *Spartina alterniflora* made up 32.2% of the total marsh area. Mud flat (25.0%) and Mud flat/*Spartina alterniflora* (14.8%) were the most prevalent non-vegetated cover types. *Phragmites* Dominated vegetation comprised 4.5 percent of the total marsh area and was also present within areas mapped as *Spartina* spp./Other Desirable Marsh Vegetation with *Phragmites* cover category (1.0%). Internal water areas were primarily channels (4.3%) and channel banks (2.1%).

Alloway Creek Watershed *Phragmites* Dominated Wetland Restoration Site

The extent of each cover category at the ACW Site based on the interpretation of the 2006 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 70.7 percent of the total marsh at the ACW Site in 2006. Individual cover types present within this cover category included: *Spartina*

alterniflora/desirable mixed marsh (32.4%), desirable mixed marsh (17.9%) and *Spartina alterniflora* (10.5%). *Spartina spp*./Other Desirable Marsh Vegetation with *Phragmites* consisted of 3.8 percent of the total. Within this sub-cover category Desirable Mixed Marsh / *Phragmites* comprised the highest percent of total marsh at 2.6 percent. The *Phragmites* dominated cover category was 14.4 percent of the total marsh area. Live *Phragmites australis* dominated stands represented 8.5 percent of the total marsh area. *Phragmites australis* alone dominated 3.9 percent of this total. The Dead *Phragmites australis* cover types within the *Phragmites* cover category totaled 5.9%. Non-vegetated Marsh Plain comprised <1 percent of the total marsh area. Mud flat / *S. alterniflora* (<1%) was the dominant cover type within the Non-vegetated Marsh Plain cover category. Internal Water Areas (14.1%) was comprised of channels (10.1%), followed by channel banks at 4.0%.

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 2006 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 (72.9%) was the dominant cover category at The Rocks Site in 2006. Desirable Mixed Marsh (66.1%) and *Spartina cynosuroides*/Desirable Mixed Marsh (2.3%) were the most common cover types within this cover category. *Spartina* spp./Other Desirable Marsh Vegetation with *Phragmites* comprised 9.5 percent of The Rocks Site. Mixed Marsh (8.5%) was the primary cover type. Dead *Phragmites australis* cover types within the *Phragmites* dominated cover category totaled 4.3 percent. *Phragmites australis* cover category (8.5%) was dominated by *Phragmites australis* / Desirable Mixed Marsh (5.6%). Non-vegetated Marsh Plain comprised <1 percent and Internal Water Areas comprised 4.3 percent of the total marsh.

Cedar Swamp. *Spartina alterniflora/Spartina cynosuroides* (22.9%), *Spartina cynosuroides* (14.4%) and *Spartina alterniflora* / Desirable Mixed Marsh (14.2%) were the main components in the *Spartina* spp./Other Desirable Marsh Vegetation Cover Category (74.7%) for the Cedar Swamp Site in 2006. The other sub-categories: *Spartina* spp./Other Desirable Marsh Vegetation with *Phragmites* comprised 6.6 percent of the Cedar Swamp Site. *Phragmites* dominated vegetation (7.3%) cover category included *Phragmites australis* (1.9%) in the *Phragmites* dominated sub-category and the Dead *Phragmites* dominated sub-category (2.5%). The remaining marsh area was divided between Non-Vegetated Marsh Plain (1.0%) and Internal Water Areas (10.2%).

GEOMORPHOLOGIC MAPPING

Maps showing existing hydraulic features as interpreted from the October 2006 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. The channel systems for the MHC Reference Marsh and the MBW Reference Marsh as mapped in 2005 are shown in Figures C-1 and C-2, respectively, in Appendix C.

Commercial Township Salt Hay Farm Wetland Restoration Site

Mapping of the hydrologic features at the CT Site, based on the 2006 aerial photography, are shown in 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 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 Delaware wetland restoration sites 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) 2006 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 2006 macrophyte sampling events are presented in Appendix D. The individual 2006 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.

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 by far the dominant species sampled along transects at the MHC Reference Marsh and MBW Reference Marsh in 2006, occurring in 93 and 100 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 2006 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	84 (43 S-d)
MBW Reference Marsh	24 (14 S-d)

The mean percent coverage (± SE) for all quadrats in the 2006 sampling event at each reference marsh is graphically shown in Figure 8-8 and was as follows:

Site	Peak Season (%)
MHC Reference Marsh	34 (±3)
MBW Reference Marsh	22 (±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.

[5] *Spartina alterniflora* dominated quadrats include those dominated by *Spartina cynosuroides* where it occurs as a dominant species.

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 2006 peak season sampling event. For *Spartina alterniflora* dominated quadrats (which include *Spartina alterniflora* and *Spartina cynosuroides),* the mean height (±SE) for the 2006 sampling event at each reference marsh was as follows:

Site	Peak Season (cm)
MHC Reference Marsh	95 (±5)
MBW Reference Marsh	102 (±5)

Heights of other species measured within quadrats during the 2006 peak season are presented in Tables D-1 and D-2 (Appendix D).

Flowering Status. Most of the *Spartina alterniflora* in quadrats sampled along the MHC Reference Marsh transects were not flowering during the 2006 peak season sampling event, while none of the *Spartina alterniflora* in quadrats sampled along the MBW Reference Marsh transects were flowering during the 2006 peak season sampling event. 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 2006 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	21 (10 S-d)
MBW Reference Marsh	6 (4 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 2006 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	646 (±71)
MBW Reference Marsh	533 (±163)

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 2006 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	167 (±91)
MBW Reference Marsh	0 (±n/a)

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 2006 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	154 (±37)
MBW Reference Marsh	145 (±52)

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 2006 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 by far the dominant species present in quadrats sampled along transects at MHC Reference Marsh, occurring in approximately 93 percent of the quadrats. Some additional species found to be present in the quadrats at MHC Reference Marsh were *Amaranthus cannabinus*, *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 2006 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	30 (21 S-d)
MHT2	7 (3 S-d)
MHT3	47 (19 S-d)

The mean percent cover (± SE) for all quadrats along each transect in 2006, and for *Spartina alterniflora* dominated quadrats (shown graphically in Figure 8-12) only were as follows:

Transect	All Quadrats (%)	S-d Quadrats (%)
MHT1	30 (±3)	33 (±3)
MHT2	26 (±7)	42 (±9)
MHT3	38 (±4)	37 (±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 2006 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	101 (±4)
MHT2	75 (±10)
MHT3	82 (±6)

Heights for all species of vegetation present in the quadrats in 2006 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	8 (6 S-d)
MHT2	2 (1 S-d)
MHT3	12 (3 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2006 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	895 (±89)	792 (±79)
MHT2	697 (±461)	236 (±0)
MHT3	418 (±65)	491 (±85)

Mean live standing crop determinations for *Spartina alterniflora* dominated quadrats only sampled during the 2006 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 2006 peak season sampling of MHC Reference Marsh transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MHT1	422 (±215)	100 (±23)
MHT2	16 (±16)	32 (±0)
MHT3	9 (±9)	34 (±34)

Litter. The mean values (±SE) for litter biomass in clip quadrats during the 2006 peak season sampling of MHC Reference Marsh transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (gdw/m^2)
MHT1	214 (±80)	106 (±28)
MHT2	112 (±28)	84 (±0)
MHT3	108 (±36)	69 (±42)

Moores Beach West Reference Marsh - Transects

The field and laboratory data representing clip and ocular quadrats along MBW Reference Marsh transects during the 2006 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 in 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 100 percent of the quadrats in 2006.

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 2006 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 (2 S-d)
MBT2	8 (8 S-d)
MBT3	8 (4 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	18 (±2)	25 (±0)
MBT2	31 (±2)	31 (±2)
MBT3	16 (±3)	23 (±1)

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 2006 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	103 (±22)
MBT2	107 (±5)
MBT3	92 (±8)

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 2006 was as follows:

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

The mean values (±SE) for live standing crop in all clip quadrats during the 2006 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	804 (±395)	1199 (±0)
MBT2	639 (±68)	639 (±68)
MBT3	156 (±93)	249 (±0)

Live standing crop determinations for the 2006 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 2006 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	0 (±n/a)	0 (±n/a)
MBT2	0 (±n/a)	0 (±n/a)
MBT3	0 (±n/a)	0 (±n/a)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2006 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	95 (±4)	99 (±0)
MBT2	42 (±24)	42 (±24)
MBT3	299 (±60)	238 (±0)

REFERENCE MARSH PLOT SAMPLING

The field and laboratory data representing clip quadrats within 60 m x 60 m plots during the peak season 2006 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 2006 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	38 (±3)
MBW Reference Marsh	26 (±3)

Live Standing Crop. Peak season 2006 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	628 (±93)
MBW Reference Marsh	554 (±74)

The following sections present data for individual 60 m x 60 m plots at each reference marsh in 2006.

Mad Horse Creek Reference Marsh - Plots

Three 60 m x 60 m plots were sampled at MHC Reference Marsh in August 2006. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop. Individual quadrat data are presented in Table E-1.

Percent Cover. The peak season 2006 mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum), for each plot is 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	34 (±5)
MHP2	31 (±5)
MHP3	48 (±7)

Live Standing Crop. The peak season 2006 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	599 (±130)
MHP2	547 (±159)
MHP3	738 (±199)

Moores Beach West Reference Marsh - Plots

Three 60 m x 60 m plots were sampled at MBW Reference Marsh in August 2006. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop. Individual quadrat data are presented in Table E-2.

Percent cover. The peak season 2006 mean percent aerial cover, as well as measures of dispersion (standard error of the mean, standard deviation, minimum and maximum), for each plot is 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	33 (±3)
MBP2	29 (±6)
MBP3	16 (±5)

Live standing crop. The peak season 2006 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	643 (±115)
MBP2	654 (±113)
MBP3	365 (±142)

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 2006 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 2006 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 at the CT Site in 2006. *Spartina alterniflora* was dominant in approximately 63 percent of the quadrats. No other marsh species occurred in quadrats at the CT Site in 2006. Thus, the other 37% of the quadrats sampled were predominantly mudflat.

Percent Cover. Percent cover was estimated within all (ocular and clip) quadrats sampled at the sites during the 2006 peak season sampling event. A total of 19 quadrats were sampled along transects at the CT Site. The mean percent cover (±SE) for all quadrats during the 2006 peak season sampling event at the CT Site (graphically shown in Figure 8-16) was 23% (±2%). 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. The mean height (±SE) of *Spartina alterniflora* at the CT Site in 2006 was 147 cm (±8 cm).

Flowering Status. Most of the *Spartina alterniflora* in quadrats sampled along the CT Site transects were not flowering during the 2006 peak season sampling event. The flowering status for plants within each quadrat sampled is provided in Table D-3.

Live Standing Crop. Peak season 2006 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 2006 was eight (8), five (5) 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 1275 gdw/m^2 (±180 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 2006 are presented in Table 8-7. There was no dead standing crop present during the 2006 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 2006. The mean value (±SE) for litter biomass at the site was 33 gdw/m^2 (±33 gdw/m^2).

The above discussions are based on the pooled data for all quadrats at the CT Site during the 2006 peak growing season. The following sections present a summary of data from Appendix D, Table D-3 for quadrats along individual transects at each site.

CT Site - Transects

The field and laboratory data representing the clip and ocular quadrats along the CT Site transects during the peak season 2006 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. Vegetation data were collected from the four transects at the CT Site. *Spartina alterniflora* was the only species present in quadrats sampled at the CT Site, occurring as a dominant in 63 percent of the quadrats. The other 37% of the quadrats sampled were predominantly mudflat.

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 2006 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	5 (4 S-d)
CTT2	4 (3 S-d)
CTT3	5 (3 S-d)
CTT4	5 (2 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	29 (±5)	33 (±5)
CTT2	25 (±4)	28 (±3)
CTT3	21 (±2)	25 (±0)
CTT4	17 (±4)	25 (±0)

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 2006 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	136 (±12)
CTT2	165 (±5)
CTT3	113 (±6)
CTT4	188 (±3)

Live Standing Crop. Peak season 2006 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 (1 S-d)
CTT3	2 (1 S-d)
CTT4	2 (1 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2006 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	1469 (±19)	1469 (±19)
CTT2	1337 (±516)	1853 (±0)
CTT3	980 (±251)	730 (±0)
CTT4	1315 (±670)	1985 (±0)

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during

the 2006 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 (±n/a)	0 (±n/a)
CTT2	0 (±n/a)	0 (±n/a)
CTT3	0 (±n/a)	0 (±n/a)
CTT4	0 (±n/a)	0 (±n/a)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2006 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 (±n/a)	0 (±n/a)
CTT2	0 (±n/a)	0 (±n/a)
CTT3	0 (±n/a)	0 (±n/a)
CTT4	132 (±132)	263 (±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 2006. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop, except where mud flats or areas of *Phragmites* (living or wrack) occurred. Individual quadrat data are presented in Appendix E, Table E-3.

Percent Cover. The 2006 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	11 (±5)
CTP2	19 (±5)
CTP3	17 (±3)
CTP4	19 (±7)

Live Standing Crop. The 2006 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	300 (±153)
CTP2	687 (±143)
CTP3	442 (±71)
CTP4	379 (±153)

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 2006 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 at the ACW Site, dominating in 56 percent of the quadrats. *Phragmites australis* was dominant in approximately 13 percent of the quadrats. Eight other species were also identified in quadrats at the ACW Site. These included *Echinochloa walteri, Amaranthus cannabinus, Typha latifolia, Scirpus robustus,* and *Peltandra virginica.*

Percent Cover. Percent cover was estimated within all (ocular and clip) quadrats sampled at the ACW Site during the 2006 peak season sampling event. A total of 72 quadrats were sampled along transects at the ACW Site, 42 of which were *Spartina alterniflora* dominated. The mean percent cover (±SE) for all quadrats (graphically shown in Figure 8-16) was 44% (±2%). 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 2006 peak growing season sampling event. For *Spartina alterniflora* dominated quadrats (which include *Spartina alterniflora* and *Spartina cynosuroides),* the mean height (±SE) at the ACW Site was 145 cm (±7 cm). Heights for other species of vegetation present in the quadrats are presented in Table D-4.

Flowering Status. Of the ten species identified in quadrats at the ACW Site, most were not flowering in the quadrats at the time of the 2006 peak season sampling. The flowering status for species within each quadrat at the ACW Site in 2006 is provided in Table D-4.

Live Standing Crop. Peak season 2006 live standing crop was determined for the ACW Site based on collections of standing living plant material from clip quadrats along transects. The number of clip quadrats along each transect was 18 (9 S-d). The mean value (±SE) for live standing crop is shown in Figure 8-21 and was 1016 (±116) (gdw/m^2).

In addition to the mean live standing crop for all quadrats at the ACW 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 2006 dead standing crop was determined based on collections of standing dead plant materials from clip quadrats along transects at the ACW Site. The mean value (±SE) for dead standing crop was 5 (±5) (gdw/m^2).

Litter. The plant litter biomass present on the marsh surface in 2006 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 ACW Site was 160 (±35) (gdw/m^2).

The above discussions are based on the pooled data for all quadrats at the ACW Site during the 2006 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.

ACW Site - Transects

The field and laboratory data representing the clip and ocular quadrats along the ACW Site transects during the peak season 2006 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 the most common dominant species present in quadrats sampled at the ACW Site, dominating in 56 percent of the quadrats. *Phragmites australis* was dominant in approximately 13 percent of the quadrats. Eight other species were also identified in quadrats at the ACW Site. These included *Echinochloa walteri, Amaranthus cannabinus, Typha latifolia, Scirpus robustus,* and *Peltandra virginica.*

Percent Cover. The peak season 2006 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	16 (9 S-d)
ACWT2	14 (13 S-d)
ACWT3	30 (12 S-d)
ACWT4	13 (9 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)	48 (±7)
ACWT2	44 (±4)	46 (±3)
ACWT3	53 (±4)	62 (±6)
ACWT4	22 (±3)	27 (±4)

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 2006 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	101 (±6)
ACWT2	117 (±7)
ACWT3	94 (±7)
ACWT4	126 (±8)

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

Live Standing Crop. Peak season 2006 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	4 (0 S-d)
ACWT2	4 (3 S-d)
ACWT3	8 (4 S-d)
ACWT4	2 (2 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2006 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	519 (±248)	0 (±n/a)
ACWT2	1487 (±132)	1569 (±146)
ACWT3	1093 (±143)	1045 (±283)
ACWT4	765 (±60)	765 (±60)

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during the 2006 peak season sampling of the ACW Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
ACWT1	15 (±15)	0 (±n/a)
ACWT2	0 (±n/a)	0 (±n/a)
ACWT3	10 (±10)	0 (±n/a)
ACWT4	0 (±n/a)	0 (±n/a)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2006 peak season sampling of the ACW Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
ACWT1	182 (±51)	0 (±n/a)
ACWT2	196 (±124)	261 (±149)
ACWT3	171 (±40)	235 (±53)
ACWT4	0 (±n/a)	0 (±n/a)

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 2006. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop, except where mud flats or

areas of *Phragmites* wrack occurred. Individual quadrat data are presented in Appendix E, Table E-4.

Percent Cover. The peak season 2006 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	25 (±4)
ACWP2	32 (±4)
ACWP3	35 (±5)

Live Standing Crop. The peak season 2006 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	676 (±163)
ACWP2	450 (±75)
ACWP3	885 (±147)

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 2006 peak season macrophyte sampling event are presented in Tables D-5 and D-6, respectively, 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 in 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 at The Rocks Site. It was dominant in approximately 46 percent of the quadrats. Seven other species were identified as dominant in quadrats at The Rocks Site.

Spartina alterniflora was also the most common dominant species present in quadrats sampled along transects at the Cedar Swamp Site, dominating in approximately 68 percent of the quadrats. *Spartina cynosuroides* was dominant in 14 percent of the quadrats at the Cedar Swamp Site. Other species present included *Phragmites australis, Echinochloa walteri, Amaranthus cannabinus* and *Polygonum punctatum.*

Percent Cover. Percent cover was estimated within all (ocular and clip) quadrats sampled at the sites during the 2006 peak season sampling event. A total of 102 quadrats were sampled along transects at The Rocks Site and 80 quadrats were sampled at the Cedar Swamp Site. The mean percent cover (±SE) for all quadrats during the 2006 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	42 (±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 2006 sampling event at each Delaware *Phragmites* dominated restoration site was as follows:

Site	Peak Season (cm)
The Rocks	127 (±7)
Cedar Swamp	112 (±5)

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

Flowering Status. Of the thirteen species identified in quadrats at The Rocks Site in 2006, most were flowering in at least some of the quadrats. Of the nine species present at the Cedar Swamp Site in 2006, most were not flowering in the quadrats sampled during the peak season sampling event. Detailed information on the flowering status for species within each quadrat at The Rocks and Cedar Swamp Sites is provided in Tables D-5 and D-6.

Live Standing Crop. Peak season 2006 live standing crop was determined for the 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	26 (14 S-d)
Cedar Swamp	20 (15 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	1136 (±120)
Cedar Swamp	1055 (±96)

In addition to the mean live standing crop for all quadrats at each 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 2006 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	72 (±26)
Cedar Swamp	44 (±26)

Litter. The peak season 2006 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 site was as follows:

Site	Peak Season (gdw/m^2)
The Rocks	103 (±15)
Cedar Swamp	200 (±38)

The above discussions are based on the pooled data for all quadrats at The Rocks and Cedar Swamp Sites during the 2006 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 2006 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* was the most common dominant species present in quadrats sampled at The Rocks Site. It was dominant in approximately 46 percent of the quadrats. Seven other species were identified as dominant in quadrats at The Rocks 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 Rocks Site during the 2006 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	24 (16 S-d)
TRT2	30 (18 S-d)
TRT3	24 (21 S-d)
TRT4	24 (9 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	38 (±3)	46 (±3)
TRT2	46 (±3)	52 (±4)
TRT3	53 (±5)	51 (±4)
TRT4	29 (±2)	34 (±2)

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 2006 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	94 (±5)
TRT2	126 (±12)
TRT3	125 (±7)
TRT4	209 (±25)

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

Live Standing Crop. Peak season 2006 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	6 (3 S-d)
TRT2	8 (4 S-d)
TRT3	6 (6 S-d)
TRT4	6 (1 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	994 (±134)	1083 (±126)
TRT2	1530 (±282)	1507 (±218)
TRT3	907 (±187)	907 (±187)
TRT4	982 (±218)	808 (±0)

Dead Standing Crop. The peak season 2006 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 (±n/a)	0 (±n/a)
TRT2	117 (±62)	235 (±94)
TRT3	154 (±58)	154 (±58)
TRT4	0 (±n/a)	0 (±n/a)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2006 peak

season sampling of The Rocks Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
TRT1	130 (±39)	172 (±49)
TRT2	101 (±23)	118 (±30)
TRT3	79 (±35)	79 (±35)
TRT4	104 (±32)	161 (±0)

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 2006 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 in 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 most common dominant species present in quadrats sampled along transects at the Cedar Swamp Site, dominating in approximately 68 percent of the quadrats. *Spartina cynosuroides* was dominant in 14 percent of the quadrats. Other species present included *Phragmites australis, Echinochloa walteri, Amaranthus cannabinus* and *Polygonum punctatum.*

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 2006 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	24 (19 S-d)
CST2	24 (20 S-d)
CST3	24 (18 S-d)
CST4	8 (8 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	34 (±2)	37 (±1)
CST2	48 (±3)	49 (±3)
CST3	38 (±3)	38 (±3)
CST4	43 (±6)	43 (±6)

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 2006 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	132 (±14)
CST2	126 (±8)
CST3	76 (±5)
CST4	110 (±13)

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

Live Standing Crop. Peak season 2006 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	6 (5 S-d)
CST2	6 (4 S-d)
CST3	6 (4 S-d)
CST4	2 (2 S-d)

The mean values (±SE) for live standing crop in all clip quadrats during the 2006 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	1197 (±157)	1309 (±134)
CST2	1261 (±206)	1118 (±150)
CST3	738 (±129)	757 (±202)
CST4	966 (±8)	966 (±8)

Dead Standing Crop. The mean values (±SE) for dead standing crop in all clip quadrats during the 2006 peak season sampling of the Cedar Swamp Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
CST1	0 (±n/a)	0 (±n/a)
CST2	89 (±62)	123 (±92)
CST3	59 (±59)	89 (±89)
CST4	0 (±n/a)	0 (±n/a)

Litter. The mean values (±SE) for litter biomass in all clip quadrats during the 2006 peak season sampling of the Cedar Swamp Site transects were as follows:

Transect	All Quadrats (gdw/m^2)	S-d Quadrats (%)
CST1	129 (±45)	155 (±45)
CST2	135 (±18)	141 (±27)
CST3	317 (±97)	345 (±131)
CST4	261 (±178)	261 (±178)

DELAWARE *PHRAGMITES* DOMINATED WETLAND RESTORATION SITES PLOT SAMPLING

One 60 m x 60 m plot was sampled at The Rocks Site, as well as the Cedar Swamp Site, in August 2006. Nine (9) quadrats were sampled within each plot for percent cover and live standing crop, except where mudflats or areas of *Phragmites* wrack occurred. These areas were not sampled for standing crop. Individual quadrat data are presented in Appendix E, Tables E-5 and E-6.

Percent Cover. The peak season 2006 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 is 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)	39 (±5)
Cedar Swamp (CSP1)	34 (±4)

Live Standing Crop. The peak season 2006 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)	732 (±69)
Cedar Swamp (CSP1)	931 (±117)

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 2006. 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 2006.

GEOMORPHOLOGIC MAPPING

Evidence of successful wetland restoration at the CT Site is provided by the quantitative analysis of 2006 geomorphology mapping. The drainage density in 2006 (877 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 system since 2002, when the drainage density was 374 ft/acre. The channel frequency at the CT Site in 2006 (14.9 channels/acre) was also higher than that found in MBW Reference Marsh in 2005 (4.7 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 values for the ACW Site in 2006 were 523 ft/acre. Drainage densities for the *Phragmites* dominated sites in Delaware ranged from 414 ft/acre at The Rocks to 477 ft/acre at Cedar Swamp. In comparison, the drainage density at the MHC Reference Marsh in 2005 was 708 ft/acre.

The channel frequency value for the ACW Site in 2006 was 5.5 channels/acre. The Rocks and Cedar Swamp 2006 channel frequencies were 4.9 channels/acre and 5.8 channels/acre, respectively. In comparison, the channel frequency for the MHC Reference Marsh in 2005 was 8.9 channels/acre.

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[11]	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/n^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 2006 and from all quadrats sampled within plots at each site in 2006.

MACROPHYTE PRODUCTION AT THE REFERENCE MARSHES IN 2006

The MHC Reference Marsh and MBW Reference Marsh are both *Spartina alterniflora* dominated tidal wetland systems. In each system, *Spartina alterniflora* occurs as the dominant species and represents the majority of the vegetative cover and macrophyte standing crop as measured during the peak 2006 growing season. While non-*Spartina alterniflora* dominated quadrats were also sampled, the following discussion is limited to data representing *Spartina alterniflora* dominated areas that represent the majority of the marsh area of each site. In this way, the greater variability that is typical of the data for non-*Spartina alterniflora* dominated quadrats is excluded from interpretation of the data.

Percent Coverage. The mean percent coverage within all *Spartina alterniflora* dominated quadrats (clip and ocular) sampled during the 2006 peak season was 36 percent at MHC Reference Marsh and 28 percent at MBW Reference Marsh (Figure 8-8).

Height. The mean macrophyte height measurement within *Spartina alterniflora* dominated clip and ocular quadrats along transects at the MHC Reference Marsh in 2006 was 95 cm, while the mean for the MBW Reference Marsh quadrats was 102 cm.

MACROPHYTE PRODUCTION AT COMMERCIAL TOWNSHIP SALT HAY FARM SITE IN 2006

Of the 19 quadrats sampled at the CT Site along the four transects, 12 were *Spartina alterniflora* dominated. The mean peak season 2006 live standing crop collected from *Spartina alterniflora* dominated clip quadrats at the CT Site (1501 ±219 gdw/m^2) is above the range of values found for individual transects at the MBW Reference Marsh in 2006 (249 ± 0gdw/m^2 - 1199 ±0 gdw/m^{-2}).

MACROPHYTE PRODUCTION AT ALLOWAY CREEK WATERSHED *PHRAGMITES* DOMINATED WETLAND RESTORATION SITE IN 2006

Of the 72 quadrats sampled at the Alloway Creek Watershed, 42 were *Spartina alterniflora* dominated. The mean peak season 2006 live standing crop collected from *Spartina alterniflora* dominated clip quadrats at the ACW Site (1157 ±165 gdw/m^2) is above the range of values found for individual transects at the MHC Reference Marsh in 2006 (236 ±0 gdw/m^2 - 792 ±79 gdw/m^2).

MACROPHYTE PRODUCTION AT THE DELAWARE *PHRAGMITES* DOMINATED WETLAND RESTORATION SITES IN 2006

Of the 102 quadrats sampled at The Rocks Site, 64 were *Spartina alterniflora* dominated. The mean peak season 2006 live standing crop collected from *Spartina alterniflora* dominated clip quadrats at The Rocks Site (1109 ±121 gdw/m^2) is above the range of values found for individual transects at the MHC Reference Marsh in 2006 (236 ±0 gdw/m^2 - 792 ±79 gdw/m^2).

Of the 80 quadrats sampled at the Cedar Swamp Site, 65 were *Spartina alterniflora* dominated. The mean peak season 2006 live standing crop collected from *Spartina alterniflora* dominated clip quadrats at the Cedar Swamp Site (1065 ±93 gdw/m^2) is above the range of values found for individual transects at the MHC Reference Marsh in 2006 (236 ±0 gdw/m^2 - 792 ±79 gdw/m^2).

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TABLES

Table 8-1
2006 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				
A. cannabinus / Desirable Mixed Marsh	0.5	0.0%	0.0	0.0%
Desirable Mixed Marsh	252.8	6.6%	0.0	0.0%
Desirable Mixed Marsh / Mud Flat	3.1	0.1%	0.0	0.0%
High Marsh Shrubs	34.0	0.9%	0.0	0.0%
High Marsh	1.3	0.0%	8.2	0.6%
High Marsh / Deciduous Forest	0.0	0.0%	1.8	0.1%
High Marsh / Salt Hay	0.0	0.0%	4.1	0.3%
High Marsh / *S. alterniflora*	0.0	0.0%	0.8	0.1%
Salt Hay *(S. patens;D.spicata; J. gerardii)*	0.0	0.0%	2.5	0.2%
Salt Hay / High Marsh	0.0	0.0%	0.1	0.0%
Salt Hay */ S. alterniflora*	0.0	0.0%	9.6	0.8%
Spartina alterniflora	1154.5	30.1%	786.0	62.3%
S. alterniflora (Tall Form)	0.0	0.0%	214.3	17.0%
S. alterniflora / A. cannabinus	60.3	1.6%	0.0	0.0%
S. alterniflora / Beach	1.8	0.0%	5.3	0.4%
S. alterniflora / Desirable Mixed Marsh	251.0	6.5%	0.0	0.0%
S. alterniflora / Mud Flat	295.3	7.7%	30.0	2.4%
S. alterniflora / *S. cynosuroides*	299.7	7.8%	0.0	0.0%
S. alterniflora / *S. cynosuroides /* Mud Flat	68.9	1.8%	0.0	0.0%
S. alterniflora / *S. patens /* Mud Flat	2.4	0.1%	0.0	0.0%
S. cynosuroides	18.8	0.5%	0.0	0.0%
S. cynosuroides / Mud flat	0.8	0.0%	0.0	0.0%
S. cynosuroides / S. alterniflora	207.8	5.4%	0.0	0.0%
S. patens	0.4	0.0%	0.0	0.0%
S. patens / S. alterniflora	2.3	0.1%	0.0	0.0%
subtotal w/o Phragmites	2656	69.1%	1063	84.2%
w/ Phragmites				
High Marsh / *P. australis*	0.0	0.0%	23.0	1.8%
High Marsh Shrubs / *P. australis*	6.1	0.2%	0.0	0.0%
Mixed Marsh	51.4	1.3%	0.0	0.0%
Mixed Marsh / Mud Flat	7.7	0.2%	0.0	0.0%
Mixed Marsh / Wrack	0.9	0.0%	0.0	0.0%
S. alterniflora / *P. australis*	26.0	0.7%	0.0	0.0%
S. cynosuroides / P. australis	8.4	0.2%	0.0	0.0%
subtotal w/ Phragmites	100.6	2.6%	23.0	1.8%
Subtotal	**2756**	**71.8%**	**1086**	**86.1%**

Table 8-1
2006 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)]
***Phragmites* Dominated Vegetation**				
Phragmites australis	290.5	7.6%	5.6	0.4%
P. australis / Dead Trees	0.0	0.0%	3.0	0.2%
P. australis / Desirable Mixed Marsh	2.3	0.1%	0.0	0.0%
P. australis / High Marsh	0.0	0.0%	38.4	3.0%
P. australis / High Marsh Shrubs	3.5	0.1%	0.0	0.0%
P. australis / Mud Flat	0.6	0.0%	0.0	0.0%
P. australis / Mixed Marsh	0.7	0.0%	0.0	0.0%
P. australis / *S. alterniflora*	77.1	2.0%	0.0	0.0%
P. australis / *S. alterniflora* / Mud Flat	0.5	0.0%	0.0	0.0%
P. australis / *S. alterniflora* / *S. cynosuroides*	1.4	0.0%	0.0	0.0%
P. australis / *S. cynosuroides*	24.0	0.6%	0.0	0.0%
P. australis / Wrack	0.0	0.0%	0.0	0.0%
Subtotal	**401**	**10.4%**	**47**	**3.7%**
Non-vegetated Marsh Plain				
Beach	3.2	0.1%	0.0	0.0%
Beach / Channel Banks	0.3	0.0%	0.0	0.0%
Beach / Mud Flat	0.0	0.0%	1.8	0.1%
Beach / *P. australis*	0.6	0.0%	0.0	0.0%
Beach / *S. alterniflora*	0.8	0.0%	1.4	0.1%
Beach / Wrack	0.1	0.0%	0.0	0.0%
Mud Flat	5.3	0.1%	1.7	0.1%
Mud Flat / Beach	0.1	0.0%	8.5	0.7%
Mud Flat / Desirable Mixed Marsh	0.5	0.0%	0.0	0.0%
Mud Flat / Mixed Marsh	3.1	0.1%	0.0	0.0%
Mud Flat / *P. australis*	0.5	0.0%	0.0	0.0%
Mud Flat / *S. alterniflora*	24.9	0.6%	9.2	0.7%
Mud Flat / Wrack	3.3	0.1%	0.0	0.0%
Wrack	13.4	0.3%	0.0	0.0%
Wrack / Mixed Marsh	1.3	0.0%	0.0	0.0%
Wrack / *P. australis*	0.2	0.0%	0.0	0.0%
Wrack / *S. alterniflora*	0.9	0.0%	0.0	0.0%
Subtotal	**58**	**1.5%**	**23**	**1.8%**
Internal Water Areas				
Channels	495.3	12.9%	38.5	3.0%
Channel Banks	125.2	3.3%	51.7	4.1%
Ponded Water	3.5	0.1%	10.1	0.8%
Subtotal	**624**	**16.2%**	**100**	**7.9%**
Open Water				
Delaware Bay	1.4	0.0%	6.0	0.5%
Upland Vegetation / Miscellaneous Cover Categories				
Agricultural Land	24.8	0.6%	14.8	1.2%
Deciduous Forest	61.3	1.6%	29.2	2.3%
Deciduous Forest / High Marsh	2.1	0.1%	20.3	1.6%
Deciduous Forest / High Marsh Shrubs	5.4	0.1%	0.0	0.0%
Developed Land	3.0	0.1%	8.6	0.7%
Dike	0.5	0.0%	2.9	0.2%
Old Field	2.3	0.1%	20.7	1.6%
Road	1.8	0.0%	1.7	0.1%
Subtotal [(b)]	**101**	**2.6%**	**98**	**7.8%**
Total Marsh Area	**3841**	**100.0%**	**1261**	**100.0%**
Total Site Area	**3942**	--	**1360**	--

[(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
2006 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		
Eleocharis spp. / Mud Flat	5.1	0.2%
Desirable Mixed Marsh	18.9	0.7%
High Marsh	7.1	0.2%
Recovering Desirable Species Area	0.1	0.0%
Salt Hay (*S. patens* ; *D. spicata* ; *J .gerardii*)	8.0	0.3%
Salt Hay / Desirable Mixed Marsh	2.4	0.1%
Salt Hay / *S. alterniflora*	0.2	0.0%
Salt Hay / Mud Flat	0.1	0.0%
Spartina alterniflora	931.3	32.2%
S. alterniflora / Dead Trees	22.7	0.8%
S. alterniflora / Desirable Mixed Marsh	40.5	1.4%
S. alterniflora / High Marsh	12.5	0.4%
S. alterniflora / Mud Flat	299.8	10.4%
S. alterniflora / Salt Hay / Mud Flat	0.4	0.0%
S. alterniflora / Sand	0.0	0.0%
S. alterniflora / Wrack	1.0	0.0%
subtotal w/o P. australis	*1350*	*46.7%*
w/ P. australis		
High Marsh / *P. australis*	0.4	0.0%
Mixed Marsh	8.5	0.3%
Mixed Marsh / Mud Flat	0.5	0.0%
Salt Hay / *P. australis*	1.1	0.0%
S. alterniflora / Mixed Marsh	5.4	0.2%
S. alterniflora / *P. australis*	12.3	0.4%
S. alterniflora / *P. australis /* Dike	0.2	0.0%
S. alterniflora / *P. australis /* Mud Flat	0.7	0.0%
subtotal w/ P. australis	*29.2*	*1.0%*
Subtotal	**1379**	**47.7%**
P. australis **Dominated Vegetation**		
Dead *P. australis*	0.1	0.0%
Dead *P. australis* / *P. australis*	4.2	0.1%
subtotal - Dead *P. australis*	*4*	*0.2%*
P. australis Dominant		
Phragmites australis	64.8	2.2%
P. australis / Dead *P. australis*	0.6	0.0%
P. australis / Dead *P. australis /* Mud Flat	0.7	0.0%
P. australis / Dead *P. australis /* Salt Hay	2.3	0.1%
P. australis / Dead Trees / High Marsh	2.3	0.1%
P. australis / Dike	1.3	0.0%
P. australis / High Marsh	19.7	0.7%
P. australis / Mixed Marsh	1.7	0.1%
P. australis / Mud Flat	2.3	0.1%
P. australis / S. alterniflora	28.1	1.0%
P. australis / S. alterniflora / Dead *P. australis*	0.1	0.0%
P. australis / S. alterniflora / Mud Flat	0.6	0.0%
P. australis / Salt Hay	0.1	0.0%
subtotal - P. australis	*125*	*4.3%*
Subtotal	**129**	**4.5%**

Table 8-2
2006 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		
Mud Flat	723.3	25.0%
Mud Flat / Mixed Marsh	0.1	0.0%
Mud Flat / *P. australis*	0.8	0.0%
Mud Flat/ *S. alterniflora*	427.8	14.8%
Subtotal	**1152**	**39.8%**
Internal Water Areas		
Channels (>5 ft. wide at low tide)	123.7	4.3%
Channel Banks	59.6	2.1%
Ponded Water	39.8	1.4%
Subtotal	**223**	**7.7%**
Open Water		
Delaware Bay	5.4	0.2%
Upland Vegetation / Miscellaneous Cover Categories [b]		
Dike	5.4	0.2%
Subtotal [c]	**5**	**0.2%**
Total Site Area	**2894**	**100%**

[a] Areas listed are for portions of the site within the Wetland Restoration Area Boundary, as shown in Appendix B, Figures B-3 and B-4.

[b] Areas of upland / developed land listed, are in most cases due to annual variability in the mapping of the upland 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 rounding.

Table 8-3
2006 Alloway Creek Watershed Wetland Restoration Site -
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Alloway Creek Watershed** [(a)]	
	Acres	**Percent of Total Marsh**
***Spartina* spp./ Other Desirable Marsh Vegetation**		
Amarnthus cannabinus / Spartina alterniflora	4.6	0.3%
Desirable Mixed Marsh	286.4	17.9%
Desirable Mixed Marsh / Mud Flat	29.1	1.8%
Echinochloa walteri	1.2	0.1%
E. walteri / Desirable Mixed Marsh	0.3	0.0%
E. walteri / S. alterniflora	23.3	1.5%
High Marsh	4.4	0.3%
Spartina alterniflora	168.5	10.5%
S. alterniflora / A. cannabinus	4.3	0.3%
S. alterniflora / Desirable Mixed Marsh	517.8	32.4%
S. alterniflora / Mud Flat	28.2	1.8%
S. cynosuroides	2.0	0.1%
S. cynosuroides / S. alterniflora	0.5	0.0%
subtotal w/o P. australis	*1070.4*	*66.9%*
w/ P. australis		
Mixed Marsh	52.6	3.3%
Mixed Marsh / Mud Flat	0.6	0.0%
S. alterniflora / Mixed Marsh	0.1	0.0%
S. alterniflora / P. australis	8.1	0.5%
subtotal w/ P. australis	61.4	3.8%
Subtotal [(a)]	**1131.8**	**70.7%**
***P. australis* Dominated Vegetation**		
Dead P. australis Dominant		
Dead *P. australis*	70.4	4.4%
Dead *P. australis /* Desirable Mixed Marsh	11.1	0.7%
Dead *P. australis / P. australis*	10.9	0.7%
Dead *P. australis / S. alterniflora*	1.7	0.1%
Subtotal	***94.0***	***5.9%***
P. australis Dominant		
Phragmites australis	62.5	3.9%
P. australis / Dead *P. australis*	1.6	0.1%
P. australis / Desirable Mixed Marsh	60.0	3.7%
P. australis / *S. alterniflora*	12.3	0.8%
Subtotal	***136.4***	***8.5%***
Subtotal [(a)]	**230.5**	**14.4%**

Table 8-3
2006 Alloway Creek Watershed Wetland Restoration Site -
PSEG Detrital Production Monitoring

Cover Category / Cover Type	**Alloway Creek Watershed** [a]	
	Acres	**Percent of Total Marsh**
Non-Vegetated Marsh Plain		
Mud Flat	1.2	0.1%
Mud Flat / Desirable Mixed Marsh	0.2	0.0%
Mud Flat / Mixed Marsh	0.0	0.0%
Mud Flat / *S. alterniflora*	7.5	0.5%
Wrack	0.3	0.0%
Wrack */ Mud Flat*	0.2	0.0%
Subtotal	**9.4**	**0.6%**
Internal Water Areas		
Channels	161.3	10.1%
Channel Banks	64.2	4.0%
Subtotal	**225.5**	**14.1%**
Open Water		
Delaware River/Alloway Creek	0.7	0.0%
Upland Vegetation / Miscellaneous Cover Categories		
Agricultural	0.0	0.0%
Deciduous Forest	0.2	0.0%
Developed	0.1	0.0%
Road	1.1	0.1%
Upland Island	0.9	0.1%
Subtotal	**2.4**	**0.1%**
Total Area	**1600**	**100.0%**

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

Table 8-4
2006 Delaware 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**				
<u>*w/o P. australis*</u>				
A. cannabinus / S. alterniflora	0.0	0.0%	1.0	0.1%
Aster spp.	0.0	0.0%	0.8	0.0%
Desirable Mixed Marsh	485.6	66.1%	113.5	6.1%
Desirable Mixed Marsh / High Marsh Shrubs	0.0	0.0%	0.4	0.0%
Desirable Mixed Marsh / Mud Flat	0.0	0.0%	4.8	0.3%
High Marsh	5.1	0.7%	7.7	0.4%
High Marsh Shrubs	0.0	0.0%	13.6	0.7%
High Marsh Shrubs / Dead *P. australis*	0.0	0.0%	0.0	0.0%
High Marsh Shrubs / Desirable Mixed Marsh	0.0	0.0%	2.6	0.1%
High Marsh Shrubs / Mud Flat	0.0	0.0%	0.3	0.0%
High Marsh Shrubs / *S. alterniflora*	0.0	0.0%	0.0	0.0%
Salt Hay (*Spartina patens, Distichlis spicata, Juncus gerardii)*	3.6	0.5%	3.0	0.2%
Salt Hay / Desirable Mixed Marsh	4.5	0.6%	7.5	0.4%
Salt Hay / *Scirpus olneyi*	1.9	0.3%	0.8	0.0%
Salt Hay / *Scirpus punctatum*	0.0	0.0%	1.4	0.1%
Salt Hay / *S. alterniflora*	0.0	0.0%	0.0	0.0%
Salt Hay / *S. alterniflora / Scirpus robustus*	0.0	0.0%	1.1	0.1%
Salt Hay / *S. cynosuroides*	0.0	0.0%	0.2	0.0%
Scirpus olneyi	2.9	0.4%	7.2	0.4%
S. olneyi / Salt Hay	0.0	0.0%	4.6	0.2%
S. olneyi / S. cynosuroides	0.0	0.0%	0.2	0.0%
Scirpus punctatum	0.0	0.0%	1.5	0.1%
S. punctatum / Desirable Mixed Marsh	0.0	0.0%	0.6	0.0%
Scirpus robustis	0.0	0.0%	0.2	0.0%
S. robustis / S. alterniflora	0.0	0.0%	0.3	0.0%
Spartina alterniflora	9.0	1.2%	85.3	4.6%
S. alterniflora / Beach	0.0	0.0%	0.1	0.0%
S. alterniflora / Desirable Mixed Marsh	0.1	0.0%	265.0	14.2%
S. alterniflora / Mud Flat	2.9	0.4%	21.1	1.1%
S. alterniflora / *S. olneyi*	0.0	0.0%	0.6	0.0%
S. alterniflora / *S. cynosuroides*	0.0	0.0%	426.5	22.9%
S. alterniflora / *S. cynosuroides* / High Marsh Shrubs	0.0	0.0%	1.6	0.1%
S. alterniflora / *S. cynosuroides* / Mud Flat	0.0	0.0%	0.8	0.0%
Spartina cynosuroides	3.2	0.4%	268.9	14.4%
S. cynosuroides / Desirable Mixed Marsh	17.1	2.3%	39.8	2.1%
S. cynosuroides / I. frutescens	0.0	0.0%	0.7	0.0%
S. cynosuroides / S. olneyi	0.0	0.0%	2.6	0.1%
S. cynosuroides / S. alterniflora	0.0	0.0%	105.0	5.6%
<u>*subtotal w/o P. australis*</u>	<u>*535.9*</u>	<u>*72.9%*</u>	<u>*1391.2*</u>	<u>*74.7%*</u>

Table 8-4
2006 Delaware 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)]**
w/ P. australis				
Desirable Mixed Marsh / Dead *P. australis*	0.0	0.0%	2.1	0.1%
High Marsh / *P. australis*	0.0	0.0%	2.1	0.1%
High Marsh Shrubs / Dead *P. australis*	0.0	0.0%	1.1	0.1%
High Marsh Shrubs / *P. australis*	0.0	0.0%	2.0	0.1%
Mixed Marsh	62.6	8.5%	37.3	2.0%
Mixed Marsh / Beach	3.3	0.4%	0.0	0.0%
Mixed Marsh / Dead *P. australis*	0.0	0.0%	0.9	0.0%
Mixed Marsh / Mud Flat	2.4	0.3%	8.1	0.4%
Salt Hay / Mixed Marsh	0.0	0.0%	0.1	0.0%
Salt Hay */ P. australis*	1.6	0.2%	0.0	0.0%
Scirpus robustis / P. australis	0.0	0.0%	0.1	0.0%
S. alterniflora / Dead *P. australis*	0.0	0.0%	1.1	0.1%
S. alterniflora / Dead *P. australis /* Mud Flat	0.0	0.0%	0.1	0.0%
S. alterniflora / Dead *P. australis / P. australis*	0.0	0.0%	0.3	0.0%
S. alterniflora / Mixed Marsh	0.0	0.0%	0.0	0.0%
S. alterniflora / P. australis	0.0	0.0%	2.8	0.1%
S. alterniflora / P. australis / Dead *P. australis*	0.0	0.0%	0.1	0.0%
S. alterniflora / P. australis / Mud Flat	0.0	0.0%	1.4	0.1%
S. alterniflora / Sand / *P. australis*	0.0	0.0%	0.0	0.0%
S. alterniflora / S. cynosuroides / P. australis	0.0	0.0%	1.3	0.1%
S. cynosuroides / Dead *P. australis*	0.0	0.0%	5.4	0.3%
S. cynosuroides / Mixed Marsh	0.0	0.0%	0.3	0.0%
S. cynosuroides / P. australis	0.0	0.0%	47.9	2.6%
S. cynosuroides / P. australis / Mud Flat	0.0	0.0%	0.2	0.0%
S. cynosuroides / P. australis / S. alternoflora	0.0	0.0%	6.3	0.3%
S. cynosuroides / S. alternoflora / P. australis	0.0	0.0%	2.4	0.1%
subtotal w/ P. australis	*69.9*	*9.5%*	*123.4*	*6.6%*
Subtotal	**605.8**	**82.4%**	**1514.7**	**81.3%**
***P. australis* Dominated Vegetation**				
Dead P. australis Dominant				
Dead *Phragmites australis*	0.6	0.1%	12.0	0.6%
Dead *P. australis /* Desirable Mixed Marsh	26.8	3.6%	13.0	0.7%
Dead *P. australis /* Mixed Marsh	0.0	0.0%	3.7	0.2%
Dead *P. australis* / Mud Flat	0.0	0.0%	2.5	0.1%
Dead *P. australis* / Mud Flat / *P. australis*	0.0	0.0%	0.9	0.0%
Dead *P. australis / P. australis*	4.1	0.6%	7.4	0.4%
Dead *P. australis / P. australis / S. alterniflora*	0.0	0.0%	0.4	0.0%
Dead *P. australis / P. australis / S. cynosuroides*	0.0	0.0%	0.2	0.0%
Dead *P. australis / S. alterniflora*	0.0	0.0%	2.1	0.1%
Dead *P. australis / S. alterniflora / P. australis*	0.0	0.0%	0.1	0.0%
Dead *P. australis / S. cynosuroides*	0.0	0.0%	3.4	0.2%
Dead *P. australis / S. cynosuroides* / High Marsh Shrubs	0.0	0.0%	1.0	0.1%
subtotal - Dead P. australis	*31.5*	*4.3%*	*46.7*	*2.5%*

Table 8-4
2006 Delaware 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]**
P. australis Dominant				
Phragmites australis	19.2	2.6%	35.2	1.9%
P. australis / Beach	0.6	0.1%	7.2	0.4%
P. australis / Dead *P. australis*	1.0	0.1%	5.0	0.3%
P. australis / Dead *P. australis / S. alterniflora*	0.0	0.0%	0.8	0.0%
P. australis / Dead *P. australis / S. cynosuroides*	0.0	0.0%	0.4	0.0%
P. australis / Desirable Mixed Marsh	41.1	5.6%	2.0	0.1%
P. australis / High Marsh	0.0	0.0%	0.6	0.0%
P. australis / High Marsh Shrubs	0.0	0.0%	0.3	0.0%
P. australis / Mixed Marsh	0.0	0.0%	1.1	0.1%
P. australis / Mud Flat	0.0	0.0%	3.7	0.2%
P. australis / S. alterniflora	0.7	0.1%	5.5	0.3%
P. australis / S. alterniflora / S. cynosuroides	0.0	0.0%	0.9	0.0%
P. australis / S. cynosuroides	0.0	0.0%	26.7	1.4%
P. australis / S. cynosuroides / S. alterniflora	0.0	0.0%	1.1	0.0%
subtotal - P. australis	*62.5*	*8.5%*	*90.7*	*4.8%*
Subtotal	**94.0**	**12.8%**	**137.3**	**7.3%**
Non-vegetated Marsh Plain				
Beach	0.2	0.0%	4.7	0.3%
Beach / Mixed Marsh	0.9	0.1%	0.0	0.0%
Beach / *P. australis*	0.0	0.0%	0.1	0.0%
Beach / *S. alterniflora*	0.1	0.0%	0.7	0.0%
Beach / Wrack	0.4	0.1%	0.0	0.0%
Mud Flat	0.0	0.0%	3.4	0.2%
Mud Flat / Dead *P. australis*	0.0	0.0%	0.2	0.0%
Mud Flat / Dead *P. australis / S. alterniflora*	0.0	0.0%	0.1	0.0%
Mud Flat / Desirable Mixed Marsh	0.0	0.0%	0.4	0.0%
Mud Flat / High Marsh Shrubs	0.0	0.0%	0.2	0.0%
Mud Flat / Mixed Marsh	0.0	0.0%	2.2	0.1%
Mud Flat / *P. australis*	0.0	0.0%	0.5	0.0%
Mud Flat / *P. australis / S. alterniflora*	0.0	0.0%	0.0	0.0%
Mud Flat / *S. alterniflora*	0.7	0.1%	3.4	0.2%
Mud Flat / *S. alterniflora* / Dead *P. australis*	0.0	0.0%	0.1	0.0%
Wrack	0.2	0.0%	1.0	0.1%
Wrack / Mud Flat	0.2	0.0%	0.2	0.0%
Wrack / Sand	0.2	0.0%	2.1	0.1%
Wrack */ S. alterniflora*	0.0	0.0%	0.1	0.0%
Subtotal	**2.7**	**0.4%**	**19.4**	**1.0%**
Internal Water Areas				
Channels	10.2	1.4%	118.6	6.4%
Channel Banks	21.1	2.9%	71.1	3.8%
Ponded Water	0.2	0.0%	0.5	0.0%
Subtotal	**31.6**	**4.3%**	**190.3**	**10.2%**
Open Water				
Appoquinimink River	0.3	0.0%	0.4	0.0%
Subtotal	**0.3**	**0.0%**	**0.4**	**0.0%**
Upland Vegetation / Miscellaneous Cover Categories				
Agricultural	0.1	0.0%	0.0	0.0%
Deciduous Forest	0.5	0.1%	0.5	0.0%
Subtotal [b]	**0.5**	**0.1%**	**0.5**	**0.0%**
Total Marsh Area	**735**	**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
2006 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 2006	37	1	1	1			0.0	0.0%	--	0.5	1.00
	36	2	217	109			0.0	0.0%	224.8	1.0	1.05
	35	2	95	47			0.0	0.0%	0.4	0.5	1.01
	34	4	299	75			0.0	0.0%	3.2	0.7	1.08
	33	6	301	50			0.0	0.0%	1.0	0.8	1.02
	32	8	541	68			0.0	0.0%	1.8	0.6	1.04
	31	13	675	52			0.0	0.0%	1.2	1.6	1.06
	30	8	324	41			0.0	0.0%	0.5	0.6	1.01
	29	13	833	64			0.0	0.0%	2.6	0.8	1.07
	28	17	786	46			0.0	0.0%	0.9	0.3	1.06
	27	50	2475	50			0.0	0.1%	3.1	0.7	1.06
	26	75	3387	45			0.0	0.1%	1.4	1.0	1.05
	25	77	3346	43			0.0	0.1%	1.0	0.6	1.05
	24	120	4978	41			0.0	0.2%	1.5	0.8	1.05
	23	158	7146	45			0.1	0.3%	1.4	0.8	1.05
	22	203	9373	46			0.1	0.4%	1.3	0.9	1.05
	21	235	12458	53			0.1	0.5%	1.3	0.8	1.04
	20	297	16736	56			0.1	0.7%	1.3	0.8	1.04
	19	359	19231	54			0.1	0.8%	1.1	0.8	1.04
	18	476	25726	54			0.2	1.0%	1.3	0.8	1.05
	17	601	30902	51			0.2	1.2%	1.2	0.8	1.07
	16	740	36645	50			0.3	1.4%	1.2	0.8	1.05
	15	976	50098	51			0.3	2.0%	1.4	0.7	1.06
	14	1348	68800	51			0.5	2.7%	1.4	0.8	1.06
	13	1784	90931	51			0.6	3.6%	1.3	0.8	1.05
	12	2358	119102	51			0.8	4.7%	1.3	0.8	1.06
	11	2909	151638	52			1.0	6.0%	1.3	0.8	1.06
	10	3489	183177	53			1.2	7.2%	1.2	0.9	1.05
	9	3881	205391	53			1.3	8.1%	1.1	0.9	1.06
	8	4350	234971	54			1.5	9.2%	1.1	0.9	1.06
	7	4588	257241	56			1.6	10.1%	1.1	1.0	1.07
	6	4665	261054	56			1.6	10.3%	1.0	1.1	1.06
	5	4341	262546	60			1.5	10.3%	1.0	1.3	1.07
	4	3436	237121	69			1.2	9.3%	0.9	2.0	1.07
	3	1688	180007	107			0.6	7.1%	0.8	44.4	1.09
	2	38	41178	1084			0.0	1.6%	0.2	4.8	1.14
	1	8	25642	3205			0.0	1.0%	0.6	0.0	1.17
	Total	43,324	2,545,376		2901	877	14.9	100.0%			
Alloway Creek Watershed 2006	20	2	155	78			0.001	0.0%	1.2	--	1.09
	19	2	128	64			0.001	0.0%	0.6	1.0	1.05
	18	2	228	114			0.001	0.0%	0.3	1.0	1.19
	17	8	688	86			0.005	0.1%	1.1	4.0	1.10
	16	13	619	48			0.008	0.1%	0.3	1.6	1.08
	15	24	1773	74			0.015	0.2%	0.9	1.8	1.13
	14	29	1869	64			0.018	0.2%	0.4	1.2	1.11
	13	60	4368	73			0.037	0.5%	0.8	2.1	1.14
	12	90	5419	60			0.056	0.6%	0.4	1.5	1.10
	11	152	10292	68			0.095	1.2%	0.3	1.7	1.10
	10	213	14438	68			0.133	1.7%	0.5	1.4	1.12
	9	424	29489	70			0.265	3.5%	0.6	2.0	1.11
	8	689	48349	70			0.430	5.8%	0.7	1.6	1.11
	7	1003	74024	74			0.626	8.8%	0.8	1.5	1.12
	6	1258	96026	76			0.786	11.5%	0.8	1.3	1.13
	5	1560	126125	81			0.974	15.1%	0.8	1.2	1.13
	4	1702	156956	92			1.063	18.8%	1.0	1.1	1.15
	3	1356	159468	118			0.847	19.1%	3.4	0.8	1.27
	2	81	46407	573			0.051	5.5%	0.8	0.1	1.16
	1	94	60272	641			0.059	7.2%	--	1.2	1.18

TABLE 8-5
2006 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
	Total	8,762	837,092		1,601	523	5.473	100.0%			
The Rocks 2006	19	2	224	112			0.003	0.1%	---	1.0	1.03
	18	2	61	30			0.003	0.0%	0.3	0.3	1.04
	17	8	363	45			0.011	0.1%	1.5	0.8	1.05
	16	10	415	42			0.014	0.1%	0.9	0.7	1.07
	15	15	725	48			0.020	0.2%	1.2	0.8	1.04
	14	20	1136	57			0.027	0.4%	1.2	1.1	1.06
	13	19	1129	59			0.026	0.4%	1.0	0.5	1.07
	12	37	2215	60			0.050	0.7%	1.0	0.5	1.07
	11	73	3838	53			0.099	1.3%	0.9	0.5	1.08
	10	151	8628	57			0.205	2.8%	1.1	0.7	1.07
	9	203	11879	59			0.275	3.9%	1.0	0.6	1.09
	8	337	18578	55			0.457	6.1%	0.9	0.7	1.08
	7	454	27977	62			0.616	9.2%	1.1	0.9	1.10
	6	534	33889	63			0.725	11.1%	1.0	0.8	1.09
	5	629	43829	70			0.853	14.4%	1.1	1.0	1.11
	4	632	51006	81			0.858	16.7%	1.2	1.3	1.12
	3	473	66815	141			0.642	21.9%	1.8	27.8	1.14
	2	17	14062	827			0.023	4.6%	5.9	1.1	1.30
	1	15	18603	1240			0.020	6.1%	1.5	--	1.43
	Total	3,631	305,371		737	414	4.927	100.0%			
Cedar Swamp 2006	30	6	635	106			0.003	0.1%	--	1.5	1.09
	29	4	364	91			0.002	0.0%	0.9	0.7	1.06
	28	6	947	158			0.003	0.1%	1.7	0.9	1.07
	27	7	471	67			0.004	0.1%	0.4	0.9	1.12
	26	8	600	75			0.005	0.1%	1.1	0.4	1.10
	25	18	1288	72			0.010	0.2%	1.0	0.8	1.07
	24	22	1445	66			0.013	0.2%	0.9	0.6	1.01
	23	34	2152	63			0.020	0.3%	1.0	0.6	1.10
	22	53	4423	83			0.031	0.5%	1.3	0.6	1.19
	21	85	5670	67			0.049	0.7%	0.8	0.7	1.11
	20	118	7363	62			0.068	0.9%	0.9	0.8	1.09
	19	156	9522	61			0.090	1.2%	1.0	0.7	1.08
	18	228	13629	60			0.132	1.7%	1.0	0.8	1.09
	17	298	18077	61			0.172	2.2%	1.0	0.8	1.10
	16	397	25203	63			0.229	3.1%	1.0	0.8	1.09
	15	516	29310	57			0.298	3.5%	0.9	0.8	1.10
	14	652	39578	61			0.377	4.8%	1.1	0.9	1.09
	13	724	44407	61			0.418	5.4%	1.0	0.9	1.10
	12	779	48342	62			0.450	5.9%	1.0	0.9	1.09
	11	849	52827	62			0.490	6.4%	1.0	1.0	1.09
	10	824	55342	67			0.476	6.7%	1.1	1.0	1.10
	9	822	55633	68			0.475	6.7%	1.0	1.0	1.08
	8	783	57568	74			0.452	7.0%	1.1	1.0	1.10
	7	760	62151	82			0.439	7.5%	1.1	1.0	1.09
	6	731	66620	91			0.422	8.1%	1.1	1.2	1.09
	5	598	70633	118			0.345	8.6%	1.3	1.4	1.10
	4	432	81557	189			0.249	9.9%	1.6	3.3	1.13
	3	131	54510	416			0.076	6.6%	2.2	43.7	1.41
	2	3	14510	4837			0.002	1.8%	11.6	3.0	1.02
	1	1	865	865			0.001	0.1%	0.2	--	1.00
	Total	10,045	825,641		1,732	477	5.801	100.0%			

TABLE 8-6
AERIAL COVER SUMMARY
2006 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	36%
Standard Error of Mean	2%
Standard Deviation	14%
Minimum	20%
Maximum	85%
Count (n)	43
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	33%
Standard Error of Mean	5%
Standard Deviation	30%
Minimum	1%
Maximum	96%
Count (n)	41
All Quadrats	
Mean	34%
Standard Error of Mean	3%
Standard Deviation	23%
Minimum	1%
Maximum	96%
Count (n)	84
Moores Beach West Reference Marsh	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	28%
Standard Error of Mean	2%
Standard Deviation	6%
Minimum	20%
Maximum	35%
Count (n)	14
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	13%
Standard Error of Mean	1%
Standard Deviation	4%
Minimum	5%
Maximum	15%
Count (n)	10
All Quadrats	
Mean	22%
Standard Error of Mean	2%
Standard Deviation	9%
Minimum	5%
Maximum	35%
Count (n)	24

TABLE 8-6
AERIAL COVER SUMMARY
2006 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	28%
Standard Error of Mean	2%
Standard Deviation	7%
Minimum	25%
Maximum	45%
Count (n)	12
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	14%
Standard Error of Mean	1%
Standard Deviation	4%
Minimum	5%
Maximum	15%
Count (n)	7
All Quadrats	
Mean	23%
Standard Error of Mean	2%
Standard Deviation	9%
Minimum	5%
Maximum	45%
Count (n)	19

TABLE 8-6
AERIAL COVER SUMMARY
2006 CLIP AND OCULAR QUADRAT TRANSECT DATA
PSEG EEP DETRITAL PRODUCTION MONITORING PROGRAM

	Peak Season Percent Cover
Alloway Creek Site	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	48%
Standard Error of Mean	3%
Standard Deviation	19%
Minimum	25%
Maximum	90%
Count (n)	42
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	39%
Standard Error of Mean	4%
Standard Deviation	20%
Minimum	10%
Maximum	80%
Count (n)	30
All Quadrats	
Mean	44%
Standard Error of Mean	2%
Standard Deviation	20%
Minimum	10%
Maximum	90%
Count (n)	72

TABLE 8-6
AERIAL COVER SUMMARY
2006 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	47%
Standard Error of Mean	2%
Standard Deviation	16%
Minimum	20%
Maximum	80%
Count (n)	64
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	32%
Standard Error of Mean	3%
Standard Deviation	21%
Minimum	5%
Maximum	100%
Count (n)	38
All Quadrats	
Mean	42%
Standard Error of Mean	2%
Standard Deviation	19%
Minimum	5%
Maximum	100%
Count (n)	102
Cedar Swamp Site	
***Spartina alterniflora* dominated Quadrats Only (a)**	
Mean	42%
Standard Error of Mean	2%
Standard Deviation	13%
Minimum	25%
Maximum	85%
Count (n)	65
Non-*Spartina alterniflora* dominated Quadrats Only (b)	
Mean	34%
Standard Error of Mean	6%
Standard Deviation	24%
Minimum	5%
Maximum	85%
Count (n)	15
All Quadrats	
Mean	40%
Standard Error of Mean	2%
Standard Deviation	16%
Minimum	5%
Maximum	85%
Count (n)	80

(a) Also includes *Spartina cynosuroides* dominated quadrats, when present.

(b) Includes quadrats dominated by *Spartina patens.*

TABLE 8-7
SUMMARY OF 2006 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
Mad Horse Creek Reference Marsh							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	39%	646	0	73	93	720	812
Standard Error of Mean	3%	81	0	19	20		
Standard Deviation	11%	258	0	61	64		
Minimum	25%	236	0	0	0		
Maximum	55%	1017	0	162	220		
Count (n)	10	10	10	10	10		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	32%	646	0	253	210	899	1,108
Standard Error of Mean	10%	118	0	172	64		
Standard Deviation	33%	393	0	570	214		
Minimum	5%	249	0	0	0		
Maximum	96%	1,260	0	1,598	696		
Count (n)	11	11	11	11	11		
All Quadrats							
Mean	35%	646	0	167	154	813	967
Standard Error of Mean	5%	71	0	91	37		
Standard Deviation	25%	327	0	415	168		
Minimum	5%	236	0	0	0		
Maximum	96%	1,260	0	1,598	696		
Count (n)	21	21	21	21	21		
Moores Beach West Reference Marsh							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	28%	681	0	0	105	681	787
Standard Error of Mean	2%	198	0	0	47		
Standard Deviation	5%	395	0	0	95		
Minimum	25%	249	0	0	18		
Maximum	35%	1,199	0	0	238		
Count (n)	4	4	4	4	4		
Non-*Spartina alterniflora* dominated Quadrats Only							
Mean	10%	236	0	0	225	236	461
Standard Error of Mean	5%	173	0	0	134		
Standard Deviation	7%	244	0	0	189		
Minimum	5%	63	0	0	92		
Maximum	15%	409	0	0	359		
Count (n)	2	2	2	2	2		
All Quadrats							
Mean	22%	533	0	0	145	533	678
Standard Error of Mean	4%	163	0	0	52		
Standard Deviation	10%	398	0	0	128		
Minimum	5%	63	0	0	18		
Maximum	35%	1,199	0	0	359		
Count (n)	6	6	6	6	6		

TABLE 8-7
SUMMARY OF 2006 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	27%	1,501	0	0	53	1,501	1,554
Standard Error of Mean	2%	219	0	0	53		
Standard Deviation	4%	489	0	0	118		
Minimum	25%	730	0	0	0		
Maximum	35%	1,985	0	0	263		
Count (n)	5	5	5	5	5		
Non-*Spartina alterniflora* dominated Quadrats Only							
Mean	15%	899	0	0	0	899	899
Standard Error of Mean	0%	174	0	0	0		
Standard Deviation	0%	301	0	0	0		
Minimum	15%	644	0	0	0		
Maximum	15%	1,231	0	0	0		
Count (n)	3	3	3	3	3		
All Quadrats							
Mean	23%	1,275	0	0	33	1,275	1,308
Standard Error of Mean	3%	180	0	0	33		
Standard Deviation	7%	509	0	0	93		
Minimum	15%	644	0	0	0		
Maximum	35%	1,985	0	0	263		
Count	8	8	8	8	8		
Alloway Creek Site							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	47%	1,157	0	0	191	1,157	1,348
Standard Error of Mean	6%	165	0	0	60		
Standard Deviation	19%	496	0	0	181		
Minimum	25%	296	0	0	0		
Maximum	75%	1,833	0	0	558		
Count (n)	9	9	9	9	9		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	50%	876	0	9	128	885	1,013
Standard Error of Mean	8%	159	0	9	34		
Standard Deviation	23%	477	0	28	103		
Minimum	15%	179	0	0	0		
Maximum	80%	1,360	0	83	279		
Count (n)	9	9	9	9	9		
All Quadrats							
Mean	49%	1,016	0	5	160	1,021	1,181
Standard Error of Mean	5%	116	0	5	35		
Standard Deviation	21%	494	0	20	147		
Minimum	15%	179	0	0	0		
Maximum	80%	1,833	0	83	558		
Count	18	18	18	18	18		

TABLE 8-7
SUMMARY OF 2006 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
The Rocks Site							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	51%	1,109	0	133	116	1,242	1,358
Standard Error of Mean	4%	121	0	42	21		
Standard Deviation	14%	455	0	158	79		
Minimum	25%	277	0	0	0		
Maximum	75%	2,057	0	449	242		
Count (n)	14	14	14	14	14		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	32%	1,168	0	0	88	1,168	1,256
Standard Error of Mean	4%	223	0	0	22		
Standard Deviation	13%	774	0	0	77		
Minimum	10%	441	0	0	0		
Maximum	50%	3,172	0	0	215		
Count (n)	12	12	12	12	12		
All Quadrats							
Mean	42%	1,136	0	72	103	1,208	1,311
Standard Error of Mean	3%	120	0	26	15		
Standard Deviation	17%	610	0	133	78		
Minimum	10%	277	0	0	0		
Maximum	75%	3,172	0	449	242		
Count	26	26	26	26	26		

TABLE 8-7
SUMMARY OF 2006 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
Cedar Swamp Site							
***Spartina alterniflora* dominated Quadrats Only (a)**							
Mean	42%	1,065	0	57	216	1,122	1,338
Standard Error of Mean	4%	93	0	34	45		
Standard Deviation	15%	361	0	131	176		
Minimum	25%	184	0	0	70		
Maximum	70%	1,740	0	388	631		
Count (n)	15	15	15	15	15		
Non-*Spartina alterniflora* dominated Quadrats Only (b)							
Mean	45%	1,025	0	8	153	1,033	1,186
Standard Error of Mean	15%	289	0	8	75		
Standard Deviation	34%	647	0	17	168		
Minimum	15%	630	0	0	0		
Maximum	85%	2,161	0	39	439		
Count (n)	5	5	5	5	5		
All Quadrats							
Mean	43%	1,055	0	44	200	1,100	1,300
Standard Error of Mean	5%	96	0	26	38		
Standard Deviation	20%	429	0	115	172		
Minimum	15%	184	0	0	0		
Maximum	85%	2,161	0	388	631		
Count	20	20	20	20	20		

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

TABLE 8-8
SUMMARY OF 2006 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	33%	101	792	100	106
Standard Error of Mean	3%	4	79	23	28
Standard Deviation	12%	20	192	56	68
Count (*n*)	21	22	6	6	6
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	22%	--	1202	1390	539
Standard Error of Mean	6%	--	57	208	157
Standard Deviation	17%	--	81	295	222
Count (*n*)	9	--	2	2	2
All Quadrats					
Mean	30%	--	895	422	214
Standard Error of Mean	3%	--	89	215	80
Standard Deviation	14%	--	252	609	225
Count (*n*)	30	--	8	8	8
Mad Horse Creek Reference Marsh - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	42%	75	236	32	84
Standard Error of Mean	9%	10	0	0	0
Standard Deviation	15%	17	0	0	0
Count (*n*)	3	3	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	14%	--	1159	0	140
Standard Error of Mean	4%	--	0	0	0
Standard Deviation	8%	--	0	0	0
Count (*n*)	4	--	1	1	1
All Quadrats					
Mean	26%	--	697	16	112
Standard Error of Mean	7%	--	461	16	28
Standard Deviation	18%	--	653	23	39
Count (n)	7	--	2	2	2

TABLE 8-8
SUMMARY OF 2006 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	37%	82	491	34	69
Standard Error of Mean	4%	6	85	34	42
Standard Deviation	16%	28	147	59	73
Count (*n*)	19	22	3	3	3
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	39%	--	394	0	121
Standard Error of Mean	6%	--	83	0	47
Standard Deviation	34%	--	250	0	141
Count (*n*)	28	--	9	9	9
All Quadrats					
Mean	38%	--	418	9	108
Standard Error of Mean	4%	--	65	9	36
Standard Deviation	28%	--	226	30	126
Count (n)	47	--	12	12	12
Moores Beach West Reference Marsh - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	25%	103	1199	0	99
Standard Error of Mean	0%	22	0	0	0
Standard Deviation	0%	30	0	0	0
Count (*n*)	2	2	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	15%	--	409	0	92
Standard Error of Mean	0%	--	0	0	0
Standard Deviation	0%	--	0	0	0
Count (*n*)	6	--	1	1	1
All Quadrats					
Mean	18%	--	804	0	95
Standard Error of Mean	2%	--	395	0	4
Standard Deviation	5%	--	559	0	5
Count (*n*)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2006 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	31%	107	639	0	42
Standard Error of Mean	2%	5	68	0	24
Standard Deviation	5%	15	97	0	34
Count (*n*)	8	8	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	0%	--	0	0	0
Standard Error of Mean	0%	--	0	0	0
Standard Deviation	0%	--	0	0	0
Count (*n*)	0	--	0	0	0
All Quadrats					
Mean	31%	--	639	0	42
Standard Error of Mean	2%	--	68	0	24
Standard Deviation	5%	--	97	0	34
Count (*n*)	8	--	2	2	2
Moores Beach West Reference Marsh - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	23%	92	249	0	238
Standard Error of Mean	1%	8	0	0	0
Standard Deviation	3%	17	0	0	0
Count (*n*)	4	4	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	10%	--	63	0	359
Standard Error of Mean	3%	--	0	0	0
Standard Deviation	6%	--	0	0	0
Count (*n*)	4	--	1	1	1
All Quadrats					
Mean	16%	--	156	0	299
Standard Error of Mean	3%	--	93	0	60
Standard Deviation	8%	--	131	0	85
Count(n)	8	--	2	2	2

TABLE 8-8
SUMMARY OF 2006 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	33%	136	1469	0	0
Standard Error of Mean	5%	12	19	0	0
Standard Deviation	10%	24	27	0	0
Count (*n*)	4	4	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	15%	--	0	0	0
Standard Error of Mean	0%	--	0	0	0
Standard Deviation	0%	--	0	0	0
Count (*n*)	1	--	0	0	0
All Quadrats					
Mean	29%	--	1469	0	0
Standard Error of Mean	5%	--	19	0	0
Standard Deviation	11%	--	27	0	0
Count (*n*)	5	--	2	2	2
Commercial Township Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	28%	165	1853	0	0
Standard Error of Mean	3%	5	0	0	0
Standard Deviation	6%	8	0	0	0
Count (*n*)	3	3	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	15%	--	821	0	0
Standard Error of Mean	0%	--	0	0	0
Standard Deviation	0%	--	0	0	0
Count (*n*)	1	--	1	1	1
All Quadrats					
Mean	25%	--	1337	0	0
Standard Error of Mean	4%	--	516	0	0
Standard Deviation	8%	--	730	0	0
Count (*n*)	4	--	2	2	2

TABLE 8-8
SUMMARY OF 2006 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 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	25%	113	730	0	0
Standard Error of Mean	0%	6	0	0	0
Standard Deviation	0%	10	0	0	0
Count (*n*)	3	3	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	15%	--	1231	0	0
Standard Error of Mean	0%	--	0	0	0
Standard Deviation	0%	--	0	0	0
Count (*n*)	2	--	1	1	1
All Quadrats					
Mean	21%	--	980	0	0
Standard Error of Mean	2%	--	251	0	0
Standard Deviation	5%	--	355	0	0
Count (*n*)	5	--	2	2	2
Commercial Township Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	25%	188	1985	0	263
Standard Error of Mean	0%	3	0	0	0
Standard Deviation	0%	4	0	0	0
Count (*n*)	2	2	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	12%	--	644	0	0
Standard Error of Mean	3%	--	0	0	0
Standard Deviation	6%	--	0	0	0
Count (*n*)	3	--	1	1	1
All Quadrats					
Mean	17%	--	1315	0	132
Standard Error of Mean	4%	--	670	0	132
Standard Deviation	8%	--	948	0	186
Count (*n*)	5	--	2	2	2

TABLE 8-8
SUMMARY OF 2006 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 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	48%	101	0	0	0
Standard Error of Mean	7%	6	0	0	0
Standard Deviation	22%	19	0	0	0
Count (*n*)	9	9	0	0	0
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	37%	--	519	15	182
Standard Error of Mean	4%	--	248	15	51
Standard Deviation	10%	--	496	30	102
Count (*n*)	7	--	4	4	4
All Quadrats					
Mean	44%	--	519	15	182
Standard Error of Mean	5%	--	248	15	51
Standard Deviation	18%	--	496	30	102
Count (*n*)	16	--	4	4	4
Alloway Creek Watershed Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	46%	117	1569	0	261
Standard Error of Mean	3%	7	146	0	149
Standard Deviation	12%	28	253	0	259
Count (*n*)	13	14	3	3	3
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	15%	--	1239	0	0
Standard Error of Mean	0%	--	0	0	0
Standard Deviation	0%	--	0	0	0
Count (*n*)	1	--	1	1	1
All Quadrats					
Mean	44%	--	1487	0	196
Standard Error of Mean	4%	--	132	0	124
Standard Deviation	14%	--	264	0	248
Count (*n*)	14	--	4	4	4

TABLE 8-8
SUMMARY OF 2006 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	62%	94	1045	0	235
Standard Error of Mean	6%	7	283	0	53
Standard Deviation	19%	24	567	0	106
Count (*n*)	12	12	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	47%	--	1141	21	106
Standard Error of Mean	5%	--	115	21	44
Standard Deviation	20%	--	231	42	89
Count (*n*)	18	--	4	4	4
All Quadrats					
Mean	53%	--	1093	10	171
Standard Error of Mean	4%	--	143	10	40
Standard Deviation	21%	--	404	29	114
Count (*n*)	30	--	8	8	8
Alloway Creek Watershed Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	27%	126	765	0	0
Standard Error of Mean	4%	8	60	0	0
Standard Deviation	12%	21	85	0	0
Count (*n*)	9	8	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	11%	--	0	0	0
Standard Error of Mean	1%	--	0	0	0
Standard Deviation	3%	--	0	0	0
Count (*n*)	4	--	0	0	0
All Quadrats					
Mean	22%	--	765	0	0
Standard Error of Mean	3%	--	60	0	0
Standard Deviation	13%	--	85	0	0
Count (*n*)	13	--	2	2	2

TABLE 8-8
SUMMARY OF 2006 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	46%	94	1083	0	172
Standard Error of Mean	3%	5	126	0	49
Standard Deviation	13%	24	218	0	84
Count (*n*)	16	21	3	3	3
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	23%	--	905	0	89
Standard Error of Mean	4%	--	257	0	60
Standard Deviation	10%	--	445	0	104
Count (*n*)	8	--	3	3	3
All Quadrats					
Mean	38%	--	994	0	130
Standard Error of Mean	3%	--	134	0	39
Standard Deviation	16%	--	328	0	96
Count (*n*)	24	--	6	6	6
The Rocks Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	52%	126	1507	235	118
Standard Error of Mean	4%	12	218	94	30
Standard Deviation	18%	51	435	189	61
Count (*n*)	18	19	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	37%	--	1553	0	84
Standard Error of Mean	3%	--	569	0	38
Standard Deviation	11%	--	1138	0	76
Count (*n*)	12	--	4	4	4
All Quadrats					
Mean	46%	--	1530	117	101
Standard Error of Mean	3%	--	282	62	23
Standard Deviation	17%	--	798	176	66
Count (*n*)	30	--	8	8	8

TABLE 8-8
SUMMARY OF 2006 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	51%	125	907	154	79
Standard Error of Mean	4%	7	187	58	35
Standard Deviation	16%	34	459	143	86
Count (*n*)	21	24	6	6	6
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	70%	--	0	0	0
Standard Error of Mean	30%	--	0	0	0
Standard Deviation	52%	--	0	0	0
Count (*n*)	3	--	0	0	0
All Quadrats					
Mean	53%	--	907	154	79
Standard Error of Mean	5%	--	187	58	35
Standard Deviation	23%	--	459	143	86
Count (*n*)	24	--	6	6	6
The Rocks Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	34%	209	808	0	161
Standard Error of Mean	2%	25	0	0	0
Standard Deviation	6%	83	0	0	0
Count (*n*)	9	11	1	1	1
Non-*Spartina alterniflora* dominated Quadrats Only (c)					
Mean	26%	--	1017	0	92
Standard Error of Mean	4%	--	263	0	36
Standard Deviation	14%	--	589	0	80
Count (*n*)	15	--	5	5	5
All Quadrats					
Mean	29%	--	982	0	104
Standard Error of Mean	2%	--	218	0	32
Standard Deviation	12%	--	533	0	77
Count (*n*)	24	--	6	6	6

TABLE 8-8
SUMMARY OF 2006 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
Cedar Swamp Site - Transect 1					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	37%	132	1309	0	155
Standard Error of Mean	1%	14	134	0	45
Standard Deviation	6%	63	299	0	101
Count (*n*)	19	20	5	5	5
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	23%	--	636	0	0
Standard Error of Mean	7%	--	0	0	0
Standard Deviation	16%	--	0	0	0
Count (*n*)	5	--	1	1	1
All Quadrats					
Mean	34%	--	1197	0	129
Standard Error of Mean	2%	--	157	0	45
Standard Deviation	11%	--	383	0	110
Count (*n*)	24	--	6	6	6
Cedar Swamp Site - Transect 2					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	49%	126	1118	123	141
Standard Error of Mean	3%	8	150	92	27
Standard Deviation	15%	42	299	183	54
Count (*n*)	20	30	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	44%	--	1546	19	122
Standard Error of Mean	13%	--	615	19	18
Standard Deviation	25%	--	870	27	25
Count (*n*)	4	--	2	2	2
All Quadrats					
Mean	48%	--	1261	89	135
Standard Error of Mean	3%	--	206	62	18
Standard Deviation	17%	--	504	152	44
Count (*n*)	24	--	6	6	6

TABLE 8-8
SUMMARY OF 2006 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
Cedar Swamp Site - Transect 3					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	38%	76	757	89	345
Standard Error of Mean	3%	5	202	89	131
Standard Deviation	11%	23	403	177	263
Count (*n*)	18	24	4	4	4
Non-*Spartina alterniflora* dominated Quadrats Only					
Mean	37%	--	699	0	262
Standard Error of Mean	12%	--	69	0	177
Standard Deviation	29%	--	97	0	251
Count (*n*)	6	--	2	2	2
All Quadrats					
Mean	38%	--	738	59	317
Standard Error of Mean	3%	--	129	59	97
Standard Deviation	16%	--	317	145	236
Count (*n*)	24	--	6	6	6
Cedar Swamp Site - Transect 4					
Spartina alterniflora dominated Quadrats Only (b)					
Mean	43%	110	966	0	261
Standard Error of Mean	6%	13	8	0	178
Standard Deviation	18%	37	12	0	252
Count (*n*)	8	8	2	2	2
Non-*Spartina alterniflora* dominated Quadrats Only (d)					
Mean	0%	--	0	0	0
Standard Error of Mean	0%	--	0	0	0
Standard Deviation	0%	--	0	0	0
Count (*n*)	0	--	0	0	0
All Quadrats					
Mean	43%	--	966	0	261
Standard Error of Mean	6%	--	8	0	178
Standard Deviation	18%	--	12	0	252
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.*
(d) All quadrats in this transect were *Spartina* -dominated.

Table 8-9
2006 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*	
Spartina alterniflora	X*	X*
Spartina cynosuroides	X*	
Spartina patens	X*	
Scirpus americanus	X	
Scirpus robustus	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 2006 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent Cover	Live Standing Biomass	
		gdw/m2	lb/acre
Mad Horse Creek Reference Marsh			
Plot 1 (MHP1)			
Mean	34%	599	5,347
Standard Error of Mean	5%	130	1,162
Standard Deviation	14%	391	3,487
Minimum	15%	0	0
Maximum	61%	1,131	10,089
Count (n)	9	9	
Plot 2 (MHP2)			
Mean	31%	547	4,878
Standard Error of Mean	5%	159	1,414
Standard Deviation	15%	476	4,243
Minimum	5%	0	0
Maximum	45%	1,181	10,534
Count (n)	9	9	
Plot 3 (MHP3)			
Mean	48%	738	6,589
Standard Error of Mean	7%	199	1,779
Standard Deviation	20%	598	5,338
Minimum	25%	0	0
Maximum	85%	2,056	18,345
Count (n)	9	9	
All Plots			
Mean	38%	628	5,604
Standard Error of Mean	3%	93	830
Standard Deviation	18%	483	4,311
Minimum	5%	0	0
Maximum	85%	2,056	18,345
Count (n)	27	27	

TABLE 8-10
SUMMARY OF 2006 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent	Live Standing Biomass	
	Cover	gdw/m2	lb/acre
Moores Beach West Reference Marsh			
Plot 1 (MBP1)			
Mean	33%	643	5,737
Standard Error of Mean	3%	115	1,030
Standard Deviation	9%	346	3,091
Minimum	25%	0	0
Maximum	50%	1,319	11,767
Count (n)	9	9	
Plot 2 (MBP2)			
Mean	29%	654	5,831
Standard Error of Mean	6%	113	1,006
Standard Deviation	17%	338	3,017
Minimum	5%	123	1,094
Maximum	55%	1,390	12,401
Count (n)	9	9	
Plot 3 (MBP3)			
Mean	16%	365	3,260
Standard Error of Mean	5%	142	1,265
Standard Deviation	15%	425	3,796
Minimum	1%	5	49
Maximum	45%	1,417	12,641
Count (n)	9	9	
All Plots			
Mean	26%	554	4,942
Standard Error of Mean	3%	74	657
Standard Deviation	15%	382	3,412
Minimum	1%	0	0
Maximum	55%	1,417	12,641
Count (n)	27	27	

TABLE 8-10
SUMMARY OF 2006 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent	Live Standing Biomass	
	Cover	gdw/m2	lb/acre
Commercial Township Site			
Plot 1 (CTP1)			
Mean	11%	300	2,674
Standard Error of Mean	5%	153	1,368
Standard Deviation	16%	460	4,103
Minimum	0%	0	0
Maximum	35%	1,120	9,988
Count (n)	9	9	
Plot 2 (CTP2)			
Mean	19%	687	6,133
Standard Error of Mean	5%	143	1,274
Standard Deviation	14%	428	3,822
Minimum	0%	0	0
Maximum	45%	1,256	11,206
Count (n)	9	9	
Plot 3 (CTP3)			
Mean	17%	442	3,942
Standard Error of Mean	3%	71	636
Standard Deviation	9%	214	1,907
Minimum	5%	100	893
Maximum	30%	843	7,523
Count (n)	9	9	
Plot 4 (CTP4)			
Mean	19%	379	3,386
Standard Error of Mean	7%	153	1,363
Standard Deviation	20%	458	4,089
Minimum	0%	0	0
Maximum	45%	1,343	11,980
Count (n)	9	9	
All Plots			
Mean	17%	452	4,034
Standard Error of Mean	3%	69	614
Standard Deviation	15%	413	3,682
Minimum	0%	0	0
Maximum	45%	1,343	11,980
Count (n)	36	36	

TABLE 8-10
SUMMARY OF 2006 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	25%	676	6,030
Standard Error of Mean	4%	163	1,458
Standard Deviation	13%	490	4,374
Minimum	0%	0	0
Maximum	45%	1,410	12,583
Count (n)	9	9	
Plot 2 (ACWP2)			
Mean	32%	450	4,011
Standard Error of Mean	4%	75	672
Standard Deviation	13%	226	2,016
Minimum	15%	261	2,328
Maximum	50%	856	7,639
Count (n)	9	9	
Plot 3 (ACWP3)			
Mean	35%	885	7,895
Standard Error of Mean	5%	147	1,309
Standard Deviation	15%	440	3,927
Minimum	25%	318	2,841
Maximum	65%	1,799	16,052
Count (n)	9	9	
All Plots			
Mean	31%	670	5,979
Standard Error of Mean	3%	82	733
Standard Deviation	14%	427	3,807
Minimum	0%	0	0
Maximum	65%	1,799	16,052
Count (n)	27	27	

TABLE 8-10
SUMMARY OF 2006 PLOT DATA
PSEG EEP VEGETATION MONITORING

	Percent Cover	Live Standing Biomass	
		gdw/m2	lb/acre
The Rocks Site			
Plot 1 (TRP1)			
Mean	39%	732	6,535
Standard Error of Mean	5%	69	620
Standard Deviation	15%	208	1,860
Minimum	20%	386	3,446
Maximum	65%	1,164	10,387
Count (n)	9	9	
Cedar Swamp Site			
Plot 1 (CSP1)			
Mean	34%	931	8,304
Standard Error of Mean	4%	117	1,040
Standard Deviation	12%	350	3,121
Minimum	10%	534	4,760
Maximum	45%	1,697	15,137
Count (n)	9	9	

FIGURES

PSEG Estuary Enhancement Program

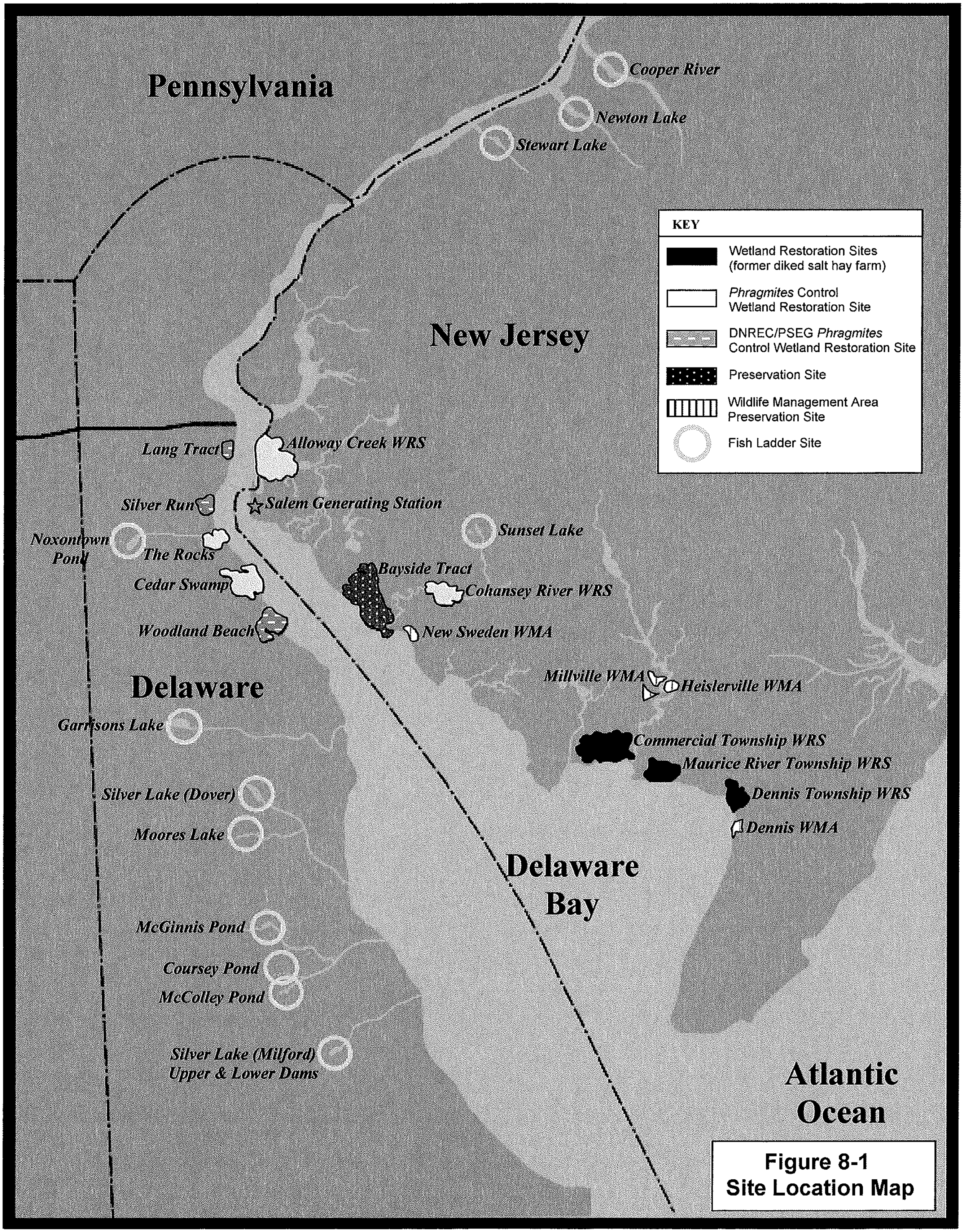
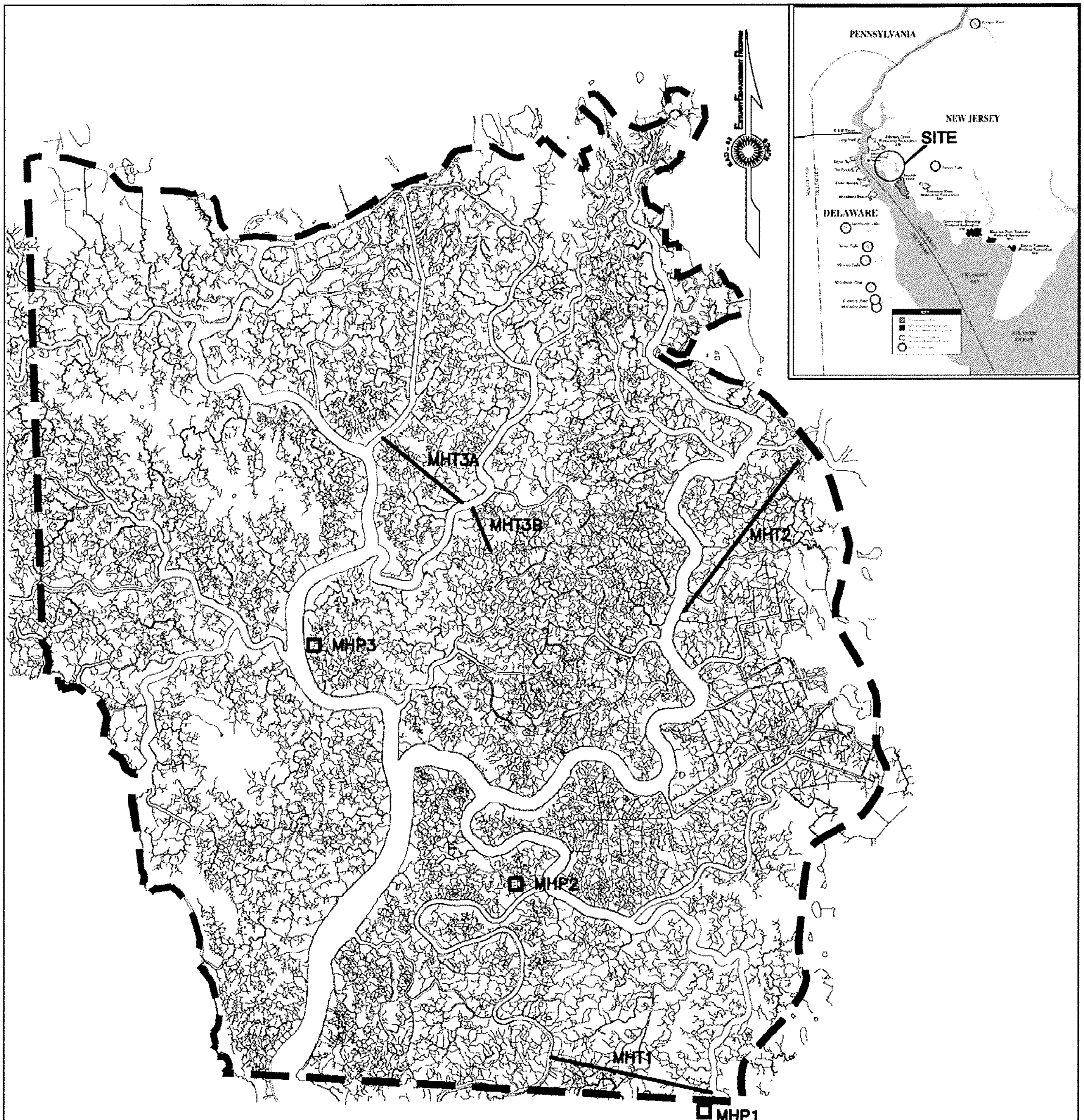


Figure 8-1
Site Location Map



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

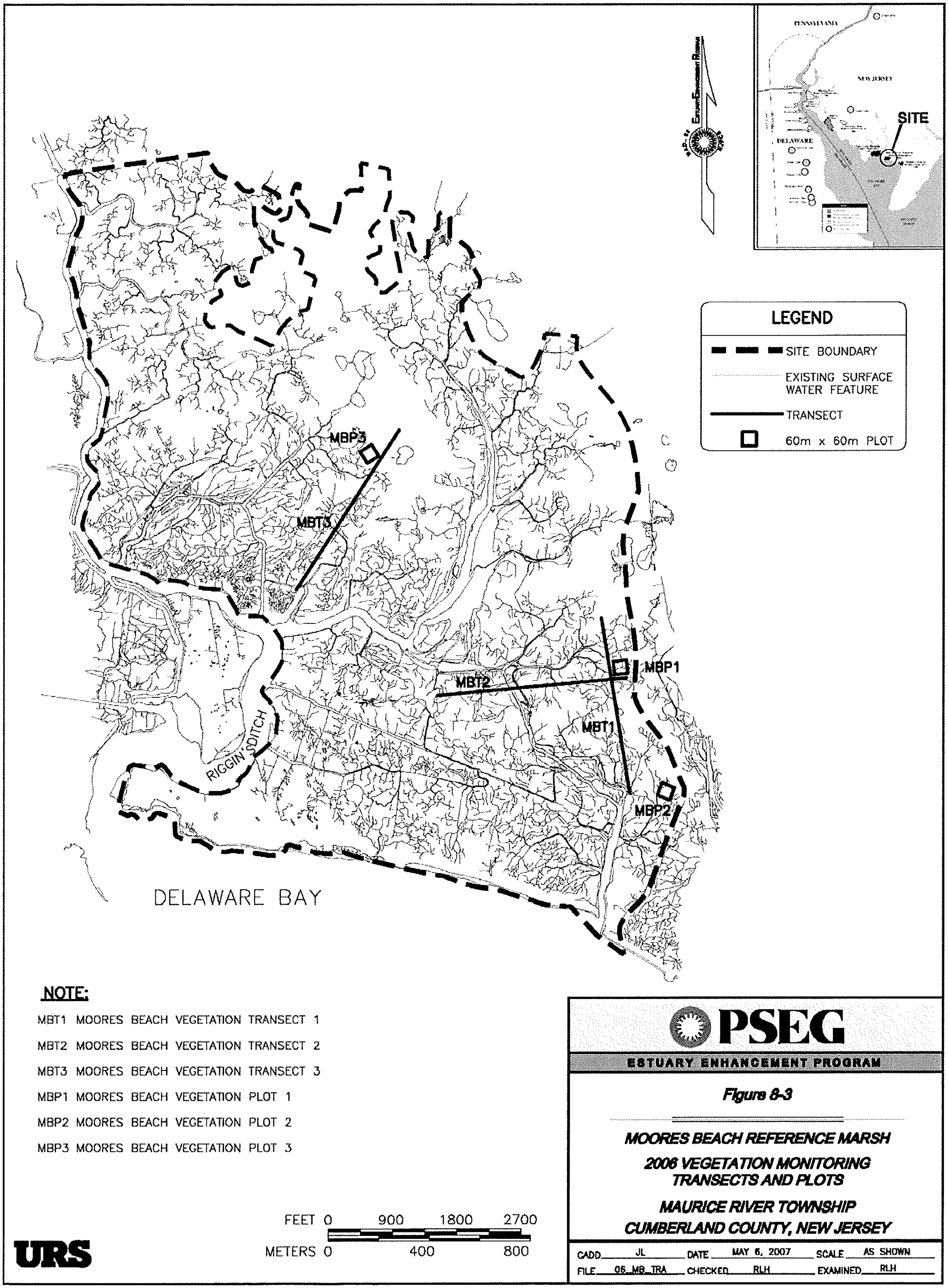
Figure 8-2

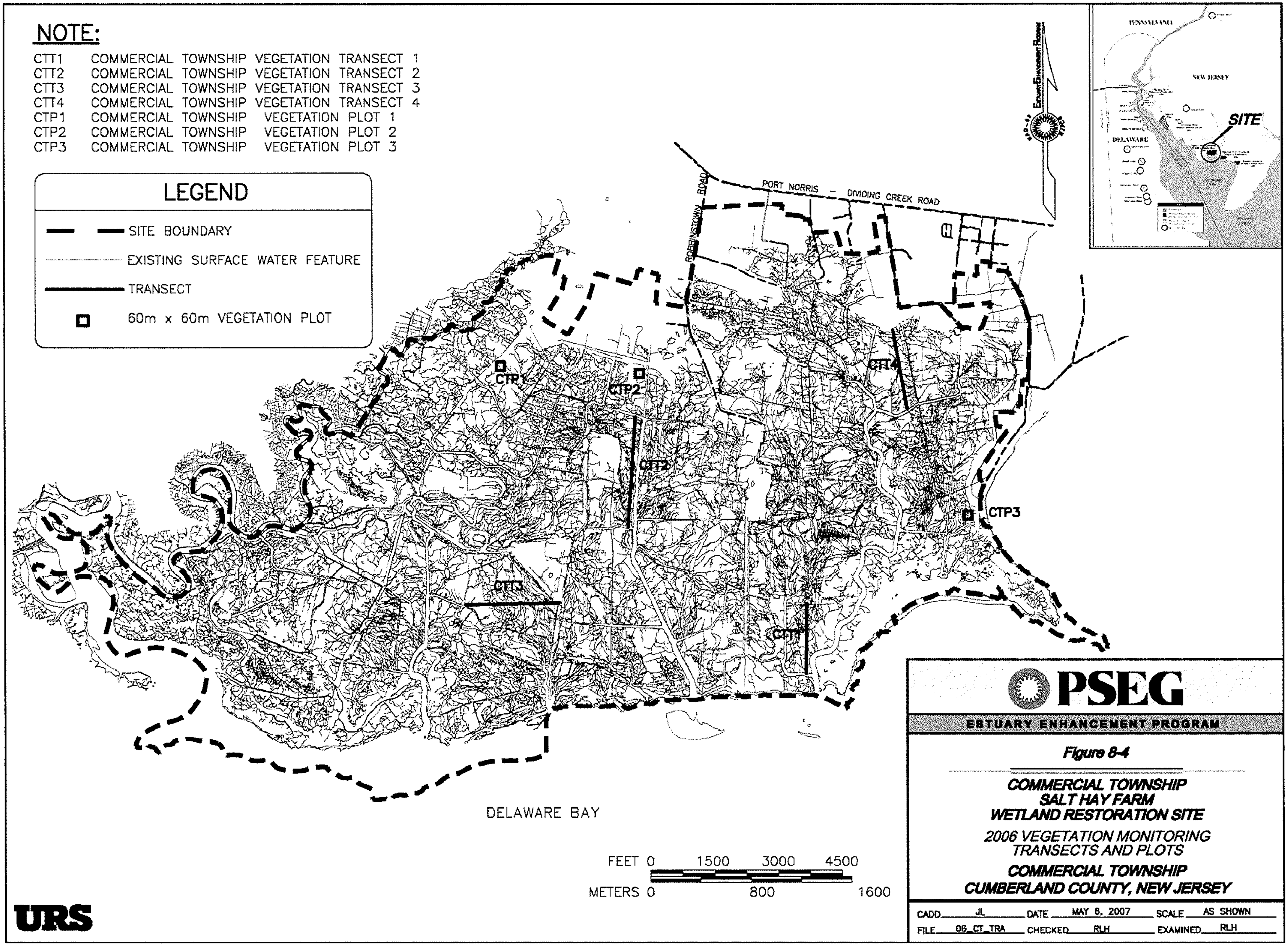
MADHORSE CREEK REFERENCE MARSH

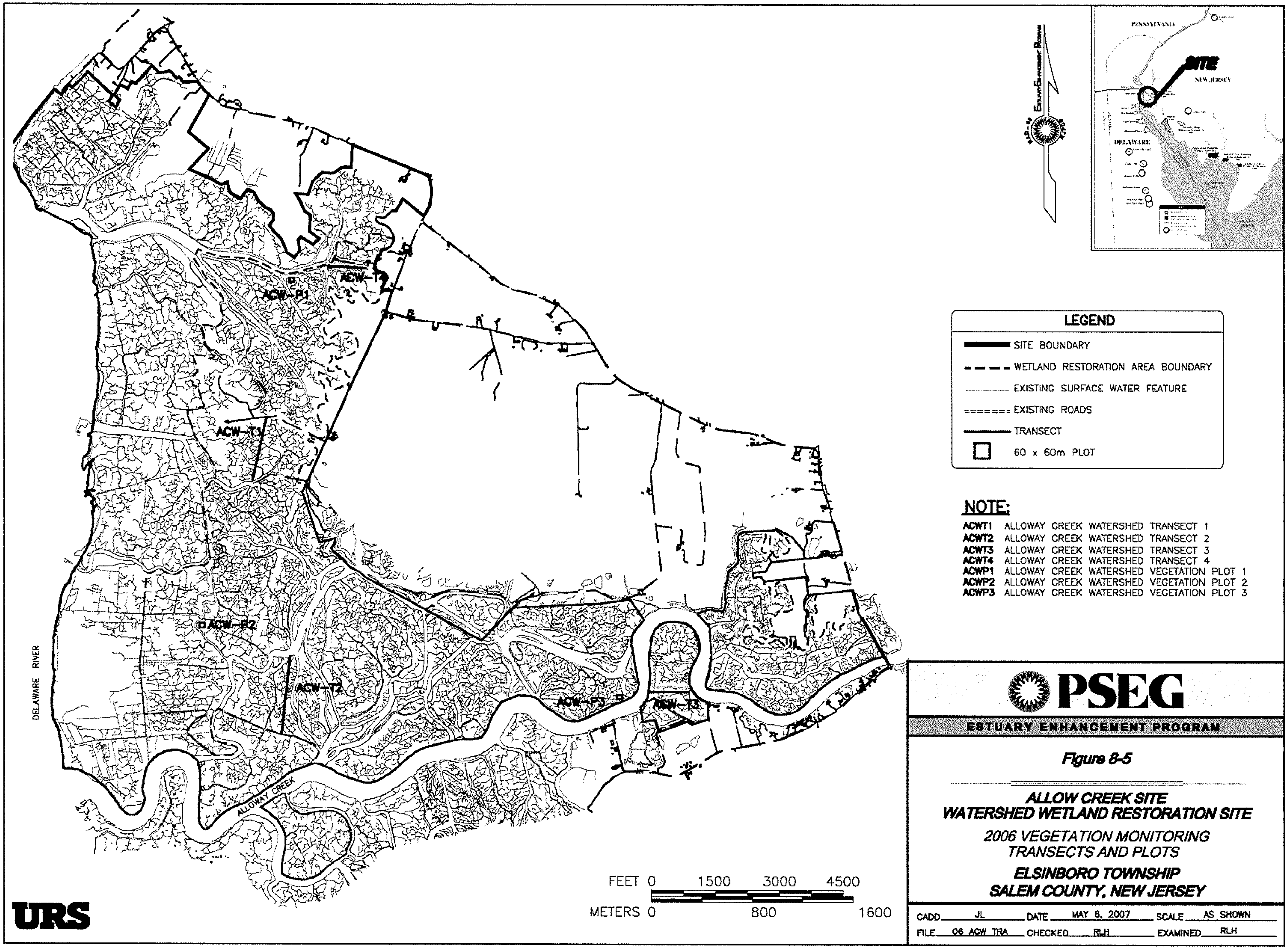
2006 VEGETATION MONITORING
TRANSECTS AND PLOTS

LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY, NEW JERSEY

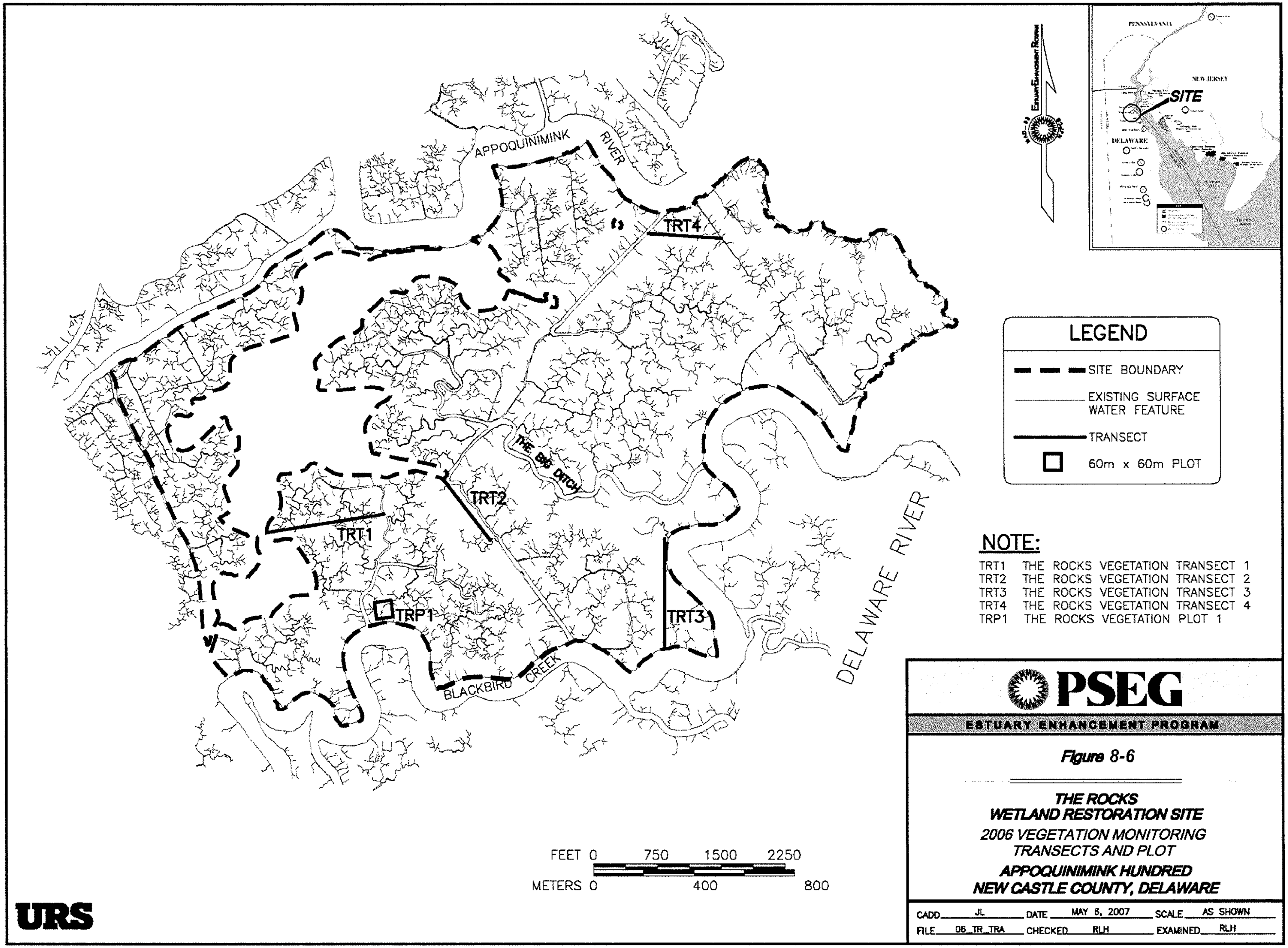
CADD JL DATE MAY 5, 2007 SCALE AS SHOWN
FILE 06_MH_TRA CHECKED RLH EXAMINED RLH


SITE
LEGEND
SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
TRANSECT
60m x 60m PLOT
MBP3
MBT3
MBP1
MBT2
MBT1
MBP2
RIGGIN'S DITCH
DELAWARE BAY
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
2006 VEGETATION MONITORING
TRANSECTS AND PLOTS
MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY
CADD JL DATE MAY 6, 2007 SCALE AS SHOWN
FILE 06_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
LEGEND
SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
TRANSECT
60m x 60m VEGETATION PLOT
PORT NORRIS - DIVIDING CREEK ROAD
ROBBINSTOWN ROAD
CTP1
CTP2
CTP3
CTT1
CTT2
CTT3
CTT4
DELAWARE BAY
SITE
FEET 0 1500 3000 4500
METERS 0 800 1600
URS
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure 8-4
COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE
2006 VEGETATION MONITORING
TRANSECTS AND PLOTS
COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY
CADD JL DATE MAY 8, 2007 SCALE AS SHOWN
FILE 06_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
ACW-P1
ACW-T4
ACW-T1
ACW-P2
ACW-T2
ACW-P3
ACW-T3
DELAWARE RIVER
ALLOWAY CREEK
PENNSYLVANIA
NEW JERSEY
DELAWARE
SITE
FEET 0 1500 3000 4500
METERS 0 800 1600
URS
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure 8-5
ALLOW CREEK SITE
WATERSHED WETLAND RESTORATION SITE
2006 VEGETATION MONITORING
TRANSECTS AND PLOTS
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY
CADD JL DATE MAY 8, 2007 SCALE AS SHOWN
FILE 06 ACW TRA CHECKED RLH EXAMINED RLH


APPOQUINIMINK RIVER
TRT4
TRT2
TRT1
TRT3
TRP1
THE BIG DITCH
BLACKBIRD CREEK
DELAWARE RIVER
PENNSYLVANIA
NEW JERSEY
DELAWARE
SITE
LEGEND
SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
TRANSECT
60m x 60m PLOT
NOTE:
TRT1 THE ROCKS VEGETATION TRANSECT 1
TRT2 THE ROCKS VEGETATION TRANSECT 2
TRT3 THE ROCKS VEGETATION TRANSECT 3
TRT4 THE ROCKS VEGETATION TRANSECT 4
TRP1 THE ROCKS VEGETATION PLOT 1
FEET 0 750 1500 2250
METERS 0 400 800
URS
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure 8-6
THE ROCKS
WETLAND RESTORATION SITE
2006 VEGETATION MONITORING
TRANSECTS AND PLOT
APPOQUINIMINK HUNDRED
NEW CASTLE COUNTY, DELAWARE
CADD JL DATE MAY 8, 2007 SCALE AS SHOWN
FILE 06_TR_TRA CHECKED RLH EXAMINED RLH

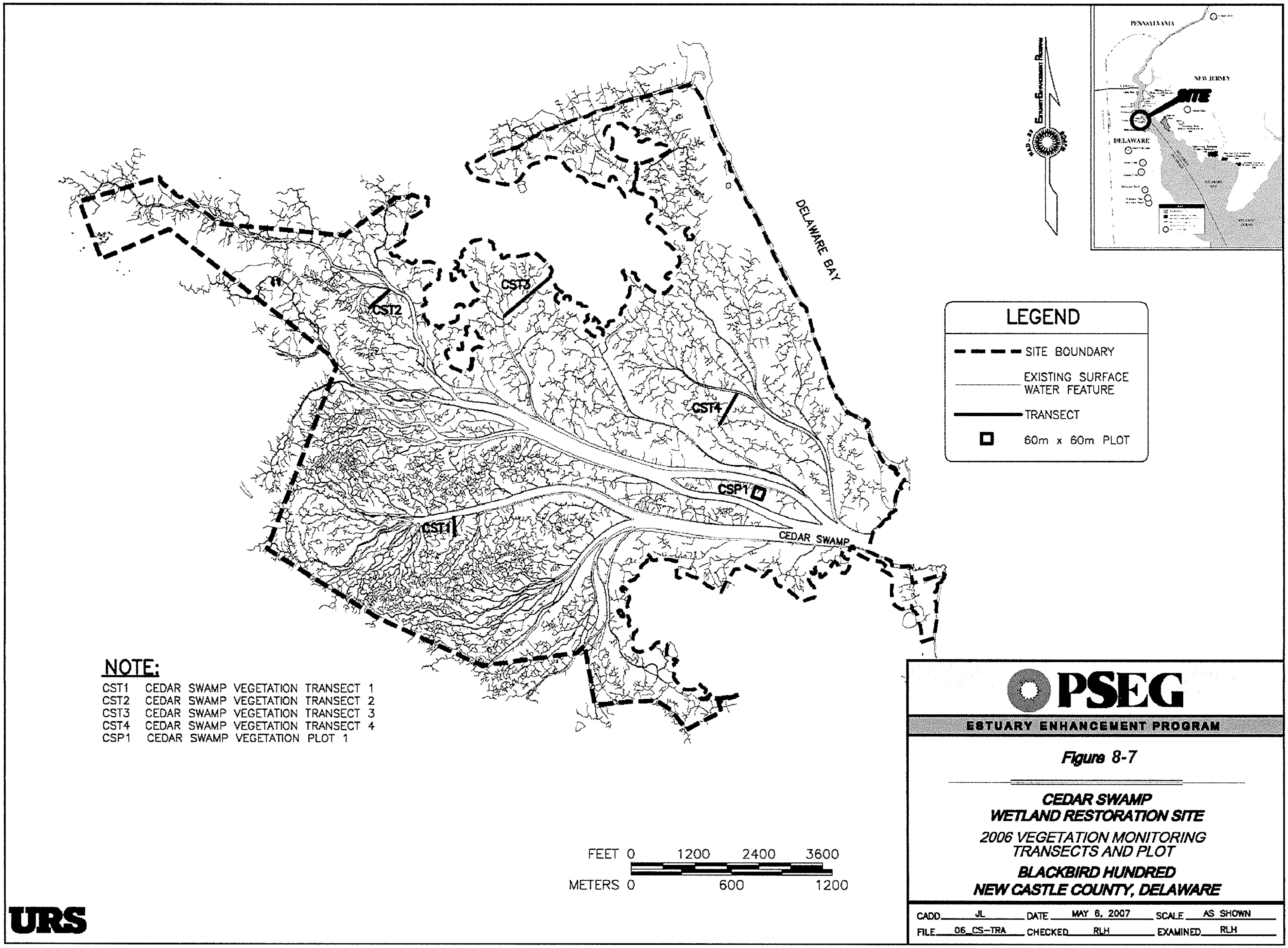
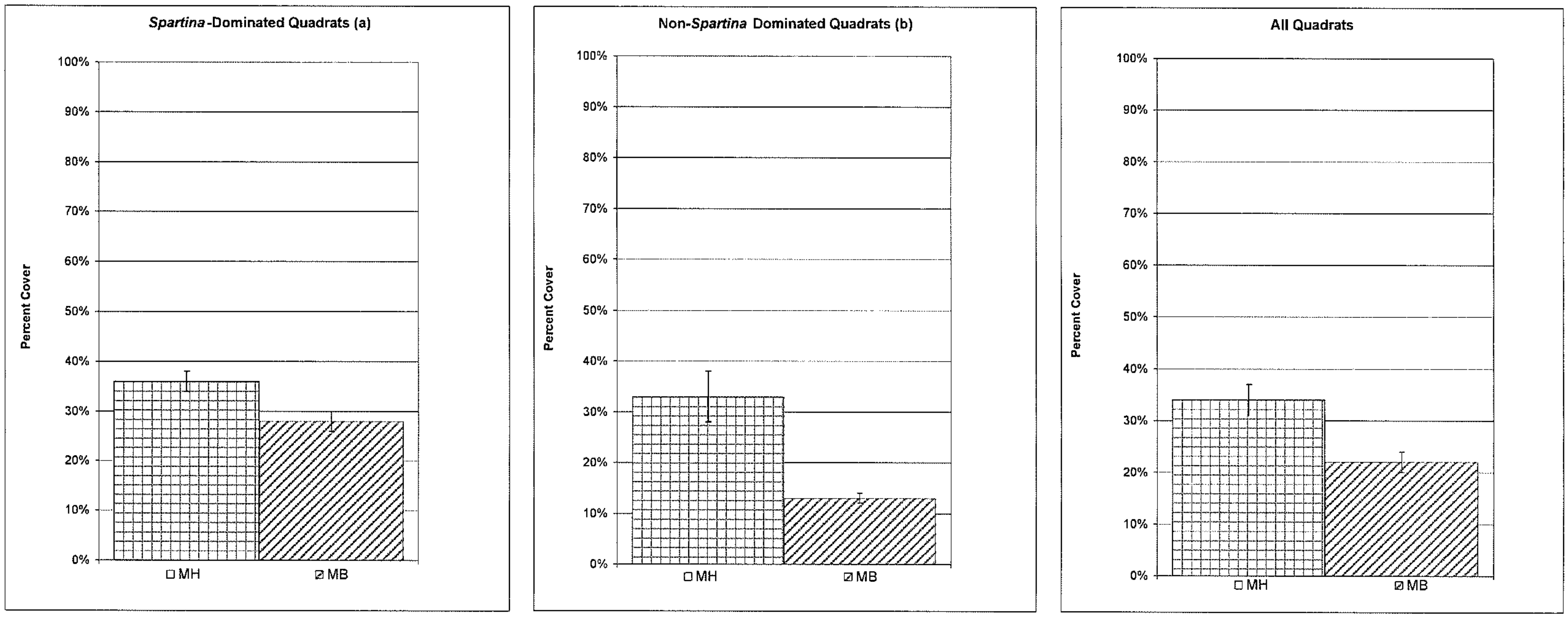

DELAWARE BAY
CST1
CST2
CST3
CST4
CSP1
CEDAR SWAMP
LEGEND
SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
TRANSECT
60m x 60m PLOT
NOTE:
CST1 CEDAR SWAMP VEGETATION TRANSECT 1
CST2 CEDAR SWAMP VEGETATION TRANSECT 2
CST3 CEDAR SWAMP VEGETATION TRANSECT 3
CST4 CEDAR SWAMP VEGETATION TRANSECT 4
CSP1 CEDAR SWAMP VEGETATION PLOT 1
FEET 0 1200 2400 3600
METERS 0 600 1200
PENNSYLVANIA
NEW JERSEY
DELAWARE
SITE
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure 8-7
CEDAR SWAMP
WETLAND RESTORATION SITE
2006 VEGETATION MONITORING
TRANSECTS AND PLOT
BLACKBIRD HUNDRED
NEW CASTLE COUNTY, DELAWARE
CADD JL DATE MAY 8, 2007 SCALE AS SHOWN
FILE 06_CS-TRA CHECKED RLH EXAMINED RLH
URS

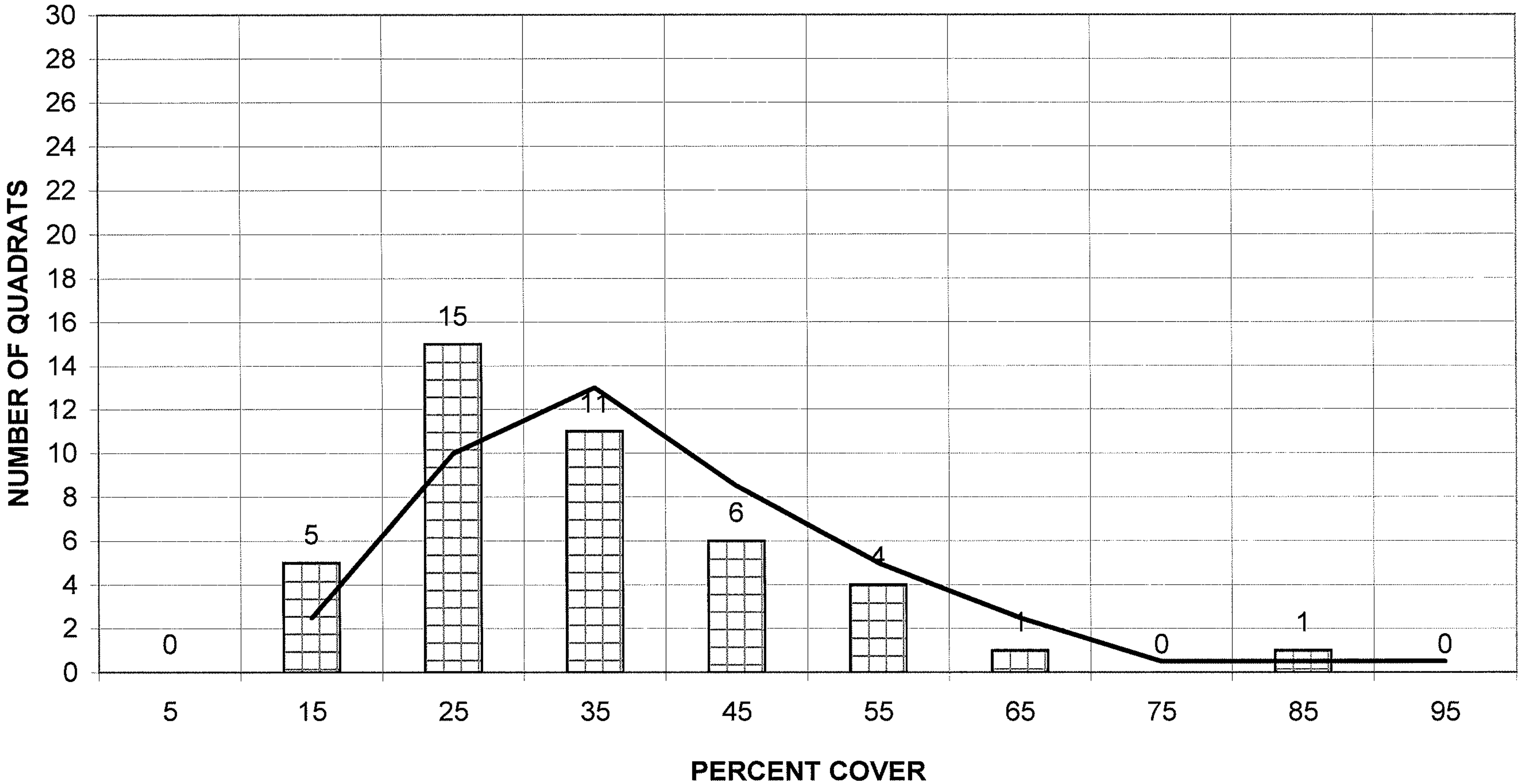
FIGURE 8-8
MEAN PERCENT COVER
2006 REFERENCE MARSH TRANSECT DATA



(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.

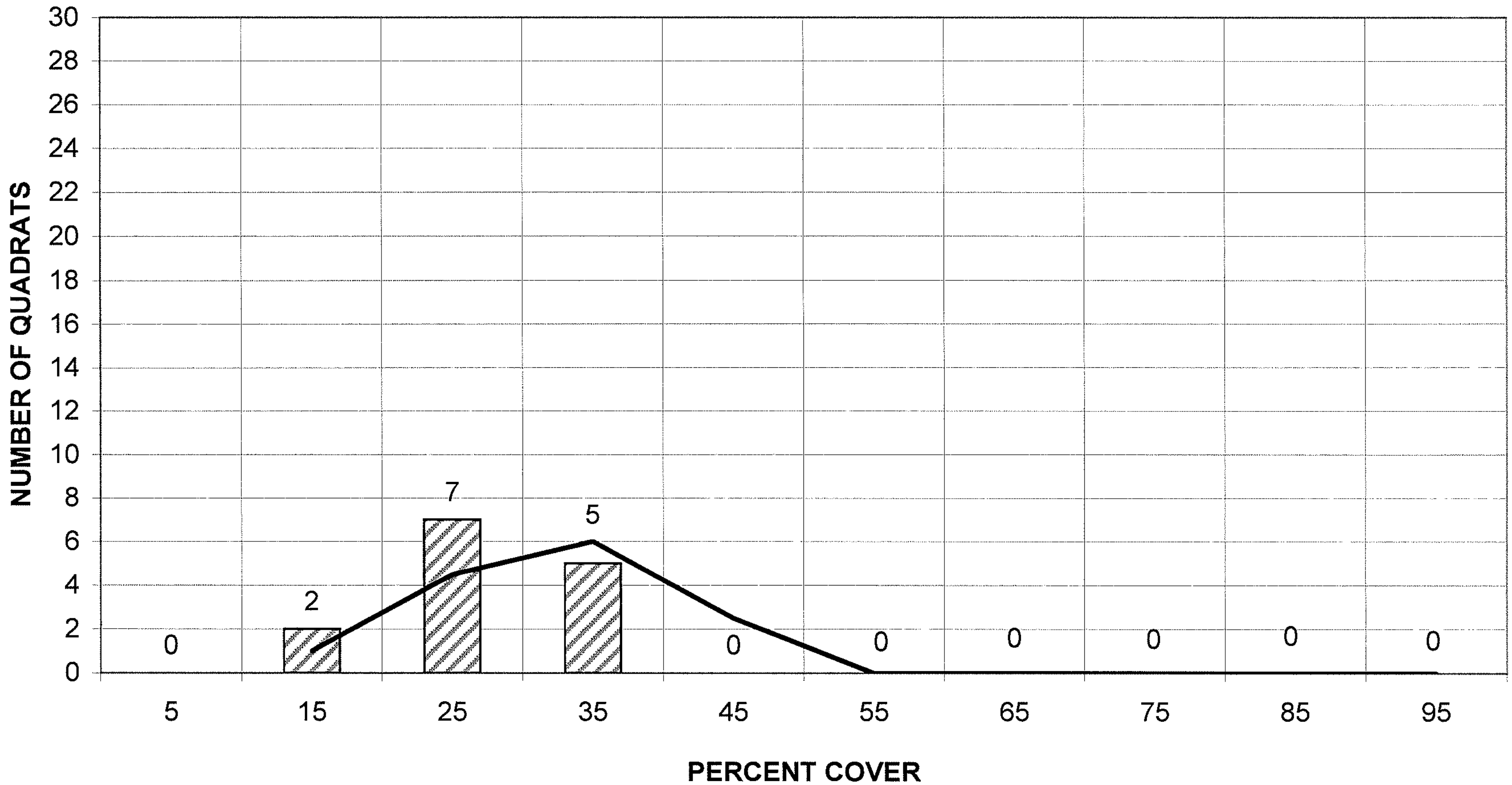
MH = Mad Horse Creek Reference Marsh
MB = Moores Beach West Reference Marsh

FIGURE 8-9
2006 PERCENT COVER GROUPINGS
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
MAD HORSE CREEK REFERENCE MARSH TRANSECTS



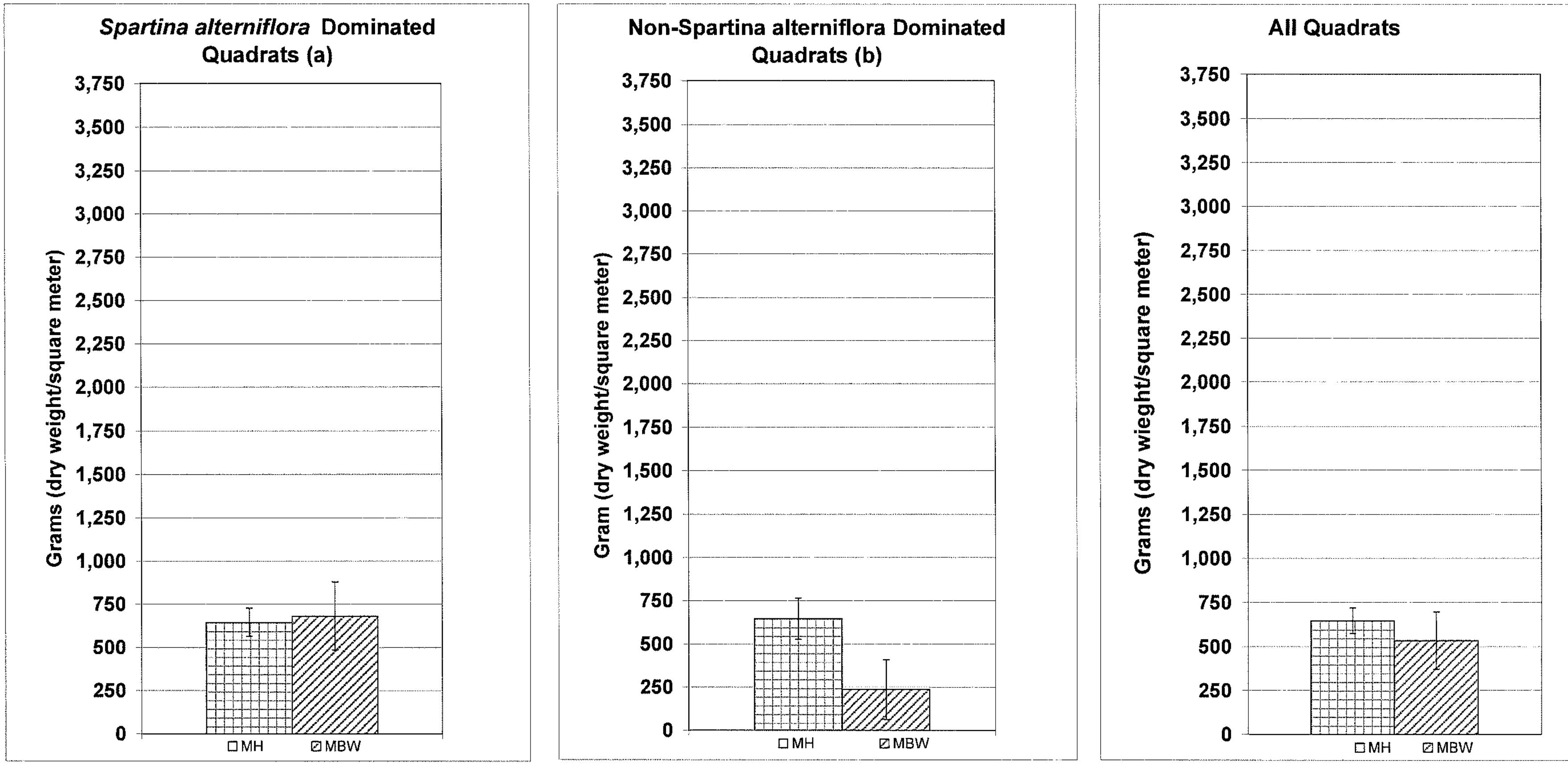
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-10
2006 PERCENT COVER GROUPINGS
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
MOORES BEACH WEST REFERENCE MARSH TRANSECTS



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

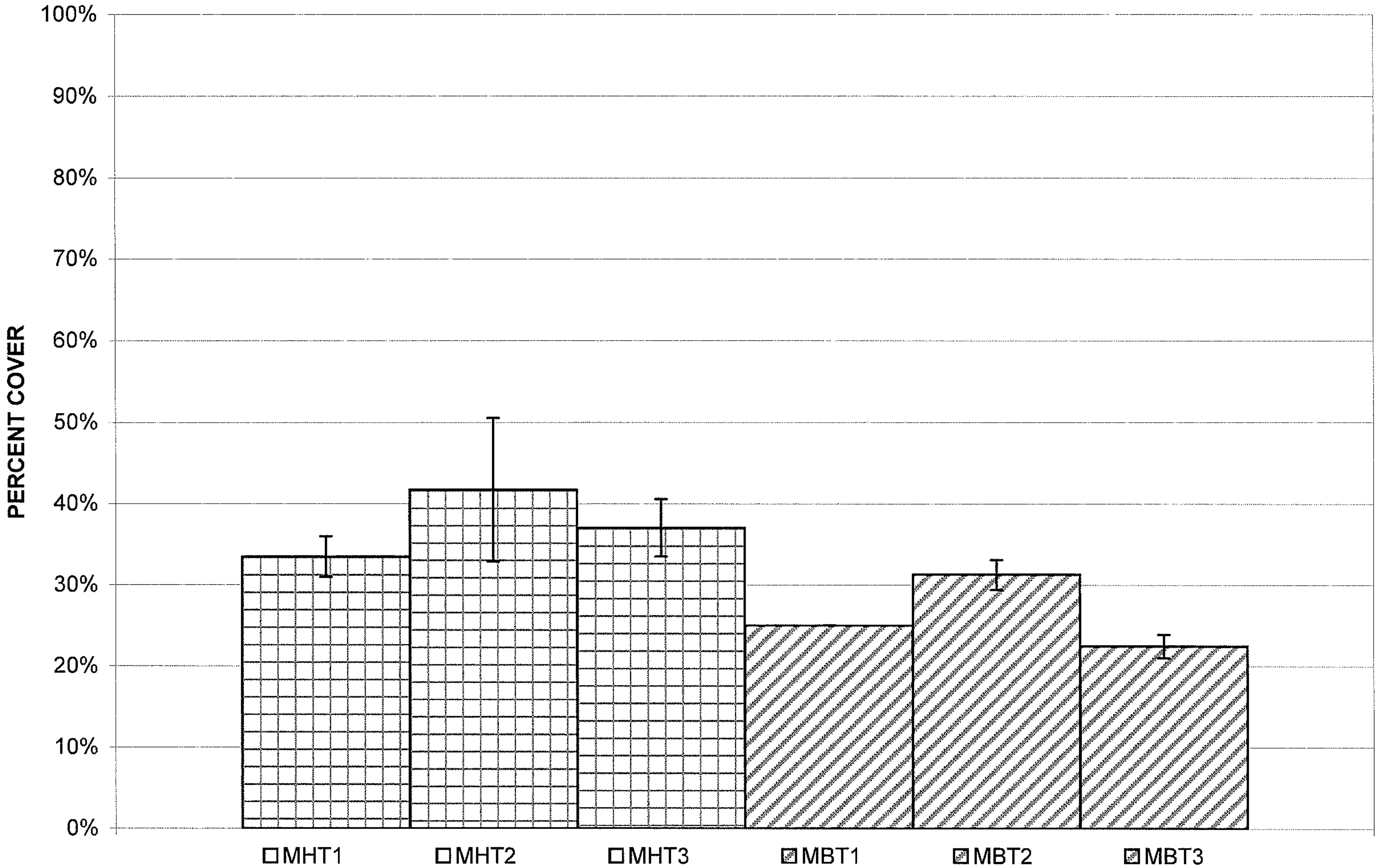
Figure 8-11
Mean Live Standing Crop
2006 Reference Marsh Transect Data



(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

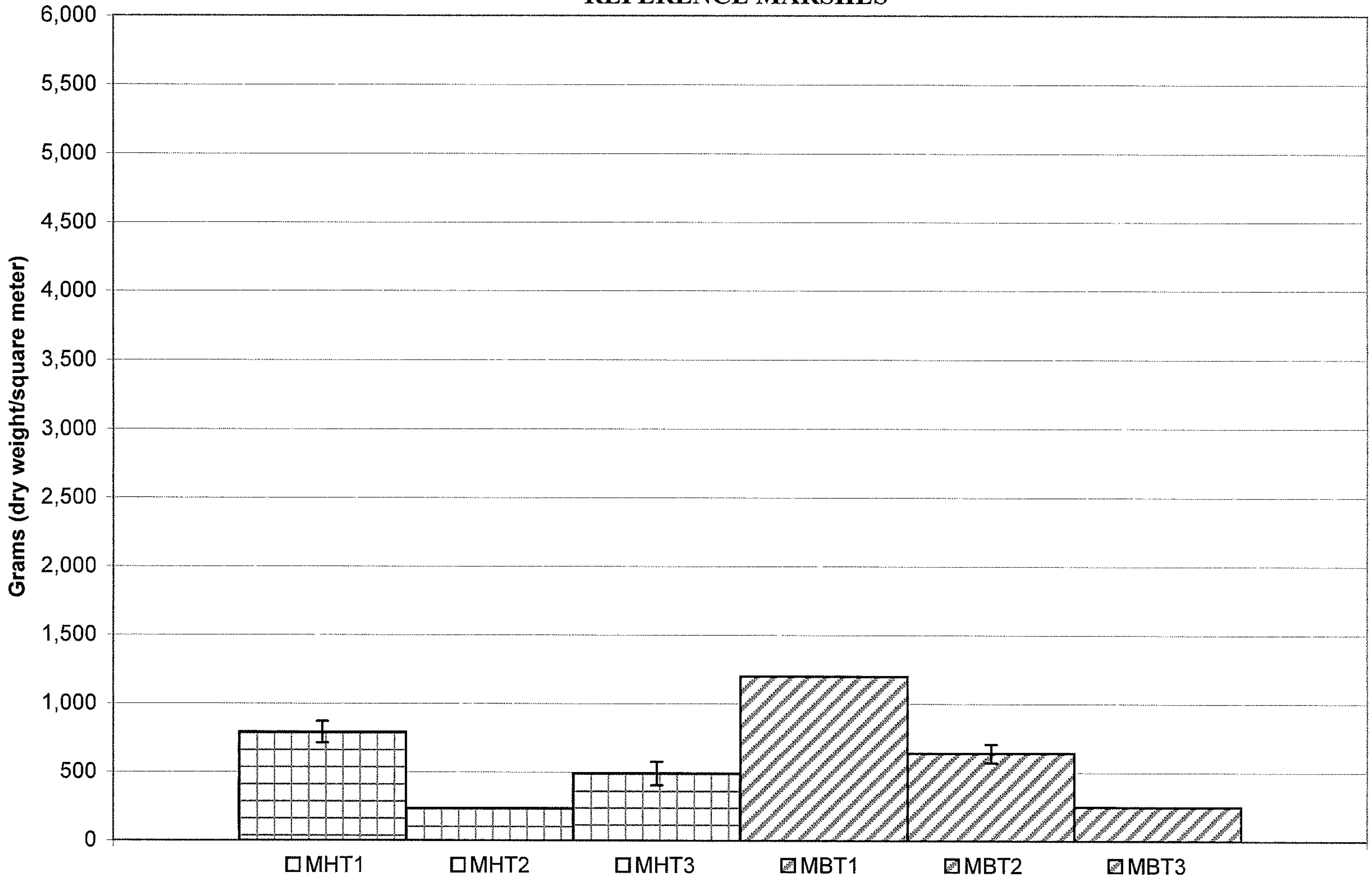
FIGURE 8-12
2006 MEAN PERCENT COVER by TRANSECT
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
REFERENCE MARSHES



(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

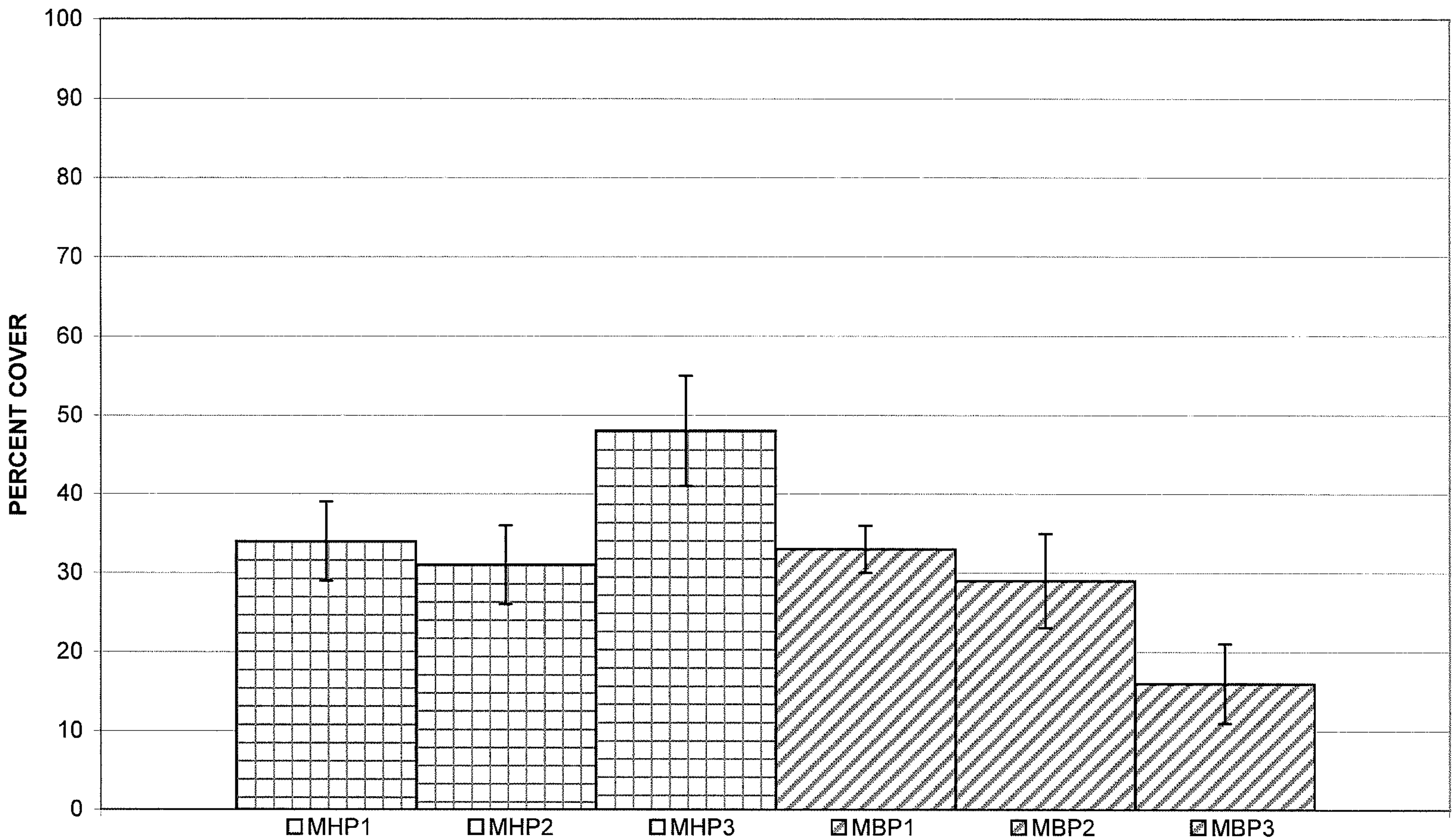
FIGURE 8-13
2006 MEAN LIVE STANDING CROP by TRANSECT
SPARTINA ALTERNIFLORA DOMINATED QUADRATS (a)
REFERENCE MARSHES



(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

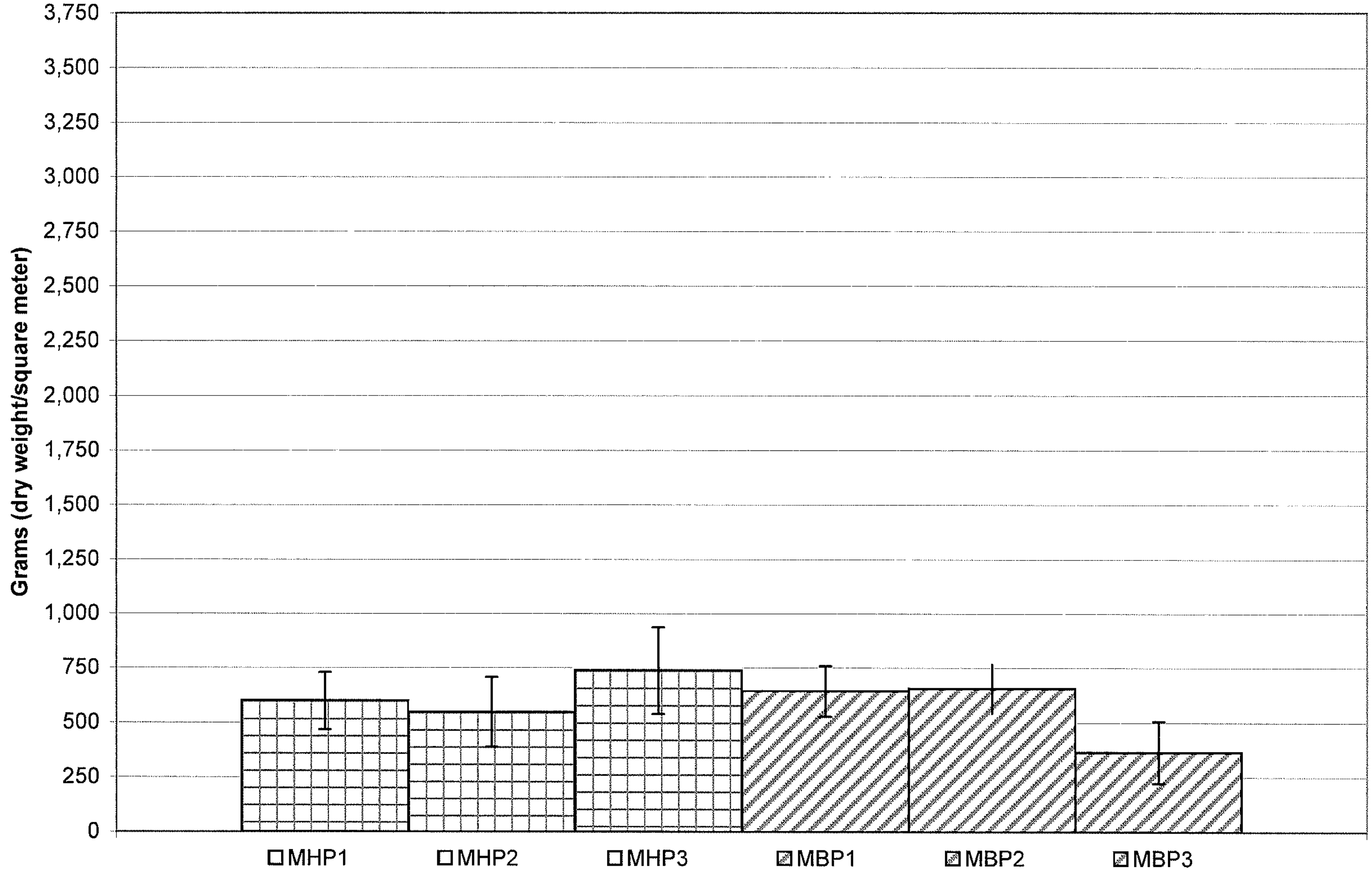
FIGURE 8-14
2006 MEAN PERCENT COVER 60x60 METER PLOTS
REFERENCE MARSHES



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

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

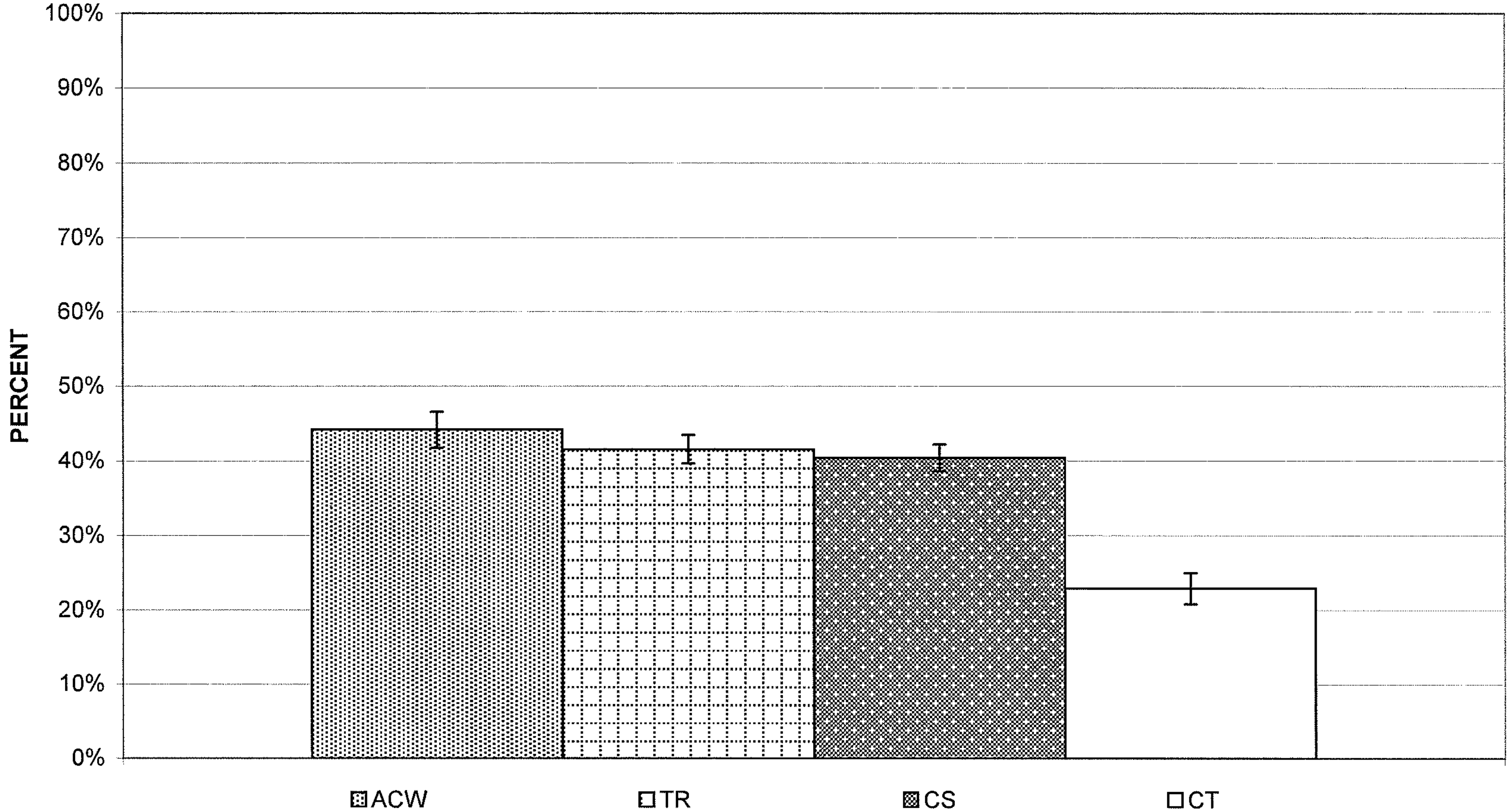
FIGURE 8-15
2006 MEAN LIVE STANDING CROP 60x60 METER PLOTS
REFERENCE MARSHES



MH = Mad Horse P1 = Plot 1

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

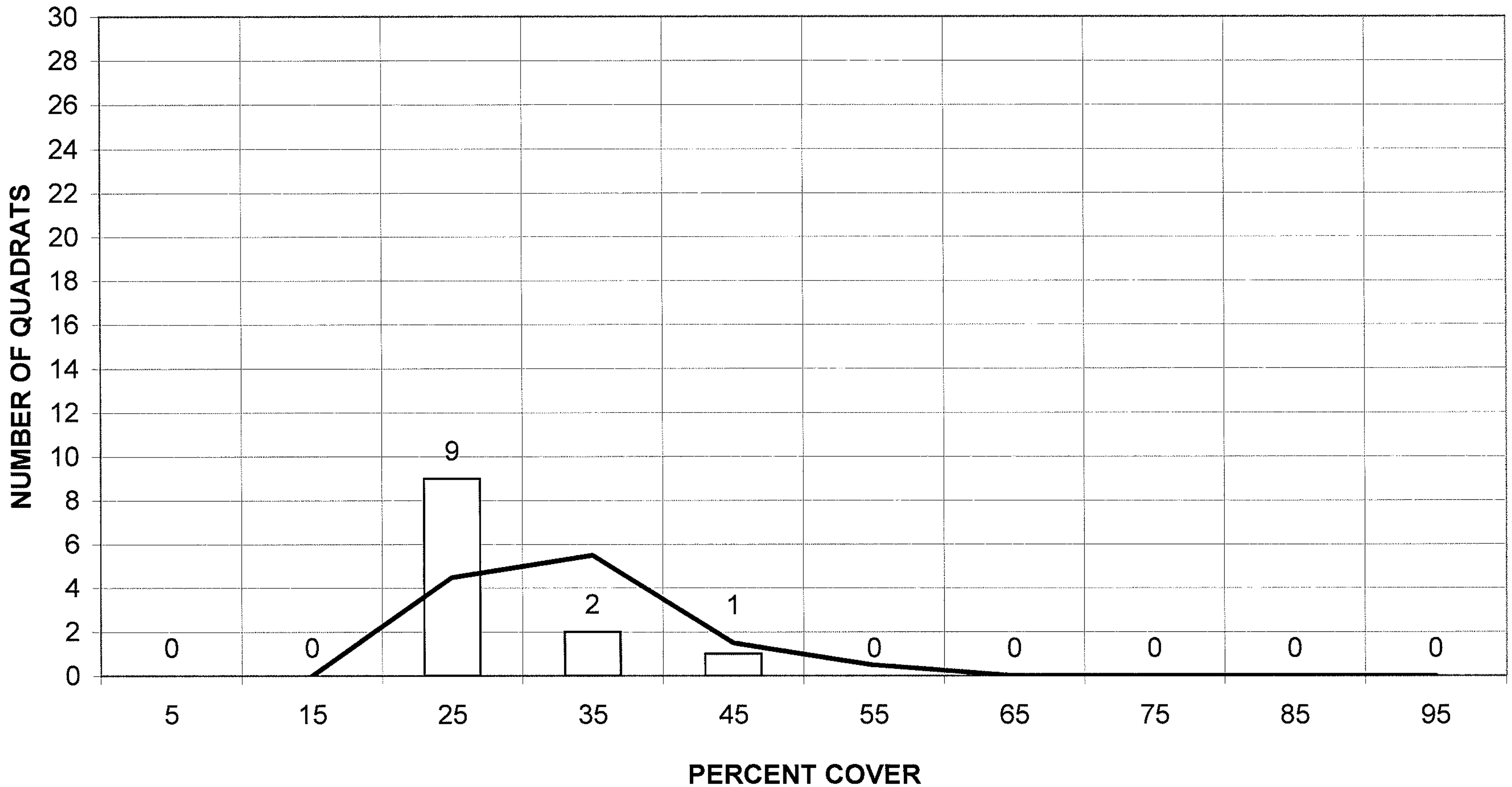
FIGURE 8-16
MEAN PERCENT COVER
2006 RESTORATION SITE TRANSECT DATA



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

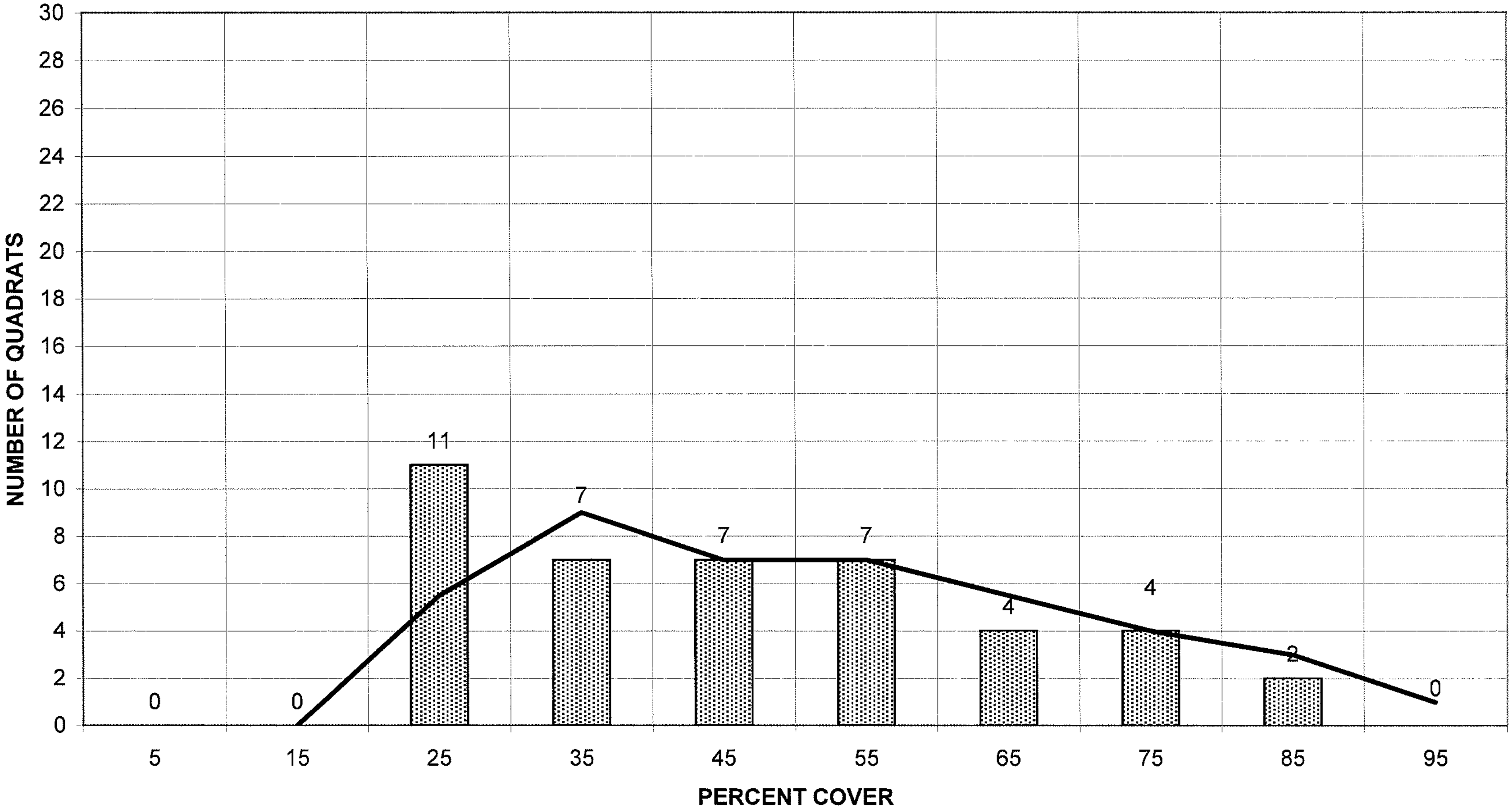
CT = Commercial Township Site
TR = The Rocks
CS = Cedar Swamp
ACW = Alloway Creek Site

FIGURE 8-17
2006 PERCENT COVER GROUPINGS
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
COMMERCIAL TOWNSHIP RESTORATION SITE TRANSECTS



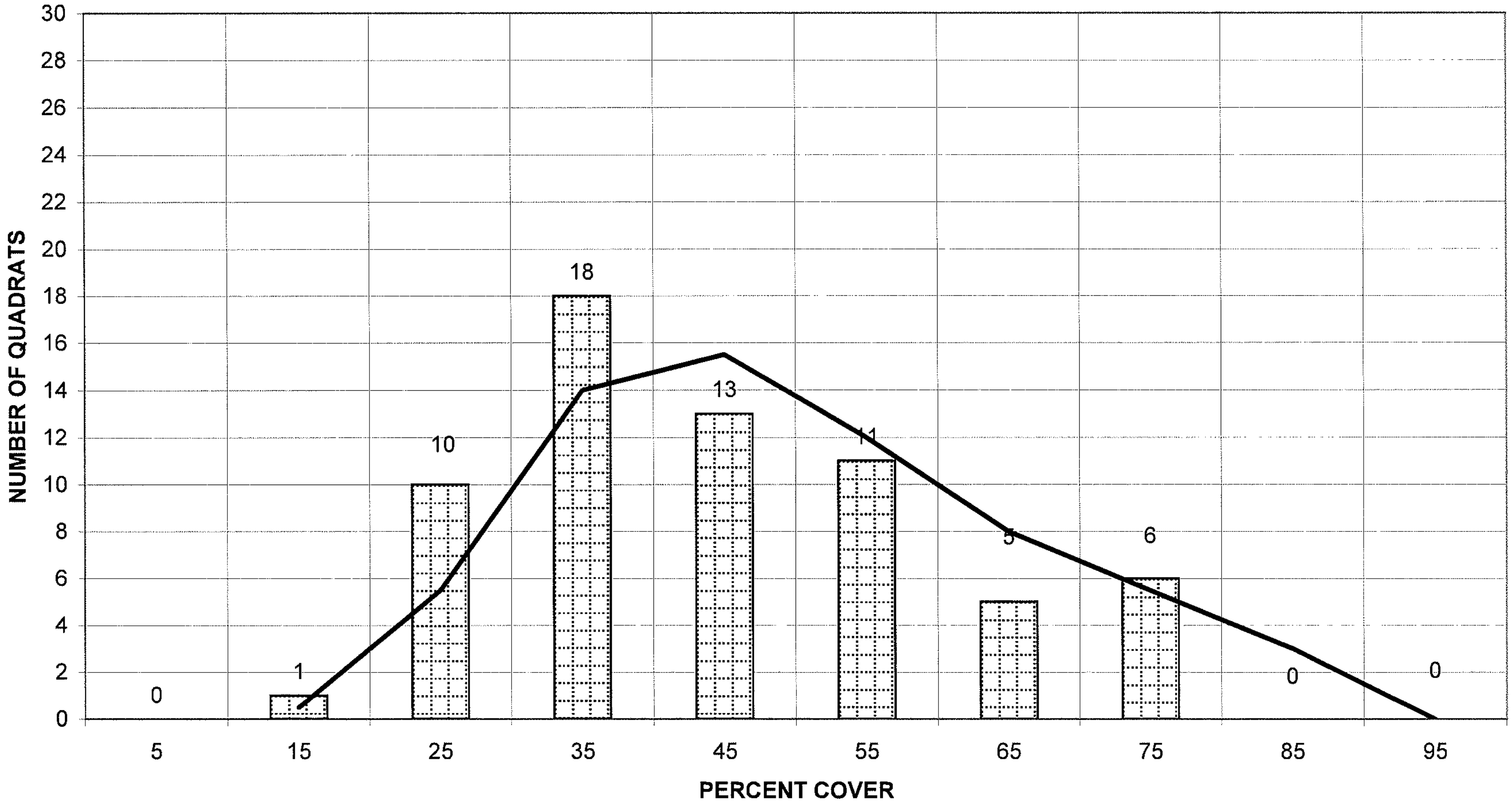
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-18
2006 PERCENT COVER GROUPINGS
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
ALLOWAY CREEK WATERSHED RESTORATION SITE TRANSECTS



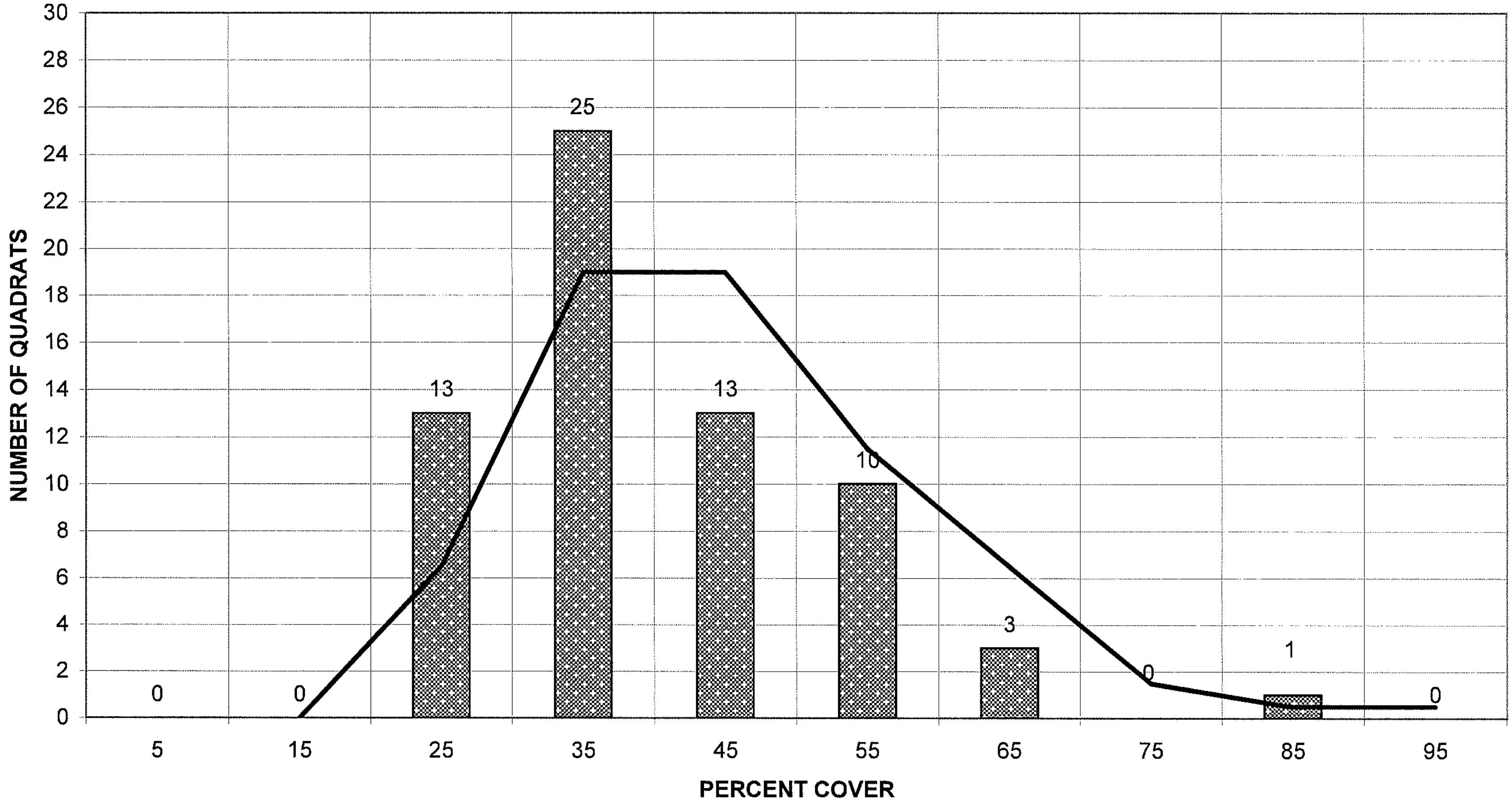
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-19
2006 PERCENT COVER GROUPINGS
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
THE ROCKS RESTORATION SITE TRANSECTS



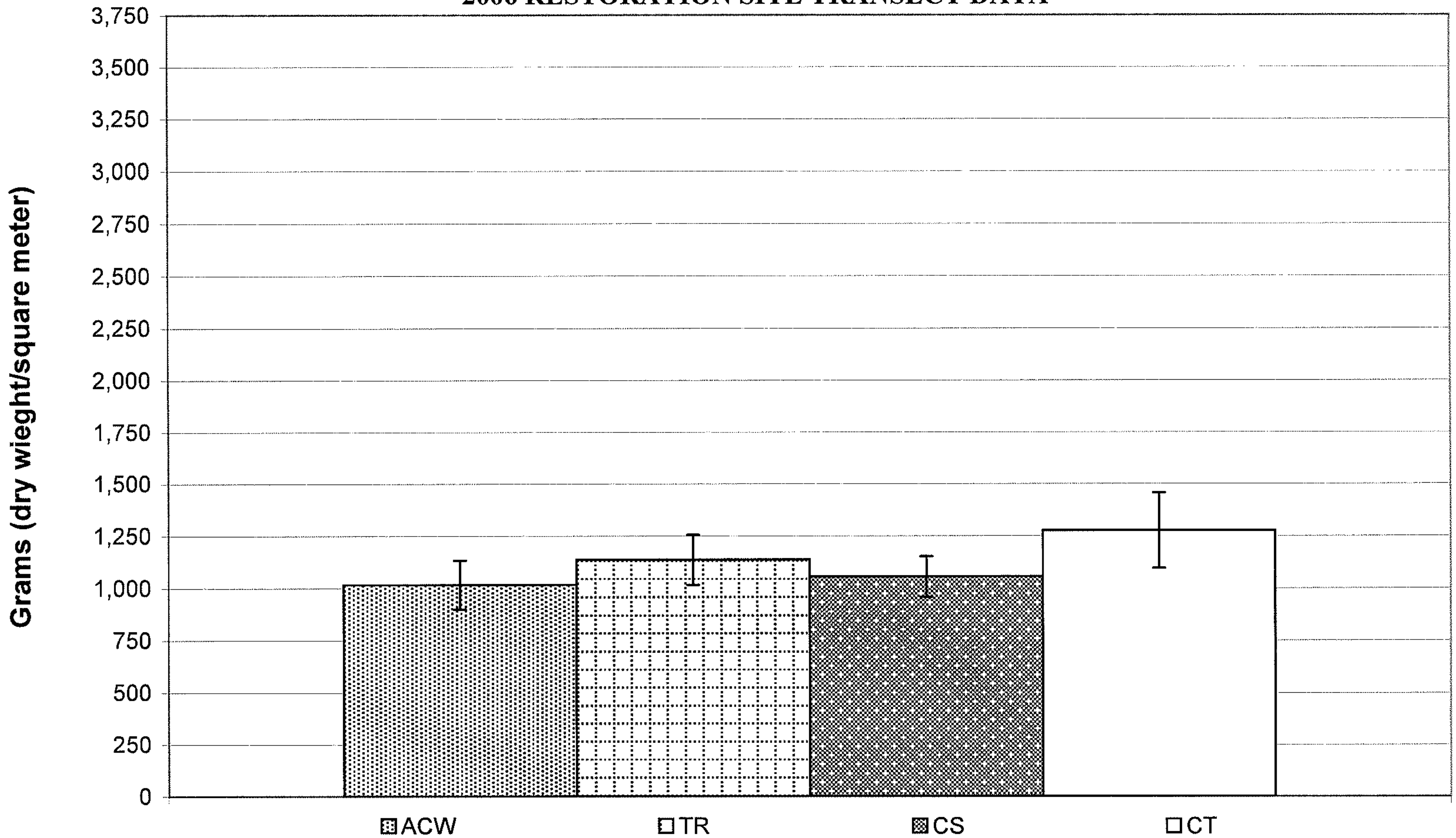
(a) Includes *S. cynosuroides* dominated quadrats, when present.

FIGURE 8-20
2006 PERCENT COVER GROUPINGS
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
CEDAR SWAMP RESTORATION SITE TRANSECTS



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

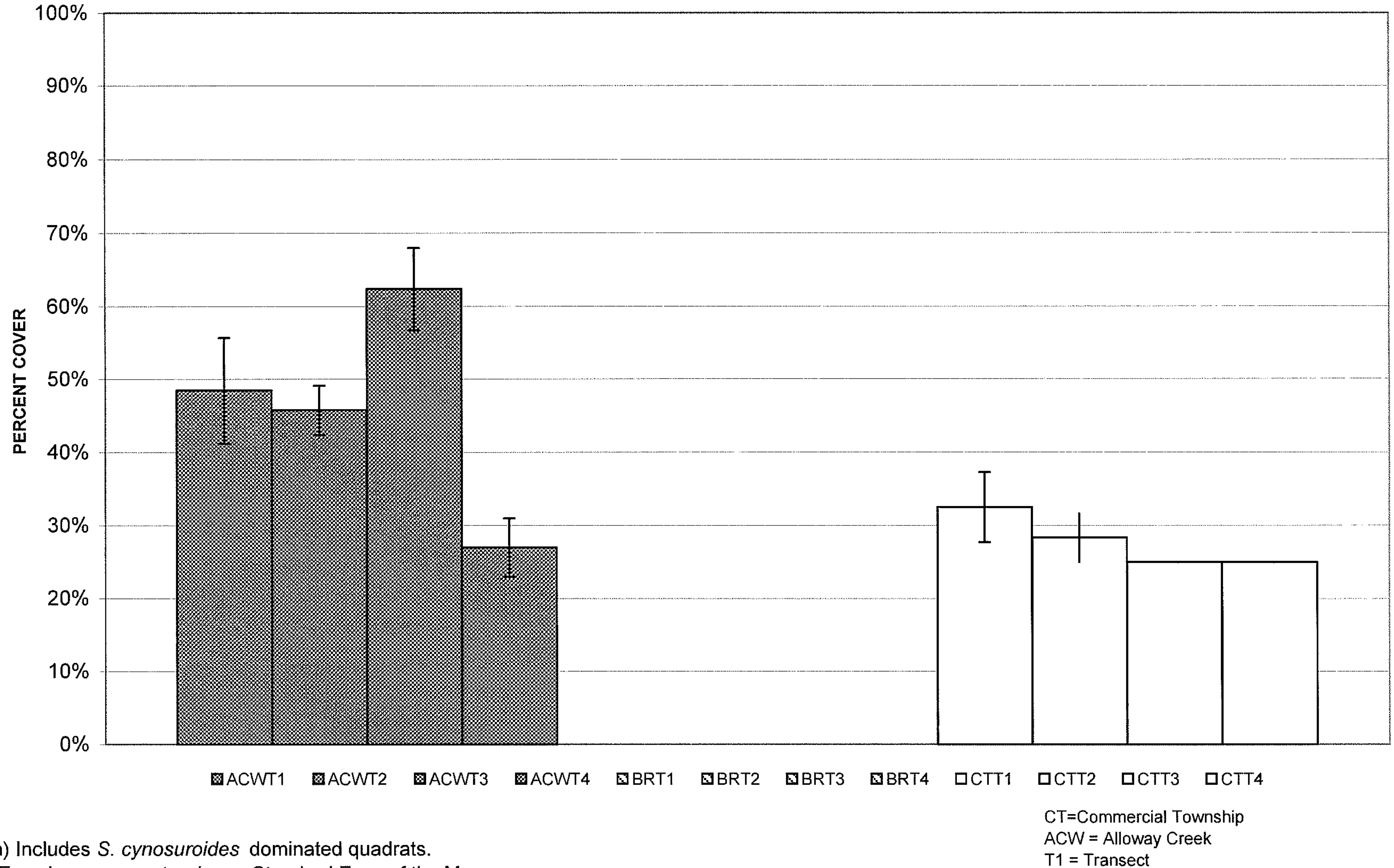
FIGURE 8-21
MEAN LIVE STANDING CROP
2006 RESTORATION SITE TRANSECT DATA



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

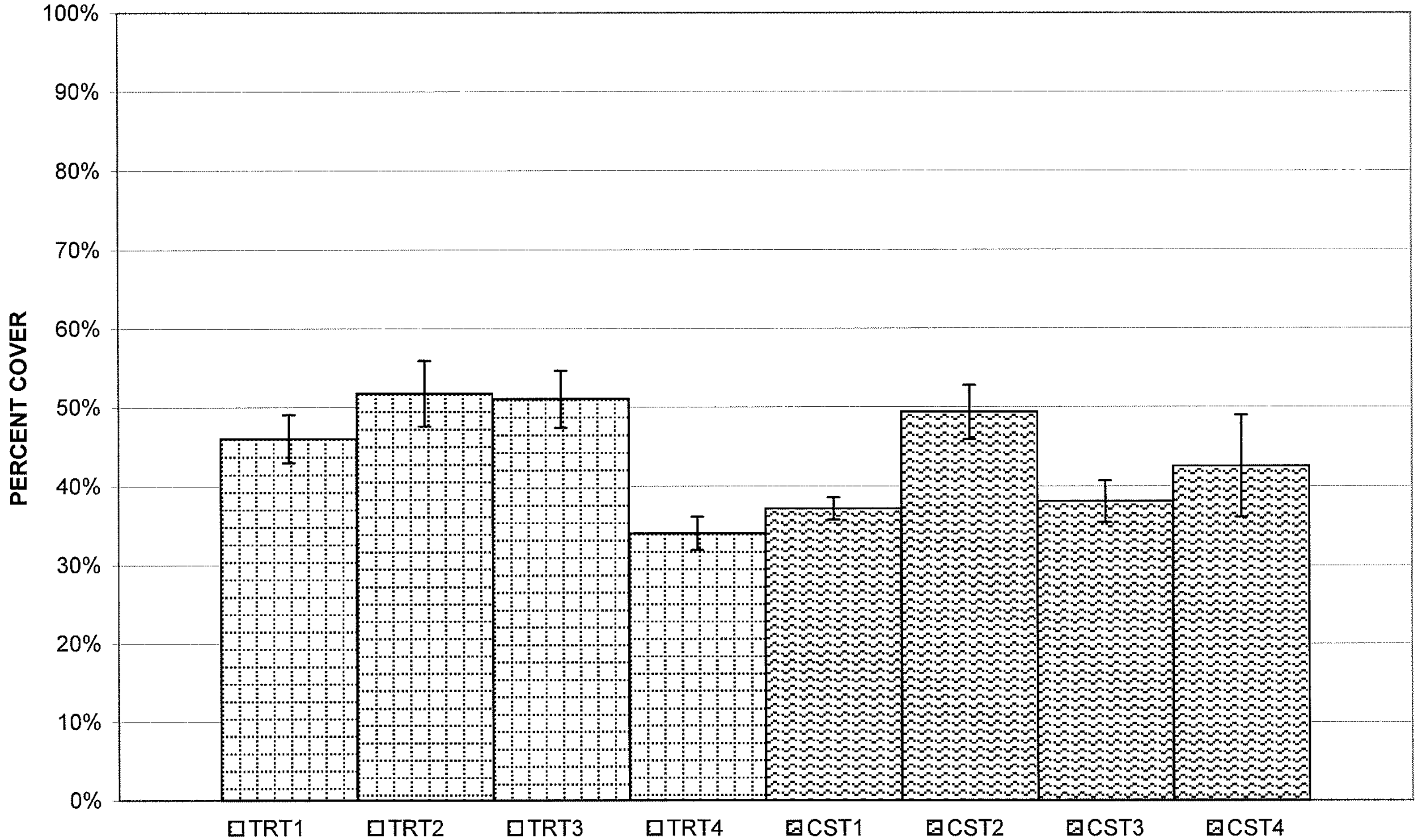
- Error bar represents +/- one Standard Error of the Mean.

FIGURE 8-22
2006 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
2006 MEAN PERCENT COVER by TRANSECT
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
DELAWARE WETLAND RESTORATION SITES

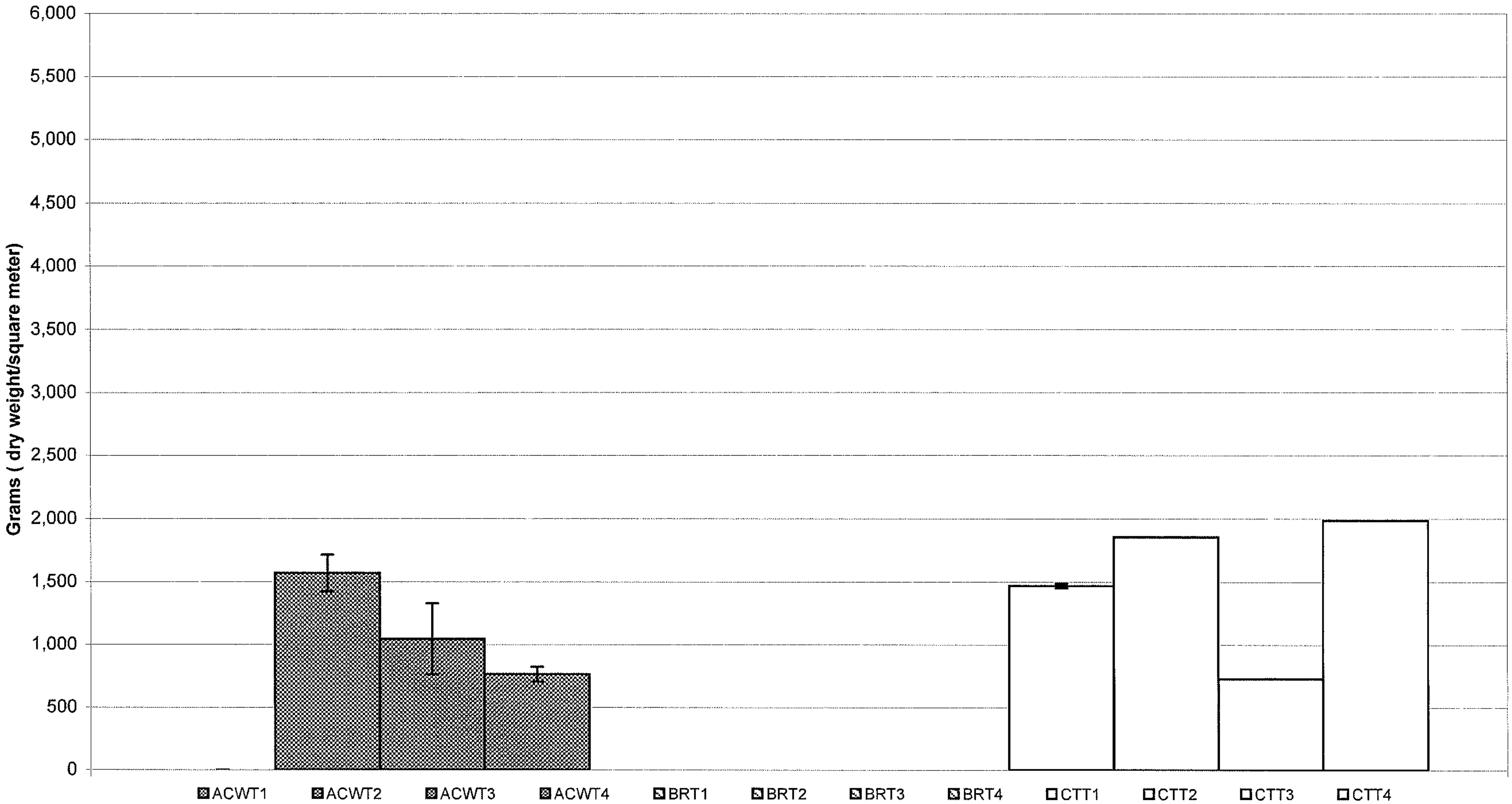


(a) Includes S. cynosuroides dominated quadrats.
Error bar represents +/- one Standard Error of the Mean.

TR = The Rocks
CS = Cedar Swamp

T1 =Transect 1

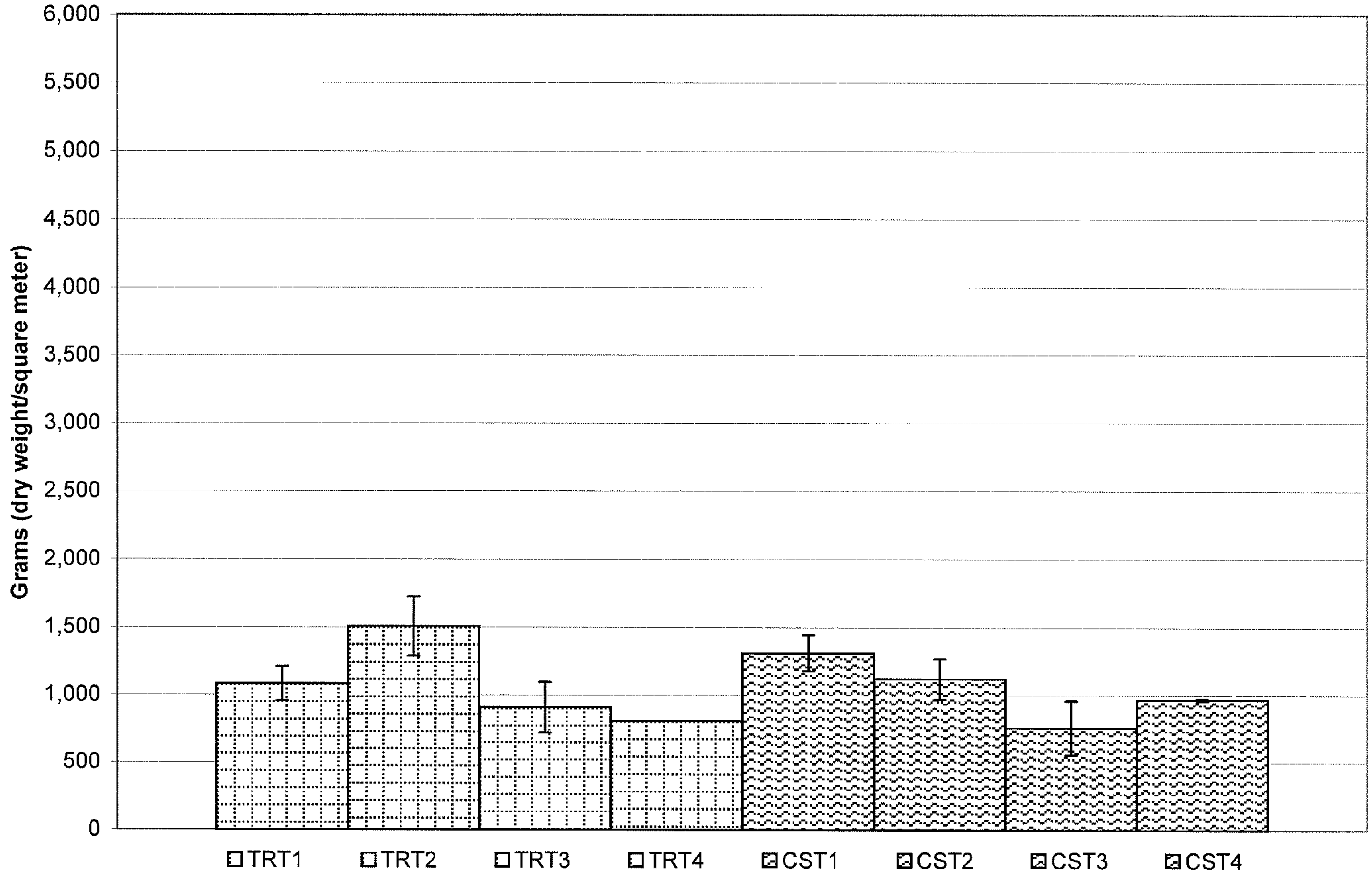
FIGURE 8-24
2006 MEAN LIVE STANDING CROP by TRANSECT
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
NEW JERSEY WETLAND RESTORATION SITES



CT=Commercial Township
ACW = Alloway Creek
T1 = Transect

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

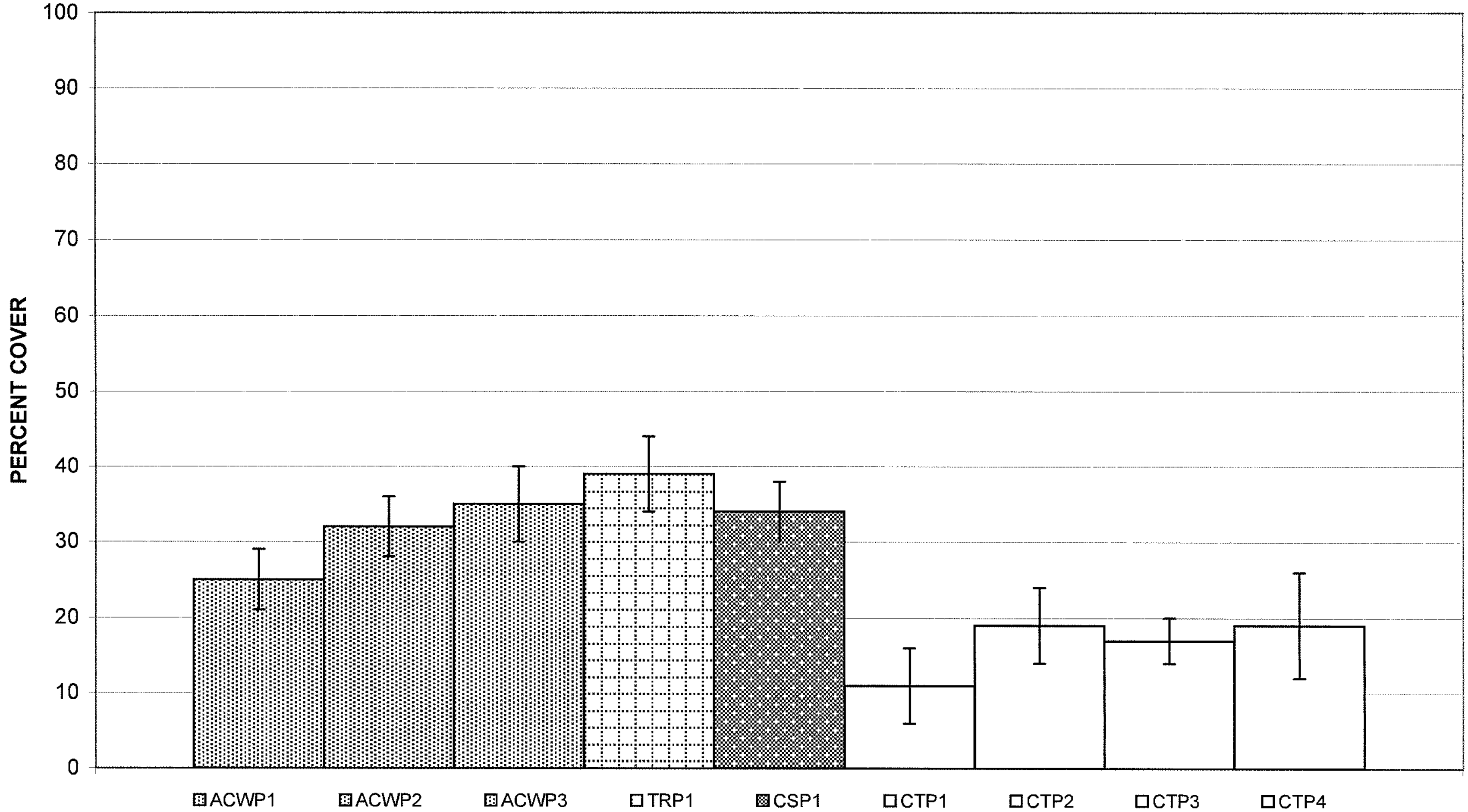
FIGURE 8-25
2006 MEAN LIVE STANDING CROP by TRANSECT
***SPARTINA ALTERNIFLORA* DOMINATED QUADRATS (a)**
DELAWARE WETLAND RESTORATION SITES



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

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

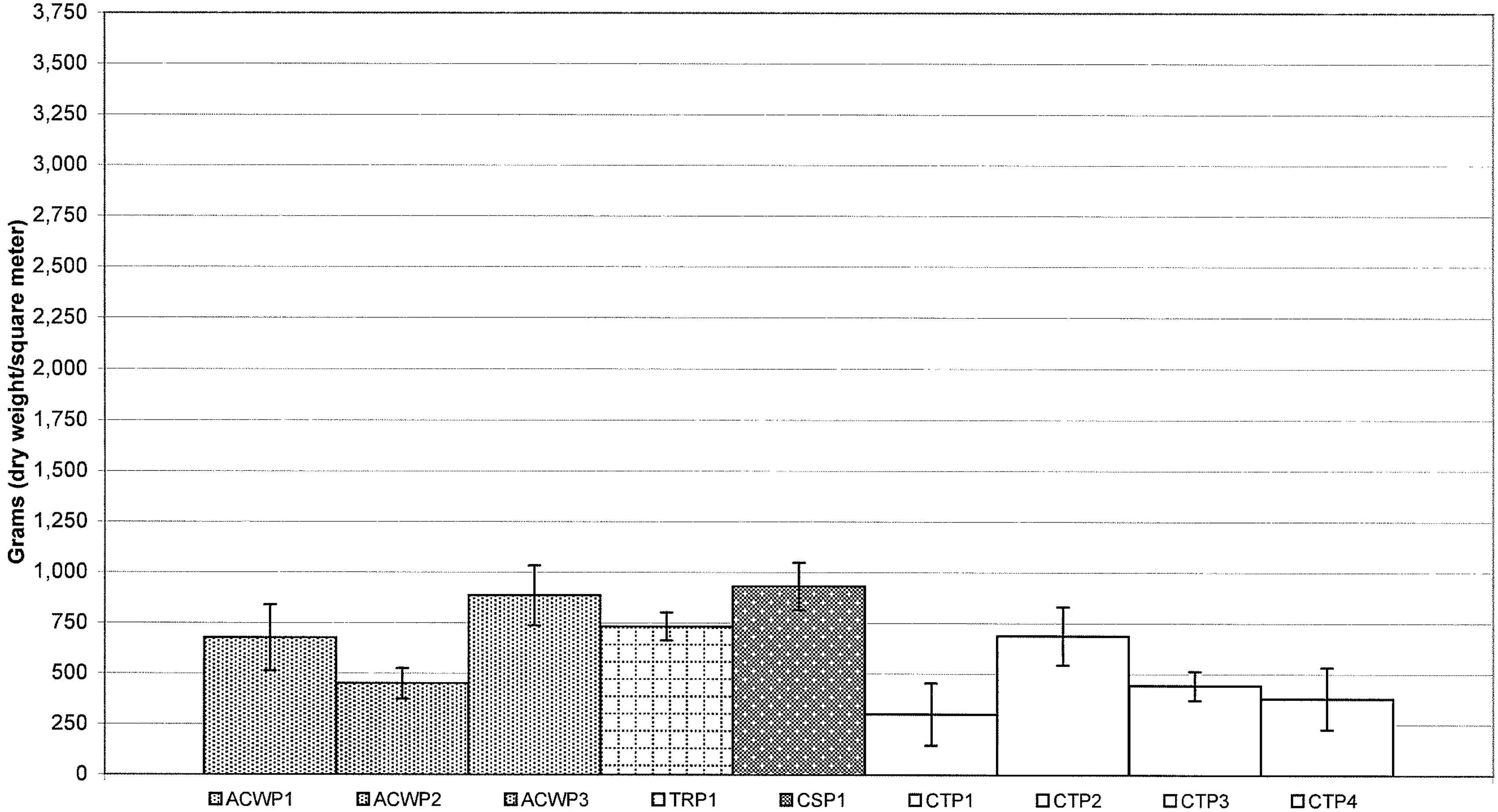
FIGURE 8-26
2006 MEAN PERCENT COVER 60x60 METER PLOTS
WETLAND RESTORATION SITES



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

Error bar represents +/- one Standard Error of the

FIGURE 8-27
2006 MEAN LIVE STANDING CROP 60x60 METER PLOTS
WETLAND RESTORATION SITES



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

Error bar represents +/- one Standard Error of the

APPENDIX A

MACROPHYTE FIELD SAMPLING WORKSHEETS

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

Site:______________ ______________ **Transect:** ____________ **Date:** ________________

Investigators:________________________________ **Compass Reading:**________________

Weather Conditions:________________________________

Notes:

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

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: _________________

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

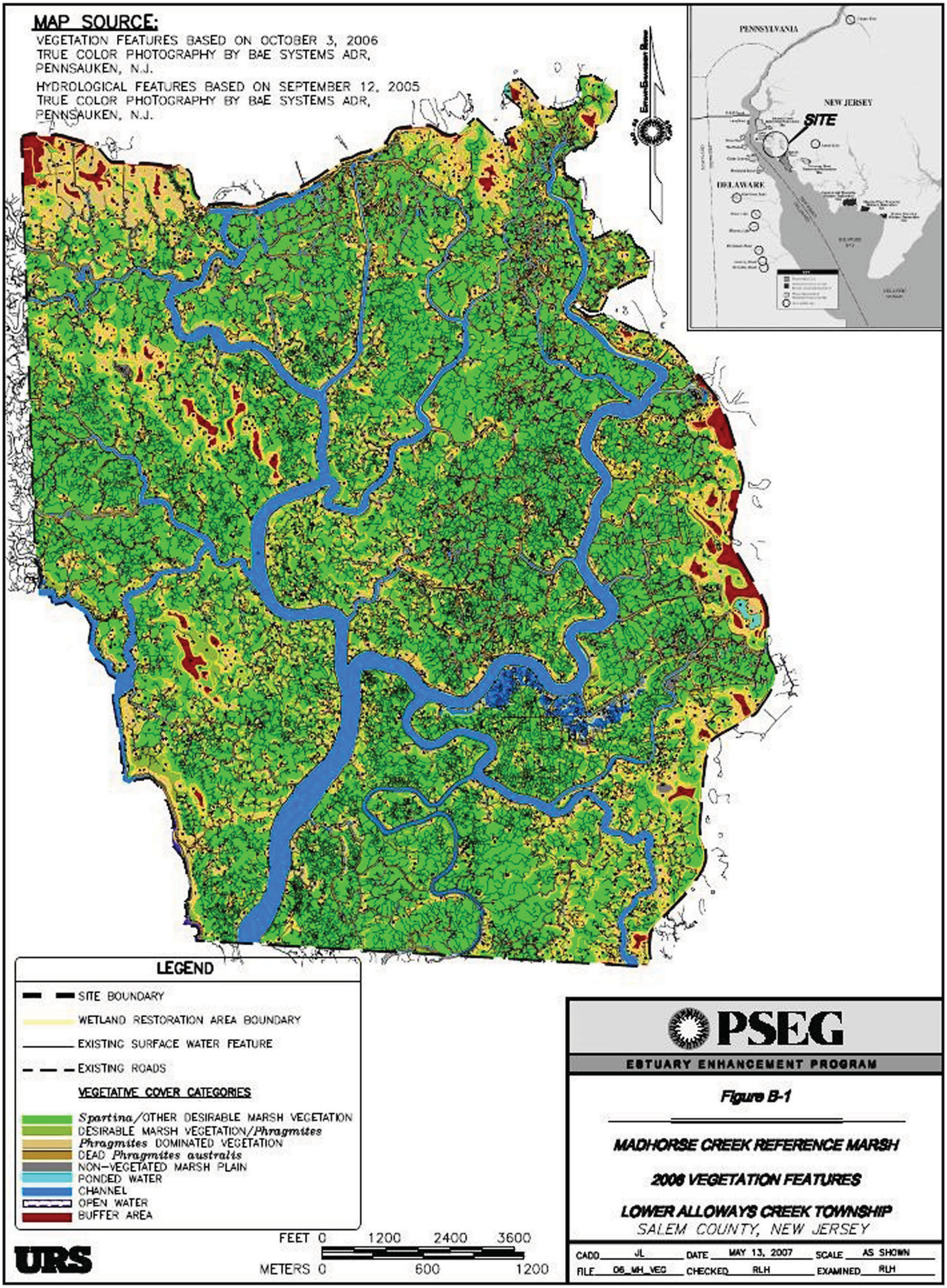
Quadrat ID	Date	Species	Live (g)	Dead Standing (g)	Litter (g)

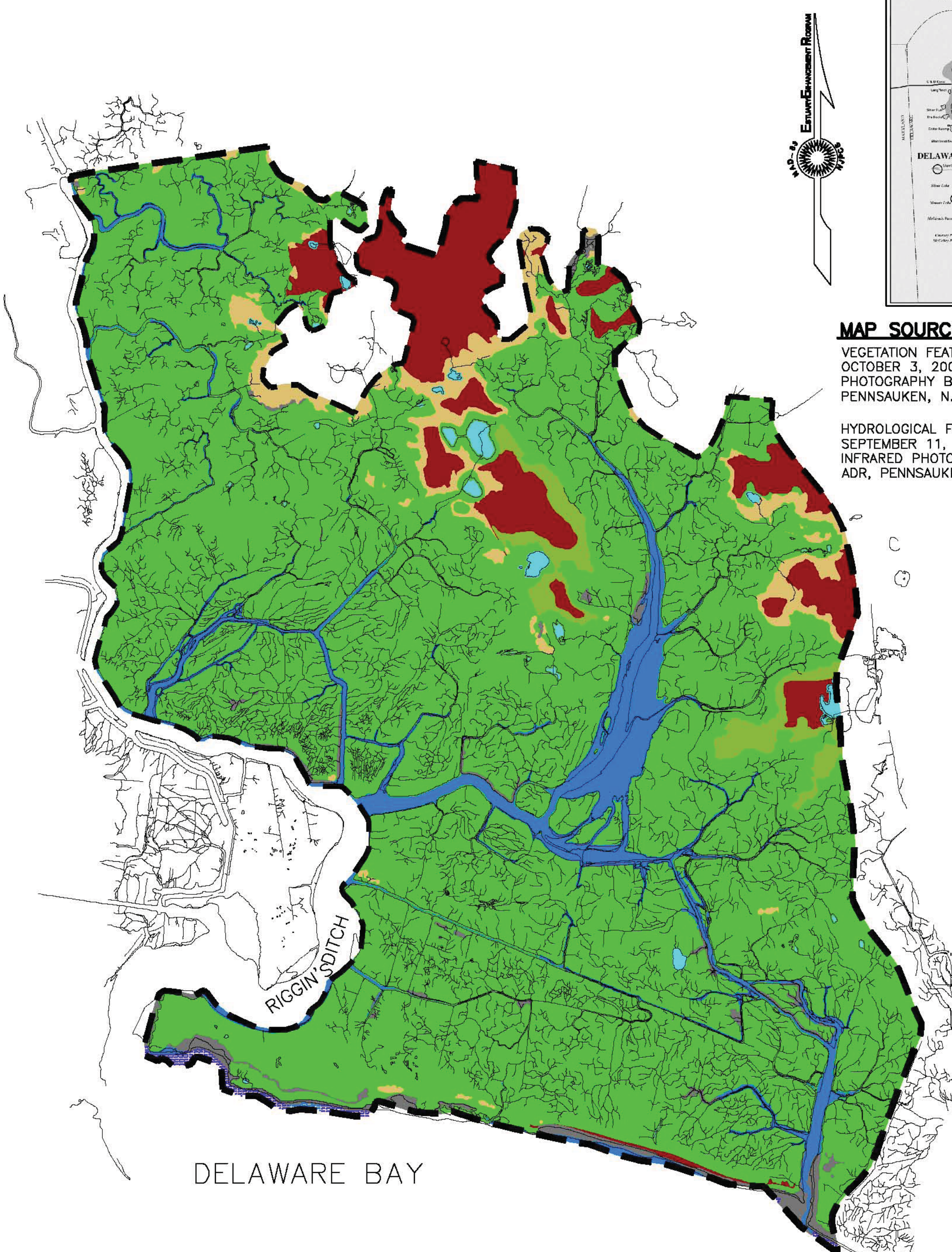
<u>Species abbreviations</u>

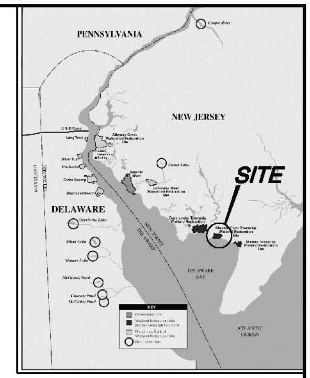
AA = arrow arum - *Pelatandra virginica*
AC = water hemp - *Amaranthus cannabinus*
BJ = Blue joint - *Calamagrostis canadenis*
DS = spike grass - *Distichlis spicata*
JG = black grass - *Juncus gerardii*
PA = common reed - *Phragmites australis*
PP = salt marsh fleabane - *Pluchea purpurascens*
PUNC = 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 OCTOBER 3, 2006
TRUE COLOR PHOTOGRAPHY BY BAE SYSTEMS ADR,
PENNSAUKEN, N.J.
HYDROLOGICAL FEATURES BASED ON SEPTEMBER 12, 2005
TRUE COLOR PHOTOGRAPHY BY BAE SYSTEMS ADR,
PENNSAUKEN, N.J.
PENNSYLVANIA
NEW JERSEY
SITE
DELAWARE
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
2006 VEGETATION FEATURES
LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY, NEW JERSEY
CADD JL
DATE MAY 13, 2007
SCALE AS SHOWN
FILE 06_MH_VEG
CHECKED RLH
EXAMINED RLH





MAP SOURCE:

VEGETATION FEATURES BASED ON OCTOBER 3, 2006 FALSE COLOR INFRARED PHOTOGRAPHY BY BAE SYSTEMS ADR, PENNSAUKEN, N.J.

HYDROLOGICAL FEATURES BASED ON SEPTEMBER 11, 2005. FALSE COLOR INFRARED 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

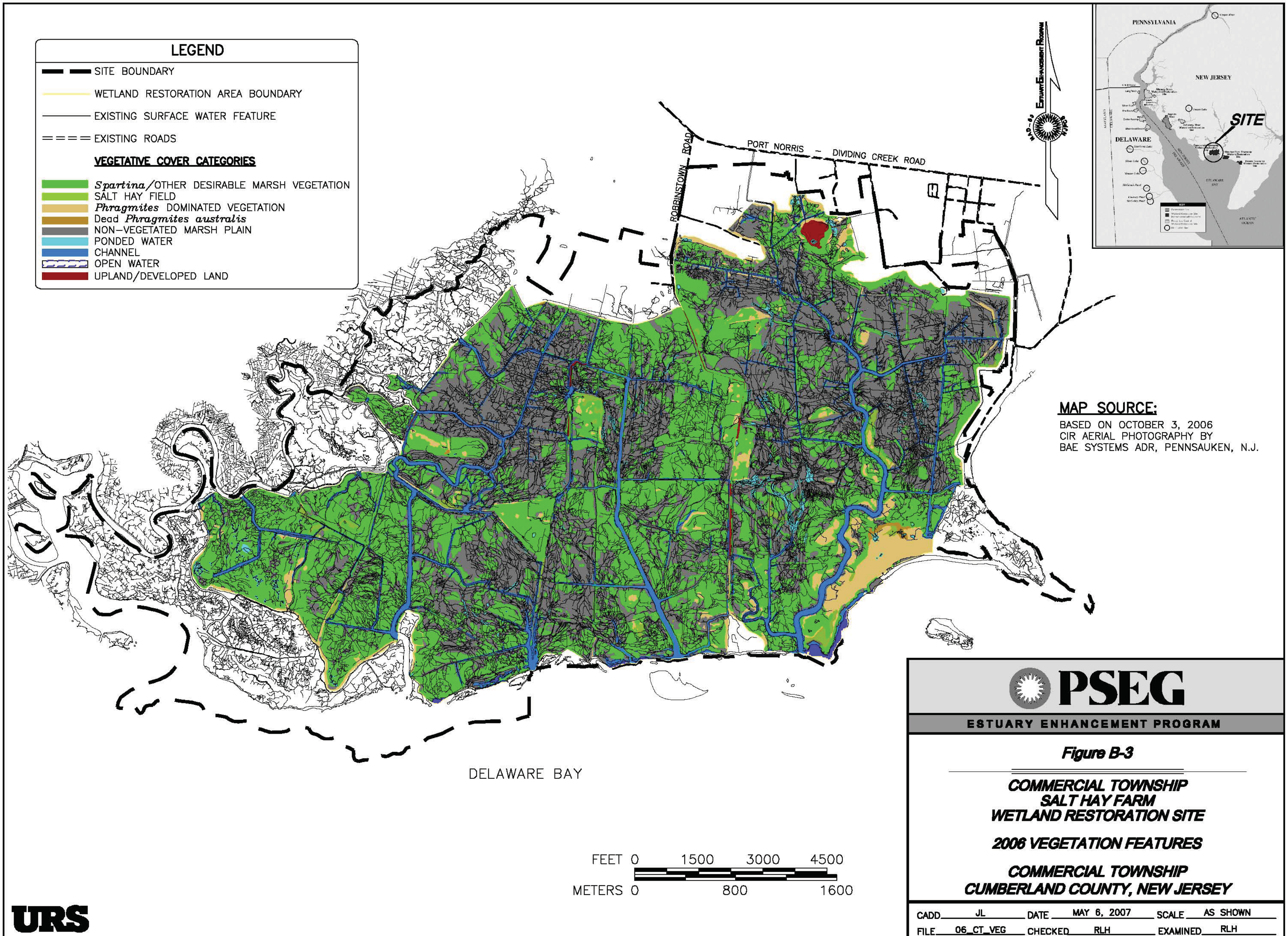
Figure B-2

MOORES BEACH REFERENCE MARSH

2006 VEGETATION FEATURES

MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD	JL	DATE	MAY 6, 2007	SCALE	AS SHOWN
FILE	06_MB_VEG	CHECKED	RLH	EXAMINED	RLH



PSEG
ESTUARY ENHANCEMENT PROGRAM

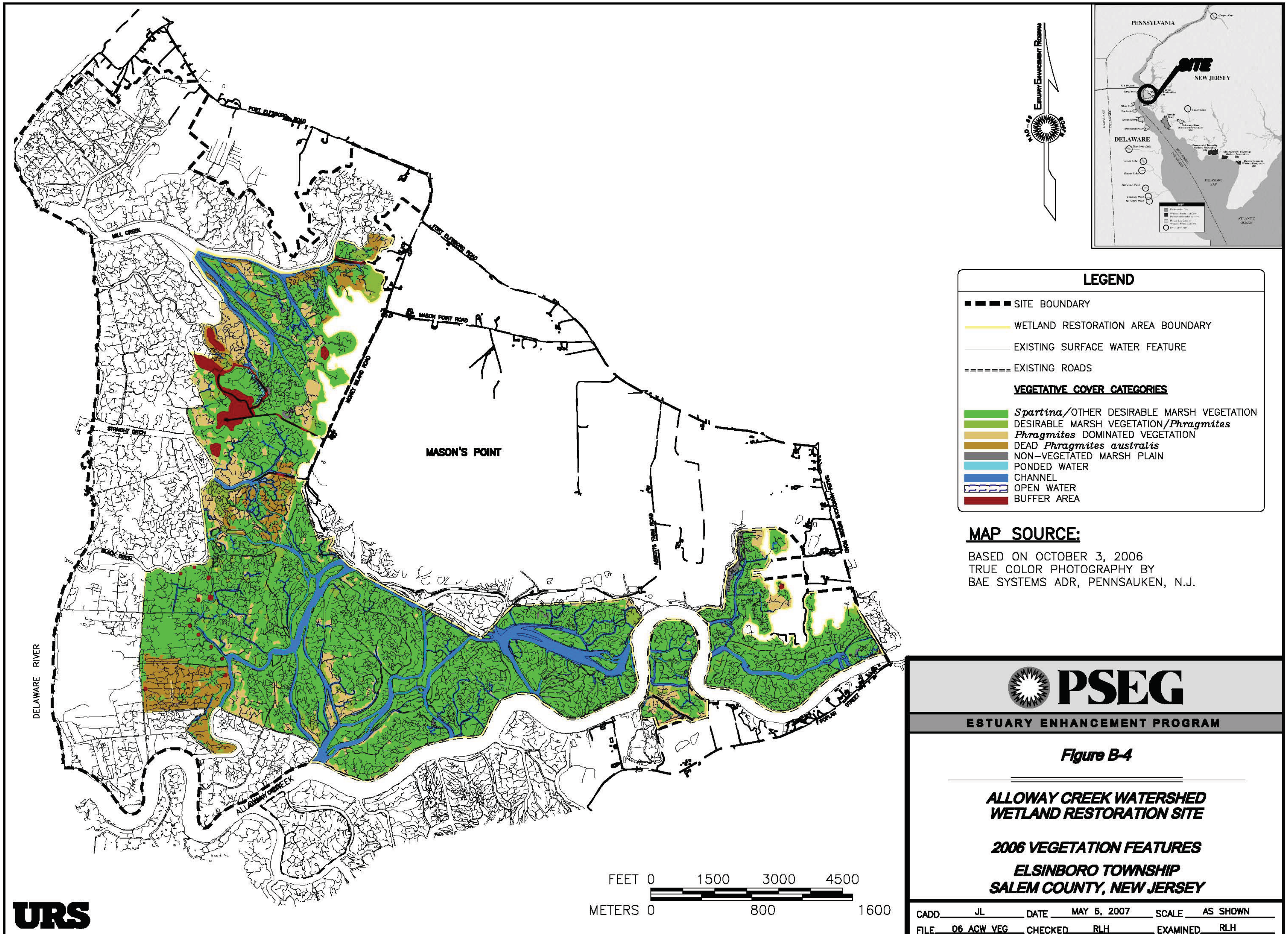
Figure B-3

COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE

2006 VEGETATION FEATURES

COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD JL DATE MAY 6, 2007 SCALE AS SHOWN
FILE 06_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 OCTOBER 3, 2006
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.

FEET 0 1500 3000 4500
METERS 0 800 1600

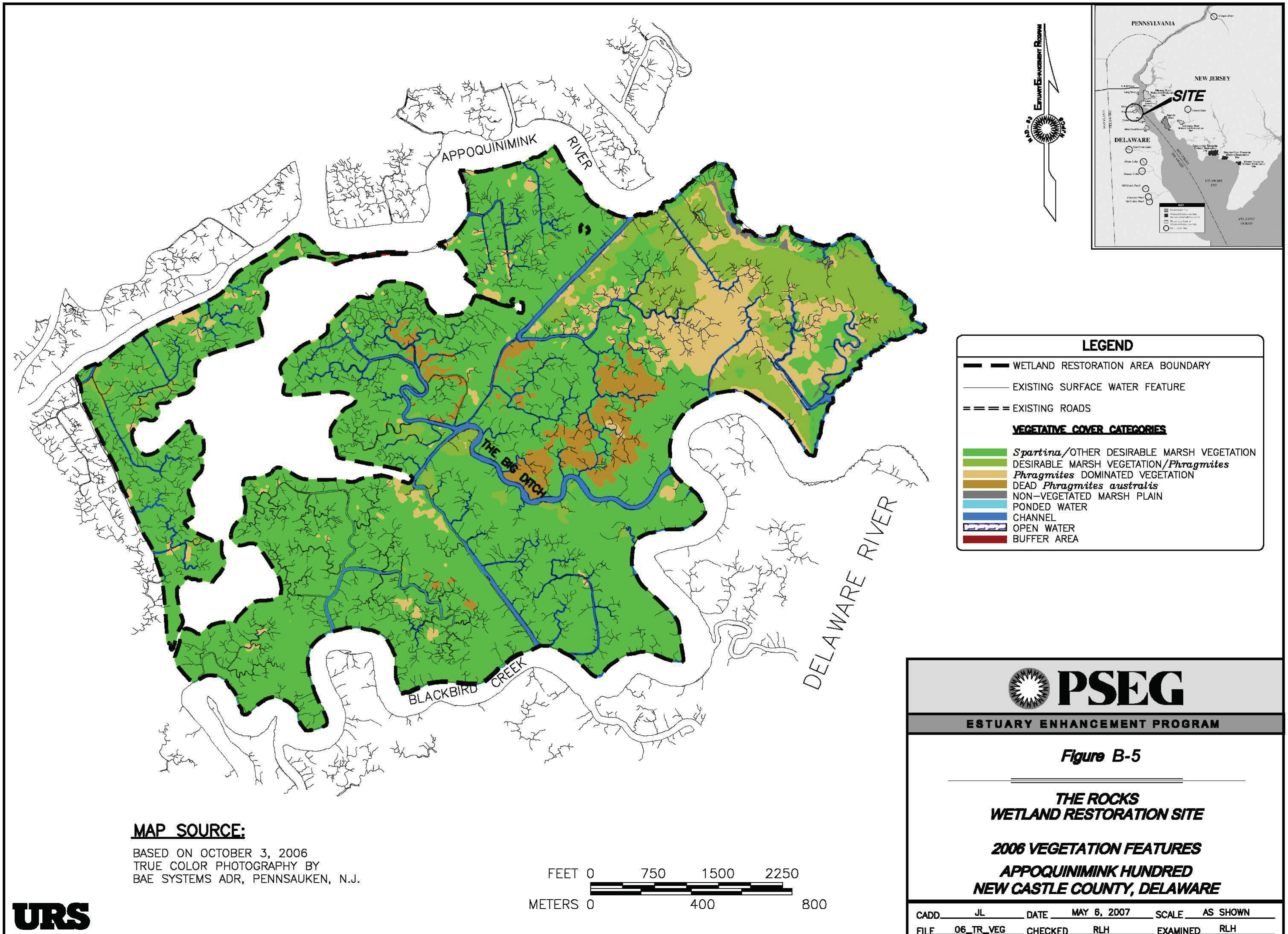
PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure B-4

ALLOWAY CREEK WATERSHED
WETLAND RESTORATION SITE

2006 VEGETATION FEATURES
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD	JL	DATE	MAY 6, 2007	SCALE	AS SHOWN
FILE	06 ACW VEG	CHECKED	RLH	EXAMINED	RLH



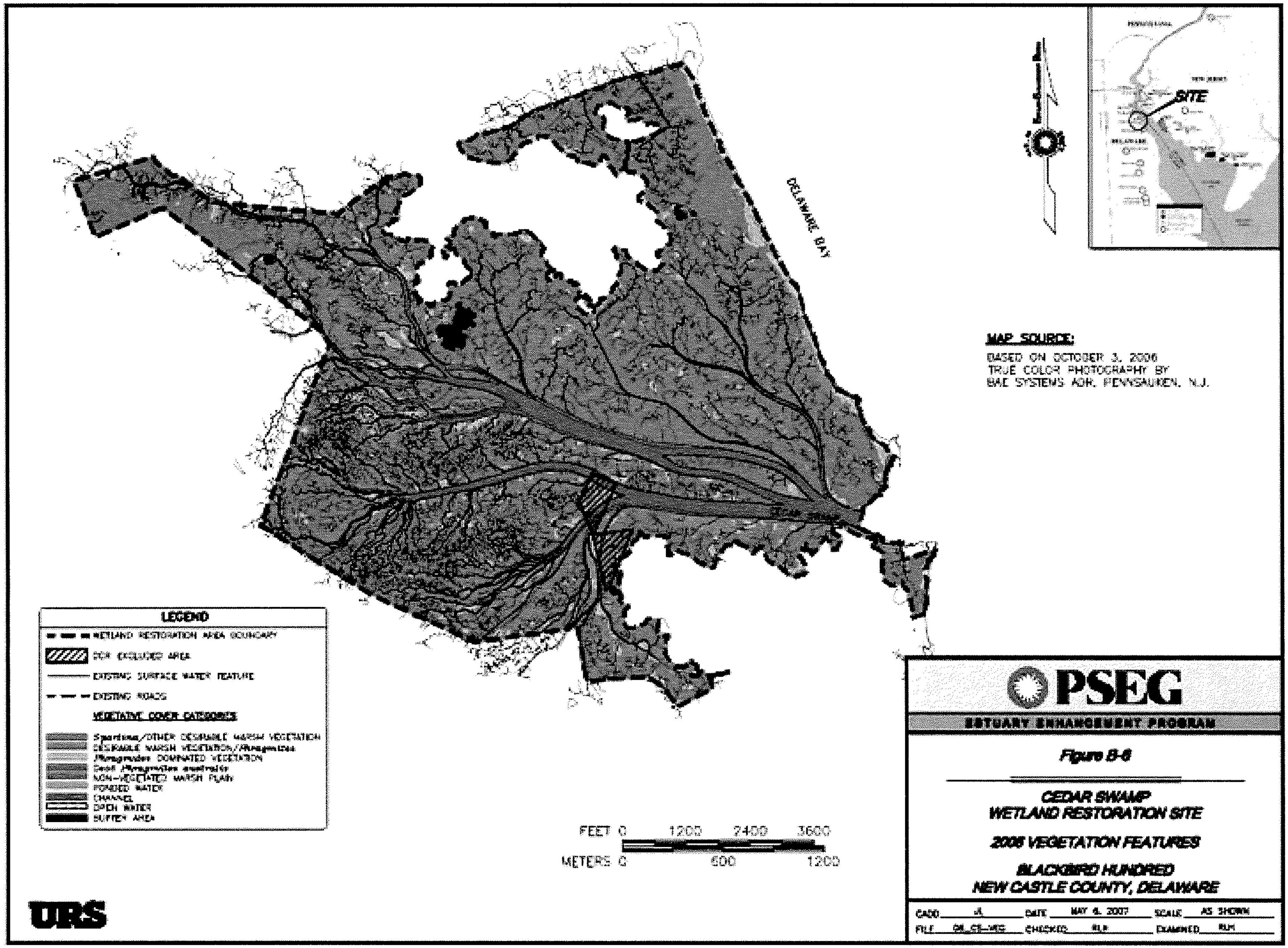
PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure B-5

**THE ROCKS
WETLAND RESTORATION SITE**

**2006 VEGETATION FEATURES
APPOQUINIMINK HUNDRED
NEW CASTLE COUNTY, DELAWARE**

CADD	JL	DATE	MAY 6, 2007	SCALE	AS SHOWN
FILE	06_TR_VEG	CHECKED	RLH	EXAMINED	RLH



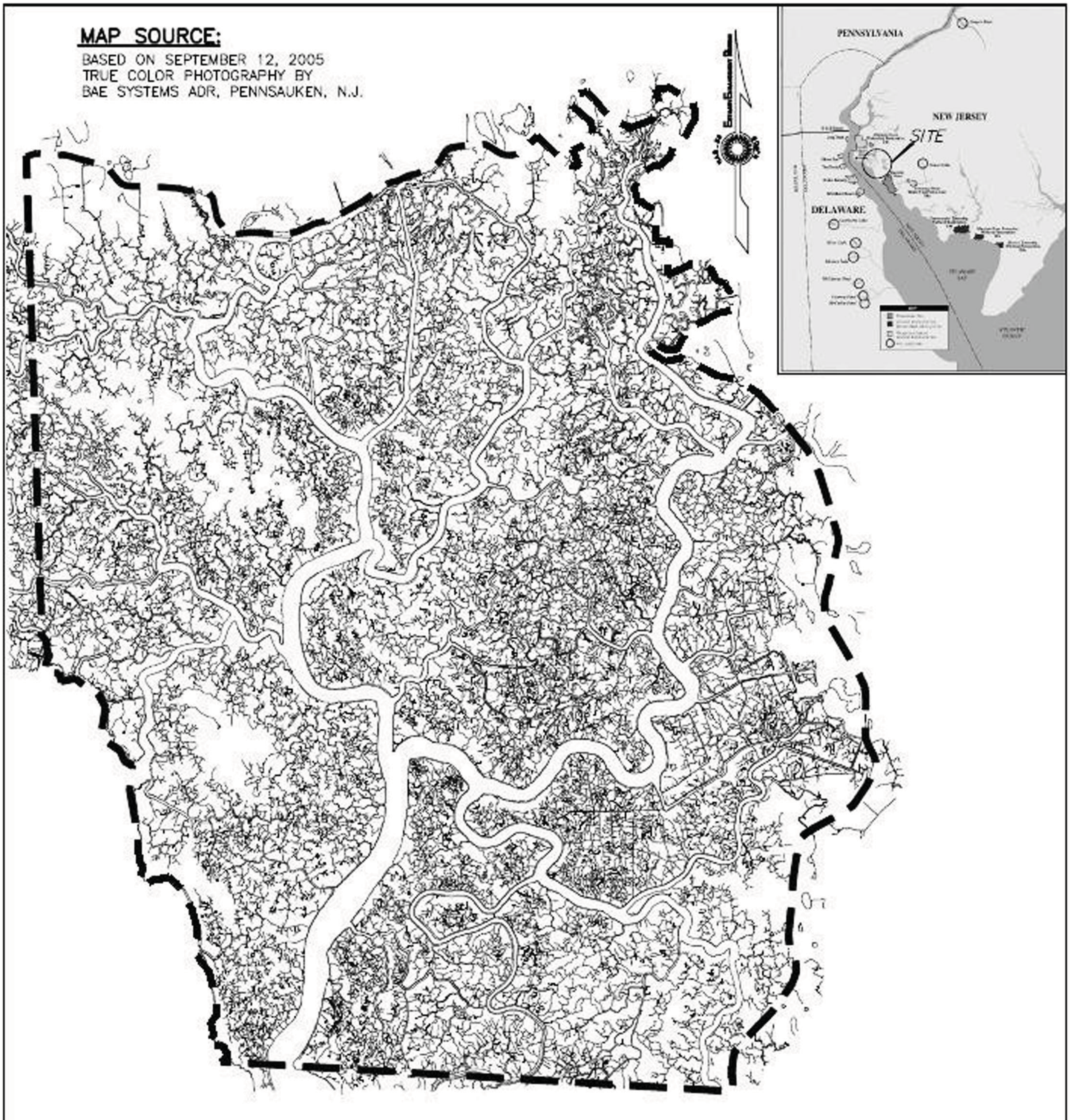
DELAWARE BAY
MAP SOURCE:
BASED ON OCTOBER 3, 2006
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.
SITE
LEGEND
WETLAND RESTORATION AREA BOUNDARY
DOR EXCLUDED AREA
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATEGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
Phragmites DOMINATED VEGETATION
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-6
CEDAR SWAMP
WETLAND RESTORATION SITE
2006 VEGETATION FEATURES
BLACKBIRD HUNDRED
NEW CASTLE COUNTY, DELAWARE
DATE MAY 6, 2007
SCALE AS SHOWN

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

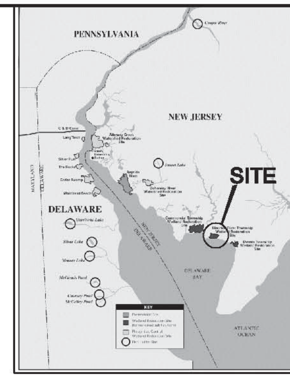
Figure C-1

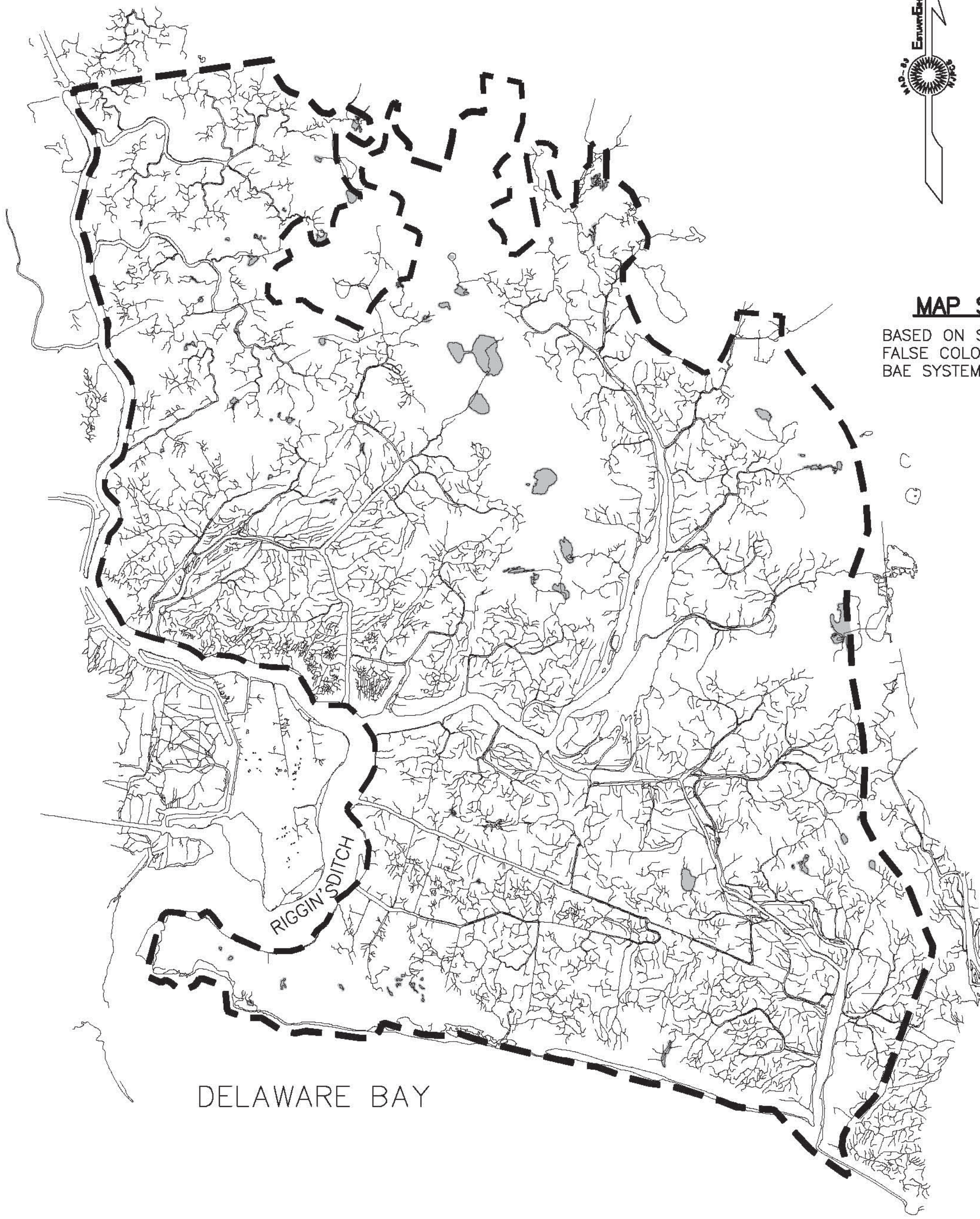
MADHORSE CREEK REFERENCE MARSH

2005 HYDROLOGICAL FEATURES

LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL DATE MAY 6, 2007 SCALE AS SHOWN
FILE 06_MH_HYD CHECKED RLH EXAMINED RLH





MAP SOURCE:

BASED ON SEPTEMBER 11, 2005
FALSE COLOR INFRARED 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

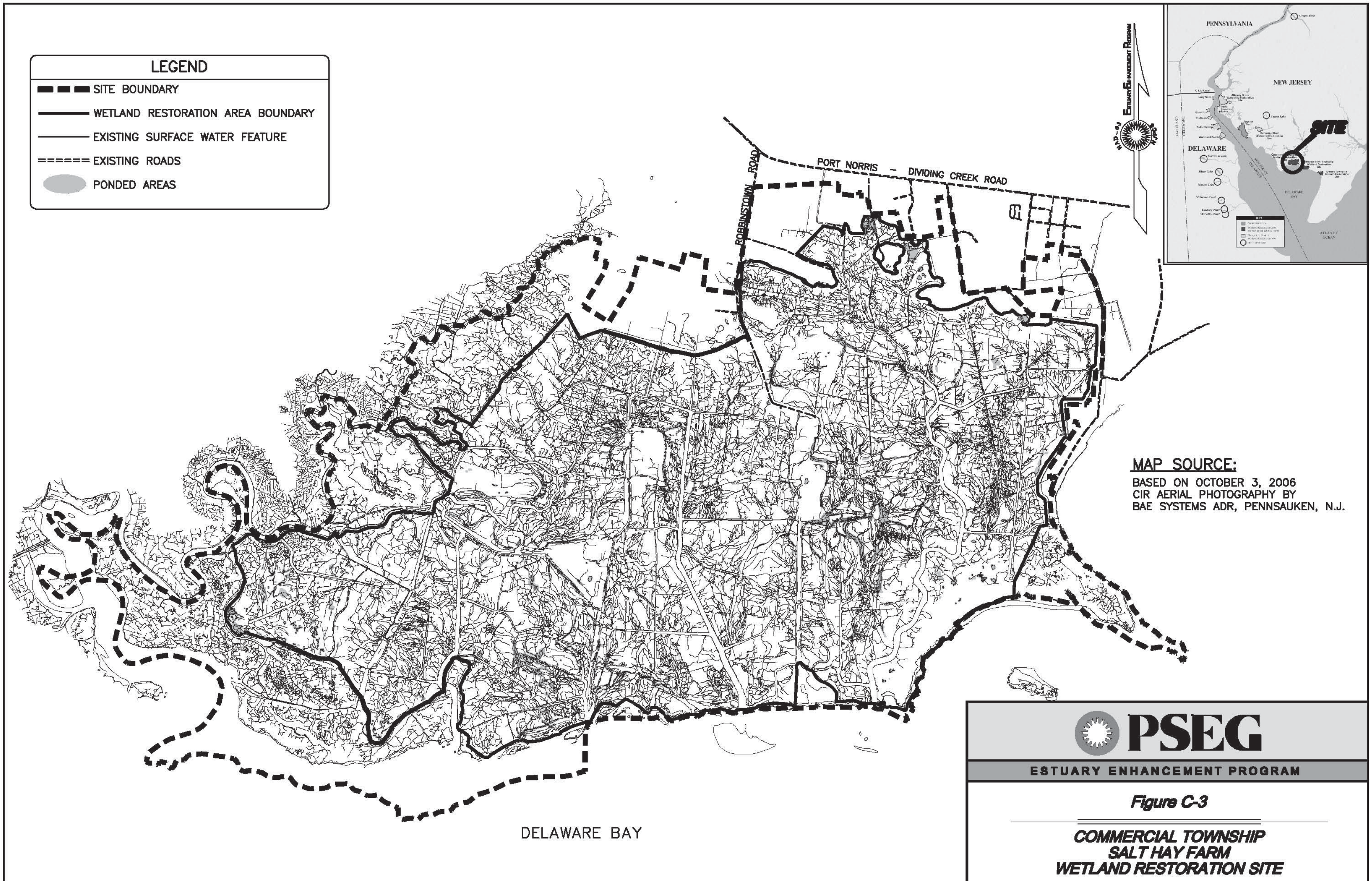
Figure C-2

MOORES BEACH REFERENCE MARSH

2005 HYDROLOGICAL FEATURES

MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD JL	DATE MAY 6, 2007	SCALE AS SHOWN
FILE 06_MB_HYD	CHECKED RLH	EXAMINED RLH



URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

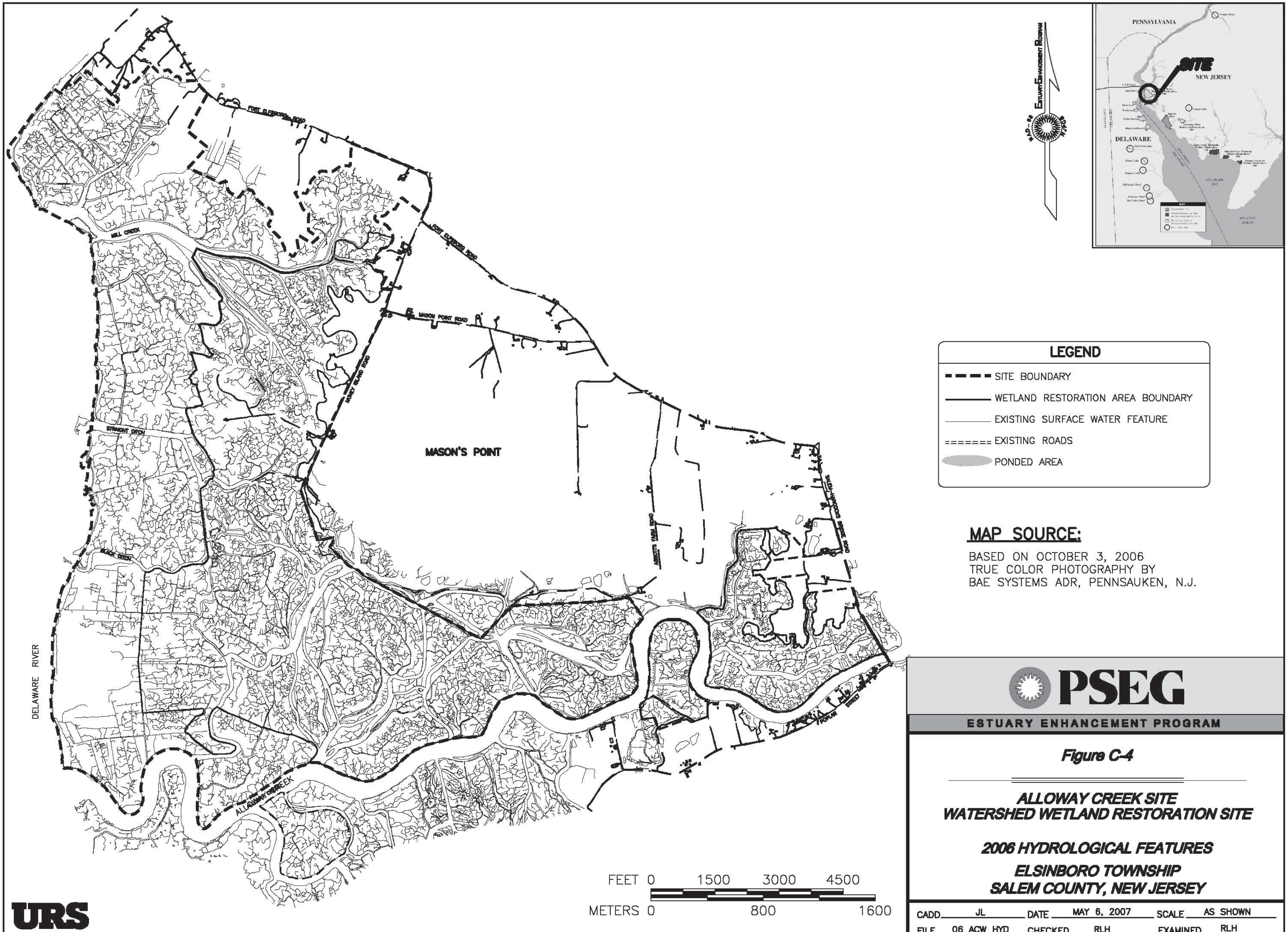
Figure C-3

**COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE**

2006 HYDROLOGICAL FEATURES

**COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY**

CADD	JL	DATE	MAY 6, 2007	SCALE	AS SHOWN
FILE	06_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 OCTOBER 3, 2006
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.

URS

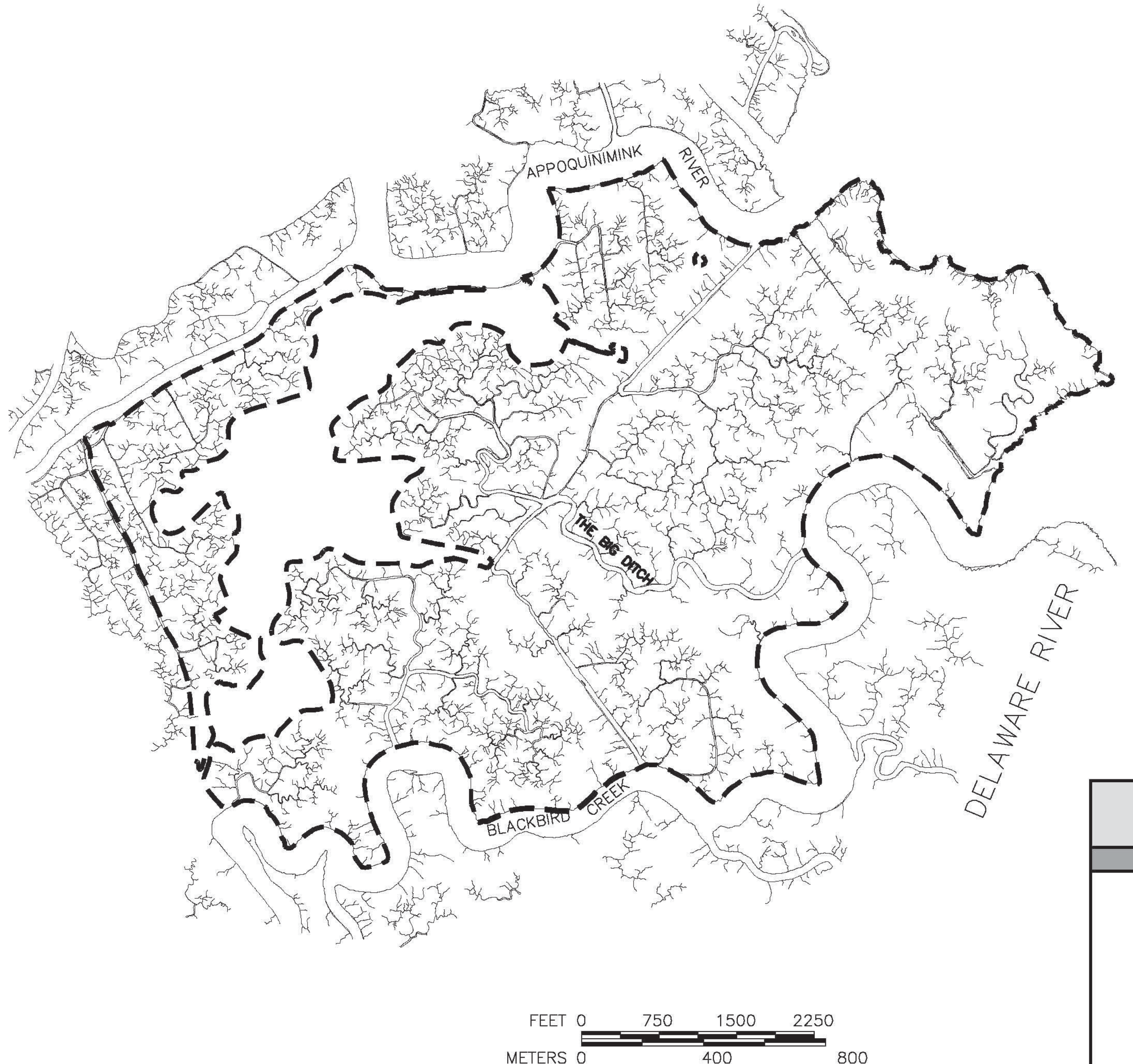
PSEG
ESTUARY ENHANCEMENT PROGRAM

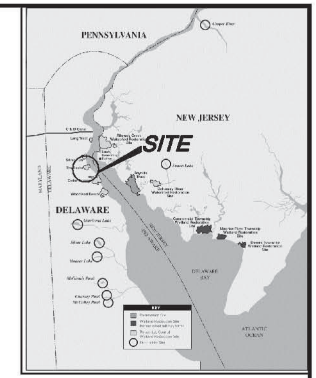
Figure C-4

ALLOWAY CREEK SITE
WATERSHED WETLAND RESTORATION SITE

2006 HYDROLOGICAL FEATURES
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD	JL	DATE	MAY 6, 2007	SCALE	AS SHOWN
FILE	06 ACW HYD	CHECKED	RLH	EXAMINED	RLH





LEGEND

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

MAP SOURCE:

BASED ON OCTOBER 3, 2006
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.

URS

PSEG

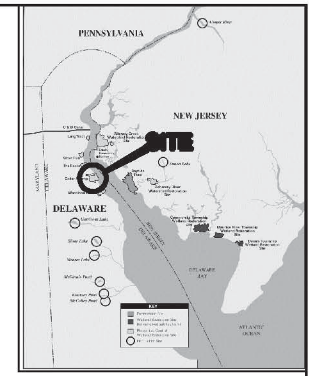
ESTUARY ENHANCEMENT PROGRAM

Figure C-5

THE ROCKS
WETLAND RESTORATION SITE

2006 HYDROLOGICAL FEATURES
APPOQUINIMINK HUNDRED
NEW CASTLE COUNTY, DELAWARE

CADD	JL	DATE	MAY 6, 2007	SCALE	AS SHOWN
FILE	06_TR_HYD	CHECKED	RLH	EXAMINED	RLH



NOTE:

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

MAP SOURCE:

BASED ON OCTOBER 3, 2006
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, 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

URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure C-6

CEDAR SWAMP
WETLAND RESTORATION SITE

2006 HYDROLOGICAL FEATURES

BLACKBIRD HUNDRED
NEW CASTLE COUNTY, DELAWARE

CADD	JL	DATE	MAY 6, 2007	SCALE	AS SHOWN
FILE	06_CS-HYD	CHECKED	RLH	EXAMINED	RLH

APPENDIX D

MACROPHYTE QUADRAT DATA - TRANSECTS

Table D-1
MAD HORSE CREEK REFERENCE SITE
PEAK SEASON 2006 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	Litter
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Mad Horse Creek - Transect 1 8/18/06										
MHT1-OQ1	676	*Spartina alterniflora*	20%	95%	97	N				
		Scirpus robustus	1%	5%	104	N				
MHT1-OQ2	628	*S. alterniflora*	25%	100%	119	N				
MHT1-OQ3	625	*S. alterniflora*	15%	100%	81	N				
MHT1-OQ4	618	*S. alterniflora*	15%	100%	102	N				
MHT1-OQ5	614	*S. alterniflora*	20%	100%	99	N				
MHT1-OQ6	609	*S. alterniflora*	20%	100%	114	N				
MHT1-OQ7	603	*S. alterniflora*	10%	100%	114	N				
MHT1-OQ8	596	*S. alterniflora*	20%	100%	94	N				
MHT1-OQ9	564	*S. alterniflora*	20%	100%	107	N				
MHT1-OQ10	533	*S. alterniflora*	15%	100%	109	N				
MHT1-OQ11	527	*S. alterniflora*	45%	100%	86	N				
MHT1-OQ12	507	*S. alterniflora*	30%	86%	102	N				
		Amaranthous cannabinus	5%	14%	109	Y				
MHT1-OQ13	505	*S. alterniflora*	45%	100%	86	N				
MHT1-CQ1	425	*S. alterniflora*	50%	100%	102	N	745	6646	96	153
MHT1-OQ14	373	*S. alterniflora*	25%	100%	109	N				
MHT1-CQ2	364	*S. alterniflora*	30%	100%	76	N	494	4404	0	48
MHT1-OQ15	329	*S. alterniflora*	10%	100%	102	N				
MHT1-OQ16	310	*S. alterniflora*	15%	100%	112	N				
MHT1-CQ3	290	*Phragmites australis*	20%	100%	284	Y	1145	10215	1598	382
MHT1-OQ17	272	*S. alterniflora*	10%	17%	97	N				
		Spartina patens	50%	83%	71	N				
MHT1-OQ18	250	*S. alterniflora*	20%	57%	81	N				
		S. patens	15%	43%	76	N				
MHT1-CQ4	244	*S. alterniflora*	15%	56%	89	N	469	4181	0	100
		Spartina cynosuroides	10%	37%	157	N	388	3459	130	0
		S. robustus	1%	4%	99	N	152	1359	0	0
		D. spicata	1%	4%	43	N	8	71	0	0
MHT1-OQ19	242	*S. alterniflora*	30%	100%	127	N				
MHT1-CQ5	236	*P. australis*	40%	100%	264	Y	1260	11239	1182	696
MHT1-CQ6	184	*S. alterniflora*	25%	45%	64	N	525	4682	85	59
		S. americanus	5%	9%	79	N	25	219	0	0
		S. patens	25%	45%	48	N	128	1142	0	0
MHT1-OQ20	119	*S. alterniflora*	40%	100%	86	N				
MHT1-OQ21	109	*S. alterniflora*	30%	100%	104	N				
MHT1-CQ7	102	*S. alterniflora*	35%	100%	122	N	941	8397	124	220
MHT1-OQ22	101	*S. alterniflora*	35%	64%	91	N				
		S. patens	20%	36%	86	N				
MHT1-CQ8	42	*S. alterniflora*	35%	88%	112	N	746	6659	0	55
		P. australis	5%	13%	117	Y	135	1202	162	0
MHT1 - Mean - Spartina dominated Quadrats (b)			33%		109		792	7070	100	106
MHT1 - Mean - Non-Spartina dominated Quadrats (b)			22%		--		1202	10727	1390	539
MHT1 - Mean - All Quadrats			30%		--		895	7984	422	214
Mad Horse Creek - Transect 2 8/18/06										
MHT2-OQ1	133	Mud Flat	0%	0%	0					
MHT2-OQ2	375	*S. alterniflora*	25%	100%	94	N				
MHT2-CQ1	488	*S. alterniflora*	45%	82%	61	N	137	1224	0	84
		S. robustus	10%	18%	99	N	98	878	32	0
MHT2-CQ2	525	*S. alterniflora*	10%	40%	76	N	1075	9591	0	140
		S. robustus	15%	60%	114	N	84	745	0	0
MHT2-OQ3	562	*S. alterniflora*	15%	100%	79	N				
MHT2-OQ4	585	*S. alterniflora*	45%	100%	71	N				
MHT2-OQ5	624	*S. alterniflora*	10%	100%	81	N				
MHT2-OQ6	731	*S. alterniflora*	5%	83%	66	N				
		P. australis	1%	17%	97	N				
MHT2 - Mean - Spartina dominated Quadrats (b)			42%		77		236	2102	32	84
MHT2 - Mean - Non-Spartina dominated Quadrats (b)			14%		--		1159	10336	0	140
MHT2 - Mean - All Quadrats			26%		--		697	6219	16	112

Table D-1
MAD HORSE CREEK REFERENCE SITE
PEAK SEASON 2006 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	Litter
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Mad Horse Creek - Transect 3A 8/18/06										
MHT3A-OQ1	569	*P. australis*	10%	100%	251	Y				
MHT3A-OQ2	542	*S. alterniflora*	10%	40%	79	N				
		S. patens	15%	60%	79	N				
MHT3A-OQ3	535	*S. alterniflora*	10%	67%	86	N				
		S. patens	5%	33%	79	N				
MHT3A-OQ4	443	*S. alterniflora*	5%	17%	74	N				
		S. cynosuroides	20%	67%	173	Y				
		S. robustus	5%	17%	107	N				
MHT3A-OQ5	417	*S. alterniflora*	5%	20%	71	N				
		S. patens	5%	20%	53	N				
		S. robustus	15%	60%	114	N				
MHT3A-OQ6	385	*S. alterniflora*	15%	100%	89	N				
MHT3A-OQ7	364	*S. alterniflora*	10%	29%	84	N				
		S. patens	25%	71%	71	N				
MHT3A-OQ8	331	*S. patens*	75%	100%	58	N				
MHT3A-CQ1	304	*S. alterniflora*	15%	100%	79	N	249	2223	0	168
MHT3A-OQ9	289	*S. alterniflora*	5%	6%	99	N				
		S. patens	80%	94%	58	N				
MHT3A-OQ10	288	*S. alterniflora*	10%	11%	84	N				
		S. patens	80%	89%	66	N				
MHT3A-OQ11	281	*S. alterniflora*	5%	20%	107	N				
		S. patens	20%	80%	81	N				
MHT3A-CQ2	280	*S. alterniflora*	25%	100%	102	N	598	5334	0	146
MHT3A-CQ3	249	Mud Flat	0%	0%			0	0	0	0
MHT3A-CQ4	206	*P. australis*	15%	100%	251	Y	462	4125	0	320
MHT3A-CQ5	199	*P. australis*	5%	100%	216	Y	397	3546	0	83
MHT3A-OQ12	101	*S. alterniflora*	5%	5%	74	N				
		S. patens	90%	95%	61	N				
MHT3A-OQ13	72	*S. alterniflora*	5%	5%	53	N				
		S. patens	90%	95%	36	N				
MHT3A-CQ6	56	*S. alterniflora*	15%	100%	79	N	258	2304	0	356
MHT3A-OQ14	31	*S. alterniflora*	25%	56%	71	N				
		S. patens	20%	44%	56	N				
MHT3A-OQ15	24	*S. alterniflora*	10%	18%	81	N				
		P. australis	35%	64%	104	Y				
		S. patens	10%	18%	43	N				
MHT3A-OQ16	18	*S. alterniflora*	10%	29%	76	N				
		P. australis	25%	71%	109	N				
MHT3A-OQ17	11	*S. alterniflora*	40%	62%	84	N				
		P. australis	25%	38%	135	N				
MHT3A-OQ18	10	*S. alterniflora*	35%	64%	56	N				
		S. cynosuroides	20%	36%	135	N				
MHT3A - Mean - Spartina dominated Quadrats (b)			44%		94		598	5334	0	146
MHT3A - Mean - Non-Spartina dominated Quadrats (b)			41%		--		273	2440	0	185
MHT3A - Mean - All Quadrats			41%		--		328	2922	0	179

Table D-1
MAD HORSE CREEK REFERENCE SITE
PEAK SEASON 2006 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	Litter
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Mad Horse Creek - Transect 3B 8/18/06										
MHT3B-OQ1	337	*S. alterniflora*	25%	100%	58	N				
MHT3B-OQ2	324	*S. alterniflora*	25%	100%	69	N				
MHT3B-OQ3	314	*S. alterniflora*	1%	100%	41	N				
MHT3B-OQ4	302	*S. alterniflora*	15%	100%	79	N				
MHT3B-OQ5	243	*S. alterniflora*	25%	100%	69	N				
MHT3B-OQ6	231	*S. alterniflora*	10%	67%	94	N				
		A. cannabinus	5%	33%	76	N				
MHT3B-OQ7	224	*S. alterniflora*	25%	100%	79	N				
MHT3B-OQ8	195	*S. alterniflora*	35%	100%	109	N				
MHT3B-CQ1	186	*S. alterniflora*	10%	67%	61	N	271	2419	0	0
		P. australis	5%	33%	66	N	29	258	0	0
MHT3B-CQ2	170	*S. alterniflora*	20%	57%	69	N	459	4091	0	0
		P. australis	10%	29%	124	Y	90	807	102	0
		A. cannabinus	5%	14%	84	Y	4	31	0	61
MHT3B-OQ9	139	*S. alterniflora*	20%	80%	79	N				
		P. australis	5%	20%	66	N				
MHT3B-OQ10	135	*S. alterniflora*	30%	35%	56	N				
		A. cannabinus	5%	6%	30	Y				
		S. patens	50%	59%	41	N				
MHT3B-OQ11	122	*S. alterniflora*	10%	13%	66	N				
		A. cannabinus	5%	7%	61	Y				
		S. patens	60%	80%	61	N				
MHT3B-CQ3	116	*S. alterniflora*	15%	16%	64	N	118	1055	0	0
		S. patens	80%	84%	28	N	405	3617	0	0
MHT3B-CQ4	103	*S. alterniflora*	1%	1%	51	N	10	87	0	0
		S. patens	95%	99%	33	N	905	8077	0	0
MHT3B-CQ5	98	*S. alterniflora*	10%	100%	41	N	436	3889	0	162
MHT3B-OQ12	94	*S. alterniflora*	35%	100%	71	N				
MHT3B-OQ13	84	*S. alterniflora*	35%	100%	71	N				
MHT3B-OQ14	63	*S. alterniflora*	15%	60%	81	N				
		S. robustus	10%	40%	104	N				
MHT3B-CQ6	57	*S. alterniflora*	35%	100%	89	N	323	2883	0	0
MHT3B-OQ15	50	*S. alterniflora*	45%	100%	86	N				
MHT3B-OQ16	33	*S. alterniflora*	15%	100%	71	N				
MHT3B-OQ17	17	*S. alterniflora*	25%	100%	79	N				
MHT3B-OQ18	5	*S. alterniflora*	35%	100%	81	N				
MHT3B - Mean - Spartina dominated Quadrats (b)			35%		76		438	3906	51	30
MHT3B - Mean - Non-Spartina dominated Quadrats (b)			36%		--		0	0	0	0
MHT3B - Mean - All Quadrats			36%		--		508	4536	17	37
Site Mean - Spartina dominated Quadrats (b)			36%		95		646	5767	73	93
Site Mean - Non-Spartina dominated Quadrats (b)			33%		--		592	5282	232	192
Site Mean - All Quadrats			34%		--		617	5503	160	147

Table D-2
MOORES BEACH REFERENCE SITE
PEAK SEASON 2006 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	Litter
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Moores Beach - Transect 1 8/21/06										
MBT1-CQ1	79	*S. alterniflora*	25%	100%	124	N	1199	10699	0	99
MBT1-OQ1	381	*S. alterniflora*	15%	100%	104	N				
MBT1-OQ2	447	*S. alterniflora*	15%	100%	58	N				
MBT1-OQ3	528	*S. alterniflora*	15%	100%	69	N				
MBT1-CQ2	601	*S. alterniflora*	15%	100%	86	N	409	3646	0	92
MBT1-OQ4	637	*S. alterniflora*	15%	100%	61	N				
MBT1-OQ5	642	*S. alterniflora*	15%	100%	76	N				
MBT1-OQ6	681	*S. alterniflora*	25%	100%	81	N				
MBT1 - Mean - Spartina dominated Quadrats (b)			25%		103		1199	10699	0	99
MBT1 - Mean - Non-Spartina dominated Quadrats (b)			15%		--		409	3646	0	92
MBT1 - Mean - All Quadrats			18%		--		804	7172	0	95
Moores Beach - Transect 2 8/21/06										
MBT2-OQ1	807	*S. alterniflora*	35%	100%	117	N				
MBT2-OQ2	715	*S. alterniflora*	25%	100%	79	N				
MBT2-OQ3	519	*S. alterniflora*	35%	100%	97	N				
MBT2-OQ4	420	*S. alterniflora*	35%	100%	107	N				
MBT2-CQ2	185	*S. alterniflora*	25%	100%	122	N	571	5090	0	18
MBT2-OQ5	137	*S. alterniflora*	35%	100%	122	N				
MBT2-CQ1	98	*S. alterniflora*	35%	100%	99	N	707	6311	0	66
MBT2-OQ6	82	*S. alterniflora*	25%	100%	109	N				
MBT2 - Mean - Spartina dominated Quadrats (b)			31%		107		639	5701	0	42
MBT2 - Mean - Non-Spartina dominated Quadrats (b)			0%		--		0	0	0	0
MBT2 - Mean - All Quadrats			31%		--		639	5701	0	42
Moores Beach - Transect 3 8/21/06										
MBT3-OQ1	517	*S. alterniflora*	5%	100%	76	N				
MBT3-OQ2	496	*S. alterniflora*	20%	100%	109	N				
MBT3-OQ3	328	*S. alterniflora*	25%	100%	69	N				
MBT3-OQ4	306	*S. alterniflora*	15%	100%	89	N				
MBT3-OQ5	180	*S. alterniflora*	20%	100%	94	N				
MBT3-CQ1	159	*S. alterniflora*	25%	100%	94	N	249	2220	0	238
MBT3-CQ2	119	*S. alterniflora*	5%	100%	71	N	63	565	0	359
MBT3-OQ6	103	*S. alterniflora*	15%	100%	91	N				
MBT3 - Mean - Spartina dominated Quadrats (b)			23%		92		249	2220	0	238
MBT3 - Mean - Non-Spartina dominated Quadrats (b)			10%		--		63	565	0	359
MBT3- Mean - All Quadrats			16%		--		156	1393	0	299
Site Mean - Spartina dominated Quadrats (b)			28%		102		681	6080	0	105
Site Mean - Non-Spartina dominated Quadrats (b)			13%		--		236	2105	0	225
Site Mean - All Quadrats			22%		--		533	4755	0	145

Table D-3
COMMERCIAL TOWNSHIP SALT HAY FARM
PEAK SEASON 2006 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	Litter
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Commercial Township - Transect 1 8/19/06										
CTT1-OQ1	2	*S. alterniflora*	45%	100%	155	Y				
CTT1-OQ2	17	*S. alterniflora*	25%	100%	122	Y				
CTT1-OQ3	36	*S. alterniflora*	15%	100%	99	N				
CTT1-CQ1	48	*S. alterniflora*	25%	100%	109	N	1488	13278	0	0
CTT1-CQ2	67	*S. alterniflora*	35%	100%	157	N	1450	12940	0	0
CTT1-OQ4	293	Mud Flat	0%	0%	0					
CTT1-OQ5	362	Mud Flat	0%	0%	0					
CTT1-OQ6	401	Mud Flat	0%	0%	0					
CTT1 - Mean - Spartina dominated Quadrats (b)			33%		136		1469	13109	0	0
CTT1 - Mean - Non-Spartina dominated Quadrats (b)			15%		--		0	0	0	0
CTT1- Mean - All Quadrats			29%		--		1469	13109	0	0
Commercial Township - Transect 2 8/19/06										
CTT2-OQ1	2	*S. alterniflora*	25%	100%	157	N				
CTT2-OQ2	11	*S. alterniflora*	35%	100%	173	Y				
CTT2-CQ1	25	*S. alterniflora*	25%	100%	165	N	1853	16532	0	0
CTT2-CQ2	35	*S. alterniflora*	15%	100%	160	N	821	7327	0	0
CTT2-OQ3	57	Mud Flat	0%	0%	0					
CTT2-OQ4	320	Mud Flat	0%	0%	0					
CTT2-OQ5	580	Mud Flat	0%	0%	0					
CTT2-OQ6	603	Mud Flat	0%	0%	0					
CTT2 - Mean - Spartina dominated Quadrats (b)			28%		164		1853	16532	0	0
CTT2 - Mean - Non-Spartina dominated Quadrats (b)			15%		--		821	7327	0	0
CTT2- Mean - All Quadrats			25%		--		1337	11930	0	0
Commercial Township - Transect 3 8/19/06										
CTT3OQ1	2	*S. alterniflora*	25%	100%	124	N				
CTT3-CQ1	19	*S. alterniflora*	15%	100%	107	N	1231	10984	0	0
CTT3OQ2	19	*S. alterniflora*	15%	100%	107	N				
CTT3OQ3	47	*S. alterniflora*	25%	100%	107	Y				
CTT3-CQ2	47	*S. alterniflora*	25%	100%	107	Y	730	6509	0	0
CTT3OQ4	350	Mud Flat	0%	0%	0					
CTT3OQ5	390	Mud Flat	0%	0%	0					
CTT3 - Mean - Spartina dominated Quadrats (b)			25%		113		730	6509	0	0
CTT3- Mean - Non-Spartina dominated Quadrats (b)			15%		--		1231	10984	0	0
CTT3- Mean - All Quadrats			21%		--		980	8746	0	0
Commercial Township - Transect 4 8/19/06										
CTT4-OQ1	1	*S. alterniflora*	25%	100%	185	Y				
CTT4-CQ1	3	*S. alterniflora*	25%	100%	191	N	1985	17708	0	263
CTT4-OQ2	8	*S. alterniflora*	15%	100%	155	Y				
CTT4-CQ2	8	*S. alterniflora*	15%	100%	155	Y	644	5749	0	0
CTT4-OQ3	28	*S. alterniflora*	5%	100%	97	Y				
CTT4-OQ4	140	Mud Flat	0%	0%	0					
CTT4- Mean - Spartina dominated Quadrats (b)			25%		188		1985	17708	0	263
CTT4- Mean - Non-Spartina dominated Quadrats (b)			12%		--		644	5749	0	0
CTT4- Mean - All Quadrats			17%		--		1315	11728	0	132
Site Mean - Spartina dominated Quadrats (b)			28%		147		1501	13394	0	53
Site Mean - Non-Spartina dominated Quadrats (b)			14%		--		899	8020	0	0
Site Mean - All Quadrats			23%		--		1275	11379	0	33

Table D-4
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
PEAK SEASON 2006 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	Litter
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Alloway Creek Watershed - Transect 1 8/23/06										
ACWT1-CQ1	448	*S. alterniflora*	10%	29%	130	N	158	1411	0	47
		P. australis	15%	43%	188	Y	258	2303	0	0
		S. robustus	10%	29%	147	Y	63	564	0	0
ACWT1-CQ2	425	*P. australis*	50%	91%	178	Y	1233	11002	0	162
		Echinochloa walteri	5%	9%	109	Y	0	0	61	0
ACWT1-OQ1	385	*S. alterniflora*	40%	100%	86	N				
ACWT1-OQ2	320	*S. alterniflora*	25%	100%	132	N				
ACWT1-OQ3	319	*S. alterniflora*	10%	22%	99	N				
		S. robustus	25%	56%	132	Y	0	0	0	0
		P. australis	10%	22%	191	N	0	0	0	0
ACWT1-OQ4	314	*S. alterniflora*	15%	50%	91	N				
		S. robustus	15%	50%	119	N	0	0	0	0
ACWT1-OQ5	303	*S. alterniflora*	25%	100%	89	N				
ACWT1-OQ6	283	*E. walteri*	30%	100%	43	Y				
ACWT1-OQ7	241	*S. alterniflora*	25%	56%	89	N				
		S. robustus	15%	33%	114	N	0	0	0	0
		P. australis	5%	11%	137	N	0	0	0	0
ACWT1-OQ8	195	*S. alterniflora*	55%	100%	124	N				
ACWT1-CQ3	279	*S. alterniflora*	5%	13%	56	N	89	792	0	240
		E. walteri	35%	88%	76	Y	90	802	0	0
ACWT1-CQ4	185	*S. alterniflora*	10%	40%	51	N	90	800	0	279
		S. robustus	15%	60%	178	N	95	846	0	0
ACWT1-OQ9	155	*S. alterniflora*	65%	81%	99	N				
		Peltandra virginica	15%	19%	71	N				
ACWT1-OQ10	108	*S. alterniflora*	65%	98%	76	N				
		P. australis	1%	2%	79	N				
ACWT1-OQ11	76	*S. alterniflora*	70%	93%	99	Y				
		P. australis	5%	7%	130	Y				
ACWT1-OQ12	59	*S. alterniflora*	25%	100%	112	N				
ACWT1 - Mean - Spartina dominated Quadrats (b)			48%		101		0	0	0	0
ACWT1 - Mean - Non-Spartina dominated Quadrats (b)			37%		--		519	4630	15	182
ACWT1- Mean - All Quadrats			44%		--		519	4630	15	182
Alloway Creek Watershed - Transect 2 8/15/06										
ACWT2-CQ1	4	*S. cynosuroides*	60%	100%	188	N	1833	16353	0	558
ACWT2-CQ2	7	*S. cynosuroides*	45%	90%	147	N	1389	12396	0	135
		S. robustus	5%	10%	104	Y	157	1399	0	0
ACWT2-OQ1	20	*S. alterniflora*	35%	100%	102	N				
ACWT2-OQ2	80	*S. alterniflora*	30%	86%	97	N				
		S. cynosuroides	5%	14%	114	N	0	0	0	0
ACWT2-OQ3	104	*S. alterniflora*	35%	100%	114	N				
ACWT2-OQ4	128	*S. alterniflora*	50%	91%	112	N				
		A. cannabinus	5%	9%	71	Y	0	0	0	0
ACWT2-OQ5	157	*S. alterniflora*	45%	100%	130	N				
ACWT2-CQ3	180	*S. alterniflora*	30%	86%	119	N	1214	10827	0	61
		S. robustus	5%	14%	107	N	115	1026	0	28
ACWT2-OQ6	238	*S. alterniflora*	55%	100%	132	N				
ACWT2-OQ7	264	Mud Flat	0%	0%	0					
ACWT2-CQ4	269	S. alterniflora	15%	100%	122	N	1239	11057	0	0
ACWT2-OQ8	285	Mud Flat	0%	0%	0					
ACWT2-OQ9	382	*S. alterniflora*	45%	100%	124	N				
ACWT2-OQ10	443	*S. alterniflora*	25%	100%	97	N				
ACWT2-OQ11	529	*S. alterniflora*	55%	100%	76	N				
ACWT2-OQ12	532	*S. alterniflora*	65%	100%	86	N				
ACWT2 - Mean - Spartina dominated Quadrats (b)			46%		117		1569	14000	0	261
ACWT2 - Mean - Non-Spartina dominated Quadrats (b)			15%		--		1239	11057	0	0
ACWT2- Mean - All Quadrats			44%		--		1487	13264	0	196

Table D-4
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
PEAK SEASON 2006 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	Litter
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Alloway Creek Watershed - Transect 3 8/15/06										
ACWT3-OQ1	259	*S. alterniflora*	15%	30%	94	N				
		Scirpus robustus	30%	60%	114	Y				
		A. cannabinus	5%	10%	81	N				
ACWT3-CQ1	255	*S. alterniflora*	5%	6%	81	N	160	1429	0	229
		P. australis	20%	25%	188	Y	294	2627	0	0
		A. cannabinus	25%	31%	102	Y	76	677	0	0
		S. robustus	30%	38%	112	Y	317	2825	0	0
ACWT3-OQ2	248	*S. alterniflora*	40%	56%	107	N				
		Scirpus robustus	5%	7%	142	Y	0	0	0	0
		A. cannabinus	25%	35%	132	N	0	0	0	0
		Atriplex patula	1%	1%	91	N	0	0	0	0
ACWT3-OQ3	236	*S. alterniflora*	60%	98%	107	N				
		S. robustus	1%	2%	43	N	0	0	0	0
ACWT3-OQ4	233	*S. alterniflora*	55%	92%	147	N				
		P. australis	5%	8%	130	N	0	0	0	0
ACWT3-OQ5	227	*S. alterniflora*	20%	67%	79	N				
		A. cannabinus	5%	17%	76	Y	0	0	0	0
		P. australis	5%	17%	99	N	0	0	0	0
ACWT3-OQ6	215	*S. cynosuroides*	10%	32%	97	N				
		P. australis	20%	65%	165	N	0	0	0	0
		Polygonum punctatum	1%	3%	74	Y	0	0	0	0
ACWT3-CQ2	210	*S. cynosuroides*	5%	7%	71	N	65	579	0	47
		A. cannabinus	35%	46%	127	Y	702	6264	0	0
		A. patula	30%	39%	48	N	193	1726	0	0
		P. australis	5%	7%	152	N	47	421	83	0
		E. walteri	1%	1%	127	N	66	588	0	0
ACWT3-OQ7	203	*A. cannabinus*	5%	14%	109	Y				
		P. australis	30%	83%	198	Y	0	0	0	0
		E. walteri	1%	3%	94	Y	0	0	0	0
ACWT3-OQ8	197	*S. cynosuroides*	15%	50%	89	N				
		A. cannabinus	5%	17%	132	Y	0	0	0	0
		P. australis	10%	33%	152	Y	0	0	0	0
ACWT3-OQ9	181	*S. alterniflora*	45%	52%	69	N				
		S. robustus	1%	1%	124	N	0	0	0	0
		A. cannabinus	40%	47%	107	Y	0	0	0	0
ACWT3-OQ10	175	*S. cynosuroides*	10%	16%	122	N				
		S. robustus	1%	2%	150	Y	0	0	0	0
		P. australis	50%	82%	241	N	0	0	0	0
ACWT3-OQ11	173	*P. australis*	30%	100%	201	N				
ACWT3-OQ12	165	*P. australis*	55%	100%	236	Y				

Table D-4
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Alloway Creek Watershed - Transect 3 8/15/06 - Continued										
ACWT3-OQ13	159	*P. australis*	15%	100%	185	Y				
ACWT3-CQ3	140	*S. alterniflora*	70%	93%	79	N	987	8802	0	308
		P. australis	5%	7%	160	Y	180	1608	0	0
ACWT3-OQ14	136	*S. alterniflora*	5%	11%	38	N				
		S. robustus	40%	89%	109	N	0	0	0	0
ACWT3-OQ15	130	*S. alterniflora*	30%	60%	91	N				
		A. cannabinus	20%	40%	152	Y	0	0	0	0
ACWT3-CQ4	118	*S. alterniflora*	40%	57%	97	N	1058	9435	0	202
		A. cannabinus	30%	43%	137	Y	610	5439	0	0
ACWT3-OQ16	105	*S. alterniflora*	60%	67%	56	N				
		A. cannabinus	30%	33%	132	Y	0	0	0	0
ACWT3-OQ17	98	*S. alterniflora*	70%	93%	97	N				
		S. robustus	5%	7%	150	Y	0	0	0	0
ACWT3-OQ18	80	*P. australis*	25%	100%	201	Y				
ACWT3-OQ19	78	*A. cannabinus*	5%	11%	104	Y				
		P. australis	40%	89%	183	Y	0	0	0	0
ACWT3-OQ20	69	*P. australis*	15%	60%	191	Y				
		Typha latifolia	10%	40%	193	N	0	0	0	0
ACWT3-OQ21	62	*P. australis*	35%	100%	185	Y				
ACWT3-CQ5	59	*S. alterniflora*	20%	67%	89	N	208	1858	0	330
		P. australis	10%	33%	135	N	87	781	0	0
ACWT3-CQ6	55	*S. alterniflora*	50%	100%	114	N	1049	9358	0	99
ACWT3-CQ7	17	*S. alterniflora*	1%	1%	94	N	159	1415	0	113
		S. robustus	40%	59%	165	Y	959	8561	0	0
		P. australis	1%	1%	155	N	43	387	0	0
		A. patula	25%	37%	84	N	118	1051	0	0
		A. cannabinus	1%	1%	91	Y	6	52	0	0
ACWT3-OQ22	15	*S. alterniflora*	10%	14%	76	N				
		S. robustus	60%	85%	163	Y	0	0	0	0
		A. cannabinus	1%	1%	66	Y	0	0	0	0
ACWT3-CQ8	3	*S. alterniflora*	10%	17%	114	N	763	6808	0	36
		P. virginica	40%	67%	89	N	361	3217	0	0
		S. robustus	10%	17%	127	Y	236	2105	0	0
ACWT3 - Mean - Spartina dominated Quadrats (b)			62%		93		1045	9320	0	235
ACWT3 - Mean - Non-Spartina dominated Quadrats (b)			47%		--		1141	10183	21	106
ACWT3- Mean - All Quadrats			53%		--		1093	9751	10	171

Table D-4
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Alloway Creek Watershed - Transect 4 8/23/06										
ACWT4-OQ1	246	*S. alterniflora*	30%	67%	147	Y				
		A. cannabinus	5%	11%	160	Y				
		P. virginica	10%	22%	66	N				
ACWT4-OQ2	243	Mud Flat	0%	0%	0					
ACWT4-OQ3	238	*S. alterniflora*	10%	100%	107	Y				
ACWT4-OQ4	225	*S. alterniflora*	20%	57%	107	Y				
		A. cannabinus	5%	14%	79	Y				
		E. walteri	10%	29%	84	Y				
ACWT4-OQ5	217	*S. alterniflora*	25%	100%	119	Y				
ACWT4-CQ1	217	*S. alterniflora*	25%	100%	119	Y	705	6286	0	0
ACWT4-CQ2	213	*S. alterniflora*	25%	100%	119	Y	825	7358	0	0
ACWT4-OQ6	208	*S. alterniflora*	20%	80%	142	Y				
		A. cannabinus	5%	20%	155	Y				
ACWT4-OQ7	206	*S. alterniflora*	25%	100%	160	Y				
ACWT4-OQ8	194	*A. cannabinus*	10%	67%	104	Y				
		E. walteri	5%	33%	58	Y				
ACWT4-OQ9	191	*A. cannabinus*	5%	50%	97	Y				
		E.walteri	5%	50%	61	Y				
ACWT4-OQ10	176	*S. alterniflora*	10%	100%	66	Y				
ACWT4-OQ11	175	*S. alterniflora*	20%	57%	97	Y				
		A. cannabinus	5%	14%	117	Y				
		P. virginica	10%	29%	56	Y				
ACWT4 - Mean - Spartina dominated Quadrats (b)			30%		103		765	6822	0	0
ACWT4 - Mean - Non-Spartina dominated Quadrats (b)			11%		--		0	0	0	0
ACWT4- Mean - All Quadrats			24%		--		765	6822	0	0
Site Mean - Spartina dominated Quadrats (b)			48%		101		1157	10325	0	191
Site Mean - Non-Spartina dominated Quadrats (b)			39%		--		876	7812	16	128
Site Mean - All Quadrats			44%		--		1016	9068	8	160

Table D-5
THE ROCKS WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
The Rocks - Transect 1 8/17/06										
TRT1-OQ1	48	*S. alterniflora*	25%	71%	107	N				
		S. cynosuroides	5%	14%	155	Y				
		A. cannabinus	5%	14%	137	Y				
TRT1-OQ2	99	*S. alterniflora*	40%	73%	81	N				
		A. cannabinus	15%	27%	109	Y				
TRT1-OQ3	103	*S. alterniflora*	40%	89%	86	N				
		A. cannabinus	5%	11%	99	Y				
TRT1-CQ1	144	*S. alterniflora*	25%	42%	99	N	712	6351	0	75
		S. patens	25%	42%			419	3737	0	0
		S. cynosuroides	10%	17%	107	N	193	1721	0	0
TRT1-OQ4	160	*S. alterniflora*	25%	56%	91	N				
		S. cynosuroides	10%	22%	107	N				
		A. cannabinus	10%	22%	97	Y				
TRT1-OQ5	198	*S. alterniflora*	55%	100%	99	Y				
TRT1-OQ6	224	*S. alterniflora*	20%	57%	66	N				
		S. cynosuroides	5%	14%	99	N				
		A. cannabinus	5%	14%	109	Y				
		Typha angustifolia	5%	14%	107	N				
TRT1-CQ2	234	*S. cynosuroides*	5%	14%	127	N	1010	9009	0	64
		S. robustus	25%	71%	109	Y	290	2583	0	0
		P. australis	5%	14%	86	N	30	265	0	0
TRT1-CQ3	247	*S. alterniflora*	5%	33%	74	N	147	1313	0	0
		S. robustus	5%	33%	107	N	75	673	0	0
		P. australis	5%	33%	117	N	218	1948	0	0
TRT1-OQ7	257	*S. alterniflora*	30%	86%	97	Y				
		S. robustus	5%	14%	124	N				
TRT1-CQ4	270	*S. alterniflora*	75%	100%	79	N	901	8036	0	212
TRT1-OQ8	285	*S. alterniflora*	35%	100%	76	N				
TRT1-CQ5	290	*S. alterniflora*	30%	60%	76	N	730	6517	0	229
		T. angustifolia	20%	40%	114	N	293	2614	0	0
TRT1-OQ9	290	*S. alterniflora*	45%	82%	58	N				
		T. angustifolia	10%	18%	94	N				
TRT1-OQ10	301	*S. alterniflora*	15%	43%	61	N				
		T. angustifolia	20%	57%	114	Y				
TRT1-CQ6	315	*S. alterniflora*	5%	33%	61	N	148	1318	0	203
		T. angustifolia	10%	67%	127	Y	796	7103	0	0
TRT1-OQ11	317	*T. angustifolia*	5%	33%	140	Y				
		S. robustus	5%	33%	99	Y				
		P. australis	5%	33%	241	Y				
TRT1-OQ12	327	*S. alterniflora*	20%	80%	107	N				
		S. cynosuroides	5%	20%	112	N				
TRT1-OQ13	342	*S. alterniflora*	45%	100%	109	N				
TRT1-OQ14	349	*S. alterniflora*	40%	89%	109	N				
		T. angustifolia	5%	11%	94	N				
TRT1-OQ15	360	*S. alterniflora*	15%	100%	89	N				
TRT1-OQ16	374	*S. alterniflora*	35%	100%	86	N				
TRT1-OQ17	381	*T. angustifolia*	25%	71%	127	N				
		S. robustus	10%	29%	114	Y				
TRT1-OQ18	400	*S. alterniflora*	5%	33%	56	N				
		S. robustus	10%	67%	124	Y				
TRT1 - Mean - Spartina dominated Quadrats (b)			46%		94		1083	9659	0	172
TRT1 - Mean - Non-Spartina dominated Quadrats (b)			23%		--		905	8070	0	89
TRT1- Mean - All Quadrats			38%		--		994	8865	0	130

Table D-5
THE ROCKS WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
The Rocks - Transect 2 8/17/06										
TRT2-CQ1	309	*S. cynosuroides*	50%	100%	185	N	1648	14700	449	111
TRT2-OQ1	306	*S. cynosuroides*	30%	100%	211	Y				
TRT2-CQ2	240	*S. cynosuroides*	35%	88%	203	Y	1815	16192	0	68
		S. americanus	5%	13%	152	Y	242	2159	0	0
TRT2-OQ2	238	*P. australis*	20%	67%	152	Y				
		S. robustus	10%	33%	122	Y				
TRT2-OQ3	230	*P. australis*	50%	100%	208	Y				
TRT2-OQ4	223	*S. cynosuroides*	25%	69%	216	Y				
		S. robustus	10%	28%	104	Y				
		E. walteri	1%	3%	74	Y				
TRT2-OQ5	190	*S. alterniflora*	25%	61%	163	N				
		S. robustus	15%	37%	145	Y				
		Pluchea purpurascens	1%	2%	48	Y				
TRT2-CQ3	185	*P. australis*	15%	37%	163	Y	35	311	0	121
		S. robustus	20%	49%	74	Y	281	2511	0	0
		T. angustifolia	5%	12%	137	N	339	3025	0	0
		P. purpurascens	1%	2%	41	Y	13	118	0	0
TRT2-OQ6	182	*P. australis*	20%	56%	163	Y				
		S. robustus	15%	42%	137	Y				
		P. purpurascens	1%	3%	38	Y				
TRT2-CQ4	180	*S. robustus*	15%	60%	142	Y	474	4227	0	43
		P. australis	10%	40%	178	Y	384	3429	0	0
TRT2-CQ5	175	*S. alterniflora*	10%	25%	140	Y	160	1428	0	169
		P. australis	25%	63%	180	Y	1128	10066	0	0
		T. angustifolia	5%	13%	132	N	223	1993	0	0
TRT2-OQ7	174	*P. australis*	20%	67%	175	Y				
		S. robustus	10%	33%	127	Y				
TRT2-OQ8	170	*S. cynosuroides*	20%	74%	155	Y				
		S. robustus	5%	19%	137	Y				
		P. purpurascens	1%	4%	28	Y				
		T. angustifolia	1%	4%	107	Y				
TRT2-OQ9	168	*S. alterniflora*	5%	13%	137	N				
		S. robustus	5%	13%	137	Y				
		S. americanus	30%	75%	140	N				
TRT2-OQ10	159	*S. alterniflora*	75%	99%	58	N				
		P. australis	1%	1%	76	N				
TRT2-OQ11	152	*S. alterniflora*	15%	29%	64	N				
		P. australis	1%	2%	157	Y				
		S. robustus	35%	69%	119	Y				
TRT2-OQ12	150	*S. alterniflora*	80%	100%	89	N				
TRT2-OQ13	141	*S. alterniflora*	25%	33%	140	Y				
		P. australis	25%	33%	155	Y				
		S. robustus	25%	33%	124	Y				
TRT2-CQ6	110	*P. australis*	50%	100%	213	Y	3172	28300	0	0
TRT2-OQ14	102	*P. australis*	35%	100%	196	Y				
TRT2-OQ15	99	*S. alterniflora*	65%	100%	79	N				
TRT2-CQ7	95	*S. alterniflora*	60%	100%	81	N	1219	10879	192	205
TRT2-OQ16	89	*S. alterniflora*	60%	100%	107	N				
TRT2-OQ17	75	*S. alterniflora*	70%	100%	114	N				
TRT2-OQ18	69	*S. alterniflora*	60%	98%	124	N				
		P. australis	1%	2%	104	N				
TRT2-OQ19	40	*S. alterniflora*	40%	100%	79	N				
TRT2-OQ20	34	*S. alterniflora*	15%	100%	74	N				
TRT2-OQ21	30	*S. alterniflora*	30%	100%	84	N				
TRT2-OQ22	27	*S. alterniflora*	30%	100%	89	N				
TRT2-CQ8	10	*S. alterniflora*	50%	83%	74	N	918	8189	298	88
		S. cynosuroides	10%	17%	142	N	185	1652	0	0
TRT2 - Mean - Spartina dominated Quadrats (b)			52%		126		1507	13443	235	118
TRT2 - Mean - Non-Spartina dominated Quadrats (b)			37%		--		1553	13852	0	84
TRT2- Mean - All Quadrats			46%		--		1530	13648	117	101

Table D-5
THE ROCKS WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
The Rocks - Transect 3 8/17/06										
TRT3-OQ1	387	*S. alterniflora*	30%	60%	132	N				
		P. punctatum	10%	20%	97	Y				
		A. patula	10%	20%	64	N				
TRT3-OQ2	380	*S. alterniflora*	40%	50%	97	N				
		S. cynosuroides	5%	6%	168	N				
		P. punctatum	20%	25%	107	Y				
		A. patula	15%	19%	91	Y				
TRT3-OQ3	375	*S. alterniflora*	30%	43%	117	N				
		P. punctatum	20%	29%	89	Y				
		A patula	20%	29%	97	Y				
TRT3-OQ4	363	*S. alterniflora*	25%	63%	147	Y				
		S. cynosuroides	15%	38%	160	Y				
TRT3-CQ1	339	*S. alterniflora*	60%	100%	160	N	1669	14892	0	0
TRT3-OQ5	344	*S. alterniflora*	50%	100%	142	N				
TRT3-OQ6	300	*S. alterniflora*	60%	100%	160	Y				
TRT3-OQ7	272	*S. alterniflora*	20%	100%	64	N				
TRT3-OQ8	248	*S. alterniflora*	40%	100%	86	Y				
TRT3-CQ2	217	*S. alterniflora*	70%	100%	122	N	1054	9407	0	69
TRT3-CQ3	204	*S. alterniflora*	40%	89%	102	Y	665	5937	318	17
		S. cynosuroides	5%	11%	157	Y	68	605	0	0
TRT3-OQ9	192	*S. alterniflora*	30%	67%	114	N				
		P. australis	15%	33%	104	N				
TRT3-CQ4	192	*S. alterniflora*	30%	67%	114	N	539	4812	0	242
		P. australis	15%	33%	104	N	217	1936	262	0
TRT3-OQ10	187	*S. cynosuroides*	50%	100%	175	Y				
TRT3-OQ11	172	*S. cynosuroides*	60%	100%	173	Y				
TRT3-OQ12	157	*S. cynosuroides*	30%	100%	135	N				
TRT3-CQ5	132	*S. cynosuroides*	25%	100%	135	N	953	8503	262	68
TRT3-OQ13	102	*S. cynosuroides*	5%	5%	102	N				
		S. patens	95%	95%	64	Y				
TRT3-OQ14	92	*S. patens*	90%	90%	58	Y				
		S. americanus	10%	10%	94	Y				
TRT3-OQ15	52	Dead *Phragmites australis*	10%	100%	183	Y				
TRT3-CQ6	50	*S. alterniflora*	40%	100%	94	N	277	2474	85	75
TRT3-OQ16	26	*S. alterniflora*	75%	100%	76	N				
TRT3-OQ17	22	*S. alterniflora*	70%	100%	66	Y				
TRT3-OQ18	12	*S. alterniflora*	40%	100%	107	Y				
TRT3 - Mean - Spartina dominated Quadrats (b)			51%		125		907	8094	154	79
TRT3 - Mean - Non-Spartina dominated Quadrats (b)			70%		--		0	0	0	0
TRT3- Mean - All Quadrats			53%		--		907	8094	154	79

Table D-5
THE ROCKS WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
The Rocks - Transect 4 8/17/06										
TRT4-OQ1	252	*S. cynosuroides*	30%	86%	269	Y				
		P. australis	5%	14%	279	Y				
TRT4-OQ2	249	*Phragmites australis*	10%	67%	127	Y				
		P. punctatum	5%	33%	94	Y				
TRT4-OQ3	241	*S. cynosuroides*	10%	100%	191	N				
TRT4-OQ4	232	*S. alterniflora*	5%	14%	127	Y				
		S. cynosuroides	30%	86%	163	N				
TRT4-OQ5	225	*S. alterniflora*	5%	11%	104	Y				
		S. patens	30%	67%	79	N				
		S. americanus	10%	22%	130	Y				
TRT4-CQ1	170	*S. patens*	30%	67%	79	N				
		P. australis	5%	11%	163	N	69	612	0	0
		S. americanus	10%	22%	109	Y	703	6275	0	0
TRT4-OQ6	168	*S. patens*	20%	57%	79	N				
		S. americanus	15%	43%	135	Y				
TRT4-OQ7	119	*S. patens*	25%	71%	81	N				
		S. americanus	5%	14%	112	N				
		Alhaea officinalis	5%	14%	61	Y				
TRT4-CQ2	107	*S. alterniflora*	5%	13%	102	N	43	386	0	161
		S. cynosuroides	25%	63%	160	N	549	4896	0	0
		P. australis	5%	13%	170	Y	115	1030	0	0
		A. officinalis	5%	13%	109	Y	101	897	0	0
TRT4-OQ8	98	*S. cynosuroides*	20%	80%	244	Y				
		P. australis	5%	20%	188	Y				
TRT4-OQ9	95	*S. cynosuroides*	25%	96%	279	Y				
		P. australis	1%	4%	249	Y				
TRT4-OQ10	89	*S. cynosuroides*	25%	83%	130	N				
		P. australis	5%	20%	178	N				
TRT4-CQ3	87	*P. australis*	1%	2%	137	N	145	1294	0	84
		S. patens	40%	95%	58	N	367	3277	0	0
		S. americanus	1%	2%	135	N	31	278	0	0
TRT4-OQ11	81	*S. cynosuroides*	5%	19%	152	N				
		P. australis	1%	4%	137	N				
		S. americanus	20%	77%	119	Y				
TRT4-OQ12	72	*P. australis*	15%	75%	193	Y				
		S. robustus	5%	25%	142	Y				
TRT4-OQ13	69	*P. australis*	5%	100%	264	Y				
TRT4-CQ4	65	*S. cynosuroides*	10%	40%	203	Y	834	7442	0	215
		P. australis	5%	20%	218	Y	191	1701	0	0
		S. robustus	10%	40%	137	Y	97	862	0	0
TRT4-OQ14	61	*S. cynosuroides*	30%	86%	279	Y				
		P. australis	5%	14%	305	Y				
TRT4-OQ15	54	*P. australis*	10%	100%	244	Y				
TRT4-CQ5	52	*P. australis*	10%	100%	218	Y	654	5836	0	50
TRT4-OQ16	50	*S. cynosuroides*	30%	67%	180	Y				
		P. australis	10%	22%	150	Y				
		S. robustus	5%	11%	157	Y				
TRT4-OQ17	47	*S. cynosuroides*	30%	86%	368	Y				
		P. australis	5%	14%	318	Y				
TRT4-CQ6	8	*S. cynosuroides*	10%	29%	259	Y	1341	11968	0	111
		P. australis	15%	43%	318	Y	554	4942	0	0
		T. angustifolia	10%	29%	257	N	101	899	0	0
TRT4-OQ18	2	*P. australis*	35%	97%	305	Y				
		S. robustus	1%	3%	91	N				
TRT4 - Mean - Spartina dominated Quadrats (b)			34%		209		808	7210	0	161
TRT4 - Mean - Non-Spartina dominated Quadrats (b)			26%		--		1017	9077	0	92
TRT4- Mean - All Quadrats			29%		--		982	8766	0	104
Site Mean - Spartina dominated Quadrats (b)			47%		129		1109	9895	133	116
Site Mean - Non-Spartina dominated Quadrats (b)			32%		--		1168	10417	0	88
Site Mean - All Quadrats			42%		--		1136	10136	72	103

Table D-6
CEDAR SWAMP WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Cedar Swamp - Transect 1 8/16/06										
CST1-OQ1	106	*S. alterniflora*	35%	85%	86	N				
		P. australis	5%	12%	107	N				
		A. cannabinus	1%	2%	86	Y				
CST1-OQ2	100	*S. alterniflora*	40%	100%	84	N				
CST1-CQ1	98	*S. alterniflora*	45%	100%	99	N	1194	10649	0	104
CST1-OQ3	93	*S. alterniflora*	45%	100%	69	N				
CST1-OQ4	89	*S. alterniflora*	45%	100%	89	N				
CST1-OQ5	84	*S. alterniflora*	35%	100%	99	N				
CST1-OQ6	82	*S. alterniflora*	35%	100%	102	N				
CST1-CQ2	78	*S. alterniflora*	25%	100%	99	N	1148	10244	0	70
CST1-OQ7	75	*S. alterniflora*	15%	100%	107	N				
CST1-OQ8	72	*S. alterniflora*	5%	100%	69	N				
CST1-OQ9	58	*S. alterniflora*	45%	100%	102	N				
CST1-OQ10	54	*S. alterniflora*	10%	22%	91	N				
		S. robustus	35%	78%	112	Y				
CST1-OQ11	53	*S. alterniflora*	35%	100%	89	N				
CST1-OQ12	50	*S. alterniflora*	10%	29%	71	N				
		S. robustus	25%	71%	119	N				
CST1-CQ3	41	*S. alterniflora*	25%	71%	86	N	914	8152	0	105
		S. robustus	10%	29%	112	N	73	655	0	0
CST1-OQ13	39	*S. alterniflora*	35%	100%	81	N				
CST1-CQ4	36	*S. alterniflora*	15%	100%	86	N	636	5673	0	0
CST1-OQ14	33	*S. cynosuroides*	35%	100%	239	Y				
CST1-CQ5	28	*S. cynosuroides*	30%	86%	229	Y	1442	12864	0	323
		A. patula	5%	14%	84	N	37	329	0	0
CST1-OQ15	27	*S. cynosuroides*	30%	86%	257	Y				
		A. patula	5%	14%	157	N				
CST1-OQ16	20	*S. cynosuroides*	35%	100%	259	Y				
CST1-CQ6	7	*S. cynosuroides*	30%	86%	145	N	1711	15262	0	172
		A. patula	5%	14%	81	Y	29	259	0	0
CST1-OQ17	4	*S. cynosuroides*	20%	80%	157	N				
		A. patula	5%	20%	97	N				
CST1-OQ18	1	*S. alterniflora*	15%	33%	119	N				
		S. cynosuroides	10%	22%	152	Y				
		A. patula	20%	44%	122	Y				
CST1 - Mean - Spartina dominated Quadrats (b)			37%		132		1309	11683	0	155
CST1 - Mean - Non-Spartina dominated Quadrats (b)			23%		--		636	5673	0	0
CST1- Mean - All Quadrats			34%		--		1197	10681	0	129

Table D-6
CEDAR SWAMP WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Cedar Swamp - Transect 2 8/16/06										
CST2-OQ1	116	*S. alterniflora*	40%	89%	109	N				
		S. robustus	5%	11%	117	N				
CST2-OQ2	113	*S. alterniflora*	45%	75%	94	N				
		S. robustus	15%	25%	112	Y				
CST2-CQ1	105	*S. alterniflora*	50%	83%	81	N	731	6524	0	104
		S. robustus	10%	17%	130	N	32	283	0	0
CST2-OQ3	103	*S. alterniflora*	15%	30%	89	Y				
		S. cynosuroides	25%	50%	155	Y				
		S. robustus	10%	20%	135	Y				
CST2-OQ4	94	*S. alterniflora*	15%	18%	97	N				
		S. cynosuroides	15%	18%	157	Y				
		S. robustus	5%	6%	135	Y				
		P. purpurascens	50%	59%	79	Y				
CST2-OQ5	86	*S. cynosuroides*	35%	100%	165	Y				
CST2-CQ2	81	*S. alterniflora*	20%	33%	102	N	1052	9383	0	86
		S. cynosuroides	35%	58%	147	N	145	1289	106	0
		S. robustus	5%	8%	135	N	30	264	0	0
CST2-OQ6	76	*S. alterniflora*	15%	50%	117	N				
		S. cynosuroides	15%	50%	150	N				
CST2-CQ3	62	*S. cynosuroides*	60%	100%	170	Y	1467	13084	388	180
CST2-OQ7	61	*S. alterniflora*	10%	29%	97	N				
		S. cynosuroides	25%	71%	188	Y				
CST2-OQ8	58	*S. alterniflora*	5%	20%	89	N				
		S. cynosuroides	20%	80%	193	Y				
CST2-OQ9	56	*S. alterniflora*	5%	14%	69	N				
		S. cynosuroides	25%	71%	216	Y				
		S. robustus	5%	14%	142	N				
CST2-OQ10	51	*S. alterniflora*	10%	29%	99	N				
		S. cynosuroides	20%	57%	160	N				
		S. robustus	5%	14%	130	Y				
CST2-OQ11	48	*S. alterniflora*	5%	14%	84	N				
		S. cynosuroides	30%	83%	173	Y				
		S. robustus	1%	3%	124	N				
CST2-OQ12	31	*S. alterniflora*	30%	59%	109	N				
		S. cynosuroides	15%	29%	193	N				
		S. robustus	1%	2%	137	Y				
		P. australis	5%	10%	180	Y				
CST2-OQ13	25	*S. cynosuroides*	5%	14%	203	N				
		P. australis	30%	86%	241	Y				
CST2-CQ4	24	*S. cynosuroides*	10%	13%	196	N	497	4435	0	104
		P. australis	70%	88%	229	Y	1316	11737	0	0
CST2-OQ14	22	*S. cynosuroides*	15%	38%	20	Y				
		P. australis	25%	63%	234	Y	0	0	0	0
CST2-CQ5	20	*S. cynosuroides*	5%	24%	173	Y	192	1711	0	139
		P. australis	15%	71%	168	Y	724	6460	39	0
		S. robustus	1%	5%	91	N	15	133	0	0
CST2-OQ15	14	*S. alterniflora*	45%	75%	97	N				
		P. australis	15%	25%	132	Y				
CST2-OQ16	10	*S. alterniflora*	40%	100%	119	N				
CST2-CQ6	8	*S. alterniflora*	70%	100%	102	N	1018	9087	0	195
CST2-OQ17	6	*S. alterniflora*	55%	100%	76	N				
CST2-OQ18	2	*S. alterniflora*	60%	100%	89	N				
CST2 - Mean - Spartina dominated Quadrats (b)			49%		126		1118	9979	123	141
CST2 - Mean - Non-Spartina dominated Quadrats (b)			44%		--		1372	12238	19	122
CST2- Mean - All Quadrats			48%		--		1203	10732	89	135

Table D-6
CEDAR SWAMP WETLAND RESTORATION SITE
PEAK SEASON 2006 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
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Cedar Swamp - Transect 3 8/16/06										
CST3-CQ1	5	*P. punctatum*	85%	100%	69	Y	767	6847	0	85
CST3-OQ1	9	*E. walteri*	20%	44%	109	Y				
		A. cannabinus	15%	33%	114	N				
		P. punctatum	10%	22%	58	Y				
CST3-CQ2	10	*A. cannabinus*	15%	60%	76	Y	270	2412	0	439
		P. punctatum	10%	40%	48	Y	360	3208	0	0
CST3-OQ2	10	*A. cannabinus*	5%	11%	79	N				
		P. punctatum	40%	89%	71	Y				
CST3-OQ3	30	*S. alterniflora*	25%	100%	97	N				
CST3-OQ4	66	*S. alterniflora*	5%	100%	48	N				
CST3-OQ5	103	*S. alterniflora*	5%	33%	76	N				
		P. australis	10%	67%	86	N				
CST3-OQ6	112	*S. alterniflora*	25%	63%	69	N				
		P. australis	15%	38%	109	N				
CST3-CQ3	113	*S. alterniflora*	40%	89%	61	N	757	6752	0	498
		P. australis	5%	11%	71	N	12	103	0	0
CST3-OQ7	125	*S. alterniflora*	35%	100%	69	N				
CST3-OQ8	132	*S. alterniflora*	35%	100%	71	N				
CST3-OQ9	143	*S. alterniflora*	30%	86%	64	N				
		P. australis	5%	14%	155	N				
CST3-OQ10	160	*S. alterniflora*	40%	89%	56	N				
		S. cynosuroides	5%	11%	86	Y				
CST3-OQ11	165	*S. alterniflora*	25%	100%	56	N				
CST3-OQ12	186	*S. alterniflora*	65%	100%	61	N				
CST3-OQ13	195	*S. alterniflora*	55%	100%	61	N				
CST3-CQ4	200	*S. alterniflora*	15%	33%	69	N	99	881	0	631
		S. cynosuroides	30%	67%	84	N	85	757	0	0
CST3-OQ14	238	*S. alterniflora*	45%	100%	76	N				
CST3-OQ15	256	*S. alterniflora*	20%	44%	56	N				
		S. cynosuroides	25%	56%	104	N				
CST3-OQ16	284	*S. alterniflora*	35%	100%	66	N				
CST3-OQ17	301	*S. alterniflora*	5%	20%	56	N				
CST3-OQ18	366	*S. alterniflora*	5%	14%	51	N				
		S. cynosuroides	30%	86%	114	N				
CST3 - Mean - Spartina dominated Quadrats (b)			38%		76		757	6756	89	345
CST3 - Mean - Non-Spartina dominated Quadrats (b)			37%		--		699	6233	0	262
CST3- Mean - All Quadrats			38%		--		738	6582	59	317
							0	0	0	0

Quadrat No. (a)	Distance From Start	Species Identification	% Cover		Height (cm)	Flowering (Y/N)	Biomass Live Standing		Dead Standing gdw/m2	Dead Standing gdw/m2
			Aerial	Relative			gdw/m2	lb/acre	gdw/m2	gdw/m2
Cedar Swamp - Transect 4 8/16/06							0	0	0	0
CST4-OQ1	179	*S. alterniflora*	60%	100%	89	N				
CST4-OQ2	160	*S. alterniflora*	30%	100%	145	N				
CST4-CQ1	150	*S. alterniflora*	25%	100%	104	N	958	8546	0	82
CST4-OQ3	135	*S. cynosuroides*	30%	100%	183	Y				
CST4-CQ2	110	*S. alterniflora*	40%	100%	112	N	975	8696	0	439
CST4-OQ4	100	*S. alterniflora*	40%	57%	86	N				
		P. purpurascens	30%	43%	48	Y				
CST4-OQ5	60	*S. alterniflora*	60%	100%	89	N				
CST4-OQ6	25	*S. alterniflora*	25%	100%	74	N				
CST4 - Mean - Spartina dominated Quadrats (b)			43%		110		966	8621	0	261
CST4 - Mean - Non-Spartina dominated Quadrats (b)			0%		--		0	0	0	0
CST4- Mean - All Quadrats			43%		--		966	8621	0	261
Site Mean - Spartina dominated Quadrats (b)			42%		112		1065	9506	57	216
Site Mean - Non-Spartina dominated Quadrats (b)			34%		--		955	8523	8	153
Site Mean - All Quadrats			40%		--		1038	9261	44	200

(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 2006 60 X 60 M PLOT DATA
PSE&G 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		
Mad Horse Creek - Plot 1 8/22/06									
MHP1-06-VP1	*Spartina alterniflora*	20%	80%	58	N	525	4684	0	0
	Phragmites australis	5%	20%	155	Y	0	0	0	0
MHP1-06-VP2	*S. alterniflora*	50%	82%	86	N	699	6235	0	83
	Scirpus robustus	10%	16%	99	Y	0	0	0	0
	Aster sp.	1%	2%	71	N	13	120	0	0
MHP1-06-VP3	*S. alterniflora*	30%	100%	91	N	311	2779	0	0
MHP1-06-VP4	*S. alterniflora*	15%	100%	58	N	455	4056	0	0
MHP1-06-VP5	*S. alterniflora*	25%	100%	99	N	0	0	0	101
MHP1-06-VP6	*S. alterniflora*	30%	67%	84	N	0	0	0	0
	Spartina cynosuroides	5%	11%	117	N	60	535	0	0
	S. robustus	10%	22%	135	N	186	1660	0	0
MHP1-06-VP7	*S. alterniflora*	35%	100%	86	N	1131	10087	0	0
MHP1-06-VP8	*S. alterniflora*	30%	67%	140	N	1037	9255	0	104
	S. robustus	15%	33%	124	N	0	0	0	0
MHP1-06-VP9	*S. alterniflora*	25%	100%	122	N	976	8704	0	0
Mean for Plot		34%		98		599	5346	0	23
Mad Horse Creek - Plot 2 8/22/06									
MHP2-06-VP1	*S. alterniflora*	45%	100%	107	N	974	8694	0	33
MHP2-06-VP2	*S. alterniflora*	35%	100%	66	N	1005	8971	0	0
MHP2-06-VP3	*S. alterniflora*	35%	100%	56	N	799	7130	0	0
MHP2-06-VP4	*S. alterniflora*	35%	97%	84	N	0	0	0	0
	S. robustus	1%	3%	112	N	0	0	0	0
MHP2-06-VP5	*S. alterniflora*	5%	100%	41	N	0	0	0	0
MHP2-06-VP6	*S. alterniflora*	15%	100%	56	N	331	2950	0	210
MHP2-06-VP7	*S. alterniflora*	45%	100%	99	N	1181	10534	0	92
MHP2-06-VP8	*S. alterniflora*	45%	100%	81	N	630	5621	0	0
MHP2-06-VP9	*S. alterniflora*	20%	100%	99	N	0	0	0	0
Mean for Plot		31%		85		547	4878	0	48
Mad Horse Creek - Plot 3 8/22/06									
MHP3-06-VP1	*S. alterniflora*	45%	100%	56	N	1025	9149	0	0
MHP3-06-VP2	*S. alterniflora*	25%	100%	48	N	339	3028	0	0
MHP3-06-VP3	*S. alterniflora*	35%	100%	64	N	427	3812	0	68
MHP3-06-VP4	*S. alterniflora*	15%	18%	99	N	0	0	0	0
	Spartina patens	70%	82%	64	N	457	4074	0	0
MHP3-06-VP5	*S. alterniflora*	30%	86%	76	N	461	4116	0	0
	S. patens	5%	14%	56	N	0	0	0	0
MHP3-06-VP6	*S. alterniflora*	45%	100%	84	N	0	0	0	64
MHP3-06-VP7	*S. alterniflora*	45%	100%	122	N	2056	18345	0	110
MHP3-06-VP8	*S. cynosuroides*	40%	100%	173	Y	886	7901	41	350
MHP3-06-VP9	*S. alterniflora*	15%	19%	91	N	289	2578	0	0
	S. patens	65%	81%	76	N	706	6296	0	0
Mean for Plot		48%		85		738	6589	5	59
Mean for Site		38%		90		628	5604	2	44

Table E-2
MOORES BEACH REFERENCE MARSH
PEAK SEASON 2006 60 X 60 M PLOT DATA
PSE&G 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		
Moores Beach - Plot 1 8/20/06									
MBP1-06-VP1	*S. alterniflora*	50%	100%	97	N	1319	11767	0	46
MBP1-06-VP2	*S. alterniflora*	30%	100%	79	N	697	6215	0	40
MBP1-06-VP3	*S. alterniflora*	25%	100%	97	N	637	5681	0	67
MBP1-06-VP4	*S. alterniflora*	25%	100%	89	N	592	5282	0	16
MBP1-06-VP5	*S. alterniflora*	45%	100%	124	N	867	7738	0	118
MBP1-06-VP6	*S. alterniflora*	25%	100%	61	N	0	0	0	56
MBP1-06-VP7	*S. alterniflora*	30%	100%	81	N	650	5802	0	0
MBP1-06-VP8	*S. alterniflora*	35%	100%	74	N	511	4559	0	11
MBP1-06-VP9	*S. alterniflora*	35%	100%	97	N	514	4587	0	59
Mean for Plot		33%		89		643	5737	0	40
Moores Beach - Plot 2 8/20/06									
MBP2-06-VP1	*S. alterniflora*	35%	100%	56	N	773	6897	0	43
MBP2-06-VP2	*S. alterniflora*	5%	100%	64	N	123	1094	0	45
MBP2-06-VP3	*S. alterniflora*	15%	100%	99	N	522	4657	0	122
MBP2-06-VP4	*S. alterniflora*	30%	100%	94	N	1390	12401	0	63
MBP2-06-VP5	*S. alterniflora*	45%	100%	56	N	512	4565	0	41
MBP2-06-VP6	*S. alterniflora*	55%	100%	56	N	627	5596	0	66
MBP2-06-VP7	*S. alterniflora*	45%	100%	56	N	776	6923	0	87
MBP2-06-VP8	*S. alterniflora*	20%	100%	86	N	658	5870	0	47
MBP2-06-VP9	*S. alterniflora*	15%	100%	86	N	502	4479	0	0
Mean for Plot		29%		67		654	5831	0	57
Moores Beach - Plot 3 8/21/06									
MBP3-06-VP1	*S. alterniflora*	15%	100%	69	N	372	3321	0	97
MBP3-06-VP2	*S. alterniflora*	15%	100%	89	N	348	3108	0	295
MBP3-06-VP3	*S. alterniflora*	5%	100%	69	N	247	2201	0	199
MBP3-06-VP4	*S. alterniflora*	5%	100%	86	N	42	374	0	110
MBP3-06-VP5	*S. alterniflora*	1%	100%	36	N	5	49	0	366
MBP3-06-VP6	*S. alterniflora*	45%	100%	107	N	1417	12642	0	72
MBP3-06-VP7	*S. alterniflora*	35%	100%	86	N	508	4533	0	93
MBP3-06-VP8	*S. alterniflora*	15%	100%	74	N	159	1420	0	124
MBP3-06-VP9	*S. alterniflora*	10%	100%	76	N	189	1688	0	129
Mean for Plot		16%		97		365	3260	0	165
Mean for Site		26%		82		554	4942	0	87

Table E-3
COMMERCIAL TOWNSHIP SALT HAY FARM RESTORATION SITE
PEAK SEASON 2006 60 X 60 M PLOT DATA
PSE&G 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		
Commercial Township - Plot 1 8/19/06									
CTP1-06-VP1	Mud Flat	0%	0%	0		0	0	0	0
CTP1-06-VP2	*S. alterniflora*	35%	100%	122	N	1120	9988	0	0
CTP1-06-VP3	Mud Flat	0%	0%	0		0	0	0	0
CTP1-06-VP4	Mud Flat	0%	0%	0		0	0	0	1676
CTP1-06-VP5	*S. alterniflora*	35%	100%	109	Y	755	6740	0	59
CTP1-06-VP6	Mud Flat	0%	0%	0		0	0	0	0
CTP1-06-VP7	*S. alterniflora*	25%	100%	64	N	823	7339	0	0
CTP1-06-VP8	Mud Flat	0%	0%	0		0	0	0	1417
CTP1-06-VP9	Mud Flat	0%	0%	0		0	0	0	0
Mean for Plot		11%		98		300	2674	0	477
Commercial Township - Plot 2 8/19/06									
CTP2-06-VP1	*S. alterniflora*	15%	100%	160	N	916	8171	0	32
CTP2-06-VP2	*S. alterniflora*	15%	100%	89	N	454	4055	0	260
CTP2-06-VP3	*S. alterniflora*	15%	100%	127	N	746	6660	0	73
CTP2-06-VP4	Mud Flat	0%	0%	0		0	0	0	0
CTP2-06-VP5	*S. alterniflora*	25%	100%	79	N	892	7961	0	256
CTP2-06-VP6	*S. alterniflora*	45%	100%	170	N	1256	11207	0	216
CTP2-06-VP7	*S. alterniflora*	5%	100%	38	N	55	492	0	0
CTP2-06-VP8	*S. alterniflora*	35%	100%	142	N	928	8280	0	572
CTP2-05-VP9	*S. alterniflora*	15%	100%	114	N	938	8371	0	187
Mean for Plot		19%		130		687	6133	0	177
Commercial Township - Plot 3 8/19/06									
CTP3-06-VP1	*S. alterniflora*	25%	100%	99	N	379	3379	0	156
CTP3-06-VP2	*S. alterniflora*	30%	100%	99	Y	843	7523	0	137
CTP3-06-VP3	*S. alterniflora*	5%	100%	124	N	591	5275	0	201
CTP3-06-VP4	*S. alterniflora*	15%	100%	107	N	313	2794	0	0
CTP3-06-VP5	*S. alterniflora*	15%	100%	94	N	387	3450	0	0
CTP3-06-VP6	*S. alterniflora*	10%	100%	99	N	301	2686	0	354
CTP3-06-VP7	*S. alterniflora*	25%	100%	109	N	586	5230	0	372
CTP3-06-VP8	*S. alterniflora*	25%	100%	66	N	476	4245	0	135
CTP3-06-VP9	*S. alterniflora*	5%	100%	46	N	100	893	0	140
Mean for Plot		17%		93		442	3942	0	166
Commercial Township - Plot 4 8/19/06 (Grasshopper)									
CTP4-06-VP1	*S. alterniflora*	25%	100%	76	N	299	2668	0	0
CTP4-06-VP2	*S. alterniflora*	40%	100%	127	N	1343	11980	0	48
CTP4-06-VP3	Mud Flat	0%	0%	0		0	0	0	0
CTP4-06-VP4	*S. alterniflora*	45%	100%	61	N	784	6993	0	73
CTP4-06-VP5	*S. alterniflora*	5%	100%	33	N	21	192	0	0
CTP4-06-VP6	*S. alterniflora*	45%	100%	56	N	501	4468	0	0
CTP4-06-VP7	*S. alterniflora*	15%	100%	89	N	467	4170	0	37
CTP4-06-VP8	Mud Flat	0%	0%	0		0	0	0	0
CTP4-06-VP9	Mud Flat	0%	0%	0		0	0	0	1265
Mean for Plot		19%		80		379	3386	0	269
Mean for Site		17%		99		452	4034	0	278

Table E-4
ALLOWAY CREEK WATERSHED PHRAGMITES RESTORATION SITE
PEAK SEASON 2006 60 X 60 M PLOT DATA
PSE&G 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		
Alloway Creek Watershed - Plot 1 8/23/06									
ACWP1-06-VP1	*S. alterniflora*	25%	83%	163	Y	1024	9133	0	0
	Amaranthous cannabinus	5%	17%	170	Y	117	1044	0	0
ACWP1-06-VP2	*S. alterniflora*	15%	100%	135	Y	701	6252	0	116
ACWP1-06-VP3	*S. alterniflora*	15%	100%	81	Y	317	2825	0	0
ACWP1-06-VP4	*S. alterniflora*	20%	80%	135	Y	0	0	0	66
	A. cannabinus	5%	20%	122	Y	10	89	0	0
ACWP1-06-VP5	*S. alterniflora*	35%	100%	142	N	707	6308	0	0
ACWP1-06-VP6	*S. alterniflora*	25%	100%	175	Y	1410	12583	0	0
ACWP1-06-VP7	*S. alterniflora*	35%	100%	157	Y	1035	9234	0	0
ACWP1-06-VP8	*P. australis*	45%	100%	262	Y	763	6807	0	0
ACWP1-06-VP9	Mud Flat	0%	0%	0		0	0	0	489
Mean for Plot		25%		154		676	6031	0	116
Alloway Creek Watershed - Plot 2 8/23/06									
ACWP2-06-VP1	*S. alterniflora*	35%	88%	74	N	412	3680	0	258
	A. cannabinus	5%	13%	142	Y	43	382	0	0
ACWP2-06-VP2	*S. alterniflora*	45%	90%	61	N	732	6534	0	92
	A. cannabinus	5%	10%	117	Y	41	366	0	0
ACWP2-06-VP3	*S. alterniflora*	20%	57%	61	N	167	1487	0	106
	Echinochloa walteri	15%	43%	53	Y	128	1146	0	0
ACWP2-06-VP4	*S. alterniflora*	45%	100%	56	N	856	7639	0	50
ACWP2-06-VP5	*S. alterniflora*	35%	100%	109	Y	515	4598	0	24
ACWP2-06-VP6	*S. alterniflora*	35%	100%	48	N	349	3118	0	99
ACWP2-06-VP7	*S. alterniflora*	15%	100%	48	N	261	2328	0	311
ACWP2-06-VP8	*S. alterniflora*	15%	100%	48	N	261	2330	0	294
ACWP2-06-VP9	*S. alterniflora*	15%	100%	66	N	280	2494	0	0
Mean for Plot		32%		68		450	4011	0	137
Alloway Creek Watershed - Plot 3 8/15/06									
ACWP3-06-VP1	*S. alterniflora*	15%	50%	56	N	337	3003	0	123
	S. robustus	15%	50%	91	N	110	983	0	0
ACWP3-06-VP2	*S. alterniflora*	10%	40%	79	N	360	3213	0	263
	A. cannabinus	15%	60%	135	Y	296	2637	0	0
ACWP3-06-VP3	*S. alterniflora*	40%	62%	79	N	765	6822	0	327
	A. cannabinus	25%	38%	198	Y	1034	9230	0	0
ACWP3-06-VP4	*S. alterniflora*	20%	80%	64	N	267	2379	0	57
	P. australis	5%	20%	61	N	52	462	0	0
ACWP3-06-VP5	*S. alterniflora*	20%	80%	97	N	1036	9246	0	302
	A. cannabinus	5%	20%	64	Y	22	197	0	0
ACWP3-06-VP6	*S. alterniflora*	40%	89%	86	N	741	6616	0	154
	A. cannabinus	5%	11%	119	Y	97	862	0	0
ACWP3-06-VP7	*S. alterniflora*	20%	80%	97	N	801	7149	0	627
	A. cannabinus	5%	20%	81	Y	13	113	0	0
ACWP3-06-VP8	*S. alterniflora*	45%	90%	102	N	1180	10532	0	389
	A. cannabinus	5%	10%	79	Y	32	285	0	0
ACWP3-06-VP9	*S. alterniflora*	25%	100%	79	N	821	7325	0	124
Mean for Plot		35%		86		885	7895	0	263
Mean for Site		31%		99		670	5979	0	170

Table E-5
THE ROCKS PHRAGMITES RESTORATION SITE
PEAK SEASON 2006 60 X 60 M PLOT DATA
PSE&G 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		
The Rocks - Plot 8/17/06									
TRP1-06-VP1	*S. alterniflora*	25%	100%	99	Y	741	6610	0	17
TRP1-06-VP2	*S. alterniflora*	30%	67%	130	N	589	5252	0	83
	Scirpus americanus	5%	11%	132	N	90	799	0	0
	Typha angustifolia	10%	22%	119	N	62	554	0	0
TRP1-06-VP3	*S. cynosuroides*	20%	100%	142	Y	761	6794	146	67
TRP1-06-VP4	*S. robustus*	15%	60%	224	N	345	3074	0	20
	T. angustifolia	10%	40%	218	Y	820	7313	0	0
TRP1-06-VP5	*S. alterniflora*	20%	56%	127	Y	555	4947	0	74
	S. robustus	15%	42%	119	Y	94	838	0	0
	T. angustifolia	1%	3%	135	N	27	244	0	0
TRP1-06-VP6	*S. alterniflora*	50%	100%	109	N	778	6945	0	68
TRP1-06-VP7	*S. alterniflora*	20%	57%	91	Y	266	2371	0	67
	S. robustus	15%	43%	122	Y	288	2574	0	0
TRP1-06-VP8	*S. americanus*	5%	8%	117	N	188	1674	0	103
	T. angustifolia	10%	15%	152	N	44	389	0	0
	S. patens	50%	77%	89	N	559	4990	0	0
TRP1-06-VP9	*S. robustus*	15%	30%	119	N	93	831	0	33
	S. americanus	30%	60%	69	N	256	2283	0	0
	T. angustifolia	5%	10%	51	N	37	332	137	0
Mean for Plot		39%		116		732	6535	31	59
Mean for Site		39%		116		732	6535	31	59

Table E-6
CEDAR SWAMP PHRAGMITES RESTORATION SITE
PEAK SEASON 2006 60 X 60 M PLOT DATA
PSE&G 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		
Cedar Swamp - Plot 1 8/16/06									
CSP1-06-VP1	*S. alterniflora*	20%	100%	147	N	943	8417	354	152
CSP1-06-VP2	*S. alterniflora*	40%	100%	107	N	1113	9931	117	218
CSP1-06-VP3	*S. alterniflora*	30%	100%	94	N	583	5199	268	337
CSP1-06-VP4	*S. alterniflora*	10%	100%	130	N	534	4760	0	258
CSP1-06-VP5	*S. cynosuroides*	45%	100%	142	Y	1697	15137	0	184
CSP1-06-VP6	*S. alterniflora*	35%	100%	109	N	919	8203	0	79
CSP1-06-VP7	*S. alterniflora*	45%	100%	89	N	1058	9438	0	55
CSP1-06-VP8	*S. alterniflora*	40%	89%	81	N	621	5536	0	165
	S. cynosuroides	5%	11%	122	N	77	690	0	0
CSP1-06-VP9	*S. alterniflora*	35%	100%	86	N	832	7424	0	111
Mean for Plot		34%		109		931	8304	82	173
Mean for Site		34%		109		931	8304	82	173